NATIONAL MARINE FISHERIES SERVICE
BEAUFORT, NORTH CAROLINA 28516

UNITED STATES COMMISSION OF FISH AND FISHERIES
SPENCER F. BAIRD, COMMISSIONER

THE FISHERIES

AND

FISHERY INDUSTRIES

OF THE

UNITED STATES

PREPARED THROUGH THE CO-OPERATION OF THE COMMISSIONER OF FISHERIES AND THE SUPERINTENDENT OF THE TENTH CENSUS

BY

GEORGE BROWN GOODE
ASSISTANT DIRECTOR OF THE U. S. NATIONAL MUSEUM
AND A STAFF OF ASSOCIATES

SECTION I

NATURAL HISTORY OF USEFUL AQUATIC ANIMALS

WITH AN ATLAS OF TWO HUNDRED AND SEVENTY-SEVEN PLATES

TEXT

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PREFATORY NOTE.

U. S. COMMISSION OF FISH AND FISHERIES,
Washington, May 30, 1884.

In July, 1879, an arrangement was made with General Francis A. Walker, Superintendent of the Tenth Census, by which an investigation of the fisheries of the United States was undertaken as the joint enterprise of the United States Fish Commission and of the Census Bureau. It was decided that this investigation should be as exhaustive as possible, and that both the United States Fish Commission and the Census should participate in its results. The preparation of a statistical and historical monograph of the fisheries, to form one of the series to be presented by the Superintendent of the Census in his report, was from the first the main object of the work, but in connection with this work extensive investigations into the methods of the fisheries, into the distribution of the fishing-grounds, and the natural history of useful marine animals were inaugurated and carried on.

The direction of this investigation was placed in the hands of Mr. G. Brown Goode, Assistant Director of the National Museum, who had already been engaged for a number of years in a systematic, historical, and statistical investigation of the American fisheries, and who as early as 1877 had drawn up a scheme for an exhaustive exploration of the coast, quite as elaborate as that now adopted and not essentially different.

The first step taken was to secure the co-operation of as many as possible of those persons who had in the past given attention to the subject of the fisheries, and this was so successfully accomplished that it is safe to say that every one who has been of late years prominent in such studies has taken part in the preparation of this report.

The plan of the proposed investigation was drawn up by Mr. Goode before beginning the work, and was published in an octavo pamphlet of fifty-four pages, entitled "Plan of Inquiry into the History and Present Condition of the Fisheries of the United States." Washington: Government Printing Office; 1879.

The scheme of investigation divided the work into the following departments:

I. *Natural history of marine products.*—Under this head was to be carried on the study of the useful aquatic animals and plants of the country, as well as of seals, whales, turtles, fishes, lobsters, crabs, oysters, clams, etc., sponges, and marine plants and inorganic products of the sea with reference to (A) geographical distribution, (B) size, (C) abundance, (D) migrations and movements, (E) food and rate of growth, (F) mode of reproduction, (G) economic value and uses.

II. *The fishing grounds.*—Under this head were to be studied the geographical distribution of all animals sought by fishermen, and the location of the fishing-grounds; while, with reference

to the latter, are considered: (A) location, (B) topography, (C) depth of water, (D) character of bottom, (E) temperature of water, (F) currents, (G) character of invertebrate life, etc.

III. *The fishermen and fishing towns.*—Here were to be considered the coast districts engaged in the fisheries, with reference to their relation to the fisheries, historically and statistically, and the social, vital, and other statistics relating to the fishermen.

IV. *Apparatus and methods of capture.*—Here were to be considered all the forms of apparatus used by fishermen; boats, nets, traps, harpoons, etc., and the methods employed in the various branches of the fishery. Here each special kind of fishery, of which there are more than fifty in the United States, is considered separately with regard to its methods, its history, and its statistics.

V. *Products of fisheries.*—Under this head were to be studied the statistics of the yield of American fisheries, past and present.

VI. *Preparation, care of, and manufacture of fishery products.*—Here were to be considered the methods and the various devices for utilizing fish after they are caught, with statistics of capital and men employed, etc.: (A) preservation of live fish, (B) refrigeration, (C) sun-drying, (D) smoke-drying, (E) pickling, (F) hermetically canning, (G) fur dressing, (H) whalebone preparation, (I) isinglass manufacture, (K) ambergris manufacture, (L) fish guano manufacture, (M) oil rendering, etc.

VII. *Economy of the fisheries.*—Here were to be studied: (A) financial organization and methods, (B) insurance, (C) labor and capital, (D) markets and market prices, (E) lines of traffic, (F) exports, imports, and duties.

The fishery industry is of such great importance, and is undergoing such constant changes that a visit of a few days or weeks to any locality, even by the most competent experts, has invariably proved unsatisfactory. We were able therefore to collect only the most important facts, selected with special reference to the needs of the report in contemplation, leaving many subjects of interest undiscussed.

The field-work, and the correspondence in connection with it, was carried on by the following-named special agents, and approximately between the dates below mentioned:

I.—Coast of Maine, east of Portland. Mr. R. Edward Earll and Captain J. W. Collins, August 1 to October 31, 1879; July 29 to October 20, 1880; January 1, 1881, to January 1, 1883.

II.—Portland to Plymouth (except Cape Ann) and eastern side of Buzzard's Bay. W. A. Wilcox, September 2, 1879, to March 1, 1881.

III.—Cape Ann. A. Howard Clark, September 1, 1879, to November 1, 1880; July, August, and September, 1883.

IV.—Cape Cod. Frederick W. True, July 1 to October 1, 1879; September 1 to October 31, 1880; Vinal N. Edwards, October 1, 1880, to July 31, 1882.

V.—Provincetown. Captain N. E. Atwood, August 1, 1879, to August 1, 1880.

VI.—Rhode Island and Connecticut, west to the Connecticut River. Ludwig Kumlien, August 16 to October 16, 1880.

VII.—Long Island and north shore of Long Island Sound, and west to Sandy Hook. Frederick Mather, August 1, 1879, to July 1, 1881.

VIII.—New York City. Barnet Phillips, January 1, 1880, to July 1, 1881.

IX.—Coast of New Jersey. R. Edward Earll, December, 1880.

X.—Philadelphia. C. W. Smiley and W. V. Cox, November, 1880.

XI.—Coast of Delaware. Captain J. W. Collins, December, 1880.

XII.—Baltimore and the oyster industry of Maryland. R. H. Edmonds, October 1, 1879, to October 1, 1880.

XIII.—Atlantic coast of Southern States. R. Edward Earll, January 1 to July 25, 1880.

XIV.—Gulf coast. Silas Stearns, August, 1879, to July, 1880.

XV.—Coast of California, Oregon, and Washington. Professor D. S. Jordan and C. H. Gilbert, January, 1880, to January, 1881.

XVI.—Puget Sound. James G. Swan, January, 1880, to January, 1881.

XVII.—Alaska fisheries. Dr. T. H. Bean, June to October, 1880.

XVIII.—Great Lakes fishery. Ludwig Kumlien, August, 1879, to August, 1880.

XIX.—River fisheries of Maine. C. G. Atkins, January 1, 1880, to July 3, 1882.

XX.—The shad and alewife fisheries. Colonel Marshall MacDonald, October, 1879, to January 1, 1883.

XXI.—Oyster fisheries. Ernest Ingersoll, October 1, 1879, to July 1, 1881.

XXII.—Lobster and crab fisheries. Richard Rathbun, January 1, 1880, to January 1, 1882.

XXIII.—Turtle and terrapin fisheries. Frederick W. True, October 1, 1880, to January 1, 1882.

XXIV.—The seal, sea-elephant, and whale fisheries. A. Howard Clark, November 1, 1880, to February 1, 1881.

In addition to the field assistants already mentioned a staff of office assistants were employed in carrying on correspondence, searching past records, and preparing the report for publication. Mr. C. W. Smiley, Mr. James Temple Brown, and Mr. George S. Hobbs were connected with the work from its start, and subsequently Mr. J. E. Rockwell, Mr. C. W. Scudder, Mr R. I Geare, Mr. G. P. Merrill, Mr. W. S. Yeates, and others were thus employed. A number of clerks were temporarily detailed for this work by the Superintendent of the Census; at one time as many as twenty.

A portion of the clerical force was placed under the immediate direction of Mr. C. W. Smiley, who had in special charge the distribution of circulars and the compilation of their results, and the compilation of summary tables from the records of the Treasury Department.

The expense of the field-work from July 1, 1879, to July 1, 1881, was for the most part borne by the Census, together with a large amount of compilation office-work carried on by clerks detailed from the Census Office in Washington.

The expense of the preparation of the report, final tabulation of statistics of production, and preparation of illustrations has been mainly at the cost of the Fish Commission. Since February, 1881, Mr. Goode's relation to the work has been that of a volunteer, and his services in the preparation of the reports and in connection with their publication have been rendered without compensation, in addition to his regular duties as Assistant Director of the National Museum. In the same manner a large share of the most important work upon special parts of the report has been done as volunteer labor by officers of the National Museum and Fish Commission, in addition to their regular duties. A number of employees of the Fish Commission have been detailed from time to time for special work upon this report, for periods varying from four months to two years.

The participation of the Census Office and the Commissioner of Fish and Fisheries has involved the expenditure of probably nearly equal amounts of money, and the division of the results, so far as they are represented in reports ready for the printer, has been arranged to the satisfaction of both. The extent of the material collected has, however, been much greater than was anticipated, and the portion assigned to the Fish Commission being too bulky for publication in the annual reports, application was made to Congress for permission to print as a separate special report an illustrated work in quarto upon the Food Fishes and Fisheries of the United States.

This permission was granted in a joint resolution, worded as follows, which passed the Senate July 16, 1882:

Resolved by the Senate (the House of Representatives concurring), That the Public Printer be, and is hereby, instructed to print, in quarto form, a report by the U. S. Commissioner of Fish and Fisheries, upon the food fishes and fisheries of the United States, the engravings to be in relief, and to be contracted for by the Public Printer, under the direction of the Joint Committee on Printing, and to receive the approval of the Commissioner before being accepted; the work to be stereotyped, and 10,000 extra copies printed, of which 2,500 shall be for the use of the Senate, 5,000 for the use of the House, and 1,500 for the use of the Commissioner of Fish and Fisheries. There shall also be printed 1,000 extra copies for sale by the Public Printer, under such regulations as the Joint Committee on Printing may prescribe, at a price equal to the additional cost of publication and 10 per cent. thereon added.

The manuscript for the entire report is for the most part ready for the printer, and several hundred drawings for the illustrations are finished. Part I was placed in the hands of the printer in August 1882, and would have been published more than a year ago but for the absence of Mr. Goode in England. The contents of these reports, it is proposed, shall be approximately as follows, though it is probable that other topics may be added to the discussion before the work is completed:

THE FOOD FISHES AND FISHERY INDUSTRIES OF THE UNITED STATES.

PART I.—The Natural History of Useful Aquatic Animals.
PART II.—The Fishing-Grounds.
PART III.—The Fishing-Towns, containing a geographical review of the Coast, River, and Lake Fisheries.
PART IV.—*The Fishermen.*
PART V.—The Apparatus of the Fisheries and the Fishing-Vessels and Boats.
PART VI.—The Fishery Industries, a discussion of methods and history.
PART VII.—The Preparation of Fishery Products.
PART VIII.—Fish Culture and Fishery Legislation.
PART IX.—Statistics of Production, Exportation, and Importation. Summary Tables.
PART X.—The Whale Fishery; a special monograph.
PART XI.—A Catalogue of the Useful and Injurious Aquatic Animals and Plants of North America.
PART XII.—A list of Books and Papers relating to the Fisheries of the United States.
PART XIII.—A general Review of the Fisheries with a statistical summary.

The report prepared for the Superintendent of the Census, the manuscript of which is now for the most part in his possession, is divided into the following sections:

A REPORT UPON THE STATISTICS OF THE FISHERIES AND FISH TRADE OF THE UNITED STATES.

INTRODUCTION (giving a comprehensive abstract of the matter contained in the quarto report referred to above).
PART I.—A Review of the Fisheries of the Atlantic Seaboard, with statistics of production and manufacture.
PART II.—*A Review of the Fisheries of the Pacific Coast, with statistics of production and manufactures.*
PART III.—A Review of the Fisheries of the Great Lakes, with statistics of production and manufactures.
PART IV.—A Review of the River Fisheries of the United States. (Prepared by C. W. Smiley.)
PART V.—A Review of the Consumption of Fish by Counties, with an estimate of the extent and value of the inland fisheries. (Prepared by C. W. Smiley.)
PART VI.—A Review of the Fish Trade of cities of the United States having a population of more than 10,000 in 1880. (Prepared by C. W. Smiley.)
PART VII.—Statistics of Importation and Exportation of Fishery Products from 1730 to 1880.
PART VIII.—List of the Fishing-Vessels of the United States in 1880, giving tonnage, value, number of crew, name of owner, branches of fisheries engaged in, together with other important details.
PART IX.—Monograph of the Seal Islands of Alaska. By Henry W. Elliott. (Already in type; 171 pages. 4to.)
PART X.—Monograph of the Oyster Fisheries. By Ernest Ingersoll. (Already in type; 251 pages.)

The Census volume thus is arranged to include all compilations from circulars, and the results of the work performed by clerks detailed from the Census Office, together with much derived from

the archives of the Fish Commission. The first three sections are mainly made up from the material collection by the special agents in the field, and the form is as nearly as possible that in which it was originally collected; much, however, has been added from the archives of the Commission.

By the plan just detailed, the statistical matter gathered by the joint efforts of the two organizations is assigned to the Census, together with a sufficient amount of descriptive and explanatory text to make the statistics fully intelligible, while the descriptive, historical, and natural history papers are taken by the Fish Commission, these being enriched by a sufficient amount of statistical detail to render them as useful as possible for the class of readers and students for whom they are intended.

The statistical results of the investigation have already been published in a preliminary way. A series of special statistical tables appeared in the Bulletins of the Census Office, as follows:

(1.) CENSUS BULLETIN No. 176.—[Preliminary Report upon the Pacific States and Territories] prepared by Mr. Goode from returns of Special Agents Jordan, Swan, and Bean. Dated May 24, 1884. 4to. Pp. 6 (+2).

(2.) CENSUS BULLETIN No. 261.—Statistics of the Fisheries of the Great Lakes. Prepared by Mr. Frederick W. True from notes of Special Agent Kumlien. Dated September 1, 1881. 4to. Pp. 8.

(3.) CENSUS BULLETIN No. 278.—Statistics of the Fisheries of Maine. Prepared by Mr. R. E. Earll from his own notes and those of Capt. J. W. Collins and Mr. C. G. Atkins. Dated November 22, 1881. 4to. Pp. 47 (+1).

(4.) CENSUS BULLETIN No. 281.—Statistics of the Fisheries of Virginia. Prepared by Colonel Marshall MacDonald. Dated December 1, 1881. 4to. Pp. 8.

(5.) CENSUS BULLETIN No. 295.—Statistics of the Fisheries of Massachusetts. Prepared by Mr. A. Howard Clark from returns of Special Agents Wilcox, Clark, True, Collins, and Atwood. Dated March 1, 1882. 4to. Pp. 35 + 1.

(6.) CENSUS BULLETIN No. 291.—Statistics of the Fisheries of New Hampshire, Rhode Island, and Connecticut. Prepared by Mr. A. Howard Clark. Dated April 5, 1882. 4to. Pp. 7 (+1.)

(7.) CENSUS BULLETIN No. 297.—Commercial Fisheries of the Middle States. Prepared by Mr. R. E. Earll and Colonel M. MacDonald. Dated June 5, 1882. 4to. Pp. 14.

(8.) CENSUS BULLETIN No. 298.—Commercial Fisheries of the Southern Atlantic States. Prepared by Mr. R. E. Earll and Colonel M. MacDonald. Dated June 5, 1882. 4to. Pp. 18. (This bulletin includes statistics of No. 4 (C. B., No. 281).

In all 148 pages, quarto. In addition to these certain special tables have appeared.

(10.) STATISTICAL TABLE.—Statistics of the Fisheries of the United States in 1880. [Prepared by Messrs. Goode and Earll from the reports of special agents.] Printed in Compendium of the Tenth Census, p. 88. Pp. —. Republished in Bulletin of the United States Fish Commission, Vol. III, 1883, pp. 270–71, and in Preliminary Catalogue, International Fisheries Exhibition, January, p. 5.

(11.) STATISTICAL TABLE.—Table showing by States the quantity of Spanish mackerel taken in 1880, and the total catch for the United States. By R. Edward Earll. Report United States Fish Commission. Part VIII, 1880, p. 416.

(12.) STATISTICAL SUMMARY.—Statistics of the Davis Strait Halibut Fisheries. By Newton P. Scudder. Report United States Fish Commission. Part VIII, pp. 190–192.

(13.) STATISTICAL SUMMARY.—Statistics of the Swordfish Fishery. By G. Brown Goode. Report United States Fish Commissioners. Part VIII, pp. 361–367.

(14.) STATISTICAL SUMMARIES.—Statistics of the Mackerel Fishery in 1880. By R. Edward Earll. Report United States Fish Commission. Part IX, pp. [124]–[127.]

[Statistics of the Mackerel Canning Industry.] By R. Edward Earll. Ibid, p. [131.]

Statistics of the Inspection of Mackerel from 1804 to 1880. By A. Howard Clark. Ibid, pp. [162]–[213.]

Vessels in the Mackerel Fishery in 1880. Ibid, p. 418.

Catch of Mackerel by Americans in Canadian waters. 1873–'81. Ibid, p. [430.]

(15.) INTRODUCTION to Section B., U. S. Catalogue International Fisheries Exhibition, London. (Collection of Economic Crustaceans, Worms, Echinoderms, and Sponges.) By Richard Rathbun. Pp. [3]–[20.] Crabs, p. [3]: Lobsters, p. [6]: Crayfish, p. [10]: Shrimp and Prawns, p. [11]: Sponges, p. [18], etc.

(16.) INTRODUCTION to Section D., U. S. Catalogue Int. Fisheries Exhibition. (Catalogue of the Economic Mollusca and the apparatus and appliances used in their capture and preparation for market, exhibited by the U. S. National Museum.) By Lieut. Francis Winslow, U. S. N., pp. [3] to [58]. Aggregate table of production, p. [3]: Special tables and statistical statements throughout.

(17.) INTRODUCTION to Section E., U. S. Catalogue Int. Fisheries Exhibition. (The Whale Fishery and its Appliances.) By James Temple Brown, pp. [3]-[25.]

(18.) Statistics of the Whale Fishery. By A. Howard Clark, in the preceding, pp. [26]-[29.]

(19.) A Review of the Fishery Industries of the United States, etc. By G. Brown Goode. An address at a conference of the International Fisheries Exhibition, June 25, 1883. 8vo., pp. 84. Numerous statistical statements, summaries, and tables.

(20.) ADMINISTRATIVE REPORT.—Method and results of an effort to collect statistics of the fish trade, and consumption of fish throughout the United States. By Chas. W. Smiley. Bulletin U. S. Fish Commission, vol. ii, 1882, pp. 247-52.

Two special reports have also been published, as follows:

(21.) A Monograph of the Seal Islands of Alaska. By Henry W. Elliott. 4to., illustrated. Pp. 172. An edition of this report with substitutions on pp. 102-9 was also issued as a Special Bulletin of the Fish Commission, No. 170.

(22.) The Oyster Industry. By Ernest Ingersoll. 4to., illustrated. Pp. 252.

The general results of the investigation, from the statistician's stand-point, may be briefly summarized as follows:

In 1880 the number of persons employed in the fishery industries of the United States was 131,426, of whom 101,684 were fishermen, and the remainder shoresmen. The fishing fleet consisted of 6,605 vessels (with a tonnage of 208,297.82) and 44,804 boats, and the total amount of capital invested was $37,955,340, distributed as follows: Vessels, $9,357,282; boats, $2,465,393; minor apparatus and outfits, $8,145,261; other capital, including shore property, $17,987,413.

The value of the fisheries of the sea, the great rivers, and the Great Lakes, was placed at $43,046,053, and that of those in minor inland waters at $1,500,000—in all $44,546,053. These values were estimatedupon the basis of the prices of the products received by the producers, and if average wholesale prices had been considered, the value would have been much greater. In 1882 the yield of the fisheries was much greater than in 1880, and prices both "at first hand" and at wholesale were higher, so that a fair estimate at wholesale market rates would place their value at the present time rather above than below the sum of $100,000,000.

The fisheries of the New England States are the most important. They engage 37,043 men 2,066 vessels, 14,787 boats, and yield products to the value of $14,270,393. In this district the principal fishing ports in order of importance are: Gloucester, New Bedford, the center of the whale fishery, Eastport, Boston, Provincetown, and Portland.

Next to New England in importance are the South Atlantic States, employing 52,418 men, 3,014 vessels (the majority of which are small, and engaged in the shore and bay fisheries), 13,331 boats and returning products to the value of $9,602,737.

Next are the Middle States, employing in the coast fisheries 14,981 men, 1,210 vessels, 8,293 boats, with products to the amount of $8,676,579.

Next are the Pacific States and Territories with 16,803 men, 56 vessels, 5,547 boats, and products to the amount of $7,484,750. The fisheries of the Great Lakes employ 5,050 men, 62 vessels, and 1,594 boats, with products to the amount of $1,784,050. The Gulf States employ 5,131 men, 197 vessels, and 1,252 boats, yielding products to the value of $545,584.

SPENCER F. BAIRD,
Commissioner of Fisheries.

WASHINGTON, *May* 30, 1884.

LETTER OF TRANSMITTAL.

UNITED STATES NATIONAL MUSEUM,
Washington, July 18, 1882.

SIR: I have the honor to transmit herewith, for approval and for publication, Section I of a general work upon THE FISHERIES AND FISHERY INDUSTRIES OF THE UNITED STATES, consisting of an illustrated history of the useful aquatic animals of the United States. This work is intended especially for the use of the reading public, and technical zoölogical discussions and descriptions have therefore been intentionally avoided.

I desire, in this place, to express my high appreciation of the manner in which the gentlemen associated with me in the preparation of this work have performed the tasks which they had undertaken, their work having been in large degree voluntary and unremunerated.

I have the honor to be, very respectfully, your obedient servant,

G. BROWN GOODE.

Professor SPENCER F. BAIRD,
United States Commissioner of Fish and Fisheries.

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TABLE OF CONTENTS.

PART I.—MAMMALS.

Page.

A.—THE WHALES AND PORPOISES. By G. BROWN GOODE.

1. The Sperm Whale 7
2. The Blackfishes or Pilot Whales 11
3. The Grampuses or Cowfishes 13
4. The Harbor Porpoises or Herring Hogs 14
5. The Dolphins 16
6. The Killer Whales or Orcas 17
7. The Sperm Whale Porpoise 18
8. The White Whale or Beluga 18
9. The Narwhal 19
10. The Greenland, Bowhead, or Polar Whale 20
11. The Right Whales 24
12. The Humpback Whales 26
13. The Sulphur Bottom Whales 27
14. The Finback Whales 28
15. The Scrag Whales 30
16. The California Gray Whales 31

B.—THE SEALS AND WALRUSES. By JOEL A. ALLEN.

17. The Seal tribe in general 33
18. The Walruses 34
19. The Sea Lions and Fur Seals in general 37
20. The Sea Lion 38
21. The California Sea Lion 44
22. The Fur-Seal 49
23. The Harbor Seal 55
24. The Harp Seal 62
25. The Ringed Seal 65
26. The Ribbon Seal 67
27. The West Indian Seal 67
28. The Hooded Seal 68
29. The California Sea Elephant 72

C.—THE HABITS OF THE FUR-SEAL. By HENRY W. ELLIOTT.

30. A life history of the Fur-Seal 75

D.—THE MANATEES AND THE ARCTIC SEA-COW. By FREDERICK W. TRUE.

31. The Manatees 114
32. The Arctic Sea-Cow 128

PART II.—REPTILES AND BATRACHIANS.

BY FREDERICK W. TRUE.

Page.

E.—THE ALLIGATOR AND THE CROCODILE:

33. The Alligator and the Crocodile 141

F.—*TORTOISES, TURTLES, AND TERRAPINS*:

34. The Marine Turtles in general 147
35. The Loggerhead Turtle 147
36. The Hawk's-bill Turtles 149
37. The Green Turtles 150
38. The Soft-shelled tortoises 152
39. The Snapping Turtles 153
40. The Musk Tortoises 154
41. The Fresh-water Terrapins 155
42. The Diamond-back or Salt-water Terrapin 156
43. The Pond Tortoises 157
44. The Box Tortoises 158

G.—THE AMPHIBIANS:

45. The Bull-frog 159

PART III.—FISHES.

BY G. BROWN GOODE.

WITH DISCUSSIONS OF THE PACIFIC SPECIES BY DAVID S. JORDAN AND TARLETON H. BEAN, NOTES ON THE FISHES OF THE GULF OF MEXICO BY SILAS STEARNS, AND CONTRIBUTIONS FROM JOSEPH W. COLLINS, N. E. ATWOOD, MARSHALL MACDONALD, R. EDWARD EARLL, LUDWIG KUMLIEN, AND OTHER AUTHORITIES.

H.—THE FILE FISHES, PIPE FISHES, AND ANGLERS:

46. The Ocean Sun Fishes (*Orthagoriscidæ*) 169
47. The Porcupine Fishes (*Diodontidæ*) 170
48. The Bellows-Fish Family (*Tetrodontidæ*) 170
49. The Trunk Fishes (*Ostraciontidæ*) 170
50. The File-Fish Family (*Balistidæ*) 171
51. The Sea-Horse Family (*Hippocampidæ*) 172
52. The Pipe-Fish Family (*Syngnathidæ*) 172
53. The Devil Fishes (*Antennariidæ* and *Maltheidæ*) 173
54. The Goose Fish (*Lophius piscatorius*) 173

I.—THE FLAT FISHES AND FLOUNDERS:

55. The American Soles (*Soleidæ*) 175
56. The Plaice (*Paralichthys dentatus*) 178
57. The Bastard Halibut (*Paralichthys maculosus*) 182
58. The Flat Fish or Winter Flounder (*Pseudopleuronectes americanus*) 182
59. The Flat Fishes and Soles of the Pacific Coast 184
60. The Halibut (*Hippoglossus vulgaris*) 189
61. The Sand Dab or Rough Dab (*Hippoglossoides platessoides*) 197
62. The Greenland Turbot (*Platysomatichthys hippoglossoides*) 197
63. The Pole Flounder or Craig Flounder (*Glyptocephalus cynoglossus*) 198
64. The Spotted Sand Flounder (*Lophopsetta maculata*) 199

Page.

J.—THE COD FAMILY AND ITS KINDRED:

65. The Cod (*Gadus morrhua*) 200
66. The Tom Cods (*Microgadus tomcod* and *M. proximus*) 223
67. The Haddock (*Melanogrammus aeglefinus*) 223
68. The Pollock (*Pollachius carbonarius*) 228
69. The Cusk (*Brosmius brosme*) 233
70. The Hakes (*Phycis chuss*, etc.) 234
71. The Burbot (*Lota maculosa*). By TARLETON H. BEAN 235
72. The Silver Hake and the Merluccio 240
73. Several Families related to the Gadidæ 243
74. The Lant, or Sand Eel (*Ammodytes lanceolatus*) 244

K.—WOLF-FISHES, SCULPINS, AND WRASSES:

75. The Lycodes Family (*Lycodidæ*) 247
76. The Wolf-Fishes or Sea Catfishes (*Anarrhichadidæ*) 248
77. The Blenny Family (*Blenniidæ*) 250
78. The Toad-Fish (*Batrachus tau*) 251
79. The Lump-Suckers: Lump-fish and Sea-Snails 253
80. The Gobies (*Gobiidæ*) 255
81. The Sea-Robin or Gurnard Family (*Triglidæ*) 255
82. The Sculpin Tribe (*Cottidæ*) 258
83. The Rose-Fish or Red Perch (*Sebastes marinus*) 260
84. The Rock Cods of the Pacific. By DAVID S. JORDAN 262
85. The Rock Trouts (*Chiridæ*). By DAVID S. JORDAN 267
86. The Tautog or Black Fish (*Tautoga onitis*) 268
87. The Chogset or Cunner (*Ctenolabrus adspersus*) 273
88. The Parrot Fishes and some of their Allies 274
89. The Demoiselle and the Cichlid Families 275
90. The Surf-Fish Family (*Embiotocidæ*). By DAVID S. JORDAN 276
91. The Moharra Family (*Gerridæ*) 279
92. The Thread-Fish Family (*Polynemidæ*) 279
93. The Surgeon-Fish Family (*Acanthuridæ*) 279
94. The Angel-Fish Family (*Chætodontidæ*) 280

L.—THE MACKEREL AND ITS ALLIES:

95. The Mackerel (*Scomber scombrus*) 281
96. The Chub Mackerel (*Scomber colias*) 303
97. The Frigate Mackerel (*Auxis thazard*) 305
98. The Spanish Mackerel and its Allies 307
99. The Bonito (*Sarda mediterranea*) 316
100. The Horse Mackerel, Tunny, or Albicore (*Orcynus thynnus*) 320
101. The Little Tunny or Albicore (*Orcynus alliteratus*) 322
102. The Silver Moon-Fishes 322
103. The Cavally, the Scad, and the Jurels 323
104. The Pompanos (*Trachynotus carolinus*, etc.) 326
105. The Pilot Fish (*Naucrates ductor*) 330
106. The Amber Fishes and the Leather Jackets 331
107. The Dolphins (*Coryphænidæ*) 332
108. The Rudder-Fish Family (*Stromateidæ*) 332
109. The Dory, Hen-Fish, and Opah Families 335
110. The Cutlass Fish (*Trichiurus lepturus*) 335
111. The Sword Fish Family (*Xiphiidæ*) 336

Page.

M.—THE TILE-FISH FAMILY AND OTHERS:

112. The Tile-Fish Family (*Latilidæ*) ... 360
113. The Red Mullet Family (*Mullidæ*) ... 361
114. The Icosteus Family (*Icosteidæ*) ... 361
115. The *Beryx* family (*Berycidæ*) ... 361

N.—THE DRUM FAMILY:

116. The Squeteague (*Cynoscion regale*) ... 362
117. The Spotted Squeteague (*Cynoscion maculatum*) ... 365
118. The Silver Squeteague (*Cynoscion nothum*) ... 367
119. The Drum (*Pogonias chromis*) ... 367
120. The Fresh Water Drum (*Haploidonotus grunniens*). By DAVID S. JORDAN ... 370
121. The Spot, or Lafayette (*Liostomus xanthurus*) ... 370
122. The Red Fish, or Bass of the South (*Sciæna ocellata*) ... 371
123. The Yellow Tail (*Bairdiella chrysura*) ... 375
124. The King Fish (*Menticirrus nebulosus*) ... 375
125. The Whitings (*Menticirrus alburnus* and *M. littoralis*) ... 376
126. The Croaker (*Micropogon undulatus*) ... 378
127. The Corvinas and Roncadors of the Pacific coast. By DAVID S. JORDAN ... 378

O.—SHEEPSHEAD, BASS, BREAM, PERCH, ETC:

128. The Sheepshead (*Diplodus probatocephalus*) ... 381
129. The Scup or Scuppaug (*Stenotomus chrysops* and *S. aculeatus*, = *S. Gardeni* of text) ... 386
130. The Sailors' Choice (*Lagodon rhomboides*) ... 393
131. Certain Minor Sparoids ... 394
132. The Red and Gray Snappers ... 395
133. The Grunts or Pig Fishes ... 397
134. The Big-Mouth Black Bass (*Micropterus salmoides*), and the Small-Mouth Black Bass (*M. Dolomieï*) 401
135. The Sun-Fishes and their Allies. By DAVID S. JORDAN ... 404
136. The Sea Bass (*Serranus atrarius*) ... 407
137. The Groupers ... 410
138. The Serranoid Fishes of the Pacific coast. By DAVID S. JORDAN ... 413
139. The Yellow Perch (*Perca americana*) ... 414
140. The Log Perch (*Percina caprodes*). By DAVID S. JORDAN ... 417
141. The Pike Perches ... 417
142. The Striped Bass (*Roccus lineatus*) ... 425
143. The White Bass (*Roccus chrysops*) ... 428
144. The Yellow Bass (*Roccus interruptus*) ... 431
145. The White Perch (*Raccus americanus*) ... 431
146. The Bluefish Family (*Pomatomidæ*) ... 433
147. The Cobia or Crab-Eater (*Elacate canada*) ... 444
148. The Triple Tail or Black Perch (*Lobotes surinamensis*) ... 444
149. The Moon Fish (*Chætodipterus faber*) ... 445
150. The Remora Family (*Echeneidæ*) ... 446

P.—BARRACOUTA, MULLET, PIKE, AND MUMMICHOGS:

151. The Barracouta Family (*Sphyræna*) ... 448
152. The Deal-Fish Family (*Trachypteridæ*) ... 449
153. The Mullets (*Mugil albula* and *M. brasiliensis*) ... 449
154. The Sand Smelts or Silver Sides (*Atherinidæ*) ... 456
155. The Stickleback Family (*Gasterosteidæ*) ... 457
156. The Silver Gar-fishes (*Belonidæ*) ... 458
157. The Flying-fish Family (*Scomberesocidæ*) ... 459
158. The Pike Family (*Esocidæ*) ... 461
159. The Mummichog Family (*Cyprinodontidæ*) ... 466

Page.

Q.—THE SALMON TRIBE:

160. The Salmon (*Salmo salar*) 468
161. The Salmons of the Pacific. By DAVID S. JORDAN 474
162. The Quinnat or California Salmon (*Oncorhynchus chouicha*). By LIVINGSTON STONE 479
163. The Namaycush or Lake Trout (*Salvelinus namaycush*) 485
164. The Speckled Trout (*Salvelinus fontinalis*) 497
165. The Saibling or Bavarian Char (*Salvelinus alpinus*) 500
166. The Dolly Varden Trout (*Salvelinus malma*). (By DAVID S. JORDAN 504
167. The Grayling (*Thymallus tricolor*) 505
168. The Lake White-fish (*Coregonus clupeiformis*). By R. I. GEARE 507
169. The Lesser White-fishes. By DAVID S. JORDAN 541
170. The Smelt Group 543
171. Families related to the Salmonidæ 547

R.—THE HERRINGS AND THE MENHADENS:

172. The Herring (*Clupea harengus*) 549
173. The Herrings of the Pacific Coast. By DAVID S. JORDAN 568
174. The Menhaden (*Brevoortia tyrannus*) 569
175. The Gulf Menhaden (*Brevoortia patronus*) 575

S.—THE SHAD AND THE ALEWIVES. By MARSHALL MACDONALD.

176. The River Herrings or Alewives (*Clupea æstivalis C. and vernalis*) 579
177. On the occurrence of the Branch Alewife in certain Lakes of New York. By TARLETON H. BEAN .. 588
178. The Inland Alewife or Skipjack (*Clupea chrysochloris*) 594
179. The Shad (*Clupea sapidissima*) 594
180. The Hickory Shad or Mattowacca (*Clupea mediocris*) 607

T.—FAMILIES RELATED TO THE CLUPEIDÆ:

181. The Mud Shad (*Dorosoma cepedianum*) 610
182. The Tarpum (*Megalops thrissoides*) 610
183. The Big-eyed Herring 611
184. The Anchovies (*Engraulidæ*) 611
185. The Lady-fish Family (*Albulidæ*) 612
186. The Moon-eye Family (*Hyodontidæ*) 612

U.—CARP, SUCKERS, CATFISH, AND EELS:

187. The Sucker Family (*Catostomidæ*). By DAVID S. JORDAN 614
188. The Carp Family (*Cyprinidæ*). By DAVID S. JORDAN 616
189. The Carp (*Cyprinus carpio*). By RUDOLPH HESSEL 618
189. The Catfish Family (*Siluridæ*). By DAVID S. JORDAN 627
190. The Morays (*Muræniдæ*) 629
191. The Eel (*Anguilla vulgaris*) 630
192. The Conger Eel (*Leptocephalus conger*) 656

V.—STURGEONS, SKATES, SHARKS, AND LAMPREYS:

193. The Bowfins (*Amiidæ*) 659
194. The Paddle-fishes (*Polyodontidæ*) 660
195. The Sturgeons (*Acipenseridæ*) 660
196. The Chimæra Family (*Chimæridæ*) 663
197. The Gar Pikes (*Lepidosteidæ*) 663
198. The Torpedoes and Skates (*Raiæ*) 665
199. The Saw-fish (*Pristis pectinatus*) 668
200. The Sharks (*Squali*) 668
201. The Sharks of the Pacific Coast. By DAVID S. JORDAN 675
202. The Lampreys (*Petromyzontidæ*) 677
203. The Hag Fishes (*Myxinidæ*) 681
204. The Lancelets (*Branchiostomidæ*) 682

PART IV.—MOLLUSKS.

Page.

W.—MOLLUSKS IN GENERAL. BY ERNEST INGERSOLL.

205. The Cuttles: Cephalopoda 687
206. The Sea-snails: Gasteropoda 693
207. The Wing-shells: Pteropoda 702
208. The Tusk-shells: Solenoconcha 703
209. The Bivalves: Lamellibranchiata 703

X.—THE LIFE HISTORY OF THE OYSTER. BY JOHN A. RYDER.

210. Outline Sketch of the Coarser Anatomy of the Oyster 711
211. *The Minute Anatomy of the Oyster* 715
212. Sex of the American and European Oysters 719
213. New Methods of Distinguishing the Sexes and of Taking the Eggs of the Oyster 722
214. Rate of Growth of Ostrea virginica:
215. The Food of the Oysters 729
216. The Cause of the Green Color of Oysters 735
217. Local Variations in the Form and Habits of the Oyster 742
218. The Oyster Crab as a Mess-mate and Purveyor 744
219. Physical and Vital Agencies Destructive to Oysters 746
220. Natural and Artificial Oyster Banks 750

PART V.—CRUSTACEANS, WORMS, RADIATES, AND SPONGES.

BY RICHARD RATHBUN.

Y.—CRUSTACEANS:

221. The Crabs 763
222. The Common Edible or Blue Crab 775
223. The Lobsters 780
224. The American Lobster 781
225. The Cray Fishes, Astacus and Cambarus 812
226. The Shrimps and Prawns 816
227. The Mantis Shrimps: Squillidæ 823
228. The Amphipods 824
229. The Isopods 826
230. *The Entomostracans* 827
231. The Cirripedia 828
232. The Xiphosura 829

Z.—WORMS:

233. The Annelids 831
234. The Leeches 833

ZA.—THE RADIATES:

235. The Echinoderms 838
236. The Coelenterates 841

ZB.—THE PORIFERS:

237. The Sponges 843
238. The Genus Spongia, and the American Commercial Sponges 846
239. Injurious Sponges 850

LIST OF PLATES.

(Engraved by the Photo-Engraving Company of New York City.)

[The plates are bound together in the accompanying volume. The figures at the right refer to the pages of the text upon which the species illustrated are described.]

Page.

1. The Sperm Whale, *Physeter macrocephalus* L. 7
   Outline from Scammon's Marine Mammals of the Northwest Coast, plate xiv.
2. The Pygmy Sperm Whale, *Kogia Goodei* True 11
   Drawing by H. L. Todd, from No. 13738, U. S. National Museum. Stranded at Spring Lake, New Jersey, April 27, 1883.
   The Blackfish, *Globiocephalus melas* (Traill) 11
   From Transactions of the Zoological Society of London, vol. 8, plate 30.
3. The capture of a school of Blackfish in Cape Cod 12
   Drawing by Henry W. Elliott, from a sketch by John S. Ryder.
4. The Cowfish or Grampus, *Grampus griseus* (Less.) Gray 13
   Outline by Henry W. Elliott, from cast No. 12820, U. S. National Museum.
   The Harbor Porpoise, or "Herring Hog," *Phocæna brachycion* Cope 14
   Outline by Henry W. Elliott, from photograph by U. S. Fish Commission.
5. The Skunk Porpoise or Bay Porpoise, *Lagenorhynchus gubernator* Cope (= *L. perspicillatus* Cope) 16
   Outline from plate iv, Proceedings Academy of Natural Sciences, Philadelphia, 1876.
   The High-finned Killer, *Orca rectipinnis* Cope 17
   Outline from Scammon's Marine Mammals of the Northwest Coast.
   The Sperm Whale-Porpoise, *Hyperoodon bidens* Owen 18
   Sketch by James Henry Blake, 1859, from specimen stranded at North Dennis.
6. The White Whale, or Beluga, *Delphinapterus catodon* (L.) Gill 18
   Outline by Henry W. Elliott, from cast No. 12488, U. S. National Museum, obtained near Quebec, 1875.
   The Narwhal, *Monodon monoceros* L. 19
   Sketch by Henry W. Elliott, adapted from Vogt and Specht's "Saugethiere," p. 256.
7. The Bowhead or Arctic Whale, *Balæna mysticetus* L. 20
   Outline from Scammon's Marine Mammals, plate xi.
   The Right Whale of the Pacific, *Balæna japonica* Gray. (*Eubalæna cullamach*) 24
   Outline from Scammon's Marine Mammals, plate xii.
8. *Diagrams illustrating the use of the whalebone plates in the mouth of the Bowhead Whale* 22
   From sketches by Captain David Grey in Land and Water, December 1, 1877.
   (Upper.) The Bowhead with its mouth open.
   (Lower.) The Bowhead with its mouth shut.
9. The Humpback of the Pacific, *Megaptera versabilis* Cope 26
   Outline from Scammon's Marine Mammals, plate vii.
   The Sulphur Bottom of the Pacific, *Sibbaldius sulfureus* Cope 27
   Outline from Scammon's Marine Mammals, plate xiii.
10. Cutting in a Humpback Whale at Provincetown, Massachusetts 28
    From a sketch by John S. Ryder.
11. The Finback of the Pacific, *Balænoptera velifera* Cope 28
    Outline from Scammon's Marine Mammals, plate ii.
    The California Gray Whale or Devil-fish, *Rhachianectes glaucus* Cope 31
    Outline from Scammon's Marine Mammals, plate ii.
12. The Pacific Walrus, *Odobænus obesus* (Illiger) Allen 34
    Sketch by Henry W. Elliott, Walrus Island, Alaska, July 5, 1872.
13. Steller's Sea Lion, *Eumetopias Stelleri* (Less.) Peters 38
    Sketch from life by Henry W. Elliott.
14. The California Sea Lion, *Zalophus californianus* (Less.) Allen 44
    Sketch from life by Henry W. Elliott.
15. The Harbor Seal, *Phoca vitulina* L. 56
    Sketch from life by Henry W. Elliott, Alaska, 1872.

Page.

16. The Harp Seal, *Phoca grœnlandica* Fabricius 62
Sketch by Henry W. Elliott, from specimens in the U. S. National Museum, Nos. 13741, 13748, 13938, and 13939 obtained on the north shore of the Gulf of Saint Lawrence by Dr. C. Hart Merriam.

17. The Ringed Seal, *Phoca fœtida* Fabricius 65
Sketch by Henry W. Elliott, adapted from figure in Allen's North American Pinnipeds, p. 601.

18. The Ribbon Seal (Male and Female) *Histriophoca fasciata* (Zimmermann) Gill 67
Drawing by Henry W. Elliott, from specimens in U. S. National Museum, No. 13284, obtained at Plover Bay, East Siberia, August 12, 1880, by W. H. Dall, and No. 13285, obtained from Bering Sea, 1880, by Captain H. E. Williams.

19. The West Indian Seal, *Monachus tropicalis* Gray 68
Drawing by Henry W. Elliott, from specimen in U. S. National Museum, No. 13950, obtained by Professor Felippe Poey at Matanzas, Cuba.

20 The Hooded Seal (adult and young) *Cystophora cristata* (Erxl.) Nilss. 68
Sketch by Henry W. Elliott, from specimens in U. S. National Museum, Nos. 13742 and 13753, collected by Dr. C. Hart Merriam, off Labrador, 1883.

21. The Gray Seal, *Halichœrus grypus* (Fabricius) Nilss 70
Sketch by Henry W. Elliott, from specimen in U. S. National Museum, No. 5851, collected at Sable Island, Nova Scotia, 1862.

22. The Square Flipper Seal, *Erignathus barbatus* (Fabricius) Gill 70
Sketch by Henry W. Elliott, from specimen in U. S. National Museum, No. 13755, collected by Dr. C. Hart Merriam, off Battle Harbor, Gulf of Saint Lawrence, 1883.

23. The Sea Elephant, *Macrorhinus angustirostris* Gill 72
Drawing by Henry W. Elliott, from specimen in U. S. National Museum, from Santa Barbara Island, California.

24. Map of the world on Mercator's Projection, showing the geographical distribution of the Species of the Hair Seal Family. Prepared by J. A. Allen 33

25. Map of the world on Mercator's Projection, showing the geographical distribution of the Walruses, Fur Seals, Sea Lions, and Sea Elephants, prepared for the illustration of the chapter by J. A. Allen. Prepared by J. A. Allen 33

26. The countenance of Callorhinus 75
A life study of an adult male fur-seal. (Full face of old male, profile and under view of female heads.) Drawing by Henry W. Elliott, North Rookery, Pribylov Group, July 5, 1873.

27. The Fur-Seal, *Callorhinus ursinus* 88
A series of life studies by Henry W. Elliott, Pribylov Islands, 1872–1876.
A.—Old "Seecatch" or male, eight to twenty-four years.
B.—Young "Seecatch," six to eight years.
C.—"Holluschickie," or young males, two years.
D.—"Matkah" or mother nursing her "Pup," I.
E.—"Cow" fanning herself.
F.—"Cow" sleeping.
G.—"Cow" napping and fanning herself.
H.—"Cow" crooning to the male.
J.—Characteristic position of old males.

28. Sundry Seal Sketches on the Pribylov Islands 96
From the portfolio of Henry W. Elliott, 1872–1876.

29. Hauling and Breeding Grounds of the Fur-Seal 99
Sketched from nature on the North Rookery, Saint George's Island, Pribylov Group, by Henry W. Elliott, July, 1874.

30. The north shore of Saint Paul's Island, Pribylov Group 99
Sketched from the summit of Hutchinson's Hill, by Henry W. Elliott, looking over a wing of the great Norastoshoah Rookery, July, 1872.

31. Pelagic attitudes of the Fur-Seal 101
Sketched from life by Henry W. Elliott, Saint Paul's Island, 1872. Village of Saint Paul in distance. Black bluffs to the right on middle ground.
1. Position while sleeping.
2. Position when rising to breathe, survey, etc.
3. Position when scratching.
4. "Dolphin jumps."

32. Fur-Seals Sporting around the "bidarrah" 102
Sketched from life by Henry W. Elliott in Zoltoi, Saint Paul's Island, 1872. A view of the Reef Point and Gorbatch *Rookery on the horizon.*

33. The Manatee, *Trichechus manatus* L 114
Sketch by Henry W. Elliott, from plate in Transactions, Zoological Society of London.

34. Manatees swimming 114
Sketch by Henry W. Elliott, from plate in Transactions, Zoological Society of London.

35. The Sunfish, *Mola rotunda* Cuvier 170
From wash-drawing by H. L. Todd, from a cast.

36. The Swell-fish or Burr-fish, *Chilomycterus geometricus* (Schneider) Kaup 170
Drawing by H. L. Todd, from No. 14825, U. S. National Museum, collected at Noank, Connecticut, 1874, by U. S. Fish Commission.

Page—

The Rabbit-fish, *Lagocephalus lævigatus* (L.) Gill 170
Drawing by H. L. Todd from No. 20757, U. S. National Museum, collected at Newport, Rhode Island, by Hon. Samuel Powel.

37. The Trunk-fish or Cow-fish, *Ostracion quadricornis* L. 170
Drawing by H. L. Todd, from No. 21548, U. S. National Museum, collected at Charleston, South Carolina, July, 1878, by C. C. Leslie.

38. The Trigger-fish, *Balistes capriscus* Gmelin 172
Drawing by H. L. Todd, from No. 15233, U. S. National Museum, collected at New York by Mr. Sutherland.

39. The Sea Horse, *Hippocampus heptagonus* Raf. 172
Drawing by H. L. Todd, from No. 3451, U. S. National Museum, collected at Old Point Comfort, Virginia, by Commodore Farragut, U. S. N.

40. The Goose-fish or Bellows-fish, *Lophius piscatorius* L. 174
Drawing by H. L. Todd, from specimen collected in Vineyard Sound, Massachusetts, by the U. S. Fish Commission.

41. The American Sole or "Hog Choker," *Achirus lineatus* (L.) Cuv. 176
Drawing by H. L. Todd, from No. 12985, U. S. National Museum, collected at Wood's Holl, Massachusetts, July 14, 1871, by Vinal N. Edwards.
(Upper.) Showing upper side of fish.
(Lower.) Showing under side of fish.

42. The American Plaice or Turbot Flounder, *Paralichthys dentatus* (L.) J. & G. 178
Drawing by H. L. Todd, from No. 21279, U. S. National Museum, collected at Arlington, Saint John's River, Florida, 1878, by G. Brown Goode.

43. The Four-spotted Flounder, *Paralichthys oblongus* (Mitch.) J. & G. 181
Drawing by H. L. Todd, from No. 10730, U. S. National Museum, collected at Wood's Holl, Massachusetts, by Professor S. F. Baird.

44. The Flatfish or Winter Flounder, *Pseudopleuronectes americanus* (Walb.) Gill 182
Drawing by H. L. Todd.

45. The Smooth Flounder, *Pleuronectes glaber* (Storer) Gill. 183
Drawing by H. L. Todd, from No. 5368, U. S. National Museum, collected at Salem, Massachusetts, by C. Putnam.

46. The Starry Flounder, *Pleuronectes stellatus* Pallas 184
Drawing by H. L. Todd, from No. 24164, U. S. National Museum, collected at San Francisco, California, January 1880, by Professor D. S. Jordan.

47. The Arctic Flounder, *Pleuronectes glacialis* Pallas 184
Drawing by H. L. Todd, from No. 27947, U. S. National Museum, collected at Kotzebue Sound, September 2, 1880, by Dall and Bean.

48. The Rough Limanda, *Limanda aspera* (Pallas) Bean 184
Drawing by H. L. Todd, from No. 27944, U. S. National Museum, collected at Sitka, Alaska, 1880, by Dr. T. H. Bean.

49. The Rusty Dab, *Limanda ferruginea* (Storer) Goode & Bean 184
Drawing by H. L. Todd, from No. 21020, U. S. National Museum, collected at Halifax, Nova Scotia, September 4, 1877, by U. S. Fish Commission.

50. The California "Sole," *Lepidopsetta bilineata* (Ayres) Gill 185
Drawing by H. L. Todd, from No. 27602, U. S. National Museum, collected at Saint Paul's, Kodiak Island, Alaska, 1880, by Dr. T. H. Bean.

51. The San Francisco "Sole," *Psettichthys melanostictus* Girard 186
Drawing by H. L. Todd, from No. 24167, U. S. National Museum, collected at San Francisco, California, January, 1880, by Professor D. S. Jordan.

52. The Alaska Sand Dab, *Hippoglossoides elassodon* J. & G. 188
Drawing by H. L. Todd, from No. 27938, U. S. National Museum, collected at Humboldt Harbor, Shumagins, Alaska, July 19, 1880, by Dr. T. H. Bean.

53. The Atheresthes Flounder, *Atheresthes stomias* J. & G. 188
Drawing by H. L. Todd, from No. 27186, U. S. National Museum, collected at Point Reyes, California, 1880, by Jordan and Gilbert.

54. The Halibut, *Hippoglossus vulgaris* Fleming 190
Drawing by H. L. Todd, from No. 10439, U. S. National Museum, collected at Eastport, Maine, 1872, by U. S. Fish Commission.

55. The Sand Dab, *Hippoglossoides platessoides* (Fab.) Gill 197
Drawing by H. L. Todd, from No. 21062, U. S. National Museum, collected at Le Have Bank, August 21, 1877, by U. S. Fish Commission.

56. The Greenland Turbot, *Platysomatichthys hippoglossoides* (Walb.) Goode & Bean 198
Drawing by H. L. Todd, from a specimen obtained in Fulton Market, New York.

57. The Pole Flounder, *Glyptocephalus cynoglossus* (L.) Gill. 198
Drawing by H. L. Todd.

58. The Codfish, *Gadus morrhua* L. 200
Drawing by H. L. Todd, from No. 10444, U. S. National Museum, collected at Eastport, Maine, 1872, by U. S. Fish Commission.

The Atlantic Tom Cod, *Microgadus tomcod* (Walb.) Gill 223
Drawing by H. L. Todd, from No. 17733, U. S. National Museum, collected at Wood's Holl, Massachusetts, December 23, 1875, by Vinal N. Edwards.

Page.

59. The Haddock, *Melanogrammus æglefinus* L. Gill 223
Drawing by H. L. Todd, from No. 10440, U. S. National Museum, collected at Eastport, Maine, 1872, by U. S. Fish Commission.

The Saida Cod, *Boreogadus saida* (Lepechin) Bean 0
Drawing by H. L. Todd, from No. 21746, U. S. National Museum, collected at Annanactook Harbor, Cumberland Gulf, October 19, 1877, by Ludwig Kumlien.

60. The Pollock, *Pollachius carbonarius* (L.) Gill 226
Drawing by H. L. Todd, from No. 10443, U. S. National Museum, collected at Eastport, Maine, 1872, by Professor S. F. Baird.

The Alaska Pollock, *Pollachius chalcogrammus* (Pallas) 232
Drawing by H. L. Todd, from No. 27637, U. S. National Museum, collected at Pirate Cove, Shumagin Islands, Alaska, 1880, by William H. Dall.

61. The Cusk, *Brosmius brosme* (Müller) White 233
Drawing by H. L. Todd, from No. 29967, U. S. National Museum, collected at Boston Market, January 11, 1882, by W. A. Wilcox.

The Burbot or "Freshwater Cusk," *Lota maculosa* (Le Sueur) C. and O. 235
Drawing by H. L. Todd, from No. 10553, U. S. National Museum, collected at Ecorse, Michigan, by J. W. Milner.

62. The Common Hake, *Phycis chuss* (Walb.) Gill 234
Drawing by H. L. Todd, from No. 28707, U. S. National Museum, collected at Martha's Vineyard, July 16, 1881, by U. S. Fish Commission.

The Squirrel or White Hake, *Phycis tenuis* (Mitchill) De Kay 234
Drawing by H. L. Todd, from No. 21029, U. S. National Museum, collected in Halifax Harbor, November 30, 1877, by U. S. Fish Commission.

63. The King Hake, *Phycis regius* (Walb.) Gill 234
Drawing by H. L. Todd, from No. 20023, U. S. National Museum, collected at New York Aquarium, 1878, by E. G. Blackford.

Earl's Hake, *Phycis Earllii* Bean 234
Drawing by H. L. Todd, from No. 25207, U. S. National Museum, collected at Charleston, South Carolina, March 25, 1880, by R. E. Earll.

64. Chester's Hake, *Phycis Chesteri* Goode & Bean 234
Drawn by H. L. Todd from

The Blue Hake, *Haloporphyrus viola* Goode & Bean 0
Drawing by H. L. Todd, from No. 21837, U. S. National Museum, collected on Le Have Bank, August 26, 1878, by Captain J. W Collins, schooner Marion.

65. The Merluccio, *Merluccius productus* (Ayres) Gill 243
Drawing by H. L. Todd, from No. 26638, U. S. National Museum, collected at Seattle, Washington Territory, 1880, by Colonel F. W. Prosser.

The Silver Hake or New England Whiting, *Merluccius bilinearis* (Mitch.) Gill 240
Drawing by H. L. Todd, from No. 21016, U. S. National Museum, collected at Halifax, Nova Scotia, September 8, 1877, by the U. S. Fish Commission.

66. The Sand Cusk, *Ophidium marginatum* De Kay 243
Drawing by H. L. Todd, from No. 10762, U. S. National Museum, collected at Tompkinsville, New York, by C. L. Copley.

The Onion-fish or Grenadier, *Macrurus rupestris* (Muller) Bloch 244
Drawing by H. L. Todd, from No. 15808, U. S. National Museum, collectedat Saint George's Bank, October 27, 1875. Presented by E. G. Blackford.

The Laut or Sand Eel, *Ammodytes americanus* De Kay 244
Drawing by H. L. Todd, from No. 16500, U. S. National Museum, collected at Nantucket, Massachusetts, August 12, by U. S. Fish Commission.

67. The Mutton-fish, *Zoarces anguillaris* (Peck) Storer 247
Drawing by H. L. Todd, from No. 10438, U. S. National Museum, collected at Eastport, Maine, 1872, by U. S. Fish Commission.

Vahl's Lycodes, *Lycodes Vahlii* Reinhardt 247
Drawing by H. L. Todd, from No. 21991, U. S. National Museum, collected on Le Have Bank, by Captain Z. Hawkins, schooner Gwendolen.

68. The Common Catfish or Wolf-fish, *Anarrhicas lupus* L. 248
Drawing by H. L. Todd, from No. 21846, U. S. National Museum, collected on George's Bank, September 27, 1878, by Captain John Gourville.

The Spotted Catfish, *Anarrhicas minor* Olafsen 249
Drawing by H. L. Todd, from No. 21618, U. S. National Museum, collected at sea November, 1878, by Captain R. H. Hurlbert.

69. The Gulf Toadfish, or "Sapo," *Batrachus pardus* Goode & Bean 251
Drawing by H. L. Todd, from No. 22237, U. S. National Museum, collected at Pensacola, Florida, 1878, by Silas Stearns.

"The Naked Star-gazer," *Astroscopus anoplus* (C. & V.) Brevoort 0
Drawing by H. L. Todd, from No. 4622, U. S. National Museum, collected at Norfolk, Virginia.

70. The Lump-fish, *Cyclopterus lumpus* L. 254
Drawing by H. L. Todd, from No. 14795, U. S. National Museum, collected at Eastport, Maine, 1872, by U. S. Fish Com-

Page.

71. The Sea Robin or Wingfish, *Prionotus palmipes* (Mitch.) Storer 256
Drawing by H. L. Todd, from No. 774, U. S. National Museum, collected at Beesley's Point, New Jersey, 1858, by Professor S. F. Baird.

The Striped Sea Robin, *Prionotus evolans* (L.) Gill 256
Drawing by H. L. Todd, from No. 5556, U. S. National Museum, collected at Wood's Holl, Massachusetts, by Vinal N. Edwards.

72. The Northern or European Sculpin, *Cottus scorpius* L 258
Drawing by H. L. Todd, from No. 21980, U. S. National Museum, collected at Cumberland Gulf, September 25, 1877, by Ludwig Kumlien.

The Common Sculpin, *Cottus scorpius* L., subspecies *grœnlandicus* (C. & V.) Bean 258
Drawing by H. L. Todd, from No. 10441, U. S. National Museum, collected at Eastport, Maine, 1872, by U. S. Fish Commission.

73. The Alaska Sculpin, *Cottus polyacanthocephalus* Pallas 258
Drawing by H. L. Todd, from No. 23499, U. S. National Museum, collected at Unalashka, 1879, by William H. Dall.

The Southern Sculpin, *Cottus octodecimspinosus* Mitch 258
Drawing by H. L. Todd, from No. 4552, U. S. National Museum, collected at Beesley's Point, New Jersey, 1858, by Professor S. F. Baird.

74. The Sea Raven, *Hemitripterus americanus* (Gmelin) C. & V. 258
Drawing by H. L. Todd, from No. 23199, U. S. National Museum, collected at Halifax, Nova Scotia, September 13, 1877, by U. S. Fish Commission.

Jordan's Cabezon, *Hemilepidotus Jordani* Bean 258
Drawing by H. L. Todd, from No. 27598, U. S. National Museum, collected at Iliuliuk, Unalashka Island, 1880, by Dr. T. H. Bean.

75. The Rose-fish or Norway Haddock, *Sebastes marinus* (L.) Lütken 260
Drawing by H. L. Todd, from No. 10442, U. S. National Museum, collected at Eastport, Maine, 1872, by U. S. Fish Commission.

76. The Black-banded Rockfish, *Sebastichthys nigrocinctus* (Ayres) Gill 263
Drawing by H. L. Todd, from No. 27285, U. S. National Museum, collected at Puget Sound, 1880, by Jordan and Gilbert.

77. The Tree-fish, *Sebastichthys serriceps* J. & G 263
Drawing by H. L. Todd, from No. 27041, U. S. National Museum, collected at Monterey, California, 1880, by Jordan and Gilbert.

78. The Yellow-backed Rockfish, *Sebastichthys maliger* J. & G. 264
Drawing by H. L. Todd, from No. 27713, U. S. National Museum, collected at Sitka, Alaska, June 2, 1880, by Dr. T. H. Bean.

79. The Corsair, *Sebastichthys rosaceus* (Grd.) Lock 265
Drawing by H. L. Todd, from No. 26961, U. S. National Museum, collected at Santa Barbara, California, 1880 (?), by Jordan and Gilbert.

80. The Orange Rockfish, *Sebastichthys pinniger* (Gill.) Lock 265
Drawing by H. L. Todd, from No. 27488, U. S. National Museum, collected at Neeah Bay, Wyoming Territory, December, 1859, by James G. Swan.

81. The Black Rockfish, *Sebastichthys mystinus* J. & G 266
Drawing by H. L. Todd, from No. 27031, U. S. National Museum, collected at Monterey, California, 1880, by Jordan and Gilbert.

82. The Spotted Black Rockfish, *Sebastichthys melanops* (Grd.) J. & G. 266
Drawing by H. L. Todd, from No. 27628, U. S. National Museum, collected at Sitka, Alaska, May 28, 1880, by Dr. T. H. Bean.

83. The "Black Cod," "Black Candle-fish," or Beshow, *Anoplopoma fimbria* (Pallas) Gill 268
Drawing by H. L. Todd, from No. 27745, U. S. National Museum, collected at Sitka, Alaska, December, 1880, by Commander L. A. Beardslee, U. S. N.

The "Atka Mackerel" or Yellow-fish, *Pleurogrammus monopterygius* (Pallas) Gill 268
Drawing by H. L. Todd, from No. 27954, U. S. National Museum, collected at Iliuliuk, Unalashka, 1880, by Dr. T. H. Bean.

84. Steller's Rock-trout, *Hexagrammus asper* Steller 268
Drawing by H. L. Todd, from No. 21530, U. S. National Museum, collected at Saint Michael's, Alaska, June, 1875, by L. M. Turner.

The Cultus Cod, *Ophiodon elongatus* Girard 267
Drawing by H. L. Todd, from No. 65727, U. S. National Museum, collected at Sitka, Alaska, June 7, 1880, by Dr. T. H. Bean.

85. The Tautog, *Tautoga onitis* (L.) Gthr 268
Drawing by H. L. Todd, from No. 17736, U. S. National Museum, collected at Wood's Holl, Massachusetts, December 13, 1875, by Vinal N. Edwards.

86. The Chogset or Cunner, *Ctenolabrus adspersus* (Walb.) Goode 274
Drawing by H. L. Todd, from No. 17741, U. S. National Museum, collected at Wood's Holl, Massachusetts, December 11, 1875, by Vinal N. Edwards.

87. The Fat-head or Redfish, *Pimelometopon pulcher* (Ayres) Gill. = *Trochocopus pulcher* 275
Drawing by H. L. Todd, from No. 24890, U. S. National Museum, collected at San Diego, California, January, 1880, by Jordan and Gilbert.

Page.

88. The Hogfish or Capitaine, *Lachnolæmus falcatus* (L.) C. & V. 275
Drawing by H. L. Todd.

89. The Alfione, *Rhacochilus toxotes* Agassiz 277
Drawing by H. L. Todd, from No. 27015, U. S. National Museum, collected at Monterey, California, 1880, by Jordan and Gilbert.

90. The Spanish Pompano, *Gerres olisthostoma* Goode & Bean 279
Drawing by H. L. Todd, from No. 25118, U. S. National Museum, collected at Indian River, Florida, March 8, 1880, by R. E. Earll.

91. The Mackerel, *Scomber scombrus* L. 281
Drawing by H. L. Todd, from No. 25256, U. S. National Museum, collected at Provincetown, Massachusetts, September, 1879, by U. S. Fish Commission.

The Chub Mackerel or "Thimble Eye," *Scomber colias* De La Roche 303
Drawing by H. L. Todd, from No. 23480, U. S. National Museum, collected at Provincetown, Massachusetts, September, 1879, by U. S. Fish Commission.

92. The Frigate Mackerel, *Auxis thazard* Lacépède 305
Drawing by H. L. Todd, from No. 25757, U. S. National Museum, collected at Newport, Rhode Island August, 1880, by U. S. Fish Commission.

The Bonito, *Sarda mediterranea* (Schn.) J. & G. 316
Drawing by H. L. Todd, from No. 10419, U. S. National Museum, collected at Wood's Holl, Massachusetts, 1871, by U. S. Fish Commission.

93. The Spanish Mackerel, *Scomberomorus maculatus* (Mitch.) J. & G. 307
Drawing by H. L. Todd, from No. 15582, U. S. National Museum, collected at Fulton Market, New York, by E. G. Blackford.

94. The Spotted Cero, *Scomberomorus regalis* (Bloch) J. & G. 316
Drawing by H. L. Todd, from No. 12527, U. S. National Museum, collected at Key West, Florida, by E. G. Blackford

The Cero or Kingfish, *Scomberomorus caballa* (C. & V.) J. & G. 316
Drawing by H. L. Todd, from No. 10418, U. S. National Museum, collected at Wood's Holl, Massachusetts, 1875, by U. S. Fish Commission.

95. The Alalonga or Long-finned Tunny, *Orcynus alalonga* (Gmel.) Risso 320
Drawing by H. L. Todd, from No. 21884, U. S. National Museum, collected at Banquereau, September 10, 1878, by Captain William Thompson, schooner Magic.

The Striped or Oceanic Bonito, *Euthynnus pelamys* (L.) Lütken 319
Drawing by H. L. Todd, from No. 20702, sent from Museum of Comparative Zoology, Cambridge, Massachusetts.

96. The Horse Mackerel or Tunny, *Orcynus thynnus* (L.) Poey 320
Drawing by H. L. Todd, from specimen collected in Vineyard Sound by U. S. Fish Commission.

97. The Horsefish or Blunt-nosed Shiner, *Selene setipinnis* (Mitch.) Lutken 322
Drawing by H. L. Todd, from No. 16252, U. S. National Museum, collected in Fulton Market, New York, by E. G. Blackford.

98. The Silver Moonfish or "Look-down," *Selene argentea* Lacépède 323
Drawing by H. L. Todd, from No. 22279, U. S. National Museum.

99. The Cavally or Crevallé, *Caranx hippos* (L.) Gthr. 323
Drawing by H. L. Todd, from No. 10431 U. S. National Museum, collected at Wood's Holl, Massachusetts, 1871, by U. S. Fish Commission.

100. The Goggler or "Goggle Eye," *Caranx crumenophthalmus* (Bloch) Lac. 324
Drawing from *H. L. Todd, from No. 20681, U. S. National Museum, collected at Wood's Holl, Massachusetts, October 3,* 1877, by Vinal N. Edwards.

101. The Jurel or Hard Tail, *Caranx pisquetus* C. & V. = C. *chrysos* Gthr. 324
Drawing by H. L. Todd, from No. 16512, U. S. National Museum, collected at Wood's Holl, Massachusetts, by U. S. Fish Commission.

102. The Round Robin or Cigar-fish, *Decapterus punctatus* (Ag.) Gill 325
Drawing by H. L. Todd, from No. 20639, U. S. National Museum, collected at Wood's Holl, Massachusetts, September 11, 1877, by Vinal N. Edwards.

103. The Scad or Dutch Marsebanker, *Trachurus saurus* Raf. 326
Drawing by H. L. Todd, from No. 23421, U. S. National Museum, collected at Newport, Rhode Island, by S. Powell.

104. The Common Pompano, *Trachynotus carolinus* (L.) Gill 327
Drawing by H. L. Todd, from No. 15178, U. S. National Museum, collected at Wood's Holl, Massachusetts, October 5, 1871, by Professor S. F. Baird.

105. The Short Pompano, *Trachynotus ovatus* (L.) Gthr. 329
Drawing from No. 26385, U. S. National Museum, collected at Florida by Silas Stearns.

106. The Banner Pompano, *Trachynotus glaucus* C. & V. 329
Drawing by H. L. Todd, from No. 26176, U. S. National Museum, collected at Pensacola, Florida, January 7, 1882, by Silas Stearns.

107. The Pilot-fish, *Naucrates ductor* (L.) Raf. 330
Drawing by H. L. Todd, from No. 23197, U. S. National Museum, collected at New Bedford, Massachusetts, September 27, 1878, by William A. Bansett.

Page.

108. The California Yellow-tail, or Amber-fish, *Seriola dorsalis* C. & V 331
Drawing by H. L. Todd, from No. 26835, U. S. National Museum, collected at San Pedro, California, 1880 (?), by Jordan and Gilbert.

109. The Dolphin, *Coryphæna hippurus* L 332
(Male.) Drawing by H. L. Todd, from specimen in Fulton Market, New York, collected by E. G. Blackford, September 18, 1875.
(Female.) Drawing by H. L. Todd, from specimen in Fulton Market, New York, collected by E. G. Blackford, September 18, 1875.

110. The Harvest-fish, *Stromateus alepidotus* (L.) J. & G 333
Drawing by H. L. Todd, from No. 15234, U. S. National Museum, collected at New York, by Mr. Sutherland.

111. The Butterfish or Dollar-fish, *Stromateus triacanthus* Peck 333
Drawing by H. L. Todd, from No. 787, U. S. National Museum, collected at Beesley's Point, New Jersey, 1858, by Professor S. F. Baird.

The Log-fish or Black Rudder-fish, *Lirus perciformis* (Mitch.) J. & G 334
Drawing by H. L. Todd, from No. 22650, U. S. National Museum, collected at Le Have Bank, by Captain James Hawkins.

112. The Pomfret, *Brama Rayi* Schn 335
Drawing by H. L. Todd, from No. 26234, U. S. National Museum, collected at west end of Grand Bank, May, 1881, by Captain Andrew McKinney.

113. The Boar Fish, *Zenopsis ocellatus* (Storer) Gill 335
Drawing by H. L. Todd, from specimen taken at Provincetown, Massachusetts, in museum of Boston Society of Natural History.

114. The Cutlass-fish, *Trichiurus lepturus* L 335
Drawing by H. L. Todd, from No. 18028, U. S. National Museum, collected at Saint Augustine, Florida, 1877, by Dr. Janeway, U. S. N.

115. The Swordfish, *Xiphias gladius* L 338
(Adult.) Drawing by H. L. Todd, from No. 16126, U. S. National Museum, collected at New Bedford, Massachusetts, July 17, 1875, by U. S. Fish Commission.
(Young.) Drawing by H. L. Todd, from plate 225, Cuvier & Valenciennes, Histoire Naturelle des Poissons.

116. The Sail-fish, *Histiophorus gladius* (Brown) Gthr 356

The Spear-fish, *Tetrapturus albidus* Poey 357

117. The Tilefish, *Lopholatilus chamæleonticeps* Goode & Bean 360
Drawing by H. L. Todd, from No. 22899, U. S. National Museum, collected 60 miles south by east of No Man's Land, May, 1879, by Captain Kirby.

118. The Gulf Blanquillo, *Caulolatilus microps* Goode & Bean 360
Drawing by H. L. Todd, from No. 20971, U. S. National Museum, collected at Pensacola, Florida, March 18, 1878, by Silas Stearns.

The Ronchil, *Bathymaster signatus* Cope 361
Drawing by H. L. Todd, from No. 27646, U. S. National Museum, collected at Shumagins, Alaska, 1880, by E. P. Hercudeen.

119. The Squirrel-fish, *Holocentrum pentacanthum* (Block) Vaill. & Bocourt 361
Drawing by H. L. Todd, from No. 26380, U. S. National Museum, collected at Key West, Florida, 1880, by Silas Stearns.

120. The Spotted Squeteague, *Cynoscion maculatum* (Mitch.) Gill 365
Drawing by H. L. Todd, from No. 15000, U. S. National Museum, collected at Norfolk, Virginia, 1872, by Mr. Sibley.

The Common Squeteague, *Cynoscion regale* (Schn.) Gill 362
Drawing by H. L. Todd, from No. 10421, U. S. National Museum, collected at Wood's Holl, Massachusetts, 1871, by U. S. Fish Commission.

121. The Drum, *Pogonias chromis* (L.) C. & V 367
(Young.) Drawing by H. L. Todd, from No. 18036, U. S. National Museum, collected at Matanzas River Inlet, Florida, February, 1877, by John C. Willets.

122. The Drum, *Pogonias chromis* (L.) C. & V 367
(Adult.) Drawing by H. L. Todd, from No. 22936, U. S. National Museum.

123. The Fresh-water Drum or Gaspergou, *Haploidonotus grunniens* Raf 370
Drawing by H. L. Todd, from No. 10542, U. S. National Museum, collected at Ecorse, Michigan, by J. W. Milner.

124. The Spot or Goody, *Liostomus xanthurus* Lac 370
Drawing by H. L. Todd, from No. 20222, U. S. National Museum, collected at Newport, Rhode Island, November, 1875, by Samuel Powel.

125. The Red-fish or Buss of the South, *Sciæna ocellata* (L.) Gthr 371
Drawing by H. L. Todd, from No. 622, U. S. National Museum, collected at Indianola, 1858, by Major Emory.

126. The Yellow Tail, *Bairdiella chrysura* (Lac.) 375
Drawing by H. L. Todd, from No. 771, U. S. National Museum, collected by Beesley's Point, New Jersey, 1858, by Professor S. F. Baird.

127. The Kingfish or Sea Mink, *Menticirrus nebulosus* (Mitch.) Gill 375
Drawing by H. L. Todd, from No. 25403, U. S. National Museum, collected at Charleston Harbor, South Carolina, March 25, 1880, by R. E. Earll.

The Carolina Whiting, *Menticirrus alburnus* (L.) Gill 376
Drawing by H. L. Todd, from No. 22832, U. S. National Museum, collected at Pensacola, Florida, 1878, by Silas Stearns.

Page.

128. The Croaker, *Micropogon undulatus* (L.) C. & V. 378
Drawing by H. L. Todd, from No. 20742, U. S. National Museum, collected at Newport, Rhode Island, 1877, by Samuel Powel.

129. The Roncador, *Roncador Stearnsii* (Steindachner) J. & G. 379
Drawing by H. L. Todd, from No. 26864, U. S. National Museum, collected at Santa Barbara, California, 1880, by Professor D. S. Jordan.

130. The Sheep's-head, *Diplodus probatocephalus* (Walb.) J. & G. 381
(Young). Drawing by H. L. Todd, from specimen in U. S. National Museum.

131. The Sheep's-head, *Diplodus probatocephalus* (Walb.) J. & G. 381
(Adult). Drawing by H. L. Todd, from specimen in U. S. National Museum.

132. The Charleston Bream or Pin-fish, *Diplodus Holbrookii* Bean 386
Drawing by H. L. Todd, from No. 26979, U. S. National Museum, collected at Charleston, South Carolina, March 29, 1878, by G. Brown Goode.

133. The Scuppaug, Scup, or Northern Porgy, *Stenotomus chrysops* (Mitch.) Bean 386
Drawing by H. L. Todd, from No. 10425, U. S. National Museum, collected at Wood's Holl, Massachusetts, 1871, by Professor S. F. Baird.

134. The Southern Scup, *Stenotomus Gardeni* Bean 387

135. The Gulf Scup, or Goat's Head Porgy, *Stenotomus caprinus*, Goode & Bean 393
Drawing by H. L. Todd, from No. 32683, U. S. National Museum, collected at Pensacola, Florida, by Silas Stearns.

136. Milner's Pagellus, *Pagellus Milneri*, Goode & Bean 393
Drawing by H. L. Todd, from No. 6134, U. S. National Museum, collected at Charlotte Harbor, Florida, by C. B. Baker.

137. The Margate Fish, Bastard Snapper of Charleston, or Porgy of Pensacola, *Sparus pagrus* L. 394
Drawing by H. L. Todd, from specimen in U. S. National Museum, collected at Charleston, South Carolina, by G. Brown Goode.

138. The Sailor's Choice, *Lagodon rhomboides* (L.) Holbrook 393
Drawing by H. L. Todd, from No. 21280, U. S. National Museum, collected at Saint John's River, Florida, April, 1878, by G. Brown Goode.

139. The Bermuda Chub, *Cyphosus Bosci* (Lac.) J. & G. 394
Drawing by H. L. Todd, from No. 20635, U. S. National Museum, collected at Wood's Holl, Massachusetts, September 11, 1877, by Vinal N. Edwards.

140. The Medialuna, *Scorpis californiensis* Steindachner 395
Drawing by H. L. Todd, from No. 26952, U. S. National Museum, collected at Santa Barbara, California, 1880 by Jordan and Gilbert.

141. The Florida Red Snapper, *Lutjanus Blackfordii* Goode & Bean 395
Drawing by H. L. Todd, from No. 21330, U. S. National Museum, collected at Pensacola, Florida, May, 1878, by Silas Stearns.

142. The Pensacola Snapper, *Lutjanus Stearnsii* Goode & Bean 396
Drawing by H. L. Todd, from No. 21337, U. S. National Museum, collected at Pensacola, Florida, May, 1878, by Silas Stearns.

143. The Mangrove Snapper, *Rhomboplites aurorubens* (C. & V.) Vaillant 396
Drawing by H. L. Todd, from No. 21338, U. S. National Museum, collected at Pensacola, Florida, May, 1878, by Silas Stearns.

144. The Black Grunt, *Hæmulon Plumieri* (Lac.) J. & G. 398
Drawing by H. L. Todd, from No. 26980, U. S. National Museum, collected at Charleston, South Carolina, May 29, 1878, by G. Brown Goode.

145. The Striped Grunt, *Hæmulon elegans* (C. & V.) 397
Drawing by H. L. Todd, from No. 32603, U. S. National Museum, collected at Key West, Florida, by Dr. J. A. Henshall.

146. The Pigfish, *Pomadasys fulvomaculatus* (Mitch.) J. & G. 398
Drawing by H. L. Todd, from No. 3113, U. S. National Museum, collected at Charlotte Harbor, Florida, by C. B. Baker.

147. The Big-mouth Black Bass or Oswego Bass, *Micropterus salmoides* (Lac.) Henshall 401
Drawing by H. L. Todd, from No. 14143, U. S. National Museum, collected at Little Falls, Potomac River, 1874, by Major T. J. Hobbs.

148. The Small-mouth Black Bass, *Micropterus Dolomieu* Lac. 401
Drawing by H. L. Todd, from No. 10328, U. S. National Museum, collected at Sandusky, Ohio, by J. W. Milner.

149. The Rock-Bass or Red Eye, *Ambloplites rupestris* (Raf.) Gill 404
Drawing by H. L. Todd, from No. 9401, U. S. National Museum, collected at Ecorse, Michigan, by George Clark.

150. The Mud-Bass, *Acantharchus pomotis* (Baird) Gill. 405
Drawing by H. L. Todd, from No. 6475, U. S. National Museum, collected at Tarborough, North Carolina, by Mr. Bridger.

151. The Sacramento Perch, *Archoplites interruptus* (Girard) Gill 405
Drawing by H. L. Todd, from No. 27137, U. S. National Museum, collected at San Francisco, California, 1880, by Professor D. S. Jordan.

152. The War-mouth Bass, *Chænobrytus gulosus* (C. & V.) Jordan 405
Drawing by H. L. Todd, from No. 17603, U. S. National Museum, collected at Jackson's Lake, Alabama, July 14, 1876, by Knublen and Bean.

Page.

153. The Pumpkin-Seed or Sunfish, *Lepomis gibbosus* (L.) McKay 406
Drawing by H. L. Todd, from No. 4163, U. S. National Museum, collected at Root River, Wisconsin, July 1853, by Professor S. F. Baird.

154. The Long-eared Sunfish, *Lepomis auritus* (L.) Raf 406
Drawing by H. L. Todd, from No. 15351, U. S. National Museum, collected at Susquehanna River, Bainbridge, Pennsylvania, May, 1875, by Dr. T. H. Bean.

155. The Blue Sunfish or Copper-nose, *Lepomis pallidus* (Mitch.) J. & G 406
Drawing by H. L. Todd, from No. 8448, U. S. National Museum, collected in Tennessee.

156. The Chinquapin Perch, *Lepomis punctatus* (C. and V.) Jordan 406
Drawing by H. L. Todd, from No. 4227-'46, U. S. National Museum, collected in Florida.

157. The Broad-eared Sunfish, *Lepomis obscurus* Ag 406
Drawing by H. L. Todd, from No. 20031, U. S. National Museum, collected at Cumberland River, Tennessee, by A. Winchell.

158. The Rainbow Sunfish, *Centrarchus macropterus* (Lac.) Jordan 406
Drawing by H. L. Todd, from No. 20395, U. S. National Museum, collected at Kinston, North Carolina, 1875, by Welsher and Hyatt.

159. The Calico Bass or Strawberry Bass, *Pomoxys sparoides* (Lac.) Grd 406
Drawing by H. L. Todd, from No. 10077, U. S. National Museum, collected at Rochester by J. W. Milner.

160. The *Crappie or Sac-à-lait*, *Pomoxys annularis* Raf 407
Drawing by H. L. Todd, from No. 10387, U. S. National Museum, collected at Norfolk, Virginia, 1873, by Dr. H. C. Yarrow.

161. The *Black-banded Sunfish*, *Mesogonistius chætodon* (Baird) Gill 0
Drawing by H. L. Todd, from No. 20354, U. S. National Museum, collected at Trenton, New Jersey, 1875, by Dr. C. C. Abbott.

162. The Sea Bass, *Serranus atrarius* (L.) J. and G 407
Drawing by H. L. Todd, from No. 14838, U. S. National Museum, collected at Noank, Connecticut, 1874, by U. S. Fish Commission.

163. The Squirrel-fish, *Serranus fasciolaris* C. and V 410
Drawing by H. L. Todd, from No. 21843, U. S. National Museum, collected at Charleston, South Carolina, July, 1878, by C. C. Leslie.

164. The Red Grouper, *Epinephelus morio* (Cuv.) Gill 411
Drawing by H. L. Todd, from No. 22129, U. S. National Museum, obtained in the Washington Market, District of Columbia, by G. Brown Goode.

165. The Jew-fish or "Warsaw," *Promicrops guasa* Poey 412
Drawing by H. L. Todd, from No. 22306, U. S. National Museum, collected at St. John's River, Florida.

166. The West Indian Cabrilla, *Serranus clathratus* (Grd.) Steind 413
Drawing by H. L. Todd, from No. 26574, U. S. National Museum, collected at Key West, Florida, May, 1880, by Silas Stearns.

167. The Pensacola Black Grouper, *Trisotropis microlepis* Goode and Bean 413
Drawing by H. L. Todd, from No. 5137, U. S. National Museum, collected at West Florida by Kaiser and Martin.

168. The Yellow Perch, *Perca americana* Schrank 414
Drawing by H. L. Todd, from No. 25199, U. S. National Museum, collected at Washington Market, District of Columbia, April, 1880, by U. S. Fish Commission.

169. The Wall-eyed Pike or Dory, *Stizostedium vitreum* (Mitch.) Jordan and Copeland 421
Drawing by H. L. Todd, from No. 22494, U. S. National Museum, collected at Port Deposit, Maryland, April 7, 1879, by R. E. McClenahan.

The Sauger or Land Pike, *Stizostedium canadense* (Smith) Jordan 424
Drawing by H. L. Todd, from No. 10072, U. S. National Museum, collected at Rochester, New York, by J. W. Milner.

170. The Striped Bass or Rockfish, *Roccus lineatus* (Bloch.) Gill (= *Roccus saxatilis* auctorum) 425
Drawing by H. L. Todd, from No. 25219, U. S. National Museum, collected at Washington Market, District of Columbia, April 24, 1880, by U. S. Fish Commission.

171. The White Bass, *Roccus chrysops* (Raf.) Gill 428
Drawing by H. L. Todd, from No. 10326, U. S. National Museum collected at Sandusky, Ohio, by J. W. Milner.

172. The Yellow Bass, *Roccus interruptus* (Gill) J. and G 431
Drawing by H. L. Todd, from specimens in National Museum.

173. The White Perch, *Roccus americanus* (Gml.) J. and G 431
Drawing by H. L. Todd, from No. 15681, U. S. National Museum, collected at New York, November 15, 1875, by E. G. Blackford.

174. The Bluefish *Pomatomus saltatrix* (L.) Gill 433
Drawing by H. L. Todd, from specimens in U. S. National Museum.

The Cobia or Crab-eater, *Elacate canada* (L.) Gill 444
Drawing by H. L. Todd, from No. 18563, U. S. National Museum.

175. The *Triple-Tail or* Black Grouper, *Lobotes surinamensis* (Bl.) Cuvier 444

176. The Moon-fish or Spade-fish, *Chætodipterus faber* (Brouss.) J. and G 445

Page.

177. The Spear-fish Remora, *Rhombochirus osteochir* (Cuv.) Gill 446
Drawing by H. L. Todd, from No. 19022, U. S. National Museum, collected at Wood's Holl, Massachusetts, 1875, by U. S. Fish Commission.

The Sword-fish Remora, *Remoropsis brachyptera* Lowe 446
Drawing by H. L. Todd, from No. 23374, U. S. National Museum, collected at sea in 250 fathoms of water by Daniel McEachran.

178. The West Indian Barracouta or Sennet, *Sphyræna picuda* Schn 448
Drawing by H. L. Todd, from No. 14978, U. S. National Museum, collected at Florida by E. G. Blackford.

The Northern Barracouta, *Sphyræna borealis* De Kay 448
Drawing by H. L. Todd, from No. 18662, U. S. National Museum, collected at Wood's Holl, Massachusetts, 1876, by Vinal N. Edwards.

179. The Striped Mullet, *Mugil albula* L 449
Drawing by H. L. Todd, from No. 24456, U. S. National Museum, collected at Wood's Holl, Massachusetts, December 15, 1879, by Vinal N. Edwards.

The White Mullet, *Mugil brasiliensis* Agass 449
Drawn by Miss M. Smith, from No. 21496, U. S. National Museum, collected at Pensacola, Florida, 1878, by Silas Stearns.

180. The Sand Smelt or Silversides, *Menidia notata* (Mitch.) J. and G 456
Drawing by H. L. Todd, from specimen in U. S. National Museum, collected at Noank, Connecticut, by U. S. Fish Commission.

The California "Smelt" or Pescadillo, *Atherinopsis californiensis* Girard 457
Drawing by H. L. Todd, from No. 26784, U. S. National Museum, collected at San Diego, California, 1880, by Professor D. S. Jordan.

181. The Two-spined Stickle-back, *Gasterosteus aculeatus* L 457
Drawing by H. L. Todd, from No. 20875, U. S. National Museum, collected at Wood's Holl, Massachusetts, December 3, 1877, by Vinal N. Edwards.

The Silver Gar-fish, *Tylosurus longirostris* (Mitch.) J. and G 458
Drawing by H. L. Todd, from specimens in National Museum.

The Skipper or Saury, *Scomberesox saurus* (Walb.) Fleming 460
Drawing by H. L. Todd, from No. 19853, U. S. National Museum, collected at Wood's Holl, Massachusetts, November 3, 1875, by Vinal N. Edwards.

182. The Half Beak, *Hemiramphus unifasciatus* Ranzani 461
Drawing by H. L. Todd, from No. 16944, U. S. National Museum, collected in Chesapeake Bay, August, 1876, by Otto Lugger.

The California Flying-fish, *Exocœtus californiensis* Cooper 459
Drawing by H. L. Todd, from No. 26907, U. S. National Museum, collector at Santa Barbara, California, 1880, by Jordan and Gilbert.

183. The Pike, *Esox lucius* L 461
Drawing by H. L. Todd, from No. 9289, U. S. National Museum, collected at Ecorse, Michigan, by George Clark.

The Pickerel or Federation Pike, *Esox reticulatus* Le Sueur 464
Drawing by H. L. Todd, from No. 20381, U. S. National Museum.

184. The Western Brook Pickerel, *Esox umbrosus* Kirtland 464
Drawing by H. L. Todd, from No. 20708, U. S. National Museum, collected by E. G. Blackford.

The Muskellunge, *Esox nobilior* Thompson 464
Drawing by H. L. Todd, from No. 10607, U. S. National Museum, collected at Ecorse, Michigan, by George Clark.

185. The Mummichog, *Fundulus majalis* (Walb.) Gthr. (Female) 466
Drawing H. L. Todd, from No. 13788, U. S. National Museum, collected at Wood's Holl, Massachusetts, September 15, 1871, by U. S. Fish Commission.

The Blackfish of Alaska, *Dallia pectoralis* Bean 466
Drawing by H. L. Todd, from 23498 A, U. S. National Museum, collected at Saint Michaels, Alaska, February, 1877, by L. M. Turner.

186. The Atlantic Salmon, *Salmo salar* L 468
Drawing by H. L. Todd, from specimen in the U. S. National Museum, taken in the Delaware River.

The Quinnat or California Salmon, *Oncorhynchus chouicha* (Walb.) J. and G 479
Drawing by H. L. Todd, from No. 24671, U. S. National Museum, collected at Neeah Bay, December, 1879, by James G. Swan.

187. The Steel Head, *Salmo Gairdneri* Richardson 474
Drawing by H. L. Todd, from No. 27218, U. S. National Museum, collected at Columbia River, 1880, by Professor D. S. Jordan.

The Rainbow Trout, *Salmo irideus* Gibbons 475
Drawing by H. L. Todd, from No. 29093, U. S. National Museum, collected at McCloud River, California, 1881, by Livingston Stone.

188. The Black-spotted Trout, *Salmo purpuratus* Pallas 475
Drawing by H. L. Todd, from No. 27905, U. S. National Museum, collected at Sitka, Alaska, 1878, by L. A. Beardsley.

Page.

The Kayko or Dog Salmon, *Oncorhynchus keta* (Walb.) Gill and Jordan 476
Drawing by H. L. Todd, from No. 27617, U. S. National Museum, collected at Fort Alexander, Cook's Inlet, Alaska, July 4, 1880, by J. Cohen.

189. The Gorbuscha or Hump-backed Salmon, *Oncorhynchus gorbuscha* (Walb.) Gill and Jordan 476
Drawing by H. L. Todd, from No. 27743, U. S. National Museum, collected at Cook's Inlet, Alaska, July 6, 1880, by Dr. T. H. Bean.

The Kisutch or Silver Salmon, *Oncorhynchus kisutch* (Walb.) J. and G 477
Drawing by H. L. Todd, from No. 27712, U. S. National Museum, collected at Illiulik, Unalashka, October 12, 1880, by Dr. T. H. Bean.

190. The Krasnaya Ryba, Red-fish of Idaho, or Blue Back Salmon, *Oncorhynchus nerka* (Walb.) Gill and Jordan. 477
(Hook-jawed Male.)
(Female) Drawings by H. L. Todd, from specimens in U. S. National Museum, collected by Captain C. Bendire, U. S. N., in the Wallowa River, Idaho.

191. The Krasnaya Ryba or Blue Back Salmon, *Oncorhynchus nerka* (Walb.) J. and G 477
Drawing by H. L. Todd, from fresh run male, sent to U. S. National Museum from the Columbia River, April, 1884, by A. Booth, esq.

The Namaycush or Lake Trout, *Salvelinus namaycush* (Walb.) Goode 485
Drawing by H. L. Todd, from No. 17012, U. S. National Museum, collected at Raquette Lake, New York, February 23, 1877, by Verplanck Colvin.

192. The Speckled Trout, *Salvelinus fontinalis* (Mitch.) Gill and Jordan 497
Drawing by H. L. Todd, from No. 28051, U. S. National Museum, obtained in New York Market, July, 1881, by E. G. Blackford.

193. The Oquassa Trout, *Salvelinus oquassa* (Grd.) Gill and Jordan 503
Drawing by H. L. Todd, from No. 20688, U. S. National Museum, collected at Oquassoc Lake, New York, November 9, 1877, by E. G. Blackford.

The Malma or Dolly Varden Trout, *Salvelinus malma* (Walb.) J. and G 504
Drawing by H. L. Todd, from No. 27740, U. S. National Museum, collected at Port Chatham, Cook's Inlet, Alaska, 1880, by Dr. T. H. Bean.

194. The Grayling, *Thymallus tricolor* Cope 505
Drawing by H. L. Todd, from No. 11115, U. S. National Museum, obtained from Au Sable River, Michigan, by J. W. Milner.

195. The Alaska Grayling, *Thymallus signifer* Richardson 505
Drawing by H. L. Todd, from No. 3333, U. S. National Museum, collected at Port Simpson, June, 1860, by R. R. Ross.

196. The Whitefish, *Coregonus clupeiformis* (Mitch.) Milner 507
Drawing by H. L. Todd, from No. 10300, U. S. National Museum, collected at Ecorse, Michigan, by George Clark.

197. The Cisco or Lake Herring, *Coregonus Artedi* Lesueur 541
Drawing by H. L. Todd, from No. 33958, U. S. National Museum, collected at Neer Field Bay, Wisconsin, by J. W. Milner

The Moon-eye or Cisco, of Lake Michigan, *Coregonus Hoyi* (Gill) Jordan 541
Drawing by H. L. Todd, from No. 32162, U. S. National Museum, collected at Seneca Lake, New York, June, 1878, by Professor H. L. Smith

198. The Alaska Whitefish, *Coregonus Merki* Gthr 0
Drawing by H. L. Todd, from No. 27698, U. S. National Museum, collected at Alaska, 1880, by U. S. Steamer Corwin.

The Laurettа White-fish, *Coregonus Laurettæ* Bean 0
Drawing by H. L. Todd, from No. 27695, U. S. National Museum, collected at Point Barrow, Alaska, July, 1880, by U. S. Steamer Corwin.

199. The Eastern Smelt, *Osmerus mordax* (Mitch.) Gill 543
Drawing by H. L. Todd, from No. 21435, U. S. National Museum, collected at Wood's Holl, Massachusetts, 1878, by Vinal N. Edwards.

The Alaska Smelt, *Osmerus dentex* Steindachner 544
Drawing by H. L. Todd, from No. 27914, U. S. National Museum, collected at Port Clarence, Alaska, 1880, by Dr. T. H. Bean.

200. The Alaska Surf Smelt, *Hypomesus olidus* (Pallas) Gthr 544
Drawing by H. L. Todd, from No. 23973, U. S. National Museum, collected at Saint Michaels, Alaska, May 20, 1877, by M. L. Turner.

The California Surf Smelt, *Hypomesus pretiosus* (Grd.) Gill 544
Drawing by H. L. Todd, from No. 27095, U. S. National Museum, collected at Yakutat Bay, Alaska, 1880, by Dr. T. H. Bean.

201. The Capelin, *Mallotus villosus* (Muller) Cuv 544
Drawing by H. L. Todd, from No. 3418 U. S. National Museum, collected at Grosswater Bay, by Dr. E. Coues.

The Eulachon, *Thaleichthys pacificus* (Rich.) Girard 547
Drawing by H. L. Todd, from No. 28001, U. S. National Museum, collected at Chilkat River, Alaska, June, 1880, by Marcus Baker.

202. The Hand Saw fish, *Alepidosaurus ferox* Lowe 547
Drawing by H. L. Todd, from No. 18028, U. S. National Museum, collected at Saint Augustine, Florida, 1877, by Dr. Janeway, U. S. N.

Page.

Baird's Alepocephalus, *Alepocephalus Bairdii* Goode & Bean 548
Drawing by H. L. Todd, from No. 22468, U. S. National Museum, collected on Grand Bank, by Christian Johnson, Schr. William Thompson.

203. Müller's Scopelus, *Scopelus Mülleri* (Gmel.) Collett 547
Drawing by H. L. Todd, from No. 20943, U. S. National Museum, collected by F. Mather.

The Snake fish, *Trachinocephalus myops* (Forster) Gill 548
Drawing by L. H. Todd, from No. 16951, U. S. National Museum, collected at Wood's Holl, 1870, by Vinal N. Edwards.

204. The Herring, *Clupea harengus* L. 549
Drawing by H. L. Todd, from No. 16667, U. S. National Museum, collected at Washington market, June, 1875, by J. H. Richards.

The California Herring, *Clupea mirabilis* Girard 568
Drawing by H. L. Todd, from No. 24865, U. S. National Museum, collected at San Diego, California, January, 1880, by Jordan & Gilbert.

205. The Menhaden or Mossbunker, *Brevoortia tyrannus* (Latrobe) Goode 569
Drawing by H. L. Todd, from No. 20666, U. S. National Museum, collected at Wood's Holl, October 18, 1877, by Vinal N. Edwards.

206. The Gulf Menhaden, *Brevoortia patronus* Goode 575
Drawing by H. L. Todd, from No. 892 A, U. S. National Museum, collected at Brazos, Santiago, Texas, by Captain Van Vleet.

207. The Branch Herring (Female), *Clupea vernalis* Mitchill 579
Drawing by H. L. Todd, from No. 27197, U. S. National Museum, obtained from Potomac River, March 29, 1880, by U. S. Fish Commission.

208. The Branch Herring (Male), *Clupea vernalis* Mitchill 579
Drawing by H. L. Todd, from No. 25196, U. S. National Museum, obtained from Potomac River, March 27, 1880, by U. S. Fish Commission.

209. The Glut or Summer Herring (Male), *Clupea æstivalis* Mitchill 580
Drawing by H. L. Todd, from No. 32639, U. S. National Museum, obtained from the Washington market, April, 1883, by H. L. Todd.

210. The Glut Herring (Female), *Clupea æstivalis* Mitchill 580
Drawing by H. L. Todd from No. 32640, U. S. National Museum, obtained at Washington Market, April 21, 1883, by H. L. Tod.

211. The Inland Alewife or Skipjack, *Clupea chrysochloris* (Raf.) J. & G 594
Drawing by H. L. Todd, from No. 30159, U. S. National Museum, collected at Pensacola, Florida, by Silas Stearns.

212. The Shad, *Clupea sapidissima* Wilson (Male) 594
Drawing by H. L. Todd from No. 25096 U. S. National Museum, collected at Norfolk, Virginia, March 12, 1880, by U. S. Fish Commission.

213. The Shad, *Clupea sapidissima* Wilson (Female) 594
Drawing by H. L. Todd, from No. 25095, U. S. National Museum, collected at Norfolk, Virginia, March 10, 1880, by U. S. Fish Commission.

214. Map of the River Basins of the Atlantic Slope. By Col. M. MacDonald 598

215. Diagram illustrating the influence of Hydro-Thermals in determining the direction, and limiting the range of the migrations of the Shad and Herring (Alewives). By Col. M. MacDonald 600

216. The Hickory Shad or Mattowacca, *Clupea mediocris* Mitch 607
Male. Drawing by H. L. Todd, from No. 25148, U. S. National Museum, obtained from Potomac River, March 19, 1880, by H. L. Todd.
(Female.) Drawing by H. L. Todd, from No. 25132, U. S. National Museum, collected at Potomac River, March, 1880, by Dr. T. H. Bean.

217. The Mud Shad or Gizzard Shad, *Dorosoma Cepedianum* (Le S.) Gill 610
Drawing by H. L. Todd, from No. 20034, U. S. National Museum, collected at Cumberland River, Tennessee, May, 1877, by Mr. A. Winchell.

The Tarpum or Grand-Ecaille, *Megalops thrissoides* (Schn.) Gthr 610
Drawing by H. L. Todd, from No. 14924, U. S. National Museum, collected at New Jersey, 1874, by E. G. Blackford.

218. The Big-eyed Herring, *Elops saurus* L. 611
Drawing by H. L. Todd, from specimen in U. S. National Museum, from Massachusetts.

The Anchovy, *Engraulis vittatus* Mitchill 611
Drawing by H. L. Todd, from No. 14087, U. S. National Museum, collected at Noank, Connecticut, September 21, 1874, by U. S. Fish Commission.

The Lady-fish or Bone-fish, *Albula vulpes* (L.) Goode 612
Drawing by H. L. Todd, from No. 25962, U. S. National Museum, collected three miles southeast of Eastern Point, Newport, Rhode Island, August 11, 1880, by Captain Rockliff, U. S. Fish Commission.

219. The Moon-eye, *Hyodon tergisus* Le Sueur 612
Drawing by H. L. Todd, from No. 8710, U. S. National Museum, collected at Ecorse, Michigan, February, 1872, by George Clark.

220. The Chub Sucker, *Erimyzon succetta* (Lac.) Jordan 614
Drawing by H. L. Todd, from No. 27867, U. S. National Museum, collected at Nippersink Lake, Illinois, by Professor S. A. Forbes.

Page.

221. Goode's Sucker, *Erimyzon Goodei* Jordan 614
Drawing by Miss M. Smith, from No. 25539, U. S. National Museum, collected at Ogechee Ponds, near Savannah, Georgia, March 6, 1880, by Colonel M. McDonald.

222. The Red Horse, *Moxostoma macrolepidotum* (Le S.) Jordan 614
Drawing by H. L. Todd, from No. 9393, U. S. National Museum, collected at Ecorse, Michigan, February, 1872, by George Clark.

The Carp Mullet, *Moxostoma carpio* (Val.) Jordan 614
Drawing by H. L. Todd, from No. 10793, U. S. National Museum, collected at Cincinnati, Ohio, by J. W. Milner.

223. The Montana Sucker, *Catostomus retropinnis* Jordan 615

The Brook Sucker or Common Sucker, *Catostomus Commersoni* (Lac.) Jordan 615
Drawing by H. L. Todd, from No. 10548, U. S. National Museum, collected at Ecorse, Michigan, by J. W. Milner.

224. The Black Horse, *Cycleptus elongatus* (Le S.) Ag 615
Drawing by H. L. Todd, from No. 10790, U. S. National Museum, collected at Cincinnati, Ohio, by J. W. Milner.

225. The Quill-back, *Carpiodes cyprinus* (Le S.) Ag 615
Drawing by H. L. Todd, from No. 33073, U. S. National Museum, collected at Havre de Grace, Maryland, June, 1882, by Dr. T. H. Bean.

226. The Red Mouth Buffalo-fish, *Ictiobus bubalus* (Raf.) Ag 615
Drawing by H. L. Todd, from No. 20774, U. S. National Museum, collected at Normal, Illinois, 1877, by Professor S. A. Forbes.

227. The Golden Shiner or Bream, *Notemigonus chrysoleucus* (Mitch.) Jordan 616
Drawing by H. L. Todd, from No. 20243, U. S. National Museum, collected at Hackensack River, 1875, by Professor S. F. Baird.

The Sacramento "Pike," *Ptychochilus oregonensis* (Rich.) Grd. 616
Drawing by H. L. Todd, from No. 27291, U. S. National Museum, collected at Columbia River, 1880, by Professor D. S. Jordan.

228. The Fall-fish or Silver Chub, *Semotilus bullaris* (Raf.) Jordan 616
Drawing by H. L. Todd, from No. 15359, U. S. National Museum, collected at Bainbridge, Pennsylvania, May, 1875, by Dr. T. H. Bean.

The Horn Dace, *Semotilus corporalis* (Mitch.) Putnam 617
Drawing by H. L. Todd, from No. 19163, U. S. National Museum, collected at Aux Plains River by R. Kennicott.

229. The Horny Head or River Chub, *Ceratichthys biguttatus* (Kirtland) Girard 617
Drawing by H. L. Todd, from No. 10969, U. S. National Museum, collected at Bainbridge, Pennsylvania, 1875, by Dr. T. H. Bean.

The Orthodon Chub, *Orthodon microlepidotus* (Ayres) Girard 617
Drawing by H. L. Todd, from No. 27139, U. S. National Museum, collected at Sacramento River, California, 1880, by Jordan and Gilbert.

230. The Leather Carp, *Cyprinus carpio* L. (var. *coriaceus*) 618
Drawing by H. L. Todd, from No. 25217, U. S. National Museum, collected at the Carp Ponds, Washington, D. C., April 26, 1880, by U. S. Fish Commission.

231. The Gold Fish, *Carassius auratus* (L.) Bleeker 0
Drawing by H. L. Todd, from No. 22107, U. S. National Museum, collected at Carp Ponds, Washington, D. C., January 24, 1878, by William Palmer.

232. The Channel Catfish of the Potomac, *Ictalurus albidus* (Le S.) J. & G 628
Drawing by H. L. Todd, from No. 20925, U. S. National Museum, collected at Potomac River, 1877, by Professor D. S. Jordan.

233. The Bull-Head, *Amiurus melas* (Raf.) Jord. & Copeland 628
Drawing by H. L. Todd, from No. 1497, U. S. National Museum, collected at Aux Plains River by R. Kennicott.

The Bull-Head or Catfish, *Amiurus catus* (L.) Gill 628
Drawing by H. L. Todd, from No. 33075, U. S. National Museum, collected at Havre de Grace, Maryland, June, 1882, by Dr. T. H. Bean.

234. The Bull-Head, *Amiurus vulgaris* (Thompson) Nelson 628
Drawing by H. L. Todd, from No. 31946, U. S. National Museum, collected at Winnepeg, Manitoba, 1883, by Historical and Scientific Society.

235. The Gaff Topsail Catfish, *Æluriichthys marinus* (Mitch.) B. & G 628
Drawing by H. L. Todd, from No. 10422, U. S. National Museum, collected at Wood's Holl, Massachusetts, 1871, by Professor S. F. Baird.

236. The Salt Water Catfish, *Arius felis* (L.) J. & G 629
Drawing by H. L. Todd, from No. 21487, U. S. National Museum, collected at Pensacola, Florida, 1878, by Silas Stearns.

237. The Spotted Moray, *Gymnothorax moringa* (Cuv.) Goode & Bean 629
Drawing by H. L. Todd, from No. 6994, U. S. National Museum, collected at Garden Key, Florida.

238. The Spiny-back Eel, *Ptilichthys Goodei* Bean 0
Drawing by H. L. Todd, from No. 20619, U. S. National Museum, collected at Iliuliuk, Alaska, July 28, 1880, by Dall & Bean.

Page.

239. The Common Eel, *Anguilla vulgaris* Turton 630
Drawing by H. L. Todd, from No. 20470, U. S. National Museum, collected at Holyoke, Massachusetts, 1876, by U. S. Fish Commission.

240. The Conger Sea Eel, *Leptocephalus conger* (L.) J. & G 656
Drawing by H. L. Todd, from No. 16027, U. S. National Museum, collected at Noank, Connecticut, October 10, 1874, by J. H. Latham.

241. The Bowfin or Mudfish, *Amia calva* L... 659
Drawing by H. L. Todd, from No. 6702, U. S. National Museum.

The Short-nosed Gar Pike, *Lepidosteus platystomus* Raf 664
Drawing by H. L. Todd, from No. 3241, U. S. National Museum, collected at Cleveland, Ohio, by Professor S. F. Baird.

242. The Paddle-fish, *Polyodon spatula* (Walb.) J. & G 660
Under view. Drawing by H. L. Todd, from No. 12235, U. S. National Museum, collected at Cincinnati, Ohio, by J. W. Milner.
Side view. Drawing by H. L. Todd, from No. 12235, U. S. National Museum, collected at Cincinnati, Ohio, by J. W. Milner.

243. The Common Sturgeon, *Acipenser sturio* L. (= *A. oxyrhynchus*) 660
Drawing by H. L. Todd, from No. 22495, U. S. National Museum, collected in Potomac River by William Woltz.

The Short-nosed Sturgeon, *Acipenser brevirostris* Le Sueur 660
Drawn from a photograph of a specimen collected at Wood's Holl, Massachusetts, 1871.

244. The Lake Sturgeon, *Acipenser rubicundus* Le Sueur 661
Drawing by H. L. Todd, from No. 10252, U. S. National Museum, collected at Ecorse, Michigan, by J. W. Milner.

The Shovel-nose Sturgeon, *Scaphirhynchops platyrhynchus* (Raf.) Gill 663
Drawing by H. L. Todd, from No. 22159, U. S. National Museum, collected at Mount Carmel, Illinois, 1878, by Robert Ridgway.

245. The Southern Sting Ray, *Trygon sabina* Le Sueur 665
Drawing by H. L. Todd, from No. 31043, U. S. National Museum, collected at Galveston, Texas, by Professor D. S. Jordan.

246. The Barn-door Skate, *Raia lævis* Mitchill 667
Drawing by H. L. Todd, from No. 21577, U. S. National Museum, collected at Gloucester, Massachusetts, October, 1878, by U. S. Fish Commission.

247. The Torpedo, *Torpedo occidentalis* Storer 667
Drawing by H. L. Todd, from cast of specimen in U. S. National Museum, collected at Wood's Holl, Massachusetts, 1871, by U. S. Fish Commission.

248. The Sawfish, *Pristis pectinatus* Latham 668
(Side view.) Drawing by H. L. Todd, from No. 30678, U. S. National Museum, collected at Pensacola, Florida, by Silas Stearns.
(Under view.) Drawing by H. L. Todd, from No. 30678, U. S. National Museum, collected at Pensacola, Florida, by Silas Stearns.

249. The Basking Shark or Bone Shark, *Cetorhinus maximus* (L.) Blainville 668
Copied by H. L. Todd, from Plate 6, Annales du Musee d'Histoire Naturelle, Vol. 18.

The Mackerel Shark, *Lamna cornubica* (Gmel.) Fleming 670
Drawing by H. L. Todd, from No. 27868, U. S. National Museum, collected at Santa Cruz, California, 1880, by Jordan & Gilbert.

250. The Thrasher Shark, *Alopias vulpes* (Gmel.) Bonap 672
Drawing by H. L. Todd, from No. 25962, U. S. National Museum, collected at Eastern Point, Newport, Rhode Island, August 11, 1880, by Captain Rockliff.

The Horned Dogfish, *Squalus acanthias* L..... 673
Drawing by H. L. Todd, from No. 22316, U. S. National Museum, collected at Gloucester, Massachusetts, 1878, by U. S. Fish Commission.

The Tope, or Oil Shark, *Galeorhinus galeus* (L.) Blainville 676
Drawing by H. L. Todd, from No. 26973, U. S. National Museum, collected at Monterey, California, 1880, by Jordan & Gilbert.

251. The Sea Lamprey, *Petromyzon marinus* L. 677
Drawing by H. L. Todd, from No. 10654, U. S. National Museum, collected at Wood's Holl, Massachusetts, by Vinal N. Edwards.

The Alaska Brook Lamprey, *Ammocœtes aureus* Bean 0
Drawing by H. L. Todd, from No. 21524, U. S. National Museum, collected at Yukon River, Alaska, by L. M. Turner.

252. The Slime Eel or Hag, *Myxine glutinosa* L 681
Drawing by H. L. Todd, from No. 23466, U. S. National Museum, collected at sea, by Captain R. L. Morrison.

253. The Short-finned Squid, *Ommastrephes illecebrosus* (Le S.) Verrill 687
Drawing of young male from Provincetown, Massachusetts.

The Giant Squid, *Architeuthis princeps* Verrill 687
Drawing by Professor A. E. Verrill, from specimen obtained at Fortune Bay, Newfoundland, December, 1874.

Common Squid, *Loligo Pealei* (Le S.)..... 687
Drawing of female from Vineyard Sound, Massachusetts.

Page.

254. Sea Snails, Periwinkles, Drills, and Borers 693
FIG. 1. *Lunatia heros.* See Report U. S. Fish Commission. Part I, p. 700.
FIG. 2. *Purpura lapillus.* See Report U. S. Fish Commission. Part I, p. 698.
FIG. 3. *Purpura lapillus*, banded variety.
FIG. 4. *Neverita duplicata.* See Report U. S. Fish Commission. Part I, p. 700.
FIG. 5. *Ilyanassa obsoleta.* See Report U. S. Fish Commission. Part I, p. 696.
FIG. 6. *Tritia trivittata.*
FIG. 7. The Whelk, *Buccinum undatum.* See Report U. S. Fish Commission. Part I, p. 699.
FIG. 8. The Periwinkle, *Fulgur carica.* See Report U. S. Fish Commission. Part I, p. 694.
FIG. 9. *Astyris zonalis.*
FIG. 10. *Astyris lunata.*
FIG. 11. *Rissoa acalcatus.*
FIG. 12. The Drill or Borer, *Urosalpinx cinerea*, p. 697.

255. Various species of clams 703
FIG. 1. *Angulus tener.*
Animal reduced one-half. See Report U. S. Fish Commission. Part I, p. 677.
FIG. 2. The Long Clam, Soft Clam, or Mananose, *Mya arenaria.*
With animal in extension, reduced to one-half the natural size.
FIG. 3. *Tagelus gibbus.*
With animal, the siphon not fully extended. One-half natural size. See Report U. S. Fish Commission. Part I, p. 675.
FIG. 4. The Razor Clam, *Ensatella americana.* See Report U. S. Fish Commission. Part I, p. 707.
With animal extended. One-half natural size.
FIG. 5. Shows some of the terminal papillæ enlarged.
FIG. 6. The Razor Clam, *Ensatella americana.*
Shell. Natural size.
FIG. 7. The Ship Worm, *Teredo navalis.*
Enlarged two diameters.
FIG. 8. The Scallop, *Pecten irradians.* See Report U. S. Fish Commission. Part I, p. 709.
Natural size.
FIG. 9. The Bloody Clam, *Argina pexata.*
Natural size.

256. Various species of clams 703
FIG. 1. The Quahaug or Little-necked Clam, *Venus mercenaria.*
Natural size.
FIG. 2. The Quahaug of Puget Sound, *Saxidomus Nuttalli.*
Natural size of large specimen. Drawn by J. H. Emerton.
FIG. 3. The Gaper Clam of the West Coast, *Schizothærus Nuttalli* (Conrad).
(I.) Specimen of ordinary size, reduced about one-fourth in length. The siphons are somewhat contracted; the foot (F) expands about as usual.
(II.) Outline of the left valve of a larger specimen, reduced to the same extent. Drawn from nature by R. E. C. Stearns.

257. The Geoduck, or Giant Clam of the Pacific, *Glycimeris generosa* 708
Natural size; specimens with siphons partly contracted; weight when alive, 6½ pounds. Drawn by R. E. C. Stearns.

258. Mussels and Sea Clams 709
FIG. 1. The Beach Clam or Hen Clam, *Spisula solidissima.* See Report U. S. Fish Commission. Part I, p. 708.
Natural size.
FIG. 2. The Sea Clam, *Cyprina islandica.*
Natural size.
FIG. 3. The Black Mussel, *Mytilus edulis.* See Report U. S. Fish Commission. Part I, p. 709.
FIG. 4. The Black Horse Mussel, *Modiola nigra.*
FIG. 5. The Rough Mussel, *Modiola plicatula.* See Report U. S. Fish Commission. Part I, p. 709.
FIG. 6. The Horse Mussel, *Modiola modiolus.* See Report U. S. Fish Commission. Part I, p. 709.

259. The anatomy of the oyster. (See opposite page for full explanation) 711

260. FIG. 1. The Rock Crab, *Cancer irroratus* Say; male one-half natural size 766
FIG. 2. Zoëa of the same, in the last stage before it changes to the megalops condition; lateral view, enlarged seventeen diameters.
FIG. 3. Megalops stage of the same, just after the change from the zoëa condition; dorsal view, enlarged thirteen diameters.
FIG. 4. The Jonah Crab, *Cancer borealis* Stimpson; male, two-thirds natural size 769
FIGS. 5, 6. Terminal joints of the big claws of the same, viewed from the outer side, natural size.
Drawings by J. H. Emerton.

261. The Common Crab of the Pacific Coast, *Cancer magister* Dana; male, somewhat smaller than natural size.. 770
Drawing by H. L. Todd, from No. 2558, U. S. National Museum. California, William Stimpson.

262. The Red Crab, *Cancer productus* Randall; male, natural size 771
Drawing by H. L. Todd, from No. 2529, U. S. National Museum. San Francisco, California, R. Hemphill.

263. The California Rock Crab, *Cancer antennarius* Stimpson; natural size 771
Drawing by H. L. Todd, from No. 2633, U. S. National Museum. California. William Stimpson.

264. The Stone Crab, *Menippe mercenaria* Gibbes; male, about four-fifths the natural size 772
Drawing by H. L. Todd, from specimen obtained at Charleston, South Carolina.

265. The Green Crab, *Carcinus mœnas* Leach; slightly enlarged 774
Drawing by J. H. Emerton, from specimen obtained at Wood's Holl, Massachusetts, 1882.

266. The Lady Crab, *Platyonichus ocellatus* Latreille; about one-third larger than natural size 774
Drawing by J. H. Emerton, from specimen obtained at Wood's Holl, Massachusetts, 1882.

267. The Common Edible or Blue Crab *Callinectes hastatus* Ordway; male, somewhat smaller than natural size. 775
Drawing by J. H. Emerton, from specimen obtained at Wood's Holl, Massachusetts, 1882.

268. The Kelp Crab, *Epialtus productus* Randall; female, natural size 778
Drawing by H. L. Todd, from No. 2139, U. S. National Museum. Pacific coast of the United States, Dr. Suckley.

269. FIG. 1. The Fiddler Crab, *Gelasimus pugilator* Latreille; male, slightly enlarged 763
FIG. 2. The Oyster Crab, *Pinnotheres ostreum* Say; male, enlarged four diameters 765
FIG. 3. The Mud Crab, *Panopeus depressus* Smith; male, natural size 772
FIGS. 4, 5. The Spider Crabs. Fig. 4, *Libinia emarginata* Leach; male. Fig. 5, *Libinia dubia* Edwards; male. Both three-fourths natural size 778
FIG. 6. The Sand Bug or Bait Bug, *Hippa talpoida* Say; enlarged about two diameters 779
FIG. 7. The Hermit Crab, *Eupagurus bernhardus* Brandt; about natural size 780
Drawings by J. H. Emerton.

270. The Spiny Lobster or Rock Lobster, *Panulirus interruptus* Randall; somewhat smaller than natural size... 780
Drawing by H. L. Todd, from specimen obtained on the coast of California.

271. The American Lobster, *Homarus americanus* Edwards; male, much below natural size 781
Drawing by J. H. Emerton, from specimen obtained at Eastport, Maine, 1882.

272. The River Cray-fish, *Cambarus affinis* Erichson; one and one-half times the natural size 812
Drawing by H. L. Todd, from specimen obtained at Havre de Grace, Maryland.

273. The Southern Shrimp, *Penæus setiferus* Edwards; about one-fifth larger than natural size 821
Drawing by J. H. Emerton, from specimen obtained on the coast of Louisiana.

274. The Mantis Shrimp, *Squilla empusa* Say; natural size 823
Drawing by H. L. Todd, from No. 2752, U. S. National Museum. Wood's Holl, Massachusetts, V. N. Edwards.

275. FIG. 1. The Common Shrimp, *Crangon vulgaris* Fabr.; male, natural size 816
FIG. 2. The Common Prawn, *Palæmonetes vulgaris* Stimpson; male, enlarged one and one-half diameters.
FIG. 3. The Deep water Prawn, *Pandalus Montagui* Leach; slightly smaller than natural size.
FIG. 4. The Beach-Flea, *Orchestia agilis* Smith; male, enlarged five diameters.
FIG. 5. The Scud, *Gammarus locusta* Gou'd; male, enlarged two diameters.
FIG. 6. The Boring Amphipod, *Chelura terebrans* Phillipi; enlarged about fourteen diameters.
FIG. 7. The Gribble, *Limnoria lignorum* White; enlarged ten diameters.
FIG. 8. The Salve Bug, *Æga psora* Kröyer; young specimen, enlarged three diameters.
FIG. 9. The Horse-Shoe Crab, *Limulus Polyphemus* Latreille; much smaller than natural size.
Drawings by J. H. Emerton, S. I. Smith, and O. Harger.

276. Marine Annelids, used as bait 832
FIGS. 1, 2, 3. *Nereis pelagica* Linné. Fig. 1, larger figure, female; smaller, male; natural size. Fig. 2, head. Fig. 3, proboscis, enlarged.
FIG. 4. *Nereis limbata* Ehlers; male, anterior part of body, head, and extended proboscis, enlarged.
FIGS. 5, 6. *Diopatra cuprea* Claparède. Fig. 5, head and anterior part of body, showing part of the branchiæ, side view. Fig. 6, ventral view, showing the mouth open and jaws thrown back, enlarged.
FIGS. 7, 8, 9. *Clymenella torquata* Verrill. Fig. 7, entire animal, side view, natural size. Fig. 8, head and extended proboscis, front view, enlarged. Fig. 9, posterior and caudal segments, dorsal view, enlarged.
Drawings mostly by J. H. Emerton.

277. FIG. 1. The Sea-Cucumber, *Pentacta frondosa* Jæger; much smaller than natural size 840
FIG. 2. The Green Sea Urchin, *Strongylocentrotus Dröbachiensis* A. Ag.; side view, much smaller than natural size.
FIG. 3. The Sand Dollar, *Echinarachnius parma* Gray: upper surface, with the spines mostly removed, natural size; *a*, ambulacral zones; *b*, inter-ambulacral zones.
FIG. 4. The Star-fish or "Five Finger," *Asterias Forbesii* Verrill; much smaller than natural size.
FIGS. 5, 6, 7. The Jelly Fishes. Fig. 5, *Zygodactyla Grœnlandica* Agassiz; profile view, one-half natural size. Fig. 6, *Aurelia flavidula* Peron and Le Sueur; dorsal view, about one-fourth natural size. Fig. 7, *Dactylometra quinquecirra* Agassiz; lateral view, one-fourth natural size.

PART I.

MAMMALS.

A.—THE WHALES AND PORPOISES.....By G. Brown Goode.
B.—THE SEALS AND WALRUSES.....By Joel A. Allen.
C.—THE HABITS OF THE FUR-SEAL.....By Henry W. Elliott.
D —THE MANATEES AND THE ARCTIC SEA-COW...By Frederick W. True.

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ANALYSIS.

Page.

A.—The Whales and Porpoises:

1. The Sperm Whale 7
2. The Blackfishes or Pilot Whales 11
3. The Grampuses or Cowfishes 13
4. The Harbor Porpoises or Herring Hogs 14
5. The Dolphins 16
6. The Killer Whales or Orcas 17
7. The Sperm Whale Porpoise 18
8. The White Whale or Beluga 18
9. The Narwhal 19
10. The Greenland, Bowhead, or Polar Whale 20
11. The Right Whales 24
12. The Humpback Whales 26
13. The Sulphur Bottom Whales 27
14. The Finback Whales 28
15. The Scrag Whales 30
16. The California Gray Whales 31

B.—The Seals and Walruses:

17. The Seal tribe in general 33
18. The Walruses 34
19. The Sea Lions and Fur Seals in general 37
20. The Sea Lion 38
21. The California Sea Lion 44
22. The Fur Seal 49
23. The Harbor Seal 55
24. The Harp Seal 62
25. The Ringed Seal 65
26. The Ribbon Seal 67
27. The West Indian Seal 67
28. The Hooded Seal 68
29. The California Sea Elephant 72

C.—The Habits of the Fur-Seal:

30. A life history of the Fur-Seal 75

D.—The Manatees and the Sea-Cow:

31. The Manatees 114
32. The Arctic Sea-cow 128

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THE FISHERIES AND FISHERY INDUSTRIES OF THE UNITED STATES.

MAMMALS.

A.—THE WHALES AND PORPOISES.

1. THE SPERM WHALE.

DISTRIBUTION.—The Sperm Whale, *Physeter macrocephalus* Linn., was first described by Clusius in 1605 from specimens cast up on the coast of Holland in 1598 and 1601. It is the Cachalot of the French, the Pottfisch of the Germans, Potvisch or Kazilot of Holland, Kaskelot or Pottisk of Scandinavia, and one of the most valuable of cetaceans. Sperm Whales occur in every ocean, and though preferring warmer waters, are to be found at times close to the limits of the arctic regions. In the Pacific they have been taken off Cape Ommany, Alaska, latitude 56° 12′, and in the Atlantic as far north as Scotland and Orkney, and perhaps even Greenland. In both Pacific and Atlantic they range below the southern tips of the continents and are believed to pass freely from ocean to ocean, around Cape Horn, though they are said never to round the Cape of Good Hope. Murray states that they have been seen and captured in almost every part of the ocean between latitude 60° south and 60° north. He mentions that they have been recorded as found off the north of Scotland but no further, though he gives some credence to ancient authors who mentioned their having been seen off Greenland.

Beale, writing in 1836,[1] gave a list of their favorite resorts. It is interesting to compare the range of the species as then understood with their present range as indicated by the locations, and this comparison has been carefully made by Mr. A. Howard Clark, in the chapter on THE WHALE FISHERY, in a subsequent section of this report. In discussing the facts before him, Murray[2] expresses the opinion that almost every place which has been mentioned as a favorite resort of the Sperm Whales, although out of soundings, has claims to be considered the site of submerged lands. The islands of Polynesia, which are their special feeding ground, are the beacons left by the submerged Pacific continent. "They are also to be seen," he continues, "about the equinoctial line in the Atlantic Ocean, but they would seem to be either straggling 'schools' which have rounded Cape Horn, or unprospering colonies. It is from these that the specimens which have been occasionally met with in the North Atlantic or in the English seas have wandered. They have been now and then cast ashore, and then they are usually in an emaciated condition. They seem to be unprepared for, or not to be adapted for, shallow seas. Accustomed (perhaps not individually, but

[1] 1836. BEALE, THOMAS: Natural History of the Sperm Whale. London, 1836, p. 180.
[2] 1866. MURRAY, ANDREW: The Geographical Distribution of Mammals. London, 1866, p. 212.

by hereditary practice or instinct) to swim along the coral islands of the Pacific, within a stone's throw of the shore, they cannot understand, their instinct is not prepared to meet, shallow coasts and projecting headlands."

Murray's views, though suggestive, are, perhaps, not entirely well founded. It is certain, however, that the favorite haunts of the species have always been in the warmer seas, within or upon the verge of the tropics.

ABUNDANCE IN FORMER DAYS ON THE COAST OF THE UNITED STATES.—There is no reason to doubt that Sperm Whales were at one time, nearly two centuries back, as abundant in the North Atlantic as in more recent years in the North Pacific. The vigorous prosecution of the whale fishery since the early part of the eighteenth century by American vessels has had much to do with their present scarcity. The traditions of the American whale fishery all point to their considerable abundance near the eastern coast of the United States.

Macy, the historian of Nantucket, narrates that the first Sperm Whale known to that settlement was found dead and ashore on the southwest part of the island, and that the first taken by Nantucket whalemen was captured about the year 1712 by Christopher Hussey, who, "cruising near the shore for Right Whales, was blown off some distance from the land by a strong northerly wind, where he fell in with a school of that species of whale, and killed one and brought it home."[1] That Sperm Whales cannot at that time have been rare near the shore, may be inferred from the fact that the Nantucket Sperm Whale fleet which was then fitted out, and which three years later consisted of six sloops, producing oil to the value of $5,500 annually, were usually absent only six weeks, during which time they procured the blubber of one or two whales.[2] The Boston "News Letter" of October 2, 1766, stated: "Since our last a Number of Vessels have arrived from Whaling. They have not been successful generally. One of them viz: Capt. Clark on Thursday morning last discovered a Spermaceti Whale near George's Banks, mann'd his Boat, and gave Chase to her & she coming up with her Jaws against the Bow of the Boat struck it with such Violence that it threw a son of the Captain (who was forward, ready with his Lance) a considerable Height from the Boat, and when he fell the Whale turned with her devouring Jaws opened, and caught him. He was heard to scream, when she closed her Jaws, and part of his Body was seen out of her Mouth when she turned and went off."[3]

The log of the whaling sloop "Betsey," of Dartmouth, records that on August 2, 1761, her crew saw two Sperm Whales and killed one in latitude 45° 54′, longitude 53° 57′: this would be in the gully between the Grand Bank and Green Bank, about fifty miles west of Whale Deep, in the Grand Bank, and sixty miles south of the entrance to St. Mary Bay, Newfoundland. August 9, this vessel and her consort killed two to the south and west of the Grand Bank in latitude 42° 57′. In 1822 Captain Atwood was on the "Laurel," of Provincetown, which took a Sperm Whale on the sixth day out, on the course to the Azores, just east of the Gulf Stream, and less than 500 miles from Cape Cod. The nearest grounds upon which Sperm Whales now regularly occur are those to the north and east of Cape Hatteras, the "Hatteras Ground," and a ground farther south known as the "Charleston Ground." The last one observed on the New England coast was very young, only sixteen feet long, and was taken near New Bedford, Mass., March 29, 1842.[4]

In Douglass' "North America," published in 1755, it is stated that Spermaceti Whales "are to be found almost everywhere, but are most plenty upon the coast of Virginia and Carolina."

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[1] MACY, ZACCHEUS: History of Nantucket, p. 36.

[2] STARBUCK, ALEXANDER: in Report U. S. Fish Commission, part iv, 1878, p. 20.

[3] STARBUCK, *op. cit.*, p. 46–47.

[4] 1845. JACKSON, J. B. S.: Boston Journ. Nat. Hist., 1845, p. 138, pl. 16, fig. 1 (the stomach).

A Sperm Whale came ashore in 1668 in Casco Bay, and the circumstance seems not to have been regarded as unusual in those days.[1]

A person writing in 1741 discourses as follows: "Some Years since, there stranded on the *Coast of New England a dead Whale, of the Sort which, in the Fishers Language, is called Trumpo*, having Teeth like those of a Mill; it's Mouth at a good Distance from and under the Nose, and several Partitions in the Nose, out of which ran a thin oily Substance that candy'd, the Remainder being a thick fat Substance, being scraped out, was said to be the Sperma Ceti; it was said so, and I believe that was all. Whales were often caught formerly between New-England and New-York, and if the Sperma Ceti had really been in the Nose of that, it must have been more common, and more cheap, than Experience tells us, it has been even since this Discovery, and at this present time. As to the Whale Fishery, 'tis now almost as much a Rarity in New as Old England; the Fishery of Cod is at this time very great here, tho' still far short of that of Newfoundland."[2]

OCCURRENCE ON THE COAST OF EUROPE.—In the Eastern Atlantic, also, the occurrence of this species has been by no means unusual. Fleming, in "British Animals," 1828, states that "the Spermaceti Whale often comes ashore in Orkney."[3] In 1788, twelve males ran ashore in the English Channel.[4] Other instances of their stranding on the English coast occurred in February, 1689,[5] 1795,[6] 1766,[7] February 16, 1829,[8] in 1825,[9] and 1863,[10] while others were obtained on the coast of Brittany in 1784,[11] and in the Mediterranean, at St. Nazaire, in 1856,[12] and on other occasions for which dates are not given.

OCCURRENCE ON THE CALIFORNIA COAST.—Although Sperm Whales have occasionally been taken off the California coast for the past thirty years, it would appear that few have been seen in those waters since 1874. Captain Scammon has cited in his book no instances of individuals personally observed by him.

SIZE AND COLOR.—The sexes differ greatly in size and form, the female being slenderer and from one-fifth (Beale) to one-third or one-fourth (Scammon) as large as the male. The largest males measure from eighty to eighty-four feet in length, the head making up about one-third of the whole. In the head is the cavity known as the "case," from which is obtained the spermaceti and a quantity of oil. The youngest Sperm Whale on record is the one measuring sixteen feet, already mentioned as having been taken near New Bedford in 1842; its weight was 3,053 pounds.

The Sperm Whale is black or brownish-black, lighter on the sides, gray on the breast. When old it is gray about the nose and top of the head.

HABITS OF ASSOCIATION, MOTION, BLOWING, ETC.—Sperm Whales are gregarious and are often seen in large schools, which are, according to Beale, of two kinds, (1) of females accompanied by the young and one or two adult males, (2) of the young and half-grown males; the adult males always go singly. Their manner of motion is well described by Scammon as follows:

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[1] In 1668 a Spermaceti Whale of 55 foot long was cast up in Winter Harbor, near Casco Bay. The like hath happened in other places of the country at several times, when, for want of skill to improve it, much gain hath slipped out of the hands of the finders.—Hubbard's History of New England, From the Discovery to 1680. Boston, 1848, p. 642.

[2] British Empire in America. London, 1741, vol. i, pp. 188–189.

[3] FLEMING: British Animals, 1828, p. 29.

[4] GRAY: Catalogue of Seals and Whales, 1866, p. 203.

[5] SIBBALD: Phalainologia, 1773, p. 33, pl. 1.

[6] MOLYNEUX: Phil. Trans., xix, 1795, p. 508.

[7] RUTTY: *fide* Gray, *op. cit.*

[8] HUNTER and WOODS: Mag. Nat. Hist., ii, 1829, p. 197.

[9] THOMPSON: Mag. Nat. Hist., ii, 1827, p. 477.

[10] GRAY: *op. cit.*, p. 204.

[11] BLAINVILLE: Ann. fr. et étr. d'Anatomie et de Physiologie, ii, p. 235.

[12] GERVAIS: Comptes-Rendus, 1864, p. 876.

"Among the whole order of cetaceans there is none which respires with the same regularity as the Cachalot. When emerging to the surface, the first portion of the animal seen is the region of the hump; then it raises its head, and respires slowly for the space of about three seconds, sending forth diagonally a volume of whitish vapor like an escape of steam; this is called the 'spout,' which, in ordinary weather, may be seen from the mast-head at a distance of three to five miles. In respiring at its leisure, the animal sometimes makes no headway through the water; at other times it moves quietly along at the rate of about two or three miles an hour; or if 'making a passage' from one feeding ground to another, it may accelerate its velocity. When in progressive motion, after 'blowing,' hardly an instant is required for inspiration, when the animal dips its head a little, and momentarily disappears; then it rises again to blow as before, each respiration being made with great regularity. * * * * With the largest bulls, the time occupied in performing one inspiration is from ten to twelve seconds, and the animal will generally blow from sixty to seventy-five times at a rising, remaining upon the surface of the sea about twelve minutes. As soon as 'his spoutings are out' he pitches headforemost downwards; then 'rounding out,' turns his flukes high in the air, and, when gaining nearly a perpendicular attitude, descends to a great depth, and there remains from fifteen minutes to an hour and a quarter.

"When the Cachalot becomes alarmed or is sporting in the ocean, its actions are widely different. If frightened, it has the faculty of instantly sinking, although nearly in a horizontal attitude. When merely startled, it will frequently assume a perpendicular position, with the greater portion of its head above water, to look and listen; or, when lying on the surface, it will sweep around from side to side with its flukes to ascertain whether there is any object within reach. At other times, when at play, it will elevate its flukes high in the air, then strike them down with great force, which raises the water into spray and foam about it; this is termed 'lob-tailing.' Oftentimes it descends a few fathoms beneath the waves; then, giving a powerful shoot nearly out of the water, at an angle of 45° or less, falls on its side, coming down with a heavy splash, producing a pyramid of foam which may be seen from the masthead on a clear day, at least ten miles, and is of great advantage to the whaler when searching for his prey. * * * * When individually attacked it makes a desperate struggle for life, and often escapes after a hard contest. Nevertheless, it is not an unusual occurrence for the oldest males to be taken with but little effort on the part of the whaler. After being struck, the animal will oftentimes lie for a few moments on the water as if paralyzed, which affords the active man of the lance opportunity to dart his weapon effectually and complete the capture."[1]

Owing to the peculiar shape and position of the mouth, the Sperm Whale has to turn upon its side to seize large objects between its jaws, and when one of them attacks a boat, it is in a reversed position, holding its lower jaw above the object it is trying to bite, as is shown in many pictures of whaling adventure.

FOOD.—The food of this species consists of squids and of various kinds of fish. Couch tells of a young one, twenty feet long, taken on the coast of Cornwall, which had three hundred mackerel in its stomach. Captain Atwood states that when struck by the harpoon they eject from the stomach quantities of large squids.

REPRODUCTION.—They are said to breed at all seasons of the year. Scammon states that the time of gestation is supposed to be ten months, that the number of cubs is rarely two, never more, and that they are about one-fourth the length of their mother. In suckling the female reclines upon her side in the water.

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[1] SCAMMON, CHARLES M.: The Marine Mammals of the Northwestern Coast of North America, described and and illustrated, together with an account of the American Whale Fishery. San Francisco, 1874, pp. 74–84.

USEFUL PRODUCTS.—The peculiar products of the head of this cetacean, the *sperm oil* and the *spermaceti*, render its capture particularly profitable. According to Captain Atwood about one-fifth of the yield of oil may be generally set down as the amount of spermaceti afforded by a Sperm Whale. The *teeth* are used by ivory cutters, and the *ambergris* is a substance valuable to druggists and perfumers. The parts of the body are to be described in the chapter on oil making, where the manner of cutting away the blubber will be discussed. The great lower jaws with their rows of bristling teeth are often brought home as trophies by whalers, and in Provincetown, New Bedford, or Nantucket may be seen gateways spanned by arches made of these bones.[1]

The following statement of yield of oil from whales taken by New Bedford whalers was furnished by Capt. Benjamin Russell in 1875:

Capt. C. Allen captured one Sperm Whale, which tried out 150 barrels.

Captain Tilton captured one Sperm Whale, which tried out 154 barrels.

Captain Spooner captured one Sperm Whale, which tried out 130 barrels.

Captain Knowles captured one Sperm Whale, which tried out 127 barrels.

A number of captains report Sperm Whales yielding from 80 to 120 barrels each.

THE PORPOISE SPERM WHALE.—A small cetacean rather closely allied to the Sperm Whale, and called by certain authors the Porpoise Sperm Whale, occurs in the warmer parts of the Pacific. A specimen nine feet long was taken at Mazatlan, and was described by Professor Gill under the name *Kogia Floweri*.[2] It is of no economic importance. Nothing is known of its habits. A sketch of the animal and its jaw are preserved in the National Museum.

2. THE BLACKFISHES OR PILOT WHALES.

DISTRIBUTION.—The Blackfish, *Globicephalus intermedius* (Harlan) Gray, is one of the most important and most abundant of the small whales of the east coast. It occurs in great numbers to the northeast of the Grand Bank, and off the New England and Middle States. How far south it ranges is not certainly known. A closely related species is the Pilot Whale or Caing Whale of Europe, *G. svineval* (Lac.) Gray, also called Black Whale, Social Whale, Blowing Whale, and Bottlehead, the Svine-hval of Scandinavia; abundant in the North Sea and the northeastern

[1] In Douglass's North America (Boston and London, 1755, vol. i, p. 57), the products of the Sperm Whale are thus discoursed upon:

"Sperma ceti Whales are to be found almost everywhere, they have no bone, so called; some may yield 60 to 70 barrels oil called viscous oil, the fittest for lamps or a burning light. It is from this whale that we have the parmacitty or spermaceti (very improperly so called). The ancients were at a loss whether it was an animal or mineral substance; Schroder, a celebrated Pharmacopoeia writer about the middle of last century, calls it Aliud genus bituminis quod sperma ceti officinae vocant, he describes it Pinguedo furfurosa producta exhalatione terrae sulphureae. We now find that any part of its oil, but more abundantly the head-matter, as the whalers term it, if it stand at rest and in the sun will shoot into adipous fleaks resembling in some manner the chrystalisation of salts: instead of sperma ceti, it ought to be called adeps ceti, in the materia medica. This same whale gives the ambergrease, a kind of perfume, as is musk: anciently it was by the natural historians described as a kind of bitumen, hence the name *Ambra grisea*. Dale, a noted author, in his pharmacologia not long since publishes it as such. It is now fully discovered to be some production from this species of whale, for some time it was imagined some peculiar concreted juice lodged in a peculiar cystis, in the same manner as is the castoreum of the beaver or *Fiber Canadensis*, and the zibethum of the civit-cat or hyena, in cystis's both sides of the Ani rima; thus, not long since, some of our Nantucket whalers imagined that in some (very few and rare) of these male or bull whales, they had found the gland or cystis in the loins near the spermatick organs: late and more accurate observations seem to declare it to be some part of the ordure, dung, or alvine excrement of the whale; squid-fish, one of the Newfoundland baits for cod, are sometimes in Newfoundland cast ashore in quantities, and as they corrupt and fry in the sun they become a jelly or substance of an ambergrease smell; therefore as squid bills are sometimes found in the lumps of ambergrease, it may be inferred, that ambergrease is some of the excrement from squid-food, with some singular circumstances or dispositions that procure this quality, seldom concurring; thus the Nantucket whalers for some years last, have found no ambergrease in their whales. The Sperma ceti Whale has no bone or baleine in his mouth, but fine white teeth; they are most plenty upon the coast of Virginia and Carolina."

[2] GILL: Sperm-Whales, Giant and Pigmy, < American Naturalist, iv, p. 738, fig. 167.

Atlantic. Another species is the Blackfish of the Eastern Pacific, G. Scammonii Cope, once abundant, according to Scammon, on the coast of Lower California, but now usually found off Guatemala, Ecuador, and Peru, though occasionally ranging to high northern and southern latitudes.

SIZE.—The ordinary length of the New England Blackfish is fifteen to eighteen feet, though they sometimes grow larger. The largest ever seen by Capt. Caleb Cook, a veteran oil maker of Cape Cod, measured twenty-five feet and yielded five barrels of oil. The weight of a fifteen-foot Blackfish is estimated at 800 to 1,000 pounds.

MOVEMENTS.—They swim in large schools, sometimes several hundred together. They make little commotion at the surface of the water as they swim, not rolling like their little kindred, the Porpoises, but come up often to spout, the jet of spray rising three or four feet, and emitted with a *low, deep, snorting sound. When at the surface they often remain in sight several minutes.* Usually their movements are sluggish, though at times energetic enough, as can testify any one who has seen a school of them driven up on the beach. They feed upon schooling fish, menhaden, mackerel, herring, and squids. Blackfish are in great terror of the Killer Whales, which drive them about mercilessly. In September, 1878, I saw a school of them which had for some days been hovering around the entrance to Provincetown Harbor fleeing tumultuously before two large whales with high back-fins.

REPRODUCTION.—They breed in summer about Cape Cod. Out of one hundred and nineteen driven ashore at Dennis in August, 1875, fully eighty were females with young, or recently born calves of seven or eight feet. A fœtus cut from a gravid Blackfish of eighteen feet was nearly seven feet long. All the females were yielding milk, and as the fishermen cut into their sides the warm fluid poured out in copious streams.

Watson records, in the case of a female on the British coast suckling its young, that the calf was four feet six inches long in December and seven feet in January. Scammon thinks that in the Pacific they breed at all seasons. He found mothers with young calves off the Gulf of Dulce, Guatemala, in February, 1853.

STRANDING OF THE BLACKFISH SCHOOLS.—*As will be told more in detail in another chapter,* hundreds, and often thousands, of them are stranded yearly on the shores of Cape Cod. They occasionally run ashore at Nantucket, and instances have occurred of their being driven in at Cape Breton. Although there have been similar instances in Europe, especially at the Orkneys, I cannot learn that such occurrences are sufficiently common anywhere else to be counted on by the people as a regular source of income. A Cape Cod fisherman occasionally wakes up in the morning to find two or three of these animals stranded in his back yard. "A pretty windfall," remarked one of them to me. Cape Cod, projecting far out to sea, with its sloping, unbroken sandy shores, seems like a trap or weir naturally adapted for their capture, and the Indians took advantage of this circumstance long before the European settlement. The Pilgrims, in 1620, found Indians on the shore at Wellfleet cutting up a Grampus, and in the shell-heaps of the surrounding region are yet to be found many evidences of their use of the smaller cetaceans for food. It is doubtful whether the Blackfish, stupid as they seem, would ever run ashore if not frightened by such enemies as the Killer. In fact a large share of those which become stranded are purposely driven up out of shoal water, into which they have strayed, by men in boats.

Little can be said about the time when they are most abundant. It seems to depend on the supply of suitable food. Captain Cook believes that they feed mostly or entirely upon squids, and if this be the case their appearance must be regulated by the abundance of these animals. They are never seen earlier than June or later than December. Thirty years ago they were most

plentiful in August. Before 1874 they had never been seen before July. In July, 1875, a school of 120 came ashore at North Dennis. Those taken in the fall are usually the fattest.

CAPTURE OF BLACKFISH.—Many years ago several Cape Cod whalers made a business of pursuing the Blackfish on the whaling grounds east of the Grand Bank. This enterprise, described in the chapter on the whale fishery, has been abandoned, but it is not uncommon for ordinary whalemen to kill them from their boats to obtain supplies of fresh meat, and of oil to burn on shipboard. That the flesh is not unpalatable the writer maintains, and can summon as witnesses a number of persons who tasted one at the Smithsonian Institution in 1874. There is a fishery for them at the Faroe Islands, and in the Pacific, says Scammon, small vessels are occasionally fitted out for their capture. "Sperm whalers," he writes, "do not lower their boats for Blackfish when on Sperm Whale ground, unless the day is far spent and there is little prospect of 'seeing whales.' The northern polar or whale-ships pay but little attention to them, except, perhaps, when passing the time 'between seasons,' cruising within or about the tropics."

USEFUL PRODUCTS.—The yield of oil from a Blackfish varies, according to the size and fatness of the animal, from ten gallons to ten barrels. This is dark in color, and is classed with the ordinary "body oil" or "whale oil." The blubber varies from one to four inches in thickness, and is nearly white. The jaws yield a fine quality of machine oil, known as "porpoise jaw-oil", of which however, a limited quantity suffices to supply the market. The value of a stranded Blackfish in Cape Cod varies from $5 to $40.

As is related elsewhere, Blackfish are often taken by whaling vessels when on a cruise, to obtain oil for burning and a supply of fresh meat. The brains are made by the ship's cook into "dainty cakes," as the whalemen call them, and the livers are said to be delicate and appetizing.[1]

Blackfish are harpooned by the Grand Bank cod-fishermen to be cut up and used for bait.

3. THE GRAMPUSES OR COWFISHES.

DISTRIBUTION.—Associated with the Blackfish on our east coast, though not so common, and rarely stranded, is the Cowfish, *Grampus griseus* (Lesson) Gray, also found in Europe, south to the British channel or farther, and there known as the "Grampus."

COLOR AND SIZE.—Its slate-colored sides are curiously variegated with white markings, very irregular in size, shape and direction, evidently the results of accidental scratches in the epidermis.

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[1] 1635, July 25 (on the Newfoundland Banks).—On Friday, in the evening, we had an hour or two of marvellous delightful recreation, which also was a feast unto us for many days after, while we fed upon the flesh of three huge porpoises, like to as many fat hogs, striked by our seamen, and hauled with ropes into the ship. The flesh of them was good meat, with salt, pepper and vinegar; the fat, like fat bacon, the lean like bull-beef; and on Saturday evening they took another also.—Richard Mather's Journal. Young's Chronicles of the First Planters of Mass. Bay Colony. Boston, 1846, p. 466.

I cannot refrain from quoting the following passage from the journal of the Rev. Richard Mather, one of the earliest of the Massachusetts colonists:

"1635, June 27, 28.—The first Sabbath from Milford Haven, and the sixth on shipboard; a fair, cool day; wind northerly, good for our purpose. I was exercised in the forenoon, and Mr. Maud in the afternoon. This evening we saw Porpoises about the ship, and some would fain have been striking, but others dissuaded because of the Sabbath; and so it was let alone.

"Monday morning, wind still northerly; a fair, cool day. This morning, about seven of the clock, our seamen struck a great Porpoise, and hauled it with ropes into the ship; for bigness, not much less than a hog of 20 or 25 shillings apiece, and not much unlike for shape, with flesh fat and lean, like in color to the fat and lean of a hog; and being opened upon the deck, had within his entrails, as liver, lights, heart, guts, &c., for all the world like a swine. The seeing of him hauled into the ship, like a swine from the sty to the trestle, and opened upon the deck in view of all our company, was wonderful to us all, and marvellous merry sport, and delightful to our women and children. So good was our God unto us, in affording us the day before spiritual refreshing to our souls and this day morning also delightful recreation to our bodies, at the taking and opening of this huge and strange fish."—Young's Chronicles of the First Planters of Mass. Bay Colony. Boston, 1846, p. 460.

Captain Cook thinks that these are the marks of the teeth made by the animals in playing with each other. It attains the length of fifteen or twenty feet, but is slenderer than the Blackfish. Its jaws are esteemed by the makers of fine oil.

HABITS.—Regarding this species, Captain Cook writes: "About the same time that the Blackfish made their appearance in our waters, there was another of the whale kind made their appearance also, called by the fishermen Cowfish. These whales are very much in shape of the Blackfish, only smaller, not so fat, and not so dark colored. These fish have only made their appearance in our waters three or four times for the last forty years, or about once in ten years. Probably not more than fifty have been taken in this period. The method of taking them is the same as that used for Blackfish."

Several specimens, old and young, were obtained by the Fish Commission in 1875, November 29, November 30, and December 2, and their casts are in the National Museum. That this animal was known to the early colonists of New England appears probable from allusions in the early records.[1]

PRODUCTS.—The oil of the Cowfish, particularly that of its jaws, is highly prized, though probably no better than that of the Blackfish. The "Barnstable Patriot" of November 7, 1828, has this item: "A quantity of oil from the Grampus lately caught at Harpswell has been sold at Bath at $18 per barrel." It is very possible, however, that the Barnstable people of 1828 designate the Blackfish and the Grampus by the same name. Douglass' "North America," published in 1755, remarks: "Blackfish, *i. e.* Grampus, of six to ten barrels oil, Bottlenose of three or four barrels, may (like sheep) be drove ashore by boats."

THE CALIFORNIA GRAMPUS.—On the California coast occurs the Whiteheaded or Mottled Grampus, *G. Stearnsii* Dall, described by Scammon as growing to the average length of ten feet. "They are gregarious," he writes, "and congregate frequently in large schools; at times two or three, or even a solitary individual will be met with, wandering about the coast or up the bays in quest of food, which consists of fish and several varieties of crustaceans. It is rarely taken, as it is extremely shy." He refers also to four other forms, unknown to zoologists, but familiar to whalemen: chief among these is the "Bottlenose," which grows to be twenty-five feet long, and has occasionally been taken, though with much difficulty owing to its great strength and speed. Its oil is reputed to be equal in quality to that of the Sperm Whale.

4. THE HARBOR PORPOISES OR HERRING HOGS.

DISTRIBUTION.—On the Atlantic coast occurs most abundantly the little Harbor Porpoise, *Phocæna brachycion* Cope, known to the fishermen as "Puffer," "Snuffer," "Snuffing Pig," or "Herring Hog." The Bay Porpoise of California, *P. vomerina* Gill, and the Common Porpoise or Marsuin of Europe, are very similar in size, shape, and habits: with the latter in fact it is probably specifically identical. The Atlantic species occurs off Nova Scotia and probably farther northward, and ranges south at least to Florida. The California species, according to Scammon, has been found at Banderas Bay and about the mouth of the Piginto River, Mexico (latitude 20° 30′), and north to the Columbia River (latitude 46° 16′). In the winter these Porpoises are seen off Astoria and in Cathlamet Bay twenty miles above, but in spring and summer, when the river is fresh to its mouth, they leave the Columbia. The Atlantic Porpoise also ascends rivers. They go

[1] Belknap's American Biography has the following account of one of the journeys of the first settlers of Massachusetts in 1620:

"The next morning, Thursday, December 7, they divided themselves into two parties, eight in the shallop, and the rest on shore, to make farther discovery of this place, which they found to be 'a bay, without either river or creek coming into it.' They gave it the name of Grampus Bay, because they saw many fish of that species."—Belknap's American Biography, New York, 1846, vol. ii, p. 318.

up the Saint John's in Florida to Jacksonville, and about 1850 one was taken in the Connecticut at Middletown, twenty miles from brackish water. In Europe they ascend the Thames, the Weser, and other streams.

SIZE AND MOVEMENTS.—They rarely exceed four or four and a half feet in length. Every one has seen them rolling and puffing outside of the breakers or in the harbors and river mouths. The western Atlantic species swim in droves of from ten to one hundred, but Scammon says that those of California are never found associated in large numbers, though six or eight are often seen together. In England, according to Couch, seldom more than two are seen at once. They never spring from the water like Dolphins, but their motion is a rolling one and brings the back-fin often into sight, this always appearing shortly after the head has been exposed and the little puff of spray seen and the accompanying grunt heard. The rolling motion is caused by the fact that to breathe through the nostrils, situate on the top of the snout, they must assume a somewhat erect posture, descending from which the body passes through a considerable portion of a circle.

REPRODUCTION.—The breeding season is in summer, in August and September, in Passamaquoddy Bay, perhaps also at other times. The new-born young of an English Porpoise fifty-six inches long, measured twenty-six inches, and was sixteen inches in circumference.

FOOD.—They feed on fish, particularly on schooling species like the herring and menhaden, and are responsible for an enormous destruction of useful food material.

USES.—Though frequently taken in the pounds and seines along both coasts and off Massachusetts in the gill-nets set for mackerel, they are of little importance except to the Indians of Maine and our Northwestern Territories, who carry on an organized pursuit of them, shooting them from their canoes. This industry will be described in the chapter upon ABORIGINAL FISHERIES.

DESTRUCTIVENESS.—The Porpoise is pugnacious as well as playful. A fisherman in Florida told me that he once tried to pen a school of them in a little creek by anchoring his boat across its entrance. When they came down the creek they sprang over the boat against the sail, through which they tore their way and regained the river. A correspondent, whose name has been mislaid, writes: "A very unusual event occurred at Far Rockaway on Tuesday morning, about four o'clock, in front of the Nelson House. A school of Drumfish were chased into shallow water by a school of Porpoises. The Drumfish tried their best to get away, but the Porpoises pursued them so hotly that a number of the former were driven ashore. The people of the hotel were awakened by a great splashing and a noise somewhat similar to but less distinct than the grunt of a frightened hog. Looking out of the windows they saw the Porpoises striking the Drumfish with their tails. Soon after the Porpoises turned and left. The porters at the hotel and some of the fishermen secured with boat-hooks about twenty-five dead Drumfish, and a large number are still floating around Jamaica Bay. The Drumfish secured weighed from thirty to seventy pounds each. Some were sent to Canarsie for exhibition and others to Fulton Market for sale."

The Drum being an enemy of the Oyster, it is possible that the Porpoise by destroying them is a benefactor. It would be no more curious than the experience of the Canadian Government in decreasing their Salmon fishery in the St. Lawrence by destroying the White Whales which preyed upon the seals, the enemies of the Salmon. The story about the Porpoises *killing* drum seems incredible, but is supported by Sir Charles Lyell's account of a battle between the Porpoises and the Alligators in Florida: "Mr. Couper told me that in the summer of 1845 he saw a shoal of Porpoises coming up to that part of the Altamaha where the fresh and salt water meet, a space about a mile in length, the favorite fishing ground of the Alligators, where there is brackish water, which shifts its place according to the varying strength of the river and the tide. Here were seen about fifty Alligators, each with head and neck raised above water, looking down the stream at

their enemies, before whom they had fled terror-stricken and expecting an attack. The Porpoises, not more than a dozen in number, moved on in two ranks, and were evidently complete masters of the field. So powerful indeed are they that they have been known to chase a large Alligator to the bank, and, putting their snouts under his belly, toss him ashore."[1]

The authority referred to, Mr. Hamilton Couper, of Hopeton, Ga., was a gentleman of some prominence as a geological observer.

5. THE DOLPHINS.

HABITS.—The Dolphins constitute a large group of cetaceans, represented by many species, and abundant everywhere in temperate and tropical seas. They are often seen in mid-ocean sporting in large schools, pursuing the pelagic fishes, but are still more common near the coast. They are from five to fifteen feet long, gracefully formed, and very swift. Nowhere are they the objects of organized pursuit, though frequently caught in nets or harpooned from the bows of vessels at sea. Many cod schooners fishing on the Grand Banks, especially those from Cape Cod, depend chiefly for bait upon the Porpoises they can kill and the birds they can catch. The best known species on the Atlantic coast are the "Skunk Porpoise" or "Bay Porpoise," *Lagenorhynchus perspicillatus* Cope, and related forms. Large schools are often seen in the sounds and along the shore. They are easily distinguished from the little Harbor Porpoise, just spoken of, by the broad stripes of white and yellow upon their sides. When schools of a hundred or more can be surrounded and driven ashore by the fishermen, as is often done on Cape Cod, a large profit is made from the sale of their bodies to the oil-makers, though they are not so much prized as the Blackfish, so much larger and fatter. A closely related species is the Common Porpoise of California, *Lagenorhynchus obliquidens* Gill. "They are seen," writes Captain Scammon, "in numbers varying from a dozen up to many hundreds tumbling over the surface of the sea, or making arching leaps, plunging again on the same curve, or darting high and falling diagonally sidewise upon the water with a spiteful splash, accompanied by a report which may be heard to some distance. In calm weather they are seen in numerous shoals, leaping, plunging, lobtailing and finning, while the assemblage moves swiftly in various directions. They abound more along the coasts where small fish are found. Occasionally a large number of them will get into a school of fish, frightening them so much that they lose nearly all control of their movements, while the Porpoises fill themselves to repletion."

The Right Whale Porpoise, *Leucorhamphus borealis* (Peale) Gill, is found in the Pacific from Bering Sea to Lower California, though not so abundantly as the last. The Right Whale Porpoise of the Atlantic, often spoken of by our whalers, is a related species, perhaps *L. Peronii* (Lac.) Lilljeborg, abundant in the South Atlantic and Pacific, but not yet recorded by naturalists for our waters. Several species of the true Dolphins occur in the North Atlantic, but only one, *Delphinus clymenis*, has been found with us, Cope having secured it in New Jersey. Baird's Dolphin *D. Bairdii* Dall, a species six or seven feet long and weighing 100 to 175 pounds, is frequent in California. The Cowfish of California, *Tursiops Gillii* Dall, is a sluggish species known to the whalemen of the lagoons,[2] and an allied species, *T. erebennus* (Cope) Gill, is known on the Atlantic coast. New forms of this group are constantly being discovered. All are of commercial value when taken.

[1] LYELL: Second Visit to the United States, vol. i, 1849, p. 252.

[2] The habits of the Cowfish, as observed on the coasts of California and Mexico, are strikingly different from those of the true Porpoises. It is often remarked by whalemen that they are a "mongrel breed" of doubtful character, being frequently seen in company with Blackfish, sometimes with Porpoises, and occasionally with Humpbacks, when the latter are found in large numbers on an abundant feeding ground. They are met with likewise in the lagoons along the coast, singly or in pairs, or in fives and sixes—rarely a larger number together—straggling about in a vagrant manner through the winding estuaries, subsisting on the fish that abound in these circumscribed waters. At times they are seen moving lazily along under the shade of the mangroves that in many places fringe the shores, at other times lying about in listless attitudes among the plentiful supplies of food surrounding them.—SCAMMON: *op. cit.*, p. 101.

6. THE KILLER WHALES OR ORCAS.

HABITS AND DISTRIBUTION.—The Killer Whales are known the world over by their destructive and savage habits. Although their strength and speed render it almost impossible to capture them, they are of importance to the fisherman as enemies of all large sea animals, often putting them to flight at inconvenient times. The Atlantic species, *Orca gladiator* (Bonnaterre) Gill, was first brought to notice in 1671 in Martens' "Voyage to Spitzbergen." It is often seen on the New England coast in summer, driving before it schools of the blackfish or others all whales: it is a special enemy of the tunny or horse mackerel: Captain Atwood tells of the consternation shown by these enormous fishes when a number of them have gathered in Provincetown Harbor and the Killers come in. They are a great annoyance to the Cape Cod people when they are trying to drive a school of blackfish ashore, and on the other hand often drive these ashore when they would not be accessible to the fishermen. They prey largely, too, upon the white whale in northern seas. In the Pacific there are two species at least, the Low-finned Killer, *Orca atra* Cope, and the High-finned Killer, *Orca rectipinna*. The latter, though rarely more than twenty feet long, has an enormous dagger-shaped fin, six feet high, upon its back, which towers above the surface when the animal swims high. In fact the Killer Whales all have these high back-fins, by which they may be recognized at any distance.

DESTRUCTIVENESS.—Captain Scammon, in his "Marine Mammals of the Northwestern Coast," gives a long account of their habits, and of their fierce attacks upon the largest whales. The stories of the combats of the swordfish and the thresher shark upon whales have probably originated in such combats as these, witnessed at a distance and imperfectly understood. Captain Scammon writes: "The attacks of these wolves of the ocean upon their gigantic prey may be likened in some respects to a pack of hounds holding the stricken deer at bay. They cluster about the animal's head, some of their number breaching over it while others seize it by the lips and haul the bleeding monster under water; and when captured, should the mouth be open, they eat out its tongue. We saw an attack made by three Killers upon a cow whale and her calf in a lagoon on the coast of Lower California, in the spring of 1858. The whale was of the California gray species, and her young was grown to three times the bulk of the largest Killers engaged in the contest, which lasted for an hour or more. They made alternate assaults upon the old whale and her offspring, finally killing the latter, which sunk to the bottom, where the water was five fathoms deep. During the struggle, the mother became nearly exhausted, having received several deep wounds about the throat and lips. As soon as their prize had settled to the bottom, the three Orcas descended, bringing up large pieces of flesh in their mouths, which they devoured after coming to the surface. While gorging themselves in this wise the old whale made her escape, leaving a track of gory water behind."[1]

ANNOYANCE TO WHALEMEN.—Instances are given where whales which had been killed by whalemen and were being towed to the ship have been forcibly carried away by bands of Killers. They are also obnoxious as destroyers of the young fur seal, and often remain for a long time in the vicinity of the seal islands. Eschricht says that thirteen porpoises and fourteen seals were found in the stomach of an Atlantic Killer, sixteen feet in length. They are particularly abundant in the bays and sounds of British Columbia and Alaska, in search of seals and porpoises feeding there upon small fish. They even attack the full-grown walrus and rob it of its young.

USES.—Their range is cosmopolitan. They are never attacked by whale ships, and their only pursuers in America are the Makah Indians of Washington Territory, who, according to Scammon,

[1] SCAMMON: *op. cit.*, pp. 89–90.

occasionally take them about Cape Flattery, considering their fat and flesh luxurious food. Their jaws, studded with strong conical teeth, are often sold in our curiosity shops.

7. THE SPERM WHALE PORPOISE.

CAPTURE OF TWO INDIVIDUALS IN NEW ENGLAND.—A specimen twenty-five feet long of this animal, *Hyperoodon bidens* Owen, was found on the beach at North Dennis, Mass., January 29, 1869; another was obtained in 1866 or 1867 at Tiverton Stone Bridge, R. I. I am indebted to Mr. J. H. Blake for an outline of this cetacean, and the following notes, taken by him at the time, he having visited Dennis and obtained the skeleton for the Museum of Comparative Zoology: "When found," he writes, "the blood was still warm. It was twenty-five feet long, six feet high, and the tail was six feet across. The flippers were twenty-nine inches long, the snout twenty inches. The hump on the back was three or four inches high, thick at the base and narrowing toward the tip. The blubber was two and a half to four inches thick, and sold for $175. Squid-beaks enough to fill two water-buckets were taken from the stomach."

8. THE WHITE WHALE.

DISTRIBUTION.—The White Whale, *Delphinapterus catodon* (Linn.) Gill, first described in 1671 in Martens' "Voyage to Spitzbergen," resembles in form the other members of the Dolphin family, slender and graceful, with a small head and powerful tail. The adult, which attains a length of fifteen or sixteen feet, is creamy white in color; the young, five or six feet long when newly born, is lead-colored, passing through a period of mottled coloration before assuming the mature appearance. The species is abundant in the North Atlantic, North Pacific, and Arctic Oceans. Stragglers have been seen in the Frith of Forth, latitude 56°, while on the American coast several have been taken within the past decade on the north shore of Cape Cod. They are slightly abundant in New England waters, but in the Saint Lawrence River and on the coast of Labrador are plentiful, and the object of a profitable fishery. They abound in the Bering and Okhotsk Seas, and ascend the Yukon River, Alaska, to a distance of 700 miles. The names in use are Beluga and Whitefish among whalers, Porpoise, Dauphin Blanc, Marsuin or Marsoon in Canada, and Keela Luak with the Greenland Eskimos.

HABITS.—The species is familiar to many from having been recently exhibited in several aquariums, and also by traveling showmen. When in captivity they feed on living eels, of which a grown individual consumes two or three bushels daily. They are also known to subsist on bottom fish, like flounders and halibut, on cod, haddock, and salmon, squids and prawns. They are, in their turn, the food of larger whales, such as the killer or orca. They swim in small schools, entering shallow sounds and rapid rivers in swift pursuit of their food. They spout inconspicuously, and are not easily distinguished when swimming.

The few which have been taken recently along our Atlantic coast have been sold to aquariums or to natural history museums, yielding good prices to their captors. The fishery in the river Saint Lawrence is of considerable importance.

HISTORICAL NOTE.—The first allusion to the occurrence of this cetacean in our waters was printed by Josslyn in 1675, in his "Account of Two Voyages to New England": "The *Sea-hare* is as big as Grampus or Herrin-hog, and as white as a sheet; There hath been of them in Black-point Harbour, & some way up the river, but we could never take any of them, several have shot sluggs at them, but lost their labour."

CAPTURES IN MASSACHUSETTS.—"About the year 1857," writes Captain Atwood, "a species of cetacean twelve or fourteen feet long was killed in Provincetown Harbor, off Long Point, which no

one knew. I examined it and found it to differ from all the others then known here. Not long after it was announced that there was a White Whale on exhibition at the Aquarial Gardens in Boston; that Mr. Cutting had brought alive from the River Saint Lawrence a species that had never been seen south of that river. Soon after I visited Boston and called to see it. I pronounced it to be identical with the unknown species taken at Provincetown. In 1875 or 1876 another was seen in the harbor, but the boats could not get it."

October 11, 1875, two individuals, a cow about ten feet long and weighing 700 pounds approximately, and a calf nearly as large as its mother, weighing about 500 pounds, were taken in the Yarmouth River by Capt Benjamin Lovell. They were sold to the Boston Society of Natural History.[1]

USES.—Certain oil manufacturers from Cape Cod have agencies in Canada, from which they obtain the materials for the manufacture of an excellent machine oil, sold under the name of "Porpoise-jaw oil." A large White Whale yields from eighty to one hundred gallons of ordinary oil, besides the more precious head oil. Porpoise leather is made from the skins, a leather of almost indestructible texture, and peculiarly impervious to water. From this the Canadian mail-bags are made, and, to some extent, tourists' walking shoes. On our Alaska coast they are not unfrequently taken, chiefly by the natives, but the fishery has not yet become of commercial importance. In Eastern Siberia, according to Scammon, there are extensive fisheries carried on by the natives from June to September, with nets and harpoons. They eat the flesh and sell the oil, a considerable portion of which is no doubt secured by American whale ships.[2]

9. THE NARWHAL.

DISTRIBUTION.—The Narwhal, *Monodon monoceros* Linn., whose long spiral tusk has always been an object of curiosity, and gave rise to the stories of the imaginary creature known as the Unicorn, is now found in only one part of the United States—along the northern shores of Alaska. It is still abundant in the Arctic Ocean, and many tusks are brought down yearly by American and European whalers, obtained from the natives of Greenland and Siberia. It has long since ceased to appear on the coasts of Great Britain, the last having been seen off Lincolnshire in 1800. There is a record of one having been seen in the Elbe at Hamburg in 1736.

SIZE, USES, ETC.—The Narwhal is ten to fourteen feet long, somewhat resembling the white whale in form, is black, and in old age mottled or nearly white. The tusk, a modified tooth, grows out of the left side of the upper jaw, to the length of eight or ten feet. All its teeth, except its tusks, are early lost, and it is said to feed on fish and soft sea-animals. The Eskimos utilize it in many ways. Its ivory, however, is the only product of value to civilized man, this being made

[1] Yesterday morning Capt. Benjamin Lovell captured two fine specimens of the White Whale in the weir at Yarmouth, which is probably the first time this kind of fish has been taken in the waters of the United States on the Atlantic seaboard. The specimens captured are a cow and calf, the former about ten feet long, perfectly white, and weighing about 700 pounds, and the latter some two feet less in length, of a dark gray color, and about 500 pounds weight, both being quite fat.—Evening Standard, New Bedford, October 12, 1875.

[2] At a meeting, in 1860, of the Polytechnic Association of the American Institute, in New York, a paper was read, prepared by D. H. Tetu, of Kamouraska, Canada, on the White Whale of the Saint Lawrence. The Canadians call it a Porpoise; it is found for a distance of 200 miles between Saint Roch and Father Point, also in the rivers emptying into Hudson's Bay. Since the discovery of Canada, an article of commerce, but the oil not very good and little use found for the skin; lately M. Tetu has succeeded in purifying the oil and tanning the skin. The oil is equal to the best sperm oil. The average price of the animal ten years ago was $40, now it is $150. The average weight is 2,500 pounds; the largest weigh 5,000 pounds, and are worth $200. The average length is twenty-two feet, and circumference fifteen feet. M. Tetu caught the whale in nets near the river Saguenay.

The skin does not make good sole-leather, being too pliable. Ordinary tanning processes are employed, except that the lining is omitted, and the "training" takes more time on account of the closeness of the fiber of the skin. The leather is very durable, and the skin of a whale is equal to the skins of twelve to twenty-four calves. The leather is chiefly used in the British army.

into canes and other articles of ornament. The supply in this country is chiefly imported from Denmark. In New York City in 1880 a good tusk sold for $50.

10. THE GREENLAND, BOWHEAD, OR POLAR WHALE.

CONFUSION BETWEEN THE BOWHEAD AND THE RIGHT WHALE.—Much uncertainty has resulted from the manner in which the Bowhead of the arctic regions has been confused with the right whales of the adjoining temperate seas. Murray, writing in 1866,[1] made no attempt to clear up the subject; previous writers were confused as well as vague, and it is only in Scammon's writings that a clear account of the distribution and habits of the species is to be found. The materials for the following biographical sketch are derived in the main from the statements of this author, and quotation marks are omitted only because the facts are arranged in a new sequence.[2]

DISTRIBUTION.—The range of the true *Balæna mysticetus* extends west from Nova Zembla to the coast of Eastern Siberia. Its northern limits yet remain undefined: it is seldom seen in Bering Sea south of the fifty-fifth parallel, which is about the southern extent of the winter ice, though in the Sea of Okhotsk it ranges south to the parallel of 54°. It was formerly found to the north of Spitzbergen, but it has been shown by Eschricht and Reinhardt that its habitat is, and always has been, confined to the polar seas, and that it has no claim to a place in the fauna of Europe.[3]

Everything tends to prove that the Bowhead is truly an "ice-whale," for its home is among the scattered floes or about the borders of the ice-fields or barriers. It is true that these animals are pursued in the open water during the summer months, but in no instance has their capture been recorded south of where winter ice-fields are occasionally met with. In the Okhotsk Sea they are found throughout the season after the ice disappears, nevertheless they remain around the floes till these are dispelled by the summer sun, and they are found in the same localities after the surface of the water has again become congealed in winter.

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[1] MURRAY: Geographical Distribution of Mammals, pp. 207–208.

[2] In "A Digression concerning Whaling," written in 1748, published in Douglass' North America, Boston and London, 1755, vol. i, p. 56, is the earliest discrimination I have met with of the Bowhead and the Right Whale of the extra-polar regions. Some interesting facts are given:

"The New-England whalers distinguish 10 or 12 different species of the whale-kind; the most beneficialis the black whale, whale-bone whale, or true whale, as they call it; in Davis's-straits in N. lat. 70 D. and upwards they are very large, some may yield 150 puncheons being 400 to 500 barrels oil, and bone of 18 feet and upwards; they are a heavy loggy fish, and do not fight, as the New-England whalers express it, they are easily struck and fastened, but not above one third of them are recovered; by sinking and bewildering themselves under the ice, two thirds of them are lost irrecoverably; the whalebone whales killed upon the coast of New-England, Terra de Labradore, and entrance of Davis's-straits, are smaller, do yield not exceeding 120 to 130 barrels oil, and 9 feet bone 140 lb. wt.; they are wilder more agile and do fight.

"The New England whalers reckon so many ct. wt. bone, as bone is feet long; for instance, 7 foot bone gives 700 wt. bone: New England bone scarce ever exceeds 9 feet; and 100 barrels oil is supposed to yield 1000 wt. of bone; whales killed in deep water, if they sink, never rise again."

A few paragraphs below, however, he proceeds to mix the subject up again, speaking of the Finback, when it is quite evident that the Whale he has in mind is not the right-whale but the "Right Whale."

"The fin-back, beside two small side-fins, has a large fin upon his back, may yield 50 to 60 barrels oil, his bone is brittle, of little or no use, he swims swifter, and is very wild when struck. The Bermudians some years catch 20 of these whales, not in sloops, but in whale-boats from the shore as formerly at Cape-Cod. The governor of Bermudas has a perquisite of 10£. out of each old whale.

"Whales are gregarious," he continues, "and great travellers or passengers; in the autumn they go south, in the spring they return northward. They copulate like neat cattle, but the female in a supine posture. The true or whalebone whale's swallow is not much bigger than that of an ox, feeds upon small fish and sea insects that keep in sholes, has only one small fin each side of his head of no great use to him in swimming, but with a large horizontal tail he seals himself in the water. The North Cape (in N. Lat. 72 D. in Europe) whales, are of the same small kind as are the New-England, and entrance of Davis's-straits: here we may again observe, that the high European latitudes are not so cold as the same American latitudes, because 72 D. is the proper N. Lat. in Davis's-straits for the large whales, and the Dutch fish for them longside of fields or large islands of ice, they use long warps, not drudges as in New-England."

[3] ESCHRICHT & REINHARDT: Om Nordhvalen, 1861.

REPRODUCTION.—The time and place of breeding are not certainly known, but it is supposed that the young are born in the inaccessible parts of the Arctic Ocean. In Tchantar Bay are found small whales called "Poggys," which resemble the Bowhead, and are by many believed to be their young.

The Bowheads of the Arctic are classed by Scammon as follows: (1) the largest whales of a brown color, average yield of oil 200 barrels; (2) smaller, color black, yield 100 barrels; (3) smallest, color black, yield 75 barrels, and to these should perhaps be added (4) the "poggy," yield 20 to 25 barrels. Those of the third class are generally found early in the season among the broken floes, and have been known to break through ice three inches thick that had been formed over water between the floes. This they do by coming up under and striking it with the arched portion of their heads. Hence they have been called "ice-breakers."

ECONOMIC IMPORTANCE.—The Bowhead is the most valuable of the whalebone whales, not so much by reason of its size, for it rarely exceeds fifty feet in length, never sixty-five, but because it yields so large an amount of oil and whalebone. It is short, bulky, and bloated in appearance. Like the sperm whale, it has a head the length of which is nearly one-third of the total, and which is its most striking feature. The caudal fin is immense, being sixteen to twenty feet in extent from tip to tip, and correspondingly thick and broad.

SIZE.—Scammon gives measurements of two individuals. One, from the Arctic Ocean, August, 1867, was forty-seven feet long, and yielded eighty barrels of oil. The other, from the same ocean, in 1870, was forty-five feet long, yielded sixty barrels of oil and 1,050 pounds of bone. Capt. David Gray, of Peterhead, also gives measurements of an individual taken in Greenland. Some of the most important dimensions of these three whales are presented here, in order to impart to the reader an idea of their proportions:

	Scammon, "Captain Poole's whale."	Scammon, "Captain Smith's whale."	"Captain Gray's whale."
	Feet. *in.*	*Feet.* *in.*	*Feet.* *in.*
Length	47 0	45 0	47 0
Length of head—nose to eye			17 8
Breadth of body between fins			11 0
Girth in largest place		28 0	
Length of pectorals	8 0	7 3	
Breadth of tail	19 0	16 0	20 0
Length of longest bone	10 6	9 6	10 1
Thickness of blubber	11	9	
Breadth of lip			5 0
Gape of mouth			10 8

MOVEMENTS.—When not disturbed the animal remains up, generally to respire, from one and a half to two minutes, during which time it spouts from six to nine times, and then disappears for the space of ten to twenty minutes. The volume of vapor is similar to that ejected by the right whale. Sometimes, when engaged in feeding, it remains down for twenty-five minutes or more. When struck by the whalemen they have been known to remain on the muddy bottom, at a depth of fifty fathoms or more, for the space of an hour and twenty minutes. Their movements and the periods of time they remain above or below the surface are, however, irregular. When going gently along or lying quietly, they show two portions of the body—the spout-holes, and a part of the back.

BALEEN.—The baleen, or "whalebone," of the Greenland and the Right Whales, being of so much importance commercially, it cannot be amiss to explain, by means of diagrams and a description,

how it is attached to the mouth of the animal, and for what purposes it is used, even at the risk of being a trifle too elementary for many of the readers of this chapter.

It is wrongly called "whalebone," since it is not bone, but a substance, resembling equally hair and horn, which grows in the mouth of the animal as a substitute for teeth,[1] being, as anatomists generally admit, a peculiar development of hair growing upon the palate.[2] This substance is developed into a sieve-like apparatus, consisting of extensive rows of compact, flexible, closely set plates or blades, growing from the thick gum at the circumference and palatal surface of the upper jaw, hanging down upon both sides of the tongue.

Capt. David Gray, of the whaling ship "Eclipse," of Peterhead, Scotland, has recently made a number of important observations upon these whales, one of the most important of which was the ascertainment of the manner in which the Baleen Whales operate the powerful sieve-like organs within their jaws. He has also published some very interesting diagrams of the interior of the mouth of the Greenland Whale.[3]

"*Along the middle of the crown-bone,*" writes Captain Gray, "*the blades of whalebone* are separated from each other by three-quarters of an inch of gum, but the interval decreases both towards the nose and the throat to a quarter of an inch. The gum is always white; in substance it resembles the hoof of a horse, but softer. It is easily cut with a knife, or broken by the hand, and is tasteless. The whalebone representing the palate is lined inside the mouth with hair, for the purpose of covering the space between the slips, and prevents the food on which the Whale subsists from escaping. This hair is short at the roof of the mouth, but is from twelve to twenty inches long at the points of the whalebone. This it requires to be, because when the mouth is *opened the bone springs forward, and the spaces are greatest at the points.* I counted the number of blades of whalebone in a whale's head last voyage, and found 286 on the left, and 289 on the right side of the head.

"Hitherto it has been believed that the whale bone had room to hang perpendicularly from the roof of the mouth to the lower jaw, when the mouth was shut, but such is not the case. The bone is, however, arranged so as to reach from the upper to the lower jaw when the mouth is open; were it otherwise the whale would not be able to catch its food; it would all escape underneath the points of the whalebone. The whale has no muscular power over its whalebone, any more than other animals have over their teeth. When the animal opens its mouth to feed, the whalebone springs forward and downward, so as to fill the mouth entirely; when in the act of shutting it again, the whalebone being pointed slightly towards the throat, the lower jaw catches it and carries it up into a hollow in front of the throat."[4]

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[1] The unborn Greenland Whale has undeveloped teeth ("sixty to seventy dental pulps on each side of each jaw"), but they never cut the gum, but are reabsorbed into the system.

[2] Buckland remarks: "Aristotle first remarked this fact: '*Mysticetus etiam pilas in ore habet vice dentium suis setis similes*'—the whale has hairs in his mouth, instead of teeth, like the hairs of a pig." Professor Owen has also *remarked that "to a person looking into the mouth of a stranded whale, the concavity of the palate would appear to* be beset with coarse hair."

[3] Land and Water, December 1, 1877, p. 468.

[4] Capt. David Gray's observations upon the position of the whalebone in the mouth of the Greenland Whale are quite novel, and of great interest. They arose, as the captain tells me in a letter just received, in consequence of a conversation which we had together a few years ago, while looking at the skeleton of the large Whale mounted in the Museum of the College of Surgeons. I asked if he could explain, what had always been to me, as to others who have never had Captain Gray's opportunities of observation, a great puzzle, viz, how the whalebone could be so much longer than the space which it occupied in the animal's mouth, supposing the blades to be placed, as usually represented, at right angles with the long axis of the jaws. This difficulty occurred in looking at all the authentic figures, such as Scoresby's, in which the height of the head is far too small for the length assigned to the whalebone on the supposition stated above, and equally in looking at the actual bony frame-work of the head. Captain Gray's explana*tion that the slender ends of the whalebone blades fold backwards when the mouth is shut, the longer ones from the*

FOOD.—The food of the Bowhead consists of floating animals, classed by the whalemen under the names "right whale feed" and "brit." Many kinds of invertebrates are, of course, included under these general terms, one of the most abundant of which is, perhaps, a kind of winged or pteropod mollusk, the *Clio borealis*, which occurs in northern seas, floating in great masses. When the Bowhead is feeding it moves with considerable velocity near the surface, its jaws being open to allow the passage of currents of water into the cavity of the mouth and through the layers of baleen at the sides. All eatable substances are strained out by the fringes of the baleen and are swallowed.

FEEDING HABITS.—The manner of feeding is well described by Captain Gray: "When the food is near the surface they usually choose a space between two pieces of ice, from three to four hundred yards apart, which we term their beat, and swim backwards and forwards, until they are satisfied that the supply of their food is exhausted. They often go with the point of their nose so near the surface that we can see the water running over it just as it does over a stone in a shallow stream; they turn round before coming to the surface to blow, and lie for a short time to lick the food off their bone before going away for another mouthful. They often continue feeding in this way for hours, on and off, afterwards disappearing under the nearest floe, sleeping, I believe, under the ice, and coming out again when ready for another meal. In no other way can this sudden reappearance at the same spot be accounted for.

"Very often the food lies from ten to fifteen fathoms below the surface of the water. In this case the whales' movements are quite different. After feeding they come to the surface to breathe and lie still for a minute. One can easily see the effort they make when swallowing. They then raise their heads partially out of the water, diving down again, and throwing their tails up in the air every time they disappear. Their course below the water can often be traced from their eddy. This is caused by the movement of the tail, which has the effect of smoothing the water in circles immediately behind them.

"More whales have been caught when feeding in this way than in any other; they lie longer on the surface, often heading the same way every time they appear, which is very important to whale fishers, because whales must be approached tail-on to give any certainty of getting near enough to have a chance of harpooning them, and the harpooner has a better idea where to place his boat to be in readiness to pull on to them whenever they come to the surface.

"Like all the other inhabitants of the sea, whales are affected by the tides, being most numerous at the full and change of the moon, beginning to appear three days before, and disappearing entirely three days after, the change. Often this will go on for months with the utmost regularity, unless some great change in the ice takes place, such as the floes breaking up on the ice being driven off the ground; in either case they will at once disappear.

"No doubt whales are seen, and often taken at any time of the tides; but if a herd is hunted

middle of the jaw falling into the hollow formed by the shortness of the blades behind them, as seen in the side view, is perfectly clear and satisfactory. It shows, moreover, how, whether the mouth is shut or open, or in any intermediate position, the lateral spaces between the upper and lower jaw are always kept filled up by the marvelously constructed hair sieve, or strainer, which adapts itself by its flexibility and elasticity to the varying condition of the parts between which it is, as it were, stretched across. If the whalebone had been rigid and depending perpendicularly from the upper jaw when the mouth was opened, a space would be left between the tips of the whalebone forming the lower edge of the strainer, which, as Captain Gray justly remarks, would completely interfere with its use, although the stiff, wall-like lower lip, closing in the sides of the mouth below, may have the effect of remedying such a contingency to a certain extent; at least, it would do so if the whalebone were short and firm as in the finners. The function of this great lip in supporting the slender and flexible lower ends of the blades of the Greenland Whale and preventing them being driven outwards by the flow of water from within when the animal is closing its mouth, is evident from Captain Gray's drawings and explanation. The whole apparatus is a most perfect piece of animal mechanism.—FLOWER, W. H.: Land and Water, December 1, 1877, p. 470.

systematically, and they are attached to a particular feeding bank, this is their usual habit. Neither can this peculiarity in their habits be easily accounted for; their food is as abundant during the neap as it is in the spring tides.

"The principal food of the Greenland Whale consists of a small crustacean, not larger than the common house-fly, which is found in greatest abundance when the temperature of the sea is from 34° to 35°, the ordinary temperature amongst ice being 29°, the color of the water varying from dark brown to olive green and clear blue, the blue water being the coldest.

"The crustacea live upon the animalculæ which color the water. They are transparent, and the contents of their stomachs can be easily seen to be dark brown or green as the case may be."[1]

11. THE RIGHT WHALES.

DISTRIBUTION AND AFFINITIES.—There is no group of existing mammals so important as the Right Whales, concerning which so little that is satisfactory is known. Zoologists have not yet determined how many species there are, nor what are the limits of their distribution. All that can be certainly said is, that Right Whales—that is, the right kind to kill for the whalebone—occur in the North Atlantic and the North Pacific, and also in the cooler waters of the southern hemisphere. In the northern hemisphere they never cross the Tropic of Cancer, though in the south, both in the Pacific and the Atlantic, they have occasionally been known to cross that of Capricorn.

The Right Whales of the north have, until very recently, been confounded by whalemen and zoologists with the bowhead, or polar whale, to which they are closely related. There is one group of baleen-bearing whales, the rorquals, finners, or finbacks, which have a fin upon the back: the true Right Whales, however, have none. The rorquals, the largest of whales, are very swift and slender, and are believed to occur in tropical as well as temperate seas, all the world over.

The Right Whale of the Western Atlantic has been described by E. D. Cope, under the name *Eubalæna cisarctica*. This species, not remotely related to the *Eubalæna biscayensis*, of the Eastern Atlantic, was formerly abundant on the coast of New England, and, as will be shown in the chapter on the shore whale fishery of New England, its presence in such numbers about Cape Cod was one of the chief reasons for planting the early English settlements in this district. Captain Atwood informs me that they are most abundant off Provincetown, in April and May, though occasionally seen at other seasons. One was killed in Cape Cod Bay, near Provincetown, in 1867; it was forty-eight feet long, and yielded eighty-four barrels of oil, as well as 1,000 pounds of baleen, valued at $1,000. Two or three others have since then been killed in the vicinity, but years now often pass by without any being seen.[2]

A Right Whale of forty to fifty feet was killed in the harbor of Charleston, S. C., January 7, 1880, after it had been swimming about within the bar several days.[3]

In evidence of the former abundance of this species, may be mentioned the fact, that when, about the middle of the last century, whales began to be scarce along the coast, a large fleet was dispatched to Davis Straits, where none but whalebone whales occur. *E. cisarctica* occurs at least as far south as the Bermudas. A species of Right Whale is found also about the Azores.

In the North Pacific occurs the Pacific Right Whale, or "Northwest Whale" of the whalers,

[1] Land and Water, December 1, 1877, p. 470.

[2] WHALING AT PROVINCETOWN.—A Right Whale was captured in Provincetown Harbor last Thursday, by a party in three boats. Estimated to yield sixty barrels of oil.—Gloucester Telegraph, November 6, 1850.

[3] See Charleston News, January 8, 1880.

Eubalæna cullamach (Chamisso) Cope. Its distribution is not well understood. Dall gives it as occurring in the Arctic, Bering, and Okhotsk Seas, off Lower California, and, perhaps, in Japan.[1]

Scammon writes that in former years they were found on the coast of Oregon, and occasionally in large numbers; but their chief resort was upon what is termed the "Kodiak Ground," which extends northwestward from Vancouver's Island to the Aleutian Islands, and westward to the one hundredth and fiftieth meridian. They also abounded in the Okhotsk and Bering Seas, and along the Kamschatka coast. He supposes that those which have been observed on the coast of California were stragglers from the north. "Some, indeed," he writes, "have been taken (from February to April) as far south as the Bay of San Sebastian Viscarrio, and about Cedros, or Cevros, Island, both places being near the parallel of 29° north latitude; while on the northwestern coast they are captured by the whalers from April to September inclusive."[2]

None appear to have been killed on the California coast, within thirty or forty years, if we may judge from Captain Scammon's failing to mention such instances.

In the Antarctic Seas and the adjoining waters are other Right Whales. *Eubalæna australis*, the Cape Whale or Black Whale, abounds about the Cape of Good Hope, and is regarded by Murray as an inhabitant of the South Atlantic, South Pacific, and Indian Oceans.[3] *E. antipodarum* was described by Gray from New Zealand, and in Murray's map is designated as a more antarctic form than the Cape Whale, though in the text of his book he denies that this is known to be a fact.[4] Owing to the fact that the bowhead and the Right Whales have until recently been considered identical, there is a dearth of reliable observations upon habits known to refer definitely to these animals.

MOVEMENTS.—Their manner of feeding and general mode of life are, as might be expected, very similar to those of the bowhead. I quote from Scammon:

"They are often met with singly in their wanderings, at other times in pairs or triplets, and scattered over the surface of the water as far as the eye can discern from the masthead. Toward the last of the season they are seen in large numbers crowded together. The herds are called 'gams,' and they are regarded by experienced whalemen as an indication that the whales will soon leave the grounds.

"Their manner of respiration is to blow seven to nine times at a 'rising,' then, 'turning flukes' (elevating them six or eight feet out of the water), they go down and remain twelve or fifteen minutes. It is remarked, however, since these whales have been so generally pursued, that their action in this respect has somewhat changed. When frightened by the approach of a boat they have a trick of hollowing the back, which causes the blubber to become slack, thus preventing the harpoon from penetrating. Many whales have been missed, owing to the boat-steerer darting at this portion of the body. Having been chased every successive season for years, these animals have become very wild and difficult to get near to, especially in calm weather."

REPRODUCTION.—The time of gestation is fixed by Scammon at about one year. Twins are occasionally though rarely born. The time and place of calving is not known, but are supposed to be variable, as in the case of the sperm whale. These whales are said to resort to the Californian "bays" to bring forth their young, and formerly were sought for in the inland waters of these high southern latitudes, where many a ship has in past years quickly completed her cargo by "bay whaling."[5]

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[1] DALL: Catalogue of the Cetaceans of the North Pacific Ocean. <SCAMMON: Marine Mammalia, p. 305.
[2] SCAMMON: *op. cit.*, p. 67.
[3] MURRAY: Geographical Distribution of Mammals, p. 208, map.
[4] MURRAY: *op. cit.*
[5] SCAMMON: *op. cit.*, p. 67.

SIZES AND YIELD OF OIL.—The following statement of sizes of whales taken by New Bedford vessels, as indicated by their yield of oil, is very instructive. It was furnished by Capt. Benjamin Russell, in 1875. There is no means of distinguishing the bowheads from the Right Whales:

Captain Devot took one Right Whale off Kodiac; made 200 barrels.
Captain Devot took four Right Whales off Kodiac; made 920 barrels.
Captain Clark took one Right Whale off Kamtchatka; made 180 barrels.
Captain Wood took one Right Whale off Kamtchatka; made 230 barrels.
Captain Rice, of New London, took ten Right Whales off Kamtchatka; made 700 barrels.
Captain Winston took one Right Whale off Kamtchatka; made 270 barrels.
Captain Winston took two Right Whales off Kamtchatka; made 480 barrels.
Captain Spooner took one Right Whale off Kamtchatka; made 260 barrels.
Captain Cox took one Right Whale off Kodiac; made 225 barrels.
Captain West took two Right Whales; made 508 barrels.
Captain West took thirteen Right Whales; made 1,780 barrels.
Captain Wood took one Right Whale; made 280 barrels.
A number of captains report one each, from 80 to 200 barrels.

12. THE HUMPBACK WHALES.

DISTRIBUTION.—The Humpback Whales, also often called Bunch Whales by Europeans, occur in both Atlantic and Pacific. Captain Ross saw them as far south as latitude 71° 50′. In the Pacific they range to the Arctic Circle, and there is reason to believe that they occur also about Greenland. Our Atlantic species is *Megaptera osphyia* Cope, that of the California region *M. versabilis*. As usual, the inquirer must go to Scammon for accurate observations, little being known about the species of the Atlantic.

MIGRATIONS.—They appear to resort periodically, and with some degree of regularity, to certain localities where the females bring forth their young. Scammon found them breeding in July and August, 1852 and 1853, in the Gulf of Guayaquil, Peru; in December in the Bay of Valle de Banderas, Mexico, latitude 20° 30′; and in May, 1855, at Magdalena Bay, Lower California, latitude 24° 30′. Captain Beckerman observed them at Tongataboo, Friendly Group, latitude 21° south, longitude 174° west, in August and September. Large numbers of both sexes migrate north in summer and south in winter.

SIZE.—They attain the length of twenty-five to seventy-five feet, and yield from eight to seventy-five barrels of oil. The largest taken in 1871 by Captain Beckerman was seventy-five feet long, and produced seventy-three barrels, but the average yield was forty barrels, including the entrail fat, which amounted to about six barrels. One taken off the bay of Monterey, in 1858, yielded 145 barrels.

The blubber, according to Bennett, is yellowish-white, five to fifteen inches thick, and the oil is said to be better than that of the right whale.

The baleen possesses a moderate commercial value. In a specimen fifty-two feet long, Scammon records 540 laminæ, the longest two feet eight inches long and nine inches broad, and elsewhere he estimates its yield at 400 pounds to 100 barrels of oil.[1]

FOOD.—Their food consists of fish and crustaceans scooped up at the surface. When feeding they are most easily captured. The time and place of breeding have already been spoken of. "In the mating season," writes Scammon, "they are noted for their amorous antics. At such times their caresses are of the most amusing and novel character, and these performances have doubtless given rise to the fabulous tales of the swordfish and thrashers attacking whales. When

[1] SCAMMON: *op. cit.*, pp. 40, 41.

lying by the side of each other, the Megapteras frequently administer alternate blows with their long fins, which love-taps may on a still day be heard at a distance of miles. They also rub each other with these same huge and flexible arms, rolling occasionally from side to side, and indulging in other gambols."

HUMPBACK WHALES IN NEW ENGLAND.—The Humpback Whale was formerly a frequent visitor to the waters of New England, but of late years has not often been seen. Captain Atwood tells me that a great many have been killed near Provincetown within his recollection: that is to say, or since 1817. One harpooned in the harbor in 1840 yielded fifty-four barrels of oil. Two were killed in the spring of 1879, with bomb-lances.

This species is the most valuable of the ordinary whales of the region, though, of course, far inferior to the right whale. In addition to the oil, the baleen or whalebone is of some worth. In past years it has sold for as much as six and one-quarter cents a pound. It rarely exceeds two feet in length and is not very elastic. The shore fishery of Cape Cod, which was quite vigorously prosecuted in the early part of the last century, was probably largely concerned with this species.

In 1879 the Humpbacks were abundant on the coast of Maine. One of the most successful whalers out of Provincetown this season is the "Brilliant," a very old pink-stern schooner of seventeen tons, which had been hunting this species off Deer Isle, Maine. Up to September 1, she had taken four whales, yielding one hundred and forty-five barrels. The "Brilliant" carries but one whale-boat and tries out the oil upon shore, towing in the whales as they are killed. On the 14th of May, 1881, twenty Humpbacks were shot with bomb-lances in Provincetown harbor.

"The Humpback," says Douglass, of the New England whales, in 1748, "has a bunch in the same part of his back, instead of a fin. The bone is not good; makes fifty to sixty barrels oil."

The oil of the Humpbacks is said by Bennett to be superior to that from the right whale, and but little less valuable than sperm oil.

13. THE SULPHUR-BOTTOM WHALES.

DISTRIBUTION AND MOVEMENTS.—The Sulphur-bottom Whale of the Pacific coast, *Sibbaldius sulfureus* Cope, is said to be the largest known cetacean.[1] Its name and that of its related Atlantic species, *S. borealis* (Fischer) Geoffroy, is derived from a yellowish tint upon the white belly. The Atlantic Sulphur-bottom, which is also called by English whalers the "Flat Back," does not grow to the immense size characteristic of the Pacific form. In the Atlantic, the Sulphur-bottom is not uncommon, though rarer than the humpback and finback. On the coast of the Californias, writes Scammon, it occurs at all seasons, and from May to September is often found in large numbers close in with the shore, at times playing about ships at anchor in the open roadsteads, near islands or capes, but, as a general rule, not approaching vessels with the same boldness as the finbacks. It glides over the surface of the ocean, occasionally displaying its entire length. When it respires its vaporous breath ascends to such a height that its immense size is evident to the observer. It is occasionally captured with a bomb-lance, but never except by aid of the bomb-lance. Being considered the swiftest of all whales, it is seldom pursued, and still more rarely taken.

The Sulphur-bottom of the Atlantic resembles the finbacks in shape and habits, and is probably often confounded with them by those who see it swimming. Captain Atwood informs me that none have been seen near Provincetown of late years. Professor Baird obtained a fine skeleton at Nantucket in 1875 (No. 16039, U. S. N. M.). Captain Atwood writes: "Like the finback, it

[1] Captain Roys, quoted by Scammon, gives the following memoranda of an individual measurement by him: Length, ninety-five feet; girth, thirty-nine feet; length of jaw-bone, twenty-one feet; length of longest baleen, four feet; yield of baleen, 800 pounds; yield of oil, 110 barrels; weight of whole animal by calculation, 294,000 pounds.

has on its back a very small dorsal fin. Being very much elongated, it is a swift runner and hurries through the water with a velocity so great that the whaleman cannot kill them in the same way that they take the other species. I have never seen it dead and know but little about it."[1]

14. THE FINBACK WHALES.

DISTRIBUTION.—The Finback Whales of the Atlantic, *Sibbaldius tectirostris* Cope, and *S. tuberosus* Cope, are closely related to the sulphur-bottoms. The former is the most common of the larger cetaceans in Massachusetts Bay, and half a dozen or more may be seen in an afternoon's cruise any sunny afternoon of summer. They become abundant in the Gulf of Maine soon after the beginning of April. They swim near the surface, often exposing the back for half its length, and I have several times seen them rise within fifty feet of the yacht on which I stood. September 12, 1879, four were swimming and spouting in Provincetown Harbor.

The skeleton obtained by the Fish Commission in 1875 (No. 16045, U. S. N. M.) belongs to the species whose name heads this paragraph. The Museum of Comparative Zoology also has a specimen, taken at Provincetown, forty-seven feet long, which yielded eighty barrels and fourteen gallons of oil.

MOVEMENTS.—Captain Atwood tells us that Finbacks are rapid swimmers and are not often attacked by the whalers. They "run" so hard that the boats "cannot tow to them," and it is impossible to get up to them to lance them. They sometimes strand on the shore, and of late years a few are occasionally killed with a bomb-lance in the spring. One was lanced one autumn, about the year 1868, by boats pursuing blackfish. It was sixty feet long, and made about twenty barrels of oil. The "bone" is shorter than that of the humpback, and is of little value.[2] When lanced, not being oily enough to float at once, they sink and remain at the bottom for a few days, during which time much of the blubber is eaten off by sharks. They yield very little oil.

ABUNDANCE IN NEW ENGLAND.—Two ran ashore some years ago in Provincetown Harbor, one of which yielded fourteen, the other twenty barrels of oil. One killed at Provincetown, though fifty-four feet long and a good fat whale of its kind, yielded only twenty barrels of oil.[3]

THE DUBERTUS.—An interesting question regarding the name by which this whale was known in the early days of the American colonies has recently been discussed.

The charter of Rhode Island and Providence Plantations, granted in 1663 by Charles II, provides, among more important rights and privileges:

"*And ffurther*, for the encouragement of the inhabitants of our sayd collony of Providence Plantations to sett upon the businesse of takeing whales, itt shall bee lawefull ffor them, or any of them, having struck whale, DUBERTUS or other greate ffish, itt or them to pursue unto any parte of that coaste, and into any bay, river, cove, creeke or shoare belonging thereto, and itt or them upon the sayd coaste, or in the sayd bay, cove, creeke or shoare belonging thereto, to kill and order to the best advantage, without molestation, they makeing noe wilfull waste or spoyle, anything in these presents conteyned, or any other matter or thing, to the contrary notwithstanding."

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[1] Bulletin Museum Comparative Zoology, vol. viii, p. 204.

[2] A large Finback Whale, forty feet in length, got aground on the flats near the light-house at Wellfleet, on Wednesday, by the fall of the tide, and he was killed by cutting a hole in him and then using an oar as a spade. When the tide is out people can walk around the whale.—Semi-Weekly Advertiser, Boston, February, 27, 1872.

On the 2d of May, 1828, a whale was cast ashore at Whale Reach, Swampscott, measuring sixty feet in length, and twenty-five barrels of oil were extracted from it.—LEWIS & NEWHALL: History of Lynn, p. 391.

1755. A whale, seventy-five feet in length, was landed on King's Reach, on the 9th of December. Dr. Henry Burchsted rode into its mouth, in a chaise drawn by a horse; and afterwards had two of his bones set up for gate-posts at his house in Essex street, where they stood for more than fifty years. [Opposite the doctor's house, the cot of Moll Pitcher, the celebrated fortune-teller, stood. And many were the sly inquiries from strangers for the place where the big whale-bones were to be seen.]—*Ibid.*, p. 330.

[3] Bulletin of the Museum of Comparative Zoology, vol. viii, p. 204, and in letters.

In answer to a letter of inquiry from Professor Baird, *Professor* Trumbull wrote as follows:

HARTFORD, *February* 1, 1880.

DEAR PROFESSOR BAIRD: *Your query of January* 20 just now comes to hand. Isn't that troublesome *Dubertus rhodiensiensis* satisfactorily disposed of yet? More than twenty-one years ago (in *November*, 1858) the Rev. S. C. Newman, of Pawtucket, questioned *Professor* Agassiz on the subject. His reply was, that having looked in the only work *in which* he supposed the desired information was likely to be found—Nemnich's *Polyglottaes Lexicon*—he could only say that it did not even contain the name "Dubertus." *The correspondence*, so far unsatisfactory, was printed in the "Providence Journal," December 9. The next day the Hon. Albert G. Greene wrote to the "Journal" that "before and at the time of the granting of the charter of Rhode Island, 'Dubertus' was the word used to distinguish the *sperm* whale from the *common or right* whale," and referred for his authority to the description given by *Sir Thomas Browne* "of the spermaceti whale," which "mariners (*who are* not the best *nomenclators*) called a *Jubartas*, or rather *Gibbartus*." Mr. Greene came very near being right, *and* undoubtedly was right in identifying the "Dubertus" of the charter with the "Jubartas" or "Gibbartas" of the old whale fishermen; but he was wrong on the main point that either "Jubartas" or "Dubertus" was a *distinctive* name of the *sperm* whale, except by a "vulgar error" of the Norfolk mariners, who, *as Sir Thomas* Browne understood, "are not the best nomenclators." The "*Jubartas*," "*Gibbartas*," or "Gubartas"—as the name which, by an error of the engrossing clerk, appears as "Dubertus" in the Rhode Island charter, was variously written by naturalists in the seventeenth century—was a *Finback*, the "*Balæna Novæ Angliæ*," as Klein calls it, the "*Jupiterfisch*" of the Dutch whalers, *Balænoptera Jubartes* of *Lacépède*. (The last name I heard for it was, I think, *Sibbaldius tuberosus*; but this was a year or two ago, and it may have been rechristened *a dozen* times since then.) The name, however, has been applied to more than one species of *Finback*, for naturalists, when dealing with cetacea, were not, in the last century, much better "nomenclators" than the English mariners; but it has always been restricted to the *Balænopteridæ*, and has never designated *any* species of either *sperm* or *right* whales.

The history of the name is curious. *Rondelet* ("De Piscibus" lib. xvi, p. 482) gives a figure of a "*Balæna Vera*" (drawn from *life*, he *says*) which "the whale fishers of Saintonge call *Gibbar*, a Gibbero Dorso, that is, raised in a *hump*, on which is the fin." From this provincial name came *Gibbartas*, *Gubartas*, *Jubart*, *Jubartes*, *Jupiter*, and half a dozen other corruptions, introduced first among mariners, and afterwards adopted or recognized as *synonyms* by naturalists, and distributed among three or four different species.

Lacépède, under *Balænoptera Jubartes*, includes *Balæna boops* (Gmelin), and "probably the *sulphur-bottom* of the west coast of *North* America," the *Jubartes* of Klein, and the *Jupiter Fisch*, described by Anderson, as well as *Baleine Jubarte* of Bonnaterre (*Encyc. Méth.*).

Klein ("Misc. Pisc.," 11, 13) says that the whale catchers *have* corrupted the name of the *Jupiter*, or Piscis Jovis, to *Jubartes*, which is reversing the *actual process* of corruption. He calls this the "Whale of *New England*."

Anderson, cited by Lacépède, in "*Nachrichten* von Island, Grönland, etc.," p. 220, describes "the *Jupiter* or Jupiterfisch" as a *kind* of fin-fish, saying that its name, without doubt, comes *from* that of *Gubartes* or *Gibbartas*, which has been given it by *others*, *and which* is itself a corruption of the Biscayan *Gibbar*.

But Lacépède makes "*Balæna nodosa*," "Humpback Whale of the English," and *Balæna gibbosa*," the Whales of New *England*, and refers to Bonnaterre, who separates *le Gibbar*, Engl. *Fin-fish*, from *la Jubarte B. boops*. Between *Gibbar* and *Gibbosa*, *Jupiter* and *Gubartus*, the things get rather mixed.

Cranz, in his history of Greenland (Engl. transl., vol. i, p. 110) describes "the Jupiter Whale, which the Spanish whale fishers call more properly *Gubartas*, or *Gibbar*, from a protuberance, *gibbero*, which grows towards the tail, besides the fin."

Returning to the "Dubertus" of the charter, Senator Anthony will see how easy it was for an engrossing clerk to mistake the initial "G," in seventeenth century chancery-hand, for a "D," in an unfamiliar name. A more troublesome mistake was made by the engraver of the seal of the Massachusetts Bay Company, which obliged Governor Winthrop always to describe himself, in official papers, as governor of the Company of *Mattachusetts* Bay, etc.

J. HAMMOND TRUMBULL.

THE PACIFIC FINBACK.—The Finback of the Pacific, *Balænoptera velifera* Cope, also called the Oregon Finner, is common in Oregon and California, and is the rival of the sulphur-bottom in swiftness. Like the Atlantic Finbacks, it can be taken only with the bomb gun. Scammon gives the measurements of an individual sixty feet long which came ashore near the Golden Gate. He states that enormous quantities of codfish have been found in their stomachs. "The habitual movements of the Finback in several points are peculiar. When it respires, the vaporous breath passes quickly through its spiracles, and when a fresh supply of air is drawn into the breathing system, a sharp and somewhat musical sound may be heard at a considerable distance, which is quite distinguishable from that of other whales of the same genus. (We have observed the intervals between the respirations of a large Finback to be about seven seconds.) It frequently gambols about vessels at sea, in mid-ocean, as well as close in with the coast, darting under them, or shooting swiftly through the water on either side; at one moment upon the surface, belching forth its quick, ringing spout, and the next instant submerging itself beneath the waves as if enjoying a spirited race with the ship darting along under press of sail. Occasionally *they* congregate in schools of fifteen to twenty or less."[1]

"An instance occurred in Monterey Bay in 1865, of five being captured; a 'pod' of whales was seen in the offing, from their shore station, by the whalemen, who immediately gave chase. One was harpooned, and, although it received a mortal wound, they all 'run together' as before. One of the gunners managed to shoot the whole five, and they were all secured.

"A Finback sixty-five feet long yielded seventy-five barrels of oil. The blubber was clear white, seven to nine inches thick. The largest baleen measured twenty-eight inches in length, thirteen in width, and was provided with a long fringe."[2]

Another related form, the Sharp-headed Finner, *B. Davidsonii* Scammon, has habits similar to the Finback, but frequents more northern waters, where it is sometimes taken by the Indians of Cape Flattery.

15. THE SCRAG WHALE.

HISTORY OF THE SCRAG WHALE.—The Hon. Paul Dudley, writing in 1809 of the whales of New England, remarked upon a certain kind in these words: "*A Scrag Whale:* Is near akin to the *Fin Back*, but instead of a fin upon its back, the ridge of the after part of its back is scragged with half a dozen knobs or knuckles. He is nearest the right whale in figure and quantity of oil. His bone is white but won't split."[3]

Atwood also writes: "A species of whale known by this name, nearly allied to if not identical with the right whale, is sometimes taken here. It is the opinion of many of our whalemen that they are not a distinct species, but the young right whale that lost its mother while very young,

[1] SCAMMON: *op. cit.*, p. 35.
[2] SCAMMON: *op. cit.*, p. 34.
[3] DUDLEY, PAUL: Philosophical Transactions, xxxiii, 1809, p. 259.

and grew up without parental care, which has caused a slight modification. The most prominent feature is that in its dorsal ridge, near the tail, there are a number of small projections or bunches, having some resemblance to the teeth of a saw. It has no dorsal fin or hump on its back."[1]

Douglass, writing in 1748, also mentioned the Scrag and the humps upon its body.

Cope has formed for this whale the genus *Agaphelus*, and it stands in the lists under the name *Agaphelus gibbosus* [Erxl.] Cope.

The Scrag is of special interest on account of its influence in first developing the whaling industries of Nantucket. Macy, the historian of the island, states that in the very early days of that colony, prior to 1672, "A whale of the kind called the Scragg came into the harbor and continued there three days. This excited the curiosity of the people and led them to devise measures to prevent his return out of the harbor. They accordingly invented and caused to be wrought for them a harpoon with which they attacked and killed the whale. This first success encouraged them to undertake whaling as a permanent business; whales being at that time numerous in the vicinity of the shores."[2]

Scammon remarks: "Our observations make it certain that there is a 'Scrag' Right Whale in the North Pacific which corresponds very nearly to that of the Southern Ocean, - - - and which yields a paltry amount of oil."[3] No identification of this form has yet been made. Dieffenbach states that in the southern seas "Scrags" is the whalers' name for the young of the right whale.[4]

16. THE CALIFORNIA GRAY WHALE.

DISTRIBUTION.—The California Gray Whale, *Rhachianectes glaucus* Cope, called by whalemen "Devil-fish," "Hard Head," "Gray Back," "Rip Sack," and "Mussel Digger," though long known to fishermen, was first described in 1869, from specimens brought to the United States National Museum by Capt. W. H. Dall, of the United States Coast Survey. The only account of its habits is in Scammon's book, already often quoted. Its range is from the Arctic Seas to Lower California. From November to May it is found on the California coast, while in summer it resorts to the Arctic Ocean and the Okhotsk Sea. In October and November it is seen off Oregon and Upper California, returning to warm water for the winter.

HABITS.—They follow close along the shore, often passing through the kelp, and congregate in the lagoons of the southern coast, where they are the objects of the extensive lagoon or bay whale fishery.

ABUNDANCE.—Their abundance in former years and at present was thus discussed by Captain Scammon in 1874: "It has been estimated, approximately, by observing men among the shore whaling parties that a thousand whales passed southward daily from the 15th of December to the 1st of February, for several successive seasons after shore whaling was established, which occurred in 1851. Captain Packard, who has been engaged in the business for over twenty years, thinks this a low estimate. Accepting this number without allowing for those which passed off shore out of sight from the land, or for those which passed before the 15th of December, and after the 1st of February, the aggregate would be increased to 47,000. Captain Packard also states that at the present time the average number seen from the stations passing daily would not exceed forty. From our own observation upon the coast, we are inclined to believe that the numbers resorting annually to the coast of California from 1853 to 1856 did not exceed 40,000—probably not over 30,000; and at the present time there are many which pass off shore at so great a distance as to

[1] ALLEN: Mammalia of Massachusetts. <Bulletin of the Museum of Comparative Zoology, 8, p. 203.
[2] MACY: History of Nantucket, p. 28.
[3] SCAMMON: *loc. cit.*, p. 67.
[4] DIEFFENBACH, E.: Travels in New Zealand, i, 1843, p. 45.

be invisible from the lookout stations; there are probably between 100 and 200 whales going southward daily from the beginning to the end of the 'down season' (from December 15 to February 1). The estimate of the annual herd visiting the coast is probably not large, as there is no allowance made for those that migrate earlier and later in the season. From what data we have been able to obtain, the whole number of California Gray Whales which have been captured or destroyed since the bay whaling commenced in 1846 would not exceed 10,800, and the number which now periodically visits the coast does not exceed 8,000 or 10,000."[1]

On another page he writes: "None of our whales are so constantly and variously pursued as this; and the large bays and lagoons where these mammals once congregated, brought forth and nurtured their young, are already nearly deserted. The mammoth bones of the California Gray lie bleaching on the shores of these silvery waters, and are scattered along the broken coasts from Siberia to the Gulf of California; and ere long, it may be questioned whether this mammal will not be numbered among the extinct species of the Pacific."[2]

SIZE.—The male attains the average length of thirty-five feet, while the female grows to forty or more. A female forty-four feet long and twenty-two feet in circumference is considered large, though some still greater have been caught, yielding sixty or seventy barrels of oil. The average yield of the male is twenty to twenty-five barrels. The baleen is light brown or nearly white, coarse-grained, with a heavy, uneven fringe, the longest strips measuring from fourteen to sixteen inches. The blubber is solid and tough, reddish in color, and from six to ten inches thick.

FOOD AND REPRODUCTION.—The nature of the food of the California Gray Whale is not satisfactorily known, though it is reasonable to suppose that it consists of surface animals, strained out by the baleen.

They breed in the winter, the females entering the California lagoons, while the males remain outside. To their disturbance on their breeding grounds may be attributed the great diminution in numbers. The period of gestation is about a year. After the young are born, male and female and calf are seen working northward together, and Scammon thinks that they bear young only once in two years.

CAPTURE.—The habit of frequenting shoal bays is peculiar to this one species. They are often seen among the breakers, where they are tossed about by the groundswell, and where the water is hardly deep enough to float them. The pursuit of this whale is very dangerous, owing to their savage disposition and the shoalness of the water into which they are followed. The Eskimos and Indians of the Northwest kill many, using their flesh for food and their skins for clothing.

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[1] SCAMMON: *op. cit.*, p. 23.
[2] SCAMMON: *op. cit.*, p. 33.

B.—THE SEALS AND WALRUSES.

NOTE.—The following biographies of the Seals and Walruses are, by the permission of the author, J. A. Allen, extracted from the "Monograph of the Pinnipeds of North America." It is considered important to present in this Report, in a form convenient for reference, biographies of all the important aquatic animals of the United States; and since it is manifestly impossible to secure from any other source so complete and reliable a discussion of the Seals as that given by Allen, it has been thought allowable to reprint the biographical portion of his monograph. The material is here published in such a different form, being divested of the great mass of technical matter, interesting chiefly to zoologists, with which it was originally surrounded, that it is to all intents a fresh presentation of the subject.

The Biography of the Walruses has been condensed and rewritten by Mr. Goode, during the ill-health and absence of Mr. Allen, the discussions in the monograph being too extended for the needs of this Report. For an exceedingly interesting biography of these most interesting animals the reader is referred to Mr. Allen's more detailed work.[1]

17. THE SEAL TRIBE IN GENERAL.

The Pinnipeds, or *Pinnipedia*, embracing the Seals and Walruses, are commonly recognized by recent systematic writers as constituting a suborder of the order *Fera*, or Carnivorous Mammals. They are, in short, true *Carnivora*, modified for an aquatic existence, and have consequently been sometimes termed "*Amphibious Carnivora*." Their whole form is modified for life in the water, which element is their true home. Here they display extreme activity, but on land their movements are confined and labored.

The existing Pinnipeds constitute three very distinct minor groups or families, differing quite widely from each other in important characters: these are the Walruses, or *Odobænidæ*, the Eared Seals, or *Otariidæ*, and the Earless Seals, or *Phocidæ*. The first two are far more nearly allied than are either of these with the third, so that the *Odobænidæ* and *Otariidæ* may be together contrasted with the *Phocidæ*. The last named is the lowest or most generalized group, while the others appear to stand on nearly the same plane, and about equally remote from the *Phocidæ*. The Walruses are really little more than thick, clumsy, obese forms of the otarian type, with the canines enormously developed, and the whole skull correlatively modified. The limb-structure, the mode of life, and the whole economy are essentially the same in the two groups, and aside from the cranial modifications presented by the *Odobænidæ*, which are obviously related to the development of the canines as huge tusks, the Walruses are merely elephantine Otariids, the absence or presence of an external ear being in reality a feature of minor importance.

The Pinnipeds present a high degree of cerebral development, and are easily domesticated under favorable conditions. They manifest strong social and parental affection, and defend their young with great persistency and courage. They are carnivorous (almost without exception), subsisting upon fishes, mollusks, and crustaceans, of which they consume enormous quantities. The Walruses and Eared Seals are polygamous, and the males greatly exceed the females in size. The ordinary or Earless Seals are commonly supposed to be monogamous, and there is generally little difference in the size of the sexes. The Walruses and Eared Seals usually resort in large numbers to certain favorite breeding grounds, and during the season of reproduction leave the water, and pass a considerable period upon land. The Earless Seals, on the other hand, with the exception of the Sea Elephants, do not so uniformly resort to particular breeding grounds on land,

[1] 1880. ALLEN, JOEL ASAPH: History of North American Pinnipeds; a monograph of the Walruses, Sea Lions, Sea Bears, and Seals of North America. Washington, Government Printing Office, 1880, 800 pp., xvi, 785. Miscellaneous publications, No. 12, U. S. Geol. & Geog. Surv., F. V. Hayden, Geologist in charge.

and leave the water only for very short intervals. They usually bring forth their young on the ice, most of the species being confined to the colder latitudes. Only one of the various species of the *Pinnipedia* appears to be strictly tropical, and very few of them range into tropical waters. As a group, the Pinnipeds are distinctively characteristic of the arctic, antarctic, and temperate portions of the globe, several of the genera being strictly arctic or subarctic in their distribution. The Walruses are at present confined mainly within the Arctic Circle, and have no representatives south of the colder portions of the Northern Hemisphere. The *Otariidæ* and *Phocidæ*, on the other hand, are abundantly represented on both sides of the Equator, as will be noticed more in detail later.

18. THE WALRUSES.

Discussion of the Atlantic and Pacific species.—There are two species of Walrus, that of the Atlantic, *Odobænus rosmarus* Malmgren, and that of the Pacific, *O. obesus* (Illiger) Allen. These animals are found only in the extreme north, and it was for many years commonly supposed that there was but a single circumpolar species. Mr. Allen has confirmed the views of Pennant, expressed in 1792 and emphasized since 1870 by Elliott and Gill. Their differences are thus described:

The Pacific Walrus is similar in size, and probably in general contour, to that of the Atlantic (though possibly rather larger, and commonly described or depicted as more robust or thicker at the shoulders), but quite different in its facial outlines. The tusks are longer and thinner, generally more convergent, with much greater inward curvatures, the bristles upon the muzzle shorter and smaller. The chief external difference appears to consist in the shape of the muzzle and the size and form of the bristly nose-pad, which has a vertical breadth at least one-fourth greater than in the Atlantic species. Very important differences between the two species are exhibited in the skulls, which are fully described in Mr. Allen's book.

Distribution of the Atlantic Walrus.—The Atlantic Walrus is not now to be found within the limits of the United States, nor has it been within historic time, or during the last three hundred and fifty years, though, like the musk ox, the caribou, and the moose, it ranged during the great Ice Period much beyond the southern limit of its boundary at the time the eastern coast of North America was first visited by Europeans. During the last half of the sixteenth century they are known to have frequented the southern coast of Nova Scotia as well as the shores and islands to the northward, but this appears at that time to have been their southern limit of distribution, and to these islands New England vessels seem occasionally to have resorted to kill them for their teeth and oil.[1] In 1775 they were abundant in the Gulf of Saint Lawrence, at the Magdalen Islands, Saint John's, and Anticosti, where they congregated yearly to the number of seven or eight thousand, and where they were soon exterminated by the "Americans."[2]

In 1866 and 1869 Packard and Gilpin recorded the killing of individuals near the Straits of Belle Isle, and in 1868 one was driven ashore in Saint George Bay, Newfoundland. The last seen in the Gulf of Saint Lawrence was, according to Professor Packard, in 1841, when one was killed at Saint Augustine, Labrador. Dr. Bernard Gilpin speaks of the occurrence of their bones at Miscou, on the Bay of Chaleur, in such numbers as to form artificial sea-beaches. These were, doubtless, victims of "the Royal Company of Miscou," founded during the earlier part of the seven-

[1] A vessel that returned at that time (1641) from the Isles of Sables made a better voyage, bringing four hundred pair of Sea-horse teeth with divers tun of oil, besides much other goods of like sort which they left behind, worth £1500.—Hubbard's History of New England from the discovery to 1648, p. 379.

The Sea-Cow or Morse is plenty upon the coasts of Nova-Scotia and the Gulph of St. Laurence, particularly at the island of St. John's; it is of the bigness of a middling cow (it is not the same with the Manatee of the Gulph of Mexico), a very thick skin with hair like that of a seal.—Douglass' North America, 1755.

[2] Meaning, of course, people from the southern colonies.

teenth century by the King of France, and whose ephemeral city of New Rochelle has passed away, leaving no sign. The murdered Sea-horses have left a more enduring monument than their murderers. At the present time its distribution in the Western Atlantic seems to be limited on the south by the parallel of latitude 65°, and on the west along the arctic coast by the ninety-seventh meridian of longitude. It inhabits the shore of Hudson's Bay, Davis's Strait, and Greenland, ranging north to Repulse Bay and Prince Regent Inlet. In the Old World it is found only about the islands and in the icy seas of Eastern Europe and the neighboring waters of Western Asia. It has rarely been met with to the eastward of the Jenisei (longitude 82° E.), and has not been seen eastward of the one hundred and thirtieth meridian. As lately as 1857 a straggler was seen at Orkney and another in Nor' Isles. The distribution of this species has been thus carefully noted because its destruction has been participated in, and the time of its extermination doubtless to some extent hastened, by the efforts of American whalemen.

The Walrus is the Morse or Sea-horse of ancient writers, many quaint extracts from whom, with reproductions of their figures, are given by Mr. Allen.

Distribution of the Pacific Walrus.—While the Atlantic Walrus has been familiar to our race since A. D. 871, when the Norman explorer Othere brought tusks of the "Horsewhale" from the Arctic Sea to King Alfred of England, that of the Pacific was not discovered until 1648, when the Cossack adventurer Staduchin found its tusks on the arctic coast of Eastern Asia; nor was it fairly known until the time of Steller, Cook, Kotzebue, and Pallas, in the latter half of the eighteenth century. Its range is comparatively narrow, being confined on the one hand to a comparatively small stretch of the northern and eastern coasts of Asia, and to a still smaller portion of the opposite American coast. To the westward the Walrus appears not to have been traced beyond Cape Schelatskoi (157° 30′ east longitude), and to have occurred in large herds only as far west as Koljutschin Island (150° east longitude). On the eastern coast of Asia, as early as 1742, none had been seen south of latitude 60°, and of course their southern range in that direction is now still more limited. In the Arctic Sea, north of Bering Strait, they have been met with as far north as ships have penetrated, their westward range being limited only by the unbroken ice sheet. On the American coast they have been traced eastward only as far as Point Barrow. They were formerly abundant about the islands in Bering Sea, but there is no evidence that they ever ranged as far south as the outermost islands in the Aleutian chain. On the mainland they were found by Cook, at Bristol Bay, latitude 58° 42′, where now, according to Elliott, they are more numerous than at any point south of the Arctic Circle. Their immense destruction, chiefly by American whalers, renders it probable that before long they will be entirely exterminated in the territory of the United States.

Size.—The length of a full-grown male Atlantic Walrus is given by Dr. Gilpin at twelve feet three inches, its weight being estimated at 2,250 pounds, while Elliott gives the length of a similar Alaska specimen at twelve to thirteen feet, its girth ten to fourteen feet, and its weight 2,000 pounds, the skin alone weighing from 250 to 400, the head from 60 to 80 pounds.

Habits.—The Walruses are at all times more or less gregarious, occurring generally in large or small companies, according to their abundance. Like the Seals, they are restricted in their wanderings to the neighborhood of shores or large masses of floating ice, being rarely seen far out in the open sea. Although moving from one portion of their feeding ground to another, they are said to be in no sense a migrating animal. They delight in huddling together on the ice floes, or on shore, to which places they resort to bask in the sun, pressing one against another like so many swine. They are also said to repair in large herds to favorable shores or islands, usually in May and June, to give birth to their young, at which times they sometimes remain constantly on land

for two weeks together, without ever taking food. They are believed to be monogamous, and to bring forth usually but a single young at a time, and never more than two. The period of gestation is commonly believed to be about nine months. The young are born from April to June, the time probably varying with the latitude. The Walrus, like the common Seal, is said to have its breathing hole in the ice. The tusks appear to be used for two purposes, to aid in landing upon icy and rocky shores, and in aid of their clumsy locomotion, and also in digging up the shell-fish and roots of marine plants upon which they feed. Their voice is a loud roaring or "hucking," and the voices of a herd may be distinguished at the distance of several miles. Although savage in appearance, they are inoffensive and harmless, except when attacked, but when enraged are fierce and vindictive, especially in defense of their young, for which they exhibit much affection. They are wary and shy, however, and difficult to approach except under cover of darkness.

The hide, the oil, and the tusks of the Walrus are of commercial value, and the walrus fishery of the Pacific is of considerable importance.

"In looking at this uncouth animal," writes a contributor to 'Scribner's Monthly Magazine,' "the most natural question at once arises, What earthly service can such an ungainly, stupid beast render? What, indeed, is the use of its existence? But the answer is swift and satisfactory: were it not for the subsistence furnished so largely by the flesh and oil of the Morse, it is exceedingly doubtful whether the Esquimaux of North America, from Bering Strait clear around to Labrador, could manage to live. It is not to be inferred that walrus meat is the sole diet of these simple people, for that is very wide of the truth; but there are several months of every year when the exigencies of the climate render it absolutely impossible for the hardiest native to go out and procure food, and then the value of the *cache* of walrus meat is appreciated, when for weeks and weeks it forms the beginning and end of every meal. The Walrus responds to as many demands of the Innuit as the camel of the Arab, or the cocoa-palm of the South Sea Islander. Its flesh feeds him; its oil illuminates and warms his dark hut; its sinews make his bird-nets; its tough skin, skillfully stretched over the light wooden frame, constitutes his famous kayak, and the serviceable oomiak, or bidarrah; its intestines are converted into water-proof clothing, while the soles to its flippers are transferred to his feet; and, finally, its ivory is a source of endless utility to him in domestic use and in trade and barter. Walrus famines among the Esquimaux have been recorded in pathetic legends by almost all of the savage settlements in the arctic. Even now, as I write (November, 1880), comes the authentic corroboration of the harsh rumor of the starvation of the inhabitants of Saint Lawrence Island—those people who live just midway between the Old World and the New, in Alaskan waters. The winter of 1879–'80 was one of exceptional rigor in the arctic, though in this country it was unusually mild and open. The ice closed in solid around Saint Lawrence Island, so firm and unshaken by the mighty powers of wind and tide that the Walrus were driven far to the southward and eastward, out of reach of the unhappy inhabitants of that island, who, thus unexpectedly deprived of their mainstay and support, seem to have miserably starved to death, with the exception of one small village on the north shore. The residents of the Poonook, Poogovellyak, and Kagallegak settlements perished, to a soul, from hunger—nearly 300 men, women, and children. I was among these people in 1874, during the month of August, and remarked their manifold superiority over the savages of the northwest coast and the great plains. They seemed then to live, during nine months of the year, almost wholly upon the flesh and oil of the Walrus. Clean-limbed, bright-eyed, and jovial, they profoundly impressed one with their happy subsistence and reliance upon the walrus herds of Bering Sea; and it was remarked then that these people had never been subjected to the temptation, and subsequent sorrow, of putting their trust in princes; hence their independence and good heart. But now it appears that it will not suffice, either, to put your trust in Walrus."

19. THE SEA LIONS AND FUR SEALS IN GENERAL.

GENERAL CHARACTERS.—The largest species of the Otaries (genera *Otaria* and *Eumetopias*) are Hair Seals, while the smallest (genera *Callorhinus* and *Arctocephalus*) are Fur Seals; but the species of *Zalophus*, although Hair Seals, are intermediate in size between the other Hair Seals and the Fur Seals. All the Hair Seals have coarse, hard, stiff hair, varying in length with age and season, and are wholly without soft underfur. All the Fur Seals have an abundant soft, silky underfur, giving to the skins of the females and younger males great value as articles of commerce. The longer, coarser overhair varies in length and abundance with season and age. All the Hair Seals are yellowish or reddish brown (in *Zalophus* sometimes brownish-black), generally darkest when young, and becoming lighter with age, and also in the same individuals toward the molting season. There is also considerable range of individual variation in representatives of the same species, so that coloration alone fails to afford satisfactory diagnostic characters. All the Fur Seals are black when young, but they become lighter with age, through an abundant admixture of grayish hairs which vary from yellowish-gray to whitish-gray. The southern Fur Seals are generally, when adult, much grayer than the northern. *There is hence a wide range of color variation with age in* the same species, as there is also among conspecific individuals of the same sex and age. While some have the breast and sides pale yellowish-gray, others have these parts strongly rufous, the general tint also showing to some extent these differences.

There is also a wonderful disparity in size between the sexes, the weight of the adult males being generally three to five times that of the adult females of the same species. There are also very great differences in the form of the skull, especially in respect to the development of crests and protuberances for muscular attachment, these being only slightly developed in females and enormously so in the males. With such remarkable variations in color and cranial characters, dependent *upon age and sex, it is not a matter of surprise that many nominal species have arisen* through a misappreciation of the real significance of these differences.

HABITS.—The Eared Seals show also a remarkable resemblance in their gregarious and polygamous habits. All the species, wherever occurring, like the Walruses and Sea Elephants, resort in great numbers to particular breeding stations, which, in sealers' *parlance*, have acquired the strangely inappropriate name of "rookeries." The older males arrive first at the breeding grounds, where they immediately select their stations and await the arrival of the females. They keep up a perpetual warfare for their favorite sites, and afterward in defense of their harems. The number of females acquired by the successful males varies from a dozen to fifteen or more, which they guard with the utmost jealousy—might being with them the law of right. The strongest males are naturally the most successful in gathering about them large harems. The males, during the breeding season, remain wholly on land, and they will suffer death rather than leave their chosen spot. They thus sustain, for a period of several weeks, an uninterrupted fast. They arrive at the breeding stations fat and vigorous, and leave them weak and emaciated, having been nourished through their long period of fasting wholly by the fat of their own bodies. The females remain uninterruptedly on land for a much shorter period, but for a considerable time after their arrival do not leave the harems. The detailed account given a century ago by Steller, and recently confirmed by Bryant and Elliott, of the habits of the northern Fur and Hair Seals during the breeding season, is well known to apply, in greater or less detail, to nearly all the species of the family, and presumably to all. As the observations by Messrs. Elliott and Bryant are presented later in this work at length, it is unnecessary to give further details in the present connection.

GEOGRAPHICAL DISTRIBUTION.—The most striking fact in respect to the distribution of the *Otariidæ* is their entire absence from the waters of the North Atlantic.

As already noticed, the Eared Seals are obviously divisible, by the character of the pelage, into two groups, which are commercially distinguished as the "Hair Seals" and the "Fur Seals," which are likewise respectively known as the "Sea Lions" and the "Sea Bears." The two groups have nearly the same geographical distribution, and are commonly found frequenting the same shores, but generally living apart. Usually only one species of each is met with at the same localities, and it is worthy of note that, with the exception of the coast of California, no naturalist has ever reported the occurrence together of two species of Hair Seals or two species of Fur Seals, although doubtless two species of Hair Seals exist on the islands and shores of Tasmania and Australia, as well as on the Californian coast.

The Hair and Fur Seals are about equally and similarly represented on both sides of the Equator, but they are confined almost wholly to the temperate and colder latitudes. Of the nine species provisionally above recognized, two of the five Hair Seals are northern and three southern; of the four Fur Seals, three are southern and one only is northern; but the three southern are closely related (perhaps doubtfully distinct, at least two of them), and are evidently recent and but slightly differentiated forms of a common ancestral stock. Of the two Eared Seals of largest size (*Eumetopias Stelleri* and *Otaria jubata*), one is northern and the other southern, and, though differing generically in the structure of the skull, are very similar in external characters, and geographically are strictly representative. *Zalophus* is the only genus occurring on both sides of the Equator, but the species are different in the two hemispheres. The Fur Seals of the north are the strict geographical representatives of those of the south. *Phocarctos Hookeri* is Australasian, and has no corresponding form in the Northern Hemisphere. No species of Eared Seal is known from the North Atlantic. Several of the southern species range northward into the equatorial regions, reaching the Galapagos Islands and the northern shores of Australia.

THE DISTRIBUTION OF THE FUR SEALS IN THE SOUTHERN SEAS.—They occur not only on both the Atlantic and Pacific coasts of the South American continent, about its southern extremity, and on all the outlying islands, including not only the Falklands, the South Shetland and South Georgian, but at other small islands more to the eastward, at Prince Edward's, the Crozets, Kerguelen, Saint Paul, and Amsterdam, the southern and western shores of Australia, Tasmania, New Zealand, and at the numerous smaller islands south of the two last named. They have been found, in fact, at all the islands making up the chain of pelagic islets stretching somewhat interruptedly from Cape Horn and the Falkland Islands eastward to Australia and New Zealand, including among others those south of the Cape of Good Hope, so famous in the annals of the seal-fishery. It has been stated by Gray and others that the Cape of Good Hope Fur Seals (really those of the Crozets and neighboring islands) are far inferior in commercial value to those of other regions; but in tracing the history of the sealing business I have failed to notice any reference to the inferior quality of those from the last-named locality, or that there has been any difference in the commercial value of the fur seal skins obtained at different localities in the Southern Seas. The quality differs at the same locality, wherever the Fur Seals are found, with the season of the year and age of the animals, so that skins may come not only from the Cape of Good Hope, but from any other of the sealing places, that one "might feel convinced could not be dressed as furs," being "without very thick underfur."

20. THE SEA LION.

GEOGRAPHICAL DISTRIBUTION.—The known range of this species, *Eumetopias Stelleri* (Lesson) Peters, extends along the west coast of North America from the Farallone Islands, in latitude 37° 40′ north, to the Pribylov Islands. Its northern limit of distribution is not definitely known, but

it does not appear to have been met with north of about the latitude of Saint Matthew's Island (about latitude 61°). Neither Mr. W. H. Dall nor Mr. H. W. Elliott has met with it above this point, and they have both informed me that they have no reason to suppose it extends any further northward or beyond the southern limit of floating ice. According to Steller, it existed in his time along the whole eastern coast of Kamtchatka and southward to the Kurile Islands. He found it abundant on Bering's and Copper Islands, where it is still well known to exist. If Dr. Gray's *Eumetopias elongatus*, as originally described in 1873 (the same specimen was referred by him in 1872 to *E. Stelleri*), be referable, as I believe, to the female of *E. Stelleri*, the range of this species appears to extend southward on the Asiatic coast as far as Japan.

Although the Sea Lions of the California coast that have of late years attracted so much attention appear to be the smaller species, *Zalophus Californianus*, the occurrence of the present species there is also fully established, where it is resident the whole year, and where it brings forth its young, as proven by specimens transmitted some years since by Dr. Ayres to the Smithsonian Institution.

GENERAL HISTORY.—The Northern Sea Lion was first described in 1751 by Steller, who, under the name of *Leo marinus*, gave a somewhat detailed account of its habits and its geographical range, so far as known to him.

Captain Scammon, in 1874, published a very interesting account of the Sea Lions of the Aleutian Islands, particularly as respects the methods employed in their capture, portions of which will be quoted later. His account is devoted largely, however, to the Sea Lions of the California coast, and certainly includes the history of the smaller species, if in fact this part does not relate mainly to the latter. About the same time appeared Mr. H. W. Elliott's more detailed history of the northern species, which is so full and explicit that I transcribe it almost entire.

The Sea Lion, he says, "has a really leonine appearance and bearing, greatly enhanced by the rich golden-rufous of its coat, ferocity of expression, and bull-dog muzzle and cast of eye, not round and full, but showing the white, or sclerotic coat, with a light, bright-brown iris.

"Although provided with flippers to all external view as the Fur Seal, he cannot, however, make use of them in the same free manner. While the Fur Seal can be driven five or six miles in twenty-four hours, the Sea Lion can barely go two, the conditions of weather and roadway being the same. The Sea Lions balance and swing their long, heavy necks to and fro, with every hitch up behind of their posteriors, which they seldom raise from the ground, drawing them up after the fore feet with a slide over the grass or sand, rocks, &c., as the case may be, and pausing frequently to take a sullen and ferocious survey of the field and the drivers.

"The Sea Lion is polygamous, but does not maintain any such regular system and method in preparing for and attention to its harem like that so finely illustrated on the breeding-grounds of the Fur Seal. It is not numerous, comparatively speaking, and does not 'haul' more than a few rods back from the sea. It cannot be visited and inspected by man, being so shy and wary that on the slightest approach a stampede into the water is the certain result. The males come out and locate on the narrow belts of rookery ground, preferred and selected by them; the cows make their appearance three or four weeks after them (1st to 6th June), and are not subjected to that intense jealous supervision so characteristic of the Fur Seal harem. The bulls fight savagely among themselves, and turn off from the breeding ground all the younger and weak males.

"The cow Sea Lion is not quite half the size of the male, and will measure from eight to nine feet in length, with a weight of four and five hundred pounds. She has the same general cast of countenance and build of the bull, but as she does not sustain any fasting period of over a week or ten days, she never comes out so grossly fat as the male or 'see-catch.'

"The Sea Lion rookery will be found to consist of about ten to fifteen cows to the bull. The cow seems at all times to have the utmost freedom in moving from place to place, and to start with its young, picked up sometimes by the nape, into the water, and play together for spells in the surf-wash, a movement on the part of the mother never made by the Fur Seal, and showing, in this respect, much more attention to its offspring.

"They are divided up into classes, which sustain, in a general manner, but very imperfectly, nearly the same relation one to the other as do those of the Fur Seal, of which I have already spoken at length and in detail; but they cannot be approached, inspected, and managed like the other, by reason of their wild and timid nature. They visit the islands in numbers comparatively small (I can only estimate), not over twenty or twenty-five thousand on Saint Paul and contiguous islets, and not more than seven or eight thousand at Saint George. On Saint Paul Island they occupy a small portion of the breeding ground at Northeast Point, in common with the *Callorhinus*, always close to the water, and taking to it at the slightest disturbance or alarm.

"The Sea Lion rookery on Saint George Island is the best place upon the Seal Islands for close observation of these animals, and the following note was made upon the occasion of one of my visits (June 15, 1873):

"'At the base of cliffs, over four hundred feet in height, on the east shore of the island, on a beach fifty or sixty feet in width at low water, and not over thirty or forty at flood tide, lies the only Sea Lion rookery on Saint George Island—some three or four thousand cows and bulls. The entire circuit of this rookery belt was passed over by us, the big, timorous bulls rushing off into the water as quickly as the cows, all leaving their young. Many of the females, perhaps half of them, had only just given birth to their young. These pups will weigh at least twenty to twenty-five pounds on an average when born, are of a dark chocolate-brown, with the eye as large as the adult, only being a suffused, watery, gray-blue where the sclerotic coat is well and sharply defined in its maturity. They are about two feet in length, some longer and some smaller. As all the pups seen to-day were very young, some at this instant only born, they were dull and apathetic, not seeming to notice us much. There are, I should say, about one-sixth of the Sea Lions in number on this island, when compared with Saint Paul. As these animals lie here under the cliffs, they cannot be approached and driven; but should they haul a few hundred rods up to the south, then they can be easily captured. They have hauled in this manner always until disturbed in 1868, and will undoubtedly do so again if not molested.

"'These Sea Lions, when they took to the water, swam out to a distance of fifty yards or so, and huddled all up together in two or three packs or squads of about five hundred each, holding their heads and necks up high out of water, all roaring in concert and incessantly, making such a deafening noise that we could scarcely hear ourselves in conversation at a distance from them of over a hundred yards. This roaring of Sea Lions, thus disturbed, can only be compared to the hoarse sound of a tempest as it howls through the rigging of a ship, or the playing of a living gale upon the bare branches, limbs, and trunks of a forest grove.' They commenced to return as soon as we left the ground.

"The voice of the Sea Lion is a deep, grand roar, and does not have the flexibility of the *Callorhinus*, being confined to a low, muttering growl or this bass roar. The pups are very playful, but are almost always silent. When they do utter sound, it is a sharp, short, querulous growling.

"The natives have a very high appreciation of the Sea Lion, or *see-vitchie*, as they call it, and base this regard upon the superior quality of the flesh, fat, and hide (for making covers for their skin boats, *bidarkies* and *bidarrahs*), sinews, intestines, &c.

"As I have before said, the Sea Lion seldom hauls back far from the water, generally very

close to the surf-margin, and in this position it becomes quite a difficult task for the natives to approach and get in between it and the sea unobserved, for, unless this silent approach is made, the beast will at once take the alarm and bolt into the water.

"By reference to my map of Saint Paul's, a small point, near the head of the northeast neck of the island, will be seen, upon which quite a large number of Sea Lions are always to be found, as it is never disturbed except on the occasion of this annual driving. The natives step down on to the beach, in the little bight just above it, and begin to crawl on all fours flat on the sand down to the end of the neck and in between the dozing sea-lion herd and the water, always selecting a semi-bright moonlight night. If the wind is favorable, and none of the men meet with an accident, the natives will almost always succeed in reaching the point unobserved, when, at a given signal, they all jump on their feet at once, yell, brandish their arms, and give a sudden start, or alarm, to the herd above them, for, just as the Sea Lions move, upon the first impulse of surprise, so they keep on. For instance, if the animals on starting up are sleeping with their heads pointed in the direction of the water, they keep straight on toward it; but if they jump up looking over the land, they follow that course just as desperately, and nothing turns them, *at first*, either one way or the other. Those that go for the water are, of course, lost, but the natives follow the land-leaders and keep urging them on, and soon have them in their control, driving them back into a small pen, which they extemporize by means of little stakes, with flags, set around a circuit of a few hundred square feet, and where they keep them until three or four hundred, at least, are captured, before they commence their drive of ten miles overland down south to the village.

"The natives, latterly, getting in this annual herd of Sea Lions, have postponed it until late in the fall, and when the animals are scant in number and the old bulls poor. This they were obliged to do, on account of the pressure of their sealing business in the spring, and the warmth of the season in August and September, which makes the driving very tedious. In this way I have not been permitted to behold the best-conditioned drives, *i. e.*, those in which a majority of the herd is made up of fine, enormously fat, and heavy bulls, some four or five hundred in number.

"The natives are compelled to go to the northeast point of the island for the animals, inasmuch as it is the only place with natural advantages where they can be approached for the purpose of capturing alive. Here they congregate in greatest number, although they can be found, two or three thousand of them, on the southwest point, and as many more on 'Seevitchie Cummin' and Otter Island.

"Capturing the Sea Lion drive is really the only serious business these people on the islands have, and when they set out for the task the picked men only leave the village. At Northeast Point they have a barrabkie, in which they sleep and eat while gathering the drove, the time of getting which depends upon the weather, wind, &c. As the squads are captured, night after night, they are driven up close by the barrabkie, where the natives mount constant guard over them until several hundred animals shall have been secured and all is ready for the drive down overland to the village.

"The drove is started and conducted in the same general manner as that which I have detailed in speaking of the Fur Seal, only the Sea Lion soon becomes very sullen and unwilling to move, requiring spells of frequent rest. It cannot pick itself up from the ground and shamble off on a loping gallop for a few hundred yards, like the *Callorhinus*, and is not near so free and agile in its movements on land, or in the water for that matter, for I have never seen the *Eumetopias* leap from the water like a dolphin, or indulge in the thousand and one submarine acrobatic displays made constantly by the Fur Seal.

"This ground, over which the Sea Lions are driven, is mostly a rolling level, thickly grassed and mossed over, with here and there a fresh-water pond into which the animals plunge with great apparent satisfaction, seeming to cool themselves, and out of which the natives have no trouble in driving them. The distance between the sea-lion pen at Northeast Point and the village is about ten miles, as the Sea Lions are driven, and occupies over five or six days under the most favorable circumstances, such as wet, cold weather; and when a little warmer, or as in July or August, a few seasons ago, they were some three weeks coming down with a drove, and even then left a *hundred or so along on the road.*

"After the drove has been brought into the village on the killing-grounds, the natives shoot down the bulls and then surround and huddle up the cows, spearing them just behind the fore flippers. The killing of the Sea Lions is quite an exciting spectacle, a strange and unparalleled exhibition of its kind. . . . The bodies are at once stripped of their hides and much of the flesh, sinews, intestines (with which the native water-proof coats, &c., are made), in conjunction with the throat-linings (*œsophagus*), and the skin of the flippers, which is exceedingly tough and elastic, and used for soles to their boots or '*tarbosars.*'

"As the Sea Lion is without fur, the skin has little or no commercial value; the hair is short, and longest over the nape of the neck, straight, and somewhat coarse, varying in color greatly as the seasons come and go. For instance, when the *Eumetopias* makes his first appearance in the spring, and dries out upon the land, he has a light-brownish, rufous tint, darker shades back and under the fore flippers and on the abdomen; by the expiration of a month or six weeks, 15th June, he will be a bright golden-rufous or ocher, and this is just before shedding, which sets in by the middle of August, or a little earlier. After the new coat has fairly grown, and just before he leaves the island for the season, in November, it will be a light sepia, or vandyke-brown, with deeper shades, almost dark upon the belly. The cows, after shedding, do not color up so dark as the bulls, but when they come back to the land next year they are identically the same in color, so that the eye, in glancing over a sea-lion rookery in June and July, cannot discern any noted dissimilarity of coloring between the bulls and the cows; and also the young males and yearlings appear in the same golden-brown and ocher, with here and there an animal spotted somewhat like a leopard, the yellow, rufous ground predominating, with patches of dark-brown irregularly interspersed. I have never seen any of the old bulls or cows thus mottled, and think very likely it is due to some irregularity in the younger animals during the season of shedding, for I have not noticed it early in the season, and failed to observe it at the close. Many of the old bulls have a grizzled or slightly brindled look during the shedding period, or, that is, from the 10th August up to the 10th or 20th of November. The pups, when born, are of a rich, dark chestnut-brown; this coat they shed in October, and take one much lighter, but still darker than their parents', but not a great deal.

"Although, as I have already indicated, the Sea Lion, in its habit and disposition, approximates *the Fur Seal, yet in no respect does it maintain and enforce the system and regularity found* on the breeding-grounds of the *Callorhinus.* The time of arrival at, stay on, and departure from the island is about the same; but if the winter is an open, mild one, the Sea Lion will be seen frequently all through it, and the natives occasionally shoot them around the island long after the Fur Seals have entirely disappeared for the year. It also does not confine its landing to these Pribylov Islands alone, as the Fur Seal unquestionably does, with reference to our continent, for it has been and is often shot upon the Aleutian Islands and many rocky islets of the northwest coast.

"The Sea Lion in no respect whatever manifests the intelligence and sagacity exhibited by the Fur Seal, and must be rated far below, although next, in natural order. I have no hesitation

in putting this *Eumetopias* of the Pribylov Islands, apart from the Sea Lion common at San Francisco and Santa Barbara, as a distinct animal; and I call attention to the excellent description of the California Sea Lion, made public in the April number for 1872 of the Overland Monthly, by Capt. C. M. Scammon, in which the distinguishing characters, externally, of this animal are well defined, and by which the difference between the *Eumetopias* of Bering Sea and that of the coast of California can at once be seen; and also I notice one more point in which the dissimilarity is marked: the northern Sea Lion never barks or howls like the animal at the Farrallones [*sic*] or Santa Barbara. Young and old, both sexes, from one year and upward, have *only* a deep *bass growl*, and *prolonged, steady roar;* while at San Francisco Sea Lions break out incessantly with a 'honking' bark or howl, and *never roar*.

"I am not to be understood as saying that *all* the Sea Lions met with on the Californian coast are different from *E. Stelleri* of Bering Sea. I am well satisfied that stragglers from the north are down on the Farrallones, but they are not migrating back and forth every season; and I am furthermore certain that not a single animal of the species most common at San Francisco was present among those breeding on the Pribylov Islands in 1872–'73.

"According to the natives of Saint George, some fifty or sixty years ago the *Eumetopias* held almost exclusive possession of the island, being there in great numbers, some two or three hundred thousand; and that, as the Fur Seals were barely permitted to land by these animals, and in no great number, the Russians directed them (the natives) to hunt and worry the Sea Lions off from the island, and the result was that as the Sea Lions left, the Fur Seals came, so that to-day they occupy nearly the same ground covered by the *Eumetopias* alone sixty years ago. This statement is, or seems to be, corroborated by Choris, in his description of the Iles S.-George's et S.-Paul's [*sic*], visited by him fifty years ago;[1] but the account given by Bishop Veniaminov, . . . differs entirely from the above, for by it almost as many Fur Seals were taken on Saint George, during the first years of occupation, as on Saint Paul, and never have been less than one-sixth of the number on the larger island. . . . I am strongly inclined to believe that the island of Saint George never was resorted to in any great numbers by the Fur Seal, and that the Sea Lion was the dominant animal there until disturbed and driven from its breeding-grounds by the people, who sought to encourage the coming of its more valuable relative by so doing, and making room in this way for it.

"The Sea Lion has but little value save to the natives, and is more prized on account of its flesh and skin, by the people living upon the islands and similar positions, than it would be elsewhere. The matter of its preservation and perpetuation should be left entirely to them, and it will be well looked after. It is singular that the fat of the Sea Lion should be so different in characters of taste and smell from that of the Fur Seal, being free from any taint of disagreeable flavor or odor, while the blubber of the latter, although so closely related, is most repugnant. The flesh of the Sea Lion cub is tender, juicy, light-colored, and slightly like veal; in my opinion, quite good. As the animal grows older, the meat is dry, tough, and without flavor."

The food of the Sea Lion is well known to consist, like that of the other species of Eared Seals, of fish, mollusks, and crustaceans, and occasionally birds. As shown by animals kept in confinement, they require an enormous quantity. Captain Scammon states that the daily allowance of a pair kept in Woodward's Gardens, San Francisco, amounted to forty or fifty pounds of fresh fish.

"From fifteen to twenty thousand Sea Lions," says Captain Bryant, "breed annually on the Pribylov or Fur Seal Islands. They do not leave the islands in winter, as do the Fur Seals, to return in spring, but remain during the whole year. They bring forth their young a month earlier

[1] Voyage Pittoresque autour du Monde.

than the Fur Seals, landing during the months of May and June. They advance but little above high tide-mark, and those of all ages land together. The strongest males drive out the weaker and monopolize the females and continue with them till September. They go with them into the water whenever they are disturbed, and also watch over the young. When in the water they swim about the young and keep them together until they have an opportunity to land again. The females also keep near, rushing hither and thither, appearing first on one side and then on the other of the groups of young, constantly uttering a deep, hoarse growl at the intruder whenever they come to the surface. When left undisturbed they all soon land again, preferring to spend the greater portion of their time at this season on the shore. During the breeding season they visit the same parts of the shore as the Fur Seals, but the Sea Lions, by their superior size and strength, crowd out the Seals, the latter passively yielding their places without presuming to offer battle to their formidable visitors. After having been disturbed the Sea Lions continue for some time in a state of unrest, occasionally uttering a low moaning sound, as though greatly distressed. Even after the breeding season they keep close to the shore near the breeding station until the severe weather of January. After this time they are seen only in small groups till the shores are free from snow and ice in the spring."

21. THE CALIFORNIA SEA LION.

GEOGRAPHICAL DISTRIBUTION.—The exact boundaries of the habitat of *Zalophus californianus* cannot at present be given. The only specimens I have seen are from the coast of California and its islands, from San Diego and San Nicholas Island northward to the Bay of San Francisco. Captain Scammon (see *infra*, pp. 301, 302) twice alludes incidentally to its presence "along the Mexican and Californian coasts," and Dr. Veatch states that "Sea Lions" (which he calls "*Otaria jubata*," but which are, almost beyond doubt, the present species) had populous breeding stations *twenty years ago, and doubtless have still, on Cerros or Cedros Island, in about the latitude of* 28½°, off the Lower California coast. Whether they occur southward of this point at the present time I am unable to state, but should infer that such was the case from Scammon's allusion to their capture along the "Mexican" coast. In any case, it appears probable that in Dampier's time they ranged as far south as the Chametly and Tres Marias Islands, respectively in latitudes about 23° and 21°, at which points he saw "Seals" in the year 1686. In describing the Chametly Islands (the most northerly of the two groups mentioned by him under this name), situated off the west coast of Mexico in latitude 23° 11′, he says, "The Bays about the Islands are sometimes visited with Seals; and this was the first place where I had seen any of these Animals, on the North side of the Equator, in these Seas. For the Fish on this sandy Coast lye most in the Lagunes or Salt-Lakes, and Mouths of Rivers; For this being no rocky Coast, where Fish resort most, there seems to be but little Food for the Seals, unless they will venture upon Cat-Fish."[1]

He also met with Seals at the Tres Marias Islands (in latitude "21° 5′"), and consequently two degrees south of the Chametly Islands, in describing one of which islands, named by him St. George's Island, he says: "The Sea is also pretty well stored with Fish, and Turtle or Tortoise, and Seal. This is the second place on this Coast where I did see any Seal: and this place helps to confirm what I have observed, that they are seldom seen but where there is plenty of Fish."[2]

It is of course not certain that the Seals here alluded to are *Zalophus californianus*, since the Sea Elephant of the California coast also occurs at Cedros Island, and probably still further south, the two species having apparently about the same range. If they had been the latter, Dampier would probably have made some allusion to their large size.

[1] A New Voyage round the World, 5th ed., vol. i, 1703, pp. 253, 264.
[2] *Ibid.*, p. 276.

The species of *Zalophus* occurring in Japan has been by some writers considered to be the same as the Californian one; but, though doubtless closely allied, its affinities, as will be noticed later (see *infra*, p. 293), appear to be not as yet satisfactorily determined. As *Zalophus californianus* has not yet been detected on the American coast north of California, its occurrence on the Asiatic coast seems hardly to be expected.

This species has hitherto been believed to be free from any serious complications of synonymy, and to have been first brought to the notice of the scientific world by McBain in 1858. Allen has, however, shown that it was noticed in 1822 by Choris and described by Lesson under the name of *Otaria californiana*.

HABITS.—Several more or less full accounts of the habits of the Californian Sea Lions have been given by different writers, who have, however, failed to distinguish the two species occurring along the Californian coast, and consequently their descriptions are not wholly satisfactory. The large northern species certainly occurs, and rears its young, as far south as the Farallones, but probably exists there only in small numbers, while I have seen no evidence of its presence at Santa Barbara Island. Even Captain Scammon, in his account of the Sea Lions of California, has not distinctly recognized the two species occurring there, and his description doubtless refers in part to both species, but unquestionably relates mainly to the present one.[1] His "Sketch of a sealing season upon Santa Barbara Island," in 1852, presumably relates exclusively to *Zalophus californianus*, but in addition to this I quote a few paragraphs from his general account of "the Sea Lion," since it is the testimony of a trustworthy eye-witness.

"On approaching an island, or point, occupied by a numerous herd," he observes, "one first hears their long, plaintive howlings, as if in distress; but when near them, the sounds become more varied and deafening. The old males roar so loudly as to drown the noise of the heaviest surf among the rocks and caverns, and the younger of both sexes, together with the 'clapmatches,' croak hoarsely, or send forth sounds like the bleating of sheep or the barking of dogs; in fact, their tumultuous utterances are beyond description. A rookery of matured animals presents a ferocious and defiant appearance; but usually at the approach of man they become alarmed, and, if not opposed in their escape, roll, tumble, and sometimes make fearful leaps from high precipitous rocks to hasten their flight. Like all the others of the Seal tribe, they are gregarious, and gather in the largest numbers during the 'pupping season,' which varies in different latitudes. On the California coast it is from May to August, inclusive, and upon the shores of Alaska it is said to be from June to October, during which period the females bring forth their young, nurse them, associate with the valiant males, and both unite in the care of the little ones, keeping a wary guard, and teaching them, by their own parental actions, how to move over the broken, slimy, rock-bound shore, or upon the sandy, pebbly beaches, and to dive and gambol amid the surf and rolling groundswells. At first the pups manifest great aversion to the water, but soon, instinctively, become active and playful in the element; so by the time the season is over, the juvenile creatures disappear with the greater portion of the old ones, only a few of the vast herd remaining at the favorite resorts throughout the year. During the pupping season, both males and females, so far as we could ascertain, take but little if any food, particularly the males, though the females have been observed to leave their charges and go off, apparently in search of subsistence, but they do not venture far from their young ones. That the Sea Lion can go without food for a long time is unquestionable. One of the superintendents of Woodward's Gardens informed me that in

[1] That Captain Scammon confounded the two species of northern Sea Lions is evident not only from his published writings, but from his having transmitted to the National Museum specimens of *Zalophus* from Santa Barbara Island, labeled by him "*Eumetopias Stelleri*."

numerous instances they have received Sea Lions into the aquarium which did not eat a morsel of nourishment during a whole month, and appeared to suffer but little inconvenience from their long fast.

"As the time approaches for their annual assemblage, those returning or coming from abroad are seen near the shores, appearing wild and shy. Soon after, however, the females gather upon the beaches, cliffs, or rocks, when the battles among the old males begin for the supreme control of the harems; these struggles often lasting for days, the fight being kept up until one or both become exhausted, but is renewed again when sufficiently recuperated for another attack; and, really, the attitudes assumed and the passes made at each other, equal the amplification of a professional fencer. The combat lasts until both become disabled or one is driven from the ground, or perhaps both become so reduced that a third party, fresh from his winter migration, drives them from the coveted charge. The vanquished animals then slink off to some retired spot as if disgraced. Nevertheless, at times, two or more will have charge of the same rookery; but in such instances frequent defiant growlings and petty battles occur. So far as we have observed upon the Sea Lions of the California coast, there is but little attachment manifested between the sexes; indeed, much of the Turkish nature is apparent, but the females show some affection for their offspring, yet if alarmed when upon the land, they will instantly desert them and take to the water. The young cubs, on the other hand, are the most fractious and savage little creatures imaginable, especially if awakened from their nearly continuous sleeping; and frequently, when a mother reclines to nurse her single whelp, a swarm of others will perhaps contend for the same favor.

"To give a more detailed and extended account of the Sea Lions we will relate a brief sketch of a sealing season on Santa Barbara Island. It was near the end of May, 1852, when we arrived, and soon after the rookeries of 'clapmatches,' which were scattered around the island, began to augment, and large numbers of huge males made their appearance, belching forth sharp, ugly howls, and leaping out of or darting through the water with surprising velocity, frequently diving outside the rollers, the next moment emerging from the crest of the foaming breakers, and waddling up the beach with head erect, or, with seeming effort, climbing some kelp-fringed rock, to doze in the scorching sunbeams, while others would lie sleeping or playing among the beds of seaweed, with their heads and outstretched limbs above the surface. But a few days elapsed before a general contention with the adult males began for the mastery of the different rookeries, and the victims of the bloody encounter were to be seen on all sides of the island, with torn lips or mutilated limbs and gashed sides, while now and then an unfortunate creature would be met with minus an eye or with the orb forced from its socket, and, together with other wounds, presenting a ghastly appearance. As the time for 'hauling-up' drew near, the island became one mass of animation; every beach, rock, and cliff, where a Seal could find foothold, became its resting-place, while a countless herd of old males capped the summit, and the united clamorings of the vast assemblage could be heard, on a calm day, for miles at sea. The south side of the island is high and precipitous, with a projecting ledge hardly perceptible from the beach below, upon which one immense Sea Lion managed to climb, and there remained for several weeks—until the season was over. How he ascended, or in what manner he retired to the water, was a mystery to our numerous ship's crew, as he came and went in the night; for 'Old Gray,' as named by the sailors, was closely watched in his elevated position during the time the men were engaged at their work.[1]

[1] "Relative to the Sea Lions leaping from giddy heights, an incident occurred at Santa Barbara Island, the last of the season of 1852, which we will here mention. A rookery of about twenty individuals was collected on the brink of a precipitous cliff, at a height at least of sixty feet above the rocks which shelved from the beach below; and our party were sure in their own minds, that, by surprising the animals, we could drive them over the cliff. This was easily accomplished; but to our chagrin, when we arrived at the point below, where we expected to find the huge beasts helplessly mutilated, or killed outright, the last animal of the whole rookery was seen plunging into the sea."

"None but the adult males were captured, which was usually done by shooting them in the ear or near it; for a ball in any other part of the body had no more effect than it would in a Grizzly Bear. Occasionally, however, they are taken with the club and lance, only shooting a few of the masters of the herd. This is easily accomplished with an experienced crew, if there is sufficient ground back from the beach for the animals to retreat. During our stay, an instance occurred, which not only displayed the sagacity of the animals, but also their yielding disposition, when hard pressed in certain situations, as if naturally designed to be slain in numbers equal to the demands of their human pursuers. On the south of Santa Barbara Island was a plateau, elevated less than a hundred feet above the sea, stretching to the brink of a cliff that overhung the shore, and a narrow gorge leading up from the beach, through which the animals crowded to their favorite resting-place. As the sun dipped behind the hills, fifty to a hundred males would congregate upon the spot and there remain until the boats were lowered in the morning, when immediately the whole herd would quietly slip off into the sea and gambol about during the day, returning as they saw the boats again leave the island for the ship. Several unsuccessful attempts had been made to take them; but at last a fresh breeze commenced blowing directly from the shore, and prevented their scenting the hunters, who landed some distance from the rookery, then cautiously advanced, and suddenly yelling, and flourishing muskets, clubs, and lances, rushed up within a few yards of them, while the pleading creatures, with lolling tongues and glaring eyes, were quite overcome with dismay, and remained nearly motionless. At last, two overgrown males broke through the line formed by the men, but they paid the penalty with their lives before reaching the water. A few moments passed, when all hands moved slowly toward the rookery, which as slowly retreated. This maneuver is termed 'turning them,' and, when once accomplished, the disheartened creatures appear to abandon all hope of escape, and resign themselves to their fate. The herd at this time numbered seventy-five, which were soon dispatched, by shooting the largest ones, and clubbing and lancing the others, save one young Sea Lion, which was spared to see whether he would make any resistance by being driven over the hills beyond. The poor creature only moved along through the prickly pears that covered the ground when compelled by his cruel pursuers; and, at last, with an imploring look and writhing in pain, it held out its fin-like arms, which were pierced with thorns, in such a manner as to touch the sympathy of the barbarous sealers, who instantly put the sufferer out of its misery by a stroke of a heavy club. As soon as the animal is killed, the longest spires of its whiskers are pulled out, then it is skinned, and its coating of fat cut in sections from its body and transported to the vessel, where, after being 'minced,' the oil is extracted by boiling. The testes are taken out, and, with the selected spires of whiskers, find a market in China—the former being used medicinally, and the latter for personal ornaments.

"At the close of the season—which lasts about three months, on the California coast—a large majority of the great herds, both males and females, return to the sea, and roam in all directions in quest of food, as but few of them could find sustenance about the waters contiguous to the islands, or points on the mainland, which are their annual resorting places. They live upon fish,[1] mollusks,

[1] THE SEA LIONS DESTRUCTIVE OF FISH.—The Farallone Egg Company, several years ago, attempted to kill the Sea Lions which frequented those barren islands for their oil and skins. They built try works and went to considerable expense, but it was found that the oil obtained from a carcass did not pay for trying it, and the only disposition that could be made of the skins was to sell them to glue factories. The best return they got from the carcass was from bristles or whiskers and the livers. Both of these were sold to Chinamen. The former they make use of to clean their opium pipes, while the latter is chopped up, put into a mixture of alcohol and another fluid, and administered as a radical cure for many acute diseases. The company accordingly gave up the plan of sea-lion hunting, but the effect of their brief warfare upon these animals was to drive vast droves of them over to the rocks about the Cliff House and the neighborhood of the Heads. In consequence of their being protected by law in these localities, they have doubled and trebled in number within the past three years. The Sea Lions are a very expensive luxury. It is probable

crustaceans, and sea-fowls; always with the addition of a few pebbles or smooth stones, some of which are a pound in weight.[1] Their principal feathery food, however, is the penguin in the Southern Hemisphere, and the gulls in the Northern; while the manner in which they decoy and catch the *Gaviota* of the Mexican and California coasts displays no little degree of cunning. When in pursuit the animal dives deeply under water and swims some distance from where it disappeared; then, rising cautiously, it exposes the tip of its nose above the surface, at the same time giving it a rotary motion, like that of a water bug at play. The unwary bird on the wing, seeing the object near by, alights to catch it, while the Sea Lion at the same moment settles beneath the waves, and at one bound, with extended jaws, seizes its screaming prey, and instantly devours it.[2]

"A few years ago great numbers of Sea Lions were taken along the coast of Upper and Lower California, and thousands of barrels of oil obtained. The number of Seals slain exclusively for their oil would appear fabulous, when we realize the fact that it requires on an average, throughout the season, the blubber of three or four Sea Lions to produce a barrel of oil. Their thick, coarse-grained skins were not considered worth preparing for market, in a country where manual labor was so highly valued. At the present time, however, they are valued for glue-stock, and the seal hunters now realize more comparative profit from the hides than from the oil. But while the civilized sealers, plying their vocation along the seaboard of California and Mexico, destroy the *Lobo marino*, for the product of its oil, skin, testes, and whiskers, the simple Aleutians of the Alaska region derive from these animals many of their indispensable articles of domestic use. . . . ."[3]

The whiskers are carefully saved and sent to China, where they are used for cleaning opium pipes; the livers are also used in the Chinese pharmacopœia.

Mr. Elliott, in referring to the differences between the Californian and Alaskan Sea Lions, calls attention to the dissimilarity of their voices. The Northern Sea Lion, he says, "never barks or

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that they consume more fish than are caught in the bay for food, and if they continue to increase in the future as in the past, it will be but a few years before the waters of the bay will be destitute of fish. Formerly these animals seldom came within the Golden Gate, but now it is a very common thing for passengers on the Oakland boats to see their mischievous-looking heads rise from the water with a large fish in the mouth—they give it a shake, bite out a piece, drop it, and then, diving again, catch it, and rising to the surface, take another nibble until it is consumed. It is certain that something should be done to diminish their numbers. If the legislature was to offer a royalty of from 75 cents to $1 per skin, it is thought by many interested in our fish supply that it would be an economical act. As it is now, the Sea Lions are protected by law—no one being allowed to molest or kill one within a mile of the Cliff House. An effort has been made on several occasions to repeal this law, but at the first intimation of anything in that direction, the lobby in Sacramento has been re-enforced by delegations from a certain stratum of society which history tells us has had more or less influence with legislation since the days of Marc Antony. The consequence is, the law is still upon the statute-books, and the Sea Lions continue to increase, while the fish supply proportionately decreases.—San Francisco Call, November 13.

[1] "The enormous quantity of food which would be required to maintain the herd of many thousands, which, in former years, annually assembled at the small island of Santa Barbara, would seem incredible, if they daily obtained the allowance given to a male and female Sea Lion on exhibition at Woodward's Gardens, San Francisco, California, where the keeper informed me that he fed them regularly, every day, forty pounds of fresh fish. . . . ."

[That the destruction of fish by the Sea Lions on the coast of California is very great is indicated by the following item, which recently went the rounds of the newspapers: "In a recent meeting at San Francisco of the Senate Committee on Fisheries, the State Fish Commissioners, and a committee representing the fishermen of the coast, the question as to the destructive performances of the Sea Lions in the harbor was actively discussed. One of the fishermen's representatives said that it was estimated that there were 25,000 Sea Lions within a radius of a few miles, consuming from ten to forty pounds each of fish per day; the Sea Lions were protected while the fishermen were harassed by the game laws. Another witness declared that salmon captured in the Sacramento River often bore the marks of injury from Sea Lions, having barely escaped with life; but it was supposed that the salmon less frequently fell victims to the amphibian than did other fishes that cannot swim as fast."—Country, January 26, 1878.]

[2] [This account appeared originally in Captain Scammon's account of the "Islands off the West Coast of Lower California," in J. Ross Browne's "Resources of the Pacific Slope," second part, p. 130 (1869), and has been quoted by Mr. Gurney in the "Zoölogist" for 1871, p. 2762.]

[3] SCAMMON: Marine Mammalia, pp. 130-135.

howls like the animal at the Farallones or Santa Barbara. Young and old, both sexes, from one year and upward, have *only* a deep *bass growl*, and *prolonged, steady roar;* while at San Francisco Sea Lions break out incessantly with a 'honking' bark or howl, and *never roar*."

The California Sea Lion is now a somewhat well-known animal with the public, various individuals having been at different times on exhibition at the Central Park Menagerie in New York City, and at the Zoölogical Gardens at Philadelphia and Cincinnati, as well as Woodward's Gardens in San Francisco. They have also formed part of the exhibition of different traveling shows, especially that of P. T. Barnum. They have also been carried to Europe, where examples have lived for several years at the Zoölogical Gardens of London, Paris, and elsewhere. Their peculiar "honking" bark, referred to by Mr. Elliott, is hence not unfamiliar to many who have never met with the animal in a state of nature. Their various attitudes and mode of life on the Farallones have also been made familiar to many by the extensive sale of stereoscopic views of the animals and their surroundings. The Sea Lions that have been exhibited in this country all, or nearly all, belong to the present species, although often wrongly labeled "*Eumetopias Stelleri*." The true *E. Stelleri* has, however, at least in one instance, been exhibited in Eastern cities.

22. THE NORTHERN FUR SEAL OR SEA BEAR.

GEOGRAPHICAL DISTRIBUTION AND MIGRATION.—The Fur Seal, *Callorhinus ursinus* (Linné) Gray, is well known to have been formerly abundant on the western coast of North America, as far south as California, but the exact southern limit of its range I have been unable to determine. Captain Scammon speaks of having seen them "on one of the San Benito Islands, on the coast of Lower California," and again says, "On the coast of California many beaches were found fronting gullies, where [Fur] Seals in large numbers formerly gathered; and, as they there had plenty of ground to retreat upon, the sealers sometimes drove them far enough back to make sure of the whole herd, or that portion of them the skins of which were desirable."[1] He also states that the "Fur Seal and Sea Elephant once made the shores [of Guadalupe Island] a favorite resorting place," and refers to their former occurrence on Cedros Island, in latitude 28°.[2] Although at one time abundant on the California coast, they are by no means numerous there now, having been nearly exterminated by unrestricted destruction by the sealers. The writer above cited refers also to their capture by the Indians at the mouth of the Strait of Juan de Fuca. The Seals appear here and on the neighboring coast, he adds, "some years as early as the first of March, and more or less remain till July or August; but they are most plentiful in April and May. During these two months the Indians devote nearly all their time to sealing when the weather will permit." He reports their increase there in later years, and that while only a few dozens were annually taken there from 1843 to 1864, fully five thousand were taken in 1869.[3] Captain Bryant has given a similar report, referring especially to their abundance along the coasts of Oregon, Washington Territory, and British Columbia in 1869, as compared with former years. He says those taken "were mostly very young Seals, none appearing to be over a year old. Formerly in March and April the natives of Puget Sound took large numbers of pregnant females,[4] but no places where they have resorted to breed seem to be known off this coast." He thinks it probable, however, that they may occupy rocky ledges off shore which are rarely visited by boats.[5] In his MS. report just

[1] SCAMMON, C. M.: The Marine Mammals of the Northwestern Coast, &c., pp. 152, 154.
[2] BROWNE, J. ROSS: Resources of the Pacific Slope, second part, p. 128.
[3] SCAMMON, C. M.: The Marine Mammals of the Northwestern Coast, &c., p. 154.
[4] There are six skulls in the National Museum from Puget Sound and the neighboring coast (collected at several different points by Messrs. Scammon and Swan), *all of which are females.*
[5] Bulletin Museum Comparative Zoölogy, ii, p. 88.

received he states that a half-breed hunter told him that he found in summer, "on Queen Charlotte's Island, groups of these animals consisting of two or more beach-masters with a dozen or more females and pups, but no half-grown males."

As is well known, the Pribylov or so-called "Fur Seal Islands," off the coast of Alaska, form *the great breeding-ground of the Fur Seals, to which hundreds of thousands annually resort* to bring forth their young. The Pribylov Group consists of four small islands, known respectively as Saint Paul's, Saint George's, Otter, and Walrus Islands. The two last named are of small size, and are not used as breeding-grounds by the Seals, although Otter Island is visited by a large number of "non-breeding Seals." Saint Paul's Island is the largest, containing an area of about thirty-three square miles, and having a coast line of about forty-two miles, nearly one half of which is sand beach. Of this, sixteen and a half miles, according to Mr. Elliott, are occupied in the breeding season by the Fur Seals. Saint George's Island is somewhat smaller, with only twenty-nine miles of shore line. *It presents a bold coast, a grand wall of basalt extending continuously for ten miles, with no passageway from the sea. It has, in all, less than a mile of sand beach, and* only two and a quarter miles of eligible landing grounds for the Seals.

A few old male Fur Seals are said to make their appearance at the rookeries on these islands between the 1st and 15th of May, they acting, as it were, the part of pioneers, since their number is not much increased before the first of June. At about this date, and with the setting in of the humid, foggy weather of summer, the male Seals begin to land by "hundreds and thousands," to await the arrival of the females, which do not appear before about July first. The young are born soon after, and toward the last of this month the rookeries begin to lose their compactness and definite boundaries, but they are not fully broken up till about the middle of September. The Seals begin to leave the islands about the end of October, the greater proportion departing in *November, while some remain till the end of the following month, and even later.*

The number of Fur Seals present on Saint Paul's Island in July, 1872, was estimated by Mr. Elliott to exceed *three million,* and on Saint George's Island in July, 1873, at about one hundred and sixty-three thousand. Although these islands form by far their most populous resorts, they are said to occur in considerable numbers on some of the islands to the northward, but I am unable to find definite statements as to their numbers or favorite stations. Mr. Elliott, after examining Saint Matthew's and Saint Lawrence Islands, became convinced that they were not only not resorted to as breeding stations by the Fur Seals, but that these islands, by their constitution and climatic conditions, were unsuitable for this purpose, and adds, "*it may be safely said that no land of ours in the north is adapted to the wants of that animal, except that of Saint Paul and Saint George.*" Mr. W. H. Dall states that "they have never been found in Bering Strait, or within three hundred miles of it." In early times these animals are well known to have been abundant on Behring's and Copper Islands. According to Krascheninikow, they were so numerous upon Behring's Island about the middle of the last century as to cover the whole southern shore of the island. Their range on the Asiatic coast is given by Steller and others as extending southward along the Kamtchatkan coast to the Kurile Islands. Krascheninikow states that they appeared there, however, only in spring and in September, none being seen there from the beginning of June till the end of August, at which time he says they *return from the south* with their young. Von Schrenck speaks of their occurrence in the Ochotsk Sea and the Tartarian Gulf as far south as the forty-sixth degree of latitude, or to the southern point of Saghalien Island. The natives reported to him the occurrence of great numbers of the animals on the eastern coast of that island. Captain Scammon also refers to their abundance twenty years since on the eastern side of Saghalien.

Except during the season of reproduction, these animals appear to lead a wandering life, but the extent and direction of their migrations are not yet well known. Steller spoke of their migra-

tions as being as regular as those of the various kinds of sea-fowl, and they are recorded as arriving with great regularity at the Pribylov Islands, but where they pass the season of winter is still a matter of conjecture.

SIZE.—Mr. Elliott has given a table showing the weight, size, and rate of growth of the Fur Seal, from the age of one week to six years, based on actual weight and measurement, with an estimate of the size and weight of specimens from eight to twenty years of age. From this table it appears that the pups when a week old have a length of from twelve to fourteen inches, and a weight of six to seven and a half pounds. At six months old the length is two feet and the weight about thirty pounds. At one year the average length of six examples was found to be thirty-eight inches, and the weight thirty-nine pounds, the males and females at this time being alike in size The average weight of thirty males at the age of two years is given as fifty-eight pounds, and the length as forty-five inches. Thirty-two males at the age of three years were found to give an average weight of eighty-seven pounds, and an average length of fifty-two inches. Ten males at the age of four averaged one hundred and thirty-five pounds in weight, and fifty-eight inches in length. A mean of five examples five years old is: weight, two hundred pounds; length, sixty-five inches. Three males at six years gave a weight of two hundred and eighty pounds, and a length of six feet. The estimated average weight of males from eight years and upward, when fat, is given as four hundred to five hundred pounds, and the average length as six feet three inches to six feet eight inches. Mr. Elliott further adds that the average weight of the female is from eighty to eighty-five pounds, but that they range in weight from seventy-five to one hundred and twenty pounds, and that the five and six year old males, on their first appearance in May and June, when fat and fresh, may weigh a third more than in July, or at the time those mentioned in the table were weighed, which would thus indicate an average maximum weight of about three hundred and seventy-five pounds for the six-year-old males. According, however, to my own measurements of old males, from mounted and unmounted specimens, the length is between seven and eight feet, and of a full-grown female about four feet. Captain Bryant states that the males attain mature size at about the sixth year, when their total length is from seven to eight feet, their girth six to seven feet, and their weight, when in full flesh, from five to seven hundred pounds. The females, he says, are full grown at four years old, when they measure four feet in length, two and a half in girth, and weigh eighty to one hundred pounds. The yearlings, he says, weigh from thirty to forty pounds. The relative size of the adults of both sexes and the young is well shown in the accompanying illustration drawn by Mr. Elliott.

GENERAL HISTORY.—The northern Fur Seal was first made known to science by Steller, in 1751, under the name of *Ursus marinus*. During his visit to Kamtchatka and its neighboring islands, in 1742, he met with these animals in great numbers at Bering's Island, where he spent some time among them, and carefully studied their habits and anatomy, a detailed account of which appeared in his celebrated memoir entitled "De Bestiis Marinis," in the Transactions of the Saint Petersburg Academy for the year 1749.[1] This important essay was the source of nearly all of the accounts of this animal that appeared prior to the beginning of the present decade. The twenty-eight quarto pages of Steller's memoir devoted to this species gave not only a detailed account of its anatomy, with an extensive table of measurements, but also of its remarkable habits, and figures of the animals themselves. A little later Krascheninikow, in his History of Kamtchatka,[2] under the name of "Sea Cat," gave also a long account of its habits, apparently based

[1] Nov. Comm. Acad. Petrop., ii, pp. 331–359, pl. xv, 1751. This, as is well known, is a posthumous paper, published six years after Steller's death, Steller dying of fever November 12, 1745, while on his way from Siberia to Saint Petersburg. The description of the Sea Bear was written at Bering's Island in May, 1742.

[2] Hist. Kamtchatka (English edition), translated from the Russian by James Grieve, pp. 123–130, 1764.

mainly on Steller's notes,[1] but it embraces a few particulars not given in "De Bestiis Marinis." Steller's description of the habits of this animal has been largely quoted by Buffon, Pennant, Schreber, Hamilton, and other general writers.

Buffon, Pennant, Schreber, Gmelin, and nearly all writers on the Pinnipeds, down to about 1820, confounded the northern Fur Seal with the Fur Seals of the Southern Hemisphere, blending their history as that of a single species. Péron, in 1816, first recognized it as distinct from its southern allies, as it was so treated somewhat later by Demarest, Lesson, Fischer, Gray, and other systematic writers,[2] but its distinctive characters were not clearly set forth till 1859, when Dr. J. E. Gray described and figured its skull, and showed that the northern species was not even congeneric with the Sea Bears of the south. Very few specimens of either the northern or southern Sea Bears appear to have reached European museums prior to about that date, so that naturalists had not previously been able to make a direct comparison of this species with any of its southern affines. Dr. Gray, in referring to this point in 1859, wrote as follows: "I had not been able to see a specimen of this species in any of the museums which I examined on the Continent or in England, or to find a skull of the genus [*Arctocephalus*] from the North Pacific Ocean, yet I felt so assured, from Ste'ler's description and the geographical position, that it must be distinct from the Eared Fur Seals from the Antarctic Ocean and Australia, with which it had usually been confounded, that in my 'Catalogue of Seals in the Collection of the British Museum' [1850] I regarded it as a distinct species, under the name of *Arctocephalus ursinus*, giving an abridgment of Steller's description as its specific character." "The British Museum," he adds, "has just received, under the name *Otaria leonina*, from Amsterdam, a specimen [skull and skin] of the Sea Bear from Bering's Straits, which was obtained from Saint Petersburg";[3] which is the specimen already spoken of as figured by Dr. Gray. From the great differences existing between this skull and those of the Southern Sea Bears, Dr. Gray, a few weeks later, separated the northern species from the genus *Arctocephalus*, under the name *Callorhinus*.[4]

It seems, however, that there were two skulls of Steller's Sea Bear in the Berlin Museum as early as 1841,[5] and three skeletons of the same species in the Museum of Munich in 1849,[6] yet Dr. Gray appears to have been the first to compare this animal with its southern relatives, and to positively decide its affinities.

Misled, however, by erroneous information respecting specimens of Eared Seals received at the British Museum from California, a skin of the *Callorhinus ursinus* was doubtfully described by this author, in the paper in which the name *Callorhinus* was proposed, as that of his *Arctocephalus monteriensis*, which is a Hair Seal. This skin was accompanied by a young skull, purporting, by the label it bore, to belong to it, but Dr. Gray observes that otherwise he should have thought it too small to have belonged to the same animal. Seven years later,[7] he described the skull as that of a new species (*Arctocephalus californianus*), still associating with it, however, the skin of the

[1] Krascheninikow, it is stated, "received all of Mr. Steller's papers" to aid him in the preparation of his "History of Kamtchatka."

[2] Nilsson and Müller in 1841, and Wagner in 1846 and 1849, on the other hand, still considered all the Sea Bears as belonging to a single species. Wagner, in 1849 (Arch. für Naturg., 1849, pp. 37–49) described the osteological characters of the northern species from three skeletons in the Munich Museum received from Bering's Sea. One of these was apparently that of a full-grown female; a second was believed to be that of a half-grown male, while the third belonged to a very young animal, in which the permanent teeth were still not wholly developed. Wagner compares the species with Steller's Sea Lion, and with the figures of the skulls of the southern Sea Bears given by F. Cuvier, Blainville, and Quoy and Gaimard, and notes various differences in the form of the teeth and skull, but believes that these differences must be regarded as merely variations dependent upon age.

[3] GRAY, J. E., in the Proceedings of the Zoölogical Society of London, 1859, p. 102.

[4] *GRAY, J. E., in the Proceedings of the Zoölogical Society of London, 1859, p. 359.*

[5] See Archiv für Naturgesch., 1841, p. 334.

[6] GRAY, J. E., in the Proceedings of the Zoölogical Society of London, 849, p. 39.

[7] GRAY, J. E., Catalogue of the Seals and Whales in the British Museum, 1866, p. 51.

Callorhinus ursinus. The skull he subsequently considered as that of a young *A. monteriensis* (=*Eumetopias Stelleri*); and referring his *A. californianus* to that species, he was consequently led into the double error of regarding the *Eumetopias Stelleri* as a Fur Seal (as already explained under that species and elsewhere in the present paper), and of excluding the *Callorhinus ursinus* from the list of Fur Seals. To this I called attention in 1870, and in 1871 Dr. Gray correctly referred his *A. monteriensis* and *A. californianus* in part (the "skin only") to *Callorhinus ursinus*.[1]

What may be termed the second or modern epoch in the general history of this species began in 1869, when Captain C. M. Scammon published a highly important contribution to its biology,[2] he describing at considerable length, from personal observation, its habits, distribution, and products, as well as the various methods employed for its capture. The following year Mr. W. H. Dall devoted a few pages[3] to its history, in which he made many important suggestions relative to the sealing business. During the same year I was able to add not only something to its technical history,[4] but also to make public an important communication on its habits kindly placed at my disposal by Captain Charles Bryant,[5] government agent in charge of the Fur Seal Islands of Alaska. In 1874, Captain Scammon republished his above mentioned paper,[6] adding thereto a transcript of Captain Bryant's observations already noted. Almost simultaneously with this appeared Mr. H. W. Elliott's exhaustive Report on the Seal Islands of Alaska,[7] in which the present species properly comes in for a large share of the author's attention. The work is richly illustrated with photographic plates, taken from Mr. Elliott's sketches, about twenty-five of which are devoted to the Fur Seal. The text of this rare and privately distributed work has been since reprinted,[8] with some changes and additions, and has been widely circulated. It contains very little relating to the Fur Seal that is strictly technical, but the general history of its life at the Pribylov Islands is very fully told, while the commercial or economic phase of the subject is treated at length. A few minor notices of this species have since appeared (mostly popular articles in illustrated magazines, chiefly from the pen of Mr. Elliott), but nothing relating to its general history requiring special notice in the present connection, until the publication, in 1881, by the Census Bureau and the Fish Commission, of the two editions of Mr. Elliott's elaborate monograph of the Seal Islands of Alaska.[9]

FIGURES.—The first figures of the Northern Sea Bear were given by Steller, in his paper already cited. They represent an adult male, in a quite natural attitude, and a female reclining on her back. In respect to details, these early figures were naturally more or less rude and inaccurate. They

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[1] GRAY, J. E.: Supplementary Catalogue of the Seals and Whales, p. 15; Hand-List of Seals, p. 32.

[2] SCAMMON, C. M., in the Overland Monthly, vol. iii, Nov., 1869, pp. 393–399.

[3] DALL, WILLIAM H.: Alaska and its Resources, 1870, pp. 492–498.

[4] Bulletin of the Museum of Comparative Zoölogy, Cambridge, ii, pp. 73–89.

[5] Bulletin of the Museum of Comparative Zoölogy, Cambridge, pp. 89–108.

[6] SCAMMON, C. M.: The Marine Mammals of the Northwestern Coast, &c., 1874, pp. 141–163.

[7] ELLIOTT, HENRY W.: Report on the Prybilov Group, or Seal Islands of Alaska, 4to, unpaged, 1873 [1874].

[8] ELLIOTT, HENRY W.: Condition of Affairs in Alaska, 1875, pp. 107–151.

[9] 1881. ELLIOTT, HENRY W.: Department of the Interior. | — | Tenth Census of the United States. | Francis A. Walker, | Superintendent. | — | The history and present condition | of the fishery industries. | Prepared under the direction of Professor S. F. Baird, U. S. Commissioner of Fish and Fisheries, by G. Brown Goode, Assistant Director, U. S. National Museum. | — | The Seal-Islands of Alaska, | by | Henry W. Elliott. | (Seal of Department of the Interior.) | Washington: | Government Printing Office: | 1881. Quarto, pp. 176. Two maps; twenty-nine plates.

1881. ELLIOTT, HENRY W.: U. S. Commission of Fish and Fisheries. | Spencer F. Baird, Commissioner. | — | 176. | Special Bulletin. | — | A Monograph | of the | Seal Islands of Alaska | by | Henry W. Elliott | — | Reprinted, with additions, from the Report on the Fishery Industries | of the Tenth Census. | Washington: | Government Printing Office. | 1882. Quarto, pp. 176. Two maps; twenty-nine plates.

These two editions differ in the fact that in the census edition, pp. 102 to 109, relating to "The Reproduction of the Fur Seal, Sea Lion, and Walrus," are replaced by "A Brief Review of the Official Reports upon the Conduct of Affairs on the Seal Islands."

were copied, however, by Buffon, Schreber, Pennant, and other early writers, and are the only *representations of this species known to me that were made prior to about the year 1839, except* Choris's plate of a group of these animals entitled "Ours marins dans l'île de St. Paul,"[1] published in 1822. This represents three old males, surrounded by their harems, and indicates very faithfully the mode of grouping and the variety of attitudes assumed by these animals when assembled on the rookeries. Hamilton, in 1839, gave a figure of the "Sea Bear of Steller (*Otaria ursina*)" which he tells us is "*from the engraving of the distinguished Naturalist of the Rurick*,"[2] the original of which I have not seen. This represents a male and female, the latter reclining on its side, with a pup resting on its right flipper.

The first figure of the skull is that published by Gray in 1859,[3]—a view in profile of the skull of an adult male. A wood-cut of the same was given in 1866,[4] and a fine lithographic plate in 1874,[5] representing the skull in profile, from above and from below.[6]

In 1870 I gave figures of two adult male skulls (two views of each), of an adult female skull (three views), of a very young skull (three views), and of the scapula, dentition, etc. These, so far as known to me, are the only figures of the skull or other details of structure thus far published.

In 1874 Captain Scammon gave figures of the animal,[7] a zincograph of an old male,[8] from a sketch by Mr. Elliott, a wood-cut of the head of a female seen from below (drawn by Elliott),[9] two outline figures representing the female as seen from below and in profile, and two others in outline illustrating "attitudes of the Fur Seals." Mr. Elliott, in his first Report on the Seal Islands, in a series of over two dozen large photographic plates (from India ink sketches from nature), has given an exhaustive presentation of the phases of fur seal life so faithfully studied by him at Saint Paul's Island. Among these may be mentioned especially those entitled "The East Landing and Black Buttes—The beach covered with young Fur Seals"; "The North Shore of Saint Paul's Island" (giving an extensive view of the rookeries); "Lukannon Beach" (Fur Seals playing in the surf, and rookeries in the distance); "Old male Fur Seal, or 'Sceecatch'" (as he appears at the end of the season after three months of fasting); "Fur-seal Harem" (showing the relative size of males, females, and young, various attitudes, positions, etc.); "Fur-seal Males, waiting for their 'Harems'" (the females beginning to arrive); "Fur-seal 'Rookery'" (breeding-grounds at Polavina Point); "Fur-seal Harem" (Reef Rookery, foreground showing relative size of males and females); "Fur-seal Pups at Sleep and Play"; "Hauling Grounds" (several views at different points); "Capturing Fur Seals"; "Driving Fur Seals"; "Killing Fur Seals—Sealing gang at work," etc.

The only other pictorial contributions to the history of the Fur Seal of noteworthy importance prior to the publication by the Census of Mr. Elliott's latest work, is Mr. Clark's colored plate, on which are represented a nearly full-grown male, a female, and a pup, prepared from skins sent to the British Museum by the Alaska Commercial Company. In these the attitudes are excellent and the coloring fair.

For detailed discussions of this species, its capture and its commercial uses, the reader is referred to Elliott's "Monograph" and to the chapters on THE HABITS OF THE FUR SEAL, and THE FUR SEAL FISHERY, in subsequent pages of this work.

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[1] CHORIS, L.: Voyage pittoresque autour du Monde, Paris, 1822. Iles Aléoutiennes, pl. xv.

[2] HAMILTON, R.: Marine Amphibia, p. 266, pl. xxi.

[3] GRAY, J. E., in Proceedings of the Zoölogical Society of London, 1859, pl. lxviii.

[4] GRAY, J. E.: Catalogue of the Seals and Whales in the British Museum, p. 45, fig. 16.

[5] GRAY, J. E.: Hand-List of Seals, pl. xix.

[6] *I infer this to be the same specimen in each case, not only from the resemblance the figures bear to each other, but from Dr. Gray, so far as I can discover, referring to only the single skull from Bering's Strait, received in 1859.*

[7] SCAMMON, C. M.: The Marine Mammals of the Northwest Coast, &c., pl. xxi, two figures.

[8] ELLIOTT, HENRY W.: Report on the Pribylov Group, or Fur Seal Islands, of Alaska, unpaged, and plates not numbered.

[9] Proceedings of the Zoölogical Society of London, 1878, 271, pl. xx.

23. THE HARBOR SEAL.

GENERAL HISTORY AND SYNONYMY.—The common Seal, *Phoca* (*Phoca*) *vitulina* Linné, is mentioned in the earliest works on natural history, having been described and rudely figured by various writers as early as the middle of the sixteenth century as well as during the seventeenth century. Even down to the time of Linné it was the only species recognized; or, more correctly, all the species known were usually confounded as one species, supposed to be the same as the common Seal of the European coasts. Consequently almost down to the beginning of the present century the "common Seal" was generally supposed to inhabit nearly all the seas of the globe, Buffon, Pennant, Schreber, and others referring to it as an inhabitant of the Southern Hemisphere. Linné distinguished only a single species, even in the later editions of his "Systema Naturæ." As is well known, the smaller species of Seal are with difficulty distinguishable by external characters, particularly during their younger stages. Few, however, are so variable in color as the present, and none has so wide a geographical range.

GEOGRAPHICAL DISTRIBUTION.—The Harbor Seal appears to have formerly been much more numerous on portions of our eastern coast than it is at present.[1] Dr. DeKay, writing in 1842, states that the "common Seal, or Sea Dog," is "now comparatively rare in our [New York] waters," though "formerly very abundant." He adds, "A certain reef of rocks in the harbor of New York is called *Robin's Reef*, from the numerous seals which were accustomed to resort there; *robin* or *robyn* being the name in Dutch for *Seal*. At some seasons, even at the present day, they are very numerous, particularly about the Execution Rocks in the Sound; but their visits appear to be very capricious." He further alludes to their capture nearly every year in the Passaic River, in New Jersey, and states that a Seal was taken in a seine in the Chesapeake Bay, near Elko, Maryland, in August, 1824, supposed by Dr. Mitchill, who saw it, to be of this species.[2] Although still occasionally appearing on the coast of the Atlantic States as far southward as North Carolina,[3] it is of probably only accidental occurrence south of New Jersey, and rare south of Massachusetts.

In respect to its occurrence on the New Jersey coast, Dr. C. C. Abbott, the well-known naturalist of Trenton, N. J., kindly writes me, in answer to my inquiries on this point, as follows: "In going over my note-books, I find I have there recorded the occurrence of Seals (*Phoca vitulina*) at Trenton, N. J., as follows: December, 1861; January, 1864; December, 1866; February, 1870; and December, 1877. In these five instances a single specimen was killed on the ledge of rocks crossing the river here and forming the rapids. In December, 1861, three were seen, and two in February, 1870. A week later one was captured down the river near Bristol, Bucks County, Pennsylvania. My impression is that in severe winters they are really much more abundant in the Delaware River than is supposed. Considering how small a chance there is of their being seen when the river is choked with ice, I am disposed to believe that an occasional pair or more come up the river, even as high as Trenton, the head of tide-water, and one hundred and thirty-eight miles from the ocean.

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[1] The "Semi-Weekly Advertiser," Boston, January 10, 1872, had the following:

"The keeper of the Bird Island light-house at Marion reports that one day last week he saw over 300 Seals on the ice at one time. He shot one and obtained from it two gallons of oil. In eight years that he has kept the light he never saw more than three at a time until now."

[2] DEKAY, JAMES E.: New York Zoölogy, or the Fauna of New York, part i, 1842, pp. 54, 55.

[3] A recent record of its capture in North Carolina is the following, the reference, I think, unquestionably relating to the present species:

"SOUTHERN RANGE OF THE SEAL.—The Wilmington, N. C., 'Star' of February 28, mentions the capture, in New River, Onslow County, of a large female Spotted Seal, measuring about seven feet in length, and weighing 250 pounds. This is an interesting note. The species must probably have been the common Harbor Seal (*Phoca vitulina*). The same newspaper says one was reported near Beaufort some time ago."—[W. E. D. SCOTT,] "Country," vol. i, No 21, p. 322, March 16, 1878.

"On examination of old local histories, I find reference to the Seals as not uncommon along our coast, and as quite frequently wandering up our rivers in winter. I can find no newspaper references to the occurrence of Seals later than February or earlier than December, but as historical references to climate, as well as the memory of aged men still living, show conclusively that our winters are now much milder than they were even fifty years ago, it is probable that Seals did come up the river earlier in past years.

"In conversation with an old fisherman, now seventy-six years old, who has always lived at Trenton, and has been a good observer, I learn that every winter, years ago, it was expected that one or more Seals would be killed; and that about 1840 two were killed in March, which it was supposed had accompanied a school of herring up the river.

"In my investigations in local archæology I have found, in some of the fresh-water shell heaps, or rather camp-fire and fishing-village sites along the river, fragments of bones which were at the time identified as those of Seals. I did not preserve them, as I had no knowledge of their being of interest. They were associated with bones of deer, bear, elk, and large wading birds, and then gave me the impression, which subsequent inquiry has strengthened, that the Seal, like many of our large mammals, had disappeared gradually, as the country became more densely settled, and that in pre-European times it was common, at certain seasons, both on the coast and inland."[1]

In later communications (dated January 25 and March 20, 1879) he inclosed to me newspaper slips and notes respecting the capture of eight specimens in New Jersey, mostly near Trenton, during the winter of 1878–'79.

On the coast of Massachusetts they occur in considerable numbers about the mouth of the Ipswich River, where I have sometimes observed half a score in sight at once. They are also to be met with about the islands in Boston Harbor, and along the eastern shore of Cape Cod. Captain N. E. Atwood states that they are now and then seen at Provincetown, and that in a shallow bay west of Rainsford Island "many hundreds" may be seen at any time in summer on a ledge of rocks that becomes exposed at low water.[2]

Farther northward they become more numerous, particularly on the coast of Maine and the shores of the Gulf of Saint Lawrence, Newfoundland, and Labrador, and are also common on the shores of Davis's Strait and in Greenland, where, says Dr. Rink, "it occurs here and there throughout the coast," and is likewise to be met with at all seasons of the year. Mr. Kumlien says it is one of the "rarer species" in the Cumberland waters, but its exact northern limit I have not seen stated.

On the European coasts it is said to occur occasionally in the Mediterranean, and to be not rare on the coast of Spain. It is more frequent on the coasts of France and the British Islands, and thence northward along the Scandinavian peninsula is the commonest species of the family. It also extends northward and eastward along the arctic coast of Europe, but late explorers of the Spitzbergen and Jan Mayen Islands do not enumerate it among the species there met with. Malmgren states distinctly that it is not found there,[3] and it is not mentioned by Von Heuglin nor by the other German naturalists who have recently visited these islands. From its littoral habits its absence there might be naturally expected. It is also said by some writers to occur in the Black and Caspian Seas, and in Lake Baikal, but the statement is seriously open to doubt, as will be shown later in connection with the history of the Ringed Seal.

On the Pacific coast of North America it occurs from Southern California northward to

[1] Letter dated Trenton, N. J., Dec. 26, 1878.
[2] See Bull. Mus. Comp. Zoöl., vol. i, p. 193.
[3] Weigm. Arch. für Naturg. 1864, p. 84.

Bering's Strait, where it seems to be an abundant species. I have examined specimens from the Santa Barbara Islands, and various intermediate points to Alaska, and from Plover Bay, on the eastern coast of Siberia. The extent of its range on the Asiatic coast has not been ascertained. If it is the species referred to by Pallas under the name *Phoca canina*, and by Temminck, Von Schrenck, and other German writers, under the name *Phoca nummularis*, as seems probable, it occurs in Japan and along the Amoor coast of the Ochotsk Sea. Von Schrenck speaks of it, on the authority of the natives, as entering the Amoor River.[1] The late Dr. Gray referred a specimen from Japan to his "*Halicyon Richardsi*," which, as already shown, is merely a synonym of *Phoca vitulina*. It thus doubtless ranges southward along the Asiatic coast to points nearly corresponding in latitude with its southern limit of distribution on the American side of the Pacific.

The Harbor Seal not only frequents the coast of the North Atlantic and the North Pacific, and some of the larger interior seas, but ascends all the larger rivers, often to a considerable distance above tide-water. It even passes up the Saint Lawrence to the Great Lakes, and has been taken in Lake Champlain. DeKay states, on the authority of a Canadian newspaper, that a Seal (in all probability of this species) was taken in Lake Ontario near Cape Vincent (Jefferson County, New York) about 1824, and adds that the same paper says that Indian traders report the previous occurrence of Seals in the same lake, though such instances are rare.[2] Thompson gives two instances of its capture in Lake Champlain; one of the specimens he himself examined, and has published a careful description of it, taken from the animal before it was skinned.[3]

They are also known to ascend the Columbia River as far as the Dalles (above the Cascades, and about two hundred miles from the sea), as well as the smaller rivers of the Pacific coast, nearly to their sources. Mr. Brown states that "Dog River, a tributary of the Columbia, takes its name from a dog-like animal, probably a Seal, being seen in the lake whence the stream rises."[4]

HABITS.—The Harbor Seal is the only species of the family known to be at all common on any part of the eastern coast of the United States. Although it has been taken as far south as North Carolina, it is found to be of very rare or accidental occurrence south of New Jersey. Respecting its history here, little has been recorded beyond the fact of its presence. Captain Scammon has given a quite satisfactory account of its habits and distribution as observed by him on the Pacific coast of the United States, but under the supposition that it was a species distinct from the well-known *Phoca vitulina* of the North Atlantic. Owing to its rather southerly distribution, as compared with its more exclusively boreal affines, its biography has been many times written in greater or less detail. Fabricius, as early as 1791, devoted not less than twenty pages to its history, based in part on his acquaintance with it in Greenland, and partly on the writings of preceding authors;[5] and much more recently extended accounts of it have been given by Nilsson and

[1] VON SCHRENK: Reisen im Amoor-Lande, Bd. i, p. 180.

[2] DEKAY: New York Zoölogy, or the Fauna of New York, pt. i, 1842, p. 55.

[3] His record of the capture of these examples is as follows:

"While several persons were skating upon the ice on Lake Champlain, a little south of Burlington, in February, 1810, they discovered a living Seal in a wild state which had found its way through a crack and was crawling upon the ice. They took off their skates, with which they attacked and killed it, and then drew it to the shore. It is said to have been four and a half feet long. It must have reached our lake by way of the Saint Lawrence and Richelieu."—Thompsons' Nat. and Civil Hist. of Vermont, 1842, p. 38.

"Another Seal was killed upon the ice between Burlington and Port Kent on the 23d of February, 1846. Mr. Tabor, of Keeseville, and Messrs. Morse and Field, of Peru, were crossing over in sleighs when they discovered it crawling upon the ice, and, attacking it with the butt end of their whips, they succeeded in killing it and brought it on shore at Burlington, where it was purchased by Morton Cole, esq., and presented to the University of Vermont, where its skin and skeleton are now preserved. * * * * At the time the above-mentioned Seal was taken, the lake, with the exception of a few cracks, was entirely covered with ice."—*Ibid.*, Append., 1853, p. 13.

[4] Proc. Zoöl. Soc. Lond., 1868, p. 412, foot-note.

[5] Fabricius appears to have exhaustively presented its literary history, his references to previous authors, in his table of synonymy, occupying nearly four pages.

Lilljeborg, but unfortunately for English readers the first of these histories is written in Danish and the other in Swedish. It has, however, been noticed quite fully by Bell, Macgillivray, and other British authors, while lesser and more fragmentary accounts of it are abundant. On the New England coast, as elsewhere, it is chiefly observed about rocky islands and shores, at the months of rivers and in sheltered bays, where it is always an object of interest. Although ranging far into the arctic regions, it is everywhere said to be a sedentary or non-migratory species, being resident throughout the year at all points of its extended habitat. Unlike most of the other species, it is strictly confined to the shores, never resorting to the ice-floes, and is consequently never met with far out at sea, nor does it habitually associate with other species. On the coast of Newfoundland, where it is more abundant and better known than at more southerly points, it is said to bring forth its young during the last two weeks of May and the early part of June, resorting for this purpose to the rocky points and outlying ledges along the shore. It is said to be very common along the shores of the Gulf of Saint Lawrence and of Newfoundland in summer, or during the period when the shores are free from ice, but in winter leaves the ice-bound coast for the remoter islands in the open sea. It is at all times watchful, and takes great care to keep out of reach of guns. Still, many are surprised while basking on the rocks, and fall victims to the seal-hunters, while considerable numbers of the young are captured in the seal-nets. They are described as very sagacious, and as possessing great parental affection. Mr. Carroll states that when an old one is found on the rocks with its young it will seize the latter and convey it in its mouth so quickly to the water that there is not time to shoot it; or, if the young one be too large to be thus removed, it will entice it upon its back and plunge with it into the sea. The same writer informs us that this species is a great annoyance to the salmon-fishers, boldly taking the salmon from one end of the net while the fisherman is working at the other end. It is also troublesome in other ways, since, whenever the old ones get entangled in the strong seal-nets, they are able to cut themselves free, a feat it is said no other Seal known in Newfoundland will do.

This species is known to the inhabitants of Newfoundland as the "Native Seal," in consequence of its being the only species found there the whole year. The young are there also called "Rangers," and when two or three years old—at which age they are believed to bring forth their first young—receive the name of "Dotards." Here, as well as in Greenland, the skins of this species are more valued than those of any other species, owing to their beautifully variegated markings, and are especially valued for covering trunks and the manufacture of coats, caps, and gloves.[1] Mr. Brown informs us that the natives of the eastern coast of Greenland prize them highly "as material for the women's breeches," and adds "that no more acceptable present can be given to a Greenland damsel than a skin of the 'Kassigiak,' as this species is there called." The Greenlanders also consider its flesh as "the most palatable of all 'seal-beef'".[2]

According to Mr. Reeks, the period of gestation is about nine months, the union of the sexes occurring, according to the testimony of the Newfoundlanders, in September.[3] Only rarely does the female give birth to more than a single young. This agrees with what is stated by Bell and other English authors respecting its season of procreation.

Respecting its general history, I find the following from the pen of Mr. John Cordeaux, who, in writing of this species, as observed by him in British waters, says: "The Seal (*Phoca vitulina*) is not uncommon on that part of the Lincolnshire coast adjoining the Wash. This immense estuary, lying between Lincolnshire and Norfolk, is in great part occupied with large and dangerous

[1] CARROLL, MICHAEL: Seal and Herring Fisheries of Newfoundland, 1873, pp. 10, 11.
[2] BROWN, ROBERT, in Proceedings of the Zoölogical Society of London, 1868, p. 413
[3] REEKS, HENRY: Zoölogist, 2d ser., vol. vi, 1871, p. 2541.

sand-banks, intersected by deep but narrow channels. At ebb the sands are uncovered; and at these times, on hot days, numbers of Seals may be found basking and sunning themselves on the hot sands, or rolling and wallowing in the shallow water along the bank. Sometimes a herd of fifteen or twenty of these interesting creatures will collect on some favorite sand-spit; their chief haunts are the Long-sand, near the centre of the Wash; the Knock, along the Lincoln coast; and the Dog'shead sand, near the entrance to Boston Deeps. In the first week of July, when sailing down the Deeps along the edge of the Knock, we saw several Seals; some on the bank; others with their bodies bent like a bow, the head and hind feet only out of the water. They varied greatly in size, also in color, hardly any two being marked alike; one had the head and face dark colored, wearing the color like a mask; in others the upper parts were light gray; others looked dark above and light below, and some dark altogether. . . . The female has one young one in the year; and as these banks are covered at flood, the cub, when born, must make an early acquaintance with the water. In most of the *Phocidæ* the young one is at first covered with a sort of wool, the second or hairy dress being gradually acquired; and until this is the case it does not go into the water. This, however, does not appear to be the case with the common Seal, for Mr. L. Lloyd says (I believe in his 'Game Birds and Wild Fowl of Norway and Sweden,' but I have not the book to refer to) that the cub of the common species, whilst still in its mother's womb, casts this wooly covering; and when ushered into the world has acquired its second or proper dress.[1] If this is the case, it fully accounts for the cub being able to bear immersion from the hour of its birth. The Seal, if lying undisturbed and at rest, can remain for hours without coming to the surface."[2]

I am informed by competent observers that on the coast of Maine they assemble in a similar manner on sand bars, but take to the water before they can be closely approached.

Mr. Kumlien (in his MS. notes) observes: "The so-called 'Fresh-water Seal' of the whalemen is one of the rarer species in the waters of Cumberland Sound. They are mostly met with far up in the fjords, and in the fresh-water streams and ponds, where they go after salmon. They are rather difficult to capture, as at the season when they are commonly met with they have so little blubber that they sink when shot. . . . The adult males often engage in severe combats with each other. I have seen skins so scratched that they were nearly worthless. In fact, the Eskimo consider a 'Kassiarsoak' (a very large 'Kassigiak') as having an almost worthless skin, and seldom use it except for their skin tents. The skins of the young, on the contrary, are a great acquisition." He further states that they do not make an excavation beneath the snow for the reception of the young, like *Phoca fœtida*, "but bring forth later in the season on the bare ice, fully exposed."

Under the name "Leopard Seal," Captain Scammon has given a very good account of the habits of this species as observed by him on the Pacific coast of North America. He speaks of it as displaying no little sagacity, and considerable boldness, although exceedingly wary. He says it is "found about outlying rocks, islands, and points, on sand-reefs made bare at low tide, and is frequently met with in harbors among shipping, and up rivers more than a hundred miles from the sea. We have often observed them," he continues, "close to the vessel when under way, and likewise when at anchor, appearing to emerge deliberately from the depths below, sometimes only showing their heads, at other times exposing half of their bodies, but the instant any move was made on board, they would vanish like an apparition under water, and frequently that would be

[1] A statement to this effect is also made by Mr. Carroll, but Mr. Robert Brown affirms, on the authority of Captain McDonald, that in the Western Isles of Scotland the young are "born pure white, with curly hair, like the young of *Pagomys fœtidus*, but within three days of its birth begins to take dark colors on the snout and tips of the flippers."—Proc. Zoöl. Soc. Lond., 1868, p. 413.

[2] CORDEAUX, JOHN, in *Zoölogist*, 2d ser., vol. vii, 1872, pp. 3203, 3204.

the last seen of them, or, if seen again, they would be far out of gunshot." They come ashore, he observes, "more during windy weather than in calm, and in the night more than in the day; and they have been observed to collect in the largest herds upon the beaches and rocks, near the full and change of the moon. They delight in basking in the warm sunlight, and when no isolated rock or shore is at hand, they will crawl upon any fragment of drift-wood that will float them. Although gregarious, they do not herd in such large numbers as do nearly all others of the Seal tribe; furthermore, they may be regarded almost as mutes, in comparison with the noisy Sea Lions. It is very rarely, however, any sound is uttered by them, but occasionally a quick bark or guttural whining, and sometimes a peculiar bleating is heard when they are assembled together about the period of bringing forth their young. At times, when a number meet in the neighborhood of rocks or reefs distant from the mainland, they become quite playful, and exhibit much life in their gambols, leaping out of the water or circling around upon the surface. . . . Its rapacity in pursuing and devouring the smaller members of the piscatory tribes is quite equal, in proportion to its size, to that of the orca. When grappling with a fish too large to be swallowed whole, it will hold and handle it between its fore flippers, and, with the united work of its mouth . . . the wriggling prize is demolished and devoured as quickly, and in much the same manner, as a squirrel would eat a bur-covered nut. . . .

"Leopard Seals are very easily captured when on shore, as a single blow with a club upon the head will dispatch them. The Indians about Puget Sound take them in nets made of large hemp line, using them in the same manner as seines, drawing them around beaches when the rookery is on shore. They are taken by the whites for their oil and skins, but the Indians and Esquimaux make great account of them for food." He adds that the natives of Puget Sound singe them before a fire until the hair is consumed and the skin becomes crisp, when they are cut up and cooked as best suits their taste.[1]

The apparent fondness of this animal, in common with other species of the family, for music, has been often noted.

The food of this species consists largely of fish, but, like other species, it doubtless varies its fare with squids and shrimps. That it aspires to more epicurean tastes is evidenced by its occasional capture of sea-birds. This they ingeniously accomplish by swimming beneath them as they rest upon the water and seizing them. An eye-witness of this pastime relates an instance as observed by him on the Scottish coast. "While seated on the bents," he writes, "watching a flock of [herring] gulls that were fishing in the sea near Donmouth, I was startled by their jerking high in the air, and screaming in an unusual and excited manner. On no previous occasion have I observed such a sensation in a gull-hood, not even when a black-head was being pursued, till he disgorged his newly-swallowed fish, by that black-leg, the skua. The excitement was explained by a Seal [presumably *Phoca vitulina*, this being the only species common at the locality in question] showing above the water with a herring gull in his mouth. On his appearing the gulls became ferocious, and struck furiously at the Seal, who disappeared with the gull in the water. The Seal speedily reappeared, but on this occasion relinquished his victim on the gulls renewing their attack. The liberated gull was so disabled as to be unable to fly, but it had strength enough to hold up its head as it drifted with the tide."[2]

They are evidently discriminating in their tastes, and not loath to avail themselves of a fine salmon now and then not of their own catching. Their habit of plundering the nets of the fishermen on the coast of Newfoundland has been already alluded to, but this peculiarity is evidently

[1] Scammon, C. M.: Marine Mammals, etc., pp. 166, 167.
[2] Angus, W. Craibe, in Zoölogist, 2d ser., vol. vi, 1871, p. 2762.

not confined to the Newfoundland representative of the species, as shown by the following incident related by the writer last quoted. "On a sunny noon in the autumn of 1868," says this observer, "I observed a Seal, not far from the same place, with a salmon in his mouth, which he forced through the meshes of a stake net. The struggling salmon, whose head was in the jaws of the Seal, struck the water violently with his tail, which gleamed like a lustre in the lessening ray. The Seal rose and sank alternately, keeping seaward to escape Eley's cartridges from the shore. When above the water he shortened the silver bar, which continued to lash his sides long after its thickest part had disappeared, by rising to his perpendicular, as if to allow the precious metal by its own weight to slip into his crucible. The Seal evidently swallowed above, and masticated below, water—the process lasting about twelve minutes, during which the Seal had travelled a full half-mile."

In their raids upon the nets of the fishermen they become sometimes themselves the victims, being in this way frequently taken along our own coast as well as elsewhere. They are, however, at all times unwelcome visitors. DeKay states that formerly they were taken almost every year in the "fyke-nets" in the Passaic River, greatly to the disgust of the fishermen, the Seals when captured making an obstinate resistance and doing much injury to the nets. Their accidental capture in this way often affords a record of their presence at localities they are not commonly supposed to frequent, as in the Chesapeake Bay, and at even more southerly localities on the eastern coast of the United States.

Owing to the difficulty of capturing this species, and its comparatively small numbers, it is of little commercial importance, although the oil it yields is of excellent quality, and its skins are of special value for articles of dress, and other purposes, in consequence of their beautifully variegated tints. Though not a few are taken in strong seal-nets, they are usually captured by means of the rifle or heavy sealing gun. On rare occasions they are surprised on shore at so great a distance from water that they are overtaken and killed by a blow on the head with a club. Like other species of the seal family, the Harbor seal is very tenacious of life, and must be struck in a vital part by either ball or heavy shot, in order to kill it on the spot. Says Mr. Reeks, "I have been often amused at published accounts of Seals shot in the Thames or elsewhere, but which 'sank immediately.' What Seal or other amphibious animal would not do so if 'tickled' with the greater part of, perhaps, an ounce of No. 5 shot?" He adds that it is only in the spring of the year that this seal will "float" when killed in the water, but says that he has never seen a Seal "so poor, which, if killed *dead on the spot*, would not have floated from five to ten seconds," or long enough to give "ample time for rowing alongside," supposing the animal to have been killed by shot, and the boat to contain "two hands." The oil of this species, according to the same writer, sells in Newfoundland for fifty to seventy-five cents a gallon, while the skins are worth one dollar each. Mr. Carroll gives the weight of the skin and blubber of a full-grown individual as ranging from eighty to one hundred pounds, while that of a young one averages, at ten weeks old, thirty to thirty-five pounds. The flesh of the young, the same writer quaintly says, is "as pleasant to the taste as that of any description of salt-water bird." Its flesh, as already stated, is esteemed by the Greenlanders above that of any other species. Few statistics relating to the capture of this species are available, but the number taken is small in comparison with the "catch" of other species, particularly of the Harp or Greenland Seal. Dr. Rink states that only from one thousand to two thousand are annually taken in Greenland, which is about one to two per cent. of the total catch. They are hunted to a considerable extent, however, wherever they occur in numbers.

The Harbor Seal received this name from its predilection for bays, inlets, estuaries, and fjords,

from which habit it is also often termed Bay Seal, and, on the Scandinavian coast, Fjord Sea, (Fjordskäl), and also Rock Seal (Steen-Kobbe).[1]

24. THE HARP SEAL.

GENERAL HISTORY AND NOMENCLATURE.—The Harp Seal, *Phoca (Pagophilus) grœnlandica* Fabricius, like the Crested Seal, presents characters, at least in the male sex, that readily attract the attention of even the casual observer—the one by its "saddle" or "harp-mark" of black on a light ground, the other by its inflatable hood. Accordingly both were mentioned by various early writers, but notably by Egede, Ellis, and Cranz, and the indications they gave of their existence enter into the technical history of the species, forming as they do the basis of the first systematic names. Erxleben described the species in 1777, under the name *Phoca grœnlandica*, his description being founded mainly on information previously made public by Cranz.

Few Seals vary so much in color with age as the Harp Seal. This was long since mentioned by Cranz, who says: "All Seals vary annually their color till they are full grown, but no sort so much as this [the *Attersoak*], and the Greenlanders vary its name according to its age. They call the fœtus *iblau;* in this state these are white and wooly, whereas the other sorts are smooth and coloured. In the 1st year 't is called *Attarak*, and 't is a cream-colour. In the 2d year *Atteitsiak* then 't is gray. In the 3d *Aglektok*, painted. In the 4th *Milaktok*, and in the 5th year *Attarsoak*. Then it wears its half-moon, the signal of maturity."

Dr. Rink states that at the present day the Greenlanders, as well as the Europeans, divide the "Saddle-backs" into four or five different classes according to their age, but that in familiar language they only distinguish by different names the full-grown animals from the half-grown ones, the latter being called "Bluesides."

The young, when first born, are called by the Newfoundland sealers "White-coats"; later, during the first molt, "Ragged-jackets"; when they have attained the black crescentic marks they are termed "Harps," or "Saddlers," and also "Breeding Harps"; the yearlings and two-year-olds are called "Young Harps" or "Turning-Harps," and also "Bedlimers" (or "Bellamers," also spelled "Bedlamers"). The older and some recent writers state that the mature pattern of coloration is not attained till the fifth year, while Jukes, Brown, Carroll, and others state that it is acquired in the third or fourth year. There is also a diversity of statement respecting the sexual differences of color in the adults, some writers affirming that the sexes are alike, while others state that the female is without the harp-mark, or has the dark markings of the male only faintly indicated. Mr. Carroll says: "The reason why they are called Harp Seals, or 'Saddlers,' is, the male Seal, as well as the female, has a dark stripe on each side from the shoulders to the tail, leaving a muddy white stripe down the back. The male Harp Seal is very black about the head as well as under the throat. . . . The female Harp is of a rusty gray about the head and white under the throat." Both Jukes and Reeks, however, refer to the *absence* of the harp-mark in the female.

GEOGRAPHICAL DISTRIBUTION.—Although the Harp Seal has a circumpolar distribution, it

[1] Seals appear to be increasing in numbers in Massachusetts Bay. We observed them frequently near Race Point, Provincetown, in 1879, where they sometimes get into the gill-nets set for mackerel. At Barnstable they have become very numerous and troublesome of late. They are often shot or taken in the weirs at Barnstable and Yarmouth, and are accused of seriously depleting the fisheries in this locality, as well as at Plymouth, where they have been preserved for a number of years. Crossing the entrance to Barnstable Harbor at sunset November 10, I counted eight or ten heads above the surface. The number here is estimated at sixty-five or seventy, and there are probably not less than three hundred in the bay. They are resident, disappearing for a time in the spring and returning accompanied by their young, about one-quarter as large as their parents, in April or May. *Capt. Gideon Bowley, of Provincetown,* tells me that they feed on "sun squalls," or medusæ, and that he has seen them "boil 'em up," or vomit them, when caught.—G. BROWN GOODE.

appears not to advance so far northward as the Ringed Seal or the Bearded Seal; yet the icy seas of the north are pre-eminently its home. It is not found on the Atlantic coast of North America in any numbers south of Newfoundland. A few are taken at the Magdalen Islands, and while on their way to the Grand Banks some must pass very near the Nova Scotia coast. Dr. Gilpin, however, includes it only provisionally among the Seals that visit the shores of that Province. It doubtless occasionally wanders, like the Crested Seal, to points far south of its usual range, as I find a skeleton of this species in the collection of the Museum of Comparative Zoölogy, bearing the legend "Nahant, Mass., L. Agassiz." I have at times felt doubtful about the correctness of the assigned locality, as this seems to be the only proof of the occurrence of this species on the Massachusetts coast. I have, however, recently been informed by Dr. C. C. Abbott, of New Jersey, that a Seal, described to him as being about six feet long, white, with a broad black band along each side of the back, was taken near Trenton, in that State, during the winter of 1878–'79. This description can of course refer to no other species than *Phoca grœnlandica*, and as it comes from a wholly trustworthy source it seems to substantiate the occasional occurrence of this species as far south as New Jersey. Von Heuglin gives it as ranging "in den amerikanischen Meeren *südwärts bis New York*,"[1] but I know not on what authority.

The Harp Seals are well known to be periodically exceedingly abundant along the shores of Newfoundland, where, during spring, hundreds of thousands are annually killed. In their migrations they pass along the coast of Labrador, and appear with regularity twice a year off the coast of Southern Greenland. Capt. J. C. Ross states that in Baffin's Bay they keep mostly "to the loose floating floes which constitute what is termed by the whale-fishers 'the middle ice' of Baffin's Bay and Davis' Straits." He says he never met with them in any part of Prince Regent's Inlet, but states that they are reported by the natives to be very numerous on the west side of the Isthmus of Boothia, but that they are not seen on the east side.[2] They are well-known visitors to *the shores of Iceland*, and swarm in the icy seas about Jan Mayen and Spitzbergen. They also occur about Nova Zembla, and Payer refers to their abundance at Franz Josef Land. They occur in the Kara Sea, and along the arctic coast of Europe. Malmgren, Lilljeborg, and Collett state that it is of regular occurrence on the coast of Finmark, where it occurs in small numbers from October and November till February. Although reported by Bell and others as having been taken in the Severn, and by Saxby as observed at Baltasound, Shetland, the capture of a specimen in Morecombe Bay, England, reported by Turner in 1874, Mr. E. R. Alston says is "the first British specimen that has been *properly identified*."

The distribution of this species in the North Pacific is not well known. Pallas (under the name *Phoca dorsata*) records it from Kamtchatka, where its occurrence is also affirmed by Steller. Temminck mentions having examined three skins obtained at Sitka, but adds that it was not observed by "les voyageurs néerlandais" in Japan. In the collections in the National Museum from the North Pacific this species is unrepresented, the species thus far received from there being the following four, namely: *Phoca vitulina*, *Phoca fœtida*, *Erignathus barbatus*, and *Histriophoca fasciata*.

HUNTING AND PRODUCTS.—As so large a part of what has been already said in the general account of the seal fishery of the North Atlantic and Arctic waters necessarily relates to the present species, it is scarcely requisite in the present connection to more than recall the leading points of the subject, with the addition of a few details not previously given. As already stated, the sealing grounds *par excellence* are the ice-floes off the eastern coast of Newfoundland and around

[1] VON HEUGLIN: Reisen nach dem Nordpolarmeer, p. 56.
[2] CARROLL: Seal and Herring Fisheries of Newfoundland, p. 26.

Jan Mayen Island, where the present species forms almost the sole object of pursuit. The sealing season lasts for only a few weeks during spring; the enterprise[1] gives employment during this time to hundreds of vessels and thousands of men, the average annual catch falling little short of a million Seals, valued at about three million dollars. While the pursuit is mainly carried on in vessels, sailing chiefly from English, German, and Norwegian ports, or from those of Newfoundland and the other British Provinces, many are caught along the shores of the countries periodically visited by these animals, as those of South Greenland, Southern Labrador, Newfoundland, and the Gulf of Saint Lawrence. The pursuit with vessels, and the various incidents connected therewith, have already been detailed, and sufficient allusions have perhaps also already been made to the Greenland method of seal-hunting.

In consequence of the gregarious habits of the species, and the fact that one-half to two-thirds of those taken are young ones that are not old enough to make any effectual attempt to escape, the success of a sealing voyage depends almost wholly upon the mere matter of luck in discovering the herds. While the old Seals are mostly shot, the young are killed with clubs. In respect to the ease and facility with which they are captured it may be noted that it is not at all unusual, in the height of the season, for the crew of a single small vessel to kill and take on board from five hundred to a thousand in a day. Mr. Brown states: "In 1866 the steamer Camperdown obtained the enormous number of 22,000 Seals in nine days," or an average of 2,500 per day. "It is nothing uncommon," he adds, "for a ship's crew to club or shoot, in one day, as many as from 500 to 800 old Seals, with 2,000 young ones."[2] Such slaughter is necessarily attended with more or less barbarity, but this seems to be sometimes carried to a needless extreme. The Seals are very tenacious of life, and, in the haste of killing, many are left for a long time half dead, or are even flayed alive. Jukes states that even the young are "sometimes barbarously skinned alive, the body writhing in blood after being stripped of its skin," and they have even been seen to swim away in that state, as when the first blow fails to kill the Seals their hard-hearted murderers "cannot stop to give them a second." "How is it," he adds, "one can steel one's mind to look on that which to read of, or even think of afterwards, makes one shudder? In the bustle, hurry, and excitement, these things pass as a matter of course, and as if necessary; but they are most horrible, and will not admit of an attempt at palliation." Scoresby and other writers refer to similar heartless proceedings—as though the necessary suffering attending such a sacrifice of unresisting creatures were not in itself bad enough without the infliction of such needless cruelty. The young Seals not only do not attempt any resistance, but are said to make no effort to move when approached, quietly suffering themselves to be knocked on the head with a club. The old Seals are more wary, and are generally killed with fire-arms. Scoresby relates that "When the Seals are observed to be making their escape into the water before the boats reach the ice, the sailors give a long-continued shout, on which their victims are deluded by the amazement a sound so unusual produces and frequently delay their retreat until arrested by the blows of their enemies."

The annual catch of Harp Seals in Greenland is stated by Rink to be 17,500 full-grown "Saddle-backs" and 15,500 "Bluesides," or 33,000 in all. The catch from the Newfoundland ports alone often reaches 500,000, and in the Jan Mayen seas often exceeds 300,000, so that the total annual catch of this species alone doubtless ranges from 800,000 to 900,000.

The commercial products are the oil—used in the lubrication of machinery, in tanning leather, and in miners' lamps—and the skins, which are employed for the manufacture of various kinds of

[1] For statistics of the seal fishery, see Allen's "North American Pinnipeds," pp. 497–502.
[2] Man. Nat. Hist., Geol., &c., Greenland, Mammals, p. 67, foot-note.

leather and articles of clothing. The skins are said to be mostly sold to English manufacturers, who employ them in the preparation of a superior article of "patent" or lacquered leather. The flesh is esteemed by the Greenlanders as superior to that of their favorite *Neitsik* (*Phoca fœtida*).

25. THE RINGED SEAL.

GENERAL HISTORY AND NOMENCLATURE.—The earliest notices of *Phoca fœtida*, Fabricius, in systematic works are based on the brief account given by Cranz in 1765, but there appear to be still earlier references to it by Scandinavian writers.

GEOGRAPHICAL DISTRIBUTION.—Although the Ringed Seal is a well-known inhabitant of the Arctic Seas, of both hemispheres, the southern limit of its distribution cannot be given with certainty. Wagner[1] records specimens from Labrador, which is the most southern point on the eastern coast of North America from which it seems to have been reported. It is not enumerated by Jukes or Carroll as among the species hunted by the Newfoundland sealers,[2] nor is it mentioned by Gilpin[3] as occurring in Nova Scotia. Its occasional presence here and in the Gulf of Saint Lawrence is doubtless to be expected. Further northward, and especially along the shores of Davis's Straits and Greenland, its abundance is well attested. It has also been found as far north as explorers have penetrated, having been met with by Parry as high as latitude 82° 40′. J. C. Ross states that it is common on both sides of the Isthmus of Boothia, where it forms the chief means of subsistence to the inhabitants during eight or nine months of the year.[4] It is common in Iceland, and Malmgren and Von Heuglin state it to be numerous at Spitzbergen. The last-named author gives it as abundant in summer in the Stor-Fjord and its branches, in Henlopen Strait, and in the bays of the northwest coast of Spitzbergen, occurring in great herds as well as singly, in the open water along the shores and in the openings in the ice-floes. He states that it is also numerous about Nova Zembla, where great numbers are killed for their skins and fat.[5] It is a common species on the coast of Finland, and farther eastward along the arctic coast of Europe and doubtless also of Western Asia.[6] It is also a common inhabitant of the Gulf of Bothnia and neighboring waters, and also of the Ladoga and other interior seas of Finland. It is said by Blasius to extend southward along the coast of Middle Europe to North Germany, Ireland, and the British Channel. Professor Flower has recorded its capture on the coast of Norwich, England; it undoubtedly occurs at the Orkneys and the Hebrides, where it is supposed to be represented by the species known there as "Bodach" or "Old Man." A specimen was also taken many years since on the coast of France, but here, as on the

[1] SCHREBER'S Säugethiere, vii, 1846, p. 31.

[2] Professor Jukes says four species are known on the coast of Newfoundland, namely, the "Bay Seal" (*Phoca vitulina*), the Harp Seal (*Phoca grœnlandica*), the Hooded Seal (*Cystophora cristata*), and the "Square Flipper" (probably *Halichœrus grypus*). The first he did not see on the ice among the Seals pursued by the sealers. The second is the one that forms the principal object of the chase. The third seems not to be numerous, but occurs occasionally out on the ice-floes with the Harp Seals. The fourth is referred to as very rare, and as being larger than the Hooded Seal. Not one was heard of or seen that season. He supposes it may be the *Phoca barbata*.—Excursions in Newfoundland, vol. i, pp. 308-312.

Carroll states that the species of Seal that are taken on the coast of Newfoundland are the "Square Flipper Seal" (probably *Halichœrus grypus*), the "Hood Seal" (*Cystophora cristata*), the "Harp Seal" (*Phoca grœnlandica*), and the "Dotard" or "Native Seal" (*Phoca vitulina*).—Seal and Herring Fisheries of Newfoundland, 1873, p. 10.

[3] The species given by Gilpin as found on the coast of Nova Scotia are the Harbor Seal (*Phoca vitulina*), the Harp Seal (*Phoca grœnlandica*), the Gray Seal (*Halichœrus grypus*), and the Hooded Seal (*Cystophora cristata*).

[4] Ross's Second Voyage, App., 1835, p. xix.

[5] Reise nach dem Nordpolarmeer, Th. iii, p. 50.

[6] In an account of Professor Nordenskjöld's late arctic voyage, published in "Nature" (vol. xxi, p. 40, November 13, 1879), it is stated that *Phoca fœtida* "was caught in great numbers, and along with fish and various vegetables forms the main food of the natives" at Cape Serdze (about 120 miles from Bering's Straits), the point where the "Vega" wintered, this and the polar bear being the only mammals seen.

shores of the larger British Islands, it can occur as merely a rare straggler.[1] Its fossil remains have been reported by Professor Turner as having been found in the brick clays of Scotland. It appears also to be a common species in the North Pacific, there being specimens in the National Museum, unquestionably of this species, from the coast of Alaska, and from Plover Bay, on the Siberian side of Bering's Strait. Its southern limit of distribution along the shores of the North Pacific, on either the American or the Asiatic side, cannot at present be given. Judging from its known distribution in other portions of the arctic waters, there is no reason to infer its absence from the northern shores of Eastern Asia and Western North America.

HABITS, PRODUCTS, AND HUNTING.—The Ringed Seal is pre-eminently boreal, its home being almost exclusively the icy seas of the arctic regions. Its favorite resorts are said to be retired bays and fjords, in which it remains so long as they are filled with firm ice; when this breaks up they betake themselves to the floes, where they bring forth their young. It is essentially a littoral, or rather glacial species, being seldom met with in the open sea. From its abundance in its chosen haunts it is a species well known to arctic voyagers, and frequent reference is made to it in most of the narratives of arctic explorations.[2]

The habits of the Ringed Seal, as observed in European waters, seem to agree with what has already been related respecting their life-history in Davis's Strait and Cumberland Sound. Malmgren, for example, states that the females bring forth their young on the western coast of Finland, on the ice, near the edge of great openings, between the 24th of February and the 25th of March, or at the time given by Fabricius and later writers for the same event on the coast of Greenland, and in no respect does their mode of life appear to differ in the icy seas about Spitzbergen from what has already been related.

The Ringed Seal is of far less commercial value than the Harp Seal, but in this respect may be considered as holding the second rank among the northern Phocids. Brown states that "it is chiefly looked upon and taken as a curiosity by the whalers, who consider it of very little commercial importance and call it 'Floe-rat.'" Von Heuglin, however, states that many thousands are annually taken by the sealers for their skins and fat, in the vicinity of Nova Zembla and Spitzbergen. It is of the greatest importance, however, to the Esquimaux and other northern tribes, by whom it is captured for food and clothing. Mr. Brown informs us that it forms, during the latter part of summer and autumn, "the principal article of food in the Danish settlements, and on it the writer of these notes and his companions dined many a time; we even learned to like it and to become quite epicurean connoisseurs in all the qualities, titbits, and dishes of the well-beloved Neitsik! The skin," he continues, "forms the chief material of clothing in North Greenland. All of the *oi πολλοί* dress in Neitsik breeches and jumpers; and we sojourners from a far country soon encased ourselves in the somewhat *hispid* but most comfortable nether garments. It is only high dignitaries like 'Herr Inspektor' that can afford such extravagance as a Kassigiak (*Callocephalus vitulinus*) wardrobe! The arctic *belles* monopolize them all." Rink states that the number annually captured in South Greenland has been calculated at 51,000. Capt. J. C. Ross

[1] Respecting the southern limit of the habitat of this species in Europe, Professor Flower has the following: "Nilsson speaks of it as being found on all the Scandinavian coasts, and as having been met with as far south as the Channel, on the strength of specimens in the Paris Museum from that locality; but he was unable to find any proofs of its having been met with on the coast of England. Nor have I been able to discover any positive evidence that it can, at the present day, be reckoned a British species, although there is little doubt that it must occasionally visit our shores, where its occurrence would be easily overlooked."—Proc. Zoöl. Soc. Lond., 1871, p. 150.

Collett, contrary to the testimony of Nilsson, excludes it from the mammalian fauna of Norway, and states that he does not know of an authentic instance of its capture on the Norwegian coast.—Bemærkninger til Norges Pattedyrfauna, 1876, p. 57, foot-note 2.

[2] In Allen's Pinnipeds, *l. c.*, is a long and interesting account of their habits, from the pen of Ludwig Kumlien.

states that the Esquimaux wholly depend upon it for their winter food, and von Schrenck alludes to the great importance of this animal to the natives of Amoor Land.

26. THE RIBBON SEAL.

GENERAL HISTORY.—The first account of the present species was published by Pennant, under the name "Rubbon Seal," in the first quarto edition of his "History of Quadrupeds," in 1781 (vol. ii, p. 523).

GEOGRAPHICAL DISTRIBUTION.—According to Pallas, the present species, *Histriophoca fasciata* (Zimm.) Gill, occurs around the Kurile Islands and in the Ochotsk Sea. Von Schrenck states that Hr. Wosnessenski obtained specimens that were killed on the eastern coast of Kamtchatka, and that he himself saw skins of examples killed on the southern coast of the Ochotsk Sea, where, however, the species seems to be of rare occurrence. He further states that it occurs also in the Gulf of Tartary, between the island of Saghalien and the mainland, but apparently not to the southward of that island, the southern point of which (in latitude 46° N.) he believes to be the southern limit of its distribution. Mr. Dall secured specimens taken at Cape Romanzoff.[1] Captain Scammon states, "It is found upon the coast of Alaska, bordering on Bering Sea, and the natives of Ounalaska recognize it as an occasional visitor to the Aleutian Islands. . . . The Russian traders who formerly visited Cape Romanzoff, from Saint Michael's, Norton Sound, frequently brought back the skins of the male *Histriophoca*, which were used for covering trunks and for other ornamental purposes." This writer also states that he "observed a herd of Seals upon the beaches at Point Reyes, California," in April, 1852, which, "without close examination, answered to the description given by Gill" of the present species. Probably, however, a "close examination" would have shown them to be different, as no examples are yet known from the Californian coast, and the locality is far beyond the probable limits of the habitat. Its known range may, therefore, be given as Bering's Sea southward—on the American coast to the Aleutian Islands, and on the Asiatic coast to the island of Saghalien.

HABITS.—Almost nothing appears to have been as yet recorded respecting the habits of the Ribbon Seal. Von Schrenck gives us no information of importance, and we search equally in vain for information elsewhere. All of the four specimens obtained by Wosnessenski were taken on the eastern coast of Kamtchatka, at the mouth of the Kamtchatka River, about the end of March. According to the report of hunters, it very rarely appears at this locality so early in the season, being not often met with there before the early part of May. The natives use its skins, in common with those of other species, for covering their snow-shoes.

27. THE WEST INDIAN SEAL.

GEOGRAPHICAL DISTRIBUTION.—Respecting the present geographical distribution of the West Indian Seal, *Monachus tropicalis* Gray, I am indebted for valuable information to Mr. R. W. Kemp, who, under date of "Key West, Fla., April 29, 1873," wrote me as follows: "Some two or three years ago there were two seen near Cape Florida. It was supposed that they had strayed from some of the Bahama Islands, as there are some few to be found in that vicinity. I am informed by reliable parties that Seals are to be found in great numbers at the Anina Islands, situated between the Isle of Pines and Yucatan. One of my informants says that as he was sailing about the islands fishing and wrecking, he and his party discovered a number of Seals on one of them, and went on shore to kill some, merely 'for fun.' On nearing the shore the Seals got into

[1] The National Museum possesses four fine specimens, two obtained by Mr. Dall, in 1880, and two by Mr. E. W. Nelson, as well as several large pouches, each made of an entire skin of this species by the Eskimos.

the water. They then hid themselves in the shrubbery along the beach, and in about ten or fifteen minutes the Seals came on the beach again. The men, armed with axes, sprang upon them, the Seals trying to get into the water again. Two of them were killed, and another one, as one of the men came up to him, turned around and barked furiously at him, which frightened the poor man so badly (he having never seen one before, and knowing nothing of their habits) that he almost fainted. The Seals are said to be very easily killed or captured alive. They yield a great deal of oil. The skins are very large, but not easy to cure, on account of their fatty substance." In a later letter he refers to their great rarity on the Florida coast, where he says they occur "only once or twice in a life-time," but alludes to their comparative abundance on the coast of Yucatan, and their occasional occurrence at the Bahama Islands.

Mr. L. F. de Pourtalès also informs me that there is a rock on Salt Key Bank, near the Bahamas, called "Dog Rock," presumably from its having been formerly frequented by the Seals. Also, that his pilot, in 1868–'69, told him he had himself killed Seals among the rocky islets of Salt Key Bank.

I learn from Dr. S. W. Garman, who accompanied Mr. Agassiz during his dredging expedition in the Caribbean Sea, in the United States Coast Survey steamer "Blake," during the winter of 1877–'78, that the Seal of those waters is well known to the wreckers and turtle-hunters of that region, and that they often kill it for its oil. He also informs me that these animals had also been frequently seen and killed by one of the officers of the "Blake," especially about the Isle of Pines, south of Cuba, and at the Alacranes, where, as already noted, they occurred in such abundance at the time of Dampier's visit in 1676 as to be extensively hunted for their oil. They are also known to the whalers who visit these waters.

The specimens described by Messrs. Hill and Gosse were taken at the Pedro Kays, off the southern coast of Jamaica, where thirty years ago they appear to have occurred in considerable numbers.

On a "Chart of the Environs of Jamaica," published in 1774,[1] as well as on later maps of this region, are indicated some islets off the Mosquito coast, in about latitude 12° 40′, which bear the name "Seal Kays," doubtless in reference to the presence there of these animals.

It therefore appears that the habitat of the West Indian Seal extends from the northern coast of Yucatan northward to the southern point of Florida, eastward to the Bahamas and Jamaica, and southward along the Central American coast to about latitude 12°. Although known to have been once abundant at some of these localities, it appears to have now well nigh reached extinction, and is doubtless to be found at only a few of the least frequented islets in various portions of the area above indicated. Being still well known to many of the wreckers and turtle-hunters, it seems strange that it should have so long remained almost unknown to naturalists. The only specimen extant in any museum seems to be the imperfect skin transmitted by Mr. Gosse to the British Museum thirty years ago. Consequently, respecting none of the Pinnipeds, at least of the northern hemisphere, is information still so desirable.

28. THE HOODED SEAL.

GEOGRAPHICAL DISTRIBUTION AND MIGRATIONS.—The Hooded or Crested Seal, *Cystophora cristata* (Erxl.) Nilss., is restricted to the colder parts of the North Atlantic and to portions of the Arctic Sea. It ranges from Greenland eastward to Spitzbergen and along the arctic coast of Europe, but is rarely found south of Southern Norway and Newfoundland. As is the case with

[1] History of Jamaica, vol. i, facing title-page. The work is anonymous, but the authorship is attributed to Edward Long.

other pelagic species, stragglers are sometimes met with far to the southward of the usual range of the species. On the North American coast it appears to be of uncommon occurrence south of the point already mentioned, as it is said by Gilpin[1] to be "a rare visitor to the shores of Nova Scotia." Like the Harp Seal, it appears also to be regularly migratory, but owing to its much smaller numbers and less commercial importance, its movments are not so well known. Carroll states that it visits the coast of Newfoundland at the same time as the Harp Seal, or about the 25th of February, the time, however, varying with the state of the weather. He further states that Hooded Seals always keep to the eastward of the Harp Seals, amongst the heavy ice; also that they are quite numerous in spring in the Gulf of Saint Lawrence, where "many of them are killed by persons who reside on Saint Paul's Island."[2] Dr. Packard states that it "is not uncommonly, during the spring, killed in considerable numbers by the sealers" along the coast of Labrador.[3] Rink says, "It is only occasionally found along the greater part of the coast [of Greenland], but visits the very limited tract between 60° and 61° N. lat., in great numbers, most probably in coming from and returning to the east side of Greenland. The first time it visits us is from about May 20 till the end of June, during which it yields a very lucrative catch."[4] Robert Brown observes, "With regard to the favorite localities of this species of Seal, Cranz and the much more accurate Fabricius disagree—the former affirming that they are found mostly on great ice islands where they sleep in an unguarded manner, while the latter states that they delight in the high seas, visiting the land in April, May, and June. This appears contradictory and confusing; but in reality both authors are right, though not in an exclusive sense." Again he says: "This Seal is not common anywhere. On the shores of Greenland it is chiefly found beside large fields of ice, and comes to the coast, as was remarked by Fabricius long ago, at certain times of the year. They are chiefly found in South Greenland, though it is erroneous to say that they are exclusively confined to that section. I have seen them not uncommonly about Disco Bay, and have killed them in Melville Bay, in the most northerly portion of Baffin's Bay. They are principally killed in the district of Juliansh aab, and then almost solely in the most southern part, on the outermost islands, from about the 20th of May to the last of June; but in this short time they supply a great portion of the food of the natives and form a third of the colony's yearly production. In the beginning of July the Klapmyds leaves, but returns in August, when it is much emaciated. Then begins what the Danes in Greenland call the magre Klapmydse fangst, or the 'lean-Klapmyds-catching,' which lasts from three to four weeks. Very seldom is a Klapmyds to be got at other places, and especially at other times. The natives call a Klapmyds found single up a fjord by the name of Nerimartout, the meaning of which is 'gone after food.' They regularly frequent some small islands not far from Juliansh aab, where a good number are caught. After this they go farther north, but are lost sight of, and it is not known where they go to (Rink, *l. c.*). Those seen in North Greenland are mere stragglers, wandering from the herd, and are not a continuation of the migrating flocks. Johannes (a very knowing man of Jakobshavn) informed me that generally about the 12th of July a few are killed in Jakobshavn Bay (lat. 69° 13′ N.). It is more pelagic in its habits than the other Seals, with the exception of the Saddleback."[5]

I conclude the account of the geographical distribution of the Hooded Seal in Baffin's Bay with the following from Mr. Kumlien's account:

[1] Proceedings and Transactions Nova Scotian Institute of Natural Sciences, vol. iii, pt. 4, p. 884.
[2] Seal and Herring Fisheries of Newfoundland, pp. 13, 14.
[3] Proc. Bost Soc. Nat. Hist., vol. x, p. 271.
[4] Danish Greenland, etc., 1877, p. 126.
[5] Proc. Zoöl. Soc. Lond., 1868, pp. 436, 437; Man. Nat. Hist., etc., Greenland, Mam., pp. 65, 66.

"The Bladder-nose appears to be very rare in the upper Cumberland waters. One specimen was procured at Annanactook in autumn, the only one I saw. The Eskimo had no name for it, and said they had not seen it before. I afterward learned that they are occasionally taken about the Kikkerton Islands in spring and autumn. I found their remains in the old kitchenmiddens at Kingwah. A good many individuals were noticed among the pack-ice in Davis's Straits in July."[1]

On the European coast this species is said to be of not very common occurrence on the northern coast of Norway, but more to the southward only stragglers appear to have been met with.[2] In March and April, according to Malmgren, they are seen about Jan Mayen, and they are said to occur on the coast of Finmark, and at the mouth of the White Sea. Von Baer[3] and Schultz also state that it is rarely found not only in the White Sea, but along the Timanschen and Mourman coasts. Von Heuglin says it appears to be found in the Spitzbergen waters only on the western coast of these islands,[4] and states that it is not known to occur at Nova Zembla. He gives its principal range as lying more to the westward, around Iceland and Greenland.

It thus appears that the range of the Crested Seal is restricted mainly to the arctic waters of the North Atlantic, from Spitzbergen westward to Greenland and Baffin's Bay, and thence southward to Newfoundland. Stragglers have been captured, however, far to the southward of these limits, on both sides of the Atlantic. Thus Gray observes:

"A young specimen has been taken in the river Orwell; at the mouth of the Thames; and at the Island of Oleron, west coast of France, but I greatly doubt if it had not escaped from some ship coming from North America; there is no doubt of the determination of the species. The one caught on the River Orwell, 29th June, 1847, is in the Museum of Ipswich, and was described by Mr. W. B. Clarke, on the 14th August, 1847, in 4to, with a figure of the Seal and skull. The one taken on the Isle d'Oleron is in the Paris Museum, and is figured, with the skull, in Gervais, Zool. et Paléont. Franç., t. 42, and is called *Phoca Isidorei*, by Lesson, in the Rev. Zool., 1843, 256. The young is very like that of *Pagophilus grœnlandicus*, but is immediately known from it by being hairy between the nostrils, and by the grinders being only plated and not lobed on the surface."[5]

Its capture has occurred a few times on the coast of the United States, as far from its usual range even as on the European coast. A large Seal is occasionally seen on the coast of Massachusetts, which has been supposed to be the Crested Seal, but just what this large Seal is remains still to be determined.[6] DeKay, in 1824, recorded[7] the capture of a male example of this species

[1] Bulletin of the United States National Museum, No. 15, 1879, p. 64.

[2] Says Blasius, writing in 1857, "An den südlichen Küstenländern der Nordsee hat man sie bis jetzt noch nicht gesehen."—Naturgesch. der Säugeth. Deutschlands, p. 260.

[3] *Bull. Acad. Imp. des Sci. de St. Pétersb., iii, 1838, p. 350.*

[4] Malmgren, writing some years earlier, says that in recent times it has not been observed with certainty at Spitzbergen, though reported as occurring there by Martens and Scoresby. Possibly, he says, during its summer wanderings it may extend to the latitude of Spitzbergen. During Torell's first journey to Spitzbergen a young individual was killed in the vicinity of Bear Island. He says it is only exceptionally taken by the seal-hunters about Jan Mayen, only a comparatively small number being captured.—Arch. für Naturgesch., 1864, p. 72.

[5] GRAY, J. E., in Zoölogist, 2d ser., vol. vii, 1872, p. 3338.

[6] In my "Catalogue of the Mammals of Massachusetts," I refer to this large Seal as follows, supposing it to be the Hooded Seal: "From accounts I have received from residents along the coast of a Seal of very large size observed by them, and occasionally captured, I am led to think this species is not of unfrequent occurrence on the Massachusetts coast. Mr. C. W. Bennett informs me of one taken some years since in the Providence River, a few miles below Providence, which he saw shortly after. From his very particular account of it I cannot doubt that it was of this species. Mr. C. J. Maynard also informs me that a number of specimens have been taken at Ipswich within the past few years, that have weighed from seven hundred to nine hundred pounds. It seems to be most frequent in winter, when it apparently migrates from the north."—Bull. Mus. Comp. Zoöl., vol. i, No. 8, 1869, pp. 193, 194. This identification was made almost solely on the ground of size, taken in connection with the fact that the species had been taken in Long Island Sound near New York City. The question, however, may fairly be raised whether the large Seals more or less frequently seen on the coast of New England are not really the Gray Seal (*Halichœrus grypus*).

[7] Ann. New York Lyceum Nat. Sci., vol. i, 1824, p. 94.

in a small creek that empties into Long Island Sound at East Chester, about fifteen miles from New York City. Twenty years[1] later he refers to this as the first and only known instance of its occurrence within the limits of the State of New York, where, he says, "it can only be regarded as a rare and accidental visitor." Professor Cope, however, has recorded its capture in the Chesapeake Bay, where he says it has twice occurred.[2] The first specimen was recorded in 1865[3] as "some species of *Cystophora*, taken near Cambridge, Maryland, on an arm of the Chesapeake Bay, eighteen miles from salt water, by Mr. Daniel M. Henry." The specimen, it is said, "measured 6½ feet, and weighed, when living, about 330 lbs." Although Professor Cope adds, "Whether this species is the *C. cristata* or *antillarum*, cannot be determined, owing to the imperfection of extant descriptions," there is no reason for doubting that it was really the Crested Seal, a conclusion to which Professor Cope seems to have later arrived. Although Gray's suggestion about the English specimen naturally arises, namely, transportation from the north in some ship, it seems more probable that they were really wanderers from the usual home of the species.

HABITS.—As already noted in the account of the geographical distribution of this species, it is, like the Harp Seal, pelagic and migratory, preferring the drift ice of the "high seas" to the vicinity of land, and seems rarely if ever to resort to rocky islands or shores. It brings forth its young on the ice, remote from the land, in March, a week or ten days later than the Harp Seal, with which it appears only rarely to associate, although the two species are often found on neighboring ice-floes. It is commonly described as the most courageous and combative of the Phocids, often turning fiercely upon its pursuers.

The Hooded Seal is described as very active when in the water. It swims very low, with only the top of the head above the surface. During the rutting season the males wage fierce battles for the possession of the females, the noise of which may be heard miles away. At times the sexes are said to live apart, but associate in families during the breeding season. Their affection for each other, and especially for their young, is represented as very strong, both parents remaining by them with such persistency that the whole family are easily killed.

FOOD.—The food of this species doubtless consists chiefly of fishes of different species. Malmgren supposed it to subsist mainly on those of large size. That it also feeds upon squids, and probably on other mollusks, is evinced by their remains having been found in their stomachs, as well as "the beaks of large cuttle-fish."[4]

HUNTING AND PRODUCTS.—This species, owing to its scarcity, is of relatively small commercial importance, yet many are taken every year by the Newfoundland and Jan Mayen sealers; generally no separate estimates, however, are given of the number taken. Dr. Rink states that the average annual catch in Greenland is 3,000. The flesh is greatly esteemed by the Greenlanders.

The Hooded Seal is usually taken on the ice, but Mr. Reeks states that many are also shot in the spring of the year by the settlers along the coast of Newfoundland. As already stated, the hood of the male affords such a protection to its owner as to render the animal so provided very hard to kill with the ordinary seal-club, or even with a heavy load of shot; and they are, furthermore, "at times very savage, and it requires great dexterity on the part of the seal-hunters to keep from being bitten."

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[1] New York Zoölogy, or the Fauna of New York, 1842, pt. i, p. 56.
[2] New Topographical Atlas of Maryland, 1873, p. 16.
[3] Proceedings of the Academy of Natural Sciences, Philadelphia, 1865, p. 273.
[4] JUKES: Excursions in Newfoundland, vol. i, p. 312.

29. THE CALIFORNIAN SEA ELEPHANT.

GENERAL HISTORY.—The California Sea Elephant, *Macrorhinus angustirostris* Gill, was first described by Dr. Gill, in 1866, from a skull of a female in the Museum of the Smithsonian Institution, received from Saint Bartholomew's Bay, Lower California. Its external characters were first made known by Capt. C. M. Scammon in 1869, and the species was redescribed by him in 1874, with detailed measurements of two adult females and a newly-born pup. This is all that has thus far appeared relating to its technical history. Captain Scammon, as early as 1854, gave some account of the habits of this species, under the name Sea Elephant, and earlier incidental references to it doubtless occur in the narratives of travelers. Dr. Gill observes, in his paper already cited, "For a long time, the fact that a species of the genus *Macrorhinus* or Elephant Seal inhabits the coast of Western North America has been well known. But, on account of the want of opportunity for comparison of specimens, the relations of the species have not been understood." I fail to find, however, in any technical account of the Sea Elephant, any previous notice of their occurrence on the coast of North America.

GEOGRAPHICAL DISTRIBUTION.—The Sea Elephant seems to have been formerly very abundant on the coast of California and Western Mexico, whence it became long since nearly extirpated. Captain Scammon, in writing (about 1852) of Cedros Island, off the coast of Lower California, says: "Seals and Sea Elephants once basked upon the shores of this isolated spot in vast numbers, and in years past its surrounding shores teemed with sealers, sea-elephant and sea-otter hunters; the remains of their rude stone houses are still to be seen in many convenient places, which were once the habitations of these hardy men."[1] A few Sea Elephants are still found at Santa Barbara Island, where they are reported, however, to be nearly extinct. Whether or not they still occur elsewhere along the Californian coast I am without means of determining, although it is probable that a small remnant still exists at other points, where scarcely more than a quarter of a century ago vessels were freighted with their oil. Neither is it possible to determine with certainty the limits of their former range. Captain Scammon, who doubtless obtained his information from trustworthy sources, states that it extended from Cape Lazaro, latitude 24° 46′ north, to Point Reyes, in latitude 38°, or for a distance of about two hundred miles. As has heretofore been stated, Dampier, in 1686, met with Seals on the islands off the western coast of Mexico, as far south as latitude 21° to 23°, but of what species his record unfortunately fails to show. They were doubtless either Sea Elephants or Sea Lions (*Zalophus californianus*), and may have included both. This rather implies its former extension, two hundred years ago, considerably to the southward of the limit assigned by Captain Scammon, on probably traditional reports current among the residents of this part of the coast at the time of his visit there in 1852.

"The sexes vary much in size, the male being frequently triple the bulk of the female; the oldest of the former will average fourteen to sixteen feet; the largest we have ever seen measured twenty-two feet from tip to tip." "The adult females average ten feet in length between extremities."—*Scammon.* "Round the under side of the neck, in the oldest males, the animal appears to undergo a change with age; the hair falls off, the skin thickens and becomes wrinkled—the furrows crossing each other, producing a checkered surface—and sometimes the throat is more or less marked with white spots. Its proboscis extends from opposite the angle of the mouth forward (in the larger males) about fifteen inches, when the creature is in a state of quietude, and the upper surface appears ridgy; but when the animal makes an excited respiration, the trunk becomes elongated, and the ridges nearly disappear." The females "are destitute of the proboscis, the nose being like that of the common Seal, but projecting more over the mouth."—*Scammon.*

Captain Scammon gives the length of a "new-born pup" as four feet.

HABITS.—We are indebted to Captain Scammon, who has fortunately had favorable opportunities for observation, for everything of importance that has thus far been recorded respecting the habits of the Sea Elephant of California. "The habits of these huge beasts," he tells us,[1] "when on shore, or loitering about the foaming breakers, are in many respects like those of the Leopard Seals [*Phoca vitulina*]. Our observations on the Sea Elephants of California go to show that they have been found in much larger numbers from February to June than during other months of the year; but more or less were at all times found on shore upon their favorite beaches, which were about the islands of Santa Barbara, Cerros, Guadalupe, San Bonitos, Natividad, San Roque, and Asuncion, and some of the most inaccessible points on the mainland between Asuncion and Cerros. When coming up out of the water, they were generally first seen near the line of surf; then crawling up by degrees, frequently reclining as if to sleep; again moving up or along the shore, appearing not content with their last resting place. In this manner they would ascend the ravines, or 'low-downs,' half a mile or more, congregating by hundreds. They are not so active on land as the Seals; but, when excited to inordinate exertion, their motions are quick—the whole body quivering with their crawling, semi-vaulting gait, and the animal at such times manifesting great fatigue. Notwithstanding their unwieldiness, we have sometimes found them on broken and elevated ground, fifty or sixty feet above the sea.

"The principal seasons of their coming on shore are, when they are about to shed their coats, when the females bring forth their young (which is one at a time, rarely two), and the mating season. These seasons for 'hauling up' are more marked in southern latitudes. The different periods are known among the hunters as the 'pupping cow,' 'brown cow,' 'bull and cow,' and 'March bull' seasons;[2] but on the California coast, either from the influence of climate or some other cause, we have noticed young pups with their mothers at quite the opposite months. The continual hunting of the animals may possibly have driven them to irregularities. The time of gestation is supposed to be about three-fourths of the year. The most marked season we could discover was that of the adult males, which shed their coats later than the younger ones and the females. Still, among a herd of the largest of those fully matured (at Santa Barbara Island, in June, 1852), we found several cows and their young, the latter apparently but a few days old.

"When the Sea Elephants come on shore for the purpose of 'shedding,' if not disturbed they remain out of water until the old hair falls off. By the time this change comes about, the animal is supposed to lose half its fat; indeed, it sometimes becomes very thin, and is then called a 'slimskin.'

"In the stomach of the Sea Elephant a few pebbles are found, which has given rise to the saying that 'they take in ballast before going down' (returning to the sea). On warm and sunny days we have watched them come up singly on smooth beaches, and burrow in the dry sand, throwing over their backs the loose particles that collect about their fore limbs, and nearly covering themselves from view; but when not disturbed, the animals follow their gregarious propensity, and collect in large herds." "The largest number I ever found in one herd," he states in another connection, "was one hundred and sixty-five, which lay promiscuously along the beach or up the ravine near by."

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[1] Marine Mammals, 1874, pp. 117–119. See also Proc. Acad. Nat. Sci. Phila., 1869, pp. 63–65, where the account here quoted was first published. See further J. Ross Browne's "Resources of the Pacific Coast" [Append.], p. 129, where the same author has also given a short account of its habits as observed at Cedros (or Cerros) Island in 1852. Also an article entitled "Sea-elephant Hunting," in the "Overland Monthly," iii, pp. 112–117, Nov., 1870.

[2] Referring to the habits of the Southern Sea Elephant (*Macrorhinus leoninus*), as he had "learned from shipmasters who have taken Seals about Kerguelen's Land, the Crozets, and Hurd's Island." See Proc. Acad. Nat. Sci. Phila., 1869, p. 64.

Nothing further respecting the breeding habits or sexual relations of the species appears to *have been as yet recorded, but they may be presumed to be similar to those of the Sea Elephant* of the Antarctic Seas.[1]

COMPARISON WITH THE SOUTHERN SEA ELEPHANT.—*So far as can be determined by descriptions*, the Northern and the Southern Sea Elephants[2] differ very little in size, color, or other external features. Captain Scammon gives the average length of the full-grown male of the northern species as twelve to fourteen feet, and says that the largest he ever measured had a length of twenty-two feet "from tip to tip." Péron gives the length of the southern species as twenty to twenty-five, and even thirty feet, with a circumference of fifteen to eighteen feet. Anson gives the length as twelve to twenty feet, and the circumference as eight to fifteen feet. Pernety records the total length as twenty-five feet. Scammon gives the length of the young of the northern species, at birth, as four feet; and Péron gives four or five feet as the length of the young at birth for the southern species. The skeletons of the two old males of the southern species, already mentioned, allowing for the intervertebral cartilages that have disappeared in maceration, measure respectively not over fifteen and sixteen feet, adding to which the length of the hind flipper and the proboscis gives a total length, from "tip to tip," of about twenty-one to twenty-two feet. From the foregoing we may infer that the usual difference in size between the two species is not great, the southern species on the whole appearing to be somewhat the larger of the two. It would seem *that the Northern and Southern Sea Elephants, though presumably distinct, are closely allied*, as well in structural characters as in habits. In respect to geographical distribution, I am not aware *that the southern species has* been found north of about the 35th degree of south latitude (the Island of Juan Fernandez), or the northern species south of about the 24th degree of north latitude. It *may consequently* be safely assumed that the two forms have been long isolated, and that the southern is an offshoot from northern stock, since the only other known species of the *Cystophorinæ* is also northern in its distribution.

[1] It is here assumed that the Sea Elephants of the Southern Hemisphere are all referable to a single species, the *Phoca leonina* of Linné, 1758, based on the Sea Lion of Lord Anson, which was renamed *Phoca elephantina* by Molina, 1782, and again renamed *Phoca proboscidea* by Péron, in 1816, and of which *Phoca Byroni* of Desmarest, and also *Phoca Ansoni* of the same author (the latter species in part only), and the *Mirounga patagonica* of Gray are synonyms. I am aware, however, that Peters has recently proposed the recognition of four species, namely, *Cystophora leonina* (= Anson's Sea Lion), *C. falklandica* (= Pernety's Sea Lion), *C. proboscidea* (*ex* Péron), and *C. kerguelensis* (the Sea Elephant of Kerguelen Island). He seems not, however, to have arrived at this course by an examination of an extensive suite of specimens from various localities, as he refers in this connection to only a single old male example from Kerguelen Island. He seems to have been influenced merely by the varying statements in respect to size and some other features given by Pernety, Anson, and Péron. His entire presentation of the case is as follows: "Pernety gibt von seinem Seelöwen eine lange Mähne, eine Totallänge von 25 Fuss und einem Durchmesser der Basis der Eckzähne von 3 Zoll an. Pérons See-Elephanten sollen bis 30 Fuss lang und von blaugrauer Farbe sein. Vielleicht sind alle diese Arten verschieden und es würde dann der Name *C. leonina* L. bloss dem Anson'schen Seelöwen zu belassen sein, während die *C. falklandica*, wie man die von Pernety benennen könnte, die *C. proboscidea* Péron, die *C. angustirostris* Gill der nördlichen Hemisphäre und die von Kerguelenland besonderen Arten angehören würden. Für den letzteren Fall schlage ich vor, *diese Art kerguelensis zu benennen.*" (*Monatsb. d. K. P. Akad. Wissensch. zu Berlin 1875, p. 394, foot-note*).

[2] The Sea Elephants appear to be exceptional among the *Phocidæ* in the great disparity of size between the sexes, in which, as well as in their breeding habits, they closely resemble the Otaries. Although, unlike the latter, they have not the power of using the hind limbs in locomotion on land, and are hence unable to walk, they manage to crawl to a considerable distance from the sea—according to Scammon, a "half a mile or more." The habits of the Southern Sea Elephant (*Macrorhinus leoninus*) were long since described by Anson and Pernety, and later by Péron, but their accounts seem in some respects to be tinged with romance. According to these writers the males fight desperately for the possession of the females.

C.—THE HABITS OF THE FUR SEAL.

By HENRY W. ELLIOTT.

30. LIFE-HISTORY OF THE FUR SEAL.

DESCRIPTION OF AN ADULT MALE.—The Fur Seal, which repairs every year to the Pribylov Islands to breed and to shed its hair and fur, in numbers that seem almost fabulous, is the highest organized of all the *Pinnipedia*, and, indeed, for that matter, when land and water are weighed in the account together, there is no other animal known to man which can be truly, as it is, classed superior, from a purely physical point of view. Certainly there are few, if any, creatures in the animal kingdom that can be said to exhibit a higher order of instinct, approaching even our intelligence.

I wish to draw attention to a specimen of the finest of this race—a male in the flush and prime of his first maturity, six or seven years old, and full grown. When it comes up from the sea early in the spring, out to its station for the breeding season, we have an animal before us that will measure six and a half to seven and a quarter feet in length from tip of nose to the end of its abbreviated, abortive tail. It will weigh at least 400 pounds, and I have seen older specimens much more corpulent, which, in my best judgment, could not be less than 600 pounds in weight. The head of this animal now before us, appears to be disproportionately small in comparison with the immense thick neck and shoulders; but as we come to examine it we will find it is mostly all occupied by the brain. The light frame-work of the skull supports an expressive pair of large bluish hazel eyes; alternately burning with revengeful, passionate light, then suddenly changing to the tones of tenderness and good nature. It has a muzzle and jaws of about the same size and form observed in any full-blooded Newfoundland dog, with this difference, that the lips are not flabby and overhanging; they are as firmly lined and pressed against one another as our own. The upper lips support a yellowish white and gray moustache, composed of long, stiff bristles, and when it is not torn out and broken off in combat, it sweeps down and over the shoulders as a luxuriant plume. Look at it as it comes leisurely swimming on toward the land; see how high above the water it carries its head, and how deliberately it surveys the beach, after having stepped upon it (for it may be truly said to step with its fore-flippers, as they regularly alternate when it moves up), carrying the head well above them, erect and graceful, at least three feet from the ground. The fore-feet, or flippers, are a pair of dark bluish-black hands, about eight or ten inches broad at their junction with the body, and the metacarpal joint, running out to an ovate point at their extremity, some fifteen to eighteen inches from this union; all the rest of the forearm, the ulna, radius, and humerus being concealed under the skin and thick blubber-folds of the main body and neck, hidden entirely at this season, when it is so fat. But six weeks to three months after this time of landing, when that superfluous fat and flesh has been consumed by self-absorption, those bones show plainly under the shrunken skin. On the upper side of these flippers the hair of the body straggles down finer and fainter as it comes below to a point close by, and slightly beyond that spot of junction where the phalanges and the metacarpal bones unite, similar to that point on our own hand where our knuckles are placed; and here the hair ends, leaving the rest of the skin to the end of the flipper bare and wrinkled in places at the margin of the inner side; showing, also, fine small pits, containing abortive nails, which are situated immediately over the union of the phalanges with their cartilaginous continuations to the end of the flipper.

On the other side of the flipper the skin is entirely bare, from its outer extremity up to the body connection; it is sensibly tougher and thicker than elsewhere on the body; it is deeply and regularly wrinkled with seams and furrows, which cross one another so as to leave a kind of sharp diamond-cut pattern. When they are placed by the animal upon the smoothest rocks, shining and slippery from algoid growths and the sea-polish of restless waters, they seldom fail to adhere.

When we observe this Seal moving out on the land, we notice that, though it handles its fore-feet in a most creditable manner, it brings up its rear in quite a different style; for, after every second step ahead with the anterior limbs, it will arch its spine, and in arching, it drags and lifts up, and together forward, the hind-feet, to a fit position under its body, giving it in this manner fresh leverage for another movement forward by the fore-feet, in which the spine is again straightened out, and then a fresh hitch is taken upon the posteriors once more, and so on as the Seal progresses. This is the leisurely and natural movement on land, when not disturbed, the body all the time being carried clear of and never touching the ground. But if the creature is frightened, this method of progression is radically changed. It launches into a lope, and actually gallops so fast that the best powers of a man in running are taxed to head it off. Still, it must be remembered that it cannot run far before it sinks trembling, gasping, breathless, to the earth; thirty or forty yards of such speed marks the utmost limit of its endurance.

The radical difference in the form and action of the hind-feet cannot fail to strike the eye at once; they are one-seventh longer than the fore-hands, and very much lighter and more slender; they resemble, in broad terms, a pair of black kid gloves, flattened out and shriveled, as they lie in their box.

There is no suggestion of fingers on the fore-hands; but the hind-feet seem to be toes run into ribbons, for they literally flap about involuntarily from that point where the cartilaginous processes unite with the phalangeal bones. The hind-feet are also merged in the body at their junction with it, like those anterior; nothing can be seen of the leg above the tarsal joint.

The shape of the hind-flipper is strikingly like that of a human foot, provided the latter were drawn out to a length of twenty or twenty-two inches, the instep flattened down, and the toes run out into thin, membraneous, oval-tipped points, only skin-thick, leaving three strong, cylindrical, grayish, horn-colored nails, half an inch long each, back six inches from these skinny toe-ends, without any sign of nails to mention on the outer big and little toes.

On the upper side of this hind-foot the body-hair comes down to that point where the metatarsus and phalangeal bones join and fade out. From this junction the phalanges, about six inches down to the nails above mentioned, are entirely bare, and stand ribbed up in bold relief on the membrane which unites them as the web to a duck's foot; the nails just referred to mark the ends of the phalangeal bones, and their union in turn with the cartilaginous processes, which run rapidly tapering and flattening out to the ends of the thin toe-points. Now, as we are looking at this Fur Seal's motion and progression, that which seems most odd, is the gingerly manner (if I may be allowed to use the expression) in which it carries these hind-flippers; they are held out at right angles from the body directly opposite the pelvis, the toe-ends or flaps slightly waving, curled, and drooping over, supported daintily, as it were, above the earth, the animal only suffering its weight behind to fall upon its heels, which are themselves opposed to each other, scarcely five inches apart.

We shall, as we see this Seal again later in the season, have to notice a different mode of progression and bearing both when it is lording over its harem, or when it grows shy and restless at the end of the breeding season, then faint, emaciated, dejected; but we will now proceed to observe him in the order of his arrival and that of his family. His behavior during the long period of fasting and unceasing activity and vigilance, and other cares which devolve upon him as the most

eminent of all polygamists in the brute world, I shall carefully relate; and to fully comprehend the method of this exceedingly interesting animal, it will be frequently necessary for the reader to refer to my sketch-maps of its breeding-grounds or rookeries, and the islands.

ARRIVAL AT THE SEAL GROUNDS: COMING IN OF THE BULLS.—The adult males are the first examples of the *Callorhinus* to arrive in the spring on the seal ground, which has been deserted by all of them since the close of the preceding year.

Between the 1st and 5th of May, usually, a few males will be found scattered over the rookeries, pretty close to the water. They are at this time quite shy and sensitive, seeming not yet satisfied with the land; and a great many spend day after day idly swimming out among the breakers, a little distance from the shore, before they come to it, perhaps somewhat reluctant at first to enter upon the assiduous duties and the grave responsibilities before them in fighting for and maintaining their positions in the rookeries.

The first arrivals are not always the oldest bulls, but may be said to be the finest and most ambitious of their class. They are full grown and able to hold their places on the rookeries of the breeding-flats, which they immediately take up after coming ashore. Their method of landing is to come collectively to those breeding-grounds where they passed the prior season; but I am not able to say authoritatively, nor do I believe it, strongly as it has been urged by many careful men who were with me on the islands, that these animals come back to and take up the same position on their breeding-grounds that they individually occupied when there last year. From my knowledge of their action and habit, and from what I have learned of the natives, I should say that very few, if any, of them make such a selection and keep these places year after year. Even did the Seal itself intend to come directly from the sea to that spot on the rookery which it left last summer, what could it do if it came to that rookery margin a little late and found that another "See-catch" had occupied its ground? The bull could do nothing. It would either have to die in its tracks, if it persisted in attaining this supposed objective point, or do what undoubtedly it does do—seek the next best locality which it can attain adjacent.

One old "See-catch" was pointed out to me at the "Gorbatch" section of the Reef Rookery as an animal that was long known to the natives as a regular visitor close by or on the same rock every season during the past three years. They called him "Old John," and they said they knew him because he had one of his posterior digits missing, bitten off, perhaps, in a combat. I saw him in 1872, and made careful drawings of him in order that I might recognize his individuality should he appear again in the following year, and when that time rolled by I found him not; he failed to reappear, and the natives acquiesced in his absence. Of course it was impossible to say that he was dead when there were ten thousand rousing, fighting bulls to the right, left, and below us, under our eyes, for we could not approach for inspection. Still, if these animals came each to a certain place in any general fashion, or as a rule, I think there would be no difficulty in recognizing the fact; the natives certainly would do so; as it is, they do not. I think it very likely, however, that the older bulls come back to the same common rookery-ground where they spent the previous season; but they are obliged to take up their position on it just as the circumstances attending their arrival will permit, such as finding other Seals which have arrived before them, or of being whipped out by stronger rivals from their old stands.

It is entertaining to note, in this connection, that the Russians themselves, with the object of testing this mooted query, during the later years of their possession of the islands, drove up a number of young males from Lukannon, cut off their ears, and turned them out to sea again. The following season, when the droves came in from the "hauling-grounds" to the slaughtering-fields, quite a number of those cropped Seals were in the drives, but instead of being found all at one

place—the place from whence they were driven the year before—they were scattered examples of croppies from every point on the island. The same experiment was again made by our people in 1870 (the natives having told them of this prior undertaking), and they went also to Lukannon, drove up 100 young males, cut off their left ears, and set them free in turn. Of this number, during the summer of 1872, when I was there, the natives found in their driving of 75,000 Seals from the different hauling-grounds of Saint Paul up to the village killing-grounds, two on Novostashnah Rookery, ten miles north of Lukannon, and two or three from English Bay and Tolstoi Rookeries, six miles west by water; one or two were taken on Saint George Island, thirty-six miles to the southeast, *and not one from Lukannon was found among those that were driven from there; probably, had* all the young males on the two islands this season been examined, the rest of the croppies that had returned from the perils of the deep, whence they sojourned during the winter, would have been distributed quite equally about the Pribylov hauling-grounds. Although the natives say that they think the cutting off of the animal's ear gives the water such access to its head as to cause its death, yet I noticed that those examples which we had recognized by this auricular mutilation were normally fat and well developed. Their theory does not appeal to my belief, and it certainly requires confirmation.

These experiments would tend to prove very cogently and conclusively, that when the Seals approach the islands in the spring, they have nothing in their minds but a general instinctive *appreciation of the fitness of the land, as a whole; and no special fondness or determination to elect* any one particular spot, not even the place of their birth. A study of my map of the distribution of the seal-life on Saint Paul, clearly indicates that the landing of the Seals on the respective rookeries is influenced greatly by the direction of the wind at the time of their approach to the islands in the spring and early summer. The prevailing airs, blowing, as they do at that season, from the north and northwest, carry far out to sea the odor of the old rookery flats, together with the fresh scent of the pioneer bulls which have located themselves on these breeding-grounds, three or four weeks in advance of their kind. The Seals come up from the great North Pacific, and hence it will be seen that the rookeries of the south and southeastern shores of Saint Paul Island receive nearly all the seal-life, although there are miles of perfectly eligible ground at Nahsayvernia, or north shore. To settle this matter beyond all argument, however, I know is an exceedingly difficult *task, for the identification of individuals, from one season to another, among the hundreds of* thousands, and even millions, that come under the eye on one of these great rookeries, is well nigh impossible.

AGE OF FEMALES WHEN FIRST PREGNANT.—As to the time when the virgin cow is first covered by the bull, I found a strange medley of ideas among the people on the island. The common opinion of the others and the natives was, that they were not covered until they were three years of age, bringing forth their first young in the former case, in the generally accepted version, when they reached their fourth year. But this, on examination, was not a difficult problem at all to solve. The evidence every year decides when the yearlings are driven up to the village in the fall, that although to external appearance there is no difference between the sexes, an examination conclusively established the fact, that the yearling females herded with the yearling males on the hauling-grounds, each about equal in number, and that when the balance of the "Holluschickie," two-year-olds and upward, were driven in they never found a female[1] in the droves. Where were these two-year-old females then? They were not upon the hauling-grounds with the yearling females and bachelors. Where were they? The answer is, they have come up on the breeding-grounds, clothed with desire and supplied with physical life to meet prospective maternity.

[1] *i. e., virile female.*

RELATIVE DURATION OF LIFE: REPRODUCTION IS TERRESTRIAL.—This fact also shows that, as the female Fur Seal is so conspicuously inferior to the male, physically viewed, as to size and weight, so also is her life lessened. In other words, when she is matured, as she must be by her third year, in bearing then her first pup, she can reasonably be expected to live no longer than nine or ten years, according to the general natural law governing this question; while the male, not coming to his maturity and physical prime until he is five or six years of age, lives, in obedience to the same law, fifteen or twenty years.

OLD AND YOUNG MALES FIGHTING.—The males under six years of age, although hovering about the sea margins of the breeding-grounds, do not engage in much fighting there; it is the six and seven year old males, ambitious and flushed with their reproductive consciousness, that swarm out and do battle with the older males of these places. The young male of this latter class is, however, no match for an old fifteen or twenty year old bull, provided that the aged "Seecatchie" retains his teeth; for, with these weapons, his relatively harder thews and sinews give him the advantage in almost every instance, among the hundreds of combats that I have witnessed. These trials of strength between the old and the young are incessant until the rookeries are mapped out; and by common consent the males of all classes recognize the coming of the females. After their arrival and settlement over the whole extent of the breeding-grounds, about the 15th July at the latest, very little fighting takes place.[1]

ONLY ONE PUP BORN AT TIME OF PARTURITION.—Touching the number of young born at a birth, the most diligent inquiry and scrutiny of observation on the rookeries have satisfied me that it is confined to a single pup. If they have twins, I have failed to discover a single instance of that character. I also failed to notice a malformed pup or a monster anywhere throughout the multitudes under my observation, from July until the middle of November every season. I think this somewhat noteworthy, as it presents, perhaps, better than any other exhibition in the animal

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[1] It has been suggested to me that the exquisite power of scent possessed by these animals enables them to reach the breeding-grounds at about the place where they left them the season previously; surely the nose of the Fur Seal is endowed to a superlative degree with those organs of smell, and its range of appreciation in this respect must be very great.

"In carnivorous quadrupeds the structure of the bones of the nasal cavities is more intricate than in the herbivorous, and is calculated to afford a far more extensive surface for the distribution of the nerve. In the Seal this conformation is most fully developed and the bony plates are here not turbinated, but ramified, as shown in the woodcut. Eight or more principal branches rise from the main trunk, and each of these is divided and subdivided to an extreme degree of minuteness, so as to form in all many hundred plates. The olfactory membrane, with all its nerves, is closely applied to every plate in this vast assemblage, as well as to the main trunk and to the internal surface of the surrounding cavity, so that its extent cannot be less than 120 square inches in each nostril. An organ of such exquisite sensibility requires an extraordinary provision for securing it against injury, and nature has supplied a mechanism for the purpose, enabling the animal to close at pleasure the orifice of the nostril."—HARWOOD: Comp. Anat. and Physiol., Bridgewater Treatise, vol. ii, p. 402.

I noticed in all sleeping and waking Seals that the nasal apertures were never widely expanded; and that they were at intervals rapidly opened and closed with inhalation and exhalation of each breath; the nostrils of the Fur Seal are, as a rule, well opened when the animal is out of water, and remain so while it is on land.

The distances at sea, away from the Pribylov Islands, in which Fur Seals are found during the breeding season, are very considerable; scattered records have been made of seeing large bands of them during August as far down the northwest coast as they probably range at any season of the year, viz, well out at sea in the latitude of Cape Flattery, 47° to 49° south latitude. In the winter and spring, up to middle of June, all classes are found here spread out over wide areas of the ocean; then, by the 15th June they will have all departed, the first and the latest, en route for the Pribylov Islands. Then, when seen again in this extreme southern range, I presume the unusually early examples of return, toward the end of August, are squads of the yearlings of both sexes, for this division is always the last to land on, and the first to leave, the Seal Islands, annually. Also, the two-year-old females which have been covered on the breeding-grounds during June and July undoubtedly stray back to sea, and down again from the Pribylov group, very early in August, some of them as far as the coast-heads of Fuca Straits; at least, many of them at one time are never seen massed on the rookeries, and as they do not consort with the Holluschickie and yearlings on land, quite a number of their large aggregate doubtless make frequent and extended fishing excursions during the height of the breeding season.

kingdom, the survival of the fittest in the struggle for existence; for these bulls, by their own evolution, permit only the strongest and most perfect of their kind to stamp their impress on the coming generations.[1]

From the time of the first arrival in May up to the beginning of June, or as late as the middle of that month, if the weather be clear, is an interval in which everything seems quiet. Very few Seals are added to the pioneers that have landed, as we have described. By the 1st of June, however, sometimes a little before, and never much later, the seal-weather—the foggy, humid, oozy damp of summer—sets in; and with it, as the gray banks roll up and shroud the islands, the bull Seals *swarm from the depths by hundreds and thousands, and locate themselves in advantageous* positions for the reception of the females, which are generally three weeks or a month later than this date in arrival.

PRE-EMPTION OF THE ROOKERIES: BATTLES OF THE SEALS.—The labor of locating and maintaining a position on the rookery is really a terribly serious business for those bulls which come in last; and it is so all the time to those males that occupy the water-line of the breeding-grounds. A constantly sustained fight between the newcomers and the occupants goes on morning, noon, and night, without cessation, frequently resulting in death to one or even both of the combatants.

It appears, from my survey of these breeding-grounds, that a well-understood principle exists *among the able-bodied bulls, to wit: that each one shall remain undisturbed on his ground*, which is usually about six to eight feet square, provided that at the start, and from that time until the arrival of the females, he is strong enough to hold this ground against all comers; inasmuch as the crowding in of the fresh arrivals often causes the removal of those which, though equally able-bodied at first, have exhausted themselves by fighting earlier and constantly, they are finally driven by these fresher animals back farther and higher up on the rookery, and sometimes off altogether.

Many of these bulls exhibit wonderful strength and desperate courage. I marked one veteran at Gorbatch, who was the first to take up his position early in May, and that position, as usual, *directly* at the water-line. This male Seal had fought at least forty or fifty desperate battles, and fought off his assailants every time—perhaps nearly as many different Seals which coveted his *position—and when the fighting season was over (after the cows are mostly all hauled up), I saw* him still there, covered with scars and frightfully gashed; raw, festering, and bloody, one eye gouged out, but lording it bravely over his harem of fifteen or twenty females, who were all huddled together on the same spot of his first location and around him.

This fighting between the old and adult males (for none others fight) is mostly, or rather entirely, done with the mouth. The opponents seize one another with their teeth, and then clenching their jaws, nothing but the sheer strength of the one and the other tugging to escape can shake them loose, and that effort invariably leaves an ugly wound, the sharp canines tearing out deep gutters in the skin and furrows in the blubber, or shredding the flippers into ribbon-strips.

They usually approach each other with comically averted heads, just as though they were ashamed of the rumpus which they were determined to precipitate. When they get near enough to reach one another they enter upon the repetition of many feints or passes, before either one or the other takes the initiative by gripping. The heads are darted out and back as quick as a flash;

[1] A trained observer, Kumlien, who passed the winter of 1877-'78 in Cumberland Sound, and, speaking of this *feature in the Ringed Seal (Phoca fœtida), says, "There is usually but one young at a birth; still twins are not of rare* occurrence, and one instance came under my observation where there were triplets; but they were small, and two of them probably would not have lived had they been born."

their hoarse roaring and shrill, piping whistle never ceases, while their fat bodies writhe and swell with exertion and rage; furious lights gleam in their eyes; their hair flies in the air, and their blood streams down; all combined, makes a picture so fierce and so strange that, from its unexpected position and its novelty, is perhaps one of the most extraordinary brutal conte ts man can witness.

In these battles of the Seals, the parties are always distinct; the one is offensive, the other defensive. If the latter proves the weaker he withdraws from the position occupied, and is never followed by his conqueror, who complacently throws up one of his hind flippers, fans himself, as it were, to cool his fevered wrath and blood from the heat of the conflict, sinks into comparative quiet, only uttering a peculiar chuckle of satisfaction or contempt, with a sharp eye open for the next covetous bull or "See-catch."[1]

ATTITUDES AND COLORATION OF THE FUR SEAL.—The period occupied by the males in taking and holding their positions on the rookery, offers a very favorable opportunity to study them in the thousand and one different attitudes and postures assumed, between the two extremes of desperate conflict and deep sleep—sleep so profound that one can, if he keeps to the leeward, approach close enough, stepping softly, to pull the whiskers of any old male taking a nap on a clear place; but after the first touch to these moustaches, the trifler must jump with electrical celerity back, if he has any regard for the sharp teeth and tremendous shaking which will surely overtake him if he does not. The younger Seals sleep far more soundly than the old ones, and it is a favorite pastime for the natives to surprise them in this manner—favorite, because it is attended with no personal risk; the little beasts, those amphibious sleepers, rise suddenly, and fairly shrink to the earth, spitting and coughing their terror and confusion.

The neck, chest, and shoulders of a fur-seal bull comprise more than two-thirds of his whole weight; and in this long, thick neck, and the powerful muscles of the fore-limbs and shoulders, is embodied the larger portion of his strength. When on land, with the fore hands he does all climbing over the rocks and grassy hummocks back of the rookery, or shuffles his way over the smooth parades; the hind-feet being gathered up as useless trappings after every second step forward, which we have described at the outset of this chapter. These anterior flippers are also the propelling power when in water, the exclusive machinery with which they drive their rapid passage; the hinder ones floating behind like the steering sweep to a whale-boat, used evidently as rudders, or as the tail of a bird is while its wings sustain and force its rapid flight.

The covering to the body is composed of two coats, one being a short, crisp, glistening over-hair, and the other a close, soft, elastic pelage, or fur, which gives the distinctive value to the pelt. I can call it readily to the mind of my readers, when I say to them that the down and feathers on the breast of a duck lie relatively as the fur and hair do upon the skin of the Seal.

At this season of first "hauling up,"[2] in the spring, the prevailing color of the bulls, after they dry off and have been exposed to the weather, is a dark, dull brown, with a sprinkling in it of lighter brown-black, and a number of hoary or grizzled gray coats peculiar to the very old males. On the shoulders of all of them, that is, the adults, the over-hair is either a gray or rufous ocher, or a very emphatic "pepper and salt"; this is called the "wig." The body-colors are most intense and pronounced upon the back of the head, neck, and spine, fading down on the flanks lighter, to much lighter ground on the abdomen; still never white, or even a clean gray, so beautiful and peculiar to them when young, and to the females. The skin of the muzzle and flippers is a dark

[1] "See-catch," native name for the bulls on the rookeries, especially those which are able to maintain their position.

[2] "Hauling up," a technical term, applied to the action of the Seals when they land from the surf and haul up or drag themselves over the beach. It is expressive and appropriate, as are most of the sealing phrases.

bluish-black, fading in the older examples to a reddish and purplish tint. The color of the ears and tail is similar to that of the body, being somewhat, if anything, a trifle lighter; the ears on a bull Fur Seal are from one inch to an inch and a half in length; the pavilions or auricles are tightly rolled up on themselves, so that they are similar in shape to, and exactly the size of, the little finger on the human hand, cut off at the second phalangeal joint, a trifle more cone-shaped, however, as they are greater at the base than they are at the tip. They are haired and furred as the body is.

I think it probable that this animal has and does exert the power of compressing or dilating this scroll-like pavilion to its ear, just according as it dives deeper or rises in the water; and also, I am quite sure that the Hair Seal has this control over the *meatus externus*, from what I have seen of it. I have not been able to verify it in either case by actual observation; yet such opportunity as I have had gives me undoubted proof of the fact, that the hearing of the Fur Seal is wonderfully keen and surpassingly acute. If you make any noise, no matter how slight, the alarm will be given instantly by these insignificant-looking auditors, and the animal, rising up from deep sleep with a single motion erect, gives you a stare of stupid astonishment, and at this season of defiance, mingling it with incessant, surly roaring, growling, and "spitting."

VOICE OF THE FUR SEAL.—This spitting, as I call it, is by no means a fair or full expression of the most characteristic sound or action peculiar, so far as I have observed, to the Fur Seals alone, the bulls in particular. It is the usual prelude to all their combats, and it is their signal of astonishment. It follows somewhat in this way: when the two disputants are nearly within reaching or striking distance, they make a number of feints or false passes, as fencing-masters do, at one another, with the mouth wide open, lifting the lips or snarling so as to exhibit the glistening teeth, and with each pass of the head and neck they expel the air so violently through the larynx, as to make a rapid *choo-choo-choo* sound, like steam-puffs as they escape from the smoke-stack of a locomotive when it starts a heavy train, especially when the driving-wheels slip on the rail.

All of the bulls have the power and frequent inclination to utter four distinct calls or notes. This is not the case with the Sea Lion,[1] whose voice is confined to a single bass roar, or that of the walrus, which is limited to a dull grunt, or that of the Hair Seal,[2] which is inaudible. This volubility of the Fur Seal is decidedly characteristic and prominent; he utters a hoarse, resonant roar, loud and long; he gives vent to a low, entirely different, gurgling growl; he emits a chuckling, sibilant, piping whistle, of which it is impossible to convey an adequate idea, for it must be heard to be understood; and this spitting or *choo* sound just mentioned. The cows[3] have but one note—a hollow, prolonged, bla a-ting call, addressed only to their pups; on all other occasions they are usually silent. It is something strangely like the cry of a calf or an old sheep. They also make a spitting sound or snort when suddenly disturbed—a kind of a cough, as it were. The pups "blaat" also, with little or no variation, their sound being somewhat weaker and hoarser than their mother's, after birth; they, too, comically spit or cough when aroused suddenly from a nap or driven into a corner, opening their little mouths like young birds in a nest, when at bay, backed up in some crevice, or against some tussock.

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[1] *Eumetopias Stelleri.*

[2] *Phoca vitulina.*

[3] Without explanation, I may be considered as making use of paradoxical language by using these terms of description; for the inconsistency of talking of "pups" with "cows," and "bulls," and "rookeries," on the breeding-grounds of the same, cannot fail to be noticed; but this nomenclature has been given and used by the American and English whaling and sealing parties for many years, and the characteristic features of the Seals themselves so suit the naming, that I have felt satisfied to retain the style throughout as rendering my description more intelligible, especially so to those who are engaged in the business, or may be hereafter. The Russians are more consistent, but not so "pat"; they call the bull "See-catch," a term implying strength, vigor, etc.; the cow, "Matkah," or mother; the pups, "Kotickie," or little seals; the non-breeding males under six and seven years, "Holluschickie," or bachelors. The name applied collectively to the Fur Seal by them is "—Morskie-kot," or Sea Cat.

Indeed, so similar is the sound, that I noticed a number of sheep which the Alaska Commercial Company had brought up from San Francisco to Saint George Island, during the summer of 1873, were constantly attracted to the rookeries, and were running in among the "Holluschickie"; so much so that they neglected the good pasturage on the uplands beyond, and a small boy had to be regularly employed to herd them where they could feed to advantage. These transported *Oridæ*, though they could not possibly find anything in their eyes suggestive of companionship among the Seals, had their ears so charmed by the sheep-like accents of the female pinnipeds, as to persuade them against their senses of vision and smell.

The sound which arises from these great breeding-grounds of the Fur Seal, where thousands upon tens of thousands of angry, vigilant bulls are roaring, chuckling, and piping, and multitudes of seal-mothers are calling in hollow, blaating tones to their young, that in turn respond incessantly, is simply defiance to verbal description. It is, at a slight distance, softened into a deep booming, as of a cataract; and I have heard it, with a light, fair wind to the leeward, as far as six miles out from land on the sea; and even in the thunder of the surf and the roar of heavy gales, it will rise up and over to your ear for quite a considerable distance away. It is the monitor which the sea-captains anxiously strain their ears for, when they run their dead reckoning up, and are laying to for the fog to rise, in order that they may get their bearings of the land; once heard, they hold on to the sound and feel their way in to anchor. The seal-roar at "Novostashnah," during the summer of 1872, saved the life of the surgeon,[1] and six natives belonging to the island, who had pushed out on an egging-trip from Northeast Point to Walrus Island. I have sometimes thought, as I have listened through the night to this volume of extraordinary sound, which never ceases with the rising or the setting of the sun throughout the entire season of breeding, that it was fully equal to the churning boom of the waves of Niagara. Night and day, throughout the season, this din upon the rookeries is steady and constant.

EFFECTS OF HEAT ON THE SEALS.—The Seals seem to suffer great inconvenience and positive misery from a comparatively low degree of heat. I have been often surprised to observe that, when the temperature was 46° and 48° Fahr. on land during the summer, they would show everywhere signs of distress, whenever they made any exertion in moving or fighting, evidenced by panting and the elevation of their hind-flippers, which they used incessantly as so many fans. With the thermometer again higher, as it is at rare intervals, standing at 55° and 60°, they then seem to suffer even when at rest; and at such times the eye is struck by the kaleidoscopic appearance of a rookery—in any of these rookeries where the Seals are spread out in every imaginable position their lithesome bodies can assume, all industriously fan themselves; they use sometimes the fore-flippers as ventilators, as it were, by holding them aloft motionless, at the same time fanning briskly with the hinder ones, according as they sit or lie. This wavy motion of fanning or flapping gives a hazy indistinctness to the whole scene, which is difficult to express in language; but one of the most prominent characteristics of the Fur Seal, and perhaps the most unique feature, is this very fanning manner in which they use their flippers, when seen on the breeding-grounds at this season. They also, when idle as it were, off-shore at sea, lie on their sides in the water with only a partial exposure of the body, the head submerged, and then hoist up a fore- or hind-flipper clear out of the water, at the same time scratching themselves or enjoying a momentary nap; but in this position there is no fanning. I say "scratching," because the Seal, in common

[1] Dr. Otto Cramer. The suddenness with which fog and wind shut down and sweep over the sea here, even when the day opens most auspiciously for a short boat-voyage, has so alarmed the natives in times past, that a visit is now never made by them from island to island, unless on one of the company's vessels. Several bidarrahs have never been heard from, which, in earlier times, attempted to sail, with picked crews of the natives, from one island to the other.

with all animals, is preyed upon by vermin, and it has a peculiar species of *louse*, or *parasitic tick*, that belongs to it.

SLEEPING AFLOAT.—Speaking of the Seal as it rests in the water, leads me to remark that they seem to sleep as sound and as comfortably, bedded on the waves or rolled by the swell, as they do on the land; they lie on their backs, fold the fore-flippers across the chest, and turn the hind ones up and over, so that the tips rest on their necks and chins, thus exposing simply the nose and the heels of the hind-flippers above water, nothing else being seen. In this position, unless it is very rough, the Seal sleeps as serenely as did the prototype of that memorable song, who was "rocked in the cradle of the deep."

FASTING OF THE SEALS AT THE ROOKERIES: INTESTINAL WORMS.—All the bulls, from the very first, *that have been able to hold their positions, have not left them* from the moment of their landing for a single instant, night or day; nor will they do so until the end of the rutting season, which subsides entirely between the 1st and 10th of August, beginning shortly after the coming of the cows in June. Of necessity, therefore, this causes them to fast, to abstain entirely from food of any kind, or water, for three months at least; and a few of them actually stay out four months, in total abstinence, before going back into the water for the first time after "hauling up" in May; they then return as so many bony shadows of what they were only a few months anteriorly; covered with wounds, abject and spiritless, they laboriously crawl back to the sea to renew a fresh lease of life.

Such physical endurance is remarkable enough alone; but it is simply wonderful, when we come to associate this fasting with the unceasing activity, restlessness, and duty devolved upon the bulls as the heads of large families. They do not stagnate like hibernating bears in caves; there is not one torpid breath drawn by them in the whole period of their fast; it is evidently sustained *and accomplished by the self-absorption of their own fat*, with which they are so liberally supplied when they first come out from the sea and take up their positions on the breeding-grounds, and which gradually disappears, until nothing but the staring hide, protruding tendons and bones, marks the limit of their abstinence. There must be some remarkable provision made by nature for the entire torpidity of the Seals' stomachs and bowels, in consequence of their being empty and unsupplied during this long period, coupled with the intense activity and physical energy of the animals during the same time, which, however, in spite of the violation of a supposed physiological law, does not seem to affect them, for they come back *just as sleek, fat, and ambitious as ever, in* the following season.

I have examined the stomachs of hundreds which were driven up and killed immediately after their arrival in the spring, near the village; I have the word of the natives here, who have seen hundreds of thousands of them opened during the slaughtering seasons past, but in no single case has anything ever been found, other than the bile and ordinary secretions of healthy organs of this class, with the marked exception of finding in every one a snarl or cluster of worms,[1] from the size of a walnut to a bunch as large as a man's fist. Fasting apparently has no effect upon the worms, for on the rare occasion, and perhaps the last one that will ever occur, of killing three or four hundred old bulls late in the fall to supply the natives with canoe skins, I was present, and again examined their paunches, finding the same worms within. The worms were lively in these empty stomachs, and their presence, I think, gives some reason for the habit which the old bulls have (the others do not) of swallowing small water-worn bowlders, the stones in some of the stomachs weighing half a pound apiece, in others much smaller. In one paunch I found over five

[1] *Nematoda.*

pounds, in the aggregate, of large pebbles, which, in grinding against one another, I believe, must comfort the Seal by aiding to destroy, in a great measure, these intestinal pests.

The Sea Lion is also troubled in the same way by a similar species of worm, and I preserved the stomach of one of these animals in which there was more than ten pounds of stones, some of them alone very great in size. Of this latter animal, I suppose it could swallow bowlders that weigh two and three pounds each. I can ascribe no other cause for this habit among these animals than that given, as they are the highest type of the carnivora, eating fish as a regular means of subsistence, varying the monotony of this diet with occasional juicy fronds of sea-weed or kelp, and perhaps a crab or such once in a while, provided it is small and tender or soft-shelled. I know that the sailors say that the *Callorhinus* swallows these stones to "ballast" himself; in other words, to enable him to dive deeply and quickly; but I noticed that the females and the "Holluschickie" dive quicker and swim better than the old fellows above specified, and they do so without any ballast. They also have less muscular power, only a tithe of that which the "Sea catch" possesses. No, the ballast theory is not tenable.

ARRIVAL OF THE COW SEALS AT THE ROOKERIES.—Between the 12th and 14th of June, the first of the cow Seals, as a rule, come up from the sea; then the long agony of the waiting bulls is over, and they signalize it by a period of universal, spasmodic, desperate fighting among themselves. Though they have quarreled all the time from the moment they first landed, and continue to do so until the end of the season, in August, yet that fighting which takes place at this date is the bloodiest and most vindictive known to the Seal. I presume that the heaviest percentage of mutilation and death among the old males from these brawls occurs in this week of the earliest appearance of the females.

A strong contrast now between the males and females looms up, both in size and shape, which is heightened by the air of exceeding peace and dove-like amiability which the latter class exhibit, in contradistinction to the ferocity and saturnine behavior of the males.

DESCRIPTION OF THE COW SEAL.—The cows are from four to four and a half feet in length from head to tail, and much more shapely in their proportions than the bulls; there is no wrapping around their necks and shoulders of unsightly masses of blubber; their lithe, elastic forms, from the first to the last of the season, are never altered; this they are, however, enabled to keep, because in the provision of seal economy, they sustain no protracted fasting period; for, soon after the birth of their young, they leave it on the ground and go to the sea for food, returning perhaps to-morrow, perhaps later, even not for several days in fact, to again suckle and nourish it; having in the mean time sped far off to distant fishing banks, and satiated a hunger which so active and highly organized an animal must experience, when deprived of sustenance for any length of time.

As the females come up wet and dripping from the water, they are at first a dull, dirty-gray color, dark on the back and upper parts, but in a few hours the transformation in their appearance made by drying is wonderful. You would hardly believe that they could be the same animals, for they now fairly glisten with a rich steel and maltese gray luster on the back of the head, the neck, and along down the spine, which blends into an almost snow-white over the chest and on the abdomen. But this beautiful coloring in turn is again altered by exposure to the same weather; for after a few days it will gradually change, so that by the lapse of two or three weeks it is a dull, rufous-ocher below, and a cinereous brown and gray mixed above. This color they retain throughout the breeding season, up to the time of shedding their coat in August.

The head and eye of the female are exceedingly beautiful; the expression is really attractive, gentle, and intelligent; the large, lustrous, blue-back eyes are humid and soft with the tenderest expression, while the small, well formed head is poised as gracefully on her neck as can be well

imagined; she is the very picture of benignity and satisfaction, when she is perched up on some convenient rock, and has an opportunity to quietly fan herself, the eyes half-closed and the head thrown back on her gently-swelling shoulders.

The females land on these islands not from the slightest desire to see their uncouth lords and masters, but from an accurate and instinctive appreciation of the time in which their period of gestation ends. They are in fact driven up to the rookeries by this cause alone; the young cannot be brought forth in the water, and in all cases marked by myself, the pups were born soon after landing, some in a few hours, but most usually a day or so elapses before delivery.

ORGANIZATION OF THE ROOKERIES.—They are noticed and received by the males on the water-line stations with attention; they are alternately coaxed and urged up on to the rocks, as far as these beach-masters can do so, by chuckling, whistling, and roaring, and then they are immediately under the most jealous supervision; but, owing to the covetous and ambitious nature of the bulls which occupy these stations to the rear of the water-line and way back, the little cows have a rough-and-tumble time of it when they begin to arrive in small numbers at first, for no sooner is the pretty animal fairly established on the station of male number one, who has welcomed her there, than he, perhaps, sees another one of her style in the water from whence she has come, and, in obedience to his polygamous feeling, he devotes himself anew to coaxing the later arrival, by that same winning manner so successful in her case; then when bull number two, just back, observes bull number one off guard, he reaches out with his long strong neck and picks up the unhappy but passive cow by the scruff of her's, just as a cat does a kitten, and deposits her upon his seraglio ground; then bulls number three and four, and so on, in the vicinity, seeing this high-handed operation, all assail one another, especially number two, and for a moment have a tremendous fight, perhaps lasting half a minute or so, and during this commotion the little cow is generally moved, or moves, farther back from the water, two or three stations more, where, when all gets quiet again, she usually remains in peace. Her last lord and master, not having the exposure to such diverting temptation as her first, gives her such care that she not only is unable to leave, did she wish, but no other bull can seize upon her. This is only a faint (and I fully appreciate it), wholly inadequate description of the hurly-burly and the method by which the rookeries are filled up, from first to last, when the females arrive. This is only one instance of the many trials and tribulations which both parties on the rookery subject themselves to, before the harems are filled.

Far back, fifteen or twenty "See-catchie" stations deep from the water-line, and sometimes more, but generally not over an average of ten or fifteen, the cows crowd in at the close of the season for arriving, which is by the 10th or 14th of July; then they are able to go about pretty much as they please, for the bulls have become so greatly enfeebled by this constant fasting, fighting, and excitement during the past two months, that they are quite content now even with only one or two partners, if they should have no more.

The cows seem to haul up in compact bodies from the water, filling in the whole ground to the rear of the rookeries, never scattering about over the surface of this area; they have mapped out from the first their chosen resting places, and they will not lie quietly in any position outside of the great mass of their kind. This is due to their intensely gregarious nature, and admirably adapted for their protection. And here I should call attention to the fact that they select this rookery-ground with all the skill of civil engineers. It is preferred with special reference to the drainage, for it must lie so that the produce of the constantly dissolving fogs and rain-clouds shall not lie upon them, having a great aversion to and a firm determination to rest nowhere on water-puddled ground. This is admirably exhibited, and will be understood by a study of my

sketch-maps which follow, illustrative of these rookeries and the area and position of the Seals upon them. Every one of these breeding-grounds slopes up gently from the sea, and on no one of them is there anything like a muddy flat.

I found it an exceedingly difficult matter to satisfy myself as to a fair general average number of cows to each bull on the rookery; but, after protracted study, I think it will be nearly correct when I assign to each male a general ratio of from fifteen to twenty females at the stations nearest the water; and for those back in order from that line to the rear, from five to twelve; but there are so many exceptional cases, so many instances where forty-five and fifty females are all under the charge of one male; and then, again, where there are two or three females only, that this question was and is not entirely satisfactory in its settlement to my mind.

Near Ketavie Point, and just above it to the north, is an odd washout of the basalt by the surf, which has chiseled, as it were, from the foundation of the island, a lava table, with a single roadway or land passage to it. Upon the summit of this footstool I counted forty-five cows, all under the charge of one old veteran. He had them penned up on this table-rock by taking his stand at the gate, as it were, through which they passed up and passed down—a Turkish brute typified.

UNATTACHED MALES.—At the rear of all these rookeries there is invariably a large number of able-bodied males who have come late, but who wait patiently, yet in vain, for families; most of them having had to fight as desperately for the privilege of being there as any of their more fortunately located neighbors, who are nearer the water, and in succession from there to where they are themselves; but the cows do not like to be in any outside position. They cannot be coaxed out where they are not in close company with their female mates and masses. They lie most quietly and contentedly in the largest harems, and cover the surface of the ground so thickly that there is hardly moving or turning room until the females cease to come from the sea. The inaction on the part of the males in the rear during the breeding-season only serves to qualify them to move into the places which are necessarily vacated by those males that are, in the mean time, obliged to leave from virile exhaustion, or incipient wounds. All the surplus able-bodied males, that have not been successful in effecting a landing on the rookeries, cannot at any one time during the season be seen here on this rear line. Only a portion of their number are in sight; the others are either loafing at sea, adjacent, or are hauled out in morose squads between the rookeries on the beaches.

COURAGE OF THE FUR SEALS.—The courage with which the Fur Seal holds his position as the head and guardian of a family, is of the highest order. I have repeatedly tried to drive them from their harem posts, when they were fairly established on their stations, and have always failed, with few exceptions. I might use every stone at my command, making all the noise I could. Finally, to put their courage to the fullest test, I have walked up to within twenty feet of an old veteran, toward the extreme end of Tolstoi, who had only four cows in charge, and commenced with my double-barreled fowling-piece to pepper him all over with fine mustard-seed shot, being kind enough, in spite of my zeal, not to put out his eyes. His bearing, in spite of the noise, smell of powder, and painful irritation which the fine shot must have produced, did not change in the least from the usual attitude of determined plucky defense, which nearly all of the bulls assumed when attacked with showers of stones and noise; he would dart out right and left with his long neck and catch the timid cows, that furtively attempted to run after each report of my gun, fling and drag them back to their places under his head; and then, stretching up to his full height look me directly and defiantly in the face, roaring and chuckling most vehemently. The cows, however, soon got away from him; they could not stand my racket in spite of their dread of him; but he still stood

his ground, making little charges on me of ten or fifteen feet in a succession of gallops or lunges, spitting furiously, and then comically retreating to the old position, with an indescribable leer and swagger, back of which he would not go, fully resolved to hold his own or die in the attempt.

This courage is all the more noteworthy from the fact that, in regard to man, it is invariably of a defensive character. The Seal is always on the defensive; he never retreats, and he will not attack. If he makes you return when you attack him, he never follows you much farther than the boundary of his station, and then no aggravation will compel him to take the offensive, so far as I have been able to observe. I was very much impressed by this trait.

BEHAVIOR OF THE FEMALE SEALS ON THE ROOKERIES.—The cows, during the whole season, do great credit to their amiable expression by their manner and behavior on the rookery; they never fight or quarrel one with another, and never or seldom utter a cry of pain or rage when they are roughly handled by the bulls, which frequently get a cow between them and actually tear the skin from her back with their teeth, cutting deep gashes in it as they snatch her from mouth to mouth. If sand does not get into these wounds it is surprising how rapidly they heal; and, from the fact that I never could see scars on them anywhere except the fresh ones of this year, they must heal effectually and exhibit no trace the next season.

The cows, like the bulls, vary much in weight, but the extraordinary disparity in the size of the sexes, adult, is exceedingly striking. Two females taken from the rookery nearest to Saint Paul Village, right under the bluffs, and almost beneath the eaves of the natives' houses, called "Nah Speel," after they had brought forth their young, were weighed by myself, and their respective returns on the scales were fifty-six and one hundred pounds each, the former being about three or four years old, and the latter over six—perhaps ten; both were fat, or rather in good condition—as good as they ever are. Thus the female is just about one-sixth the size of the male.[1] Among the Sea Lions the proportion is just one-half the bulk of the male,[2] while the Hair Seals, as I have before stated, are not distinguishable in this respect, as far as I could observe, but my notice was limited to a few specimens only.

ATTITUDES OF FUR SEALS ON LAND.—It is quite beyond my power, indeed entirely out of the question, to give a fair idea of the thousand and one positions in which the Seals compose themselves and rest when on land. They may be said to assume every possible attitude which a flexible body can be put into, no matter how characteristic or seemingly forced or constrained. Their joints seem to be double-hinged; in fact, all ball and socket union of the bones. One favorite position, especially with the females, is to perch upon a point or edge-top of some rock, and throw their heads back upon their shoulders, with the nose held directly up and aloft; and then closing their eyes, to take short naps without changing their attitude, now and then softly lifting one or the other of their long, slender hind-flippers, which they slowly wave with their peculiar fanning motion to which I have alluded heretofore. Another attitude, and one of the most common, is to curl themselves up just as a dog does on a hearth rug, bringing the tail and nose close together. They also stretch out, laying the head close to the body, and sleep an hour or two without rising, holding one of the hind-flippers up all the time, now and then gently moving it, the eyes being tightly closed.

I ought, perhaps, to define here the anomalous tail of the Fur Seal. It is just about as important as the caudal appendage to a bear, even less significant: it is the very emphasis of abbreviation. In the old males it is positively only four or five inches in length, while among the females only two and a half to three inches, wholly inconspicuous, and not even recognized by the casual observer.

[1] Adult male and female—*Callorhinus ursinus.*
[2] Adult male and female—*Eumetopias Stelleri.*

SLEEPING SEALS.—I come now to speak of another feature which interested me nearly, if not quite, as much as any other characteristic of this creature; and that is their fashion of slumber. The sleep of the Fur Seal, seen on land, from the old male down to the youngest, is always accompanied by an involuntary, nervous, muscular twitching and slight shifting of the flippers, together with ever and anon quivering and uneasy rollings of the body, accompanied by a quick folding anew of the fore-flippers; all of which may be signs, as it were, in fact, of their simply having nightmares, or of sporting, in a visionary way, far off in some dream-land sea; but perhaps very much as an old nurse said, in reference to the smiles on a sleeping child's face, they are disturbed by their intestinal parasites. I have studied hundreds of such somnolent examples. Stealing softly up, so closely that I could lay my hand upon them from the point where I was sitting, did I wish to, and watching the sleeping Seals, I have always found their sleep to be of this nervous description. The respiration is short and rapid, but with no breathing (unless the ear is brought very close) or snoring sound; the quivering, heaving of the flanks only indicates the action of the lungs. I have frequently thought that I had succeeded in finding a snoring Seal, especially among the pups; but a close examination always gave some abnormal reason for it; generally a slight distemper, never anything severer, however, than some trifle by which the nostrils were stopped up to a greater or less degree.

The cows on the rookeries sleep a great deal, but the males have the veriest cat-naps that can be imagined. I never could time the slumber of any old male on the breeding-grounds, which lasted without interruption longer than five minutes, day or night; while away from these places, however, I have known them to lie sleeping in the manner I have described, broken by these fitful, nervous, dreamy starts, yet without opening the eyes, for an hour or so at a time.

With the exception of the pups, the Fur Seal seems to have very little rest awake or sleeping; perpetual motion is well nigh incarnate with its being.

FUR-SEAL PUPS.—As I have said before, the females, soon after landing, are delivered of their young. Immediately after the birth of the pup (twins are rare, if ever) the little creature finds its voice, a weak, husky *blaat*, and begins to paddle about with its eyes wide open from the start, in a confused sort of way for a few minutes, until the mother turns around to notice her offspring and give it attention, and still later to suckle it; and for this purpose she is supplied with four small, brown nipples, almost wholly concealed in the fur, and which are placed about eight inches apart, lengthwise with the body, on the abdomen, between the fore- and hind-flippers, with about four inches of space between them transversely. These nipples are seldom visible, and then faintly seen through the hair and fur. The milk is abundant, rich, and creamy. The pups nurse very heartily, almost gorging themselves, so much so that they often have to yield up the excess of what they have taken down, mewling and puking in the most orthodox manner.

The pup from birth, and for the next three months, is of a jet-black color, hair and flippers, save a tiny white patch just back of each forearm. It weighs first from three to four pounds, and is twelve to fourteen inches long. It does not seem to nurse more than once every two or three days, but in this I am very likely mistaken, for they may have received attention from the mother in the night, or other times in the day when I was unable to keep up my watch over the individuals which I had marked for this supervision.

The apathy with which the young are treated by the old on the breeding-grounds, especially by the mothers, was very strange to me, and I was considerably surprised at it. I have never seen a seal-mother caress or fondle her offspring; and should it stray to a short distance from the hare , I could step to and pick it up, and even kill it before the mother's eye, without causing her the slightest concern, as far as all outward signs and manifestation would indicate. The same indiffer-

ence is also exhibited by the male to all that may take place of this character outside of the boundary of his seraglio; but the moment the pups are inside the limits of his harem-ground, he is a jealous and a fearless protector, vigilant and determined; but if the little animals are careless enough to pass beyond this boundary, then I can go up to them and carry them off before the eye of the old Turk without receiving from him the slightest attention in their behalf—a curious guardian, forsooth!

It is surprising to me how few of these young pups get crushed to death while the ponderous males are floundering over them, engaged in fighting and quarreling among themselves. I have seen two bulls dash at each other with all the energy of furious rage, meeting right in the midst of a small "pod" of forty or fifty pups, tramp over them with all their crushing weight, and bowling them out right and left in every direction by the impetus of their movements, without injuring a single one, as far as I could see. Still, when we come to consider the fact that, despite the great weight of the old males, their broad, flat flippers and yielding bodies may press down heavily on these little fellows without actually breaking bones or mashing them out of shape, it seems questionable whether more than one per cent. of all the pups born each season on these great rookeries of the Pribylov Islands are destroyed in this manner on the breeding-grounds.[1]

The vitality of the Fur Seal is simply astonishing. His physical organization passes beyond the fabled nine lives of the cat. As a slight illustration of his tenure of life, I will mention the fact, that one morning the chief came to me with a pup in his arms, which had just been born, and was still womb-moist, saying that the mother had been killed at Tolstoi by accident, and he supposed that I would like to have a "choochil."[2] I took it up into my laboratory, and finding that it could walk about and make a great noise, I attempted to feed it, with the idea of having a comfortable subject to my pencil, for life-study of the young in the varied attitudes of sleep and motion. It refused everything that I could summon to its attention as food; and, alternately sleeping and walking, in its clumsy fashion, about the floor, it actually lived nine days—spending the half of every day in floundering over the floor, accompanying all movement with a persistent, hoarse, *blaating* cry—and I do not believe it ever had a single drop of its mother's milk.

In the pup, the head is the only disproportionate feature at birth, when it is compared with the adult form; the neck being also relatively shorter and thicker. The eye is large, round, and full, but almost a "navy blue" at times, it soon changes into the blue-black of adolescence.

The females appear to go to and come from the water to feed and bathe, quite frequently, after bearing their young, and the immediate subsequent coitus with the male; and usually return to the spot or its immediate neighborhood, where they leave their pups, crying out for them, and recognizing the individual replies, though ten thousand around, all together, should *blaat* at once. They quickly single out their own and nurse them. It would certainly be a very unfortunate matter if the mothers could not identify their young by sound, since their pups get together like a great swarm of bees, and spread out upon the ground in what the sealers call "pods," or clustered groups, while they are young and not very large; but from the middle or end of September, until they leave the islands for the dangers of the great Pacific, in the winter, along into the heat of November, they gather in this manner, sleeping and frolicking by tens of thousands, bunched together at various places all over the islands contiguous to the breeding-grounds, and right on them. A mother comes up from the sea, whither she has been to wash, and perhaps to feed, for the last day or two, feeling her way along to about where she thinks her pup should be—at least where she left

[1] The only damage which these little fellows have up here, is being caught by an October gale down at the surf-margin, when they have not fairly learned to swim; large numbers have been destroyed by sudden "nips" of this character.

[2] A specimen to stuff.

it last—but perhaps she misses it, and finds instead a swarm of pups in which it has been incorporated, owing to its great fondness for society. The mother, without first entering into the crowd of thousands, calls out just as a sheep does for a lamb; and, out of all the din she—if not at first, at the end of a few trials—recognizes the voice of her offspring, and then advances, striking out right and left, toward the position from which it replies. But if the pup happens at this time to be asleep, it gives, of course, no response, even though it were close by; in the event of this silence the cow, after calling for a time without being answered, curls herself up and takes a nap, or lazily basks, to be usually more successful, or wholly so, when she calls again.

The pups themselves do not know their own mothers—a fact which I ascertained by careful observation; but they are so constituted that they incessantly cry out at short intervals during the whole time they are awake, and in this way the mother can pick out from the monotonous blaating of thousands of pups, her own, and she will not permit any other to suckle it; but the "Kotickie" themselves attempt to nose around every seal-mother that comes in contact with them.

I have repeatedly watched young pups as they made advances to nurse from another pup's mother; the result invariably being, that while the mother would permit her own offspring to suckle freely, yet, when these little strangers touched her nipples, she would either move abruptly away, or else turn quickly down upon her stomach, so that the maternal fountains were inaccessible to the alien and hungry "Kotickie." I have witnessed so many examples of the females turning pups away, to suckle only some particular other one, that I feel sure I am entirely right in saying that the seal-mothers know their own young; and that they will not permit any others to nurse save their own. I believe that this recognition of them is due chiefly to the mother's scent and hearing.

Disorganization of the rookeries.—Between the end of July and the 5th or 8th of August of every year, the rookeries are completely changed in appearance; the systematic and regular disposition of the families or harems over the whole extent of the breeding-ground has disappeared; all that clock-work order which has heretofore existed seems to be broken up. The breeding-season over, those bulls which have held their positions since the first of May leave, most of them thin in flesh and weak, and of their number a very large proportion do not come out again on land during the season; but such as are seen at the end of October and November, are in good flesh. They have a new coat of rich, dark, gray-brown hair and fur, with gray or grayish-ocher "wigs" of longer hair over the shoulders, forming a fresh, strong contrast to the dull, rusty brown and umber dress in which they appear to us during the summer, and which they had begun to shed about the first of August, in common with the females and the "Holluschickie." After these males leave, at the close of their season's work and of the rutting for the year, those of them that happen to return to the land in any event do not come back until the end of September, and do not haul upon the rookery-grounds again. As a rule they prefer to herd together, like the younger males, upon the sand-beaches and rocky points close to the water.

The cows and pups, together with those bulls which we have noticed in waiting in the rear of the rookeries, and which have been in retirement throughout the whole of the breeding-season, now take possession, in a very disorderly manner, of the rookeries. There come, also, a large number of young, three, four, and five year old males, which have been prevented by the menacing threats of the older, stronger bulls, from landing among the females during the rutting-season.

Before the middle of August three-fourths, at least, of the cows at this date are off in the water, only coming ashore at irregular intervals to nurse and look after their pups a short time. They presented to my eye, from the summits of the bluffs round about, a picture more suggestive than anything I have ever seen presented by animal life, of entire comfort and enjoyment. Here,

just out and beyond the breaking of the rollers, they idly lie on the rocks or sand-beaches, ever and anon turning over and over, scratching their backs and sides with their fore- and hind-flippers. The Seals on the breeding ground appear to get very lousy.

The Fur Seal spends a great deal of time, both at sea and on land, in scratching its hide; for it is annoyed by a species of louse, a *Pediculus*, to just about the same degree and in the same manner that our dogs are by fleas. To scratch, it sits upon its haunches, and scrapes away with the toe-nails of first one and then the other of its hind-flippers; by which action it reaches readily all portions of its head, neck, chest, and shoulders; and, with either one or the other of its fore-flippers, it rubs down its spinal region back of the shoulders to the tail. By that division of labor with its feet, it can promptly reduce, with every sign of comfort, any lousy irritation wheresoever on its body. This *Pediculus*, peculiar to the Fur Seal, attaches itself almost exclusively to the pectoral regions; a few, also, are generally found at the bases of the auricular pavilions.

When the Fur Seal is engaged in this exercise, it cocks its head and wears exactly the same expression that our common house-dog does while subjugating and eradicating fleas; the eyes are partly or wholly closed; the tongue lolls out; and the whole demeanor is one of quiet but intense satisfaction.

The Fur Seal appears also to scratch itself in the water with the same facility and unction so marked on land; only it varies the action by using its fore-hands principally, in its fluviatile exercise, while its hind-feet do most of the terrestrial scraping.

While I have written with much emphasis upon the total absence of any record as to the prevalence of an epidemic in these large rookeries, I should, perhaps, mark the fact that no symptoms of internal diseases have ever been noticed here, such as tuberculosis of the lungs, etc., which invariably attack and destroy the Fur Seal when it is taken into confinement, as well as the Sea Lions also; the latter, however, have a much greater power of endurance under such artificial circumstances of life. The thousands upon thousands of disemboweled Pribylov fur-seal carcasses have never presented abnormal or diseased viscera of any kind.

MANGY COWS AND PUPS.—The frequent winds and showers drive and spatter sand into their fur and eyes, often making the latter quite sore. This occurs when they are obliged to leave the rocky rookeries and follow their pups out over the sand-ridges and flats, to which they always have a natural aversion. On the hauling-grounds they pack the soil under foot so hard and tightly in many places, that it holds water in the surface depressions, just like so many rock-basins. Out of and into these puddles the pups and the females flounder and patter incessantly, until evaporation slowly abates the nuisance. This is for the time only, inasmuch as the next day, perhaps, brings more rain, and the dirty pools are replenished.

The pups sometimes get so thoroughly plastered in these muddy, slimy puddles, that the hair falls off in patches, giving them, at first sight, the appearance of being troubled with scrofula or some other plague: from my investigations, directed to this point, I became satisfied that they were not permanently injured, though evidently very much annoyed. With reference to this suggestion as to sickness or distemper among the Seals, I gave the subject direct and continued attention, and in no one of the rookeries could I discover a single Seal, no matter how old or young, which appeared to be suffering in the least from any physical disorder, other than that which they themselves had inflicted, one upon the other, by fighting. The third season, passing directly under my observation, failed to reward my search with any manifestation of disease among the Seals which congregate in such mighty numbers on the rookeries of Saint Paul and Saint George. The remarkable freedom from all such complaints enjoyed by these animals is noteworthy, and the

most trenchant and penetrating cross-questioning of the natives, also, failed to give me any history or evidence of an epidemic in the past.

HOSPITALS.—The observer will, however, notice every summer, gathered in melancholy squads of a dozen to one hundred or so, scattered along the coast where the healthy Seals never go, those sick and disabled bulls which have, in the earlier part of the season, been either internally injured or dreadfully scarred by the teeth of their opponents in fighting. Sand is blown by the winds into the fresh wounds and causes an inflammation and a sloughing, which very often finishes the life of the victim. The sailors term these invalid gatherings "hospitals," a phrase which, like most of their homely expressions, is quite appropriate.

YOUNG SEALS LEARNING TO SWIM.—Early in August, usually by the 8th or 10th, I noticed one of the remarkable movements of the season. I refer to the pup's first essay in swimming. Is it not odd—paradoxical—that the young Seal, from the moment of his birth until he is a month or six weeks old, is utterly unable to swim? If he is seized by the nape of the neck and pitched out a rod into the water from shore, his bullet-like head will drop instantly below the surface, and his attenuated posterior extremities flap impotently on it; suffocation is the question of only a few minutes, the stupid little creature not knowing how to raise his immersed head and gain the air again. After they have attained the age I indicate, their instinct drives them down to the margin of the surf, where the alternate ebbing and flowing of its wash covers and uncovers the rocky or sandy beaches. They first smell and then touch the moist pools, and flounder in the upper wash of the surf, which leaves them as suddenly high and dry as it immersed them at first. After this beginning they make slow and clumsy progress in learning the knack of swimming. For a week or two, when overhead in depth, they continue to flounder about in the most awkward manner, thrashing the water as little dogs do, with their fore feet, making no attempt whatever to use the hinder ones. Look at that pup now, launched out for the first time beyond his depth; see how he struggles—his mouth wide open, and his eyes fairly popping. He turns instantly to the beach, ere he has fairly struck out from the point whence he launched in, and, as the receding swell which at first carried him off his feet and out, now returning leaves him high and dry, for a few minutes he seems so weary that he weakly crawls up, out beyond its swift returning wash, and coils himself up immediately to take a recuperative nap. He sleeps a few minutes, perhaps half an hour, then awakes as bright as a dollar, apparently rested, and at his swimming lesson he goes again. By repeated and persistent attempts, the young Seal gradually becomes familiar with the water and acquainted with his own power over that element, which is to be his real home and his whole support. Once boldly swimming, the pup fairly revels in his new happiness. He and his brethren have now begun to haul and swarm along the whole length of Saint Paul coast, from Northeast Point down and around to Zapadnie, lining the alternating sand-beaches and rocky shingle with their plump, black forms. How they do delight in it! They play with a zest, and chatter like our own children in the kindergartens—swimming in endless evolutions, twisting, turning, or diving—and when exhausted, drawing their plump, round bodies up again on the beach. Shaking themselves dry as young dogs would do, they now either go to sleep on the spot, or have a lazy terrestrial frolic among themselves.

How an erroneous impression ever got into the mind of any man in this matter of the pup's learning to swim, I confess that I am wholly unable to imagine. I have not seen any "driving" of the young pups into the water by the old ones, in order to teach them this process, as certain authors have pointedly affirmed.[1] There is not the slightest supervision by the old mother or father of the pup, from the first moment of his birth, in this respect, until he leaves for the North Pacific,

[1] ALLEN: History of North American Pinnipeds, p. 387.

full-fledged with amphibious power. At the close of the breeding-season, every year, the pups are restlessly and constantly shifting back and forth over the rookery ground of their birth, in large squads, sometimes numbering thousands upon thousands. In the course of this change of position they all sooner or later come in contact with the sea; they then blunder into the water for the first time, in a most awkward, ungainly manner, and get out as quick as they can; but so far from showing any fear or dislike of this, their most natural element, as soon as they rest from their exertion they are immediately ready for a new trial, and keep at it, provided the sea is not too stormy or rough. During all this period of self-tuition they seem thoroughly to enjoy the exercise, in spite of their repeated and inevitable discomfitures at the beginning.

PODDING OF THE PUPS.—The "podding" of these young pups in the rear of the great rookeries of Saint Paul, is one of the most striking and interesting phases of this remarkable exhibition of highly organized life. When they first bunch together they are all black, for they have not begun to shed the natal coat: they shine with an unctuous, greasy reflection, and grouped in small armies or great regiments on the sand-dune tracts at Northeast Point, they present a most extraordinary and fascinating sight. Although the appearance of the "Holluschickie" at English Bay fairly overwhelms the observer with the impression of its countless multitudes, yet I am free to declare, that at no one point in this evolution of the seal-life, during the reproductive season, have I been so deeply stricken by the sense of overwhelming enumeration, as I have, when, standing on the summit of Cross Hill, I looked down to the southward and westward over a reach of six miles of alternate grass and sand-dune stretches, mirrored upon which were hundreds of thousands of these little black pups, spread in sleep and sport within this restricted field of vision. They appeared as countless as the grains of the sand upon which they rested.

SECOND CHANGE OF COAT.—By the 15th of September, all the pups born during the year have become familiar with the water; they have all learned to swim, and are now nearly all down by the water's edge, skirting in large masses the rocks and beaches previously this year unoccupied by Seals of any class. Now they are about five or six times their original weight, or, in other words, they are thirty to forty pounds avoirdupois, as plump and fat as butter-balls, and they begin to take on their second coat, shedding their black pup-hair completely. This second coat does not vary in color, at this age, between the sexes. They effect this transformation in dress very slowly, and cannot, as a rule, be said to have ceased their molting until the middle or 20th of October.

This second coat or sea-going jacket, of the pup, is a uniform, dense, light-gray over-hair, with an under-fur which is slightly grayish in some, but in most cases is a soft, light-brown hue. The over-hair is fine, close, and elastic, from two-thirds of an inch to an inch in length, while the fur is not quite half an inch long. Thus the coarser hair shingles over and conceals the soft under-wool completely, giving the color by which, after the second year, the sex of the animal is recognized. The pronounced difference between the sexes is not effected, however, by color alone until the third year of the animal. This over-hair of the young pup's new jacket on the back, neck, and head, is a dark chinchilla-gray, blending into a stone-white, just tinged with a grayish tint on the abdomen and chest. The upper lip, upon which the whiskers or moustaches take root, is covered with hair of a lighter gray than that of the body. This moustache consists of fifteen or twenty longer or shorter bristles, from half an inch to three inches in length, some brownish, horn-colored, and others whitish-gray and translucent, on each side and back and below the nostrils, leaving the muzzle quite prominent and hairless. The nasal openings and their surroundings are, as I have before said when speaking of this feature, similar to those of a dog.

EYES OF THE PUP-SEALS.—The most attractive feature about the fur-seal pup, and that

which holds this place as it grows on and older, is the eye. This organ is exceedingly clear, dark, and liquid, with which, for beauty and amiability, together with real intelligence of expression, those of no other animal that I have ever seen, or have ever read of, can be compared; indeed, there are few eyes in the orbits of men and women which suggest more pleasantly the ancient thought of their being "windows to the soul." The lids to the eye are fringed with long, perfect lashes, and the slightest annoyance, in the way of dust or sand, or other foreign substances, seems to cause them exquisite annoyance, accompanied by immoderate weeping. This involuntary tearfulness so moved Steller that he ascribed it to the processes of the Seal's mind, and declared that the seal-mothers actually shed tears.

RANGE OF VISION.—I do not think that their range of vision on land, or out of the water, is very great. I have experimented frequently with adult Fur Seals, by allowing them to catch sight of my person, so as to distinguish it as of foreign character, three and four hundred paces off, taking the precaution of standing to the leeward of them when the wind was blowing strong, and then walking unconcernedly up to them. I have invariably noticed, that they would allow me to approach quite close before recognizing my strangeness; this occurring to them, they at once made a lively noise, a medley of coughing, spitting, snorting, and blaating, and plunged in spasmodic lopes and shambled to get away from my immediate neighborhood; as to the pups, they all stupidly stare at the form of a human being until it is fairly on them, when they also repeat in miniature these vocal gymnastics and physical efforts of the older ones, to retreat or withdraw a few rods, sometimes only a few feet, from the spot upon which you have cornered them, after which they instantly resume their previous occupation of either sleeping or playing, as though nothing had happened.

BEHAVIOR OF FUR SEALS AT NIGHT.—I naturally enough, when beginning my investigation of these seal-rookeries, expected to find the animals subdued at night, or early morning, on the breeding-grounds; but a few consecutive nocturnal watches satisfied me that the family organization and noise was as active at one time as at another throughout the whole twenty-four hours. If, however, the day preceding had chanced to be abnormally warm, I never failed then to find the rookeries much more noisy and active during the night than they were by daylight. The Seals, as a rule, come and go to and from the sea, fight, roar, and vocalize as much during midnight moments as they do at noonday times. An aged native endeavored to satisfy me that the "Seec tchie" could see much better by twilight and night than by daylight. I am not prepared to prove to the contrary, but I think that the fact of his not being able to see so well himself at that hour of darkness was the true cause of most of his belief in the improved nocturnal vision of the Seals.

As I write, this old Aleut, Phillip Vollkov, has passed to his final rest—"un konchielsah"—winter of 1878-'79. He was one of the real characters of Saint Paul; he was esteemed by the whites on account of his relative intelligence, and beloved by the natives, who called him their "wise man," and who exulted in his piety. Phillip, like the other people there of his kind, was not much comfort to me when I asked questions as to the Seals. He usually answered important inquiries by crossing himself, and replying, "God knows." There was no appeal from this.

SULLENNESS OF OLD MALE SEALS.—The old males, when grouped together by themselves, at the close of the breeding-season, indulge in no humor or frolicsome festivities whatsoever. On the contrary, they treat each other with surly indifference. The mature females, however, do not appear to lose their good nature to anything like so marked a degree as do their lords and masters, for they will at all seasons of their presence on the islands be observed, now and then, to suddenly unbend from severe matronly gravity by coyly and amiably tickling and gently teasing one another, as they rest in the harems, or later, when strolling in September. There is no sign

given, however, by these seal-mothers of desire or action in fondling or caressing their pups; nor do the young appear to sport with any others than the pups themselves, when together. Sometimes a yearling and a five or six months old pup will have a long-continued game between themselves. They are decidedly clannish in this respect—creatures of caste, like Hindoos.

POWER OF SCENT: ODOR OF THE SEALS.—The greatest activity displayed by any one of the five senses of the Seal, is evidenced in its power of scent. This faculty is all that can be desired in the line of alertness. I never failed to awaken an adult Seal from the soundest sleep, when from a half to a quarter of a mile distant, no matter how softly I proceeded, if I got to the windward, though they sometimes took alarm when I was a mile off.

They leave evidences of their being on these great reproductive fields, chiefly at the rookeries, in the hundreds of dead carcasses which mark the last of those animals that have been rendered infirm, sick, or were killed by fighting among themselves in the early part of the season, or of those which have crawled far away from the scene of battle to die from death-wounds received in the bitter struggle for a harem. On the rookeries, wherever these lifeless bodies rest, the living, old and young, clamber and patter backward and forward over and on the putrid remains, and by this constant stirring up of decayed matter, give rise to an exceedingly disagreeable and far-reaching "*funk*." This has been, by all writers who have dwelt on the subject, referred to as the smell which these animals emit for another reason—erroneously called the "rutting odor." If these creatures have any odor peculiar to them when in this condition, I will frankly confess that I am unable to distinguish it from the fumes which are constantly being stirred up and rising out of these decaying carcasses of the older Seals, as well as from the bodies of the few pups which have been killed accidentally by the heavy bulls fighting over them, charging back and forth against one another, so much of the time.

They have, however, a very characteristic and peculiar smell, when they are driven and get heated; their breath exhalations possess a disagreeable, faint, sickly odor, and when I have walked within its influence at the rear of a seal-drive, I could almost fancy, as it entered my nostrils, that I stood beneath an ailanthus tree in bloom; but this odor can by no means be confounded with what is universally ascribed to another cause. It is also noteworthy, that if your finger is touched ever so lightly to a little fur-seal blubber, it will smell very much like that which I have appreciated and described as peculiar to their breath, which arises from them when they are driven, only it is a little stronger. Both the young and old Fur Seals have this same breath taint at all seasons of the year.

REVIEW OF STATEMENTS CONCERNING LIFE IN THE ROOKERIES.—To recapitulate and sum up the system and regular method of life and reproduction on these rookeries of Saint Paul and Saint George, as the Seals seem to have arranged it, I shall say that—

First. The earliest bulls land in a negligent, indolent way, at the opening of the season, soon after the rocks at the water's edge are free from ice, frozen snow, etc. This is, as a rule, about the 1st to the 5th of every May. They land from the beginning to the end of the season in perfect confidence and without fear; they are very fat, and will weigh at an average 500 pounds each; some stay at the water's edge, some go to the tier back of them again, and so on until the whole rookery is mapped out by them, weeks in advance of the arrival of the first female.

Second. That by the 10th or 12th of June, all the male stations on the rookeries have been mapped out and fought for, and held in waiting by the "Seecatchie." These males are, as a rule, bulls rarely ever under six years of age; most of them are over that age, being sometimes three, and occasionally doubtless four, times as old.

Third. That the cows make their first appearance, as a class, on or after the 12th or 15th of

June, in very small numbers; but rapidly after the 23d and 25th of this month, every year, they begin to flock up in such numbers as to fill the harems very perceptibly; and by the 8th or 10th of July, they have all come, as a rule—a few stragglers excepted. The average weight of the females now will not be much more than eighty to ninety pounds each.

Fourth. That the breeding-season is at its height from the 10th to the 15th of July every year, and that it subsides entirely at the end of this month and early in August; also, that its method and system are confined entirely to the land, never effected in the sea.

Fifth. That the females bear their first young when they are three years old, and that the period of gestation is nearly twelve months, lacking a few days only of that lapse of time.

Sixth. That the females bear a single pup each, and that this is born soon after landing; no exception to this rule has ever been witnessed or recorded.

Seventh. That the "Seecatchie" which have held the harems from the beginning to the end of the season, leave for the water in a desultory and straggling manner at its close, greatly emaciated, and do not return, if they do at all, until six or seven weeks have elapsed, when the regular systematic distribution of the families over the rookeries is at an end for the season. A general medley of young males now are free, which come out of the water, and wander over all these rookeries, together with many old males, which have not been on seraglio duty, and great numbers of the females. An immense majority over all others present are pups, since only about 25 per cent. of the mother-seals are out of the water now at any one time.

Eighth. That the rookeries lose their compactness and definite boundaries of true breeding limit and expansion by the 25th to the 28th of July every year; then, after this date, the pups begin to haul back, and to the right and left, in small squads at first, but as the season goes on, by the 18th of August, they depart without reference to their mothers; and when thus scattered, the males, females, and young swarm over more than three and four times the area occupied by them when breeding and born on the rookeries. The system of family arrangement and uniform compactness of the breeding classes breaks up at this date.

Ninth. That by the 8th or 10th of August the pups born nearest the water first begin to learn to swim; and that by the 15th or 20th of September they are all familiar, more or less, with the exercise.

Tenth. That by the middle of September the rookeries are entirely broken up; confused, straggling bands of females are seen among bachelors, pups, and small squads of old males, crossing and recrossing the ground in an aimless, listless manner. The season now is over.

Eleventh. That many of the Seals do not leave these grounds of Saint Paul and Saint George before the end of December, and some remain even as late as the 12th of January; but that by the end of October and the beginning of November every year, all the Fur Seals of mature age—five and six years, and upward—have left the islands. The younger males go with the others: many of the pups still range about the islands, but are not hauled to any great extent on the beaches or the flats. They seem to prefer the rocky shore-margin, and to lie as high up as they can get on such bluffy rookeries as Tolstoi and the Reef. By the end of this month, November, they are, as a rule, all gone.

Such is the sum and the substance of my observations which relate to the breeding-grounds alone on Saint Paul and Saint George. It is the result of summering and wintering on them, and these definite statements I make with that confidence which one always feels, when he speaks of that which has entered into his mind by repeated observation, and has been firmly grounded by careful deductions therefrom.

THE "HOLLUSCHICKIE" OR "BACHELOR" SEALS: A DESCRIPTION.—I now call the attention

of the reader to another very remarkable feature in the economy of the seal-life on these islands. The great herds of "Holluschickie,"[1] numbering from one-third to one-half, perhaps, of the whole aggregate of near 5,000,000 Seals known to the Pribylov group, are never allowed by the "Seecatchie," under the pain of frightful mutilation or death, to put their flippers on or near the rookeries.

By reference to my map, it will be observed that I have located a large extent of ground—markedly so on Saint Paul—as that occupied by the Seals' "hauling-grounds"; this area, in fact, represents those portions of the island upon which the "Holluschickie" roam in their heavy squadrons, wearing off and polishing the surface of the soil, stripping every foot, which is indicated on the chart as such, of its vegetation and mosses, leaving the margin as sharply defined on the bluffy uplands and sandy flats as it is on the map itself.

The reason that so much more land is covered by the "Holluschickie" than by the breeding Seals—ten times as much at least—is due to the fact, that though not as numerous, perhaps, as the breeding Seals, they are tied down to nothing, so to speak—are wholly irresponsible, and roam hither and thither as caprice and the weather may dictate. Thus they wear off and rub down a much larger area than the rookery Seals occupy; wandering aimlessly, and going back, in some instances, notably at English Bay, from one-half to a whole mile inland, not traveling in desultory files along winding, straggling paths, but sweeping in solid platoons, they obliterate every spear of grass and rub down nearly every hummock in their way..

DEFINITION OF "HOLLUSCHICKIE."—All the male Seals, from six years of age, are compelled to herd apart by themselves and away from the breeding-grounds, in many cases far away; the large hauling-grounds at Southwest Point being about two miles from the nearest rookery. This class of Seals is termed "Holluschickie" or the "Bachelor" Seals by the natives, a most fitting and expressive appellation.

The Seals of this great subdivision are those with which the natives on the Pribylov group are the most familiar: naturally and especially so, since they are the only ones, with the exception of a few thousand pups, and occasionally an old bull or two, taken late in the fall for food and skins, which are driven up to the killing grounds at the village for slaughter. The reasons for this exclusive attention to the "Bachelors" are most cogent, and will be given hereafter when the "business" is discussed.

LOCATING THE HAULING-GROUNDS: PATHS THROUGH THE ROOKERIES.—Since the "Holluschickie" are not permitted by their own kind to land on the rookeries and stop there, they have the choice of two methods of locating, one of which allows them to rest in the rear of the rookeries, and the other on the free beaches. The most notable illustration of the former can be witnessed on Reef Point, where a pathway is left for their ingress and egress through a rookery—a path left by common consent, as it were, between the harems. On these trails of passage they come and go in steady files all day and all night during the season, unmolested by the jealous bulls which guard the seraglios on either side as they travel; all peace and comfort to the young Seal if he minds his business and keeps straight on up or down, without stopping to nose about right or left; all woe and desolation to him, however, if he does not, for in that event he will be literally torn in bloody griping, from limb to limb, by the vigilant old "Seecatchie."

Since the two and three year old "Holluschickie" come up in small squads with the first bulls in the spring, or a few days later, such common highways as those between the rookery-ground and the sea are traveled over before the arrival of the cows, and get well defined. A passage for the "Bachelors," which I took much pleasure in observing day after day at Polavina, another at Tolstoi, and two on the Reef, in 1872, were entirely closed up by the "Seecatchie" and obliterated,

[1] The Russian term "Holluschickie" or "Bachelors" is very appropriate, and is usually employed.

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Beaufort, North Carolina

when I again searched for them in 1874. Similar passages existed, however, on several of the large rookeries of Saint Paul; one of those at Tolstoi exhibits this feature very finely, for here the hauling-ground extends around from English Bay, and lies up back of the Tolstoi Rookery, over a flat and rolling summit, from 100 to 120 feet above the sea-level. The young males and yearlings of both sexes come through and between the harems, at the height of the breeding-season, on two of these narrow pathways, and before reaching the ground above, are obliged to climb up an almost abrupt bluff, which they do by following and struggling in the water-runs and washes which are worn into its face. As this is a large hauling-ground, on which, every favorable day during the season, fifteen or twenty thousand commonly rest, the sight of skillful seal-climbing can be witnessed here at any time during that period; and the sight of such climbing as this of Tolstoi is exceedingly novel and interesting. Why, verily, they ascend over and upon places where an ordinary man might, at first sight, with great positiveness say that it was utterly impossible for him to climb.

HAULING-GROUNDS ON THE BEACHES.—The other method of coming ashore, however, is the one most followed and favored. In this case they avoid the rookeries altogether, and repair to the unoccupied beaches between them, and then extend themselves out all the way back from the sea, as far from the water, in some cases, as a quarter and even half of a mile. I stood on the Tolstoi sand-dunes one afternoon, toward the middle of July, and had under my eyes, in a straightforward sweep from my feet to Zapadnie, a million and a half of Seals spread out on these hauling-grounds. Of these, I estimated that fully one-half, at that time, were pups, yearlings, and "Holluschickie." The rookeries across the bay, though plainly in sight, were so crowded, that they looked exactly as I have seen surfaces appear upon which bees had swarmed in obedience to that din and racket made by the watchful apiarian, when he desires to hive the restless honey-makers.

The great majority of yearlings and "Holluschickie" are annually hauled out and packed thickly over the sand-beach and upland hauling-grounds, which lie between the rookeries on Saint Paul Island. At Saint George there is nothing of this extensive display to be seen, for here is only a tithe of the seal-life occupying Saint Paul, and no opportunity whatever is afforded for an amphibious parade.

GENTLENESS OF THE SEALS.—Descend with me from this sand-dune elevation of Tolstoi, and walk into that drove of "Holluschickie" below us; we can do it; you do not notice much confusion or dismay as we go in among them; they simply open out before us and close in behind our tracks, stirring, crowding to the right and left as we go, twelve or twenty feet away from us on each side. Look at this small flock of yearlings, some one, others two, and even three years old, which are coughing and spitting around us now, staring up in our faces in amazement as we walk ahead; they struggle a few rods out of our reach, and then come together again behind us, showing no further sign of notice of ourselves. You could not walk into a drove of hogs at Chicago, without exciting as much confusion and arousing an infinitely more disagreeable tumult; and as for sheep on the plains, they would stampede far quicker. Wild animals indeed! You can now readily understand how easy it is for two or three men, early in the morning, to come where we are, turn aside from this vast herd in front of and around us two or three thousand of the best examples, and drive them back, up and over to the village. That is the way they get the Seals; there is not any "hunting" or "chasing" or "capturing" of Fur Seals on these islands.

"HOLLUSCHICKIE" DO NOT FAST.—While the young male Seals undoubtedly have the power of going for lengthy intervals without food, they, like the female Seals on the breeding-grounds, certainly do not maintain any long fasting periods on land; their coming and going from the shore is frequent and irregular, largely influenced by the exact condition of the weather from day to day;

2776

for instance, three or four thick, foggy days seem to call them out from the water by hundreds of thousands upon the different hauling-grounds (which the reader observes recorded on my map). In some cases, I have seen them lie there so close together that scarcely a foot of ground, over whole acres, is bare enough to be seen; then a clear and warmer day follows, and this seal-covered ground, before so thickly packed with animal life, will soon be almost deserted: comparatively so at least, to be filled up immediately as before, when favorable weather shall again recur. They must frequently eat when here, because the first yearlings and "Holluschickie" that appear in the spring are no fatter, sleeker, or livelier than they are at the close of the season; in other words, their condition, physically, seems to be the same from the beginning to the end of their appearance here during the summer and fall. It is quite different, however, with the "Seecatch"; we know how and where it spends two to three months, because we find it on the grounds at all times, day or night, during that period.

SPORTS AND PASTIMES OF THE YOUNG "BACHELORS."—A small flock of the young Seals, one to three years old, generally, will often stray from these hauling-ground margins, up and beyond, over the fresh mosses and grasses, and there sport and play one with another, just as little puppy-dogs do; and when weary of this gamboling a general disposition to sleep is suddenly manifested, and they stretch themselves out and curl up in all the positions and all the postures that their flexible spines and ball-and-socket joints will permit. They seem to revel in the unwonted vegetation, and to be delighted with their own efforts in rolling down and crushing the tall stalks of the grasses and umbelliferous plants; one will lie upon its back, hold up its hind-flippers, and lazily wave them about, while it scratches, or rather rubs, its ribs with the fore-hands alternately, the eyes being tightly closed during the whole performance; the sensation is evidently so luxurious that it does not wish to have any side-issue draw off its blissful self-attention. Another, curled up like a cat on a rug, draws its breath, as indicated by the heaving of its flanks, quickly but regularly, as though in heavy sleep; another will lie flat upon its stomach, its hind-flippers covered and concealed, while it tightly folds its fore-feet back against its sides, just as a fish carries its pectoral fins—and so on to no end of variety, according to the ground and the fancy of the animals.

These "Bachelor" Seals are, I am sure, without exception, the most restless animals in the whole brute creation, which can boast of a high organization. They frolic and lope about over the grounds for hours, without a moment's cessation, and their sleep, after this, is exceedingly short, and it is ever accompanied with nervous twitchings and uneasy muscular movements; they seem to be fairly brimful and overrunning with spontaneity—to be surcharged with fervid, electric life.

Another marked feature which I have observed among the multitudes of "Holluschickie," which have come under my personal observation and auditory, and one very characteristic of this class, is, that nothing like ill-humor appears in all of their playing together; they never growl or bite, or show even the slightest angry feeling, but are invariably as happy, one with another, as can be imagined. This is a very singular trait; they lose it, however, with astonishing rapidity, when their ambition and strength develop and carry them, in due course of time, to the rookery.

The pups and yearlings have an especial fondness for sporting on the rocks which are just at the water's level and awash, so as to be covered and uncovered as the surf rolls in. On the bare summit of these wave-worn spots, they will struggle and clamber in groups of a dozen or two at a time throughout the whole day, in endeavoring to push off that one of their number which has just been fortunate enough to secure a landing; the successor has, however, but a brief moment of exultation in victory, for the next roller that comes booming in, together with the pressure by its friends, turns the table, and the game is repeated, with another Seal on top. Sometimes, as well as I could see, the same squad of "Holluschickie" played for a whole day and night, without a

moment's cessation, around such a rock as this, off Nah Speel Rookery; but in this observation I may be mistaken, because the Seals cannot be told apart.

SEALS AMONG THE BREAKERS.—The graceful unconcern with which the Fur Seal sports safely in, among, and under booming breakers, during the prevalence of the numerous heavy gales at the islands, has afforded me many consecutive hours of spell-bound attention to them, absorbed in watching their adroit evolutions within the foaming surf, that seemingly, every moment, would, in its fierce convulsions, dash these hardy swimmers, stunned and lifeless, against the iron-bound foundations of the shore, which alone checked the furious rush of the waves. Not at all. Through the wildest and most ungovernable mood of the roaring tempest and storm-tossed waters attending its transit, I never failed, on creeping out, and peering over the bluffs, in such weather, to see squads of these perfect watermen—the most expert of all amphibians—gamboling in the seething, creamy wake of mighty rollers, which constantly broke in thunder tones over their alert, dodging heads. The swift succeeding seas seemed, every instant, to poise the Seals at the very verge of death. Yet the *Callorhinus*, exulting in his skill and strength, bade defiance to their wrath, and continued his diversions.

SWIMMING FEATS OF THE "BACHELORS."—The "Holluschickie" are the champion swimmers of all the seal tribe; at least, when in the water around the islands, they do nearly every fancy tumble and turn that can be executed. The grave old males and their matronly companions seldom indulge in any extravagant display, as do these youngsters, jumping out of the water like so many dolphins, describing beautiful elliptic curves sheer above its surface, rising three and even four feet from the sea, with the back slightly arched, the fore-flippers folded tightly against the sides, and the hinder ones extended and pressed together straight out behind, plumping in head first, to reappear in the same manner, after an interval of a few seconds of submarine swimming, like the flight of a bird, on their course. Sea Lions and Hair Seals never jump in this manner.

All classes will invariably make these dolphin-jumps, when they are surprised or are driven into the water, curiously turning their heads while sailing in the air, between the "rises" and "plumps," to take a look at the cause of their disturbance. They all swim rapidly, with the exception of the pups, and may be said to dart under the water with the velocity of a bird on the wing; as they swim they are invariably submerged, running along horizontally about two or three feet below the surface, guiding their course by the hind-flippers as by a rudder, and propelling themselves solely by the fore-feet, rising to breathe at intervals which are either very frequent or else so wide apart that it is impossible to see the speeding animal when he rises a second time.

How long they can remain under water without taking a fresh breath, is a problem which I had not the heart to solve, by instituting a series of experiments at the island; but I am inclined to think that, if the truth were known in regard to their ability of going without rising to breathe, it would be considered astounding. On this point, however, I have no data worth discussing, but will say that, in all their swimming which I have had a chance to study, as they passed under the water, mirrored to my eyes from the bluff above by the whitish-colored rocks below the rookery waters at Great Eastern Rookery, I have not been able to satisfy myself how they used their long, flexible hind-feet, other than as steering media. If these posterior members have any perceptible motion, it is so rapid that my eye is not quick enough to catch it; but the fore-flippers, however, can be most distinctly seen, as they work in feathering forward and sweeping flatly back, opposed to the water, with great rapidity and energy. They are evidently the sole propulsive power of the Fur Seal in the water, as they are its main fulcrum and lever combined, for progression on land. I regret that the shy nature of the Hair Seal never allowed me to study its swimming motions, but it seems to be a general point of agreement among authorities on the *Phocidæ*, that all motion in

water by them arises from that power which they exert and apply with the hind-feet. So far as my observations on the Hair Seal go, I am inclined to agree with this opinion.

All their movements in water, whether they are traveling to some objective point or are in sport, are quick and joyous; and nothing is more suggestive of intense satisfaction and pure physical comfort, than is that spectacle which we can see every August, a short distance out at sea from any rookery where thousands of old males and females are idly rolling over in the billows side by side, rubbing and scratching with their fore- and hind-flippers, which are here and there stuck up out of the water by their owners, like the lateen-sails of the Mediterranean feluccas, or, when the hind-flippers are presented, like a "cat-o'-nine tails." They sleep in the water a great deal, too, more than is generally supposed, showing that they do not come on land to rest—very clearly not.

LEAPING OUT OF WATER: "DOLPHIN-JUMPS."—As I never detected the Sea Lions or the Hair Seals leaping from the water around these islands, in those peculiar dolphin-like jumps which I have hitherto described, I made a note of it early during my first season of observation, for corroboration in the next. It is so: neither the Sea Lion nor the Hair Seal here ever leaped from the ocean in this agile and singular fashion heretofore described. Allen, so conservative usually, seems, however, to have fallen into an error by reading the notes of Mr. J. H. Blake, descriptive of the Sea Lions of the Gallapagos Islands. As Allen quotes them entire in a foot-note,[1] I am warranted in calling attention to the fact, that no authentic record has as yet been made of such peculiar swimming by *Phocidæ*, or the sea-lion branch of the *Otariidæ*. My notice has been called to this mistake by Professor Allen's own note, page 367, upon a quotation from my work, citing Mr. Blake's notes above referred to, which are themselves very interesting, but do not even hint at a dolphin-jump.

How fast the Fur Seal can swim, when doing its best, I am naturally unable to state. I do know that a squad of young "Holluschickie" followed the "Reliance," in which I was sailing, down from the latitude of the Seal Islands to Akootan Pass with perfect ease, laying around the vessel, while she was logging straight ahead, 14 knots to the hour.

The Fur Seal, the Sea Lion, the Walrus, and the Hair Seal all swim around these islands, and in these waters, submerged, extended horizontally and squarely upon their stomachs. I make this note here because I am surprised to read[2] that the Harp (Hair) Seal's "favorite position when swimming, as affirmed by numerous observers, is on the back or side, in which position they also sleep in the water." Although this is a far-distant, geographically speaking, relative of the Hair Seal of Saint Paul Island, yet the remarkable difference in fashion of swimming seems hardly warranted, when the two animals are built exactly alike. Still, I have no disposition to question, earnestly, the truth of the statement, inasmuch as I have learned of so many very striking radical differences in habits of animals as closely related, as to pause, ere seriously doubting this assertion that a Harp Seal's favorite way in swimming is to lie upon its back when so doing. It is simply an odd contradiction to the method employed by the Hair Seals of the North Pacific and of Bering Sea.

While I am unable to prove that the Fur Seal possesses the power to swim to a very great depth, by actual tests instituted, yet I am free to say that it certainly can dive to the uttermost depths, where its food-fish are known to live in the ocean; it surely gives full and ample evidence of possessing the muscular power for that enterprise. In this connection, it is interesting to cite the testimony of Mr. F. Borthen, the proprietor of the Fro Islands, a group of small islets off Trondhjems Fiörd, in Norway; this gentleman has had an opportunity of watching the Gray Seal

[1] *History of North American Pinnipeds, p. 211.*
[2] ALLEN: *op. cit.*, p. 651.

(*Halichœrus grypus*) as it bred and rested on these rocks during an extended period of time. Among many interesting notes as to the biology of this large Hair Seal, he says: "As a proof that they [the Seals] fetch their food from a considerable depth, it is related that a few years ago a young one was found caught by one of the hooks of a fishing line that was placed at a depth of between seventy and eighty fathoms, on the outer side of the islands. Gray Seals have several times been seen to come up to the surface with lings (*Molva vulgaris*) and other deep-water fishes in their mouths, such fishes seldom or never found at a less depth than between sixty and seventy fathoms."[1]

CLASSING THE "HOLLUSCHICKIE" BY AGE.—When the "Holluschickie" are up on land they can be readily separated into their several classes as to age by the color of their coats and size, when noted, namely, the yearlings, the two, three, four, and five years old males. When the yearlings, or the first class, haul out, they are dressed just as they were after they shed their pup-coats and took on the second covering during the previous year in September and October; and now, as they come out in the spring and summer, one year old, the males and females cannot be distinguished apart, either by color or size, shape or action; the yearlings of both sexes have the same steel-gray backs and white stomachs, and are alike in behavior and weight.

Next year these yearling females, which are now trooping out with the youthful males on the hauling-grounds, will repair to the rookeries, while their male companions will be obliged to come again to this same spot.

SHEDDING THE HAIR: STAGEY SEALS.—About the 15th and 20th of every August, they have become perceptibly "stagey," or, in other words, their hair is well under way in shedding. All classes, with the exception of the pups, go through this process at this time every year. The process requires about six weeks between the first dropping or falling out of the old over-hair, and its full substitution by the new. This takes place, as a rule, between August 1 and September 28.

The fur is shed, but it is so shed that the ability of the Seal to take to the water and stay there, and not be physically chilled or disturbed during the process of molting, is never impaired. The whole surface of these extensive breeding-grounds, traversed over by us after the Seals had gone, was literally matted with the shed hair and fur. This under-fur or pelage is, however, so fine and delicate, and so much concealed and shaded by the coarser over-hair, that a careless eye or a superficial observer might be pardoned in failing to notice the fact of its dropping and renewal.

The yearling cows retain the colors of the old coat in the new, when they shed it for the first time, and from that time on, year after year, as they live and grow old. The young three-year-olds and the older cows look exactly alike, as far as color goes, when they haul up at first and dry-out on the rookeries, every June and July.

The yearling males, however, make a radical change when they shed for the first time, for they come out from their "staginess" in a nearly uniform dark gray, and gray and black mixed, and lighter, with dark ocher to whitish on the upper and under parts, respectively. This coat, next year, when they appear as two-year-olds, shedding for the three-year-old coat, is a very much darker gray, and so on to the third, fourth, and fifth season; then after this, with age, they begin, to grow more gray and brown, with rufous-ocher and whitish-tipped over-hair on the shoulders. Some of the very old bulls change in their declining years to a uniform shade all over of dull-grayish ocher. The full glory and beauty of the Seal's moustache is denied to him until he has attained his seventh or eighth year.

COMPARATIVE SIZE OF FEMALES AND MALES.—The female does not get her full growth and weight until the end of her fourth year, so far as I have observed, but she does most of her

[1] ROBERT COLLETT: On the Gray Seal. Proceedings Zoölogical Society London, part ii, 1881, p. 387.

growing longitudinally in the first two; after she has passed her fourth and fifth years, she weighs from thirty to fifty pounds more than she did in the days of her youthful maternity.

The male does not get his full growth and weight until the close of his seventh year, but realizes most of it, osteologically speaking, by the end of the fifth; and from this it may be perhaps truly inferred, that the male Seals live to an average age of eighteen or twenty years, if undisturbed in a normal condition, and that the females attain ten or twelve seasons under the same favorable circumstances. Their respective weights, when fully mature and fat in the spring, will, in regard to the male, strike an average of from four to five hundred pounds, while the females will show a mean of from seventy to eighty pounds.

I did not permit myself to fall into error in estimating this matter of weight, because I early found that the apparent huge bulk of a sea-lion bull or fur-seal male, when placed upon the scales, shrank far below my notions: I took a great deal of pains, on several occasions, during the killing season, to have a platform scale carted out into the field, and as the Seals were knocked down, and before they were bled, I had them carefully weighed, constructing the following table from my observations:

Table showing the weight, size, and growth of the Fur Seal (Callorhinus ursinus), from the pup to the adult, male and female.

Age.	Length.	Girth.	Gross weight of body.	Weight of skin.	Remarks.
	Inches.	*Inches.*	*Pounds.*	*Pounds.*	
One week	12 to 14	10 to 10½	6 to 7½	1½	A male and female, being the only ones of the class handled, June 20, 1873.
Six months	24	25	39	3	A mean of ten examples, males and females, alike in size, November 28, 1872.
One year	38	26	39	4½	A mean of six examples, males and females, alike in size, July 14, 1873.
Two years	45	30	58	5½	A mean of thirty examples, all males, July 24, 1873.
Three years	52	36	87	7	A mean of thirty-two examples, all males, July 24, 1873.
Four years	58	42	135	12	A mean of ten examples, all males, July 24, 1873.
Five years	65	52	200	16	A mean of five examples, all males, July 24, 1873.
Six years	72	64	280	25	A mean of three examples, all males, July 24, 1873.
Eight to twenty years.	75 to 80	70 to 75	400 to 500	45 to 50	An estimate only, calculating on their weight when fat, and early in the season.

WEIGHT OF FEMALE SEALS.—The adult females will correspond with the three-year-old males in the above table, the younger cows weighing frequently only seventy-five pounds, and many of the older ones going as high as one hundred and twenty, but an average of eighty to eighty-five pounds is the rule. Those specimens of the females which I have weighed were examples taken by me for transmission to the Smithsonian Institution, otherwise I should not have been permitted to make this record of their weight, inasmuch as weighing them means to kill them; and the law and the habit, or rather the prejudice of the entire community up there, is unanimously in opposition to any such proceeding, for they never touch females here, and never set their foot on or near the breeding-grounds on such an errand. It will be noticed, also, that I have no statement of the weights of those exceedingly fat and heavy males which first appear on the breeding-grounds in the spring; those which I have referred to, in the table above given, were very much heavier at the time of their first appearance in May and June, than at the moment when they were in my hands, in July; but the cows, in the other class, do not sustain protracted fasting, and therefore their weights may be considered substantially the same throughout the year.

CHANGE IN WEIGHT.—Thus, from the fact that all the young Seals and females do not change much in weight from the time of their first coming out in the spring, till that of their leaving in the fall and early winter, I feel safe in saying that they feed at irregular but not long intervals,

during the time that they are here under our observation, since they are constantly changing from land to water and from water to land, day in and day out. I do not think that the young males fast longer than a week or ten days at a time, as a rule.

DISPERSAL OF THE "HOLLUSCHICKIE."—By the end of October and the 10th of November, the great mass of the "Holluschickie," the trooping myriads of English Bay, Southwest Point, Reef Parade, Lukannon Sands, the table-lands of Polavina, and the mighty hosts of Novostashnah, at Saint Paul, together with the quota of Saint George, had taken their departure from its shores, and had gone out to sea, spreading with the receding schools of fish that were now returning to the deep waters of the North Pacific, where, in that vast expanse, over which rolls an unbroken billow, five thousand miles from Japan to Oregon, they spend the winter and the early spring, until they reappear and break up, with their exuberant life, the dreary winter isolation of the land which gave them birth.

TASTE OF THE SEALS IN THE MATTER OF WEATHER.—A few stragglers remain, however, as late as the snow and ice will permit them to, in and after December; they are all down by the water's edge then, and haul up entirely on the rocky beaches, deserting the sand altogether; but the first snow that falls makes them very uneasy, and I have seen a large hauling-ground so disturbed by a rainy day and night, that its hundreds of thousands of occupants fairly deserted it. The Fur Seal cannot bear, and will not endure, the spattering of sand into its eyes, which always accompanies the driving of a rain-storm; they take to the water, to reappear when the nuisance shall be abated.

The weather in which the Fur Seal delights is cool, moist, foggy, and thick enough to keep the sun always obscured, so as to cast no shadows. Such weather, which is the normal weather of Saint Paul and Saint George, continued for a few weeks in June and July, brings up from the sea millions of Fur Seals. But, as I have before said, a little sunshine, which raises the temperature as high as 50° to 55° Fahr., will send them back from the hauling-grounds almost as quickly as they came. Fortunately these warm, sunny days on the Pribylov Islands are so rare that the Seals certainly can have no ground of complaint, even if we may presume they have any at all. Some curious facts in regard to their selection of certain localities on these islands, and their abandonment of others, I will discuss in a succeeding chapter, descriptive of the rookeries; this chapter is illustrated by topographical surveys made by myself.

ALBINOS.—I looked everywhere and constantly, when treading my way over acres of ground which were fairly covered with seal-pups, and older ones, for specimens that presented some abnormity, that is, monstrosities, albinos, etc., such as I have seen in our great herds of stock; but I was, with one or two exceptions, unable to note anything of the kind. I have never seen any malformations or "monsters" among the pups and other classes of the Fur Seals, nor have the natives recorded anything of the kind, so far as I could ascertain from them. I saw only three albino pups among the multitudes on Saint Paul, and none on Saint George. They did not differ, in any respect, from the normal pups in size and shape. Their hair, for the first coat, was a dull ocher all over; the fur whitish, changing to a rich brown, the normal hue; the flippers and muzzle were a pinkish flesh-tone in color, and the iris of the eye sky-blue. When they shed the following year, they are said to have a dirty, yellowish-white color, which makes them exceedingly conspicuous when mixed in among a vast majority of black pups, gray yearlings, and "Holluschickie" of their kind.

MONSTROSITIES AMONG THE SEALS.—Touching this question of monstrosities, I was led to examine a number of alleged examples presented to my attention by the natives, who took some interest, in their sluggish way, as to what I was doing here. They brought me an albino fur-seal

pup, nothing else, and gravely assured me that they knew it owed its existence to the fecundation of a sea-lion cow by a fur-seal bull; if not so, how could it get that color? I was also confronted with a specimen—a full and finely grown four-year-old *Callorhinus* which had, at some earlier day, lost its testicles either by fighting or accident while at sea; perhaps shaven off by the fangs of a saw-toothed shark, and also gravely asked to subscribe to the presence of a hermaphrodite!

Undoubtedly some abnormal birth shapes must make their appearance occasionally; but at no time while I was there, searching keenly for any such manifestation of malformation on the rookeries, did I see a single example. The morphological symmetry of the Fur Seal is one of the most salient of its characteristics, viewed as it rallies here in such vast numbers, but the osteological differentiation and asymmetry of this animal are equally surprising.

WHERE DO THE SEALS DIE?—It is perfectly evident that a large percentage of this immense number of Seals must die every year from natural limitation of life. They do not die on these islands; that much I am certain of. Not one dying a natural death could I find or hear of on the grounds; they evidently lose their lives at sea, preferring to sink with the *rigor mortis* into the cold, blue depths of the great Pacific, or beneath the green waves of Bering Sea, rather than to encumber and disfigure their summer haunts on the Pribylov Islands.

THE REPRODUCTION OF THE FUR SEAL.[1]—By treating this subject at length, my object is to fix attention upon several points connected with the reproduction of the Fur Seal which have vital importance to its relation with, and residence upon, the breeding-grounds of these islands under discussion. In the first place, naturalists generally have taken notice of the generative apparatus exhibited by the *Phocidæ;* and, while they have spoken at length in anatomical detail and discussion of the male organs of the *Otariidæ*, yet they exhibit a strange neglect or oversight with respect to those of the female. The singular cloacal arrangement of the female organs of generation in the *Phocidæ* has excited comment and description from the earliest times.

The modification of the generative apparatus peculiar to the male *Otariidæ*, in contradistinction to those organs possessed by the male *Phocidæ*, has been noticed to some extent by several authorities[2] prior to the date of this publication; but, while calling attention to this marked change in the morphology of the male organs of the *Otariidæ*, they are silent in regard to the fact that, though the *Phocidæ* are very distinct, by the armature of the males, from the *Otariidæ*, yet the cloacal arrangement of the females in both genera is identical. This is in itself, as I view it, quite as remarkable with regard to the females as it is noteworthy in respect to the males. Surely the wonderful modification of the physical structure of the male Fur Seal from that of his kindred, the Hair Seal, is very great; and we are not surprised to find that his generative organs are pronounced, in common with all the others, distinct. So the females differ, physically, in every respect, to as great a degree, with the solitary exception of the intra-uterine life, and the cloacal form of the external generative organs.

NECESSITY OF UNDERSTANDING THE SUBJECT.—This subject of the method of reproduction,

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[1] When they the approaching time perceive,
They flee the deep, and watery pastures leave:
On the dry ground, far from the swelling tide,
Bring forth their young, and on the shores abide
Till twice six times they see the Eastern gleams
Brighten the hills, and tremble on the streams,
The thirteenth morn, soon as the early dawn
Hangs out its crimson folds or spreads its lawn,
No more the fields and lofty coverts please,
Each hugs her own, and hastes to rolling seas.
—*Old Roman poem: Hair Seals of the Mediterranean.*

[2] ALLEN: North American Pinnipeds, 1880. MURIE: Trans. Zool. Soc., 1869–'72.

as carried out by the Fur Seals on the breeding-grounds of the Pribylov Islands, should be understood distinctly and authoritatively, before the truth or falsity of certain hypotheses, which depend upon it, can be intelligently discussed. The general impression and commonly-received opinion in the popular, as well as the scientific world, is that the amphibian life of the ocean breeds in the water thereof; or, in other words, that the fertilization of the seal-life takes place by coition therein, and that the young may be born in this watery element, safely nurtured and cared for by their mothers.[1] No end of fanciful rumor and romance has been published touching this point. We are told that some man of great credibility has seen Seals in the water, with their new-born clasped to their bosoms, rising in the waves to look at their disturbers, and then sinking, to carry away their young to safety and quiet. To this fanciful description, undoubtedly, the mermaid owes its origin in our recent mythology; for the Hair Seal, in especial, has a bland, round, full physiognomy; the large circular eyes are placed more in front of the skull than in the crania of any other genera of its kind. Such a head popping up suddenly in front of the mariner might naturally suggest a human face; and it needs but a very little embellishment to trim it with long hair, place mammæ on its bosom, and all the other peculiar attributes of the yellow-haired mermaid so celebrated in song and art.

FINE OPPORTUNITIES FOR OBSERVATION.—Therefore, what I wish to distinctly settle with regard to the reproduction of the Fur Seal, which I now have under consideration, is that mooted question as to the place, the manner, and the time of the union of the two sexes necessary for the reproduction of its kind. I have no personal knowledge of the system of fertilization employed, with reference to it, by the *Phocidæ;* hence I shall not attempt to describe it.[2] What I have

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[1] Reasonably enough, the closet naturalist, no matter how able, will be deceived now and then in this manner by untrustworthy statements made by those who are supposed to know by personal observation of what they affirm.

As an apt illustration of this confusion which the best of closet naturalists are thrown into by untrustworthy information touching this very matter, I may cite the case of Hamilton, who, in 1839, while writing of the Fur Seal of Cook and Forster, discovered in particular by them on South Georgia, in 1771, declares it to be no Fur Seal at all! He feels warranted in doing so, because one Captain Weddell says so. This authority was a hardy sailor who made sealing a specialty in the Antarctic during 1823–'26. Hamilton, after specifying the wide range of this *Arctocephalus*, "at Dusky Bay, New Zealand, in New Georgia, Staten Land, Juan Fernandez, and the Gallapagos," goes on to say:

"It will be observed that several of these authorities, particularly Dampier and Cook, speak of the fineness of the fur of this Seal. It is probably these statements which have led the able author of the article *Phoque* in the "Dict. Classique d'Hist. Naturelle" to state that this Seal is the Fur Seal of commerce. His words are: 'L'otarii de Forster est le Phoque à fourrures des pêcheurs européens.' But this, we suspect, is a mistake. No one will doubt that Captain Weddell was familiar with the Fur Seal. He was also familiar with the Ursine Seal, both as encountered in its haunts and as described by naturalists; and yet, when speaking of the Ursine Seal (so denominated by him), he never once hints that its fur has any peculiar value, but the contrary."—Amphibious Carnivora. Edinburg, 1839, p. 265.

Thus Hamilton quotes this old sailor, Weddell, throughout his whole memoir, with the utmost trust; and in the same manner others have been cited. They are worthless, unless taken "cum grano salis." The "long and short" of it is this: when most of the seafaring sealers and whalers are in the field, they are blind to everything except the mere capture of their quarry. When they return, they are importuned, usually at first, for details which, in fact, they have never thought of, while away.

[2] "The inconsequential numbers of the Hair Seal around and on the Pribylov Islands, seem to be characteristic of all Alaskan waters and the northwest coast; also, the *Phocidæ* are equally scant on the Asiatic littoral margins. Only the following four species are known to exist throughout the entire extent of that vast marine area, viz:

PHOCA VITULINA—Everywhere, between Bering Straits and California.

PHOCA FŒTIDA—Plover Bay, Norton's Sound, Kuskokvim mouth, and Bristol Bay, of Bering Sea; Cape Sëartze Kammin, Arctic Ocean to Point Barrow.

ERIGNATHUS BARBATUS—Kamtchatkan coast, Norton's Sound, Kuskokvim mouth, and Bristol Bay, of Bering Sea.

HISTRIOPHOCA FASCIATA—Yukon mouth, and coast south to Bristol Bay, of Bering Sea and drifting ice therein.

Then, in addition to this, Mr. Ivan Petrov, the special agent of the Tenth Census, United States Army, reports the presence of a land-locked Seal in the fresh waters of Iliamna Lake, and also in Lake Walker. It may be as distinct from any of the *Phocidæ* above enumerated as is the Baikal or the Caspian Seals; and, as such, I suggest that it shall receive the name of *Phoca petrovi*, when it is eventually secured, and if identified as new to our lists.—Preliminary Report of Progress, Census of Alaska: Ivan Petrov, Washington, December, 1880, p. 45.

In this connection, it is a somewhat curious fact that the description which Aristotle [300 B. C.] gives of the

heard from the natives would point clearly to the fact, that they know nothing really worthy of scientific attention; but in regard to the Fur Seal I have had unusual advantages, and an extended experience, ranging over four consecutive breeding-seasons, in which thousands of these animals, all perfectly in accord, have passed within the scope of my observation and record.

GENITALIA OF THE MALE AND FEMALE FUR SEAL.—Considering the male *Callorhinus:* When it is first born the external organs of generation are not evidenced to the sight, and it requires a nice touch to find them under the skin. It is not until this animal has rounded off the second year of its existence, that the testes descend and become externally exposed: first faintly, but rapidly succeeding to the same prominence and same relative position that they occupy in the example of the dog. When this creature becomes three and four years old, its testes hang pendant in a somewhat flabby scrotum, which in the old male is as pendulous as that of an ordinary bull; *the sack is smooth and shiny, entirely devoid of hair, and black, with a slightly wrinkled* surface. The sheath of the penis is so merged with the skin of the abdomen that it does not lie ribbed there and prominent as in the other carnivora; but it is an erectile organ, with a bony skeleton, *measuring, when fully developed, from five to seven inches in length. The females have* their parts of generation exactly as they are described by Owen and Huxley—which descriptions are based upon examples of the well-known *Phocidæ;* their external organs are entirely concealed, by the fact that the rectum terminates on the opposite side of the vulva; and a common, somewhat flaccid, sphincter closes both apertures. In other words, the anal and genital openings of the female are united into a single one, through which the regular secretions of the body pass, and the forces of reproduction are received and introduced. Thus, while the female *Phocidæ* correspond in this respect with the female *Otariidæ*, yet the extraordinary development of the male organs in the *Otariidæ* are quite marked, when contrasted with those peculiar to the *Phocidæ*.[1]

NO EVIDENCE OF RUTTING ODORS: SPEEDY BIRTH OF PUPS.—When the male Fur Seals or "Seecatchie," as the natives call them—a term implying strength and virility—arrive first upon the breeding-grounds, long before the coming of the females, as described in a preceding chapter of this monograph, they give no evidence of being in rut; nor do they emit any odor during the rest of the season which at all resembles the "rutting odor" ascribed to many animals. I call attention to this because a common blunder has been made, and likely will be made, whereby the smell upon the rocks, so far-reaching and so offensive, is called the "rutting funk." It is, as I have also stated, due to other causes which are conspicuous and which have been specified heretofore. When the females came to land upon the breeding grounds, I noticed that, with the exception of the virgin cows, they were heavy with young; that the period of their gestation must soon culminate by the birth of their offspring, which usually took place within a couple of hours after they reached the shore, or within as many days at the most. Frequently I have observed the mothers land, and ere they were dry the young would be expelled; and the thought rose then to my mind "how wonderfully well-timed the return of those gravid cows was"—for, in spite of tempests and currents, and *many of them quite two and three thousand miles from their winter*

Hair Seal (*Monachus albiventer*, very likely) is, in most respects, correct; while Buffon, the celebrated French zoölogist, as late as 1785, has not, despite his vast advantages, been nearly as accurate in his treatment of the Pinnipeds. That *this old Grecian philosopher, three hundred years before the Christian era, should have done better in this respect* than that world-wide distinguished academician did more than two thousand years afterward, affords an entertaining suggestion as to the alleged degeneracy of the present age, especially so since the monument erected over Buffon's remains bears an inscription which declares that he possessed "a mind equal to the majesty of nature." (!)

[1] See Owen's Anatomy of Vertebrates," vol. iii, p. 699, London, 1868. The *Phocidæ* are the subject of this eminent author's examination and report.

feeding-places, yet they reach this land-speck in Bering Sea just in season for instant delivery after arrival![1]

PANGS OF IMPENDING PARTURITION ALONE PROMPT FEMALES TO LAND.—The females do not land until they are obliged to by the precipitation of this event of parturition. They land upon the breeding-grounds of Saint Paul just as they come in contact with the shore—guided and influenced at the moment of approach to the islands by only one ruling thought, and that is, to reach as near as possible the locality upon which they resided in former years. Soon after landing, which I have heretofore described, the birth of the young takes place, and in this wise: the cow shows, an hour or so prior to delivery, great nervous agitation; she trembles all over; her eyes blinking, and flippers twitching; rolling, stretching, and thoroughly uneasy, until the labor-pains. If the ground where she happens to rest is rocky, she manages to lie upon the top of a bowlder, her hind-flippers working spasmodically with a wavy, fan-like motion backward and forward, as she rests full upon her stomach, with the fore-flippers alternately pressed tightly to the rock or closely to her sides, like pectoral fins; she sways her head, her eyes are partly closed and her mouth slightly opened in panting, during the fifteen or twenty minutes which usually ensue between the first contraction of the uterus, until the expulsion of the intra-uterine life takes place. These labor-pains are not, in my opinion, at all very severe or abnormal in any respect. The pup carries with it, at the moment of birth, the entire placental pouch or "after-birth." This envelope is broken, usually by the mother, in forcing the labor and during the first expulsion of the pup's head, which is always presented in advance. The little "Kotick" may be said to fairly drop upon

[1] If there is any one faculty better developed than the others in the brain of the intelligent *Callorhinus*, it must be its "bump" of locality. The unerring directness with which it pilots its annual course back through thousands of miles of watery waste to these spots of its birth—small fly-dots of land in the map of Bering Sea and the North Pacific—is a very remarkable exhibition of its skill in navigation. While the Russians were established at Bodega and Ross, California, sixty years ago, they frequently shot Fur Seals at sea, when hunting the Sea Otter off the coast between Fuca Straits and the Farallones. Many of these animals, late in May and early in June, were so far advanced in pregnancy that it was deemed certain by their captors that some shore must be close at hand upon which the near impending birth of the pup took place; thereupon, the Russians searched over every rod of the coast-line of the mainland and the archipelago, between California and the peninsula of Alaska, vainly seeking everywhere there for a fur-seal rookery. They were slow to understand how animals, so close to the throes of parturition, could strike out into broad ocean to swim fifteen hundred or two thousand *miles* within a week or ten days ere they landed on the Pribylov group, and almost immediately after gave birth to their offspring.

There is no record made which shows that the Fur Seals have any regular or direct course of travel up or down the northwest coast. They are principally seen in the open sea, eight or ten miles from land, outside the heads of the Straits of Fuca, and from there as far north as Dixon Sound. During May and June they are aggregated in greatest numbers here, though examples are reported the whole year around. The only Fur Seal which I saw, or which was noticed by the crew of the Reliance, in her cruise, June 1 to 9, from Port Townsend to Sitka, was a solitary "Hollu-schack" that we disturbed at sea well out from the lower end of Queen Charlotte's Island; then, from Sitka to Kadiak, we saw nothing of the Fur Seal until we hauled off from Point Greville, and coming down by Ookamok Islet, a squad of agile "Holluschickie" suddenly appeared among a school of hump-back whales, sporting in the most extravagant manner around, under, and even leaping over the wholly indifferent cetacea. From this eastern extremity of Kadiak Island clear up to the Pribylov group we daily saw them here and there in small bands, or also as lonely voyageurs, all headed for one goal. We were badly outsailed by them; indeed, the chorus of a favorite "South Sea pirate's" song, as incessantly sung on the cutter's "'tween decks," seemed to have special adaptation to them:

"For they bore down from the windw'ard,
A sailin' seven knots to our four'n."

The ancient Greeks seemed to have been impressed somewhere by rookery odors, for old Homer says—

"The web-footed seals forsake the stormy swell,
And, sleeping in herds, exhale nauseous smell."

Where this illustrious bard sniffed up this characteristic unpleasantness of breeding-seals, I am at loss to say. The Pribylov Islands and the great Antarctic grounds were as far from that poet then as the moon is from us to-day. He must have been introduced to it within the confines of the Caspian Sea, or else credibly informed, by trustworthy authority, of this peculiarity of the large herds of *Phocidæ* in those waters. Small bands, however, of Hair Seals breed now, as they bred then, in the Mediterranean and Black Seas. He may have stumbled upon a few of them while provoking his muse in lonely travels over Grecian pelagic shores.

its feet, for the moment it appears from within the natal walls it seems to be in full possession of all its faculties; its eyes are wide open, and its voice is raised in weak, husky bleatings, as it feebly paddles around, still attached to the umbilical cord, which it, by its own efforts, pulls asunder as it flounders about on the rocks or ground of the rookery. The mother, in the mean time, gives her offspring none of that attention so marked in the case of the *Canidæ* and other carnivores, not even turning to look at it; but she draws herself up with an expression of intense comfort and relief, throwing her head back with a gentle, swaying motion, as she fans herself slowly with either one or both of the hind-flippers. She also pays no attention to the cleansing of her own person, the after-birth lying undisturbed by her, it being speedily trampled under foot and ground out of recognizance by the restless multitudes around her, which pass to and fro. The pup quickly dries off, with rapid alternations of short naps with awakenings, in which it gets up and on its flippers to essay brief scrambles over the rocks and ground until, in nosing about, it claims the attention of its mother (sometimes hours after birth): this she gives by gently elevating her abdomen and turning her parts posteriorly, so that one or two of the obscure teats, filled with milk, can be seized by the hungry pup, which now nurses therefrom greedily, even to gorging itself.

MILK OF THE FUR SEAL.—The milk of the Fur Seal mother is very rich and creamy, and the secretion is always abundant, but there is not, under any circumstances, the enlarged udder and mammæ peculiar to dogs and similar animals; the nipples are scarcely distinguishable, even when exposed to the reach and notice of the young.

IRREGULAR FEEDING OF THE PUPS.—The umbilicus of the pup rapidly sloughs off, and the little fellow grows apace, nursing to-day heartily in order that he may, perhaps, go the next two, three, or four days without another drop from the maternal fount; for it is the habit of the mother Seal to regularly and frequently leave her young, on this spot of its birth, to repair for food in the sea; she is absent on these excursions, on account of the fish not coming inshore within a radius of at least one hundred miles of the breeding-grounds, through intervals varying, as I have said, from a single day to three or four, as the case may be. The manner in which she returns after feeding, and in which she singles out by scent, and at a glance, her own offspring from many thousands surrounding it, I have clearly described in a foregoing chapter.[1]

PRELIMINARY ADVANCES OF THE SEXUAL UNION.—The pup being born, the cow rapidly passes into "heat." I have noticed examples where ten hours only elapsed between the event of the birth and that of copulation, and I doubt not of full impregnation for another period. But as a rule forty-eight hours is a fair figure to express the time from the birth to the state known as "being in heat." The cow always makes the first advances to the bull. If she is one of the earlier subjects for his attention, the union is soon accomplished; but should she be of the later applicants in his

[1] When the females first come ashore there is no sign of affection manifested, whatever, between the sexes. The males are surly and morose, and the females entirely indifferent to such reception. They are, however, subjected to very harsh treatment sometimes in the progress of battles between the males for their possession, and a few of them are badly bitten and lacerated every season.

One of the cows that arrived at Nah Speel, Saint Paul Island, early in June, 1872, was treated to a cruel mutilation in this manner, under my eyes. When she had finally landed on the barren rocks of one of the numerous "Seecatchie" at the water front of this small rookery, and while I was carefully making a sketch of her graceful outlines, a rival bull, adjacent, reached out from his station and seized her with his mouth at the nape of the neck, just as a cat lifts a kitten. At the same instant, almost simultaneously, the old male that was rightfully entitled to her charms, turned, and caught her in his teeth, by the skin of her posterior dorsal region. There she was, lifted and suspended in mid-air, between the jaws of her furious rivals, until, in obedience to their powerful struggles, the hide of her back gave way, and, as a ragged flap of the raw skin more than six inches broad and a foot in length was torn up and from her spine, she passed, with a rush, into the possession of the bull who had covetously seized her. She uttered no cry during this barbarous treatment, nor did she, when settled again, turn to her torn and bleeding wound to notice it in any way whatsoever that I could observe.

When severe inflammation takes place, they seek the water, disappearing promptly from your scrutiny.

harem, after he has been more or less exhausted by the vital drafts made upon him, she must wait. I have observed instances of this character in which the female teased the male for hours and hours before arousing him.

PELAGIC COITION IMPOSSIBLE.—In this act of coition on these breeding-grounds of Saint Paul and Saint George, I have noticed the fact that, whenever the female was well covered by the male on the flat or smooth shelves of rock or earth, they moved and shuffled about without any particular effective coition until brought up against a rougher inequality, or some fragments of lava shingle, so characteristic of the rookery grounds. The reason for this is due to the fact, that in spite of the great weight of the male, six times more than that of the female which he covers, the orgasms are so rapid and violent that, unless the female is held by some other agency than the weight of the male, she is literally shoved ahead and away from under him. This fact I call attention to, as it alone is sufficient, upon the slightest reflection, to satisfy any judicial mind that it is a physical impossibility for these Seals to copulate in the water. Under no conceivable position assumed for this supposed pelagic coition could effectual sexual connection be made.[1]

ACTION OF REPRODUCTION.—The male serves the female exactly as a big Newfoundland dog would serve a small terrier slut. The "Seecatchie" draws his heavy body over and upon the outstretched spine of the female, who lies prone before him on her stomach; so that when the male has adjusted himself, which he does by arching his back from the shoulders to the *os coccyx*, he covers her so completely that nothing of her body can be seen, except a portion of her head just peering out from between his fore-flippers and under his broad chest.

Notwithstanding their great rapidity and the muscular power employed, the orgasms last, without interruption, for the surprising space of from eight to fourteen minutes—not a second's intermission. Of course, toward the close of the season, when the male is tired, he does not remain *in coitu* longer than three or four minutes. On account of the vigor and duration of this first coitus, I am inclined to think that that female has no further intercourse with that male, or any other one, during the rest of the season. She is satisfied, and passes rapidly out of heat. Certain it is that she is not noticed by him again; she goes up to his seraglio-grounds, to and from the sea, seeking her young and feeding undisturbed for the balance of the time; also, that the other bulls seem to recognize this condition of passed sexual requirement and satisfaction, in her case, by paying her no attention.

PERIOD OF GESTATION.—Thus it is apparent that the period of gestation in the Fur Seal is nearly, lacking a few days, twelve calendar months; for the next year finds her again heavy with young at almost exactly the same day that she gave birth to her previous offspring in the prior season. The systematic and regular appearance of the females every year upon the Pribylov Islands at such a time, usually in June or July, without the slightest regard to what the weather

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[1] Those extremely heavy adult males which arrive first in the season, and take their stations on the rookeries, are so fat that they do not exhibit a wrinkle or a fold of the skins enveloping their blubber-lined bodies; most of this fatty deposit is found around the shoulders and the neck, though a warm coat of blubber covers all the other portions of the body save the flippers; this blubber thickening of the neck and chest is characteristic of the adult males only, which are, by its provisions, enabled to sustain the extraordinary protracted fasting periods incident to their habit of life and reproduction.

When those superlatively fleshy bulls first arrive, a curious body tremor seems to attend every movement which the animals make on land; their fat appears to ripple backward and forward under their hides, like waves; as they alternate with their flippers in walking, the whole form of the "Seecatchie" shakes as a bowl full of jelly does when agitated on the table before us.

There is also a perfect uniformity in the coloration of the breeding coats of the Fur Seals; and it is strikingly manifest while inspecting the rookeries late in July, when they are solidly massed thereon. At a quarter mile distance, the whole immense aggregate of animal life seems to be fused into a huge homogeneous body that is alternately roused up in sections and then composed, just as a quantity of iron filings, covering the bottom of a saucer, will rise and fall, when a magnet is passed over and around the dish.

may have been during the winter and spring previous, or is when they land, establishes without doubt this exact limit of their gestation.

IMPORTANCE OF THIS SERVICE.—The reason why I dwell upon these details is because they have a very important bearing upon the question as to what ratio of males every year is needed for service on this great breeding-ground of Bering Sea. If the common opinion, hitherto entertained, was tenable, of free and effective pelagic coition, then it will be readily understood that nearly all the males from four years up, and on, could have easy access to the females; and that it would be a matter of very small concern how many old males, or rather those males upon the land located over the rookeries, were fit for service. But understanding, as I now do, without a shadow of tenable contradiction, that these "Seecatchie" which receive, fight for, and cover the females on the rookeries, are the only active *fertilizing* powers toward the reproduction and perpetuation of their kind, the importance of my detailed description of the method of coition is evident; for it shows conclusively that unless we see every year, long prior to the arrival of the females, a full supply of able-bodied "Seecatchie" holding out upon and located over the rookeries of Saint Paul and Saint George—unless we see such a number in good condition—we may safely count upon the fact that danger will arise of imperfect and nugatory fertilization for the coming year. It will not do to indulge the hope, should a scarcity or diminution of the old males ever occur, when the rookeries are mapped out in spring, of the deficiency being made good by the young males which are swimming around everywhere in the water.

VITALITY OF THE MALE.—I believe that an able-bodied adult "Seecatchie" is capable of serving well from the 14th June to the 14th July, during which period the height of the breeding season occurs, one hundred females. If he is, however, as he frequently is, enfeebled by previous fighting and struggling with other males to hold the station which he has selected and fought for, it is more than likely that his virility will not extend beyond the proper serving of twenty or thirty cows. As I have said in another place, I found great difficulty in finding, to my own satisfaction, a fair number of females as the average to every harem on the rookery.[1] Some instances occur where the male treats forty-five or fifty females, owing to the peculiar configuration of the landing grounds; but most generally, and as the rule, I think fifteen or twenty cows to every bull is a true computation; hence I do not believe, under any normal circumstances and all normal disadvantages, such as fighting involves by weakening the males, that, when the females arrive, there is the least risk of a single one of them getting back to the water without a perfect and effectual impregnation. A common opinion was prevalent on the islands among the employés touching this matter, that, when the female was not instantly covered during her first heat, she went to the water, cooled off, and on returning, sexual desire never reappeared, and she became a *farrow* or barren cow from that time to the end of her natural life. Analogous physiology confutes this

[1] This striking and accurate average is still further complicated by that unknown distribution of the virgin females which come up to the rookeries every year for their first meeting with the virile males. What proportion of them reach the rear of the breeding-grounds compared with their numbers which are served at the water-line? I surely am at fault to say, for they do not leave that tangible evidence which the other older cows do in the forms of their young. One of the curious contradictions to generally received ideas of the habit of Seals is the fact that the Fur Seal will not rest either upon snow or ice; it seems to positively avoid all contact with either of those substances upon which the *Phocidæ* wholly, and the Sea Lions to some degree, delight in hauling over. *Callorhinus* has the warmest of seal coats, by all odds, yet it dreads a snowy or an icy bed with as much sincerity as any habitué of the tropics can. The Sea Lions and Hair Seals have often been surprised in sporting, or sleeping on the ice floes of Bering Sea in the spring, by whalemen while cruising at the edge of the frozen pack, waiting for the channel to open, clear into the Arctic Ocean; as neither *Eumetopias* nor *Phoca* has any under wool, their sea-jackets are not half as heavy as those peculiar to the bodies of Fur Seals; hence in taking personal notice of this odd aversion of the *Callorhinus* to snow and ice, I believe that its dislike is one of pure sentimentality rather than one based on physical inability to rest upon as cold surfaces, for there is not much difference between the water's temperature and that of the snow and ice in the spring—10° Fahr., perhaps—both cold enough at all events.

completely; that such warm-blooded, highly-organized creatures should never have a rapid recurrence of sexual desire, in common with all other animals of their class, until it is gratified in the usual way, is not at all probable, though it may be possible.

SMALL NUMBER OF BARREN FEMALES.—To show, however, that a very small proportion of the myriads of breeding females are barren, I have only to present this illustration, which is happy in its conclusion, and easily portrayed: Whenever a female ceases to breed she refuses to haul up on the rookeries; she roams with the "Holluschickie," or the "Bachelors," growing a third heavier and marked with corresponding darker tones to her coat, yet still preserving the familiar pattern of the female, so that she can be picked out quickly by an experienced eye from the old and young males around her. In driving up every season the "Holluschickie" to the killing-grounds, the natives noticed, and pointed out to me, those barren females in the drive, several of which were secured for my examination and measurement; but the proportion of barren females is not more than one in a thousand to the "Holluschickie" with which they consort.

6.—THE SIRENIANS OR SEA-COWS.

By FREDERICK W. TRUE.

31. THE AMERICAN MANATEES.

SPECIES OF NORTH AMERICAN MANATEES.—The numerous zoölogists and travelers who have written upon the American Manatees are not agreed as regards the number of existing species. In the many and oftentimes discordant descriptions and observations extant, some see but the variations of a single species;[1] others discern two species,[2] one of Florida, the other of South and Central America; and others still are able to distinguish three species, one, as before, in Florida, but two in South America, a marine and a fluviatile species. I have satisfied myself by examination of specimens in the National Museum that there are at least two species, and that both occur within the borders of the United States. Regarding the Manatee of the upper water-courses of South America I am still in doubt. In the following pages I shall refer to the southern form, *Trichechus manatus*, Linné, as the South American Manatee, and to the Floridan form, *Trichechus latirostris*, (Harlan) True, as the Florida Manatee.

DISTRIBUTION OF THE FLORIDA MANATEE.—We have, then, upon our coasts two representatives of the Sirenians. The Florida Manatee, the least widely spread species, apparently inhabits only the Floridan Peninsula and the eastern Gulf States. Regarding its distribution Mr. Silas Stearns of Pensacola, Fla., contributes the following notes:

"It is generally supposed in Florida and the Gulf States that there are very few Manatees in existence in this country, and that these are to be found in the southern portion of the Florida Peninsula, in the fresh-water rivers, both on the Atlantic and Gulf sides. I have heard of their being taken or seen in the Myakka River, Peace Creek, Caloosahatchie River, and other small streams south of Charlotte Harbor and Okeechobee Lake, on the Gulf side, and in the Sainte Lucie River on the Atlantic side.

"On the Gulf coast (where I am better acquainted) the oldest settlers say that ten, fifteen, or twenty years ago Manatees were occasionally seen in nearly all the inland waters from Key West westward to civilization at Pensacola, Mobile, and New Orleans. It is evident that they have been abundant along the entire Gulf coast, and probably on the Atlantic as far north as the Carolinas, for their bones can be found along the shore nearly everywhere that civilization has not reached.

"Those generally found in the salt water along sand-beaches are petrified and black. I have reason to think that there are still scattering individuals all through Florida, for during the summer of 1880 I saw one in Santa Rosa Sound, some twenty miles east of Pensacola, where there has been none seen for many years. While landing a sail-boat on the island we surprised the animal in shoal water and had a fine opportunity to examine it as it swam by into deeper water. As they are so shy, there may be many more existing in the State than we are aware of, and their range may include the whole State of Florida."

Mr. Goode informs me that specimens could be taken from time to time in the year 1878 near Sainte Lucie on Indian River.

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[1] GRAY: Cat. Seals and Whales, Brit. Museum, 1866, p. 358, and others. (*Manatus australis.*)
[2] HARLAN: Journal Acad. Nat. Sci. Philadelphia, first series, iii, 1824, pp. 390–394.

A writer in the journal "Forest and Stream," of June 11, 1874, under the heading "The Manatee at Saint Augustine, Fla.," quotes from the Saint Augustine "Press," as follows:

"The Manatee continues her domicile in Bar Creek (Saint Augustine). Fishermen have again reported it and citizens are anxious to go after it. . . . There are also vague rumors of a very large animal of the same species having been seen roaming about a place on the North River called Oleander Town. If so, the one is probably the dam and the other the calf that have become separated. It is also probable that during some of the heavy blows along the coast between here and Indian River some herd of these animals has become dispersed and these two may have wandered into our harbor. It will be remembered that two or three years ago a very large one was seen in this harbor, which came up to the water-battery of the fort, where it remained until pelted by the boys. Fishermen report them as having been frequently seen in the harbor."

Mr. C. J. Maynard, who has been much in Florida, has recorded some valuable notes on the distribution of the Florida Manatee. He writes: "This singular animal is found in large numbers about the inlets of Indian River, and Capt. Dummett informs me that he has captured specimens as far north as his place, which is within five miles of the head of the river. I have been informed by creditable authorities that it is remarkably abundant upon the western coast in the various rivers and creeks which abound between Tampa Bay and Cape Sable. I have never seen it in Mosquito or Halifax Lagoons, and am confident that it does not occur there. This species is said to feed upon the leaves of the mangrove during the night."[1]

Dr. von Frantzius stated some years ago, in an essay on the mammals of Costa Rica, that the Florida Manatee was the only species found in that country. He writes as follows: "If we recognize *M. latirostris* as a separate species, we shall be able to say that only *this species is found* on the coast of Costa Rica."[2] It is evident, however, that he has confounded the two species, for a few lines further on he says: "Nearly all the museum specimens arriving in Europe in later years come from Surinam and belong to the species known as *M. latirostris;* so far as I know no specimens from the coast of Costa Rica or from Greytown have ever been sent to Europe. I had but one opportunity of seeing the Manatees on the shores of the Sarapiqui, and that at a distance."[3]

This statement is in part erroneous; a large proportion of the different figures of specimens in European museums are those of the southern form, *Trichechus manatus.*

DISTRIBUTION OF THE SOUTH AMERICAN MANATEE.—The South American Manatee is most abundant in the northern part of that continent and in Central America. Its range extends much farther north, I believe, than is generally supposed. A skull in the National Museum, belonging undoubtedly to this species, was received from Texas in 1855. It would seem that the animal must occur in some abundance along the Mexican coast. Its range extends on the south at *least* as *far* as the Saint Matthew's River in Brazil.[4] Manatees are found in nearly all the rivers of northern South America, particularly in the Amazon and its tributaries, and in the Orinoco. Those which are found in the upper water-courses, as has been already stated, are by some regarded as distinct, and by others as identical with those of the lower regions and the sea.

THE MANATEE OF THE WEST INDIES.—A species of Manatee occurs more or less abundantly in the West Indies, particularly about Cuba, San Domingo, and Porto Rico, but whether it is the Florida or South American species seems not to have been ascertained. It is supposably, however, the Florida Manatee.

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[1] MAYNARD, C. J.: Cat. Mammals of Florida. Ex. Bull. Essex Institute, iv, 9–10, 1872, pp. 8–9.
[2] VON FRANTZIUS: Säugethiere Costa Ricas, in Wiegmann's Archiv, xxxv, Jahrg. i, pp. 304–307.
[3] *Loc. cit.*
[4] Prince Maximilian.

BOUNDARIES OF THE RANGE OF AMERICAN MANATEES.—The entire range, therefore, of the American Manatees extends over about forty-nine degrees of latitude—that is, from 30° north to 19° south. It is probable, as Mr. Stearns surmises, that the existing species ranged farther north in former days, and, furthermore, it is not definitely known that the southern Manatee does not extend south of 19° south in Brazil. It is certain, however, as Burmeister distinctly states, that it is not found on the coast of the Argentine Republic.[1]

As an instance of the unusual wandering of (probably) the Florida Manatee, it may be noted that an animal, the description of which fairly portrayed the appearance of that species, was cast on the coast of Shetland in 1785. It was described by the British zoölogist Fleming as probably being a Rhytina, but this seems very unlikely to one acquainted with the facts of the geographical range and size of that animal. Gray refers it to his *Manatus australis*, which includes both the Florida and South American Manatees. It seems to me that if it was carried across the ocean by the Gulf Stream, as Gray suggests, it most probably "set sail" from the Floridan coast.[2]

Dr. Leidy has described the teeth of two fossil species, *Manatus antiquus*[3] and *Manatus inornatus*,[4] from the "phosphate beds" of the Ashley River, South Carolina, showing that, as in the case of many other American genera, there has been a movement southward in geological time.

ORIGIN OF THE NAME "MANATEE."—I doubt if it is possible to arrive at any satisfactory conclusion regarding the origin of the name Manatee. Certain it is that it was first used by the early Spanish and Portuguese explorers. Pietro Martire, who is the first to record the existence of the animal, in 1500, as I gather from Ramusio's collection of early voyages, does not give it a name.[5] The notes which he gives regarding the animal were probably taken from the original records of Columbus's fourth voyage, in the midst of the narrative of which they are given. Oviedo, in 1535, calls it "Manati";[6] Exquemelin, about 1650, states that the Spanish call it "Manentine";[7] Atkins in 1735 uses "Manatea"; Gumilla, in 1741, uses "Manati."[8] The French writers, beginning with Biet, in 1664, employ the names "Lamantin," "Lamentin" (Condamine, 1745), and "Manaty" (Du Tetre, 1667). The appellation "Manatee" occurs for the first time, so far as I am aware, in 1703, in Dampier's account of his voyages round the world. The word in this form, or as "Manati," has been used by most English writers. Whether this name, in its various forms, refers to the peculiar fore-legs of the Manatee or to its means of suckling its young, can only be decided by the investigations of philologists more learned and more zealous than myself.

DIFFERENT NAMES OF THE MANATEE.—Other names for the Manatee occur, most of which define, as it were, the characteristics of the animal. Such are "Pegebuey," a native Amazonian name, employed by Acuña in 1641, and its translations: "Ox Fish," as written by Sloane in his natural history of Jamaica, in 1725, and "Poisson bœuf," as given by Condamine, in 1667, in his history of the Antilles. The French name, "Vache marin," and the corresponding English word, "Sea-cow," occur in numerous instances in scientific literature. In Guiana the natives use the name "*Cojumero*" (*Gray*). *Bellin (1763) alludes to "Lamenum."* The term "Petit Lamentin du nord," used by French writers to distinguish the South American Manatee from the Floridan species, is, I believe, of later origin.

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[1] BURMEISTER: Description physique, Répub. Argentine, iii, part i, 1879, p. 530.
[2] FLEMING: British Animals, p. 30. GRAY: Cat. Seals and Whales, Brit. Museum, 1866, p. 359.
[3] LEIDY, in Proc. Acad. Nat. Sci. Philadelphia, viii, 1856, p. 165.
[4] LEIDY, in Rept. U. S. Geological Survey, 4°, i, 1873, p. 376, pl. xxxvii, figs. 16, 17.
[5] Oceani Dec. Hispali, 1500, fol., libr. 8, *fide* Brandt.
[6] OVIEDO: Hist. general de las Indias, 1535, lib. xii, c. 10.
[7] EXQUEMELIN: Buccaneers of America, English translation, 1684, p. 92.
[8] GUMILLA: El Orinoco Illustrado, 1741.

SIZE OF THE FLORIDA MANATEE.—In treating of the size of the American Manatees, it will be necessary to consider the two species separately, although the adults seem to attain nearly equal proportions. Harlan gives, as the maximum length of the Florida Manatee, eight or ten feet, but these measurements were not made by himself.[1] Mr. W. A. Conklin, director of the Central Park menagerie, in New York City, gives the following dimensions of a specimen kept alive in that establishment in 1873: "The following are its absolute dimensions: length, 6 feet 9½ inches; circumference around the body, 4 feet 9 inches; length of flipper, 1 foot; width of same, 4¾ inches; width of tail joining body, 1 foot 6¾ inches; greatest width of tail, 1 foot 8½ inches; weight, 450 pounds."[2]

I am not aware that any other measurements of the Florida Manatee, under its proper name, are on record.

SIZE AND WEIGHT OF THE SOUTH AMERICAN MANATEE.—The size of the South American Manatee has been differently estimated by different observers. "This Creature," says Dampier, "is about the bigness of a Horse, and 10 or 12 foot long. . . . I have heard that some have weighed above 1200 L. but I never saw any so large."[3]

Stedman, alluding to a Manatee which floated past his encampment on the river Cottica, in Surinam, says: "This Manatee was exactly sixteen feet long, almost shapeless, being an enormous lump of fat, tapered back to a fleshy, broad, horizontal tail."[4]

Smyth and Lowe captured a Manatee in 1835 in Peru, at their encampment at Sarayacu, on the Ucayali. "We had one opportunity," they relate, "while at this place, of examining a *vaca marina*, or manatee, that was just caught; but, not being anatomists, are unable to give a scientific account of it. The animal was seven feet eight inches long from the snout to the tip of the tail. . . . This was not considered a large one. . . . When the animal was killed, it took the united strength of at least forty men to drag it up from the water to the town, which they effected by means of our ropes."[5]

In 1872 Dr. Murie published a valuable memoir on the South American Manatee, in which he gives measurements of two specimens which reached London in 1866, fresh but not alive. The length of one, a young male, from the Maroni River, in Surinam, was forty eight inches or four feet; that of the second specimen, a young female, from Porto Rico, sixty-five inches, or five feet five inches. In his remarks on these animals, Dr. Murie says: "When studying in the Stuttgart Museum, I derived much information from Professor Krauss, the able director. Among other things he mentioned that their large stuffed specimen of Manatee was the mother of our Society's young male, as attested by Herr Koppler, of Surinam, who transmitted it. The length of the female mounted skin I ascertained to be 122 inches [ten feet two inches], therefore twice and a half the length of the young animal possibly six or eight months old. Another stuffed male specimen at Stuttgart measures 94 inches. Both of the above are doubtless stretched to their fullest extent; still, one is justified in assuming the adult *Manatus* to be from 9 to 10 feet long."[6] Of the weight of the specimens he remarks: "According to Mr. Greey, the entire carcass of the Zoölogical Society's female, when weighed immediately after death on board ship, was 228 lbs. That of the young male as ascertained by myself was 61 lbs."[6]

[1] HARLAN: Fauna Americana, 1825, p. 277.
[2] CONKLIN: The Manatee at Central Park, in "Forest and Stream," i, 1874, p. 166.
[3] DAMPIER: A New Voyage round the World, i, 1703, pp. 33, 34.
[4] STEDMAN: Narrative of an expedition to Surinam, ii, 1796, p. 175.
[5] SMYTH and LOWE: Journey from Lima to Para. London, 1836, p. 197.
[6] MURIE: On the form and structure of the Manatee. Transactions Zoölogical Society of London, viii, 1873, pp. 129–131.

Another specimen, a female, received by the same society from Surinam, measured eighty inches, but no indication of its age is given.[1] Still another specimen, this time a male, arrived in London. When dead, measurements showed its length to be ninety-four and five-tenths inches or seven feet ten and one-half inches.[2]

Of two male Surinam specimens which died in the Zoölogical Gardens at Philadelphia, one measured exactly six feet from snout to tip of tail, the other six and a half feet.[3]

General Thomas Jordan, writing in "Forest and Stream," in 1873, says: "Three of these huge mammals I saw on Indian River, in 1849–'50, each weighing at least fifteen hundred pounds, and between fifteen and twenty feet in length." He adds: "The Florida species (*T. latirostris*) are *much larger than those found in the Antilles, South America, or Africa."*[4] *This last statement can* scarcely be strictly correct. Other writers, as we have seen, have found quite as large specimens as those here referred to in South America.

BREEDING HABITS OF MANATEES.—In relation to the breeding of Manatees, and the size and habits of the young, almost nothing is known. Ogilby, in his account of Cuba, says: "No less wonderful is the Fish *Manate;* it breeds for the most part in the Sea, yet sometimes swimming up the Rivers, comes ashore and eats Grass."[5]

This account, however, is of little value, as it was copied by Ogilby, who does not state whence he derived it. Du Tertre states that two calves are born at a time. "If the mother is taken," he writes, "one is assured of having the young: for they follow their mother and continue to move about the canoe until they are made companions of her misfortune."[6]

Descourtlitz, writing regarding his own observations in 1809, says: "The Manatees possess a gentle and amiable nature, and lament when they are separated from their young, which the mother nourishes with much tenderness. They appear sensitive and intelligent; they weep when *they are taken without having received any bad treatment, seeming to regret that they can never* return to their haunts. Although sometimes they appear to avoid man, at other times they regard him without suspicion and seem to implore his pity. The young do not quit the mother for many years, and, sharing her dangers, often become the victims of their filial devotion."[7]

Brandt, who has examined much of the literature of the subject, states that it is said that the period of gestation lasts eleven months, and that the young follow the mother a half year.[8]

FOOD OF SIRENIANS.—The Sirenians, as a group, are very strictly graminivorous, and the American Manatees form no exception. The structure of their lips and teeth is such that this fact might be surmised were nothing known of their habits. Living as they do at the mouths of rivers and about the coast, or in the upper waters of streams, they find no lack of aquatic vegetation on *which to subsist. Exactly what plants they thrive best upon has been the subject of inquiry by* several observers, especially those who have been interested in the attempt to keep the Manatee in captivity. Mr. Chapman informs us that the specimen at the Philadelphia gardens ate freely of various garden vegetables—cabbage, celery tops, spinach, kale, baked apples, and others, while they devoured as well quantities of the aquatic plant *Vallineria spiralis*, and the sea-weed *Ulva latissima*.[9] The Central Park specimen seems to have been more dainty. "A variety of aquatic

[1] GARROD: Transactions Zoölogical Society of London, x, 1877, p. 137.
[2] MURIE: Transactions Zoölogical Society of London, xi, 1880, p. 27.
[3] CHAPMAN: Proc. Acad. Nat. Sci. Philadelphia, xxvii, 1875, p. 452.
[4] Forest and Stream, i, 1873, p. 169.
[5] OGILBY: America, 1671, p. 315.
[6] DU TERTRE: Histoire Nat. des Antilles, 1667, pp. 201, 202.
[7] DESCOURTLITZ: Voyage d'un Naturaliste, ii, 1809, pp. 274, 275.
[8] BRANDT: Symbolæ Sirenologicæ, fasc. iii, 1861–'68, p. 256.
[9] CHAPMAN, H. C., in Proc. Acad. Nat. Sci. Philadelphia, xxvii, 1875, pp. 459–461.

plants were placed before its mouth," says Mr. Conklin, "and each in turn rejected. At length some canna, *Canna indica*, was procured, which it devoured greedily, and which it continues to use alternately with sea-weed, *Fucus vesiculosus*, obtained in the East River."[1] The process of eating takes place under water, which seems strange, in view of the fact that the animal cannot breathe while therein engaged.

Dr. Murie thus interestingly narrates the feeding habits of the Manatee at the London Zoölogical Gardens in 1878: "On first arrival at the aquarium, cabbage, lettuce, water-cress, pieces of carrot and turnip, loose and bundles of hay, and quantities of pond-weed were put into the tank, both floating and sunk by weights attached. Occasionally it would sniff or examine these by snout and lips without chewing or swallowing, until its appetite returned as above mentioned. It then showed a preference to water-cress, though often taking cabbage, but afterwards it chose lettuce, and entirely eschewed the others. When in the height of health it consumed, according to Mr. Carrington, from ninety to one hundred and twelve pounds of green food daily. As lettuce became scarce and dear it cost ten shillings a day to supply it with the French sort; and although cabbage, etc., was then cheap and abundant, it daintily chose the former, and as steadily avoided and refused the latter."[2]

EARLY ALLUSIONS TO THE HABITS OF THE AMERICAN MANATEES: BY COLUMBUS.—What relates to the food of the Manatee in the writings of travelers and explorers is so connected with observations on its habits in general, that I may be pardoned for not withdrawing the facts for insertion in the previous paragraph. We shall find in reviewing the various accounts of the habits of Sea-cows that there is not always a harmony of statements, and it will be necessary to look with a critical eye upon the narratives of some of the earlier voyagers, who seem to have been a little confused sometimes by the unfamiliar phenomena with which they were surrounded.

The first apparent reference to the American Manatees in literature appears to be that in the narrative of Columbus's first voyage, at the stage of his first departure for Spain, in 1493. Taking up the thread of the narrative as given by Herrera, we read as follows:

"*Wednesday* the ninth of *January*, he hoised sail, came to *Punta Roxa*, or Red Point, which is thirty-six Leagues East of *Monte Christo*, and there they took Tortoises as big as bucklers, as they went to lay their eggs ashore. The Admiral [Columbus] affirm'd he had thereabouts seen three Mermaids, that rais'd themselves far above the Water, and that they were not so handsome as they are painted, that they had something like a human Face, and that he had seen others on the Coast of *Guinea*."[3]

The probability of the fact that the mermaids here referred to were really Manatees is in Columbus's statement of having seen others on the coast of Guinea, as it is in that region that the African Manatee, *T. senegalensis*, is abundant. Not many years later, in 1502, on the occasion of Columbus's fourth voyage to America, the Manatee became well known to the adventurers while at San Domingo. Oviedo, as quoted by Herrara, says:

"The Spaniards at this Time found a new sort of Fish, which was a considerable advantage to them: tho' in those parts there is much Variety. It is call'd Manati, in shape like a skin they use to carry Wine in, having only two Feet at the Shouldars, with which it swims, and it is found both in the Sea and in Rivers. From the Middle it sharpens off to the Tail, the Head of it is like that of an Ox, but shorter, and more fleshy at the Snout; the Eyes small, the Colour of it grey, the Skin very hard, and some scattering Hairs on it. Some of them are twenty Foot long, and ten in Thick-

[1] CONKLIN, in Forest and Stream, i, 1874, p. 163.
[2] MURIE, in Trans. Zoölogical Society London, xi, 1880, pp. 22, 23.
[3] HERRARA (STEVENS): Hist. America, i, 1725, p. 82.

ness. The Feet are round, and have four Claws on each of them. The Females bring forth like the Cows, and have two Dugs to give suck. . . . Sometimes they are taken ashore, grazing near the Sea, or Rivers, and when young they are taken with Nets."[1]

Then follows the oft repeated story of the tame Manatee of the Cazique Carametex:

"Thus the Cazique *Carametex* took one, and fed it twenty-six Years in a Pond, and it grew sensible and tame, and would come when call'd by the name of *Mato*, which signifies Noble. It would eat whatsoever was given it by Hand, and went out of the Water to feed in the House, would play with the Boys, let them get upon him, was pleas'd with Musick, carry'd Men over the Pool, and took up ten at a Time, without any Difficulty."[2]

FATHER ACUÑA UPON THE "PEGEBUEY."—In the fourth decade of the succeeding century Father Acuña, in narrating his adventures on the Amazon River, makes mention of the South American Manatee somewhat at length. Among other things he says: "But above all, the fish, that like a king lords it over all the others, and which inhabits this river from its sources to its mouth, is the *Pegebuey* (Fish Ox), a fish which when tasted only can retain the name, for no one could distinguish it from well-seasoned meat. It is large as a calf a year and a half old, but on its head it has neither ears nor horns. . . . This fish supports itself solely on the herbage on which it browses, as if in reality a bullock; and from this circumstance the flesh derives so good a flavour, and is so nutritious, that a small quantity leaves a person better satisfied and more vigorous than if he had eaten double the amount of mutton. It cannot keep its breath long under water; and thus, as it goes along, it rises up every now and then to obtain more air, when it meets with total destruction the moment it comes in sight of its enemy."[3]

ROCHEFORT UPON THE HABITS OF THE ANTILLEAN MANATEE.—After Oviedo, Gomara, and Acuña no one seems to have added any new facts, or supposably new facts, to the history of the habits of the Manatees until Hernandez and Rochefort published their narratives. The work of the former I have not had at command, but from F. Cuvier's notes it would seem that it contains nothing of importance. Rochefort, the second edition of whose work on the Antilles was published in 1665, gives the following information: "This fish feeds upon plants which it collects about the rocks and on the shallows which are not covered with more than a fathom (*brasse*) of water. The females breed at the same season as do cows, and have two mammæ with which they suckle their young. Two calves are born at a birth, which are not adandoned by the mother until they have no more need of special nourishment, or until they can browse upon plants like the mother."[4]

15. BIET'S AND DU TERTRE'S ACCOUNTS.—Biet repeats these observations, although it is to be believed independently, saying that the Manatee roams about the shores near the sea browsing on the plants which grow there.[5]

Du Tertre in effect repeats the little that his predecessors have laid down, but adds some additional observations which are interesting if sufficiently substantiated. "The food of this fish," he says, "is a little plant which grows in the sea, and on this it browses after the manner of an ox. After being filled with this food it seeks the fresh-water streams, where it drinks and bathes twice a day. Having eaten and been refreshed it goes to sleep (*s'en dort*) with its snout half out of water, a sign by which its presence is recognized by the fishers from afar."[6]

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[1] HERRARA (STEVENS): History of America, i, 1725, p. 278.
[2] HERRARA (STEVENS): History of America, i, 1725, p. 279.
[3] CHRISTOVAL DE ACUÑA: River of the Amazons 1641, pp. 68-99. (*Hakluyt Society.*)
[4] ROCHEFORT: Histoire des Iles Antilles, 2d ed., 1665, pp. 194, 195.
[5] BIET: Voyage en l'Isle de Cayenne, 1664, p. 346.
[6] DU TERTRE: Hist. générale des Antilles, 1667, p. 200.

THE BUCCANEER EXQUEMELIN'S ACCOUNT.—Only a few years later we find the buccaneers making fair use of the Manatee in replenishing their oftentimes empty larders, and, in the interval of slaughtering the defenseless Indians and colonists, one of these hardy pirates finds time to record some observations regarding the animal. After the destruction of Panama, in 1670, Exquemelin and his companions sail along the coast of Costa Rica, *en route* for Jamaica. He alludes to the Sea-cow in the following language:

"This Accident and Encounter retarded our Journey, in the space of two days, more than we could regain in a whole Fortnight. This was the occasion that obliged us to return unto our former Station, where we remained for a few days. From thence we directed our Course for a Place, called *Boca del Dragon*, there to make Provisions of Flesh. Especially of a certain Animal which the *Spaniards* call *Manentines*, and the *Dutch*, *Sea-Cows*, because the Head, Nose, and Teeth, of this Beast, are very like unto those of a Cow. They are found commonly in such places, as under the depth of the Waters, are very full of Grass, on which, it is thought, they do pasture. . . . Their manner of engendering likewise, is the same with the usual manner of the Land-Cow, the Male of this kind being in similitude, almost one and the same thing with a Bull. Yet notwithstanding they conceive and breed but once. But the space of time that they go with Calf, I could not as yet learn. These Fishes have the sense of Hearing extremely acute, in so much as in taking them, the Fishermen ought not to make the least noise, nor row, unless it be very slightly."[1]

The buccaneer seems to have gathered correct information as to the mode of life of the Manatee, but as to their breeding but once, although, as I believe, we have no facts to disprove the statement, analogical considerations would lead us to reject it.

CONDAMINE'S ACCOUNT.—Condamine is, perhaps, the only other early writer to whom it will be necessary to refer. He alludes to the South American Manatee among other fish, in which group of animals all the early explorers insisted in placing it. "It is not amphibious, properly speaking," he says, "because it never comes entirely out of the water, and cannot walk, not having but the two fins near the head, in the form of wings 16 inches long, which serve in place of arms and feet; it lifts only the head out of the water, and that to gather the plants along the shore."

In regard to the habits of Manatees in confinement, I can only quote from the writings of the American and English observers who have had the opportunity to study the specimens in the Philadelphia, New York, and London zoölogical gardens. Of the Central Park specimen Mr. Conklin states: "It manifests at times extreme playfulness, and will answer the call of the keeper by a peculiar noise, somewhat resembling the squeak of a mouse. Some time ago the epidermis on the back peeled off in small pieces, leaving a bright new skin similar to that of a snake just after shedding. It was kept out in the open air until the thermometer fell to 53°, when it was removed to a building. It appears to be very sensitive to cold, curling up its back if the water is in the least chilly. It has been observed to remain under water five or six minutes at a time without coming to the surface to breathe."[2]

MISS CRANE'S OBSERVATIONS.—Miss Agnes Crane, who attentively observed the South American Manatees at the Brighton Aquarium in 1879, has given us some interesting facts regarding the mode of respiration of the Sirenians and their attitudes when at rest. After stating that the specimens were received from Trinidad, she says:

"The young male, a fine animal in robust condition, measured, in November, 1879, four feet ten inches from snout to tail, with a maximum girth of four feet. The female was four feet eight

[1] EXQUEMELIN: Buccaneers of America, English translation, 1684, pp. 82, 83.
[2] CONKLIN, in Forest and Stream, i, 1873, p. 166.

inches in length, of a lighter slate-colour than her companion, of more slender build and proportions. Both are marked with white on the under sides of their bodies. The pair occupied a tank twelve feet six inches in length by eight feet six inches in breadth, with an almost flat bottom. Temperature of water, about 70° F.: depth, two feet six inches in the daytime, reduced to six inches at night. The water is run off daily, a fresh supply being admitted at the requisite heat from a neighboring tank filled with warmed fresh water. Although the area of these quarters appear somewhat limited when compared with the bulk of the animals, the Manatees seem perfectly comfortable, and, being of a sluggish disposition, rarely explore the whole of their small domain. Nor do they, so far as I observed, avail themselves of the shallowness of the water and, by supporting their bodies on the tail-fin, keep their heads above the surface and avoid the constant repetition of the upward movement in order to breathe the necessary air. They habitually rest side by side at the bottom of the tank, with the caudal fin stretched out quite straight, and the tips of the fore fins just touching the ground.

"Thence they rise gently, often with the least perceptible movement of the tail and flapping motion of the paddles, raising the upper part of the body until the head reaches the surface, when the air is admitted through the nostril flap-valves, which are closely shut after the operation, and the original and usual position is gently resumed. They seem generally to be compelled to rise to the surface for aërial respiration every two or three minutes, but the interval between respiration varies much at different times. In one quarter of an hour, during which one was carefully timed, it rose nine times, at very irregular intervals. I have been informed that they occasionally remain under the water for a much longer period, but have never observed them to exceed six minutes, although I have timed them before and after feeding, and at all hours of the day. The respiratory movement appears to be repeated almost mechanically and without effort."[1]

The fact that these Manatees in confinement kept constantly beneath the surface does not accord with the observations of Du Tertre, already quoted. It is probable that the air about the aquarium was not sufficiently warm to induce them to float with the head out of water, as they do in their native haunts. The same observer furnishes some facts of a highly important character regarding the attempts made by the Manatees at terrestrial progression.

"The habits of the animals in captivity, while affording occasional evidence of the ease and rapidity with which they move in the water, do not furnish much support to the views of their capability of habitual active progression on land. Yet it must be admitted that, supplied with a sufficiency of nicely varied food, they have no inducement to leave the water, and that the construction of their straight-walled tank precludes such efforts, as a rule. The male, however, has recently been observed to make some slight attempts at terrestrial movement, turning himself round and progressing a few inches when his tank was empty. With jaws and tail-fin pressed closely to the ground, the body of the animal becomes arched, and is moved by a violent lateral effort, aided and slightly supported by the fore-paddles, which are stretched out in a line with the mouth. But the effect of these very labored efforts was not commensurate with their violence; in fact, their relation to active locomotion may be compared to those of a man lying prone, with fettered feet and elbows tied to side. Nor does the Manatee seem at all at ease out of water, as he lies apparently oppressed with his own bulk, while he invariably makes off to the deepest corner of his tank directly the water is readmitted."[2]

ABUNDANCE OF THE FLORIDA MANATEE.—In the great struggle for life no animal is, in a manner, more destructive than man himself. The fierce carnivora may prey upon the more peaceful

[1] CRANE, AGNES, in Proc. Zoölogical Society of London, 1880, pp. 456–457.
[2] *Loc. cit.*, pp. 459, 460.

graminivora, but the attack must be made, one may say, in person, subject to all the dangers attendant upon an encounter with those weapons which a long course of selection has developed in the prey. Man ensnares alike the lion and the deer by the devices of his brain, with little or no danger to himself. Notwithstanding, the fleetest animals oftentimes escape him and the strongest intimidate him; but such drowsy beasts as the Sirenians fall helpless victims to his strategy. The past century witnessed the extinction of one of these animals, the Rhytina, through no other apparent agent than man. The inquiry intrudes itself, Will the Manatees succumb to the same fate which overtook their huge relative?

It is undoubtedly a fact that the American Manatees are much less abundant in many regions than they were at the time of the discovery of America. They have withdrawn before the advance of civilization into the more inaccessible places out of the reach of man.

In regard to the Floridan Manatee, the statement of Harlan (who obtained it from Dr. Burrows), made so late as 1825, namely, that an Indian could readily obtain a dozen in a year,[1] is now doubtfully true. The statements of Mr. Stearns, given in the early part of this essay, show that it has disappeared from some localities in Florida within a comparatively recent period. Nevertheless, the Florida Manatee cannot yet be considered as threatened with extinction, and in Southwestern Florida, if we may believe Mr. Maynard, is still abundant. Specimens are received from time to time for our museums and zoölogical gardens, and to satisfy the curiosity of the gaping crowds at the circus. The prices obtained for specimens of both American Manatees in this country and in England show, however, that they are not to be obtained without difficulty.[2]

Gundlach refers to the abundance of the Manatee in Cuba in the following terms: "In former times very abundant; at present much reduced in numbers, but not rare though difficult to capture."[3]

According to Dr. Von Frantzius, the South American Manatee was abundant along the western shores of the Gulf of Mexico, especially in Costa Rica. "They are still very common," he says, "along the Atlantic coast, where they find abundant nourishment in the numerous lagoons (*Haffbildungen*), and likewise the needed protection; they pass into the rivers and are found abundantly in San Juan and neighboring streams, the Rio Colorado, Sarapiqui, and San Carlos. Apparently they are prevented from going far into the San Carlos on account of the rapids which occur near its mouth, and hence are not found in the Rio Frio nor in Lake Nicaragua itself."[4]

ABUNDANCE OF THE SOUTH AMERICAN MANATEE.—In relation to the present abundance of Manatees in South America, it is perhaps unnecessary for me to enter into details here. Brandt has reviewed the subject at length quite recently, giving many particulars.[5] His investigations show that in many regions, particularly about the mouths of rivers and in other places where sufficient shelter is wanting, the Sea-cows are disappearing or have become entirely extinct. In the upper waters of the rivers, however, where the native Indians are few and civilization has not reached, little diminution is probable.

PROBABILITY OF EXTINCTION.—Putting all the facts together, it seems evident that not many centuries will pass before Manatees will be extremely rare, especially in our own country. More specimens should be accumulated in our museums, both of the entire animal and of its bones, and its wanton destruction should cease.

MODES OF CAPTURE.—The methods of capturing Manatees are numerous. In Florida, Mr. Goode informs me, strong rope nets, with large mesh, are often employed. The details of this

[1] HARLAN: Fauna Americana, 1825, p. 277.
[2] Trans. Zoölogical Society London, xi, 1880, p. 21. Edwards' Guide to Florida, 1875, p. 69.
[3] GUNDLACH: Revista y Cat. de los Mamiferos cubanos. Repert. Fisico-nat. de Cuba, ii, no. 2, 1866, p. 56.
[4] VON FRANTZIUS: Säugethiere Costa Ricas. Archiv für Naturgeschichte, xxxv, i, 1868 (†), pp. 304–307.
[5] BRANDT: Symbolæ Sirenologicæ, fasc. iii, 1861–'68, p. 253.

method are given in the notes of an observer, Mr. J. Francis Le Baron, writing from Titusville in 1880. His account of the fishery, given with much fullness, bears all the evidences of correctness. I may be allowed to quote the part which pertains to my subject: "The manatee hunter aims to catch the animal alive, and for this purpose quite an extensive outfit is required. It consists, first, of a large seine net, about one hundred yards long and six or eight feet wide, made of 'spun yarn,' so called, which consists of three or four rope yarns spun into one line, about the size of a clothes-line, and very strong. The meshes are fifteen inches wide. The head-line consists of a strong rope, and floats made of wood, shaped like a double-ended boat, are placed at intervals along this to keep the top of the net near the surface of the water. The bottom is weighted with small pieces of brick or stone, just enough to cause the net to hang perpendicularly in the water. A large sail-boat is also required. The hunter, taking the net in the boat, proceeds quietly to the part of the river frequented by the manatee, and keeps a sharp lookout for the animals, which have a habit of passing up and down the river by certain points. If the lookout perceives a manatee in the river above him he knows that sooner or later the animal will take a cruise down the river, and he proceeds accordingly to stretch his net across the channel. One end of the net he first makes fast to a small bush or twig, or, if no tree is available, to a stake driven for the purpose into the bank. To this the shore end of the net is fastened by a small cord secured to the head-line, and the stake or bush before mentioned, care being taken to use a cord so small that in its struggles it will be easily broken by the animal, for a reason which will appear hereafter. The boat is then rowed across the stream with the other end of the net, and when the latter is stretched to its full length, the boat is anchored and the net secured by a similar easily broken cord to the boat in such a manner that the first struggle of the animal will be felt by the occupants of the boat, being communicated by the cord to a tell-tale, or the cord is fastened to the body of one of the hunters, who now go to sleep if night has come on, or perhaps while away the time by a game of cards, keeping perfectly quiet. There are very likely several manatee in the river, and before long one attempts to pass by the boat. His progress is of course arrested by the net, and his struggles to force a passage are at once communicated by the tell-tale cord. Unsuccessful in his first attempt to effect a passage, the manatee increases his efforts, and the result is that the slender cords holding the net to the shore and the boat are broken, and the net with the manatee entangled drifts away with the current. The frantic efforts of the animal only serve to closer enwind him in the meshes of the net, which doubles and wraps itself around him closer and closer. It is now that the objects of the light sinkers and slender holding cords are apparent. The manatee is a warm-blooded animal and must come to the surface for air every few minutes. If the sinkers are too heavy, or if the net is immovable in the water, he is unable to do this and is drowned. The large floats serve now to show the hunters the location of the prey, and they bear down upon it and tow it with the confined animal into shoal water. Here a large box or tank is ready. The net is unwound, ropes are placed around the animal, and by the united efforts of the hunters, he is transferred to the box. The box is then towed to the 'crawl,' which is an inclosure formed by driving stakes close together in the water with their tops projecting several feet above, and is generally near the home of the hunters. The box is floated into the crawl and the animal let out. He is there kept and fed daily until an opportunity occurs for shipment. This is made in the same large box, which is water-tight and about half filled with water. Such is the method employed by the Indian River hunters for catching the manatee alive. It is, however, often shot with a rifle, from the shore or a boat, when feeding or coming to the surface to breathe, but the hunter must be very quick and expert with his weapon, as they show only one-third of the head, and that only for a second. The profits of manatee hunting are large. The skeleton, if properly cleaned, will readily bring a hundred

dollars, and the skin a like sum if taken off whole, being in demand by scientists for museums all over the world."[1]

"So valuable an animal," says Wood, alluding more particularly to the South American Manatee, "is subject to great persecution on the part of the natives, who display great activity, skill, and courage in the pursuit of their amphibious quarry. *The skin of the Manatee* is so thick and strong that the wretched steel of which their weapons are composed—the 'machetes' or sword-knives, with which they are almost universally armed, being sold in England for three shillings and six pence *per dozen—is quite unable* to penetrate the tough hide. Nothing is so effectual a weapon for this service as a common English three-cornered file, which is fastened to a spear-shaft, and pierces through the tough hide with the greatest ease."[2]

Many of the early explorers give lively accounts of the manatee fishery in South America. "Diuers other fishes," says Oviedo, in alluding to the fishes of the Orinoco River, as quaintly translated by Purchas, "both great and small, of *sundrie sorts and kinds*, are accustomed to follow the ships going vnder saile, of the which I will speak somewhat when I haue written of *Manatee*, which is the third of the three whereof I haue promised to entreat. *Manatee*, therefore, is a fish of the sea, *of the biggest sort*, and much greater than the *Tiburon* in length and breadth, and is very brutish and vile, so that it appeareth in forme like vnto one of those great vessels made of Goats skins, wherein they vse to carry new wine in *Medina de Campo* or in *Arenale*: the head of this beast is like the head of an Oxe, with also like eyes, and hath in the place of armes, two great stumps wherewith he swimmeth. It is a very gentle and tame beast, and commeth *oftentimes out* of the water to the next shoare, where if he finde any herbes or grasse, he feedeth thereof. Our men are accustomed to kill many of these, and diuers other good fishes, with their Crosse-bowes, pursuing them in Barkes or Canoas, because *they swim in* manner aboue the water, the which thing when they see, they draw them with a hooke tyed at a small corde, but somewhat strong. As the fish fleeth away, Archer letteth goe, and prolongeth the corde by little and little, vntill he haue let *it goe many fathoms*: at the end of the corde, there is tyed a corke, or a piece of light wood, and when the fish is gone a little way, and hath coloured the water with his blood, and feeleth himselfe to faint and draw toward the end of his life, he resorteth *to the shoare*, and the Archer followeth, gathering vp his corde, whereof while there yet remaine sixe or eight fathoms or somewhat more or lesse, he draweth it toward the Land, and draweth the fish therewith by little and little, as the waues *of the Sea helpe him* to doe it the more easily: then with the helpe of the reste of his companie, he lifteth this great beast out of the Water to the Land, being of such bignesse, that to conuey it from thence to the Citie, it shall be requisite to haue a Cart with a good *yoke of Oxen*, and sometimes more, according as these fishes are of bignesse, some being much greater then other some in the same kinde, as is seene of other beasts: Sometimes they lift these fishes into the Canoa or Barke without drawing them to the Land *as before, for as soone* as they are slaine, they flote aboue the water: And I beleeue verily that this fish is one of the best in the world to the taste, and the likest vnto flesh, especially so like vnto beefe, that who so hath not seene it whole, can *iudge it to* be nother when hee seeth it in pieces then very Beefe or Veale, and is certainly so like vnto flesh, that all the men in the world may herein be deceiued: the taste likewise, is like unto the taste of very good Veale, and lasteth long, if it be powdred: so that in fine, the Beefe of these parts is by no means like vnto this. The *Manatee* hath a certaine stone, or rather bone in his head within the braine which is of qualitie greatly appropriate against the disease of the stone, if it be burnt and ground into small powder, and taken fasting in the morning

[1] LE BARON: In Forest and Stream, xiii, 1880, p. 1005, 1006.
[2] WOOD: Illustrated Natural History. Mammals, p. 548.

when the paine is felt, in such quantities as may lye vpon a peny with a draught of good white wine. For being thus taken three or foure mornings it acquieteeth the griefe, as diuers haue told me which haue proved it true, and I my selfe by testimonie of sight doe witnesse that I have seen this stone sought of divers for this effect."[1]

Du Tertre, whose narrative we have already several times quoted, gives an account of the mode of capture, which has all the tokens of accuracy. He writes:

"Three or four men go in a small canoe (which is a small boat, all of one piece, made of a single tree in the form of a canoe). The oarsman is at the back of the canoe and dips the blade of his paddle right and left in the water in such a way that he not only governs the course of the canoe but makes it advance as swiftly as if it were propelled by a light wind or under reef. The Vareur (who lances the beast) stands on a small plank at the bow of the canoe holding the lance in his hand (that is to say, a sort of spear, at the end of which a harpoon or javelin of iron is fastened). The third man, in the middle of the canoe, arranges the line, which is attached in order to be paid out when the animal is struck.

"All keep a profound silence, for the hearing of this animal is so acute that the least noise of water against the canoe is sufficient to cause it to take flight and frustrate the hopes of the fishers. There is much enjoyment in watching them, for the harpooner is fearful lest the animal escape him, and continually imagines that the oarsman is not employing half his force, although he does all that he is able with this arms and never turns his eyes from the harpoon, with the point of which the harpooner points out the course he must follow to reach the animal, which lies asleep.

"When the canoe is three or four paces away the harpooner strikes a blow with all his force and drives the harpoon at least half a foot into the flesh of the animal. The staff falls into the water, but the harpoon remains attached to the animal, which is already half caught. When the animal feels itself thus rudely struck it collects all its forces and employs them for its safety. It plunges like a horse let loose, beats the billows as a negro beats the air, and makes the sea foam as it passes. It thinks to escape its enemy, but drags him everywhere after it so that one might take the harpooner for a Neptune led in triumph by this marine monster. Finally, after having dragged its misfortune after it, and having lost a great part of its blood, its power fails, its breath gives out, and being reduced to distress, it is constrained to stop short in order to take a little rest; but it no sooner stops than the harpooner draws in the line and strikes it a second blow with a harpoon better aimed and more forcibly thrown than the first. At this second blow the animal makes a few more feeble efforts, but is soon reduced to extremities, and the fishermen readily drag it to the shore of the nearest island, where they place it in their canoe, if the latter is of sufficient size."[2]

Barbot, after quoting the account of the fishery by Acuña, in the quaint translation which I shall quote on a following page, adds some valuable notes on the commercial transactions which are carried on in connection with salted Manatee meat. He says:

"The *Manati's* flesh used at *Cayenne* is brought ready salted from the river of the *Amazons;* several of the principal inhabitants sending the barks and brigantines thither with men and salt to buy it of the *Indians* for beads, knives, white hats of a low price, some linen, toys, and iron tools. When those vessels are enter'd the river of the *Amazons*, the *Indians*, who always follow the *Manati* fishery, go aboard, take the salt, and with it run up the river in canoes or *Piraguas* to catch the *Manati's;* which they cut in pieces, and salt as taken, returning with that salt fish to the brigantines; which go not up, because the *Portuguese* who dwell to the eastward, at *Para*, and other places of *Brazil*, claim the sovereignty of the north side of that river, and give no quarter

[1] Purchas his Pilgrimes, iii, 1625, pp. 987, 988.
[2] Du Tertre: Histoire des Antilles, ii, 1667, pp. 200, 201.

to the *French* or other *Europeans* they can take in their liberties, which has occasion'd many disputes and quarrels between them, as I shall observe hereafter.

"That controversy was decided by the treaty of *Utrecht*, in the year 1713. The *Portuguese* some years since designing to settle on the west side of the *Amazons*, cruelly massacred many, who before used to go unmolested, and consequently mistrusting no danger.

"The brigantines having got their lading of salted *Manati*, return to *Cayenne*, and sell it there, commonly at three pence a pound."[1]

"The flesh of the Manatee being much esteemed," writes Descourtilitz, in 1809, from his own observations, "and its fat never becoming rancid, the negroes employ many means to destroy them, sometimes by the use of nets, in the places where they feed, sometimes by shooting them from canoes; more commonly they harpoon them when they are able to approach sufficiently near, but as the animal, although seriously wounded, does not die immediately, they let out a cord in order not to lose so precious a prey, which one sees reappear at the surface of the water, drowned and lifeless."[2]

PRODUCTS FURNISHED BY MANATEES.—The Sirenians possess the quality, most fatal to them, of furnishing palatable food for man. The huge Sea-cow of Bering Sea disappeared from this cause, and the Dugong, the Sirenian of the Indian Ocean, and the Manatees suffer not less on the same account. For the Indian of South America the Manatee is a fund of wealth. On its flesh he subsists, with its oil he anoints himself, from its skin he makes shields and cords, in its bones he finds medicine. The early explorers were not long in discovering its virtues. Herrara gathers the following estimate of its importance from their accounts of America:

"The Taste of it is beyond Fish: when fresh it is like Veal, and salted like Tunny-Fish, but better, and will keep longer: the Fat of it is sweet, and does not grow rusty. Leather for Shoes is dress'd with it. The Stones it has in the head[3] are good against the Pleurisy and the Stone."[4]

Rochefort is not less impressed with the good qualities of the animal. He exclaims: "Among all the fishes there is none having so good flesh as the Lamantin. Two or three of these beasts will fill a large canoe, and the flesh is like that of a land animal, firm, pink and appetizing, and mixed with fat, which being rendered never becomes rancid. When it has been two or three days in pickle, it is better for the health than when eaten entirely fresh."[5] He also gives some very good advice in regard to the use of the ear bones for medicine. "The superstitious," he says, "lay great store by the stones which are found in the head, because they possess the power, they say, when reduced to powder, to stop the formation of calcareous deposits, and to remove those already formed; but, since the remedy is very violent, no one ought to use it without the advice of a wise and experienced physician."[6]

Biet mentions the Manatee first in his list of the fishes [*sic*] of the Ile de Cayenne. Alluding to the flesh, he says: "It is very excellent, and although one may have other provisions, it will be preferred to beef. Its fat, also, is as sweet as butter, and can be used to advantage in all kinds of pastry, friessees, and soups."[7]

Barbot seems to have summed up all that was known of the Manatee of South America up to his time, early in the eighteenth century, and quotes, also, Father Acuña, in a translation which,

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[1] BARBOT: Op. cit., p. 563.
[2] DESCOURTILITZ: Voyage d'un Naturaliste, ii, 1809, p. 276.
[3] The ear bones.
[4] HERRARA: History of America, i, 1725, p. 278.
[5] ROCHEFORT: Nat. Histoire des Iles Antilles, 2d ed., 1665, p. 195.
[6] *Loc. cit.*, p. 195.
[7] BIET: Voyage en l'Ile de Cayenne, 1664, pp. 346, 347.

according to my notion, is preferable to that of the Hakluyt Society. Having alluded to its small eye, but quick ear, and to other characteristics of its organization, he says:

"The flesh of this creature is excellent, very wholesome, and tastes very much like veal of *Europe*, when young: for the biggest are not so delicate and agreeable to the palate. Their fat is hard, and very sweet, as that of our hogs; the flesh resembles veal. It dies with very little loss of blood, and is not observ'd to come upon dry land; nor is there any likelihood it should, considering its shape, as in the cut, whence it is concluded not to be amphibious.

"The *Spaniards* about the island of *St. Margaret*, or *Margarita*, called the *Manati Pece-Buey*, that is, Ox Fish; and particularly value the stomach and belly part of it, roasted on spits. Others cut long slices of the flesh of its back, which they salt a little, only for two days, and then dry it in the air; after which it will keep three or four months. This they roast and baste with butter, and reckon delicious meat. A gentleman has assur'd me, that at *Jamaica* they give eighteen pence a pound for young *Manati*. At *Cayenne* it yields but three pence a pound salted.

"F. *Christopher de Acunna*, in the relation of his voyage on the river of the *Amazons*, chap. 25, describes this fish as follows:

"The *Pece-Buey*, says he, is of a delicious taste; any one that eats it, would think it to be most excellent flesh well season'd. This fish is as big as a heifer of a year and a half old; it has a head and ears just like those of a heifer, and the body of it is all cover'd with hair, like the bristles of a white hog; it swims with two little arms, and under its belly has teats, with which it suckles its young ones. The skin of it is very thick, and when dressed into leather, serves to make targets, which are proof against a musket bullet. It feeds upon grass, on the bank of the river, like an ox; from which it receives so good nourishment, and is of so pleasant taste, that a man is more strengthen'd and better satisfy'd with eating a small quantity of it, than with twice as much mutton.

"It has not a free respiration in the water, and therefore often thrusts out its snout to take breath, and so is discover'd by them that seek after it. When the *Indians* get sight of it they follow it with their oars in little canoes; and when it appears above water to take breath, cast their harping-tools made of shells, with which they stop its course, and take it. When they have kill'd it, they cut it into pieces, and dry it upon wooden grates, which they call *Boucan*; and thus dressed, it will keep good above a month. They have not the way of salting and drying it to keep a long while, for want of plenty of salt; that which they use to season their meat being very scarce, and made of the ashes of a sort of palm-tree, so that it is more like salt-petre than common salt."[1]

For the Romanist of South America the Manatee is, as the old voyagers persisted in calling it, a fish. It is, therefore, eaten on days when a meat diet is forbidden by the rites of the church.

CONCLUSION.—In the Manatee, then, we have an animal of great size, of gentle disposition and apparently of rapid growth, which lives in places readily accessible to man, and is easily captured, and which furnishes meat which is not inferior, oil which is remarkably fine, and leather which possesses great toughness. From these considerations it would seem evident that, with the proper protection, it would furnish no small revenue to the people in those portions of our country which it inhabits, for centuries to come.

32. THE ARCTIC SEA-COW.

THE EXTINCTION OF SPECIES IN HISTORICAL TIME.—The catalogue of animals which are known to have become extinct within historical times is not a long one. I do not allude, of

[1] BARBOT: A Description of the Island of Cayenne, in Appendix to Description of the Coasts of North and South Guinea, 1732, p. 563.

course, to those animals which have been driven from their native haunts before advancing civilization, and which with its decline would flourish again amidst the fallen columns and crumbling walls, but to those of which no remnant remains, whose existence as the representatives of certain definite stages of organic development is forever closed. Such a one is the Rhytina (*Rhytina gigas*, Zimmermann), which inhabited Bering Sea until within about a century. The story of its discovery and extermination forms one of the most interesting pages of zoölogical history.

THE GREAT NORTHERN EXPEDITION.—At the opening of the last century the northeastern portion of the Russian Empire was one of the least known quarters of the globe. The barrenness of the land, the dreadful winter, and the almost impassable sea, had deterred travelers and voyagers to a large extent from penetrating into its wilds. Those who adventured in the frozen seas went principally in search of a northwest passage, or in pursuit of other matters relating to geography and commerce, and paid little attention to the products of the land or of the waters. Early in the seventeenth century, however, Peter the Great, desirous of knowing whether Asia and America were contiguous, gave orders that an expedition should proceed to ascertain the truth. Before they could be executed he died, but the Empress Catherine commanded that they should be fulfilled. Capt. Vitus Bering was placed in charge of the expedition, and Gmelin, of the St. Petersburg Academy, was appointed chief naturalist. After several preliminary cruises had been made which extended over a number of years, two ships set sail from Kamtchatka on the 15th (4th) of June, 1741. Before the departure of this final voyage, however, Gmelin had withdrawn on account of ill-health, and George William Steller, who had been sent out by the St. Petersburg Academy as his assistant, was commissioned to complete the scientific researches.

THE DISCOVERY OF BERING ISLAND AND WRECKING OF THE "ST. PETER."—The two vessels, the "St. Peter," commanded by Bering, and the "St. Paul," in charge of Tschirikov, sailed eastward toward the American continent. Before arriving, however, on the 1st of July (20th of June) a storm separated them. Having touched at Alaska, Bering started westward again, encountering before long the most tempestuous weather. The crew grew weak and sick through long-continued hardship. On the 10th of November (30th of October) the ship approached Bering Island, then unknown. A few days after the storm drove her upon the rocks, and the crew were forced to take up winter quarters on the island.

DEATH OF BERING.—Many of the sick died as soon as they were removed to the land, and on the 19th (8th) of December the commander also perished. After some days "it was resolved to examine what store of provisions there was, and compute how long they would last, to regulate the distribution of the shares accordingly, notwithstanding which thirty persons died on the island. They found the stores were so much exhausted that if they had not been supplied with the flesh of sea-animals they must have all perished for want of food."[1]

USE OF THE RHYTINA TO THE SURVIVORS.—Prominent among the animals which served them as food was the Rhytina. Its well-flavored flesh and pleasant fat proved a great boon to them. "And the sick found themselves considerably better, when, instead of the disagreeable hard beaver's flesh, they eat of the Manati, tho' it cost them more trouble to catch than one of the beavers. They never came on the land, but only approached the coast to eat sea-grass, which grows on the shore, or is thrown out by the sea. This good food may, perhaps, contribute a great deal to give the flesh a more disagreeable[2] taste than that of the other animals that live on fish. The young ones, that weighed 1,200 pounds and upwards, remained sometimes at low water on the dry land between the rocks, which afforded a fine opportunity for killing them; but the old ones,

[1] MÜLLER: Voyages from Asia to America. English translation, Jefferys, 1761, p. 58.
[2] This is surely a typographical error for *agreeable*.

which were more cautious, and went off at the right time with the ebb, could be caught no otherwise than with harpoons fixed to long ropes. Sometimes the ropes were broke, and the animal escaped before it could be struck a second time. This animal was seen as well in the winter as in the summer time. They melted some of the fat, with which, like hogs, they are covered from three to four inches thick, and used it as butter. Of the flesh, several casks full were pickled for ship's provision, which did excellent service on their return."[1]

STELLER'S OBSERVATIONS.—In the midst of these privations, Steller did not fail to make and record observations relative to the animals which came about the island. To his most praiseworthy perseverance we owe all that we know of the appearance and habits of the Rhytina. Not a word has been added to his account of the characteristics of the animal, which a few years later became extinct.

THE RETURN TO KAMTCHATKA; MISFORTUNES OF STELLER.—In the summer of 1742 the shipwrecked crew of the "St. Peter" built a boat from the wreck of their vessel, and on the 21st (10th) of August sailed toward Kamtchatka. "The next day at noon they were in sight of the southeast point of *Bering's* Island, at a distance of four leagues N. by E., to which they gave the name of *Cape Manati;* from the above-mentioned Sea-cows, which herd more here than in any other parts."[2] Shortly after they arrived safely in Kamtchatka. But while some of the crew soon afterward reached St. Petersburg, and had distinctions conferred upon them by the government, Steller was most shamefully treated because he dared to condemn the abuses of the officials, and finally died, in November, 1746, in an obscure town, with but a single friend to sympathize with him.[3] His observations on the Rhytina, which I shall quote at length, together with those on other marine animals, were published by the St. Petersburg Academy in 1751.

His statements, it should be remembered, relate to the occurrence of Rhytina on Bering Island only. The somewhat numerous facts which have accumulated regarding the reality or probability of its occurrence in other regions, I shall cite on another page.

After giving a table of measurements, and a very detailed description of external and internal parts, which I am not at liberty to quote in this connection, Steller expands upon the natural history of the Sea-cow.[4] The following translation of the original Latin is the product of the unremunerated labor of my brother, Mr. A. Charles True, of the State Normal College, Westfield, Massachusetts, who has taken pains to make it as accurate as possible.

STELLER'S OBSERVATIONS ON THE NATURAL HISTORY OF THE SEA-COW.—"It was my fortune on an unlucky occasion," writes the naturalist, "to observe daily during ten months the habits and

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[1] *Loc. cit.*, pp. 61, 62.

[2] *Loc. cit.*, p. 64.

[3] "As to the academical company of travellers," says Müller, "*Gmelin* and I arrived at *Petersburg* on *Feb.* 15 [26], 1743, having passed through all the ports of *Siberia*. But *Steller*, who stayed in *Kamtschatka* after *Waxel*, to make researches in natural history, did not enjoy this good luck. He immerged himself without necessity, though with good intention, in matters that did not belong to his department; for which he was called to an account by the provincial chancery at *Jakutzk*. *Steller* vindicated himself so perfectly that the Vice Governor there gave him permission to proceed on his journey. The proceedings were not sent to the Senate at *Petersburg* so soon as transacted. The Senate, who had intelligence of his passing through *Tobolsk*, sent an express to meet him, and to carry him back to *Jakutzk*. And soon after advice being received from *Irkutzk*, of his acquittal, another express was dispatched to annul the first order. In the mean time, the first express met *Steller* at *Solikamsk*, and had carried him back as far as *Tara*, before the second express overtook him. He then proceeded without delay on his return for *Petersburg* by the way of *Tobolsk*, but got no farther than *Tumen*, where he died of a fever in *November*, 1746, in company of one *Hau*, a surgeon, who had been with him in the *Kamtschatka* expedition. I have thought it necessary to relate these circumstances, because many falsities have been propagated abroad concerning him, nay, even his death has been doubted. He was born on the 10th of *March* (21st), 1709, at *Windheim* in *Franconia*."—MÜLLER: *op. cit.*, pp. 65, 66. Scheerer (*fide* Nordenskiold), in his biography, attached to Steller's account of Kamtchatka, states that Steller got as far as Moscow when ordered to return, and was frozen by the way.

[4] STELLER, GEORGE WILLIAM: De bestiis marinis auctore Georgio Wilhelmo Stellero. <Nov. Comm. Acad. Imp. Petropolitanæ, tom. ii, 1751, pp. 289, 294, et seq.

manners of these animals before the door of my hut. Hence in a few words I will subjoin the facts which were most faithfully observed by me.

"These animals love shallow and sandy places about the shore of the sea, but most willingly spend their time about the mouths of rivers and small streams, allured by the pleasant motion of the running waters, and they are always found in herds. In feeding they drive before them those who are tender and not yet full grown, surround them carefully on the flanks and in the rear, and always keep them in the middle of the herd, and when the tide is risen they approach so near the shore that they not only have been often attacked by me with a stick or a spear, but sometimes I stroked their backs even with my hand.

"Having received any severe injury, they do nothing else than to depart farther from the shore, and after a short time; having forgotten the injury, they again approach nearer. Whole families of them live most harmoniously as neighbors, the male and female with one full-grown and one young offspring. They seem to me to be monogamous; they produce their young at any season of the year, but most commonly in the autumn, as I inferred from the number of new-born young seen about that time; and from the fact that I observed them in sexual intercourse most especially in the early spring I concluded that the period of gestation covers more than a year, and from the shortness of the horns and the dual number of the breasts I conclude that they produce not more than a single calf, and besides I never observed more than one calf near a mother.

"Moreover, these animals eat most voraciously and without limit, and on account of too great greed have the head always under the water. They are not at all anxious about life or safety, so that in a boat or as a naked swimmer you can go into their midst and safely select whichever one you wish to strike with the harpoon. Four or five minutes having been passed in this intense devotion to eating, they breathe out air and a little water with a noise like the neighing of horses. While feeding they move one foot after another slowly forward and so partly swim quietly, partly, as it were, walk after the manner of feeding cows or sheep. Half of the body, the back and sides, always rises above the water. During the feeding of the Rhytina, gulls are wont to sit on his back and refresh themselves with the fleas clinging to his skin in the same way as crows are wont to feed on the fleas which infest hogs and sheep. Moreover, they do not devour all sea-plants promiscuously, but especially, (1) a fucus with the crisped leaf of the Savoy cabbage, (2) a club-shaped fucus, (3) a fucus with the form of an ancient Roman whip, (4) a very long fucus with wavy edges whose sinuses reach to the nerves.

"Where they have pastured even for a single day great heaps of roots and stems are seen thrown out by the waves upon the shore. When their bellies are filled some among them, lying on their backs, sleep, and retreating farther from the shore, lest they should be left on dry ground by the receding tide, are often choked in winter by the ice floating around the shore, which also happens if, caught by the waves dashing violently about the rocks, they are thrown against the latter. In winter these animals are so lean that besides the spine all the ribs appear. Coition takes place in the spring, and especially about evening, in a tranquil sea. They perform many gambols in anticipation. The female swims quietly hither and thither in the sea while the male continually pursues. For a long time the female eludes him with many turnings and meanderings until herself impatient of further delay, as if wearied and overpowered, she throws herself on her back, when the male, rushing upon her furiously, extorts the *tributum Veneris* and both mutually embrace.

"Their capture was accomplished with a great iron harpoon, the point of which resembled the flattened blade of an anchor fluke, and the other extremity, with the aid of an iron ring, was fastened to a very long and strong cable. A vigorous man took this harpoon, and, together with four or five others, embarked in a boat, and while one guided the helm and three or four rowed

hastened out to the herd. The striker stood in the prow, held the harpoon in his hand, and, as soon as he was near enough to strike the animal from the boat, hurled his weapon. As soon as this was done thirty men standing on the shore, seizing the other extremity of the rope, held the animal, and in spite of his desperate efforts to resist drew him with great labor toward the shore. Those who were in the boat re-enforced themselves with another rope and wearied the animal with repeated blows until, exhausted and quiet, he was dispatched with dirks, knives, and various weapons, and was drawn to the shore. Some cut great pieces from the living animal. All that the animal did was violently to move his tail and struggle so with his fore-limbs that often great pieces of the skin split off. He breathed heavily, and as with a groan. From his wounded back the blood was thrown in a spray high up after the manner of a spouting fountain. As long as the head was *hidden under the water the blood did not flow, but as soon as he raised his head and breathed the* blood gushed out. The reason for this is that the lungs, situated on the back, were wounded first, and as often as these were afterward filled with air they increased the strength of the flow of blood. *From this phenomenon I almost came to the conclusion that the circulation of the blood in this* animal, as in the seal, is completed in a twofold manner—in the open air through the lungs, but under water through an oval aperture (*foramen ovale*) and arterial duct, though I did not find both. But that they at the same time respire in a different way from fishes I think happens on account of the deglutition of solid food rather than because of a forward-moving circulation.

"The full-grown and very large animals are captured more easily than the calves, because the calves move with a far more violent motion; and though the harpoon remains intact, yet when the skin is broken they easily escape, a thing which is repeatedly attempted.

"But if an animal captured by the harpoon begins to move quite violently, those near or in a neighboring herd are frequently stirred and are aroused to bear aid to the captive. On account of this, sometimes they attempt to overturn the boat with their backs, sometimes they fall upon the rope and strive to break it, or, by the vibration of the tail, labor to extract the harpoon from the back of the wounded animal, which oftentimes they attempt not without success. It is a most curious proof of their disposition and conjugal affection that when the female has been taken and drawn in with the harpoon, the male, after he has attempted her liberation with all his strength, *but in vain, and has been struck many blows by us, none the less will follow* her even to the shore, and sometimes unexpectedly and suddenly will approach her when she is already dead. On the next day at early dawn when we came to cut the flesh in pieces and carry it home we have found *the male still standing near his female, and I have even seen this on the third day when I* approached alone for the sake of examining the intestines.

"As regards voice, the animal is mute and does not give forth any sound, but only breathes heavily, and when wounded sighs.

"How much power lies in his eyes and ears I dare not affirm, but frequently he sees and hears very little for the reason that he keeps the head continually under water; nay, the animal himself seems to neglect and despise the use of these organs. Among all who have written concerning Sea-cows,[1] no one has produced a more full and careful account than the most curious and diligent Captain Dampier in the narrative of his travels published in London in 1702. As I read his account, nothing seemed to me to be worthy of censure, although some few things did not agree with our animal. For he says that two species of Sea-cow exist, one of which has stronger eyes than ears and the other stronger ears than vision. What he says concerning the hunting of this animal, namely, that the Americans approach it without any noise or talking lest the Sea-cow flee,

[1] The allusions to the "Sea-cow" in this paragraph relate to the American and African Manatees. Steller at this time seems to have regarded both these and the Rhytinia as forming but a single species.

is without doubt so in localities where they are frequently captured and by long experience have learned that men are hostile to them, in the same way as others, otters and seals, which in this deserted island never before have seen men, nor have been disturbed in their enjoyment of secure peace, and were killed by us strangers on Bering's Island without any labor, have already been rendered equally wild, and in the Kamtchatkan land, not only when an enemy is seen, but when they scent his tracks, hastily commit themselves to flight. It happens sometimes that these animals are thrown out dead by the tempests around the promontory called Kronozkoi Nos, and also around Awatscha Land, and are called by the Kamtchatkans, on account of their use for food, in their language, Kapustnik, 'Kraut Emser,' which fact I learned after my return in 1742. Finally, concerning the use of the parts of this animal, according to Hernandes, the thick, firm, and tough skin is used by the Americans for the soles of shoes and for belts. I hear that the skin is used by the Tschuktschi for boats. They are accustomed to stretch the skin on sticks, and to treat it in the same way as the tribe of Koraeccica do the skins of the very large seals called Lachtak.

"The fat encircling the whole body under the skin, a span, and in some places almost nine inches thick, glandulous, consistent, white, when exposed to the sun turning yellow like hog's lard, of a very pleasant odor and flavor, is to be compared with the fat of no marine animals, nay, rather much to be preferred to the fat of quadrupeds; for besides that it can be heated for a very long time on the warmest days and not become rancid or otherwise offensive to the smell, when tried out it is so sweet and palatable that it took from us all desire for butter; in taste it comes very near to the oil of sweet almonds, and can be applied to the same uses as butter; in a lamp it burns brightly without smoke or smell. Nor, indeed, is its use for medicine to be despised, since it gently relaxes the bowels; drunk from cups it causes neither nausea nor loss of appetite, and, as I think, for those afflicted with gravel the Sea-cow would be of more benefit than the masticatory bones or stones (*masticatoria ossa seu lapides*), so called. The fat of the tail is harder and more consistent, and when cooked more delicate. The flesh consists of fibers somewhat more stout and thick than those of neat cattle, is a deeper red than the flesh of terrestrial animals, and, what is wonderful, even in the hottest days warms in the open air a very long time without stench, though it is beset on every side with worms. The reason I allege for this fact is, that since the animal subsists only on marine fuci and herbs, and these fuci are more sparingly composed of sulphur and more largely of sea salt and niter, these salts prevent the exhalation of sulphur and the softening and resolution of the flesh in the same way as salts or salt brine sprinkled on flesh, and the more because these salts are mingled intimately with the substance of the flesh and cohere very strongly to sulphurous parts. Though the flesh must be cooked a longer time, yet when cooked it is of the best flavor and not easily to be distinguished from the flesh of neat cattle. The fat of the calves so resembles fresh hog's lard that you can scarcely perceive the difference; and the flesh does not differ at all from veal, is quickly softened with cooking, and, that continuing, so swells, like the flesh of a young pig, that it claims for itself very much greater room in the pot than before. The tendinous fat about the head and tail is scarcely fit for boiling; on the other hand, the muscles of the abdomen, back, and sides are far to be preferred. It not only does not resist salting, as many have thought, but only grows soft; so that it comes out like salted beef in all respects, and very palatable. The viscera, heart, liver, and kidneys are too hard, and were not much sought after by us because there was a very abundant supply of flesh.

"The full-grown animal weighs about 8,000 pounds (eighty hundredweight), or 200 Russian puds.

"There is so great a multitude of these animals about this single island that they continually suffice to support the inhabitants of Kamtchatka.

"The Rhytina is infested with a peculiar insect, like a louse, which is wont to occupy and inhabit in large numbers especially the wrinkled limbs, breasts, nipples, pudendum, anus, and the rough cavities of the skin, and which bore through the cuticula and cutis. From the extravasated lymphatic fluid conspicuous warts arise everywhere; the gulls (*Lari*) are also allured to hunt with their sharp beaks these insects (clinging to the backs of these animals), a pleasant food, and moreover the birds perform a friendly and grateful office for the animals troubled by these parasites."[1]

ADDITIONAL OBSERVATIONS.—This narrative, as I have already stated, contains all that we know of the natural history of the Arctic Sea-cow, and, I venture to say, all that we shall ever know from visual observation. There are a number of facts, however, bearing upon the mode of capture, geographical distribution, and the history of the extinction of this animal which have been the theme of writers after Steller. Dr. Brandt, a celebrated naturalist of St. Petersburg, and the Danish explorer Nordenskiöld, have taken pains to bring together all that is known on these topics up to the present time. Most of the books and manuscripts from which they have gathered their information being inaccessible to me, I must content myself with summing up the results of their investigations.

THE EXTINCTION OF RHYTINA.—The extinction of the Rhytina followed close upon its discovery. If we may accept the results of Nordenskiöld's investigations upon this point, the animal was last seen in 1854, or a little more than a century after its discovery. Long before this, at all events, it had become so diminished in numbers as not to furnish any considerable food supply.

It appears that the existence of the Sea-cow on Bering Island had no sooner been made known in Russia than the vessels engaged in the fur trade in Bering's Sea began to make a practice of wintering on the island, in order to take in a supply of the flesh of the animal for food. That this custom became general in a few years, appears from Scherer's narrative of the first Russian hunting expeditions to the Aleutian Islands. "Ivan Krasselnikoff's vessel," he writes, "started first in 1754, and arrived on the 8th October at Bering Island, where all the vessels fitted out for hunting the sea-otter on the remote islands are wont to pass the winter, in order to provide themselves with a sufficient stock of the flesh of the Sea-cow."[2]

The next year, 1755, the engineer Jakovlev, who visited Bering Island and the adjacent Copper Island, in search of copper, recorded in his journal the mode of capturing Rhytina, which differs in no way from the method employed by Steller and his companions. Jakovlev, however, was so impressed with the rapidity with which the Sea-cow was disappearing from the islands that he petitioned the Kamtchatkan authorities that its capture might be restricted. It appears that at the time of his visit the Rhytina had been driven away from Copper Island.[3]

Scherer informs us of the landing of three other hunting expeditions at Bering Island, between 1757 and 1762, for the purpose of capturing Sea-cows, implying at the same time, as in the instance already quoted from him, that such was the custom of all expeditions sent thither. His allusions to the subject are as follows: "The autumn storms, or rather the wish to take on board a stock of provisions, compelled them (a number of hunters sent out by the merchant Tolstyk under command of the Cossack Obeuchov) to touch at Commander's Island (Bering Island), where, during the winter up to the 24th (13th) June, 1757, they obtained nothing else than sea-cows, sea-lions, and large seals."

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[1] Specimens of this crustacean were found in a small piece of Rhytina skin discovered in the British Museum.

[2] SCHERER: Neue Nachrichten von denen neuentdeckten Inseln in der See zwischen Asien und Amerika, 1776, p. 38, *fide* Nordenskiöld.

[3] Jakovlev's diary was published in Russian in 1867, by Pekavski, and translated into Latin and republished in 1868 by Brandt. See BRANDT: Symbolæ Sirenologicæ, fasc. iii, pp. 295, 296.

Again: "They (a Russian hunting vessel under Studenzov, in 1758) landed on Behring Island to kill Sea-cows, as all vessels are accustomed to do." On another page he states that "after Korovin, in 1762 (on Bering Island), had provided himself with a sufficient stock of the flesh and hides of the Sea-cow for his boats . . . he sailed on."[1] Sauer, in his account of Bering's voyages, published in 1802, alluding to the Rhytina, says: "The last was killed on Behring Island in 1768, and none has been seen since then."[2]

In this conclusion most authorities are agreed. Nordenskiöld, however, obtained information, of a character which he regards reliable, which would seem to show that the Sea-cow was not entirely exterminated before 1854. The first informant was a creole. Nordenskiöld writes: "A *creole* (that is, the offspring of a Russian and an Aleutian), who was sixty-seven years of age, of intelligent appearance, and in the full possession of his mental faculties, stated 'that his father died in 1847 at the age of eighty-eight. He had come from Volhynia, his native place, to Behring Island at the age of eighteen, accordingly in 1777. The two or three first years of his stay there, *i. e.*, until 1779 or 1780, sea-cows were still being killed as they pastured on sea-weed. The heart only was eaten, and the hide used for *baydars*. In consequence of its thickness the hide was split in two, and the two pieces thus obtained had gone to make a *baydar* twenty feet long, seven and a half feet broad, and three feet deep. After that time no sea-cows had been killed.'

"There is evidence, however, that a sea-cow had been seen at the island still later. Two *creoles*, Feodor Mertchenin and Stepnoff, stated that about twenty-five years ago [in 1854] at Tolstoj-mys, on the east side of the island, they had seen an animal unknown to them which was very thick before, but grew smaller behind, had small fore-feet, and appeared with a length of about fifteen feet above water, now raising itself up, now lowering itself. The animal 'blew,' not through blow-holes, but through the mouth, which was somewhat drawn out. It was brown in colour with some lighter spots. A back fin was wanting, but when the animal raised itself it was horrible, on account of its great leanness, to see its backbone projecting. I instituted a thorough examination of both my informants. Their accounts agreed completely, and appeared to have claims to be regarded as trustworthy. That the animal that they saw was actually a sea-cow, is clearly proved both by the description of the animal's form and way of pasturing in the water, and by the account of the way in which it breathed, its colour, and leanness. In *Ausfürliche Beschreibung von sonderbaren Meerthieren*, Steller says, page 97: 'While they pasture, they raise every fourth or fifth minute their nose from the water in order to blow out air and a little water. Page 98: 'During winter they are so lean that it is possible to count their vertebræ and ribs'; and page 54, 'some sea-cows have pretty large white spots and streaks, so that they have a spotted appearance.' As these natives had no knowledge of Steller's description of the animal, it is impossible that their statements can be false. The death-year of the Rhytina race must therefore be altered at least to 1854."[3]

Neither of the statements appear improbable, but they should be accepted, I believe, with caution. At all events, the Sea-cow was practically extinct within four decades from the time of its discovery.

CAUSES OF THE EXTINCTION.—Two causes have been assigned for this rapid destruction. The most generally accepted notion is that the rate of capture much exceeded that of the increase of the animal, and that extinction followed as a matter of course. Nordenskiöld, however, and, in a certain way, Brandt also avows his belief that the Sea-cow had gotten out of harmony with its environment many years before the Russians discovered it, and that its extermination would have

[1] SCHERER: *Op. cit.*, pp. 40, 45, and 82, *fide* Nordenskiöld.
[2] SAUER: Bering's Voyage, 1802, p. 181, *fide* Nordenskiöld.
[3] NORDENSKIÖLD: Voyage of the Vega. English translation, ii, 1881, pp. 277, 278.

occurred within a comparatively short time without the intervention of man. The fact that in Steller's time the range of the animal was much circumscribed, seems to give weight to the latter view.

The range of the Sea-cow, when discovered by Europeans, seems to have been confined to Bering and Copper Islands, but the investigations of Brandt show that it probably extended from Nishne-Kamtchatka or the bay of Karaguescensi to the coast of China and included also the outermost islands of the Aleutian Archipelago. Sauer's statement that "Sea-Cows were very common on Kamtchatka and on the Aleutian Islands, when they were first discovered," seems without foundation, and is properly rejected by Nordenskiöld. Whether the Sea-cow ever occurred on the Aleutian Islands appears somewhat uncertain. Vosnessenski found a rib of the animal on Attu, the last island of the archipelago, but, as Brandt suggests, it may have been derived from a Rhytina washed thither by the waves. Mr. Lucien Turner kindly informed me that an aged Aleut woman stated that Rhytina had been seen at Attu by her father, but such testimony is, perhaps, not altogether satisfactory.

PART II.

THE USEFUL AQUATIC REPTILES AND BATRACHIANS

OF THE

UNITED STATES.

BY

FREDERICK W. TRUE.

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ANALYSIS.

Page.

E.—THE ALLIGATOR AND THE CROCODILE:

33. The Alligator and the Crocodile 141

F.—TORTOISES, TURTLES, AND TERRAPINS:

34. The Marine Turtles in general 147

35. The Loggerhead Turtle 147

36. The Hawk's-bill Turtles 149

37. The Green Turtles 150

38. The Soft-shelled Tortoises 152

39. The Snapping Turtles 153

40. The Musk Tortoises 154

41. The Fresh-water Terrapins 155

42. The Diamond-back or Salt-water Terrapin 156

43. The Pond Tortoises 157

44. The Box Tortoises 158

G.—THE AMPHIBIANS:

45. The Bull-frog 159

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E.—THE ALLIGATOR AND THE CROCODILE.

33. THE ALLIGATOR AND THE CROCODILE.

THE NORTH AMERICAN ALLIGATOR AND CROCODILE.—We have in the United States two reptiles of the Crocodile family, one a true Crocodile, *Crocodilus acutus*, Cuv., and the other the well-known Alligator *Alligator mississippiensis*, Daudin.[1] The former animal is of rare occurrence, only a few specimens having been captured in the United States, and it can, therefore, scarcely claim attention from a commercial standpoint.[2] I shall confine my remarks to the Alligator.

ORIGIN OF THE NAME "ALLIGATOR."—The origin of the name "Alligator" is involved somewhat in obscurity, but several theories have been entertained regarding it. "Some," says Holbrook,[3] "have supposed it derived from the word 'Legateer' or 'Allegater,' a name by which the young Crocodile is distinguished in some parts of India. Cuvier says it is much more probable that it is a corruption of the Portuguese 'Lagarto,' derived from the Latin '*Lacerta*,' as Hawkins writes it 'Alagartos,' and Sloan, in his 'History of Jamaica,' spells it 'Allagator.'"

The matter was undoubtedly set right by Cuvier. In the writings of all the very early English explorers which I have been able to consult the terms "Crocodile" and "Cayman" are generally used in alluding to the Alligator. Under the name "Cayman" it would seem that the Alligator and the true Cayman of South America have been confounded. In Sir Walter Raleigh's account of his travels in 1595, however, he used the name "Lagartos" for the Alligator. He says:

"Vpon this riuer there were great store of fowle, and of many sorts: we saw in it diuers sorts of strange fishes, and of maruellous bignes; but for lagartos it exceeded, for there were thousands of those vgly serpents; and the people call it for the abundance of them, The riuer of Lagartos, in their language."[4]

The name Alligator, with its present orthography, seems to have been adopted about 1730.

GEOGRAPHICAL DISTRIBUTION.—The geographical range of the Alligator has not been very accurately defined. Holbrook[5] fixes the northern limit on the Atlantic coast at the mouth of the Neuse River, North Carolina, although at the present day it is doubtful whether any specimens could be found so far north. It occurs in increasing numbers southward, and is comparatively abundant on the northeast coast of the Gulf of Mexico. It ascends the Mississippi River as far as the mouth of the Red River. In regard to the western limit of its range, Cope states that "it

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[1] A recent writer, the place of publishing of whose article I have forgotten, raises the question of the occurrence of two species of Alligator in the South. No herpetologist, however, so far as I am aware, has made such a distinction, and I cannot, therefore, give the matter more than a passing notice here.

[2] I have been able to gather but few references to instances of the actual capture of *C. acutus* in Florida. Wyman, I believe, first pointed out its existence in that state, in 1869, basing his remarks on the features of a skull sent from the Miami River by Mr. William H. Hunt. (See Amer. Journal of Sci. & Arts, xlix, 1870, pp. 105–106.)

Another specimen, this time a full-grown animal, was obtained by Mr. H. A. Ward, of Rochester, New York, in Biscayne Bay, Florida. This specimen is now in the National Museum.

Still another Crocodile was said to have been captured in North Lake, Florida, in 1875, by a Mr. William Butler, but whether this specimen was ever sent to a museum, or was identified by a professional herpetologist, I am unable to say. (See Forest and Stream, iv, 1878, p. 167.) Two other writers, Mr. C. J. Maynard, of Newtonville, Mass., and a gentleman concealed under the pseudonym "Wanderer," claim to have seen the Crocodile in Florida, the former in 1867. (See Forest and Stream, xiii, 1880, p. 867.)

[3] HOLBROOK: North American Herpetology, ii, 1842, p. 61.

[4] RALEIGH: The Discoverie of the large, rich, and beautifull empire of Guiana. <Hakluyt's Collection of Voyages, iv, 1811, p. 137.

[5] *Op. cit.*

is common in the waters of the Guadalupe drainage, and is occasionally seen in the San Antonio River, *within the limits of the city of San Antonio*,"[1] and Professor Baird has recorded a specimen from Brownsville, Tex., on the Rio Grande.[2] From thence its range extends southward into South America.

ABUNDANCE.—The Alligator is growing less and less abundant, particularly on the Atlantic coast, and on the west coast of Florida, owing to the increase of population and the reckless manner in which it has been hunted and destroyed. Many persons have engaged in slaughtering these creatures merely for the sport which is supposed to be derived from so doing, no use having been made of the carcasses.

SIZE.—The Alligator is the largest living reptile occurring within the United States, and is approached in size only by the marine turtles. Holbrook records having seen one which was thirteen and a half feet long,[3] while Bartram, in his narrative of travels in Florida, affirms that they attain a length of twenty to twenty-three feet in that region.[4] The latter statement, however, must be taken with some caution; if true, it would seem that the Alligator does not now attain his former wonted proportions. From a note in "Forest and Stream," of 1876, we learn that "the largest alligator killed in Florida for many years was shot last spring [1876] by Dr. De Marmon, of Kingsbridge, N. Y. The animal measured 12 feet 6 inches in length when spread on the dock. It was 6 feet 10 inches round the body, 5 feet 10 inches around the jaws, and weighed about 700 pounds. The head, which is now in the doctor's possession, is 30 inches long. It was killed on the Homosassa River, about two miles from Alfred Jones's grove."[5] The average length would appear to be about ten feet.

FOOD AND MANNER OF OBTAINING IT.—The food of Alligators consists almost exclusively of fish and such small land or semi-aquatic animals as it is able to secure. It would appear that they are also expert fly-catchers. The quaint allusion of Exquemelin to this subject is too interesting to be omitted. "The *Caymanes*," he says, "are ordinarily busied in hunting and catching of flies, which they eagerly devour. The occasion is, because close unto their skin, they have certain little scales, which smell with a sweet sent, something like unto musk. This aromatick odour is coveted by the flies, and here they come to repose themselves and sting. Thus they both persecute each other continually, with an incredible hatred, and antipathy."[6]

The existence of this habit, I have recently been informed, has been frequently confirmed in Louisiana by reliable observers; but the gentleman who informed me was inclined to believe *that it is the saliva which attracts the flies into the gaping jaws of the Alligator. The manner* in which the reptile secures his fill of fishes is related by Dowler in a paper written in 1846, who founded his remarks on the statements of some, to him, credible observers. He writes as follows:

"Many authors assert that Alligators cannot swallow under water. In offering some facts to disprove this assumption, the sagacity of these animals will be more or less illustrated. A gentleman, on two occasions, watched Alligators when catching sunfish, which were swimming in shoals in shallow water. The Alligator placed his long body at a suitable distance from the shore. As soon as the fish came between him and the land, he curved his body so that they could not pass; the tail was moored on land; the mouth was opened under water, and brought so close to

[1] COPE: On the Zoölogical Position of Texas. Bull. U. S. National Museum, No. 17, 1880, p. 13.
[2] GIRARD: Herpetology, U. S. and Mex. Boundary Survey, ii, pt. 2, p. 5.
[3] HOLBROOK: North American Herpetology, ii, 1842, p. 56.
[4] BARTRAM: Travels through East and West Florida, 1791, p. 128.
[5] Forest and Stream, vii, 1876, p. 84.
[6] EXQUEMELIN: Buccaneers of America. English translation, 1684, p. 48.

the shore that the fish had no method of escaping but through the mouth, where they were entrapped. *Incidit in Scyllam, qui vult vitare Charybdim.*"[1]

PUGNACITY OF THE ALLIGATOR.—When we come to consider the possibility of the Alligator's ability to attack successfully large terrestrial animals, such as horses and cows, as well as men, we find ourselves in great doubt. The accumulated testimony of travelers and observers on this point can hardly be set aside, although several critical writers have done so, with ridicule. Whether it was that the earlier observers, misled by the forbidding appearance of the Alligator, were repeatedly imposed upon by fabulous stories, or whether they actually saw, at least in part, what they recorded, seems to me, I must confess, a very open question. To cite all the accounts of mishaps which are said to have occurred to man and beast through the aggressiveness of the Alligator, would be to fill many pages of this volume. I can only refer to one or two prominent examples.

Herrara gives the following account of the Alligator in the harbor near Porto Belo, at the Isthmus of Panama, on the occasion of Columbus's explorations there in 1502:

"In the Harbour there were extraordinary large Alligators, that went to sleep ashore, and smelt like Musk, being so ravenous, that if they find a Man asleep on the Land, they drag him away to devour him: tho' they are so timorous, that they fly, when attack'd. There are many of them in these Rivers that fall into the North Sea, but many more in those that empty themselves in the South Sea, and they are very like, if not the same as the Crocodiles of the River Nile."[2]

Raleigh, after his allusion to the "river of Lagartos," a tributary of the Orinoko, as already quoted, adds: "I had a negro a very proper yoong fellow, who leaping out of the galley to swim in the mouth of the river, was in all our sights taken and devoured with one of those lagartos."[3]

Herrara, again, relating what happened to the Spaniards in Central America in 1516, writes:

"At Panama an Alligator has been known to take a Man off from the Stearn of a Boat, and carry him away to the Rocks, where as he was tearing him in pieces he was kill'd by a Musket Shot: the Man being recover'd as the Monster was biting him off near the Groin was carried to the Hospital, where he liv'd long enough to receive the Rites of the Church."[4]

Velasquez seems also to have been impressed with the ferocity of the Alligator during his sojourn in Cuba. By Herrara he is made to say:

"On the South Side about the Middle there runs down into the Sea a mighty River, which the *Indians* call *Cauto*, the Banks of it are very agreeable, and in it are a vast Multitude of Alligators. Those who happen to be benighted near it, must be upon their Guard, for those Creatures then come out of the Water, walk about the Land, and if they can surprize a Man, they drag him into the Water, and devour him. They sometimes do so by such as venture to ford the River, and even by Horses. They are to be found all over the *Indies*, especially to the southward, but in *Cuba* only in this River."[5]

In the eighteenth century the writer who is most loud in the denunciation of the Alligator is Bartram. He has devoted several pages of his book to the relation of the habits of these animals, from which I will quote a few lines. Although he begins his account with a query as to how he shall do credit to what he observed without arousing the suspicion of his readers regarding his veracity, his description seems overdrawn:

"My apprehensions were highly alarmed after being a spectator of so dreadful a battle; it was obvious that every delay would but tend to increase my dangers and difficulties, as the sun was

[1] DOWLER, BENNET, M. D.: Contributions to the Natural History of the Alligator. New Orleans, 1846.
[2] HERRARA (STEVENS): Hist. Amer., i, 1725, p. 271.
[3] RALEIGH: *loc. cit.*, p. 137.
[4] HERRARA (STEVENS): Hist. Amer., ii, 1725, p. 100.
[5] HERRARA (STEVENS): Hist. Amer., ii, 1725, pp. 11, 12.

near setting, and the alligators gathered around my harbour, from all quarters; from these considerations I concluded to be expeditious in my trip to the lagoon, in order to take some fish. Not thinking it prudent to take my fusee with me, lest I might lose it overboard in case of a battle, which I had every reason to dread before my return, I therefore furnished myself with a club for my defence, went on board, and penetrating the first line of those which surrounded my harbour, they gave way; but being pursued by several very large ones, I kept strictly on the watch and paddled with all my might towards the entrance of the lagoon, hoping to be sheltered there from the multitude of my assailants; but ere I had half-way reached the place, I was attacked on all sides, several endeavoring to overset the canoe.

"My situation now became precarious to the last degree: two large ones attacked me closely, at the same instant, rushing up with their heads and part of their bodies above the water, roaring terribly and belching floods of water over me. They struck their jaws together so close to my ears as almost to stun me, and I expected every moment to be dragged out of the boat and instantly devoured, but I applied my weapons so effectually about me, though at random, that I was so successful as to beat them off a little."[1]

Writers of the present century also allude to cases of fatal attacks by Alligators; I may quote one instance. Wells, writing of Lake Nicaragua in 1857, says: "Large *tiberones* (sharks) have been captured in the lake; and a few months previous, a woman at Virgin Bay, washing on the banks, was seized and killed by an alligator."[2] Many other similar statements are on record. The mass of most recent writers and investigators, however, seem inclined to regard all tales of the Alligator's aggressiveness as idle fiction, and contend with one accord that he is sluggish, harmless, and even timid, and that the damage which he sometimes does with tail and jaws when wounded and tormented is due to aimless madness induced by pain, and not to any deliberate attempt at revenge.

The stomach of Alligators is often found to contain, in addition to its natural food, a number of rounded masses of hard material, large pebbles and other indigestible matter. Zoölogists are not agreed regarding the function of these objects, some supposing that they aid in reducing other matter taken into the stomach, and others that they serve to keep the stomach distended when the animal is in a state of hibernation in winter. It seems probable, however, that they are swallowed by mistake for better food, or are taken down with more nutritious matter when he feeds too greedily.

MODE OF LIFE.—Alligators are pre-eminently fitted for an aquatic or semi-aquatic life. In the water they seem perfectly at ease, and move about with great velocity, propelling themselves by powerful strokes of their broad paddle-like tails. The peculiarities of their internal structure, too, are such as fit them for remaining a considerable time beneath the surface. On land, however, the Alligator moves slowly and with evident difficulty on account of the weight of the body and the shortness of the legs. Nevertheless they come frequently to shore, being very fond of sunning themselves for hours on the sandy or muddy banks of the streams they inhabit. They are protected from assault while indulging in these siestas by their dull colors and their perfect immobility. Holbrook states that "such Alligators as dwell in ponds and streams out of the influence of tide-water, wander much further from the banks and are not unfrequently seen a mile or more from water."[3]

This statement is confirmed in the writings of other observers. "Following the lonely track

[1] BARTRAM: Travels in East and West Florida, 1791, p. 119.
[2] WELLS: Honduras, 1857, p. 35.
[3] HOLBROOK, *op. cit.*, p. 57.

which leads for thirty-three miles through Savannah's sand-hills and pine barrens from New Smyrna, Florida, to the St. John's River," writes a correspondent of "Forest and Stream," "we once came upon an alligator seven feet long, taking his siesta in the middle of the road. . . . Many alligators have I seen in Florida lakes and rivers, but never before met one on the high road. Probably the dry weather had drawn the reptile from its accustomed haunts in search of water."[1]

VOICE.—In spring and during the breeding season Alligators utter a cry, which has been likened to that of the bull-frog, but intensified, and to the noise of distant thunder. It is probably to this cry that Bartram frequently refers, as, for example, in the following sentences: "But what is yet most surprising to a stranger, is the incredible loud and terrifying roar which they are capable of making, especially in the spring season, their breeding time; it most resembles very heavy distant thunder, not only shaking the air and waters, but causing the earth to tremble; and when hundreds and thousands are roaring at the same time, you can scarcely be persuaded but that the whole globe is violently and dangerously agitated."[2] Most evident hyperbole!

HIBERNATION.—At the approach of winter the Alligators embed themselves in holes and pits on the banks of their favorite streams, and remain dormant until spring.

BREEDING HABITS.—When the breeding season arrives, early in spring, the female resorts to a sheltered spot on the bank of the stream, and constructs a small mound of mud and other materials, in which she deposits her eggs, one to two hundred in number. The eggs hatch in about thirty days, and the young Alligators immediately take to the water. Although I am loath to quote so much from one observer, I must refer again to the narrative of Bartram, for I find no other in which the nests of the Alligator are so fully described, with so great an appearance of accuracy. He writes:

"I now lost sight of my enemy again. Still keeping close along shore; on turning a point or projection of the river bank, at once I beheld a great number of hillocks or small pyramids, resembling hay cocks, ranged like an encampment along the banks, they stood fifteen or twenty yards distant from the water, on a high marsh about four feet perpendicular above the water; I knew them to be the nests of the Crocodile, having had a description of them before, and now expected a furious and general attack, as I saw several large Crocodiles swimming abreast of these buildings.

"These nests being so great a curiosity to me, I was determined at all events immediately to land and examine them. Accordingly I ran my bark on shore at one of their landing places, which was a sort of nick or little dock, from which ascended a sloping path or road up to the edge of the meadow, where their nests were; most of them were deserted, and the great thick whitish egg-shells lay broken and scattered upon the ground round about them.

"The nests or hillocks are of the form of an obtuse cone, four feet high and four or five feet in diameter at their bases; they are constructed with mud, grass, and herbage: at first they lay a floor of this kind of tempered mortar on the ground, upon which they deposit a layer of eggs, and upon this a stratum of mortar seven or eight inches in thickness, and then another layer of eggs, and in this manner one stratum upon another, nearly to the top: I believe they commonly lay from one to two hundred eggs in a nest: These are hatched I suppose by the heat of the sun, and perhaps the vegetable substances mixed with the earth, being acted upon by the sun, may cause a small degree of fermentation, and so increase the heat in those hillocks. The ground for several acres about these nests shewed evident marks of a continual resort of alligators:

[1] "S. C. C." [S. C. CLARKE] in Forest and Stream, xii, 1879, p. 307.
[2] BARTRAM: *op. cit.*, p. 129.

The grass was everywhere beaten down, hardly a blade or straw was left standing; whereas, all about, at a distance, it was five or six feet high, and as thick as it could grow together."[1]

ECONOMICAL VALUE.—The principal commercial products furnished by Alligators are leather, ivory, oil, and musk. The first two are by far the most important.

Alligator leather is quite impervious to water, and consequently a valuable material from which to manufacture shoes and boots. Besides serving for these purposes, however, it is frequently more carefully prepared and used in making articles which require a soft leather, such as satchels, card-cases, and the like, the oddity of its appearance being much admired. It has many cheap imitations. Hides of large size and good quality bring about eight dollars in the market.

The ivory is obtained from the teeth. These are carved into a variety of forms, such as whistles, buttons, and cane-handles, and also sold as jewelry. This industry is carried on principally in Florida.

Alligator oil, which is extracted from the fat of the animal, has been recommended for the cure of quite a variety of diseases.

The musk of the Alligator is obtained from glands situated in the lower jaw. It is not of the best quality, but serves as the basis of certain perfumes.

THE FISHERY.—In regard to the capture of Alligators in Florida for the products they furnish, and their consequent diminution, a writer in "Forest and Stream" states:

"Alligator hunting is growing less and less successful in Florida as the game diminishes in numbers. From being simply a pastime it has become a regular business, and thousands upon thousands of these creatures are now annually slaughtered for their hides and teeth. The former are converted into leather, and make a valuable commodity, while the teeth are manufactured into various articles of use and ornament. At the rate the alligator family is now disappearing, not many years will elapse before the supply will be wholly exhausted, and the capture of an alligator become an uncommon event in sporting life."[2]

MODE OF CAPTURE.—There is but one mode of capturing Alligators, so far as I am aware, namely, that of shooting them with the rifle. This is not so expeditious a method as would at first appear. The iron-like hide of the upper surface of the reptile's body, with its rugged bosses, secures him impunity against the ill-aimed shot. The eye is the most vulnerable spot, and it is through this organ that the rifle-ball penetrates into the vital region, the brain.

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[1] BARTRAM: *op. cit.*, pp. 126, 127.

[2] "P. H. A." in Forest and Stream, vi, 1876, p. 264.

F.—TORTOISES, TURTLES, AND TERRAPINS.

INTRODUCTION.—The species of Tortoises which inhabit the territory of the United States and the adjacent seas are forty-two or forty-three in number. With the exception of the Musk Tortoises, all are more or less available for food and other economic uses. The number of species actually in demand, however, is small. It includes the Marine Turtles, two or three species of Soft-shell Turtles, the Snapping Turtle, three or four kinds of Terrapins, and the Gopher or Land Tortoise. Some are too small to be of any great value, and others are of too rare occurrence, at least within the limits of the United States.

For convenience of treatment, following in a certain way the classification of Duméril,[1] we may separate the Tortoises into three large groups, namely, (1) the Marine Turtles, (2) the Marsh Tortoises, and (3) the Land Tortoises.

34. THE MARINE TURTLES IN GENERAL.

MODE OF LIFE.—The Marine Turtles are especially adapted for their aquatic life. Their bodies, which are large and broad, have a specific gravity almost exactly equivalent to that of the water in which they are immersed, so that they are able to sustain themselves at the surface of the sea for any length of time without fatigue. Their feet are transformed into broad paddles, enabling them to swim freely and rapidly. The fore-feet are used in propelling the body, while the hind-feet serve as rudders. The motion of the fore-feet is very similar to that of a bird's wings, and, indeed, all their movements are more those of flying than of swimming. These Turtles never go on shore except to lay their eggs, and their movements at such times are slow and constrained.

DISTRIBUTION OF THE MARINE TURTLES.—The Marine Turtles are most abundant in tropical regions, and occur in considerable numbers only along the extreme southern portions of our coast. Specimens are occasionally seen as far north as Long Island Sound, and still more rarely in Massachusetts Bay and on the southern coast of Maine. I am further informed by Capt. Joseph W. Collins, a most reliable observer, that he has frequently seen Turtles, which he believed to be Green Turtles, about the fishing banks of Newfoundland. Such occurrences, however, must be considered accidental, and are unimportant from a commercial point of view.

SPECIES OF COMMERCIAL IMPORTANCE.—The species which are of commercial importance are, 1. The Loggerhead; 2. The Hawk's-bill Turtles of the east and west coasts; and, 3. The Green Turtles of the east and west coasts. In addition to these, a species known as the "Bastard," *Thalassochelys Kempii*, Garman, has been recently described. It occurs commonly in the Gulf of Mexico, but is not at all sought for. In contrast to the other species, it lays its eggs in the winter months, from December to February.

THE LEATHER TURTLE.—Another species which may be mentioned is the so-called "Leather Turtle," or "Luth," or "Trunk Turtle." It belongs to a different family from those enumerated above, is larger than they, and occurs sparingly all along our Atlantic coast, from Massachusetts Bay to Florida. It has no commercial value with us, so far as known, but in the West Indies a fat is procured from it which is used as a lubricator.

35. THE LOGGERHEAD TURTLE.

DISTRIBUTION OF THE LOGGERHEAD.—This Turtle is commonly known in the United States as the "Loggerhead," *Thalassochelys caretta*, (Linné) True, in allusion to its large and thick head.

[1] DUMÉRIL and BIBRON: Erpétologie générale.

It occurs along the Atlantic coast from Virginia to Guiana and Brazil, and is common everywhere in the Gulf of Mexico and among the West Indies. It is also found in the Mediterranean, where formerly it was very abundant, and specimens have been taken on the coasts of England and Scotland. Thus it appears that the Loggerhead inhabits generally somewhat more northerly localities than most other species of Marine Turtles.

SIZE OF THE LOGGERHEAD.—In size the Loggerhead is second only to the huge Leather Turtle, previously mentioned. A specimen of moderate size, captured in 1871, measured six feet in length, and nine feet across the back to the extremities of the fore-feet or "flippers." The head was eleven inches long and eight inches broad. Its weight was about 850 pounds. In the more southern localities the species sometimes attains a weight of 1,500 or 1,600 pounds. The specimens taken on our coast about Beaufort and Morehead City, N. C., which enter into commerce, are undoubtedly young animals. Their average weight, according to Mr. Earll, is not more than fifty pounds.

FOOD.—The Loggerhead is one of the most powerful of the Marine Turtles. It swims with very considerable speed and not ungracefully. It is frequently seen far from land, floating on the waves and apparently asleep or resting. Unlike most of the members of the group, it is generally considered carnivorous, feeding upon crabs, various shells, and fishes. It is said to be particularly fond of a large conch (*Strombus*), which it breaks with its powerful jaws and devours in great quantity.[1]

BREEDING HABITS OF THE LOGGERHEAD.—On our shores this Turtle breeds in April, May, and June, during which months the female comes to land and deposits its eggs in the sand, usually selecting a spot on the southern side of a shoal. She scoops out a shallow pit with her hind legs, and deposits a number of eggs, varying from 150 to 200. Having laid this large number, the Turtle covers them with sand and leaves them to be hatched by the heat of the sun. While these animals are engaged in this operation they seem unconscious of the presence of intruders, and from this fact, and because they are very helpless on land, they are frequently captured while so engaged. They breed sometimes as far north as Virginia, and commonly in Georgia, Florida, and the eastern Gulf States. The young make their way to the water as soon as hatched.

RATE OF GROWTH.—Like all other species of Turtles, the Loggerhead is probably very slow in coming to maturity, and many years must elapse before it is fully grown. One of the small Marsh Terrapins is said to be ten or eleven years old before it breeds,[2] and it would seem that in marine species, which are many times larger, the period must be much longer.

ECONOMIC VALUE.—The economic value of the Loggerhead, aside from that of its eggs, is very small. The flesh of the adult is leathery and oily, and smells very strongly of musk; it is, therefore, not generally eaten, although some pretend that they have partaken of it when fresh without nausea. Formerly it was salted in the West Indies and given to the slaves for food. Young Loggerheads are considered tolerably esculent and are eaten to a limited extent in the United States. They are captured from time to time on the coast of North Carolina, and sold in the markets of the interior cities.

A large amount of oil can be obtained from this Turtle, but its rank odor unfits it for use in cooking. It has been employed, however, to smear on the sides of vessels, which it is said to preserve from worms; and to soften certain kinds of leathers. Its scales, although larger than those of the Tortoise-shell Turtle, are very thin, and apt to be wrinkled and filled with impurities, and therefore are not used to any considerable extent in the arts.

The eggs of the Loggerhead are larger than those of other species, and are not inferior in flavor. They are highly esteemed as food, and also furnish a considerable quantity of oil.

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[1] HOLBROOK: North American Herpetology, ii, 1842, p. 37.

[2] AGASSIZ: Contributions to the Natural History of the United States, ii, 1857, p. 496.

36. THE HAWK'S-BILL TURTLES.

NORTH AMERICAN SPECIES.—These two Turtles, the former inhabiting the Atlantic and the latter the Pacific Ocean, were for a long period erroneously considered identical. But though different, the distinctions which separate them are of a technical nature, and we can readily treat of them together. They are commonly known under the names "Hawk's-bill" and "Tortoise-shell" Turtles (*Eretmochelys*).

RANGE OF THE HAWK'S-BILL TURTLES.—The Atlantic species, *E. imbricata*, occurs on the southern coasts of Florida and of the States bordering on the Gulf of Mexico, and from thence its range extends southward over the Gulf, among the West Indies, northeastward to the Bermudas, and as far south as Guiana and Brazil. Holbrook records as an unusual occurrence the presence of a Turtle of this species on the shores of Carolina, whither, he says, it was probably driven by a heavy storm.[1] The Pacific species, *E. squamata*, occurs on our western coast, and is common also in the Chinese and Japanese waters, and in the Indian Ocean generally.

SIZE.—The Hawk's-bill is smaller than either the Loggerhead or the Green Turtle. It is generally considered that a Turtle must have a weight of about one hundred and sixty pounds before its "shell is of suitable thickness to be used in the arts, but it often attains to at least twice that weight, and sometimes even approaches in weight the Green Turtle."

FOOD AND HABITS.—The habits of the Hawk's-bill Turtle do not differ essentially from those of the Loggerhead. Its diet is strictly vegetable, but it is said to be much more fierce than the carnivorous but harmless Loggerhead. It bites severely, and occasions painful wounds, so that the fishermen have to be on their guard against its attacks. On our shores its breeding season extends from the latter part of April to the first of July. It usually selects a gravelly rather than a sandy beach in which to deposit its eggs.

ECONOMIC VALUE: GRADES OF "SHELL."—The Hawk's-bill Turtle is chiefly valued for the horn-like scales or plates which cover its bony shell. These form the "tortoise-shell" of commerce. The back of the Turtle is covered with three rows of plates, a central and two lateral rows. The central row contains five plates and each of the lateral rows four plates; in addition, the margin of the shell is occupied by twenty-five small plates. The plates of the three rows covering the back are known as "blades," and collectively as the "head" of shell. The small marginal plates are denominated "feet," or "noses." These, together with the thinner plates of the central row, are also sometimes known as "hoofs and claws." The plates which have the highest value are the two middle ones on each lateral row, since they have the greatest thickness and size. The colors of tortoise-shell which are preferred are mingled "golden yellow, reddish jasper, and white, or brown approaching black." A variety of shell in which a large amount of white occurs is also much esteemed, especially by the Chinese. Such shell is known as "white" head or "blonde" shell. Plates in which the patches of color are nearly of equal size, and occupy nearly the same position on both sides, are also highly valued. The largest Turtle does not furnish more than fifteen or sixteen pounds of tortoise-shell. "The best tortoise-shell comes from the Indian Archipelago, where Singapore is the principal port for its exportation. It is also sent from the West Indies, from the Gallapagos Islands, situated on the west coast of South America, and from Mauritius, Cape Verde, and Canary Islands."

The plates on the plastron, or under part of the shell, are golden yellow in color. Articles made from them are much admired in some localities. It is said that combs of this color are eagerly sought for by Spanish ladies, who will readily pay fifteen or twenty dollars for them.

[1] HOLBROOK: North American Herpetology, ii, 1842, p. 42.

THE HAWK'S-BILL AS FOOD.—The flesh of the Hawk's-bill Turtle is comparatively valueless; indeed, in the West Indies it is said that it possesses cathartic qualities in a high degree. The Turtle is occasionally brought to our markets from North Carolina. I have seen it in Washington several times recently, both in the markets and before certain restaurants of the city. *The eggs are not inferior to those of other Marine Turtles, and are valuable both as food and as* the source of a limpid and not ill-flavored oil, which is used in cookery and in the arts.

37. THE GREEN TURTLES.

NORTH AMERICAN SPECIES.—The two species of Green Turtle, the one, *C. mydas*, inhabiting the Atlantic and the other, *C. virgata*, the Pacific Ocean, like the two Hawk's-bill Turtles, are very similar in general aspect, and have been confounded by many observers. The Atlantic species, however, has been most often described and commented upon, and it is to that species that most of my remarks will refer.

NAMES.—As far as known, the Green Turtle has no other popular name in the United States *or in England. In France it is called the "Tortue Franche," in Portugal the "Tartaruga," and* in Brazil the "Jurucua."

DISTRIBUTION.—The Atlantic species occurs all along our coast, from Long Island Sound, where it has been taken several times, but is not common, to Florida and the coasts of the Gulf States. Captain Collins believes that he has seen this species on the northern fishing-banks. It is abundant in the West Indies, and is found as far south as Guiana and Brazil; is said to occur also along the west coast of Africa. I am informed by Mr. E. G. Blackford that the supply for New York market is brought principally from Indian River, Cedar Keys, and Key West, Florida. The Pacific species is "found along the whole southern coast of California," but its northern limit has not been ascertained. It is said to occur also in the Indian Ocean.

SIZE.—In size the Green Turtle ranks intermediate between the Loggerhead and the Tortoise-shell Turtles. Those taken on the coast of the Carolinas are very small, but the species increases in size southward. The specimens taken at the more northerly localities seem to be young or dwarfed individuals, as in the case of the Loggerhead. At Beaufort and Morehead City, as Mr. Earll ascertained, they weigh only about eight pounds; at Charleston, usually from five to fifteen pounds, the largest weighing twenty-five pounds; about Saint Augustine, the average size is twenty or twenty-five pounds; at Halifax River, thirty-five pounds; at Indian River, fifty or sixty pounds, specimens weighing as much as two hundred pounds being not infrequently taken; at Key West the weight is usually from forty to one hundred pounds; at Cedar Keys specimens weighing from six hundred to eight hundred pounds are sometimes taken, and rarely some weighing a thousand pounds. Thus it appears that there is gradual increase in size as we pass southward.[1]

FOOD AND FEEDING HABITS.—Holbrook makes the following statements in regard to the food of the Green Turtle: "The *Chelonia mydas* lives mostly in deep water, feeding on marine plants, especially one called turtle-grass (*Zostera marina*). This, according to Audubon, they cut near the roots, to procure the most tender and succulent part, which alone is eaten, while the rest of the plant floats to the surface, and is there collected in large fields, a sure indication that the feeding ground of the Green Turtle is near. In confinement, however, they eat readily enough purslain (*Portulaca oleracea*), and even grow fat on this nourishment."[2] A specimen taken at Noank, Connecticut, in August, 1874, was full of Irish moss (*Chondrus crispus*). After browsing for a

[1] This fact, which corresponds with what has been observed regarding some other animals, is of great interest from a zoölogical point of view.

[2] HOLBROOK: North American Hepetology, ii, 1842, p. 29.

time in these pasturages of sea-weed, the Turtles seek the mouths of rivers, where they apparently take great pleasure in bathing in the fresh water, which seems to be necessary to them from time to time. They are very timid on such occasions, and hasten away into deep water at the approach of man. In Florida, it "is said by turtle-fishers to enter the creeks which abound on that coast, and having eaten its fill of the sea-grass growing there, to roll together masses of it of the size of a man's head, which it cements with clay on which the grass grows, and then when the turn of the tide takes it out to sea, follows it, feeding upon it. When, therefore, the fishermen find any of these balls floating down from a creek, they at once spread a strong net across the mouth, and almost always secure a number of these Turtles."[1]

BREEDING OF GREEN TURTLES.—The Green Turtle breeds on the coasts of Florida and in the Bahamas and West Indies generally. On our coast its breeding season is from April to July. Holbrook gives also an excellent account of the breeding habits of this Turtle, and we cannot do better than quote his words. "In the months of April and May, great numbers seek for this purpose [the laying of eggs] the sandy shores of desolate islands, or the uninhabited banks of certain rivers, where they are least liable to interruption in their work of reproduction. The Tortugas Islands are a favorite haunt; these are four or five uninhabited sand banks, which are only visited by turtlers and wreckers. Between these islands are deep channels, so that the Turtles come at once to a good landing. They are not confined, however, to these islands, but are found abundantly on keys and inlets on the main. The female arrives by night. Slowly and cautiously she approaches the shore, and if undisturbed, crawls at once over the sand above high water mark; here with her fins she digs a hole one or two feet deep, in which she lays her eggs, between one and two hundred in number. These 'she arranges in the most careful manner, and then scoops the loose sand back over the eggs, and so levels and smooths the surface that few persons on seeing the spot could imagine that anything had been done to it.' This accomplished, she retreats speedily to the water, leaving the eggs to be hatched by the heat of the sun, which is generally accomplished in about three weeks.[2] Two or three times in the season does the female return to nearly the same spot and deposit nearly the same number of eggs, so that the amount annually would be four or five hundred."[3] The young make their way at once to the water, but many of them fall a prey to the various carnivorous birds which frequent the breeding grounds.

USES.—The flesh of the Green Turtle is considered an excellent article of diet, and forms the basis of the well-known "turtle soup." Two portions of the body have received special names in the language of cookery. These are "calipash," a name for the flesh which is attached to the upper shell of the Turtle, and is of a dull greenish color; and "calipee," the corresponding name for the flesh adhering to the lower shell, which is of a yellowish hue.

The animal is brought to the markets of New York, Philadelphia, Baltimore, and other cities regularly during the season, and large numbers are sold. The Pacific species, Professor Jordan informs me, is seen from time to time in the markets of San Francisco, being brought in occasionally by vessels coming from the south. The eggs of the Atlantic Green Turtle are eagerly sought for, both on our coast and in the West Indies, and are valuable both as food and on account of the oil they furnish. I am informed by a prominent manufacturer of soap that the article bearing the name of "turtle-oil" soap is in reality made from beef or other fats, and contains not the least modicum of turtle oil. The name is simply a "trade name"; no turtle oil has been imported into the United States for many years.

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[1] KNIGHT: Proceedings Boston Society of Natural History, 1870, p. 16.

[2] Agassiz says the period cannot be less than seven weeks.

[3] HOLBROOK: *Op. cit.*, p. 29.

38. THE SOFT-SHELLED TORTOISES.

The marsh and river Tortoises constitute a large group, well represented in North America. It includes all the Tortoises which live in the marshes, fresh and salt, and in ponds and running streams. It may be conveniently divided into six sections, comprising (1) the Soft-shelled Tortoises; (2) the Snapping Turtles; (3) the Musk Tortoises; (4) the Fresh-water Terrapins; (5) the Salt-water Terrapin and Geographic Tortoises; (6) the Pond Tortoises.

RANGE OF THE SOFT-SHELLED TORTOISES.—The species of Soft-shelled Tortoises, *Trionychidæ*, inhabiting our country are six in number, and belong to two different genera, known scientifically as *Amyda* and *Aspidonectes*. Their combined range extends from Lake Champlain, the Lower Saint Lawrence, and the Upper Hudson on the east, westward through the great lakes and Northwestern States, to the Yellowstone and Musselshell Rivers; thence southward, east of the Rocky Mountains, to Eastern Texas; thence along the Gulf States to Florida, and from there northward, west of the Alleghanies, to the Upper Hudson.

"In the Northwestern States, two species occur together, belonging to two different genera, *Amyda mutica* and *Aspidonectes spinifer;* in the middle Western States one species, *Aspidonectes nuchalis;* in the South-Eastern and Southern States, two species, belonging to two different genera, *Platypeltis* [*Aspidonectes*] *ferox* and *Aspidonectes asper;*[1] and in the South-West, in Texas, one species, *Aspidonectes Emoryi.*"[2]

These Tortoises seem to be known everywhere in the country under the single name "Soft-shell Turtle." As the habits of all the species are very similar, it will be scarcely necessary to consider each separately. They vary in length from six or eight inches to two feet or even more, and their weight is from four or five pounds to fifteen or sixteen pounds. Probably the largest species is *A. spinifer*.

FOOD.—The food of the Soft-shell Turtles consists of small fishes, snails, and other small animals, and a variety of vegetable matter. It is said that some species do great damage in potato fields, situated near the streams they inhabit, since they are very fond of browsing on the stems. It is improbable, however, that they go very far from the water. They are most frequently seen on the margin of sluggish, shallow streams, their bodies buried in the mud, and only the tip of their long snout protruding, or crawling over the muddy bottom of the stream, or floating on its surface. The fact of their fierceness has been regarded with doubt by some authorities, but they will undoubtedly bite severely if provoked. They breed in June and July, seeking a dry sandy spot on the bank of the streams they inhabit, in which to deposit their eggs. The female leaves the water for this purpose, and returns to it immediately after the eggs are laid, leaving them to be hatched by the heat of the sun. The number of eggs is large, varying from thirty or forty to sixty or seventy.

ECONOMIC VALUE.—Soft-shell Turtles are commonly eaten in the regions where they occur, and are frequently seen in the markets. Their flesh furnishes a superior article of food, surpassing, it is said, in delicacy the flesh of the Green Turtle. The eggs also are considered very excellent. The Turtles are captured with hook and line, almost any bait being suitable, for they snap greedily at any kind of food. They are also shot with the rifle while sunning themselves or floating on the surface of the water. Mr. E. C. Pridgen, of Oakohay, Mississippi, informed me that the eggs are discovered by following the tracks of the animal to the nest, the location of which is recognized by the presence of a little depression of the earth.

[1] Both belong to the same genus, according to Cope. See COPE: Check-list, North American Batrachia and Reptilia, 1875, p. 51.

[2] AGASSIZ: Contributions to the Natural History of the United States, i, 1857, pp. 402, 403.

39. THE SNAPPING TURTLES.

NORTH AMERICAN SPECIES.—The Snapping Turtles, or *Chelydridæ*, of the United States are two in number, belonging to two different genera, *Chelydra* and *Macrochelys*. The more northern species, *Chelydra serpentina*, known everywhere throughout the United States as the "Snapping Turtle," is very widely distributed. It has been found as far north as Nova Scotia, and its range extends from that point southward to Florida and the Gulf States, and westward to the States immediately on the west bank of the Mississippi River. It has not been recorded from farther west than the limits given, but it is probable that it occurs even as far as the Sierra Nevadas. The southern species, *Macrochelys lacertina*, known as the "Alligator Turtle," or "Loggerhead,"[1] is found in western Georgia, and in all the States bordering on the Gulf, from Florida to Texas. It also occurs in Missouri, where it is said to receive the name "Caouane."

SIZE.—The northern species is considerably smaller than the southern; twenty or thirty pounds may be considered the maximum weight of the former, but the latter commonly attains a weight of fifty or sixty pounds, and frequently as much as one hundred. In both the strength of the jaws is very great. I have myself seen an "Alligator Snapper," of perhaps forty pounds weight, bite the handle of a broom quite in two when enraged.

Both species inhabit running streams and stagnant, muddy ponds and lakes, but they apparently prefer the latter.[2] They are sometimes seen at a considerable distance from the water, walking with a constrained and limping gait, very similar to that of the Alligator. At such times they are probably in search of food or of a suitable place for the deposit of their eggs. Their food consists of various animal matter, fishes, frogs, and shells, and lastly of ducks and other water fowl, which they draw under water to be devoured at leisure.

BREEDING SEASON AND HABITS.—The breeding season of the Snapping Turtle is in June, in the North from the 10th to the 25th (*Chelydra serpentina*). In preparing to deposit its eggs, it "excavates at first directly downward, and then laterally, so that the widest part of the hole, in which the eggs are deposited, is on one side of the external opening of the nest. Hence a stick thrust straight into the mouth of the nest would not touch the eggs, which are laid in the lateral dilation of the excavation.

"The fact that these animals oftentimes dig several holes before selecting one for deposit, shows that they exercise a discrimination with regard to the fitness or unfitness of these several spots for the encouragement and rapid development of their young. When engaged in digging or laying, notwithstanding their habitual shyness at other times, they seem utterly unconscious of any intruder, but proceed in their occupation till it is finished, and then trampling down and smoothing over the earth, so that when dry the place of the nest may not be noticeable, leave the spot and disappear among their usual haunts."[3] The place of deposit is usually at a short distance from the water in a sandy bank. The number of eggs varies from twenty to forty, or even more.

Regarding the breeding habits of the Alligator Turtle little is exactly known, but they are probably similar to those of the Snapping Turtle.

ECONOMIC VALUE.—Both the Snapping Turtle and the Alligator Turtle are esteemed as food, and are commonly eaten by the people in the localities where they occur. The former is generally considered inferior to the Soft-shell Turtles, or the Green Turtle, while it is claimed by some, although it seems hardly probable, that the flesh of the latter is even more delicate than that of the Green Turtle. In old animals, at any rate, the smell of musk is very strong and disagreeable.

[1] This is not to be confounded with the marine Loggerhead.

[2] During the summer of 1877 two specimens of Snapping Turtle were caught in the salt waters of Provincetown Bay, Cape Cod, Massachusetts.

[3] AGASSIZ: Contributions to the Natural History of the United States, ii, 1857, pp. 500, 501.

The Snapping Turtle is regularly seen in spring in the markets of Washington, dressed for cooking, that is, having the under part of the shell and the entrails removed. The eggs of both species are comparatively small, but delicate, and are eaten in many localities. They may be found by probing in the sand with a small rod, in places indicated by the tracks of the animal.

A large proportion of the commercial supply of the Snapping Turtle, as the observations of Capt. J. W. Collins show, is derived from Delaware.

Storer remarks that in many localities in the interior of Massachusetts the oil of the Snapping Turtle is carefully preserved on account of its supposed curative properties for bruises and strains, when externally applied.[1] The carapace is used by the Indians as a rattle and ornament.

40. THE MUSK TORTOISES.

CHARACTERISTICS OF THE MUSK TORTOISES.—It is perhaps scarcely necessary to mention the Musk Tortoises, or *Cinosternidæ*, in this connection. They are of small size, and possess a very strong and rank scent of musk, which makes them entirely unavailable as a source of food supply. Indeed, the exceeding rankness of the odor of one species, *Aromochelys odorata*, has gained for it the very expressive appellation of "Stink-pot." They are very troublesome to fishermen, in placid waters, often swallowing the bait so quietly as to produce no agitation of the float, so that their presence for some time is unperceived. They are often seen devouring dead and decaying animals in streams, and therefore undoubtedly prove efficacious as scavengers. In fact, it has been surmised that one cause of the prevalence of yellow fever in the Southern States is to be found in the wholesale destruction of various Tortoises which feed on the refuse vegetable and animal matter which collects in the rivers, some for food and others because supposedly obnoxious.

DISTRIBUTION.—Of the six species of Musk Tortoises inhabiting the United States, three are found only in Arizona and the Sonoran region generally, one in the Southern States, except lower Florida and Texas, and the remaining three in the Eastern and Southern States, and the central States westward to the extremities of the tributaries of the Mississippi.

41. THE FRESH-WATER TERRAPINS.

TERRAPINS AND POND TORTOISES.—In the group of Terrapins and Pond Tortoises are comprised about one-half of all the Tortoises inhabiting the United States. The members of the group vary greatly in habits and size and in other relations. Exclusive of the Marine Turtles, they furnish the greater proportion of the reptilian food of the country. All the species are available for food; that is to say, none of them have disagreeable qualities such as the Musk Tortoises, for instance, possess, but some are too small and others of too rare occurrence to furnish any considerable supply.

The *Emydidæ* of the United States have been divided among six genera,[2] based on certain differences of their structure, and since the division is a convenient one for the present purpose, we will adopt it and treat of the species of each genus together.

THE FRESH-WATER TERRAPINS.—The habitat of the members of this group is decidedly southern, for they are rarely seen north of the forty-first parallel of latitude. They live in moist and marshy localities and in running water, their structure being well adapted for semi-aquatic and aquatic life. Some are vegetable feeders, while others are carnivorous. The genus includes seven North American species. Of these the most important is the "Red-bellied Terrapin," *Pseudemys rugosa*. The animal is also known under the names "Potter," "Red-fender," and

[1] STORER: Report on the Fishes, Reptiles, and Birds of Massachusetts, 1839, p. 213.

[2] COPE: Check-list of North American Batrachia and Reptilia, 1875, pp. 52, 53.

"Slider." Its range seems to be limited to the Delaware River, the Susquehanna River, and other streams emptying into Chesapeake Bay. It is common in the vicinity of Washington, and is frequently seen in the markets in considerable numbers. It is a large species; the shell is usually ten or eleven inches in length. As has been already stated, the Red-bellied Terrapin is regularly seen in the markets, and as it is more abundant and less esteemed than the "Diamond-back Terrapin," it is usually much lower in price. It is commonly substituted in certain proportion for the "Diamond-back" in making terrapin stew.

Aside from its somewhat slow growth there is apparently no reason why this Terrapin should not be introduced into waters both north and south of its present range. It furnishes a very considerable amount of nutritious food at no expense to the producer.

THE MOBILIANER.—Another important species is that known as the "Mobilianer," *Pseudemys mobiliensis*. This is perhaps the largest representative of the genus or of the whole group in the United States. The shell is often from 14 to 16 inches in length. It is found more or less abundantly in all the Gulf States, from extreme Western Florida to the Rio Grande of Texas. Its form would suggest that it lives mostly in the water. Of what its food consists is not definitely known, but it is undoubtedly mostly of a vegetable character. It is considered quite delicate, and is esteemed as food. It is frequently sold in the markets of Mobile, New Orleans, and other Southern cities.[1]

THE YELLOW-BELLIED TERRAPIN.—*Pseudemys scabra*, a species which occurs in the Carolinas, Georgia, and Northern Florida, is used to a considerable extent for food. It is known popularly as the "Yellow-bellied Terrapin." That it is a very abundant species, at least in Florida, we may learn from the following note, communicated to the Boston Society of Natural History in 1870, by the Rev. C. F. Knight:

"In the early summer [this species] congregates in great numbers in the shallow parts of certain lakes, and the warm and still bayous near the mouths of those streams which empty into the Gulf. On one occasion the speaker [Mr. Knight], floating quietly down stream, came upon one of these gatherings where there seemed to be many thousands within the space of two or three acres, covering every log and stump and hummock almost as thickly as shingles lie upon a roof."

The Yellow-bellied Terrapin is largely a carnivorous animal. It lives on small reptiles and other such animals as it can capture in the streams and ponds which it inhabits. In confinement, however, it will condescend to partake of vegetable food, particularly of the common purslain, *Portulaca oleracea*, of which it seems quite fond. It is frequently brought to Charleston, South Carolina, and other Southern markets in considerable numbers. The flesh is not considered as delicate as that of the "Diamond-back Terrapin," but the amount furnished is greater.

OTHER SPECIES.—Of the remaining species it will be necessary to speak only of *Pseudemys concinna*. The other three species, *Pseudemys hieroglyphica*, inhabiting the Middle, Western, and Gulf States, *Pseudemys Troostii*, inhabiting the Mississippi Valley, as far north as Illinois, and *Pseudemys elegans*, inhabiting Ohio and Texas and the States through which the western and northern tributaries of the Mississippi River flow, seem not to be sufficiently abundant to furnish regular supplies of food. *Pseudemys concinna*, the "Florida Cooter," is found in all the Southern States, from southern North Carolina to Florida, and from thence westward to Texas, and also in Arkansas. They seem to prefer brackish waters, but are found also in fresh-water streams. Their diet is principally of animal matter; in Florida they are said to feed upon certain species of worms which they capture by thrusting their long claws into the worm-holes in the clay. Although

[1] HOLBROOK: North American Herpetology, i, 1842, p. 74.

not as abundant as the Yellow-bellied Terrapin, they are sufficiently so to furnish considerable food, but whether they are brought to market I am not aware.

42. THE DIAMOND-BACK OR SALT-WATER TERRAPIN.

Three species of the genus *Malacoclemmys* inhabit the United States. By far the most important of these, and the most valuable of all Terrapins, is the *Malacoclemmys palustris*, or "Diamond-back Terrapin."

The other two species, the Geographic Tortoises, *M. geographica* and *M. Lesueuri*, are of comparatively rare occurrence, and are not used for food to any considerable extent.

DISTRIBUTION.—The "Diamond-back," or "Salt-water Terrapin," is common along our entire Atlantic coast from Nantucket and New Bedford, in Massachusetts, to Texas. It also occurs in South America. It was introduced into Italy by the Prince of Canino, a number of years ago, but of the success of the enterprise I have been unable to learn. Those which enter into commerce, however, are principally from Chesapeake Bay and the coast of the Carolinas. Some very fine ones also come from Egg Harbor, N. J.

CHARACTERISTICS AND HABITS.—The Diamond-back lives in salt marshes near the coast, and is seldom found far from them. They were formerly very abundant in such localities, and could be often seen on warm days sunning themselves on the bars and flats. But the increasing demand for them and the wholesale capture of old and young have reduced their numbers very materially. The species is a comparatively small one, and varies much in external appearance. The females attain a larger size than the males, and are much more highly prized in market. The average length of the under part of the shell is seven inches, and the weight of the animal four or five pounds. Rarely the length reaches ten inches, and the Terrapin weighs about ten pounds. The fixed standard of length for salable females in most markets is six inches, but in some it is as low as five inches. Terrapin having that length are known as "counts." The small specimens are separated into "heifers" and "little bulls"; their under shell rarely exceeds five inches in length. As has been already said, they are deemed very inferior to the females, and the price of them is therefore much lower.

In regard to the rate of growth, I have seen it stated that the Diamond-back reaches maturity, or rather lays eggs, when four years old, but this is hardly probable. It does not accord with the observations of Agassiz and others, nor with the peculiarities of the group generally. Experiments made by a dealer in North Carolina seem to show that the species grow about one inch each year, so that "counts" are at least six years old. Probably ten years at least elapse before they are fully grown.

FOOD.—What the food of the Diamond-back Terrapin is does not seem to be exactly known. Very probably, however, it consists of such matter, both animal and vegetable, as the animal is able to find in the marshes in which it lives. When penned, preparatory to sending them to market, they are fed on crabs, oysters, and fish. To give them the finest flavor they are said to be fed upon celery for some days previous to being served. In the winter the tortoise hibernates and takes no food, remaining buried several inches in the mud. Unfortunately for its welfare, a little mound of mud is always raised above the spot where it disappears, which at once catches the eye of the terrapin fisherman. A large proportion of the Terrapins are taken while they are in this torpid condition.

BREEDING HABITS.—Like all other species of Tortoises, the Diamond-back deposits its eggs on land. When the laying season arrives the female seeks some sandy bar or bank above water, and having excavated a shallow pit with the hind legs, deposits from five to seven eggs.

The breeding season occurs in the latter part of June and early part of July. It is said that the young show no disposition to seek the water, but prefer to remain in the sand.

ECONOMIC VALUE.—The Diamond-back is highly prized for food. Philadelphia furnishes the best market for this species, but it is also sold in large numbers in Baltimore, Washington, New York, Boston, Chicago, Pittsburgh, Cincinnati, Saint Louis, and many other cities. The season lasts from the beginning of October to the first or middle of June; the best months are October and November. The specimens from North Carolina usually appear in the market last. The "counts," or those over six inches long, bring from eighteen to thirty-six dollars per dozen in the market; the smaller ones are usually sold separately, at prices of from fifteen to fifty cents apiece. These prices, however, are almost sixty per cent. higher than the prices received by the catcher, for the Terrapins pass through several hands on their way to market. The majority of Terrapins are actually caught in the summer months and are penned in yards, known as "crawls," until the marketing season arrives. A description of the crawls and of the method of capturing the Terrapin will be found in the chapter on THE TERRAPIN FISHERY.

There are two principal modes of cooking the Diamond-back Terrapin, one known as the Maryland style, and the other as the Philadelphia style. The Maryland style is as follows: The Terrapin is first thrown alive into tepid water, the skin and claws are removed; a second immersion in the water follows. The under shell is then cut away and the gall-bladder and liver removed. After this operation the Terrapin is stewed until thoroughly cooked. The stew is then garnished with eggs, cream, butter, and spices, and when ready for the table a little wine is added. The Philadelphia style is different from the preceding only in the addition of terrapin eggs, which, in the estimation of epicures, are necessary to complete the dish.

43. THE POND TORTOISES.

THE GENUS CHRYSEMYS.—Three species of genus *Chrysemys*, the Pond Tortoises, inhabit the United States: *C. picta*, whose range extends from Nova Scotia and Maine to Wisconsin and the States on the east bank of the Mississippi, and southward to Louisiana, Northern Mississippi, and Georgia; *C. Belli*, whose range is from the States on the west bank of the Mississippi, and Texas, westward to the Sierra Nevadas, excepting the Sonoran region; and *C. reticulata*, whose range is from Southern North Carolina to Florida and west to Louisiana. Of these the most important, perhaps, is the *Chrysemys picta*. It is a very abundant species, is of considerable size, the shell being six or seven inches in length, and has no disagreeable qualities. It lives in ponds, ditches, and sluggish rivers, where it is almost invariably seen lying on rocks and fallen trees, basking in the sun. It is very timid, dropping into the water immediately on the approach of man, and soon dies in confinement. It feeds on worms, insects, and small aquatic reptiles.

THE "CHICKEN TORTOISE."—Of the two remaining species *C. reticulata* is the more valued. It is known under the name of "Chicken Turtle" in the region where it occurs. Its habits are very similar to those of the preceding species, but it is a somewhat larger animal. It is frequently brought to the Southern markets, and is somewhat more highly esteemed than the Yellow-bellied Terrapin *Pseudemys scabra*.

BELL'S TORTOISE.—The remaining species, *C. Belli*, is a fine Tortoise, but appears to be rare, except in the Cumberland and Tennessee Rivers. Little is known of its habits, except that it prefers clear waters. So far as I am aware it is but rarely eaten.

THE GENUS CHELOPUS: THE "EL-LA-CHICK."—Four species belonging to this genus inhabit the United States, of which the most important, commercially, is *C. marmoratus*, occurring on the Pacific coast between the Sierras and the sea, from Vancouver's Island to Monterey, California.

It lives in the rivers and fresh-water ponds, preferring those of which the water is somewhat warm. It grows to a very considerable size, the shell frequently measuring seven or eight inches. It is said to deposit its eggs in June. "They are almost constantly for sale in the markets of San Francisco, and make pretty good soups, though much inferior to the Sea Turtles." They are also seen in the markets in other parts of California. The species is called "El-la-chick" by the Nisquallies.

THE WOOD TORTOISE: OTHER SPECIES.—*Chelopus insculptus*, or the "Wood Tortoise," which inhabits the Eastern States from Maine to Pennsylvania and west to Ohio, is a species of medium size, but though available for food, it is, as far as I am aware, rarely eaten. It lives mostly in ponds, but is frequently seen on land, either in search of food, or, as has been suggested, to rid itself of the leeches which cling very persistently to it. The "Spotted Tortoise" or "Speckled Turtle," *Chelopus guttatus*, and Muhlenberg's Tortoise, *Chelopus Muhlenbergi*, are comparatively worthless varieties. The former occurs in the New England States and in New York, Pennsylvania, and Michigan, and probably also in Ohio. The latter inhabits southern New York, New Jersey, and eastern Pennsylvania. The Speckled Turtle lives in ponds and running waters, but *C. Muhlenbergi* is frequently found on land. Both subsist principally on an animal diet. The Speckled Turtle, when feeding, uses the fore-feet in retaining the prey, in a manner reminding one of that of the domestic cat.

THE GENUS EMYS.—Only one species of this genus inhabits the United States; it has, so far as I am aware, no common name. This is the *Emys meleagris*. It occurs in the New England States and westward to Wisconsin. It is a rare animal and seldom seen, and hence little is known of its habits.

44. THE BOX TORTOISES.

THE CAROLINA BOX TURTLE.—To the genus *Cistudo* belong the Tortoises which have the power of shutting the body and limbs within the shell, and from this peculiarity are known as "Box Turtles." The most common species is *Cistudo carolina*, with its Southern variety, *triunguis*, which singularly has but three claws on the hind foot. It occurs all over the eastern United States from the coast to the States on the west bank of the Mississippi River. In the Southern States it is known as the "Pine-barren Terrapin," and is also called "Cooter" by the negroes. It lives almost entirely on land, feeding on insects and other animal matter, and also on certain kinds of vegetables.

It is said to do damage in the fields to cucumbers and other growing vegetables. In confinement it can be readily raised on apples and other fruits. It has been sometimes kept in cellars to destroy mice and rats, but it is doubtful whether so sluggish a tortoise would be able to capture so nimble a rodent as a mouse.

Another species, or perhaps only a variety of the preceding, known as *Cistudo ornata*, occurs in the Mississippi Valley.[1]

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[1] Although not appertaining strictly to the subject of this report, but as completing the foregoing sketch of the Tortoises of the United States, I may be allowed to allude to the three Gopher Tortoises of the South and West. The Florida "Gopher," *Xerobates polyphemus*, (Daudin) Cooper, inhabits the Southern States from South Carolina to Texas; Agassiz's Gopher, *X. Agassizi*, Cooper, is found in Southern California and Arizona; and Berlandier's Tortoise, *X. Berlandieri*, Agass., Southern Texas and Northeastern Mexico. All five in dry and sandy regions, and feed upon vegetable matter. The eastern and western Gophers, and possibly Berlandier's Tortoise, dig deep burrows in which to dwell. The Florida Gopher furnishes no inconsiderable proportion of the meat supply of many negro families in the South.

G.—THE AMPHIBIANS.

45. THE BULL-FROG.

DISCOVERY OF THE BULL-FROG.—The first mention of the Bull-frog, *Rana Catesbiana*, Shaw, is found in the eighteenth volume of the *Philosophical Transactions*, published in London in 1694, in which Clayton alludes to it as being a larger Frog than any found in England, and one which "makes a noise something like the bellowing of a bull."[1] Years later it was accurately described by Catesby under the name of "Bull-frog," an appellation by which it is now universally known.

RANGE.—The geographical range of the Bull-frog has never been accurately defined. It is found in all the States on the Atlantic seaboard, and in Canada. In the collections of the National Museum there are specimens from Alabama, Mississippi, Louisiana, and Arkansas, among the southwestern States; from Ohio, Wisconsin (Racine), and Montana (Yellowstone River); and from California (San Diego). If the specimens have been correctly identified, the species must extend over the greater part of the United States.

SIZE: MODE OF LIFE.—In regard to size, the Bull-frog is undoubtedly the largest animal of its kind inhabiting North America. Holbrook[2] states that it reaches a length of twenty-one inches, although the average, of course, is considerably less. It lives in quiet ponds and sluggish rivers, and is solitary in habit, collecting together only during the breeding season. Like other Frogs, it is carnivorous, feeding upon insects, mollusks, and other small animals which live in or near bodies of fresh water. It seizes its prey when in motion, and bites greedily at the hook.

BREEDING HABITS: FROG CULTURE.—The Bull-frog breeds in spring, at which time hundreds are to be seen together in small ponds. During this season the male utters the well-known bellowing cry which may be heard at a long distance.

The artificial culture of Frogs has been attempted in a number of localities, with greater or less success. Mr. Seth Green gives the following account of a method for propagating them, which he employed with good results:

"1. *How to get the spawn.*—Take a large dipper and go to the pond where the frog casts its spawn. You will find them in a glutinous bunch. When you dip them up, be very careful not to break the glutinous matter which binds them together. Put them in a pail or can, filled with water, and take them to your hatching-box, which is made after the fashion of the shad-hatching box. It is a box two feet long, eighteen inches wide, and a foot deep, covered on the bottom with gas-tarred wire sieving, twelve wires to the inch. Anchor the box in a gentle current. They will hatch in from seven to fifteen days, according to the temperature of the water.

"2. *How to take care of them.*—Soon after they are hatched, they should be turned loose in a pond prepared with great care, as they have numerous enemies, such as fish, snakes, birds, lizards, coons, and many other animals. The pond should be made where the ground is springy, and have plenty of soft muck in the bottom. In this muck the frog lies during the winter. The pond should have a tight board fence, so that no animals could get in, and should be built so close to the water that no bird could stand on the ground inside the fence and pick up the

[1] Philosophical Transactions, xviii, 1694, p. 125.
[2] HOLBROOK: North American Herpetology, iii, 1838, p. 82.

polliwogs. If you do not heed all these precautions, and more too, your young fry will all disappear down the stomach of some bird or animal; and if you are not an unusually close observer, you will be in great wonder where they have gone. You will have no trouble in feeding the young while they are polliwogs; nature has provided for that in all waters. They feed upon microscopic forms found in the sediment."[1]

MODES OF CAPTURE.—The capture of Frogs is effected in various ways. In Canada the fishery is carried on largely by boys, who employ spears, in the use of which they are said to become quite expert. In some localities scoop-nets are used. Mr. Paul Pieombo, of Oakland, California, informs me that he seldom has need of any apparatus, as he finds no difficulty in securing the Frogs by grasping them with his hands.

In regard to the capture of Frogs in Europe, where the species *Rana esculenta* is most generally eaten, Mr. Buckland furnishes us with the following information:

"The old fishwife of whom I bought the frogs informed me that she had a man regularly in her employ to catch them. He went out every evening at dusk to the ponds in the neighborhood of Paris, with a lantern and a long stick, to end of which was attached a piece of red cloth. The frogs were attracted by the light to the place where the fisherman stood. He then lightly dropped his cloth on the surface of the water; the frogs, imagining that some dainty morsel was placed before them, eagerly snapped at it, and, their teeth becoming entangled, they became an easy prey, destined for to-morrow's market and the tender mercies of the fish or rather frog woman."[2]

ECONOMIC USES.—Desmarest, in his article on Frogs in the "Dictionnaire d'Histoire Naturelle," makes the following remarks regarding the uses to which these animals may be put:

"The flesh of Frogs is white and delicate, and contains a great deal of gelatine. It is eaten almost everywhere in Europe, but particularly in France. Frogs taken in autumn are in the best condition for food, but they are also taken in the summer. In spring the flesh is not at all delicate. In England all parts of the Frog are eaten except the skin and the viscera, but with us only the hind legs are employed.

"Frog soup is used in medicines in cases of phthisis, hypochondria, and all those chronic affections which are accompanied by permanent irritation. This remedy, which has been prescribed by a celebrated Doctor Pomme, is not in use at the present time. In ancient days many preparations were made from Frogs, such as oil and salve, and from the spawn, water and oil, etc. Dioscorides recommended Frogs cooked with salt and oil as a remedy for the bite of the venomous serpents, and would have the patient swallow a heart every morning as a pill for incurable diseases. In the country the lack of ice is sometimes supplied by the application of a frog to the forehead in cases of cerebral congestion."[3]

The late Mr. Buckland, in his entertaining work on "Curiosities in Natural History," already quoted, also alludes to the gastronomic value of the Frog, in his usual inimitable style, as follows:

"Frogs are not often used in Germany, but in France they are considered a luxury, as any *bon vivant*, ordering a dish of them at the 'Trois Frères' at Paris, may, by the long price, speedily ascertain. Not wishing to try such an expensive experiment in gastronomy, I went to the large market in the Faubourg Saint-Germain and inquired for Frogs. I was referred to a stately looking dame at a fish stall, who produced a box nearly full of them, huddling and crawling about, and occasionally croaking, as though aware of the fate for which they were destined. The price fixed was two a penny, and, having ordered a dish to be prepared, the Dame de la Halle dived her hand in

[1] Report, United States Fish Commissioner, part ii, 1874, pp. 587, 588.
[2] BUCKLAND, FRANCIS T.: Curiosities of Natural History, 1840, p. 39.
[3] Dictionnaire Universel d'Histoire Naturelle, vi, 1845, p. 328.

among them and, having secured her victim by the hind legs, severed him in twain with a sharp knife; the legs minus skin still struggled and were placed on a dish, and the head with the fore legs affixed retained life and motion and performed such motions that the operation became painful to look at. These legs were afterwards cooked at the restaurateur's, being served up fried in bread-crumbs, as larks are in England; and most excellent eating they were, tasting more like the delicate flesh of the rabbit than anything else I can think of.

"I afterwards tried a dish of the common English frog, but his flesh is not so white nor so tender as that of his French brother.

"Should any person wish to have a dish of real French frogs, he can buy them at Fortnum and Mason's for half-a-guinea, a tin-caseful. They are beautifully preserved and are ready for cooking. I have eaten them at the house of a lady who kindly invited me to luncheon when she tried the experiment. . . .

"The edible frog (*rana esculenta*) is brought from the country, in quantities of from thirty to forty thousand at a time, to Vienna, and sold to great dealers who have conservatories for them. These conservatories are large holes, four or five feet deep, dug in the ground, the mouth covered with a board, and in severe weather with straw. In these conservatories, even during a hard frost, the frogs never become quite torpid; they get together in heaps one upon another, instinctively, and thereby prevent the evaporation of their humidity, for no water is ever put to them."[1]

The custom of eating Frogs was introduced into the United States from Europe, and has spread from the cities on the east coast to those in the interior and on the west coast. On account of the limited supply which is sent to market, frog meat has hitherto been considered an article of luxury, rather than one of general consumption. In restaurants and hotels it is seldom found on the regular bill of fare, but in those of the better class, in the large cities at least, it is not wanting on the order-list.

The supply of Frogs for the New York market, according to the statement of Mr. E. G. Blackford, is obtained principally from Canada, Northern New York, and the vicinity of Philadelphia. The season lasts from May to November. The hind legs, or "hind quarters" as they are termed, are the only portions usually eaten, there being but an insignificant amount of flesh on other parts of the animal. Mr. Blackford states that he is accustomed to sell about 12,000 pounds of frog meat annually, and it is probable that the consumption of New York City is not less than 60,000 pounds. The average retail price is thirty cents per pound.

At Boston "Frogs are sold generally by the dozen, and bring from twenty to fifty cents, according to quality. As the demand increases the business will furnish quite a source of rural income. . . . The subject of canning Frogs is being talked of, and efforts are being made to discover a good process for this purpose."[2]

The following paragraph from an American newspaper of recent date contains some information regarding the extent of the business in Minnesota: "A new industry has recently sprung up in parts of Minnesota, that has already arrived at the dignity of statistics. Frog culture is the new thing; it is a simple matter, consisting chiefly in the protection of eggs and tadpoles from birds and other enemies, by means of wire screens. The product, thus far reported, amounts to 3,000 dozen of frogs' legs, of which about two-thirds have been shipped to Saint Louis. The average quotation of prices is twenty cents per dozen."

Frogs are quoted regularly as appearing in the San Francisco market. Mr. Paul Pieombo,

[1] BUCKLAND, FRANCIS T.: Curiosities of Natural History, 1840, pp. 38–40.

[2] Boston Commercial Bulletin.

whose name has been already mentioned, if his statements are reliable, is one of the largest dealers in Frogs in California. He writes, in answer to a circular: "Most of the Frogs caught in this State are caught by me"; and in response to the questions propounded, states that he sells about three hundred dozens of live Frogs annually, sending two-thirds of them to San Francisco, and the remainder to various other localities in California. The price during summer ranges from one dollar to two dollars and a half, and in winter from three to five dollars.

PART III.

THE FOOD FISHES

OF THE

UNITED STATES.

BY

G. BROWN GOODE.

WITH DISCUSSIONS OF THE PACIFIC SPECIES BY DAVID S. JORDAN AND TARLETON H. BEAN, NOTES ON THE FISHES OF THE GULF OF MEXICO BY SILAS STEARNS, AND CONTRIBUTIONS FROM JOSEPH W. COLLINS, N. E. ATWOOD, MARSHALL McDONALD, R. EDWARD EARLL, LUDWIG KUMLIEN, AND OTHER AUTHORITIES.

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ANALYSIS.

	Page.
H.—The File Fishes, Pipe Fishes, and Anglers	169
46. The Ocean Sun Fishes (*Orthagoriscidæ*)	169
47. The Porcupine Fishes (*Diodontidæ*)	170
48. The Bellows-Fish Family (*Tetrodontidæ*)	170
49. The Trunk Fishes (*Ostraciontidæ*)	170
50. The File-Fish Family (*Balistidæ*)	171
51. The Sea-Horse Family (*Hippocampidæ*)	172
52. The Pipe-Fish Family (*Syngnathidæ*)	172
53. The Devil Fishes (*Antennariidæ* and *Malthidæ*)	173
54. The Goose Fish (*Lophius piscatorius*)	173
I.—The Flat Fishes and Flounders	175
55. The American Soles (*Soleidæ*)	175
56. The Plaice (*Paralichthys dentatus*)	178
57. The Bastard Halibut (*Paralichthys maculosus*)	182
58. The Flat Fish or Winter Flounder (*Pseudopleuronectes americanus*)	182
59. The Flat Fishes and Soles of the Pacific Coast	184
60. The Halibut (*Hippoglossus vulgaris*)	189
61. The Sand Dab or Rough Dab (*Hippoglossoides platessoides*)	197
62. The Greenland Turbot (*Platysomatichthys hippoglossoides*)	197
63. The Pole Flounder or Craig Flounder (*Glyptocephalus cynoglossus*)	198
64. The Spotted Sand Flounder (*Lophopsetta maculata*)	199
J.—The Cod Family and its Kindred	200
65. The Cod (*Gadus morrhua*)	200
66. The Tom Cods (*Microgadus tomcod* and *M. proximus*)	223
67. The Haddock (*Melanogrammus æglefinus*)	223
68. The Pollock (*Pollachius carbonarius*)	228
69. The Cusk (*Brosmius brosme*)	233
70. The Hakes (*Phycis chuss*, etc.)	234
71. The Burbot (*Lota maculosa*). By Tarleton H. Bean	235
72. The Silver Hake and the Merluccio	240
73. Several Unimportant Families related to the Gadidæ	243
74. The Lant, or Sand Eel (*Ammodytes lanceolatus*)	244
K.—Wolf-Fishes, Sculpins, and Wrasses	247
75. The Lycodes Family (*Lycodidæ*)	247
76. The Wolf-Fishes or Sea Catfishes (*Anarrhichadidæ*)	248
77. The Blenny Family (*Blennidæ*)	250
78. The Toad-Fish (*Batrachus tau*)	251
79. The Lump-Suckers: Lump-fish and Sea-Snails	253
80. The Gobies (*Gobiidæ*)	255
81. The Sea-Robin or Gurnard Family (*Triglidæ*)	256
82. The Sculpin Tribe (*Cottidæ*)	258
83. The Rose-Fish or Red Perch (*Sebastes marinus*)	260
84. The Rock Cods of the Pacific. By David S. Jordan	262
85. The Rock Trouts (*Chiridæ*). By David S. Jordan	267
86. The Tautog or Black Fish (*Tautoga onitis*)	268
87. The Chogset or Cunner (*Ctenolabrus adspersus*)	273
88. The Parrot Fishes and some of their Allies	274
89. The Demoiselle and the Cichlid Families	275
90. The Surf-Fish Family (*Embiotocidæ*). By David S. Jordan	276
91. The Moharra Family (*Gerridæ*)	279
92. The Thread-Fish Family (*Polynemidæ*)	279
93. The Surgeon-Fish Family (*Acanthuridæ*)	279
94. The Angel-Fish Family (*Chætodontidæ*)	280

Page.

L.—The Mackerel and its Allies 281
95. The Mackerel (*Scomber scombrus*) 281
96. The Chub Mackerel (*Scomber colias*) 303
97. The Frigate Mackerel (*Auxis thazard*) 305
98. The Spanish Mackerel and its Allies 307
99. The Bonito (*Sarda mediterranea*) 316
100. The Horse Mackerel, Tunny, or Albicore (*Orcynus thynnus*) 320
101. The Little Tunny or Albicore (*Orcynus alliteratus*) 322
102. The Silver Moon-Fishes 322
103. The Cavally, the Scad, and the Jurels 323
104. The Pompanos (*Trachynotus carolinus, etc.*) 326
105. The Pilot Fish (*Naucrates ductor*) 330
106. The Amber Fishes and the Leather Jackets 331
107. The Dolphins (*Coryphænidæ*) 332
108. The Rudder-Fish Family (*Stromateidæ*) 332
109. The Dory, Hen-Fish, and Opah Families 335
110. The Cutlass Fish (*Trichiurus lepturus*) 335
111. The Sword Fish Family (*Xiphiidæ*) 336
M.—The Tile-Fish Family and Others 360
112. The Tile-Fish Family (*Latilidæ*) 360
113. The Red Mullet Family (*Mullidæ*) 361
114. The Icosteus Family (*Icosteidæ*) 361
115. The Beryx Family (*Berycidæ*) 361
N.—The Drum Family 362
116. The Squeteague (*Cynoscion regale*) 362
117. The Spotted Squeteague (*Cynoscion maculatum*) 365
118. The Silver Squeteague (*Cynoscion nothum*) 367
119. The Drum (*Pogonias chromis*) 367
120. The Fresh Water Drum (*Haploidonotus grunniens*). By David S. Jordan 370
121. The Spot, or Lafayette (*Liostomus xanthurus*) 370
122. The Red Fish, or Bass of the South (*Sciæna ocellata*) 371
123. The Yellow Tail (*Bairdiella chrysura*) 375
124. The King Fish (*Menticirrus nebulosus*) 375
125. The Whitings (*Menticirrus alburnus* and *M. littoralis*) 376
126. The Croaker (*Micropogon undulatus*) 378
127. The Corvinas and Roncadors of the Pacific coast. By David S. Jordan 378
O.—Sheepshead, Bass, Bream, Perch, etc 381
128. The Sheepshead (*Diplodus probatocephalus*) 381
129. The Scup or Scuppang (*Stenotomus chrysops* and *S. Gardeni*) 386
130. The Sailors' Choice (*Lagodon rhomboides*) 393
131. Certain Minor Sparoids 394
132. The Red and Gray Snappers 395
133. The Grunts or Pig Fishes 397
134. The Big-Mouth Black Bass (*Micropterus salmoides*), and the Small-Mouth Black Bass (*M. Dolomieï*) 401
135. The Sun-Fishes and their Allies. By David S. Jordan 404
136. The Sea Bass (*Serranus atrarius*) 407
137. The Groupers 410
138. The Serranoid Fishes of the Pacific coast. By David S. Jordan 413
139. The Yellow Perch (*Perca americana*) 414
140. The Log Perch (*Percina caprodes*). By David S. Jordan 417
141. The Pike Perches 417
142. The Striped Bass (*Roccus lineatus*) 425
143. The White Bass (*Roccus chrysops*) 428
144. The Yellow Bass (*Roccus interruptus*) 431
145. The White Perch (*Roccus americanus*) 431
146. The Bluefish Family (*Pomatomidæ*) 433
147. The Cobia or Crab-Eater (*Elacate canada*) 444
148. The Triple Tail or Black Perch (*Lobotes surinamensis*) 444
149. The Moon Fish (*Chætodipterus faber*) 445
150. The Remora Family (*Echeneididæ*) 446
P.—Barracouta, Mullet, Pike, and Mummichogs 448
151. The Barracouta Family (*Sphyrænidæ*) 448
152. The Deal-Fish Family (*Trachypteridæ*) 449
153. The Mullets (*Mugil albula* and *M. brasiliensis*) 449

Page.

P.—Barracouta, Mullet, Pike, and Mummichogs—Continued.
154. The Sand Smelts or Silver Sides (*Atherinidæ*) 456
155. The Stickleback Family (*Gasterosteidæ*) 457
156. The Silver Gar-fishes (*Belonidæ*) 458
157. The Flying-fish Family (*Scomberesocidæ*) 459
158. The Pike Family (*Esocidæ*) 461
159. The Mummichog Family (*Cyprinodontidæ*) 466
Q.—The Salmon Tribe 468
160. The Salmon (*Salmo salar*) 468
161. The Salmons of the Pacific. By David S. Jordan 474
162. The Quinnat or California Salmon (*Oncorhynchus chouicha*). By Livingston Stone 479
163. The Namaycush or Lake Trout (*Salvelinus namaycush*) 485
164. The Speckled Trout (*Salvelinus fontinalis*) 497
165. The Saibling or Bavarian Char (*Salvelinus alpinus*) 500
166. The Dolly Varden Trout (*Salvelinus malma*). By David S. Jordan 504
167. The Grayling (*Thymallus tricolor*) 505
168. The Lake White-fish (*Coregonus clupeiformis*). By R. I. Geare 507
169. The Lesser White-fishes. By David S. Jordan 541
170. The Smelt Tribe 543
171. Families related to the Salmonidæ 547
R.—The Herring Tribe 549
172. The Herring (*Clupea harengus*) 549
173. The Herrings of the Pacific Coast. By David S. Jordan 568
174. The Menhaden (*Brevoortia tyrannus*) 569
175. The Gulf Menhaden (*Brevoortia patronus*) 575
S.—The Shad and the Alewives. By Marshall MacDonald 579
176. The River Herrings or Alewives (*Clupea æstivalis* and *C. vernalis*) 579
177. On the occurrence of the Branch Alewife in certain Lakes of New York. By Tarleton H. Bean 588
178. The Inland Alewife or Skipjack (*Clupea chrysochloris*) 594
179. The Shad (*Clupea sapidissima*) 594
180. The Hickory Shad or Mattowacca (*Clupea mediocris*) 607
T.—Families Related to the Clupeidæ 610
181. The Mud Shad (*Dorosoma cepedianum*) 610
182. The Tarpum (*Megalops thrissoides*) 610
183. The Big-eyed Herring 611
184. The Anchovies (*Engraulidæ*) 611
185. The Lady-fish Family (*Albulidæ*) 612
186. The Moon-eye Family (*Hyodontidæ*) 612
U.—Carp, Suckers, Catfish, and Eels 614
187. The Sucker Family (*Catostomidæ*). By David S. Jordan 614
188. The Carp Family (*Cyprinidæ*). By David S. Jordan 616
189. The Carp (*Cyprinus carpio*). By Rudolph Hessel 618
189. The Catfish Family (*Silurida*). By David S. Jordan 627
190. The Morays (*Muræenidæ*) 629
191. The Eel (*Anguilla vulgaris*) 630
192. The Conger Eel (*Leptocephalus conger*) 656
V. Sturgeons, Skates, Sharks, and Lampreys 659
193. The Bowfins (*Amiidæ*) 659
194. The Paddle-fishes (*Polyodontidæ*) 660
195. The Sturgeons (*Acipenseridæ*) 660
196. The Chimæra Family (*Chimæridæ*) 663
197. The Gar Pikes (*Lepidosteidæ*) 663
198. The Torpedoes and Skates (*Raiæ*) 665
199. The Saw-fish (*Pristis pectinatus*) 668
200. The Sharks (*Squali*) 668
201. The Sharks of the Pacific Coast. By David S. Jordan 675
202. The Lampreys (*Petromyzontidæ*) 677
203. The Hag Fishes (*Myxinidæ*) 681
204. The Lancelets (*Branchiostomidæ*) 682

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H.—THE FILE FISHES, PIPE FISHES, AND ANGLERS.

NOTE.—In preparing the following chapters upon the food-fishes of the United States, the authors have avoided all technical discussions, all descriptions of form, all digressions of the kind in which naturalists, even when writing for the general reading public, are so prone to indulge. We anticipate the criticism that the book is of no use in identifying the different kinds of fish, by the statement that we expressly desire that it shall not be. We have tried to present in concise form the information suited to the needs of the fisherman, the fish purchaser, the statistician, and the general reader. Most of our important species can be identified by reference to the plates. If greater accuracy of identification be needed, the inquirer is advised to consult Jordan's Synopsis of the Fishes of North America, which forms Bulletin No. 16 of the United States National Museum series.

46. THE OCEAN SUN FISHES—ORTHAGORISCIDÆ.

The family *Orthagoriscidæ* is represented in the Western Atlantic by two species.

The common Sun Fish, *Orthagoriscus mola*, with its compressed, disk-shaped body and its elongated dorsal and anal fins, is one of the most grotesque of sea animals. This species is found in all parts of the world in temperate and tropical seas, and has been recorded from the coasts of Japan and California. It occurs also in the Mediterranean and on both sides of the Atlantic. On our own eastern coast it may be observed every summer, from the Banks of Newfoundland to Florida. It has not been seen in the Gulf of Mexico, but there is one instance of its capture at the Bermudas. It rarely frequents the New England coast except in summer. In the winter of 1874–'75 two large specimens were taken at the mouth of the Saint John's River, Florida.

Sun Fishes attain a length of seven or eight feet and a weight of seven or eight hundred pounds. They may be seen along our coast on almost any calm summer's day. As many as ten or twelve are often met with in the course of a day's cruise. They float lazily, with one of the bright sides of the body just at the surface. As they float, the waves ripple and break over them, and the heavy pectoral fins move slowly to and fro through the air; thus lying, they are very conspicuous objects, and may be seen at long distances. They spend whole days in this position, and may very easily be approached and harpooned. From this habit of sunning themselves they have gained the name of Sun Fishes.

Their food consists of the jelly-fish, or sun-squalls, which are so abundant along the New England coast in summer. Their jaws, however, are strong, and it would seem probable that they sometimes seek more substantial food.

Nothing whatever is known of the place or time of their breeding: the young are occasionally taken in mid-ocean.

Many individuals are harpooned by our fishermen every summer. They are not applied to any practical use, but are brought to the cities and exhibited as curiosities. The fishermen of Cape Cod sometimes make oil from the livers. This oil is prized highly as a remedy for sprains and bruises.

In the "Transactions of the Royal Society of London," 1740, was published a communication "Concerning the *Mola Salu*, or Sun Fish, and Glue Made from It," contributed by the Rev. William Barlow, in which mention is made of the capture of a specimen near Newfoundland. I am not aware that the suggestions of this author have ever been further carried out.

As a food-fish the Sun Fish is probably the most worthless species in our waters. The flesh is thin and hard, and, when cooked, separates into oil and bunches of tough fibers.

On the California coast, according to Jordan, this species is very abundant, especially in the

Santa Barbara Channel in summer, where it may be seen lying near the surface, or even sometimes leaping from the water. It is known to the Italians as the Mola, to the Americans as the Sun Fish. It seldom appears before June, and disappears in the winter. No use is made of it, as *it is not easily caught, and rarely, if ever, eaten. A specimen weighing 636 pounds was brought* to San Francisco some years ago.

There is a small species, *Ranzania truncata*, much more elongated in form, which has been taken in various parts of the Atlantic and Pacific, but never nearer to our shores than the Bermudas, where an individual of eight inches was captured in 1878.

47. THE PORCUPINE FISHES—DIODONTIDÆ.

SWELL FISHES AND PUFFERS.—*There are four species of this family inhabiting the Atlantic* coast, and two on the coast of California. The best known is the Swell Fish of New England, *Chilomycterus geometricus*. These fishes are commonly known by such names as "Burr Fish," "Ball Fish," "Swell Fish," and "Toad Fish"; while in Southern Florida the names "Porgy," "Puffer," and "Puff Fish" are sometimes used.

With their short, thick, spiny bodies, which they have the power of inflating to twice their ordinary size, and their harlequin-like colors, they are always conspicuous, and are favorite fish for aquaria. After they have inflated their bellies by swallowing air, they turn upon their backs and swim at the surface.

They have the power, when handled, of uttering loud grunting sounds.

No practical use is made of them, but their skins are often stuffed and exposed for sale in the curiosity shops, particularly those at places of popular resort, like Nantucket, Oak Bluffs, Jacksonville, and Saint Augustine. These fish belong to a tropical family, and are only seen in summer.

Nothing definite is known about their food or breeding habits.

48. THE BELLOWS-FISH FAMILY—TETRODONTIDÆ.

Of this family, which is extremely numerous in warm seas, over sixty species being known, there are seven species in the waters of the United States, one of them being found on the California coast. They are summer visitors from a warmer climate, and, like the members of the preceding family, are chiefly important to curiosity hunters. They are known by such names as "Swell Fish," "Bottle Fish," "Bellows Fish," "Egg Fish," "Rabbit Fish," "Globe Fish," "Swell-toad," "Box Fish," "Porcupine Fish," and "Blower."

One species, the common Swell Fish, or Egg Fish, *Tetrodon turgidus*, ranges from Cape Cod to the Gulf of Mexico, being very abundant about the eastern end of Long Island, where a hundred or more are sometimes taken in one haul of a fyke-net.

The Rabbit Fish, *Lagocephalus lævigatus*, is known in New England waters through the occasional visits of stragglers. It is quite abundant in the Gulf of Mexico, where it is occasionally taken with hook and line upon the red-snapper banks. According to Stearns, it breeds about Pensacola in June and July.

This fish, which attains *the length of three feet and the weight of five or six pounds, is used* for food in Cuba, but it is not sufficiently abundant with us to have any commercial value.

49. THE TRUNK FISHES—OSTRACIONTIDÆ.[1]

The Trunk Fishes, *Ostracionticlæ*, are occasionally taken on our coasts, especially to the south of Cape Hatteras. We have five species, one of them being Californian. Like the Porcupine and

[1] See GOODE: A study of the Trunk Fishes (*Ostracionticlæ*), with notes upon the American species of the family. <Proceedings United States National Museum, ii, 1880, pp. 261–283.

Swell Fishes, which have just been described, great numbers of them are preserved for sale in curiosity shops.

The Trunk Fishes appear to have been objects of curiosity in the early days of American exploration, and were evidently among the choicest treasures of the primitive museums of the seventeenth and eighteenth centuries. Their strange shape naturally attracted the attention of travelers, while the ease with which their shells could be preserved then, as now, made them valuable to the curiosity hunters.

No group of tropical fishes is so thoroughly worked out in the writings of the fathers of Natural History as this one. Over two hundred years ago every species of Trunk Fish now taken from the Atlantic was known to and described by the naturalists of Northern Europe, and it is a well-deserved tribute to their discrimination as zoölogists to say that none of the many efforts, which have since been made to subdivide their species, have been at all successful.

Artedi, in his notes upon the different forms of Ostracion, mentions the various collections in which he observed specimens. "The Nagg's Head," "White Bear," and the "Green Dragon in Stepney," to which he very often alludes, seem to have been London taverns where curiosities were kept. He also speaks of seeing them in the museum of Hans Sloane, which was the nucleus of the British Museum; also in the collections of D. Seba, in Amsterdam, of Mr. Lillja, in London, of Mr. (Don) Salteros, in Chelsey, and of seeing various specimens at Stratford, and "in Spring Garden." No other kinds of fishes appear to have been preserved except "*the monk- or Angel-fish Anglis, alias Mermaid-fish*," probably a species of *Squatina*, which he saw in London at the Nagg's Head and in the town of Chelsea. The art of taxidermy was evidently not thoroughly established in 1738.

Of *Ostracion bicaudalis* he remarks, "Vidi Londini, in the White Bear," and "Apud D^m^ Sebam vidi." *Ostracion trigonus* he saw "Apud Sir Hans Sloane et in Nagg's Head"; *Ostracion triqueter* and *O. quadricornis*, "Londini in the Nagg's Head et apud Mr. Lillia."

These specimens were all said to have come from India.

In the West Indies and in Florida the Trunk Fishes are sometimes baked in their own shells, and, when cooked in this manner, are considered by many persons to be great delicacies.

There are instances on record of serious cases of poisoning which have resulted from eating them. These cases occurred in tropical countries, where the flesh of fish often becomes deleterious after a few hours' keeping.

50. THE FILE-FISH FAMILY—BALISTIDÆ.

File Fishes, *Balistidæ*, are found everywhere in tropical and sub-tropical seas. It is supposed that they breed in mid-ocean. There are numerous species in this family, of which nine or ten occur along our Atlantic coast. They belong in warm seas, and only four species are found as far north as New England. With their strong teeth they are able to break the shells of mollusks, upon which they feed. They are known to be very injurious to the pearl fisheries in regions where such fisheries exist. The best known species on our coast is the Orange File Fish, *Alutera Schoepfii*, also called "Barnacle-eater" and "Fool Fish," which is rather common in Southern New England and in the Gulf of Mexico.

This species is conspicuous on account of its bright skin, sometimes of an orange and sometimes of a tawny hue. It attains the length of eighteen to twenty inches, and feeds upon many species of soft marine animals.

There are one or two small species which are of no importance except to the possessors of aquarium tanks, with whom they are great favorites.

The Leather-jacket of Pensacola, *Balistes capriscus*, called "Trigger Fish" in the Carolinas, and at Key West and the Bermudas known as the "Turbot," occasionally finds its way as far north as Massachusetts. It is, however, of no importance north of Florida. In the Bermudas it is considered a valuable food-fish. According to Mr. Stearns, "it is very common in the Gulf of Mexico from Key West to the Mississippi River, and lives in deep waters near the coast on the grounds where Red Snappers and Groupers are caught. It is one of the most abundant species. In regions where it is not eaten it is regarded as a pest by the fishermen from its habit of stealing bait from their hooks. Its manner of taking the bait is rather peculiar, I think, for instead of pulling the line backward or to one side it raises it upward so quietly that the fisherman does not perceive the motion, and then, by careful nibbling, cleans the hook without injury to itself. Expert fishermen, however, can tell by the "lifting of the lead," as it is called, what is going on below, and know what they have to contend against. The usual remedy is to seek other fishing grounds where Leather-jackets are not so troublesome. When one of these crafty fish has been hooked there is not much probability that it can be landed, for its sharp, powerful teeth are almost sure to cut some part of the gear, enabling it to escape. I have several times known of their biting in two the large red-snapper hooks on which they were caught. They remain throughout the year on the fishing grounds, where the water varies from ten to forty fathoms. On these same grounds it is probable that they spawn."

Only adult specimens have been seen in West Florida. More could probably be learned of its spawning habits in the vicinity of Key West, where it occurs in shallow water and quite near to the shore. At Key West it is known as the Turbot, and is a favorite article of food. It is to be seen almost daily in the market.

The skin of this species is used for scouring and polishing purposes at Key West and the Bahama Islands. In the Bermudas also the skin of the Turbot is used by carpenters almost to the exclusion of sand-paper, the former being better adapted for fine work in polishing wood.

51. THE SEA-HORSE FAMILY—HIPPOCAMPIDÆ.

There are one or more species of the Sea-horse family on the Atlantic coast, and also one on that of California. Their strange shapes and interesting habits render them very popular inmates of aquaria, and dried specimens are frequently sold in the curiosity shops in seaside towns.

The ordinary species of the Western Atlantic is the *Hippocampus heptagonus;* this also occurs in Europe. There have been only one or two instances of the capture of this fish north of Cape Cod; one was seined with a school of mackerel on George's Bank in August, 1873. Two or three specimens have been taken at Wood's Holl during the last ten years, and instances of their capture in Connecticut and about the mouth of the Hudson are not rare.

A Sea-horse was described many years ago under the name *H. hudsonius*, but it seems to be identical with *H. heptagonus*. On the New Jersey coast and south to the Gulf of Mexico it appears to be very abundant. An excellent account of the habits of this fish may be found in an article by the Rev. Samuel Lockwood in the "American Naturalist."[1] Three other species occur on our southern coast. *H. ingens*, the Californian species, is very large, often attaining the length of eight to ten inches.

52. THE PIPE-FISH FAMILY—SYNGNATHIDÆ.

The Pipe Fishes, *Syngnathidæ*, which are closely related to the sea-horse, but have small heads and elongated bodies, so that at first sight they closely resemble small eels, are found nearly everywhere on our coasts, living among the eel-grass and feeding upon very minute marine

[1] LOCKWOOD, SAMUEL. The Sea Horse and its young. <Amer. Naturalist, i, 1867, pp. 225–234.

animals. There are three or four species in Eastern North America, but their relations have not been definitely learned. I have observed them in Florida spawning in April, and in Southern New England in July and August. They are of no importance to man except as interesting objects for the aquarium. They are too hard and fleshless even to serve as food for other fishes.

53. THE DEVIL-FISHES—ANTENNARIIDÆ AND MALTHEIDÆ.

The fishes of this group are very grotesque in form and very remarkable in their habits Some of them are pelagic and are met with in tropical seas, especially where there are masses of floating vegetation, whilst others are found in the depths of the ocean. On our coast are several species, the names and distribution of which are given in the list which accompanies this report. Although they are among the most interesting of all fishes, they have no commercial value, and it is therefore inappropriate that they should be discussed in this report. The best known species are the Marbled Angler, *Pterophryne histrio*, and the Sea Bat, *Malthe vespertilio*.

54. THE GOOSE FISHES—LOPHIUS PISCATORIUS.

The Goose Fish or Monk Fish, *Lophius piscatorius*, is common to the coasts of the North Atlantic States and of Europe. In the Western Atlantic the species has not been observed south of latitude 38°, where, according to Uhler and Lugger, it is found in the drains of Worcester County, Maryland, and along the coast of that region, though there is reason to believe that stragglers occur at Cape Lookout (latitude 34° 40′), where the jawbones have been found, and the fishermen claim to know them. It abounds along the coast of New England, and has been found at depths of three hundred fathoms or more off Newport, Rhode Island, and one hundred off Halifax. The limits of its northern range are not known, Nova Scotia being the most northerly point of record. Richardson suggests that the *Thutinameg* or "Wind-fish" of Hudson's Bay, which is said to come to the surface in windy weather only, belongs to this family; and, indeed, this was thought by Pennant to be *Lophius piscatorius*. This is at best extremely doubtful, for its range, as now understood, is limited by the parallel of 50°. It is not known to occur in Greenland.

Instances are on record of its capture in Iceland,[1] and it is said very rarely to occur at the Faroe Islands. It has been found at the North Cape, latitude 71°, and doubtless penetrates to the White Sea. It is found along the coasts of Scandinavia, south to Spain, and throughout the Mediterranean, where it is abundant in the Italian waters. Either this or an allied species occurs at the Cape of Good Hope. On the American coast it occurs at temperatures of 32° to 60°. There is some reason to think that south of Cape Cod it retreats to deep water in summer.

The names of the fish are many; that most commonly in use among the Massachusetts fishermen is "Goose Fish." In Maine it is often called "Monk Fish"; in Rhode Island, "Bellows Fish"; in Eastern Connecticut, "Molligut," and in North Carolina, "Allmouth." The Connecticut name reminds us of the "Greedigut," a fish, probably the same, mentioned by early colonial writers, particularly in the poem in Wood's "New England's Prospect."

In England the same names are in use; also, "Angler," "Fishing Frog," "Frog Fish," "Mermaid," "Round Robin," "Sea Devil," "Toad Fish" (Germany), "Wide Gut," and "Wide Gap." "Kettlemaw" is like the American "Allmouth." Scotland has "Keethie," "Keghie," and "Keithok." The continental languages have at least fifty distinct names in addition.

Goose Fishes are sluggish, slow-moving animals, and are occasionally seen swimming near the surface, though ordinarily found upon the bottom. They feeds upon other fish—often on large ones, their swallowing powers being practically unlimited. Mackerel, sculpins, sea ravens, and

[1] FABER: Fische Islands, p. 58.

dog-fish, crabs, squids, and lobsters have been found in their stomachs by observers of the United States Fish Commission. They often attempt to feed upon each other. The common name refers to the fact that they have been known to swallow live geese. A fisherman told me he once saw a struggle in the water, and found that a Goose Fish had swallowed the head and neck of a large loon, which had pulled it to the surface and was trying to escape. There is authentic record of seven wild ducks having been taken from the stomach of one of them. Slyly approaching from below, they seize birds as they float upon the surface. They annoy the fishermen by swallowing the wooden buoys attached to the lobster pots. Mr. Minot, of Magnolia, Massachusetts, caught one by using his boat-anchor for a hook.

Although they come thus to the surface to feed, the Goose Fish is emphatically a bottom-loving species. "It is adapted," writes the Duke of Argyle, "for concealment at the bottom of the sea—for lying perfectly flat on the sand or among the weeds—with its cavernous jaws ready for a snap. For more perfect concealment, every bit of the creature is imitative both in form and in coloring. The whole upper surface is mottled and tinted in such close resemblance to stones and gravel and sea-weeds that it becomes quite undistinguishable among them. In order to complete the method of concealment, the whole margins of the fish, and the very edge of the lips and jaws, have loose tags and fringes which wave and sway about amid the currents of water, so as to look exactly like the smaller algæ which move around them and along with them. Even the very ventral fins of this devouring deception, which are thick, strong, and fleshy, almost like hands, and which evidently help in a sudden leap, are made like two great clam-shells, while the iris of the eyes is so colored in lines radiating from the pupil as to look precisely like some species of *Patella* or limpet. But this is not all; not only is concealment made perfect to enable the Lophius to catch the unwary, but there is a bait provided to attract the hungry and the inexperienced. From the top of the head proceeds a pair, or two pair, of slender elastic rods, like the slender tips of a fishing-rod, ending in a little membrane or web which glistens in the water and is attractive to other fish. When they come to bite, or even to look, they are suddenly engulfed, for portals open with a rush and close again—portals over which the inscription may well be written: '*Lasciate ogni speranza voi ch' entrate.*'"

From the time of Ælian every popular essay on the "Habits of Fish" or "Curious Fishes" has told how the Angler entices its prey with its long tentacles. No one has ever seen the performance, and, although the theory is not altogether incredible, it seems more probable that the tops of these organs are intended by their sensitiveness to warn the fish of the approach of its prey than to act as allurements to attract other fishes.

The Goose Fish spawns in summer, in the sounds and at sea along the coast. The eggs are very numerous, enclosed in a ribbon-shaped gelatinous mass about a foot in width and thirty or forty feet long, which floats near the surface. One of these ribbons will weigh perhaps forty pounds, and is usually partially folded together, and visible a foot or eighteen inches from the top of the water, its color being brownish purple. The number of eggs in one of them I have estimated at from forty to fifty thousand. The spawning season on the New England coast is in summer. I have observed the floating eggs in July and August, and in the same months young fish two or three inches long, and undeveloped eggs in the parent fish. The young have rarely been taken except at considerable depths. Their growth is rapid. The adult is commonly four feet long, weighing from thirty-five to forty-five pounds.

The Goose Fish is extensively used for baiting lobster pots. Although not commonly eaten, its flesh is very palatable. The full-grown fish will yield from ten to fifteen pounds of good meat. In Italy it is much esteemed as an article of food, and in parts of Great Britain it is also eaten, the steaks from the neighborhood of the tail being preferred.

I.—THE FLAT FISHES AND FLOUNDERS.

55. THE AMERICAN SOLES—SOLEIDÆ.

AMERICAN SOLES.—The much-prized Sole of Europe, *Solea vulgaris*, does not occur in the Western Atlantic, although attempts have been made to introduce it, and in 1877 two individuals were set free in Massachusetts Bay by the United States Commission of Fisheries. Its nearest representative, the American Sole, is found along our coast from Boston and Nahant to the mouth of the Mississippi River. It occurs in all of the rivers south of the Susquehanna, and is taken in great numbers in the shad seines. It rarely attains a greater length than six inches, and, though edible, is never eaten, and it must be regarded as of extremely small importance. There are also two or three other fishes belonging to this family in our Southern waters which are insignificant in size and of no importance whatever.

Aphoristia atricauda is a very small species of Sole, the only genuine representative of the European Sole on our Pacific coast. It reaches a length of six inches, and is occasionally taken in San Diego Bay. It has no economic value.

TURBOT AND SOLE IN AMERICA.—A Philadelphia writer has lately tried in the newspapers to revive the long-obsolete belief that the Turbot and Sole of Europe occur on our coast. Although he has never seen them himself, and fails to bring forward evidence that any one else has seen them, he insists that they occur in the greatest abundance in New Jersey, particularly in the vicinity of Atlantic City, "and doubtless all along the Atlantic coast from Portsmouth, N. H., to Wilmington, S. C." (*sic*). He upbraids the American public for their incredulity, though this does not surprise him so much when he calls to mind that "our Government Fish Commissioner has actually contemplated sending a steamer to English waters to procure turbot-seed to plant along our shores." He would not be surprised if incredulity were to continue longer "under such official indorsement." He accounts for the ignorance regarding them by the theory that the English trawl-net is unknown in America, and that our fishermen would not know how to catch such fish if they were aware of their presence, and have not become aware of their presence because they have no means of catching them. He intimates that he is preparing to form a company for the purpose of developing a turbot fishery upon our coast; an enterprise "in which but little will be risked, and the results will be a surprise to all." He closed one of his letters to a New York journal with the following appeal: "I trust that you will not let this question subside, but persevere in calling attention to it until we do away with the extraordinary anomaly of this enlightened nation being within reach of treasure that for more than a century they have been unaware of, and have remained persistently blind to."

All this is very entertaining, and furnishes a neat text for a few remarks on the history of this belief, as well as an opportunity for demonstrating to the public a fact which has for forty years or more been known to ichthyologists, that the Turbot and the Sole never have been seen on the western side of the Atlantic, and never will be, unless they are introduced by artificial means.

From the beginning to the end we encounter the well-known sources of confusion—the giving of old-world names to species which resemble in a general way the old-world species which bear them, and the unquestioning acceptance of these names as authoritative, by persons who are not trained to close discrimination.

When Boston was occupied by the British during the revolutionary war, the officers of the fleet are said to have been bountifully supplied with Turbot, which was caught in the neighborhood of an outer harbor. This fact is recorded by Dr. J. V. C. Smith, in his "Natural History of the Fishes of Massachusetts" (Boston, 1833), on the authority of William Ladd, esq., of Maine. He also mentions "a statement of Mr. Parker, the conductor of the marine telegraph," who told him that "many years before, Admiral Sir Isaac Coffin brought out to this country a trawl-net, such as is used on the coast of Holland, for taking Sole for the London markets, with which he succeeded in capturing that delightful fish in Ipswich Bay, which was not before supposed to exist here." The fish found in this manner were no doubt the common Flat Fishes of Massachusetts Bay. The common Flounder, *Paralichthys dentatus*, taken in Provincetown water, where it is commonly called "Plaice," was in 1880 sold in Boston under the name "Turbot." Captain Mackinnon, of the Royal Navy, who visited this country in 1850, conceived the idea that Turbot ought to be found on the shores of the United States, and took pains to search for them with a trawl-net. The nets which he used had been imported ten years before by Mr. Nathan Smith, an American gentleman, who had hoped to introduce them, but had never used them. Captain Mackinnon tried one net at Newport, Rhode Island, and succeeded in taking a number of different kinds of Flat Fish. He carefully refrains, however, from pronouncing any one of them to be identical with the Turbot or Sole, though from the vagueness of his language it is evident that his ichthyological knowledge was very scanty, and that he was not accustomed to observe the differences between the different species of fishes which somewhat resemble each other. His experiences are described at length in his book of travels, entitled "Atlantic and Trans-Atlantic Sketches, Afloat and Ashore" (Harper & Bros., New York, 1852, pp. 166–170). Capt. C. C. Churchill, U. S. A., who saw the results of Captain Mackinnon's experiment, tells us that the fish taken were the common species of New England flat fishes and flounders.

We fancy that the inspiration of the new advocate of the turbot-in-America question, as well as the information upon which he bases his conclusions, was drawn from this very same book of Captain Mackinnon, for he uses many of the same phrases, and he repeats, in almost the same words, Captain Mackinnon's statement: "The fish markets in America are not at all in keeping with the size and wealth of the States," a statement which, however true it may have been thirty years ago, will be amusing to any one who has recently had opportunity to compare the fish markets of America and Europe. The Philadelphia gentleman sums up his evidence as follows:

"The Turbot, Sole, and Plaice are, however, in abundance in your deep-water sand banks. They were caught there in 1812 by English sailors, and in 1880 Turbot have been obtained off Atlantic City, if the 'Baltimore American' is any authority."

The notion that the introduction of the English trawl in America would be novel and would at once open up a field for a fishery industry of boundless extent, deserves a word. The trawl has been assiduously used by the summer collecting party of the United States Fish Commission for ten years past, and also by Professor Agassiz upon various exploring trips. The steamers of the Fish Commission have used it on every portion of the New England coast, and as far north as Halifax. Professor Agassiz has used it in the Gulf of Mexico and on the coast of Florida, and during the present summer, while on the Coast-Survey steamer "Bache," has employed it in running five lines of research at right angles to the coast from Cape Hatteras, at points nearly equidistant between Charleston and Cape Cod, one of them directly out from the entrance to Delaware Bay. These lines were carried from near the shore to a depth of twelve hundred fathoms or more.

In 1854 Professor Baird made a careful exploration of the coast of New Jersey with a special reference to the fishes, and since that time every stretch of coast line from Brownsville, Texas, to Eastport, Maine, has been thoroughly investigated by the officers of the United States Fish Commission. It is true that a new species of fish is occasionally discovered, but the new fishes always belong to one or two classes. These are either swift-swimming species, members of the West India fauna, which come upon our northern shores in summer, or they are inhabitants of waters more than six hundred feet deep, which have never previously been explored. The Turbot and the Sole are shallow-water species, and, had they occurred in our waters, would have been discovered many years ago.

There are twenty-six species of flat fishes on the east coast of the United States. Four of these belong to the same family with the Sole, but are utterly worthless as articles of food. The nearest relative of the Sole is often called the American Sole, *Achirus lineatus*, and is known on the coast of New Jersey as the Hog-choker, Cover-clip, or Cover. Of the other flat fishes only two are positively unfit for food, and these two, strangely enough, are the representatives of the subfamily *Rhombinæ*, to which belong the Turbot and Brill of Europe. One of these, *Lophopsetta maculata*, is sometimes called the Spotted Turbot, and in New Jersey is called Window-pane, or Daylight, because it is so thin that when held to the light the sun can be seen through its translucent flesh.

The most important Flat Fish is the Halibut, which is identical with that of Europe. This species, and the Pole Flounder, which has recently been brought to light in our waters by the Fish Commission, are the only two of the number referred to that are found on both sides of the Atlantic. We have in our waters an abundance of flat fishes, some of which, for instance, the common Flounder of the New York market, *Paralichthys dentatus*, are probably fully equal to the Turbot for food uses. In fact, it may be had in the New York restaurants and hotels under this name. Another fish, *Platysomatichthys hippoglossoides*, resembling the Turbot in flavor, is sometimes brought to New York in winter. It is found at great depths on the coast of Newfoundland, and is often called the American or the Newfoundland Turbot. The Pole Flounder is very similar to the Sole in flavor and in the texture of its flesh, but it unfortunately inhabits somewhat inaccessible localities at great depths, and it is hardly to be expected that, with the present supply of excellent food-fish to be obtained at so much smaller expense, our fishermen will take the pains to go in search of it. That the popular taste for flat fish is already cultivated is shown by the fact that, in 1879, 1,796,000 pounds were sold in New York alone.

It is needless to refer to the efforts of the United States Fish Commission to introduce Sole; they are familiar to all who are interested in the subject. The introduction of the trawl-net has been for many years under consideration, but this expensive mode of fishing does not seem to be required at present, since the supply of fine-flavored food-fishes is more than equal to the demand. With an eye to the interest of the American fishermen, Professor Baird has recently detailed an attaché of the Fish Commission, one of the most experienced fishermen of Massachusetts, to study the trawl fishery in the German Ocean, and his report will soon be published.

Finally, it may not be amiss to state that Mr. E. G. Blackford, of Fulton Market, New York, has for some time been authorized by the Commissioner of Fisheries to pay twenty-five dollars to any one who should present a true Turbot or a true Sole, caught on this coast. This offer is still standing.[1]

[1] Forest and Stream, xv, No. 6, September 9, 1880, pp. 103, 104.

56. THE PLAICE—PARALICHTHYS DENTATUS.

The Plaice, Summer Flounder, or Turbot Flounder, *Paralichthys dentatus*, is, next to the Halibut, the most important flat-fish on the eastern coast. It is a member of a genus not existing in Europe, though represented on our own Pacific coast, in China and Japan, and in the Indian Ocean. Its affinities are with the Halibut, which it much resembles in form, and to which it is more similar in flavor than to the Turbot and Brill, so well known in transatlantic fish markets. Our common species was first brought to notice in 1766, when Linnæus received specimens from South Carolina, sent him by Dr. Garden. It seems at that time to have been of recognized commercial importance, since it was one of the few received by Linnæus from Garden which had a common name. In South Carolina at this time it was called Plaice, and this is a name which is now accepted in the New York market and about Cape Cod, although it has never been recognized by those who have written books on American fishes. The fishermen of the Saint John's River also use the name Plaice, but whether for this species has not been determined. In Connecticut, North Carolina, and in Florida, east and west, as well as on other parts of the coast, the names Flounder and Common Flounder are current. In New York and New England the name Summer Flounder is also frequently heard. In Rhode Island the names Brail and Puckermouth are used, the former doubtless a modification of the English name Brill, while on the bills of fare in Boston and New York hotels it is often called the Deep-sea Flounder, at least since the Pole Flounder has been brought to notice by the Fish Commission, and has obtained a reputation as a delicious table fish. Fishermen sometimes mistake them for young Halibut, and they doubtless at times are sold under the name of "Chicken Halibut." Turbot Flounder is another name which has been suggested, but, upon the whole, Plaice seems most desirable for general adoption.

This fish is abundant upon the eastern coast of the United States from Cape Cod to Cape Florida, and according to Mr. Stearns' report is also found along the entire Gulf coast. Southward, its range extends at least as far as Paraguay. To the northward it barely rounds Cape Cod. Captain Atwood remembers that in the first half of the present century great quantities of Plaice were found inside the Point at Provincetown. They were so numerous that in one afternoon he caught two thousand pounds. They are now only occasionally taken, and have not recently been seen north of Provincetown, though Storer has recorded their occurrence at Wellfleet. Captain Atwood attributes their disappearance, which was nearly simultaneous with the advent of the blue fish, to the fact that blue fish destroyed their favorite food, the squid, and rendered it impossible for them to live longer in these waters. The Plaice has been much less abundant in Cape Cod Bay within the last thirty years, but there is no evidence of considerable diminution in numbers elsewhere. On the eastern coast of Connecticut and Long Island, where the Plaice fishery is most extensively prosecuted, it is the opinion of experienced fishermen that no change in numbers has been perceptible within the last thirty years. The Connecticut fishermen say that they are frequently so abundant that they have only to throw out and pull in their lines, catching "all they choose," while the bottom seems to be carpeted with them.

Like others of its tribe, the Plaice are usually upon the bottom, where their peculiar shape and color protect them from observation and give them excellent opportunity to capture their prey. In the north they are usually found at a depth of two to twenty fathoms, and in winter move off into deeper water. In New Jersey they occur at lesser depths. Professor Baird records that they are sometimes taken in large numbers by means of nets in the deep slues along the beach. In winter they do not run out so far into deep water, and "at times," says Professor Baird, "seem to be quite torpid on the shallow grounds, suffering themselves to be taken up with oyster-tongs

without making any attempt to escape." Still farther south they are found in the shallowest of water. The fishermen of Saint John's River seine them in the grass along the shores at a depth of three or four feet. Mr. Stearns writes, speaking of the eastern part of the Gulf of Mexico: "They are found mostly in the bays and bayous where the bottom is muddy or grassy, but it is not unusual to find them in shoal water along the sand beaches of the coast and bays. Very shoal water seems to be particularly attractive, and they are often found at the water's edge embedded in the sand, with only their eyes in view. When alarmed or in pursuit of prey their movements are very swift, and the quickness with which they bury themselves in the sand is quite wonderful."

Their habit of ascending Southern rivers is remarkable. They are said to occur in Lake George and the other lakes at the headwaters of the Saint John's and the Ocklawaha Rivers. At Jacksonville they are commonly taken in company with bream, black bass, and other fresh-water fish, in winter as well as summer.

Although present in the shoal waters of Florida throughout the year, Mr. Stearns states that they are most abundant in summer. On the Connecticut coast, however, their habit of migrating seaward is much more pronounced. The Noank fishermen never find them until May. They say that they never catch them until after they have fished awhile for sea-bass. As early as the first of October they begin to grow scarce, and none are ordinarily caught after the middle of the month. I cannot find that they have ever been seen moving in schools, though fish taken in the same locality at the same time are usually quite uniform in size. They shift their position, probably in search of food, and where any are found they are plenty. This indicates that they are gregarious in habit: the abundance of food in special localities sufficiently explains this fact.

The Plaice feed upon small fish, shrimps, crabs and hermit crabs, squid, small species of shell-bearing mollusks, and certain radiates, such as sand-dollars. They are frequently seen at the surface, rapidly swimming, and even jumping out of the water, in pursuit of schools of sand-eels and sand-smelts. They also feed upon dead fish thrown out from the fish-houses. Little is known of their breeding habits. All the large females observed in July and August, 1874, upon the Connecticut coast contained spawn, but this was, evidently, far from maturity. The Fish Commission has obtained no very small specimens; in fact, none less than eight or nine inches in length, though the fishermen speak of capturing six-inch individuals. Their average length is from sixteen to thirty inches, and the weight about two and a half pounds, though it is not unusual to take individuals weighing seven or eight pounds. At Noank about eighty fish are ordinarily packed in a barrel, weighing from 160 to 175 pounds. The largest ever brought to Noank weighed twenty-six pounds. Others, of whose capture I have informed, weighed twenty, seventeen and a half, and fifteen pounds. In Florida and at Provincetown I have seen them three feet in length. A one-pound fish measures about fifteen inches; a one and a quarter pound fish, sixteen or seventeen; a two-pound fish, seventeen or eighteen; a three-pound fish, about twenty; a four-pound fish, about twenty-two; an eight-pound fish, about twenty-seven, and a ten-pound fish, about thirty inches. These proportions are taken from notes relating to a large number weighed and measured at Noank, Connecticut. The Winter Flounder or Flat Fish spawns in late winter and early spring near the shore, and it is possible that the Plaice breeds at about the same period.

The most extensive fishery for the Plaice is in the waters of Southern New England. Favorite fishing grounds are on sandy bottoms, at a depth of ten to twenty fathoms, along the Atlantic side of Block Island, Martha's Vineyard, and Eastern Long Island, where they are most plentiful. They are obtained in smaller numbers in the harbors and bays along the south shore of New England, on Shagwam and Middle Ground Reefs, in Fisher's Island Sound and Long Island

Sound, and outside of Fisher's Island. They are also taken in considerable numbers in the pounds of this region, occasionally five or six hundred at a time. The quantity taken in the weirs of New England in 1876 was estimated as follows:

	Pounds.
Weirs on north side of Cape Cod	436
Weirs on south side of Cape Cod	36,000
Weirs in Vineyard Sound	326,620
Weirs in Buzzard's Bay	15,749
Weirs on Block Island, estimated	94,500
Weirs in Fisher's Island Sound, estimated	4,000
Weirs on east end of Long Island	14,000
Traps in Rhode Island	172,250
	663,555
From other localities	50,000
	713,555
Estimated annual catch of Flat Fish	600,000
	1,313,555

Value of the above, at four cents a pound, $52,542.

These statistics of the catch in pound-nets include Plaice and Flat Fish, and in the statement of the total catch no distinction will be made between these two species.

Immense numbers of them are sometimes taken in large seines hauled up on the beach. In 1876 E. Cleveland seined 128,000 pounds at Menemsha Bight, Massachusetts. By far the greater quantity, however, is taken by small fishing smacks belonging to and hailing from Noank, Mystic, and New London, which pursue this special business from May until October. These vessels are usually absent from port four or five days, and spend two days in fishing. The fish are shipped in ice from Noank and New London principally to New York, and also to inland cities in the vicinity. A single smack, with a crew of a man and two boys, usually will obtain and ship to New York, on an average, about 12 barrels a week, about 160 barrels a year, or 25,000 to 28,000 pounds. Captain Palmer, of Noank, in 1873, caught on one trip of two days about 1,000 fish, weighing, perhaps, 2,000 pounds. On this trip he used four lines. A good fisherman is able to manage two lines, each carrying two hooks. Menhaden bait is always used by professional fishermen, though I have caught Plaice to good advantage with lobster bait. A vessel usually consumes one barrel of menhaden on each trip. The fish strike the hook sharply as soon as it approaches the bottom, giving little opportunity to the skates, which very seldom get a chance at a Plaice's hook. In this respect they are very different from the cod. When the fish have been hauled to the surface, they are quickly transferred, with as little injury as possible, to the well of the smack, which is amply large enough to hold a product of two or three days' fishing. They are thus brought alive to the place of shipment and reach the markets in excellent condition, a fact which partially explains their popularity compared with that of other fish of the same family.

In 1877 there were seven smacks engaged in this fishery—one from Mystic, one from New London, and five from Noank. It was estimated by the owner of one of these vessels that each vessel made on an average fifteen trips during the summer, and that each trip averaged 800 fish, weighing 1¾ pounds each, making a total of 1,400 pounds to a trip, or 21,000 pounds to the season, thus giving an aggregate of 147,000 pounds as the result of this branch of the fishery.

Captain Atwood states that in 1846 he began catching Plaice for the Boston market, in Provincetown Harbor, anchoring where the keel of the smack would just clear the bottom, and anywhere near Race Point he could catch them in great numbers, the largest weighing from ten to fifteen pounds each. In one afternoon he caught two thousand pounds. These he carried to Boston in the

well of his smack and tried to sell, but was unsuccessful, though they were offered under the name of Turbot, local prejudice being against them. In 1879 there were seven or eight boats engaged in the plaice fishery during the month of June, this month being the best for plaice fishing. In the latter part of July, when I made my observations, all of the winter boats had quitted for the year.

The method in use here is somewhat peculiar, and merits description. The fishermen call it "drailing for Plaice." The boat used is an ordinary cat-boat, managed by one person, and is allowed to drift with free sheet before the wind, while the fisherman stands in the stern dragging the line over the bottom, baited with a bit of squid or clam. The boat is kept as nearly as possible over the places where the flats are deepening most abruptly into the basin of the harbor, and where the water is from eight to eighteen fathoms deep. Only very large fish, weighing ten, fifteen, sometimes even twenty pounds, are taken in this manner. The average catch is from eight to twenty a day. In one day one man reported eight, one fourteen, one twenty-three. Some of these fish are sold in Provincetown, but the greater portion is sent iced to New York, where a price of twelve cents a pound, wholesale, is easily obtained. In Boston there is no market for them.

On the coast of New Jersey Professor Baird states that in 1854 they were taken in large numbers, by means of nets, in the deep slues along the beach. Along the southern coast they are occasionally taken by the line fishermen, and a considerable quantity is seined by the river fishermen. In the Gulf of Mexico they are rarely taken by hook and line, and are usually speared or jigged at night, by torchlight.

The Plaice has always been the most popular of our in-shore flat fishes, being exempt in a certain degree from the prejudice attaching to the fishes of this family. It seems to have been a common food-fish in South Carolina as early as 1760, and Schoepf mentions it as one of the food-fishes of New York in 1776. In 1856, according to Gill, it was found in the New York market in autumn, but seems to have been less in favor than the Flat Fish. At present the Plaice is growing in favor in New York, and is upon the lists of all good restaurants, though perhaps not so generally consumed as the Flat Fish, which comes in the winter, when the market is less lavishly supplied.

In Boston, and indeed throughout the greater part of New England, this, with all other Flounders, is considered unfit to eat, and it is by no means generally popular along the Southern coast, though in Florida its flesh is highly prized. The Connecticut fishermen esteem it greatly, and when preparing it for their own use are accustomed to hang it in the open air for a day or two "to dry," as they say. The wholesale price in New York varies from one and a half to six cents, but is usually three cents a pound.

Another species of Flounder, closely related to the Plaice, is the common Four-spotted Flounder, *Paralichthys oblongus*, which occasionally finds its way to market in company with the Plaice, and is doubtless sold under the same name. It is a small species, rarely attaining a greater length than twelve inches and a weight of one pound. It may be readily distinguished by the presence upon the back of four large, dark spots, elliptical in form, but these soon fade out after death.

Its distribution is much more restricted than that of the Plaice; it is most abundant, at a depth of ten to forty fathoms, off the southern coast of New England; it rarely occurs north of Cape Cod, though one individual was taken by the Fish Commission at the mouth of Salem Harbor, nor has it been recorded south of New York. There are two smaller species upon the Southern coast—one, *Paralichthys quadrocellatus*, broader than *Paralichthys oblongus*, also marked with four dorsal spots, and known in the South as the Four-spotted Flounder. This species has been observed as far north as Charleston and Fort Macon, while its western record of limit is Pensacola. Stearns records it as common from Cedar Keys south to Key West, and pronounces it an excellent food-fish.

It cannot at present, however, be considered very important. The other species, *Paralichthys stigmatias*, occurs in deep water (seventy-five fathoms) off the coast of South Carolina, and may be distinguished by the presence of three conspicuous spots upon the upper side of the body.

57. THE BASTARD HALIBUT.

This fish (*Paralichthys maculosus* Girard), writes Jordan, is known as the Halibut, Bastard Halibut, and Monterey Halibut. South of San Francisco, where the true Halibut is not found, the larger individuals, which really greatly resemble the Halibut, are known by that name, the young being rarely distinguished from other "Soles." At San Francisco, where the true Halibut is known, this species is called the Bastard Halibut, and sometimes the Monterey Halibut, as they are mostly brought from Monterey. It reaches a length of three feet and a weight of sixty pounds; the largest seen by us weighing fifty-five pounds. A great majority of those taken weigh less than three pounds, and it is said that large individuals are much less plenty than they formerly were. Its range is from Tomales Bay to San Diego, and south of Point Concepcion. It is the commonest species of its family. Although not rare at San Francisco, it forms no more than four per cent. of the entire flounder catch. It lives in rather shallow water, the young abounding close to shore, large ones being taken in the gill-nets. Large ones are more abundant at Monterey than farther south. It feeds upon fishes and crustacea, and in its habits seems very similar to the Eastern *P. dentatus*. It spawns in early summer, like other large fishes. It is subject to the attacks of the Hag Fish, *Bdellostoma Dombeyi*.

As a food-fish, it does not rank very high, the large specimens being tough and coarse compared to the Halibut, while the young are inferior to most of the species termed "Sole."

58. THE FLAT FISH, OR WINTER FLOUNDER.

Next in importance to the Plaice comes the Flat Fish, *Pseudopleuronectes americanus*, or Common Flounder, sometimes called the "Winter Flounder," said to be known in Massachusetts Bay as Mud-dab, and occasionally to be sold in New York under the name of Sole. This fish, like the Plaice, belongs to a genus unknown to Europe, but is closely related to the common Flounder, or Fluke, of the British coast. Its range is somewhat extensive, and in a certain degree it replaces the Plaice along our northern coast. It has not been observed south of Chesapeake Bay, but northward is common in the Bay of Fundy, on the eastern shores of Nova Scotia, and in the Gulf of Saint Lawrence, and, as far as observations have been made, upon the coast of Labrador.

Storer, writing in 1849, remarks: "It is probably the most common Flounder on the southwest coast of Labrador; we met with it first, though but sparingly, at the Saint Mary's Island, and observed it as far easterly as Bras d'Or, where it is to be found in immense numbers, the bottom being almost alive with them, and of large size."

Flat Fish are always upon the bottom, feeding chiefly upon minute shells, such as *Nucula* and *Bulla*, upon young crabs, or whatever they can find among the stones in the mud. Their mouths are very small, and since they would be unable to seize and kill other fish, they never come to the surface in pursuit of prey, as do the large-mouthed Flounders. They prefer sheltered bays and harbors, and appear to be equally abundant on the bottoms of the sand, mud, or rock; when at rest, they are usually partially embedded in the mud or sand at the bottom. I have observed that, when they come to a stop, they always settle themselves by convulsive motions of the fins and body, which has the effect of pushing them down into the soft bottom. This species is probably a more permanent resident of the localities which it inhabits than any other on our coast,

unless it be the sculpins. There is very little evidence of a tendency to move to and from the shore with a change of season. Winter and summer, they appear to be equally abundant from New York to the Bay of Chaleur, where, in the tide-way of Miramichi River, they are caught in winter through holes in the ice. In Labrador they are described as exceedingly abundant in summer, but nothing is known of their winter habits. Professor Baird found them scarce in Southern New Jersey in summer, but learned that they were very abundant in the bays in winter. Small quantities are brought to Washington in winter from the mouth of the Chesapeake.

The spawning season occurs early in spring, in February and March on the Connecticut coast, and is thought to be closed by the first part of April. Young fish of half an inch in length are found in July in the deeper parts of the bays and sounds, and in August and September, having attained the length of one and one-half to five inches, occur in great abundance in the coves and along the sandy shores of the Southern New England coast, in very shallow water. Their growth is probably rapid, though it would seem most likely that the five-inch specimens, just referred to, were eighteen months rather than six months old. The largest that have been discovered were fifteen inches long, and would weigh from one to one and a half pounds.

The flesh of the Flat Fish is solid, white, and of excellent flavor, and deserves a more general popularity than it has yet attained. It is, and has been for the last century, largely consumed in New York in winter. Schoepf, writing in 1776, mentions it as occurring in the market in spring; later, writing in 1818, he states that small numbers were found in the stalls in January and February, taken with spears while searching for eels. These were not very inviting, owing to their mangled appearance and frozen state, but, with the disappearance of ice and the approach of spring, their numbers increased, and in March the stalls were well filled with them, cheap and fresh and good. They were only used as pan-fish. Gill wrote, in 1856: "This is the most common species of flounder that is brought to the city markets in the winter and spring months; it is seldom sold at a higher price than eight to ten cents per pound. Flounders are chiefly sold by the weight; occasionally they are strung through the branchial apertures on twigs and nominally sold by the bunch."

The Smooth Flounder, or Christmas Flounder, *Pleuronectes glaber*, is very similar in habits and appearance to the Flat Fish, and is still closer to the Flounder of Europe, being a member of the same genus. It may be distinguished from the former by its smooth skin, which has given to the species, in some localities, the name "Eel-back." Its distribution is extremely limited, it having been recorded as only found in Salem, Massachusetts, Portland and Belfast, Maine, or within the limits of two degrees of latitude. Its range may in the future be extended farther to the north, but it is certain that at present none occur south of Salem. In Casco Bay they are very abundant in summer, and the Fish Commission secured great quantities of them in water three or four fathoms deep in Bluelight Cove. They have never elsewhere been observed, except in winter, about Christmas time, when they come into the harbors to spawn. At Salem they are, on this account, called the Christmas Fish. Considerable quantities are caught every year by spearing them upon the sand. At this place they are also called "Fool Fish," because, in their anxiety for food, they will bite at any kind of bait, even at a rag. The spawning season is short, and they soon retire into deeper water. At Portland, and in the vicinity, considerable numbers are taken in the winter fishery in company with the Flat Fish, and with them are sent to New York and neighboring markets. In one instance a quantity was offered for sale in the markets of Washington. The spawning season on the coast of Maine is slightly earlier than that of Massachusetts, beginning as early as the middle of December, while in Penobscot Bay they are taken at the very beginning of the month, full of spawn. In Penobscot Bay they are taken in traps, or "fliers," as the fishermen call them, shaped

something like lobster-traps and baited. The young Smooth Flounder may be taken in summer on the beaches. The largest females observed weighed twenty-three ounces, the weight of the spawn being seven ounces. Too little attention has hitherto been paid to this fish, but it seems more than probable that in the future it will greatly increase in favor.

59. THE FLAT FISHES AND SOLES OF THE PACIFIC COAST.

By DAVID S. JORDAN.

THE STARRY FLOUNDER—PLEURONECTES STELLATUS Pallas.

This species is known, wherever found, as the "Flounder," all others being considered as Bastard or False Flounders. At San Francisco the name Flounder is rarely used in a generic sense, but only as a special appellation of this species. It reaches a length of nearly three feet, and a weight of fifteen to twenty pounds, larger individuals being found northward than southward along the coast. The average length in the market is about fifteen inches, and the weight two or three pounds. Its rate of growth is probably rapid, but we have no certain data in regard to it.

It ranges from San Luis Obispo to Kamtchatka, and from San Francisco northward it is by far the most abundant species. It probably constitutes half, by weight, of the total annual catch of Flounders on the Pacific coast. It enters the mouths of rivers, and considerable numbers are taken in the salmon-nets on the Lower Columbia. It is found in water of moderate depth, and is taken in seines and gill-nets, and sometimes with the hook.

Its food is crustacea, mollusca, and such fishes as it can swallow, its mouth being comparatively small. It spawns in summer. Nothing special is known of its breeding habits. It has no especial enemy that we know of, with the exception of a tetradecapod, known as "fish-louse," which is very frequently found attached to the fins, gill-membranes, and gills of this and other species of flounders.

As a food-fish this species is held in rather high esteem. The flesh is firm, and although coarser than in the so-called Soles, is of fair flavor in the young. The very large individuals (eight to twenty pounds) are sold at a lower price, and are considered poor eating. A considerable portion of those in the San Francisco market come from Humboldt Bay.

This, according to Dr. Bean, is one of the most widely distributed littoral fish known to exist, ranging in North America to the mouth of the Colville and Anderson Rivers on the arctic coast. It enters extensively into the resources of Alaska, being the largest and most abundant of its kind in that region.

A related species, *P. glacialis*, is especially abundant in Northern Alaska, occurring plentifully as far south as Saint Michael's. Although small, its great abundance and fine flavor make it important as an article of food. Traveling parties of Eskimos generally have a supply of this fish in their bidarras. They are usually eaten raw.

THE ROUGH LIMANDA—LIMANDA ASPERA (Pallas) Bean.

This species, according to Dr. Bean, is smaller than its Atlantic relative, *Limanda ferruginea*, which it closely resembles, and its range is rather limited. It is found about Unalashka and has been taken at Sitka, Wrangel, and other localities in the Gulf of Alaska. Its flavor is fine, and it is used extensively for food by Eskimos and Indians.

THE DIAMOND FLOUNDER.—HYPSOPSETTA GUTTULATA (Girard) Gill.

In the neighborhood of San Francisco this species is known as the "Turbot," many of the dealers stoutly averring that it is identical with the English fish of that name. South of Point Concepcion the name Diamond Flounder is in use. This refers to the rhombic form of the fish, and the name seems an appropriate one. It reaches a length of eighteen inches and a weight of four pounds, but as usually seen in the market its length is about one foot.

The geographic range of this species seems to be from Cape Mendocino to Magdalena Bay. It seems to be more plentiful in the bays of Tomales and San Diego than elsewhere, apparently preferring shallow water and sandy bottoms. It is one of the more abundant species, forming perhaps two per cent. of the catch of Flounders in the neighborhood of San Francisco.

Its food consists mainly of crustacea and small mollusks. Nothing special is known of its breeding habits. Its enemies are those of all Flounders, and no diseases have been noticed. As a food-fish it ranks high. It is one of the most firm-fleshed of the Flounders.

THE "SOLES" OF CALIFORNIA.

LEPIDOPSETTA BILINEATA (Ayres) Gill.

This species has no other distinctive name than "Sole." It reaches a length of twenty inches and a weight of five or six pounds. Its average weight in the market is about three pounds. It ranges from Monterey to Alaska, and its relative abundance steadily increases as we go northward from Monterey to Vancouver's Island. In Puget Sound it makes about thirty per cent. of the flounder catch; about San Francisco barely two per cent. It lives in rocky places in deep water, and most of those taken about San Francisco come from the neighborhood of the Farallones. It takes the hook more readily than any of the other small-mouthed Flounders, and considerable numbers are taken by the Chinese on their set-lines, especially at Monterey. They feed chiefly on crustaceans and small fishes.

Nothing special is known of its breeding habits, and nothing distinctive of enemies or diseases. It is perhaps more subject to the parasitism of the fish-louse than any of the other species.

Dr. Bean found this fish abundant in Alaska, and one of the most important of the flat fishes in that territory. It is there regarded as an excellent food-fish. The natives spear it as it lies entirely concealed in the loose sand along shore, where it comes at eventide to feed on small crustaceans.

PAROPHRYS ISCHYRUS Jordan and Gilbert.

Four specimens only of this species have been seen. These were taken with a seine at Seattle. It resembles the preceding in appearance, and probably in habits. Those seen were about eighteen inches long, and weighed about three pounds.

"This is a coarse, rough fish in its general appearance, greatly resembling the Flounder, *Pleuronectes stellatus*, but differing from it in the ctenoid scales, and in the presence of an accessory lateral line, characters in which it agrees with the next species. It has hitherto been found only in Puget Sound, and reaches a length of about eighteen inches."—*Lockington*.

PAROPHRYS VETULUS Girard.

This species is always called Sole by the fishermen. It is one of the smallest species, reaching a length of about fourteen inches and a weight of about two pounds. Those usually seen in

market average less than half a pound. It is found from Santa Barbara to Alaska, and from San Francisco northward is extremely abundant. In number of individuals taken, this species is exceeded only by *Pleuronectes stellatus*. In number of pounds it probably ranks below *Hippoglossoides Jordani*. It forms about one-fifth the whole flounder catch of the coast. It lives near the shore, and is taken in gill-nets and seines. It feeds on crustacea and the like. As a food-fish it meets with a ready sale, but its flesh is rather poor and tasteless. It spawns in spring. Nothing further is known of its breeding habits, and nothing of its enemies or diseases. It is often found in the stomachs of larger predaceous fishes.

Its flesh is softer than that of other Flounders, and it does not make an attractive appearance in the market. It always readily sells, however, and the quality of the flesh is probably better *than that of some of the other kinds.*

PAROPHRYS ISOLEPIS (Lockington) Jordan and Gilbert.

This species, too, is a Sole to the fishermen. It reaches a length of about fifteen inches and a weight of about two and a half pounds. Its usual length is about ten inches, with a weight of half a pound. It ranges from Monterey to Puget Sound, inhabiting rather deep water and becoming larger in size and more plentiful northward. About San Francisco it is mainly taken by the paranzelle fishermen, who obtain it in great numbers, but it forms less than one per cent. of the flounder catch of the coast. Its food is mainly crustacea and mollusks. It spawns in spring, at which season the largest catches of it are made.

Large specimens of this species are sold with the best Soles (*Psettichthys*), which they greatly resemble. Small ones rank with *Glyptocephalus pacificus* and the like, and often cannot be sold.

CITHARICHTHYS SORDIDUS (Girard) Gthr.

This species is often known as the "Plaice" in Puget Sound. About San Francisco it becomes, like the others, a "Sole." It is one of the smallest species, reaching a length of fifteen inches, and a weight of two pounds. Its average weight in market is little more than half a pound. It ranges from San Diego to Puget Sound, being rare south of Point Concepcion, and most abundant about Monterey. It lives in comparatively deep water, and is considered distinctively a deep-water species by the fishermen in Puget Sound. It takes the hook very readily, and great numbers are taken on set-lines by the Chinese, to dry for market. It probably makes about eight per cent. of the entire flounder catch of the coast. It feeds on small fishes, the anchovy being one of its special articles of food.

PSETTICHTHYS MELANOSTICTUS Girard.

This species is everywhere a Sole, and at San Francisco it is considered to have a better claim to that title than any other species. It reaches a length of about twenty inches, and a weight of four or five pounds. Its average length is about fifteen inches. It ranges from Monterey to Wrangel, Alaska. It lives at no great depths, and is about equally abundant the entire length of the coast. Although never found in large numbers, it is always present in the markets, and forms some five per cent. of the entire flounder catch of the coast. It feeds upon fishes and crustacea.

Nothing special is known of its breeding habits, enemies, or diseases. As a food-fish it is considered the best of the family by those who distinguish it from related species.

HIPPOGLOSSOIDES JORDANI Lockington.

This species is known universally as the "Sole." I have also heard the Italian name "Soglia" applied to it more often than to related species. It reaches a length of eighteen inches, and a weight of six or eight pounds, the average being about three. It ranges from Monterey to Puget Sound, being comparatively scarce north of Cape Mendocino, but in Monterey Bay the commonest species, and forming probably fifteen per cent. of the Flounders in the market of San Francisco. Great numbers are taken by Chinamen on set-lines baited with anchovies. It lives in water of no great depth. It feeds upon anchovies, shrimps, and all sorts of small fishes and crustacea. It spawns in early summer. Nothing especial is known of its breeding habits. Its enemies and diseases are similar to those of other Flounders.

It is one of the best of the Flounders as a food-fish. Great numbers are dried yearly by the Chinese, who suspend them by strings on a frame placed on the roofs of the houses, as they are too fleshy to dry well on tables. Here they rustle in the wind, and, striking together, produce a sound like the wind among the leaves.

"It appears strange," remarks Lockington, "that this common species should have escaped the notice of naturalists until last year. In the markets of San Francisco it abounds throughout every month of the year, and in Monterey Bay it is the most abundant of its tribe. Professor Jordan informs me that about five hundred pounds' weight of this fish are taken daily at Monterey alone by the Chinese, besides large quantities taken by the Italians. An examination of the stock in trade of the Chinese located near Monterey, proved that over nineteen-twentieths of the fish that dry on hurdles and flap in the wind around the hovels consisted of this fish; a few sharks, with *Psettichthys melanostictus* and *Citharichthys sordidus*, constituting the remainder."[1]

It occasionally reaches sixteen inches or more in length and a weight of five pounds, and is considered one of the best of its tribe, but is inferior to the Black-dotted Flounder, the Turbot, and one or two others. It becomes rare northward, yet occurs in Puget Sound; south of Monterey it is not on record.

HIPPOGLOSSOIDES EXILIS Jordan and Gilbert.

This species is one of the smallest, reaching a length of about nine inches, and a weight of less than a pound. It inhabits deep waters on sandy bottoms from San Francisco to Puget Sound. It is taken in the sweep-nets of the paranzelle in spring off Point Reyes in enormous numbers, sometimes nearly a ton at a time. In Puget Sound it is less common, although frequently taken in seines. It has not been noticed by naturalists until the present year, and has probably been rarely taken until the introduction of the paranzelle. It feeds on small fishes, crustaceans, etc. It spawns in spring, perhaps coming from still deeper water, as in the winter none were noticed in the markets. Its enemies and diseases are unknown. Most of those taken by the paranzelle are thrown overboard. The flesh is soft, and the fish does not sell for enough to pay for bringing it in.

This species is readily distinguished from the preceding by its much more slender form, and by the large size of the scales, which are very delicately ciliate on their hinder edge. The eyes are very large, their longitudinal diameter contained about three and one-third times in the length of the head. The greatest depth is contained about three and a half times in the total length.

In July it was tolerably common in the markets of San Francisco, and its previous rarity is probably occasioned by the fact that it is only taken in tolerably deep water, and is too small to be considered of much value.

[1] Report, Commissioner of Fisheries State of California, 1880, p. 25.

The specimens I have seen were from eight to ten inches in length, and three-quarters of a pound in weight. It occurs in Puget Sound, but is not very common.

HIPPOGLOSSOIDES ELASSODON Jordan and Gilbert.

This species reaches a length of about fifteen inches, and a weight of two or three pounds at least. It has been found in Puget Sound, in rather deep water about the wharves of Seattle, Washington Territory, and New Tacoma. It takes the hook very readily, and affords the boys considerable amusement. Its value as food is probably similar to that of *H. Jordani*.

Dr. Bean states that he has specimens from Kodiak, Unalashka, and the Shumagin Islands, Alaska. It is a food-fish of some importance in these localities.

XYSTREURYS LIOLEPIS Jordan and Gilbert.

This species reaches a length of fourteen inches and a weight of two pounds; ranges from Point Concepcion southward. It lives in water of moderate depth, usually about the kelp. It takes the hook readily, spawns in spring, and feeds on crustacea and small fish. It is too scarce to have any special economic value.

ATHERESTHES STOMIAS Jordan and Gilbert.

This species, so far as known, does not exceed eighteen inches in length and one and a half pounds in weight. It is perhaps the slenderest Flounder known. It has only been seen among fishes taken in the sweep-nets of the paranzelle off Point Reyes, and only about a dozen specimens are known. It probably inhabits considerable depths, and will doubtless be found to belong to the Alaskan fauna.

THE SLIPPERY SOLE—GLYPTOCEPHALUS PACIFICUS Lockington.

Like various other species, this fish is known as the Sole, wherever found. It reaches a length of fifteen inches and a weight of two pounds. As usually seen in the market, it is about eight inches in length and weighs about half a pound. It inhabits deep or cold waters, and ranges from Monterey to Vancouver's Island. In California it is only taken in deep water, and is therefore rarely brought in except by the paranzelle, who obtain it sometimes in enormous numbers. In Puget Sound it comes nearer shore, and is often taken in the seines. It has been brought into the San Francisco market only since the establishment of the paranzelle fishing a few years ago. Since then, it has rapidly increased in abundance in the market, and now makes about five per cent. of the Flounders sold in San Francisco. Many pounds of small ones are daily thrown away in the spring and summer. It feeds on crustacea and the like.

It spawns in May and June, and probably then comes into shallow water, as the catch is then greater than in winter. The large ones are considered among the best of the Flounders. The small ones are little valued. The whole body is excessively slimy when out of water, more so than in any other Flounder.

THE LONG-FINNED SOLE—GLYPTOCEPHALUS ZACHIRUS Lockington.

This species is likewise known as a Sole, but occasionally distinguished as long-finned. It reaches a length of eighteen inches and a weight of about two pounds. The average length is more than a foot. It has been thus far noticed only in deep water about San Francisco and Monterey. It is one of the least abundant of the Flounders, rarely more than a dozen coming into the San Francisco market in a week, and often for long periods none at all. Until the introduction of the paranzelle, it was unknown at San Francisco.

In respect to food, breeding habits, and localities, it agrees entirely with *G. pacificus* so far as we know. Its skin is not slimy, and its flesh is very firm and white, and said to be of very superior flavor, similar to that of the European Sole.

"Up to the present time," says Lockington, "this species is only known from the markets of San Francisco, to which it is brought from deep water near Point Reyes, some thirty miles north of the city. It is comparatively rare; seldom more than three or four are offered for sale on any one day, and it is not brought in at all in the winter. It attains a length of eighteen inches, and a weight of about two pounds, and is held in high esteem. Hitherto it is only known to occur in Monterey Bay and in the vicinity of San Francisco. As its mouth is too small for the hook, and its habitat too deep for the gill-nets, it is taken chiefly in sweep-nets."

The three following species are very similar in size, appearance, habits, and value, and the same remarks, except in regard to distribution, will apply to them all:

PLEURONICHTHYS VERTICALIS Jordan and Gilbert.

PLEURONICHTHYS QUADRITUBERCULATUS (Pallas) Lockington.

PLEURONICHTHYS CŒNOSUS Girard.

These three species have no distinctive popular names, the fishermen confounding them with various other species under the name of Turbot and Sole.

As usually seen in the markets, these species average about ten inches in length, *P. verticalis* being usually the smallest of the three, and *P. quadrituberculatus* the largest; all, however, reach sometimes a length of fifteen inches and a weight of two or three pounds.

P. quadrituberculatus and *P. verticalis* have been thus far noticed only in Monterey Bay and about Point Reyes and the Farallones. *P. cœnosus* is found from San Diego to the Aleutian Islands, and is especially abundant in rocky coves about Puget Sound. All three of them are now migratory and live in considerable depths of water, being rarely taken near shore except in the spawning time.

Compared with other Flounders, none of these are ever abundant. Fifteen individuals of the three species together would be a large proportion in one haul of the gill-net in Monterey Bay, in the season of their spawning. At other times they rarely come near enough to shore to enter a gill-net.

Unlike the other Flounders, these three species feed chiefly or entirely on plants; the stomach and intestines are always full of algæ, and, although they occasionally take the hook, animal food makes a small portion of their diet.

These species spawn in the spring, chiefly in May and June. Nothing is known of their breeding habits, further than that they are taken in the gill-nets and in the sweep-nets of the paranzelle in greater numbers at that season than earlier in the year, and they probably spawn in sandy places, and otherwise live among the rocks.

No special enemies are known, other than predatory fish, and no diseases have been observed. As food-fish, they are not distinguished from related species.

60. THE HALIBUT—HIPPOGLOSSUS VULGARIS.

The Halibut, *Hippoglossus vulgaris*, is widely distributed through the North Atlantic and North Pacific, both near the shores, in shallow water, and upon the off-shore banks and the edges of the continental slope down to a depth of two hundred to two hundred and fifty fathoms or more. In the Western Atlantic the species has not been observed south of the fortieth parallel, stragglers

having occasionally been taken off Sandy Hook, Block Island, and Montauk Point, while it ranges north at least to Cumberland Gulf, latitude 64°, and to Holsteinborg Bank in Davis Strait, and as far as Disko and Omenak Fiord, latitude 71°, on the coast of Greenland, five or six degrees within the Arctic Circle. Along the entire west coast of Greenland they exist, abundant about Iceland and north to Spitzbergen, in latitude 80°. No one knows to what extent they are distributed along the European and Asiatic shores of the Arctic Ocean, but they have been observed on both sides of the North Cape, in East and West Denmark, and from the North Cape, latitude 71°, south along the entire western line of the Scandinavian Peninsula, in the Skager Rack and Cattegat, but not, however, so far as I can learn, in the Baltic. Halibut are occasionally seen in the southern part of the North Sea and in the English Channel: south of latitude 50° their range in the Eastern Atlantic appears to cease. There is yet some question whether it is found in Southern Ireland, but some of the largest individuals recorded from Great Britain were taken in the Irish Sea, off the Isle of Man.

On the Pacific coast the Halibut, which has been shown by Dr. Bean to be identical with that of the Atlantic, ranges from the Farallone Islands northward to Bering Straits, becoming more abundant northward. "Its center of abundance," says Bean, "is in the Gulf of Alaska, particularly about Kodiak, the Alexander Archipelago, and the Shumagins. Large halibut are numerous about the Seal Islands, but the small ones have been killed by the seals. I have heard from good authority of their capture as far north as Saint Lawrence Bay, near East Cape, in Siberia. It has several times been reported from off the heads of Marcus Bay, Siberia." It is occasionally taken off San Francisco and about Humboldt Bay. In the Straits of Fuca and in the deeper channels about Puget Sound it is taken in considerable numbers.

A large halibut bank exists in the mouth of the Straits of Fuca, about nine miles from Cape Flattery in a northwesterly direction, and their capture is an important industry to the Coast Indians.

The Halibut is emphatically a cold-water species. That it ranges nine or ten degrees farther south on the American than on the European coast, is quite in accordance with the general law of the distribution of fish-life in the Atlantic; indeed, it is only in winter that Halibut are known to approach the shore to the south of Cape Cod, and it is safe to say that the temperature of the water in which they are at present most frequently taken is never, or rarely, higher than 45°, and seldom higher than 35°, and often in the neighborhood of 32°. Its geographic range corresponds closely to that of the codfish, with which it is almost invariably associated, though the cod is less dependent upon the presence of very cold water, and in the Western Atlantic is found four or five degrees—in the Eastern Atlantic at least two—nearer the Equator, while the range of the two species to the north is probably, though not certainly, known to be limited relatively in about the same degree. In the same manner the Halibut appears to extend its wanderings further out to sea, and in deeper and colder water than the cod. Although observations on this point have necessarily been imperfect, it seems to be a fact that, while cod are very rarely found upon the edge of the continental slope of North America, beyond the 250-fathom line, Halibut are present there in abundance.

COMMON NAMES.—The name of this species is quite uniform in the regions where it is known, though, of course, subject to certain variations in the languages of the different countries, and its characteristic features are so unmistakable that it is rarely confounded with other species, the only fish for which it is ever mistaken seeming to be the Turbot of the European coast, with which it sometimes interchanges names. In Scotland it is said that the Halibut is frequently called the Turbot, and Yarrell has expressed the opinion that in instances where it had been

claimed that Halibut had been taken in the south of Ireland the Turbot was the species actually referred to.

"Halibut" and "Holibut" are words which are as old as the English language. In Germany it is called "Heilbutt" or "Heiligebutt"; in Sweden, "Hällefisk" or "Hällefiundra," while in Holland the name is "Heilbot."

In studying these names it should be borne in mind that "but" or "bott" is another word for a flounder or flat fish, and that the English, Dutch, German, and Scandinavian prefixes to either this word or the equivalent word Flounder are presumably of the same meaning. A false derivation has been imagined for the name, which is exemplified in the German word "Heiligebutt" just mentioned, and also in the English orthography, which is sometimes encountered "Holybut." This is without foundation, for the Halibut has never been mentioned more than any other species of flat fish, and the derivation is as fanciful as the New England one of "Haul-a-boat," which our fishermen have frequently assured me was the proper name, referring to the size and strength of the fish. The true derivation of the word is best understood by a study of its Scandinavian names, from which it appears that the prefix has reference simply to the holes or deep places at sea in which the fish is found, and that the name simply means "a deep-sea fish," or "a deep-sea flounder." The name "Flétan" which a species bears in France is not distinctive, the fish being almost unknown in that country.

DISTRIBUTION IN THE NORTHWESTERN ATLANTIC.—The general distribution of the Halibut having been sketched in outline, it seems appropriate to discuss more fully the range and abundance of the fish upon the coast of North America, where they are sought by American fishing vessels, and in this discussion some of the facts already briefly stated will necessarily be repeated in part or at length. Halibut are taken abundantly on Holsteinborg Bank, at the southern entrance to Davis Strait, latitude 67° north and longitude 54° to 56° west, where several Gloucester schooners have in past years obtained large cargoes of salted fish. In Etzel's "Grönland," the materials for which were largely derived from Rink's "Grönland geographisk og statistisk Beskrevet," published in 1857, the distribution of the species in this region is quite fully discussed. It is there stated that Halibut are taken chiefly in the southern part of North Greenland, and especially on the shoals among the islands in the district of Egedesminde, especially about Agto, Riskol, and Ikerasak, in latitude 68°, and somewhat less near Disko, in latitude 70°. They are captured most abundantly in the spring and fall, when the Greenlanders take many in these localities. They are even taken, at greater depths, as far north as Omenak, in latitude 71°. In a later work, however, Rink asserts that "the Netarnak or larger Halibut is found on the banks, as well as in different places outside the islands, up to 70° north latitude, in depths of from thirty to fifty fathoms."[1]

In the same later work Rink remarks that Halibut are plentiful in the fall about Egedesminde, especially about Agto, the southernmost outpost of North Greenland.[2]

Regarding the occurrence of Halibut in South Greenland, Etzel goes on to state that in July and August they are taken on the outer coast and among the islands at depths of thirty to fifty fathoms, while in winter they frequent deeper regions and are but seldom seen, chiefly on the cod-

[1] BROWN, ROBERT: Danish Greenland | its People and its Products | By | Henry Rink | Knight of the Order of Dannebrog | Director of the Royal Greenland Board of Trade | Formerly Inspector of South Greenland | Author of Tales and Traditions of the Eskimoes, etc | (Cut of medal.) | Edited by | Dr. Robert Brown, F. L. S. F. R. G. S. | Author of The Races of Mankind, etc | With Illustrations by the Eskimo, and a Map | Henry S. King & Co., London | 1877. 8vo, pp. xvii, 468, 16 plates, and a map on p. 1 (p. 134).

[2] RINK: *Op. cit.*, pp. 340, 341.

banks off Holsteinborg and in the sounds farther south.[1] Rink narrates that "in the year of the war," when the Europeans were obliged to supply themselves with provisions from Greenland, there were taken among the islands off Godthaab (64° 8′ north latitude) two thousand Halibut, and that in a single half day two boats took over one hundred. This was in 1809. They are rarely taken in the district of Julianshaab, in latitude 60° 43′ north.

Peter C. Sutherland, writing of Riskol Bank, in 1850, stated that Halibut were then very abundant in that locality, and that the cod-fishing vessels which visited Davis Strait every season use them to bait their hooks, though the supply far exceeded the demand for this purpose.[2]

On the return of the Penny Expedition, in 1851, Sutherland narrates that when crossing the Arctic Circle, in longitude 53°, the sailors put over lines baited with pork and hooked a cod and a Halibut at the depth of forty fathoms.[3]

The most northern occurrence of the Halibut on the western side of Davis Strait is that recorded by Mr. Ludwig Kumlien, naturalist of the Howgate expedition, who saw a large individual taken by the Eskimos off the mouth of Davis Strait, near latitude 64° north.

Richardson, in the "Fauna Boreali-Americana," speaks of the occurrence of the species on the Greenland coast, but seems to have no authentic information of its having been observed even as far north as Labrador on the opposite side.

There can be no reasonable doubt that Halibut are found along the entire eastern coast of Labrador, though there is no other published record of their occurrence north of Red Bay, in the Straits of Belle Isle, near latitude 51° 46′ north, where they were observed by Mr. Horatio R. Storer, several having been taken during his stay at that place in the summer of 1849.[4]

They are abundant in certain parts of the Gulf of Saint Lawrence, especially the island of Anticosti, and are also found along the entire coasts of Newfoundland and the eastern shores of Nova Scotia.

In June, 1878, the schooner "G. P. Whitman," of Gloucester, caught a fare of Halibut in two to twelve fathoms of water near Green Point, Newfoundland. The crew said that they could see the fish lying on the bottom in shallow water.

Capt. George Olsen, schooner "Proctor Brothers," arrived at Gloucester August 2, 1880, with 22,000 pounds' weight of fresh Halibut, from Anticosti. He reported Halibut plenty then at the western end of the island close inshore—within half a mile; he saw the Halibut sporting near and on the surface; he found they would not bite, as on the banks, at Halibut bait, and since fresh herring or capelin could not be obtained, could get only a partial trip of Halibut. They were good fish, weighing sixty to eighty pounds.[5]

According to M. H. Perley they are found in the Bay of Fundy up to its very head, where they are taken in summer in Cumberland Bay, near the light-house off Apple River, and also in West Bay. He states that they are also found on the south shore of the Bay of Fundy, and abundantly from Cape Split to Brier Island, as well as in the Annapolis Basin.[6]

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[1] ETZEL, ANTON VON: Grönland geographisch und statistisch beschrieben. Aus dänischen Quellschriften von Anton von Etzel. Stuttgart, J. G. Cotta'scher Verlag, 1860. 8vo, pp. xiv, 635 (p. 254).

[2] SUTHERLAND, PETER C.: Journal of a Voyage in Baffin's Bay and Barrow Straits in the years 1850–1851, performed by H. M. Ships "Lady Franklin" and "Sophia" . . . in search of the missing crews of H. M. Ships "Erebus" and "Terror." . . . By Peter C. Sutherland, M. D., M. R. C. S. E., Surgeon to the Expedition. In two volumes. . . . London: . . . 1852. (Vol. i, p. 26.)

[3] SUTHERLAND: *Op. cit.*, ii, p. 341.

[4] STORER, HORATIO ROBINSON: Observations on the Fisheries of the Coasts of Nova Scotia and Labrador, with Descriptions of New Species. <Proc. Bost. Soc. Nat. Hist., vi, 1857, pp. 247–270, pls. vii–viii (p. 267).

[5] Statement of A. Howard Clark.

[6] Reports on the Sea and River Fisheries of New Brunswick, 1852, pp. 159–163.

Perley's report was prepared in 1852, and there is no evidence of a diminution in that region since the time he wrote.

Mr. J. Matthew Jones tells me that Halibut are occasionally taken at Five Islands in the Basin of Minas, but that this is of rare occurrence.

I am indebted to Captain Ashby for the following facts about the southern limits of the distribution of the Halibut:

He has never known them to be found south of Sandy Hook, where large ones are occasionally taken in winter. In May, 1876, the schooner "Cartwright," fishing ten miles southeast of Montauk Point, caught many Halibut. In February, 1876, some Noank smacks caught a few Halibut about eight miles from land, off the southeast point of Block Island. Within the last forty years one or two Halibut have been taken off the outer shore of Fisher's Island. He has never known any to be taken in Long Island Sound. Halibut are sometimes taken in three fathoms of water among the breakers of Nantucket, in "blowy weather." Forty years ago they were abundant about Gay Head and Noman's Land. There has been no systematic fishing there lately, but some Halibut have probably been taken.

The local papers chronicled the capture, on May 1, 1876, off Watch Hill, Rhode Island, of an eighty-pound Halibut, the first taken in that vicinity for many years.

They are occasionally taken along the shores of Maine and Massachusetts, but so seldom that a capture of this kind by one of the inshore fishermen is always mentioned in the local papers.

ABUNDANCE.—Half a century ago Halibut were extremely abundant in Massachusetts Bay. Elsewhere in this essay are given several instances of their great plenty and voracity, as narrated by some of the early fishermen of Cape Ann. Of late years, however, few are found except in deep water on the off-shore banks.

The presence of so important a food-fish as the Halibut in America did not long escape the observations of the early English explorers. Capt. John Smith, in his "History of Virginia," wrote: "There is a large sized fish called Hallibut, or Turbut: some are taken so bigg that two men have much a doe to hall them into the boate; but there is such plenty, that the fisher men onely eate the heads & finnes, and throw away the bodies: such in Paris would yeeld 5. or 6. crownes a peece: and this is no discommodity."

SIZE.—The Halibut is surpassed in size by only three of our eastern species—the sword fish, the tunny, and the tarpum. There is said, by experienced fishermen, to be a great difference in the size of the two sexes, the females being much the larger; the male is said rarely to exceed fifty pounds in weight, and to be, ordinarily, in poor condition and less desirable for food. The average size of a full-grown female is somewhere between one hundred and one hundred and fifty pounds, though they are sometimes much heavier. Captain Collins, who has had many years' experience in the Gloucester halibut fishery, assures me that he has never seen one which would weigh over two hundred and fifty pounds, and that one weighing over two hundred and fifty pounds is considered large. There are, however, well-authenticated instances of their attaining greater dimensions. Captain Atwood, in communication with the Boston Society of Natural History, in 1864, stated that the largest he had ever taken weighed, when dressed, two hundred and thirty-seven pounds, and would probably have weighed three hundred pounds as taken from the water. In July, 1879, however, the same reliable observer saw at Provincetown two individuals taken near Race Point, one of which weighed three hundred and fifty-nine pounds (three hundred and two pounds when dressed), the other, four hundred and one pounds (three hundred and twenty-two pounds when dressed).

There is a tradition in Boston that Mr. Anthony Holbrook, one of the early fish-dealers of that city, had in his possession a Halibut, taken at New Ledge, sixty miles southeast of Portland, which weighed over six hundred pounds. This story, which is recorded by Storer in his "Fisheries of Massachusetts," Captain Atwood believes to be untrue. Halibut, weighing from *three to four hundred pounds, though unusual in comparison with the ordinary size, are by no* means rare. I have before me a record of ten or twelve such, captured on the New England coast during the past ten years. Nilsson, a Swedish ichthyologist, has mentioned the capture of a Halibut on that coast which weighed seven hundred and twenty pounds. There are stories of Halibut ten feet in length; a fish weighing three hundred and fifty pounds is between seven and eight feet long and nearly four feet in width. The largest individuals are not considered nearly so good for table use as those of less than one hundred pounds' weight. A fat female of eighty pounds is, by good judges, considered to be in the highest state of perfection. Males are not, however, so highly esteemed. Small Halibut, known as "Chicken Halibut," ranging from ten to twenty pounds, are much sought after by epicures, and bring a high price in the New York and Boston markets. They are comparatively rare, however, and a Halibut weighing ten pounds or less is rarely seen; the smallest recorded on our coast was about five inches in length and was taken by *Professor Verrill in a dredge-net in the Strait of Canso.*

The Halibut of the Pacific are apparently similar in dimensions to those of New England. Mr. Anderson, inspector of fisheries for British Columbia, states that they there attain a weight of 200 pounds.

The wholesale dealers of Gloucester, in buying fresh Halibut from the fishermen, recognize two grades; one, which they call "Grey Halibut," they consider to be of inferior value, and pay a lower price for. The Grey Halibut are distinguished by dark clondings or blotches upon the under side, which in the most remarkable fishes are pure white. Almost all the largest Halibut are classed among the Greys. Fishermen claim that there is no actual difference between the gray and the white fish, and it is a fair question whether they are not right.

MIGRATIONS.—It is useless to attempt to describe here the migrations of the Halibut from *place to place; although much information has been received upon this subject, the problem re*quires long and careful study.

The history of the halibut fishery has been a peculiar one. At the beginning of the present century these fish were exceedingly abundant in Massachusetts Bay. From 1830 to 1850, and even later, they were extremely abundant on George's Banks; since 1850 they have partially *disappeared from this region, and the fishermen have since been following them to other banks,* and since 1874 out into deeper and deeper water, and the fisheries are now carried on almost exclusively in the gullies between the off-shore banks and on the outer edges of the banks in water one hundred to three hundred and fifty fathoms in depth.

Captain Benjamin Ashby, of Noank, Connecticut, who is familiar with the fisheries south of Cape Cod, informs me that they frequent the deepest water in the spring and fall, and that they come up in the shoal water, in sixty or seventy fathoms, in May and June, while in July they begin to go out again into deep water, and by the latter part of the month are on the way into the gully on northeast part of George's Bank.

Captain Collins briefly expresses his views as follows: "Halibut are found in the deep water—say from one hundred to two hundred and *fifty fathoms in depth—on the edge of all the banks* from George's to the Grand Bank the year round. Sometimes, however, they are found more numerous in comparatively shallow water in the winter and early spring. This was the case in the winters and springs of 1875–'76 and 1876–'77, as well as in the year preceding. But in 1878 there was no great

catch of Halibut in less than one hundred fathoms on any of the banks. The great schools that were found in the western part of the Grand Bank in February and March, 1876 and 1877, appear to be migrating. The fish that were found to the south of latitude 44° north were mostly small-sized white Halibut. They went off the bank into deep water, and nobody knew what became of them. Those that were caught to the north of this parallel were mostly large gray fish, and were traced as far as Saint Peter's Bank. These are possibly the same fish—they are certainly the same kind of fish—that struck in on the western coast of Newfoundland in the summer months in pursuit of capelin."

Capt. George A. Johnson states that the large Halibut frequent the outer and deeper part of the banks, while the little "bull fish" lie inside, on shallower ground, and are caught on the inner end of the trawl lines, but that sometimes the large Halibut come up on the shallow grounds.

On the coast of Newfoundland, Anticosti, and Labrador, Halibut frequently run inshore in summer after capelin. When in shallow water near the shore they are usually wild and very active. The fishermen within eight years have extended their fishing much farther out to sea; previous to that time the greater part of the Halibut were taken on the top of the Grand Bank in thirty to fifty fathoms of water, but after the beginning of April the fish went elsewhere, and the fishermen lost sight of them. They soon learned, however, to follow them down the slopes of the banks, but before 1876 had rarely fished in water deeper than seventy to ninety fathoms. Since that time, as has already been stated, fishing has been carried into twice or three times that depth. All that can at present be said in explanation of their movements is that they occur in great schools, and, soon consuming the available food in any one locality, are obliged to shift their position to some other place where they can find fresh pastures. It does not seem possible that their migrations can be caused by conditions of temperature or are in connection with their breeding habits. During the breeding season the schools sometimes remain for months in one locality, and these places are generally of limited extent. While spawning but little if any food is found in their stomachs.

Food.—They are large-mouthed, sharp-toothed, voracious, although adapted for life upon the bottom, and doubtless feed largely upon crabs and mollusks; they are particularly fond of fish of all kinds; these they waylay, lying upon the bottom, invisible by reason of their flat bodies, colored to correspond with the general color of the sand or mud upon which they rest. When in pursuit of their prey they are active, and often come quite to the surface, especially when in the summer they follow the capelin to the shoal water near the land. They feed upon skates, cod, haddock, menhaden, mackerel, herring, lobsters, flounders, sculpins, grenadiers, turbot, Norway haddock, bank clams, and anything else that is eatable and can be found in the same waters. Captain Ashby tells me that common flounders and flat fish are among their most favorite food; they follow them up on the shoals of George's and Nantucket; they lie in wait for them on the sand-rips and catch them as they swim over. He has seen a half bushel of flat fish in the stomach of one; they stow them away very tightly. He has often seen Halibut chasing flat fish over the surface of the water. About Cape Sable their favorite food seems to be haddock and cusk. He has seen eight or ten pounds of haddock and cod taken out of one of them. When they are on the shoals they are sometimes filled with flat-fish, haddock, cusk, sculpin, and herring, but when in deep water he has found very little food in them. They eat crabs and other crustaceans, but shells are rarely found in their stomachs, except those of clams and mussels.

Captain Hurlbert tells me that when the vessels are dressing codfish on the Grand Banks, and the back-bones and head are thrown overboard, these are frequently found in the stomachs of Halibut taken in the same locality.

Mr. William H. Wonson, of Gloucester, has seen live lobsters six inches long taken from the stomach of a Halibut. Captain Marsh states that they feed on whiting, mackerel, and herring. He remarks: "Halibut will drive off any kind of fish and take charge of the ground."

At the meeting of the Boston Society of Natural History, in 1852, Dr. W. O. Ayres stated that he had seen a block of wood, a cubic foot in dimensions, taken from the stomach of a Halibut, where it had apparently lain for a long time. Capt. George A. Johnson found an accordion key in one of them. Olafson, in 1831, studying them on the coast of Greenland, found not only pieces of iron and wood in them, but in the stomach of one individual a large piece of floe ice. Captain Collins has observed that they often kill their prey by blows of the tail, a fact which is quite novel and interesting. He described to me an instance which occurred on a voyage home from Sable Island in 1877: "The man at the wheel sang out that he saw a Halibut flapping its tail about a quarter of a mile off our starboard quarter. I looked through the spy-glass, and his statement was soon verified by the second appearance of the tail. We hove out a dory, and two men went in her, taking with them a pair of gaff-hooks. They soon returned bringing not only the Halibut, which was a fine one, of about seventy pounds' weight, but a small codfish which it had been trying to kill by striking it with its tail. The codfish was quite exhausted by the repeated blows, and did not attempt to escape after his enemy had been captured. The Halibut was so completely engaged in the pursuit of the codfish that it paid no attention to the dory, and was easily captured."

The Halibut, in its turn, is the prey of seals, of the white whale, and of the various large sharks, especially the ground shark, or sleeping shark, in the stomachs of which they have sometimes been found; their sides, I am told by Captain Collins, are often deeply scarred, probably by the teeth of the sharks, or in their early lives by mouths of larger individuals of their own kind.

SPAWNING.—There is diversity of opinion regarding their spawning. Some fishermen say that they spawn at Christmas time, in the month of January, when they are on the shoals. Others declare that it is in summer, at the end of June. Capt. George A. Johnson, of the schooner "Augusta H. Johnson," of Gloucester, assures me that Halibut "spawn, just like the human race, at any time of the year." In April, 1878, he was fishing on Quereau Bank, and found large and small Halibut, the large ones full of spawn. In May he was on the Le Have Bank, where he found only small male fish full of milt; in June he was on Le Have again, fishing in shallow water, where he found plenty of "small bull fish, with their pockets full of milt"; in July he was again on Quereau Bank, where he found a school of small and big male and female fish, all, apparently, spawning, or ready to spawn, "with milt and pees soft"; in August he was on the outer part of Sable Island, where he found females full of spawn.

Captain Ashby, speaking of the Halibut on George's Banks, states that roe is always found in them in May and June. The roes of a large Halibut caught by him in 1848 on the southwest part of George's, and which weighed 356 pounds, after it had been dressed and its head removed, weighed 44 pounds. He states that the Halibut in this region have spawn in them as long as Connecticut vessels continue to catch them, or until September. He has seen eggs in Halibut of twenty pounds' weight, and thinks that they begin to breed at that size. The spawn of the Halibut is a favorite food of the fishermen of Southern New England, though never eaten by those of Cape Ann.

Captain Hurlbert, of Gloucester, tells me that on the Grand Banks of Newfoundland the halibut school used to come up in shoal water, in forty or fifty fathoms, in summer, and that the spawn was ripest about a fortnight later. In August, 1878, he found many with the spawn already run out. At that time several Gloucester fishermen reported that the Halibut on Le Have and Quereau Banks were full of spawn. Captain Collins told me that in July and August, and up

to the first of September, they are found here with the ovaries very large, and are often seen with the ova and milt exuding. The ovaries of a large fish are too heavy to be lifted by a man, without considerable exertion, being often two feet or more in length. At this time very little food is found in their stomachs. In September, 1878, the Fish Commission obtained from Captain Collins the roes of a fish weighing from 190 to 200 pounds, taken by the schooner "Marion" on the 13th of the month on Quereau Bank. This fish was taken at the depth of 200 fathoms, and the temperature of the water was roughly recorded at 36° F. These ovaries were put into a basket with ice and brought to the laboratory of the Fish Commission, where they were found to weigh seventeen pounds, two ounces. Part of the eggs were nearly ripe, and separated readily, while others were immature and closely adherent to each other. A portion of the roe, representing a fair average of the size of the eggs, was weighed, and was found to contain 2,185 eggs; the weight of this portion was two drams. The total number of eggs was from this estimated to be 2,182,773. It is not yet known whether the eggs float or rest upon the bottom, nor is it known how long is the period of incubation, nor what is the rate of growth of the fish. As has already been mentioned, young fish are very unusual; the smallest ever seen by Captain Ashby in Southern New England was taken on Nantucket Shoals, and weighed two and a half pounds after it had been eviscerated.

ABNORMAL INDIVIDUALS.—Left-handed Halibut are sometimes taken. Perhaps one out of five thousand is thus abnormal in its form, having the eyes upon the left rather than upon the right hand side of the head.

Halibut with dark spots or patches on the under side of the same dark color as the back are occasionally taken. These are called by the fishermen "Circus Halibut." They are generally of medium size, and thick, well-fed fish.

61. THE SAND DAB, OR ROUGH DAB.

The Sand Dab, or Rough Dab, *Hippoglossoides platessoides*, also sometimes known as the Rusty Flounder, is taken in winter by the line fishermen of New England, and small quantities are doubtless brought to market and sold with other flat fishes without discrimination as to species. It often attains the length of twenty to twenty-four inches, and the weight of two to five pounds, and is, in all respects, a desirable food-fish, being highly esteemed on the other side of the Atlantic. In summer, individuals of this species are to be found only in very deep water, thirty fathoms or more, on the New England coast, and, though never very abundant in any one locality, might be taken in considerable quantities, in company with the Pole Flounder, by the use of a trawl-net, or even by specially devised trawl-lines.

The Rough Dab has not been observed south of Wood's Holl, Massachusetts, but ranges north to Greenland, is abundant on the English coast, and is a well-known food-fish of Scandinavia. Its breeding habits in our waters have not been observed, but in Southern Sweden the spawning time is in April and May. It is a large-mouthed species, feeding upon fish as well as upon large invertebrates, such as crustaceans and annelids, and mention has been made of it more on account of its possible value in the future than for its present importance.

62. THE GREENLAND TURBOT.

The Greenland Turbot, *Platysomatichthys hippoglossoides*, though never occurring in our inshore waters, is found on the off-shore banks, as far south as George's Bank, and a certain quantity of them is usually brought to New York every winter. It is emphatically an arctic species, being abundant on the coast of Greenland, often found at Holsteinborg and beyond, and along this entire coast very eagerly sought by the natives. The Eskimo name is "Kalleraglik," and the fish is also known as "Little Halibut." In Günther's great work on "The Fishes of the British

Museum," he has confused this species with the true Halibut, making it appear that only the former is to be found on the coast of North America. In Northern Greenland the Turbot is found only at very great depths, and is fished for, in water of three hundred and fifty to three hundred and eighty fathoms, through holes in the ice, over certain banks in Omenak Fiord and at the mouth of the Jacob's-Haven ice-fiord, which is also packed with great ice-floes. It is said to be found only in the ice-fiords and between the great ice-fields, and there only in the coldest months of the year.

In South Greenland they are taken on the oceanic banks at a depth of sixty to one hundred and eighty fathoms, though there considered to be not so abundant as in North Greenland. In Fortune Bay, Newfoundland, according to Captains G. Johnson and A. Leighton, of Gloucester, they are very abundant in sixty to three hundred fathoms, and are caught chiefly in winter. They are also obtained by the Gloucester halibut fleet on the outer edge of the oceanic banks, in two hundred and fifty to three hundred fathoms of water.

Their habits are not at all well understood, but it would appear from the statements of several experienced fishermen, whom I have questioned, that they occur on the very edge of the continental slope in deeper water than the true Halibut, in fact in places where the slope is so nearly perpendicular that the Halibut can hardly hold their places on the bottom. This species is more symmetrical than any other of the family on our coast, and, moreover, is colored upon both sides of the body—a fact which indicates that its movements are more like those of the ordinary symmetrical fishes and that it can rest with the body in a vertical attitude.

It would seem probable that its chosen haunts are along the declivities of the outer slope of the continental plateau, where abundance of food is known to occur, and where other fishes are not so well adapted to live. Many hundreds of pounds are caught, every year, on the halibut trawls, and the fish are frequently iced and brought to market with the Halibut, and frequently eaten by the fishermen themselves. The greater portion of those brought to New York in winter are, however, taken on trawl lines at the mouth of Fortune Bay, and brought down by the vessels which go there to procure cargoes of frozen herring. It is impossible to obtain statistics of the quantities thus brought in, because the market returns do not discriminate between the different species of flounders and flat fishes.

The Greenland Turbot is an exceedingly palatable fish, its flesh being firm, white, and less dry and more delicate in flavor than that of the Halibut. The average weight is from ten to twenty-five pounds. In Greenland they are perhaps more highly esteemed than any other fish. The Greenlanders begin fishing as soon as the fiords are frozen over and the white whales, which prey greedily upon this fish, have left the entrances open. They fish through holes in the ice, and attach little threads at intervals to their lines, so that they may better see the motion which the nibbling fish makes. Under favorable circumstances a man may take ten to eighteen of these fishes daily. The fishery continues from January to the middle of March, sometimes, however, only a week or two, and usually only about a month. The fish are cut into strips and dried for the consumption of the Danish colonists. It is said that a very fine oil can be made out of their fat, so that in hard times the fish serves to warm and light their houses as well as feed their occupants. In South Greenland they are not so numerous, but are constantly sought for, being taken in company with the sea perch, or red fish.[1]

88. THE POLE FLOUNDER, OR CRAIG FLOUNDER.

This fish, *Glyptocephalus cynoglossus*, often known as the Deep-sea Flounder, was first observed on this coast in 1877, when numerous specimens were obtained by the United States

[1] These facts are taken from Rink's "Greenland."

Fish Commission, in the deepest part of Massachusetts Bay. Specimens have since been obtained south of Cape Cod, at a depth of one hundred fathoms or more, by the Fish Commission, and by Professor Agassiz, off the entrance to Delaware Bay, at a depth of three hundred and ninety-five fathoms. The Pole Flounder appears to be a permanent resident, throughout the whole year, in the deep basins of Massachusetts Bay and on the edge of the continental slope, and is found abundant in Bedford Basin, the inner expansion of Halifax Harbor, at a depth of thirty-seven fathoms. It ranges nearly to Greenland, and is also found on the coast of Northern Europe, where it is found in the Trondhjem Fjord, in latitude 65°, and south to the coast of Ireland. Its thermal range appears to be confined by the limits 34° and 45°.

It breeds abundantly in our waters in summer time, numerous individuals, full of spawn, and young from half an inch upward, having been taken, from July to October, in various localities.

The Pole Flounder has been pronounced, by all who have tasted it, a most delicious food-fish, resembling more closely than any other species on our coast the English Sole, having a great quantity of peculiarly flavored mucilaginous tissue about the base of the fins; it has never been taken by our fishermen, because, on account of its exceedingly small and weak mouth, it could not hold fast to an ordinary hook and line; and, should it ever come into demand, it will be necessary for our fishermen to introduce the English trawl-net.

64. THE SPOTTED SAND FLOUNDER.

The Turbot, or Steinbutt, *Rhombus maximus*, and the Brill, or Glattbutt, do not occur in our waters, although many attempts have been made to prove that they do. The nearest representative of the Turbot is the Spotted Sand Flounder, *Lophopsetta maculata*, a species found from Bucksport, Maine,[1] to Fort Macon, North Carolina, variously known along the coast as Water Flounder, Window-pane, and Daylight; the latter name refers to the remarkable thinness of the fish, its flesh being so transparent that, when held to the light, the shadow of an object on the other side can be seen. Its flavor is good, but the amount of flesh is so small that it is of no consequence as a food-fish. There are other smaller representatives of the family on the southern coast, and in deep water from Cape Cod southward, belonging to the genus *Citharichthys*, which, although edible, are never eaten.

[1]According to Mr. G. A. Boardman, of Calais, Maine, an individual was taken in Passamaquoddy Bay in September, 1880.

J.—THE COD FAMILY AND ITS KINDRED.

The Codfish and its allies constitute, from an economical point of view, the most important of all the families of fishes, containing, as it does, a large number of species, most of them of considerable size, distributed throughout all parts of the northern hemisphere, usually found together in great numbers, readily captured, and easily preserved for future use.

An elaborate discussion of the geographical distribution of the cod family, and its relations to fisheries and commerce, by Karl Dambeck, was published in "Gæa," in 1877. A translation of this paper may be found in the Report of the United States Commission of Fish and Fisheries, Part V, 1877, pp. 531–557. This paper is not without value, although it contains many false statements, the writer appearing to have been but slightly acquainted with the more recent ichthyological discoveries. In the translation referred to, the paper has been revised and annotated by Dr. Bean, and is sufficiently accurate so far as the American species are concerned.

65. THE COD—GADUS MORRHUA.

NAMES OF THE CODFISH.—Mr. J. Carson Brevoort, of New York, contributes the following interesting sketch of the names applied to the cod family by the different nations of Europe:

"The appellations under which the weather-dried Codfish, split and stretched on a short stick, is known throughout the civilized world can all be traced to one common root, based upon the mode of preparation for the market.

"Among the Greeks the large Codfish were called *Bacchi*, from Bacchus, a rod. By the Latins the fish was named *Gadus*, from a Sanscrit root *cad* or *gad*, a rod. We find this root in English in 'goad,' and, perhaps, in 'cat-o'-nine-tails'; in Gaelic *gad* and *godan*, signifying a small rod. By the Iberians the dried Cod were called *Bacalaos*, from Baculeum, a small stick.[1] This points also to the root of the French *Baguette*, a rod, *Bilboquet*, the toy known as cup and ball, really a *stick* and ball, and other words. By the Anglo-Saxons it was called the *Cod*, from the word *gad* or *goad*, a rod. By the Germans it was known as the *Stockfisch*, from *Stock*, a stick.

"The Hollanders varied a little from this, and as far back as the year 1400 called it the *Kabeljaauw*, which seems to be from the Dutch *gabel*, a fork. They also called it the *Bakkeljauuc*.

"The French *Morue* is not from the above root. It may be from the Celtic *Mor*, the sea. The French, however, never prepared the Cod by drying it on a stick, but salted it as the *Morue verte*, or green Cod. The French *Molue* is merely a change in the liquid consonants.

"When the Cod is dried on the downs it is called Dunfish, from the Gaelic root *Duin*, a hill. If dried on the rocks it becomes the *Rock Cod*, or the *Klippfisk* of the Norwegians. Among these last the Cod is called the *Dorsct*, or *Torsk*, in English *Tusk*, from the Gothic *Dürren*, to dry.

"The English 'Aberdeen fish,' or French *Laberdan*, is from the Gaelic *Abar*, the mouth; *Dan*, a river, or fish caught near the river's mouth."

These remarks are suggestive in the extreme, since they explain the origin of almost all of the names now applied to this species both in its fresh and cured condition.[2]

[1] The rod held by Mercury was called a *Baculeum*.

[2] Skeat in his Etymological Dictionary, recently published, does not confirm the views advanced by Mr. Brevoort, remarking, "I suppose that this word *cod* must be the same as the Middle English *codde* or *cod*, a husk, bag, bolster; though the resemblance of the fish to a bolster is but fanciful. It is obvious that Shakespeare knew nothing of the Linnean name *gadus* (Greek γαδος), nor is the derivation of *cod* from *gadus* at all satisfactory."

The name by which this species was known among the Narragansett Indians is indicated by the following sentence from Roger Williams' "Key into the Languages of America":

"Panganaut, tamwock. Cod, Which is the first that comes a little before the Spring."

In the vicinity of Cape Ann the young Cod, too small to swallow a bait, are sometimes known to the fishermen as "Pickers," and throughout all Eastern Massachusetts the name "Scrod," or "Scrode," is in common use. In its primary meaning it seems to refer to these small fish slightly corned, in which condition they are a favorite article of food, but the name is also transferred to the young fish themselves. The fishermen recognize several varieties of Cod for which they have different names. Rock Cod are those which are found in shoal water among the reefs and ledges, and which usually are of a dark color: these fish are often brilliant red in color, owing to the fact that the small animals upon which they live feed upon the red algæ, abundant in those localities, and from them have absorbed the red coloring matter into their tissues. "Rockling" are probably young Rock Cod. In the vicinity of Scituate, Massachusetts, Rock Cod are also called "Native Cod."

Another class of names appears to apply to those fish which live near the shores, but which are less closely limited to the reefs. These are called "Shoal-water Cod," "Shore Cod," "Inshore Cod," "Worm Cod," "Clam Cod," "Black Snappers," "Black Biters," "Brown Cod," "Ground Keepers," and "Ground Tenders" or "Groupers."

Still another class of fish is known by such names as "Deep-water Cod," "Bank Cod," and "School Cod."

There are also certain local schools of fish which have names of their own; for instance, the "Herring Fish" or "Herring Cod" of Southeastern Maine, and the "Squid School" of Nantucket and other parts of the coast, the "Pasture School" of Cape Ann, and the so-called "Shad School" which frequented Massachusetts Bay between 1815 and 1830.

In Southeastern Maine the name "Pine-tree Cod" is also in use. It is difficult at present to determine exactly to what extent these names are used and what their precise meaning may be, but it is almost certain that each community of fishermen has its own peculiar names by which to designate local peculiarities of habit and movement.

In the markets the Cod from George's Bank are usually classed as "George's fish," and are considered to be of superior value. George's fish are very fat fish with white "napes." This name is becoming a commercial term to describe Codfish of the finest quality. No one of these names, excepting Rock Cod, or Red Cod, appears to be in use in Great Britain, although there, as here, there are various names of local significance, which are of little interest, however, to Americans.

"Bank Cod" and "Shore Cod" are commercial names, used in the same manner as the name "George's Cod."

HISTORY OF THE CODFISH IN AMERICA.—As early as 1415 A. D., English vessels frequented the fishing grounds near Iceland, and it is claimed by some authorities that the Banks of Newfoundland were known to the Basques centuries before the discovery of the American continent. The Banks of Newfoundland were among the principal inducements which led the English to establish colonies in this country, and in the records of early voyages are many allusions to the abundance of Cod along our shores.

In the Appendix may be found an essay, by Mr. Robert S. Rantoul, on "The Cod in Massachusetts' History," a paper read at a field meeting of the Essex Institute at Gloucester, September 14, 1866. It is really an epitome of the early history of the cod fisheries of the United States, containing much interesting information upon the use of the Codfish upon the seal of Massachusetts and upon the colonial coinage.

A Nova Scotia coin or bank-token has upon it the figure of a Codfish. Upon the obverse is a plow with the legend "Speed the Plough," upon the reverse a salted Codfish with the words, "Success to the Fisheries."

DISTRIBUTION OF THE COD.—The Codfish is found in the North Atlantic, in the North Pacific, and in the Polar Ocean, its range extending far beyond the Arctic Circle. It seems unnecessary to enumerate all the localities in which it has been observed, for its geographical range may be defined with sufficient accuracy and by a much more comprehensive statement: In the Western Atlantic the species occurs in the winter in considerable abundance as far south as the mouth of the Chesapeake Bay, latitude 37°, and stragglers have been observed about Ocracoke Inlet.[1] The southern limit of this species may safely be considered to be Cape Hatteras, in latitude 35° 10′. Along the coast of the Middle States, New England, and British North America, and upon all the off-shore banks of this region, Cod are found usually in great abundance, during part of the year at least. They have been observed also in the Gulf of Boothia, latitude 70° to 75°, and in the southeastern part of Baffin's Land to the northward of Cumberland Sound, and it is more than probable that they occur in the waters of the Arctic Sea to the north of the American continent, or away round to Bering Straits.[2]

The Cod has been observed on the western coast of Greenland. In the North Atlantic the range of the species extends to Iceland and Spitzbergen, latitude 80°; along the arctic coast of Europe, as far as Eastern Finmark, and probably round to Siberia; while southward it ranges at least to Brittany. Its southern limit is probably near the Bay of Biscay, latitude 40°, although Yarrell states that it is found south to Gibraltar. It does not enter the Mediterranean, but penetrates into the Baltic to the coast of Western Russia. Its distribution in the North Pacific is not so well understood, though it appears to occur in the same abundance on all the off-shore banks of this region, and also close to the coasts to the north of the Straits of Fuca. According to Jordan, there is said to be a cod bank outside of the mouth of the Columbia, but the species at present is of no economic importance south of Alaska. A full discussion of the Alaskan Codfish is given below by Dr. Bean in the chapter on THE ALASKA COD-FISHERY.

The Cod enters fresh water upon occasion.[3] It is found, according to Canadian authors, well up the estuary of the Saint Lawrence, though how far up is not definitely stated, probably not beyond the limits of brackish water. Dr. C. C. Abbott records that on the 23d or 24th of January, 1876, a healthy, strong, active Codfish, weighing nearly four pounds, was taken in a draw-net in the Delaware River near Trenton, New Jersey; the stomach of the fish showed that it had been in river-water several days. Many of them had been taken about Philadelphia between 1856 and 1869.[4]

Mr. George R. Smith, of Millbridge, Maine, states that Cod are found all along the coast, even entering brackish water at the mouths of rivers.

Mr. Wilson M. Albee, of Mohegan, Maine, affirms that Cod occur in all places along the coast of that region, even in brackish water.

Mr. A. T. Gamage, of Damariscotta, Maine, says: "There is not a place of any extent on the coast of Maine and seaward where Cod are not found. They occur from the edge of the breakers

[1] The mackerel schooner "Relenter," of Gloucester, April 5, 1880, caught, on one hand-line, some 600 pounds of large Cod, with mackerel bait, in twenty fathoms of water, when about eight miles off Cape Charles.—A. H. CLARK.

[2] RICHARDSON: Fauna Boreali Americana, p. 243.

[3] "Forest and Stream," December 25, 1873, contains the following astounding statement, which, of course, is entirely unworthy of credence: "Three Codfish, weighing six pounds each, were caught in the Saint John's River, Florida, near Palatka, last week; the first of the kind ever caught in Southern waters. The 'Herald,' says Captain Vogel, of the steamer 'Dictator,' pronounced them genuine Codfish."

[4] American Naturalist, iv, p. 116.

out to seventy-five fathoms and up to fifty miles and further, wherever any bank has been discovered. Quite frequently they enter brackish water in pursuit of their natural food."

Thomas Day, of Parker's Island, Maine, says that small Cod have been caught in the Kennebec River.

Mr. M. A. Hanna, of Bowery Beach, says that they are sometimes caught in rivers at some distance from the sea, where the water at the surface is quite fresh.

These statements are confirmed by several other persons. The New York "Evening Post" of February 6, 1877, says that a six-pound Codfish was taken on February 1 in the Hudson River above Peekskill, New York.

THE SCHOOLING OF THE CODFISH.—Before taking into consideration the periodical movements of the Codfish, it seems necessary to study the manner in which they assemble together in schools. Mr. Earll, who has studied with great thoroughness the habits of the Codfish about Cape Ann, writes as follows upon this topic:

"In examining the Codfish landed from time to time, one cannot but notice the great individual variation in the species. But in addition to this seemingly accidental variation, that gives every gradation to either extreme, there is a more constant difference in both form and color, due perhaps to the peculiar habits and surroundings of the individual. This difference is so noticeable that the fishermen can easily distinguish the one from the other, and they have come to call the one a school fish in distinction from the other, which they call a shore fish or 'ground-tender.'

"The school fish are supposed to be constantly on the move, remaining usually in the deep water, where they are very active in the pursuit of their prey, consuming such quantities as to keep them in excellent flesh. Such fish are usually very shapely, with small and very distinct dark spots on a light background, and seem to have the head quite small in proportion to the body. On the whole, they are just such fish as would be expected from continued activity and good living. On the other hand, the shore fish, or 'ground-tenders,' live constantly among the rocks and sea-weeds along the shore, where the water is less pure and the food less abundant. They seem to lead solitary lives during a greater part of the year, being scattered along different portions of the coast, living upon the little rocky spots, where they feed upon such animals as they chance to find; or at times entering the shoaler water among the sea-weeds, where they feed upon the mollusks and articulates that are often so abundant in such localities. They are generally in poorer flesh than the school fish, having a relatively larger head in proportion to their bulk, with larger and less distinct spots on a darker background. In addition to these large fish, that for some reason seem to prefer the shore as a feeding ground, there are many young and immature that have not yet joined the school fish in their migrations. These fish are the sole dependence of the boat fishermen in summer, or from June to November, and one must know the grounds pretty thoroughly, and row about from one feeding spot to another, in order to secure any considerable number of them. During the months of June, July, and August the fishing is quite limited, being confined to a few boat fishermen who row, or sail, out daily with hand-lines, returning in the afternoon with from one hundred and fifty to three hundred pounds, which they usually sell at fair prices to supply the fresh-fish trade.

"Early in the fall the spawning instincts of the fish cause them to gradually gather from the different parts of the shore to special rocky grounds, where they remain until they have deposited their eggs. At such times, being more numerous in these localities, the fishing becomes more profitable, so that many small vessels and a larger number of boats frequent these grounds, and by the middle of October the daily catch reaches about four hundred pounds per man.

"Thus far the catch has been composed almost wholly of the young and shore fish; but about

the 1st of November the fall school of spawning fish, known as the 'pasture school,' makes its appearance. All the smaller vessels and boats are now pressed into service, and the winter fisheries are soon at their height. The vessels are usually provided with dories, taking from three to twelve each, according to the size of their crews. Such fishermen as are unable to ship on the vessels now row or sail out in boats. These often endure great hardships, as the wind may rise suddenly and drive them out to sea, giving them a hard pull of hours before they can regain the shore, while an occasional unfortunate fails to return.

"The pasture school is composed of fish averaging probably between twelve and fourteen pounds, some being much larger, while others are quite small. In the falls of 1877 and 1878 the fishing was unusually good until the first of January, the average daily catch per man often reaching eight to nine hundred pounds, while an active fisherman at times caught nearly twice that quantity.

"At the present time there are but few towns on the north side of the cape extensively engaged in the shore fisheries, and for this reason little is definitely known about the first appearance of the Ipswich Bay school of Codfish in that locality. We cannot even feel certain of the month when they reach the grounds, as the fishermen have many and conflicting opinions on the subject. From the best obtainable information it seems probable that Cod have visited these waters regularly for many years, and that they were formerly taken in considerable numbers by the boat fishermen of the section who rowed out from the shore in pleasant weather during the winter months. But for a number of years these grounds were nearly deserted, and it was not until 1877–'78 that the shore fishermen of Gloucester and Swampscott learned their value.

"In January, 1879, after the fish had left 'the pasture,' several vessels sailed for Ipswich Bay, where they found the Cod remarkably plenty, returning in a short time with unusually large fares. The news spread rapidly, and soon all the shore fleet were in the bay, while vessels of sixty to seventy tons abandoned the other fisheries and fitted out for this locality. Vessels from other towns along the shore soon joined the fleet, and by the middle of February 104 sail, with upwards of 600 men, were fishing within a radius of five or six miles, and twenty to twenty-five thousand pounds of round fish were sometimes taken in a day by the crew of a single schooner.

"The above number of vessels was reached only during the height of the season, and several causes operated to reduce the fleet so that at times it was quite small. But allowing an average of 45 sail during the entire four months, each vessel carrying six dories, the trawls averaging 800 hooks each, and we have the enormous number of 216,000 baited hooks spread out upon the sandy bottom to tempt the spawning fish. It is not surprising, therefore, that the catch reached fully 11,250,000 pounds on this little patch of ground between the first of February and the last of May.

"Fishermen are agreed that the individuals composing this school averaged larger than those of any school that had previously visited the shore. There were almost no small ones among them, the great bulk being of uniformly large size with a few very large. Of over five thousand, selected without regard to size at different times during the season, the average weight was 20¾ pounds.

"Fishing continued good in Ipswich Bay until the first of June, when the school left the shore, being perhaps hurried in their movements by a large school of dogfish (*Squalus americanus*) that made their appearance in the bay about this time.

"After the school-fish leave the shore in summer the fishermen frequently resort to the outer grounds, such as Jeffry's and Stellwagen Banks, when they often secure good fares from what they suppose to be a new school that visits these grounds for the purpose of feeding. We have had little opportunity for examining these fish, but there seems a strong probability that they belong to the

school that has just left the shore, and that they remain on these grounds for a few days or weeks on their way to deeper water."

I have before me the statements of ninety-four fishermen, most of whom are of the opinion that the Cod associate together in schools throughout the entire year; many of them, however, speak of particular schools of very large size which they noticed at particular seasons. Captain Atwood, on the other hand, makes the assertion that the Cod never school, but that they wander independently over the bottom in search of food.

It seems most reasonable to suppose that the Codfish, like most other species which habitually feed on the bottom, are less disposed to wander together in great bodies from place to place than the surface-swimming fishes which usually feed upon substances or animals which are found collected together in one place in great quantity. The Codfish, being habitually bottom-feeders, find their food, it is probable, with more or less uniformity, over the areas which they frequent, and are ordinarily met with moving about independently. They are most likely to occur in great numbers in places where food is particularly abundant. At certain seasons of the year they are brought together by a common desire for wandering together from place to place in immense bodies, sometimes their object being a united attack upon some special kind of food only to be found at that season, and in particular places. The capelin and lant schools, known to the fishermen of Newfoundland, Labrador, and the Grand Banks, are examples of such association, as also is the herring school observed in the spring in Massachusetts Bay, and the great schools known on the coast of Norway under the name of *Lödde-fisk*.

Capt. Epes W. Merchant, of Gloucester, tells me about a remarkable school of Codfish which frequented Massachusetts Bay between the years 1815 and 1830. This was called the "shad school." They continued in the bay from early April until the middle of May. They were caught with alewives and shad for bait. The fishermen were accustomed to get these fish for bait as soon as they began to run. The Cod seemed to be waiting for them. The "shad school" was composed of young, sharp-nosed, bright-eyed school fish of regular size, very different from the ground-tenders or grubbers.

Professor Baird has made some interesting generalizations concerning the effect upon the abundance of Cod of the decrease in the shad and alewives off the mouths of our rivers caused by over-fishing in inland waters.[1]

Another cause of the assembling of the Codfish together is the reproductive instinct, in obedience to which the fish gather together in localities where the temperature and depth of water are suitable for the deposition of eggs. A school of this kind is the so-called "pasture school," already referred to in the quotation from Mr. Earll, and the great schools—the so-called "fish-mountains"—which make their appearance on the coast of Norway in January, February, and March, and which have been so well described by Professor Sars.[2]

The fisheries carried on at this time are called "spawn fisheries" to distinguish them from those which are carried on later in the spring on the coast of Finmark, the object of which is the capture of Codfish following schools of bait.

"Codfish," continues Mr. Earll, "are gregarious in their habits, going in schools of greater or less size, and are governed in their movements by the presence or absence of food, the spawning instinct, and the temperature of the water. When migrating, the schools are quite dense, though by no means like schools of menhaden or mackerel. But when they reach the feeding ground they

[1] Report United States Commission of Fish and Fisheries, pt. ii, 1874, pp. xi–xiv.

[2] Report of the "Practical and Scientific Investigations of the Cod Fisheries near the Lofoden Islands," made during the years 1864–'69 by S. O. Sars; translated by H. Jacobson. Report United States Commission of Fish and Fisheries, pt. v, 1879, pp. 565–661.

seem to distribute themselves over a large area, though more or less grouped together in little bunches. This is particularly noticeable on the shore, when the fish are moving about in search of food, and the fisherman soon catches up all that chance to be on one patch of rocks, and must then row to another in order to find a new supply. The same thing is seen on western banks, where a vessel usually carries dories to distribute her crew over different parts of the ground, and often, by setting her trawls in one locality for a day or two, seems to catch up all of the fish, and must then 'shift her berth.' Fishermen also cite many instances where the fishing is excellent on a few particular, well-defined spots on different parts of the ground, while almost no fish can be taken in other places.

"During the spawning season this tendency to become scattered is less noticeable, for the instincts of the fish seem to bring them nearer together, and great numbers are often taken in one particular locality. Even here, however, the tendency to separate into groups occurs, for some boats find good fishing, while others, but a few rods away, catch almost nothing; and in trawling, some parts of the line have a fish on nearly every hook, while other parts take only a scattering one.

"In schooling, both sexes are always found together, whether it be on the spawning or feeding ground or on the journey; but the relative numbers of each seem to vary greatly, and we have been able to discover no invariable rule whereby one can predict with certainty the sex that will first appear, or that which will be most abundant at any given time during the season. The fishermen have a commonly accepted tradition that in the spawning schools the females always come first and the males later, but this theory is not supported by facts. Observations were frequently made on the relative numbers of the two sexes landed by the shore-fishermen between September, 1878, and July, 1879. The results showed that during the early fall, or before the school fish had made their appearance, the fish were nearly equally divided between males and females—first the one and then the other being more abundant. When the school fish first reached the shore early in November the males were a trifle more plenty than the females for about a week, but from that date until they left the grounds the females were taken in greater numbers, sometimes in the proportion of two to one, and at others in nearly equal quantities. In the Ipswich Bay school during the first two or three days in February there were ten males to one female; by the middle of the month the females composed about forty per cent. of the catch, and from this date until the 1st of June the males numbered two to one. From reliable fishermen we learned that the same was true of the fish on the off-shore banks, and that, though varying greatly in their relative numbers, both males and females were always present.

"There is usually a great difference in the size of the individuals taken by the fishermen on the shore feeding grounds in a single day, for the young and 'ground-tenders' remain on these rocky ledges during the entire year, and late in the season the school fish come in upon the same grounds and are naturally taken with them.

"But when the school fish visit a locality not frequented by the young, as they do in Ipswich Bay, there is a noticeable absence of immature fish, and the catch is composed almost wholly of individuals of large size. Thus, in the winter of 1878–'79 many trips of from twenty-five to forty thousand pounds were landed with scarcely a small fish among them, while vessels fishing only a few miles distant found young fish plenty, and there were occasional instances where such vessels caught only small ones. Again, though the school fish may differ considerably in size, we have not found one, thought to belong to their number, that had not reached maturity. Indications strongly favor the idea that the young remain separate from the school fish during the first few years of their lives, and we are led to believe that, though they are often taken together, the

occurrence is accidental and the young will not follow the old in their migrations until they reach maturity, though after this point is reached they seem to mingle freely without regard to age.

"Codfish are probably governed in their movements by the abundance and migrations of food, the spawning instinct, and the temperature of the water, though the last named seems to exert but little influence. It is generally acknowledged by the fishermen that during the feeding season fish are plenty only where food exists in considerable quantity, and that after 'cleaning up" one part of the bank they go to another. They also follow schools of bait for long distances, living upon them until they are broken up or entirely destroyed. Thus they often follow the capelin (*Mallotus villosus*) into the shoal water, and even drive immense numbers of them upon the shore.

"The spawning instinct seems to exert a decided influence upon the movements of the fish, for we find them visiting the same locality year after year during the spawning season, often remaining for several months at a time. The fish that visit the waters of Cape Ann during the winter, doubtless come in for the purpose of spawning rather than for food. This seems clear from the fact that they do not arrive when bait is most plenty, nor do they follow any species to the shore. On the contrary, the pasture-school usually arrives about three weeks after the large herring have left the coast, and remains on the south side of Cape Ann, while sperling are abundant in Ipswich Bay. The Ipswich school is also the largest after the sperling have been driven away by the cold weather, and remains on the sand-flats, which supply almost no food. From these facts we are led to believe that food has little influence upon the movements of the fish during the spawning season.

"The instinct that leads the spawning fish to seek the shoal water in such great numbers is certainly a wise one, for they generally select spawning-grounds where the tide runs strong and the water is rough, and the large number of individuals is absolutely necessary, that the water may be filled with germs for their successful impregnation. If, instead of schooling in such numbers during this period, they remained scattered over a large area, almost no eggs would be fertilized.

"Again, while food is not essential to the spawning fish, it is of vital importance to the young, and it seems a wise provision that these should be brought into being where food is abundant, rather than that they should be hatched in mid-ocean, where almost no suitable food exists."

MIGRATIONS AND MOVEMENTS OF THE SCHOOLS.—The causes which influence Codfish to assemble together in schools also influence their movements from place to place. It seems most probable that while great numbers of these fish may remain together in the same locality, feeding upon the same kind of food without it being said that they are schooling, a movement from place to place is, however, usual, in obedience to some tangible law, and is made simultaneously by numerous individuals.

The migrations of the Codfish are usually of the class which I have described under the name "bathic."[1]

The Cod, like most of the other species which migrate to and from the shore instead of northward and southward, is, doubtless, more or less dependent upon temperature conditions than fishes like the menhaden and the blue-fish, and, as Mr. Earll has suggested,[2] the abundance of food doubtless has much more influence upon its movements. We cannot doubt, however, that the Cod moves periodically to and from the shore as a direct result of the sensonal changes of temperature. The Cod prefers a temperature of from 35° to 42° F., approximately, and this it secures in a temperate climate, such as that of Southern New England, by remaining on the off-shore banks in

[1] Report of United States Commissioner of Fish and Fisheries, pt. v, 1879, p. 51.
[2] *Op. cit.*, p. 707.

fifteen to thirty fathoms of water, coming into the shallows in winter. On the coasts of Labrador, Newfoundland, Nova Scotia, and Eastern Maine, moving to and from the shore from deeper to shallower water and *vice versa* to secure at different seasons of the year a temperature environment best suited to their needs, they are near the shore in summer and in deep water in winter.

In Norway they are caught, to some extent, in the fiords in the summer season, though more are caught in winter, while in summer great numbers of them still remain on the off-shore banks.

Professor Hind gives this exposition of the movements of the Cod on the Labrador coast.[1]

"The following tables show the periods of the first arrival and last catch of Cod on the Newfoundland and Labrador coasts. In framing these tables I have been careful to eliminate extreme seasons, for the Cod have been known to approach the shore during an exceptionally early season, a fortnight or three weeks sooner than during the average of years. Early and late springs occur in the movements of fish just as irregularly as in the movements of migratory birds or in the leafing and flowering of plants. The salmon and the Cod generally come within a week of one another, and the Eskimo of Ukkasiksalik have a tradition that the salmon may always be looked for on the day of the first spring tide after the 16th July. In 1875, a very late season, Codfish were not taken before the 7th August; this year they came in on the 20th July, and this accords with the experience on other parts of the coast.

"*Table showing the approximate mean date of arrival of Cod, mean date of departure, and mean length of the fishing season for Cod, in Northeastern Newfoundland, Southern and Northern Labrador.*

Lat.	Locality.	Mean date of arrival.	Mean date of close of fisheries.	Mean length of fishing season.
	NEWFOUNDLAND.			
° ′				
47 30	Conception Bay	June 1	Nov. 20	
48 20	Bonaviata Bay	June 10	Nov. 10	
48 30	Notre Dame Bay	June 20	Nov. 10	
50 00	Cape Saint John to Par. Point	June 20	Nov. 1	143 days.
49 30	White Bay	June 10	Nov. 1	
51 00	Cape Rouge Harbor	June 10	Nov. 1	
51 30	Cape Bauld to Cape Onion	June 20	Oct. 20	
	(Over four degrees of latitude.)			
	SOUTHERN LABRADOR.			
52 00	Chateau Bay	June 20	Oct. 1	
53 24	Batteaux	July 12	Oct. 10	87 days.
54 26	Indian Harbor	July 15	Oct. 1	
54 56	Cape Harrison	July 18	Oct. 1	
	(Over three degrees of latitude.)			
	NORTHERN LABRADOR.			
55 14	Aillik	July 20	Oct. 1	
54 57	Kypokok	July 20	Oct. 1	
55 27	Hopedale	July 20	Oct. 1	
53 30	Double Island Harbor	July 22	Oct. 1	
55 52	Ukkasiksalik	July 28	Oct. 1	61 days.
56 33	Nain	July 28	Oct. 1	
57 30	Okak	July 28	Oct. 1	
58 30	Hebron	Aug. 15	Sept. 25	
58 46	Lampson	Aug. 15	Sept. 15	
	(Over three and a half degrees of latitude.)			

"From this table, imperfect as it is, we may deduce the following law: 'Over an area extending northerly from Conception Bay for seven hundred miles, the Cod approach the shore about one week later for every degree of latitude we advance to the north.'

[1] HIND, H. Y.: The Effect of the Fishery Clauses of the Treaty of Washington upon the Fishermen of British North America. Halifax, 1877.

"The table shows also that for a period of about forty days the cod fishery goes on simultaneously during August and September, throughout the length of a coast line extending from latitude 47° to latitude 50° 30′, or more than seven hundred statute miles in one continuous line. Hence it appears that the migrations of the schools of this fish are merely from deep-water winter feeding grounds to the nearest coast spawning grounds, and from the coast to the nearest deep-water feeding grounds again. The coast migrations during the summer months appear to be of equally limited extent, and schools of Cod frequenting any particular coast may be said to be *indigenous* to it.

"On the Labrador, especially in well-known deep bays, such as Hamilton Inlet, the coast movements of the fish appear to be very regular, and determined to a large degree by the tidal currents. The caplin generally precede the Cod by a few days, and these fish are known to approach the coast and enter sandy coves for the purpose of spawning. The same meteorological influence which guides the movements of the Cod affects also the periods of spawning of the caplin. I saw numerous schools of this fish spawning in Trinity Bay on the 27th June; a month later they spawn in Kypokok Bay, and still later further to the north."[1]

I have before me the statements of nearly a hundred observers which I hope to discuss more fully at some future time. These opinions confirm, in a very striking manner, the generalization just stated. They show that while on the coast of Maine the Cod leave the immediate shores in the autumn, not reappearing in any considerable numbers until late in the following spring, south of Cape Cod they approach the shore only in the winter season, while during the summer they keep out in the cold Labrador current, which extends south to the inside of the current of the Gulf Stream. In Vineyard Sound, Buzzard's Bay, and off the shores of Connecticut, New York, Delaware, New Jersey, and even in Eastern Virginia, there is excellent cod fishing during the winter season. "A wise provision of nature," remarks Professor Baird, "in the absence of so many species that supply food during the summer."

It will probably be found that fishing in deeper water in these same regions in summer will bring to light an abundance of Cod.

"In European seas," writes Professor Hind, "the depth at which the fishermen look for Cod varies with the season of the year, and is a point toward which much attention is paid in Norway and England. On the Dogger Bank, the smacks fish at the following depths during the months named:

	Fathoms.
December	12 to 15
January	14 to 18
February	18 to 22
March	10 to 12"

From Professor Hind's pen the following paragraphs are also taken:

"When the coasts of Finmark are thronged with fishermen catching their fares of the 'Lodde,' or Summer Cod, the shores of Northeast Newfoundland and the shore of the Gulf of Saint Lawrence are alive with fishermen successfully capturing the same variety of fish in British American waters; and when the Russian on the Murmanian coast is laying in his winter stock of Cod, and accumulating a large overplus for a foreign market, the Newfoundlander and the Labradorian are securing their fares as far as the Moravian Missionary Stations, Okak and Nain. So, also, in the North Sea and on the coast of the British Isles, around the Faroe Islands, all along the Icelandic shores, on the south coast of Greenland, off Arksut Fiord, away up north to Torske Banks, and down the Atlantic

[1] HIND: *op. cit.*, pt. ii, p. 70.

coast of America to over the Grand Banks, and as far as, and even beyond, Saint George's Shoal, the Cod is taken simultaneously and in great abundance.

"Local variations of days, and even weeks, occur in a coast line or stretch of shallow sea of not more than one hundred miles in length; but these arise from the one great leading cause which guides the Cod in its approach to known feeding grounds on the coast or known banks at sea. This leading cause is temperature, which determines the movement toward the coast of the various forms of marine life on which the Cod, inhabiting different waters, is accustomed to feed. . . . The Cod, caught on each stretch of coast line within variable but tolerably well-defined limits, are *indigenous* to the sea area adjacent to the sea-coast which they frequent.

"Thus the winter haunts of the Codfish on the Northern Labrador coast are the slopes of the *great range of outside banks on that coast. The summer haunts of the 'Winter Cod' caught on* the coast of Norway during the winter season, are on the slope of the 'Storegg' and its continuations which lie seawards from the Norwegian coast, following the edge of the barrier separating the 'polar deeps' from the shallower coastal seas. The seasonal movements of the Cod are reversed in this case, purposely introduced, but have afforded a beautiful illustration of the principles adopted and confirmed by Professor Baird and of the influence of marine climate on fish-life."[1]

The depth at which Codfish are found varies greatly with the season and locality. It is stated by Mr. Earll that they seem to prefer water less than seventy fathoms deep, and that by far the greater numbers are caught in from eighteen to forty fathoms. This generalization will doubtless hold true for the whole coast of North America. Many of our correspondents state that they are occasionally seen in water two or three feet in depth. In the course of the recent explorations by Professor Agassiz, Cod were found three hundred fathoms below the surface.

"In February, 1879, there was good fishing in three fathoms of water, within a few rods of shore in Ipswich Bay, while in May of the same year large numbers were taken in one hundred *and ten fathoms from the channel near Clarke's Bank.*"

It would be extremely interesting to know the extent of the migrations of Codfish, from deep to shallow water and back again, on different parts of the coast. This, however, varies with local conditions. There have already been many observations made, the study of which will doubtless aid in the solution of this problem, but it is exceedingly important that there should be systematic exploration at a distance from the shore both in winter and summer. This is one of the tasks proposed by the Commissioner of Fisheries for the new sea-going steamer now being constructed. Mr. Marcus A. Hanna, of Bowery Beach, Maine, states that he knows certain places on the coast of Maine where Cod are found in mid-winter not more than two miles from land, in water from *forty to fifty fathoms deep, and upon soft bottom. A portion of the Gloucester George's Bank* fleet continues fishing through the winter months, though at this season the vessels do not, as in spring and summer, fish upon the shallow parts of the bank, but rather seek the deep waters around its edge. The fish make their appearance, however, on the bank early in February.

An experimental cruise made in winter by Captain Mar throws some light on the movements of the Cod in this region: "One winter I started on a cruise before the time for the Cod to come, which was usually from February 7th to the 10th. I sounded all over the usual ground. None there. Cruised seventy-five miles to the south'ard, sounding in thirty to one hundred fathoms of water. Found none—only one Codfish. Got back to the banks and found the Codfish there." At another time he was going over the shoal ground of the banks in February, with a load of fish; in sounding, *passing over the shoals in sixteen fathoms of water, he caught six pairs of large fish. He thinks* that they were "solid," passing over the shoal. It should be borne in mind that these fish were

[1] *Hind, op. cit.*, pt. i, pp. 15, 16.

caught on hooks fastened to the sounding-lead, which was thrown over while the vessel was in motion.

The remarks made in the previous section regarding the times at which Cod were present and absent on different parts of the coast should be understood as expressing the facts only in a general way. It is undoubtedly true that Cod may be found in greater or less numbers within reach of the land from Block Island to Newfoundland, and perhaps to Labrador, at all seasons of the year. South of Block Island, Codfish are very rarely noticed in summer, even in the deepest water frequented by the fishermen, though a few remain on the grounds in the vicinity of the islands during the whole summer.

In the waters from Cape Cod to Cape Ann, and perhaps a little farther to the north, we find the district in which the bathic migrations of the Codfish are least apparent, the periodical changes in depth being but slight from winter to summer—the fish being within easy reach of the fishermen at all seasons of the year. Even here, however, there is a great increment in their numbers in winter.

The statements which have been made regarding the periodical movements of the Cod I do not by any means consider satisfactory or final. These movements are the results of many influences, and no one yet understands how much weight to attach to the relative importance of these three influences, *i. e.*, (1) the direct effect of temperature upon the fish themselves; (2) the abundance of food, as affected by temperature and other causes; and (3) the direct relations between temperature and the reproductive habits of the fish. There is no more difficult problem in ichthyological science.

"The Codfish sometimes make long journeys from one bank to another, and, indeed, from one region to a very distant one. It is, of course, nearly impossible to trace their movements at such times, and one can usually only guess at the place from whence they come or the distance traveled.

"During the winter of 1877–'78 an unusually large school visited the coast of the United States. At this time Cod were more plenty along the shores of New England than for many years. Among the fish captured at Cape Ann and other points were quite a number with peculiar hooks in their mouths. These hooks gave a clew to the movements of the fish, for they differed from any in use by the American fishermen, and proved identical with those used by French trawl-fishermen on the Grand Banks, and indicated that the fish must at some time have been in that locality, as the hooks probably came from no other place. If the above be granted as proven, the fish must have traveled a distance of five to eight hundred miles at least, and, as a portion of the school continued well to the southward, some individuals must have journeyed much farther. . . .

"In moving from one bank to another, where the intervening depth is much greater, it seems probable that, instead of following the bottom, they swim in a horizontal plane, following a stratum of nearly uniform density and temperature. The fishermen of Cape Ann have often caught them with seventy to eighty fathoms of line, between Brown's and George's Banks, where the sounding-line indicated a much greater depth. The finding of pebbles and small stones in their stomachs is not an uncommon occurrence. The fishermen regard these as an unfailing sign that the fish have either just arrived or are about to leave the bank. These stones may play no small part in adjusting the specific gravity of the fish to that of the stratum of water in which they are to move.

"There seems to be a tendency for the large fish to remain in deeper water or nearer the bottom than the small; and usually, beyond a certain depth, the deeper one fishes the larger the fish. Formerly, in hand-lining from deck on the banks, the vessels often anchored in eighty or even ninety fathoms, and the catch averaged over two-thirds large; but in hand-lining from dories they seldom fish in over fifty and usually less than thirty-five fathoms, as they find it difficult to

handle so much line, and the catch runs about two-thirds small. The same is true in fishing at different depths at the same time and in the same place. Thus, of two men fishing side by side from the deck of a vessel, the one with his hook on the bottom will catch much larger fish than the other who lets his line but part way down. Larger fish are also taken on the trawl than on the hand-line, for the former lies constantly on the bottom, while the latter may be raised to any distance above it."[1]

FOOD.—Codfish feed upon all marine animals smaller than themselves which are found in the same waters with them and are digestible. It would seem useless to give a catalogue of the species which have been discovered in their stomachs. For a long period of years, before our naturalists learned to use the hand-dredge, a favorite place in which to search for the rare invertebrates of the deep water was the fish-dealer's store, and from the stomachs of Codfish scores of shells new to science have been taken. Since the introduction of improved methods of deep-sea research this mode of collecting has been somewhat less prosperous, but even at the present time many important additions to zoölogy are yearly made by the aid of this omnivorous animal. In the Report of the United States Commission, Part I, pp. 516, 517, may be found a list of the species of mollusks obtained by Mr. J. Hammond Trumbull from Cod caught near Stonington, Connecticut, and this includes but a very small percentage of the number that has thus been observed.

Codfish swallow bivalve shells of the largest size, like the great sea clams, which are a favorite article of food on certain portions of the coast; for instance, in Ipswich Bay great beds of empty shells of the sea-clam, *Mactra ovalis*, may be found upon the bottom. These shells are "nested," the smaller inside of the larger, sometimes six or seven in a set, having been packed together in this compact manner in the stomachs of the Codfish after the soft parts have been digested out. Some of them had shreds of the mussels remaining in them and were quite fresh, having evidently been but recently ejected by the fish. In Dana's "Geology" are mentioned great banks of dead shells off the island of Grand Manan, which doubtless originated in the same manner. Mr. W. H. Dall found some similar beds on the coast of Alaska which he attributed to the walrus, but which are more probably the remains of mollusks eaten by the Codfish. They feed also upon crabs of all kinds, lobsters and star fish, and have been seen at the surface catching the potato beetles and "June-bugs" which have drifted out from the shore. It is said that they succeed occasionally in capturing a duck,[2] and that they vary their diet by browsing upon carrageen, or Irish moss, which grows on the ledges near the shore. In searching at the bottom for shells and worms, Codfish often pick up objects which can hardly be regarded as nutritious. A very amusing catalogue of such objects might be included in this chapter, in which would be enumerated articles such as scissors, brass oil-cans, potato parings, corn cobs, and head of a rubber doll. The finding of finger-rings and fragments of oil-clothing, and the heel of a boot, inside of a large Codfish has suggested the idea that sometimes they swallow the fishermen.

"A wedding ring which belonged to Pauline Burnam, an English lady who was lost in the steamship Anglo Saxon, wrecked off Chance Cove, N. F., in 1861, was lately restored to her relations by a St. Johns (N. F.) fisherman, who found the ring in the entrails of a Codfish. The lucky fisherman received a present of £50 for restoring the highly prized memento to the lady's son."[3]

Stones of considerable size are often found in their stomachs, and fishermen have a theory that this is a sign of an approaching storm and that the fish thus take in ballast to enable them

[1] EARLL: *loc. cit.*

[2] The Vineyard Gazette says that Mr. James Osborne took a Codfish on Wednesday, at the "South Side," which weighed over sixty pounds. On dressing it, two full-grown ducks (old squaws) were found in its entrails. They were quite fresh, having most of their feathers on.—Gloucester Telegraph, May 6, 1857.

[3] Boston Journal, July 6, 1871.

to remain at the bottom when the waters are troubled. It is more likely that these stones are swallowed on account of sea-anemones or other edible substances which may be attached to them, in just the same manner that the shells of mollusks are taken in for the sake of the nutritious parts which they contain.

It is believed that certain schools of Codfish feed almost entirely at the bottom, while others prey upon fish. The fishermen claim to be able to distinguish these two classes by their general appearance, the first being heavier, with shorter heads, blunter noses, and smaller fins, and frequently known as "grubbers" or "ground-keepers," while fish belonging to what are known as the squid school, the herring school, and the lant school, which are probably the same fish at different seasons of the year, are brighter-eyed, slenderer in form, with sharper head, and in every way better adapted for swift locomotion. On the coast of Labrador, as well as in Scandinavia, Codfish follow the schools of spawning capelin in to the shore and prey greedily upon them, and elsewhere, at other seasons, they feed with no less voracity upon other species of fish which may be schooling, and of which they destroy vast numbers, such as mackerel, menhaden, herring, alewife, salmon, sculpin, flounders, cunners, and haddock.

In November, 1877, Mr. Vinal N. Edwards found in the stomachs of Cod taken at Noman's Land many species of fish, some of which, like *Eumesogrammus subbifurcatus*, are found only at great depths, and others, like the two-spined stickle-back, *Gasterosteus biaculeatus*, and the little file-fish, *Monocanthus setifer*, must have been taken at the surface or near the shore.

On the Grand Banks, especially in shallow water about the Virgin Rocks, I have been told that they follow the lant to the surface, pursuing them with great fierceness. Along our northern coasts they replace, to some extent, the voracious bluefish and bonito of the South. Captain Atwood remarks that the amount of food which they consume is enormous, when the size of the fish is taken into account. He has seen them on the coast of Labrador, where the capelin were in great numbers, with their stomachs filled to the greatest possible extent, and capelin in their mouths which they were unable to swallow for want of room, and in this condition they were still biting at the hook. They even feed upon the young of their own kind. They are said to feed largely upon herring spawn, though they are not seen in great numbers, about the spawning grounds until the schools of parent fish have departed. The herring, also, is a favorite article of food, and when these fish approach the shores or are seen on the banks it is a very good sign that Cod will soon be abundant. Mr. Earll remarks:

"I am told that in the spring of 1879 an immense school of herring moved closely across George's Bank, and that with them came the largest school of Cod that has been seen in that locality for a long time. The Cod remained constantly among the herring, so that when the latter had passed the fishing fleet, the vessels were obliged to weigh anchor and follow them in order to secure the Cod.

"About Provincetown the common squid sometimes appear in great numbers, and they are most vigorously preyed upon by the Cod."

The same accurate observer gives the following notes concerning their food while breeding:

"During the spawning season the Codfish cease to search for food, and give less attention to feeding than at other times, though they will usually take the bait when placed before them. That they do not search for food is shown by the fact that the pasture school remained within a few miles of a large school of sperling without being drawn after them; and that the Ipswich Bay school was largest after the sperling had left the coast, and remained for a number of months on sandy wastes which supported only three species of invertebrates, *Buccinum undatum*, *Fusus* sp., and *Asterias vulgaris*, in any considerable abundance. The examination of the stomachs of several

hundred individuals showed four-fifths of all to be entirely empty, while a greater part of the remainder contained only bait picked from the trawls of the fishermen. A small number contained fish of one or more species that had probably been captured in the locality, while a few scattering invertebrates were found. Of the species mentioned as abundant on the grounds, not a star-fish and but two shells of one species and one of the other were found. But it was clearly shown that the fish would not refuse food, for often the stomachs were well filled with bait picked from the trawl before the fish were hooked. From ten to fifteen pieces were frequently found, and in one case eighteen were counted.

"The females when fully ripe seemed less willing to feed than at other times, and few were caught with the moving hand-lines; but when the trawl was used, thus leaving the bait motionless on the bottom for hours at a time, they were induced to bite, and many were taken with the eggs running from them. Ripe males seemed to bite readily at any time.

"The young fish, as has been remarked, seems to spend the first three or four years of its life in shoal water, among the rocks and algæ. Here its food consists at first of the minutest forms, and later principally of small crustacea, though it often picks up mollusks and worms, and even enters the harbors in summer, where it remains about the wharves, picking up bits of refuse thrown from the fish-houses."

Capt. R. H. Hurlbert tells me that sometimes a school of Codfish will bite at night; these the fishermen call "*Night Cod.*"

In 1860 the schooner "C. C. Davis" caught one entire trip of fish on George's Bank all in the night, and there are other instances on record, though, as a rule, these fish feed only in the daytime.

REPRODUCTION.—Two important papers on the breeding of the Codfish have recently been printed in the Report of the United States Fish Commission. The first of these is a translation of a report by Prof. G. O. Sars upon the practical and scientific investigations concerning the Cod-fish of the Loffoden Islands, Norway, made during the years 1864–'69, in behalf of the Norwegian Government.[1] His observations are full of interest. He tells us how, from year to year, he observed the movements of the Codfish and studied out their spawning habits.

In 1864 he visited the Loffoden Islands, in January, February, and March. He observed the coming in of the fish, as they approached the coast, swimming up the fiords in large schools, and in the latter part of February, and from that time until the end of March, found the eggs in immense numbers floating at the surface.

In 1865 he reached the islands in the beginning of March and remained until the middle of May. He gathered the eggs as they floated at the surface, and hatched them out in glass jars. He also artificially impregnated the eggs and found that the period of incubation lasted eighteen days. He also observed a few very small young fish at the surface.

In 1866 he was on the ground on the 7th of May, and remained until July. This year he found great quantities of young Codfish—the largest being about one and a half inches in length—swimming under the jelly fish (which are so numerous in those northern waters), and also under other objects floating in the sea.

In 1867 he reached the islands late in July, and remained until the beginning of October, and succeeded in finding the young fish, two inches or slightly more in length, swimming near the surface in the "slicks," and also in the shallow inlets near the shores, in company with the young pollock, while the stomachs of all the larger Codfish and pollock taken in the neighborhood were full of them. He also found in the beginning of October many larger young Codfish, upwards

[1] United States Fish Commission, pt. v, pp. 565–661.

of four inches in length and about seven months old, as estimated, at the bottom, at a depth of several fathoms.

In 1868 he began his observations in November, and in November and December found young fish six or seven inches in length at a depth of eight to twelve fathoms, usually in the vicinity of steep ledges and rocks. This year he remained until March, and in February found great numbers of young Codfish, the average length of which was about one foot, at an average of twenty to thirty fathoms, on sandy bottom. "In the beginning," he remarks, "I thought that these must be two-year-old fish, but when I afterwards set my line in shallower places I also collected smaller fish, so that I soon had all the different grades of size."

This last visit extended over into the year 1869, and at the time of his departure the schools of spawning fish were again on the ground. He had thus traced the development of the Codfish throughout a period of twelve months, and had secured a very complete chain of evidence with which to bind together the isolated facts regarding the growth and habits of the young fish which had hitherto been or should hereafter be observed.

From 1870 to 1873 he continued his observations upon the young and adult fish, and in midsummer found Cod at a distance of twenty to thirty Norwegian miles from the shore, and at a depth of from one hundred to one hundred and fifty fathoms. These observations, as has already been remarked, are of the utmost importance, and the reports of Professor Sars are full of observations of the most suggestive kind concerning the food, the movements, and the general habits of the fish.

The other paper referred to, which is of equal value, is the report of Mr. R. E. Earll upon the natural history and artificial propagation of the Cod, as observed at the station of the United States Fish Commission at Gloucester, Massachusetts.[1] His remarks upon the reproduction of the Codfish are here quoted in full, with the single observation that no one has so carefully observed the spawning habits of any other species of fish.

"The Cod is one of the most prolific of the ocean fishes, and we find not only thousands but millions of eggs in a single female. All members of this family contain large numbers of eggs, but the Codfish is the most prolific of all.

"The exact number of eggs in a female varies greatly with the individual, being dependent largely upon its size and age. To ascertain the number for the different sizes, a series of six fish, representing various stages of growth from twenty-one to seventy-five pounds, was taken, and the eggs were estimated. Care was exercised that the series should contain only immature females, so that no egg should have been lost, and that all might be of nearly equal size. The ovaries were taken from the fish and their weight accurately ascertained; after which small quantities were taken from different parts of each and weighed on delicately adjusted scales, the eggs in these portions being carefully counted. The number contained in a given weight being known, it was easy to ascertain approximately the entire number for each fish.

"The results obtained are given in a table, quoted below, showing a twenty-one-pound fish to have 2,700,000, and a seventy-five-pound one, 9,100,000. The largest number of eggs found in the pollock was 4,029,200, and in the haddock 1,840,000.

"When the eggs are first seen in the fish they are so small as to be hardly distinguishable, but they continue to increase in size until maturity, and, after impregnation, have a diameter, depending upon the size of the parent, varying from one-nineteenth to one-seventeenth of an inch. A five to eight pound fish has eggs of the smaller size, while a twenty-five-pound one has them between an eighteenth and a seventeenth.

[1] Report of United States Commission of Fish and Fisheries, pt. 6, 1878, pp. 685–740.

"From weighing and measuring known quantities it is found that one pound avoirdupois will contain 190,000 of the smaller size, or that 1,000,000 eggs well drained will weigh about five pounds. Again, by assuming one-nineteenth of an inch as the standard, or by precipitating a known quantity in chromic acid and measuring, we find one quart, or fifty-seven and three-quarters cubic inches, to contain a little less than 400,000, or that 1,000,000 will measure between two and a half and three quarts.

"With these facts in mind, it will be an easy matter to estimate the quantity of eggs taken for hatching purposes during any given season.

"When the little fish first breaks through the shell of the egg that confines it, the fetal curve or crook is still quite noticeable, but it soon straightens, and is then about five-sixteenths of an inch in length. At this time the yelk-sack, situated well forward, is quite large, but so transparent as to escape the notice of the ordinary observer. This is gradually absorbed, disappearing wholly in about ten to fifteen days, and the little fish begins to move about with a peculiar serpentine motion, at times darting quite rapidly, and then remaining motionless, as if resting from its exertions. It now begins its independent existence, and moves about more frequently, apparently in search of food. From this date it is impossible to follow the Cod, for none have been confined, and it is only by catching large numbers at different seasons and carefully recording their weights and measurements that one is enabled to judge of their growth. The habits of the species, that cause them to live near the shore for the first few years, furnish excellent opportunities for such observations, and many were examined during our stay at Cape Ann.

"At the outset the problem becomes difficult, in that the spawning period, instead of being limited to a few weeks, as is the case with most species, extends over fully three-fourths of the year, and the difficulty is greatly increased by other causes that affect the rate of growth of individuals hatched at the same time.

"The results were what might be expected; for a table of measurements, made late in June, gave an almost continuous series, with only one or two breaks, that could with certainty be taken to represent the non-spawning period of the fish. But though the gaps were so completely closed by the extremes in variation, which seemed to cause even an overlapping, showing the last hatched of one season to be smaller than the first hatched of the next succeeding, yet there was a tendency for the greater number of individuals to be thrown into groups at intervals in the series, these seeming to represent the height of the spawning season for the different years. The break was distinct between the smallest and those of a year earlier, so that, taking the height of the spawning season on the south side of Cape Ann to be December, the large number of young fry ranging from one and a half to three inches must have been hatched the previous winter, and were consequently about six months old. The large number of individuals having a length of nine to thirteen inches indicated the normal growth of those hatched a year earlier, or fish of eighteen months, to be ten to eleven inches, and their weight seven to eight ounces. The next group, or the fish thought to be thirty months old, measured from seventeen to eighteen inches, with an average weight of two to two and a quarter pounds. The fish now begin to increase more in weight than in length, soon appearing in the markets as 'Scrod,' and by the following summer measure about twenty-two inches and weigh from four to five pounds.

"Beyond this period nothing can be determined, for the variation, constantly growing greater, now gives every size and weight, with no indication of breaks in the series.

"But enough has been learned, if the above be correct, to show that the male reaches maturity at three and the female at four years; for the smallest ripe male noticed during the season of 1878–'79 weighed three and a half and the smallest ripe female five pounds.

"Evidence is not wanting to show that a Cod spawns every year, and that it deposits the entire number of eggs in the ovaries each season. We have examined hundreds of specimens and have failed to find a single instance where the condition of the ovaries did not clearly indicate that such was the case. During the first of the season no mature fish were found in which eggs were not present, though they often varied greatly in development from very small to nearly ripe. Again, later in the season, no spent fish were seen with any eggs remaining in the ovaries; and no fish were found during the spawning period in which the condition of the ovaries did not indicate that the eggs were gradually maturing, and would be deposited before the close of the season.

"The eggs contained in the ovaries are separated into little irregular conical clusters, each being connected with the general mass by a slender thread that expands into a delicate membrane containing minute and diffusely branched blood-vessels. This membrane envelops each of the eggs, and the blood-vessels supply the nutrition so necessary to their future growth and development. As the eggs mature they gradually increase in size, until, when ripe, they become detached from the membrane, and pass down through secondary channels into the main channel leading to the genital opening of the female.

"The first ripe female seen during the season of 1878–'79 was found in a lot of shore-fish or ground-tenders landed September 2. The eggs were noticed to be running from this fish as it lay upon the floor of the fish-house. On opening it, we found that it had just begun spawning, for a few eggs only, perhaps five per cent. of the entire number, were transparent, and a small number of these had separated from the membrane and fallen into the channels leading to the genital opening, while the great bulk were far less mature and represented almost every stage of development from green to ripe.

"From this date ripe fish, both males and females, were occasionally taken, though they did not become abundant until the middle of October. Early in November, when the school-fish made their appearance on the south side of Cape Ann, the individuals varied greatly in their spawning condition; some were quite ripe and had already thrown a portion of their eggs, while others were so green as to indicate that they would not spawn for several months at least, though, in nearly all, the eggs had begun to enlarge. By the first of December fully fifty per cent. of the catch had commenced spawning, but when driven away, probably by the unusually heavy storms, in January, a few were not quite ripe, and the majority had not thrown all their eggs.

"About the first of February the fish in Ipswich Bay were found to average fully ninety per cent. males, with the spermaries mostly well developed. At this time there was a great variation in the ovaries of the females; of these not more than one in ten had spawned, while fully sixty per cent. were still green. By the middle of the month the females numbered about forty per cent., though over half had not commenced spawning. On March 13, three hundred fish from this school were opened, with the following results: Fourteen per cent. were spent males; fifty-three per cent. were ripe males; six per cent. were spent females; fourteen per cent. were females in various stages of spawning; and eleven per cent. were green females. May 10, fully half of the females had not finished spawning, and an occasional green one was noticed. Even in June, when the fish left the coast, a very few, though ripe, had not finished throwing their eggs.

"The results of the above observation prove not only interesting, but surprising, for we find the Codfish spawning through nine consecutive months in the same locality, a period far exceeding that required by any other species of which we have any knowledge.

"This fact can be more easily understood when we remember that the individuals do not deposit all their eggs in a single day or week, but probably continue the operation of spawning

over a period of fully two months. That this is true there can be little doubt, for when the females first begin to throw their eggs only a very small percentage of the whole number are ripe, while the balance show every gradation to the perfectly green and immature. By frequent examination of individuals in more advanced stages, it was found that the eggs gradually continue to increase in size as they mature, and that as fast as they become detached from the membrane they pass down through the channels to the opening, and are excluded from the body, either at the will of the parent or by internal pressure caused by the increasing size of the eggs, to make room for others. It would be impossible for a fish to retain all, or even a small part, of its eggs in the roe-bags until the last had matured, for the increase during the development is very great, and they would come to have a bulk greater than the entire stomach cavity of the fish. The products of the ovaries of a seventy-five pound fish, after impregnation, would weigh about forty-five pounds and measure nearly seven gallons, equal to over half of either the weight or bulk of the fish.

"Another proof that the Codfish deposits its eggs gradually during a long period is seen in the fact that few can be taken from the fish at a time. In 'stripping the fish,' at the hatchery in Gloucester, it was found that only one quart, or less than 400,000 eggs, could be taken from a twenty-one pound fish at a single stripping. Allowing the ovaries of this fish to contain 2,700,000 eggs, and the time of spawning to be two months, the fish must deposit in the natural way 337,500, or nearly a quart, each week.

"But by the artificial method, where strong external pressure is applied, many more eggs are probably secured at once than would be naturally thrown by the fish. Thus the fish must either gradually deposit more or less eggs each day, during the entire spawning season, or it must deposit at intervals separated by only a day or two at most.

"The schools of Cod move about but little during the spawning season, except when driven away by enemies or by violent storms. After they reach the waters of Cape Ann, fishing continues best in the same localities, and even upon the same spots, until they leave. The individuals, too, seem to move about but little among themselves. When the female becomes ripe she remains quietly near the bottom, while the male, a little more active, often swims higher up. This is indicated by the fact that greater numbers of spawning females are taken with the trawl, which lies directly on the bottom, than with the hand-line a little way above it, while the males are taken on one as readily as on the other.

"It may not be impossible that the eggs are fertilized while floating about in the water some minutes after exclusion, and that the strong tides usually found on the spawning grounds play an important part in distributing the germs, thus making the chances of impregnation more favorable. Indeed it may be possible, and, if the spawning goes on gradually for several months, seems not improbable, that the immediate presence of the opposite sexes during the act of spawning is not necessary, but rather that the eggs are fertilized mainly by accidental contact. Observations would seem to strengthen the probabilities of this theory; for, if the fish went in pairs, they would often be taken on adjoining hooks of the trawl, or one on either hook of the hand-line. Such is not usually the case, however, but, on the contrary, several of the same sex are more frequently taken together.

"The eggs have a specific gravity of 1.020 to 1.025, as indicated by the fact that they float in salt water and sink rapidly in fresh. They may be found at the surface in common with eggs of the Pollock, Haddock, and probably other species of the cod family, when the sea is smooth; but when the water becomes rough they are carried to a depth of several fathoms by the current, though the tendency is to remain near the surface. The oldest fishermen had not the slightest knowledge of this fact, but held to the theory that the females deposited their eggs on the rocks,

where they were visited and impregnated by the males, and left to become the food of the various animals so abundant in such localities. They had at times noticed the little transparent globular bodies in the water, but it had never occurred to them that they were the eggs of any fish.

"There are many ways in which the eggs may be destroyed. The principal loss is probably the result of non-impregnation, for unless they come in contact with the milt of the male very soon after being thrown from the parent they lose their vitality. Again, being drifted about by the winds and tides, they are often carried long distances from the spawning grounds into the little bays and coves, and are driven in immense numbers upon the shores, or are left dry by the tides, where they soon die from exposure to the atmosphere, or, during the cold winter weather, are instantly destroyed by freezing. Ipswich Bay, the most extensive spawning ground in the locality, is especially unfortunate in this particular, for the heavy storms from the north and east sweep with unbroken force across its surface, and each breaker as it rolls in upon the beach must carry with it many millions of eggs.

"But such impregnated eggs as escape destruction upon the shores are subjected to the ravages of the myriads of hungry animals living about the rocks and coves. One day in January we placed a jelly-fish or medusid, having a diameter of but one and a half inches, into a tray of eggs in the hatching-room, and in less than five minutes it had fastened seventy eggs to his tentacles, loading some of them so heavily that they were severed from the body by the weight or resistance of the eggs as they were dragged through the water.

"By the aid of a microscope, numbers of *vorticelli* were frequently found upon the eggs, in one case forty-six being counted on a single egg. In addition a peculiar growth, thought to be minute algæ, was often noticed upon them. Just what influence these would exert, or whether they would occur in the clear water outside the harbor, is not known. Thus, owing to the many different circumstances that tend to destroy the eggs, probably but a very small number out of a million are successfully hatched, and of the young fish but few reach maturity."

In the winters of 1878–'79 and 1880–'81 the United States Fish Commission successfully carried on the work of artificial propagation of Codfish. The results of the first winter's work at Gloucester will be found detailed in Mr. Earll's paper, from which quotations have already been so extensively taken.

In addition to his other observations, Mr. Earll computed the number of eggs in Codfish of different sizes. The results of his observations are shown in the following table:

Table showing the number of eggs in Codfish of different sizes.

Number.	Length of fish.	Weight of fish.	Weight of ovaries.	Estimated weight of ovary walls.	Net weight of eggs.	Number of troy grains weighed out.	Number of eggs in the portion weighed out.	Number of eggs to the grain.	Total number of eggs in fish.
	Ft. in.	*Lbs.*	*Lbs. oz.*	*Oz.*	*Lbs. oz.*				
1	.....	70–75	8 8	6	8 2	7	1,198	160	9,100,000
1 (a)[1]	.....	70–75	8 8	6	8 2	7	1,132		
2[2]	4 2½	51	7 2	5	6 13	6	1,131	188.5	8,989,094
3	3 8	30	2 8¾	2¾	2 6	6	1,341	223.5	3,715,687
4	3 5	27	2 9⅜	2⅜	2 7	7	1,080	240	4,095,000
5	3 4½	22¾	2 2⅝	2	2 0½	6	1,368	228	3,229,388
6	3 3	21	1 15¾	1¾	1 14	6	1,249	208.17	2,732,237

[1] No. 1 (a) represents a second quantity taken from the same ovary the following day, and the greater number may be partially accounted for by the evaporation of moisture during the night.

[2] No. 2 contained a few ripe eggs.

It is interesting to compare these with the observations made during the last century, references to which may be found in all the standard works on natural history. Leuwenhoek is said to have found in a Cod of middling size 384,000 eggs. Harmer found, in one weighing eighteen or twenty pounds, between 3,000,000 and 4,000,000 eggs. It was examined December 23, and was estimated to have 294 eggs to the grain, the ovaries weighing 12,540 grains; the total number, according to this calculation, is 3,686,760.[1]

THE SIZE OF CODFISH.—The result of Mr. Earll's observations indicates that in June the fish hatched the previous winter, or about six months old, range from one and a half to three inches in length; while those from nine to thirteen inches long, and weighing seven or eight ounces, were eighteen months old; those seventeen to eighteen inches long, and weighing two to two and a quarter pounds, were supposed to be two years and a half old; those of about twenty-two inches, which weighed four to five pounds, were three years and a half old. He also concludes that the male reaches maturity at the age of three, and the female at the age of four years, for the smallest ripe male noticed during the season of 1878–'79 weighed three and one-half pounds, and the smallest ripe female five pounds.

On pages 733–734 of Mr. Earll's report may be found the measurements of a large number of Codfish of different weights, and with the ovaries and spermaries in different stages of development. These measurements are interesting, since they show the relation between the length and weight of individual fish.

I have before me memoranda relating to a large number of enormous Codfish, taken along the New England coast at various times from 1830 to 1879. It seems unnecessary to refer to them, excepting the cases of a few which exceed one hundred pounds in weight.

Capt. King Harding, of Swampscott, tells me that he once caught, on the eastern side of Cape Cod, a fish weighing 101 pounds as it came from the water.

On the 22d of July, 1873, Miss Fannie Belis, of Saint Louis, while on a fishing excursion off Eastern Point, on board the yacht "United States," caught a Cod which weighed 130 pounds.

Capt. G. H. Martin caught, off Chatham, a Codfish which weighed, dressed, 111 pounds.

Capt. Stephen Mar, of Gloucester, saw a Codfish taken on George's Banks in 1838 which, after having been eviscerated, weighed 136 pounds.

Captain Atwood says, on the coast of Cape Cod he has never seen a male Codfish, with one exception, which weighed more than 60 pounds; he once saw one, however, which weighed 160 pounds. This fish was not much larger than an ordinary fish weighing 75 pounds, but was very *thick.*

Captain Atwood remarks: "In regard to size, the Cod differs very widely in different localities. When taken on the Grand Bank it usually requires from thirty to forty to make a quintal when dried. Those caught in the Gulf of Saint Lawrence with hand-lines are smaller, requiring seventy to eighty per quintal; in the same locality, however, Cod caught on trawl-lines require *only twenty to twenty-five per quintal, while on the coast of Labrador they are all small,* and it requires about one hundred to one hundred and ten to make a quintal."

Writing in the summer of 1877, Captain Atwood expressed the opinion that the average weight of the fish taken about Cape Cod was in the neighborhood of ten pounds; but he informed me that in the winter of 1877, in two days, thirty thousand pounds of Codfish were landed from the boats, and that there was not a fish among them small enough to be classed as a market Cod, a market Cod weighing from six to ten or twelve pounds.

[1] Philosophical Transactions, lvii, 1778, p. 267.

I have before me much information concerning the average size of the fish caught at different seasons of the year by the fishermen at different localities along the coast, but it seems at present hardly necessary to discuss this subject at greater length.

CONCLUSIONS AS TO DECREASE OF COD FISHERIES ON THE NEW ENGLAND COAST.—In conclusion, it may not be amiss to quote the remarks of Professor Baird concerning the decrease of Codfish along our coast, and the probable causes for such decrease:

"Of all the various fisheries formerly prosecuted directly off the coast of New England, north of Cape Cod, the depreciation in that of the Cod appears to be of the greatest economical importance. Formerly the waters abounded in this fish to such an extent that a large supply could be taken throughout almost the entire year along the banks, especially in the vicinity of the mouths of the larger rivers. At that time the tidal streams were almost choked up with the alewives, shad, and salmon that were struggling for entrance in the spring, and which filled the adjacent waters throughout a great part of the year.

"As is well known, the erection of impassable dams across the streams, by preventing the ascent of the species just mentioned to their spawning grounds, produced a very great diminution, and almost the extermination, of their numbers; so that whereas in former years a large trade could be carried on during the proper season, now nothing would be gained by the effort.

"Of late the attention of the legislatures of the New England States has been called to this fact, and to the importance of restoring their fisheries, and a great deal has been already accomplished toward that end. Unfortunately, however, the lumbering interest in Maine, and the manufacturing in New Hampshire and Massachusetts, are so powerful as to render it extremely difficult to carry out any measures which in any way interfere with their convenience or profits; and notwithstanding the passage of laws requiring the construction of fishways through the dams, these have either been neglected altogether, or are of such a character as not to answer their purpose. The reform, therefore, however imperatively required, has been very slow in its progress, and many years will probably elapse before efficient measures will be taken to remedy the evils referred to.

"It would, therefore, appear that while the river fisheries have been depreciated or destroyed by means of dams or by exhaustive fishing, the Codfish have disappeared in equal ratio. This is not, however, for the same reason, as they are taken only with the line, at a rate more than compensated by the natural fecundity of the fish. I am well satisfied, however, that there is a relation of cause and effect between the present and past condition of the two series of fish; and in this I am supported by the opinion of Capt. U. S. Treat, of Eastport, by whom, indeed, the idea was first suggested to me. Captain Treat is a successful fisherman and dealer in fish on a very large scale, and at the same time a gentleman of very great intelligence and knowledge of the many details connected with the natural history of our coast fishes, in this respect worthily representing Captain Atwood, of Provincetown. It is to Captain Treat that we owe many experiments on the reproduction of alewives in ponds, and the possibility of keeping salmon in fresh waters for a period of years. The general conclusions which have been reached, as the result of repeated conversations with Captain Treat and other fishermen on the coast, incline me to believe that the reduction in the cod and other fisheries, so as to become practically a failure, is due to the decrease off our coast in the quantity, primarily, of alewives; and, secondarily, of shad and salmon, more than to any other cause.

"It is well known to the old residents of Eastport that from thirty to fifty years ago Cod could be taken in abundance in Passamaquoddy Bay and off Eastport, where only stragglers are now to be caught. The same is the case at the mouth of the Penobscot River and at other points along

the coast, where once the fish came close in to the shore, and were readily captured with the hook throughout the greater part of the year. That period was before the multiplication of mill-dams, cutting off the ascent of the alewives, shad, and salmon, especially the former. The Saint Croix River was choked in the spring with the numbers of these fish, endeavoring to ascend; and the same may be said of the Little River, the outlet of Boynton's Lake, about seven miles above Eastport. The lake in question is one of considerable size, and was visited by immense numbers of alewives, which could be dipped out, to any extent, on their passage upward, while the waters of the adjacent bay were alive with the young fish on their return.

"The fish themselves enter the waters of the streams in May or June, and return almost immediately after spawning to the sea. But they may be taken by the drift-nets along the shores as early as March and April; and, indeed, it is quite probable that the whole period of their abode in the salt water is spent adjacent to the rivers in which they were born. The young come down from the ponds in which they are hatched, from August to October, keeping up a constant stream of the young fish. In this way a supply of alewives was to be met with throughout the greater part of the year, and nearer the coast they furnished every inducement for the Cod and other ground fish to come inshore in their pursuit.

"It is true that the sea-herring is also an attraction to these fish, and probably but for their presence our pollock, haddock, and hake fisheries would be greatly diminished. Nevertheless, the alewife appears to be more attractive as a bait, and furthermore the sea-herring are less constantly on the coast, especially inshore, occurring as they do at stated intervals, when they come in from the deep sea to spawn. It is possible, too, that they are less easily captured by the Cod, since they swim nearer the surface than the alewives. Corroboration of this idea is furnished in the testimony of Mr. W. B. McLaughlin, of Southern Head, Grand Manan. This gentleman informs me that the only stream in the island which ever furnished alewives to any extent was Seal Cove Creek, which discharges to the east of the southern extremity of Grand Manan, and into which these fish entered in immense numbers in the spring. At that time Cod, Haddock, and Pollock, as well as halibut, were taken in great abundance in Seal Cove Sound, between Harwood Cove, on Wood Island, and Indian or Parker's Point, on the main island. They were to be met with during the greater part of the year, especially from May to January; and the fishery in the channel-way within a quarter of a mile of the shore was really more productive than on the banks much farther out to sea.

"Although still a young man, Mr. McLaughlin recollects the capture of these fish; and, indeed, as a mere boy, enjoyed the sport within a very short distance of his father's house. Soon after that time a dam was built across this stream about two hundred yards above its mouth, cutting off entirely the upward passage of the alewives, and by a remarkable coincidence, if it be nothing more, the cod fishery in question diminished very soon after, and in a very few years ceased almost entirely, so that up to the present time there are not enough Cod in those waters to repay the experiment of attempting to catch them. A few alewives still find their way up to the foot of the dam, but in such small numbers as to make it often doubtful whether there are any there or not.

"The other fishing grounds about Grand Manan are farther out to sea, at the northern end of the island, where there are no alewives, and where herring appear to be the principal food, although the variation in the abundance of these in different seasons appears to have an important bearing upon the number of Hake and Cod.

"If these conclusions be correct—and I am quite satisfied of their general validity—we have, for the efforts made to establish fishways in the rivers of Maine, New Hampshire, and

Massachusetts, a much more weighty reason than that of merely enabling a few salmon to enter the streams in order to permit their capture while on their way.

"Whatever may be the importance of increasing the supply of salmon, it is trifling compared with the restoration of our exhausted cod fisheries; and should these be brought back to their original condition, we shall find, within a short time, an increase of wealth on our shores, the amount of which it would be difficult to calculate. Not only would the general prosperity of the adjacent States be enhanced, but in the increased number of vessels built, in the larger number of men induced to devote themselves to maritime pursuits, and in the general stimulus to everything connected with the business of the seafaring profession, we should be recovering, in a great measure, from that loss which has been the source of so much lamentation to political economists and well-wishers of the country."

66. THE TOM CODS. MICROGADUS TOMCOD AND M. PROXIMUS.

THE ATLANTIC TOM COD.—The Atlantic Tom Cod, *Microgadus tomcod*, is found only in the Western Atlantic, ranging from New York at the south to Cape Sable at the north. It is ordinarily known as the Tom Cod, but in the Bay of Fundy, and in various places south of Cape Cod, it is known as the Frost Fish, owing to the fact that it becomes most abundant in the early part of the winter, when it approaches the shore and even ascends the rivers and creeks for the purpose of spawning. Dr. DeKay states, on the authority of Dr. Yates, that Tom Cods sometimes appear at Albany in abundance, while I am informed by the Rev. Dr. F. Gardiner that they are taken in winter in the Kennebec, sixty miles from its mouth, and far above the reach of the tide. They ascend the Charles River to Watertown, where they are taken in dip-nets and by the hook from the wharves and bridges. Although most abundant near the shores and in the streams in early winter, they are found along the coast at all seasons of the year. In form the Tom Cod is the miniature of the Codfish, rarely exceeding ten or twelve inches in length, and there is much difficulty in distinguishing the young of the two species. The Tom Cod, however, varies even more in its color than the Cod, and several varieties have been described under different names. When these fish approach the shores in winter they are taken in great quantities with nets, and are esteemed in many localities as a great delicacy.

The Tom Cod feeds upon numerous species of crustaceans and mollusks, and also upon the young of many other kinds of fishes.

THE PACIFIC TOM COD.—Professor Jordan gives the following notes upon the closely related species, *Microgadus proximus*, found in California, and there known as the Tom Cod:

"The English at Victoria know this species by the name 'Whiting.' Elsewhere on the coast the name of 'Tom Cod' is universally applied to it. In the restaurants at San Francisco, it is usually served under the name of Smelt. It reaches the length of a foot and a weight of about half a pound. It ranges from Monterey to Puget Sound and northward, being everywhere very abundant, and taken in great numbers in seines and sweep-nets, both outside and in the bays. Its food is small fishes. Nothing special is known of its breeding habits; it is apparently abundant at all seasons. It is one of the important food fishes of the coast, always abundant and always meeting a ready sale. Its flesh is, however, watery and tasteless, and cannot be rated high."

67. THE HADDOCK. MELANOGRAMMUS ÆGLEFINUS.

DISTRIBUTION.—The Haddock, *Melanogrammus æglefinus*, is found only in the Atlantic. Its wanderings are more limited than those of the Cod. It is not found nearly as far to the north; while its southern range is no wider. Haddock are probably found in company with Codfish on all

the northern fishing grounds, as far south, at least, as the Capes of Delaware, though concerning their occurrence in southern waters there is dearth of information. In winter and spring they are taken in Fisher's Island Sound and outside of Fisher's Island, on the coast of Eastern Connecticut; and also in great quantities on Nantucket Shoals by the smacks, and are carried thence with Cod into New York market. In 1871 it was estimated that the catch of Haddock here was nearly equal to that of Cod, although the latter usually predominate. They abound north of Cape Cod, in the Gulf of Maine, and in the Bay of Fundy, in the Basin of Minas, on the coast of Nova Scotia, in the Gulf of Saint Lawrence, and in the Bay of Chaleur. In the Gulf of Saint Lawrence, according to Captain Atwood, they are not very abundant, but the individuals taken are very large. They are taken on the western coast of Newfoundland in winter; their northern limit appears to be marked by the Straits of Belle Isle, latitude 52° N. The researches of Dr. A. S. Packard on the coast of Labrador failed to bring this species to light, and fishermen of that region told him that in the course of forty years' experience thay had never seen a Haddock. In 1863 and 1864 they were found in abundance on the southern border of the Grand Bank. Capt. R. H. Hurlbert states that he has seen them in great abundance in May at Louisburg, Cape Breton, playing at the surface among the reefs, but that they are not so frequent on the Grand Bank as on the Western Bank, and, in turn, less common there than on George's Bank.

In the Eastern Atlantic the range of the Haddock is somewhat wider, for they are found in the seas of Iceland, the whole length of the Scandinavian coast to East Finmark and Varanger Fjord, and on all the shores of Great Britain, and in the North Sea, where they are particularly abundant, though rarely or never entering the Baltic. There is no evidence that they are found to the south of the English Channel. De La Blanchère states that they are caught in considerable numbers on the coast of Manche. In the Eastern Atlantic, then, they are found between the parallels 48° and 66°; in the Western Atlantic between the parallels 38° and 53°.

NAMES.—The Haddock is often called "Dickie" by Connecticut fishermen. Hadot and Hadou are old French names for the same fish, though the species is now usually known by the name Égrefin. In Scotland the name is said to be pronounced almost in the same way as in France, and is often varied to Haddie. It is the Schellfisch of Germany. Concerning this fish many of our fishermen entertain the same idea, which with them can hardly be called a superstition, that the black spots upon their side are due to the impression of the thumb and finger of Saint Peter when the apostle took the tribute money out of the mouth of a fish supposed to be of this species, the fisherman's mark having been continued among its descendants ever since. This notion is prevalent also in England, and in Southern Europe is attached to other fishes, particularly to the John Dory, *Zeus faber*. It is needless to say that no member of this family occurs in the Sea of Galilee.

MOVEMENTS.—Haddock are not so active and powerful as the Cod. Dr. Gilpin has expressed the opinion that on the coast of Nova Scotia they do not retreat so far from the shore in winter as the Cod, but this does not appear to be true in Massachusetts Bay.

Storer, in 1839, made the assertion, which was repeated in 1867, in another edition of the "History of the Fishes of Massachusetts," that in Massachusetts Bay in the warm season about twelve hundredweight of Haddock are taken to each hundredweight of Codfish, and in the winter about twelve hundredweight of Cod to each hundredweight of Haddock; but since the haddock fishery is of longer duration, the proportion throughout the year averages about three Haddock to one Cod. They abound in Massachusetts Bay throughout the summer, and it is at this season also that they are taken in the greatest abundance on the off-shore banks in the Gulf of Saint Lawrence.

There is a strange absence of information concerning their movements on the European coast. On the coast of East Friesland the haddock fishery is permitted by law from March to the begin-

ning of June, and from October to the middle or end of January, a winter recess being allowed for the purpose of spawning. It is stated by Dr. Wittmack that during the heat of summer they retreat from these coasts, with the Cod and the flounder, into the deepest waters, appearing again towards the end of September. On the coast of Scotland they are said to be most abundant in winter. In Massachusetts Bay, as it has been said, they are most abundant in summer, coming in after the cod pass out, though they are also taken in deeper parts of the bay the whole winter long, and are sought at this season on George's and other off-shore banks as well as localities farther to the north.

A study of such data as these is unsatisfactory in the extreme, since it is impossible to draw from them any conclusions concerning the relation of the movements of the Haddock to the temperature of the water in which it is found. The only movements which are now intelligible are those which take place at the period of spawning.

ABUNDANCE.—Remarkable variations in the abundance of this fish are upon record; at certain times they have been exceedingly rare, at others abundant in the extreme. They appear to be much more gregarious than the Codfish, and to swim together in large schools from place to place. Storer, writing in 1839, said that they were common about Cape Cod, but that ten years before they had been rare. An item in the "Gloucester Telegraph," June 3, 1837, stated that Haddock were at that time brought in abundantly and sold from the Swampscott boats at a cent apiece.

According to Capt. E. W. Merchant, in the years from 1814 to 1820 there was a great catch in the vicinity of Nahant, about five miles at sea, east-southeast. So plenty were they that two men and one boy could catch with hand-lines from one boat 600 to 1,000 in number in one day. This school of fish came in about the 20th of March and continued until the first of May, then gradually decreased and spread over the fishing banks in Massachusetts Bay. At this time the majority of the boats belonged to Sandy Bay, now Rockport, and to Gloucester.

Capt. King Harding, of Swampscott, tells me that in 1843 Haddock were so scarce that they were sold singly. The fishermen received twenty-five cents each for all they could get. A vessel could not get more than one hundred in the course of a day's fishing.

At this time Isaac Rich & Co. chartered the schooner "Harriet," of Duxbury, to go out on a special cruise for Haddock, paying $200 toward the venture. She started out with a crew of five men about the 20th of February, and fished on soft bottom in the deepest water. Her fare was two hundred and twenty Haddock, and the trip was considered a remarkable success.

In May of the next year great schools of little Haddock came in. They were six or eight inches long and a great bother to the fishermen. The following year they were about half grown, or a foot or so in length and very thick. They came in May.

In 1846 they came in earlier, many in March, but mostly in May. They were quite large and very abundant.

Haddock were also very abundant in 1857. On the 13th of March one hundred Swampscott fishermen, in twelve vessels, caught in a period of about six hours 160,000 pounds of fish, chiefly Haddock.[1]

In 1877 and 187[illegible] Haddock were very large and quite scarce. In the winter of 1877 and 1878 they were larger than for many years. Some were caught near Swampscott which weighed fifteen and sixteen pounds. The average size is from four to six pounds.

Captain Atwood states that in 1834 Haddock were very scarce on the Grand Bank, and few were caught anywhere on the coast, but in 1840 they became so numerous about Cape Cod as to interfere seriously with the cod fishery, devouring the bait before the Cod could reach it, and about 1850

[1] LEWIS: History of Lynn, p. 450.

they had increased so rapidly that the markets were glutted. In 1864 they were caught in great numbers and were still on the increase. In 1870 the same observer related to the Massachusetts senate the story of another period of scarcity and abundance. His statements may be found in the Report of the United States Commission of Fish and Fisheries, part 1, 1873, p. 119. He elsewhere says:

"If over-fishing were possible, it seems to me that we should see some of its results where great changes have taken place in the modes of our fisheries of Cod and Haddock in Massachusetts Bay. What is called 'trawl fishing' was first introduced about 1850, and it resulted in the taking of a vast number of fish of these varieties. In consequence of the competition in the business, the Swampscott people petitioned the legislature for a law prohibiting trawl-fishing, on the ground that it would exterminate the Haddock. At that time I proved before the legislature that Haddock was much more abundant than it had been at any previous time, and that I was selling them at thirty-seven and a half cents per hundred pounds. That fishery has been going on ever since, and the amount taken was greater this last winter than for many years past. A fisherman in a dory fifteen feet long has often brought in as much as 1,800 pounds in a single day. There are eighty boats fishing out of the harbor, and 83,000 pounds have been caught in one day. This increase has taken place in spite of the constant practice of the new mode of fishing, by which twice as many are taken in the same time as formerly."[1]

Captain Atwood explains the great increase at this time by the introduction of fishing with long trawl lines, which destroyed many species of fish preying upon haddock spawn. At the present time Haddock are very abundant; they are caught throughout the summer in great numbers by the Irish market-boats of Boston, and in winter a large fleet of Gloucester and Portland vessels are engaged in catching them upon George's and other off-shore banks. These vessels fish with trawl lines, and it has been stated that a single crew has been known to take nearly 60,000 pounds in a day.[2]

FOOD.—The food of the Haddock resembles that of the Cod, except that they are, if possible, more omnivorous; their diet consists, however, largely of invertebrates. They are rarely seen feeding at the surface, though they devour the spawn of other fishes, particularly that of the herring, with great eagerness. They devour great quantities of shells, many of them of the burrowing species. Professor Verrill has well said that a complete list of the animals devoured by the Haddock would doubtless include all the mollusks belonging to the fauna of New England.

The Haddock are said to be particularly abundant on clam-banks. From this habit of feeding on shells has originated the German name for the fish. The difference between the habits of the Haddock and the Cod is illustrated by the remark of Captain Atwood that Haddock will take a baited hook as it rests upon the ground, while the Cod will only notice it when it is raised a short distance from the bottom. Salted menhaden is a favorite bait for Haddock, but not desirable for Cod, while both Cod and Haddock will readily take stale clams, which are much better for bait than fresh ones.

REPRODUCTION.—The spawning habits of the Haddock in our waters have been carefully observed by Mr. Earll, whose statements are quoted below: On the German coast the Haddock spawn on rocky bottoms in February and early March at a depth of twenty-two to twenty-five fathoms;[3]

[1] Extracts from Captain Atwood's manuscript biography.

[2] BIG HADDOCK TRIP.—Schooner "E. L. Rowe," of this port, Capt. Sewell W. Smith, arrived from George's on Monday at Boston, with 70,380 pounds of Haddock, the largest trip ever landed. Time absent, five days. The largest trip previous to this was landed by the same skipper in schooner "Cora E. Smith," 52,679 pounds, February 13, 1877. In February of the same year, schooner "Paul Revere," Capt. John Bentley, landed 51,700 pounds of Haddock and 2,500 pounds of Codfish as the result of one day's fishing.—*Cape Ann Advertiser*, February 21, 1878.

[3] WITTMACK, L.: Beiträge zur Fischerei-Statistik des Deutschen Reichs, 1875, p. 25.

and according to Yarrow the spawning period is the same on the British coast, the young growing to a length of six or seven inches before the beginning of September. At the Loffoden Isles, according to Sars, the spawning season of the Haddock takes place a little later, beginning toward the end of February and being at its height late in March.[1]

Mr. Earll's observations are as follows:

"The fish usually remain on the off-shore banks till the winter is over, and they do not reach Cape Ann until just before the spawning season, which for this species begins about the middle of April and continues during nearly three months, the height of the season being in May.

"In the spring of 1879 it is thought that two schools visited this coast, the first, composed of fish of large size, arriving early in April and leaving by the middle of May; and the other, composed of smaller individuals, reaching the grounds about the 20th of May and leaving gradually after the 1st of July, a few remaining during the greater part of the summer. When the fishing first began the fish were several miles from the shore, but they continued to 'work in,' until there was good fishing at the mouth of the harbor for several days, after which they seemed to move back again, and toward the close of the season remained on muddy bottom, when trawls were extensively used in their capture.

"Early in May Haddock were so plenty that one man caught 1,881 pounds in one day with hand-lines, and about the same time many different fishermen secured over 1,000 pounds daily. The males were usually a trifle more abundant, though at times the females composed fully half of the catch. The latter average larger than the former, and some days there would be a difference of two pounds in favor of the female.

"The first ripe females were noticed on the 23d of April, and in the middle of July an occasional one had not finished spawning. The first eggs were secured May 5, and others were taken at intervals to June 2, the total quantity being about 250,000. The method of impregnation was similar to that used for eggs of the Cod, and the size of the eggs was one-nineteenth of an inch. Though the number contained in the larger individuals of the species reaches over 1,800,000 (see table), the quantity obtained for hatching purposes at any one time was quite small as compared with the number taken from the Cod or the Pollock, and the quantity of milt in the male fish was very much less than in either of the other species."

Mr. Earll's observations confirmed those of Professor Sars, that the spawn of the Haddock floats at the surface like that of the Cod, and that the spawning process is in every way similar. The following table gives the result of his enumerations of the number of eggs in Haddock of different sizes:

Table showing the number of eggs in Haddock of different sizes.

Number.	Length of fish.	Weight of fish.	Weight of ovaries.	Estimated weight of ovary walls.	Net weight of eggs.	Number of grains (troy) weighed out.	Number of eggs in part weighed out.	Number of eggs to the grain.	Total number of eggs in fish.
	In.	Lbs.	Oz.	Oz.	Oz.				
1	28½	9 5/8	9½	½	8¾	4	1,950	487.5	1,839,581
2	28½	6 13/16	5½	½	5¼	4	1,479	369.75	849,315
3	26	6 5/8	6½	½	6	4	1,457	364.25	856,156
4	24	4 13/16	6½	½	6¼	5	1,160	232	634,380
5	23	4	5½	¼	4¾	6	970	194	403,132
6	20½	3 5/16	5¼	½	4¾	5	960	192	398,976
7	19½	2 1/16	2¾	¾	2	5	966	193.2	169,950

[1] Report of the United States Commission of Fish and Fisheries, part 5, 1879, p. 586.

The average size of the Haddock is probably not far from three or four pounds; many twelve-pound fish are brought to market, and individuals weighing seventeen pounds are on record.

In 1879 Haddock were successfully hatched, under the supervision of Mr. Earll, at the Gloucester station of the United States Fish Commission.

USES.—The Haddock is now very highly esteemed as a food fish, having grown in favor during the last twenty years. It is especially desirable for boiling or for making chowders, and is a great favorite in Boston, while in Philadelphia enormous quantities are yearly consumed. Being well adapted for preservation in ice, great numbers of them are distributed through the interior of the country, together with the Codfish. The success with which the Scotch method of smoking Haddock has been introduced into this country has also greatly increased the demand for them, and Finland Haddies are manufactured in enormous quantities in Portland and Boston. At Provincetown a Haddock salted and dried after being split is called by the name "Skulljoe," or "Scoodled Skulljoe."

68. THE POLLOCK. POLLACHIUS CARBONARIUS.

The Pollock, *Pollachius carbonarius*, which is the Coalfish of England, the Köhler of Germany, and the Sei of Norway and Sweden, is closely related to the Pollack of Great Britain, *Pollachius virens*, from which, however, it is specifically different. It is one of the best-known fishes of Northern Europe, as may be inferred from the abundance of its common names. The following names are in use in different parts of England: *Baddoch, Billet, Billard, Black-Pollock, Black-Jack*, Black-Coalsey, Blockan, Blockin, Coal, Coal-fish, Coalsay, Coalsey, Coal-Whiting, Colemie, Colmey, Cooth, Cudden, Cuddy, Dargie, Gilpin, Glassock, Glashan, Glossan, Glossin, Green-Cod, Green Pollock, Grey-lord, Gull-fish, Harbin, Kuth, Lob, Lob-Keling, Maulrush, Parr, Piltock, Podley, Poddlie, Podling, Pollack, Prinkle, Rauning Pollack, Rawlin Pollack, Rock Salmon, *Raw Pollock, Saithe*, Sethe, Sey, *Sey Pollack, Sillock, Skrae-fish, Stenlock, Tibrie.*

DISTRIBUTION.—Its geographical distribution is quite different from that of either the Cod or Haddock, its northern range, at least in the Eastern Atlantic, being fully as wide as that of the Cod, the species having been found in the northern part of Spitzbergen, beyond the parallel of 80°, and on the arctic coast of Europe. It rarely enters the Baltic. Bloch records a specimen from *Lubeck, and it is said to occur on the coast of Pomerania.*

Concerning the limits of its southern range authorities differ. Günther places this at latitude 46° in the Bay of Biscay, while others claim that it enters the Mediterranean. Canestrini states that it has been observed at Taranto.[1] It does not appear, however, that the species is abundant south of the English Channel. It occurs about Iceland and on the west coast of Davis Straits, *where specimens were obtained by Sir Edward Parry on his first voyage. North of Newfoundland* it does not seem to be very abundant, while to the south the limit appears to be in the vicinity of Nantucket Shoals, where specimens are occasionally taken by the cod smacks.

In Perley's "Catalogue of the Fishes of Nova Scotia," he states that he had never seen the fish in the Gulf of Saint Lawrence, nor heard of it except near the Straits of Canso, although it was found very abundant *in the Bay of Fundy and everywhere except in the muddy waters*, such as those of Cumberland Bay and the Basin of Minas.

I have seen large individuals taken in midsummer in the pounds in Vineyard Sound, and the capture of small individuals in these waters is not unusual. They are often taken, according to De Kay, off New York, in company with the Cod. In June, 1881, the schooner "Edward E. Webster," of Gloucester, Solomon Jacobs, captain, returning from a southern mackerel trip, fell in

[1] CANESTRINI: Fauna d' Italia. Peschi, 1872, p. 155.

with a school of Pollock and captured sixty thousand pounds of them in her purse seine. Its range, as now understood, is in the Eastern Atlantic between the parallels 46° and 80°, in the Western Atlantic between 40° and 70°. That its southeastern limit is as near the equator as the parallel of 36° seems quite improbable.

HABITS AND FOOD.—Unlike the Cod and the Haddock, the Pollock is, to a great extent, a surface-swimming species. The fishes of this species congregate together in large schools, roaming from place to place in search of food. To a certain extent they feed at the bottom, like Cod, but are more often seen at the surface of the water, where they prey upon young fish of all kinds.

Professor Sars gives the following account of the manner in which they prey upon little Codfish:

"I was much interested to see how the Pollock caught the young Codfish. It looked like a systematic chase, and it certainly looked as if the Pollock were acting with a common and well-defined purpose. As far as I could observe, the schools of Pollock surrounded the little Codfish on all sides, making the circle constantly narrower until all the Codfish were gathered in one lump, which they then, by a quick movement, chased up to the surface of the water. The poor little fish now found themselves attacked on all sides: below, the voracious Pollock, which in their eagerness often leaped above the water; and above, hundreds of screeching sea-gulls, which, with wonderful voracity and precision, pounced down upon the places where the Pollock showed themselves, to share the spoils with them. The whole chase is carried on so rapidly, and the young fish stay only so short a time at the surface of the water before they are scattered in all directions with lightning-like rapidity, that it was not even possible for me to see any, much less to catch any with my insufficient implements."[1]

On the coast of New England they are much disliked by the fishermen, who claim that they consume great quantities of other fish much more valuable than themselves; in consequence of this the fishermen have a great prejudice against them and refuse to eat them.

Captain Atwood states that about Cape Cod they do not take to the hook freely; that in other localities they are exceedingly voracious, and great numbers of them may be caught in Massachusetts Bay with a surface bait.

When the United States Fish Commission steamer has been stationed north of Cape Cod, a favorite amusement of the officers has been to catch young Pollock with a fly. The older fish are less active and remain more at the bottom.

MOVEMENTS.—Concerning this species, Captain Atwood states that they appear about Cape Cod in schools in early May, frequently passing round Race Point so closely to the shore as to be caught with the seine among the "tide-rips."

Capt. E. W. Merchant, of Gloucester, tells me that the Pollock were very abundant in Massachusetts Bay early in this century—before the war of 1812. They were especially abundant on Middle Bank. They were at that time chiefly caught with bait of herring, taken in seines from the beaches. The fishing boats were of about thirty tons, and carried three men and a boy. Fishing was carried on chiefly at night, when the vessels would all "fleet up," and the bait on their hooks would toll the schools of fish together. The vessels would take about fifty quintals in a night. There were about thirty fish to the quintal. This abundance of Pollock lasted until about 1820. These Pollock were salted, and consumed at home or carried to Maine. They sold for about two dollars a quintal. The oil of their livers was tried out in kettles on the shore. Their roe was exported largely in those days. It was sold by the bushel, at the rate of about sixty cents.

[1] Report of the United States Fish Commission, part 5, 1879, p. 593. Another vivid description of the manner in which the Pollock feed upon the sand-eels, or lant, may be found on pp. 619 and 620.

Mr. Earll writes:

"Large Pollock are absent from the waters of Cape Ann from the middle of January till early in May, the small ones leaving earlier, in the fall, and returning in April.[1] The young may be taken almost anywhere along the shore, but the large fish seem to confine themselves to definite localities; and though not particularly abundant during the summer at Cape Ann, it is a favorite spawning ground for the species, and during this period large schools visit this shore.

"They begin to grow plenty about the first of October, and by the last of the month are so numerous as to greatly annoy the cod-fishermen by taking the hook before it can get to the bottom.

"During this season some of the smaller vessels fish exclusively for Pollock, 'seizing up' their lines a number of fathoms from the bottom, and at times the fish bite as fast as the fishermen can haul them. Early in November, a crew of four men landed 10,420 pounds, or about 1,100 fish, the result of less than two days' fishing. Owing to a foolish prejudice, the price is always low, at times being less than thirty cents per one hundred pounds. The average weight of the fish is about nine or ten pounds, and during the spawning season the sexes are taken in about equal numbers."

Early in May, 1881, two vessels at Chatham caught in one day 35,000 pounds each. The fish were caught with seines as they schooled at the surface like mackerel.

Perley, writing in 1851, mentioned that he observed that a large number of small fishing schooners was engaged in the capture of Pollock in the rips, or riplings, off Grand Manan. "These rips are formed by strong currents and the conflict of tides, in which the lively Pollock delight to play. Here there is found an abundance of small herring for food. For this description of fishing the vessels are kept in easy sail, the lines attached to poles of seven feet in length, which project from the sides of the vessel. A round, bright lead is used, about seven inches in length, weighing from one-half pound to one and one-half pounds; the bait is a piece cut from the under, or bright, side of the Pollock; it is called the 'last'; this, being kept in brisk motion by the sailing of the vessel, closely resembles the living fish darting through the water, and is eagerly chased by the Pollock. The fishers often take twenty Pollock with a single 'last,' it being a very tough bait."

In the Bay of Fundy and along the coast of Maine the capture of young Pollock from the rocks is a favorite amusement. At Eastport these fish are often called "Quoddy Salmon." Hind states that in the Gulf of Saint Lawrence they are known as "Sea Salmon"; this name may refer both to their active and voracious habits, and to the excellence of their flesh in those localities.

The capture of young Pollock, or mort, on the coast of Norway, is described by Sars in the paper already referred to.[2]

REPRODUCTION.—The spawning of the Pollock occurs in the German Ocean, according to Wittmack, from December to February; in Scotland, according to Parnell, in February, after which it remains out of condition until May.

About the Lofodens, as indicated by the observations of Sars, the breeding time corresponds with that of the Codfish, the young Pollock being found in early summer in company with the young Cod, swimming under the protection of the jelly-fishes.

Mr. Earll found Pollock spawning at Cape Ann in November and December, but he does not state whether the breeding season continued through the winter and early spring. Concerning the observations made at the Gloucester station, he writes:

"They seem to spawn while swimming about in the water, and their eggs, being buoyant, are found at the surface with those of the Cod; but they may easily be distinguished from the latter by their smaller size. The first ripe female was seen at the fish wharves October 23. November

[1] In 1881 the first Pollock came into Gloucester Harbor May 2.

[2] See Report of the United States Commission Fish and Fisheries, part 5, p. 720.

11, a few good eggs were taken, and, after impregnation, found to have a diameter of one twenty-fifth of an inch. They were placed in an aquarium at the hatchery, and within forty-eight hours the fish could be distinctly seen, though no pigment cells were visible. This proved that the development of the eggs after leaving the parent was quite rapid, and indicated that they would hatch in five or six days at most, with water of the ordinary temperature.

"At the time of taking these eggs no suitable apparatus had been arranged, and we did not succeed in hatching them; and as no others were obtained during the season positive statements cannot be made; but the eggs were well advanced before they died, and careful observations up to this point fully convinced us that these eggs are as hardy as those of the Cod, and that they may be successfully hatched by a similar method.

"The table gives the result of our computation of the number of eggs in individuals of different size, from which it will be seen that a twenty-three and one-half pound fish has over 4,000,000 of eggs, while a thirteen-pound one has 2,500,000."

Table showing the number of eggs in Pollock of different sizes.

Number.	Length of fish.	Weight of fish.	Weight of ovaries.	Estimated weight of ovary walls.	Net weight of eggs.	Number of grains (fry) in part weighed out.	Number of eggs in part weighed out.	Number of eggs to the grain.	Total number of eggs in fish.
	Ft. In.	*Lbs.*	*Lbs. Oz.*	*Oz.*	*Lbs. Oz.*				
1	3 3½	23½	2 2	2	2 0	6	1,727	287.8	4,029,200
2	2 8½	13	1 2¾	1¼	1 1½	6	2,043	340.5	2,569,753

Captain Atwood states that in Cape Cod Bay they are caught in large numbers about the 10th or 15th of November, when going to spawn. They spawn upon the same rocky ground as the Cod, and it is only at this time that they dare to take the hook freely. In the vicinity of Provincetown the deposition of eggs takes place in November.

The growth of the Pollock is probably somewhat more rapid than that of the Cod, since the young fish are so much more voracious, but we have no means of determining the length of time required for them to attain maturity. The average size is probably not far from ten or twelve pounds, but individuals of twenty, and even of thirty pounds, are by no means uncommon.

USES.—The Pollock is one of those species whose value as an article of food is very much underestimated. Many persons, who have investigated the subject accurately, prefer salted Pollock to salted Codfish, although the flesh is not so white. Its value for use in the fresh state, we think, deserves the highest commendation. I quote from "Land and Water," December, 1866, the following remarks upon the Pollock fisheries of the Orkney Islands, showing how highly they are esteemed in that region. The writer signs himself "A. R. D.":

"Having observed in 'Land and Water,' of the 20th October, an article by Mr. Buckland, on the *Merlangus carbonarius*, or Saith, it has occurred to me that some additional information as to the habits and uses, and more especially with respect to the commercial value of that fish, might be interesting.

"The Saith occurs in great abundance among the Orkney Islands. The fry, called Sillocks, are first observed in May or June, and are very small. In July and August they are about four or five inches long, and are caught in great numbers with flies (made with a bit of white feather tied to the hook), by means of boats, and often from the rocks on the shore. They are much esteemed as food, and more especially for the oil prepared from the livers. Towards winter they generally

set in to the Shetland bays in immense and closely congregated shoals, from which they are swept ashore by nets in enormous quantities, and are often bought by the farmer for the dunghill. At this season they fall off in quality as an article of food, but are still eagerly purchased by the country people on account of the oil, which suits better for their cottage lamps than any other kind. Next year, when nine or ten inches long, they are called Cooths, or Cuths, and are caught with the fly in the months of May, June, July, and August. In June and July they are in perfection for eating, and are cooked without taking out the entrails, after being rolled in salt and flour, or oatmeal, and done on the gridiron; but unless used within an hour or two after being caught, the fine flavor and curdy quality of the fish quickly disappear. If used next day they are somewhat coarse eating. It is a singular circumstance that they will not take the fly except an hour before or an hour after sunset and sunrise. In the third summer they become larger, and are called Cuttims, or Cuddons, in which state they betake themselves to deeper water, and are comparatively seldom caught. After this, when full grown, they are known by the name of Saith, and become an important object of fishery. The fishing commences in May, and continues till September. In July and August they are in their best state, and are sought after with great assiduity. They chiefly occur in very rapid tideways, where there is much broken water, and the fishing is not unattended with danger, several fatal accidents having occurred within my recollection by the boats having been swept by the current into the breakers. The fish average from fifteen to twenty pounds, but many specimens are met with weighing much more. When cleaned and thoroughly dried on the rocks, about seventeen will weigh one hundredweight, and yield three gallons of oil, which is equivalent to 340 fish and sixty gallons of oil to the ton. The dried article sells at market for about £12 per ton, when Codfish fetch £20 per ton, but the extra quantity of oil in the former far more than compensates for the difference in price, and consequently when a shoal of Saith sets in, the fishermen invariably desert the cod-fishing in favor of the other. Dried Saith are perfectly well known in the market, and are tolerably good eating, though inferior to Cod. The oil is chiefly used by tanners, and is in good demand. In the fresh state they are extremely good eating, firm and curdy, if cooked within an hour or two after being caught, but if kept some time they lose their flavor and become coarse. The inhabitants of Fairisle, which lies half way between the Orkney and Shetland groups of islands, pay their rent exclusively by saith-fishing."

Pollock are more highly prized in New Brunswick than anywhere else on the Western Atlantic coast, and the pollock fishery was in 1850 pronounced by Perley the most valuable and extensive of the deep-sea fisheries of the Bay of Fundy.[1] It is stated by this authority that directly after the spawning season the fish is lank and almost worthless, but that it becomes in good condition again in August and improves as the season advances.

The liver of the Pollock yields a great quantity of oil, proportionally much more than that of the Cod. It is probable that most of the cod-liver oil in the market is more or less adulterated with pollock-liver oil. No one has yet demonstrated that its medicinal properties are inferior. The eggs of the Pollock are very large, and great quantities of them have been in past years salted and exported to France.

THE ALASKA POLLACK, *Pollachius chalcogrammus* (Pallas) J. & G.[2]—The Alaska Pollock is thus described by Professor Jordan: "This species is known as Pollack to those who have seen

[1] 1877. NEW METHOD OF CAPTURING POLLOCK.—For some days past the schooner "Matchless," of Barrington, has been fishing for Pollock with a purse-seine in the vicinity of Cape Sable, and doing very well at the business, which is a kind of experiment, as the purse-seine, we believe, has been used hitherto in taking only mackerel, herring, and such small fish. On Monday of last week the crew of the "Matchless" caught at one haul about 130 quintals of Pollock, an immense catch, which took the men over twenty-fours hours to dress and salt.—*Cape Ann Advertiser*. August 17, 1877.

[2] *Gadus chalcogrammus* Pallas. Zoögr. Ross. Asiat., iii, 198. *Gadus periscopus*, Cope. Proc. Am. Philos. Soc., 1870.

the Atlantic species. It is possibly identical with the 'Beshow' of the Makah Indians, the 'Coal-fish' of the English settlers northward, a deep-water fish noted for its rich, fat flesh. It reaches a length of about two feet. It ranges from Monterey to Behring's Straits. It is taken with hook and line in deep water, and is never plentiful south of Cape Flattery. It feeds upon anchovies and the like. Nothing is known of its breeding habits, enemies, or diseases, and, unless it be the 'Beshow' above noticed, it is not sufficiently abundant to attract any notice as an article of food."

69. THE CUSK—BROSMIUS BROSME.

The Cusk, *Brosmius brosme*, is a deep-water species, inhabiting rocky ledges in the North Atlantic. It has not been observed south of Cape Cod, but ranges northward to the banks of Newfoundland and of Greenland. It occurs in Iceland and Spitzbergen and along the entire length of the Scandinavian Peninsula, but is not known on the coast of Germany, while Faber states that it just touches the most northern part of Denmark at the Scaw in Jutland, and that it is occasionally taken in the Frith of Forth and brought to the Edinburgh market. It is also plentiful about the Faroe Islands. Its range in the Western Atlantic is from latitude 42° to latitude 65°, or beyond; in the Northeastern Atlantic to latitude 80°, and south to latitude 55°.

The Massachusetts fishermen tell me that these fish are usually found in considerable abundance on newly-discovered ledges, and that great numbers may be taken for a year or two, but that they are soon all caught. Sometimes, after a lapse of years, they may be found again abundant on a recently-deserted ground. From these facts it has been reasoned that the Cusk is very local in its habits and rarely changes from one locality to another.

On the "Broken-ground Ledge" Cusk are said to be abundant at any season, and also on "New Ledge," and Captain Atwood says that they inhabit deep water in rocky localities, not hard, smooth, rocky bottoms, but large, angular rocks. About Cape Cod they are quite rare; he has seen a few to the eastward of and near Cape Cod, but they are more commonly found farther north; at a rocky spot near the eastern portion of the Middle Bank, between Cape Cod and Cape Ann, large numbers had been taken prior to 1866, and in that year 400 quintals, or probably 60,000 pounds of Cusk, had that year been taken by one Provincetown firm. Off Wells Bay, in Maine, about Cape Porpoise, and on Cashe's Ledge, he had also observed them in large quantities.

The food of the Cusk doubtless consist chiefly of mollusks and small crustaceans.

Concerning its spawning habits nothing is known, except that, according to Faber, it spawns in April and May on the coast of West and South Ireland.

The Cusk is considered a very excellent fish, especially for boiling, but there is a very limited demand for it, and most of those which are taken are salted. On account of their low prices, fishermen shun them, and they are hardly in better favor than dogfish. In the spring of 1878 they were worth in Gloucester from twenty to fifty cents per hundred, and in August of the same year about one dollar per hundred. One of their peculiar habits, eel-like, renders their capture difficult, and frequently causes the destruction of the fishing-tackle; it is said that after they have taken the hook they curl their tails round the angles of the rock and cling to them with such strength that it is impossible to dislodge them. Fishermen say that when they are brought to the surface the skin rises from the body in great blisters. This they regard as a favorable sign, as showing that the fish are "thrifty," or healthy. The name "Tusk," used for this fish in Newfoundland, is now never used in the United States, although it seems to have been in use a century ago, a well-known fishing ground in the Gulf of Maine being known as the "Tusk Rock."

70. THE HAKES—PHYCIS CHUSS, ETC.

DISTRIBUTION.—We have five species of the genus Phycis. One, *P. Chesteri*, recently discovered by the Fish Commission, occurs off the coast from Cape Ann to Cape Hatteras, at a depth of from seventy-five to three hundred fathoms. It has been collected in great numbers with the deep-sea trawl-nets used by the Fish Commission and the Coast Survey, and appears to be extremely abundant. It is, at present, of no economic importance. It may be distinguished by its exceedingly long fin-filaments.

Another species, the King Hake, *P. regius*, occurs in deep water with the preceding, and has also been found near the shore in the vicinity of Cape Hatteras, in Chesapeake Bay, and at the eastern end of Long Island. A specimen was obtained many years ago at Halifax, Nova Scotia. In the Chesapeake, according to Major Ferguson, it is very abundant.

This fish attains the length of twelve to fifteen inches. Concerning its habits little is known, except that it has the power of communicating strong electric shocks. It may be distinguished by the low first dorsal fin, unprovided with a filament and black at its tip, and by the peculiar row of white spots along the lateral line. *P. Earllii* occurs only on the coast of South Carolina.

The two species which have a commercial value are *P. chuss* and *P. tenuis*. These species are very similar in appearance, and it is with difficulty that they can be distinguished from each other by the trained eye of the zoologist. The most tangible distinction may be found in the number of scales, which are much smaller in *P. tenuis*, there being from one hundred and thirty-five to one hundred and forty oblique rows between the bronchial opening and the root of the caudal fin, while there are about twelve rows between the lateral line and the region of the first dorsal. In *P. chuss* there are only one hundred rows in the lateral line and nine rows above the lateral line; in the former the ventral does not ordinarily reach quite to the vent, in the latter it extends beyond the vent. This character, however, could not always be relied upon.

Our Hakes are all quite different from the Forked Beard, *P. blennioides*, of Great Britain, sometimes called the Hake's Dame, which is a member of the same genus.[1] Owing to their great similarity, *Phycis chuss* and *P. tenuis* are usually known indifferently by the name "Hake"; the former, however, is sometimes called the Old English Hake, and the other, *Phycis tenuis*, the Squirrel Hake or White Hake. In the Gulf of Saint Lawrence and the Bay of Chaleur, and also south of Cape Cod, they are invariably called Ling. There has been much confusion both in the names and descriptions applied to them by fishermen and ichthyologists. Their geographical range appears to be essentially the same. The young of one or both species are frequently taken swimming at the surface, on the southern coast of New England, in midsummer, and numerous individuals have been found off Block Island and Watch Hill, seeking shelter between the valves of a large species of scallop, *Pecten tenuicostatus*; the majority appear to belong to the species of *P. chuss*. About sixty were obtained from a single trawl-full of Pectens taken off Watch Hill, September, 1874, where they were found in one out of every three or four shells taken. Their companions in the interior of the shells were a species of *Pinnotheres*, related to the oyster-crab, and a species of lump-sucker, *Liparis lineatus*.

One or both species are frequently taken by the cod-fishermen, on the shoals south of Cape Cod, but they are there considered to be of but little value. They are more or less abundant in Massachusetts Bay, in the Bay of Fundy, and in the Gulf of Saint Lawrence. Large specimens of one or both species have been taken at a depth of three hundred fathoms as far south as Virginia.

[1] The Hake of Europe is a different fish, more closely related to the Silver Hake or Whiting of the New England coast, *Merlucius bilinearis*.

HABITS.—Captain Atwood gives this account of the Hake in Cape Cod Bay: "It is a ground fish, found close to the bottom, and rarely comes to the surface. They are much more inclined to take the hook by night than by day; are found on muddy bottoms, during the whole summer and autumn, along the coast of Maine and Massachusetts. They yield a large quantity of oil, which is used for the same purpose as that of the Pollock and Cod. The autumn finds them in the best condition, and, if prepared with care, they are a tolerably good table fish." Captain Atwood has known them to grow to the size of forty pounds, but the average in summer is only five to ten pounds.

Perley remarks that they are taken largely on muddy bottoms, both in the Bay of Fundy and in the Gulf of Saint Lawrence, chiefly during the night, at which time they feed on the smaller crustacea; their stomachs are then generally found to be filled. Hake are frequently taken, in the Gulf especially, measuring three feet in length.

The Hakes appear to be bottom-loving fishes, and rarely change locality. They feed on crustaceans, and occasionally indulge in a fish diet. One taken at Gloucester, in July, 1878, had a menhaden in its stomach.

It is believed that they spawn throughout the summer, for the young fish are found during all the summer months, while specimens taken at the depth of thirty-seven fathoms, August 18, 1878, off Ipswich, at a temperature of 41° F., contained well-developed ova, and were apparently ready to spawn.

USES.—An extensive fishery is carried on from Cape Ann for these fish in winter, and there are sometimes as many as fifty vessels engaged. It was estimated in 1878 that the total quantity landed at Gloucester was not far from 5,000,000 pounds. The fishing is carried on almost entirely at night with the use of trawls, which are about the size of those used in the capture of Haddock.

Hake are salted and dried in the same manner as Codfish, and are often sold under the name of Codfish. Before the introduction of boneless fish it was sometimes difficult to sell them on account of the difference in appearance, but at the present time great quantities of Hake are put up in boxes under the trade name of "boneless fish," the qualifying word "Cod" being usually omitted from the brands and labels. Hake are rarely eaten fresh.

The air-bladder, or sound, of the Hake is of great commercial value, being used extensively in the manufacture of isinglass; great quantities of sounds are sent from the British Provinces to the United States annually, sounds from the Gulf of Saint Lawrence being considered much better than those from farther south. In 1880 New England produced 255,698 pounds of dried sounds, worth $178,808. Massachusetts had eight isinglass and glue factories, employing one hundred and eighty-two men and a capital of $315,000, and producing $450,000 worth of ribbon isinglass and glue in 1879. These sounds were for the most part derived from the Hake.

Capt. Epes W. Merchant gave me the following account of hake-fishing at Gloucester in 1818: "Hake used to come in September, October, and the first half of November, and then we would get ready to go haking. Father would say, 'Go down, get your pork, and put on your squid-jig.' We were always sure of bait; the boy would catch enough bait for three men; the squid were in great schools. We used to lay out two nights and get fifteen or twenty quintals of Hake. These were worth fifteen shillings per quintal, and we sold them in Boston for the West Indies trade."

71. THE BURBOT—LOTA MACULOSA.

BY TARLETON H. BEAN.

NAME.—The first name applied to the American Burbot was *Gadus lota*. This was used by Pennant. Walbaum established the name *Gadus lacustris* for the *Mathemeg*, or Land Cod of Pen-

nant. This fish has, however, proved to be a catfish, and the name *lacustris* is untenable for the Burbot. In 1817, Le Sueur described a Burbot from Lake Erie under the name of *Gadus maculosus*, and another species from Northampton, Connecticut, as *Gadus compressus*. The name *maculosus* is the oldest available specific name for the American species. In 1818 Mitchill described a *Gadus lacustris* in the "American Monthly Magazine," evidently not knowing that the same name had been previously applied by Walbaum. In 1819 Le Sueur redescribed *Gadus compressus* under the name *Molva Huntia*. In 1842 De Kay described *Lota inornata* from the State cabinet at Albany. In 1844 D. H. Storer set up the Winnipiseogee Lake Burbot as *Lota brosmiana*. From this it will appear that six specific names have been applied to the American Burbot, and that the form from Hudson's Bay was considered identical with the European species. All of these names following *Gadus maculosus* are considered synonyms of *maculosus*. The name *compressa* was retained longer than any of the others, but it is now known that the compressed form is simply an individual variation.

Günther, in his "Catalogue of Fishes in the British Museum," volume iv, 1862, places all the names applied to the American Burbot in the synonymy of *Lota vulgaris*, believing that we have only one species, and that identical with the European. Even if his view be correct, he should use the name *Lota maculosa*, which, dating from 1817, has priority over *vulgaris*. The combination *Lota vulgaris* was not employed, as far as I know, by any author until Jenyns used it in a Manual of British Vertebrate Animals in 1835. It is not, however, established that the European and American Burbot represent the same species. The number of vertebræ seems to be smaller in the European. Günther gives it as twenty-one abdominal and thirty-eight caudal vertebræ. In two skeletons examined by myself the abdominal vertebræ were twenty-two to twenty-three, and the caudal thirty-eight to thirty-nine. There seems to be no other important difference. For the present it may be best to consider the European Burbot as varietally distinct from the American, and we should call it *Lota maculosa*, variety *vulgaris*.

POPULAR NAMES.—In the Hudson's Bay region, according to Pennant, the Burbot is known as "Marthy"; according to Richardson, as "Methy." In Alaska, according to Dall and Turner, it is known as "Losh"; in Canada, as "la Loche." In Vermont it is called the "Eel-pout" (Thompson); by which name also it is known in Mohawk River, New York, according to Loomis; in Massachusetts (Storer); in Connecticut (Wood), and in Bighorn River, Montana (Brackett). It is known as the "Dogfish" in Lake Erie, according to Le Sueur. Commander L. A. Beardslee says it is called "Chub-eel," also, in Mohawk River, New York. It is known as the "Ling" in Lake Ontario (Professor Baird), lakes of Western New York (Baird and Blackford), and New York market (Blackford). It is the "Lawyer" of Lake Michigan, according to Earll; "Lake-cusk" in Lake Winnipiseogee (Davis); "Fresh-water Cod" (Baird). It is called "Burbot" in New York (De Kay), and in the Bighorn River, Montana (Brackett). Professor Jordan gives the names "Aleby-trout" and "Mother of Eels" as in use in the Upper Great Lake region.

The above list is incomplete, both as to names and geographical range. The name "Burbot" is the one which should come into general use. The first four will hardly be adopted by English-speaking people. "Chub-eel" is a mere off-hand name given to the species by a fisherman who supposed it to be a hybrid between an eel and a catfish; this name is known to very few persons. The remaining names, except "Burbot," are preoccupied and well established for marine species, as follows: "Eel-pout," *Zoarces anguillaris*; "Ling," *Molva vulgaris*; "Lawyer," *Lutjanus caxis*; "Cusk," *Brosmius brosme*; "Cod," *Gadus morrhua*; "Dogfish," *Mustelus canis*. The European variety, *Lota maculosa*, variety *vulgaris*, is called "Burbot," a name which has never been applied to any other species than the one under consideration, so far as I can learn. This

name, therefore, should be retained. In Norfolk, England, "Cony-fish" is a name given to the European Burbot, from its habit of skulking in rat-holes and corners under the banks.

SIZE.—We are told by J. R. Forster, in Philosophical Transactions, lxiii, 1773, p. 149, that the weight of the Burbot in the Hudson's Bay region is from one to eight pounds. According to Pennant, who derives his information from Forster, the Burbot of the Hudson's Bay region reaches a weight of eight pounds. In Alaska, Mr. Dall says that they grow to a very large size, reaching a length of five feet, and weighing as much as sixty pounds. In the Bighorn and Little Bighorn Rivers, Montana, the species reaches an average weight of less than a pound, and does not exceed eighteen inches in length. Mr. W. Ainsworth, of Cape Vincent, New York, says that the Burbot in the waters of Lake Ontario and Saint Lawrence River average two and a half pounds in weight, occasionally reaching four pounds. The United States National Museum has received from Mr. E. G. Blackford, of New York, numerous individuals from the Great Lake region, averaging certainly not less than five pounds in weight. In the United States National Museum collection the Burbot from the lakes are, as a rule, larger and plumper than those from rivers. The exceptions are one from Fort Pierre, Nebraska, and two from the Yukon River. These are longer but more slender than the lake Burbot. It seems highly probable that river Burbot may generally be recognized by their slender bodies and small size, which characters we may attribute to the small amount of food obtainable in the rivers, as compared with the supplies found in lakes. The Burbot of the Connecticut River, which furnished the type of *Lota compressa*, is short, but really less compressed than some from England, Southern Europe, and from our own lakes. Le Sueur's type of compressed Burbot may have been the starved or emaciated form known to fishermen as "Racer," and it may have been the ordinary little Burbot of the Connecticut already referred to.

RELATION TO THE EUROPEAN BURBOT.—The American Burbot cannot be distinguished from its European ally by external characters; in both, the color, the position of the fins, the number of the fin-rays, the structure and arrangement of the teeth, the situation and size of the eyes, and the relative proportions being substantially alike. There is less difference between the average American and European types of Burbot than there is between extremes of the former. At one time I thought that the number of pyloric cœca, or the length of the intestines, might be available in classification, but the amount of individual variation is so great in this respect that no division can be based thereon. The pyloric cœca in the European specimens which I have studied ranged in number from 20 to 77; in America from 36 to 138. There is only one example having the latter number, and that came from the Yukon River. Another individual from the same stream had 102 cœca, and in all probability a large series would still further reduce the gap. This variation in the number of cœca is paralleled in other species, notably in the Cod and the Salmon, *Salmo salar*. In the former I have counted 140, 160, 256, 271, 289, and 340 in six individuals. In the Salmon Mr. J. K. Thacher records a variation between 44 and 70.[1]

Even in the Craig flounder, *Glyptocephalus cynoglossus*, which has few cœca, I have counted 9 in one adult and 11 in another. The basis of distinction between the European and American forms of Burbot is solely the smaller number of vertebræ in the former. It may be that an examination of a large series of skeletons will show that the difference is constant, and it is also possible that other good characters will be found which will entitle the European form to separate specific rank, or such examination may show a European Burbot with as many vertebræ as one of our American series; in which event it would seem proper to unite the two under the name of *Lota maculosa*.

[1] Report of United States Fish Commission, part 2, 1874, p. 371.

DISTRIBUTION.—The United States National Museum has specimens of the Burbot from a tributary of Hudson's Bay, Mackenzie's River, Yukon River and Kodiak (Alaska), Winnipiseogee Lake, the Connecticut River and Scantic River, Connecticut; Seneca Falls and Madrid, New York; the Great Lakes, Winnebago Lake and Oshkosh, Wisconsin; Kansas City, Missouri; Fort Pierre, Nebraska; *the Bighorn and Little Bighorn Rivers in Montana, and Great Slave Lake.* The species occurs in the Yellowstone River, the Missouri River, in tributaries of the Ohio, in the Mohawk River, and has once been obtained in the Susquehanna River, according to Professor Cope in the report of the Pennsylvania Fish Commission, 1881.

ABUNDANCE.—The Burbot is most abundant in lakes, to wit: The Great Lakes, lakes of New *York, Winnipiseogee Lake, and lakes of Maine and New Brunswick. In general terms, including* under the name "Burbot" both the American and European forms, the species may be said to inhabit the fresh waters of the northern regions both of Europe and America, being particularly abundant in the Great Lakes and in all ponds, lakes, and large streams, thence northward to the Arctic Circle. According to Dall it is exceedingly abundant in the rivers and lakes of Alaska. *The Burbot is not known to enter brackish water at the mouths of rivers. According to* Mr. W. Ainsworth, Burbot are found principally in deep water and on mud, except during the spawning season, which occurs in March, when they run on rock or hard bottom. This refers to the Lake Ontario region. Col. A. G. Brackett, U. S. A., states that the fish seem to be quite common in the Bighorn River, Montana. In the northern rivers, as a rule, the species is very abundant, though within the limits of the United States, so far as we know, the species is less common in rivers. Mr. Charles Lanman writes that it is abundant in Lake Timisconti, and also in the Eagle and Saint Francis Lakes.

REPRODUCTION.—The spawning season of *the* Burbot *is* late winter or early spring. *It is* probable that the eggs, which are small and numerous, are deposited in deep water. Mr. Dall says that the eggs of the Burbot are of a creamy-yellow color in Alaskan specimens. The same writer states that the fish are full of spawn from November to January. He also says that a single Burbot (Losh) contains millions of eggs.

According to Pennant, the Burbot spawns early in February, and "is unhappily most prolific. Mr. Hutchins counted in a single fish 671,248 ovaria." In the Great Lake region it is considered probable that the Burbot spawns in deep water. Specimens forwarded from that region by Mr. E. G. Blackford, in the month of November, 1877, were distended with ripe eggs.

According to Mr. Dall, the males are usually much smaller than the females, averaging only *eighteen or twenty inches in length, while the female attains a length of four or five feet.* He states also that the male has a smaller liver and one pyriform gall-bladder on the left side. Some specimens, however, present the physiological curiosity of having two, or even three, distinct gall-bladders opening into the same duct, and uniform in size and shape. Mr. Dall has, however, never seen a double gall bladder in a female Burbot. The only marked feature in reference to these fish *at the spawning season is the greatly increased abundance. The young of this species are not* described in any American work, so far as I know. Richardson found small Burbots in the stomach of the Lake Trout, *Salvelinus namaycush.* He states in "Fauna Boreali Americana," p. 180, that "in the month of March, in latitude 64°, we saw that capacious receptacle [stomach of *Salvelinus namaycush*] crammed with the young of the *Lota maculosa.*"

The development of the European variety is partially illustrated by text and figures in a paper by Carl J. Sundevall on "The Development of Fishes," published in the "*Proceedings of the* Swedish Academy," 1862. The text is here in part translated:

"The spawning season of the Burbot commences in January or February. The eggs are laid

separate and loose upon the river or lake bottom. They are very small and numerous. According to the calculation of Baron C. G. Cederström, a medium-sized female contained 160,000 (by estimate, 159,776) eggs. This result nearly coincides with that of a more recent estimate, viz, that the average female contains 178,000 eggs. (Skand. Fiskar. vid., p. 41.) Some eggs are clear, some yellow, all nearly colorless, and both kinds are capable of development. In some cases the eggs commence to hatch in three weeks; generally, however, an additional week is required. At the end of the first day after the eggs have been deposited cleavage of the yolk commences. The eyes appear in fifteen or sixteen days, and in about two days more small star-like spots may be observed on the surface of the embryo. At that period, also, the beating of the heart can be plainly discerned, and I have alternately counted fifteen, thirty, and fifty pulsations in successive minutes. The evolutions of the embryo are now more distinctly seen, and it will be noticed that the anterior end of the embryo is the heavier. In many cases the eggs appear to have been prematurely hatched, and assume the shape of a ring. These move but seldom, and always in a circle. A great many die early; others are developed. The fish with straight tails are very lively, moving with a tremor of the body, usually toward the surface of the water, whence they passively fall to the bottom. When fully developed, the operation of swimming is accomplished by a quick movement of the pectorals."

MODE OF CAPTURE.—The Burbot is taken on hooks, chiefly at night. It is also captured largely in pounds and gill-nets. In Lake Winnipiseogee it is caught with the hook through holes in the ice. At Fort Custer, Montana, it takes the hook freely. In the Yukon River it is captured in fish-traps.

FOOD AND FEEDING HABITS.—The Burbot is carnivorous and voracious, having a craving and wonderfully distensible stomach, which makes the fish an efficient dredge in securing bottom fishes. Through its medium was obtained the rare sculpin-like fish *Triglopsis Thomsoni*. The Burbot feeds upon various small fishes and crustacea, frequenting the bottom, and devouring more particularly fishes with habits like its own.

Forster gives the following notes in the "Philosophical Transactions,"[1] which were furnished him by Mr. Andrew Graham: "[The Marthy is] extremely voracious, eating fish, the pike, and the tickomeg (*Salmo*), and other fish, carrion, putrefying deer, and even stones. Mr. Graham took a stone weighing a pound from the stomach of one. . . . It does not masticate its food."

Pennant says that the Marthy "is so voracious as to feed even on the tyrant pike; will devour dead deer or any carrion, and even swallow stones to fill its stomach."

The Burbot seems to feed principally at night. Pennant states that it is caught with hooks after nine o'clock at night. Charles Lanman states that "in the Saint John River, New Brunswick, some hundreds are taken annually by night-lines, dropped through the ice at the beginning of winter. Many are thus taken near Fredericton, but the best fishing ground is on the sand-bars, a little above the mouth of the Oromocto River, where this fish resorts previous to spawning, which operation takes place in February or March. This fish is not unlike the eel in many of its habits, concealing its food under stones, waiting and watching for its prey. It feeds principally at night, and is, therefore, generally taken by night-lines."

The specimens obtained by the National Museum from the Great Lakes always contained in abundance the common species associated with itself in that region, such as *Perca americana*, a species of *Lepomis*, &c.

According to Mr. Dall, the Burbot in the rivers of Alaska feed upon whitefish, lampreys, and other species.

[1] Vol. lxiii.

ECONOMIC VALUE.—There is a great difference of opinion as to the edible qualities of the Burbot. In the region of the Great Lakes it is usually pronounced worthless, but some few consider the liver a delicacy; it is held in low esteem as a food-fish, and rarely appears in the markets. It was formerly thrown away, according to Mr. Milner, although it is a very good edible fish, and some who know its qualities cook the livers of the larger specimens, considering them very choice. Mr. Ainsworth, of Cape Vincent, New York, regards the Burbot as a great annoyance to gill net fishermen. He states that they are a soft fish and unmarketable. I have been told that the Burbot caught through holes in the ice in Winnipiseogee Lake are highly esteemed. In the fur countries, according to old writers, the roe is an article of food. The liver is eaten in the Yukon River region, and the flesh is by some regarded as equal to that of whitefish. At Fort Custer, Montana, Col. A. G. Brackett says, "The soldiers eat all they can get of them." Indians generally are fond of them. No doubt the quality of the flesh depends largely upon the habitat, those found in cold, clear, rapid streams being probably the best.

According to Professor Jordan, there is a popular prejudice against the looks of this fish, and its flesh is less rich than that of most of the lake fish. From the manuscript of Charles Lanman, referring to the species in New Brunswick, I quote the following: "The flesh of the fresh-water Cusk is white, firm, and of good flavor. The liver and roe are considered delicacies; when well bruised and mixed with a little flour, the roe can be baked into very good biscuits, which are used in the fur countries as tea-bread."

Forster states that the roe and liver, when fresh, are considered delicacies, but that they turn rancid in a few days. On the coast of Hudson's Bay the fish is considered dry and insipid.

The Burbot, therefore, does not appear to be a very important fish, commercially speaking, although when taken in cold streams, where it occurs in abundance, it is freely eaten. In Siberia, according to Mr. Dall, the skins of the European variety are used as a substitute for glass in windows.

INFORMATION DESIRED CONCERNING THE BURBOT.—Information is greatly desired on all of the points already mentioned concerning the Burbot, and especially on the following particulars:

1. Its occurrence in rivers and lakes *anywhere*. Kansas City, Missouri, is the most southern locality represented in the collections of the United States National Museum.
2. The temperature and depth of the water in which it is captured.
3. Its capture in salt water.
4. Its time and mode of spawning in different waters.
5. The appearance of the young.
6. Its food. Bottom fishes are frequently found in the stomach.
7. Whether it is eaten.
8. How caught.

The Commissioner of Fisheries is desirous of obtaining specimens in alcohol or in the fresh state from any river or lake, except the Great Lakes and lakes of Western New York.

72. THE SILVER HAKE AND THE MERLUCCIO.

THE SILVER HAKE, OR NEW ENGLAND WHITING. MERLUCIUS BILINEARIS.

DISTRIBUTION.—It is the opinion of certain writers, among whom Dr. Günther is leader, that the Hake of Europe, *Merlucius merlus* (or *M. vulgaris* of recent authors), is identical with the species of *Merlucius* occurring in the Western Atlantic. This is, however, a mistake; the American species may easily be distinguished from that of Europe by the greater number of rays

in the first dorsal (10 to 11 in *M. merlus*, 12 to 13 in *M. bilinearis*), and by the larger size of the scales (the number in the lateral line being about 150 in *M. merlus*, 100 to 110 in *M. bilinearis*).

The general appearance of the two species is very similar, and it requires careful study to separate them. It is probable that at no very remote period they diverged from a common stock. The distribution of the two species upon the opposite sides of the Atlantic coincides very closely with that of other Gadoid fishes, which are specifically identical in Europe and America. The Hake of Europe is found along the coast from Trondhjem Fjord, latitude 65°, south to 36°, being very abundant in the Mediterranean; also found on the coast of Portugal and in Western France. In the English Channel, however, and in the waters of Holland and Germany, it is considered very unusual. On our coast it ranges from New York to the Gulf of Saint Lawrence, where it is common—especially in the Bay of Chaleur—but it has rarely been observed as far north as the Straits of Belle Isle. Dr. Packard was told by fishermen that during a period of forty summers spent on the coast of Labrador they had taken but one specimen of this fish. This fish has been found at great depths as far south as latitude 36° and 37°.

The name Silver Hake, by which this fish is known in the Bay of Fundy, is much more appropriate than that of Whiting, though the latter is more frequently heard in New England; its similarity to the European Hake is very great; while the name Whiting, which is in Europe applied to a species (*Merlangus vulgaris*), somewhat resembling the Pollock, has been appropriated in this country for a fish on the southern coast and belonging to the drum family.

MIGRATIONS AND MOVEMENTS.—The Silver Hake commonly inhabits the middle depths of ocean, or the outer edge of the continental slope, and comes to the surface to feed. Like the Pollock, it is a fish of prey; its teeth are sharp, its mouth large and powerful, and its form lithe, muscular, and adapted to rapid locomotion. It comes to the surface to prey upon the schools of herring and other small fish, and is frequently caught in the mackerel and bluefish nets. Its appearance in our waters is irregular, and when seen it is usually in considerable numbers. Storer, writing in or before 1867, remarked: "When my report was published in 1839 I stated that the Whiting was taken—not, however, in large quantities—in our bay in the summer upon the cod-fishery grounds; since that period this species has increased very perceptibly in our waters; it is frequently caught in considerable numbers with the hook upon Crab Ledge, a few miles from Boston light-house, and has become at Provincetown a serious inconvenience to the fishermen. Captain Atwood informs me that when the fishermen at the latter place commence the mackerel fishery with nets, which usually takes place about the 20th of May, the Whiting are scarce and few are caught. By the 1st of June they become more plenty, and from the middle of June to the last of the fishery, which closes about the 20th of July, they are exceedingly numerous in parts of the bay in all depths of water. In such quantities are they taken in nets that frequently eight or ten hours are required for a man to clear the nets of them. At this season of the year so many of them are thrown from the boats upon the shore that the board of health is sometimes called upon to interfere and to compel the fishermen to bury them from the fear of sickness being produced by their decomposition. By visiting this point, the easterly extremity of Cape Cod, in June, 1847, I saw quite a number of this species strewed along the shore, where they had been left by the tide while in pursuit of sand-eels and other small fishes. Since that period, the bluefish having been more common, this species does not exist in as great abundance."

It is difficult in this case, as in many other similar ones, to decide exactly what dates to assign to the observations of Dr. Storer—his "History of the Fishes of Massachusetts," in its last edition, having been published at various times from 1863 to 1867—as in some instances he contented himself with quoting the exact words of his report printed in 1839. It would seem,

however, that the statements attributed to Captain Atwood should be dated prior to 1850. The Cape Cod naturalist, in his address before the senate committee of the Rhode Island legislature in 1872, stated that in Provincetown Harbor, from a very early period until the "horse-mackerel" (bluefish) made its appearance, the fish called Whiting was immensely abundant; but since the horse-mackerel had appeared this fish was driven out, and at the time of speaking a specimen was hardly ever seen. Perley, writing in 1850 and 1852, stated that at Grand Manan these fish were often taken in herring nets, in which they become entangled while pursuing their prey, and that he observed the fishermen throwing away these fish by thousands while clearing their nets.

HABITS.—They average one foot in length. They are of roving habits, following the shoals of herring, which they devour in great quantities. Until 1880 little was known concerning the breeding habits of the Silver Hake, but, in exploring the bottom, at a depth of from one hundred and fifty to three hundred fathoms, off Newport and in the edge of the Gulf Stream, immense numbers of young fish, from half an inch to three inches in length, were found at the bottom, and with them were many adults, twelve to eighteen inches in length, apparently in the act of spawning; some of them with the ova ripe, or nearly ripe, but not yet shed; others evidently spent fish. This discovery was exceedingly interesting, since it may serve as a clew to the spawning habits of other species, like the bluefish and menhaden, which have been supposed to spawn at a distance from the shore, but have never been detected in the act. The spawning period doubtless extends over a considerable space of time; some of the eggs from which the largest of the young were hatched off Newport must have been laid as early as July. In September an adult, obtained at Halifax, Nova Scotia, had the ova well developed and nearly ready for deposition. It is not known whether the eggs of the Silver Hake float or sink. Couch states that the spawning season of the European Hake is from January to April, at which time the fish are caught near the bottom, and lose the great voracity by which they are characterized at other times, so that multitudes are caught in trawls, and a few with lines. When pilchards approach the shore the Hake follows them, continuing in incalculable numbers throughout the winter. Mr. Couch continues:

"It rarely happens that pilchards are taken in the seine without many Hakes being inclosed with them, and thus, when the net remains in the water for several days, they have an opportunity of glutting themselves to their hearts' desire, which is to such an extent as to render themselves helpless, and I have seen seventeen pilchards taken from the stomach of a Hake of ordinary size. Their digestion is quick, so that they speedily get rid of their load, and fishermen observe that when hooked the fish evacuates the contents of its stomach to facilitate its escape, so that when hundreds are taken with a line in the midst of prey, not one will have anything in its stomach. When near the surface, however, this ejection does not take place until they are dragged on board."

In Holland this fish is known as the Stokvisch, and in Germany as the Meerhecht or Little Stockfisch; the first name signifies sea-pike, this name being the equivalent of the Latin generic name.

USES.—The Hake of Europe is always considered a coarse fish, and though great quantities are annually salted and dried it is not held in very high esteem. Many of the salted fish are sent to Spain. They are said to be quite common on the northern shore of the Mediterranean, where considerable traffic is carried on with them; they are packed with aromatic plants and sent to the towns remote from the coast.

Storer remarks: "Occasionally this species is brought to market, and when perfectly fresh is a very sweet fish, boiled, broiled, or fried. It soon becomes soft and is preserved with difficulty. As it does not appear to be known abroad, and the fishermen consequently have no call for it, it is

not cured, but is considered worthless. In the months of September and October the Whiting is used somewhat for bait for the dogfish and answers a good purpose."

It is, as a rule, hardly worth while to criticise statements in a work so generally unreliable as J. V. C. Smith's "History of the Fishes of Massachusetts," published in 1843, but since he has been quoted by De Kay[1] in a misleading manner, it should here be stated that in discussing this fish this author had also in mind other fishes belonging to the genus *Phycis*, which are known by the name of Hake all along the coast.

THE MERLUCCIO OR CALIFORNIA HAKE. MERLUCIUS PRODUCTUS.

The California Hake, writes Professor Jordan, is most commonly known along the coast by its Italian name, "Merluccio", pronounced *merlo͝och*. At Soquel and elsewhere it goes by the name of Horse-mackerel, a name used on our coasts with the greatest carelessness, being applied to *Elops saurus*, *Anoplopoma fimbria*, and *Merlucius productus*, as well as to various scombroids and carangoid fishes. It reaches a length of about thirty inches and a weight of ten pounds, its average weight being five or six. It is found from the Island of Santa Cruz to Alaska, being very irregular in its appearance, some years very abundant and at other times wanting altogether. It is exceedingly voracious, feeding on all sorts of small fishes and squids. The stomach is always filled almost to bursting.

It spawns in the spring, and its arrival near the coast always precedes the deposition of the spawn. It probably then retires to deeper water.

Its value as a food-fish is very little. It is scarcely salable in the market of San Francisco. Its flesh is very soft, and it is always ragged-looking when shipped. Nothing was learned as to the quality of its flesh, but it probably differs little from *M. bilinearis*.

73. SEVERAL UNIMPORTANT FAMILIES RELATED TO THE GADIDÆ.

THE CONGROGADUS FAMILY (*Congrogadidæ*).—This family, which in some respects resembles the eels and in others the Codfishes, contains, in all, three species: one from Australia, one from the Red Sea, and the third, a small eel-like fish, of great activity, *Scytaliscus cerdalis*, which lives among the rocks on the coast of Washington Territory.

THE FIERASFER FAMILY (*Fierasferidæ*).—These are never of very large size, and are eel-like in shape. As far as is known, they live parasitically in the cavities of other marine animals, especially in the respiratory cavities of star-fish and sea-slugs. Not unfrequently they attempt to live in animals less suited to their habits, as, for instance, bivalves, and cases have been known where they have been imprisoned below the mouth of the mollusk or covered over with a layer of the pearly substance secreted by it. They are perfectly harmless to their host, and merely seek for themselves a safe habitation, feeding on the animalcules which enter with the water the cavities inhabited by them.[2] Three or four species of this family are known to occur on our Florida and Gulf coasts.

THE SAND CUSK FAMILY.—The family *Ophidiidæ* is represented on the Atlantic coast by a fish so rare as to have no common name, the *Ophidium marginatum*, which is found burrowing in the sand banks near Beaufort, North Carolina, occasionally at other places, and on the coasts of our Southern and Middle States,[3] and by several rare deep-sea forms. On the California coast is a similar

[1] New York Fish Fauna, p. 82.

[2] GÜNTHER: Study of Fishes, p. 549.

[3] "We dug two specimens out of the sand near low-water mark (Great Egg Harbor, April, 1871), where they burrowed to the depth of a foot or more. When placed upon moist sand, they burrowed into it, tail foremost, with surprising rapidity, disappearing in an instant. The species appears to be rare.—VERRILL: American Naturalist, v. 399.

species, *Ophidium Taylori*, about a foot in length. This species occurs from San Francisco to the Santa Barbara Islands. It is rare, and only brought into the market by accident.

THE RED CUSK FAMILY (*Brotulidæ*).—This family, which is composed of fishes belonging in the deeper regions of the Atlantic and Indian Oceans, is not represented on our Atlantic coast, save by certain obscure deep-sea forms. A single species is known in California, the so-called Red Cusk, *Brosmophycis marginatus*, known to the Italians of that region by the names Mustèt or Musteta. This fish reaches the length of eighteen inches. It has been noticed only in the neighborhood of San Francisco, where it occurs in waters of considerable depth. On account of its bright colors, it meets with a ready sale in the San Francisco market, but is too rare to be considered as of any great economic importance.

THE GRENADIER FAMILY (*Macruridæ*).—The Grenadiers, or, as the fishermen frequently call them, on account of the size and shape of their eyes, "Onion-fishes," inhabit the deep parts of the ocean. They are particularly abundant in the Western Atlantic. They are occasionally eaten, but are chiefly important to the fishermen on account of their habit of stealing the bait and taking possession of the hooks, which would otherwise be free for the capture of more useful fishes. The largest species, and the one best known to the fishermen, is *Macrurus rupestris*, called "Rat-tail Fish" as well as "Onion-fish". It is exceedingly abundant on all of our off-shore banks, attaining a length of three feet and a weight of four or five pounds.

A smaller species, *Macrurus Bairdii*, is found everywhere along the coast where the depth is greater than eighty or ninety fathoms. It is probably an important article of food for the larger fishes of these regions, such as the halibut. At least four species of this family occur on our coast, all of which have been brought to light by the explorations of the United States Fish Commission within the past four years.

74. THE LANT, OR SAND-EEL—AMMODYTES AMERICANUS.

HABITS.—Of all the small species of fishes occurring in the North Atlantic there is probably none more important to man than the Lant—Launce, as it is called in Europe, frequently also the Sand-eel both in Europe and America, Tobias-fish in Germany, and Smelt in Holland. The American and European species, though similar, are quite distinct forms.

Although it is never used for food in this country, it is of great economic importance, since it constitutes one of the chief articles of food for the codfish, the halibut, and other flesh-feeding species, such as the bonito, bluefish, squeteague, flounder, and mackerel, and in Europe the turbot.

The Lant is a slender species, with a rounded body, the height of which is contained from eleven to twelve times in its total length; the largest individuals grow to be about sixteen inches long, but they are usually much smaller. They swim in immense schools at the surface, and frequently imbed themselves in the sand, where they often remain above the low-water mark while the tide is out. Why they do this is not well understood, for in their habits they are wanderers, sometimes appearing in immense numbers at certain points upon the coast and disappearing as rapidly as they came. With their sharp noses and slender muscular bodies they have little difficulty in imbedding themselves in the soft sand several inches deep. I shall never forget my surprise when, many years ago, unfamiliar with the habits of this fish, which, indeed, was at that time entirely unknown to me, I was digging up shells in one of the sandy beaches in Provincetown Harbor, when suddenly, as I struck my hoe into the earth, a great section of the beach became alive with glancing forms of dozens of these agile little fishes.

"On the sands of Portobello, near Edinburgh, and at other places, people take advantage of

this well-known habit, and when it is discovered that a shoal of Sand-eels have hidden themselves in the sand they sally out, armed with spades, rakes, shovels, and forks, and dig them out. When extricated from the sand-beds the fish leap about with singular agility, and afford much sport in capturing them. Perhaps the fun in catching them has originated the saying, 'As jolly as a sand-boy.'"[1]

They are captured in a similar manner on the coast of Holland. It is Buckland's idea that they go into the sand to take refuge from fish which are pursuing them.

Captain Atwood, writing to Dr. Storer during 1847, said: "On last Friday night they ran ashore in such quantities in Provincetown Harbor that they covered the ground from one to two inches deep, and when the water covered the flats the whole bottom looked like an immense sea of silver." "When thus situated," continues Storer, "they are readily devoured by their enemies, among whom are the cuttle-fish," or squids.

Various authors have stated that they feed upon the very young fry of other fish and upon small worms.

Speaking of a closely related species, *Ammodytes tobianus*, which has not yet been found in the Western Atlantic, but which may yet very probably be discovered here, and whose habits are doubtless very similar, Oliver writes that they follow the young fry of the coalfish, or pollock, into the harbor, and are frequently caught with the same bait. They swim rapidly and dash at a shoal of fry with the voracity and swiftness of a pike, and they even feed upon the young of their own kind.

As has already been stated, they constitute a favorite bait for many other species of fish. They are very conspicuous by reason of their bright silver color, and their swift motion is easily imitated by trawling them behind the boat in rapid motion. Their form has been imitated in India rubber and metal for use in angling. In England they are a favorite bait for the bass. Couch states that they are frequently followed by mackerel, and that their presence is a sure sign of good fishing. "On a calm evening it is an interesting sight to see the surface of the water broken by the repeated plunges of the voracious fishes as they break upon the little school of Launces from beneath. Their only certain place of refuge from these pursuers is the sand."

Owing to the confusion between the two species of *Ammodytes*, European naturalists have not yet come to a definite decision as to their time of spawning, but the observations of Benecke indicate that this takes place, in the Baltic at least, in May, the fish being most abundant in those waters from July to September. No one has observed these habits on our own coast.

DISTRIBUTION.—The distribution of the Lant in the Western Atlantic appears to be limited at the south in the vicinity of Long Island Sound, although it is stated by Uhler and Lugger to occur on the coast of Maryland. Northward it is found at least as far as Sloop Harbor, Labrador. On the Scandinavian coast it has not been found north of Trondhjem Fjord, latitude 65°, though the other species is found up as far as North Cape. It enters the Baltic, occurs everywhere throughout the British Isles, is abundant in Holland and along the northern coast of France. In summer they are frequently seen in immense schools on the southern coast of Massachusetts. Captain Atwood gives the following account of their movements in Cape Cod Bay:

"Lants are common, and sometimes they are plentiful. Some winters there comes on a cold spell, and if the wind is just right they drive ashore, and you may pick up bucketfuls, while sometimes winters have passed away when I have not noticed but a few. One year, before 1847 I should think, the Lant came in in immense quantities. The whiting drove the Lant in, and they began to run ashore at high water, and ran ashore till low water, and they covered the whole ground so I should think they would be one and a half or two inches deep. There was not a place

[1] BUCKLAND: Familiar History of British Fishes, p. 193.

on the whole inside of the point the next day but was sheeted over with these Lant. On the day after the wind came on and blew heavy from the westward, and it swept the beach off as clean as you could sweep a floor. They come in winter and in summer, and are quite common on the coast, and on the Banks of Newfoundland there are immense numbers of them. I have frequently seen them in the stomachs of codfish."

The Lant is found in spring or early summer in the open sea, in the neighborhood of banks and shoals remote from land, as is also the sprat in Europe and the "brit," "eyebait," or small herring in America. Professor Sars has given a detailed description of the manner in which the vast schools of young herring to the Norwegian shore in summer not only attract the large cod and many other fish from the deep sea towards the shore, but also draw the yearling and two-year-old cod *from* the shore to meet the incoming schools.

USES.—As has already been stated, this fish is not used for food in the United States. Its importance is well understood by our fishermen who go after cod to Labrador and Newfoundland. They are said to be common in the Edinburgh market in summer, while in Southern England they are salted and dried for winter use. In Edinburgh, too, the other species, called the Horness, or Horned Eel, is brought to the market in August and sold by the thousand. Parnell states that this species spawns in September, and that their flesh is wholesome and palatable.

Captain Atwood has also recorded some curious observations concerning the manner in which these fish, with their sharp snouts, penetrate through the stomach of the codfish which has eaten them, into the walls of the body, and there become encysted in the flesh, forming hard, black masses which are very inconvenient to the fishermen, because they dull their knives which they use in dressing the fish before drying them.

K.—WOLF-FISHES, SCULPINS, AND WRASSES.

75. THE LYCODES FAMILY—LYCODIDÆ.

This family is represented on our Atlantic coast by eight or ten species, and on the Pacific coast by three others. They are large-headed, elongate fishes, with eel-like bodies, covered with a lax, thick, slimy skin, and for the most part inhabit very deep water, and are seldom seen except by the naturalist, and by the fisherman, who counts them among the refuse products of his lines.

MUTTON-FISH.—The Mutton-fish, *Zoarces anguillaris*, called Congo Eel and Ling, and also Lamper Eel, especially by the Maine fishermen, is often seen near the shore north of Cape Cod, and in winter especially is frequently taken with hook and line from the wharves. This species occasionally attains the length of three feet and the weight of six or seven pounds.

The Mutton-fish feeds upon crustaceans and mollusks, and spawns in July and August in the deep waters of Massachusetts Bay, its eggs being as large as buckshot and not very numerous. The young fish are frequently taken in the Fish Commission trawl-nets. This species has been recorded as far south as Fort Macon, in North Carolina, where Dr. Yarrow claims to have taken two specimens, fishing from one of the wharves; and H. R. Storer found it in Southern Labrador, at Bras d'Or, where he observed that it was frequently taken in the herring seines. In Northern Europe is an allied species, *Z. viviparus*, which brings forth its young alive, the embryos attaining a length of four or five centimeters before leaving the mother, and in the Baltic making their appearance in August or later. Malm records the capture in Southern Sweden, November 17, 1873, of a female with three hundred fully developed young, about forty millimeters long. It is not yet definitely determined whether or not our species is viviparous, but it seems somewhat improbable, although one taken in Gloucester Harbor, at a depth of eight fathoms, in a temperature of 41° F., July 30, 1878, contained eggs which seemed almost mature enough to be deposited. This is known in Germany as the Aalmutter, or Mother of Eels; in Holland, Puit Aal; in Scotland as the Bard or Maroona Eel; in England as the Guffer, Eel-pout, or Green-bone; and in Southern Sweden as the Aolkussa; the distribution of which is limited on the south by the English Channel, on the north by the North Cape and Varanger Fjord, latitude 71°. It enters the Baltic, where it is frequently taken on the Prussian coast, especially about Memel.

The Mutton-fish, like the Wolf-fish, or Sea Catfish, is one of those species which, while possessing excellent qualities as a food-fish, is not generally eaten. Mitchill speaks of having seen them in considerable numbers in the New York markets in March, 1813, and De Kay in 1842 wrote: "I have noticed this fish is most abundant in the New York markets in February and March. It is caught on the coast in company with the common cod. It feeds on various marine shells and affords a very savory food."

In Gill's paper on the "Fishes of New York Markets," written in 1856, this fish is not mentioned as one of the kinds at that time sent to New York.

Storer writes: "It feeds upon the mollusca and testacea, and the flesh of the young fish is sweet and very palatable. It is seldom met with in Boston market; occasionally, however, it is brought in by the cod-fishermen of Massachusetts Bay."

It is occasionally eaten by the Cape Ann fishermen, by whom it is known as the Mutton-fish,

the name referring to a supposed resemblance of its flesh to mutton; and I can myself testify to the delicacy of its flavor. The European species is also on the border-line between food and refuse fishes. Parnell writes: "In the Firth of Forth it exists in great plenty, hiding under sea-weed in rocky situations. They are even taken with lines in the winter months and brought to market, where they fetch a ready sale at the rate of three a penny. Some people consider the flesh as very fine and wholesome, while others, again, announce it as dry and of a disagreeable flavor. The bones of this fish when boiled assume a green appearance, from which circumstance the fish oft-times receives the name of Green-bone."[1]

Mr. Neill says: "Though not a delicate morsel, this fish is often brought to the Edinburgh market."

In Holland and Germany they are not often eaten; there is a general impression, however, that they are edible.

PACIFIC LYCODIDS.—This family is represented on the Pacific coast by *Lycodopsis pacidens* (Lockington) Jor. & Gilb., and *L. microstomus* Lockington, small fishes, scarcely a foot in length, living in rather deep water from San Francisco northward. They have no economic importance, being only brought into the market when mixed with the tomcod and "soles."

76. THE WOLF-FISHES OR SEA CATFISHES—ANARRHICHADIDÆ.

SEA CATFISHES.—The Wolf-fish family is represented on our Atlantic coast by three species—all large, voracious, and frequently taken by cod and halibut fishermen. The best known, and in fact the only species definitely ascertained to occur in the Western Atlantic until the other two were recently brought to light by the labors of the Fish Commission, is the common "Catfish" of the fishermen, *Anarrhicas lupus* Linnæus, and which is found throughout the northern parts of the Northern Atlantic, ranging upon the New England coast south to the region of the Nantucket Shoals, where it ever breeds in deep water, young specimens having been obtained by the Fish Commission at a depth of over one hundred fathoms in the summer of 1880, while in 1874 several specimens were brought to Noank, caught by the New York smacks on the Nantucket Shoals, the largest four feet or more in length. De Kay records the capture of a specimen four feet long off Block Island, and states that they are not unfrequently taken off Rock Beach in company with the common cod.

In the Eastern Atlantic it is found in the German Ocean, on the south coast of Great Britain and in the Channel, and along the shores of Holland.[2] According to Richardson it is somewhat common on the French coast. Though it does not appear to enter the Baltic, it is found on the coast of Norway and in the Cattegat. Yarrell records the capture of this fish on the coast of Yorkshire, in the Frith of Forth, and in the Orkneys. Collet records its presence everywhere along the Norwegian coast up to the North Cape and Varanger Fjord in Eastern Finmark, while it is known to occur in Iceland and Greenland and along the entire eastern coast of Northern North America. This is the best known species, and until recently all others have been confounded with it. It is readily distinguished from the others by its general color of gray slate, or light brown, marked with from nine to twelve transverse bands of darker hue. By many of the nations of Northern Europe it is called the Catfish; and this name is still in general use among our own sea-fishermen, although the fishes most generally known in North America by this name are fresh-water species of the family Siluridæ, closely related to the sheet-fish or wels of Europe. To an untrained observer there is some resemblance between these fishes and the Catfish of the

[1] There is no evidence that the bones of the American species ever become green. The name Green-bone is also applied in Europe to the silver gar-fish.

[2] SCHLEGEL: De Dieren van Nederland. Visschen, p. 68.

sea, to which resemblance they doubtless owe their common name, bestowed upon them by the early English settlers. They are also called in this country "Wolf-fish," this being the common book-name. In the Orkneys the name is "Swine-fish," professedly on account of a peculiar movement of the snout which has been observed; while in Scandinavia the name "Stone-biter" is also common. Another species, which may be called the Spotted Cat-fish, or the Wolf-fish, is occasionally obtained by our cod-fishermen on the off-shore banks, and has been taken near the shore in the Bay of Fundy. In form and general appearance it is similar to the species just described, but instead of transverse bands of brown or black it is marked with numerous circular spots and blotches; sometimes several of these are confluent, forming a large, irregular blotch. This species, *Anarrhicas minor*, Olafsen, has been observed on the coast of Norway throughout nearly its whole extent, north of latitude 58°; it occurs in Iceland, whence were received the first specimens, and on our own coast has been seen in the Bay of Fundy and on several of the banks north of Georges.

Besides these two, there is the "Blue Cat-fish", *A. latifrons*, which is much smaller, rarely exceeding three feet in length, with a very soft and flabby body, and of a uniform blue-slate or mouse color. This is a resident of the deep waters, in two to four hundred fathoms, on the outer edge of the off-shore banks, and has also been observed in the northern parts of Europe. Dr. Bean has recently described a species from Alaska somewhat resembling *Anarrhicas lupus*, but without the cross bands; the color of the alcoholic specimens is dark brown without bands or spots, and with belly of light brown or gray clouded with very dark brown. To this he has given the name *Anarrhicas lepturus*. The types were obtained at Saint Michaels.

The Wolf- or Cat-fishes are, emphatically, lovers of cold water, their range corresponding closely to that of the halibut, though perhaps not extending quite so far southward. They are almost invariably found upon the same feeding-grounds, where the Cat-fish devour the heavy-shelled crustaceans and mollusks which are too strongly protected to be eaten by other fishes. According to Fabricius it migrates from the coast to the deep sea in the autumn and returns again in the spring, being associated in these movements with the common lump-fish.

It is impossible to imagine a more voracious-looking animal than the Sea Cat fish, with its massive head and long, sinuous, muscular body, its strongly rayed fins and its vise-like jaws, armed with great pavements of teeth, those in front long, strong, pointed like those of a tiger, closely studded, re-enforced in the rear by others rounded and molar-like, adapted for crushing the objects which have been seized by the curved teeth in the front of the jaw. The character of their food has already been mentioned. Professor Verrill found in the stomach of one of these fishes over a quart of spiny sea-urchins, and it is believed that upon these and upon hermit-crabs they depend very largely for food. They are pugnacious in the extreme, and have been known to attack furiously persons wading at low tide among the rock-pools of Eastport, Maine. When one is lifted into a fishing-boat, which is a not unfrequent occurrence, it is necessary to kill it at once to prevent it from injuring the fishermen, by biting or stabbing them with its sharp spines. They are quickly killed by blows upon the head.

The only record of the spawning time of the *Anarrhicas lupus* in Europe, which I can at present find, is in Schlegel's "Fishes of the Netherlands," where it is stated that it occurs in May and June. It is probable that on our own coast the period is approximately the same, since young fish of one and two inches in length have been several times taken by the fishermen in August and September. DeKay states that they spawn in May. According to Fabricius, it spawns on the Greenland coast in May among the largest seaweeds, a short way from the shore. The largest individuals of this species are six or seven feet in length, and would probably weigh forty pounds. The specimen mentioned by Richardson, three feet long, weighed twenty pounds.

It cannot be said that they are at present of great economic importance. Storer, writing in 1867, said: "By many of our fishermen it is considered very delicate; the smallest specimens, from five to ten pounds, are quite palatable when fried or broiled, the skin having been previously removed; it is also occasionally split and salted or dried and smoked, and is said to be, when thus prepared, very good."[1]

Parnell wrote: "It is quite common in the rocky parts of the Firth of Forth, and also found on the haddock lines, and is occasionally taken in the same nets above Queen's Ferry. About June the young are about two feet in length, and are sold in the market for sixpence each. The appearance of this fish is not very prepossessing, and the natives are not aware of its quality as food; but if properly dressed and disguised by the head being cut off, it is considered equal to many of the marine fishes."[2]

Yarrell says: "According to Mr. Neill, specimens of small size, about two feet in length, are frequently brought to the Edinboro' market; and those who are able to overcome the prejudices caused by its appearance find it good food. Mr. Hoy and Mr. Low have borne their testimony to the excellence of its flesh, and Mr. Donovan states that it is delicious. It may be observed here that this is the general character of the flesh of those fishes that feed on crustaceous animals. It is eaten by the Greenlanders and Norwegians, as well as by most of the inhabitants of the northern part of Europe, the head and skin being first taken off. The skin is converted into very durable bags and pockets.[3] Malm writes: "They occur along the whole coast of Bohuslan, and are caught most frequently of all from March to May."

Frank Buckland remarks: "Notwithstanding the ugly appearance of this fish its flesh is said to be of a very good flavor. It is sometimes seen hung up in the shops of London fish-mongers, and I can, for the most part, say that it is very good; I can compare it to nothing but a nice veal chop." DeKay also bears testimony to their excellence, saying that "when smoked their flesh is very similar to that of salmon." Schlegel says they are not eaten on the coast of Holland.

On the Pacific coast there is a fish of a closely-related genus commonly known as the Eel, *Anarrichthys ocellatus*. This species is commonly known as the "Eel," or "Wolf-eel," the latter name probably having been given by some one familiar with the Atlantic Wolf-fish. The name "Azia" is given to it by the Dalmatian fishermen on Puget Sound, and that of "Morina" by the Italians at Monterey. It reaches a length of eight feet and a weight of about thirty pounds. The average length is five to six feet. It ranges from Monterey to Puget Sound, lurking among the rocks, and occasionally left by the falling tide. It is not rare about San Francisco, but becomes much more abundant northward. It feeds on crustaceans, echinoderms, and fishes. According to Mr. Lockington the broken shells of *Echinarachnius excentricus* are often found in its stomach. Nothing special is known of its breeding habits, enemies, or diseases. As a food-fish it meets always with a ready sale.

77. THE BLENNY FAMILY—BLENNIIDÆ.

The Blenny family is represented on the Atlantic coast of the United States by two species of insignificant size and absolutely without value. Upon the Pacific coast they are represented by numerous small fishes, mostly living about the rocks between tide-marks, and often exceedingly abundant. A few of them live in the kelp, and some of them swim freely in shallow water. Large individuals are occasionally brought into the markets, especially of *Xiphister mucosus*, *Cebedichthys*

[1] Fishes of Massachusetts, p. 100.
[2] Fishes of the Firth of Forth, p. 240.
[3] British Fishes, 1836, vol. 1, p. 246.

violaceus, and *Heterostichus rostratus*, often selling as "eels," at thirty cents per pound. In general these fishes are, from an economic point of view, entirely insignificant, and probably not a hundred pounds a year of them are sold on the whole coast. The *Lumpenus anguillaris* is often taken in large numbers in the seines, but a prejudice seems to exist against it and no one will eat it.

The following is a list of the Blennioid fishes: *Lumpenus anguillaris* (Pallas) Gill, from Cape Mendocino northward; abundant. *Apodichthys violaceus* (Ayres) Grd.; *Xiphister rupestris* Jor. & Gilb.; *Xiphister mucosus* (Grd.) Jor.; *Xiphister chirus* Jor. & Gilb.; *Aproplarchus atropurpureus* (Kittlitz) Gill; *Apodichthys flavidus* Grd.; *Apodichthys fucorum* Jor. & Gilb.; all these living among rocks and ranging from Monterey to Alaska; *Muræoides ornatus* Girard, from Cape Mendocino northward; *Cremnobates integripinnis* Rosa Smith; *Gibbonsia elegans* Cooper, and *Hypleurochilus gentilis* (Girard) Gill, among rocks, chiefly from Point Concepcion southward; and finally *Neoclinus satiricus* Grd., *Neoclinus Blanchardi* Girard, and *Heterostichus rostratus* Girard, living in the kelp along the shore from Monterey to Lower California.

78. THE TOAD-FISH—BATRACHUS TAU.

The Toad-fish, *Batrachus tau*, called also on the coast of New Jersey and in some parts of the Southern States "Oyster-fish," is one of the most repulsive looking fishes upon our coast, with its dark, slimy, almost shapeless body and its mud-wallowing habits. In general appearance it resembles a sculpin without prominent spines upon its head or upon its fins. Although it is armed with by no means insignificant spines, which are capable of inflicting serious cuts, when touched they show no disposition to bite, but erect their opercular spines in a very threatening manner; these are so covered by the lax skin that they can scarcely be seen.[1]

Species of this family inhabit the coasts of nearly all the tropical and temperate regions of the world. The American species was the first brought to notice, specimens having been sent about 1761 from South Carolina by Dr. Garden to Linnæus, by whom it was described under the name *Gadus tau*, the great Swedish naturalist considering it to be a kind of codfish. The name which he gave it refers to a character not discernible except in dried specimens, the bones of the upper surface of the scale forming a group of ridges which resemble in shape the Greek letter *T*.

Our species is found in shallow waters from Cape Cod south at least as far as to the mouth of the Mississippi River. In the Gulf of Mexico, however, it is found in deep water, and many large ones are taken on the snapper grounds at a considerable distance from shore. In the South it would appear to be somewhat more active in its habits, though frequently found on the oyster-beds, hiding between the valves of empty oyster-shells.

There are at least three distinct forms: (1) The northern variety, rarely exceeding ten, twelve, and even fifteen inches in length, the general color of which is brown coarsely marbled with darker marks. (2) The southern variety of Günther, which is found on the Florida Keys and in the Gulf, though often associated with the northern variety, which is similar in color to this, but has the body and the fins dotted and spotted with white. (3) A form found only in the Gulf, *Batrachus pardus*, which is much larger and of a light-yellow color spotted and blotched with brown. This form is known to the fishermen as the "Sarpo" and the "Sea-robin," the former name being doubtless a corruption of the Spanish word *sapo*, meaning toad. This form is said by Mr. Stearns frequently to attain the length of eighteen inches. The color of these fish usually corresponds very

[1] A closely related form, *Thalassophryne maculosa*, which occurs on the Atlantic side of the isthmus of Panama, has true poisoning glands at the base of its opercular spines, by means of which it can inflict injurious wounds; this being almost the only fish which possesses weapons of this character.

closely to that of the bottom upon which they are resting, and, like many other muddy-water species, they have the power of changing their color to lighter or darker shades when exposed to the light in shallow vessels with dark or light-colored bottom. They are very voracious, feeding upon small fishes of all kinds, especially upon anchovies and sand-smelt, and upon shells, crabs, shrimps, and marine worms. "It secures its food rather by strategy and stealth than by swiftness of motion," writes Mr. Stearns, "hiding under or behind stones, rocks, or weeds, or stealing from one cover to another it watches its victim until the latter is near by, when it darts forth with a quickness quite astonishing, considering its usual sluggishness, and back again to its hiding place, having one or more fish in its stomach and on the alert for others."

On the south coast of New England it is found chiefly in the shallow bays. "The sandy or *muddy bottom of these*," writes Storer, "*is overgrown with eel-grass, under cover of which it lives* in security and finds abundant sources of food. Where the coast, on the contrary, is more or less rocky, we meet with it chiefly under stones. Examining the places where the water is but a few inches in depth at low tide, we see that under many of the stones and smaller rocks the sand on one side has been removed, leaving a shallow cavity perhaps a foot in width and extending back beneath the stone. If we approach this cautiously we shall probably distinguish the head of a Toad-fish very much in the position of that of a dog as he lies looking out of his kennel. The fish is at rest, and might be overlooked by a careless observer; a closer attention, however, readily distinguishes the curve of its broad mouth and delicately laciniated tentacles with which its jaws and other parts of its head are ornamented. Its eyes, and sometimes the anterior portion of its body, are truly beautiful. At the slightest alarm it retreats beneath the stone, but presently reappears; it is lying here merely as in a safe resting-place, perhaps on the watch for its prey. But during the months of June, July, and August we shall in many instances be able to discover another purpose; it is apparently guarding its eggs or young; we shall then find on the interior surface of the stone the young Toad-fish adhering, to the number of several hundreds. They will be in different stages of development, according to the season of our examination. We may see the eggs not larger than very small shot; a little later they are increased in size, the young fish plainly visible through their walls; a little later still the young have made their escape, but are still attached to the stone. The attachment now, however, is accomplished in a different manner; the yolk not being yet absorbed, occupies a rounded sac protruding by a narrow orifice from the ~~abutment~~, and the part of this sac near its outer border being constricted leaves, externally to it, *a disc, by means of which, acting as a sucker, the young fish adheres so firmly as to occasion difficulty* in detaching it. They remain thus until they have attained the length of one-half or three-fourths of an inch, or until the yolk sac is entirely absorbed. During this period the adult fish occupies the cavity beneath the stone, and if driven from it speedily returns. The fish is in all cases the mother of the young ones, but that she is there for the purpose of guarding them we have no means of determining; we can only infer it."

At Noank, Connecticut, in 1874, I had an opportunity of watching the progress of the spawning season. July 14, numerous eggs were found clinging to the stones in water one to two feet in depth; later in the season, July 21, young fish, half an inch long, were plenty, and September 1 these had attained an average length of one inch. Individuals, apparently of the second year's growth, were also common, and would average three-fourths of an inch in length.[1]

[1] Silas Stearns writes: "In the Gulf of Mexico the Toad-fish spawns in April or May. When its young have been hatched, the older fish seem to guard them, and teach them the devices of securing food in much the same manner that a hen does her chickens. I have spent hours in watching their movements at this time, and was at first much surprised by the sagacity and patience displayed by the parent fish."

The bottom temperature of the water frequented by these fish would appear to range from 50° F. to 90° F. In the more northern regions throughout which they are distributed they appear to become torpid, or nearly so, in winter; and it is stated by Storer that they are frequently found in the mud by men spearing eels. They are very hardy, and when taken from the water will lie for many hours, and soon recover their ordinary activity when restored to the water. When handled they utter a loud croaking sound.

The Toad-fish is very abundant throughout the whole extent of its range, and is easily captured with hook and line. In the Gulf of Mexico many are taken in seines. Mr. Stearns states that its flesh is highly esteemed by many of the Gulf fishermen. Dr. Storer writes: "The Toad-fish is not commonly employed as an article of food. Its generally repulsive aspect causes it to be looked upon rather with disgust. That its flesh is delicate and good, however, can scarcely be questioned, though the small size which it attains and the fact that it never is taken in any large quantities prevent it from being of any economic value." Professor Baird also bears testimony to the fact that its flesh is very sweet and palatable.

The Toad-fish may be regarded as constituting one of the undeveloped resources of our waters, and it can scarcely be questioned that in future years it will be considered as much more important than at present. No estimates can be given as to the quantity now yearly entering into consumption, and, since it is almost never offered for sale, no price quotations can be presented. It has still another, and at present more important, relation to the fisheries than this; on account of its great abundance and its pertinacity in taking the hook baited for nobler game it is regarded by the fishermen as one of their worst pests.

The *Batrachidæ* are represented on the Pacific coast by the "Singing-fish," or "Toad-fish," *Porichthys porosissimus*. This fish lives on muddy bottoms from Alaska to Panama, and is everywhere extremely abundant. It reaches the length of eighteen inches, but being never used for food has no economic importance.

The family *Trichodontidæ*, which follows Batrachidæ in the classification of Gill, is represented on the California coast by the species *Trichodon Stelleri*, an estray from Alaska, rarely seen. On the Atlantic coast this family is entirely absent.

79. THE LUMP-SUCKERS; LUMP-FISH AND SEA-SNAILS.

The Sea Snails—Liparididæ.

The three families *Gobiesocidæ*, *Liparididæ*, and *Cyclopteridæ* are represented on our coast by several species, most of them minute and of no economic value; all of them characterized by the presence of a peculiar suctorial organ upon the belly, a modification of the ventral fins, by which they are able to cling to rocks and shells and to retain their positions in currents of water. The Lump-suckers, *Liparis lineatus* and *L. vulgaris*, which are found on oyster and scallop beds and among the roots of the kelp, and along the New England coast, are interesting from the fact that they are often parasitic, living within the shells of the large scallops, in company with a small crab resembling the oyster-crab. From the Chesapeake Bay southward, and in the Gulf of Mexico, allied forms belonging to the genus *Gobiesox* occur, especially among the oyster-beds, but these also are of no economic value.

The Lump-fish—Cyclopterus lumpus.

To this group belongs a fish which, though of little value, is often seen in our markets, and is so conspicuous, on account of its grotesque form and striking colors, that it is worthy of passing

mention. This is the common Lump-fish, *Cyclopterus lumpus*, known in England by the names "Lump-sucker," "Sea-owl," "Cock-paddle," and by numerous local appellations. This fish is widely distributed throughout the entire North Atlantic, ranging on our coast from the mouth of the Chesapeake to the Straits of Belle Isle, abundant in Greenland and Iceland, along the entire western coast of Scandinavia, from the North Cape to the Cattegat, entering the Baltic, and not rare along the shores of East and West Prussia, well known in Holland, Northern France, and everywhere in the British Isles. The largest English specimen recorded weighed eleven and a half pounds; the largest on our own coast, as observed by Storer, eighteen and three-quarters pounds.

"The Lump-fish," writes Benecke, "lives on the bottom of the sea, swims slowly and with difficulty, and in May and June comes into shallow water to spawn. The male makes pits in the sand, between the stones, in which the female deposits its eggs. The male watches over the eggs, and later over the tender young which cling to its body with their suckers. The number of eggs ranges from 200,000 to 400,000. It is a voracious species, which preys upon small crustaceans, mollusks, and fish-spawn."

Benecke's observations were made in the southern part of the Baltic; the spawning time is recorded by him as probably not very different from that in Southern New England. Young specimens from one-fourth to one inch in length are very abundant in Southern Massachusetts and Connecticut in July and August, swimming at the surface. They have not yet assumed the ponderous, unwieldy shape of the adults, and swim much more rapidly and gracefully. In Sweden, according to Malm, the spawning time is in June; "In England," says Yarrell, "in April and the beginning of May"—dates which correspond precisely to those given by Fabricius for Greenland.

The male Lump-fish is said to be very fierce in defense of its young, and to be able to protect them from much larger fish than themselves, even from the wolf-fish. It is, in its turn, a favorite prey for the seals and wolf-fish. At the time of the spawning season the ordinary translucent green color of the body becomes much brighter, and the under parts of the fish are of a brilliant red. After spawning, the red disappears and the general color of the body becomes dull. When in the season of the brightest coloration they are frequently shown in the fish markets, where their remarkable appearance attracts much attention.

"If the authority of Sir Walter Scott is to pass current in gastronomy," writes Richardson, "Lump, or *Cock-paidle*, as it is named in Scotland, is a fish of good quality, for he makes Mr. Oldbuck give the same price for one that he does for the bank-fluke or turbot."

Parnell states: "On the west coast of Scotland sometimes as many as two dozen are taken in the salmon nets at almost every tide, principally in the month of June, when they seek the sandy ground to deposit their spawn. The fishermen boil them down with vegetables for their pigs, and consider them to be fattening food. The flesh, when cooked, is soft and very rich, and is considered by some of the inhabitants of Edinburgh as a luxury; but there are few stomachs with which it agrees, in consequence of its oily nature. The males are considered the best for the table." In Scotland it is also sometimes eaten in a salted state.

Buckland also has an opinion on record: "So great is the difference between the different specimens that our fishermen consider them to be distinct species and call them the "Red-lump" and the "Blue-lump," but the difference in color and flavor is only the effect of the season. I do not like the flesh at all myself; it is like a glue pudding."

It is stated that the Greenlanders eat the flesh either cooked or dried and the skin raw, while they eat the roe, which is remarkably large, after having reduced it by boiling it to a pulp.

Perley records that "In the spring the Lump-fish approaches the shores of New Brunswick

and Nova Scotia to deposit its spawn. It is then taken in considerable numbers near the harbors at Halifax, the largest weighing about five pounds. They are taken there of two different colors, the one being a dark blue approaching to black, and the other quite red. Those of a red color only are used as food; they are considered good by many, although very fat and somewhat oily; the dark-colored is considered very inferior and is not eaten."

On the Pacific coast the *Gobiesocidæ* are represented by *Gobiesox reticulatus* (Grd.) J. & G., a small fish four or five inches long, adhering to rocks by a sucking disk on the breast. It is found from Monterey northward, and has no economic value. The *Cyclopteridæ* are represented by the rare *Cyclopterus orbis* occasionally taken in the Straits of Fuca and northward. The *Liparididæ* are represented by *Liparis pulchellus* Ayres, and *Neoliparis mucosus* (Ayres) Steindachner, small fishes occasionally taken about San Francisco and Monterey, of no economic importance.

80. THE GOBIES—GOBIIDÆ.

The Goby family is represented on the Atlantic coast by several species, none of which have ever been found north of Cape Cod, and none of which are or ever can be of the slightest importance. Chief among these are the scaleless Goby, *Gobiosoma alepidotum*, which is found between Cape Cod and Texas; the Chubby Goby, *Gobius soporator*, common along the Gulf coast, and several species belonging to the genera *Eleotris* and *Dormitator*. They are not even abundant enough to be worthy of consideration as food for other fishes. On the Pacific coast there are several small species, which may be seen lying on the bottoms entering the lagoons. They reach the length of three to six inches, and are of no economic importance, though the Chinese eat the Long-jawed Goby, *Gillichthys mirabilis*, and its flesh is said to be very good. The other species are *Gobius glaucofrænum* (Gill) J. & G., in Puget Sound; *Lepidogobius gracilis* (Girard) Gill, from San Francisco northward; *Eucyclogobius Newberrii* (Girard) Gill, rarely seen about San Francisco, and *Gillichthys mirabilis* Cooper, found the entire length of the coast, but abundant only from San Francisco southward. The latter species burrows in the muddy bottoms of the lagoons.

81. THE SEA-ROBIN OR GURNARD FAMILY—TRIGLIDÆ.

This family is represented on our Atlantic coast by several species, some of them being quite abundant. The most striking of them all is the Sea-bat or Flying Gurnard, *Dactylopterus volitans*, which is remarkable on account of its enormous spreading fins, larger than those of a flying-fish—wings which, however, are not sufficiently powerful to lift the body above the surface of the water, though useful in maintaining the equilibrium of the heavy-headed body swimming through the water. The colors of the body and of the fins are very brilliant, and the fish is often exhibited as a curiosity. It is found along our entire coast south of Cape Cod, and in the waters of Brazil; also in the Mediterranean and in the neighboring parts of the Eastern Atlantic.

The genus *Prionotus*, of which we have five specimens, resembles *Dactylopterus* in general form, but the wings are much smaller, while two or three of the lower rays of these fins are developed into finger-like appendages which are used in stirring up the weeds and sand to rout out the small animals upon which they feed. In Southern New England there are two large species, *P. palmipes* and *P. evolans*, the latter distinguished by the presence of dark stripes upon its sides. These attain the length of fifteen to eighteen inches and the weight of one and a quarter to two pounds. They have excellent food qualities, but are eaten, so far as we have record, only in the vicinity of Hartford, Connecticut, where they are known as "Wing-fish." They are taken in great quantities in the pound-nets along the Vineyard Sound, especially the unstriped species, the habits

of which are better understood than those of the allied species. It feeds upon crabs, shrimps, and small fishes.[1]

In Vineyard Sound the Sea-robin spawns during the summer months. A specimen obtained at Wood's Holl, August 12, 1875, contained eggs nearly ripe. Another, observed at Noank, Connecticut, July 11, 1874, was in precisely the same condition. Lyman states that in 1871 the eggs, which are bright orange, were thrown up in quantities during the last third of May on the beach *on the inner parts of Waquoit Bay, and the females had well developed spawn in them.*

The species just mentioned are found as far north as Cape Cod; the web-fingered Sea-robin, *P. palmipes*, even north of the cape, two or three specimens having been obtained in the vicinity of Salem and Lynn. These two species apparently do not occur much to the south of Cape Hatteras, and on our Southern coast they are replaced by others which are smaller and, at present, of no *economic importance.*[2] The genus *Prionotus does not occur in Europe, the family being there represented* by a very similar form, genus *Trigla*, which, however, has still smaller wings. Its habits are much the same. A single specimen of the Red Gurnard of Europe, *Trigla cuculus*, is said to have once been taken at New York. Europe has nine species of *Trigla*, most of which are highly esteemed for food; some of these species have been known to attain the length of two feet and the weight of eleven pounds. These fishes are held in high estimation, and are frequently seen in the markets.

USES.—Parnell writes: "The Red Gurnard occurs on the Devonshire coast in great numbers, *and on some occasions thousands of them may be seen exposed for sale daily, especially in those* small towns where the trawl-boat fishing is carried on. The flesh is firm and well-flavored. The Tub-fish, *T. hirundo*, is of frequent occurrence on the west coast of Scotland, and is occasionally brought to the Edinburgh market. Its flesh is firm and wholesome, and is considered by some to be superior to the last species, but in general more dry. In the north of Europe it is salted for *keeping. The Gray Gurnard, T. gurnardus, is considered* by all fishermen richer and sweeter than any of the other Gurnards, although in the markets it is less sought after than the Red Gurnard, which is the drier and worse flavored of the two. It is taken generally with hooks baited with mussels. These fish are taken in very great numbers in the trawl-nets; they appear to be much more abundant on the European coast than their cousins, the Sea-robins, with us."[3] Their recommendations *are quoted here in order to draw attention to this neglected group of fishes*, which are certainly worthy of greater consideration than they have hitherto received.

Mr. J. Carson Brevoort has given the following testimony regarding the food qualities of the American species:

"*The Gurnard as an edible fish.*—Among the fish that may be classed as edible, but which are entirely neglected here, is the Sea-robin, Grunter, or Gurnard. This curious, but rather forbidding creature, is, in reality, one of the most delicate morsels that can be laid before an epicure, the flesh being snow-white, firm, and fully as good as that of the king-fish, or whiting. In fact it would be hard to distinguish them when placed on the table.

"In Europe every one of the various kinds of Trigla, or Gurnard family, is sought after eagerly, and finds a ready sale on the fish-stalls. They have eight or ten kinds of the group there, and we have but six here; all but one different from the European kinds, though belonging to the same

[1] Specimens caught at Wood's Holl, Massachusetts, May 29, 1871, contained shrimp, *Crangon vulgaris*, and a small flounder. Another, taken May 29, contained a small beach-flea, *Anonyx, sp.*, and *Crangon vulgaris*. Others, dredged in Vineyard Sound in August, contained crabs, *Panopeus Sayi*, *Cancer irroratus*, and small fishes. Another, taken at Noank, Connecticut, in July, 1874, contained sand-fleas, *Unciola irrorata* and *Ampelisca sp.*

[2] A single specimen of *S. palmipes* was taken by Mr. C. H. Gilbert, at Charleston, South Carolina, in 1882.

[3] PARNELL, RICHARD: Fishes of the Firth of Forth, 1838, p. 174.

family. We shall not attempt to describe all these fish, which resemble each other very much in all but the color. They all have large heads, sheathed with rough, bony plates, and armed with many acute points, and their dorsal fin has also several sharp, thorny rays. These prickles are all erected by the fish when taken alive, and they inflict a painful, though not, as many say, a poisonous wound. The broad mouth is furnished with rough, but not sharp, teeth; the pectoral fins in most of the species are very long, and can be expanded like a fan, whence they are sometimes called Flying-fish and Butterfly-fish. It is doubtful, however, whether they can actually fly like a flying-fish, but they have been said to skip from wave to wave, a peculiarity often alluded to by halieutic poets. They also emit a grunting sound, which can be distinctly heard in still weather while lying at anchor on a shallow, which they frequent. At such a time the sound resembles the distant lowing of kine. When freshly taken from the water they grunt quite loudly, whence their popular name of Grunter, or Cuckoo-fish.

"The Gurnards live on crabs and delicate fresh food, taking all such baits readily, on a clean bottom, and they sometimes annoy fishermen hugely by their voracity. They play well on the hook, and a large one tugging at a rod is often supposed to be a game fish and a prize, till the ugly Sea-robin, with his spiky helmet, shows himself at the surface.

"The Gurnards of our coasts do not reach a large size, at least we have but rarely seen any that weighed over a pound, while in Europe some of the species, such as the Tub-fish, *Trigla hirundo*, have been found weighing eleven pounds, and those of seven or eight are common. The Red Gurnard, or Rotchet, *T. cuculus*, and the Piper, *T. lyra*, reach three or four pounds, averaging about two, while the other European kinds resemble ours as to size.

"Small as our species are, they are not the less delicate when cooked, and we have often verified this fact. They are sold in England by the number, and not by weight, for their large heads are inedible, while they add, perhaps, one-quarter to their weight. The English fishermen take them almost everywhere along the coast in large trawl-nets, constructed for their capture, though other bottom fish may find their way into the net. These trawls are generally twelve or sixteen feet wide at the mouth, with a bag proportioned to their beam, which has one or two labyrinths like a fyke-net inside. The trawl is managed from a large sail-boat, with a block and tackle, and is hauled in water as deep as eight or ten fathoms. We do not recommend this special fishery to our coast fishermen, as our Gurnards are small, but wish only to call attention to the edible qualities of this generally despised fish.

"Piscator (the anonymous author of the 'Practical Angler'), in his excellent little treatise entitled 'Fish; How to Choose and How to Dress,' published in 1843, says of the Gurnard that their flesh is 'white, excellent, exceedingly firm, and shells out into snowy flakes, and is of a remarkably agreeable flavor,' and that 'they keep well.' He recommends them to be boiled—that is, the large ones; while the small ones may be split and fried.

"We have no popular names for the species that are found in our waters. All are called Sea-robins, Flying-fish, Grunters, &c.

"Having drawn attention to this first as one that deserves a place on our tables, we leave his fate hereafter to the tender care of a good cook and a discerning palate."

Another member of this family is the *Peristedium miniatum* Goode, a brilliant red species recently discovered by the Fish Commission in the deep waters on the coast of Southern New England.

THE AGONUS FAMILY.—Another family closely related to the family *Triglidæ* is the family *Agonidæ*, the members of which are remarkable on account of their angular bodies encased in spinous, bony plates; it is represented on our east coast by one species. The *Aspidophoroides*

monopterygius—the "Greenlander," as it has been christened by the seamen on the Fish Commission steamer—has been observed as far south as Watch Hill, Rhode Island, and is quite abundant in deep water north to the polar regions, having been frequently observed on the coast of Greenland. This fish attains a length of seven or eight inches, and, although it is not much thicker or softer than an iron spike, is sometimes found in the stomachs of codfish and halibut.

"On the Pacific coast," writes Professor Jordan, "the Agonidæ are represented by numerous species inhabiting deep waters from Santa Barbara northward. They have no economic importance, being brought into market only by accident. These species are *Leptagonus verrucosus* (Lockington), J. & G.; *Leptagonus xyosternus*, J. & G.; *Podothecus acipenserinus* (Pallas), J. & G.; *Podothecus vulsus*, J. & G.; *Odontopyxis trispinosus* Lockington; *Bothragonus Swani* (Steind.), Gill, and *Aspidophoroides inermis* Gthr. The Triglidæ are represented by *Prionotus stephanophrys* Lockington; rarely seen at San Francisco."

82. THE SCULPIN TRIBE—COTTIDÆ.

SCULPINS OF THE ATLANTIC COAST.—On our Atlantic coast are found several species of this family, generally known by the name "Sculpin," and also by such titles as "Grubby," "Puffing-grubby," "Daddy Sculpin," "Bullhead," "Sea-robin," "Sea-toad," and "Pig-fish." Their economic value is little or nothing, but they are important as scavengers, and are used for lobster bait. They are often a source of great annoyance to the fishermen by cumbering their hooks and by stealing their bait. The most abundant species is the Eighteen-spined Sculpin, *Cottus octodecimspinosus*, which frequents shallow and moderately deep waters from Labrador to New York. It is usually associated with a much smaller species, *Cottus æneus*, which may be called the "Pigmy Sculpin," and which ranges from the Bay of Fundy to New York.

Cottus scorpius, of Europe, is represented on our coasts by *C. scorpius* subsp. *grœnlandicus*, which is abundant everywhere from New York to Greenland and Labrador. This subspecies has been found on the coast of Ireland,[1] and the typical *Cottus scorpius* has been shown by Dr. Bean to occur in Maine. There is also, in addition to several insignificant species seldom seen except by naturalists, a large, brilliantly colored form, known as the "Sea-raven," "Rock Toad-fish," or "Deep-water Sculpin," which is found as far south as the entrance to Chesapeake Bay, is abundant throughout New England, and has been discovered off the coast of Nova Scotia. This fish, *Hemitripterus hispidus*, or *H. americanus*, attains the length of two feet, and is conspicuous by reason of its russet-orange or brick-red colors, its harlequin-like markings, its warted body, its grotesquely elongated fins, and, above all, by its peculiar habit of swallowing air until its belly is inflated like a balloon.

These fishes feed upon all bottom animals, mollusks, crustaceans, sea-urchins, and worms, and may also be found in the harbors devouring any refuse substances which may be lying upon the bottom. They breed, for the most part, in summer, and certain species, like the Sea-raven and the Greenland Sculpin, at that time assume very brilliant colors. They are not eaten by our people, although the Sea-raven is decidedly palatable. Those species which occur in Greenland are said to be eaten by the natives. As has been remarked, they are a source of annoyance to fishermen, whose bait they steal and whose hooks, especially the hooks of their trawl-lines, they encumber. Boys delight to catch them and fix a piece of light wood between their teeth; they are then unable to swim and struggle vigorously at the top of the water.

About the fish-curing stations they are very abundant, and exceedingly useful as scavengers,

[1] *Annals of Natural History*, 1841, p. 402.

gorging themselves with refuse thrown back into the sea; they care little for the presence of man, and can hardly be driven away, even when roughly punched with a boat-hook.

In the lakes and streams of the Northern States are numerous species of *Uranidea* and allied genera, known in some localities by the English name of "Miller's Thumb," also called "Bull-heads," "Goblins," "Blobs," and "Muffle-jaws." They are small and of no importance except as the food of larger species.

SCULPINS OF THE PACIFIC COAST.—The Cottidæ, according to Jordan, are represented on the Pacific coast by about eighteen separate species, known by such names as "Sculpin," "Drummer," "Salpa," "Johnny," "Biggy-head," and "Cabezon." Only one of these species, *Scorpænichthys marmoratus*, has any sort of economic importance; the others may be considered collectively. The names applied to them may be briefly considered. The name Sculpin, of course, is derived from that in use for the Atlantic species of Cottus. "Drummer" comes from the quivering noise made by many species when taken alive out of the water. "Salpa" is a Spanish word for toad, and applied also to species of Batrachidæ. "Johnny" is applied only to very little Sculpins along the shore, notably *Oligocottus maculosus*. The same name is given in the Ohio Valley to fishes of precisely similar habits, the *Etheostomatinæ*. "Biggy-head" and its Spanish cognate "Cabezon" are used by the Italians and Spanish about Monterey, Santa Barbara, and elsewhere, for different Cottidæ.

Most of the Cottidæ feed upon small fishes, and especially crustacea; one species, *Enophrys bison*, being a vegetable feeder. All take the hook readily. The flesh is poor, tough, and dry, and the waste by the removal of the head, viscera, and skin is so great that even the poorest people do not use them as food. Various sorts (notably *Leptocottus armatus*) are dried by the Chinese, who consider them the poorest of all dried fishes.

The species are: *Psychrolutes paradoxus* Gthr., found from the Straits of Fuca northward; *Ascelichthys rhodorus* Jor. and Gilb., also chiefly northward; *Cottus polyacanthocephalus* Pallas, one of the largest species, from Cape Flattery northward; *Artedius lateralis* Grd., found among the rocks from Monterey northward; *Artedius notospilotus* Grd., in the kelp, etc., from Santa Barbara to San Francisco; *Artedius fenestralis* Jor. and Gilb., about Vancouver's Island; *Artedius quadriseriatus* Lockington and *Artedius megacephalus* Lockington, taken in deep water off San Francisco; *Artedius pugettensis* Steind., in deep water from Puget Sound northward; *Hemilepidotus spinosus* Ayres, found chiefly about San Francisco and Monterey, and the large *Hemilepidotus trachurus* (Tilesius), ranging from San Francisco to Alaska; *Enophrys bison* Grd., a large species, the sole member of the group feeding exclusively on plants, ranging from San Francisco to Alaska, and exceedingly abundant in Puget Sound; *Scorpænichthys marmoratus* Grd., noticed below; *Leptocottus armatus* Grd., the commonest of all the species, abundant in every bay; *Liocottus hirundo* Grd., and *Oligocottus analis* Grd., two species ranging chiefly southward; *Oligocottus globiceps*, Grd., and *Oligocottus maculosus* Grd., small and active inhabitants of the rock pools northward; and, finally, the curious *Blepsias cirrhosus* (Pallas) Gthr., *Nautichthys oculofasciatus* Grd., and *Rhamphocottus Richardsoni* Gthr., Alaskan fishes straggling southward to San Francisco. In the fresh waters and often running into the sea are *Uranidea aspera* (Rich.) J. and G., and *Uranidea gulosa* (Grd.) J. and G., found in all the streams north of the San Joaquin. Only one of this numerous series merits especial consideration, namely the "Cabezon," *Scorpænichthys marmoratus* (Ayres) Grd. The names "Cabezon," "Sculpin," "Scorpion," "Salpa," and "Biggy-head" are applied to this species. The latter is heard chiefly among the Italians, who have about Monterey and elsewhere adopted the Spanish "Cabezon," which appears to be the most distinctive term. The names "Sculpin," "Scorpion," and "Salpa" are applied to various other species, and are rather collective than specific names.

This species reaches a length of more than two feet, and a weight of more than ten pounds, being by far the largest member of its family on the Pacific coast. It is found from San Diego to Victoria, but is more abundant about Monterey and San Francisco than either northward or southward. It inhabits moderate depths, and is taken in considerable numbers with gill-nets and hooks. It feeds upon crustacea and small fish. Its value is very small, the flesh being tough and flavorless, and it is rarely sent to the market when good fish are abundant.

83. ROSE-FISH OR RED PERCH—SEBASTES MARINUS.

Although upon the west coast of North America the fishes of the family (*Scorpænidæ*) are among the most important, there are only four species on the Atlantic coast of North America; of these, two have been discovered within the past year, and the others, though well known and very widely distributed, are not of great importance. The Rose-fish, *Sebastes marinus*, is conspicuous and unique among cold-water fishes by its brilliant scarlet color; it is also known as "Red Perch,"[1] "Norway Haddock," "Hemdurgan," and "Snapper," as "Bream" in Gloucester, Massachusetts, and called "John Dory" in Halifax, Nova Scotia. It is found also in Northern Europe, where it has been recorded as far south as Newcastle, in Northern England, latitude 55°,[2] and it has also been found in Aberdeen and Berwick, and in Zetland, where it is called "Bergylt" and "Norway Haddock."

On the eastern side of the North Sea the species has not been seen south of Gothenborg, latitude 58°, but is said to be abundant along the entire western coast of Norway to the North Cape and Varenger Fjord in East Finmark, while Malmgren records it from Bären Island, and Scoresby found it at Spitzbergen, latitude 80°. In Iceland it is abundant, and in Davis' Straits, at least as far north as Disco, where it is found associated with the halibut, and is said to constitute a liberal share of its food. In Eastern Labrador, about Newfoundland, and in the Gulf of Saint Lawrence, it is abundant, and also along the shores of Nova Scotia and in the Bay of Fundy. In these northern regions the Rose-fish prefers shallow water, and may be taken in the greatest abundance in the bays and around the wharves in company with the sculpins and the cunner or blue perch. On the coast of the United States, south of the Bay of Fundy, they are rarely seen near the shore, but have been found in deep water in all parts of the Gulf of Maine and Massachusetts Bay, and also abundantly south of Cape Cod. In the fall of 1880 the United States Fish Commission obtained great quantities of them, young and old. DeKay included this fish in his New York list, stating, however, that it was very rare in those waters. He remarks that "the coast of New York is probably its extreme southern limit."

Of late years none have been taken south of the locality already mentioned, which was in water from one to three hundred fathoms in depth, at the inner edge of the Gulf Stream, from fifty to one hundred miles southwest of Newport, and about the same distance east of Sandy Hook. A hundred or two hundred miles farther south it is replaced by a fish resembling it somewhat in form and color, *Scorpæna dactyloptera* De la Roche, discovered by the Fish Commission during the past year, and by *Scorpæna Stearnsi*, detected at Pensacola by Silas Stearns, and at Charleston by C. H. Gilbert.

It may fairly be said that the Rose-fish, as a shore species, is not known south of parallel 42°, which is 13° south of its transatlantic limit. When the deep waters of Southern Europe have been as carefully explored as those of the United States, it is probable that the range of this fish will be extended considerably farther to the south.

[1] In distinction from the "blue perch" or "cunner" (*Ctenolabrus adspersus*), which it resembles in form, but not in color.

[2] GÜNTHER; Cat. Fishes Brit. Mus. 2, p. 96.

The temperature range of the Rose-fish corresponds closely to that of the halibut, and its limits will, on more careful study, probably be found included between 32° and 50°. It is found everywhere on the shallow off-shore banks north of Cape Cod, where it attains its greatest size. A specimen, brought in by one of the Gloucester halibut schooners, was about two feet in length and weighed about fourteen pounds. Along the Maine coast they are much smaller than this, rarely exceeding eight or ten inches and the weight of twelve ounces, but occasionally growing to the weight of one and a half pounds.

In Scandinavia there have been recognized two species: one, a large, orange-colored form, inhabiting deep water, known to the Norwegians as the "Red-fish" (Röd-fisk), and considered to be *S. marinus* (*S. norwegicus*); the other, a smaller species of much deeper color, called the "Lysanger," and described by Kroyer under the name "*S. viviparus*," and by Ekström as "*S. regulus*." After the most careful study of all the specimens in the National Museum, we have been unable to recognize more than one species on our coast, and recent Norwegian ichthyologists, among them especially Mr. Robert Collet, believe that the two Norwegian forms are not actually distinct species, but that the smaller one is simply a pigmy race which is especially adapted to life in the long, shallow fiords of that region. Dr. Lütken, always conservative, is inclined to believe the two forms distinct, regarding the large fish of the deep water as the primitive type from which the smaller littoral form has been derived by development. According to the last-mentioned authority, the two forms have very different geographical distribution, *S. viviparus* inhabiting the shallows in the vicinity of the Faroe Islands, Southern Sweden, Norway, and New England, but unknown to Great Britain, Denmark, Finmark, Iceland, and Greenland; while *S. marinus* is found in Greenland and Iceland and all the length of the Norwegian coast, in Spitzbergen, Bären Island, on the coasts of Denmark, and occasionally in the north of England and Ireland. Possibly, he suggests, it inhabits the deep waters at a distance from shore, off the Faroe Islands and North America, but that is not yet certainly known. *S. viviparus*, then, he declares, is a form less arctic as well as more littoral.[1]

This subject is here referred to in the hope that additional observations may be drawn out tending to settle the question whether or not there are two forms of *Sebastes* on the American coast. It seems, however, improbable, since the physical conditions are so different from those under which they occur on the other side of the Atlantic.

The food of the Rose-fish consists, like that of its cousins, the Sculpins, of small fish, crustaceans, and, to some extent, of mollusks, although its teeth are not formed for crushing the thick-shell species. In Greenland they are said to feed upon the pole-flounder. A specimen taken off Eastern Point, Gloucester, in July, 1878, had its throat full of shrimp-like crustaceans (*Mysis* sp.), and others, taken at Eastport, were feeding extensively on a larger crustacean (*Thysanopoda* sp.), which is also a favorite food of the mackerel. They may be caught with almost any kind of bait, but are not, like their associates, the cunners, given to feeding upon refuse substances, and, being also more shy and watchful, cannot be captured in bag-nets. They breed in summer, from June to September, in deep holes in Massachusetts Bay and off the coast of Southern New England, where it has not been uncommon for the Fish Commission to obtain thousands of young one, two, and three inches long, at one set of the trawl-net, and also adults full of spawn. The young are lighter in color than the adults, and are conspicuously banded with reddish-brown upon a grayish ground. The young constitute a favorite food of the codfish, while, at all ages, they are preyed upon by the halibut and other large predaceous fishes of the cold-water districts.

[1] 1879. LÜTKEN, CHR.: Forelöbige Meddelelser om nordiske Ulkefiske (Cottoidei). <Aftryk af Vidensk. Meddel. naturh. Foren. 1870, pp. 355–388.

Although the Rose-fish is much esteemed as an article of food, and is caught in considerable numbers all along the coast of Maine and the British Provinces in the season when it frequents the shallows near the shore, and in winter at Gloucester when flocking in large numbers into the harbor, the most extensive fisheries are probably on the coast of Greenland, where they are highly prized by the natives, who feed on the flesh and use the spines of the fins for needles, and in Massachusetts Bay, where great quantities are taken by the Irish market-fishermen on trawl-lines. In winter they are occasionally found in the New York markets, and on one or two occasions have been brought in considerable numbers to New Haven, and even to Philadelphia. The flesh is firm, rich, and delicate in flavor; the young fish, fried crisp, make an excellent substitute for white-bait.

84. THE ROCK CODS OF THE PACIFIC.

By DAVID S. JORDAN.

[On the Pacific coast, as has already been stated, the fishes of this family, known as Rock-cod and Rock-fish, are of great importance. They are discussed at length by Professor Jordan, who writes:]

One of the most remarkable features of the Californian fish fauna is the enormous abundance both in individuals and in species of the group of Scorpænidæ. All of them are excellent food-fishes, and scarcely a boat returns from any kind of fishing in which these fishes do not form a conspicuous part of the catch. In every fish-market they are found, and from their large size and brilliant coloration they are everywhere the most conspicuous fishes on the stalls.

These fishes have so many traits in common, that a review of the group as a whole is desirable before we proceed to the consideration of the several species.

NAMES.—These fishes are universally known by the names of Rock-fish and Rock-cod. The latter name is the one most commonly heard, the other name being apparently a reaction against the obvious error of calling these fish "Cod." The name Rock-fish is an appropriate one, and in time it will probably supplant that of Rock-cod. The name Cod or Cod-fish is never applied to them without the accompanying "Rock." In the southern part of California, the name "Garrupa" or "Grouper" is in common use, especially for the olivaceous species. This is a Portuguese word, and belonged originally to the species of *Epinephelus* and related genera. Different species have also special names, mostly given by the Portuguese fishermen. These are noticed below.

The average size of the species of the group is about fifteen inches in length, and a weight of two or three pounds. Some of them reach a length of nearly three feet, and a weight of twelve pounds. Nothing is known of their rate of growth.

The greatest abundance both of individuals and of species in this group is to be found from Santa Barbara to San Francisco, the maximum about Monterey. They occur from Cerros Island, where they are rather scarce, at least as far as Kodiak, and other species similar are found on the coasts of Japan, Chili, etc. The individuals are extremely local. Most of the species are found about rocky reefs, often in considerable depths, and they probably stray but little from their abodes. In general, the red species inhabit greater depths than the brown or green ones, and the latter swim about more freely. Their abundance on certain reefs about Monterey and the Farallones is doubtless being diminished; elsewhere there has been little danger of overfishing. All are predatory and voracious, feeding mainly upon other fishes, and sometimes on crustaceans.

All of the species are ovo-viviparous. The eggs are small and exceedingly numerous, and are hatched within the body. The eggs themselves are bright yellow. In the spring, at a season varying with the latitude and perhaps with different species, these yellow eggs turn to a grayish color.

If then examined, the two eyes of the young fish can be distinctly seen. Later a slender body appears, with traces of vertical fins, the length then being about one-fourth to one-third of an inch. They are probably extruded at about the length of one-third of an inch, and in a very slender and pellucid condition, as I have never seen them in any more advanced stage of development. Nothing is known of the modes of copulation, nor of the circumstances under which the young are excluded, but the time of breeding is probably for the most part in May. Young fishes of one and a half to two inches are common in August, and in the fall they are large enough (*S. paucispinis*, *flavidus*) to be taken with hook and line from the wharves. Individuals of less than six or eight inches are rare in the spring, and the fish of that length are probably a year old.

The enemies of these fishes are of course their predatory neighbors, and the larger individuals prey upon the smaller. The hag-fish (*Polistotrema*) destroys considerable numbers. They are usually very free from internal parasites.

All the members of this family rank high as food-fishes. The flesh is firm and white, and, although not very delicate, is of a fair quality. That of *Scorpæna guttata* is probably best; that of *Sebastichthys mystinus* brings the lowest price in market, but the prejudice against the latter species perhaps rests on its color.

SCORPENE (*Scorpæna guttata* Girard).—This species is known by the names "Scorpene," "Scorpion," and "Sculpin." "Scorpene" (Scorpina), in common use among the Italian fishermen, is, of course, the name of *Scorpæna porcus*, *S. scrofa*, and other Mediterranean fishes, transferred to this very similar North American fish. The wound made by the dorsal spines of this fish is excessively painful, far more so than the sting of a bee, as though the spines had some venomous secretion. The name *Scorpæna* is evidently derived from this. This species reaches a length of something over a foot and a weight of about two pounds. It is found only from Point Concepcion southward to Ascension Island, living about rocks and kelp, but often entering the bays. It is generally common, and takes the hook freely. It feeds upon crustacea and small fishes, and spawns in spring. Nothing distinctive is known of its breeding habits. As a food-fish it ranks with the best, being superior to the species of *Sebastichthys*, and it always is in good demand where known.

BLACK-BANDED ROCK-FISH (*Sebastichthys nigrocinctus* (Ayres) Gill).—This species has, so far as we know, received no distinctive name from the fishermen. It reaches a weight of about four pounds and a length of eighteen to twenty inches. It ranges from Monterey northward, being found only in deep water (ten to twenty fathoms). About San Francisco it is exceedingly rare, not half a dozen usually coming into the markets in a year. In the Straits of Fuca and outside in the open ocean it is tolerably abundant. The food and the breeding habits, so far as known, differ little in this family, and the general remarks on the group apply to all the species of *Sebastichthys*. As a food-fish this species sells readily on account of its brilliant and attractive colors, second only in brilliancy to those of the "Spanish Flag."

TREE-FISH (*Sebastichthys serriceps* Jor. & Gilb.).—Wherever this species receives a distinctive name, it is known as the "Tree-fish," an appellation originating with the Portuguese at Monterey, and without obvious application. Southward it is confounded with other species as a Garrupa. Its size is rather less than that of *S. nigrocinctus*, which it much resembles. It ranges from San Martin Island to San Francisco, being found in rather deep water among rocks. It is most common about the Santa Barbara Islands and is rare in the markets of San Francisco. It is a handsomely-colored species, and therefore sells well in the markets.

SPECKLED GARRUPA (*Sebastichthys nebulosus* (Ayres) Gill).—This species is known as "Garrupa" and "Rock Cod," rarely receiving any distinctive name. It reaches a weight of three and one-half pounds. It ranges from Monterey to Puget Sound, being generally common at all points,

and most abundant northward. It lives in water of moderate depth. It forms about two per cent. of the total rock-fish catch, and is always readily salable. It is the most attractive in color of any of the dark-colored species.

BLACK AND YELLOW GARRUPA (*Sebastichthys chrysomelas* Jor. & Gilb.).—This species also is confounded under the names "Garrupa" and "Rock-cod." It is one of the smaller species, reaching a weight of about two pounds. It ranges from San Nicolas Island to San Francisco, and is generally common in water of moderate depth, although not one of the most abundant species. It is an attractive fish in color and therefore readily salable.

FLESH-COLORED GARRUPA (*Sebastichthys carnatus* Jor. & Gilb.).—This species reaches a somewhat larger size than the last, and ranges from Santa Barbara to San Francisco. About San Francisco it is considerably more abundant, forming nearly seven per cent. of the total rock-fish catch.

YELLOW-BACKED ROCK-FISH (*Sebastichthys maliger* Jor. & Gilb.).—We have heard no distinctive name for this species. It ranges from Monterey to Puget Sound, in rather deep water. It is not very common about San Francisco, but many are caught in the Straits of Fuca. It is one of the largest of the species, reaching a weight of six or eight pounds. As a food-fish it is not as good as some of the others.

RED GARRUPA (*Sebastichthys caurinus* and subsp. *vexillaris* Jor. & Gilb.).—This species is known as "Garrupa," "Rock-fish," and "Rock-cod." It reaches a length of twenty inches and a weight of six pounds. It ranges from San Nicolas to Puget Sound, being generally common in water of moderate depth. It is subject to greater variations than any of the other species in the different parts of its range. It forms about seven per cent. of the total rock-cod catch. Its flesh ranks as about average.

GRASS ROCK-FISH (*Sebastichthys rastrelliger* Jor. & Gilb.).—This species, like all those of dusky color, is known as "Garrupa." At San Francisco it is often called "Grass Rock-fish," perhaps from its color. It reaches a weight of two to four pounds. It lives in water of moderate depth, and is rather common everywhere from San Nicolas to Humboldt Bay. Its abundance is greatest south of Point Concepcion. It is said to be the best of all the Rock-fish for the table, and to be an especial favorite with the Jews.

BROWN ROCK-FISH (*Sebastichthys auriculatus* (Girard) Gill).—This species seldom receives a distinctive name from the fishermen. It reaches a weight of three or four pounds, although as usually seen in the markets it is smaller than any other of the species. This is owing to the fact that its young are caught in seines in the bay, while those of other species are less frequently taken, and then only in the open ocean. It ranges from San Martin Island to Puget Sound, living in shallow water and entering all the bays, and being taken with a hook from all the wharves. It is thus apparently more abundant than any other species, although in actual numbers probably many of the deep-water forms (*S. flavidus, pinniger, rosaceus*) far exceed it. As a food-fish it is held in lower esteem than most of the others.

PESCE VERMIGLIA (*Sebastichthys chlorostictus* Jor. & Gilb.).—This species is known as "Pesce Vermiglia," or "Vermilion-fish," by the Portugnese fishermen at Monterey. It is known only from Monterey Bay and the Farallones, occurring about the rocks in considerable depths of water and being taken only with the hook. In its native haunts it is not a rare species. It reaches a weight of three or four pounds, and is excellent food.

FLY-FISH (*Sebastichthys rhodochloris* Jor. & Gilb.).—The inexplicable name of "Fly-fish" is given to this species by the fishermen at Monterey. Like the preceding, it is known only from very deep

water about Monterey and the Farallones. It is one of the smallest species, rarely weighing more than a pound.

CORSAIR (*Sebastichthys rosaceus* (Grd.) Lock).—This species is known to the Portuguese fishermen at Monterey by the name "Corsair," a name of unknown application transplanted from the Azores. It is one of the smallest species, rarely weighing more than a pound and a half. It ranges from Santa Barbara to San Francisco, in deep water, and, where found, it is the most abundant of the red species. When the weather permits outside fishing with trawl-lines, this is one of the most abundant species in the San Francisco markets. It ranks high as a food-fish.

SPOTTED CORSAIR (*Sebastichthys constellatus* Jor. & Gilb.).—In size, distribution, habits, and value this species agrees with the "Corsair." It is, however, considerably less abundant, although not a rare fish in the markets of San Francisco.

YELLOW ROCK-FISH (*Sebastichthys umbrosus* Jor. & Gilb.).—Two specimens only of this species are known, both of which are from Santa Barbara.

SPANISH FLAG (*Sebastichthys rubrivinctus* Jor. & Gilb.).—At Monterey this species is known by the very appropriate name of "Spanish Flag," from its broad bands of red, white, and red. It reaches a weight of about six pounds. It is found in very deep water on rocky reefs about Santa Barbara and Monterey. It is perhaps the least common in the markets of all the species, except *Sumbrosus*. In coloration it is the most brilliant fish on the coast.

RED ROCK-FISH (*Sebastichthys ruber* (Ayres) Lock.).—This species is usually the "Red Rock-fish" *par excellence*. At Monterey it is called by the Portuguese "Tambor," a name evidently transferred from some Atlantic species. It probably reaches a larger size than any other species, attaining a weight of twelve or more pounds. It ranges from Santa Barbara to Puget Sound, its abundance increasing to the northward. It lives in water of considerable depth. In the markets of San Francisco it is one of the most common species. Large specimens about Victoria, in the Straits of Fuca, had the skull above the brain infected by an encysted parasitic worm. Great numbers of them were seen in the Straits of Fuca, according to Mr. Swan, swimming stupidly near the surface, so torpid that the Indians killed them with clubs. According to the Indians, they had been struck by the Thunder-bird, which, with its companion, the Lightning-fish, causes many of the phenomena in that region. The smaller specimens of this species rank well as food-fishes; the larger ones are likely to be coarse or tough.

RASHER (*Sebastichthys miniatus* Jor. & Gilb.).—This species is known to the Portuguese at Monterey as the "Rasher," a name of unknown origin and orthography. It ranges from Santa Barbara to San Francisco, living in water of moderate depth. It is comparatively common, and is frequently seen in the markets, though in much less numbers than *S. ruber* and *S. pinniger*. In size and quality it agrees closely with *S. pinniger*.

ORANGE ROCK-FISH (*Sebastichthys pinniger* (Gill) Lock.).—This species is usually called simply "Red Rock-cod" or "Red Rock-fish" and not distinguished from the two preceding. The Portuguese at Monterey know it by the name "Fliaum," a word of unknown origin. It is one of the largest species, reaching a weight of eight or ten pounds. It ranges from Monterey to Puget Sound, being generally very abundant in deep water, where it is taken on trawl-lines. This is probably the most abundant of the larger species. At San Francisco individuals are often found with black discolored areas, looking like ink-blotches, on their sides. No cause for this has been noticed, and if it be a disease it does not seem to discommode the fish. In the market this species grades with *S. ruber*, and, like it, is often split and salted.

GREEN GARRUPA (*Sebastichthys atrovirens* Jor. & Gilb.).—This species is commonly known as "Garrupa" and "Green Rock-fish," being rarely distinguished from *S. rastrelliger*. It reaches a

weight of about three pounds. It ranges from San Diego to Monterey, being more southerly in its distribution than the other species. It lives in rocky places, in rather shallow water, and is generally common, especially south of Point Concepcion. It is considered excellent food.

REINA (*Sebastichthys elongatus* (Ayres) Gill).—This species is known as "Reina" (Queen) at Monterey. It is a small fish, reaching a weight of less than two pounds, and lives in deep water about Monterey and the Farallones. It is never very common in the markets, although frequently taken in considerable numbers.

RED ROCK-FISH OF ALASKA (*Sebastichthys proriger* Jor. & Gilb.).—In habits this species agrees with *S. elongatus*. It is usually still smaller, rarely weighing more than a pound. Its range extends northward to the Aleutian Islands, where it reaches a large size, and is of considerable importance as a food-fish.

VIUVA (*Sebastichthys ovalis* (Ayres) Lock.).—This species is known at Monterey as "Viuva" (Widow); the reason not evident. It reaches a weight of three or four pounds. It is found from Santa Barbara to Monterey, in deep water, and is seldom brought to market.

Sebastichthys entomelas Jor. & Gilb., is a species very similar to the preceding in size and habits. Thus far it has been only found in deep water outside of Monterey Bay.

BLACK ROCK-FISH (*Sebastichthys mystinus* Jor. & Gilb.).—This species, usually called the "Black Rock-fish," in Puget Sound is known, with its more abundant relative, *Sebastichthys melanops*, as the "Black Bass." The Portuguese at Monterey call it "Pesce Prêtre," or Priest-fish, in allusion to its dark colors, so different from those of most of the other members of the family. It reaches a weight of five pounds, but as usually seen in the markets varies from two to three. It ranges from Santa Barbara to Vancouver's Island, inhabiting water of moderate depths. It is much more abundant about Monterey and San Francisco than either northward or southward, and large numbers are taken in Tomales Bay. In the markets of San Francisco it is found, taking the year through, in greater numbers than any other species. It sells at a lower price than the others, its color causing a prejudice against it, although the quality of the flesh doubtless differs little from that of the rest.

ALASKA BLACK ROCK-FISH (*Sebastichthys ciliatus* (Tiles.) Jor. & Gilb.).—Specimens of this species from the Aleutian Islands are in the National Museum. Nothing distinctive is known in regard to its habits, which probably agree with those of *S. melanops*.

SPOTTED BLACK ROCK-FISH (*Sebastichthys melanops* (Grd.) Jor. & Gilb.).—This species is confounded with *S. mystinus* by the fishermen, under the name of "Black Bass" in Puget Sound, "Black Rock-fish" in San Francisco, and "Pesce Prêtre" at Monterey. In size and value it agrees with *S. mystinus*. Its range is more northerly, from Monterey to Puget Sound, being not very common at San Francisco, and one of the most abundant species in Puget Sound.

YELLOW-TAIL ROCK-FISH, (*Sebastichthys flavidus* (Ayres) Lock.).—This species is occasionally called the "Green Rock-fish" or "Rock-cod" at San Francisco. At Monterey it is always known by the appropriate name of "Yellow-tail," the caudal fin being always distinctly yellow. To distinguish it from the Yellow-tail of farther south we may call it the Yellow-tail Rock-fish. This species reaches a weight of six or seven pounds, but its usual weight is about two. It ranges from Santa Catalina Island to Cape Mendocino, and is taken both in deep water and near shore. About Monterey and San Francisco it is very abundant, and is one of the principal species in the markets. As a food-fish it is considered as one of the best in the group.

BOCCACCIO (*Sebastodes paucispinis* (Ayres) Gill).—About Monterey and San Francisco this species is known as "Boccaccio" or "Boccac'" (*bocatch*) to the Italians, and as "Mérou" (*mâroo*) to the Portuguese. American fishermen use the name "Jack," and those who fish for the young from

the wharves call them "Tom-cod." The name "Boccaccio" (Big-mouth) is very appropriate; "Mérou" is transferred from Atlantic species of *Epinephelus;* "Jack" comes from the species of *Esox* and *Stizostedium* which in the Southern States are called by that name. This species is one of the largest of the group, reaching a weight of twelve to fifteen pounds. Its average size in the markets is greater than that of any of the others. It ranges from the Santa Barbara Islands to Cape Mendocino. It inhabits reefs in deep water, only the young coming near the shore. It is rather more abundant southward than about San Francisco. It is, however, a common market-fish, and its flesh is considered excellent. It is probably the most voracious of the family.

Five species of the genus *Sebastichthys*, namely, *S. melanops*, *S. caurinus*, *S. maliger*, *S. proriger*, and *S. ciliatus*, attain to large size and considerable commercial importance in Alaska, and are discussed by Dr. Bean in his paper on the "SHORE FISHERIES OF ALASKA" in another section of this work. *S. melanops* is called "Black Bass" at Sitka.

85. THE ROCK TROUTS—CHIRIDÆ.

By DAVID S. JORDAN.

A family of fish of considerable importance on our Pacific coast is that of the *Chiridæ*, or Rock Trouts, no representatives of which are known in the Atlantic. One or two species of the family occur in the Sea of Japan.

BOREGATA (*Hexagrammus Stelleri* Tilesius).—This species is known in Puget Sound by the Italian name of "Boregata" or "Boregat'." The name "Starling" is applied to some fish, supposed by us to be this species, in the Straits of Fuca. It reaches a length of fifteen inches and a weight of three pounds. It ranges from Puget Sound to Kamtschatka. In Puget Sound it is comparatively abundant, living about rocks. It spawns in July. It feeds on crustaceans, worms, and fishes, and apparently gets its food on the bottom in deep water, as the animals taken from its stomach are often of a kind not seen near shore. Its intestines are very often full of long taenioid worms, supposed to be parasitic. As a food-fish, it ranks with the other Rock-trout, being of fair quality, but inferior to *Ophiodon* and *Sebastichthys*.

GREEN ROCK TROUT (*Hexagrammus lagocephalus* (Pallas) Jor. & Gilb.).—This species is confounded with others of this genus under the names of "Rock Trout," "Sea Trout," "Boregat'," and "Bodieron." At Cape Flattery this fish and the preceding receive the Indian name of "Tsebarqua." In size and value it corresponds very closely to the preceding. It ranges from Monterey to Kamtschatka, being nowhere very abundant, although not a rare fish. Its food is largely crustacean. Its flesh, like that of *Ophiodon*, is often colored green.

SPOTTED ROCK TROUT (*Hexagrammus decagrammus* (Pallas) Jor. & Gilb.).—The name "Boregata" is applied to this species by the Italians on Puget Sound. The name "Rock-cod" is also given to it. From San Francisco southward, the names "Rock Trout" and "Sea Trout" are common. The Portuguese at Monterey call it "Bodieron." It reaches a length of fifteen inches and a weight of two or three pounds. It ranges from San Luis Obispo to Alaska, and is much more generally common than any of the other species, and large numbers are brought into the market of San Francisco. It lives in rocky places at no great depth. It feeds voraciously on crustacea and worms. It spawns in July. It dies at once on being taken from the water, and the flesh becomes rigid and does not keep as well as that of the rock-fish. It is a food fish of fair quality, but not extra. The sexes are very unlike in color, and have been taken for distinct species.

CULTUS COD (*Ophiodon elongatus* Girard).—This species is universally called "Cod-fish" where the true cod is unknown. About Puget Sound the English call it "Ling." Among the

Americans the word "cod" is used with some distinctive adjective, as Cultus Cod ("cultus" meaning, in the Chinook jargon, *of little worth*), "Bastard Cod," "Buffalo Cod," etc. The name "Blue Cod" is also given to it from the color of its flesh. The name "Rock Cod" applied to other Chiroids and to Sebastichthys, and thence even transferred to *Serranus*, comes from an appreciation of their affinity to *Ophiodon*, and not from any supposed resemblance to the true codfish. The Cultus Cod reaches a length of five feet, and a weight of fifty or sixty pounds, the largest specimens being taken in northern waters. Many very small ones come into the San Francisco market, being taken in the sweep-nets of the paranzelle. These weigh less than a pound; the average of the large ones is from six to ten pounds. It ranges from Santa Barbara to Alaska, being very abundant everywhere north of Point Concepcion. It lives about rocky places, and sometimes in considerable depths, and spawns in summer. It feeds upon fishes and crustacea and is excessively voracious. It often swallows a red rock-fish when the latter is on the hook, and is thus taken. Like other large fishes, it is subject to the attacks of the hag-fish (*Polistotrema*). As a food-fish it holds a high rank, being considered rather superior to the rock-fish. From its great abundance, it is one of the most important fishes on the Pacific coast.

Zaniolepis latipinnis Girard.—This species ranges from San Francisco northward in deep water. It reaches a length of about a foot, and is of no economic value.

Oxylebius pictus Gill.—This bright-colored little fish ranges from Santa Barbara to Vancouver's Island, living among rocks near shore. It reaches a length of six inches, is rarely taken, and then used only for bait.

Myriolepis zonifer Lock.—The single specimen known was taken at Monterey.

BLACK CANDLE-FISH (*Anoplopoma fimbria* (Pallas) Gill).—This species is known in Puget Sound by the name of "Horse-mackerel." At San Francisco it is usually called "Candle-fish." In the markets it is sometimes fraudulently sold as Spanish mackerel. It reaches a length of twenty inches and a weight of five pounds. It ranges from Monterey northward to Sitka, in rather deep water, and is generally common, especially northward. At Seattle it is one of the most abundant fishes, but in the San Francisco market it is seldom seen in large numbers. It feeds on crustaceans, worms, and small fishes. As a food-fish it is held in low esteem, the flesh being rather tough and tasteless.

In the Straits of Fuca it reaches a much larger size than has been noticed elsewhere. It is here very highly valued by the Indians, according to Mr. Swan. It is called by the Indians "Beshow."

In Alaska, according to Dr. Bean, the most important chiroid fishes are *Ophiodon elongatus*, *Anoplopoma fimbria*, *Hexagrammus decagrammus*, *H. lagocephalus*, *H. ordinatus*, *H. asper*, and the "Yellow Fish," "Striped Fish," or "Atka Mackerel," *Pleurogrammus monopterygius* (Pallas) Gill, which is the chief of them all. This fish is most abundant about the Aleutian chain and the Shumagins, its northern limit as now understood being about Kodiak, and its western limit at Attu. It congregates in immense schools, and can be taken in purse-seines like the mackerel, which it strongly resembles in taste after being salted in the same manner.

86. THE TAUTOG OR BLACK-FISH—TAUTOGA ONITIS.

NAMES.—One of the best known shore species of the Atlantic coast is the Tautog or Black-fish. This fish is now found in greater or less abundance from Saint John, New Brunswick, to Charleston, South Carolina. East of New York it is usually called Tautog, a name of Indian origin, which first occurs in Roger Williams' "Key to American Language," printed in 1643, in which this fish is enumerated among the edible species of Southern New England. "Tautauog" would consequently seem to be a word from the dialect of the Narragansett Indians. On the coast of New

York it is called "Black-fish"; in New Jersey also "Black-fish" and "Smooth Black-fish," "Tautog," or "Chub"; on the eastern shore of Virginia "Moll," or "Will George"; at the mouth of the Chesapeake "Salt-water Chub," and in North Carolina the "Oyster-fish." Of all these names Tautog is by far the most desirable for general use. There are several other species along our coast called Black-fish, especially the sea-bass, which is often associated with the Tautog. The names Oyster-fish and Chub are also pre-engaged by other species.

DISTRIBUTION.—Though the present geographical distribution of the Tautog is well understood, there is reason to believe that its range has been very considerably extended in the present century by the agency of man. That this species was known in Rhode Island two hundred and thirty years ago is reasonably certain from the reference by Roger Williams, already referred to, and in 1776 it was stated by Schoepf that it was very abundant in summer at New York. It is in greatest abundance between the southern angle of Cape Cod and the Capes of Delaware, which would indicate that within these limits, at least, the species has always existed. The waters of Long Island Sound and those immediately adjoining seem especially well adapted for its residence.

Mitchill, writing in 1814, remarked: "The Tautog was not originally known in Massachusetts Bay; but within a few years he has been carried beyond Cape Cod, and has multiplied so abundantly that the Boston market has now a full supply without the necessity of importing from Newport and Providence." This statement is confirmed in a way by Mr. Isaac Hinckley, of Philadelphia, who tells me that in 1824 he saw several individuals from Cohasset Rocks, Jerusalem Road, Massachusetts, and that the fish was at that time said by the fishermen to be entirely new to them. Storer, writing about 1867, remarked: "Although a few years only have passed since this species was brought into Massachusetts Bay, it is now taken along a large portion of the coast. At Plymouth, Nahant, and Lynn, at some seasons, it is found in considerable numbers, and is frequently caught from the bridges leading from Boston. The Boston market is for the most part supplied by Plymouth and Wellfleet." As early as 1851 they had spread northward to the Bay of Fundy, and in that year it is stated that many were sold in the fish market at Saint John, the largest of which weighed eight pounds: Mr. Lanman wrote that he obtained there in July and August specimens nineteen inches long and weighing four pounds.

The rocky shores of Cape Ann seem particularly well adapted to its peculiar habits, and large numbers are annually obtained from the rocks. So long has it been acclimated and so well known is it, that the local authorities of that region are inclined to doubt that it is not native, The "Gloucester Telegraph" of May 5, 1860, challenged the statement that the Tautog was a new fish, declaring that many years ago they were very plenty, and that after a period of scarcity they reappeared. So abundant had they become in 1836 in the harbor of Wellfleet, Massachusetts, that three Connecticut smacks were accustomed summer after summer to devote their entire energies to their capture in this locality, and this fishery has continued up to the present day. In sandy localities, like the harbor of Provincetown, they have never secured a firm hold, though large specimens are sometimes taken under the wharves.

As to the extension of the range of this species southward we have the statement of Holbrook, quoted by DeKay, writing in 1842: "Attempts have been made to introduce this fish farther south, but with limited success. I am informed by my friend, Dr. Holbrook, that General Thomas Pinckney imported from Rhode Island a smack load of the Tautog and set them adrift in the harbor of Charleston, South Carolina, where they are to be found to this day. They are still occasionally caught, weighing from one to two pounds, but never in such quantities as to be brought to market." Mr. Earll obtained specimens at Charleston in January, 1880. Certain ich-

thyologists, among whom is Professor Jordan, express skepticism as to the range having been thus artificially extended southward.

At Cape Lookout, North Carolina, Jordan records the species, under the name "Oyster-fish," as rather common, the young abundant about the wharves. About Norfolk and in the mouth of Chesapeake Bay they occur, and also on the coast of Southern New Jersey, where they are taken in the vicinity of Beasley's Point, in the channel ways and along the shores, and they are said to be somewhat common on the banks off Sandy Hook and in the southern bays of Long Island. These sandy regions, however, are not so much frequented by them as those abounding in rocky beaches and ledges.

HABITS.—Although the Tautog appears to thrive in cool water, as has been shown by the rapid extension of the northern range, they seek refuge from too great cold by retreating in winter to somewhat deeper water than that preferred in summer. Here they appear to take refuge under the stones and in crevices of the rocks, if we may judge from their habits as observed in aquaria, their smooth, slimy skins, with scales protected from abrasion by a thick epidermis, enabling them to move about among the sharp-pointed rocks unharmed. They are on this account also especially well suited for confinement in the wells of smacks and in "live-cars," where it is customary to keep them living until required for market. They appear to enter upon an actual state of hibernation, ceasing to feed and the vital functions partially suspended. It is the opinion of fishermen that during the hibernating season the vent becomes entirely closed up, as is known to be the case with hibernating mammals. It is certain that they do not retreat far from the shore in winter, and that very cold weather, especially in connection with a run of low tides, often causes very remarkable fatalities. There are instances of their death in immense numbers. In February, 1857, after a very cold season, hundreds of tons drifted upon the beach at Block Island, and along the southern shores of Massachusetts and Rhode Island, and a similar catastrophe took place in 1841. In March, 1875, it is stated that as much as a ton was thrown ashore in the drift ice at Cuttyhunk. They were seen floating by the Hen and Chickens light-ship for three successive days. In Southern New England they become torpid in November and December. It is stated that they are sometimes caught as late as Christmas. It is probable that many do not enter upon a state of complete torpidity, but remain in a partially active state in deep holes not far from the shore, and that it is these, rather than the hibernating individuals, which are especially liable to injury from the cold. A few are taken in Rhode Island in midwinter both by line and in lobster-pots. North of Cape Cod they are rarely taken except in summer,[1] while towards the southern limit of their range they are apparently as abundant in winter as at any other time. Mr. Nathan King, a Rhode Island fisherman, states that when the sun is very hot the Tautog leaves the clear spots for shelter among the weeds and rocks.

FOOD.—As might be inferred from its haunts and from the character of its strong, sharp teeth, the food of this fish consists of the hard-shelled mollusks and crustaceans which are so abundant among the rocks. In their stomachs have been found, among other things, lobsters, crabs of various species, clams, mollusks, squids, scallops, barnacles, and sand-dollars. Many of the smaller mollusks they swallow, shells and all, ejecting the hard parts after the flesh has been digested. The common bait for Tautog in the spring is the clam, preferably the soft clam, for at this time the fishermen say they have tender mouths. In the fall crabs and lobsters are used, the fiddler-crab and rock-crab being the favorites. They are sometimes taken with a bait of marine worms.

REPRODUCTION.—In Narragansett Bay and vicinity they spawn from the end of April until August.

[1] The first of the season were taken at Gloucester May 13, 1881.

The pound fishermen find them to be full of ripe eggs when they begin to approach the shore in early summer. Mr. Christopher E. Dyer, of New Bedford, has witnessed the operation of spawning in Buzzard's Bay in the middle of June, in water about two fathoms deep. This was in 1859 or 1860, about two miles east of Seconnet Point. The number of eggs has not yet been determined, nor is it known how long the period of incubation continues, but young fish are found abundantly in the eel-grass along the shore in August and September, and have been observed at various points from Cape Lookout to Monomoy. There can be no question, however, that there are breeding grounds near Charleston, South Carolina, and north to Cape Cod, since the species is very local in its habits and does not make long journeys to select spawning beds. Little is known of their rate of growth, though it is probably slow. Capt. Benjamin Edwards, of Wood's Holl, Massachusetts, kept thousands of small Tautog confined in a pond for five years, and at the end of that time, when six years old, none weighed more than two and one-half pounds. A half-pound fish which he confined in a lobster-car, with plenty of room and plenty of food, increased from one-half to three-quarters of a pound in six months. The average weight of those sent to market does not exceed two or three pounds, though individuals weighing ten, twelve, and fourteen pounds are by no means unusual. The largest on record was obtained near New York in July, 1876, and is preserved in the National Museum—its length thirty-six and one-half inches, its weight twenty-two and one-half pounds.

ABUNDANCE.—The abundance of this species past and present has been actively discussed and much interesting testimony on the subject may be found in the report of the United States Commissioner of Fisheries. This was one of the fish regarding which the claim was made that it has been almost exterminated in Rhode Island by overfishing: upon this point, however, the opinions of fishermen and experts are much at variance. In 1870 when, according to general opinion, Tautog had been almost exterminated in the waters of Narragansett Bay, the records of Newport fish-markets show that in one day, November 2, eleven men caught about 3,000 pounds of Tautog with hook and line, besides cod and other fish, while on the following day the catch of fifteen men was 28,000 pounds, besides codfish caught to the amount of 600 pounds, being an average of over 2,600 pounds to each man. These catches compare very favorably with that recorded at Fir Rock Ledge, Wareham, ten years previous, when, on the 9th of October, two men caught, in three hours, 271 pounds of Tautog, a catch which was pronounced by local authorities the greatest ever made in those waters.[1] Colonel Lyman, Massachusetts commissioner, writing in 1872, remarked: "Great complaint is made of the scarcity of this valued species north and south of Cape Cod, but especially near the mouth of Narragansett Bay, where they are said to be not more than one-eighth as numerous as they were a score of years ago." Although much testimony has been printed in the reports of the Fish Commission of the United States and of Rhode Island, the general tendency of which is to show that old fishermen believe that Tautog and other fish are much less abundant than in the days of their youth, nothing definite has yet been proved.

The Tautog has always been a favorite table fish, especially in New York, its flesh being white, dry, and of a delicate flavor. Storer states that they are frequently pickled, and may be kept in weak brine for a long time, and in this state they are considered by epicures a delicacy.

THE TAUTOG OR BLACK-FISH FISHERY.—The capture of Tautog is chiefly accomplished by the line fishermen of Southern Massachusetts and Rhode Island, and the weir fishermen of the same district. No one fishes for Tautog alone, and it is consequently more difficult to estimate the

[1] Barnstable Patriot, October 9, 1860.

quantity annually taken. About 200,000 pounds were brought to the New York market last year. Local consumption is considerable, and the total amount annually taken may be estimated at from 400,000 to 450,000 pounds. At least two hundred fishermen are entirely or partly engaged in this business between Cape Cod and New York. The catch of such fishermen in Narragansett Bay is estimated at 6,000 pounds each annually. This gives in round numbers 100,000 pounds taken by hook and line along this stretch of coast. To this should be added 20,000 pounds estimated to be taken on the coast of New Jersey and southward, and 20,000 more north of Cape Cod. Tautog are also frequently taken in the weirs and pounds, and the catch of these for the year 1876 was estimated as is shown in the following table:

	Pounds.
Weirs on north side of Cape Cod	2,274
Weirs on south side of Cape Cod	561
Weirs in Vineyard Sound	29,220
Weirs in Buzzard's Bay	39,423
Weirs in Narragansett Bay	156,750
Weirs on Block Island	33,153
Weirs in Fisher's Island Sound	14,000
Weirs on eastern end of Long Island	36,000
	311,381

At Noank, Connecticut, there is in the fall a season of "black-fishing" which continues from the middle of October until the snow begins to fall, about the first of December. About twenty-five men are engaged in this fishery during the season specified, some of whom begin a month or two earlier. They fish in Fisher's Island Sound at a depth of six to eight fathoms, using crabs and lobsters for bait. The average catch of each man for the season is estimated by Captain Ashby at one thousand pounds. The most northerly point where there is a regular fishery for them is, as has already been mentioned, in Wellfleet harbor. According to DeKay, three smacks were constantly employed from April to November. These smacks doubtless, then as now, hailed from Connecticut. In 1879 these vessels were still upon the old ground, one of them hailing from Westport and one or two from New London. One of the skippers was said to have fished upon this ground every season for thirty years. I was told in Wellfleet that they ordinarily remained about three weeks to fill their wells, obtaining in that time from two to four thousand pounds.

Angling for Tautog from rocks is a favorite pursuit of amateur fishermen all along the coast, particularly about New York, where there are precipitous shores, the anglers standing upon the rocks. July 12, 1879, Capt. S. J. Martin caught in this way, at Eastern Point, Gloucester, seven, two of which weighed twenty-one and a half pounds. In Long Island Sound and other protected waters they are usually fished for from a boat anchored among the reefs or near wrecked vessels. Mitchill, writing in 1814, describes the methods of this fishery better than any other subsequent authority: "Rocky shores and bottoms are the haunts of Blackfish. Long experience is required to find all these places of resort. Nice observations on the landmarks in different directions are requisite to enable a fishing party to anchor on the proper spot. For example, when a certain rock and tree range one way, with a barn window appearing over a headland the other way, the boat lying at the point where two such lines intersect each other, is exactly over some famous rendezvous. . . . At some places Black-fish bite best upon the flood. In others they are voracious during the ebb. Thunder accompanying a shower is an indication that no more of them can be caught. The appearance of a porpoise infallibly puts an end to the sport. Dull weather with an easterly wind is generally the omen of ill luck. . . . Some persons who live contiguous to

the shores where are situated the rocks which are frequented by Tautog invite the fish there by baiting. By this is meant the throwing overboard broken clams or crabs to induce the Black-fish to renew their visits; and fine sport is procured."

As has been already stated, the Tautog on the coasts of the United States is extremely sensitive to cold, and at the approach of the time of hibernation the vent becomes sealed, the fish thus becoming prepared for a minimum consumption of its own fat during its winter sleep.

The subjoined notice of the torpidity of the Tautog and the Scup by Captain Atwood will be found on page 212 of the Report of the United States Commissioner of Fish and Fisheries for 1871–'72.[1]

87. THE CHOGSET OR CUNNER—CTENOLABRUS ADSPERSUS.

The Chogset or Cunner, *Ctenolabrus adspersus*, is very similar in appearance to the Tautog, though much smaller and far less important. Its range is more northerly. I can find no record of its occurrence south of New York. DeKay remarks: "I am not aware that it is found south of Delaware Bay." From New York to the Straits of Canso the species is exceedingly abundant, being found everywhere in harbors and bays, particularly in the vicinity of fish-houses where offal is thrown overboard. Cuvier had specimens from Newfoundland, but it abounds on the coast of Labrador. It is closely related to the "Goldsinny," *Ctenolabrus rupestris*, and the "Connor" or "Gilt-head," *Crenilabrus melops*, of Great Britain and adjoining Europe. It has numerous common names. In Southern New England it is called "Chogset," a name of Indian origin, sometimes pronounced Cachogset. This name appears to have been in occasional use as far west as New York, where, in Mitchill's time, it was also called "Bluefish." In Maine, the British Provinces, and in some parts of Massachusetts the name "Cunner" is in use, evidently having been brought over by the English colonists who remembered a very similar fish at home which has this name. In New York, in revolutionary times, the name "Burgall" was in use, and continued in use at least until 1854, when it is stated by Gill to have been the accepted name in the New York market. This name also is of English origin, certain species of this family being called "Bergylt" in parts of England. This name appears to hold in Eastern Long Island at the present time. At Provincetown they are called "Sea-perch," and at the Isle of Shoals and occasionally on the adjoining mainland "Blue-perch" and "Perch," this also being a reminiscence of English usage. At Salem they are called "Nippers," and occasionally here and elsewhere "Bait-stealers." Where Cunners are found at all they are exceedingly abundant, and, though performing a useful duty as scavengers, are a pest of fishermen, from their habit of nibbling the bait from their hooks. They are the especial detestation of those who fish for tautog, since the two species are ordinarily found together. Their

[1] In Brown's "American Angler's Guide," in the article on Tautog or Black-fish, it is remarked: "The Black-fish abounds in the vicinity of Long Island, and is a stationary inhabitant of the salt water. He may be kept for a long time in ponds or cars, and even fatted there. When the cold of winter benumbs him he refuses to eat any more, and a membrane is observed to form over the vent and close it. He begins to regain appetite with the return of warmth in the spring." (P. 178.)

"Now we know that Tautog hibernate among rocks near the coast and in our rivers, and it has been stated by Mr. L. Tallman or Mr. Daniel Church that some years ago, after a very cold snap, not only many Tautog were washed ashore frozen stiff, but afterward quantities were also found dead among rocks off the coast. If, during the winter, they don't feed as stated above, and this membrane closes them up, the conclusion must be that they remain in a state of torpor or sleep during cold weather. Now it happens that the scup, when first taken by traps, are in a state of torpor; they neither eat nor have any passage. It is probably sealed up like the Tautog, and nothing in the shape of food is to be found within them. Some say they are blind, and they seem hardly able or willing to move.

"The inference, then, is, that the scup have also been hibernating within a short distance from the coast, in the same state as the Tautog. This would account for the stray scup mentioned by Mr. Southwick as having been occasionally found in March. A warm day wakes him up, and he visits the shore for a day or so and then returns. To my mind this is a more reasonable way of accounting for his presence than to assume that he has been left behind. If these facts are as stated, it is to be presumed that scup are a local fish, and do not leave their localities any more than Tautog, about the propriety of the classification of which as a local fish there is no question."—ATWOOD.

food is very similar to that of the tautog, except that they cannot swallow large shells. They feed also upon dead animal matter, and are among the most important scavengers of our harbors. Numbers of them may be taken by lowering a net containing a piece of meat or fish and quickly raising it to the surface. Like the tautog, Cunners are local in their habits, only moving from the shoal water in extreme cold weather, and, though adapted for living in colder water, rarely retreat except in the severest weather. In winter, however, they rarely are caught with the hook. The first of the season of 1881 at Gloucester were caught May 8. A very cold season sometimes destroys them. It is recorded that in January, 1835, great quantities were frozen and thrown up on the shore between Gloucester and Marblehead.[1] In June and July they spawn on their feeding grounds in Southern New England, and in July and August young fish three-quarters of an inch or more are taken abundantly along the shores. They appear to become adult and to breed when three inches long. The largest I have observed was taken at Wood's Holl, in July, 1875: its weight was twelve ounces, its length ten and a half inches, and it was spawning freely. Storer claims to have seen them fourteen inches long, and I am assured that they sometimes attain a weight of two pounds. From Eastport, Maine, to the vicinity of Boston, the Cunner is a favorite article of food. Elsewhere it is rarely eaten and is usually regarded with disgust—a foolish prejudice, for it is one of the most agreeably flavored small fishes on our coast. Immense quantities are taken with the hook from the rocks, bridges, and boats, especially in the vicinity of cities like Boston and Portland. They are also taken in immense quantities in nets. The Irish market-boats of Boston make a special business of catching them, using circular nets three or four feet in diameter which are baited and set among the rocks. Dr. Storer records that on the occasion of his visit to Labrador, in 1849, he found them so plentiful in the Gut of Canso that, by sinking a basket with a salt fish tied therein for bait, he continually caught them by the score, and by putting a few hundreds in the well of his sloop kept the crew well supplied with fish while at sea on the way to Labrador. The people of Nova Scotia, like those south of Cape Cod, rarely, if ever, eat the Cunner. Mr. J. Matthew Jones informs me that in the summer of 1863, when the French fleet was anchored in Halifax Harbor, the sailors caught them for food in great numbers. About Saint Margaret's Bay, according to Mr. Ambrose, they are given as food to pigs: since, however, the pork of these fish-fed pigs always tastes oily, they are generally fed on some other food for a short time before being killed, and well dosed with sulphur. It was formerly customary in Boston to keep these fish alive for market in large cars, described by Storer as three feet deep, twelve to fifteen feet long, closed beneath and latticed at the sides, and anchored in deep water. Storer states that sometimes as many as five thousand fish were kept in a single car, and that these cars were replenished every week or fortnight. It is impossible to estimate with any degree of accuracy the quantity of Cunners annually taken. The catch of the Irish market-boats of Boston cannot fall much short of 300,000 pounds, and that of the other towns and States on the coast of New England is certain to be from 200,000 to 250,000 pounds.

88. THE PARROT-FISHES AND SOME OF THEIR ALLIES.

Several of the Parrot-fishes occur on the Florida coast, notably the Blue Parrot-fish, *Platyglossus radiatus* (Linn.) Goode, sometimes, according to Jordan, seen in Key West market, and *P. bivittatus*, known in Bermuda as "Slippery Dick," recorded by Jordan from Charleston market. They are gorgeous in color, but the flesh is so dry that they are held in slight esteem for table use.

[1] Gloucester Telegraph, January 14, 1835.

The Red-fish, of California.

This species, *Trochocopus pulcher*, writes Jordan, is everywhere known as the "Red-fish": the name "Fat-head" is occasionally used, and it is very rarely called "Sheepshead." It reaches a weight of twelve to fifteen pounds. It is found from Point Concepcion southward to Cerros Island in enormous numbers in the kelp. It is taken chiefly with hook and line. It feeds on crustaceans and mollusks. It is taken chiefly by the Chinese, who salt and dry it. It forms half of the total catch of the Chinese south of Point Concepcion. It does not rank high as a food-fish, its flesh being coarse. The fat forehead is said to make excellent chowder.

The Señorita-fish, of California.

At Monterey, California, this species, *Pseudojulis modestus*, is known as, "Pescerey"; southward it is called "Señorita." It reaches a weight of less than half a pound. It is found in the kelp from Monterey southward to Cerros Island, and is generally common. It feeds chiefly on crustacea. It is used chiefly for bait, although the flesh is said to be of excellent quality.

The Kelp-fish, of California.

This species, *Platyglossus semicinctus*, bears in company with *Heterostichus rostratus*, and perhaps others, the name of "Kelp-fish." It reaches a pound weight, and a length of nearly a foot. It is found in the kelp about Santa Catalina Island and southward, and is not very abundant. It feeds on crustacea, and spawns in July. Its flesh is said to be of good quality.

The Hog-fish—Lachnolæmus falcatus.

This fish is, according to Mr. Stearns, abundant at Key West and among the Florida coral reefs, although he has not observed it north of the Gulf of Mexico. It there attains a considerable size, and a weight of twelve or fifteen pounds, although the average size is not more than one-fourth that size. In the Key West market it appears almost daily, and is much esteemed for food. This species occurs throughout the West Indies, and is one of the favorite food-fish of Cuba, although its sale is forbidden by law, on account of the supposed poisonous nature of its flesh. In the Bermudas it is one of the most important of the food-fish, attaining sometimes the weight of twenty pounds. It is caught by line-fishermen among the reefs, at a depth of five to forty fathoms. Like the other members of this family, it feeds upon small fish and upon bottom crustaceans and mollusks. Its brilliant red color renders it a conspicuous object in the markets. During the different stages of growth its species undergoes many changes of form, and has been described under several different names. The large adult male is remarkable on account of a heavy black blotch over the forehead and over the eyes. The name "Hog-fish" refers to the swine-like appearance of the head, jaws, and teeth. At the entrance to the Great Sound, in Bermuda, is a reef called Hog-fish Shoal, which is surmounted by a beacon bearing an enormous effigy of a Hog-fish in metal.

89. THE DEMOISELLE AND THE CICHLID FAMILIES.

Among the reefs of Florida two or three species of the family *Pomacentridæ* are abundant. Most prominent among these is the "Sergeant Major," *Glyphidodon saxatilis* (L.) C. & V., called in Bermuda the "Cow-pilot," from an alleged habit of being always found in the society of the "Cow-fish," or *Ostracion*. This fish sometimes attains the length of ten inches and the weight of a pound or so, but is usually of a smaller size and is not highly esteemed for food. It is found throughout the tropical waters of the entire world.

There are several smaller species of this and of allied genera in the Gulf of Mexico, and on the western side of the Isthmus of Panama and in the Gulf of California. On the California coast occurs a species, *Pomacentrus rubicundus*, conspicuous by reason of its uniformly deep crimson or orange coloration, which is usually known as the "Garibaldi" among the Italians. The names "Gold-fish" and "Red Perch" are also used, all of them referring to its brilliant orange colorations. It reaches a weight of three pounds, and a length of less than a foot. It is found about the Santa Barbara Islands and southward to Lower California. It lives about rocky places, and is generally abundant. Its food is largely crustaceous. It is a food-fish of low grade, and has little economic importance. Another somewhat noteworthy species is known in California, on account of its dusky colors, as the "Blacksmith," *Chromis punctipinnis*, Cooper.

"This fish," writes Jordan, "is known as the 'Blacksmith' from its dusky colors. It reaches a weight of about two pounds. It ranges from the Santa Barbara Islands southward, living about reefs of rock, and is locally abundant. It feeds on shells and crustacea. It is considered as indifferent food."

The family *Cichlidæ* is large, and is composed chiefly of fresh-water fishes occurring in the tropical parts of Africa and America. Among its members is a South American species, *Geophagus surinamensis*, which is often mentioned by writers on the instincts of animals on account of a peculiar habit of the males which carry in their mouths the eggs until they are hatched, and which are even said to allow the young fish to seek refuge within their jaws. We have no representatives of the family on our Atlantic coast, though one or two species of the genus *Heros* occur in the brackish waters of Texas.

90. THE SURF-FISH FAMILY—EMBIOTOCIDÆ.

By DAVID S. JORDAN.

This remarkable group of fishes forms the most characteristic feature of the fauna of our Pacific coast. Of the nineteen species now known, all but one (*Ditrema Temmincki* of Japan) occur on the coast of California, and most of them in very great abundance. The species are most of them very similar in habits and economic value, and the following general remarks are proffered before proceeding to the discussion of the different species.

NAMES.—The general name "Perch" is applied to these fishes everywhere along the coast. This unfortunate misnomer came about from their resemblance to the sun-fishes or "perch" of the Southern States, and to the "white perch," *Roccus americanus*, of the East. On the coast of Oregon the large species (especially *Damalichthys argyrosomus*) are called "Pogy" or "Porgee," in allusion to their undoubted resemblance to the scup or porgee of the East. The names "Minny," "Sparada," and "Moharra" are also applied to the smaller species northward. About San Francisco, the name "Perch" is given to them all, as well as to *Archoplites interruptus*, and separate names for the different species are seldom heard. From Monterey southward, the name "Surf-fish" is in common use, although the name "Perch" is still more common.

HABITS, &C.—The largest *Rhacochilus toxotes*, reaches a weight of four pounds; the smallest, *Abeona minima*, a length of four or five inches. So far as we are able to judge, the growth of the young is quite rapid, as the specimens are about half grown the first winter, and probably reach full size in two and a half to three years—perhaps, in some cases, in the second year.

The center of distribution of this group is from Santa Barbara to Tomales Bay. Northward the number of species decreases, while the number of individuals is, perhaps, equally great as far as the Gulf of Georgia. Southward both individuals and species rapidly diminish in number.

Their range probably extends from Cerros Island to Sitka; certainly no farther. Most of them live in shallow water, on a sandy bottom, both in the open sea and in sheltered bays. A seine drawn in the surf will often be filled with the silvery species (*Amphistichus: Holconotus*), and a seine drawn in a bay may be equally full of *Ditrema laterale*, *Ditrema Jacksoni*, etc. One species is confined to the fresh waters. Nearly all of them feed chiefly on crustacea, together with such small fish as they can swallow. The species of *Abeona* are chiefly herbivorous, feeding on seaweed.

The Embiotocoids are all oviparous. The young are fifteen to twenty in number, and are brought forth in summer: when born, the little fish are from three-fourths of an inch to two and a half inches in length, according to the species. They are closely packed together in the uterus, the inner surface of which forms folds partly separating the young from each other. The young are at first excessively compressed, with the soft parts of the vertical fins excessively elevated. As their development proceeds they resemble more and more the parent, and when born their form is quite similar, the body, however, more compressed, the fins higher, and the color usually red.

Impregnation probably takes place in the fall. In January most of the species have the young half grown as to length, and when the parent fish is caught the young readily slip out from the ovary. From January to June the fish-stalls where these fishes are sold are littered with these fœtal fish. Little is known of the place of spawning, but I suppose that the young are simply extruded in the water just outside the breakers and left to shift for themselves. As to the mode of impregnation, we have made no observations. Dr. Blake thinks that the fleshy thickening on the anal fin of the male is to give the female something to hold to with the ventral fins, and that the two sexes approach each other, ventral surfaces together, and with their heads in opposite directions. They have no special enemies except the larger predatory fishes and the fishermen, who destroy great numbers at the breeding time. No diseases have been noticed.

The species are all, with the exception of two or three of the smallest, used as food. Their flesh is watery, flavorless, and much inferior to that of the Scorpænoid, Sciænoid, and Percoid fishes, and only their abundance gives them value. Great quantities of them are consumed by the Chinese.

ALFIONE *Rhacochilus toxotes* Agassiz).—This species is called "Alfione" at Soquel, "Sprat" at Santa Cruz; elsewhere it is simply "Perch." It reaches a length of eighteen inches and a weight of five pounds, being much the largest of the group. It ranges from San Pedro to Cape Mendocino, and is generally common, although not nearly so abundant as some of the others. As a food-fish it is considered the best of this very indifferent group.

PORGEE (*Damalichthys argyrosomus* (Girard) J. & G.).—On the coast of Oregon and Washington this species is known as "Porgee"; elsewhere simply as "Perch," or "White Perch." It reaches a weight of two and a half pounds. It ranges from San Pedro to Vancouver's Island, its abundance steadily increasing to the northward so far as traced. At San Francisco it is rather common, but south of Point Concepcion rather rare. As a food-fish it ranks next to the preceding.

WHITE PERCH (*Ditrema furcatum* (Grd.) Günther).—This species occasionally reaches a weight of a pound, but is usually smaller. It ranges from Cape Mendocino to the Mexican line, being everywhere exceedingly abundant. It lives in sheltered bays. It is always present in the markets and is held in low esteem.

Ditrema atripes Jor. & Gilb.—This species reaches a weight of one and a half pounds. It has been noticed only in the Bay of Monterey, where it is generally rather common, being taken in seines near the shore.

BLUE SURF-FISH (*Ditrema laterale* (Agassiz) Günther).—This species is known as the "Blue Perch" or "Surf-fish." It reaches a weight of about two and a half pounds. It ranges from Santa

Barbara to Vancouver's Island, and is everywhere abundant. North of San Francisco it is the most common of the larger species. It is an important food-fish, although not of very good quality.

BLACK SURF-FISH (*Ditrema Jacksoni* (Agassiz) Günther).—This species is known as "Perch," "Surf-fish," "Black Perch," etc. About San Diego it is called "Croaker," which name, however, belongs properly to the Sciænoid fishes. It reaches a weight of two pounds. It ranges from San Diego to Puget Sound. North of Cape Mendocino it is scarce. From San Francisco southward it is probably brought into the market in greater numbers than any other species. It is but an indifferent food-fish.

Hypsurus Caryi (L. Agass.) A. Agass.—This species is known as "Moharra" to the Portuguese at Monterey; elsewhere it is a "Perch." It reaches the weight of a pound. It ranges from Tomales Bay to Santa Barbara, and is rather common, being sometimes taken in great numbers in spring. It is used chiefly as bait for rock-fish, the larger individuals only being sent to market. It is the most brightly colored of its family.

SILVER SURF-FISH (*Amphistichus argenteus* Agassiz).—This species is known as "Surf-fish" and "White Perch." It reaches a weight of three pounds. It ranges from Tomales to San Diego, and is locally often very abundant, especially along sandy beaches.

ROSY SURF-FISH (*Holconotus rhodoterus* Agassiz).—This species has no distinctive name with the fishermen. It reaches a weight of one and a half pounds. It ranges from Cape Mendocino to Santa Barbara, being often locally abundant, especially at Soquel, but it is not one of the more common species.

Holconotus Agassizi (Gill) Jor. & Gilb.—This species reaches a weight of but half a pound. In distribution and abundance it agrees with the preceding.

WALL-EYE SURF-FISH (*Holconotus argenteus* (Gibb.) Jor. & Gilb.).—This species is usually known as the "Wall-eye," in allusion to the great size of its eyes. It reaches a weight of half a pound. It ranges from Cape Mendocino to the Mexican line, and is generally abundant, especially in the surf. It is taken in large quantities, and is little esteemed.

Holconotus analis (A. Agass.) Jor. & Gilb.—This species reaches a weight of a quarter of a pound. It is found from San Luis Obispo to San Francisco. It is only locally abundant, and is not purposely sent to market. At Soquel, where it is abundant, it is used for bait.

Brachyistius rosaceus Jor. & Gilb.—This species weighs less than half a pound. It has been taken only in deep water off Point Reyes.

Brachyistius frenatus Gill.—This species rarely weighs more than a quarter of a pound. It ranges from Catalina Island to Vancouver's Island, living in water of moderate depth, and is locally exceedingly abundant, as at Monterey, Point Reyes, etc. It comes into the market only by accident, and is used chiefly for bait.

SPARADA (*Cymatogaster aggregatus* Gibb.).—This fish is usually known as the "Shiner." On Puget Sound the Americans call it "Minny," and the Italians "Sparad" or "Sparada." It is found from Vancouver's Island to the Mexican line, everywhere in great numbers, and is perhaps the most abundant species on the coast. It is rarely used except for bait.

Abeona aurora Jor. & Gilb.—This species reaches a weight of nearly half a pound. It is abundant in rocky places from Monterey to San Francisco, often frequenting rock-pools. It feeds on plants, and is occasionally sent to market.

SHINER (*Abeona minima* [Gibbons] Gill.).—This little fish is usually known as the "Shiner." It is the smallest of the group, rarely weighing a quarter of a pound. It ranges from Tomales Bay to San Diego, and is generally common, although not one of the most abundant species. Its appearance in the market is accidental.

"RIVER PERCH" (*Hysterocarpus Traski*, Gibbons).—This species very often reaches the weight of about half a pound. It is confined to the fresh water, being found in the Sacramento and San Joaquin Rivers, and other streams as far southward at least as San Luis Obispo. It is sent in small numbers to the markets of San Francisco, and is chiefly eaten by the Chinese.

91. THE MOHARRA FAMILY—GERRIDÆ.

This family is represented on our eastern coast by four species, all of which are very small and of little consequence except as food for larger fishes.

Gerres argenteus, first discovered by Professor Baird at Beesley's Point, New Jersey, appears to be common from North Carolina to New Jersey, and has been, within two or three years, observed at Wood's Holl, Massachusetts.

G. harengulus and *G. homonymus* occur in the Gulf of Mexico. In the Bermudas there are three species of this genus; these are known by the names "Shad" and "Long-boned Shad." They are seined in great numbers, and constitute an important article of food.

92. THE THREAD-FISH FAMILY—POLYNEMIDÆ.

The family *Polynemidæ* is remarkable by reason of the elongate filaments which are developed in connection with the pectoral fin. Günther has remarked: "Their eyes are large, but generally obscured by a filmy skin, so that these feelers must be of great use to them in helping them to find their way to their food. It is evident, from the organization of these fishes, that they live in thick water or muddy bottoms, such as are found near the mouths of great rivers."

There are two or three species upon our coast, one of which, the "Thread-fish" of Pensacola, *Polynemus octonemus*, is the subject of the following interesting observations by Mr. Stearns:

"The Thread-fish is rather common at Pensacola in summer, and has not been observed elsewhere in the Gulf by me. My first specimen was taken at the surface of the water in Pensacola Bay, May 21, 1878. Later in the season I saw large schools of them in shoal water along the sea-beach swimming towards the harbor mouth. On June 14 a very large school of them came into the surf near Fort McRae, and large numbers were thrown ashore by the waves, until perfect windrows of dead fish were found upon the sands. Sharks and other fishes were preying upon them in the water, and vast numbers of sea-birds and buzzards awaited them on land. The individuals composing this school were of various sizes, the majority being adults. (Several of these were sent to the National Museum.) They were evidently moving towards the bay. Small schools were seen during the months of July of that and the following year."

93. THE SURGEON-FISH FAMILY—ACANTHURIDÆ.

On the coast of Florida, as well as through the West Indies and in the Bermudas, occur two species of this family, *Acanthurus cæruleus* and *A. nigricans*, generally known as "Doctor-fish" or "Surgeon-fish." They are distinguished by slight differences of proportion and color. Each side of the tail is provided with a sharp, lancet-like spine, which, when at rest, is received into a sheath, but it may be thrust out at right angles to the body, and used as a weapon of offense; sweeping the tail from side to side as they swim, they can inflict very serious wounds, and I have seen, in the Bermudas, large fishes, confined in the same aquarium tank with them, covered with gashes inflicted in this manner. They are available for food, but are more worthy of consideration on account of their power of wounding the fishermen. The "Bone-fish" of Key West, according to Stearns, belongs to this family and genus. It is quite common about the coral reefs of the South Florida coast.

94. THE ANGEL-FISH FAMILY—CHÆTODONTIDÆ.

This family contains numerous species of fully-formed, beautifully-tinted fishes, usually of small size, which abound in all tropical seas, especially among the coral reefs. Their teeth are very small and feeble, and they feed upon minute invertebrates. To this group belong the beautiful "four-eyed fish" of the West Indies; also the Angel-fish, *Holacanthus ciliaris*, a lovely species, familiar to the residents of New York, specimens having been brought from the Bermudas at various times during the past thirty years for exhibition in the aquaria of that city. This species is found also along the Florida coast, and as far north as Charleston, South Carolina. It is considered the most delicious food-fish of the Bermudas.

Stearns writes: "The 'White Angel-fish,' the 'Yellow Angel-fish,' and the 'Black Angel-fish' are reported as common about the Florida reefs, the two first as being abundant and the last as rare. I did not secure a specimen of either."

The Black Angel-fish is probably the species known under this name in the Bermudas, *Holacanthus tricolor*.

L.—THE MACKEREL AND ITS ALLIES.

95. THE MACKEREL—SCOMBER SCOMBRUS.

GEOGRAPHICAL DISTRIBUTION.—The common Mackerel, *Scomber scombrus*, is an inhabitant of the North Atlantic Ocean. On our coast its southern limit is in the neighborhood of Cape Hatteras in early spring. The fishing schooners of New England find schools of them in this region at some distance from the shore, but there is no record of their having been taken in any numbers in shoal water south of Long Island. A. W. Simpson states that the species has been observed in the sounds about Cape Hatteras in August, September, and October. R. E. Earll finds evidence that stragglers occasionally enter the Chesapeake. Along the coasts of the Middle States and of New England Mackerel abound throughout the summer months, and are also found in great numbers in the Gulf of Saint Lawrence, where, in past years, fishermen of the United States congregated in great numbers to participate in their capture. They are also found on the coast of Labrador, though there is no evidence that they ordinarily frequent the waters north of the Straits of Belle Isle.

Captain Atwood[1] has expressed the opinion that they visit Northern Labrador only in seasons remarkable for the prevalence of westerly winds, and that in other seasons they do not go so far north.

Professor Hind was told by the residents of Aillik and Kypokok, Labrador, one hundred and fifty miles northwest of Hamilton Inlet, that Mackerel were abundant there in 1871, and that a few were caught in cod-seines. While at Double Island harbor, some fifteen miles north of Hopedale, a French Canadian resident informed him that there is "a scattering of Mackerel" on that part of the coast.

They appear also at times to have been abundant on the northeastern coast of Newfoundland, though their appearance there is quite irregular. Mackerel do not occur in Hudson's Bay nor on the coast of Greenland. It seems probable that the natural northern limit of the species in the Western Atlantic is not far from the Straits of Belle Isle. Professor Packard, who visited this region in 1866, recorded that a few Mackerel are taken in August in Salmon Bay and Red Bay, but that the Straits of Belle Isle were evidently the northern limits of the genus, while Fortin, one of the best Canadian authorities on fisheries, in his annual report for 1864, stated that in summer they appear in some places, such as Little Mecattina, on the adjoining coast, latitude 50½° north, and even sometimes enter the Straits of Belle Isle.[2]

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[1] Proceedings, Boston Society of Natural History, vol. 10, p. 66.

[2] In 1860 Capt. Peter Avery, of the schooner Alabama, of Provincetown, took 100 barrels of fat Mackerel at Port au Port, Newfoundland. Captain Atwood, however, has seen them at the Bay of Islands. He has also seen large schools at Mecattina.

Capt. J. W. Collins writes: "As early as 1837 or 1838, Capt. Stephen Rich, of Gloucester, spent almost the entire mackerel-fishing season on the coast of Labrador in pursuit of Mackerel. He was induced by the reports brought him by the Labrador cod-fishermen to make this attempt. They had reported seeing Mackerel abundant in the vicinity of the Straits of Belle Isle, and Captain Rich, being of an adventurous turn, decided to devote one summer to the investigation of the subject, feeling in hopes of obtaining a large catch. My father was one of the crew, and I have often heard him tell that the trip was entirely unsuccessful, notwithstanding the fact that they cruised all the way from Mecattina Islands through the Straits of Belle Isle, and on the northwest coast of Newfoundland as far down as the Bay of Islands. Few or no Mackerel were taken until the vessel returned in the fall to the southern part of the Gulf of Saint Lawrence, where a small fare was obtained in a few weeks' fishing."

Perley says that they are rarely known to visit the coast of Labrador. H. R. Storer, after carefully studying the fauna of Southern Labrador, in 1849, came to the conclusion that they were sometimes found at Little Mecattina.

In the various reports of the Canadian inspectors of fisheries on the Labrador coast from 1864 to 1870 may be found evidence that Mackerel are rarely taken even on the Labrador coast of the Gulf of Saint Lawrence.

Professor Verrill, who visited Anticosti and Mingan in 1861, was unable to find any Mackerel in the waters of that region, although the best methods of catching them were often used.

Some years ago Mackerel were abundant in the Bay of Fundy, as many as twelve vessels from Eastport, besides others, being engaged in their capture, chiefly about Digby and Saint Mary's Bay. They have now so completely disappeared as not to form an item in the commercial record of the catch.

The species is found throughout the entire length of the Norwegian coast from the Christiania Fjord to the North Cape and Varanger Fjord, latitude 71°. It occurs on the south coast of Sweden, and, entering the Baltic, is found along the shores of Eastern Denmark and Eastern Prussia, and also abundantly in the German Ocean and the English Channel, as well as everywhere in all parts of the British Isles, and southward to the Mediterranean, where it abounds, especially in the Adriatic. There is no record of its capture in Africa, South America, in the West Indies, the Gulf of Mexico, or even about the Bermudas.

The Mackerel, then, would appear to be a shore-loving fish, not addicted to wide wanderings in the ocean, and with range limited in the Western Atlantic between latitudes 35° and 56°; in the Eastern Atlantic between 36° and 71°.

MIGRATIONS.—The migrations of the Mackerel, the causes of their appearance and disappearance at certain seasons at different points along the coast, the causes of their relative abundance and scarcity in different years, have previously been discussed by numerous writers. The subject has received special attention on account of the disputes between our own and the Canadian Government concerning the value to our fishermen of the right to participate in the mackerel fisheries in the Provincial waters.

Notwithstanding the great amount of paper which has been covered with theories to explain the various mooted questions, it cannot be said that the habits of the Mackerel are understood at all better than those of other fishes which have not attracted so much attention. The most voluminous writer upon this subject has been Prof. Henry Youle Hind, who devotes many pages of his book, "The Effect of the Fishery Clauses of the Treaty of Washington on the Fisheries and Fishermen of British North America," to the attempt to prove that the Mackerel which have been at certain seasons in the past so abundant in the Gulf of Saint Lawrence and on the Atlantic coast of Nova Scotia remain there throughout the year, hibernating in deep waters not very remote from the shore.[1] I have attempted to show the weakness of his argument in an essay published in the

[1] Mr. Barnet Phillips, in the New York Times, December 31, 1880, thus criticises the theory of Mr. Hind, while referring to Mr. William H. Rideing's essay entitled "First Families of the Atlantic":

"In an article entitled 'First Families of the Atlantic,' to be found in the January number of Harper's Magazine, certain assertions are advanced in regard to the habits of the Mackerel which are entirely of an *ex parte* character, and might unintentionally act injuriously to our interests in case future disputes arose between the Provinces and the United States on the fishery question. The writer states that, 'seeking a soft muddy or sandy bed at the approach of winter, it [the Mackerel] buries itself therein, first drawing a scale or film over each eye.' In a prior paragraph of this same article the possibility of the hibernation of the Mackerel is advanced. Now, exactly these two arguments were presented by Professor Hind, who wished to prove that the Mackerel was a local fish, in favor of the Provinces, which assertions were entirely refuted by Prof. Spencer F. Baird, Secretary of the Smithsonian Institution, and by Prof. G. Brown Goode. *The great argument used by the Provincial fish experts was to show that the* Mackerel belonged to their waters, and the ideas of hibernation were therefore represented. If this had been granted, our case

Fifth Annual Report of the United States Commissioner of Fisheries for the year 1877, pp. 50–70. It is by no means demonstrated that certain schools of Mackerel do not remain throughout the year in waters adjacent to the coast of Canada, but the weight of evidence at present seems to rest with those who believe that the Mackerel are given to extensive migrations north and south along our coasts. These migrations are believed to be carried on in connection with another kind of migration which I have called "bathic migration," and which consists in a movement, at the approach of cold weather, into the deeper waters of the ocean. The menhaden and many other fishes have these two kinds of migrations, littoral and bathic. The sea-herring, on the other hand, has extensive littoral migrations and probably very slight movements of a bathic nature. In some the latter is most extended, in others the former. Anadromous fishes, like the shad and the alewife, very probably strike directly out to sea without ranging to any great degree northward or southward, while others, of which the Mackerel is a fair type, undoubtedly make great coastwise migrations, though their bathic migrations may, without any great inconsistency, be as great as those which range less.

Upon this point I cannot do better than to quote from a manuscript letter from Professor Baird to the Hon. Hamilton Fish, Secretary of State, dated July 21, 1873. Having expressed certain views concerning the well-known phenomenon of the migration of the herring and shad, he continues:

"The fish of the Mackerel family form a marked exception to this rule. While the alewife and shad generally swim low in the water, their presence not being indicated at the surface, the Mackerel swim near the surface, sometimes far out to sea, and their movements can be readily followed. The North American species consist of fish which as certainly, for the most part at least, have a migration along our coast northward in spring and southward in autumn, as do the throngs of pleasure-seekers, and their habit of schooling on the surface of the water enables us to determine this fact with great precision. Whatever may be the theories of others on the subject, the American mackerel-fisher knows perfectly well that in the spring he may find the schools of Mackerel off Cape Henry, and that he can follow them northward day by day as they move in countless myriads on to the coasts of Maine and Nova Scotia."

The movements of the mackerel schools, like those of the menhaden, appear to be regulated solely by the temperature of the ocean.

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would have had, as far as Mackerel go, little to rest upon. As to hibernation of the Mackerel there are innumerable reasons to suppose that nothing of the kind exists. In fact, hibernation is one of those ichthyological questions which require very long research to know anything about. It does seem that sturgeon in Russian waters, and carp in cold temperatures, take to the mud, and may, perhaps, do something like hibernation, but this habit has no precedent in sea-fish. It may happen that a few individuals of the *Scomber* family have been inclosed in the winter season in the waters of the Newfoundland coast. Such cases have undoubtedly happened, for on page 62 of the late report of the United States Commission the statement is made that in a river of Nova Scotia where a school of Mackerel had been detained the fish were speared out of the mud. Returning to the numbing effects of cold weather on sea-fish, in order to show how unusual it must be, the American turbot is taken with hooks in the dead of winter under the floe ice of North Greenland at a depth of 300 fathoms. If sea-fish were mummified in the ocean depths by the cold, because at the deeper strata of the ocean temperatures are fairly uniform, once a fish had hibernated his sleep might continue on forever. There can be no better proof of the migratory character of the Mackerel than to cite a paragraph from the 'Cape Ann Advertiser,' published this week, where the fact is announced that the mackerel fleet have gone off Hatteras in hopes of securing Mackerel, and that some time ago 'vessels reported having sailed through immense schools for forty miles.' The film over the eye of Mackerel Professor Hind placed great stress on, as he supposed it was a preparatory step to the hibernating process. Now, this film over the eye, as Mr. Goode shows, is not peculiar to the *scombers*, for many fish, such as the shad, the alewife, the menhaden, the bluefish, the mullet, the lake whitefish, and various cyprinoid fishes, have this membrane, though it never does cover the whole eye. The fact remains also to be proved that a skin forms over the eye in winter only. The writer of this article has apparently culled his facts in regard to Mackerel from one side, and has read most superficially the whole of the testimony. 'Public documents' are rarely of an amusing character, but when they happen to be of interest, as were those published as 'The Award of the Fisheries Commission,' it is most unfortunate when false deductions are derived from them."

In my essay upon menhaden, which has just been referred to, I have attempted to show, in a preliminary way, the relations of the movements of the menhaden schools to the temperature of the water at different stations along the coast in accordance with certain crude observations, which at present constitute the only material available as a basis for such generalizations. I have there claimed that menhaden make their appearance near the shore in the spring as soon as the temperature of the water in the harbors has reached a weekly average of 50°, and that they disappear in the fall soon after the waters have again cooled down to the same average temperature.

The Mackerel are partial to much colder waters. They range ten to fifteen degrees farther to the north, and their southern limit is proportionally high. They appear earlier in the spring and disappear later in the fall, and their presence is nearly synchronous with the time when the water temperatures of the harbor have reached a weekly average of 45°. It has been remarked that the presence of the menhaden depends upon a weekly average of the harbor temperature of 50° or more. These harbor temperatures are several degrees—it is not known exactly how many—higher than those of the open ocean at the same latitude, and there can be no question that the menhaden thrives in water as cold as 45°. Mackerel will remain active and contented in a temperature of 40°, or even less. The normal time of the departure of Mackerel from the coast is, therefore, a month or two later than that of the menhaden.

There are well recorded instances of the capture of menhaden in Massachusetts Bay as late as December, and there are also many instances where Mackerel have been taken not only on the New England coast, but also in the Gulf of Saint Lawrence, in midwinter.[1]

Mr. John Fletcher Wonson tells me that at one time he left Gloucester on a halibut trip January 1, and January 3 or 4, on George's Bank, caught a hogshead of herring and seven or eight Mackerel in a gill-net. Schooner "Shooting Star" took a number of Mackerel on George's Bank in March, 1856.[2]

The fishermen on George's took Tinkers from the stomachs of codfish in February, 1878, using them for bait. Sometimes five or six were taken from one fish.

In January, 1868 or 1869, Capt. Warren Brown, of the schooner "Charles Frederick," of Gloucester, caught thirty Mackerel on a trawl-line set on the Middle Bank.

The "Yarmouth Herald" (Yarmouth, Nova Scotia), January 2, 1879, states that "two fine, fat, fresh Mackerel were found among the kelp at Green Cove on Friday, December 28, 1878."

Basing their arguments upon such occurrences as these, Canadian writers have attempted to prove that large bodies of Mackerel hibernate along their shores in the winter months. It is still believed by many fishermen that the Mackerel, at the approach of cold weather, go down into the mud and there remain in a state of torpidity until the approach of warm weather in spring. All that can be said regarding this claim is that, although we do not know enough about the subject to pronounce this impossible, American ichthyologists think they know enough to be of the opinion that it is very decidedly improbable.

It seems only fair to quote in this connection a letter printed in "Forest and Stream," a leading New York journal devoted to field sports and the fisheries, in criticism of views published at the

[1] Twenty Mackerel were caught in a gill-net at Provincetown January 17, 1878. Others were taken late in December. Captain Harding tells me that they sometimes come ashore frozen in cold weather, and are found in the ice on the beach.

Early in February, 1881, small Mackerel five or six inches in length were found in considerable numbers in the stomachs of hake and cod, taken on the eastern part of George's Bank in fifty fathoms, and on the southeastern part of Le Have in sixty and eighty fathoms of water; sometimes ten, twelve, or fifteen in the stomach of a single fish. On the 8th and 9th of February, Captain Olsen observed them schooling at the surface on George's. Gloucester fishermen had before seen them in winter on George's, but never so abundant.

[2] "Gloucester Advertiser," April, 1856.

time in that paper, and also in the Report of the Fish Commission, part v. I feel the utmost confidence in Dr. Gilpin's statements as to facts observed, though my interpretation might perhaps be different:

HALIFAX, *June* 19, 1878.

MR. EDITOR: In some papers published some time since in the "Forest and Stream" upon the habits of the Mackerel, it is asserted by Prof. Brown Goode that there is no reliable evidence of Mackerel being seen upon the coast of Nova Scotia after the 25th of October, quoting me as his authority. Had he quoted me as giving the 1st of November, 1868, when the fish market at Halifax was full, I should have felt more complimented, as I should have known he had read my paper with more attention. In summing up my remarks I stated that Mackerel remain usually all November on the surface in Nova Scotia, and during mild winters linger to December. This, Professor Goode says, is not reliable as scientific evidence, because no specific dates are given. To admit this would be to destroy almost the whole mass of information compiled in the report of both the Royal and American Commissioners of English and American fisheries. But as I am certain that Professor Goode's desire is to have the truth simply, will you allow me a place in your columns to add to my previous assertions such specific dates as I may be able now to obtain, though not admitting his principle?

On May 23, 1875, going into the Halifax fish market, I asked generally how long are Mackerel in market. I was answered, generally all through November. On asking how long in December they had known them in market, Mr. Greywire said: "I recollect them as late as the 10th of December. We keep our nets out to the 30th of November. Men hire to that time. Mackerel are seen after that date, but the seas are so boisterous that our nets are destroyed. Some few parties will keep them out in December in spite of cold and storms." Mr. White corroborated this. Mr. Thomas Brackett said he had taken them often in December, and often in weather so cold that the fish were frozen in removing them from the meshes of the nets, but could remember no dates. Mr. William Duffy stated he saw one once on the 24th of December. He recollected it because it was Christmas eve, and on account of its rarity; but he had frequently taken them during December, though having no dates. The nets used are about two fathoms deep, set near the shore in about five to ten fathoms of water. My own recollections, but without dates, are seeing stops made in very cold weather and frozen ground, which must have been late in November. I think I have now made good my assertion that they linger to December, and that in any future history of their habits it must be assumed as truth that they remain in numbers during November, but are found sparingly later on our coasts. Where they are during those dates in any intermediate point from Maine to Virginia, must be left to American observers. When these blanks are filled and a generalization made their history will be more complete, a task we may well leave in the hands of the American Commissioners of Fisheries.

In my paper (1865) I speak of their asserted torpidity and the story of their blindness as needing more proof before they are asserted as facts. I have had nothing to alter my opinion since. In examining the eyes of many Mackerel on May 23 and 27 and October 27, in different years, I have found that, as in most fish, the bony orbit is much larger than the base of the eye, and that the space is filled by gelatinous substance, which may be called cellular membrane, and adipose deposit to this transparent membrane arising from the outer angle of this orbit and spreading half over the pupil of the eye. It may easily be raised and defined by passing a penknife between it and the eye. At the inner angle there is also a similar, but much smaller, membrane, not reaching to the eye. As the Mackerel appear on our coasts about the 15th of May, and these

observations were made the 23d, I do not think it can be asserted the eye is closed entirely in spring; and as the same appearance is found in September, we must admit it to be a permanent structure. An analogous membrane is found in the *Clupeidæ* and doubtless other fish. On asking *Thomas Loyd, our roughest and oldest fisherman: "I don't know anything about the scales of the* eyes, but I do know that, curse them, they see too sharp for us, steering clear of our spring nets," and doubtless old Tom was right.

On dissecting a Mackerel, May 23, I found the heart first presenting the tricornered ventricle with its white aorta and deep-red auricle resting upon the fringe of cœca that covered the intestines, sweeping down to the vent. The liver and stomach were both covered by the cœca. The latter was about three inches long, its upper lobe thick and round, but ending in a narrow tail or point. The cardiac end of the stomach was prolonged two and a half inches, ending in a point. The cœca were attached to the gut about an inch below the pylorus. There was but little difference in appearance and size between stomach and gut. This we may roughly sum up: Stomach and gut very simple; cœca usually large and complicated; liver small—all noteworthy facts in the study of *comparative life. The fish being a male one, lobe on either side of ivory-white; milt* reached from gills to vent, slightly adhering to the sides by thin membrane, and covered by a similar one. They were divided in lobes by shallow lines, the upper lobes slightly fimbriated. On removing both entrails and milt a dark purple space about an inch wide extended from gills to *vent beneath the back bone. This, when opened, seemed filled with coagulated blood. It had in* some respects the appearance of the air-bladder in the *Salmonidæ*, though wanting in the direct communication they have with the œsophagus. But this communication is also wanting in the *Gadidæ, where, especially in the hake, the air-bladder assumes its highest form of organization.* I have often found coagulation and reticulated plexi in air-bladders of other fish.

It has been asserted the European Mackerel have no air-bladders, and a new genus proposed, but with more probability they have the same organization as our own, and the difference lies in the opinion whether or not it is an air-bladder.

The Mackerel appear on the Atlantic coast of Nova Scotia, and almost simultaneously on the Bay of Fundy, about the 15th of May. Nearly all spawners, male and female, perform a somewhat easterly and northerly route, disappear from the surface in a few weeks and reappear again in September without spawn and fat, remain in numbers during November, and very sparingly during December, coming from the eastward, and then disappear. It may be asserted, generalizing from observation extending over a series of eight or ten years, that they are irregular in their movements as regards localities, though probably not as regards ocean surfaces.

The very great difficulty of accounting how these enormous masses of surface feeders find food after disappearing from the surface has caused many ingenious theories as to the question in what state and where they pass that time. These are all pleasant reading, but valuable more or less as regards the ingenuity and scientific standing of the writers. In this paper and the one I inclose (1865) I have stated what I think are facts, and which must be accepted in the future history of American Mackerel, which I hope soon to see written by that commission which has already done so much in Atlantic waters.

BERNARD GILPIN.

The appearance of the mackerel schools at the approach of summer in ordinary years has been noticed somewhere in the neighborhood of the following dates: At sea, off Cape Hatteras, March 20 to April 25; off Norfolk, Virginia, March 2 to April 30; off the Capes of Delaware, April 15 to May 1; off Barnegat and Sandy Hook, May 5 to May 25, and at the same date along the whole

southern coast of New England, and as far east as Southern Nova Scotia, while in the Gulf of Saint Lawrence they appear late in May, and in abundance early in June.[1]

There appears to be a marked difference between the movements of Mackerel and the menhaden, for while the menhaden are much more gradual in their approach to the shore, and much more dependent upon a small rise of temperature, the Mackerel make their appearance almost simultaneously in all the waters from New Jersey to Nova Scotia at about the same time. Stragglers, of course, appear much earlier than the dates just mentioned; a few Mackerel were observed at Waquoit, Massachusetts, as early as April 19, 1871.

In the fall the Mackerel disappear as suddenly as they came in the spring, but they have only in one instance been observed off the Carolina coast, except during the spring run. This is very probably because no fishing vessels ever visit this region later than June.

The instance referred to is the experience of Mr. Peter Sinclair, a well-known fisherman of Gloucester, who states that he has frequently taken them in great abundance off Cape Hatteras in December, where they are not known at all in the summer season. He has found them in the spring as far south as Charleston, and followed them from Cape Henry to the Bay of Fundy and the Gulf of Saint Lawrence.

The very vagueness of the statements just made is evidence to show how little is actually known about the movements of these fish. The subject must be studied long and carefully before it can be understood, and the interests of the American fishermen demand that it should be thus studied.

"There is," writes Professor Baird, "no very satisfactory evidence of the occurrence of Mackerel in the winter or any other season south of Cape Hatteras, and it is not given by Poey and other writers as occurring in the West Indies. A few Mackerel are said to be occasionally brought into the Charleston market, and Mr. Moses Tarr, of Gloucester, thinks that some years ago he saw in the early part of March, a short distance to the southeast of Key West, a large school of Mackerel. He, however, did not capture any, and it is more likely that the fish observed belonged to some other small species of the mackerel family which occasionally school like the Mackerel itself, and might easily be mistaken for it. The skip-jack or leather-back may possibly have been the species referred to.

"I have been quite surprised to find the extent of belief among Massachusetts fishermen that the Mackerel goes into the mud in the winter time. I have, indeed, been assured by trustworthy parties that they have known Mackerel caught on eel spears when fishing for eels in the mud of Provincetown harbor.

"A similar belief is referred to by Dr. Gilpin in his paper on the Mackerel in the Transactions of the Nova Scotia Scientific Association, and it is difficult to refuse assent to the testimony of otherwise credible observers. There is nothing apparently in the economy of the Mackerel to prevent its following the example of the sand lance, the eel, and other fish. We know that the

[1] The following letter from the skipper of the schooner "Edward E. Webster" is important, in that it gives the exact positions as well as the dates of some of the earliest captures in 1878, '79, '80, and '81:

NEW YORK, *April* 22, 1881.

Captain COLLINS:

DEAR SIR: I have just received your letter of March 14, in which you wanted to know whereabouts I caught my first Mackerel. The first catch in 1878, April 16, lat. 36° 10′ N., long. 74° 45′ W.; in 1879, April 12, lat. 36° 35′ N., long. 74° 50′ W.; in 1880, April 1, lat. 35° 30′ N., long. 74° 15′ W.; in 1881, March 20, lat. 37° 10′ N., long. 74° 05′ W.; and this trip we got them April 18 in lat. 38° 38′ N., and long. 74° 00′ W. This is our second trip this season. I have seen Mackerel in lat. 35° 15′ N. and long. 73° 46′ W., which is the farthest south I have ever seen any. I have been off Cape Lookout many times, but have never seen Mackerel there. . . .

Yours, truly,

SOLOMON JACOBS.

melanora, the tench, and many other fresh-water fish have the burrowing habit, some of them being imbedded very deep in the mud at the bottom of a dried-up pond, to emerge again when the water is restored.

"The entire disappearance of Mackerel during the winter season is a noteworthy fact, as we can hardly suppose that if it schooled on the surface in the Gulf Stream during that season it would not be noticed by the experienced eyes of sea captains, and we can hardly imagine that the fish would remain in the depths without an occasional rise.

"It appears to be a well-established fact that Mackerel are not unfrequently found in the stomachs of cod, and possibly of halibut, taken on the George's Banks in the winter season. Perhaps the number noted would be still larger if fishermen had the time and inclination to examine more frequently than they do the stomachs of the fish captured by them.

"Another curious fact in relation to the Mackerel is in respect to the membrane, the vertical edge of which is observed during the summer season on the corner of the eye. This, it is claimed, during the winter extends over the whole eye, and imparts the appearance of blindness. This the Mackerel is said to possess on making its first appearance near the coast in the spring, when it extends over the greater part of the eye, thus preventing the fish from seeing the bait, and it is a matter of common remark that Mackerel in the spring cannot be taken with the hook, but must be captured with the net. The membrane appears to recede with the advancing season, and during a considerable portion of the time of its abode in the north it is scarcely appreciable."

Mr. Perley, of Saint John, New Brunswick, in his work upon the fishes of the Provinces, remarks that Mackerel have been taken on cod-hooks in deep water, near Grand Manan, in the winter season, and there is evidence to show that a few remain on the coast. It is, however, believed that these cases are exceptional and confined to stragglers, as such instances frequently occur with all the migratory fishes.

The Mackerel belongs to what may technically be termed pelagic or wandering fish, as their movements, something like those of the herring, are apparently more or less capricious, though probably governed by some definite law, which has not yet been worked out. It moves in large schools or bands, more or less isolated from each other, which sometimes swim near the surface and give distinct evidence of their presence, and at others sink down into the depths of the ocean and are entirely withdrawn from observation. The army of fish, however, moves along with a very broad front, a portion coming so close to the shore as to be taken in the weirs and traps along the coast of the Middle States, especially in Vineyard Sound and on Cape Cod; while at the same time other schools are met with from twenty to fifty miles, or even more, out to sea. It is, however, still a question whether the fish that skirt the coast of the United States enter the Bay of Saint Lawrence, or whether the latter belong to another series, coming directly from the deep seas off the Newfoundland and Nova Scotia coast. Until lately the former has been the generally accepted theory, in view of the alleged fact that the fishermen of the Nova Scotia coast always take the fish coming from the west in the spring and from the east in the fall.

Capt. Hanson B. Joyce, of Swan's Island, Maine, one of the most expert and observing mackerel-fishermen of New England, thinks that the movements of the spring schools of Mackerel are very much influenced by the direction and force of the prevailing winds while the fish are performing their northerly migration. He has generally found, he says, that when there has been a continuance of strong northerly winds about the last of May and early in June, the season at which the Mackerel are passing the shoals of Nantucket and George's Bank, the schools have taken a southerly track, passing to the southward of George's Shoals and continuing on in an easterly direction to the coast of Nova Scotia, and thence to the Gulf of Saint Lawrence.

When southerly winds or calms prevail at that season the Mackerel are carried into the waters of the Gulf of Maine, and in consequence are much plentier off the New England coast than in the Saint Lawrence Gulf.

On this theory Captain Joyce bases his actions in cruising for Mackerel, always fishing off the New England shores when southerly winds have predominated in the spring, and going to the Saint Lawrence if northerly winds have been exceptionally strong and continuous about the last of May.

The movements of the fish, as already stated, season by season, are quite uncertain, sometimes being very abundant in one direction and sometimes in another, and occasionally, indeed, they may disappear almost entirely for several years, subsequently reappearing after a considerable absence. In some years the fish are very abundant on the coast of the United States, and at others rare; the same condition applying to the fish of the Bay of Saint Lawrence. It is not certain, of course, that this indicates an entire absence of the fish from the localities referred to, but they may, possibly, for some reason, remain in the depth of the sea, or some change in the character of the animal life in it, which constitutes the food of the fish, may produce the changes referred to. A notable instance of a somewhat permanent change in the migration of the Mackerel is found in the entire failure since 1876 of the mackerel fishery in the Bay of Fundy, which, a few years ago, enabled a merchant of Eastport to employ successfully as many as a dozen vessels, especially in Digby and Saint Mary's Bays, but which is now abandoned. There are indeed faint suggestions, in the early history of the country, of their total absence from the whole coast for several years, as was also the case with the bluefish.

ABUNDANCE.—The wonderful abundance of Mackerel in our waters has always been a subject of remark. Francis Higginson, in his "Journal of his Voyage to New England, 1629," speaks of seeing "many schools of Mackerel, infinite multitudes on every side of our ship," off Cape Ann on the 26th of June; and Richard Mather, in his "journal," 1635, states that the seamen took abundance of Mackerel off Menhiggin (Monhegan). In Governor Winthrop's journal, speaking of the year 1639, he remarks: "There was such store of exceeding large and fat Mackerel upon our coast this season as was a great benefit to all our Plantations, since one Boat with three men would take in a week ten hogsheads, which were sold at Connecticut for £3 12*s.* 0*d.* per hogshead."

Their abundance has varied greatly from year to year, and at times their numbers have been so few that grave apprehensions have been felt lest they should soon depart altogether.

As early as 1670, laws were passed by the colony of Massachusetts forbidding the use of certain instruments of capture, and similar ordinances have been passed from time to time ever since. The first resource of our State governments has always been, in seasons of scarcity, to attempt to restore fish to their former abundance by protective legislation. It seems to us at the present day absurd that the Massachusetts people should have supposed that the use of shore-seines was exterminating the Mackerel on the coast of Massachusetts, but it is a fair question whether their apprehensions were not as well grounded as those of legislators of the present century who have endeavored to apply a similar remedy for a similar evil. In connection with the chapter on THE MACKEREL FISHERY will be shown a diagram, which, by means of curves, exhibits the catch of Mackerel in New England for a period of seventy-five years.

From a study of this it seems quite evident that the periods of their abundance and scarcity have alternated with each other without reference to overfishing or any other causes which we are prepared to understand. In the year 383,548½ barrels of Mackerel were caught by the citizens of Massachusetts. In 1881 the number of barrels salted was 269,495; to this, however, should be added 125,000 barrels caught and marketed fresh by the Massachusetts fleet, making an aggregate

of 394,495 barrels. The fluctuations in the catch year by year from 1804 to 1881 are shown most instructively in a plate accompanying this report.

The stories which are told by experienced fishermen of the immense numbers of Mackerel sometimes seen are almost incredible. Capt. King Harding, of Swampscott, Mass., described to me a school which he saw in the South Channel in 1848: "It was a windrow of fish," said he; "it was about half a mile wide, and at least twenty miles long, for vessels not in sight of each other saw it at about the same time. All the vessels out saw this school the same day." He saw a school off Block Island, 1877, which he estimated to contain one million barrels. He could see only one edge of it at a time.

Upon the abundance of Mackerel depends the welfare of many thousands of the citizens of Massachusetts and Maine. The success of the mackerel fishery is much more uncertain than that of the cod fishery, for instance, for the supply of cod is quite uniform from year to year. The prospects of each season are eagerly discussed from week to week in thousands of little circles along the coast, and are chronicled by the local press. The story of each successful trip is passed from mouth to mouth, and is a matter of general congratulation in each fishing community. A review of the results of the American mackerel fishery, and of the movements of the fish in each part of the season, would be an important contribution to the literature of the American fisheries. Materials for such a review are before me, but space will not allow that it should be presented here.

Food of the Mackerel.—The food of the Mackerel consists, for the most part, of small species of crustaceans, which abound everywhere in the sea, and which they appear to follow in their migrations. They also feed upon the spawn of other fishes and upon the spawn of lobsters, and prey greedily upon young fish of all kinds.[1] In the stomach of a "Tinker" Mackerel, taken in Fisher's Island Sound, November 7, 1877, Dr. Bean found the remains of six kinds of fishes—of the anchovy, sand-lants, the smelt, the hake, the barracuda, and the silver-sides, besides numerous shrimps and other crustaceans. Captain Atwood states that when large enough they devour greedily large numbers of young herring several months old. Specimens taken July 18, 1871, twenty miles south of Noman's Land, contained numerous specimens of the big-eyed shrimps, *Thysanopoda*, larval crabs in the *zoea* and *megalops* stages, the young of hermit crabs, the young lady crabs, *Platyonichus ocellatus*, the young of two undetermined Macrura, numerous Copepoda and numerous specimens of *Spirialis Gouldii*, a species of Pteropod. They also feed upon the centers of floating jelly-fishes (discophores). In Gaspé the fishermen call jelly-fishes "mackerel bait."

The greed with which Mackerel feed upon the chum, or ground menhaden bait, which is thrown out to them by the fishing-vessels, shows that they are not at all dainty in their diet, and will swallow without hesitation any kind of floating organic matter.

Large Mackerel often eat smaller ones. Captain Collins has frequently found young Mackerel three or four inches long in the stomachs of those full grown. This is generally noticeable only in the fall, and the young fish are probably those which have been hatched in the spring.

In the fall of 1874 the writer made a trip upon a gill-net schooner to the grounds off Portland, Maine, some distance to sea, for the purpose of studying the food of the Mackerel, and found their stomachs full of a species of *Thysanopoda* and of a large copepod crustacean. The greater part of the food of Mackerel consists, however, of minute crustaceans. Owing to the infinite abundance of these in the sea, Mackerel probably have very little difficulty in finding food at almost any portion of the ocean visited by them, whether on the edge of the Gulf Stream or near the shore.

[1] Near the New London light-house is a small brook which empties into the harbor and abounds with a small species of fish of which the Mackerel appear to be fond. A few days since the keeper of the light-house, while the Mackerel were indulging in a meal, caught five hundred at one haul with a scoop-net.—Gloucester Telegraph, December 3, 1870.

In an interview with Capt. King Harding, of Swampscott, one of the most experienced mackerel catchers on our coasts, I obtained the following amusing observations: He described one kind of crustacean Mackerel food which looked like spiders, which were red, and crawled over his hand when he took them up. They look like little spiders; the Mackerel are especially fond of them. At Boone Island, Maine, in July, 1850, the water all around the island was red for one hundred yards from the shore; these crawled up the rock-weed on the shore until it was red. He took the sprays of rock-weed in his hands and pulled them slowly to him, and the Mackerel, one and a half pound fish, would follow in quite to the rocks. He killed three with his oar, and tried to catch some in a basket by tolling them over it, but they were too quick for him. He asked his old skipper, Capt. Gorham Babson, what they were, and was told that they were "Boone Island bed-bugs." And, said he, "Young man, when you see this kind of bait, no matter if you don't see any fish, never leave; the fish will be there in a few days."

Then there is another kind, called "snappers." These are white, and dart rapidly about in the water; they are doubtless small crustaceans. He says that sometimes they swim at the surface, where the Mackerel follow them. A few days before he had been standing on the stern of his vessel, and though he could see nothing under the water he knew the snappers were there about two feet below the surface, for he could see a school of Mackerel swimming along, opening their mouths and taking in their food, and then letting the water out through their gills.

When the Mackerel are tolled up from twelve or fifteen fathoms below the surface their stomachs are often full of bait; so it is certain that these little animals swim at all depths.

Another kind of food is red, and is hot to the hands. This is called "Cayenne"; it spoils the fish.

Years ago, according to Captain Harding, Mackerel did not school as they do now.

When you see pollock jumping near the shore, it is a pretty good sign that there is plenty of mackerel food.

The presence of abundance of mackerel food is indicated by the great schools of sea-birds, particularly by the flocks of phalaropes, or sea-geese, as the fishermen call them, which congregate together, floating upon the water, and when seen in summer give a sure sign of the presence of Mackerel also.

The various invertebrate animals preyed upon by Mackerel are known to the fishermen by such names as "shrimp," "red-seed," and "Cayenne."

"The wide-spread distribution from shore seaward of the Thysanopoda and other minute crustacea, which constitute to so great an extent the food of the Mackerel and herring on our shores, was proved," writes Professor Baird, "during a trip of the 'Speedwell' from Salem to Halifax in 1877." At numerous points and at regular intervals on the way across, including the middle of the route, immense numbers of these shrimp were met with and collected by the towing net. They were found in especial abundance at Le Have Bank. These prove to be specifically identical with those found in immense quantities in Eastport Harbor at the surface.

"That these same animals occur at least as far east as the Gulf Stream is shown by the list of the collections made by Professor Smith off the Georges near the edge of the Gulf Stream, and published in the Transactions of the Connecticut Academy of Arts and Sciences, vol. iii, July, 1874."

Capt. Stephen Mar, of Gloucester, confirms the statements of Captain Harding regarding the effects of "red-seed" upon Mackerel; he states that when Mackerel are feeding on "red-seed" the fishermen have great trouble in keeping them sufficiently long to dress them properly. Their bellies soften at once. When the weather is good and dogfish are not troublesome, the common

practice is to allow the fish to lie in the net until they have disposed of the food in their stomachs. Capt. Henry Willard, of the schooner "Henry Willard," of Portland, Maine, carries a large net of coarse twine, which is suspended over the side of the vessel from two long booms. Into this he turns the fish and leaves them until the seed works out.[1]

Captain Mar states that the "red-seed" is very troublesome to the men engaged in dressing the fish; it makes their hands very sore, often causing the blood to run. A man can clean twice as many fish in a given time if he is not annoyed by the "red-seed" in their stomachs.

Captain Mar describes another kind of mackerel food, which he calls "small brit," which, he says, resembles young herring, which also rots the fish. This is probably, as he supposes it to be, "white-bait" in the young of the sea herring, *Clupea harengus*. It is known as "eye-bait" to the Canadian fishermen.

Captain Merchant tells me that when Mackerel are found with "red-seed" in their stomachs fishermen are sure that they are on the right fishing grounds.

I am told by Captain Collins that it is common for many of the American fishermen to consider it a good sign of Mackerel when they see floating seaweed, more especially eel-grass, "chopped up," *i. e.*, cut into short pieces, which they think is done by these fish. Perhaps there may be a good reason for this supposition, as the Mackerel, while feeding on the diminutive shells with which the weeds are covered, may also bite the latter in two. The presence of gannets is also considered a good sign of Mackerel.

In England the food of the Mackerel is called the "mackerel mint," and this is said to consist at certain seasons of the year of the sand-lants and five other fish, especially the herring and the sprat, while they have also been observed to devour, in the summer months, minute crustaceans, the swimming larvæ of tape-worms, and the embryos of the small spiral shell Rissoa, which, in its adult state, is found in great abundance upon seaweed. It is probably some animal of this kind which was referred to by Captain Harding in the statement above quoted, concerning the abundance of red-seed about Boone Island. Mr. J. F. Whiteaves has recorded a similar habit for the Mackerel of the Gulf of Saint Lawrence.[2]

Professor Hind has pointed out certain relations which exist in the Gulf of Saint Lawrence *between the Mackerel and the lant, or sand-eel, which appears to be one of its most important* articles of diet in these waters. I quote here in full his observations upon this subject, and also his views upon the relations of currents and tides to the presence of mackerel food, and the constant movements of the schools of fish:

"The movements of the Mackerel, like those of the cod, and indeed of most species of fish, are determined at different seasons of the year by the geographical position of its food; and the first important kind of food which appears to lure the Mackerel inshore, after spawning in the Gulf of Saint Lawrence, is the launce or sand-eel.

"The relation of the launce or sand-eel (*Ammodytes americanus*) to the Mackerel is very much *greater than appears at the first blush*, and resembles *the relation of the herring to the cod in* general, and in particular the relation of the so-called Norwegian 'Sull cod,' or launce cod, to this wide-spread and important bait-fish. The approach of the launce to the coast in spring is most probably the cause why the so-called spring cod fishing suddenly ceases on many banks and shoals, commencing again at different localities two and three weeks later.

"The cod leaves the banks and shoals to meet and to follow the launce as they approach the

[1] This "large net of coarse twine" is the mackerel pocket described in the chapter on THE PURSE-SEINE MACKEREL FISHERY.

[2] Report on the Second Deep-sea Dredging Expedition of the Gulf of Saint Lawrence, 1872.

coast. In the same manner they meet and follow the caplin, guided no doubt by the peculiar odor developed by each species at the approach of the spawning season.

"But it is the habit of the sand-eel of burying itself in the sand between the tides, or in submerged sand beaches, that leads the Mackerel so close inshore.

"There can be little doubt that a similar indraught and outdraught of Mackerel and other fish occur in our waters when the launce leave the deep sea to approach the land, or when they return to the deep sea again. Unlike many of the shrimps and larval forms on which the Mackerel feed, which are drifted to and fro by winds and currents, the launce is independent of the wind; but it is only in certain favorable localities frequented by this fish that the burying process between tide-marks, from which it derives its name, can be easily effected; hence, these resorts are not only valuable as bait grounds, but generally noted mackerel grounds, such as Seven Islands, and some parts of Bay of Chaleur, and part of the gulf coast of New Brunswick.

"This bait-fish approaches the sandy beaches fringing the shores of the gulf in the early summer months to spawn; and here the Mackerel are found pursuing them while engaged in depositing their comparatively large reddish-colored ova on the sands between high and low water. Hence, during flood tide, and in the launce season, Mackerel are commonly taken close inshore on these coasts, in pursuit of the launce; and the best catches are said to be made during the period of high tide, for the following reason: In dull, cloudy weather the launce buries itself in the sands left bare by the ebbing tides; but in bright, hot weather it rarely seeks the shelter of the sand, except near low-water mark, probably because the heat of the sun would be oppressive. The breadth of sandy ground in which the launce buries itself for the brief period between high and low water marks is thus dependent upon the clearness of the sky.

"A continuance of cloudy weather is conducive to this kind of close inshore fishery; whereas a bright sky, and a day with a drying wind, leads the launce to select the narrow bands of sandy beach near the margin of ebb-tide, which always remain moist. In cloudy weather with a moist wind, the area in which the launce bury themselves and emerge during the incoming tide is thus very much greater than in bright, hot weather; and it is not unfrequently found by experience that the Mackerel catch in such localities is much greater in cloudy weather than in bright weather, because the bait ground is then far more extensive close inshore.

"As the summer advances and the launce retire to deep water the Mackerel feed upon the free-swimming and floating embryonic forms of crustaceans; among the latter the zoea of different forms of crabs are the most common. Adult shrimps of many species form also a large portion of their food, and the infinite numbers of these forms of life which exist in the sea, from the coast line to a thousand miles from land, may be inferred from the fact that, together with fish, they form the great staple of food of seals in northern seas.

"Dr. Robert Brown states that, during the sealing season in Spitzbergen seas, he has taken out of the stomachs of seals various species of *Gammarus* (*G. Sabini; G. loricatus; G. pinguis; G. dentatus; G. mutatus*, etc.), collectively known to whalers under the name 'mountebank shrimps,' deriving the designation from their peculiar agility in water.[1]

"These small crustaceans are found in countless numbers on the great outlying banks off the North American coast, and in the Labrador seas they are also in great profusion.

"It is of special importance to notice that very many if not all of these free-swimming creatures in the sea, from invisible microscopic forms to the largest shrimp, sink to different zones of water or rise to the surface with the variations in temperature and changes in the direction and force of the wind. In fine weather, when the food is at the surface, the Mackerel, the herring, and

[1] Dr. R. Brown: On the Seals of Greenland.

other surface feeders swim open-mouthed against the wind. Dr. Brown states that the right whale and most of the whale species feed in a similar manner. The right whale feeding swims leisurely at the rate of about four miles an hour. Mackerel, when feeding, come often by millions, like a swiftly moving ripple on the water, with eager, staring eyes and mouths distended to entrap the floating prey. *Many of the free-swimming pteropoda are active only during the night-time*, sinking during the day to a certain zone of depth.

"The effect of currents and tides, assisted by winds, is to drive these free-swimming forms towards the different shores and into land-locked or sheltered bays. On the shores of the open sea a continued land breeze drives them far out to sea, and the fish following them will be lost to view. *Off the coast of the United States the Mackerel ground is not unfrequently found near the* summer limit of the Gulf Stream where wide-spreading eddies prevail, caused by the meeting of the great Labrador current flowing in an opposite direction, or the surging up of the arctic underflow. In these vast eddies the temperature is greatly reduced by the mixing of almost ice-cold water from beneath with a warm overlying stratum.

"*It is here, too, that the free-swimming mackerel food will congregate, sometimes at the surface*, at other times at different depths, dependent upon the temperature of the mixed waters. In the vicinity of the south edge of the Grand Bank of Newfoundland the line of contact between the Arctic and the Gulf Streams is sometimes very marked by the local currents which 'boil and form strong eddies.' The line of contact of the two great cold and warm currents is continually changing for hundreds of miles with the varying seasons, and under the influence of winds; hence, also, the changes in geographical position and in the depth or zone of the open-sea mackerel grounds.[1]

"Inshore the floating and free-swimming food is drifted to and fro by winds and tides, and great accumulations are sometimes thrown up upon the beaches in windrows after storms. This floating and swimming food gathers in eddies, either near the coast line or at the junction of opposing tidal waves or currents. Hence, along sheltered and embayed coasts, confronting the open sea in the vicinity of banks where great tidal currents and eddies are formed, or in the gulf and estuary of the Saint Lawrence, where two opposite and wholly different tides dragging along the coast line approach to meet, there will be the mackerel ground of the fishermen, but not necessarily *at the surface*."

The winged pteropods very properly form an important part of the mackerel food, as they sink and rise with changes of the temperature of the zone or sheet of water in which they are feeding.

REPRODUCTION.—Although little is actually known concerning the spawning habits of the Mackerel compared with those of fish which, like the shad and the salmon, have been artificially propagated, it is perhaps safe to say that the subject is understood in a general way. The testimony of reliable observers among the fishermen of our coast and the coast of the British Provinces indicates that the spawning takes place in rather deep water all along the shore from the eastern

[1] There are no mackerel-fishing grounds within 300 miles or more of the Grand Bank, and certainly none nearer than 400 miles of its southern edge. It is possible that mackerel have occasionally been seen, or stray specimens captured, nearer the Grand Bank than this, but no mackerel fishermen would think of trying for these fish east of the west coast of Newfoundland. There are but two instances on record where mackerel fishermen have gone so far east as that. Whatever influence may be exerted upon other forms of ocean life by the meeting of the Gulf Stream and the Arctic Current, it can be quite safely asserted that the Mackerel are never found in summer near the junction of these currents, excepting, perhaps, on the southern edge of George's Bank and off the south shoal of Nantucket. These localities are the nearest mackerel-fishing grounds to the Gulf Stream of any on the United States coast. And even here Mackerel are rarely or never taken nearer than fifty or sixty miles from the northern edge of the stream.—J. W. COLLINS.

end of Long Island to Eastport, Maine, along the coast of Nova Scotia, and in the Gulf of Saint Lawrence. The spawning season occurs in May in Southern New England, in May and June in Massachusetts Bay, and in June in the Gulf of Saint Lawrence, and on the Bradley Banks and about the Magdalenes early in the month, and, according to Hind, on the northeast coast of Newfoundland toward the end of the month.[1]

Capt. Benjamin Ashby, of Noank, Connecticut, states that in the spring of 1877 Mackerel spawned in great numbers in Vineyard Sound and Buzzard's Bay. Many Mackerel were taken in the pounds, and the eggs were so ripe that when the fish were thrown from the net to the boat the eggs escaped to such an extent that in cleaning out the boat afterwards he found at least half a bushel at the bottom. This was as early as the 2d of May, and continued through the month.

Capt. R. H. Hurlbert, of Gloucester, found the spawn running out of Mackerel taken off Kettle Island, south of Cape Ann, in May and June.

Capt. Henry Webb, who owns a weir on Milk Island, under the shadow of the Thatcher's Island lights, obtains many Mackerel every year in his nets. He informs me that when they first make their appearance, about the first of June, the spawn is running out of them, and many of them are half through the process of spawning. The eggs will spurt from a female fish in a stream six feet long, and there is a large percentage of females in the catch, probably two-thirds of the whole. The spawn begins to dry up after the first of August, and young fish begin to appear about the 4th of August. He thinks that it takes Mackerel four or five weeks to spawn; after that they begin to grow fat, and when they are fat there is no sign of spawn to be seen, the male and female not being distinguishable.

The growth is rapid, and in about seven weeks the young fish are about four or five inches long.

Mackerel spawn abundantly in Grover's Beach at a depth of one and a half to two fathoms. The eggs are very minute, and the old Mackerel feed upon them greedily.

Captain Fisher, of Portland, Maine, told me, in 1874, that when the Mackerel come in they are almost empty and have a muddy taste. They first engage in spawning, but toward the last of June they have finished and begin to grow fat.

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[1] During the entire month of June Mackerel are taken in the Bay of Saint Lawrence with roes fully developed. Having been engaged in the Mackerel fishery in the Gulf for twenty-two consecutive seasons, ten of which I went to the Bay early in June, I have therefore had abundant opportunity to learn the spawning season of the Mackerel in that region. It is my opinion that Mackerel spawn in the Gulf of Saint Lawrence some time between the 1st and the 15th of July. Have caught them in abundance and full of roe as late as the 4th and 5th of July, and it is exceedingly rare to find spent Mackerel previous to the 20th of June. In the period when hook-and-line fishing was most prosperous, the fishermen usually planned to leave the Gulf about the first week in July if they had succeeded in getting nearly a fare of Mackerel previous to that time, since while the fish were spawning, or between the 1st and the 15th of the month, but little could be done, as the Mackerel would not readily take the hook. The fishermen, therefore, knowing that they could catch few fish during this period, between "hay and grass," as they termed it, usually improved the opportunity thus afforded of making their passage home and refitting for another trip with comparatively little loss of time. Apparently one of the most favorite breeding grounds for Mackerel in the Gulf of Saint Lawrence is the area along the shores of New Brunswick and Prince Edward Island (on the north side of the latter) lying inside of a line drawn from North Cape to Point Miscou. Bank Bradley is also a breeding ground for Mackerel of considerable importance. The fish seemed to assemble on the grounds mentioned above during June, in a depth varying from three to forty fathoms. The greater part, however, were found in a depth varying from ten to twenty fathoms. The spawning season being over, they usually stay on the same grounds, though later in the summer and during autumn the Mackerel were abundant around the Magdalenes and the bend of Prince Edward Island; when the fall migration takes place they move farther south. It is probable that large numbers of Mackerel may deposit their spawn around Magdalene Island, though it is worthy of note that but few or no fish have been taken in that locality on hook and line during the month of June. Considerable quantities are, however, caught by the gill-net fishermen early in June, though the catch was small compared with that formerly obtained by hook-and-line fishing in the western part of the Bay.—J. W. Collins.

Captain Hurlbert caught a dozen fish off Camden July 1, 1870, which were half spawned and had spawn running out of them.

According to Mr. Wilkins, of Two Isles, Grand Manan, the Mackerel spawn there on the rocks and sand in water from one foot to ten feet or more in depth. This is in the first half of June. The spawn is in bunches and does not float on the water.

During the spawning season Mackerel are taken in seines, as they will not bite and are then very poor. They come again in September and October, and are then taken with the hook.

Mr. Hall, of Charlottetown, Prince Edward Island, says that Mackerel spawn only once in seven years in large numbers, this period representing the interval between the successive large catches. The Mackerel strike in there about the 10th of June. They spawn about the 2d or 3d of July on the Bradley Bank to the north of Prince Edward Island. At that time they have been taken with spawn running out of them. They cease to bite for several weeks while spawning. One of the principal spawning grounds on our coast appears to be on the Nantucket Shoals, where for a period of three or four weeks after their first appearance the Mackerel hug the bottom and rarely take the hook. At this time there is a lull in the prosecution of the mackerel fishery, although before its beginning great quantities are taken in the purse-seines far south along the coast. After the close of the spawning season the old fish are said to be very poor, but take the hook greedily along the entire coast, as also before the beginning of the spawning season. Although the fish first brought to market are sold at a high price on account of their previous scarcity, it is not until after the close of the spawning season and the subsequent fattening up of the fish that they attain their highest excellence as an article of food. Fall Mackerel are well understood to be by far the best fish. Storer, in his "History of the Fishes of Massachusetts," remarks: "From the 10th of May to the 15th of June they appear at the entrance to Massachusetts Bay, having been a few days previous at Nantucket and the Vineyard Sound. Nine-tenths of those first seen are males, and they are all large but poor, weighing from one pound to one pound and a half. At their first appearance they will not take the hook, and are therefore captured in seines."

The contrast between the statements of Storer and Captain Webb should be carefully noted. The former states that the early fish taken near the end of Cape Cod are mostly males. This would naturally be the case, as the females at this time are either engaged in spawning or are perhaps so weak that they would not be likely to come to the surface. At Milk Island, however, which seems to be in the middle of the spawning region, the majority of the fish are females.

We are indebted to Capt. N. E. Atwood for the most complete series of observations upon the spawning of the Mackerel which has ever been made, and what he has seen he shall be allowed to tell in his own words:

"I have many seasons been engaged in fishing for Mackerel in our bay with gill-nets. I watched the Mackerel more particularly in regard to their time for spawning. In 1856, owing to the fact that a measure had passed the Massachusetts legislature authorizing the appointment of three commissioners to make investigations with regard to the artificial propagation of the fish, and that I expected to be named one of the commissioners, I went to the upper part of Massachusetts Bay, where it is about twenty miles broad, and I found these spawning Mackerel there near the bottom. This year the Mackerel came in about the middle of May; few at first. On the 20th I went out for the first time with my drifting-nets all night in the bay; I caught 2,250 Mackerel; on the following night I caught 3,520. When I first began to catch them I observed that the spawn had come to its full size, though it was not free to run from them, not being yet fully matured. On or about the 1st of June we found that some of them were depositing spawn, and as I took them from the nets the spawn ran freely. On the 5th of June I took the mature eggs as they came from

the fish and put them in alcohol, marking the date, as I considered this time the middle of the spawning season. (By the 10th of June the fish had all deposited their spawn, and they then proceeded to the grounds where they expected to meet with better food in order to fatten and recruit. The spawning takes place at a depth of from five to fifteen fathoms.) Thirty days after I went out in the bay and found any quantity of schools of little Mackerel which were, I should think, about two inches long, though their length might have been a little less. I took a number of specimens and put them in alcohol, marking the date. Twenty-five days later I procured another lot of them which had grown to double that size. I don't mean to imply that they were twice as long, but twice as heavy. I put them also in alcohol, marking the date. The first time I subsequently went to Boston I called on Professor Agassiz and gave him the specimens. He said that he had never before been able to ascertain these facts so clearly and so well, and that he was very much pleased with them. I watched the growth of these young Mackerel all along, and I saw them grow considerably from month to month, so much so that the same fall, in the latter part of October, I caught some of them with a very small mesh net and found they had grown to a length of six and a half or seven inches. I kept a small quantity of them, split, salted, and packed them, in accordance with the Massachusetts inspection law, as No. 4's, and since Mackerel were then scarce and very high in price, I sold them for as much as $6 a barrel."

"Much yet remains to be learned in regard to the spawning season of the American Mackerel," writes Professor Baird, "and little more is known of this except in regard to the European variety. It is, however, well established by the researches of Sars that this fish, like the cod, and many of the flat fish, etc., spawns in the open sea, some times at a great distance from the land, at others closer inshore. Sars found them on the outer banks of the coast of Norway; and Mr. Matthias Dunn, of Mevagissey, England, communicates to 'Land and Water' his observations of Mackerel found, with ripe spawn, six miles from the coast.[1]

"The fish taken in the weirs and pounds on Vineyard Sound and about Cape Cod in the early spring are filled with ripe spawn; and that the operation of spawning takes place on the American coast is shown by the immense schools of small fish that are taken throughout the summer, of various sizes, from a few inches up, and from Buzzard's Bay to Portland and Penobscot Bay. No species of young fish is, at times, more abundant throughout the summer season than the Mackerel.

"The egg of the Mackerel is exceedingly minute, not larger than that of the alewife or gaspereau. It appears to be free from an adhesive envelope, such as pertains to the egg of the herring, and in consequence of which it agglutinates together, and adheres to gravel, the rocks, or the seaweed at the bottom. As with the egg of the cod, that of the Mackerel is provided with an oil globule, which makes it float nearly at the level of the surface."

I am indebted to Mr. Frederick W. True for an enumeration of the eggs in two Mackerel taken at Wood's Holl, Massachusetts, in May, 1873; one of these contained 363,107, the other 393,887.

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[1] SIR: I have been again fortunate in taking a Mackerel alive in the act of spawning, on the night of May 10, about six miles from land. A better specimen could not possibly be had, and the roe ran freely without assistance. I got a bucket of sea-water, and allowed the fish to spawn in it; for some time I had a difficulty in finding what became of it, as the globules would not reflect the light of the candle like the pilchard spawn; but by running the water into a clean bottle, and holding it to the light, I found them floating on the surface, but not so buoyant as the pilchard roe. In this state they continued for about half an hour, and then gradually sank to the bottom; but, unlike the pilchard spawn, they retained their vitality there for more than twelve hours. With the daylight the globules could scarcely be discerned by looking directly down into the water; but on holding it towards the light in a bottle they could be seen, with that healthy, bright silvery hue so peculiar to living ones, each marked with a dark spot in the center. Believing the pilchard spawn would have reached you, I did not send you any of these. As I sent that spawn by post, I suppose the bottle must have been broken in the post-bag.—MATTHIAS DUNN (Mevagissey, Cornwall, May 15, 1871), *Land and Water, May 20, 1871, p. 353.*

The only previous record of the number of eggs yielded by Mackerel is that made by Thomas Harmer, in 1764, and published in the "Philosophical Transactions" of London, vol. 57, p. 285. He found in one large Mackerel, weighing one and a quarter pounds, 454,961 eggs; in a second, of much the same weight, 430,846; and in a third, weighing about one pound two ounces, 546,681.[1]

RATE OF GROWTH AND SIZE.—The rate of growth of the Mackerel during the first summer has been quite carefully studied by Captain Atwood; and the same authority has, perhaps more satisfactorily than any other, interpreted the facts from which may be deduced the conclusions as to their growth year by year.

Referring to the small fish, six and a half or seven inches in length, which he believed to be the young of the year, caught by him in October, 1856, he says: "Fish of this size are sometimes called 'Spikes,' but I do not know their proper name. The next year I think they are the 'Blinks,' being one year old; the following year they are the 'Tinkers,' two years old, and the year after they return to us as the second-size, three years old. It is probable that the fish reaches its full maturity in four years." He continues: "The first Mackerel that come in are very large and spawners, but these do not bite at the hook; and you don't catch them with the seine, because they don't show themselves. You would not know of their presence if you did not set nets for them. When they are taken in nets set anywhere along the coast, at Provincetown, etc., a good many people imagine that they are the remnant of the Mackerel which were there the year before, and which have been imbedded in the mud; and when they taste these fish they fancy that they taste mud. When the next school arrives there appear Mackerel of different sizes, which take the hook. They are carried to Boston market and are sold fresh in their season. They are not sold by weight, but are culled, and are denominated as follows: Large ones, second-size, "Tinkers," and "Blinks." When the large ones are worth twelve cents, the others may sell, second-size, eight cents; Tinkers, four cents, and Blinks, one and a half cents. These prices may fluctuate when there occurs a large proportion of one or more of the above-named kinds at the same time. Any man who is well acquainted with them will make the same culling, as there seems to be a line of demarkation between the different kinds which stands out prominently.

"Admitting this to be the fact, those that come as Blinks are from the spawn of the year before, while those which are called "Tinkers" are from the Blinks of the year previous, being the two-year-old fish; and those that are called second-size are from the Tinkers of the year before; when they grow up and mix with the bigger ones, I don't know how they live, or much about them. This is my opinion about these matters. You will find that fishermen will tell you they think that Mackerel are six or seven years in getting their growth."

Mackerel, when full grown, are from seventeen to eighteen inches in length; sometimes they attain a larger size. In August, 1880, a school of Mackerel was taken in the vicinity of Plymouth; they weighed from three to three and a half pounds each, and were from nineteen to nineteen and a half inches long. They were regarded as extraordinarily large, and a barrel of them were sent to the Fishery Exhibition at Berlin as an illustration of the perfection to which the Mackerel attains in this country. Although the size just mentioned is unusual at present, in past years many thousands of barrels have been taken nearly, if not quite, as large. The size varies from year to year, sometimes very few barrels which can be rated as No. 1's being found in our waters.

No.	Date.	Weight.	Weight of spawn.	Number of eggs.	Number to a grain.
		Ounces.	*Grains.*		
1	June 20, 1764	20	1,027	454,961	443
2	June 29, 1764	20	949	430,846	454
3	June 18, 1765	18	1,223½	546,681	447

A No. 1 Mackerel, according to the Massachusetts inspection laws, measures thirteen inches from the tip of the snout to the crotch or fork of the caudal fin. The average length from year to year for the whole coast is probably not far from twelve inches in length, and a weight of twelve to sixteen ounces. The following quotations from writers of two centuries ago are interesting, since they show that large Mackerel were known to the early colonists of New England:

"The mackerel, of which there is choicefull plenty all summer long; in the spring they are ordinarily 18 inches long; afterwards there is none taken but what are smaller."[1]

"The Makarels are the baite for the Basse, & these have been chased into the shallow waters, where so many thousands have shott themselves a shore with the surfe of the Sea that whole hogges-heads have been taken up on the Sands; & for length they excell any of other parts: they have bin measured 18. & 19. inches in length and seaven breadth: & are taken with a drayee, (as boats use to pass to & froe at Sea on business,) in very greate quantities all along the Coaste.

"The Fish is good, salted; for store against the winter, as well as fresh, & to be accounted a good commodity."[2]

ENEMIES OF THE MACKEREL.—The gannet is one of the most destructive enemies of the Mackerel. These birds are often seen so heavily weighted with these fish that they are unable to rise on the approach of the vessel until they have disgorged from two to four good-sized Mackerel. This is so common an occurrence that there are but few fishermen who have not witnessed it.

Porpoises and whales may also be included in the list of enemies of the Mackerel. It is by no means an unusual sight on the fishing grounds to see hundreds of the former rushing and leaping among schools of Mackerel, scattering them in every direction.

The shark known to fishermen as the "mackerel shark" is one of the principal enemies of the Mackerel. I have often seen them chasing Mackerel, and, when jigging was practiced, it was a common occurrence for sharks to drive off a school from alongside of a vessel.

Dogfish often hover around the outside of large schools of Mackerel, and doubtless feed on them. Great difficulty is sometimes experienced in saving fish that have been inclosed in a purse-seine, owing to the immense numbers of dogfish that gather around and, in their efforts to eat the Mackerel, which they see through the meshes, bite off the twine, making large holes in the seine through which the inclosed fish escape.

Among the other principal enemies of the Mackerel are the bluefish, mackerel shark, and the cod. The appearance of a school of bluefish in waters crowded with Mackerel is an almost sure signal for their disappearance.

The young Mackerel are eaten by squids also. Professor Verrill has recorded the following account of the maneuvers of the squid known to zoologists by the name *Ommastrephes illecebrosus*:

"Messrs. S. I. Smith and Oscar Harger observed it at Provincetown, Massachusetts, among the wharves, in large numbers, July 28, engaged in capturing and devouring the young Mackerel, which were swimming about in 'schools,' and at that time were about four or five inches long. In attacking the Mackerel, they would suddenly dart backward among the fish with the velocity of an arrow and suddenly turn obliquely to the right or left and seize a fish, which was almost instantly killed by a bite in the back of the neck with the sharp beaks. The bite was always made in the same place, cutting out a triangular piece of flesh, and was deep enough to penetrate to the spinal cord. The attacks were not always successful, and were sometimes repeated a dozen times before one of these active and wary fishes could be caught. Sometimes after making several unsuccessful attempts one of the squids would suddenly drop to the bottom, and, resting upon the sand, would

[1] JOSSELYN, 1675.

[2] New England's Fish, JOHN SMITH, 1622. United States Fish Commission Report, Part I, p. 153.

change its color to that of the sand so perfectly as to be almost invisible. In this way it would wait until the fishes came back, and when they were swimming close to or over the ambuscade, the squid, by a sudden dart, would be pretty sure to secure a fish. Ordinarily when swimming they were thickly spotted with red and brown, but when darting among the Mackerel they appeared translucent and pale. The Mackerel, however, seemed to have learned that the shallow water is the safest for them and would hug the shore as closely as possible, so that in pursuing them many of the squids became stranded and perished by hundreds, for when they once touch the shore they begin to pump water from their siphons with great energy, and this usually forces them farther and farther up the beach. At such times they often discharge their ink in large quantities. The attacks on the young Mackerel were observed mostly at or near high water, for at other times the Mackerel were seldom seen, though the squids were seen swimming about at all hours; and these attacks were observed both in the day and evening."

The dogfish is doubtless a dangerous foe to the Mackerel weakened by the act of spawning and remaining near the bottom. An old fisherman has described to me with great animation how greedily the dogfish devour the Mackerel which have become gilled in the nets, how they follow them to the surface and linger about the vessel while the process of cleaning is going on, drinking the blood of the fish as it flows from the scuppers.

STUDIES OF THE MOVEMENTS OF THE MACKEREL SCHOOLS.

HIND ON THE CAUSES OF IRREGULAR MOVEMENTS.—In closing this chapter upon the natural history of the Mackerel, it seems appropriate to quote from the writings of Professor Hind some very important paragraphs in which he has attempted to interpret the irregular movements of the mackerel schools in our waters, and to explain the causes of the alleged annual variation of their numbers:

"What is the proper interpretation of the movements of the Mackerel from its first appearance in the spring to its disappearance in the fall? These movements vary with the geographical position of local schools of this fish. On the coasts of the United States and Nova Scotia, its annual movements resemble in all particulars those of the same species in European seas where the schools have a free and unobstructed ocean in which to seek their prey.

"In the spring, at the end of April and May, the Atlantic schools of this fish which have wintered off the coasts approach the land in separate bodies, full of spawn and poor, coming direct from winter homes where they have remained in a torpid condition, partially buried in sand or mud. After spawning, the different schools feed for a short time on the fry of fish, and as the temperature rises they go out to sea in search of free-swimming crustaceans and larval forms of food according as they are distributed by wind and tide.

"They pursue this food against the current or tide. They often feed during the night, because at that period great numbers of free-swimming larval forms approach the surface. This is one reason why mackerel schools are frequently missed by fishermen, and areas supposed to be deserted may really abound with this fish, which would be discovered by sink-net fishing. The currents are constantly changing with the seasons under the influence of temperature and prevailing winds, hence the course of direction and depth of the food is constantly changing also.

"Sometimes it is carried far off from the land, at other times towards it, and the mackerel schools following the food move first in one direction, then in another, and range from close inshore to fifty miles and more seawards, and often, doubtless, at a considerable depth below the surface.

"The general direction of these movements, when plotted on paper, would be a series of irregu-

lar circles or elongated ellipses, the range of each school or group of schools being opposite and often adjacent to that part of the coast where they spawn.

"As the fall approaches, owing to the diminution in the supply of their floating food out at sea, they come more inland.

"All the free-swimming larval forms of most species of shrimps, crabs, lobsters, sea-urchins, star-fish, sea-worms, &c., have disappeared in the open sea, after passing through their final transformation. But near the shore there are great numbers of other forms of life, which are developed later in the year. Coming inshore to feed on these on the Atlantic coast, the Mackerel are found by American fishermen later and later on their return voyage to the southwest, which gives rise to the impression that they are following the schools, when they are only meeting with fresh schools approaching the shore from their feeding grounds. Similar movements occur on the Atlantic coast of Nova Scotia and Cape Breton. As winter approaches, beginning at Cape Breton in November, the different schools retire to their winter homes off the coast in deep water later and later from north to south.

"In the Gulf of Saint Lawrence, where land is, as it were, on all sides, the local schools come from their winter haunts to the banks and beaches of the Magdalens, of Prince Edward Island, in the Bay Chaleur, etc., to spawn about the first week in June. They retire after spawning to deep water, and meet the incoming sand-launce. They follow the sand-launce inshore or on to banks, and for some weeks feed on these fish. When the sand-launce again retires to deep water, the season of the small crustaceans has arrived, and these by tidal action, already described, and winds, are concentrated near the coast lines of Prince Edward Island, New Brunswick, the north and south shore of the estuary and gulf of Saint Lawrence, and the shores of Cape Breton. On all these coasts the effect of the single and confluent tides, dragging along the coast line and retarded by it, is to produce eddies, where the free-swimming food concentrates. The course of direction of the different schools during the summer is thus dependent upon winds and tides, and their movements would, if correctly plotted, resemble long narrow ellipses adjacent to the coast, which are doubtless many times repeated.

"At the approach of winter the different schools seek their winter quarters opposite and near to the places where they spawned in the preceding spring, as is the case of the schools on the Atlantic coasts. In these particulars their movements resemble those of different species of fish which feed and move in great schools in directions outlined by circles or ellipses throughout the period during which they are at the surface.[1]

[1] It is a fact well known to all experienced mackerel fishermen that during the month of May and the early part of June large bodies of Mackerel pass along the shores of Nova Scotia and Cape Breton from west to east, and while many schools move through the waters of Chedabucto Bay and the Straits of Canso to the Gulf of Saint Lawrence, another body passes in around the east end of Cape Breton Island, their destination being the same as those fish taking the shorter route. No better evidence of this migratory habit can be deduced than the fact that at this season of the year the fishermen along the Nova Scotian coast and about the Strait of Canso are busily employed in catching Mackerel both in gill-nets and in drag-seines. On some occasions when the season has been exceptionally favorable the amount of Mackerel so taken has often been very great. This movement of the Mackerel is so regular and so well-defined that the fishermen rarely fail to tell within a few days, or perhaps even a few hours, of the time when they will appear on certain portions of the coast. The fall migrations are quite as regular. As the season advances and the temperature of the water decreases, the Mackerel, instead of simply changing their position into deeper water near their summer habitat, as has been stated by Professor Hind, move in vast bodies towards the southern part of the Gulf of Saint Lawrence, frequently striking in a succession of waves, as it were, on the northern shores of Cape Breton Island, where, deflected from their southern course, they divide into two streams or branches, one passing through the Strait of Canso, and the other out round the north cape of the island, and by its eastern and southern sides, and so on up along the south coast of Nova Scotia. The Mackerel which are found about the Magdalene Islands during the summer and early autumn apparently move in a nearly direct line towards the northeast end of Cape Breton Island, when they begin their fall migration. I have often had occasion to notice, in a practical way, these movements, the knowledge of which is of vital importance to the fishermen and of considerable interest to the

"Sars has shown that this form of movement is taken by the herring on the Norwegian coast.[1]

"The Mackerel are pursued by cod and hake, and these fish gather where offal is thrown over from vessels on which the Mackerel are cleaned. As a natural consequence the Mackerel avoid the sea areas where their enemies are congregated, and fishermen attribute the desertion of the mackerel ground *directly to the throwing of offal overboard. Cod, and probably hake, follow* up the scent of offal or food of any description carried by currents with remarkable facility, as may be witnessed during the process of jigging for cod in calm and clear waters. On looking over the side of a boat, with a man engaged in jigging at the bow or stern, as soon as a fish is wounded merely by the jigger and blood flows from the wound, the creature may be seen to dart here and there in pain. The neighboring fish of the cod tribe are attracted by the scent and follow the blood 'tracks' against the current, hunting their wounded comrade to the death. A fish coming across the stream of scent immediately follows it up, and it is thus that fish offal or bait thrown overboard in the open sea, or some distance from shore, gathers the fish on the course of the current. In harbors and confined or land-locked bays, where there is no constant strong current to *carry off the results of decomposition, and where the sea-scavengers are not sufficiently numerous* to consume it, the effect cannot fail to be extremely prejudicial to young fry and to fish-spawn.[2]

"The effect of temperature on the local movements of the Mackerel may be recognized in the process employed by fishermen to 'raise' Mackerel by toll bait, and luring them seawards. The Mackerel follow the bait for some distance from shore, where suddenly they cease to bite and disappear. They probably find long exposure to the warm temperature of the surface waters unsuited to their habits, and sink to a cooler zone.

"Hence the reason why a 'mackerel breeze,' mixing the heated surface water with the cooler understratum, is favorable to prolonged mackerel fishing with bait. The mixing produced by agitation cools the surface and permits the fish to feed for a lengthened period."[3]

"The Mackerel, like the herring and the cod, seeks cold water for its spawning grounds wherever the Labrador current exercises its influence. Between Block Island and No Man's

naturalist. On one occasion, in the fall of 1867, an immense body of Mackerel was found along the north shore of Cape Breton, and on the last day that the fish were seen the schools came near the surface of the water, and I feel safe in saying, from actual observation, that they moved at a rate of no less than three or four miles per hour in the direction of the north cape of the island. On another occasion, a body of Mackerel that was found near Amherst Island (one of the Magdalenes) one day, were met with the following morning about thirty miles distant from the first locality, in the direction of the north cape of Cape Breton Island, towards which they were moving at the rate of one or two miles an hour. I have myself seen schools of Mackerel off the Nova Scotian coast, in the fall, moving quite rapidly in a westerly direction, but all efforts to catch them with a hook failed, since they seemed to pay no regard whatever to toll bait. All of my own observations, and those of the Nova Scotian fishermen with whom I have been brought in contact, lead me to believe that Mackerel will not bite the hook to any extent during their fall migrations along the southern coasts of Nova Scotia. This is all the more remarkable since they seem to take the hook very eagerly up to the last moment of their stay on their feeding grounds in the gulf. The spring and fall migrations of the Mackerel on our own coast are carried on with equal regularity and precision. On more than one occasion, in autumn, I have followed these fish day after day in their progress to the south and west along the shores of Maine and Massachusetts. On one occasion, in the fall of 1862, I caught Mackerel nearly down to the fishing rip on the Nantucket *Shoals. These fish were moving rapidly southward, and the schools could be kept alongside of the vessel only a short* time, and each trial had to be made two or three miles farther south than the previous one. At another time, in the fall of 1870, the Mackerel moved in large schools very rapidly from Ipswich Bay across in the direction of Cape Cod. The schools were at the surface of the water, and it is not an exaggeration to say that their speed was not less than three or four miles an hour. Each body of fish was separated from the others, perhaps many hundred fathoms, but all seemed to be impelled by the same motive, and were moving steadily in the same direction. These fish would bite eagerly at the hook for a few minutes at a time, but so strong was their instinct of migration that it was impossible to detain them only a short time in their onward movement.—J. W. COLLINS.

[1] See chart by Dr. G. O. SARS, in his report for 1874.

[2] Fisheries of British North America, pp. 20, 21.

[3] Fisheries of British North America.

Land, where the spawning grounds on the United States coast south of Cape Cod are alleged to exist, a thin wedge of the Labrador current stretches far into Long Island Sound.

"In Massachusetts Bay, where a mackerel spawning ground also exists, as also in the vicinity of Stellwagen Bank, the temperature when observed by Dr. Packard in September ranged from 41½° to 45°, and the fauna resembled the cold-water species on each side of Jeffrey's Ledge. On George's Shoals the marine life is said by Verrill to be the same as that found in the deeper muddy parts of the Gulf of Saint Lawrence, and indicates a temperature not above 40°, and probably considerably lower. Bradelle Bank, according to Mr. Whiteaves, presents the phenomenon of a small stony patch tenanted by an assemblage of marine animals which usually inhabits very cold water, and are almost entirely surrounded by another series, which are for the most part prevalent where the bottom is warmer and more affected by surface conditions of temperature.

"Wherever the areas are situated where young Mackerel are found in the summer we find near at hand a cold-water zone, either existing as a part of the Labrador current at the surface or brought up from greater depths by banks and shoals. On the coast of Prince Edward Island, and in the gulf generally, the cold water lies frequently near the shore, because the diurnal tides mix the strata warmed during the daytime with the cold underlying strata. In the estuary of the Saint Lawrence Dr. Kelly found the surface temperature 57° F. on the 9th July, but three feet below the surface it was 44°, having in that short vertical space sunk 13°; at twenty-four feet it was 40°, or 17° below the surface temperature."

96. THE CHUB MACKEREL—SCOMBER COLIAS.

The Chub Mackerel, or, as it is also called, the "Thimble-eye," "Big-eyed Mackerel," or "Bull Mackerel," closely resembles in general appearance the common Mackerel, from which it is distinguished chiefly by the presence of an air-bladder, and also by the occurrence of a row of indistinct circular spots upon the sides below the lateral line. This is the fish which is called "Spanish Mackerel" in England, and the name was brought to us by the early English fishermen of New England. It has been found at Pensacola and Charleston, as well as in New England. There is another fish closely related if not identical with *S. colias*, which Professor Jordan found to be abundant in California, which corresponds to the *S. pneumatophorus* of the Mediterranean,[1] and has been described from the Pacific as *S. diego*. Professor Jordan considers this to be the *S. grex* of various authors, but writes that he is not yet prepared to accept as final the judgment of Steindachner and Vaillant that it is the young of *S. colias*. The lower half of its sides is silvery and without any gray spots, such as are conspicuous in *S. colias*. Jordan has specimens of the unspotted form much larger than his smallest specimens of the true *S. colias*.

The history of the Chub Mackerel on our coast is a peculiar one. At the beginning of the present century it was exceedingly abundant all along the coast of New England and New York. Mitchill, writing in 1814, remarked of it:

"Comes occasionally in prodigious numbers to the coast of New York in autumn. This was memorably the case in 1781 and 1813, when the bays, creeks, and coves were literally alive with them, and the markets full of them."

DeKay remarks: "In the early part of November, 1828, they were also very abundant, and many persons were poisoned by eating them."

Capt. Epes W. Merchant, of Gloucester, a veteran fishing skipper, who has been familiar with the fisheries of Massachusetts Bay for the past seventy years, told me that the Thimble-eye

[1] CANESTRINI: Fauna d' Italia. Pesci, 1872, p. 101.

were so abundant from 1814 to 1820 that with three men and a boy and a small vessel he could catch ten barrels of them, or about three thousand fish, in a day.

The "Fishermen's Memorial and Record Book," published in Gloucester, contains the following note:

"In 1812 a large school of Spanish Mackerel visited this bay, and so plenty and numerous were they that they would bite readily at the bare hook and seize upon small bits of line hanging from the vessel. Standing-room boats were then mostly in use, of from fifteen to twenty tons. These rooms held from fifteen to twenty barrels, and the crews would catch them full in a few hours. Mr. Timothy Rogers, at Rowe's Bank, bought most of these Mackerel, fresh, after being dressed, at two cents per pound, salting them in his buildings, and the business, which lasted two months, was a lively one. These Mackerel did not continue on this coast but a few years, and have now almost entirely disappeared. There were a few caught, with the other Mackerel, as late as 1825, since which time it is very rare to see one during the entire season."

Captain Oakes states that the "Thimble-eye Mackerel," or "Mixed Mackerel," were very plentiful from 1826 to 1830. In 1826 he went fishing in the schooner "Delegate." The season's catch amounted to fifteen hundred barrels. Perhaps twenty-five barrels of these were "Thimble-eyes."

Capt. N. E. Atwood, of Provincetown, wrote, in 1878, that sixty years ago, when he was a boy, and many years afterwards, they were very abundant in Massachusetts Bay, but that he has not seen them for nearly thirty years. They went away before the bluefish returned, and before any weir, trap, pound, or any other engine of wholesale destruction was set in the New England waters.

Storer, writing in 1846, remarked: "This fish is of late years found more rarely along our coast than formerly. Captain Blanchard informs me that during some seasons but two or three individuals are taken by the fishermen. Captain Atwood has seen but a single specimen during the last four or five years. Many years ago it was abundant at Provincetown, and would run up the small creeks and be left by the tide."

J. V. C. Smith, in his "Natural History of the Fishes of Massachusetts," published in 1843, remarked that "they abound at New York, but for some reason make their appearance north of Cape Cod."

From these testimonies it would appear that between 1840 and 1850 the species, formerly so abundant, had disappeared along the whole coast line. In an essay by the writer, written in the spring of 1879, this sentence occurs: "For ten years past the Smithsonian Institution, with its collectors stationed at various points from Halifax to Galveston, has tried in vain to secure one of them, and it is probable that no museum in the world possesses a species of this fish, once so common."

In the summer of 1879, however, during the stay of the Fish Commission at Provincetown, a considerable school of these fish came into the harbor and were taken in company with the Tinker Mackerel. None were observed there in 1880, however, and it remains to be seen whether they have returned to be again counted among the permanent members of the fauna. This fish, during the period of its abundance on our coast, was considered an excellent article of food, and was by many preferred to the common Mackerel. On account of its small size, however, it was not so much sought after by the fishermen.

Concerning the Mackerel of the Pacific coast, which Professor Jordan considers to be identical with the *Scomber pneumatophorus* of the Eastern Atlantic, this authority writes:

"The Tinker Mackerel, *S. pneumatophorus*, is known as 'Mackerel,' 'Easter Mackerel,'

'Tinker Mackerel,' and 'Little Mackerel.' It reaches a length of about fourteen inches. It ranges northward to Monterey Bay, appearing in the fall in irregular and often large schools, usually disappearing in November. Some years few or none are seen. It is a good food-fish, but little attention is paid to it, on account of its small size and irregular occurrence."

The following account of the early discovery of Mackerel on the California coast appeared in the Gloucester "Telegraph" of July 20, 1870:

"Mackerel are reported quite abundant along the coast of California, but the people of that State have not learned to catch them, and continue to import their Mackerel from the Eastern States. Only one or two attempts have been made to avail themselves of a supply nearer home. In 1855 a few San Francisco fishermen made a trip to Santa Barbara Channel, in a small schooner, and soon filled her with Mackerel, but instead of cleaning them and soaking them out they threw them into salt without dressing, and when they arrived home their fish were, of course, in bad order. A more experienced captain in 1858 put up properly a hundred barrels of No. 2 Mackerel at Santa Barbara, which he disposed of at $16 per barrel. The San Francisco 'Bulletin' claims that enough can be caught there to supply the want of their market, while salt of the best quality for curing them can be got free from the neighboring salt-water lagoons. It says that the Mackerel abound there all the year round—which is probably incorrect—but that the months for taking them in the largest quantities are June, July, and August. 'If Mackerel are caught before June and after August,' says the 'Bulletin,' 'they are too poor to cure to advantage, and deserve the name of "leather-bellies." And if they are not cleaned and washed in salt water immediately after being caught, and before salting, they will spoil and become at least inferior food. But with necessary experience, skill, and judgment on the part of the fishermen, and the encouragement, enterprise, and outlay on the part of all interested in trade and the development of our home industries, there are Mackerel enough on our coast of the best quality to supply all the wants of our city and State.'"

97. THE FRIGATE MACKEREL—AUXIS THAZARD.

This species has also lately made its appearance in our waters, none having been observed before 1880, when they came in almost countless numbers. It is yet to be determined whether this species is to be a permanent accession to our fauna. It is the "Timberello" of the Adriatic fisher folk.

The United States Fish Commission obtained numerous specimens, twenty-eight barrels having been taken in a mackerel seine ten miles east of Block Island on August 3, 1880, by the schooner "American Eagle," Capt. Joshua Chase, of Provincetown, Massachusetts.

The Frigate Mackerel resembles, in some particulars, the common Mackerel; in others, the bonito, the genus *Auxis* being intermediate in its character between the *Scomber* and the related genera *Pelamys* and *Orcynus*. It has the two dorsal fins remote from each other as in *Scomber*, and the general form of the body is slender, like that of the Mackerel. The body is, however, somewhat stouter, and, instead of being covered with small scales of uniform size, has a corselet of larger scales under and behind the pectoral fins. Instead of the two small keels upon each side of the tail, which are so noticeable in the Mackerel, it has the single, more prominent keel of the bonito and the tunny. Its color is grayish-blue, something like that of the pollock, the belly being lighter than the back. Under the posterior part of the body, above the lateral line, are a few cloudings or maculations resembling those of the Mackerel. The occurrence of a large school of this beautiful species in our waters is very noteworthy, for the fish now for the first time observed are very possibly the precursors of numerous schools yet to follow. It is not many years

since the bonito became an inhabitant of our waters, and the distribution and habits of the Frigate Mackerel are supposed to be very similar to those of the bonito, *Sarda pelamys*, and the little tunny, *Orcynus thynnus*, which also first came on the coast in 1871, and have since been found in considerable numbers.

The Frigate Mackerel has been observed in the West Indies, and other parts of the tropical Atlantic, as well as on the coast of Europe. In Great Britain it is called the "Plain Bonito." It is not unusual in the Bermudas, where it is called the "Frigate Mackerel," a name not inappropriate for adoption in this country, since its general appearance is more like that of the Mackerel than the bonito, while in swiftness and strength it is more like the larger members of this family.

Since the first appearance of this fish many new observations of its abundance have been received. These fish appeared to come in immense schools into the waters between Montauk Point and George's Bank; and from Mr. Clark's statements it appears that they have been observed in small numbers by fishermen in previous years. Several vessels have come into Newport recently reporting their presence in immense numbers in the vicinity of Block Island. It will interest the "ichthyophagists" to know that several persons in Newport have tested the fish, and pronounce it inferior to the bonito. Part of the flesh, that on the posterior part of the body, is white, but behind the gills it is black and rank, while the meat near the backbone is said to be of disagreeable, sour flavor.

It is hard to predict what its influence will be upon other fishes already occupying our waters. Its mouth is small and its teeth feeble, so that it is hardly likely to become a ravager, like the bonito and the bluefish. There is little probability, on the other hand, that its advent will be of any special importance from an economical point of view, for its oil does not seem to be very abundant, and it will hardly pay at present to capture it solely for the purpose of using its flesh in the manufacture of fertilizers.

Mr. A. Howard Clark, at that time in charge of the Fish Commission station at Gloucester, communicated to Professor Baird interesting statements regarding its abundance. From these it would also appear that the species has been observed occasionally in past years. He wrote under date of August 10: "I have received this morning from the schooner 'Fitz J. Babson,' just arrived from Block Island, a fish answering to your description of the Auxis, having a corselet of scales around the pectoral fin, as in the tunny. The captain of the vessel, Joshua Riggs, reports that about a week ago we had a hundred barrels in the seine at one time, and saw over twenty schools of them. He saw them as far east as Sow-and-Pig light-ship. They are very easy to catch, flip like menhaden, do not rush, and are not frightened at the seine. They go in immense numbers—he thinks as many as one thousand barrels to a school. The day after the appearance of these fish the Mackerel disappeared, but he does not know whether the Mackerel were driven away by them or not. They feed on Mackerel food. Mr. Daniel Hiltz, of the same vessel, says that he caught one of just the same kind, in February, 1879, on a haddock trawl on the eastern part of the Middle Bank, in forty fathoms of water. He took it to Boston, where it was called a young bonito.

"Mr. John Henderson, of the schooner 'Sarah C. Wharf,' says that two vessels caught such fish recently eastward of here. The schooner 'American Eagle,' of Provincetown, took a number of barrels of them into Newport, and sold them for a dollar a barrel. Another Cape Cod vessel [he does not know her name] took about fifty barrels of them and threw them away. All the mackerel seiners from Block Island report seeing quantities of this new fish within the past fortnight. The captain of the schooner 'Sarah C. Wharf' says he first saw them a fortnight ago, some

fifteen miles off Block Island. The captain and several of the crew of the 'Ella M. Johnson,' of Newburyport, just arrived from Block Island, state they saw abundance of the Auxis, but did not know what it was until the reports came from you at Newport. They opened one and found in its stomach the ordinary red mackerel food. This crew differ with the crew of the schooner 'Fitz J. Babson' with regard to the ease of capturing them; think them rather difficult to take; say they flip like pogies, and do not rush like Mackerel. "They saw ten large schools of them on Saturday last, when some fifteen miles south of Block Island."

It is very important that any observations made upon this species in years to come should be reported to the United States Fish Commission. The length of those I have seen ranges from twelve to sixteen inches, and their weight from three-quarters of a pound to a pound and a half or more. Those sent to New York market were part of the lot taken by the schooner "American Eagle" and brought into Newport, whence they were shipped by Mr. Thompson, a fish-dealer of that place. It would require from eighty to one hundred of them to fill a barrel; so the estimate of Captain Riggs, that there are a thousand barrels in one of the schools, shows how exceedingly abundant they must be. The name "Frigate Mackerel," used in Bermuda, would seem to be the best name for use in this country, since the fish resemble the Mackerel more than they do the bonito or tunny.

Capt. N. E. Atwood, of Provincetown, Massachusetts, the veteran fisherman-ichthyologist, has examined the specimens, and is satisfied that they belong to the same species with a fish which he found abundant in the Azores in 1840, when, led by the reports of Cape Cod whalers, he went to these islands in search of the Mackerel, the mackerel fishing being poor at home. No Mackerel were found except the Frigate Mackerel.

98. THE SPANISH MACKEREL AND ITS ALLIES.

The genus *Scomberomorus*, until recently known to naturalists under the name *Cybium*, is represented upon our Atlantic coast by three species, and on the coast of California by one. Of the three eastern species the Spanish Mackerel, *S. maculatus*, is the most important, although the others grow to a larger size. The three species may be distinguished by the following characters:

The Spanish Mackerel, *Scomberomorus maculatus*, has the teeth somewhat conical and very pointed. It has seventeen dorsal spines and a black spot upon the first dorsal.

The Cero, *Scomberomorus caballa*, has fourteen dorsal spines and the first dorsal fin immaculate. The young fish have the sides of the body marked with roundish yellow spots, which disappear with age, and the lateral line is very sinuous upon the posterior portion of the body.

The Spotted Cero, or King Cero, *Scomberomorus regalis*, has seventeen dorsal spines, and upon the front of the first dorsal, which is white, is a spot of deep blue, which is prolonged far back upon the upper edge of the fin. The sides are marked with broken longitudinal bands with brown spots.

The Spanish Mackerel—Scomberomorus maculatus.

The Spanish Mackerel is found along our coast from Cape Cod to the eastern part of the Gulf of Mexico, and has also been observed about Cuba and on the coast of Brazil. A few individuals have been seen north of Cape Cod. Storer records the capture of one at Lynn, July 24, 1841, and states that specimens were obtained at Provincetown in August, 1847, and by Captain Atwood, at Monhegan Island, off the coast of Maine. Although abundant in the Gulf of Mexico, the species is rarely seen on the coast of Eastern Florida.

The history of this species, like that of several others of the Mackerel tribe, is very interesting, since it shows that its abundance upon the coast has varied much during the past two cen-

turies. The early chronicles of the colonies do not refer to it under its present name, but it is possible that this was the "Speckled Hound-fish" mentioned by Josselyn in his "New England's Rarities Discovered," published in 1673. Josselyn wrote: "Of Blew-fish, or Hound-fish, two kinds, Speckled Hound-fish and Blew Hound-fish, called Horse-fish."

The "Blew Hound-fish" can have been nothing other than the common bluefish of our coast, and it is hard to imagine what fish, except the Spanish Mackerel, can have been described under the other name. No other allusion to the fish is found in literature before 1815, when the fish was described by Mitchill in his work on the fishes of New York, under the name *Scomber maculatus*. The biographical portion of his notice consisted of two sentences: "A fine and beautiful fish. Comes in July."

Even the publication of this description does not seem to have satisfied contemporary ichthyologists of the existence of such a fish, for some of them did not hesitate to express the opinion that Dr. Mitchill had been deceived by accidental differences of color at different seasons of the year, and that there were not so many varieties of Mackerel as he imagined.[1]

In an essay on the fishes of New York market, published in 1854, Professor Gill referred to the Spanish Mackerel as a species of slight importance.

In 1878 the quantity sold in the New York market cannot have fallen much below 300,000 pounds, with a retail value of $225,000, while large numbers were sent away to Baltimore and other cities. There is, however, need of caution in drawing inferences from market reports without at the same time keeping in mind the true history of the fisheries. It is possible that Spanish Mackerel abounded in our waters long before they began to appear in the markets. Even now the number taken by the use of hook and line is very small. They are caught chiefly in traps and weirs, which have come into use since 1845, and many fishermen have expressed their belief that of late they have been rapidly increasing.

Genio C. Scott wrote, in 1875: "My experience in trolling for Spanish Mackerel off the inlets of Fire Island has convinced me that the fish is as numerous as the bluefish, and more so than the striped bass, at certain seasons, and is found a little farther seaward than either of those fishes. Every year the shoals of Spanish Mackerel become more and more numerous, and more are taken, but never in sufficient numbers to reduce the average price below sixty cents per pound. The shoals which I saw when last trolling for them would have formed an area nearly five miles square, and still the most successful boat did not take more than a dozen in three days. They will not bite freely at any artificial lure, and though numbers came near leaping on the deck of our yacht, they treated our lures with an indifference which savored of perverseness."

Mr. J. M. K. Southwick states that the first Spanish Mackerel taken in the vicinity of Newport were found in the summer of 1857. No one knew what they were.

The Gloucester "Telegraph" of August 17, 1870, contains the following item: "At Newport the epicures are in ecstasies over the fact that Spanish Mackerel, the most delicious fish caught in the sea, are taken there now in seines. It is only by southerly winds that they are tempted so far north."[2]

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[1] SMITH, J. V. C.: Natural History of the Fishes of Massachusetts, 1843, p. 295.

[2] The Newport "Daily News," August 19, 1872, has this item:

"LARGE HAUL OF SPANISH MACKEREL.—Saturday, Arnold James & Co., of this city, caught 208 Spanish Mackerel, weighing 495 pounds. This is the largest haul of this kind of fish that has ever been taken at any one time by any of our Newport fishermen. They were caught in the West Bay, and subsequently sold to Messrs. Carry Brothers, of this city."

And two days later, August 21, the Providence "Press" chronicled a still more remarkable catch:

"Another haul of Spanish Mackerel was made yesterday. This time it was over four hundred fish, averaging about two and a half pounds each. They were sold to a dealer at twenty-five cents a pound."

Mr. R. E. Earll, who has studied the history of the species on the coast of New Jersey and the Southern States, writes as follows:

"Prior to 1850 almost nothing was known of the fish about Sandy Hook. This is shown by the fact that about this time Mr. Robert Lloyd, a fisherman of Seabright, was engaged in trolling for bluefish, having a contract with one of the hotels to take his entire catch. He secured quite a number of Spanish Mackerel (these being the first he had ever seen), which were carried with the bluefish to the hotel; but the proprietor knew nothing of their value, and even objected to taking them at the nominal price of twenty-five cents each.

"From this date they were taken more frequently, and soon came to be highly prized as an article of food. They were caught wholly by trolling, the average daily catch being from ten to twenty fish to a boat; the fishing being best when the water was a little rough. They continued to increase in number, or at least came to be more generally noticed by the fishermen, until 1866, when they were quite plentiful, becoming most abundant between 1870 and 1875. During that period it is said that they were often nearly as plenty as the bluefish, though comparatively few were taken, owing to the lack of suitable apparatus, and it was not until the introduction of properly arranged gill-nets and pound-nets that the fishermen were successful in securing any considerable quantities.

"Since 1875 it is claimed that their numbers have gradually decreased on the inshore grounds, though they are said to be as numerous as formerly eight to ten miles from land, where they remain beyond the reach of gill-nets and pound-nets.

"Many of the fishermen of Chesapeake Bay never saw the species prior to 1875, though there are authentic records showing that individuals were occasionally taken in the haul-seines along the Eastern Shore as early as 1860, and hauls of between one and two hundred are reported by Dr. J. T. Wilkins in 1866. It is, however, very easy to explain the ignorance of the fishermen as to the abundance of the species in that region, for, until recently, the fisheries of the Chesapeake appear to have been of small commercial importance, having been prosecuted only during the spring and fall by means of gill-nets and haul-seines. During the summer months, when the Mackerel are most plenty, no fishing of importance was done. Pound-nets were introduced into the Chesapeake region in 1875, and it was through their use that the fishermen came to know of the abundance of the species in these waters.

"On the North Carolina coast most of the fishermen, and, indeed, a majority of the dealers, are still unacquainted with either the name or the value of the Mackerel, and when, in 1879, several thousand pounds of them were brought to Wilmington the dealers refused to buy them, supposing them to be a species of horse-mackerel (*Orcynus*), which they understood had no value as a food-fish. As no purchasers could be found for them, they were finally thrown away. Farther south few have been taken, owing to the lack of suitable apparatus, as well as to the fact that the fishermen seldom fish beyond the inlets. The smack fishermen of Charleston catch a few on troll-lines during the pleasant weather of the spring and early summer, but they fish only occasionally in this way.

"Though the fishing is at present limited to certain localities, there is no reason to believe that the fish are absent from other places; on the contrary, it seems probable that, should proper apparatus be employed, the species could be taken at almost any point along the outer shore where the menhaden are abundant.

"In the Chesapeake region there seems to be no diminution in the catch; on the contrary, it has increased rapidly from year to year, until in 1879 it amounted to fully 1,000,000 pounds, and in 1880 the quantity was increased to 1,609,663 pounds. The average daily catch for the pound-

nets about Cherrystone, Virginia, is fully 500 fish; while as many as 4,000 have been taken at a single 'lift,' and hauls of 2,500 are not uncommon during the height of the season. At Sandy Hook the catch is quite large; in 1879, 3,500 pounds were taken at one haul in a pound-net at Seabright, and the average stock for the pound-nets in that locality often exceeds $1,000 for Mackerel alone, while the catch of other species is proportionately large.

"We see no reason for believing that the present enormous catch will have any serious effect upon the future abundance of the species; for, assuming that the fish are plenty all along the coast, the catch, though extensive at certain points, must be insignificant in comparison with the immense number of individuals in the water. As has been shown, however, there is good reason for believing that the numbers have varied from time to time in the past, and it may be that natural causes, of which we are still ignorant, and over which we may have no control, may cause a like variation in the future."

In 1879 the writer, in preparing an essay upon this fish, remarked: "Mitchill, when he described the *Scomber maculatus*, sixty-five years ago, summed up what he knew of its habits in a single sentence: 'Comes in July,' and the studies of later naturalists have added but little to this terse story."

Since that time the studies of Mr. Earll and Mr. Stearns have added so much to our knowledge of the life and history of this fish that it may be said that its habits are now about as well understood as those of any other species on our coast. Instead of weaving the facts which have lately been recorded into a compact narrative, the statements of different observers will be given as nearly as possible in their own words.

Mr. Earll thus discusses its movements along the Southern Atlantic coast:

"Spanish Mackerel are gregarious in their habits. They are sometimes seen in enormous schools, covering several square miles of ocean surface. A single school seen off Long Island a few years ago was estimated to contain several million individuals. The density of these schools, however, is very different from that of the schools of menhaden on which they feed. The latter are usually found in compact masses, often many feet in thickness; while the former are considerably scattered, a large percentage of them being at or near the surface of the water.

"The fish make annual excursions to the coast of the United States in summer; starting from their home in the warmer waters of the South, or, perhaps, from the deeper waters along the inner edge of the Gulf Stream, in the early spring, and proceeding northward, or landward, as the season advances. After remaining for a few weeks, or months at most, they again move southward, or seaward, and at the approach of cold weather entirely disappear. They seem to prefer water ranging from 70° to 80° Fahrenheit, and seldom enter that which is colder than 65°.

"Off Charleston, South Carolina, the fish are first seen about the last of March, and late in April they enter the sounds of the North Carolina coast. By the 20th of May the vanguard reaches the Chesapeake, and others follow in rapid succession, so that by the middle of June the capture of Mackerel constitutes the principal occupation of the fishermen. Off Sandy Hook the first individuals are not seen till late in July,[1] and from that time they continually increase in numbers till the middle, or even the last, of August. Their time of arrival at Narragansett Bay is about the same as that for Sandy Hook. In this northern region they remain till the middle of

[1] The Canadian fishery report for 1880 contains the following notice of the capture of a Spanish Mackerel at Prince Edward's Island, in the Gulf of Saint Lawrence, which (if there is no mistake in the identification) extends by several hundred miles the range of the species. The report says: "An undoubted specimen of the Spanish Mackerel, male, *Cybium maculatum* of the United States, was caught by hook at New London, Queen's County, on the 7th of September. It is rare to find this fish in so high a latitude."—Supplement No. 2 to the Eleventh Annual *Report of the Minister of Marine and Fisheries for the year 1880, p. 229.*

With all deference to the author of this report, I am unwilling without further evidence to accept this identification as accurate.—G. B. G.

September, after which the number gradually diminishes, and by the first of October the last individuals have disappeared. A little later they leave the Chesapeake, and few are seen on the Carolina coast after the 1st of November.

"Their summer movements are doubtless affected to a considerable extent by the movements of the menhaden and other small fishes on which they feed, as they are usually most plenty in the localities where these fish are found. When feeding they remain constantly among these fish, exhibiting great activity in the capture of their prey, rushing through the water with great speed, and often leaping into the air in long and graceful curves. This peculiar leap is characteristic of the species, and by it the fishermen are enabled to distinguish the Mackerel from their allies, the bluefish, that, after jumping from the water, fall back upon its surface with a splash, instead of cutting it, as is the case with the Mackerel.

"During the spawning season the Mackerel enter the warmer and shoaler water of the bays, the individuals at this time being more generally disturbed and the schools often considerably scattered. On entering the Chesapeake, they remain about 'The Capes' for some time, but as the season advances, according to Mr. Sterling, of Crisfield, Maryland, they start for the upper waters, and distribute themselves over the large spawning grounds of the region. Some weeks later they reassemble, and proceed down and out of the bay on the way to their winter quarters.

"In moving along the coast the Mackerel seem to avoid fresh or even brackish water, and for this reason are seldom taken near the mouth of the larger rivers. This habit is thought to account for their greater abundance on the eastern than on the western side of the Chesapeake. Along the last-named shore the saltness of the water is considerably affected by the enormous quantity of fresh water brought down by the large rivers of the State, while no rivers of importance occur along the eastern shore, and the water is therefore nearly as salt as the ocean.

"During its stay on our coast, the Spanish Mackerel may properly be styled a surface fish. It seldom descends to any great depth, but rather remains at or near the surface, and may often be seen leaping into the air or sporting at the top of the water. On a calm, bright day the surface of the ocean is sometimes broken for miles together by the movements of a large school of these fish."

Concerning its migrations in the Gulf Stearns writes: "The Spanish Mackerel is extremely abundant on the West Florida coast. They are first seen in March or April, four or five miles from land, moving along swiftly towards the westward, or playing at the surface with no apparent aim or course of movement. The time of their arrival is not certainly known, but they are quite sure to appear some time between the first of March and the last of April. One season, 1877, schools were seen off the coast in February, and the 'run' continued as late that year as usual. It is not an unusual habit for these early schools to remain at sea several weeks before approaching the land. During the latter part of April the first schools are seen coming into the Pensacola Bay, and from this time on through the summer they are continually passing in. I do not think the tide influences their movements, as far as entering or leaving the harbor is concerned, for I have seen them swimming against and with the tide. They move at the surface of the water, frequently jumping from it and splashing conspicuously. By this commotion are attracted many sea-birds, which learn that there is food for them in the shape of fragments of small fishes upon which the Mackerel prey. The individuals that make up the schools vary considerably in size; as a rule, the first to arrive are the largest fish, and measure from twenty to twenty-four inches, while those coming later measure only about fourteen or fifteen inches. Specimens of thirty-six and forty inches are sometimes caught by the use of trolling-lines, but these large fish are rarely found in the schools. Their abundance varies with different years, although not to so great an extent as some other migratory

species. The first few weeks they spend in the bays. They continue playing at the surface, preying on such schools of small fish or fry as may be present, but at the commencement of July they are less frequently seen, and after another space of two or three weeks are not seen at all, unless caught by trolling-lines at sea, or when a solitary individual leaps from the water in some remote place. There is a great difference in the movements of the fish which are ready to spawn and those which have finished spawning: the former keep away from the shore, playing at the surface with no apparent aim, while the latter swim in shoal water near the shore, underneath the surface, shaping their course with all possible directness for the harbor mouth. The school, as it moves along, resembles a compact mass of reddish-brown sea-weed. Santa Rosa Island seems to possess attractive features for the Spanish Mackerel, for they are very abundant there. This is a convenient station from which to watch their movements, on account of its narrowness and length. In August, September, and October small schools of Mackerel are seen following the shore along to the sea, and on reaching it they are lost to view in deep water. Many, probably, follow the deep water out of the harbor and are not seen at all, but enough are under observation to signify when they are 'running' and when the majority are gone."

As has already been remarked, the Spanish Mackerel is but rarely seen on the east coast of Florida, though abundant in the Gulf of Mexico. I have never seen one in this region, though the fishermen assure me that a few have been caught, and that small ones are occasionally taken on the bar at the mouth of the Saint John's River. Melton & Co., of Jacksonville, received a quantity from Cedar Keys in 1876, and they were exposed for sale in the city markets, where, however, they met with no purchasers. In the Indian River region there is a fish called there the Spanish Mackerel; it perhaps is the Spanish Mackerel, or one of the allied species.

Holbrook wrote in 1860: "But little is known of the habits of this fish; it seems, however, more solitary than the fishes of this family generally are, as it seldom happens that more than four or five are taken at the same time. It appears on the coast of Carolina in April and May, but is rarely seen during the summer months. It feeds on various species of small fish."

Dr. Yarrow wrote in 1873 of this species, as observed in the vicinity of Fort Macon, North Carolina: "They are abundant in the latter part of August and September, and are frequently found with the bluefish. A favorite locality is near the southern point of Shackelford Banks, where it is taken with nets and by hook; a great many are also taken near Cape Lookout in September in gill-nets. Is highly esteemed as food, but is not often eaten fresh, being generally salted. Size from ten to thirty inches."

Mr. A. N. Simpson stated in 1874 that the species was caught in small quantities in the shoals near Cape Hatteras, though seldom seen in the sounds.

Dr. Wilkins, of Hunger's Wharf, observed in 1880 that the average weight in that vicinity is from two to three pounds. They arrive about the first of June, and leave about the first of September. Twenty-five years ago it was a very rare occurrence to catch a Mackerel in the Chesapeake Bay, but now they are very plenty.

Mr. C. R. Moore, of Johnsontown, Virginia, wrote in 1874: "Spanish Mackerel come in September and October and stay until frost. They are most numerous about the mouth of the York River, where a large number are caught in seines and salted. They bring about $40 a barrel."

Professor Baird, who was one of the first to speak of the abundance of this species and to testify to its excellent qualities, wrote in 1854: "But two specimens were taken during my stay at Beasley's Point, and the species is scarcely known to the fishermen. It was more abundant at Greenport, Long Island; in the Peconic Bay, towards Riverhead, four hundred were caught at one haul of the seine. The flesh is excellent, having much the flavor of true Mackerel, only a little

richer and softer. The fish bring a high price in the New York market, where it has been but recently sold at from fifty cents to one dollar a pound, the prices varying with the season. It has been more abundant off our coast than ever before, and in the lower part of the Potomac numbers have been taken and salted down. They may frequently be found in this state in the Washington market, and readily recognized by the round yellow spots on the sides, and also by the size, which is so much larger than that of the common Mackerel."

DeKay, in 1842, mentioned that he had seen this species, taken in the seine, in the New York market, in August and September, nearly two feet long, but that they were not common.

REPRODUTION.—The breeding habits of this fish were never understood until the spring of 1880, when, to everybody's astonishment, it was found by Mr. Earll that one of the principal spawning grounds was in the Chesapeake Bay.

I quote in full the remarks of Mr. Earll upon their reproductive habits:

"Prior to 1880, nothing was definitely known regarding the spawning habits of the Spanish Mackerel. Neither the time nor place of spawning had been discovered. Mr. Scott had surmised that they spawned in the waters of our Atlantic States in the spring, as small ones which he supposed to be the young of the previous year were occasionally seen in June.[1] Professor Goode, in his 'Game Fishes,' had ventured the assertion 'that they probably spawned in midwinter, in the Gulf of Mexico and about the West Indies. These were, as far as we knew, the only writers that had referred to the spawning habits of the Mackerel. During an extended tour of the Atlantic coast, in company with Col. Marshall McDonald, the writer had an excellent opportunity for examining the species in different localities, and succeeded in proving that the theory advanced by Mr. Scott was the more nearly correct, and that the Spanish Mackerel spawn along many portions of the Atlantic coast in midsummer. The investigations of the southern fisheries began in Florida in January, 1880, and when the fisheries in that region had been sufficiently studied, we proceeded northward, visiting every important fishing station along the coast of Georgia and the Carolinas, reaching the Chesapeake early in May. After spending some time at Norfolk, and at the fishing shore of Capt. W. E. Taylor, at Willoughby, we accepted the invitation of Mr. O. E. Maltby to visit his fishing station at New Point, forty miles up the bay. Here we spent a number of days in examining the spawning condition of the different species taken in the pound-nets of the locality, and soon discovered that many of the male Mackerel were nearly ripe, while the eggs in the ovaries of some of the females were well developed. A little later we succeeded in finding thoroughly ripe males and one or two females from which ripe eggs could be taken. Appreciating the importance of this discovery, we continued our investigations, and soon satisfied ourselves that the spawning time was near at hand, as the eggs and milt in all of the specimens examined were well advanced. Later, the writer visited the Eastern Shore of Virginia, including the counties of Accomack and Northampton, and found ripe eggs and milt in a large number of individuals. Further investigation proved that the spawning season, as in many migratory species, varied with the locality, being earliest on the Southern coast, and latest about Long Island. The temperature of the water seems to have a decided effect upon the spawning time of the Mackerel, and the ovaries and spermaries do not develop very rapidly until it has risen to upwards of 70° Fahrenheit. The time of spawning for the Carolinas begins in April, while the season at Long Island commences by the 20th of August, and continues till the latter part of September. On the arrival of the species in the Chesapeake, in May, a few of the males are nearly ripe, and the ovaries of the females

[1] The following is the language of Mr. Scott on this point: "Both the Spanish Mackerel and Cero are spring-spawning fishes, and no doubt spawn in our bays, for there are occasionally small ones taken by the anglers in June, before the large ones visit our shores, and I argue, therefore, that the small half-pounders are of last year's patch."—Angling in American Waters.

are very much enlarged. By the 1st of June occasional ripe fish are seen. The spawning season proper begins about two weeks later, and continues during the greater part of the summer. The fishermen report many of the Mackerel to be full-roed when they reach the Sandy Hook region, and claim that by the last of August the eggs begin to separate and run from the female. From this date to the close of the season numerous individuals are taken from which eggs or milt will run freely.

"The limits of the spawning grounds have not yet been definitely ascertained, though enough has been learned to show that the Mackerel spawn at numerous points between Narragansett Bay and South Carolina, and it seems probable that when a thorough investigation is made the southern limits will be found to extend as far as Mississippi, and perhaps to Texas. It is certain that they spawn in some of the sounds of the Carolinas, in Chesapeake Bay, off Sandy Hook, and along the southern shores of Long Island; the Chesapeake and Sandy Hook regions being visited by immense numbers of Mackerel for this purpose.

"As has been said, the spawning season for our coast continues throughout the entire summer, and, in any particular locality, it lasts from six to upwards of ten weeks. The time of spawning for individuals of the same school varies considerably, the ovaries of some of the fish being fully mature while those of others are still quite green. Again, a single individual is a number of weeks in depositing its eggs, as shown by the fact that when the first are excluded a large percentage are still small and immature. All of the eggs in the ovaries of a shad, salmon, or whitefish develop uniformly, and the whole number are deposited at about the same time, so that the spawning season for the individual lasts only a few days at most. Up to the winter of 1878–'79 it had been supposed that all fishes were alike in this particular; but our study of the cod at that time proved that the individuals of that species were several months in depositing their eggs, and the same is found to be true, within smaller limits, of the Spanish Mackerel.

"The number of eggs varies with the size of the parent fish, that for a one-pound Mackerel being estimated at 300,000, while that for a six-pound fish can scarcely be less than 1,500,000. To ascertain definitely the number for the average fish, an immature female, weighing one pound and thirteen ounces, and measuring eighteen and a half inches, was selected, and the number of eggs was carefully computed. The ovaries, when placed on accurately adjusted balances, were found to weigh 34.275 grams. These were then opened, and 100 milligrams, selected from different portions of the roe-bags, so that all sizes might be represented, were weighed out. When counted this mass was found to contain 1,5 .6 eggs. From these data it was found that the ovaries of the fish should contain 526,464 eggs. This number would be too great, as no allowance was made for the weight of the ovary walls; allowing for these, the number would be not far from 525,000. It is thus seen that the species is more prolific than the salmon, shad, or whitefish, though it is much less so than many of the gadoids, a seventy-five-pound codfish yielding fully 9,000,000.

"The eggs of the Spanish Mackerel are smaller than those of any other species with which we are familiar. During the early part of the season they can scarcely be distinguished by the unaided eye, and although they gradually increase in size, when fully ripe they have a diameter—varying somewhat with the size of the parent and the condition of the eggs when pressed from the ovaries—of only one twenty-second to one twenty-eighth of an inch. Most of those secured by us were of the last-named size, and, taking these as a basis, it will be seen that a cubic inch would contain 21,952 eggs, and that 1,267,728 could be placed in a quart cup.

"After impregnation the eggs have a specific gravity between that of fresh and salt water, as shown by the fact that they sink in one and float in the other. When thrown from the parent they rise to the surface and are driven hither and thither by the winds and tides during the earlier period of development. Many are lost from lack of fertilization, others are destroyed by the animals of the water, and considerable quantities are doubtless driven upon the shore during

stormy weather, where they soon perish. When first hatched the little Mackerel is very small and transparent, its length scarcely exceeding one-tenth of an inch, while its diameter, even with the comparatively large yelk-sac, is so small as to allow it to pass through wire-cloth having thirty-two wires to the inch. For several hours after hatching it remains comparatively quiet at the surface in an almost helpless condition, a small oil globule attached to the yelk-sac keeping it from sinking and causing it to lie belly uppermost. Later the umbilical sac with its oil globule is gradually absorbed, and the little fish begins to manifest greater activity, and by vigorous and spasmodic efforts penetrates to the depth of an inch or so below the surface. In a few hours it finds little or no difficulty in swimming at various depths, and even lies at the bottom of the vessel in which it is confined, darting off with surprising rapidity when disturbed.

"Little is known of the rate of growth. We know of but two instances where small Mackerel have been caught or even seen along our shores. The first is that mentioned by Mr. Scott, in the passage already quoted, of half-pound fish having been taken off the Long Island coast in June. A second instance was made known to us by Mr. Robert Bosman, superintendent of a fishing station at New Point, Virginia, who, in a letter dated Norfolk, Virginia, September 25, 1880, says: 'I have recently noticed large numbers of young Spanish Mackerel, varying from four to six inches in length.' Assuming that the fish referred to were the young of the Spanish Mackerel, there still remains a difficulty in determining the rate of growth. Some species grow very rapidly, reaching the last-named dimensions in a few months, while others develop more slowly and would not attain a weight of half a pound for several years. From our limited knowledge of the growth of other species we would suppose that the fish mentioned by Mr. Bosman as being four to six inches long in September were the fry of the previous year, and were therefore about fourteen months old, while the half pounders mentioned by Mr. Scott were probably nearly two years old."

The observations of Mr. Stearns, recorded also in 1880, are exceedingly interesting as confirming and supplementing those of Mr. Earll:

"When the Spanish Mackerel first appear, late in March and early in April, they contain spawn in the half-developed state. By July this has become quite full, and it is believed by the most intelligent fishermen that when they disappear from sight at that time they do so for the purpose of spawning, and that the spawning-grounds are in the quiet bayous and lagoons, the places where the old fish are last seen. These views of the fishermen are partly conjectural, and at first I did not agree with them, but the more I observed the movements of the fish the more plausible seemed the fishermen's views. The following facts have led me to adopt them: (1) The Spanish Mackerel arrive in the spring with spawn and milt and go away without them. (2) They disappear into out-of-the-way places with nearly ripe spawn, and in a short time reappear in or about the same places without it. The operation of spawning leaves them somewhat emaciated. They do not, of course, spawn all at one time, and it is not unfrequent that fish with spawn and those which have deposited it are caught by a fishing-crew on the same day."

The Spanish Mackerel sometimes attains the weight of eight or nine pounds, though it rarely exceeds three or four pounds. A specimen taken off Block Island, July 8, 1874, the first of the season, measured twenty-six and one-fourth inches and weighed three pounds and five ounces. It is said to be the largest ever taken in this section, and was a female with the ovary spent. Those taken on the coast of New Jersey and farther to the eastward are considered much more delicately flavored than the Chesapeake fish, and command a higher price in the market. In the Gulf States, according to Mr. Stearns, the Spanish Mackerel are in great demand, though but few are caught in the Gulf of Mexico, on account of the absence of proper nets.

This species was ascertained by Professor Jordan to occur abundantly in the Gulf of California, and south as far as Mexico. It is for some reason not highly valued by the Mexicans.

The Cero or King-fish—Scomberomorus caballa.

The Cero is a West Indian species which has been recorded from Santo Domingo, Jamaica, Cuba, Martinique, Porto Rico, and Brazil. A few specimens have been observed as far north as Wood's Holl, Massachusetts. It is a magnificent fish. It often grows to twenty-five pounds, and sometimes, it is said, to one hundred pounds in weight. Its habits are probably not unlike those of the Spanish Mackerel. The name Cero is commonly accepted in the United States; it is a corruption of the Spanish *sierra*, and the Mexicans call the fish by that name.

"The King-fish," writes Mr. Stearns, "are very abundant in the southern part of the Gulf and common at some places in its northern portion. They live altogether at sea and are caught with trolling-lines. At Key West they are important as food-fishes, large quantities being sold in the markets. Two men in a small sail-boat sometimes catch more than a hundred in a day, and I have seen the market so glutted with them that five cents would buy one of the largest size."

Professor Jordan states that they are regularly caught with trolling hooks by nearly every steamer from Savannah to New York.[1]

The King Cero or Spotted Cero—Scomberomorus regalis.

The King Cero of the Florida Keys grows to be five or six feet long and to twenty or thirty pounds in weight. This fish also occasionally wanders as far north as the southern shores of Cape Cod in summer. It is abundant in the West Indies, having been recorded from Cuba, Santo Domingo, Jamaica, and Barbadoes. Cuvier, moreover, had a specimen from Brazil. It is more than likely that this and the preceding species are both included by the Key West fishermen under the name "King-fish," the differences in general appearance being so slight that it is hardly likely that they would be noticed by ordinary observers.

The Monterey Mackerel—Scomberomorus concolor.

The Pacific species may be called the Monterey Mackerel. It attains a length of about thirty inches and a weight of about five or eight pounds. It has only been seen in the Monterey Bay, where from five to forty individuals are taken every fall, most of them at Soquel. They appear in September and disappear perhaps in November. Nothing further is known of their distribution or habits. They always bring a very high price in the market (30 to 50 cents per pound), the flesh being similar to that of the Spanish Mackerel of the East, which species this fish closely resembles.

99. THE BONITO—SARDA MEDITERRANEA.

This fish is one of those which appear to live for the most part in the open ocean, wandering hither and thither in large schools, preying upon other pelagic fishes, and approaching land only when attracted by abundance of acceptable food. Several of the smaller species of the group of Tunnies, to which it belongs, are known to sailors by the same name. The common Bonito of England, *Orcynus pelamys*, is what is here called the "Striped Bonito," two or three specimens

[1] A RARE FISH.—Captain Matthews, of the steamer "Oriental," who arrived Tuesday from Savannah, brought home a fine specimen of the King-fish, which was caught in the Gulf Stream on the passage. It was placed on exhibition in the Quincy market, at stalls 127 and 129, and attracted considerable attention from the fact that it is the first one of the kind ever seen here. It weighs about forty pounds, and more nearly resembles the Spanish Mackerel in color and form than any other fish usually seen in this market, although it is much larger. It is a very fat, handsome fish, and is said to be a nice article for food.—Boston Journal, July 26, 1871.

of which have been detected in our waters since 1876, but the fish which most frequently and in greatest numbers approaches our shores is the one which is named at the head of this section. Almost nothing is known of its habits, and it is even impossible to define its geographical range with any degree of certainty, its distribution being quite unlike that of any other fish with which we are acquainted. It may be said, however, that it is found only in the Atlantic Ocean. On our coast it is found in summer between Cape May and Cape Sable, though rarely north of Cape Ann;[1] occasionally off Cape Hatteras and the mouth of the Chesapeake and in the Gulf of Mexico. Specimens have been taken about the Canaries and Madeira, at the Cape of Good Hope and in the Mediterranean. It has not been observed on the coast of Europe north of Gibraltar, nor at the Bermudas.

This fish does not appear to have been abundant in former years: it attracted but little attention in our waters before 1860, although it was alluded to in 1815 by Mitchill, in 1842 by DeKay, and in 1856 by Gill; none of these authors, however, seem to have regarded it as at all abundant.[2]

A note from Prof. J. Hammond Trumbull states: "This fish used to be quite common, in some years, in the Stonington market. I have a note of a considerable number in market July 22, 1842, their first appearance for the season."

Storer remarked in 1846: "This species, called by the fishermen in Boston market the 'Skipjack,' and by those at the extremity of Cape Cod the 'Bonito,' is very rarely met with in Massachusetts Bay. It is occasionally taken at Provincetown, and even at Lynn. At some seasons it is frequently caught at Martha's Vineyard with trailing bait."

During the past ten or fifteen years they have become exceedingly abundant about Block Island and the eastern end of Long Island.[3] Fabulous quantities are taken in the pound-nets.

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[1] August 6, 1876, Captain Webb, of Milk Island, took seventy-three Bonitos in his weir, and August 7 twenty-eight more in an eight-inch gill-net.

[2] The following extracts from the journal of one of the earliest settlers of New England may refer either to this fish or to one of the smaller species of Tunny:

"1635, JULY 18 [near Newfoundland]. Saturday, wind northwest, a fair, cool day. We saw this morning a great many of Bonitoes leaping and playing about the ship. Bonito is a fish somewhat bigger than a cod, but less than a porpoise."—Mather's Journal. Young's Chronicles of the First Planters of Massachusetts Bay Colony. Boston: 1846, p. 464.

"1635, JULY 21 [near Newfoundland]. Tuesday morning, a great calm after a hot night. This morning our seamen took a Bonito and opened him upon the deck; of which, being dressed, our master sent Mathew Michel and me part, as good fish in eating as could be desired. About noon the wind became northeast, good for our purpose, so that we went that afternoon nine or ten leagues a watch."—Mather's Journal. Young's Chronicles of the First Planters of Massachusetts Bay Colony. Boston: 1846, p. 464.

[3] BONITA.—We did not say half enough the other day about the new visitor in our bay, the Bonita. If it shall become plentiful in our waters, as it promises to be, it will become a most valuable article of food. A correspondent, whose opinion upon matters of this kind is ultimate, writes: "Your article on the Bonita is every word true; pray, have your attention turned to fish, the great question (economical) of the day. Last night I had a fish on my table which they said was a kind of Spanish mackerel; the moment I tasted it I said it was a Bonita, having eaten it thirty years since, on my first voyage to India, and the taste had never been forgotten. It is the salmon of the sea. Mark its solidity of flesh, its great weight, its purity of taste, entire absence of the slightly decayed taste all fish has during warm weather. It is as nourishing as beef." The remainder of the note is "strictly confidential," and so was the basket which accompanied it with the choicest treasure of the sea covered with the greenest leaves of the land. We certify from actual experiment that Bonita is the worthy rival of the Spanish mackerel, the sheepshead, and the salmon. We are pleased to quote it in our household market report at the more reasonable price of twenty cents a pound.—Providence Journal, July, 1871.

The people of Rhode Island are happy in consequence of the appearance in their waters of that excellent fish, the Bonita. This fish is esteemed superior to the Spanish mackerel, and nearly equal in flavor to the salmon. It has not been known in Rhode Island waters until recently; now it is so plentiful that it is sold in the Providence fish markets at twenty cents per pound.—Germantown Telegraph, August 2, 1871.

THE BONITA.—Mr. John Flynn, of the Citizens' Market, yesterday received another supply of that new and dainty fish, the Bonita, and those who have not yet tasted of this worthy rival of the Spanish mackerel, the sheepshead, and the salmon, will do well to call at his market to-day and obtain one of these rare visitors.—Providence Journal, 1871.

In 1877 four smacks were constantly running between Block Island and New York, carrying each from 4,000 to 8,000 Bonitoes a week, or perhaps 20,000 pounds. The yield of Block Island alone that summer was probably not less than 2,000,000 pounds. In one haul of the purse-seine by the schooner "Lilian," of Noank, 1,500 were taken; and in August, 1874, 1,200 in one pound-net.

They seem first to have attracted the attention of New England authorities about 1865. Genio C. Scott, writing in 1875, remarked: "His first arrival along our beaches and in our bays was about eight years ago, and his shoals have increased remarkably fast ever since his advent. As a table luxury it ranks, with epicures, below the striped bass and bluefish, but, because of its comparative rarity, it commands a price rather above either. The numbers of this fish annually taken about the approaches to our harbors with the troll and in nets has increased so much that it bids fair to become nearly as numerous as the bluefish."

HABITS, &C.—In habits the Bonito has much in common with the blue-fish, though it is, if possible, even more active and more the embodiment of perpetual and insatiable hunger. They come to and go from the coast together, and are often taken together in the nets. Sometimes two lines in one boat will fasten at the same time a bluefish and a Bonito. The Bonito, like the bluefish, appear to be attracted to our waters by the great schools of mackerel and menhaden, upon which they feed. The Bonito schools create much confusion as they pass through the water, and their progress is marked by flocks of screaming gulls and terns, which follow them to prey upon the remnants of their feasts. At the end of summer they disappear entirely. No very young Bonitos have been found in our waters. Genio C. Scott, however, records the capture of one in Jamaica Bay in 1874, weighing less than a pound, and which he believes to have been hatched the previous year. The Fish Commission also has one of the same size taken off Southern New England. Charles Potter, of Norwalk, Connecticut, states that small specimens, six inches in length, were from 1870 to 1874 frequently taken late in the fall in the weirs at Fisher's Island.

SIZE.—A fish weighing ten pounds measures twenty-eight to twenty-nine inches; eight pounds, twenty-seven to twenty-eight inches; seven pounds, twenty-six to twenty-seven inches; six pounds, twenty-five to twenty-six inches; four pounds, twenty-two to twenty-three inches. There have not yet been found in the adults any traces of mature spawn, though one taken off Norwalk, July 23, 1874, had the eggs well formed though not nearly mature.

THE FISHERY.—In 1875 the earliest Bonito was taken in the Robinson's Hole weir July 7, and two more came along July 24. They were not abundant until August, when many more were taken in Vineyard Sound by Oak Bluffs boats, trolling. The fishermen then believed that they were gradually increasing in numbers and importance and taking the place of the squeteague which were dying out. August 7 the weir at Cedar Tree Neck had taken nothing but Bonitoes, while those farther west at Menemsha Bight had taken only squeteague.

Bonitos are caught in the vicinity of Block Island with trolling-hooks. They bite sharply, like bluefish. The best bait is an ordinary bluefish hook with a petticoat of red and white flannel, though the fish will also take any bluefish lure.

On the eastern shore of Virginia Bonito are caught by harpooning, says Mr. C. R. Moore, and also with the hook. They are most numerous about the mouth of the York River. They come in in June and leave in September. It is quite possible, however, that the Bonito referred to by Mr. Moore is quite another fish—the Cobia, *Elacate atlantica*.

USES.—Tested side by side with the bluefish, at the same table, the Bonito seems not much inferior, though the flesh is somewhat softer and more perishable.

The Bonito may be ranked among the many excellent food-fishes of our coast, and, in any

country not so abundantly supplied with finely-flavored fishes, it would be considered of the highest value. Their vitality is so great and their supply of blood so abundant that unless bled immediately after capture their flesh, especially in warm weather, is apt to deteriorate. Great quantities of them are taken to New York, and there, as well as in Rhode Island and Connecticut, they are sold extensively under the name of "Spanish mackerel," at prices ranging from thirty five to fifty cents a pound. This was the common practice in 1874, and has continued since. The statement made by Scott in 1875, viz, that on account of their rarity they were preferred to the bluefish and striped bass, would not now be true; his prediction that they would in time become as abundant as the bluefish seems, however, during some years to have been almost verified. The dealers, by the change of name in the market above referred to, are able to obtain a high price for a fish which, under its own name, would be looked upon with suspicion. An absurd report that the Bonito was poisonous was current in 1874, probably owing to the fact that similar fish taken in warm climates are sometimes deleterious.

In 1874 the ordinary price in New York was one cent apiece, though in the wholesale markets they commanded the same price as bluefish, and many were sold, as has been stated, at the high rates of Spanish mackerel. The market was so glutted that many of the vessels could not dispose of their cargoes.

According to Stearns, our Bonito occurs also in the Gulf of Mexico, where it is everywhere abundant, and is found in the bays on the Florida coast: It usually moves, according to the same authority, at the surface of the water in small schools. At sea it is found throughout the year, and along the shore only in the summer. Small schools are sometimes taken in drag-seines in shallow water. Its market value at Pensacola is not great, although it has become an article of food.

THE PACIFIC BONITO.—On the California coast occurs a closely related species, *Sarda chilensis*, which is thus described by Professor Jordan:

"This fish is everywhere known as the Bonito. The names 'Spanish Mackerel,' 'Skipjack,' and 'Tuna' are also sometimes applied to it. It reaches an average weight of about twelve pounds, but the body is considerably longer and more slender than that of an Albicore of the same weight. It ranges from San Francisco southward to Chili, being abundant in Monterey Bay and about the Santa Barbara Islands in the summer and fall. It approaches to within half a mile of the shore, where, in company with the barracuda, it is taken in great numbers by trolling. It spawns in August or September. Its arrival is in early summer and its departure in the fall, at which season the young are said to be found abundantly in the kelp. It feeds chiefly on anchovies and squids. As a food-fish it is not held in high esteem, the flesh being coarse. Great numbers are salted and dried, and are in that state considered far inferior to the barracuda and yellow-tail."

THE STRIPED BONITO.—The Striped Bonito, already mentioned, is distinguished from other species by the presence of four dark lines, which begin at the pectoral fin and run along the side of the belly to the tail, the sides of the common Bonito being of a silvery white. This species, the Striped Bonito, is occasionally taken on the European coast, but rarely entering the Mediterranean. It is found in the Pacific on the coast of China and Japan, and is the species most commonly known to mariners as the Bonito, or Albicore, of the activity and voracity of which, as observed from the decks of vessels at sea, so many descriptions have been written. The first individual noticed on our coast was taken by Mr. J. H. Blake at Provincetown in July, 1877. Others have since been observed at Wood's Holl and in the New York markets.

One of the American men-of-war of Revolutionary times was named "Bonetta," after the fishes of this group.

THE LITTLE TUNNIES.—In addition to the Striped Bonito, which is, properly, a Tunny, there are two other small Tunnies—the Long-finned Tunny, *Orcynus alalonga*, and the Silver-spotted Tunny, *Orcynus argentivittatus*—which have since 1877 been added to the fauna of the United States.

The former of these two occurs in considerable abundance on the coast of California, and is there also known as the Albicore. Concerning it Professor Jordan writes: "This fish reaches a weight of about twelve pounds, and is much shorter and deeper than the Bonito of the Pacific. It is found from San Francisco southward, but is abundant only in the channels about the Santa Barbara Islands. It seldom comes within six miles of the shore, and it is taken by trolling. It spawns about the middle of August, its arrival on the coast being determined by the spawning season. It usually is present in June and July and disappears in the fall. It feeds chiefly on anchovies and squid, and various deep-water fishes (*Merlucius, Sudis, Myctophum*) are found in its stomach. As a food-fish it is even less valued than the Bonito, rarely selling for more than twenty to twenty-five cents. It is abundant, but of little economic importance, being usually fished for by sportsmen."

100. THE HORSE MACKEREL, TUNNY, OR ALBICORE.

The most important of the Tunnies is the so-called Horse Mackerel, or Albicore, *Orcynus thynnus*, the "Ton" or "Tuna" of the Mediterranean, and the "Tunny" of English-speaking people.

The distribution of this fish corresponds more closely with that of the ordinary species of the Atlantic, since it occurs not only in the Mediterranean and the Western Atlantic north to the Gulf of Saint Lawrence, but also on the coast of Europe to the Loffoden Islands, latitude 69°.

The following account of this species is for the most part from the notes of Professor Baird:

Of this fish, as found in American waters, our naturalists have not much to say, the species, although abundant at certain seasons of the year off particular parts of the coast, being not a very familiar one to our writers. They seem to be rather a northern fish, and are said by Storer to make their first appearance on our shores about Provincetown early in June, remaining until October. Of late years they seem to be increasing in abundance northward, becoming more and more common during the summer season at Newfoundland.

In 1878, Capt. Henry Webb, of Milk Island, near Gloucester, harpooned and killed thirty of these monsters, weighing in the aggregate at least thirty thousand pounds. They had entered his pound in pursuit of small fish, cutting without difficulty through the netting. One had his stomach full of small mackerel.

According to Captain Atwood, on their first appearance in Massachusetts Bay they are very poor, but by the beginning of September become quite fat and are very much hunted for the oil, the head and belly especially furnishing sometimes as many as twenty gallons. They are harpooned on the surface of the water, much like the Sword-fish.

The early traditions of this fish in Massachusetts Bay speak of them as being sometimes so tame as to take food from the hand; but they have long since given up this engaging habit. Their flesh is not esteemed in the United States, being rarely, if ever, eaten, although much used for mackerel bait. It is, however, more in favor in the Provinces. This species attains a very great size. One specimen, taken in 1838 off Cape Ann, measured, according to Dr. Storer, fifteen feet in length, and weighed one thousand pounds, while still larger individuals than this are on record.

Their food while in our waters consists, it is said, mainly of menhaden, of which they destroy a vast number. Their inclosure in the fishermen's nets is not much desired, as they are apt to

become entangled in them and to do much injury in their efforts to escape. They are pursued by the killer whales, before which they flee in great terror.

Strange to say, although highly prized in the Old World from the time of the ancient Romans to the present day, they are seldom, if ever, used for food in this country. Although occurring in large numbers and of remarkable size, no effort is made toward their capture; and though not unfrequently taken in weirs and pounds along the coast, they are always allowed to rot on the shore. Occasionally a portion of the flesh may be used as food for chickens, but seldom, if ever, for human consumption.

In the Mediterranean the Tunny is taken in large nets, known as *madragues* similar in many respects to the so-called "traps" of Seconnet River in Rhode Island. The fish are used partly fresh and partly salted, and they are put up in oil to a considerable extent and largely consumed in all the Latin countries of Europe. Considerable quantities are salted and canned, and canned Tunny of European manufacture is imported to New York in small quantities. The flesh is dark and not usually attractive, although wholesome. They appears to attain a greater size in America than in Europe, one of five hundred pounds in the Mediterranean being considered rather a monster, while in America their weight is not unfrequently given at from twelve to fifteen hundred pounds.

Nothing definite is known in regard to their mode of reproduction. The eggs are said to be deposited early in June, and the young at hatching, according to Yarrell, weigh an ounce and a half, reaching a weight of four ounces by August, and thirty ounces by October.[1]

Mr. Matthew Jones, of Halifax, Nova Scotia, writes: "The Tunny is very common on the eastern coast of Nova Scotia in summer, and is known to fishermen and others as the 'Albicore.' The Rev. J. Ambrose informs me that it regularly visits St. Margaret's Bay every summer, several specimens being taken and rendered down for oil. They were particularly abundant in 1876. They are never seen in the Basin of Minas."

Captain Atwood contributes the following note on Horse-Mackerel in Cape Cod Bay:

"They don't come till the weather gets warm. We don't see them at first when we begin setting mackerel nets, but about June they are liable to appear, and we find holes in the nets. Sometimes in September they gill them for the sake of their oil. My brother had forty-seven holes through one eighty-yard net in one night. When they strike a net they go right through it, and when they go through it the hole immediately becomes round. It looks as if you could put a half bushel through it. I said in my Lowell Institute lectures that a shark in going through a net would roll himself up in it, but the Horse-Mackerel get right through, and the hole that they cut could be mended in five minutes. The fishermen don't dread them much because they do the nets so little injury. They remain with us through the summer and early autumn, when they are killed for the oil. When they are here they feed upon any small fish, and when menhaden were here I have seen them drive the harbor full of them. I have seen the Horse-Mackerel swallow dogfish whole weighing eight pounds. As fast as we got out the livers of the dogfish they would catch them and eat them. There was a great deal of whiting here at that time. They have almost totally disappeared. The Horse-Mackerel seems to be the enemy of all kinds of fish. There

[1] *Orcynus thynnus.*—According to Dr. Fortin, the Horse-Mackerel is quite abundant in the Gulf of Saint Lawrence, especially in the bay of Chaleur and of Gaspé, and also in the Straits of Belle Isle and Blanes Sablon Bay. It is taken in increasing numbers in the Gulf, partly by spearing and partly by baiting. For this latter purpose strong steel hooks are used tied to solid lines and baited with herring. This fishing is prosecuted more particularly in the Bay of Chaleur and off Caraquette, where in 1863 over one hundred were captured. The fishing is quite exciting, although tiresome and requiring a good deal of skill, as in the efforts of the fishes to escape they pull with such violence as to endanger the lives of the fishermen by dragging them overboard.—Canadian Fishery Report for 1863, 62.

is nothing to trouble the Horse-Mackerel until the killer comes, and then they know it, I tell you. Then the Horse-Mackerel will run! Some fishermen say that they have seen a killer poke his head out of the water with a Horse-Mackerel in his mouth. I have known a Horse-Mackerel to yield twenty-three gallons of oil. The average size is about eight feet in length."[1]

101. THE LITTLE TUNNY OR ALBICORE.

This fish, *Orcynus alliteratus*, known in the Gulf of Mexico, where it is confounded by the fishermen with other similar species, as the "Bonito," and in the Mediterranean by the names "Tonnina" (Trieste), "Carcàne" (Venice), and "Tanna" (Nice), has a geographical range very similar to that of the Bonito, except that it is found in the Pacific on the east coast of Japan, and in the Malay Archipelago. It has also been recorded from Cuba, Brazil, and the Bermudas. This active species, which attains the weight of from thirty to forty pounds, first made its appearance in our waters in 1871, when several large schools were observed by the Fish Commission in Buzzard's Bay and the Vineyard Sound. Nearly every year since, they have been seen in greater or less numbers, but, as they are of little value for food, no effort has been made to capture them, nor are they often brought to the markets. This species, known at the Bermudas as the "Mackerel," is frequently seen in the markets at Hamilton and Saint Georges.

In the Mediterranean its flesh is considered to be very excellent. My own experiments with it are hardly confirmatory of this statement, but in Southern Europe all the fishes of this family are very highly esteemed, and that it is not appreciated with us is perhaps due to the fact that we do not know how to cook them. I find the following note by Professor Baird: "Flesh, when cooked, dark brown all around the backbone, elsewhere quite dark, precisely like horse-mackerel. Flesh very firm, compact, and sweet."

Stearns records its frequent occurrence in the Gulf of Mexico, where he has observed individual specimens at Pensacola and Key West.

The habits of this fish have not been specially studied, but there is no reason to doubt that they correspond closely with those of others of the same family.

THE CARANGOID FISHES.

The members of the family *Carangidæ*, which is closely allied to the mackerel family, are distinguished chiefly by the form of the mouth, and by the fact that they have uniformly but twenty-four vertebræ, ten abdominal and fourteen caudal, while the mackerel have uniformly more, both abdominal and caudal. They are carnivorous fishes, abounding everywhere in temperate and tropical seas. On our own eastern coast there are at least twenty-five species, all of them eatable, but none of them of much importance except the Pompanoes. On the California coast there are two or three species of this family, of small commercial importance.

102. THE SILVER MOON-FISHES.

THE BLUNT-NOSED SHINER—SELENE SETIPINNIS.

This fish, known on some parts of the coast as the "Horse-fish," in North Carolina as the "Moonfish" or "Sunfish," and in Cuba by the name "Jorobado," was called by DeKay "Blunt-nosed Shiner," and since this name, sometimes varied to "Pug-nosed Shiner," is in common use in the New York market and in Narragansett Bay, while the other names are shared by other species,

[1] HORSE-MACKEREL.—One weighing three hundred pounds was harpooned at Minot's Ledge August 10, 1859, by a seaman on the United States steamer "Granite." Another, nine feet in length and weighing six hundred and fourteen pounds, in Marblehead Bay about the same time.

similar and dissimilar, it seems the most suitable for general adoption. The fish is found everywhere throughout the West Indies, as well as in Northern Brazil and in the Gulf of Guinea, the Gulf of Mexico, the Gulf of California, and southward along the coast to Panama, but has not been found in Europe. In Eastern Florida it is not very unusual, being frequently taken in the Lower Saint John's, and sometimes driven up as far as Jacksonville by easterly storms. Here and in the Indian River it is known as the "Moonfish." It is a frequent summer visitor all along the coast as far north as Wood's Holl, Massachusetts, where it has a peculiar name, the people there calling it the "Hump-backed Butterfish." The species attains the length of ten or twelve inches, and is esteemed an excellent article of food. Considerable numbers are brought yearly to New York, but elsewhere it rarely appears in the markets. Young from three inches in length upwards are found, but we have no definite knowledge as to its breeding habits.

THE SILVER MOON-FISH—SELENE ARGENTEA.

This species is almost certain to be confused by fishermen with the one last described, which it resembles and is often spoken of under the same names. It occurs abundantly on our coast as far north as Wood's Holl, and is found in the West Indies, in Brazil, and in the Gulf of Mexico, as well as in the Pacific, from the Gulf of California to Panama.

The young of the Silver Moon-fish is abundant in our waters, and has been frequently taken in Massachusetts Bay, and, in one or two instances, as far north as Halifax, Nova Scotia. Their bodies are so thin that they can be dried in the sun without the use of any preservatives, without loss of form and color. They are, consequently, of no importance for food. In the Chesapeake this fish is often called by the names "Horse-head" and "Look-down."

103. THE CAVALLY, THE SCAD, AND THE JURELS.

THE CAVALLY—CARANX HIPPOS.

The Cavally of the Gulf of Mexico and Eastern Florida—the "Horse Crevallé" of South Carolina—occurs abundantly on our Southern coast, and has been recorded by Professor Poey from Cuba and by Cope from St. Christopher and St. Croix. It is generally distributed throughout the West Indies, and is found along the Pacific coast from the Gulf of California to Panama. The species was originally described from specimens sent from South Carolina by Garden to Linnæus. The name of this fish is usually written and printed "Crevallé," but the form in common use among the fishermen of the South, "Cavally," is nearer to the Spanish and Portuguese names, *Cavalha* and *Caballa*, meaning "horse." The name as used in South Carolina is a curious reduplication, being a combination of the English and Spanish names for "horse." It should be carefully remembered that in South Carolina the name Crevallé is most generally applied to quite another fish, the Pompano.

The Cavally, as it seems most appropriate to call *Caranx hippos*, though in individual cases occurring as far north as Cape Cod, and even, in one instance, at Lynn, Massachusetts, is not commonly known in the United States north of Florida. Storer remarks: "This fish is so seldom seen in the waters of South Carolina that we are unacquainted with its habits." I observed a specimen in the Jacksonville market in April, 1874. Concerning the Cavally of Southern Florida, which is either this or a closely allied species, Mr. H. S. Williams writes:

"In the Indian River this is one of the best of the larger varieties. Its season is from the 1st of May to November. It ranges in weight from three to twenty pounds, being larger and more numerous to the southward toward the Mosquito Inlet. The south end of Merritt's Island and the inlets opposite old Fort Capron seem to be a sort of headquarters for the Cavalli. When in

pursuit of prey they are very ravenous and move with the rapidity of lightning. They readily take a troll either with bait or rag. The favorite mode of capturing them, as well as all other large fish that feed in shallow water or near the shore, is with a rifle. The high, rocky shores afford an excellent opportunity for this sport, though the rapid movements of the fish render them very difficult targets."

Mr. Stearns writes: "The Crevallé is common on the Gulf coast. In West Florida it appears in May and remains until late in the fall, and is equally abundant in the bays and at sea. In the bays it is noticeable from the manner in which it preys upon fish smaller than itself, the Gulf menhaden and mullet being the most common victims. On arrival it contains spawn which it probably deposits in the salt-water bayous, for in the fall schools of young are seen coming out of those places on their way to the sea. These young are then of about one pound weight, appearing to the casual observer like pompano, and I am told that they equal it for edible purposes. They are caught accidentally by seines and trolling-lines. Large ones are not considered choice food, the flesh being dark and almost tasteless. The average weight is twelve pounds; occasionally they attain the size of twenty pounds."

Professor Jordan found this species abundant in Lake Ponchartrain.

The Goggler—Caranx crumenophthalmus.

This fish, called in the Bermudas, where it is of some importance as a food-fish, the "Goggler," or "Goggle-eyed Jack," and in Cuba the "Cicharra," occurs in the West Indies and along the Atlantic coast of the United States north to the Vineyard Sound. It is also found at Panama and in the Gulf of California, and in the Indian Ocean, the Red Sea, and off the coast of Guinea, while, as has been remarked, it is abundant in the Bermudas. Its large, protruding eyes are very noticeable features, and the Bermuda name seems appropriate for adoption, since the fish has with us never received a distinctive name. In form it somewhat resembles the species last discussed, with which it is probably often confused.

Stearns speaks of a fish, common at Key West, which is known as the "Horse-eyed Jack," and this may prove to be the same species.

The Jurel—Caranx pisquetus.

This fish, known about Pensacola as the "Jurel," "Cojinua," and "Hard-tail"; along the Florida coast as "Jack-fish" and "Skipjack"; in the Bermudas as the "Jack" or "Buffalo Jack"; in South Carolina as the "Horse Crevallé"; at Fort Macon as the "Horse-Mackerel"; about New York and on the coast of New Jersey as the "Yellow Mackerel," is found in the Western Atlantic from Brazil, Cuba, and Hayti to Halifax, Nova Scotia, where specimens were secured by the United States Fish Commission in 1877. It is one of the commonest summer visitants of the West Indian fauna along the whole coast of Southern New England and the Middle States, being especially abundant in the Gulf of Mexico, and one of the commonest fishes in the Bermudas. This fish is occasionally brought to the New York market, but is of no special importance as an article of food north of the Gulf of Mexico. Concerning its habits in those waters, Mr. Stearns has contributed a very interesting series of notes. They are especially entertaining, since nothing has previously been known of its life-history:

"It is extremely abundant everywhere on the Gulf coast of Florida, Alabama, and Mississippi. At Pensacola it is one of the important fishes of trade, and is highly prized for food. It is one of the class of migratory fishes of this coast, like the pompano, mullet, Spanish mackerel, and red-fish, having certain seasons for appearing and disappearing on the coast, and also has habits during these seasons that are peculiar to themselves or their class. It appears on the coast in April, in

small schools that swim in shoal water near the beach during pleasant weather, when there is little or no surf, in eight or ten feet of water, and in stormy weather some little distance from the breakers. Their movement is from the eastward to the westward. As they seldom swim at the surface, their movements can be watched only when in shoal water. The schools 'running' in April and first of May are usually smaller than those of a few weeks later, but the individuals of the first are somewhat larger. The mass, or largest 'run,' comes in May, and it is on the arrival of these that schools are first seen coming in the inlets.

"A noticeable peculiarity of the Hard-tail compared with some other common migratory fishes is that the first schools do not stay about the mouths of an inlet and along the beach weeks before coming inside as those of the latter do, but continue their westward movement, without seeming to stop to feed or play, until the time has come for a general movement towards the bays. In this way they must be distributed along the coast, with no unequal accumulation at any one point. When once inside, the numerous schools break up into smaller ones of a dozen or two fish, which are found in all parts of the bay during the summer. On their arrival the larger fish contain spawn, which in July and August becomes quite full, after which none are seen but the young fish of about ten inches in length, until there is a general movement towards the sea. It is believed that the adult fish spawn in the bays, but the only evidence to support that belief is that they come inside with spawn, go away without it, and that very young fish are found there. In October and November small Hard-tails are caught in Santa Rosa Sound, measuring five and six inches in length.

"The smallest of the spring run are nine or ten inches long. Adult fish measure twelve, fourteen, and fifteen inches in length, very rarely more than the last. During the months of October and November Hard-tails leave the bays, formed in small schools and swimming below the surface in deep water. The only time that they can then be seen is when they cross the 'bars' at the inlet or sandy shoals in the bay. A few stragglers remain in Pensacola Bay and Santa Rosa Sound all winter, which are taken now and then with hook and line. I have found them in abundance in winter on the South Florida coast, where, owing to less variable conditions of the water, their habits are decidedly different. The Hard-tail is a most voracious fish, waging active war upon the schools of small fish. Its movements are rapid, and sometimes in its eagerness it will jump high out of the water. It has its enemies also, for I have seen whole schools driven ashore by sharks and porpoises; a great many are destroyed in this way. Hard-tails are caught for the market in seines."

The Cuba Jurel—Caranx fallax.

The occurrence of this species on our coast was first announced by a drawing made by Mr. J. H. Richard of a fish taken in South Carolina. Upon this drawing Holbrook founded his species, *C. Richardii*. *Caranx fallax* occurs abundantly throughout the West Indies and along the Gulf coast of the United States, and it is by no means impossible that stragglers should have found their way to Charleston. According to Professor Poey, this fish has been prohibited from sale in Cuba from time immemorial, and with good reason, since many disastrous cases of sickness have followed its use as food. This species occurs, according to Jordan, from the Gulf of California to Panama, and also in the East Indies.

The Round Robin—Decapterus punctatus.

The Round Robin, or, as it is called at Pensacola, the "Cigar-fish," occurs in the Bermudas, where it is an important food-fish; it occurs also in the West Indies and along the coast of the United States north as far as Wood's Holl.

A closely related species, *Decapterus macarellus*, is found also in the West Indies and along the eastern coast of the United States. According to Stearns, individuals of this species are rather rare in the northern part of the Gulf, but more common along the South Florida coast. They live in shallow water and in harbors, usually moving about in small schools. At Key West they are caught in seines, and are eaten.

The Scads—Trachurus saurus, etc.

The Scads, known in England as the "Horse-Mackerels," appear to occur in all temperate and tropical waters. The distribution is given by Günther as follows: "From the coasts of the temperate parts of Europe, along the coasts of Africa, round the Cape of Good Hope into the East Indian seas, to the coasts of New Zealand and West America." As has been shown by Lütken, Steindachner, and Jordan and Gilbert, three distinct species are confounded by Günther under the name *Trachurus trachurus*.

In Europe our Scad ranges north to the Trondhjem Fjord, latitude 65°, and is said to occur as far south as Portugal. On the coast of Holland it is known as the "Marse Banker," or "Hors." It is interesting to American ichthyologists, since the similarity of its habits to those of the menhaden, so important in our waters, caused the latter fish to be called among the early Dutch colonists of New York by the same name. European writers describe the Scads as occurring upon those coasts in schools of immense numbers, and it would seem that although their manner of swimming resembles that of the menhaden, in their other habits they more closely resemble our own bluefish. They are considered to be food-fishes of fair quality, and attain the length of about twelve inches. They are supposed to spawn about the same time as the mackerel. Only three specimens of this species have ever been taken in the United States, one by the Fish Commission in Southern New England in 1878, and subsequently two others by Jordan and Stearns, at Pensacola. In California, according to Jordan, the allied species *T. picturatus* occurs and is known as the "Horse-Mackerel." He continues: "It reaches a length of about a foot and a weight of less than a pound. It ranges from Monterey southward to Chili, appearing in California in the summer, remaining in the spawning season, and disappearing before December. It arrives at Santa Barbara in July, and at Monterey in August. In late summer it is exceedingly abundant. It forms part of the food of larger fishes, and great numbers are salted for bait. As a food-fish it is held in low esteem, but whether this is due entirely to its small size we do not know. It is identical with the well-known Mediterranean species."

The Thread-fish—Blepharis crinitus.

This fish, also known as the "Shoemaker-fish," is found along our coast from Cape Cod to the Caribbean Sea, as also on the Pacific coast of tropical America. It possesses no importance in our Atlantic waters, but on account of its strange shape and the long thread-like appendages to its fins, which float behind it to the distance of five or six times its own length, it is often brought *to the markets as a curiosity. "It is not found in California," writes Jordan, "but in* Western Mexico it attains the length of two or three feet, and is brought to the markets for food."

104. THE POMPANOS—TRACHYNOTUS CAROLINUS, ETC.

There are four species of Pompano in the Western Atlantic, very similar to each other in general appearance, but easily distinguished by differences in proportion and in the number of fin-rays.

The commonest and by far the most important species, the Carolina Pompano, *Trachynotus carolinus*, has the height of the body contained two to two and two-thirds times in the total length; the length of the head five to five and one-third times; one of the caudal lobes four times. It has

twenty-four to twenty-five rays in the second dorsal, while the anterior rays of the dorsal and anal fins, if laid backward, reach to the middle of the fin.

The Round Pompano (*T. ovatus*) has the height of the body contained two to two and one-third times in the total length; the length of the head five to five and one-fourth times; one of the caudal lobes three and a half to four times. In the second dorsal are from eighteen to twenty-one rays, in the second anal from sixteen to nineteen, while in the Carolina Pompano there are twenty-one to twenty-two.

The African Pompano (*T. goreensis*) resembles in general form the Round Pompano, though somewhat more elongate, while the head is larger, being contained four and a half times in the total length. The anterior rays of the dorsal and anal extend beyond the middle of the fin, if laid backward. In the number of the fin-rays it corresponds most closely with the Round Pompano.

The Banner Pompano (*T. glaucus*) has a somewhat elongate body and a small head. It is much thinner than either of the other species. Its silvery sides are marked with four blackish vertical streaks; the best distinguishing mark is in the length of the first rays of the dorsal and anal, which extend back nearly to the tip of the caudal fin. The name Pompano, applied in this country to all of these fishes, is a Spanish word, one of the meanings of which is "grape-leaf." This name is applied in Western Europe to a very different fish.

The Common Pompano—Trachynotus carolinus.

The Common Pompano or Carolina Pompano occurs in both the Atlantic and Pacific waters of the United States. On our eastern coast it ranges north to Cape Cod, south to Jamaica, east to the Bermudas, and west in the Gulf of Mexico, at least as far as the mouth of the Mississippi River. In the Pacific it is rare, and as yet known only from the Gulf of California, where it has recently been observed by Mr. C. H. Gilbert.

In our New England and Middle States it is a summer visitor, appearing in June and July, and departing in September. Although it is at present impossible to ascertain the lower limit of its temperature range, it is probable that it corresponds very nearly to that indicated by a harbor temperature of 60° to 65° Fahrenheit.

This species was described at an early day by Linnæus from South Carolina, and never had been observed in any numbers north of Cape Hatteras until the summer of 1854, when Professor Baird discovered them near Great Egg Harbor. In his "Report on the Fishes of New Jersey" he states that he had seen them taken by thousands in the sandy coves on the outer beach of Beasley's Point. These, however, were young fish, few of them weighing more than half a pound. In 1863 he obtained both species in Southern Massachusetts, where in subsequent years they have been frequently captured.

"My first acquaintance with the Pompano in New England," writes Professor Baird, "was in 1863, during a residence at Wood's Holl, where I not unfrequently caught young ones of a few inches in length. I was more fortunate in the summer of 1871, which I also spent at Wood's Holl; then the Pompano was taken occasionally, especially in Captain Spindle's pound, and I received at different times as many as twenty or thirty, weighing about one and one-half or two pounds each. Quite a number were caught in Buzzard's Bay and Vineyard Sound in 1872."

It is a fair question whether the Pompano has recently found its way into northern waters, or whether its presence was unknown because nobody had found the way to capture it. When Mitchill wrote on the fishes of New York in 1842 he had access to a single specimen which had been taken off Sandy Hook about the year 1820.

The spawning times and breeding grounds of these fishes are not well known. Mr. S. C.

Clarke states that in the Indian River they spawn in March, in the open sea near New Smyrna, Florida. It is supposed that those visiting our northern coasts breed at a distance from the shore. The eggs, like those of the mackerel, being lighter than the water, float at or near the surface. The Pompanoes may, however, be truly migratory, seeking the waters near the equator in winter and following along a coastwise migration, north and south, in summer. They are rapid, powerful swimmers; their food consists of mollusks, the softer kinds of crustaceans, and probably the young of other fishes. S. C. Clarke remarks that they have been known to bite at a clam bait. Genio Scott remarks: "It is mullet-mouthed; never takes a bait except by mistake." Their teeth are very small and disappear with age. As seen in the New York market they rarely exceed five or six pounds in weight. I quote in full the observations of Mr. Stearns:

"The common Pompano is abundant on the Gulf coast from the Mississippi River to Key West, and, as far as I can learn, is rare beyond this western limit until the Yucatan coast is reached, where it is common. It is considered the choicest fish of the Gulf of Mexico, and has great commercial demand, which is fully supplied but a few weeks in the year, namely, when it arrives in spring. The Pompano is a migratory fish in the Pensacola region, but I think its habits on the South Florida coast are such that it cannot properly be so classed.

"At Pensacola it comes in to the coast in spring and goes away from it in fall, while in South Florida it is found throughout the year. In the former section it appears on the coast in March in schools varying in numbers of individuals from fifty to three or four thousand, which continue to 'run' until the latter part of May, when it is supposed that they are all inside. Their movement is from the eastward, and they swim as near to the shore as the state of the water will permit, very seldom at the surface so as to ripple or break the water, although sometimes while playing in shoal water they will jump into the air.

"Before any schools enter the bays certain ones will remain for days, or even weeks, in a neighborhood, coming to the beach during the flood-tide to feed on the shell-fish that abound there and returning again to deeper water on the ebb-tide. The holes or gullies in the sand along the beach are their favorite feeding-grounds on these occasions. Sharks and porpoises pursue the Pompano incessantly, doubtless destroying many. The largest numbers come in April, and sometimes during that month the first schools are seen entering the inlets, others following almost every day, until about June 1, when the spring run is said to be over. Every year they appear in this way at Pensacola and adjoining bays, although there are many more some years than others. As the abundance is judged by the quantity caught I think that the difference may lie more in the number of fishing days (pleasant ones) than in the real numbers of fish present. The sizes of Pompano that make up these schools are large or adult fish averaging twelve or fourteen inches in length, and small fish (probably one year old) averaging eight inches in length. The largest Pompano that I have seen measured nineteen and a half inches in length, and weighed six and a quarter pounds, the extremely large fish called Pompano of two or three times that size probably being another species. After entering the bays the schools of Pompano break up and the fish scatter to all parts where the water is salt and there are good feeding grounds. Except single individuals that are taken now and then, nothing is seen of Pompano until late in the fall, when they are bound seaward. In regard to its spawning habits nothing very definite has been learned. It has spawn half developed when it arrives and has none when it leaves the bays. Large quantities of the fry are seen in the bays all summer, which is some proof of its spawning inside. In June, 1878, I caught specimens of the fry varying in size from three-quarters of an inch to three inches in length. Very many schools of these sizes were also observed in July and August of the same and following years of 1879–'80.

"The schools of fry go to sea in August and September. The older or adult fish leave the coast in September and October in small schools, that are only seen and caught at the inlets where they happen to cross shoals or follow the beach. These Pompano of the fall are very fat and in every way superior to those caught in the spring. As before mentioned, the Pompano is found on the South Florida coast all the year. The sea-beach from Tampa Bay to Charlotte's Harbor seems to be its favorite feeding-ground owing to the quantity of shell-fish that occur there. It does not form in large schools as in the Pensacola region, and therefore is not taken in such large quantities by seine fishermen.

"Smacks from Mobile and Pensacola sometimes go to Tampa Bay for them. I have been told that Pompano are caught at Key West in considerable quantities by hook and line, and I have known of a few being taken in that manner at Pensacola. It feeds entirely upon small shell-fish, which are crushed between the bones of its pharyngeal arch."

The Round Pompano—Trachynotus ovatus.

The Round Pompano, in the South sometimes called the "Shore Pompano," is known in the Bermudas by the name "Alewife." This fish is very often confused by market-men with the Carolina Pompano, and I have seen them sold together in the Charleston market under the same name, just as I have seen the young of four species of the herring family sold indiscriminately in New York.

The Round Pompano is cosmopolitan in its distribution, occurring in the North and South Atlantic, and in various parts of the Indian Ocean. The young have been obtained in the harbor of Vineyard Haven, Massachusetts, and at Beaufort, South Carolina. It is probable that the species is far more abundant in our waters than we now suppose it to be. About the Bermudas they are sometimes very abundant, and in 1875 a school of them, numbering six or seven hundred, was seined on the south shore of the islands. They are there highly esteemed for table use.

The African Pompano—Trachynotus goreensis.

This species, originally described from the Island of Gorea, on the west coast of Africa, was observed by the writer at the Bermudas in 1876, and in 1877 was discovered in Florida. It is the largest of the Pompanos. Two or three specimens, weighing from fifteen to twenty pounds each, have been sent from Florida to the New York market. One of these, taken at Jupiter Inlet, was sent by Mr. Blackford to the National Museum. In the Gulf of Mexico it is not unusual, being known at Key West as the "Permit."

Stearns remarks: "This fish is rather common along the lower end of the Florida Peninsula, specimens being caught quite often in seines at Cedar Keys, and at the mullet fisheries of Sarasota and Charlotte's Harbor, and also Key West. It is said to attain a considerable size—fifteen or twenty pound specimens being common. It is not a choice food-fish when so large, and even smaller ones are comparatively dry and tasteless. I have not found it north or west of Cedar Keys."

The Banner Pompano—Trachynotus glaucus.

This species is a member of the West Indian fauna, and occasionally occurs at the Bermudas. Stearns remarks that it is obtained frequently at Pensacola with the other species, but is never very common, is seen only in the spring, and is not valued as a food-fish. Professor Jordan writes: "Along the Carolina and Gulf coasts it is not rare. At Pensacola it is known as the 'Gaff-topsail Pompano,' and is held in low esteem." An allied species, *Trachynotus fasciatus*, has lately been noticed by Jordan and Gilbert on the Pacific side of the Isthmus of Panama.

105. THE PILOT-FISH—NAUCRATES DUCTOR.

The Pilot-fish, though of little or no economic importance, deserves passing mention, since it is so frequently referred to in literature. It is occasionally taken on our coast. Captain Atwood mentions a specimen which was taken in a mackerel net in Provincetown Harbor, in October, 1858. A whale-ship had come in a few days before, and he supposes that the Pilot-fish had followed it into the harbor.

"The Pilot-fish (*N. ductor*) is a truly pelagic fish, known in all tropical and temperate seas. Its name is derived from its habit of keeping company with ships and large fish, especially sharks. It is the Pompilus of the ancients, who describe it as pointing out the way to dubious or embarrassed sailors, and as announcing the vicinity of land by its sudden disappearance. It was therefore regarded as a sacred fish. The connection between the shark and the Pilot-fish has received various interpretations, some observers having, perhaps, added more sentiment than is warranted by the actual facts. It was stated that the shark never seized the Pilot-fish; that the latter was of great use to its big companion in conducting it and showing it the way to its food. Dr. Meyer, in his 'Reise um die Erde,' states: 'The Pilot swims constantly in front of the shark; we ourselves have seen three instances in which the shark was led by the Pilot. When the shark neared the ship the Pilot swam close to the snout, or near one of the pectoral fins of the animal. Sometimes he darted rapidly forwards or sidewards, as if looking for something, and constantly went back again to the shark. When we threw overboard a piece of bacon fastened on a great hook, the shark was about twenty paces from the ship. With the quickness of lightning the Pilot came up, smelt at the dainty, and instantly swam back again to the shark, swimming many times round his snout and splashing as if to give him exact information as to the bacon. The shark now began to put himself in motion, the Pilot showing him the way, and in a moment he was fast upon the hook.[1] Upon a later occasion we observed two Pilots in sedulous attendance on a blue shark which we caught in the Chinese Sea. It seems probable that the Pilot feeds on the shark's excrements, keeps his company for that purpose, and directs his operations solely from this selfish view.' We believe that Dr. Meyer's opinion, as expressed in his last words, is perfectly correct. The Pilot obtains a great part of his food directly from the shark, in feeding on the parasitic crustaceans with which sharks and other large fish are infested, and on the smaller pieces of flesh which are left unnoticed by the shark when it tears its prey. The Pilot, also, being a small fish, obtains greater security when in company of a shark, which would keep at a distance all other fishes of prey that would be likely to prove dangerous to the Pilot. Therefore, in accompanying the shark, the Pilot is led by the same instinct which makes it follow a ship.

"With regard to the statement that the Pilot itself is never attacked by the shark, all observers agree as to its truth; but this may be accounted for in the same way as the impunity of the swallow from the hawk, the Pilot-fish being too nimble for the unwieldy shark.

"The Pilot-fish does not always leave the vessels on their approach to land. In summer, when the temperature of the sea-water is several degrees above the average, Pilots will follow ships to the south coast of England into the harbor, where they are generally speedily caught. Pilot-fish attain a length of twelve inches only. When very young their appearance differs so much from the mature fish that they have been described as a distinct genus, *Nauclerus*. This fry is exceedingly common in the open ocean, and constantly obtained in the tow-net; therefore the Pilot-fish retains its pelagic habits also during the spawning season, and some of the spawn found by voyagers floating on the surface is, without doubt, derived from this species."[2]

[1] In this instance one may entertain reasonable doubts as to the usefulness of the Pilot to the shark.

[2] GÜNTHER: Study of Fishes, p. 414.

The Pilot-fish has been observed in one or two instances about New York, and has also been recorded from South Carolina. It is, however, rare in the Western Atlantic, and our museums have very few specimens.

106. THE AMBER-FISHES AND THE LEATHER-JACKETS.

The Amber-fish—Seriola carolinensis.

Mr. Silas Stearns writes concerning the habits of this fish in the Gulf of Mexico:

"The Amber-fish is quite common off the West Florida coast, occurring in from ten to thirty fathoms of water on or near the 'snapper banks' throughout the year. It is a very active fish, swimming just below the water's surface, preying upon schools of small fish. It is rather shy of a baited hook, and but few are caught. It is a good food-fish. It attains a size of forty inches length and fifteen pounds weight. Its average size but little more than half that." It is also, according to Jordan, rather common on the Carolina coast, where it is known as the "Jack-fish."

The Pensacola Rock Salmon—Seriola falcata.

The "Rock Salmon" of Pensacola, *Seriola falcata*, is recorded by Stearns as occasionally occurring near Pensacola in company with the preceding species, which it resembles in habits. It is caught with hook and line and is eaten; in his opinion, it attains a larger size than the Amber-fish. There is a third species of Amber-fish of which the National Museum has received a single specimen from South Florida. It is closely related to the fish described by Cuvier under the name *Seriola Lalandii*. The same species is sometimes sent to the New Orleans market, where an example was seen by Professor Jordan.

The California Yellow-tail—Seriola dorsalis.

Another closely allied species, *Seriola dorsalis*, occurs on the coast of California, where, according to Jordan, it is known under the names "Yellow-tail," "White Salmon," and "Cavasina."

Of the "Yellow-tail," Professor Jordan says: "It reaches a length of four to five feet, and a weight of thirty to forty pounds, and individuals of less than fifteen pounds weight are rarely seen. It ranges from Cape San Lucas northward to the Santa Barbara and Coronados Islands, where it is found in great abundance in the spawning season, arriving in July, and departing in early fall. It spawns about August 18. It is caught chiefly by trolling. It feeds on squid and such fish as the anchovy and sardine. As a fresh fish it ranks high, although large individuals are sometimes coarse and tough. When salted and dried it is inferior to none on the coast, ranking with the white-fish and barracuda."

The Banded Rudder-fish—Seriola zonata.

This species has been observed as far north as Salem and Beverly, Massachusetts. Several specimens have been taken north of Cape Cod during the past forty years. It is a small fish, rarely exceeding six or eight inches in length, conspicuous by reason of its brilliant and beautiful colors, and good to eat, though rarely saved by the fishermen who accidentally capture it. It is called in Southern New England the "Rudder-fish" on account of its resemblance to the Rudder-fish of the ocean, *Naucrates ductor*.

The Medregal—Seriola fasciata.

This fish, called in Cuba the "Medregal" and in Bermuda the "Bonito", has been observed in South Florida and along the coasts of the Carolinas. It is apparently exceedingly rare in the

waters of the United States. In Bermuda it attains a length of two feet or more, and is highly esteemed as a food-fish.

THE LEATHER-JACKET—OLIGOPLITES SAURUS.

This fish, which is found throughout the West Indies and south as far as Bahia, and on the Pacific coast of Mexico and Central America, has since 1875 been several times observed between Florida and Newport, Rhode Island. It is known to fishermen as the "Skipjack," sharing this name with a number of other scombroid fishes which leap from the water as they pursue their prey. It is one of the most beautiful and graceful fishes in our waters, but at present is of no economic importance, its flesh being hard and dry.

THE RUNNER—ELAGATIS PINNULATUS.

This West Indian fish, known at Key West as "Skipjack" or "Runner," and at Pensacola as "Yellow-tail" or "Shoemaker," is, according to Stearns, "abundant on the western and southern coasts of Florida. At Pensacola it spawns in spring; the young fish are seen in July and August. It is found in the bays and along the sea-beaches, seeming to prefer clear, salt water, swift currents, and sandy bottoms. It usually moves in small schools of a dozen or two individuals. It feeds upon small fishes and crustaceans. When pursued by larger fish it jumps repeatedly from the water, very much in the same manner as the flying fish, only its flights are much shorter and oftener repeated. This habit has given it the names of 'Skipjack' and 'Runner' at Key West, where it may be seen at almost any time. It is sometimes eaten at Key West, and at Havana is quite an important fish in the markets, being also exposed for sale at stands on the streets, cooked and ready for use."

107. THE DOLPHINS—CORYPHÆNIDÆ.

The Dolphins are found usually in mid-ocean, where they feed upon other pelagic fishes, such as the flying-fish. They are strong, rapid swimmers, and are widely distributed throughout all temperate and tropical waters. The name Dolphin is wrongly applied to them, being the peculiar property of a group of small cetaceans. They are often caught by sailors at sea, and are considered most excellent food. It is an almost universal custom before eating them to test the flesh by putting a piece of silver into the vessel in which they have been cooked, it being a common belief that if the flesh is poisonous the silver will turn dark. Narratives of ocean voyages abound in descriptions of the beautiful colors of the Dolphin and the brilliant changes of hue exhibited by the dying fish. There are in the Atlantic two species of Dolphins, though the number was, until lately, supposed to be very much greater. But one of these, *Coryphæna hippurus*, is definitely known from our shores.

The young, less than two feet in length, are beautifully marked with numerous small circular spots, and have, until lately, been considered by many writers to belong to a distinct genus and species. Dolphins are abundant also, it is said, in the Gulf of Mexico.

THE STROMATEOID FISHES.

108. THE RUDDER-FISH FAMILY—STROMATEIDÆ.

The family *Stromateidæ* is represented on the east coast by three species, two of which are important food-fishes, and in our Pacific waters by one species, the so-called "California Pompano." The family is a small one, and is widely distributed throughout the warm seas.

The Butter-fish—Stromateus triacanthus.

The "Butter-fish" of Massachusetts and New York, sometimes known in New Jersey as the "Harvest-fish," in Maine as the "Dollar-fish," about Cape Cod as the "Sheepshead" and "Skipjack," in Connecticut as the "Pumpkin-seed," and at Norfolk as the "Star-fish," is common between Cape Cod and Cape Henry. It has been observed south to South Carolina and north to Maine. It has been found in some abundance along the north side of Cape Cod in nets with bass and mackerel. It is a summer visitor, appearing in our waters in company with the mackerel and disappearing about the same time. It appears to breed in the sounds and in the open ocean in June and July, and the young are found in great abundance in July, August, and September, swimming about in company with certain species of jelly-fish. During these months several large species of jelly-fish, or sun-squalls, are found abundantly floating about in waters near the shore, and each one of these is almost invariably accompanied by ten or twelve, or more, young Butter-fishes, which seem to seek shelter under their disks, and which, perhaps, may obtain a supply of food from among the numerous soft-bodied invertebrates which are constantly becoming attached to the floating streamers of their protectors. The young fish, thus protected, range from two to two and a half inches in length. I have seen fifteen, and more, sheltered under an individual of *Cyanea arctica* not more than three inches in diameter. This refuge is not always safe for the little fishes, for they sometimes are destroyed by the tentacles of their protector, which are provided, as every one knows, with powerful lasso cells. The little fish seem to rise at the approach of danger and seek refuge among the lobes of the actinostome. They are, of course, thus safe from the attacks of many kinds of larger fishes which prey upon them, but they themselves often fall victims to the stinging power of the jelly-fish and are devoured. The habit of thus seeking shelter is very much like that of the rudder-fish. The Butter-fish attains an average size of seven or eight inches in length, and is very often taken in the pounds. The fishermen of Noank, Connecticut, tell me that often a barrelful of them is taken in one haul of a pound-net. They are much valued for food at New Bedford. When sent to New York they command a good price, and the poundmen at Lobsterville sometimes eat them and consider them better than scup. Their flavor is excellent, resembling that of the mackerel, though less oily; it is very palatable when nicely broiled. At many places, for instance, Noank and Wood's Holl, they are thrown away. Storer stated that they were extensively used as manure in certain parts of Massachusetts. No observations have been made upon their food, though, since their mouths are nearly toothless, it seems probable that they subsist, for the most part, upon minute vertebrates. These fishes are remarkable on account of their brilliant, iridescent colors, which, in freshly caught individuals, are as beautiful as those of a dolphin.

The Harvest-fish—Stromateus alepidotus.

This species has not been observed north of New York. Mitchill referred to it in his work on the fishes of New York, published in 1815, saying that it derived its common name, "Harvest-fish," from the fact that it usually appeared during harvest time. DeKay, too, mentions having had several specimens in his possession. It is somewhat abundant at the mouth of the Chesapeake and along the Southern coast. In the Gulf of Mexico it is rather rare; occasionally it is taken in seines at Pensacola. Dr. Günther, in his "Catalogue of the Fishes of the British Museum," makes the astounding statement that he has seen specimens from Lake Champlain. The species ranges south to Bahia, Brazil. It is not commercially valuable except at Norfolk, Virginia, where it is consumed for food in large quantities, its market name being "Whiting."

The California Pompano—Stromateus simillimus.

The California Pompano, *Stromateus simillimus*, is thus described by Professor Jordan:

"This species, known here as the Pompano, reaches a length of eight inches and a weight of rather less than half a pound. It occurs along the entire coast of California and Oregon, being most abundant about Santa Barbara and Soquel, and is not known from farther south than San Diego. It appears in schools chiefly in the summer and fall; occasionally, also, during the winter, its times of arrival and departure being quite variable. It is said that it was an extremely rare visitant till about 1870, and that its abundance since then has steadily increased, it being now often found in greater quantities than can be readily sold. It feeds on worms, small crustacea, &c. Nothing special is known of its breeding habits. As a food-fish it is held in the highest repute, the price of individual fish ranging from two to four for a 'quarter.' Its flesh is fat, rich, and excellent."

The Black Rudder-fish—Lirus perciformis.

This fish is also called by the fishermen "Log-fish" and "Barrel-fish." It has been observed at various points along our coast from New Jersey to Nova Scotia, where schools of them were several times observed off Halifax in 1877. It has hitherto been considered very rare north of Cape Cod. I cannot doubt that it will be hereafter found at least as far south as Cape Hatteras and probably along the whole length of our Atlantic coast. The habits of this fish are peculiar in the extreme. They are almost always found in the vicinity of floating barrels and spars, sometimes inside of the barrels; hence the fishermen often call them "Barrel-fish," though the most usual name is "Rudder-fish." They are occasionally taken in lobster-pots. When cruising in the Fish Commission yacht "Mollie," off Noman's Land, July 13, 1875, we observed numerous specimens swimming under floating spars and planks. Sometimes as many as from fifty to seventy-five were observed under a single spar, a cloud of shadowy black forms being plainly visible from the deck. We went out to them in a row-boat and succeeded in taking thirteen of them in the course of a day. After the first thrusts of the dip-net they grew shy and sought refuge under the boat, under which they would sink far below our reach. A lull of a few moments would bring them back to the log under which they had clustered until disturbed again. When the boat was rowed away they followed in a close-swimming school until we gained full speed, when they suddenly turned, as if by one impulse, and swam back to the log or spar. Once they followed us about two hundred yards from the spar, and then leaving us retreated to their old shelter, reaching it some time before we could turn the boat and row back to it. I had before this supposed them to be quite unusual, but on this one day we must have seen two hundred or two hundred and fifty at the lowest computation. They doubtless have gained the name of Rudder-fish from the sailors who have seen them swimming about the sterns of becalmed vessels.

When the Fish Commission steamer has been dredging off Halifax, I have several times noticed schools of them hovering around her sides. They doubtless gather around the logs for the purpose of feeding upon the hydroids and minute crustaceans and perhaps mollusca which accumulate around them. Their stomachs were found to contain amphipod crustaceans, hydroids, and young squids. They are doubtless to some degree protected by the spars under which they congregate, in the same manner as their kindred, the Butter-fish, which swim under the disk of the jelly-fish. Their colors undergo considerable change from time to time, possibly at the will of the fish.

The Rudder-fish attains the length of ten or twelve inches, and is excellent eating. DeKay states that the fishermen of New York, in 1842, called this species the "Snip-nosed Mullet," but this name does not appear to have become permanent.

109. THE DORY, HEN-FISH, AND OPAH FAMILIES.

The Dory Family—Zenidæ.

The fishes of this family are found in all temperate and tropical seas. The Boar-fish and the John Dory, both somewhat important species in Great Britain, are members of this and related families. A single specimen, recorded by Storer and Gill, the species which is peculiar to America and described under the name *Zenopsis ocellatus*, was taken off Provincetown.

The Hen-fish Family—Bramidæ.

The only member of this family of interest to us is the *Brama Raii*, called "Pomfret" in Bermuda, where a few individuals were observed by the writer in 1876. In 1880 an individual was obtained on the Grand Bank of Newfoundland, and more recently the species has been found to be somewhat abundant on the coast of Washington Territory and Vancouver's Island. This species was described from the coast of South America under the name *Brama chilensis*.

The Opah Family—Lamprididæ.

This family is represented in the Atlantic by a single species, *Lampris guttatus*, a pelagic fish, which appears to be more abundant in the deep waters of northern seas than elsewhere. It has been observed at many points upon the Norwegian coast, about Iceland and Madeira, as well as in the Mediterranean, but is of unusual occurrence everywhere, except perhaps about Madeira. On the coast of England it is one of the great rarities, and is much sought for by collectors on account of its beauty. It is said to be one of the most brilliantly colored fishes known—"red and green, with tints of purple and gold dotted over with silvery round spots. Iris of the eye is scarlet, and fins of lively red." A specimen was obtained years ago near Sable Island, Nova Scotia, and the species will doubtless be found still nearer our shores. It is said that no young specimens have yet been seen. The species attains the length of four feet and more, and is said to be very excellent for eating.

110. THE CUTLASS-FISH—TRICHIURUS LEPTURUS.

This fish is unfortunately known in Eastern Florida and at Pensacola as the "Sword-fish"; at New Orleans, in the Saint John's River, and at Brunswick, Georgia, it is known as the "Silver Eel," on the coast of Texas as "Sabre-fish," while in the Indian River region it is called the "Skipjack." No one of these names is particularly applicable, and the latter being preoccupied, it would seem advantageous to use in this country the name "Cutlass-fish," which is current for the same species in the British West Indies.

Its appearance is very remarkable on account of its long, compressed form and its glistening silvery color. The name "Scabbard-fish," which has been given to an allied species in Europe, would be very proper also for this species, for in shape and general appearance it looks very like the metallic scabbard of the sword. It attains the length of four or five feet, though ordinarily not exceeding twenty-five or thirty inches. This species is found in the tropical Atlantic, on the coast of Brazil, in the Gulf of California, the West Indies, the Gulf of Mexico, and north to Wood's Holl, Massachusetts, where, during the past ten years, specimens have occasionally been taken. In 1845 one was found at Wellfleet, Massachusetts; and in the Essex Institute is a specimen which is said to have been found in Salem Harbor. The species occurs also on the coast of Europe, two specimens having been found on the shores of the Moray Frith many years ago, and during the past decade it has become somewhat abundant in Southern England. It does not, however, enter the Mediterranean. Some writers believe the allied species, *Trichiurus haumela*, found in the Indian

Ocean and Archipelago and in various parts of the Pacific, to be specifically the same. The Cutlass-fish is abundant in the Saint John's River, Florida, in the Indian River region, and in the Gulf of Mexico. Several instances were related to me in which these fish had thrown themselves from the water into row-boats, a feat which might be very easily performed by a lithe, active species like the *Trichiurus*. A small one fell into a boat crossing the mouth of the Arlington River, *where the water is nearly fresh.*[1]

Many individuals of the same species are taken every year at the mouth of the Saint John's River, at Mayport. Stearns states that they are caught in the deep waters of the bays about Pensacola, swimming nearly at the surface, but chiefly with hooks and lines from the wharves. He has known them to strike at the oars of the boat and at the end of the ropes that trailed in the water. At Pensacola they reach a length of twenty to thirty inches, and are considered good food-fish. Richard Hill states that at Jamaica this species is much esteemed, and is fished for assiduously in a "hole," as it is called, that is, a deep portion of the waters off Fort Augusta. This is the best fishing place for the Cutlass-fish, *Trichiurus*. The fishing takes place before day; all *lines are pulled in as fast as they are thrown out, with the certainty that the Cutlass has been* hooked. As many as ninety boats have been counted on this fishing ground at day-break during the season. All carry on this kind of uninterrupted hauling in of fish.

A closely allied species, *Lepidopus caudatus*, is the "Scabbard-fish" of Europe, which also occurs in the Gulf of California. In New Zealand it is called the "Frost-fish," and is considered the most *delicious food-fish of the colony.*

111. THE SWORD-FISH FAMILY—XIPHIIDÆ.

Although it may not seem desirable at present to accept in full the views of Dr. Lütken regarding the specific unity of the Spear-fishes and the Sail-fishes of the Atlantic and Indian Oceans, it is convenient in discussing their geographical distribution to group the different species in the manner he has suggested.

The Sword-fish, *Xiphias gladius*, ranges along the Atlantic coast of America from *Jamiaca*, latitude 18° N., Cuba, and the Bermudas, to Cape Breton, latitude 47°. It has not been seen at Greenland, Iceland, or Spitzbergen, but occurs according to Collet, at the North Cape, latitude 71°. It is abundant along the coasts of Western Europe, entering the Baltic and the Mediterranean. I can find no record of the species on the west coast of Africa south of the Cape Verdes, though Lütken, who may have access to facts unknown to me, states that they occur clear down to the Cape of Good Hope, South Atlantic in mid-ocean, west coast of South America and north to Southern California, latitude 34°, New Zealand, and in the Indian Ocean off Mauritius. Good authorities state that sperm-whales, though constantly passing Cape Horn, never round the Cape of Good Hope. Can this be true in the case of the Sword-fish?

The Sail-fish, *Histiophorus gladius* (with *H. americanus* and *H. orientalis*, questionable species, and *H. pulchellus* and *H. immaculatus*, young), occurs in the Red Sea, Indian Ocean, Malay Archipelago, and south at least as far as the Cape of Good Hope, latitude 35° S.; in the Atlantic on the coast of Brazil, latitude 30° S. to the equator, and north to Southern New England, latitude 42° N.; in the Pacific to Southwestern Japan, latitude 30° to 10° N. In a general way the range may be said to be in tropical and temperate seas, between latitude 30° S. and 40. N., and in the western parts of those seas.

The Bill-fish or Spear-fish, *Tetrapturus indicus* (with various related forms, which may or may not be specifically identical, occurs in the Western Atlantic from the West Indies, latitude 10° to 20° N.,

[1] Exiliens ex aquis sæpe in cymbam.—LINNÆUS.

to Southern New England, latitude 42° N.; in the Eastern Atlantic, from Gibraltar, latitude 45° N., to the Cape of Good Hope, latitude 30° S.; in the Indian Ocean, the Malay Archipelago, New Zealand, latitude 40° S., and on the west coast of Chili and Peru. In a general way, the range is between latitude 40° N. and latitude 40° S.

The species of *Tetrapturus* which we have been accustomed to call *T. albidus*, abundant about Cuba, is not very unusual on the coast of Southern New England. Several are taken every year by the Sword-fish fishermen. I have not known of their capture along the Southern Atlantic coast of the United States. All I have known about were taken between Sandy Hook and the eastern part of George's Banks.

The Mediterranean Spear-fish, *Tetrapturus belone*, appears to be a land-locked form, never passing west of the Straits of Gibraltar.

NAMES OF THE SWORD-FISH.—The names all have reference to its most prominent feature, the prolonged snout. The "Sword-fish" of our own tongue, the "*Zwaard-fis*" of the Hollander, the Italian "*Sifio*" and "*Pesce-spada*," the Spaniard's "*Espada*," "*Espadarte*," and varied by "*Pez de spada*" in Cuba, and the French "*Espadon*," "*Dard*," and *Épée de Mer*," are simply variations of one theme, repetitions of the "*Gladius*" of ancient Italy, and "*Xiphias*," the name by which Aristotle, the father of zoology, called the same fish twenty-three hundred years ago. The French "*Empereur*," and the "*Imperador*" and "Ocean King-fish" of the Spanish and French West Indies, carry out the same idea; the Roman emperor was always represented holding a drawn sword in his hand. The Portuguese names are "*Agulha*" and "*Agulhao*," meaning "needle" or "needle-fish."

This species has been particularly fortunate in escaping the numerous redescriptions to which almost all widely distributed forms have been subjected. By the writers of antiquity it was spoken of under its Aristotelian name, and in the tenth edition of his Systema Naturæ, at the very inception of binomial nomenclature, Linnæus called it *Xiphias gladius*. By this name it has been known ever since, and only one additional name is included in its synonymy, *Xiphias Rondeletii*, Leach.

The Sword-fish has been so long and so well known that its right to its peculiar name has seldom been infringed upon. The various species of *Tetrapturus* have sometimes shared its title, and this is not to be wondered at, since they closely resemble *Xiphias gladius*, and the appellative has frequently been applied to the family *Xiphiidæ*—the Sword fish family—which includes them all.

The name "Bill-fish," usually applied to the *Tetrapturus albidus*, a fish of the Sword-fish family often taken on our coast, and described below, is objectionable, since it is in many districts used for the various species of *Belonidæ*, the "gar-fishes" or "green-bones" (*Belone truncata* and others), which are members of the same fauna. "Spear-fish" is a much better name.

The "Sail-fish," *Histiophorus americanus*, is called by sailors in the south the "Boohoo" or "Woohoo." This is evidently a corrupted form of "Guebucu," a name, apparently of Indian origin, given to the same fish in Brazil. It is possible that the *Tetrapturus* is also called "Boohoo," since the two genera are not sufficiently unlike to impress sailors with their differences. Bleeker states that in Sumaba the Malays call the related species *H. gladius* by the name "Joohoo" (*Juhu*), a curious coincidence. The names may have been carried from the Malay Archipelago to South America, or *vice versa*, by neighbors.

In Cuba the Spear-fishes are called "*Aguja*" and "*Aguja de Palada*"; the Sail-fish, "*Aguja, Prieta*" or "*Aguja Voladora*"; *Tetrapturus albidus* is specially known as the "*Aguja Blanca*," *T. albidus* as the "*Aguja de Casta*."

In the West Indies and Florida the scabbard-fish or silvery hair-tail, *Trichiurus lepturus*, a form allied to the *Xiphias*, though not resembling it closely in external appearance, is often called

"Sword-fish." The body of this fish is shaped like the blade of a saber, and its skin has a bright metallic luster like that of polished steel; hence the name.

The various species of sticklebacks, *Gasterosteus aculeatus* and *Pygosteus pungitius*, are known as "Little Sword-fish" by the boys of Portland, Maine, and vicinity. The spines, damaging in the extreme to small fingers of tyro fish-gatherers, give reason to the name.

Sail-fish appear to occur throughout the tropical and southern parts of the Atlantic and the Indian Ocean. Its names, wherever it may be found, point to the most striking characters. In Maregrave's time the Portuguese of Brazil called it "*Bicuda*," referring to its snout, and Rochefort, in his "History of the West Indies," calls it "*Bécasse de Mer*"; a *bécasse* being a long snouted bird like a woodcock or a snipe, while in the Malay Archipelago the Dutch call it "*Zee-snip*" or "Sea-snipe." The Malays of Amboyna called it the "*Ikan-layer*" or Fan-fish, in allusion to the fan-like movements of its dorsal fin, while those of Sumatra called it "*Ikan-jegan*" or "Sail-fish." The French "*Voilier*" and the Dutch "*Zeyl-fisch*" and "*Bezaan fisch*" mean the same; a *bezaan* being the sail upon the mizzen mast of a ship. The family name is "*Myl-meen*," signifying "Peacock-fish." The names "*Boohoo*" and "*Woohoo*" have already been referred to.

GEOGRAPHICAL DISTRIBUTION AND MOVEMENTS.—The Sword-fish was known to Pliny, who wrote: "The Sword-fish, called in Greeke Xiphias, that is to say in Latin Gladius, a sword, hath a beake or bill sharp pointed, wherewith he will drive through the sides and plankes of a ship, and bouge them so, that they shall sinke withall. The experience whereof is scene in the ocean, neare to a place in Mauritania called Gotta, which is not far from the river Lixos."[1]

Many other classical and mediæval writers made curious allusions to the Sword-fish. The summary of their views is given by Bloch, and is quoted below. This summary is very satisfactory though the skepticism of this author is sometimes a little excessive:

"This fish is found in the North Sea and the Baltic, but is rare in those waters. In the Mediterranean, however, it is very abundant. It lives for the most part in the Atlantic, where in winter it is found in mid-ocean. In spring it appears on the coast of Sicily, where its eggs are deposited on the bottom in great numbers. However, according to what I have been told by the illustrious Chevalier Hamilton, it is never seen in that region more than three or four feet long. The larger ones, often weighing four or five hundred pounds, and eighteen to twenty feet long, are found on the coast of Calabria, where they appear in June and July. Pliny remarked that they often exceed the dolphin in size. . . .

"Various writers have spoken of the 'Emperor of the Sea' as occurring in the Baltic. Olearius and Schelhammer record its capture near Holstein; Schoneveld mentions one from Mecklenburg; Walbaum one from the vicinity of Lübeck; Hanover and Klein one from the vicinity of Danzig; Hartmann one from near Pillau, and Wolf another taken near Königsberg.

"One mentioned by Schoneveld as taken near Mecklenburg was so large that it required two strong horses to draw it from the water. The body, without the sword, was eleven feet long, the sword three. The eyes were as large as hens' eggs, and the tail was two feet broad. Of four seen by Professor Koelpin during his stay at Greifswald, one measured more than three and one-half feet in circumference. . . .

"These fish, according to the story of the Chevalier Hamilton, always appear in pairs as they approach Messina, a female and a male together.

"This fish lives upon marine plants and fish. It has such a terrible defensive weapon that other voracious fishes do not dare to attack it. According to Aristotle, it is, like the tunny, tormented by an insect, and in its fury leaps out of the sea and even into vessels. According to

[1] Holland's Pliny, ii, p. 428.

Statius Müller, the skin is phosphorescent at night. Although such large fishes are not usually well flavored, this one is considered palatable. Pieces of the belly and the tail are especially esteemed, and hence they are expensive. The fins are salted and sold under the name '*callo*'. . . .

"Ælian errs in saying that it enters fresh water, and in cataloguing it among the fishes of the Danube."

ALLUSIONS TO THE SWORD-FISH IN AMERICA BY EARLY WRITERS.—The ancient city of Siena, secluded and almost forgotten among the hills of Northern Italy, should have a peculiar interest for Americans. Here Christopher Columbus was educated, and here, in the height of his triumphs as a discoverer, he chose to deposit a memento of his first voyage across the seas. His votive offering hangs over the portal of the old collegiate church, closed for many years, and rarely visited save by enterprising American tourists. It consists of the helmet and armor worn by the discoverer when he first planted his feet on New World earth, his weapons, and the weapon of a warrior killed by his party when approaching the American coast—the sword of a Sword-fish.[1]

It is not probable that Columbus, or some of his crew, seafaring men of the Mediterranean, had never seen the Sword-fish. Still, its sword was treasured up by them, and has formed for more than four centuries and a half a striking feature in the best preserved monument of the discoverer of America.

The earliest allusion in literature to the existence of the Sword-fish in the Western Atlantic seems to occur in Josselyn's "Account of Two Voyages to New England," printed in 1674, in the following passage:

First Voyage:—"The Twentieth day, we saw a great number of Sea-bats, or Owles, called also flying fish, they are about the bigness of a Whiting, with four tinsel wings, with which they fly as long as they are wet, when pursued by other fishes. Here likewise we saw many Grand pisces, or Herring-hogs, hunting the scholes of Herrings, in the afternoon we saw a great fish called the Vehuella or Sword-fish, having a long, strong and sharp finn like a Sword-blade on the top of his head, with which he piereed our Ship, and broke it off with striving to get loose, one of our Sailors dived and brought it aboard."

A half century later I find a reference in Catesby's work.[2]

Pennant, though aware of the statement made by Catesby, refuses the species a place in his "List of the Fishes of North America,"[3] supposing him to refer to the orca or high-finned killer-whale: "I am not certain whether *Catesby* does not mean the high-finned *Cachalot* by his Sword-fish; yet, as it is found in most seas, even to those of *Ceylon* (Mr. Sotur), I give it a place here."

Catesby's testimony was soon confirmed by Dr. Alexander Garden. This enthusiastic collector, through whose correspondence with Linnæus so many of our Southern plants and animals were first brought to knowledge and named, writes to John Ellis, from Charleston, South Carolina, March 25, 1755: "I have sent you one of the rostrums of a fish found on the Florida coast, which I take to be a species of the *Ziphias rostr. apice ensiforme, pinnis ventralibus nullis*.[4] I have been told that they are frequently found on the Carolina coast, though I have never seen any of them, and I have been all along the coast to the Florida shore."[5] (Vol. i, p. 353.)

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[1] For this fact, which I do not remember to have ever seen on record, I am indebted to Col. N. D. Wilkins, of the Detroit Free Press, who visited the locality in 1879.

[2] Historia Naturalis Carolinæ, &c., 1731.

[3] Arctic Zoology, iii, 1784, p. 364.

[4] The name by which this fish was designated in the earlier editions of Linnæus's writings.

[5] A Selection of the Correspondence of Linnæus and other Naturalists, from the original manuscripts. By Sir James Edward Smith, M. D., F. R. S., &c., president of the Linnæan Society. In two volumes. London. Printed for Longman, Hurst, Rees, Orme and Brown, Paternoster Row, 1821.

Another allusion occurs in a communication by Dr. S. L. Mitchill, of New York, to the "American Monthly Magazine":

"An individual of this species was taken off Sandy Hook, by means of a harpoon, on the 19th June, 1817. The next day it was brought to New York market and cut up like halibut and sturgeon for food. The length was about twelve feet, and girth, by estimation, five. . . . The stomach contained seven or eight mackerel. The flesh was remarkably firm; it was purchased at a quarter of a dollar the pound. I tasted a chop of it, broiled, and found it savory and excellent. It resembled the best sturgeon, without its strong and oily flavor. While I ate it I thought of veal cutlet. . . . I have been informed by my friend John Renny that a Sword-fish sixteen feet long was exhibited at New York in the year 1791."[1]

DISTRIBUTION IN THE EASTERN ATLANTIC.—The Sword-fish is abundant in the Mediterranean[2] even as far east as Constantinople. Ælian said that it was frequent in the Black Sea, entering the Danube. Unfortunately, this is neither confirmed nor contradicted by any later writer whose works I have seen. Ælian says that this species, with several others, is frequently taken in the Danube at the breaking up of the ice in spring. This is so contrary to the known habits of the fish that it throws discredit on the whole story, for the present at least. From the entrance to the Mediterranean they range south to Cape Town. Berthelot saw great numbers of them off the Canaries. They have been frequently noticed on the coasts of Spain and France. They occur sparingly in summer in the British waters, even to the Orkneys and the Hebrides. They occasionally reach Sweden and Norway, where Linnæus observed them, and, according to Lütken, have been taken on the coast of Finmark. They are known to have occurred in Danish waters and to have found their way into the Baltic, thus gaining a place in the fauna of Russia. A number of instances of the occurrence of Sword-fish in the Baltic have been recorded.

DISTRIBUTION ON THE COAST OF THE UNITED STATES.—Allusion has been made to the early accounts of the Sword-fish on the coast of the United States both in the work of Catesby and the letters of Garden to Ellis and Linnæus; also, to Mitchill's account of it in 1818. Though it is strange that this very conspicuous species was not recorded more frequently by early American authors, it is still more remarkable that its right to a place in the fauna of the Western Atlantic was either denied or questioned, as late as 1836, by such well-informed authors as Sir John Richardson and MM. Cuvier and Valenciennes.

Storer's "Report on the Ichthyology and Herpetology of Massachusetts," published in 1839, was the first American faunal list, after Catesby's, in which the Sword-fish was mentioned among the American fish.

The range of the species on the eastern coast of America can now be defined with some accuracy. Northward and eastward these fish have been seen as far as Cape Breton and Sable Island Banks.

Captain Rowe states that during a trip to George's Banks he has seen them off Chebucto Head, near Halifax, where the fishermen claim occasionally to have taken them with seines.

Capt. Daniel O'Brien, of the schooner "Ossipee," took five Sword-fish on his halibut trawl, in two hundred fathoms of water, between La Have and Brown's Banks, in August, 1877.

Capt. Jerome B. Smith, of the schooner "Hattie Lewis," of Gloucester, killed a Sword-fish off Cape Smoke, near Sidney, Cape Breton.[3]

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[1] American Monthly Magazine, ii, 1818, p. 242.
[2] Risso, Cuvier and Valenciennes, Guichenot, etc.
[3] Capt. R. H. Hulbert.

Mr. J. Matthew Jones, of Halifax, Nova Scotia, writes, in 1877: "The Sword-fish is by no means common on our coast, and only makes its appearance at intervals in our harbors and bays. One was taken in 1864 in Bedford Basin, at the head of Halifax Harbor. September 6, 1866, an individual weighing two hundred pounds was taken in a net at Devil's Island. November 12, 1866, the Rev. J. Ambrose sent me a sword, three feet and six inches long, from a fish taken at Dover, Nova Scotia, a few days previously."

On the coasts of Maine, Massachusetts, and Rhode Island they abound in the summer months. Southward they are less frequently seen, though their occurrence off New York is not unusual. I have never known one to be taken off New Jersey, and in our southern waters they do not appear to remain. Uhler and Lugger vaguely state that they sometimes enter the Chesapeake Bay.[1] This is apparently traditionary evidence.

Dr. Yarrow obtained reliable information of their occasional appearance near Cape Lookout, North Carolina.[2]

Mr. A. W. Simpson states, in a letter to Professor Baird, that Sword-fish are sometimes seen at sea off Cape Hatteras, in November and December, in large quantities. They sometimes find their way into the sounds.

An item went the rounds of the newspapers in 1876 to the effect that a Sword-fish four feet long had been captured in the Saint John's River, near Jacksonville. After personal inquiry in Jacksonville, I am satisfied that this was simply a scabbard-fish or silvery hair-tail (*Trichiurus lepturus*).

Professor Poey states that the fishermen of Cuba sometimes capture the *Pez de Espada* when in pursuit of *Agujas* or Spear-fishes.[3] They have also been seen in Jamaica.

Lütken gives instances of the capture of young Sword-fish at various points in the open Atlantic, as follows:

(1) Latitude 32° 50′ N., longitude 74° 19′ W. (about 150 miles southeast of Cape Hatteras).

(2) Latitude 23° W., longitude 55° W. (about 500 miles northeast of the island of Antigua).

(3) Latitude 20° N., longitude 31° W. (about 150 miles northwest of Teneriffe, and 250 southwest of Madeira).

(4) On the equator, longitude 29° (about 500 miles northeast of Cape St. Roque).

(5) Latitude 25° 4′ S., longitude 27° 26′ W. (about 500 miles south of the island of Trinidad, South Atlantic).

Occurrence in the Pacific and Indian Oceans.—We have no record of their occurrence on the eastern coast of South America, but the species is found on the Pacific coast of the same continent, and north to California.

Professor Jordan writes: "Occasionally seen about Santa Catalina and the Coronados, but never taken, the fishermen having no suitable tackle. One seen by us off Santa Monica, in 1880, about eight feet in length."

Mr. Willard Nye, of New Bedford, Massachusetts, kindly communicates the following notes: Captain Dyer, of this port, says that Sword-fish are plentiful off the Peruvian coast, a number being often in sight at one time. The largest he ever saw was one caught by himself about 150 miles from the shore, and which he estimates to have weighed 900 to 1,000 pounds; the ship's crew subsisted on it for several days and then salted 400 pounds.

[1] List of the Fishes of Maryland. By P. R. Uhler and Otto Lugger, in Report of the Commissioners of Fisheries of Maryland, January, 1876, p. 90.

[2] Notes on the Natural History of Fort Macon, North Carolina, and vicinity (No. 3). By H. C. Yarrow, in Proceedings of the Academy of Natural Sciences of Philadelphia, 1877, p. 207.

[3] Synopsis Piscium Cubensium, Catálogo razonado de los Peces de la Isla de Cuba, in Repertorio físico-natural de la Isla de Cuba, ii, 1868, p. 379.

Captain Allen also states that while cruising in the Pacific for whales he has found the Sword-fish very abundant on the coasts of Peru and Chili, from the immediate coast 300 miles out, though outside of that limit they are seldom seen. They are most plenty during the month of January, when they are feeding on the common mackerel, with which those waters at that time abound. The largest he ever caught weighed about 600 pounds.

Both Captain Allen and Captain Dyer have made several voyages as masters of whaling ships, and are perfectly familiar with Sword-fish on our coast; both speak of seeing plenty of *Bill-fish in the Pacific, but they never had taken the trouble to catch them.* Günther mentions them in his book on the "Fishes of the South Sea."

In 1874 Dr. Hector discovered a sword-fish snout in the museum at Auckland, New Zealand, and his announcement of the discovery was followed by the publication of two other instances of its occurrence in this region.[1]

SWORD-FISH ENTERING RIVERS.—Sword-fish have been known to enter the rivers of Europe. We have no record of such a habit in those frequenting our waters.[2]

Ælian's improbable story that they were taken in the Danube in winter has been mentioned. Southey and others relate that a man was killed while bathing in the Severn, near Worcester, by one of these fishes, which was afterwards caught.

Couch states that a Sword-fish, supposed to weigh nearly three hundred pounds, was caught in the river Parret, near Bridgewater, in July, 1834.[3]

According to De la Blanchere, one of them was taken, in the ninth year of the French Republic, in the river of Vannes, on the Bay of Biscay.[4]

In the great hall of the *Rathhaus* in the city of Bremen hangs a large painting of a Sword-fish which was taken in the river Weser by some Bremen fishermen some time in the eighteenth century.

Underneath it is painted the following inscription:

"ANNO. 1696. DEN. 18. JULI. IST. DIESER.
FISCH. EIN. SCHWERTFISCH. GENANNT. VON. DIESER.
STADT. FISCHERN. IN. DER. WESER. GEFANGEN.
UND. DEM. 20. EJUSDEM. ANHERO. NAEHER.
BREMEN. GEBRACHT. WORDEN. SEINE. GANZE.
LENGTE. WAR. 10. FUSS. DAS. SCHWERT. WAR.
7½. VIRTEL. LANG. UND. 3. ZOLL. BREIT."

PERIODICAL MOVEMENTS OF THE SWORD-FISH—TIMES OF ARRIVAL AND DEPARTURE.—Before entering upon a discussion of the movements of the Sword-fish and their causes, it

[1] HECTOR: Trans. New Zealand Inst., vii (1874), 1875, p. 246. HUTTON: *Ibid.*, viii (1875), 1876, p. 211. CHEESEMAN: *Ibid.*, p. 219.

[2] They sometimes approach very near the shore, however, as is shown by the following extract from a Cape Cod paper:

"*A Sword-fish in close quarters.*—Monday afternoon, while Mr. A. McKenzie, the boat-builder on J. S. Atwood's wharf, was busily at work, his attention was attracted by a splashing of water under his workshop, as if a score of boys were swimming and making all the noise they possibly could by beating the water with their feet and hands. After this had been kept up awhile his curiosity became excited, and upon investigating the cause of the disturbance discovered a Sword-fish among the piles, where, in his attempts to escape, he had become bewildered and imprisoned. Quickly getting a harpoon, Mr. McKenzie fastened the fish, and with the aid of bystanders drew it alive upon the wharf, where it was visited by many spectators, and subsequently dressed and sold. It measured ten feet from the end of its sword to the tip of the tail—the sword itself being three feet in length. It is the first instance known of one of these fish being so near the shore, and why it should have been there at the time described is not easily explained."—*Provincetown Advocate*, September 29, 1875.

[3] History of British Fishes, ii, p. 148.

[4] Dictionnaire Général des Pêches.

seems desirable to bring together the facts which have been learned, by conversation with fishermen and otherwise, in one group. Each man's views are given in his own style, and as nearly as possible in his own words. There is no attempt at a classification of the facts. This will be made subsequently.

An old sword-fish fisherman at New York informed Mr. Blackford that the season opens in the neighborhood of Sandy Hook about the first of June and continues along the coast as far east as Martha's Vineyard and Nantucket Shoals until about the middle of September. He has heard of their being caught as far east as Cape Sable. At the first cold winds of September they disappear. They are, like the mackerel, at first very poor and lean, but as the season advances they grow fatter.

Mr. John H. Thomson, of New Bedford, who kindly interviewed some of the local fishermen, writes: "The Sword-fish appear on our coast, south of Block Island, about May 25 to June 1. They appear to come from the southwest, or just inside the track of the Gulf Stream. They gradually approach the Vineyard Sound and vicinity during June, and until July 10 or 15, then appear to leave, working to the southeast, and are to be found to the southeast of Crab Ledge about the middle of July. This school is composed of comparatively small fish, averaging about one hundred and fifty pounds gross, or about one hundred pounds without head and tail, as they are delivered in the market. The smallest are four feet long, including the sword, and weigh from thirty to forty pounds; the largest eight and a half feet long, with sword, and weighing three hundred pounds gross. These fish are of a light plumbeous hue, darker on the back and white on the belly.

"Of late years another school has appeared southeast of Cape Cod and George's Banks about the 1st of August. These fish are altogether different, being much larger, weighing from three to eight hundred pounds gross, and are entirely black. I have this week conversed with an old smackman, M. C. Tripp, who has all his life been a fisherman, and has this year (1874) captured about ninety fish, and his opinion is that they are not the same school. They appear to be of about the same abundance in average years, the catch depending on weather, fogs, etc. They come and leave in a general school, not in close schools like other fish, but distributed over the surface of the water, the whole being called by the fishermen the 'annual school,' though it cannot strictly be so named."

According to Mr. Willard Nye, Sword-fish appear on the coast of Massachusetts from the 8th to the 20th of June, and are first seen southwest of Block Island. They begin to leave in August, but stray ones are sometimes seen as late as the last of October. The usual explanation of their movements is that they are following their food—mackerel and menhaden—which swarm our waters in the season named, and which are of course driven off by the approach of winter and rough weather.

Capt. R. H. Hurlbert took a very large Sword-fish on George's Banks, in November, 1875, in a snow-storm.

The first Sword-fish of the season of 1875 was taken June 20, southwest of Montauk Point; its weight was one hundred and eighty-five pounds.

One taken off Noman's Land, July 20, 1875, weighed when dressed one hundred and twenty pounds, and measured seven feet. A cast was taken (No. 360), which was exhibited in the Government Building at Philadelphia.

Capt. Benjamin Ashby, of Noank, Connecticut, tells me that the New London and Noank vessels leave home on their sword-fishing cruise about the 6th of July. Through July they fish between Block Island and Noman's Land; in August between Noman's Land and the South

Shoals light-ship. The fish "strike in" to Block Island and Montauk Point every year about the 1st of July. They are first seen twenty to twenty-five miles southeast of Montauk. At the end of August they are most abundant in the South Channel. Captain Ashby never saw them at any time so abundant as August 15, 1859. He was cruising between George's Banks and the South Shoals. It was a calm day, after a fog. He could at any time see twenty-five or thirty from the mast-head. They turn south when snow comes.

Capt. George H. Martin, of East Gloucester, tells me that the Gloucester vessels employed in this fishery expect to be on the fishing grounds south of George's Banks by the 10th of June. They almost always find the fish there on their arrival, following the schools of mackerel. They "tend on soundings," like the mackerel. The first Sword-fish of 1877 was taken June 10; the first of 1878, June 14.

The statements already quoted, and numerous conversations with fishermen not here recorded, lead me to believe that Sword-fish are most abundant on the shoals near the shore and on the banks during the months of July and August; that they make their appearance on the frequented cruising grounds between Montauk Point and the eastern part of George's Banks some time between the 25th of May and the 20th of June, and that they remain until the approach of cold weather in October or early in November. The dates of the capture of the first fish on the cruising ground referred to are recorded for three years, and are reasonably reliable: 1875, June 20; 1877, June 10; 1878, June 14.

South of the cruising ground the dates of arrival and departure are doubtless farther apart; north and east the season being shorter. There are no means of obtaining information, since the men engaged in this fishery are the only ones likely to remember the dates when the fish are seen.

REASONS OF THE COMING OF SWORD-FISH UPON OUR COAST.—The Sword-fish comes into our waters in pursuit of its food. At least this is the most probable explanation of their movements, since the duties of reproduction appear to be performed elsewhere. Like the tunny, the blue-fish, the bonito, and the squeteague, they pursue and prey upon the schools of menhaden and mackerel which are so abundant in the summer months. "When you see Sword-fish, you may know that mackerel are about," said an old fisherman to me. "Where you see the fin-back whale following food, there you find Sword-fish," said another. The Sword-fish also feeds upon squid, which are at times abundant on our banks.

THE INFLUENCE OF TEMPERATURE UPON THE MOVEMENTS OF THE SWORD-FISH.—To what extent this fish is amenable to the influences of temperature is an unsolved problem. We are met at the outset by the fact that they are frequently taken on trawl-lines which are set at the depth of one hundred fathoms or more, on the off-shore banks. We know that the temperature of the water at those localities and at that depth is sure to be less than 40° Fahrenheit. How is this fact to be reconciled with the known habits of the fish, that it prefers the warmest weather of summer and swims at the surface in water of temperature ranging from 55° to 70°, sinking when cool winds blow? The case seemed clear enough until this inconvenient discovery was made, that Sword-fish are taken on bottom trawl-lines. In other respects their habits agree closely with those of the mackerel tribe, all the members of which seem sensitive to slight changes in temperature, and which, as a rule, prefer temperature in the neighborhood of 50° or more.

There is one theory by which this difficulty may be avoided. We may suppose that the Sword-fish take the hooks on their way down to the bottom; that in their struggles they get entangled in the line and hooks, and when exhausted sink to the bottom. This is not improbable. A conversation with some fishermen who have caught them in this way develops the fact that the fish are usually much tangled in the line, and are nearly lifeless when they are brought to the

surface. A confirmation is found in the observations of Captain Baker, of the schooner "Peter D. Smith," of Gloucester, who tells me that they often are taken on the hand-lines of the cod-fishermen on George's Banks. His observations lead him to believe that they only take the hook when the tide is running very swiftly and the lines are trailing out in the tideway at a considerable distance from the bottom, and that the Sword-fish strike for the bottom as soon as they are hooked. This theory is not improbable, as I have already remarked, but I do not at present advocate it very strongly. I want more facts before making up my own mind. At present the relation of the Sword-fish to temperature must be left without being understood.

The appearance of the fish at the surface depends apparently upon temperature. They are seen only upon quiet summer days, in the morning before ten or eleven o'clock, and in the afternoon about four o'clock. Old fishermen say that they rise when the mackerel rise, and when the mackerel go down they go down also.

PROBABLE WINTER HABITAT OF THE SWORD-FISH.—Regarding the winter abode of the Sword-fish conjecture is useless. I have already discussed this question at length with reference to the menhaden and mackerel. With the Sword-fish the conditions are very different. The former are known to spawn in our waters, and the schools of young ones follow the old ones in toward the shores. The latter do not spawn in our waters. We cannot well believe that they hibernate, nor is the hypothesis of a sojourn in the middle strata of mid-ocean exactly tenable. Perhaps they migrate to some distant region, where they spawn. But then the spawning time of this species in the Mediterranean, as is related in a subsequent paragraph, appears to occur in the summer months, at the very time when Sword-fish are most abundant in our own waters, apparently feeling no responsibility for the perpetuation of their species.

MOVEMENTS OF INDIVIDUAL SWORD-FISHES.—A Sword-fish when swimming near the surface usually allows its dorsal fin and the upper lobe of its caudal fin to be visible, projecting out of the water several inches. It is this habit which enables the fisherman to detect the presence of the fish. It swims slowly along, and the fishing schooner with a light breeze finds no difficulty in overtaking it. When excited its motions are very rapid and nervous. Sword-fish are sometimes seen to leap entirely out of the water. Early writers attributed this habit to the tormenting presence of parasites, but this theory seems hardly necessary, knowing what we do of its violent exertions at other times. The pointed head, the fins of the back and abdomen snugly fitting into grooves, the absence of ventrals, the long, lithe, muscular body, sloping slowly to the tail, fit it for the most rapid and forcible movement through the water. Prof. Richard Owen, testifying in an English court in regard to its power, said:

"It strikes with the accumulated force of fifteen double-handed hammers. Its velocity is equal to that of a swivel-shot, and is as dangerous in its effects as a heavy artillery projectile."

Many very curious instances are on record of the encounters of this fish with other fishes, or of their attacks upon ships. What can be the inducement for it to attack objects so much larger than itself it is hard to surmise. Many are familiar with the couplet from Oppian:

> Nature her bounty to his mouth confined,
> Gave him a sword, but left unarmed his mind.

It surely seems as if a temporary insanity sometimes takes possession of the fish. It is not strange that, when harpooned, it should retaliate by attacking its assailant. An old sword-fish fisherman told Mr. Blackford that his vessel had been struck twenty times. There are, however, many instances of entirely unprovoked assault on vessels at sea. Many of these are recounted in a later portion of this memoir. Their movements when feeding are discussed below, as well as their alleged peculiarities of movement during the breeding season.

It is the universal testimony of our fishermen that two are never seen swimming close together. Captain Ashby says that they are always distant from each other at least thirty or forty feet.

MAXIMUM AND AVERAGE SIZE OF AMERICAN SWORD-FISH.—The only individual of which we have the exact measurements was taken off Seaconnet, Rhode Island, July 23, 1874. This was seven feet seven inches long, weighing 113 pounds. Another, taken off Noman's Land, July 20, 1875, and cast in plaster for the collection of the National Museum, weighed 120 pounds, and measured about seven feet. Another, taken off Portland, August 15, 1878, was 3,999 millimeters long, and weighed about 600 pounds. Many of these fish doubtless attain the weight of 400 and 500 pounds, and some, perhaps, grow to 600; but after this limit is reached, I am inclined to believe larger fish are exceptional. Newspapers are fond of recording the occurrence of giant fish, weighing 1,500 pounds and upwards, and old sailors will in good faith describe the enormous fish which they saw at sea, but could not capture; but one well-authenticated instance of accurate weighing is much more valuable. The largest one ever taken by Capt. Benjamin Ashby, for twenty years a sword-fish fisherman, was killed on the shoals back of Edgartown, Massachusetts. When salted it weighed 639 pounds. Its live weight must have been as much as 750 or 800. Its sword measured nearly six feet. This was an extraordinary fish among the three hundred or more taken by Captain Ashby in his long experience. He considers the average size to be about 250 pounds dressed, or 325 alive. Captain Martin, of Gloucester, estimates the average size at 300 to 400 pounds. The largest known to Captain Michaux weighed 625. The average about Block Island he considers to be 200 pounds.

There are other stories of large fish. Capt. R. H. Hurlbert, of Gloucester, killed one on George's Banks, in September, 1876, which weighed when dressed 480 pounds. Capt. John Rowe, of the same port, salted one which filled two and one-half barrels. This probably weighed 600 pounds when alive. I have been told that a Sword-fish loses one-third of its weight in dressing, but I should think that one-fourth would be nearer to the truth. Captain Baker, of the schooner "Peter D. Smith," of Gloucester, assures me that he killed, in the summer of 1874, off Portland, a Sword-fish which weighed 750 pounds.

Mitchill and DeKay state that in 1791 a Sword-fish sixteen feet in length was exhibited in New York. It is questionable whether they often exceed this measurement. My own observations have been made on specimens from seven to twelve feet long. A stuffed specimen in the United States National Museum measures about ten feet, and this seems to be very nearly the average size.

MINIMUM SIZE OF AMERICAN SWORD-FISH.—The size of the smallest Sword-fishes taken on our coast is a subject of much deeper interest, for it throws light on the time and place of breeding. There is some difference of testimony regarding the average size, but all fishermen with whom I have talked agree that very small ones do not find their way into our waters. I have collected several instances from the experiences of men long wonted to this fishery.

Capt. John Rowe has seen one which did not weigh more than 75 pounds when taken out of the water.

Capt. R. H. Hurlbert killed, near Block Island, in July, 1877, one which weighed 50 pounds, and measured about two feet without its sword.

Captain Ashby's smallest weighed about 25 pounds when dressed; this he killed off Noman's Land. He never killed another which weighed less than 100. He tells me that a Bridgeport smack had one weighing 16 pounds (or probably 24 when alive), and measuring eighteen inches without its sword.

In August, 1878, a small specimen of the mackerel shark, *Lamna cornubica*, was captured at the mouth of Gloucester Harbor. In its nostril was sticking the sword, about three inches long, of a young Sword-fish. When this was pulled out the blood flowed freely, indicating that the wound was recent. The fish to which this sword belonged cannot have exceeded ten or twelve inches in length. Whether the small Sword-fish met with its misfortune in our waters, or whether the shark brought this trophy from beyond the sea, is a question I cannot answer.

Lütken speaks of a very young individual taken in the Atlantic, latitude 32° 50′ N., longitude 74° 19′ W. This must be about 150 miles southeast of Cape Hatteras.

SIZE IN THE MEDITERRANEAN.—In the Mediterranean, near Sicily and Genoa, young fish, ranging in weight from half a pound to twelve pounds, are said to be abundant between November and March.

About La Ciotat and Martigues, in the south of France, many are taken too small to injure the fishing-nets, and very rarely reaching the weight of 100 pounds.

From the statements of Bloch and later writers it appears that large Sword-fish also are abundant in the Mediterranean. Late Italian fishery reports state that the average weight of those taken on the coast of Italy is 50 kilograms (110 pounds).

Of the coasts of Spain and Portugal Steindachner remarks: "More abundant on the southern coasts of Spain than on the northern, western, and eastern sides of the Iberian Peninsula. We saw quite large examples in the fish-markets at Gibraltar, Cadiz, Lisbon, La Coruña, and Barcelona, and at Santa Cruz, Teneriffe. The largest of three specimens in my possession is forty-three inches long, another twenty-four inches."[1]

RATE OF GROWTH.—Little is known about the rate of growth. The young fish taken in winter in the Mediterranean, ranging in weight from half a pound to twelve pounds, are thought to have been hatched during the previous summer. Those of a larger size, ranging from twenty-four to sixty pounds, taken on the New England coast in the summer, may perhaps be the young of the previous year. Beyond this, even conjecture is fruitless. As in other species, the rate of growth depends directly upon the quantity of food consumed. It is to be presumed that a summer passed in feasting among the crowding schools of menhaden and mackerel in our waters would bring about a considerable increase in weight. That this is the case is clearly shown by the testimony of the fishermen, who say that in the spring Sword-fish are thin, growing fatter and heavier as the season goes on.

Dr. Lütken and Dr. Günther have lately made some exceedingly interesting observations upon the young of the Sword-fish and of the Spear-fish and Sail-fish.

Dr. Günther's studies were made upon very small specimens of undetermined species, belonging to either *Tetrapturus*, *Histiophorus*, or both. In his latest work, "The Study of Fishes," he summarizes the facts observed by him as follows:

"The Sword-fishes with ventral fins (*Histiophorus*) belong to the Teleosteans of the largest size. In young individuals, nine millimeters long, both jaws are produced and armed with pointed teeth, the supraorbital margin is ciliated, the parietal and preoperculum are prolonged into long spines, the dorsal and anal fins are a long fringe, and the ventrals make their appearance as a pair of short buds. When fourteen millimeters long the young fish has still the same armature of the head, but the dorsal fin has become much higher, and the ventral filaments have grown to a great length. At the next stage, when the fish has attained to a length of sixty millimeters, the upper jaw is considerably prolonged beyond the lower, losing its teeth, the spines of the head are shortened, and the fins assume nearly the shape which they retain in mature individuals.

[1] Sitzungsb. d. k. Akad. d. Wissensch., Wein, 1868, p. 396.

"Young Sword-fishes without ventral fins (*Xiphias*) undergo similar changes, and, besides, their skin is covered with small, rough excrescences, longitudinally arranged, which continue to be visible after the young fish has attained the form of the mature in other respects."

Dr. Lütken's description of the young Sword-fishes is an exceedingly valuable contribution to knowledge.

I have collected together, in the plates which accompany this paper, the various published figures of young Sword-fishes, and have had them redrawn as nearly as possible to a uniform scale.

Of the Sword-fish, *Xiphias gladius*, two figures are given. One, taken from Lütken's "Spolia Atlantica," is thirty-seven millimeters long; the other is a reproduction of the often-copied figure in Cuvier and Valenciennes' "Histoire Naturelle des Poissons," twelve to eighteen inches long. Lütken had a similar specimen, ten millimeters long, but it was too poorly preserved to be figured.

Of the various species of *Tetrapturus* and *Histiophorus*, six figures are given. The smallest is that from "Spolia Atlantica," and is of a fish five and one-half millimeters long. Lütken remarks that he has a series from five and one-half to twelve millimeters long which differ very little from each other. The next in size is copied from Günther, and is probably about ten millimeters long; the third, also from Günther, is fourteen millimeters long. Lütken has another link in the series, a specimen twenty-one millimeters long, which he has not figured. The fourth stage is from Günther, a specimen sixty millimeters long; the fifth, from Cuvier and Valenciennes, their *Histiophorus pulchellus*, about four hundred and ten millimeters long; the sixth, from Rüppell, a copy of his figure of *H. immaculatus*, said to be about eighteen hundred millimeters long. These illustrations show the development in a very satisfactory manner.

ABUNDANCE AT PRESENT.—For many years from three to six thousand of these fish have been taken annually on the New England coast. It is not unusual for twenty-five or more to be seen in the course of a single day's cruising, and sometimes as many as this are visible from the mast-head at one time. Captain Ashby saw twenty at one time, in August, 1839, between George's Banks and the South Shoals. One Gloucester schooner, the "Midnight," Capt. Alfred Wixon, took fourteen in one day on George's Banks, in 1877.

Capt. John Rowe obtained twenty barrels, or four thousand pounds, of salt fish on one trip to George's Banks; this amount represents twenty fish or more.

Captain Ashby has killed one hundred and eight Sword-fish in one year; Capt. M. C. Tripp killed about ninety in 1874.

Such instances as these indicate in a general way the abundance of the Sword-fish. A vessel cruising within fifty miles of our coast, between Cape May and Cape Sable, during the months of June, July, August, and September, cannot fail, on a favorable day, to come in sight of several of them. Mr. Earll states that the fishermen of Portland never knew them more abundant than in 1879. This is probably, in part, due to the fact that the fishery there is of very recent origin.

ABUNDANCE IN THE PAST AND PROBABILITY OF FUTURE DECREASE.—There is no evidence of any change in their abundance, either increase or decrease. Fishermen agree that they are as plenty as ever, nor can any change be anticipated. The present mode of fishing does not destroy them in any considerable numbers, each individual fish being the object of special pursuit. The solitary habits of the species will always protect them from wholesale capture, so destructive to schooling fish. Even if this were not the case, the evidence proves that spawning Sword-fish do not frequent our waters. When a female shad is killed, thousands of possible young die also. The Sword-fish taken by our fishermen carry no such precious burden.

EFFECTS OF OVERFISHING IN THE MEDITERRANEAN.—A very different tale was once told of

the winter fishery in the Mediterranean. Meunier quotes this testimony by Spallanzani: "I took part many times in this fishery, and I dare not tell how many young fish are its victims; being of no value they are thrown back into the sea, mutilated or already dead from the rubbing of the net-meshes. I write denouncing this destructive method, and I urge forcibly the harm which results from it. They tell me it is true that there is a law of Genoa which forbids its use, or rather its abuse, but this does not do away with the fact that each year there sail from the Gulf of Spezzia three or four pairs of fishing boats which go to the sea to carry on this fishing. Still more, the governor of the place, who should carry out this law, is the first to favor, by means of a gift of silver, the abuse which it is intended to prevent."

This, however, was a century ago. I have met with no complaints of decrease in the works of later writers, though in Targioni-Tozzetti's report, published in 1880, it is stated that there is much opposition to the capture of small fish.

NATURE OF FOOD.—Dr. Fleming found the remains of Sepias in its stomach, and also small fishes. Oppian stated that it eagerly devours the *Hippuris* (probably *Coryphæna*).

A specimen taken off Seaconnet, July 22, 1875, had in its stomach the remains of small fish, perhaps *Stromateus triacanthus*, and jaws of a squid, perhaps *Loligo Pealii*.

Their food in the Western Atlantic consists for the most part of the common schooling species of fishes.

They feed on menhaden, mackerel, bonitoes, bluefish, and other species which swim in close schools. Their habits of feeding have often been described to me by old fishermen. They are said to rise beneath the school of small fish, striking to the right and left with their swords until they have killed a number, which they then proceed to devour. Menhaden have been seen floating at the surface which have been cut nearly in twain by a blow of a sword. Mr. John H. Thomson remarks that he has seen them apparently throw the fish in the air, catching them on the fall.

Capt. Benjamin Ashby says that they feed on mackerel, herring, whiting, and menhaden. He has found half a bucketful of small fish of these kinds in the stomach of one Sword-fish. He has seen them in the act of feeding. They rise perpendicularly out of the water until the sword and two-thirds of the remainder of the body are exposed to view. He has seen a school of herring crowding together at the surface on George's Banks as closely as they could be packed. A Sword-fish came up through the dense mass and fell flat over on its side, striking many fish with the sides of its sword. He has at one time picked up as much as a bushel of herrings thus killed by a Sword-fish on George's Banks.

REPRODUCTION.—But little is known regarding their time and place of breeding. They are said to deposit their eggs in large quantities on the coasts of Sicily, and European writers give their spawning time as occurring the latter part of spring and the beginning of summer. In the Mediterranean they occur of all sizes from four hundred pounds down, and the young are so plentiful as to become a common article of food. Except in this region the young are never taken; on our own coast, plentiful as they are, they are never seen less than three feet, and are usually much larger. M. Raynaud, who brought to Cuvier a specimen of *Histiophorus* four inches long, taken in January, 1829, in the Atlantic, between the Cape of Good Hope and France, reported that there were good numbers of young Sail-fish in the place where this was taken.[1]

Old fishermen who have taken and dressed them by the hundred assure me that they have never seen traces of spawn in them. The absence of young fish and spawning females on the coast of North America would indicate that they do not breed with us. Judging from the locations where young fish have been taken, it seems probable that they breed in the open ocean.

[1] CUVIER & VALENCIENNES: Hist. Nat. Poiss., viii, p. 305.

Meunier,[1] quoting Spallanzani, states that the Sword-fish does not approach the coast of Sicily except in the season of reproduction; the males are then seen pursuing the females. It is a good time to capture them, for when the female has been taken the male lingers near and is easily approached. The fish are abundant in the Straits of Messina from the middle of April to the middle of September; early in the season they hug the Calabrian shore, approaching from the north; after the end of June they are most abundant on the Sicilian shore, approaching from the south.

From other circumstances, it seems certain that there are spawning grounds in the sea near Sicily and Genoa, for from November to the 1st of March young ones are taken in the Straits of Messina, ranging in weight from half a pound to twelve pounds.

ABSENCE OF ORDINARY HABITS OF BREEDING SEASON AMONG OUR SWORD-FISH.—In the Mediterranean, as has been already stated, the very young fish are found from November to March, and here from July to the middle of September the male fish are seen pursuing the female over the shoals, and at this time the males are easily taken. Old sword-fish fishermen, Captain Ashby and Captain Kirby, assure me that on our coast, out of thousands of specimens they have taken, they have never seen one containing eggs. I have myself dissected several males, none of which were near breeding time. In the European waters they are said often to be seen swimming in pairs, male and female. Many sentimental stories were current, especially among the older writers, concerning the conjugal affection and unselfish devotion of the Sword-fish, but these seem to have originated in the imaginative brain of the naturalist rather than in his perceptive faculties. It is said that when the female fish is taken the male seems devoid of fear, approaches the boat, and allows himself easily to be taken; but, if this be true, it appears to be the case only in the height of the breeding season, and is easily understood. I cannot learn that two Sword-fish have ever been seen associated together in our waters, though I have made frequent and diligent inquiry.

There is no inherent improbability, however, in this story regarding the Sword-fish in Europe, for the same thing is stated by Professor Poey as the result of his studies upon the habits of *Tetrapturus*.

A curious fancy was prevalent in former days regarding an anatomical character of the Sword-fish. In an article by Mr. Dale in "Philosophical Transactions" (abridged edition, ii, p. 835), he remarks: "I cannot concede it to be consonant to that Care and Industry of Nature, in providing convenient Receptacles for preserving the *Fœtus;* neither is it agreeable to Reason to believe, that when Nature had provided an Uterus in all Animals, not only the Viviparous, and such as only cherish the Embryo in Utero, but in the Oviparous also and Insects, the *Eel* and the *Xiphia*, or Sword-fish, should be the only Animals without it."

ENEMIES AND FATALITIES: PUGNACITY.—The pugnacity of the Sword-fish has become a by-word. Without any special effort on my part the following instances of their attacks upon vessels have in the last six years found their way into the pigeon-hole labeled "Sword-fish."

Ælian says (b. xxxii, c. 6) that the Sword-fish has a sharp-pointed snout, with which it is able to pierce the sides of a ship and send it to the bottom, instances of which have been known near a place in Mauritania known as Cottè, not far from the river Lixus, on the African side of the Mediterranean. He describes the sword as like the beak of the ship known as the trireme, which was rowed with three banks of oars.

One of the earliest accounts is that given in the second part of vol. i, lib. ii, p. 89, 1615, of "Purchas his Pilgrimes":

"The sixth Circum-Navigation, by William Cornelison Schovten of Horne; who Sovthwards

[1] Les Grandes Pêches, p. 142.

from the Straights of Magelan in Tierra-Delfvogo, fovnd and discovered a new passage through the great Sovth-Sea, and that way sailed rovnd about the World," etc.

Off the coast of Sierra Leone:

"The fift of October we were vnder foure degrees seuen and twentie minutes, the same day about noone, there was such a noyse in the Bough of our Shippe, that the master, being behind in the Gallerie, thought that one of the men had fallen out of the Fore-ship, or from the Boe-sprit into the sea, but as hee looked out over the side of the Ship hee saw the Sea all red, as if great store of bloud had beene powred into it, whereat hee wondred, knowing not what it meant, but afterward hee found, that a great Fish or a Sea monster having a horne had therewith stricken against the ship with most great strength. For when we were in Porto Desire where we set the Ship on the Strand to make it cleane, about seven foot under water, before in the Ship, wee found a Horne sticking in the Ship, much like for thicknesse and fashion to a common Elephants tooth, not hollow, but full, very strong hard Bone, which had entered into three Plankes of the Ship, that is two thicke Plankes of greene and one of Oken wood, and so into a Rib, where it turned upward, to our great good fortune, for if it had entered between the Ribbes, it would happily have made a greater Hole and have brought both Ship and men in danger to be lost. It strucke at least halfe a foote deepe into the Ship and about half a foote without, where, with great force it was broken off, by reason whereof the great monster bled so much."

More than a century later C. Mortimer, M. D., records this experience:

"Mr. Bankley shewed me the *Horn* of a *Fish* that had penetrated above 8 inches into the Timber of a Ship and gave me the following Relation of it: 'His MAJESTY'S Ship *Leopard*, having been at the *West Indies* and on the Coast of *Guiney*, was ordered by Warrant from the Honourable *Navy-Board*, dated Aug. 18, 1725, to be cleaned and refitted at Portsmout for Channel-Service: Pursuant thereto, she was put into the great Stone-dock; and, in stripping off her Sheathing, the Shipwrights found something that was uncommon in her Bottom, about 8 Feet from her Keel, just before the Fore Mast; which they searching into, found the Bone or Part of the Horn of a Fish of the Figure here described; the Outside Rough not unlike *Seal-Skin;* and the End, where it was broken off shewed itself like coarse Ivory. The Fish is supposed to have followed the Ship, when under Sail, because the Sharp End of the Horn pointed toward the Bow: It penetrated with that Swiftness or Strength that it went through the Sheathing 1 Inch thick, the Plank 3 Inches thick, and into the Timber, 4½ inches.'"[1]

Don Joseph Cornide, in his "Ensayo de una Historia de los Peces de la Costa de Galicia," 1787:

"This fish is taken in the seas of Galicia, where it is more common toward the Rio de Vigo, where it is well known that the 'Balandia' (a small fishing vessel), of S. M. le Ardilla, was pierced in its side and sunk by the arm of one of these fishes, which is preserved in the Royal Cabinet of Natural History."

The following statement is from the note book of Professor Baird:

In 1871 the little yacht "Redhot," of New Bedford, was out sword-fish fishing, and a Sword-fish had been hauled in to be lanced, and it attacked the vessel and pierced the side so as to sink the vessel. She was repaired and used in the service of the Commission at Wood's Holl.

Couch quotes the personal statement of a gentleman, who says:

"We have had the pleasure of inspecting a piece of wood cut out of one of the fore planks of a vessel (the 'Priscilla,' from Pernambuco) through which was struck about eighteen inches of

[1] An account of the horn of a Fish struck several Inches into the side of a Ship, by C. Mortimer, M. D., F. R. S. Philos. Trans., xl, No. 461, p. 862, 1741. Abr. ed., ix, p. 72.

the bony weapon of the Sword-fish. The force with which it must have been driven in affords a striking exemplification of the power and ferocity of the fish. The 'Priscilla' is quite a new vessel. Captain Taylor, her commander, states that when near the Azores, as he was walking the quarter-deck at night, a shock was felt which brought all hands from below, under the impression that the ship had touched upon some rock. This was, no doubt, when the occurrence took place."

The New York Herald of May 11, 1871, states:

"The English ship 'Queensberry' has been struck by a Sword-fish, which penetrated to a depth of thirty inches, causing a leak which necessitated the discharge of the cargo."

The "London Daily News of December" 11, 1868, contained the following paragraph, which emanated, I suspect, from the pen of Prof. R. A. Proctor:

"Last Wednesday the court of common pleas—rather a strange place, by the by, for inquiring into the natural history of fishes—was engaged for several hours in trying to determine under what circumstances a Sword-fish might be able to escape scot-free after thrusting his snout into the side of a ship. The gallant ship 'Dreadnought,' thoroughly repaired and classed A1 at Lloyd's, had been insured for £3,000 against all the risks of the seas. She sailed on March 10, 1864, from Colombo, for London. Three days later the crew, while fishing, hooked a Sword-fish. Xiphias, however, broke the line, and a few moments after leaped half out of the water, with the object, it should seem, of taking a look at his persecutor, the 'Dreadnought.' Probably he satisfied himself that the enemy was some abnormally large cetacean, which it was his natural duty to attack forthwith. Be this as it may, the attack was made, and at four o'clock the next morning the captain was awakened with the unwelcome intelligence that the ship had sprung a leak. She was taken back to Colombo, and thence to Cochin, where she was hove down. Near the keel was found a round hole, an inch in diameter, running completely through the copper sheathing and planking.

"As attacks by Sword-fish are included among sea-risks, the insurance company was willing to pay the damages claimed by the owners of the ship if only it could be proved that the hole had really been made by a Sword-fish. No instance had ever been recorded in which a Sword-fish had been able to withdraw his sword after attacking a ship. A defense was founded on the possibility that the hole had been made in some other way. Professor Owen and Mr. Frank Buckland gave their evidence, but neither of them could state quite positively whether a Sword-fish which had passed its beak through three inches of stout planking could withdraw without the loss of its sword. Mr. Buckland said that fish have no power of 'backing,' and expressed his belief that he could hold a Sword-fish by the beak; but then he admitted that the fish had considerable lateral power, and might so 'wriggle its sword out of the hole.' And so the insurance company will have to pay nearly £600 because an ill-tempered fish objected to be hooked, and took its revenge by running full tilt against copper sheathing and oak planking."

"The Gloucester schooner 'Wyoming,' on a last trip to George's Banks," records the 'New York World' of August 31, 1875, "was attacked by a Sword-fish in the night-time. He assailed the vessel with great force, and succeeded in putting his sword through one of her planks some two feet, and, after making fearful struggles to extricate himself, broke his sword off, leaving it hard and fast in the plank, and made a speedy departure. Fortunate was it that he did not succeed in drawing out his sword, as the aperture would undoubtedly have made a leak sufficient to sink the vessel. As it was, she leaked badly, requiring pretty lively pumping to keep her free."

Another instance of a similar nature is this, which was recorded in the "Liverpool Mercury" about the year 1876:

"Mr. J. J. Harwood, master of the British brigantine 'Fortunate,' in dock at Liverpool, reports that whilst on his passage from the Rio Grande, when in latitude 20° 12′ north and longitude 47°

9′ west, this ship was struck by a large fish, which made the vessel shake very much. Thinking the ship had been merely struck by the tail of some sea-monster, he took no further notice of the matter; but, after discharging cargo at Runcorn, and coming into the Canada half-tide dock, he found one of the plank ends in the stern split, and on closer examination he discovered that a Sword-fish had driven his sword completely through the plank, four inches in thickness, leaving the point of the sword nearly eight inches through the plank. The fish in its struggle broke the sword off level with the outside of the vessel, and by its attack upon the ship lost nearly a foot length of the very dangerous weapon with which it was armed. There is no doubt that this somewhat singular occurrence took place when the vessel was struck as Captain Harwood describes."

In "Forest and Stream" of June 24, 1875, was recorded the following incident:

"On Wednesday of last week a Sword-fish attacked the fishing-boat of Capt. D. D. Thurlow while he was hauling mackerel-nets off Fire Island, thrust its sword clear through the bottom, and stuck fast, while the fishermen took several half-hitches around its body and so secured it. It was afterwards brought to Fulton Market, and found to weigh three hundred and ninety pounds. Its sword measured three feet and seven inches, and its entire length was over eleven feet. The stuffed skin will adorn the Central Park Museum."

In the "Landmark," of Norfolk, Virginia, February, 1876, was mentioned a similar occurrence:

"The brig 'P. M. Tinker,' Captain Bernard, previously mentioned as having arrived here from Richmond, leaking, for repairs, has been hauled up on the ways at Graves' ship-yard. On examination it was discovered that the leak was caused by a Sword-fish, the sword being found broken off forward the bands, about sixteen feet abaft the forefoot. The fish, in striking the vessel, must have come with great force, as the sword penetrated the copper sheathing, a four-inch birch plank, and through the timbers about six inches—in all about ten inches. It occurred on the morning of the 23d of December, when the brig was eighteen days out from Rio, and in the neighborhood of Cape Saint Roque. She was pumped about four o'clock in the morning, and found free of water. About six o'clock the same morning she was again pumped, when water was obtained, and on examination it was found that she had made ten inches of water. The men were kept steady at the pumps until her arrival at Richmond, and while there, and on her trip here."

Mr. Willard Nye, of New Bedford, Massachusetts, sends the following note:

"A few years ago Captain Dyer, of New Bedford, struck a Sword-fish, from a thirty-foot boat, forty miles southwest of Noman's Land, threw overboard the keg, tacked, and stood by to the windward of it. When nearly abreast of it the man at the mast-head called out, 'Why, here he is, right alongside.' The fish was then about ten feet from the boat, and swimming in the same direction, but when he got where he could see the splash of water around the bow he turned and struck the boat about two feet from the stern and just below the water-line. The sword went through the planking, which was of cedar an inch and three-quarters thick, into a lot of loose iron ballast, breaking off short at the fish's head. A number of boats, large and small, have been 'stove' by Sword-fish on our coast, but always after the fish had been struck."

A nameless writer in "Harper's Weekly," October 25, 1879, narrates these instances, for which I am unable to give the original authority:

"In a calm day in the summer of 1832, on the coast of Massachusetts, a pilot was rowing his little skiff leisurely along, when he was suddenly roused from his seat by a thrust from below by a Sword-fish, who drove his sharp instrument more than three feet up through the bottom. With rare presence of mind, with the butt of an oar he broke it off level with the floor before the fish had time to withdraw it. Fortunately, the thrust was not directly upward. Had it been so, the frail boat would have been destroyed.

"A Boston ship hauled up on the ways for repair, a few years since, presented the shank of a Sword-fish's dagger, which had been driven considerably far into the solid oak plank. A more curious affair was brought to light in 1725 in overhauling His Majesty's ship 'Leopard,' from the coast of Africa. The sword of this marine spearsman had pierced the sheathing one inch, next it went through a three-inch plank, and beyond that three inches and a half into the firm timber. It was the opinion of the mechanics that it would have required nine strokes of a hammer weighing twenty-five pounds to drive an iron bolt of the same dimensions to the same depth in the hull. Yet the fish drove it at a single thrust.

"On the return of the whale-ship 'Fortune' to Plymouth, Massachusetts, in 1827, the stump of a sword blade of this fish was noticed projecting like a cog outside, which, on being traced, had been driven through the copper sheathing, an inch board undersheathing, a three-inch plank of hard wood, the solid white-oak timber twelve inches thick, then through another two and a half inch hard-oak ceiling, and lastly penetrated the head of an oil-cask, where it stuck, not a drop of the oil having escaped."[1]

Such instances could be found by the score, if one had the time and patience to search. The thing happens many times a year, and nearly as often affords a text for some paragrapher or local editor.

ENEMIES.—Such a large animal as the Sword-fish can have but few antagonists whose attacks would be disastrous. The tunny or horse-mackerel, *Orcynus thynnus*, other Sword-fishes, and sharks are its only peers in size, and of these the sharks are probably its worst foes.

Capt. N. E. Atwood exhibited to the Boston Society of Natural History, December 7, 1864, the lower jaw of a large shark, taken at Provincetown, Massachusetts, in whose stomach nearly the whole of a large Sword-fish was found. Some ten or twelve wounds were noticed in the skin of the shark, giving an idea of the conflict. The shark was doubtless *Galeocerdo tigrinus*.

Couch was told by a sailor that he had watched with interest the anxious motions of one as it was followed closely and rapidly in all its turnings by a blue shark. Twice did it leap above the surface to escape the near approach of its pursuer, but with what success at last the observer had no opportunity of knowing.

Mr. John H. Thomson states that the Bill-fish (probably *Tetrapturus albidus*) is their especial enemy. Bill fish, six to twelve feet long, appear about the last of the season, and their appearance is a signal that the Sword-fish are about leaving.

INVERTEBRATE PARASITES OF THE SWORD-FISH.—Aristotle thus explains the leaping movements of the fish: "The tunny and the *Xiphias* suffer from the œstrus at the rising of the dog-star, for both these fish at this season have beneath their fins a little worm which is called œstrus, which resembles a scorpion, and is about the size of a spider; they suffer so much from this torment that the *Xiphias* leaps out of the sea as high as the dolphin, and in this manner frequently falls upon our ships."

This description of the parasite is somewhat vague; yet it is evident that allusion is made to one of the Lerneans or gill-lice, little crustaceans remotely resembling crabs and lobsters, which attach themselves to the gills and skin of many kinds of fishes, sucking the blood from their veins, and often causing death; dreadful to their victims as was their namesake, the fabled Lernean Hydra, to the Argives of old, and not to be destroyed by any piscine Hercules and Iolaus.

In one of the early volumes of the "Philosophical Transactions" is an account by S. Paulo Boccone of "an extraordinary *Sanguisuga*, or *Leech*, found sometimes sticking fast in the Fish called *Xiphias* or *Sword-fish*." It is described as "about four Inches long, the Belly of it white, cartilaginous and transparent, without Eyes or Head, but instead of a Head it had a hollow Snout,

encompassed with a very hard Membrane; which Snout it thrusts whole into the Body of the Fish, as strongly as an *Augre* is wound into a piece of Wood, and fills it full of Blood into the very Orifice." He names it "*Hirudo*" or "*Acus cauda utrinque pennata.*"[1]

A specimen taken off Seaconnet, July 22, 1875, had fluke-worms in the external coat of the stomach and in the air-bladder.

The Sword-fish is infested by many species of invertebrate parasites. Some hang on the gills, others fasten themselves to different parts of the alimentary canal—the œsophagus, the stomach, and the intestines; and others still bore into the flesh. Several species, as might be expected from the size of the fish, are among the giants of their races. All undoubtedly cause more or less pain to their host, but especially those which attach themselves to the gills, disturbing their action and destroying their substance.

The parasites of the Sword-fish, for convenience, may be classified in two groups, the worm-like parasites (*Helminthes*) and the crustacean parasites.

FISH-PARASITES—THE SUCKERS OR REMORAS.—Several species of "stay-ships" or "remoras" occur on our coast. The ordinary kinds, such as *Echeneis naucrates*, the one with a black stripe down its side and white corners to its caudal fin, appears to choose companionship with the sharks, while the oceanic species, *Remora squalipeta*, is most often found clinging to ships.

A third species, *Remora brachyptera*, is the particular parasite of the Sword-fish. I have several times identified specimens found attached to the fish, and have never known this species to be found on any other member of the family. It has never come to us, moreover, from locality and season which would be inconsistent with a theory that it had been brought near shore by a Sword-fish.

Still another, *Rhombochirus osteochir*, seems equally inseparable from *Tetrapturus albidus*. This fact is known to the Cuban fishermen, who call it by the name *Pega de las Agujas*—the parasite of the Spear-fish.

Perhaps the two species are not so steadfast in their likings that they will not change from *Xiphias* to *Tetrapturus*. My friend Professor Giglioli, of Florence, who speaks of *R. brachyptera* as a fish new to the Mediterranean, obtained from Taranto a specimen said to have been taken from the gills (operculum?) of *Tetrapturus belone*.

These parasites probably prefer to cling with their curious suckers to the hard exterior surface of the opercular flap of the Sword-fish.

SWORD-FISH AS AN ARTICLE OF FOOD.—"The small Sword-fish is very good meat," remarked Josselyn, in writing of the fishes of New England in the seventeenth century. Since Josselyn probably never saw a young Sword-fish, unless at some time he had visited the Mediterranean, it is fair to suppose that his information was derived from some Italian writer.

It is, however, a fact that the flesh of the Sword-fish, though somewhat oily, is a very acceptable article of food. Its texture is coarse; the thick, fleshy, muscular layers cause it to resemble that of the halibut in consistency. Its flavor is by many considered fine, and is not unlike that of the bluefish. Its color is gray. The meat of the young fish is highly prized on the Mediterranean, and is said to be perfectly white, compact, and of delicate flavor.[2] Sword-fish are usually cut up into steaks, thick slices across the body, and may be broiled or boiled.

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[1] Philosophical Transactions, Vol. II, p. 821.

[2] The flesh, which is much esteemed by the better classes at Palermo, is dressed in almost as many modes as that of the tunny, and fetches a higher price. During our sojourn there it was as two to one, the price of the first averaging fourpence per *rebolo*, while the *porομαι* of the latter were disposed of at twopence or twopence-halfpenny. The fiber is invitingly white, and the round segments look, as they lie in rows along the stalls, like so many fillets of veal. Four to six feet is the usual run of those taken off the Trinacrian coast and displayed in the fish-markets of Sicily.—BADHAM.

Considerable quantities of Sword-fish are annually salted in barrels in Portland, Gloucester, Boston, New Bedford, and New London. Sword-fish pickled in brine is in considerable demand in certain sections of the country, and particularly in Lower Connecticut Valley, where a barrel may be found in almost every grocery store. By many persons it is considered much more palatable than salted mackerel.

THE SAIL-FISH—HISTIOPHORUS AMERICANUS.

Strange as it may seem, the American species of *Histiophorus* has never been studied by an ichthyologist, and no attempt has ever been made to describe it or to compare it carefully with the similar species occurring in the Indian Ocean. The identity of the two has been assumed by Dr. Günther,[1] but since no American specimens have ever been seen by this authority, I hesitate for the present to follow his lead.

The history of the Sail-fish in ichthyological literature is as follows:

The first allusion to the genus occurs in Piso's "Historia Naturalis Brasiliæ," printed at Amsterdam in 1648. In this book[2] may be found an identifiable though rough figure of the American species, accompanied by a few lines of description, which, though good, when the fact that they were written in the seventeenth century is brought to mind, are of no value for critical comparison.

The name given to the Brazilian Sail-fish by Marcgrave, the talented young German who described the fishes in the book referred to, and who afterward sacrificed his life in exploring the unknown fields of American zoology, was *Guebucu brasiliensibus*. The use of the name *Guebucu* is interesting, since it gives a clew to the derivation of the name "Boohoo," by which this fish, and probably the Spear-fishes, are known to English-speaking sailors in the tropical Atlantic.

Sail-fishes were observed in the East Indies by Renard and Valentijn, explorers of that region from 1680 to 1720, and by other eastern voyagers. No species of the genus was, however, systematically described until 1786, when a stuffed specimen from the Indian Ocean, eight feet long, was taken to London, where it still remains in the collections of the British Museum. From this specimen M. Broussonet prepared a description, giving it the name *Scomber gladius*, rightly regarding it as a species allied to the mackerel.

In 1803 Lacépède established the genus *Histiophorus* for the reception of this species.

When Cuvier and Valenciennes published the eighth volume of their Natural History of Fishes, they ignored the name *gladius*, which had been given to the East Indian fish by Broussonet, redescribing it under the name *Histiophorus indicus*. At the same time they founded another species upon the figure in Piso's Natural History of Brazil, already mentioned. This they called *Histiophorus americanus*.

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[1] Catalogue of the Fishes in the British Museum, ii, 1860, p. 513.

[2] 1648. PISO and MARCGRAVE:

Historia Naturalis | Brasiliæ, | Auspicio et Beneficio | Illustrissi. | Mauritii Com. Nassau | illius Provinciæ et Maris summi Præfecti Adornata: | In qua | Non tantum Plantæ et Animalia, sed et In- | digenarum morbi, ingenia et mores describuntur et | Iconibus quingentis illustrantur | (Elaborate engraved title-page, upon which the preceding inscription is inserted upon a scroll, the following upon a shell.) Lvgdvn Batavorum, | Apud Franciscum Hackium, | et | Amstelodami, | Apud Lud. Elzevirium. 1648. | 1 pp. (12), 122, (2), (8), 293, (7).

Second title.

Guilielmi Pisonis, M. D. | Lugduno-Batavi, | de Medicina Brasiliensi | Libri Quatuor: | I. De Aëre, Aquis & Locis | II. De Morbis Endemiis. | III. Venenatis & Antidotis. | IV. De Facultatibus Simplicium | et Georgi Marcgravi de Liebstad. | Misnici Germani, | Historiæ Rerum Naturalium | Brasiliæ | Libri octo: | Quorum | Tres priores agunt de Plantis. | Quartus de Piscibus. | Quintus de Avibus. | Sextus de Quadrupedibus & Serpentibus. | Septimus de Insectis. | Octavus de Ipsa Regione, & Illius Incolis. | Cum | Appendice de Tapuyis, et Chilensibus. | Ioannes de Læt, | Antverpianus, | In ordinem digessit & Annotationes addidit, & varies ab Auctore | Omissa supplevit & Illustravit.

In a paper printed in 1833, Dr. Nardo, of Venice, proposed the establishment of a new genus allied to *Tetrapturus* and *Xiphias*, to be called *Skeponopodus*. In this he included the fish described by Marcgrave under the name *Skeponopodus guebucu*, and also a form observed by him in the Adriatic in 1829, which he called *S. typus*. I am not aware that ichthyologists have yet learned what this may have been.[1]

From the time of Marcgrave until 1872 it does not appear that any zoologist had any opportunity to study a Sail-fish from America, or even from the Atlantic; yet in Günther's "Catalogue" the name *H. americanus* is discarded and the species of America is assumed to be identical with that of the Indian Ocean.[2]

Günther restores Lacépède's name, *H. gladius*, for the Indian species. Possibly, indeed probably, this name will be found to include the Sail-fish of our own coast. At present, however, it seems desirable to retain a separate name. To unite species from widely distant localities without ever having seen them is very disastrous to a proper understanding of the problems of geographical distribution.

The materials in the National Museum consist of a skeleton and a painted plaster cast of the specimen taken near Newport, Rhode Island, in 1872, and a drawing made of the same, while fresh, by Mr. J. H. Blake.

The occurrence of the Sail-fish is, as has been already stated, very unusual. Marcgrave saw it in Brazil as early as 1648. Sagra and Poey mention that it has been seen about Cuba, and Schomburg includes it in his Barbados list. The specimen in the United States National Museum was taken off Newport, Rhode Island, in August, 1872, and given to Professor Baird by Mr. Samuel Powell, of Newport. No others were observed in our waters until March, 1878, when, according to Mr. Neyle Habersham, of Savannah, Georgia, two were taken by a vessel between Savannah and Indian River, Florida, and were brought to Savannah, where they attracted much attention in the market. In 1873, according to Mr. E. G. Blackford, a specimen in a very mutilated condition was brought from Key West to New York City.

MOVEMENTS OF SAIL-FISHES.—No observations have been made in this country, and recourse must be had to the statements of observers in the other hemisphere.

In the life of Sir Stamford Raffles there is the following account from Singapore, under date of November 30, 1822:

"The only amusing discovery we have recently made is that of a sailing fish, called by the natives *Ikan layer*, of about ten or twelve feet long, which hoists a mainsail, and often sails in the manner of a native boat, and with considerable swiftness. I have sent a set of the sails home, as they are beautifully cut and form a model for a fast-sailing boat. When a school of these are under sail together they are frequently mistaken for a fleet of native boats."

The fish referred to is in all likelihood *Histiophorus gladius*, a species very closely related to, if not identical with, our own.

THE SPEAR-FISH—TETRAPTURUS ALBIDUS.

This species appears to be limited to the waters of the Mediterranean. It was not noticed by Linnæus, or indeed by any of the binomial writers before Schneider. In his posthumous edition of the writings of Bloch, the latter has made reference to a figure and description in Duhamel, and has given to a fish, which he figures in Plate XXI of this work, the name *Xiphias imperator*.

[1] *Isis*, 1833, Heft iv, pp. 415–419.

[2] The specimens in the British Museum are catalogued as follows: *a*. Eight feet long; stuffed. Indian Ocean. Type of the species. *b*. Seven feet long; stuffed. Cape of Good Hope. *c*. Dorsal fin. N. S. Wales (?). Presented by Dr. G. Bennett. *d*. Snout; dried.

This name was rejected by Cuvier (Règne Animal, *l. c.*), and has not been recognized by later writers. It seems to me, however, that Schneider has, perhaps unintentionally, yet quite intelligibly, expressed the principal differential characters of *Tetrapturus*. By "*dorso scabro*" he covers the question of the scales; by "*carina caudali nulla*" he refers to the absence of the single caudal carina of *Xiphias*, while by figure and by implication in his description he admits the presence of ventral fins. His figure, though bad, is as good as most of the old figures of *Xiphias*—that in Lacépède, for example.

T. imperator is said to attain the length of five or six feet, and the weight of one hundred and fifty pounds. It has been taken in the Straits of Messina with the harpoon, but according to Rafinesque is very rarely seen on the coasts of Sicily, and then only in autumn, when it is following the dolphin and flying-fish, upon which it feeds. It is ordinarily seen in pairs, male and female together, and they are taken often in the nets together. Its flesh is white, but not particularly well flavored. At Messina it is called "*Aguglia imperiale*" (Cuvier and Valenciennes).

Two species have been described by Poey from Cuba, one of which, *T. albidus*, is not uncommon on the Atlantic coast of the United States. Lütken is disposed to consider them both identical with the *T. indicus* type, and it seems to me that there is as much reason for doing this as for throwing together the Sail-fishes of the Atlantic and Indian Oceans, as has been persistently done by all writers on ichthyology.

Many individuals are taken every year by the sword-fish fishermen of New England, and they also frequently find their way into the pounds along the coast.

MOVEMENTS OF SPEAR-FISHES.—The Spear-fish in our waters is said by the fishermen to resemble the Sword-fish in its movements and manner of feeding. Professor Poey narrates that both the Cuban species swim at a depth of one hundred fathoms, and they journey in pairs, shaping their course toward the Gulf of Mexico, the females being full of eggs. Only adults are taken. It is not known whence they come, or where they breed, or how the young return. It is not even known whether the adult fishes return by the same route. When the fish has swallowed the hook it rises to the surface, making prodigious leaps and plunges. At last it is dragged to the boat, secured with a boat-hook, and beaten to death before it is hauled on board. Such fishing is not without danger, for the Spear-fish sometimes rushes upon the boat, drowning the fisherman, or wounding him with its terrible weapon. The fish becomes furious at the appearance of sharks, which are its natural enemies. They engage in violent combats, and when the Spear-fish is attached to the fisherman's line it often receives frightful wounds from these adversaries.

In "Land and Water" for August 31, 1872, Col. Nicholas Pike, author of "Subtropical Rambles," at that time United States consul at Mauritius, describes the habits of a species of *Tetrapturus* occurring in that vicinity. He states that they have the habit of resting quietly on the surface in calm weather, with their dorsals expanded and acting as sails. They are taken in deep water with hook and line, or speared when near the surface, like Sword-fish. When hooked or speared they make for the boats, taking tremendous leaps in the air, and if care is not taken they will jump into the boats, to the great consternation of the fishermen, or else pierce the boats with their bills. The fish is highly esteemed in the Mauritius, the flesh being of a salmon-color near the vertebræ; lower down it is red and like coarse beef. The species attains a large size, one having been seen measuring twenty-six feet.

PUGNACITY OF THE SPEAR-FISH.—The Spear-fish strikes vessels in the same manner as the Sword-fish. I am indebted to Capt. William Spicer, of Noank, Connecticut, for this note:

"Mr. William Taylor, of Mystic, a man seventy-six years old, who was in the smack 'Evergreen,' Capt. John Appleman, tells me that they started from Mystic, October 3, 1832, on a fishing

voyage to Key West, in company with the smack 'Morning Star,' Captain Rowland. On the 12th they were off Cape Hatteras, the wind blowing heavily from the northeast, and the smack under double-reefed sails. At ten o'clock in the evening they were struck by a 'Woho' (*sic*), which shocked the vessel all over. The smack was leaking badly, and they made a signal to the 'Morning Star' to keep close by them. The next morning they found the leak, and both smacks kept off to Charleston. On arrival they took out the ballast, hove her out, and found that the sword had gone through the planking, timber, and ceiling. The plank was two inches thick, the timber five inches, and the ceiling one and a half inches white oak. The sword projected two inches through the ceiling, on the inside of the 'after-run.'[1] It struck close by a butt on the outside, which caused the leak. They took out and replaced a piece of the plank, and proceeded on their voyage."

J. Matthew Jones, esq., of Halifax, Nova Scotia, in his delightful little book "The Naturalist in Bermuda," records the case of the Bermudian schooner "Earl Dundonald," arrived in the port of Hamilton, which was pierced by one of these formidable fish off the coast of British Guiana.

In the museum of Charleston College, Charleston, South Carolina, is preserved a fragment of the snout of a Spear-fish, apparently *Tetrapturus albidus*. By the kindness of the curator, Dr. G. E. Manigault, I was allowed to examine it and copy the label, which reads as follows: "The brig 'Amsterdam,' bound to Charleston, owned by F. C. Bray, was struck in the Gulf Stream by a monster or Sword-fish, which caused the vessel to leak considerably. By great exertion she was kept free, and gained the port in safety."

Messrs. Foster, Waterman & Co., of Boston, presented to the Boston Society of Natural History, in 1869, a plank of Southern pine, from the side of the ship "Pocahontas," owned by them, perforated by and containing a portion of the sword of a "Sword-fish," probably a species of *Histiophorus*.[2]

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[1] A hold under the cabin.

[2] Proc. Bost. Soc. Nat. Hist., xiii, 1869, p. 64.

M.—THE TILE-FISH FAMILY, AND OTHERS.

112. THE TILE-FISH FAMILY—LATILIDÆ.

This family, which has some relations both with the perch-like fishes and with those of the mackerel tribe, although until within a few years not known to occur within the territory of the United States, is now coming into considerable prominence, and there is every reason to believe that some of its members will yet grow into such favor and be found so abundant as to rank among the important food-fishes of the United States. The most important is the Tile-fish, *Lopholatilus chamæleonticeps*, a form discovered on a hitherto unexplored ground, eighty miles southeast of Noman's Land, Massachusetts, in 1879, and in 1880 demonstrated by the explorations of the Fish Commission to be exceedingly abundant everywhere on the coast of Southern New England, at a depth of eighty to two hundred and fifty fathoms. This fish, which is one of the most brilliantly colored species known outside the tropics, is very remarkable by reason of the presence of a soft dorsal fin, resembling that of the salmon, which is placed upon the neck in advance of the regular dorsal fin, instead of behind it, as in the salmon family. Numerous specimens have been obtained, varying from ten to fifty pounds, and, although there has been no opportunity to study the breeding habits, there is every reason to believe that it is resident in our waters in precisely the same manner as the codfish. Its abundance is very great. Captain Kirby, of Gloucester, who was the first to obtain specimens of this fish, caught in a few hours several hundred, which he salted down like codfish. In September, 1880, a small boat, sent out from the Fish Commission steamer while it was dredging upon the "Tile-fish Ground," caught twelve large individuals on one short line, the aggregate weight of which cannot have been less than two hundred and fifty pounds. They were tasted at the ward-room table and the flesh was found to be fine-grained and delicate in flavor, resembling in some respects that of the cod, in others, that of the striped bass.

The habits and food of this fish are probably very similar to those of the codfish, and the ground upon which they are taken has been ascertained to be very richly supplied with all the forms of small marine life which occur on the best cod banks. In time these fish cannot fail to be the object of a popular demand, and the proximity of the grounds they inhabit to several large cities will greatly enhance the importance of the Tile-fish.

In the Gulf of Mexico there is a related species which has as yet no popular name, but which has been described under the binomial *Caulolatilus microps*, and which is occasionally taken on the snapper banks. This was first observed by Mr. Silas Stearns, who sent specimens to the National Museum. As yet only five specimens have been brought into Pensacola, all in March and April, 1879, these having been taken with hook and line in thirty-five fathoms of water off Pensacola. These fish range in weight from six to ten pounds. It is not yet known whether they are sufficiently abundant to be of commercial importance, though there can be no question regarding their edibility.

Another species, *Caulolatilus chrysops* (C. & V.) Gill, occurs in the Caribbean Sea and on the coast of Brazil, while other related forms are known in China and Japan and on the west coast of South America.

"In California," writes Professor Jordan, "there is a species, *Caulolatilus anomalus* (Cooper), Gill, very similar to that of the Gulf of Mexico, and of some prominence as a food-fish, and known as the 'White-fish' or 'Blanquillo.' It reaches a length of about thirty inches and a weight of ten or fifteen pounds, though its average weight is four or five pounds. It ranges from Monterey southward to Mexico, being very abundant about the Santa Barbara Islands. It lives about rocks in water of considerable depth and takes the hook freely. Its food consists of crustaceans and fishes; it is considered to be a fish of fair but not excellent quality when fresh. When salted and dried it is graded as first quality with the barracuda and the yellow-tail. South of Point Concepcion it is one of the most important food-fishes, but is rarely sent to the market of San Francisco."

An allied form is *Bathymaster signatus* Cope, the "Ronchil," found in deep water from Puget Sound northward.

113. THE RED MULLET FAMILY—MULLIDÆ.

This family is represented in our waters by a single species, *Upeneus flavovittatus*, which has been observed in two or three instances on the coast of Southern New England, and is doubtless an estray from the West Indies. It has not yet been brought to light on the Gulf coast of the United States. A closely related species is the Mullet or Surmullet of Europe, the Mullus of the ancient Romans, highly prized by them. This fish was brought living into the banquet-hall that the guests might admire the brilliant changes of color exhibited in its expiring struggles.

Another species of this family is occasionally taken at Pensacola, but is not sufficiently abundant to possess any considerable economic importance.

114. THE ICOSTEUS FAMILY.

This family consists of two small fishes, peculiar to our California coast, which live in considerable depths of water: *Icichthys Lockingtoni* J. & G., only one specimen of which is known; and *Icosteus ænigmaticus* Lockington, likewise rarely taken, and only in deep water.

In the last two species the skeleton is scarcely ossified, and the body is as limp as a rag.

115. THE BERYX FAMILY—BERYCIDÆ.

Of this family, which is widely distributed throughout the temperate and tropical seas, and which has many representatives in the deeper parts of the ocean, only one species here appropriate to be mentioned occurs upon our coast, viz, the Bermuda "Squirrel-fish," *Holocentrum pentacanthum*. This fish ranges south to Brazil, east to the Bermudas, and is very abundant in the West Indies. Professor Gill has recorded the capture of a specimen at Newport, Rhode Island, in 1873. It is abundant on the Florida coast south of Cedar Keys, a few being found, as stragglers, north and west of that limit. It is caught with hook and line in all the channels and on the reefs. Stearns obtained several specimens at Pensacola Bay in 1876 and in 1882. He testifies that he has eaten them frequently and that they are as good a pan-fish as any on the coast. They attain a length of twelve to fifteen inches. About the Bermudas they are very abundant, and are conspicuous on account of their brilliant red hue and their habit of skulking in holes about the reefs. They feed upon small fishes and breed abundantly, apparently spawning in the summer season. At Cuba this fish is called the "Matajuelo."

N.—THE DRUM FAMILY.

The family *Sciænidæ* is distributed along the coasts of temperate and tropical countries the world over, though most abundant in the Western Atlantic, the Eastern Pacific, and Indian Oceans, and in the Mediterranean Sea. Many of the species are most abundant about the mouths of rivers, and there are several species, such as the fresh-water Drum, *Haploidonotus grunniens*, of the Mississippi Valley, which are found only in fresh water. In general form many of the members of this family are not unlike the salmon, and are sometimes mistaken for this fish. They are, however, true spiny-rayed fishes. The Drum and its congeners may be distinguished *from all others by the presence of the comparatively short, spiny dorsal fin, and a very long,* soft-rayed fin upon the posterior portion of the back.

Many of them are ground-loving species, and are provided with barbels by which they feel their way over the bottom, and with strong, pavement-like teeth for crushing shell-fish and strong shelled crustaceans. To this group belong the fresh-water Drum, the King-fish, and others.

Another group, typified by the Squeteagues, are without the barbels and possess long, sharp teeth, being surface feeders, rapid swimmers, and voracious.

The Red Drum of our coast, *Sciæna ocellata*, resembles in some respects both of these groups. Nearly all the members of this family have the power of uttering loud sounds. This, as has been demonstrated by M. Dufossé, is accomplished through a peculiar structure of the air-bladder.

116. THE SQUETEAGUE—CYNOSCION REGALE.

NAMES.—This well-known fish is one of those which bear a great variety of names. About Cape Cod they are called "Drummers"; about Buzzard's Bay and in the vicinity the largest are known as "Yellow-fins"; in New York and in New Jersey, "Weak-fish"; from Southern New Jersey to Virginia, "Bluefish." The name "Squeteague" is of Indian origin, and "Squit," "Succoteague," "Squitee," and "Chickwit" are doubtless variations of this name in different ancient and modern dialects. In the Southern Atlantic States it is called "Grey Trout," "Sun Trout," and "Shad Trout," and with the other members of the genus is spoken of under the name "Sea Trout" and "Salt-water Trout," though, of course, distinct from the "trout" of the fresh waters of the South, the large-mouth Black Bass. The name "Squeteague," since it is the aboriginal Indian name, seems most characteristic, and is well worthy of being permanently retained.

ABUNDANCE.—The Squeteague is found on the Atlantic coast from Cape Cod to Eastern Florida, where I observed it sparingly in 1878. Its extreme southern distribution has not yet been indicated. Some writers have claimed that it occurs at New Orleans, but Mr. Stearns did not succeed in finding it in the Gulf, and Professor Jordan writes that it is certainly not found in the Gulf of Mexico, unless as a stray.

The Squeteague is abundant throughout the above range, except in the regions where its productiveness is interfered with by the bluefish. In Massachusetts Bay, according to Dr. Storer, it is very rare, but scattering individuals have been found as far north as the Bay of Fundy. The early annals of New England make frequent mention of this fish and of its variations in number with that of the bluefish. Thus, according to Dr. Storer, it was very abundant in the Vineyard Sound in the early part of the present century, but gradually became more scarce, until about

1870, when it was no longer to be met with, and for several years it was entirely unknown in these waters; so much so, indeed, that fishermen of many years' experience were totally unacquainted with its characteristics. In 1867 or 1868, however, scattering individuals were taken on the south coast of Massachusetts, and in 1870 they were quite abundant and have since held their own.[1]

This variation in their numbers is ascribed by writers generally to the action of the bluefish, which, by its constant attacks, is supposed to influence their abundance. Some cause or other produced a similar influence upon the bluefish, which became scarce in turn; thus the Squeteague was enabled to recover its ground, and to resume its place in the food economy of the coast. To what extent this disappearance or reappearance of the Squeteague is actually connected with that of the bluefish, it is impossible at present to state. It is quite likely that other causes, at least, are concerned, with which we are now unacquainted.

We have intimations, in the writings of the early historians of New England, of the disappearances and returns of the Weak-fish, like those referred to in the present century.

The Squeteague, as well as the bluefish, varies in size with the locality. While on the coast of New Jersey they do not average much over one pound, they are stated to occasionally attain the weight of from six to ten pounds, and have even been known to weigh thirty.

Although essentially a coast and still-water fish, they occasionally run up tidal waters, and are thought on the coast of New Jersey to prefer the vicinity of the mouths of fresh-water streams, where they can find a mixture of fresh water. In the vicinity of Beasley's Point, where at times, in consequence of drought, there is more fresh water brought down into Egg Harbor than usual, they are known to move to a considerable distance up towards the headwaters, and to leave, to a great measure, their ordinary grounds more seaward.

The Squeteague in the South is a resident fish, although said by Holbrook to be most abun-

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[1] A GREAT CATCH OF FISH—WHAT THREE STEAM SMACKS CAUGHT OFF ROCKAWAY.—A great catch of Weak-fish was made yesterday about two miles off Rockaway Beach, by the steam smacks "E. T. De Blois," Capt. J. A. Keene; "Leonard Brightman," Capt. Elijah Powers, and "J. W. Hawkins," Capt. J. W. Hawkins. These smacks are engaged in the menhaden or "moss-bunker" fishery for the oil-rendering and fish-scrap works on Barren Island, and were cruising off Rockaway yesterday in search of schools. About noon a vast school of what the fishermen supposed at first to be menhaden was discovered stretching along the coast for miles. To borrow their language, "The water was red with the fish, but they didn't break the surface as menhaden always do." The boats were lowered, the seines spread, and then it was discovered that the school was of Weak-fish and not menhaden. "I have been in the business for twenty years," said the mate of the Brightman, "and I never saw anything like it before." The fish varied in length from one and a half to three feet, and in weight from three to seven pounds. The "De Blois" took over 200 barrels, the "Hawkins" 150 barrels, and the "Brightman" 350 barrels. The entire catch was estimated at something over 200,000 pounds, which, at the ordinary market price for Weak-fish—seven cents a pound—would amount to $14,000. But, of course, the market price could not be maintained in the presence of such a catch as this, and it was said yesterday afternoon that a strong effort was being made by the wholesale fish-dealers of Fulton Market to prevent the greater part of the fish from being put on sale. The captain of the "Hawkins," which landed at Pier No. 22 East River, foot of Fulton street, obtained a promise from a Fulton Market dealer to take part of his catch, and then made overtures to Mr. Eugene G. Blackford, of E. G. Blackford & Co., Beekman street, to sell the remainder. As soon, however, as the Fulton Market dealer learned of the offer to Mr. Blackford, he refused to take any of the fish. The captain of the "Brightman," however, had better luck. H. M. Rogers & Co., of No. 11 Fulton Market, engaged to take his entire catch of 350 barrels, and immediately put two men in charge of the boat. The "De Blois" meanwhile had made fast against the bulkhead at the foot of Beekman street, and Captain Keene failing to come to terms with the Fulton Market dealers, engaged P. Owens, of No. 104 South street, who manages the peddling trade for the Fulton Market dealers, to dispose of his fish. A crowd speedily gathered about the boat, and the fish sold almost as fast as they could be handled at twenty-five cents a pair. The pressure of the crowd became so great at one time that police assistance was invoked, and Officer William Brown, of the steamboat squad, was detailed to stay on the boat. While Owen was selling the fish at twenty-five cents a pair, an attempt to break the price was made by two well-known "longshore" characters, Jack Sullivan, the shark-catcher, and T. Long, *alias* "Blindy," who bought one thousand pounds of the fish at one cent per pound, and stood on the street retailing them at twenty cents per pair.

Fish-dealers say that there will be no difficulty in selling all the fish this morning at from one to three cents per pound. Friday morning, they say, is the best in the week for the sale of fish. Tons of ice were cracked last evening and put on the fish to keep them fresh until to-day.—*New York Times*, 1881.

dant and largest in the autumnal months, when, in his opinion, they come from the north. It is not satisfactorily ascertained, however, whether these fishes, leaving the northern coast during winter time, migrate southward or move towards the warm waters of the Gulf Stream. They return to the coast of the Middle and Northern States early in the spring, the first being taken in May, and are most abundant from June to September.

They are common in summer in Eastern markets, but do not bring high prices, the flesh being soft and flabby, and of little value except when fresh from the water.

According to the report of the Commission of Inquiry into the Fishes of Narragansett Bay, the Squeteague was ten times as abundant in 1870 as in 1869, and was first noticed there, after a long absence, about 1866. It is said that when they appear off the coast of New Jersey, about the middle of June, they are found to be filled with spawn, but this statement requires confirmation. Thousands of individuals have been examined by the Fish Commission naturalists at different times in the summer, and it is but rare that traces of spawn have been found. The precise period of spawning along the coast and the localities where the eggs are laid, as well as the habits of the fish during that period, are but little known, and are well worthy of careful investigation.

At Beasley's Point, the young fish of the year have in August attained a length of about four inches, and differ from the adults in lacking entirely the characteristic spots, these being replaced by broad, vertical bands, which, together with their more compressed form, render their appearance very unlike that of the adult.

The sport of catching the Squeteague is very great, and is highly enjoyed by our coast fishermen on account of the great number that can be taken in a very short time. They usually move about in schools of greater or less size, swimming near to the surface, and requiring a line but little leaded. They take almost any kind of bait, especially clams, soft crabs, or pieces of fish. They bite with a snap, rarely condescending to nibble, and in consequence of the extreme tenderness of the mouth it requires constant vigilance to fasten them, and great care to haul them successfully out of the water.

During the flood tide they occupy the channel-ways of the bays, and during the ebb they generally settle down in some deep hole, where they remain until the next flood brings them out again.

In the night the Squeteague run up the creeks in the salt meadows, where they are sometimes taken in great numbers by interposing between them and the sea, just before the period of high water. This experiment is not a very satisfactory one, however, on the New Jersey coast, in consequence of the great abundance of crabs that accompany the fish: the smaller fish become entangled in the meshes of the nets, thus inviting the attack of the crabs, which cut the nets to pieces, sometimes ruining them altogether in the course of a single night. When taken, the Squeteague makes a peculiar croaking, audible at a considerable distance; and it is said that this is not unfrequently heard from a boat when passing over a school of them in the water beneath.

In the North, as has been already stated, this species is but little esteemed, but in the South it ranks very high. In the Chesapeake they usually average from one to one and a half pounds in weight, though they sometimes attain the weight of twelve pounds. They make their appearance about the 1st of May and remain until cold weather. They are very abundant, and immense quantities of them are salted for winter use.

The Sea Trout, or Deep-water Trout, of Charleston, described by Holbrook under the name *Otolithus thalassinus*, is without much question identical with the Northern Squeteague, although that author states that it differs from this fish entirely in its habits, since it is only found in the

ocean and deep water, and never approaches the bays and inlets along the coast, while it is a larger animal.

The few specimens which he had seen were taken off Charleston Bar, at about twenty miles from land and in about fifteen or twenty fathoms of water. The very peculiarities which he mentioned are characteristic of the adult Squeteague.

117. THE SPOTTED SQUETEAGUE—CYNOSCION MACULATUM.

Associated with the Squeteague in the waters off the coast of New Jersey and on the eastern shore of Virginia is a species belonging to the same genus, but somewhat different, being characterized by the presence of well-defined dark spots. It becomes more abundant as we proceed southward, until off the coast of North Carolina and Georgia, where it is one of the most abundant food-fishes. Owing to its shape and the presence of well-marked spots on the sides it is usually known on the Southern coast as the "Salmon" or "Spotted Trout," and there are not wanting sportsmen in the Southern States who maintain with dogmatic earnestness the existence of the true Salmon Trout in the waters of their coast. This fish is of course in every respect very unlike a trout, and the name "Spotted Squeteague" has been proposed for it. It is difficult, however, to bring about a change in a name which has been in use for several generations, and it is probable that the name "Sea Trout" will always be used. Genio Scott proposed the name "Spotted Silver-sides," which is not particularly appropriate, and which no one but himself has ever used.

The history of American fishes contains very little respecting the habits of this species, although it is so important an element of food to the inhabitants of the Southern coast. We have, however, been favored by Dr. H. C. Yarrow with notes made at Fort Macon, North Carolina, in which many of the deficiencies in our information are supplied. According to his account, the Spotted Trout is not found in that locality during the winter, or only in small numbers, making its first appearance in February on its way from the south, and attaining its greatest abundance about the middle of April.

Little is known of its rate of growth, although, according to some observers, this increase amounts to about six inches per annum; so that a fish of average size, or eighteen inches, may be considered as three years old. There is no perceptible difference in the sexes as to rate of growth or general appearance, excepting in the fuller belly of the female.

Dr. Yarrow states that they come from the south in the spring and pass through the inlets on the flood tide, the date of their first appearance varying with that of the opening of spring. They remain in the vicinity of the inlets and sounds on the coast of North Carolina until about May, when they gradually proceed northward, extending their journey as far as the shores of Long Island, where a few only are taken, although, perhaps, their number may be considerable. They reappear on the coast of North Carolina in September, and thence proceed south, following the same course as that by which they came, but leaving on the ebb instead of the flood tide. They are found in the winter as far south as Saint Augustine, and possibly below this point, although we have no positive assurance of this fact.

At present they are thought to be more abundant than any other fish on the Carolina coast, with the exception of the mullet, having increased in numbers very largely (at least twofold) within the last ten years, possibly in consequence of the intermission of capture during the war. The average length is about eighteen inches, with a weight of two pounds, although they are not unfrequently found three feet in length and ten pounds' weight. They are often found outside of

the beach in great numbers in January, coming in to the shore when the water is warm, about February, as stated. School follows school at intervals of about four or five days, when they seem to go northward and to be absent from the Southern coast for several months. On their return in September, after a short stay, they gradually leave the coast until they finally disappear for the season. Their return season by season is very regular and definite, being relied upon with much confidence. The successive "runs" do not seem to be classified in any particular way, large and small fish of both sexes coming in together. The colder the weather the less tendency they appear to exhibit to come towards the shore.

At their first appearance in the spring the spawn is not appreciable, nor, according to Dr. Yarrow, do they have any development of the ovaries during their stay on that coast; and he is under the impression that they breed during their autumnal and winter stay farther south. This, however, is scarcely probable, it being more likely that their spawning ground is more to the north, perhaps off the coast of Virginia.

They are said never to take the hook, and to be captured entirely by nets. Their presence is generally made known by the schools of porpoises which follow and feed upon them. Swimming low in the water, they make no ripple on the surface, as is the case with mullets. The time of their capture is usually on the young flood, as in their movements along the shore they come in on the rising tide and depart on the ebb.

Like their representatives in the north, these fishes are fond of penetrating, for a short distance at least, into the mouths of rivers, remaining, however, only about a week; this, according to Dr. Yarrow, is their habit on the coast of North Carolina, before leaving for the North.

They prefer sandy and grassy bottoms, and are particularly fond of shallow water, four or five feet deep, especially in still water and eddies. Their favorite food is small mullet and other diminutive fish, as well as still more largely shrimps and small crustaceans; while, on the other hand, they are eaten voraciously by Weak-fish, bluefish, Drum, porpoises, etc.

As already stated, this fish is seldom if ever taken with the hook, at least for purposes of the market, nets being generally employed, some few being occasionally speared. They are taken in seines, usually having a mesh of about one and one-half inches, made of No. 8 cotton twine, about one hundred yards long and ten feet deep. When the fish first begin to make their appearance the fishermen establish themselves in their boats, just outside the surf, and watch along the crest of the breakers. When the fish are seen the net is paid out from the stern of the boat, one man leaping overboard with a rope attached to one end of the net, while a man in the boat pulls rapidly around the school so as to inclose it. The net is then drawn carefully to the shore. The average catch of two men for a day may be set at about three hundred pounds, although a much greater amount than this could be taken if desirable.

They are used when fresh, and sent up into the small towns in the interior in large numbers. The flesh is of an excellent quality, much superior to that of the Weak-fish, being firm, white, and flaky, and will keep well for three or four days, unless the weather be too warm. It is sometimes salted down for home use by the inhabitants along the coast, and much esteemed. Dr. Yarrow estimates that about two hundred barrels were salted during the season of 1871 by the fishermen in his vicinity. The fish bring about $3 per hundred at wholesale, and $5 at retail, this being equal to the average for the last ten years.

Mr. Silas Stearns has recently prepared the following notes regarding the habits of the Spotted Squeteague as observed by him in the Gulf of Mexico:

"The Spotted Trout is abundant from Key West to Mexico. In the Pensacola region it is present all the year, although most abundant in summer. It prefers to remain in shoal waters

on grassy bottom, where it finds small fish and shrimps in abundance for food. It breeds in inside waters in July or August. Quantities of the fry are seen in August and September. They do not often form in schools in the bays, but in some places are so plentiful that it is not unusual to catch five or eight barrels at one drag of a seine. One man fishing with hook and line sometimes catches one hundred in less than a day. The Trout is an excellent food-fish, and of considerable importance to the fish trade. The demand for it would be much greater if it was not so hard to preserve in this climate."

118. THE SILVER SQUETEAGUE—CYNOSCION NOTHUM.

The Silver Squeteague, *Cynoscion nothum*, called at Charleston the "Bastard Trout," while resembling in shape the two species already described, is easily distinguished from them, being of an uniform silvery hue, the back being slightly darker than the rest of the body.

One or two individuals have been taken in Chesapeake Bay, but it has rarely been observed north of South Carolina, whence Holbrook obtained the specimens from which the original description was made. I have obtained one or two individuals from the mouth of the Saint John's River, where they are not distinguished by the fishermen from the Shad Trout, or Northern Squeteague. In the Gulf of Mexico, according to Stearns, it is common in company with the Spotted Squeteague, and, as far as has been observed, its habits are similar. It is, however, according to Jordan, less abundant, and is not to be found at all seasons. It is most abundant in September and October, but no spawning fish or young have been seen. The "White Trout," as it is called in Pensacola, is is caught with hook and line in company with the Spotted Trout.

119. THE DRUM—POGONIAS CHROMIS.

Next to the sword-fish, tunny, Jew-fish, and halibut, the Drum is perhaps the largest of the food-fishes of our coast. It is most abundant in the Gulf of Mexico and in the Southern Atlantic States, though nearly every summer a few specimens appear on the south coast of New England. In one or two instances individuals have been observed as far north as Provincetown, Massachusetts. In the Gulf it is common everywhere, even to the southern boundary of Texas; how much farther south it goes there is at present no means of determining. Ichthyologists formerly supposed that there were two species, one of which, of small size and conspicuously banded with brown and white, was called the "Banded Drum," *P. fasciatus*, or "Little Drum." This is now well known to be the young of the *P. chromis*. It seems curious that the changes of color in relation to age, although known to Cuvier forty years ago, should have been overlooked by American naturalists, and that the species *P. fasciatus* should have stood as valid until 1873.

My own observations upon the Drum have been made chiefly in Florida. Specimens of ten and fifteen inches are abundant in the Lower Saint John, and are frequently taken at Jacksonville, even as high up the river as Doctor's Lake. Large ones are seldom known to pass the bar at Mayport. The young are very dissimilar to the adult fish, though the fishermen recognize the actual relations. In this respect they are more discriminating than the ichthyologist Holbrook, who described them as distinct species. The adult is known as the "Black Drum," the young as the "Striped Drum." In addition to the marked differences in color, the young has a much more shapely body than the adult, much higher in proportion to its length. The full-grown fish sometimes weigh eighty pounds, though the average is perhaps not more than one-quarter as large. They are sluggish swimmers, and are especially adapted to life on the bottom, where their

long, sensitive barbels aid them in their search for buried treasures of food. They feed upon all bottom-dwelling invertebrates. Their teeth are extremely heavy and pavement-like; their jaws are provided with very powerful muscles, by means of which they can crush with great ease the shells of the most strongly protected invertebrates.

It is claimed by oyster-planters that the Drum is very destructive[1] to the oyster-beds. Mr. Stearns writes: "Oysters are their favorite food on the Gulf coast, and they destroyed a great many at Apalachicola, Saint Andrew's, Mobile, and Galveston Bays. The Mobile oyster-planters attribute the bulk of their losses to Drums. At Pensacola I have known a boat-load of oysters, fifty barrels, that were thrown overboard to be preserved, to be entirely consumed in eight or ten days by them, leaving but a heap of broken shells."

While it is probable that the Drum feeds upon oysters as well as upon crabs or shrimps, it is probable that the extent of their destructiveness has been somewhat exaggerated; for instance, it was claimed a few years ago that oysters in New York Bay to the value of hundreds of thousands of dollars were destroyed by Drums. This seems quite unlikely, since the Drum is by no *means a common fish so far north as New York.*

The name "Drum," as every one knows, alludes to the loud drumming noise which is heard, especially in the breeding season, and is doubtless the signal by which the fish call to their mates. This habit of drumming is shared by many fishes of this family, but appears to be most highly developed in the Drum, and in a European species known as the Maigre, *Sciæna aquila.* M. Dufossé has investigated very thoroughly the physiological causes of these sounds, which appear to depend largely upon the action of the air-bladder.

Mr. S. C. Clarke has made some interesting communications regarding their breeding habits. The male is the larger, and is more brightly colored, particularly at the breeding season. The male drums very loud, the female in a softer tone. Fish under twenty pounds in weight do not breed. About the Halifax Inlet, Southern Florida, they spawn in March in the salt-water rivers. The ova sink to the bottom. They are as large as B-shot, dark brown in color, and are often seen to run from the parent fish when it is captured. In a large fish the roe sometimes weighs six *or seven pounds. In the northern part of the Gulf of Mexico, according to Silas Stearns, they* spawn in April and May in inside waters.

The northern limit of the species appears to be defined by Cape Cod. In 1873 Mr. James H. Blake captured one at Provincetown. Another, of twenty-five pounds' weight, was secured by Vinal Edwards for the Fish Commission from Rogers' Pound, Quissett, Massachusetts, July, 1874; another large individual, of sixty pounds' weight, was taken near Noank, Connecticut, July 10, 1874, the third instance of its capture known to the fishermen of that vicinity.

Schoepf, writing about the year 1786, says that they were at that time very rare about New York, though he had occasionally seen them at the city market, where they met with sale, though their flesh was none of the hardest.

The Drums captured north of Sandy Hook have been, so far as I can learn, large adult fish Professor Baird found the young fish of this species very abundant in August in the small bays along the shores of Beasley's Point, New Jersey, though few were seen in the rivers.

North of Maryland the fish is of little economical importance. In the Chesapeake region, according to Uhler and Lugger,[2] its flesh is much esteemed, and its roe is a great delicacy; considerable numbers are brought to the Baltimore markets in spring and fall.

[1] New York fishermen say that a school of these fish destroyed seven thousand barrels of oysters in Prince's Bay in two days some years ago.—FRED. MATHER, Chicago Field, September 13, 1879, p. 67.

[2] Rep. Com. Fish. Maryland, reference 76, p. 99.

In the Carolinas, according to a statement of a correspondent, the roe is considered very delicious, and it is customary for the residents of the coast to salt and dry them and send them "up country" to their friends as a very acceptable present.

They are sometimes caught in seines in great numbers and retained living in the seines until disposed of. Their flesh is coarse, but tender, and it is thought to compare favorably with any of the salt-water fish of the region. Drum-fishing with hook and line is one of the most exciting exploits of the sportsmen of this region. In the Nassau River large Drum are taken with hook and line in the spring, and are sold at Fernandina.

The young Drum are often taken in seines in the Saint John's River and sold in the Jacksonville market, and are excellent pan-fish, as my own experience testifies. The large fish are often eaten, but are not so much sought after; perhaps the cause of this is that they are liable to be infested by parasitic worms. A Drum of sixty pounds, taken at Wood's Holl, Massachusetts, 1864, was completely riddled by nematode worms, neatly encysted among the layers of muscle. Some of them were two feet long, with heads larger than large buck-shot.

In the Indian River, according to Mr. Clarke, Drum are caught with hooks and crab bait, and with cast-nets. In summer they are caught in the open ocean; in the winter, in the bays and inlets. Four or five a day is considered good fishing luck. Tides do not affect the fishing. Their flesh is not greatly esteemed. They are sometimes salted, but are chiefly used for compost. "In the Gulf of Mexico," says Stearns, "the Drum is often caught in seines and gill-nets, but is very rarely eaten, as the flesh is dry and tasteless. It attains a large size; specimens weighing thirty-five or forty pounds are taken."

The scales of the Drum are extensively used in the manufacture of the sprays of flowers and other articles of fancy work which are sold, especially in Florida, under the name of "fish-scale jewelry." They are large and silvery, and so hard that it is necessary to remove them from the fish with an axe or hatchet.

The Drum is interesting to the fishery economists less on account of any intrinsic value in itself, than because of its destructive influence upon the oyster-beds. Concerning its relation to the oyster-culturist, I cannot do better than to quote the words of Mr. Ernest Ingersoll: "Knowing the carnivorous propensity of the fish, one can easily imagine how an inroad of such a host must affect an oyster-ground. They do not seem to make any trouble, however, north of New York City, and rarely along the south side of Long Island. At Staten Island and Keyport they come in every few years and devastate thousands of dollars' worth of property. Such a memorable visitation happened about 1850, in July. The following summer the planters in Prince's Bay, fearing a repetition of the onslaught, anchored shingles and pieces of waste tin on their beds, scattering them at short intervals, in the hope that their dancing, glittering surfaces might act as 'scare-crows' to frighten the fish away. Whether as an effect of this, or because of a general absence, no more Drums appeared. In New York Bay, off Caven Point, where the old 'Black Tom Reef' is now converted into an island, one planter of Keyport lost his whole summer's work—material and labor—in a single September week, through an attack by Drums. A City Island planter reported to me a loss of $10,000 in one season a few years ago; but the East River is about the northern limit of the Drums, at least as a nuisance to oyster-culture, so far as I can learn. The vexation of it is, too, that the Drum does not seem to eat half of what he destroys; but, on the contrary, a great school of them will go over a bed, wantonly crushing hundreds of oysters and dropping them untasted, but in fragments, on the bottom."[1]

[1] The great schools in which these fish go are illustrated by the following records from contemporary newspapers: On Monday last John Earle and sons caught, at one draught, in Bristol Ferry, 719 Drum-fish, weighing upwards of fifty pounds each. Niles' *Weekly Register*, July, 1833, also says: "Some days ago a haul was made in Great Egg

120. THE FRESH-WATER DRUM—HAPLOIDONOTUS GRUNNIENS.

By DAVID S. JORDAN.

This species is in the Great Lakes always known by the name of Sheepshead. In the Ohio River it is usually called "White Perch" or "Gray Perch," often simply "Perch." In the lakes of Northern Indiana it is called "Crocus," evidently a corruption of "Croaker." In the Southern States the name "Drum" predominates; that of "Thunder-pumper," also used for the bittern, *Botaurus lentiginosus*, is heard along the Mississippi River. Southwestward, in Louisiana, Texas, and Arkansas, it is always known as the "Gaspergou." These names, "Croaker," "Drum," "Thunder-pumper," etc., refer to the croaking or grunting noise made by this species in common with most Sciænoids. This noise is thought to be made in the air-bladder by forcing the air from one compartment to another. Another name used in the southwest is "Jewel-head."

This Drum is very abundant in all large bodies of water throughout the Western States, from the Great Lakes to the Rio Grande. It seldom enters small streams. It feeds largely upon crustaceans and mollusks, but sometimes swallows other fishes. It is rather a bottom fish than otherwise. Its value as a food-fish depends on the water and food, and, unlike most fishes, its quality seems to improve to the southward. Although from its size and abundance it becomes an important market fish, it cannot at best be considered one of high quality. Its flesh is tough and coarse in fiber, and often of a disagreeable shark-like odor, particularly in the Great Lakes, where it is never eaten. The flesh of partly grown specimens is better than that of the adult.

This fish reaches a length of four feet and a weight of forty to sixty pounds. Those usually seen in market are much smaller.

Nothing special is recorded concerning its breeding habits. It is apparently not at all migratory.

This species in the Lakes often contains numerous parasitic worms.

121. THE SPOT, OR LAFAYETTE—LIOSTOMUS XANTHURUS.

The Lafayette, or "Spot," *Liostomus xanthurus*, is found along our coast from New York to the Gulf of Mexico, and is known in New York and elsewhere as the "Spot," on the coast of New Jersey as the "Goody" and sometimes as the "Cape May Goody," in the Chesapeake region also as the "Spot" and the "Roach," at Charleston, South Carolina, as the "Chub," in the Saint John's River, Florida, as the "Masooka"—this name being probably a corruption of a Portuguese name, "Bezuga"—and at Pensacola as the "Spot" and "*Chopa blanca*." The name "Lafayette" was formerly used for this fish in New York, though seldom heard at the present day.

Although they sometimes enter the large fresh waters of the South (such as the Saint John's, which they ascend as far as Jacksonville), Günther is by no means justified in his remarkable statement that this is "a fresh-water fish inhabiting the rivers of North America."

Like the other bottom-feeding members of this family, their food consists chiefly of the smaller mollusks and crustaceans. Little is known about their breeding habits in the North. Mr. S. C. Clarke states that at New Smyrna, Florida, they spawn in the bays and inlets in November and December, while Stearns remarks that they spawn in the lower bays and inlets about Pensacola

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Harbor Bay, near Beasley's Point, Cape May, at which 218 Drum-fish were caught, their entire weight being from 8,000 to 9,000 pounds. This is said to be the largest haul of that description of fish ever made in that bay."

Another still larger, noticed as a great haul of Drum-fish: "On Wednesday, June 5, 1804," says the postmaster of Oyster Ponds, Long Island, "one seine drew on shore at this place at a single haul 12,250 fish, the average weight of which was found to be thirty-three pounds, making in the aggregate 202 tons 250 pounds. This undoubtedly is the greatest haul of this kind ever known in this country. A hundred witnesses are ready to attest the truth of the above statement. They are used for manure." (The fish, I suppose, and not the witnesses.—INGERSOLL.)

late in the fall, while the young of all sizes are very abundant in the spring. Concerning this species Professor Baird writes:

"Of the smaller pan-fish of our coast, in excellence of flavor none is considered superior to that known as the 'Lafayette.' Its precise eastern range is not well ascertained, although it is occasionally taken in great numbers off Long Island and the coast of New Jersey. It is most plentiful off the coast of Virginia. The name of Lafayette was given to it by the New York fishermen in consequence of one of its periodical reappearances in large numbers in that region having been coincident with the arrival of Lafayette in this country in 1834. It had been known before that time, but only in scattering numbers.

"According to Dr. Holbrook, it is not much esteemed for food at Charleston, owing to a want of flavor. In the case of this species, as in many others, it is probable that the colder waters of the North impart a superior flavor and excellence to the flesh. This is well known to be the case with the sheepshead, as well as many other species.

"At Beasley's Point, New Jersey, where I have had an opportunity of studying its habits, it makes its appearance in large numbers in August, the first school being composed of small fish, larger ones following them. A short time later they ascend the creeks in great numbers and are taken there in company with the white perch. Their usual size in New Jersey is about six inches, although occasionally measuring ten inches. They do not make their appearance in the New York markets in any abundance until towards the 1st of September, and remain until the end of October, when they disappear. I did not succeed in finding any very young fish, and am unable to state whether they actually spawn on the New Jersey coast, or whether the supply found there and farther north consists of a 'run' from the more southern waters of fish migrating northward, perhaps to escape the increased heat of the southern coast."

The Spot is abundant at Mayport, Florida, in spring and summer. In the Gulf of Mexico, according to Stearns, it is present in the bays all the year, living in shoal water, feeding upon the bottom upon small invertebrate animals, and taken with hook and line and seine. It is extremely abundant, and is considered a good food-fish.

There is a rare species which has been recorded only from Charleston, South Carolina, and Saint George's Island, Texas, known by naturalists under the name *Stelliferus lanceolatus*. It is found in deep water, and is not sufficiently abundant to have acquired a common name.

122. THE RED FISH, OR BASS OF THE SOUTH—SCIÆNA OCELLATA.

The following biography of the Red Drum, *Sciæna ocellata*, is quoted in full from the text prepared by the writer for the illustrated work on "The Game Fishes of the United States," recently published by Charles Scribner's Sons, of New York:

The Southern Red Fish is among the important species upon the coast of the United States from the Chesapeake to the Mexican boundary. Abundant as it is in the Carolinas, in Florida, and in the Gulf of Mexico, the limits of its range appear to be very sharply defined, there being little tendency on the part of individuals to stray away from their wonted pastures. Although the species is often found in the Chesapeake, I am unable to find any record of its capture north of Cape Charles. Mitchill and DeKay refer to it in their treatise on the fishes of New York, but their descriptions are based upon market specimens, probably brought from more southern localities. Professor Baird did not obtain any specimens when he explored the New Jersey coast in 1854, nor are they to be found in Professor Webster's collections from the Atlantic side of the east shore of Virginia. Its range to the south seems to terminate with equal abruptness. Mr. Silas Stearns gives the result of his observations in 1880: 'From Tampa Bay and northward to the Mississippi River it is one of the most common edible fishes, while west of the Mississippi River it is more

abundant than any other sea-fish, evidently increasing in numbers as the Texas coast is approximated.' On the Texas coast it is taken in greater quantity than all other species combined. West of the mouth of the Rio Grande the species has not been recorded, chiefly, no doubt, for the reason that no explorations have been made along the shores of Mexico. The fish fauna of the Caribbean coast of Panama has, however, been carefully studied, and this fish has not been found. It is, therefore, probable that its range is as abruptly limited at the south, perhaps by the peninsula of Yucatan, as it is in its northward extension. It is a noteworthy fact that *Sciæna* does not wander more; for every other species, I think without exception, which is abundant north of Cape Hatteras, is occasionally met with in Buzzard's and Narragansett Bays, these two great pockets in the coast-line of Southern New England in which are lodged so many of the straying Southern marine animals.

"This fish is very much in need of a characteristic name of its own. Its local names are all preoccupied by other more widely distributed or better-known forms which seem to have substantial claims of priority. In the Chesapeake, and south to below Cape Hatteras, it is called the 'Drum'; but its kinsman, *Pogonias chromis*, is known by the same name throughout its whole range from Provincetown to Texas, and is the possessor of a much larger and more resonant musical organ. Some of the old writers coined names for it like 'Branded Drum,' referring to the brand-like spots upon the tail, and 'Beardless Drum'; but these are valueless for common use, like most other 'book-names.' In the Carolinas, Florida, and the Gulf, we meet with the names 'Bass,' and its variations, 'Spotted Bass,' 'Red Bass,' 'Sea Bass,' 'Reef Bass,' and 'Channel Bass.' Many persons suppose 'Channel Bass' to be a characteristic name, but this is a mistake, for the term is applied properly only to large individuals which are taken in the channels of streams and sounds; wherever this name is used, the smaller fish of the species are called simply 'Bass,' or 'School Bass'; even if the word 'Bass' could be so qualified as to be applicable to the species, there is an insuperable objection to its use for any fish of this family. It is a modification of an old Saxon word, *Bears*, or *Baers;* also found in German under the forms *Bars* and *Barsch*, from which 'Perch' and 'Bass' are both evident developments. This name should evidently be retained for the spiny-formed fishes of the perch tribe. I find in my note-book references to thirty-eight distinct kinds of fish called by the name 'Bass,' with various prefixes, all of which are justly entitled to bear this name.

"'Spot' is another name erroneously applied to this fish, and which is the property of a much smaller species of the same family, otherwise known as 'Lafayette,' or 'Cape May Goody.'

"Finally, we have the 'Red Fish' and 'Red Horse' of Florida and the Gulf States, the 'Poisson Rouge' of the Louisiana Creoles, and 'Pez Colorado' of the Mexicans. Although this name is occasionally applied to a much redder fish, the Norway haddock, or red perch of the north, and to the big labroid *Trochocopus* in California, it is perhaps the most characteristic one and that most suitable for general use, especially if modified into 'Southern Red Fish.' The chief objection is that the fish is not always red; in the young there is not a suggestion of this color, while in the adult it is more a tint, an evanescent, metallic reflection of claret from the scales, which is often absent, and at all events soon disappears after life is gone. The number of spots on the tail is variable; sometimes there is one, sometimes eight or ten, and their arrangement is a matter of chance; occasionally they are absent.

"The Red Fish grows to a length of four or five feet and a weight of forty pounds or more. In April, 1877, those to be seen in the markets of Jacksonville, Florida, ranged from one to four feet. In the markets of Washington and New York strings of small ones are often seen. The average size is perhaps ten pounds.

The food is similar to that of the striped bass, which it seems to resemble in habits. It preys upon small fish and the crustaceans with which Southern waters are filled. They swim in scattered schools at times, probably in the spawning season, and may be heard spring above the surface while feeding. At this time the fish are taken in large gill-nets, which are set around them by the fishermen. This species undoubtedly gathers much food from the bottom, although it cannot be so much of a grubber as many other members of the same family, better provided for this kind of foraging by the tactile organs under the chin, and a set of grinding teeth with which to liberate the shells of muscles and barnacles. An accurate observer describes them as swimming along close to the bottom, with head down and body obliquely upward, wriggling through the water, rooting up the weeds and grass, among which it finds quantities of shrimps and crabs. Their enemies are sharks, porpoises, and saw-fish. The power of uttering sounds is also shared by this fish, but probably not to any very great degree. No one has reported observations upon this point.

The movements and breeding habits of this fish have not been sufficiently studied to warrant the framing of a generalized statement of their character. There is need of a careful investigation of this question at different stations along the coast. I cannot here do better than to quote the observations, as yet unpublished, of two excellent observers, one upon the east, the other upon the west coast of the Florida Peninsula: "In the spring," writes Mr. Stearns, "they are seen in large numbers in the Gulf, swimming in shoal water near the coast. This is usually in March and April, though the weather and the temperature of the water seem to influence the time of their arrival. Arriving at the entrance of a bay, their migratory movement ceases, and for days and weeks they may be seen in shoal water near the inlet swimming lazily about in search of food, or lying quite still in deep holes between shoals, where there is comparatively little current and few enemies can reach them. Some seasons immense numbers of Red Fish gather about the inlets before any are noticed inside or coming in, while in other seasons there is but slight accumulation, the schools working in as fast as they arrive. By the 1st of June the 'run' is over, and the fish are believed to have all come in. When once inside the schools break up into small squads, which proceed to the weedy bottoms of the bayous and to the heads of the bays. About the river mouths, where the water is brackish, and even in fresh water, they are found through the summer. While at sea their color is light, and they are so thin in flesh that they are far from desirable as food. In the bays they become very fat and their colors are much darker. In September spawn is found in them in a half-developed state. In October and November they again form in schools and are observed moving out of the inlets to the sea. They do not leave the coast immediately, but follow the beach for some days. At this time they contain spawn which I should think to be three-fourths developed. Many reliable fishermen here have observed that the Red Fish go to sea with spawn in them."

I have never found the young in the north less than ten inches long, but in Pensacola Bay Jordan and Stearns secured numerous young in the seine in April, the smallest measuring two and a half inches. Jordan supposes that they spawn in water of no great depth.

Mr. S. C. Clarke, however, tells the following story about Bass in the Indian River region: 'They enter the rivers and creeks from the sea. The young fish are here all the time. The adults leave the shore in a body when done spawning. They are first seen off the coast in January and February, and remain in the rivers until late in the spring. The males and females swim together, frequenting localities on shoals and sand-banks, where the water is from one to four feet deep and warm. After spawning they scatter. They begin to breed in August and September in the shallow bays and inlets, at which time both sexes are poor and unfit for food. The

spawn is small, brown, about as large as number five shot, and floats. The young are found abundantly in the creeks and bays.'

The fishermen of the Saint John's River told me that in November, when schooling begins, the fish are full-roed, but that in December the eggs have all been spent.

Little need be said here about their commercial value except that they are taken with gill-nets and spears and by the use of bottom-lines, baited with pieces of fish or shrimps. They are much esteemed for food all through the South, resembling the striped bass or rock-fish in flavor and flesh-texture, though possibly somewhat inferior. They enter largely into local consumption, though a few thousand pounds are sent every year to New York and other cities of the North.

In discussing the rank of this species as a game-fish, I cannot do better than quote the words of Mr. H. S. Williams, regarding his experiences in the Indian River region: "I have seen them swimming in shallow water by the hundreds, sometimes ten and twenty, almost, moving with all the regularity of solid columns of infantry; all apparently of the same size. The Red Fish are in season at all times, but best from the 1st of April until January 1. In size they run up to forty, and even fifty, pounds. They readily take mullet bait, and when securely hooked furnish fine sport, for the Red Fish is emphatically a game-fish. I shall never forget my first experience in this line, a day or two before the full of the moon in November. I concluded to try a new hook just sent me by a distant friend. Just at dusk I went down to the river, and baiting my hook with a half mullet, I walked out on a shelving coquina rock, and swinging the hook around my head a few times sent it out into the river to the full length of the line; then filling and lighting my pipe I took a seat and quietly awaited results. The moon, nearly full, was half an hour or more high, not a cloud obscuring its brightness, and it made a highway of silver across the broad river, now calm and smooth as glass. Scarcely a breath of air stirred the leaves of the huge live-oaks above my head, and everything was so still that I could distinctly hear the fish in shallow water a mile away as the small-fry dashed and jumped in their frantic endeavors to escape from the ravenous jaws of their pursuers; in fact, everything was so still that I remember to have heard the sound of a cow-bell, two miles away, as its low, mellow notes were borne over the broad expanse of water. I had occasionally taken a whiff or two at my pipe and watched the fleecy clouds of smoke float slowly upward and dissolve into space, before *something* sent an electric message to my finger from the other end of the line. It was a faint message, scarcely felt, but distinct enough to tell me what was there. A moment's pause and then it was repeated; this time it was emphatic, for the fish picked up the bait in its mouth as daintily as a neatly-gloved lady would pick up an orange, and then let it fall again. Aha! my boy. You are an old hand at the business, and know by past experience that sometimes even the most tempting morsels are dangerous. A moment more it is picked up again, and yet again, and then it is carried a couple of yards or so before it is dropped; and then back again; then further off. Our fish is playing with the bait as a coquette with hearts. The very moment a novice would think that he was going to take it, 'tis dropped and he is gone again. No, not gone, only swimming around in circles, keeping one eye on the prize and keeping away all such intruders as sharks and cat-fish.

"Now for it. The bait is picked up, seized with a vim, as though he meant business, and away he starts with it. Here the inexperienced would jerk the line and perhaps lose the fish, or at least have the whole formula to go over again. But wait; the successful sportsman must practice patience. Again the bait is dropped, but not for long. In a moment it is seized, and this time there is no feint about it. He darts off, the line is drawn tight, then a sudden jerk and a wild plunge tell that the game is safely hooked. And now commences the struggle for life. Away he goes up the stream for fifty yards or more, straining every nerve to get free; then down,

then back again, while the line is pulled just hard enough to draw him in a little nearer the shore; then up and down, each time a still shorter distance. At each effort I feel his powers give way, and then as he makes a turn we pull his head toward the shore and keep it there. Now is the critical period; now, if at all, the line will part or the hook break. I haul the line in rapidly, hand over hand, keeping it taut, for the least slack or a failure to grasp the line firmly would perhaps lose the game. Swerving to and fro, I draw him rapidly in, and with such force does he come that far up the shelving rocks we land our prize, a thirty-pound Bass, a magnificent fellow, his scales glistening like burnished silver in the moonlight."[1]

123. THE YELLOW-TAIL—BAIRDIELLA CHRYSURA.

The Yellow-tail, known as "Silver Perch" on the coast of New Jersey, is quite an important food-fish in the Southern States. But little has been written regarding it, and its excellent qualities are not yet thoroughly appreciated. In fact, it has been confused with other species by both Holbrook and Günther. This fish has not been observed north of New York, where it was recorded by Mitchill and DeKay, the latter of whom stated that it was not uncommon in the summer season.

Professor Baird found the young very abundant about Beasley's Point in 1854, though the adults were unknown to the fishermen Uhler and Lugger, who, following the mistaken nomenclature of Holbrook, confusing this with a species of *Liostomus*, state that it is common in the Chesapeake and Lower Potomac. It is also abundant about Beaufort, North Carolina, and in the vicinity of Charleston.

According to many observers, Yellow-tails are highly esteemed for food at Saint Simon's Island, New Brunswick, Georgia, and in the Lower Saint John's River. They probably never ascend the river much above Jacksonville, though in 1877 great quantities were taken in the month of April at the mouth of the Arlington River. In 1878 the water was so fresh at this point that none could be taken there, though I saw them at Yellow Bluffs in water not perceptibly brackish to the taste. A large majority of those observed at Mayport on April 7, 1875, were full grown and taken at the point of spawning. Others taken by fishermen at Mayport, April 15, 1878, had the spawn running freely from them. The largest adult did not exceed eight inches in length.

On the Florida coast of the Gulf of Mexico, according to Mr. Stearns, they are very common. They were found by Jordan to be very abundant along the shores of Louisiana and Texas. At Pensacola they are known by the name "Mademoiselle." They are present throughout the year, but most plenty from May until November, and are found in company with the Trout and the Spot on the grassy shoals of the bays where they feed and spawn. The time for spawning is in June and July. They feed chiefly upon small fishes and shrimps. They do not school, but swim singly or in pairs. Their extreme length does not exceed ten or eleven inches, the average being about eight. They are regarded as excellent pan-fish.

124. THE KING-FISH—MENTICIRRUS NEBULOSUS.

The King-fish, also known as the "Hake" on the coast of New Jersey and Delaware, and as the "Tom-cod" on the coast of Connecticut, the "Black Mullet" in the Chesapeake, the "Sea Mink" in North Carolina, and sometimes also in the South as the "Whiting," ranges from Cape Ann south at least as far as the mouth of the Saint John's River, Florida, although in the southern part of its range it is frequently confused with the Whiting. It has been obtained by Jordan and Stearns at Pensacola; it is, however, rare in the Gulf. It is discussed as follows by Professor Baird in an unpublished manuscript:

[1] *The Semi-Tropical, iii, 1877, p. 663.*

"This species, well worthy of the name which has been given it, and the estimation in which it is held by New York epicures, as it is certainly savory when taken fresh from the water, leaves nothing to be desired in the way of a fish diet. It is quite abundant off the Middle States, but is rare much to the eastward. A few specimens are occasionally taken in Buzzard's Bay and Vineyard Sound, and Dr. Storer mentions four as having been captured in Massachusetts Bay. It is almost as capricious in its occurrence in the more northern waters as the Lafayette, sometimes being scarcely met with for several successive summers, and then suddenly reappearing, as if migrating from more southern waters. At Beasley's Point, New Jersey, where I have had most opportunity of studying its habits, it appears quite early in the spring with the Squeteague, and is found a good deal in company with it, like that fish seeming to prefer a slight mixture of fresh water, as shown by its keeping in the mouths of rivers and running farther up during the dry season. It takes bait readily and affords excellent sport to the fishermen, although not caught in anything like the same number in a given time as the Squeteague, thirty or forty at a single tide being considered an excellent catch for one boat.

"Nothing has been recorded in regard to the precise time of their spawning or the places where they lay their eggs. The young were met with at Beasley's Point in immense numbers on the sandy bottom as well as in the surf. The smallest were about an inch long. I have taken the young also in considerable number in Vineyard Sound at a time when the old fish were scarcely known. They occasionally run to a considerable distance up the rivers, as I have caught young fish of this species at Sing Sing, on the Hudson, where the water is scarcely brackish. The King-fish run much in schools, and keep on or near a hard, sandy bottom, preferring the edge of channels and the vicinity of sand bars; and they congregate about oyster-beds, especially when the oysters are being taken up, and may be seen under the boats, fighting for the worms and crustaceans dislodged in the operation. They bite readily at hard or soft clams, or even pieces of fish, and are taken most successfully on the young flood. Like the Squeteague, they will occasionally run up the salt creeks at night, and may be captured in gill-nets as the water recedes. This, however, is not so common a habit with them as it is with its associate.

"The price of this fish varies at different seasons of the year, but it is always well maintained, and it is generally valued at nearly as high a figure as the Spanish mackerel. The European analogue of this species (*Umbrina cirrhosa*) is somewhat similar in general appearance, and its flesh is highly esteemed. This feeds on small fishes, mollusks, and, according to Yarrow, on sea-weed, sometimes obtaining a weight of forty pounds. This magnitude I have not seen approximated by our species, although it is possible that it may occasionally reach a large size. Of its distribution southward I can find no satisfactory account."

In 1879 numerous small individuals of this species appeared in the harbor of Provincetown, Massachusetts; they seemed, however, to be out of their proper habitat, and many were chilled by the coldness of the water and cast up on the beach. In 1880 and 1881, the species is said to have been particularly abundant on the coast of New Jersey, and to have afforded much sport to anglers of that vicinity, many of whom had not been familiar with it in previous years.

125. THE WHITINGS—MENTICIRRUS ALBURNUS AND M. LITTORALIS.

The Whiting, one of the favorite food-fishes of the Southern coast, is a species very closely allied in its general character to the King-fish of more northern waters. It is said to occur abundantly from Cape Fear River, North Carolina, to the Rio Grande, in Texas. Uhler and Lugger claim that it inhabits the salt water of the Chesapeake Bay and its estuaries, but it is not probable that it is at all abundant. On the coast of South Carolina, according to Dr. Holbrook, "the Whiting

remains all the year round, and although few are taken in December and January, yet they are sufficient to prove themselves constant residents. Near Charleston in the spring and summer months they are very abundant; they enter the mouths of bays and rivers, and are captured in great numbers. They take the hook readily; their favorite bait is the Drum, and being a strong, lively, and active animal, they afford great sport to the fishermen. They prefer deep and running waters, and seldom approach so near the shore as to be taken in seines. Their ordinary food seems to be various species of a small shell-fish," etc.

Speaking of the "Surf Whiting" of Charleston, Holbrook remarks: "This species makes its appearance on the coast of Carolina in the month of April, and continues with us during the entire summer, though very few are taken in July or August. It is only found in shallow water where the bottom is hard and sandy, often forming, when the tide is out, an extensive beach. Its favorite resort is in the neighborhood of the shore where the surf can roll over it from the ocean and bring with it doubtless the animals on which it feeds. In such localities many are captured with the seine and are sold in the market under the name 'Surf Whiting,' in contradistinction to the other species which is called the 'Deep-water Whiting.' Its food seems to be similar to that of the Deep-water Whiting, judging from the contents of its stomach, and yet it is seldom taken with the hook. Hitherto I have only seen this fish in the immediate neighborhood of Charleston. This fish is very commonly supposed to be the adult male of the common Whiting, approaching the shoal water to deposit its spawn. I believed it, from common report, to be such, until frequent dissections proved to me that there are both males and females among them. The flesh of this species is good, but by no means so finely flavored as that of the Deep-water Whiting."

At Mayport, Florida, the Whiting is abundant, and also at the mouth of the Saint John's. The largest observed by me measured ten inches, and in the first week of April was within two or three weeks of spawning. A few are taken in the Saint John's as high up as Arlington. They are abundant in the Indian River. About New Smyrna, Florida, according to Mr. S. C. Clarke, it is called "Whiting," "King-fish," "Barb," and "Bull-head Whiting." They occur in the winter and spring, though seldom in summer. The largest reached the weight of one and a half pounds. They average three-quarters of a pound, the female being usually the larger. They appear about the last of November, and spend the winter in bays and still rivers. They bite in strong currents, not in slackwater. They prefer deep channels and sandy bottoms. They are found in the deepest water and prefer cold water. Their food consists of crabs, shrimps, and small crustaceans, and they feed at the bottom. Half-grown to full-grown fish contain spawn. They spawn in the sea in May. They are taken with a hook by the use of mullet or clam bait at half-tide. They bite best in a strong current in winter and spring. In the Gulf of Mexico, according to Stearns, they are abundant from Key West to the Rio Grande, and are known as the "Whiting," though at Pensacola the name "Ground Mullet" is in use. He writes:

"There are two varieties, which, if they have no specific differences, have at least different habits. One variety lives exclusively in very shoal water along the sandy beaches, appearing to take pleasure from the action of the surf, and swimming in small schools. The other inhabits deeper waters; is found singly, and is of much darker coloring. The former seldom leaves the sea-water, while the latter are often found in brackish and fresh water. I have found ripe spawn in the surf variety in April, and believe they deposit it on the sea-beach. Large specimens of the dark variety were taken in September, 1879, in the Apalachicola River, where the water is fresh. The Whiting is an excellent food-fish."

The two varieties thus referred to by Stearns have been identified by Jordon as the two species *M. albumus* and *M. littoralis*, the latter being the surf-loving species first mentioned.

The Whiting is a delicious pan-fish, sweet and hard, though soon losing its delicate flavor. In Charleston it is regarded as a special dainty. According to Colonel Lyman, when Charleston was closely blockaded and fishing was a hazardous occupation, the commandant of the garrison, who was a *bon vivant*, gave $100 of Confederate money for a string of Whiting.

Some of the early writers called this fish the "Bermuda Whiting," for what reason it is difficult to understand, for the Whiting of Bermuda at the present day is a fish very unlike that of our Southern coast.

The "Surf Whiting," according to Jordan, is not rare at Charleston, and in the Gulf of Mexico is as common as the other species, but is chiefly found in the surf, and hence is less frequently brought into the markets.

126. THE CROAKER—MICROPOGON UNDULATUS.

The Croaker, *Micropogon undulatus*, ranges from New York at least to the Gulf of Mexico, although rarely seen north of Delaware. It occurs also in some of the West Indian islands and south of Brazil. Its name refers to the peculiar grunting sound which it utters, but in the Chesapeake this name has been corrupted into "Crocus." In Texas it is called "Ronco."

At Beaufort, North Carolina, according to Jordan, it is very abundant, and, next to the mullet and the Spot, is the commonest food-fish of the region. Holbrook states that the Croaker makes its appearance off Charleston in the month of May, but becomes common in shallow water in June and July, and is most abundant and attains its largest size in October and November. It is not much esteemed as food, and is only used as a pan-fish.

It is abundant and highly esteemed at Brunswick, Georgia, and everywhere in Eastern Florida, in company with the Spot, ascending the Saint John's as far as Jacksonville.

Stearns writes: "In the Gulf of Mexico it is very common. Is found everywhere in the bays and bayous throughout the year. Lives mostly in shoal water or grassy bottoms. Feeds upon crustaceous animals. Breeds in the bays in November and December. The young are seen in the spring, having grown to a size of two and three inches in length. Is caught with hook and line and seine. Sells with other pan-fish for a low price. It is an excellent food-fish; average length ten inches. At Sarasota Bay, December 8, 1879, I caught two specimens of spawning Croakers that were each fully eighteen inches long—the largest that I have ever seen."

An allied species is *Larimus fasciatus*, which is called "Chub" in Charleston.

127. THE CORVINAS AND RONCADORS OF THE PACIFIC COAST.

By DAVID S. JORDAN.

THE WHITE SEA BASS—CYNOSCION NOBILE.

This species is everywhere known as the "Sea Bass" ("Sea Trout"), sometimes as "White Sea Bass," to distinguish it from the Black Sea Bass, or Jew-fish. The young, while yet banded, are known as "Sea Trout," and generally considered a distinct species, and both are frequently called "Corvina" and "Caravina."

It reaches a length of four to six feet and a weight of fifty to seventy-five pounds, perhaps more. Those usually seen in market average about fifteen.

It ranges from Cape Mendocino southward to below San Diego, being especially abundant from Santa Barbara to Monterey in spring and summer. It is not often seen in winter. Only adults are taken in spring, and it probably comes to the shore from deeper water for the purpose of spawning. It goes in small schools, and its movements are irregular. Its food consists of crustaceans and fishes. It spawns in June or July. It is one of the most important food-fishes

of the coast. Its flesh is excellent, firm and well flavored, and its great size renders it a very valuable species. In the firmness of its flesh it differs strikingly from most of the other species of the genus.

The Corvina—Cynoscion parvipinne.

This species is usually known as the "Corvina" or "Caravina." It is also occasionally called Bluefish. It reaches a length of about two feet, and a weight of eight pounds. It is found from San Pedro southward to the Gulf of California, rarely straying to the north. In San Diego Bay it is abundant. It feeds on crustacea, and especially on small fishes, as anchovies and sardines, and is very voracious. It spawns in July or August. Its flesh is tender, being very similar to that of the weak-fish (*C. regale*). It softens soon, but when fresh is of a fine, delicate quality, and scarcely surpassed by any fish on the coast. Several other species of this genus occur southward along the Mexican coast, where they are among the most important of the food-fishes.

The Red Roncador—Corvina saturna.

This fish is known where found as the "Red Roncador," less commonly as "Black Roncador" or "Croaker." It reaches a length of sixteen inches and a weight of three or four pounds. It is found from Point Concepcion southward in moderate abundance. It feeds largely on crustaceans and spawns in July. It is a food-fish of good quality.

The Roncador—Roncador Stearnsi.

This species is generally known as the "Roncador" (snorer, from the Spanish *roncar*, to snore), and is always considered as the genuine Roncador, the other Sciænoids being to the fishermen bastards. The name "Croaker" is often applied to it. It makes a very distinct grunting noise, probably with its air-bladder, on being taken from the water. It reaches a length of over two feet, and a weight of six to eight pounds. It is found from Santa Barbara southward, usually in abundance. It feeds on crustacea and spawns in July. It is a food-fish of excellent quality.

The Little Roncador—Genyonemus lineatus.

This species is known about San Francisco as the Little Bass. Southward it is called the Little Roncador. The name "Coguard," said by Dr. Ayers to be given to it in San Francisco, is unknown to us. It reaches a weight of little over a pound, and a length of one foot; it is found from Tomales to San Diego, being most abundant from Santa Barbara to San Francisco. It often comes into the markets in large numbers; it feeds chiefly on crustacea and spawns in July. It is a food-fish of good quality when fresh, but its flesh becomes soft in the market sooner than that of most species. Many are dried by the Chinese.

The Yellow-finned Roncador—Umbrina roncador.

This fish is generally known as the "Yellow-tailed" or "Yellow-finned Roncador." It reaches a length of more than a foot, and a weight of two or three pounds. It is found from Santa Barbara southward, and is generally abundant, especially in summer. It feeds on crustacea and spawns in July. It is a food-fish of good quality. Many are split and salted.

The Bagre—Menticirrus undulatus.

This fish is known as the "Bagre" or "Sucker." It reaches a length of twenty inches, and a weight of four or five pounds. It is found close to shore from Point Concepcion southward to Cerros Island, and is generally abundant. It feeds on crustacea, spawns in July, and is a food-fish

of fair quality. In appearance and in value it approaches closely to the Surf Whiting of the Atlantic, *M. littoralis*.

The Queen-fish—Seriphus politus.

This species is known as "King-fish" or "Queen fish." It reaches a length of eight inches, and a weight of half a pound. It ranges from Tomales Bay southward, and is abundant in summer, when it is found in great numbers in the surf along sandy shores. Enormous numbers of them are sometimes taken in seines, especially at Santa Barbara and Soquel. It is not often brought into the San Francisco market. It feeds on small fishes, crustaceans, etc. It spawns in summer. It is a food-fish of excellent quality, but it is too small to possess much economic value.

O.—SHEEPSHEAD, BASS, BREAM, PERCH, ETC.

THE SHEEPSHEAD FAMILY—SPARIDÆ.

The members of this family are especially characterized by their heavy, rather compressed bodies, and by their large heads, strong jaws and teeth, for cutting or crushing the hard-shelled marine animals upon which they feed. They are usually sedentary in their habits, living close to the bottom and browsing among the rocks and piles. Their colors are usually inconspicuous and their motions sluggish. Representatives of this family are found throughout the world in temperate and tropical waters.

128. THE SHEEPSHEAD—DIPLODUS PROBATOCEPHALUS.

The Sheepshead is one of the choicest fishes of our coast. It derives its name from the resemblance of its profile and teeth to those of a sheep, and also from its browsing habits. Unlike most of those fishes which are widely distributed along our seaboard, it has only this one name by which it is known from Cape Cod to the Mexican border. The negroes of the South, however, frequently drop the "s" out of the middle of the word and call it "Sheephead."

This fish has never been known to pass to the north of the sandy arm of Cape Cod, and its northern range is at present somewhat more limited than it was eighty years ago. In the records of Wareham, Massachusetts, they are referred to as being somewhat abundant in 1803, and in Narragansett Bay there is a tradition that they began to disappear in 1793, when the scuppaug commenced to increase in abundance. In 1871, Mr. E. Taylor, of Newport, testified before Professor Baird that his father caught Sheepshead in abundance forty-five or fifty years previous. In 1870 and 1871 the species was again coming into notice in this region, though not at that time nor since has it appeared abundantly. On the south shore of Long Island it is quite abundant, and in New York Harbor and its various approaches, at times, may be taken in considerable numbers. On the coast of New Jersey it is also abundant, and between Cape May and Montauk Point the species is said to attain its greatest perfection as a food-fish. Lugger states that it frequents the oyster localities of all parts of the Chesapeake Bay, but is now more common among the southeastern counties of Virginia, where it comes in considerable numbers to feed upon the animals which live on the oyster bars. It is found about wrecks of old vessels, on which barnacles and shells abound. About Bedford, North Carolina, it is also abundant, and also along the entire coast of the Atlantic and Gulf States, where it frequently ascends, especially in Florida, high up the fresh-water rivers. In the Gulf, according to Stearns, it is abundant on the coast from Southern Florida to Mexico.

The Sheepshead is a bottom-loving species, quiet in its habits, and little given to wandering. North of Charleston it is absent from the inshore waters during the winter season, but it is probable that its wanderings do not extend very far. Holbrook records that it has been taken in Port Royal Sound as early as January, while in Charleston it makes it appearance in April and continues until November. Dr. Mitchill, whose observations of this species in the vicinity of New York, made sixty years ago, are perhaps as satisfactory as any which have been made, remarked that its term of continuance was from the beginning of June to the middle of September. He had, however, known it to stay later, for one of the most numerous collections of Sheeps-

head he ever saw was on the 4th of October, 1814; he had observed it as late as the 17th of October.

In Florida the Sheepshead is abundant along the shores throughout the entire year, and this is also the case throughout the Gulf of Mexico.

It is curious to see how much at variance were the statements of early observers concerning its habit of entering fresh water streams. Mitchill states explicitly: "He confines himself strictly to the salt water, never having been seen in the fresh rivers." Holbrook, speaking of the vicinity of Charleston, says: "It enters shallow inlets and mouths of rivers, but never leaves the salt for fresh water." In the Saint John's and other rivers of Florida the Sheepshead becomes almost a fresh-water species, the young especially being constantly taken in seines in company with Bass, Perch, and suckers, far above the limits of perceptibly brackish water. It is not yet possible to infer with any certainty what the temperature limits of this species may be, but it would seem probable that they never willingly encounter water colder than 60°, except perhaps in fall, when they are reluctant to leave their feeding grounds.

The statement just made, however, requires a certain qualification. No one knows whether the Sheepshead of our Northern waters go south in winter or whether they simply become torpid and remain through the season in deep holes near their summer haunts, their presence unsuspected. Perhaps it would be wiser to say that they are not actually engaged in feeding when the temperature is lower than 60°, and that their winter habits are entirely unknown. Where the water is throughout the year warmer than 60° they are constantly active. The Sheepshead feeds almost exclusively upon hard-shelled animals, mollusks and barnacles, and particularly on young oysters as they grow attached to stones and sticks of wood. With its strong cutting and grinding teeth and powerful jaws it can easily rip off thick bunches of shells and grind them to pieces. The ordinary bait for it in the North is the soft-shelled clam, while in the South it is caught frequently by the use of shrimps and crabs.

In discussing the habits of this species I cannot do better than to quote quite fully the observations of several writers on fish and angling, many of whom have taken a special interest in the study of its haunts and movements.

Mitchill wrote in 1814: "This noble fish visits the neighborhood of Long Island annually, emerging from the depths of the ocean. He feeds in the recesses and inlets upon the clams and mussels, which are abundant, and on which he loves to feed. He confines himself strictly to the salt water, never having been seen in the fresh rivers. His term of continuance is only during the warmest season; that is, from the beginning of June to the middle of September. He then disappears to the unknown depths of the Atlantic, and is seen no more until the ensuing summer. The Sheepshead swims in shoals, and is sometimes surrounded in great numbers by the seine; several hundreds have often been taken at a single haul with the long sweeping nets in use near Rayner Town, Babylon, and Fire Island. They even tell of a thousand brought to land at a draught. He also bites at the hook, and several are not unfrequently thus caught in succession. The outfitting of a Sheepshead party is always an occasion of considerable excitement and high expectation, as I have often experienced. Whenever a Sheepshead is brought on board the boat more joy is manifested than by the possession of any other kind of fish. The sportsmen view the exercises so much above common fishing that the capture of the Sheepshead is the most desirable combination of luck and skill; and the feats of hooking and landing him safely in the boat furnish abundant materials for the most pleasing and hyperbolical stories. The Sheepshead is a very stout fish, and the hooks and lines are strong in proportion; yet he frequently breaks them and makes his escape. Sheepshead have been caught with such fishing-tackle fastened to their jaws.

When the line or hook gives way, the accident makes a serious impression on the company. As the possession of the Sheepshead is a grand prize, so his escape is felt as a distressing loss. I know an ancient fisherman who used to record in a book the time, place, and circumstances of every Sheepshead he had caught. This fish is sometimes speared by torchlight in the wide and shallow bays of Queens County and Suffolk." Dr. Mitchill concludes his naive remarks by the mournful words: "It is to be regretted that the Sheepshead too often corrupt for want of ice."

Schoepf, writing of the same region forty years before, states that during the period of the Revolutionary war the Sheepshead was very abundant in the summer months and was a very highly prized species. Some unknown writer contributed to Brown's "American Angler," in 1846, the following memorandum:

"These noble fish have become quite scarce in our harbor. The writer has taken them repeatedly near Governor's Island, opposite the Battery, but this was in days long since gone by. Still, they are still taken, occasionally, at Caving Point and at the Signal Poles, at the Narrows, also at Pelham Bridge and Little Hell Gate."[1]

Scott gives the following advice to the Sheepshead angler: "If a resident of New York, you will find Canarsie on the Old Mill, near East New York, the most convenient place from which to take a sail-boat; a boat is generally at hand at either place. Sail down the channel above the inlet toward Near Rockaway, about a mile below Remsen's Hotel; feel by sounding for a mussel-bed (they are numerous for a mile along shore), about two hundred yards from which, when found, cast anchor far enough away so that, when the boat toles round from the tide toward the feeding-ground, the cast required for dropping your anchor will be about fifty feet. The water should be about seven feet deep at low tide, and it rises there from four to six feet. The best time is during the period between high and low tides when the water is slack, and until it runs at the rate of five miles an hour, or one hour after it begins to run; for when the tide runs out it is then considered that Sheepshead seek some still-water ground and wait for a moderate motion of the waters. At the right times of tide the location of the mussel-beds is plainly indicated by a fleet of fifteen to twenty sail-boats or hand-line fishermen. Many of them are farmers, who, residing near the shore of Jamaica Bay, employ the interregnum between hay and grass, uniting their profits, and earning from $3 to $10 a day, by fishing for Sheepshead.

"There are many places along our shores better than Jamaica Bay. The Hand-line Committee makes it pay at Fire Island, and there are many superior feeding places in the South Bay; about the wreck of the 'Black Warrior,' near the Narrows, is celebrated for great numbers of them; in truth, our whole coast south of Long Island is rendered inviting by this delicious fish."

Norris wrote: "In fishing for Sheepshead it is a common practice in Lower Virginia and other waters to drive down stout stakes forming an inclosure; to these different species of mollusks will attach themselves in a few months and entice the Sheepshead; when they have made it a place of resort the fisherman ties his boat to a single stake on either side at a convenient distance and throws his bait towards the pen."

Holbrook wrote, in 1860: "At present the best fishing-grounds for the Sheepshead in South Carolina is the breakwater at Sullivan's Island, or the Foundation Rocks at Fort Sumter, at the entrance to Charleston Harbor.

The Hon. William Elliott, in his "Carolina Sports," gives the following account of the peculiar methods employed in catching Sheepshead in Port Royal Sound, South Carolina:

"They are exceedingly choice in their feeding, taking no other bait but shell-fish. Their favorite food is the young oyster, which, under the form of barnacle, they crush with their strong

[1] American Angler's Guide, fifth edition, p. 198.

teeth. Of course they frequent those shores that abound with fallen trees. On the Florida coast they are taken in great quantities among the mangrove trees, whose roots, growing in the salt water, are covered with barnacles. Formerly they were taken in considerable numbers among our various inlets. Wherever there were steep bluffs, from which large trees had fallen in the water, there they might confidently be sought. But as these lands have been cleared for the culture of sea-island cotton, the trees have disappeared, and with them the fish; and it has been found necessary to renew their feeding-grounds by artificial means. Logs of pine or oak are cut and framed into a sort of hut without a roof. It is floored and built up five or six feet high, then floated to the place desired, and sunk in eight feet of water by casting stones or live-oak timber within. As soon as the barnacles are formed, which will happen in a few weeks, the fish will begin to resort to the ground. It is sometimes requisite to do more before you can succeed in your wishes. The greatest enemies of this fish are the sharks and porpoises, which pursue them incessantly and destroy them, unless they can find secure hiding-places to which to retreat. Two of these pens, near each other, will furnish this protection; and when that course is not adopted, piles driven near each other, quite surrounding the pen, will have the same effect. Your work complete, build a light staging by driving down four upright posts at a distance of fifteen feet from the pen, and then take your station on it, provided with a light, flexible, and strong cane reed, of twenty feet length, with fourteen feet of line attached, a strong hook and a light lead. Instead of dropping your line directly down and poising it occasionally from bottom, I prefer to throw the line out beyond the perpendicular and let the lead lie on the bottom. The Sheepshead is a shy fish, and takes the bait more confidently if it lies on the bottom. When he bites you perceive your rod dipping for the water; give a short, quick jerk, and then play him at your leisure. If the fish is large, and your jerk too violent, the rod will snap at the fulcrum—the grasp of your left hand. It has happened that, at one of these artificial grounds, I have taken sixteen Sheepshead at one fishing. What was unusual was, that they were taken in February, when no one thinks of fishing for these or any other sea-fish within the inlets. I ascertained, from the continued experiments of several years, that they could always be taken at this season, and frequently in January also. The difficulty is to find bait, for neither shrimps nor crabs are then in season. In the case referred to the difficulty was thus removed: The lines were rigged with two hooks; upon one was placed an oyster taken fresh from the shell, on the other an oyster boiled. The scent of the first attracted the fish, but so little tenacity was found in it that, before the fish had taken hold of the hook, the oyster was detached; but when, encouraged by the taste of the first, the fish advanced to the second, that having acquired toughness from boiling, would adhere until the hook was fairly taken into the fish's mouth. They clearly prefer the uncooked to the cooked oyster, but the latter was more to the fisherman's purpose. Their fondness for this food suggested the expedient of breaking up the live oysters in the shell and scattering them in the vicinity of the ground; also that of letting down the broken oysters in a wicker basket. Each plan is found effectual in attracting the fish.

"The bluffs, in their primitive state, in which trees enough are found fallen to give the fish both food and protection against their enemies, are only to be met with now among the Hunting Islands, where the barrenness of the land had secured them against cultivation. On two occasions I have enjoyed excellent sport at such places. On one I took twenty-three to my own rod; on another, twenty-four, and desisted from fatique and satiety. They are never taken in such numbers when fishing from a boat with a drop-line on the rocks. It is very rare that as many as twenty are taken in one boat."[1]

[1] ELLIOTT, WILLIAM: Carolina Sports by Land and Water. New York, 1859, pp. 145–149.

Mr. S. T. Walker writes: "In regard to the consumption of moss, etc., by the Sheepshead, I must say that I can hardly answer intelligently. At high tide, when the flats are overflowed, I have often observed the Sheepshead standing on end, tail up and often out of the water, grubbing at the roots of a coarse, rough grass that grows on the flats. When engaged in this way it is easy to capture from two to six at a single throw of the casting-net. I have often observed a yellowish-green vegetable matter among the broken shell in their intestines, but imagined it was swallowed accidentally with the shell-fish, or was possibly attached to the shells themselves."

In the Saint John's River Sheepshead are abundant as far up as the lakes, and about Jacksonville are always associated with the sailor's choice, *Lagodon rhomboides*. They are never seen of large size; individuals of eight inches and less were taken around the piles and river at Arlington and Mayport. "In the Indian River region," says Mr. Williams, "the season for Sheepshead begins the 1st of May. They range in weight from three to seven pounds. Half-grown specimens, which can be taken along the rocks with cast-net or spear, are good pan-fish. They do not take mullet bait readily, hence are seldom taken with the hook. Hundreds of a larger size may be seen in shallow water on the east side of the river, or in calm water, on barnacles attached to sunken logs, or rocks under water."

Mr. S. C. Clarke, writing from New Smyrna, Florida, states that they occur throughout the year and are most abundant from December to March, having decreased in numbers perhaps one-fourth during the past ten years. They winter in the deep water of the inlets and rivers, are regular in their appearance, take the hook at most times, come and go with the tide, swim low, except in the spawning season, when they come inshore and prefer warm and muddy water with shelly bottom. They feed about rocks and logs on clams, shrimps, barnacles, crabs, and oysters, and are best taken in the latter part of the ebb and young flood, and during the season of plenty, from November to March, twenty-five fish may be considered the average result of a day's fishing with hook and line. They are taken with cast-nets and with hooks, using crabs, clams, mussels, and shrimps for bait. They are highly prized, fresh and salt, though they are mostly consumed in the fresh state.

Mr. Clarke also gives some important information regarding the spawning of this fish. He says: "Before spawning they go in schools, but afterwards they scatter. They spawn at the mouths of rivers and inlets in March and April, the sexes mixing together in schools. The eggs are deposited in shallow water near the shore, and are about the size of mustard seed, and dark. At the spawning season the fish play near the surface and become thin and unfit for food. The young fish are abundant in shallow water among the rocks."

Finally, I append in full the statement of Mr. Stearns, which is especially important since it contains an account of their spawning. He writes:

"The habits of the Sheepshead depend somewhat on the nature of the feeding-grounds in those localities where the fish occurs. At such places as Saint Mark's River, Cedar Keys, Homassassa River, and the Mangrove Islands, farther south, it is present throughout the year, in about the same abundance, whether it will take the hook or not; while at Apalachicola, Saint Andrew's, Pensacola and Mobile Bays, and the Louisiana marshes, its habits are those of a migratory fish, which, in a body, at a certain season, approaches, and, later on, leaves the coast. At the latter-mentioned places it is found to a limited extent during the spring and summer. At these same places large schools of Sheepshead appear on the coast during the months of September, October, and November, finally entering the harbors. This is as important and noticeable a movement as the 'runs' of pompano, Spanish mackerel, or hard-tails in the spring, and it is the only time when large quantities are caught. The fish composing the 'run' are very

thin in form and hardly marketable, but after a few days' rest and refreshment in the bays they become fat and desirable for food. The schools having entered the harbors, become somewhat scattered and go to the feeding-grounds, where they are largely taken with hook and line and seine. Any movement seaward to balance this must be gradual, and takes place, I think, in summer, for it is not noticeable.

"The Sheepshead spawns in April and May, in the bays. On June 18, 1878, and in June, 1879, I caught young Sheepshead, measuring a quarter of an inch, in Pensacola Bay. It lives about wharves, rock-piles, old wrecks, oyster-reefs, and, in South Florida, about the roots of the mangrove tree, feeding upon the barnacles that grow in such places. It is caught with hook and line, in fall and winter, at which seasons it is in its best condition. Its average weight is three or four pounds, and its maximum twenty pounds."

When the Sheepshead first appear on our northern coast it is stated by several writers that they are always thin and unfit for food; it would seem from this as if their spawning season was just ended. No one, however, has made any careful observations upon this point north of Florida.

In the South, Sheepshead are usually small, rarely exceeding two pounds in weight. This is also the case in Florida, although large individuals are occasionally seen. About New York Harbor they sometimes weigh from twelve to fifteen pounds, though the average size is not more than half this weight. All authorities agree that the Sheepshead is one of the very finest food-fishes in our waters, many persons preferring it to the salmon, while others compare it to the English turbot, to which, however, it is doubtless much inferior.

In the North the Sheepshead is almost always boiled, but the smaller fish, more commonly taken in the South, are well suited for frying or broiling.

The Pin-fish—Diplodus Holbrookii.

This fish, which is abundant at Charleston and about Beaufort, North Carolina, was first scientifically described by Dr. Bean from specimens obtained in Charleston market, in March, 1878. Jordan found it abundant everywhere near the shores of Beaufort, North Carolina, in which region it reaches but a small size, and is not used as food. It is confounded by the fishermen with the Sailor's Choice.

129. THE SCUP OR SCUPPAUG—STENOTOMUS VERSICOLOR AND S. GARDENI.

Until very recently only one species of the genus *Stenotomus* was known to occur in our waters. Dr. Bean has recently shown that there are two on the Atlantic coast of the United States, in addition to the unimportant species, *S. caprinus*, recently described from the Gulf of Mexico.

The "Scup" of the North, *Stenotomus versicolor*, is by far the most important, though the Southern species, *S. Gardeni*, has considerable commercial value. The former, which is distinguished by its larger teeth and more abrupt profile, is abundant between Cape Cod and Cape Hatteras, the latter has its metropolis on the Carolina coast, but has been found sparingly as far north as Wood's Holl, Massachusetts.

The Scup, which in many respects resembles the Sheepshead, is often known in New England as the "Scuppaug," this word being an abbreviation of *Mishcuppauog*, the name applied to it by the Narragansett Indians. It is to be regretted that it has been corrupted to form two others, neither of which is euphonious or significant. In New England it is generally called "Scup," while about New York the second syllable of the abbreviated Indian name has been lengthened into "Paugy" or "Porgy." The latter name is particularly objectionable because it belongs to the

English fish, and its proper etymology as a fish name is very different. Another Indian word, "poghaden," a corrupted form of the Abnaki name for the menhaden, or moss-bunker, has been changed to "pogy" and "porgy," thus leading to much confusion. "Scuppaug" is an excellent name for the fish, and its claims for general adoption will be recognized by all who wish to see preserved the name of the aboriginal languages of America.

On the Virginia coast the Southern Scup is known as the "Fair Maid." The name "Porgy" is in use about Charleston, South Carolina, but is usually applied to other members of the same family. Their range is much more limited to the south and extends farther to the north than that of the Sheepshead. Holbrook wrote in 1860: "The Porgy is found along our coasts at all seasons of the year, though most abundant in June and July." He further states that its southern limit on the Atlantic border is Cape Florida, a statement probably not susceptible of proof.

The Northern Scup rarely passes the boundary of Cape Cod; in 1878, however, thirty-seven were taken at the Milk Island weir off Thatcher's Island, Cape Ann, Massachusetts, and they appear to be increasing in abundance.

This species does not appear to be indigenous north of Cape Cod. Storer gives the following account of its introduction: "Mr. James Newcomb, fishmonger in the Boston market, informs me that in the year 1831 or 1832 a smack-load of Scapaugs arrived in Boston Harbor. A portion of them were purchased by subscription among the fishermen in the market and thrown into the harbor. The next season two specimens were caught from our wharves; in the summer of 1835, one individual was taken at Nahant, and was considered a very strange fish, no specimen having been known to have been seen there before; in 1836, still another was captured at Nahant. As no specimen had ever been taken so far north before, and as the few taken would lead to the inference that those which had been transplanted from Buzzard's Bay had not bred in the cold waters of this portion of Massachusetts Bay, we are led to believe that the individuals taken immediately around Boston were of the number originally brought from the South. In the year 1834 or 1835, Capt. William Downes, of Holmes' Hole, carried a smack-load of this species from Vineyard Sound and threw them overboard in Plymouth Harbor." Storer, writing in 1867, says that "within a few years small numbers have appeared north of Cape Cod and are yearly captured at Wellfleet and Sandwich."

Judging from the rare occurrence of the species thus introduced, it can hardly be considered to have become naturalized; the few which have been taken were doubtless summer stragglers. In the Boston Society's museum is a specimen taken at Swampscott, June 29, 1860, by J. Phillips. In the Salem Museum is another taken in Salem Harbor, July 23, 1860, by C. A. Putnam. Scup become abundant on the south side of Cape Cod from the 5th to the 12th of May, which would allow ample time for the appearance of a part of the school off the eastern coast of Massachusetts as early as the dates recorded.

Mr. Hinckley, president of the Philadelphia, Wilmington and Baltimore Railroad, informs us that in the winter of 1833 he found a dead Scuppaug on the Cohasset shore; this was its first occurrence in that locality, and none of the fishermen knew it.

In 1856, Captain Atwood recorded the Scup as very rare at Provincetown.

"Sometimes," says Captain Atwood, "I have seen a dozen of these fish. The Scup were never here at all abundantly; only scattering individuals have been taken from year to year. Since 1842, when the mackerel nets were first set in the outside of the harbor, Scup were first seen, and a few have been seen since."

The history of this species, like that of the bluefish, has been very carefully worked out by

Professor Baird;[1] and from this article and an unpublished essay written in 1877 the remainder of this section is made up. Professor Baird writes:

"It makes its appearance, at least in considerable quantity, on the coast of New England about the middle of May, although the advance-guard of very large fish arrive sometimes as early as the middle of April; and it is most abundant toward the 1st of June, and arrives in successive detachments or 'runs' differing in size, the smallest fish coming last. The first run on the southern coast of New England, as stated, takes place about the beginning of May, and consists of large breeding fish, weighing from two to four pounds, and measuring up to eighteen inches or more in length. The spawn is quite well developed at that time, and is said to be at first red, but gradually to become light yellow as it matures. The particular time and place, however, of laying the eggs is not yet known, although it is probable that this occurs early in June, since the schools are said to break up about the middle of that month, and the fish to scatter. It is thought probable that the spawning takes place in the eel-grass which covers the shoal waters of Narragansett Bay and Vineyard Sound.

"According to the fishermen generally, the Scup on first coming into the shores do not take the hook readily, being apparently too much occupied in the business of reproduction, and two weeks usually elapse before they can be caught in this way. They present themselves in large schools of immense extent, and moving very slowly, at about the rate of three miles an hour. From the testimony presented before the committee of investigation of the Rhode Island legislature, they appear to come from the south and west, as when they enter Narragansett Bay they strike the western shore and move up along its edge. They are said, however, to drift slowly backward and forward with the tide, especially at the entrance of this bay. At this time they are very sluggish, and are said sometimes to appear as if blind, and can frequently be taken with the hand, or a very short scoop-net.

"According to Captain Edwards, of Wood's Holl, in proceeding to their breeding-grounds, on the coast of New England, they are taken at Montauk Point three weeks earlier than at Wood's Holl, and a week earlier at Wood's Holl than at Hyannis, still farther east.

"The Scup feed upon a great variety of marine animals, such as worms, small crustaceans, mollusks, etc., and take the hook very freely during the greater part of their stay; in fact, the smaller ones become veritable nuisances to the fishermen, from the readiness with which they pounce upon the baited hook whenever thrown overboard.

"The flesh of the Scup is very much prized by most persons, as it is firm and flaky, and usually sweet, although occasionally a bitter flavor detracts from its palatability. Since the settlement of the coast by the whites, it has been by far the most important food-fish of Fisher's Island and Vineyard Sounds, Narragansett Bay, and of Buzzard's Bay; and the rapid diminution in number has caused the greatest solicitude.

"Of their abundance on the south coast of New England in former times, almost incredible accounts are given. They swarmed to such a degree that their capture ceased to be a matter of sport. The line when thrown overboard could be immediately withdrawn with the assurance of having a fish on each one of two hooks. Any number of fishermen from boats could take five hundred to one thousand pounds a day without the slightest difficulty, the limits of the catch being simply the ability to find a sale.

"In flavor the flesh of this fish is surpassed by very few others on the coast, although its superabundance caused it to be undervalued. The period of greatest development in number of

[1] Report U. S. Commission Fish and Fisheries, part i, pp. 223-235.

this fish coincided with that of the absence of the bluefish, and since the return of the latter to the coast of New England the Scup has become scarce, although still a very important object of pursuit.

"Immense numbers are caught in the pounds and traps in Rhode Island and Massachusetts, and for several weeks the market is usually glutted, a barrelful being frequently sold for twenty-five to fifty cents, or a small fraction of a cent a pound. It is extremely doubtful whether any part of the more northern coast of North America can furnish, within three miles of the shore, as large a weight of fish in mackerel, herring, and cod as has been furnished by the Scup, sea-bass, and tautog alone in the waters of Rhode Island and Massachusetts. Mr. William Davol, of Rhode Island, with his 'gang,' caught 2,400 barrels of Scup, valued at $1,200, at Seconnet, in May, 1860. Fish were purchased by Messrs. Reynolds, Young & Co., of Fall River, and shipped to Philadelphia.[1]

"The Scup is a fish that grows with rapidity, and at two years is almost of sufficient size to be marketable. Throughout the summer young fish of the spring spawning are to be seen floating around in the eel-grass and over the sandy bottoms, having attained a length of from two and a half to three and a quarter inches by the 1st of October. When these fish reappear the next season, thus completing one year of existence, they measure about six inches, six to eight or nine weighing a pound; and by the 1st of September attain an average length of eight inches, including the tail, and a breadth of three inches. (Twelve individuals, measured on the 31st of August, measured from 7.75 to 9 inches in length, and from 2.75 to 3.25 inches in breadth, not including the dorsal and anal fins.) On the 8th of September twenty-five of this age weighed four and three-quarter pounds, or an average of little over three ounces each. In the third year of existence, or at the age of two years, they have increased considerably, though not so rapidly as was once supposed, measuring, on their reappearance, about ten inches, with an average weight of one-half pound. Six weighed in New Bedford, October 9, averaged but little over five ounces each, while the average of those on the stalls in New York, October 17, was a little over eight ounces. After this they grow more quickly. One hundred and ninety-nine, presumed to be three years' fish, weighed on the 6th of September, averaged one and a half pounds each, and measured about twelve inches in length by four and a half inches in width, some individuals being larger and some smaller. The female fish of the second year not unfrequently contains mature eggs. It is in the fifth year, or after the lapse of four years from birth, that the Scup presents its finest development; specimens believed to be of this age measured fourteen or fifteen inches by five to six inches or more, with a weight of two and a half to three pounds. They, however, still continue to grow, specimens being not unfrequently met with eighteen inches long, and weighing four pounds and even more. The dimensions may belong to fish of six or more years of age; more probably, however, of five years. It is, of course, impossible to do more than give average estimates of the weight and size of fish of the same age, the differences probably depending on the fact whether they were spawned by old or young fish, and the period when the eggs were laid, this extending over a considerable length of time in each locality, although the great majority of fish undoubtedly spawn at nearly the same season.

"Abundant as the Scup has been during the greater part of the present century, there appears to be good evidence to show that prior to the year 1800 there was at least one period, if not more, when it was extremely rare. According to Mr. Southwick (page 11), there is a tradition that they first occurred at Newport about 1793, the sheepshead disappearing about the same time. Mr. Lyman, in an article on the possible exhaustion of the sea fisheries, written in 1871, also

[1] Fall River News, 1860.

quotes some negative evidence of the absence of this fish at Compton, Rhode Island, from 1794 to 1803, the 'sheepshead' (more probably the tautog is meant) being spoken of as common, and the Scup not mentioned.

"Mr. John C. Parker, an octogenarian of Falmouth, Massachusetts, states that the Scup were observed there, according to his father's statement, some time after 1790, and had become quite abundant by 1814. On the other hand, however, in 1621, again quoting from Mr. Lyman, Massasoit entertained his half-famished Puritan visitors with 'fishes like bream, but three times so big, and better meat'; this fact, with the description, being applicable to no other fish than the Scup. The European sea-bream is very similar to the Scup, and would readily be referred to the same species by the unobservant traveler.

"Again, Roger Williams, in his 'Key to the Language of the Indians,' speaking of the Scup, says 'mushcup, the bream.' 'Of this fish there is abundance, which the natives dry in the sun and smoke, and some English begin to salt. Both ways they keep all the year, and it is hoped they may be as well accepted as cod at market, and better if once known.' We find no reference to the occurrence of the fish from this date, 1642, up to 1794.

"The time of the arrival of the Scup on the coast varies with the locality. The young probably spend the winter in our southern waters or out in the Gulf Stream, but in the spring commence their migration either along the coast or from the deep seas toward the waters on the south coast of New England. The latter supposition is the more probable, as no Scup are taken on the southern coast of anything like the size of the breeders that visit New England, making their appearance at once in a huge body, extending, apparently, from Block Island to Martha's Vineyard.

"The western division of this army appears to strike first at Watch Hill, to the west of Point Judith, and to make its way slowly along eastward, the smaller or eastern division moving through Vineyard Sound. According to Captain Luce, the Menemsha pounds take the Scup three days or a week earlier than the pounds at Lombard's Cove, and nearly two weeks earlier than at the guano-works at Wood's Holl. The progress of this fish is at first very slow, scarcely exceeding a few miles a day, and its movements appear to be largely regulated by the flow of the tide, going forward with the flood, and partly retrograding with the ebb. According to Mr. Whalley (page 24), of Narragansett Pier, it occupies about four tides, or two days, in moving from Point Judith to Seconnet Point.

"The precise period of their reaching the coast varies with the season, although their abundance generally occurs from the 5th to the 12th of May. In 1871 the fish appeared much earlier than usual, and were on the shore before traps were down in readiness for their capture. Their occurrence was about the 15th to the 25th of April. Breeding Scup were taken at Hyannis the same year on the 27th of April, at least two weeks earlier than usual. They were taken in the fish-pound at Wood's Holl on the 27th of April, but were most abundant on the 8th of May. In 1872 the season was late, and a few scattering Scup were taken at Wood's Holl from the 10th to the 13th of May, but were most abundant at a later date. On the 17th of May ten barrels were taken, and one hundred and fifty barrels on the 9th of June. Some of those captured in the middle of May were of unusual size, weighing four pounds and over. At Newport they were most abundant on the 15th of May, or two days earlier than at Wood's Holl. Here, too, the number of mature fish was less than usual, but the average size greater. Over one thousand barrels were taken in Luce's pound, at Menemsha Bight. It is mentioned as an unusual occurrence that in the spring of 1872 large fish were caught in purse-nets five or ten miles off the shore of Newport, mostly with spawn, although very poor and thin.

"According to Capt. Thomas Hinckley, after passing Seaconnet Point and entering Buzzard's

Bay, the Scup keep along the northern shore and make almost the entire circuit of the bay before appearing at Quissett Harbor and Wood's Holl, their appearance being always later there than at the head of the bay or about New Bedford. Whether it is the fish alone that belong to Buzzard's Bay that enter it, or whether others pass directly between the Elizabeth Islands and Martha's Vineyard, is not yet satisfactorily ascertained. We know, however, that they reached Waquoit, the first pound on the north side of Vineyard Sound, in 1871, as early as April 25, but that the largest numbers were taken from the 10th to the 13th of May. This gives about a week's difference between this point and Newport.

"On the south of Vineyard Sound the fish are netted at Menemsha Bight, where there are several large and effective pounds, three days or a week earlier than at Lombard's Cove, and nearly two weeks earlier than at the Wood's Holl pound.

"According to Mr. Luce, breeding fish enter the tidal ponds on the north side of Martha's Vineyard (formerly in large numbers), where they spawn, accomplishing this operation by the end of June, the ponds being filled with young in August. As soon as frost comes these fish leave for their winter abode.

"A new point was made in the capture of Scup by the fishermen of Block Island during the spring of 1877. Heretofore Scup have been taken in quantities only in the vicinity of the shores, being captured in immense numbers in traps at Seconnet River and by pounds elsewhere, and sometimes by seines. The capture by hand-lines is the more common, and may be carried on at some distance from the shore; but it has never been taken very far from the land. On the occasion referred to, some fishermen, while engaged in capturing mackerel off Block Island, saw what they supposed to be a school and put their purse-seine around it. To their surprise they found their net to contain Scup exclusively. Of these they took at one haul six hundred barrels of one hundred and eighty pounds each, all of marketable size and bringing a good price in the New York market.

"As a general rule, in their movement along the coast the Scup are not found in water shallower than a few fathoms; and it sometimes happens, in the course of heavy storms, that in consequence of the discoloration of the water near the shore the fish move farther out to sea, and on such occasions measurably escape falling into the traps.

"The Scup is very largely a bottom feeder, and depends very much upon mollusks or shellfish for subsistence. I have been informed by the fishermen that they may frequently be seen feeding upon small bivalves of different species, rooting them out of the sand or mud. The stomachs of about two hundred one and one-half pound Scup were examined at one time in the beginning of September. These almost exclusively contained shells of various genera, with some worms and a few amphipods. Its especial food appears to be small shells, crabs, shrimp, and possibly small fish. The abundance of such food on the south coast of New England must be prodigious to support the swarms that even now are found there. It is in regard to this species that a close time is desirable, so that access to the spawning-grounds and freedom from disturbance may be enjoyed by a sufficient number to maintain the species.

"Like all other small fish, they are devoured by their more rapacious fellows, and very largely by bluefish, notwithstanding a general impression to the contrary. The extent to which this takes place will be considered under the head of the bluefish. Halibut, cod, sharks, and other ground-feeders likewise use them up in great numbers.

"As already remarked, the breeding fish do not appear to feed on their first arrival, being then too much occupied in carrying out the reproductive function. As, however, they can be taken with the hook about the 1st of June, we may infer that this is about the time they begin to feed

for themselves. The younger fish probably feed as soon as they reach the shores. No remains of fish have hitherto been found in the stomachs of Scup, and we may conclude that they are not piscivorous.

"Although the period and the general region where the eggs are deposited has been pretty well ascertained, I regret that nothing is known of the peculiar method by which this is accomplished. I have been informed (page 47) that, on hauling up of anchors of boats that have been lying overnight in two fathoms of water, the rope is frequently found coated with spawn sticking upon it. The eggs are doubtless fertilized as discharged, and probably adhere to the gravel, grass, and other objects at the bottom; but as to the precise period of development, nothing is known.

"INCREASING ABUNDANCE OF SCUP.—According to Captain Ashby, of Noank, the young Scup have been extremely abundant in Buzzard's Bay during the summer of 1877, he himself having turned out 2,500 barrels from a small pound worked by him at the Wepeckets, opposite Naushon. He estimates that at least 25,000 barrels have been thus liberated from the various pounds in Buzzard's Bay. In 1880 immense numbers of young Scuppaug were noticed in Narragansett Bay.

"The Scup, like other shore fish, not unfrequently suffer from changes of weather. Mr. Southwick informed me that he has evidence to show that in the early part of May in 1809, 1818, and 1838, after a cold spell in each of those years, large numbers were thrown on the shore. On the 29th of November, 1871, there was a fall of snow at Wood's Holl, and the next day Scup and sea-bass came ashore in considerable numbers, generally, according to Mr. Edwards, about ten Scup to every yard along the shore for a considerable distance. They were, however, all small fish. While Scup were in greatest abundance, the other fish observed were sea-bass, butter-fish, mullet, etc. Similar facts have been observed in regard to tautog, which indeed seemed to suffer very much more than Scup from this agency.

"As may be inferred from what has already been said, the market at the present time is supplied with Scup from the spring traps and pounds, the capture by these means having become almost entirely exclusive. Formerly, however, they could be taken with the hook from the latter end of May until the end of October, and in any desired abundance. There is no fish on the American coast that bites so freely when abundant, and which can be captured with so much ease.

"I am informed by Mr. Dunham that in the deep holes of the pond at Nantucket, where he has been with his boat, he has sometimes thrown a stone overboard so as to give the Scup a start toward the shore, and then following and throwing his dog overboard, he has driven the fish clear out of the water upon the beach, and has taken as many as five hundred in this way at one time. A similar mode of capture was reported to me as having taken place in the pond at Menemsha Bight.

"The value of the Scup as a marketable fish varies, of course, with the supply; and while they have been sold in early times as low as from ten to twenty-five cents a barrel, and were used as a manure, they are now too scarce for any such purpose. They were worth in 1871 from six to eight cents a pound at Newport, and about two cents at Hyannis. At New Bedford they generally brought ten cents as a maximum price.

"On the coast of Carolina they are said to prefer deep, clear water, with rocky bottom, although they may be taken in almost any locality in the region of their occurrence.

"The Scup remain along the northern coast until about the middle of October, when the larger ones, at least, begin to leave the shores and move out into deeper water. Mr. Vinal Edwards has, however, taken young fish at Wood's Holl as late as the 10th of December, and Capt. John Rogers, of Noank, states that, in fishing for cod on Nantucket Shoals late in Novem-

ber, their stomachs are occasionally filled with small Scup, which drop out of their mouths when hauled on deck, found to be to the extent of five or six at a time. It is quite possible that they, as well as other fish, seek in winter that portion of the Gulf Stream that corresponds in temperature to that of their summer abode; and as the mean summer temperature of the waters of Southern Massachusetts and Rhode Island amounts to about 63° Fahrenheit, they must go nearly to the latitude of Norfolk, Virginia, before they can find that same temperature in the winter season.

The European analogue of our American Scup or Porgy is the *Sparus auratus*, the braize or becker, sometimes bream, of the fishermen. These come on to the European coast in the summer time, and are said to have much the same habits as the American species."

A species closely related to the Scup is the "Goat's-head Porgy" of the Gulf of Mexico, *Stenotomus caprinus*.

Sparus pagrus is rather common at Charleston and Pensacola, and is found also in the south of Europe. There are also in our southern waters various species of the genus *Pagellus*, which resemble in a general way the "Scup."

130. THE SAILOR'S CHOICE—LAGODON RHOMBOIDES.

This species, which bears considerable resemblance in its form to the scuppaug, is found in great abundance from Cape Hatteras south, and around the Gulf coast; also occasionally north of Cape Hatteras; it is known in the lower parts of the Chesapeake Bay, and two or three stragglers have recently been taken at Wood's Holl, Massachusetts. It is not uncommon in the Bermudas. It may readily be recognized by the longitudinal stripes of iridescent color upon the sides, and by the peculiar character of the teeth, each having a prominent notch on either edge.

The "Sailor's Choice," as it is called in the Saint John's River, at Brunswick, Georgia, and about Key West, bears several other names, being known about Cape Hatteras as the "Robin" and "Pin-fish," at Charleston as the "Salt-water Bream," at Brunswick, Georgia, as the "Squirrel-fish" and "Sailor's Choice," in the Saint John's River as the "Sailor's Choice" and "Porgy," in the Indian River region as the "Sailor's Choice," "Scup," and "Yellow-tail," at Cedar Keys as the "Porgy" and "Shiner," and at Pensacola as the "Chopa Spina."

South of Cape Hatteras this fish is exceedingly abundant, and is usually found in company with the sheepshead, which it much resembles in habits. Its jaws, however, are not so strong as those of the sheepshead, by reason of which it is debarred from feeding upon the stronger shelled mollusks and crustaceans, which constitute the principal diet of the latter.

On the Atlantic coast the largest individuals rarely exceed ten inches in length, the ordinary size in Eastern Florida being six or eight inches, with the weight of five or six ounces.

The Sailor's Choice is one of the most deliciously-flavored fishes of our coast, being preferred to the young sheepshead by many of those who are familiar with its good qualities. Lugger states that it enters the drains of the ocean coast of Maryland, and is occasionally caught in the lower part of the Chesapeake Bay. According to Jordan they are excessively abundant everywhere in the harbor of Beaufort, North Carolina, where they are taken by the thousand by boys with hook and line from the wharves, but are seldom used for food, and are found equally numerous through the Gulf States coast.

At Charleston, according to Holbrook, this fish is taken at all seasons of the year, though most plentiful in May and June. No reference is made by this author to its value as an article of food. At Brunswick, Georgia, the Sailor's Choice is highly esteemed; in the Saint John's it is very abundant, and is taken in company with the sheepshead far up the river. It is easily

captured with hooks baited with shrimp, and is considered to be a very superior pan-fish, its flesh resembling that of the scuppaug, though much sweeter and harder.

In the Indian River region, according to Mr. S. C. Clarke, this fish is resident all the year, and is very abundant. The weight of the largest observed by him was one pound. The average weight is about five ounces. They are found in the deep water, or salt water, feeding upon minnows, small crabs, and shrimps. The spawn is pale blue, and of the size of mustard-seed. Young fish are seen in great abundance. They are taken by hook with mullet or clam bait, and also in cast-nets and seines. One hundred are often taken by a fisherman in a day. They are highly prized for food, and are occasionally salted. They are sometimes sent in ice to Savannah and Charleston. "On the Gulf coast," writes Mr. Stearns, "they are very abundant, living and breeding in the bays and bayous. They spawn in winter or early spring, and the young of different sizes may be seen in May and June. The adult fish live in deep water, while the young remain near the shore. Many are caught by hook and line, and with the seine."

131. CERTAIN MINOR SPAROIDS.

The Margate-fish.

This species is known only in the Gulf of Mexico. Stearns writes that it is abundant off the Florida coast, and is found throughout the year in all the gulches, and commonly on the snapper banks in water from ten to thirty fathoms deep. About Pensacola, where it is called the "Porgy," it is seldom eaten, being regarded by the fishermen as a nuisance, for it steals their baits and interferes generally with their fishing. It is, however, used to some extent as bait for red snappers. At Key West it is brought to market in well-boats, and sells readily. The small ones are there called "Porgies" and the large ones "Margate-fish" and "Market-fish."

In West Florida Stearns states that he has often found spawn in them in April. At Cedar Keys, October 28, 1879, he obtained a specimen, seven inches in length, with a gill-net. The largest one he has seen measured fifteen or sixteen inches in length.

The Porgies of the Gulf.

A fish known as the "Sheepshead Porgy" is said by Stearns to be common about the Florida Reefs. It is caught with hook and line, and is sold in the markets of Key West. There are other species, known by the name "Porgy," which are found in this region, such as *Calamus bajonado*, common also at Charleston, where it is called the "White-boned Porgy," *C. megacephalus*, *C. arctifrons*, and *C. macrops*.

The Bermuda Chub—Cyphosus Boscii.

This fish, which is one of the most important of the food species of Bermuda, occurring also in the West Indies and east to Madeira, has but recently been found on our coast. Stearns has observed it in the Gulf of Mexico, where the fishermen call it the "Bream," and individuals have also been taken at Wood's Holl, Massachusetts. It is a most delicious food-fish, and it is hoped that the few which have been seen on our coasts are the precursors of large schools to follow.

Californian Sparoids.

California has two important species belonging to this family, concerning which Professor Jordan has communicated the following information:

"The 'Bluefish,' *Girella nigricans*, inappropriately so called, reaches a length of about fourteen inches, and a weight of three or four pounds. It ranges from Monterey southward, and is very abundant about the Santa Barbara Islands. The young of this species are common inhabitants

of the rock-pools. The 'Bluefish' is entirely herbivorous. It is a food-fish of good quality, but the flesh softens sooner after death than is usually the case with related fishes. It is very tenacious of life.

"The 'Half-moon,' more commonly known by its Spanish name, 'Medialuna,' *Scorpis californiensis*, reaches a length of more than a foot, and a weight of three or four pounds. It ranges from Point Concepcion southward, chiefly about the Santa Barbara Islands, where it is exceedingly abundant, and, in the winter, forms the greater part of the catch at San Pedro. It feeds chiefly upon crustaceans, but is, to some extent, herbivorous. It takes the hook readily, is an excellent food-fish, and, in the Los Angeles market, is second only to the barracuda in importance."

THE SNAPPER FAMILY—PRISTIPOMATIDÆ.

132. THE RED AND GRAY SNAPPERS.

The Red Snapper—Lutjanus blackfordii.

The Red Snapper, although it has been for many years a favorite food-fish of the Gulf of Mexico and Eastern Florida, has but recently become known in Northern markets. About 1874 individuals of this species were occasionally seen in New York and Washington, and shortly after they began to come into notice in the cities of the Mississippi Valley. It was not even described and named until 1877, when Messrs. Goode and Bean, having determined that it was distinct from the West Indian form, which it resembles, described it under the name *Lutjanus Blackfordii*, in honor of Mr. Eugene G. Blackford, of New York City, who has for many years been prominent in all matters relating to fish culture and the fish trade. By reason of its bright crimson color it is the most conspicuous fish ever seen in our markets.

Three years ago the geographical range of this species was supposed to be limited at the north by Savannah Bank, but during the summer of 1880 several specimens were taken along the coast of the Middle States; one, nine and a half pounds in weight, off Port Monmouth, New Jersey, October 5; another, about August 10, near Block Island. This northern extension of its range is quite unexpected, and the fact that even stragglers find their way into our northern waters suggests great possibilities for the future in the way of their artificial propagation and introduction along the coast of the Middle States. In the South it is found associated on the same grounds with the sea-bass, *Serranus atrarius*, which it resembles in habits and manner of feeding. The sea-bass is abundant as far north as Cape Cod, and it is hard to understand why the banks, which are favorite haunts of this fish, should not also be shared by the Red Snapper. In the Gulf of Mexico the Red Snapper is exceedingly abundant in suitable localities from Key West to the Rio Grande.

"About the Florida reefs and as far north as Temple Bay, where there are reefs and rocks, they live in holes and gullies where all kinds of marine animals and fish are most abundant, and sometimes, as I have noticed, off Charlotte Harbor numbers of them will congregate about a solitary ledge protruding over a level bottom of white sand. Throughout this southern district the fishing spots are small, but very numerous; and away from the reefs, where the bottom is chiefly sand, it is only necessary to find rocks or a rocky bottom to find Red Snappers. Since it is impracticable to make use of bearings by which to find the fishing grounds, the fishermen sail about, throwing the lead continually until it indicates the proper bottom. Along the coast from Temple Bay to Texas the bottom declines very gradually to the hundred-fathom curve, forming vast, almost level, plains of sand. In these barren wastes there are gullies of variable size, having rocky bottoms and teeming with animal and vegetable life. These gullies occur at a depth of from twelve to forty-five fathoms, the water in them being several fathoms deeper than the sur-

rounding bottom, and more rocky, and in the deepest parts richer in animal life. Red Snappers are exceedingly abundant in these places, which are the so-called 'snapper banks.' From Temple Bay to Cedar Keys the gullies are numerous in sixteen, eighteen, and twenty fathoms; from Cedar Keys to Saint Mark's, in fifteen and sixteen fathoms. Off Saint Mark's and Dog Island there are a few in five and ten fathoms. From Cape San Blas to the mouths of the Mississippi River occur the best fishing grounds in the Gulf, so far as is now known; gullies in ten and fifteen fathoms of water especially abundant from the cape, fifty miles to the west. West of the Mississippi, on the Texas coast, there are a few which are in twelve and fifteen fathoms. These grounds are found by the use of the sounding-lead, which shows every position by the sudden increase in the depth of the water. Red Snappers live in such places all the year, except, perhaps, in some of the five and ten fathom ones, which are nearly deserted in winter. Off Pensacola there seems to be quite a movement inshore in spring and offshore in fall. In South Florida they are usually associated with the groupers, which occur in the proportion of about three to one, while in West Florida the case is reversed; not more than one fish in ten of those caught is a grouper."[1]

Red Snappers are also known to be abundant on the Savannah Bank and on the Saint John's Bank, off Eastern Georgia and Florida.

The Red Snappers are strictly carnivorous, feeding upon small fish, crabs, and prawns. The temperature of the water in which they live probably rarely falls below 50°. They have no enemies except sharks and two or three enormous spiny-rayed fishes, such as the jew-fish or warsaw (*Guasa*). The only reliable observations upon their breeding habits have been made by Mr. Stearns, who states that they spawn in May and June in the bays and at sea. In June, July, and August they are found in some of the bays of the Northern Gulf, about wrecks and rock-piles, in considerable numbers, and none are taken but the larger adults and the young from one to eight inches long. The spawning season probably extends over a period of several months, Mr. Stearns having found well-developed ovaries in them from April to July. Nothing is known of their rate of growth. They attain the size of forty pounds. In East Florida, however, the average is much less. Mr. Stearns remarks that in the Gulf of Mexico they very seldom exceed thirty pounds' weight, though he has seen several of that size, while the average is eight or nine pounds, and in a large lot may usually be found individuals weighing from two and a half to twenty pounds.

Red Snappers from Florida are frequently quoted in the New York market returns. In 1879 about 12,000 pounds were there sold. They are also shipped to New York, Washington, and Baltimore in winter, the supply in these cities being derived chiefly from Pensacola. Mobile and New Orleans consume considerable quantities, and from these ports they are shipped up the Mississippi River to the principal cities along its line, where the fish is growing to be a staple of much importance. In Saint Louis it is already one of the most highly esteemed food-fishes. The price in New York in 1879 ranged from twenty to twenty-four cents per pound, but they are now less expensive.

The Pensacola Snapper.

The Red Snapper belongs to a genus which is found everywhere in tropical waters; fish resembling it occur everywhere throughout the West Indies. There is a kind of Red Snapper which is abundant on the Bahama Banks and in South Florida. This is *L. campechianus* Poey, perhaps also accompanied by *L. torridus* Cope. Two other brilliant red species occur with *L. Blackfordii* in the Gulf of Mexico—the Pensacola Snapper, *L. Stearnsii*, and the Mangrove Snapper, *Rhomboplites aurorubens*, the former of which might easily be mistaken for the *L. Blackfordii*,

[1] Silas Stearns, MS.

although its color is somewhat less vivid. Concerning this species, Mr. Stearns, whose name it bears, writes: "It is abundant on the Gulf coast, and lives in the bays all the year. In summer it is to be found about stone-heaps, wharves, and old wrecks, where it obtains crustaceous food in abundance. In winter it returns to the deeper places in search of food, and to escape from the cold surface water. During a cold snap in 1876 a great many of these fish were benumbed and floated at the surface, until the sun appeared and warmed them, when they revived and sought the bottom. They spawn in May and June. They are very cunning, and will not readily take the hook. Those commonly seen in the bays are quite small, averaging ten inches in length, while those taken with the Red Snappers at sea are from twenty to twenty-four inches long. It is an excellent food-fish, generally thought to be superior in flavor to the Red Snapper." This fish has as yet been found only on the Gulf coasts of the United States, where it is known as the "Mangrove Snapper." Since this name is used on the Atlantic coast for another species, and has been so used since the time of Catesby, it seems desirable to designate *Lutjanus Stearnsii* by another name, and "Pensacola Snapper" has been suggested.

The Mangrove Snapper—Rhomboplites aurorubens.

The "Mangrove Snapper" of Charleston, called at Pensacola the "Bastard Snapper," is a much more slender and elegantly formed fish than either of the Snappers already described. Its color is less vivid, being somewhat more russet, and is enlivened by the presence of narrow, oblique lines, with gold and yellow upon the sides. It is a swift-swimming fish, probably less given to feeding on the bottom, and more partial to a diet of living fish. It has been found at Jamaica, and as far north as Charleston, South Carolina.

"In the Pensacola region," writes Stearns, "it is a well-known, but not common, species." Single individuals are occasionally brought in from the sea with the Red Snappers and groupers. It is caught at all depths, from ten to thirty-five fathoms, and seldom exceeds eighteen inches in length. As a food-fish it is equal to the Red Snapper. The Bermuda Red Snapper, abundant and much esteemed in those islands, is a small but very brilliantly colored species, not yet described, which is to be called *Lutjanus autolycus*.

The Gray Snapper—Lutjanus caxis.

Another snapper, similar in form to these others, but not red in color, which is called the 'Gray Snapper' at South Florida, and the 'Black Snapper' at Pensacola, *L. caxis*, is abundant about the Bermudas, and has been found on the east coast of Florida, in tropical South America, in Western Africa, and about the Bermudas, where it attains the enormous size of sixty to eighty pounds, and is known as the 'Gray Snapper,' and also, on account of its sly, cunning habits, the 'Sea Lawyer.' Mr. Stearns writes: "It is most abundant in South Florida, living in deep channels, on rocky bottoms, about old wrecks, stone-heaps and wharves; it is considered the most cunning fish on the coast, and is extremely difficult to catch. The young may be seen about the wharves, and the breeding-ground is probably near by. Those usually observed are from ten to twelve inches in length, but I think I have seen specimens which would measure two feet."

133. THE GRUNTS OR PIG-FISHES.

In the inshore waters of the Southern Atlantic and Gulf States occur several species of small fish belonging to the genus *Diabasis*. They are closely related to the snappers, which they resemble in form, and have remote affinities with the perch, the bass, and the porgy and sheepshead. Their colors are usually striking, and they, without exception, are distinguished by the brilliant red color of the inside of the mouth and throat, from which they have sometimes been

called Red Mouths, or Flannel Mouths. From their habit of uttering a loud, rather melodious sound when taken from the water they have acquired the name of "Grunt" and "Pig-fish." In some localities they are also called "Squirrel-fish," in allusion to the same habit. They are, for the most part, bottom feeders, preying chiefly upon crustaceans and small fish. In fact, they are, in most respects, miniature counterparts of the red snapper. In many localities they are in high favor as a food-fish. They have not yet been very carefully studied, but so far as they are now understood the following species are known to occur in sufficient numbers to prove of commercial importance:

The Black Grunt—Diabasis Plumieri.

This species has a brownish body, lighter upon the sides, and has the sides of the head ornamented with numerous horizontal stripes of bright blue, while the posterior half of the lower lip is red. It occurs as far north as Charleston, and Dr. Yarrow claims to have seen it at Beaufort, North Carolina, though there is some question whether this species was not mistaken for another. Holbrook records that it has been observed on the Atlantic borders of South Carolina, Georgia, and Florida. I noticed several small individuals in the markets of Saint Augustine in March, 1877. Stearns mentions the Black Grunt as abundant at Key West among the reefs, and as frequently seen in the markets.

The Red-mouth Grunt—Diabasis aurolineatus.

The Red-mouth Grunt, *Diabasis aurolineatus*, is probably the Flannel-mouthed Porgy, familiar to Florida fishermen, and often taken on the Saint John's Bar. It has also been recently found to be common in Charleston in summer. This species was mentioned in Catesby's great work, published in 1743, under the name of "Margate-fish." When alive its color is bright silvery, but it soon becomes, when taken from the water, of a dull amber-brown, with a slight brazen tint along the back and sides, though the belly remains white. The upper jaw within is white; the palate is salmon-colored; the lower jaw and mouth below are also white in their interior third; the posterior two-thirds, both within and without, are red, and the mouth below; the tongue and fauces are of a similar color.[1] This fish occurs in Northern Brazil and throughout the West Indies, and specimens are recorded from Jamaica, Trinidad, and the Bahamas; it is found in the Bermudas and on our coast at least as far north as Charleston. Stearns writes: "It is quite common on the Gulf coast of Florida from Pensacola to Key West. It is caught with hook and line, and is eaten as a pan-fish. I took an extremely large specimen from the snapper ground between Cedar Keys and Saint Mark's in fifteen fathoms of water. It is not found in the vicinity of Pensacola." Holbrook writes: "The Red-mouthed Grunt is occasionally taken in our waters at all seasons of the year, but is never abundant, as seldom more than a dozen or two are met with in the market at one time. It is not highly esteemed for food, since its flesh lacks both firmness and flavor."

Uhler and Lugger say that it occurs occasionally in the lower part of the Chesapeake Bay, where it is not considered to possess great economical value. The occurrence of this species so far north needs confirmation.

The Pig-fish—Pomodasys fulvomaculatus.

A species belonging to a closely related genus is the Hog-fish, or Grunt, of the Chesapeake, called also "Pig-fish" or "Grunt" in the Gulf of Mexico, *Pomodasys fulvomaculatus*, and known in South Carolina as well as in Bermuda under the name of "Sailor's Choice." Its color is thus

[1] Description by Holbrook.

described by Holbrook: "Body above, pale brown; belly, silvery; sides marked with numerous orange-colored or yellow spots; those above the lateral line disposed in irregular oblique lines, those below it in horizontal rows. Dorsal, anal, and caudal fins with similar spots; sides of the head pale bluish with a silvery tint and marked with yellow spots; lower jaw, orange at the angle of the mouth; internal surface of the gill membrane, bright orange."[1]

Mr. S. C. Clarke has communicated a full account of a species which is either identical or closely related to this. "The common Pig-fish or Grunt of the Indian River region: This fish, answering the same description, occurs at the mouth of Saint Johns River, and is probably the same." Mr. Clarke states that in the Indian River region they spawn in April in deep salt-water rivers, the spawn being very small and of a brown color. The young fish are not abundant, nor are the adults very numerous, though the number has increased of late years. In 1872 and 1873, three or four might be taken in a day, while in 1874 twenty or thirty were taken by one line on a tide. The largest weight is one and a half pounds; the average fish weighs three-quarters of a pound. The Pig-fish come from the sea into the salt-water rivers in December. Their appearance is regular, though they vary in abundance from year to year. They swim low, and prefer to live in deep water with shell bottom. They go out to sea soon after spawning in April; they feed upon small fish, crab, and shrimp. They are captured by hook, with mullet, clam, and shrimp bait; never with nets. They are much prized for food; the best of table fish, rich and delicate.

This species was first described by Mitchill from a specimen taken in the bay of New York. The National Museum has many specimens from various parts of the Southern coast and the Gulf of Mexico. "In New York," wrote DeKay in 1842, "this is a rare fish, but occasionally appearing, as I am informed, in our harbor in considerable numbers. It is a very savory food." Professor Baird did not find it on the coast of New Jersey in 1854. Uhler and Lugger state that it occurs in the salt water of the lower part of the Chesapeake Bay, and is much esteemed for food.

A correspondent, at Hunger's Wharf, Virginia, writes: "In my estimation it is the finest fish that swims. It grows to the size of about one pound, and is now rather scarce. When I was a boy, about forty years ago, they were very plentiful, and I have known three hundred pounds caught at one haul of the seine. They have since gradually become scarcer, and a few years ago we rarely caught one during the season. In 1879 and 1880 they are coming in plenty, especially in 1880, and I believe that in a few years we will have them in plenty again. They come about the 1st of July and remain until November."

At Beaufort, North Carolina, where it is also called "Hog-fish," according to Jordan, it is extremely common everywhere in the harbor. Holbrook wrote about 1860: "The 'Sailor's Choice' makes its appearance in our waters about the month of April and continues with us until November, when the largest are taken. I have found in the stomach of this animal only the remains of smaller fish, and yet it takes the hook readily when baited with shrimps and clams. It is found along the coast from Georgia to Virginia, where it is called "Hog-fish," and is held in great estimation by epicures."

"In the Gulf coast," writes Stearns, "it is common everywhere and throughout the year. It lives in shallow water among the grass, feeding upon small and crustaceous animals. It spawns in April and May and is a choice food-fish. The average length is about ten inches." Stearns also refers to three species known respectively as the "White," "Yellow," and "Black" Grunt, which are found at Key West and upon the neighboring reefs in great abundance. He states that

[1] The colors of the fishes of this group are thus minutely described in order to aid observers in discriminating between the different kinds of these fish which so closely resemble each other. In most cases this has been thought unnecessary, since the plates and the reference to Jordan's "Synopsis" are thought to be sufficient.

"they are taken with hook and line and are brought daily into the market. Before the poisoned water visited that neighborhood the Grunt was the most important as well as the favorite food-fish in the market, but since then they have been scarce, and other fish, to a great extent, have taken their place."

CALIFORNIAN GRUNTS.

On the California coast occur two species of this family; one, known to the fishermen by the name "Sargo," *Pristipoma Davidsoni*, is found from San Pedro southward to Cerros Island, chiefly about the islands, and is nowhere common. It feeds on crustaceans and is a good pan-fish, but is too scarce to have much economic value. It reaches a length of about fifteen inches. Still another, *Xenistius californiensis Steindachner, occurs from San Diego to Cape San Lucas. It is too scarce* to be of any importance for food.

THE BLACK BASS FAMILY CENTRARCHIDÆ.

134. THE BIG-MOUTH BLACK BASS—MICROPTERUS SALMOIDES, AND THE SMALL-MOUTH BLACK BASS—M. DOLOMIEI.

Professor Gill's paper, in which he defines the differences between the two species of Black Bass, was published in 1873 in the "Proceedings of the American Association for the Advancement of Science"; but since this volume is not easily accessible, the most important differences are mentioned here. In the Large-mouth the upper jaw extends far behind the eyes, in the other to a point below it. The Large-mouth has from sixty-five to seventy rows between the gill-opening and the base of the tail, instead of seventy-two or more, while on the cheek there are about ten oblique rows instead of seventeen. There are other distinctions, such as the absence in the Large-mouth of scales on the bases of the dorsal and anal fins, the smaller number of rays in the pectoral fins (there being thirteen or fourteen instead of sixteen or seventeen), and the lesser height of the spinous dorsal.[1]

Numerous as have been the zoological names, they are outnumbered by the popular names still in use in different localities. Charlevoix, a Jesuit missionary who explored Canada in 1721, mentions a fish called "Achigan," which is thought to have been the Large-mouth. An earlier allusion to this species, which in the Southern States is still called "Trout," occurs in the writings of René de Laudonnière, who describes the incidents of the first Huguenot expedition to Florida in 1652, under the command of Jean Ribault. The Large-mouth is known in the Great Lake region, especially in Northern New York, as the "Oswego Bass." This name should not be confounded with "Otsego Bass," a local name for the common whitefish. In Kentucky it is called "Jumper"; in Indiana, "Moss Bass"; in the Southern States, generally, "Trout," though on the Tar River of North Carolina it is called "Chub," and on the Neuse "Welshman."

The Small-mouth shares with the Large mouth in the Southern States the names "Jumper," "Perch," and "Trout," and in Alabama, according to Professor Jordan, it is called the "Mountain Trout."

Both species are very widely distributed over the Atlantic slope of the continent east of the Rocky Mountains, and their range is probably much wider than is now supposed, for many of our northern and western waters are unexplored. The Large-mouth and the Small-mouth dwell together in the Great Lakes, and in the upper parts of the Saint Lawrence and Mississippi basins. The Small-mouth is found north to latitude 47° and west to Wisconsin, while southward it ranges to latitude 33°, where Professor Jordan found it in the headwaters of the Chattahoochee and Ocmulgee Rivers, the latter being the only instance of its presence in a stream emptying east of the Alleghanies into which it is not known to have been introduced by man. The Large-mouth ranges farther to the west and north, occurring in the Red River of the North, perhaps as far as Manitoba, in latitude 50°. It abounds in all the rivers of the Southern States, from the James to the Saint John, and in the lower reaches of the streams and bayous connected with the Gulf of Mexico, around to Texas, in latitude 27°.

[1] For fuller information upon this and every other point connected with the species now under discussion the reader is referred to Dr. J. A. Henshall's elaborate and exhaustive illustrated treatise, entitled "Book of the Black Bass," published in 1881 by Robert Clarke & Co., of Cincinnati.

To the waters of New England and the eastern part of the Middle States they are not native. The Small-mouths found their way into the Hudson in 1825 or soon after, through the newly-opened Erie Canal, and they have since been introduced by man into hundreds of eastern lakes and rivers. Many circumstances suggest the idea that in early days, before the various drainage systems were connected by canals, the distribution limits of the two species were much more sharply defined, the Large-mouth inhabiting, perhaps, the upper part of the basin of the Great Lakes and Saint Lawrence and the rivers of the southern seaboard, while the Small-mouth was found chiefly in the northern part of the Mississippi basin. This theory can never be demonstrated, however, for the early ichthyologists had not adopted the accurate methods of study now in use, and their descriptions of the fish they saw are scarcely good enough to guess by. The mingling of the two forms might have been accomplished in an incredibly short time. A few young Bass will multiply so rapidly as to stock a large lake in five years. The Potomac and its tributaries swarmed with them ten years after their first introduction.

Gill states that the two forms of Micropterus were represented in waters of the cismontane slope of the United States, except those of the New England States and the Atlantic seaboard of the Middle States. But one, the Small-mouth, appears to have been an original inhabitant of the hydrographic basin of the Ohio River.

The Bass do not seem to depend closely on temperature. Having no opportunity of avoiding the cold, they sink to the deepest part of their watery domain at the approach of winter, and if the chill penetrates to their retreats their vitality is diminished, their blood flows more slowly, they feel no need of food, and forthwith enter into a state of hybernation. Mr. Fred. Mather kept one in his aquarium nearly all of one winter. It ate nothing, and seldom moved any member except its eyes. In deep lakes, however, they can sink below the reach of surface chills, and here they are sometimes caught with a hook through the ice. In the South their activity never ceases. Any one who has seen Black Bass feeding must have been impressed with their immense power of movement. They soon become masters of the waters in which they are placed. Sunfish, perch, trout, young salmon, and even the ravenous pickerel, are devoured. They feed at the surface on moths, flies, and frogs; they turn over stones in search of crawfish and insect larvæ. Rats and snakes have been seen in their stomachs. A correspondent of "Forest and Stream" relates that once, while fishing in the Chicago River, one of the small frogs used for bait escaped and perched on a portion of an old wreck above the water. A Black Bass came along, and, lifting his head from the water, picked off the frog, and descended to the depths below. The angler finds them at the proper seasons equally eager for fly-hook, trolling-spoon, or still-bait, and always ready for a struggle which puts his rod and line to a severe test. Their leaps are almost as powerful as those of the salmon. The negro fishermen of Florida often surround a body of Large-mouths with a seine, but as the lines are hauled in and the arc grows smaller the dark forms of the "Trout" begin to appear, springing over the cork-line and returning, with a splash and a jet of spray, to liberty. I have seen them rise five or six feet above the water. They are said to be taken best at night, or when the river is high and the water muddy. Otherwise they leap over the seine. Expert seiners coil their nets in such a manner as to prevent the escape of part of the school. The Small-mouths are said, generally, to prefer deep or swift, cool waters, while the Large-mouths live in muddy, black pools, or in the shelter of old stumps and ledges. In Florida they lurk among the lily-pads and aquatic plants in shallow, dark streams, where they feed on a grub called the "bonnet-worm," which burrows in the flower-buds of the "bonnets" or yellow water-lilies (*Nuphar advena*).

The spawning season occurs on the approach of warm weather. Its date does not vary much with latitude. In Florida, in Virginia, and in Wisconsin they build their nests in May and June.

The oldest fish, we are told, sometimes anticipate the ordinary season, while many late spawners are occupied with family cares until the last of July, and some young fish are not ready until October and November.[1] After the spawning is over the Bass are "in season." They take the hook eagerly from July till November. In the winter they are lank and black, though in season till the ice comes.

Concerning their spawning habits, Mr. Hallock, of the Blooming Grove Association, wrote in 1875: "Four years ago one hundred and thirteen Black Bass from Lake Erie were placed in Lake Giles, and their progeny has increased so fast as to insure good sport to the angler at any time. The late spawners are now (early July) in their gravel beds, in the shallow waters along shore, protecting either their spawn or their newly-hatched fry, as the case may be. It is interesting to note the pertinacity with which they guard their precious charges, and the vigor with which they drive away depredators and intruders of all kinds. They will frequently allow a boat to pass over them, scarcely six inches above their backs, and obstinately keep their ground. Sunfish and such are impelled to keep their distance. There are hundreds of these bowl-shaped excavations, eighteen inches or so in diameter, all along the sandy shallow shores of this lake, which is very clear, and in the center some seventy feet deep, fed by bottom springs."[2]

The eggs are much smaller than those of a trout, and, being heavier than the water, rest on the bottom within the limits of the nest. The only estimate of their number with which I am familiar is that made by Mr. E. L. Sturtevant, who found about seventeen thousand in a Large-mouth weighing two and one-half pounds. The rate of growth is easily determined by experience in artificial ponds. In Granby, Connecticut, four-pound fish were taken in 1874, the progeny of two hundred and fifty fish placed in the pond in 1868. The eggs require two or three weeks to hatch. The parents watch them. In September the young are about two inches long; when well fed they grow to four inches the first season. At two years of age they weigh about a pound, few caught in the North weighing more than four pounds. Leaving the egg in June, they grow to two or three inches before cold weather begins—trim, sprightly little darters, with black bands across the bases of their tails. Another twelvemonth finds them in the garb of maturity, eight or nine inches long, and with their organs swelling in preparation for the act of spawning, which they are said to undertake at the age of two years, and when less than a foot long. The ordinary size of the adult fish is two and one-half to three pounds, though they are sometimes taken in the North weighing six or seven pounds. In Florida the Large-mouths grow larger. A seven or eight pounder is not unusual in the Saint John's; and I was told that in March, 1875, a fish weighing nineteen and one-half pounds was caught in the lake at Gainesville, Florida.

Fish-culturists have made many efforts to hatch the eggs of the Black Bass, and have never succeeded. One reason for their failure, perhaps, lies in the fact that while in the shad and salmon the eggs fall from the ovaries into an abdominal cavity, whence they are easily expressed, in the Bass and other spiny-rayed fishes they are retained until the parent fish are ready to deposit them. This failure is the less to be regretted since the young Bass may easily be transported from place to place in barrels of cool water, and, when once introduced, they soon multiply, if protected, to any desired number.

Black Bass are very tenacious of life. The "Germantown Telegraph" mentions some taken at

[1] Mr. Small records the capture of Black Bass containing milt and spawn in November, in the Potomac (Forest and Stream, iii, p. 212). "Sculls," in the same paper, October 30, states that there are in the Schuylkill Bass with unripe spawn; others in July. "R. M. T." speaks of having seen a Bass of half a pound guarding a nest July 10, in the Housatonic (Forest and Stream, iii, p. 292).

[2] Forest and Stream, iv, 357.

10 o'clock a. m., sold and wrapped in paper, left in a warm room till 5 p. m., when they were found to be alive and well.[1]

The first experiment in their transportation seems to have been that mentioned by A. M. Valentine, who states that a pond near Janesville, Wisconsin, was stocked with Black Bass about 1847.[2] In 1850, Mr. S. T. Tisdale carried twenty-seven Large-mouths from Saratoga Lake, New York, to Flax Pond, in Agawam, Massachusetts. The manner in which the Potomac was stocked with Small-mouths is also well known. It was in 1853, soon after the Baltimore and Ohio Railroad was finished, that General W. W. Shriver, of Wheeling, carried a number of young fish from the Ohio to Cumberland, Maryland, in the water-tank of a locomotive engine. These he placed in the basin of the Chesapeake and Ohio Canal, whence they soon penetrated to all parts of the Potomac Basin, and as far down the river as Mount Vernon.[3] The custom of stocking streams soon became popular, and through private enterprise and the labors of State fish commissioners nearly every available body of water in New England and the Middle States has been filled with these fish. This movement has not met with universal approval, for by the ill-advised enthusiasm of some of its advocates a number of trout streams have been destroyed, and complaints are heard that the fisheries of certain rivers have been injured by them. The results have been on the whole very beneficial. The Bass never will become the food of the millions. The New York market receives probably less than ten thousand pounds of them annually, and they are nowhere very numerous. Yet hundreds of bodies of waste water are now stocked with them in sufficient numbers to afford pleasant sport and considerable quantities of excellent food.

135. THE SUN-FISHES AND THEIR ALLIES.

By DAVID S. JORDAN.

THE ROCK BASS—AMBLOPLITES RUPESTRIS Gill.

This species is known by the names of "Rock Bass," "Goggle-eye," and "Red-eye." All these names are in general use; the first most common in the Lake region, the last farther south. It is everywhere abundant in lakes, ponds, and larger streams throughout the Great Lake region and the Mississippi Valley. It prefers clear waters, and is not often found in muddy bayous. It is a hardy and gamy fish, and takes the hook readily. It is a good pan-fish, but not large, its weight seldom exceeding one and a half pounds. Like other "Sun-fishes," it spawns in early summer.

[1] Forest and Stream, i, p. 410.

[2] Forest and Stream, ii, p. 341.

[3] THE BLACK BASS OF THE POTOMAC.—The Cumberland Daily News claims for Mr. W. W. Shriver, of Wheeling, West Virginia, the credit of originating and executing the plan of transferring the Black Bass, now so abundant in our waters, from the Ohio to the Potomac. The Daily News is no doubt correct. The performance was one to be proud of, and proper credit should be given to the right man. It has been well said that he is a public benefactor who "makes two blades of grass grow where only one grew before." How much more is he a public benefactor who fills a river with food-fishes where there were none before. A letter from Mr. Shriver, written in 1860, is republished in support of the claim for him in this matter, in which he says:

"The enterprise or experiment was contemplated by me long before the completion of the Baltimore and Ohio Railroad to the Ohio River at Wheeling, but no satisfactory mode of transportation presented itself until the completion of that great work (in, I believe, the year 1853), and in the following year I made my first trip, although I made several afterwards in the same year, carrying with me my first lot of fish, in a large tin bucket, perforated, and which I had made to fit the opening in the water tank attached to the locomotive, which was supplied with fresh water at the regular water stations along the line of the road, and thereby succeeded well in keeping the fish (which were young and small, having been selected for the purpose) alive, fresh, and sound."

Mr. Shriver made several other similar excursions, and on each occasion put the young fish into the basin of the Chesapeake and Ohio Canal, at Cumberland, Maryland, where they had free egress and ingress into the Potomac River and its tributaries. The stock originally transferred, some seventeen years ago, has increased prodigiously, and to-day they abound in the Potomac and all its tributaries. They are of good size, frequently being caught to weigh as much as from three to four and a half or five pounds.—*Baltimore Sun*, April 28, 1871.

Rock Bass spawn about the same time as Black Bass. They keep much about sunken logs, roots, etc.

The Mud Bass—Acantharchus pomotis.

This species is found only in the coastwise streams of the lowlands from New Jersey to North Carolina. Its habits are similar to those of the Warmouth, but it is smaller in size, and has little value as a food-fish.

The Sacramento Perch—Archoplites interruptus.

This species is known only by the name of "Perch," a name applied in the San Francisco markets to many very different fishes. It has been thus far found only in the Sacramento and San Joaquin Rivers and tributaries. It is abundant in the lower parts of these rivers, large numbers being shipped to the market in San Francisco. It is there bought and consumed mainly by the Chinese, who value it highly, paying for it more than for any other fish which they consume. Although it is an excellent pan-fish, very similar to the Black Bass, we have never seen any of them bought by Americans. It reaches a weight of little more than one pound. Nothing distinctive is known of its habits.

The Warmouth—Chænobryttus gulosus.

This species is known throughout the South by the name of "Warmouth." The names "Perch," "Sun-fish," "Goggle-eye," and "Red-eye" it shares with others of its relatives. It is found in all the lowland streams from Virginia to Texas, in all the Southern States, and is generally abundant. In habits, food, size, and value it agrees closely with the Rock Bass.

The Black Warmouth—Chænobryttus antistius.

This species, known as "Warmouth," "Big-mouth," "Sun-fish," "Goggle-eye," etc., abounds in the tributaries of the Upper Mississippi, and is often taken in Lake Michigan. In Illinois it is an important food-fish. In size, habits, and value it is sufficiently similar to the Rock Bass.

Common Sun-fish—Lepomis gibbosus.

This is the common "Sun-fish," "Pumpkin-seed," or "Sunny" of the brooks of New York and New England. It is everywhere abundant in the Great Lake region and in the coastwise streams from Maine to Georgia. It is never found in the Mississippi Valley except in its northernmost part, its distribution being precisely like that of the Perch. It reaches, in the Lakes, a weight of about one and a half pounds, and as usually taken is of not over a pound weight. Its flesh is of good quality, similar to that of other Sun-fish of the same size, and is graded as superior to that of the Perch, but inferior to the Black Bass and White Bass. It takes the hook freely, and to the small boy is the perfection of a game-fish. Its breeding habits are thus described by Dr. Kirtland:

"This fish prefers still and clear waters. In the spring of the year the female prepares herself a circular nest by removing all reeds or other dead aquatic plants from a chosen spot of a foot or more in diameter, so as to leave bare the clean gravel or sand; this she excavates to the depth of three or four inches and then deposits her spawn, which she watches with the greatest vigilance; and it is curious to see how carefully she guards this nest against all intruders; in every fish, even those of her own species, she sees only an enemy, and is restless and uneasy until she has driven it away from her nursery. We often find groups of these nests placed near each other along the margin of the pond or river that the fish inhabits, but always in very shallow water; hence they are liable to be left dry in times of great drought. These curious nests are most frequently encir-

cled by aquatic plants, forming a curtain around them, but a large space is invariably left open *for the admission of light.*"[1]

So far as known, the breeding habits of the other species of Sun-fishes agree with those of *Lepomis gibbosus.*

The Long-eared Sun-fish—Lepomis auritus.

This species, like its relatives, receives the general name of "Sun-fish," "Brim" (*Bream*), and "Pearch" (*Perch*). It is found in all the coastwise streams from Maine to Louisiana, but does not penetrate far into the interior. It seldom reaches a weight of much over a pound, but from its abundance becomes in the rivers of the South a food-fish of some importance. Like the others, it feeds on worms, crustacea, and small fishes, and spawns in early summer.

The Blue Sun-fish—Lepomis pallidus.

This fish is known as the "Blue Bream," "Blue Sun-fish," "Copper-nosed Bream," etc., and in Kentucky sometimes as the "*Dollardee.*" *This is the most widely distributed of our Sun-fish,* ranging from New Jersey and the Great Lakes to Florida and Mexico. It reaches a weight of one and one-half to two pounds, and forms an important market fish in some places. Its habits adapt it especially for cultivation in ponds.

Lepomis cyanellus Raf., L. megalotis Raf., L. miniatus Jordan, L. punctatus (Cuv. & Val.) Jor., L. notatus (Ag.) Cope, and L. Holbrookii (C. & V.) McKay.

The small Sun-fishes, and several others of similar size, abound in the fresh waters of the Mississippi Valley, and are known as "Sun-fish," "Bream," and "Perch." *L. cyanellus* and *L. megalotis* are universally abundant both North and South; the others are chiefly Southern. All take the hook readily and are good pan-fish, but from their small size they have no economic importance, and are valued chiefly by urchins and negroes.

Centrarchus macropterus Jor.

We have never heard for this species any name more distinctive than "Sun-fish" or "Perch." It is found throughout the lowland streams of the South, from North Carolina to Florida, Southern Illinois, and Texas, preferring generally rather deep, clear waters. It is rarely seen in upland streams. It is a fish of good quality, but small, rarely weighing more than half a pound. Little distinctive is known of its habits.

The Calico Bass—Pomoxys sparoides.

This species is known by a variety of names, some of the principal of which are the following: In Lake Erie, and in Ohio generally, it is the "Strawberry Bass," or "Grass Bass." The names "Bitter Head" and "Lamplighter" are also ascribed to it by Mr. Klippart, and "Bank Lick Bass" by Dr. Kirtland. In Lake Michigan, the name "Bar-fish" is in general use, giving place in Illinois to the name "Calico Bass." The latter is the most appropriate of these designations, having allusion to the variegated coloration. In the South, like *Ambloplites rupestris*, it becomes a "Goggle-eye" or "Goggle-eyed Perch." The Calico Bass is found in abundance in all the lakes and ponds of the Great Lake region and the Upper Mississippi. It is also diffused throughout the Mississippi Valley, and appears in the streams of the Carolinas and Georgia east of the mountains. Its preference is for quiet, clear waters, with a bottom covered with grass; and in the muddy sloughs and bayous, where the Crappie is abundant, it is rarely seen. *It is an excellent pan-fish,* reaching

sometimes a weight of two pounds, although not usually weighing more than one pound. It is, like its relatives, gamy, but it is not so voracious as most of them. The following notes on its habits and value are from the pen of Professor Kirtland:

"The 'Grass Bass' has not hitherto been deemed worthy of consideration by fish-culturists; yet, from a long and intimate acquaintance with its merits, I hesitate not to pronounce it *the fish for the million.* It is a native of our Western rivers and lakes, where it usually resorts to deep and sluggish waters; yet in several instances, where it has found its way into cold and rapid streams, and even small-sized brooks, by means of the constructing of canals or by the hand of man, it has adapted itself to the change, and in two or three years stocked to overflowing these new locations. As a pan-fish, for the table, it is surpassed by few other fresh-water species. For endurance and rapidity of increase it is unequaled. . . . The Grass Bass is perfectly adapted to stocking ponds. It will thrive without care in very small ponds of sufficient depth. . . . It will in nowise interfere with the cultivation of any number of species, large or small, in the same waters. It will live harmoniously with all others, and while its structure and disposition restrain it from attacking any other but very small fry, its formidable armature of spinous rays in the dorsal and abdominal fins will guard it against attacks of even the voracious pike."[1]

The Crappie—Pomoxys annularis.

This species is commonly called "Crappie" in the valley of the Mississippi. Other names are "Bachelor" in the Ohio Valley, "New Light" and "Campbellite" in Kentucky and Indiana, "Sac-à-lait" and "Chinquapin Perch" in the Lower Mississippi. It is also often confounded with the preceding species, and some of the names of the two are interchangeable. This species is not often seen in the Great Lake region, but throughout the Lower Mississippi and its tributaries it is very abundant. Its young swarm in all the muddy bayous along the rivers, and great numbers of them are destroyed in the fall when these bodies of water dry up. With the exception of its predilection for muddy waters, we know little in its habits distinctive from those of the Calico Bass, and like the latter it is said to be an excellent fish for ponds. Both take the hook, feed *upon small fishes, crustaceans, etc., and both spawn in spring.*

136. THE SEA BASS—SERRANUS ATRARIUS.

The members of the Sea Bass family *Serranidæ,* are similar in form and habits to the Perches, from which they are distinguished by certain anatomical characters, scarcely tangible to persons not experts in ichthyology. The family contains a very large number of species, some of which are to be found in every part of the tropical and temperate seas. On our Atlantic coast there are some twenty species, while in California there are four at least which are of economic importance. Certain European members of this family are hermaphrodite, but there is as yet no evidence that any American species is thus peculiar.

The Sea Bass, *Serranus atrarius,* known south of Cape Hatteras as the "Blackfish," is the most important species on our coast. In the Middle States the Sea Bass is called "Black Will," "Black Harry," and "Hannahills"; about Newport and New Bedford, "Bluefish," and at New Bedford also "Rock Bass." Curiously enough, the Southern name, "Blackfish," is also in use at Oak Bluff, Martha's Vineyard, and, it is said, also in New Jersey. In Gill's "Catalogue of the Fishes of the East Coast" it is stated that the name "Black Bass" is also used for the fish, but this usage has not yet fallen under my observation.

Storer, in his "Fishes of Massachusetts," makes the statement that it is known as the "Black

[1] American Sportsman, February 28, 1874, quoted by Klippart, Report Ohio Fish Comm. for 1875–'76, p. 78.

Bass" and "Black Fish." If this was true at the time of Storer's writing, the usage has since then undergone a very considerable change. The species should be carefully distinguished from the Black-fish of Long Island Sound, which is the tautog, a member of a very different family.

It is claimed by some writers that the Black-fish of the South is distinct from the Sea Bass of the North. This seems improbable, but is worthy of investigation. The chief advocate of this idea was Holbrook, in whose "Ichthyology of South Carolina" may be found a statement of the supposed differences.[1]

The geographical range of the Sea Bass, as at present understood, is as follows: It is at home in all the waters between the Vineyard Sound and the eastern part of the Gulf of Mexico. Stearns writes that it is rather abundant at a few places on the Gulf coast of Florida, where there are rocks and rocky bottoms. In Pensacola Bay they are seen round the piles of stone ballast that lie in shoal water, and also at sea on the fishing grounds near the entrance. They occur in some places in Saint Andrew's, Saint Joseph's, and Apalachicola Bay. South of these places there is more or less rocky bottom, showing either in reefs or in channel-beds, on which Sea Bass are found in abundance. In the vicinity of Saint Mark's, Cedar Keys, and Saint Martin's Reef are some of the best localities. "It is rarely or never," says Jordan, "seen on the sandy coast of Texas." This species has already been recently discovered north of Cape Cod. Previous to 1878 there were on record only four instances of its occurrence east of Monomoy, but in the summer of 1878 several were taken in the Milk Island weir, off Gloucester. There is reason to believe that fifty years ago the Sea Bass was much less abundant in Southern New England than it is now. In Linsley's catalogue of the fishes of Connecticut, published in 1842, the species is described as a great novelty. It is curious, however, that some time between 1830 and 1840 there were, according to Storer, fifty or sixty vessels fishing for Sea Bass in the Vineyard Sound.

In 1787, if Schoepf is to be believed, they were rarely seen in the New York market. A diligent search through the works of the early writers on the fisheries of New England fails to bring to light any allusion to them. It would be interesting to know whether there has actually been an increase in their abundance, or whether this increase has been, as it seems to have been in the case of the Spanish mackerel, due to the introduction of new modes of fishing or the discovery of new fishing grounds. Sea Bass live among the rocky ledges and "spots of ground" which abound along the entire outer coast from Cape Cod to Cape Florida, and in the North it is also found in the large bays and sounds, like Long Island Sound. In the North the best bass grounds are in seven to twelve fathoms of water; off Charleston they are at a depth of twenty to forty fathoms, though throughout this whole region the fish are found also close to shore, and at all intermediate depths where suitable feeding grounds occur. In the Gulf of Mexico, on the other hand, they are found, for the most part, in shoal water; indeed all along the Southern coast the young fish are found close in to the shore, and I have seen a great many taken with hook and line from the sea-wall at Saint Augustine. The temperature of the water affected by this species and by the red snapper corresponds very closely, and in most instances is probably not less than 50°, though in the case of the banks of Connecticut and New York it may be slightly lower.

The Sea Bass is a bottom-feeding and a bottom-loving fish, and rarely comes to the surface.[2] Whether or not those occurring in northern waters migrate southward in winter, or merely go into deeper water, is not yet ascertained. According to Captain Edwards and Captain Spindle, they

[1] HOLBROOK: Ichthyology of South Carolina, page 49.

[2] An exception to this has been recorded by Mr. Charles Hallock, who writes: "Although the Sea Bass is a bottom fish, yet once on an outward-bound voyage to the southward of the Gulf Stream we made fast to a ship's lower mast, found drifting on the surface, which was covered with clams and barnacles and surrounded with Sea Bass. We caught all that we wanted and cut loose. They weighed from five to twelve pounds each, and were all male fish."

make their appearance in the Vineyard Sound from the 1st to the 20th of May up to the 10th of June. Captain Spindle states that no stragglers are ever seen in April. Captain Edwards declares, on the other hand, that they are found in that region in the winter. A careful study of their habits would form an important contribution to zoology.

Bass are somewhat sluggish in their habits The temperature of the body is low, being very nearly that of the surrounding water and the digestion is slow. Although very voracious at times, they seem very much less fat than bluefish of the same size, and their growth is less rapid. They seldom leave the bottom, and there is as yet no evidence that cold weather drives them far from their summer haunts. They retreat, in all probability, into water of greater depth, where they pass the winter in a somewhat torpid state. Like the tautog, they appear to have a habit of lying under loose stones and in cavities among the rocks. I have observed this habit in the tanks of the New York Aquarium. The food of this species, as of its associates upon the same grounds, consists of crabs, shrimps, squids, and small fish. It is stated that the intestines of mackerel and the stomach of menhaden are considered the best bait about Wood's Holl, Massachusetts, while farther south shrimps and pieces of the flesh of fishes, such as small sharks, are frequently used. They are voracious feeders and easily taken on the hook, and their mouths are tough and leathery, so that when once taken they are not easily lost.

Scott states that their feeding time is during the lull of the waters between the turn of the tides, when they are easily taken by the angler. In the North the Sea Bass occupies its feeding grounds in company with the scuppaug or porgy, the flounder, and the tautog, while in the South its associates are the red snapper and the various species of grunt, and on the inshore grounds, among the rocks, it occurs in company with the sheepshead and the king-fish.

The breeding-time is believed to occur in July and August. Mr. Dyer, of Naushon, states that the Sea Bass, when they come into the pounds in the spring, are full of spawn, ready to shoot. Young fish, one or two inches long, are abundant among the eel-grass along the shores of Southern New England. "In the Gulf of Mexico," according to Stearns, "they spawn in early summer, and the young are caught in July and August."

The average size of the fish in New England is about one and one-half pounds. A Sea Bass nine inches long weighs about five ounces; ten inches long, seven to ten ounces; eleven inches long, nine to twelve ounces; twelve inches long, ten to sixteen ounces; while the length of a three-pound fish varies from eighteen to twenty inches. They occasionally attain the weight of four or five pounds, but this is unusual. In the South they are, as a rule, much smaller than in the North. This is especially the case in the Gulf of Mexico. In these waters, and along the southern part of the South Atlantic coast, they rarely exceed a pound in weight. Large male fish are remarkable on account of the presence of a large hump upon the top of the head. This is particularly prominent during the breeding season, and at this time the colors of the whole body are much brighter. The colored plate of this species, drawn by Mr. Kilburn for Scribner's "Game Fishes of the United States," represents a large male at the breeding season, the only picture of this kind that has ever yet been made.

The Sea Bass is of interest to fish-culturists as being the first marine fish upon which the experiment of artificial propagation was tried in this country. This was in June, 1874, when Mr. Mather fertilized a number of eggs at the station of the United States Fish Commission, at Noank, Connecticut. These eggs were placed in shad boxes and were watched for several days as they passed through the early stages of segmentation. A storm interfered with the completion of the experiment.

The Sea Bass is considered one of our most available food-fishes, being especially excellent

for use in chowders; in this respect a rival of the haddock, its flesh being very sweet, flaky, and firm. By reason of the hardness of its flesh it is especially adapted to packing and shipment in ice, and in summer is probably one of the most desirable fishes to be obtained in the city markets. The principal commercial fisheries are located in the Vineyard and Fisher's Island Sound and the vicinity, carried on by Noank and New London smacks off the mouth of the Delaware Bay, and off Charleston, South Carolina. As has already been stated, its distribution is very wide all along the coast, and it is probable that its importance as a food-fish will increase in years to come.

There is a small species (*Serranus trifurcus*) resembling the Sea Bass which has been found only in the vicinity of Charleston, South Carolina, and Pensacola, Florida, where it is called the "Rock Black-fish"; it occasionally finds its way to the Charleston markets.

The Squirrel-fish—Serranus fascicularis.

The Squirrel-fish is usually to be seen in the markets of Charleston, north of which it has never been discovered. The following paragraph from Holbrook's "Ichthyology of South Carolina" contains all that has been observed regarding its habits:

"Little can be said of the habits of this fish. It however appears in our waters in May and June and remains until November. It is occasionally taken with the hook on the black-fish grounds, but is never abundant. Southward it ranges at least to Brazil."

137. THE GROUPERS.

The Red Grouper—Epinephelus morio.

Next in importance to the Sea Bass are the various species of Grouper, members of the genus *Epinephelus*. The "Red Grouper," as it is called in Florida, and in New York markets *Epinephelus morio*, is a large species, sometimes attaining the weight of forty or fifty pounds. There is no certain record of its having been captured north of Florida, where it is called the "Brown Snapper," or "Red-bellied Snapper." DeKay, writing in 1842, stated that it was not unusual in the New York market in June and July, where it was called by the fishermen 'Groper,' or 'Red Groper'; that it is a Southern species and is brought from the reefs of Florida, but that he had been informed by Indian fishermen that it is occasionally, but very rarely, taken off the coast of New York; he added that Dr. Holbrook informed him that it was brought into the Charleston markets from Florida in the months of January, February, and March.

Holbrook wrote: "The Grouper is so seldom seen on our coast that nothing can at this time be said of its habits; but in confinement, as it is brought to us from Key West, it appears very voracious and bold, taking food even from the hand when offered, and always injuring such other species of fish as may be its fellow-captives."

It is very abundant in the Gulf of Mexico and about the Florida Keys, and is said also to be abundant *along the whole coast of East Florida, and is often taken on the Saint John's bar.* Mr. S. C. Clarke writes that it occurs in the vicinity of New Smyrna, Florida, where it spawns in bays and inlets in the months of May and June, as does also the Black Grouper. The only reliable study of its habits which has been made we owe to Mr. Silas Stearns, whose biographical sketch of this species may here be quoted in full:

"The Red Grouper is extremely abundant in the Gulf of Mexico in company with the red snapper. It is most abundant on the South Florida coast, and is found throughout the year on the 'grounds' at sea and in summer in some of the bays. It probably spawns in both places, and in June and July. The young are often caught in Pensacola Bay. In June, 1880, I obtained a young

one about one inch in length. The Grouper is more of a bottom fish than the red snapper, for it swims much more slowly and very seldom rises to the surface. It is very voracious, consuming, as is shown by an examination of the contents of its stomach, enormous quantities of crustaceans and small fish. Large horny crabs in almost perfect condition are often found inside of it. Its movements are rather slow, and when hooked it is hauled up more like a dead-weight than like a line-fish. In South Florida it is extensively eaten when procurable, and at Key West it is particularly important, since a large fleet of smacks is constantly employed in carrying fares of Groupers to Cuba. In West Florida, where red snappers are more abundant, Groupers are not in demand and have but a small market value. After being taken from the water, the Grouper is remarkably tenacious of life, and will live several hours, even though exposed to considerable heat. This is one reason why the Key West fleet prefer Groupers for transportation to Cuba, since they are obliged to go a long way to market and through warm water, and no other fish of the kind would bear crowding and chafing in the wells of the smacks The Grouper attains the weight of forty pounds, and is an excellent food-fish."

In Cuba this fish is called by the Spanish name "Cherna." The name "Grouper" is a corruption of "Garoupa," a name given by the Portuguese to similar species. In DeKay's time, as has been remarked, this fish was not unusual in the New York market, where it sold for from six to twelve cents a pound, though its flesh was considered tough and not very highly esteemed. Gill, writing of the same market in 1856, states: "This species is sometimes sent to our market from Key West and the reefs of Florida in May and the summer months. I have never seen more than two or three exposed for sale at a single time; it appears to be considerably esteemed, and is sold at from twelve to fifteen cents a pound."

Genio Scott writes: "The Grouper is an excellent dinner-fish, and when boiled and served with drawn butter and shrimp or lobster sauce is said to fully equal the turbot."

The Black Grouper—Epinephelus nigritus.

The Black Grouper, *Epinephelus nigritus*, called in Florida and Texas the "Jew-fish," is at Pensacola known by the name "Warsaw," evidently a corruption of the Spanish name "Guasa." It was first brought to notice by Holbrook, who had received one specimen from the vicinity of Charleston; north of that point it had not yet been observed, though it appears to be abundant along the coast of East Florida and in the Gulf of Mexico. Mr. S. C. Clarke has observed it in the Indian River region, and has communicated the following notes to Professor Baird:

"The Black Grouper is resident all the year, though not abundant. The greatest size attained is about fifteen pounds; the average, three pounds. They pass the winter in the salt-water rivers, living in holes in the rocks and under roots and snags and about piles. They are solitary in their habits. They feed on small fish, particularly mullet, and on crustaceans, and breed in the salt rivers in May and June. Their spawn is very small, and pale yellow. They are taken with hook and line by the use of mullet and crab bait, and are seldom seen except when thus captured. They are much esteemed as food."

Mr. Stearns remarks that it is a common fish at sea along the Gulf coast, living chiefly on the same spots with snappers and Groupers. At some places it is found in abundance in the bays, and lives on the bottom, feeding upon small fishes, crabs, etc. On the fishing grounds where fish are being caught rapidly it not unusually occurs.

A very large Jew-fish will follow and finally swallow a hooked fish, usually a red snapper, with hooks, lead, line and all. If the line does not then break the fish may be hauled in with gaffs. The Jew-fish attains an enormous size, and specimens weighing from eighty to one hundred pounds

have been caught. The smaller fish are quite choice, but large ones are too coarse and tough to be salable.

There is another fish which is also called "Jew-fish," or "Warsaw," and "Black Grouper," of which only enormously large specimens have been obtained, and which is entered upon our catalogues under the name *Promicrops guasa*. It is a fair question whether this great fish be not the adult of the common Black Grouper or some closely allied species, the appearance of which has become somewhat changed with age. A large specimen, weighing about three hundred pounds, was taken near the Saint John's bar in March or April, 1874, by James Arnold. It was shipped by Mr. Hudson, a fish-dealer in Savannah, to Mr. Blackford, who presented it to the Smithsonian Institution. A fine cast of this specimen in papier-maché graces the cast-room of the National Museum. Professor Poey, by whom this species was named, states that in Cuba it attains to the weight of six hundred pounds. An old Connecticut fisherman, who was for many years engaged in the Savannah market fishery, states that the Savannah smacks often catch Jew-fish. They are so voracious that when put into the well with the Groupers they would do much damage. The fishermen have therefore found it necessary to sew their jaws together before placing them with other fish.

The Spotted Hind—Epinephelus Drummond-Hayi.

The Spotted Hind of the Gulf of Mexico, *Epinephelus Drummond-Hayi*, has been but recently discovered, and has been observed only in the Gulf of Mexico and at the Bermudas. It was observed at the Bermudas in 1851 by Col. H. M. Drummond-Hay, of the British army. Specimens were sent to the National Museum in 1876 and 1877 by Mr. Blackford and Mr. Stearns. It is one of the many important species which have been brought to notice by the labors of the United States Fish Commission. Although it is an excellent food-fish, it is even now not well appreciated.

Mr. Stearns records the following facts concerning its habits: "The Spotted Hind is common in company with the Grouper and the Jew-fish, and is most abundant in South Florida about the reefs. Off Pensacola it lives in the deep fishing grounds, in seventeen, nineteen, and twenty-two fathoms. It swims close to the bottom, and is of sluggish movements. I have not known of its occurrence in the bays, and believe that it spawns at sea. Specimens weighing fifty pounds have been caught, but that is fully four times the average size. It is seen daily in the Key West market and sells readily, but at Pensacola, Mobile, and New Orleans it is hardly marketable. Its color varies very considerably with the different colored bottoms on which it lives."

The Coney, *Epinephelus apua*, of Key West, the Hind of Bermuda, is an important food-fish which occurs throughout the West Indies. Specimens have been sent by Mr. Stearns, who recorded that it is common in South Florida among the reefs, and is often seen in the Key West market, where it is readily sold.

The Banded Grouper—Epinephulus striatus and others.

The common Grouper of Bermuda, *Epinephelus striatus*, one of the most important food-fishes of those islands, is sure to be found in the vicinity of Key West, and will probably prove to be one of the important fishes of our own southern coasts. About Key West and in the Gulf there are several species of the sub-genus *Myctroperca*, which may be grouped together under the name "Rock-fish," the name by which all fishes of this genus are also known in Bermuda. They are large fishes of excellent food quality, similar in habits to the others of the family which have already been discussed. The material at present on hand is not sufficient to admit of satisfactory identification of all the species. The "Black Grouper" of Pensacola, which has been variously

named *Mycteroperca brunnea*, *M. microlepis*, *and M. stomias*, is said by Mr. Stearns to be common in company with the Red Grouper, although not so abundant. It spawns in June and July, at sea and in the inlets. As a food-fish it is considered superior to the Red Grouper, although it is not more readily sold. It attains a weight of fifty pounds. Professor Jordan is of the opinion that the form recently described by Goode and Bean as *M. stomias* is the adult of that previously characterized by them under the name *M. microlepis*.

The Rock-fish of Key West, which has not yet been identified, is said by Mr. Stearns to be very common, and is sold almost every day in the market. The average weight is four or five pounds, the maximum twenty-five to thirty. There appear to be, from Mr. Stearns' notes, at Key West, as well as in Bermuda, various local forms closely related to this, one of which is known by the name "Gag"; another fish of this genus, *Mycteroperca falcata*, is called at Pensacola by the name "Scamp." It is common off the Florida coast, living near the bottom in company with the other species of Groupers. It is found on the coast all the year round, and is caught with hook and line. It seldom exceeds the weight of twenty pounds, and the average size is much smaller. It is considered an excellent table fish.

Several of these fishes, whose relations have not yet been determined, have been taken along the Atlantic coast, particularly at the mouth of the Chesapeake and at Wood's Holl, Massachusetts.

There are several other species belonging to this family which have been observed, none of which, however, are of any economic importance.

138. THE SERRANOID FISHES OF THE PACIFIC COAST.

By David S. Jordan.

The Jew-fish—Stereolepis gigas.

This species is everywhere known as the "Jew-fish." It is also sometimes called the "Black Sea Bass." It reaches a weight of five hundred pounds, being the largest food-fish on the coast. It ranges from the Farallones to below San Diego, and is generally abundant in deep water about the islands, but from its great size is seldom taken. It feeds upon smaller fishes, and is voracious. It is often taken by swallowing a white-fish when the latter is on the hook. Its flesh is of excellent quality, and those small enough to be available always bring a very high price in the market.

The Cabrilla—Serranus clathratus.

This species is called at Monterey, where it is not common, the "Kelp Salmon"; farther South it is known to the "Americans" usually as "Rock Bass," and to the Italians and Spaniards as "Cabrilla," a name applied to other species of Serranus in the Mediterranean. The Chinese call it "Lockee Cod" (Rock Cod). It reaches a length of eighteen inches and a weight of about five pounds. It ranges from San Francisco to Cerros Island, being very abundant about the Santa Barbara Islands, where it is taken in large numbers. It lives in water of no great depth, chiefly about the rocks. It feeds on squid, crustacea, and small fishes. It is an excellent food-fish, similar in quality to the related Atlantic species.

The Johnny Verde—Serranus nebulifer (Grd.) Steind.

This species receives the name "Rock Bass" and "Cabrilla" with the other species. The distinctive Spanish name of "Johnny (Juan) Verde" is also in frequent use, especially at San Pedro. It reaches a length of twelve to twenty inches and a weight of about five pounds. Most individuals seen are, however, small, not averaging two pounds. It has been taken at Monterey, but it is common only from San Pedro southward to Magdalena Bay. So far as known to us, it agrees in habits and value with the preceding.

THE SPOTTED CABRILLA—SERRANUS MACULOFASCIATUS Steindachner.

This species receives the same names, "Rock Bass" and "Cabrilla," as the others. It agrees with the preceding in value, distribution, and habits, so far as known. Its a rather smaller size. It is an excellent food-fish, and from its great abundance about San Diego it may become of considerable economic importance. Its range extends southward to Mazatlan, it being one of the very few California fishes which extend their range to the south of the Tropic of Cancer.

139. THE YELLOW PERCH—PERCA AMERICANA.

"Wherever found," writes Jordan, "this species is the Perch *par excellence*," the name *Perch* being elsewhere wrongly applied to various Serranoid, Sciænoid, Centrarchoid, and Embiotocoid fishes. The descriptive names "Yellow Perch" and "Ringed Perch" are in common use. The Perch is found throughout the Great Lake region, the rivers of New England and of the States east of the Alleghany Mountains as far south as Georgia. It occurs in some tributaries of the Ohio in the northern parts of Ohio and Indiana, and of the Mississippi in Wisconsin and Minnesota, but throughout the lower basin of the Mississippi and the west slope of the Alleghanies it is entirely absent. The Perch is one of the common market fish of the North and East. Its usual length is about a foot, and its weight generally less than two pounds. It is a fish of fair but not excellent quality. It is a carnivorous fish, feeding on minnows, etc., and usually freely taking the hook. It spawns in spring. Dr. Steindachner, of Vienna, has recently attempted to demonstrate the identity of the American Perch with the similar species in Europe, but this I cannot admit, for they are no more alike than various of our species of *Lepomis*, *Amiurus*, etc. It is true enough that the distinctive characters noticed by Steindachner are unreliable, but, so far as I have seen, they differ strongly in gill-rakers, pseudobranchiæ, position of first dorsal, etc. Of course, no sane man doubts their community of origin, but different "species" they are now, or at least sub-species."

The following observations with regard to the abundance of the Yellow Perch, in the Great Lakes have been made by Mr. Ludwig Kumlien and others:

On the eastern shore of Minnesota, and especially about Duluth and vicinity, these fish are common. On the southern shore of Lake Superior, as far east as Keeweenaw Point, and about the islands included—such as the Apostle Islands, Sand, York, and Rock Islands—they are also common. In this region they have been on the increase for the last ten years, being quite rare as lately as 1870. They are, however, never shipped to the large markets, being used for home consumption. In the small bays running southeast from Keweenaw Point Yellow Perch are very abundant; in this locality they are not found plentifully at a great distance from shore. In Marquette Harbor a few are taken in the herring seines, but none are caught in the pound-nets. The yellow-perch fishery is of no importance between this point and Sauk's Head.

At the north end of Green Bay Yellow Perch are not abundant. They are found chiefly in the mouths of the small bays included in Green Bay, and are said to be rare about the islands; they are not taken in the pound-nets at least. Toward Cedar River this fish is not plentiful, being taken almost entirely in the shoal-nets. A little farther south, about the mouth of Menomonee River, there is a greater abundance of them; here also they are taken in some quantities in the inshore nets. They are shipped from here with the "dory," but complaint is made by the dealers if there is too large a proportion of Perch. When shipped separate they command a low price. Writing on September 24, 1880, Mr. Kumlien remarks: "I have seen a good many that were taken near Menomonee River within the last few days and was surprised at their small and uniform size; few of them would exceed eight inches. The fishermen inform me that there has been a run of these small Perch since last winter in excess of anything ever known in previous years."

The fishermen are under the impression that Perch instead of white-fish were hatched out and deposited here by the State Fish Commission.

Between the Menomonee River and Oconto Bay this fish is common, but of little importance. It brings a low price and is not sought after. It is caught inshore in the sloughs. At the southern extremity of Green Bay the Yellow Perch is abundant. All along the eastern shore of Green Bay it is very plentiful; there has been a greater abundance of it during the past year (1880) than ever before.

Along the western shore of Lake Michigan, as far as Manitowoc, the Yellow Perch is extremely rare, except about Two Rivers and Manitowoc, at which two points it is common and meets with a ready sale. Between Manitowoc and Port Washington the Yellow Perch occurs very sparingly, especially in the vicinity of Cedar Grove. The other fishing grounds between the above-named points are White Fish Bay, and Sheboygan.

In the vicinity of Milwaukee this fish is extraordinarily abundant, and was especially so during 1879. In less than ten fathoms they are sometimes caught in the gill-net; the majority, however, are taken on hooks. They are of considerable importance in this locality and meet with a ready sale. At Racine a great many, and of a large size, are caught. At Waukegan, a little farther south, they are especially abundant in June and July. They were more plentiful in 1879 than they had ever been before.

At the southern end of Lake Michigan, about New Buffalo and Michigan City, they are abundant, being caught on hooks and sold in large numbers to the railway baggage-men, who peddle them on the cars. They have been more abundant this year (1880) than ever before. The finest specimens are caught as far out from shore as fifteen miles, but the smaller ones do not go out so far. Many are shipped to the Chicago market.

Around the docks of Saint Joseph, at the southern end of Lake Michigan, the yellow perch fry fairly swarms. In the summer of 1880, two hundred hooks were set two miles out from shore; each hook had a Perch, some weighing as high as two pounds. From Saint Joseph Yellow Perch are often shipped with white-fish and trout. They are chiefly caught in gill-nets, several miles from shore.

On the eastern shore of Lake Michigan, about Ludington and Manistee, they were as plentiful as ever before in 1880; some years they are less common, and then come on again. At Grand Haven they were less abundant than usual, and are seldom taken at this point at any great distance from shore. About Little and Great Traverse Bays and the Fox Islands they are generally common, but were less plentiful in 1880 than ever before. They are occasionally taken in the pound nets, and even in the gill-nets, but are of no commercial importance.

The Yellow Perch is reported as common at the northeast end of Lake Michigan, through the Straits of Mackinaw, and down the western shore of Lake Huron to Thunder Bay. Captain Dingman, who appears to be well informed as to the fisheries of that region, says they are not one-tenth as numerous as they were in 1879. If this be true of the northeastern shore of Lake Michigan, it may account for their being unusually numerous on the opposite (western) shore of that lake. Near the Les Cheneaux Islands a large variety is reported as having been caught. Yellow Perch are more common about these islands than generally along the shore. They are not often taken in the deep pounds but are quite abundant in shallow water and in the small lakes.

In Thunder Bay Yellow Perch are abundant, and are taken principally in the pound-nets in spring. Mr. Case thinks they are increasing. Very few are shipped from this point; during 1879 not over five hundred, in which year the run was very large.

In the rivers running into Saginaw Bay Yellow Perch are abundant, but not so much so as

formerly. Mr. Riker thinks they have left the rivers for the bay, during the last few years, to a great extent. From places on this bay they are shipped as soft fish. Down from Saginaw Bay to Port Huron, the remainder of the western shore of Lake Huron, Yellow Perch are very abundant, as also in the Saint Clair River; Mr. Canham thinks that they are on the steady increase. From this region few are shipped, the demand being principally local, but outside markets are springing up. A good many are taken on the lake shore in the bait-nets.

On the fishing grounds at the west end of Lake Erie, from Toledo to the mouth of the Detroit River, including the pound fisheries of the last named locality, Yellow Perch are said to be very abundant and on the increase. They are usually dressed (skinned) and sent to inland towns. There is a great demand for them by the peddlers who supply the farms.

About the vicinity of Maumee Bay and Toledo, and in Maumee Bay, Yellow Perch are very abundant at all times. In late autumn and winter a few are shipped to New York City. East of Port Clinton the pounds do not catch any, though they are very abundant in the Sandusky River and small bays adjacent. About Toussaint and Locust Point a few are caught in spring in the pounds, but are thrown overboard.

In Sandusky Bay, Upper and Lower, and in the lake between Ottawa City, on Catawba Island, and the Huron fisheries, Yellow Perch are very abundant in early spring and late fall. At Sandusky they are very abundant, and it is thought that the offal thrown into the lake helps to keep them in that locality. They are usually counted as "rough" fish and sold with the herring, but are sometimes counted as "soft" fish early in the season. A very large variety is taken outside of Sandusky Bay in the lake, and Mr. Stoll, one of the authorities of that district, affirms that the lake and marsh varieties are distinct. About the islands of this region Yellow Perch are common, and, according to Mr. Anthony, from five to ten tons have been caught there, several years ago, at one lift.

In the fishing grounds at Huron, Ohio, on the south shore of Lake Erie, this species is abundant. Six or seven years ago few were taken in the lake pounds in comparison with the numbers taken in them at the present day. About nine-tenths of those now taken are thrown away. A few are shipped to New York City in late autumn, and a few are frozen. Yellow Perch, in this locality, are not even graded as a soft fish, and seldom bring more than do the sheepsheads.

Yellow Perch are very abundant at Vermillion, Ohio. Ten tons have been caught in a day and set at liberty for lack of demand. A few tons of the late autumn catch is generally frozen. Here they do not even count as a soft fish, but sell separately, and rarely for a higher price than the sheepshead. The Yellow Perch are here of a uniform size, averaging about three-fourths of a pound apiece.

At Black River and Amherst this species is very common; they are classed as soft fish, but are not considered a "good" soft fish. They are most abundant in the spring—usually in April—but unimportant. At these points the Yellow Perch average a large size.

This species is very abundant during some years at Cleveland and Dover Bay, Ohio, and again for some time but few are taken. They are most plentiful in spring, during which season of the year as high as two or three hundred pounds are taken in a day. When abundant, they have a poor sale, but when a few only are in the Cleveland market they command a fair price. They are of uniform size, and average about three-quarters of a pound.

At Conneaut and Ashtabula Yellow Perch are abundant and quite important. They are taken in gill-nets in winter as far as eight miles from shore. In May, when they spawn, few are caught over a mile from shore. At Painesville Yellow Perch are not so common as east and west of that place. At Dunkirk and Barcelona, New York, this species is very abundant, and especially

so at Erie, Pennsylvania, where it is considered as of great importance. Off Erie Bay a very large grade of this fish occurs. Many are taken in gill-nets. At Oswego, Port Ontario, Lake Vincent, Chaumont, and Sacket's Harbor, and other points on the southern and eastern shores of Lake Ontario, Yellow Perch are very abundant. At Port Ontario they are of some commercial importance and are more highly prized as a food-fish than is usual, as is also the case at Lake Vincent, where they are more highly prized than the sun-fish. From Chaumont they are shipped in spring and winter as "Perch." At Lake Vincent they are known as "Striped Perch." At Sacket's Harbor they are of no special importance.

Mr. Eveland says he has frequently caught Yellow Perch weighing two pounds. They are seldom found in water deeper than from twenty-five to thirty feet. It is a prevalent belief among fishermen that Yellow Perch are very destructive of white-fish. Mr. Hatch thinks that the decrease of the latter may be to some extent due to increase of the former. Perch caught in the Lakes are much larger than those caught in the rivers running into them.

140. THE LOG PERCH—PERCINA CAPRODES (RAF.) GRD.

By DAVID S. JORDAN.

This species is known as the "Rock-fish," "Hog-fish," or "Log Perch." It is the largest of a large group of little perch-like fishes known as "Darters" or *Etheostomatidæ*. These fishes may be described as little perch, reduced in size and compacted, thus fitted for a life in rocky brooks where the water is too shallow, swift, and sterile to support larger fish. All the Darters are brilliantly colored, and all have a way of lying quiescent on the bottoms, resting on their large fins, and then suddenly darting away for a short distance when disturbed. They are carnivorous, feeding chiefly on insects and crustaceans. Only one of them (*Percina caprodes*) is large enough to take the hook. This one is often found on the urchin's string, but it cannot be said to have any economic value. The others are too small for the urchin even, and although, according to Rafinesque, "they are good to eat fried," few people think it worth while to cook them. Darters are found in all fresh waters of the United States east of the Rocky Mountains, but all the species are peculiar to America.

141. THE PIKE PERCHES.

In the interior of North America occur two species of the genus *Stizostedium*, the Wall-eyed Pike, *S. vitreum* (Mitch.), J. & G., and *S. canadense* (Smith) Jordan. Both of these occur in the Great Lake region and the Upper Mississippi, and the valley of the Ohio and the Tennessee; the former penetrating northward to the fur countries, and into some of the Atlantic streams south of New England.

"*S. vitreum*," according to Jordan, "may be readily known from *S. canadense* by the presence of a single black spot on the posterior part of the spinous dorsal, instead of one or two rows of smaller spots on the middle part of the fin."

THE WALL-EYED PIKE OR DORY—STIZOSTEDIUM VITREUM.

"*Stizostedium vitreum*," writes Jordan, "is most commonly called the 'Wall-eyed Pike.' In the Upper Lakes, where the true Pike (*Esox lucius*) is known as 'Pickerel,' the Wall-eyed Pike becomes simply 'Pike.' The names 'Glass-eye' and 'Yellow Pike' are sometimes heard, and the name 'Blue Pike' is applied to a local variety. The name 'Pike Perch,' a translation of *Lucioperca*, a name given by Cuvier to the genus *Stizostedium*, is often used in books, but has never taken root among fishermen. Among the French about Lake Michigan and in Canada

the name 'Dory' is in common use. Southward the name 'Jack' is applied to this species as well as to the Pike. The most unfortunate misnomer of 'Salmon' is also common in the South, and the names 'Okow,' 'Blow-fish,' "Green Pike," and 'Jack Salmon' are also current in various localities. This species is very abundant throughout the Great Lake region and the Upper Mississippi and Missouri. It has also an extensive but not well-known distribution through the larger streams of the Southern States, at least of the upland portion. It feeds upon other fishes, and is a voracious and gamy species. It reaches a length of three feet or more, and a weight of fifteen to twenty-five pounds or more. Those seen in market are generally much smaller. This is one of the best of our food-fishes, with firm, white flesh of good flavor. In the markets supplied from the Great Lakes it ranks in importance below the white-fish and lake trout only. It is the most valuable of our fresh-water percoids."

Jordan recognizes two varieties of this species, namely, var. *vitreum* and var. *salmoneum;* the latter, known as the "Blue Pike," is a local variety in Ohio and southward; it is bluer in color, and is smaller, besides having the body shorter and deeper.

The abundance of the Wall eyed Pike, *Stizostedium vitreum*, in the region of the Great Lakes has been recorded by Mr. Kumlien as follows:

"At the western extremity of Lake Superior, at the head of Saint Louis Bay, Wall-eyed Pike are abundant. They are there taken extensively with seines. Off the Wisconsin coast of Lake Superior, and, passing east, as far as Ontonagon, Michigan, Pike have, within the last two years, become abundant. Four years ago the fishermen could scarcely find sufficient for their own tables, while in 1879 there was an immense "run" of Pike. They are most abundant in Squaw and Siscourt Bays and are of larger size than in Keweenaw Bay. The sudden appearance of Pike is a deep puzzle to the fishermen.

"At Portage Entry and L'Anse, Pike are abundant; they are common, however, all along the shore from Ontonagon to Huron Bay, between which two points they rank third, and would take the second place (*i. e.*, that of lake trout) if the "runs" of Pike were as continuous as those of trout—which latter can be caught at all times. Pike are here taken principally in the pounds. They average a smaller size than in the Lower Lakes. At Portage Entry the fishermen used to keep the Pike in a pond until required for shipment. They are here called "Yellow Pike."

On the fishing grounds between Grand Island and Sauk's Head, including Ontario Bay, Sucker Bay, Laughing-fish Point, Short Point, Marquette and Big Presque Isle, Pike are taken to some extent, but are not abundant enough to be of much importance. Twelve years ago they were quite rare; they have since that time been increasing steadily. They are taken in the pound-nets to some extent, but rarely in the gill-nets. Some pounds do not get half a dozen to a lift. In this region they are known as "Yellow Pike," as also at White-fish Point, where they are sometimes taken at the rate of two or three hundred pounds at a lift, but are not plentiful.

At the north end of Green Bay the name "Doré" is given to this species. In this locality, including the fishing grounds of Escanaba, Chippewa Point, Summer Island, Saint Martin's Island, and Point aux Barques, they are equally abundant, and grow to a large size, occasionally weighing twenty pounds. They here rank third in importance, and are taken in gill-nets, except in winter and spring. Of late years they have been salted to some extent.

Along the shore of Green Bay, between the mouths of Cedar River and Peshtego River, they rank third in importance, the white-fish taking the first place and the sturgeon the second. They are taken more plentifully in the fall than in the spring, the reverse being the case at the head of the bay, where they spawn in great numbers. When shipped fresh they are not dressed at all. In spring they are, to some extent, salted, and are sold as "Salt Pickerel." This business of

salting was carried on during the summer of 1880 along the whole western shore of Lake Michigan. In spring they are taken quite extensively on rocks in the Menomonee River, where they go to spawn. At this season many are taken with spears also, especially for home consumption. One man says he took five barrels in a night. They are prized very highly by the fishermen. In the deep-water nets a very large grade is caught. In this region they are known as "Dory."

Between Peshtego Point and Longtail Point they are called "Wall-eyed Pike" and "Dory," are of much importance, and greatly sought for. In this division of the western shore of Green Bay they are principally taken in gill-nets, but do not enter a pound-net well. The chief shipments of these fish salted take place between the 1st of April and the 15th of June, when they are shipped as "Salt Pickerel" to the Western markets; during the rest of the year they are shipped fresh, on ice. In 1878 one was taken at Oconto weighing nineteen pounds. They spawn early in spring, and are considered destructive to young fish and spawn. In scaling the fish a common curry-comb is used. This fish and the White Bass are the two most important kinds taken at the Green Bay City fisheries, where the former is called "Dory."

Along the eastern shore of Green Bay the Pike is not, as on the western shore, abundant. About Little Sturgeon Bay two and three a week are considered the average number taken. One kind only is recognized between Bay Settlement and the island of Saint Martin. Between Port des Morts and Manitowoc, on the western shore of Lake Michigan, Pike are rare, and the few caught are taken in the spring. Mr. Kirtland took three packages of Pike at Jacksonport in 1879. At Two Rivers they only occur as stragglers. At Manitowoc the name "Pike" alone is used, "Dory" being unknown. They likewise only occur as stragglers at the fishing grounds between Manitowoc and White-fish Bay.

In the vicinity of Milwaukee they are by no means abundant; they are caught, when occurring, in pound-nets, but never in gill-nets. In the small inland lakes they are pronounced to be quite common. South of Milwaukee, as far as Evanstown, Illinois, they are far from abundant, but were formerly quite plentiful about Racine, though now nearly exterminated at that point. When shipped they are packed with the white-fish. In this region they are called "Yellow Pike." At the extreme south of Lake Michigan, including the New Buffalo and Michigan City fisheries, this species is called "Wall-eyed" Pike. It is rare, but taken at all seasons of the year. Three or four at a lift of the pound-net is the average. When shipped South it is called "Salmon." The size attained is large, probably averaging fully ten pounds.

At the Saugatuck, South Haven, and Saint Joseph fisheries, on the east shore of Lake Michigan, "Wall-eyed Pike" (as the species is there designated) are becoming more common of late. It is thought that they have, to a great extent, replaced the pickerel in the small lakes and river bayous. They are not yet of sufficient abundance to be of any commercial importance. Individuals of this species are here taken chiefly with hooks, and occur but sparingly in the lake.

At Ludington, Point Sable, Grand Haven, and other fishing towns, between Saugatuck and Glen Haven, Lebanon County, Pike are by no means abundant, being most plentiful in August at Ludington and Manistee. White Hall is an exceptional place, wagon-loads being sometimes exposed on the streets for sale. At Grand Haven not more than half a dozen a year are caught in the lake, but in the Grand River they are not at all rare.

On the fishing grounds of Little and Grand Traverse Bays, and about Fox Islands, Pike are extremely rare. They are occasionally found in Grand Traverse Bay, but are scarcely at all known by the fish authorities of that region. In the fishing grounds comprised between Little Traverse Bay (passing north and east through the Straits of Mackinaw as far down the western shore of Lake Huron as Hammond's Bay) and Adams Point the name "Pickerel" is given to this species.

except by the French fishermen, who call it "Dory." Throughout this region this fish is common, but principally in the rivers and bayous. Mr. Bennett reports thirteen hundred pounds from one pound-net in two nights in Hammond Bay. This fish is by far the most plentiful in spring. It is much sought for because of its good keeping qualities. About Mud Lake and in the Sault Ste. Marie River this species is quite extensively fished for and is sold separately. In the outer pounds in the lake (Huron) not many are caught. The majority of fishermen salt them and sell as "Salted Pickerel"; the proportion of this fish to white-fish is about as one to one hundred.

At Alpena, Thunder Bay, Pike, usually here called "Yellow Pike," form quite an important fishery during May and June, after which but few are taken until September. The largest lift known here was in 1874, when three thousand were taken from one net in a single lift. During September very few of any other kind than Pike are taken in the pound-nets. In comparison with Saginaw Bay, but few are taken at Alpena.

In Saginaw Bay this species, known as "Yellow Pike," "Pickerel," and "Wall-eyed Pike," is thus spoken of in a circular by Riker & Kelbourn: "Saginaw Bay produces more fish yearly than any equal extent of inland water in the United States, and of as good quality, and in one notable exception a good deal better. This is the Yellow Pike, or what are termed South 'Lake Salmon,' and on Lake Erie are known as 'Pickerel.' They are a harder, firmer, fish, and will bear transportation better, and keep longer, than pickerel caught in the Lower Lakes. Because of these qualities, and their superior adaptation for the use of the table, they are regarded South and West as the fish first of all desired. This immense catch of fish is prepared for shipment, in parcels to suit customers, to the East, South, and West, embracing several States."

The "Pickerel" is the most abundant and important fish in Saginaw Bay. Besides those taken in the pounds and with seines, large quantities are speared in winter through the ice. In spring they are taken till July, and then very few are caught again till the latter part of August. It is presumed they go into deep water during the warmest weather. In spearing them through the ice a decoy fish is used to lure them within reach; they are very rarely taken in the gill nets. There seems to be no very alarming decrease among them, yet it is readily admitted that they have been more plenty than they are at present. Spawn in the bay during April.

From Point aux Barques to Port Huron, Pike are very abundant, and are the most important fish in the Saint Clair River on the Canada side, where they are of great commercial value. They are here known as "Yellow Pickerel." It is an interesting question why they should be more abundant on the Canadian than on the American side. Saginaw Bay is the hot-bed for this species, and from there they seem to strike across the lake to the Canada shore, entirely avoiding the east shore of the peninsula from Point aux Barques to Port Huron. When they come into the Saint Clair River they follow close to the Canada shore, and return the same way.

Between Toledo and the mouth of Detroit River, Pike, called "Yellow Pickerel" in this region, are not abundant. Unlike Maumee Bay, they do not seem to delight in this western shore of Lake Erie. The runs occur in places in the spring irregularly, and no dependence is placed on a fair supply at any time. It is not considered one of the important fish.

In Maumee Bay Pike are very abundant. Early in the season large quantities come from the bay and river of the same name. They rank second in importance, and are exclusively salted, being then known as "Salmon," otherwise as "Yellow Pike." In autumn few are taken in comparison with the number caught in the spring. Pike, or "Yellow Pike," here called, strike on the south shore of Lake Erie, around Port Clinton, about April 1, and stay only a few days. They rank about fourth at that place. At Locust Point they are caught in considerable numbers in spring, and some in fall also. Here they rank third in importance.

At all the fishing points between Ottawa City, on Catawba Island, and the Huron fisheries, with the neighboring islands, the greater part of the "Pickerel" are called "Gray Pickerel," and many say that they are totally different from the "Yellow" or "Blue" Pickerel. In Sandusky Bay they are particularly abundant; also about the islands and in the harbors. They have extensive spawning grounds at Cedar Point, Marblehead, Spit Island, East and West Harbors, Mouse Island, Sugar Bluff, Moose's Point, North and Middle Bass Islands, Put-in Bay, and Kelley's Island. They are sold as hard fish, and usually run large. When less than a pound they are sold with the "Saugers."

Connected with the Huron (Ohio) fisheries, the Pike, here called "Yellow Pike," are considered quite important, but not so abundant as farther west. They are caught principally in the spring, and are thought to work westward toward Maumee Bay about their spawning time. They rank about fourth in importance. The general impression among fishermen here is that the true Yellow Pike is not caught at all here—by which they mean the Yellow Pike of Saginaw Bay. Many call this fish the "Gray Pike," and yet consider it an entirely different fish from the "Blue Pike."

At Vermillion, Ohio, there is caught, early in the spring, what is termed the "Spawn Pike," running from twenty to thirty pounds. Later the runs average much smaller—one to five pounds—and these are supposed not to spawn. Pike here are not abundant, and it is only in the spring that they are regarded as important.

A little farther east, including the fisheries of Black River, Amherst, and Brownhelm Bay, "Yellow Pike," so called in this section, are not abundant. They are taken early in spring. On account of their fewness they are of but little importance. There is said to be too much waste in dressing to make them a salable fish among the poorer classes. The markets are never glutted with this fish. None are salted. At Cleveland and Dover, Ohio, this species is known as "Yellow Pickerel" and "Pickerel." At the Dover Bay fisheries they are not abundant, in the largest lifts not over one hundred and fifty to two hundred pounds being taken. They are caught principally in early spring, and range from one to five pounds. Until the last six years this fish was unknown here. Farther east, at Conneaut and Ashtabula, "Yellow Pike," as they are there called, do not seem to be common; a few large ones (from ten to twelve pounds) are taken every season. About Painesville, Fairport, and Willoughby this species is known as "Yellow Pickerel." They are not very common; some are taken in spring. In 1879 not over two tons were taken in sixteen nets. They are much more common farther west. Years ago they were abundant and one of the most important of fish, but since the dynamite explosion at Fairport (the port of Painesville, three miles from the city, on the lake shore), about eight years ago, they have been rare, and the fishermen think the explosion—which was so strong that it broke window-lights in Cleveland and Buffalo—drove them away. A decrease in other species was noticeable for some time afterwards. Those taken at Painesville are remarkably dark colored, much darker than those taken at the islands.

When pound-nets were used in the fisheries of Dunkirk and Barcelona, New York, Erie, Pennsylvania, and Mill's Grove, Ohio, a good many Pike were taken; even now a few are taken in the gill-nets. At the above places they are called "Wall-eyed Pike."

Concerning the Lake Ontario pike fishery, we learn that at Oswego they are fairly common and rank third in importance. At Port Ontario they are known as "Yellow Pike." They were formerly abundant at this point, but of late years few have been taken. Since pound-net fishing began they have gradually grown less abundant—been "caught out." A few are yet taken in the seines.

At Cape Vincent Pike are abundant. The fish of one variety, with a longer and more pointed head than the Upper Lake fish, are called "Spike-noses." They rank second in commercial impor-

tance. They are brought over from Canada to a great extent, but the bulk that is shipped from Cape Vincent is caught in American waters. They are common everywhere. At Chaumont they rank first in commercial importance. The largest runs occur in the bay in early spring. Pike do not come as near shore as formerly. At Sacket's Harbor they rank first in importance, and are caught in the spring as soon as the ice is out, and in fall till winter sets in. During the winter they are brought from Canada. It is thought that they have increased since the alewives came here, and that the average weight now is one-third greater than ten years ago.

It is said that Yellow Pike, *Stizostedium vitreum*, can be confined in a small pond much more successfully than most species. They are said to prefer the vicinity of river mouths, and not to go far out into the lakes.

The following facts concerning the abundance of the Blue Pike, identified as *Stizostedium vitreum* var. *salmoneum*, in the region of the Great Lakes, were gathered by Mr. Kumlien:

In the fishing grounds of the west end of Lake Erie "Blue Pickerel" are known only as rare stragglers. In the vicinity of Toledo and Maumee Bay Blue Pike are very seldom seen. At some of the principal fisheries not more than one in a year is taken. This fish is generally not recognized by the local fishermen. On the south coast also, at Port Clinton and Locust Point, this fish is a great rarity, and only appears as a straggler. It is of no importance whatever.

About Upper and Lower Sandusky Bay, and all the fishing grounds between Ottawa City and Catawba Island to the Huron fisheries, the Blue Pike are abundant from May till June 5, the largest runs occurring from the 20th of May until June. They rank in this region about fifth in importance. They are sold fresh, frozen and salted, about half the catch being salted and sold as "Medium Pickerel." It is somewhat improbable that individuals exceed one and a half or two pounds in weight. They are less abundant around the islands, among which may be named Spit Island, Mouse Island, North Bass Island, Middle Bass Island, and Kelley's Island. The "Gray," "Yellow," and "Blue" Pike grade into each other in this locality in such a manner that it is hard to draw the limiting line. Mr. Kumlien thinks that all of these represented as "Gray" and some "Blue" were *S. vitreum*, but that the bulk of those called "Blue" are readily distinguishable from *S. vitreum*.

In the Huron (Ohio) fisheries Blue Pike are extraordinarily abundant, in fact too much so. Such quantities are sometimes caught that not one-quarter can be made use of. The largest runs come on late when the market is already full, consequently a very low price is realized for them. A few are taken in early spring, as soon as the fishing begins, but the bulk are caught from the 12th to the 20th of May. As high as one hundred and fifty tons have been brought to Huron in a day. They are largely salted. The average weight is about a pound, though some are taken in early spring weighing ten to fifteen pounds. The direction of the movement made by the Blue Pike is supposed to be easterly in the spring, when they start from the vicinity of the islands, returning (westward) in the fall. Between Cedar Point (east side entrance to Sandusky Bay) and Black River they occur in greater numbers than at any other point in Lake Erie. Some are caught in autumn, but the catch then is nothing as compared with that of late spring.

At Vermillion, Ohio, the Blue Pike are more abundant than any other species, and rank second in importance. They are taken as soon as the fishing commences, but from the 24th of May till June 1 to 6 they come in such myriads that it is impossible to take care of them, and tons upon tons are let out of the nets. The average weight is about a pound, but specimens weighing as high as fifteen pounds are said to be taken early in spring among the spawning Yellow Pike. This fish was formerly graded as "hard," but of late years they have been classed "soft," principally on account of their numbers, but also because in flavor they are far inferior to the Yellow Pike. They come into

the nets in such quantities, and at a season when the market is already full, that they are often sold for the freight charges only. Mr. McGraw thinks there is an appreciable increase in their numbers each year. In 1879 as high as four tons were taken from one pound at a single lift. When salted they are called "Medium" and "No. 2 Pickerel." The reason so few are salted in proportion to the amount caught is on account of the low price realized for them, coming, as they do, into competition with more valuable kinds. From the following it will be seen that the profits to the fishermen are very small:

Cost of packing 100 pounds salt fish ready for market: Half barrel, 35 cents; dressing fish, 12 cents; salt, 15 cents; salting, 10 cents; inspection, 25 cents; total, 97 cents. Then add cost of from 160 to 175 pounds of undressed fish, and sell for $1.50 per half barrel, and the profits are very small.

At Black River, Amherst, and Brownhelm, Ohio, the most important fish is the Blue Pike. The largest runs occur in May and October. Mr. Freund thinks that they spawn in June or the latter days of May. The general impression amongst the fishermen is that they do not spawn, as none of them have seen the spawn in the fish. Such quantities are sometimes taken that it is very difficult to take care of them all. They are used fresh, and are also salted.

At Cleveland and the Dover Bay fisheries the Blue Pike is the principal fish and very abundant. They are taken as soon as the fishermen get their nets in, but more plentifully at the end of spring and fall than at the beginning of those two seasons. It often happens that such quantities are taken that they cannot be disposed of. They appear to be increasing every year; as high as twenty tons are reported from four nets in one day. About one-fourth of the catch is salted; the fishermen say that the early-caught fish do not salt so well as those taken later. The average weight is about one pound, those coming on first in spring averaging, perhaps, less than this weight, but the late runs are larger. It is said that specimens have been caught among the islands at the west end of the lake weighing fifteen pounds. All the fishermen say they never saw one with ripe spawn. Formerly they were classed as "hard fish," but now they sell as "soft."

At Oswego this species is called "Gray Pike," is quite common, and unusually silvery in appearance. At Cape Vincent they are known only as stragglers. At Chaumont they are very rare, and at Sacket's Harbor very few are caught.

The "Jack" on the Ohio River, as described by Jordan in the lately published report on the fishes of Ohio, reaches occasionally forty pounds. "It possesses great activity and strength, and is a ravenous destroyer of Perch and other species. Were it not so superior in every way to others, this habit might condemn it; as it is, we regard it as one of the best species we possess. In the South it is eagerly bought, and forms the principal table fish for the various places of resort, where it can be obtained."[1] "The 'Blue Pike,'" says Jordan, "is said to frequent only bayous and inlets, not being taken in the deeper waters of the Lakes, where *S. vitreum* especially abound. It also reaches a smaller size, according to Mr. Klippart, who asks, 'Why does the Blue Pike frequent the bayous and get to be no more than twelve to fifteen inches in length, and to weigh not to exceed two or three pounds, if it is identical with the Wall-eyed Pike which frequents the deep waters of the lake and attains a length of three feet and a weight of eighteen to twenty pounds?' This species, according to Mr. Klippart, is at the Lake Erie fisheries split and salted with the Sauger, *S. canadense*, the two together being known to the commercial world as 'Pickerel No. 2,' and bringing about two-thirds the price of Pickerel No. 1, which is *S. vitreum*."[2]

[1] Cope, Rept. Comm. Fish Penn., 1881, 128.
[2] Geological Survey of Ohio, iv, part i, p. 64.

THE SAUGER.—STIZOSTEDIUM CANADENSE.

The "Sauger," known also as the "Gray Pike," "Sand Pike," "Ground Pike," "Pickering," "Pickerel," and "Horse-fish," has its habitat, according to Jordan, in the Saint Lawrence River, *Great Lake region, Upper Mississippi, and Upper Missouri Rivers, also in the Ohio, where, according* to the fishermen, it has been introduced from the Lakes through the canals.

"The different form and coloration, particularly the markings of the dorsal fin," writes Jordan," distinguish this species at once from *Stizostedium vitreum*. This species has, moreover, always fewer dorsal rays, more scaly cheeks, and permanent armature of the operculum.

"*In comparing Saugers from widely separated localities certain differences appear, which are* perhaps sufficiently constant to indicate distinct varieties. Of these, three are perhaps worthy to be designated by name. The common Sauger or Sand Pike of the Lakes (*Lucioperca grisea* DeKay) should bear the name of *Stizostedium canadense*, var. *grisea*. The Sauger or Pickering of the Saint Lawrence was the original *Lucioperca canadensis* of Col. C. H. Smith. It should, therefore, be the typical variety, *canadensis*. Its head is rougher and more closely scaled, and the number of spinous points on the opercle is greater. The 'Sand Pike' of the Upper Missouri averages rather slender, with a long, slender nose and more flattened and snake-like head. This is the *Lucioperca borea* of Dr. Girard, and may be called var. *borcum*, if the difference here noted prove at all constant.

"The Sauger never reaches a large size, the largest I have seen being from fifteen to eighteen inches in length. It is abundant everywhere in the Great Lakes, and is valued as food, although less highly rated than its relative, the Pike Perch.

"It is plentiful in the Ohio River, where it is probably indigenous, although some claim that it has been introduced there through the canals."

Mr. Kumlien has collected many interesting notes concerning this as well as the preceding species. These will be printed at a future time.

THE STRIPED BASS FAMILY.

Fishes of this family are common on both sides of the North Atlantic. The Bass of Europe, *Roccus labrax*, is one of the favorite food-fishes of that region, and is found from Tromsoe, in Norway, latitude 70°, south to the Mediterranean, where it is abundant. A very closely related species is our own Striped Bass, or Rock-fish, *Roccus saxatilis*, which is found from the Gulf of Saint Lawrence to the Gulf of Mexico. These two species are very similar in form, although the colors are different, the American Bass being conspicuously striped, while that of Europe is silvery gray. They are both strong, active, and voracious fishes, and both ascend rivers, although the American Bass seems to be much more addicted to life in fresh water than its transatlantic relative, probably owing to the fact that our rivers are more numerous, larger, and much more plentifully stocked with the fish upon which the Bass rely for food. They ascend the Potomac to the Little Falls, the Hudson to Albany, the Connecticut to Hartford, and the Saint Lawrence to Quebec. Before the erection of dams in the Susquehanna individuals were taken as high up as Luzerne. Europe has two other species, which it is unnecessary to discuss here, and North America has three—the White Bass or Striped Lake Bass, *Roccus chrysops;* the Brassy Bass of the Lower Mississippi Valley, *Roccus interruptus;* and the White Perch of the Atlantic coast, *Roccus americanus*. All of these are of considerable economic importance, though the Striped Bass is beyond comparison more valuable than all the others together.

142. THE STRIPED BASS—ROCCUS LINEATUS.

GEOGRAPHICAL DISTRIBUTION.—The Striped Bass, as has been already stated, occurs in all the waters of our coast from latitude 50° to latitude 30°. In the North it is called the "Striped Bass," in the South the "Rock-fish" or the "Rock." The neutral territory where both these names are in use appears to be New Jersey. The fishermen of the Delaware use the latter name, those of the sea-coast the former. Large sea-going individuals are sometimes known in New England by the names "Green-head" and "Squid-hound." There is still some uncertainty regarding the southern limits of the distribution of this species. In the Saint John's River, Florida, they are very unusual. Though familiar in the fisheries of that region since 1873, I have only known of the capture of two individuals. Mr. Stearns has obtained one or two specimens in the Gulf of Mexico, and gives an account of the degree of their abundance in those waters. He writes: "They are occasionally caught on the northern shores of the Gulf, and are evidently more common about the mouths of the Mississippi River than elsewhere, since they are taken in this region only in seines, and in shallow water their abundance cannot be correctly determined. The earliest account I have been able to obtain of the capture of Striped Bass in Pensacola Bay is that of Capt. John Washington, of Mystic, Connecticut, who states that in 1850, while seine-fishing from the smack 'Francis Parkes,' he surrounded with his seine a large school of fish, which were quite unmanageable; a few of them were saved, and proved to be large Striped Bass, weighing from fifteen to forty pounds. At long intervals since solitary individuals have been taken at various points on the coast. At New Orleans it is found in the market quite often. An eighteen-pound specimen was sold there in March, 1880."

In Hallock's "Sportsman's Gazetteer" the following statement occurs: "It is constantly seen in rivers of fresh water at great distances from the ocean, even as far up the Mississippi as Saint Louis, and it is common in White River, Arkansas, and in all the rivers of the Southern States."

While there can be no question that straggling individuals of this species have been taken in the Gulf of Mexico, it seems probable that both Mr. Stearns and Mr. Hallock have been mistaken by the resemblance of this species to the Brassy Bass, *Roccus interruptus*, which abounds throughout the Lower Mississippi Valley.

Canadian authorities inform us that, though the Bass still occur along the New Brunswick and Nova Scotia shores of the Gulf, they are much less abundant and of smaller size than formerly. They have been known to ascend the Saint Lawrence as far as Quebec, and Mr. Roosevelt has seen a specimen, a female fish, which was taken in the Niagara River, near Lewiston. The Bass is most abundant in the bays and inlets about Cape Hatteras, in the Chesapeake and Delaware Bay region, and in the protected waters of Long Island and Southern New England. In winter they occur in considerable numbers in the Altamaha River, and are not unusual in the markets of Charleston, South Carolina.

HABITS.—The Striped Bass is not migratory, being found along our coast in winter as well as in summer, and in our markets in every month of the year. Great quantities are taken in winter in the rivers tributary to the Chesapeake, and in the rivers of New Brunswick quantities of them are speared through holes in the ice. During the past four years I have known of their capture in Long Island and Block Island Sounds and in the Merrimac River in December, and in Martha's Vineyard Sound and the lower part of the Hudson River in January. Though they appear to avoid a temperature higher than 65° or 70° they are not sensitive to cold, and there is good evidence that they frequently, when detained throughout the winter in shallow places, enter upon a state of torpidity.

FOOD.—They are very voracious feeders. Entering the rivers, they prey upon small fishes.

They are particularly abundant at the time of the spring runs of the shad and herring, and at this season are particularly plump and well fed, doubtless owing to the ease with which they can obtain food. They also frequent the rocky shores of the bays and sounds at high tide in search of crabs, shrimps, and squids; and they are said to feed upon clams and mussels, which they obtain by delving with their snouts.

REPRODUCTION AND GROWTH.—They spawn in the late spring and early summer, some of them in the rivers, others probably at sea, although this has not been definitely ascertained. The European Bass are said to deposit their spawn near the mouths of rivers in the summer months. From North Carolina to New Jersey the spawning time appears to be in May; in New Brunswick in June. Dr. Blanding, many years ago, estimated the number of eggs at 2,248,000. Their rate of growth is very rapid. Dr. C. C. Abbott, for five successive years, found in the Delaware River young an inch long in the second week in June. About the middle of October these had grown to the length of four and a half inches. The young fish—five to nine inches in length—which are taken in such quantities in the Potomac in February and March, are supposed to be the young of the previous year. Captain Gavitt, of Westerly, Rhode Island, has caught Bass in June that weighed from one-half to one pound, put them into a pond and taken them out in the following October, when they weighed six pounds. The average size of this fish probably does not exceed twenty pounds. In the Potomac, Hudson, and Connecticut Rivers the largest seldom exceed thirty or forty pounds, though in the Potomac fifty-pound fish are not unusual. The Fish Commission has for several years had a standing offer of a reward for a sixty-pound fish from the Potomac, but none has been forthcoming as yet. The largest Striped Bass on record was one weighing one hundred and twelve pounds, taken at Orleans, Massachusetts, in the town cove. Such a fish would be at least six feet in length. A fairly proportioned Bass thirty-six inches long would weigh at least eighteen pounds.

USES.—The Striped Bass is one of the most valuable of our food-fishes, its flesh being firm, finely flavored, and hard enough to bear exposure to the air for some time without injury. It is also the most popular game-fish, next to the salmon. Those in the markets are chiefly obtained in seines and traps set at various points along the coast from the south side of Cape Cod to New Jersey. Great quantities are also taken in shad seines in the spring.[1] They may be readily taken, also, by heaving and hauling in the surf with menhaden bait, the fish being tolled by the use of great quantities of menhaden ground into small bits, and in fresh or brackish water by the use of the artificial fly. At various points on the coast of Southern New England are club-houses supported by wealthy amateurs for the purpose of carrying on these sports.[2]

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[1] Messrs. Christian, Austin, Haight, McKeel, Van Nort Brothers, and about forty others from Peekskill and Verplanck's Point, have about four hundred nets fishing on the ice between Gees Point and Warner's Island, and from the way they are shipping the Striped Bass to New York and Peekskill they must be doing quite a business. On the 14th and 15th instant they shipped about 800 pounds each day, and on the 16th they shipped about 1,200 pounds, and on the 18th they had over 1,000 pounds. They sell them at wholesale for nine and ten cents per pound, and at retail for twelve cents. They use nets about twelve feet square, with two and a quarter inch meshes, to which they attach lines and heavy weights, and sink them about forty feet below the ice. The average weight of the Bass is about one and a half pounds, but a large number have been caught that weigh from twelve to fifteen pounds. They lift their nets at the ebb and flood tides, but are usually caught on the flood tide. The river being clear of ice from this point all the way to New York accounts for their coming from down the river to this place to fish.—*Springfield Republican*, May 24, 1878.

[2] "The Island of Cuttyhunk is about sixteen miles from New Bedford, at the extreme southwesterly boundary of Buzzard's Bay, whose foaming billows wash its northern shore, while the ocean itself beats upon the south, and near Penekese, the island school of Professor Agassiz. The Cuttyhunk Club own about three hundred acres of land, and have the exclusive right to fish on the shores and in the ponds of the island. When the club was first formed they stocked one of the ponds on the island with Black Bass, and these have multiplied so plentifully that they are now caught in large numbers. No fishing was allowed for three years from the time the pond was stocked. Perch and trout are also plenty in ponds on the island. Twenty-six fishing stands have been built at Cuttyhunk, and they

It has already been stated that the Striped Bass are believed to be less abundant in the Gulf of Saint Lawrence than in former years; similar complaints are heard from the Bay of Fundy and from Cape Cod, where the period of diminution is believed to date from the last advent of the Bluefish, about 1850. The bass fishery in Cape Cod Bay was formerly of great importance, but the capture of this fish is now of rare occurrence.[1] The early settlers of New England seem to have been more impressed by the abundance of Bass than by any other circumstance connected with the fisheries, and the early chronicles are full of allusions to their exceeding plenty and excellence. Capt. John Smith saw so many in one river that he declares that he thinks he might have walked across on their backs dry-shod. While there can be no doubt that north of Cape Cod their numbers have decreased, there is no reason to believe that elsewhere on our coast the fisheries have had any special effect upon them. A Hessian officer, writing in 1777, declared that enormous numbers were at that time brought to New York, and the same might be said at the present day. Three fishing gangs at Bridgehampton, New York, took over 8,000 in less than a week, in December, 1874. Capt. Charles Ludlow secured at one set of his seine 1,672 Bass, or about three and a half tons; shortly afterwards a New London fisherman brought in 419 Bass, 185 of which had been caught with a hook in three hours. Near Norfolk, Virginia, 1,500 have been taken with a single set of the seine. A few years ago, it is stated on credible authority, that 600 were once taken, the average weight of which was eighty pounds. In the first half of June, 1879, one fisherman near Fire Island, New York, caught and sent to New York the following quantities of Bass:

	Pounds.
June 2	1,222
June 4	1,137
June 5	913
June 6	1,521
June 8	1,298
June 9	1,255
June 14	1,258
June 18	1,560
Total	10,164

extend completely round the island. These stands are built upon prominent rocks, and are supported above the breakers by iron rods. Foot bridges, supported in the same way, are built from the shore to the stands. The stands are all named or numbered, and are drawn for every night by the members of the club. A member drawing a stand can fish from it the next day, or it can be used by any one else by his permission. The stands bear such names as 'Nashawena Point,' 'Canepitset,' 'Old Water Line,' 'Cove Point,' 'Little Bass,' 'Big Bass,' and 'Gulf Rocks.' The stands are all removed after the season is over, to be put up again the next year. 'Central Park' seats have this season been placed on the bluffs round the island at convenient points, from which to watch the fishing at each stand, so that members who are not lucky enough to secure favorite stands can sit with ease and enjoy the sport of their fellow-members. The favorite fishing is for Striped Bass, and, during the best of the season, the sport is commenced as early as three o'clock in the morning. A record is kept at the club house of the daily catch, by whom caught, where taken, on what station, the number of fish, weight, and date. Some members of the Cuttyhunk Club also belong to the West Island Club, which controls only five acres of land. The West Island Club is limited to thirty members, with an admission fee of $1,000." (Correspondent.)

[1] The harbor and contiguous waters were, in early times, as is well known, richly supplied with great varieties of fish. Bass were abundant many years, so that generally three hundred quintals were ready for market in a single season; *few*, comparatively, of these are now taken. We say *few* in comparison with former days. They are still taken in goodly numbers, and the way of bass-fishing at Race Point affords a finely athletic exercise for chest and limbs. The fisherman stands on the beach and throws out the line with sinker attached as far as strength will permit, and then hauls in, dragging a bouncing fish, if the throw be a good one.—History of Cape Cod (Freeman), ii, 1862, p. 623.

Three hundred Bass, of good size, were taken at one haul with a seine on Yarmouth Flats on Tuesday last. These fish are taken in abundance in our harbor at this season of the year. Many of them are packed in ice and sent to the Boston market, where they bring a good price. "Going a-bassing," as it is termed, is both a pleasant and profitable amusement.—*Barnstable Journal*, July 30, 1829.

Capt. Sam. T. Soper, Provincetown, took seven hundred Bass last Saturday. Fish were seined. Mr. Stephen A. Mayor also caught three hundred Bluefish off the harbor one day last week at one haul.—*Barnstable Patriot*, October 19, 1858.

Wood, writing in 1634, remarked: "The Bass continue at Lynn from the middle of April to Michaelmas" (September 29).

Allen Look, of Tisbury, Massachusetts, testified before the fishery committee of the Massachusetts legislature, in 1870, that in 1845 he caught twenty-seven tons, or about 17,000 Striped Bass, in Tisbury Great Pond, and that the largest catch within the pond from 1865 to 1870 was one hundred, taken in December, 1869.[1]

The following extract from a Newport (Rhode Island) paper for 1861 shows how abundant these fish have been in past years in Narragansett Bay:

"As an evidence that fish are not scarce in our waters, the recent haul of Bass by hook and line is evidence. Within a week the market has been more than supplied, as the following will show:

"Purchased by Samuel Albro: Of Nason & Tenant, 1,339 pounds; William James, 960 pounds; W. A. Munroe, 429 pounds; Dunwell & Gladding, 1,500 pounds; James Hazard, 357 pounds.

"Purchased by Carry & Co.: Of George Crabb, 950 pounds; John Heath, 130 pounds; James Read, 300 pounds; Edward Smith, 60 pounds; G. Dunwell, 50 pounds.

"Henry Gladding & Co. shipped to New York 1,100 pounds. Making a total of 7,175 pounds for one week, and these were all taken from the rocks at the south end of the city."

The Rock-fish has been propagated artificially by the United States Fish Commission, the first experiment having been made by Mr. Holton in 1873, supplemented by more satisfactory operations in 1879, under the direction of Major Ferguson, when about 400,000 eggs were hatched out and turned loose in Salmon Creek, North Carolina. The species was introduced into California some years ago, and Jordan reported in 1880 that several specimens had been captured along the coast.

143. THE WHITE BASS—ROCCUS CHRYSOPS (Raf.) Gill.

This species is generally known by the name of "White Bass"; occasionally as "Striped Bass." Its greatest abundance is in the Great Lake region, although it has a wide distribution in the Ohio and upper tributaries of the Mississippi, and is found in many streams farther south. It frequents chiefly the lakes and ponds and the deeper parts of the rivers. It feeds upon minnows and the like, usually taking the hook readily, and is considered gamy by the angler. As a food-fish it ranks high, being little inferior to the Black Bass. Its usual weight is from one to three pounds. The White Bass is said to be an excellent fish for cultivation in artificial ponds. Like most of its relatives, this species spawns in late spring.

"It is frequently taken in the Ohio River," writes Jordan, "and frequents chiefly deep or still waters, seldom ascending small streams. It is said to thrive well in ponds."

This is doubtless the Silver Bass of Canada (*le Silver Bass du Canada*), the details of whose introduction into France, and successful propagation by M. Carbonnier, from 1877 to 1879, are recorded by that experimenter in the "Bulletin of the Society of Acclimation for 1881."[2]

The following notes upon the abundance of the White Bass, *Roccus chrysops*, in the Great Lakes and bays adjacent have been made by Mr. Kumlien:

Two instances only of the presence of this species at and in the vicinity of the Apostle Islands are known to Mr. Bantin. Some of the other fishing points of that region are as follows: Sand Island, York and Rock Islands, Magdalen Island, Chequamegan Point, and Siscourt and Fry Bays.

[1] Four hundred Bass were taken at a single haul in Tisbury Great Pond, Martha's Vineyard, on one day last week, and shipped to New York.—*Gloucester Telegraph, November* 23, 1870.

A cargo of four hundred and nineteen Striped Bass, one of which weighed more than fifty pounds, was brought into New London by an old fisherman a few days since. One hundred and eighty-five of them were caught with a hook and line in three hours.—*New York Evening Post, December* 1, 1874.

[2] *Bulletin Mensuel de la Société d'Acclimation, viii, No. 2, p. 10.*

In all other parts of Lake Superior this fish is not recorded as being known. In the fishing grounds at the north end of Green Bay, White Bass are known only as stragglers. Farther down the bay, about Cedar River, they are rare, but are more common on the shoals between Menomonee and Peshtego. They are taken principally in September, are important, and command a ready sale. They do not frequent deep water. Between Peshtego and Longtail Point, including the fishing points at Maple Bend, Pensaukee, Gail's Point, and Oconto Bay, White Bass are rather common, and important during August and September; at other times they are seldom taken. They are caught in the pound-nets, are much sought for early in autumn, and are shipped principally to Saint Louis.

The White Bass is a beautiful, clean-looking fish, presenting a fine appearance and bearing shipment well. At Green Bay City, the southern extremity of Green Bay, this species is abundant. On the eastern shore of Green Bay, bordering upon the counties of Door and Kewaunee, and as far north as Saint Martin's Island, they are taken in small quantities in autumn, but are not abundant enough to be shipped.

At Jacksonport, on the western shore of Lake Michigan, a few White Bass are taken in autumn. At Two Rivers they are not rare in September. A couple of dozen may be found among one or two thousand pounds of fish, and then may be entirely absent for a long time. At Manitowoc they are often taken in some numbers in September, when large runs sometimes occur, and then none are taken, perhaps, for two or three years. During the last three years very few have been taken. Mr. Patterson, of that district, thinks the bass family is increasing in the vicinity of Manitowoc.

At Milwaukee White Bass used to be so abundant that they were largely caught on hooks off the piers, but now only a few are taken in the pound-nets. At the south end of Lake Michigan White Bass come in great numbers in April and September, entering the river, but not being taken to any extent in the pound-nets. The principal fisheries of that region are those of New Buffalo and Michigan City. Here they run small, and are of no commercial importance.

White Bass are abundant on the eastern shore of Lake Michigan, between New Buffalo and Saugatuck, making their first appearance during the warm days of May or June. At this time they strike in from the lake in great numbers. They remain about the mouth of Saint Joseph's River till September, and sometimes October, and even ascend the river several miles. After September they work out into the lake again. They associate with the Black Bass in schools. They are not sufficiently abundant, however, to be of any commercial importance, as no seining is done; if that kind of fishing were carried on, almost any number might be taken. The White Bass is considered one of the "game" fish. Specimens have been taken weighing over three pounds. When coming in from the lake to the river they are very light in color, but become darker during their stay. Mr. Hatch has put specimens in his fish ponds, the bottom of which is of black muck, and these have become black on the back.

Along the eastern shore of Lake Michigan, from Allegan County to Leelenaw County, they are reported as quite common, especially about Manistee, Ludington, and Point au Sable, but as having been less abundant this year (1880) than usual. At Grand Haven they are plentiful and of a large size. About and in Grand Traverse Bay, Little Traverse Bay, and Fox Islands, they must be of great rarity, the first instance of their occurrence known to Miller, in this region, having been in Little Traverse Bay during the summer of 1880. Off the shores of Emmet, Cheboygan, and Presque Isle Counties, Michigan, which coast line includes the northeast portion of Lake Michigan, the Straits of Mackinaw, and the northwest portion of Lake Huron, White Bass are by all pronounced rare. Captain Coats reports the capture of three in 1880, and thinks they are

decreasing in abundance; and Captain Dingman says he has not taken half a dozen in fifteen years' fishing. Some report them as more plentiful about river mouths and bayous. At Alpenà, Thunder Bay, Mr. Case knows of but four or five White Bass having been caught.

On the fishing grounds of Saginaw Bay, including also those of Charity Islands, a very few White Bass are occasionally taken in May and the first part of June. They were never abundant in this region. South of Saginaw Bay, on the western shore of Lake Huron as far as Port Huron, White Bass are not at all abundant, and are now far less abundant than formerly. Those now taken are captured principally in the Saint Clair River, though they occur, sparingly, however, on both the American and Canadian shores of the lake between Point aux Barques and Port Huron. From Toledo to the mouth of the Detroit River, Lake Erie, they are now rather rare, so much so as to render them of no commercial value. Formerly they were plenty. In Lake Erie, about the mouth of Maumee Bay, White Bass are not so abundant, as they once were. They now occur principally in the bay, ascending the Maumee River until prevented by obstructions. At present they are not taken in sufficient numbers to be of any commercial value. No reason can be assigned for their sudden decrease in this locality. In 1865 a catch of from ten to thirty tons was an event of no rare occurrence, and now it is seldom that more than one to two hundred pounds are taken at a lift.

On the fishing grounds of Ottawa City, Toussaint, and Locust Point, White Bass are now quite rare and of no importance. Formerly they were very abundant. On the reefs off Port Clinton they are still taken in some quantities with the Black Bass. On these reefs no driving is possible, but the leads are buoyed up across the reefs, and the heart and pot stakes are set in the mud off the rocks.

In the vicinity of the Huron fisheries and Sandusky Bay, White Bass have decreased very much within a few years, and in fact are now rather scarce. At present, in early fall and late spring a few are taken; some years, almost none. They occur at all the fisheries, without any apparent choice of locality. They are a good market fish, but do not keep well during warm weather; are sold fresh, if possible, but a good many are salted. Rank higher than the herring. This species is now almost extinct on the same grounds where they were once fairly swarming. The following is said to be true, and many prominent men of Sandusky offer to corroborate it, unlikely as it sounds: In May, 1855, off Marble Head light-house, with a twenty-two-foot net, sixty rods leader and old-fashioned funnel, were taken out, at one lift, forty tons of White Bass! This was at that time the only pound between Huron and Marble Head. On the same ground, from March 28 to May 4, twelve hundred dollars' worth were taken in one net. For many years they were considered the most abundant fish in the vicinity of Sandusky. It is also thought that they were the most destructive of all fish to the white-fish. Mr. Anthony says he saw in 1848, on the Ottawa beach, the white-fish eggs driven up on the shore inches deep after a heavy gale, and it was well known to the fishermen that in spring the White Bass swarmed on the spawning grounds of the white-fish for the purpose of devouring the young fish. No one seems to have any theory about their sudden and mysterious decrease. It is also remarked that simultaneous with the disappearance of the White Bass the herring and blue pike increased. The fishermen consider them so destructive to other fish that their decrease is welcomed with satisfaction.

The white-bass fishery was very important at Huron, Ohio, some years ago, but the fish have decreased, and now the catch is almost nominal. At Vermillion, Ohio, White Bass are not very abundant; they are caught principally early in spring and during the first few days of autumn fishing. They average less than one pound in weight. Formerly they were more abundant and of a larger size. A few are salted. Between the mouth of Black River and Brownhelm Bay

White Bass are taken in considerable numbers in the small pounds, close inshore; most of the pound-nets are set in water too deep for this fish. Until two years ago they were abundant, and after that time (1878) few were taken until the fall of 1879, when they again appeared in considerable numbers. The average weight in these localities is about one pound. They are graded as "soft" fish, but have an excellent sale, and if sold separately bring a higher price than soft fish. They are said to spawn close inshore during the latter days of May. Between Black River and Vermillion there are now only three nets set in water shallow enough to take them in abundance.

At the Cleveland and Dover Bay fisheries White Bass are quite plentiful, much more so than the Black Bass. There is a great difference in the average size in different years, although in those years when they are small they are none the less numerous. The "runs" occur early in spring. They are classed as "soft" fish. At Conneaut and Ashtabula they are considered a rare fish. They do not frequent deep water, and consequently are not taken in the gill-nets. On the Lake Erie shore of Lake County, Ohio, White Bass are quite common. About five tons were caught at Painesville in the autumn of 1879. They are generally large fish, and are caught at all seasons during calm weather, but strike for deep water during wind storms. Off Erie, Pennsylvania, Mr. Olds says he has known of the occurrence of one very large school, but they are generally considered quite rare.

At the principal points on the New York shore of Lake Ontario the occurrence of White Bass is thus noted: At Oswego they are not abundant. They occur principally in the lake, but are also found in the river. At Port Ontario only one or two specimens have been known. At Cape Vincent they are rarely caught, and are of no commercial importance. Those consumed are brought, for the most part, from Canada. At Chaumont a very few are occasionally caught; the fish here are of no importance. At Sacket's Harbor very few occur. They have slightly increased, rather than the reverse, in abundance.

144. THE YELLOW BASS—ROCCUS INTERRUPTUS.

This species is, so far as known to us, always known as the Yellow Bass. It is found throughout the lower course of the Mississippi, ascending the tributaries which are deep and sluggish, but not running past rapids or into the upper courses of the rivers. Jordan states that its range extends up the Ohio to the mouth of the Wabash or beyond, though it does not seem to be common anywhere except in the Lower Mississippi. It probably enters salt water, but of that we have no certain information. It is taken in considerable numbers in the regions where found, and is graded with the White Bass, which it much resembles in size and color. Little is known in regard to its habits. The criterion by which it may be distinguished from the White Bass is the low membrane connecting the two dorsal fins. Its color is yellow, not silvery, and the black stripes are very prominent.

145. THE WHITE PERCH—ROCCUS AMERICANUS.

Next in importance to the Striped Bass is the so-called White Perch, *Roccus americanus*. This fish occurs in brackish water in the mouths of rivers, and even, in many instances, in fresh-water ponds, where it had become land-locked, and all along the coast from Georgetown, South Carolina, to Nova Scotia. Dr. Yarrow states that it abounds in the Tar and Neuse Rivers, North Carolina. In the Chesapeake and tributary streams it is exceedingly abundant. It also abounds in the lakes and streams of the Saint John River, New Brunswick, and in the vicinity of Halifax, Nova Scotia. It has been claimed by certain observers in Florida that White Perch were formerly abundant in that region, and the market-men of New Orleans state that they were common in Lake

Pontchartrain until the "Bonnet Carré crevasse" changed the water from salt to fresh. Mr. Stearns, having investigated the subject, is of the opinion that they are mistaken.[1] The habits of this fish have been but little observed; in fact, it has been the custom of nearly all writers on our fishes to speak slightingly of it. It found an earnest advocate in Mr. Thaddeus Norris, who, after protesting strenuously against the statement of various writers that it is rarely brought to market for food, that it is only fit for chowder, that it is not of sufficient importance to merit particular notice, and so on, goes on to state, what is undoubtedly true, that in season the White Perch is *the* pan-fish, excelled by none of the Philadelphia, Baltimore, Washington, Norfolk, and Richmond markets; and he might have added, had he been writing at the present time, of the New York market also, for there is, probably, no fish of its size which is more universally popular throughout the Eastern States than the White Perch. In a single paragraph Mr. Norris, who, though he made no professions of scientific skill, has been one of our best observers of fishes, has given almost the only reliable information which has ever been collected regarding this species. "Its most natural habitat is in fresh tidal rivers, where it is found on flat clay and muddy bottoms, and in shallow water. It is frequently found far above the terminus of the tide, and is often more abundant in fresh than in brackish water in the season of the year when sought for by anglers. This fish, when found in salt-water creeks, is darker in color, but there is no specific difference. The White Perch is a congener of the magnificent Rock-fish, and is frequently found feeding in the same place and in his company. Its average length is eight or nine inches; it is not often more than twelve, though in rare instances it is found fourteen inches long.

"White Perch hibernate in the deep waters of our bays, and ascend the fresh tidal rivers soon after the ice and snow-water have run off. They feed greedily on the spawn of other fish, particularly that of the shad; on insects, crabs, minnows, and on the migratory schools of young eels which are found in the months of April and May in great numbers at any rapid or dam obstructing the upward flow of the tide. Perch usually spawn in May and then resort to deeper waters to recuperate, and all summer long are found by the angler ever swimming around the deep-sunk pier or the timbers of the rickety old bridge, snapping at shrimps or chasing the minnows; at flood tide high up amongst the water-lilies, and never refusing a bait, if of the right sort and properly presented."[2]

Dr. C. C. Abbott has added some important observations. He found female fish heavy with apparently ripe ova as late as June 10. The largest specimens of White Perch taken in the Delaware weighed, respectively, one pound nine ounces, one pound thirteen ounces, and two pounds one ounce. These were caught in a shad net in May, 1865, at the fishery opposite Trenton. The average adult fish may be said to measure eight inches and weigh from seven to nine ounces. He continues: "I believe, for reasons to be given, that the growth of the young is very rapid, and that the August Perch are young hatched late in the preceding May and April; in June these August Perch measuring about two and a half to three inches in length. . . . I should judge that spawning occurred between May 10 and June 10, usually nearer the former than the latter date. This is based on the fact of having gathered very young fish, the age of which I *guessed* from the general condition and amount of development of the specimens. After the middle of June the White Perch are found in localities widely different; even waters with a dense growth of lily and river weed are found to contain them in apparent health and vigor—spots where the Rock-fish could not live a day. Still later in the summer, as the young Perch become quite strong and

[1] Certainly the Bonnet Carré crevasse never drove the White Perch out of Lake Pontchartrain. That lake now contains small Sharks, *Trygon*, *Pogonias Bairdiella*, and hosts of fish of salt-water habits, with less liking for fresh water than the White Perch.—D. S. JORDAN.

[2] American Angler's Book, p. 90.

of some size, the river, although in and above tide-water, fairly teems with them. At this season they go in schools, sometimes of large size. I have known of twelve, fifteen, and twenty dozen August Perch being taken with a line in as short a time as from three to five hours. Fishing in this way a line with half a dozen hooks is used, and worms, sturgeon spawn, or live minnows are used as bait. These schools of small Perch I supposed to be broods of the preceding May, and that they kept together until late in November. They pass down to the salt water and there separate. Larger adult fish are not as restless as these smaller ones, and are found in deeper water, and usually in the tide-waters. In their feeding habits the White Perch agree very closely with the rock-fish. In all their habits, in fact, the two fish are much alike, and in the Delaware they are always associated, the most noticeable difference in their habits being the ability of the Perch to remain and thrive in warmer waters than the Rock-fish is ever found frequenting."[1]

So much has been said by the standard authorities in past years regarding the inferior quality of this fish as an article of food that it seems worth while to recur to this point, and to state that at the present time there is no fish found in the markets of our seaboard towns which is more generally a favorite for frying, or, as the phrase goes, as a pan-fish, than the White Perch.

146. THE BLUEFISH FAMILY—POMATOMIDÆ.

THE BLUEFISH.—POMATOMUS SALTATRIX.

NAMES.—This fish, which on the coast of New England and the Middle States is called the Bluefish, is also known in Rhode Island as the "Horse Mackerel"; south of Cape Hatteras as the "Skipjack"; in North Carolina, Virginia, and Maryland it is said to be called the "Green-fish." Young Bluefish are in some parts of New England called "Snapping Mackerel" or "Snappers"; about New Bedford "Blue Snappers"; to distinguish them from the Sea Bass they are sometimes spoken of as the "Bluefish." About New York they are called "Skip Mackerel," and higher up the Hudson River "White-fish." In the Gulf of Mexico the name "Bluefish" is in general use.

DISTRIBUTION.—This species is widely distributed—in the Malay Archipelago, Australia, at the Cape of Good Hope, at Natal and about Madagascar; in the Mediterranean, where it is a well-known and highly-prized food-fish in the markets of Algiers, though rare on the Italian side. It has been seen at Malta, at Alexandria and on the coast of Syria, and about the Canaries. It has never been seen on the Atlantic coast of Europe, and, strangely enough, never in the waters of the Bermudas or any of the Western Islands. On our coast it ranges from Central Brazil and the Guianas through the Gulf of Mexico and north to Nova Scotia, though never seen in the Bay of Fundy. From Cape Florida to Penobscot Bay, Bluefish are abundant at all seasons when the temperature of the water is propitious. It is not yet known what limits of temperature are the most favorable to their welfare, but it would appear, from the study of the dates of their appearance during a period of years in connection with the ocean temperature, that they prefer to avoid water which is much colder than 40°. It is possible that the presence of their favorite food, the menhaden, has as much influence upon their movements as water temperature. It is certain that few Bluefish are found on our Middle and Southern coast when the menhaden are absent; on the other hand, the Bluefish do not venture in great numbers into the Gulf of Maine at the time when menhaden are schooling and are at their greatest abundance. Their favorite summer haunts are in the partially protected waters of the Middle States, from May to October, with an average temperature of 60° to 75°. The menhaden, or certain schools of them, affect a cooler climate and thrive in the waters of Western and Central Maine in the months when the harbor temperatures are little above 50° and 55°, and that of the ocean considerably lower.

Professor Baird has published in the First Report of the United States Fish Commission an

[1] Report U. S. Fish Commis., part iv, 1878, p. 375.

exhaustive account of the habits of the Bluefish which will be quoted from freely in this chapter. The presence of quotation marks will be sufficient to indicate the source of the paragraphs taken from his essay without further reference to his name.

"MOVEMENTS AND MIGRATIONS.—The Bluefish is pre-eminently a pelagic or wandering fish, and like many others, especially of the *Scombridæ*, is apparently capricious in its movements, varying in numbers at particular localities with the year, and sometimes disappearing from certain regions for a large fraction of a century, again to return as before. The cause of this variation it is impossible to explain, being due in some instances, probably, to the disappearance of its favorite food in consequence of its own voracity, or for other undetermined reasons.

"*They occur during the summer throughout the entire range indicated for the United States*, but are much larger in size and in greatest abundance from the coast of New Jersey northward. From New Jersey southward, in the season mentioned, with the exception of an occasional wandering school, they are generally only about eight to twelve inches in length, representing, *therefore, in all probability, individuals of the second year's growth.*

"They appear to have a regular migration along our coast, presenting themselves later and later in the spring, the farther they are found to the north, and disappearing in the inverse order from the same regions in the autumn. First noticed on the Carolina coast as early as March and April, immense schools of them, bound eastward, are seen off the coast of the Middle States from the middle of May to the middle of June,[1] and in October similar bodies, perhaps embracing fewer individuals, pass to the southward. It is possible, however, that in the autumn some schools *move well out to sea, and are, therefore, less likely to be observed. They leave the northern coast* about the middle of October, and about the middle of November appear in vast numbers off the coast of North Carolina, where, from Nag's Head, in Currituck County, to Cape Lookout, there is a very extensive fishery prosecuted, which furnishes Bluefish for the Northern markets. It is *estimated that at least one hundred and fifty crews are engaged in this fall fishing*, which lasts generally until late in December. At this time individuals may be taken weighing fifteen to eighteen pounds, although their average size is about ten.

"Their occurrence in autumn off the coast of North Carolina is preceded and first indicated by the vast schools of menhaden, which they follow in, several miles from the sea, and by the usual accompaniment of flocks of gulls attending them to take a share in the feast. Of the particular mode of fishing in this neighborhood we shall take occasion to speak hereafter.

"According to Dr. Yarrow, the Bluefish are first seen in spring on the North Carolina coast (the smaller ones first) in March or April, when, however, they are much less in size than the specimens referred to as occurring in the fall. The precise time of their appearance at most of the points farther north has not yet been ascertained. Whether they actually migrate from south to north, and *vice versa*, or merely come in from the outer seas in regular order, as is believed to be the case with the shad, etc., has not been settled, although the former supposition appears the more probable. They reach the New Jersey coast some time in the early part of May, and usually appear at Newport and in Vineyard Sound (the time varying with the season) from the middle of May to the first week in June. They are expected at Edgartown from the 25th to the 30th of May; but I am informed that, on their first arrival, they feed at the bottom, and sometimes for a while are not seen at the surface at all, seldom being taken with the hook, but caught in large numbers in pounds and with the gill-net, usually along the lower edge of the net. According to Dr. Yarrow,

[1] *In the Chesapeake, according to Dr. Wilkins, at Hunger's Wharf, Virginia, the Taylor is one of the most abundant fish, as many as four thousand being caught at one lift of the pound. The average size is about three pounds. They come about the first of June and leave early in October.*

they are not taken with the hook about Beaufort until about the 1st of July. They do not bite, however, in Vineyard Sound until from the 10th to the 15th of June, when they appear on the surface, and are caught in large numbers in the usual manner."

In the first week of May, 1878, about a thousand Bluefish, weighing four pounds each, were caught off Long Island at Canarsie and West Hampton. This is about two months earlier than is usual for them to be taken in any considerable numbers.

"PERIODICITY.—Great interest attaches to this fish in consequence of the changes in its abundance, and even its actual occurrence on our coast, within the historic period. The precise nature and extent of the variation has not been established, nor whether it extended along the entire coast or not. Its earliest mention for our waters is in the work of Josselyn ('New England Rarities Displayed,' 1672), where, on page 96, he mentions the 'blew-fish, or horse,' as being common in New England (his residence was on the New Hampshire coast, or near by in Maine,) and 'esteemed the best of sort of fish next to rock-cod.' He says: 'It is usually as big as the Salmon, and a better meat by far.' He also, on page 24, catalogues two kinds of 'Blew-fish' or 'Houndfish'; the 'Speckeled Houndfish' and the 'Blew Houndfish, called Horsefish.' There appears to be no species to which this reference could apply excepting the subject of our present article, this being the opinion of Mr. J. Hammond Trumbull, who has devoted much research to determining the modern equivalents of ancient Indian names of animals, and to whom I am indebted for the hint. Mr. Trumbull also remarks that in a manuscript vocabulary obtained by President Stiles, in 1762, from a Pequod Indian at Groton, Connecticut, there is mentioned the 'Aquaundunt or Blue-fish,' clearly the same as what now bears that name, which shows that this fish was found in Fisher's Island Sound in 1762.

"Again, according to Zaccheus Macy,[1] the Bluefish were very abundant about Nantucket from the first settlement of the English on the island, in 1659, to 1763, and were taken in immense numbers from the 1st of June to the middle of September. They all disappeared, however, in 1764, a period of great mortality among the Indians of that island. It has been suggested that the disease which attacked the Indians may have been in consequence of an epidemic in the fish upon which they fed, or else that it invaded both fish and Indians simultaneously, resulting in almost their entire extermination.[2]

"According to Dr. Mitchill, this fish was entirely unknown about New York prior to 1810; but they began to be taken in small numbers about the wharves in 1817, and were abundant in 1825. Immense numbers were caught at the Highlands in 1841. The doctor remarks, as has been done repeatedly by others, that as the Bluefish increased, the squeteague or weak-fish diminished in about the same ratio.

"According to Mr. Smith, of Newport (Rhode Island), his father used to catch Bluefish some time about the year 1800, when they were very abundant and of large size, weighing from sixteen to eighteen pounds.

"Capt. Francis Pease, of Edgartown, also testified that his father spoke of large Bluefish at the end of the preceding century, some of them weighing forty pounds. This leaves an interval between 1764 and toward the end of the century in which no mention is made of the Bluefish, and which may probably indicate its absence, as during that time there were many works published

[1] Collections Massachusetts Historical Society for 1794, iii, 1810.

[2] "From the first coming of the English to Nantucket (1659) a large fal-fish, called the blue-fish, thirty of which would fill a barrel, was caught in great plenty all round the island from the 1st of the sixth month (June) till the middle of the ninth month (September). But it is remarkable that in the year 1764 . . . they all disappeared, and that none have ever been taken since. This has been a great loss to us."—*Ibid.*, 1792, p. 159. Zaccheus Macy's Account of Nantucket."

relating to the local history and domestic economy of New England, and which would doubtless have taken note of so conspicuous a fish had it been present.

"Whether they existed uninterruptedly during the century intervening between Josselyn's time, 1672 (or even 1659, according to Macy), and 1764, I am at present unable to say. According to Captain Pease, they were known about Edgartown at the end of the last century.[1] As already stated, Dr. Mitchill speaks of their first making their appearance about New York in 1810. They are noted as having been seen in Vineyard Sound again as early as 1820. It would therefore appear that they were in such small numbers about New York in 1810 that the young only were noticed flocking about the wharves, and that in ten years they were observed as far east as Nantucket, where the specimens seen from 1824 to 1826 were very small, not over four inches. The next year they measured seven, and the third year ten inches, according to the testimony of one witness, although this does not represent, in all probability, the rate of growth.

"According to Captain Burgess, of Monument, Massachusetts, they were caught about Nantucket in 1825, and were very abundant in 1830. Dr. Storer states the first Bluefish recorded as having been noticed in the present century north of Cape Cod was captured on the 25th of October, 1837. Captain Atwood remarks that in 1838 he saw Bluefish for the first time about Provincetown. These were very small, the largest weighing only two pounds. In a few years, however, they became larger and more numerous, and finally increased to such an extent as to exercise a very marked influence upon the fisheries. According to the captain (Proceedings of Boston Society of Natural History, 1863, p. 189), they arrive in Massachusetts Bay in a body, coming at once, so as to almost fill the harbor at Provincetown. In one year they came in on the 22d of June, and although the day before eight thousand mackerel were taken, the day after not one was seen or captured. He says that they leave about the last of September, with the first cold northeasterly storm, although stragglers are taken as late as December at Provincetown.

"According to Messrs. Marchant and Peter Sinclair, of Gloucester (October, 1872), Bluefish made their first appearance in numbers about Cape Ann twenty-five years ago, coming in great force and driving out all other fish. They are now much scarcer than twenty years ago; about the same as tautog; some seasons scarcely noticed.

"Mr. J. C. Parker, an aged gentleman of Falmouth, says the first Bluefish seen at Wood's Holl in this century was taken in July, 1831; but his father informed him that they were abundant in the preceding century, about 1780 or 1790, at which time they disappeared; and that when the Bluefish left, the scup first made their appearance. They are also noted as having shown themselves at the head of Buzzard's Bay in 1830 and 1831, and, although numerous, were of small size, measuring about a foot in length.

"To sum up the evidence, therefore, in regard to the periodical appearance of the Bluefish, we find notice of its occurrence in 1672, or even 1659, and up to 1764. How long it existed in the waters prior to that date cannot now be determined. The oral testimony of Mr. Parker refers to its occurrence at Wood's Holl in 1780 or 1790; and it is mentioned by Mr. Smith as being at Newport in 1800, and at Edgartown, Massachusetts, about the same time by Captain Pease. Mitchill testifies to its occurrence in New York, of very small size, in 1810; and it is recorded as existing again at Nantucket in 1820, and about Wood's Holl and Buzzard's Bay in 1830 to 1831; and a little later at Hyannis. In 1830 it had become abundant about Nantucket, and in the fall

[1] President Dwight bears witness to the fact that Bluefish were abundant in the Narragansett Bay region as late as 1780. "The Horse Mackerel formerly frequented this coast in immense numbers, and in the season were constantly to be found in the market. But about the close of the Revolutionary war they forsook our waters and have not made their appearance since. They were esteemed a great delicacy, and are the largest of the mackerel species.—Note on Fishes of Newport, Rhode Island. Dwight's Travels, iii, 1822, p. 50.

of 1837 it was first noticed in Massachusetts Bay; and then year by year it became more and more numerous, until now it is very abundant. Several accounts agree in reference to the very large size (even to forty or fifty pounds) of those taken in the last century.

"Further research into ancient records may tend to throw more light on the early history of the Bluefish, and even materially to change the conclusions already reached. It will be observed that the references to its occurrence, from 1780 to 1800, are on the testimony of aged persons who have heard their fathers speak of it, although I find no printed records anywhere in reference to it between 1764 and 1810. The rate of progression to the north of Cape Cod I have at present no means of indicating, although they probably gradually extended farther and farther north, and may possibly occur much farther east than we have any mention of at present.

"During the present century the maximum of abundance of these fish off the middle coast of the United States appears to have been reached from 1850 to 1860. The testimony elicited from various parties, as well as from printed records, indicates a decrease since that period much greater in some localities than others. About New York they are said to have been unusually plenty in the summer of 1871, but farther East the diminution which had been observed in previous years appeared to continue."

Since the writing of the above, in 1871, there has been no special change in the abundance of Bluefish. They are quite sufficient in number to supply the demand for them and to make great inroads upon the other fishes, some of which, like the menhaden and mackerel, would perhaps, if undisturbed by the Bluefish, be more valuable than they are at present. They have now been with us for fifty years. Their numbers are subject to periodical variation, of the cause of which we are ignorant. It is to be regretted that there are no records of it in the South Atlantic States. If such existed, we might, perhaps, learn from them that the Bluefish remained in those waters while absent from the northern coasts. Only one statement is to be found which covers this period, although Lawson, in his "History of North Carolina," published in 1709, and Catesby, in his "Natural History of the Carolinas," published in 1743, refer to its presence. In "Bartram's Travels," published in 1791, "Skipjack" is mentioned as one of the most abundant fish at the mouth of the Saint John's River. When Bluefish again became abundant their presence was first noticed at the South, and they seem to have made their inroads from that direction. The Bluefish was unknown to Schoepf, if we may judge from his work on the "Fisheries of New York," published in 1787. Dr. Mitchill recorded their frequent capture about New York in 1814, though before 1810 they are said to be unknown in that locality. In 1825 they were abundant here, and in 1841 immense numbers were captured in the Vineyard Sound, and about Nantucket they were on the increase from 1820 to 1830. It is certain that they had not reappeared in 1822 in Narragansett Bay, for in "Bertram's Travels" it is stated that, though formerly abundant, they had not been seen in that region since the time of the Revolution.

The first one which was noticed north of Cape Cod was captured in October, 1837, while we have no record of their appearance about Cape Ann before 1847.

FOOD AND VORACITY.—The Bluefish is a carnivorous animal of the most pronounced type, feeding solely upon other fish. In this connection it cannot be out of place to reprint Professor Baird's remarks upon this subject, which have been so often quoted during the past ten years:

"There is no parallel in point of destructiveness to the Bluefish among the marine species on our coast, whatever may be the case among some of the carnivorous fish of the South American waters. The Bluefish has been well likened to an animated chopping-machine, the business of which is to cut to pieces and otherwise destroy as many fish as possible in a given space of time. All writers are unanimous in regard to the destructiveness of the Bluefish. Going in large schools,

in pursuit of fish not much inferior to themselves in size, they move along like a pack of hungry wolves, destroying everything before them. Their trail is marked by fragments of fish and by the stain of blood in the sea, as, where the fish is too large to be swallowed entire, the hinder portion will be bitten off and the anterior part allowed to float away or sink. It is even maintained, with great earnestness that such is the gluttony of the fish, that when the stomach becomes full the contents are disgorged and then again filled. It is certain that it kills many more fish than it requires for its own support.

"The youngest fish, equally with the older, perform this function of destruction, and although they occasionally devour crabs, worms, etc., the bulk of their sustenance throughout the greater part of the year is derived from other fish. Nothing is more common than to find a small Bluefish of six or eight inches in length under a school of minnows making continual dashes and captures among them. The stomachs of the Bluefish of all sizes, with rare exceptions, are found loaded with the other fish, sometimes to the number of thirty or forty, either entire or in fragments.

"As already referred to, it must also be borne in mind that it is not merely the small fry that are thus devoured, and which it is expected will fall a prey to other animals, but that the food of the Bluefish consists very largely of individuals which have already passed a large percentage of the chances against their attaining maturity, many of them, indeed, having arrived at the period of spawning. To make the case more clear, let us realize for a moment the number of Bluefish that exist on our coast in the summer season. As far as I can ascertain by the statistics obtained at the fishing stations on the New England coast, as also from the records of the New York markets, kindly furnished by Middleton & Carman, of the Fulton Market, the capture of Bluefish, from New Jersey to Monomoy, during the season, amounts to not less than one million individuals, averaging five or six pounds each. Those, however, who have seen the Bluefish in his native waters, and realized the immense number there existing, will be quite willing to admit that probably not one fish in a thousand is ever taken by man. If, therefore, we have an actual capture of one million, we may allow one thousand millions as occurring in the extent of our coasts referred to, even neglecting the smaller ones, which, perhaps, should also be taken into the account.

"An allowance of ten fish per day to each Bluefish is not excessive, according to the testimony elicited from the fishermen and substantiated by the stomachs of those examined; this gives ten thousand millions of fish destroyed per day. And as the period of the stay of the Bluefish on the New England coast is at least one hundred and twenty days, we have in round numbers twelve hundred million millions of fish devoured in the course of a season. Again, if each Bluefish, averaging five pounds, devours or destroys even half its own weight of other fish per day (and I am not sure that the estimate of some witnesses of twice this weight is not more nearly correct), we will have, during the same period, a daily loss of twenty-five hundred million pounds, equal to three hundred thousand millions for the season.

"This estimate applies to three or four year old fish, of at least three to five pounds in weight. We must, however, allow for those of smaller size, and a hundred-fold or more in number, all engaged simultaneously in the butchery referred to.

"We can scarcely conceive of a number so vast; and however much we may diminish, within reason, the estimate of the number of Bluefish and the average of their captures, there still remains an appalling aggregate of destruction. While the smallest Bluefish feed upon the diminutive fry, those of which we have taken account capture fish of large size, many of them, if not capable of reproduction, being within at least one or two years of that period.

"It is estimated by very good authority that of the spawn deposited by any fish at a given time not more than thirty per cent. are hatched, and that less than ten per cent. attain an

age when they are able to take care of themselves. As their age increases, the chances of reaching maturity become greater and greater. It is among the small residuum of this class that the agency of the Bluefish is exercised, and whatever reasonable reduction may be made in our estimate, we cannot doubt that they exert a material influence.

"The rate of growth of the Bluefish is also an evidence of the immense amount of food they must consume. The young fish which first appear along the shores of Vineyard Sound, about the middle of August, are about five inches in length. By the beginning of September, however, they have reached six or seven inches, and on their reappearance in the second year they measure about twelve or fifteen inches. After this they increase in a still more rapid ratio. A fish which passes eastward from Vineyard Sound in the spring, weighing five pounds, is represented, according to the general impression, by the ten to fifteen pound fish of the autumn. If this be the fact, the fish of three or four pounds which pass along the coast of North Carolina in March return to it in October weighing ten to fifteen pounds.

"As already explained, the relationship of these fish to the other inhabitants of the sea is that of an unmitigated butcher; and it is able to contend successfully with any other species not superior to itself in size. It is not known whether an entire school ever unite in an attack upon a particular object of prey, as is said to be the case with the ferocious fishes of the South American rivers; should they do so, no animal, however large, could withstand their onslaught.

"They appear to eat anything that swims of suitable size—fish of all kinds, but perhaps more especially the menhaden, which they seem to follow along the coast, and which they attack with such ferocity as to drive them on the shore, where they are sometimes piled up in windrows to the depth of a foot or more.

"The amount of food they destroy, even if the whole of it be not actually consumed, is almost incredible. Mr. Westgate (page 33) estimates it at twice the weight of the fish in a day, and this is perhaps quite reasonable. Captain Spindle goes so far as to say that it will destroy a thousand fish in a day. This gentleman is also of the opinion that they do much more harm to the fishes of the coast than is caused by the pounds. They will generally swallow a fish of a very large size in proportion to their own, sometimes taking it down bodily; at others, only the posterior half. The peculiar armor of certain fish prevents their being taken entire; and it is not uncommon to find the head of a sculpin or other fish, whose body has evidently been cut off by the Bluefish. In the summer time the young are quite apt to establish themselves singly in a favorite locality, and, indeed, to accompany the fry of other fishes, usually playing below them, and every now and then darting upward and capturing an unlucky individual, while the rest dash away in every direction. In this manner they attend upon the young mullet, atherinas, etc. They are very fond of squid, which may very frequently be detected in their stomachs. In August, 1870, about Fire Island, Mr. S. I. Smith found their stomachs filled with marine worms, a species of *Heteronereis*, which, though usually burrowing in the mud, at that season swims freely toward the surface *in connection with the operation of reproduction. This, like the squid, is a favorite bait for the* Bluefish; and they appear to care for little else when these are to be had. This fact probably explains the reason why, at certain seasons, no matter how abundant the fish may be, they cannot be taken with the drail or squid boat."[1]

[1]The following extract from the "Gloucester Telegraph" of June 4, 1870, gives an idea of their influence upon other fishes:

"ABUNDANCE OF FISH IN NEW JERSEY—1870.—Accounts from New Jersey say that the Bluefish came in at Barnegat Inlet last week, sweeping through the bay, over flats as well as through the channel, driving millions of bushels of bunkers before them and filling the coves, creeks, ditches, and ponds in the meadows full. At Little Egg Harbor Inlet they drove shad on shore so that people gathered them up by wagon-loads. Fish lie in creeks, ponds, etc., along

The Bluefish are believed to have had a very important influence upon the abundance of other species on some parts of the coast. This has been noticed especially on the north side of Cape Cod. South of Cape Cod the small fish occur in such enormous abundance that even the voracity of millions of Bluefish could hardly produce any effect upon them. Captain Atwood has recorded his belief that the advent of the Bluefish drove away the plaice or large flounder from those waters, not so much by their direct attacks upon them as by destroying the squid upon which the latter formerly subsisted. He is also of the opinion that the mackerel once, for a time, were affected by them. The mackerel have since returned to those waters in their wonted numbers, but the Bluefish are not now sufficiently plenty north of Cape Cod to interfere with them. The flight of the mackerel was not an unmitigated evil, however, since, as Captain Atwood pointed out, the number of lobsters for a time was very considerably increased. The mackerel fed upon their eggs, and when they were driven away by the Bluefish the lobsters had a better chance to multiply.

"The Bluefish sometimes make their way up the rivers to a considerable distance, the adults, however, apparently never entering the perfectly fresh water. They are found in the Potomac as far north as Aquia Creek, and also far up the Hudson; indeed, the young of the year are taken as high as Sing Sing on the Hudson and other tidal rivers, where the water is entirely fresh."

REPRODUCTION.—"Little is known of their reproduction. Dr. Yarrow does not give any facts in regard to this subject, at Fort Macon, except that spawn was seen to run out of a small female caught July 14. Dr. Holbrook is also silent on this head. Mr. Genio C. Scott says the spawning beds are visited by the parent in June, and consist of quiet nooks or bays. Mr. R. B. Roosevelt states that very diminutive young occur in immense numbers along the coast at the end of September or beginning of October ('Game Fish of America,' 1862, 159). I found the young fish at Carson's Inlet, Beasley's Point, New Jersey, in July, 1854, two or three inches in length, and more compressed than the adult; but farther east, on Vineyard Sound, although diligent search was conducted, between the middle of June and the first of October, with most efficient apparatus in the way of fine-meshed nets, I met with nothing excepting fish that made their appearance all at once along the edge of the bay and harbor.

"According to Captain Edwards, of Wood's Holl, a very accurate observer, they have no spawn in them when in Vineyard Sound. This statement is corroborated by Captain Hinckley; and Captain Hallett, of Hyannis, 'does not know where they spawn.' The only positive evidence on this subject is that of Captain Pease, who states it as the general impression about Edgartown that they spawn about the last of July or the first of August. He has seen them when he thought they were spawning on the sand, having caught them a short time before, full of spawn, and finding them afterward for a time thin and weak. He thinks their spawning ground is on the white sandy bottom to the eastward of Martha's Vineyard, toward Muskeeget. While not discrediting the statement of Mr. Pease, it seems a little remarkable that so few persons on the eastern coast have noticed the spawning in summer of the Bluefish; and, although there may be exceptions to the fact, it is not impossible that the spawning ground is in very early spring, or even in winter, off New Jersey and Long Island or farther south. It is not impossible that, at a

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the meadows two feet deep, so that one can take a common fork and pitch them into a boat or throw them on the bank. In some places they lie in windrows on the meadows where the tide has taken them, so they take large wood-scows alongside and load them."

1857.—"Bluefish were very plenty off our shores in the early part of autumn. They are great enemies to the menhaden; and for several days such a war raged that the beaches were strewn with dead fish, chiefly of the latter species. Mr. Lewis, the historian, said that in two tides he picked up nine bushels and buried them in his garden for manure.—LEWIS AND NEWHALL, p. 452. History of Lynn.,

suitable period after spawning, the young, in obedience to their migratory instinct, may move northward along the coast, growing rapidly as they proceed. This explains the almost sudden appearance of fish of five inches about Wood's Holl.

"We have the statement of Dr. Yarrow that vast schools of small Bluefish were met with in Beaufort Harbor during the last week in December, 1871. These were in company with small schools of young menhaden and yellow-tail shad, and were apparently working their way toward the sea by the route of the inlet. When observed, they were coming from the southward through the sound, moving very slowly, at times nearly leaving it, and then returning. The largest were about four inches in length, and others were much smaller; and as many as twenty schools were observed from the wharf at Fort Macon, each of them occupying an area of from sixty to eighty feet square, and apparently from four to six feet in depth. I would not be much surprised if these fish should prove to have been spawned late in the year off the southern coast."

Diligent research by numerous inquirers during a period of ten years has failed to add anything of importance to what Professor Baird has already stated in the paragraph above quoted, and it may be regarded as almost certain that Bluefish do not spawn in our inshore waters. The only important contribution to our knowledge on this subject is found in the notes of Mr. Silas Stearns, who believes that he has abundant evidence of their spawning in the Gulf of Mexico. His remarks are quoted in full below. The Hon. Robert B. Roosevelt records that he observed the bluefish fry less than an inch in length in the inlet of Far Rockaway, New York, on the 10th of July.

SIZE.—"The size varies considerably with season and locality, those spending the summer on the southern coast, according to good authority, rarely exceeding two or three pounds in weight, and being generally considerably less. The largest summer specimens are those found farther to the eastward, where they are not unfrequently met with weighing from ten to fifteen pounds, although this latter weight is quite unusual. Mr. Snow, however (page 44), mentions having seen one of twenty-two pounds, and others give as their maximum from fourteen to twenty. The average size of the schools in Vineyard Sound, during the early season, is from five to seven pounds. The schools, however, that make their appearance in October embrace many individuals of from ten to fifteen pounds. It is, therefore, not improbable that the difference between the first-mentioned average and the last represents the increase by their summer feeding. As already remarked, Bluefish in the last century sometimes attained a weight of forty or fifty pounds in Vineyard Sound; according to Zaccheus Macy, thirty of them would fill a barrel."

"Forest and Stream," June 25, 1874, states that L. Hathaway, esq., a veteran fisherman, while fishing from the bridge at Cohasset Narrows, Massachusetts, with rod and reel, captured a Bluefish weighing twenty-five pounds. The largest previously caught weighed seventeen pounds.

"On getting back to the Carolina coast in the early part of November, according to Dr. Yarrow's statement, they are from three to five feet in length and weigh from ten to twenty pounds. What becomes of these large fish, that so few of them are seen in the early spring, it is impossible to say. If it be really true that they are much scarcer than in the fall, we may infer that their increased size makes them a more ready prey to the larger fish and cetaceans, or that they have accomplished their ordinary period of life; possibly that they have broken up into smaller parties, less conspicuous to observation, or that they have materially changed their locality. The average length of the fish that appear in the spring off the coast of Virginia and the southern part of New Jersey, according to Dr. Coues, Dr. Yarrow, and my own observations, is about one foot, being probably about one year old. As a general rule, those of the smaller size keep close to the shore and can always be met with, while the larger ones go in schools and remain farther outside.

"I was unable to obtain any very young fish about Wood's Holl in 1871, the smallest found making their appearance quite suddenly along the coast, especially in the little bays, about the middle of August, and then measuring about five by one and one-fifth inches. By the end of September, however, these had reached a length of seven or eight inches, and at the age of about a year they probably constitute the twelve or fourteen inch fish referred to as occurring along the southern coast. The fish of the third year, or those two years old, are possibly the three-pound fish, while the five to seven pound fish may be considered a year older still. Accurate observations are wanting, however, to determine these facts; as also whether they require two years, or three or more, to attain sufficient maturity for breeding. As far as I know, there is no appreciable difference between the sexes in their rate of growth or weight, excepting that the female is likely to be a little deeper in the body."

A Bluefish weighing one pound measures about fourteen inches; two pounds, seventeen inches; three pounds, twenty-one inches; four pounds, twenty-four inches; five pounds, twenty-six inches; six pounds, twenty-six to twenty-seven inches, and eight pounds, twenty-nine inches.

STEARNS ON BLUEFISH IN THE GULF OF MEXICO.—Mr. Stearns' notes on the occurrence of the Bluefish in the Gulf of Mexico are so important that they are quoted here in full:

"The Bluefish is abundant in West Florida and as far west as the Mississippi River, but is rare or not found at all in other parts of the Gulf. At Pensacola and vicinity it is at certain seasons one of the most important fishes of trade. Here it is caught only in seines and when migrating, during the months of April, May, June, November, and December. It usually appears on the coast in April—sometimes a little sooner—and comes from the southeast, swimming directly in from deep water, or parallel to the land, according to the condition of the sea. It sometimes swims near the surface, either to sport or prey upon smaller surface-swimming fishes, but more commonly at some depth in shoal water along the beach. Many schools are observed through the months of April, May, and June approaching the land from the eastward, and it is supposed that there are several distinct 'runs' in that period. These 'runs' take place every year, although much larger some years than others. It is usually the case that the fish arriving in the spring are small, averaging two and a half pounds weight, and that those caught in the fall are larger, averaging four pounds or more. A few very large individuals are found in both seasons.

"In May and June Bluefish enter the bays. They remain for some days in the swift tideways when inside, and then disappear almost entirely from observation. A few are taken through the summer with hook and line in the bays and at sea. Excepting the smallest ones, all the Bluefish contain spawn when they arrive in the spring. With the larger fish the spawn is nearly ripe, and with the small and intermediate size is found in nearly all stages. April 29, 1879, I examined two female Bluefish, weighing seven and eight pounds, and found spawn almost ripe enough to flow from the oviduct. The same day others, smaller ones, were examined, in which the ovaries were scarcely visible. The spawning season of the Bluefish includes several months, I think, which are May, June, July, and August.

"There can be no doubt of its spawning in the bays, sounds, and bayous, as all evidence gained goes so far to prove it. On June 18, 1878, and August 9, 1878, I caught young Bluefish of about three-quarters of an inch in length in Pensacola Bay. These fry were very active and gave me no little trouble in capturing them. Their color was a brilliant green, which faded considerably when placed in alcohol. These, with others, were sent to the National Museum with my collections of that year. Many other specimens of about that size were seen in August, but escaped my net. During the months of November and December many small schools of Bluefish are seen to pass out of the inlets, and, if there is not much surf, to follow along the beach eastward.

Bluefish of all sizes may be seen at this time, the smaller ones measuring in length three to five inches, the intermediate sizes ten, twelve, and fifteen inches, and the large ones from the last-mentioned size to a size weighing fifteen or eighteen pounds. Ten pounds is not an unusual weight for large Bluefish, but those of eighteen pounds are rare. Bluefish are said to be more abundant on this coast than formerly, and any change in the last five years has tended to an increase rather than a decrease. It is an exceedingly voracious fish, preying upon any kind of fish through which its teeth can cut and which its jaws can surround. I think its migratory movement on this coast is caused more on account of its food becoming scarcer in cold weather than on account of its being influenced by the change of the temperature of the water, for on the coldest days of the year (in December) Bluefish are sometimes caught in shoal water in great abundance as well as at any other time. The Bluefish is one of the choicest food-fishes of this coast, and is much used, both fresh and salted."

EARLL ON THE BLUEFISH IN NORTH CAROLINA.—Below is given an outline of the winter Bluefish fisheries of the Southern coast as gathered from notes made during the visit of Mr. R. E. Earll to that region:

The large fish are taken in two localities—first, a few miles off Cape May, and again on the Carolina coast between Cape Henry and Ocracoke Inlet. They are most abundant between Cape Hatteras and New Inlet. Small fish frequently enter the sounds during the summer months, and have long been taken by the residents. The larger ones seldom enter the inlets, but remain near the outer shore, where they feed upon the menhaden, shad, and alewives, during the season of their migrations to and from the larger sounds in fall and spring.

Apparently, the first that was known of the presence of large Bluefish in this region was in 1842, when a quantity was taken in a haul-seine near New Inlet. Gill-nets were first used for the capture of the species in this locality in 1847, though they were not generally adopted till several years later. The first vessel visited the region in 1866, and from that date to 1879 six to twelve sail came regularly to the locality. The fishery reached its height between 1870 and 1876, when in addition to the vessels fully one hundred crews of five men each fished along the shores. The catch varies greatly from time to time, as the fish are constantly on the move and often go beyond reach of the seines and gill-nets. Some seasons each boat's crew has averaged four or five thousand fish weighing ten to fifteen pounds each, and again they have taken almost nothing. Frequently the bulk of the catch of an entire season is taken in three or four days.

Since the winter of 1877 and 1878 the fish are said to have been much less abundant and of smaller size. In the winter of 1879 and 1880 about seventy-five crews were engaged in the fishery from the first of November till Christmas. The total catch did not exceed fifty thousand fish averaging six pounds each. The small number taken is partially accounted for by the fact that many of the fish were so small as to readily pass through the meshes without being caught.

During my visit in May, 1880, large schools of Bluefish were reported along the shore, and a considerable number of shad and other species were found upon the beach where they had been driven by their pursuers. A good many Bluefish were also stranded while in pursuit of their prey. It seemed that there is no reason to believe that the fish have permanently left the coast, or that they are even so scarce as is at present claimed, for the men have fished with little regularity, and have gone only a short distance from the shore, while the bulk of the Bluefish may have been farther out.

USES.—This is one of the most important of our food-fishes, and surpassed in public estimation only by the Spanish mackerel and the pompano. It may be said to furnish a large part of the supply to the middle and Northern States. It is a standard fish in New York, Boston, and

other seaports, and is carried in great numbers into the interior. Its flesh is very sweet and savory, but it does not keep very well. In the Vineyard Sound the fishermen are in the habit of crimping their fish, or killing them, by cutting their throats in such a manner that they bleed freely. Every one who has opportunities for observing admits that fish thus treated are far superior to any others. Great quantities of Bluefish are frozen in New York for winter consumption. They are still considered unfit for food on our Southern coast, and even in the markets of Washington, District of Columbia. I have frequently been stopped by fish-dealers who asked me to assure their customers that Bluefish were eatable. They are growing into favor everywhere, however, just as they did in Boston. Captain Atwood tells me that in 1865 but very few were sold in Boston, and that the demand has been increasing ever since. When he first went to Boston with a load of Bluefish he got two cents a pound for them; the second year they were scarcer and he got two and one-half cents, and the year afterwards three cents.

147. THE COBIA OR CRAB-EATER—ELACATE CANADA.

This fish, known in the Chesapeake Bay as the "Bonito" and "Coal-fish," and as the "Sergeant-fish" in Southern and Eastern Florida, and in Western Florida as the "Ling" or "Snooks," is considered one of the most important food-fishes of Maryland and Virginia, though it is but little known elsewhere. Like the Bluefish, it is cosmopolitan in its distribution, having been recorded in the seas of China and Japan, in Southeastern Hindostan, in the Malay Archipelago, on the coast of Brazil, in the West Indies and the Bermudas, where it is called the "Cubby-yew," and along our own shores from the Gulf of Mexico to Cape Cod. DeKay speaks of the capture of a single individual in Boston Harbor. The species was originally described by Linnæus from a specimen sent to him from South Carolina by Dr. Garden. The name "Sergeant-fish" refers to its peculiar coloration, several stripes of brown and gray being visible on the sides of the body. The name "Crab-eater" appears to have been ascribed to the fish by Dr. Mitchill. What is known of its habits may be very shortly told. Holbrook remarks: "The Crab-eater is a solitary fish; it prefers deep and clear water and is only taken singly with a hook. It lives on the coast of Carolina late in May, and is occasionally captured until September, when it is no longer seen in our waters. It is exceedingly voracious, and destroys many smaller fish, which make its ordinary food, though it does not reject crustaceous animals."

Mitchill cut up a specimen which he obtained in New York market in June, 1815, which had been caught in the bay. He found its stomach distended with food of various sorts, including twenty spotted sand-crabs and several young flounders. DeKay tells us that the specimen from which his description was taken was captured in a seine in the harbor of Boston and placed in a car with other fish. It was soon discovered that he had destroyed and eaten every fish in the car. These fish were chiefly sculpins or porgies. Mr. S. C. Clarke, speaking of the fish fauna of Florida, remarks: "This fish I have never seen except in the Indian River, where it is a common species, lying under the mangrove bushes in wait for prey like a pike, which it much resembles in form and in the long under jaw full of sharp teeth." The size is from two to three feet. It attains the length of five feet and the weight of fifteen or twenty pounds. Stearns writes: "It is said by Maj. E. B. Staples, of Sarasota, to be quite common in South Florida."

The Cobia breeds in the Chesapeake Bay, where in 1880 Mr. R. E. Earll succeeded in artificially fertilizing the eggs. Dr. Mitchill speaks of its availability as a food-fish in the highest terms.

148. THE TRIPLE-TAIL OR BLACK PERCH—LOBOTES SURINAMENSIS.

The Triple-tail of the New York market, *Lobotes surinamensis*, known in South Carolina as the "Black Perch," and to the fishermen of Saint John's River as the "Grouper," is also called

by various authors the "Black Triple-tail," and in 1856, according to Gill, was called in New York market the "Flasher." It is remarkable on account of its extraordinarily wide range, having been found in China, the Malay Archipelago, at Sunda and Molucca, in the Bay of Bengal, and in the Mediterranean about Sicily; at Ceylon, in the West Indies about Cuba and Jamaica, on the coast of South America, from Surinam, whence the first specimen was derived and from which locality the species takes its scientific name, and along the coast of the United States from Saint John's River to Wood's Holl, Massachusetts. The Triple-tail is a short, thick, heavily built fish. The dorsal and anal fins project backwards towards the base of the caudal so prominently as to give origin to the common name. When alive it is a very beautiful species, silvery and gray in color, but after death it soon becomes dingy—so dingy, in fact, that many of the common names are prefixed by the adjective "black." I saw four specimens at Jacksonville, Florida, on the 5th of April, 1875. The largest weighed about ten pounds and measured nearly two feet in length. The species is abundant about Charleston, where, according to Holbrook, it appears in June and remains until September. It feeds upon small fishes and mussels, and is said to take the hook readily when baited with clams or with shrimps. It is occasionally taken in the lower part of the Chesapeake Bay, and Professor Baird obtained specimens about three inches long in August among the eel-grass on Tuckahoe River in New Jersey. Stragglers have been taken at New York, and even as far north as Wood's Holl, Massachusetts. They are occasionally brought to the New York market, where they are highly esteemed. Gill, writing in 1856, said: "I saw a single specimen of this species in Fulton Market last year, which remained exposed on the stall from August 30 to September 6. It did not seem to be known. It was about fifteen inches in length, and one dollar was demanded for it." By the fishermen of Saint John's River, Florida, it is considered one of the finest food-fishes, and its large silver scales command a high price at the fancy shops, where they are sold to be used in the manufacture of scale works.

149. THE MOON-FISH—CHÆTODIPTERUS FABER.

The Moon-fish is one of the rarer species on our coast, and has recently come so much into favor in New York that among connoisseurs it is one of the most highly esteemed food-fishes. It is also highly esteemed by residents of Washington who know it, being abundant in the markets of that city in summer. In the northern parts of the Gulf of Mexico it is called the "Spade-fish"; from Florida to Charleston the "Angel-fish," a name which, according to Schoepf, appears to have been current during the last century at Beaufort, North Carolina, where it is called the "Porgee" or "Pogy," and at New York, where it is stated to be found in summer. "Three-tail Sheepshead" and "Three-tail Porgee" are names which are said to have been formerly in use among the New York fishermen.

The range of this species along our coast is very wide. It has been found in Guatemala, and perhaps farther south, and the British Museum has specimens from Texas, Santo Domingo, and Jamaica. It is said to be somewhat abundant on the coast of South Carolina, and not uncommon at the entrance to the Chesapeake Bay. They are occasionally taken about New York, and several individuals have been obtained by the Fish Commission at Woods' Holl. It is occasionally taken in Southern California, about San Diego. It attains the length of eighteen inches and the weight of several pounds. The large adult specimens have a peculiar globular bone in the head, unlike anything which has been found in any other fish. Two species have been recognized by American ichthyologists. It seems probable that these represent different ages of the same fish. The only study of its habits in existence is the following, which is quoted from Mr. Stearns' manuscript:

"The Spade-fish, *Chætodipterus faber*, is common on the West Florida, Alabama, and Louisiana

coasts. I have not observed it in South Florida. It is found throughout the summer and fall in the bays, about wharves, rock-piles, and old wrecks, where crustaceous animals are abundant. In October and November large schools are seen along the sea-beaches, evidently leaving the coast for warmer waters, at which time many are caught by seine fishermen. It spawns in early summer, and the young are seen until October. I have seen specimens of Spade-fish fifteen inches long; but the average size is not more than eight inches. It is an excellent pan-fish, selling readily in market."

This species is known to the fishermen of the Saint John's and Indian Rivers, Florida, under the name "Angel-fish." Holbrook states that it appears on the shores of South Carolina in May and June, and is then taken in considerable numbers with the seine. Jordan states that it is common at Beaufort, North Carolina, where it is used as a food-fish. Lugger remarks that it is not uncommon in the salt-water region near the entrance to Chesapeake Bay, but is seldom, if ever, brought to the Baltimore markets. DeKay remarks that in the waters of New York it only appears periodically, and occasionally in great numbers during the summer months. About 1822 they were caught here in seines in great numbers, and exposed in the markets for sale. I am not aware that any such incursion has since been observed. On the coast of California, where, according to Jordan, it is occasionally taken about San Diego in the kelp, it is too rare to be of commercial importance.

150. THE REMORA FAMILY—ECHENEIDIDÆ.

This family is represented on our coast by five species, which are generally known as "Suckers" or "Sucking-fishes." They are among the most remarkable of fishes, the first dorsal fin having become transformed into a sucking organ, by means of which the fish can attach themselves very firmly to the sides of vessels or to the gill-covers or sides of larger species of fish. One or two of the species, such as the *E. naucrates*, are frequently found adhering to the sides of vessels. Others attach themselves to sharks, and are carried by them from place to place. Since they are themselves excellent swimmers, the purpose of this peculiar habit is hard to understand. It appears to be more for the purpose of following the larger fishes in order that they may share the fragments of their feasts. Very often, especially in the case of sharks, the fish to which the Suckers attach themselves become very much emaciated and exhausted by the effort of swimming under this impediment. The common sword-fish is frequently accompanied by one of the Sucking-fishes, which has been called the "Sword-fish Sucker," *Remoropsis brachyptera*. It has not been known to attach itself to any other fish. The "Bill-fish," *Tetrapturus*, has another species of sucker peculiar to itself, the Cuban "*Pega de las Agujas*" *Rhombochirus osteochir*.

Mr. Stearns states that in the Gulf of Mexico, when on the snapper banks fishing, he has seen these fish leave sharks that were in the vicinity and remain about the vessel as long as it staid there for the purpose of securing the bait that had been thrown overboard. He noticed some that were four or five feet in length. These "Sucking-fish" are never eaten, and are interesting chiefly as enemies of other more important species.

The Remora was one of the first fishes observed by the early discoverers of North America. In Ogilby's "America" is the following description of the manner in which the Indians used these fishes as aids in the capture of other larger species. The incident seems to have occurred about the West Indian islands:

"*Columbus* from hence (from Cuba) proceeding on further Westward, discover'd a fruitful Coast, verging the Mouth of a River, whose Water runs Boyling into the Sea. Somewhat further he saw very strange Fishes, especially of the *Guaican*, not unlike an Eel, but with an extraordinary

great Head, over which hangs a Skin like a Bag. This Fish is the Natives Fisher; for having a Line or handsom Cord fastned about him, so soon as a Turtel, or any other of his Prey, comes above Water, they give him Line; whereupon the *Guaican*, like an Arrow out of a Bowe, shoots toward the other Fish, and then gathering the Mouth of the Bag on his Head like a Purse-net holds them so fast, that he lets not loose till hal'd up out of the Water."[1]

[1] Narrative of Voyage of Columbus, in Ogilby's "America," 1671, p. 49 (with very curious picture of Indian fishing).

P.—BARRACOUTA, MULLET, PIKE, AND MUMMICHOGS.

151. THE BARRACOUTA FAMILY—SPHYRÆNIDÆ.

This family is represented on our Atlantic coast by several species, none of which appear to be at all abundant north of Florida, except one species, which has recently appeared in considerable numbers on the coast of Southern Massachusetts, and which is recorded by Jordan as abundant in its young state in Beaufort Harbor, North Carolina. This species, called by DeKay *Sphyræna borealis*, is closely related to, if not identical with, *S. spet* of the Mediterranean. No specimens of greater length than ten or twelve inches have ever been taken, and individuals of this size are very unusual, though smaller ones, ranging from two to six inches, are occasionally found in large schools about the western end of Martha's Vineyard and about Wood's Holl, Massachusetts. It seems incredible that the young should occur so abundantly in these waters and the full-grown individuals should be absent. This is, possibly, because we do not yet know how to capture them. The common Barracouta, or "Barracuda," of the West Indies, *Sphyræna picuda*, occasionally finds its way into our northern waters, and one or two specimens of them and other West Indian species have been taken at Wood's Holl.

S. picuda is the common Barracouta of Key West and the southern coast. It is caught with hook and line, and appears occasionally in the markets. Mr. Stearns states that it is only of average merit as a food-fish. He records the capture of several very small specimens belonging to this genus in Pensacola and Choctawhatchee Bays in June, 1880. In the West Indies this, or some closely related species, grows to the enormous length of eight feet and the weight of forty pounds, and is as much dreaded as the large sharks.

Although to some extent used as food, this is one of the forbidden fishes of the Cuban markets, there having been instances of severe sickness caused by eating its flesh. Since, however, a large part of the best food-fishes of the West Indian waters are tabooed by Cuban law, this is hardly to be regarded as a fair criterion. In the Bermudas both *Sphyræna picuda*, called "Sennet," and *S. spet*, which is called the "Barracuda," are highly esteemed for food and meet with ready sale.

On the California coast occurs another species, *Sphyræna argentea*, which is everywhere known as the 'Barracuda,' or 'Barracuta'; this species reaches a length of about three feet and a weight of twelve pounds.

Professor Jordan remarks concerning it as follows: "It is abundant in summer from San Francisco southward, great numbers having been taken everywhere from Santa Cruz southward. It is found mainly at a distance of three miles or more from the shore. In open water it will sometimes take a still hook, but near the shore it must be trolled for. It arrives in late spring or summer, at different times in different places, the main 'runs,' about the Santa Barbara Islands, being in July; farther north, somewhat later. It spawns at San Pedro about the 1st of August. In September it usually disappears, but the young often remain in the south and are taken with the seine in the winter. It is not known whether it retreats to the south or to deep water. It feeds upon anchovies and other fishes. As a food-fish it is one of the best and most important on the coast. It is highly esteemed when dried and salted, and, like the white-fish and yellow-tail, then sells at a price higher than that received for the Alaska codfish."

152. THE DEAL-FISH FAMILY—TRACHYPTERIDÆ.

The members of this family are found in the deep parts of the sea in various parts of the world, though none have yet been found on our Atlantic coast. They are eel-shaped fishes of great length and brilliant colors, and have even been described under the name of "Sea-serpent." It is probable that most of the stories regarding the "sea-serpent" have had reference to some member of this family, and to this family most of the descriptions of large marine animals of a serpent-like nature are very applicable. Several individuals of the species known as the "Oar-fish," *Regalecus Banksii*, have been cast up on the British coast, the largest in Yorkshire, in 1845, twenty-four feet in length. In 1860, an individual, eighteen feet in length, ran ashore at the Bermudas, but none have been found in the more western portions of the Atlantic, although descriptions which have been given by various observers would indicate that they occasionally appear near our shores. On the Pacific coast there is a species which is sometimes cast ashore by the storms, *Trachypterus altivelis;* it is considered by the Makah Indians to be the King of the salmons, and they will permit no one to eat the flesh upon any condition, for fear the salmon will never return. It is curious that a similar tradition exists on the coast of Norway regarding a related species which is called the "Sillkung," or "King of the herring." "The same notion," says Jordan, "is commemorated in the generic name *Regalecus*."[1]

153. THE MULLETS—MUGIL ALBULA AND MUGIL BRASILIENSIS.

NAMES.—There are,upon our coast two species of Mullet, the differences between which are sometimes, though not always, recognized by fishermen. The most usual species is the Striped Mullet, *Mugil albula;* the other is the so-called "White Mullet," *Mugil brasiliensis*. The former is the larger, and has eight instead of nine rays in the anal fin, and forty-two instead of thirty-eight scales between the gill openings and the base of the caudal fin. There has been so much confusion among writers regarding the species of this family upon our coast that it has until very recently been impossible to define precisely their geographical range. The Striped Mullet occurs in the West Indies, the Gulf, and from Southern California to Chili, the other species from Southern Massachusetts to the West Indies, and from Lower California to Peru. A single specimen of *M. brasiliensis*, was taken at Provincetown, in November, 1851. North of New Jersey the capture of a large individual is very unusual. In July great numbers of them, about an inch in length, have been observed on the Connecticut coast, especially in the vicinity of Noank; the fishermen there call them by the name of "Bluefish Mummichog." On various parts of the coast they have special names, which, however, do not appear to refer to special peculiarities. About Cape Hatteras the names "Jumping Mullet" and "Sand Mullet" occur; in Northampton County, Virginia, "Fat-back," and in Southeastern Florida "Silver Mullet" and "Big-eyed Mullet." The name "Fat-back" is also in use, but whether this name is used for Mullets in general, or simply for those in particularly good condition, I have been unable to learn. In the Gulf of Mexico the Striped Mullet is known simply as the "Mullet"; the other species as the "Silver Mullet."

GENERAL HABITS.—There are seventy or more species of Mullets, one or more of which are found on every stretch of coast line in the world in the temperate and tropical zones. They live in the sea, and in the brackish waters near the mouths of rivers. They, like the menhaden, though indeed to a still greater degree, subsist on the organic substances which are mingled with the mud and sand on the bottom.

"In order to prevent the larger bodies from passing into the stomach, or substances from

[1] *Rex—halec*=King of Herring.

passing through the gill openings, they have the organs of the pharynx modified into a filtering apparatus. They take in a quantity of sand and mud, and after having worked it for some time between the pharyngeal bones, they eject the roughest and most indigestible portion of it. Each branchial arch is provided on each side, in its whole length, with a series of closely set gill-rakers, which are laterally bent downward, each series closely fitting into the series of the adjoining arch; they constitute together a sieve, admirably adapted to permit a transit for the water, retaining, at the same time, every other substance in the cavity of the pharynx. The intestinal tract is no less peculiar, and the stomach, like that of the menhaden, resembles the gizzard of a bird. The intestines make a great number of circumvolutions, and are seven feet long in a specimen thirteen inches in length."[1]

ABUNDANCE.—Although Mullets are abundant almost everywhere, it is probable that no stretches of sea-coast in the world are so bountifully supplied with them as those of our own Southern Atlantic and Gulf States, with their broad margin of partially or entirely land-locked brackish water and the numerous estuaries and broad river mouths. The Mullet is probably the most generally popular and the most abundant fish of our whole southern seaboard. Like the menhaden, it utilizes food inaccessible to other fishes, groping in the bottom mud, which it swallows in large quantities. Like the menhaden, it is not only caught extensively by man, but is the main article of food for all the larger fishes, and is the best bait fish of the regions in which it occurs. In the discussion of the habits of the Mullet, when it is not otherwise stated, the Striped Mullet, which is in our waters by far the most important species, is kept chiefly in mind.

Since the time of Capt. John Smith every observer has remarked upon the great abundance of Mullets. Numerous correspondents of the Fish Commission, from Wilmington south, agree that the Mullet is far more abundant than any other species, except Mr. Simpson, who thinks that at Cape Hatteras they are less numerous than the tailors or bluefish, and about as numerous as the fat-backs or menhaden.

In 1875 circulars were sent out by the United States Fish Commission asking information concerning the habits of the Mullet. The replies, although suggestive, were not sufficiently numerous to afford the data necessary for a complete biography of this species. In fact its habits are so peculiar that in order to understand them it will be necessary for some naturalist to devote a considerable period of time to study them throughout the whole extent of their range. At present, therefore, I propose to present first the results of my own observations upon this fish, as it occurs in Eastern Florida, supplementing them by the observations of three or four other observers upon the Atlantic coast, and the excellent study of the Gulf Mullet from the pen of Mr. Stearns.

MULLET IN EASTERN FLORIDA.—They abound in the Saint John's River, sometimes running up to the lakes, and along the coast in all the inland bays, or "salt-water rivers". It is probably incorrect to call them anadromous. They appear to ascend the rivers to feed, and the relative saltness of the water is a matter of small importance. Small Mullet are abundant all the year round, and so are scattered individuals of a larger size. Cast-nets at Mayport take them throughout the year. I have taken quantities of small fish, from one to five inches long, in the Saint John's River at Arlington. They begin to assemble in schools in midsummer. This is probably preparatory to spawning, for at this time the ova are beginning to mature. In midsummer they swim at the surface, pursued by enemies in the water and the air, and are an easy prey to the fisherman. They prefer to swim against the wind, and, I am told, school best with a northeast wind. They also prefer to run against the tide. The spawning season appears to continue from the middle of

[1] This description of the anatomy of the Mullet is derived from Günther's "Study of Fishes."

November to the middle of January, and the weight of evidence tends to show that they spawn in brackish or salt water. Some of the fishermen say that they go on the mud-flats and oyster-beds at the mouth of the river to deposit their eggs. What becomes of them after this no one seems to know, but it is probable that they spread themselves throughout all the adjacent rivers, bays, and sounds, in such a manner as not to be perceptible to the fishermen, who make no effort at this time to secure the spent, lean fish. Many of them probably find their way to the lakes, and others remain wherever they find good feeding ground, gathering flesh and recruiting strength for the great strain of the next spawning season. There is no evidence of any northern or southern coast-wise migration, the habits of the species apparently being very local.

The fisherman recognizes three distinct periods of schooling or separate runs of Mullet. To what extent these are founded on tradition, or upon the necessity of change in the size of the mesh of their nets, it is impossible to say. The "June Mullet" average about five to the pound; the "Fat Mullet," which are taken from August 20 to October 1, weigh about two pounds; these have, the fishermen say, a "roe of fat" on each side as thick as a man's thumb. The "Roe Mullet" weigh about two and a half pounds, and are caught in November and until Christmas. Between the seasons of "Fat Mullet" and "Roe Mullet" there is an intermission of two or three weeks in the fishing. How to interpret these curious statements is surely a difficult problem, and one which can be solved only by careful study of the fishes themselves at these seasons. The fishermen insist that these schools come successively down the river and proceed directly out to sea. They will not believe that the "Fat Mullet" and the "Roe Mullet" are the same schools under different circumstances. I would hazard the suggestion that the "Fat Mullet" of September are the breeding fish of November, with roes in an immature state, the ova not having become fully differentiated.

The largest fish appear rarely to exceed six pounds. This is exceptional, however. Mr. W. H. Tate, of Melton & Co., Jacksonville, tells me that he never saw one exceeding seven pounds, though he had heard of one weighing fourteen. He showed me on the floor of the fish-market a line indicating the length of a very large one; this measured twenty-nine inches. At Mayport none had been seen exceeding six pounds in weight. At the mouth of the Saint John's cast-nets of ten feet in diameter are used, but most Mullet are taken in gill-nets, which are swept around the school, the fish being easily visible at the surface.[1] These nets are from seventy to ninety fathoms long and forty meshes deep. The size of the mesh varies with the season. Very few are used from December to July, but where they are used the mesh two and one-half to two and three-quarters inches is preferred; from August 1 to October 1, for "Fat Mullet," the mesh is three and one-half to three and three-quarters inches, and in late October, November, and December, for "Roe Mullet," four inches—at least so said my informant, an intelligent negro fisherman. At Mayport there are two sweep-seines, seventy-five fathoms long and thirty feet deep, belonging to Kemp, Mead & Smith, used in the mullet fishery.

There is a large trade in fresh Mullet iced, of the extent of which I could gain but little idea: they are shipped chiefly to Central Florida and Georgia. Some have been sent in ice to Atlanta. About twenty thousand are shipped from Yellow Bluffs, by way of Jacksonville.

It is the general opinion of the fishermen that the Mullet have greatly diminished in abundance of late years, and that they are not one-third as plenty as they were ten years ago. This falling off is attributed to the presence of steamers, to the chances of the seasons, and, most of all, to the use of small-meshed seines, which catch the young fish in great numbers, and to the constant fishing by numerous nets, which destroys a large proportion of the mother-fish from year to year. Mr. Isaac

[1] "Roe Mullet" are often taken in a drift gill-net. When the net is being set it is customary to drum with the oars on the gunwale of the boat to make the fish "gill" better.

Balsam, of New Berlin, told me that ten or twelve years ago a man with a cast-net could easily take four or five hundred Mullet in a day, while now it is difficult to get any; this is due in part to their shyness. Mullet were comparatively scarce in the Saint John's in 1877, though plenty in 1876. The fishermen with whom I have talked favor the passage of laws prohibiting the use of gill-nets with a smaller mesh than three inches, and thus to allow the escape of the young fish, and of a close time during which fishing shall cease—for instance, from Saturday night to Monday morning. And then they say, with a regretful shake of the head, that the Mullet always run best on Sunday. There are probably one hundred or more mullet nets on the Saint John's, yielding an average of perhaps five thousand Mullet each, annually. The fisheries are chiefly carried on by negroes in small boats, dug-outs, and skiffs, although every resident fishes for Mullet in summer when there is nothing else to do, and when the Mullet is the best food and the easiest obtained. There is no salting business of commercial importance in East Florida, though considerable quantities are put up for domestic consumption. Salt Mullet sell at the rate of eight or ten dollars a barrel, or five or six fish for twenty-five cents. I had an opportunity of tasting some salted by a negro at Mill Cove, and can bear testimony to their excellence. Their flavor is more like that of a salted salmon than of a mackerel, and they are hard, toothsome, and not at all "muddy" in taste, this last being the usual charge made against the Mullet. Usually only the "Fat Mullet" are salted, the "Roe Mullet" coming later in the season, when they can easily be shipped.

To prepare a Mullet for salting, the head is first cut off, then a cut is made on each side of the back-bone, down the back, and the bone is removed; the fish may then be spread out flat and packed in a barrel. In packing, the flesh side is carefully placed up, the skin down. The fish are spread out flat upon the skin side and are laid in tiers across the bottom of the barrel, each tier being covered with salt. Care is taken to have the direction of the bodies in the different tiers at right angles to each other. When the Mullet are scaled before packing they command a somewhat higher price. Mullet roes, though usually eaten fresh, are sometimes salted and dried in the sun. In this condition they are eaten raw, like dried beef, or are fried. Large ones sell for ten cents a pair. Fishermen often boil the heads to extract the oil, which they use to lubricate their guns.

"In the Lower Saint John's," according to Capt. David Kemps, an experienced Connecticut fisherman who has lived and fished for twelve years at Yellow Bluffs, "the Mullet are resident throughout the year, though most abundant in September and October. The fishing season begins in July and August and continues until December. They are three times more abundant than any other species, though not half as abundant as they were ten years ago. The decrease in numbers is due in part to the fisheries, but chiefly to the great number of steamers. The largest Mullet weigh eleven pounds and are twenty-three inches long; this, however, is above the average size, which measures thirteen inches and weighs two and a half pounds. They attain their growth in four years, each year adding half a pound to their weight. They school best in easterly weather, the schools being largest toward the end of the season. They swim at the surface, and usually against the wind. The "Fat Mullet" come down the river in August and September, and rapidly increase in size, becoming "Roe Mullet" in October and November. They feed by suction and on blind mosquitoes. They run out into salt and brackish water to spawn. They are supposed to spawn in November, on the shallows near the mouth of the river, in warm and brackish water. When they are caught in the gill-nets the spawn runs out of them; it is of the size of No. 3 shot, and red; it floats at the surface until it is hatched, which takes place in about three days. They spawn at about four years of age, the fish mixing indiscriminately in the schools. Cat-fish and eels prey

upon the eggs. They are caught chiefly on the flood-tides with gill-nets and seines. A gill-net seventy-five fathoms long will take ten thousand in a season. They are eaten fresh, commanding a price of one to five cents a pound, and are salted largely. About seventy-five boats and one hundred and fifty men are employed in the Lower Saint John's."

In the Saint Mary's River.—"At the mouth of the Saint Mary's," according to Mr. W. E. Myers, "the Mullet is resident and more abundant than any other fish, especially in August, September, October, and November. The general abundance is not apparently changed, though the supply varies. The average "Finger Mullet" is about four and a half inches long, while the "Sea Mullet" ranges from eight to eighteen inches, weighing from eight ounces to two pounds. They never leave this region, but spend the whole time in the salt-water bayous along the coast. They frequently run up into brackish or almost fresh water, probably for the purpose of feeding. Fishes of all sizes and ages mingle together in the schools. Their favorite haunts are on the shallow mud-flats and up little creeks or "rivers." At high water they feed among the black rushes or marsh grass. The shallows which they frequent are warmer than the off-shore water. After spawning they are generally found in small schools. They are preyed upon by porpoises, sharks, fish-hawks, cranes, and gulls. They feed on bottom mud and floating scum, also on shrimps. They spawn around their feeding-grounds in August and September, and young Mullets are always found in abundance in company with the old. Fish-lice are found in their gills. At Saint Mary's they are caught exclusively in cast-nets—the Spanish and American kinds—at all seasons, but chiefly in August and the fall months. They are usually caught in the last quarter of the ebb and first quarter of the flood tide. They are caught only in small quantities for home consumption, and are more in demand than any other fish, selling for about eight cents per pound. Very few are salted."

In Southeastern Florida.—At Saint Augustine, according to Mr. Peter Masters, Mullet are resident, but most abundant in September and October. They are thought to have diminished, "owing," says Mr. Masters, "to the gill-nets on the Saint John's." They move in and out of the harbor, over the Saint John's and Smyrna Bars. They run into fresh water three months in the year. They spawn in deep water in November and December. Thirty or forty men with small boats are engaged in the fishery, using gill and cast nets. The Mullet is the favorite food-fish, commanding a price of three or four cents per pound. Very few are salted.

About New Smyrna, says Mr. S. C. Clarke, the "Silver or Big-eyed Mullet," though resident, are most plenty in November, December, and January, and have for years retained their abundance, which is much greater than that of any other fish. The average size is three pounds, though they sometimes weigh four or five; the female is the larger. They are always to be found in shoal water with muddy bottoms, spending the winter in the creeks and bays. They run into fresh water to feed. They swim in schools, assorted in uniform sizes, rippling the surface and thus attracting predatory birds of all kinds, and followed by predatory fishes. The schools break up after the spawning season. They feed upon mud and floating scum. They spawn in large schools, in strong currents, in January and February; the eggs, which are yellow and about the size of mustard seed, floating at the surface in the currents and hatching within ten days. They prefer warm water for spawning. The roe often runs from the fish when caught. They spawn at the age of three years, and after spawning are thin and unfit for food. Young fish are seen in great abundance in shallow water near the shore; they are preyed upon by every fish and by every predatory bird. Mullet are taken with nets of all kinds, usually at low water. Some hundreds of barrels are put up yearly for shipment, commanding the price of six to eight dollars. They are also used for oil manufacture, and for manure.

Mr. H. S. Williams states that in the Indian River the Mullet season lasts from May until the

last of December, and during the whole time they are so numerous that scarcely a day passes in which some cannot be taken with proper exertion. In September they usually commence schooling, the schools increasing in size until the last of December, when they go outside to spawn, returning in January, February, and March, poor and tasteless. In November, 1876, he relates, he took one hundred and twenty-five from a single school with a cast-net in less than an hour's time, taking twenty-six large ones at a single throw. During the dark nights in October, November, and December, the Mullet swarm along the shore, feeding on the minute animals found in the sand and attached to the rocks, where they can be taken in great numbers, often thirty to fifty in a few minutes' time. They are preyed upon by all larger fish, from cat-fish to sharks, while porpoises, ospreys, eagles, and pelicans consume enormous quantities. The Mullet is here thought very fine either stewed, baked, or as a pan-fish. From the first of November to the end of the season they take salt as well as mackerel, and every resident family is accustomed to cure a barrel or two for private use.

STEARNS ON MULLET IN THE GULF OF MEXICO.—This chapter will be closed by quoting in full the observations of Mr. Silas Stearns:

"The Mullet is one of the most abundant and valuable food-fishes of the Gulf coast. It is present on the coast and in the estuaries of the Gulf throughout the year, and in most places is pursued by fishermen at all seasons, yet, for so common and important a fish, its habits seem to be but little known or understood. Intelligent fishermen of long experience at particular points have learned many details regarding their local movements, which may disagree in many respects with those at some other point a hundred miles or so away. A few months spent on the southern part of the Florida coast has led me to believe that there is a less migratory movement of Mullet in that section than along the northern Gulf coast. It is probable that in each bay or section or coast Mullet have peculiar habits as to time and manner of arrival, time and place of spawning, and the general habits of old fish after spawning and young after hatching. It is also likely that their manner of spawning, feeding, etc., is the same everywhere. My own observations have been chiefly made in Pensacola and Choctawhatchee Bays and Santa Rosa Sound, which take in fifty miles of coast line. In this section, which I have called the Pensacola region, there is a spring 'run' of Mullet composed of various sizes of young which are in part, no doubt, of the previous year's hatching. The first school of this run appears on the coast in April or in the first part of May, and they continue to come for two or three weeks, when they are all inside and scattered about the bay shores. These fish are very thin on their arrival, but rapidly fatten and grow on the feeding grounds. Some of these contain spawn at first, and in some it is developed during the summer.

"In September and October there is a 'run' of large fish, which comes, as the young one does, from the eastward, swimming at the surface of the water and making considerable commotion. Some years there is but one large school in the 'run' and at others many small schools, and it is thought that the fish are more abundant when they come in the latter form. At Choctawhatchee Inlet, when the spawning grounds are near by, the fish come in with the flood tide and go out again with the ebb tide; and at the Pensacola Inlet, when the spawning grounds are far away, they come into the bay and stay until the operation of spawning is over. The spawn in this fall 'run' is fully developed, and is deposited in October and November. The spawning grounds are in fresh or brackish water at the heads of bayous, in rivers or heads of bays. The many bayous of Choctawhatchee Bay are almost blocked up with spawning Mullet in October, and they are very abundant at the head of Pensacola Bay near the mouths of fresh-water rivers at that time. Although I have been in the bayous when Mullet were supposed to be spawning, I have not witnessed the operation,

nor seen any person who has. In such places the bottom is grassy, sandy, and muddy, the water varying with the tide from fresh to brackish, and of a temperature varying from 70° to 75° Fahrenheit. It is supposed that the spawn is deposited upon the bottom. If they have been spawning at the times when I have been present, I would say that the operation was a general one. That they do spawn at or near these places is quite certain, for they go to them with spawn and come away without it, and the young fry first appear near the same places. Crabs and alligator-gars are abundant in such places, and they doubtless destroy great quantities of the eggs and fry. Before spawning Mullet are very fat, but after the operation are extremely thin and almost worthless for food. Their colors also undergo some changes, at sea being bright blue on the back, which deepens to a light brown in the bays and to a dark brown in fresh water. By these characteristics it is not difficult to determine the locality where a lot of Mullet are caught.

"Some persons of this coast agree that Mullet, or any other sea-fish, will not bear sudden change from salt to fresh water, and to meet this argument I made an experiment with Mullet in 1879. I took a dozen or more medium-sized Mullet from the warm shoal water of the bay and placed them in cool, fresh spring water. They swam around very rapidly for about half an hour, then sank to the bottom of the spring, where they remained, apparently comfortable, for twelve hours. Before leaving the spring I returned them to their native waters, seemingly in as good condition as when first caught. The bay water was at that time 77° Fahrenheit and the spring water 71° Fahrenheit, a difference of 6° and a change from pure salt to pure fresh water.

"After spawning, in October and November, the Mullet leave these bays in small schools, going directly to deep water if the weather is stormy, and following the beach along if there is not much surf. Those that have been in the bays all the summer leave also at about this time, many of them having spawned at the same time with the full 'run.' A few of these, having just reached maturity, are found with spawn nearly all winter; also, some young stragglers. In February, March, and April, young Mullet, varying from one to two and a half inches long, are found in great abundance along the bay shores. Mullet grow to about eight inches in length the first year, to twelve or thirteen inches the second year, when they are mature. The average size of adults is twelve inches in length, weight about one and a quarter pounds. The largest I have seen measured twenty inches long and weighed four and a half pounds. It was caught at Charlotte Harbor, Florida. Mullet of that size are extremely rare in West Florida. Those of South Florida are much larger, as a rule, than those found farther north. There they are also far more abundant than on the coasts of West Florida, Alabama, Mississippi, Louisiana, and Texas.

"In October, Charlotte Harbor, Sarasota and Palmasola Bays, seem to be the headquarters of all the Mullet of the Gulf. Tampa Bay, Anclote River, Homosassa River and vicinity, are also favorite spawning places. During the fall they move in such immense schools that the noise of their splashing in the water resembles distant thunder; and to persons living near the river or bay, their noise, kept up day and night, becomes very annoying. These schools are followed by large numbers of sharks, porpoises, and other destructive fishes, as well as pelicans and like sea-birds, all of which eat of the Mullet until they can eat no more, and have to make way for fresh arrivals. In spite of these enemies and those of the eggs and fry, Mullet are as plentiful as formerly, according to the general opinion of the fishermen of the coast.

"The Mullet is a bottom-feeding fish, prefers still, shoal water with grassy and sandy bottom. It swims along the bottom, head down, now and then taking a mouthful of earth, which is partially culled over in the mouth, the microscopic particles of animal matter or vegetable matter retained, and the refuse expelled. When one fish finds a spot rich in their desired food, its companions immediately flock around in a manner that reminds one of barn-yard fowls feeding from one dish. The Mullet eats very little compared with other fish of its size. It preys on no

other fish, and is preyed upon by nearly all other common fishes larger than itself. It does not readily take the hook, but can sometimes be caught with a bait of banana, or one manufactured from cotton and flour. It is the most widely distributed fish of the Gulf of Mexico, being found on the sea-beach everywhere, in all the bays and sounds, and even far up fresh-water rivers and in fresh-water lakes that have outlets."

Concerning the other species of Mullet, *Mugil brasiliensis*, as occurring in the Gulf, Mr. Stearns writes:

"It is common, and is found in company with the *Mugil albula* and usually considered with it, and the old fishermen of Pensacola distinguished it and have given it the above name. I have found spawn in them in May and June. On the southern coast they are very abundant, and appear in Key West almost daily in the fall and winter."

MULLET IN CALIFORNIA.—"On the California coast occurs *Mugil albula*," writes Professor Jordan, "which is commonly known as the 'Mullet.' It reaches a length of about fifteen inches. It is very abundant about San Diego, and thence south to Mazatlan, and it ranges occasionally northward as far as Monterey. It enters creeks and lagoons, ascending as far as the brackish water extends, in the winter, and thus is often land-locked in great numbers, which are then destroyed by the sea-birds, especially by the pelicans, and a few are taken in seines. It swims in schools in the bays, and its presence is made known by its frequent leaps from the water. It is said that the Mullet has long been known at San Diego, but that it first made its appearance at San Pedro in 1877. It is not well known either at Santa Barbara or Soquel, although now occasionally taken at both places. Those fishermen who have given the matter any attention assert that the Mullet is gradually extending its range northward. It feeds on mud and minute organisms contained in it. It is considered a good food-fish when taken from the ocean. In the muddy lagoons it acquires in summer a rank flavor."

154. THE SAND SMELTS OR SILVER SIDES—ATHERINIDÆ.

The "Sand Smelts" or "Silver Sides" are small carnivorous fishes which occur everywhere along the coasts of temperate and tropical regions. They are found in almost countless numbers in brackish water and at the mouths of rivers, living, for the most part, within a few yards of the shore, where they prey upon other small fish, upon crustaceans, and upon refuse organic matter, and are in their turn the prey of other fish, particularly the young of the larger fishes of prey which create so much havoc farther out at sea; for instance, young bluefish, squeteague, and mackerel. In general appearance they resemble the smelt, and at various places are called "Sand Smelts" and "Green Smelts." They may be readily distinguished from the true smelt by the absence of the adipose second dorsal fin, which occurs in all members of the salmon tribe, and by the presence of the small spinous dorsal. The most important species on the Atlantic side is the Green Smelt of the Connecticut coast, *Menidia notata*, also called in some parts of New England the "Friar," by the boys about Boston the "Capelin," about New York the "Sand Smelt" and "Anchovy," and about Watch Hill the "Merit-fish." In Beaufort Harbor, according to Jordan, two other species of the genus are very abundant in company with a species of *Engraulis*, and are known as "Sardines."

The range of this species extends from Maine at least to North Carolina. They spawn all along our sandy shores, where at any time in summer tens of thousands of them may be gathered in an hour with a small seine. In the shallow sandy bays the young fish, about an inch in length, were found in schools, while in more exposed localities, such as the Napeague Harbor, Watch Hill Beach, and the north part of Montauk Point, the largest schools of adult fishes were found, though large individuals were also frequently found in the more protected coves. They swim in

immense schools, generally those of the same size together; they vary in length from half an inch to seven inches. They apparently breed throughout the hot season. Individuals two and a half inches long, taken in the Little Harbor, Wood's Holl, Massachusetts, July 2, 1875, were full of ripe spawn and milt which they yielded freely.

Capt. John B. Smith, of New Bedford, furnishes an interesting account of the spawning of this fish, *Menidia notata*, as witnessed by him during a visit to the head of Buzzard's Bay, on the 13th of June, 1872. He observed great numbers of the fish in the sedge grass, in the afternoon of that day, when the falling tide was about one-fourth down. The fish came in a body into shallow water, within three feet of the shore, then darted among the grass, and rolled over from one side to the other, struggling with all their strength, some of them jumping entirely out of the water while in the operation. The eggs were then to be seen fastened in sheets and in masses to the grass, like frogs' eggs in a mill-pond. These were about the size of No. 9 shot. During the operation of spawning, which lasted about a minute, the fish were very sluggish, and could readily be taken with the hand. The number of fish engaged in spawning was so great that the water was quite whitened with the milt, and the grass was so full of the eggs that they could be taken up by the handful. Eels and small fishes of various kinds were attracted there in great numbers, helping themselves to the dainty repast.

In addition to consuming great quantities of food such as has been described, it was found that they were very destructive to the eggs of other fishes. Although not generally eaten, they are finely flavored and an excellent article of food, not very greatly inferior to smelt. Uhler and Lugger are quite mistaken in their opinion that this species is the gudgeon of Maryland and Virginia, which is in fact a fresh-water fish, *Hybognathus regius*, together with one or two other species which are apparently often included under the same name.

In Florida this fish is replaced by two or three others belonging to the same family, which, though very abundant, are of no special importance except as food for other fishes.

On the California coast this family is of much greater importance, two of the species being in high favor as food. These are the so-called "California Smelt" and "Little Smelt." Of the former Jordan writes: "This species, the California Smelt, *Atherinopsis californiensis*, is everywhere known as the 'Smelt.' It reaches a length of about eighteen inches, and the average size as seen in the markets is not much below this. It ranges from Cape Mendocino to Magdalena Bay, inhabiting especially rocky bays sheltered from the waves. It occurs in great schools, and is extremely abundant. It is non-migratory. Its food consists chiefly of worms and small crustaceans. It is a fish of fine, firm flesh and good flavor, although a little dry. From its great abundance it is one of the most important food-fishes on the coast, being never absent from the markets. It is often used as bait, especially for the rock-fish."

Of the Little Smelt he writes as follows: "The Little Smelt, *Atherinops affinis*, or Petite Smelt, reaches a length of about a foot. It associates with the 'California Smelt,' being scarcely less abundant. It is, however, more often found in sheltered, sandy bays and lagoons than the other species, and is sometimes found in brackish water. As a food-fish it is equal to the California Smelt, but from its smaller size is of less value. Both species are greedily devoured by the larger predatory fishes."

155. THE STICKLEBACK FAMILY—GASTEROSTEIDÆ.

The Sticklebacks are represented on our Atlantic coast by three species: The four-spined Stickleback, *Apeltes quadracus*, which is found in brackish water from Cape Ann southward at least to New Jersey; the ten-spined Stickleback, *Gasterosteus pungitius*, associated with the preceding, and found also in fresh water; the two-spined Stickleback, *Gasterosteus aculeatus*,

occuring as far north as Newfoundland and south to New York. The latter species also occurs on the coast of California north to San Francisco. The Sticklebacks are great favorites with persons who own aquaria on account of the skillful manner in which they build their nests. The two-spined Stickleback attains a length of four or five inches. Schools of them are sometimes found swimming in the open sounds in midsummer. On the California coast, in addition to the two-spined Stickleback, there occurs another species, *G. microcephalus*, along the whole length of the coast from Southern California to Puget Sound. In Puget Sound, according to Jordan, the two-spined Stickleback is abundant, and forms an important part of the food of the salmon and trout. The stomach of *Salvelinus malma*, particularly, is often full of them. The name "Salmon-killer" is applied to them about Seattle, but whether the wounds are inflicted by their sharp spines in the stomach of the salmon is not known. Ducks catch and swallow the Stickleback, and are often killed by them. Excepting as food for other fishes they have no value, though on the Prussian coast, near Dantzig, where they abound, they are said to be used for feeding ducks, fattening pigs, and in the manufacture of oil.

156. THE SILVER GAR-FISHES—BELONIDÆ.

The family *Belonidæ* occurs in temperate and tropical waters all over the world, at least fifty species being known. Its members are easily recognized by their long, lithe bodies and by the shape of their jaws, which are prolonged into a long, slender beak, provided with numerous sharp, conical teeth.

"Swimming along the surface of the water, the Gar-pike seize with these long jaws small fish as a bird would seize them with its beak; but their gullet is narrow, so that they can swallow small fish only. They swim with an undulating motion of the body. Although they are in general active, their progress through the water is much slower than that of the mackerel, the shoals of which appear simultaneously with them on our coast. Young specimens are frequently met with in the open ocean. When they are young their jaws are not prolonged, and during the growth the lower jaw is much in advance of the upper, so that these young fishes resemble a *Hemiramphus*."[1]

The name "Gar" is said to be derived from a Saxon word meaning "needle," and in the Gulf of Mexico they are commonly known as "Needle-fish." On the Atlantic coast, however, the usual appellative is "Gar-fish." In Great Britain there are several names, such as "Sea-pike," "Mackerel-guide," "Green-bone," "Sea-needle," and "Garrick." They are also here called "Gray Pikes," but this name should be avoided in America, having been appropriated for the species of *Lepidosteus*, with bony scales, inhabiting the rivers of the South and West. The name "Sea-snipe" is said to be also occasionally in use, as well as "Bill-fish," which is also applied by our fishermen to the slender species of the sword-fish family. On our Atlantic coast are at least four species, the most common of which is *Tylosurus longirostris* which is found in Massachusetts Bay and south to the Gulf of Mexico and the northern parts of Central America, occurring also in the West Indies. This species attains a length of two feet, and ascends the rivers for great distances, having been found in the Connecticut as high as Hartford, in the Susquehanna at Columbia, and in the Potomac above Washington. They are also frequently seen in the harbors along the coast, but are rarely sufficiently abundant to be used for food. DeKay states that this species is highly prized by epicures.

Little attention has been paid to its habits by our naturalists, and we are again obliged to rely upon Mr. Stearns for our information. He writes: "It is common on all points of the Gulf coast. At present it is found at Pensacola only in the summer (about eight months), but on the more southern coast all the year. It is a surface-swimming fish that preys largely upon small fish that move in schools. It seems to be rather dull of observation, and I have often watched small

[1] Günther's "Study of Fishes," p. 620.

schools of minnows, that perhaps know the failing, elude it for a long time by huddling together directly above or below, when, if they moved to either side, the Needle-fish would be sure to see them, and they quite certain to lose some of their number. Its movements are very rapid and its aims most sure. I have seen a Needle-fish of fifteen or twenty inches length seize mullet and other fish fully one-third of its own size, which often prove more than it can manage. They are sometimes washed ashore dead, with some spiny fish that was a little too large fixed in their throats. The Needle-fish spawns in the bays in May and June. It is very seldom eaten on this coast, yet it is an excellent food-fish, which I prefer to many others."

Tylosurus hians is a species recently discovered on our coast and abundant throughout the West Indies.

Tylosurus caribbæus is a giant species, of which one or two specimens have been found at Wood's Holl, and which is common about Cuba. A species resembling that last mentioned, *Tylosurus Jonesii*, is abundant about Bermuda, and is emphatically the game fish of those islands, where it is known as the "Hound-fish." Individuals attain the length of five or six feet. They are fished for with salmon rods and artificial flies by the British officers in the garrison.

A related species, *Tylosurus vulgaris*, abounds on the coast of Northern Europe, and is usually found in company with the mackerel, ranging north to North Cape, and occurring in considerable numbers in the Baltic, but apparently not often found south of the English Channel. Great numbers are caught on the coast of Holland, where they are used for bait, and in many other parts of Europe they are said to be prized for food. The Germans prepare them by smoking or drying.

"In the autumn months," writes Buckland, "Gar-fish are very plentiful on the Cornish coast. In the autumn of 1867 scarcely two thousand were taken in the seines at Mevagissey, which fetched good prices, as they are much eaten by the Jews. One of the advantages of railway communication may be seen in the fact that before the opening of the Cornwall Railway the fishermen would not spend time by catching sea-fish, for which there was no demand, so that what were caught were used for manure. Mr. Hinkston, of Mevagissey, inclosed at one time in a seine-net one thousand at one time. They were at first thought to be mackerel, but, proving to be Gar-fish, the seine-net was opened and they were allowed to escape. That number would now command the sum of £90. In by-gone days they were not esteemed by the Cornish people as an article of food, but are now eaten with the greatest avidity."

The peculiar green color of the bones is said to prejudice many people against them. I have myself tasted the American Gar-fish and found it exceedingly palatable; and I cannot doubt that at some future time they will be highly prized by our people, as they richly deserve to be.

A species commonly known as the "Needle-fish," *Tylosurus exilis*, exists on the California coast. It reaches a length of about two and a half feet and a weight of little more than two pounds. It is found from Santa Barbara southward, and is rather common in the bays, its habits being similar to those of the Atlantic Gar-fish. It spawns in August. It feeds upon anchovies and similar fishes. It is a food-fish of good quality, but is not sufficiently common to be of much economic importance.

157. THE FLYING-FISH FAMILY—SCOMBERESOCIDÆ.

The Flying-fishes.

This group is represented on the Atlantic coast by several species, the most abundant being probably the common *Exocœtus Rondeletii*. They are usually seen quite a distance out at sea, and sometimes fly on board of passing vessels. They are considered excellent food, but are so rarely taken as to require no notice here.

Professor Jordan says: "The California Flying-fish, *Exocœtus californiensis*, known to the

Italians and Spaniards of the Pacific coast as the 'Volator,' reaches a length of eighteen inches and a weight of one and a half pounds, being one of the largest of the Flying-fishes. It is found only about Santa Barbara and the Coronados Islands, where it is excessively abundant in the summer, appearing in June and disappearing probably in September. This fish flies for a distance sometimes of nearly a quarter of a mile, usually not rising more than three or four feet. Its motions in the water are extremely rapid, and its motive power is certainly the movement of its powerful tail in the water. On rising from the water the movements of the tail are continued for *some seconds, until the whole body is out of the water. While the tail is in motion the pectorals* are in a state of very rapid vibration, and the ventrals are folded. When the action of the tail ceases, the pectorals and ventrals are spread, and, as far as we can see, held at rest. When the fish begins to fall, the tail touches the water and the motion of the pectorals recommences, and it is enabled to resume its flight, which it finally finishes by falling into the water with a splash. When on the wing it resembles a large dragon-fly. The motion is very swift; at first it is in a straight line, but this becomes deflected to a curve, the pectoral on the inner side of the arc being bent downward. It is able to some extent to turn its course to shy off from a vessel. The motion seems to have no reference to the direction of the wind; and we observed it best from the bow of a steamer off Santa Catalina Island in early morning, when both air and water were free from motion."

Two other species of *Scomberesocidæ* occur on the Pacific coast. *Hemirhamphus Rosæ*, J. & G., inhabiting San Diego and San Pedro Bays, is too small and too scarce to be of any value as a food-fish. *Scomberesox brevirostris* Peters is found from Tomales to Monterey, and is sent to market when taken. It is, however, extremely rare and only one was seen by Jordan.

The Skipjack—Scomberesox saurus.

The Skipjack, although in general appearance very dissimilar to the Flying-fish, is a member of the same family. It is quite similar in form to the silver gar-fish, *Tylosurus*, from which it differs in the long beak-like jaws, slender and flexible, and in having finlets behind the dorsal and anal fins. In England it is known as the "Skipper," "Skopster"; also in the books as the "Saury," or the "Egypt Herring," and by the Scotch as the "Gawnook."

This species is probably found in all parts of the Atlantic, although it has not yet been recorded from South America. On our coast it is abundant at times from the Gulf of Mexico to the Banks of Newfoundland. In the Eastern Atlantic it ranges from the Loffoden Isles, latitude 69°, to the Cape of Good Hope, specimens having also been observed about Saint Helena; it does not, however, occur in the Mediterranean, where it is replaced by an allied species, *Sayrus Camperii*, which is distinguished from it by the absence of the air-bladder. On the New England coast large schools are occasionally seen in autumn, and this is the only part of our Atlantic seaboard where they are of any special importance. Codfish feed upon them voraciously, and they are sometimes eaten by bluefish. Storer remarks: "Large quantities are yearly thrown upon the shore at Provincetown, but are considered worthless, while by the inhabitants of the other towns of Cape Cod it is taken in immense numbers and considered by many of them very nutritious food."

DeKay supposed New York to be the extreme limit of the southern range of this species, but it has been observed at the mouth of the Chesapeake Bay, and at Bedford, North Carolina, by Jordan.

Neill states that it is not an uncommon fish in the Frith of Forth. Numbers run up with the flood-tide in the autumn; they do not, like other fishes, retire from the shoals at the ebb of the tide, but are then found by hundreds, having their long noses stuck in the slush, and are picked up by people from Kincardine, Alloway, and other places. The fullest account of their habits is the following, from the pen of Mr. Couch:

"The Skipper is, more strictly than the gar-pike, a migratory fish, never being seen in the channel until the month of June, and it commonly departs before the end of autumn. It does not swim deep in the water, and in its harmless manners resembles the flying-fish, as well as in the persecutions it suffers from the ravenous inhabitants of the ocean. The methods it adopts to escape from their pursuit are peculiar. It is sometimes seen to rise to the surface in large schools and fly over a considerable space. But the most interesting spectacle, and that which best displays their great agility, is when they are followed by a large company of porpoises, or their still more active and oppressive enemies, the tunny and bonito. Multitudes then mount to the surface and crowd on each other as they press forward. When still more closely pursued they spring to the height of several feet, leap over each other in singular confusion, and again sink beneath. Still further urged, they mount again and rush along the surface by repeated starts for more than one hundred feet, without once dipping beneath, or scarcely seeming to touch the water. At last the pursuer springs after them, usually across their course, and again they all disappear together. Amidst such multitudes—for more than twenty thousand have been judged to be out of the water together—some must fall a prey to the enemy; but so many hunting in company, it must be long before the pursuers abandon. From inspection we could scarcely judge the fish to be capable of such flights, for the fins, though numerous, are small, and the pectoral far from large, though the angle of their articulation is well adapted to raise the fish by the direction of their motions to the surface. Its power of springing, therefore, must be chiefly ascribed to the tail and the finlets. It rarely takes bait, and when this has happened the boat has been under sail, the men fishing with a 'lash' or slice of mackerel made to imitate the living body. The Skipper has not been commonly taken since drift-fishermen began the practice of sinking their nets a fathom or two below the surface, a circumstance which marks the depth to which they swim; but before this it was usual to take them, sometimes to the amount of a few hundred, at almost evey shoot of the pilchard nets."

This description of their habits is doubtless very applicable to those of the same species in the Western Atlantic. I have frequently seen them in schools springing above the surface, but have never had an opportunity to study their movements closely. The Skipjack probably feeds, *for the most part, on soft pelagic animals, the teeth in their jaws being very minute.* Günther states that the young, having the beak is still undeveloped, are met with everywhere in the open ocean, in the Atlantic as well as in the Pacific.

The Half-beak—Hemiramphus unifasciatus.

Species of this genus are abundant all over the world, and are particularly numerous in the West Indies, where they are sometimes known by the Indian name "Balahoo." They are closely related to the Skipjack, but have the upper jaw short and the lower jaw prolonged into a long, slender beak. Our own species ranges in abundance from Cape Hatteras, through the West Indies, to Rio Janeiro; stragglers have been taken at Wood's Holl, Massachusetts, and a single specimen at Danvers, Massachusetts. Stearns writes that it is a common fish along the Florida coast, living in shoal water, and although so different in appearance is confused with the silver gar-fish, *Tylosurus*. On some parts of the coast it remains all the year; in others, only in warm weather. It swims in small schools, and it is probable that it spawns in the fall.

158. THE PIKE FAMILY.

The Pike—Esox lucius.

The Pike, *Esox lucius*, is one of the very few species of fish which is found on both sides of the Atlantic, and is equally familiar to the inland fishermen and anglers of North America, Europe,

and Northern Asia. Notwithstanding its broad distribution in the Old World, however, the genus *Esox* may be claimed by Americans as pre-eminently American, since all the known species occur in North America, while only one of them is found in Europe. The Pike—the "Hecht" of Germany; the "Brochet" of France; the "Luccio," or "Luzzo," of Italy, and the "Gädda" of Sweden—is easily distinguished from the allied species in the United States by its coloration, which is uniform brown, green, or black, with numerous elongate white blotches upon the sides. It is further distinguished from the Muskellunge, *Esox nobilior*, by the fact that the cheek in front of the fore operculum is covered with scales, while in the latter the lower half of the cheek is entirely naked.

It is sometimes known as the "Great Lake Pike." The name "Pickerel," which in England is used as a diminutive, and applicable to the young Pike, has in this country been appropriated to represent a smaller species of the same genus, *Esox reticulatus*, etc.; but our fishermen are not usually so skilled in ichthyology as to be able to distinguish infallibly between a small Pike and a large Pickerel: consequently there is frequent confusion of nomenclature, nor is this lack of precision altogether absent from the writings of our early ichthyologists.

The earliest biography of the Pike, written with reference to its American habitat, is that of Richardson, in the "Fauna Boreali Americana." He states that "by the Cree Indians it is called 'Eithinyoo-cannooshœoo.' As it takes a bait set under the ice more rapidly than any other fish of the same districts, it forms an important resource to the Indian hunter in the depth of winter, when the chase fails him. In the summer it is occasionally shot while basking in shallow waters, but, except in very urgent cases, powder and ball are of too high value in the fur countries to be thus expended. No quadruped, bird, or fish that the Pike can capture seems to be secure from its voracity, and even the spring perch is an acceptable prey to this water tyrant. The Pike rarely weighs more than twelve pounds in the northern parts of America. One specimen, taken in Lake Huron, was submitted to Cuvier's inspection, and it has also been carefully compared with English Pike without any specific differences having been detected."[1]

Richardson further remarks that the Pike was not mentioned by Fabricius as a native of Greenland, and has not been found on the islands of the Polar Sea. It has, however, been recently discovered by Dr. Bean in a collection received from the island of Kodiak, Alaska.

The Pike, almost universally despised, and generally, on account of its predacious habits, regarded by the fishermen of our Great Lakes as a pest, is in Europe considered one of the most important of game fishes. Walton devotes to it an entire chapter, concluding with directions how to "roast him when he is caught," and declaring that "when thus prepared he is 'choicely good'—too good for any but anglers or honest men." Mr. Chalmondeley-Pennell, a well-known English writer on angling, has published a work, of considerable size, entitled "The Book of the Pike."

HABITS OF THE PIKE IN EUROPE.—So few have been the observations in this country, and so much has *Esox lucius* been confused with the other species of the genus, that it seems impracticable to compile from American authorities a satisfactory account of its life history, and in default thereof is here presented a synopsis of what has been written concerning the habits of the species in Europe, by Dr. L. Wittmack, director of the Agricultural Museum of Germany. It is not probable that the habits of the fish in America differ materially from those here described: still the European investigations cannot fail to be interesting and suggestive to those who may hereafter have the opportunity to study the fish in our own Great Lakes.

The Pike occurs from Northern Asia to North America, and from Scandinavia to Italy. It appears, according to Kroyer, to be absent from the Spanish Peninsula. It is found in all parts of

[1] Fauna Boreali Americana, p. 124.

Germany, not only in the high mountain regions, but along the sea-coast of Northern Germany, and even close to the shores of the Baltic. The highest vertical distribution of the Pike occurs on the northern side of the Alps, in Tyrol, in various lakes, from that of Tristac, 2,670 feet, to that of Halden, 3,618 feet. On the south side of the Alps it occurs in certain lakes of the Tyrol, and in the Lake of Reschen, 4,637 feet, which is apparently the loftiest point of its distribution. In Switzerland, according to Tschudi, it ranges to the height of 3,398 feet."

The spawning time of the Pike, as is shown in an elaborate table presented by Wittmack, often begins in the latter part of February, and lasts, depending somewhat upon temperature and the weather, into March and April, sometimes even into May. It deposits its eggs upon water-plants, especially rushes and grasses. Examples one-third of a meter long are capable of reproducing their kind.

The predacious nature of the Pike is proverbial. It eats nearly all other kinds of fishes, sparing not even its own species, and also devours frogs, mice, rats, and even young ducks. Although it is voracious in its attacks upon its prey, it remains generally in quiet and seems to prefer quiet and slow-flowing waters rather than swift streams.

Wittmack gives a number of statements from authorities in different parts of Germany showing the annual rate of growth of the Pike, which appears to vary from two to three pounds, the maximum size attained being from forty-five to seventy pounds. He cites one instance in which, in two summers, a few individuals, liberated in a pond full of a species of carp, grew from the weight of one and three-quarters to that of about ten pounds.

BENECKE ON THE SPAWNING OF THE PIKE.—The breeding habits of the Pike are still further described as follows by Professor Benecke, of Königsberg:

"The Pike inhabits all of our waters with the exception of shallow and rapid brooks. It prefers clear, quiet water with clean bottom; is usually active at night and quiet in the daytime; lurks among plants in convenient corners, whence it rushes forth with arrow-like velocity. It lives a hermit life, only consorting in pairs during the spawning season. The pairs of fish then resort to shallow places upon meadows and banks which have been overflowed, and, rubbing violently upon each other, deposit their spawn in the midst of powerful blows of their tails. The female deposits generally about 100,000 yellowish eggs, about three millimeters in diameter, out of which in the course of fourteen days the young with their great umbilical sacs escape. The spawning time occurs in Eastern Prussia in the months of February to April, and occasionally the spawning of the first Pikes occurs before the departure of the ice. When well nourished the Pike grows very rapidly, and in the first year often reaches the length of more than a foot, and sometimes eventually the length of seven or eight feet. Only the young, rapidly growing Pikes are eatable, the old ones being dry and tasteless."

PIKE IN THE GREAT LAKES.—In his excursion around the Great Lakes for the purpose of gathering fishery statistics, Mr. Kumlien obtained the following notes upon the abundance of the Pike:

"On the western shore of Lake Michigan it appears to be resident in those portions of the lake off Racine, and is very rarely taken in gill-nets. It is, however, not known to Waukegan or Kenosha fishermen. At the west end of Lake Erie individuals are at rare intervals taken in pound-nets set in the deepest water. About Sandusky and vicinity, like the Muskellunge, they are said to be rather rare, though a few taken in winter around Put-in Bay Island are there regarded as residents of cold, deep water. Above Cleveland they are not known to the fishermen, but in the vicinity of Ashtabula considerable numbers are sometimes taken in spring—one or two hundred pounds at a haul of a pound-net. On the south shore of Lake Erie very few are taken in

pounds, and it is there thought that they keep constantly in deep water and seldom approach the shore. They are very salable and much sought after, but apparently nowhere abundant."

The common Pickerel—Esox reticulatus.

This fish is known in the North always by the name of "Pickerel"; in the Southern States it is usually the "Jack." It is found chiefly in the streams along the Atlantic coast, from Maine to Alabama, it being generally abundant, especially in clear, grassy streams and ponds. It is not found in the Lake region, nor west of the Alleghanies. It sometimes reaches a weight of seven or eight pounds, but is usually much smaller. As a food-fish its rank is rather high; its flesh is white and well flavored, but is rather dry and not very tender. It is, however, a very undesirable fish for propagation, from its inordinate voracity. They are "mere machines for the assimilation of other organisms."

The Brook Pickerels—Esox americanus and Esox umbrosus.

These two small Pickerel are very abundant, the former in the coastwise streams east of the Alleghanies, the latter in the Mississippi Basin. Neither reaches a length of much over a foot. These have, therefore, little economic value, and from their voracity are undesirable inmates of streams and ponds.

The Muskellunge—Esox nobilior.

The following facts regarding the abundance of Muskellunge, *Esox nobilior*, in the Great Lakes have been ascertained by Mr. Kumlien:

Among the islands dotting the southwestern part of Lake Superior, including the Apostle Islands, Sand, York, and Rock Islands, and others, this fish is caught in small quantities in the pound-nets. The Muskellunge is occasionally caught in the small bays indenting the shore south of Keweenaw Point as far as Huron Bay, and with it a large and much lighter-colored fish that may possibly be *Esox lucius*. This latter is not well known among the fishermen, but Mr. Edgerton says he has often noticed it, and has remarked that the general aspect was different from that of the Muskellunge. On the fishing grounds at the north end of Green Bay this is a rare fish, only half a dozen or so being taken each year. When it occurs it is found at any and at no particular point. Not a single specimen of this fish was taken by Mr. Nelson in ten years' fishing in the Cedar River district, and Mr. Everland in thirty-six years has not taken half a dozen. They are reported of occasional occurrence in the Menomonee River, but are not found in deep nets far out in the bay.

Lower down on the west coast of Green Bay, from Longtail Point to Peshtego Point, this fish occurs everywhere, but nowhere in abundance. A specimen was taken at Washington Island in 1866 that weighed forty-four pounds. The fishermen of this stretch of coast-line pronounce it Musk-ka-long. At Green Bay City this fish is caught frequently weighing forty pounds. It is common at this point, *i. e.* the southern end of Green Bay. Ascending the eastern shore of Green Bay as far as Saint Martin's Island the Muskellunge is very rare, being known by name only to a great many of the fishermen. Following the western shore of Lake Michigan southward from Porte des Mortes on the north as far south as Manitowoc this fish is rare. At Jacksonport two have been taken in seven years. At Two Rivers only one has ever been recorded, viz., in 1878. At Manitowoc it is less scarce, being caught sometimes in pound-nets and more frequently in the river. At Milwaukee the Muskellunge occurs in the lake but rarely; it is never caught in gill-nets. In 1868 Mr. Schultz took one in a small seine, in the old harbor, weighing one hundred pounds. This is believed by Mr. Kumlien to be a fact, having been testified to, as he says, "by so many reliable persons." He adds: "Formerly, fish of this kind weighing eighty pounds were far from rare."

On the 9th of April a fish of this species four feet in length was taken at Racine; head to operculum, ten inches; to eye, four inches; greatest circumference, twenty and one-half inches; over eye, eighteen inches; at gills, eighteen inches; weight, forty-five pounds. These fish are never here taken in the gill-nets; they are resident in the lake about Racine in winter. A very few have been known to occur at Waukegan. On the southeastern shore of Lake Michigan, including the fisheries of Saugatuck, South Haven, and Saint Joseph, this fish is reported as always being of a large size. At Ludington, farther north, only one instance of capture is on record; it is also said to be very rare at Grand Haven.

But little has been reported regarding the occurrence of the Muskellunge upon the numerous fishing grounds along the north shore of the southern peninsula of Michigan between Little Traverse Bay and Thunder Bay. It is generally rare through the Straits of Mackinaw, only about half a dozen being taken each season; and most abundant of all at Les Cheneaux Islands. Captain Coats caught one here, in 1874, weighing sixty-two pounds. These fish are rarely taken in pound-nets, and are chiefly caught with hook and line about the Les Cheneaux and Drummond Islands. Captain Dingman has caught only one in his pound-net in the past fifteen years. All caught, of which he has heard, have been large. In Thunder Bay about a dozen, on an average, are taken in twelve months. In Saginaw Bay they are taken in about the same numbers as in Thunder Bay. Here too they are always large fish. A few are taken in seines along the coast between Port aux Barques and Port Huron. A few also are taken annually in the Saint Clair River; perhaps a dozen or two altogether in this region during a year. Between Toledo and Detroit River, Lake Erie, a specimen of this fish is taken now and then in the pound-nets. When taken, it is always large. The same remark will apply to the vicinity of Toledo and Maumee Bay.[1]

MUSKELLUNGE IN LAKE ERIE.—About Locust Point a few are taken in the fall. Twenty years ago, in this region, including the fisheries of Ottawa, Port Clinton, Toussaint, and Locust Point, Musquellunge were taken weighing sixty and seventy pounds. In Sandusky Bay specimens are caught of forty-five pounds weight, and at Kelley's Island one was caught weighing fifty-seven pounds, and another sixty-two pounds.

In connection with the Huron (Ohio) fisheries, it is reported that about one hundred and fifty fish of this species were taken in seventy-five nets during the year 1879. They are here generally large, and are always taken in pairs. Three or four represent a year's catch of this fish at Vermillion, Ohio. About Black River, Lorain County, Ohio, Amherst, and Brownhelm Bay, it is very scarce, few being caught in nets; all that are taken are large. Of this fish, in connection with the Cleveland and Dover Bay fisheries, it may be said that it is very rare, and is becoming more so each year. Mr. Sadler says he took one weighing eighty pounds. The fishermen say they are always found in pairs.

The Muskellunge is taken at Conneaut at the rate of half a dozen in ten years. Only one specimen was taken in the Painesville pounds in 1879. At Fairport and Willoughby, Ohio, no mention is made of its occurrence. Erie Bay, especially at Dunkirk and Barcelona, New York, Erie, Pennsylvania, and Mills' Grove, Ohio, is famous for its Muskellunge fishing; this past season over sixty were caught, weighing from twenty to forty-five pounds. They are caught by trawling. Fancy prices are paid for them; about twenty-five cents per pound retail in the city and twelve and a half cents when shipped. More were caught during the season of 1879 than ever before.

MUSKELLUNGE IN LAKE ONTARIO.—The following notes relate to the fishery in Lake Ontario: At Oswego the fish is very rare on the American side; at Port Ontario one is occasionally caught;

[1] Mr. Fred. Alvord states that he procured a Muskellunge from Maumee Bay, in 1864, weighing eighty-five pounds.

at Cape Vincent they are common, especially in the Saint Lawrence. Nine have been brought in in one day, the smallest of which weighed thirty-two pounds. They are not now, however, so plentiful here as formerly.[1] At Chanmont very few are caught. Seven years ago one was captured here weighing sixty-five pounds. At Sacket's Harbor very few Muskellunge are caught.

159. THE MUMMICHOG FAMILY—CYPRINODONTIDÆ.

In the brackish waters along our coast and near the mouths of rivers, as well as in many of our fresh-water streams and lakes, are found members of the family *Cyprinodontidæ*. These are all small fishes, the size of adults, rarely exceeding four inches, never exceeding six or eight in the largest of them, *Fundulus majalis*. In New England they are usually known by the Indian name "Mummichog"; farther south by the name "Brook-fish" or "Killifish," a legacy from the early Dutch colonists, and in other localities, especially in the interior, less correctly known as "Minnow."

There are some twenty species in North America, none commonly used for food, but all of much more importance as food for larger fish, and frequently used for bait. The common species of the shores of the Gulf of Mexico, *Fundulus grandis*, is known at Pensacola by the name "Sac-à-lait," an unexplained French name also applied to a species of *Pomoxys* at New Orleans. The brackish-water species breed in summer, and young are found in immense schools among the eel-grass and on the sandy beaches in company with the sand smelt, *Menidia notatum*, and the allied species.

The *Cyprinodontidæ* are represented in California by *Fundulus parvipinnis* Gir., a little fish very abundant in brackish waters from Santa Barbara southward, and by *Cyprinodon californiensis* Gir., a small species once found at San Diego.

These fishes are particularly interesting to the physiologist, from the fact that many of them are viviparous, and that the anal fin of the adult male is modified into a copulatory organ. The two sexes of the species thus modified are usually very different in appearance, and might be mistaken for members of different genera. Those members of the family belonging to the genera *Cyprinodon* and *Fundulus* are carnivorous, while *Pœcilia* and *Mollienesia* feed upon mud.

The famous "Blind Fish" of the Mammoth Cave, *Amblyopsis spelæus*, and its allies, are closely allied to the *Cyprinodon*, though belonging to another family, *Amblyopsidæ*. These fish are useless economically, but are regarded as great curiosities, and often sold for considerable sums.

The Blackfish of Alaska—Dallia pectoralis, Bean.

By E. W. Nelson.

This species, known as the "E-ruang-uk" to the Eskimo of the Lower Yukon and adjoining region; "E-lo-ki-nik" to the Malemut Eskimo in Kotzebue Sound region; "Chorruy Ryba" to the Russian fur-traders; and "Blackfish" to American fur-traders, though insignificant in size, exists in such numbers in all the grass-grown, sluggish fresh-water streams and shallow lakes from the vicinity of Kotzebue Sound on the north to the mouth of the Kuskoquim River on the south, and up the Yukon to the mouth of the Tanana River, and for some distance up the Lower Kuskoquim, that it forms a very important source of food supply to the natives within these limits. In the low country between the Lower Yukon and Kuskoquim Rivers these fish exist in greatest abundance, and here, also, is found the most dense Eskimo population in Alaska. In this region alone

[1] By the north shore Indians this fish was called "Noscononge." A very old man, the first white child born on Prince Edward's Island, told Mr. McPherson that when he was a boy, fifty years ago, the name was an Indian one, and that our modern word "Muskellunge" is but a corruption of the old Indian word "Noscononge."

a population of nearly three thousand Eskimos rely upon this fish for one of their most abundant and certain sources of food supply. The fish is caught in wicker-work traps set in its haunts—a wicker-work or brush fence leading into the funnel-shaped mouth of the trap from each side. In many of the muddy streams and ponds the water fairly swarms with these "Blackfish." Every fall, especially after the ice forms, great quantities are taken and packed in grass bags holding from forty to one hundred pounds each. These bags of fish freeze into a solid mass, and are then stored either in turf-covered pits, or upon platforms erected upon four posts, and thus kept for future consumption. They are eaten either raw or boiled by the natives, and are chopped up and fed frozen to the dogs.

ECONOMIC VALUE OF THE BLACKFISH.—It is difficult to estimate the amount of these fish used annually. It is well within the limits, however, to state that during October, November, and December at least 1,500 pounds per day are taken in the roughly triangular region between the Lower Yukon and Kuskoquim Rivers. This amounts to 138,000 pounds, or 69 tons. During the remainder of the year they are fished with varying success, owing to different causes, and for this period it is fair to allow one-half the amount just mentioned, thus giving 103.5 tons for the annual estimated catch in this region. Over the remainder of the territory where this fish occurs my data are very meager, but by a rough estimate I would allow about one-half the preceding amount, or 51.7 tons, raising the entire estimated amount of these fish used to 155.2 tons per annum. I have been very cautious in making the estimate small, but I am satisfied that careful observation over this region will raise the amount to perhaps double that given.

The Vega expedition under the command of Baron Nordenskjöld obtained numerous specimens of this fish, and it has since been redescribed by Professor F. A. Schmidt, of the University of Christiana, under the name *Dallia delicatissima*. There can be little doubt that Nordenskjöld's specimens belong to the species above described.

Q.—THE SALMON TRIBE.

In Dr. Suckley's "Monograph of the Genus Salmo," printed in 1873, forty-three species of Trout and Salmon were enumerated as members of the fauna of North America. In the course of the extensive revisions of our ichthyology which have recently been made, this group has been sedulously studied. Only eighteen species are retained upon the list as amended by Professors Gill and Jordan. While the number of species has been lessened, several new genera have been proposed, and many changes in nomenclature necessitated.

According to the latest system, the old genus *Salmo*, which in the standard works on angling includes everything called by the names "Trout" and "Salmon," has been divided into groups. The first, for which the name *Salmo* is retained, includes the Atlantic Salmon and the black-spotted species of the west, the Rainbow Trout of the Pacific slope, *Salmo irideus*, the Rio Grande Trout, *S. spilurus*, with the two closely-related forms, more widely distributed through the Rocky Mountain region, and regarded as subspecies of this type, also the Steel Head of the Columbia, *S. Gairdneri*, and the common Black-spotted Trout, *S. Clarkii*, which occurs in the Upper Missouri, in Utah, in the Columbia River, and numerous other districts of the Northwest. In this same group are included the Quinnat, or California Salmon, and its allies, which will be discussed hereafter. These have been placed in the genus *Oncorhynchus*.

The second group includes the Chars, or Red-spotted Trout, and the gray-spotted species known as Salmon Trout, or Lake Trout. These are assigned to the genus *Salvelinus*.

160. THE SALMON—SALMO SALAR.[1]

"In Aquitania the River Salmon surpasseth all the fishes of the sea," wrote Pliny, eighteen hundred years ago. This was the Salmon's christening, and though nearly one hundred species of the family *Salmonidæ* are now known to naturalists, one has always stood pre-eminent, like a Scottish chieftain, needing no other name than that of his clan. The luxurious Romans prized highly the salmon streams in their Gallic and British provinces, if we may trust Pliny and Ausonius, and that this fish was well known to the early English is evinced by the many Saxon names, such as "Parr," "Peal," "Smolt," "Grilse," "Kipper," and "Baggit," given it in different stages of growth in Great Britain and America. The Normans brought over the name of Latin origin, which they applied to the perfect adult fish, ready for the banquets of the conqueror. When Cabot discovered Newfoundland, in 1497, he found Salmon in its waters, but the red men had long before this known the art of killing them with torches and wooden spears.

DISTRIBUTION.—Salmon inhabit the North Atlantic and its affluents. No one knows how far beyond the Arctic Circle they range, though their occurrence in Greenland, Iceland, Northern Scandinavia, and Middle Labrador is well established. They occur in Norway, Sweden, Denmark, entering the Baltic and the waters of Russia, and, according to some authorities, the White Sea. They abound in all the British Islands, where they are protected and fostered with great success, and are more or less plenty in France, Belgium, Holland, and Prussia, ascending the Rhine as far as Basle. The southern limit of their occurrence is in Galicia, the northwestern province of Spain,

[1] This chapter is based upon the essay on the Salmon in "The Game Fishes of North America," by G. Brown Goode, published by Charles Scribner's Sons.

in latitude 43°. "There is a river in Macedon," says Fluellen, in "King Henry the Fifth," "and there is also moreover a river at Monmouth: it is called Wye, at Monmouth; but it is out of my prains, what is the name of the other river; but 'tis all one, 'tis so like as my fingers is to my fingers, and there is salmons in both." Fluellen was in the wrong, for there are no Salmon in any part of the Mediterranean water system.

On our own side of the Atlantic, their presence in Hudson's Bay and on the arctic coast of America is doubtful, yet probable. They range far north on the eastern shores of Labrador, and in the waters of the Great Lake system up to Niagara.

Nova Scotia, New Brunswick, and Maine have many salmon rivers; New Hampshire, Massachusetts, and Connecticut, a few very good ones. The natural limit of the southward range of the Salmon appears to be in latitude 41°, near the Connecticut River, where they were once extremely abundant, but many stragglers have been taken in the Housatonic and Hudson. Much effort has been made in trying to prove that the Salmon, of which Hendrick Hudson saw "great store" in 1609, when sailing up the river which bears his name, were weak-fish, or some equally remote species. Surely weak-fish do not go up the river to the Highlands. Salmon have from time to time been seen in the Delaware, it is said, and, if this be true, it renders the story of Hudson still more credible.

ABUNDANCE.—Wonderful things are said about their abundance in colonial days. Every one has heard of the epicurean apprentices of Connecticut who would eat Salmon no oftener than twice in the week.[1] Like many other good ones, this story seems to be prehistoric, and was doubtless told of some other fish in the times when our Aryan ancestors dwelt on the plains of Central Asia. You may find it in Fuller's "Worthies of England," where it has the same archaic and indefinite flavor which is so evident now two centuries later. "Plenty of them in this country," wrote Fuller, "though not in such abundance as in Scotland, where servants (they say) indent with their masters not to be fed therewith above twice a week." There can be no doubt that one hundred years ago salmon fishery was an important food resource in Southern New England. Many Connecticut people remember hearing their grandfathers say that when they went to the river to buy shad the fishermen used to stipulate that they should also buy a specified number of Salmon. At the beginning of this century they began rapidly to diminish. Mitchill stated, in 1814, that in former days the supply to the New York market usually came from Connecticut River, but of late years from the Kennebec, covered with ice. Rev. David Dudley Field, writing in 1819, stated that Salmon had scarcely been seen in the Connecticut for fifteen or twenty years. The circumstances of their extermination in the Connecticut are well known, and the same story, names and date changed, serves equally well for other rivers.

In 1798 a corporation, known as the "Upper Locks and Canals Company," built a dam sixteen feet high at Miller's River, one hundred miles from the mouth of the Connecticut. For two or three years fish were observed in great abundance below the dam, and for perhaps ten years they continued to appear, vainly striving to reach their spawning grounds; but soon the work of extermination was complete.[2] When, in 1872, a solitary Salmon made its appearance, the Saybrook fishermen did not know what it was.

HABITS.—At least half of the Salmon's life is spent in the ocean. "He is ever bred in the fresh rivers," said Walton, "and never grows big but in the sea." "He has (like some persons of honour

[1] "The shad, bass, and Salmon more than half support the province. From the number of seines employed to catch the fish passing up the lakes one might be led to suppose that the whole must be stopped, yet in six months' time they return to the sea with such multitudes of young ones as to fill the Connecticut River for many days, and no finite being can number them."—PETERS: History of Connecticut, 1783.

[2] MITCHILL and FIELD.

and riches, which have both their winter and summer houses) this fresh water for summer and the salt water for winter to spend his life in."[1] Most of his tribe, however, are peculiarly fresh-water fishes, though several share his sea-dwelling habit, and others, like the Brook-trout, descend into salt water, when not prevented by barriers of temperature.[2] All of the family run into very shoal water, and usually to the sources of streams, to deposit their eggs, and all of them seek food and cool temperatures in the largest and deepest bodies of water accessible. I am inclined to the view that the natural habitat of the Salmon is in the fresh waters, the more so since there are so many instances—such as that of the Stormontfield Ponds in England—where it has been confined for years in lakes without apparent detriment. The "Land-locked" or "Fresh-water" Salmon, known also in the Saguenay region as "Winninish," in the Shubenacadie and other rivers of Western Nova Scotia as the "Grayling," and in different parts of Maine as "Schoodic Trout," "Sebago Trout," or "Dwarf Salmon," probably never visit salt water, finding ample food and exercise in the lakes and large rivers. In some regions in Maine and New Brunswick their access to salt water is cut off by dams, and some investigators have claimed that Land-locked Salmon did not exist there until these obstructions were built, some fifty years ago. This hypothesis, however, is not necessary, for in the Saguenay the Winninish have easy, unobstructed access to the sea. The Salmon of Lake Ontario and its tributaries are not thought to enter salt water, and there are similar instances of land-locking in the lakes of Northern Sweden. In the Maine lakes Salmon feed on minnows and other small fishes. The Salmon while it remains in the sea or in the brackish estuaries takes particular delight in feeding on crustaceans and their eggs, small shrimps, and young crabs. When in the rivers they eat but little, though they are at times eager enough for food, as testify their voracious rushes at the angler's fly-hook. The absenteeism of the Salmon is due principally to the dearth of desirable food in the rivers. The young fish stay in fresh water for one, and frequently two, years. When they pass down to the sea they weigh but a few ounces. They find congenial food and begin to grow rapidly. The broad world of ocean affords them new opportunities for adventure and self-advancement, and it is only when summoned by the duties of family life that they return within the narrow limits of the old home. When Salmon live in the lakes they prey upon minnows and other small fishes, but those of the sea delight also in small crustaceans and their eggs, to which they owe the vivid color of their flesh. The habits of successive generations become hereditary traits, and the differences in their life-histories seem to justify the claim of the Land-locked Salmon to be regarded as a variety of *Salmo salar*, though it is hardly to be distinguished except by its lesser size and some slight peculiarities in coloration. It is to be designated as *Salmo salar*, variety *sebago*. Although both originated in the same primitive stock, it is not probable that one changes to the other except after many generations, under the influence of forced changes in their environment.

REPRODUCTION.—Although, like the Trout, and unlike shad, Salmon spawn on a falling temperature, not depositing their eggs until the water is at least as cold as 50°, yet they seem to enter the rivers on a rising temperature. Yarrell remarked that English rivers issuing from large lakes afford early Salmon, while rivers swollen by melting snows in the spring months are later in their season of producing fish, and yield their supply when the lake rivers are beginning to fail. In America the Southern streams seem to yield the earliest fish. In the Connecticut they appear in April and May, in the Merrimack in May and June, in the Penobscot most abundantly in June

[1] WALTON: Compleat Angler.

[2] The notion of marking Salmon is not a new one. Walton, writing two hundred and twenty-five years ago, speaks of observations made by tying ribbons in the tails of some number of young Salmon which were taken subsequently at the same place, "which hath inclined many to think that every Salmon usually returns to the same river in which it was bred, as young pigeons taken out of the same *dove-cote* have also been observed to do."

and July, though some come as early as April, and in the Miramichi from the middle of June to October. I can only account for this seeming paradox by the theory that, while Salmon are not harmed by extreme variation of temperature, they may be averse to sudden changes, and though strongly impelled to seek the spawning grounds are prevented by the cold. I have ascertained that the cod possess very little animal warmth. The temperature of the blood of a number of individuals caught in twenty-five fathoms of water was 47° Fahrenheit, precisely that of the water at the bottom whence they were lifted. Mackerel swimming at the surface registered 59° or 60°, while the temperature of the water was 58°, thus indicating that they possess a trifling amount of animal heat. The Salmon unquestionably changes its temperature with that of the surrounding water in much the same way, and if, as is probable, rivers rising in the mountains are colder in early spring than the ocean strata frequented by the Salmon, here is a possible solution of the problem. It is stated that in the English rivers, which are always open, there are no regular seasons of ascent, the fish constantly passing in and out; indeed, Mr. Atkins thinks it pretty certain that large Salmon in prime condition are running into the Penobscot from the sea every month in the year. It is likely, also, that the warmth of the rivers is an important factor in accelerating the vegetative growth of the eggs in the ovaries of the mother fish.

The movements of the Salmon are not so intimately related to the temperature of the water as those of many other species. They are not sensitive to sudden changes, and are capable of enduring a range of at least forty-five degrees. In this they resemble less the migratory fishes than the permanent residents of our fresh waters; indeed, it is quite allowable to speak of them as resident, for a large proportion of the whole colony belonging in one river may be found in it at any season. This proportion cannot fall much below two-thirds, if we consider that the fish less than a year old would make up at least half its number, and that the breeding fish are in the rivers six or seven months after the breeding. The breeding fish remain during the season of greatest heat and greatest cold, though their stay after they have deposited their eggs is no doubt chiefly because their vitality is diminished and their circulation retarded by the falling temperature, depriving them alike of the craving for food and the power to seek it. Those which spawn early are believed to return at once to the sea; the more tardy ones often remain all winter, and are carried out by the spring freshets. Salmon eggs are not injured by freezing, and the fish are unquestionably quite as hardy. English fish-culturists claim that their Salmon will not thrive where the water is warmer than 60°, or at most 65° in the summer, but Mr. Atkins kept fish in his ponds at Bucksport, Maine, with the water at the bottom as warm as 74° at midday, the means of bottom and surface temperature for June, July, August, September, and October, 1872, being 60°.6, 65°.9, 69°.8, 59°, 50°.3, and 72°.9, 73°.1, 73°.6, 62°.2, 54°.3, respectively. In the Gaspé salmon streams, where the fish are in the perfection of activity, the temperature of the pools in July ranges from 40½° to 59°.

KELTS.—At the approach of the spawning season their trim shapes and bright colors disappear. They grow lank and misshapen, the fins grow thick and fleshy, and the skin, which becomes thick and slimy, is blotched and mottled with brown, green or blue, and vermilion or scarlet. These changes are chiefly apparent in the males, whose jaws now become curved so that they touch only at the tips, the lower one developing a large, powerful hook, which is his weapon in the savage combats with his rivals in which he at this period engages. When in this condition, and after spawning, when they retrace their course to the sea, they are known as "Kelts."

Having entered a river, they press on to its headwaters, where the earliest of them arrive two or three months before spawning time. As soon as the water is cool enough they proceed to deposit their eggs, in deep furrows which they plow up in the sandy or gravelly bottom of the stream,

usually near the verge of a rapid. European observers state that the furrows are shaped by the noses of the two parent fish, every nest being filled with eggs before the next one is made, and the first covered up by the sand which is loosened in digging the second, chiefly by the action of the current. Mr. Atkins observed a female Land-locked Salmon excavating a nest by turning on her side and flopping violently against the bottom with her tail, while the male was engaged in driving away rivals and predaceous foes. Spawning is not accomplished at once, but the eggs are deposited by installments, as fast as they mature, during a period of from five to twelve days. "When the furrow is made, the male and the female retire to a little distance, one to the one side, the other to the other side of the furrow; they then throw themselves on their sides, again come together, and rubbing together both shed their spawn into the furrow at the same time." This is the observation of Mr. Ellis on the European Salmon, and a similar habit has been observed by Mr. Whitcher in Canada. In the tributaries of the Saint Lawrence spawning begins by the middle of October; in Maine, with both Land-locked and Sea Salmon, a week or two later, and it is presumable that in the Connecticut it will be found to occur well along towards December. In Great Britain and in the Rhine the season begins in October or November, continuing in some rivers till February.

Salmon eggs are about one-quarter of an inch in diameter, and of a bright reddish or yellowish hue. English fish-culturists estimate the number of eggs yielded by a large fish at 1,000 to each pound of her weight; experiments in the Penobscot indicate a yield of not more than 5,000 or 6,000 for a fish of eight pounds, and about 15,000 for one of forty pounds. In the Scotch streams the eggs come to maturity in one hundred to one hundred and forty days, but in our colder waters, at a temperature of 33° through winter and spring, the period of incubation is supposed to extend over six or seven months, the young fish not appearing until May. In the hatching-houses the period varies greatly, eggs having been hatched in fifty-four days with a temperature of 55°, and in one hundred and fourteen at 36°.

YOUNG FISH.—The newly hatched Salmon measures about three-quarters of an inch, and has the yolk-sac adherent from four to six weeks. When this is absorbed it begins to feed, rising greedily to seize any minute floating object. At two months the fry has grown to an inch and a half, and begins to assume the vermilion spots and transverse bars or finger marks which entitle it to be called a "Parr," and which it retains while remaining in fresh water, sometimes until it is seven or eight inches long. It continues a "Parr" until the second or third spring, when, in preparation for, or perhaps in consequence of, a descent toward the sea, a uniform bright silvery coat is assumed, and the Parr becomes a "Smolt." After remaining from four to twenty-eight months in the salt water it again seeks its native river, having become either a "Grilse" or a "Salmon." The "Grilse" is the adolescent Salmon; it weighs from two to six pounds, and is more slender and graceful than the mature fish, with smaller head, thinner scales, more forked tail, and spots rounder, more numerous, and bluish rather than jetty black. The two may easily be distinguished even though both should be of the same size, as not unfrequently happens. The male Grilse is sexually mature, but not the female, in America; in Europe the same is claimed for the male Parr and the female Grilse. "There is nothing in the water," says Norris, "that surpasses a Grilse in its symmetrical beauty, its brilliancy, its agility, and its pluck. I have had one of four pounds to leap from the water ten times, and higher and farther than a Salmon. Woe to the angler who attempts, without giving line, to hold one even of three pounds; he does it at the risk of his casting line, or his agile opponent tears a piece from its jaw or snout in its desperate effort to escape."

Mr. Atkins calls attention to the fact that the great run of Grilse which is so prominent a feature in Canada and Europe is almost entirely absent in the rivers of the United States, the fish

not returning until they have become adult. In rivers where Grilse are found, the Salmon always precede them in their ascent, for they do not enter fresh water until toward the end of summer.

Who can wonder at the angler's enthusiasm over "a Salmon fresh run in love and glory from the sea?" Hear Christopher North's praise of a perfect fish: "She has literally no head; but her snout is in her shoulders. That is the beauty of a fish, high and round shoulders, short waisted, no loins, but all body and not long of terminating—the shorter still the better—in a tail sharp and pointed as Diana's, when she is crescent in the sky." Mr. Kilbourne's painting in Scribner's "Game Fishes of North America" represents a thirty-pound fish drawn to a scale of one-fourth. The largest on record was one of eighty-three pounds, brought to London in 1821; the Scotch fish rarely exceed twenty-five pounds. Perley speaks of a sixty-pounder taken long ago in the Restigouche; in 1852 many of forty, and one of forty-seven, pounds were caught in the Cascapediac. Mr. Frederick Curtis' score for York River, Canada, July 7, 1871, shows nine fish ranging from seventeen to thirty-four and averaging twenty-six and a quarter pounds. Another, for the same locality, July, 1876, shows one hundred and ten fish, averaging more than twenty-two pounds. This was by Mr. Thomas Reynolds, who caught in the same river a fish of forty-seven pounds, the largest ever killed in Gaspé with a fly. In the Penobscot forty-pounders have occasionally been taken, but not more than one out of a thousand weighs thirty, and the common size is from ten to twelve pounds. A fish two feet long would weigh about six pounds; one of thirty inches, nine or ten; one of three feet, sixteen to seventeen; and one four feet long, nearly fifty. A score of twenty-two days' fishing, with four rods, in the Godbout, in June and July, 1865, foots up four hundred and seventy-eight fish, averaging nine and three-quarters pounds.[1]

Salmon in Lake Ontario.—The following notes by Mr. Kumlien on Salmon in Lake Ontario possess much interest: "At Oswego they were formerly very abundant and very important; they used to go up the river (Oswego) to the falls. In the last eighteen years they have gradually decreased till now they are caught only as stragglers. Forty have been speared by one man in a day. Navigation and various kinds of mill refuse have driven them away. A few years after the dams were built they yet came in abundance, and tons of them were speared from the dams, but they have gradually grown less till now only an occasional straggler is caught.

"At Port Ontario," Mr. Harrington says, "in 1879 only a very few were caught in the seines. For the last three or four years have been scarce in the river. I think it is because the mills and factories—especially the book-board mill at Pulaski—throw the refuse into the river. They have not been plenty in the river as far up as Pulaski since 1875. It is currently reported that considerable numbers were caught in the river five or six years ago, and disposed of on the sly. They seem to have turned their course from this river. Of late years a few weighing eighteen to twenty pounds have been taken; we used to consider twelve pounds an average. Some weighing thirty pounds have been taken."

"At Pulaski, Mr. J. A. Mathewson & Bro. (Mathewson has fished here the last fifty-five years) report as follows on the salmon fisheries: "In October, 1836, two men took two hundred and thirty Salmon between 8 p. m. and 12, with spears and fire-jacks, and after 12 till morning two other men in the same skiff took two hundred odd, the average weight of the entire lot being fourteen and three-quarters pounds. We have had fifteen hundred fresh Salmon in the fish-house at one time. When a freshet occured in June a few would always come up, and sometimes a few early in the spring. Any time from June till winter when there was a freshet they were sure to come. The principal time, however, was in fall, during September, October, and November. Twelve skiffs in one night

[1] Norris: American Angler, p. 117.

have taken an average of three hundred Salmon each. For the last twenty years the catch has been nothing to what it used to be, though some are taken even now. The gill-nets stretched across the mouth of river assisted to a large extent in causing the decrease. The fish used to run up to the falls, ten miles above Pulaski; now there are two dams in the way. They never could go above the falls, as they are one hundred and eight feet in perpendicular height. I think the mills (factories), tanneries, etc., are prolific causes of the disappearance of Salmon. Lime is one of the worst things thrown into the river; vats of refuse lime have been emptied when the river was full of fish, and upon the next they were gone. Lime, tan-bark, sawdust, and gill-nets have driven the Salmon from our river.

"There were formerly three salmon streams in this vicinity—Grindstone Creek, Deer Creek, and Salmon River—and each stream had a different type of fish. An experienced fisherman could readily tell from which stream a fish was caught, though they are but four miles apart. In Deer Creek the fish were long and slim, in Grindstone short and chubby, and in Salmon River large and heavy.

"The largest specimen ever caught here weighed forty-four and three-quarters pounds. Some have been taken as small as one pound. A few will come up now as soon as there is a freshet. There is a fish-way here on the lower dam, but its construction is so defective that very few if any of the fish are able to get over it; they were seen to try last fall and fail. They are caught (and always were) with a large three-tined spear from a skiff with a jack-lantern. Two thousand have been landed at the bridge in one night."

"Mr. Cross says: 'They often went over the dam before the apron was put in, but now they must jump along a twenty-foot apron besides the height of the dam (eight feet). The way it is now, a few manage to get as far as the first pocket and then fall back again. Forty years ago the salmon fisheries on this river brought more money to the people than all the machinery now on the river.'

"At Cape Vincent they were formerly taken on the lake shore during the migrations. Never went up the Chaumont Bay. No rivers here to spawn in. Never seemed abundant in the Saint Lawrence only as they passed by. Even now one is occasionally taken in the gill-nets in the lake.—(McPherson.)

"At Chaumont four were caught in 1879; were formerly common during their migrations.—(Dewy.)

"At Sacket's Harbor very rarely taken now; used to get them at Phillips Point as they were passing by."—(Clark.)

161. THE SALMONS OF THE PACIFIC.

By David S. Jordan.

The Steel-head—Salmo Gairdneri.

This species is everywhere known as the "Steel-head." The name "Hard-head" is sometimes applied to it, and it is known to the Russians as "Seomga." The name "Mykiss" is said to have been formerly applied to it in Kamtchatka. Large individuals are often called "Salmon Trout." The Indian name "Humaāna" is said to be given to it on the Upper Columbia. It reaches a weight of twenty-two pounds, the average weight when fully grown being about sixteen. Young specimens are very scarce in our experience. It is found from Monterey to Kamtschatka, always close to the coast. In the Columbia and Frazer Rivers it occurs in abundance in the spring at the time of the salmon run. None have yet been noticed to the eastward of the Cascade Range,

and so far as appearances go it is a permanent inhabitant of river mouths. It probably spawns late in the fall or in the winter, as many of those taken at the first run of the Salmon are spent fish, with the flesh white and worthless.

The history of this species is still obscure. According to Pallas, it migrates singly, from June to September; some remaining all the year in the rivers, returning to the sea in May. It feeds in the fresh waters on any living thing. Hence, unlike the other Trout, which during the ascent of the rivers grow lean with fasting, breeding, and exertion, this species is plump and well fed, and, with *S. alvelinus malma* only, does not perish in the winter. Elsewhere than in the Columbia this species is highly valued as a food-fish. When taken in the Columbia in spring little or no use is made of it. Its flesh is pale, and its bones too firm for it to be used in canning, and at that season the old individuals taken are usually spent and worthless. In the Sacramento it is not very common.

The Rainbow Trout—Salmo irideus.

This species is generally known as the "Brook Trout," "Mountain Trout," "Speckled Trout," "Golden Trout," and other evanescent names are also sometimes applied to it. It does not reach a weight of more than five or six pounds, so far as we know, and most of them as taken are fingerlings ranging from four inches to a foot in length. It is found throughout California in all streams of the mountains. It is said to occur in the northern part of Lower California. The southernmost seen by us were from San Luis Rey River. We have seen but few specimens of this species from salt water. These weighed from three to five pounds each. It may probably run into the sea from streams in which the lower waters are clear. Specimens referred to this species from the north of Mount Shasta are perhaps the young of *S. Gairdneri*. It feeds on worms, larvæ, and the like. For a Trout, it is a fish of little "gaminess" or activity. It is not often brought into the markets of San Francisco, and at present has little economic importance, although of course a good table-fish. It has been rather extensively introduced into the waters of the Eastern United States.

The Black spotted Trout—Salmo purpuratus.

This fish is known as the "Trout," "Mountain Trout," "Spotted Trout," "Black Trout," "Silver Trout," etc., in the mountains, but when in the ocean, full grown, as "Salmon Trout" or "Steel-head." The Indian name "Preestl" is also ascribed to it on the Upper Columbia. It reaches a weight of thirty pounds under the most favorable circumstances, but may be found in any stream or lake of any length from two inches up to two or three feet. Unlike *S. Gairdneri*, the young are very common, and it probably begins breeding in mountain streams at a length of less than a foot. It is universally distributed through the Rocky Mountain region, chiefly east of the Sierra southward, but reaching the sea from Mount Shasta northward. It occurs in every lake of New Mexico, Utah, Western Colorado, Wyoming, Montana, Idaho, Oregon, and Washington. Every stream throughout the most of this region abounds in them, and in Puget Sound the young of every size occur in the salt water in abundance. Individuals are occasionally taken along the California coast. Local variations occur in abundance. Specimens from Seattle have the scales notably larger than those from Victoria and Astoria, which agree with Utah Lake specimens in this respect. Those that live in the depths of shady lakes are almost black, while others are pale. Those in the sea are silvery and only faintly spotted. Only in Lake Tahoe do the variations assume any marked importance (var. *Henshawi*). Individuals intermediate between this species and *S. Gairdneri* are not rare, and there is no doubt that the latter is simply an offshoot from this general stock, as are *S. irideus* and *S. stomias*. It feeds on any living thing it finds near it. In the

mountain lakes it spawns in the spring, running into the rivers for that purpose. Its great enemies at that season are the various species of suckers and chubs, which feed, the former upon its eggs, the latter upon the young Trout. So very destructive are the former in many trout lakes, as Utah Lake, that the destruction or diminution of the suckers ought to be accomplished by law.

A parasitic tape-worm, *Dibothrium cordiceps*, Leidy, is said to frequently infest this species, so as to render its flesh uneatable in the summer, in the Yellowstone Lakes. (Yarrow.)

As a food-fish this Trout is excellent. Large numbers of the variety *Henshawi* are shipped to the market of San Francisco. Attempts have been made to cultivate it in parts of California, I believe with success. A small hatchery has been established at Tahoe City for the purpose of keeping stocked a small branch of the lake in which summer visitors may fish.

In the opinion of the writer this species is likely to prove much more valuable for introduction into Eastern waters than the Rainbow Trout. It is more active, more gamy, reaches a larger size, and thrives in a greater variety of waters.

The Rio Grande Trout—Salmo spilurus.

This species is abundant in the headwaters of the Rio Grande, Rio Colorado, and their tributaries, being the finest food-fish in New Mexico and Western Colorado. It has also been taken in Bear River, and probably is found in most of the mountain streams of Utah, being in general rather southern in its distribution. It probably inhabits all streams within the circle of its distribution, without regard to the direction in which they may flow. We have not seen this species in life, and little distinctive is known of its habits. It is probably a comparatively recent offshoot from *S. purpuratus*. As in other species, considerable variation is shown in specimens from different localities. Its usual size is larger than that of *S. purpuratus*.

The Dog Salmon—Oncorhynchus keta.

This species, during the period of its run in the fall, generally goes by the name of "Dog Salmon," under which name the males of the Silver Salmon, and even of the Quinnat, are often confounded with it. The Russians now, as in the time of Pennant, Pallas, and Walbaum, call it "Kayko," the name "Keta" (whale) being no longer in use. On Frazer River the name (Musquam) is now "Qualoch," at Seattle (Nisqually) "Ktla-why," and in the Chinook jargon "Le-Kai." This species is very uniform in its size, and averages ten to twelve pounds. It ranges from the Sacramento River to Bering Strait, where it seems to be especially abundant; it being the only Salmon brought from there in a recent cruise of the revenue-cutter Corwin. It is seldom or never seen in the rivers in spring.

The Hump-backed Salmon—Oncorhynchus gorbuscha (Walb.) Gill & Jor.

This species is known to the Russians still, as in the time of Pennant and Pallas, by the name of "Gorbuscha," *gorb* meaning hump. The English-speaking people call it generally the "Hump-back Salmon," and often the "Dog Salmon." On Frazer River it is known as "Holia" or "Hone" Salmon, and on Puget Sound as the "Haddoh." This is one of the smallest Salmon, not averaging over four or five pounds, and probably never exceeding ten. It ranges from the Sacramento River to Alaska and Kamtchatka. In the Sacramento and Columbia it is only an estray, on the latter river being sometimes called "Lost Salmon." In Puget Sound it runs in large numbers in late summer and fall, like the *Keta* or Dog Salmon, ascending every little stream. Its run in Puget Sound takes place on alternate years, a fact which seems to be well established. It was very plenty in 1879. None were noticed in 1880, but stragglers are occasionally taken during the year of

scarcity. A few were seen by us on the Columbia and Sacramento. We are told that this species runs every year in Alaska. During its run in Puget Sound the females are canned, and the males are thrown away or given to the Indians. The flesh is then pale, and the canned product is inferior in quality. In economic value the Hump-back Salmon is far inferior to the Quinnat, the Blue-back, and the Silver Salmon, and, like the Dog Salmon, is mainly useful in furnishing a winter supply of food to the Indians.

THE SILVER SALMON—ONCORHYNCHUS KISUTCH.

This species is almost everywhere known by the name of "Silver Salmon." It has also a series of local names. In Kamtchatka it is still known by the name "Kisutch," in use in Pennant's time, a hundred years ago. The name "Bielaya Ryba," or "White-fish," is also ascribed to it. On Frazer River it is known by the Musquam name of "Coho"; at Seattle, by the Nisqually name of "Skowitz"; about Cape Flattery by the Makah name of "Hoopid"; on the Columbia it is called "Silver Salmon" or "White Salmon," and southward the same names prevail. It reaches a weight of twenty pounds, the usual range being from seven to ten. The Silver Salmon enters all the rivers from the Sacramento to Kamtchatka. In the fall it is abundant in probably all the rivers. Few or none, however, are seen in the spring. They are often taken with seines in Puget Sound at all seasons. Like the other fall-running Salmon, it seldom ascends the rivers to any great distance.

THE BLUE-BACK SALMON—ONCORHYNCHUS NERKA.

This species is known as the "Red-fish" to the English-speaking inhabitants of Alaska and Kamtchatka, and to the Russians, now as in the time of Pennant and Pallas, as "Krasnaya Ryba," which signifies *red-fish*, the name having reference to the color of the flesh. It is not unlikely that other species are occasionally confounded under this name, but there is little doubt that the present species is the one to which it is chiefly applied. On Frazer River, where this species is the most important Salmon, it is known as the "Suk-kegh." Elsewhere in Puget Sound it is rarely seen. In the Lower Columbia it is known by the appropriate name of "Blue-back"; in the Upper Columbia as "Red-fish." Its average weight does not exceed eight pounds, and its extreme weight is probably not above fifteen. Its range is from the Columbia River to Japan and Kamtchatka. It runs in considerable numbers in the Columbia, and in much greater abundance in Frazer River, where it is the principal spring Salmon. We have no information as to its occurrence in California, or as to its entrance into any of the streams south of the Columbia. Like the Quinnat Salmon, it is attracted in early spring into all those streams which are fed by the melting snows, and into no others. Its run in spring on the Columbia is, so far as we know, contemporaneous with that of the Quinnat Salmon. The numbers are, however, much less, and I think that its run is over earlier in the fall. On Frazer River it runs with the Quinnat, or a little earlier in the spring, the run mostly ceasing in midsummer, while that of the Quinnat continues on through the fall months. This species and the Quinnat run early and go far up the streams, where, after spawning, they all die. In Puget Sound this species is not known to the fishermen, only stray individuals being taken there. It does not accompany the Silver Salmon and Dog Salmon in their ascent of the Dwamish, Puyallup, and other small streams; neither is it caught near the shore when out of the spawning season, as the other species are. In Alaska and Kamtchatka we are told that the Red-fish (*nerka*) and King Salmon (*chawytcha*) run in spring and early summer, while the other species run in late summer and fall, the Silver Salmon last.

The Blue-back is the most graceful of the Salmons and the most elegant in color. Its flesh is very similar to that of the Quinnat, but less firm and more watery, and it is not quite so rich when

canned. Next to the Quinnat, it is the most valuable of the different species, and its inferiority is mainly that of size. At the canneries four Blue-backs are taken as one Quinnat. A very few of the Columbia River canneries refuse this species, in order to be able to say that they can the Chinnook Salmon only.

BENDIRE ON THE RED-FISH.—This is the Red-fish of Idaho, the identity of which was first determined by Capt. Charles Bendire, United States Army, whose field-notes upon its appearance and habits, published in the Proceedings of the National Museum,[1] are here reproduced:

"The females are much more uniformly colored. The head is considerably tinged with steel blue, and the red tint on the sides is more or less clouded with blue and bronze. Females after spawning show considerable amount of red, only after spawning I noticed that the red coloring matter deposited in the skin appears to be drawn from the flesh, and I find that in proportion to the bright coloring of the skin of the fish the flesh loses this tint. In some instances it is barely pink-colored or almost white. After the spawning of these fish they are brightest outside and palest inside (as far as the flesh is concerned). The average size of a number of males by actual weight is only five pounds, and of females only three and three-quarters pounds. After death, within half an hour the color of these fish rapidly changes about the head and becomes a dark olive green with bluish reflections, in some instances almost bluish-black. Among any number of fish there is almost an endless variation in color, caused, perhaps, by some remaining a longer time in the lake than others. Wallowa Lake is about four and one-quarter miles in length by one and a half to two miles wide. It deepens very rapidly out a few feet from the shore, and is said to be four hundred feet deep, and more than that in places. Two small streams flow into the lake, and these form the spawning ground proper for these fish; and as there are falls about two miles above the mouth of these streams over which the fish cannot leap, they are restricted to rather limited quarters for spawning. The only place I saw any of these fish was on the bar near the head of the lake, and there most of them are caught. They can be seen in schools of one hundred or more at almost any time during the month of August and later. This year the run has been very light, and fishing had to a great extent stopped when I arrived at the lake on the last day of August. Four fisheries had been in operation, and these had put up about twenty thousand pounds of fish. I believe two or three years ago it had been the practice to obstruct the entrances to the small streams at the head of the lake to prevent the fish from running up these streams. This year this was not done, and a number of the settlers about the lake seem to be anxious to have the fish properly protected, and it is not at all too soon to do it, either. The placing of obstructions in the above-mentioned streams, and perhaps this year of gill-nets on the bar, has no doubt something to do with the scarcity of these fish. But the most abominable things of all which I saw personally in use are several clusters of hooks tied together, so that they form a circle with a radius of about three inches. Just above these hooks a lump of Red-fish eggs is laid. These are covered with mosquito-netting, and by this contrivance thousands of young Red-fish (the settlers call them "Shiners," others call them "Trout," but I am satisfied that it will be found that they are yearling Red-fish)[2] are caught and salted as well as the full-grown ones. Now, these fish are only about four inches long, and for every one caught two are crippled and die. So it can readily be seen that an immense number are destroyed yearly, as some parties make it a business to salt these down as well as mature fish.

"I examined all these modes of fishing, and when I hooked with a single hook about one out of three in some other part of the body than the head, it can readily be understood how murderous

[1] Vol. iv, pp. 82-84.

[2] No doubt of it.—D. S. J.

such a contrivance as the above must be, and how many young fish can be destroyed by a single person in a day. They bait them first, and when they become plenty use their grappling hooks.

"The fishermen at the lake complain that the Indians destroy the fish, but from personal observation I can't at all agree with them. It is true that numbers of Indians come from various parts of the country to Wallowa Lake yearly to fish, and they catch a good many. While I was camped at the lake I examined the catch of every Indian that passed my camp, and I looked at as many as fifty Indians a day; each one had from six to twelve fish usually tied on his horse, and I found that there was about one female to ten males, and most of these were spent fish which had already spawned. They are not at all particular about this, and a fish which may be all bruised up and skinned is apparently just as well relished by them as a perfectly sound one, and even these Indians appreciated the fact that it would not do to catch too many females; at any rate they told me that as a rule they let the females go, and this is a good deal more than most of our white fishermen are willing to do. Mostly every one out here now concedes that the Red-fish is not a resident of the lakes wherein it is found, and I am perfectly satisfied that they are anadromous and not land-locked. The only thing as yet which I can't understand is, how do they get rid of the hooked nose and the hump after going back to salt water? They surely can't all die after spawning, and sometimes one that weighs as much as ten pounds is caught, and this fish is certainly older than a five-pounder; and it would not be presuming too much to assert that a Salmon of that size must have made more than one trip to sea. While in the lake they do not appear to eat anything, and the stomachs of several which I examined were entirely empty. I cannot understand how they get rid of their long hooked nose and hump."

162. THE QUINNAT OR CALIFORNIA SALMON—ONCORHYNCHUS CHOUICHA.

By Livingston Stone.

"In Alaska and Kamtchatka," writes Jordan, "this species is known as the 'King Salmon,' and as 'Choweecha' or 'Tchawytcha,' a name easier to pronounce than to spell, to the Russians. In Frazer River it is called by the Musquam name of 'Sah-Kwey'; in Puget Sound it is called the 'Columbia River Salmon,' or in the Chinook jargon 'Tyee.' On the Columbia River the name 'Chinook Salmon' is in universal use. Farther south the name 'Salmon' is applied to this species, while the others receive specially distinctive names. The Quinnat Salmon reaches a weight of sixty to ninety pounds, being the largest of the salmon family. The average weight is, however, much less. On the Columbia River the average is twenty-two pounds each; on the Sacramento River, about sixteen. It is probable that the individuals of about twenty pounds' weight are four years old, and the larger ones occasionally taken are older, having probably lived through one or more spawning seasons. Those which enter the river late in the fall cannot ascend far before the necessity for spawning comes, and such may be able to return to the sea, and thus escape the death which overtakes all that spawn far inland.

"In all streams having their rise in the snows this species begins running as early as March, and the run continues with various interruptions until the spawning time in the fall. When a freshet occurs in spring, the run for a time after is much increased. In regard to this species and the 'Blue-back,' it would appear that they, when adult, enter the streams whenever cold fresh water comes in contact with them in the sea. After entering fresh water they do not feed, and they continue their ascent until the season for spawning actually overtakes them. Often they ascend hundreds of miles, until they are almost worn out, and after the spawning act all that have thus ascended die. Those streams which do not have their source in the melting snows have no spring run of Salmon, and in them the Quinnat runs only after the fall rains have set in.

"The distribution of the Quinnat is from Ventura River, where individuals occasionally run in the winter, to Kamtchatka. It also occurs in the rivers of the corresponding latitude in Asia The abundance of this species has probably not yet materially diminished in the Columbia. More than a million and a half have been canned on the Lower Columbia during the present season (April, May, June, July, 1880), a greater number than has ever been taken before. In the Sacramento the numbers have doubtless been reduced by overfishing, and a systematic process of keeping up the supply in the Columbia by means of hatcheries will very soon be necessary.

"The Salmon take no food in fresh water. In the headwaters of the rivers, in the clear water, they (at least the males) will sometimes take an artificial fly. In the ocean they take a trolling bait readily. They then feed on anchovies, herring, smelts, sand launces, shrimps, and in general on any living object. Even at the time of first entering the rivers in spring the stomach is found empty and contracted.

"The enemies of the Salmon are, when very young, the chubs, suckers, and other small fishes, which prey upon the eggs and young fish. In the ocean their chief enemies are the seals of different species, who bite out their throats and destroy very great numbers of them all along the coast. No diseases were noticed by us, except those produced by the accidents and great exertions accompanying the spawning season.

"The economic value of this species at present exceeds that of all others on the Pacific coast combined. It is brought fresh to the markets of all the cities, and the flesh is canned for export to the East and to other countries, especially to England."

NAMES.—The first scientific name by which this fish was commonly known was *Salmo quinnat*. This name is generally reputed to be derived from a river, called the Quinnault, where a particularly good variety of this Salmon was found. This the writer is quite positive is an error. The common name of the Salmon, at least among the Columbia River Indians that lived near the mouth of the Willamette, was "Quinnault," of which *Quinnat* is a corruption, and the scientific name was undoubtedly taken directly from the Indian name of the fish. The river might have been named after the fish, but it is not likely that the fish was named after the river.

Not long ago Professor Jordan, after a critical examination of the fish, pronounced it to be not correctly a Salmon, but an *Oncorhynchus*, and rechristened the fish *Oncorhynchus quinnat*, which name it held till last summer (1880), when Professor Jordan discovered that the fish had probably been described by Walbaum, in 1792, under the name of *Salmo chouicha*, and yielding to prior authority restored its original name, by calling it *Oncorhynchus chouicha*, which name it will now probably retain until a more captivating successor presents itself. The small fish which were called by Girard, Suckley, Jordan, and Copeland by the appellations *Fario argyreus*, *Salmo argyreus*, and *Salmo Warreni* were without doubt the young of the *Oncorhynchus chouicha*, and the names will now be given up.

DISTRIBUTION.—The distribution of this Salmon is quite limited, being at present restricted to the Pacific slope of North America, between the neighborhood of the bay of Monterey and the Alaska border, although if it is the same as the "King Salmon" of the Yukon and the Alaska Rivers its range extends as far north as the Arctic Ocean.

The California Salmon is taken in the largest quantities in the Sacramento and Columbia Rivers, these being the largest rivers on the coast, but is also found in considerable numbers in the smaller rivers of California, Oregon, Washington Territory, and British Columbia, notably in the Eel, Russian, Klamath, Rogue, and Frazer Rivers.

The adult fish vary widely in size. The smallest mature fish on record was caught in the McCloud River, California, and weighed about four pounds. The largest on record was caught in

the Columbia River, and weighed eighty-three pounds. The writer has seen one on the Columbia that weighed sixty-seven pounds.

The California Salmon is easily caught with hook and line in the fresh-water tributaries, where it goes to deposit its eggs. It does not readily take a fly, but becomes an easy victim when tempted with salmon roe, which is the most effective of all baits for catching this fish. When prime it very much resembles in appearance the well-known Atlantic Salmon (*Salmo salar*) in the same condition, with this exception, that it has on its back and sides nearly black, star-like spots, while the Atlantic Salmon has none, when fresh from the ocean.

The California Salmon is a remarkable fish, and has had an extraordinary career. Fifty years ago it was hardly known, except to students of natural history. Now it is known and eaten almost all over the world, for there is hardly a port in the world where ships have not carried the canned Salmon of the Columbia, which is the same fish under a different name; and not only has this fish, in the form of food, traveled nearly all over the world, but the living embryos of the California Salmon have been transported to England, France, Germany, Belgium, Denmark, Russia, Australia, and New Zealand, so that there is probably no one fish inhabiting a limited locality which is known over the world in so many different places as the California Salmon.

This magnificent fish is deserving of its career. If splendid proportions, of unsurpassed vigor and spirit, it has no equal in external attractiveness among the race of fishes, except its own cousins of the Atlantic and other oceans, while as regards the quality of its flesh and its marvelous abundance in its habitat, it has but few equals in the world. As to the quality of its flesh, it closely resembles the highly-prized Salmon, *Salmo salar*, of Great Britain and the Atlantic coast of North America, which has no superior, and as to its abundance I need only say that nearly two hundred million pounds have been caught in the Columbia River alone during the last six years, without producing, according to the most recent testimony of the Columbia fishermen, any serious diminution of the river's stock.

DEVELOPMENT.—The Salmon begins life as a bird does, in an egg. When the egg first leaves the parent fish it is about one-fourth of an inch in diameter and of an orange tint. In a few days there can be seen in the egg a fine dark line, which is the first visible beginning of the future salmon. In nineteen days, in water at 55° Fahrenheit, the black pigment of the eye begins to show through the translucent shell. In thirty-five days in the same water the young Salmon is hatched. When it first emerges from the shell it is about an inch long, and carries under its body in a little round sac the yolk of the egg it came from, on which it lives by absorption for about a month longer, till its mouth is sufficiently completed to take food and its other organs to dispose of the food it takes. When it first hatches it is a clumsy-looking and an awkwardly-moving object, being about as graceful and efficient in its attempts to swim like a fish as a human beginner's attempts are to ride a bicycle. After it has lived in its sac a week or two it develops a disposition to dive and hide under something, which it does with a pertinacity which is both characteristic of the full-grown Salmon and prophetic of the tenacity of purpose it will show in ascending its breeding rivers to spawn. This irresistible instinct to dive and hide takes it still deeper under the gravel and rocks in the bed of the river which formed its birth-place, and it stays here in the crevices of the rocks and gravel, as snug as possible, until the sac of food which nature started it in life with is gone, and it is obliged to work for a living or starve. It would not be safe for the little helpless creature now to venture out of the rocks and gravel where it was born, for it would undoubtedly pay for its rashness by becoming food, while yet alone, for the larger fishes above. So like the early Christians in the catacombs, it spends a large portion, if not all, of its earlier life in or close by the under-world where it was born. As it gets larger it ventures out and

takes its chances for life in the world of waters above it, usually, I think, going up some brook or keeping near some rocks, or close inshore where it can quickly retreat to a place of safety when alarmed. It feeds now voraciously on whatever it can find in the way of smaller fishes and insects and other animal life in the water, and in a few months, probably not over six or seven, it joins the host of its comrades, of about the same size, which are preparing to go to sea, and forming a school which, without doubt, gathers myriads of recruits as it proceeds, it hastens with all its might down the stream. It is now a beautiful silvery fish from four to six inches long, and in a few days finds itself in the midst of the allurements and dangers of the great unknown ocean which it was so eager to seek.

Strange as it may seem, very little, almost nothing in fact, is known of its ocean history. We know that the Salmon leave the mouths of the rivers at stated times and return to their rivers at other stated times, but where they go, or how they fare, or what motives guide their course in their mysterious ocean sojourns, no one knows. From analogies derived from our knowledge of the history of the Atlantic Salmon, we suppose that they go into deep water when they leave the rivers, and seek the best feeding places they can find, but that is about all one can say of their ocean history. The few facts that we know of this portion of their existence are pretty much confined to the following:

They are found to have deep-sea fish in their stomachs when they first make their appearance near enough to the mouths of the rivers to be captured, which points to the deep sea as their ocean feeding ground. They are also caught by the fishermen at Monterey Bay, which shows that they go as far south as Monterey, but does not show, what some claim, that the course of their migration is southward, for there may be hundreds of unknown places to the north where they could be caught if the fishermen were there. It only proves that some California Salmon go south to Monterey. One thing more is known about their ocean life, and that is that they are often caught with marks of seals' and sea-lions' teeth upon them, which shows that they are preyed upon in the sea by these enemies, though, perhaps, it is only in their journey to the rivers' mouths that they have to run the gauntlet of seals and sea-lions, for they probably have a capacity for standing deeper water than their just mentioned enemies.

THE RIVER ASCENT.—But if their ocean history is little known, their inland career, if I may use the expression, is interesting enough to make up for it. From the moment the Salmon enters the river, which it is sure to seek once in one or two years, its progress is one of interest. It first *proceeds, at its leisure, to the head of tide-water.* Here it stops awhile and seems to play about between the fresh and salt water. Whether it shrinks from encountering the sudden change from salt water to fresh, which is probably the cause of its dallying, or for other causes, it usually spends two weeks or more hovering about the border line between sea water and river water. When it has overcome its apparent repugnance to making the change to fresh water, it makes a rapid charge up the river for the clear gravelly streams which its instinct or sixth sense tells it to seek. Now, paradoxical or unreasonable as it may seem, it stops eating. If it is caught a short distance above the head of the tide, the undigested remains of what it ate in the salt sea water are sometimes found in its stomach, but after that nothing, absolutely nothing, is ever found inside of the California Salmon to show that it has eaten a particle of food in fresh water. As a proof of this statement I may mention that out of a great many thousand specimens that have been examined no food has been in the stomachs of any.

After the Salmon cross over the line into the fresh water above them they begin a strange and almost inexplicable journey. In the case at least of the Salmon that go up the McCloud River, they begin a journey which is a long fast, and ends only in death. If they could be credited with

a knowledge of what lies before them, none of the martyrs of Christendom could claim greater merit than these devoted Salmon that march on unflinchingly to inevitable death. From the time the Salmon leave the border land, so to speak, of tide water, they pursue their upward course towards the rivers' sources with an inflexible pertinacity. Nothing can now check their upward career, except an obstacle positively insurmountable, and nothing whatever can make them turn back. They steadily pursue their way through the deeper and stiller waters of the lower portions of the rivers. They dash furiously up the rapids, halting awhile usually before they enter them to recruit their strength, and continue to rush on and on through the swiftest, shallowest, and roughest waters until they reach suitable places for depositing their spawn. The earliest runs, that is, those that enter the rivers first, usually go farthest up the stream. Those that come in next seem to take their places below them, and so on down the river, so that there is a series of sets of spawning fishes, extending from the head of the river down as far as suitable spawning grounds are to be found; the set highest up the river spawning first, and so on down the river in regular order. If the Salmon on their way up a river meet with anything that frightens them, like a bridge for instance, they usually stop and cautiously examine it until they are satisfied that they can risk the venture, and then they all together, as if by a given signal, make a swift rush past it. When they come to a fall they show more perseverance than Robert Bruce's famous spider, for they try innumerable times to jump it, and never give it up until they have found it to be a hopeless case and are completely worn out with the exertion.

I said nothing can turn them back. When thoroughly frightened and panicked, however, they act like stampeded cattle and can be driven down the river in droves. The Indians take advantage of this weakness of the Salmon in one of their methods of capturing them. They build a trap nearly across a river that is not too deep for the purpose, and then great numbers of them wading into the stream a mile or two above the traps form a line across the river, and with sticks, poles, and branches of trees, use their utmost exertions to frighten the Salmon, till at last the fish, too astounded and panic-stricken to know what they are about, turn around, and heading down the river, rush with all their speed into the traps that are waiting for them.

In their course up the river it does not discourage them if the water is shallow. They will push on where the water does not cover their backs, and crowd together in doing so, till, as some one has jokingly remarked, they hardly leave room for the water.

There is something amazing about these pilgrimages of theirs up the rivers. The wonder is not so much that the Salmon go without food for so long a time—the black bass does the same—nor that they make such great exertions in getting up the rivers, for other creatures make greater exertions in getting their food, but the marvel is in the combination of these two facts, viz, in their making these exhausting efforts without taking any food to keep up their strength. It seems incredibly contradictory to nature's laws of life and offers a puzzling problem to biologists to discover where the fuel comes from which does this immense amount of work, accomplished by the migratory Salmon between leaving tide water and completing the season's spawning.

SPEED OF ASCENT.—Their rate of progress up the rivers varies between very wide limits. The earlier runs are the longest time on their way up the river. The latest runs make the journey most quickly. The fish seem to regulate their speed according to the forwardness of their eggs. When their eggs are very small or almost wholly undeveloped, as is the case with the earliest runs—that is, those that enter the mouth of the rivers first—they seem to be in no hurry, but loiter along as they please, and probably spend a great deal of time between the ocean and the fresh-water line; but when their eggs are nearly ripe, as is the case with the later runs, they

advance as if they had no time to lose, as indeed they have not, and hasten, apparently at the top of their speed, to their spawning destinations. This is illustrated by the fact that it is six or seven months before the early runs of the Sacramento Salmon, which enter the Golden Gate in November and December, reach the sources of the river at Mount Shasta, four hundred miles from the river's mouth, while the later runs, which reach Rio Vista about the 1st of August, arrive at the McCloud River, two hundred and fifty miles distant, in ten or twelve days.

When they have reached the vicinity of their spawning grounds they seem to rest two or three weeks in deep holes and eddies of the river, until they are just ready to build their nests, and then they emerge from their holes and literally cover the rapids for miles, in the clear shallow water of which they can be seen from the river banks by hundreds. They now, comparatively speaking, lose their fear of danger, and will not leave the places they have selected unless very closely approached, and then they will persistently return again and again unless actually driven off and kept off. Here comes in once more very noticeably the marvel of their living without food, for they now for many days stem the force of powerful currents every moment, day and night, not only without partaking of food, but in many instances without having taken any food for months. A copious rain starts a movement along the whole line from the river sources to tide water, except where the fish are actually engaged in spawning, and during the rain the river currents seem to be full of Salmon eagerly striving to reach higher portions of the stream.

SPAWNING HABITS.—After the Salmon have occupied the rapids a short time, they proceed to build their nests and deposit their eggs. They scoop away the gravel from a selected spot with their noses and sweep it off with their tails, until they have made clear a spot a few feet in diameter, usually about circular in shape, and depressed towards the center, not unlike in form a common hen's nest. The eggs and milt having been deposited, the nest is covered over again with gravel by the parent fish, which use their noses and tails as before to move the gravel. This being done, they seem, at least on the upper tributaries, to act as if they realized that their life-work was ended. They do not hasten back to the ocean, where, if they reached it, they would regain their pristine health and vigor, but they hover about the vicinity of their spawning ground, growing weaker, more emaciated and diseased every day, till death comes to their relief.

Having briefly traced the Salmon's career from the ocean to the final stages of its journey and its life, let us look for a moment at the various changes which gradually transform it from the healthy and magnificent creature of the ocean to the pitiable emaciated object calmly awaiting its final summons at the river's source.

When the Salmon come into the rivers from the ocean they are royal creatures wearing a beautiful silvery coat and possessing rare symmetry and immense vitality and muscular vigor. As long as they stay in tide water, there is saltness enough in it to keep up their appetites, and they are usually sufficiently successful in their foraging to hold their own. But the moment they cross the line into the fresh water of the rivers above them they lose their appetite, they take no more food, and from that day they fall off in symmetry, beauty, and vitality. This physical deterioration always bears a constant ratio to the proximity of their time of spawning, and regularly increases as this time approaches. As this spawning season occurs at different periods at different locations, no specific time can be named for their successive stages of deterioration, but taking the salmon-breeding station of the United States Fish Commission on the McCloud River as a point of observation, it is noticed here that the Salmon which pass the station in March and April are very much like the tide water fish. In May and June they are still in their prime. In July they change rapidly for the worse, and by the end of that month their silvery look is gone and they are of an olive-green color. The males are deeper and the females are broader. Their scales are nearly absorbed

into the skin, which has become smooth and slimy. The heads of the females have not changed much, but the heads of the males have become more or less pointed, their jaws have developed rows of large white teeth, and the whole expression of their face has become ferocious and repulsive in the extreme. They are now fast losing their marks of nobility with which nature had so richly endowed them in their broad ocean domains. They begin to spawn at the McCloud station the latter part of August, and from that time to the end, which soon comes, their downward progress is rapid. They grow less comely in appearance, more slimy to the touch, more unsymmetrical in form; parasites collect by thousands in their gills and under their fins; their tails and fins fray off; a white and loathsome fungus gathers over all parts of them, frequently destroying their eyesight; and swarms of suckers—the carrion-birds among fishes—wait about them to feed upon their lifeless bodies when they die. For some unknown and strange reason, the Salmon in the higher tributaries do not hasten back to the salt water which would clean their bodies of the parasites and fungus and restore their appetite and with it their health and vigor, but they linger, with a strange indifference to their fate, around the spots where they have deposited their eggs, waiting patiently for the only possible relief from their wretchedness, which is death.

Some uninformed persons, who have never seen these fish in their natural habits, have expressed some incredulity in regard to their all dying after they have spawned. Under this head, I will only say that it is probably true that those that spawn near the ocean return to the ocean and recover their vitality, but those that pass the United States station on the McCloud River in the summer never do. In order to make sure whether I was mistaken in my views about it, I took the testimony, a year ago, of all the white men who have lived or worked on the river, and of all the Indians I could reach. It was the unanimous testimony of all that the Salmon which pass the McCloud hatching station in the summer, on their way up the river to spawn, die in the river and never return to the ocean.

In conclusion I will say that the Quinnat Salmon has been a favored object of artificial culture. It was among the first of the fishes to receive attention from Professor Baird, the United States Commissioner of Fish and Fisheries, who, in 1872, deputized the writer to go to the Pacific coast to collect and distribute its eggs. Since that time over fifty million Quinnat Salmon eggs have been distributed over the world, or hatched for the benefit of the Sacramento River. Professor Baird has in some instances sent them as far as Denmark, Germany, Russia, New Zealand, and Australia.

163. THE NAMAYCUSH OR LAKE TROUT—SALVELINUS NAMAYCUSH.

The Lake Trout, or Salmon Trout, is a non-migratory species inhabiting the chain of Great Lakes from Superior to Ontario, as well as Lake Champlain and many other smaller lakes of the United States and of British America. With the exception of the doubtful species known as the "Siscowet," its nearest relative is the Brook Trout of the Eastern States, *Salvelinus fontinalis*. The Lake Trout is, in fact, a member of the same group of the salmon family with the Chars. Gill and Jordan were the first to point out that the true relations of the Lake Trout are with the Chars rather than with the Salmon. The Lake Trout is peculiar to North America and its inland seas, though the Char and the Black-spotted Trout are very similar to European forms. Every one is familiar with the phenomenon of the Land-locked Salmon, these fish being true Salmon for a time debarred from access to the sea, assuming a peculiar coloration, and with habits modified by confinement within narrower bounds than those of others of the same species which are free to range between river and ocean.

The Lake Trout appears to have undergone somewhat similar modifications. It is a Char, not land-locked, but placed under conditions directly opposite to those connected with those which

are land-locked. Certain modifications of structure have resulted from access to nutritious food in almost unlimited quantity and from existence for many generations in extensive bodies of water.

SIZE.—The most striking of these is the greater size. It sometimes attains the weight of one hundred and twenty pounds, while our common Char, *Salvelinus fontinalis*, even under similar conditions, never exceeds fourteen or fifteen. This is due, perhaps, to the greater ease with which, for hundreds of generations, the Lake Trout have obtained their food. They are almost always found in the same lakes with one or more kinds of white-fish, whose slow, helpless movements render them an easy prey, and upon whose tender, luscious flesh the Lake Trout feeds voraciously. From abundant food and slight exertion results bulk of body. This becomes hereditary. Even the eggs in time are larger, just as in the Land-locked Salmon they are smaller, than in the parent species, and the young fish begins its career with an advantage. As the nascent species gains in magnitude the scales, always small like those of the Char, increase in number, that the growing body may be covered. In like manner an additional ray or two may be developed to re-enforce the dozen supporters of the dorsal fin. The change in dentition is a result of the change of habits. Feeding upon large, strong-scaled fish, instead of insects and minnows, natural selection provides the Lake Trout with more and stronger teeth. It would perhaps seem like a hasty generalization to point to *Salvelinus fontinalis* as the form from which the Lake Trout has been developed, but one may fairly take into consideration the fact that this species alone, of all the *Salmo* group, is usually associated with the fish under consideration, occupying the streams which flow into the lakes of Northeastern America, and frequently entering these lakes. That *S. fontinalis*, even when retaining its predilection for the streamlets, shows a tendency to extraordinary growth when ample waters, like the lakes of Maine or the lower stretches of the Nepigon, are accessible, is also known.

VARIATIONS.—The Brook Trout shares with the Lake Trout its tendency to variations in size, shape, and color. Every lake of Northern New York and New England has its own variety, which the local angler stoutly maintains to be a different species from that found in the next township. Some are as black as a tautog, some brown with crimson spots, some gray, with delicate reticulations like those of a pickerel. The usual type to be found in the Great Lakes is brown or gray, dappled with lighter shades of the same general tint. Naturalists have been sadly misled by their Protean modifications. The "Namaycush" of the North, the "Togue" or "Tuladi" of the Maine and New Brunswick Indians and lumbermen, the "Siscowet" or "Siskawitz" of Lake Superior, the "Trout" of Winnipiseogee, and that of the Adirondack lakes, have each been honored with a distinct binomial.

The angling authorities still refuse to admit that the Lake Trout of the East is identical with the Mackinaw Trout, or Namaycush, supporting their views by accounts of their very different habits. A careful study of the dead fish is sufficient, however, to convince a trained observer that there are no structural characters by which these different forms may be separated into species. The local variations should undoubtedly be taken into consideration, and when these are better understood it is probable that zoologists and anglers will compromise by agreeing to consider the most strongly marked types as races, or breeds, such as are now recognized among dogs, pigeons, and other domesticated animals. Having never seen the fish called the "Siscowet," *Salvelinus siscowet*, I cannot express an opinion as to its distinctness from the Mackinaw Trout, but good ichthyologists assure me that its peculiarities are very slight, consisting chiefly in the smaller head-teeth, and fins, and the stouter body. Since, however, it is always distinguished from the Namaycush by the Indians and fishermen of Lake Superior, who often see them side by side, it seems probable that it may claim at least sub-specific rank. The matter of land-locking is one which

deserves more attention than it has hitherto received. From what we know of the influence of environment upon animals, it need not surprise us to discover that the fishes of each separate lake possess distinctive characters, rising, perhaps, to sub-specific value. No definite proof can be gathered, however, until large series of specimens from each body of water have been examined and compared.

LAKE TROUT IN THE GREAT LAKES.—The Lake Trout reaches its greatest perfection in the northern parts of lakes Huron, Michigan, and Superior, where it is quite generally known as the "Mackinaw Trout." In the lakes of Northern New York the same species occurs, being known by the names "Lake Salmon," "Lake Trout," and "Salmon Trout." This form, which is considerably smaller than that of the northern lakes, was described by DeKay under the name *Salmo confinis*, and was observed by this author as far south as Silver Lake, in Northern Pennsylvania. Still another form is recognized by sportsmen, which, although undoubtedly specifically identical with that of the Great Lakes, has been described under various names, such as *Salmo toma* and *Salmo symmetrica*.

"This fish," writes Lanman,[1] "is found in all the great lakes of New Brunswick, and in very many of those of Maine, but it is believed not to exist in the lakes of Nova Scotia. It is called by the lumbermen the 'Togue'; the Indians designate it by a name equivalent to 'Fresh-water Cod.' It is found in great numbers and of large size in the Eagle Lakes, at the head of Fish River, in the Saint Francis lakes, from which it follows the river of that name, and in the Matapediac Lake, which discharges itself into the Restigouche, and in the Miramichi Lake, at the head of that river. In Lake Temiscouata this fish has been taken of the weight of twenty-one pounds. It is there called the '*Tuladi*.' It is often taken of the weight of twelve pounds and upwards in the Cheputnecticook lakes, at the head of the eastern branch of the Saint Croix. It has been found of late years that this species of fish exists in considerable numbers in Loch Lomond, twelve miles from the city of Saint John."

Hamlin writes:[2] "This Trout inhabits many of the great lakes and deep mountain torrents of Maine and New Brunswick, but it is believed not to exist in those of Eastern New Brunswick, which singular hiatus in its distribution, perhaps, may be explained by the absence of deep waters in that country. It haunts the deepest waters, where the cold or the repose to which it leads favors that development and conservation of fat which is indeed a characteristic, and it steals forth in quiet at the approach of twilight or at early morn to the shoals and the shores in quest of its prey."

The Winnipiseogee Trout,[3] somewhat abundant in Lake Winnipiseogee and supposed to occur in Lake George, is also a form of this species, closely related to the Togue.

The popular and scientific names which have been given to this species are due to the wonderful tendency of variation in size, shape, and coloration which this species, like the Brook Trout, exhibits. Every lake in which they occur has its own varieties, which local authorities believe to be quite peculiar. Some are black, some brown, with crimson spots, some gray, with delicate reticulations like those of a pickerel. The usual type to be found in the Great Lakes is brown or gray dappled with lighter shades of the same general tint. Throughout Lakes Superior, Michigan, and Huron the fishermen are generally of the opinion that there are at least two kinds of Lake Trout. It seems probable, however, that they are led by superficial characters, finding it con-

[1] Report United States Fish Commission, part 2, p. 220.

[2] *Ibid.*, p. 356.

[3] *Salmo symmetrica*. PRESCOTT: Silliman's Journal, 2d series, ii, p. 340. Report United States Fish Commission, Pt. 2, p. 257.

venient to give names to the extremes of development in different directions, and neglect to take into account the forms intermediate between these extremes. Mr. Kumlien studied the subject in different localities in the summer of 1880, and the results of his observations are here presented.

In the vicinity of Green Bay those having salmon-colored flesh were called "Black Trout," while others, with white flesh, were known as "Lake Trout." On the eastern shore of Green Bay, on the east shore of Lake Michigan, two species of "Mackinaw Trout" are recognized by the fishermen. About Grand Traverse Bay, Lake Michigan, two varieties are also recognized, one being long, slim, and coarse-meated, taken in shallow water, and are known as "Reef Trout," or when very large are called "Racers"; they are supposed to follow the schools of white-fish, among which they are always taken; those of the other form are called "Pot-bellies," being short and chubby, and invariably taken in deep water. In the vicinity of Two Rivers, Wisconsin, two forms are recognized, one known as "Reef Trout," corresponding to the one just mentioned, large and lank, with tough and coarse flesh, while the other, which is much more highly prized, is taken in deep water. At the south end of Lake Michigan two forms are known: one, which is darker-colored and has red flesh, being considered by far the more valuable. At Grand Haven there are two forms of Mackinaw Trout, known as the "Shoal-water Trout" and the "Deep-water Trout." In the vicinity of Thunder Bay, Lake Huron, the name "Buckskin" is applied to one variety, which is held in very slight esteem, while another form is known by the name of "Racer."

The angling authorities as well as the fishermen refuse to be convinced that ichthyologists are right in including all the Lake Trouts in one species; the former are especially dissatisfied that the Lake Trout of the East should be thought identical with the Mackinaw Trout of the Northwestern and Great Lakes, and they support their views by reference to their very different habits. Local variations should, undoubtedly, be taken into consideration, and when these are better understood it is probable that zoologists and anglers will compromise by agreeing to consider the most strongly marked types as races or breeds, such as are now recognized among dogs, pigeons, and other domesticated animals.

NAMES.—In addition to the names which have already been mentioned, the Lake Trout has other appellatives, such as "Lunge," in Canada; "Tyrant of the Lake," "Laker," "Red Trout," "Gray Trout," "Black Lunge," "Silver Lunge," "Racer Lunge," "Black Salmon," and "Lake Salmon." The name "Tuladi" is said to be derived from Lake Toledi at the head of the Saint John River, of New Brunswick.

IMPORTANCE.—"The Trout of the Great Lakes," writes Milner, "is one of the three most numerous fishes, and, except the sturgeon, attains the greatest weight of any of the Lake species. It is captured almost exclusively in gill-nets, and in some portions of the Lakes they take them in pound-nets during the spawning season. In winter a great many are taken in the bays through holes cut in the ice."

SPAWNING.—In the spawning season they approach the shore, but do not ascend the rivers, and although they are known to exist in a few inland lakes, connected with the main lakes by rapids, there is no record of their having been seen or taken in the outlets.

The observations of Mr. Kumlien concerning the relative abundance of this species in different parts of the Great Lake region, and the periodicity of their movements, are deemed of sufficient importance to be recounted somewhat at length below. The whole subject of their movements is, however, so closely connected with their habits during the spawning season that it is perhaps desirable to discuss first their breeding habits. The spawning season in Lakes Michigan and Superior occurs in October. Their habits at this time have not been studied by any zoologists, the visits of Milner and Kumlien to their haunts having been made at other seasons of the year.

They spawn late in October, coming up to the rocky shoals and reefs in from seventy to ninety feet depth of water. They are said to spawn close to the projections and edges of cavernous rocks, the eggs settling into the depressions, where they doubtless remain until hatched. The young fish make their entry into the world in late winter or early spring, though in a hatching house, with water at an average temperature of 47° Fahrenheit, they have been known to hatch the last week in January.

Milner remarks: "The universal testimony is that the spawn is found running from the females in the latter part of the month of October, the fish coming to the spawning grounds a week or more earlier. At Detour, at the head of Lake Huron, on the 16th of October, I saw a large lift of Trout brought in from the spawning grounds; the ova were large and separated, but were still entirely retained in the folds of the ovaries, and the fishermen said that they had not found them running from this fish as yet.

"The localities selected by the Trout for their spawning ground are usually rock bottoms in from fifteen fathoms to seven feet of depth. The Trout are said to settle close to the projections and edges of the honey-combed cavities of the rock, and that frequently, when a loose fragment of the rock is drawn up by the nets, the cells are found to contain numbers of the eggs."

Mr. Milner counted the eggs of a Mackinaw Trout, of twenty-four pounds' weight, and found that there were 14,943. The average weight of these fish as taken in the gill-nets was about five pounds, though fish of fifteen pounds are frequently seen. Mr. Milner obtained authentic accounts of one, taken at Mackinaw in 1870, which weighed eighty pounds. The species is the largest, except the sturgeon, occurring in the Great Lakes.

"The knowledge of the time at which the young fish make their appearance is limited to the experience of the few fish-culturists in the country who have hatched the eggs. In water of an average temperature of 47°, they are found to hatch about the last week of January. At the lower temperatures of the water, in a state of nature, their development would be retarded for several weeks.

"Of the habits of the young Trout I am entirely destitute of information. I have seen one of eight inches in length, and learn of rare instances in which the fishermen have seen small ones."

The principal spawning grounds of the Lake Trout are the following:

I. The north shore of Lake Superior, from Duluth northward to the vicinity of Isle Royale, comprising the whole lake coast of Minnesota, and in all the small bays of the region.

II. In the vicinity of the Apostle Islands, in the western part of Lake Superior, especially about Gull Island.

III. Very extensive spawning grounds in the vicinity of Huron Bay, Michigan, particularly near L'Anse and Bête-Grise Bay, and on a reef about four miles from Porte Gentre.

IV. Very extensive spawning grounds in the southeastern part of Lake Superior, at Big Presque Isle, Laughing Fish Island, Sharp Point, and Sauk's Head, Michigan.

V. On the west shore of Lake Michigan, from Racine northward, particularly upon a reef about forty miles off Milwaukee, and on a smaller reef about six miles from the same town. On this ground, according to Milner, a large type of Trout has been taken for many years, also on certain shoals in the vicinity of Green Island in Green Bay.

VI. On the eastern shore of Lake Michigan, from Saint Josephs northward.

VII. In the vicinity of Detour, at the head of Lake Huron. At this point, according to Milner (also according to Kumlien, along the islands off Thunder Bay and Harrisville), the spawning ground was so close to the shore that the tips of the floats of the nets set upon it were visible above water.

VIII. On the Canadian shore of Lake Ontario.

"Their usual home at other seasons than the spawning period," remarks Milner, "is in deep water. A few stragglers approach the shore and are taken in the pound-nets or with the hook from the piers extending into the lakes. In the northern portions of Michigan they are taken in fifteen fathoms in some numbers with the gill-nets, and more plentifully through holes cut in the ice in the winter time, though a depth of over thirty fathoms is more favorable for their capture."

Milner made the following remark: "Pound-nets have not made extensive inroads upon their numbers, and none but mature fishes are taken."

In Green Bay alone does it appear that small-meshed gill-nets have interfered with the abundance of the fish by capturing their young.

The best study of the habits of this species, as an inhabitant of the Great Lakes, was that made by Milner, in 1871. He observed that in Lake Michigan, except in the spawning season, they remain in the deepest parts of the lake. In their autumnal migrations they do not ascend the rivers, and although they are known to exist in a few small inland lakes, connected with the main lakes by rapids, there is no knowledge that they have ever been seen or taken in the outlets. In the northern parts of Lake Michigan they are caught in depths of fifteen fathoms in small numbers by the gill-nets, and more plentifully through the ice in winter, chiefly at a depth of more than thirty fathoms.

Food.—They are ravenous feeders. In Lake Michigan, where a careful investigation into the nature of their food was made, it was found that they were preying upon the cisco (*Coregonus Hoyi*), a well-known fish closely resembling the white-fish. Mr. Milner was inclined to combat the generally accepted theory of the fishermen that they are large consumers of young white-fish, stating that for a great part of the year they live in much deeper water than is resorted to by the *young white-fish, though Trout straying into shoal water, or migrating upon shallow spawning* grounds, would undoubtedly prey upon the smaller white-fish as readily as they would upon any other species.

It is not uncommon for a Trout to swallow a fish nearly as large as itself. One measuring twenty-three inches was brought ashore at Two Rivers, Wisconsin, from the mouth of which some three inches of the tail of a fish (*Lota maculosa*) projected. The "lawyer," when taken from the Trout, measured about seventeen inches. "Their exceeding voracity," writes Mr. Milner, "induces them to fill their maws with singular articles of food. Where the steamers or vessels pass, the refuse of the table is eagerly seized upon, and I have taken from the stomach a raw peeled potato and a piece of sliced liver, and it is not unusual to find pieces of corn-cobs, in the green-corn season."

Kumlien's observations led him to believe that large Trout feed, to some extent, upon white-fish, while the smaller ones capture the herring. In Green Bay the fishermen say that the Trout leave the white-fish spawning beds in autumn before the spawning season begins, but that they are not accused of being troublesome spawn-eaters, though otherwise extremely voracious, and especially hurtful to the white-fish and herring. The fishermen of Port Huron informed him that it was no unusual occurrence to obtain white-fish two or three pounds in weight from the stomachs of large Trout. Captain Dingman, of Beaver Island, informed him that the Trout do not come upon the white-fish reefs during the spawning season, and that they do not trouble the white-fish at that time. In that vicinity they are thought to prefer herring to any other kind of fish. A twenty-pound Trout was caught off Beaver Islands which had in its stomach thirteen herrings and was caught biting at the fourteenth. They are as omnivorous as codfish, and among the articles which

have been found in their stomachs may be mentioned an open jack-knife, seven inches long, which had been lost by a fisherman a year before at a locality thirty miles distant, tin cans, rags, raw potatoes, chicken and ham bones, salt pork, corn-cobs, spoons, silver dollars, a watch and chain, and, in one instance, a piece of tarred rope two feet long. In the spring wild pigeons are often found in their stomachs. It is thought that these birds frequently become bewildered in their flight over the lakes, settle on the water, and become the prey of the Trout.

In the review of localities already given mention has been made of many large individuals; the only estimate of average accessible is that by Milner, who remarks: "The smallest ones that are taken in any numbers are fifteen to eighteen inches in length, and these are not very numerous. The average weight of the Lake Trout taken in the gill-nets is nearly five pounds. It is claimed that in years past they averaged much higher. They are quite frequently taken weighing fifteen pounds. A specimen of a female was obtained last summer at Shoal Island, Lake Superior, weighing twenty-four pounds. One taken at Grand Haven, Michigan, in the month of June, 1871—a female—weighed thirty-six pounds and one-half. After the gills and entrails were removed it weighed twenty-nine pounds. It measured three feet six and one-half inches in length.

"The tradition of the largest Trout taken is preserved at each locality, ranging from fifty to ninety pounds. One that I am satisfied was authentic, from having taken the testimony of those who saw it weighed, and having the story confirmed by Father Peret, of Mackinaw, was taken at that place in 1870, and weighed eighty pounds."[1]

ENEMIES.—"There are no species of fishes in the lakes," writes Milner, "sufficiently formidable to be considered enemies of the Trout after they mature. The spawn and fry probably suffer to some extent from the same causes that the ova and young white-fish do. They are troubled with a few parasites, especially a tape-worm that is found very numerous in the intestines of some of them. Solitary individuals, known among the fishermen as 'Racers,' are found in the summer time swimming sluggishly at the surface. They are easily taken with the gaff-hook, and bite readily at any bait thrown to them. They are always very thin in flesh. Dissection of the few that I have taken failed to find any adequate cause for their condition. The parasites were generally present, but not in any larger number than in healthy fish. The fishermen on the north shore of Lake Michigan generally keep a few hogs. The offal of the white-fish is fed to them freely, but they are very careful to allow no trout offal to be thrown in their way, asserting that the hogs, after eating Trout, frequently become crazy and die. The only plausible explanation of this fact, if it is a fact, is that some entozoon of the Mackinaw Trout passes through one stage of its development in the hog, and occasions disturbance of the brain, having much the same habit as the cystic *Cœnurus* does in the sheep. Dr. Bannister informs me that the opinion prevailed among some of the Russian residents of Alaska that a tape-worm was occasionally produced in the human subject by eating the *Chaiwicha*, *Salmo orientalis* Pal., the largest species of Salmon common in that country. The fact that it was quite a common practice to eat fish frozen, or dried, or salted, without cooking, would favor the introduction of any parasite existing in the body of the fish."

The livers of Lake Trout are thought by the fishermen to be poisonous. Mr. James Patterson, of Manitowoc, Wisconsin, cites an instance, which occurred not many years ago, where all the members of a family were poisoned by eating trout livers, and were a long time in recovering from the effects.

CULTURE.—"The Lake Trout has for years been the subject of attention on the part of the New York State commissioners, and their agent, Seth Green, who every autumn collects millions

[1] MILNER: Fisheries of the Great Lakes.

of eggs from the fisheries on the Canadian side of Lake Ontario to be hatched at Caledonia, New York, for distribution to the lakes in the interior of New York. The experiment has lately been made of planting the young fish in running water, as the Susquehanna, etc.; but it yet remains to be seen how they will thrive. The Lake Trout is eminently worthy the attention of States along the Great Lakes, since, with the white-fish, it constitutes by far the most important element in the great fisheries."[1]

In the fall of 1857 and 1858 a large number of eggs of Salmon Trout were obtained for Saltonstall Lake, in Connecticut, from Lake Ontario. A considerable number of this species, obtained in Lake Ontario, was introduced into Newfound Lake, New Hampshire, in 1871, by the State commissioner. The enterprise is referred to more fully in the report of the United States Fish Commission.[2]

A minor experiment in hatching Salmon Trout, or Mackinaw Trout (*Salmo namaycush*), was made by Mr. Samuel Wilmot, of Newcastle, Canada, in 1868. He also obtained a hybrid between a male *Salmo salar* and a female *S. namaycush*. The next published records we have of experiments are by Seth Green and by N. W. Clark in 1870. Mr. Clark's was with but a few eggs. In an address before the legislature of Michigan he refers to the fact of having young Salmon Trout on exhibition. The quantity of eggs taken by Seth Green that year and hatched was very large, and the fish proving to be a great favorite among the people of the State he has continued to breed it on a large scale, and it has been widely distributed throughout the State. The greatest drawback in the culture of this species is the difficulty and danger attending the procuring of the eggs. The spawning places of the fish in the region of the hatching houses are in the open lake, and the time when the ova are ripe is in October, when there are frequent storms, so that going out in an open boat to the nets is a task of hardship and danger, and has resulted, in a late instance, in the loss of six men, one of them Marcellus Holton, an accomplished fish-culturist and the inventor of the Holton hatching-box. There are, however, points on the lakes accessible by steamer, though not contiguous to the breeding establishments, where the salmon-trout spawning grounds are near the shore, and even entirely land-locked from wind and sea.[3]

Neither the Mackinaw Trout nor the Siscowet are game fishes in high esteem, though the latter is taken by trolling with a bright-colored fly, with a minnow bait, or a spoon-hook. It does not rise like the Brook Trout, and its play is likely to be sluggish and sulky. It is also taken with a bottom line on grounds which have been previously baited. The Indians of the Sault Ste. Marie display great skill in spearing the Mackinaw Trout through the ice, luring them within reach by means of decoy fishes of wood or lead. By far the largest quantities are taken in pounds and gill-nets in the Great Lakes.

In Lake Superior Lake Trout are caught principally in September, October, and November in pounds and gill-nets. Formerly they were fished for with hooks only, but of late years this practice has been abandoned by professional fishermen. In the Green Bay region large Trout are caught principally with hooks, though in the western part of the bay and in Oconto Bay many are taken in gill and pound nets in deep water. Those captured in the gill-nets are thought by the fishermen to be meshed, for the most part, while these nets are being lifted; the Trout dart after the other fish which have been gilled and thus become entangled. In Lake Huron they are caught entirely with gill-nets. They may be taken with hooks baited in the ordinary way, but can hardly be said to afford sport to the angler, since they allow themselves to be pulled to the surface as easily as codfish do.

[1] Professor BAIRD: Report, United States Fish Commission, part ii, p. lxxii.
[2] Report, U. S. Fish Commission, part ii, p. 534.

The Togue or Lunge of our northeastern boundary is held in much higher favor by the angler. Hallock states that the young fish rise freely to trout-flies in rapid water, while the adults are extremely voracious, particularly in May and June, when they can be taken near the surface.

Prof. Arthur L. Adams, in "Field and Forest Rambles," gives a vivid picture of the habits of this peculiar type: "It repairs to shallows to feed on Trouts, smelts, and the like; indeed, the last-named fish would appear to constitute its favorite winter subsistence. It preys extensively, also, on eels and cyprinids, and is in fact a tyrant with an appetite so voracious that quantities of twigs, leaves, and fragments of wood are constantly found in its stomach. The great monster will sometimes rise to spinning tackle, but in so sluggish and undemonstrative a manner that the troller may fancy he has caught a water-logged pine or stone. In this way I had my line checked in Schoodic Lake, when, striking gently, I found I had missed a large Togue, whose trenchant teeth had made a series of deep furrows in the chub with which the hook was baited. It is naturally sluggish and inert, and apparently much of a bottom feeder. As we glided along the shore of one of the islets, composed more or less of granitic bowlders, our attention was directed by the guide to a large black object on the bottom, among a mass of stones. This he asserted was a monster Togue, which, if such was the case, must have exceeded three feet in length; moreover, he showed us two notches on the side of his canoe, representing the dimensions of an enormous individual which an Indian had speared in the same waters during the spawning season, the admeasurement being no less than four feet five inches."

TROUT IN THE GREAT LAKES.—The following facts concerning the abundance of the Lake Trout in different parts of the Great Lakes were gathered by Mr. Kumlien in 1880:

"In the western part of Lake Superior, according to common testimony, the Lake Trout is second in importance to the white-fish; they constitute about one-half of the catch of the gill-nets.

"In the vicinity of Whitefish Point the Lake Trout is more abundant than any other species. The average size is from ten to sixteen pounds. About the Apostle Islands they are abundant at all times and in all places; one was caught at Oak Island weighing fifty-seven and one-half pounds when dressed. In the fall the best fishing grounds are off Isle Royale, and nearly all the gill-nets are fishing there; it is not unusual for a single net to take one or two barrels at a setting. In Huron Bay and vicinity Lake Trout are abundant everywhere, except in the most shallow bays, especially about Stanard's Rock. On this reef, in 1880, one Mr. Egerton caught with one hook enough Trout to weigh, after dressing, six hundred pounds. In the winter of 1878 one specimen was caught through the ice, in a gill-net, at Porte Gentre, that weighed seventy-four pounds. Thirty-five and forty pound fish are common on the off-shore shoals. On the southern shore of Lake Superior, from Grand Island to Sauk's Head, this species is more abundant than any other. They are caught principally in September, October, and November. In the vicinity of Grand Island, in the opinion of Mr. Parker, a local authority, there has been no marked decrease in numbers during the past fifteen years. Individuals weighing from forty to fifty pounds are by no means unusual, and much larger ones are reported.

"In Green Bay, Lake Trout are reported to be far less common than formerly. In the southern part of this bay, in the vicinity of Bay City, they are now rare; somewhat more abundant from Oconto to Peshtigo, though not taken to any considerable extent, and north of Menomonee they are less plentiful than about Oconto. Seven to ten years ago, at Washington Island, it was not an unusual thing for men trolling for Trout to fill their boat in a short time, but this cannot now be done. The decrease is accounted for, by local observers, by the injudicious use of small-meshed pound-nets, which are supposed to capture great quantities of young Trout.

The largest individuals on record from this locality relate to one specimen, caught in 1864 at Grand Haven, which weighed eighty-eight pounds, and one taken at Oconto in 1876 weighing forty-five pounds. At the north end of Green Bay they are reported as very abundant at all seasons, though less common than the white-fish. They are most common about Saint Martin's and Gull Islands. In the fall and spring they are less abundant towards the heads of the bays. About Milwaukee they are abundant, particularly at the spawning season, though not so plentiful as formerly. A little farther north, in the vicinity of Manitowoc, they are plentiful. In 1855 Mr. Patterson caught one that weighed fifty-seven and a half pounds, dressed. Capt. J. Gagnon says that he has often taken a dozen at a single lift which would average twenty-five to thirty pounds in weight; these were taken in ninety fathoms of water, about fifteen miles from shore, off Two Rivers. The "Salmon-fleshed" and "White-fleshed" Trout are both found, but the former is far the more abundant and sells much more readily. At Racine they are very abundant and of considerable importance. During spawning time they are taken plentifully on a reef a short distance north of the city, but it is thought that they are decreasing in numbers. At Waukegan they are abundant in June and July and in the fall months, but, since the pound-nets are taken up in September, few are caught late in the fall. The fishermen claim to be able to tell from which locality any fish has been obtained, those from the clay bottom being short, thick, and fat, resembling the Siscowet. Individuals have here been caught which weighed sixty-five pounds. The common weight for a "Racer" is twenty-five pounds, and from this up to forty pounds.

"In the vicinity of Chicago, according to Nelson, Lake Trout are common in spring and fall. They commence running in the middle of April, and are taken at that time with set lines at a short distance out from the shore. "They are taken most plentifully in spring," continues Kumlien, "when the fishing first begins and before the runs of white-fish come on; at this time they are caught in from twelve to sixteen fathoms. Later they retreat into the lake, where, at a distance out from seven to nine miles from shore, they are found at all seasons."

"At New Buffalo and vicinity the Trout make up about one-fourth of the entire amount of fish taken. Fourteen years ago fish of from fourteen to twenty pounds' weight were obtained at every lift of the nets, but now they are much smaller. The largest ever known here weighed sixty-two pounds dressed.

"On the eastern shore of Lake Michigan, the Lake Trout is next in importance to the white-fish. At Ludington, Manistee County, they are very abundant. The runs begin early in May, but they decrease in number until July, after which none are taken until October. Gill-net fishermen obtain them throughout the winter in deep water. At Grand Haven they are said to be equally common all the year round, possibly because there are no spawning grounds in the vicinity.

"In the vicinity of the Straits of Mackinaw, in the northern part of Lakes Huron and Michigan, Mackinaw Trout is considered, next to the white-fish, the most important species. There is, however, a general opinion among the fishermen that they are much too numerous, for they are thought to be very destructive to young white-fish. As many as nine thousand pounds have been packed for shipment at Mackinaw in one day. They were formerly bought by the "count," as they ran, at three cents apiece. On Spectacle Reef, according to Captain Ketchum, two men lifting their nets every two hours, have caught thirty-six hundred pounds in one night. In the vicinity of Spectacle Reef Captain Coats reports them as even more abundant than the white-fish, though he thinks that at least eight times as many white-fish as Trout are shipped from Mackinaw. It is believed by the fishermen of Grand Traverse Bay that, when the moon is full, the Trout are much more abundant than white-fish.

"On the Michigan shore of Lake Huron, about Thunder Bay, Lake Trout are very abundant in August, and especially about Thunder Bay Island, where the men employed at the life-saving station gained quite a revenue by fishing for them. The best and most productive grounds in this vicinity are near Harrisonville and southward along the coast for a few miles. There are some fishing grounds north of North Point where all the Trout are said to be very large. In the vicinity of Saginaw Bay they are abundant, but will not rank commercially higher than fourth or fifth. Not many are taken in the pounds in Saginaw Bay, but the deep-water pounds, especially those about the Charity Islands, obtain a few. In April few fish other than Trout are taken in the gill-nets. In the vicinity of Port Huron they are very abundant, and it is the prevailing opinion among the fishermen that they are increasing in numbers, more being taken now than ever before. Very few enter the Detroit River. In the western part of Lake Erie, about Toledo, they are exceedingly rare, and unknown to many of the fishermen at Port Clinton. No instance of their capture is on record, and at Locust Point they occur only very rarely. About the islands off Sandusky they have in two or three instances been captured, and at the other fisheries in this vicinity local authorities do not think that more than five or six are taken in the course of a year. About Huron and Vermillion, Ohio, they are also very rare. It sometimes happens that one or two are taken in the course of a year's fishing; those which are here taken are always small, scrawny, and sickly. The same statements are made concerning Black River and Cleveland. Some are taken at Cleveland, but never more than three or four in a year. About fourteen years ago four were taken in Brownhelm Bay, but none since. They have never been taken at Black River; a man who has fished there for twenty-five years has never seen one. In the vicinity of Conneaut, Ohio, a few are occasionally taken in the spring. At Painesville, Ohio, they are rare. In 1869 only a single specimen was taken, and in 1878 only six. The wandering gill-netters who fish off Painesville sometimes capture a few in deep water. The only locality in Lake Erie where they are at all abundant is at Barcelona, New York, where there is said to be an extensive spawning ground five or six miles long, and about three miles from the shore. Some years ago the fishermen used to load their boats with Trout, sometimes as many as eighteen hundred pounds of dressed fish being taken with a small gang of nets. At Conneaut a few are taken in the spring. In the eastern end of Lake Erie they are caught to some extent, especially in the very deep water off Erie Bay, though they are not very plentiful. Off Dunkirk they are much more common, and in 1866 a specimen four and one-half feet in length, weighing seventy pounds, was captured. The fish dealers of Erie, Pennsylvania, claim that the Trout here taken are very different from those of Lake Superior; as a rule, only those with white meat are found.

"In Lake Ontario, especially in its eastern portion, about Cape Vincent, they are very abundant, and in the headwaters of the Saint Lawrence, as far down as Alexandria Bay; they enter the river only in winter and for the purpose of feeding. In abundance they rank far below the white-fish, three times as many white-fish as Trout being usually taken. In Chaumont Bay they are becoming less common, and at the present time are not very abundant, ranking sixth in importance, while at Cape Vincent they are third. The Trout handled at Chaumont are almost entirely from Canada, and the dealers do not depend upon the supply from American waters. At Oswego they are caught in the lake, though not entering the Oswego River. They are not plentiful at Port Ontario, although they have been in some seasons past. Since alewives came few Trout have been caught. The alewives are now so abundant that the Trout do not come near the shore to seek for food. In 1860 thirteen hundred pounds were caught in one night on five hundred hooks."

The Siscowet—Salvelinus namaycush var. siscowet.

The Siscowet, or "Siskawitz," is a form of Lake Trout which, according to many authorities, is a distinct species, and which has been observed only in Lake Superior. Having never seen the fish in a fresh condition, I cannot express an opinion as to its distinctness from the Lake Trout, but good ichthyologists assure me that its peculiarities are very slight, consisting chiefly in the smaller size of the head, teeth, and fins, and in its having a stouter body. Since, however, it is always distinguished from the Lake Trout by the Indians and fishermen of Lake Superior, who often see them side by side, it seems possible that it may claim a sub-specific rank. It was first described in 1850, in Agassiz's "Lake Superior,"[1] under the name *Salmo siscowet*. Herbert, in his "Fish and Fishing," p. 17, gives the following description of its peculiarities:

"This fish, like the former species, came frequently under my eye during my late northern tour; and I rejoice in the possession of a barrel of him in his pickled state, which I procured at the Sault Ste. Marie, on the strength of which I can recommend him to all lovers of good eating as the very best salt fish that exists in the world. He is so fat and rich that when eaten fresh he is unsufferably rank and oily, but when salted and broiled, after being steeped for forty-eight hours in cold water, he is not surpassed or equaled by any fish with which I am acquainted. Since my return he has been tasted by very many gentlemen of my acquaintance, and by no one of them has he been pronounced anything less than superlative. His habits closely resemble those of the 'Namaycush,' and, like him, I cannot learn that he ever takes the fly or is ever taken by trolling. I do not, however, believe that either of these methods is often resorted to for his capture, although there are many scientific fly-fishers about the Sault, and the Brook Trout of those waters are principally taken with large and gaudy lake-flies. The average weight of the 'Siskawitz' does not exceed four or five pounds, though he is taken up to seventeen. His excellence is so perfectly understood and acknowledged in the lake country that he fetches double the price per barrel of his coarser big brother, the 'Namaycush'; and he is so greedily sought for there that it is difficult to procure him, even at Detroit, and impossible almost at Buffalo."

Milner states that the Siscowet lives at depths greater than forty fathoms, and feeds chiefly upon a species of fresh-water sculpin. It spawns in September in deep water. The average size is about four and one-half pounds. Two five-pound fish yielded respectively 2,796 and 3,120 eggs. This species, like the Lake Trout, is for the most part taken in gill-nets.

Mr. George Barnston, of Montreal, Canada, formerly of the Hudson Bay Company, who made an extensive natural-history collection on Lake Superior, claims that there is a third species of Lake Trout, different from the Siscowet, on the south shore of Lake Superior, called the "Mucqua" or "Bear Trout."

Mr. Robert Ormsby Sweeny, chairman of the Minnesota fish commission, in a letter dated Saint Paul, Minnesota, October 19, 1880, conveys the following information concerning the Siscowet, which is more precise and comprehensive than anything hitherto published:

"I have not only examined the Siskowet carefully myself and compared them with Agassiz's formulas, but asked and consulted with traders, voyagers, Indians and half-bloods, and fishermen, in regard to their habits, size, color, weight, etc., and all come to the same conclusion. They are not possibly a 'Namaycush' and should never be considered the same fish. The name 'Sis-ko-wet' is an Ojibewa word, and means literally 'cooks itself.' It is so fat that you can set fire to it and cook it by itself. The fish when fresh is most deliciously rich, tasting like the belly of a mackerel, and with salt and potatoes to the hungry fisherman or hunter is a complete *menu*. The 'Namay-

[1] P. 333, plate 1, fig. 3.

cush' is dry and lacks delicacy, and cannot be even fried without pork-fat or lard. Some years ago I spent a winter at the head of Lake Superior, and our diet most of the time was fish and potatoes; only twice during the winter did we have fresh beef. At almost every meal and every day we had fish in some of its numberless styles of preparation, and you may be sure I became quite familiar not only with the taste, but the appearance of both Namaycush and Siscowet. As an edible [fish] the two are no nearer alike than fresh mackerel and sucker, but, of course, that would not be conclusive if there were no other differences.

"The amateur is likely to confound the Namaycush with the Siscowet, but when the differences are once pointed out, no confusion of the two again arises. The fishermen recognize them before taken from the water when hauling in the nets; even the Indian children know them at a glance. The head of the Siscowet is shorter and broader in proportion, eyes nearer the end of nose and are wider apart; the whole osseous structure of the head lighter, more delicate and flexible, particularly the sub-maxillaries, which in the Namaycush are heavy, rigid, and rounded. I intended to send you some Namaycush heads for comparison, but all of those procurable have had tongues and gills removed, so that the heads are in consequence unnaturally compressed and their characteristic appearance altered. The only variation from Agassiz's description that I find is in the lingual teeth; sometimes there is a furrow or a groove in the tongue, and between the 'pair of lateral rows' a V-shaped row is found, but this is so inconstant in occurrence as to be the exception. The coloring varies in different specimens considerably, according to locality from whence taken. The spots or markings are unlike those of the Namaycush, more even in size and shape, and more decided and stronger in color, and I can clearly see in some specimens that the spots are compound or an indistinct quincunx arrangement. The Namaycush spawn only in the fall, beginning in October. We have just taken half a million eggs. The Siscowet, I am told by the fishermen and Indians, are always spawning, or that ripe females are taken at all times of the year. At first I thought this an exaggeration, but I find it so very universally reported and by reliable men that I give it credence. They are very rarely found at the lower parts of the lake. They begin to be more plentiful as La Pointe is reached and most plentiful along the north shores and Isle Royale, but still they are a rare fish, comparatively. If one barrel of Siscowet to fifteen Namaycush are caught, they are said to be *very* abundant. They are so much prized that they bring a higher price, and it is rare that we get them here unless in winter time, when they are frozen and brought down fresh. A peculiarity I have noticed is, in winter when pulled out on the ice they puff up like a pouter pigeon full of air around the pectoral region, and when frozen can be instantly distinguished at a glance. They rarely exceed thirty pounds in weight and thirty-six inches in length, I am told by those very familiar with the fishes of the lake. On the same authority I learn that Namaycush reach ninety pounds' weight and six feet in length sometimes. I have just had a talk with a man from the lake, and he says this season they are catching about five Siscowet to the one hundred Namaycush only. Another fact: Siscowet are never caught alone, but always among Namaycush; but sometimes no Siscowet are seen or caught for weeks, and then they appear and disappear without disturbing the movements of Namaycush. You will find it impossible to keep Siscowet in alcohol, but I think the camphor water and glycerine will do it. I have succeeded with salmon thus, although in alcohol they fall to pieces as if they had been boiled."

164. THE SPECKLED TROUT—SALVELINUS FONTINALIS.

The following chapter is a reprint of Mr. Goode's essay upon the Speckled Trout, in Scribner's "Game Fishes of the United States":

The Speckled Trout must have been discovered at a very early day by the first settlers of

North America, yet, strangely enough, the only allusion to it in colonial times is in the 'Remonstrance of New Netherland,' addressed by that colony to the States General in 1649. It was first brought before the world of science in 1814, when Professor Mitchill named it *Salmo fontinalis*, a name which has become almost classical, and will be regretfully set aside for the more recent one, *Salvelinus fontinalis*.

DISTRIBUTION.—The Speckled Trout has its home between latitudes 32½° and 55°, in the lakes and streams of the Atlantic watershed, near the sources of a few rivers flowing into the Mississippi and the Gulf of Mexico, and in some of the southern affluents of Hudson's Bay. Its range is limited by the western foothills of the Alleghanies, and nowhere extends more than three hundred miles from the coast, except about the Great Lakes, in the northern tributaries of which Trout abound. At the south they inhabit the headwaters of the Chattahoochee, in the southern spurs of the Georgia Alleghanies, and tributaries of the Catawba in North Carolina. They also occur in the great islands in the Gulf of Saint Lawrence—Anticosti, Prince Edward's, Cape Breton, and Newfoundland. Temperature is of course the chief factor in determining the distribution of the species, and since few observations have been made in the field, our conclusions must needs rest on a study of the species in domestication, an instructive though not entirely reliable method. The experience of Messrs. Green, Stone, and Ainsworth, indicates that Trout cannot thrive in water warmer than 68° Fahrenheit, though they have been known to live in swift-running water at 75°. Fishes hatched in artificial ponds may probably be inured to greater warmth than wild fishes can endure, and it is doubtful whether the latter are often found in water warmer than 60° or 65°. At the Oquossoc and Cold Spring hatching establishments the water ranges from 45° to 49° throughout the year. Below 36° Trout are torpid and refuse to feed, and instances are on record of their reviving after being frozen stiff. The remarkable variations in the habits of Trout in different regions are easier to understand in the light of these facts. The identity of the Canadian Sea Trout and the Brook Trout is still denied by many, though the decision of competent authorities has settled the question beyond doubt. This being admitted, let us compare the habits of the Sea Trout and the Salmon. Both inhabit the ocean a part of the year; both ascend rivers to spawn; both change their sea-garb of silvery gray for the gorgeous crimsons, purples, and bronzes of the pairing season. Some Salmon, detained by barriers or by their own preference, become permanent denizens of fresh water, where they reproduce their kind, relinquishing their gray coloration, and assuming a brighter dress peculiar to themselves. Does not the analogy still hold out, and do not our Brook Trout correspond with the Land-locked Salmon? In the Long Island region Trout live in salt water in the coldest months, when its temperature is below 50°. North of the Bay of Fundy, at the entrance to which the water barely registers 50° in midsummer, they inhabit the ocean abundantly, except at the spawning time. South of New York the coast reaches of the rivers appear to present a barrier of warm water which the Salmon do not seek to penetrate from without, and which immures the Trout in their homes in the hill country as closely as would a mountain wall.

When Trout have no access to the sea they still contrive to avoid a change of temperature with the seasons. In midsummer they lie in the bottoms of lakes cooled by springs, in the channels of streams, or in deep pools, lurking behind rocks and among roots. In spring and early summer they feed industriously among the rapids. At the approach of cold weather in autumn they hasten to the clear shallow water near the heads of the streamlets. It is at this time that they deposit their eggs in little nests in the gravel which the mother-fish have shaped with careful industry, fanning out the finer particles with their tails, and carrying the large ones in their mouths. After the eggs are laid, the parent fish covers them with gravel, and proceeds to excavate another nest. The same nests are said to be revisited by the schools year after year.

SPAWNING HABITS.—Of the Trout Mr. Milner writes: "His whole wooing is the most polite attention and the gentlest of persuasions. He moves continually to and fro before his mate, parading his bright colors, while she rests quietly, with her head up stream, vibrating her fins just sufficiently to keep her from floating down. At Waterville, Wisconsin, I had the opportunity of watching their habits. A pair of large Trout had selected a spot near the bank of the stream, where the water was about ten inches deep. The female had fanned the gravel with her tail and anal fin until it was clean and white, and had succeeded in excavating a cavity. They were frightened away as I came to the edge of the bank. Concealing myself behind a willow bush, I watched their movements. The male returned first, reconnoitering the vicinity, and, satisfying himself that the coast was clear, spent a half hour in endeavoring to coax the female to enter the nest. She, resting half concealed in the weeds, a few feet away, seemed unwilling to be convinced that the danger was gone; and he, in his full, bright colors, sailed backward and forward from the nest to his mate, rubbing himself against her, and swimming off again in a wide circle close along the bank, as if to show her how far he could venture without finding danger. She finally entered the nest."

The spawning season begins in New England in October, continuing from three to six months, and during this period the fish should be protected by stringent laws. Mr. Livingston Stone observed that in his ponds at Charlestown, New Hampshire, spawning began October 12, and ended early in December; at Seth Green's establishment, near Rochester, New York, it began on the same day, and continued until March. At the former station spring water, with a uniform temperature of 47°, was in use, while at Caledonia the eggs were kept in brook water, which is colder in midwinter, retarding development.

Trout eggs are usually three-sixteenths of an inch in diameter, although varying greatly, and are colorless, red, or orange-hued. The quantity yielded by a fish is in direct proportion to its size, the average being from four to six hundred. Mr. Stone took sixty from a half-ounce fish, and eighteen hundred from one which weighed a pound. The eggs having been laid, their time of development depends strictly on the temperature of the water. According to Mr. Ainsworth, they will hatch in one hundred and sixty five days with the mercury at 37°, one hundred and three at 41°, eighty-one at 44°, fifty-six at 48°, forty-seven at 50°, thirty-two at 54°, etc. Seth Green's rule is that at 50° they hatch in fifty days, every degree warmer or colder making a difference of five days. After the eggs are hatched the yolk sac is absorbed in from thirty to eighty days, and the young fish begin to lead an independent life. Now the rate of growth is determined by the amount of food consumed. Some two-year-old fish weigh a pound, some half an ounce, as Mr. Stone's experiments show. In domestication growth is more even. Mr. Ainsworth's estimate allows an average of two ounces for yearlings, a quarter of a pound for two-year-olds, half a pound for three-year-olds, and a pound for four-year-olds. Wild fish often grow much faster. One of a large number of Rangely Trout, tagged by Mr. George Shepard Page in 1871, and caught in 1873, was found to have grown in two years from half a pound to two pounds and one-quarter. All two-year-old Trout and some yearlings can reproduce their kind.

SIZE.—The size attained varies in different regions. Brook Trout seldom exceed two or three pounds, and a five-pounder is thought a monster. Saint Lawrence Sea Trout usually weigh two and one-half pounds, though they are not seldom caught weighing six or eight. A famous locality for large fish is the headwaters of the Androscoggin River in Northwestern Maine. Professor Agassiz in 1860 obtained one of them which weighed eleven pounds. The well-known specimen taken by Mr. George Shepard Page in 1867, in Rangely Lake, weighed ten pounds after three

days' captivity, and was thought by experts to have lost a pound and a half in transit from Maine to New Jersey, where it died. Its length was thirty inches, and its circumference eighteen. Another, from Mooschuemaguntic, weighed eight and one-half pounds, and measured twenty-five inches. The Nepigon River claims still heavier fish. Hallock mentions one said to have weighed seventeen pounds.

VARIATION.—There are many local races of Trout; the same stream often contains dissimilar forms, and those bred in different hatcheries may easily be distinguished. Whoever has seen the display at the April opening of the trout season at Mr. Blackford's, in Fulton Market, New York, can understand the possibility of almost infinite variety in form and tint within the limits of one species. Fish inhabiting swift streams have lithe, trim bodies and long, powerful fins; those in quiet lakes are stout, short-finned, and often overgrown. In cool, limpid brooks, with sunlight, much oxygen, and stimulating food, their skins are transparent and their hues vivid; in dark, sluggish pools they are somber and slimy, and are called "Black Trout." Agassiz noticed that those of the same river varied accordingly as they haunted its sunny or shady side. They have the power of changing their tint at will. The influence of the nerves over color was neatly demonstrated by M. Pouchet, who produced a white side in a Trout by destroying the eye of that side. In the sea, for reasons unexplained, both Trout and Salmon lose their gay colors and become uniform silvery gray, with black spots. In the sea, too, the flesh assumes a reddish color, due no doubt to the absorption of the pigments of crabs and shrimps eaten by the fish. Red flesh is also found in some inland races.

CHARACTERISTICS.—Our Trout are strong feeders, but are dainty rather than greedy. They consume moderate quantities of food, and it suits their capricious appetites to seize their prey while living. They take objects at the surface with an upward leap instead of downward from above like the Salmon. Of all foods they prefer the worms washed out of the bank, then gayly colored flies, water insects, little fishes, larvæ, and the eggs of fishes. Those in domestication are usually fed on the heart, liver, and lungs of animals killed for the market.

Their daintiness, shyness, cunning, and mettle render them favorites of the angler, who lures them into his creel by many sly devices. The most skillful fisherman is he who places before them least obtrusively the bait which their momentary whims demand, or a clever imitation thereof. Trout are always in season from April to August, and in some States for a longer period.

CULTURE.—They have always been the pets of fish-culturists; indeed, the experiments of Dr. Garlick and Professor Ackley, who inaugurated in 1853 the practice of this art in America, were made with this fish. They become thoroughly domesticated, and are as much under the control of their owner as his horses and cattle. They have been acclimatized in England since 1868, and are always on exhibition in Frank Buckland's museum of fish-culture at South Kensington. The "Domesticated Trout," by Livingston Stone, and "Trout Culture," by Seth Green, are books which give full information concerning the practical details of trout-breeding.

The Trout can scarcely be considered a market fish; still, about five thousand pounds of them, mostly domesticated, are brought to New York market each year, principally in April and May.

165. THE SAIBLING, OR BAVARIAN CHAR—SALVELINUS ALPINUS.

Like the Red-spotted Trout of North America, the Saibling belongs to the division of the same family known to the English as "Chars," a group confined, for the most part, to fresh-water lakes and streams, and distinguished from the true Salmons by a peculiar arrangement of teeth on the

little triangular bone in the roof of the mouth known to anatomists as the "vomer," from its resemblance in shape to a plowshare.

The Chars are also distinguished from the Salmon by their very small scales, and usually by numerous crimson or orange-colored spots, which are especially conspicuous in the breeding season. The Saibling is, in its habits, perhaps more similar to the well-known Blue-backed Trout or Oquassa Trout of Rangely Lake, Maine, than to our Brook Trout. The Chars of Europe are, as a rule, lake fishes like the Saibling. On the other hand, the Chars of North America are usually found in streams and rivers, although the Oquassa Trout, just mentioned, and the Lake or Mackinaw Trout, which is apparently nothing but a giant Char, together with the closely related form the "Siscowet," resemble in their habits the Chars of Europe.

VARIATION.—There is probably no group of fishes in which individual specimens and communities inhabiting certain areas of water show more tendency to variation in color and form than they do in the salmon family. Dr. Günther has very justly remarked: "We know of no other group of fishes which offers so many difficulties to the ichthyologist with regard to the distinction of the species as well as to certain points in their life-history. Although this may be partly due to the unusual attention which has been given to their study, it has revealed rather a greater amount of unexplained fact than a satisfactory solution of the questions raised. The almost infinite variations of these fishes are dependent upon the age, sex, and sexual development, food, and the properties of the water."

No one who has ever seen the remarkable display of Brook Trout at the annual trout opening at Blackford's in New York can fail to have been impressed by the wonderful differences which exist between individuals of the same species from different localities—differences which lead an untrained observer, or even an ichthyologist who has had no experience in the study of this group, to decide at once that several species were represented among the hundreds of specimens lying on the marble slabs.

The tendency of modern ichthyology, with its more exact methods, and with access to better and more comprehensive material for research than was formerly available, has led to the rejection of many of the nominal species formerly recognized. Out of the forty-three species of Salmon ten years ago believed to exist in North America, only thirteen or fourteen are now recognized. In Günther's catalogue of "The Fishes in the British Museum," published in 1866, thirty-one species of Chars were mentioned, while in his lately published "Study of Fishes" the same author ventures to enumerate only thirteen, all others being regarded as insufficiently characterized. In his treatment of the Chars of Europe, Günther is, notwithstanding, one of the most conservative writers, for he catalogues eight species of these fish, while most other European students, following the lead of the great German ichthyologist, von Siebold, regarded them as members of one polymorphic species. As for American ichthyologists, our sympathies are naturally with the school of von Siebold. It is difficult to believe, in the light of our own observations upon the salmon family in America, that every little lake or group of lakes in Europe possesses a well-characterized species of fish, and for the present it seems safer to consider the Chars of Europe to be of a single well-marked species which undergoes numerous variations under the influence of changes in temperature, elevation, food, and light, and that the Saibling of Bavaria and Austria is one and the same thing with the "Ombre Chevalier" of France and Switzerland, "Salmarino" of Northern Italy, the "Torgoch" of Wales, the fresh-water "Herring" of Ireland, the "Char" of England and Scotland, the "Röding" of Sweden, and the "Kulmund" of Norway.

DISTRIBUTION.—This fish, whether it be regarded as a single species or several related species, is distributed over all of Northwestern Europe, and possibly also over a portion of Asia, although, since the Asiatic representatives of the genus have not been sufficiently studied, it is impossible yet to make this generalization. They are, emphatically, cold-water fishes, thriving at a temperature little above the freezing point, and in their period of greatest vigor and perfection at the approach of winter, as is indicated by the fact that at this time their spawning takes place. No fish of any kind has ever been found nearer to the North Pole than the Char, a species, *Salvelinus arcturus*, having been discovered by the last English polar expedition in 12° north of the Arctic Circle. In the south of Europe its range is limited by the Alps, and in this region its study has brought to light a very curious fact which confirms still more strongly the idea just spoken of, that the fish thrive the best in a very cold climate. In the extreme north and in the extreme south this fish reaches its greatest perfection. The northern species, found everywhere in the lakes of the Scandinavian Peninsula and Scotland, is a fish sometimes, it is said, attaining a length of four feet. In England and France and in the lower lakes of Switzerland it is comparatively insignificant, while in the deep, cold Alpine lakes it often grows to two feet or more in length, and weigh ten or twelve, and even, in exceptional cases, twenty-four pounds. The highest development, however, seems to be attained in the largest lakes—like that of Geneva—while in the shallower lakes, higher up among the mountains, they are smaller. A similar phenomenon is exhibited by certain sub-arctic plants, which thrive in the extreme north and upon the summits of the Alps, becoming dwarfed or almost extinct in the lowlands between.

It is interesting, too, to compare the effect of temperature, and secondarily of elevation, upon the Saibling and upon our own Red-spotted Trout. This species has its home between latitude 32½° and 55°, in the lakes and streams of the Atlantic watershed, in the mountain sources of a few rivers flowing into the Mississippi and the Gulf of Mexico, and in some of the southern affluents of Hudson's Bay. In the north, for instance in the valley of the Saint Lawrence, it is common in the lowland streams and estuaries, and even in the adjoining parts of the ocean, and here it attains its greatest development. As we proceed farther south, in accordance with the limitations of temperature, its range becomes more restricted, and in Southern New England it is only at certain seasons of the year—at the approach of winter—that they find their way into the lowland streams which are in summer too warm to be endurable, and at other times they are found near their sources among the hills. On Long Island, however, they are still found in the meadows, and to some extent in the estuaries. Passing to the southward of New York, the natural southern limit of the Salmon, the range of the Trout becomes more and more restricted to the highlands; and although they are found as far south as latitude 32°, in the western districts of the Carolinas and the extreme northern part of Georgia, they there occur only at great elevations among the mountains of the Alleghany chain. South of New York they are effectually land-locked by the prevailing high temperature of the lowland streams, and are never able to gain access to salt or brackish water. Their supply of food is, consequently, limited, and they are confined to brooklets among the mountains. Although the temperature of this region is usually very favorable, other requisites for high development are lacking, and the species is represented throughout the southern part of its range by diminutive individuals. A similar phenomenon is met with in those instances where the European Char exists in the high and comparatively shallow mountain lakes of the Swiss and Austrian Alps.

In the southern part of its habitat the American Brook Trout finds its environment unfavorable to its perfect development; on the other hand, the European Char meets, in the Alpine

lakes, conditions precisely similar to those of the lakes of Norway and of Scotland, and under these favorable conditions has survived in a state of great perfection.

We have in the Great Lakes of North America a fish closely allied to the Chars, which, under remarkably favorable circumstances, with plenty of room and an immense supply of rich and easily attainable food, has developed into one of great size and commercial importance, the Lake Trout, and its cousin, the Siscowet.

RELATIONSHIPS.—The various Lake Trouts of Maine and Eastern Canada, found in the smaller lakes of those regions, are very similar to the European Char. The American species which, however, bears the closest resemblance to the European Char is, as has been stated, the Blue-backed Trout, or Oquassa Trout, of Rangely Lake, the Red-spotted Trout of the Pacific coast, *Salvelinus malma*, known also as the "Dolly Varden," being very similar in habits to the Brook Trouts of the East.

The resemblances between the Saibling and the Oquassa are as follows:

1. They inhabit the deepest waters of their lake home, and are never seen except at their spawning season.

2. They spawn late in the fall.

3. At the spawning season they come into shallow water near the shores, or in the mouths of streams, and may be taken with the greatest of ease.

4. They never willingly inhabit streams of running water.

These peculiarities the two species have in common, and, excepting the habit of autumn spawning, they share them with no other members of the family. The Saibling, however, is a much larger and finer species than the Oquassa, and it is hoped that it may be adapted for cultivation in many of the smaller lakes in which our Great Lake Trout is not likely to thrive. It is regarded as a very excellent food-fish, and is doubtless more delicate in flavor than the Lake Trout, sharing most of the excellent qualities of the Brook Trout.

HABITS.—The Saibling, which through the courtesy of the German Government is now being introduced into the United States, is the European Char in its highest state of perfection. The following account of its habits is translated from a sketch by Dr. Wittmack, of Berlin:

"The Saibling varies much in form, size, and color, according to its age, sex, and habitat. Those which come from the highest Alpine lakes are always small, but those in the lakes of Switzerland and Savoy have higher bodies, larger scales, and also a clearer color—yellowish-white, with red belly. This form was formerly considered distinct, and was known as the 'Ritter' or 'Knight' among the river Trout, the species which is found at the greatest height above the sea. In Switzerland, according to Tschudi, it is found at a height of 4,400 feet; in Bavaria, according to von Siebold, in the Green Lake, at the height of 5,000 feet; in the Tyrol, in the Gaislacher Sea, at the height of 7,000 feet, and in the Pleuderle Sea, at the height of 7,603 feet. In the Green Lake, as well as in other Alpine lakes, this is the only species of fish which occurs. It seems certain that it is found at greater heights in the eastern than in the western Alps, and is also more abundant. The breeding season occurs in the months of October, November, and December, and continues until February; for example, in certain lakes in Steiermark. In Lake Fuessen it occurs in October and November; in Lake Messkirch, where they are artificially propagated, in February and March; in the lakes at Saltzberg they spawn from November to January, and apparently also in February; and, in spite of the extensive fishery during the spawning time, there is no evidence of a decrease in their numbers. They feed upon small fish, and also, when at liberty, upon the small crustaceans, daphnids, and cyclopids. In the Alpine lakes these constitute their only food.

In Germany and in Austria it has been found that the Saibling is one of the most expensive fish to propagate artificially, on account of its food. The ordinary size of the Saibling is from eleven to twelve inches, and its weight from one-half to one pound. In the highest lakes they are, as has been mentioned, smaller, while when they are moved from such lakes into those that are deeper they increase rapidly in size. In the Saltzberg lakes, where they are taken upon certain spawning grounds from November to January, it takes about five of them to make a pound, but large specimens of three to twelve pounds are taken in August and September. In the Lake of Zug, which, according to Hoch, yields more Saibling than any other lake in Switzerland, it takes five or six, often eight or nine, to make a pound. In the Lake of Geneva they are often taken weighing twenty to twenty-four pounds. Herr Hoch himself saw one weighing seventeen pounds."

To this may be added a paragraph from Millet's "La Culture de l'Eau." "Itis very voracious, and, like the Trout, very swift and active in its movements. It habitually feeds upon small fishes, upon crustaceans, upon mollusks and insects, and in two or three years, under favorable circumstances, attains the length of fifteen to twenty inches. Its flesh is very delicate and savory, and it is preferred about Lake Leman to any other fish."

CULTURE.—The Saibling has been propagated by German fish-culturists for a period of ten years or more, and thrives magnificently in captivity. The hatchery at Oussee, in Germany, produces yearly three or four hundred thousand of artificially-brooded Saibling, and plants them in the neighboring lakes. In the tanks at the late International Fishery Exhibition in Berlin were exhibited many superb specimens of this fish, some of them over two feet in length, and one of these was sent to the National Museum by Herr von Behr, president of the Deutsche Fischerei Verein. It is as large as the famous Rangely Lake Trout caught by Mr. George Shepard Page, which everybody has seen at Blackford's in Fulton Market.

In selecting a place in which to deposit the saibling eggs just received, the Commissioner of Fisheries has endeavored to find a lake as similar as possible in depth and temperature to the larger Swiss lakes, and he has, therefore, sent them to Lake Winnipiseogee, N. H. Here the whole sixty thousand were planted, with the hope that by placing so large a number together in a lake of moderate size the experiment of introduction may be a success. It is a question of some interest which of the many European names of this fish should be adopted in the United States should the experiment of acclimation be a success.

It would seem most appropriate that, since the fish acquires its greatest perfection in Germany, the German name should be adopted, particularly since the German fish-culturists, who have so kindly made this gift to the people of the United States, will regard as a compliment the adoption of the German name of one of the favorite fishes of Germany.

166. THE DOLLY VARDEN TROUT—SALVELINUS MALMA.

By DAVID S. JORDAN.

This species is known in the mountains as "Lake Trout," "Bull Trout," "Speckled Trout," and "Red-spotted Trout." In the ocean, where it is found in large numbers, it is the "Salmon Trout." In the Sacramento the name "Dolly Varden" was given to it by the landlady at a hotel, and this name it still retains in that region. As none of the other names are distinctive, this one may well be adopted. In Siberia it was formerly known as the "Malma" or "Golet." The Indian name "Chewagh" is ascribed to it in British Columbia. In size this species reaches a weight of fourteen pounds. The largest I have seen weighed twelve pounds, which weight is not uncommon in the

ocean. In the lakes it averages smaller, and in the mountain streams it breeds at a length of six or eight inches. In all these peculiarities it agrees with its near relative, the common Brook Trout of the Atlantic coast. It ranges from the upper waters of the Sacramento to Kamtchatka on the west side of the Rocky Mountain chain, and for the most part in and west of the Cascade range. From Puget Sound northward it is generally abundant. It feeds voraciously in the salt water on smelt of various sorts, young Trout, sand lances, shrimps, anchovies, herrings, and even sticklebacks. In fresh waters it probably eats whatever living thing it can get. Nothing is certainly known of their breeding habits. They probably spawn late in the fall in the rivers, and therefore those which are in the sea must be to some extent migratory. They are taken in Fraser River at the time of the eulachon run, but they probably then ascend the river to feed upon the eulachon, and not for spawning purposes. As a food-fish this beautiful species ranks high.[1]

167. THE GRAYLING—THYMALLUS TRICOLOR.

The following essay upon the Grayling is quoted, in a modified form, from Goode's Game Fishes of the United States.

DISCOVERY.—The discovery of Grayling in Michigan and Montana was a surprise to American naturalists, though the areas to which this distribution is restricted are so small that one can hardly wonder at the delay in finding them out. The credit of discovering them is divided between Surgeon J. F. Head, United States Army, who found in 1860, in the headwaters of the Missouri, specimens of the form described by Milner in 1874, under the name *Thymallus montanus*, and Prof. Manly Miles, of Lansing, Michigan, whose specimens from the Michigan Peninsula were sent, in 1864, to Professor Cope, and described by him as *Thymallus tricolor*. A third species occurs in Alaska, and in the rivers emptying into the Arctic Ocean. This was first found by Capt. John Franklin's expedition toward the North Pole, in 1819, and called *Thymallus signifer*, by Sir John Richardson, who thus describes its discovery: "This very beautiful fish abounds in the rocky streams that flow through the primitive country lying north of the sixty-second parallel of latitude between Mackenzie's River and the Welcome. Its highly appropriate Esquimaux name ('Hewlook-Powak,') denoting 'wing-like,' alludes to its magnificent dorsal, and it was in reference to the same feature that I bestowed upon it the specific appellation of *Signifer*, or the 'standard-bearer,' intending also to advert to the rank of my companion, Captain Back, then a midshipman, who took the first specimen that we saw with the artificial fly. It is found only in clear waters, and seems to delight in the most rapid parts of the mountain streams." As is implied in these remarks, this species is remarkable for its immense dorsal fin, which is nearly twice as high as the body of the fish.

It is, however, the Michigan Grayling which is at present most interesting to the angler, the others being so remote as to be thoroughly inaccessible. Professor Cope's description was printed in 1865, but being expressed in technical terms, and published in the proceedings of a scientific society not generally read by sportsmen, it attracted little attention. Popular interest was first excited in 1873, by the discussions in "Forest and Stream," and by a letter from Professor Agassiz, published extensively in the daily papers, acknowledging the receipt of two specimens sent to him from New York through the agency of Mr Hallock, who had received them from Michigan. The subject was then taken up by the newspapers, and the Grayling was soon well known. A name closely associated with the study of the Grayling is the honored one of the late James W. Milner. In 1871, Mr. Milner, in company with Mr. D. H. Fitzhugh, of Bay City, Michigan, visited the Jordan River for the purpose of procuring specimens of this fish; but, although many

[1] For Pallas's account, see Günthe. vi, 144.

were seen in the clear cold waters, they could not be induced to take the hook during the day spent on the river. In 1873 he again visited this region, and subsequently published several popular articles on the subject of "Graylings of North America," which constitute one of the very few memoirs finished by him out of the many which were planned, and interrupted by his untimely death.

DISTRIBUTION.—His description of the habitat of the Grayling is excellent: "In the center of the Lower Peninsula of Michigan is a wide, elevated plateau, a sandy region, with a soil containing a very small per cent. of organic matter, and covered with a forest of pines, generally the Norway pine, *Pinus resinosa*, Linn., growing in grand dimensions, the long, limbless shafts making wide boards, free from knots, yet but little utilized, while immense forests of the favorite lumber material, white pine, *Pinus strobus*, are yet uncut. From this plateau arise several large streams and rivers, flowing each way into Lakes Huron and Michigan. Among these are three rivers of note, the Muskegon, the Manistee, emptying into Lake Michigan, and the Ausable, entering into Lake Huron. Among the minor streams are the Cheboygan, Thunder Bay, and Rifle, tributary to Lake Huron, and the Jordan, emptying through Pine Lake into the Traverse Bays of Lake Michigan. A few branches and streams, spring-fed, are formed, in which the water has a uniform degree of coldness throughout the summer, seldom rising above 52°. The rivers Rifle, Ausable, Jordan, Mersey branch of the Muskegon, and the headwaters of Manistee, all have this character, and in all of these, and only in this limited locality, short of the Yellowstone region, is found the already famous Michigan Grayling."

The town of Grayling, Michigan, formerly called Crawford, is in the midst of this district, and the headquarters of Grayling fishermen. The Grayling is said to live also in Portage Lake, in the extreme northern part of the State. These streams seem to be remarkably cold, being fed by numerous springs. Milner found the Ausable to vary between 45° and 49°, morning and evening, in September; and Mr. Fitzhugh has remarked that the south branch of this river, which rises in a swampy lake, contains no Grayling except near its mouth, where its volume is swelled by large springs, and its water becomes clear and cold.

The Grayling of Europe, *Thymallus vulgaris*, is also restricted to cold streams, and appears to be found within limited areas. It is found in Norway, Sweden, Lapland, and the Orcades, in Switzerland and Hungary, and southward to lakes Constance and Leman, and Bavaria. A Grayling, possibly of different species, occurs in Lake Maggiore, and others have been recognized from Russia and Siberia. It is constantly being discovered in new localities. In England the species was formerly known as the "Umber." "And in this river be Umbers, otherwise called Grailings," wrote Holinshed, in "The Description of Britaine," A. D. 1577. The German name, "Aesche," has been thought to refer, like "Grayling," to its color. The European and American fishes are so similar that only a trained ichthyologist can distinguish them, and their habits are very much the same. Our Grayling spawns in April in the Ausable, that of Europe in March and April, and sometimes, it is said, in May. Ours rarely grows to the length of sixteen inches, and the largest Milner could find weighed less than two pounds, the average length being ten or eleven inches, with a weight of half a pound. The European fish is said to grow to eighteen inches long, and the weight of four pounds and one-half. Milner remarks: "Like the Brook Trout, their natural food consists of the insects that light or fall upon the surface of the stream. Their stomachs were found to contain broken and partially digested specimens of coleoptera, neuroptera, as well as the larvæ of species of the dragon-flies. There were also found in their stomachs the leaves of the white cedar, *Thuja occidentalis*, which drop continually on the surface of the stream, and are probably taken because the fish in their quick darts to the surface mistake

them for insects falling upon the water." In France they are said also to devour little mollusks and the eggs of fishes.

CULTURE.—The propagation of the Michigan Grayling was attempted as soon as its existence was known. Mr. Fred. Mather and Mr. Seth Green, always pioneers in such enterprises, were the first to attempt it, and they were soon followed by others. Mr. Mather was first on the field, visiting the Ausable between March 25 and April 3, 1874; but he was too early, for the fish were not ready for him. Mr. Green followed on April 28, but he was too late, the fish having finished spawning. Not to be daunted, he dug over one hundred fertilized eggs out of the gravel where the fish had left them, and took them home to his hatching-house. In 1875 Mr. Mather visited the river between April 6 and 12, and obtained eight thousand eggs, which were successfully hatched. Young fish have been introduced into various streams in Michigan and Western New York. Frank Buckland tried many years ago to introduce the English Grayling into the Thames by transplanting its ova, but this experiment was a failure, and we have yet to learn that his American associates have been more successful in their efforts. An interesting fact observed in the course of these experiments is that the Michigan Grayling is much more prolific than the Brook Trout, yielding between three and four thousand eggs.

There has been much discussion over the claims of the Grayling as a game-fish, and also its excellence for food. It has many ardent admirers and detractors. The enthusiasm with which it was greeted ten years ago has somewhat subsided, and it seems doubtful whether a vote of the guild of American anglers would now place it in the first rank of noble fishes.

"There is no species sought for by anglers that surpasses the Grayling in beauty. They are more elegantly formed and more graceful than the Trout, and their great dorsal fin is a superb mark of loveliness. When the well-lids were lifted, and the sun's rays admitted, lighting up the delicate olive-brown tints of the back and sides, the bluish-white of the abdomen, and the mingling of tints of rose, pale blue, and purplish-pink on the fins, they displayed a combination of colors equaled by no fish outside of the tropics."

Mr. Mather describes the colors of the Grayling as follows: "His pectorals are olive-brown, with a bluish tint at the end; the ventrals are striped with alternate streaks of brown and pink; the anal is plain brown; the caudal is very forked and plain, while the crowning glory is the immense dorsal. This fin rises forward of the middle of the back, and in a fish a foot long it is nearly three inches in length and two high, dotted with large, brilliant-red or bluish-purple spots, surrounded with a splendid emerald green, which fades after death—the changeable shade of green seen in the tail of the peacock."

168. THE LAKE WHITE-FISH—COREGONUS CLUPEIFORMIS.

FROM NOTES OF LUDWIG KUMLIEN AND OTHERS—BY R. I. GEARE.

NAMES.—With the exception of the local name "Otsego Bass," said to be applied to this fish about Otsego Lake, New York, we have never heard any other name for it than "White-fish." It is found in all the Great Lakes, as well as in several of the smaller lakes tributary to them, and in lakes of British America northward, perhaps as far as the Arctic Ocean. It is very abundant, and is the most important food-fish of the Great Lake region. In quality of flesh it stands pre-eminent among our fresh-water fishes. The flesh is white, tender, and juicy, and, unlike the flesh of the Salmon, it does not produce satiety.

SIZE.—The largest specimens of White-fish are found in Lake Superior, one having been taken at White-fish Point weighing twenty-three pounds, and at the same place out of seventy-four half-barrels there was not one under six pounds in weight. At Duluth, White-fish weighing

from twelve to sixteen pounds are occasionally taken. Their average at the extreme west end of the lake is less than at the Apostle Islands, where some very large fish are caught. At Grand Island the fish average fourteen pounds, few being taken weighing less than ten pounds. In Green Bay, Lake Michigan, it is no uncommon occurrence to catch with deep nets fish from four to seven pounds, and in one lift there were twenty that exceeded five pounds, and some weighed eight pounds. About ten years ago a White-fish weighing nineteen and three-quarters pounds was taken near Menomonee. The Cisco, a variety of White-fish, in Green Bay attains a weight of three pounds; this is sometimes called the "Menomonee White-fish."

Next, in respect to the size of its White-fish, is Lake Michigan. On the west shore, where large fish are usually taken, in the vicinity of Manitowoc, a White-fish weighing twenty two pounds was taken in 1880. At the south point of Lake Michigan, the average weight is a pound and a half. Thirty-three hundred of that average were taken out of thirty gill-nets at one lift. The largest specimen ever taken here weighed fourteen pounds dressed. At Grand Haven, on the east shore of Lake Michigan, White-fish average about two pounds. Higher up on the east shore they are again larger, and average about ten pounds each in weight.

Lake Erie contains White-fish weighing as much as fourteen pounds. In the vicinity of Maumee they are larger than at any other point on the lake. In 1876 a seventeen-pound fish was taken at Vermillion, Lake Erie; and in 1879 one weighing sixteen pounds was captured. They are often taken weighing ten and twelve pounds. Farther east the average size becomes smaller, the season's average weight for White-fish at Ashtabula, Ohio, being not more than two pounds and a half. Farther to the east they are smaller still, and in the Detroit River they do not exceed a pound and three-quarters average weight.

In Lake Ontario White-fish average two and a half pounds for those taken in gill-nets, while those taken in seines will not exceed two pounds.

In order to ascertain the rate of the growth of the White-fish, Mr. George Clark tried an experiment to which he called the attention of the Detroit fishermen in the following words:

"ATTENTION, FISHERMEN."

"The 14th of May last I marked a number of White-fish with brass tags and put them into the Detroit River. The tags were a piece of brass about the size of a ten-cent piece, and a ring about the same size, and a similar ring linking these two together. The largest ring I put in the small fin on the back of the fish near the tail, each fish weighing about a pound and a half, the object being to ascertain the growth of the fish.

"Fishermen, one and all, if you catch any of these fish, will you please state when and where caught, weigh and measure length, and send them with the tags to Crowel & Co., S. John and Buck, of Toledo; the Paxtons, of Monroe; James Craig, A. M. Campau, C. Hurlburt and J. P. Clark, of Detroit; B. Reaume, of Springwells; George Clark, of Ecorse; Mr. Reaume, of Grosse Isle.

"I hope the fishermen on the Canadian shore will take an interest in this matter, and, if they catch any of these fish will please send them with the abovesaid specifications to the aforesaid parties, or to Davis & Co., and Merrill, fish dealer, in Detroit, or George Clark & Co.'s fish house, Detroit.

"If the fish cannot be sent, please send the exact weight and length of the fish, with the tag, by mail, to any of the above parties.

"GEORGE CLARK.

"ECORSE, *October* 9, 1872."

Mr. Clark never heard anything from these marked fishes.

On the same point Mr. Clark, writing to Professor Baird in March, 1872, says: "In June, 1868, I made a sweep with a seine, eighteen miles from the outlet of Lake Huron, on the shore of the lake, and caught at one sweep fish from three or four inches to twenty inches in length. Some of the largest fish weighed fifteen pounds. I concluded that they would increase in weight from three-fourths of a pound to a pound each year, which would require ten or fifteen years for the fish to get its growth. . . . He [speaking of Mr. Wilmot of the Wilmot Fishery Company at Newcastle, Ontario, Canada] has some White-fish two and a half years old last November, from some eggs which he procured here. The largest would weigh one and a half pounds. From this we judge the fish will gain in weight from one half to three-quarters of a pound each year."

MIGRATIONS.—Relative to the movements of the White-fish in Lake Superior, Mr. George Barnston is of the opinion that the young and immature White-fish confine their range entirely to shallow waters near the shore. The pound nets, set in twenty to forty-five feet of water, catch great numbers of small fish—seven or eight inches long and weighing only a few ounces. The gill-nets, usually employed in water not less than seventy to ninety feet deep, capture very few of these small White-fish. In a tour of Lake Michigan not one case of such small fish being captured in a gill-net—scarcely any under one pound—occurred. Again, a pound-net set on a thirty-six-foot shoal, six miles from land, at Bay de Noquet, contained only Nos. 1 and 2 fish. It might be urged that the small fish escape through the meshes of the gill-net; yet it is more than likely that occasional ones, entangled about the body and fins, would be taken, it being conceded that the head of the White-fish is to a slight extent better guarded against entanglement in the mesh than that of its congeners, the Lake Herring and the Cisco. Again, it is a significant fact that no young White-fish are found in the stomachs of the Lake Trout. The range of the Trout in summer is in deep water, and, if the young White-fish were there also, the Trout would surely feed on them. The conclusion of Mr. George Barnston, then, is that White-fish do not migrate at all into deep water until they have attained a weight of one and one-fourth pounds. He also corroborates Major Long's statement, that White-fish ascend Michipicoten River, Lake Superior, to spawn; "but," he says, "they cannot and do not run up far, for very high falls and long sweeps of raging rapids obstruct their course in both the main river and its tributary, not far from the Great Lake. Half a mile above the station I have assisted in seining White-fish at the spawning season, and succeeded occasionally in making a good haul. These fish must have come from the bay or lake, for they could never have descended the falls in safety, and the native fishermen (in all such cases good judges) consider them lake fish."

The line of migration followed by this fish in Lake Michigan is unerring and sure, and it is more apparent at the south end of Lake Michigan than at any other point on the lake; in the spring they always come down the east shore, and in the fall the west shore. About Point au Sable the runs begin in June and finish by the end of July, commencing again in September and continuing more or less throughout the winter.

During the last six years the White-fish are supposed to have changed their route of migration in the vicinity of Vermillion, Lake Erie. The spring run here comes in May and the fall run in October. The runs of the White-fish by no means occur simultaneously at all fishing points on Lake Erie, for the fishermen, at different points, are fishing for them as soon as the ice disappears in the spring, and continue until the ice comes again. The height of the runs may generally be considered as occurring during May and the fore part of June. Thence on until the end of July may be called the slack time, after which the fishing again becomes good, and continues to be so until the end of September.

In the spring the fish work from the west end of the lake and hunt for a certain depth of

water, remaining at their chosen spot until August, when they strike shorewards. Off Erie, Lake Erie, the water is shallow, and the fishermen are obliged to go out six to fifteen miles for White-fish; but off Dunkirk and Barcelona the water is deeper, and consequently shorter trips from land will suffice for fishing. This tends to show that White-fish are lovers of deep water.

In Lake Ontario, about Port Ontario, it is probable that the White-fish migrate from the Canadian shore to the American shore regularly. In 1870 they were more plentiful on the American shore; ten years before that, again, the reverse was the case. In 1880, following the rule, they have been scarce on the American shore, but will probably in a few years migrate again to this side of the lake. At Kingston Harbor they occur regularly. They have been known to run twenty miles up the river at this point; this is, however, unusual. Sometimes all the "Gray Backs" are found on the Canadian shore just before the regular spring run of the White-fish comes on. They are nowhere abundant on the American shore.

Mr. Peter Kiel, fishery overseer, Lake Ontario, says that White-fish are caught in early spring at a considerable distance from the shore in about two hundred feet of water, but about the 1st of June they approach the shore, and are then caught in great numbers on their favorite feeding grounds, a sort of honey-combed rock, in about thirty feet of water. About the 1st of August they retreat hastily toward the deeper and cooler portions of the lake, where they are found in their best condition. About the middle of October they again swim shoreward for the purpose of spawning, arriving at the proper locality from the middle of November to the 1st of December, depending upon the severity or mildness of the season, for they do not deposit their spawn until the water has attained a temperature of about 40° F. After spawning they again retire to the deep water, remaining there until the next spring.

Mr. Milner has contributed the following facts regarding the movements of the White-fish in the Great Lakes. From his observations it will appear that the migration shoreward is dependent upon the locality; depth of water, temperature, etc., are points which must be taken into consideration. Thus, in Lake Michigan, the summer migration into shoal water seems to be almost universal, while in Lake Erie, where the temperature is high in summer, the shoreward summer migration is unknown.

"The assertion was sometimes made among the fishermen that the scarcity of White-fish at any one locality was no reliable indication that the number had decreased, but that the schools had probably migrated to some other region.

"At Waukegan, Illinois, the White-fish come into shallow water in the greatest abundance in the months of June and July. The same habit is observed in various localities on the lakes, though by no means at all points. Several points on the shores of Lake Michigan, in the south half of the lake, the vicinity of the Apostle Islands, Lake Superior, and at the Thunder Bay Islands of Lake Huron, may be referred to as localities where the July migration occurs. George Keith, esq., a factor of the Hudson Bay Company at Michipicoten, in 1840, affords Sir John Richardson the same information upon the habits of a species of the *Coregonus*. It was for a long time a difficult matter to discover the reason for this summer run on the shore, if indeed it has been correctly accounted for. The contents of the stomach were found to be the same as at other seasons of the year. It was not probable that the White-fish was an exception to all its congeners of the salmonoid family, and preferred the warmer temperature of shallow water to the colder waters outside. Besides, the schools of White-fish were always found to leave a region where wide areas of shoal water existed as the heat of summer advanced. The theory adopted to account for this summer visit to the shore was that the calm, quiet weather of the summer months, from the slight disturbance of the surface, prevented the amount of aëration to the water that occurred at

other seasons of the year, and the fish sought the shore where the splashing on the beach and sand-bars supplied the water with the requisite amount of air, just as other species of this family of fishes delight in rapids and falls, because the breaking up of the masses of water supplies it with a large amount of respiratory gases.

"In waters like Lake Erie, where, according to the Lake Survey, the temperature attains as high as 75°, the White-fish seek the cooler deep waters in the summer, and I have not learned of a migration upon the shore at any point, they, perhaps, preferring a less amount of aëration to a high degree of heat.

"The fact that in the month of August the White-fish of the Sault Ste. Marie Rapids leave the river entirely, and do not return until in September, weakens the force of the theory that the aëration of the water is the necessity that brings them to the shore of the lake in the summer.

"Professor Agassiz, in his tour of the north shore of Lake Superior in 1849, found the White-fish scarce along the shore and at the rapids in the month of August. Among the Apostle Islands, Lake Superior, and in most of the deeper portions of the lakes, no scarcity is observed at this season of the year. At the rapids, they so entirely abandon the locality in August that the supply of fish for the hotels has to be obtained from Point Detour, at the head of Lake Huron.

"It was a disputed point among the Waukegan fishermen whether the migration was directly in from deep water or along the shore. The fact that, in some instances, the schools of fish struck the nets at one point, and afterwards entered the nets in succession along the line of the shore, was thought by many to prove a littoral migration. But the fact was that, in all likelihood, the advance portion of a school would touch the shore at some point and then move in either direction along its line.

"The presence of large White-fishes in numbers at certain localities on the north shore of Lake Michigan, of a size that are never taken at other parts of the lake, would indicate a local habit, with no disposition to range through long distances. Another observation sustaining the probability of this is the fact that there are many localities on the Lakes where the pound-nets, a few years ago, found prosperous fishing, and in the first few years took the White-fish in great abundance, but found afterwards a decrease from year to year until the locality was abandoned, while fifty miles away the business still continued successful. The well-known local instincts of the Salmon would, to a slight extent, confirm the probability of like instincts in its related genera. The fact that certain types of the White-fish are peculiar to particular localities, as the north shore of Lake Michigan, the Sault Ste. Marie Rapids, Bachewauna Bay, on Lake Superior, indicates a local habit through many generations until certain characters of a race have become established. The same fact has been stated for the shad on the Atlantic coasts. Some observations, made in 1871, perhaps indicate the opposite of all the foregoing statements.

"In the early part of the season there had been very few fish caught on the west shore of Lake Michigan, between Chicago and the Door Islands. South of Chicago, at the mouth of the Calumet River, the run of White-fish was in excess of anything had for years. But, about the 15th of June, the schools of fish left Calumet, and a few days later there was a decided improvement in the catch at Evanston. About June 22, the lifts at Waukegan began to be heavier than they had been before. During the first week of July the fishing was observed to improve at Milwaukee, Manitowoc, and Bailey's Harbor, and, a little later, at the Door Islands. The coincidence in dates rather indicated a probability that the same schools of fish that clogged the nets at Calumet during six or seven weeks had ranged northward along two hundred and sixty miles of coast. Still, the effect on the fishing would have been the same if it had been the migrations of schools of fish from deep water at these points in to the shore. In order to obtain a definite knowledge of

their habits in this particular, metal tags, with numbers indicating the locality, were distributed to fishermen at twenty points along the lake, to be fastened to the fins of live fish, which were then to be released. Instructions were at the same time sent to all fishermen to report the capture of fish bearing these marks, and the distances from where they were taken to the point of departure would indicate the extent of their migrations. It is thought that but few of them were used. A similar proceeding was afterward carried out by Mr. George Clark, of Ecorse, on the Detroit River, but none of the fish were ever heard from.

"Some of the fishermen of the west shore assert that, after severe storms encroaching on the shore, and making the water muddy for a long distance out, when the storm subsides there is a heavy deposit of mud on the bottom, and that the White-fish abandon the locality for a time, because, as they surmise, their food is buried in the sediment. On the contrary, after ordinary storms, there is generally an improvement in the catch of fish, probably for the reason that the great aëration of the water renders them lively and incites them to move about. The migration from the southern portion of Lake Michigan is of yearly occurrence, about the middle of June, and is, without doubt, occasioned by the large extent of shoal water becoming heated. The same thing occurs in Green Bay, and in the shoal regions of the western end of Lake Erie. The migrations into shallow water, and up certain streams, in the fall of the year, for the purpose of spawning, will be considered further on. This migration, and the summer visit to the shore, are the general migrations peculiar to the White-fish, while the departure from shoal regions in summer, and from certain localities in August, are local peculiarities."

ENEMIES.—This section of the natural history has been fully worked up by Mr. Milner in his "Report on the Fishes of the Great Lakes," from which the following extracts are made:

"The largest percentage of destruction the White-fish suffers is without doubt in the ova stage. The spawn-eaters of the Lakes are a numerous and widely distributed list of animals, including fishes, amphibians, and, it is claimed, divers and ducks. The destruction of the spawn by these methods is immense, and far exceeds the losses while in the stage of fry. The most wholesale devourer of the eggs is undoubtedly the Lake Herring. On opening the stomachs of the Herring from the ponds in Detroit River, in November, they were found to contain the eggs of White fish. At first it was considered possible that, as they were confined in the ponds, their eating spawn might be a matter of necessity; but later, at Sandusky, their stomachs were found gorged with the ova. The Herring, the most numerous species inhabiting the spawning grounds of the White-fish, are without doubt the principal agents in keeping in check the increasing numbers supplied from the fertilized ova. The suckers, sturgeon, and smaller bottom-feeding fishes are found with spawn in the stomach.

"The so-called 'water-lizard,' *Menobranchus lateralis*, Say, is very numerous in some of the streams and portions of the lake shore. Mr. George Clark, of Ecorse, Michigan, had a minnow-seine fitted to the bag of a sweep-seine, and at one haul took two thousand of the 'water-lizards.' Estimating the extent that the net had passed over, he calculated the average number of lizards to each square rod to be four. He says, further, in one of the Detroit papers, 'The lizards were so gorged with White-fish spawn that when they were thrown on the shore hundreds of eggs would fly out of their mouths. . . . Some of the larger lizards would devour the whole spawning of a White-fish in a day or two; and when we consider that these reptiles are feeding upon eggs from November till April, some idea may be formed of their vast capacity for destruction.'

"Mr. Browne, of Grand Haven, Michigan, states that some three years ago an epidemic seemed to prevail among the *Menobranchi* in Grand River in the mouth of June, and that their dead carcasses were washed ashore by hundreds, so that they lined the banks of the river, and

the millmen were obliged to throw the bodies off into the current, to be carried down stream to prevent the offensive stench that was wafted into the mills from the decaying remains.

"A fisherman at Evanston, Illinois, a few years ago had nine hundred hooks set in the lake, and in one day took from these five hundred lizards, removing them all himself, as his men, sharing the popular notion on the Lakes, believed them to be poisonous, and preferred to cut away hook and all to taking hold of the slimy amphibian. They are, of course, entirely harmless in this particular, and make no more attempt to bite than a frog does. A full series of this species was this season collected from Detroit River, from the length of one and one-fourth inch to thirteen inches. Later, about the middle of the month of July, Mr. George Clark collected a quantity of their eggs, proving this month to be the spawning season of the animal.

"The sturgeon are very generally believed to be spawn-eaters. Though the ova of the White-fish and the perch have been observed among the stomach contents of this fish, the principal food has always been found to be snails, the fresh-water genera being generally represented, the weaker shells crushed into fragments, and the stronger ones of the *Paludinidæ* and even *Limneas* remaining unbroken. Dr. E. Sterling, of Cleveland, who examined the stomachs of a large number of sturgeon in the vicinity of the Sandusky fisheries, made the same observation. There are few of the bottom-feeding fishes but whose stomachs will not generally be found to contain a few eggs, though in company with other food in greater quantity.

In the fry stage they must suffer to some extent from the piscivorous fishes. The most numerous and voracious of their enemies is likely to be the wall-eyed pike, *Stizostedion americana*, numerous in the shoal waters of the lakes and comparatively rare on the deeper shores. The perch, *Perca flavescens*, are very generally distributed and quite numerous; the contents of their stomachs are generally found to be vertebrate forms. The black bass, *Micropterus nigricans*, is plentiful in Lake Erie, but as its ordinary food is the crawfish, where these are numerous its depredations on the schools of young fish would be of comparatively little importance. The white bass, *Roccus chrysops*, the muskellunge, *Esox nobilior*, and the lake pike, *Esox lucius*, do not inhabit the Lakes in sufficient numbers to be very troublesome to the White-fishes. It is the prevailing idea on the Lakes that the Mackinaw or Salmon Trout feeds largely on the White-fish. Here as everywhere civilized man disturbs the balance of nature, and becomes the great enemy to all forms of life that do not conform to his artificial methods for their protection. Not only by the hundreds of artifices for the capture of the White-fish, but in the foul drainage from the cities, smelting-works and manufactories, and in the quantities of sawdust from the mills, they are driven from their favorite haunts and spawning grounds, and their food destroyed by waters tainted with fatal chemical combinations."

Mr. Milner mentions the natural casualties of storms, deposits of sediment smothering the eggs, the vegetable growth found to be so fatal in the hatching troughs, as causes of destruction to immense quantities of White-fish spawn.

Mr. Lanman, speaking of the enemies of the White-fish, says that the great Gray Trout (*Salmo ferox*) follows the White-fish to the shore and preys upon it. While the nets are set for White-fish, the fishers, with torch and spear, attack and capture the *Salmo ferox*, frequently of large size; and hence this latter fish has acquired the name of *Tuladi* from the river to which it is attracted by its favorite prey.

FOOD.—Mr. Milner, in his "Report upon the Fisheries of the Great Lakes," wrote the following paragraphs on the White-fish:

"The food of the White-fish has been a problem inciting numerous conjectures among fishermen, sportsmen, and fish-culturists, and baffling the investigation of a few naturalists for a number of years past. To Dr. P. R. Hoy, of Racine, we think, belongs the credit of first

discovering correctly the character of their food. On opening the stomachs of numerous White-fish he at first failed to determine the character of the stomach contents, until, after washing the half-digested mass in a basin of water, he found the sediment to be full of small *Crustacea*, whose existence in the lake had never before been suspected. My examination and preservation of the stomach contents from all quarters of the Lakes confirmed Dr. Hoy's observations, and discovered a few other small forms of life as the food of White-fish. The invertebrates found were of crustaceans: species of the families *Gammaridæ* and *Mysidæ;* of the mollusks: species of the genus *Pisidium;* and certain insect larvæ. A few fish-ova were frequently found in the stomach, and it was not unusual to find a little gravel.

"In the greater portion of the lake the *Gammaridæ* constituted the principal food. In shallow regions small *Conchifers* were more numerous. At Point aux Barques, on the north shore of Lake Michigan, where a very large type of the White-fish was found, the stomach contents were entirely of the *Mysis relicta* Loven. In the Sault Ste. Marie Rapids, in July, a mass of small chrysalides was found in the stomachs of a number of White-fish. In October, from the same locality, the larvæ of the caddis-fly were found in the stomachs, apparently carefully separated from their artificial coverings. Stomachs opened in Lake Superior contain principally the *Mysidæ*. At Rocky Island, in the northwestern part of Lake Michigan, a vessel with a cargo of wheat was lost a few years ago. The fishermen say that White-fish were taken in that vicinity for several years afterward with wheat in their stomachs.

"Rarely White-fish will take a bait. The breakwater protecting the Illinois Central Railway at Chicago was formerly a favorite fishing place, and in early summer was often lined with a row of boys and men fishing for perch. There was seldom a day passed but that a few White-fish were taken. Mr. Trompe, of Sault Ste. Marie, has frequently taken them in that locality with a hook baited with a May-fly, *Ephemeridæ*. At a fishing dock on Sand Island, one of the group of the Apostle Islands, Lake Superior, there were a few taken this season with a worm bait.

"The leech, *Ichthyobdella punctata*, Smith, parasitic on the White-fish, and numerous in some localities, was in no instance found in the stomach. This corroborates Dr. Hoy's observations. A similar fact was noticed afterward at Detroit River. A parasitic crustacean, a *Lernæa*, was found adhering to the White-fish in numbers, and, though many stomachs were examined, in no instance were any of the parasites found in the contents. Both the *Lernæa* and the *Ichthyobdella* are related to species made use of as food by the White-fish, as near in the one instance as being in the same class, and the other in the same order. The mouth is constructed for nibbling along the bottom, the opening being directed nearly downward, and they gather in the small life of the bottom and the gravel as they move slowly along.

"Dredging in the lake at different localities and examination of stomach contents at numerous points prove that the crustaceans and the mollusk constituting the principal food of the White-fish are distributed throughout the lake bottom, in all localities, and at all depths over about twenty fathoms. In Torch Lake, a deep inland lake in the Grand Traverse region, Michigan, where a large type of White-fish is found, the dredge brought up the same species of crustaceans and mollusks as were found in Lake Michigan. The failure to find food in the stomachs of White-fish has frequently resulted from the fact that the fish examined were taken from the pound-nets, where they had remained long enough to digest the contents of the stomach before they were taken from the water. Fish from the gill-nets have generally the food in the stomach only partially digested, while a hundred fish in succession from the pound-nets may be opened and every stomach found empty.

It is frequently asserted that aquatic vegetation afforded sustenance to the White-fish. The

investigations in the past two years did not result in any confirmation of this notion, and it would not accord with the habits of any species of the family of fishes to which the lake White-fish belongs."

A list of the precise contents of the stomachs of individuals examined by Mr. Milner is now appended:

"Specimens from Outer Island, Lake Superior, contained great quantities of *Mysis relicta*, *Pontoporeia Hoyi*, and *Pisidium abditum*, var. *abyssorum;* and with these were a few specimens of dipterous larvæ of the genus *Chironomus*, a small worm (*Lumbricus lacustris*), *Daphnia galeata*, *D. pellucida*, and a small species of *Planorbis*.

"From Sand Island, Lake Superior, *Pontoporeia Hoyi;* larvæ and pupæ of *Chironomus;* *Valvata sincera*, and *Gyraulus parvus*.

"From Sault Ste. Marie, one lot contained scarcely anything but small shells. Among these, *Valvata tricarinata*, *V. sincera*, var. *striatella*, *Amnicola generosa*, *A. palida* (?), *Gyraulus parvus*, and a species of *Limnæa* were in abundance; while there were fewer specimens of *Goniobasis livescens*, *Physa vinosa* (?), young, *Sphærium striatinum*, and *Pisidium compressum*.

"Other specimens contained nothing but the remains of insects, among which were the imagos of two species of *Diptera;* larvæ and pupæ of *Chironomus;* larvæ and pupæ of some specimens of *Ephemeridæ;* great numbers of the larvæ, pupæ, and subimagos of a species of *Hydropsyche*, and the larvæ of a species of some other genus of *Phryganeidæ*.

"From Ecorse, Michigan, specimens contained a species of *Hydrachna*, the leg and the scales from the wing of some lepidopterous insect, and a species of *Limnæa*.

"White-fish which I examined at Isle Royale, in August, 1871, contained scarcely anything but *Mysis relicta* and *Pontoporeia Hoyi*.

"Ecorse, Michigan—remains of a small fish and several specimens of a species of water-boatmen (*Corixa*).

"Specimens of *Coregonus quadrilateralis* from Madeline Island, Lake Superior, contained a number of specimens of a leech (*Nephelis fervida*) and a neuropterous larva allied to *Perla*.

"These few observations are sufficient to show that the White-fish, like the different species of Trout, feeds on a large number of species belonging to very different groups of animals. In this brief enumeration, twenty-five species are mentioned—nine of insects, four of crustacea, one worm, and eleven of mollusks; and these are undoubtedly only a small part of the species upon which the White-fish really feeds."

Much difficulty was experienced by Mr. Milner in his attempts to discover the food required for the sustenance of some young White-fish which had been sent to him. His experiments, together with a letter written to him by Mr. Briggs, editor of the "Lens," Chicago, with regard to the contents of the stomachs of embryo White-fish, are here reproduced:

"*Food of embryonic White-fish.*—The young fish reached Waukegan in safety, and were placed in five-quart glass jars, and an experiment begun in attempting to supply them with suitable food. A numbered label was pasted on each jar, so as to keep them distinct. Knowing that the larger White-fish fed largely on crustaceans, an attempt to feed them on food of this character was thought worth a trial. A few crawfish were procured and pounded to a paste, and small portions put into jar No. 1; the young fish ate it readily. They were fed at night, and the next morning every one of them was found to be dead. Jar No. 2 was supplied with bread-crumbs, and the fish were seen to take small particles in their mouths; they did not die so suddenly. Jar No. 3 was supplied with sweet cream, but no evidence was afforded that the occupants fed upon it. A quantity of rain-water was exposed to the rays of the sun for the purpose of generating minute forms of life, and a teaspoonful was poured into jar No. 4, morning and evening, in hopes that

their proper food was of this character. In jar No. 5 a variety of food was provided, dry fresh beef, milk, boiled potato, and bread. The crumbs of bread and the scrapings from the beef were all that the fish were seen to take into their mouths. They died, one after another, very rapidly, and in a few days all were dead.

"*There were other things unfavorable to them, in these experiments, besides the lack of their* natural nourishment. To conduct these experiments favorably, they should be placed in a large vessel, and a stream of fresh water should be supplied constantly so that the water should continue pure and the production of confervæ be avoided. This difficulty of procuring a suitable food for the young White-fish has been the experience of the few fish-culturists who have hatched them.

"A set of specimens, representing young fish from the Detroit River, from the troughs at Clarkston, and from the jars, were preserved in alcohol and submitted to Mr. S. A. Briggs, editor of the 'Isens,' Chicago.

"A letter from Mr. Briggs contained the following:

"CHICAGO, *May* 28, 1872.

"MY DEAR SIR: The four vials containing *C. albus* came duly to hand, and have, with the alcohol and water in which the specimens were preserved, been carefully examined.

"The intestines of specimens Nos. 77 and 78 from Clarkston were entirely destitute of organic matter recognizable under a power of 400 linear, which ought to be ample for the purpose. Those of specimens 76 and 79, from Detroit River, contained numerous specimens of two species of *Diatomaceæ*, viz, *Fragilaria capucina and Stephanodiscus Niagaræ*. The former is a filamentous form which grows very abundantly in our lake inlets attached to stems of lilies. The latter is a large form which, from its peculiar build, contains considerable nutritious material.

"Very sincerely, yours,

"S. A. BRIGGS."

Two statements of a more general character are made regarding the food of the White-fish in Lakes Erie and Ontario; the one, an extract from a letter by Mr. John W. Kerr, Hamilton, Ontario, the other by Mr. Peter Kiel, of Wolfe Bay:

"The White-fish at this season of the year, fall and winter, feed on small shell-fish. This you can ascertain yourself by analyzing the contents of their stomach. In spring and summer they feed on a kind of shrimp-like insect; and from my knowledge and experience I have never known them to change to any other kind of food than those two kinds now described to you by me."

"The White-fish is of a fine organism, and, being entirely destitute of teeth, is neither predaceous nor yet very voracious in its nature, but lives on the most simple fare, which consists principally of small worms and insects that abound in great numbers among the plants and porous rocks on the bottom."

SPAWNING AND DEVELOPMENT.—The most elaborated discussion of (*i*) the habits of the White-fish at the spawning season (noted day by day in the journal of the author), concluding with a table showing the relative weight of ovaries and number of eggs in proportion to the weight of the fish, (*ii*) the development of eggs and embryo, and (*iii*) the rate of the young White-fish's growth, has been written by Mr. Milner in his "Report on the Fisheries of the Great Lakes," and is here given in full:

(*i*) *The habits at spawning season.*—"The White-fishes throughout the larger portion of the Lakes, come into shallow water to deposit their spawn about the middle of November, just at the time when the Salmon Trout has finished spawning and is returning to deep water. At this

season they come in from deeper water in vast schools, and are taken in large quantities by the nets. A notion, prevalent among the fishermen in some localities, that the female fishes arrived first, and were followed, a few days later, by the male, was not confirmed by my observation. The bottoms on the spawning grounds vary in character in different localities; rock, sand, clay, and mud being used indifferently for the spawning beds. The depths at which they spawn range from eight feet to fifteen fathoms; the larger number probably spawning in depths of about eight or ten fathoms. In the Sault Ste. Marie River, and in the Detroit River, in the fall of the year, they congregate in great numbers, for the purpose of spawning. In a number of rivers emptying into Green Bay the White-fish was formerly taken in abundance in the spawning season. Saw-mills are numerous on all of these streams at the present day, and the great quantity of sawdust in the streams is offensive to the fish, and has caused them to abandon them. In one or two rivers of the north shore of Lake Michigan they are still found in the autumn.

"The Michipicoten River of Lake Superior, on the authority of Major Long, who commanded an expedition to this region in 1823, and George Barnston, esq., of Montreal, Canada, formerly of the Hudson Bay Company, is a favorite spawning ground of the White-fish. The Nepigon River, which our steamer entered while returning from the north shore of Lake Superior, about the middle of October, was said to contain schools of White-fish, which had probably entered the river for the purpose of spawning.

"There is a probability that there was a time when the White-fish ascended many of the clear rivers of the Northern Lakes, though that this was a universal habit is not probable, at any rate since the white man has been in the country.

"The fishermen, with their gill-nets, follow inshore the migration of the White-fish in the month of October, and a few days before the middle of November the spawn is ripe in a few fishes, and by the middle of the month is running freely, so that boats and nets are covered with the spawn and milt. Just at the time the ova are beginning to ripen, the Lake Trout, *Salmo namaycush*, has finished spawning, and is leaving for deep water. The White-fish continue to spawn until the last week of November or the first week of December, when they, too, leave the shore and seek deeper water.

"In the Detroit River, where there were fine opportunities for observing the fish at this period, owing to the advantages afforded by Mr. George Clark, of Ecorse, we found that the fish ascended the river about the last week of September, usually following the same course among the islands year after year. Mr. Clark's observations on the migration of the White-fishes had discovered that they ascended much farther years ago than they do now. They are still taken as high up as Cottrelville, twelve miles up the Saint Clair River. None have been caught above this point for many years. It is a singular fact that the White-fish are not known to descend from Lake Huron into the Saint Clair River. This is established by abundant evidence from continued fishing at Fort Gratiot, where Mr. Clark, between the years 1830 and 1842, took large quantities of the wall-eyed pike, *Stizostedion americana*, taking frequently one thousand barrels in a year. The catch of White-fish amounted to an occasional supply for his own table, except after long-continued storms from the northward, when the fish sometimes entered the river in schools. They were never found in this portion of the river in the spawning season.

"The same fact is claimed by the Indians in the Sault Ste. Marie River, that the White-fishes of the lake above never descend the rapids, while the White-fishes of the river, it is also asserted, never ascend to Lake Superior. There is not as good evidence for the truth in this locality as at Fort Gratiot; still, it may be the case.

"Examining the fish on the 30th of October, it was found that the spawn of the White-fish was hard and firm, with rarely a fish approaching ripeness. On the 1st of November, in the picketed pond, where the fishes are inclosed, numbers of fish were seen jumping from the water, principally the Herring, who take delight in this exercise at different seasons of the year. Occasionally a White-fish threw its bulkier form above the surface. On the 8th of the month Mr. Clark and I were out on the piling surrounding the pond, and found the White-fish jumping in numbers, so that there was a continual splashing of the water. They almost uniformly jumped in pairs, and we could see quantities of spawn in the water immediately afterwards, which rapidly sank. Mr. Clark and I both succeeded in capturing a pair in the act of leaving the water, and found male and female with milt and spawn running freely. Mr. Clark made use of a fine wire scoop as the pairs of fish disappeared from the surface, and almost invariably took a quantity of spawn from the water. The males were uniformly smaller than the females. I succeeded in catching a pair in which the female weighed seven pounds, and the male, who escaped before he was weighed, did not exceed one and a half pounds.

"November 9.—I again saw the White-fish jumping from the water in the evening, almost uniformly in pairs. Rarely there were three leaped together, one female and two males. In the pairs there was always a large one, evidently a gravid female, and a smaller one, the male. At this season of the year it is easy to detect the difference in sex, the abdomen of the female being swollen and rounded, while the males are leaner and angular in the abdominal lines. I saw by long watching that the males were worrying the females. They seemed possessed of strong sexual ardor, and followed the female with persistence, keeping close against her and with the head about even with the pectoral fin. Driven by the persistent attention of the male, the female arose vertically, he following, and she making a convulsive effort to escape, the water being from three to ten feet deep, they threw themselves together above the surface, and the spawn and milt were emitted at the time when, from their position, their vents were approximated. The spasmodic fluttering and effort observed suggested a sexual orgasm. At times I saw them moving rapidly beneath the water in the same close contact, and the male with his snout even with the pectoral fin of the female, often turning together with the white of the belly upward as she turned and twisted to escape him. Often as they came out of the water they would fall apart in different directions, but the male invariably turned immediately in pursuit, so that I was led to think they were monogamous, as is the fact with their relatives the Salmon and the Speckled Trout.

"November 10.—The White-fish jumping in great numbers toward sunset. In most instances, when near by, I observed a quantity of eggs, perhaps three hundred or five hundred, emitted at once. The milt of the male did not discolor the water. The same actions occurred as before observed, springing vertically from the water with a spasmodic, fluttering effort, the male's head opposite the pectoral fin of the female, turning together beneath the water until both abdomens showed upwards. Occasionally three sprang above the surface together. Sometimes the pair fluttered along the surface together for a long distance.

"November 14 and 15.—Went out to the pond at midnight, and again at 1 o'clock a. m., and found the White-fish jumping. The fact that they are quiet in the daytime, previous to four or five o'clock in the afternoon, indicates a parallel habit to that observed by Seth Green, of New York, in the shad, they, as he asserts, spawning principally in the night, though, unlike what was the case with the shad, we had no difficulty in finding spawners in the forenoon with the seine.

"November 18.—The fishing stopped all along the river. Visited the island. Cold, strong wind from the southwest. Thermometer 26°. No White-fish to be seen in the pond. A few Herring coursing around the piling.

"November 19.—Same as yesterday; no White-fish to be seen. Caught some of the herring with the dip-net; found their spawn still hard and small; their stomachs were full of White-fish spawn. Mr. Clark and I took a boat with two men and dredged in the river, obtaining a quantity of White-fish eggs. Nearly all were dead. Afterwards dipped a quantity from the pond, nearly all of which were dead.

"November 20.—Made another visit to the island. No White-fish seen in the pond. Cold, freezing weather.

"On the 24th and 25th of the month, while at Sandusky, Ohio, numbers of White-fish were found with the spawn in different stages of ripeness, though a majority of them had spawned.

"After spawning, the abdomen of the female fish is somewhat flabby and wrinkled, and the fish is undoubtedly relaxed and weak; but not to the extent that the Salmon, as well as certain other species of the *Coregoni*, are said to be reduced. The male shows but little indication of weakness.

"A series of ovaries were preserved from fishes of different sizes, and a count made by weighing the entire ovaries and then counting the eggs of a definite fraction, and calculating from it the number of the whole. Accurate scales were used for this work, and the table may be relied upon as correct:

Weight of fish.	Weight of ovaries.	Number of eggs.
	Ounces.	
2 pounds	5¾	21, 229
2¾ pounds	7½	28, 500
4 pounds	16	48, 000
7½ pounds	25	66, 606

"This makes an average of about ten thousand increase for every additional pound weight in the fish, which is precisely Mr. Seth Green's estimate, from his observations in spawning White-fish. Considerable variation in the weight of an equal number of eggs was observed, depending upon the stage of development at which they had arrived in the ovaries. During the spawning season, the fish from the river were found to have very little in their stomachs.

(ii) Development of eggs and embryo.—"It has been proven by repeated observations by fish-culturists that the higher the temperature of the water in which the eggs are placed the more rapidly the embryo fish develops within the egg, and the sooner it escapes from its inclosure in the shell. The temperature of the succeeding months after the spawning period probably regulates to a considerable extent the time of hatching of the White-fish in the Lakes.

"On the 11th day of April, at Ecorse, on the Detroit River, I visited Grassy Island in company with Mr. George Clark. The inside of the bag of a seine was lined with millinet and dragged in the river, bringing ashore a great quantity of mud and the small forms of life inhabiting the bottom. Sifting and washing out the mud resulted in finding one little worm-like fish-embryo, one-half inch in length, which I at once suspected to be the specimen sought after. Other attempts with the seine failed entirely of taking any more. Mr. Clark then proposed that we take a boat and search carefully on the surface for the young fish. Taking a pail and dipper, we shoved off our boat, and Mr. Clark pulling very slowly with the oars, I hung over the gunwale, and in a very few minutes found a little, active fish swimming with his head at the surface, and captured him with the dipper. He proved to be identical with the one taken with the seine. In the course of half an hour we captured forty, all of the same size and state of development. Most of them

were taken within five or six inches of the surface, though they were frequently seen coming up from as far below as they were visible. They were nearly white, with a pair of large, black eyes, were very active, moving continually, propelling themselves with a constant motion of the tail, and swimming with the head up and the body depending at an inclination of about 50°. They seemed apprehensive of danger, and turned quickly from the dipper when it came near them, occasionally escaping. They had no gregarious instinct whatever, and though occasionally taken in pairs it was probably an accidental circumstance.

"On April 14 we again visited the island and caught a number more of the young fish.

"A few days later Mr. Clark and I visited the breeding-house of Mr. N. W. Clark, of Clarkston. He had put down a large quantity of White-fish ova in November, and had taken the water flowing over the eggs from a pond that had remained frozen over nearly all the winter. The temperature of the water had remained at 34° or 35°, and the young fish had begun to hatch out on the 1st of April, and about the 9th or 10th were all out of the shell. This temperature is probably much the same as Detroit River at Ecorse, sixty-eight miles below Lake Huron, the current flowing at the rate of two miles per hour.

"The appearance of the umbilical sac in the specimens from both places made it evident that they were of about the same age, and indicated the fact that in waters that are frozen over throughout the winter the young White-fish escape from the egg about the first week of April.

"The temperature of Lake Michigan, Huron, or Superior probably does not descend below about 40° or 43° in ordinary winters, and the young fish would be likely to make their appearance a week or two earlier.

"The young fish lived in the glass jar of water two days, were then transferred to an eight-ounce bottle, and carried over thirty hours by rail and steamer, and did not arrive at their destination, Waukegan, Illinois, until thirty-six hours after they left Ecorse, Michigan. They were all in good condition, and were placed in a quart jar of fresh water. There were thirteen of them altogether.

"April 19.—The young White-fish are very vigorous, and are in continual motion. The water has been changed once. Although the yelk sac has not diminished, they act as if seeking food in their movements around the jar. They open their mouths very wide. Occasionally they take in dust masses and eject them again as if they were unpalatable.

"April 21.—Umbilical sac in one individual diminishing.

"April 22.—Umbilical sacs reducing rapidly.

"April 23.—Yelk sacs being rapidly absorbed. The membrane on the anterior part of dorsal line is also slightly diminished.

"April 24.—The umbilical sacs becoming minute. The fin-membrane anterior to position of dorsal becoming absorbed. At the center of the anterior ventral section of fin-membrane a slightly opaque white spot is apparent. In front of the anus, and on lower half of caudal, are similar ones. The color of the head is assuming a greenish tinge.

"April 25.—The globule in anterior part of yelk sac has become divided up into numerous smaller globules, scattered like beads, or more like a row of bubbles, through the length of the sac. When they open their mouths the gill-arches show quite distinctly. Excrement voided by some of them.

"April 28.—Umbilical sac entirely absorbed. First dorsal fin becoming well defined. Posterior section of dorsal membrane contracting. Furcation of caudal slightly indicated.

"After an absence from home of six days, I returned on May 6 to find only one alive. A

brown confervoid growth had developed in the water, and the young fish attempting to swallow it always got it entangled in its gills and soon died.

"In my absence I visited Clarkston and purchased for private parties from Mr. N. W. Clark one thousand young Trout, which I brought safely to a brook two miles north of Waukegan, Illinois. Mr. Clark gave me one hundred and fifty young White-fish, most of them with the yelk sac only partially absorbed. The difference in temperature evidently made some difference in the rapidity with which the umbilical sac disappeared, as the young fish I had carried home were in the same stage of development, April 14, as when I had visited Clarkston previously. Now, May 1, the fish in Mr. Clark's troughs still retained considerable of the sac, while on the 28th of April the young fish in the jar had lost it entirely. The jar had been kept in a moderately warm room, with a temperature of about 65°, while the water in the troughs at Clarkston flowed from a pond that had been covered with ice until within a few days previous.

(iii) Rate of Growth.—"Further research for the young fish was unavoidably delayed until the 1st of July. Towards the end of June, from a seine-haul at Waukegan, a specimen of *Coregonus albus*, measuring eight and three-tenths inches in length, one of *C. quadrilateralis*, measuring seven and four-tenths, and one of *Coregonus harengus*, measuring three and four-tenths inches, were obtained.

"At Sault Ste. Marie, Michigan, on July 2, with an Indian in a birch canoe, the vicinity both above and below the rapids was explored in the current and in the still water and along the shores, to find the smallest grade of White-fishes that were to be had. Along the shore, in the sharp current, schools were found of which the smallest taken measured four inches and nine-tenths, and the largest six inches and one-tenth. It was quite evident that they had all been hatched the same season. Another excursion in the birch resulted in nothing materially different. The minimum measurement of the next grade taken was eight inches and three-tenths.

"At Shoal Island, one of the Apostle Islands of Lake Superior, a White-fish was taken from the pound-net about the middle of August measuring six inches in length, and another measuring six and one-half inches.

"On the 3d of December, at Point Edward, Canada, at the outlet of Lake Huron, two specimens of *Coregonus albus* were obtained from a seine, one measuring six inches and eight-tenths, and the other seven inches and seven-tenths.

"It is very probable that the Shoal Island fishes of August and the Point Edward ones of December 3 were the larger-grown individuals of the same generation as those taken at Sault Ste. Marie in July. The difficult point to decide was in what year the beginning of this generation should be placed.

"The only positive data with reference to the growth of White-fish are found in the observations of Mr. Samuel Wilmot, of Newcastle, Ontario, in charge of the government hatching house of Canada. Mr. Wilmot reports that in November, 1868, he placed a quantity of spawn in the hatching troughs for an experiment, and in the following March and April a large number of young fry made their appearance. He failed in finding food adapted to the young fish, but a number that escaped through the screens were carried down to a small pond, where they seemed to thrive and soon became well-developed young fish. In the month of September they were exhibited at a fair in London, Canada. They were then about five inches long. In December the young fish had attained the length of seven inches.

"Mr. N. W. Clark, of Clarkston, Michigan, visited Wilmot's hatching-house in 1871, and in an address before the house of representatives of Michigan said: 'Enough is known, from the success of Samuel Wilmot, esq., of Canada, to sustain us in the assertion that they (the White-fish) in-

crease in weight about three-quarters of a pound a year, as those he had when we saw them, last January, we judged to have weighed about one and a quarter pounds, being then about eighteen months old.' These are the only records of observations of the growth of the White-fish, and evidences of this character are the only ones of any value of the rate of growth.

"An attempt was made several times from large lifts of fish lying in the fish shanties to arrange the different sizes of White-fish in series, with the hope that some evidence of the rate of growth per year would result. It was always found that the row of fishes, from the larger to the smaller, assumed the form of a spire-like pyramid, and a 'straight-edge' laid at their heads would have touched the noses of every one in the series, and on the opposite end it would have touched every tail, so perfectly regular was the gradation. It was difficult to believe that the White-fishes, of from nearly five inches to six or seven, had attained these dimensions in three months from the little half-inch embryos of April and May, though none of less size were found with the most diligent search.

"Mr. Wilmot's young fish measured about five inches in September when four months old. Experience has proved that there is a more rapid growth of the young Trout and Salmon afterward than during the first two months. The observation on the development of the young White-fish from April to the first week of May showed the slightest perceptible difference of length and bulk. If we assume them to be the fish of this season, then they had increased ten times in length in two months, precluding the possibility of a more rapid growth afterward.

"It is altogether probable that the fish measuring from four to seven inches in July were those of the previous season's hatching, and about sixteen months old. It is equally probable that the Point Edward fish of seven inches are those of the same season, as the five months intervening the 1st of July and the 3d of December should have produced considerable growth. To confirm this opinion we have Mr. Wilmot's statement that his White-fish had attained the length of seven inches in December. These evidences of the rate of growth are the only conclusions we have been enabled to adopt with reference to the size attained at different ages. Nor does this decide the average size of the growth of the White-fishes the first and second seasons."

The act of spawning, with the accompanying movements, is thus detailed by Mr. Peter Kiel, of Wolfe Bay:

"From thirty years' experience as a fisherman, and after obtaining all the information possible from others on the habits of White-fish, I beg leave to remark that during the month of November the White-fish are known to unite, or join in pairs, male and female, and that they approach the shore for the purpose of spawning. Should the weather be very cold they move more rapidly and arrive at their destination about the 15th. Their favorite place is a sheltered or land-locked bay or inlet having a sandy or gravelly bottom. When in from ten to twenty feet of water the female, endowed with an instinctive knowledge that her time has come for depositing a part of her spawn, selects a spot and commences to dig vigorously with her head, at the same time moving the tail rapidly to stir the sand or gravel; in a short time she forms a nest about two inches deep; the male, staying close by, seems to be attentively watching her movements. When the nest is satisfactorily arranged she ejects a quantity of spawn into it. The male immediately darts alongside of her and impregnates it with the milt. He then moves off a little way while she covers it partly over with her nose and tail. They remain near the spot two or three days, until all the eggs are deposited in the same nest, when they return to the deep in search of food, leaving the eggs and young fish, when hatched out, to shift for themselves. In the mean time the spawn, being heavier than water, remains on the bottom, which it would do even if not partly covered

over, nature having provided an adhesive substance which fastens it to the sand or gravel. It remains about one hundred days, when the young fish emerge into life. While they were exposed for so long a time, we cannot fail to admire the beautiful and mysterious laws of nature manifested in their protection from the severity of the weather, from predaceous wild fowl, from voracious fish, and from reptiles, which during the winter are in a semi-dormant state. As soon as the young fish are strong enough to move off they gradually work out into the deep, where they remain three or four years, when they attain their full or average size, and move round periodically with the parent fish to their various feeding and spawning grounds.

"White-fish are very prolific, and would multiply very rapidly if not destroyed by a reckless mode of fishing. Many valuable fishing grounds have been rendered useless by hauling seines during the breeding season, since, in such case, the parent fish are not only destroyed, but the spawn is disturbed by the seines dragging along the bottom so that it will not hatch. Another destructive mode of fishing is to set gill-nets across the mouths of bays or inlets, where the fish, in accordance with their habit, enter in periodically; these nets turn their course some other way, and it will be clearly understood that they are so social in their nature that in whatever direction the main body of them incline the others are sure to follow. Our fishery laws have done much, already, toward the prevention of such abuses."

Mr. John W. Kerr, overseer of the Hamilton district, Ontario, Canada, wrote the following paragraph in a letter to Professor Baird, on the spawning of the White-fish in Lakes Erie and Ontario:

"The White-fish spawn, both in Lakes Erie and Ontario, on the reefs and rocks, during the month of November. The eggs dropping into the crevices of the rocks are protected from suckers, a fish always on the alert at this season of the year to devour the eggs. The two specimens sent herewith you will please find by examination differ from each other in many respects. This you will be able to find out to be the case only by close study and observation. The Lake Ontario fish you will find to be a finer and superior fish than the Lake Erie White-fish, both in delicious delicacy of flavor and taste, and the whiteness and richness of the flesh. Still, as regards the food for this fish, in both lakes, I have in every instance and on all occasions found it the same. The fish live by suction.

"There is an observable difference in the shape of the White-fish of Lake Ontario as compared with the shape of the White-fish of Lake Erie. Thus you will please find that the Lake Ontario White-fish are rounder and broader on the back, while the Lake Erie White-fish are flatter and sharper on the back."

ARTIFICIAL PROPAGATION.—At so early a date as November, 1857, according to Mr. Milner, the first attempt placed on record was made by Mr. Carl Muller, of New York, and Mr. Henry Brown, of New Haven, to propagate the White-fish artificially. The lake which it was proposed should be first stocked was Lake Saltonstall, near the city of New Haven. Eggs were procured and impregnated artificially. The knowledge of the art was, however, crude, pisciculture being in its infancy, and the experiment was but partially successful. The eggs were packed in moist sand and placed in the bed of the stream on their arrival, the White-fish eggs on a sandy shoal of less than three feet in depth. The presence of young fish in great numbers in the following March and April was believed to result from the eggs, although the exceedingly common error on the Great Lakes of mistaking the schools of small cyprinoids for young White-fish (which they very much resemble except in the absence of the adipose dorsal), may have been repeated here. In the fall of 1858 the experiment was renewed. There has been no reference made to any permanent results from this experiment in the reports of the State commissioners.

"A more successful series of tests were begun in 1868 by Seth Green and Samuel Wilmot in applying artificial culture to this species, and in the succeeding year by Mr. N. W. Clark, of Clarkston, Michigan. They were found to be very delicate and difficult to hatch in the first few years of experimenting, but methods were perfected that made their production as certain and with losses nearly as small as in other species. The necessity of production of immense numbers in attempting to multiply the market species of fishes established the fact that the apparatus used in trout-hatching had to be extended over a wide area to accommodate them. The culture of the White-fish and the Salmon Trout induced modifications of apparatus at the New York State hatching establishment."[1]

On page 548 of the same report Mr. Milner continues his observations:

"A few extracts from a letter of Mr. Clark, to the board of fish commissioners of the State of Michigan, will advance his arguments in favor of brook or surface waters in preference to spring water. Mr. Clark began his experiments with White-fish in 1869, hatching a small percentage of the eggs he procured:

"'In November, 1870, I started again for Ecorse for the purpose of procuring more spawn. Mr. George Clark, at his fishery, very kindly rendered me all the aid in his power, furnishing the parent fish for the purpose of trying further experiments in this new enterprise. I succeeded in obtaining all the spawn needed for further trial, but he was so anxious to make it a success that he sent his man to me with an extra lot which he thought might be in better condition. I succeeded in hatching a much larger proportion of them than the year before, but raising them with artificial food was attended with no better success. This second effort and failure led me to investigate the cause, and after much thought I came to the conclusion that, if we ever succeeded in making this branch of pisciculture a success, we must study the principles of nature more than had ever been done before. I became fully satisfied that by arranging so as to use water taken from a pond or lake entirely frozen over, it would retard the development of the eggs to the time required by nature, which proved by subsequent experience to be about April 1. I then consulted Messrs. George Clark and John P. Clark, and made known to them my convictions, and so strongly were they convinced that I had struck the key-note to insure ultimate success that they proposed to furnish all the necessary materials and a portion of the labor to enable me to go on and erect a large hatching establishment. This was located about eighty rods below the spring where we had been experimenting the two years previous with the unsatisfactory results above stated. This location was supposed to be a sufficient distance below the main spring, so that by damming the water and raising a pond it would freeze over and remain so during the period of incubation. Our views proved to be correct, as the 500,000 of eggs which we placed in the hatching boxes November 15 of that year were preserved in fair condition, and with one-quarter less labor in caring for them than formerly. They did not commence to hatch until April 1, and it was estimated that we succeeded in hatching at least fifty per cent. of the eggs we had taken four and one-half months previously at the fishery of George Clark. Of these young fry, some 100,000 of them were put in Detroit River, at or near his fishery place, and no doubt at this time they are thriving finely in the waters of Lake Erie, which abounds with abundant natural food for them, and in a year or two more they will doubtless return to the same place where they were deposited. The balance of them we placed in three small lakes in Oakland County, some of which have been seen within the last few months, doing finely.

"'This experiment proved so great a success that again, the next November, 1872, through

[1] Milner in Report of Commissioner of Fish and Fisheries, Part II, p. 545.

the encouragement of the Messrs. Clark and the United States Fish Commissioner, I doubled the capacity of this hatching house and procured 1,000,000 of the ova from the same grounds, and proceeded as before with some improvements I made in the *modus operandi* of hatching, about February 20. Mr. Milner, deputy United States commissioner, arrived at this place for the purpose of aiding me in packing and shipping a lot of the ova, which were then in an advanced stage of incubation. We estimated from actual count that sixty-six per cent. were in such an advanced state that they were secure from any further mortality. We then shipped to San Francisco 216,000 in the most perfect condition. About March 10 I received an order from the Commissioner at Washington to send the same number again to the same place, which I should have done, but from the fact that the eggs had become so far advanced that I felt quite confident they could not be transported so great a distance successfully, and only sent 116,000, which I am most happy to have heard arrived in excellent condition. Soon after this the weather became much warmer and the ice all thawed from the pond, and by the 20th of the month the eggs then remaining in the troughs commenced hatching. The water had then risen to a temperature of 45°, which sudden change caused the eggs to turn white, and soon all were worthless. Quite a large number had already hatched out, and I removed part of them to the same lake where Mr. George Clark and myself had put in a large number the year before, and placed about 25,000 in a small lake at Clarkston Village.

"'This sudden change in the condition of these eggs I cannot account for, only from the fact of the change in the temperature of the water at this late stage of their development. I am fully satisfied that if the ice had remained in the pond as late as the previous year I should not have lost two per cent. from the time I made the last San Francisco shipment. This experience satisfied me that spring water, although it may not be used until it advances a long way down from its source, is not the place to hatch White-fish. Although this pond was clear from ice March 15, the ice remained in our lakes in this region until May 1.

"'This species of eggs, and especially those not good and not perfectly impregnated, placed in spring water at a temperature of 46° (which is about the same as all good springs) in winter, will start out a growth of vegetable fungi more than four times faster than if placed in water at 33°, which is the temperature of ice-water, and it is next to impossible to employ help enough to pick out the dead eggs (when in spring water) when you have over a million, as I had the last two seasons. Even in ice-water last winter, which preserved the eggs much longer than in spring water, it required from eight to ten persons to keep them in fair condition, and then sometimes they were necessarily left too long in an unfavorable condition.

"'These facts are conclusive proof to my mind that the ova of White-fish should be kept entirely away from the influence of spring water, or any water which will be liable to change during incubation, and all houses where White-fish are to be hatched should be constructed upon some lake or pond that freezes over early and does not thaw out until April 1. It is stated as a reason why spring water is better for hatching fish eggs than lake water, that it is generally more free from sediment, some kinds of which are highly detrimental to the successful hatching of the fish ova. Whereas our inland lakes freeze over early in the fall, and are not free from ice until late in the spring, this ice is perfect protection against any agitation of the water, and gives an opportunity for any sediment that may be in it to settle to the bottom, where it must remain until spring, and until the eggs are hatched and distributed. Consequently the water in all of our inland lakes is, during winter, as clear as crystal.

"'You also wish me to give my views in reference to using Detroit River water. To this I will

frankly say that I should much prefer it to any spring water in this or any other State for hatching White-fish. But there are some objections which arise in my mind even to this water. I am aware that this species of fish are natives of our great lakes and rivers, and consequently it would be supposed that this water must agree with them, and that success would be certain if this water was used. But has it not occurred to all persons who have given this subject much thought that much the largest proportion of these fish run to the shoals of those lakes during spawning season to deposit their ova? These shoals are the first to freeze over in the fall and the last to thaw in the spring. This keeps at nearly the same temperature during incubation. Although it may be said that during their migration from Lake Erie to Lake Saint Clair some deposit their spawn in the rivers, it is not very probable that much of it is hatched. I am aware that many hatch in and about the ponds where the fishermen preserve their fish for winter use. This tends to prove that the shoals are the place where they hatch most largely, as the ice remains in these ponds much longer in the spring than in the strong current in Detroit River. If water is used from this river it must change in temperature many times during the winter, as it is well known that the ice leaves the river quite often during the four and a half months of the period of incubation. No one can gainsay the fact that in the hatching of fish ova, if the water is of a perfectly even temperature, it will be attended with more favorable results than when frequently changing, from any cause, even if such change is not more than two or three degrees. Is it not also a fact that the ice frequently leaves the lower part of Lake Saint Clair early in March? If so, would not the westerly winds roll the water in the upper part of the river? This sediment would be deposited on the eggs, and, in consequence of its fine, clammy nature, would be injurious to them. I noticed this was the case in a little experimental arrangement of A. M. Campau, some two years since, where this water was used. I examined these eggs several times during this process, and found a fine clammy substance accumulating on them. They were gradually dying, and I do not think any were hatched. These eggs were taken from our hatching boxes, and were in perfect condition, as they were so far advanced in development that the embryo fish could be plainly seen with the naked eye. For these reasons I am forced to the conclusion that there is more suitable water for hatching this species of fish eggs than the Detroit River.

"In conclusion, the advantages afforded American fish-culture from the cultivation of the White-fish, as they have just been enumerated: These are, (1) more careful and perfect methods, resulting from the experience in the culture of the most delicate and difficult species whose propagation has been attempted by culturists; (2) the perfection of three forms of apparatus for hatching fish eggs, embodying the important improvements of facility in handling the eggs and removing sediment and confervæ, and greatly economizing space; (3) the contrivance of a superior case for the carriage of eggs; and, besides, a possibly successful, entirely new method in the hatching of eggs and the discussion of and practical tests of conditions of water suitable to the eggs of a species that we are not (at any rate thus far) able to supply with food."

"These experiments," wrote Mr. Milner, referring to those made by Mr. N. W. Clark, "were all attended with considerable success, though the large percentage of loss, compared with that in trout and salmon hatching, was anything but encouraging. The screens in the troughs, in most instances, were the same as those used for the Trout, and the embryo White-fishes, being smaller, escaped and ran over into the waste troughs and down into the ponds below. This was in some measure a fortunate circumstance, at Mr. Wilmot's establishment, for the young fish, finding their natural food in the ponds, grew and thrived, and afforded the only positive data there are of their rate of growth. In the succeeding year (1870) Mr. Green and Mr.

Clark made additional experiments, and from the experience of the preceding year, having learned the necessity of immediate attention to the White-fish eggs after they were placed in the troughs, began the work of removing the unimpregnated eggs within two or three days' time, and, giving them close attention, during the season hatched out a much larger percentage of eggs. Mr. Green, in 1869, distributed a quantity of the White-fish spawn to numerous applicants who responded to an advertisement offering it for distribution. Some packages of spawn from this supply were sent by steamer to Mr. Frank Buckland, inspector of salmon fisheries for Great Britain. In referring to the condition of the eggs on their arrival in London, he says, 'A good proportion of the White-fish eggs were alive and well.'

"Some temporary troughs were put up in Detroit, Michigan, and supplied with the ova, under the direction of Mr. A. M. Compeau, Mr. J. P. Clark, Mr. George Clark, and Mr. James Craig.

"Experiments were again made by Mr. Green, Mr. Clark, and Mr. Wilmot, in 1870. More than a million of ova were supplied by the liberality of Mr. J. P. Clark and George Clark, without expense, from their ponds in Detroit River. Mr. Green also made experiments in the breeding of Salmon Trout and Lake Herring, with some success.

"In 1871 these gentlemen just referred to, from Detroit and vicinity, failing to arouse the interest of the State authorities in the matter of fish propagation to the extent they desired, furnished Mr. N. W. Clark, of Clarkston, with the necessary funds for the erection of a building, sixty-four feet in length by twenty in width, in which were put up twenty-six troughs, sixteen feet long and one foot wide. The entire building was devoted to the hatching of White-fish, and the number of eggs laid down estimated at about one million. The experience of the previous years aided Mr. N. W. Clark to a most complete success, and by the 1st of April the fish began hatching, and before the 13th of the month the troughs were swarming with young White-fishes. Between the 20th and the 30th of April these were all distributed by Mr. Clark in a number of inland lakes in Oakland County, Michigan, and into the Detroit River. Mr. Wilmot again procured about one-half million of White-fish eggs, which were handled with improved success.

"Mr. Green gave less space to white-fish eggs this season, and laid down large quantities of salmon-trout ova, with the purpose of distributing the Trout in the inland waters of the State.

"In 1872 an employé of Mr. Green devised a new apparatus for hatching fish, that economized space to a great extent and afforded him room for a large supply of both salmon-trout and white-fish ova. Visiting his establishment in January last, we found them hatched out in large quantities, and orders arriving daily for the fry, to stock the waters of inland lakes in all parts of the State. Mr. Wilmot obtained a supply of white-fish spawn at Sandwich, on the Canadian side of the Detroit River."

The employé of Mr. Green above referred to was a Mr. M. C. Holton, whose invention is thus more fully described:

"Instead of placing a single layer of eggs in a long, narrow trough, he has prepared a can or box, of perhaps a foot square and several feet in height. This is filled with shallow trays of about half an inch in depth, with wire-gauze bottoms, on which the eggs are placed, so that with twelve trays, having a surface of one square foot each, he accommodates twelve times as many eggs as by the ordinary method. The box is so arranged that a current of water is carried by a covered pipe down the side of the can to the bottom and allowed to enter at that point. The current in its overflow passes from the bottom to the top, and the water circulates freely over the eggs. This arrangement has the additional advantage that once a day, or oftener if necessary, the trays can be taken out singly, and any diseased or defective eggs removed, thus improving the entire mass."

In 1873, a device to accomplish like results was made by Mr. N. W. Clark, of Clarkston, Michigan, and patented in 1874.[1]

This arrangement employed the troughs, but divided them into compartments by means of water-tight partitions or bulkheads; into each compartment a box containing a series of trays filled with eggs is placed and covered with a pan of perforated tin, upon which the water falls and descends through the perforations upon the screens and eggs beneath, passing through all and escaping at the bottom, afterward flowing over the partition upon the cover of the next box, and so throughout the series of compartments until it escapes through the waste-way at the end of the trough. By this arrangement a very small quantity of water is required for a very large number of eggs, and all the advantages of handling and removal of sediment and considerable economy of space are afforded.

Another combination of the trough and tray methods is in use in California, devised by Mr. John Williamson, of the California Acclimatizing Society. This is very similar to the one just described, except that the flow of water through the screens and eggs is from below instead of from the top. This model was not the result of work in white-fish hatching, as in the case with the two first named.

An experiment was made by Mr. N. W. Clark in the hatching of white-fish eggs, which were laid in single layers of woolen cloth stretched on very thin frames of wood, packed in a box imbedded in sphagnum moss within a refrigerator, and the whole kept at a temperature a little above the freezing point by ice. The eggs are left entirely undisturbed after they are first arranged, and the only care on the part of the attendant is to keep the temperature above the freezing point. The presence of dead eggs does not seem to contaminate the living ones in this condition, and very little confervoid growth appears. A quantity of eggs carried forward in this manner through the winter appeared to be in excellent condition, development progressing slowly, and a few, taken from the cloths and placed in spring water, hatched out within a short time as well-developed embryos. If this method, after full and thorough trial, should prove successful, it would make the work of hatching a matter of neither effort, care, nor expense. It has been a matter of too short experience and of experiment on too small a scale to warrant its positive success.

An improved case for the carriage of eggs long distances by railroad is another device perfected by Mr. N. W. Clark in 1872. It is a modification of the ordinary case containing circular cups, the cups being square, and in this form economizing space very much. The cups of tinned iron, about four inches square and two inches high, rest in trays, with low partitions forming low compartments that retain the bottom of each cup and hold it solidly in place. The trays are set within a square tin box, in which they fit with moderate tightness, and are placed, when containing the cups, eight or ten in the box, one above the other; this box is set within another box of tin large enough to leave an open space on all sides, to be filled with sawdust; a tube is inserted through the bottom of the inner box, piercing the bottom of the outer one, so as to permit communication with the air on the outside. The whole is then placed for protection within a strong wooden box, in the bottom of which is a frame resting upon stiff springs which relieve the eggs from heavy jarring; rubber or cloth bumpers on the sides of the box prevent lateral swaying and jolting. A cover is fitted to the inner box, which may then be covered with sawdust to the level of the higher outer one, when the cover of this is to be shut down. The outside wooden box is

[1] Report U. S. Fish Commission, part vi, p. 546.

fitted with handles and with a tight lid on hinges, which may be locked. Small auger-holes are bored through the outer or packing box, and air may be admitted to the whole interior of the egg case through the tube referred to in the bottom, the cups being pierced with small holes, so that when in place they are directly over circular openings in the trays, and a communication of air is established throughout. The eggs may be packed in moss, in the ordinary manner, in the cups which experience seems to prove to be the best manner for long journeys.

The method of Mr. Atkins in shipping salmon-eggs packed in moss, but with pieces of mosquito-netting laid above and below the eggs, is a great convenience in unpacking them, and could just as well be applied in the cups. This, though less simple than the ordinary egg-carrier, is sufficiently simple for practical purposes, and possesses most important advantages for carrying eggs long distances and over rough roads, the small area of surface within the boxes preventing any tendency of the eggs to slide together at one side. The square boxes resting in trays are put together in much more compact form than the cylindrical boxes embedded in moss, and the springs beneath the boxes of eggs are of course an important addition. Mr. Clark believes the hatching apparatus in the refrigerator to be as well adapted for the carriage of eggs as for hatching them.

The use of surface or brook water in any permanent establishment seems to have been first employed by Mr. Samuel Wilmot, of Newcastle, Canada, the greater number of hatching establishments using spring water.

In the hatching of White-fish, Mr. Clark has contended for the use of brook water in preference, because of its lower and evener temperature throughout the winter, and the consequent retardation of the hatching of the fish which he has contended is an essential provision in nature to their welfare, and that hatching them two months or more previous to the natural time under artificial conditions is a mistaken method that will not result in the maturing of any considerable numbers in the cold waters in which they are released. Although this view has not been established by practical observation, yet it raises a question of considerable importance, and one which merits a full discussion, in view of its bearing on the practical work of fish culture.

Mr. Milner's account of the further progress made in this branch of fish culture is resumed in another place, as follows:

"November 11, 1872, I met Mr. N. W. Clark at Ecorse, and in company with Mr. George Clark we visited Grassy Island for the purpose of obtaining white-fish spawn. The box which Mr. N. W. Clark has devised for carrying ova is constructed so as to carry a greater quantity of eggs, with easier carriage, than any in present use. It is a large square can, of zinc, about thirteen inches square and twenty-two inches deep. This, for protection, is set inside of a strong wooden box, with a light frame in the bottom, supported on stiff springs. Strong handles are fastened to the box, for convenience in handling, and to prevent any necessity for throwing it out of level while carrying it. The zinc can contains ten trays, each of which carries fifty-four small boxes, two inches square and two inches deep, set in compartments, each compartment having an inch hole cut in the center. The partitions between the compartments are just high enough (about five-eighths of an inch) to inclose the bottom of a box and hold it firmly in its place. No covers are provided for the boxes, but a large cover can be fitted to the zinc can, and a lid, with a good lock, is fitted to the outside box. The bottoms of all the little boxes are perforated, the position of the holes being directly over the circular hole in the compartment of the tray. The zinc can has also holes in the bottom, and the wooden box has three-quarter inch holes bored on each side, near the bottom, so that there is drainage for the surplus water of all the boxes, and a free circulation of air throughout, which is deemed important by some of the fish-culturists.

"At the island the most perfect arrangements were provided by Mr. George Clark for obtain-

ing the spawn. Two tanks of about five feet diameter were placed at the edge of the shore and partly filled with water. As soon as the bag of the seine was on the beach the men picked up the White-fish and put them immediately into the tanks. The pans for impregnation were close at hand, and as one man lifted the fish above the water in a dip-net, another took it from the net, and with his right hand over the head of the fish and his left around the tail he held it over the pan, standing at the left of the operator. The left hand of the operator was put against the back of the fish and the right hand used in manipulating the abdomen. It was found that to induce the eggs to flow freely from a fully ripe female, all that was necessary was to apply a gentle pressure just behind the pectoral fins, just where the nudging and bunting of the head of the male fish is applied while racing her through the water. Not until the greater part of the free eggs had fallen into the pan was it necessary to slide the hand along the abdomen. The free eggs came away in a steady, liquid stream, but from a fish partially ripe their extrusion was slow, and in masses comparatively dry that did not freely disengage themselves from the fish and fall into the pan.

"The female exhibited the most indications of pain when the pressure was applied in the vicinity of the ovipore. The milt from the male will flow in from one to three jets by pressure in the vicinity of the anus.

"The method employed by Mr. N. W. Clark was that which was original with Mr. Seth Green, using the smallest quantity of water possible. The eggs, after falling into the pan, and the milt, having been stirred up with the water, were allowed to stand about half an hour, when the milt, and water were poured off and the eggs carefully rinsed through several changes of water. A small quantity of water was left with the eggs when they were perfectly clean. By repeated actual counts, and by arranging on a plate in a true square, it was found that a large tablespoon, moderately heaped up, contained about a thousand eggs. Eight ripe white-fish eggs will lie entirely within the space of an inch, and the ninth will lie partially across the line.

"A pat of moss was then put into the cups, and a piece of canton flannel, cut into the form of the Swiss cross, after thorough saturation with water, was pressed lightly down into the cup, and a tablespoonful of eggs poured upon it. The canton flannel was used to line the sides of the boxes, because it was found that the contact of the zinc was fatal to the eggs, probably from the poisonous elements of the oxide. The patch of canton flannel proved to be a great convenience in taking out the eggs, as all that was necessary was to take the edges lightly in the fingers and remove it from the box, and dipping the cloth with the eggs into a pan of water, they were rinsed off with a few quick motions, without any tedious picking and rinsing the eggs free from particles of moss. In arranging the eggs for transportation for a short distance, the use of the cloth patches is undoubtedly a good method. After filling the boxes they were placed in the trays, and the trays adjusted within the zinc can, when water was poured on until the whole contents were thoroughly saturated, when the lid was closed and locked and the case was ready for transportation to the hatching house. A small fee to the baggage-master excites considerable interest in the safe-handling of the box.

"Two trips were made from Ecorse to the hatching house at Clarkston, and about 1,330,000 eggs were put into the troughs, Mr. Clark having increased the number of troughs to fifty for the purpose of receiving the extra supply of eggs. One half of the eggs were the property of the commission, the other half to be controlled by Mr. J. P. Clark, of Detroit, Mr. George Clark, of Ecorse, and Mr. N. W. Clark, of Clarkston. The eggs received attention from the second day after they were placed in the troughs until about the middle of January, the eyes of the embryo then showing distinctly, and the subsequent loss being very small.

"Upon receipt of the instructions to ship a quantity of eggs to the State commissioners of California, a case similar to Mr. Clark's was made, substituting a good quality of tin for the zinc, and adding a *second square can, large enough* to contain the can with the trays and cups, and leave the space of an inch on all sides.

"Arriving at Clarkston on the 18th of January, *the weather was considered too severe to hazard* the shipment of the eggs at the time, and it was delayed until the 20th. The thick covering of frozen snow and ice prevented the possibility of obtaining moss, and a good quality of sponge was substituted. This was prepared first by whipping out the calcareous dust that it contained, and, after being cut in thin slices, was thoroughly washed through several changes of warm water. Pieces were then fitted to the bottom of the cups, and while standing in a pan of water a half tablespoonful of eggs was poured in, a thin slice of sponge, fitting the inside of the cup, laid *lightly over the eggs, and the remainder* of the spoonful poured in, when a third piece of sponge was put over them to cover them. The tray, with the cups, was then put into the inner can, which was placed within the second can, with *one inch of sawdust filling the vacant* space on the sides, bottom, and top. A piece of burlaps was tied over the top, and the whole placed upon the springs, within the packing-box, and the lid fastened down. The packing-box had two half-inch holes bored near the bottom to admit the air. The filling of sawdust was considered as a necessary safeguard against the cold weather of the time.

"The case was put in charge of the baggage-master, and I accompanied *it as far as Omaha*, Nebraska, attending to its transfer from one train to another, and regulating its position in the car. At Omaha it was given in charge of the express company, and the messenger instructed as to the effect of heat and cold upon the eggs, and a letter containing full instructions sent with the box to be delivered to the messenger at Ogden, where the box was transferred to his care, there *being no further* change of messenger between that and San Francisco, California. On two sides of the box, in distinct letters, was printed the caution, 'Fish-eggs; must not be jolted or allowed to freeze.'

"The weather continued cold throughout the time the eggs were on the way, and they arrived at their destination in very bad condition. Mr. Stone *attributed the damage to the use of* sponge, and the sawdust packing preventing ventilation. Mr. Rudolph Hessel, an experienced fish-culturist of Offenburg, Germany, while visiting Washington, informed me that he had used sponge for packing eggs for long distances with entire success. The lack of ventilation is a more probable cause, though the description given by Mr. Buckland of the method of packing the eggs received from Seth Green's establishment in January, 1870, was similar in the fact that the cups containing the moss and eggs were buried in the sawdust. A small quantity, received from Mr. N. W. Clark *at the Smithsonian Institution* this winter, was packed in the same manner, using sponge and burying the cups in a pail of sawdust, and they were found to be all alive after a fifty hours' journey.

"The necessity of a certain supply of oxygen to the eggs has been very thoroughly proven by the researches of W. H. Ransom, M. D., of Nottingham, England, published in the first volume of the 'Journal of Anatomy and Physiology.' The experiments were made while investigating the nature of the rhythmic contractions of the yelk, known to occur in the living eggs of fishes. Among several experiments, in which by ingenious methods the oxygen of the atmosphere was kept from *contact with the eggs, those of the stickleback* being employed, he *relates as follows*:

"'I therefore made a series of suffocative experiments on impregnated and unimpregnated eggs, using aërated distilled water in cells, *all of the capacity of .05 cubic inch, sealing the covers* with hot wax, and varying the number of eggs in each cell. Five observations were made with

unimpregnated eggs, having, respectively, thirty-five, thirty, eighteen, nine, and seven eggs in a cell; and although, in consequence of the accidental loosening of the wax, and the entrance of a little bubble of air, the duration of the contractions was not in all cases inversely as the number of ova in the cells, yet the general result was rhythmic contraction, and the pseudo cleavage continued longer in the cells containing the smaller number of ova, the eggs which lay nearest to the air-bubble always being the last to cease to move; the accidental failure of the luting affording thus additional evidence of the importance of oxygen. In all the cells the contraction ceased in from twenty-three to thirty hours, or one-fourth of the time they continued in aërated water and unlimited space. Five similar observations were made on impregnated eggs, with forty-eight, thirty-eight, seventeen, ten, and seven eggs in each cell, with similar but more marked results; the yelk contractions ceasing earlier than in the unimpregnated ova. The cleavage was more rapidly checked than the pseudo cleavage, and still more so than the yelk contractions. Seven experiments were then made to ascertain the relative dependence upon the presence of oxygen of the movements which result in cell multiplication and differentiation, and of the muscular contractions of the embryo compared with the yelk contractions. Two healthy developing ova were sealed in similar cells at seventy-six, one hundred and one, one hundred and twenty-seven, one hundred and fifty, and one hundred and seventy-four hours each, after impregnation, and two free embryos at twenty-four and forty-eight hours after hatching. Although the proportion of active organic matter to the medium was so very much less than in the previous experiments with recently impregnated eggs, yet the process of development ceased in all in about seven hours, and the yelk contractions did not continue more than eighteen hours. The movements of the heart continued about the same time, those of the trunk ceasing before the heart. The embryos in the later stages of development more quickly ceased to move than those in the earlier. The inference is, I think, not to be resisted, that oxygen in the surrounding medium is an essential condition of the exercise of the property of rhythmic contractility possessed by the food yelk, as well as of the fissile contractility of the formative yelk.'

"Though Dr. Ransom admits that the quantity of oxygen consumed in these movements appears to be very minute, yet it indicates that a large quantity of eggs, confined, in a small, air-tight space, would consume the oxygen to an injurious extent, during a long journey, and sufficient ventilation is to be considered as one of the necessities in packing eggs for transportation. The sawdust that filled the space around the inner can, in the California shipment, was crowded down with a piece of board, and may have, in consequence, rendered the package more completely air-tight than in the shipments referred to similarly packed. A later shipment arrived in most excellent condition. The cups in the cases were made four by four inches square, by two deep, with no packing between the cans, and the eggs packed in moss. The most ample ventilation was provided for in the egg-cases. The oxygen given off by live moss is probably the principal reason for its special adaptation in packing eggs for shipment.

"Dr. Ransom's experiments on the effect of heat have also a practical value in the treatment of fish ova, both in transportation and in the troughs. He says: 'Some eggs on the stage of active contraction were cooled until the thermometer placed on the cell stood at 32° F. They all became still, and their yelks globular. They were not frozen; and I do not doubt that their temperature was higher than that indicated by the thermometer.' The contractions were afterwards restored by a weak galvanic current. In another observation, 'I froze the water in which the eggs were placed, so that some of them were completely, and others incompletely, frozen. The frozen eggs were all more or less opaque, and had their inner sacs ruptured and emptied of yelk in various degrees, and their formative yelks lobulated and darkly granular. Those which were least frozen

were slightly opalescent only, and when allowed to thaw they contracted as before, ultimately going on to cleave in an irregular manner, the ruptures in their sacs having healed. Slighter reductions of temperatures to 40° F. and 48° F. retarded without destroying the contractions. In such cases the commencement of cleavage was delayed. By raising the temperature moderately the movements were accelerated; but at about 80° F. (it is difficult to speak with certainty of the temperature actually obtained by the object) the contractions were arrested, the yelk-ball becoming globular, and the oil-globules being scattered. Such eggs, however, soon recovered themselves when left at 58° F., and cleft in even less time than eggs did which had not been warmed. In other eggs, heated in a chamber at 102 F., the cleavage was retarded to three times the usual period, and when it took place was wanting in symmetry. The yelk began to become opalescent at about 103° F.; but a true coagulation of the albumen did not take place, the yelk being fluid and opaque. Thus a temperature too low or too much elevated retards or arrests the contractions, but they are not destroyed before commencing physical and chemical changes set in.'

"Whether the point at which the contractions of the yelk ceased was the point at which vitality left the egg, might or might not have been the fact, but it is quite evident that the egg was, at the temperatures stated, in an abnormal state, and the necessity of sustaining a temperature around the eggs of fishes between these extremes is apparent, if they are to be kept in their most favorable condition.

"Mr. Green and Mr. Wilmot both procured eggs this season from the Detroit River. Mr. Green made use of a newly devised apparatus for hatching, that proved to be a most excellent contrivance, both for the economy of space and the facility for caring for the eggs. By this method he will be enabled to hatch five or six times the quantity of eggs in the same building. The young fishes were distributed in accordance with the excellent plan adopted by the New York commissioners for supplying demands from all parts of the State, without expense, on application.

"The success attained by these persevering experiments is now complete, and the White-fish may be restored by artificial propagation, to the same extent as the Salmon, or the Brook-Trout, or the shad. As has been shown, the White-fish has advantages in this particular that the other species have not. The obstruction of streams is no obstacle in the way of their multiplication, because they have no necessity of ascending them, and, unlike the Trout and the Salmon, they cannot be suspected of eating each other.

"Attempts at feeding the young fishes have all been failures, and the only natural food that has been found in their intestines is the species of *Diatomaceæ* reported by Mr. Briggs. But as they are more vigorous and strong in the earlier stages of growth, there is not the same necessity of caring for them until they are partly grown, and they should be put into the waters they are to inhabit soon after the ovisac is absorbed, and allowed to find their natural food for themselves, just as the young shad are treated when hatched artificially.

"Artificial propagation affords advantages that compensate for all the overfishing and losses that the fish faunæ suffer from man and natural causes. The great numbers of eggs found in the ovaries of fishes in reality afford little evidence of their capacity for populating the waters. It is a fact, illustrated in nearly if not all branches of the animal kingdom, that the most fecund species do not, by any means, increase the fastest in numbers, but from the greater evils they are subject to, and the greater number of enemies they encounter, there is such a fatality during the earlier stages of growth that the losses balance the numbers produced, and less fecund species, by being better protected, equal them in numbers. The most perfect illustrations of this fact may be found among our lake fishes. The muskellunge, *Esox nobilior*, has a very large number of eggs. A cast

of the ovaries of a large female specimen, made by Dr. E. Sterling, of Cleveland, Ohio, is in the possession of the Smithsonian Institution. The ovaries measure over two feet in length, and the eggs are about the same diameter as those of the White-fish; they contain at least five times as many eggs as a pound White-fish, and yet, as regards numbers, the muskellunge is a comparatively rare fish. There are, undoubtedly, exigencies attending the egg stage of this fish that will account for this fact.

"In the case of the White-fishes, though annually depositing millions of eggs, the delicate nature of the embryo, and the numerous spawn-eaters, effect a certain balance of numbers with relation to the general faunæ of the lakes, so that, up to the time of the early settlement of the Lake region, the fish were found in great abundance. The nets now came in as an additional agent in preventing the increase, the pound-net, particularly, killing a large percentage of the fishes that had not matured sufficiently to assist the increase by depositing spawn, and in consequence the numbers of fishes were rapidly reduced.

"The care of the eggs in the hatching troughs has proved, beyond question, the frail nature of the eggs of the White-fish. They are smaller, and have a much thinner investing membrane, or shell, and have not the same enduring vitality that the ova of the Trout and Salmon have. So that in the open water of the lakes and rivers by far the greater number are lost because of the disturbance of the bottom by the autumn storms and the deposit of sediment from the muddy water, the failure of many of the eggs to come in contact with the milt of the male fish, the myriads devoured by the army of spawn-eaters, and the additional evils of pollution of the waters from the drainage of cities, manufactories, and saw-mills, and the dragging of seines over the spawning beds.

"A quantity of White-fish eggs taken from the bottom of the Detroit River, a very extensive spawning ground, while dredging in company with Mr. George Clark, at the close of the spawning season, were found to be dead and white, or so coated and stained with the black ooze that they could not have survived. In the pond on Grassy Island, where as many as ten thousand female White-fish deposit their spawn in a season, we succeeded in taking between fifty and sixty embryo fishes, by drawing a seine lined with millinet, and a diligent search through several hours at the surface in the month of April.

"In obviating all of these evils, artificial propagation asserts its advantage, and though the number of eggs that may be handled is exceedingly small compared with the millions sown by the fishes, yet the number of fishes produced may really exceed the present production in a state of nature. This assertion has ample proof in the restoration of fishes in regions where they have been nearly exterminated, and even where no change was made in the restrictions upon the fishing that might have assisted the increase.

"The experience of the past few years has proved entirely the possibility of increasing the numbers of the White-fish by artificial propagation. The running water in the troughs supplies the conditions required by the eggs; the fertilization of the ova in the pan brings every egg in contact with the milt; they lie undisturbed and free from injurious sediment or filthy water; the spawn-eaters have no access to them whatever, and the dead eggs are immediately removed from contact with the living ones; the young fish are under control in the troughs until the ovisac is absorbed, when they are ready to be placed in their natural home, the cold waters of the Northern Lakes.

"The experiments of Mr. Seth Green and Mr. N. W. Clark have reduced the loss of the eggs to an inconsiderable number, and with a small outlay of money this fish may be restored with a success equal to that of the shad in the rivers of the Atlantic coast.

"The losses in the fry stage merit consideration, though there is every evidence to believe that they are very small. One great advantage in favor of the young White-fish is its strength and vigor almost from the time it leaves the egg, and its disposition to seek the surface, as observed in the troughs and where they were seen in their natural condition in Detroit River."

DISEASES.—Nothing definite has been ascertained regarding the diseases to which White-fish are liable. A roughness, however, on the scales may be observed from about November 15 to November 20. This roughness has the appearance of small tubercles, and is most apparent on the sides toward the vent. The male fish is said to exhibit this possible symptom of disease the more plainly.

Mr. Milner's observations on the White-fish, with regard to its being infested with parasites, led him to write:

"The White-fish, as far as my observations have extended, is infested with two external and two intestinal parasites. The external ones are a crustacean, a *Lernæa*, and an annelid, the *Ichthyobdella punctata*. The lernean was found only in the Detroit River, adhering to the fish on the dorsal region, and with its bell-shaped sucker buried in the epidermal sheath of the scales. On the White-fish swimming in schools near the surface around the edge of the pond in Detroit River, it could be detected by close examination fastened to the fish. There were seldom more than four on one fish. The Lake Herring, confined in the same pond, swam in close contact with the White-fish, but in no instance, although careful observations were made repeatedly of the Herring while in the water and after capture, was the lernean found upon them. In Lake Superior they are found to be numerous on the siscowet.

"The *Ichthyobdella*, a leech of three-fourths of an inch long, grayish-white in color, with brown tesselated markings, was seen in great numbers in the mouth of April, while the fishermen were lifting their nets from about fifty fathoms some fifteen miles out from Kenosha, Wisconsin. They covered the nets and fishes of all species, and fell in such numbers on the deck that it became slippery, and an old coat was thrown down for the man who was lifting the gang to stand upon. They were very tenacious of life, living for a long time on the deck, and for several days in the bilge-water of the fish-boats. They were in such numbers that it was difficult to decide whether they had a preference for any species, and were found filled with blood both in the gills and while attached to the body, though it was difficult to imagine that they could fill themselves with blood from the epidermal sheath of the scales. They were thought to be most numerous on the White-fishes, as they were in greater numbers on them than on the Trout, the Lawyer, or the Cisco, the only other fishes taken.

"A prevailing but mistaken opinion in the vicinity was that the White-fish fed upon the leech. Dr. Hoy's investigations disproved the notion, and all examinations of stomach contents confirmed this fact. One of the intestinal parasites resembled the leech somewhat in form. The other was an *Echinorhynchus*. They were never found within the stomach, but always in the duodenal portion of the intestine near the mouths of the cæcal tubes."

METHODS OF CAPTURE.—The methods employed whereby the largest numbers of this fish may be taken varies in different localities. At Whitefish Point, Lake Superior, the greater part of the catch is made with pound-nets. About the Apostle Islands the gill-net is used at all times. The best grounds are along the shore from Ashland to Ontonagon. From Grand to Sauk's Island the catch of White-fish is made with pound-nets in the spring and gill-nets in the fall. At the south end of Lake Michigan there are no pound-nets; the fish, consequently, are of large size. The White-fish fishery of Saint Joseph is carried on far out in the lake, formerly nearer shore. About Little and Grand Traverse Bays all the pounds were blown away on

October 26, 1880. They were reset and were again destroyed at the end of November. From Bay View to Evanston pound-nets are used exclusively.

Across the northern end of Lake Huron, from the Straits of Mackinac to the Detour Passage, the White-fish are followed by the fishermen with pound-nets as far as twelve or more miles from shore, and with gill-nets fifteen to twenty miles. At Port Ontario, Lake Ontario, gill-nets are extensively used in the capture of White-fish, and at Wolfe Bay it is remarked by Mr. Peter Kiel that they cannot be caught with hook and line at any season of the year. Mr. Lanman says that they are occasionally taken along Madawaska River, and that he has caught them with rod and line below the falls of that river, at its confluence with the Saint John, in the early part of the summer. The same writer states that in Eagle Lakes the White-fish is caught abundantly by torch-light with dip-nets. Of its capture in the Grand Lake, Mr. Lanman writes:

"Some years since this fish was abundant in the Grand Lake, where the writer, in the month of May, saw great numbers taken out of gill-nets set for gaspereau, and thrown away by the fishermen as worthless. At the same time, the writer caught a number of them with rod and line, in one of those small pieces of water connected with the Grand Lake, usually called 'key-holes.' It is occasionally taken in the Saint John, throughout its whole extent. In the harbor of Saint John, in spring, it has been often caught in the seines and weirs with the gaspereau, and salted with that fish, because its value was not known."

The White-fish caught in Green Bay, Lake Michigan, are thus prepared for shipment, if as fresh fish: the gills and viscera are removed and the fish carefully washed.

Referring to the west shore of Lake Michigan, down as far as Manitowoc, Wisconsin, Kumlien thus writes in 1880 in regard to the White-fish market: "The demand for No. 1 White-fish is steadily increasing, and as high as seven and eight cents are often realized when the supply is not abundant. The average price for the whole season Mr. Niquette estimates will be a trifle over four cents per pound, three and a half being paid to the fishermen. The demand for fresh fish is such, and the facilities for shipping so good, that very few White-fish are salted now. In 1870 there were about 3,000 packages sent from Two Rivers, while in 1867 there were above 6,300, and for 1879 there were not over 1,000; but a much larger amount of fresh fish has been shipped. The vicinity of Two Rivers has long been a noted White-fish ground, and still keeps up its reputation; but only a few miles to the south, off Manitowoc, it no longer pays to fish for White-fish."

At Waukegan, Lake Michigan, White-fish are largely smoked. At Oswego and vicinity, Lake Ontario, no White-fish have been salted for five years. Of those shipped from Port Clinton and vicinity, at least two-thirds to three-fourths come from Canada. Five years ago not more than one-half were received for shipment from Canada. At the present time more are being sent from this place than ever. This business has steadily increased since 1855, the increase being the most striking since 1865. "At the falls, on the Madawaska River," writes Mr. Lanman, "the inhabitants take about forty barrels every autumn, which are cured in pickle for winter use."

ABUNDANCE.—The following observations on the abundance of White-fish in the Great Lakes were made by Mr. Kumlien:

At Duluth, at the extreme west end of Lake Superior, and in this vicinity, the White-fish ranks first in importance. Mr. McClau thinks that their numbers have not decreased since 1870, but that the fishing must be carried on in deeper water than was then necessary.

Three reasons are assigned for the decrease of White-fish in Huron Bay, south of Keweenaw, Lake Superior, and vicinity, during the past fifteen years: sawdust, navigation, and overfishing. The fish are here placed in a "live-box" until required for shipping. As many as seventy-two

half barrels have been taken in one pound-net at one lift (net thirty-five feet). They here rank first in importance, are abundant and very large.

Along the shore of Lake Superior, from Ashland to Ontonagon, White-fish rank first in importance. In the vicinity of Marquette the decrease of this fish, according to Parker, has been very great within the last fifteen years, and especially since 1877. At White-fish Point this species ranks first in importance.

Down Green Bay White-fish are becoming more abundant, at Guamico the proportion as compared with the abundance of Herring being about one half barrel of White-fish to fifty of Herring. Ten years ago White-fish were the most important, but have been driven from their spawning beds in the rivers by saw-dust and other causes. The largest hauls here are made by gill-nets through the ice in winter. The appearance of this fish here is very irregular, often absenting itself for several years from hitherto favorite localities. In June, 1877, Mr. Levellé, of Pensaukee, caught in one pound-net seven hundred half barrels, besides shipping a large quantity fresh. They were all No. 1 fish. As high a number as fifty barrels were taken from the net in one morning; other nets, which were set on either side of his, took no fish. Mr. Levellé chose a ledge of rock, having a light coating of mud, for the spot on which to set his net. One of the fish which he caught weighed eleven pounds; since this large catch many other attempts have been made to catch fish in the same place, but without any great success.

The most important fish on the west coast of Green Bay is the White-fish. In 1843 the principal spawning beds for this fish were in the rivers. In 1863 thirty-six barrels were taken at one lift of a pound-net; now, five hundred pounds are regarded as a very good catch. In 1878 the largest catch on record was eight hundred and fifty pounds. In 1850 the most profitable grounds of this region were in the Menomonee River, where they were taken in racks on their return from spawning. Six hundred barrels were often taken on one rack during the autumn; now, not one example has been caught in the river for twelve years. The same cause is assigned for their disappearance as from other grounds already spoken of. About 1859, and a few years previous to the introduction of the pound-net, the greater part of the White-fish was taken in seines close inshore, usually having a warp of only thirty rods. In July and August of 1879 there were large runs of small White-fish—five or six inches in length—on Peshtigo Bar; one fisherman took out several boat-loads, and, on account of their small size, was obliged to throw them away. It was thought by the fishermen that these fish had been artificially hatched by the Wisconsin State fish commission. A more sensible plan on the part of the fishermen would have been to replace them in the water to grow, finding them too small for market.

The temperature of the water is supposed to have a great influence upon the movements of this fish, especially at the time of their arrival upon the feeding grounds in spring. "In winter," says Mr. Eveland, "they seek deep water and live upon the 'winter feed'—the so-called 'White-fish worm,' which they seek upon a muddy bottom; but about the middle of June, on an average, the water becoming warm enough, they strike inshore on sandy or on slightly gravelly shoals and bars and entirely change the character of their food; at this time feeding on the 'shell feed' (small mollusks)."

Towards Cedar River the White-fish are more plentiful than between Peshtigo Point and Menomonee. They alone are taken almost exclusively in deep-water pound-nets.

At and near Green Bay City the White-fish has been for years past the most abundant species of fish. It is now, according to the fisherman's language, "played out."

This fish is first in importance in the waters at the north end of Green Bay. The principal runs occur during the spawning season. There are a great many spawning grounds in this section, espe-

cially about the islands. After spawning they retire to the deep water in the lake. In 1879 there was an increase in the catch of White-fish in these waters. A point opposite the mouth of Escanaba River is regarded as having very superior advantages for the profitable establishment of a hatchery. In 1879, near the mouth of Manistigue River, a specimen weighing twenty-nine pounds was caught.

Between Manitowoc and Whitefish Bay the White-fish is of the first importance. At nearly all the fisheries the best runs occur during August and September. A very few are taken in the spring in the pound-nets at Cedar Grove. A great many small White-fish are taken in the vicinity of Milwaukee. The White-fish ranks first in importance in this section. In 1860 the average catch was one hundred to the net; it is now not more than one-eighth of that number. Overfishing and the capture of the spawning fish are assigned as reasons for this decrease. Their size has also of late diminished, many being so small that, were the meshes of the nets not stift from being tarred, the fish could easily escape. In this vicinity there are no spawning grounds of note.

At the south end of Lake Michigan two varieties or grades are recognized, viz, the "shore" and the "outside" fish. The latter are firmer than the "shore" grade and bear shipment with less loss. The "outside" fish are taken in gill-nets, and the others in pound-nets. The "outside" fish, moreover, has a smaller head and reddish fins. There are no spawning grounds on this coast, and no White-fish, consequently, are taken in autumn.

Between Glen Haven and Saugatuck the White-fish ranks first in importance. Capt. J. J. Brown says that at least three-fourths of the fish taken here are White-fish. He recognizes no different varieties, and knows nothing of the "blood-fish."

There has been a decrease during the last ten years in the waters between the Straits of Mackinac and the Detour Passage; the principal cause being, probably, that the fish have been disturbed there on their spawning grounds. Captain Bennett is of the opinion that fishermen should be prohibited by law from taking White-fish after the first of November. This gentleman asserts positively that some of the once most famous spawning grounds are now entirely abandoned, and he assigns the above as the cause for this desertion. Too small fish are taken by reason of the use of fine-meshed seines. North Point, Thunder Bay, is considered the best spot in that locality for the capture of the White-fish—where it ranks first in importance—and one of the best points of all the lake region. A few are caught in gill-nets in early spring, but the bulk is taken from the latter part of September until winter, the height of runs being from the 10th to the 15th of November, at which time they are spawning. It is thought that the number of nets has doubled during the last two years, and that the fish have decreased fully two-thirds since 1865. Formerly a "rig" consisted of about one hundred twelve-rod nets: now, of two hundred and fifty forty-five-rod nets. One rig has salted twelve hundred barrels in one season. Mill-refuse thrown into the streams is supposed to be a prolific cause of the decrease in abundance of this fish.

The White fish ranks first in importance in Saginaw Bay. Mr. Fitzgerald, however, says that they are annually decreasing in the river seines, estimating the yearly diminution for each seine at about fifty barrels. In 1878 three thousand White-fish were taken in the river, and in 1879, he thinks, not one dozen. Seining for White-fish in the river was formerly a very profitable business. It is still profitable outside the bay, in the lake. The best grounds are off Point Aux Barques and eastward. Here the whole fleet of Lake Huron tugs congregate at certain seasons of the year. They seem at this point to spawn more abundantly on the Canadian than on the American shore. Comparatively few are taken here during early spring, the principal season being from May to September. It is thought that the greatly increased navigation in the river has driven the White-fish out into the lake; and even there they are not as abundant as they were formerly.

About the Charity Islands, Lake Huron, White-fish rank about third in importance. The best time for fishing is in October; some are taken in May and June. Gill nets take them all the summer. About Point Sable are the most profitable fishing grounds. The deeper the water, the more abundant the White-fish appear to be. They spawn in large numbers about the islands and at Gravelly Point. It is thought by old fishermen of this region that since 1865 the decrease of this fish has been fully one-half.

In Maumee Bay, Lake Erie, the White-fish are thought to be as abundant as they ever were, though the facilities for capture are better and more extensively used than ever before. Within the last two years a steady increase has been marked, due, it is thought, to artificial propagation. About Toledo great numbers have been planted during the last few years, and the universal verdict of the fishermen is that the White-fish are on the increase in that region. In 1875 forty tons were in one day brought into the Toledo market. The spring catch is considered as of little importance.

Between the mouth of the Detroit River and Toledo, Ohio, the White-fish ranks first in importance. On this shore they are all said to be good-sized, mature fish. It is not thought that they are on the decrease to any perceptible extent. From Ottawa City westward to Port Clinton the spring catch of White-fish is very light. The fall run usually commences about the first of October. Around the Sister Islands and on innumerable reefs are excellent spawning grounds, where they are caught in small numbers by wandering gill-netters. The catch about Port Clinton for the last five years is said to have been very poor. Gill-net fishing during their spawning season and overfishing generally are assigned as the reasons for this falling off. In 1876, Matthews & Bell, of Port Clinton, had on their warehouse floor forty-seven tons of White-fish at one time, and the next day thirty tons more. At Locust Point and Toussaint the White-fish are reported as scarce in spring. They there rank about fifth in importance at that season. The runs are very irregular, some years being fairly abundant and others very scarce.

Since 1870, in the vicinity of the Upper and Lower Sandusky Bays, the decrease of White-fish has been alarming. Its decrease, however, has been irregular, for in 1874 there was quite a large catch. Since then the decline has been greater every year.

It is thought that the spawn is now deposited in places where it becomes a prey to larger fish. Some of the best spawning grounds at present are on the reefs off North Bass and north and east of Kelley's Island; the principal portion of the reefs are in Canadian waters.

In 1846 Mr. Anthony was hired by Dr. Ackley, of Cleveland, to convey a party of students to the famous Toussaint marshes for a hunting and fishing expedition. To their surprise, they hauled up in their seine some White-fish. Further attempts were made by Mr. Anthony, aided by two Frenchmen, and in the morning, after a whole night's work, he had taken nearly fifteen hundred fine White-fish. They had never been caught on this ground before. The fish were taken to Sandusky, but the people would not believe that they had been taken near their city. In the next year a forty-rod seine was fitted out, and with it White-fish amounting to twenty-five hundred barrels when salted were caught; this was repeated the next year with a similar success. In 1849 the first pound (twelve feet deep) was set, and the result was so successful that the seine was discarded. After four years' successful fishing they moved to the south point of Bass Island and set in thirty feet of water; this attempt was successful. At that time the season lasted from September 15 to winter; now, at the same place, it only lasts for a few days in spring.

During the best fishing days of the season—in the fall—in the vicinity of Huron, Ohio, a ton of White-fish is sometimes taken from ten nets; this is above the average. They are thought to have decreased fifty per cent. since 1875. Before 1868 they appeared to be on the increase; after that year their decrease has been continuous to the present time. The diminution in their

abundance is attributed to over fishing. In heavy weather these fish leave for deep water. In the vicinity of Vermillion, Ohio, the White-fish have no spawning grounds. A great decrease in their abundance has taken place during the past few years. In 1879 thirteen nets succeeded in taking but three tons of this fish.

In Brownhelm Bay, Lake Erie, and at and in the vicinity of the mouth of Black River, White-fish rank fourth in importance. They were more abundant in 1877 than during many previous years. Between Black River and Dover Bay is a small spawning ground, on a rocky-bottomed reef. During spawning time no White-fish are taken at Black River or Brownhelm Bay. They are most abundant in this part of Lake Erie during southwest winds, when—on their way from the shore to deep water—they are caught in the pounds. At Brownhelm Bay a great number are taken in the spring at a point just above Beaver Creek. At Black River but few can be taken, because the nets can be set but a short distance out from the shore; farther to the westward, however, the nets can be set at a greater distance from the shore, by which means the catch is greatly increased.

In the neighborhood of Cleveland, Ohio, and in Dover Bay the White-fish are not very abundant, ranking about fourth in importance. The runs are irregular, the largest ones occurring in the spring, that of 1879 being the most abundant ever known up to that time. The fishermen there say that on approach of a wind storm they will run into deep water; if they are frightened when feeding or spawning they will not return to their grounds for a long while. They are taken only in mild weather. In the waters off Conneaut and Ashtabula, Lake Erie, it is supposed that White-fish are not one-third as abundant as in 1870, but since 1876 the annual decrease has not been perceptible. Near Painesville, Ohio, no spawning or feeding grounds for the White-fish have been found; but on a shoal—some miles to the east—the gill-netters take a great many during the spawning season.

Toward the east end of Lake Erie, around Dunkirk, New York, the first run of White-fish takes place early in the spring. In June, July, and the early part of August also, large hauls of these fish are made; the best time is, however, from the latter part of September until November, when a larger grade of fish, and one which is preferred for freezing, is taken. Lately (in 1880) six thousand pounds from forty nets and thirty-five hundred pounds from twenty-five nets are reported. The largest haul in 1879 was nineteen hundred pounds from one gang of nets.

At Port Ontario, on Lake Ontario, White-fish rank first in importance. Near Oswego this fish is far from being common, and never enters the river. White-fish, up to the year 1867, have been on the increase since 1855 in the vicinity of Port Clinton, especially so during the years 1865, 1866, and 1867. Since that time they have decreased in numbers to a small extent. This decrease is largely merely a supposition, arising from ignorance regarding the movements of this fish, and the application of the latest and best methods in fishing. Probably it is true that the decrease is in the number that is caught, not in the number that might be taken. In 1859, forty-nine thousand White-fish are said to have been taken at one haul; many were small and young; fully a half of this catch were thrown away before the net could be hauled in. At Stonington Beach it is claimed that seventy-five thousand fish have been taken ashore by one haul of the seine. At Chaumont, where the White-fish ranks second commercially, there has been a great decrease during the past twenty years. Now, there are no spawning grounds in the bay, the fishing necessarily being carried on outside in the lake. Formerly, in this locality, sixty to seventy men, taking three to five tons a day, were engaged in this fishery; now, sufficient fish cannot be caught to pay the men for their time and labor.

An alarming decrease is reported from Sacket's Harbor, where they are taken inside only during their spawning season. The fish caught here are usually large. In 1876 an immense school of small ones came into the harbor.

169. THE LESSER WHITE-FISHES.

By David S. Jordan.

The Musquaw River White-fish—Coregonus labradoricus.

The name "Whiting" is said by Prescott to be applied to this fish in New Hampshire. It occurs throughout the lakes of Northern New England and Northern New York, and in the Great Lakes. It is, however, not generally abundant except in the Great Lakes. It attains a smaller size than the White-fish, those seen by us rarely weighing more than a pound.

The Moon-eye or Cisco—Coregonus Hoyi.

The Moon-eye or "Cisco" of Lake Michigan has thus far been noticed only in Lakes Michigan, Erie, and Ontario. It is the smallest of our White-fish, rarely weighing over half a pound, and it is seldom taken in shallow water. It has, from its small size and rare occurrence, little economic value. Nothing distinctive is known of its food or breeding habits.

The Lake Herring—Coregonus Artedi.

This species is almost universally known as the "Lake Herring." The name "Cisco" is also often applied to it, especially about the smaller lakes, and in many regions also the name "Michigan Herring." The Lake Herring is one of the most abundant fishes of the Great Lake region, probably second only to the White-fish in importance as a food-fish. It goes in large schools, and is taken in great numbers in comparatively shallow waters. It occurs also in the lakes of British America, and probably in Northern New England and New York. Its usual length is little more than a foot. Its mouth is much larger than that of the White-fish, and its range of food is doubtless greater. It spawns in November and December, coming into shallow water for the purpose. It exists in most of the small lakes of Northern Indiana and Eastern Wisconsin (Tippecanoe, Geneva, Oconomowoc, etc.), where it is known as the "Cisco." In these lakes it usually remains in deep water until the spawning season, when great numbers come near shore to spawn. As a food-fish the Lake Herring ranks high, although considerably inferior to the White-fish.

The Blue-fin—Coregonus nigripinnis.

This species is known as the "Blue-fin" or "Black-fin." It has thus far been taken only in the deeper waters of Lake Michigan. At times it comes in considerable numbers to the Chicago market, but it is in general a rare species. It reaches a much larger size than the Lake Herring, which species it very closely resembles. Nothing distinctive is known of its food or breeding habits.

The Mongrel White-fish—Coregonus tullibee.

This species is occasionally taken in the Upper Great Lakes, where it is generally considered a hybrid between a White-fish and a Lake Herring, hence the name of "Mongrel White-fish." It is a rare fish in collections, and nothing distinctive is known of its habits. Its range is probably to the northward.

The Menomonee White-fish—Coregonus quadrilateralis.

The only name which I have heard applied to this fish is that of "Menomonee White-fish." The name of "Round-fish" is given to it by Richardson, and that of "Shad Waiter" (Winnipiseogee Lake) by Prescott. It is found in the lakes of New Hampshire, Northern New York, the Great Lakes, and northward to the Arctic Seas. In the Great Lakes it is much less abundant than the

common White-fish. Its size is less than that of the White-fish. I know nothing of its comparative value as food. The stomach of one specimen examined by me contained small *Limnæa*-like shells. Nothing definite is known of its breeding habits.

Rocky Mountain White-fish—Coregonus Williamsoni.

This species is usually known as the White-fish; in Utah as the "Mountain Herring." It reaches a length of a little more than a foot, and a weight of about a pound. It is found throughout the Rocky Mountain region, in cold, clear lakes. It is abundant in Utah Lake, Lake Tahoe, and in most of the lakes of Washington, Oregon, and Idaho. It is frequent in the market of Salt Lake City, and sometimes comes into the San Francisco market. It spawns in October and November, running from the lakes into the small streams for this purpose. As a food-fish it ranks high, being similar to its Eastern relative, *C. quadrilateralis*.

The Chief Mountain White-fish—Prosopion Couesii.

"*A specimen of a White-fish was taken in Chief Mountain Lake, writes Milner, at the eastern* edge of the Rocky Mountains, by Dr. Elliott Coues, U. S. A., surgeon and naturalist of the Northern Boundary Commission. This specimen is very different in its type of form from any species hitherto described from this continent. In Günther's arrangement of the species of *Coregonus*, it would be placed in group (*a*), with the upper jaw produced into a cutaneous appendage. In this particular it resembles *Coregonus oxyrhynchus* Lin. and *C. Lloydii* Günth. Unlike these species, it is an elongate fish, the proportion of height to length being much the same as in *C. Williamsoni* Gir. and *C. quadrilateralis* Rich.; it also resembles this type of form in the narrow supplementary bone of the maxillary, and the former species in the shape of the maxillary.

"The only previous reference to a fish supposed to be of this genus, from the Saskatchewan River, is in some remarks appended to the description of *C. labradoricus* in the "*Histoire Naturelle des Poissons.*" Valenciennes refers, in the most undecided manner possible, to a fish which he believes to be a salmonoid, and makes his diagnosis from a drawing. There is, in fact, no direct evidence in what he says to prove that the specimen was in his possession. He admits that he is "not able to determine with certainty the genus"; and, after stating that "my first impression was to make it a *Coregonus*, since I have placed the design by the side of the other species of the same genus," ends this most uncertain and undecided effort to determine its relationship, with the question, "Could one name it *Coregonus angusticeps?*"

"It may be that the specimen at hand is a fish of the species indicated in the above name, the ascribed locality heightening this possibility; but there can be no consideration of the matter that will decide it, and the name is consequently passed over. The character given of fifty-five scales in the lateral line is very far from agreeing with Dr. Coues's specimen, and, in fact, with any description of a *Coregonus* we have seen, and may indicate that the author was right in his hesitancy to decide upon the genus.

"The most marked feature is the extensive prolongation of the snout, which protrudes far beyond the opening of the mouth. The head narrows regularly toward the anterior of the frontals, where two strong angles are found narrowing the head abruptly at the point where the short supraorbitals join, and the frontals and nasals continue forward in a narrow, blade-like extension. The supraorbitals form a bold prominence at the anterior of the orbit. The maxillary is short, dilated at its posterior portion, and has a narrow supplementary bone. The premaxillaries are somewhat retroverted, and have very little width, making the muzzle thin and narrow, as it is in *C. quadrilateralis* and *C. Williamsoni*. The adipose fin is large, attached to the body almost to the posterior extremity, and is ensheathed in scales for a considerable distance from the dorsal line.

The greatest height of body is equal to the length of the head. The least height of tail is equal to the length of the snout. The lengths of the caudal peduncle, of the snout, and of the mandible are equal to each other. The width of the interorbital area is equal to the length of the maxillary.

170. THE SMELT FAMILY—MICROSTOMIDÆ.

The Smelt—Osmerus mordax.

The Smelt is found along our Atlantic coast from the Raritan River, latitude 40° 30′, to the Gulf of Saint Lawrence. The northern limit of its range has not been precisely defined, although it is known to be extremely abundant along the northern shores of New Brunswick. It is also found in many of the fresh-water lakes of Maine, New Brunswick, and Nova Scotia, where they have become land-locked, and in some instances, as in Belgrade Lake, Maine, seem to have rather been improved by the change from salt to fresh water.

The European Smelt, *O. eperlanus*, which, though very similar in form to our own, differs from it in the size of its scales, is found in Southern Sweden, as far north as Christiania Fjord district, latitude 62°, and south as far as the entrance to the river Loire, latitude 47°, ascending the Seine as high as Rouen. It is the "Stint" and the "Spearling" of Germany, the "Smelt" or "Sparling" of England, and the "Spiering" or "Spearling" of Holland. It is found in the Baltic, and, entering the Gulf of Finland, becomes a member of the fauna of Russia, and is found land-locked in cool lakes, especially those of Norway, and also in many of the lakes of Northern Germany, and even as far south as Bavaria.

The Smelt enters our rivers and brackish bays during the winter months for the purpose of spawning, and at this period is caught in immense quantities in nets and by hook and line. John Smith wrote in 1622: "Of Smelts there is such abundance, that the Salvages doe take them up the rivers with baskets, like sives"; while Josselyn, fifty-five years afterward, remarked: "The *Frost-fish* (*O. mordax*) is little bigger than a *Gudgeon*, and are taken in fresh brooks; when the waters are frozen they make a hole in the Ice, about half a yard or yard wide, to which the fish repair in great numbers, where, with small nets bound to a hoop about the bigness of a firkin-hoop, with a staff fastened to it, they take them out of the hole."

It is to be regretted that no one has made careful observations upon the beginning and close of the breeding season of this species at different points along the coast, but the spawn appears to be deposited, generally, late in the winter and early in the spring. The smelt fishery is increasing yearly in importance, owing to the greater facilities for the transportation of fish in ice. As long ago as 1853, Storer stated that in Watertown, Massachusetts, alone, about 750,000 dozen were annually taken in scoop-nets from the 1st of March to the 1st of June. Perley, writing in 1852, stated that on the Gulf coast of New Brunswick large quantities were used every season as manure, while at the fishing stations in the Bay of Chaleur it was taken in the seine and used as bait for cod. At the present time, however, there is an enormous shipment of Smelt from this region to the United States, forty car-loads sometimes being received in New York in the course of one winter. As early as 1864, according to a note from Mr. J. Matthew Jones, quantities of Smelt were packed at Halifax for shipment to the United States.

The Smelt feeds, for the most part, on shrimps and other small crustaceans.

Although on account of their great abundance they sell in the markets at a low price, they are among the very choicest of all our food-fishes. The "green" Smelts, as they are called, or those which have never been frozen, are much the more highly esteemed, especially those which come from the Raritan Bay and other points in the neighborhood of New York.

The California Smelt—Osmerus thaleichthys.

"This species," writes Jordan, "is known as Smelt, especially in those parts of the coast where the *Atherinopsis* or California Smelt is unknown. It reaches a length of six to eight inches. It ranges from Monterey to British Columbia. It does not occur in such abundance as the Surf Smelt and the Eulachon, and it has not been noticed in fresh water. Nothing is known to us of its breeding habits. It is the prey of the various predatory fish, the larger flounders, salmon, etc. It is not brought into the market in large quantities, and, being a soft-bodied fish, is not in good condition when kept long. It has, therefore, little economic value.

The Alaska Smelt—Osmerus dentex.

This species, according to Bean, occurs around the shores of Kamtschatka, and has been observed by him at Port Clarence, and by Messrs. Turner and Nelson at Port Clarence. It is similar in size and appearance to the Atlantic Smelt. It is of much importance to the Eskimos, and is dried in great quantities for use in their boat voyages. A similar species, perhaps identical, is that described by Pallas under the name *Osmerus spirinchus*. This, it is thought by Dr. Bean, may prove to be an emaciated form of *O. dentex*.

The Surf Smelt—Hypomesus olidus.

"This species is known as the 'Smelt,'" writes Jordan, "and sometimes as the 'Surf Smelt.' It reaches a length of about a foot. It ranges from the Bay of Monterey to Alaska, being especially abundant in Puget Sound and not common about San Francisco, although occasionally brought into the markets. They feed upon worms and small crustacea, and are eaten by all the large flounders and other predatory fish. They are found at all seasons, but in the month of August they go in great schools near the shore. They spawn in the surf along the shore. The females are thought to come first, and then the males. As a pan-fish this fine oily species is unsurpassed."

The Capelin—Mallotus villosus.

Distribution.—This species inhabits the North Atlantic and North Pacific. It does not occur much south of Halifax, Nova Scotia, and never approaches near the shores of New England, but is, notwithstanding, of great importance to New England fishermen. It abounds on the shores of Newfoundland and on the coasts of Labrador, and during the month of July occurs in great numbers near the Virgin Rocks, the only portion of the Grand Banks above water. It is found, also, near Greenland, and about Iceladn and Spitzbergen, and the entire length of the Scandinavian coast, from Varanger Fjord south to Christiania Fjord, latitude 58°; the species touches Denmark, but does not appear to have been observed around the British Isles. It is the "Lodde" of Norway, where it bears so important a relation to the cod fishery. According to Richardson, it has been found very far up in Carnation Gulf and Bathurst Inlet, latitude 70° north, longitude 125° west. It occurs on the arctic coast of North America, and it seems probable that its range extends also into the icy sea of Siberia, completing the circuit of the Arctic Seas.

"The first voyager who takes notice of them," writes Pennant, "is Master Anthony Parkhurst, who visited that island (Newfoundland) in 1578, and gives a very facetious account to his shipmates of his art in charming these, and another fish he calls a squid, into his power. I refer to Mr. Hackluyt, vol. iii, p. 133, for the account."

Parkhurst observes that this fish, which is like a Smelt, and is called by the Spaniards "Anchovas," and by the Portuguese "Capelinas," "commeth also in the night, but chiefly in the day being forced by the cod that would devour him, and therefore for feare comming so near the shore,

is driven drie by the surge of the sea on the pibble and sands. Of this, being as good as a smelt, you can take up with a shove-net as plentiful as you do wheate in a shovell sufficient in three or four hours for a whole citie."

In 1880 Dr. Bean found this fish abundant and in immense schools on the cod grounds of the North Pacific, and found forty individuals in the stomach of one cod of ten pounds weight.

The abundance of this fish in northern waters, and the voracity with which schools of cod follow them, have been described by many writers, by none perhaps better than by Anspach, who thus describes the appearance of Conception Bay about the year 1818:

"It is impossible to conceive, much more to describe, the splendid appearance of Conception Bay and its harbors on such a night, at the time of what is there called the Capelin Skull. Then its vast surface is completely covered with myriads of fishes of various kinds and sizes, all actively engaged either in pursuing or avoiding each other; the whales alternately rising and plunging, throwing into the air spouts of water; the codfish bounding above the waves and reflecting the light of the moon from their silvery surface; the Capelins hurrying away in immense shoals to seek a refuge on the shore, where each retiring wave leaves countless multitudes skipping upon the sand, an easy prey to the women and children who stand there with barrows and baskets ready to seize upon the precious and plentiful booty; while the fishermen in their skiffs, with nets made for that purpose, are industriously employed in securing a sufficient quantity of the valuable bait for their fishery."[1]

"The manner in which the Capelin deposits its spawn is one of the most curious circumstances attending its natural history. The male fishes are somewhat larger than the female, and are provided with a sort of ridge projecting on each side of their backbones, similar to the eaves of a house, in which the female Capelin is deficient. The latter, on approaching the beach to deposit its spawn, is attended by two male fishes, who huddle the female between them, until the whole body is concealed under the projecting ridges, and her head only is visible. In this position all three run together, with great swiftness, upon the sands, when the males, by some inherent imperceptible power, compress the body of the female between their own, so as to expel the spawn from the orifice and the tail. Having thus accomplished its delivery, the three Capelins separate, and, paddling with their whole force through the shallow water of the beach, generally succeed in regaining once more the bosom of the deep, although many fail to do so, and are cast upon the shore, especially if the surf be at all heavy. Like the common Smelt, the Capelin possesses the cucumber smell; but it differs from the Smelt in never entering fresh-water streams."[2]

"Instances are common of vast numbers of Capelin being found dead, or in a dying state, where the schools come inshore to spawn. The sandy bottom of the sloping beach is not unfrequently strewed with dead fish, and dying Capelin may be seen wandering about and spasmodically gasping in the water from which millions of the species had abstracted the oxygen necessary for their existence.

"The Capelin spawn, as is well known, on sandy, sloping beaches, but they also spawn in waters of different depths where the bottom is composed of sand. The fishermen take Capelin with their casting-nets in from fifteen to thirty fathoms, and probably also in water of much greater depth, the needed condition being a smooth, sandy bottom over which the trio engaged in spawning may 'run' touching the bottom. In the neighborhood of Baccalieu Tickle, Mr. Jabez Tilly relates that in 1864 the fishermen took Capelin for a month, from the third week in June to the third week in July, in water varying from fifteen to thirty fathoms, with the casting-net. In the second week

[1] Page 305.

[2] LANMAN: Report United States Commission Fish and Fisheries, part II, 1874, p. 225.

of July capelin spawn was brought up from the bottom in twenty-seven fathoms of water. The spawn is said by fishermen to require about fifteen to eighteen days to arrive at maturity. The young fish leave the egg after that period. They are found near the coast until about the end of December, according to the season, and the contents of the stomachs of murrs and puffins, according to Mr. Jabez Tilly, are often full of young Capelin at that season.

"At the Fishot Islands, in 1876, the Capelin were taken in deep water about the 20th of June, before they 'came in.' The appearance of schools of Capelin coming in to spawn in May, June, or July, according to the latitude of the place, has always excited astonishment at their numbers, and often, in the present day, in Conception Bay and some other noted spawning grounds, remarkable scenes may be witnessed; an idea may thus be formed of the extraordinary number of fry, serving as food, which swarm even now in the Newfoundland seas. Nor is it less easy to conceive how greatly these innumerable hosts have contributed to the drawing inshore of the deep-sea fish; first the adult fish forming the attraction, next the spawn, then the young fry, and thus continuing to the approach of winter. So great has been the importance attached to the preservation of the Capelin that legal enactments have passed the legislature of Newfoundland prohibiting the use of this fish as manure, and the public documents abound with remonstrances against this palpable abuse of one of the most important means for preserving the Newfoundland fisheries."[1]

MIGRATIONS.—In the opinion of Professor Hind the Capelin winter with the cod in the deeper portions of the bays of Newfoundland and Labrador, though in different zones of water. Cod taken through the ice in January, 1852, in Saint Mary's Bay, had undigested Capelin in their stomachs. Professor Hind remarks that an impression prevails among the fishermen that the Capelin are moving north, and that the cod are following them, but this opinion is not shared by the fishermen who have occupied the coast of Labrador for a century. They have known the Capelin as far north as Nain for many years. On the Admiralty chart of Fort Manvers, latitude 57°, longitude 62° 7′, thirty miles north of Nain, and published in 1871, Capelin Bay is the name given to an anchorage, from which it is manifest that Capelin were seen there half a century before the fishermen passed Aullik Bay, or even Cape Harrison, nearly two hundred miles to the south. The Capelin, however, is not known to the officers of the Hudson Bay Company, or to the missionaries beyond Cape Mumford.[2]

IMPORTANCE.—The Capelin are consumed in great quantities by halibut, and also by whales. In Finmark the cod fishery is divided into two seasons, the fishery which takes place early in the spawning season, and the Lodde or Capelin fishery, which occurs later, and which, when the Capelin is abundant, is of great importance.[3]

The Labrador cod fishery, at one time of considerable importance to Provincetown, Marblehead, Newburyport, and other fishing towns of Massachusetts, like the Lodde fishery of Finmark, depended entirely upon the presence of Capelin.

The Capelin is extensively used for bait in the Grand Bank fishery, especially by the French, by whom it is stated that sixty thousand hogsheads are annually taken about Newfoundland for this purpose. In Greenland the Capelin forms so important an article of food that it has been termed the "daily bread" of the natives. In Newfoundland they are dried in large quantities and exported to London, where they are sold principally in the oyster shops.[4]

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[1] HIND: Fishery Clauses of the Treaty of Washington, 1877, p. 134.
[2] HIND: *Ibid.*, part ii, p. 70.
[3] Report United States Commission Fish and Fisheries, part v, 1879, p. 709.
[4] LANMAN: *Ibid.*

THE EULACHON—THALEICHTHYS PACIFICUS (Richardson) Girard.

This species, common in the North Pacific, resembles the Capelin, and is usually known by the Indian name "Eulachon," or "Oulachan," more commonly pronounced "hoolakins" by the English at Victoria. Those salted and sent south are commonly called "Candle-fish" by the trade. In the Columbia River and elsewhere southward it is known as "Smelt," being confounded with the other species. It reaches a length of less than a foot. It ranges from Oregon northward to Kamtchatka. It occurs in some abundance in the Columbia River, where little notice is taken of it. In Frazer River and streams to the northward it runs in enormous numbers in spring. The Eulachon run up the rivers and deposit their spawn on gravel beds at no great distance from the mouth of the stream, probably not above thirty miles. Their run is from the last of March to the middle of May, probably varying in different streams. During the run they are beset by all sorts of enemies—halibut, sharks, sea-birds, Indians, porpoises, and all manner of predatory fish, some of which chase them in the ocean only; others pursue them up the rivers. Even the sturgeons and the rays have their stomachs full of them.

The Eulachon is greatly valued on account of the oil which permeates its flesh. As a pan-fish it has no superior. A factory has been established on the Noss River for the manufacture of eulachon oil, which is intended to be used as a substitute for cod-liver oil. It has the drawback of becoming solid and lard-like at ordinary temperatures.

"Nature," the chief London journal of science, stated, May 12, 1881: "A new medicinal oil has just been introduced into this country by Messrs. Burgoyne & Burbridge, the well-known chemists of Coleman street. It is known as Oolachian oil, and is said to be scarcely distinguishable from cod-liver oil. It is obtained from a fish called by the North American Indians 'Oolachan,' or 'Candle-fish,' from the fact that when dried the fish itself can be used as a candle, on account of the large quantity of oleaginous matter it contains. . . . In America the oil has already a great reputation as a valuable and efficient substitute for cod-liver oil, and there is every probability, as it becomes known in this country, of its taking a prominent place as an important medicine." Diligent inquiry fails to bring to light evidences of any extensive use of this oil as yet in the United States.

171. FAMILIES RELATED TO THE SALMONIDÆ.

THE SCOPELUS FAMILY—SCOPELIDÆ.

The species of this family are small and pelagic, and are found throughout all the temperate and tropical seas. They are so numerous that the surface net, when used in a night of moderate weather, in mid ocean, scarcely ever fails to inclose some specimens. They come to the surface at night only; during the day, in very rough weather, they descend to depths where they are safe from sunlight and from the agitation of the water.[1]

In the Western Atlantic there are five or six species, which are catalogued in the check-list. In California there is only one, *Myctophum crenulare*, a single specimen of which was taken from the stomach of an albicore at Santa Barbara.

THE HANDSAW FISH FAMILY—ALEPIDOSAURIDÆ.

The fishes of this family inhabit very deep water, and are never seen at the surface. The Handsaw Fish of the Pacific, *Alepidosaurus borealis*, is occasionally found along the coast from

[1] GÜNTHER: Study of Fishes, p. 585.

Monterey to Kamtchatka. The Atlantic species, *A. ferox*, very closely allied to, if not identical with, its ally in the Pacific, is found in great numbers on the off-shore banks, being frequently brought up on the lines of the halibut trawl fishermen from a depth of one hundred and fifty to three hundred fathoms. It is one of the largest and most ferocious looking of the deep-sea fishes, growing to a length of six feet, its mouth provided with double rows of sharp, lancet-shaped teeth, a half to three-quarters of an inch in length. They are very slender and lithe in form, and are the personification of voracity. Günther states that from the stomach of one example have been taken several cuttle-fishes, crustaceans, and sea-squirts, a young Brama, twelve young boar-fishes, a horse-mackerel, and one young of its own species. Nothing is known of its breeding habits. Its only importance to the fisheries lies in the fact that it cumbers the hooks of the fishermen.

The Alepocephalus family—Alepocephalidæ.

This family is represented in the deep water of the Western Atlantic by two species, *Alepocephalus Bairdii* and *A. Agassizii*, of each of which single specimens have been obtained on the off-shore banks, a magnificent fish, attaining the length of at least three feet, shaped like a salmon, covered with thin silvery scales. Only one other species of the genus is known—a rare fish from the Mediterranean.

The Paralepis family—Paralepidæ.

These are small, pelagic fishes, occurring in the Mediterranean, Atlantic, and Pacific. In our waters there are three species: In the Atlantic, *Paralepis borealis*, a Greenland form, of which we have seen one specimen from the Gulf of Saint Lawrence; in the Pacific there are two, each known from a single specimen, *Sudis ringens*, from the Santa Barbara Channel, and *Paralepis coruscans*, from the Straits of Fuca.

The Snake-fish family—Synodontidæ.

The family is represented on our Atlantic coast by three species, on the Pacific by one, *Synodus lucioceps*, which is closely related to the Atlantic species, *S. fœtens*. The Pacific species occurs from San Francisco southward, and is occasionally eaten. The Atlantic forms occur in the West Indies and range north to Cape Cod, but are of no economic importance.

R.—THE HERRING TRIBE.

172. THE HERRING—CLUPEA HARENGUS.

ABUNDANCE AND IMPORTANCE.—The Herring is beyond question the most important of food-fishes. Distributed, as it is, throughout the whole of the North Atlantic, it affords occupation, during a portion of the year at least, for immense fleets of fishing boats, and, according to the estimate of Professor Huxley, the number taken every year out of the North Sea and Atlantic is at least 3,000,000,000, with a weight of at least 1,500,000,000 pounds. This estimate is perhaps more likely to be too low than too high. According to the statement of Carl Dambeck, given in the United States Fish Commission Report, volume 3, page 21, the average yield of Herring in Norway from 1850 to 1870 amounted to 1,452,000,000 pounds. Widegren[1] estimates that the total yield of Herring on the Swedish coast of the Baltic amounts to 300,000,000 pounds. Holdsworth placed the yield of Scotland in 1873 at 188,000,000 pounds, their capture requiring 15,095 boats with crews of 45,494 men. In the same period in the English fisheries he states that 15,331 boats were used. He gives no estimate of the yield, but it is probably not very different from that of Scotland. France, Ireland, and Belgium have also herring fisheries of considerable extent, and Germany in a less degree. In 1874, according to compilation and estimates of Professor Hind, 200,000,000 pounds of Herring were taken in the waters of British North America, and in 1880 nearly 43,000,000 pounds were obtained on the east coast of the United States.[2] Summing up the aggregate of these statements and estimates, and allowing to Ireland, Belgium, Germany, and France a product equal to that cited of Scotland, we have an aggregate of 250,000,000 pounds. This total is not presented as an item of statistical information, but simply to emphasize by way of illustration the statement made at the beginning of this paragraph.

Commenting upon the supposed injurious effect of the fisheries upon the abundance of this fish, Professor Huxley in his well-known lecture upon the Herring, delivered at the International Fishery Exhibition at Norwich in 1881, remarked as follows:

"It is said that 2,500,000,000, or thereabout, of Herrings are every year taken out of the North Sea and the Atlantic. Suppose we assume the number to be 3,000,000,000, so as to be quite safe. It is a large number, undoubtedly, but what does it come to? Not more than that of the Herrings

[1] United States Fish Commission Report, part iii, p. 33.

[2] The Herring appears to have been one of the most conspicuous fishes in the Western Atlantic at the time of the discovery and early exploration of America, as the following extracts from the voyages of early navigators will show:

Josselyn wrote in 1675: "The Herrin, which are numerous, they take of them all summer long. In *Anno Dom.* 1670, they were driven back into *Black-Point* Harbour by other great fish that prey upon them so near the shore that they threw themselves (it being high water) upon dry land in such infinite numbers that we might have gone up half-way the leg amongst them for near a quarter of a mile. We used to qualifie a pickled *Herrin* by boiling of him in milk."

John Smith, in 1631, remarked: "Herring, if any desire them, I haue taken many out of the bellies of Cods, some in nets; but the Saluages compare their store in the sea, to the haires of their heads: & surely there are an incredible abundance upon this Coast." And again: "Of Herrings, there is great store, fat, and fair; & (to my minde) as good as any as I have seene, & these may be preserved, and made a good commodity at the Canaries.'

which may be contained in one shoal, if it covers half a dozen square miles, and shoals of much larger size are on record. It is safe to say that, scattered through the North Sea and the Atlantic, at one and the same time, there must be scores of shoals, any one of which would go a long way toward supplying the whole of man's consumption of Herrings."

NAME.—So well known was the Herring from the earliest days to the inhabitants of Northern Europe and to their descendants who migrated to the western shores of the Atlantic, that one name serves to designate the fish in the languages of a majority of the peoples to whom it is known. Its name in English, German, and Dutch, though differently spelled, is pronounced in exactly the same way. To the Scandinavian tribes it is known by the name "Sill." France in the name *Clupée* employs a form of the Latin name for fishes of this group by which the same fish is known to these nations when described in the language of their men of science. There are certain local names for the Herring which are used not to replace the general one, but to designate certain conditions and ages. To this class belongs the name "Sperling," employed by our own *fishermen of Cape Ann to denote the young Herrings. Corresponding to this name the word "Strömming"* is used in Sweden. British fishermen, according to Huxley, distinguish four states of the Herring: (1) "Fry," or "Sill," for the young fish when not larger than sprats; (2) "Maties," a name which is a corruption of the Dutch word for a maiden; Herrings in this class are larger than fry, but with undeveloped roe or milt; (3) "Full," fish with larger developed roe or milt; and (4) "Spent" or "Shotten," fish which have recently spawned. "Maties," when gorged with their favorite food, small crustaceans, are called by the Scotch fishermen "Gut-pock" Herrings. In Sweden, according to Widegren, the following names are known in the trade: "Norwegian Herring," "Gråben Herring," "Fat Herring," "Gottenburg" or "Bohuslän" Herring, "Kulla Herring," "Bleking Herring," "Small Herring," "Anchovies," "Skarp Herring," "Spiced Herring," etc.[1]

These names are cited to indicate how many variations are customarily made upon the well-known name of Herring. In the United States there are few trade names for this fish, though a large portion of our Herring pass from producer to consumer under a name which is intentionally deceptive, that of "French Sardine," and a few are canned in spices and sold under the still more imaginative name of "brook" and "sea" trout. "Bloater," "Digby Chicken," and "Hard Herring" are other trade names used on this side of the Atlantic, the significance of which will be explained in the paragraph relating to "economic uses."

Small Herring are frequently called "Brit" by the fishermen of Eastern New England. "Anchovy" is another name for these small fish—still in use among our fishermen—and had its origin in one of the devices of trade.

By far the most confusing congeries of names, however, is to be found in the literature produced in such lavish quantities during the past twenty years by the Scandinavian naturalists who have been attempting to reconcile with fact the theories prevalent among fishermen and others in Northern Europe concerning the movements of the different schools of Herring and the race characteristics and habits which were supposed to characterize them.

In the "Preliminary Report for 1873–'74 on the Herring and the Herring Fisheries of the West Coast of Sweden," by A. V. Ljungman,[2] are given numerous names of this sort, such as "Boundary Herring," "Grass Herring," "Great Herring," "Norwegian Winter Herring," "Norwegian Fall Herring," "Old Herring," "Real Sea Herring," "Cattegat Herring," "Sea Herring,"

[1] United States Fish Commission Report, part vi, p. 124.

[2] Translation in United States Fish Commission Report, part iii, 1876, pp. 123–167.

"Fjord Herring," "Scotch Dutch Herring," "Lard Herring," "Half Herring," and "Tender Herring." In this report Mr. Ljungman attempted to distinguish and described at least four varieties, and in so doing was much more conservative than his predecessor, Professor Nilsson, (?) who in the year 1832 described, under binomial names, as distinct species eight of the forms known in his country under separate popular names. In a later report on the salt-water fisheries of Bohuslän, published in 1878,[1] Mr. Ljungman, who had, in the six years intervening between this date and the writing of his first essay, devoted much time to the study of the subject, appears to have abandoned his early idea, since he makes no attempt to distinguish the races, and simply announces himself as maintaining that "more than one race of Herrings may be found in one and the same place."

GEOGRAPHICAL DISTRIBUTION.—The Herring is found in the temperate and colder parts of the North Atlantic. On the west its range extends south to Sandy Hook, at the entrance of New York Harbor, where they are found occasionally in midwinter, and on the north as far as Northern Labrador, diminishing in numbers perhaps toward the northern extreme. On the east its southern limit is in the vicinity of the Bay of Biscay, while northward it is found in the White Sea and on the southern shores of Spitzbergen. It of course does not enter the Mediterranean, though it is abundant in the North Sea and in the Baltic. Huxley hazards the conjecture that it perhaps inhabits some parts of the North Sea, and states that there is a very similar, if not identical, species in the North Pacific. His surmise as to the identity of the Pacific Herring with that of the Atlantic is not confirmed by the recent careful explorations of Dr. Bean in that region. The fish which he had in mind is probably *C. mirabilis*.

On our own coast Herring are not known to enter water which is in the least degree brackish, except occasionally in the spawning season in Saint Andrew's Bay, where the admixture of fresh water is but slight. According to Professor Huxley, Herrings spawn freely not only in the narrows of the Baltic, such as the Great Belt, in which the water is not half as salt as it is in the North Sea and in the Atlantic, but even in such long inlets as the Schlei in Schleswig, the water of which is quite drinkable and is inhabited by fresh-water fish.

Ljungman[2] cites instances in which Herrings are said to have ascended rivers in Sweden and Germany to a distance of several miles. The same author, however, seems inclined to believe that the Herring is far from having a predilection for fresh water, and that the few instances in which they have been observed spawning in brackish waters have been purely incidental and induced by the fact that suitable spawning places could not be found in waters of an ordinary degree of saltness.

The temperature preferred by the Herring has been more carefully determined in Europe than here. The observations of the Scotch and Dutch meteorological societies have demonstrated that the temperature of the water most favorable to the summer herring fisheries of their respective countries is about 55°.4 F., though during the Scotch winter fisheries the temperature ranges from 40°.1 F. to 41°.9 F., and during the Norwegian spring herring fisheries it ranges from 37°.4 F. to 39°.2 F. Commenting upon these figures, Ljungman remarks:

"There is good reason to suppose that the Herrings prefer a certain even temperature of the water, and that they consequently avoid too warm or too cold water. This degree of temperature, however, differs greatly according to the different locations, fisheries, and races of Herrings. The fishing for spawning Herrings is, for example, on the east coast of Scotland, going on at a season of

[1] Translation in United States Fish Commission Report, part vi, pp. 143–220.

[2] Report United States Fish Commission, part vi, p. 177.

the year when the temperature of the water is very high (from the middle of July till the middle of September), or very low (January to March). The observations of the Scotch and Dutch meteorological societies made during the Scotch and Dutch summer herring fisheries have shown that the temperature of the water most favorable to these fisheries is about 13° C. (55°.4 F.). During the Scotch winter fisheries, however, the temperature of the water ranges from 4°.5 C. to 5°.5 C. (40°.1 F. to 41°.9 F.), and during the Norwegian spring herring fisheries it only ranged from 3° C. to 4° C. (37°.4 F. to 39°.2 F.). But our observations are still so incomplete, and relate so exclusively to the spawning Herrings, that it is impossible to say anything with absolute certainty excepting the fact that the Herrings, when the temperature of the surface waters is either too high or too low, go to deeper waters."

The theory advanced by Ljungman in this last sentence is perhaps a little premature. Is it not supposable that local races of Herring exist and perform the various functions of life in totally different scales of temperature? This is undoubtedly the case with sedentary fresh-water species, such as the black bass, which, in its extreme northern range in North America, lives in waters which in midsummer are colder than those which southern fish ever experience even in winter. This view is not presented as a new one, but simply for the sake of introducing the illustration.

MIGRATIONS AND MOVEMENTS.—In Ljungman's report on the fisheries of Bohuslan, already quoted from,[1] is given the following recapitulation of the different scientific theories that have been in the past and are now heard concerning the migrations of the Herrings:

"In briefly recapitulating the different scientific theories regarding the migrations of the Herrings, it will be found that they may all be arranged under the following heads:

"*a*. The theory of a central race of Herrings, according to which all Herrings which are in the world belong to one great central race, from which all kinds of Herrings, both great and small, come. This theory is varied as follows:

"1. This central race of Herrings is supposed to live in the northern Polar Sea, from which large schools emigrate every year to those coasts where herring fisheries are carried on (Anderson, Pennant, and others).

"2. This central race of Herrings is constantly moving through the Northern Atlantic Ocean in a circle, whose extent is regulated by the declination of the sun (Gilpin).

"3. Besides this great central race of Herrings living in the Northern Atlantic Ocean, causing the great herring fisheries, smaller local races having separated in course of time, causing the smaller coast fisheries (Lundbeck).

"According to the first two of these three theories there would be no regular migrations, whilst such would take place according to the third.

"*b*. The theory of separate races of Herrings, according to which the different fisheries are caused by separate races of Herrings, each having its own locality. This theory is varied as follows:

"1. The theory of a coast race of Herrings, considering the Herring exclusively as a bottom fish. This may again be subdivided:

"*a*. Some suppose that there is only one local race of Herrings in every place, which, if not driven away by human agencies, always stays near the coast. There is consequently no difference between coast Herrings and sea Herrings, and there are no regular migrations (Nilsson).

"*b*. Others think that more than one race of Herrings may occur in one and the same place. There is consequently a difference between coast Herrings and sea Herrings, and there are regular

[1] Report, United States Fish Commission, part vi, p. 218.

migrations; but the proper homes even of the sea Herrings are the deep valleys on the bottom of the sea near the coast (Axel Boeck).

"2. The theory of a sea race of Herrings, considering the Herring as a surface fish. This theory is also subdivided:

"*a*. Some deny the occurrence of more than one race of Herrings in one and the same place, the difference between coast Herrings and sea Herrings (littoral and pelagian Herrings) and regular migrations (G. O. Sars).

"*b*. Others maintain that there is a relative difference between coast Herrings and sea Herrings, that more than one race of Herrings may be found in one and the same place, and that the great schools of Herrings migrate regularly (A. V. Ljungman)."[1]

This table is quoted as an illustration of the uncertainty which even to the present time exists concerning the migrations of this fish—an uncertainty which in all probability will never be removed. It is safe, however, to say that the theories enumerated in catalogue *a* had been long since abandoned by all scientific thinkers. The views of Sars and Ljungman that the Herring is practically a surface fish, not usually descending to great depth, perhaps never more than one hundred fathoms below the surface, are supported by many arguments of analogy; at any rate, they agree with what many investigators believe to be true concerning certain fish with some similar habits, such as the mackerel and menhaden. On the other hand, Herrings are known to occur off the Newfoundland coast, according to Mr. Earll, at a depth of fully one hundred fathoms, and there is no reason why they may not descend to still greater depths.

"If you read," writes Professor Huxley, "any old and some new books on the natural history of the Herring, you will find a wonderful story about the movements of these shoals: how they start from their home in the Polar Seas, and march south as a great armada which splits into minor divisions—one destined to spawn on the Scandinavian and one on our own shores; and how, having achieved this spawning raid, the spent fish make their way as fast as they can back to their arctic refuge, there to repair their exhausted frames in domestic security. This story was started in the last century, and was unfortunately adopted and disseminated by our countryman Pennant. But there is not the least proof that anything of the kind takes place, and the probabilities are wholly against it. It is, for example, quite irreconcilable with the fact that Herring are found in cods' stomachs all the year around. And the circumstance to which I have already adverted, that practiced eyes distinguish local breeds of Herrings, though it does not actually negative the migration hypothesis, is very much against it. The supposition that the Herring spawn in the north in the early spring, and in the south in the autumn, fitted very well into the notion that the vanguard of the migrating body of Herrings occupied the first spawning ground it reached, and obliged the rest of the horde to pass on. But, as a matter of fact, the northern Herrings, like the southern, have two spawning times; or perhaps it would be more correct to say that the spawning time extends from autumn to spring, and has two maxima—one in August–September and one in February–March."

Discussing the causes of the movements of the Herring schools, Professor Baird in 1877 wrote as follows:

"Although the movements of the Herring appear to be very capricious, they are doubtless governed as much by well-defined laws as any other portion of creation, although we are yet far from understanding fully the conditions which control their actions. They sometimes frequent a portion of the European coast for many successive years, and then abandon it gradually or suddenly, presenting themselves usually at the same season in some far remote locality. Sometimes

[1] Report United States Fish Commission, part iv, p. 178.

a wind blowing on shore will favor their inward migration; at other times it appears to have a directly opposite effect. Even when they reach the portion of the coast for which they are bound, the facilities of their capture depend upon meteorological conditions; and the Scottish Meteorological Society has been engaged for several years in ascertaining what these are, and how they may be best applied by the fishermen.[1]

[1] "The inquiry was restricted at first to the east coast of Scotland, and to pond-fishing districts therein, viz, Wick, Buckie, Peterhead, and Eyemouth, the last including the fishing ports of Dunbar and Eyemouth, Berwick and North Sunderland. Copies of the weekly returns sent to the fishery board from these districts during July to September, the season for the herring fishing for that part of Great Britain, for six years, beginning with 1867 and ending with 1872, giving the catch per week, the number of boats out in each district, were extracted from the reports, and an average of these six years calculated at several of the stations. These were finally compared day by day with two series of sea temperatures; one taken off Harris, and the other near Edinburgh.

"The temperature of the sea was found to rise very rapidly about the middle of July, and to keep oscillating slightly about a uniform temperature of 56° until the 13th of August, when it rapidly rose to the annual maximum, namely, 57°.2, and ranged relatively high until the first of September. This period of highest annual temperature, *namely, from the middle of July to the first of September, was found to be coincident with the fishing season in the* northern districts of Scotland; and the period when the temperature rises to the absolute maximum is farther coincident with the date of the largest catches during the fishing season. The committee, however, consider it premature to lay great stress on the striking coexistence of these facts, since it is impossible, without further statistics, to say whether these relations are of a permanent character. The fishing season did not begin until the sea temperature had risen to about 55½° in July, nor did it continue after it had fallen below 55½° in September.

"An important omission in these tables is, that they do not show whether they indicate the surface or bottom temperature of the sea, the difference in this respect being very appreciable. Another omission is, as to the relation between the spawning season of the Herring and their shoreward movement. Along the coast of the United States, the great spawning ground of the sea Herring is off the southern end of Grand Manan, where the surface and bottom temperatures sometimes differ at the spawning season by as many as five or six degrees.

"An important relation was also observed by the committee between the exceptional atmospheric temperatures and the migrations of the Herring, the fishing season beginning much later in the year, when the summer temperatures are low, than when they are high. As regards the relation between barometric observations and the fisheries, it appears that during the periods when good or heavy catches were taken, in a great majority of cases the barometer was high and steady, the winds light or moderate, and electrical phenomena wanting; when the captures were light, the observations often indicated a low barometer, strong winds, unsettled weather, and thunder and lightning.

"In conclusion, the committee recommend that, in further elucidation of the subject, steps should be taken to obtain information which may lead to the solution of the following queries:

"1. What determines the time of the commencement of the fishing?

"2. What determines the fluctuations in the catches of Herring in different districts, or in the same district on different days?

"3. What causes the absence of Herring during some seasons from certain districts of the coast?

"4. What determines the ending of the fishing season?

"The information required demands—

"1. An extension of the area examined, so as to include the Moray Firth, the Shetland, Orkney, and Hebrides Islands, and the west coast of Scotland.

"2. Daily returns of the number of boats fishing and the catch.

"3. The erection of self-registering sea thermometers at different points on the coast, similar to those now in operation at Peterhead Harbor.

"4. Thermometric observations taken by the fishermen themselves over the grounds fished; as it is only by the observations of numerous thermometers in continuous immersion that we can hope to obtain accurate information regarding those currents of cold and warm water round our coasts which are often found to interpenetrate each other, and which are supposed, with apparently good reason, to influence greatly the migration of the Herring. It is said that the Dutch fishermen derive valuable practical advantages from a system of this kind, and there can be no doubt that favorable results might confidently be looked for if a similar system were generally adopted by our fishermen.

"It is an interesting fact in the natural history of the Herring that, while the season for their capture is quite definite and generally uniform at any one point, it varies on different parts of the coast; thus, on the east of Great Britain, from Shetland in the north to Flamborough Head in the south, it occurs in July, August, and September, and a little earlier in the north than in the south. At Yarmouth the Herring season is in October and November; off the Kentish coast, in November and December; along the south coast of England, from October to December; off Cornwall, in August and September; in the North Channel, in June and July; and in the Hebrides, May and June.

"It is suggested by the Scottish committee in their report that when the periods of migration on all parts of the British sea-coast will have been calculated as closely as in Scotland, these will be found to bear a critical relation to the annual epochs of the temperature of the sea. This gives a renewed importance to the inquiries undertaken by

"In reference to the capture of Herrings far out at sea, Holdsworth refers to the fact that the Lowstoft herring fishery commences early in the spring, fifty to sixty miles from the coast, when the fish are poor and the roe very little prominent. The fishermen, however, accompany the schools in their slow progress to the coast; and when they get within a few miles the fish will be fattened up and the roe is in a much more advanced condition."

In his latest report, already several times quoted, Ljungman discusses the annual migrations of the herring schools and their causes:

"It has been mentioned before that the young Herrings begin to wander about at an early age, chiefly to seek food or shelter from their enemies, or possibly more agreeable places of sojourn. It has frequently been observed that the young Herrings, as they grow up, leave the shallow waters near the coast and go into deeper waters farther out towards the ocean, whence, after a while, they return to the coast in company with the older Herrings. The knowledge of the details of these migrations is, like our knowledge of their physical and biological causes, so limited that very little can be said regarding them.

"Regarding the coming of the Herrings from the sea to the coast, we only know that during the spawning season they generally approach the spawning places in dense schools, coming from the north, and that when visiting the coast for other purposes the schools are smaller and more scattered, extending over a larger stretch of coast, and come both from the north and the south. Those Herrings which come to seek food generally remain for some time in the outer waters before they come near the coast, and their visits are neither as regular nor as long as when they come to spawn. But even the great mass of Herrings does, during the spawning season, not remain near the coast longer than one or two months, exceptions from this rule being rare indeed. Herrings which have thus remained near the coast over their regular time become almost entirely worthless. During the last great Bohuslan herring fisheries this seems to have occurred more frequently.

"In approaching the coast the Herrings generally begin at a certain point, spreading from it either to the left or right, or in both directions, influenced in this by the weather, the currents of the sea, and the nature of the bottom. The Herrings do not like to visit the place where they have spawned a second time. It has also been noticed that the large Herrings do not go as high up the fiords as the small ones, and that when the spawning season comes in winter or spring the large Herrings spawn before the small ones, whilst when the spawning season comes in summer or autumn the small or younger Herrings spawn before the larger and older ones. After spawning, the Herrings have often been observed to go nearer the coast than before spawning; fishing with drag-nets may therefore be carried on long after fishing with stationary nets has ceased, as the 'empty' fish (those that have spawned) do not easily enter a stationary net.

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the United States Signal Service and the Fish Commission, on the American coast, in the way of determining of the sea temperature, etc., as connected with a very important branch of our domestic industries.

"In this connection we may state that the spawning season of the Herring, and the time of its catch, vary remarkably in different portions of our own coast. Thus, in parts of the Bay of Fundy and in the Gulf of Saint Lawrence it takes place in May and June, as in the Hebrides; at the Southern Head of Grand Manan, the great spawning ground, it occurs in September, commencing possibly in August, and extending into October; taking place later and later in the season as we proceed south. At the most southern point at which the Herring is positively known to spawn, namely, off Noman's Land and possibly Block Island, this does not occur until December and January.

"From this we may draw the inference that a certain minimum of temperature, rather than a maximum, is needed for the operation in question; and this occurring in the autumn, that the proper temperature is reached later and later as we proceed southward.

"It is to be hoped that the temperature observations now being made by the United States Fish Commission and by the Signal Service may enable us to solve these problems and to co-operate with our Scottish scientific brethren in getting at the true relation between physical conditions and the movements of such important food-fishes as the Herring, mackerel, cod, etc.—*Report of the Scottish Meteorological Society.*

"The going out of the Herrings is generally a much quicker process than their coming in, and as it is more difficult to catch Herrings whilst they are leaving the coast we know very little about it. After the Herrings have left the coast they do not stay outside any length of time, but immediately go out to sea to seek food and enjoy the greater protection which the deeper water affords. When the Herrings have been to the coast for the purpose of spawning they generally leave the coast in a northerly direction.

"With regard to the extent of the annual migrations of the Herrings I have already mentioned the different opinions, and I will only add here that the larger a school of Herrings is the greater will be the extent of territory where they must seek their food, and the farther from the coast must they extend their migrations. It is not known from direct observations how far the largest schools of Herrings extend their migrations, but certainly much farther than Macculloch, Nilsson, Boeck, and their followers assert.

"The annual migrations of the Herrings may be influenced by physical causes both as regards their time and their direction. It is well known that favorable, mild weather accelerates, whilst bad weather retards, the approach of the Herrings to the coast, and that wind and current may bring a much greater number of Herrings to one part of the coast than to another near it. The general rule, however, is that the Herrings, when coming in to spawn, visit the place where they were born. When the Herrings come in to seek food they will generally go to those waters where they have been accustomed to find food in the greatest abundance; those physical causes, therefore, which have an influence on the occurrence of food will also influence the direction of the Herring's migrations, as I have had occasion to remark before.

"The annual migrations of the Herrings are chiefly caused by the desire to propagate the species and to seek food. For spawning, the Herrings need a suitable bottom for depositing their eggs, a bottom which also must contain a sufficient quantity of food for the young Herrings and afford shelter for them. All these requirements are only met near a coast. Even if Herrings, as has sometimes been said, not without a show of reason, spawn on the Dogger Bank, or other still more distant banks in the North Sea, this does not disprove our assertion, for it is doubtless only the greater ease with which the young fish can reach the coast from these banks which has made it possible for the Herrings to spawn there.

"The grown Herrings must again go to the ocean to seek their food, which they chiefly find in the currents and those waters which come from the Polar Sea. In some places, however, they find the required food during some part of the year near the coast; and thus there may be fishing towards the end of summer and the beginning of autumn, as on the western coast of Norway, or during autumn and winter, as on the coast of Bohuslan. The influence which the desire for food exercises on the annual migrations of the Herrings has sometimes been overrated, so that it has occasionally been considered as the chief cause, even in cases when the desire to propagate was undoubtedly the principal cause.

"As the spawning Herrings, on account of their being packed more closely together and on account of the steady course which they pursue, are more exposed to the persecutions of their enemies, and as this danger of course increases the nearer they get to the coast, they generally go into deep water immediately after having spawned, in order to find the necessary shelter, and leave the coast much quicker than they came. The larger Herrings seem likewise to thrive better in the open sea than near the coast, and consequently do not stay there longer than is absolutely necessary. Neucrantz, however, goes too far when he supposes that the Herrings leave the coast only to escape unpleasant physical conditions; for instance, cold or violently agitated water. It has already been mentioned that want of space or the persecutions of enemies have in former

times by some been considered as the chief causes of the annual migrations and regular coast visits of the Herrings. Such opinions are, however, no longer entertained, and therefore cannot claim our attention."

PERIODICITY OF THE ABUNDANCE OF HERRINGS ON THE EUROPEAN COAST.—So far as is known, the abundance of Herrings in the Western Atlantic has been constant during the past two centuries; at the same time so little is our fishing population dependent on the herring fisheries when compared with that of Northern Europe that variations in abundance not being regarded as national disasters would, except, perhaps, in the case of Newfoundland, scarcely have been placed definitely upon record. Concerning the periodicity of the herring supply in Northern Europe Professor Baird writes:

"Among the various problems of interest in Northern Europe there are few of more economical importance than that connected with the movements of the Herring, a fish which in some years furnishes a supply of almost millions of barrels, and in others a few thousand are all that can be secured. While the cod always maintains its numbers and comes with unerring regularity in winter to spawn in the Loffoden Islands, and is found in moderate numbers on the coast throughout the rest of the year, the Herring appears and disappears without any, at present, intelligible cause. This variation in abundance is by some ascribed to a total disappearance from the coast, while others believe that it remains within a hundred miles of the Scandinavian shore, far out in the deep water between the banks of the North Sea and the coast of Norway, but that, owing to some peculiarity of temperature, currents, or possibly tainting of the water by the abundance of the so-called gurry, or offal, from the herring and cod fisheries, it is kept away. Down to a late period of the preceding century the Herring appeared in immense numbers with tolerable regularity, then left the coast, and did not return till 1808—a lapse of twenty years. For sixty-two years after that it presented itself with unfailing certainty, so much so that all fears of a possible diminution were banished; but since 1871 it has almost disappeared from the usual fishing stations, a few thousand barrels being the maximum catch where a million or more was the rule. This is what is known as the spring herring. The so-called 'great' Herring fishery has since 1870 attained a considerable importance at a distance of from five hundred to seven hundred miles from the spring herring locality. This diminution of the spring herring fishery of Scandinavia was for a few years of considerable advantage to the American fishery interest."

The following memoranda, communicated in 1878 by Mr. Joshua Lindahl, will serve to show the periodicity in the movements of the Herring in Europe:

"Before the sixteenth century no records were kept of the fisheries. As, however, both king and church had some income from taxation and tithe on the Herring, it has been possible to ascertain that such fisheries have existed periodically ever since the beginning of the eleventh century. Before that time the archipelago was hardly inhabited, and the fishing seems not to have been of any importance but to the scanty population on the fiords, who had too primitive implements for capturing large quantities of fish, and no means of preparing the article for a distant market. The following is a list of the herring periods of which we have any knowledge:

"1. About the year 1020.

"2. In the latter part of the twelfth century.

"3. From about 1260 to about 1341, thus lasting more than eighty years.

"4. About the middle of the fifteenth century.

"5. From 1556 to 1590, thus lasting for thirty-five years; interval to next period, sixty-nine years.

"6. From 1660 to 1680, thus lasting for twenty-one years; interval to next period, sixty-six years.

"7. From 1747 to 1808, thus lasting for sixty-two years; interval to next period, sixty-eight years.

"8. From November, 1877, to February, 1878.

"The most important period was the above No. 7, especially during the last twenty years of the last century. It has been calculated that in some years during that time the annual quantity of Herring fished in Bohuslan amounted to at least 1,500,000 barrels.

"During the six weeks January 1 to February 15, this present year, about 160,000 barrels of fresh and salt Herring were shipped from the archipelago of Bohuslan to neighboring markets. The fishermen and merchants are preparing largely for making big hauls when the Herring will return in the fall, as is expected."

As early as the middle of the last century one of the periods of scarcity was foretold by Prof. Hans Ström, of Norway, who observed that the Herrings during the period they visited the coast of Sondmor (1736–1756) came later and later every year, and predicted, in accordance with an old tradition and the experience had at Stät, that the Herring fisheries of Sondmor would come to an end. This really took place in Bohuslan, where it had been observed already towards the middle of the last great fishery period that the Herrings came to the coast later and later every year, which led people to fear that, as in times of old, the Herrings might again gradually leave the Swedish coast. Somewhat later (1782) Ström compared the Bohuslan fisheries with those of Norway, and, basing his opinion on their evident similarity, predicted that the end of the Bohuslan fisheries was near at hand.

About ten years later Lybecker expresses himself more distinctly, as follows: "If with prophetic eye we could see the future and predict the fate of the fisheries, we might say with a great degree of probability that a change will take place soon. We know from history that when Herrings or other fish of passage arrive near the coast later and later, and at the same time keep farther and farther away from the coast, this means a change in the migrations of the Herrings, and may even point to their leaving the coast entirely. This has been the course of the Norwegian herring fisheries, and even of the Swedish herring fisheries during their older periods, and in fact with all those fisheries where fish of passage are the principal object, with the only exception of the Scotch and English fisheries. . . . If we take into consideration the roving nature of the Herrings and the examples from olden times, it is highly probable that the Herrings will come later every year, and finally leave our coast altogether."

It had frequently been maintained that too much fishing and fishing with destructive apparatus were the proper causes of the growing tardiness of the arrival of the Herrings and might even lead to the complete cessation of the fisheries; and people therefore made futile attempts to obviate this danger by legislation. As the ominous predictions regarding the herring fisheries were, however, not immediately fulfilled, they were almost forgotten; but when the herring fisheries came to an end in the year 1808, people imagined that the Herrings arriving later and later every year fully proved the assertion that they had been driven away by the imprudent actions of the fishermen. It was said that refuse thrown into the water, and noise, had prevented the Herrings from coming near to the coast, and they had spawned in the open sea, and had then, in consequence of the languor and weakness following the spawning, been driven towards the coast by storms.

During the more recently closed Norwegian spring herring fisheries, it was, according to Loberg, noticed, not without anxious forebodings, that the Herrings, which in the beginning of the fishing period did not come near the coast till early in February, gradually came earlier and

earlier, so that finally the fisheries commenced before New Years; and that this change was followed by another, the Herrings coming later and later, till the fisheries did not commence before February. This peculiarity, however, was thought to be a consequence of the irregularity with which the Herrings visited the same places on the coast. It was not till Axel Boeck began to investigate the matter that this whole question was treated from a more scientific standpoint. He showed that the coming of the herrings to the coast at different times during the period was subject to certain rules, and that this regularity in the movements of the Herrings was observed not only during the Norwegian spring herring fisheries of the seventeenth and eighteenth centuries, but also during those herring fisheries which were going on on the coast of Bohuslan during the second half of the fifteenth and seventeenth centuries. This peculiar phenomenon has therefore become far more important than it was thought to be in former times; and it may well be said to contain the key to the question of the periodicity of the great Scandinavian herring fisheries. Boeck was not able to assign any cause for these entirely regular changes in the time of the Herrings' visits to the coast. This has been attempted, however, by G. O. Sars and myself, and an account of these attempts will be given below.

In a paper entitled "The Great Bohuslan Herring Fishery,"[1] A. N. Ljungman gives a very interesting account of the periods of abundance of Herring in Sweden and of the herring fisheries of that region from 1000 A. D. to the present date.

REPRODUCTION.—There are several interesting series of observations upon the spawning habits of the Herring, the hatching of the egg, and the development of the young; all of which may be found in the later volumes of the Report of the United States Commissioner of Fisheries.

In his lecture on the Herring, Professor Huxley describes in a very concise and lucid way their spawning habits. He remarks: "We have hitherto met with no case of full or spawning Herrings being found, in any locality, during what may be termed the solstitial months, namely, June and December; and it would appear that such Herrings are never (or very rarely) taken in May, or the early part of July, in the latter part of November, or the early part of January. But a spring spawning certainly occurs in the latter part of January, in February, in March, and in April; and an autumn spawning in the latter part of July, in August, September, October, and even as late as November. Taking all parts of the British coast together, February and March are the great months for the spring spawning, and August and September for the autumn spawning. It is not at all likely that the same fish spawn twice in the year; on the contrary, the spring and the autumn shoals are probably perfectly distinct; and if the Herring, according to the hypothesis advanced above, come to maturity in a year, the shoals of each spawning season would be the fry of the twelvemonth before. However, no direct evidence can be adduced in favor of this supposition, and it would be extremely difficult to obtain such evidence.

"I believe that these conclusions, confirmatory of those of previous careful observers, are fully supported by all the evidence which has been collected; and the fact that this species of fish has two spawning seasons, one in the hottest and one in the coldest month of the year, is very curious.

"Another singular circumstance with the spawning of the Herring is the great variety of the conditions, apart from temperature, to which the fish adapts itself in performing this function. On our own coast, Herrings spawn in water of from ten to twenty fathoms, and even at greater depths, and in a sea of full oceanic saltness. Nevertheless, Herrings spawn just as freely not only in the narrows of the Baltic, such as the Great Belt, in which the water is not half as salt as it is in the North Sea and in the Atlantic, but even in such long inlets as the Schlei in Schleswig, the water

[1] A translation of which is published in United States Fish Commission Report, part vi; pp. 221–239.

of which is quite drinkable and is inhabited by fresh-water fish. Here the Herrings deposit their eggs in two or three feet of water; and they are found, along with the eggs of fresh-water fish, sticking in abundance to such fresh-water plants as *Potamogeton*.

"Nature seems thus to offer us a hint as to the way in which a fish like the shad, which is so closely allied to the Herring, has acquired the habit of ascending rivers to deposit its eggs in purely fresh water.

"If a full female Herring is gently squeezed over a vessel of sea-water, the eggs will rapidly pour out and sink to the bottom, to which they immediately adhere with so much tenacity that, in half an hour, the vessel may be inverted without their dropping out. When spawning takes place naturally, the eggs fall to the bottom and attach themselves in a similar fashion, but at this time the assembled fish dart wildly about, and the water becomes cloudy with the shed fluid of the milt. The eggs become thus fecundated as they fall, and the development of the young within the ova sticking to the bottom commences at once.

"The first definite and conclusive evidence as to the manner in which herring-spawn is attached and becomes developed that I know of was obtained by Professor Allman and Dr. Macbain in 1862, in the Frith of Forth. By dredging in localities in which spent Herring were observed on the 1st of March, Professor Allman brought up spawn in abundance at a depth of fourteen to twenty-one fathoms. It was deposited on the surface of the stone, shingle, and gravel, and on old shells and coarse shell-sand, and even on the shells of small living crabs and other crustacea, adhering tenaciously to whatever it had fallen on. No spawn was found in any other part of the Forth; but it continued to be abundant on both the east and the west sides of the Isle of May up to the 13th of March, at which time the incubation of the ovum was found to be completed in a great portion of the spawn, and the embryos had become free. On the 25th scarcely a trace of spawn could be detected, and nearly the whole of the adult fish had left the Forth.

"Professor Allman draws attention to the fact that 'the deposit of spawn, as evidenced by the appearance of spent Herrings, did not take place till about sixty-five days after the appearance of the Herring in the Frith,' and arrives at the conclusion that 'the incubation probably continues during a period of between twenty-five to thirty days,' adding, however, that the estimate must, for the present, be regarded as only approximative. It was on this and other evidence that we based our conclusion that the eggs of the Herring 'are hatched in at most from two to three weeks after deposition.'

"Within the last few years a clear light has been thrown upon this question by the labors of the West Baltic Fishery Commission, to which I have so often had occasion to refer. It has been found that artificial fecundation is easily practiced, and that the young fish may be kept in aquaria for as long as five months. Thus a great body of accurate information, some of it of a very unexpected character, has been obtained respecting the development of the eggs and the early condition of the young Herring.

"It turns out that, as is the case with other fishes, the period of incubation is closely dependent upon warmth. When the water has a temperature of 53° F. the eggs of the Herring hatch in from six to eight days, the average being seven days. And this is a very interesting fact when we bear in mind the conclusion to which the inquiries of the Dutch meteorologists, and, more lately, those of the Scottish Meteorological Society, appear to tend, namely, that the shoals prefer water of about 55° F. At 50° F. the period of incubation is lengthened to eleven days; at 46° F. to fifteen days; at 38° F. it lasts forty days. As the Forth is usually tolerably cool in the month of March, it is probable that Professor Allman's estimate comes very near the truth for the particular case which he investigated.

"The young, when they emerge from the egg, are from one-fifth to one-third of an inch in length, and so extremely unlike the adult Herring that they may properly be termed 'larvæ.' They have enormous eyes and an exceedingly slender body, with a yelk-bag protruding from its fore part. The skeleton is in a very rudimentary condition; there are no ventral fins; and, instead of separate dorsal, caudal, and anal fins, there is one continuous fin, extending from the head along the back, round the tail, and then forward to the yelk-bag. The intestine is a simple tube, ciliated internally; there is no air-bladder, and no branchiæ are yet developed. The heart is a mere contractile vessel, and the blood is a clear fluid without corpuscles. At first the larvæ do not feed, but merely grow at the expense of the yelk, which gradually diminishes.

"Within three or four days after hatching, the length has increased by about half the original dimensions, the yelk has disappeared, the cartilaginous skeleton appears, and the heart becomes divided into its chambers; but the young fish attains nearly double its first length before blood-corpuscles are visible.

"By the time the larva is two-thirds of an inch long (a length which it attains one month after hatching), the primitive median fin is separated into dorsal, caudal, and anal divisions, but the ventral fins have not appeared. About this period the young animal begins to feed on small crustacea; and it grows so rapidly that at two months it is one and a quarter inches long, and at three months has attained a length of about two inches.

"Nearly up to this stage the elongated, scaleless little fish retains its larval proportions; but in the latter part of the third month the body rapidly deepens, the scales begin to appear, and the larva passes into the 'imago' state, that is, assumes the forms and proportions of the adult, though it is not more than two inches long. After this, it goes on growing at the same rate (eleven millimeters, or nearly half an inch) per month, so that at six months old it is as large as a moderate-sized sprat.

"The well-known 'Whitebait' of the Thames consists, so far as I have seen, almost exclusively of Herrings under six months old, and as the average size of Whitebait increases from March and April onward until they become suspiciously like sprats in the late summer, it may be concluded that they are the progeny of Herrings which spawned early in the year in the neighborhood of the estuary of the Thames, up which these dainty little fish have wandered. Whether it is the general habit of young Herring, even of those which are spawned in deep water, to migrate into the shallow parts of the sea, or even into completely fresh waters, when such are accessible, is unknown.

"In the 'Report on Trawling' (1863) we observe: 'It is extremely difficult to obtain any satisfactory evidence as to the length of time which the Herring requires to pass from the embryonic to the adult or full condition. Of the fishermen who gave any opinion on this subject, some considered that a Herring takes three, and others that it requires seven, years to attain the full or spawning condition; others frankly admitted that they knew nothing about the matter; and it was not difficult, by a little cross-examination, to satisfy ourselves that they were all really in this condition, however strongly they might hold by their triennial or septennial theories. Mr. Yarrell and Mr. Mitchill suppose with more reason that Herring attain to full size and maturity in about eighteen months. It does not appear, however, that there is any good evidence against the supposition that the Herring reaches its spawning condition in one year. There is much reason to believe that the eggs are hatched in, at most, from two to three weeks after deposition, and that in six to seven weeks more (that is, at most, ten weeks from the time of laying the eggs) the young have attained three inches in length. Now, it has been ascertained that a young smolt may leave a river and return to it again in a couple of months increased in bulk eight or ten fold, and as a

Herring lives on very much the same food as a smolt, it appears possible that it should increase in the same rapid ratio. Under these circumstances nine months would be ample time for it to enlarge from three to ten or eleven inches in length. It may be fairly argued, however, that it is not very safe to reason analogically from the rate of growth of one species of fish to that of another; and it may be well to leave the question whether the Herring attains its maturity in twelve, fifteen, or sixteen months open, in the tolerably firm assurance that the period last named is the maximum.'

"On comparing these conclusions with the results of the careful observations of the Baltic commissioners, it appears that we somewhat overestimated the rate of growth of the young Herring, and that the view taken by Yarrell and Mitchill is more nearly correct. For, supposing that the rate of growth after six months continues the same as before, a Herring twelve months old will be nearly six inches long, and at eighteen months eight or nine inches. But full Herrings may be met with little more than seven inches long, and they are very commonly found not more than nine inches in length.

"Herrings which have attained maturity, and are distended by the greatly enlarged milt or roe, are ready to shed the contents of these organs, or, as it is said, to spawn. In 1862 we found a great diversity of opinion prevailed as to the time at which this operation takes place, and we took a great deal of trouble to settle the question, with the result which is thus stated in our report: 'We have obtained a very large body of valuable evidence on this subject, derived partly from the examination of fishermen and of others conversant with the herring fishery; partly from the inspection of the accurate records kept by the fishery officers at different stations, and partly from other sources; and our clear conclusion from all this evidence is, that the Herring spawns at two seasons of the year, in the spring and in the autumn.'

"The milt and roe are elongated organs attached beneath the air-bladder, which lie one on each side of the abdominal cavity, and open behind the vent by an aperture common to the two. The spermatic fluid of the male is developed in the milt and the eggs of the female in the roe. These eggs, when fully formed, measure from one-sixteenth to one twenty-fifth of an inch in diameter; and as, in the ripe female, the two roes or ovaries stretch from one end of the abdominal cavity to the other, occupying all the space left by the other organs, and distending the cavity, the number of eggs which they contain must be very great; probably ten thousand is an underestimate of the number of ripe eggs shed in spawning by a moderate-sized female Herring. But I think it is safer than the thirty thousand of some estimates, which appear to me to be made in forgetfulness of the very simple anatomical considerations that the roe consists of an extensive vascular framework as well as of eggs; and, moreover, that a vast number of the eggs which it contains remain immature and are not shed at the time of spawning."[1]

Professor Baird, in 1877, wrote as follows concerning the spawning habits of the Herring on our own coast:

"In the Bay of Saint Lawrence they appear to spawn in the spring, especially in the vicinity of the Magdalen Islands, the fishes there taken being ripe with eggs. At that time they come so close to the land as to permit their capture in immense numbers in seines. It is also thought that a so called school spawns in the spring in the Bay of Fundy, from the head to the mouth. Such a spawning ground is believed to exist in the Bay of Saint Andrew's, and in certain portions of

[1] The observations of Mr. Earll at Eastport indicate that in his opinion none of the Herrings used in the sardine factories are old enough to show any traces of developing spawn, although there can be no doubt that they are not less than a year old. The fish upon which his observations were made were taken in September, and must have been hatched as early as the September of the preceding year.

Passamaquoddy Bay. One principal spawning ground of the Herring in the Bay of Fundy, is near the southern head of Grand Menan; and by a very wise provision of the New Brunswick Government, a close time was many years ago enacted, extending from the 15th of June to the 15th of September, during which the capture of these fish was forbidden. They now resort to that portion of the coast in considerable numbers, and the quantity of eggs deposited is said to be something almost inconceivable.

"The spawning season, too, appears to be later and later as we proceed westward from Maine. Thus, allowing it to be at its height there in the beginning of August,[1] it occurs in September off the coast of Maine, and in October off Eastern Massachusetts; in November at Cape Cod, and in December at Noman's Land and Block Island; possibly still later farther south.

"The eggs are minute, less in size than those of the shad, and adhere when discharged to rocks, seaweed, etc., being scattered singly or in bunches over a vast extent of sea bottom. I have frequently brought them up at various depths and at a considerable distance from the shore, off Grand Menan."[2]

ARTIFICIAL PROPAGATION OF THE HERRING.—In the spring of 1878 the first successful experiments in the artificial propagation of Herring were carried on in Germany by Dr. H. A. Meyer, of the Commission for Scientific Investigation of the German Seas at Kiel, and in the fall of the same year by Mr. R. E. Earll, of the United States Fish Commission, at Gloucester. A translation of Dr. Meyer's paper may be found in part vi, United States Fish Commission Report, pp. 629–638, and a brief summation of Mr. Earll's experiments in the same volume, pp. 727–729.

FOOD.—Much has been written upon the food of the Herring, but the following translation from an article in "Die Natur," No. 47, 1869, gives in a very satisfactory manner recent views of European authorities upon the subject:

"Of the various fishes that inhabit the waters, few have, perhaps, more direct bearing upon the prosperity of the maritime people of the north than the sea Herring; the shores of both hemispheres being visited regularly by countless myriads that furnish an inexhaustible source of food. It is, therefore, not to be wondered at that the attention of fishermen, as well as statesmen and political economists, has been directed to the different questions connected with the migrations and preservation of these fish, and that much research should have been expended in determining various points connected with their history. Until quite

[1] A large school of Herrings appears annually in the vicinity of Boisbobert Island, in Eastern Maine, off Millbridge, where they spawn on the rocky bottom.—R. E. EARLL.

[2] A visit in 1872 to the Southern Head of Grand Menan, during the spawning season of the Herring, enabled my assistant, Dr. Palmer, to obtain a very interesting series of eggs and young by using the dredge, the eggs being found at low water, from near the shore, out to a distance of several miles.

Over an extended area, whenever any gravel, stones, or sea-weed were brought up with the dredge they were found to be thickly dotted over with these eggs, sometimes single, at others in clusters.

It would appear that in the operation of exclusion, the eggs fall away into the water in masses varying in size, although in no instance was the entire spawning of any one fish observed in a single mass. The largest aggregations consisted of masses of the size of a hazel-nut. Sometimes these heat up and separate entirely. The eggs were very minute, not larger than No. 7 shot, and when taken up nearly all the eggs contained embryos, of which the eyes were very large and distinct. The eggs appear to sink to the bottom if not laid there originally, and to adhere at once to adjacent objects. A careful straining of the surface-water and down to a considerable depth with the towing-net, or hand gauge-net, brought up no floating eggs.

A large number of eggs were brought over to Eastport in salt water and a considerable number of these hatched out on the way, during an interval of a few hours, and many others became developed soon after they were brought ashore. All the embryos had left their envelopes by the next morning. The young could be distinctly seen inside of the egg, and when this was ruptured they were extremely active in their movements through the water, springing up and down and crosswise, wriggling precisely like the larvæ of a dipterous insect. Their length at this time was about thirty one-hundredths of an inch, some few being larger and others rather smaller.

recently, however, one important element of their biography has been unsolved, namely, the precise nature of the food upon which they subsist, at least during the time when they come into the vicinity of the shore, although their varying degree of excellence throughout the year is believed to depend largely upon what they find to eat in the different months.

"Intimately connected with this same subject of the food of the Herring is the fact that at times it is found almost impossible to preserve the fish after being caught, since, notwithstanding the prompt use of salt, decomposition ensues and spoils the entire catch. Indeed, at certain seasons of the year, it is said that Herrings cannot be preserved at all except by taking the precaution of retaining them alive in the net for a period of from three to ten days.

"A very important communication on the food of the Herring has lately been published by a Danish author, Mr. Axel Boeck, from which we learn that the herring food, or 'meat,' consisting almost entirely of minute invertebrate animals, is divided by the northern fishermen into three classes; the 'red,' the 'yellow,' and the 'black,' the names being derived from the color of this food when living, or else from its appearance when in the fish's stomach. The red meat (*Rödaat*) is the most common and best known, and occurs along the entire coast of Norway and in the mouths of the bays (but more sparingly in the bays themselves), and in the open sea, diminishing in amount, apparently, with the depth. At certain periods of summer, however, it appears in such immense abundance that the sea is colored red by it. When floating in this way upon the surface, it attracts innumerable schools of mackerel, as well as of Herrings, which are then much less shy than usual, and the scene is one of impressive activity, owing to the number of boats and nets employed in fishing. On a careful examination this substance was found to consist almost entirely of small crustaceans, Copepod, the largest, scarcely the thirtieth of an inch in length and barely distinguishable by the naked eye.

"It can hardly be believed that such minute and almost microscopic animals can be of so much importance to the welfare of a nation; but in reality the mackerel and the autumnal Herrings owe their fatness to them, the microscope revealing through their thin shells the fat lying in distinct strips between the muscles and intestines.

"These same crustaceans occur also off Spitzbergen in such abundance as to furnish food to innumerable water fowl; and even the whales feed upon them to a great extent.

"If, now, the Herring has taken in a large quantity of this 'red food,' and is then captured and killed without its having been fully digested, the animal matter in the stomach of the fish begins to spoil before it can be reached by the salt, and the stomach thus becomes putrid, as well as the large bloodvessel which lies under the back, the coloring matter of the blood imparting a reddish tinge to the flesh alongthe backbone. For this reason it is required by law to keep Herrings three days in the nets, in order that all the contents of the stomach may be completely digested, while the fish is prevented from taking in a fresh supply. Sometimes, however, the winds drift this herring food into the nets, and furnish to the Herrings an opportunity, which they eagerly embrace, rendering them again liable to the difficulty just mentioned.

"When a Herring, on being squeezed, discharges a yellow pulp, this is known as 'yellow meat,' or *Gulaat*. This is not so abundant as the other, but appears, like the 'red meat,' to be composed in part of transparent Copepods, together with the larvæ of tapeworms and other annelids which occur on the Norwegian coast in immense numbers. It is stated that the surface of the sea is sometimes seen to be completely covered with little worms of about the twenty-fourth of an inch in length, swimming actively about by means of certain hairs which encircle their bodies like a girdle. These animals were sufficiently developed to permit their

identification as the young of *Leucodore ciliata*. Herring and mackerel feed largely upon these animals, so that the 'yellow meat' consists in greater part of the fine hairs which cover the exterior of the larvæ in question. This kind of food is considered to interfere less with the proper curing of the Herring, as it is much more quickly digested.

"The most objectionable kind of herring food, however, is that which is known as the 'black meat,' or *Svartaat*, sometimes called *Krutaat*, and occurring on the surface of the sea in the form of little granules moving freely about, but which sink on being touched. This is said to be most abundant in rainy seasons when there is a short interval of fine and clear weather. Herring that have fed on this substance are considered to be entirely unfit for salting, even when kept in the nets for a much longer time than that already mentioned. The salted fish has an extremely disagreeable smell, even after the stomach with its contents has been removed. A microscopic examination of this matter showed that it consists entirely of the larval young of small shells found among the sea-weed and belonging to the genus *Rissoa*. These swim by means of two flippers, covered with hairs, which are protruded from a transparent shell having from three to seven turns or windings. They are about one-tenth of an inch in length, and on being touched draw within the shell and sink to the bottom. When full grown, these mollusks lose their flippers and creep about the sea-weed by means of a large foot. Thus, it is easy to understand why this 'black meat' is more dangerous than the other kinds. While the shells of the animals forming the 'red meat' are quite thin and the bodies of the 'yellow meat' are very soft, those of the 'black meat,' on the contrary, being inclosed in hard shells, are not so readily reached by the digestive fluid, so that while the exterior parts, namely, the swimming flippers, are quickly digested the rest of the body within the shell becomes decomposed. On this account the flesh of the Herring after feeding upon these mollusks soon becomes tainted by their decomposition and gives out a disagreeable smell, notwithstanding the application of salt.

"It may be asked why the summer and autumnal Herrings feed upon this food and not the spring Herring, nor those taken in the open sea, both the latter being capable of preservation without any detention in the nets. The reason of this seems to be that the spring and open-sea Herrings are captured when under the stimulus of the spawning season and in the search for a suitable place for the development of their young. At this time the question of food is reduced to zero or near it, and a careful examination of the stomachs of Herrings taken under such circumstances shows comparatively little animal matter. Summer and autumn Herrings, on the other hand, are specially engaged in seeking for food and bringing up their flesh, and that at a time when the larvæ of the lower animals are found swimming freely about in large quantity upon the surface of the sea."[1]

CAPTURE AND USES.—The methods of capture of the Herring are fully described in the chapter by Mr. Earll upon the herring fisheries of the United States (to be printed in a subsequent portion of this report).

"It is not a little remarkable," writes Professor Baird, "that while with most fish the spawning

[1] Professor Möbius found that almost the sole food of the Herring taken in Kiel Bay, in the winter and spring of 1872, when they were captured in immense quantities, consisted of a minute crustaceous animal, nearly allied to the common fresh-water cyclops, and but little larger. The apparatus, which enables the Herring to feed on these minute creatures, is described by Professor Möbius as a sort of basket or "lobster-pot," formed by the arches of the gills, each of which is furnished with a close-set fringe of teeth, while each of the latter bears two rows of minute spines. The interlacing of these teeth and spines produces a narrow lattice-work, through which the water can readily pass, while the little swimming animals contained in it are left behind in the mouth of the fish and gradually pass down into its stomach. Some notion of the number of little crustaceans consumed by the Herring may be formed from the fact that Professor Möbius reckons 10,000 as the average number to be found in a Herring's stomach, and in one instance no fewer than 61,000 were found. The sprat, the mackerel, and some other fishes, are provided with an apparatus more or less resembling that of the Herring.—*Annals of Natural History*.

season is considered an undesirable period for their capture, with the *Clupeidæ*, such as the shad, the alewife, and the sea Herring, they are then thought to be in the greatest perfection; indeed, females, full of partially developed eggs, are esteemed a great delicacy, both in regard to the fish and the roe. Nearly all the European fisheries, especially those on the coast of Scotland, are carried on when the fish is in full roe, when the taking of fish is considered very prejudicial to the perpetuation of the species. The number taken, however, does not appear to affect the abundance of the Herring, and, indeed, with the enormous yield of eggs, a very small percentage of adults will keep up the supply.

"There appears to be as much uncertainty in Europe as there is in this country in regard to the exact period of the growth of the Herring, Ljungman[1] remarking that the spring Herring spawned in March attain a length of two and a half to three and a half inches by the end of the year, and that in the following May, or at the age of one year, their average length is four inches. He states that the two-year-old fish range from five and a half to six inches in length, and that those of three years are six or seven inches long, having the sexual apparatus complete but not highly developed. The eight-inch fish are four years old, while those larger are of still greater age."

In Europe the ways in which Herrings are prepared for use as food are very numerous and varied, there being many ways of salting them, many ways of smoking them, and many ways of preserving them in spices. The day is probably not distant when Europe will follow the example of the United States and employ them extensively in the manufacture of sardines. The European fishery reports are full of codes of instruction for preparing the different grades of Herrings for exportation and local consumption; but, as a rule, these preparations are not congenial to the American palate, and need not here be particularly described. Our supply of other excellent food fishes is so great that but little attention is paid by American fishermen to the capture of Herrings for food. Many cargoes of frozen Herrings are brought from Newfoundland and the Bay of Fundy to Boston, New York, and Philadelphia to serve for the food of the poorer classes during the Lenten season. A limited quantity of pickled Herrings is also imported from the British Provinces. Smoked Herrings are produced to the amount of 370,615 boxes in Eastern Maine, and large quantities are imported from New Brunswick and Nova Scotia, which are sent chiefly to the West and South, though small quantities are consumed in the rural districts of New England. Before the rebellion Eastern Maine engaged largely in herring-smoking for the purpose of supplying the demand of the slave-owning States, and many cargoes of fish slightly pickled for smoking were brought from the Magdalen Islands. This business was broken up by the war, and most of the smoke-houses remain abandoned to this day. Considerable quantities of smoked Herrings are now put up in small packages with skin and bones removed, under the trade name of "boneless Herring." By far the greatest consumption of Herrings for food is in the shape of so-called sardines, packed for the most part in cotton-seed oil, and in cans made in imitation of those imported from France. This industry began in 1875 and increased yearly until 1880, when the production amounted to 2,377,152 one-pound cans, worth $772,176.

Fresh Herrings and salted Herrings are used extensively for bait in the halibut and cod fisheries, and a special night fishery with torches for young Herrings, or Sperling, is carried on in the fall months about Cape Ann, Massachusetts, for the supply of the shore fishermen.

THE ALLEGED DESTRUCTIVENESS OF THE HERRING FISHERY.—As has already been remarked, the Herring fishery is not at present of sufficient importance upon our coast to have provoked the protection of the law, although the only place in the world where the spawning Herrings are protected by the law is at the southern end of Grand Manan, within twenty-five miles

[1] United States Fish Commission Report, p. 144.

from the western boundary of the United States. The question of the protection of the Herring is not likely soon to come up in our legislatures. It has, however, for many years been deeply agitated in Europe, and in Great Britain especially has occupied the attention of learned commissions for periods extending over many months. In 1862 and 1865 special commissions were engaged in the investigation of the influence of the trawl-net fishery, particularly with reference to its connection with the herring fishery. And it is a matter of considergble interest to be able to quote in a few paragraphs the conclusions reached by Professor Huxley, who was a member of each of these commissions, not because, as already suggested, the question of protecting the herring fishery is likely to be agitated in the United States, but because the same class of facts and the same train of reasoning will apply with almost equal force to the problem of the protection of the mackerel, menhaden, and other similar fisheries. He spoke as follows in 1881 in the lecture already referred to:

"I do not believe that all the herring fleets taken together destroy five per cent. of the total number of Herrings in the sea in any year, and I see no reason to swerve from the conviction my colleagues and I expressed in our report, that their destructive operations are totally insignificant when compared with those which, as a simple calculation shows, must regularly and normally go on.

"Suppose that every mature female Herring lays 10,000 eggs, that the fish are not interfered with by man, and that their numbers remain approximately the same year after year, it follows that 9,998 of the progeny of every female must be destroyed before they reach maturity. For, if more than two out of the 10,000 escape destruction, the number of Herrings will be proportionately increased. Or, in other words, if the average strength of the shoals which visit a given locality is to remain the same year by year, many thousand times the number contained in those shoals must be annually destroyed. And how this enormous amount of destruction is effected will be obvious to any one who considers the operations of the fin-whales, the porpoises, the gannets, the gulls, the codfish, and the dog-fish, which accompany the shoals and perennially feast upon them; to say nothing of the flat-fish, which prey upon the newly-deposited spawn; or of the mackerel and the innumerable smaller enemies which devour the fry in all stages of their development. It is no uncommon thing to find five or six—nay, even ten or twelve—Herrings in the stomach of a codfish, and in 1863 we calculated that the whole take of the great Scotch herring fisheries is less than the number of Herrings which would in all probability have been consumed by the codfish captured in the same waters if they had been left in the sea. Man, in fact, is but one of a vast co-operative society of herring catchers, and the larger the share he takes the less there is for the rest of the company. If man took none, the other shareholders would have a larger dividend, and would thrive and multiply in proportion, but it would come to pretty much the same thing to the Herrings.

"As long as the records of history give us information, Herrings appear to have abounded on the east coast of the British Islands, and there is nothing to show, so far as I am aware, that, taking an average of years, they were ever either more or less numerous than they are at present. But, in remarkable contrast with this constancy, the shoals of Herrings have elsewhere exhibited a strange capriciousness—visiting a given locality for many years in great numbers, and then suddenly disappearing. Several well marked examples of this fickleness are recorded on the west coast of Scotland; but the most remarkable is that furnished by the fisheries of Bohuslan, a province which lies on the southwestern shore of the Scandinavian Peninsula. Here a variety known as the 'old' or 'great' Herring, after being so extremely abundant, for about sixty years,

as to give rise to a great industry, disappeared in the year 1808, as suddenly as they made their appearance, and have not since been seen in any number.

"The desertion of their ordinary grounds by the Herring has been attributed to all imaginable causes, from fishing on a Sunday to the offense caused to the fish by the decomposing carcasses of their brethren, dropped upon the bottom out of the nets. The truth is, that absolutely nothing is known on the subject, and that little is likely to be known until careful and long-continued *meteorological and zoological observations have furnished definite information respecting the* changes which take place in the temperature of the sea, and the distribution of the pelagic crustacea which constitute the chief food of the herring shoals. The institution of systematic observations of this kind is an object of international importance, toward the attainment of which the British, Scandinavian, Dutch, and French Governments might wisely make a combined effort.

"A great fuss has been made about trawlers working over the spawning grounds of the Herring. 'It stands to reason,' we were told, 'that they must destroy an immense quantity of the spawn.' Indeed, this looked so reasonable that we inquired very particularly into a case of the alleged malpractice which was complained of on the east coast of Scotland, near Pittenweem. Off this place there is a famous spawning ground known as the Traith Hole, and we were told that the trawlers worked vigorously over the spot immediately after the Herring had deposited their spawn. Of course our first proceeding was to ask the trawlers why they took the trouble of doing what looked like wanton mischief. And their answer was reasonable enough. It was to catch the prodigious abundance of flat-fish which were to be found on the Traith at that time. Well, then, why did the flat-fish congregate there? Simply to feed on herring eggs, which seem to be a sort of flat-fishes' caviare. The stomachs of the flat-fish brought up by the trawl were, in fact, crammed with masses of herring eggs. Thus every flat-fish caught by the trawl was an energetic destroyer of Herring arrested in his career. And the trawling, instead of injuring the Herring, captured and removed hosts of their worst enemies. That is how 'it stood to reason' when one got to the bottom of the matter.

"I do not think that any one who looks carefully into the subject will arrive at any other conclusion than that reached by my colleagues and myself, namely, that the best thing for governments to do in relation to the herring fisheries is, to let them alone, except in so far as the police of the sea is concerned. With this proviso, let people fish how they like, as they like, and when they like. At present, I must repeat the conviction we expressed so many years ago, that there is not a particle of evidence that anything man does has an appreciable influence on the stock of Herrings. It will be time to meddle when any satisfactory evidence that mischief is being done is produced."

173. THE HERRINGS OF THE PACIFIC COAST.

THE CALIFORNIA HERRING—CLUPEA MIRABILIS.

"This species," writes Professor Jordan, "is universally known as the Herring. It indeed scarcely differs in size, appearance, or qualities from the Herring of the Atlantic. It reaches a length of about a foot. It is found for the entire length of the coast, being exceedingly abundant northward. All the bay sand outlets of Puget Sound are filled with them in the summer. South of Point Concepcion they are seldom seen except in winter. At San Diego they spawn in the bay in January. Farther north their spawning season comes later. They are so abundant in San Francisco Bay in the spring that eighty pounds can often be bought for twenty cents. They are fattest and bring the best price in early winter. The Herrings are smoked and dried, or salted, or

sent fresh to the markets. Sometimes herring oil is expressed from them. The principal herring-curing establishment is at Port Madison, on Puget Sound."

THE CALIFORNIA SARDINE—CLUPEA SAGAX.

"This species," writes Professor Jordan, "is everywhere known as the Sardine, or by the Italians as 'Sardina.' It is, in fact, almost exactly identical with the Sardine of Europe. It reaches a length of a little less than a foot. It ranges from Cape Mendocino to Chili, and is extremely abundant southward, especially in the winter, when it fills all the bays. In the summer it is generally scarce southward, although still taken northward. The young are, however, seen in San Diego in the summer. It is probably to some extent migratory along the coast, but as little attention is paid to it, no definite data can be given. It is brought into the markets when taken, and is sold with the Herring. The question of the possibility of canning it in oil, like the Sardine, has been considerably discussed. It would probably prove unprofitable, from the high price of labor and the uncertain supply of fish."

174. THE MENHADEN—BREVOORTIA TYRANNUS.[1]

NAMES.—The Menhaden has at least thirty popular names, most of them limited in their use within narrow geographical boundaries. To this circumstance may be attributed the prevailing ignorance regarding its habits and migrations, among our fishermen, which has perhaps prevented the more extensive utilization of this fish, particularly in the South.

North of Cape Cod the name "Pogy" is almost universally in use, while in Southern New England the fish is known only as the "Menhaden." These two names are derived from two Indian words of the same meaning; the first being the Abnaki name "Pookagan," or "Poghaden," which means "fertilizer," while the latter is the modification of a word which in the Narragansett dialect meant "that which enriches the earth." About Cape Ann, "Pogy" is partially replaced by "Hard-head," or "Hard-head Shad," and in Eastern Connecticut by "Bony Fish." In Western Connecticut the species is usually known as the "White-fish," while in New York the usage of two centuries is in favor of "Mossbunker." This name is a relic of the Dutch colony of New Amsterdam, having evidently been transferred from the "Scad," or "Horse Mackerel," *Trachurus lacerta*, a fish which visits the shores of Northern Europe in immense schools, swimming at the surface in much the same manner as our Menhaden, and known to the Hollanders as the "Marshbanker." New Jersey uses the New York name with its local variations, such as "Bunker" and "Marshbanker." In Delaware Bay, the Potomac, and the Chesapeake, we meet with the "Alewife," "Bay Alewife," "Pilcher" (Pilchard), and "Green-tail." Virginia gives us "Bug-fish," "Bug-head," and "Bug-shad," referring to the parasitic crustacean found in the mouths of all Southern Menhaden. In North Carolina occurs the name "Fat-back," which prevails as far south as Florida, and refers to the oiliness of the flesh. In this vicinity, too, the names "Yellow-tail" and "Yellow-tailed Shad" are occasionally heard, while in Southern Florida the fish is called "Shiner" and "Herring." In South America, among the Portuguese, the name "Savega" is in use. On the Saint John's River, and wherever northern fishermen are found, "Menhaden" is preferred, and it is to be hoped that this name will in time be generally adopted. A number of trade names are employed by the manufacturers in New Jersey who can this fish for food; these are "American Sardine," "American Club-fish," "Shadine," and "Ocean Trout."

In 1815 the species was described by Mitchill, of New York, under the name *Clupea menhaden*,

[1]For a fuller account of this fish, see an elaborate memoir in part v of the Report of the Commissioner of Fisheries.

which has since been constantly accepted. A prior description by Latrobe, in 1802, long lost sight of, renders it necessary, as I have elsewhere demonstrated, to adopt the specific name *tyrannus*. The genus *Brevoortia*, of which this species is the type, was established by Gill in 1861.

DISTRIBUTION.—The geographical range of *Brevoortia tyrannus* varies from year to year. In 1877 it was, so far as it is definable in words, as follows: The wanderings of the species are bounded by the parallels of north latitude 25° and 45°; on the continental side by the line of brackish water; on the east by the inner boundary of the Gulf Stream. In the summer it occurs in the coastal waters of all the Atlantic States from Maine to Florida, in winter only south of Cape Hatteras. The limits of its winter migration oceanward cannot be defined, though it is demonstrated that the species does not occur about the Bermudas or Cuba, nor presumably in the Caribbean Sea. In Brazilian waters occurs a geographical race of the same species, *Brevoortia tyrannus*, subspecies *aurea* (the *Clupanodon aureus* of Agassiz and Spix); on the coast of Paraguay and Patagonia by *Brevoortia pectinata*; in the Gulf of Mexico by *Brevoortia patronus*.

MOVEMENTS.—With the advance of spring Menhaden appear near our coasts in company with, and usually slightly in advance of, the other more resilient species, such as the Shad, Alewife, Bluefish, and Squeteague. The following general conclusions regarding their movements are deduced from the statements of about two hundred observers at different points on the coasts from Florida to Nova Scotia.

At the approach of settled warm weather they make their appearance in the inshore waters. It is manifestly impracticable to indicate the periods of their movements except in an approximate way. The comparison of two localities distant apart one or two hundred miles will indicate very little. When wider ranges are compared there becomes perceptible a certain proportion in the relations of the general averages. There is always a balance in favor of earlier arrivals in the more southern localities; thus it becomes apparent that the first schools appear in Chesapeake Bay in March and April; on the coast of New Jersey in April and early May;[1] on the south coast of New England in late April and May; off Cape Ann about the middle of May, and in the Gulf of Maine in the latter part of May and the first of June. Returning, they leave Maine late in September or in October; Massachusetts in October, November, and December, the latest departures being those of fish which have been detained in the narrow bays and creeks; Long Island Sound and vicinity in November and December; Chesapeake Bay in December, and Cape Hatteras in January. Farther to the south they appear to remain more or less constantly throughout the year.

It is a strange fact that their northern range has become considerably restricted within the past twenty-five years. Perley, writing in 1852, stated that they were sometimes caught in considerable numbers about Saint John's, New Brunswick, and there is abundance of other testimony to the fact that they formerly frequented the Bay of Fundy in its lower parts; at present the eastward wanderings of the schools do not extend beyond Isle au Haut and Great Duck Island, about forty miles west of the boundaries of Maine and New Brunswick. They have not been known to pass these limits for ten or fifteen years. They have this year hardly passed north of Cape Cod, and forty or more steamers, which have usually reaped an extensive harvest on the coast of Maine, have been obliged to return to the fishing grounds of Southern New England, where Menhaden are found as abundantly as ever.

I have elsewhere shown the arrival of the Menhaden schools to be closely synchronous with the period at which the weekly average of the surface temperatures of the harbors rises to 51° F., that they do not enter waters in which, as about Eastport, Maine, the midsummer surface tem-

[1] The first catch of Menhaden by the fleet in 1881 was off Long Branch, May 6, when Gallup & Holmes' steamer took eight hundred bushels.

peratures, as indicated by monthly averages, fall below 51° F., and that their departure in the autumn is closely connected with the fall of the thermometer to 51° F. and below. In 1877 a cold summer seemed to threaten the success of the Maine Menhaden fisheries. In September and October, however, the temperatures were higher than in the corresponding months of the previous year, and the scarcity of the early part of the season was amply amended for.

The season of 1878 in Maine was fairly successful, the three summer months being warmer than in 1877, but cooler than in 1876. The absence of the Menhaden schools north of Cape Cod in 1879 is also easily explained by the study of temperatures of the water of the Gulf of Maine, as indicated by the observations made in Portland Harbor. The averages for the three summer months are as follows, the numerator of the fraction being the average surface temperature, the denominator that of the bottom: 1876, 62°.5–57°.9; 1877, 58°.5–56°.7; 1878, 61°.5–58°.1; 1879, 56°.1–54°.6.

The average for the three summer months of 1879 is less than that of June, 1876.

This may perhaps be explained by a study of ocean temperatures. In August, 1878, there was a very rapid fall in the temperature of the surface in the Gulf of Maine, so that the average temperature of that month was less than that of July, instead of being higher, as is usual. This may have had the effect of driving the fish into the warmer water of the bays and estuaries. The monthly averages for 1876, 1877, 1878, and 1879 are as follows:

1876—June, 56°.9–54°; July, 66°.7–59°.4; August, 63°.9–60°.4.
1877—June, 54°.9–53°.3; July, 58°.1–56°.3; August, 62°.4–60°.6.
1878—June, 56°.8–55°.2; July, 66°.9–59°.3; August, 60°.7–59°.9.
1879—June, 52°.9–51°.7; July, 55°.9–54°.1; August, 59°.6–58°.

The arrival of the Menhaden is announced by their appearance at the top of the water. They swim in immense schools, their heads close to the surface, packed side by side, and often tier above tier, almost as closely as sardines in a box. A gentle ripple indicates their position, and this may be seen at a distance of nearly a mile by the lookout at the masthead of a fishing vessel, and is of great assistance to the seiners in setting their nets. At the slightest alarm the school sinks toward the bottom, often escaping its pursuers. Sailing over a body of Menhaden swimming at a short distance below the surface, one may see their glittering backs beneath, and the boat seems to be gliding over a floor inlaid with blocks of silver. At night they are phosphorescent. Their motions seem capricious and without a definite purpose; at times they swim around and around in circles; at other times they sink and rise. While they remain thus at the surface, after the appearance of a vanguard they rapidly increase in abundance until the sea appears to be alive with them. They delight to play in inlets and bays, such as the Chesapeake, Peconic, and Narragansett Bays, and the narrow fiords of Maine. They seem particularly fond of shallow waters protected from the wind, in which, if not molested, they will remain throughout the season, *drifting* in and out with the tide. Brackish water attracts them, and they abound at the mouth of streams, especially on the Southern coast. They ascend the Saint John's River more than thirty miles; the Saint Mary's, the Neuse, the York, the Rappahannock, the Potomac nearly to Washington, and the Pawtuxent to Marlborough. They come in with or before the Shad, and are very troublesome to the fishermen by clogging their nets. I am not aware that this difficulty occurs in Northern rivers, though they are found in the summer in the Hudson and its tributaries, the Housatonic, Mystic, Thames, and Providence Rivers, in the creeks of Cape Cod, and at the mouth of the Merrimack. A curious instance of capriciousness in the movements occurred on the coast of Maine, where much alarm was felt, because their habits were thought to have been

changed through the influence of seining. The shore fishermen could obtain none for bait, and vessels followed them far out to sea, capturing them in immense quantities forty miles from land. The fisheries had produced no such effect south of Cape Cod, and it was quite inexplicable that their habits should have been so modified in the north. In 1878, however, after ten years or more, they resumed their former habits of hugging the shores, and the Menhaden fishery of Maine was carried on, for the most part, in the rivers.

Why the schools swim at the surface so conspicuous a prey to men, birds, and other fishes is not known. It does not appear to be for the purpose of feeding; perhaps the fisherman is right when he declares that they are playing.

An old mackerel fisherman thus describes the difference in the habits of the mackerel and Menhaden: "Pogies school differently from mackerel; the Pogy slaps with his tail, and in moderate weather you can hear the sound of a school of them, as first one and then another strikes the water. The mackerel go along 'gilling,' that is, putting the sides of their heads out of the water as they swim. The Pogies make a flapping sound; the mackerel a rushing sound. Sometimes in calm and foggy weather you can hear a school of mackerel miles away." They do not attract small birds as do the schools of predaceous fish. The fish-hawk often hovers above them, and some of the larger gulls occasionally follow them in quest of a meal. About Cape Cod one of the gulls, perhaps *Larus argentatus*, is called "Pogy Gull."

On warm, still, sunny days the fish may always be seen at the surface, but cold or rainy weather and prevailing northerly or easterly winds quickly cause them to disappear. When it is rough they are not so often seen, though schools of them frequently appear when the sea is too high for fishermen to set their nets. The best days for menhaden-fishing are when the wind is northwesterly in the morning, dying out in the middle of the day, and springing up again in the afternoon from the southwest, with a clear sky. At the change of the wind on such a day they come to the surface in large numbers.

A comparison of the effect of the weather upon the Menhaden and the Herring yields some curious results. The latter is a cold-water species. With the advance of summer it seeks the north, returning to our waters with the approach of cold. The Menhaden prefers the temperature of 60° F. or more; the Herring, 55° F. and less. When the Menhaden desert the Gulf of Maine they are replaced by the Herring. Cold weather drives the former to the warmer strata, while it brings the latter to the surface. The conditions most favorable on our coast for the appearance of Herring on the surface, and which correspond precisely with those which have been made out for the coast of Europe, are least so for the Menhaden.

Their winter habitat, like that of the other cold-water absentees, has never been determined. The most plausible hypothesis supposes that instead of migrating towards the tropics or hibernating near the shore, as has been claimed by many, they swim out to sea until they find a stratum of water corresponding to that frequented by them during their summer sojourn on the coast.

This is rendered probable by the following considerations: 1. That the number of Menhaden in southern waters is not diminished in seasons of their abundance on the northern coast, nor increased in those of their absence from the latter region. 2. That there are local varieties of the species, distinguished by physical characters almost of specific value, by differences in habits, and in the case of the southern schools by the universal presence in the mouth of a crustacean parasite, which is never found in the specimens caught north of Cape May. 3. That the same schools usually reappear in the same waters in successive years. 4. That their very prompt arrival in the spring suggests their presence in waters near at hand. 5. That their leanness when they first appear

renders it evident that they have had no food since leaving the coast in autumn. The latter consideration, since they are bottom-feeders, is the strongest confirmation of the belief that their winter home is in the midoceanic substrata.

ABUNDANCE.—As is indicated by the testimony of many observers, whose statements are elsewhere reviewed at length, the Menhaden is by far the most abundant species of fish on the eastern coast of the United States. Several hundred thousand are frequently taken in a single draft of a purse-seine. A firm in Milford, Connecticut, captured, in 1870, 8,800,000; in 1871, 8,000,000; in 1872, 10,000,000; in 1873, 12,000,000. In 1877, three sloops from New London seined 13,000,000. In 1877, an unprofitable year, the Pemaquid Oil Company took 20,000,000, and the town of Booth Bay alone 50,000,000. There is no evidence whatever of any decrease in their numbers, though there can be in the nature of the case absolutely no data for comparison of their abundance in successive years. Since spawning Menhaden are never taken in the nets, no one can reasonably predict a decrease in the future.

FOOD.—The nature of their food has been closely investigated. Hundreds of specimens have been dissected, and every stomach examined by me has been found full of dark greenish or brownish mud or silt, such as occurs near the mouths of rivers and on the bottoms of still bays and estuaries. When this mud is allowed to stand for a time in clear water, this becomes slightly tinged with green, indicating the presence of chlorophyl, perhaps derived from the algæ, so common on muddy bottoms. In addition to particles of fine mud the microscope reveals a few common forms of diatoms.

There are no teeth in the mouth of the Menhaden, their place being supplied by about fifteen hundred thread-like bristles, from one-third to three-quarters of an inch long, which are attached to the gill-arches, and may be so adjusted as to form a very effective strainer. The stomach is globular, pear-shaped, with thick, muscular walls, resembling the gizzard of a fowl, while the length of the coiled intestine is five or six times that of the body of the fish. The plain inference from these facts, taken in connection with what is known of the habits of the Menhaden, seems to be that their food consists in large part of the sediment, containing much organic matter, which gathers upon the bottoms of still, protected bays, and also of the vegetation that grows in such localities. They also, as was demonstrated by Mr. Rathbun in 1880, feed very extensively upon the minute crustaceans, *Copepoda*, etc., which are found in great quantities swimming near the surface in the summer months all along our coast.

Their rapid increase in size and fatness, which commences as soon as they approach our shores, indicates that they find an abundant supply of some kind of food. The oil manufacturers report that in the spring a barrel of fish often yields less than three quarts of oil, while late in the fall it is not uncommon to obtain five or six gallons.

REPRODUCTION.—There is a mystery about their breeding. Thousands of specimens have been dissected since 1871 without the discovery of mature ova. In early summer the genitalia are quite undeveloped, but as the season advances they slowly increase in size and vascularity. Among the October fish a few ovaries were noticed in which the eggs could be seen with the naked eye. A school of large fish driven ashore in November, in Delaware Bay, by the bluefish, contained spawn nearly ripe, and others taken at Christmas time, in Provincetown Harbor, evidently stragglers accidentally delayed, contained eggs quite mature. Young Menhaden from one to three inches in length and upward are common in summer south of New York, and those of five to eight inches in late summer and autumn in the southern part of New England. These are in schools, and make their appearance suddenly from the open ocean like the adult fish. Menhaden have never been observed spawning on the Southern coast, and the egg-bearing individuals when observed are

always heading out to sea. These considerations appear to warrant the theory that their breeding grounds are on the off-shore shoals which skirt the coast from George's Banks to the Florida Keys. There are indications, too, that a small school of Menhaden possibly spawn at the east end of Long Island in the very early spring.

The fecundity of the Menhaden is very great, much surpassing that of the Shad and Herring. The ovaries of a fish taken in Narragansett Bay, November 1, 1879, contained at least 150,000 eggs.

ENEMIES.—Among its enemies may be counted every predaceous animal which swims in the same waters. Whales and dolphins follow the schools and consume them by the hogshead. Sharks of all kinds prey upon them largely; one hundred have been taken from the stomach of one shark. All the large carnivorous fishes feed upon them. The tunny is the most destructive. "I have often," writes a gentleman in Maine, "watched their antics from the masthead of my vessel—rushing and thrashing like demons among a school of fish; darting with almost lightning swiftness, scattering them in every direction, and throwing hundreds of them in the air with their tails." The pollock, the whiting, the striped bass, the cod, the squeteague, and the gar-fish are savage foes. The sword-fish and the bayonet-fish destroy many, rushing through the schools and striking right and left with their powerful swords. The bluefish and bonito are, however, the most destructive enemies, not even excepting man; these corsairs of the sea, not content with what they eat, which is of itself an enormous quantity, rush ravenously through the closely crowded schools, cutting and tearing the living fish as they go, and leaving in their wake the mangled fragments. Traces of their carnage remain for weeks in the great "slicks" of oil so commonly seen on smooth water in summer. Professor Baird, in his well-known and often-quoted estimates of food annually consumed by the bluefish, states that probably ten thousand million fish, or twenty-five million pounds, daily, or twelve hundred million million fish and three hundred thousand million pounds are much below the real figures. This estimate is for the period of four months in the middle of the summer and fall, and for the coast of New England only.

Such estimates are professedly only approximations, but are legitimate in their way, since they enable us to appreciate more clearly the luxuriance of marine life. Applying similar methods of calculation to the Menhaden, I estimate the total number destroyed annually on our coast by predaceous animals at a million million of millions; in comparison with which the quantities destroyed by man, yearly, sink into insignificance.

It is not hard to surmise the Menhaden's place in nature; swarming our waters in countless myriads, swimming in closely packed, unwieldy masses, helpless as flocks of sheep, near to the surface and at the mercy of every enemy, destitute of means of defense and offense, their mission is unmistakably to be eaten.

In the economy of nature certain orders of terrestrial animals, feeding entirely upon vegetable substances, seem intended for one purpose—to elaborate simple materials into the nitrogenous tissues necessary for the food of other animals, which are wholly or in part carnivorous in their diet; so the Menhaden feeding upon otherwise unutilized organic matter is pre-eminently a meat-producing agent. Man takes from the water every year eight or nine hundred millions of these fish, weighing from two hundred to three hundred thousand tons, but his indebtedness does not end here; when he brings upon his table bluefish, bonitoes, weak-fish, sword-fish, or bass, he has before him usually Menhaden flesh in another form.

USES.—The commercial importance of the Menhaden has only lately been rightly appreciated. Twenty-five years ago and before, it was thought to be of very small value. A few millions were taken every year in Massachusetts Bay, Long Island Sound, and the inlets of New Jersey. A small portion of these were used for bait; a few barrels occasionally salted in Massachusetts to be exported to the West Indies. Large quantities were plowed into the soil of the farms along the

shores, stimulating the crops for a time, but in the end filling the soil with oil, parching it and making it unfit for tillage. Since that time manifold uses have been found. As a bait-fish this excels all others; for many years much the greater share of our mackerel was caught by its aid, while the cod and halibut fleet use it rather than any other fish when it can be procured. The total consumption of Menhaden for bait in 1877, did not fall below 80,000 barrels, or 26,000,000 fish, valued at $500,000. Ten years before, when the entire mackerel fleet was fishing with hooks, the consumption was much greater. The Dominion mackerel fleet buy Menhaden bait in quantity, and its value has been thought an important element in framing treaties between our government and that of Great Britain.

As a food resource it is found to have great possibilities. Many hundreds of barrels are sold in the West Indies, while thousands of barrels are salted down for domestic use by families living near the shore. In many sections they are sold fresh in the market. Within six years there has sprung up an important industry, which consists in packing these fish in oil, after the manner of sardines, for home and foreign consumption. In 1874 the production of canned fish did not fall below 500,000 boxes.

The discovery made by Mr. S. L. Goodale, that from these fish may be extracted, for the cost of carefully boiling them, a substance possessing all the properties of Liebig's "Extract of beef," opens up a vast field for future development. As a food for the domestic animals in the form of "fish meal," there seems also to be a broad opening. As a source of oil, the menhaden is of more importance than any other marine animal. Its annual yield usually exceeds that of the whale (from the American fisheries) by about 200,000 gallons, and in 1874 did not fall far short of the aggregate of all the whale, seal, and cod oil made in America. In 1878 the menhaden oil and guano industry employed capital to the amount of $2,350,000, 3,337 men, 64 steamers, 279 sailing vessels, and consumed 777,000,000 fish; there were 56 factories, which produced 1,392,644 gallons of oil, valued at $450,000, and 55,154 tons of crude guano, valued at $600,000; this was a poor year. In 1874 the number of gallons produced was 3,373,000; in 1875, 2,681,000; in 1876, 2,992,000; in 1877, 2,427,000. In 1878 the total value of manufactured products was $1,050,000; in 1874 this was $1,809,000; in 1875, $1,582,000; in 1876, $1,671,000; in 1877, $1,608,000. It should be stated that in these reports only four-fifths of the whole number of factories were included. In 1880 the number of persons employed in the entire industry was placed at 3,635, the amount of capital invested $2,362,841, the value of products $2,116,787, including 2,066,396 gallons of oil, worth $733,424, and 68,904 tons of guano, worth $1,301,217. The refuse of the oil factories supplies a material of much value for manures. As a base for nitrogen it enters largely into the composition of most of the manufactured fertilizers. The amount of nitrogen derived from this source in 1875 was estimated to be equivalent to that contained in 60,000,000 pounds of Peruvian guano, the gold value of which would not have been far from $1,920,000. The yield of the menhaden fishery in pounds is probably triple that of any other carried on by the fishermen of the United States.

In estimating the importance of the Menhaden to the United States, it should be borne in mind that its absence from our waters would probably reduce all our other sea-fisheries to at least one-fourth their present extent.

175. THE GULF MENHADEN—BREVOORTIA PATRONUS.

In addition to the common Menhaden, a second North American species has recently been discovered.[1] This species has been reported only from the Gulf of Mexico, where the following observations were made by Mr. Silas Stearns:

[1] See Report United States Commission Fish and Fisheries, part v, pp. 17 and 26, and Proceedings of the United States National Museum, vol. i.

POPULAR NAMES.—"The Gulf Menhaden has several vernacular names. At Key West it is called 'Sardine,' in common with other fish of the same general appearance. At Apalachicola, Pensacola, and Mobile it is called 'Alewife'; at New Orleans the names 'Sardine' and 'Alewife' are both in use, the latter perhaps more generally. On the Texan coast it is known as 'Herring,' 'Alewife,' 'Sardine,' and 'Shad,' each locality having its peculiar name.

"I have observed the Gulf Menhaden from Key West to the Texan coast, and am told that its range extends along the Mexican coast. It seems to be most abundant along the coast between Cedar Keys and New Orleans. On other parts it is only an ordinarily common fish or an occasional visitor. My observations have been made at Pensacola, where their movements are as follows: On the first calm, warm days of April many small schools appear in the bays and sounds. From the first appearance of these schools they can be seen at all times in fine weather until late in the summer, when they disappear. They remain in these bays until late in November and December, but keep to deeper waters, and are seen, after the close of summer, only when taken in nets.

MOVEMENTS.—"The first which arrive measure only five to six inches. In June they average seven inches, and schools have been observed composed of fish of different sizes, as five, six, seven, and eight inches long. In July the average size is about eight inches, and in August, September, and October the individuals composing the schools measure seven, eight, nine, and ten inches in length. Those fish caught in October and November in nets are eleven, twelve, and thirteen inches long, and are probably full-grown. In fine weather they are first seen approaching the coast in large schools, but if windy and cold they are not seen until they have entered the bay and the weather has become pleasant. When once inside the large schools are broken up into many small schools, which swim at the surface, rippling the water as they go. Their movements seem not to be affected by the tide. Their favorite feeding or playing grounds are in quiet bayous, creeks, and nooks in the bay, where they are unmolested by larger fishes of prey. Brackish water is also much sought by them, and I think most, if not all, of them visit it some time during the season. A person stationed at the mouth of a fresh-water stream or river, in August or September, will see little schools of these fish swimming round and round at the surface, just where the two kinds of water meet. As they become accustomed to the fresh water they enter the stream and move upwards until they reach a quiet creek or bayou. How long they stay in the river I cannot determine, for I have noticed as many moving down as up stream. Late in September and October very few or none are seen at the surface of the water, but I have caught many in the river and at its mouth at that season, proving that they are still present. About the first of November I have known of a few being taken in gill-nets in or about the rivers. During the months September and October they are rarely seen in salt water, but come to notice again in November, by being taken in small quantities in seines along the outside beaches with other fish, such as bluefish, channel bass, and sheepshead. After a few catches in November and December we see or hear nothing more of them until the following spring; but from this we cannot safely conclude that they have left these waters, for the proper nets (gill-nets) in which to catch them in deep water are but little used in this vicinity, and if they remained they would not be observed.

MESSMATES.—"When the Gulf Menhaden arrive in spring, each one has a parasite in its mouth, a crustacean called *Cymothoa prægustator*. This animal is found always in one position, clinging with its hooked claws to the roof of the fish's mouth, with its head looking outward and very near to the jaw of the fish. These parasites remain with the Menhaden as long as the latter is in salt water; in brackish water they are less frequently observed, disappearing altogether in fresh water. With all the fall fish of this species which I have examined there were no parasites. The fish do

not seem to suffer physically from the company of this parasite, but I have fancied that it was to get rid of them that the fish visit fresh water. I have noticed no other parasites upon them.

REPRODUCTION.—"The first traces of spawn are found in May. By July it has become sufficiently developed to be noticed by any person unaccustomed to the examination of such objects. In the latter part of September or first of October, at which time they are last seen in abundance, the ovaries are sufficiently grown to distend the fish's abdomen, yet not fully ripe. When they are next caught, in November and December, on the sea-beach, they are without ovaries and show signs of having spawned.

FOOD.—"The Gulf Menhaden are bottom-feeding fish, as their stomachs always contain soft brown mud, from which I suppose it extracts microscopic animal or vegetable matter. Some believe that it gains its nourishment in the shape of animalculæ from the water, as it swims along with its mouth open, straining water through its gills. It is not a food-fish. A few trials have been made to use them as bait for deep-sea fish, such as red snappers, groupers, etc. Such experiments have proved successful."

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S. THE SHAD AND THE ALEWIVES.

By MARSHALL MCDONALD.

176. THE RIVER HERRINGS, OR ALEWIVES—CLUPEA ÆSTIVALIS AND C. VERNALIS.

HISTORY AND NOMENCLATURE.—Early writers on American fishes, especially Mitchill and De Kay, seem to have experienced great difficulty in differentiating into species the various forms of river Herring or Alewives in our waters. These early writers were, however, apparently more discriminating than some of their successors, for they recognized differences which have been ignored by subsequent writers. They were as much at fault, however, in making too many species as were Storer and Gill in uniting all the forms under one specific name. Mitchill recognized seven species, to wit, the "New York" Herring, *Clupea halec;* the "Tiny" Herring, *C. pusilla;* the "Little" Herring, *C. parvula;* the "Sprat" Herring of New York, *C. indigena;* the "Spring" Herring or "Alewife," *C. vernalis;* the "Summer" Herring of New York, *C. æstivalis;* and the "Blue" Herring, *C. cærulea;* all of which are apparently founded upon hasty studies of individuals of different ages and varying proportions, and in reality belong to the two species named in the heading of this article. The work of Mitchill is valuable, since by him were well defined the two species which we recognize at the present time under the names now accepted by us, the "Spring" and "Summer" Herrings, respectively *C. vernalis* and *C. æstivalis.* These are described in such terms that they cannot be mistaken. It is not worth while to attempt an identification of the other species, most of which are evidently based upon very small individuals.

De Kay took up and discussed under the same or different names most of the forms enumerated by Mitchill, and, taking advantage of his more accurate methods of description, we are able to form a very satisfactory idea of what was intended under each name. The *Alosa tyrannus* of De Kay corresponds to the *C. vernalis* of Mitchill, while the *C. vernalis* of De Kay, in the synonym of which he cites Mitchill's *C. halec,* is without much doubt the summer Herring of Mitchill, although De Kay loses sight of Mitchill's name *C. æstivalis.* The *C. fasciata* of De Kay, to which he, without hesitation, refers Mitchill's *C. pusilla,* is probably the young of the summer Herring.

It is useless to attempt to trace throughout the entire literature on the subject the various errors in the identification of the river Herrings. Storer, in his "History of the Fishes of Massachusetts," distinguishes the two species under the names *Alosa cyanonoton* and *A. tyrannus,* and supplies figures of each. These are not, however, sufficiently characteristic to be serviceable in identification. The name *tyrannus,* which was used by both De Kay and Storer for the spring Herring, belongs by rights to the Menhaden, as has been elsewhere demonstrated.

Douglass in his "North America," Boston and London, 1740, remarks, in speaking of New England:

"Alewives by some of the country people are called Herrings. They are of the Herring tribe, but somewhat larger than the true Herring. They are very mean, dry, and insipid fish. Some of them are cured in the manner of white Herrings, and sent to the sugar islands for the slaves, but because of their bad quality they are not in request; in some places they are used to manure land. They are very plenty, and come up the rivers and brooks into ponds in the spring. Having

spawned, they return to the sea. They never take the hook. Many fish go up the rivers into ponds earlier or later in the spring to spawn, viz, salmon, Shad, Alewives, tomcod, smelts, etc., and many good laws have been made in New England to prevent the obstruction of their passage by weirs, etc., as they are of great benefit to the inhabitants near these rivers and ponds."

From 1861 until 1880 nearly all American zoologists were contented to consider the various kinds of river Herrings as members of a single species, which was designated *Pomolobus pseudo-harengus*, the specific name *pseudo-harengus* having originated in Wilson's article in volume ix of the American edition of Rees' Encyclopædia. There is no positive evidence to prove that this volume was published prior to Mitchill's work on the "Fish of New York," which appeared in 1815, and in which the names now accepted by us were first proposed. The American edition is said by Allibone to have been in course of publication from 1809 to 1820. There is, however, no date upon the title-page of volume ix, and consequently the priority of the name *pseudo-harengus* over the others is doubtful. At any rate, the description given by Wilson is so vague that it cannot well be assigned to one species in preference to the others.[1] If it is to be assigned to either, it most assuredly belongs to the species which Mitchill calls *C. vernalis*, and which is characterized by its long head, large eye, and high fin. Wilson, however, did not distinguish the two species, and his intention was evidently to include them both under one name. The only specific characteristic given is the date of its advent, which, according to him, precedes that of the Shad by about three weeks. Since there is no statement of the locality where this occurs, this also is quite indefinite. Taking into consideration also the fact that Wilson's article was published anonymously in a book without date, I think we can safely set aside the name *pseudo-harengus* and consider that the two names used by Mitchill in the discussion of his spring and summer Herrings are definitely assigned to these two species.

The attention of the zoologists of the Fish Commission was first called to the probable existence of two species by the persistent opinions of the fishermen of the Potomac, who recognized two forms—differing in habit and in general appearance—which they called the "Branch" Herring and the "Glut" Herring respectively. The late Mr. Milner, in the course of his river work, as early as 1876, came to the conclusion that the two forms were specifically distinct, but the problem was not definitely worked out until 1879. The announcement of the discovery of the two species and a definition of their characters were first published in the report of the Virginia Fish Commission for 1879.

These species may easily be distinguished from each other by the following characters: *C. æstivalis* is more elongate in form, has a lower body, less elevated fins, and smaller eyes than *C. vernalis*. The proportions of the bones of the head in *C. æstivalis* differ from those in *C. vernalis*, as also does the coloration of the lining of the abdomen, which in *C. æstivalis* is black, and in *C. vernalis* gray.

The popular names applied to these fishes differ in almost every river along the coast. *C. vernalis* is known along the Potomac River as the "Branch" Herring; on the Albemarle River as the "Big-eyed" Herring and the "Wall-eyed" Herring; in Canada it is known as the "Gaspereau" or "Gasperôt." It is pre-eminently the "Alewife" of New England; the "Ellwife" or "Ellwhop" of the Connecticut River. The other species, *C. æstivalis*, undoubtedly occurs occasionally in its company, but is probably not common in the Connecticut and Housatonic Rivers, and in many parts of Massachusetts is distinguished by another name.

[1] "*Pseudo-harengus* (American Herring). Body above ash-color, inclining to dull greenish-blue; sides and belly silvery; no spots on the sides; head small, tapering; under jaw little longer; ascends our rivers from the sea with the Shad to deposit their eggs in shallow water; they are about three weeks in advance of the Shad; well tasted either fresh or salted, but not so fat as European Herring."

From the "Collections of the Massachusetts Historical Society, 1816,"[1] are taken the following physiological and historical notes on the occurrence of the Alewife at Wareham, Massachusetts:

"Of the Alewife there are evidently two kinds, not only in size but habit, which annually visit the brooks passing to the sea at Wareham. The larger, which set in some days earlier, invariably seek the Weweantitt sources. These, it is said, are preferred for present use, perhaps because they are earliest. The second, less in size, and usually called 'Black backs,' equally true to instinct, as invariably seek the Agawam. These are generally barreled for exportation. In the sea, at the outlet of these streams, not far asunder, these fish must for weeks swim in common, yet each selects its own and peculiar stream. Hence an opinion prevails on the spot that these fish seek the particular lake where they were spawned.

"Another popular anecdote is as follows: Alewives had ceased to visit a pond in Weymouth, which they had formerly frequented. The municipal authorities took the usual measures, by opening the sluiceways in the spring at mill-dams, and also procured live Alewives from other ponds, placing them in this, where they spawned, and sought the sea. No Alewives, however, appeared here until the third year;[2] hence three years have been assumed by some as the period of growth of this fish.

"These popular opinions, at either place, may or may not agree with the laws of the natural history of migratory fish.

"The young Alewives we have noticed to descend about the 20th of June and before, continuing so to do some time, when they are about two inches long, their full growth being from twelve to fifteen inches. We have imbibed an opinion that this fish attains its size in a year, but if asked for proof we cannot produce it.

"These fish, it is said, do not visit our brooks in such numbers as in former days. The complaint is of old date. Thus, in 1753, Douglass remarks on migratory fishes: 'The people living upon the banks of Merrimack observe, that several species of fish, such as salmon, Shad, and Alewives, are not so plenty in their seasons as formerly; perhaps from disturbance, or some other disgust, as it happens with Herrings in the several friths of Scotland.' Again, speaking of Herrings, he says: 'They seem to be variable or whimsical as to their ground.' It is a fact, too, that where they most abound, on the coast of Norway and Sweden, their occasional disappearance is a subject of remark.[3]

"The Herring is essentially different from the Alewife in size (much smaller) and in habit. It continues, we believe, in the open sea, and does not seek pond-heads. Attempts are sometimes made, by artificial cuts, to induce them to visit ponds which had not before a natural outlet. These little cuts, flowing in the morning, become intermittent at noon, as the spring and summer advance. Evaporation, therefore, which is very great from the surface of the pond, should, probably, be considered in the experiment, making the canal as low as the midsummer level of the pond, otherwise it may be that the fish perish in the passage. This may, in other respects, have its inconveniences, at seasons when the ponds are full.

"The town of Plymouth, for a series of years, annually voted from one thousand to five hundred and two hundred barrels of Alewives to be taken at all their brooks, in former years.

"In the year 1730, the inhabitants were ordered not to take more than four barrels each; a

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[1] Vol. iv, second series, pp. 294–296.

[2] This anecdote was related in a circle of the members of the general court at Boston, when a member from Maine remarked that a similar event had occurred in his vicinity.

[3] Previous to 1752 the Herrings had entirely disappeared seventy-two years on the coast of Sweden; and yet, in 1782, 139,000 barrels were cured by salt at the mouth of the Gothela, near Gottenburg.—STUDIES OF NATURE.

large individual supply indeed, compared with the present period (1815), when it is difficult for an householder to obtain two hundred Alewives, seldom so many.

"In 1762, at a vendue the surplus appears to have been sold in twenty-five barrel lots, which sold at 3*s.* 7*d.* and 4*s.* the barrel. In 1763, Plymouth and Wareham took one hundred and fifty barrels at the Agawam brook;[1] two hundred barrels was the usual vote, down to a modern date, perhaps 1776. Menhaden were also taken in quantity at Wareham, and barreled for exportation, in former years."

The *C. æstivalis* is the "Glut" Herring of the Albemarle and the Chesapeake, and the "English" Herring of the Ogeechee River. In the Saint John's River, Florida, it is known simply as the "Herring." On the coast of Massachusetts it is called the "Blue-back," a name which is common to the late runs of the same species of the Rappahannock. Around the Gulf of Maine this species is also known by the names "Kyack" or "Kyauk," "Saw-belly," and "Cat-thrasher." Although the coast fishermen of Massachusetts and Maine claim to distinguish the two species, the "Blue-backs" and the "Alewives," their judgment is by no means infallible, for I have frequently had them sort out into two piles the fishes which they distinguish under these names, and found that their discrimination was not at all reliable. The features to which they mainly trusted in the determination of *C. æstivalis* are the bluer color of the back and the greater serration upon the ventral-ridge. The other species, when the scales on its back are rubbed off, is as blue as this, and the serration of the belly is dependent entirely upon the extent to which the back has become stiffened in the death struggle and the consequent degree of arching of the ventral ridge. The young of one or both species are sold in the Boston markets under the name "Sprats," and in New York they make up a large proportion of the so-called "Whitebait." In the report of the Massachusetts Commissioner of Fisheries for 1869, Col. Theodore Lyman called attention to the probable occurrence of two species in Massachusetts, but his diagnostic characters seem hardly well chosen. The form which he calls the "Gray-back" is undoubtedly *C. vernalis*, and the "Black-bellies," which he is inclined to believe distinct, would appear to be another run of the same species. The river Herring, which he speaks of as a large variety, not much esteemed, and supposed to spawn in tidal water, may possibly be the same as *C. æstivalis*. The Black-bellies, if their habits are properly described, have much in common with *C. æstivalis*. There is, however, much to be learned concerning all the fishes of this group, and it is more than probable that careful study will reveal facts of which we are at present entirely ignorant.

ABUNDANCE.—The Alewife is by far the most abundant of our river fishes, and throughout the whole Southern region where they are caught, together with the Shad, the number of individuals is not far from ten to twenty times as great as that of the Shad. For instance, in the Albemarle region, in 1879, 750,000 Shad were taken and upwards of 20,000,000 Alewives. Again, in 1880, about 600,000 Shad were taken from the Potomac, and 11,000,000 Alewives. By far the greatest number of the Alewives thus taken were "Glut Herring," *C. æstivalis;* but, since the two species are sold together, without discrimination, no accurate statement of proportional numbers can be made. In the Northern rivers they are not taken in any great numbers, owing to the fact that the meshes of the nets used in the capture of the Shad are too large to retain the fish. In the Connecticut and other rivers a large mesh is required by law, but throughout this entire region the abundance of valuable sea-fishes is so great that there could be but little gain in capturing the Alewives. There is on Cape Cod an extensive alewife fishery, described in another chapter. This has for more than a century been regulated by law, and the fish are allowed during stated periods to swim without interruption to their spawning beds. The streams in which they are taken are so

[1] Plymouth retains a fishing privilege in this brook within Wareham. The Alewives, arewe told, were more numerous in 1815 than for some years.

small, and the fish in their ascent so crowded together, that they appear to be extremely abundant, although the aggregate catch for the entire Cape is not perhaps much greater than the yield of many single seines in the South. Here, however, there has been no great decrease in abundance, while in the South the herring fishery is much less productive than in former years. Even now, however, the great seines of the Potomac and Albemarle regions could not be operated without the herring fishery, and hauls are yearly made which seem incredible to those who have not seen them. In 1879, at Wood's fishery, on the Albemarle, three hundred thousand Alewives were landed at a single haul of the seine. Hauls of half a million, and even more, were not unfrequent prior to the late war. Considerable quantities of these fish are taken yearly in the weirs on the south coast of New England, and form an important element in the bait supply of the Massachusetts fishing fleet. In the report of the Massachusetts Commissioner of Fisheries for 1872 are given the statistics of the catch of the Waquoit weir for seven years, from 1865 to 1871, inclusive, the yearly average being 105,000. The annual product of two streams emptying into the head of Buzzard's Bay is given in the same place,[1] one for fifteen, the other for seven years; the average annual yield of the first was 539,000, that of the second 366,000. In 1864 the yield was 804,000. Numerous details of a similar character may be found by those who are interested in the statistical part of this report.

South of Cape Fear River the Alewife occurs in all the Atlantic streams in considerable quantities, but as yet their capture is apparently not of such importance to the fishermen as to cause the formation of a special alewife fishery between that point and the great fisheries of the Albemarle.

In the works of early writers occur allusions to the Alewives of our Eastern coast, which appear, in almost every instance, to refer to all the fishes known under that name. In Josselyn's "Account of Two Voyages to New England," 1675, he remarks:

"The *Alewife* is like a *Herrin*, but has a bigger bellie; therefore, called an *Alewife;* they come in the end of April into fresh Rivers and Ponds; there hath been taken in two hours' time by two men without any Weyre at all, saving a few stones to stop the passage of the River, above ten thousand."

Captain John Smith, in his "Advertisements for the Inexperienced Planters of New England," London, 1631,[2] remarked:

"The seven and thirty passengers miscarrying twice upon the coast of *England*, came so ill-provided, they onley relyed upon the poore company they found, that had lived two yeares by their naked industry, and what the country naturally afforded; it is true, at first there hath been taken a thousand Bayses at a draught, and more than twelve hogsheads of Herrings in a night; of other fish when and what they would, when they had meanes; but wanting most necessaries for fishing and fowling, it is a wonder how they could subsist, fortifie themselves, resist their enemies, and plant their plants."

Thomas Morton, in his "New England Canaan," London, 1632, remarks:

"Of Herrings, there is a great store, fat, and faire; & (to my minde) as good as any I have seene, & these may be preserved, and made a good commodity at the Canaries."

Mr. Higginson, in his "New England's Plantation," 1630, refers to the great abundance of Herring in the waters of New England.

In the "Chronicles of the Pilgrim Fathers of the Colony of Plymouth," from 1692 to 1725, speaking of Town Brook, Plymouth, Massachusetts, it is stated that before the brook was so much impeded by dams vast quantities of Alewives passed up through it annually to Billington Sea.

[1] Page 30. [2] Page 19.

William Wood, in his "New England's Prospects," London, 1634, remarks:

"The Herrings be much like them that be caught on the *English* coast. *Alewives* be a kind of fish which is much like a Herring, which in the latter end of Aprill come up to the fresh Rivers to spawne, in such multitudes as is almost incredible, pressing up in such shallow waters as will scarce permit them to swimme, having likewise such longing desire after the fresh water ponds, that no beating with poles, or forcive agitations by other devices, will cause them to returne to the sea, till they have cast their spawne."

The same writer makes mention of the fact that in the spring, when the Alewives pass up the rivers, abundance of bass may be caught in the rivers.

Wood, writing in 1633, states that a little below the fall in Charles River the inhabitants of Watertown had built a *wear* to catch fish, wherein they took great store of Shads and Alewives. "In two tides they have gotten 200,000 of these fishes."

Schoepf, in his "Fishes of New York," 1788, refers to the American Herring under the name *C. harengus*, stating that it is similar to that of Europe, but that the body has scales which are more easily detached. The back is glistening blue, the belly white, widely carinate, and provided with saw-like scutes. The fish which he has in mind is undoubtedly one of the river Herrings, since he states that it appears in May and June on the coast of New York, later than the Shad and not in such great numbers.

Pennant, in his "Arctic Zoology," states that "Herrings leave the salt water in March and run up the rivers and shallow streams of Carolina in such numbers that the inhabitants fling them ashore by shovels full. Passengers trample them under foot fording the rivers. They are not so large as the 'English,' but exceed them in flavor when pickled."

GEOGRAPHICAL DISTRIBUTION.—The geographical distribution of the two species has not been thoroughly worked out, but as now understood may be stated as follows: The "Blue-back," or "Glut" Herring, *C. æstivalis*, Mitchill, occurs in the Saint John's River, Florida, and in all the coast waters of the Eastern United States to the Gulf of Maine. On the coast of Maine this species rarely enters rivers, but is found abundantly at sea. It is probably the "Spring" Herring referred to by Col. Theodore Lyman as occurring below the dams in the rivers of Massachusetts. Its area of greatest abundance is in the Albemarle and Chesapeake regions. The name of "Glut" Herring is derived from the fact that it makes its appearance in great schools, and all at once becomes so abundant as to glut the markets. The former appears later than the "Spring" Herring, or "Gaspereau," and some time after the Shad. Its advent is much less gradual than that of the "Spring" Herring. Its peculiar movements are due to certain conditions of temperature, which will be discussed below.

At present, as the latest investigations show, the river range of this species in the Southern States does not extend far beyond tide water. In early days, before obstructions were placed in the James River, they are said to have ascended as far as Lexington; now they do not reach the vicinity of Richmond, although there are no obstructions below that city. The "Spring" Herring, or Gaspereau, *C. vernalis*, Mitchill, is more northerly in its range. Until discovered by Colonel McDonald in the Neuse River of North Carolina, in the spring of 1880, it had not been definitely recorded south of the Chesapeake Bay. Although in that year this species was particularly abundant in the Albemarle and Chesapeake regions, constituting a considerable portion of the entire catch, it is ordinarily much less numerous, and the area of its greatest abundance is in the region from the Gulf of Saint Lawrence to Cape May. As has already been stated, the Alewives of the Connecticut River are chiefly of this species, as also is the Herring of the Hudson and of the streams emptying into Cape Cod. In the Chesapeake region this species is from three to four

weeks earlier than the other, reaching the maximum of its abundance and beginning to decline in numbers before the other comes. The approach of the latter is more gradual, and unlike the other species, it makes its way into the small streams and branches; hence the name "Branch" Herring. In the rivers of Massachusetts the "Branch" Herring ascends much farther toward the headwaters than the other species, and in some streams is found to the exclusion of the other—facts which will be discussed below when considering the influences of temperature. Perley states that the Gaspereau appears in the harbor of Saint John's in April, but the main body does not enter the river before May 10; that the fish is abundant in the Bay of Fundy, but that the species is less plentiful and smaller in the Gulf of Saint Lawrence. He also states that in the Bay of Chaleur it has never been noticed, and that, as in the case of Shad, the Bay of Merrimachi would appear to be its extreme northern limit. It ascends the river of the same name to its source, spawning in the Merrimachi Lake. In the Saint John's River, New Brunswick, it ascends to Darling's Lake (Kennebecasis), Douglas Lake (Nerepis), the Washademoac Lake, the Oenabog Lake, the Grand Lake, and the Oromocto River, and in company with the Shad deposits its spawn. Its abundance in the harbor of Saint John, New Brunswick, may be inferred from the fact that the catch varies from twelve to sixteen thousand barrels each season, sometimes reaching twenty thousand. This statement was made in 1852.

A very remarkable phenomenon, recently observed, has been the appearance of this species in immense numbers in Lake Ontario and lakes of New York. Dr. T. H. Bean has collected a large number of facts upon this point, which are recorded in an essay at the end of this chapter.

MIGRATIONS AND MOVEMENTS.—Like the Shad, the Alewives are anadromous in habit. The dates of their first appearance in any given river may be very closely determined by an examination of the tables which show the movements of the Shad. The Gaspereau or "Spring" Herring usually precedes the Shad by a period of several weeks, while the run of the "Blue-back" or "Glut" Herring occurs in the middle of the shad season.

In 1879 the first Shad made their appearance in the markets of Washington March 25, preceded four weeks by the Menhaden, a little more than three weeks by the Branch Herring, and about four weeks in advance of the "Glut" Herring. Colonel Lyman, in his report for 1872, already referred to, gives the dates of the appearance of the Alewives, Menhaden, and bluefish at Waquoit weir for thirteen years, from 1859 to 1871 inclusive. The Alewives always came first, from March 24 to April 7; the scup from a month to forty days later; the Menhaden about the same time with the scup, though usually two or three days later; and the bluefish from ten days to two weeks after the Menhaden.[1]

Concerning the time of their departure from the river as little is known as in the case of the Shad. Their winter habitat has yet to be found. I am convinced, after several years of study, that in mild winters they remain about the mouths of the rivers, ascending them in the spring. Late in December, 1879, he captured numerous specimens of both species in gill-nets, at Yorktown, in company with Menhaden, and it is my opinion that they might be taken in a similar manner in Pamlico Sound. Thus, also, it is possible that many Shad winter in Long Island Sound and New York Bay, but we know that in the fall they are found in abundance forty or fifty miles at sea in the Gulf of Maine. The Branch Herrings ascend the river probably as far as the Shad, and are believed to penetrate small streams to a much greater distance, entering many waters in which the Shad never occur. The "Blue-back" or "Glut" Herring, however, does not go far above tide water, and the area of reproduction seems to be confined to the large streams or to their tidal tributaries.

[1] Report of Massachusetts Commissioner of Inland Fisheries, January, 1874, p. 64.

FOOD.—As in the case of the Shad, very little is known concerning the food of the river Alewives in their salt-water habitats. It is, however, supposed that they, like other similar species, exist largely upon swimming crustaceans. When in the rivers they do not feed to any considerable extent, although they have been known in many instances to take the fly.

REPRODUCTION.—The eggs of the Alewife are adhesive, like those of the sea Herring, though to a much less degree. The number of eggs varies from sixty thousand to one hundred thousand, in accordance with the size of the individual. They are deposited upon the bottom in shoal water, or on whatever object they may come in contact with. The time for spawning, after the fish have entered the river, depends, as in the case of the Shad, entirely on the temperature of the water. The spawning of the "Glut" Herring takes place under ordinary conditions at a temperature of 70° to 75° F.; that of the "Branch" Herring, when the water is as low as 55° to 60° F. The period of development varies directly with the temperature.

The season of incubation with the "Glut" Herring is about the same as with the Shad—that is, about three or four days. With the "Branch" Herring the spawning takes place when the water is colder, for which reason the period of incubation is doubtless longer. The young Alewife before winter attains a length of two to three inches, and the period of growth continues, probably, as in the Shad, for three or four years.

"There seems to be," remarks Professor Baird,[1] "a difference of opinion as to the age at which Alewives first return from the sea, some fixing it at two and others at three or more years. Captain Treat, of Eastport, however, many years ago transported several hundred pairs of breeding fish to a small sheet of water, known as Keene's Pond, situated some five or six miles from Robinston, Maine, and having its outlet into the Calais River just below Red Beach. The level of the lake is several hundred feet above that of the river, and the outlet is very precipitous, consisting of several falls entirely impassable to fish from below. No Alewives had ever been known in this pond at the time of their introduction by Captain Treat. The young fish were seen i : the pond in the course of the summer in myriads, all of them disappearing, however, after a heavy rain in the autumn, which swelled the waters to produce a sufficient discharge. Due examination was made for successive years, but not until the expiration of the fourth were they seen, when the outlet was observed to be almost choked up by a solid mass of Alewives, struggling to make their way back again to the place of their birth."

During past years the Alewife has frequently been artificially introduced into new waters or over dams by the transportation of fish of considerable size. This is constantly done on Cape Cod in the restocking of the herring streams which have been exhausted, and was successfully accomplished by General N. L. Lincoln, in Maine, as long ago as 1750. Colonel Lyman, in his report for 1870,[2] describes the experiment by Mr. E. S. Haddoway in restocking Eel River, Town Brook, Plymouth, in 1865. The crop sown by him in that year came up in 1869 in the shape of a good run of fish, chiefly males full grown.

Herring eggs have frequently been artificially impregnated by men engaged in shad culture. The young fish artificially hatched have in some instances been transported. In 1882 two million were sent to Texas by the United States Fish Commission and deposited in the Colorado River. Artificial hatching would seem less necessary in the case of the Alewife than in that of the Shad, since with the former, owing to its peculiar spawning habits, the eggs stand a better chance of hatching out, and very slight protection of the fish during spawning season will be sufficient to keep up the supply. The present law of the District of Columbia, by which pound-nets are kept

[1] Report, United States Fish Commission, part ii, 1874, p. lxi. [2] Page 7.

out of the water after June 1, will doubtless have a very important effect in keeping up the supply of Alewives in the Potomac.

SIZE.—According to the ordinary mode of estimating the weight of River Herring in the Potomac three make a pound, and the maximum weight per individual does not exceed half a pound.

USES.—The Herrings, or Alewives, taken in the great fisheries of the South, are almost without exception salted for local consumption, though early in the season they are shipped fresh from the Albemarle region to Philadelphia, New York, and Baltimore, and are sold in the markets at a low price. There is of course a considerable consumption in the fresh state in the region of the fisheries, immense quantities being taken by peddlers and carried by wagons inland from the rivers of the South, as well as from the Hudson, Connecticut, and smaller rivers of Massachusetts. Great numbers are smoked in North Carolina for local consumption; in fact, almost all which are used in the vicinity of the fisheries are taken out of the brine (after having been saturated with the salt, or "struck" or "corned") and hung up for a few days in the smoke-houses belonging to the purchasers who intend them for their own use.

When intended for shipment into the interior they are treated in several ways: (*i*) They may be taken out of the first pickle and packed in dry salt; in that case they are called "salt Herring." (*ii*) The roe Alewives may be selected, the heads and entrails removed and salted down in dry salt and sent to market as roe Alewives, of which there are several grades. (*iii*) They may be packed as split Alewives. In this operation the heads and entrails are removed by a single cut and twist of the knife, with surprising rapidity and packed in dry salt, or smoked. The heading and evisceration are done by a single stroke, and an expert operator will prepare forty to fifty per minute. This work is done by negro women. In Washington a superior brand of smoked Alewives is prepared and sold as "Potomac Roe Herring." These are highly esteemed by judges of smoked fish, and command a price of three or four cents each in the city markets. They are equal to the finest Labrador Herring. Small quantities are prepared after the German fashion—*Bückling*.

In conclusion, we quote from Professor Baird's second report as Commissioner of Fisheries the following remarks upon the uses and importance of this fish:

"I am inclined to think, for various reasons, that too little has been done in our waters towards the restoration to their primitive abundance of the Alewife (*Pomolobus mediocris*), the Herring of our Southern and Middle States, not to be confounded with the sea Herring (*Clupea elongata*).

"The Alewife in many respects is superior, in commercial and economical value, to the Herring, being a much larger and sweeter fish, and more like the true Shad in this respect. Of all American fish none are so easily propagated as the Alewife, and waters from which it has been driven by the erection of impassable dams can be fully restocked in the course of a few years, simply by transporting a sufficient number of the mature fish taken at the mouth of the stream to a point above the dams, or placing them in ponds or lakes. Here they will spawn and return to the sea after a short interval, making their way over dams which carry any flow. The young Alewives, after a season, descend, and return, if not prevented, at the end of their period of immaturity, to the place where they were spawned.

"In addition to the value of the Alewife as an article of food, it is of much service in ponds and rivers as nutriment for trout, salmon, and other valuable fishes. The young derive their sustenance from minute crustaceans and other objects too diminutive for the larger fish, and in their great abundance are greedily devoured by the other species around them. In waters inhabited

by both pickerel and trout these fish find in the young Alewives sufficient food to prevent their preying upon each other. They are also, for the same reason, serviceable in ponds containing black bass.

"As a cheap and very abundant food for other fishes, the young Alewives can be placed in waters that have no connection with the sea by merely transferring from any convenient locality a sufficient number of the living mature parents, taken at the approach of the spawning season; they will remain for several months, and, indeed, can often be easily penned up by a suitable dam and kept throughout the year.

"It is in another still more important connection that we should consider the Alewife. It is well known that within the last thirty or forty years the fisheries of cod, haddock, and hake along our coast have measurably diminished, and in some places ceased entirely. Enough may be taken for local consumption, but localities which formerly furnished the material for an extensive commerce in dried fish have been entirely abandoned. Various causes have been assigned for this condition of things, and among others the alleged diminution of the sea Herring. After a careful consideration of the subject, however, I am strongly inclined to believe that it is due to the diminution, and in many instances to the extermination, of the Alewives. As already remarked, before the construction of dams in the tidal rivers the Alewife was found in incredible numbers along our coast, probably remaining not far from shore, excepting when moving up into the fresh water, and at any rate spending a considerable interval off the mouths of the rivers either at the time of their journey upward or on their return. The young, too, after returning from the ocean, usually swarmed in the same localities, and thus furnished for the larger species a bait such as is not supplied at present by any other fish, the sea Herring not excepted. We know that the Alewife is particularly attractive as a bait to other fishes, especially for cod and mackerel. Alewives enter the streams on the south coast of New England before the arrival of the bluefish; but the latter devote themselves with great assiduity to the capture of the young as they come out from their breeding ponds. The outlet of an alewife pond is always a capital place for the bluefish, and, as they come very near the shore in such localities, they can be caught there with the line by what is called 'heaving and hauling,' or throwing a squid from the shore and hauling it in with the utmost rapidity.

"The coincidence, at least, in the erection of the dams, and the enormous diminution in the number of the Alewives, and the decadence of the inshore cod fishery, is certainly very remarkable. It is probable, also, that the mackerel fisheries have suffered in the same way, as these fish find in the young Menhaden and Alewives an attractive bait.

"The same remarks as to the agency of the Alewife in attracting the deep-sea fishes to the shores, and especially near the mouths of rivers, apply in a proportional degree to the Shad and salmon."

177. ON THE OCCURRENCE OF THE BRANCH ALEWIFE IN CERTAIN LAKES OF NEW YORK.

By TARLETON H. BEAN.

The Branch Alewife, *C. vernalis*, Mitchill, has of late years attracted considerable attention in Cayuga and Seneca Lakes, New York, and in Lake Ontario. The United States National Museum has received a great many individuals from each of these lakes, and upon examination they were all found to be the species above named. This would be expected from the well-known habits of the Branch Alewife, which ascends far up the streams and pushes its way into the interior, while, on the other hand, its relative, the Glut Alewife, appears never to penetrate far beyond

the limits of tidal waters. The United States Commissioner has received many letters concerning this Alewife from persons living on the shores of Lake Ontario and in the vicinity of Lakes Cayuga and Seneca. Some thought that these fish were Shad; others, however, recognized the fact of their disagreement from that fish, and spoke of them as a species of Herring. It is noteworthy that the Alewife, so far as we know, did not appear in Lake Ontario until after the introduction of Shad into that lake by the Fish Commissioner of New York. We have been unable to obtain any evidence of its occurrence in that lake before the Shad was introduced. Again, Lakes Seneca and Cayuga are separated from Lake Ontario by obstructions which could not well be overcome by spawning fish. The only theory on which the fact of the presence of this fish in these New York lakes can be explained would appear to be either that young Herring have been introduced by the employés of the New York Fish Commission when instructed to place shad eggs in the lakes, or that young Herring have been taken out of the cans in the act of changing the water upon the shad spawn prior to their transportation to these waters. It is a significant fact that these broods of young Herring have been found only in the lakes in which Shad have been introduced.

We are in possession of information which seems to establish conclusively that the Alewife does not occur in the lower waters of the Saint Lawrence River, nor was there any evidence of its presence at Montreal until within the last nine years.

The name which is most universally applied to this species wherever it is known along the Saint Lawrence River is "Gaspereau." In the vicinity of Cayuga Lake it sometimes receives the name "Cayuga Lake Shad."

"The Alewife is known to exist in Lakes Seneca and Cayuga, and in Lake Ontario, specimens from all these waters being amongst the collections of the National Museum. It is said to occur also in the headwaters of the river Saint Lawrence, and the probability of its presence there is strengthened by the following extract from a communication to "Forest and Stream," August 13, 1878, by a gentleman who writes under the pseudonym "Piscator":

" . . . a lively little visitor which came to us in shoals a few weeks ago, and disappeared again. The visitor in question was a little, silvery fish, very similar to a Herring, but having its belly (as I found to my cost in taking it off my flies) serrated or edged with sharp spines. I presume it is the same fish which has appeared in such abundance in the Upper Saint Lawrence and Lake Ontario."

Mr. Fred Mather, in a letter dated July 22, 1878, says: "I have heard of their being taken with a fly at Quebec (where they are called Gaspereaux), and also above there on the Saint Lawrence."

They appear to be little known, however, in the Province of Quebec, for Mr. J. F. Whiteaves, of Montreal, in a letter dated July 26, 1878, writes: "So far as I know, the Gaspereau, or Alewife, is not found at all in the waters of the Province of Quebec. I have never seen a living or recently caught specimen."

SCARCITY OF ALEWIVES IN THE SAINT LAWRENCE.—Professor J. W. Dawson, writing from Little Metis, Province of Quebec, July 30, 1878, states as follows: "The species is quite abundant in the Northumberland Strait and the Bay de Chaleur and rivers entering these, but so far as I can learn rare in the river Saint Lawrence. . . . At this place (Metis, which you will find on the south side of the Saint Lawrence a little below Father Point), I am told that Gaspereaux are mere stragglers, appearing only very rarely and in small numbers; but that they are more plentiful at Matane, thirty miles farther east. I do not know of their occurrence on the north shore opposite this place, but have no positive information. I have never heard of the occurrence of the Gaspereau at Montreal, though the Shad ascends the river to that place, and far up the Ottawa."

The above extracts concerning the appearance of the Alewife in the Saint Lawrence tend to prove that, at least until a very recent period, it has been almost unknown in the lower waters of that river.

Specimens of the Alewife, obtained by Prof. S. F. Baird, from Croton River, Sing Sing, New York, are in the collections of the United States National Museum.

Prof. Hamilton L. Smith, Geneva, New York, furnishes the following information, obtained from an old angler, concerning the appearance of Alewives in the vicinity of Seneca Lake: "Their first appearance in the neighborhood of Seneca Lake was in the dam below the rapids at Waterloo, near Geneva, in June, 1868. In the spring of 1869 the surface of the water in the lake here was covered with them." The species was known in Cayuga Lake as early as 1868.

According to Mr. E. Tyler, of Henderson, New York, it was first noticed in Lake Ontario in June, 1873, when large quantities were taken in pounds and trap-nets.

Mr. W. Ainsworth, of Cape Vincent, New York, wrote on August 13, 1878: "This fish (the Alewife) first appeared in Lake Ontario and the river Saint Lawrence at Cape Vincent, in 1873, in large quantities."

THE ORIGIN OF THE ALEWIFE IN LAKE ONTARIO AND THE NEW YORK LAKES.—As already stated, there seems to be no reasonable doubt that the Branch Alewife was introduced into Lake Ontario with Shad, prior to whose introduction no evidence of its occurrence in that lake appears. It is an undecided point whether Alewives go down the Saint Lawrence to the ocean in the fall and return in the spring, as they do upon the Atlantic slope, or whether they spend the winter in the deeper waters of the lake. We have not the specimens at hand to enable us to establish the facts concerning the migrations of this species through the Saint Lawrence. It is noteworthy, however, that when they appear in the waters which they frequent, they come in immense schools, and at the time of, or a short time prior to, their spawning season. The first schools that appear seem to consist of large, adult fish. It may be that the schools descend the Saint Lawrence in the fall and ascend in spring. However this may be, we are justified in believing that Alewives were artificially introduced into Lake Ontario; and this is a more reasonable view of the case than to admit a total change in their habits, such as would be involved by their sudden departure from their accustomed waters into new and untried regions.

As to their presence in Cayuga and Seneca Lakes, New York, we have grounds for believing that they have, of their own accord, penetrated thus far into the interior of New York State. Mr. Fred. Mather writes that he has seen Alewives go up the canal locks at West Troy, and Prof. H. L. Smith, of Geneva, who first noticed them in the neighborhood of Seneca Lake in June, 1868, states that the canal was opened about that time, and thinks that they might have come into the New York lakes from the Chesapeake or Delaware Bays through Elmira and Painted Post.

We learn from Prof. Hamilton L. Smith that Alewives obtained near Geneva, New York, in June, 1868, were eight to nine inches long. He also sent to the National Museum specimens from Seneca Lake, four of which were, respectively, three and two-fifths, four and four-fifths, four and nine-tenths, and six and one-fifth inches in length. One specimen, forwarded by Prof. D. S. Jordan from Cayuga Lake, measured five and three-tenths inches. Two spent females, received from Horton Brothers & Ainsworth, and obtained by them in Lake Ontario, ranged from eight to nine and a half inches in length. Nearly all the specimens received from the interior lakes of New York are small—considerably smaller than those from Lake Ontario, and present a somewhat starved appearance. This characteristic was specially noticeable in the individuals which were found dead in immense numbers. The specimens from Lake Ontario are, on an average, equal in length to those which enter streams on the Atlantic coast. Mr. Ainsworth says that those cap-

tured at Cape Vincent vary in length from one and a quarter to eight inches. He never saw one that would weigh over half a pound. Mr. E. Tyler writes that the largest individuals are about nine inches long.

Reference has already been made, in another place, to the statement of Prof. H. L. Smith concerning the abundance of this fish in Seneca Lake, New York, near Geneva.

Mr. Ainsworth says that they were present at Cape Vincent in large shoals in 1873, and that they increased in numbers until, in 1878, immense quantities were taken throughout the waters of the lake and in the headwaters of the Saint Lawrence. He also states that he knew one fisherman to take fifteen barrels of Alewives from a small pound-net at one time. Mr. Tyler corroborates the statement of their abundance in June, 1873, and in a letter dated July 27, 1878, adds: "Now our waters are literally filled with them. In hauling seines they are often a terrible nuisance. Such countless millions are hauled ashore at times, that it becomes necessary to lift the seine and let them run out; it could never be got ashore with safety."

Messrs. Clark & Robbins, in a letter dated December 19, 1879, state that "they [Alewives] interfere with pound and trap net fishing, as they fill the nets to the exclusion of other fish."

Mr. George Burn, of the Exchange Bank of Canada, Montreal, says, in a letter dated August 20, 1878, that the Alewives come into the Saint Lawrence in great shoals at first, "the water being fairly alive with them."

MOVEMENTS.—It will be observed, from what has already been said, that the Branch Alewife is found in the waters under consideration, just as in the coast streams, at or near the surface of the water in immense schools. Mr. W. Ainsworth, in a letter previously quoted from, writes: "They swim in large schools and rise to the surface, and, when the water is still, they cause a ripple upon it similar to that produced by a school of mackerel."

Mr. George Burn, it will be remembered, has stated that in the Saint Lawrence River they appear in great shoals at first.

It would seem that the disappearance of the Alewife from these waters is as sudden as its appearance. Mr. E. Tyler, under date of September 1, 1878, remarks: "If possible for you to wait until October, I will be able to give you every grade from three inches in length to full-grown fish. The pound-nets at that time will be hauling, and barrels of them are taken at each haul. We can get the large ones at any time with cisco gill-nets." Mr. Tyler was, however, unable to secure specimens for us at the time when he supposed they would be abundant, and on January 20, 1879, he wrote: "We set to work every kind of device to get the Alewives. Our cisco fishermen could get none in their gill-nets here, and I went to Sacket's Harbor, a distance of nine miles, and made arrangements with the fish-dealers to notify all the pound-net fishermen to save some; but only one was caught in Chaumont Bay during the fall. I also went once, and sent twice, up the shore towards Oswego, seven miles, where an immense seine is hauled, and where, in the summer, these Alewives are so abundant that it is impossible to get the net ashore at times; I certainly thought I could not fail there; but only one was taken during the fall. Our cisco nets are often in one hundred feet of water, and no Alewives are gilled after the 1st of September.

Mr. George Burn has observed the sudden disappearance of the Alewife at Montreal, but he believes that they sometimes reappear after their first disappearance. It would seem from the above statements that different schools of Alewives are present at various times during the summer, and that all of them leave late in September or early in October. It seems also as if they go into the deeper water of the lake, and are sometimes caught in gill-nets. Mr. E. Tyler, writing from Henderson, New York, October 5, 1879, makes the following statement: "The

Alewives left us, as usual, about August 10, and the Shad also; at least none have been caught since."

In a letter dated June 14, 1879, he says: "Since about August 25 [1878] no Alewives were seen in these waters until the first of May last [1879]. . . . This spring [1879] I made arrangements with the owner of the seines (six miles south of Henderson) to send me the first ones taken, and he brought me five on May 14. . . . I drove over next day, but not one could be found in the net; but in a short time there was an abundance here, but all of one size. The first that came appeared to be large. . . . In answer to your question as to the route by which they come, I can only reply that the first seen of them was the last of April [1879]; the trout taken at the mouth of Saint Lawrence were filled with them. From the best information obtainable, they come here from the ocean with the Shad, and return with them in the fall to the same place."

Mr. W. Ainsworth, whom we have frequently quoted, writes that the spawning season for the Alewife in Lake Ontario is in June.

Mr. N. H. Lytle, of Ogdensburg, New York, wrote, September 26, 1879, concerning the Alewife as follows: "In June, 1878, a fisherman came into the 'Journal' office with several of these fish. He was not able to give them a name. I had frequently seen Shad on the butchers' stalls, and was of the opinion that they also were Shad. . . . I opened the fish and found them full of eggs and almost ready to spawn. A few days later they came up the Oswegatchie River in thousands as far as the dam, and many were caught by the boys. They were then from seven to ten inches in length. . . . This year they made their appearance again in the latter part of June, and came up the Oswegatchie River. They were noticed at many points on the Saint Lawrence and in Lake Ontario. Steamers passing up and down the river reported seeing them in schools of millions."

The following note was sent by a correspondent, "H. W. P.," at Waddington, May 31, 1878, to the Ogdensburg Journal, and forwarded to us by Mr. Lytle: "A colony of . . . Shad appeared here yesterday in full spawning order. John Stark caught thirteen, measuring eight inches and under." It is evident from the size of these fish and their spawning condition that *they must have been Alewives. Two large females, received from Horton Brothers & Ainsworth*, who collected them in Lake Ontario September 17, 1877, were spent.

ENEMIES AND FATALITIES.—According to the statements of persons living on the shores of Lake Ontario, Alewives are largely consumed by lake trout (*Salvelinus namaycush*), pike (*Esox lucius*), pickerel (*Esox reticulatus*), muskellunge (*Esox nobilior*), black bass (*Micropterus salmoides and M. dolomiei*). *There is no doubt that other predatory fishes destroy large numbers of the* Alewives, the wall-eyed pike (*Stizostedium*) and burbot (*Lota maculosa*) doubtless proving very destructive to this species. The yellow perch (*Perca americana*), species of *Lepomis*, *Ambloplites*, and other centrarchids doubtless kill vast numbers of the young.

According to the testimony of those who are familiar with the fisheries of the lakes, incredible numbers of Alewives are destroyed by the use of fishing implements intended for the capture of edible fish. Vast quantities of dead Alewives have been observed upon the shores of Seneca and other lakes of New York. Examples of such fish have been received by the United States National Museum from Seneca Lake, whence they were forwarded by Prof. Hamilton L. Smith. An examination of some of these specimens shows that the air-bladder is abnormally distended, filling the major portion of the abdominal cavity. What may have been the cause of this distension is of course unknown, but it will account for the presence of the dying fish at the surface.

Appended are two extracts (the one from the "Utica Herald" and the other from the "Rochester Union"), which may throw some light upon this subject:

"The cause [of the sudden death of vast numbers of fish] is the explosion of dynamite. Fishermen deposit crabs and other bait to attract particular species of fish, and when they [the fish] are supposed to be collected, they [the fishermen] drop a cartridge, charged with dynamite, to which is attached a fuse, and the explosion of which will kill every fish within a radius of sixty to eighty feet, and shock those at a greater distance, which, though they do not immediately rise to the surface, in their gasping, weakened condition, take into their gills the sand set free by the explosion, which ultimately produces death. By this means thousands of fish, not large enough for profitable sale or use, are destroyed; and, if the practice be continued, it will neutralize all efforts of our Fish Commission to stock our lakes and rivers. The quantity of black bass and other choice fish of Lake Erie and Niagara River daily exposed for sale in the fish markets has been and is suspicious, and led me to make diligent inquiry as to their mode of wholesale capture and destruction."

The second extract reads thus:

"Although 'Game Constable' Swartz succeeded in cleaning all the nets out of Irondiquoit Bay he has continued to observe that fish were brought from that locality and sold in larger quantities than could be taken in a legitimate manner. At an early hour this morning he set out for the Sea Breeze, arriving there about three o'clock. Nobody was seen fishing; but all along the shore of the sand-bar, about two hundred yards east of the Sea Breeze House, were found quantities of dead fish of all kinds, in some places piled three or four deep, and covering a considerable space of ground. These fish, consisting chiefly of bass, perch, bull heads, and sun-fish, were all small. On cutting open and examining a number of them, their air-bladders were found to have burst, as is always the case when fish are killed by means of nitro-glycerine cartridges exploded in the water. The conclusion is, therefore, irresistible that the fish were killed in this way. When they come to the surface they are all scooped up and taken ashore, where the big ones are sorted out, and the little ones left on the sand. The deadly explosive kills every living thing, old and young, within reach of it."

CAPTURE.—Specimens have been dredged, by Prof. B. G. Wilder, in Cayuga Lake. Vast numbers, too, are taken about the foot of Lake Ontario in pounds, traps, and seines. Small numbers are caught in gill-nets, even in the cisco nets, which are set in very deep water. Mr. E. Tyler writes that at Henderson, New York, Alewives take a fly quite readily. Mr. Fred. Mather writes that he has heard of their having been taken with a fly at and above Quebec on the Saint Lawrence. Mr. George Burn, of Montreal, states that he has caught Alewives with artificial flies at that place.

Inquiries have been made as to the methods of utilizing Alewives as the basis of fertilizers, but we do not know that anything has yet been attempted in that direction. Mr. W. Ainsworth writes under date of August 13, 1878, as follows: "They furnish excellent food for salmon, trout, pike, pickerel, and black bass. They have increased the quantity, as well as improved the quality of these fish."

Mr. E. Tyler wrote on July 27, 1878: "So far I consider them a blessing. They supply all our edible fishes with an abundance of food, so that the young fry of bass, trout, pike, pickerel, and muskellunge are not destroyed as formerly, but are allowed to mature, and to-day all the above fishes are more plentiful than for many years past."

There can be no doubt that the Alewife would prove useful as food and bait for other fishes. The annoyance which it causes by filling the seines and pounds will, undoubtedly, be offset by its usefulness in the fisheries of the future.

178. THE INLAND ALEWIFE OR SKIPJACK—CLUPEA CHRYSOCHLORIS.

This fish, which is found in many parts of the Mississippi Valley, has recently been found by Mr. Silas Stearns in the salt water off Pensacola—a surprising circumstance, since the species was thought to be an inhabitant of fresh water exclusively. "It is known to most inland fishermen as the 'Skipjack,'" writes Professor Jordan, "in allusion to its habit of leaping from the water. It is also sometimes called 'Shad' and 'Herring.' It is abundant throughout the Mississippi Valley in all the larger streams. In the neighborhood of the ocean it descends to the Gulf, but in the upper courses it is permanently resident. It has also entered Lake Michigan and Lake Erie since the construction of the canals. It reaches a length of a little more than a foot. It feeds on small crustaceans, worms, and the like, rarely taking the hook. As a food-fish it is regarded as wholly worthless, its flesh being poor and dry, and full of innumerable small bones."

179. THE SHAD—CLUPEA SAPIDISSIMA.

By MARSHALL MCDONALD.

NAMES.—The following notes on the names of the Shad are taken from an unpublished manuscript by Mr. Goode upon the fisheries of Florida. The Shad appears to have been considered by early American writers on fish identical with the Shad of England, *Clupea finta*. The first to give to it a distinctive name was Alexander Wilson in the American edition of Rees' Cyclopædia.[1] I quote his description in full, since it was claimed by Rafinesque, whose remark has been since frequently quoted, that *Clupea sapidissima* was "catalogued, not described," by Wilson:

"*Clupea sapidissima* (AMERICAN SHAD).—No spots on the sides; snout entire (not bifid as in the European); from eighteen inches to two and a half feet in length; weighs from six to ten and twelve pounds. Scales large, deciduous, and of a silver color, most delicious. They are for six months about the capes or mouths of large rivers, then run into the sea. During March, April, and May, they ascend these rivers to the freshes, and thence toward their sources, in order to deposit their eggs in shallow water, where, hatching, the young fry descends in the latter part of the summer and autumn to the tide waters, and thence down to the salts; and the adults return likewise to the sea, thin, emaciated, and weak."

GEOGRAPHICAL DISTRIBUTION.—The Shad is found along the whole Atlantic coast of the United States, and its capture constitutes one of the most important fisheries in all the streams draining into the Atlantic between the Gulf of Saint Lawrence and the Saint John's River, Florida. Its northern limit is thus defined by Charles Lanman in the "Report of the United States Fish Commission," part ii:[2]

"The Shad is but rarely seen on the Atlantic coast of Nova Scotia. It is found in the Gulf of Saint Lawrence, the various rivers of which it ascends as far north as the Miramichi, which seems to be its limit in that direction, none having been seen in the Bay of Chaleur."

Throughout this entire range the Shad is found in sufficient quantities to give rise to fisheries of great commercial value. There is no run of Shad into any of the rivers draining into the Gulf of Mexico, although the capture of isolated individuals of this species has been reported from the

[1] The Cyclopedia or Universal Dictionary of Arts, Science and Literature. By Abraham Rees . . . First American edition in forty-one volumes. Philadelphia. [The American edition is said by Allibone to have been in course of publication from 1809 to 1820. Dr. Gill tells me that he has evidence to show that vol. ix was published prior to 1814.]

[2] Page 461.

Alabama River and from several tributaries of the Mississippi prior to any steps towards the artificial propagation of Shad in these waters by the United States Fish Commission. It is, however, probable that many of the so-called "White" Shad were but large specimens of the "Golden" Shad of the Mississippi Basin. Unquestionably, however, Professor Baird was referring to the capture of a genuine *Clupea sapidissima* in the waters tributary to the Gulf of Mexico when he wrote:[1] "I have already referred to the discovery of Shad in the Alabama River, whether the result of Dr. Daniel's experiments already detailed or not; and I am assured by reliable testimony that they are found at the present time in other streams of Alabama. Of this I am well satisfied, having actually received a specimen from Mr. W. Penn Yonge, of Springville, Alabama, taken at Elba, Alabama, and preserved in alcohol, and distinguishable in not the slightest particular from the Shad of the eastern coast. I have also the assurance of Dr. Lawrence of their capture at the Hot Springs of the Ouachita; of Dr. Middleton Goldsmith, at the Falls of the Ohio, near Louisville; and of Dr. Turner, in the Wabash River of Indiana and Illinois, and in the Neosho River of Kansas."

If the occasional presence of individuals of this species in the waters tributary to the Gulf of Mexico be admitted, it seems unaccountable that, since no fisheries have there been established for its capture, that the natural increase should not have been such as to cause at least as abundant a run into the rivers emptying into the Gulf as into those on the Atlantic coast.

If, moreover, assuming that this species has been present in these waters in sufficient numbers for effective reproduction, natural causes have not combined to establish a run of this fish in the tributaries of the Gulf, it can scarcely be hoped that any measures of artificial reproduction would, if resorted to, accomplish the desired result. Nor does existing proof appear sufficiently positive, as yet, to establish more than the occasional occurrence of isolated specimens in these waters under conditions simply natural. It is probable that where true Shad have been found in the tributaries of the Gulf of Mexico explanation may thus be made: Occasional individuals have strayed beyond their natural geographical range, around the Florida peninsula, and, once in the Gulf, they have entered the rivers under the impulse of reproduction, but never in sufficient quantities to maintain themselves.

In January, 1879, by direction of Prof. G. B. Goode, the writer was requested to proceed to the Alabama River to investigate the question of the natural occurrence that White Shad in this river. The report then made gives probably all the facts on this subject that have yet been obtained. They are as follows:

"There is no doubt that 'White Shad,' to the number of two or three thousand, were taken in the Alabama River and its principal tributary, the Coosa, in the seasons of 1878 and 1879, and of inferior size and in smaller numbers in the season of 1877. Whether these runs of Shad were the result entirely of the government 'plants,' beginning in 1875, or were due in part to previous plants made by individual enterprise, are the questions to the solution of which I have directed my investigation. I have not sought to determine the question whether the 'White Shad,' *Clupea sapidissima*, is indigenous to the Alabama River. This has been stated again and again. Judge Phelan, in a letter to the 'Montgomery Advertiser' of April 11, 1878, claims to have eaten 'White Shad' at Centreville, Alabama, not later than 1848. They were taken in traps at the Falls of the Cahaba, and were pronounced 'White Shad' by Mr. Samuel Jamison, an old North Carolina fisherman. Judge Phelan further states that some claimed that they were only Hickory Shad.

"No amount of such evidence can ever settle this question. There is always the possibility

[1] Report United States Fish Commission, part ii, p. 55.

of mistake on the part of those making the assertion, and since the presumed or actual introduction of Shad into these waters, we cannot settle the question by actual identification of specimens.

"If the true *Clupea sapidissima* is natural to the waters of the Alabama, or if the plants in the Coosa in 1848, and the plant in Conley Creek, near Montgomery, in 1856, were successful, then there must exist in the waters of the Alabama certain conditions which are unfavorable to natural increase, and all the efforts of the United States Commission to establish an annual run of Shad in the Alabama River by artificial plantings will prove abortive.

"On the other hand, if the planting operations of the United States Commission are successful in establishing a run of Shad in this river, the result will prove that the Shad are not indigenous to these waters and that previous plants were unsuccessful. Two or three years will settle this question.

"There seems to be nothing in the conditions presented by the Alabama River to prevent the establishment of a run of Shad in that river, unless the low temperature of the river during the running season of the fish prevents maturity of the ova."

The geographical range of the Shad, as already stated, was confined to the Atlantic coast of the United States until, by the operations of the United States Fish Commission, its limits were vastly extended. Runs of Shad, sufficiently large to be of commercial value, have been established in several of the tributaries of the Mississippi River, notably the Ohio River; and the several plants made from time to time in the Sacramento River, on the Pacific coast, have resulted in the colonization of this species in all the rivers of the Pacific slope, from the Sacramento to Puget Sound.

MIGRATIONS.—It is doubtful whether there is any general coastwise movement of the Shad. That there is an occasional migration of this kind is evidenced by the following facts: The Shad of the rivers of the South Atlantic coast, as a rule, have black-tipped caudal and dorsal fins, which distinctive marks of coloration are absent in the Shad of more northern rivers; and yet occasionally these southern Shad are caught as far north as the tributaries of the Chesapeake and Delaware Bays. These fish have undoubtedly been born and bred in southern waters, and their appearance so far north would indicate that occasionally this southern variety strays beyond its normal range.[1] At one time[2] it was imagined that the whole body of American Shad, having wintered in the south, started northward with the new year, and as each river mouth was reached a detachment would leave the entire mass for the purpose of ascending the river, the last remaining portion of the immense school entering the Gulf of Saint Lawrence.

At a later date it was thought more reasonable to suppose that the young fish, hatched out in any particular stream, went out into the sea and remained within a moderate distance of the coast until the period again occurred for their upward river migration. Their appearance, first in the extreme southern river of the coast, the Saint John's, and at later dates successively in the more northern rivers, was thought to confirm this view. It will be seen, in the discussion of the relation of the movements of the Shad to the water temperature, that this order of appearance when preserved may be reasonably accounted for; there are, however, exceptions. For instance, the Edisto River is many miles north of the Savannah, and yet the run of Shad in the former is usually coincident with that in the latter. This leads us to believe that the Shad are generally distributed along the coast at all times, entering the rivers as soon as the temperature of the

[1] Report United States Fish Commission, part ii, p. 48.

[2] It may here be mentioned that there are probably several well-defined hydrographical areas along the Atlantic coast beyond each of which Shad indigenous to that area rarely stray. Each race has its own peculiar characteristics.

water is suitable. It is but natural that the waters of a creek or short stream, not having its source in the mountains, should in the spring become warm long before those of a large river whose headwaters are far up among the mountains; for which reason we may expect to find, in the case of two rivers, the most southerly of which has a longer water-course than the other, that the Shad will first enter the more northerly, yet shorter, and consequently, at a given date, warmer stream. The question, therefore, appears to be rather one of temperature than of geographical location.

The greater portion of the life of the Shad being spent in salt water, the possibility of close observation as to their food, habits, or precise habitat is precluded. The young fry, hatched out in the rivers in spring and early summer, remain there until the following fall, when, the temperature of the waters having fallen below 60°, they leave for the ocean. Nothing more is seen of them until they return to the rivers as mature fish for the purpose of spawning. In these upward migrations the schools of mature fish ascend the rivers either until obstructed by impassable falls or dams, or until the volume of water becomes very inconsiderable. Before artificial impediments were placed in the rivers, the limit of this movement was the natural and insurmountable falls to be found at the head of almost all of our principal streams. For example, in the Savannah River the Shad used to ascend to the Falls of Tallula, at the very source of the river in the northern part of Georgia. In the Potomac they ascend as high as the Great Falls. In the Susquehanna River, in which there exist no natural obstructions, their migrations extended up into the State of New York, a distance of several hundred miles above the present limit. On the Hudson River they ascended to Glens Falls. On the Connecticut at one time they went as high as Bellows Falls, but recent obstructions in this river have materially reduced the extent of their range.

The present limit of the upward movement of the Shad in our rivers, the natural limit before obstructions were interposed, and the extension of the natural limit which may be obtained by overcoming these natural and artificial obstructions now existing, are shown in the accompanying chart. It will be seen from this that the breeding area has been diminished from one-half to one-fourth its original extent, involving a corresponding reduction in the productive capacity of these streams.[1]

HEREDITARY INSTINCT OF LOCALITY.—The annual migration of the Shad in the spring of the year into the fresh waters of our rivers has been explained by various theories. In regard to the salmon, which has been long known and observed in European waters, the fact seems to have been established that the same individual will return year after year to the same stream for the purpose of spawning, and that young fish bred in a certain stream usually come back to the same upon their return from the ocean as mature fish. This habit has not been conclusively established in regard to any other family of anadromous fishes, but it is generally believed that all salt-water species which spawn in fresh water return for this purpose to those streams in which they themselves were deposited. An examination of the literature of fish culture will make it evident that this opinion has been held very generally, and, indeed, has furnished to a great extent the argument for the prosecution of the work of artificial reproduction. It is a common belief, too, among fish-culturists that the mature individuals of all anadromous species, including the Shad, are led back to the waters in which they were spawned by a conscious wish on their part to return to those very localities in which they spent their young life. Important exceptions to this rule are, however,

[1] See Chart of the River Basins of the Atlantic Slope.

well established by recent observations. For instance, it is well established that the runs of Shad into the Susquehanna and Potomac Rivers are characterized by alternations of abundance; that is to say, an excessively large yield for any given season in the one involves a corresponding diminution in the yield for the same season in the other, thus precluding the possibility of each individual returning annually to its native stream. Again, it was confidently expected that all the young Atlantic Shad which were transferred to and planted in the Sacramento River would, on their return from the Pacific Ocean as mature fish, find their way back to this stream. This was not, however, the case, for, to the utter astonishment of many fish-culturists, a considerable number of these now mature fish made their appearance in many streams of the Pacific lying far north of the Sacramento River—streams to which Shad had never been indigenous and in which none had ever been planted.

These facts go a long way to disprove the theory of instinct of locality, and indicate that the river movements of the Shad are regulated by involuntary and extraneous influences. The migration and colonization of this fish northward along the Pacific coast has been so general that at the present day new generations of a single plant are found in every stream on the Pacific from the Sacramento River to Puget Sound.

THE "FEEL" OF THE RIVERS.—Some writers, notably Mr. Charles G. Atkins, have suggested the idea that the upward river migration of the anadromous fishes is directed by an instinct which impels them to swim against the current. It is supposed by him that in their coastwise movement the Shad, when opposite the mouths of the rivers, feel the outflowing current and, responding to the invitation, immediately turn to and stem it and are thus led into and up the stream. The conclusive reply to this supposition is that in the wide estuaries of our North Atlantic streams there is no sensible current, excepting that produced by the tidal ebb and flow, which is far too indeterminate to be the directing cause of the migrations of those vast schools of Shad, Alewives, and other species which annually enter our rivers. Even if the fish were attracted up stream by the gratification of that presumed impulse or desire to swim against the current, how can we account for their migration down stream, at the appropriate season, this movement being as regular and as universal as the upward migration?

CHANGE OF SALINITY.—It has been suggested that Shad may be sensible of the decreasing salinity of the water as they enter and ascend the rivers, and that they may be led into continental waters in order to enjoy a more congenial habitat; but in this event it is necessary to explain why they do not remain in the rivers altogether.

WATER TEMPERATURES.—Prior to the last decade, very little attention was paid to the water temperatures in connection with the migrations of fish. We have on record but few series of observations of water temperature during the season of our river fisheries. Since the inauguration of the United States Fish Commission, however, and the establishment of hatching stations on the rivers, it has become possible to make a closer study of this subject. It will, however, require a connected series of such observations, made during several seasons and at many stations, in order to obtain sufficient data for a satisfactory discussion of "the relation of the movements of fish to the water temperatures." Up to the present time the drift of investigation goes to prove that the movements of fish, anadromous and otherwise, are controlled largely, if not entirely, by the temperature of the medium in which they live.

In the case of "bottom-feeders," their movements are dependent, no doubt, principally upon the

migrations of their prey; but here again it is probable that the movements of the latter are influenced by temperature.

In the case of Menhaden and Shad, which species feed as they swim, the temperature of the water is probably the main factor in determining their movements. It is a fact, for example, that the disappearance of Menhaden from the coast of Maine[1] was, and has each year since been, coincident with a uniformly lower temperature of the water along that coast during the menhaden season.

The causal relations of the migrations of the sea Herring to water temperatures is a matter recognized by the pisciculturists and fishermen of the North European Atlantic region; but their observations, as with our Shad, have not been sufficiently extensive to enable them to define accurately the relations of the one to the other.

In regard to the Shad, and presumptively to other fishes also, it is believed to be true that there is a certain temperature of the water in which these fish prefer to live; in other words, that they aim to occupy a hydrothermal area of certain temperature; and, further, that their migrations are determined by the shifting of this area.

To state this theory somewhat differently, it is believed that all migratory fish have a normal range of temperature in which they seek to remain. As before stated, observations on this point are not as yet extensive, and therefore the limiting hydro-isothermals within which a given species may at any time be found cannot yet be absolutely defined.

So far as this matter has been examined with regard to the Shad, the following conclusion has been reached, namely, that they occupy an hydro-isothermal belt, or area, limited by the temperature of 60° F. to 70° F.; that they move with this belt, *i. e.*, as the season advances, into and up the rivers. This movement, at least in the case of the Shad and Herring, takes place at the time when they have nearly matured their spawn, and just at that important crisis, by means of that exact balance and adjustment which nature everywhere provides, the fish are brought by influences of which they are entirely unconscious into such relations and under such conditions as make reproduction possible. But, although the operation of spawning is mainly that for which the fitness of relations and conditions has been ordained, the following statements will show that the fish in moving up the rivers are not always actuated by the immediate desire to deposit their spawn.

OBSERVATIONS ON THE SAINT JOHN'S RIVER, FLORIDA.—In the Saint John's River, Florida, the Shad appear in the river several months before the spawning time, and, although this season in the Upper Saint John's is not largely in advance of the same season in rivers as far north as certain tributaries of the Chesapeake, yet by reason of their early presence in the Saint John's the shad fisheries, as has before been noted, are there prosecuted during the entire winter. They do not enter the river at this time for the purpose of spawning. By reference to tables giving the temperatures of the Saint John's River at Jacksonville for twelve months beginning March 1, 1877, and ending February 28, 1878, it will be seen that in the Saint John's River the temperature of the water gradually descends, reaching 60° F. at Jacksonville about the last of November. This date is coincident with the first appearance of Shad in the Saint John's.

[1] This commenced in 1879, and they have not yet reappeared to any extent.

Table of temperatures, Saint John's River, Jacksonville, Florida.

RECORD OF DAILY OBSERVATIONS TAKEN AT 3 P.M.

[Data furnished by Prof. G. Brown Goode.]

Date.	Location of thermometer.			Date.	Location of thermometer.			Date.	Location of thermometer.		
	Air.	Surface.	Bottom.		Air.	Surface.	Bottom.		Air.	Surface.	Bottom.
1877.	° F.	° F.	° F.	1877.	° F.	° F.	° F.	1877.	° F.	° F.	° F.
Mar. 1	60	60	60	May 1	71	69	69	July 1	90	83	83
2	61	61	61	2	76	68	68	2	92	84	83.5
3	70	62	61.5	3	81	69	68	3	90	85	85
4	76	62	62	4	80	70	69	4	95	85	85
5	78	65	64	5	86	70	70	5	89	85	85
6	54	62	62	6	84	72	71	6	90	84	83
7	70	64	63	7	83	71	70	7	85	82	82
8	76.3	64	64	8	77	70	70	8	83	81	81.5
9	73	64	64	9	76	71	70	9	87	82	82
10	51	64	64	10	80	73	72	10	83	83	83
11	61	63	63	11	75	70	70	11	85	83	82.5
12	74	65	64	12	74	70	70	12	85	80	80
13	78	66	66	13	80	71	70	13	87	82	81
14	72	65	64	14	79	71	70	14	89	82	82
15	69	65	64	15	78	70	70	15	89	81	81
16	72	66	65	16	77	70	70	16	88	80	80
17	77	66	65	17	75	70	70	17	87	82	81
18	61	65	65	18	74	70	70	18	80	82	82
19	70	64	63	19	80	70	70	19	90	82	82
20	74	62	61	20	82	71	71	20	81	79	79
21	73	62	62	21	84	75	75	21	84	81	80
22	63	62	61	22	91	76	76	22	80	81	81
23	69	62	62	23	95	77	77	23	87	82	81
24	72	62	62	24	78	76	76	24	89	82	81
25	67	63	63	25	82	76	76	25	88	82	82
26	54	59	59	26	74	74	74	26	91	82	82
27	75	58	57	27	72	71	71	27	91	84	84
28	81	59	57	28	67	69	70	28	92	84	84
29	67	60	59	29	73	69	68	29	97	85	84
30	66	60	60	30	78	70	69	30	98	84	84
31	77	60	60	31	79	70	70	31	87	84	84
Apr. 1	71	61	60	June 1	80	71	70	Aug. 1	86	83	82
2	78	62	61	2	81	72	72	2	85	82	82
3	75	63	62	3	84	75	74	3	90	83	83
4	79	64	63	4	89	77	76	4	90	83	83
5	78	64	63	5	89	77	77	5	90	85	85
6	79	66	66	6	86	76	75	6	92	87	87
7	84	68	67	7	95	78	78	7	95	86	86
8	76	64	64	8	94	78	78	8	92	86	86
9	75	66	65	9	80	80	80	9	91	83	83
10	62	64	55	10	87	80	79	10	94	83	83
11	62	63	63	11	77	79	79	11	90	84	84
12	68	63	63	12	77	77	77	12	90	83	83
13	71	64	64	13	81	76	76	13	92	84	83
14	61	60	60	14	81	75	76	14	81	83	83
15	67	61	61	15	85	78	77	15	87	82	82
16	74	62	61	16	84	78	78	16	92	83	82
17	77	64	63	17	86	78	78	17	88	83	83
18	81	64	63	18	88	79	79	18	78	79	79
19	79	65	64	19	95	83	82	19	81	79	79
20	84	66	66	20	80	83	83	20	83	79	79
21	80	68	67	21	84	84	84	21	84	80	80
22	74	67	66	22	87	83	82	22	78	79	79
23	76	68	67	23	90	82	81	23	81	79	79
24	84	70	69	24	90	81	81	24	87	80	80
25	84	72	71	25	95	84	84	25	80	79	79
26	79	69	69	26	97	85	85	26	82	78	78
27	85	70	70	27	98	85	85	27	86	79	78
28	83	70	70	28	97	85	85	28	85	79	78
29	78	70	69	29	88	85	85	29	87	79	78
30	75	69	69	30	89	84	84	30	90	80	79
		*						31	90	80	80

EXTREME AND MEAN TEMPERATURES, BY MONTHS.

	Air.	Surface.	Bottom.		Air.	Surface.	Bottom.
	° F.	° F.	° F.		° F.	° F.	° F.
March:				June:			
Maximum	81.0	66.0	66.0	Maximum	98.0	85.0	85.0
Minimum	51.0	58.0	57.0	Minimum	77.0	71.0	70.0
Mean	69.1	62.6	62.2	Mean	87.4	79.4	79.2
April:				July:			
Maximum	85.0	72.0	71.0	Maximum	96.0	85.0	85.0
Minimum	61.0	60.0	60.0	Minimum	81.0	79.0	79.0
Mean	76.0	65.7	65.1	Mean	87.0	82.5	82.4
May:				August:			
Maximum	95.0	77.0	77.0	Maximum	95.0	87.0	87.0
Minimum	71.0	68.0	68.0	Minimum	81.0	79.0	78.0
Mean	78.7	74.3	71.0	Mean	87.0	81.7	81.4

Table of temperatures, Saint John's River, Jacksonville, Florida—Continued

RECORD OF DAILY OBSERVATIONS TAKEN AT 3 P. M.

[Data furnished by Prof. G. Brown Goode.]

Date.	Location of thermometer.		
	Air.	Surface.	Bottom.
1877.	°F.	°F.	°F.
Sept. 1	94	82	81
2	90	80	80
3	83	80	80
4	85	80	80
5	88	80	80
6	90	81	81
7	83	82	81
8	80	81	80
9	86	81	80
10	85	81	81
11	88	81	81
12	90	82	82
13	91	82	82
14	84	80	80
15	86	81	81
16	89	82	81
17	89	82	82
18	86	82	82
19	88	82	82
20	90	82	82
21	88	81	81
22	83	81	81
23	80	81	81
24	82	79	79
25	81	78	77.5
26	75	77	77
27	78	77	77
28	81	76	75
29	80	75	75
30	73	74	74
Oct. 1	78	74	74
2	80	74	74
3	80	74	74
4	81	73	72.5
5	72	71	71
6	70	70	71
7	71	70	70
8	84	71	70
9	76	70	70
10	78	70	70
11	79	70	70
12	77	70	70
13	76	70	70
14	78	70	70
15	77	70	70
16	77	70	70
17	80	71	71
18	80	71	71
19	83	72	71
20	81	72	72
21	77	71	71
22	69	70	70
23	72	70	70
24	71	70	70
25	84	70	70
26	79	70	70
27	77	70	70
28	79	70	69
29	80	70	69
30	82	71	71
31	79	71	70.5

Date.	Location of thermometer.		
	Air.	Surface.	Bottom.
1877.	° F.	° F.	° F.
Nov. 1	80	71	71
2	83	71	71
3	68	70	70
4	73	69	69
5	78	69	69
6	67	68	68
7	71	68	68
8	75	68	68
9	66	67	67
10	58	64	64
11	59	62	61
12	63	61	60
13	68	60	59.5
14	73	61	61
15	70	61	61
16	75	63	62
17	76	63	63
18	73	63	63
19	71	63	63
20	70	63	63
21	72	63	63
22	64	62	62
23	63	62	62
24	64	61	61
25	67	60	60
26	67	60	60
27	73	60	60
28	64	60	60
29	57	59	59
30	46	56	56
Dec. 1	51	54	54
2	51	52	52
3	56	52	52
4	65	53	52
5	65	52	52
6	50	51	51
7	54	51	51
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19	60	58	58
20	62	58	58
21	71	60	60
22	71	61	61
23	69	61	60.5
24	71	61	61
25	73	61	61
26	64	61	61
27	63	61	61
28	62	61	61
29	67	61	61
30	55	61	61
31	52	57	56.5

Date.	Location of thermometer.		
	Air.	Surface.	Bottom.
1878.	° F.	° F.	° F.
Jan. 1	56	56	56
2	58	55.5	55
3	60	56	56
4	58	56	56
5	48	54	54
6	48	52	51.5
7	48	52	52
8	48	52	52
9	62	52	51.5
10	52	52	51.5
11	60	52	51
12	60	52	51
13	70	53	53
14	60	53	53
15	51	52	52
16	54	52	52
17	59	53	52
18	63	54	53
19	70	55	54
20	73	56	56
21	67	56	56
22	62	56	56
23	62	56	56
24	65	51	58
25	66	56	56
26	67	57	56
27	71	58	58
28	65	58	58
29	63	58	58
30	65	59	59
31	61	59	58.5
Feb. 1	62	58	58
2	72	59	59
3	56	58	57.5
4	59	57	57
5	52	56	56
6	56	56	56
7	71	58	57
8	71	58	58
9	67	58	57
10	65	58	57
11	55	57	57
12	52	56	55
13	61	55.5	55
14	70	57	56
15	68	57	57
16	62	58	58
17	69	58	58
18	69	58	58
19	61	58	58
20	67	59	59
21	68	59	59
22	72	60	60
23	66	61	61
24	71	63	63
25	64	61	61
26	55	60	60
27	55	59	59
28	67	60.5	59.5

EXTREME AND MEAN TEMPERATURES, BY MONTHS—Continued.

	Air.	Surface.	Bottom.
September:	° F.	° F.	° F.
Maximum	94.0	82.0	82.0
Minimum	73.0	74.0	74.0
Mean	85.2	80.1	79.9
October:			
Maximum	84.0	74.0	74.0
Minimum	70.0	70.0	69.0
Mean	77.7	70.8	70.7
November:			
Maximum	83.0	71.0	71.0
Minimum	46.0	56.0	56.0
Mean	68.4	62.6	63.5

	Air.	Surface.	Bottom.
December:	° F.	° F.	° F.
Maximum	73.0	61.0	61.0
Minimum	51.0	51.0	51.0
Mean	62.1	57.4	57.9
January:			
Maximum	73.0	59.0	59.0
Minimum	48.0	52.0	51.0
Mean	60.4	54.8	54.5
February:			
Maximum	72.0	63.0	63.0
Minimum	50.0	55.5	55.0
Mean	63.3	46.3	58.0

Now, in all other streams on the Atlantic coast, the fish appear to wait until the temperature of the river has risen above that of the salt-water area into which the river empties, before they ascend in the spring. The migration of the Shad into the Saint John's River is clearly not for the immediate purpose of spawning, as that operation is not performed for months, but in order that they may keep within the limits of the hydro-isothermal area appropriate to them. We must suppose that the temperature of the ocean waters, on the continental plateau outside the coast line, is higher than 60° F., and although uncongenial to the fish, yet they must necessarily remain in that temperature until the waters of the Saint John's, cooling as winter advances, have fallen below the temperature of the outside waters. As soon, therefore, as water of a lower temperature than that in which they are commingles with the ocean water, it serves as an incentive—as it were the signal—for their migration into the estuary of the Saint John's.

OBSERVATIONS ON THE POTOMAC RIVER IN 1881.—In 1881 the writer, then in charge of the shad-hatching operations on the Potomac River, collected full statistics of the catch of Shad and Alewives from four of the seine fisheries occupying that section of the river lying between Indian Head and Mount Vernon. From these statistics the fluctuations in the run of the Shad up the river have been closely approximated, and at the close of this paragraph general deductions relative to the same will be made. Through the courtesy of the Light-House Board and the United States Signal Office, observations on the water temperature at Winter Quarter Shoals and at Norfolk, Virginia, have been obtained. The former point is a light-house in the Atlantic, lying about fifteen miles from the Virginia coast, and situated, it is believed, on the inner edge of the cold arctic current that flows down the coast inside of the Gulf Stream. The observations taken there represent the temperature of the water on the continental plateau between Cape Charles and Cape Henry. The records taken at Norfolk serve as an index of the temperature of the waters of the Chesapeake Bay, but are subject to inaccuracies, Elizabeth River being hardly more than a tidal estuary, and the temperature of its waters being influenced very materially by local meteorological conditions.

A graphical representation of the temperatures at these two points, as also of the corresponding temperatures at the Potomac hatching station, is given in the accompanying diagram, which serves to illustrate the influence of hydrothermals in determining the direction of the movements of the Shad and Alewives and in limiting their range. In the diagram are also presented the fluctuations of the run of these fish in the fishing season, as deduced from the records of "catch," furnished by the four seine fisheries already alluded to.[1]

By reference to the diagram it will be seen that during the first seventeen days of April (1) the temperature of the water in the Potomac was occasionally lower than at Winter Quarter Shoals during the same period of time; (2) that the water of the Chesapeake Bay was warmer than that of the ocean between Cape Charles and Cape Henry, and also warmer than the water in the Potomac River, and that (3) during that time the temperature was in none of those waters above 50° F. As soon as with the advancing season the water in the river became warmer than in the bay the Shad commenced to ascend the Potomac, and when the temperature of the river rose to 60° F. the upward run attained its maximum; the main body of Shad and Herring ascended the river when its temperature ranged from 56° F. to 66° F.; and, further, that when the temperature of the river passed above 66° F. the run of Shad and Herring rapidly diminished. It may be seen also that in general the fluctuations in the run of the Herring closely followed that of the

[1] Although the data obtained from those four shores do not by any means represent the total catch for the whole river, yet, covering as they do a complete section of the river, they furnish figures from which the fluctuations in the upward migrations of the Shad and Alewife for the whole river can be approximated.

Shad. The run of Alewives indicated by the diagram in the early part of the season at low temperature was undoubtedly *C. vernalis*, or the Branch Herring, which makes its run on a temperature several degrees lower than suitable to the Shad or the Glut Herring. The fact that the Shad commence running into the Potomac when the temperature of the river is 56° F. or less, does not antagonize the theory here stated, that the hydro-isothermal area which they prefer to occupy is that having the temperature of about 60° F. If, as is probably the case, there is oceanwards a limiting wall of low temperature for the Shad occupying the Chesapeake area,[1] then at all seasons of the year the Shad must be found at some point within that area, be the temperature exactly what they prefer or not. In other words, the Shad in their migrations travel on temperature paths, the direction being always towards 60° F.

Shad ready to deposit their spawn seem to prefer waters of a warmer temperature than 60° F. Therefore, when the mature Shad, intent on reproduction, leave the hydrothermal area of 60° F. and ascend the rivers into waters of 65° F. to 70° F. and upwards, they are unaccompanied by the half-grown Shad, the latter ceasing to ascend as soon as they encounter a temperature of more than 60° F. In 1882, however, when the temperature of the water was below 60° F. for the greater portion of the season, the spawning had to take place in water colder than the fish would have preferred, and therefore mature and young Shad were found together on the spawning grounds.

Observations made during that season show that large numbers of young Shad were taken, which would not have been the case had the temperature of the river waters risen above 60° F. Inasmuch as the fishing operations are conducted with a view to obtain mature fish, and in most years the young do not accompany the full-grown fish up to the fishing grounds, it would certainly appear as though this was a special provision of nature to secure the continuance of the species, providing against the capture of the young Shad during the fishing season.

OBSERVATIONS ON THE MOVEMENTS OF YOUNG SHAD IN THE POTOMAC.—The young Shad which are hatched out during May and June remain in their native streams until the temperature of the water falls below 60° F. They then move down the rivers as the temperature falls, passing into the salt water as soon as the cooler weather has reduced the river temperature below the degree congenial to them, and, as a rule, return no more to the fresh waters until they are full-grown fish. This statement is borne out by observations made in 1881 by Mr. W. E. Stuart and Mr. Gwynn Harris, inspectors of marine products. These gentlemen, who have been largely engaged for many years in the Potomac fisheries, whose interest is always manifested in connection with all matters relating to the fisheries, undertook, at the instance of Professor Baird, United States Fish Commissioner, to observe the movements of the young Shad in the Potomac in front of the city of Washington. Their observations show that on November 16, when the thermometer showed the temperature of the water to be 68° F., young Shad were present in the Potomac at Washington in large numbers. From this date the temperature of the water gradually fell, coincident with which the numbers of young Shad decreased until on November 23 the fish had entirely disappeared, the thermometer then showing 58° F. The disappearance of these fish can be referred only to the fact that the water had fallen below 60° F., for as long as that temperature was preserved the fish remained in the portion of the river under observation. The lowering of the temperature of the water seems to present the only variable factor in the conditions which surrounded them, and to this we may reasonably refer their disappearance.

THE PERIOD OF RIVER LIFE.—The deposit of the eggs of the mature Shad in fresh waters seems to be a necessary condition for their development. The idea has prevailed to some

[1] The Chesapeake area includes the Potomac River, the Chesapeake Bay and its tributary streams, and the ocean between Cape Henry and Cape Charles.

extent that the Shad under certain circumstances spawn in salt or brackish waters. Experiments have, however, been made to verify this supposition, but have proved unsuccessful. Whilst impregnation under such conditions has been shown to be possible, and development has proceeded to a certain point, yet before the hatching took place the development of the embryo broke down. The annual migrations of the Shad into our streams are made apparently for the sole purpose of reproduction, excepting in the Saint John's River, Florida, where their first movement into the river seems to be attributable to an influence other than that above mentioned. The time of these migrations into the rivers varies with the geographical position of the river. As a general rule, it is usually later as we proceed farther to the north, though we find some exceptions. It may be stated generally that this migration takes place as soon as the continental waters have become warmer than the salt-water areas into which they discharge. The schools of fish having entered the streams, ascend until they have reached suitable spawning grounds. The deposit and fertilization of the eggs having been accomplished, their development commences, and in a few days, the period varying with the temperature, the young fish, bursting their shells, make their appearance. These remain in the rivers, feeding and growing all summer, and leave late in the fall, at which time they are two or three inches in length. The life history of the Shad from this time is unknown to us. The young fish, having disappeared, do not again come under our observation until they return as mature fish to deposit their spawn.

The motive of their movement into the rivers being for purposes of reproduction, we would expect that with the accomplishment of this desire the mature fish would return to salt water. This is the general impression among fishermen, and may be true as a general fact, but there are instances on record where a full-grown Shad in good condition has been taken in our rivers long after the spawning season is over, and even late in autumn. One of the largest Shad I have ever seen from the Potomac was taken in the vicinity of the White House in the month of November. In the season of 1880, I believe, several full-grown Shad were taken below Holyoke Dam on the Connecticut River in the latter part of the summer. These instances would seem to indicate that under certain conditions the Shad may remain in our rivers during the whole season.

The appearance of the spent fish, or those which have deposited their eggs, enables the fishermen to recognize them at once, and various names have been given to them. From the fact that they are supposed to be moving down the stream when taken, they are called "Down-runners," and from their lean, slim appearance, they are also called "Racers."

The Shad make their first appearance in the Saint John's River about the middle of November, the height of their spawning season in that river being about the 1st of April. In the Savannah River they appear early in January, and in the Neuse River at a period not much later than in the Savannah. In the Albemarle the important Shad seine-fisheries begin early in March, but doubtless the fish are in the Sound some time before that date; not, however, in numbers sufficient to justify the great expenses attendant upon the operation of these large seines. In the Chesapeake Bay they make their appearance in February, although the height of the fishing season in its waters is during April and May, and at a date somewhat later in the more northern tributaries. In the Delaware, Connecticut, Merrimac, and Saint John (Nova Scotia) Rivers, Shad are first seen at periods successively later as we proceed farther north. The date of their first appearance in any of these waters, however, varies from season to season, the limit of such variation being from three to four weeks.

These irregularities in the time of the run into our rivers, which cause so much perplexity and discouragement to the fishermen, are, however, readily explained when we keep in view what

has been already said in regard to the influences of temperature in determining the movements of these fishes.

CAUSES INFLUENCING THE RATE OF MOVEMENT UP RIVERS.—The rate and duration of the movement of Shad in our rivers are influenced by various causes. If, in consequence of warm rains at the river's source, the temperature of the water becomes suitable to the Shad at an earlier date than usual, then their upward movement takes place very rapidly, and, we may say, tumultuously, the great schools of fish crowding in and moving up all at once, so as to produce what is termed a "glut." If, however, the temperature of the river rises by insensible degrees with the advance of the season, then the upward movement begins when the water temperature of the river has passed above that of the sea, and takes place gradually, the rate of movement in such cases being slow and the period prolonged. Again, when the Shad have entered the rivers, the temperature conditions being such as to determine a rapid upward movement, yet should the fish encounter floods and consequent muddy waters, their upward movement is arrested, the schools back down before the flood, and if this condition be prolonged, may be driven entirely out of the river. In short, fluctuations in the river temperature have corresponding influences upon the shad movements; any sudden change, whether to a higher or lower temperature, apparently arresting their upward course for a time, and sometimes even determining a retrograde movement.

Many of the anomalies which perplex fishermen in the course of their work may be explained by the varying movements of the fish, as controlled by the water temperature in the rivers. We find, for example, that while at a particular seine-shore, during one season, a very large catch is made, yet in the following season, although the general run of fish in the river has not diminished, the fishery in the same locality may prove a failure. If we suppose a seine to sweep the flats at the mouth of such a stream as the Occoquan Creek,[1] and if we further suppose that the river waters in the channel are colder than, or as cold as, the waters of the Chesapeake Bay, the Shad in their movement up the river would avoid the main current, and would slowly work their way up along the shores and over the flats, where the temperature of the waters will be found to be, under such circumstances, several degrees warmer than in the channel. Such a season would be profitable to a seine sweeping the flats. Again, if the waters in the main channel of the river were of suitable temperature, then the upward movement of the Shad would take place in the channel and not along the flats. Under such circumstances a "channel seine," *e. g.*, that of the "White House," would make a very large catch, whilst a seine hauled over the flats, as on the Pamunkey shore, would probably find very indifferent fishing.

REPRODUCTION.—The age at which the Shad reaches maturity and becomes capable of reproducing is not definitely determined; it is generally held by fish-culturists, however, that the female Shad attains this condition when three or four years old. The period of maturity for the male, if the relative size of the two sexes be taken as an indication, is much earlier than for the female. Males, or "Buck Shad," weighing less than one and a half pounds (numbers of which always accompany the schools of larger fish), are found to be milters, and at the shad-hatching stations—especially during the earlier part of the season—the spawn-takers are frequently compelled to have recourse to these fish in order to get the milt necessary for the fertilization of the eggs. These fish cannot be more than two years of age. It appears that the first part of the run of fish up the rivers consists almost entirely of males, which precede the females by several days. The records of the fishing shores agree with this statement, their main catch in the earlier part of the season being composed of "bucks," with a very sparing intermixture of "roe Shad," which latter, in their turn,

[1] A tributary of the Potomac River.

increase in proportion as the season advances. The favorite spawning grounds of the Shad, or "Shad Wallows," as they are termed by the fishermen, are on the sandy flats which border the streams, and the sand-bars which are found at intervals higher up the river. When the fish have reached suitable spawning grounds and are ready to cast their eggs, they move up to the flats seemingly in pairs. The time of this movement is usually between sundown and 11 p. m. When in the act of coition they swim close together and near the surface, their back fins projecting above the water. The rapid, vigorous, spasmodic movements which accompany this operation produce a splashing in the water which can be plainly heard from the shore, and which the fishermen characterize as "washing."

The eggs are spun out by the female while in rapid motion. The male, swimming close to her, ejects his milt at the same time, and the contact of egg and milt, and the consequent impregnation of the egg, is coincident with or immediately subsequent to the ejection of the ova from the female. The specific gravity of the egg being slightly greater than that of water, it sinks to the bottom, and, under favorable conditions, develops and hatches out. Large numbers of these eggs are, of course, destroyed by the predaceous fishes that have learned to frequent the spawning grounds of the Shad. A sudden lowering in the temperature of the water may, and frequently does, produce a large destruction of eggs. Floods, too, bring down mud which may smother and destroy vast numbers. But, escaping these casualties, they hatch out in a period of from three to eight days. Unlike the *Salmonidæ*, although with a sac relatively as large, the new-born Shad swim vigorously as soon as they break the shell, and, according to Mr. Seth Green, make their way immediately to the middle of the stream, where they are too small to be an object of prey to the larger fishes, and where the smaller ones dare not come after them.

The number of eggs in the ovary of a Shad, as in all other fish, bears a certain relation to the size and weight of the fish. As the result of experience in the artificial propagation of the Shad we conclude that a ripe roe Shad weighing four or five pounds contains from 20,000 to 40,000 eggs, the average number being about 25,000. A much larger number, however, has been obtained from some individuals. In the season of 1881 we obtained from a single Shad, weighing about six pounds, over 60,000 impregnated eggs; again, in 1880, on the Potomac River, the yield of eggs from a single Shad was over 100,000. These were full-sized, thoroughly impregnated, and were hatched out with a loss of hardly one per cent.

SIZE.—A female Shad of a certain age is always larger than a male of corresponding age. A general average for both sexes along the whole coast would be about four pounds, the extremes—for males—being from one and a half to six pounds, and for females from three and a half to eight pounds, the latter representing a maximum weight for Shad at the present time; although, in the early history of the fisheries, there are records of the capture of fish weighing eleven, twelve, and as much as fourteen pounds. These extreme figures, of course, are for fish which, in consequence of the imperfections of the ordinary kinds of fishery apparatus, the want of skill on the part of the fishermen, or the accidents of fortune have escaped for a long period the fate which befel their less happy companions and have returned to the rivers year after year.

FOOD.—The shad fry, which spend the first six months in our rivers, must of necessity find their food therein. From examinations made of the stomachs of these young fish, they have been found to feed upon certain species of crustacea and insect larvæ, common to the fresh waters of our rivers. During the spring of 1882 some young fry, which were hatched out at Central station, were confined by Dr. John A. Ryder in a glass aquarium, through which the circulation of the water was maintained, and fed with Copepoda, obtained in large quantities from the United States carp ponds. In about seven days after hatching some of the young fry were

observed to eat, and a few days later they were all vigorously engaged in pursuit of food. While the ratio of mortality was large, some of the fish survived for six weeks, the last specimen having attained a length of considerably more than an inch, and a weight many times greater than that at birth.

From these experiments we deem it altogether probable that under natural conditions the Copepoda, which are abundant in the Potomac in places frequented by the young Shad, are their natural food during the early stages of their existence. Although we are able to obtain from the river late in the season young Shad which are two and a half to three and a half inches in length, I am not aware that such examinations have been made upon the contents of their stomachs as to show the character of their food. In order to take observations upon the food of the Shad at the stages indicated above, I procured from the Potomac a number of young Shad, two to three inches in length, which were placed in the basin under the dome of the United States National Museum. These were tempted with various kinds of food; oysters, liver, sturgeon, and beef finely chopped were offered successively to them, but they declined to take the food. In some cases they would seize particles, which having held for an instant they would eject from their mouths with evident expression of disgust. I then tried them with the white of hard-boiled eggs. This, much to my gratification, they devoured readily. As soon as the particles reached the surface of the water, the fish rose vigorously and seized them as they sank through the water, but, strange to say, in no case did I observe them take the food after it had touched the bottom. This would seem to show that their food under natural circumstances is taken swimming, and consists probably of swimming crustaceans, or allied forms of life found in salt water. Later in the season, in consequence of my absence from the city, these fish were neglected and fed irregularly. By way of experiment, I had also placed in this basin a number of young California salmon, and, to my surprise, I discovered that the young Shad were pursuing and eating them. In several cases I noticed the Shad with the salmon in their mouths half swallowed. Finally the salmon disappeared, and the presumption was that they had all been eaten by the young Shad. It is possible, therefore, that Shad in their early lives vary their food with minnows and the young of other species of fish. Indeed, from the stomach of a Shad, taken in one of the pounds at Saybrook, I found an undigested minnow two or three inches in length. In the fresh-water life of the mature Shad, the fish do not seem to take food at all. Repeated observations of the contents of the stomach show no food whatever. Occasionally, however, they can be induced to rise to a fly dexterously cast on the water. This fact is presumptive evidence that the desire for food, although subordinated to the impulse of reproduction (which brings them into the river), is not wholly lost.

180. THE HICKORY SHAD, OR MATTOWACCA—CLUPEA MEDIOCRIS.

By MARSHALL MCDONALD.

NAMES.—This fish, *C. mediocris*, Mitchill, was first brought to notice in 1815 in Mitchill's paper on the fishes of New York, wherein it was described under two names, being called the "Staten Island" Herring, *C. mediocris*, and the "Long Island" Herring, *C. mattowacca*. The latter name was adopted by Storer for the species, but more recent authorities, guided by a rather questionable interpretation of the rules of priority, have substituted the name *C. mediocris*, because it was printed on the page preceding the other. Mitchill stated that the "Long Island" Herring occupied a middle station between the Shad and the "Staten Island" Herring, but it seems strange that so accomplished an ichthyologist should not have at once perceived the identity of the two. The name "*mediocris*" was founded upon small specimens. The names given this species are as

varied as those of the river Herrings. The name "Mattowacca" is of Indian origin, and is perhaps to be preferred. It is said by De Kay to have been derived from the Indian name for Long Island, *Mattowaka* or *Mattowax*. De Kay also gives the names of "Fall" Herring and "Shad" Herring, and states that in the Connecticut River they are called "*Weesick*," a name which from personal knowledge we can state as having been long in disuse in that locality. The name "Hickory" Shad is applied to this species on all parts of the coast from Cape Cod to Florida. It is used in the Chesapeake and in the Albemarle regions, and on the Ogeechee, Savannah, and Altamaha Rivers, where it is familiarly called "Hicks." In the Saint John's River the name "Hickory" Shad is also used, and in the Alabama River it is applied to this or to some closely related species. The derivation of the name "Hickory" Shad cannot easily be traced. It may be that the word "Hickory" is used in a derogatory sense, but a more reasonable explanation is that it refers to the striped markings on the fish, which resemble those upon the coarse cotton fabric known in the South as "Hickory," and frequently used by the fishermen.

also "Hickory Jack"

In the Potomac the species is called the "Tailor Shad," or the "Fresh-water Tailor," in contradistinction to the bluefish, which is called the "Salt-water Tailor." The comparison between the bluefish and this species is doubtless due to a fancied resemblance between their jaws, those of the "Tailor Shad" being very long and strong. The "Tailor Shad" may be distinguished from the common Shad and from the river Herrings by the extreme projection and thickness of the lower jaw. This species is in some rivers called a "Forerunner," from the fact that it makes its appearance shortly before the Shad.

It is the opinion of Mr. Perley[1] that the so-called "Quoddy" Herring, taken in Passamaquoddy Bay and vicinity, belongs to this species—a rather questionable decision and one which needs confirmation.

GEOGRAPHICAL DISTRIBUTION.—The "Hickory Shad" is most abundant in the region between the Chesapeake Bay and Altamaha River and intermediate waters, ascending the rivers as high as the Shad. In the Saint John's River it is somewhat abundant, making its appearance the first or second week in November, and shortly before the Shad. North of New York it has not been observed to enter the rivers in any great numbers, and there is no record north of Cape Cod of its having been seen in fresh water. In the fall small schools of them occasionally enter the brackish estuaries and tideways of Cape Cod. Hickory Shad are taken to some extent by the mackerel gill-net fishermen of Maine, together with young Shad and Blue-Back Herring, and are doubtless found off the mouth of the Bay of Fundy; although, as has already been stated, their identity with the "Quoddy" Herring is by no means proven. There is no record of their presence in the Gulf of Saint Lawrence.

ABUNDANCE.—In the Altamaha River, Georgia, the catch of "Hickory" Shad is equal to that of "Common" or "White" Shad, and in the markets they sell for more than one-half as much. In the Saint John's River they are not exceedingly abundant, and two "Hickory" Shad are equal in value to one "White" Shad. In the Ogeechee and Savannah Rivers the proportion of the catch of the "Hickory" to that of "White" Shad is about one to four. All taken here are used for local consumption, and are sold at prices equal to about one-half of the White Shad. In the Albemarle they are less abundant than farther south and are of less value. Here they are sold with the herring for local consumption, two of them counting for one herring, or are used for manure. In the Chesapeake region they are not highly esteemed, although great quantities are sold by hawkers, especially in the cities, where people are not well informed, under the name of "Shad." At the

[1] Fisheries of New Brunswick, 1852, p. 209.

beginning of the season hundreds of men may be seen going about the city of Washington with strings of these fish, which they cry for Shad, and which with great insolence they press upon such would-be purchasers as are inclined to question their genuineness. In the pound-nets of the Chesapeake in the beginning of the season they are caught in immense numbers, and are shipped to the markets with the true Shad until their price falls below three cents apiece, after which they are sold with the Herring, one counting as two Herrings. The "Hickory" Shad are occasionally seen in the fall and winter in the New York market. Mitchill, writing in 1814, remarks: "Some call this fish the 'Shad' Herring and some the 'Fall' Shad. He is reckoned to be almost equal to the Shad as an article of food." Storer states that in Massachusetts it is a lean fish, and not used for food.

Concerning the "Quoddy" Herring, Perley writes that in flavor and excellence it ranks only second to the best Shad of the Petitcodiak.

SIZE.—Mitchill states that the length of this fish is frequently twenty to twenty-four inches, its depth is often four and a half to six inches, and that it sometimes attains a weight of four or five pounds. At the present time, however, the size of the fish is much less than that described by Mitchill. The largest full-roed specimen observed by Colonel McDonald cannot have exceeded three to three and a half pounds in weight.

REPRODUCTION.—No observations have been made on the breeding habits of this fish, but it is almost certain that it spawns in spring, like the other members of the family, but whether in salt or fresh water has not been ascertained. It seems more than probable, however, that it spawns in fresh water under the same conditions as the Shad, at a little earlier period.

T.—FAMILIES RELATED TO THE CLUPEIDÆ.

181. THE MUD-SHAD—DOROSOMA CEPEDIANUM.

The family *Dorosomatidæ* is represented on our Atlantic coast by a single species, the "Mud-Shad," *Dorosoma cepedianum*, which is abundant in brackish waters along the coast from Delaware Bay southward to Mexico. In the Chesapeake region it is known as the "Mud-Shad," "Winter Shad," or "Stink Shad"; in North Carolina as the "Hairy-back" or the "Thread Herring"; in the Saint John's River as the "Gizzard Shad," "Stink Shad," or "White-eyed Shad."

The names "Gizzard Shad" or "Hickory Shad" refer to the peculiar muscular stomach, which is of about the size of a hickory-nut and is shaped like the gizzard of a fowl. The fish is found in brackish waters, or in the sea, for the whole length of our coast. It enters all streams after becoming land-locked in ponds, and throughout the whole Mississippi Valley it is permanently resident in large numbers in the larger streams and reservoirs. Since the construction of the canals it has appeared in force in Lake Erie and Lake Michigan.

This fish is extremely abundant in many localities, particularly in the Saint John's River, Florida, where it becomes an annoyance to the fishermen by getting into their nets, several hundred bushels being sometimes taken in a shad net. They are also sometimes annoying to fishermen using gill-nets for catching mullet. In the Potomac they are abundant and attain a maximum size and weight. Their flesh is coarse and not delicate in flavor, but they are by no means unpalatable, and on the tributaries of the Chesapeake they are extensively eaten by the negroes. In the Saint John's River they are made into guano. A factory for this purpose was in existence in 1874 at Black Point, above Palatka. They breed in summer, and are supposed to feed, like the Menhaden, to a great extent upon the bottom mud, from which, after swallowing, they separate the organic contents.

In the Great Lake regions the Gizzard Shad is sometimes split and salted as "Lake Shad," but it probably meets with little sale, owing to the inferior quality of the flesh and the presence of the vast number of small bones that make up the skeleton. It is usually thrown away by the fishermen, and when brought to market it is only bought by the poor or the ignorant. It is not infrequently seen in the markets of Washington in spring. In the West it is sometimes seined by farmers in winter in still places in the rivers and peddled about the towns.

182. THE TARPUM—MEGALOPS THRISSOIDES.

In our waters the most important member of this family is the Tarpum, *Megalops thrissoides*, an immense herring-like fish, which occurs in the Western Atlantic and in the Gulf of Mexico, ranging north to Cape Cod and south at least to Northern Brazil. It is somewhat abundant in the West Indies, and stragglers have been taken as far to the eastward as the Bermudas. This species attains the length of five or six feet, and is covered with enormous circular scales of one inch to two inches and a half in diameter, the exposed portions of which are covered with a silvery epidermis. The fish, when alive, presents a very brilliant metallic appearance, and the scales are much prized by curiosity hunters and for fancy work in the Florida curiosity shops. They are a staple article of trade, selling for from ten to twenty-five cents each, the price paid to the fishermen being about fifty cents per dozen.

The sailors' name for this fish, by which same name it is also known at Key West, Bermuda, Brunswick, Georgia, and elsewhere, is "Tarpum" or "Tarpon." In Georgia and Florida it is commonly called the "Jew-fish," a name also applied by the fishermen of South Florida to a species of percoid which has already been discussed. It is the "Silver-fish" of Pensacola, the "Grande-Écaille" (Large-scale fish), or "Grandykye," as it is pronounced and sometimes spelled, and the "Savanilla" of Texas.

The species can hardly be said to be common on our Atlantic coasts, though from fifty to one hundred specimens are doubtless taken every year between Florida and Cape Cod. In 1874 and 1875 none were caught in the Saint John's River, though several had been brought in during the previous winter. In the Indian River region these fish are sometimes harpooned.

Mr. Stearns contributes the following notes upon the fish, as observed by him:

"The Silver-fish, or Grande Écaille, is common everywhere on the Gulf coast. It is an immense and active fish, preying eagerly upon schools of young fry, or any small fish that it is able to receive into its mouth, and in pursuit of which it ascends fresh-water rivers quite a long distance. During September, 1879, I saw large numbers of Silver-fish eight or ten miles up the Apalachicola River, and am told that that was not an unusual occurrence. They go up the Homosassa River in Florida, and several of the Texas rivers, so I have subsequently learned. The Tarpum will take a baited hook, but it is difficult to handle and seldom landed. The Pensacola seine fishermen dread it while dragging their seines, for they have known of persons having been killed or severely injured by its leaping against them from the seine in which it was inclosed. Even when it does not jump over the cork-line of a seine, it is quite likely to break through the netting before landed. I have secured several specimens, the smallest of which weighed thirty pounds and the largest about seventy-five pounds."

The Tarpum is sometimes eaten, and is said to be very palatable.[1]

183. THE BIG-EYED HERRING.

The "Big-eyed Herring" or "Ten-pounder," *Elops saurus*, was described by Linnæus from a Carolina specimen sent to him by Garden. It occurs all along the coast from Martha's Vineyard southward, but only in the summer in the northern part of its range. It is cosmopolitan in its distribution, occurring throughout the West Indies, on the coast of South America, on both coasts of Mexico, at the Cape of Good Hope, in East Africa, Arabia, and China. At Fort Macon it is known as the "Horse Mackerel." It is rarely or never eaten in the United States, its flesh being said to be dry and bony.

184. THE ANCHOVIES—ENGRAULIDÆ.

A species of Anchovy, *Stolephorus Browni*, is extremely common about Fort Macon, where it is known as the "Sardine" and occurs in large schools. Specimens of this and of an allied species (*S. Mitchilli*) are occasionally taken in the vicinity of Wood's Holl, Massachusetts, and in greater abundance in New Jersey.

The presence of a true Anchovy in America was first announced by Professor Baird in 1854. A species was noticed by Mitchill, but its relations to the Anchovy of Europe were not recognized. In his Report on the Fish of the New Jersey Coast, Professor Baird remarked of *S. Browni*: "The Anchovy made its appearance early in August in the shallow waters along the beach, though of very small size; it subsequently became more abundant, and towards the end of the month, while hauling a large net in the surf, many were taken, measuring over six inches in length; as the

[1] See statement of W. H. Burrall, Forest and Stream, ii, 1874, p. 324.

meshes of the net were large, a great portion escaped, but with a seine properly constructed enough could be secured to supply the American market. I procured several specimens of this fish in 1847 at the residence of Mr. Audubon, on the Hudson River above New York."

There is little reason to doubt that this species of Anchovy might be prepared in salt or in paste, like that of Europe, and that the results would be equally satisfactory; as an actual fact, however, most of the Anchovies put up in Europe do not belong to this genus at all, but are simply pilchards or sprats preserved in a peculiar manner, the name "Anchovy" having come to be descriptive of a peculiar method of preparation rather than of the fish which is prepared. Our Anchovy has recently been sold in considerable numbers in New York under the name "Whitebait," although the fishermen distinguish it from the true "Whitebait," the young of the herring, calling it "Spearing."[1]

CALIFORNIA ANCHOVY—STOLEPHORUS RINGENS.

The Anchovy of the Pacific coast is reported by Jordan to be of little economic value. The commonest form is what he calls the California Anchovy, *Stolephorus ringens*, and which is thus described by him:

"This species is everywhere known as the Anchovy. It reaches a length of about six inches. It ranges from British Columbia to Chili, and is probably found on the coast of Asia also. It is found in sheltered bays, and is everywhere extremely common, but rather more abundant south of San Francisco than northward. It serves as food for the larger species to a greater extent than any other single species. The salmon, bonito, mackerel of all sorts, barracuda, sea-bass, the larger flounders, and, in fact, a majority of the larger fishes make a large percentage of their food of Anchovy. At San Francisco it is occasionally brought into the market. Some attempts have been made to pickle them with spices for the trade, but this amounts to little as yet. A great many are salted by the Chinese, who use them as bait for the flounders and rock-fish. Two other species of Anchovies, *Stolephorus compressus* (Grd.) and *Stolephorus delicatissimus* (Girard), abound south of Point Concepcion. They have no economic value."

185.—THE LADY-FISH FAMILY—ALBULIDÆ.

The Lady-fish, *Albula vulpes*, occurs in the West Indies, in the Gulf of Mexico, on the Atlantic and Pacific coasts of North and South America, and stragglers have been found in the Western Atlantic as far north as Cape Cod. It is also found about the Bermudas and Cape Verde Islands, in the Indian Ocean, the Red Sea, and on the coast of Japan. With us it is usually called the "Lady-fish"; in the Bermudas the "Bone-fish," or "Grubber." At the Bermudas large schools are taken, and there considered most excellent food-fish. From personal observation I can testify that their reputation is by no means a false one. The "Lady-fish" doubtless occurs about Key West, although the National Museum has as yet received no specimen from that locality. The species is found in some numbers in San Diego Bay, on the coast of California, where it is taken with the mullet. On account of its beautiful color it sells readily, but is not especially esteemed as a table fish.

186.—THE MOON-EYE FAMILY—HYODONTIDÆ.

Three species of this family are known by the names of "Moon-eye," *Hyodon tergisus* Le Sueur, "Toothed Herring," *Hyodon alosoides* (Raf.) J. & G., and "Silver Bass," *Hyodon selenops* Jor. & Bean. The first-named species is abundant throughout the Lake region and the larger tributaries

[1] J. C. Brevoort states that while trolling in August, 1873, near New York light-ship, every bluefish captured was gorged with the American Anchovy. The Anchovy is preserved by salting or by grinding into fine paste with salt. They may be caught with fine purse-nets.

of the Mississippi; the second is found in the Ohio Valley and northward to the Upper Missouri and Saskatchewan; the third is confined to the rivers of the Southern States. None of the species occur east of the Alleghanies. They are little valued as food.

THE MOON-EYE—HYODON TERGISUS.

The Moon-eye is a handsome and gamy fish, taking the hook readily, and feeding upon minnows, crustaceans, and insects. It reaches a weight of one to two pounds. In Lake Pepin, according to Dr. D. C. Estes, "in some seasons they seem to be quite plenty, and at others but very few are seen. On the whole, I have always regarded it as a rare fish. They are vigorous biters, and are as gamy as the striped bass (*Roccus saxatilis*). They take freely the minnow or fly, and are one of the smartest of fishes. They will come up, taste of a fly, let go and be gone before the angler has time to strike. Therefore, to be a 'Moon-eye' fly-fisher, one must be very sharp and not read a book while casting, as I once knew a man to do. As to his being a food-fish there is not a single doubt. I ate one this very morning for my breakfast, and it was excellent, the bones being far less in number and of larger size than in the herring."

U.—CARP, SUCKERS, CATFISH, AND EELS.

187. THE SUCKER FAMILY—CATOSTOMIDÆ.

By David S. Jordan.

The members of this family, known as "Suckers," "Mullets," "Red Horse," "Buffalo fish," etc., are extremely abundant in all fresh waters of the United States, no stream or pond containing fish at all being without them. As all of them reach a length of more than a foot, and are found in the markets, all must be considered as food-fishes. In all of them the flesh is coarse and flavorless, and the number of small bones is provokingly great. They are therefore always the cheapest of fish-food, while from their great numbers they form a large percentage of the food supply of the country. Their value is no more than the cost of catching, and often less. The Suckers feed on mollusks, insects, entomostracans, fish-spawn, and some of them chiefly on mud. They rarely catch other fishes. Like the *Cyprinidæ*, they form a large part of the food of the larger carnivorous fishes. The Suckers spawn in spring, many of the species ascending small streams for that purpose. At this season great numbers of them are speared or snared on shallow rapids. The distribution of the different species can be ascertained by reference to the check-list, and only a few of the most important need be mentioned here.

The Rabbit-mouth Sucker—Quassilabia lacera.

The "Rabbit-mouth," "Hare-lip," "Split-mouth," or "May Sucker" is found in abundance in many rivers of Tennessee and in some streams in Ohio. It reaches a length of about eighteen inches, being one of the smaller species, but its qualities as a food-fish are said to be better than usual in this family.

The Red Horse—Moxostoma macrolepidotum.

The common "Red Horse" or "Mullet" abounds in most streams westward and southward of New York. It reaches a length of two feet, and is a market fish of importance. Its coloration is attractive, but its flesh is tasteless and coarse. Numerous other species closely related to the Red Horse, belonging to the genera of *Moxostoma*, *Minytrema*, and *Placopharynx*, are found in the waters of the West and South, all going by the general names of Red Horse, White Sucker, and Mullet. All are alike poor as food-fishes.

The Chub Sucker—Erimyzon sucetta.

The "Chub Sucker," "Sweet Sucker," or "Creek-fish" is one of the most abundant and widely diffused of the Suckers, being found from Maine to Texas. It is one of the smallest species, reaching a length of little more than a foot. It is not essentially different from the rest as food. A closely related species (*E. Goodei*) abounds in Florida.

The Common Sucker—Catostomus Commersoni.

The common "Brook Sucker" is the most familiar and generally abundant of the group. It inhabits all bodies of water, large and small, from New England to Colorado. In the Great Lakes

* In N. C. a species of Moxostoma (M. carpio) is known as "Carp Mullet," being liked as a food-fish in spring & fall. See Plate 222 B. (- W. R. Fraley, Salisb.)

it reaches a length of two feet or more. In small brooks it is mature at eight or ten inches. It is a soft, poor fish. It varies much in size, color, and form in the different streams. It bites at a small hook baited with a worm, and is one of the numerous tribe of boy's fish which may be found on every urchin's string.

All the lakes and rivers of the Rocky Mountain region and the Pacific slope are inhabited by one or more species of this genus, or of the allied genera *Chasmistes* and *Pantosteus*. In Utah Lake, said to be the "greatest Sucker-pond in the world," are found *Catostomus fecundus* and *ardens*, *Chasmistes liorus* and *Pantosteus platyrhynchus*, all in abundance. In Lake Tahoe, *Catostomus tahoënsis;* in the Sacramento *C. occidentalis;* in the Columbia *C. macrochilus;* in Klamath Lake, *Chasmistes luxatus* and *Ch. brevirostris*, abound, while in the Great Lakes and all waters thence to Alaska and the Arctic Ocean *C. longirostris* is an important food-fish. The Stone-roller or Hammer-head Sucker, *Catostomus nigricans*, abounds in most waters from the Great Lakes southward. The Stone-roller is extremely abundant in every running stream in the North and West, where its singular, almost comical form is familiar to every school-boy. It delights in rapids and shoals, preferring cold and clear water. Its powerful pectorals render it a swifter swimmer than any other of its family. Its habit is to rest motionless on the bottom, where its mottled colors render it difficult to distinguish from the stones among which it lies. When disturbed it darts away very quickly, after the manner of the etheostomoids. They often go in small schools. I have never found this fish in really muddy water, and when placed in the aquarium it is the first fish to die as the water becomes foul. Although called the "Mud Sucker" in the books, it is most characteristically a fish of the running streams. This species reaches a length of about two feet, and is often caught in its spawning season by means of a spear or snare. It is, like *C. Commersoni*, a "boy's fish," and not worth the eating.

The Black Horse—Cycleptus elongatus (Le S.) Ag.

The "Black Horse," "Gourd-seed Sucker," "Missouri Sucker," or "Suckerel" is found chiefly in the river channels of the Ohio and Mississippi. It reaches a considerable size, weighing five to twelve pounds, and is said to be a much finer fish in flesh than any other of its family. The writer has had no opportunity of testing this.

The Carp Sucker—Carpiodes cyprinus.

The different species (*Ictiobus cyprinus, carpio*, etc.) known as "Carp," "Carp Suckers," "Spear-fish," "Sail-fish," "Quill-back," etc., abound in all the larger bodies of water south and west of New York as far as the Rio Grande. The species are probably but two in number, very similar. They reach a weight of four or five pounds, and form an abundant but not excellent food.

The Buffalo-fishes.

The three species known as "Buffalo-fishes" (*Ictiobus bubalus, urus*, and *cyprinella*) are found mainly in the river channels of the Mississippi and its tributaries. They are the largest of the Suckers, reaching a weight of fifteen pounds or more. In the Mississippi and Ohio Valleys they form a large percentage of the food-fish consumed. They usually bring a better price than the smaller Suckers, excepting the Black Horse, but at the best they are coarse, poor fishes, the flesh being full of small bones and scarcely worth the trouble of picking. The Buffalo-fishes are found by Professor Forbes to feed on small crustaceans more than do the other Suckers, and less on mollusks.

188. THE CARP FAMILY—CYPRINIDÆ.

By DAVID S. JORDAN.

The species of this family known as "Minnows," "Chubs," "Shiners," and "Dace" literally swarm in all of the fresh waters of the United States, as in those of Europe and Africa. Most of them reach a length of less than six inches. Such have of course no value as food. They are, however, important as furnishing the greater part of the food of all our carnivorous fresh-water fishes—the bass, perch, trout, pike, etc. A few of our species reach a considerable size, especially in the Sierra Nevada region. Some of these become food-fish of importance. The flesh in all is, however, deficient in flavor and full of small bones. Not one of our native species has any high money value, and only the Carp (*Cyprinus carpio*), of all the family, can be compared as a food-fish with the percoids and salmonoids.

Most of the *Cyprinidæ* are carnivorous, the smaller species feeding upon insects, fish-spawn, etc. Many large individuals are quite voracious, some of them being very destructive to young trout. All of them spawn in spring, some of them running up small brooks for that purpose.

Some of the more important of our *Cyprinidæ* are the following:

THE GOLDEN SHINER—NOTEMIGONUS CHRYSOLEUCUS.

This fish, the American representative of the European Bream, abounds in most rivers east of the Great Plains. It is a sluggish fish, frequenting ponds, bayous, and cut-offs, preferring those in which the bottom is covered with aquatic plants. It reaches a length of nearly a foot, and is sometimes brought to market.

THE CHUB OF UTAH LAKE—SQUALIUS RHOMALEUS.

This species is excessively abundant in Utah Lake, and as it ascends the streams to spawn almost simultaneously with the trout (*Salmo purpuratus*), it is extremely destructive to the young of the latter. It is taken in considerable numbers in seines, and is sold in the markets of Salt Lake City and other towns. It reaches a length of nearly a foot.

Numerous other species, belonging to the same genus and similar in size and habits, abound in the region between the Rocky Mountains and the Sierra Nevada, and are used as food by the Indians and by the white settlers. Among these are *S. niger*, *S. purpureus*, *S. obesus*, *S. pandora*, etc. Species very similar abound in Europe and Asia.

SQUALIUS GIBBOSUS.

The "Chub" of the San Francisco markets abounds in the Sacramento River, and is taken in great numbers. It reaches a length of about a foot, and is eaten chiefly by the Chinese.

GILA ELEGANS.

The various species of *Gila* abound in the basin of the Rio Colorado and Rio Gila, and are used as food in New Mexico and Arizona. They reach a length of about eighteen inches. *Gila elegans*, *robusta*, and *Grahami* are the principal species.

THE SACRAMENTO "PIKE"—PTYCHOCHILUS OREGONENSIS.

This species abounds in the Columbia and Sacramento Rivers and their tributaries, where it is usually known as the "Pike." It reaches a length of three or four feet at least, a size much greater than that of any other of our representatives of this family. A great many are brought into the markets of San Francisco in the winter. Its flesh is of course not much esteemed. A

second species (*Ptychochilus Harfordi*) accompanies *P. oregonensis* in the Sacramento, and is brought with it to the markets. A third species (*Ptychochilus lucius*) occurs in the lower course of the Rio Colorado, and is said to reach a still larger size—a length of five or six feet.

Mylopharodon conocephalus.

This species occurs with *Ptychochilus oregonensis* in the Sacramento, and is brought with it into the markets. It reaches a size scarcely less than that of *P. oregonensis*, but is less plentiful.

Mylochilus caurinus.

This species abounds from California to Puget Sound in all the streams of Oregon, Washington, and Idaho, and often enters the sea. It reaches a length of little more than a foot, and is little used for food where trout and other better fishes abound. Its great numbers, however, give it a special claim to notice.

The Split-tail—Pogonichthys macrolepidotus.

The "Split-tail" is very common in the Sacramento, and is brought in considerable numbers to the San Francisco market. It reaches a length of about eighteen inches.

The Fall-fish—Semotilus bullaris.

The "Fall-fish," "Chub," "Roach," or "Dace" is abundant in the streams of the Eastern and Middle States east of the Alleghanies. It reaches a length of eighteen inches, being the largest of the *Cyprinidæ* east of the Rocky Mountains. It has no special importance as a food-fish, although often taken with hook and line. According to Thoreau, the Chub is a soft fish and tastes like brown paper salted.

The Horned Dace—Semotilus corporalis.

This species abounds in all small streams and ponds from Western Massachusetts to Nebraska and southward. It reaches a length of about a foot, and is *par excellence* a small-boy's fish. Large specimens are often found in streams which the boy can step across, and a small hook baited with an angle-worm will draw the fish from its lurking place. The "horns" in this and other Minnows and Chubs are dermal excrescences developed on the males in the breeding season.

The Horny-head—Ceratichthys biguttatus.

The "Horny-head," "River Chub," or "Jerker" is one of the most widely-diffused of fresh-water fishes, occurring from New York to Utah and Alabama. It reaches a length of ten or twelve inches. It inhabits larger streams than the Horned Dace, which delights in little brooks. It takes the hook readily, and throughout the Southwest forms a source of satisfaction to the juvenile angler. The flesh of this and other small *Cyprinidæ* is very palatable when fried crisp soon after being taken from the water.

Platygobio gracilis.

Toward the Northwest this Chub takes the place of the preceding, and reaches a somewhat larger size.

The Shiner—Minnilus cornutus.

The "Shiner," "Red-fin," or "Red Dace" abounds in all streams from New England to Kansas and Alabama, being in most waters more numerous than any other species. In clear, cool lakes it is often found in great schools. At the mouths of small rivers in Lake Michigan

hundreds of them can be taken in a short time on a small hook baited with worms or flies. This species reaches a length of about ten inches. It assists to swell the urchin's string, but has no tangible importance as a food-fish. Its flesh spoils very quickly after the fish is taken from the water, hence the name "Rot-gut Minnow," applied to it in Alabama. A large part of the food of the black bass, trout, and other predatory fish is contributed by the Shiner and by its numerous congeners.

THE CUT-LIPS—EXOGLOSSUM MAXILLINGUA.

The "Cut-lips," "Day Chub," or "Nigger Chub," has but a narrow distribution, being found in abundance only in the basin of the Susquehanna. It reaches a length of six or eight inches, and has no economic importance.

LAVINIA EXILICAUDA.

This species is found in some abundance in most streams of California, and comes occasionally into the markets. It reaches a length of about fifteen inches.

ORTHODON MICROLEPIDOTUS.

This species occurs in most streams of California in considerable abundance. A good many are sent to the market of San Francisco, where they are eaten by the Chinese. It reaches a length of about eighteen inches.

HARD-MOUTH—ACROCHILUS ALUTACEUS.

The Hard-mouth Chub is found in the rivers of Washington and Oregon. It reaches a length of about a foot but is only rarely eaten.

189. THE CARP—CYPRINUS CARPIO.

By RUDOLPH HESSEL.[1]

THE RACES OF CARP—THEIR HISTORY AND HABITS.—The Carp, *Cyprinus carpio*, of the family *Cyprinidæ*, has a toothless mouth, thick lips, and four barbels on the upper jaw. In place of the usual teeth of the mouth there are a number of stout teeth on the pharyngeal bones, which are arranged in three rows. It has one single dorsal, which is longer than the anal. Both these fins have at their origin, on the anterior edge, a strong ray, which is serrated in a downward direction. The caudal is of semicircular shape, and the natatory bladder is divided into two sections, with connecting air-passage. The scales have an entire edge, and the body is compressed on the sides. The general color of the back and sides is a dark olive-brown, the abdomen often of a whitish-yellow or orange tint. The coloring depends, as with all fishes, partly upon the age and season, partly upon the water, the soil, and also upon the food of the fish.

Be it remarked that the Carp, which has occasionally been compared to the buffalo-fish, has no resemblance to it, with the exception of the similarity of their coat of scales; neither does the flesh of the buffalo-fish ever come up to the excellence of that of the Carp.

The Carp was, in all probability, originally introduced into Europe from Central Asia many centuries ago, and is now common in most of the large rivers. In some parts of Europe, principally in Bohemia, Austria, Southern, Central, and Northern Germany, it has become domesticated.

The Carp is alleged to have been imported into England in the year 1504. In Austria, which possesses the most extensive carp fisheries in Europe, the culture of the Carp can be traced as far back as the year 1227. The Emperor Charles IV of Germany, by granting sundry privileges,

[1] Extract from Report of United States Fish Commission, part iv, 1875–'76, pp. 865–876.

favored the establishment of ponds in his dominions, and the monks were especially assiduous in the culture of fish in ponds. As early as the first half of the fourteenth century, Bohemia had its first large carp pond, and the culture of this fish progressed in that country, as also in Poland, and that district which now comprises German Austria; also in Upper Lusatia, Saxony, Silesia and Bavaria. A celebrated establishment for carp-culture, with large, extensive ponds, was located, as early as the fourteenth century, near the town of Wittingau, in Bohemia, Austria. The first beginning of it may be traced back to the year 1367. At that time the lords of Rosenberg called into existence and maintained for centuries these establishments on a scale so extensive that to this day they are the admiration of the visitor, the main parts having survived, while the race of the Rosenbergs has long been extinct.

The manor of Wittingau suffered greatly from the calamities of the Thirty Years' War, and with it, in consequence, its fish-culture. The latter only recovered the effects of it after passing, together with the large estate of a rich monastery of the same name, in the year 1670, into possession of the princes of Schwarzenberg, their present owners. The extent which carp-culture has reached on these princely domains will be seen from the circumstance that their artificial ponds comprise an area of no less than twenty thousand acres. The proceeds amount to about five hundred thousand pounds of Carp per annum. The ponds of the princes of Schwarzenberg are probably the most extensive of the kind on the globe. They are usually situated in some undulating low-land country, where small valleys have been closed in by gigantic dams for the purpose of forming reservoirs. Similar establishments, though not equally extensive, are found in the provinces of Silesia and Brandenburg; as, for instance, near Breslau and Cottbus, in Peitz and Pleitz, which I visited last year. In Hesse-Cassel, Hanover, Oldenburg, Mecklenburg, and Holstein there are also many hundreds of ponds, none of them covering more than a few acres, but almost every large farm possessing at least one of them.

It will be easily understood that after such an exclusive culture in ponds, continued through centuries, as also an existence in open water, where the *Cyprinidæ* were left more to themselves, a number of varieties or rather genuine species *Cyprinus carpio*, showing striking differences from the races, were developed: these races, though derived directly from the original type, just as with our domestic animals. They are divided into three chief groups:

1. *Cyprinus carpio communis*, the "Scale Carp"; with regular, concentrically arranged scales, being, in fact, the original species improved.

2. *Cyprinus carpio specularis*, the "Mirror Carp"; thus named on account of the extraordinarily large scales which run along the sides of the body in three or four rows, the rest of the body being bare.

3. *Cyprinus carpio coriaceus, sive nudus*, the "Leather Carp"; which has on the back either only a few scales or none at all, and possesses a thick, soft skin, which feels velvety to the touch.

The two last named are distinguished from the original form by a somewhat shorter and stouter but more fleshy body. It is rather difficult to decide which of these three species is the most suitable for culture. There are some districts where only Scale Carp are bred and Mirror Carp are not valued, as there is no demand for any but the former in the market, as, for instance, in Bohemia, in the above-mentioned domain of Wittingau. Again, in other districts, as in parts of Bavaria and Saxony, etc., for the same reason, Mirror Carp or Leather Carp only are bred. There is, in fact, no sufficient reason for making any distinction among these three varieties, for if they are genuine types of their respective species, they are indeed excellent and desirable fish.

The assertion which has been made at times that the Scale Carp is better adapted for transportation than either the Mirror or Leather Carp by reason of its coat of scales, which would pro-

tect it more efficiently from the accidents incidental to transfer, as also against inimical or hurtful attacks in the ponds (the Mirror Carp having very few and the Leather Carp no scales), is not correct. In transportation scales are not only inefficient for protection, but they frequently cause the death of the fish, especially in transporting the so-called breeding fish; for if a scale be torn off in part only ulceration will ensue, and the fish, of course, will die. Again, should any scale be lost, the bare spot will very soon begin to fester, or develop a confervaceous growth, and the consequences will be the same. On the contrary, the Leather Carp, which oddly enough, like the frog, is destitute of covering, will bear a great deal more ill-usage and injury, whether young or old, than the Scale Carp. The smooth, slippery skin of the Leather Carp suffers much less from friction during transportation than the Scale Carp, and any slight wound will heal up much more easily, as the epithelium will cover it immediately and the formation of a new skin can progress under its protection. I have often had the opportunity of seeing such scars upon the skin of the Mirror Carp, and even more so on that of the Leather Carp. They are the effects of injury from the sharp edges of the heron's bill, the bite of a pike, or some other hurt, and I never saw anything of the kind on a Scale Carp, for if one of these be wounded it almost invariably dies.

The Carp will sometimes cross with some related species of the *Cyprinidæ*, for instance, *Carassius vulgaris;* and, in consequence, hybrids have been engendered which sometimes resemble the genuine Carp so much that it is often difficult for the student as well as for the professed culturist and experienced fisherman to immediately recognize them. Such fishes are valueless as food, on account of their bad and very bony flesh. One of the hybrids mentioned is the *Carpio Kollarii—Cyprinus striatus*, which was formerly regarded as a separate species. It is a cross between the Carp and *Carassius vulgaris* (crucian Carp), a very poor and bony fish, which, in Germany, is sometimes called "Poor man's Carp." Some varieties exist of this common fish. The latter has even been dignified by a specific name of its own, *Carassius gibelio.*

The spawning seasons of the crucian and the true Carp coincide, and, where kept together, hybrid races may readily be formed; that period including the time from the month of May until August.

In order to determine this question, I myself managed to bring about such crosses by placing (1) female common Carp with male crucian Carp, and (2) female crucian Carp with male common Carp, in small tanks, constructed with this end in view; (3) I also put together female *Carpio Kollarii* with male common Carp; this for the sole purpose of testing the capability of propagation of the *C. Kollarii*, which had been doubted. In the two former cases I obtained forms analogous to the *Carpio Kollarii* sometimes approaching in appearance the true Carp, at others the crucian Carp. In the third case, however, having placed ripe *Carpio Kollarii* together with *Cyprinus carpio*, I obtained a product with difficulty to be distinguished from the genuine Carp. I took the trouble to feed them for three years, in order to try their fitness for the table, but their flesh was exceedingly poor and very bony, and could not be compared by any means to that of the common Carp.

Considering, then, the whole extensive tract of country devoted to fish-culture in Central Europe, where crucian Carp are to be found from Italy to Sweden and Norway, from France to the boundary of Eastern Siberia, considering the many who cultivate on a small scale and the owners of badly stocked ponds, with their different doubtful productions, how often do we find in the markets or ponds very nice crosses which have been propagated through from three to ten generations and which are sold for Carp! There are many small sheets of water in Germany, France, Austria, Italy, Holland, and Belgium, and probably also in England, the proprietors of which imagine, in good faith, that they have stocked their ponds with good, genuine Carp, which in

reality, through careless selection or ignorance, are hybrids which may even have been cultivated for two or three generations. In some ponds in Switzerland, near the lake of Constance, some crosses of *Abramis brama* were found as late as twenty years ago.

HABITS.—The Carp is partial to stagnant waters, or such as have a not too swift current, with a loamy, muddy bottom and deep places covered with vegetation. It inhabits now most of the larger and smaller rivers of Europe, particularly the Elbe, Weser, Rhine, Danube, Po, Rhone, Garonne, Loire, then the Bavarian and Swiss lakes, the lake of Constance, etc.; even salt water seems to agree with it very well. I have taken it in the Black Sea, where its weight often amounts to from fifteen to twenty pounds. It is also found in the Caspian Sea in great numbers, and is known there by the name of *Sassan*.

It is an advantage that the Carp is able to live in water where other fishes could not possibly exist; for instance, in the pools of bog meadows or sloughs. However, it is not by any means to be inferred from this that the best locality for carp ponds of a superior kind could be in such situations. The presence of too much humic acid is unfavorable to the well-being of the Carp, as we shall see presently in the chapter upon the establishing of fish-ponds.[1]

The Carp lives upon vegetable food as well as upon worms and larvæ of aquatic insects, which it turns up from the mud with the head. It is very easily satisfied, and will not refuse the offal of the kitchen, slaughter-houses, and breweries, or even the excrement of cattle and pigs. I propose to enter further upon the subject of feeding it when I speak of its culture in ponds.

In the moderate zone, that is to say in Central Europe, the Carp will, at the beginning of the cold season, seek deeper water to pass that period in a kind of sleep. This will sometimes occur as early as the beginning of November, if the winter should set in early; and it is to be remarked that they will retire at an earlier period in ponds than in rivers. They do so always in groups of from fifty to one hundred and more. They make a cavity in the muddy ground, called a "kettle"; in this they pass the time until spring, huddled together in concentric circles with their heads together, the posterior part of the body raised and held immovably, scarcely lifting the gills for the process of breathing, and without taking a particle of food. They do not take any food from the beginning of October, and continue to abstain from it, in some countries, until the end of March, and in colder districts even somewhat later. It will not answer, however, to depend on this habit when transporting them for propagation in the spring or winter time, more especially young Carp one or two years old. The fish will arrive in a worn and hungry condition, and must be kept in a tank constructed on purpose for observation, where it has no chance to bury itself in the mud; here it will sometimes take a little food. At such times I generally make use of boiled barley, or rye flour converted into a kind of tough paste by the addition of hot water, and with this I mix a little loam and dry bread; but I continue the feeding only until I can judge from the looks of the fish that they have recovered. This method I followed with the Carp which I imported from Europe for the purpose of breeding in the winter of 1876–'77. It is a most striking fact that the Carp, though it does not take any food during this winter sleep in its natural retreat, does not diminish in weight, while, in the so-called "winter chambers," it does so to a remarkable degree. These "winter chambers" are large tanks, one thousand to five thousand square feet in size or less; they are sometimes walled in with masonry, sometimes they are constructed of wood. Fishes intended for sale are kept in them for a few weeks or months during the winter.

The Carp does not grow in the winter. Warmth alone seems to exercise a favorable influence upon it and to promote growth. It only grows in the months of May, June, July, and August, and does not appear to continue doing so in September. This slight increase in weight which

[1] Report United States Fish Commissioner, pt. iv, p. 876 *et seq.*

takes place during the latter month seems to grow out of an accumulation of fat which is being deposited around the entrails. In ponds which contain plenty of food and healthy water, in an ordinary year, the growth and increase of weight in the year will be represented in figures as follows:

	Per cent. of original weight.	Per cent. of growth.
May	10–15	13
June	33	31
July	36	34
August	20	18
September	6	4
Total	110	100

If the weather in the month of May be mild and warm from the beginning, a better growth may be expected, amounting, as in June, to about thirty per centum. This month (May) is decidedly of great importance for the growth of the fish during the current year, for, in proportion as the fish has grown in the short space of one month, it will take more food in the following ones, as the increase of its growth and consequent wants will demand. Culturists, therefore, consider the month of May as being the most important of the whole period of the Carp's growth. The above-given calculations, of course, are limited to ponds in which no artificial feeding is resorted to, but in which there is sufficient food by reason of the good quality of the water and soil which produces it.

In small ponds, situated in parks or gardens, which possess favorable soil and river water, the increase of weight will be even a little greater if feeding is had recourse to, for such small ponds (covering only half an acre) cannot produce sufficient food themselves. On the whole, feeding is a makeshift, as will be seen presently, and which in very large ponds of more than from twenty to one thousand acres should not be made use of.

The above calculations are only admissible for Central Europe, from the Adriatic to the Baltic and the North Sea. In countries farther north, as in Sweden, the growth of the Carp is less, as, on the contrary, in more southern countries than Central Europe, for instance in Illyria, Dalmatia, Southern Italy, Southern Spain, and partly, also, Southern France, the result is more favorable still. There a milder and warmer climate, an early spring, a very warm summer and autumn, and a late winter, which, in addition, is mild and short, combine to exercise a favorable influence upon the thriving condition of the fishes. In these warm climates the fish becomes lively at a much earlier season, if it does at all pass the winter in that lethargic state, without taking any food, than it does in the countries of the northern parts of Central Europe.

REPRODUCTION.—The pond Carp of Central Europe generally leaves its winter retreat when the rays of the spring sun have warmed the water thoroughly, while at the same time it begins to seek for food at a somewhat earlier period in rivers and lakes. At the beginning of the month of March the eggs have developed themselves considerably in the body of the fish, and it only needs a few weeks of warm weather to bring about the spawning season. This commences in the middle of May in such lakes and ponds of Central and Northern France, Southern Germany and Austria, as have a warm situation and are sheltered from the cold winds. It continues in some localities throughout June and July, and sometimes, in more elevated situations, until August, as, for instance, in Franconia and Upper Bavaria. The spawn of so late a season, however, is scarcely fit for breeding purposes, as the fish cannot grow much more during the short space of warm weather. It remains very small and suffers greatly from the ensuing winter weather, and is easily

dwarfed at that time. The spawning of the individual fish does not take place all at once. Days and weeks may pass before it will have left the last egg to the care of nature. At times, upon the setting in of rainy, cool weather during this period, it will be interrupted, but reassumed as soon as the temperature grows warmer again. Culturists altogether dislike cold weather at this time, as not only the eggs but the young fry also suffer much from it. Wet, cold summers are no more profitable to the culturists of Carp than to the agriculturist. In the southern part of Europe the spawning season commences at an earlier date than in Central Europe. In Sicily, in the neighborhood of Palermo, where there are some private ponds, the Carp begins to spawn at the commencement of the month of April. This is said to be the case also in the French province of Constantine, Algeria, Africa.

The abundance of eggs in the Carp is very great, and it is this circumstance which will explain its extraordinary increase in the natural waters. A fish weighing from four to five pounds contains, on an average, 400,000 to 500,000 eggs. Other statements figure still higher. I not only made calculations myself formerly, repeating them in 1876 on a female Mirror Carp, which I obtained from the environs of Gunzenhausen, Bavaria, and which, curiously enough, at the end of November, was entirely ripe, but I also obtained statements from culturists on whom I could depend. The calculation I made in the following manner: After freeing the eggs from all the fat and the inclosing membrane, and after having washed them in alcohol, I counted off exactly 1,000 of them; these I weighed, and according to the result I deduced the number of the whole. In the somewhat longer-bodied Scale Carp, I generally found comparatively more eggs than in a Mirror or Leather Carp, though all were of equal age and weight.

During the spawning season an appreciable change takes place in the male, protuberances, like warts, appearing on the skin of the head and back, and disappearing upon the expiration of that period. This is a peculiarity with most of the cyprinoids. Some time before the spawning season sets in, the falling out of the pharyngeal teeth takes place; these grow anew every year.

Some days before spawning the fish show an increased vivacity; they rise more often from the depths below to the surface. Two or three or more of the male fish keep near the female; the latter swims more swiftly on a warm, sunny morning, keeping mostly close to the surface, followed by the males. This is called "*streichen*"=running-spawning, and is more frequent in warm than in windy and rainy weather. The female prefers spots which are overgrown with grasses and other kinds of aquatic plants, such as *Utricularia*, *Nymphea*, and *Alisma*. The male fishes follow close to the very water's edge, as far as the diminished depth will allow them. They lose all their timidity and precaution, so that they may be taken quite easily. They lash the water in a lively way, twisting the posterior portion of the body energetically, and shooting through the water near its surface with short, tremulous movements of the fins. They do so in groups of two or three males to one female fish, and forming an almost compact mass. This is the moment when the female drops the eggs, which immediately are impregnated by the milter. As this process is repeated several times, the female drops probably only from four hundred to five hundred eggs at a time, in order to gain resting time, so that it will require days and weeks before it has given up the last egg.

The eggs of the Carp are adhesive, not detached, like those of the *Salmonidæ*, these latter lying loosely on the ground, while the former adhere in lumps to the object upon which they have fallen. As soon as the egg has left the body of the fish it swells up a little, the mucus, which surrounds it, serving as a means to fasten itself upon some aquatic plant, stone, or brush-wood. Those eggs which have no such object to cling to are lost. I found numerous eggs on the reverse sides of the leaves of the *Nymphaceæ* and their stems, the *Phellandrium* and *Utricularia*, but the

greater number of them I discovered on the *Festuca fluitans*, which among fishermen is known generally by the name of "water-grass." Its narrow, long, strap-shaped, thin leaves spread softly over the water's surface, as also its numerous branches in the water afford to the fish the sought-for opportunity to deposit its eggs upon its tender leaves. The seeds of this grass are an excellent food for the Carp. This may be regarded as a useful indication to be acted upon in the construction of ponds.

The eggs will develope themselves quickly if assisted by warm weather. As early as the fifth or sixth day the first traces of dusky spots, the eyes, will be visible, and toward the twelfth, or at the latest the sixteenth day the little embryo fish will break through its envelope. This rapid development takes place only in shallow, thoroughly-warmed ponds, or in such as were expressly constructed for hatching, and called breeding ponds. If these ponds are deep, and consequently their water is colder, the hatching process may require as many as twenty days. In from three to five days the young fish has absorbed the yolks, and seeks its food. If the breeding pond be productive enough to furnish the necessary food for so many young fishes, these will grow very rapidly. I shall return to this subject hereafter.

I remarked above that the Carp prefers stagnant or slowly-running water with a muddy bottom, and that it lives upon vegetable as well as animal food, aquatic plants, seeds, worms, and larvæ of water insects; it is therefore no fish of prey. It does not attack other fishes, and has no teeth in its mouth, but only in the throat, and is, on account of its harmlessness, an excellent fish for the culturist, as well as for stocking large lakes and rivers in general.

GROWTH AND SIZE.—Its growth differs, according as the fish inhabits cold or warm water, a river, lake, or pond, finding plentiful food therein, or being fed. An additional factor is the quality of the soil, whether muddy or stony. In cold water, or such as has a stony ground, the Carp will not progress favorably. For this reason, the statements concerning its normal size, attained to in a certain given time, differ widely. Very naturally, it will exercise an extremely great influence upon the thriving of the fishes whether the pond contains a great number or only a few of them; whether it is overstocked, as culturists term it, or whether there are only a proportionate number of fishes in it, according to its capability of producing food. Other considerations remain to be mentioned, namely, Is the pond provided with supplies from brooks falling into it, or are the fishes to be fed? The latter course is almost indispensable in the culture of trout. The expenses incurred in this case diminish the income of the culturist; if not resorted to, the result will be the same, as the value of the fish will be smaller. This feeding is needless with the Carp, if it be cultivated judiciously in suitable ponds, and for this reason alone the culture of the Carp is preferable to that of the trout.

In rivers and lakes it grows larger, although the same fish; for the reason, probably, that in a larger space, which at the same time yields more sheltered retreats, it escapes from the pursuit of man more easily than in regular artificial ponds, and finds more plentiful supplies of food.

The question of the species, or I would rather say the race, is of great moment, particularly in respect to carp-culture in ponds.

A favorable result may be expected from the culture of this fish wherever the necessary water is to be found, be it in the north or south, and that, too, as well in ponds as in open lakes and rivers.

The normal weight which a Carp may attain to in three years, whether it be Scale Carp, Mirror Carp, or Leather Carp, is an average of from three to three and one-fourth pounds; that is, a fish which has lived two summers, consequently is eighteen months old, will weigh two and three-fourths to three and one-fourth pounds the year following. The growth may turn out to be

even more favorable in a warm year, or if only a few fishes have been placed in a pond, as we shall see farther on, in the chapter treating of pond-culture and the operations of the culturist.[1]

Carps may reach a very advanced age, as specimens are to be found in Austria over one hundred and forty years old. The increase in length only continues up to a certain age, but its circumference will increase up to its thirty-fifth year.

I have seen some common Carp in the southern parts of Europe—in the lowlands of Hungary, Servia, Croatia, Wallachia, as also in Moldavia and the Buckowina—which weighed from thirty to forty pounds and more, measuring nearly three and one-half feet in length by two and three-fourths feet in circumference.

Old men, whose credibility and truthfulness could not be doubted, assured me and gave the most detailed accounts of the capture of this species of fish in former years, giants, which weighed from fifty to sixty pounds, and which they had seen themselves. During the Crimean war in 1853, a French engineer officer, stationed at Widdin, on the Danube, in Turkey, killed a Carp by a bullet-shot, some distance below the city; this fish weighed sixty-seven pounds. I had some of its scales in my possession, of which each had a diameter of two and one-half inches. Their structure indicated to a certainty that the age of this fish could be no more than twenty-four years at the most. It is a well-known fact that two large Carps, weighing from forty-two to fifty-five pounds, were taken several years ago on one of the Grand Duke of Oldenburg's domains in Northern Germany. They have been kept in some particularly favorable water, productive of plentiful food, and had been used as breeding fishes. These two specimens might, from their size, be calculated to be comparatively very aged fishes; it was proved that they were only fifteen years old. If we may credit the chronicles kept centuries ago by old families, and especially by the monks, who had taken possession of all the best localities along the banks of the beautiful blue Danube, then still greater giants had been caught, and that in the waters of the Danube itself. A chronicle of the monastery of Mölk, in Austria, refers to a Carp weighing seventy-eight pounds, which had been captured on Ascension Day in 1520. Another record speaks of a Carp which had been taken in the third decennium of the present century in the lake of Zug, in Switzerland, and which weighed ninety pounds. These giants are certainly only wonderful exceptions, and have become celebrated through the scarcity of such occurrences, but still these facts are encouraging illustrations that it is possible for such large specimens to grow up in favorable waters. All the countries where these large fishes have been found, and which are situated between the Black, the North, and the Baltic Seas, are pretty nearly such as have a late spring and a long, cold winter. Near Widdin the Danube has been frozen repeatedly. There the Carp passes from five to seven months in its winter sleep, during which it does not grow. If this fish thrives so well in the countries which have such a very cold winter (on an average they have the same winter temperature as Boston, Chicago, Milwaukee, Pittsburgh, Philadelphia, New York, Baltimore and Saint Louis), where the rivers have not enough food for these fishes by far, their level being regulated by dams, which are a subject of constant complaint to the fishermen, how much more would they thrive in the waters of this country with their great riches of food? But if we take into account the rivers of the mild South and Southwest of the United States, what success may not be expected for this fish in those regions?

If the Carp finds food in superfluity it will grow much more rapidly than the above statement indicates. This gives an increase of from three to three and one-fourth pounds in one year and six months; but this is only the normal one, the food consumed being of an average amount. If the fish obtain food very plentifully it will grow more rapidly. In this case, again, it is to be consid-

[1] Report of the United States Fish Commision, pt. iv, p. 876 *et seq.*

ered that the waters of the milder climates of this country possess this advantage, scarcely to be judged of or estimated at its proper value as yet, that the fish may be able during three-quarters of the year, or even the whole year round, to take food, and will omit the lethargic winter sleep conditioned by the cold winter. There is scarcely a comparison to be made, so far as the Carp is concerned, between the rivers of this country, so richly supplied with food, which it will not be compelled to seek under a constant strife for existence, and the much poorer waters of the Rhine, Elbe, Rhone, etc. In the waters of its native country, in Central Europe, after its first awakening from the long winter sleep, it seeks most diligently the contents of the seeds of the *Nuphar luteum* and *Nymphæa alba* (the yellow and white water-lily), the *Phellandrium aquaticum*, *Festuca fluitans*, etc. The waters of the United States abound in all these plants and numerous others the seeds of which will serve the fish as food; for instance, the wild rice (*Zizania aquatica* and *Z. fluitans*), the well known Tuscarora rice or "water-oats" with its great riches of seeds, and many others, which will yield food profusely, and which European waters do not possess, thus giving a great advantage to the American carp culturist. And then there is the culture of fish in ponds. There are culturists in Central Europe who, wishing to see the fish grow more rapidly, take the trouble to feed them with soaked barley, which they occasionally throw out in different places, and by doing so they have had a very full success, the fish growing larger, that is, more quickly than when not thus fed. By introducing the above-named wild or natural water plants in carp ponds they will be perpetuated, and the grains which have fallen to the bottom of the water will form an ample article of food for the first spring days, if we do not prefer to give them the almost worthless offal of the slaughter-houses. I do not advocate the so-called artificial feeding of this fish where the ponds themselves yield food in ample abundance, a consummation toward which the Tuscarora rice will largely contribute.

Let us once more consider the fact of its extraordinary increase of weight of about one hundred and ten per centum in the exceedingly short space of four months, for during the cold winter time, when ice thickly covers rivers and lakes, nature banishes it into its temporary tomb which it chooses and digs for itself, to hold its winter sleep in. This fish needs from fifteen to eighteen months of growth to gain, according to a low estimation, the weight of three pounds without being fed. But much more satisfactory results are frequently arrived at when favorable circumstances combine and when it will reach a greater weight. There are some culturists who obtain in the same space of time fishes of four pounds' weight; of course they possess warmly situated ponds which thaw very early in spring, and perhaps they assist nature in some degree by feeding the fishes. I have done so myself in two successive years, which were exceptionally warm, when I fed the fishes with the almost worthless malt refuse or "grains." They increased visibly and attained to the above-mentioned weight in the same space of time.

This fifteen to eighteen months of the actual time of growth transpires during a period of three years and six months, as intervening months of winter sleep are to be included, during which the growth is interrupted.

I will not recur to what this fish promises to become in the milder regions of the South, where neither ice-bound water nor cold temperatures force upon it the lethargy of the winter sleep, where it will have the longer space of from eight to ten months, or may be the whole year, including the mild winter, for the most vigorous and rapid development, not, as in Europe, the sparingly allotted four or five months. It is not to be doubted that the Carp will arrive at the weight of from two and three-fourths to four pounds in one year in those warm climates, when in colder regions it requires two years and six months. I do not think that I am mistaken in this; I am ready to stand by this assertion, which the future will surely verify.

For a full account of the methods of culture the inquirer is referred to the Report of the United States Commission of Fisheries, part iv, 1875–'76, pp. 876–900, and to other papers in the subsequent reports. At the time of the publication of this volume the progeny of the three hundred and forty-five young Carp brought over from Germany in May, 1877, have been distributed to all parts of the United States, and the Carp is almost as familiar to our people as is any other kind of domesticated animal.

"The Carp," writes Jordan, "has been extensively introduced into California and Oregon, and it has thriven admirably. In many parts of California there are now carp ponds, but they are most numerous, and perhaps most profitable, in Sonoma County."

189. THE CATFISH FAMILY—SILURIDÆ.

By David S. Jordan.

The Catfishes abound in all the fresh waters of the United States east of the Rocky Mountains. The species of the three genera, *Ictalurus*, *Amiurus*, and *Leptops*, which constitute the bulk of the family as represented in North America, all reach a length of from one to five feet, and are all food-fishes of more or less importance. One of the Catfishes, *Ictalurus ponderosus*, is our largest fresh-water fish, weighing upwards of one hundred and fifty pounds, and two of the others, *Leptops olivaris* and *Ictalurus nigricans*, reach a very considerable size.

The Catfishes are voracious and indiscriminate feeders, any kind of animal substance, living or dead, being greedily swallowed by them. They are also (especially the species of *Amiurus*) extremely tenacious of life, living for a long time out of water, and being able to resist impurities in the water better than any other of our food-fishes. They spawn in spring, and the female fish keeps a watch over the school of young, much as a hen takes care of chickens. The Catfishes are especially adapted for stocking ponds and sluggish streams with muddy bottoms, or which become partly dry in summer, bodies of water not suited for the more aristocratic trout and bass.

The species of the genus *Ictalurus*—known as "Channel Cats" are much less hardy than the other Catfishes, and do not thrive well except in river channels. Any water which does not dry up absolutely to the bottom in summer will suffice to nurture the common small Catfishes.

The flesh of all the Catfishes is of fair quality, not delicate nor tender, but of good flavor. The Channel Cats have whiter meat than the ordinary small Catfish, but the flesh is drier, and the latter are usually preferred.

The common Channel Cat—Ictalurus punctatus.

The Channel Cat or Blue Cat abounds in all the larger Western and Southern streams, living in the river channels. It reaches a weight of five to ten pounds and is readily salable, but its flesh is not better than that of its less attractive relatives. It takes the hook readily. This species is abundant in the Saint John's River, Florida. In 1878 many were taken near the bar at Mayport in brackish water. For table use they are much more highly esteemed than the Mud Catfish.

Great Mississippi Cat—Ictalurus ponderosus.

This species, the largest of our Catfish, is found in the Mississippi, and probably in its larger tributaries, where it reaches a weight of about one hundred and fifty pounds. Little distinctive is known of its habits, which probably agree with those of the next species.

The Great Lake Catfish; Flannel-mouth Cat (the young)—Ictalurus nigricans.

This species, the most abundant of the large Catfishes, abounds in the Great Lakes and in the larger streams of the West and South as far as Florida. It reaches a weight of fifty to one hundred pounds, perhaps more. In all the markets of the region where found it is one of the most important species, and its flesh, which can be cut in "steaks" like halibut, is generally esteemed. Nothing distinctive is known of its breeding habits or rate of growth. Professor Goode remarks: "I have observed frequently enormous specimens of this species in the Saint John's River, where they are called Mud Cats."

The Channel Cat of the Potomac—Ictalurus albidus.

The White Catfish of the tributaries of the Chesapeake Bay is very abundant in the Susquehanna and Potomac Rivers, and forms an important part of the fish supply of the Washington market. It reaches a weight of two to five pounds, being much smaller than the preceding species, which it resembles.

The Horned Pout—Amiurus nebulosus.

The common "Horned Pout," "Bull-head," "Bull-pout," or "Minister" of the Northern and Eastern States is the most generally abundant and familiar representative of this family. It reaches a length of about eighteen inches and rarely exceeds three or four pounds in weight, while the majority of those seen in the markets are still smaller. It is probably the hardiest of all our fresh-water fishes, thriving in any waters, but preferring those which are quiet and shaded. Numerous other species very similar to this occur in our fresh waters.

The Bull-head has been introduced from the Schuylkill into the Sacramento and San Joaquin Rivers in California. It has there very rapidly multiplied, and is now common in all the sloughs and bayous of the lower courses of these rivers. As a food-fish it is not very highly valued by the Californians, most of those brought to market being taken by the Chinese.

The Mud Cat—Leptops olivaris.

The "Mud Cat," "Yellow Cat," "Goujon," or "Bashaw" is found in all the large rivers of the West and South. It reaches a weight of at least fifty pounds. It is found only in the larger streams, swimming near the bottom. It is less attractive in its appearance than the other Catfishes, but we are not aware that its flesh is inferior to that of the others. This species, and other of the larger Catfishes, are often caught by "jugging," the bait being attached to a jug filled with air, which will in time tire out the fish and bring it to the surface.

The Stone Cat—Noturus flavus.

This species reaches a length of about a foot; the other Stone Cats (*Noturus*) are still smaller, and none of them can be considered as food-fishes.

The Gaff-topsail Catfish—Ælurichthys marinus.

This species, which ranges from Cape Cod to Florida, is found chiefly in brackish water. It is not uncommonly taken at Arlington, Florida, and Empire Point. It is known here and at Pensacola as the "Sea Cat," and at Brunswick, Georgia, as "Gaff-topsail," in allusion to the shape of the first dorsal fin. According to Mr. H. S. Williams, it is abundant in the Indian River. It is common also along the Gulf Coast, but is nowhere valued as food. Many of the fishermen believe this species to be viviparous. Mr. S. C. Clarke, writing from New Smyrna March 31, 1874, remarks: "They have eggs in them as large as cherries."

The Salt-water Catfish—Arius felis.

The Salt-water Catfish is found along the coasts of the Gulf of Mexico to as far north as Cape Hatteras. In the first volume of the Proceedings of the United States National Museum, p. 278, is an interesting account of its breeding habits, as observed by Prof. N. T. Lupton. The species spawns there in July, and the parent (sex not stated) carries the eggs in its mouth. Silas Stearns says of this fish:

"The Salt-water Catfish is very abundant everywhere on the Gulf coast. It is found on the sea-beaches, the shores and bottoms of bays and bayous, and even some distance up fresh-water streams. It is a bottom-loving fish, feeding upon worms and small crustaceans chiefly, but will readily eat anything else—fish, flesh, or fowl, dead or alive. As the pest of these waters, it is ever present and never welcome. It breeds in the summer, in June, July, and August. The spawn is deposited in the depression in the sand and impregnated with the milt. One of the parent fish then takes the eggs in his mouth and by some movement fixes them against the gills, or between the leaves of the gills. The eggs are carried in this position until the embryo fish are hatched and have become perfect and able to care for themselves. The eggs when full size resemble white grapes; they are large and clear. Sometimes the parent fish's jaws are much distended by the eggs and young inside and its appearance is comical.

"The Catfish emits a grunting noise (similar, although louder, to several fishes of this coast—the grunt, drum, mademoiselle, croaker, etc.), which comes, I believe, from the swimming bladder. This noise, when there are many fish present and all else is still, is very annoying, and I have passed more than one wakeful night from hearing it on the Southern coast, where the fish were swimming under my boat. The Catfish will always take the hook, and is not at all particular as to the kind of bait; attains a weight of ten or twelve pounds, though the average is much less. It is seldom eaten except as a last resort for fresh food; it is, however, quite palatable. When caught it is almost invariably mangled and consequently thrown away."

190. THE MORAYS—MURÆNIDÆ.

On our Southern coasts are several species of eel-like fishes belonging to this family. On account of their sharp teeth and strong jaws they are rather dreaded by the fishermen, who fear their bites. Some species, however, are here, as in various parts of the West Indies, in considerable demand for food. The most important species is the Speckled Moray, *Sidera ocellata*, which is occasionally brought to the Key West markets.

California Conger Eel—Sidera mordax.

"This species," writes Jordan, "is always known as 'Conger Eel' or 'Congeree.' It reaches a length of five feet and a weight of fifteen or twenty pounds. It is found among rocks about the Santa Barbara Islands, and southward along the coast of Lower California. About the islands it is quite common. It is remarkable for its ferocious disposition. When captured it shows fight and bites savagely, striking like a snake. Its flesh is very fat, resembling that of Anguilla, and is very palatable when fried. The skin is said by the fishermen to be 'very pizen.' This species is brought into the Los Angeles market, where it meets with a ready sale. Considerable numbers are salted and dried by the Chinese."

The Sea-snakes (*Ophichthys ocellatus, O. chrysops*, etc.) are occasionally seen on the fishing-smacks in the Gulf of Mexico, having been obtained from the stomachs of large groupers and snappers, with which it is a favorite food. Stearns has obtained specimens at Pensacola caught with hook and line on the snapper banks, sixty miles east of that port.

191. THE EEL—ANGUILLA VULGARIS.

CLASSIFICATION.—There is no group of fishes concerning the classification and history of which there is so much doubt as the Eel family; an infinite number have been described, but most are so badly characterized or founded on individual or so trivial characters that the majority of ichthyologists will reject them.[1]

In his "Catalogue of the Fishes in the British Museum" Dr. Günther has claimed to retain those as species which are distinguished by such characters that they may be recognized, though he remarks that he is by no means certain whether really specific value should be attached to them, remarking that the snout, the form of the eyes, the width of the bands of teeth, etc., are evidently subject to much variation. In his more recent work he remarks, "Some twenty-five species of Eels are known from the coast waters of the temperate and tropical zones."

Other recent writers have cut the knot by combining all of the Eels into three or four, or even into one, species, and it seems as if no other course were really practicable, since the different forms merge into one another with almost imperceptible gradations. In his monograph of the family of anguilliform fishes,[2] M. C. M. Dareste remarks:

"Dr. Günther has recently published a monograph of the apodal fishes in which he begins the work of reducing the number of specific types. The study of the ichthyological collection of the Paris Museum, which contains nearly all of Kaup's types, has given me the opportunity of completing the work begun by Dr. Günther, and of striking from the catalogue a large number of nominal species which are founded solely upon individual peculiarities.

"How are we to distinguish individual peculiarities from the true specific characters? In this matter I have followed the suggestions made with such great force by M. Siebold in his 'History of the Fresh-water Fishes of Central Europe.' This accomplished naturalist has shown that the relative proportions of the different parts of the body and the head vary considerably in fishes of the same species, in accordance with certain physiological conditions, and that consequently they are far from having the importance which has usually been attributed to them in the determination of specific characters.

"The study of a very large number of individuals of the genera *Conger* and *Anguilla* has fully convinced me of the justice of this observation of Siebold; for the extreme variability of proportions forbids us to consider them as furnishing true specific characters.

"I also think, with Siebold, that albinism and melanism, that is to say, the diminution or augmentation of the number of chromatophores, are only individual anomalies and cannot be ranked as specific characters. Risso long since separated the black Congers under the name *Muræna nigra*. Kaup described as distinct species many black Anguillas. These species should be suppressed. I have elsewhere proved the frequent occurrence of melanism and albinism more or less complete in nearly all the types of fishes belonging to this family, a fact especially interesting since albinism has hitherto been regarded as a very exceptional phenomenon in the group of fishes. This also occurs in the *Symbranchidæ*. I have recently shown it in a specimen of *Monopterus* from Cochin China presented to the museum by M. Geoffroy St. Hilaire.

"I must also signalize a new cause of multiplication of species; it is partial or total absence of ossification in certain individuals. This phenomenon, which may be explained as a kind of *rachitis* (rickets), has not to my knowledge been noticed, yet I have found it in a large number of specimens. I had prepared the skeleton of a Conger of medium size, the bones of which are

[1] GÜNTHER: Catalogue of the Fishes in the British Museum, viii, p. 24.
[2] Comptes-rendus of the Academy of Sciences, Paris.

flexible and have remained in an entirely cartilaginous state. Still it is not necessary to prepare the skeleton to determine the absence of ossification, for we can establish this easily in unskinned specimens by the flexibility of the jaws. It is very remarkable that this modification of the skeleton is not incompatible with healthy existence, and that it does not prevent the fish in which it is found from attaining a very large size.

"Those fishes in which ossification is absent are remarkable by reason of the great reduction of the number of teeth, which, although the only parts which become hard by the deposit of calcareous salts, remain however much smaller than in individuals whose skeletons are completely ossified.

"We can thus understand how such specimens could present characters apparently specific, and that they should have been considered by Kaup as types of new species. These considerations have led me to reduce, on an extensive scale, the number of species in the family.

"So, in the genus *Anguilla*, I find but four species: *Anguilla vulgaris*, occurring throughout the northern hemisphere, in the New World as well as the Old; *Anguilla marmorata* and *A. mowa* of the Indian Ocean, and *Anguilla megalostoma* of Oceanica.

"There are at least four distinct types, resulting from the combination of a certain number of characters; but the study of a very large number of specimens belonging to these four specific types has convinced me that each of these characters may vary independently, and that consequently certain individuals exhibit a combination of characters belonging to two distinct types. It is therefore impossible to establish clearly defined barriers separating these four types.

"The genus *Anguilla* exhibits, then, a phenomenon which is also found in many other genera, and even in the genus *Homo* itself, and which can be explained in only two ways: Either these four forms have had a common origin and are merely races, not species, or else they are distinct in origin, and are true species, but have been more or less intermingled, and have produced by their mingling intermediate forms which coexist with those which were primitive. Science is not in the position to decide positively between these alternatives."[1]

It is the disposition of American ichthyologists, at least, to accept the views of Dareste, and to consider all the Eels of the northern hemisphere as members of one polymorphic species. Günther is inclined to recognize three species in North America: one the common Eel of Europe, *Anguilla vulgaris;* one the common American Eel, *Anguilla bostoniensis* (*rostrata*), which he finds also in Japan and China; and the third, *Anguilla texana*, described and illustrated by Girard, in the "Report of the United States and Mexican Boundary Survey," under the name of *A. texana*, which, he remarks, is scarcely specifically distinct from *A. bostoniensis*, from which it differs only in the greater development of the lips, a distinction which seems to be imaginary. The distinction between *A. bostoniensis* and *A. vulgaris*, as stated by him, consists chiefly in the fact that the dorsal fin is situated a little farther back upon the body, so that in the former the distance between the commencement of the dorsal and anal fin is shorter than the head, while in the latter it is equal to or somewhat longer than it. This character does not appear to be at all constant.

GEOGRAPHICAL DISTRIBUTION.—Assuming the specific identity of the Eels of the Old and the New World, the distribution of the common Eel may be defined somewhat as follows: In the rivers and along the ocean shores of Eastern North America, south to Texas and Mexico, and north at least to the Gulf of Saint Lawrence, but absent in the waters tributary to Hudson Bay, the Arctic

[1] These conclusions of Dareste have a very mediæval ring. "Science" is certainly in the position to say that neither of these hypotheses can be true. From the stand point of modern zoology, the common origin of the species of Anguilla admits of no reasonable doubt. Between the four "species" of Dareste and their less sharply defined races, no permanent difference exists. The name "species" certainly cannot be refused to forms having supposably a common origin.—J.

Sea and the Pacific; present in Southern Greenland (?) and Iceland, latitude 65° north; on the entire coast of Norway, from the North Cape, latitude 71°, southward; abundant in the Baltic, and in the rivers of Russia and Germany which are its tributaries, and along the entire western and Mediterranean coasts of Europe, though not present in the Black Sea, in the Danube or any of its other tributaries, or in the Caspian; occurring also off Japan and China and Formosa; also in various islands of the Atlantic, Grenada, Dominica, the Bermudas, Madeira, and the Azores.

HABITS.—The habits of the Eel are very different from those of any other fish, and are as yet but little understood.

"This, so far as we know," writes Professor Baird, "is the only fish the young of which ascend from the sea to attain maturity, instead of descending from the fresh to the salt water. Its natural history has been a matter of considerable inquiry within a few years, although even now we are far from having that information concerning it that would be desirable, in view of its enormous abundance and its great value as a food-fish.

"The eggs of the Eel are for the most part laid in the sea, and in the early spring, the period varying with the latitude, the young fish may be seen ascending the rivers in vast numbers, and when arrested by an apparently impassable barrier, natural or artificial, they will leave the water and make their way above the obstruction, in endeavoring to reach the point at which they aim. Here they bury themselves in the mud and feed on any kind of animal substance, the spawn of fish, the roes of shad, small fish, etc. At the end of their sojourn in the ponds or streams they return to the sea, and are then captured in immense numbers in many rivers in what are called fish-baskets. A V-shaped fence is made, with the opening down-stream into the basket, into which the Eels fall, and from which they cannot easily escape. This same device, it may be incidentally stated, captures also great numbers of other fish, such as shad, salmon, and other anadromous fish, to their grievous destruction.

"As might be expected, however, the Falls of Niagara constitute an impassable barrier to their ascent. The fish is very abundant in Lake Ontario, and until artificially introduced was unknown in Lake Erie. At the present time, in the spring and summer, the visitor who enters under the sheet of water at the foot of the falls will be astonished at the enormous numbers of young Eels crawling over the slippery rocks and squirming in the seething whirlpools. An estimate of hundreds of wagon-loads, as seen in the course of the perilous journey referred to, would hardly be considered excessive by those who have visited the spot at a suitable season of the year.

"The economical value of the Eel as a food-fish has been well established, and it is now greatly sought after for introduction into the localities where, for some physical or other reason, it is unknown. The advantages, as summed up by a German writer, are, first, that an Eel will live and grow in any water, however warm, and whatever be the general character of the bottom, though it prefers the latter when muddy and boggy; second, the Eel requires no special food, but devours anything living or dead; it is an excellent scavenger, feeding upon dead fish, crabs, etc., as well as upon any living prey it can secure; third, but few conditions can interfere with its development, while it grows with very great rapidity, being marketable at the age of three years; fourth, the young, on account of their hardiness, can be transported in a crowded condition, and to any distance, with very little risk of destruction. These considerations are, in the main, well established, and there is no question but that the Eel can be introduced in many waters to advantage, supplementing the earlier inhabitants. It has been planted in the waters of the Upper Lakes and the Mississippi River; in the latter they have reached an advanced development. It is, however, a very undesirable inmate of rivers in which fish are taken by means of gill-nets, the destruction of shad and herring in the waters of the Susquehanna and others farther south

being enormous. It is not unfrequent that, when a gill-net is hauled up, the greater part of the catch consists simply of heads and backbones, the remainder being devoured by myriads of Eels in the short time the net is left out. The spawning shad are considered by them a special delicacy, and are found emptied at the vent and completely gutted of the ovaries. Sometimes a shad, apparently full, is found to contain several Eels of considerable size. They do not seem to be very destructive of living fish of any magnitude, although the young fry are devoured with gusto."[1]

In describing the geographical distribution of the Eel it was stated that it occurs in the rivers and along the ocean shores of North America. This being the case, as might be supposed, there are many inland lakes and streams of the United States in which this fish does not occur; for instance, the chain of the Great Lakes above Niagara Falls, and the upper waters of other streams in which there are considerable obstructions. The cutting of canals in various parts of the country has, however, produced a great change in their distribution; for instance, it is stated by Mitchill[2] that Eels were unknown in the Passaic above the Great Falls until a canal was cut at Paterson, since which time they have become plentiful in the upper branches of that river. They have also been placed in many new localities by the agency of man. Concerning this Mr. Milner remarks:

"The Eel (*Anguilla bostoniensis*), appreciated in some localities and much vilified in others, is another species that has been frequently transplanted. It is pretty evident that it never existed naturally in the chain of Great Lakes any higher up than Niagara Falls, although specimens have been taken in Lakes Erie and Michigan. Their existence there is with little doubt traceable to artificial transportation.

"A captain of a lake vessel informed me that it was quite a common thing some years ago to carry a quantity of live Eels in a tub on the deck of a vessel while on Lake Ontario, and they were often taken in this manner through the Welland Canal. He said that it was a frequent occurrence on his vessel when they had become tired of them, or had procured better fishes, to turn the remainder alive into the waters of Lake Erie.

"In 1871 Mr. A. Booth, a large dealer of Chicago, had an Eel of four pounds' weight sent him from the south end of Lake Michigan, and a few weeks afterward a fisherman of Ahnapee, Wisconsin, nearly two hundred miles to the northward, wrote him that he had taken a few Eels at that point. It was a matter of interest to account for their presence, and a long time afterward we learned that some parties at Eaton Rapids, Michigan, on a tributary of the lake, had imported a number of Eels and put them in the stream at that place, from which they had doubtless made their way to the points where they were taken. The unfortunate aquarium-car in June, 1873, by means of the accident that occurred at Elkhorn River, released a number of Eels into that stream, and about four thousand were placed by the United States Commission in the Calumet River at South Chicago, Illinois, two hundred in Dead River, Waukegan, Illinois, and thirty-eight hundred in Fox River, Wisconsin."[3]

They have since been successfully introduced into California.

LIFE HISTORY.—Concerning the life history of the Eel much has been written, and there have been many disputes even so late as 1880. In the article upon ichthyology, contributed to the Encyclopedia Britannica, Günther writes:

"Their mode of propagation is still unknown. So much only is certain, that they do not

[1] MS. note by Professor Baird.
[2] Transactions Literary and Philosophical Society New York, i, p. 48.
[3] Report United States Fish Commission, part ii, 1874, 526.

spawn in fresh water; that many full-grown individuals, but not all, descend rivers during the winter months, and that some of them at least must spawn in brackish water or in deep water in the sea; for in the course of the summer young individuals from three to five inches long ascend rivers in incredible numbers, overcoming all obstacles, ascending vertical walls or flood-gates, entering every larger and swollen tributary, and making their way even over *terra firma* to waters shut off from all communication with rivers. Such emigrations have long been known by the name '*Eel-fairs*.' The majority of the Eels which migrate to the sea appear to return to fresh water, but not in a body, but irregularly, and throughout the warmer part of the year. No naturalist has ever observed these fishes in the act of spawning, or found mature ova; and the organs of reproduction in individuals caught in fresh water are so little developed and so much alike, that the female organ can be distinguished from the male only with the aid of a microscope."

MIGRATIONS OF EELS.—In attempting to review this subject I am sure I cannot do better than to translate at length a communication just received from my friend Dr. Berthold Benecke, professor in the University of Königsberg:

"The coloration of Eels varies greatly not only in different localities, but in the very same places: the back may be dark blue or greenish black; the sides, lighter blue or green; the belly, white; sometimes the back is only slightly darker than the sides; sometimes there are olive-green individuals with a golden-yellow band upon their back, sometimes they are entirely golden-yellow, and, very rarely, entirely white. The Eel lives in deep, quiet waters with muddy bottom; it burrows out holes and tunnels in which it rests quietly during the day, while at night it comes out in search of food. From the deck of a steamer passing through rivers or canals one may see upon the banks, which are laid bare by the waves produced by the motion of the vessels, numerous Eels with half of their bodies projecting from their lurking holes.

"The Eel feeds upon all kinds of small water animals, and may be found on the spawning places of other fish in great troops, going there for the purpose of feeding upon the eggs. They feed also upon crabs at the period when they are shedding their shells, and have in many localities in Germany completely exterminated them. Since the Eel is everywhere known as a greedy robber, many accounts have been given of their wanderings, in which they have made their way into the pea-patches to feed upon pease. The oldest reference of this kind is that of Albertus Magnus, who remarks in his book of animals, published at Frankfort-on-the-Main in 1545: 'The Eel also comes out of the water in the night-time into the fields, where he can find pease, beans, or lentils.' This statement was contradicted in 1666 by Baldner,[1] who writes concerning the Eel: 'They eat fish, do not come on the land, and do not eat pease, but remain in the water always, and are nocturnal animals.'

"Forthwith, new statements were made which tended to show the actuality of the wanderings of the Eels in the pea-patches. For instance, Bach, in his 'Natural History of East and West Prussia,' published in 1784, maintained that Eels frequently were caught in the pea-patches in the vicinity of the water, where they fed upon the leaves, or, according to other accounts, upon the pease themselves, and continues: 'These movements explain the paradoxical fact that in Prussia and Pomerania fish have been caught upon dry land by the use of the plow, for the peasants, in warm nights when the Eels are in search of the pease, towards morning when it is not yet day make furrows with the plow between them and the water, and these are the nets in which the

[1] Recht natürliche Beschreibung und Abmahlung der Wasser-Vögel, Fischen, vierfüssigen Thier, Insecten und Gewirm, so bey Strassburg in den Wassern sind, die ich selber geschossen und die Fisch gefangen, auch alles in meiner Hand gehabt. Leonhard Baldner, Fischer und Hagmeister in Strassburg gefertigt worden 1666. Manuscript. (Cited by von Siebold, "Süsswasserfische von Mitteleuropa," Leipzig, 1863.)

Eels are caught. Since the Eel moves with ease only upon the grass, its return to the water is cut off by the soil which has been thrown up. The peasants consider it as a sign of approaching stormy weather when the Eels come out of the water upon dry land.'[1]

"A person writes to me from Lyck: 'In storms they come out into the pea-patches, and at this time people spread sand or ashes around, and thus prevent their return.' Such tales are even now numerous in the newspapers.

"The small size of the gill-opening makes it possible for the Eel to live for a long time out of the water, and it is possible that in their wanderings over moist meadows they may find places in which there are snails and other desirable food. The explanation of their supposed wanderings over the pea-patches is, that the Eels, which have been found at different times in the fields or meadows, have been lost by poachers, who threw them away in their flight. Many times dead Eels have been found upon meadows over which they have swam, the meadows being flooded, and, in spite of the nearness of the water, have afterwards been unable to return to it.

"Although the activity and tendency among the young Eels to wander is very great, yet we cannot believe in the wandering of adult Eels over wide stretches of land. According to Spallanzani, in Comacchio, where for many centuries an eel fishery of immense extent has been carried on, although these fish are found in numerous ponds and lagoons, the fishermen have never yet seen an Eel wandering over the land; and once when, on account of the drying up of the water, the Eels died by the thousand, not one of them made the attempt to escape by a short journey overland into the neighboring lake or into the river Po.

"The Eel occurs in all our waters, with the exception of small rapid brooks. The fishermen distinguish many varieties based upon the differences in the form of the head or color and the varying proportions in the length of the body and tail; and the older ichthyologists have followed their opinions without sufficient reason.

"By rapid growth the Eel attains the length of twenty-four to thirty inches, and often a greater size. On account of their fat, which is very highly flavored, and the absence of bones, they are everywhere valued, and are caught in various ways. The most profitable method of capture is in eel-weirs and eel-baskets, and in traps by the use of nets, and on hooks they are also caught in great quantities. In winter many Eels are taken with spears on the shelving shores where they lie buried in the mud in a state of torpidity. In this fishery very often more are wounded than captured, and, in addition to the large Eels, great quantities of small ones are taken."

ANCIENT BELIEFS CONCERNING THE REPRODUCTION OF THE EEL.—The reproduction of the Eel, continues Benecke, has been an unsolved riddle since the time of Aristotle, and has given rise to the most wonderful conjectures and assertions. Leaving out of question the old theories that the Eels are generated from slime, from dew, from horsehair, from the skins of the old Eels, or from those of snakes, and the question as to whether they are produced by the female of the Eel or by that of some other species of fish, it has for centuries been a question of dispute whether the Eel is an egg-laying animal or whether it produces its young alive; although the fishermen believe that they can tell the male and female Eels by the form of the snout. A hundred years ago no man had ever found the sexual organs in the Eel.

Jacoby has remarked that the Eel was from the earliest times a riddle to the Greeks; while ages ago it was known by them at what periods all other kinds of fishes laid their eggs, such discoveries were never made with reference to the Eel, although thousands upon thousands were yearly applied to culinary uses. The Greek poets, following the usage of their day, which was to attribute to

[1] A live and active Eel, a few days since, was dug out from a depth of five feet in the soil of Exeter, New Hampshire.—*Gloucester Telegraph*, October 26, 1870.

Jupiter all children whose paternity was doubtful, were accustomed to say that Jupiter was also progenitor of the Eel.

"When we bear in mind," writes Jacoby, "the veneration in which Aristotle was held in ancient times, and still more throughout the Middle Ages—a period of nearly two thousand years—it could not be otherwise than that this wonderful statement should be believed, and that it should be embellished by numerous additional legends and amplifications, many of which have held their own in the popular mind until the present day. There is no animal concerning whose origin and existence there is such a number of false beliefs and ridiculous fables. Some of these may be put aside as fabrications; others were, probably, more or less true, but all the opinions concerning the propagation of the Eel may be grouped together as errors into three classes:

"I. The beliefs which, in accordance with the description of Aristotle, account for the origin of the Eel on the basis of its development not from the mud of the earth, but from slimy masses which are found where the Eels rub their bodies against each other. This opinion was advanced by Pliny, by Athenæus, and by Oppian, and in the sixteenth century was again advocated by Rondelet and reiterated by Conrad Gessner.

"II. Other authorities base their claims upon the occasional discovery of worm-like animals in the intestines of the Eels, which they described, with more or less zealous belief, as the young Eels, claiming that the Eel should be considered as an animal which brought forth its young alive, although Aristotle in his day had pronounced this belief erroneous, and very rightly had stated that these objects were probably intestinal worms. Those who discovered them anew had no hesitation in pronouncing them young Eels which were to be born alive. This opinion was first brought up in the Middle Ages in the writings of Albertus Magnus, and in the following centuries by the zoologists Leeuwenhoek, Elsner, Redi, and Fahlberg; even Linnæus assented to this belief and stated that the Eel was viviparous. It is but natural that unskilled observers, when they open an Eel and find inside of it a greater or smaller number of living creatures with elongated bodies, should be satisfied, without further observation, that these are the young of the Eel. It may be distinctly stated, however, that in all cases where Eels of this sort have been scientifically investigated, they have been found to be intestinal worms.[1]

"III. The last group of errors includes the various suppositions that Eels are born not from Eels, but from other fishes, and even from animals which do not belong at all to the class of fishes. Absurd as this supposition, which in fact was contradicted by Aristotle, may seem, it is found at the present day among the eel-catchers in many parts of the world.

"On the coast of Germany a fish related to the cod, *Zoarces viviparus*, which brings its young living into the world, owes to this circumstance its name *Aalmutter*, or Eel Mother, and similar names are found on the coast of Scandinavia."

"In the lagoon of Comacchio," continues Jacoby, "I have again convinced myself of the ineradicable belief among the fishermen that the Eel is born of other fishes; they point to special differences in color, and especially in the common mullet, *Mugil cephalus*, as the causes of variations in color and form among Eels. It is a very ancient belief, widely prevalent to the present day, that Eels pair with water-snakes. In Sardinia the fishermen cling to the belief that a certain beetle, the so-called water-beetle, *Dytiscus Roeselii*, is the progenitor of Eels, and they therefore call this 'Mother of Eels.'"

[1] It is very strange that an observer so careful as Dr. Jacoby should denounce in this connection the well-known error of Dr. Eberhard, of Rostock, who mistook a species of Zoarces for an Eel, and described the young, which he found alive within the body of its mother, as the embryo of the Eel. In Jacoby's essay, p. 24, he states that the animal described by Eberhard was simply an intestinal worm, an error which will be manifest to all who will take the pains to examine the figure.

DISCOVERY OF THE FEMALE EEL.—A scientific investigation into the generation of Eels could only begin when, at the end of the Middle Ages, the prohibition which the veneration for Aristotle had thrown over the investigations of learned men was thrown aside. With the revival of the natural sciences in the sixteenth century we find that investigators turned themselves with great zeal to this special question. There are treatises upon the generation of the Eel written by the most renowned investigators of that period, such as Rondelet, Salviani, and Aldrovandi. Nevertheless, this, like the following century, was burdened with the memory of the numerous past opinions upon the eel question, and with the supposed finding of young inside the body of the Eel.

The principal supporters of the theory that the Eel was viviparous were Albertus Magnus, Leeuwenhoek, Elsner, Redi, and Fahlberg. The naturalists Franz Redi and Christian Franz Paullini, who lived in the seventeenth century, must be mentioned as the first who were of the opinion, founded, however, upon no special observations, that the generation of the Eel was in no respect different from that of other fishes.

In the eighteenth century it was for the first time maintained that the female organs of the Eel could certainly be recognized. It is interesting that the lake of Comacchio was the starting point for this conclusion as well as for many of the errors which had preceded it. The learned surgeon Sancassini, of Comacchio, visiting an eel fishery at that place in 1707, found an Eel with its belly conspicuously enlarged; he opened it and found an organ resembling an ovary, and, as it appeared to him, ripe eggs. Thereupon he sent his find, properly preserved, to his friend, the celebrated naturalist Vallisneri, professor in the University of Padua, who examined it carefully, and finally, to his own great delight, became satisfied that he had found the ovaries of the Eel. He prepared an elaborate communication upon the subject, which he sent to the Academy at Bologna.[1]

At the very beginning there were grave questions raised as to the correctness of this discovery. The principal anatomical authority at Bologna, Professor Valsalva, appears to have shared these doubts, especially since shortly after that a second specimen of Eel, which presented the same appearance as that which was described by Vallisneri, was sent from Comacchio to Bologna. The discussion continued, and it soon came to be regarded by the scientific men of Bologna as a matter of extreme importance to find the true ovaries of the Eel. Pietro Molinelli offered to the fishermen of Comacchio a valuable reward if they would bring him a gravid Eel. In 1752 he received from a fisherman a living Eel with its belly much distended, which, when opened in the presence of a friend, he found to be filled with eggs. Unfortunately the joyful hopes which had been excited by this fortunate discovery were bitterly disappointed when it was shown that the Eel had been cunningly opened by the fisherman and filled with the eggs of another fish. The eel question came up again with somewhat more satisfactory results when, in the year 1777, another Eel was taken at Comacchio which showed the same appearance as the two which had preceded it. This Eel was received by Prof. Gaetano Monti, who, being indisposed and unable to carry on the investigation alone, invited a number of his favorite pupils, among whom was the celebrated Camillo Galvani, the discoverer of galvanism, to a council at his house. This Eel was examined by them all, and pronounced to be precisely similar to the one which had been described by Vallisneri seventy years before. It was unanimously decided that this precious specimen should be sent for exhaustive examination to the naturalist Mondini, who

[1] I fail to find any record of the publication of this paper, except that given by Jacoby, who states that it was printed at Venice in 1710, with a plate, and subsequently, in 1712, under the title "De ovario Anguillarum," in the Proceedings of the Leopold Academy.

applied himself with great zeal to the task, the results of which were published in May, 1777. The paper is entitled "De Anguillæ ovariis," and was published six years later in the Transactions of the Bologna Academy.[1] Mondini was satisfied that the supposed fish which Vallisneri described was nothing but the swimming bladder of the Eel in a diseased state, and that the bodies supposed to be eggs were simply pustules in this diseased tissue. In connection with this opinion, however, Mondini gave, and illustrated by magnificent plates, a good description and demonstration of the true ovaries of the Eel, as found by himself. This work, which in its beautiful plates illustrates also the eggs in a magnified fold of the ovary, must be regarded as classical work, and it is an act of historic justice to state that neither O. F. Müller nor Rathke, but really Carlo Mondini, was the first discoverer, describer, and demonstrator of the female organs of the Eel, which had been sought for so many centuries.[2]

Three years later, entirely independent of Mondini, the celebrated zoologist Otto Friedrich Müller published his discovery of the ovary of the Eel in the "Proceedings of the Society of Naturalists" at Berlin.[3]

The discovery of Mondini was next specially brought into prominence through Lazzaro Spallanzani. This renowned investigator, in October, 1792, went from Pavia to the lagoons of the Po, near Comacchio, for the sole purpose of there studying the eel question. He remained at Comacchio through the autumn; he was, however, unable to find anything that was new regarding the question, but in the report upon his journey of investigation he entirely threw aside the discovery of Mondini, and announced that the ovaries discovered by this authority were simply fatty folds of the lining of the stomach.[4]

"It was without doubt this absolute negative statement of such a skilled investigator as Spallanzani which for a long time discouraged further investigations on the eel question, and allowed what had already been discovered to be regarded as doubtful, and finally to be forgotten. So when Professor Rathke, of Königsberg, in his assiduous labors upon the reproductive organs of fishes, in the year 1824, described the ovaries of the Eel as two cuff-and-collar shaped organs on both sides of the backbone, and in the year 1838 described them as new, he was everywhere in Germany (and to a large extent to the present day) regarded as the discoverer.[4] The first picture of the ovary after that of Mondini, and the first microscopical plate of the egg of the Eel,

[1] De Bononiensi Scientiarum et Artium Instituto atque Academia Commentarii. Tomus VI. Bononiæ, 1783, pp. 406 *et seq.*

[2] Prof. G. B. Ercolani, of Bologna, and also Crivelli and Maggi, in their essays published in 1872, have rightly stated that Mondini's priority of discovery has been overlooked in Germany. Neither Rathke nor Hohnbaum-Hornschech nor Schlüser have mentioned his work. S. Nillson, in his "Skandinavisk Fauna," 1855, says nothing of Mondini. He mentioned as the first discoverer of the ovaries O. F. Müller, while Cuvier, in his "Histoire Naturelle des Poissons," assigns the honor rather to Rathke. Th. von Siebold is the first to announce in his work, published in 1863, "Die Süsswasserfische von Mitteleuropa," page 349, that Mondini, almost contemporaneously with O. F. Müller and independently of him, discovered the ovaries of the Eel. The error, as was discovered by Italian zoologists later than by those of Germany, arose from the fact that the announcement of Müller's discovery was printed in 1780, while that of Mondini's, which was made in 1777, was first printed in 1783.

[3] O. F. Müller: Bemühungen bei den Intestinal-würmern. Schriften, Berlin. Gesellschaft, i, 1780, p. 204.

[4] "Rathke, who first, since Mondini, has in detail described (1824, 1838, and 1850) the ovaries of the Eel, is considered by some to have recognized them; but this, however, is not true, the additions made by him to Mondini's description being to a great extent erroneous. It is not true that the transverse leaflets are wanting in the ovaries of the Eel, as he asserts in his last work, contrary to his former description, which was probably based on the law of analogy, and that thereby they are distinguished from those of the salmon and sturgeon. It is not true, what Rathke likewise asserts, that the genital opening of the Eel consists of two small canals, for I have invariably only found one, which opens in the urethra. Rathke has certainly described the eggs quite exactly, distinguishing the larger whitish ones, having a diameter of about one-fifteenth of a line, and the smaller transparent ones, with the germinal vesicle inside; but Mondini likewise says: "*innumeras sphærulas minimas, æquales, pellucidas, divisas tamen, quæ in centro maculam ostendebant, ecc. vidi,*" thus showing the true nature of the ovaries and the eggs, and contrasting them with the fatty formation and with the ovaries and eggs of other osseous fish."—SYRSKI.

Hohnbaum-Hornschuch presented in a dissertation published in 1842—a paper which should be rightly considered as of great importance in the literature of this question. The questions concerning the ovaries of the Eel may be regarded as having been brought to a distinct conclusion by Rathke, who, in the year 1850, published an article describing a gravid female Eel, the first and only gravid specimen which had, up to that time, come into the hands of an investigator.[1]

DISCOVERY OF THE MALE EEL BY SYRSKI.—The history of the search for the female of the Eel having been given, for the most part, in a translation of the work of Dr. Jacoby, it seems appropriate to quote the same author concerning the search for the male Eel, which, though much shorter, is none the less interesting.

In the dissertation of Hohnbaum-Hornschuch, published in 1842, the opinion was expressed that certain cells found by the author in the ovaries, which differed from the egg cells by their form and contents, should be regarded as the spermary cells of the Eel, and that the Eel should be regarded as hermaphrodite. Six years later Schlüser presented an interesting dissertation upon the sexes of Lampreys and Eels in which he pronounced these opinions of Hohnbaum-Hornschuch to be erroneous, and expressed the opinion that the male Eel must be extremely rare, or that it was different, perhaps, from the female. From this time up to the beginning of 1870, a male Eel was never seen, nor do we find any opinions expressed concerning the form of the male of the Eel or its reproductive organs.[2]

According to Robin, in 1846 George Louis Duvernoy (Cuvier, Anatomie comparée, éd. 2, 1848, tome viii, p. 117) described the ruffle-tube type of the testis of the Lampreys and Eels, with the free margin festooned in lobules, shorter to the right than to the left, like the ovaries, etc. He added: "At the breeding season we perceive in it an innumerable quantity of granulations, or small spermatic capsules, the rounded form of which has often led to their being confounded with the ovules, at least in the Eels, in which, in reality, these capsules are nearly of the same size as the ovules, but the latter are distinguished by their oval form." The ovules are spherical, and not oval; but the other facts are fundamentally correct. It is also in error that Duvernoy adds (p. 133): "The Eels and the Lampreys have no deferent canal, any more than an oviduct. Like the ova, the semen ruptures the capsules in which it has collected and diffuses itself in the abdominal cavity, whence it is expelled in the same way as in the ova."

By some droll coincidence the University of Bologna, and soon after that of Pavia, were again prominent participants in the eel tournament. At the meeting of the Bologna Academy, December 28, 1871, Prof. G. B. Ercolani read a paper upon the perfect hermaphroditism in the Eel.[3]

Fourteen days later Prof. Balsamo Crivelli and L. Maggi read a detailed and elaborate paper upon the "true organs of generation in Eels." These investigators, without concerted action, had all at once brought up the celebrated issue of the previous century; this time, however, having specially in view the male organs of the Eel. All were convinced that they had reached a final result by their investigations. The results were certainly very peculiar. In the paper of Ercolani it was claimed that the snake-like folds of fat, which had formerly been noticed near the ovarium, were nothing else than the spermaries of the Eel, and that upon the left side of the animal

[1] Jacoby. Der Fischfang in der Laguns von Comacchio. Berlin, 1880, pp. 23–30.

[2] Robin, Comptes rendus, 1881, p. 383.

[3] Jacoby states that in a paper by Rathke, published in 1838 in the *Archiv für Naturgeschichte*, he remarked: "I expect soon to be able to say something concerning the male organs of the Eel." It would be very interesting to know whether in the papers left by this skillful investigator there may not have been recorded some valuable observations concerning the male Eel.

this organ developed into a true testicle, while the one upon the right side shrank up and became functionless. In the work of Crivelli and Maggi, on the other hand, the folds of fat next to the ovary were also considered to be the male organs of the Eel, while the one on the right-hand side of the animal was considered without any doubt to be the male reproductive organ. The last-named authorities described the spermatozoa which they had seen in this stripe of fat upon the right side. Since these stripes of fat were universally found in all Eels, and always in connection with the former, the investigators could come to no other conclusion than that the Eels were complete hermaphrodites.

The male organ of the Eel, as described by Ercolani, as also by Crivelli and Maggi, shows how carefully investigations may be expended upon things which are not in the least equivocal, since there was not the slightest trace of structure like that of a spermary. The cells of this body in the lining of the stomach next to the ovary are simply fat cells, with all the characteristic peculiarities, just as they are given in all the manuals of histiology. Professor Rauber, of Leipsic, has examined these fat cells carefully, and they have also been investigated in many Eels by the writer, Dr. Jacoby. Never has anything but fat cells and blood-vessels been found in them. The so-called spermatozoa, described in the work of Maggi and Crivelli, proved to be microscopic fat particles or crystalline bodies, such as are commonly found in fat cells.[1]

In the mean time, at Trieste, the question concerning the male organs of the Eel was making a very important advance. Darwin had already expressed the opinion that among nearly all fishes the female was larger than the male. He states that Dr. Günther had assured him that there was not a single instance among fishes in which the male was naturally larger than the female. This opinion may, perhaps, have induced Dr. Syrski, director of the Museum of Natural History at Trieste, now professor in the University of Lemberg, when he undertook, at the request of the marine officials of Trieste, the determination of the spawning time of the fish which were caught in that region, and was obliged to take up the eel question, to devote his attention especially to the smaller Eels. Dr. Hermes, in behalf of Dr. Syrski, protests against this idea, stating, on the authority of the latter, that the published opinions of Günther and Darwin were unknown to him prior to the publication of Jacoby's paper. Up to that time every investigator had chosen for investigation the largest and fattest of Eels, thinking that the largest and oldest specimens must have the most highly developed organs of generation. On November 29, 1873, Syrski found in the second specimen which he investigated—an individual fifteen inches long, which is now preserved in the museum at Trieste—a completely new organ, which had never before been seen within the Eel by any former investigator, although tens of thousands of Eels had been zealously studied.[2] Syrski published his discovery in the April number of the Proceedings of the Imperial Academy of Sciences, Vienna, in 1874.[3] The most important point of the discovery was stated to be that, in all the specimens of Eels in which the Syrskian organ was found, the well-known collar-and-cuff shaped ovary, the female organ of generation, was entirely wanting. It was evident from this that Eels were not hermaphrodites. The question now arose, is the newly discovered organ

[1] In a microscopic investigation of fatty tissues it is very easy for the so-called Brownian molecular movements to be mistaken for moving spermatozoa, especially in fishes, whose spermatozoa, if not very much magnified, show only the head and appear like little bodies globular in form.

[2] "I commenced my investigations," writes Syrski, "on the 29th of November last year (1873), and already in the second Eel which I dissected on that day I found the testicles, and therefore a male individual of the Eel. I sent in March of the following year (1874) to the Academy of Sciences in Vienna a preliminary communication, which was read at the public session held the 15th April, and printed in the reports of the academy."

[3] In 1875, Professor von Siebold found male Eels in the Baltic at Wismar, although this discovery was not at that time made known to the public. They have since been found in the German Ocean, in the Atlantic, and in the Mediterranean.

in the Eel, in its external form, as well as inner structure, so different from the ovary that it could be considered as a partially developed or peculiarly shrunken ovary? According to all researches which have up to this time been made there is the highest kind of probability that this newly discovered structure is actually the long-sought male organ of generation. The investigator cannot, however, answer this question with complete certainty, since the thing which is most necessary to the solution of this question, namely, the finding and the recognition of the spermatozoa, has not yet been accomplished.

In February, 1879, Professor Packard announced the discovery of spermatozoa in Eels from Wood's Holl, Massachusetts, but soon after declared that this was a mistake, and that he had been deceived by molecular movements among the yolk nuclei in the female organs. The discovery of spermatozoa in the spermaries of the Conger Eel, recently announced by Dr. Hermes, of Berlin, is, however, sufficient to demonstrate fully the correctness of Syrski's theory. The confirmation in the case of the common Eel is solely a matter of time.

INTERNAL CHARACTERISTICS OF MALE AND FEMALE EELS.—The differences between the organs of sex in the Eel are well described by Benecke. The ovaries of the Eel are two yellowish or reddish-white elongate organs as broad as one's finger, situated alongside of the backbone, arranged in numerous transverse folds, extending through the entire length of the abdominal cavity. They have no special opening to the outside of the body, and their contents must be discharged into the abdominal cavity and must find exit through the very small opening situated behind the anus. These two bodies, on account of their great size, are of course not easily overlooked, but they contain such a great quantity of fatty cells and the eggs imbedded in them are so small and delicate that one might easily believe, even after a superficial microscopic examination, that the whole organ consists only of fat. While the eggs of other fishes measure from one to three millimeters in diameter, and sometimes are much larger, still the eggs in the ovary of the Eel have, on an average, a diameter of about one-tenth millimeter, and are so closely surrounded by fatty cells with outlines much more strongly marked that it requires great skill to prepare a microscopic slide in which they shall be as plainly visible as they are in the accompanying illustration, in which they are magnified one hundred and fifty diameters. When a person has a microscope which magnifies only one hundred diameters, it is best to put a portion of the ovary in water when dissecting it, in order that the eggs may be easily found. It is much easier to find the eggs in young Eels, seven or eight inches in length, than in adult fish, since in the former, although the ovaries and the eggs are smaller, the fat cells have not made their appearance, and the eggs are, therefore, plainly visible at the first glance through the microscope. The number of eggs is extraordinarily large, amounting to many millions. The eggs of larger size which sometimes are found in great quantities in Eels that have been cut up, and have been considered to be eel eggs, have always proved to be the eggs of other fish which they have swallowed, and in the course of cutting them up have been found in the Eel's belly.

The male Eels, which are found only in the sea and in the brackish water, are much smaller than the females, rarely exceeding fifteen or sixteen inches in length; in them, in the place of the ovaries in the female, are found spermaries, which differ in appearance in the manner shown in the illustration. These consist of two tubes which stretch the whole length of the body cavity, situated close to each other, and provided with numerous sacculations. Ripe spermatozoa are as rarely found in these organs as eggs ready to be laid have been found in the ovaries of the female. According to many accounts the male Eels, which later were found also by von Siebold in the Baltic Sea at Wismar, differ from the females in the possession of a proportionally sharper

snout, less conspicuous dorsal fins, darker coloration of the back, a more prominent and metallic luster upon the sides, the clean white coloration of the belly, and the larger size of the eyes. I propose to reproduce here the original descriptions and figures of Syrski, the discoverer of the male Eel.

Having met, writes Syrski, with many errors regarding the female organs of reproduction in the descriptions hitherto given of them, I intend to commence by describing these organs, first with the view of rectifying and completing the details, and also for the purpose of comparison with the male organs.

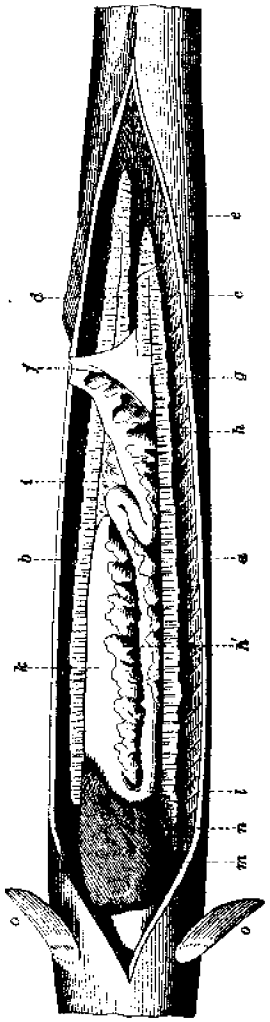

FIG. 1.—*Female Eel, longitudinal section of the abdomen; natural size.*
a. Right ovary.
b. Left ovary.
c. Accessory part of right ovary.
d. Left accessory part.
e. Dividing membrane.
f. Anal depression.
g. Urinary bladder.
h. Fat on the right side, erroneously taken for the testicles by some.
h'. Similar fat covering the stomach.
i. Fat on the left side.
k. Stomach.
l. Pylorus.
m. Liver.
n Gall-bladder.
o,o. Pectoral fins.

THE OVARIES OF THE EEL.—The organs (Fig. 1) two in number, are ribbon-shaped, with leaflets on their outer face, and with transverse folds. In the natural position of the live fish, the one extends to the left and the other to the right of the alimentary tube, following most of its angles nearly the whole length of the abdominal cavity to the place where the dorsal parietes are confluent with the lateral.

The right ovary commences at a point nearly corresponding to that where on the outside the right pectoral fin ends, and the left ovary commences about two centimeters and ends three to four centimeters behind the former. They extend three to six centimeters back of the anus, into the caudal part of the animal's body; they do not, however, unite in a single body, as some have asserted, but both are toward the end inclosed in a peritoneal membrane, and are separated from each other by the union of these membranes, having each on their inner face an accessory ovary (*pars recurrens ovarii*). In rare cases is such an accessory ovary wanting either on the right or on the left side.

The ovaries in fully grown Eels are in the middle about two centimeters larger, and posteriorly terminate in a thread-like form. They are not smooth on both sides, but have, as was said above, on their outer side numerous transverse folds (Fig. 2) full of eggs (Fig. 3).

It is another of Rathke's erroneous assertions, likewise maintained by others, that the genital opening through which the eggs pass out from the abdominal cavity is formed by two holes, a right one and a left one. I have invariably found in all specimens examined a simple hole, which communicates with the right and left half of the abdominal cavity by means of a transverse fissure between the straight intestine and the urinary bladder (*fissura recto-vesicalis*) and opens in the urethra (Fig. 4).

It is generally admitted that the eggs, when loosened from the ovaries, fall indiscriminately into the abdominal cavity, but it is not said which way they take in order to go out through the genital aperture. As I have invariably found that the fully developed ovaries lean with their outer surface against the side of the abdominal cavity, and approach with their free edges the lower portion of this side, forming, so to speak, a furrow, I must conclude that the loosened eggs

descend between the abdominal partition and the folds and leaflets of the ovary in the above-mentioned furrow, and from it pass to the genital aperture without scattering in the abdominal cavity.

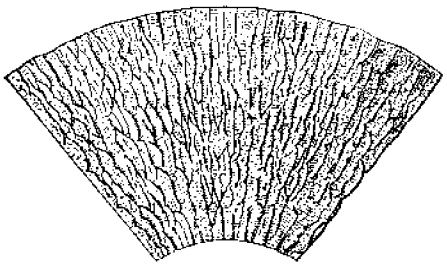

FIG. 2.—*Piece of the ovary, twice its natural size, with ovarian leaflets arranged in transversal rows, on its surface.*
The shorter border attached to the dorsal wall of the abdominal cavity; the longer being free.

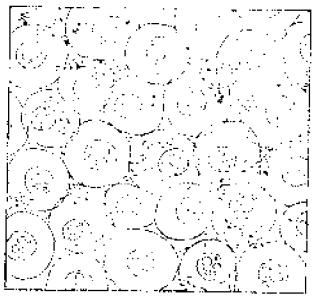

FIG. 3.—*Piece of a somewhat developed ovary, one hundred times the natural size, showing the transparent eggs with the germinative vesicle and the germinative dots.*

As to the development which the ovaries undergo, I have observed from the end of November till the beginning of March, in many adult Eels, of the length of 530 millimeters and more, that the ovaries were of the breadth of fifteen to twenty-five millimeters, and of a yellowish and sometimes reddish-white color, produced by the development of adipose tissues and of the blood-vessels and not by the eggs filled with little globules of fat; the genital aperture and the *fissura recto-vesicalis* were open.

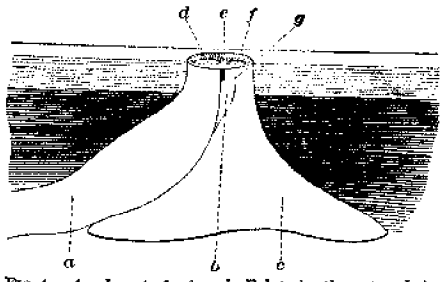

FIG. 4.—*Anal part of a female Eel, twice the natural size.*
a. Straight intestine.
b. Fissura recto-vesicalis.
c. Urinary bladder.
d. Anus.
e. Partition.
f. Urogenital opening.
g. Outlet of the genital opening in the urethra.

In other Eels, of a length sometimes of 600 millimeters and more, I found the ovaries less broad, with but little fat, and of a mucous and almost glassy appearance, so that I could discern the so-called vesicles and germinative dots (*nuclei* and *nucleoli*); the genital aperture and the *fissura recto-vesicalis* were closed.

The ovaries of young Eels, of the length of about 500 millimeters, contained invariably but little fat, and the eggs were without globules. The gradual growth and enlargement of the ovaries go on simultaneously with the opening of the genital orifice. According to the quantity of fat contained in the ovaries, they have a mucous and glassy, or more or less opaque or white, appearance, or have small shining dots. From the end of March till October I found in the majority of Eels which I examined, measuring 600 to 700 millimeters in length, that the ovaries were scarcely white, and that the genital aperture was closed. The number of eggs contained in both developed ovaries reaches, according to my calculation, five millions. The larger eggs measured by me had a diameter of one-fourth to one-fifth millimeter, while the eggs of an adult 'Grongo' (*Conger*) had, according to my measurements, a diameter of one-third of a millimeter, and those of the 'Murena' (*Muræna helena*) almost one millimeter, which explains to me why the ovaries of the two last-mentioned species of fish have long since become known.

In an Eel measuring 590 millimeters, examined on the 6th July, the left ovary was entirely wanting, and replaced by a mass of fat.

THE SPERMATIC ORGANS.—The position of these organs (Fig. 5), which are not ribbon-shaped like the ovaries, but represent two longitudinal rows, each with about fifty lobules (Fig. 6), of the width at most of three millimeters, and found only in Eels not more than 430 millimeters long, corresponds entirely with that of the ovaries. In these organs are likewise found

toward the posterior end, the spermatic organs (*partes recurrentes*), which, however, as is the case with the ovaries, are sometimes wanting.

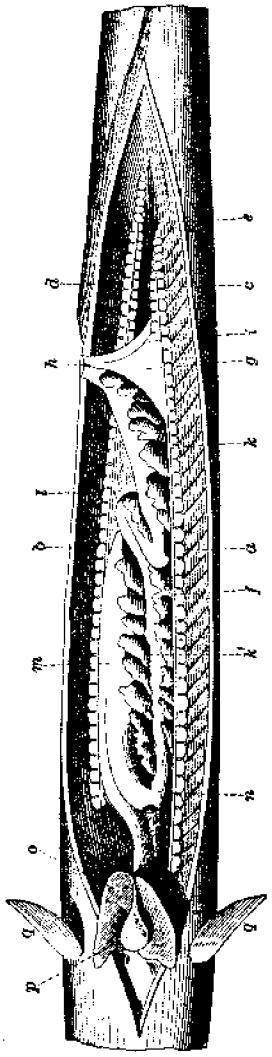

FIG. 5.—*Male Eel (natural size).*

a. Right testicle.
b. Left testicle.
c. Right accessory part.
d. Left accessory part.
e. Dividing membrane.
f. Deferent canal.
g. Seminal pouch.
h. Anal depression.
i. Urinary bladder, covered to a great extent by the seminal pouch.
k. Fat on the right side.
k'. Similar fat covering the stomach.
l. Fat on the left side.
m. Stomach.
n. Pylorus.
o. Liver, turned up to show the inner surface adhering to the œsophagus and the stomach.
p. Gall-bladder.
q, *q*. Pectoral fins.

The spermatic organs can be distinguished at the first glance from the ovaries of the adult Eels and those of the young Eels, not only by their lobular form, but also by their shining, glassy appearance, by the surface of the individual lobes, which is smooth and without leaflets, and by the much greater density of the tissue, so that with a pair of pincers one can take off a large portion of the organ, which could not possibly be done with a more developed ovary whose tissue is as tender as a cobweb, and is composed of small vessels formed of a thin membrane and filled with eggs and fat.

The fibrous tissue of the spermatic organs is composed of vascular compartments with thicker partitions, inclosing, according to the development of the organ, granular globules (Fig. 7).

These compartments are joined toward the inside and the base of the lobes, which are united to a tube (*vas deferens*), which, cæcal at the commencement, runs along the entire length of the abdominal cavity, and opens near the straight intestine (*rectum*) in a triangular pouch, which likewise contains a *vas deferens* starting from the caudal part of the spermatic organ. This pouch has its outlet in the general orifice, which opens in the urethra (Fig. 8).

As regards the development of the spermatic organs, I

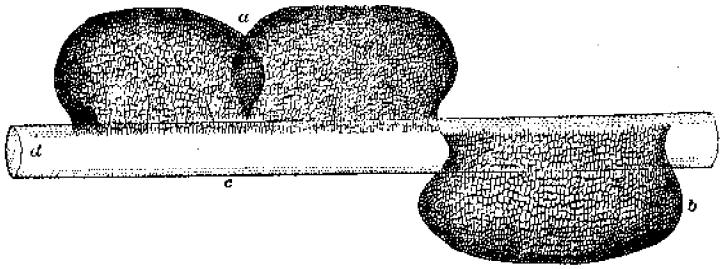

FIG. 6.—*Three lobes of the right testicle, with the deferent canal (enlarged ten times).*

a. Lobes, seen from their outer surface.
b. Lobe, seen from its inner surface.
c. Deferent canal.
d. Anterior part of the same.

have observed that the lobes of these organs in young Eels, measuring not more than 200 to 300 millimeters in length, are not yet very distinct, forming two thin ribbons differing but little from ovaries of the female in their average size. In Eels measuring about 400 millimetersin length, the testicles can easily be distinguished from the ovaries. The former, much straighter, and with tissue, as has been already remarked, much more solid, are provided with a much more developed net-work of vessels; their lobes are very distinct and the deferent canals are usually open, while the ovaries present the appearance of two continuous ribbons, have a more delicate tissue, and an almost mucous appearance, and contain the eggs with the germinative vesicles.

The deferent canals and the genital orifice are closed in young Eels of the male sex, and open simultaneously with the development of the lobes.

In the male Eels examined by me from March to October I have found individuals, of 400 millimeters and more in length, whose genital orifice and deferent canals were invariably open, while in some of the smaller ones they were closed and in others open.

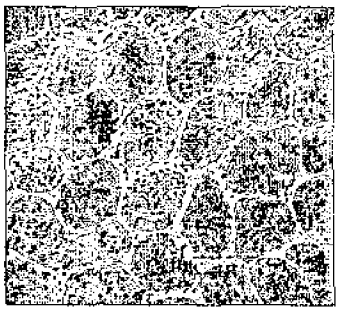

FIG. 7.—*Piece of the testicle (one hundred and sixty times enlarged), showing the vascular tissue and the small granules.*

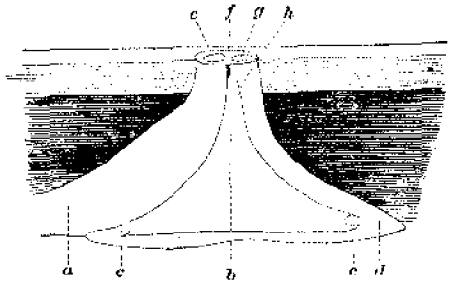

FIG. 8.—Anal part of the male Eel, enlarged twice.
a. Straight intestine.
b. Fissura recto-vesicalis, covered by the outside wall of the seminal pouch
c. c. Outlet of the anterior and posterior part of the deferent canal in the pouch.
d. Urinary bladder.

Of the 258 Eels examined by me, the males and females were in about even proportion; the greatest length of the former was about 430 millimeters, while the latter were of all sizes up to 1,050 millimeters, which shows that the males are smaller than the females.

EXTERNAL CHARACTERISTICS.—The external differences presented by living Eels (remarks Jacoby), corresponding to the presence of an ovary and the supposed male organ, are very interesting.

The most important, writes Jacoby, is (1) the difference in the size and length of the animal. Syrski states that the largest Eels found by him with the supposed male organ measured about 17 inches (430^{mm}). I have, however, found specimens with this organ at Trieste and in Comacchio which measured 17 to 19 inches (450 millimeters to 480 millimeters). All the Eels which exceeded this size, for instance those which were over three feet in length (one millimeter) many of them growing to the thickness of the arm of a strong man, have been hitherto found to be females. The other recognizable external characters in the female are (2) a much broader tip of the snout in comparison with the small, either attenuated or short and sharply pointed, snout of the Eel with the supposed male organ; also, (3) a clearer coloration in the female, usually of a greenish hue on the back, and yellowish or yellow upon the belly, while the others have a deep darkish-green, or often a very deep black upon the back and always a more perceptible metallic luster upon the sides (I, once in a while, found Eels covered all over with a brownish tint, always possessing the organ of Syrski), usually exhibiting also a white color upon the belly. In addition (4) there is an important external character in the height of the dorsal fin; all females have these fins much higher and broader than the Eels of the same size which possess the supposed male organ. Finally, (5) there is a character, which is not always a safe one, in the greater diameter of the eye in the Eels with the supposed male organ. Eels with quite small eyes are almost always found to be females; Eels with the organ of Syrski usually have comparatively large eyes, yet female Eels with quite large eyes are not unusual.

The following proportional measurements, the average results of the study of a great number of Eels measured by me, will be of general interest. Column *a* gives the total length of the Eel; *b* the breadth of the snout between the nostrils; *c* the breadth of the snout between the eyes; *d* the length of the snout from the center of the eye to its tip; *e* the average measurement of the

eyes; *f* the length of the head to the gill-opening; *g* the height of the dorsal fins, all the measurements being given in millimeters.

	A. Eels with supposed male organ.							B. Female eels.							
	a.	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	*a.*	*b.*	*c.*	*d.*	*e.*	*f.*	*g.*	
I	480	6	13.5	15	8	52	5	480	8.5	12	17	5	62	9	I
II	470	6	10.5	12	7	54	6	475	7.5	14.5	16	8	59	9.5	II
III	445	5	11	12	6	47	6	440	8	12	14	6	56	7.5	III
IV	411	4	9	12	5.5	47	6	410	8	12.5	13	7.5	51	7	IV
V	386	4.5	9	12	5.5	46	4	378	7.5	11	12	6	49	7.5	V
VI	370	3.5	7	10.5	5	40	6	369	7.5	11	13	6.5	51.5	7	VI
VII	344	4	7.5	10	4.5	40	5	342	6	8	11	4.5	44	6.5	VII
VIII	319	4	7	10	5	40	4.5	313	5.5	8	10.5	3.5	41	6	VIII

According to the distinguishing marks which have been given, special reference having been paid to the height and narrowness of the dorsal fin, much success has been met with in picking out, in the fish-market of Trieste, the Eels which possessed the organ of Syrski; absolute certainty in recognizing them cannot, however, be guaranteed. If one is searching among living Eels with no characters in mind with the exception of the first—that of length—he will find in every ten Eels, on an average, eight females, and two with the supposed male organ; but, if the selection is made with a careful reference to all these marks of difference, the proportion changes, and out of every ten examples about eight will be found with the supposed male organ.[1]

For another excellent discussion with figures of the characters of male and female Eels, the reader is referred to a translation of an article by S. Th. Cattie, in the Proceedings of the United States National Museum, vol. iii, pp. 280–284.

EELS SUPPOSED TO BE VIVIPAROUS.—The discovery of the two sexes has not, however, writes Benecke, settled the question whether the Eel lays eggs or brings its young alive into the world. There has always been a strong disposition to adopt the latter hypothesis, and there are many people at the present day who claim to have been present at the birth of young Eels, or to have found a quantity of young Eels in adult Eels which have been cut open. Frequently ichthyologists hear accounts of occurrences of this kind, and receive specimens of supposed little Eels, from one to two inches in length, which have been kept alive for several days in a glass of water. These are usually thread-worms, *Ascaris labiata*, which live by the hundred in the intestinal cavity of the Eel, and which may be easily distinguished from the Eels of the same size by the sharp ends of the body, the absence of fins, of eyes and mouth, and by the sluggishness of their motions. The smallest Eels, less than an inch in length, have already the complete form of the adult, and are also transparent, so that with a magnifying glass one may perceive the pulsations of the heart, and see behind it the brownish-red liver; the mouth, the pectoral, dorsal, anal, and caudal fins, are easily seen, and the black eyes cannot be overlooked. In addition to the intestinal worms, the young of a fish of another family, *Zoarces viviparus*, have given opportunity to the ignorant for many discoveries; for instance, Dr. Eberhard, in No. 4 of the "Gartenlaube" for 1874, described and illustrated an "embryo of the Eel," which, in company with about a thousand similar embryos, had been cut out of the belly of an Eel. This tolerably good drawing at first sight is seen to represent the embryo of *Zoarces*, which is almost ready for birth, since it still possesses a very minute umbilical sac. It is very evident that the minute egg of the Eel could hardly produce a great embryo with an umbilical sac which exceeds by more than a hundred times in size the whole egg. It is also evident that the imagination of the writer had exaggerated the two or three hundred young in the *Zoarces* to a thousand.

[1] JACOBY: Der Fischfang in der Lagune von Comacchio.

SEARCH FOR YOUNG EELS.—As might have been foreseen, remarks Jacoby, Syrski's discovery drew attention anew to the solution of the eel problem. In the spring and summer of 1877 the German and Austrian papers and journals were full of articles and paragraphs upon this subject. Among others the following announcement made the rounds of the press: "Hitherto, in spite of all efforts, science has not succeeded in discovering the secret of the reproduction of the Eel. The German Fischerei-Verein in Berlin offers a premium of fifty marks to the person who shall first find a gravid Eel which shall be sufficiently developed to enable Professor Virchow in Berlin to dissipate the doubts concerning the propagation of the Eel." Herr Dallmer, of Schleswig, inspector of fisheries in that province, offered to transmit communications to Berlin, and in 1878, in the January number of the "German Fishery Gazette," he published a detailed and very interesting report of his proceedings. He wrote, among other things, that it was quite beyond his expectation that this announcement would have found its way into nearly all the German journals between the Rhine and the Weichsel and from the Alps to the sea. The number of letters which he received first rejoiced him, then surprised him, finally terrified him, so that at last he was obliged to refuse to attend to the communications. He had learned at Berlin that an equal number of communications from all parts of Germany had been received, sent directly to the address of Professor Virchow. Objects which were said to be young Eels cut out of the parents, but which were really thread-worms, were sent to him by dozens; the most incredible stories, usually from women, about great thick eggs which they had found in Eels, were received by him. A witty Berliner communicated to him in a packet sent by express the information that the eel problem was now happily solved, since a lady Eel in Berlin had given birth to twins. Finally Herr Dallmer found himself compelled to insert the following notice in the "Schleswiger Nachrichten": "Since the German Fischerei-Verein has offered a premium for the first gravid Eel, the desire to obtain the prize, curiosity, or the desire for knowledge has created so lively an interest upon this point that it might almost be called a revolution. I at one time offered, when necessary, to serve as an agent for communications, but since business has compelled me to be absent from home a great part of the time, I would urgently request that hereafter packages should be sent direct to Professor Virchow in Berlin. I feel myself obliged to inform the public upon certain special points. The premium is offered for a gravid Eel, not for the contents of such an Eel, since if only these were sent it would be uncertain whether they were actually taken from an Eel. The Eel must always be sent alone; the majority of senders have hitherto sent me only the intestines or the supposed young of the Eel, which were generally intestinal worms; the Eel itself they have eaten; nevertheless the prize of fifty marks has been expected by nearly all senders," etc. By this transfer of the responsibilities the inspector of fisheries has rendered a very unthankful service to Professor Virchow; he was obliged to publish a notice in the papers in which he urgently stated that he wished to be excused from receiving any more packages, for he would hardly know what to do with them. The comic papers of Berlin now circulated the suggestion that hereafter the Eel should be sent to the investigators only in a smoked state. This amusing episode is interesting in showing how remarkable an interest the whole world was beginning to take in the eel problem.[1]

NORMAL REPRODUCTIVE HABITS.—"It may be assumed with the greatest safety," writes Benecke, "that the Eel lays its eggs like most other fish, and that, like the Lamprey, it only spawns once and then dies. All the eggs of a female Eel show the same degree of maturity, while in the fish which spawn every year, besides the large eggs which are ready to be deposited at the next spawning period, there exist very many of much smaller size, which are destined to mature here-

[1] Zoologischer Anzeiger, No. 26, p. 193; American Naturalist, xiii, p. 125; and Jacoby, p. 44.

after, and to be deposited in other years. It is very hard to understand how young Eels could find room in the body of their mother if they were retained until they had gained any considerable size. The eel embryo can live and grow for a very long time supported by the little yolk, but when this is gone it can only obtain food outside of the body of its mother. The following circumstances lead us to believe that the spawning of the Eel takes place only in the sea: (1) that the male Eel is found only in the sea or brackish water, while female Eels yearly undertake a pilgrimage from the inland waters to the sea, a circumstance which has been known since the time of Aristotle, and upon the knowledge of which the principal capture of Eels by the use of fixed apparatus is dependent; (2) that the young Eels with the greatest regularity ascend from the sea into the rivers and lakes.

All statements in opposition to this theory are untenable, since the young Eels never find their way into land-locked ponds in the course of their wanderings, while Eels planted in such isolated bodies of water thrive and grow rapidly but never increase in numbers. Another still more convincing argument is the fact that in lakes which formerly contained many Eels, but which by the erection of impassable weirs have been cut off from the sea, the supply of Eels has diminished, and after a time only scattering individuals, old and of great size, are taken in them. An instance of this sort occurred in Lake Müskendorf, in West Prussia. If an instance of the reproduction of the Eel in fresh water could be found, such occurrences as these would be quite inexplicable.

In the upper stretches of long rivers the migration of the Eels begins in April or May; in their lower stretches and shorter streams later in the season. In all running waters the eel fishery depends upon the downward migrations. The Eels press up the streams with occasional halts, remaining here and there for short periods, but always make their way above. They appear to make the most progress during dark nights when the water is troubled and stormy, for at this time they are captured in the greatest numbers. It is probable that after the Eels have once returned to the sea, and there deposited their spawn, they never can return into fresh water, but remain there to die. A great migration of grown Eels in spring or summer has never been reported, and it appears certain that all the female Eels which have once found their way to the sea are lost to the fisherman. In No. 8 of the German "Fischerei Zeitung" for 1878, Dr. Schock published certain statements sent to him by Dr. Jacoby. It is remarked in this paper, among other things, that after the deposition of the spawn the female Eel dies a physiological death, and that occasionally the sea in the neighborhood of the mouths of rivers has been found covered with dead Eels whose ovaries were empty. When, where, and by whom this observation was made, and who pronounced upon the empty ovaries in these dead fish, is unfortunately not mentioned.

A great number of the Eels remain in inland waters while others proceed to the sea, either because their eggs are at this time not sufficiently ripe, or perhaps because they are sterile. It would seem probable that the increase in the size of the eggs in the wandering Eels begins to be very rapid after August and September, while in the earlier months of the year, in all Eels of moderate size, the eggs were at the utmost but about 0.09 millimeters in diameter. In September of the same year, I found (as an average of numerous measurements) a diameter of 0.10; in October, 0.16; in November, 0.18 to 0.23, while the eggs showed other characters connected with approaching maturity which earlier in the season were not to be seen. All the Eels which were captured later—in December and in January—part of which came from rivers and harbors, part from the harbor of Putzig (Putziger Wiek), had eggs measuring from 0.09 to 0.16 millimeters, although among the fish examined were some which measured three feet in length.

DO MALE EELS LEAVE THE SEA AND ENTER FRESH WATER?—This problem is one of great interest, both to the biologist and the fish-culturist; it is, in fact, the one disputed point still remaining to be solved. Upon its solution appears to depend the final decision of the question, still so warmly debated both in Europe and America, "Do Eels breed in fresh water only, in salt water only, or in both fresh and salt water?" As has already been stated, the theory for a long time generally accepted is that the Eels are "catadromous," descending to the sea to spawn. This theory is, however, sharply contested by many observers, chief among whom on this side of the Atlantic is Hon. Robert B. Roosevelt, president of the American Fish Cultural Association. It appears probable to the writer that the truth lies somewhere between these two extremes, and that it will be hereafter ascertained that the Eel, like a majority of other animals, has flexible habits, sometimes deviating from its ordinary custom, which appears to be to spawn in salt or brackish water.

Male Eels have been found in the following localities:

(1) In 1874, by Syrski, in the fish markets of Trieste, these markets being supplied with Eels from Chioggia on the Adriatic, and to a lesser extent from the lagoons of Comacchio.

(2) In 1875, on the coasts of France, by Dareste.

(3) In 1875, among specimens of *Anguilla marmorata* from India.

(4) In 1875, in the Baltic, at Wismar on the Danish coast, by Professor von Siebold.

(5) In 1877, in the lagoons of Comacchio, by Jacoby. Among twelve hundred specimens, five per cent. were males; while among those less than fifteen inches in length twenty per cent. were males. This was in brackish water.

(6) In 1879, at Trieste, by Dr. Hermes, who found fifteen males among twenty Eels selected by Dr. Syrski.

(7) In 1880, on the Baltic coasts of Denmark, by Dr. Hermes. Out of one lot of thirty-six from Wismar, he obtained eight males, thus repeating von Siebold's observation.

(8) In 1880, from the Baltic between Zealand and Saland, Denmark. Out of one lot of thirty-six, Dr. Hermes obtained eight males.

(9) In 1880, in France, by Robin.

(10) In 1880, by Cattie.

(11) In 1880, by Dr. Hermes, at Cumlosen, on the Elbe, about one hundred and twenty miles from the German Ocean.

(12) In 1880, at Rügers on the Baltic, by Dr. Hermes, who found forty-four and one-half per cent. males in one lot of 137.

(13) By Dr. Pauly, among Eels planted at Hüningen, in Alsace-Lorraine.

It has been shown by Dr. Pauly that among the very young Eels [*Montée*] taken near the mouths of rivers is a considerable percentage of males, which, when transplanted to fresh water, will there retain their masculine characters and develop into perfect adult males. This discovery is, of course, of the utmost importance to fish-culturists making the attempt to introduce Eels into new waters. Its importance has already been pointed out by Director Haack.

The practical lesson to be learned is simply this, that young Eels, for introduction into strange waters, must be taken from very near the mouths of rivers, in order that both males and females may be secured. The interest to zoologists lies in the fact that Pauly's discovery renders the theory of von Siebold less plausible, indicating that the sexes of the young Eels are differentiated before they begin to mount the rivers and that the males do not ascend beyond the limits of brackish water.

Dr. Pauly's discovery is so interesting that I propose to translate his own account of it. The investigation was made, I believe, in Munich, and the report from which I quote was published in the "Austro-Hungarian Fishery Gazette," of Vienna, December 23, 1880. Dr. Pauly writes:

"During the past year I have received from Court-fisherman Kuffer a large number of Eels, which I have used in my investigations. The large individuals, all of which came from the lakes of Northern Italy, were females. I received, however, from the same individual, another lot of Eels, consisting of much smaller individuals, weighing from twenty to ninety grams (two-thirds of an ounce to three ounces), also taken in fresh water. At the request of Professor von Siebold, I had paid particular attention to the sexes of the Eels which I was engaged in investigating, and to my great astonishment I found that a large majority of these small Eels (nineteen out of twenty-seven) were males, possessing, instead of the familiar ovaries, the 'Lappenorgan' described by Dr. Syrski. A histological examination of these organs convinced me that the structure of these tissues agreed with that described by Freud. . . .

"My next inquiry was very naturally concerning the locality whence these Eels had been obtained. I learned that Kuffer had received them two years before from Director Haack at Hüningen, and, upon questioning Director Haack, learned that they had been brought from a French river, the Sèvre nantaise, where they were caught as young fry [*montée*] at a distance of ten or twelve miles from its mouth, and furthermore were at the time of examination about four years old. The small size of these fish, their age being taken into consideration, satisfied me that they had been reared in captivity, since uncultivated Eels would have been much heavier. The females in this lot of Eels exceeded the males in length and weight, and also exhibited those external characters described by Jacoby as indicating sex.

"The locality in the Sèvre niortaise where these fish were taken may easily, especially at flood tide, have been within the limits of brackish water; my observations do not prove, therefore, that male Eels enter fresh water.

"Dr. Jacoby found male Eels in the lagoons of Comacchio, where the water is brackish. These males must have ascended in the 'mounting' as fry, and probably at the approach of sexual maturity descend with the females to the sea. My investigations and those of Jacoby prove only this: that the young female Eels do not necessarily break away from their parents and from their birthplaces at sea, and entirely alone proceed upon their migrations, while the males scatter through the sea, but that their brothers seem to accompany them part of the way upon their journey. But how far? Do the males know where pure fresh water begins, and are the fry of different sexes found mingled together only at the river mouths? If we bear in mind the fact that the male organs had so long escaped discovery, that, on account of their crystal-like transparency, their detection in a fresh Eel is so difficult, etc., may we not admit that past conclusions are probably erroneous, and that although thousands of fresh-water Eels have been studied by different investigators, male Eels may yet be found in our streams, especially when more of the smaller individuals have been examined?"

Dr. Pauly then discusses the observations of Dr. Hermes, who found eleven per cent. of males among Eels taken at Wittenberge, on the Elbe, about one hundred and twenty miles from the German Ocean, and no males whatever at Havelberg, twenty or thirty miles higher up the stream, and closes his essay with the following conclusions: "*Male Eels undoubtedly ascend the rivers, but the numerical percentage of males to females appears to diminish as one proceeds up the streams.*" This fact is opposed to the theory proposed by some one that young Eels are at first of undifferentiated sex, and have the tendency under the influence of fresh water to become females, under that of salt water to develop male characters.

BENECKE ON THE MOVEMENTS OF YOUNG EELS.—Benecke gives the following thorough discussion of the movements of young Eels:

The young Eels, hatched out of the eggs at sea, doubtless live at the bottom until they grow, through consumption of rich food substances there to be found, to a size from one to three centimeters. When they have attained this size they begin their wanderings in immense schools, proceeding to ascend into the rivers and lakes. These wanderings of the young Eels have been known for a very long time; for instance, in the lagoons of Comacchio, in which they may be found, for the most part, after they have gained the length of from six to eight millimeters, and in France, later also in England, Denmark, Sweden, and, more recently, in Germany they have also been observed.

According to the French reports young Eels are hatched out early in the winter, and in February, having attained the length of four or five centimeters, they appear in the brackish water at the mouth of the Loire in immense numbers, soon to begin their wanderings up the stream. They swim in crowded schools at the surface of the river right up to the banks, and little detachments of the army deploy at the mouth of each tributary and pursue their wanderings along its course. These swarms of young Eels are called in France "Montée," in Italy, "Montata." The number of the young fish is, as might be expected from the number of the eggs in the ovary of the Eel, wonderfully large. Redi has recounted that, from the end of January to the end of April the young fish continue wandering up the Arno, and that in 1867 over three million pounds of them were taken in five hours. Into the lagoons of the Comacchio the Eels pour from February to April. In March and April they have been noticed in many French rivers, in which the migration continues for from eight to fourteen days. The first account of these wanderings in Germany was that given by von Ehlers. In 1863 he wrote to von Siebold: "This took place about ten years ago, in the village of Drennhausen, in the province of Wesen, in the Kingdom of Hanover. As we were walking, towards the end of June or the beginning of July, on a dike, which at that place projects out into the Elbe, we noticed that along the entire shore there might be seen a moving band of a dark color. Since everything which takes place in the Elbe is of interest to the inhabitants of that region, this phenomenon immediately attracted attention, and it soon became apparent that this dark band was composed of an innumerable body of young Eels, which were pressing against each other, as, at the surface of the stream, they were forcing their way upwards towards its source, while they kept themselves so close to the shore that they followed all its bendings and curves. The width of this band of fish at the place where it was observed (where the Elbe has a considerable depth) was perhaps a foot, but how deep it was could not be observed, so thickly crowded together were the young Eels. As they swam a great number could be taken in a bucket, and it was very annoying to the people who lived along the Elbe that, so long as the procession of fish lasted, no water could be taken out of the river which was not full of the little fish. The length of the young Eels was, on an average, from three to four inches; the thickness of the body was about equal to that of a goose-quill. By themselves might here and there be seen swimming Eels of greater size, but none of them were probably more than eight inches in length. All of them, even the smallest, were dark colored. This wonderful procession of fishes continued unbroken and of the same density throughout the whole of the day on which it was first observed, and continued also upon the following day. On the morning of the third day, however, not one of the young Eels was to be seen."

Similar observations have been made at Wittenberge, on the Elbe. Kuffer observed great quantities of young Eels, of about three centimeters in length, in the brackish water of the Eider at Friedrichsstadt; so also did von Stemann.

"Every year," writes the latter, "from April to the end of June, there appear great masses of young Eels, which are present in large schools towards the Upper Eider, seeking in every way to pass each other. In April the first Eels show themselves generally singly; cold weather has evidently kept them back up to this time; since this year, until to-day, no ascent whatever has taken place, and now the approach of the great schools is beginning. Where the current is feeble the procession is broad; but where the Eels encounter a strong current—near a mill—it becomes small, and presses close to the shore, in order to overcome the currents. The little animals swim eagerly and rapidly along near the banks until they find a place over which they decide to climb. Here they lie in great heaps, and appear to await the rising of the tide, which makes their ascent easier. The tide having risen, the whole mass begins to separate without delay; Eel after Eel climbs up on the steep wall of rock, determined to reach the little pools, at the height of fifteen or twenty inches, into which some of the water from the Upper Eider has found its way. Into these holes the little animals creep, and have yet to travel a distance of forty or fifty feet under the roadway before they can reach the Upper Eider. Another detachment betakes itself to the sluiceways, and clings to the cracks in the wood; also around the mills their ascent may be observed, especially about sunrise."[1]

Davy sends a similar account from Ireland. He was a witness of the ascent of young Eels, or "Elvas," at Ballyshannon, at the end of July, 1823; he speaks of the mouth of the river under the fall being "blackened by millions of little Eels about as long as a finger, which were constantly urging their way up the moist rock beside the fall." "Thousands," he adds, "died; but their bodies, remaining, served as a ladder by which the rest could make their way; and I saw some ascending even perpendicular stones, making their way through wet moss or adhering to some Eels that had died in the attempt."[2]

Such is the energy of these little animals that they continued to find their way in immense numbers to Loch Erne.

In the little Eels which ascend the rivers there are no traces of sexual organs, but in the fresh water they develop only into females. One of the most recent observations made by Dr. Pauly, in Munich, would appear to contradict this idea, since he discovered male Eels among the fish which were brought with a lot of young Eels to Hüningen, were kept there for two years in ponds, and were finally released in the fish pond of Court-fisherman Kuffer. We should bear in mind, however, that these young Eels were captured at the mouths of fresh rivers in brackish water; and that among the numerous small Eels which swim in the brackish water there must be many larger specimens, in which the male organs have already begun to develop. Such are doubtless those which were sent in the male condition to Hüningen and Munich, and were there recognized as males. This presumption can be set aside only if male Eels shall hereafter be found among the fish which are caught in the upper part of rivers in the condition of young fry.

Concerning another important fact which is connected with the movements of the young fry of the Eel, I became acquainted last year (in the course of an exploration of the waters of the district of

[1] Professor Benecke had in his possession some of the young Eels, which escaped from all the vessels in which they were confined, and even climbed to the ceiling of his room.

[2] EEL-FAIRS IN CONNECTICUT.—Fresh-water Eels may be caught in large numbers, in weirs along the lake streams, when descending at the fall equinox to deposit their spawn in some lower region, and in the following August their offspring, from three to six inches long, return in immense numbers. The basin of the Still River Falls, near Colebrook line, is for several days alive with them. They may be seen laboriously crawling up every rock which is moistened by the spray of the fall, and endeavoring to reach their ancestral lake or dam. At the foot of the Niagara Falls this phenomenon may be witnessed on a large scale at the same season of the year or later, and probably in other places where the fall is too high and the current too swift for the young Eels to stem it without contact with the rocks.—BOYD: Annals of Winchester, Connecticut, p. 26.

Konitzkunde) with the river Brahe, at Mühlhof, above Rittel, where a high dam was built in 1846 and 1847 for the purpose of watering a large system of meadows by the overflowing of the stream. Below the dam is an inclined plane (constructed of boards), about three hundred feet long, built for the purpose of preventing the water, which rushes out when the sluice-gate is opened, from washing away the bottom of the stream and its banks. This plank floor consists of two layers, the lower one of two-inch, the upper one of three-inch boards. The grade of the dam at Mühlhof (thirty-three feet three inches) has entirely cut off the ascent of the fry of the Eel into the upper part of the Brahe and the lakes tributary to it, and the number of Eels caught above the dam—which was formerly very considerable—has become reduced almost to nothing. In the year 1847 the construction of the dam and the inclined plane was completed. In 1852 the upper layer of the planks on the plane had warped and sprung up in many places, so that it had to be torn up for repairs. The cause of the warping was immediately discovered; thousands of Eels, as thick as a man's finger, somewhat flattened in shape, and, on account of the absence of light, of a pure white color, filled the space between the two layers of planks, and their united pressure from beneath had caused the upper layer to yield; these Eels had found their way between the boards as fry, where they had found sufficient food and had grown to such a size that the pressure of their united strength had pushed up the roof of their prison. These facts, observed by an old millwright, were communicated to me by Privy Councillor Schmid, of Marienwerder, who supervised the construction of the Mühlhof dam, and he fully confirmed them.

Eels of four inches in length, which in May are plenty in fish ponds, by the end of October reach a length of ten inches and the thickness of a man's little finger; in the following fall they measure from twenty to twenty-four inches, and in the third year are ready to be eaten. On account of their rapid growth and hardy nature, in consequence of which latter they live in mud-holes and unprofitable waters of all kinds, the breeding of Eels is a very remunerative business. The young fish (of which, at the time of their first appearance at the mouths of rivers, it takes 1,500 to 1,700 to make a pound, while, when taken later and a little farther from the sea, it takes only 350 to 400 for the same weight) may be obtained at low prices from France through Hüningen, or in Germany from Randesberg, and, through the Berlin Aquarium, from Wittenberge, and, when the temperature of the air is not too high, may be carried in soft moss throughout all Germany.

According to the statement of the well-known Paris fish-merchant, Millet, two pounds of Eels, planted in a muddy pond in 1840, in five years yielded 5,000 pounds of fine Eels.

JACOBY'S TOUR TO COMACCHIO IN 1877, AND HIS CONCLUSIONS.—"In the fall of 1877," writes Jacoby, "I undertook a journey from Trieste, by way of Ravenna, to Comacchio. Convinced of the difficulty of the questions to be solved by my own previous labors, I had not great hopes of finding sexually mature Eels, either gravid females or mature males. My highest aim was at the beginning to determine the following points: (1) Whether evidences of preparation for breeding might not be found in the Eels which were wandering in the fall toward the sea; (2) to what extent Eels with the organ of Syrski could be found participating in this migration; (3) as far as possible to obtain Eels from the sea at a distance from the coast in order to compare their organs of reproduction with those of the Eels in the lagoons.

"In determining the answers to the first two questions I was able to make some new and interesting discoveries, but with regard to the latter, my most diligent efforts were absolutely fruitless.

"I found that the Eels when migrating to the sea in the fall took no food. In many hundreds examined by me, caught during their movement, I found stomach and intestines entirely empty; that the Eels during their migrations eat nothing is also known to all fishermen and watermen of Comacchio. At the same time, the Eels which remained in the lagoons were more or less filled

with food, not only those which were not sufficiently mature to migrate, but also a breed of Eels which never goes to the sea, but remains throughout its entire life in the lagoons.

"There may be found in Comacchio, and doubtless everywhere where Eels live in great numbers in brackish water along the coast, a peculiar group of Eels which, as far as I could determine, consists entirely of sterile females. These female Eels with ovaries present a very peculiar phenomenon; when they are opened one finds, instead of the well-known yellowish-white, very fatty, cuff-shaped organ, a thin, scummy, slightly folded membrane, not at all fatty, often as transparent as glass, and of about the same proportional size as the so-called cuff-shaped organ. When this membrane is examined under the microscope there may be seen in it eggs very transparent in appearance, with yolk-dots absent or with yolk-dots very small and few. This organ appears to be an abnormally developed ovary incapable of fertilization. These sterile females, which I found of all sizes, even up to the length of twenty-seven inches, present all of the acknowledged female characters in great prominence and in an exaggerated degree: the snout is broader, and often, especially at the tip of the under jaw, extraordinarily broad; the dorsal fins are, on the average, higher; the eyes are much smaller, especially in large specimens, and the coloring is clearer; the back of a clearer green and the belly yellower than in the normal female. The flesh of these sterile females has a very delicate flavor, and quite different from that of other Eels. I was quite astonished at the fine flavor when I tasted them for the first time in Comacchio. The flesh, as the expression goes, melts upon the tongue. It is even possible to distinguish them while living, by feeling them with the hand, their soft bodies being very different from the hard, solid, muscular flesh of the others.

"In Comacchio these Eels are called 'Pasciuti.' Coste called them 'Priscetti,' and defined them to be those Eels which had not become ripe, but which were at least a pound in weight. The name 'Priscetti' is, however, very incorrect, as I have become convinced by questioning the fish inspectors and by hearing the conversations of the fishermen. 'Pasciuto' means 'pastured,' and the fishermen understand by this, those Eels which do not migrate, but which remain through the whole year feeding in the lagoons. They include, however, under this name, Eels of two kinds—the sterile females already described, and the Eels which are not yet ripe, as well as the normal females and supposed males whose period of migration is somewhat remote. This circumstance is a cause of much difficulty to the investigator.[1]

"The studies on the second point to be solved were of special interest, viz, the determina-

[1] It has been noticed by many early writers that there are certain Eels which never come to the sea—Risso, in his "Histoire Naturelle," tome 3, p. 198, and S. Nilsson, in his "Scandinavisk Fauna," tome 4, p. 663. The latter called this variety "Grasaal," or Grass-Eel, and spoke of its yellowish-green coloration and the soft, delicious flesh. Strange enough, both these writers spoke of the sharper snout of this Eel, and Risso, who founded upon it another species, *Anguilla acutirostris*, described it as blackish above and silvery below. These descriptions apply in every particular to the non-migratory Eel of Comacchio. Jacoby remarks that all the sterile females brought to him under the name "Pasciuti" were distinguished by their broad snouts. The following tables were prepared at Comacchio. *a* gives the total length of the body of the Eel; *b*, the breadth of the snout between the nasal tubes, in millimeters.

A.—Sterile females or Pasciuti.			B.—Normal females.			C.—Eels with supposed male organs.		
	a.	*b.*		*a.*	*b.*		*a.*	*b.*
I	508	10	I	511	8	I	—	—
II	480	8.5	II	497	7	II	480	6
III	458	11	III	465	9	III	470	6
IV	443	9	IV	447	7	IV	445	5
V	426	8.5	V	425	6	V	428	5
VI	409	8	VI	407	6	VI	403	5
VII	395	11	VII	396	7	VII	393	5.5

tion of the presence at Comacchio, and the behavior of Eels with organs of Syrski. I can answer this question very briefly, since among twelve hundred specimens examined by me at the fishing stations and at the so-called eel factories (with the exception of the largest specimens, which are always females) I found an average of five per cent. with the organ of Syrski; of the Eels under fifteen inches in length (forty-five centimeters) on an average there were twenty per cent., so that the conclusions as to their abundance were very similar to those at Trieste, where the fish market is supplied, for the greater part, with Eels from Chioggia, and to a less extent with those from Comacchio.

"In Comacchio the largest Eels with the organ of Syrski, which I have observed, were about seventeen inches (forty-eight centimeters) in length, the smallest about nine inches (twenty-four centimeters). All of these were found among the Eels taken during their migration to the sea, and, like the females, were found with stomachs completely empty or slightly filled with a slimy substance. It was impossible to find in any specimen a more advanced development of the Syrskian organ than in those examined in summer at Trieste.

"With reference to the third question undertaken by me, which relates to the actual kernel of the eel question, that is, the possibility of obtaining the Eels which have migrated out to sea, in order to obtain in this manner the sexually mature milters and spawners, I have been unable to obtain any results. I have, so far as my opportunities permitted, left no stone unturned to gain its solution. I went out to sea from Magnavacca and from Codigoro, on Chioggian vessels, and many times have fished myself, and have stimulated the fishermen by offers of reward to endeavor to obtain Eels at sea, but I am forced to the conclusion that with the ordinary means this cannot be done.

"Intelligent, gray-headed fishermen of Chioggia, who by means of their fishing apparatus know this part of the Adriatic as well as they know their own pockets, have assured me that throughout their entire lives they have never caught a grown-up river Eel in the sea at any distance from the coast. The Eels which were brought to me at Mannbach as having been caught in the sea, and which I found to be the ordinary females, or Eels with the Syrskian organ, were either from localities close to the shore where they are not rare, or were taken in the Palotta Canal. There was no lack of attempts at deception. Fishermen took Eels from the shore with them in order to be able, on their return, to claim that they had been caught at sea. In the immediate neighborhood of the coast they are, as it has been stated, in the spring-time not rare, and there are not the slightest differences between these and the Eels of the lagoons. I found both females and Eels with the organ of Syrski with their reproductive organs in the same immature condition as in Comacchio; evidently they had just come through the Palotta Canal from the lagoon into the sea. A certain distance, perhaps one or two marine miles from the coast, every trace is lost of the adult Eels which wander by the many thousand into the sea. Strange as this problem appears at first sight, it is easily understood when the character of the fishing apparatus is considered: the nets are those used in the capture of lobsters, and are thrown over the bottom; they have meshes much too large to hold the Eels, or, when they are small-meshed, they do not touch the bottom. The problem can only be solved by using apparatus constructed especially for the purpose."[1]

Jacoby proposes the following questions, which, in his opinion, cover the still unanswered points concerning the natural history of the Eel, and answers them in accordance with the results of his own observations:

[1] JACOBY: Der Fischfang in der Lagune von Comacchio, pp. 45–53.

Question 1. How can the fact be accounted for that no one has ever found mature females and males, spawners and milters, among the Eels?

Answer. The Eels require the influence of sea-water for the development of their reproductive organs. As is now definitely understood, they leave the rivers and the brackish lakes on account of the undeveloped condition of their reproductive organs, for the purpose of becoming sexually mature at sea. That these migrations to the sea take place for the purpose of reproduction appears to be certainly proved by the fact that the young Eels leave the sea in the spring, and that the migrating Eels, like other fishes at the spawning season, abstain from eating.

Q. 2. When and where occurs the necessary development of the reproductive organs of the Eel to a condition in which they are capable of fertilization?

A. Development of the reproductive organs takes place in the sea, not close to the shore, but at a distance and in deep waters. This development is extraordinarily rapid, when the immature state in which the migrating Eels are found is taken into consideration; they must become sexually mature within a few, probably five or six, weeks of the time that they enter the sea. At Comacchio the emigration takes place between the beginning of October and the end of December.

Q. 3. Where does the act of spawning take place, the fertilization, and the deposition of the eggs?

A. There are probably certain definite spawning places in the sea, off the mouths of the rivers. These are the mud-banks to which the Eels go, for the purpose of spawning, in great numbers. The young fish are developed upon these mud-banks, and from eight to ten weeks after their birth, at the beginning of spring, find their way to the mouths of rivers, which they ascend.

Q. 4. What becomes of the grown-up Eels after spawning time, and why do they remain lost to sight and never again come back into the rivers?

A. The old Eels, male and female, without doubt, die soon after the spawning season. The very unusual rapid development of their reproductive organs has such an effect upon the systems of the adult Eels that they die soon after the act of reproduction. That is the reason why they are never seen to wander back again.[1]

An intelligent Chioggian, the owner of a fishing vessel, in answer to my question as to where the old Eels staid, answered, "They die on the mud-banks after they have propagated their young."

This hypothesis may be confirmed in a scientific manner by the analogous circumstances in the history of the Lamprey. Panizza, in his description of the sea Lamprey, *Petromyzon marina*, remarks that both the males and females of this species after the spawning period are brought up dead. Concerning the river Lamprey, *P. fluviatilis*, Statius Müller remarks that when they spawn they slowly fall away and die. Concerning the little Lamprey, *P. planeri*, August Müller, the discoverer of its larval form, has recorded the same opinion.[2]

192. THE CONGER EEL—CONGER, OR LEPTOCEPHALUS CONGER.

The Conger Eel is occasionally seen in the summer on the coast of the New England and middle States, and is known to our fishermen as the "Sea Eel." No observations have been made of its habits by American zoologists.

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[1] As a confirmation of this view, von Siebold was the first to make this hypothesis.

[2] Op. cit., pp. 53–56.

The observations of Dr. Otto Hermes, director of the Berlin Aquarium, who has recently discovered the true nature of the organ of Syrski in the Conger, are extremely interesting:

"Since Syrski, in 1874, found the organs in *Anguilla vulgaris*—which are called by his name, and which, by him and most zoologists, were taken for the male reproductive organs—it is only

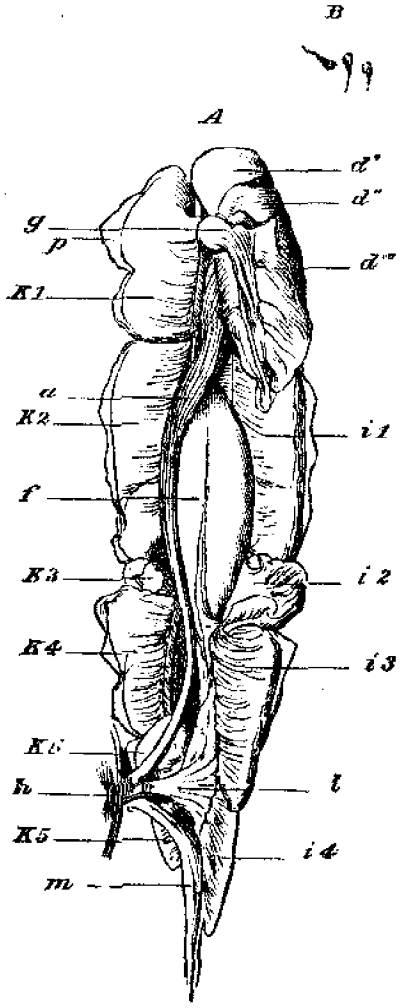

FIG. 9.—*A. Ripe male reproductive organs of a Conger Eel thirty inches in length, ½ natural size.*

a. Intestinal canal.
d', upper, *d''*, middle, *d'''*, lower portion of the liver, which has been thrown to one side.
f. Air-bladder.
g. Gall-bladder.
h. Anal aperture.
i$_1$, *i*$_2$, *i*$_3$, *i*$_4$. Folds of the left spermary.
k$_1$, *k*$_2$, *k*$_3$, *k*$_4$, *k*$_5$. Folds of the right spermary.
l. Seminal pouch.
m. Urinary bladder.
p. Skinny covering of the spermary.
B. Spermatozoa.

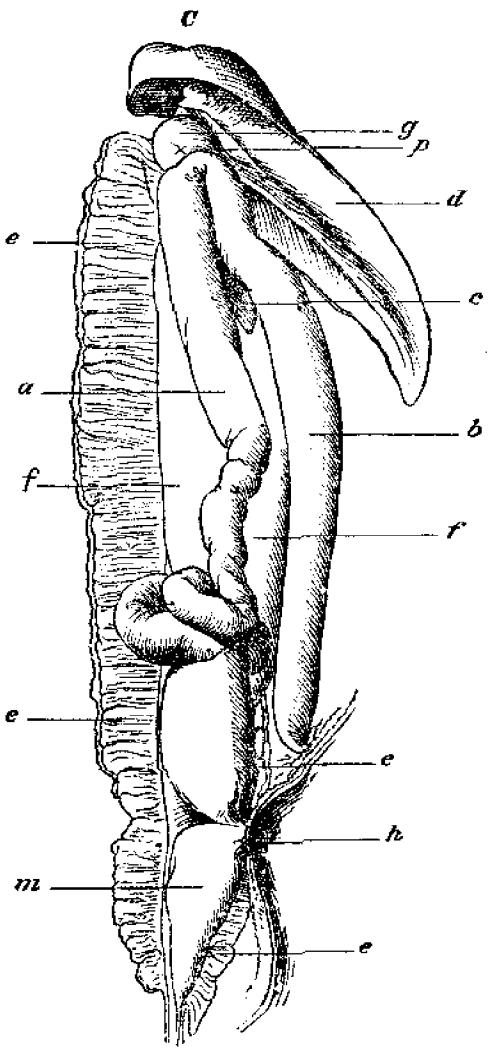

FIG. 10.—*C. Undeveloped reproductive organ of a female Conger Eel thirty-four inches long, ½ natural size.*

a. Stomach.
b. Cæcal appendage.
c. Spleen.
d. Liver.
e. Right ovary.
e'. Left ovary.
f. Air-bladder.
g. Gall-bladder.
h. Anal aperture.
m. Urinary bladder.
p. End of left ovary.

necessary that a ripe male Eel should be found in order to settle forever the question of the sexes of the Eel. Up to this time all efforts have failed to reach the desired result. The histiological investigations of the Syrskian organs pursued by S. Freud render it more probable that these were young roes; yet there remained all the time a doubt, since the spermatozoa had not been actually

observed, and this uncertainty is an insuperable obstacle to the acceptance of the Syrskian discovery. The supposed discovery of spermatozoa by A. S. Packard in the male Eel proved to be another delusion. The contradiction of this imaginary discovery appeared in No. 26 of the second volume of the Zoologischer Anzeiger, p. 193, in which it was stated that the motile bodies were not spermatozoa, but yolk particles. This correction was also made by von Siebold's assistant, Dr. Pauly,[1] and by S. Th. Cattie.

"The reproductive organs of *Conger vulgaris* are very similar to those of *Anguilla vulgaris;* in the undeveloped condition they show the ovaries lying in the same position in a cuff-shaped band of a proportionally large size. Since *C. vulgaris* reaches nearly twice the size of *A. vulgaris*, individuals of six feet in length are not rare. The ovary is developed in captivity, and this, I am convinced, is often the cause of the death of the Eel. In a Conger which died in the Berlin Aquarium, and was cut open, the ovaries protruded very extensively, and a specimen which lies in the Frankfort Aquarium burst on account of the extraordinary development of the ovaries. The ovaries of this Eel, which weighed twenty-two and one-half pounds, themselves weighed eight pounds, and the number of eggs was about 3,300,000. The want of a natural opening for the escape of the eggs was evidently in this case the cause of death. Male specimens of the Conger in an undeveloped condition I have hitherto never had the opportunity to investigate. I received, however, in the fall of 1879 a number of sea Eels, taken in the vicinity of Havre, whose average length was from twenty-four to twenty-seven inches. These Eels ate greedily and grew rapidly. Only one was tardy in its development, so that it could be easily distinguished from the rest. This, which was the smallest of the Congers in the aquarium, died on the 20th of June, 1880, and was examined by me on the same day. I was very much delighted when I found the sexual organs very different from those which I had ever noticed before. After a single cut into them, there flowed out a milky fluid, which, under the microscope, with a power of 450 diameters, showed a great number of spermatozoa, in the liveliest motion, and in which head and tail were evidently visible. There could be no doubt that I had found a sexually mature male of *Conger vulgaris*. Two fragments of the roe were laid aside for further investigation, and the Eel, which was twenty-eight inches long, was prepared first in alcohol and then in Wickersheimer fluid."

In the paper before us Dr. Jacoby presents a full anatomical description of the generative organs of the Conger as demonstrated by himself and Dr. Rabl-Rückhard. It seems unnecessary to repeat this description, since the organs are very similar to those in the common Eel. By the kindness of Dr. Hermes we are permitted to reproduce the drawings which accompany this description.

Compared with the description of the roe, and the figure of the organ found by Syrski and by Hermes, called "Lappenorgan," a great similarity is noticed between them. It must be borne in mind that in this case we were comparing the entirely undeveloped organs of the Eel with the fully ripe reproductive organs of the Conger, so every doubt as to the male nature of the Syrskian organs ought to be thrown aside. Also in the comparison of the size of the male with that of the female the Conger shows the same relations as the Eel investigated by Syrski, to wit, that the males are smaller than the females.

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[1] Austrian Fishery Gazette, 1880, No. 12, p. 90.

V.—STURGEONS, SKATES, SHARKS, AND LAMPREYS.

193. THE BOWFINS—AMIIDÆ.

THE BOWFIN OR JOHNNY GRINDLE—AMIA CALVA.

The one species belonging to the single genus in this family is peculiar to the fresh waters of the United States. It occurs in the Great Lakes, where it is called "Dogfish" and "Sawyer"; in the streams of Western Vermont, where it is the "Mud-fish"(?), as also in the streams of the Southern Atlantic coast from the Neuse southward. It is also abundant in the smaller rivers flowing into the Gulf of Mexico and in all parts of the Mississippi Valley, where it is variously called the "Johnny Grindle," "Bowfin," and "Dogfish." The Bowfin is an object of great interest to naturalists on account of its affinities with the great fossil group of ganoid fishes. It is exceedingly tenacious of life, like its allies, the garfishes. It attains the length of two feet and the weight of twelve pounds. Though not considered eatable in the North, it is very highly esteemed by the negroes of the South, who say "there is nothing sweeter than a Mud-fish." It is often taken by sportsmen on a trolling spoon, and is considered "gamy."

The Bowfin is probably more interesting on account of its voracity, and the wholesale destruction with which it pursues other fishes, than by reason of its own intrinsic worth. The young are thought to be excellent bait for pickerel and pike. The best description of the habits of this fish is here quoted from the pen of Charles Hallock:

"They take frogs, minnows, and sometimes the spoon. Their habitat is deep water, where they drive everything before them. They are very voracious and savage. Their teeth are so sharp and their jaws so strong that they have been known to bite a two-pound fish clean in two the very first snap. They are as tenacious of life as the eel. The young, when about six inches long, make a famous bait for pickerel and pike. To use it, run the hook into the mouth right up through the center of the head, through the brain, cast a hundred times, catch several fish, and at the end of three to six hours he will kick like a mule. Put one hundred in a rain-barrel and you can keep them all summer without change of water. For the aquarium the young have no equal, and on account of the spot in the tail are quite attractive; but nothing else but snails can live in the tank. He will kill a lizard or any other living thing the instant it touches the water.

"Dr. Estes says: 'I have sent these young Dogfish hundreds of miles for the aquarium. It is only necessary to keep them in water, a change scarcely being required. The adults are the great 'Jumpers' of the lake. On certain days they are to be seen in all directions jumping clean out of the water, and turning complete somersaults before again striking. They spawn in May and June among the grass and weeds of the sloughs, if they can reach them in time. As soon as the spring rise comes, usually in May and June, and connects the inland sloughs with the lake (Pepin), they run up and over into the sloughs, deposit their eggs, and remain near the beds and young just as long as they can and not be shut in by the receding water. The eggs hatch in eight and ten days, the parents remaining with the brood two or three weeks, if possible, but will leave them much sooner if necessary to save themselves. The young will not make any effort to escape to the lake until the next season, when, if an opening occurs, they come pouring out in countless numbers. At this time we take them by stretching the minnow seine across the opening and raising it when full. They are now from three to six inches long, fat and chubby. I come now to mention a

peculiar habit of this fish, no account of which I have ever seen. It is this: While the parent still remains with the young, if the family become suddenly alarmed, the capacious mouth of the old fish will open, and in rushes the entire host of little ones; the ugly maw is at once closed, and off she rushes to a place of security, when again the little captives are set at liberty. If others are conversant with the above facts, I shall be very glad, if not, shall feel chagrined for not making them known long ago.'"[1]

194. THE PADDLE-FISHES—POLYODONTIDÆ.

The "Paddle-fish" or "Duck-billed Cat," *Polyodon spathula*, is one of the most characteristic fishes of the rivers of the Western and Southern States. It reaches a length of four to six feet, and a weight of thirty pounds or more. It feeds on minute organisms present in mud. The long snout or spatula is used to stir up the mud on which, and the animals within it, the fish feeds. The fish is rarely or never used as food. Jordan states that it abounds in the lower parts of the Ohio River, where it is often taken in nets.

195. THE STURGEONS—ACIPENSERIDÆ.

The Sturgeons of the Atlantic Coast.

Two species of Sturgeon are supposed to exist on our Atlantic coast. The most abundant of these, *Acipenser oxyrhynchus*, is now generally supposed to be identical with the common Sturgeon of Europe, *A. sturio*. The other, *A. brevirostris*, which is distinguished from *A. oxyrhynchus* by its shorter and blunter nose, has not yet been found north of Cape Cod, and appears to be comparatively less abundant, although both species are found in great numbers in the larger rivers and estuaries during the summer season, and are frequently seen leaping from the water, especially at dusk. A leaping Sturgeon is a striking object, the whole length of the fish appearing above the surface before it falls back with a splash into the water.

The Sturgeon attains a length of five to twelve feet. In Europe, individuals of the common Sturgeon eighteen feet long have been secured. The spawning season is in spring and early summer. Their eggs have several times been artificially impregnated by the fish-culturists attached to the Fish Commissions of the United States and of New York. They spawn in the lower stretches of the rivers, and perhaps also at their mouths, in brackish water.

Sturgeon are classed by fishermen among the fishes which "live by suction." The mouth is situated upon the under surface of the head, and is not provided with teeth, but is surrounded with a cup-shaped organ composed of powerful muscular tissue, by means of which it grubs for its food in the mud. Its stomach resembles that of the menhaden and mullet, though comparatively more muscular, since, like the gizzard of a fowl, one of its uses is to triturate the food which has been swallowed, and which consists largely of mollusks and crustaceans. Around the mouth is a group of large and sensitive tentacles, which aid the fish in its search for food.

No one has yet made a careful study of the habits of the Sturgeon in our waters, and in fact European zoologists have made little progress in the study of their own species.

Within the past few years the capture of the Sturgeon for smoking and for the manufacture of caviare from its eggs has attained considerable importance on the Atlantic coast.

The capture and economic uses, and the statistics of the products of the sturgeon fishery, will be fully discussed by Col. M. McDonald in a subsequent portion of this work.

[1] Sportsman's Gazetteer, 1877, pp. 324–326.

THE LAKE STURGEON—ACIPENSER RUBICUNDUS.

The most satisfactory investigation of the Lake Sturgeon is that published by Milner in Part II of the Report of the United States Fish Commission, pages 67 to 75. This species inhabits the Great Lakes and the waters lying to the northward, and the rivers of the Mississippi Valley. It is especially abundant in the Upper Lakes. It is a smaller species than the Atlantic Sturgeon, and has a greater number of plates or scutes upon the sides—according to Jordan, about thirty-four instead of twenty-eight.

SPAWNING HABITS.—Milner records the following observations upon the general habits and history of the Lake Sturgeon:

"The spawning season of the Sturgeon in the more southern lakes occurs in the month of June; in Lake Superior it is a little later. Early in June, in the southern end of Lake Michigan, they begin to congregate near the shores and at the mouths of the rivers, the Kalamazoo River, emptying at Saugatuck, Michigan, being a favorite spawning ground. They may be seen in the evening in this river leaping from the surface, throwing their bulky forms entirely out of the water. At Pier Cove, Michigan, on the 11th of June, 1871, schools of Sturgeons were at the edge of the shore in a few feet of water, and men from the vicinity were in the habit of wading out and drawing them ashore with gaff-hooks. Eighteen were taken in this way the morning we visited the locality. They were said to be found in the vicinity every year about this season, remaining about a fortnight. It is likely they were spawning at the time. Whether the shore of the Lakes, where the waves would disturb the eggs in every storm, is a natural spawning ground is a question. They may have been late arrivals seeking the mouth of the Kalamazoo River, a few miles to the north of which they are said to ascend to the first dam, many miles inland.

"Mr. J. G. Portman, of Benton Harbor, successful as a fish-culturist, has seen the Sturgeon at this season lying in numbers on a shallow clay ledge at the edge of a stream, several of them lying flat on their backs, with their bellies upward, rolling and splashing in shallow water with apparent enjoyment. Two or three that were taken with spears were opened and the stomachs examined and found to contain some of the sturgeon spawn. At the mouth of Calumet River, South Chicago, Illinois, July 1 of the year just referred to, a large lift of Sturgeon were brought ashore, looking flaccid and emaciated, and but one specimen out of over twenty individuals contained spawn. In the vicinity of Bayfield, Wisconsin, on Lake Superior, they were seen late in the month of July with the ovaries full of spawn, and the milt of the male fishes large, making it probable that the time of spawning was later in colder water than in warm.

"SIZE.—The Sturgeon of this species attains the largest size of any fish of the Lakes. They are taken only within comparatively shoal waters and in some of the bays, and among the islands they are very abundant. The largest specimen it has been my fortune to see did not quite attain the length of six feet, though there are traditions in localities on the Lakes of nine-foot Sturgeons; the average of the mature ones taken is less than five feet.

"Their food consists almost entirely of the shell-fish of the Lakes, principally gasteropods, the thinner-shelled kinds of the genera *Physa*, *Planorbis*, and *Valvata* being found broken in the stomachs, while *Limnæa* and *Melantho* remain whole. A few eggs of fishes have been found at different times, but examination of stomachs during the spawning season of some of the most numerous fishes did not prove them to be very extensive spawn-eaters.

"ENEMIES.—In Green Bay the fishermen set their pounds for fall fishing about the 10th of September. The Sturgeon are in abundance, and the nets often contain a hundred or more. This is said to continue until about the middle of October, when they diminish in number and the white-

fish become plentiful. As the latter are the fish sought for, the Sturgeon are considered a nuisance and annoyance. A few fishermen are considerate enough to lower the corner of a net and allow them to escape, but the commoner way is to draw them out of the net with a gaff-hook and let them go wounded, or to take them ashore and throw them on the refuse heap, asserting that there will be so many less to trouble them in the future. A very large number are destroyed in this way, probably equaling or exceeding the number taken in the vicinity of Sandusky.

"The spawn is probably subjected to the depredations of numerous fishes. It is not likely that the young Sturgeon, except in the earliest stages of their growth, suffer from the attacks of other fishes, as they are too well defended with the sharp spine of their shields to make a comfortable mouthful for any fish of the Lakes, and after the spine disappears have attained a size large enough to render them safe.

"A parasite that troubles the Sturgeon is the Lamprey Eel, *Petromyzon argenteus*, Kirt., which is found very frequently attached to the skin. The circular scars and raw sores sometimes found upon the Sturgeon and attributed to this cause by the fishermen are correctly accounted for in this way. It is probable that their natural food is the slime or mucus exuded in abundance from the pores, but they frequently retain their hold upon a spot until they have eaten through to the flesh, and deep ulcerous cavities occasionally result from the sore.

"The decrease in numbers is apparent to a certain extent in localities where the pound-net has been in use for a number of years. At Sandusky, Ohio, the number brought in from the nets and handled at the curing establishment in a season are said to have nearly reached eighteen thousand a few years ago, while in 1872 the books showed a record of thirteen thousand eight hundred and eighty received. This fact has several times been advanced as an argument in favor of the pound-nets, that the destruction of the Sturgeon, asserted to be an extensive spawn-eater, more than compensated for the numbers of white-fish taken.

"As an article of food they are not generally popular. But few people in the cities know the modes of cooking that make their meat a palatable dish. A certain quantity is disposed of fresh by the peddlers. With the Canadian-French people of the Lake shore they are in demand, and are prepared in the form of soups (*bouillon*). With a good, hearty, outdoor appetite this is very palatable food, but too rich in the flavor of the oil of the fish for ordinary use. The flavor of the Sturgeon meat has very little of the taste of fish, and the bouillon, when carefully prepared by skimming off the oil, is very much like chicken-soup. A very good pickled meat is made of it by boiling it and preserving it in vinegar.

"*But the best form of preparing Sturgeon is by smoking it. The smoking of Sturgeon meat* has been done at different points of the Lakes on a small scale, but is only carried on to a large extent by Schacht Brothers, of Sandusky, Ohio. The method employed by this firm is the following: The Sturgeons are skinned and the viscera taken away. The thick parts are then cut into strips, and after a slight pickling in brine are smoked over a close fire. The thin portions and *offal are boiled down for oil, the spawn is made into caviare, and from the bladders isinglass* is manufactured.

"The smoked Sturgeon is a most palatable meat, and is quite popular, making an excellent substitute for smoked halibut, and, in the opinion of a great many, having some qualities superior.

"The caviare is made by pressing the ova through sieves, leaving the membranes of the ovaries remaining in the sieve and the eggs falling through into a tub. This is continued until the eggs are entirely free from particles of membrane, when they are put into salt pickle and allowed to remain for some time."

OBSERVATIONS BY LUDWIG KUMLIEN ON THE STURGEON OF THE GREAT LAKES.—Mr. Kumlien, while engaged in collecting the statistics of the Great Lakes fisheries in 1880, made a number of very important notes upon the abundance of the Sturgeon and upon the sturgeon fishery in that region, which will be quoted in a subsequent portion of this work.

THE STURGEONS OF CALIFORNIA.

"The common Sturgeon of the Pacific coast, called distinctively the 'White Sturgeon,'" writes Jordan, "is *Acipenser transmontanus*. It reaches a length of eight or ten feet or more, and is said to attain a weight of four to five hundred pounds. We have seen none of over one hundred and fifty pounds' weight. It is found in the Sacramento, Columbia, and Frazer Rivers in abundance, ascending them at the time of the salmon run in the spring for the purpose of spawning. Whether it enters the small streams, how long the run continues, and how far the Sturgeon ascend, are matters at present unknown. The Sturgeon feeds on crustacea, carrion, etc. In Frazer River they gorge themselves on the eulachon.

"The Sturgeon is one of the most important fish in the San Francisco market, being always abundant and very cheap. Elsewhere the abundance and superiority of the salmon cause it to be little used. Many are smoked. Caviare is made from the eggs.

"*Acipenser medirostris* is known as the 'Green Sturgeon.' Its size and distribution are the same as that of the White Sturgeon. It is, however, much less abundant. It is not used as food, being reputed poisonous. We are unable to say on what facts this evil reputation is based."

THE SHOVEL-NOSED STURGEON: WHITE STURGEON—SCAPHIRHYNCHOPS PLATYRHYNCHUS.

This species is found in abundance in all the larger rivers of the West and South. It spawns early in May, ascending smaller streams for that purpose. Jordan states that in the Ohio River it is taken in seines in considerable numbers and is used for food, though it does not seem to be highly valued. He surmises that its habits are very similar to those of the Lake Sturgeon.

196. THE CHIMÆRA FAMILY—CHIMÆRIDÆ.

RAT-FISH OF CALIFORNIA—CHIMÆRA COLLIEI.

"This fish," writes Jordan, "is known as the 'Rat-fish' or 'Rat-tail.' It reaches a length of nearly two feet, and a weight of six to eight pounds. It is very abundant everywhere from Monterey Bay northward along the coast, especially in deep bays. It feeds on fishes and takes the hook very readily. It spawns in July. The egg cases are two or three inches long, lanceolate, long and slender, without tentacles.

"The liver of the Chimæra is very large and well filled with an oil said to be superior to ordinary shark oil. The flesh is worthless and the fish is too small to be an object of pursuit. It has, therefore, no economic value."

THE BLUE CHIMÆRA—CHIMÆRA AFFINIS.

A species of Chimæra is frequently taken by the New England fishermen on the off-shore fishing banks. It was described by Professor Gill under the name *C. plumbea*, but proves to be a species previously discovered on the coast of Spain. It has no economic importance.

197. THE GAR-PIKES—LEPIDOSTEIDÆ.

THE LONG-NOSED GAR-PIKE—LEPIDOSTEUS OSSEUS.

This fish is known as "Gar-pike," "Bill-fish," "Sword-fish," etc., the names "Gar" and "Gar-pike" usually predominating. It is found in the Great Lakes, and throughout the Mississippi

Valley, as well as in all the streams of the South from Mexico to New Jersey. In all the larger streams it is abundant, sometimes extremely so, but in the smaller rivers it is scarce. It is a hardy and voracious fish, being usually considered very destructive to the young of other and better fishes. It is fair to say that remains of fishes are rarely found in its stomach. It reaches a length of five to six feet. It is usually considered wholly worthless, being killed and thrown away whenever taken. The flesh is very tough, and is said to be noxious. I have never known it to be eaten. It spawns in early summer, running up smaller streams, often in company with the various Sturgeons. At Ogdensburg, New York, they come upon the shoals for this purpose about May 20. Another spawning ground is on a beach near Point Salubrious, Chaumont Bay, New York, about a mile from the post-office.

The Short-nosed Gar-pike (*Lepidosteus platystomus*) occurs in the same waters, reaches about the same size, and is similar in habits. It is most common southwestward.

Le Sr. de Champlain, visiting the lake which bears his name in the year 1609, speaks of a large fish, undoubtedly the Gar-pike, there found:

"Among the rest there is one called by the Indians of the country *Chaousaron*, of divers lengths. The largest, I was informed by the people, are of eight to ten feet. I saw one of five, as thick as a thigh, with a head as big as two fists, with jaws two feet and a half long, and a double set of very sharp and dangerous teeth. The form of the body resembles that of the pike, and it is armed with scales that the thrust of a poniard cannot pierce, and it is of a silver-gray color. The point of the snout is like that of a hog. This fish makes war on all others in the lakes and rivers, and possesses, as these people assure me, a wonderful instinct; which is, that if it wants to catch any birds it goes among the rushes or reeds bordering the lake in many places, keeping the beak out of the water without budging, so that when the birds perch on the beak, imagining it the limb of a tree, it is so subtle that closing the jaws, which it keeps half open, it draws the birds under water by the feet. The Indians gave me a head of it, which they prize highly, saying that when they have a headache they let blood with the teeth of this fish at the seat of pain, which immediately goes away."[1]

The Alligator Gar—Lepidosteus spatula.

This species is known almost universally as the "Alligator Gar"; in Spanish, "Manuari." It abounds in large bodies of water tributary to the Gulf of Mexico, being found in Mexico and Cuba as well as in the United States. Its northern range extends to the Ohio River, where, however, it is not common. It reaches an enormous size, being sometimes more than ten feet in length. In habits it is probably essentially similar to the smaller Gar-pikes. It has no value as food, but is said to be somewhat dangerous to men and domestic animals.[2]

It is found in various tributaries of the Gulf of Mexico, and also in the headwaters of Saint John's River, Florida. It is distinguished by its broad snout. In Arkansas the country people

[1] Doc. Hist. of N. Y., iii, 1850, 6. See also, Sagard: Grand Voyage du Pays des Huron, Paris, 1632.

[2] A Man's Fight with a Fish.—Mr. James F. Simmons, of Redbone district, had a narrow and peculiar escape the other day. He was fishing on Flint River, and had attempted to swim across to get a bateau from the opposite side. About half way over the stream he stopped on a root or tree to rest. After remaining there a short time, he plunged off for the other shore. Just as he made a plunge a tremendous fish, known as the Gar, struck him, catching his thigh in its mouth, and leaving an ugly and painful wound. A regular battle then took place between the man and the fish, and lasted for some minutes, until finally Mr. S. got back on his resting place, and his enemy departed. During the fight Mr. S. threw the fish some feet above the water, but it continued the attack. Mr. S. was thoroughly frightened and called lustily for help. He has several ugly and painful wounds given him by the fish, yet none serious. This is the first time we ever heard of a Gar attacking a man, yet they say it frequently does so.—*Talbotton (Ga.) Standard*, July, 1879.

manufacture from it a kind of oil, which is used as a liniment to prevent the attacks of the buffalo-gnat. Mr. Stearns writes:

"The Alligator Gar is very abundant everywhere on the Gulf coast, living in both fresh and salt water. Like the salt-water catfish, it will eat anything. It preys largely upon all fish smaller than itself, and the young are, I believe, particularly destructive to fishes' eggs and young fry. Some think that this fish does more damage to the small food-fishes than any other fish on the coast does. It is simply useless to place 'set-nets' where the Gar is abundant. Many are caught in seines with other fishes and are thrown ashore to be destroyed. I have seen Gars that would measure seven feet in length; the average is two feet. With the larger ones the bill is not proportionately as long as with the smaller ones, but is stouter."

198. THE RAYS, TORPEDOES AND SKATES—RAIÆ.

There are six or seven species of Rays upon the Atlantic coast, none of which are of importance to man, except so far as they are dangerous or annoying to the fishermen, or are destructive of useful marine animals.

The Sting Rays.

The Sting Ray, *Trygon centrura*, ranges farther to the north than any of the other species, having been observed on the shoal parts of George's Banks; it does not, however, pass the limit of Cape Cod. The Sting Ray attains an enormous size, its disk sometimes measuring five or six feet across, and its entire length, including the long, flexible tail, ten feet or more. It feeds entirely upon the large species of marine invertebrates, such as crabs, squids, clams, and sea-snails. The strong serrated spine situated upon the top of the tail near its junction with the body can inflict dangerous wounds, and several instances are on record of serious injury to fishermen who have had their hands or feet transfixed by it. These fish are often taken in considerable numbers in the pounds and weirs.

There are two or three other species of Sting Ray or Stingaree on the southern Atlantic and Gulf coasts, the commonest of which, *Trygon sabina*, is found in the rivers, ascending the Saint John's to the upper lakes, and also clear along the coast. Concerning its habits in the Gulf of Mexico, Mr. Stearns writes:

"The Sting Ray or Stingaree is abundant all along the Gulf coast. It is present all the year, but is most commonly seen is warm weather, while upon the shoals in search of food. I have caught these fish with young continuously from April to the latter part of October. The usual number of a brood is three or four, but I have seen as many as eight or nine taken from large individuals. Possibly the age or size of the parent may affect the number of young they bear. They feed upon shell-fish. Small ones are quite tame, coming near the shore in search of food, and when disturbed quickly bury themselves in the sand or dart away a short distance. The larger and older ones are more wary, seldom coming into very shoal water, and at the least disturbance swim away with great rapidity to deep water. The Sting Ray has a barbed spine on its tail which it uses in self-defense. It is sometimes caught with hook and line, but more often in seines, and then it uses its tail as a whip upon its captors, trying to wound them with its spine. Such wounds are often dangerous, and very painful and difficult to heal. The Sting Ray attains an enormous size, and specimens six or seven feet across the back are frequently caught. I caught a specimen off Cedar Keys whose spine had been broken off and replaced by a new one which grew out beneath the old one.

"Capt. Joseph Fogarty, of Manatee, reports having seen a large school of Sting Rays in Long Boat Inlet. They were swimming near the bottom, very closely crowded together.

"The Sting Ray and Whip Ray are very often eaten on the Gulf coast, and are sold daily in the New Orleans market."

The Butterfly Ray.

The Butterfly Ray, *Pteroplatea maclura*, although a member of the same family with the Sting Ray, differs very much in its external appearance, and would hardly be supposed by the unlearned to be a fish at all. The tail is exceedingly small, while the pectoral flaps are enormously developed. The body often attains the weight of ten or twelve pounds, while its length is not more than three or four feet. The enormous extent of the pectoral flaps, resembling wings, have given origin to the common name. In an individual of the above-mentioned size the tail would not be more than three or four inches long. This species is taken in summer in the pounds, and, when Skates become more popular as an article of food, will doubtless, on account of its great size, be of economic importance. Little or nothing is known of its habits.

The Eagle Rays.

Of the Eagle Ray family, *Myliobatidæ*, of which there are three species, all except the Bishop Ray straggle north to Southern New England in summer, but only one seems to be found in Florida and the Gulf; this is the "Whipparee" or "Corn-Cracker" of the South (*Rhinoptera quadriloba*). Its habits are thus described by Mr. Silas Stearns:

"The Whipparee is common on the Florida coast. It is present in the bays the year round. In warm weather it lives on sand bars in shoal water, and in cold weather retires to deeper water. It feeds upon molluscous animals, chiefly the razor-shell fish, which is one of the commonest kinds. The Whip Ray is viviparous and brings forth its young in spring and summer, the breeding season apparently extending over five or six months. I have not found a Whip Ray containing more than three young ones, usually only two. When the young fish leave the parent they are quite active and undoubtedly able to care for themselves. The adults have stout dorsal spines, which they use as weapons of defense. These spines are barbed and slimy, and wounds from them are very troublesome and sometimes dangerous. The Whip Ray is sometimes six or seven feet across the back. During the last of July, 1880, I saw large schools of young Whip Rays, probably about half-grown, swimming at the surface at sea off Saint Andrew's Bay, and also at a point twenty miles up that bay."

The "Eagle Ray," or "Sharp-nosed Ray," *Mylobatis Fremenvillei*, does not attain a large size and is comparatively unusual in occurrence. Its food, as observed in Southern Massachusetts, is closely similar to that of the common Sting Ray.

The Bishop Ray, *Stoasodon narinari*, the "Obispo" of Cuba, is found in the West Indies and at the Bermudas; stragglers have been observed at Norfolk, Virginia.

The Devil-fishes.

The Devil-fish, *Manta birostris*, has been observed as far north as Cape May, and is said to be often see on the Gulf coast of Florida, as it swims on the surface of the water. This species attains an enormous size; individuals have been caught measuring thirty feet or more from tip to tip of the flaps. It is especially abundant on the coast of South Carolina, where its pursuit is a favorite amusement among the planters, or rather was in former years. Every one is familiar with the thrilling accounts given of this amusement by Elliott in his "Carolina Sports by Land and Water." There are instances on record of small vessels having been carried out to sea by these fish which have become entangled in the anchor ropes. The appearance of these fish at the surface, especially at the breeding season, has given origin, doubtless, to some of the stories of sea-serpents current on the Southern coast.

The Skates.

Of the Skates, *Raiidæ*, there are five species on our Atlantic coast, a list of which, with their common and scientific names and a statement of their geographical distribution, will be found on the check-list in the appendix. They are all troublesome to the fisherman, clogging his lines and pound-nets; but none of them are of the slightest economical value except the so-called "Barn-door Skate," *Raia lævis*, which is occasionally salted for use by the fishermen of Portsmouth, New Hampshire, and which has, within the last two or three years, attracted some notice in New York. Miss Corson, in her cooking school, has called attention to its excellent qualities as a food-fish, and Skates may be found on the bill of fare at certain restaurants, such as Mouquin's, on Fulton street. Only the "wings," or the fleshy flaps to the pectoral fins, are used.

The Torpedo—Torpedo occidentalis.

The Torpedo is found north as far as Cape Ann, a specimen having been taken at Lanesville in the summer of 1878. It is more or less abundant along the Southern New England and middle States coast.

The Torpedo is occasionally thrown upon the shore, and its capture in the pound-nets is not unusual. It is of no economic importance, but is of great interest to physiologists on account of its powerful electric apparatus. The fishermen know its peculiarities, and carefully avoid handling it, since a shock from a living individual is sufficient to knock a man down. It is usually called the "Cramp-fish," and, in pursuance of the old idea of the influence of signatures in medicines, the oil made from the liver is prized by fishermen as a specific for rheumatism and cramp. Captain Atwood writes:

"I have seen considerable many. They run ashore, and they have been harpooned from the shore. I have seen five hundred, I think. I used to go and look for them for their livers, for the oil. The oil is one of the best lamp oils that I ever saw. It has been used sometimes beneficially in cases of cramp. I got a gallon of oil from one liver. I don't know but I have seen a Cramp-fish big enough to make three gallons of oil."

The Rays and Skates of the Pacific coast.

Of the numerous Rays on the Pacific coast only two or three are of economic value, being brought into the market of San Francisco, when their pectoral fins are sold to the French and Italians. These are of little importance, as they are so cheap that there is no profit in bringing them to the city at all when any transportation charges are paid. One of the Sting Rays (*Pteroplatea marmorata*) sometimes comes into the market of Los Angeles, and the tails of *Rhinobatus productus* are sometimes preserved and eaten by the Chinese and Mexicans.

The following is a full list of the species now known: *Manta birostris*, the Devil-fish, the largest of all Rays; sometimes come north to San Diego. *Myliobatis californicus*, the common Sting Ray, from Cape Mendocino southward; is destructive to oyster beds, which are always shut in with a sort of picket-fence to keep these animals out. The "sting" of this and other species often produces severe flesh wounds, which may be accompanied by blood-poisoning, and sometimes causes death.[1] *Pteroplatea marmorata*, *Trygon dipterurus*, and *Urolophus Halleri*, all Sting Rays, found

[1] On Thursday week, as D. K. Williams, of Anaheim, was at the landing amusing himself fishing with a net, he was severely stung by a fish known as the Stingaree. He was lifting a few small fish from the net, and among others picked up what appeared to be a small flounder, when he received a fierce sting from the tail of the reptile on his right forefinger. He immediately commenced sucking the poison from the wound, but in a few moments he suffered great agony and became delirious. His friends took him at once to a house and gave him three pints of whisky, which, together with constant attention, brought him through safely in about fifteen hours, and he is now entirely recovered.—*Anaheim Gazette*, April 14, 1871.

south of Point Concepcion only. *Raia inornata, Raia binoculata, Raia rhina,* and *Raia stellulata,* all true Rays, ranging from Santa Barbara or Monterey northward; *R. binoculata* and *R. rhina* as far as Alaska. *R. inornata* and *R. binoculata* are brought into the market of San Francisco in considerable numbers. The latter reaches a length of six feet, the former of two and a half feet. *Rhinobatus exasperatus,* J. & G., in San Diego Bay; *Rhinobatus productus,* and *Rhinobatus triseriatus,* from San Francisco southward, and the Torpedo, *Torpedo californica,* about San Francisco, complete the list.

Only the French in San Francisco can be said to be fond of the Rays, and so long as the present abundance of better fish continues none of them will have any special economic value. The oil in the liver is so little that it is only preserved by the Indians.

199. THE SAW-FISH—PRISTIS PECTINATUS

Of the Saw-fishes, *Pristidæ,* there is at least one species, *Pristis pectinatus,* on the Florida coast. Stragglers are taken occasionally in the Chesapeake Bay, and even farther north. A specimen sixteen feet three inches in length and four feet in width was taken at Cape May in July, 1878. Its saw was four feet three inches long, and was armed with forty-nine teeth. The Saw-fish is, however, rarely seen north of Florida. In the Everglades these fish are said to be exceedingly abundant. In the Saint John's River individuals of all sizes, from one to eight feet in length, are taken as high up as Jacksonville. They are considered by the fishermen to be very much of a nuisance, since they are exceedingly powerful and play great havoc with the shad-nets. As they swim they move laterally, with a swinging motion, the head and snout, which latter is powerfully armed on each side with very strong teeth. Mr. Camps, of New Berlin, told me that he had three cast-iron rowlocks broken off close to the gunwale by a single blow of the saw of a large individual. In the Indian River and its tributaries the Saw-fish is said to be very common, attaining the width of six or eight feet. On the Gulf coast, according to Stearns, it is rather common, being a bottom fish and frequently caught in seines. Stearns states that he once saw a specimen in Saint Andrew's Bay that must have been fully fifteen feet long.

200. THE SHARKS—SQUALI.

There are at least twenty species of Sharks upon our Atlantic coast, some of which are of considerable economic value, while others are simply of interest as being annoyances to fishermen.

The Bone Shark—Cetorhinus maximus.

This species is a native of the Arctic Seas, but has been observed in the Western Atlantic as far south as New York, and on the European coast to Portugal. It is known among our fishermen as the "Bone Shark," and is also called the "Basking Shark" from its habit of basking or remaining quiet for a long time in one place. It is the "Sun-fish" of the Irish and Welsh coasts; the "Sail-fish" of Northern Great Britain, while in the Orkneys it is called the "Hoe-Mother," contracted to "Homer"—the word "Homer" signifying the mother of the spiny Dogfish which is there known by the name "Hoe." The Bone Shark is one of the largest of Sharks, and many years ago a learned dissertation was published by its first describer, Bishop Gunner, of Norway, attempting to prove that this was the species of fish which swallowed Jonah. Yarrell examined a specimen, taken off Brighton, which measured thirty-six feet in length; a large individual was secured in the lower harbor at New York in 1822, while in 1828 a smaller individual obtained in Maine was brought to New York, the dimensions of which were twenty-eight feet in length and sixteen feet in circumference. In September, 1839, an individual thirty-four feet long was stranded

at Eastport, Maine. Storer records the capture of an individual, taken at Provincetown in 1839 and exhibited at Boston, which measured thirty feet and three inches. It is not unfrequently harpooned by the whalers on the Pacific coast. A specimen was examined at Monterey by Jordan and Gilbert.

Very little is known of its habits. It is usually seen in summer, though this is doubtless due to the fact that the fishermen are then in a position to observe them, while in winter the fishermen remain in harbor and would not be so likely to notice their occurrence. Yarrell remarks: "When north winds prevail they are most frequent on the west coast of Scotland, also on the north and west coast of Ireland; if westerly winds, they are not unusual along the whole line of the southern coast."

If these observations are correct, it seems probable that easterly and northerly winds are most favorable for their appearance in the waters of New England.

These Sharks are sluggish in their movements, swimming lazily at the surface, and are said to be so indifferent to the approach of boats that they will allow them to touch their bodies without moving, though, when struck with the harpoon, they swim away with much rapidity and strength.

The only observations upon its food have been made in the vicinity of the Orkneys by Mr. Lowe, who states that its stomach contained a red, pulpy mass, probably the roe of sea-urchins. Linnæus supposed its food to consist chiefly of medusæ or jelly-fishes. The teeth are very small, and the structure of the gill-rakers would indicate that it feeds at the surface, straining its food, like the whalebone-whales. The gill-openings extend from the back nearly to the median line of the throat. The liver of this Shark is very large and yields a great quantity of oil. When they make their appearance in our waters they are usually harpooned by the fishermen, who consider their discovery as a great piece of good fortune. About the middle of last century there is said to have been quite an extensive pursuit of this species in Massachusetts, considerable quantities of oil being taken. In 1848 a vessel, cruising on the coast of Maine for humpback-whales, fell in with many of them off Cape Elizabeth, and secured several of them. Captain Atwood writes: "They are very rare now; once in a great while you will see one. I don't think that more than half a dozen have been caught near Provincetown since 1810. I have heard of as high as twelve barrels being taken from a single one, but have never seen one which yielded more than eight barrels."

In 1835 an individual was caught in a mackerel-net in Provincetown Harbor and harpooned; in 1836 or 1837 a second one was caught in a net, and after being secured the carcass was freed by the fishermen from the net and afterwards drifted ashore in a state of decomposition. After lying on the beach several days a fisherman visited him in order to get a slice to feed to his hens, as is the custom at Provincetown—he supposing it to be a dead whale. Ascertaining what the animal was, he removed the liver and sold the oil in Boston for $103, it having produced five or six barrels. In 1847 a third was captured. The pursuit of this animal is attended with considerable excitement and danger.

Yarrell has recorded[1] the occurrence in the summer of 1870 at Eastport, Maine, of three specimens, twenty-five to thirty feet in length, and also of one taken in 1868, which measured thirty-five feet. Captain Atwood gives the following account of his experience with one:

"Coming one time from Boston to Provincetown with my two boys, I saw the fin of a big Bone Shark. We lowered the boat and pulled up on to him. This was about 1863. I should think he was thirty-five or thirty-eight feet long. It was smooth weather, and I threw the harpoon

[1] Bulletin, Essex Institute, iii, p. 6.

into him and he darted down into the water, and finally he went down again, and kept coming up and going down. I began at four o'clock and tried to haul him up until about supper-time, but could not, and he towed the smack all night. He came on until he got abreast of the oil works at Provincetown, and then he turned and I couldn't get him up; he went about as fast as you would row a dory moderately. The water became shoaler and shoaler until there was eight or ten feet over his back, and then he went towards Beach Hill. We were in the dory and he then came back within a quarter of a mile of the vessel. We went aboard and got something to eat. We got him within six or eight feet of the top of the water and the warp parted and we lost him. I don't think one has been killed here for more than twenty years."

These monsters are occasionally stuffed and carried about the country by showmen, advertised under various high-sounding names.

The Mackerel Shark—Lamna cornubica.

This species, called at Provincetown the "Blue Shark," occurs in the Northern Atlantic, being occasionally seen at various points on the coast of the United States from Newfoundland to Florida, and in the West Indies. In the Eastern Atlantic it is found everywhere from the south of the North Cape, entering the Mediterranean. It has also been recorded from Japan. It is abundant on the coast of Great Britain, where it is known as the "Porbeagle." It also occurs in California.

The ordinary length of this species is from eight to ten feet. They roam about in summer, often several together, preying upon small fish and squids, being particularly fond of mackerel. They are very abundant on the coast of Massachusetts in the mackerel season, and are a great annoyance to the fishermen who use nets, since they become entangled in the twine, destroying the nets by tearing them and rolling them up. Although their livers yield a considerable quantity of oil, formerly prized by curriers, I am unable to learn that they are now regarded as of any practical value.

Storer wrote, in 1847, that the procuring of oil from these fish, which was once a regular business, had at that time been almost entirely abandoned. The practice of saving the oil was a common one, but had been abandoned on account of the apparent decrease in the quantity obtainable.[1] Storer also, in 1846, quoting from Captain Atwood, remarked: "Seven gallons of oil were at that time frequently extracted from the liver of a single fish, while eleven and a half gallons have been taken from one. Of late years this fish has yielded less oil than formerly, so that they are now scarcely worth saving. Formerly a barrel of oil was made from the livers of eleven fish. Captain Atwood tells me that, many years since, his father procured often a barrel of oil from eight livers; not selecting the best, but employing large and small indiscriminately; but now at least one hundred livers would be required to furnish this amount of oil."

The Man-eater Shark—Carcharodon carcharias.

The so-called "Man-eater Shark," the American form of which has been described under the name *Carcharodon Atwoodii*, in honor of Captain Atwood, who sent specimens to Storer, the historian of the "Fishes of Massachusetts," is probably identical with the Great Blue Shark, *Carcharias Rondeletii*, common throughout the Atlantic and Mediterranean, and also known to occur in the Indian Ocean and about the Cape of Good Hope and Australia. In tropical seas it attains an

[1] A Mackerel Shark, measuring nine feet in length, was seen by two men flouncing upon the flats in this harbor on Saturday last, having got entangled in the eel-grass in shoal water, who went to him and cut his throat. His liver made three gallons of pure oil.—*Barnstable Patriot*, September 8, 1833.

enormous size. The British Museum has the jaws of an individual, thirty-six feet in length, taken in Australia. Its mouth is wide, its teeth large, and its jaws strong; it is probable that this species and the Tiger Shark are among the most voracious of their kind.

This is an exceedingly rare species on our Atlantic coast. Storer could learn of the capture of but three individuals from 1820 to 1860, one measuring six feet in length, a second nine feet, and a third thirteen feet. The specimen which he described was captured at Provincetown, and was brought to Boston for exhibition. When first seen it was swimming in ten feet of water on the Long Point side of Provincetown Harbor. A boat's crew having given chase, a harpoon was thrown into it, when it turned toward the boat and seized it with great ferocity near the bows. In the act several of its teeth were broken off. It was eventually killed by being frequently lanced. A specimen was observed at Eastport, Maine, in August, 1872. It is frequently taken in Monterey Bay. A specimen lately taken at Soquel, California, had a young sea-lion whole in its stomach.

Captain Atwood writes: "The Man-eater is rare; I don't remember of having fallen in with but four; these were, with one exception, all caught in mackerel-nets. I suppose about two or three may be caught every year about Provincetown, but fishermen cut them out of the nets and let them go."

The enormous fossil Sharks' teeth which are found in the phosphate beds of South Carolina belong to a Shark closely related to our Man-eater, and, judging from the proportionate size of the teeth, individuals measuring seventy or eighty feet in length cannot have been at all uncommon.

The alleged attacks upon men by Sharks, if any credence is to be attached to them, should doubtless be credited to this species and to the Tiger Sharks. Such attacks are, however, of very rare occurrence, and the stories of them lose nothing of the marvelous in repetition. I quote one of the few accounts which have found their way into permanent record:

"On the 12th of July, 1830, Mr. Joseph Blaney, aged fifty-two, went out in a fishing-boat at Swampscot, Massachusetts, when a Shark overset his boat and killed him. [This Shark must have been extremely ferocious. Mr. Blaney went out into the bay in one of the large Swampscot boats, which he left, and in a small boat rowed away, alone, to fish. After some hours he was seen to wave his hat for assistance. Another boat immediately started toward him, and presently the fish was seen to slide off, Mr. Blaney still remaining in his boat. But the Shark renewed the attack, carrying down the boat before the other could arrive. It came to the surface bottom up, and the unfortunate man was no more seen.]"[1]

The Sand Shark—Odontaspis littoralis.

This species, known also on the coast of Maine as the "Shovel-nosed Shark," and at Provincetown as the "Dogfish Shark," is found on our coast from New England southward to Charleston, and is believed by Günther to occur also about Australia and the Cape of Good Hope. Little is known of its habits or movements; it is occasionally found straggling upon the shores at Cape Cod or entangled in the mackerel-nets. It is a sluggish species and hugs the bottom closely, feeding upon crabs, lobsters, and squids. The ordinary length is five or six feet, but about Nantucket they grow much larger, attaining the length of nine or ten feet and the weight of two hundred pounds or more. It is a favorite amusement of summer visitors at Nantucket to fish for them, and ten or twelve are frequently taken by one man in a day. Their bodies are used for manure, while the livers are saved for the oil which they contain. The liver of a large individual will yield a gallon of oil, worth about seventy-five cents.[2]

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[1] Lewis & Newhall: History of Lynn, p. 395.

[2] Jackson: Proceedings Bost. Soc. Nat. Hist., vi, 1857, p. 259.

The Thrasher Shark—Alopias vulpes.

The Thrasher Shark, known in Europe as the "Fox Shark," and to our fishermen most usually as the "Swingle Tail," is found in the Northern Atlantic and in the Mediterranean, and also off California. It is one of the most grotesque of sea animals, the upper lobe of the tail being exceedingly long, curving upwards and resembling in form the blade of a scythe.

The Thrasher attains the length of fourteen or fifteen feet and the weight of five hundred pounds. An individual was taken in November, 1864, in the harbor of Marion, Massachusetts, which was thirteen feet long and weighed four hundred pounds. This species is quite common all along the coast of New England, and is frequently an annoyance to the mackerel fishermen by becoming entangled in their nets; otherwise it is quite harmless. It is found also in California.

The tales which are current regarding the ferocious attacks of these Sharks upon whales are apparently without foundation.

These animals feed upon fish, and it is said by the fishermen that they kill them by blows of the long, flexible tail. When they become entangled in the nets, or are caught on hooks, they *make a powerful resistance and cause the fishermen much trouble. Their livers are sometimes* used by the oil-makers. There is a belief widely current to the effect that the Thrasher Shark, singly or in companies, is accustomed to attack whales. This belief is undoubtedly founded upon errors of observation, as I think I have demonstrated in the chapter relating to the Sword-fish.

The Hammer-head Shark—Sphyrna zygæna.

This species is found all along the coast from Cape Cod southward, and, indeed, in tropical and subtropical seas the world over; it may be easily recognized by the curious form of the head, which is broad, flattened, and laterally elongated into two arms, which have been compared to the arms of a balance. It attains the length of seven or eight feet. Dillwyn obtained a female *specimen at Swansea, which contained thirty-nine young ones on the point of birth.*

The Hammer-head Shark is not uncommonly taken in summer, but is of no special importance. In Mitchill's "Fishes of New York," under the head of this species it is stated: "Three Sharks of the Shovel-nosed species were taken (in September, 1805) in a net by Mr. Joshua Turry, of Riverhead. The largest was eleven feet long. On opening him, many detached parts of a man were found in his belly; these were collected and buried; there was also found a striped cotton shirt, patched on the sides and sleeves with bright-colored pieces."[1]

It seems probable that the Shovel-nosed Shark referred to in the above paragraph was rather a *Carcharias*, since these Sharks are often called "Shovel-nosed Sharks" by the coast fishermen.

Bonnet-headed Shark—Sphyrna tiburo.

This species is found in our waters in company with the preceding species, and when both are known to the fishermen, the names "Hammer-head" and "Shovel-nosed" are used indiscriminately for both. Its distribution as at present understood is less extensive, since it has been found only in the warmer parts of the Atlantic and on the coast of China. It is very common on our South Atlantic and Gulf coast, where it is often distinguished as the "Bonnet-head." The habits of the two species are doubtless very similar.

The Blue Shark and the Dusky Shark—Carcharias cæruleus and Carcharias obscurus.

These two species, which are somewhat common in our waters south of Cape Cod and which can be distinguished apart only by trained observers, attain the length of twelve or fifteen feet,

[1] Transactions of Literary and Philosophical Society of New York, i, p. 48.

and are occasionally taken in nets. They are of no special value, and cause much annoyance to the fishermen. An individual taken at Wood's Holl, Massachusetts, in July, 1875, measured nine feet seven inches, and weighed three hundred and eighty pounds, the liver weighing thirty-eight pounds. It had in its stomach a bluefish of five pounds' weight. These two species feed upon mollusks as well as upon fish. Individuals examined by the Fish Commission were found to contain bluefish, flounders, crabs, lobsters, and quantities of a small species of a bivalve shell, *Yoldia sapotilla*.

The Black-finned Shark—Isogomphodon maculipinnis.

This species resembles in shape the Blue Shark, from which it may be distinguished by its lighter color and the presence of a prominent black spot upon the tip of each fin. The species is found in the tropical parts of the Atlantic and Indian Oceans and on the Pacific coast of Central America. It was first discovered on our coast in 1875, when several specimens were taken at Wood's Holl, Massachusetts.

The Tiger Shark—Galeocerdo tigrinus.

This is a species which is found throughout the Atlantic and Indian Oceans and on the coast of Japan. It was first noticed in our waters by Captain Atwood, who obtained specimens at Provincetown, and has since been observed occasionally. It is one of the most active and graceful of Sharks, as well as one of the most ferocious. Its teeth are like razors. In the stomach of a specimen taken by Captain Atwood at Provincetown, nearly a whole full-grown sword-fish was found; ten or twelve wounds in the skin of the Shark gave evidence of the contest that must have occurred. It feeds upon mollusks as well as upon other fishes. A specimen caught at Wood's Holl in 1871 contained large univalve shells, *Buccinum undatum*, and the sea-snail, *Lunatia heros*.

The Smooth or Blue Dogfish—Mustelus canis.

The Smooth Dogfish of our waters, *Mustelus canis*, is without doubt specifically identical with one of the common European species, *M. vulgaris*. The American name has, however, the right of priority. Hitherto, only a single species has been recognized upon Atlantic coasts. It is quite abundant on the coast of Southern New England. It feeds upon crabs, lobsters, and other bottom-loving invertebrates, its smooth pavement-like teeth being adapted for crushing the thick shells of these animals rather than for seizing and holding active fishes.

In Bermuda this fish is known as the "Nurse Shark," and is highly esteemed by the negroes as food, and is also an important bait in the local fisheries. At Folkstone, England, they are dried, and go by the name of "Folkstone beef."

The Horned or Spiny Dogfish—Squalus acanthias.

This species is found in the North Atlantic, occurring on the coast of Europe from the North Cape to the Mediterranean, and in our own waters south to New York. On the west coast it ranges south to Santa Barbara. Little attention has been paid to its habits. I cannot do better than quote fully the observations of Captain Atwood, who writes:

"This Shark is the most common one upon our coast. I have seen it at Gay Head, Martha's Vineyard, but know nothing further about its southerly limits. Both above and below Cape Cod it is abundant, and is found all along the coast of Massachusetts, Maine, Nova Scotia, and the Gulf of Saint Lawrence. I myself have never seen them farther north than the Magdalen Islands and the east coast of Cape Breton Island, but reliable accounts say that it is found on the southern coast of Newfoundland. As the Dogfish appear at Provincetown a little while after the

mackerel, and disappear shortly before them, I judge that they probably need warmer water than that fish, and therefore do not probably go quite so far north. When they first appear they are in great abundance; the females always excel in numbers the males; but in the early part of the season all are females, and all have young in some stages of development, though not in every stage, there being seldom any between the young just forming and those nearly grown. The gravid females may be found with the young in some stages of development during the whole season. The mature male weighs five or five and a half pounds, rarely as much as six pounds, while the female attains the weight of eight or eight and a half pounds. In spring they are poor, and their liver is of a dark color and lean; but in autumn it is quite fat and large, and the amount of oil does not increase proportionately with the enlarged size of the liver, but rather decreases. In the *Gadidæ*, on the contrary, the liver when in poor condition affords no oil. Fat is also found in the flesh of the Dogfish, which is sometimes used for fuel, burning well when dried."[1]

The same authority also writes: "When I first began to go fishing, in 1810 to 1820, the Dogfish fishery was considered one of the most valuable fisheries that we had around the shore. They appeared here in the spring, and were very plenty, and would last a day or two and then all would be gone. Then you would not see a Dogfish again all summer; but about the 10th, or middle of September they came to us again returning south. They would stay into November, and during that time the fishermen would get—a man and a boy—all the way from eight, ten, to fifteen barrels of oil. Twenty-five years ago we would occasionally see Dogfish in the summer. The last fifteen years they have been here all summer. During the war they were plenty all summer and the livers sold for one dollar a bucket, and now they are not worth but twenty and twenty-five cents. The female Dogfish is a good deal the biggest. I have known of Dogfish to be with full-grown young in November."

The annoyance which is caused by the presence of Dogfish may be judged from the fact that a trawl line, upon which were five hundred hooks, set by the Fish Commission party of Gloucester in 1878, had nearly one hundred and forty hooks bitten off by the Dogfish at one setting.

About Cape Ann the Dogfish do not come near the shore. Capt. S. J. Martin, an experienced fisherman, assures me that he has never seen one within three miles of land off Gloucester. They leave Cape Ann, for the most part, before October, and remain on George's Bank until December. They go upon the shoals of George's about the 20th of May, and stay all summer in the shoal water, especially, at a depth of thirty-five to forty fathoms, on the western part.

In addition to the oil yielded by these little Sharks, the skin is of considerable value, and will doubtless in future be more highly prized than it is at present. It is used by the fishermen to polish their metallic mackerel-jigs, and sometimes in polishing the fancy wood-work on shipboard. If properly brought into notice, the Dogfish skins would perhaps be used to advantage in many departments of metal-working.

In Southern New England this fish is called the "Bone-fish," in the Orkneys, the "Hoe."

Couch remarks: "It is the most abundant of the Sharks, and is sometimes found in incalculable numbers, to the no small annoyance of the fishermen, whose hooks they cut from the lines in rapid succession. I have heard of twenty thousand being taken in a seine at one time; such is the strength of instinct that little creatures, not exceeding six inches in length, may be found in company with the larger and stronger, following schools of fish, although at that time it is impossible that they could be able to prey."

[1] Proc. Bost. Soc. Nat. Hist., x, 1864-'66, pp. 81–82.

THE NURSE SHARK OR SLEEPER—SOMNIOSUS MICROCEPHALUS.

This species, also called by our fishermen the "Gurry" or "Ground" Shark, is a native of the Arctic Seas, but on our coast ranges south to Cape Cod, and in the Eastern Atlantic at least to England, while in the Pacific it has been observed from Puget Sound northward. The name "Gurry Shark" refers to its habit of feeding upon the refuse fish thrown overboard from the vessels.

This species is occasionally observed in Massachusetts Bay, especially when the carcasses of whales are floating about. Scoresby writes, in his work on the Arctic Regions: "This Shark is one of the foes of the whale; it bites it and annoys it when alive and feeds on it when dead. It scoops hemispherical pieces out of its body nearly as big as a person's head, and keeps scooping and gorging lump after lump until the whole cavity of its belly is full. It is so insensible of pain that, though it has been run through the body with a scythe-knife, yet I have seen it return to its banquet upon the whale at the very spot where it received its wound. Besides feeding upon whales, these Sharks also eat small fishes and crabs. The sailors imagine that it is blind because it pays not the least attention to the presence of a man, and is, indeed, so apparently stupid that it never draws back when a blow is aimed at it with a knife or lance."

Captain Atwood writes: "We don't see them very often about Provincetown, but sometimes they are seen in the bay. They would eat a whale if one were sunk there, and they eat halibut off the trawl. I have hauled up halibut and like enough the back would be all eaten off. Some of them are quite large. Robert E. Smith, of Barnstable, got one about fifteen feet long, half of whose liver filled a barrel. I don't know of their having been taken here for a good many years. The liver furnishes five or six gallons of oil; in one case a single half lobe filled a flour-barrel and yielded fifteen gallons of oil."[1]

201. THE SHARKS OF THE PACIFIC COAST.

By DAVID S. JORDAN.

The following is a list of the Sharks known from the Pacific coast. Of these, the three very large species, *Cetorhinus maximus*, *Carcharodon carcharias*, and *Somniosus microcephalus*, are valued for the oil in their livers, but are captured rather by accident, by whalers and fishermen, than by design. They are never made objects of pursuit. The Sharks *Squalus acanthias*, *Galeorhinus zyopterus*, and *Heptranchias maculatus* are regular objects of pursuit for their oil, and in the case of *Galeorhinus zyopterus* for their fins also. The young of several other species are dried by the Chinese, who utilize everything which their brethren on the railroads will eat. Others are used as craw-fish bait, and for similar purposes.

LIST OF SHARKS OF THE PACIFIC COAST.

Squatina angelus Duméril. Angel-fish, Angelo or Squat. From San Francisco southward. Not rare.

Heptranchias maculatus (Ayres) Grd. Shovel-nosed Shark. Monterey northward.

[1] A large winter Shark was driven ashore in the storm of the 20th instant at Cotuit Port. It was fifteen feet in length, and his liver made fifteen gallons of oil.—*Gloucester Telegraph*, February 2, 1860.

The schooner "Cosmos," of Swampscot, landed a formidable Nursefish at Portsmouth recently. It measured sixteen feet in length and weighed about twenty-five hundred pounds, and was caught on a common trawl line.—*Cape Ann Advertiser*, March 11, 1881.

Hexanchus corinus J. & G. Monterey northward.
Heterodontus Francisci (Grd.) Dum. Leopard Shark. Point Concepcion southward.
Scylliorhinus ventriosus Garman. Ground Shark. From Monterey southward.
Alopias vulpes (Gmel.) Bonap. Thrasher. Monterey Bay.
Isurus sp. San Pedro.
Lamna cornubica (L.). Monterey Bay.
Carcharodon carcharias (L.) J. & G. Man-eater Shark. Monterey Bay and southward.
Cetorhinus maximus (L.) Blainv. Ground Shark. Monterey Bay northward.
Sphyrna zygæna (L.) Raf. Hammer-head Shark. San Pedro.
Carcharias glaucus (L.) J. & G. Blue Shark. San Francisco and northward.
Carcharias lamella J. & G. Bay Shark. San Diego.
Galeocerdo tigrinus Müller & Henle. San Diego.
Galeorhinus zygopterus J. & G. Oil Shark. San Francisco and southward.
Triacis semifasciatus Grd. Cat Shark. San Francisco and southward.
Triacis Henlei (Gill.) Putn. *Monterey and northward.*
Mustelus californicus Gill. Dog Shark. San Francisco and southward.
Squalus acanthias L. Dog-fish; Spinarola. Santa Barbara to Alaska.
Somniosus microcephalus (Bloch) Gill. Puget Sound northward.

Shovel-nosed Shark—Heptranchias maculatus.

This species is usually known as the "Shovel-nosed Shark." It reaches a length of three to five feet. It ranges from Monterey Bay northward, being most abundant in Northern California. About Eureka, on Humboldt Bay, it is pursued for its oil, which has some value. For a discussion of this, see the account of Humboldt County, California.

Oil Shark—Galeorhinus zyopterus.

This species, which is closely allied to the common Tope of Europe, is known in California as the "Oil Shark" or "White Shark." It reaches a length of five to six feet and a weight of thirty to forty pounds, the average being about twenty. It ranges from Tomales to San Diego, being especially abundant in spring about Monterey and Los Angeles, especially at Soquel, Monterey, Westminster, and Newport. It feeds on other fishes, herring being the best bait. It brings forth its young alive from April to August, entering small bays and lagoons for this purpose. At these times it is chiefly taken. It is valued for the oil in its liver and for its fins. A liver makes from one-half to one gallon of oil. The fins are sold to the Chinese, who dry them, and removing the skin and flesh extract from the rays a fine, clear-white gelatine, which is highly valued by them for making soups. This is the only American species the fins of which they consider valuable.

Dogfish—Squalus acanthias.

This species is everywhere called the "Dogfish." The Italian fishermen also call it "Spinarola." It reaches a length of about three feet. It ranges from Alaska southward as far as Santa Barbara, but its abundance is from Puget Sound northward among the islands. It lives especially in deep or quiet bays and channels, coming into shallower waters in pursuit of schools of herring, smelt, or salmon. It feeds on anything, even its own young, but the herring make the chief part of its diet. The young are brought forth in June in Puget Sound. It is valued for its liver, from which dogfish oil is extracted.

202. THE LAMPREYS—PETROMYZONTIDÆ.

In the fresh and brackish waters of the United States occur several species of the Lamprey family.

NAMES.—The habits of these fishes are not well understood, and in the present discussion we shall be obliged to rely to a considerable degree on the observations of European zoologists. In the United States the fishes, of whatever species, are generally known as "Lampreys" and "Lamper Eels," these names being also in use in England, where one of the smaller species, *P. branchialis*, is also known as the "Pride," "Prid," or "Sandpiper." The name "Nine-eye" is also common in England, a name which reappears on the continent in the "Neunauge" and "Neunaugel" of Germany and Austria, and the "Nejon ögon" of Scandinavia. This curious name had its origin in the eye-like appearance of the circular branchial openings, of which a considerable number appear on either side of the head. In the common "Nine-eye" of England, however, there are only seven, and even if the eye be counted only eight, eye-like circles upon each side. In Germany the name most commonly in use is "Pricke" or "Bricke," while in France "Lamproie" is their usual appellation, and in Italy "Lampreta."

DISTRIBUTION.—The Lampreys are almost the least specialized of fishes. Although in form resembling the eels, they belong to a very different group, which by Gill and others of our best authorities has been considered a distinct class, and are not even entitled to be called fishes. So slight has been the progress in the scientific study of the Lampreys, that but little can be definitely stated about their geographical distribution, excepting that they occur in the fresh waters and along the coasts of the temperate regions of both hemispheres. The largest and best known species, and the only one which has at present any commercial value, is *Petromyzon americanus*, by most authorities believed to be identical with the *P. marinus* of Europe,[1] which occurs in the streams and estuaries of our eastern coast from Nova Scotia as far south at least as Cape Hatteras.

HABITS.—The key to the habits of the Lampreys is found in the peculiar arrangement of their mouth. In *P. marinus*, according to Emile Blanchard, this is completely circular and forms a great sucker enormously capacious, surrounded by a fleshy lip studded with tentacles and supported within by a cartilaginous framework. This mouth is covered over its entire interior surface with strong teeth arranged in concentric circles, some single, others double, the larger occupying the central portion, and the smaller forming the exterior rows. A large double tooth, situated above the aperture of the mouth, indicates the situation of the upper jaw; a large cartilage, supporting seven or eight great teeth, represents the lower jaw. The tongue also carries three large teeth, deeply serrated upon their edges.

The structure of the intestine, which, as in the Sharks, is provided with an extensive spiral valve, indicates that these animals are chiefly carnivorous in diet. They are said to feed upon worms, insects, and decaying animal matter. Dr. Benecke, of Königsberg, and others have found their stomachs full of the eggs of fish. The structure of the mouth, however, would teach us, even in default of observations upon their customary mode of feeding, that they are semi-parasitic in their habits, attaching themselves to large fish by suctorial action, and, while attached, tearing the flesh of the fish with their marvelous mincing machine, which is composed of the teeth within the circular mouth, while they suck the blood of their victim. They are often found attached to the larger fishes, such as shad, sturgeons, and Sharks.

Captain Atwood states that small Lampreys of a bluish color are found attached to various

[1] GÜNTHER: Catalogue of Fishes of the British Museum, viii, p. 501.

species of fish in Massachusetts Bay, such as cod, haddock, and mackerel. They cling to the side of the fish beneath the pectoral, and suck its blood until the flesh becomes as white as paper.

There can be but little doubt that to the Lampreys may be credited an immense destruction of the various food-fishes which enter estuaries and rivers. It is by no means uncommon for fishermen to find them attached to halibut and other large species caught at sea. Lampreys are found far inland, ascending most of the creeks and rivers of Central Europe and of temperate North America far toward their sources. In fact the distances from the sea at which the so-called "sea Lamprey" of Europe is constantly found are so great, when their feeble powers of locomotion are considered, that Dr. Günther in his essay on the fishes of the Neckar was induced to advance the theory that they are carried from the sea to the river sources by the shad, salmon, and other fish to which the Lampreys attach themselves. This view is combated by Blanchard, who claims that no one has ever seen Lampreys attached to salmon. If I am correctly informed, salmon are largely annoyed by Lampreys in the United States, but it seems hardly necessary at present to accept Günther's theory in the fullest extent, since the Lamprey is apparently not much inferior to the eel in powers of locomotion, and the eel, it is well known, accomplishes long migrations without apparent inconvenience.

It has been customary among writers upon fishes to class the Lampreys among the migratory fishes, and to describe the migrations of the sea Lamprey as beginning in the spring, when they are supposed to ascend the rivers for the purpose of spawning in their headwaters. This theory seems at present hardly tenable; so little, however, is known of their habits that the theory cannot be pronounced absolutely incorrect. There are, however, certain species of Lampreys in Europe which are believed to live entirely in fresh water. A similar statement can most positively be made regarding our species inhabiting the Great Lakes and other inland waters of North America. On the other hand, many of the sea Lampreys remain in salt and brackish water throughout the year. There appears, however, to be excellent evidence that some of the Lampreys move from brackish water into fresh for purposes of spawning.

Benecke, speaking of the habits of the river Lamprey of the Baltic, remarks: "Concerning the habits of 'Nine-eyes' in the sea nothing is known. In summer they make their way from the Baltic into the Kurisches Haff and the Frisches Haff, and toward the end of September begin to ascend the rivers, and are caught in great numbers in baskets and pots. The ascent continues until January. In the upper reaches of the rivers they make their appearance in the early spring, and spawn in April and May in small schools in shallow places, where the water flows rapidly over shingly bottom. The act of spawning has been observed by us from year to year in the passage between the bridges at Braunsberg. After the eggs, which are one millimeter in diameter, grayish-yellow in color, and entirely opaque, have been deposited in little masses, the Lampreys die.

"The development of the spawn is extremely dependent upon the weather, so that during many years only a very small brood of young fishes makes its appearance. The young of this species have been found by August Müller in the Oder and the Alle, and in the latter (!) the drying up of one of its tributaries near the mill at Pinne gives an opportunity every year to collect hundreds of them in the bottom mud. They are never found partially grown, and we must believe that they go back to the sea, there to attain their full size."

REPRODUCTION.—Concerning the breeding habits of the brook Lamprey, *P. planeri*, Benecke writes: "The brook Lampreys, like the allied species, feed upon little animals, and are found in almost all the clear brooks in Prussia, seeming never to migrate to the sea, although Yarrell claims that he has found them there. The clear gray or grayish-yellow eggs, which are one millimeter in thick-

ness, are deposited in March or April. The adult fish gather themselves together in companies of from ten to fifty individuals to spawn in water of little depth, where the current flows swiftly over rough ground. In close proximity to each other they cling with their mouths to the bottom, and their bodies streaming out in the current squirming like the bodies of snakes. Every once in a while the observer can see a male, easily recognizable by its size and black color, seize upon one of the females with its suctorial mouth, and therewith firmly attaching itself to her close behind the head. The two then extend themselves with a powerful backward squirm, and while the male, with a half turn of its body, brings his abdominal aperture close to that of the female, a part of her spawn may be seen flowing forth in a clear, semi-opaque stream. This action is repeated until the female has deposited all of her eggs. The young Lampreys, when hatched, burrow in the mud. They require a period of four or five years before they attain the length of twenty centimeters."

The development of the Lamprey is extremely remarkable. It was first worked out thoroughly by Prof. August Müller in 1856.[1] The young was formerly considered to be a member of a distinct genus, *Ammocœtes*. The young of the brook Lamprey, *P. planeri*, which, in a general way, correspond to those of other species, are thus described by Professor Benecke: "They are tawny yellow, without any trace of silvery hues, and have half-moon shaped, toothless mouths, not intended for suctorial uses. Their small eyes are hidden deeply under their thick skins, and hardly visible. Their gill-openings lie in a deep furrow. The head is small and pointed, and the fins continuous."

It is a curious fact that as early as 1866 Leonhart Boldner, of Strasbourg, investigated and thoroughly understood the development and metamorphoses of the Lamprey, as is indicated in the following paragraph, translated from his work upon the water-birds, fishes, and other aquatic animals of Strasbourg:

"From August to December, Lampreys with eyes are not often seen and are rarely taken, but blind Lampreys are found throughout the entire year. The Lampreys with eyes and the blind Lampreys are all of the same kind, for the young from the very beginning are all blind, and bury themselves at once in the mud as soon as they make their escape from the eggs. The blind Lampreys develop no eggs until they develop their eyes."[2]

Like the eel, the Lamprey was formerly believed to be hermaphrodite.[3]

As far as I am aware, few observations are on record which indicate the date of the spawning of the Lampreys in this country. *P. niger* spawns in early spring. Wittmack, in his excellent work upon the "Fishery Statistics of Germany," states that *P. marinus* spawns at Hameln in June, and in the Rhine, at Zurich, in March and April; *P. fluviatilis* in various parts of Northern Germany, chiefly in March, April, May, and June, though in the Kurisches Haff also in November, December, and February. In Bavaria their spawning season is from March to June; in Austria in April and May, and in Switzerland in March and April. *P. planeri* is said by the same author to spawn in Pomerania in May; in the Rhine Provinces in March and April; in Hanover in May and June; in Gotha in March and April, and in Lower Bavaria in May, June, and July; in the Tyrol in March, April, May, and June, and in Switerland in March and April. In the rivers of Connecticut, where a lamprey fishery is still carried on, Lampreys are reported to be abundant in May and June; and it is probable that these months are included within the period of spawning. The artificial propagation of the Lamprey was first successfully accomplished on the 24th of May, 1879, when M. Frauen, employed by the German Fishery Union in gathering sturgeon-eggs in

[1] MÜLLER: Archiv für Naturgeschichte, 1856, p. 325.
[2] VON SIEBOLD: Süsswasserfische Mitteleuropas, p. 378.
[3] SIR EDWARD HOME in Philosophical Transactions, 1815, p. 266.

Schleswig-Holstein, fertilized the eggs of the river Lamprey and placed them in a breeding box. Between June 3 and June 16, many young were hatched out, and on July 17 the entire contents of the breeding box escaped.[1]

As has already been stated, it requires four or five years for the larval Lamprey to undergo its metamorphoses and become capable of reproducing its kind. The sea Lamprey, *P. marinus*, often attains the length of three feet; but those species which are found only in fresh water are usually much smaller.

The name *Petromyzon* signifies "a stone-sucker," it being a common habit of these animals to cling to stones and pebbles. In swift currents this habit is of great importance to them, since it enables them to hold their own where their swimming powers would often be severely taxed. It is stated by careful observers that they have some way of transporting stones, and that they build nests, or rather circular fortifications of stonework, around the crevices in which they lurk. As may be inferred from what has already been said of the manner in which they prey upon other fishes, Lampreys are among the most troublesome enemies of many large species. Günther states that salmon have often been captured in the middle courses of the Rhine with marine Lampreys attached to them. Milner, in his "Report on the Fisheries of the Great Lakes,"[2] remarks: "A parasite that troubles the sturgeon is the Lamprey Eel, *Petromyzon argenteus*, Kirt., which is found very frequently attached to the skin. The circular scars and raw sores sometimes found upon the sturgeon, and attributed to this cause by the fishermen, are correctly accounted for in this way. It is probable that their natural food is the slime or mucus exuded in abundance from the pores, but they frequently retain their hold upon a spot until they have eaten through to the flesh, and deep ulcerous cavities occasionally result from the sore."

ECONOMIC USES AND CAPTURE.—The Lamprey was formerly highly esteemed as an article of food, and in early days is said to have constituted an important dish in certain civic feasts of Europe. It was once the custom to drown Lampreys in wine and then to stew them. This process was supposed to impart a higher flavor to the flesh. It is stated by Lacépède that King Henry I, of England, came to an untimely end by too full a repast of Lampreys. At the present time, in Germany and France, they are cooked in earthenware jars with vinegar and spices, and are frequently seen among the relishes and *hors-d'œuvre* brought upon the tables as a preliminary course. They are also highly esteemed in many other parts of the continent. At present in this country Lampreys are but little prized, except in certain portions of New England, particularly along the Connecticut River. Col. Theodore Lyman, in his report as fish commissioner of Massachusetts for 1876,[3] states that the Lamprey Eel is a fish greatly esteemed by the country people of Massachusetts, and one which was formerly taken in almost incredible numbers in the Merrimack. It was found as far north as Plymouth, New Hampshire, and by the Connecticut River also it passes into the same State. When the Saint Lawrence dam, in 1847, was first completed, several cart-loads were daily taken by one man for a considerable period. In 1840 Mr. Joseph Ely took thirty-eight hundred in one night at Hadley Falls. It was then the custom of the country for each family to salt down several barrels of Lampreys for winter use. "Now, in 1866," he continues, "this valuable fish has become nearly extinct in both rivers." This remark should be interpreted as applying simply to the headwaters of the Connecticut, since in the tributaries of its lower stretches there is still a considerable lamprey fishery and a large local consumption.

Mr. George Lyon, of Bridgewater, Connecticut, writes under date of August 25, 1879:

[1] Circular der Deutschen Fischerei-Verein, 1879, pp. 135, 136, 159.
[2] Report United States Fish Commission, part ii, 1874, p. 74.
[3] Page 40.

"Previous to the building of the dam over the Housatonic at Birmingham, Lampreys were taken in large quantities as far up the river as the falls in the town of New Milford; now none are seen above the dam. Then, standing over the falls on shelving rocks, one could hook them, as they clung to the rocks with their suckers, by means of a large sharp hook fastened to a long pole, this hook being imbedded in the holes in the sides of their necks. Many people formerly salted barrels of them for their own consumption. Their use at present has much decreased, owing to the disturbance in the fisheries caused by the building of the dams. Those now used in the vicinity of Bridgewater are taken in the Housatonic at Birmingham, and during the months of May and June are peddled through the country by the people who catch them."

Mr. N. M. Muckett, of Lakeville, Connecticut, states that in that vicinity the annual average catch is about two thousand fish, the implement of capture used being a pole about six feet in length with a hook in its end. The fisheries are located in Salmon River about two miles from the Connecticut, just above tide-water, and the Lampreys sell in the markets of the adjoining villages at an average price of five dollars a hundred.

Mr. M. A. Hart, of Riverton, Connecticut, says that thirty years ago, and before, Lampreys were found in the Farmington River in the vicinity of Riverton, but have long ago been exhausted. Quantities are sold in the city markets of Southern Connecticut, chiefly obtained in the Connecticut River in spring and early summer. They are easily caught with the hands, and fishermen capturing them in this way always use mittens.[1]

Mr. C. M. Hunt, of Northville, Connecticut, states that in New Milford large quantities are consumed in May and June which are caught in the Housatonic at Birmingham. Before the dam was built they were caught everywhere in the Housatonic and the small streams which are its tributaries.

203. THE HAG-FISHES—MYXINIDÆ.

The "Slime Eel," *Myxine glutinosa*, is found on the Atlantic coast north of Cape Cod, and in the deeper water even further south. It occurs also on the coasts of Northern Europe. It is a great annoyance to the fishermen, whose baits it devours, and who entertain for it a superstitious dread. Little is known of its habits, and its importance to man is very slight. Jordan writes:

"The Hag-fishes (*Myxinidæ*) are represented along the California coast by one species, *Polistotrema Stouti*. It is most abundant in Monterey Bay, where it is very destructive to fishes caught

[1] The Hartford (Conn.) "Post," in June, 1876, contained the following paragraph:

"CURIOUS HABITS OF LAMPREY EELS.—Two gentlemen from Granby, Connecticut, Messrs. Dewey and Goodrich, were in town last week on a visit, and took away with them on their return one hundred and ten Lamprey Eels, which they captured in the creeks hereabout. The Eels were all of good size, sixty-two of them weighing one hundred pounds. These Eels are esteemed to be a great delicacy by the people of Granby and neighborhood, and are held to be worth twelve cents apiece, or they offer to exchange a barrel of pork for a barrel of cured Eels. The method of taking these Eels is quite novel. They are found only in shallow water, with stony or gravelly bottom, and the fisherman goes provided with a large bag of netting, the mouth of the bag being distended with a hoop, and an instrument of iron about eighteen inches long terminating in a hook.

"The Eels have what are called nests, made by heaping up stones in a circle of about eighteen inches in diameter. These stones they place in this position by fastening their sucker mouths thereon and moving themselves laterally, drawing the stones along with them. Inside this circle of stones lie usually from three to five Eels, parallel with one another, their heads all in one direction and each Eel made fast by suction to a stone. The bold fisherman approaches them from behind, and, skillfully putting his hook under an Eel, he suddenly brings it up with such force that it penetrates the hide, and brings out the fish, when, after two or three flourishes in the air to get him in the right position, he is deposited in the bag. Each Eel in the nest is in turn made the subject of a similar operation, the creatures often holding on to the stone with such tenacity as to bring it out of the water with them, when the aërial flourish causes it to become detached and to fly to a considerable distance.

"These Eels, it is said, are wholly free from bones save the backbone, which is removed in dressing, and when salted for a few weeks and fried make an article of food second to none in the way of fish."

in gill-nets. It fastens itself on the eyes, or especially the gills, of fishes and works itself into the inside of the body, where it devours all the flesh without breaking the skin, so that the fish is left a mere hulk of head, skin, and bones. Every gill-net in summer at Monterey has more or less of these empty hulks (*Sebastichthys, Ophiodon, Rhacochilus, Paralichthys,* etc.) in it. It is thought by the fishermen that the Hag-fish will eat a fish of five or six pounds weight in a single night. When a hulk is taken out of the water with a Hag-fish in it, the parasite will scramble out with great alacrity. They reach a length of fourteen inches."

204. THE LANCELETS—BRANCHIOSTOMIDÆ.

The Lancelet, or Amphioxus, *Branchiostoma lanceolatum*, interesting as being the lowest and least specialized of vertebrate animals, has been found at the mouth of the Chesapeake, at Flatts Village, Bermuda, and at San Diego, California.

PART IV.

MOLLUSKS.

W.—MOLLUSKS IN GENERAL..... By Ernest Ingersoll.
X.—THE LIFE HISTORY OF THE OYSTER .....By John A. Ryder.

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ANALYSIS.

W.—MOLLUSKS IN GENERAL. Page.

205. The Cuttles: Cephalopoda 687
206. The Sea-snails: Gasteropoda 693
207. The Wing-shells: Pteropoda 702
208. The Tusk-shells: Solenoconcha 703
209. The Bivalves: Lamellibranchiata 703

X.—A CONTRIBUTION TO THE LIFE-HISTORY OF THE OYSTER.

210. Outline Sketch of the Coarser Anatomy of the Oyster 711
211. The Minute Anatomy of the Oyster 715
212. Sex of the American and European Oysters 719
213. New Methods of Distinguishing the Sexes and of Taking the Eggs of the Oyster 722
214. Rate of Growth of Ostrea virginica 725
215. The Food of the Oysters 729
216. The Cause of the Green Color of Oysters 735
217. Local Variations in the Form and Habits of the Oyster 742
218. The Oyster Crab as a Mess-mate and Purveyor 744
219. Physical and Vital Agencies Destructive to Oysters 746
220. Natural and Artificial Oyster Banks 750

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W.—MOLLUSKS.

205. THE CUTTLES—CEPHALOPODA.

The mollusks called "Cuttles" or "Cuttle-fishes" bear a very important relation to the fisheries and consequently to the food supply of the United States. It has recently been ascertained that some of these Cuttle-fishes attain huge bulk and corresponding abilities for destruction. The two species of *Architeuthis* (*A. princeps* and *A. Harveyi*), roaming through the North Atlantic and now and then stranded upon the beaches of Newfoundland, have each a total length of from thirty to fifty feet, and a weight of solid flesh amounting to thousands of pounds.

"The Cuttles," says Dr. Philip Carpenter, "have very acute senses. They have an approach to a brain, inclosed in a cartilaginous skull. They can hear sounds, and evidently enjoy the taste of their food. They have a large, fleshy tongue, armed with recurved prickles, like that of the lion. They either crawl on their head tail upwards, or swim, tail foremost, by striking with their arms, or squirt themselves backwards by forcing water forward through their breathing funnels.

"They are ferocious creatures, the tyrants of the lower orders, and do not scruple to attack and devour even fishes. The larger kinds are deservedly dreaded by man. Their weapons consist in their powerful arms, which are abundantly furnished with rows of cup-like suckers, each of which fastens on its prey or its foe like a limpet to the rock. Often these are accompanied with sharp-curved teeth, strong enough to be preserved even in fossil species."

The giant Cuttle-fishes of the north (*Architeuthis*) and the commoner Squids and Calamaries of our Atlantic coast belong to the ten-armed division of the order termed Decapods. The three smaller species ordinarily met with are *Loligo Pealei*, *Loligo Pealei* var. *pallida*, and *Ommastrephes illecebrosus*. On the extreme southern coast they are replaced by an Octopod (*Octopus granulatus*).

Of these four, *Loligo Pealei* is the common Squid of Long Island Sound and southward, and when full grown it is more than a foot in length. The color when living is very changeable, owing to the alternate contractions of the color-vesicles or spots, but red and brown predominate, so as to give a general purplish-brown color. An allied variety or subspecies, named *pallida*, is a "pale, translucent, gelatinous-looking" creature, with few spots on the back and nearly white beneath. Commonly five or six inches long, exclusive of the arms, it frequently grows much larger, and is of broader and stouter proportions than the type-form, from which it is further distinguished by its broader caudal fin and the larger size of its suckers. It belongs especially to the western end of Long Island Sound, "where it is abundant with the schools of menhaden, on which it feeds."

"This species," writes Verrill,[1] "is found along the whole coast from South Carolina to Massachusetts Bay.

"It is the *Common Squid* from Cape Hatteras to Cape Cod. In Long Island Sound and Vineyard Sound it is very abundant, and is taken in large numbers in the fish-pounds and seines, and used to a large extent for bait. It is comparatively scarce, though not rare, north of Cape Cod. The young were trawled by us in many localities in Massachusetts Bay in 1878. Large specimens were taken in the pounds at Provincetown, Massachusetts, August, 1879. It was taken in considerable

[1] Report U. S. Fish Commission, part vii, 1882, p. 355.

quantities, in breeding condition, in the fish-pounds at Cape Ann, near Gloucester, Massachusetts, May, 1880 (var. *borealis*). It has not been observed north of Cape Ann. Its southern limit is not known to me, but it appears to have been found on the coast of South Carolina.

"In depth, it has occurred from low-water mark to fifty fathoms. The eggs[1] have often been taken by us in the trawl, in great abundance, at many localities along the southern shores of New England, in five to twenty-five fathoms.

"It is known to be a very important element in the food supply of the bluefish, tautog, sea-bass, striped bass, weakfish, king-fish, and many other of our larger market fishes.

"*In the Gulf of Mexico this species appears to be replaced by another species* (*Loligo Gahi* D'Orbigny). Of this we have several specimens, collected on the west coast of Florida, at Egmont Key, near Tampa Bay, by Col. E. Jewett and Mr. W. T. Coons. This species is closely allied to *L. Pealei*, *but has a more slender form, with the caudal fin shorter and narrower in proportion to* the length of the mantle. The pen has a shorter and broader shaft, and a narrower and more oblong blade, which has parallel, thickened, and darker-colored portions between the midrib and margins. The tentacular suckers have their horny rings more coarsely and equally toothed, there being only a partial alternation of larger and smaller teeth.

"Along our southern coast, from Delaware Bay to Florida, a much shorter and relatively stouter species (*Loligo brevis* Blainv.) occurs, which might be mistaken by a careless observer for the present species. In addition to its shorter body, it has very different large, tentacular suckers, with the teeth on the horny rim coarser and all of similar form and size. Its pen is also shorter and relatively broader, and different in structure."

"I am not aware," he says elsewhere,[2] "that any definite information has hitherto been published as to the rate of growth or length of life of any of our cephalopods. By some writers it has been stated that the Squids are all annual, but this seems to be a mere assumption, without any evidence for its basis. Therefore I have for several years past preserved large numbers of specimens of the young of *Loligo Pealei*, collected at different seasons and localities, in order to *ascertain, if possible, the rate of growth and the size acquired during the first season, at least.* One of the following tables (I) shows some of the data thus obtained.[3]

"There is considerable difficulty in ascertaining the age of these Squids, owing to the fact that the spawning season extends through the whole summer, so that the young ones hatched early in June are as large by September as those that hatch in September are in the following spring. Owing to the same cause, most of the large lots of young Squids taken in midsummer include various sizes, from those just hatched up to those that are two or three inches long. They are often mixed with some of those of the previous year, considerably larger than the rest. Earlier in the season (in May and the first part of June), before the first-laid eggs begin to hatch, the youngest specimens taken (60^{mm} to 100^{mm} long) are presumed to belong to the later broods of the previous autumn, while those somewhat larger are believed to be from earlier broods of the previous summer, and to represent the growth of one year very nearly.

"Taking these principles as a guide, I have arrived at the following conclusions from the data collected:

"1. The young Squids begin to hatch at least as early as the second week in June, on the

[1] In early summer this Squid resorts to gravelly and weedy bottoms to lay its eggs. They are contained in bunches or clusters, sometimes six or eight inches in diameter, consisting of hundreds of gelatinous capsules each holding numerous eggs. These clusters are attached to some fixed object, and the oysters upon planted beds offer conveniences which the Squid is very likely to adopt. This occurrence seems to be a source of decided harm in Delaware Bay, for the oystermen there assert that the larger "sea-grapes" (as they call the egg-bunches) lift many oysters from the bottom by their buoyancy and float them off in stormy weather.—E. I.

[2] Report U. S. Fish Commission, part vii, 1882, pp. 353–355.

[3] See the original article.

southern coast of New England, and continue to hatch till the middle of September, and perhaps later.

"2. By the second week in July, the first hatched of the June Squids have grown to the size in which the body (or mantle) is 30^{mm} to 48^{mm} long; but these are associated with others that are younger, of all sizes down to those just hatched. They begin to show a disposition to go in 'schools' composed of individuals of somewhat similar sizes.

"3. By the second week in August, the largest June Squids have become 50^{mm} to 68^{mm} in length of body, and the later broods are 5^{mm} to 30^{mm} long. As before, with these sizes occur others of all ages down to those just hatched. It should be observed, however, that in those of our tabulated lots taken by the trawl the very small sizes are absent, because they pass freely through the coarse meshes of the net.

"4. By the second week in September, the June Squids have the mantle 60^{mm} to 82^{mm} long. All the grades of smaller ones still abound. A few larger specimens, taken the last of August and in September, 84^{mm} to 110^{mm} long, may belong to the June brood, but they may belong to those of the previous autumn.

"5. In the first week of November, the larger young Squids taken had acquired a mantle-length of 79^{mm} to 85^{mm}, but these are probably not the largest that might be found. Younger ones, probably hatched in September and October, 8^{mm} to 20^{mm} in length of body, occurred in vast numbers November 1, 1874. The specimens taken November 16, off Chesapeake Bay, having the mantle 40^{mm} to 70^{mm} long, probably belong to the schools hatched in the previous summer.

"6. In May and June the smallest Squids taken, and believed to be those hatched in the previous September or October, have the mantle 62^{mm} to 100^{mm} long. With these there are others of larger sizes, up to 152^{mm} to 188^{mm}, and connected with the smaller ones by intermediate sizes. All these are believed to belong to the various broods of the previous season. In these the sexual organs begin to increase in size and the external sexual characters begin to appear. The males are of somewhat greater length than the females of the same age.

"7. In July, mingled with the young of the season, in some lots, but more often in separate schools, we take young Squids having the mantle 75^{mm} to 100^{mm} long. These we can connect by intermediate sizes with those of the previous year taken in June. I regard these as somewhat less than a year old.

"8. Beyond the first year it becomes very difficult to determine the age with certainty, for those of the first season begin, even in the autumn, to overlap in their sizes those of the previous year.

"9. It is probable that those specimens which are taken in large quantities, while in breeding condition, during the latter part of May and in June, having the mantle 175^{mm} to 225^{mm} long in the females and 200^{mm} to 275^{mm} long in the males, are two years old.

"10. It is probable that the largest individuals taken, with the mantle 300^{mm} to 425^{mm} long, are at least three years, and perhaps in some cases four years old. The very large specimens generally occur only in small schools and are mostly males. The females that occur with these very large males are often of much smaller size, and may be a year younger than their mates.

"11. When Squids of very different sizes occur together in a school, it generally happens that the larger ones are engaged in devouring the smaller ones, as the contents of their stomachs clearly show. Therefore, it is probable that those of a similar age keep together in schools for mutual safety.

"12. Among the adult specimens of var. *pallida* taken November 16 and December 7, at Astoria, there are several young ones, from 75^{mm} to 120^{mm} in length, with rudimentary reproductive organs. These may, perhaps, be the young of the year, hatched in June."

Young Squids in inconceivable numbers, and even the adults, are greedily devoured by bluefish, black bass, striped bass, weakfish, mackerel, cod, and many other marine animals. Thus they are really of great importance as food for our most valuable market fishes.

North of Cape Cod the Squid is represented by the Sea-arrow or Flying Calamary, *Ommastrephes illecebrosus*, sometimes called "short-finned" in contrast to the long "fins" characteristic of the Loligos, which they resemble in size and color.

Professor Verrill has given the following graphic account of this species:

"When living, this is a very beautiful creature, owing to the brilliancy of its eyes and its bright and quickly-changing colors. It is also very quick and graceful in its movements. This is the most common 'Squid' north of Cape Cod, and extends as far south as Newport, Rhode Island, and in deep water to the region off Cape Hatteras. It is very abundant in Massachusetts Bay, the Bay of Fundy, and northward to Newfoundland. It is taken on the coast of Newfoundland in immense numbers, and used as bait for codfish. It occurs in vast schools when it visits the coast, but whether it seeks those shores for the purpose of spawning or in search of food is not known. I have been unable to learn anything personally in regard to its breeding habits, nor have I been able to ascertain that any one has any information in regard either to the time, manner, or place of spawning. At Eastport, Maine, I have several times observed them in large numbers in midsummer. But at that time they seemed to be wholly engaged in the pursuit of food, following the schools of herring, which were then in pursuit of shrimp (*Thysanopoda norvegica*), which occur in the Bay of Fundy, at times, in great quantities, swimming at the surface. The stomachs of the Squids taken on these occasions were distended with fragments of *Thysanopoda*, or with the flesh of the herring, or with a mixture of the two, but their reproductive organs were not in an active condition. The same is true of all the specimens that I have taken at other localities in summer. From the fact that the oviducts are small and simple, and the nidamental glands little developed, I believe that it will eventually prove that this species discharges its eggs free in the ocean, and that they will be found floating at the surface, either singly or in gelatinous masses or bands, not having any complicated capsules to inclose them. Nothing is known as to the length of time required by this species to attain its full size. It probably lives several years.

"This Squid is an exceedingly active creature, darting with great velocity backward, or in any other direction, by means of the reaction of the jet of water which is ejected with great force from the siphon, and which may be directed forward or backward, or to the right or left, by bending the siphon. Even when confined in a limited space, as in a fish-pond, it is not an easy matter to capture them with a dip-net, so quick will they dart away to the right and left. When darting rapidly the lobes of the caudal fin are closely wrapped around the body and the arms are held tightly together, forming an acute bundle in front, so that the animal, in this condition, is sharp at both ends, and passes through the water with the least possible resistance. Its caudal fin is used as an accessory organ of locomotion when it slowly swims about or balances itself for some time nearly in one position in the water.

"The best observations of the modes of capturing its prey are by Messrs. S. I. Smith and Oscar Harger, who observed it at Provincetown, Massachusetts, among the wharves, in large numbers, July 28, 1872, engaged in capturing and devouring the young mackerel, which were swimming about in 'schools,' and at that time were about four or five inches long. In attacking the mackerel they would suddenly dart backward among the fish with the velocity of an arrow, and as suddenly turn obliquely to the right or left and seize a fish, which was almost instantly killed by a bite in the back of the neck with their sharp beaks. The bite was always made in the same place, cutting out a triangular piece of flesh, and was deep enough to penetrate to the spinal cord. The attacks

were not always successful, and were sometimes repeated a dozen times before one of these active and wary fishes could be caught. Sometimes, after making several unsuccessful attempts, one of the Squids would suddenly drop to the bottom, and, resting upon the sand, would change its color to that of the sand so perfectly as to be almost invisible. In this position it would wait until the fishes came back, and when they were swimming close to or over the ambuscade, the Squid, by a sudden dart, would be pretty sure to secure a fish. Ordinarily, when swimming, they were thickly spotted with red and brown, but when darting among the mackerel they appeared translucent and pale. The mackerel, however, seemed to have learned that the shallow water was the safest for them, and would hug the shore as closely as possible, so that in pursuing them many of the Squids became stranded and perished by the hundreds, for when they once touch the shore they begin to pump water from their siphons with great energy, and this usually forces them farther and farther up the beach. At such times they often discharge their ink in large quantities. The attacks on the young mackerel were observed mostly at or near high water, for at other times the mackerel were seldom seen, though the Squids were seen swimming about at all hours, and these attacks were observed both in the day and evening.

"It is probable, from various observations, that this and other species of Squids are mainly nocturnal in their habits, or at least are much more active in the night than in the day. Those that are caught in the pounds and weirs mostly enter in the night, evidently while swimming along the shores in 'schools.' They often get aground on the sand-flats at Provincetown, Massachusetts, in the night. On the islands in the Bay of Fundy, even where there are no flats, I have often found them in the morning stranded on the beaches in immense numbers, especially when there is a full moon, and it is thought by many of the fishermen that this is because, like many other nocturnal animals, they have the habit of turning toward and gazing at a bright light, and since they swim backwards, they get ashore on the beaches opposite the position of the moon. This habit is also sometimes taken advantage of by the fishermen, who capture them for bait for codfish. They go out in dark nights with torches in their boats, and by advancing slowly toward a beach drive them ashore. They are taken in large quantities in nets and pounds, and also by means of 'jigs' or groups of hooks, which are moved up and down in the water, and to which the Squids cling, and are then quickly pulled out of the water. They are also sometimes caught by fish-hooks, or adhering to the bait used for fishes.

"Their habit of discharging an inky fluid through the siphon, when irritated or alarmed, is well known. The ink is said to have caustic and irritating properties.

"This Squid, like the *Loligo*, is eagerly pursued by the cod and many other voracious fishes, even when adult. Among its enemies while young are the full-grown mackerel, who thus retaliate for the massacre of their own young by the Squids. The specimens observed catching young mackerel were mostly eight to ten inches long, and some of them were still larger.

"This species, like the common *Loligo*, has the instincts and habits of a cannibal, for small Squids of its own species form one of the most common articles of its diet. From an adult female of ordinary size (G, of our tables), caught at Eastport, Maine, I took a great mass of fragments of small Squids, with which the stomach was greatly distended. These fragments completely filled a vial having a capacity of four fluid ounces.

"From the rapidity with which the Squids devour the fish that they capture it is evident that the jaws are the principal organs used, and that the odontophore plays only a subordinate part in feeding. This is confirmed by the condition of the food ordinarily found in the stomach, for both the fishes and the shrimp are usually in fragments and shreds of some size, and smaller creatures, like amphipods, are often found entire, or nearly so; even the vertebræ and other

bones of herring are often present. On the other hand, in some specimens, the contents of the stomach are finely divided, as if the odontophore had been used for that purpose."[1]

The loss which the fisheries sustain through their voracity, however, is probably equalized by the food which Cuttle-fishes furnish the carnivorous fishes and various other denizens of the deep. For example, the sperm whale seems to rely largely upon a diet of big Squids, sinking to the bottom where they are groping about, to drag them up, or nipping off their large arms as they swim about near the surface. Dolphins and porpoises also prey upon the Cuttles, and all the flesh-eating fishes pursue and devour them at every opportunity, particularly the cod and bluefish.

Knowledge of this fact long ago led to the Squid being taken by fishermen as an attractive bait. More than half of all the Bank fishing is said to be with such bait. When the shoals of this mollusk [*Loligo* Squid] approach the coast hundreds of vessels are ready to capture them, forming an extensive cuttle fishery, engaging five hundred sail of French, English, and American ships. Their habit of moon-gazing, also, is sometimes taken advantage of on the coast of Maine by the fishermen, who capture them for bait for codfish; they go out in dark nights with torches in their boats and by advancing slowly toward a beach drive them ashore. Violent storms heap great windrows of dead Squids on the beach, where they are gathered up, and they are also sometimes taken on lines adhering to the bait set for fishes. These "drives" and accidents happen in the spring, when Cuttles are flocking into shallow water to lay their eggs.

Since this solidly-fleshed animal is so extensively eaten by other animals it is not surprising to find that men also should number it among the edible products of the sea. "The flesh of the large cephalopodous animals," says Simmonds,[2] "was esteemed as a delicacy by the ancients. Most of the Eastern nations, and those of the Polynesian Islands, partake of it and relish it as food. They are exposed for sale dried in the bazaars or markets throughout India, and . . . dried Cuttle-fish may be seen among the articles of Chinese, Japanese, and Siamese food. In Chili the flesh is also considered a delicacy, and in Barbados the bastard Cuttle-fish or 'Calmar' (*Loligo sagittata* Lam.) is used as an article of food by the lower classes."

In the Mediterranean also, particularly near Tunis, and along the Portugal coast, the catch and consumption of Cuttles is large, amounting to nearly a million pounds a year, most of which is sold in Greece, after being salted and dried or pickled. These are Octopods. The same sort of Cuttle-fish (*Octopus punctatus*) serves the double purpose on the Pacific coast, from California to Alaska, of bait for the fisheries and food for the Indians. For the latter purpose it is chiefly sought in Puget Sound, where the coast tribes hunt and kill Octopods often large enough to be dangerous foes in a quarrel, by going to their haunts in canoes and spearing them. To some small tribes the Octopus affords the chief supply of animal food. There is no reason why squid-flesh from the northern Atlantic Ocean should not become available as food, and prove desirable—to those who like it. It would be both wholesome and cheap; and a single *Architeuthis* would furnish a meal for a frigate's crew. In Bermuda the *Octopus granulatus* regularly forms a portion of the fare of the fisher families. As the Bermudan fish and methods of capture prevail across among the Florida reefs, no doubt this habit prevails there also. In New York City there is a considerable sale of fresh Squids to foreign residents, and the trade is increasing. There seems no reason why on some coasts this flesh should not be far more thoroughly utilized than it is at present.

In addition to its value as a bait, or as a source of oil (our *Ommastrephes* has been thus utilized somewhat), and as possible food, the cephalopods contribute two or three useful articles

[1] Report U. S. Fish Commission, part vii, 1882, pp. 305–306.

[2] Commercial Products of the Sea, p. 116.

to commerce. A large portion of them carry under the skin of the back a long, flat, calcareous "bone" or plate, which serves as a stay or support to the frame in lieu of a skeleton. In some species it is long and slender like a quill-pen. This bone, reduced to powder, forms a useful pounce, "used in rewriting over erasures to prevent blotting, and in medicine as an antacid." It is also combined into a dentifrice. The principal use for it, nevertheless, is for feeding to caged birds requiring lime for their health. For this purpose several hundred-weight of "cuttle-bone" are brought into the United States annually. It is furnished chiefly from Chinese waters, but is also collected floating in the Mediterranean. None of our American species afford a useful cuttle-bone, however; so that this import can scarcely be diminished. The name "Calamary" is often applied to a Cuttle-fish, and arises from the fact that each of them carries in an internal gland a supply of blue-black, ink-like liquid, which upon the slightest alarm he discharges into the water, making a dense cloud under cover of which he rapidly retreats.[1] This ink, removed and dried into little cakes, with a greater or less adulteration, forms the sepia of painters and the India ink of draughtsmen. Now it is brought almost wholly from Oriental ports, via London, but it might probably be saved on our coast as well. Provided with pen and ink on all occasions, these mollusks seem truly to stand at the head of the class of animals they represent—not wholly because of their superior size and loftier brain and organization, but also on the score of literary accomplishments.

206. THE SEA-SNAILS—GASTEROPODA.

The Gasteropod mollusks, bearing a shell in a single piece and usually spirally whorled, are not of much direct utility to man, as a rule, on this side of the world, north of the tropics; but there are a few species which deserve mention. Their principal claim to notice in this connection lies in the fact that they figure upon the habitual bill of fare of various fishes. No doubt the list appended might be greatly enlarged if we were better informed, particularly in respect to the southern coast. Thus far the chief knowledge possessed in respect to the molluscan food of American fishes is derived from Gould's "Report upon the Invertebrates of Massachusetts," and Prof. A. E. Verrill's report to the United States Fish Commission. From this and other sources is compiled the succeeding catalogue of species of Gasteropod mollusks that are fed upon by fishes; these, it must be observed, are confined to the Atlantic coast, and, to a great extent, to the waters of New England, through lack of information in respect to the similar food of the fishes of the southern and the western coast. The list includes about fifty species, and reads:

Bela turricula, Bela harpularia, Bela pyramidalis, Bela decussata, Admeté Couthouyé, Neptunea despecta, Buccinum undatum, Buccinum ciliatum, Tritia trivittata, Ilyanassa obsoleta, Trophon clathratus, Trophon clathratus var. *scalariformis, Purpura lapillus, Astyris rosacea, Astyris lunata, Natica clausa, Lunatia heros, Lunatia grœnlandica, Lunatia immaculata, Amauropsis islandica, Velutina zonata, Velutina lævigata, Lamellaria perspicua, Littorina*—several species, *Triforis nigrocinctus, Bittium nigrum, Turritella erosa, Trichotropis borealis, Crepidula fornicata, Crepidula plana, Aporrhais occidentalis, Scalaria grœnlandica, Scalaria Novangliæ, Margarita cinerea, Margarita grœnlandica, Margarita argentata, Machæroplax obscura, Puncturella noachina, Tonicella marmora, Trachydermon albus, Trachydermon ruber, Chiton*—various species, *Auricula vestita* var. *Emersonii,*

[1] There are frightful tales abroad of the ferocity with which the larger of these creatures will attack man, and they are greatly dreaded by the shell-divers of the South Seas; but the truth is the Cuttle-fish is timid, and will hide or run away whenever he can from anything so large and strange as a man; that is, any Cuttles smaller than the giants of Newfoundland. A diver who touched a large Octopus would instinctively be seized, of course, since the creature would know no different course of action; but voluntary attack is not credited by those who know most about the habits of the animal.

Odostomia striatula, Philine lineolata, Amphisphyra hiemalis, Amphisphyra debilis, Diaphana Gouldii, and *Cylichna alba* among salt-water forms; with many species of *Melampus, Paludina, Planorbis, Limnea, Physa*, and other fresh-water genera.

But many of these species, and several not mentioned here, have additional claims to our notice. For example, *Buccinum undatum*, the Cape Ann "Periwinkle," might well serve as food, since in Europe it has long been thus utilized. In all the coast towns of England and Scotland this shell is peddled for food, under the name "Whelk" or "Wilk," and it may be bought at all the street-corners in the poorer quarters of London, where it is esteemed a great luxury. Our Whelk might equally well be eaten, and is very common northward from Cape Cod to the arctic regions, living chiefly on rocky shores, but also inhabiting muddy bottoms. It is thus accessible to castaways upon bleak arctic coasts where no other edible shell-fish of consequence occurs, and ought not to be forgotten by those who take the risk of shipwreck in Labrador or Greenland.

Next demanding attention are two of the largest mollusks on the Atlantic coast north of the tropics—*Fulgur carica* and *Sycotypus canaliculata*. North of New Jersey these two are confused under the general names of "Periwinkle," "Winkle," and "Wrinkle." The former of these species extends "northward only to Cape Cod," and is uncommon beyond Long Island, while the second is of more frequent occurrence in Vineyard Sound and along the Connecticut shore than southward. Both are carnivorous, and find in the Oysters a quiet, easy prey; they consequently do great damage to the beds, and are properly destroyed by fishermen whenever a chance occurs. I believe this is especially true of the *Sycotypus*. On the coast of New Jersey and southward, where the *Fulgur* reaches an immense size, and is known as the "Conch," the oystermen complain very little of it.

The *Sycotypus* is more common north of New York, though it does not exist at all beyond Cape Cod; while along the coast of New Jersey and southward it is the *Fulgur* which is chargeable with nearly all mischief perpetrated, since the other species is rarely seen. Occasionally, as Verrill mentions, specimens of both may be found crawling on sandy flats or in the tide-pools, especially during the spawning season, but they do not ordinarily live in such situations, but in deeper water, on hard bottoms off shore. It is needless to say that they do not burrow at all, though they are able to insert the posterior part of the foot into the sand sufficiently to afford them a strong anchorage against currents. A very soft or a very rocky bottom they equally avoid.

The curious egg-cases of these mollusks, to which the names "sea-ruffle" and "sea-necklace" are often given by fishermen, always attract the attention of visitors to the sea side, who find them cast upon the beaches; and we can well echo the pious exclamation of the old historian of Martha's Vineyard,—"The Author of nature makes a wonderful and copious provision for the propagation of this worm!" The eggs are discharged in a series of disk-shaped, subcircular, or reniform, yellowish capsules, parchment-like in texture, united by one edge to a stout stem of the same kind of material often a foot and a half or two feet in length. "The largest capsules, about an inch in diameter, are in the middle, the size decreasing toward each end. On the outer border is a small circular or oval spot, of thinner material, which the young ones break through when they are ready to leave the capsules, each of which, when perfect, contains twenty to thirty or more eggs or young shells, according to the season." Verrill adds interesting particulars, as follows:

"Dr. Elliott Coues, who has observed *Fulgur carica* forming its cases at Fort Macon, North Carolina, states that the females bury themselves a few inches below the surface of the sand on the flats that are uncovered at low water, and remain stationary during the process. The string

of capsules is gradually thrust upward as fast as formed, and finally protrudes from the surface of the sand, and, when completed, lies exposed on its surface. The string begins as a single shred, two or three inches long, without well-formed cases; the first cases are small and imperfect in shape, but they rapidly increase in size and soon become perfect, the largest being in the middle; the series ends more abruptly than it began, with a few smaller and less perfect capsules. The number of capsules varies considerably, but there are usually seventy-five to one hundred or more. At Fort Macon Dr. Coues observed this species spawning in May, but at New Haven they spawn as early as March and April. It is probable that the period of spawning extends over several months. Mr. Sanderson Smith thinks that they also spawn in autumn on Long Island. It is not known how long a time each female requires for the formation of her string of capsules. There are two forms of these capsules, about equally abundant in this region. In one the sides of the capsules are nearly smooth, but the edge is thick or truncate along most of the circumference, and crossed by numerous sharp transverse ridges or partitions, dividing it into facets. Dr. Coues states that these belong to *Fulgur carica*. An examination of the young shells, ready to leave the capsules, confirms this. The other kind has larger and thinner capsules, with a thin, sharp outer edge, while the sides have radiating ridges or raised lines. Sometimes the sides are unlike, one being smooth and more or less concave, the other convex and crossed by ten or twelve radiating, elevated ridges extending to the edge. This kind was attributed to *Fulgur carica* by Dr. G. H. Perkins, and formerly by Mr. Sanderson Smith, but a more careful examination of the young shells, within the capsules, shows that they belong to *Sycotypus canaliculata*."[1]

Eggs so exposed are subject to numberless accidents, being drifted ashore, ground to pieces by storms, and no doubt eaten by bottom-feeding fishes, so that only a few eggs out of the hundreds in each "necklace" are ever born, or, accomplishing that, are able to survive the perils of unprotected youth and grow to adult age and strength. Having once done so, however, this mollusk probably lives to a very great age.

An examination of a specimen of either of these species will show that in both the muscular part is large and strong and the mouth powerful. The food of the Conch being mainly the flesh of other mollusks, its method of killing them is one of brute strength, since it is unprovided with the silicious, file-like tongue by means of which the small "Drills" set at naught the shelly armor of their victims. The Conch is a greater savage than that. Seizing upon the unfortunate Oyster, unable to run away, he envelops its shell in the concave under surface of his foot, and, by just such a muscular action as you would employ in grasping an object in the palm of your fist, crushes the shell into fragments and feasts at leisure on the flesh thus exposed. Where Oysters or other prey are abundant, this operation is quickly repeated and vastly destructive. One planter in the upper part of Buzzard's Bay, where these pests are very troublesome, thought one Winkle was capable of killing a bushel of Oysters in a single hour. They do not confine themselves to Oysters altogether, of course; any mollusks or other marine animal, sluggish and weak enough to be caught and broken up, suffers from their predacity. I was told in New Jersey, by an intelligent man, that the Conch would even draw the Razor-shell out of his burrow and devour it. If this be true, no doubt the Soft Clam also falls a victim to the same marauder. The Quahaug is generally safe in his massive shells.

The oyster-beds most subject to attack and harm by the Winkles and Conchs are those planted in water which is quite salt, as is the practice in New England and Long Island Sound. The beds of the Great South Bay, Staten Island, and the southern Jersey coast are well protected by the outer beaches from the sea, and to these barriers owe their immunity from the *Fulgur*, while the *Sycotypus*, though present inside the beaches, seems to do small damage. Oystermen

[1] Report U. S. Fish Commission, part i, 1873, pp. 355, 356.

will tell you, also, that beds which are disturbed from time to time by the planter will suffer more harm than neglected beds, especially in summer. Of course it is to be expected, as reported, that where planting has gone on for many years, there these predatory mollusks have visibly increased in numbers.

In regard to ridding our beds of this pest, I can only advise, as heretofore, that every effort be made to destroy every specimen taken and every "necklace" of eggs which can be got hold of. The trawl, tangles, etc., recommended for the suppression of star-fishes, in my Report to the Census Bureau upon the Oyster Industries, would take up these eggs at the same time, and thus do double service. Persistent fighting is the only resource against this enemy, however, as in the case of others.

Some points of minor interest may be mentioned before leaving this subject. Both of these shells were used by the Indians of the coast ceremonially, and as material for the making of white wampum, their money of inferior value, which consisted of bead-shaped sections of the central column of the shell. From them, also, were fashioned sundry articles of service and ornament, such as trowels, spoons, and dippers; they are sometimes even yet called "ladle shells." The Indians ate the animals, too, when hard pressed for food, and have been followed in this practice by the whites, to some extent. De Voe says they used sometimes be sent into Catharine Market, New York, from Long Island, and found sale; "but," he adds, "they are not generally relished. being somewhat strong flavored. They are mostly used by the poor who live near the coast." Several foreign mollusks, not greatly different, are eaten—generally being boiled—and perhaps proper cooking would make these Conchs more palatable than they have hitherto proved.

Under the name of "Drill" is included a numerous class of univalve mollusks, which are carnivorous in their tastes, and armed with a tongue-ribbon so shaped and so well supplied with flinty teeth that by means of it they can file a round hole through an enemy's shell,—a habit which renders them of much account in the fisheries, where the victim they attack is the valuable Oyster, as they are sadly prone to do. The mode in which the entrance is made has been clearly described by Rev. Samuel Lockwood, as follows:

"The tongue is set with three rows of teeth like a file; it is, in fact, a tongue-file, or dental band, and is called by conchologists the lingual ribbon. . . . Having with the utmost care witnessed a number of times the creature in the burglarious act, I give the following as my view of the case: With its fleshy disk, called the foot, it secures by adhesion a firm hold on the upper part of the Oyster's shell. The dental ribbon is next brought to a curve, and one point of this curve, on its convex side, is brought to bear directly on the desired spot. At this point the teeth are set perpendicularly, and the curve, resting at this point, as on a drill, is made to rotate one circle, or nearly so, when the rotation is reversed; and so the movements are alternated, until, after long and patient labor, a perforation is accomplished. This alternating movement, I think, must act favorably on the teeth, tending to keep them sharp. To understand the precise movement, let the reader crook his forefinger, and, inserting the knuckle in the palm of the opposite hand, give to it, by the action of the wrist, the sort of rotation described. The hole thus effected by the drill is hardly so much as a line in diameter. It is very neatly countersunk. The hole finished, the little burglar inserts its siphon or sucking-tube, and thus feeds upon the occupant of the house into which it has effected a forced entrance. To a mechanic's eye there is something positively beautiful in the symmetry of the bore thus effected—it is so 'true'; he could not do it better himself, even with his superior tools and intelligence."

These small "Snails," "Drills," "Borers," and "Snail-bores," as they are variously called, belong to several species of *Natica*, *Purpura*, *Anachis*, *Astyris*, *Tritia*, *Ilyanassa*, etc.; but the master

and most destructive, as well as most abundant of them all, is the *Urosalpinx cinerea* of Stimpson. It is this which is the common "Drill" of the oyster-beds; and it is its eggs, laid in small vase-shaped capsules, which are often found attached in groups to the under surfaces of stones. Several of the small mollusks mentioned above lay eggs in this way, but the Drill's capsules have very short stalks, or are almost sessile, and are compressed with an ovate outline, while angular ridges pass down their sides. The natural home of the Drill is the tide-pools and weedy borders of rocky shallows, where barnacles, hydroids, anemones, rock-loving limpets, and other associated forms that find shelter among the algæ afford it abundant food. Though this is precisely where the Mussels grow till the rocks are almost black with them, it is said that they are never attacked by the Drills.

The *Urosalpinx* sometimes strays to the oyster-beds, but is usually carried there with the seed supplies, and, finding plenty of nourishment, lives and increases. Though its multiplication is not very rapid, it is fast enough to make it a very serious obstacle to success in the course of a few years. In nearly every case I was told that formerly there were no Drills, but now the oyster-beds were overrun. This was reported in particular of the Great South Bay of Long Island and at Keyport, New Jersey. I heard less of its ravages in New Jersey, except in the Delaware; but in Chesapeake Bay nearly every dredge-haul in any part of Maryland or Virginia waters brings them up. The Potomac seems to be the district least infested. Of course, in such natural haunts as the rocky shores of Buzzard's Bay and Connecticut they would be present if there were no Oysters, and are all the harder to dislodge.

Once having attacked an oyster-bed, they work with rapidity, and seem to make sudden and combined attacks at considerable intervals. Their disappearance from certain restricted localities, too, for a long time is unexplained.

What is the best way to combat them, or whether there is any hope of ridding the beds of them, are questions often discussed by oyster-culturists. It is certain that a great deal of trouble might be avoided if care were exercised in culling seed to throw out—not into the water, but on the ground or deck—all the Drills, instead of carrying them to one's beds, deliberately planting them, and then grumbling at destruction which previous care would have avoided. It would cost less in point of mere labor, no doubt, to prevent this plague than to cure it when it became no longer endurable. Some planters clean up pieces of bottom very thoroughly before planting, in order to get all this sort of vermin out of their way, as well as to stir up the mud and fit it for the reception of spat. It is on hard bottom that Drills are especially troublesome, and here some planters go over the ground with a fine-meshed dredge in order to get them up, but they fail to catch all. This is done at Norwalk, Connecticut, I know, and the men who have steamers find in the celerity with which they are able to accomplish this sort of work a great argument against any restriction to exclusively sailing-rig.

The Drill can be exterminated to a great extent, also, by diligently destroying its eggs. Small boys might well be paid to search for them and destroy them among the weedy rocks by the shore at low tide. A gentleman at Sayville, Long Island, assured me that in those years when eels were plentiful the Drills were kept down because the eels fed on their eggs. This gentleman said in the Great South Bay the Drills were nearly conquering the planters, and he advised the removal of all shells from the bottom of the bay, in order that the Drills might have nothing left on which to place their eggs. This might do there, where there are no rocks along the shore and the Drill is not native; but I doubt whether so sweeping a measure of protection could ever be carried out.

On the Pacific coast *Gastrochæna* and various pholadiform mollusks are a great bane to the

oyster-beds, but they penetrate by digging burrows wherein their whole shell is lodged. Where large numbers of these are present, with the help of boring-worms and sponges, they may so riddle a reef as to cause its entire disintegration under the first gale. A fourth borer is *Purpura lapillus*, which is of interest in another direction. The famous Tyrian purple of ancient days—the regal dye that was deemed too splendid a color to be worn by any but kings and nobles—was produced from a sea-snail, and conchologists have busied themselves to discover which particular one.

In the works of Pliny and Aristotle, the earliest sources of knowledge on the subject, the information is too vague to be relied upon. Dr. Roth, of Munich, in a paper read before the Jerusalem Literary Society, says that several years ago (previous to 1857) he found at Jaffa the *Purpura patula*, sought as food by the Christians during fast days: "On puncturing this animal there issued a greenish liquid, which, when exposed to the sunshine, changed to purple. This purple increased in brilliancy when it was washed." Comparing this with the accounts left by the ancients, Dr. Roth thinks the color he produced is evidently their blue color, for they had a blue-purple, a deep purple, and a red-purple. "Between Soor and Saida," according to the same author, "the *Murex truncatus*, or *trunculus*, is found in abundance, and its color is more brilliant than that of the *Purpura*. One of these *Murex* is sufficient to dye a square inch of cloth, which would require five individuals of *Purpura patula*. Wool takes the dye better than any other substance; silk takes it with difficulty."[1]

Linton, in his work "On Ancient and Modern Colours," as quoted by Simmonds ("Commercial Products of the Sea," p. 304), states that the *Purpuræ* of the best description were chiefly found on the rocks of Tyre, on the coast of Asia. They were also collected at Mininge, on the Grætulan shore in Africa, and on the coast of Laconia in Europe. The colors varied according to the locality in which they were taken, and also according to the animal's haunt, as has since been proved by zoologists. Thus, when it lived among sea-weeds or mud the juice it contained was comparatively worthless; when among pebbles its quality was improved; and the dye was best when the food and surroundings were varied. Researches carried still further proved that to produce the richest and most costly dye which art could exhibit, the liquid must be used in conjunction with that procured from other shell-fish. Just what the species were that were used it is now impossible to tell, but they were allied to *Murex* and *Buccinum*. Niter, urine, water, salt, and certain sea-weeds were also mixed with the *Purpura* liquor in compounding certain tints. "In the reign of Augustus," says Simmonds, "one pound of wool dyed with the Tyrian purple sold for about £36 sterling [about $175]. We need not wonder at this enormous price when the tedious nature of the process is considered, and the small quantity of dye obtained from each mollusk. For fifty pounds of wool the ancients used no less than two hundred pounds of the liquor of the *Murex* and one hundred pounds of that of the *Purpura*, being six pounds of liquor to one of wool; consequently the rich Tyrian purple fabrics vied in value even with gold."

The liquor was procured by placing the small shells in a mortar and crushing them. Animals extracted from the larger shells were added, and also urine, pure water, or water in which purple Snails had been allowed to putrefy. In this mixture the cloth was soaked and afterwards exposed to the light, sometimes under the influence of warmth to accelerate the process.

It is said that the dyeing property is a transformation of uric acid into purpurate of ammonia, called murexide. This is a splendid substance when pure, presenting in one direction beautiful metallic green reflections, and in others brown and purple tints. Some chemists assert that it is

[1] PHIPSON: Utilization of Minute Life. London Groombridge & Sons, 1864, p. 144.

to this substance that the iridescent plumes of humming-birds, pheasants, and peacocks owe their wonderful brilliancy. Murexide is now obtained not only from mollusks, but from guano, etc.

Dyes from mollusks have been obtained in all ages and almost all quarters of the world, and not only our *Purpura lapillus*, but also another species which we share with Great Britain, the Whelk (*Buccinum undatum*), have been the subject of successful experiments of this sort. "If the shell of *Purpura lapillus* is broken, there is seen on the back of the animal, under the skin, a slender, longitudinal, whitish vein, containing a yellowish liquor. When this juice is applied to linen, by means of a small brush, and exposed to the sun, it becomes green, blue, and purple, and at last settles into a fine unchangeable crimson." The housewives of New England therefore have growing abundantly on their sea-side rocks little living bottles of indelible ink which cannot be excelled by any manufactured product for either beauty or durability, since neither acid nor alkali will affect its color.

On the Pacific coast occur shells of the genus *Olivella*, so called because they resemble small olives. There are three species, *Olivella biplicata*, *O. gracilis*, *and O. dama*. The first named of these shells certainly, and possibly the other two, now and then were made into money by many Californian tribes of Indians, which money circulated widely on the Pacific slope. The common Indian name for this *Olivella* money was "colcol." It was made by grinding off the apex or spire of the shells in such a way that they could be strung. They are still used by some tribes in the form of double necklaces as ornaments, but are regarded as of small value. Sometimes the shell was broken crosswise and ground into little disks which passed as coins. This money was very ancient and widespread through aboriginal traffic in connection with other forms of shell-money to be mentioned hereafter, and which the present writer has fully discussed in a paper on "Wampum" contained in the American Naturalist,[1] to which the reader is referred.

Cameos are articles of ornament made by carving portions of various shells in such a way that a raised figure of one color shall be relieved against a ground of another tint constituting the under layer of the shell. These colors may vary—white on an orange ground, or on dark claret; pale salmon-color on orange; yellow on pink, etc. Anciently cameos were cut upon gems with immense labor, but latterly this easier imitation in shell has almost entirely superseded the intaglios in onyx, agate, and jasper. The cameo artists live mostly in London and Paris, and use several species of large shells that combine a white crust with a nacreous understratum of a different tint. Two only of these shells come from American waters, and these only touch our coast in tropical Florida—*Cassis madagascariensis* and *Strombus gigas*—the "Helmet-shell" and the "Conch."

Of the Helmet-shell several sorts are used in cameo-cutting. Our American example (which got its name, *madagascariensis*, through an error in regard to the locality of the type-specimen) has a blackish inner coat, called an "onyx" ground, and shows up white on a dark claret-color. It is known to the trade as the Black Helmet, and is highly esteemed by cameo-cutters.

The Conch or Queen Conch (*Strombus gigas*) is of less account in cameo-making, because it affords a less quantity of surface suitable for the work—a portion of its broad, rose-tinted lip. Various other ornaments are often made from this and other large shells by turning and sawing with special machinery, and thus a large demand is created, which is satisfied chiefly through brokers in London and Liverpool. Just how many shells are sent to England annually it is impossible to tell; but the amount reaches some tens of thousands. There is also a large commerce in them both to Europe and to the United States to be used as ornaments alone, and to be given away by grocers and tea-dealers to promote their custom. In the West Indies, and on

[1] American Naturalist, xvii, May, 1883, pp. 467–479.

many plantations in the Gulf States, the Conch is perforated at the apex of the spire, and forms a horn, used to call workmen in from the fields and at dinner. From fragments of this great mollusk, also, the Indians of Florida and the Antilles made their most esteemed beads and pendants. Cabeza de Vaca says that the columella of large Conchs were chiefly available for this purpose. "These beads are more or less cylindrical or globular, and always drilled lengthwise. Some are tapering at both ends, resembling a cigar in shape, and were two and one-half inches in length. The aborigines also made . . . peculiar pin-shaped articles consisting of a more or less massive stem which terminates in a round knob."

The *Strombus* enters, when ground, into the manufacture of porcelain; is extensively burned for lime; and is carefully calcined for medicinal purposes. There is also derived from it a secondary product of great value—the conch-pearl. When perfect, this pearl is described as either round or egg-shaped and somewhat larger than a pea, of a beautiful rose-color, and watered, that is, presenting, when held to the light, the sheeny, wavy appearance of watered silk. It is however, very rare to find a pearl which possesses all the requirements that constitute a perfect gem, and such proves an exceedingly valuable prize. Although many of these pearls are annually obtained by the fishermen in the Bahamas, not more than one in twenty proves to be a really good gem. Pink is the most common and only desirable color, although white, yellow, and brown pearls are occasionally found. Even among the pink ones there is usually some defect which mars their beauty and materially injures them; some are very irregular in shape and covered apparently with knobs or protuberances; others are too small, while many lack the watering which gives them their great value and chief beauty. Most of the conch-pearls have been sent to London, and the demand for them is increasing; a few come to New York.

Lunatia heros is very conspicuous along our coast, from the Gulf of Saint Lawrence to Cape Hatteras or beyond, wherever sandy shores and pure waters are to be found, and it is abundant and of very large size on the outer beaches of the coast of New Jersey. "When in motion the white soft parts are protruded from the shell to a remarkable extent and spread out broadly on all sides, so as nearly to conceal the shell; the foot is large, flat, and broadly expanded, with thin edges, and by means of it the animal is able to burrow, like a mole, beneath the surface of the sand." This Snail, like many others of its tribe, drills round holes through the sides of various bivalve shells by means of the small flinty teeth on its ribbon-like tongue, which acts like a rasp, and having thus made an opening it inserts its proboscis and sucks out the contents. All sorts of burrowing bivalves in this way fall victims to this and its close ally, the *Neverita duplicata*. "Nor do they confine themselves to bivalves, but will drill any unfortunate Gasteropods they may happen to meet, not even sparing their own young." Their usual haunts are away from the oyster-beds, however, so that, although they are a familiar sight in the dredge, the harm they do to this industry is of small account.

Following this in the list come various small shells, such as those of the genera *Littorina*, *Rissoa*, *Melampus*, and *Bittium*, of which it can only be said that they serve a very useful purpose as scavengers, swarming upon the mud exposed at low tide and greedily devouring carrion of fishes, etc., which would otherwise decay and pollute both air and water. The same good service is done by the small mollusks previously noticed as "Borers," and many following.

This brings us to the beautiful family of Abalones, Ormer-shells, or Sea-ears, in which there is a very large trade on the Pacific coast, under the industry of the Chinese there, to which will be given a special chapter.

In the Limpets (*Crepidula* and *Acmea*) the oystermen consider they have a friend, since when they see these clustering upon their planted beds they look forward to a profitable harvest the

coming autumn. A Californian species (*Fissurella aculeata*) was used as money by some of the native red men of the coast.

In respect to the odd pill-bug-like shells of the several species of *Chiton* of our eastern shore I can say nothing; but in Bermuda a larger Chiton is gathered for soup, and the broth is said to be very good. The Bermudans also make use of that Chiton as a bait with which to take the large lobsters of the island, themselves intended to act as bait for fishes.

The sea surrounding Bermuda is of great transparency, and the fishermen can readily discern the long horns of the lobster protruding from his hiding place among the rocks, at a considerable depth. The only plan by which they can get him, however, is to entice him out of his refuge. To do this they mat together a quantity of Chitons until they have formed a ball several inches in diameter. To this they attach a string, and—having previously baited the bottom in front of the lobster's den and left him to enjoy it until his confidence was captured—let the ball dangle before his nose. Thinking this only a larger tidbit, he seizes it, and, to his amazement, is swiftly drawn up to daylight and torn to pieces to form a lure for equally unwary fishes.

"These shells have been called by different names, all, however, indicative of their form, such as 'Wood-louse,' 'Sea-boat,' 'Rattle-snake's Tail,' 'Lobster's Tail,' 'Sea-bug,' and 'Sea-caterpillar.' The French say that the animal may be eaten, and we are told that the Iceland fishers swallow it raw to quench thirst, and pretend that it is good, also, against sea-sickness." The American Indians of the Northwest coast, South Sea Islanders, and other savages find the Chiton acceptable as food.

In *Melamprus bidentatus* we have a small shell which swarms upon the mud and among the eel-grass, affording food to many fishes and acting as a scavenger of the marshes. In addition to this, it has a place in these remarks because it belongs to the division of air-breathing mollusks, and introduces not only the fresh-water shells *Limnea*, *Physa*, *Planorbis*, etc., that feed the inland fishes, but also the edible land Snails. To these latter interesting mollusks I lately devoted a chapter in my "Friends Worth Knowing,"[1] from which I quote whatever applies to the present purpose:

"Snails, being great eaters, meet their just reward in being eaten. The paludine forms are sought after by all sorts of water birds, particularly ducks and rails; while the thrushes and other birds crush the shells of the land Snails and extract their juicy bodies. The woodland birds, however, will not eat the naked-bodied Slugs: the slime sticks to their beaks and soils their feathers; but the ducks seem to have no such dainty prejudices. Some mammals, like the raccoons and wood-rats, also eat them; insects suck their juices, and the carnivorous Slugs prey upon one another. Lastly, man, the greatest enemy of the brute creation, employs several species of Snails for culinary purposes. By the Romans they were esteemed a great luxury, and portions of plantations were set apart for the cultivation of the large, edible *Helix pomatia*, where they were fattened by the thousand upon bran sodden in wine. From Italy this taste spread throughout the Old World, and colonies of this exotic species, survivors of classical 'preserves,' are yet found in Great Britain where the Roman encampments were. They are still regarded as a delicacy in Italy and France, the favorite method of preparation being to boil in milk, with plenteous seasoning. Frank Buckland says that several of the larger English species are excellent food for hungry people, and recommends them either boiled in milk, or, in winter, raw, after soaking for an hour in salt and water. Some of the French restaurants in London have them placed regularly upon their bills of fare. Thousands are collected annually and sent to London as food for cage-birds. Dr. Edward Gray stated, a few years ago, that immense quantities were shipped

[1] Harper and Brothers, New York, 1880.

alive to the United States 'as delicacies'; but I am inclined to consider this an exaggeration growing out of the fact that, among our fancy groceries, 'a few jars of pickled Snails, imported from Italy,' figure as a curiosity, rather than something needed for the table. The same author records that the glassmen at Newcastle once a year have a *snail feast*, collecting the animals in the fields and hedges on the Sunday before.

"Mr. W. G. Binney, for whom a sirup of Snails was prescribed by two regular physicians in Paris in 1863, points out how old is the belief that land mollusks possess valuable medicinal qualities. In the Middle Ages the rudimentary shell of the Slug acquired a high rank among the numerous bezoars and amulets which were supposed to protect the body from evil influences, and to impart health and activity. The accounts of these virtues, copied from one author to another, have perpetuated the early superstitions until it is difficult to overcome them by the light of the present day, when, even in England, Snails are supposed to possess a useful power in cases of lung trouble. A full relation of all the absurdities which gained credence would form a curious and marvelous page in the history of credulity. They have, also, from very early times, been used in the preparation of cosmetics; and no longer than two or three centuries ago the water procured from them by distillation was much celebrated, and employed by ladies to impart whiteness and freshness to the complexion. Finally, I hear that there is celebrated in Rome, even now, a midsummer festival, upon which occasion all family feuds may be made up, or any differences between friends easily adjusted, since that is the spirit of the day; and a sign or token of this renewed friendship and good-will is the present of a Snail from one party to the other, or an exchange of mollusks between them. The symbolism and virtue reside in the alleged amicable influence of the head and 'horns'—why, perhaps comparative mythologists may be able to tell us.

"In this country no such fanciful notions have ever gained credence. The Snails are too habitually hidden to attract the attention of any but a few; and even when their existence is known, they are unfortunately regarded with such a disgust as would preclude any acceptance of them, either for food or medicine."

In Thomas De Voe's "*Market Assistant*," p. 312, is the following information, which refers to about the year 1860: "From the French journals we learn that there are fifty restaurants and more than twelve hundred private tables in Paris where Snails are accepted as a delicacy by from eight to ten thousand consumers. The market price of the great vineyard Snails is from 2 francs 50 centimes to 3 francs 50 centimes (47 to 66 cents) per hundred, while those of the hedges, woods, and forest bring only from 2 francs to 2 francs 25 centimes (38 to 43 cents). Snails are, and have been for several years, imported [into New York] from Europe, but are principally used by foreigners. They are generally stewed after having been scalded out of their shells."

The custom-house counts this import among "fancy groceries," so that no separate record is obtainable of the amount consumed. In the case of several of the large Southern species, such as the Apple-snail (*Ampularia*), the *Bulimi*, and the large pond Snails, their remains in the shell-heaps show that in prehistoric time they formed a regular part of the food of the red men. The Seminoles, of Florida, and various native races west of the Rocky Mountains, eat them yet.

207. THE WING-SHELLS—PTEROPODA.

The Pteropods, or wing-footed mollusks, are a small group which swim freely throughout the broad ocean. Their shells are of small size, fragile, and semi-transparent. They form, therefore, available food for a large number of surface-feeding fishes, and particularly of the cetacea; the right whale, indeed, is said to live almost wholly upon certain species of them which abound in

arctic seas and swarm near the surface at night, so that he need only drop his jaw and engulf them by the hundred in his capacious mouth as he swims along with his head half out of water. Probably the same thing is true of the other balænoids.

208. THE TUSK-SHELLS—SOLENOCONCHA.

The class denominated in Professor Verrill's Check List *Solenoconcha* includes only one mollusk that may concern us at present—*Dentalium*. This mollusk (chiefly *D. pretiosum*) occurs all along the northern Pacific coast of America, and is known to Americans as the "Tusk-shell," to Russians as "Sookli," and to the Alaskan Indians as "Hya-qua." From Northern California all the way to the arctic regions the coast tribes collected this shell, polished it, and arranged it on strings as money—a circulating medium of trade, similar to the wampum of the eastern coast. There were certain rules as to fineness, arrangement, size, and measurement, which decided the value of the shells before and after stringing; and so useful was this *allocockick*, as the California Indians called it, that the Hudson's Bay Company and other traders adopted it as current coin in their buying and selling of peltries and provisions.

The strings of *Dentalia* were also worn as necklaces by the women, or twined in the hair of both sexes; as trimming for garments, and ornaments for horse-trappings and the equipments of war and the chase. Among other methods of employing them to enhance personal charm was to insert two of them, point to point, from opposite sides, through a perforation in the partition which separates the nostrils, which decoration was further increased by sticking a bright feather in the large end of each of the hollow shells. This money is going out of use now, and only the old Indians, conservators of ancient customs, attempt to hoard it up. A full account of it may be found in the article upon "Wampum" already alluded to, printed in "The American Naturalist" for May, 1883.

209. THE BIVALVES—LAMELLIBRANCHIATA.

It is in the class of plate-gilled or lamellibranchiate mollusks, more popularly known as "bivalves," that we find the most examples of direct utilization by man, or immediate contribution to the fisheries. Bivalves are widespread and well-known. They afford luxuries as well as solid nourishment for our tables, enter largely into manufactured products, serve as ornaments, and are so beloved by food-fishes generally that they are useful as bait.

The partial list of bivalved mollusks that are ascertained to enter into the diet of American food-fishes includes the following, mainly from the northern Atlantic coast as in the case of the gasteropods, and is instructive as showing how extensively fishes depend upon molluscan food:

Ensatella americana, Crytodaria siliqua, Mya arenaria, Spisula ovalis, Macoma sabulosa, Angulus tener, Petricola pholadiformis, Venus mercenaria, Cyprina islandica, Cardium pinnulatum, Cardium islandicum, Cryptodon Gouldii, Venericardia borealis, Astarte quadrans, Nucula proxima, Nucula tennis, Yoldia limatula, Yoldia sapotilla, Yoldia myalis, Yoldia thraciformis, Leda tenuisulcata, Argina pexata, Mytilus edulis, Modiola modiolus, Modiolaria discors, Crenella glandula, Pecten tenuicostatus, Pecten islandicus, Pecten irradians, and *Ostrea virginica;* to which must be added *Unio, Anodonta*, and other fresh-water bivalves, and the brachiopods *Rhynconella psittacus* and *Terebratulina septentrionalis.*

In this list many species are of importance otherwise, and some worth notice, although not fed upon by fishes, are not mentioned; the first to be named in this latter class is the dreaded Ship-worm (*Teredo*), of which there are seven species in the United States:

Teredo navalis, Linné. Cape Cod to Florida; Sweden to Sicily.
Teredo norvegica, Spengler. Cape Cod northward.
Teredo megotara, Hanley. Massachusetts Bay to South Carolina.
Teredo dilatata, Stimpson. Massachusetts to South Carolina.
Teredo Thompsoni, Tryon. Cape Cod, Massachusetts.
Xylophaga dorsalis, Forbes and Hanley. North Atlantic.
Xylotrya fimbriata, Jeffreys. Long Island Sound to Florida; British Columbia; Europe.

The most commonly observed of these is the *Teredo navalis*. This is the same species that has attracted so much attention in Europe, during nearly two centuries, on account of the great damage that it has done, especially on the coast of Holland. Its history has been reviewed at length by Professor Verrill in his "Invertebrates of Vineyard Sound," from which the present account is principally derived.

"Although popularly known as the 'Ship-worm,' these creatures are not at all related to the worms, but are true mollusks, quite nearly allied, in many respects, to the common 'Long Clam' (*Mya*) and to the *Pholas*. Like those shells, the Teredo excavates its holes or burrows merely for its own protection, and not for food; but the Teredo selects wood in which to form its holes, and when these have been excavated it lines them with a tube of shelly material. The holes are very small at the surface of the wood, where they were formed by the young Toredos, but they gradually grow larger as they go deeper and deeper into the wood, until they sometimes become ten inches or more in length and a quarter of an inch in diameter; but the size is generally not more than half these dimensions. The holes penetrate the wood at first perpendicularly or obliquely, but if they enter the side of the timbers or planks across the grain the burrows generally turn horizontally in the direction of the grain a short distance beneath the surface, unless prevented by some obstruction, or by the presence of other toredo tubes, for they never cross the tubes of their companions or interfere with each other in any way, and there is always a thin layer or partition of wood left between the adjacent tubes. It is, however, not necessary that they should follow the grain of the wood, for they can and do penetrate it in every direction, and sometimes not more than half the tubes run in the direction of the grain, and they are often very crooked or even tortuous. They rapidly form their burrows in all kinds of our native woods, from the softest pine to the hardest oak, and although they usually turn aside and go around hard knots, they are also able to penetrate through even the hardest knots in oak and other hard woods. The Teredos grow very rapidly, apparently attaining maturity in one season, and therefore, when abundant, they may greatly damage or completely destroy small timber in the course of four or five months, and even the largest piles may be destroyed by them in the course of two orthree years.

"When removed from its tube the animal is found to have a very long, slender, smooth, soft, whitish body, tapering somewhat toward the outer or posterior end, which has a muscular, circularly wrinkled collar, by which the animal is, when living, attached to the inside of the shelly lining of its tube. To the inside of this collar two shelly plates, known as the 'pallets,' are attached by their slender basal prolongations; their outer portions are broad and flat, and more or less emarginate or two-horned at the end. These are so connected with the muscles that when the animal withdraws its tubes into its hole the free ends of these pallets are made to fold together and close the opening, thus serving as an operculum to protect the soft tubes against enemies of all kinds. Between the bases of the pallets arise the siphonal tubes, which are soft and retractile, united together for half their length or more, but separate and divergent beyond; they are nearly equal, but the ventral or branchial tube is perhaps a little larger than the other, and is fringed with a few small papillæ at the end. The tubes are white or yellowish, sometimes speckled with

reddish-brown. At the anterior end of the body, and farthest from the external opening of the hole, is seen the small but elegantly sculptured white bivalve shell. The shell covers the mouth and palpi, liver, foot, and other important organs. The foot is a short, stout, muscular organ, broadly truncate or rounded at the end, and appears to be the organ by means of which the excavation of the burrow is effected. The shell is covered by a delicate epidermis, and probably does not assist in rasping off the wood, as many have supposed. The gills are long and narrow, inclosed mostly in the naked part of the body, and are reddish-brown in color.

"The Teredos obtain their microscopic food in the same manner as other bivalve mollusks, viz, by means of a current of water constantly drawn into the branchial tube by the action of vibrating cilia within; the infusoria and other minute organisms are thus carried along to the mouth at the other end, while the gills are supplied with oxygen by the same current; the return current passing out of the dorsal tube removes the waste water from the gills, together with the fæces and excretions of the animal, and also the particles of wood which have been removed by the excavating process.

"As the animal grows larger the burrows are deepened, the lining of shelly matter increases in length and thickness, the shell itself and the pallets increase in size, and the terminal tubes grow longer. But as the orifices of the terminal tubes must necessarily be kept at the external opening of the burrow, the muscular collar at the base of the tubes constantly recedes from the entrance, and with it the pallets; at the same time imbricated layers of shelly matter are usually deposited in the upper end of the shelly tube, which are supposed to aid the pallets in closing the aperture when the tubes are withdrawn. When the animal has completed its growth, or when it has encountered the tubes of its companions and cannot pass them, or when it approaches the exterior of a thin piece of wood and cannot turn aside, it forms a rounded or cup-shaped layer of shelly matter, continuous with the lining of the tubes and closing up the burrow in front of its shell. Sometimes it retreats and forms a second partition of the same kind.

"This species produces its young in May and probably through the greater part or all of the summer. The eggs are exceedingly numerous, probably amounting to millions, and they are retained in the gill-cavity, where they are fertilized and undergo the first stages of their development. The embryos pass through several curious phases during their growth. In one of the early stages they are covered with fine vibrating cilia, by means of which they can swim like ciliated infusoria; later they lose these cilia and develop a rudimentary bivalve shell, which is at first heart-shaped, and the mantle begins to appear and larger retractile cilia develop upon its edge, which serve as organs for swimming; but at this period the shell is large enough to cover the whole body when contracted. In this stage they swim actively about in the water; later the cilia become larger, a long, narrow, ligulate foot is developed, by means of which they can creep about and attach themselves temporarily to solid objects; the shells become rounder, a pair of eyes and organs of hearing are developed. After this the little animal begins to elongate, the locomotive cilia are lost, the eyes disappear, and the mature form is gradually assumed. These young Teredos, when they finally locate upon the surface of wood-work and begin to make their burrows, are not larger than the head of a pin, and consequently their holes are at first very minute, but owing to their rapid growth the holes quickly become larger and deeper."[1]

This species is very abundant along the southern coast of New England, from New York to Cape Cod, wherever submerged wood-work, sunken wrecks, timber buoys, or floating pieces of drift-wood occur. It also infests the bottoms of vessels not protected by sheathing. At Provincetown, Cape Cod, about forty feet of the end of the steamboat wharf was so weakened by its

[1] Report, U. S. Fish Commission, part i, 1873, pp. 384–386.

borings that it completely gave way under a ship-load of merchandise stored upon it. This pest is not confined to pure sea-water, but occurs in the piles and timbers of wharves in harbors that are not only brackish, but also muddy and contaminated with sewage. Capt. B. J. Edwards told me that formerly when the cedar channel-buoys in Buzzard's Bay, Massachusetts, were not taken up they would last not more than two years, owing chiefly to the attacks of this Teredo; but under the present system there are two sets of buoys, which are alternately taken up and put down every six months. After a set has been allowed to dry thoroughly they are scraped to remove the barnacles, etc., and then receive a thorough coat of verdigris paint each time before they are put down. With this treatment they will last ten or twelve years, but they are more or less perforated and injured every year, until finally they become worthless. This statement does not apply to the spar-buoys, which are taken up only once a year, in April and May. Captain Edwards says that the Teredos would destroy an unpainted spar-buoy in one year, but when painted with verdigris they will only work where the paint becomes rubbed off. They first attack buoys or piles just below the water's edge, but eventually will destroy the entire submerged wooden portion. Commenting upon this information, Professor Verrill says:

"Inasmuch as the Teredos produce their young all through the summer, and they develope to a very large size in one season, it is evident that the best time to take up the buoys would be in midsummer, before the early crop of young have grown large, and leaving too little time for the later crop to become large, in the buoys thus put down, before winter, when most of them would probably be killed by the cold weather. In this way the damage might be materially diminished, if not inconsistent with the other duties of the officers of the vessels employed in this service. There are, as yet, no means of estimating the extent of the damage done to our wharves, shipping, etc., by this and the various other species of Teredo found on our coast, but, judging from their abundance along the whole coast, it is much greater than is generally supposed.

"The *Teredo navalis* is also abundant on the coast of Europe, from the Mediterranean and Black seas to Christiania and the coasts of Great Britain. Its habits have been quite thoroughly investigated by several Dutch naturalists, owing to the great damage that it has done on their coast, at times even threatening a general inundation of the country by destroying the wood-work of the dikes. This Teredo occupies a zone of considerable breadth, for it often lives considerably above low-water mark, and extends several feet below it, even to the depth of fourteen feet, according to some writers.

"The best remedies in common use to resist or prevent its attacks are copper sheathing, used chiefly on vessels; broad-headed nails, closely driven, used for piles and timbers; creosote and coal-tar, frequently applied. The various poisonous substances that have been applied to timber for this purpose, however useful they may be in other respects, have little or no effect on the Teredo, for it does not depend upon the wood for its food, and even protects its body externally with a layer of shell, lining its holes. The only remedies that are likely to succeed are those calculated to prevent the lodgment and entrance of the young ones beneath the surface. Even creosote, thoroughly applied under pressure at the rate of ten pounds per square foot, has been found insufficient to prevent their attacks, for piles thus treated at Christiania were found by Mr. Jeffreys to be filled with the Teredo within two years after they were put down.

"Several other species of Teredo also occur on this coast. The *Teredo megotara* has been found in floating pine wood at Newport, Rhode Island, and in cedar buoys, etc., at New Bedford, Massachusetts; as well as in Massachusetts Bay, at Provincetown, and other places; it is also found as far south as South Carolina at least. This species sometimes grows to a large size, forming tubes at least eighteen inches long. It sometimes occurs, also, in the piles of wharves in this region

[Vineyard Sound, Massachusetts]. The *Teredo Thomsoni* has been found in great numbers in the marine railway and also in cedar buoys at New Bedford. It has also been found at Provincetown in a whaling-ship that had cruised in the West Indies.

"The *Xylotrya fimbriata* is very similar to the common *Toredo*, except that it has long, oar-shaped pallets, with slender stalks; the blade is flattened on the inside and convex externally, and consists of ten to twelve or more funnel-shaped segments which set one into another; their margins project at the sides, making the edges of the blade appear serrated. This species appears to be indigenous on this coast. It has been found living in a sunken wreck in Long Island Sound, near New Haven, and I have also taken it from the oak timbers of a vessel, the "Peterhoff," employed in the blockading service, during the late war, on the coast of the Southern States. It grows to a rather large size, often forming holes a foot or more in length and a quarter of an inch in diameter, though usually smaller. The pallets are sometimes half an inch long."

Less likely to be mistaken for worms, but equally clever at boring, is a group of shells called Pholads, from the Greek word φωλέω, lurking. They perforate all substances that are softer than their own valves, and some that seem to be harder. Woodward says: "It is to be remarked that the condition of the Pholades is always related to the nature of the material in which they are found burrowing; in soft sea-beds they attain the largest size and greatest perfection, whilst in hard and especially gritty rock they are dwarfed in size and all prominent points and ridges appear worn by friction." The Pholads have white shells, generally very thin but hard and strong, and adorned with rasp-like sculpture. It was supposed formerly that the excavation was made by twisting and moving this rough shell in the burrow; but the muscular, club-shaped foot is no doubt the instrument of abrasion.

We have upon the east coast three species, but none of them are of practical importance. They might become available for food, however, since the same mollusks are eaten in the southern counties of England, where they are called "Piddocks," and some cousins (*Zirphœa crispata*, *Platydon cancellatus*, etc.) are esteemed delicacies on the coast of California under the name of "Date-fish." Other west-coast species (*Navea*, *Gastrochæna*, etc.) are enemies of the Oyster, Abalone, and other mollusks which themselves have a commercial importance, since they burrow into their shells and so ruin them for service to man. There is, nevertheless, an attendant advantage in this, since in a state of nature the Pholads thus break to pieces and tend to level reefs that would prove obstructive to navigation, particularly in the case of coral banks. When the object leveled is an expensive dike or breakwater, however, the result is exactly reversed, as it is very likely to be where man's arts attempt to change the natural arrangement of things.

Our Razor-shell (*Ensatella americana*) is frequently used for food in Europe and in New England, and its valves have occasionally been applied to artistic service. It passes under the various names of "Razor-fish," "Razor-clam," "Knife-handle," etc., and is enticed from its sandy burrow by sprinkling salt upon the sand under which it lies, or is rooted out with a spade. John Josselyn, Gent., records that its "shell, calcin'd and pulveriz'd, is excellent to take off a pin and web, or any kind of filme growing over the eye." The Californian Razor-fish (*Siliqua patula*) is also edible.

Next upon the list comes the "Soft Clam," "Long Clam," or "Nanninose" (*Mya arenaria*), or Manning dear to New Englanders and only less numerous than the Hard Clam in the markets of New York and Philadelphia. This Clam lives just beneath the surface of the sand and mud above low-water mark, and is easily dug out with a hand-shovel. A very large class of persons all along the shore from Maine to Delaware derive their living wholly or in part by digging it and shipping to city markets. This is chiefly the case north of New York, however. On the northern coasts of New

England immense quantities of this bivalve are collected and salted to be used as bait in the cod fishery. Statistics and a full discussion of the habits and artificial culture of this Clam will be found in the special chapter devoted to the Clams.

Washed up by storms from the deep sands—down at least to ten fathoms below the low-water line—and hence known as the "Beach," "Sea," or "Surf" Clam, the huge *Spisula solidissima* furnishes occasional repasts to the dwellers along the whole Atlantic shore. It is chiefly eaten in Massachusetts, however, and its flesh is tough and by some persons considered unwholesome. It is often cast up in such great quantities as to become available for manure, mixed with various other marine animals of all sorts and sizes and much sea-weed. The large, smooth, white valves are collected in considerable quantities to be decorated inside with pictures in oil or India ink, which are again sold in the picture stores, often for a good price. This Clam is also preserved as bait. On the Pacific coast an allied species (*Spisula falcata*) serves the various purposes to which the eastern one is applied.

Following this comes the Quahaug (*Venus mercenaria*), which is known in the markets as "Hard Clam," "Round Clam," or, in New York, simply "Clam." From Cape Cod to Florida it is very abundant, but must be gathered by raking, since it does not burrow in the shore-sands like the Soft Clam. A commerce still larger than in the case of the Soft Clam is carried on with this species as bait, and also for food, in which respect it ranks next to the Oyster in the United States.

On the Pacific coast—where eastern shell-fish are constantly sent for transplantation and for immediate consumption—there are various bivalves used as food, such as *Semele decisa*, the "Flat Clam"; *Macoma nasuta*, the "Tellens," of San Francisco; *Schizothærus Nuttalli*, the "Gaper"; *Chione succincta*, and allied species, which replace eastern "Little Necks"; and *Saxidomus aratus*, to relish which was learned from the Indians.

In regard to this latter mollusk (*Saxidomus aratus*) it is interesting to note that its shell was broken into pieces by the Indians of the California coast and worked into flat, circular disks by rubbing upon stone. Eighty of these disks strung upon sinews were in recent use by the Indians of Lake County, California, as a medium of exchange in trade, and were valued at one dollar. In Sonoma County *Saxidomus gracilis* seems to have served the same purpose.

Another form of aboriginal money was made from the valves of the ponderous Hen Clam of southern California (*Pachydesma crassatelloides*), already mentioned. This money was called "*hawok*," and took the shape of perforated disks which could be strung as beads. The larger pieces, according to Stearns, were worth twenty-five cents, and were cut from the thicker parts of the shell; while the thinner portions supplied beads worth only four cents each. Further information will be found upon this in my magazine article above referred to.

The *Pachydesma* and its neighbor, the *Cardium Nuttalli*, are considered edible by the west coast people; but on the Atlantic shore, where occur several large species of "Cockle" (as the members of the genera *Cardium*, *Astarte*, *Venericardia*, and the like, are called), they are rarely or never used as food. This neglect seems curious, since this mollusk is eaten in great abundance in England, and may be bought everywhere in London during summer. "Prodigious quantities of this shell-fish are also consumed in Holland, where their cheapness recommends them to the common people as a principal article of food during the winter." In New England *Cyprina islandica* is eaten now and then, but bears a poor reputation in comparison with the Quahaug. In the Southern States the large "Painted Clam" (*Callista gigantea*) is equally available as food, and the *Gnathodon cuneatus* of the Gulf of Mexico is already an article of diet, as well as useful in road-making, to which utility many other mollusks contribute in all sea-shore towns.

These thick-shelled bivalves disposed of, a large group of thin-shelled mollusks deserve notice. Foremost among these are the Mussels, which are of several kinds. In Europe the *Mytilus edulis* (which is not different from our common Black Mussel of both the east and west coasts) holds an important place among sea-foods. In 1873 the mussel fishery of France alone was worth over 800,000 francs ($160,000). In that country they are regularly bred in inclosures of sea-water, upon frames and hanging ropes constructed for the purpose, and many persons are employed. In England, Scotland, Ireland, along the Mediterranean, in the West Indies, and along the whole circumference of South America, edible species of one name or another grow. Our *Mytilus edulis* is circumpolar in its distribution, and is excessively numerous at all rocky points suitable for its growth. In New York it is pickled in large quantities and shipped throughout the interior of the country. Its shells are extensively used by oyster-planters as a cultch upon which to catch young Oysters, and when polished are made into paint-holders for artists and various articles of bijouterie and personal ornament. The American Indians and the native New Zealanders used them as tweezers in pulling out their beards.

Mussels of a different sort are the *Modiola plicatula*, the *Modiola modiolus*, the *Modiola hamatus*, and *Modiola capax;* the first two are of the northern Atlantic, the third is more southern, and the fourth a native of California. These are sometimes eaten, but are not considered so good as the *M. edulis*. On the coasts of New Jersey and Long Island, however, incredible quantities are gathered from the banks at the inlets through the outer beaches where they grow, and are spread upon sea-shore farms as manure. In gathering this fertilizer a large number of vessels and men find irregular employment at times when they would otherwise be idle.

Another important bivalve in a commercial way is the Scallop, fisheries for which flourish in Long Island Sound, Narragansett Bay, and elsewhere. Large fleets of vessels are engaged in summer in dredging for these shell-fish. The powerful central muscle by which the animal opens and closes its shells forms the edible portion, the rest being discarded. These white fragments are to be seen piled upon platters or strung in strings as a constant delicacy in all our markets. The common Scallop of commerce is the *Pecten irradians*. Years ago the very large species, *Pecten islandicus*, an inhabitant of Eastern Maine and the Bay of Fundy, used to be obtained, and was highly prized for its flavor, but it has long been too rare to serve any purpose other than as a curiosity to conchologists. A more common and useful species, north of Cape Cod, is *Pecten tenuicostatus*, which supplied the Indians with a culinary instrument, and is good food.

"Scallop shells were formerly worn by pilgrims on their hat or the cape of their coat, as a mark of their having crossed the sea for the purpose of paying their devotions at the holy shrine in Palestine; in commemoration of which they are still preserved in the armorial bearings of many families of distinction whose ancestors had performed that ceremony. From its use by cooks now, this shell has given the name to 'scalloped' Oysters. In early times, when plates and drinking-vessels were not so plentiful as they are now, the concave or hollow valve of the Scallop served as a cup, and the flat valve for a plate. The idea has even been carried out by our pottery manufacturers, and plates and dishes have been molded after the forms of bivalve shells. Reticules, needle-books, pincushions, and other articles are made by shell-dealers with the scallop shell."

Of both the Scallop and the Mussel a special account will be given in another place, considering the value of each commercially.

The fresh-water bivalves belonging to the large family of the *Unionidæ* ought not to be omitted in this review. To the raccoon, otter, muskrat, and many other mammals and birds, as well as to the fishes, they are a steady source of food. Observing this, the Indians adopted them from the earliest prehistoric times as edible, and enormous heaps of shells upon the banks of many

of our interior rivers, especially in Pennsylvania, the Ohio Valley, and the Southern States, show how extensively and constantly they were sought. White men occasionally eat them, and in case of extreme hunger would perhaps pronounce a roasted *Unio* or *Anodonta* good. Some years ago a great furore was created by the discovery of a fine pearl in one of the Unios of North Carolina—a thing likely to happen in the case of any of them, since they have an interior which is often as finely nacreous as that of the Mother-of-pearl Oyster of the Gulf of California. Hundreds of persons immediately began searching the rivers all over that region, and total extirpation of the poor Mussels was prevented only by the discouragement of finding few pearls and these of insignificant size. It is probable that from the heavier species, in captivity, good pearls might be obtained artificially by following the plan pursued by the Chinese with their sea Pearl-oyster. The experiment is worth trying.

Shells of fresh-water Mussels are frequently worked up into pocket-books and other fancy articles, as in the case of the *Mytilus*. When the brown epidermis is removed a beautiful iridescent polish is obtainable. There are almost innumerable varieties of these fresh-water Mussels, and full cabinets have a considerable value.

The manufacture of jewelry and shell-flowers consumes large quantities of small shells and and the polished opercula of large ones, chiefly derived from Florida. It is said that in London about a million of the commoner sorts are sold to street-sellers and country peddlers, who retail them to be made into fancy work and as objects of curiosity. The same thing is frequently seen in the United States, though more commonly in the shape of the traveling dealer who brings a large and varied stock to a country town, hires a shop for several weeks, and sells his shells mainly by auction.

The spread of commerce and improved facilities for dredging have made species once rare now common; but astonishing prices, reaching hundreds of dollars for a single specimen, in some cases were paid by owners of conchological cabinets for rare species half a century ago. This stimulated research and distributed much money among sea-side collectors. Even now dealers in objects of of natural history derive a large profit by importing shells whose only value is their scientific importance; while the institutions devoted to their study and the books to which an interest in conchology have given rise are entitled to a money estimation not to be despised.

X.—A CONTRIBUTION TO THE LIFE-HISTORY OF THE OYSTER.

(*Ostrea virginica*, Gmelin, and *O. edulis*, Linn.)

By JOHN A. RYDER.

210. OUTLINE SKETCH OF THE COARSER ANATOMY OF THE OYSTER.

"The general structure of an Oyster may be roughly represented by a long, narrow memorandum book, with the back at one of the narrow ends instead of at one of the long ones. The covers of *such a book represent the two shells of the Oyster, and the back represents the hinge, or the* area where the two valves of the shell are fastened together by the hinge ligament. This ligament is an elastic, dark-brown structure, which is placed in such a relation to the valves of the shell that it tends to throw their free ends a little apart. In order to understand its manner of working, open the memorandum book and place between its leaves, close to the back, a small piece of rubber to represent the ligament. If the free ends of the cover are pulled together the rubber will be compressed and will throw the covers apart as soon as they are loosened. The ligament of the oyster-shell tends, by its elasticity, to keep the shell open at all times, and while the Oyster is lying undisturbed upon the bottom, or when its muscle is cut, or when the animal is dying or dead, the edges of the shell are separated a little.

"*The shell is lined by a thin membrane, the mantle, which folds down on each side, and may* be compared to the leaf next the cover on each side of the book. The next two leaves of each side roughly represent the four gills, the so-called 'beard' of the Oyster, which hang down like leaves into the space inside the two lobes of the mantle. The remaining leaves may be compared to the body or *visceral mass* of the Oyster.

"Although the Oyster lies upon the bottom, with one shell above and one below, the shells are not upon the top and bottom of the body, but upon the right and left sides. The two shells are symmetrical in the young Oyster, but after it becomes attached the lower or attached side grows faster than the other, and becomes deep and spoon-shaped, while the free valve remains nearly flat. In nearly every case the lower or deep valve is the left. As the hinge marks the anterior end of the body, an Oyster which is held on edge, with the hinge away from the observer and the flat valve on the right side, will be placed with its dorsal surface uppermost, its ventral surface below, its anterior end away from the observer, and its posterior end toward him, and its right and left sides on his right and left hands, respectively.

"In order to examine the soft parts, the Oyster should be opened by gently working a thin, flat knife-blade under the posterior end of the right valve of the shell, and pushing the blade forward until it strikes and cuts the strong adductor muscle, which passes from one shell to another and pulls them together. As soon as this muscle is cut the valves separate a little, and the right valve may be raised up and broken off from the left, thus exposing the right side of the body. The surface of the body is covered by the mantle, a thin membrane which is attached to the body over a great part of its surface, but hangs free like a curtain around nearly the whole circumference. By raising its edge, or gently tearing the whole right half away from the body, the gills

will be exposed. These are four parallel plates which occupy the ventral half of the mantle cavity and extend from the posterior nearly to the anterior end of the body. Their ventral edges are free, but their dorsal edges are united to each other, to the mantle, and to the body. The space above, or dorsal to the posterior ends of the gills, is occupied by the oval, firm adductor muscle, the so-called 'heart.' For some time I was at a loss to know how the muscle came to be called the 'heart,' but a friend told me that he had always supposed that this was the heart, since the Oyster dies when it is injured. The supposed 'death' is simply the opening of the shell when the animal loses the power to keep it shut. Between this muscle and the hinge the space above the gills is occupied by the body, or visceral mass, which is made up mainly of the light-colored reproductive organs and the dark-colored digestive organs, packed together in one continuous mass.

"If the Oyster has been opened very carefully, a transparent, crescent-shaped space will be seen between the muscle and the visceral mass. This space is the pericardium, and if the delicate membrane which forms its sides be carefully cut away, the heart may be found without any difficulty, lying in this cavity, and pulsating slowly. If the Oyster has been opened roughly, or if it has been out of water for some time, the rate of beating may be as low as one a minute, or even less, so the heart must be watched attentively for some time in order to see one of the contractions."[1]

The dark-purple scars near the centers of both valves are simply the areas covered by the attachments of the adductor, which is composed of a vast number of extremely fine muscular fibers, which collectively pass straight across the space between the inside of the valves, being firmly fixed at either end of the latter. The tendency to separate the valves at their free borders, inherent in the ligament, is balanced or counteracted by the muscle. The head end of the animal lies close against the hinge, the point where, as previously described, the two valves are firmly fixed to each other by a dark-brown, crescent-shaped body, the ligament, which, while it serves to attach, also tends, by reason of its elastic properties, to cause the valves to separate at their free borders in order to allow the passage of the water inward to the gills, and of food to the mouth, while it also allows the water which has passed through the gills to escape by way of the cavity above the gills which is prolonged into the cloaca, carrying along with it, in its outward passage, the fæces from the vent. The foregoing lines fairly describe the mechanism of the shell and in part the physiological significance of the same.

The structure of the shell is laminar, or, in other words, it is composed of numerous layers of a material identical in composition with chalk, deposited one on the other by the mantle, the organ which builds the whole shell in this way, the chalky substance being derived from the fluids of the animal, which in turn derives it from its food. These layers, deposited as they are internally, in a horny organic matrix, as growth proceeds project in succession past each other at the free edges of the valves and external surface of the shell, so that the successive deposits may readily be distinguished on its external surface, giving rise to a very rough imbricated appearance of the edges of the layers on the outside. Attempts which I have made to determine the age of Oysters from a supposed periodic deposition of the shelly material, corresponding to the years of its age, I find to be impracticable.

The structure in the layers of the shell of the chalk or calcic carbonate is minutely prismatic. Nathusius-Königsborn has found that certain portions of the shell of the European Oyster contain very minute air-spaces. Both native and foreign species are found to have hollow cavities in the valves, usually containing water.

[1] W. K. Brooks: Development of the American Oyster. Studies from the Biological Laboratory of Johns Hopkins University, No. IV, 1880, pp. 5–7.

"In front of the gills, that is, between them and the hinge, there are four fleshy flaps—the lips—two on each side of the body. They are much like the gills in appearance, and they are connected with each other by two ridges which run across the middle of the body close to the anterior end, and between these folds is the large oval mouth, which is thus seen to be situated, not at the open end of the shell, but as far away from it as possible. As the Oyster is immovably fixed upon the bottom, and has no arms or other structures for seizing food and carrying it to the mouth, the question how it obtains its food at once suggests itself. If a fragment of one of the gills is examined with a microscope it will be found to be covered with very small hairs, or cilia, arranged in rows. Each of these cilia is constantly swinging back and forth, with a motion something like that of an oar in rowing. The motion is quick and strong in one direction and slower in the other. As all the cilia of a row swing together, they act like a line of oars, only they are fastened to the gill, and as this is immovable, they do not move forward through the water, but produce a current of water in the opposite direction. This action is not directed by the animal, for it can be observed for hours in a fragment cut out of the gill, and if such a fragment be supplied with fresh sea-water, the motion will continue until it begins to decay. While the Oyster lies undisturbed on the bottom, with its muscle relaxed and its shell open, the sea-water is drawn on to the gills by the action of the cilia, for although each cilium is too small to be seen without a microscope, they cover the gills in such great numbers that their united action produces quite a vigorous stream of water, which is drawn through the shell and is then forced through very small openings on the surfaces of the gills into the water-tubes, inside the gills, and through these tubes into the cavity above them, and so out of the shell again. As the stream of water passes through the gills the blood is aërated by contact with it. The food of the Oyster consists entirely of minute animal and vegetable organisms and small particles of organized matter. Ordinary sea-water contains an abundance of this sort of food, which is drawn into the gills with the water, but as the water strains through the pores into the water-tubes, the food particles are caught on the surface of the gills by a layer of adhesive slime which covers all the soft parts of the body. As soon as they are entangled the cilia strike against them in such a way as to roll or slide them along the gills toward the mouth. When they reach the anterior ends of the gills they are pushed off and fall between the lips, and these again are covered with cilia, which carry the particles forward until they slide into the mouth, which is always wide open and ciliated, so as to draw the food through the œsophagus into the stomach. Whenever the shell is open these cilia are in action, and as long as the Oyster is breathing a current of food is sliding into its mouth.

"The cilia and particles of food are too small to be seen without a microscope, but if finely powdered carmine be sprinkled over the gills of a fresh Oyster, which has been carefully opened and placed in a shallow dish of sea-water, careful observation will show that as soon as the colored particles touch the gills they begin to slide along with a motion which is quite uniform, but not much faster than that of the minute-hand of a watch. This slow, steady, gliding motion, without any visible cause, is a very striking sight, and with a little care the particles may be followed up to and into the mouth.

"In order to trace the course of the digestive organs, the visceral mass may be split with a sharp knife or razor. If the split is pretty near the middle of the body, each half will show sections of the short, folded œsophagus, running upward from the mouth, and the irregular stomach, with thick, semi-transparent walls, surrounded by the compact, dark-greenish liver. Back of the liver and stomach the convoluted intestine will be seen, cut irregularly at several points by the section.

"There are no accessory organs of reproduction, and the position, form, and general appear-

ance of the reproductive organ is the same in both sexes. There is no characteristic by which a male Oyster can be distinguished from a female, without microscopic examination. As the reproductive organ has an opening on each side of the body, it is usually spoken of as double, but in the adult Oyster it forms one continuous mass, with no trace of a division into halves, and extends entirely across the body and [against] the bends and folds of the digestive tract." [1]

(The last of the foregoing statements as to the impossibility of discriminating the sexes without the aid of the microscope is no longer true, though it was true at the time the above was written. The method of discriminating the sexes discovered by the writer is discussed in another portion of this sketch of the history of the Oyster.)

The stomach is pretty definitely marked off from the other portions of the digestive tract. It may be said to be that portion of the latter which is surrounded by the liver. The portion of the intestine immediately following the short widened region which we regarded as the stomach is the most spacious portion of the gut, and in it is lodged a very singular organ which has been called the "crystalline style." This is an opalescent rod of a glass-like transparency and gelatinous consistence which measures, according to the size of the Oyster, from half an inch up to one and a half inches in length. Its anterior end is the largest, and in a large specimen measures nearly an eighth of an inch in diameter, but at its posterior end is scarcely half as thick; both ends are bluntly rounded. I fell into an error in supposing that this style was lodged in a special pouch or sac as described in my report to the Maryland commissioner in 1880. The "crystalline style" really lies in the first portion of the intestine and extends from the pyloric end of the stomach to the first bend of the intestine, where there is a marked constriction of the alimentary canal. It appears therefore to be a sort of loose valve in the cavity of the gut; its function may be to prevent coarse particles of food from passing, or it may in some way assist digestion. In specimens hardened in acid or alcohol this rod is destroyed, or at least disappears, so that I have been unable to find it. The greater portion of its substance is apparently made up of water.

The peculiar double induplication of the wall of the intestine is described in another place. The fecal matters are extruded in the form of a demi-cylinder, with one side excavated in a groove-like manner. This shape of the fæcal matters is due to the presence of the double fold. The fæces themselves are composed of extremely fine particles of quartz or sand grains, the tests of diatoms, organic matters, humus, cellulose, fragments of the chitinous coverings of some of the minute worms and articulates, etc., which have been swallowed and digested by the animal. The anus is situated on the dorsal side of the great adductor muscle where the intestine ends.

The organs of sensation of the Oyster, though not very highly developed, are of sufficient importance to merit attention. The auditory sense, although I have never been able to dissect out the auditory vesicles, I am satisfied exists, because one cannot noisily approach an Oyster bank where the Oysters are feeding without their hearing so that instantly every shell is closed. The tentacles of the mantle are often extended until their tips reach beyond the edges of the valves. If the animal in this condition is exposed to a strong light the shadow of the hand passing over it is a sufficient stimulus to cause it to retract the mantle and tentacles and to close its parted valves. The mantle incloses, like a curtain, the internal organs of the creature on either side, and lies next the shell, and, as already stated, secretes and deposits the layers of calcic carbonate composing the latter. The free edges of the mantle, which are purplish, are garnished with small, highly sensitive tentacles of the same color. These tentacles are ciliated and serve as organs of touch, and also appear to be to some extent sensitive to light.

[1] W. K. BROOKS: *Op. cit.*, pp. 8–10.

The nervous system of the Oyster is very simple, and, as elsewhere stated, is to some extent degenerate in character. It is composed of a pair of ganglia or knots of nervous matter, which lie just over the gullet, and from these a pair of nervous cords pass backward, one on each side, to join the hinder pair which lie just beneath the adductor muscle. The mantle receives nerve branches from the hindmost ganglia or knots of nervous matter; these, as their centers, control the contraction and elongation of the radiating bundles of muscular fibers, as well as those which lie lengthwise along the margin; the former contract and withdraw the edges of the mantle from the margin of the shell, while the latter in contracting tend to crimp or fold its edges. The tentacles are mainly innervated by fibers emanating from the hindmost ganglia, while the internal organs are innervated from the head or cephalic ganglia. The hind ganglia also preside over the contractions of the great adductor muscle. The nerve threads which radiate outward from it to the tentacles dispatch the warnings when intruders are at hand that it must contract and close the shells.

211. THE MINUTE ANATOMY OF THE OYSTER.

There is a spacious segmentation cavity developed in the embryo which becomes the subdivided body-cavity—schizocœl of later stages. Between the ectoderm and endoderm the mesoblastic tissue is developed apparently by proliferation, so that the segmentation or body cavity becomes in part obliterated. The mesoblast of the embryo formed as above stated is the tissue from which the mesenchyme or connective tissue of the adult is developed. The blood channels or canals are developed in the mesenchyme of the adult—mesoblast of the embryo. The large, coarse vesicular connective tissue cells form a sort of trabecular network of pillars and transverse supports between and around which the sanguineous fluids circulate. The blood channels or canals are developed directly from the spaces between the columns and their conjoining masses of connective tissue cells; an exception to this is found only in the structure of the anterior and posterior aortæ, the heart, and branchiocardiac vessels, which have proper walls lined with endothelial cells. Throughout the greater part of its extent the mesenchymal or connective tissue is spongy, its cells being built around complex anastomosing spaces for the blood. There is, therefore, a true schizocœl developed in the Oyster; it has been formed as the mesoblastic tissue has grown into the segmentation cavity and subdivided the latter into hæmal canals and spaces. The blood cells originate in all probability in the same way. These are amœboid, colorless, and measure about one three-thousandth of an inch in diameter. The vascular channels have no specialized endothelial walls in the mesenchymal parts of the body.

The adductor muscle of the shell and the radiating muscular bundles running from the insertion of the former to the edge of the mantle are derived from the mesoblastic cells of the embryo, the observations of Dr. Horst on this point having, I think, completely set at rest what was formerly a matter of theory. The radiating muscular bundles—pallial muscles—of the adult lie just beneath the epiblast or epithelium on the outer sides of the mantle leaves. These pallial muscles in the embryo are represented by two sets of dorsal and ventral muscular bundles, the functions of which are to retract the velum into which they are inserted. The muscular fibers of the walls of the heart are not striated and decussate in every direction. The inner walls of the heart are crossed in various directions by muscular bands or trabeculæ, and a more or less complete muscular septum divides the ventricle in the median line; the heart is, therefore, approximately four-chambered.

The mesenchymal or mesoblastic tissues comprise the great bulk of the body of the animal, and extend out into and form the greatest proportion of the thickness of the mantle, and also

down into the branchial sacs between their epiblastic or epithelial, ciliated, external walls. It also forms the principal bulk of the thick vertical, transverse septa which subdivide the branchial pouches internally, and forms likewise the bulk of the branchial filaments themselves. These latter are numerous and give the surface of the gills their furrowed or plaited appearance. The individual plaits or ridges seen in section are found to be quite complex and to be themselves compoundly ribbed and to have chitinous rods embedded in their substance just beneath the external epithelium. These rods run lengthwise through the substance of the branchial riblets. The branchial capillaries are excavated in the mesenchymal or connective tissue of the branchial filaments or tentacles, between which there are numerous openings or ostia for the passage of the water from the inferior portion of the pallial chamber into the gill cavities in order to effect respiration. It is difficult, however, to make this arrangement understood without the aid of figures.

The mesenchyme also gives support to all of the visceral structures, the ultimate secretory follicles or saccules of the liver being imbedded and supported by it. The same is true of the generative structures and the intestine. No portion of the walls of the stomach, œsophagus, or hepatic ducts can be found the walls of which do not lie directly in contact with this mesenchymal or mesoblastic tissue. It also extends out into and forms the greater proportion of the substance of the palps or lips of the Oyster, and is very spongy and highly vascular in this region. The internal or oral surface only of the palps or lips are closely plaited with numerous folds of ciliated epithelium. These folds may number from one hundred and twenty-five or more. The surface of the palps in the immediate vicinity of the mouth is not plaited or folded.

The mesenchymal cells are much larger than either the epithelial or endothelial cells, and will average one five-hundredth of an inch in diameter. They inclose in all cases, both in winter and summer, a large, irregular nucleus from which a complex network of intracellular granular fibrils radiate in all directions through the enveloping cellular substance. At one side of the nucleus there are always one or more accessory bodies, perfectly globular, which complicate the character of the nucleus in a singular manner. These vesicular, very hygroscopic, mesenchymal or connective tissue elements are not fat-cells, as has been erroneously supposed by Brooks. Their nuclei are invariably central and not parietal in position, as in fat-cells. These cells are probably very hygroscopic, as would appear judging from their singular appearance under the microscope. They appear to be widely distributed in the molluscous invertebrates; they were originally named "vesicular connective tissue cells" by the histologist Schaefer. An Oyster may in the summer season absorb water and swell up so as to fill up almost the whole cavity of the shell, and when opened it may lose so much blood and water in the course of half an hour that it will have shrunk to one-tenth of its original bulk. This is a common occurrence, and is explained by the probable hygroscopic character of the connective tissue cells and the spongy nature of the whole mesenchyme which consists of these elements. This also explains why it is that Oysters may be much swollen in a short time by osmotic action, when immersed in water of a less specific gravity than the sea-water from which they were first taken. The process has nothing in common with what might be called fattening, as we shall see hereafter.

There is an apparent atrophy or wasting away of the mesenchyme of the body-mass and mantle during the spawning season, with a great concomitant development of the reproductive follicles or tubules. In winter the reproductive follicles atrophy, when the mesenchyme again increases in bulk in the body-mass and mantle. It also undergoes another remarkable series of changes corresponding to summer and winter. In summer it acquires an almost glass-like transparency, so that the mantle, palps, and superficial portions overlying the viscera become

translucent. In this condition, if the reproductive glands are undeveloped, the dark mass of the liver may be seen through the body walls. Towards the autumn, on the other hand, the connective tissue cells acquire a milky opacity and great solidity as compared with their watery, transparent condition in summer. This last condition, which involves the whole mantle, the palps and superficial portions of the visceral mass, indicates to the oysterman the condition of fatness. The Oysters in this state are plump; do not so readily diminish in bulk when removed from the shell as in summer; but that this change is due to storage of fatty matters I have not yet seen any evidence of any sort which would amount to proof. There is some oily matter in the Oyster, but not enough to account for the changes which we have described.

The atrophy of the connective tissue during the summer season would appear to indicate that the material for the genesis of the reproductive elements was derived from the mesenchyme, by a direct transformation of its substance in which the generative follicles are imbedded. It is, in fact, the great development of the mesenchymal substance in the autumn and winter, when the reproductive function is in abeyance, that constitutes the condition of the animal known to oystermen as fatness. These relations illustrate very beautifully a well-known physiological principle, viz, that nutritive processes are very intimately related to the reproductive; they are in fact interdependent.

In summer, when the reproductive organs are gorged with their products, their follicles are crowded together into contact; in winter, in their atrophied condition, they lie imbedded in the superficial portion of the mesenchyme of the body-mass, the same as in summer, but are much less developed, so as to appear in sections like a very open network of strands of very small, nucleated, incipient embryo cells, the connection of which may be traced into the now collapsed and internally ciliated branches of the oviducts. All the parts of the reproductive apparatus are therefore present in winter, but in an undeveloped condition. The oviducts branch and spread over each side of the body-mass just outside of the stratum of reproductive follicles and immediately beneath the mantle. They do not ramify through the substance of the reproductive organ, but traverse its surface, the follicles emptying their contents into the ducts by way of openings upon the inner faces of the latter. The main openings of the oviducts of either side open into the upper branchial cavity on either side of the hinder and ventral portion of the body-mass just below the muscle. There is but one opening on either side, notwithstanding the various statements to the contrary.

Embryologically considered, the liver is an endodermal structure, a diverticulum of the stomach. The great bile ducts pass outward from the cavity of the stomach and subdivide again and again and end blindly in spacious ovoidal hepatic follicles, the simple plicated walls of which consist of hepatic cells. The function of the liver is in all probability both excretory and secretory, and takes an all-important share in the processes of digestion. That the function of the liver is partially excretory is rendered all the more probable from the fact that there is little or no evidence of the existence of a renal apparatus or organ of Bojanus in the Oyster such as is found in other mollusks. Dr. Horst looked in vain for a rudiment of this last structure in the embryos of *Ostrea edulis*. Transverse sections through those portions of the body where it would most likely be found, made from both native and foreign examples, exhibit no structure in the least degree resembling what is regarded as the organ of Bojanus in *Unio* and *Anodonta*.

The wall of the intestine, like that of the stomach, is ciliated throughout, and is also of endodermal or hypoblastic origin. Its wall is folded inward along one side in a peculiar way, so that its lumen is more or less crescentic in cross-section. This arrangement, together with the very minute minor folds on its inner surface composed of long, columnar, ciliated epithelial cells, increases the

amount of absorbing surface very materially. The internal surface of the stomach is also very much plicated; but here the folds are both large and conspicuous, with small folds often intervening. There are neither annular nor longitudinal muscular fibers in the wall of the intestine; the sole motive force used in the propulsion of the ingested food appears to be exerted by the ciliary covering which everywhere clothes the internal surface of the alimentary tract from the mouth to the anus.

It would appear that the intestine makes two complete bends upon itself at a very early stage of embryonic life, according to the observations of Horst, long before it measures a ninetieth of an inch in diameter. The development of the liver seems to be at first lateral and somewhat ventral; an arrangement traces of which may still be noticed in cross-sections of the adult.

The course of the intestine in the adult may be described as follows:

The mouth is a wide opening between the upper median angles of the palpi; so wide, indeed, that the animal can scarcely be said to have an œsophagus; immediately follows the stomach, which is seen to have very pronounced folds internally, with a generally transverse direction, but two of these, which lie in a somewhat ventral position, are a pair of inward-projecting folds which are themselves plicated. The intestine then follows an oblique course, downward and backward, when it makes a sharp bend returning beneath the floor of the pericardial space, passing obliquely upward and forward, somewhat to the right and dorsal of the stomach, when it crosses exactly over the mouth or very short gullet, passing downward to the left side of the animal, alongside and a little to the lower side of the stomach, when it again turns upward and passes over the pericardial space to end in the rectum just over the middle of the adductor muscle. The clusters of hepatic lobules or follicles dip down into the folds of the walls of the stomach, but the liver does not follow the course of the intestine proper, which is provided internally with a curious pair of longitudinal and parallel folds, which project into the intestinal cavity and extend from the pyloric end to very near the anus. The presence of these folds gives to the fæcal matters their singular appearance, which are not in the form of a cylinder as they leave the vent, but in the form of a tube with a part of one side removed. Tracing the course of the intestine by sections is not the proper way; they can be very easily dissected out for their entire length by means of the scissors and forceps.

The systemic heart of the Oyster is that organ which serves to propel and redistribute the colorless blood of the animal through the body for its nourishment, and through the gills that the blood itself may discharge into the water the poisonous gases with which it is loaded in passing through the body, and receive a fresh supply of oxygen as fresh supplies of water pass through the gills. The heart consists of three principal chambers; the upper, largest, whitish and partially divided by a median septum or partition, is the *ventricle*, and the two lowermost and smaller, brownish paired chambers are known as the *auricles*. These three chambers which comprise the heart of the Oyster lie in a crescent-shaped space, the pericardial space, just forward of the adductor muscle. The ventricle is almost globular; its walls are made up of a delicate meshwork of unstriped muscular fibers, which are so interlaced as to be altogether untraceable. From the ventricle a great posterior and an anterior aortic vessel arises. These two vessels distribute the blood to the posterior and anterior portions of the body of the animal, but soon divide into paired vessels which traverse the mantle on either side both anteriorly and posteriorly, while one great median branch passes forward over the stomach. The blood is really distributed soon after leaving the main vessels, especially in the body through the spongy connective tissue spaces, as already described, and is collected into a great ventral canal from which a large part of it passes into the gills. From the four gills or branchial pouches the blood flows back to the ventricles

through six great branchiocardiac vessels, three of which are arranged on each side; two pairs of these are anterior in position and one pair posterior.

The circulation of the Oyster is quite different in character from that observed in a vertebrated animal. In the latter the heart pumps the purified blood *to* and through the gills before it passes to all parts of the body; in the Oyster, on the other hand, the fresh, pure blood is pumped by the heart *from* the gills before it passes to all parts of the body.

A curious and interesting point which I think it desirable to mention, because I have not noticed that attention has hitherto been especially called to it, is the metamorphosis of the larval Oyster into the adult. A. de Quatrefages[1] has alluded to it, but not in explicit terms. I have shown in my sketch on the growth of the animal that the larval shell was quite different from that of the adult, in fact, more like a very diminutive *pisidium* than anything else. The metamorphosis of the larval shell, or rather its passage into that of the spat, is abrupt. Not so with the soft parts; the oldest larvæ yet studied by any competent biologist show that the mouth of the larva is placed on the ventral side of the embryo, and that the hinge is situated on almost exactly the dorsal or opposite side. The ventral position of the mouth of the larvæ and its anterior or cephalic position in the adult show that a very important series of changes in the position of the viscera must take place between the time when the larva loses its principal embryonic features and acquires the adult arrangement and relations of its hard and soft parts. In other words, we are made aware, after instituting the foregoing comparison, that the Oyster actually undergoes a metamorphosis.

If an Oyster be carefully opened it will be found that the animal adheres to the shell at four points, or at two points on either valve. The principal points of attachment are of course the insertions of the great compound adductor muscle, made up of two portions which may be distinguished by the color of the cut ends of the component fibers. The great shield-shaped purple areas on either valve mark the points of insertion of the great adductor in the American Oyster, and also in the Portuguese form, which resembles it considerably. In *Ostrea edulis*, or the European species, the insertion of the adductor muscle is very rarely colored, so rarely indeed that we may regard this feature as one of the specific marks of this form. But in both the American and the European species there is a second muscular attachment, as implied above, which appears to have been very generally overlooked. It is situated nearer to the hinge than to the great adductor, and is sometimes marked by a slight depression not over an eighth of an inch in its greatest transverse diameter. It gives attachment to a feeble muscular bundle which springs out of the mantle on either side of the visceral mass, and when the animal is torn loose a slight whitish scar on the soft part marks its position on the surface of the mantle. I have been informed that Mr. W. H. Dall, who has investigated the matter, has identified this muscle with the pedal muscle of some other acephalous mollusks.

212. SEX, SEXUAL PRODUCTS, AND DIFFERENCE OF THE SEXUAL HABITS OF THE AMERICAN AND EUROPEAN OYSTERS.

"The number of male cells which a single male will yield is great beyond all power of expression, but the number of eggs which an average female will furnish may be estimated with sufficient exactness. A single ripe egg measures about one five-hundredth of an inch in diameter, or five hundred laid in a row, touching each other, would make one inch; and a square inch would contain five hundred such rows, or $500 \times 500 = 250{,}000$ eggs. Nearly all the eggs of a perfectly

[1] Metamorphoses of Man and the Lower Animals. Translated by H. Lawson, M. D., pp. 104–109. London, 1864.

ripe female may be washed out of the ovary into a beaker of sea-water, and, as they are heavier than the sea-water, they soon sink to the bottom, and the eggs of a medium-sized female will cover the bottom of a beaker two inches in diameter with a layer of eggs one-twentieth of an inch deep. The area of the bottom of a beaker two inches in diameter is little more than three square inches, and a layer of eggs one-twentieth of an inch deep, covering three square inches, is equal to one three-twentieths of an inch deep and two square, and as a single layer of eggs is one five-hundredth of an inch thick, a layer three-twentieths of an inch thick will contain seventy-five layers of eggs, with 250,000 eggs in each layer, or 18,750,000 eggs. It is difficult to get the eggs perfectly pure, and if we allow one-half for foreign matter and errors of measurement, and for imperfect contact between the eggs, we shall have more than nine millions as the number of eggs laid by an Oyster of average size, a number which is probably less than the true number.

"Möbius estimates the number of eggs laid by an average European Oyster at 1,012,925, or only one-ninth the number laid by an ordinary American Oyster; but the American Oyster is very much larger than the European, while its eggs are less than one-third as large; so the want of agreement between these estimates does not indicate that either of them is correct.[1] Another estimate of the number of eggs laid by the European Oyster is given by Eyton ('History of the Oyster and Oyster Fisheries,' by T. C. Eyton, London, 1858). He says, p. 24, that there are about 1,800,000, and therefore agrees pretty closely with Möbius.

"An unusually large American Oyster will yield nearly a cubic inch of eggs, and if these were all in absolute contact with each other, and there were no portions of the ovaries or other organs mixed with them, the cubic inch would contain 500^3, or 125,000,000. Dividing this, as before, by two, to allow for foreign matter, interspaces, and errors of measurement, we have about 60,000,000 as the possible number of eggs from a single Oyster.

"Although each male contains enough fluid to fertilize the eggs of several females, there does not seem to be much difference in the number of individuals of the two sexes. When a dozen Oysters are opened and examined, there may be five or six ripe females and no males, but in another case a dozen Oysters may furnish several ripe males but no females, and in the long run the sexes seem to be about equally numerous. Oystermen believe that the male may be distinguished from the female by certain characteristics, such as the presence of black pigment in the mantle, but microscopic examination shows that these marks have no such meaning, and that there are no differences between the sexes except the microscopic ones. It is not necessary to use the microscope in every case, however, for a little experience will enable a sharp observer to recognize a ripe female without the microscope. If a little of the milky fluid from the ovary of a female with ripe or nearly ripe eggs be taken upon the point of a clean, bright knife-blade and allowed to flow over it in a thin film, a sharp eye can barely detect the eggs as white dots, while the male fluid appears perfectly homogeneous under the same circumstances, as do the contents of the ovary of an immature female, or one which has finished spawning. When the eggs are mixed with a drop of water they can be diffused through it without difficulty, while the male fluid is more adhesive and difficult to mix with the water. By these indications I was able in nearly every case to judge of the sex of the Oyster before I had made use of the microscope.[2]

"During my investigations I submitted more than a thousand Oysters to microscopic examination. My studies were carried on during the breeding season, and I did not find a single

[1] Möbius' measurement, from .15 to .18 millimeter, is given (Austern und Austernwirthschaft, 1877) as the diameter, not of the egg, but of the embryo, but his figures show that the European Oyster, like the American, does not grow much during the early stages of development, but remains of about the same size as the egg.

[2] W. K. Brooks: *op. cit.*, pp. 13–15.

hermaphrodite. The male cells are so small compared with the eggs that it would be impossible to state that a mass of eggs taken from the ovary contained no spermatozoa, although they could not escape detection if they were at all abundant.

"On the other hand, a single egg in the field of the microscope, in a drop of male fluid, would be very conspicuous and could not escape detection; and the fact that not a single case of this kind occurred is sufficient to establish the distinctness of the sexes at the breeding season."[1]

Writing about this matter in 1880, I said: "No evidence to show that our Oyster is hermaphrodite was found during the entire season; nor were my searches for embryo or eggs in the mantle or in the gills more successful than those carried on two years before by Professor Brooks. There is no doubt whatever that the Oyster of Europe nurses its young in its mantle or gills for some time; nor can we well question the very high authority of Möbius for saying that in most cases the sexes are separate, and that only one kind of products, viz, either eggs or spermatozoa, are at any time found in the generative organs. Lacaze-Duthier's observations seem to confirm the conclusions of Möbius."

In reference to the structure of the cells which make up the body of the Oyster, as well as regarding the eggs, Dr. Brooks, on page 19 of his essay, writes as follows:

"Each of these consists of a layer of protoplasm around a central nucleus, which, in the egg, is a large, circular, transparent body known as the germinative vesicle. Each cell of the body is able to absorb food, to grow and to multiply by division, and thus to contribute to the growth of the organ of which it forms a part. The ovarian eggs are simply the cells of an organ of the body, the ovary, and they differ from the ordinary cells only in being much larger and more distinct from each other; and they have the power, when detached from the body, of growing and dividing up into cells, which shall shape themselves into a new organism like that from whose body the egg came. Most of the steps in this wonderful process may be watched under the microscope, and owing to the ease with which the eggs of the Oyster may be obtained, this is a very good egg to study."

Brooks has represented the freshly laid ova of the Oyster with a spherical nucleus and nucleolus; the former is large and clear, and is imbedded near the center of the egg, and inside of it the nucleolus is lodged somewhat to one side. I do not find the latter spherical, as described, but formed as if composed of a larger and smaller highly refringent pair of spheres, partly fused with each other, or of the same form as the nucleoli of the eggs of *Anodonta* as described by Flemming.

Some investigations conducted under the auspices of the Dutch Government indicate that the structure of the generative organs of the European Oyster is not, as has been supposed, strictly follicular, but that they may rather be regarded as a mass of anastomosing tubes of irregular caliber. The complete proof of this has been developed by the writer in the course of investigations carried out upon our native Oysters, in which the generative organs were very immature during the winter season. Both Brooks and myself have spoken of the generative follicles as though they had been clearly made out; it now appears that we will be compelled to modify our terminology somewhat, in the face of the fact that I have sections of the immature generative organ which exhibit it as a network of germinal cells, as well as sections of the mature organs which show a more or less distinct tubular structure opening toward the surface into the superficial or surface outgoing canals. At the same time the tubes show more or less extensive junction or anastomosis with each other at certain points along their length, with a general tendency to be disposed vertically to the surface of the visceral mass. This arrangement reminds one somewhat of the

[1] W. K. Brooks: *op. cit.*, p. 35.

more or less parallel disposition of the seminal tubules of the testicles or milt of fishes and higher animals.

In microscopical cross-sections of the adult Oyster, whether it be male or female, the reproductive glands are found to be composed of a great number of minute pouches or follicles. In the gross arrangement of the follicles no difference between the sexes is discernible when thin sections are scrutinized with the microscope. Upon making an examination of the contents of the follicles with the microscope a great difference at once becomes manifest; in the male the spermatic particles in the follicles appear very finely granular, and if mature the tails or flagella of the spermatic particles tend to be directed toward the outlet of the follicle; in the female, sections of the follicles show the eggs in various stages of development attached by their narrow extremity to the walls of the reproductive saccules. The egg is pyriform in shape while still in the ovary, but the stalk is not as long as in the eggs of *Serobicularia*, as described by von Jhering. As elsewhere stated, the oyster-egg is not globular when first extruded. It will be readily understood that the sexes may be very readily distinguished by these and other marks observed in sections. The immature ova are vastly larger than the spermatozoa, which measure under the ten-thousandth of an inch at their largest end. The head of the spermatozoön of both the American and European Oyster is globular; that of the spermatozoön of the Soft Clam (*Mya*) is ovoidal in form. The tail or flagellum of the spermatic particle is the locomotive organ which lashes back and forth very rapidly and propels it through the water and finally brings it into contact with the egg.

213. NEW METHODS OF DISTINGUISHING THE SEXES AND OF TAKING THE EGGS OF THE OYSTER.[1]

DISCRIMINATION OF THE SEXES.—One of the first requisites of a practical system of artificial fertilization of the eggs of the Oyster is a means which, in the hands of unskilled persons, will enable them, without the aid of a microscope, to infallibly distinguish the sexes apart. Such a means we now propose to describe. Having tested it practically, and found it possible to instruct persons of ordinary intelligence in a few minutes, we have no hesitation in offering an account of the method so as to make it more generally available in the hands of those who may be interested in this subject.

It is premised that the spawn is squeezed from the reproductive glands by the method to be described further on. As soon as the spawn is emitted from the generative opening in consequence of the pressure exerted upon the gland and the ramifications of its ducts, it is drawn up by means of a small pipette or medicine dropper, provided with a small collapsible bulb at the upper end which is held between the thumb and forefinger. Pressing the bulb between the fingers, then immersing the open end of the pipette into the extruded spawn, and then allowing the bulb to expand by its own elasticity, it will draw or suck up the spawn which has been pressed out very neatly; and if one is careful, absolutely nothing but the spawn is picked up. One soon becomes very expert in the use of the pipette.

The next requisite is a shallow glass dish, or even a plain tumbler will answer, into which say a half gill of clean sea-water has been poured. Taking up the extruded spawn from the opening of the duct it is dropped from the pipette into the clear water. This last simple operation enables us to tell without fail to which sex the products belong. If the creamy white mass consists of eggs which have been pressed from the generative openings and is dropped into the water, it will at once break up into a granular cloud as the spawn strikes the latter, the granules themselves

[1] The observations and experiments discussed in this article were conducted at Saint Jerome's Creek during the months of July and August, 1882.

being very distinctly visible, especially if the glass vessel be resting upon a dark ground so as to bring the whitish granules into relief. The granules are nothing more than the ova or eggs of the Oyster, and at once indicate that the individual from which they were obtained is a female. In case the products are male, they break up as they mingle with the water into a milky white cloud in which no granules are visible to the naked eye. It is also very important to observe that as the milt is stirred in the water it breaks up at first into long, fleecy white clouds which resemble very strikingly in miniature what are known to meteorologists as cirrus clouds, or, vulgarly, "mare's tails," reminding one of these in the way in which the fine particles of milt give rise to streaks, wisps, and fibers as it breaks up in the water, without giving rise to any visible granular appearance as occurs in the case of the female products, but to an opalescent or milky aspect. These distinctions, once learned, are so palpable that the novice may as infallibly discriminate the sexes of the Oyster apart by their aid as can be done by the most skilled biologist with a powerful microscope.

THE IMPREGNATION OF THE EGGS.—The method formerly used was to first learn the sex of a number of adult Oysters with the microscope, then cut out the generative glands with their products and chop up those of different sexes separately in small dishes with sea-water. This system we may now say is barbarous, because it is crude; large numbers of eggs are destroyed by crushing, or are injured by the rough usage to which they are subjected, and, besides, there is no assurance that the eggs or milt operated with are quite mature. It is also troublesome to free the generative gland from fragments of the liver which help to pollute the water in the incubating vessels with putrescible organic matter, and thus interfere greatly with the life and healthy development of the embryos.

By our method the objectionable features of the old plan, as stated above, are overcome. If possible, select good-sized Oysters; open them with the greatest possible care so as not to mutilate the mantle and soft parts. Carefully insert an oyster-knife between the edges of the valves and cut the great adductor muscle as close as possible to the valve which you intend to remove, leaving the animal attached to the other valve, which, if possible, should be the left or deepest one. The soft parts being firmly fixed or held fast by the great adductor muscle to the left valve prevents the animal from slipping under the end of the pipette, held flatwise, as it is gently and firmly stroked over the generative gland and ducts to force out the generative products.

To prepare the animals to take the spawn from them, after opening, the following precautions are to be observed: Note that the reproductive gland in great part envelopes the visceral mass, and extends from the heart space, just in front of the great adductor, to within a half inch or so of the head or mouth end of the animal, which lies next to the hinge. Note also that both sides of the visceral mass which incloses the stomach, liver, and intestine are enveloped on either side by a membrane which also lies just next the shell and is garnished by a fringe of purplish, sensitive tentacles along its entire border except at the head end where the mantle of the left side passes into and is continuous with that of the right side of the animal. The ventral or lowermost side of the animal, anatomically speaking, is marked by the four closely corrugated gill plates or pouches, which are preceded in front by the four palps or lips, but both the gills and palps depend downward between the lower borders of the mantle of the right and left sides. Note, too, that if the mantle is carefully cut and thrown back on the exposed side of the animal between the upper edges of the gills and the lower edge of the cut or exposed end of the great adductor muscle, the lower and hinder blunted end of the visceral mass will be exposed to view. It is on either side of this blunted end of the visceral mass between the upper edge of the gills and lower side of the great muscle that the reproductive glands open almost exactly below the great adductor.

From these openings we will afterwards find, if the animal is sexually mature and the operation is properly conducted, that the spawn will be forced out in a vermicular, creamy white stream. But in order to fully expose the reproductive organ we should carefully continue to sever the mantle of one side with a sharp penknife or small scissors, some distance forward of the great muscle towards the head, cutting through the mantle just above the upper borders of the gills and following a cavity which lies between the latter and the lower border of the visceral mass. A little experience will teach one how far it is necessary to carry this incision of the mantle. For some distance in front of the heart space the mantle is free or detached from the visceral mass and reproductive organ which lies immediately beneath, and this enables one, if the last described incision has been properly made, to almost completely expose the one side of the visceral mass and the richly tinted, yellowish-white reproductive gland which constitutes its superficial portion. The opening of the gland and its superficial ramifying ducts being laid bare on the exposed side of the animal we are ready to press out the spawn on that side. Before beginning this, however, it is important to observe that the principal duct passes down just along the edge of the visceral mass where the latter bounds the heart space, in which the heart may be observed to slowly pulsate, and that this great duct ends somewhere on the surface of the ventral blunted end of the visceral mass. To expose the great or main generative duct it may be necessary to cut through or remove the pericardial membrane which incloses or covers the heart space on the exposed side. If the Oyster is sexually mature, the main duct will be observed to be distended with spawn, and that, originating from it and branching out over almost the entire surface of the visceral mass, there are minor ducts given off, which again and again subdivide. If these are noted, and it is observed that they are engorged, giving them the appearance of a simple series of much branched great veins filled with creamy white contents, it may be certainly presumed that your specimen is mature and that spawn may be readily pressed from it.

The operation of pressing the spawn out of the ducts requires care. The side of the end of the pipette may be used, being careful not to crush or break open the ducts as you gently and firmly stroke the pipette flatwise over the side of the visceral mass backward from the hinge towards the heart space and over the great duct at the border of the latter diagonally downward and backward to the opening of the reproductive organ. If this has been properly done it will be found that the generative products are being pushed forward by the pipette through the ducts, as the pressure will be seen to distend the latter, the contents of the branches flowing into the larger and larger trunks until they are forced outward through the main duct and opening below the great adductor, where they will pour out in a stream one-sixteenth of an inch or more in diameter if the products are perfectly ripe. The sexes may be discriminated as described at the outset, and it is well to first find a male by the method already given and proceed to express the milt as described above into say a gill of sea-water, adding pipetteful after pipetteful until it acquires a milky or opalescent white color. As the milt or eggs are pressed out of the opening of the ducts they are to be sucked up by the pipette and dropped into the water, the mixture of milt being first prepared, to which the eggs may be added as they are expressed from the females. The judgment of the operator is to be used in mixing the liquids; in practice I find that one male will supply enough milt to fertilize the eggs obtained from three or four females, and it does not matter if the operation takes from twenty to thirty minutes' time, as the male fluid, which it is best to prepare first, will retain its vitality for that period.

It is always desirable to be as careful as possible not to get fragments of other tissues mixed with the eggs and milt, and the admixture of dirt of any kind is to be avoided. To separate

any such fragments nicely, I find a small strainer of coarse bolting or cheese cloth to be very convenient.

In the foregoing description we have described the method of obtaining the spawn only from the side of the animal exposed in opening the shell. A little experience will enable one to lift up the head end of the animal and throw it back over the great adductor muscle, expose the opening of the reproductive organ on the left side, or whatever the case may be, and also express the spawn from that side, thus as effectually obtaining all of the ripe eggs or milt as is possible in the process of taking the same from fishes.

It is remarkable to note the success attending this method, since almost every egg is perfect and uninjured, the percentage of ova which are impregnated is much larger than by the old method, reaching, I should say, quite ninety per cent. of all that are taken when the products are perfectly ripe. It is also found that the products are not so readily removed by my process if they are not perfectly mature, which is also to a certain extent a safeguard against getting poor or immature spawn. In the course of an hour after the products of the two sexes have been mingled together it will be found that nearly every egg has assumed a globular form, has extruded a polar cell, lost the distinct germinative vesicle and spot in the center, and begun to develop.

It is noteworthy that our practice as herein described has completely vindicated the statement made by the distinguished French anatomist and embryologist, M. Lacaze-Duthiers, that there is but a single generative opening on each side of the visceral mass of the Oyster, and that, as we have stated, it is found to open just below the great adductor muscle.

We have also discovered, since the foregoing was written, that the use of an excessive amount of milt is of no advantage. The water in which the eggs are to be impregnated only requires to be rendered slightly milky; a very few drops of good milt is sufficient to make the impregnation a success. Too much milt causes the eggs to be covered by too large a number of spermatozoa; thousands more than are required if too much is used. These superfluous spermatozoa simply become the cause of a putrescent action which is injurious to the healthy development of the eggs. A drop of milt to twenty drops of eggs is quite sufficient.

Immediately after the ova have been fertilized it is best to put them into clean sea-water at once, using water of the same density as that in which the adults grew. If the attempt is made to impregnate the eggs in water much denser than that in which the adults lived, it is probable that the milt will be killed at once. This singular fact, which was accidentally discovered by Colonel McDonald and myself, shows how very careful we should be to take into consideration every variation in the conditions affecting a biological experiment. If sufficient water is used no trouble will be experienced from the pollution of the water by dangerous micro-organisms which are able to destroy the oyster embryos. From fifty to two hundred volumes of fresh, clean water may be added to the volume in which the eggs were first fertilized. This may be added gradually during the first twenty-four hours, so as to assist aëration and prevent the suffocation of the embryos.

214. RATE OF GROWTH OF OSTREA VIRGINICA.

SIZE OF THE EGG.—The egg of the American Oyster, according to Brooks, is approximately $\frac{1}{150}$ inch, being very nearly perfectly spherical after the extrusion of the polar or direction cells (*Richtungsbläschen* of the German embryologists). This accords with what the writer has observed in our species, and in the Portuguese Oyster, probably *O. angulata* Lam., the size of the egg appears to be about the same, judging from specimens of the latter examined by me in March last. Judging from the figures and the stated amplifications given in the papers of M. Davaine,

the egg of *Ostrea edulis* is $\frac{1}{150}$ inch in diameter. Estimates based on the figures of M. Lacaze-Duthiers give dimensions of $\frac{1}{210}$ inch. These discrepancies I think are probably too great, and may be due to imperfect micrometric methods. If they are real it would indicate a specific difference of some importance between *O. edulis* and *O. virginica*.

The actual volume of the egg of the American Oyster would accordingly be a little more than $\frac{1}{3500000}$ cubic inch, a solid so minute that we are unable to frame any adequate conception of its diminutiveness. Under the best conditions, as seen against a dark back-ground, it is visible as a grayish-white speck; almost an optical point. It is from this diminutive spherical mass of living matter that the young Oyster is developed. The development of the embryo proceeds, as far as I can make out, according to the accounts given by Davaine, Brooks, Horst, and others, similarly to that of other lamellibranchs. To Hatschek[1] we are indebted for the most secure foundation for our future embryological investigations upon this difficult group of mollusks; and we must not forget to mention the very important researches of Ray Lankester (Phil. Trans., 1875), principally upon *Pisidium*. I have not been able to observe the development of the larval Oyster beyond the size attained by it after the complete segmentation of the egg, the development of the shell, the velum, and alimentary tract. In fact, no embryos which I have attempted to rear from artificially impregnated eggs have ever lived long after the time when they began to take food, which is immediately after they acquire the velum, permanent mouth, and vent, and are almost or altogether covered on either side by the very symmetrical larval shells, which consist of carbonate of lime laid down in a matrix of conchioline. The isolation of the conchioline is readily effected by the use of acetic acid, the acid dissolving out the lime entirely. I find that Brooks and Dr. Horst[2] have tried a similar experiment with similar results. The latter writer has also been able to watch the development of the naturally impregnated ova of *Ostrea edulis* until a pretty advanced stage was reached. He disagrees with Brooks in his interpretation of the gastrula stage, and thinks that the invagination regarded by the American investigator as the blastopore must be considered to represent simply the first rudiment of the shell-gland. In assuming this position, from what I have been able to gather in the course of my own investigation of the development of the American species, I think we are bound to accept Dr. Horst's determination of the homology of the shell-gland of the Oyster with that of other lamellibranchiate and cephalophorous mollusks.

EARLY STAGES OF DEVELOPMENT.—The oral invagination, according to Dr. Horst, originates on the opposite or ventral side of the embryo and has no connection with the dorsal pallial invagination or shell-gland. The early stages of the American and European species, like the later ones, appear to present no marked differences, except that the latter appears, on the evidence of Dr. Horst, Möbius, and others, to carry the ova and embryo in the mantle cavity, from which the first-named author obtained his material for study, by breaking a hole through the shell near the margin, so as to enable him to introduce a pipette into the pallial chamber. This method of getting embryos is impossible in our native species, which has wholly different breeding habits, as is proved by the investigations of Brooks, Winslow, Rice, and myself. How much further than heretofore Messrs. Brooks and Winslow have been enabled to carry the development of our native Oyster during the past season at Beaufort, North Carolina, I have not been able to learn, nor do I know anything more definitely as to how much success has been attained in the artificial production of *Ostrea edulis* from artificially-impregnated eggs at the hands of Mr. Littlewood, of England,

[1] Ueber Entwickelungsgeschichte von Teredo. Arbeiten aus dem Zool. Inst. Wien., Bd. iii.

[2] Bijdrage tot de Kennis van de Ontwikkelingsgeschiedenis van de Oester (*Ostrea edulis* L.), door Dr. R. Horst. Tijdschr. d. Ned. Dierk. Vereen, Deel, vi, 1882.

who has claimed that he had succeeded in rearing them to the age of five months, specimens of which it is said were shown at the Fishery Exhibition recently held in Edinburgh.

EXPERIMENTS AT SAINT JEROME'S CREEK.—Our experiments made at Saint Jerome's Creek during the past summer gave the most contradictory results, and the interval of development between that of our oldest embryo with its diminutive Pisidium-like valves measuring about $\frac{1}{500}$ inch in diameter, and that of the embryo when its valves first begin to lose their embryonic form, still remains unbridged. The dimensions of the embryo or "fry," as we may more properly call it when it becomes fixed, are between $\frac{1}{80}$ and $\frac{1}{90}$ inch according as the measurement is made longitudinally or transversely. The difference in magnitude between the oldest artificially incubated fry seen by me and that of the youngest fixed embryos which I collected is very small, amounting only to $\frac{41}{4600}$ inch, or a little more than $\frac{1}{109}$ inch. To determine the relative volumes of these stages, and consequently the amount of food which has been taken in and converted into the structure of the more advanced stage in addition to the original bulk of the egg, we need only take the cubes of their respective diameters and compare them. Taking the diameter of the egg, or $\frac{1}{360}$ inch, as the diameter of the most advanced embryo seen by me, which we will consider unity, and comparing it with $\frac{1}{90}$ inch, or the transverse diameter of the newly fixed fry, we find, after having reduced the last quantity to its simplest form as compared with 1, or the diameter of the egg, that we have 5.1+. The diameters then of the first and last embryonic or truly larval stages are to each other as 1 is to 5.1+, and consequently their volumes will be to each other as the cubes of these numbers, or as 1 is to 132.651+. The difference between these two quantities, or 131.651+ times 1, will give us approximately the amount of food material which has been taken up by the embryo in passing from the condition when it was first able to feed until it fixed itself, showing that the process of growth has been going on vigorously in order to augment the volume of the young creature at the enormous rate indicated by our figures. We have, however, been dealing not with absolute but with relative or compared volumes only; if the egg contains $\frac{1}{2500000000}$ cubic inch of protoplasmic matter approximately, the newly-fixed fry, which we will assume to be globular, and contains, as shown above, over 132 times as much material, the absolute bulk of the latter will be $\frac{1}{2500000000}$ cubic inch multiplied by 132, or $\frac{132}{2500000000}$ cubic inch, which, in its simplest form, is therefore $\frac{1}{18939394}$ cubic inch, or the absolute volume of the newly fixed fry. Ninety cubed, or 729,000 young Oysters could therefore be contained in a cubic inch of space, if taken at the stage at which they begin to be transformed into spat. This large number is, of course, small when compared with 125,000,000, the number of eggs which might be contained by the same extent of space.

THE LARVAL CHARACTER OF THE YOUNG OYSTER.—The proof of the larval character of the youngest fixed stage of the Oyster rests upon the three following well-ascertained facts: 1st. The perfect symmetry and great convexity of the valves; 2d. The entirely different shape of the shell as compared with those of the spat and adult; 3d. Its wholly different microscopic structure when compared with the later and full-grown stages. The form of the shell, at the time the animal is about to begin to develop the spat shell, is suborbicular, very thin, ventricose, resembling in many respects the shell of *Cyclas* or *Pisidium*, having the symmetry of those genera, with umbones of about the same form and prominence. These features mark the larval shell of the Oyster so unmistakably that its valves may always be very readily recognized at the tips of the valves of spat under a year old. The larval valves lie on the tips of the valves of the spat like small hemispherical caps, but can usually not be found after the young Oyster enters upon its second year, as its umbones, together with the larval shells which surmount them,

have been eroded by the action of the carbonic dioxide in solution in the sea-water. The presence of the larval shells in an unimpaired condition on the umbones of the valves of Oysters is therefore an indication that such specimens are young, probably under a year old.

The third character, alluded to above, which distinguishes the larval shell of the Oyster is the perfect homogeneity of the calcareous matter. Unlike the valves of the spat or translucid flakes from the shell of the adult, they exhibit no prismatic arrangement of the calcic carbonate in a matrix of conchioline. In the valves of the adult and spat, on the other hand, the calcic carbonate tends to assume a prismatic arrangement vertical or at right angles to the plane of the length and breadth of the shell. This distinction is so marked that in very young individuals which have only lately become fixed one may very readily determine with the aid of the microscope the line of demarkation along which the formation of the larval shell ceased and where the prismatic calcareous structure of the valves of the spat began to be developed.

CHARACTERS OF THE LARVAL SHELL.—The only characters of structure which the larval shell has in common with that of the spat and adult are the lines of growth visible in all three. This shows that the valves grow in extent at all stages by the addition of lime to the edges of the valves, each layer of mineral matter and organic matrix extending over successively greater and greater areas, as in the growth of the shells of mollusks in general, the umbones being the points from which the valves grow in an eccentric manner in consequence of the gradually increasing extent of the mantle—the shell-secreting organ—as the growth of the animal proceeds. Having clearly defined the nature of the larval shell of the Oyster, up to the time when it is ready to begin to build or secrete the shell of the spat, we may next discuss the character of the transition from the one to the other.

The transition is apparently an abrupt one. The excessive convexity of the valves of the fry contrast strongly with the almost flat lower valve and feebly convex upper one of the spat. At the free edges of the larval shells where they pass directly into the structure of the valves of the spat there is a marked offset or angle marking very distinctly the difference of convexity between the two stages of shell development.

FOOD OF THE YOUNG OYSTER.—As already remarked, I have seen food in the intestine of the young Oyster on the second day of development, but how long it may take before the young embryo of this stage of growth shall have taken and appropriated one hundred and *thirty-two times its own volume of food material, I am not able to say. This it must do* before it can have attained to the size of the larva which is transformed into spat. The food is propelled through the alimentary canal by the action of innumerable vibratory filaments which clothe the inside of the throat, stomach, and intestine as in the adult; the intestine, stomach, and liver are not, however, as complex as in the full-grown animal.

Of the method of fixation I have as yet learned nothing of value. That this is accomplished by some sort of byssus I have no doubt. The fact that it is the left valve which is always the lowermost and attached one would indicate that the method of fixation was not capricious or haphazard in its nature.

I would infer from what we learn from the study of other animals that it may require quite a week before an embryo reaches the dimensions of one-eightieth of an inch, but we have no data upon which to base any conclusions of value. Of the later stage of development we know something definitely. The main fact which we have so far decided is the size of the larval shell.

RATE OF GROWTH.—After fixation the growth of spat is very rapid, as may be inferred from the fact that I have found spat upon collectors which had not been placed in position

more than a week to ten days, upon which I detected spat one-fourth of an inch across. In other cases the following were the observed dimensions: On a collector which had been placed near a bed of spawning Oysters for twenty days I obtained a specimen of spat seven-sixteenths of an inch across; from another collector immersed for forty-four days I obtained specimens thirteen-sixteenths of an inch in diameter; from another out forty-eight days a specimen measuring about one inch. Another set of collectors which had been out for seventy-nine days had spat attached which measured one and three-fourths inches across. Some still larger spat collected by me was not over eighty-two days old, and measured nearly two inches in length from the hinge to the distal margin of the valves. Still larger specimens have been observed by the writer, which bore every evidence of having affixed themselves during the same season.

If we contrast the above measurements with those given by Möbius of the spat of *O. edulis* of known age, I conclude that the American Oyster grows three or four times as rapidly as the former. For instance, Möbius figures a European Oyster twelve to fifteen months old, which measures only one and one-fourth inches in diameter. Contrasting this with the size of the American at seventy-nine to eighty-two days old, and measuring from one and three-fourths to nearly two inches in diameter, we see how greatly our species surpasses that of Europe in vigor and rapidity of growth.

Of the rate of growth beyond the ages given above I have only a few data, based on the spat which was caught on collectors put out in Saint Jerome's Creek in July and August, 1880. In the following autumn the collectors which had been put out into the creek were taken up and the spat removed from them. This was then put into a box, through which the water could circulate freely, and put back into the creek, in order that we might be enabled to learn how much growth these young Oysters would make during the winter and next season. I did not have an opportunity to examine them, however, until the 10th of July, 1882. From the time of their fixation in July and August, 1880, to the time when I made my last examination of these specimens, a period of about twenty-three months had accordingly elapsed. One of the largest specimens examined by me measured three and three-eighths inches in length and two and five-eighths inches in width. Another smaller specimen measured two and a half inches long and two and a quarter inches in width. They were about the size of Oysters available for planting, and I have no doubt that in the course of two or three years more, if placed under favorable conditions, they would reach a marketable size. The inference, therefore, is that it takes at least four to five years for an Oyster to grow large enough, starting from the egg, to be available for market.

In order that an Oyster may grow to attain the great size of certain single individuals which I have seen, it may take even ten years. I should think it would take at least that length of time for an Oyster to grow until its valves would measure nine inches in length, a few of which I have seen of this enormous size. These, it must be remembered, were not "Raccoon Oysters" or "Cat's-tongues," as the narrow, elongate individuals are called which grow so densely crowded together upon the banks as to be abnormally lengthened. Under favorable conditions, I do not think it improbable that an Oyster may live to the age of twenty years, attaining corresponding dimensions.

215. THE FOOD OF THE OYSTER.

OBSERVATIONS AT SAINT JEROME'S CREEK.—The following extracts, taken mainly from my report for 1880 to the Fish Commissioner of Maryland, will give some idea of the kinds of organisms usually encountered on oyster banks and beds. These observations were made at

Saint Jerome's Creek, a few miles north of the mouth of the Potomac, during the months of July, August, September, and October:

"The food of this mollusk, as is well known, consists entirely of microscopic beings and fragments of organic matter, which are carried by currents from the palps and gills, which have been already described, to the large mouth of the animal at the hinge end of the shell. The inside of the gullet and stomach, like some other parts of the body, are covered with cilia, so that food once fairly in the mouth will be carried by their action down to the cavity of the stomach, where it is carried into the folds and deep pouches in its walls, and even into the openings of the bile ducts, to undergo digestion or solution, so as to be fitted in its passage through the intestine to be taken into the circulation, and finally disposed of in building up the structures of the body.

"Along with the food which is taken, a very large amount of indigestible dirt, or inorganic matter, is carried in, which, in a great measure, fills up the intestine, together with the refuse or waste from the body. This material, when examined, reveals the fact that the Oyster subsists largely on diatoms, a low type of moving plants which swim about in the water, incased in minute sandstone cases, or boxes, of the most delicate beauty of workmanship. These, when found in the intestine, have usually had their living contents dissolved out by the action of the digestive juices of the stomach. I have found in our own species of Oyster the shells of three different genera of diatoms, viz: *Campylodiscus*, *Coscinodiscus*, and *Navicula*. The first is a singularly bent form; the second is discoidal; and the last boat-shaped, and all are beautifully marked. Of these three types, I saw a number of species, especially of the latter, but as I was not an authority upon the systematic history of any of them I had to neglect the determination of the species. No doubt many more forms are taken as food by the Oyster, since I saw other forms in which the living matter inside the siliceous cases was brown, the same as in most of the preceding forms which I have indicated. Some of these brown forms were so plentiful as to color a considerable surface whereon they grew of the same tint as themselves.

"Besides the diatoms and the spores of algæ, the larvæ or young of many animals, such as sponges, *bryozoa*, hydroids, worms, mollusks, are small enough to be taken in as aliment by the Oyster, though their bodies in most cases being soft and without a skeleton, it is impossible to find any traces, either in the stomach or intestine, of their remains, to indicate that they have formed a part of the bill of fare of the animal. What, however, demonstrates that such small larval organisms do help to feed the Oyster is the fact that at the heads of the small inlets or creeks along the Chesapeake, where the water is but little affected by the tides and is somewhat brackish and inclined to be stagnant, there always appears to be a relatively greater development of a somewhat characteristic surface or shallow water fauna of minute forms.

"In Saint Jerome's Creek the microscopic fauna of its headwaters is entirely different from that of the body of the creek; two minute forms inhabit in vast numbers the former, while I sought in vain for them in the more open and changeable waters of the main body of the inlet, which are brought into active movement twice a day by the action of the tides. One of these forms, an infusorian,[1] one twenty-fifth of an inch in length, was found covering every available surface of attachment, so that countless multitudes of the naked young would be swimming about in the water previous to building the curious spiral tubes which they inhabit—admirably fitted in this state as food for the Oyster. Besides the type referred to, there were a number of other infusorians, which in their so-called swarming stages of development would become available as Oyster food. Of such types I noticed four different species, either belonging or very nearly

[1] On the occurrence of *Freia producta*, Wright, in the Chesapeake Bay.—*Am. Naturalist*, 1880, pp. 810, 811.

related to the genus *Cothurnia;* all of the forms built tubes for themselves. I also noticed several forms of bell animalcules, the swarmers of which would become available as food for the Oysters lying in the vicinity.

"The diatoms did not seem to me to be more abundant in the headwaters than in the open creek. There was one moss animal of remarkable character, which I found in the headwaters only. This creature was very abundant, and no doubt its embryos, like those of the infusoria referred to, were available as food.

"Of free-swimming infusorians, I noticed a number of genera; one especially attracted my attention from its snake-like appearance and singularly rapid contortions; it had a tuft of vibrating hairs or cilia at the head end in close relation with the mouth. Another more abundant type was the curious genus *Euplotes*, with a thick shell inclosing the soft protoplasm of the body; the latter was of an oval form, flat beneath and rounded on the back, so that the resemblance when the large foot-like cilia were in motion, carrying the animal about, was strikingly like a very minute tortoise, the resemblance being heightened when the animal was viewed from the side.

"Rod-like algæ of minute size, the larvæ of crustacea, especially the vast numbers of extremely small larval *Copepoda*, must enter as a perceptible factor into the food supply of the Oyster.

"There is no doubt but that the comparatively quiescent condition of the headwaters of these inlets and creeks, available as oyster-planting grounds, are more favorable to the propagation of minute life than the open bay or creeks, where the temperature is lower and less constant. Practically, this is found to be true, for oystermen seem to be generally agreed that Oysters 'fatten' more rapidly, that is, feed more liberally in the headwaters—blind extremities of the creeks—than elsewhere. This notion of the oystermen is in agreement with my own observations during the past year. Oystermen also assert that Oysters 'fatten' more rapidly in shallow waters than in deep ones, a point upon which I made but few observations; but such as I did make tended to confirm such an opinion. In illustration I may contrast the condition of the Oysters in the pond leased by the commission at Saint Jerome's and those dredged off Point Lookout, in twenty or thirty feet of water, on the 3d day of October, 1880. The Oysters in the pond, by the middle or end of September, were in good condition as to flesh, and marketable, while those from deeper water off Point Lookout, and but little later in the season, were still extremely poor, thin, and watery, and utterly unfit for market. These differences in condition, it seems to me, are to be attributed in a great measure to differences of temperature and the abundance of food, but mainly to the latter."

These observations give us some hints regarding the advantages arising from the cultivation of Oysters in more or less stagnant water, in which, as in the French parks or *claires*, an abundance of microscopic life would be generated in consequence of a nearly uniform temperature, higher in the early autumn months at least than the waters of the open sea, where cold currents also would tend to make it still less uniform and thus interfere with the generation of the minute food of the Oyster. In other words, it would appear that the effect of the French method is to furnish the best conditions for the rapid and constant propagation of an immense amount of microscopic food well adapted to nourish the Oyster. That unlike Oysters exposed to a rapid flow of water on a bottom barren of life they grow and quickly come into a salable condition.

SITUATIONS BEST ADAPTED FOR OYSTER CULTURE.—In this country narrow coves and inlets with comparatively shallow water appear to furnish the best conditions for the nutrition and growth of Oysters; and according to my own experience these are the places where we actually find minute animal and vegetable life in the greatest abundance, and, as might have been expected, the Oysters planted in such situations appear to be in good condition early in the autumn, long before those which are found in deeper and more active water, where their

food has less chance to multiply. If the French mode applies successfully to an inferior species, ours, which grows so much more rapidly, ought to derive a proportionally greater benefit from being treated in the same manner. However, before we are ready to deal with the material on which the Oyster feeds, we desire a more perfect acquaintance with the microscopic life which grows upon oyster-beds and swims about in the adjacent waters. From the fact that the lower forms of life in fresh water often appear in great abundance one year, while in the next, from some unexplained cause, none of the same species will be found in the same situation, we *may conclude that similar seasonal variations occur in the phases of the microscopic life of* a given oyster-bed and its vicinity.

INFLUENCES OF ENVIRONMENT.—Such yearly variations in the abundance of microscopic life are probably the causes of the variable condition of the Oysters taken from the same beds during the same season of different years. Violent or sudden changes of temperature are probably often the cause of the destruction of a great amount of the minute life upon which the Oyster feeds. Backward and stormy seasons doubtless also affect the abundance of the microscopic life of the sea. All of these questions have, however, as yet been scarcely touched, and, judging from the disposition of many of our students of zoology to be content merely with a description of new *species and the compilation of lists, instead of also entering into investigations of the life-histories,* the relative abundance of individuals, and the influence of surrounding conditions upon the forms they study, it will take some time yet before we get the information so much desired. When we arrive at this knowledge we will know why it is that Oysters taken from a certain bed are in good condition for a season or two and then for one or more years are found to be watery and *of poor quality, as well as why it is that the Oysters of certain beds, which for years have had a* high reputation for their fine qualities, are suddenly found to be more or less green in the beard, as I have been informed is now the case with the Oysters of Lynn Haven Bay, Virginia.

As to the influence of brackish water in improving the condition of Oysters, let me observe here that those who hold to that opinion appear to forget to bear in mind that brackish-water beds are often in the case just described; that lying in shallow, relatively quiet water, an abundance of food is generated which is rapidly consumed by the animals, quickly bringing the latter into condition, the brackish state of the water getting the credit of the result.

"In a paper published in the report to the British Government on oyster-culture in Ireland, *in 1870, Prof. W. K. Sullivan, of Dublin, remarked that independently of the mechanical constitu*tion of the shore and littoral sea-bottom, *i. e.*, deposition of sediment, the currents, the temperature, etc., the nature of the soil produces a marked influence upon the food of the plants and sedentary animals that inhabit the locality, as well as upon the association of species. Especially is it the case with Oysters, that the soil exerts so much influence on the shape, size, color, brittleness of shell, and flavor of the meat, that an experienced person can tell with great certainty where any particular specimen was grown.[1] . . . Were we able to determine the specific qualities of the soil which produce those differences in the qualities of Oysters, it would be an important step in their cultivation. Again, soils favorable for the reproduction of the Oyster are not always equally favorable for their subsequent development; and, again, there are many places where Oysters thrive but where they cannot breed. This problem of the specific influence of the soil is, however, a very difficult and complicated one. First, because it is almost impossible to separate the specific action of the soil from that of the other causes enumerated; and next, because, though much has been written on the subject of Oysters, I do not know of any systematic series of experi-

[1] E. INGERSOLL: Report on Oyster Industry, Tenth Census.

ments carried out upon different soils, and for a sufficient length of time to enable accidental causes to be eliminated, which could afford a clue to the determination of the relative importance of the action of the several causes above enumerated at the different stages of development of the Oyster. . . . I believe the character and abundance of *Diatomacea* and *Rhizopoda*, and other microscopic animals, in Oyster-grounds, is of primary importance in connection with Oyster cultivation. The green color of the Colchester and Marennes Oyster shows how much the quality may be affected by such organisms. It is probable that the action or influence of the soil of Oyster-grounds upon the Oyster, at the various stages of its growth, depends mainly upon the nature and comparative abundance of the *Diatomacea*, *Rhizopoda*, *Infusoria*, and other microscopical organisms which inhabit the ground. I have accordingly always noted where the mud appeared to be rich in *Diatomacea*, *Foraminifera*, and other microscopic organisms. A thorough a study of a few differently-situated Oyster-grounds, exhibiting well-marked differences in the character of the Oyster from this point of view, by a competent microscopist, acquainted with the classes of plants and animals just mentioned, would be of great scientific interest and practical importance."

PROTOZOANS OF SAINT JEROME'S CREEK.—The Protozoan fauna of Saint Jerome's Creek presents considerable variety; several species of test-building *Cothurniæ* were noticed, one *Vaginicola*, three species of *Vorticella* or bell-animalcules, free-swimming *Euplotes*, *Nassula*; of the latter type an exceedingly elongate form was noticed, with a body almost as slender as a thread-worm. Monads were noted sometimes in profusion, though some of these may have been the spores of algæ. Amœboid forms were very few, and the only one which was frequently noticed was a form so nearly like *Actinophrys sol* that I would pronounce it the same.

The *Freia producta* Wright was most common; this creature is related to the fresh-water trumpet animalcules, and is one of the most beautiful Protozoans I have ever seen. I reproduce here, with some changes, my description of the Chesapeake form from the "American Naturalist" for November, 1880:

"The tubes in which the animalcule resides are formed of a narrow transparent ribbon of horny consistency, wound into a spiral and terminating in a trumpet-shaped extremity, from which the odd peristome of the inhabitant protrudes. The basal or attached end is usually bent at an angle to the tube and bears a striking resemblance to the foot end of a stocking resting upon the sole. This portion is not composed, like the tube, of a spiral ribbon, but is simply a thin-walled sac, from the open end of which the ribbon takes its rise, but it is composed of the same kind of material. Many of the tubes show a trumpet-like rim projecting from the sides of the former, a little above the middle, and of the same form as the terminal rim, showing that this, like the form described by Mr. Wright from British waters, may stop building its tube for a time and then recommence.

"The adult animal, tube and all, when fully extended, will measure one twenty-fifth of an inch in length. It is of the same color as *Stentor cæruleus*, or bottle-green, but has the power of elongating and twisting itself as greatly as *S. roeseli*. The peristome is quite unlike that of *Freia ampulla* and bears a strong likeness to the blades of a pair of obstetrical forceps. The blades are deeply grooved, forming a deep ciliated demi-canal with parallel sides, and at the junction of their bases lies the spacious, twisted, and spirally ciliated pharynx, which is bounded dorsally and ventrally by the prominent folds which unite on either side with the long, curved lobes of the peristome. There is a small basal disc as in *Stentor*, and the ectosarc is traversed as in that genus by parallel granular bands, regarded as muscular fibers by some writers. The usual food-balls and vacuoles are present, and I was enabled to define sharply the endosarc from the ectosarc,

and clearly see the nucleus. The tube or ribbon-secreting organ described by Wright I was unable to discover.

"When fully extended the basal portion of the animal becomes attenuated to a thin bluish filament, which widens towards the peristome, where the body is over half as thick as the inside diameter of the tube. When fully retracted and resting, the animal resembles in its oblong shape a retracted and resting *Stentor*, and measures about $\frac{1}{10}$ as long as when fully extended. The ribbon which forms the tube makes from four to twenty-four turns in specimens of different ages."

This organism I since find to be an inhabitant of the bay also, but is not so abundant as in the creek. Small mica collectors fixed to floating corks in the hatching jars and aquaria used during the past season were found to afford a nidus for *Freia* as well as *Zoöthamnium*, the latter multiplying at a most astonishing rate in a very few days. Under similar conditions, amœbæ, apparently *A. proteus*, multiplied at a suprising rate; this was the case, too, with a small brown diatom which would coat in three or four days the sides of the glass vessels with a thin brownish film composed of countless myriads of individuals of the one species. The temperature of the bay-water used in the aquaria at this time would range from 76° F. to 89° F. The *Vorticellidæ* also soon attach themselves, and next to the hypotrichous infusorians found in the locality are the most important animalcular forms found in the Chesapeake. At the mouth of the Cherrystone River I last year found *Lienophora cohnii* in great abundance ectoparasitic upon an unidentified hydroid. The heliozoön, *Actinophrys sol*, is found in the bay and Saint Jerome's Creek, and I think it capable of swallowing dead or enfeebled Oyster eggs and embryos.

MUTUAL RELATIONS BETWEEN THE OYSTER AND ITS PREY.—Möbius calls an Oyster-bank a *Biocœnosis* or interdependent community of life. The many species of animals found on the banks and beds are no doubt more or less mutually dependent upon each other for subsistence, but this is perhaps not any more true of Oyster-banks than it is of terrestrial faunæ. There are no doubt vast numbers of floating embryos of Oysters eaten by other animals growing on the beds which bring their food supply to themselves by means of currents produced by ciliary motion. On the other hand, there are no doubt vast numbers of the minute swimming embryos of these, drawn in and swallowed by the Oyster, which may, indeed, for aught we know, in this way swallow many of its own young, for the current produced by the Oyster by means of the cilia clothing its gills is by no means a feeble one, though it is exceeded in power by the current flowing into and out of the siphons of *Mya*. In the latter I have frequently, upon opening the animal, found several *Copepoda* plainly visible to the naked eye swimming about in the water in the inferior mantle cavity, which had evidently been drawn in by the inward current. It is plain in this case that very mild means may become effective as prehensile and destructive agents, so as to bring remotely related types into intimate vital relations.

Though an animal may be apparently invulnerable on account of the effectiveness of its covering, it cannot emancipate itself from the abiding struggle it has to make to obtain food, no matter how passively it may appear to conduct itself. The Oyster has such a character, yet it has been apparent from what has been observed before, that it is entirely dependent for a vigorous existence upon the favorableness of surrounding conditions. The beds and banks in a true sense are interdependent communities, whose vigor may no doubt be impaired by the removal of a single one of its members. Suppose we should take away the algæ, diatoms, Oyster-crabs, vibriones, bacteria, infusoria, in fact all the minute life; we should greatly impair if not destroy the vitality of the beds. While it is true that many of even the smallest forms may destroy food which should properly be consumed by the Oyster, that were it not for the presence of these same small forms some destructive element might attain such a development as to be more injurious still.

There is therefore no doubt but that a delicate balance of power is maintained by these rivals which is best for the health of the community. The stability of permanent oyster-beds, it must be remembered, furnishes the right conditions for the survival of many types. It is a place where they find both a home and plenty of food. It is the very favorableness offered by these places which tends to induce them to congregate and multiply, and it becomes a serious question whether the artificial establishment of banks will not in time cause the proper types to congregate and multiply so as to afford the needed food supply for the Oysters. That destructive members of the community may also be attracted is admitted, but if the beds are established in shallow waters, as I have previously suggested, the destruction of such unwelcome intruders may be very readily effected. "Drills" and boring-sponges are naturally to be thought of as types which should be destroyed, while diatoms, infusoria, small polyps, bryozoa, minute algæ, etc., are to be favored in every way. Those forms again which the oyster-culturist knows are only there for the purpose of getting a good living with little trouble to themselves ought to be destroyed.

It might be an advantage to introduce certain desirable forms onto a bank, which might be supposed to be useful as a food supply. Infusoria and diatoms not previously existing might be introduced in this way; this, I think, would be especially easy in the case of the former where the type was one which is fixed during its adult life.

218. ON THE CAUSE OF THE GREEN COLOR OF THE OYSTER.

Experiments at Washington and Philadelphia.—I have frequently read accounts of Oysters which had become green-fleshed in certain localities, and it has also been asserted that competent chemists had discovered poisonous green substances of metallic origin in such specimens. Tests made at the Smithsonian Institution by Professor Endlich in 1879 failed to disclose anything poisonous in some green Oysters which had excited the suspicion of the Board of Health of the city of Washington. This investigator, it is desirable to state, resorted to every test known to him in order to discover if anything poisonous was present, and failing to discover any harmful substance concluded that the color must be due to some inert material. In order to see if the color was due to the presence of some green compound of copper, Prof. H. C. Lewis, of the Academy of Natural Sciences of Philadelphia, kindly made some delicate tests for me, using small dried fragments of an Oyster very deeply tinged with green in various regions, especially in the liver, connective tissue, and mantle. The fragments were burned in a bead of microcosmic salt and chloride of sodium on a clean platinum wire in a gas flame; this test did not give the characteristic sky-blue flame which should have been developed had there been the minutest trace of copper present.

It is therefore clear that the substance, whatever it may be, is not a corrosive metallic poison derived from copper, which if present would almost undoubtedly be detected by a peculiar acrid metallic taste, which would be experienced when one ate such Oysters. In making some practical tests as to the relative qualities of such Oysters as compared with white-fleshed ones, opportunities for which were kindly furnished me by Mr. J. M. Carley, of Fulton Market, I failed to detect the slightest difference of flavor. Such also is Professor Leidy's verdict, who informs me that he made a similar experiment, and a restaurateur, with whom I discussed the matter, declared that he was in the habit of selecting them for his own eating, preferring their flavor to that of the white Oysters.

Variations in color.—If it be objected that the green color indicates an unhealthful condition of the animal, it may be stated that other color variations of the flesh have fallen

under my observation recently. What is now alluded to is the yellowish, verging toward a reddish cast, which is sometimes noticed in the gills and mantle of both the American and European species. This, in all probability, like the green color, is due to the reddish-brown matter which is contained in much of the diatomaceous food of the animal.

Mr. J. M. Carley has also called my attention to these variations, and was inclined to attribute them to the soil in the vicinity of the beds. But if the classical writers are to be trusted, to the green, yellow, and white fleshed sorts we must add red, tawny, and black fleshed ones. Pliny tells us of red Oysters found in Spain, of others of a tawny hue in Illyricum, and of black ones at Circeii, the latter being, he says, black both in meat and shell. Horace and other writers awarded these the palm of excellence.—(O'Shaughnessy.) However, the black appearance may only have been due to an abundance of the natural purple pigment in the mantles of the animal, which varies very much in different forms; some, judging from the dark purple color of the whole inside of the shell, must have the whole of the mantle of the same tint. The amount of color in the mantle, especially at its border, varies in local varieties of both the American and European species, as may often be noticed.

Sometimes almost the whole of the outside surface of the mantle is charged with dark purple pigment cells. That copper is not usually the cause of the green color of Oysters I also have the additional testimony of Prof. W. K. Sullivan, of Dublin, who says:

"As the green color of the mantle of Oysters from certain localities just referred to is commonly attributed to copper, and as such Oysters are consequently believed very generally to be poisonous, and their value therefore greatly depreciated, I made the most careful search for traces of that metal in the muds which I had received from grounds known to produce green-bearded Oysters. Oysters and other mollusca placed in solutions containing copper and other metals absorb them and retain them in their tissues. I have had two or three opportunities of examining Oysters which had assimilated copper, owing to mine-water containing it being allowed to flow into estuaries at places close to oyster-beds. In every case the copper was found in the body only of the Oyster, which it colored bluishg-reen, and not in the mantle or beard, *which was not green*. In the green-bearded Oysters which I have had an opportunity of examining, the body was not green, and no trace of copper could be detected in any part of the animal. The color, too, was not the same as that of the true copper Oysters, but rather that which would result from the deposition of chlorophyl or other similar chloroid vegetable body in the cells."

The American consumer, however, need not be alarmed about the presence of copper in our species, as there are no beds on our eastern coast into which the washings from mines ever flow, as we have no workable deposits of copper near any of our beds, as in Cornwall, England. Besides, I am inclined to doubt the statement of Professor Sullivan that Oysters or other mollusks can absorb copper salts until their tissues are "colored bluish-green." Every competent histologist knows how very readily organisms are killed by the action of inorganic acids and salts, several of which are constantly used by biologists in fixing histological characters. Liebig, in his "Animal Chemistry," long ago pointed out that the oxides and metallic compounds of antimony, arsenic, copper, and lead had a very remarkable affinity for protoplasm, producing its immediate death. In consequence, he suggested a very high chemical equivalency for living matter. This has since been confirmed by the studies of Loew and Pokorny, who found that silver nitrate would produce a reaction with protoplasm if diluted to the extent of one part to a million of water.

PROBABLE CAUSE OF THE GREEN COLOR.—It is highly probable that the green color of the Oyster is due to the absorption from its food of a harmless vegetable pigment. In this country green-bearded Oysters occur at Lynn Haven Bay, Hongers and York Rivers, Virginia, on the

coast of New Jersey, in New York Bay, and Long Island Sound. I have seen specimens from a number of these localities, and also tasted them both raw and cooked without being able to detect any disagreeable or apparently harmful flavor.

Diatoms and green algæ occur in great abundance in the stomach of the Oyster, especially the former. The intestine is sometimes packed with countless numbers of the empty frustules or tests of diatoms, mixed with dark, muddy ooze or sediment and very fine particles of sand or quartz. It has been objected that the green color could not be derived from diatoms, because these organisms are, as a rule, apparently brown rather than green. This objection I find to be based upon a misapprehension of the structure of the *Diatomaceæ*, as may be gathered from the following general statement taken from Sachs' "Text Book of Botany," one of the latest and highest authorities. On page 222 he says: "The diatoms are the only algæ except the *Conjugatæ* in which the chlorophyl occurs in the form of disks and bands, but in some forms it is also found in grains, and the green coloring matter is concealed, like the chlorophyl grains in *Fucaceæ*, by a buff-colored substance, diatomine or phycoxanthine." It appears, then, according to the foregoing quotation, that it is not impossible for diatoms to be the cause of the green tint in Oysters, which, let me remark, is very nearly that of some pale green forms of those organisms which I have observed in water from oyster coves where I have conducted microscopic studies. Both green and brown diatoms may frequently be found in the stomach, and in making examinations to discover them I find it best to thrust the nozzle of a pipette directly into the stomach through the mouth and œsophagus. The pipette should have a compressible bulb, so as to enable one to draw up the contents of the gastric cavity into the tube without injuring the animal or taking up any fragments of it to vitiate the experiment.

OBSERVATIONS OF GAILLON AND JOHNSTON.—Speaking of the abundance of the *Navicula ostrearia* of Kützing, M. Benjamin Gaillon, in 1820, said that they inhabit the water of the tanks or "parks" in which the Oysters are grown in such immense abundance, at certain seasons of the year, that they can only be compared to the grains of dust which rise in clouds and obscure the air in dusty weather. Dr. Johnston, speaking of the French Oysters, says that in order to communicate to them a green color, which, as with us (in England), enhances their value in the market and in the estimation of the epicure, they are placed for a time in tanks or "parks," formed in particular places near high-water mark, and into which the sea can be admitted at pleasure by means of sluices; the water being kept shallow and left at rest is favorable to the growth of the green *Conferveæ* and *Ulvæ;* and with these there are generated at the same time innumerable crustaceous animalcules which serve the Oysters for food and tincture their flesh with the desirable hue.

This last remark of Dr Johnston's at first struck me as improbable, but I have met with great numbers of small crustaceans, *Copepoda* mainly, in the branchial cavity of the common Clam (*Mya arenaria*). Certain peculiar species have also been described by Allman from the branchial cavities of ascidians. More recently, while investigating the contents of the stomach of the Oyster, by the method already described, I find that it also swallows crustaceans, which are digested and absorbed as food. The tests of nauplii or very minute larval crustaceans with the contents digested out were frequently met with. Doubtless many very small *Copepoda* are also swallowed and digested, but these are not green. Besides the foregoing, I sometimes met with the very young shells of larval gasteropods and lamellibranchs; indeed, it is not improbable that the adult Oyster may consume its own larvæ. The remains of bryozoa were also observed, such as *Pedicellina americana*. The test of a peculiar elongate rhizopod and the cephalula stage of several worms were also noticed. Of the smaller organisms usually associated with more or less clearly marked

putrefactive changes, one which I find almost uniformly present is a filiform or thread-like organism allied to *Spirillum*. It, however, was always found in the stomach in great abundance, and especially in the pyloric portion of the intestine in which the crystalline style is lodged. This organism is probably harmless; a similar one is frequently found in both fresh and salt water, and has at times been developed in prodigious numbers in the reservoirs from which the supplies of water were drawn for a large city, without any evidence of its having produced a harmful effect upon those who drank of the water.

VIEWS OF LEIDY, PUYSEGUR, AND DECAISNE.—Professor Leidy, at a recent meeting of the Academy of Natural Sciences of Philadelphia, stated it as his belief that Oysters feed at times on the zoospores of certain algæ, as those of *Ulva latissima* (sea cabbage), which he knew from personal observation to be green, and which he thought might possibly be the cause of the green coloration of the soft parts of the animal as sometimes observed in certain localities. Very possibly this may be the case, but judging from what I have seen and heard from oystermen, as well as from what I have read in various publications relating to this matter, I am not inclined to regard this as the only source of the unusual green tint of the flesh of the Oyster. I hope to be able to show that it is probably of vegetable origin, and therefore quite harmless. That it is not copper we may be equally certain, as Professor Lewis' tests have shown, for any such quantity of a copper salt as would produce the green gills, heart, and cysts in the mantle, such as are often observed, would, without doubt, be as fatally poisonous to the Oyster as to a human being. The source of the green has recently been investigated by two French savants, MM. Puysegur and Decaisne, who found that when perfectly white-fleshed Oysters were supplied with water containing an abundance of a green microscopic plant, the *Navicula ostrearia* of Kützing, their flesh acquired a corresponding green tint. These investigators also found that if the Oysters which they had caused to become imbued with this vegetable green were placed in sea-water deprived of the microscopic vegetable food the characteristic color would also disappear. Whether this will finally be found to be the explanation in all cases remains to be seen, as some recent investigations appear to indicate that it is possible that a green coloration of animal organisms may be due to one of three other causes besides the one described above as the source of the green color of the Oyster.

GEDDES UPON CHLOROPHYL-CONTAINING ANIMALS.—Patrick Geddes, in a recent number of "Nature," has pointed out that the "list of supposed chlorophyl-containing animals . . . breaks up into three categories: first, those which do not contain chlorophyl at all, but green pigments of unknown function (*Bonellia*, *Idotea*, etc.); secondly, those vegetating by their own intrinsic chlorophyl (*Convoluta*, *Spongilla*, *Hydra*); thirdly, those vegetating by proxy, if one may so speak, rearing copious algæ in their own tissues, and profiting in every way by the vital activities of these." This latter is one of the most interesting and important of modern biological discoveries, that living animal bodies may actually afford a nidus for the propagation of green microscopic plants and not be injured but rather be benefited thereby. The oxygen thrown off by the parasitic vegetable organism appears to be absorbed by the tissues of the animal host, while the carbonic-acid gas thrown off by the latter is absorbed by the vegetable parasite, thus affording each other mutual help in the processes of nutrition and excretion. This singular association and interdependence of the animal host and vegetable guest has received the somewhat cumbrous name of *Symbiosis*, which may be translated pretty nearly by the phrase "associated existence." This is not the place for the discussion of the purely scientific aspect of this question as already ably dealt with by Dr. Brandt, Patrick Geddes, Geza Entz, and others, and

we will therefore only notice their researches in so far as they appear to have a bearing upon the origin of the green color of the Oyster.

ENTZ' DISCOVERIES.—Entz has discovered that he could cause colorless infusoria to become green by feeding with green palmellaceous cells, which, moreover, did not die after the death of their hosts, but continued to live, growing and developing within the latter until their total evolution proved them to be forms of very simple microscopic green algæ, such as *Palmella*, *Glœocystis*, etc. My own observations on some green-colored *infusorial* animals have been of so interesting a character that I will here describe what I observed in a green bell animalcule (*Vorticella chlorostigma*). Upon investigating their structure, I found that next the cuticle or skin in the outer soft layer of their bodies, known as the "ectosare," at all stages there was a single stratum of green corpuscles very evenly or uniformly imbedded. In another form (*Stentor*), as already noticed by Stein, the same superficial layer of green corpuscles was observed, reminding one very forcibly of the superficial layer of chlorophyl grains observed in the cells of some plants, as, for instance, *Anacharis*. Now, it is well known that certain animalcules are at times quite colorless and at others quite green; this appears to be the case with *Ophrydium*. In this last case I have a suspicion that vegetable parasites may be the cause of the green variety, but as for the others, *Stentor* and *Vorticella*, I am not so sure that their green forms are so caused. In them the superficial positions of the green corpuscles and their behavior toward reagents lead me to think that they must be regarded as integral parts of the creatures in which they are found.

NATURE OF THE GREEN MATTER IN ANIMALS.—A grass-green planarian worm (*Convoluta Schultzii*), found at Roscoff by Mr. Geddes, was observed by him to evolve oxygen in large amounts, like a plant, and "both chemical and histological observations showed the abundant presence of starch in the green cells; and thus these planarians, and presumably, also, *Hydra*, *Spongilla*, etc., were proved to be truly vegetating animals." While some organisms, like the foregoing, appear to have true chlorophyl grains imbedded superficially in their own substance, others, like the radiolarians, some siphonophores, sea anemones, and jelly-fishes, harbor true vegetable parasites, or, preferably, vegetable guests.

That the green observed in a number of animal organisms is of the nature of chlorophyl, or leaf green, has been proved by Lankester by means of the spectroscope. A. W. Bennett, in alluding to Lankester's observations, says: "In all cases the chlorophylloid substance agrees in having a strong absorption band in the red—a little to the right or left—and, except in *Idotea*, in being soluble in alcohol, and in having strong red *fluorescence*, and in finally losing its color when dissolved."

The vegetable organisms which have been found to inhabit the lower forms of life alluded to in the foregoing paper have been regarded as belonging to two genera, which Dr. Brandt has named *Zoöchlorella* and *Zoöxanthella*, and which are probably in part synonymous with the genus *Philozoön*, afterwards proposed by Mr. Geddes. The latter gentleman, however, claims to have first demonstrated the truth of the view that the yellow cells of radiolarians and polyps are algæ; secondly, the foundation of the hypothesis of the lichenoid nature of the alliance between algæ and animal into a theory of mutual dependence; and, thirdly, the transference of that view from the region of probable speculation into that of experimental science.

Hitherto no one has apparently noticed the occurrence of green vegetable parasites in bivalve mollusks except Professor Leidy, who has very kindly permitted me to use the facts observed by him relating to *Anodon*, one of our common fresh-water Mussels. In this animal he some years ago observed what must be considered to be algous parasites. He found them in great numbers infesting the tissues of the Mussel and of a larger size than the nuclei of the cells of the host in which they were imbedded. They were also provided with a nucleus, and were, there-

fore, not a part of the animal but a distinct vegetable organism. These facts, observed a long time since, render it very probable that Professor Leidy was one of the first to notice the intracellular parasitism of a plant in an animal.

The green color of the Oyster, as far as my experience goes, is not intense, as in many green animals, such as we observe in *Stentor*, *Spongilla*, *Hydra*, etc., but is a pale pea-green tint. This has been found to be the color of affected natives as well as of foreign ones, the gills and mantle being usually most distinctly tinged. Exceptionally the heart is affected, its color sometimes being quite intense.

EXPERIMENTS UPON EUROPEAN OYSTERS.—In studying some Oysters which were obtained from England through the kind offices of Messrs. Shaffer and Blackford, in response to a request coming from Professor Baird, certain ones were found which were decidedly green. Of these the French specimens of *Ostrea edulis*, and a very singular form, labeled "Anglo-Portuguese," had the gills affected, and in some of the latter the liver, heart, and mantle were very deeply tinged in certain parts, so much so that I decided to make as critical an examination as my resources could command.

Spectroscopic investigations gave only negative results, as it was found impossible to discern any positive evidence of chlorophyl from the spectrum of light passed through thin preparations made from specimens of green-tinted Oyster, some of which, like those made from the heart, are decidedly green to the naked eye. There was no absorption noticed at the red and blue ends of the spectrum, such as is observed when the light which enters the slit of the spectroscope first passes through an alcoholic solution of leaf green or chlorophyl; indeed, the spectrum did not appear to be sensibly affected by the green substance which causes the coloration of the Oyster. No attempt was made to test the matter with the use of alcoholic green solutions obtained from affected Oysters, as the former are not easy to get with a sufficient depth of color, because of the relatively small amount of coloring matter present in the animals. Unstained (fresh) preparations were used in all of these experiments.

COLORS IN DIFFERENT PARTS.—I find the liver to be normally of a brownish-red color in both the American and European Oyster, sometimes verging toward green. When the flesh or gills of the animal is green, the liver almost invariably partakes of this color, but in an intensified degree. The green stain or tincture appears in some cases to have affected the internal ends of the cells which line the follicles or ultimate saccules of the liver. This color is able to survive prolonged immersion in chromic acid and alcohol, and does not allow carmine to replace it in sections which have been stained with an ammoniacal solution of that color, the effect of which is to produce a result similar to double staining in green and red. The singular green elements scattered through the connective tissue remain equally well defined, and do not take the carmine dye. I at first believed these to be parasitic vegetable organisms, and I also supposed I saw starch granules in them, which physical tests with an iodine solution failed to confirm. *These large and small green granular bodies in the connective tissue, and those close to* the intestinal wall, as well as those in the heart I, find present in fewer numbers in white-fleshed Oysters, but simply with this difference, that they are devoid of the green color. It is evident, therefore, that they cannot be of the nature of parasites, though the color is limited to them, only the surrounding tissue, except in the region of the heart, appearing of the normal tint. This condition of the specimens observed by me does not, however, disprove the possibility of the occurrence of vegetable parasites in the Oyster, where there is as much, or perhaps more likelihood of their occurring than in some much more highly organized animals.

It is a fact, however, that the Oyster is singularly free from true parasites of all kinds; the

oyster-crab being perhaps the only creature which is ever frequently found within its valves, and then only as a harmless messmate. More recently it has been my good fortune to be able to study a second lot of European Oysters, in two varieties of which the green color was unusually developed, especially in the heart. In a specimen of Falmouth Oyster I found a large cyst or sac in the mantle near the edge filled with green cells, which, like those in the heart, when opened readily separated from one another, being quite as independent of each other as the ordinary discoidal corpuscles in the serum of red blood. The hearts of affected specimens were found to have the wall of the ventricle abnormally thick, and covered inside with the readily detachable green cells in a thick layer and measuring one three-thousandth of an inch in diameter. An application of the test for starch with iodine gave a negative result. If iodine was first applied to these cells in strong solution, and they were then treated with sulphuric acid, the characteristic blue reaction was not developed, showing that there was no cellulose wall covering them, and that they were most positively not parasitic, algous vegetable organisms. In potassic hydrate solution they were completely dissolved, a further proof of the absence of cellulose.

Their dimensions, one three-thousandth of an inch, is the same as that of the blood-cell of the Oyster. They are nucleated, with the nucleus in an eccentric position as in the blood-cell of the animal. Their occurrence in the heart and gills so as to tinge those organs of their own color is almost positive proof of their true origin and character. Furthermore, I find in sections that they sometimes occlude the blood-channels. In the cysts in the mantle, as in the heart, they are free, and in the normal untinged heart they are not abundant. All of the foregoing facts indicate that these green bodies are in reality blood-cells which belong to the animal. How they become green is not easy to determine. The fact remains that no evidence of the presence of green *Micrococci* or *Microbia*, as independent existences, could be made out. The fact that I found instances in green Oysters where an unusual greenish material was found in the follicles of the liver, the living cells of which were also affected, would indicate that the color was probably absorbed from the food of the animal, which, as we know, consists largely of living vegetable matter. It is not improbable that the tinged nutritive juices transuded through the walls of the alimentary canal acquired the color of the food which had been dissolved by the digestive juices.

How to account for the accumulation of the green cells in the heart and in cysts in the mantle is not, however, an easy matter, unless one be permitted to suppose that the acquisition of the green color by the blood-cells is in reality a more or less decidedly diseased condition, for which we have no ground in fact, since the green Oysters are in apparently as good health as the white ones. They were found 'fat' or 'poor,' just as it may have happened that their food was abundant or the reverse. They are also found in all stages of the 'greened' condition. Sometimes they have only a very faint tinge of the gills, or they may be so deeply tinged as to appear unpalatable, with the heart of a deep green, or with green cysts developed in the mantle, or with clouds of this color shading the latter organ in certain places. A vastly greater proportion of green Oysters are eaten in this country, at all events, than is generally supposed, especially of those just faintly tinged in the gills.

The most important glandular appendage of the alimentary tract of the Oyster is the liver. It communicates by means of a number of wide ducts with a very irregularly formed cavity, which we may designate as the stomach proper, in which the food of the animal comes into contact with the digestive juices poured out by the ultimate follicles of the liver, to undergo solution preparatory to its absorption during its passage through the singularly formed intestine.

If thin slices of the animal are examined under the microscope we find the walls of the stomach continuous with the walls of the great ducts of the liver. These great ducts divide and

subdivide until they break up into a great number of blind ovoidal sacs, into which the biliary secretion is poured from the cells of their walls. A thick stratum of these follicles surrounds the stomach, except at its back or dorsal side. It is not correct to speak of the liver of the Oyster as we speak of the liver of a higher animal. Its function in the Oyster is the same as that of three different glands in us, viz, the gastric follicles, the pancreas, and the liver, to which we may add the salivary, making a total of four in the higher animals which is represented by a single organ in the Oyster. In fact, experiment has shown that the secretion of the liver of mollusks combines characters of at least two, if not three, of the glandular appendages of the intestine of vertebrated animals. There are absolutely no triturating organs in the Oyster for the comminution of its food; it is simply macerated in the glandular secretion of the liver and swept along through the intestine by the combined vibratory action of innumerable fine filaments with which the walls of the stomach, hepatic ducts, and intestine are clothed.

In this way the nutritive matters of the food are acted upon in two ways: first, a peculiar organic ferment derived from the liver reduces them to a condition in which they may be absorbed; secondly, in order that the latter process may be favored it is propelled through an intestinal canal which is peculiarly constructed so as to present as large an amount of absorbent surface as possible. This is accomplished by a double induplication or fold which extends for the whole length of the intestine, the cavity of which in consequence appears almost crescent-shaped when cut straight across. On the concave side the intestinal wall is thrown into numerous very narrow longitudinal folds, which further serve to increase the absorbing surface. Such minor folds are also noticed in the stomach, and some of these may even have a special glandular function. There are no muscular fibers in the wall of the intestine as in vertebrates, and the sole motive force which propels the indigestible as well as digestible portions of the food through the alimentary canal is exerted by the innumerable vibratory cilia with which its inner surface is clothed. The intestinal wall is wholly made up of columnar cells which are in direct contact externally with the connective tissue which is traversed by numerous large and small bloodvessels devoid of specialized walls.

This apparatus is admirably suited to render the microscopic life found in the vicinity of the animal available as a food supply. The vortices created by the innumerable vibratory filaments which cover the mantle, gills, and palps of the Oyster enables it to draw its food toward itself, and at the same time the microscopic host is hurled into the capacious throat of the animal to undergo conversion into its substance as described above. The mode in which the tissues may become tinged by the consumption of green spores, diatoms, or desmids it is easy to infer from the foregoing description of the digestive apparatus of the animal; and the colorless blood-cells, moving in a thin, watery *liquor sanguinis*, would, judging from their amœbiform character, readily absorb any tinge acquired by the latter from the intestinal juices.

217. LOCAL VARIATIONS IN THE FORM AND HABITS OF THE OYSTER.

Mr. Darwin ("Variation of Animals and Plants," vol. ii, 2d ed., p. 270) writes: "With respect to the common Oyster, Mr. F. Buckland informs me that he can generally distinguish the shells from different districts; young Oysters brought from Wales and laid down in beds where '*natives*' are indigenous, in the short space of two months begin to assume the 'native' character. M. Costa[1] has recorded a much more remarkable case of the same nature, namely, that young

[1] Bull. de la Soc. Imp. d'Acclimat., viii, p. 351.

shells taken from the shores of England and placed in the Mediterranean at once altered their manner of growth and formed prominent diverging rays, like those on the shells of the proper Mediterranean Oyster. The same individual shell, showing both forms of growth, was exhibited before a society in Paris."

VARIATIONS IN THE SHELL.—The statement by Mr. Buckland in regard to the local forms of *Ostrea edulis* is undoubtedly true, as I know from personal observation of specimens obtained for me from various parts of Europe through the efforts of Professor Baird. In some cases the local differences between the shells from different places were so marked that had a person mixed certain lots together indiscriminately without my knowledge I could afterwards certainly have sorted out the more marked varieties. Local influences also very largely determine the "greening" of Oysters, as I can assert from personal observation of both the American and European species. Practical oystermen affirm that they can readily discriminate the local varieties of Oysters grown in various noted localities along the eastern coast of the United States. From what I have seen it is very probable that this may be the case, as one may often observe well-marked differences of form as well as color.

Local adaptation undoubtedly takes place, for how else are we to account for the fact that a change in the specific gravity of the water to which the adult has been accustomed will kill the milt? This point has an important practical bearing in relation to the effect of heavy rains in diluting the water when the animals are spawning. Might not a marked change in the specific gravity of the water at the time of spawning kill all the spermatozoa which are set free, and thus also prevent the impregnation of whatever mature ova were being thrown out at that time by the adults?

INFLUENCE OF TEMPERATURE.—Certain it is that temperature has an influence upon the time of spawning. A lot of Oysters marked "Anglo-Portuguese," which had been transplanted from Portuguese to English waters, and which I received in the month of March and others in January last, had the reproductive organs remarkably advanced in development as compared with specimens of *O. edulis* from different parts of England, Wales, Scotland, Holland, and France. So great was this difference that, although planted for some time in the colder waters of England, the reproductive organs of the Portuguese form had not apparently had their disposition to become functionally active at this early season influenced to any great extent. In fact, I obtained living mature eggs and milt from a number of specimens of this variety, while I looked in vain for ripe spawn in any of the others of the true *O. edulis*. This would indicate that the influence of temperature, though not altogether hereditary in this case, was persistent, and had so impressed itself that the reproductive organs of these Oysters, coming from a warmer latitude, had begun to mature their sexual products even after transplanting into more northerly and colder waters much sooner than the natives of those same latitudes.

Like this persistent influence of a climate to which certain forms of Oysters have been long accustomed, the influence of the specific gravity of the water of a certain locality may also be persistent. The Oysters of Saint Jerome's Creek seem to be adapted to the specific gravity of the water of the vicinity, so that if artificial sea-water is prepared, differing much in this regard from the native water, we find that the spermatozoa are immediately killed if put into it. From this it follows that if the specific gravity to which the adults become accustomed is normal to their sexual products, may it not be well to look into the effect of such changes upon the health of the adults?

I have met with spawning Oysters in December, such at least in which the spawn was nearly mature, but this was an exceptional case. I find them in April and May in considerable abun-

dance; the months of May, June, and July may, however, be regarded as their principal spawning months. Ripe spawn may be sparingly obtained in the latter part of August, and even up to the first of October, but the three months mentioned are the periods during which the experimentalist ought to be in the field prepared for work in this, the latitude of Washington. What amount of variation from this period may be made manifest as we go north or south along the eastern coast of the United States I am unable to state; and what amount of local variation may also be due to causes of a purely local character I am also unable to say, not having examined the Oysters at a sufficient number of localities to make such facts as I may possess of any value.

218. THE OYSTER-CRAB AS A MESSMATE AND PURVEYOR.

It is many years since Mr. Say named the little Oyster-crab *Pinnotheres ostreum*, and its habits since that time seem to have excited but little interest. Professor Verrill, in his observations published in the "Report of the United States Fish Commissioner for 1871–'72," records the fact that it is the female which lives in the Oyster, and that the male, which is smaller and unlike the female, especially in the form of the abdominal segments of the body, is rarely if ever seen to occur as a messmate of the Oyster, but that he has seen it swimming at the surface of the water in the middle of Vineyard Sound. He also says that they occur wherever Oysters are found. This singular little crab has quite a number of allies which inhabit various living mollusks, holothurians, etc., of which admirable accounts are given by Van Beneden in his work on "Animal Parasites and Messmates," and also by Semper in his treatise entitled "Animal Life."

QUADRUPLE COMMENSALISM.—The Oyster-crab is a true messmate, and it is in the highest degree probable that the presence of these animals in the mantle cavity of the Oyster is to be regarded as advantageous rather than otherwise. The animal usually lives between the ventral lobes of the mantle of its host, into which the four lobes of the gills and palps also depend, and, as will be seen from the following observations, may be the means of indirectly supplying its passive protector with a portion of food. During a trip down the Chesapeake in July, 1880, while I was with the Fish Commission vessel, some Oysters were dredged up by the crew which contained some Oyster-crabs. In the case I am about to describe the included crab was a female with the curiously expanded, bowl-like abdomen folded forward under the thorax, partially covering a huge mass of brownish eggs. Upon examining these eggs, what was my astonishment to find that they afforded attachment to a great number of compound colonies of the singular bell animalcule, *Zoöthamnium arbusculum*. Upon further examination it was found that the legs and back of the animal also afforded points of attachment for similar colonies, and that here and there, where some of the individuals of a colony of *Zoöthamnium* had been separated from their stalks, numerous rod-like vibriones had affixed themselves by one end. In this way it happens that there is a quadruple commensalism established, since we have the vibriones fixed and probably nourished from the stalks of the bell animalcule, while the latter is benefited by the stream of water drawn in by the cilia of the Oyster, and the last feeds itself and its *protegé*, the crab, from the same food-laden current. Possibly the crab inside the shell of its host catches and swallows food which in its entire state could not be taken by the Oyster, but in any event the small crumbs which would fall from the mouth and claws of the crab would be carried to the mouth of the Oyster, so that nothing would be wasted.

We must consider the crab with its forest of bell animalcules in still another light. Since the animalcules are well fed in their strange position, it is but natural to suppose that they would

propagate rapidly, and that the branches of the curious tree-like colonies would also increase in numbers. The individuals of the colonies multiply in about three ways: first, by branching; secondly, by splitting lengthwise; thirdly, certain much enlarged and overfed zoöids divide crosswise. By the two last modes one-half of the product is often set free, the free animalcules so originated being known as "swarmers." These cast-off or free zoöids which drop from the colonies are no doubt carried along by the vortex created by the cilia of the gill and palps, and hurled into the mouth and swallowed as part of the daily allowance of the food of the Oyster. We may therefore regard *Pinnotheres*, in such instances, as a veritable nursery, upon the body and legs of which animalcules are continually propagated and set free as part of the food supply of the Oyster, acting as host to the crab. I do not suppose, however, that such a condition will always be found to obtain, and it must also be remembered that myriads of *Zoöthamnium* colonies were dredged up attached to the fronds of the handsome *Grinnelia*, a red alga commonly found in certain parts of Chesapeake Bay. Where this plant grows in abundance on the bottom I have estimated that one might find upwards of a hundred animalcules attached to a square inch of frond surface, which would indicate an animalcular population of upwards of four millions of individuals to the square rod, a number as great as that of the human inhabitants of the city of London.

DEVELOPMENT OF THE OYSTER-CRAB.—The Oyster-crab undergoes a development and metamorphosis similar to that of our edible crab, *Callinectes*, but the body in the Zoæa stage is blotched with dark, branched pigment cells. The eyes also are vastly more developed than in the adult, where they are partly suppressed from disuse. There is no dorsal spine, nor are the antennary and rostral appendages so well developed as in the Zoæa of *Callinectes*. After the young are hatched they probably leave the abdominal covering of the parent, swim out of the Oyster for a season, and, if female, seek a permanent abode in some Oyster near by, behaving somewhat like the species described by Semper as inhabiting the water-lungs of certain holothurians. After undergoing further development, the young *Pinnotheres* reaches the megalops stage of its development, when it is probable that the choice of its home takes place. After it has entered the mantle cavity of its host as a diminutive larva, and has grown to be adult, when it measures a half inch or more in diameter, it is probably ever after a prisoner within the shell of its molluscan protector. It undergoes a retrogressive metamorphosis as it grows adult, its eyes become relatively less conspicuous than in youth, and it never has a thick, hard shell like its allies which live in the open water, but the external skeleton remains almost entirely soft and chitinous, or in the state in which we commonly find the outer covering of an edible crab which has just molted. This arises apparently from the conditions by which the animal is surrounded; the protection afforded it by its host does away with the need of a thick, hard covering such as we find inclosing the bodies of its free-swimming allies. Unlike the latter, too, the limbs of the Oyster-crab are to some extent degenerate and weakened; its chelæ or claws are feeble, and, when removed from its home, seems a very sluggish, helpless sort of creature, without a particle of the pugnacity of its allies, and if placed on its back will sometimes remain in that position helplessly beating the air with its weak limbs. This is a remarkable instance, which also serves very admirably to illustrate the principle of degeneration in organic evolution, so ably dealt with by Prof. E. Ray Lankester.

The Oyster itself is also an example of the effect of disuse in producing retrograde development, and even shows signs of gradual adaptation when removed from one locality to another. Unlike most other bivalves, the Oyster has no soft muscular foot which it may protrude outward from between the edges of its valves. No visible rudiment of such a prominence can be found

in the adult, though something of the sort, it is asserted by embryologists, appears to be developed in the larvæ. As the Oyster lost its power of locomotion from the non-development of the foot, due doubtless to a gradually acquired sedentary habit which has become permanent, the pedal structures have been almost entirely aborted, leaving nothing excepting the poorly developed pedal muscles described by Dall. There is accordingly little or no evidence of the existence of a pedal or foot ganglion in the Oyster, because there is no need for one, as in other forms; it, too, has disappeared with the structure which required its presence.

Returning to the consideration of the Oyster-crab, it is well known that it is much relished by many persons. The animal may be eaten alive, and has a peculiar, agreeable sweetish taste. Recently an enterprising New York party has taken to canning them, the supplies for this purpose being obtained from some of the large oyster-canning establishments. The economic value of the animal as food, although not great, is sufficiently important to demand a passing notice.

219. PHYSICAL AND VITAL AGENCIES DESTRUCTIVE TO OYSTERS.

Most of the observations which follow were made at Saint Jerome's Creek, Maryland, but inasmuch as the physical and vital enemies of Oysters appear to be similar the world over, I have no hesitation in reproducing what I have previously published elsewhere. And of physically injurious agents the black ooze or mud found in the vicinity or on the bottom of many of our most valuable beds and planting grounds is probably the most to be dreaded if it accumulates in too great quantity.

The origin of the black ooze at the bottom can be traced directly to the sediment held in suspension in the water which slowly ebbs and flows in and out of the inclosure, carrying with it in its going and coming a great deal of light organic and inorganic *débris*, the former part of which is mainly derived from the comminuted fragments of plants growing in the creek. This seemed to be the true history indicated by what was noticed in studying the box-collector. The same opinion is held as to the origin of this mud by both Coste and Fraiche in their works on oyster-culture.

There is probably no worse enemy of the oyster-culturist than this very mud or sediment. It accumulates on the bottom of the oyster-grounds, where in course of time it may become deep enough to cause serious trouble. Especially is this true of ponds from which the sea ebbs, and to which it flows through a narrow channel. The falling leaves from neighboring trees in autumn also contribute to this pollution, as well as heavy rains which wash deleterious materials into it.

Adult Oysters which are immersed in part in this mud struggle hard to shut it out from their shells. If one will notice the inside of the shells of Oysters which have grown in a muddy bottom, it will often be seen that there are blister-like cavities around the edges of the valves filled with mud, or a black material of a similar character. There is not the slightest doubt in my mind that in these cases the animal, in order to keep out the intruding mud, has had recourse to the only available means at its command. A great many of the Oysters in the pond are affected in this manner, but it is extremely uncommon to find shells of this kind in opening Oysters coming from a hard bottom. It is easy to understand that such efforts at keeping out the mud from the shell will not only waste the life forces of the animal, but also tend to greatly interfere with its growth. The importance, therefore, of artificial preparation is apparent, where it is desirable to establish ponds for the successful culture of this mollusk.

Only in one case have I observed that the mud tended to impair the flavor and color of the Oyster. In this instance the animal was thoroughly saturated with the black ooze, the very tissues seeming to be impregnated with the color, the stomach and intestine loaded to engorgement with the mud, the animal manifesting every sign of being in a decidedly sickened condition.

The cause of this was probably that the shell with its tenant had sunken too deeply into the mud when the ingestion of the black ooze commenced, giving rise to the remarkable changes which I have recorded. No doubt had this condition of things persisted for long the animal would have been smothered by the mud.

MUD AND THE YOUNG FRY.—The accumulation of the slightest quantity of sediment around a young Oyster would tend to impede its respiration, and in that way destroy it, yet in the natural beds there are so few naturally clean places which remain so that it is really surprising that so many young Oysters pass safely through the critical periods of their lives without succumbing to the smothering effects of mud and sediment. When it is borne in mind that at the time the infant Oyster settles down and fixes itself once and for all time to one place, from which it has no power to move itself, it measures at the utmost one-eightieth of an inch, it will not be hard to understand how easily the little creature can be smothered even by a very small pinch of dirt. The animal, small as it is, must already begin to breathe just in the same way as its parents did before it. Like them its gills soon grow as little filaments covered with cilia, which cause a tiny current of water to pass in and out of the shell. The reader's imagination may be here allowed to estimate the feeble strength of that little current, which is of such vital importance to the tiny Oyster, and the ease with which it may be stopped by a very slight accumulation of dirt. Möbius estimates that each Oyster which is born has $\frac{1}{114000}$ of a chance to survive and reach adult age. So numerous and effective are the adverse conditions which surround the millions of eggs matured by a single female that only the most trifling fraction ever develop, as illustrated by the above calculation. The egg of the Oyster, being exceedingly small and heavier than water, immediately falls to the bottom on being set free by the parent. Should the bottom be oozy or composed of sediment its chances of development are meager indeed. Irrecoverably buried, the eggs do not in all probability have the chance to begin to develop at all. The chances of impregnation are also reduced, because the male and female Oysters empty their generative products directly into the surrounding water, whereby the likelihood of the eggs meeting with the male cells becomes diminished. What with falling into the mud and what with a lessened chance of becoming impregnated, it is not unlikely that Möbius' estimate is very nearly correct; but the American Oyster, whose yield of eggs is much greater, not only on account of its larger size, but also because the eggs are smaller than those of the European, has probably still fewer chances of survival. The vigorous growth of small organisms on surfaces fitted for the attachment of young Oysters also tends to cause sediment to gather in such places in the interstices of the little organic forest, where the eggs of the Oyster no doubt often become entombed or smothered by the crowded growth surrounding them.

"In addition to the active, animate enemies of the Oyster, the beds suffer seriously, at certain times, from the elements. . . . Great storms will sweep the Oysters all off the beds, bury them under shifting sand or mud, or heap upon them the drifting wrack torn from the shores. Beds which lie at the mouths of rivers are liable to be injured by floods also, which keep the water wholly fresh, or bring down enormous quantities of silt and floating matter, which settles on the beds and smothers the Oysters.

"A few years ago a large tract of peat was drained at Grangemouth, Scotland. The loose mud and moss was carried down the drains upon an oyster-bed in the estuary; the consequence was that the Oysters were covered over with mud and entirely destroyed. Nothing is so fatal to Oysters as a mud storm, except it be a sand storm. The mud and the sand accumulate in the Oyster's delicate breathing organs and suffocate him.

"North of Long Island an enemy is found which does not exist in the milder south, in the

shape of 'ground-ice' or 'anchor-frost.' It is little understood, though often experienced, and I was able to collect only vague data in regard to it. It appears that in hard winters the bottom of the bays freezes solid in great patches, even at a depth of fifteen or twenty feet. The mud freezes so hard that rakes cannot be pressed into it; and if a stronger implement, like a ship's anchor, is able to penetrate it, the crust comes up in great chunks. These frozen patches are sometimes forty feet square and continue unthawed for long periods. When such 'anchor-frost' takes place at an Oyster-bed, of course the mollusks are frozen solidly into the mass, and few of them ever survive the treatment. To the Cape Cod planters this is a serious obstacle to success."[1]

INTERFERENCE OF OTHER ANIMAL LIFE.—We have called attention to the probable interference of small organic growths to the fixation of the young fry; in practice it is found that the larger organic growths which establish themselves on the collectors also become injurious. The two most conspicuous types are the sessile ascidians or tunicates and the barnacles. I have frequently found fully one-half of the surface of a slate covered with a dense colony of ascidians; in this condition a great percentage of available surface is lost which ought to serve for the attachment of spat. The surfaces so occupied would also be comparatively clean were it not for these organisms, which actually become a serious annoyance. They, like the Oyster, affix themselves to the slates while still in the free-swimming larval stage, since the surfaces designed for the Oyster are equally well adapted to them. The barnacles, which also affix themselves in great numbers, become a nuisance for the same reason. The larval barnacle is an extremely active little creature, and dashes about in the water with great rapidity. As soon as it has completed this stage of its growth it betakes itself to some object, to the surface of which it attaches itself by the head end, when a singular change takes place, at the end of which it is found that it has begun the construction of the curious conical shell which it inhabits. They grow very rapidly, so that in a couple of months the shell will already measure over half an inch in diameter. In this way further inroads are made upon the room which should be taken up by Oysters.

Of course the larger types are not alone in taking up space, since infusorians, bryozoans, polyps, etc., are also culpable, as well as algæ, such as diatoms and the higher forms. The only remedy for this accumulation of animal growths on the surfaces of the slates and other collecting apparatus will be to have the frames which hold the slate in position so arranged that each tile, shingle, or slate can be removed, in order that it may be readily overhauled and these organisms removed from the surfaces which it is desired shall remain clean. This work would have to be done at intervals of every two or three weeks, and should be conducted with great care, so as not to remove the Oysters which have affixed themselves along with the other things which it is the intention to destroy. The removal of the smaller forms from the surfaces of the slate would be more difficult, and attended with danger to the fry already attached. With this object in view, I would suggest the use of wooden racks or frames lying horizontally, which would receive the slates into deep notches made with a saw, so as to hold them vertically or edgewise, rendering their removal, for the purposes of cleansing, and their replacement an easy matter. Other devices would no doubt answer the same purpose and be more convenient even than the last. If posts were securely fixed in the bottom eight or ten feet apart, so as to project a foot or so above the water at the highest tide, a single board six inches wide, nailed against the tops of the posts edgewise, and extending from one to the other, would provide a simple arrangement from which to hang the slates singly by means of galvanized wire fastened or hooked to nails partly driven into the board. By the help of this plan one man with a boat could overhaul many

[1] E. INGERSOLL, Report on Oyster Industry, Tenth Census.

hundreds of slates in a single day, and effectually care for them for a whole season. This last contrivance would not answer well perhaps where there was a swift current, but would be a most admirable arrangement in still ponds or 'claires.' In such places the whole area might be provided with posts grouped or placed in rows, so that when the attendant was at work he could pass in order from one row to the other in a narrow boat, or two attendants in one boat could take care of two rows, the ones on either hand, at the same time.

Star-fishes are notorious for the havoc they are capable of making among Oysters. They have the power apparently of everting their saccular stomachs and extracting the soft parts of their prey from the shell. Whole beds have been seriously injured by the inroads of these creatures. They do not seem to be dreaded much in the Chesapeake Bay, however, and appear to annoy the oyster-planters of New England most seriously.

"The oyster-catcher, and some other birds, steal not a few at low tide. Barnacles, annelids, and masses of hydroid growth sometimes form about the shells and intercept the nutriment of the poor mollusk, until he is nearly or quite starved; this is particularly true in Southern waters. At Staten Island the planters are always apprehensive of trouble from the colonization of mussels on their oyster-beds. The mussels, having established themselves, grow rapidly, knit the Oysters together by their tough threads, making culling very difficult, and take much of the food which otherwise would help fatten the more valuable shell-fish. In the Delaware Bay the spawn of squids, in the shape of clusters of egg-cases, appropriately called 'sea-grapes,' often grows on the Oysters so thickly, during the inaction of summer, that when the fall winds come, or the beds are disturbed by a dredge, great quantities of Oysters rise to the surface, buoyed up by the light parasitic 'grapes,' and are floated away. This is a very curious danger. Lastly, certain crabs are to be feared—chiefly the *Callinectes hastatus*, our common 'soft crab,' and the *Cancer irroratus*. Probably the latter is the more hurtful of the two. I have heard more complaint on this score at the western end of the Great South Bay, Long Island, than anywhere else. Mr. Edward Udall told me that the crab was the greatest of all enemies to Oysters on the Oak Island beds. They eat the small Oysters up to the size of a quarter-dollar, chewing them all to bits. These are on the the artificial beds, for they do not seem to trouble the natural growth. But tolled by broken Oysters, when the planter is working, they come in crowds to that point. Mr. Udall stated that once he put down five hundred bushels of seed brought from Brookhaven, and that it was utterly destroyed by these crabs within a week and while he was still planting. He could see the crabs, and they numbered one to every fifty Oysters. It is well known that in Europe the crabs are very destructive to planted beds, and it is quite possible that many mysterious losses may be charged to these rapacious and insidious robbers. By the way, Aldrovandus and other of the naturalists of the Middle Ages entertained a singular notion relative to the crab and the Oyster. They state that the crab, in order to obtain the animal of the Oyster, without danger to their own claws, watch their opportunity when the shell is open to advance without noise and cast a pebble between their shells, to prevent their closing, and then extract the animal in safety. 'What craft!' exclaims the credulous author, 'in animals that are destitute of reason and voice.'"[1]

In a specimen of the common *Ostrea virginica*, recently handed me for examination by my friend, Mr. John Ford, the substance of the shell was thoroughly cavernated so as to render it extremely brittle and readily crushed; in fact, the inner table of the shell left standing showed a great number of elevations within, which indicated points where the intruding parasite had been kept out by the Oyster, which had deposited new layers of calcareous matter at these places so

[1] E. INGERSOLL: Report on the Oyster Industry, Tenth Census.

as to give rise to the elevations spoken of. Besides this, the inner table had become so weakened at the insertion of the adductor muscles that the animal in closing had torn a part of it loose, which had been repaired by the deposition of a brown, horny substance. Evidence of the presence of the boring sponge may very frequently be noticed in shells of Oysters brought to the markets, though it often appears as if the parasite had left its work incomplete, being killed on its host. I find that Schmidt has also noted this, and that the boring operations of the sponge usually seem to stop in the case of living mollusks at the nacreous layer.

Upon examining some Scotch Oysters, obtained for me for study by Professor Baird, I was struck with the fact that every one was infested with this organism. The effect of the parasitism was that all of the specimens had abnormally thick shells, due evidently to the effort made by the Oyster to deposit more and more calcareous matter in order to exclude its persistent tormentor. Internally the shell showed irregularities due to the intrusion of the sponge. It is highly probable that in this case the growth of the Oysters had been impeded by the parasite, in consequence of the effort made by the animals to exclude their enemy by increasing the thickness of their shells. This same tendency to increase the thickness of the valves I have noticed in specimens of our native Oyster, the shells of which were infested with this parasite. It is very remarkable that the Oyster should make an effort to exclude its enemy by such a means; and it is not less remarkable to observe that the lime carbonate secreting function of the mantle is often stimulated to extra exertion long before the parasite has actually intruded into the cavity of the shell.

Dr. Leidy gives a lucid account of the living sponge as found in *Ostrea virginiana* and *Venus mercenaria*. He says: "This boring sponge forms an extensive system of galleries between the outer and inner layers of the shells, protrudes through the perforations of the latter tubular processes, from one to two lines long and one-half to three-fourths of a line wide. The tubes are of two kinds, the most numerous being cylindrical and expanded at the orifice in a corolla form, with their margin thin, translucent, entire, veined with more opaque lines, and with the throat bristling with siliceous spiculæ. The second kind of tubes are comparatively few, about as one is to thirty of the other, and are shorter, wider, not expanded at the orifice, and the throat unobstructed with spiculæ. Some of the second variety of tubes are constituted of a confluent pair, the throat of which bifurcates at bottom. Both kinds of the tubes are very slightly contractile, and under irritation may gradually assume the appearance of superficial, wart-like eminences within the perforations of the shell occupied by the sponge. Water obtains access to the interior of the latter through the more numerous tubes, and is expelled in quite active currents from the wider tubes."

The boring process seems to be effected by the action of the living soft material of the sponge, according to observations which have recently been made by a Russian naturalist, according to whom it appears that the calcareous matter is dissolved away by the parasite. I am told by a practical oysterman that a bed once planted with Oysters which are badly infested by the boring sponge is apt to remain so for some time, and that the beds adjoining become infested, for the reason that the embryo sponges, which are thrown off in large numbers from the infested "plants," swim about in the water, attach themselves to other Oysters, to begin their injurious growth and excavations in sound shells.

220. NATURAL AND ARTIFICIAL OYSTER-BANKS.

CHARACTERISTICS OF NATURAL OYSTER-BANKS.—I have examined a number of oyster-banks, which were readily accessible in shallow water, with gratifying results as to the habits of the animal under virtually undisturbed conditions. These banks, like those formed by the

European Oyster, always appear to be much longer than wide, but many of them are almost entirely exposed to the air during low tide, a rare occurrence, according to Möbius, with the banks on the Schleswig-Holstein coast of the North Sea. I learned from the owners of some of these banks that, although a considerable proportion of the Oysters on them were at times frozen to death during the severe winters, the fecundity of those which remained was such, combined with the naturally favorable conditions found on the banks for the growth of old and young, as to restore the beds to their wonted productiveness in one or two seasons. Whether this description of the fecundity of the beds found in shallow water is overdrawn or not matters little, since there was the plainest evidence that we had here before our eyes the best natural conditions for the propagation and feeding of the individuals. The beds are, in a word, natural spat-collecting grounds; places where such conditions obtain as will allow a large proportion of the swarming brood of the spawning season to affix itself securely and survive in positions where an abundance of food may be got. The tide ebbing and flowing over the beds not only carries with it in suspension the microscopic food best adapted for the nourishment of the Oysters, but also tends, owing to the peculiar arrangement of the shells on the banks, to keep the surface of the latter clean, so as to be well adapted as favorable points of attachment for the young.

In all of the natural banks which I have had the pleasure of examining in the Chesapeake, the individual Oysters assume an approximately vertical position. The assumption of this position seems perfectly natural; with the hinge end downwards and the free edges of the valves directed upward the animals are in an excellent position to feed, while the outside vertical surfaces of the valves are well adapted to afford places of attachment for the spat. The latter, however, appears to attach itself in the greatest abundance to the old Oysters at the surface of the bank. The result is that when one removes the Oysters from the bed they are found to adhere together in clusters, generation after generation being piled one on top of the other in succession. As many as four generations may be made out in most cases; the oldest being buried in the mud and sand below and is often found to be smothered by those which have followed. Even below the last stratum of living Oysters, if one keeps digging, it is discovered that the shells of numerous still more remote ancestors of the living ones now occupying the bed are disposed vertically in the sand and earth beneath. Attached to the upper edges of these dead shells follows, we will say, the first living generation and so on to the fourth, composed mainly of young individuals or spat only a few days or months old. Whether it is proper to regard the superimposed series of individuals as generations may be questioned, but as no more expressive word occurs to me, I wish to be understood as using it here with qualifications.

POSITIONS OF THE SPAT.—The spat does not fix itself in any constant position; the young may have the hinge of the shell directed downward, upward, or to the right or left hand. Singularly enough the shells do not grow in the directions which the free edges of the valves are made to assume in the young. Should the young happen to be fixed hinge downward the free edges of the valves grow in length directly upward; in case the hinge is directed either to the right or to the left, the layers of calcic carbonate will be deposited in such a way upon one side as to cause the free edges of the valves to be eventually directed upwards, causing the umbonal portion of the valves to describe an arc of 90°. In case the hinge is at first directed upward, the layers of carbonate of lime will be deposited in such a way by the mantle as to bring the mouth of the shell upward. The attempt to get into a vertical position will, however, not always be successful in cases like the last; the arc of 180°, which it is necessary for the animal to traverse from its starting point in order to build its shell with the free edges opening upward, seem to be a feat a little too difficult of accomplishment, in spite of the wonderful persistence of effort manifested by the inhabitant.

The habit of growing in the erect position, where the banks are prolific and undisturbed, causes the individuals to be very much crowded together, so that they do not have a chance to expand and grow into their normal shape. From this cause, overcrowding, the shells of the individual Oysters become very narrow and greatly elongated; the peculiar forms which result are known to oystermen as "Raccoon Oysters," or "Cat's-tongues," the latter name being probably derived from a suggestive resemblance to the tongue of a cat. Fossil Oysters appear to have had the same habit. In some banks their crowded condition may be inferred from the fact that I counted as many as forty Oysters in an area included by a quadrangle of wire including exactly one square foot; thirty individuals to the square foot was a fair average on one bank examined.

All of the observant writers upon the Oyster agree that it is essential that the bottom upon which oyster-banks are to be permanent should not be liable to shift or be covered by mud or sediment. The experience of the writer strongly enforces such a conclusion. The permanent banks, owing to the great number of dead shells scattered through the bottom soil upon which they have been established, acquire a peculiar solidity or fixedness which the currents of tide water cannot sensibly affect. When these banks are once covered by the clusters of Oysters more or less securely held together by the lower portions becoming imbedded in the soil below, and mutually wedged and fitted together by the any msurfaces of contiguous clusters which have become neatly adapted to each other by pressure, it is a very hard matter for the tides to smother the bank unless sufficient soil in suspension is carried by the waters to completely cover the animals.

ESTABLISHMENT OF ARTIFICIAL BEDS.—The inferences to be drawn from the foregoing observations are very important. They naturally lead to the inquiry whether artificial Oyster-beds cannot at least be established in shallow water, where the difficulties in altering the character of the bottom so as to adapt it to the wants of the Oyster are not practically insurmountable. I believe that the establishment of artificial beds, which would in time become similar in every respect to the natural ones, is possible in a moderately rapid tideway. The localities, I apprehend, are abundant along the shores of the Chesapeake, and I certainly know of few places where the existing natural conditions for such a project are any better than those found in Saint Jerome's Creek. The bottom would, of course, have to undergo such preparation as would insure to it solidity, and it might be well to imitate the flat, ridge-like character of the natural banks in constructing artificial ones. The long axis of the beds should probably lie transversely to the direction in which the tide ebbs and flows in and out of the creeks, as appears to be the case with many banks examined. The next thing to do would be to colonize these artificial banks with Oysters stuck thickly into the bottom, hinge downward, imitating the position of the animals in the natural banks. The cost of such an experimental bank would be comparatively insignificant.

Since the publication of the substance of the foregoing suggestion I have seen the idea practically realized in the Cherrystone River, Virginia. A heap of Oyster-shells had been scattered so as to form a low, solid elevation, which was submerged twice a day by the tide. Upon this spat had caught and grown until the whole in two years was as completely and solidly covered by living natural-growth Oysters as any good natural bank. The desirability of using the poorly grown stock from natural and artiffcial banks as "seed" for planting appears reasonable, and could no doubt be made profitable where banks of a sufficient exteut could be established, from which a supply of seed could be obtained.

I have been informed by an old oysterman that pine bushes stuck securely into the sea bottom so as to be submerged in shallow areas have been found very effectual as collectors. In fact, he told me that in one case which had fallen under his observation an oyster-planter who followed this plan had the satisfaction of seeing his submerged bushes load with spat, much of which afterwards grew to marketable size. Afterwards a productive ridge or bank was the result where the brush palisade had originally acted as a collector. Thick palisades of brush might be stuck into the bottom near permanent oyster-banks with good results. Doubtless it would be possible to establish banks by this method if, in addition, oyster-shells or stones were strewn on the bottom along either side of the brush palisade, in order to afford a foundation for the fixation of the first generations of oysters.

SPAT-COLLECTORS.—Lieutenant Winslow, in 1879, used hurdles or nests of half-round tiles, eight to sixteen in number; the results from one placed in the Big Annemessex were very flattering. After it had been immersed twenty-four days 1,506 Oysters had attached themselves. After forty-five days had elapsed 1,334 still remained, and after ninety-three days were past the number still adherent was 539. I have had no such success, but in other parts of the bay, as at Tangier Sound for instance, spat falls in great abundance. I have seen the inner face of one valve of a dead Oyster furnish attachment for over forty spat from one-eighth to three eighths of an inch in diameter. Sponges, pieces of wreck, old shoes, pebbles, iron ore, leather, the external surface of the shell of *Modiolaria*, branches of trees and logs which have fallen into the water act as collectors. Oysters are sometimes found inside of bottles which have been thrown upon the bottom, the fry having wandered through the neck and attached itself to the inner surface, growing to the size of two inches in diameter and over. The spat is shaped much like the scallop or *Pecten*, a form which it often retains until it measures more than two inches in diameter. The primary requisite in collectors is that they shall present clean surfaces while the spawning season is in progress. Small inequalities are probably an advantage, as the very youngest spat is often found in chinks and angles on the shells of the adults. No other organisms should be allowed to grow and cover up or smother the oyster spat. Barnacles, infusoria, moss animals, polyps, and many other organisms are liable to accumulate on the surface of the collectors to the detriment of the young Oysters which have established themselves. Many of these animals, polyps especially, eat the young fry in the free-swimming stage, as shown by Dr. Horst.

The use of the methods employed abroad for collecting spat has not been tested in the United States upon a scale large enough to enable us to arrive as yet at any very important conclusions. Roofing slate coated with mortar promises good results; the valves of oyster-shells strung upon wire, pine cones, and brush have been used, but in unfavorable places, so as to vitiate to some extent the results which were expected. A coating of cement will not answer; it gets too hard, so that the spat when it is to be removed from the collectors cannot be loosened without injuring its delicate, thin valves. The coating of lime and sand should be thick enough so as to make a layer of at least an eighth of an inch over the surface of the collector. It should also be allowed to thoroughly "set," as a stone-mason would say, after it has been applied so as not to wash off readily. A strong mortar should be mixed for the coating, composed of sharp sand and good lime, in the proportions of about equal parts, and thin enough to dip the slates or tiles into the mixture bodily. If the first coat is not found to be thick enough a second and third may be applied. The tiles or slates after coating should be allowed to dry for two or three days so as to allow the coating to "set" firmly.

Various ways of supporting the tiles and slates have been devised, cheap forms of which are described in the treatises of Coste and Fraiche. The primary requisite in putting down collectors is that they shall be so placed as not to be covered by mud, especially where the bottom is overlaid with ooze. In such cases they must be supported so as to prevent their falling into the mud, the effect of which would be to make them useless. In practice, I suspect, that it would be well to look after the collectors occasionally and to brush off the mud, because in some places I have noticed that thick deposits of sediment soon collect upon the upper surfaces. This accounts for the fact that several observers have noticed that the spat is disposed to attach itself and survive on the lower surface of the collectors.

I am informed by Mr. C. P. Hull that the practice of strewing oyster-shells as spat-collectors on hard sea-bottom two or three fathoms deep is becoming quite common on the Connecticut shores of Long Island Sound. Here, the practice is to scatter two hundred and fifty to three hundred bushels of shells over an acre of bottom. The method there has also been so successful and profitable as a means of increasing the area of the oyster fishery that the price of the dead shells has increased and is likely to continue to do so, since the demand is greater than the supply. Mr. Hull, himself a practical oyster-culturist, proposes to introduce this system into practice on his projected plantations on the Chesapeake, where a beginning has already been made by this method under the direction of Captain Hine, at Cherrystone, the superintendent of the firm of Maltby & Co., of Norfolk, now largely interested as planters in the Cherrystone River. This method is the same as that extensively practiced in Europe.

HOW AN OYSTER TAKES ON FLESH.—Among oystermen the business of fattening or feeding the Oyster is one of the most important, from the fact that upon the condition of the marketable product largely depends its value. Fatness, so called, in the Oyster is a condition wholly different in nature from the state known under that name in stall-fed domestic animals. The turgidity of the reproductive organs is not usually indicative of fatness, as it appears some authors have supposed, Möbius being the only one who has apprehended its true nature. The word "fat," as applied to indicate the condition of the Oyster when in flesh, is a misnomer, since it is not fat at all which is the immediate cause of the condition of plumpness which betokens a fitness for market, but a very extensive deposit of protoplasmic matter which has been assimilated and laid down mainly in the substance of the mantle. It is this relatively large amount of delicate, easily-digested protoplasm, stored up in the palps and mantle, which renders the Oyster so wholesome and nutritious.

The deposition of this protoplasmic material in the mantle, palps, and body stands in intimate relation to the activity of the reproductive organs. During the spawning season Oysters are said to be "poor," that is to say poor in condition, for at this time the mantle, especially where it lies next the body on each side, is very thin and quite transparent; the radiating pallial muscles along the border of the mantle, as well as its vessels and nerves, may now be readily studied under the microscope, owing to its transparency and the absence of opaque granular protoplasm. If we examine the reproductive organs at this time, as a rule, we will find them greatly developed and pouring out their products through two large ducts, the combined caliber of which is not far short of that of the intestine. It will be evident to any thinking mind that if the major part of the food material elaborated by the digestive and nutritive systems goes to the ovaries or testes to be transformed into sex products, which are continually thrown off during the breeding season, little of such material can be stored up in the tissues of the body. We have described exactly what happens. In the month of September, when the Oysters in this latitude are for the most part done spawning, the drain of elaborated material having ceased to flow from the openings of the

reproductive organs, it is diverted in another direction, but is retained in the system and has to be deposited somewhere in the body. The most extensive deposits of this elaborated living matter occur in the mantle, body, and palps, the color of which rapidly changes from the watery, transparent condition prevalent during the spawning season to a creamy white. The whole animal also acquires a solidity which it did not possess before; it loses its watery, impoverished appearance, together with its disposition to shrink to a fraction of its original bulk from an extensive loss of fluids when opened. The mantle and palps become opaque and thicker than before, and their substance is softer and more easily lacerated. The change here described undoubtedly affects the connective tissue principally, as elsewhere stated. The material of the latter has the milky appearance of the reproductive organ when mutilated, and may readily be mistaken for the latter by the inexperienced. It appears that the generative and nutritive functions are opposed to each other in the Oyster as in other animals; all of which indicates, too, the amount of energy which must be expended during the breeding season in the production of germs. Whatever surplus nutriment is stored up in the winter appears to be immediately devoted to the formation of germs upon the arrival of the warm months, when food is also probably most plentiful and when the external conditions are right for the development of the embryos. The effort which the Oyster makes, at the expense of so much material, to reproduce its kind ought to be respected. In the protection of the Oyster during the close season we are simply following the dictates of experience and common sense.

The account which we have given above of the physiology and interdependence of the fattening and reproductive processes of the Oyster, it seems to me, affords an opportunity to point out how little philosophy there is in the doctrine that Oysters may be fattened by putting them for a day or two in water less salt than that from which they were first taken, in order that they may be water-swollen by the action of osmose, so as to give to them a plump appearance. It is surprising how little dependence is to be placed upon the statements of oystermen and fishermen in regard to the habits of the objects with which they are supposed to be most familiar. And this statement, like many others of a similar kind, has no basis of fact and experimental evidence to rest upon. I may sum up the utter absurdity of the widespread belief in the possibility of fattening Oysters by removing them from salt to less salt water for a few days, by saying that it amounts to the same thing as to assert that water is a fatty or oleaginous substance!

The results of my most recent investigations upon the minute anatomy of *Ostrea virginica* may be fitly described in this place, since they have an important bearing upon the process of fattening. The subject of this investigation was one of the most impoverished-looking Oysters which it has ever been my fortune to find. It was collected on the 20th of July this present year (1882) and placed in a chromic acid solution of one per cent. for forty-eight hours, when it was washed and finally transferred to alcohol, to be cut into sections when convenient. This I have recently done. When the specimen in question was fresh it was characterized by the almost perfect transparency of the mantle, and, as it afterwards turned out, the total atrophy of the generative organ. Before the hardening process had been undergone, the mantle was greatly distended by watery fluid, so much so that, after hardening, it had shrunken to about one-tenth of its bulk while in the fresh and living state. The hardened specimen was cut into thin sections after imbedding in paraffine, by means of a modification of the Taylor freezing microtome; the sections for thinness left nothing to be desired, and revealed a condition of things different from any previously observed by the writer in sections of either native or foreign Oysters. A careful microscopic scrutiny showed that nowhere in the section was there a trace of even a rudiment of the generative network described as the atrophied condition in a previous portion of this paper. Not even

a trace of the connective tissue in which the rudiments of the latter are usually imbedded remained, but the hepatic follicles or ultimate saccules of the liver were lying in immediate contact with the mantle, with no tissue whatever intervening. I have hitherto found the liver surrounded by a thick stratum of connective tissue in all of the specimens examined. The statements in a previous portion of this essay in regard to the existence of vessels which traverse this connective tissue mass will therefore have to be modified so far as to say that not only does the connective tissue of the body mass completely disappear, but also the vessels themselves which are excavated through its substance.

Turning now to the condition of the mantle, I find this in a no less remarkable state than the parts already described. The "vesicular connective tissue cells," as they have appeared to me hitherto, have given place to an entirely different structure, apparently much less solid and substantial. Instead of the clearly defined coarsely cellular structure usually noticed in sections made from less impoverished individuals, the tissue has now become very coarsely areolar, all trace of the peculiar nuclear bodies having vanished, together with the internal protoplasmic network which they so clearly exhibit. The areolæ inclosed by the fibers of the connective tissue of the mantle are very coarse and may measure as much as half a millimeter across in sections of the hardened and shrunken specimen. When the mantle was gorged in life, with blood probably, some idea of the coarseness of these meshes may be formed. The meshes may then have measured four or five millimeters in diameter, the resulting cavernous state of this highly elastic tissue enabling the mantle to become gorged or swollen by endosmosis to a remarkable degree, so much so as to cause the animal to be apparently bulky, yet in reality distended with sanious fluids merely. The question now arises, What has become of this connective tissue which has so completely disappeared? The only interpretation which I can offer is that the connective tissue substance has been transformed into sexual products which have been poured out by way of the efferent sexual ducts, and that our specimen represents the extreme of exhaustion consequent upon the completed exercise of the reproductive function for the season. The animal, in other words, has now exhausted its germ-producing resources, and must begin to feed and store up material for the next season's generative products. It therefore becomes highly probable that the reproductive organs develop anew each season. My reason for thinking so is, that in this specimen the atrophy or wasting away of the reproductive organ has gone so far that no trace even of the efferent ducts of that body remains. The specimen, taken as it was in July, also shows that the spawning season may be completed before the end of summer.

The connective tissue of the Oyster is, therefore, in reality transformed into ova and spermatozoa, depending simply upon the sex of the individual whether it shall be the former or the latter. This also raises the question whether the same individual may not be of a different sex during different seasons, since it appears that the whole reproductive organ disappears and develops anew every year. This it is however to be noted is arguing from a very different basis from that of some foreign writers who have been absurdly illogical enough to say that the Oyster was of a different sex in different years, apparently forgetting that it would be impossible to open the same individual twice in succession; since opening it kills the animal and puts the second examination totally out of the question.

The function of the mesenchymal or connective tissue in the Oyster is, therefore, of the nature of a store of reserved material—protoplasm laid up for the purpose of conversion into germs as the reproductive organ develops anew. It is then in the highest degree improbable that it is of the nature of an oily or fatty substance, out of which it would be impossible to form such highly vitalized bodies as the ova and spermatozoa of the Oyster. While it is true that we find the mesenchyme

developed to the greatest extent during the winter when it may be said the Oyster is in the best condition as regards flesh, it does not follow that this plumpness is due to fatty matters, but rather to a larger amount of protoplasm filling up the mantle, palps, and body mass.

Our sections of the specimen described above show some other singular features which cannot be passed over in silence. The principal of these is the presence of thick-walled vessels in the ventral lobes of the mantle. In life we find branching vessels visible in the transparent mantle in very impoverished specimens, such as the one under discussion. These vessels may be followed to what are apparently their ultimate ramifications and seem to end abruptly. It is these vessels which become obscured when the animal acquires flesh; they are, in fact, hidden in the thick deposit of connective tissue laid down in the mantle. They are grayish or whitish in color as they shimmer through the transparent external epithelial and connective tissue layers of the mantle organ. They are also different in character from other vessels excavated in the connective tissue of the mantle, and which disappear with the atrophy of the latter's substance, just as we noticed was the case with the vessels of the body mass. In a specimen as greatly impoverished as the one under discussion, the thick-walled pallial vessels become very conspicuous in transverse sections. They may not have the same function as the bloodvessels of the ordinary wall-less form found in the connective tissue, from which type they may be at once distinguished by their thick, finely cellular walls.

The almost total atrophy of the mesenchyme or mesoblast during the spawning season is a very remarkable fact, no less so than its regeneration. It appears, however, as far as I have been able to learn from transverse sections of very small spat, one-eighth to one-sixteenth of an inch in diameter, that the absence of a well-developed connective tissue deposit also characterizes the soft parts of the young animal. Indeed, the liver follicles here are relatively few in number, whereas they are very numerous in the adult. The follicles in the young also lie in immediate contact with the mantle, resembling in this respect the spawn-spent adults. This, for embryological reasons, ought to be so. We find, in fact, according to the unanimous testimony of observers, that the mesoblast in the Oyster develops by the proliferation of cells from the outer and inner layers into the segmentation or body cavity. Why, then, should it not be absorbed and regenerated in the same way in the adult? There seems to be no valid reason assignable why this should not be so, if we look upon the mesenchyme with its vessels and areolar tissue and cavernous spaces as having been primarily derived from the embryonic body cavity.

The arrangement of the intestine as shown in sections of spat as small as that described above is essentially the same as in the adult. The second bend of the intestine crosses the gullet in the same way, but the double lateral longitudinal fold or induplication is not so well marked as in the intestine of the adult. The stomach is more nearly cylindrical and not so irregular as in the adult. The contents of both the stomach and intestine show that diatoms have formed a large proportion of the food of the young animal, in the sections of which, these contents, in a number of my preparations, have been kept *in situ*.

The sections of the soft parts may be very readily double stained so as to bring out the tissues of the reproductive organs very distinctly. To effect this, I throw the section into a solution of methyl green for a few minutes, then into magenta, when it will be found that the green will dye only the reproductive tissues, leaving the others scarcely tinged, while the red will stain the mantle, liver, and connective tissues, mapping out these parts so distinctly as to make a really useful as well as beautiful preparation.

Considerable care must be exercised in the preparation of the color solutions, so as not to have them too intense. The sections should also be at once and quickly dehydrated or else the

alcohol will abstract the green and spoil in part the effect of the double stain. In making sections, the best ones which I have ever made have been prepared from portions of whole Oysters which had been imbedded in paraffine, the latter substance having in the molten state interpenetrated all the cavities and spaces in the hardened specimen, which had been previously dehydrated and saturated with oil of turpentine.

Note on the organ of Bojanus of the Oyster.—In the first part of this paper it is stated that the organ of Bojanus is rudimentary or wanting in the Oyster. This statement must now be modified. Within the past year, M. Hoek, of Leyden, has demonstrated the existence of the organ of Bojanus in *Ostrea edulis*, and the writer has shown it to be present in the American species as a crescent-shaped glandular or canaliculated structure lying just below the adductor and close against it, as a paired organ which also extends slightly into the substance of the mantle on either side. M. Hoek has shown that, as in other acephalous mollusks, this organ communicates with the pericardiac cavity and the genital openings. Its function is excretory.

Valves of the heart.—A pair of very distinct valvular folds separates each of the auricles of the heart of the Oyster from the ventricle, opening upward into the latter. They prevent the blood from regurgitating into the auricles, and cause the blood-current to assume one constant direction, viz, from the auricles to the ventricles, and from the latter through the anterior and posterior aortic vessels to the various parts of the body.

Fixation of the spat.—Recent studies have led me to the conclusion that the existence of a byssus in the fry of the Oyster is very doubtful, and that fixation is accomplished at a very early stage, possibly twenty-four hours after the embryos commence to swim, by the border of the mantle, as I have endeavored to show in my paper "On the Fixation of the Fry of the Oyster," illustrated with figures, and recently prepared for the Bulletin of the United States Fish Commission, where I also show that the beaks of the larval valves are constantly directed one way, and that the hinge end of the larval shell is inclined upward, the free margin of the left larval valve being brought into close contact with the surface to which attachment occurs through the instrumentality of the margin of the mantle. The attachment itself is a very firm one, and consists of the horny matrix of the calcareous material which serves as a cement to glue the free margin of the lower valve of the fry and spat to the surface which has been chosen as a permanent abode.

SECTION I.

PART V.—CRUSTACEANS, WORMS, RADIATES, AND SPONGES.

By RICHARD RATHBUN.

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ANALYSIS.

Y.—CRUSTACEANS: Page.

221. The Crabs 763
222. The Common Edible or Blue Crab 775
223. The Lobsters 780
224. The American Lobster 781
225. The Cray Fishes, Astacus and Cambarus 812
226. The Shrimps and Prawns 816
227. The Mantis Shrimps: Squillidæ 823
228. The Amphipods 824
229. The Isopods 826
230. The Entomostracans 827
231. The Cirripedia 828
232. The Xiphosura 829

Z.—WORMS:

233. The Annelids 831
234. The Leeches 833

Z. A.—THE RADIATES:

235. The Echinoderms 838
236. The Cœlenterates 841

Z. B.—THE PORIFERS:

237. The Sponges 843
238. The Genus Spongia, and the American Commercial Sponges 846
239. Injurious Sponges 850

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Y.—CRUSTACEANS.

221. THE CRABS.

THE FIDDLER CRABS—GELASIMUS PUGNAX, Smith; GELASIMUS PUGILATOR, Latreille; GELASIMUS MINAX, Le Conte.

Three species of Fiddler Crabs occur upon the Atlantic coast of the United States, and are frequently utilized as bait. Congregating together in immense numbers, as they often do, and excavating their holes generally in convenient localities, above the reach of the tides, they might be easily collected in large quantities, were they better appreciated by the fishermen. Most dwellers upon the sea-shore are acquainted with that peculiarity of the Fiddler Crabs which has given to them their common name, and by which they are readily distinguished from our other Crabs. The males are provided with two very unequal claws, one being of large, the other of quite small size, in comparison with the size of the animal. Of these, the larger claw has been likened to a fiddle and the smaller one to a bow; hence the derivation of the name. The claws of the females are, however, of equal and small size.

The three species mentioned as living upon the Atlantic coast are *Gelasimus minax*, *G. pugnax*, and *G. pugilator*. The former species, which is the largest, ranges from the southern coast of New England to Florida, and lives upon salt marshes, usually farther from the sea than the others, and frequently where the water is nearly fresh. *G. pugnax* ranges from Cape Cod to Florida, and also occurs in the Gulf of Mexico and among the West Indies. "It makes its burrows only upon salt marshes, but is often seen in great companies wandering out upon muddy or sandy flats, or even upon the beaches of the bays and sounds." *G. pugilator* ranges from Cape Cod to Florida, upon muddy and sandy flats and beaches. Professor Verrill describes the habits and characteristics of these species as follows:[1]

"We find several species of Crabs burrowing in muddy banks along the shores of the estuaries, as well as along banks of the streams and ditches of the salt marshes. The most abundant of these is the marsh Fiddler Crab, *Gelasimus pugnax*, which is often so abundant that the banks are completely honeycombed and undermined by them. These holes are of various sizes up to about three-quarters of an inch in diameter, and descend more or less perpendicularly, often to the depth of two feet or more. Occasionally in summer these Crabs will leave their holes and scatter over the surface of the marshes, which at times seem to be perfectly alive with them, but when disturbed they will scamper away in every direction and speedily retreat to their holes; but occasionally, at least, they do not find their own, for sometimes the rightful owner will be seen forcibly ejecting several intruders. It is probable that at such times of general retreat each one gets into the first hole that he can find. Associated with this 'Fiddler,' another related Crab, the *Sesarma reticulata*, is occasionally found in considerable numbers. This is a stout-looking, reddish-brown crab, with a squarish carapax; its large claws are stout and nearly equal in both sexes, instead of being very unequal, as in the male 'Fiddlers.' It lives in holes like the 'Fiddlers,'

[1] Report upon the Invertebrate Animals of Vineyard Sound, etc., in Report United States Fish Commissioner for 1871–'72, pp. 336, 466.

but its holes are usually much larger, often an inch or an inch and a half in diameter. It is much less active than the 'Fiddlers,' but can pinch very powerfully with its large claws, which are always promptly used when an opportunity occurs.

"On the marshes farther up the estuaries, and along the mouths of rivers and brooks, and extending up even to places where the water is quite fresh, another and much larger species of 'Fiddler Crab' occurs, often in abundance; this is the *Gelasimus minax*. It can be easily distinguished by its much larger size and by having a patch of red at the joints of the legs. Its habits have been carefully studied by Mr. T. M. Prudden, of New Haven, who has also investigated its anatomy. According to Mr. Prudden, this species, like *Gelasimus pugilator*, is a vegetarian. He often saw it engaged in scraping up and eating a minute green algoid plant which covers the surface of the mud. The male uses its small claw exclusively in obtaining its food and conveying it to the mouth. The female uses either of her small ones indifferently. In enlarging its burrows, Mr. Prudden observed that these Crabs scraped off the mud from the inside of the burrow by means of the claws of the ambulatory legs, and, having formed the mud into a pellet, pushed it up out of the hole by means of the elbow-like joint at the base of the great claw, when this is folded down. He also ascertained that this Crab often constructs a regular oven-like arch of mud over the mouth of its burrow. This archway is horizontal, and large and long enough to contain the Crab, who quietly sits in this curious doorway on the lookout for his enemies of all kinds.

"This species can live out of water and without food for many days. It can also live in perfectly fresh water. One large male was kept in my laboratory in a glass jar, containing nothing but a little siliceous sand moistened with pure, fresh water, for over six months. During this whole period he seemed to be constantly in motion, walking round and round the jar and trying to climb out. He was never observed to rest or appear tired, and after months of confinement and starvation was just as pugnacious as ever.

"Although some of the colonies of this species live nearly or quite up to fresh water, others are found farther down on the marshes, where the water is quite brackish, and thus there is a middle ground where this and *G. pugnax* occur together. This was found by Mr. Prudden to be the case both on the marshes bordering West River and on those of Mill River, near New Haven. They are abundant along both these streams. The holes made by this species are much larger than those of *G. pugnax*. Some of them are from an inch and a half to two inches in diameter.

"On sandy beaches near high-water mark, especially where the sand is rather compact and somewhat sheltered, one of the 'Fiddler Crabs,' *Gelasimus pugilator*, is frequently found in great numbers, either running actively about over the sand, or peering cautiously from their holes, which are often thickly scattered over considerable areas. These holes are mostly from half an inch to an inch in diameter, and a foot or more in depth, the upper part nearly perpendicular, becoming horizontal below, with a chamber at the end. Mr. Smith, by lying perfectly still for some time on the sand, succeeded in witnessing their mode of digging. In doing this they drag up pellets of moist sand, which they carry under the three anterior ambulatory legs that are on the rear side, climbing out of their burrows by means of the legs of the side in front, aided by the posterior leg of the other side. After arriving at the mouth of their burrows and taking a cautious survey of the landscape, they run quickly to the distance often of four or five feet from the burrow before dropping their load, using the same legs as before and carrying the dirt in the same manner. They then take another careful survey of the surroundings, run nimbly back to the hole, and after again turning their pedunculated eyes in every direction suddenly disappear, soon to reappear with another load. They work in this way both in the night and in the brightest sunshine, whenever the tide is out and the weather is suitable. In coming out or going into their

burrows either side may go in advance, but the male more commonly comes out with the large claw forward. According to Mr. Smith's observations this species is a vegetarian, feeding upon the minute algæ which grows upon the moist sand. In feeding, the males use only the small claw, with which they pick up the bits of algæ very daintily; the females use indifferently either of their small claws for this purpose. They always swallow more or less sand with their food. Mr. Smith also saw these Crabs engaged in scraping up the surface of the sand where covered with their favorite algæ, which they formed into pellets and carried into their holes, in the same way that they bring sand out, doubtless storing it until needed for food, for he often found large quantities stored in the terminal chamber."

As above stated, the Fiddler Crabs are sometimes used as bait; and at the mouth of the Mississippi River *G. pugnax* has been observed, in connection with the river Cray-fish (*Cambarus*), burrowing into and greatly damaging the levees.

YELLOW SHORE-CRAB OF THE PACIFIC COAST—HETEROGRAPSUS OREGONENSIS, Stm.

PURPLE SHORE-CRAB OF THE PACIFIC COAST—HETEROGRAPSUS NUDUS, Stm.

According to W. N. Lockington, these two species are by far the most abundant of all the California coast Crabs; but they are only eaten by the Chinese. The body of these Crabs is nearly square, and the claws large in proportion. In *H. oregonensis* the anterior half of the lateral margins on each side has two rather deep indentations, resulting in the formation of two large spine-like projections, which bend strongly forward; in *H. nudus* these characters are less pronounced. The four posterior pairs of limbs in *H. oregonensis* are also more or less hairy, while in *H. nudus* they are naked. The general color of the former species is yellow, of the latter purple; *H. nudus* also has marbled hands and attains a somewhat larger size than *H. oregonensis*, measuring at times two inches broad. Hundreds of one or other of these species of both sexes and of all sizes may frequently be found together, congregated under a single stone. *H. oregonensis* is especially abundant in muddy sloughs of salt or brackish water, where it literally swarms. Hundreds of uplifted threatening claws welcome the intruder who ventures near these mud flats when the tide is out. Both species occur at Puget Sound, and range thence southward to the southern limit of California. *H. nudus* also occurs at the Sandwich Islands. Both species are eaten to some extent by the Chinese, who spit them on wires and cook them over their fires.

THE OYSTER-CRAB—PINNOTHERES OSTREUM, Say.

"The 'Oyster-crab,' *Pinnotheres ostreum*, is found wherever oysters occur. The female lives, at least when mature, within the shell of the oyster, in the gill cavity, and is well known to most consumers of oysters. The males are seldom seen, and rarely, if ever, occur in the oyster. We found them, on several occasions, swimming actively at the surface of the water in the middle of Vineyard Sound. They are quite unlike the females in appearance, being smaller, with a firmer shell, and they differ widely in color, for the carapax is dark brown above, with a central dorsal stripe and two conspicuous spots of whitish; the lower side and legs are whitish. The female has the carapax thin and translucent, whitish, tinged with pink."[1]

This Crab has been recorded from the Atlantic coast from Massachusetts to South Carolina. The females measure, when adult, about half an inch broad and a little less in length. From the European Oyster-crab (*Pinnotheres pisum*) our species differs in having a thinner and more membranaceous shell and a larger size. The colors are also different in the two species.

[1] VERRILL: Vineyard Sound Report, p. 367, 1871–'72.

Pinnotheres ostreum is eaten both raw and cooked, either along with the oysters with which it is associated, or as a separate dish. It is also pickled for domestic use and for the trade.

Another species of *Pinnotheres* (*P. maculatum*) frequently occurs in the shells of the common sea-mussel (*Mytilus edulis*) and the smooth scallop (*Pecten tenuicostatus*), between the gills of the animal. It attains a larger size than the Oyster-crab, and, as in the case of the latter, the females alone are parasitic, the males having only been found swimming at the surface of the sea. We have never heard of this species being eaten, probably because neither the mussel nor the smooth scallop has ever been used much as food in this country. In the summer of 1880, while dredging off Newport, Rhode Island, the United States Fish Commission steamer Fish Hawk came upon extensive beds of the smooth scallop, from a bushel of which nearly a pint of these Crabs were obtained. Again, in 1881, the same species was encountered in great abundance by the same party, in Vineyard Sound, in *Mytilus edulis*. As an experiment, they were cooked along with the mussels and found to be very palatable, although their shell is, perhaps, somewhat harder than that of *Pinnotheres ostreum*.

A third species of *Pinnotheres* occurs upon the west coast of the United States, in the shells of *Pachydesma* and *Mytilus californianus*.

The Rock Crab—Cancer irroratus, Say.

Distribution and habits.—This is the common Crab of the New England coast, where adult specimens occur in all depths of water from low-tide level to about twelve fathoms. Smaller specimens have, however, been obtained in from thirty to fifty fathoms, both near the coast and on George's Bank, Stellwagen's Bank, and elsewhere. Its entire range, so far as determined, is from the Straits of Belle Isle, Labrador, to South Carolina. In the Gulf of Saint Lawrence it is exceedingly abundant, but south of New Jersey it is rare. According to Prof. S. I. Smith,[1] this species is not common in the muddy bays of the New Jersey coast, but is thrown up in large numbers upon the sandy outer beaches; it is abundant on the sandy shores of the southern side of Long Island, and on the sandy and rocky shores of Long Island Sound; it is equally abundant, in similar situations, along all the rest of the south coast of New England and in Cape Cod, Massachusetts, and Casco Bays, but is apparently less common in the Bay of Fundy and at Halifax, Nova Scotia. "When found living between tides it is usually concealed among rocks or buried beneath the sand. It is usually much more abundant at or just below low-water mark, however, than between tides."

"The common 'Rock Crab,' *Cancer irroratus*, is generally common under the large rocks near low-water mark, and often lies nearly buried in the sand and gravel beneath them. It can be easily distinguished by having nine blunt teeth along each side of the front edge of its shell or carapax, and by its reddish color sprinkled over with darker brownish dots. This crab also occurs in the pools, where the comical combats of the males may sometimes be witnessed. It is not confined to rocky shores, but is common also on sandy shores, as well as on rocky and gravelly bottoms off shore. It is widely diffused along our coast, extending both north and south, and is common even on the coast of Labrador. Like all the other species of crabs, this is greedily devoured by many of the larger fishes, such as cod, haddock, tautog, black bass, and especially by sharks and sting-rays."[2]

External characters.—The carapax of the Rock Crab is transversely suboval in outline, and about two-thirds as long as broad; the upper surface is moderately convex, with unequal

[1] Trans. Conn. Acad., v, p. 38, 1879.

[2] Verrill: Vineyard Sound Report, p. 312, 1871–'72.

but symmetrically arranged mammillations, some of which are scarcely defined. The surface appears nearly smooth, but is really covered with closely-placed, minute granulations. The eyes stand on short, stout peduncles, which lie in deep circular holes on either side of the middle of the front margin. Between the eyes there are three small teeth, and on each side, between the eyes and the outer edge of the shell, the margin is indented to form nine broad and stout teeth. The claws are rather short and stout, the inner margins of the fingers bearing each a row of few, large, blunt, and sometimes double tubercles. The four posterior pairs of legs are similar to one another, long and slender, with pointed tips. The ground color of the carapax is yellowish, closely dotted with dark purplish-brown, which becomes a reddish-brown after death.

The only species of Crab upon our Atlantic coast which could possibly be confounded with the present one is *Cancer borealis*, of which a description is given following this. The differences between the two species being once pointed out, there is no difficulty in distinguishing between them.

ECONOMIC VALUE.—The Rock Crab is not much in demand as an article of food. It is sold to some extent in the markets at Boston, New Bedford, Newport, New York, and perhaps elsewhere within the limits of its range, generally, if not always, in a hard-shell condition. But even in Boston, where it could be easily supplied, its place is mainly taken by the common edible Blue Crab (*Callinectes hastatus*), which is sent there fresh from New York and other localities. The two species of *Cancer* are, however, more nearly related to the English edible Crab (*Cancer pagurus*) than is our own common edible Crab, and, were this kind of food more appreciated by the American seacoast inhabitants, there is no reason why the Rock Crab, as well as the "Jonah," should not be utilized to a very great extent. In some places, Newport for instance, the two species of *Cancer*, but especially the *Cancer borealis*, are preferred to the *Callinectes hastatus*, but this is not the rule elsewhere.

DEVELOPMENT.—The following account of the growth and development of this Crab, by Prof. S. I. Smith, will suffice, in a general way, for nearly all the American species of Crabs, and will serve to indicate the curious changes which take place before the simple crab egg becomes a well-developed Crab. Such an account as this becomes very valuable in many cases as a means of pointing out the essential details to be followed in the artificial breeding of marine animals.

"All, or at least nearly all, the species of Crabs living on the coast of New England pass through very complete and remarkable metamorphoses. The most distinct stages through which they pass were long ago described as two groups of crustaceans, far removed from the adult forms of which they were the young. The names Zoea and Megalops, originally applied to these groups, are conveniently retained for the two best marked stages in the development of the Crabs.

"The young of the common Crab (*Cancer irroratus*), in the earlier or zoea stage, when first hatched from the egg, are somewhat like the form figured [reproduced on one of the plates at the end of this volume], but the spines upon the carapax are all much longer in proportion, and there are no signs of the abdominal legs or of any of the future legs of the Megalops and Crab. In this stage they are very small, much smaller than in the stage figured. After they have increased very much in size, and have molted probably several times, they appear as in the figure just referred to. The terminal segment of the abdomen, seen only in a side view in the figure, is very broad and divided nearly to the base by a broad sinus; each side the margins project in long, spiniform, diverging processes, at the base of which the margin of the sinus is armed with six to eight spines on each side. When alive they are translucent, with deposits of dark pigment forming spots at the articulations of the abdomen and a few upon the cephalothorax and its appendages. In this stage they were taken at the surface in Vineyard Sound, in immense

numbers, from June 23 to late in August. They were most abundant in the early part of July, and appeared in the greatest numbers on calm, sunny days.

"Several Zoeæ of this stage were observed to change directly to the megalops form. Shortly before the change took place they were not quite as active as previously, but still continued to swim about until they appeared to be seized by violent convulsions, and after a moment began to wriggle rapidly out of the old zoea skin, and at once appeared in the full megalops form. The new integument seems to stiffen at once, for in a very few moments after freeing itself from the old skin the new Megalops was swimming about as actively as the oldest individuals.

"In this megalops stage the animal begins to resemble the adult. The five pairs of cephalothoracic legs are much like those of the adult, and the mouth-organs have assumed nearly their final form. The eyes, however, are still enormous in size, the carapax is elongated and has a slender rostrum and a long spine projecting from the cardiac region far over the posterior border, and the abdomen is carried extended, and is furnished with powerful swimming-legs, as in the Macroura. In color and habits they are quite similar to the later stage of the Zoeæ from which they came; their motions appear, however, to be more regular and not so rapid, although they swim with great facility. In this Megalops the dactyli of the posterior cephalothoracic legs are *styliform, and are each furnished at the tip with three peculiar setæ* of different lengths and with strongly curved extremities, the longest one simple and about as long as the dactylus itself, while the one next in length is armed along the inner side of the curved extremity with what appear to be minute teeth, and the shortest one is again simple.

"According to the observations made at Wood's Holl, the young of *Cancer irroratus* remain in the Megalops stage only a very short time, and at the first molt change to a form very near *that of the adult. Notwithstanding this, they occurred in vast numbers,* and were taken in the towing-nets in greater quantities even than in the zoea stage. Their time of occurrence seemed nearly simultaneous with that of the Zoeæ, and the two forms were almost always associated. The exact time any particular individual remained in this stage was observed only a few times. One full-grown Zoea obtained June 23, and placed in a vessel by itself, changed to a Megalops between 9 and 11.30 a. m. of June 24, and did not molt again till the forenoon of June 27, when it became a young Crab of the form described farther on. Of the two other Zoeæ obtained at the same time, and placed together in a dish, one changed to a Megalops between 9 and 11.30 a. m. of June 24, the other during the following night; these both changed to Crabs during the night of June 26 and 27.

"In the two or three instances in which the change from the Megalops to the young Crab was actually observed, the Megalops sank to the bottom of the dish and remained quiet for some time before the molting took place. The muscular movements seemed to be much less violent than in the molting at the close of the zoea stage, and the little Crab worked himself out of the megalops skin quite slowly. For a short time after their appearance the young Crabs were soft and inactive, but the integument very soon stiffened, and in the course of two or three hours they acquired all the pugnacity of the adult. *They swam about with ease and were constantly attacking* each other and their companions in the earlier stages. Many of the deaths recorded in the above memorandum were due to them, and on this account they were removed from the vessel at each observation. In this early stage the young Crabs are quite different from the adult. The carapax is about three millimeters long and slightly less in breadth. The front is much more prominent than in the adult, but still has the same number of lobes and the same general form. The antero-lateral margin is much more longitudinal than in the adult, and is armed with the five normal teeth, which are long and acute, and four very much smaller secondary teeth alternating with the

normal ones. The antennæ and ambulatory legs are proportionally longer than in the adult. The young Crabs in this stage were once or twice taken in the towing-net, but they were not common at the surface, although a large number were found, with a few in the megalops stage, among hydroids upon a floating barrel in Vineyard Sound, July 7."[1]

THE JONAH CRAB—CANCER BOREALIS, Stimpson.

AFFINITIES.—The "Jonah Crab" is very closely related to the common Rock Crab, and is also to some extent associated with it in its distribution. The two species are so much alike in shape and general characters that they were originally regarded as the male and female respectively of one and the same species. They are, however, quite distinct, and after the differences have been once noticed there is no difficulty in distinguishing between them. The Jonah Crab differs from the Rock Crab in the much larger size of adult specimens, in the rougher surface of the carapax and claws, caused by the larger granules covering it, which are of irregular size, some being much larger than others, and by the serrations of the antero-lateral margins being crenate and the posterior ones armed with numerous sharp points, instead of being simple as in the Rock Crab. The legs of the Jonah Crab are also proportionately shorter and heavier than those of the Rock Crab. The color of *Cancer borealis* is yellowish beneath and brick-red above, the limbs corresponding more or less in coloration with the lower surface, but of a light reddish tint above.

DISTRIBUTION AND HABITS.—Besides being found in moderately deep water, the Jonah Crab, in certain localities, inhabits the rocks near low-tide level, in the clear waters of the ocean shores, but it never occurs in muddy or sandy bays and harbors where the Rock Crab abounds. The range of *Cancer borealis* is from the eastern end of Long Island Sound to Nova Scotia, but it is not found everywhere within these limits, being apparently local in its distribution and abundant only within certain more or less restricted areas. The principal localities where it has been observed are as follows: off Noank, Connecticut; off Watch Hill and Newport, and in Narragansett Bay, Rhode Island; Vineyard Sound, Noman's Land, and Salem, Massachusetts; Casco Bay, Maine; Bay of Fundy and Nova Scotia. In 1880, the United States Fish Commission found the Jonah Crab abundant everywhere in the lower part of Narragansett Bay from about low-tide level down to the greatest depths of the bay, and it was likewise very common off the bay, and off the north end of Block Island. The following account of the habits and distribution of this species is taken from Prof. S. I. Smith's account:[2]

"In habits this species differs very greatly from *irroratus*. The best opportunities which I have had for observing it were at Peak's Island, in Casco Bay, August and September, 1873. Empty carapaces, chelipeds, etc., of *borealis* were at first found in abundance scattered along the outer shores, far above the action of the waves, where they had evidently been carried by gulls and crows, and were also found in considerable numbers half a mile from the shore, in a forest of coniferous trees thickly inhabited by crows. For several weeks no living specimens of *borealis* were discovered, although the *irroratus* was found living in abundance all about the island, without, however, its remains scarcely ever being found scattered about with those of *borealis*. The *borealis* was finally discovered in abundance at low water on the exposed and very rocky shores of the northern end of the island. At this locality, between eighty and ninety specimens, all females and many of them carrying eggs, were obtained in a single morning. They were all found in situations exposed to the action of the waves, and were either resting, entirely exposed, upon the bare rocks and ledges, or clinging to the seaweeds in the edge of the waves, or in the

[1] S. I. Smith, Vineyard Sound Report, pp. 530–533, 1871–'72.

[2] Trans. Conn. Acad., v, p. 40, 1879.

tide-pools. They were never found concealed beneath the rocks, where, however, *irroratus* abounded. It is a much heavier and more massive species than the *irroratus*, and is consequently much better adapted than that species to the situations in which it is found. So many individuals falling a prey to birds is evidently a result of the habit of remaining exposed between tides, although the heavy shell must afford much greater protection than the comparatively fragile covering of *irroratus* would afford to that species if similarly exposed. The *borealis* was also found at a somewhat similar locality, but more exposed to the sea, on Ram Island Ledge, a low reef open to the full force of the ocean. One specimen of moderate size was dredged in the ship channel between Peak's Island and Cape Elizabeth, in ten fathoms, rocky and shelly bottom, and specimens were several times captured in lobster-traps, set at a depth of eight or ten fathoms, among rocks. Specimens were also several times found in stomachs of the cod taken on the cod ledges.

"In the vicinity of Vineyard Sound, this species was not infrequently found thrown upon sandy beaches, but never upon beaches very far removed from rocky reefs. The following are the localities where it was seen in greatest numbers: Along the sandy beach of Martha's Vineyard, from Menemsha Bight to Gay Head; the rocky island of Cuttyhunk; and the rocky outer shores of Noman's Land, where dead specimens were found in considerable abundance. In the vicinity of Noank, Connecticut, it was occasionally found dead upon the shores, and was several times obtained from lobster-traps.

"The largest specimens I have seen are two males, of almost exactly the same size, one from Casco Bay, the other from near Noank, Connecticut. The carapax of the specimen from Casco Bay is three and one-half inches long and five and three-fourths inches broad."

ECONOMIC VALUE.—*Cancer borealis* is supplied to the Newport markets in small quantities during most of the summer months, and is much esteemed there as food, being considered by many preferable to the Blue Crab (*Callinectes hastatus*). It is taken by the fishermen on the shore and in shallow water.

NAME.—The term "Jonah Crab," which we have adopted here for this species, is the one by which it is commonly known in and about Narragansett Bay, Rhode Island, and to some extent also about Vineyard Sound, Massachusetts, but apparently not elsewhere. The origin of the name we have not been able to ascertain. In most localities where it occurs it is confounded by the fishermen with the commoner Rock Crab.

THE COMMON CRAB OF THE PACIFIC COAST—CANCER MAGISTER, Dana.

This is the largest of the edible species of Crabs of the Pacific coast of the United States, and likewise the most important. It is the only species commonly eaten in San Francisco, although two other species inhabiting the same region, and which are described further on (*Cancer productus* and *Cancer antennarius*), are also edible and of good flavor. The carapax of adult males usually measures from seven to nine inches in breadth and four to five inches in length; the females average much smaller. The color of the upper surface is a light reddish-brown, darkest in front; the limbs and under surface are yellowish. The anterior margin of the carapax forms a nearly regular elliptical curve, reaching back to about the middle of the sides and interrupted by nine slightly prominent, sharp teeth on each side. At the termination of this curve on each side, there is a strong, pointed tooth, projecting directly outward, and forming the commencement of the postero-lateral margins, which are long and slope abruptly backward so as to leave but a narrow posterior margin. The surface of the carapax is slightly convex, undulated, and covered with papillæ; the claws are strongly toothed above and ribbed at the sides.

This species has quite an extended range, having been recorded from Sitka, Alaska, in the north, and from Magdalena Bay, Lower California, in the south; but whether these are its extreme northern and southern limits or not is unknown. In the Bay of San Francisco it is very abundant, and large quantities are constantly captured and brought to the markets in that city; it is also taken for food in Monterey Bay, California.

It occurs most commonly on the sandy bottoms, below low-tide level, and is seldom found, at least to any extent, between tide-marks. The supplies sent to the San Francisco markets come mainly from the San Francisco side of the bay, especially from the south side of the Golden Gate, between the city and the sea. They are also taken in abundance from about the wharves and piers in the Bay of San Francisco. Crab-nets baited with fish and offal are used for catching them. Nothing is known regarding the spawning season and habits of this species. The fishermen say they spawn in March or April. The occurrence of a female with spawn in the San Francisco market has not yet been recorded by any naturalist.

The Red Crab—Cancer productus, Randall.

This is a very common species in the Bay of San Francisco, although less abundant than the last (*Cancer magister*). It also attains a large size, adult individuals measuring from five to seven or more inches in breadth across the carapax, and from two and a half to four inches in length. The proportion of width to length is rather greater in the males than in the females. The antero-lateral borders of the carapax form an ellipse, broken in the center in front by a slight projection, by which the specific name was suggested. The teeth of the front and of the antero-lateral borders are distinctly separate in the adult, but in the very young exist only as wrinklings of the edge of the carapax. The postero-lateral margins are concave and short. The claws are of medium size compared with the carapax, and the posterior limbs are slender and plain. The color of adult specimens is an intense dark red or reddish-brown above and yellowish-white below; the young differ from the adults in their more variable coloring, some being of a dark reddish-brown, others yellow spotted with red, and still others banded with red and yellow. The shape of the carapax, with its produced front, sufficiently distinguishes this species of *Cancer* from all the others on the Pacific coast.

Cancer productus is found along the entire Pacific coast of the United States, and has been recorded from Magdalena Bay, Lower California, and the Queen Charlotte's Islands and other localities, in British Columbia. It is very abundant in the Bays of San Francisco, Monterey, and Tomales, and also occurs at Santa Barbara and San Diego. Its habitat is in the shallow water along the shores, principally in rocky sections, and it is frequently found between tide-marks, often taking refuge in pools under stones near low-tide level.

Stimpson, in 1856, recorded seeing this species in the San Francisco markets, but it is no longer taken there, unless by accident or inadvertence, the larger and more abundant *Cancer magister* fully supplying the demands. In case of the latter becoming scarce, however, *Cancer productus* would become an important article of capture.

The Rock Crab of the Pacific coast—Cancer antennarius, Stimpson.

This species is of about the same average size as *Cancer productus*, and is tolerably abundant along the Pacific coast, from Queen Charlotte's Islands, in the north, to Magdalena Bay, Lower California, in the south. Although as regards edible qualities it is said to compare favorably with *Cancer magister*, it has not, up to the present time, been brought to the San Francisco markets. The carapax of adult specimens measures three and a half or more inches in length,

and from five to six inches across. The carpus and hand of the big claws are smooth or nearly so, and the external antennæ are very large and hairy. The margins of the abdomen and of other parts of the lower surface of the body, as well as the ambulatory feet, are very hairy, and this character, together with the great length and hairiness of the antennæ, serves as the best distinguishing feature of the species. Young individuals are more hirsute than adults. The color of the carapax is a dark purplish brown; the chelipeds in adults are marbled with purplish spots.

The Pacific Rock Crab does not often occur on the shore between tides; it appears to frequent deeper water than either *Cancer magister* or *C. productus*, being abundant in from two to three fathoms, always, however, among rocks.

The Mud Crabs—Panopeus Herbstii, Edwards; Panopeus depressus, Smith; Panopeus Sayi, Smith; Panopeus Harrisii, Stimpson.

Four species of the so-called Mud Crabs occur upon our Atlantic coast: *Panopeus Herbstii* ranges from Long Island Sound to Brazil, but is not common north of New Jersey; *P. depressus*, from Cape Cod to Florida, and often carried much farther north with oysters; *P. Sayi*, associated with the last and having the same range; *P. Harrisii*, from Massachusetts Bay to Florida. *P. Herbstii* is rather the larger species, specimens from Florida and the West Indies measuring fully two inches across the back. The color is a dark olive above, the fingers of the claws being black, though lighter at the tips. This species is occasionally sold as food in the New Orleans markets, and is sometimes used as bait. The other three species are more or less abundant in numerous localities where they could also be obtained as bait. Professor Verrill refers to them as follows:

"Two small kinds of Crabs are very abundant under the stones, especially where there is some mud. These are dark olive-brown and have the large claws broadly tipped with black. They are often called Mud Crabs on account of their fondness for muddy places. One of these, the *Panopeus depressus*, is decidedly flattened above, and is usually a little smaller than the second, the *Panopeus Sayi*, which is somewhat convex above. They are usually found together and have similar habits. A third small species of the same genus is occasionally met with under stones, but lives rather higher up toward high-water mark, and is comparatively rare. This is the *Panopeus Harrisii*. It can be easily distinguished, for it lacks the black on the ends of the big claws and has a groove along the edge of the front of the carapax, between the eyes. This last species is also found in the salt marshes, and was originally discovered on the marshes of the Charles River, near Boston. All the species of *Panopeus* are southern forms, extending to Florida, or to the Gulf coast of the Southern States, but they are rare north of Cape Cod, and not found at all on the coast of Maine. They contribute largely to the food of the tautog and other fishes."[1]

The Stone Crab—Menippe mercenarius, Gibbes.

This is one of the two edible species of Crabs occurring upon the Southern Atlantic coast of the United States, *Callinectes hastatus* being the other and more important one, on account of its greater abundance. The recorded range of the Stone Crab is from Charleston Harbor, South Carolina, to Key West, Florida, but the so-called Stone Crabs of the Gulf of Mexico probably belong, in part at least, to the same species, and it has also been recently collected on the coast of North Carolina.

[1] Vineyard Sound Report, pp. 312, 313, 1871–'72.

The Stone Crab is much stouter and heavier than the Blue Crab, of more solid build, and with a much thicker shell-covering both on the body and claws. There is, moreover, no similarity between the two species. The carapax of adult individuals measures about three inches in length by about four and a half inches in width, and the body is from one and a half to two inches thick. The large claws, when folded against the front of the body, measure about seven inches from elbow to elbow. One claw is somewhat larger than the other.

Prof. Lewis R. Gibbes has kindly furnished the following notes on the habits of this species as observed in the vicinity of Charleston, South Carolina:

"They live in holes in the mud along the borders of the creeks and estuaries of the coast, and are taken by the hand, thrust down several inches, sometimes fifteen to twenty, to reach the inhabitant at the bottom, at the risk of a severe bite from one or both of its claws. They can also be found in the crevices between fragments of any solid material, occurring near their haunts, such as rejected stone ballast, fragments of brick thrown out as waste from houses or other structures in the city or vicinity. Again, they occur in similar situations along the breakwater, constructed some forty years ago to protect a part of the front beach of Sullivan's Island, at the mouth of the harbor, from the destructive action of the waves. They offer a stout resistance to being dragged from their chosen retreat, by firmly pressing their powerful claws against the walls of their abode. From their holes in the mud they are drawn with some difficulty, with a quantity of the mud adhering to them; and if the walls of their retreat are solid, and cannot be removed from around them, they cling to them with such tenacity that *not* unfrequently they are brought out piecemeal, first one claw, then the other, and finally the body."

Professor Gibbes further states that the Stone Crabs are highly esteemed as food, and preferred to the Blue Crab, as the meat of their large claws is more lobster-like in texture and flavor. From the difficulty of capturing them, however, they are much less common in the markets than the Blue Crab, and command a higher price. They are also apparently less abundant. Like the Blue Crab, they are constant dwellers upon our coast, and could doubtless be taken at all times during the year. Soft-shelled specimens are seldom if ever brought to market.

In the Gulf of Mexico, according to Mr. Silas Stearns, the Stone Crab is not so universally common as the Blue Crab, although it is found along the entire coast. It seems to be most abundant on the southern and western coasts of Florida where the bottom, being more rocky than elsewhere, is best suited to its habits. In this section it lives in cavities in the rocks, and in deep holes which it excavates in the sand. It attains a larger size than the Blue Crab, measuring in adult species one or two inches more across the carapax than the latter species. The people living upon the coast where the Stone Crab is so abundant and so large esteem it highly, and regard it as an important food supply. Owing to the persistent way in which it keeps on the bottom, and in its biding places, it cannot be captured as easily as the other species. The most common method of capture is, after finding its hole or place of retreat, to run the hand and arm down quickly and drag it out. To one unversed in this practice it seems a dangerous operation, but it is not so. The crab lies in its hole with its claws uppermost or outermost, and considering its well-known slowness and clumsiness of action, a man's strong grip finds no difficulty in controlling them. In other parts of the Gulf, away from the Florida coast, visited by Mr. Stearns, he did not find the Stone Crabs nearly so abundant. They were mostly confined to oyster beds and stone heaps, and were inferior in size to the Florida specimens.

As the Stone Crabs generally live more or less buried beneath the bottom, their movements are probably less affected by tides and changes of temperature than the Blue Crabs. They have never appeared for sale in the markets of any of the larger cities and towns of the Gulf coast, on

account of the difficulty of procuring them. By those who have eaten them they are considered decidedly superior to the Blue Crab in flavor.

The Green Crab—Carcinus mænas, Leach.

This Crab, which is one of the most common species on the coast of Great Britain, also abounds upon our Atlantic coast, from Cape Cod to New Jersey and perhaps farther south. It is very abundant in Vineyard Sound, Buzzard's Bay, and Long Island Sound. The body is of a bright-green color, varied with spots and blotches of yellow, making it very conspicuous; adult specimens measure about two inches in width and one and a half inches in length. The surfaces of the carapax and limbs are more or less granulated.

"The Green Crab, *Carcinus mænas*, occurs quite frequently well up toward high-water mark, hiding under the loose stones, and nimbly running away when disturbed. It may also be found, at times, in the larger tidal pools. It often resorts to the holes and cavernous places under the peaty banks of the shores, or along the small ditches and streams cutting through the peaty marshes near the shore."[1]

It is most abundant between tide-marks, or near low-water mark, and is seldom found below a very few fathoms in depth.

The Green Crab is an article of food in some parts of Europe, where it occurs abundantly. In England it is occasionally used as bait, especially while in a soft-shell state. It is said to be often very annoying to the salmon fishermen in that country. "Trout and mackerel are reduced to skeletons in a very short time, and grilse and salmon often rendered unfit for market by an unseemly scar, the work of these marauders."[2]

In this country, the Green Crab is frequently used as bait on the Southern New England coast, especially for the tautog. In Vineyard Sound and Buzzard's Bay it is known to the fishermen as the "Joe Rocker."

The Lady Crab—Platyonichus ocellatus, Latreille.

The "Lady Crab," or "Sand Crab," is abundant on nearly all our sandy shores from Cape Cod to Florida, and in the Gulf of Mexico; it ranges from low-water mark to a depth of ten fathoms. This species is easily distinguished from all our other Crabs by the shape and color of its carapax, taken in connection with the character of its posterior pair of limbs, which are modified into swimming organs, as in the edible Crab. Its body is nearly as long as broad, the margins rudely indicating a six-sided figure. The front lateral margins bear five spines each, which are directed forward, and the front margin is deeply indented on each side of a slightly projecting three-spined rostrum, to form cavities for the eyes. The front limbs, those bearing the claws, are long and rather slender, and the succeeding three pairs are simple in their structure. "The color of this Crab is quite bright and does not imitate the sand on which it lives, probably owing to its mode of concealment. The ground-color is white, but the back is covered with annular spots formed by specks of red and purple. The Lady Crab is perfectly at home among the loose sands at low-water mark, even on the most exposed beaches. It is also abundant on sandy bottoms off shore, and as it is furnished with swimming organs on its posterior legs, it can swim rapidly in the water, and has been taken at the surface in several instances, and some of the specimens thus taken were of full size. When living at low-water mark on the sand beaches, it generally buries itself up to its eyes and antennæ in the sand, watching for prey, or on the lookout for enemies. If disturbed, it quickly glides backward and downward into the sand and disappears instantly.

[1] Verrill: Vineyard Sound Report, p. 312, 1871–'72.
[2] White: Popular History of the British Crustacea.

This power of quickly burrowing deeply into the sand it possesses in common with all the other marine animals of every class which inhabit the exposed beaches of loose sand, for upon this habit their very existence depends during storms. By burying themselves deep they are beyond the reach of breakers.

"The Lady Crab is predaceous in its habits, feeding upon various smaller creatures, but, like most of the Crabs, it is also fond of dead fishes or any other dead animals. In some localities they are so abundant that a dead fish or shark will in a short time be completely covered with them; but if a person should approach they will all suddenly slip off backwards and quickly disappear in every direction beneath the sand. After a short time, if everything be quiet, immense numbers of eyes and antennæ will be gradually and cautiously protruded from beneath the sand, and after their owners have satisfied themselves that all is well the army of Crabs will soon appear above the sand again and continue their operations."[1]

This species is used as bait on many parts of the coast, especially about Vineyard Sound and Buzzard's Bay. It is also an important article of food at New Orleans, Louisiana, and is occasionally taken to the New York markets.

222. THE COMMON EDIBLE OR BLUE CRAB—CALLINECTES HASTATUS, Ordway.

DISTRIBUTION.—The common edible Crab of the eastern coast of the United States, generally termed "Blue Crab" at the North and "Sea Crab" at the South, ranges from Cape Cod to Florida, and also occurs in the Gulf of Mexico, and is occasionally taken in Massachusetts Bay. Next to the Lobster, it is the most important crustacean of our waters in a commercial point of view. There are several species of the genus *Callinectes* living upon the coast of the Southern States. *Callinectes hastatus*, the genuine Blue Crab, is positively known to occur as far south as Louisiana, and is probably the only species brought to the New York markets. *Callinectes ornatus* inhabits Charleston Harbor, South Carolina, and extends southward from there, but to what extent has not been determined. Two other species, *Callinectes larvatus* and *C. tumidus*, have been recorded from Southern Florida and the West Indies. Which of these four species occurs in the greatest abundance in the Gulf of Mexico, and is there most commonly taken for food, we are unable to state, as no careful examination of market supplies from that region has ever been made.

EXTERNAL CHARACTERS.—The shell of the Blue Crab is about twice as broad as long, including the stout, sharp spines which project from each side. Between the spine of each side and the eye of that side the margin is armed with about eight short and acute spines, which are largest at the side and gradually decrease in size toward the eye. Between the eyes, which are placed in slight recesses, the margin forms four broad, unequal-sided teeth, with a median spine underneath. The front limbs, including the claws, are similar in shape but somewhat unequal in size; they have several strong sharp spines above. The three succeeding pairs of limbs are slender, similar to one another, and terminate in sharp points. The posterior pair, however, end in an expanded oval joint, especially adapted for swimming. The entire body of this species is considerably compressed, the carapax being only moderately convex above; the surface, excepting near the posterior margin, is covered with minute granulations, which are more numerous over some portions than over others. The entire margin of the carapax and abdomen is bordered with fine hairs, and most of the joints of the limbs are ornamented in the same way.

The abdomen of the female is very broad, and when not charged with eggs fills in the entire

[1] VERRILL: Vineyard Sound Report, p. 338, 1871–'72.

space between the bases of the posterior pairs of legs. During the spawning season, however, the eggs are so numerous and form such a large mass that they throw the abdomen some distance out from the lower surface of the body, causing it to project almost at right angles with the upper surface of the carapax. The upper surface of the shell and claws is of a dark-green color, and the lower surface of a dingy white; feet blue; tips of fingers and spines reddish.

HABITS, USES, ETC.—The following account of the habits of the Blue Crab is by Professor Verrill:

"The common edible Crab or 'Blue Crab' is a common inhabitant of muddy shores, especially in sheltered coves and bays. It is a very active species, and can swim rapidly. It is, therefore, often seen swimming at or near the surface. The full-grown individuals generally keep away from the shores, in shallow water, frequenting muddy bottoms, especially among the eel-grass, and are also found in large numbers in the somewhat brackish waters of estuaries and the mouths of rivers. The young specimens of all sizes, up to two or three inches in breadth, are, however, very frequent along the muddy shores, hiding in the grass and weeds or under the peaty banks at high water and retreating as the tide goes down. When disturbed they swim away quickly into deeper water. They also have the habit of pushing themselves backward into and beneath the mud for concealment. They are predaceous in their habits, feeding upon small fishes and various other animal food. They are very pugnacious, and have remarkable strength in their claws, which they use with great dexterity. When they have recently shed their shells they are caught in great numbers for the markets, and these 'soft-shelled Crabs' are much esteemed by many. Those with hard shells are also sold in our markets, but are not valued so highly. This Crab can easily be distinguished from all the other species found in this region by the sharp spine on each side of the carapax. . . . They are usually brought to market early in May, but the 'soft-shelled' ones, which are more highly esteemed, are taken later. These soft-shelled individuals are merely those that have recently shed their old shells, while the new shell has not had time to harden. The period of shedding seems to be irregular and long continued, for soft-shelled Crabs are taken nearly all summer. The young and half-grown specimens of this Crab may often be found in considerable numbers hiding in the holes and hollows beneath the banks during the flood tide. When disturbed, they swim away quietly into deeper water. These small Crabs are devoured by many of the larger fishes. During flood tide the large Crabs swim up the streams like many fishes and retreat again with the ebb. They feed largely on fishes, and often do much damage by eating *fishes caught in set-nets, frequently making large holes in the nets at the same time.*"[1]

Besides devouring living animals, the Blue Crab "feeds on dead animal matter in its various stages of putrescence, and is one of the many depurators of the ocean. It often buries itself in the sand, so that no part is visible but the eyes and anterior antennæ; these last are then in continual motion, the bifid terminal joint acting as forceps to seize and convey to its mouth the small molluscous animals for food. The shell is cast annually, and they are then known by the name of 'soft-shell Crab,' are very delicate, and in particular request for the table. In this state the Crab is incapable of any defense from its enemies; the male usually retires to a secluded situation for security, but the adult female is protected by a male whose shell is hard. They are then called double Crabs."[2]

On different parts of the coast, Crabs in the soft state are known respectively as "Soft Crabs," "Shedders," or "Peelers." The terms "Soft Crab," "Paper-shell," and "Buckler" denote the different stages of consistency of the shell, from the time of shedding until it has become nearly

[1] Vineyard Sound Report, pp. 367, 368, 408, 1871–'72.
[2] SAY: Journ. Acad. Nat. Sci. Phila., i, p. 66, 1817.

hard again. For instance, immediately after shedding it is a "Soft Crab"; as the shell becomes slightly hardened it is called "Paper-shell," and just before reaching its normal hardness it is termed "Buckler."

Callinectes hastatus does not appear to be confined to salt and brackish water only, for it has been known to ascend the Saint John's River, Florida, a distance of one hundred miles, to where the water is sufficiently fresh for drinking.

According to Prof. Lewis R. Gibbes, of Charleston, South Carolina, the Blue Crab is abundant in and about Charleston Harbor, and is largely taken for food. Average-sized specimens measure about two and a half inches long and five to five and a half broad, including the lateral spines. It occurs, feeding and swimming on the bottom and between the bottom and the surface, in the deeper water of the harbor, and in the shallower waters of rivers and creeks. It is also found walking on the muddy borders of creeks or rivers, and on the marshes, when the tide is out. For market, these Crabs are occasionally taken by the fishermen in cast-nets while seeking fish, but the customary crab-net is a sort of dip-net attached to a pole. In the deeper water, it is sometimes necessary to entice the Crabs to the surface by means of bait attached to cords. Although Blue Crabs occur in this region more or less throughout the entire year, they are chiefly taken for the market in the spring and early summer months, as they are then in the best condition and most highly esteemed for their flavor. Both hard and soft shell individuals are eaten. They seem to be as common now as formerly.

Mr. Silas Stearns, of Pensacola, Florida, writes as follows concerning the habits, etc., of *Callinectes* in the Gulf of Mexico:

"The Blue Crab is more abundant than the Stone Crab, and is distributed along the entire Gulf coast. It is found out in the Gulf, in the bays and estuaries, and very often in fresh-water rivers and lakes that have close connection with some body of salt water. It lives in the shoaler waters during the summer months, from about April to November, and retires to the deeper water on the approach of cold weather, to remain half dormant until the first warm day or settled mild weather. Its first move in the spring is to the grass-covered shoals, where various kinds of fishes and other marine animals have just deposited their eggs, upon which it feeds greedily. All through the summer it is found in such places as these, acting both as a scavenger of decomposing animal matter and as one of the most dreaded enemies of small fish and their spawn. At high tide the Crabs come nearer to the shore than at low tide, and at all times the young are more venturesome than the old. Hiding under patches of seaweed, behind and under logs and roots of trees and in the sand, the young spend the period of high tide at the very water's edge.

"The period of spawning and shedding extends through several months, probably the entire summer, for some individuals are found loaded with spawn and others in a soft state during the whole season. This summer (1880), while at Saint Joseph's Bay, on this coast, I found large quantities of females, heavy with spawn, lying just at the edge of the surf on the sea-beach. They were quite inactive, and there were no males among them. While shedding its shell, and until the new shell has become sufficiently hard to protect it, the Blue Crab remains hidden in the mud or among seaweeds. This is the most active of all the Gulf species of Crabs. It swims easily and rapidly at the surface at times, and its movements at the bottom are remarkably swift. It is also very pugnacious, and not only fights its own kind, but also shows a bold front to its enemies, including man. The average size of the Blue Crab is about six inches broad across the shell.

"Being so common that people nearly everywhere along the coast can obtain any quantity for the mere trouble of capturing them, they have given rise to no defined industry excepting in

the larger cities. Outside of New Orleans, in fact, there is no regular trade in Blue Crabs. In the early spring they are trolled from deep water to within reach of a dip-net, by means of a piece of meat attached to a long string. Later in the season, when the water has become warmer, they may be dipped up with a dip-net all along the shore. About Pensacola, the catching of Crabs is classed among the sports. During warm summer evenings, parties of men, women, and children set out for secluded portions of the bay shore, where they pursue the Crabs, with torches and jigs or dip-nets, until they are tired. A midnight supper, made up mainly of the Crabs and fish they have taken, follows, and the enjoyment concludes with a moonlight sail homeward."

The Spider Crabs—Libinia emarginata, Leach; Libinia dubia, Edwards.

The Spider Crabs are inhabitants of shallow water along the Atlantic coast, from Western Maine to the Gulf of Mexico. The two species resemble one another very closely, but the *emarginata* is more thickly covered with spines than the *dubia*, which is also further distinguished by being narrower across the front, and by having a longer rostrum. As a rule, the latter species is found more commonly than the former in the very shallow water near shore, and its range is more restricted toward the north, not passing beyond Cape Cod.

Professor Verrill says of their habits, that "they are very common on muddy shores and flats. They hide beneath the surface of the mud and decaying weeds, or among the eel-grass, and are very sluggish in their motions. The whole surface of the body is covered with hairs, which entangle particles of mud and dirt of various kinds; and sometimes hydroids, algæ, and even barnacles grow upon their shells, contributing to their more ready concealment. The males are much larger than the females, and have long and stout claws. They often spread a foot or more across the extended legs. The females have much smaller and shorter legs and comparatively weak claws."[1]

The Spider Crabs are used as bait along the Middle Atlantic States, and probably elsewhere, within their range.

The Kelp Crab—Epialtus productus, Randall.

The Kelp Crab of the Pacific coast is "easily recognized by its smooth quadrate carapax, with two distinct teeth on either side. It is the most common maioid Crab on the coast of California and Oregon, and is usually found among seaweeds on rocks, just below low-water mark. Its color is olivaceous when alive."[2]

This Crab is occasionally taken for food by the natives along the coast, but apparently has not yet found its way into the San Francisco markets. It has been especially recorded from Puget Sound, the mouth of the Columbia River, the Farallone Islands, Tomales Bay, entrance to San Francisco Bay, and Monterey.

The Red Rock Crab—Echidnocerus setimanus, Stimpson.

This is quite a large and very ornamental red Crab, which is not eaten, but is occasionally sold in the San Francisco markets as a curiosity. It is procured in moderately deep water about the Farallone Islands, which lie a short distance off the coast at San Francisco, California. The body of adult specimens measures about ten inches both in length and breadth, and the weight of such specimens is between six and seven pounds. The carapax is convex and exceedingly uneven, being covered with large tubercles and granules. The front and lateral margins on each side bear about eight principal teeth, and the beak is four-lobed. The right claw is much larger than the left, and both are covered with tufts of hair, and armed with teeth and tubercles. The

[1] Vineyard Sound Report, p. 368, 1871–'72.

[2] Stimpson: Journ. Boston Soc. Nat. Hist., vi, p. 457, 1857.

ground color of the body is vermilion, the granules and spines being generally of a deep blue or purple; the entire carapax is covered with minute bristles. According to Dr. William Stimpson, who wrote concerning this Crab in 1857, specimens of this species then readily sold in the San Francisco market for five and ten dollars each. A certain demand for them still continues, but they are apparently brought to market only occasionally.

The Sand Bug—Hippa talpoida, Say.

This is rather an odd species of Crab, related to the Hermit Crabs, from which, however, it differs greatly in appearance. The body is oval in outline and more than half as broad as long, the sides forming a nearly regular curve. The upper part of the body, formed mostly of the cephalo-thorax, is convex and rather plain, giving a decidedly bug-like appearance to the creature, as suggested by its common name. The tail, which is long and broad, is pressed up against the under surface of the body, reaching nearly to the front. The eyes are minute and placed at the ends of long, slender peduncles; the principal antennæ are about as long as the carapax, and are curved and strongly plumose.

"This species burrows like a mole, head first, instead of backward. It can also swim quite actively, and is sometimes found swimming about in the pools left on the flats at low water. It is occasionally dug out of the sand at low-water mark, and is often thrown up by the waves on sand-beaches, but it seems to live in shallow water on sandy bottoms in great numbers, for in seining on one of the sand-beaches near Wood's Holl for small fishes, a large quantity of this species was taken. Its color is yellowish-white, tinged with purple on the back. It is one of the favorite articles of food of many fishes. Mr. Smith found the young abundant at Fire Island, near high water, burrowing in the sand. This species is still more abundant farther south."[1]

The Sand Bug ranges from Cape Cod to Florida, but is much more abundant toward the South than at the North. On the New Jersey coast, and probably at other places farther south, it is used by the fishermen as bait. It is frequently called by them the "Bait Bug."

The Hermit Crabs—Eupagurus pollicaris, Stimpson; Eupagurus bernhardus, Brandt; Eupagurus longicarpus, Stimpson; and allied species.

There are numerous species of Hermit Crabs living upon our coast, in all depths from the shore down to several hundred fathoms. Three species which are of large enough size to be considered as desirable for bait occur, however, in localities where they might be easily taken by the fishermen. One of the species, *Eupagurus bernhardus*, is frequently used for that purpose in England, and could as well be utilized here. The other two species, living in shallow water, are *E. pollicaris* and *E. longicarpus*. *E. bernhardus* ranges from Cape Cod northward, and from low-water mark to depths of fifty fathoms and more. *E. pollicaris* ranges from Massachusetts to Florida, and occurs at low-water mark, but is more abundant on the rocky and shelly bottoms of the bays and sounds, and upon oyster-beds. *E. longicarpus* ranges from Massachusetts Bay to the Gulf of Mexico, and from between tide levels to a depth of ten fathoms.

The Hermit Crabs protect the hinder, soft portion of their bodies in any empty Gasteropod shell of sufficient size which is obtainable, carrying this shell upon their back. They move about very actively and are very pugnacious. Their savage dispositions toward each other has earned for them, in England, the name of "Soldier Crabs," but both in Europe and this country they are generally termed "Hermits."

[1] Verrill: Vineyard Sound Report, p. 339, 1871–'72.

E. longicarpus is smaller than either of the other species, but is more of a littoral species, and therefore, as a rule, more easily obtainable.

A fourth species, *E. pubescens*, might be added to our list of available Hermit Crabs, but it is generally limited to deeper water than the others. It ranges from New Jersey to Greenland, but south of Casco Bay, Maine, has not been found as high up as the level of low tide. In Casco Bay and the Bay of Fundy, it sometimes, but rarely, occurs upon the shore, just below low-water mark.

"Active and interesting little 'Hermit Crabs,' *Eupagurus longicarpus*, are generally abundant in the pools near low water, and concealed in wet places beneath rocks. In the pools they may be seen actively running about, carrying upon their backs the dead shell of some small Gasteropod, most commonly *Anachis avara* or *Ilyanassa obsoleta*, though all the small spiral shells are used in this way. They are very pugnacious and nearly always ready for a fight when two happen to meet, but they are also great cowards, and very likely each, after the first onset, will instantly retreat into his shell, closing the aperture closely with the large claws. They use their long, slender antennæ very efficiently as organs of feeling, and show great wariness in all their actions. The hinder part of the body is soft, with a thin skin, and one-sided in structure, so as to fit into the borrowed shells, while near the end there are appendages which are formed into hook-like organs, by which they hold themselves securely in their houses, for these spiral shells serve them both for shields and dwellings. This species also occurs in vast numbers among the eel-grass, both in the estuaries and in the sounds and bays, and is also frequent on nearly all other kinds of bottoms in the sounds. It is a favorite article of food for many of the fishes, for they swallow it shell and all. A much larger species, belonging to the same genus, but having much shorter and thicker claws (*Eupagurus pollicaris*), is also found occasionally under the rocks at low water, but it is much more common on rocky and shelly bottoms in the sounds and bays. Its habits are otherwise similar to the small one, but it occupies much larger shells, such as those of *Lunatia heros*, *Fulgur carica*, &c. This large species is devoured by the sharks and sting-rays."

223. THE LOBSTERS.

THE SPINY LOBSTER OR ROCK LOBSTER—PANULIRUS INTERRUPTUS, Randall.

The well-known Spiny Lobster of the European coast, *Palinurus vulgaris*, is represented on the western coast of the United States by a closely allied genus and species, *Panulirus interruptus*. The Spiny Lobster differs from the common Lobster in wanting the large anterior claws, the first pair of feet being simple and without pincers, and in having enormously developed antennæ or feelers, which are very large around at the base, and as long as, or longer than, the body. The gills are similar in structure to those of the true Lobster, but number twenty-one on each side.

The California Spiny Lobster, which, in the region where it occurs, is often called simply "Lobster" or "Cray-fish," attains a total length of fourteen inches, the carapax in adult individuals measuring as much as five inches. Average-sized individuals weigh from three and one-half to four pounds. One specimen weighing eleven and one-half pounds has been recorded from Santa Barbara, but very large specimens are now rarely taken in that locality. It ranges southward from Point Conception, California, the most northern point from which it has been recorded being San Luis Obispo. At this place it is rare, but at Santa Barbara and to the southward from there it is very common. These Lobsters generally inhabit rocky ledges. In the winter they remain in deep water among the kelp, and are captured in lobster-pots; in the

[1] VERRILL: Vineyard Sound Report, p. 313, 1871–'72.

summer they move into shallower water, and are taken by means of dip-nets. The best bait for the traps is fresh fish, but any flesh will answer for this purpose. The spawning season for the Spiny Lobster is the early spring, when they are found in abundance close to the shore. At this time they are less fat than at others, and are not considered as good eating; some even regard them as unwholesome at the spawning time, but nevertheless they are eaten more or less continuously through the entire year. When abundant near the shore, catches aggregating five hundred pounds have been made by a single person in the short space of two hours. They are not as abundant now as formerly in the places where they are most extensively taken as food, this having resulted from overfishing, especially during the spawning season. There is, therefore, great danger of the species becoming exterminated, unless some stringent laws are framed to protect them.

224. THE AMERICAN LOBSTER—HOMARUS AMERICANUS, Milne-Edwards.

INTRODUCTION.—Although the Lobster is one of the most important of our food invertebrates, careful observations regarding its natural history, and especially its breeding habits, rate of growth, etc., have been strangely neglected. This fact is greatly to be deplored, considering that the Lobster has recently become the subject of important legislation by the several States which it inhabits, and that its cultivation by artificial means has been frequently attempted. It is now an undisputed fact that the abundance, as well as the average size, of Lobsters has greatly decreased in our shallow-water areas during the past twenty to thirty years, thereby forcing the lobster fishermen to resort to deeper water, and increasing the hardships of their profession. The question has, therefore, very naturally arisen as to whether this continued decrease can in any way be checked either by the enactment of proper protective laws, or by means of artificial propagation. Laws for the protection of the Lobster have been passed by all the States interested in this fishery, but their want of uniformity and the difficulty of enforcing them have diminished the benefits which it was hoped might result. The success attending the artificial breeding of several of our food-fishes has inspired the hope that similar methods might succeed with regard to the Lobster, and many persons are now awaiting with interest the results of experiments in that direction. It is very certain, however, that the breeding of Lobsters can never be successfully carried on until we have become acquainted with at least the main features of their natural history. The artificial cultivation of animals can only progress through the fulfillment of natural laws, which must be thoroughly understood before they can be properly applied. As it is, however, the would-be experimenter in the matter of lobster-breeding must still follow a very uncertain pathway, meeting with numerous failures which previous studies might have averted.

To assist in a small way toward overcoming this difficulty, and as a preliminary to the industrial report which will appear hereafter, the author has brought together the following few disconnected popular notes, taken in part from published works, but mainly derived from the observations of intelligent lobster fishermen and dealers, who have always cheerfully responded when called upon for information. It is hoped that the meagerness of these notes will act as an incentive to observers in this line of research.

RELATIONS AND STRUCTURE OF THE LOBSTER.—The Lobster belongs to the highest group of the Crustacea, the so-called *Decapoda*, or ten-footed crustaceans, which group is again divided into the *Brachyura*, or short-tailed Decapods (true Crabs), the *Anomoura* (Hermit Crabs, etc.), and the *Macroura*, or long-tailed Decapods (Lobsters and Shrimps). The members of the first group

range higher in organization than those of the two latter, and the Lobster must, therefore, be regarded as lower in the scale of being than our common Crab.

The Lobsters find some of their nearest allies among the common fresh-water Cray-fish of our rivers and small streams, with which they agree structurally in most particulars. The principal differences existing between them, beyond size and shape, are such as would be readily overlooked by the casual observer. One of the most important is as to the number of gills, of which there are twenty perfect ones on each side in the Lobster and only seventeen to eighteen on each side in the Cray-fish. Some of the gills also differ in structure in the two groups. The other structural differences need not be discussed here, nor do we propose to describe the anatomical peculiarities of the Lobster in this connection, as they have been fully treated of in numerous scientific publications which are easily obtainable. It will suffice for our purpose to pass over in review the principal external characteristics.

The body of the Lobster, as may be readily observed, is made up of two general divisions, an anterior one, called the carapax or cephalo-thorax, and covered by a single shell or shield above and at the sides, and a posterior one, termed the abdomen, consisting of six segments and a terminal flap, or telson. The dividing line between the head and thorax proper, which are both contained within the carapax, is indicated on the upper surface of the carapax by a transverse, curved groove. Underneath the thoracic portion of the carapax there are five transverse segments, corresponding to the pairs of legs, of which the four posterior pairs are subequal in size and much smaller than the anterior pair or claws. All of the legs are composed of several and an equal number of joints; the two posterior ones terminate in simple points, while the two in advance of them end in small claws. The anterior legs are very much enlarged, the joints very unequal in size and very unlike in shape, the terminal joint, forming the claw proper, being very greatly developed, hard and rugged, and very powerful. Each segment of the abdomen or tail also has a pair of appendages on the lower side. In the female, the anterior five pairs are small and slender, and constitute the so-called swimmerets, to which the eggs are attached after extrusion from the body and during incubation. The appendages of the posterior abdominal segment are large, and each terminates in two broad plates which lie at each side of the telson. In the male, the anterior pair of abdominal appendages are modified into the stiffened styles, by means of which the sex may be easily distinguished. The functions of these different appendages correspond with the same in the Cray-fish, which are described as follows by Professor Huxley:

"The Cray-fish swims by the help of its abdomen and the hinder pairs of abdominal limbs; walks by means of the four hinder pairs of thoracic limbs; lays hold of anything to fix itself, or to assist in climbing, by the two chelate anterior pairs of these limbs, which are also employed in tearing the food seized by the forceps [big claws] and conveying it to the mouth; while it seizes its prey and defends itself with the forceps."

On the lower side of the body, in front of the claws, are several pairs of variously shaped small organs, which surround the mouth and subserve mastication. Still farther in front are two long feelers or antennæ, and two smaller feelers or antenules, and also the two compound eyes, situated at the ends of two short, movable stalks. The carapax terminates in front in a sharp, spiny, and prominent projection or rostrum, which reaches out between the eyes. The gills are situated on each side of the body, just inside of the carapax, in two cavities, called the branchial chambers, which open behind, below, and in front, so that the water has free entrance.

Three species of true Lobsters, constituting the genus *Homarus*, are now recognized by naturalists. They live exclusively in the sea. The American species, *Homarus americanus*, in

which we are now interested, is the largest of them all. Next in size, and of equal importance, is the European species, *Homarus vulgaris*, which differs but slightly from our own, the rostrum being narrower, and bearing teeth only on its upper margin, while in the former species the lower margin of the rostrum is also armed with teeth. The third species belongs to the southern hemisphere and attains a length of only about five inches. It is called *Homarus capensis*, and inhabits the region of the Cape of Good Hope. We are not aware of its being used as food.

NAME.—For a common and widely distributed marine animal, the American Lobster is surprisingly free from the long list of vernacular and local names which encumber some of our most important industrial fishes, such as the menhaden. The simple term "Lobster" belongs to it wherever it occurs, and in only a few rare instances have the fishermen dared to assert their well-acknowledged right of adding, through its means, a new word to their already somewhat lengthy and interesting vocabulary. On the coast of Rhode Island, Lobsters are sometimes called "Sea-craws," from their resemblance to the fresh-water Cray-fish; and at Nantucket the young Lobster is termed "Grass-hopper"; but such names are not much used, nor are they of importance to our discussion.

The different stages during the process of shedding and subsequent hardening of the new shell and during spawning are designated by descriptive terms, such as "Black Lobster," "Soft-shell," "Berried Lobster," etc., which are described in full further on.

In and about Vineyard Sound, Massachusetts, two varieties of Lobsters are recognized, and these are distinguished as "School Lobsters" and "Rock Lobsters," or "Groundholders."

DECREASE IN SIZE.—Lobsters occur of all sizes up to about forty pounds weight, but the average size of all Lobsters now caught for market is probably not above two pounds weight. It is a well-attested fact that the average size, as well as the abundance of Lobsters, has steadily decreased from year to year during the past twenty years, and the markets are now supplied with a much smaller breed, so to speak, than formerly. Not that Lobsters grow less rapidly at the present time than in previous years, or have become in any way dwarfed in size, but the avaricious fishing which has been constantly carried on along almost the entire extent of their range has caught up nearly all the larger individuals and reduced the bulk of those remaining, suitable for market, to near the minimum prescribed by law, and there they will probably remain. Were the spawning Lobsters carefully protected, and due respect paid to the laws limiting the size of those taken for food, we might expect to find about as many Lobsters now as in any past time, though they might average smaller in size; but such, unfortunately, is not the case.

Just what the decrease in average size has been we have not sufficient data to determine; but it has occurred so recently and has been so marked that no one who is familiar with the facts can refuse to acknowledge it. A New Haven correspondent states that the average length of the Lobsters sold in the markets there to-day is about ten and one-half inches and the average weight about two pounds, against an average length of about thirteen inches and an average weight of about three and one-half pounds twenty years ago. A Boston correspondent, who has spent much time in studying the lobster question from a practical standpoint, writes that "they decreased rapidly until the law was enacted regulating the size of those brought to market, the enforcement of which arrested the apparent decrease. I would say here that the effect of a law regulating the size of those saved for food is, after a time, to bring a very large majority of those offered for sale to about the legal limits, and an improvement can only be looked for by increasing the limit from time to time."

AVERAGE SIZE AT PRESENT.—From many fishermen and lobster-dealers along the entire New England coast we have solicited information as to the average size of Lobsters taken by

them in their traps and sold as food, or received at the markets. The replies were numerous, and in many cases undoubtedly reliable. In four of the principal larger markets the average sizes were stated to be as follows, the length given being exclusive of the claws:

	Inches.
Portland, Maine	10½
Boston, Massachusetts	11–11½
New Haven, Connecticut	10½
New York City	10½–15

The larger Lobsters received at New York probably came from Eastern Maine, and the smaller ones from Southern New England.

According to the fishermen, the average size of Lobsters taken upon certain sections of the New England States runs about as follows, the wide range in the figures given in some cases resulting from the combining of data from different localities:

	Inches.
Coast of Maine, from Eastport to Portland	8–15
New Hampshire	11
Vicinity of Boston	10–13
Vineyard Sound to New London, Connecticut	8–12
Western Connecticut	8–10½

The average size is said to be somewhat greater in Eastern than in Western Maine, but even at the east the smaller sizes are taken to sell to the canneries. On the coast of Nova Scotia Lobsters, at present, run larger than on the coast of Maine. According to Capt. N. E. Atwood, small Lobsters are seldom seen at Provincetown, or at least were seldom taken there when the lobster fishery was extensively carried on at that place. In an entire smack load there would not be half a dozen individuals weighing under two pounds. The average size of Lobsters taken in the traps does not appear to remain the same at any one place throughout the year. In many places they are said to run largest during the summer, or from June until the latter part of August. This may not hold good, however, for all localities. About Vineyard Sound, Massachusetts, Lobsters average largest in June, and those taken at that time are called "June" or "Sand" Lobsters. They are lighter colored and have thinner shells than those caught the remainder of the year. School Lobsters average about the same in size in the same school, but the different schools may differ more or less from one another in the average size of the Lobsters composing them, and some at times consist mostly of one sex and others of the opposite sex.

LARGE LOBSTERS.—The male Lobsters are said, as a rule, to attain the largest size, and in most localities they average larger than the females. In some few places, however, we are informed that the females average largest, and where this occurs it may possibly result from the greater protection accorded the latter sex. A correspondent at Provincetown, Massachusetts, estimates that the larger females attain there a length of about fifteen to sixteen inches, and the larger males about eighteen to twenty-two inches. Although large Lobsters have been mostly exterminated from our coast, we still occasionally hear of the capture of individuals of unusual size. From fishermen we have obtained information regarding three monster individuals, weighing respectively thirty-five, thirty-eight, and forty pounds each, but no notice as to the year when they were taken. Lobsters of over forty pounds weight have been recorded, but we are inclined to look upon these giants with some distrust, as we cannot ascertain that any of them were actually weighed. From more reliable sources we learn that sixteen to twenty-five pound Lobsters, although by no means common, have been, and still are, occasionally found. They do not seem to have been confined to any one part of the coast, as they are recorded all the way from Eastport, Maine, to New Jersey.

Much of the information regarding large Lobsters was obtained from lobster-dealers, who have had them for sale in their markets. A dealer at New Haven states that twenty years ago twelve to sixteen pound Lobsters were common, but during the past ten years a Lobster weighing ten pounds has been rarely seen. A Boston dealer writes that during the past season (1880) he has received and sold several Lobsters weighing from twelve to fifteen pounds each. On the Nova Scotia coast, ten-pound Lobsters are said to be common now. The dimensions of these heavy individuals are seldom given. A specimen taken at Boothbay, Maine, and said to weigh between thirty and forty pounds, had such large claws that the meat from one of them was equal to that of an entire ordinary-sized Lobster. Another specimen, weighing thirty-five pounds, had a length of four feet. Seventeen to twenty-four pound Lobsters are stated to measure from three to three and one-half feet long, and ten-pounders from twenty to twenty-four inches. A nineteen-pound Lobster, shipped from Eastport, in 1875, measured three feet five inches in length, the claws being eighteen inches long and eight inches across.

LARGE LOBSTERS ON THE COAST OF ENGLAND.—Although the European Lobster never attains the extreme size of the American, still large individuals are occasionally met with. Mr. Frank Buckland makes the following records of large Lobsters observed on the coast of the British Islands: "The deeper the water and the farther from the shore, the larger are the Lobsters. The Skye and the Orkney Lobsters are probably the largest in the British Islands. At St. Mawe's we heard of two Lobsters, one ten pounds and the other nine and three-fourths pounds, and at Dargan and Seunen of one of thirteen pounds. A large Lobster was caught in a large earthenware pot at Gosport in 1870; he weighed eight pounds ten ounces. In May, 1875, a Lobster, weight twelve pounds, was found at Saint's Bay, Guernsey." Another specimen caught at Hamble, near Southampton, was said to have weighed fourteen pounds.

COLOR.—The color of the Lobster is so varied as to almost defy accurate description, even in single individuals. It may be described in a general way as consisting of a groundwork of yellow or yellowish-red, covered with spots or mottlings of green, or more rarely blue. The mottlings are most numerous and dense upon the back, while on the sides of the carapax and lower surfaces of the claws the yellow generally predominates. Along the lower edge of the carapax, on each side, there is quite a broad marginal band of blue or bluish coloration, which also extends a short distance up the posterior margin of the carapax. Just above this band, which has a distinctly defined edge, the yellow (ranging in intensity from a light yellow to a deep orange) begins, and may be nearly plain for quite a breadth, or become at once covered with roundish spots of dark green or greenish or brownish olive, which increase in size and become more closely placed toward the dorsal surface, where they overlap to such an extent that the yellow seldom shows through. This combination frequently produces a very dark coloration on the back, which sometimes appears as a greenish-black. Often the entire carapax and abdomen assume a very dark shade over nearly all the sides as well as back. Sometimes the spots are fewer in number than ordinary and stand apart from one another, even on the back, producing the so-called "Spotted Lobsters." The green color is often replaced by different shades of blue. Occasionally a reddish coloration will predominate over the entire carapax. The rostrum is olive green, the spines it bears being of a deep, rich red. The abdomen corresponds in markings with the carapax. The depressed line running along the center of the back of the carapax is distinctly marked, being generally dark green. The tail-flaps are bordered along their posterior margins by a band of dark olive brown.

The upper surface of the big claws has a decidedly reddish or orange cast, the color deepening towards the ends, which are a very deep red, fading out to a whitish color just at the tips.

Over this groundwork the outer margin of the claw has a broad banding of dark olive brown or black, and numerous large spots of the same color cover more or less of the remaining surface. The under sides of the large claws are almost always an orange of variable intensity, the terminal joints being more intense than the inner ones, which are more or less marked with green or blue. The other legs are much lighter below than the claws, with green or blue markings, especially above and at the ends of the joints. The tips end in deep orange red, while the bunches of hairs which ornament them and other parts of the body are almost a ruby red, when the specimen has just been taken from the water. The soft skin covering the under surface of the abdomen, and the swimmerets are of a faint pinkish color, due to the presence of multitudes of very minute red spots.

These color variations of Lobsters probably depend, to a certain extent, upon the character or color of the bottom inhabited by them, but some of the varieties cannot be accounted for in that manner. The character of their food may also have some influence in the matter. Lobsters obtained from rocky bottoms more or less covered with sea weeds, and from dark grassy bottoms, are said to be generally much darker in color than those from sandy bottoms, and also to average shorter in proportion to their weight. Lobsters from open sandy bottoms are not only lighter in color, but also appear to be, usually, brighter. We have several recorded instances of red Lobsters from sandy bottoms, some of the specimens examined having been nearly as red as Lobsters ordinarily are after boiling. Nearly white Lobsters also occur occasionally in similar situations. One of the most curious color varieties we ever saw had numerous round, bright yellow spots, ranging in size from very small to about half an inch in diameter, scattered without order over the entire body. It is well known to all consumers of Lobsters that the shell of these animals quickly changes to a nearly uniform bright-red color on boiling.

DISTRIBUTION—GEOGRAP. ICAL RANGE.—The American Lobster ranges along the Atlantic coast from Delaware to Labrador, and has even been found as far south as the northeastern corner of Virginia. A correspondent at Johnsontown, Virginia, informs us that he has seen two or three stragglers taken in that neighborhood, and he believes them to have wandered naturally to that far southern limit, as he cannot account for their being carried there through the agency of man. The vicinity of the Delaware breakwater can be regarded with greater certainty as their southern limit, for there they occur in moderate abundance, and are occasionally fished for with lobster-pots. They are also sometimes taken on the fishing banks off Cape Henlopen and Cape May. The stonework of the Delaware breakwater seems, however, to form quite an attractive place for them at present, though previous to its construction they may not have existed there at all. They may be caught in the immediate vicinity of the breakwater in lobster-pots, and are also incidentally taken in gill-nets and on hand-lines, but the fishery is not carried on regularly, mainly on account of their scarcity, and partly from the fact that the pots are liable to be disturbed by the anchors of vessels seeking the protection of the breakwater. Mr. Burbage, of Ocean View, Delaware, states that he has occasionally seen small Lobsters in the surf along the beach, near Indian River Inlet.

Along the New Jersey coast, Lobsters have been recorded from a few places, but are nowhere very abundant. A fisherman of long experience about Cape May writes that he has never seen Lobsters in that region. Off Monmouth County they occur near to and south of Navesink. At Long Branch and Atlantic City small amounts are taken annually for local consumption and for shipment to New York and Philadelphia. Lobsters are more plentiful on a fishing ledge of rocks lying a short distance off Long Branch, and those found near the shore are supposed to be summer visitants from this locality. Several instances of large Lobsters are

recorded from this region—two in particular from off Atlantic City, weighing twenty and twenty-one pounds each.

After passing the New Jersey coast, we soon come to the region where Lobsters are more continuously abundant. At one time they were common in New York Bay, but the establishment there of large factories, which pollute the waters, has almost exterminated them and dwarfed the size of those remaining. Throughout Long Island Sound, Lobsters are moderately abundant, and are fished for at several localities. They become much more plentiful in the neighborhood of Fisher's Island, Block Island, Montauk Point, the Elizabeth Islands, Martha's Vineyard, and Noman's Land, all of which regions furnish a very important summer fishery. Nearly all favorable localities on the Massachusetts coast abound in Lobsters, though overfishing has nearly depleted some sections, as at Provincetown. New Hampshire supports a limited lobster fishery.

The Maine coast excels all others of the States in the abundance of Lobsters, which are more or less uniformly distributed from Portland to Eastport, some localities, however, being more favorable to their existence than others. The fishery for this State is much greater than for all the other States combined, Massachusetts ranking next.

The Provincial coast, or at least the Nova Scotian part of it, is said to be more prolific in Lobsters than Maine, though the fishery there is not of as long standing. We have little data as to the relative abundance of Lobsters on the Newfoundland and Labrador coasts, but they are apparently less common than to the south.

BATHYMETRICAL RANGE.—The Lobster ranges in depth from about low-water mark to at least eighty fathoms, and the fishery is regularly carried on in some localities in depths of fifty to sixty fathoms, especially during the winter. At Eastport and elsewhere on the Maine coast, in the summer, they are occasionally left upon the shore by the receding tide, either concealed under stones and seaweeds or partly buried in the sand. During the same season they may also be frequently seen about the wharves of some of the Maine sea-coast towns, attracted there by the refuse thrown over from the canneries. Twenty to thirty years ago, or before the fishery had made much advancement, Lobsters were of much more common occurrence in the littoral zone, and were often gaffed from the shore by the early fishermen. Even to-day, in some places, the pots are set in such shallow water that they are exposed at low tide. Several accounts of this shore fishery have been reserved for the industrial portion of the present report.

As explained elsewhere, Lobsters move towards the shore in summer, and away from it, or into deeper water, on the approach of cold weather. During the principal fishing season, which includes the warmer half of the year, they are most abundant in depths of a very few to about fifteen or twenty fathoms, and it is within these depths that the pots are mainly set.

OFF-SHORE RANGE.—Lobsters have been recorded from the fishing banks off Nova Scotia, from the fishing banks and ledges of the Gulf of Maine, such as Jeffrey's Ledge and Cashe's Ledge, and from other more southern off-shore banks. They have also been taken from the stomachs of cod caught on George's Banks. There is, however, no off-shore lobster fishery.

FRESH AND BRACKISH WATER.—Lobsters will not live in fresh or brackish water, although it is an unsettled question as to whether a slight admixture of fresh water is harmful to them or not. They are caught at the mouths of large rivers where the water is decidedly brackish on top, but when placed in surface cars at the same localities they are said to quickly perish, indicating that the water must be much more salt at the bottom.

CHARACTER OF THE BOTTOM.—Lobsters prefer rocky, gravelly, and sandy bottoms, and,

in shoal waters, especially those which are more or less covered with growths of the larger seaweeds. Vegetation is not, however, essential to their well-being, for they live on the barren sands, as at Provincetown, Cape Cod, and on rocky, stony, and hard bottoms, wherever they can find food. At the mouth of the Bay of Fundy, they are said to occasionally occur on the mud, and this fact is recorded of them in other localities. On rocky bottoms they remain more or less concealed under and among the rocks and stones, watching for their prey. In the Bay of Fundy and elsewhere they are often seen lurking under stones at low water, and about the wharves. The lobster-pots are generally set upon gravelly and sandy bottoms. In many localities the young, under eight or ten inches long, are often abundant in shallow coves or bays, which are more or less filled up with kelp and other large seaweeds. In such places as these they have been commonly taken in the beam trawl used by the United States Fish Commission for bottom fish, in Long Island Sound, Narragansett Bay, and Vineyard Sound. One cause assigned for the great decrease in the abundance of Lobsters in Plymouth Bay, Massachusetts, is the raking over of the rocky bottom for Irish moss, which industry is carried on to a very great extent, thereby uncovering and destroying the young and damaging their grounds.

MIGRATIONS.—The Lobsters inhabiting the shoaler grounds in summer move into deeper water, as a rule, on the approach of cold weather, and return again in the spring. In some localities, however, a few Lobsters are said to remain in moderately shoal water the entire year, especially toward the south. But all Lobsters do not leave their deeper abiding places in summer, for they appear to occur in greater or less abundance in all depths at all seasons. The extent of the fall migrations is not very great, but the Lobsters move off beyond the influence of the extreme cold into slightly deeper water, generally not far away, where the temperature remains milder and more uniform. Those who fish for Lobsters in the winter have, therefore, to set their pots at a greater distance from land than in the summer, but the winter fishery is of slight importance compared with the summer.

Lobsters are said to approach the shores of Nova Scotia in May and to recede from them in November, their winter quarters being in depths of ten to forty-five fathoms. In the summer they are abundant close to shore. At the mouth of the Bay of Fundy they generally come into shoal water in April, and move off again in October or November. During the summer months they abound under the shelter of overhanging rocks and among the kelp near shore. About five or six weeks are taken up by these migrations. They do not move in a body, but approach and recede gradually, as the temperature of the water changes. Throughout the coast of Maine the spring and fall migrations are about the same, but vary more or less according to the character and temperature of the different seasons. In the summer, they enter the numerous bays and indentations of the coast line, which they leave again in the fall. They leave the shallow waters of the coast of New Hampshire in December or November, and can be caught during the entire winter in depths of twenty fathoms. Boston Harbor has always been famous as a fishing ground for Lobsters, but in the fall it is completely deserted by these crustaceans, which repair to the deeper waters of Massachusetts Bay, where a winter fishery can be carried on. A sudden cold spell is said to send them off rapidly, and they have been known to entirely disappear from shoal water in the course of a day or two. Lobster fishing ceases at Provincetown, Cape Cod, the latter part of September, as the Lobsters become scarce after that time. In Vineyard Sound the fall migrations extend into the deeper holes not far distant from the summer grounds, but some individuals remain in comparatively shallow water the entire year. The same is true of Long Island Sound, where Lobsters do not move far from their summer haunts, but

merely seek the protection of deeper water, wherever they can find it. The season generally lasts from April to October. Off New Haven, Connecticut, Lobsters are occasionally taken in winter, on the deeper oyster banks, while dredging for oysters.

SCHOOLING.—Although Lobsters do not appear to school in the same manner as some fishes, still they often congregate in larger or smaller moving bodies, which travel from place to place, as though in search of food. On the central and southern New England coasts, especially about Martha's Vineyard and Noman's Land, two kinds of Lobsters are recognized by most fishermen—"School Lobsters," and "Rock Lobsters" or "Ground holders." The latter are said to remain more or less continuously in one place during the entire fishing season, while the former are migratory and uncertain in their movements. These two kinds of Lobsters are also stated to differ more or less from one another in appearance, especially as regards color, and the Rock Lobsters are supposed to average heavier than the School Lobsters, when of the same lengths. To what extent this habit of schooling takes place we have had no means of ascertaining, but for a short period during the spring and fall migrations it is probably more common than at other times. During the regular summer movements, the larger or stronger Lobsters are said to lead the schools, and the maimed or crippled ones to straggle on behind. The schools are apparently made up more or less of Lobsters of uniform size, as the fishermen will often catch the same sized Lobsters in their traps for a certain period, after which this size disappears and another takes its place. These changes are said to occur suddenly, and during some years quite frequently.

The strongest proof of the schooling of Lobsters is the fact that they will suddenly appear in great numbers in a region where none have been caught for several days, and as suddenly disappear therefrom without apparent cause. It is possible that the habit of schooling arises solely from the necessity of migrating, and that, while they ordinarily live more or less scattered over good feeding bottoms, yet when their common feeding ground becomes exhausted, or the temperature too severe, they are impelled to desert it in a body for some other more favorable locality.

ASSOCIATION OF MALES AND FEMALES.—The male and female Lobsters generally associate together in the same places, in about equal proportions; but some curious exceptions to this rule have been recorded. Capt. N. E. Atwood, of Provincetown, Massachusetts, writing in 1866, states that at that time about ninety per cent. of all the Lobsters taken at Cape Cod were females, while to the northward of Plymouth, on the west side of Massachusetts Bay, seventy-five per cent. of all those captured were males. In and about Narragansett Bay, the fishermen claim that, during July and August, about seven-eighths of the Lobsters taken are females, while during the balance of the season the two sexes are about equally abundant. At Eastport, Maine, it is said that, as a rule, more male Lobsters are taken than females. The above statements must be taken with some grains of allowance, from the fact that the fishermen may not always be able to readily distinguish between the two sexes, especially in the case of females not bearing eggs externally. The rude and hasty manner in which they handle Lobsters would also preclude their discriminating between the sexes with certainty, even though they were well acquainted with their anatomical differences. Prof. S. I. Smith examined quantities of Lobsters in the Provincetown market, on two occasions, in August and September, 1872, without finding any decided differences in the number of males and females. At Eastport, Maine, his examinations were made with even more thoroughness, and with the same result. Professor Verrill also states that he has found the males and females about equally abundant in market supplies received from New London, Stonington, and Waterford, Connecticut. It is possible that, at some seasons, or under

certain conditions the males and females may live more or less apart from one another, but the observations of scientific men indicate that this separation is not long continued, if it occurs at all.

Mr. S. M. Johnson, of Boston, has recently assured us that the great preponderance of females still holds true in the case of the Cape Cod region. Of the supplies received from there at Boston, during the summer months, he feels certain, from long-continued observations, that nearly if not quite ninety per cent. are females, and about seven-eighths of these bear spawn externally. The section of coast from which these Lobsters are obtained extends along the outer side of Cape Cod, *from off Highland Light to Wood End Light. The Lobsters examined at* Provincetown, by Prof. S. I. Smith, in 1872, may have come from the bay side of Cape Cod, whence Provincetown is supposed to receive its supplies for home consumption. The females may resort to the shallow waters of the outer side of the cape to spawn during the season when the fishery is carried on there, and this fact, if true, would readily account for their great abundance in that region, as has been noticed for so long a time. The males and females approach and recede *from* the shore together in the fall and spring.

WINTER HABITS.—Fishermen generally agree that Lobsters do not trap as readily in the winter as in the summer, even though the pots are set on what are supposed to be their winter grounds. The reason assigned for this is that they are not as eager for food nor as active in their movements in cold weather as in warm weather. This may be true to a great extent, but we think it is equally probable that they are scattered over broader areas in the winter, and their haunts are not as easily found. Evidence in proof of this idea has been recently furnished us by a prominent Eastern dealer, who has kept large quantities of Lobsters in confinement for the winter trade. The bottom of the area given up to their keeping is very muddy, and the surface of the water sometimes freezes over to a depth of twenty-two inches. On the approach of cold weather the Lobsters bury themselves in the mud, leaving only the long antennæ, the eyes, the tips of the claws, and perhaps a small portion of the front of the carapax, projecting above it. Over some parts of the inclosure the water is so shallow that the exposed appendages can be readily seen from the surface. In these positions the Lobsters lie, presumably all winter, unless disturbed, but whether or not they feed regularly has not been observed. If, however, a hoop-net, properly baited, is lowered in front of them, they are not slow to enter it, plainly indicating that they are still attracted by the bait, and it is just the same even after the surface of the water has become a sheet of ice. As the ice breaks up toward spring, and afterward, while the drift ice still remains in this area, the Lobsters become more timid and cannot be caught. They also seem to be easily frightened at loud noises, and perhaps retire deeper into the mud, for bait appears to have no attraction for them at such times. It is not possible, however, that they could be influenced in this manner in deeper water.

It is a question which may never be definitely decided, whether Lobsters bury themselves in the same manner in deep water as near shore. The temperature there would undoubtedly remain more favorable to them than in shallow water, but many of those caught in the pots in winter are more or less covered with mud.

MOVEMENTS.—Lobsters hold quite closely to the bottom and seldom leave it, unless it may be to escape an enemy, when they have been seen to execute a sort of swimming movement backward, by means of their tail, darting up from the bottom, but quickly settling down again. In moving about, they seem to skim over the bottom, using their four posterior pairs of feet, the anterior pair, or big claws, being held rigidly out in front of them, with the tips pointing inward and not far apart. The tail is also spread out and well expanded at the same time. The

movements of Lobsters can be easily studied in the shallow cars in which they are kept for market, providing there are not too many of them, as the bottom of the car should not be covered. Their actions appear easy and graceful, and their swimming powers may be tested by dipping them out with a scoop-net and allowing them to fall back again. If allowed to fall in tail foremost, a gentle flap or two of the tail is sufficient to give the body the proper slope in the water so that in sinking it falls obliquely and reaches bottom by a more gradual motion than would be the case if it fell directly downward. During the downward movement the tail may or may not be kept in motion. But in case the specimen is thrown in head first or sidewise, if it be in good, lively condition, it may give several vigorous flaps of the tail to right itself, and even swim off in one direction or another for a distance of several feet before settling down as in the former case. As a rule, however, the Lobster must be regarded as a bottom animal, exercising its power of swimming only in cases of emergency.

We have made the above remarks to correct the current impression among many people that the Lobster is a free swimmer and moves about in schools like many species of fish. For this belief there is no foundation in fact.

GROWTH, SHEDDING, ETC.—Soft-shelled Lobsters occur at all seasons of the year, but appear to be much less common in the winter than in the summer. The period of their greatest abundance is from June to September or October. There is, therefore, no strictly defined shedding period, and no possibility of determining, from present data, how often Lobsters shed. The shedding is connected with the growth of the individual, and when the body has attained such an increased volume that the hard covering or shell can no longer contain it, the latter breaks open, and the Lobster comes forth in a soft state, and considerably enlarged. The possibility, therefore, exists that in good feeding regions Lobsters may shed more frequently than in poor ones, for in the former it is natural to suppose that the growth would be more rapid than in the latter. Absolutely nothing is known, however, regarding this fact, and we must await future observations before generalizing. During the younger stages, shedding goes on quite rapidly, but as the Lobster increases in age it is probable that the shedding periods become much less frequent, and in very old individuals may cease altogether. There is, however, no conclusive evidence to prove that Lobsters ever attain a limit in size beyond which there is no further growth. Large individuals are occasionally taken with a very thick and heavy shell so scarred and worn as to indicate a prolonged and severe service. At times, the edges and angles of the shell and the exposed prominences of the claws are completely worn away. Large Barnacles are often found upon the shells of large Lobsters, and this fact is frequently cited as evidence that the Lobster had ceased shedding, or at least had not shed for several seasons. But after having examined the slates used by the United States Fish Commission as collectors for oyster spat, in Chesapeake Bay, in 1880, the writer can no longer regard this proof as very convincing. In the course of a month or two the common Barnacle of that region, a species of *Balanus*, which had attached itself to the slates in much greater abundance than the oysters, had attained a diameter of nearly an inch and gave promise of growing much larger in a short space of time.

The process of shedding is very interesting, and has been frequently witnessed, although it has never been minutely described by a competent observer. The following account has been furnished us by Mr. S. M. Johnson, of Boston. As a preliminary, the carapax generally, but by no means always, splits lengthwise along the middle of the back, often with a clean cut, quite to the rostrum. Otherwise, the carapax merely separates widely from the abdomen, on the upper side. The abdominal segments are the first to be withdrawn from their hard investment,[1] and

[1] This is contrary to what happens in the fresh-water Cray-fish.

as soon as they are free they are used in extricating the anterior portion of the body. The entire process requires a great amount of violent struggling and pulling, the claws occasioning the greatest difficulty, from being so much larger near the tips than at the base. Their fleshy portion, however, becomes somewhat soft and flabby so as to be easily extensible, and capable of being compressed down to a smaller diameter. The basal joint, called the thimble by fishermen, breaks lengthwise across the narrowest side, where a groove naturally exists, and the base of the next succeeding joint splits in the same way. The remainder of this second joint, and the following larger one, are compressed and flattened upon the upper or inner side, where the shell is thinner than elsewhere, the thin area being oval in outline, distinctly marked off from the surrounding surface, and more or less marked with irregular, elongate, depressed lines. Preparatory to shedding, this area, by the absorption of certain of its elements, becomes a thin, soft, and extensible membrane, or may be entirely absorbed away. No other hinderances lie in the way of the passage of the claws proper, which can be sufficiently compressed to work through the next joint above them, although the latter remains hard and firm.

The layer of skin which is to form the new shell begins to take on its distinctive character before the old one is cast, but does not harden to any extent. In this state it assumes a dark-green color and gives rise to the common fishermen's term of "Black Lobster," which is used to designate the Shedders. As the hard shell is cast, the soft skin exposed presents a velvet-like surface. The process of shedding goes on rapidly, as often happens in lobster-cars where the animals have been placed awaiting shipment to market. Lobsters which have had no marked indications of shedding, when placed in the cars, have cast their coat within a day or two afterwards. The hardening of the new shell also progresses rapidly. On many Lobsters the newly forming shell can be seen inside of the old one, and more or less closely adhering to it. It appears like a thin, semi-transparent, gelatinous lining of the old shell, and in some instances can be readily peeled off from it. Soft-shell Lobsters are sometimes called "Cullings," and those in which the new shell has become slightly hardened are named "Paper-shells."

Just before and after shedding, Lobsters remain quiet, almost dormant, and more or less concealed under stones or among seaweeds. Statements differ as to whether Lobsters seek food while in the soft shell state. They are said to be captured in the traps at times, often in great numbers; but as the food ordinarily preferred by them, and especially the baitings of the traps, require hard surfaces for their mastication, we do not know how to account for their presence in such situations. It is well known that hard Lobsters which entered the traps in that condition have shed therein, but in all such cases the cast skin should be present when the traps are brought to the surface of the water. It is possible that soft Lobsters are attracted into the traps by the smell of the bait, without the possibility of eating it. Most of the soft-shell Lobsters handled, however, are captured before shedding. Very many are often obtained in this way, but they are not considered good eating, as their flesh is described as thin and watery. They are mostly used as bait, although it is stated that they are also sold to the canneries.

Soft-shell Lobsters are more subject to dangers than the hard-shell, being helpless to protect themselves. They are greedily devoured by many species of fish, especially the cod, and are even said to be attacked by hard-shell individuals of their own species. When caught at this time, even if returned at once to the water, the slight handling they receive is said to generally kill them. Remaining, as they are supposed to, as much as possible out of harm's way, and probably not feeding while in the soft state, the mortality is undoubtedly much less than as though their habits continued the same.

The length of time required for the hardening of the new shell has never been recorded from observation. The fishermen's statements regarding it disagree, but the hardening goes on probably more rapidly in warm weather than in cold, as in the case of the edible Crab. A careful observer at Wood's Holl, Massachusetts, says that the shell becomes quite firm in the course of twenty-four hours. After three or four days it is supposed to be hard enough to enable the Lobster to go in search of food, but the hardening probably continues and the shell increases in thickness, even though it be very gradually, until the next shedding period.

A short time before shedding, the Lobster is said to be very full of meat and in the best possible condition for eating. This would seem to result naturally from the increased quantity of flesh which must accumulate within the shell preparatory to the Lobster's assuming a larger size. While shedding, but more especially while in the soft state, after the Lobster has expanded to its new size, the flesh is considered by most people as unpalatable, although it is probably as harmless then as at any time. The fishermen abhor soft Lobsters as a rule, and would not eat them under any circumstances, but customers are occasionally found. One fisherman correspondent very aptly expressed his dislike for them in the following terms: "They are sometimes eaten by aristocrats, but never by *us*." It seems very strange that soft Lobsters should be so unfavorably regarded, when we consider that the edible Crab is in its best condition just after shedding.

The female Lobster probably casts its shell soon after its spawn is hatched. The eggs are attached so firmly to the swimmerets that they remain hanging to them even after the young have gone forth, and there is no other way of getting rid of this great encumbrance to the abdomen than by shedding. This occurrence has been frequently observed in other species of crustacea, and probably happens in the case of the Lobster. In fact, we have numerous recorded instances of female Lobsters bearing spawn nearly ready to hatch, and with the new shell in process of formation. It is the common belief of lobstermen that Lobsters which have lost a claw, or been seriously maimed in any way, do not shed until after the injury has been repaired.

Prof. G. O. Sars describes the process of shedding with the European Lobster, *Homarus vulgaris*, as follows:

"The process of changing its skin is very tedious and dangerous for the Lobster, which may be imagined when it is known that not only the outer shell is changed, but even some of the inner parts, *e.g.*, the stomach-bag. The process occupies considerable time, and while it is going on the Lobster is sick and utterly unable to escape from its enemies or to defend itself against them. It is therefore but natural that under such circumstances it very easily dies in the traps. Even after the change of shell is over the Lobster remains weak for some time. It therefore hides among the stones at the bottom of the sea, and remains there until the new shell has become sufficiently hard and its strength has returned.

"The earliest changing of shell which I observed during my journey was in the first part of July, near Tananger. I here had an opportunity of observing a Lobster engaged in this process. It had just been taken out of a lobster-box, and could be handled without offering the least resistance. The shell on the back was burst in the middle, and the tail and the feet were nearly all out of the old shell, while the largest claw only stuck out half its length. This latter portion of the change of shell is evidently very dangerous, and, although I observed it for quite a while, I could see little or no progress. It is certainly a painful and dangerous process, and probably many a Lobster loses its life at such times. Immediately after casting its shell the Lobster is lean and miserable, and only obtains its proper condition after the lapse of considerable time. According to my observations, the change of shell takes place chiefly during the month of July. It certainly happens that some change later, but by far the larger number appear to shed during that month."

The following note regarding the shedding of the European Lobster, abstracted from a report by a Danish naturalist,[1] goes to confirm our previous statement, that the females shed soon after spawning:

"After the Lobster has emitted its roe, and the young have left the mother, she begins to shed. She therefore goes to safe places, and does not seem to care much for food while the old skin is being loosened; the shell finally opens in the back, and the animal goes into the water naked. It then looks as if it were covered with velvet, on account of the considerable formation of cells which is going on all over its surface. These cells afterward grow hard through small particles of lime and form the new shell. This shedding of the shell goes on from the middle of July to September, but not at the same time all along the coast, being earlier in the southern and later in the northern part. The Lobster thus gets sick, as it is called, toward the end of June near Sogndal, and the export must then cease, as the mortality among them becomes too great, while near Karmö it is still in a healthy condition till July 15. Farther north the shedding of *the shell begins still later, and Lobster may be caught all through July.*"

RATE OF GROWTH.—Nothing is known regarding the rate of growth of the Lobster for any extended period of time. Just how many years must elapse before it reaches a length of, say, ten inches has never been determined, nor can we expect to solve this problem without a long series of careful observations, which it seems almost impossible to make. It is well known that the Lobster increases in size only when shedding. As the old shell is cast away the soft body rapidly expands to a certain extent, and then soon becomes invested again with a new hard covering. Knowing the frequency of the shedding periods, and the amount of expansion at each, we could easily determine the age of Lobsters of all sizes; but these are the very data which are lacking. It is probable that the rate of growth is not the same at all shedding periods, but is greater in the younger stages than in the older. The early transformation from the embryo to the first perfect lobster form are all accomplished during a single season by several moltings, but beyond this period we know nothing accurately concerning the intervals between moltings, but in a medium-sized Lobster they probably occur only once or twice a year.

We have collected from several sources a few data as to the amount of expansion at certain stages of growth, and although we cannot vouch for their accuracy, they are probably not far from correct. The measurements given are for the length of the entire body without the claws. One Lobster eight inches long before shedding measured ten inches after shedding; another measured ten inches before and twelve inches after shedding; a third ten and one-half inches before and eleven and three-fourths inches after shedding; and a fourth ten and one-half inches before and twelve inches after shedding. If these measurements had all been taken with care they would indicate that the rate of growth was not always the same in different individuals of about the same size.

The lobster fishermen have very different notions regarding the ages of Lobsters, and while some contend that they attain a marketable size in two or three years, others extend the period to eight or ten years. The matter is one of considerable importance, bearing as it does upon the framing of proper protective laws, and the feasibility of lobster culture and breeding.

Mr. Frank Buckland, in his report for 1877, gives the two following notes on the frequency of shedding and the rate of growth of the European Lobster. They are not, however, very satisfactory; and we cannot believe that the American lobster sheds as frequently after the first year or two.

"According to some careful observations made at the marine laboratory, Concarneau, it

[1] AXEL BOECK: Om det norske Hummerfiske og dets Historie. Copenhagen, 1868–'69.

appears that the first year the Lobster sheds his shell six times, the second year six times, the third year four times, and the fourth year three times.

"The following table shows the rate of growth in a Lobster after each shedding of its shell:

Sheddings.	Length.	Weight.	
	Inches.	*Ounce.*	*Drachms.*
Eighth	2		1⅛
Ninth	2¼		2¼
Tenth	2½		3½
Eleventh	3		5⅝
Twelfth	3½		9½
Thirteenth	4		10⅝
Fourteenth	4½	1	4⅛

REPRODUCTION—GENERAL REMARKS.—Comparatively little has yet been made known regarding the reproduction of the American Lobster and the habits of the female during the *spawning season. This is very unfortunate, considering the important bearing of all such* information upon the question of the artificial breeding of Lobsters, which, if it is feasible, may ere long have to be undertaken in order to replenish our already diminished supplies. Many obstacles have been mentioned as standing in the way of such an enterprise, but from the favorable beginnings already made in Europe, as well as in this country, we are inclined to believe it will terminate successfully.

Most of our larger crustaceans, including the Lobster and common Crabs, although living mainly upon the bottom when adult, have free-swimming young, which, as soon as they leave the egg, and for a more or less prolonged period, lead a very erratic life. Not only, however, do the habits of the young generally differ very widely from those of the adults, but the appearance and structure of the two are as widely unlike. As described under "shedding," the Lobster grows by a series of molts. A molting or shedding of the skin indicates that the animal has grown too large for its inelastic outer coat. Now, the very young, or the larvæ, as they are sometimes called, grow in the same manner as the adults. When the higher crustaceans first leave the eggs they are very unlike the parent, having a very much simpler structure and often resembling one of the lower groups of crustaceans. The larva of the Lobster, for instance, is somewhat similar in structure and appearance to one of the simplest groups of Shrimps, the so-called Schizopods.

The free-swimming habits of the young furnish some of the most serious obstacles to the breeding of Lobsters. The embryos, after hatching, rise to the surface of the water, where they spend much of their time, and are borne hither and thither at the mercy of the currents, being often carried beyond the favorable influences necessary to their development. In many Lobster regions along our coast, in calm and clear weather, large quantities of the young may be dipped from the surface of the water, in the eddies and smooth streaks formed by the meeting of tidal currents. In these quiet spots the varied minute animal life characterizing the upper strata of the sea are collected together in the same manner as bits of wood and clusters of seaweed, which, from their larger size, are more familiar to the dwellers upon our coast. In stormy weather this surface life descends, in greater part, to lower levels. This vagrant life of the young Lobsters exposes them to the attacks of all kinds of predaceous surface-feeding animals, which consume them in immense numbers. In this manner a great mortality occurs—a much greater one, undoubtedly, than would arise did the young remain upon the bottom, where they could find some shelter and protection from their enemies. The means of caring for and protecting these wayward young should be the first consideration of the would-be Lobster-breeder, and in this matter he will probably encounter his greatest difficulties. The length of time required for the young to attain

the adult size is another matter of prime importance, as the breeder's success must also depend on his producing an early harvest. The age of what may be considered adult Lobsters (ten to eleven inches) is not known, estimates by different observers placing it all the way from three to a dozen years. If the latter estimate be correct, we would be almost forced to consider lobster-breeding as an industry impracticable from the start, as the care, during ten or twelve years, of the number of young necessary to produce salable Lobsters in marketable quantities would involve an expense quite out of proportion to the prices which could be obtained for them. We very much doubt, however, this prolonged extension of the immature stage of the Lobster, although we have no direct proof to the contrary. Lobstermen, as a rule, consider that Lobsters grow to be ten inches long in the course of three to five years, and they base their conclusions mainly on the fact that the increase in size at each molt is considerable; but this question is discussed elsewhere in this report. We do not pretend to say that, in case the slow growth of Lobsters is proved, breeding would be without many good results; for, if the growth and habits of Lobsters could be well understood, much care and protection might be accorded them, which would materially increase their numbers. Any new and carefully made observations on the spawning habits and growth of Lobsters would be gladly welcomed by all who are interested in the lobster question, whether from a scientific or a practical standpoint.

SPAWNING SEASON.—Lobsters appear to have no definite spawning season, as they are found with eggs, in different stages of development, during the entire year. According to the statements of lobster fishermen and others who have had abundant means of observation in this line, spawning takes place mainly from March until September. It should be remembered, however, that the winter lobster fishery is of very much less importance than the summer, and that during the former season the number of Lobsters handled does not in any way compare with the number taken in the latter, so that the proportion of spawning Lobsters to non-spawning ones, in the two seasons, may not be as great as would seem to appear. Winter observations on the natural history of the Lobster, as well as of many other of our marine food invertebrates, are very much desired. It is said that on the northern New England coast, from Cape Cod eastward, Lobsters with spawn about ready for extrusion from the body begin to appear abundantly in March, and with the spawn or eggs on the outside, as well as hatching, are most abundant from June to September. In the Bay of Fundy, Lobsters spawn principally from the last of June to the last of August. Southward of these limits the spawning season begins earlier.

Considering, now, the fact that spawning Lobsters occur throughout the entire year, we are left without data as to the frequency of spawning in each individual Lobster. Did a short, definite spawning period exist for each year, we might assume that Lobsters spawned only once a year, or at least we could assert that they spawned no oftener than once a year. The only way of determining the fact positively would be to study individual Lobsters for a certain period of time, in their natural haunts and under natural conditions, and every one knows how difficult such an undertaking would be with most marine animals. As it is, the possibility exists of Lobsters spawning more than once a year, and there is no evidence to prove that they spawn with any exact regularity as to time. We have the statements of several individuals, some published and others not, to the effect that quite fully developed eggs are sometimes apparent in the ovaries when the Lobster is carrying spawn on the outside of the body. But there is no way of determining how long a time must elapse before the second lot of spawn might be fertilized and made ready for extrusion. We are justified in believing, however, that, as a rule, Lobsters spawn but once a year. In the Lobster, as in many other marine animals, only a portion of the ova is fertilized and developed at each spawning time, often leaving the ovaries still quite

expanded with their contents, and therefore we must always expect to find spawn in some stage of development within the adult female, whether she is carrying external spawn or not. This statement will serve to explain to lobstermen the fact, which they often regard with some surprise, of females carrying both internal and external spawn at the same time, the former, of course, far less developed than the latter.

The mature ovaries form two elongate lobes of considerable size, on the upper side of the body, just within the shell, and immediately before spawning Lobsters are considered to be in very good, if not the best, condition for eating; it is probable also that at about this stage the spawn first attracts the attention of most fishermen.

HABITATS WHILE SPAWNING.—Nothing definite seems to be known regarding the haunts of spawning Lobsters, or as to whether they change their ground at such times. It is probable that, to some extent, they do prefer certain localities for this purpose; but as Lobsters with spawn are taken by the fishermen in their traps at all seasons of the year, and in all depths, this rule cannot, by any means, be regarded as universal. By assuming that certain regions are more favorable for the development and hatching of the eggs, we can readily explain the great preponderance of female Lobsters with spawn on the sandy shores about Provincetown, Cape Cod, during the summer months. Yet, in direct contrast with this region stands nearly the entire coast of Maine, rocky in the extreme, where Lobsters are even more abundant, and where they probably reproduce in equal proportions.

SIZE OF SPAWNING LOBSTERS.—Lobsters do not generally begin to spawn until they have attained a length of about ten and a half to eleven inches (exclusive of the claws), which is about the legal size of marketable Lobsters. We are informed by several correspondents, however, that spawning Lobsters have been taken as small as eight, nine, and ten inches; but such as these are very rare. It is probable that they become mature at a smaller size at the South than at the North, as Lobsters average smaller in Southern New England than in Northern New England, and yet the age may average the same in both cases. Mr. S. M. Johnson, of Boston, who has handled many thousands of Lobsters, states that he has never seen from east of Cape Cod more than two or three specimens bearing spawn under ten and a half inches. He thinks that but few begin to spawn much under eleven inches in length, and this size, in his opinion, would be the proper limit below which none should be sold in order to fully protect the species.

PAIRING.—So far as we are aware, no one has ever witnessed the operation of pairing in Lobsters, and all that we know concerning it is mere conjecture. Many of the female Lobsters obtained from sandy bottoms, as at Provincetown, Cape Cod, are said, by observers, to have the carapax more or less abraded along the top, and also somewhat worn over a limited area upon the sides. This has led the fishermen to believe that, in pairing, the female Lobster lies upon her back with the male on top, clasping her about the carapax with his claws. While in this position any strong agitation of the water by the waves in slight depths would probably cause the pairs to oscillate backward and forward, and might account for the abraded carapaces of the female, which are said to be of common occurrence. This story has been told us by several reliable parties, entirely independent of one another; but we cannot say how much reliance should be placed upon it, and the evidence is certainly very slight.

A large New York dealer in Cray-fishes, who keeps large quantities of these lobster-like crustaceans on hand during their season, says that he has frequently witnessed them pairing, and that the males and females come together belly to belly, with the claws of one tightly clasping those of the other, and spread out so as to form with the bodies a rude Y-shaped figure.

NUMBER OF EGGS.—The Lobster, like many other crustaceans, carries a very large amount of spawn on the exterior of the body at each spawning time. The number varies with the age and size of the Lobster, but to what extent is not known. Mr. S. M. Johnson, of Boston, states that two and a half pound Lobsters bear externally, on an average, about twenty thousand eggs at a time, according to several careful computations, made by comparing the weight of a certain number of eggs with the weight of the entire mass of spawn attached to the swimmerets.

Two females which I examined at Eastport, Maine, in the summer of 1882, gave the following results as regards the number of eggs carried on the swimmerets. The first specimen, measuring 13§ inches in length, had 875 grains of eggs, there being 20 eggs to a grain, making a total of 17,500 eggs. The second specimen measured 13 inches long and carried 480 grains of eggs, with 25 eggs to a grain, making a sum total of about 12,000 eggs. Neither of the above specimens, however, appeared to have their full quota of eggs, as many of the bunches seemed to have been more or less brushed away, probably by rough handling. In the last specimen, especially, had all the bunches been of equal and full size, the number would have been increased fully one-half.

According to Mr. Frank Buckland, "the [English] Berried Lobster carries five bunches of eggs on each side underneath the tail, making ten bunches in all. I have counted the eggs in one bunch and find that there are 2,496, making the number of eggs in this one lobster 24,960. Lobsters are found with berries all the year round; March, April, May are the months when they are fullest."

DESIGNATIONS OF SPAWN.—Lobster spawn is variously designated, on different parts of the coast, as "spawn," "roe," "eggs," "berry," "seed," "pea," "sweetbread," "coral," etc.; but in most places it is known simply as "spawn," "eggs," or "berry." On the Nova Scotia coast the term "coral" is sometimes used to designate the nearly mature spawn while still within the body of the Lobster, and after it has passed to the outside it is called "eggs." In the Bay of Fundy the terms "coral," "roe," and "sweetbread" refer to the spawn before extrusion from the body, and they may also be used in a similar way on other parts of the coast. In some portions of Long Island Sound, Lobsters with external spawn are called "Black-egg Lobsters."

THE SPAWN AS FOOD.—Before the spawn has passed from the body to the external appendages it is very much esteemed as food, and is generally eaten whenever it can be obtained; it is also canned. The external spawn, however, although sometimes used to garnish fish dishes and salads, *is not usually regarded as edible.*

EXTRUSION OF THE EGGS, ETC.—The spawning of the Lobster is accomplished in about the same manner as with the Cray-fish, regarding which many more carefully recorded observations are extant. According to Huxley, the fecundating material of the Cray-fish, which is extruded from a small aperture on the basal joint of the hindermost pair of legs, is a "thickish fluid, which sets into a white solid after extrusion." This substance is deposited by the male on the thorax of the female, between the bases of the hindermost pair of thoracic limbs. The apertures for the outward passage of the eggs are situated on the bases of the second pair of legs, back of the large claws. The eggs, "as they leave the apertures of the oviducts, are coated with a viscid matter, which is readily drawn out into a short thread. The end of the thread attaches itself to one of the long hairs with which the swimmerets are fringed, and as the viscid matter rapidly hardens, the egg thus becomes attached to the limb by a stalk. The operation is repeated until sometimes a couple of hundred eggs are thus glued on to the swimmerets. Partaking in the movements of the swimmerets, they are washed backward and forward in the water, and thus aërated and kept free of impurities."

The process of development is slow, and the young, when first hatched, bear a general

resemblance to the parent. For some time after they are hatched they hold on to the swimmerets of the mother, and are carried about protected by her abdomen. As they become more active they sometimes leave the mother when she is resting quietly and creep about a short distance off, but quickly return to her on the first semblance of danger. A few days later they gradually forsake her for good. The earlier stages of the embryo Lobster differ considerably from those of the Cray-fish, as described further on. The eggs of the Lobster are probably extruded in a similar manner, and are attached to the swimmerets by the same viscid substance. Accord*ing to some American observers, however, the viscid substance is first extruded from the openings* of the oviducts and appears as a thick, globular mass, which is brushed back over the swimmerets by the movements of the posterior pair of thoracic legs. The eggs are said to follow immediately afterwards and to be spread about in the same manner. Becoming thus securely attached to the swimmerets, they remain well protected and are kept constantly aërated by the movements of these posterior flaps until the young are hatched. Without further observations we cannot strongly indorse the idea of the viscid material being first excreted; but if such occurs in the *beginning*, there is *still* no reason why the eggs may not be also covered with the same substance as they are laid. The eggs are not attached to the smooth surface of the swimmerets of the Lobster, but to the long, slender hairs which project from along their sides. In that way they hang more loosely and can be given freer motion.

SHEDDING AFTER SPAWNING.—As explained under "shedding," it is probable that, as a rule, the females shed their shells soon after their eggs are hatched, as there is no other way of ridding themselves of the broken egg-shells adhering so firmly to the swimmerets by means of the tough little threads. Lobsters with very ripe spawn have frequently been seen in a condition preparatory to shedding, thus, in a measure, corroborating the above conjecture. According to Prof. S. I. Smith this shedding after spawning is known to occur in some of the Crabs. This peculiarity is also affirmed with regard to the European female *Lobster*, as described elsewhere.

DEVELOPMENT OF THE YOUNG.—The earlier embryonic stages of the Lobster have been studied by Prof. S. I. Smith, of Yale College, whose observations, however, extended over only a limited period. They were made at Wood's Holl, Massachusetts, and New Haven, Connecticut. Eggs with the embryos well advanced, taken from the females May 2, had the shape of slightly elongate spheroids, about 2.1^{mm} long and 1.9^{mm} across. "One side is rendered very opaque dark green by the unabsorbed yolk mass, while the other shows the eyes as two large black spots, and the red pigment spots on the edge of the carapax, bases of the legs, etc., as irregular lines of pink markings. . . . Fully one-half the embryo is still occupied by the unabsorbed portion of the yolk. . . . The eyes are large, nearly round, and with a central portion of black pigment. . . . The five pairs of cephalo-thoracic legs are all similar and of about the same size, except the main branch of the first pair, which is much larger than that of the others. . . . The subsequent development of the embryo within the egg was not observed."

In the account of his observations, Professor Smith goes on to describe such of the embryonic stages following hatching as he was able to obtain. From his long and technical descriptions we extract only those portions which can be best understood by the general reader, and which it will be well for the breeder to become acquainted with to aid him in his practical labors. We would suggest here that the breeder himself, or some intelligent man in his employ, should familiarize himself with the workings of an ordinary low-power microscope, in order that he may follow the development of the young Lobsters under his care, and observe whether they are doing well or die off soon after hatching. Unless such precautions as these are taken, he might continue to work for a long time completely in the dark, and without knowing whether he was making

progress or not. A continuous series of observations would enable him, at all times, to follow the success of his experiments, or determine, perhaps, the causes of his failures.

The exact number of changes or moltings which take place between the last egg stage and the first stage having the general shape and characters of the adult, is not known. Professor Smith observed three such stages, but supposes others to be wanting. His account of these stages is as follows:

"The following observations on the young larvæ, after they have left the eggs, have all been made upon specimens obtained in Vineyard Sound, or the adjacent waters, during July. These specimens were mostly taken at the surface in the daytime, either with the towing or hand net. They represent three quite different stages in the true larval condition, besides a later stage approaching closely the adult. The exact age of the larvæ of the first stage was not ascertained, but was probably only a few days, and they had, most likely, molted not more than once. Between the third stage, here described, and the last there is probably an intermediate form wanting.

"*First stage.*—In this stage the young are free-swimming Schizopods[1] about a third of an inch (7.8^{mm} to 8.0^{mm}) in length, without abdominal appendages, and with six pairs of pediform cephalo-thoracic appendages, each with the exopodus developed into a powerful swimming organ. The eyes are bright blue; the anterior portion and the lower margin of the carapax and the bases of the legs are speckled with orange; the lower margin, the whole of the penultimate, and the basal portion of the ultimate segment of the abdomen are brilliant reddish-orange. The antennæ have large, well-developed scales, furnished along the inner margin with long, plumose hairs. . . . The anterior cephalo-thoracic legs, which in the adult develop into the big claws, are exactly alike and no longer than the exterior maxillipeds. The pediform (outer) branch is, however, somewhat stouter than in the other legs, and subcheliform (bearing an imperfect claw); the legs of the second and third pairs are similar to the first, but not as stout. The legs of the fourth and fifth pairs are still more slender, and styliform at the extremity, as in the adult." Very rudimentary branchiæ or gills are observed on all of the legs and the external maxillipeds. "The abdomen is slender, the second to the fifth segments each armed with a large dorsal spine, curved backward, and with the lateral angles produced into long spines, and the sixth segment with two dorsal spines. The posterior margin of the last segment is armed with a long and stout central spine, and each side with fourteen or fifteen plumose spines or setæ, which are articulated to the margin.

"In this stage the young were first taken July 1, when they were seen swimming rapidly about at the surface of the water among great numbers of Zoëæ, Megalops, and Copepods. Their motions and habits recall at once the species of *Mysis* and *Thysanopoda*, but their motions are not quite as rapid, and are more irregular. Their bright colors render them conspicuous objects, and they must be readily seen and captured by fishes. They were frequently taken at the surface in different parts of Vineyard Sound from July 1 to 7, and several were taken off Newport, Rhode Island, as late as July 15, and they would very likely be found also in June, judging from the stage of development to which the embryos had advanced early in May in Long Island Sound. Besides the specimens taken in the open water of the Sound, a great number were obtained July 6 from the well of a lobster-smack, where they were swimming in great abundance near the surface of the water, having undoubtedly been recently hatched from the eggs carried by the

[1] The Schizopods are a group of Shrimps, lower in organization than our common Shrimp (*Crangon vulgaris*), and very abundant along the New England coast. They generally swim in large schools, either at the surface or at intermediate depths between the surface and the bottom, often at some distance from land.

female Lobsters confined in the well. Some of these specimens lived in vessels of fresh sea-water for two days, but all efforts to keep them alive long enough to observe their molting failed. They appeared, while thus in confinement, to feed principally upon very minute animals of different kinds, but were several times seen to devour small Zoëæ, and occasionally when much crowded, so that some of them became exhausted, they fed upon each other, the stronger ones eating the weaker.

"*Second stage.*—In the next stage the young Lobsters have increased somewhat in size, and the abdominal legs of the second to the fifth segments have appeared. The rostrum is much broader and there are several teeth along the edges. The basal segments of the antennulæ have become defined, and the secondary flagellum has appeared, but is not subdivided into segments. The antennæ and mouth organs have undergone but slight changes. The first cephalo-thoracic legs are proportionally larger and stouter than in the first stage, and have become truly cheliform. The succeeding legs have changed little. The epipodi of all the legs and of the external maxillipeds have increased in size, and the branchial processes are distinctly lobed along the edges, and have begun to assume the form of true branchiæ. The segments of the abdomen have the same number of spines, but they are relatively somewhat smaller, and the last segment is relatively smaller and broader at base. The appendages of the second to the fifth segments differ considerably in size indifferent specimens, but are nearly as long as the segments themselves; their terminal lamellæ, however, are represented only by simple, sack-like appendages, without sign of segmentation, or clothing of hairs or setæ. The penultimate segment is still without appendages. Specimens in this stage were taken only twice, July 1 and 15. They have the same habits and general appearance as in the first stage, but are readily distinguished by the possession of rudimentary abdominal legs. In color they are almost exactly the same, only the orange-colored markings are perhaps a little less intense.

"*Third stage.*—In the third stage the larvæ are about half an inch (12^{mm} to 13^{mm}) in length, and the integument is of a much firmer consistency than in the earlier stages. The antennulæ are still rudimentary, and considerably shorter than the rostrum, although the secondary flagellum has increased in length and begins to show division into numerous segments. The antennæ retain the most marked feature of the early stages—the large size of the scale—but the flagellum is much longer than the scale and begins to show division into segments . . . The external maxillipeds have begun to lose their pediform character. The anterior legs have increased enormously in size, and those of the second and third pairs have become truly chelate, while the swimming exopodal branches of all the legs, as well as of the external maxillipeds, are relatively much smaller and more unimportant. . . . The branchiæ have developed rapidly and have a single series of well-marked lobes along each side. The abdomen still has the spines characteristic of the earlier stages, though all of them are much reduced in size. The appendages of the second to the fifth segments have become conspicuous, their lamellæ have more than doubled in length, and the margins of the terminal half are furnished with very short ciliated setæ. The appendages of the penultimate segment are well developed, although quite different from those in the adult. The outer lamella wants wholly the transverse articulation near its extremity, and both are margined, except the outer edge of the outer lamella, with long plumose hairs. The last segment is relatively smaller and more quadrangular in outline, and the spines of the posterior margin are much smaller. The only specimens procured in this stage were taken July 8 and 15. In color they were less brilliant than in the earlier stages, the orange markings being duller and the whole animal slightly tinged with greenish-brown.

"In the next stage observed, the animal, about three-fifths of an inch (14^{mm} to 17^{mm}) long, has

lost all its schizopodal characters, and has assumed the more important features of the adult Lobster. It still retains, however, the free-swimming habit of the true larval forms, and was frequently taken at the surface, both in the towing and hand net. Although resembling the adult in many features, it differs so much that, were it an adult form, it would undoubtedly be regarded as a distinct genus. The rostrum is bifid at tip, and armed with three or four teeth on each side toward the base, and in some specimens with a minute additional spine, on one or both sides, close to the tip. The flagella of the antennulæ extend scarcely beyond the tip of the rostrum. The antennal scale is very much reduced in size, but is still conspicuous and furnished with long plumose hairs along the inner margin, while the flagellum is as long as the carapax. The palpi of the mandibles have assumed the adult character, but the mandibles themselves have not acquired the massive molar character which they have in the older animal. The other mouth organs have nearly the adult form. The anterior legs, although quite large, are still slender and just alike on the two sides, while all the cephalo-thoracic legs retain a distinct process in place of the swimming exopodi of the larva. The lateral angles of the second to the fifth abdominal segments are prolonged downward into long spiniform teeth; the appendages of these segments are proportionately much longer than in the adult, and the margins of their terminal lamellæ are furnished with very long plumose hairs. The lamellæ of the appendages of the penultimate segment are oval, and margined with long plumose hairs. The terminal segment is nearly quadrangular, as wide at the extremity as at the base, the posterior margin arcuate, but not extending beyond the prominent lateral angles, and furnished with hairs like those on the margins of the lamellæ of the appendages of the penultimate segment. In color they resemble closely the adult, but the green color of the back is lighter, and the yellowish markings upon the claws and body are proportionately larger.

"In this stage the young Lobsters swim very rapidly by means of the abdominal legs, and dart backward, when disturbed, with the caudal appendages, frequently jumping out of the water in this way like Shrimp, which their movements in the water much resemble. They appear to be truly surface animals, as in the earlier stages, and were often seen swimming about among other surface animals. They were frequently taken from the 8th to the 28th of July, and very likely occur much later. From the dates at which the different forms were taken, it is probable that they pass through all the stages here described in the course of a single season. How late the young, after reaching the lobster-like form, retain their free-swimming habit was not ascertained."

DEVELOPMENT OF THE EUROPEAN LOBSTER.—According to Prof. G. O. Sars, of Norway, the European Lobster agrees more or less closely with our own species in its spawning habits and development, as the following extract from his report will show:[1]

"The propagating of the Lobster does not seem to be strictly confined to a certain season of the year, as Lobsters with roe may be found nearly all the year round. But the rule seems to be that the development of the young goes on during the summer months, from the beginning of July until the early part of September. The more developed roe can easily be distinguished by its lighter color, and partly, also, by the larger size of the eggs. A closer examination shows distinctly in every egg two dark spots, which are the eyes of the embryo. The more distinct these spots are the more developed is the embryo. When its development is complete the egg-shell bursts, and the young Lobsters come out. These are in the beginning very helpless and sink to the bottom, where within a very short time they undergo their first change of shell. Soon afterward their swimming apparatus, which has so far been surrounded by a skin, begins to work, and the

[1] Salt-water Fisheries of Norway. Christiania, 1878.

young Lobsters soon gambol about in the water, and come up to the surface, where they remain during the entire time of their future development. . . .

"At the fifth change their metamorphosis is complete, and therewith ends their pelagian life. The young Lobster has then entirely lost its swimming apparatus attached to the fore part of its body, and in its stead the well-known fringes have grown at the lower side of the back part of the body. These fringes are the only swimming apparatus which the grown Lobster possesses; in the female Lobster they also serve to keep the roe in position. The Lobster now leaves the surface and goes to the bottom, there to lead the same life as its parents. I am not positively certain how long a time is required for the entire metamorphosis, but I am inclined to believe that it consumes a couple of months.

"Even after the Lobster has reached its final development, it continues to change its skin regularly at least once a year, and continues to do so as long as it grows. Only when it has ceased growing this change of skin does not occur so often. We shall, therefore, always find that very large Lobsters are more or less thickly covered with scales, which is not so frequent in smaller specimens. . . .

"I did not succeed in obtaining Lobsters measuring from an inch to a finger's length, and so far as I know none are contained in any museum. I consider it as certain, however, that the Lobsters keep near the coast during this stage of their development. The reason why they cannot be caught with the bottom scraper is partly their quick movements and partly the circumstance that they hide among the algæ on the bottom of the sea. The fact that they cannot be caught in the common lobster-baskets is easily explained by these having such wide openings."

The following account of the reproduction of the European Lobster on the French coast is by the late M. Coste, well remembered from his many interesting and extensive experiments in several branches of fish culture. We have no means of determining how accurate these observations are, nor do we know whether they are the result of close study or conclusions derived from the accounts of fishermen. We offer them here as affording many valuable suggestions which may aid observers on our own coast. The seasons do not entirely correspond with ours:

"The Lobster commences breeding in the month of October, and the pairing takes place sometimes as late as January. The couplings are rare at the opening of the season, but increase in frequency to the end of December, and but few take place in January. The female emits the eggs in about fifteen or twenty days after the pairing. When they have reached the stage proper for their expulsion, the female applies the inner side of the tail against the plastron or shell immediately over the stomach, in such a manner as to form a cup or cavity, in which are to be found the openings of the oviduct, placed exactly behind the third pair of legs. Consequently when the eggs escape they fall into this natural cup or cavity, as described above. They are expelled in successive jets, to the number of twenty thousand in a single day.

"The Lobster emits at the same time, along with the eggs, a kind of adhesive liquid, which binds the eggs one to the other, and attaches them all to the small feet under the tail, where they remain in perfect shelter from all harm until they are sufficiently ripe for final expulsion.

"In order to forward and force the regular incubation of the ova, the females have the power to give them more or less light, as they consider requisite, by closing or opening the fold of the tail. Sometimes the eggs are kept quite covered, and at other times they give them a kind of washing, by moving the flanges of the tail in a peculiar manner. The incubation lasts six months, during which time the female takes such good care of the ova that it is rare to find an injured embryo or barren egg.

"It is during the months of March, April, and May that the actual birth of the young Lobster takes place. The females, in order to expel the embryos, now ready to burst the shells of the eggs, extend their tails, make light oscillations with the fan and its appendages, so as to rid themselves gradually of the young Lobsters, which they succeed in doing in a few days. The young Lobster, as soon as born, makes away from its parent, rises to the surface of the water, and leaves the shore for the deep water of the sea, where it passes the earliest days of its existence in a vagabond state for thirty or forty days. During this time it undergoes four different changes of shell, but on the fourth it loses its natatory organs, and is, therefore, no longer able to swim on the surface of the water, but falls to the bottom, where it has to remain for the future; according, however, to its increase of size it gains courage to approach the shore which it had left at its birth. The number of enemies which assail the young embryos in the deep sea is enormous; thousands of all kinds of fish, mollusks, and crustaceans are pursuing it continually to destroy it. The very changing of the shell causes great ravages at these periods, as the young Lobsters have to undergo a crisis which appears to be a necessary condition to their rapid growth. In fact, every young Lobster loses and remakes its crusty shell from eight to ten times the first year, five to seven the second, three to four the third, and from two to three the fourth year. However, after the fifth year, the change is only annual, for the reason that were the changes more frequent the shell would not last long enough to protect the ova adhering to the shell of the female during the six months' incubation. The Lobster increases rapidly in size until the second year, and goes on increasing more gradually until the fifth, when it begins to reproduce, and from this period the growth is still more gradual."

TRANSPLANTING OF THE YOUNG.—For the benefit of those interested in the question of breeding Lobsters by artificial means or care, we extract the following paragraph from a communication made by Capt. N. E. Atwood, of Provincetown, Massachusetts, to one of the New York papers about fifteen years ago:

"When we take a cargo of Lobsters on board of a fishing-smack and throw them into the well, many of the young are so far developed that when they strike the water the shell of the egg is broken, and you can see hundreds of thousands of little Lobsters on or near the top of the water in the well. After the cargo has been taken on board, the smack sails for New York, and during the whole passage the young are being hatched and are passing out through the holes in the bottom of the well. On the arrival of the smack at Fulton Slip the Lobsters are taken out and put in cars. If any of the eggs are on the Lobsters, not hatched, they are soon eaten off by eels, which go out and in the car as they please."

These observations of Captain Atwood are exceedingly interesting. It is probable that the numerous young Lobsters hatched on the trips of the Cape Cod smacks through Long Island Sound have contributed toward increasing the supply of Lobsters along that section of coast. It has amounted to a transplanting of Lobsters from one prolific region to another much less prolific, and the benefits thus inadvertently derived were possibly considerable. This traffic has long ceased, however, and young Cape Cod Lobsters no longer find their way into the waters of Long Island Sound.

FOOD.—The Lobster appears to feed upon most any kind of animal matter within its reach, but is said to prefer fresh fish as bait. Feeding naturally, it probably does not discriminate closely as to its food. It digs clams from the bottom and removes mussels from their places of attachment, sometimes crushing the shells in its claws, and afterwards devouring out the soft parts. Flounders and other bottom fish undoubtedly fall a prey to its appetite, and it has been seen to catch nimbly at small fish swimming by. Very probably it feeds upon all kinds of invertebrate life which

are palatable to its taste and live within easy reach of its claws. Sea-urchins even are described as furnishing food for it on the Nova Scotia coast. Flounders, sculpins, herring, menhaden, codfish heads, haddock, and bluefish are commonly used as bait in the lobster-pots. An experienced observer who has watched their habits under peculiarly favorable circumstances, on the coast of Maine, states that, in devouring clams, he has never seen them crush the shell, but as it were they absorb the meat from between the valves, leaving the latter intact. He has never seen them catch living fish, but could not positively affirm that they did not do so at times.

CASTING A CLAW.—As is well known, Lobsters have the power of dropping or "shooting" one or both claws, which may be more or less completely replaced by a new growth. Many incentives are quoted for this curious procedure, the principal ones being handling, especially in cold weather, entanglement of the claws, and fright. Fright, or a sudden impulse to free themselves from impending danger or pain, is probably the main cause, however it may be produced. The break does not occur between any of the movable joints, but always at one particular point, near the upper end of the second or double joint, where it is smallest and encircled by a distinct groove. The claw cannot be broken off at this or any other place by main force without injury to the Lobster, causing it to bleed to death.

Occasionally in mild weather, but much more frequently in cold weather, Lobsters will shoot their claws if handled by them out of water. This also frequently occurs when Lobsters become entangled by their claws in the fishermen's nets. As they are drawn above the water, they will often, without a moment's warning, slide back into their native element, leaving their disjointed member behind. Loud noises, such as thunder, the firing of cannons, etc., are said to incite Lobsters to shoot their claws, and also the presence of very impure or fresh waters; but to what extent this happens we cannot say. When a claw becomes injured or broken, or perhaps crushed by an antagonist of the same species, so as to render it useless or painful, it is often dispensed with, in order that a new one may take its place. This process of dropping an old and growing a new claw is certainly a wise provision of nature, for this appendage is much subject to injury, and nothing more deplorable can be imagined than a Lobster with mutilated claws.

The practice of shooting a claw, even under natural conditions, seems at times to be a very common one. Out of one hundred specimens, averaging about eight or nine inches long, collected for natural history purposes in Narragansett Bay, in 1880, fully twenty-five per cent. had lost a claw each, and a few both claws. From each stump, in all these specimens, projected a short soft claw, still very imperfect in structure, and measuring from one-fourth of an inch to about an inch in length. In some of the specimens, one or more of the hinder legs were being reproduced in the same way. The fishermen state that similar specimens are also sometimes common in their catch. The breaking off of a claw, according to observers, is accomplished so quietly that the operation is scarcely perceptible. If a claw of a Lobster be seized by the hands while he is in the water, and he casts it, no unusual sensation is felt, but the claw is simply left behind, and the former owner darts quickly off. Soon after the break occurs, it is covered with a crust of coagulated blood, which prevents further bleeding until a skin has formed, from the center of which the new claw begins to grow. How long a time is required for the new claw to attain a size proportioned to that of the Lobster, if it ever reaches that size, is not known. However, the incipient claw remains soft and continues to grow probably until the first molt, after which its outer layer of skin is supposed to harden like that of the remainder of the Lobster. Specimens are frequently taken with hardened claws of regular shape, but of different sizes below the normal one, rather indicating that at least several moltings must take place before the claw can reach its full size.

The following incident, furnished by a correspondent, forcibly illustrates the process of shooting a claw and points a moral. A party who had purchased a number of Lobsters as food thought to keep them fresh overnight by hanging them over the side of his vessel, by means of cords tied to the claws. In the morning, when he went to examine his live stock, he found nothing but the claws remaining fast to the cords, the Lobsters having dropped back into their former abode.

DEFORMITIES AND DISEASES.—Lobsters are subject to many deformities or malformations, which generally occur upon the claws, and appear to originate from several causes. A broken claw is sometimes mended in an irregular manner, and there are frequent instances of what are termed double claws, resulting from the formation of a second projection or thumb upon either the larger or smaller branch of the claw, and which is more or less perfect in shape but immovable. Rarely the two branches of the claw are not regularly set with reference to one another, and instead of working in the same plane, and meeting edge to edge, they pass one another like the blades of a pair of scissors. The thumb or finger of one of the claws occasionally takes on an unusual or fantastic shape, or becomes greatly broadened and thickened, but the variations to which the claws are subject are too numerous to warrant description here. Many of them have been figured and discussed by Mr. Walter Faxon in the "Bulletin of the Museum of Comparative Zoology" for March, 1881. They probably arise in part from injuries received while in the soft state, but in great measure they have not been accounted for.

During the past winter, there was sent to the National Museum, from the coast of Nova Scotia, the carapax of a medium-sized Lobster, with two small round openings covered with membranes, placed symmetrically one on each side of the median line, a short distance back of the rostrum. By the person who sent the specimen, and who saw the Lobster when alive, these membranes were described as projecting slightly from the surface, and taking on the appearance of a second pair of eyes. Unusual but symmetrical markings also occur upon the dorsal side of the carapax. The specimen was so thoroughly cleaned and dried, however, before we received it—nothing remaining but the shell—that it is now impossible to form a correct idea as to the real import of these strange features.

Diseased Lobsters are not commonly met with. Individuals are occasionally found in a very emaciated condition, and some with soft spots like sores upon the body; but such cases are rare. Specimens are sometimes taken with small portions of the body gone, or with deep scars and dents upon the surface, the results of injury. It is usually the older individuals that are marked in this way.

PARASITES.—Lobsters do not appear to be much troubled with external parasites or messmates. Barnacles often grow upon the back and claws, and mussels sometimes attach themselves to the same places. The number of Barnacles is frequently so great and they cover so large a portion of the exterior surface as to seriously impede the movements of the Lobster, but this seldom happens. Fish-lice are mentioned by the fishermen as occasionally occurring on the Lobsters, but as we have never seen any specimens of such it is impossible to determine what they may be, if they are parasites at all.

ENEMIES.—All the larger bottom-feeding fish probably feed upon the Lobster, and the surface fish also greedily devour the young. Soft-shell Lobsters suffer most in this way, and are frequently found in the stomachs of cod taken by the fishermen. Sharks, dogfish, rays, tautog, and striped bass are also mentioned as being especially fond of Lobsters, but this list could undoubtedly be greatly extended without much trouble. Water-birds sometimes feed upon the smaller individuals in shallow water. During the earlier period of their existence, while they are still

free swimmers and very small, living mostly at the surface of the water, by far the greatest mortality must occur. At this time they are eaten in vast quantities along with other surface animals by the more active fish and invertebrates, and probably but a comparatively small proportion of those hatched from the egg ever survive this stage. We may, however, be justified in asserting that the greatest enemy of the Lobster is man.

Mr. Frank Buckland, in treating of the enemies of the European Lobster, says that "among the animate enemies the principal one, I believe, is the cod. A witness at Burghead stated that 'codfish are great enemies to Lobsters; he hardly ever opens a cod without finding young Lobsters in the stomach; this is particularly in February and March; has seen cod throwing up Lobsters on the deck of a vessel, as many as five or six Lobsters in one cod. These Lobsters would be three or four inches in length, or even smaller. Cod eat Lobsters all the season. In the spring, and in January, February, and March, there are many cod about.' Skates and congers, codling and haddock, also eat Crabs and Lobsters."

DESTRUCTION BY STORMS.—Mr. F. H. Baker, in a recent paper on American Lobsters, refers to their being occasionally destroyed in great numbers in shallow water by heavy storms. He cites as an instance the great Saxby storm on the coast of Nova Scotia, after which the dead Lobsters were piled up in immense numbers, in several places, "lining the shores like windrows of hay on a field in midsummer, the stench from which was overpowering as the Lobsters decayed in the sun."

DISTRIBUTION AND HABITS OF THE EUROPEAN LOBSTER.—The following account of the distribution and habits of the European Lobster, *Homarus vulgaris*, abstracted from a report by a Danish-Norwegian naturalist,[1] is inserted here to permit of comparison between these two closely related forms, and to fill up some of the numerous gaps in the history of our own species. The European Lobster is so similar to our own structurally that we are safe in assuming that the habits of the two are in the main alike. In comparing the European with the American species, however, it must always be borne in mind that the former never attains the extreme size of the latter, and also averages smaller in size, while the female begins to spawn when only six inches long, although at this size it may possibly be quite as old as the young spawning American female. There are so many important questions of practical value still unsolved regarding the American Lobster, that the suggestions set forth by this Norwegian report may lead to their proper investigation:

"The European Lobster seems to have its central location on the southwestern coast of Norway, and goes as far north as Finmarken, where, according to Lem, in his description of the Finmarken Laplanders, 1767, it is found north of Traenen, where he ate very fine ones on the island of Rödö, while formerly their northern limit was thought to be the island of Bröndö; but he also thinks that they would be found in Finmarken, if people only searched for them. It is very rarely found on the coasts of Iceland, where, according to Mohr's 'Islandske Naturhistorie,' it has been found by Dr. Poulsen in Gröndevig, but it does not extend to Greenland or Spitzbergen. It does not go into the Baltic, but is found all over the Kattegat, especially near Anholt, Hirsholmene, Laesö, and Hjelm, and, according to Mr. Fiedler's report, in the Great Belt as far as Sprogö. On the coast of Bohuslan it is very common, and is said to go into the Sound as far as the island of Hveen. On the west coast of Jutland, it is found wherever the bottom is stony, and it is very common near Heligoland. It rarely goes into the inlets on our western coasts, chiefly on account of their great depth. It is very rare in the inner portion of the Bay of Christiania, and not very common in the Limfiord. On the coasts of England, Scotland, and Ireland, it is

[1] AXEL BOECK: Om det norske Hummerfiske og dets Historie. Copenhagen, 1868–'69.

common wherever there is a rocky bottom, especially near Montrose, Orkney, Lewis, and Harris Island, and on the southern coast of England, near Land's End and the Scilly Islands. Near the Channel Islands it is common, as well as near several groups of islands on the French coast. In the Mediterranean it is not so common, although it is not entirely wanting; but its substitute as an article of food is another large species of Cray-fish, the *Langusta* (*Palinurus*). It is, therefore, not spread over a very large extent of sea; but it is found in its central locations in very large numbers, and there becomes an important article of food and trade.

"Its general size is eight to ten inches from the point of the spine on the forehead to the tip end of the tail. It rarely exceeds this size where large fisheries are carried on; but now and then specimens of a much greater size are found in places from which none are exported, and where it consequently has time to grow before it is caught. Thus, Pontoppidan, in his 'Norges naturlige Historie' (part ii, p. 279), says that the very large Lobsters are called 'Störjer,' and that near Utvaer, on the Bay of Evien, a Lobster had been seen which was so large and ugly that nobody dared to attack it, and that it measured a full fathom between the claws. This seems certainly to be somewhat exaggerated; but I myself have seen the claw of one which must have been about eighteen inches long. Sir John Graham Dalyell says, in his work 'The Powers of the Creator,' 1827, that he had seen a joint of the left claw of a Lobster that measured nine inches in length. According to this, the whole claw must have measured eighteen to twenty-four inches, and the whole animal three to four feet. As a general rule, those that are taken in the fiords are larger than those that are caught near the islands toward the sea. The color of the animal when alive is generally a blackish-green, with several blue spots; but it may also be lighter, especially near the mouths of fiords, while farther out toward the sea it becomes much darker. I may mention as a curiosity that during this year (1868) I found a Lobster near Haugesund, one-half of which was of a greenish-black and the other of a light-orange color, there being a sharp and clearly defined dividing line, which ran lengthwise, and divided the Lobster in two halves of equal size.

"The Lobster lives close to the coast, where there is a rocky bottom, among the large algæ; but in winter, when the water grows cooler, it descends as far down as sixteen to twenty fathoms, while in spring, when the temperature of the sea rises, it stays at a depth of from one to four fathoms. It is altogether a coast animal, which very rarely seems to go any distance from its birthplace, if it can readily find there a sufficient supply of food. Sometimes, however, they have been seen in large masses swimming toward the land from the sea, and they have then been caught in nets, having been mistaken for a school of herrings; but this is only a consequence of local migrations, when it goes from the deeper into the shallower waters. It is not able to make its way through the sea for any length of time by swimming. Its structure certainly allows it to make quick and definite movements, and it can swim freely about in the sea, but this swimming never lasts long, as it cannot keep itself afloat very long. Neither is it able, while swimming, to catch and swallow its food; but it seizes its prey only when it can hold on to something. At the bottom of the sea it can chase its prey, if necessary, with great rapidity, but while eating it remains quite still. The Lobster is a very greedy animal, and can swallow great quantities of food, which it seems to find especially during the night by its scent, while during the day it keeps quiet and digests. Its food consists chiefly of the roe of fish, and of dead fish, but likewise of small crustaceans and other marine animals. When kept in confinement, it can live for a considerable time without food. The Lobster seems to be able to propagate when it is a little more than six inches long (at least, roe is only found in animals of this size); but when the Lobster reaches a length of eight inches it contains a great quantity of roe. A real act of

copulation takes place, the male Lobster placing its double male member into the outer genital opening of the female; and the eggs are impregnated while they are yet in the ovary. This pairing seems to take place from autumn to spring, or March and April, for it is highly probable that the roe is emitted from the ovaries immediately after copulation has taken place, just as with other crustaceans; and the emitted roe is found during the entire winter. After impregnation, the eggs are emitted from the outer genital openings of the female, which are found at the bases of the third pair of feet, but do not fall into the water, as they are held in a hollow which is formed by the bent tail, which, both at the end and on the sides, has leaf-shaped fringes that inclose the space formed by the bending of the tail. Under this tail there is fastened a double row of the so-called tail-feet, to which the eggs are strung by strong, slimy strings. The embryo now begins to develope in these eggs, which are quite numerous, two to three thousand in one female, according to the size, and occasionally as many as ten to twelve thousand. The formation of the embryo does not, however, seem to begin till the temperature of the water has become milder in spring, even if the pairing should have taken place in autumn or winter; for, although loose roe is often found in winter, it is never seen in any degree developed into embryos. This pairing and the development of the roe seem to take place at different times on different portions of the coast; for the fishermen themselves, who have such an excellent opportunity of observing them, are not agreed as to the actual time. The development of the embryo seems to take at least fourteen days from the time of commencement, and it can easily be observed till the young break the shells of the eggs and begin to lead an independent life. When the young Lobster comes out of the egg it measures only a few lines in length, and does not at all resemble the old Lobster, but has a different structure. It does not leave the hollow under its mother's tail immediately after being hatched, but lives there for some time, and later frequently returns to it. It is particularly distinguished by a less complete development of its feelers and tail-feet, and by the feet being exceedingly small but furnished with long, brush-like branches, with which it swims vigorously on the surface of the water. After having spent some time in this state, it changes its skin several times and assumes the shape of its mother, when it goes to the bottom. Its life from this moment till it reaches a size of five to six inches is entirely unknown; for no young Lobsters have been caught, either by fishermen or scientists, the smallest having been found in the stomach of the torsk, so that it is probable that they spend this portion of their life at a greater depth, and live in a different manner and on other food than at a later period. There cannot, therefore, be any artificial hatching of Lobsters in the sense of artificial fish-hatching, but all that can be done is to keep the Lobster imprisoned during the development of the eggs, and thus protect it from the dangers which threaten it and its young. It is impossible to do anything for the tender young, as they die very soon when confined. I see, however, that several persons in France, and Mr. von Eris, in the lagoons of Triest, near Grado, have hatched several millions of young by keeping Lobsters with ripe roe at the bottom of the sea in perforated boxes.

"The greatest enemy of the Lobster, and one who sensibly diminishes its numbers, is man. When swimming near the surface during its youth, with a number of other small crustaceans, it becomes a welcome prey to the herring and the mackerel. As the grown Lobster keeps at no great depth, and where large fish of prey are not commonly found, it is not much exposed to them, but occasionally, when lying near the surface, it is taken by large birds of prey. An interesting scene may be witnessed near Bukkenö, north of Stavanger, where an Englishman has constructed a large pond, between some small islands, for keeping live Lobsters. Whenever the pond becomes too full of Lobsters, so that they do not find sufficient food, they leave the water and crawl about

seeking to reach the sea; but during their wanderings they fall an easy prey to large numbers of crows hovering round, which take them in their claws, fly high up, and let the unfortunate Lobsters drop down on the rocks, where their shells are broken, so that the crows can eat them in comfort. The crows are not easily scared away, but show a remarkable degree of sense, only flying away when any one approaches with fire-arms, and later they carry on their depredations in the early morning, when they have less to fear."

In addition to the above we have some interesting remarks on the natural history of the European Lobster, from observations made by Prof. G. O. Sars, about 1875, and published in 1878, in a report on the "Salt-water Fisheries of Norway." In prefacing his remarks, Professor Sars states:

"In order to judge of this matter (the protection required for the fishery) it is absolutely necessary to have as complete a knowledge as possible of the natural history of the Lobster. But in this respect very little progress has been made. Although the Lobster is one of the commonest marine animals on the coast of Europe, and has been made the subject of special investigations by many naturalists, its mode of life is still involved in darkness."

Farther on he gives the following general accounts of its habits:

"As to its organization and its analogy with similar crustaceans, the Lobster must doubtless be on the whole considered as a stationary animal. It never undertakes long migrations like some of our fish. The Lobster certainly moves about with great swiftness and ease, aided by its strong tail and the swimming apparatus attached to it; but this mode of moving about is evidently not the rule. The hard-shell and ponderous Lobster must always make an extra exertion in moving about, and its movements cannot, therefore, be of long duration. People certainly talk of the so-called 'traveling Lobsters,' which are said to come from the open sea in large schools; and some even say that they have seen such schools many miles from the coast, moving about rapidly near the surface of the sea. If this is really so, I consider it as absolutely certain that these schools came from no very great distance, possibly from some of the elevated bottoms off the coast. The grown Lobster is, as every lobster fisher will know, in its whole mode of life a genuine bottom animal, and prefers a stony or uneven bottom, overgrown with algæ, where it finds good hiding-places for lying in wait for its prey. During summer and part of autumn, the Lobster goes on higher bottoms in the bays and inlets, and is then frequently caught quite near the shore among the algæ, at a depth of less than a fathom. Toward winter it again retires into the deep; and still later in the season it has almost entirely disappeared from those places where it was quite common during summer. Occasionally, however, it is, even in the middle of winter, found in deep water, and I have reason to believe that the Lobster never leaves our coast entirely, but considers it as its proper home.

"As may be judged from its powerful claws, the Lobster is a fierce beast of prey, that is not satisfied with small marine animals, but occasionally attacks all kinds of small fish that are unfortunate enough to come within its reach. The bait used for catching Lobsters consists exclusively of fish, principally small codfish and herrings. These must, however, be tolerably fresh; as soon as they begin to get old the Lobster leaves them to his cousins, the Crabs, which are less fastidious in their tastes, and they enter the baskets in great quantities.

"The Lobster is cautious and cunning. It never pursues its prey openly, but either endeavors to surprise it, in which it is greatly aided by its very highly developed sense of smell, or waits patiently among the algæ till some marine animal comes within reach of its claws. I have several times observed with what cautiousness and evident distrust the Lobster, attracted by the bait, has gone round the traps and examined them several times on all sides, before it has

gone in. Only when it is very hungry, as is especially the case later in summer, after the spawning season and casting of the shell is over, is it less cautious and more ready to enter the traps.

"The Lobster is best and fattest in the spring and early summer, while later in the summer and autumn it becomes thin, in consequence of which the English will not take it during those seasons."

COMPOSITION OF LOBSTERS.—According to a series of careful analyses by Professor W. O. Atwater, of Middletown, Connecticut, the composition of the flesh of Lobsters is as follows, the figures given indicating the average results obtained from three specimens received from the coasts of Maine and Massachusetts:

	Per cent.
Proportions of edible portion and shell:	
Total edible portion	39.77
Shell	57.47
Loss in cleaning	2.76
Proportions of water and dry substance in edible portion:	
Water	82.73
Dry substance	17.27
Chemical analysis calculated on dry substance:	
Nitrogen	12.54
Albuminoids (nitrogen × 6.25)	78.37
Fat	11.43
Crude ash	10.06
Phosphorus (calculated as P_2O_5)	2.24
Sulphur (calculated as SO_3)	2.47
Chlorine	3.46
Chemical analysis calculated on fresh substance in flesh:	
Water	82.73
Nitrogen	2.17
Albuminoids (nitrogen × 6.25)	13.57
Fat	1.97
Crude ash	1.74
Phosphorus (calculated as P_2O_5)	.39
Sulphur (calculated as SO_3)	.43
Chlorine	.59
Nutritive value of the flesh of Lobsters compared with beef as a standard and reckoned at 100	61.97

The chemical composition of the flesh of the European Lobster is stated by Mr. Frank Buckland to be as follows:

	Flesh.	Soft internal matter.	Spawn.
	Per cent.	*Per cent.*	*Per cent.*
Nitrogenous matter	19.170	12.140	21.892
Fatty matter	1.170	1.444	8.234
Mineral matter	1.823	1.749	1.998
Non-nitrogenous matter and loss	1.219	0.354	4.893
Water	76.618	84.313	62.983
	100.000	100.000	100.000

In connection with this table, Mr. Buckland makes the following observations:

"That phosphorus exists in large quantities in Lobsters may easily be proved. A Lobster in hot weather, when it ceases to be fresh, assumes a highly phosphorescent appearance when seen in the dark, equal, if not superior, to that of a glow-worm or luminous centipede. This light increases by friction . . . and this phosphorescent appearance is probably caused by the

chemical changes in the organic tissues, when life is no longer present to resist the ordained agency of decay and decomposition; in fact, it is a slow combustion by combination with oxygen.

"The presence of phosphorus in the Lobster is of great importance to the consumers of these sea luxuries; there is no substance which conveys phosphorus so readily into the human system in an agreeable form, and which the system so readily and quickly assimilates, as the flesh of Crabs and Lobsters."

225. THE CRAY-FISHES—ASTACUS AND CAMBARUS.

RELATIONS AND DISTRIBUTION.—The so-called "Cray-fishes" or "Craw-fishes" are common inhabitants of most of the fresh-water streams of the United States and Europe, but in this country they are not eaten nearly to the same extent as in some parts of the Old World, and they are not generally regarded here as a staple article of food.

The North American Cray-fishes, although belonging to but a single family, the *Astacidæ*, constitute two distinct genera, *Astacus* and *Cambarus*, and about thirty-eight species, three of which do not, however, occur within the limits of the United States. The Cray-fishes bear a striking resemblance to the Lobsters (*Homarus*), to which they are closely related, but there are several important structural differences between them, and none of the Cray-fishes grow nearly as large as the Lobster.

Europe contains only three species of Cray-fishes, all belonging to the well-known genus *Astacus*. They are *A. nobilis* Huxley (*fluviatilis*), *A. torrentium*, and *A. leptodactylus*. Much discussion has taken place among naturalists as to whether the above species are really distinct from one another, or merely form varieties of a single variable species. The relations of *A. nobilis* to *A. torrentium* are more marked than of those two forms to *A. leptodactylus*, but probably the specific differences pointed out are as good as exist between many other unquestioned species of the same group in this country. It matters little to us in this connection, however, what may be the true affinities of these forms to one another, as long as we can define them sufficiently well to speak of their relations to the fresh-water fisheries of Europe, as an introduction to our own species.

Astacus nobilis and *A. torrentium* are the edible Cray-fishes of Western Europe, and inhabit fresh-water streams generally. They "are intermixed over a large part of Central Europe. *A. torrentium* has a wider northwestward, southwestward, and southeastward extension, being the sole occupant of Britain, and apparently of Spain and of Greece. On the other hand, in the northern and eastern parts of Central Europe, *A. nobilis* appears to exist alone. Farther to the east a new form, *A. leptodactylus*, makes its appearance."[1] Those who have treated of the two western species of Europe from a practical standpoint have generally spoken of them as a single species, to which the old and well-known name of *fluviatilis* has been applied. This distinction corresponds with the views of the older European naturalists, and this species thus constituted, with its two or more varieties, is the common fresh-water Cray-fish of European literature, which has come to have a world-wide reputation.

The structure of the Cray-fish can be best described by defining some of the principal characters in which it differs from the common Lobster, according to Huxley. The general shape of the body with its appendages and the general make-up of the two forms are very similar; but the Cray-fish has only eighteen pairs of perfect gills or branchiæ at the most, and the Lobster twenty. "Moreover, the branchial filaments of these gills are much stiffer and more closely set" in the Lobster than in most Cray-fishes. The most important distinction, however, is presented by those gills which are attached to the bases of the thoracic limbs, and which number six pairs

[1] HUXLEY: The Cray-fish, 1880, pp. 299, 300.

in both the Lobster and the Cray-fish. In the latter animals each of these gills forms a simple stem ending above in a plume and plate; in the former this "stem is, as it were, completely split into two parts longitudinally, one half corresponding with the lamina (plate) of the Cray-fish gill, and the other with its plume."

The shedding and the spawning habits of the Cray-fish correspond very closely with those of the Lobster, in connection with the description of which animal the subject has been discussed at some length.

As stated above, the American Cray-fishes belong to two genera, *Astacus* and *Cambarus*, while all the European species belong to the one genus *Astacus*. The only marked difference between the two genera is this, that while in *Astacus* there are eighteen gills on each side, in *Cambarus* there are only seventeen. This difference in structure is considered to be of sufficient importance to warrant the formation of the two genera, but the external differences, such as the variation in shape of the body, and in the proportionate sizes of the several external parts, which are more apparent and more striking to the superficial observer, have only specific value. On such differences as these are founded the thirty-two species of *Cambarus* and the six species of *Astacus*, belonging to the North American fauna. More careful and detailed studies of large collections of Cray-fishes from different parts of North America may serve to greatly reduce this number of species, and if such should follow, it would simply go to prove that some of the differences now supposed to be of specific importance are merely varietal. Strangely enough, all of the North American species of *Astacus* are limited to the western slope of the Sierra Nevada Mountains, that is to say, to that portion of our country most distant from Europe; while the genus *Cambarus* is confined to the intervening area between the Rocky Mountains and the Atlantic coast. The six species of *Astacus* are variously distributed through California, Oregon, Washington Territory, and British Columbia, but only one species, *A. nigrescens*, appears to be used as food, at least to any extent. This probably results from the fact that this is the only species found in the vicinity of San Francisco, outside of which city there is little or no demand for this sort of food. Adult individuals of this species exceed four inches in length, and when living are blackish in color; after death, however, they become of a light grayish tint. According to Mr. Lockington, of San Francisco, this species is brought to that city only in small quantities, the demand for it being slight. The supply is mostly obtained from Coyote Creek, Santa Clara County, and from the sloughs of the San Joaquin.

The genus *Cambarus* is pretty generally distributed throughout the region east of the Rocky Mountains. No Cray-fishes have ever been found, however, in the New England States, excepting in the extreme western parts of Vermont and Massachusetts and in Central Maine, and ten years ago no species had been recorded from most of the Western Territories, especially between the Rocky Mountains and the Sierra Nevada, where if any Cray-fishes should be found in the future it will be interesting to know whether they belong to the western genus, *Astacus*, or the eastern, *Cambarus*.

At present we know so little, comparatively speaking, of the invertebrate fauna of the rivers of the Territories that it is not at all strange we should have so few records of Cray-fishes from them; but it is very probable that Cray-fishes exist there in greater or less numbers. New England, on the contrary, has been too well explored to leave much doubt but that Cray-fishes are absent from it excepting in the localities above cited. To enter into a discussion of all the species of North American *Cambarus* would lead us away from the main object of this sketch, which is intended principally to point out the range and habits of those species known to be eaten. Suffice it to say that the species are more or less irregularly distributed, some States, or even sections of

States, having several species, and others again only one or two. Some species are very limited in their range, while others are widely distributed. *Cambarus acutus* is an illustration of this wide distribution, ranging as it does through a large number of the States from the Great Lakes southward to the Gulf, and from Missouri eastward to the Atlantic coast. *C. Bartonii* ranges from Canada to the District of Columbia and Kentucky; *C. obesus*, from Illinois to Louisiana, and from Missouri to New York and Virginia. *C. affinis* occurs in all of the Middle States and in Maryland and the District of Columbia, and *C. virilis* extends from Lake Winnipeg, British America, to Toronto in the east and Texas in the south. Very many of the species have been recorded from only a single locality each, but this does not necessarily imply a restricted range, as they may occur in other places in which no collections have yet been made.

ECONOMIC VALUE.—Although Americans, as a rule, do not regard the eating of Cray-fishes with much favor, these animals are probably used as food in many of the localities in which they are abundant and can be easily obtained. The French in this country are perhaps the principal consumers of this delicacy, as they are in Europe, where their own country can supply only a small part of the demand, great quantities being annually imported into France from Germany and other neighboring countries. In the United States the principal centers for the consumption of Cray-fishes are New York City and New Orleans, and we have been unable to learn of any other cities demanding a regular supply. New Orleans derives its supplies from the fresh waters near at hand, but New York depends upon more distant sources. The Cray-fish season in New York City begins early in the spring and lasts until fall, or until frost sets in. The first supplies come from the Potomac River at Washington, where the Cray-fishes are first taken soon after the breaking up of the ice in the river. About June 1 the weather becomes almost too warm for the shipment of Cray-fishes from Washington, and another more northern locality, Milwaukee and vicinity, begins to send supplies to New York. In the early part of July, Montreal adds her quota to the New York markets, and the shipments from these two latter localities continue as stated above until into the fall. The Potomac River Cray-fishes are larger than those from Milwaukee, while the Montreal species is the smallest of all. The Milwaukee Cray-fishes are most esteemed by epicures, their flesh being less coarse and of a finer flavor than any of the other species sold in the New York markets. The Potomac species is the darkest in color when living, but does not turn red by boiling, while the Milwaukee and Montreal species do. Small quantities of Cray-fish are very probably brought to New York City from the State and from New Jersey, but if so they do not pass through the larger markets, and there is no regular supply.

The Potomac River Cray-fish sent to New York is the *Cambarus affinis* Erichson, and the Milwaukee species is the *Cambarus virilis* Hagen. We have never examined specimens of the Montreal species. The New Orleans market Cray-fish is the *Cambarus Clarkii* Girard, while the San Francisco species, as already stated, is the *Astacus nigrescens*. One of the Lower Mississippi River species, either the *Cambarus Clarkii* or the *Cambarus acutus*, burrows into and causes much damage to the levees of the river in the vicinity of New Orleans.

HABITS.—Cray-fishes differ widely in their habits, and while some species prefer clear running streams, others live in more quiet waters, and still others upon muddy banks, where they dig holes, and remain much of the time out of the reach of water.

Dr. C. C. Abbott has given us the following account of the habits of three of our commoner species of Cray-fishes, which occur near Trenton, New Jersey.[1] They are *Cambarus acutus*, *C. affinis*, and *C. Bartonii*, which have already been referred to as living in regions where Cray-fishes are taken as food:

[1] American Naturalist, vii, 1873.

"It is difficult to say which of the three species is the most abundant in the general locality we have named, inasmuch as they seem to prefer different streams; one being a plant-loving, one a stone-haunting, and the third a mud-frequenting species. In their respective haunts each is apparently as numerous as is either of the others in its chosen home. . . . We have found *Cambarus acutus* to frequent running streams which have masses of vegetation growing in them, the animal in question resting upon the plants, usually near the surface of the water. We have found since our collecting excursions, on carefully approaching clear running streams, such as just mentioned, that this Cray-fish is to be seen resting on the plants, always with the head directed down-stream. If disturbed, they would dart backward, down to the roots, apparently, of the plant upon which they were sitting. After a lapse of about ten minutes they would return to their former resting place, creeping up the plant down which they had so suddenly darted tail foremost.

"The *Cambarus affinis* is apparently the river species of this locality. We have been able to find it, as yet, only in the Delaware River, usually frequenting the rocky bed, but also, in fewer numbers, on the mud-bottomed portions of the river. They are usually found resting under flat stones, well out from the banks of the stream, where the water is of considerable depth. Wherever the vegetation is dense, we have failed to find them; nor have we seen anything to indicate that it is a 'burrowing' species. . . . *Cambarus Bartonii*, it appears to us, is the one burrowing species of this locality. We have found in the deep ditches, with precipitous, muddy banks, a medium-sized Cray-fish, which in most respects accords with the species called *Cambarus Bartonii* Fabr. by Dr. Hagen. . . .

"Cray-fish are strictly omnivorous animals, but, although excellent scavengers, do not feed wholly upon decayed animal and vegetable matters. We have frequently noticed that *C. Bartonii* in an aquarium breaks off the short stems of the common river weed, and eats the main stem, after stripping it of its minute leaves. So the *C. affinis*, from beneath its sheltering flat stone, and *C. Bartonii*, in its safe burrow, will seize the minute young cyprinoids, that pass up and down the stream in such myriads, ever and anon peeping into the various little indentations in the banks. Such little fish, when once fairly caught by the big claws but by no means clumsy 'hands' of a *Cambarus*, have no chance of escape, and are soon torn to pieces."

Cambarus Bartonii described by C. Girard as *C. Diogenes*, constructs very interesting burrows on the meadow flats of the Potomac River at Washington, which Mr. Girard describes as follows:[1]

"The holes, as they appear at the surface of the ground, are nearly circular, from seven-tenths of an inch to one inch and one inch and a half in diameter. The depth of the burrows varies according to the locations; this we generally found to be from sixteen inches to two feet, and sometimes to three feet and more. The construction of the burrow itself is often exceedingly simple; from the surface of the ground the excavation exhibits gradual slope, in direction more or less undulating, for a distance of from five to ten inches, when it becomes vertical for six or eight inches, and then terminates in a sudden bottle-shape enlargement, in which the animal is found. The bottom of the burrows having no subterraneous communication, no other issue except towards the surface, it is entirely isolated from its neighbors, and leaves no chance of escape to its inhabitant. The same burrow may have several external holes connected with it, several inclined channels, which, however, meet at the depth where it becomes vertical. We constantly found the cavity full of water, but this was in March and April; the bottom, for several inches, was filled with a soft and pulpy mud.

[1] Proc. Phila. Acad. Nat. Sci., vi, pp. 88–90, 1854.

"We generally found a single individual in each burrow, it being either a male or a female, the latter in March or April, carrying under the tail a bundle of her eggs. Sometimes, when numerous individuals are gathered on a small space, it may happen that the windings of the upper part of their burrows will accidentally meet and have in this case a communication which was not contemplated. Each individual, however, remains in its own apartment; so at least we constantly found to be the case. To accomplish the act of breeding, males and females must come together at one particular time. In one of the burrows which we examined we found a male and a female. We are inclined to believe that the male quits its retreat and goes in search of the female, as one individual of the former sex was found, at one time, walking over the surface of the ground.

"In the spring, and we are told in the fall also, the burrowing Craw-fish builds over the holes of its burrow a chimney of the maximum height of one foot, but most generally lower. This chimney, circularly pyramidal in shape, is constructed of lumps of mud, varying in size, irregularly rolled up, and piled up one upon another, and intimately connected together. Its exterior has a rough and irregular appearance, whilst the interior is smooth and as uniform as the subterraneous channel, and having the same diameter as the latter. The cementing of the successive balls of mud is easily accounted for when we bear in mind that the latter are brought up in a very soft state, and that their drainage and subsequent solidification on their exposure to the atmospheric air and rays of the sun are all that is required to unite these parts. . . . The last touch consists in shutting up the aperture. This is accomplished by means of several balls of mud brought up from underneath, deposited temporarily on the edge of the chimney and drawn back in close contiguity, so as to intercept all communication with the external world. The number of such chimneys is sometimes very great in one particular locality, distributed without any geometrical regularity, and recalling to mind the scattered habitations or village of a newly settled colony."

226. THE SHRIMPS AND PRAWNS.

THE COMMON SHRIMP—CRANGON VULGARIS, Fabricius.

This species of Shrimp occurs on both sides of the Atlantic, and is eaten both in this country and in Europe. It is, therefore, of considerable economic importance, though of less value than the larger Shrimp (*Penæus*) of the Southern States. *Crangon vulgaris*, on the American coast, ranges from Labrador to North Carolina, and from low-tide level to depths of about fifty fathoms. "It is found in greatest abundance in shallow water, and on sandy or weedy bottoms, but occurs also on muddy, shelly, and rocky bottoms, and extends at least to about fifty fathoms in depth. It varies much in coloration according to the location in which it is found. Upon the exposed and light-colored sandy shores of Southern New England, specimens are invariably translucent and very pale in color, so as to closely resemble the surface upon and beneath which they live, while upon dark-colored muddy bottoms they are very much darker in color. Specimens from a dark-colored muddy inlet of Vineyard Sound and others from dark muddy and sandy bottoms at Halifax, Nova Scotia, are very dark indeed, the pigment spots covering nearly the entire surface, and the caudal appendages becoming almost black toward the tips."[1]

"When resting quietly on the bottom, or when it buries itself partially and sometimes almost entirely, except the eyes and long, slender antennæ, it cannot easily be distinguished by its enemies, and, therefore, gains great protection by its colors. When left by the tide it buries itself to a considerable depth in moist sand. It needs all its powers of concealment, however, for it is

[1] S. I. SMITH: Trans. Conn. Acad., v, p. 56, 1879.

eagerly hunted and captured by nearly all the larger fishes which frequent the same waters, and it constitutes the principal food of many of them, such as the weak-fish, king-fish, white perch, bluefish, flounders, striped bass, etc. Fortunately it is a very prolific species, and is abundant along the entire coast, from North Carolina to Labrador, wherever sandy shores occur. The young swim free for a considerable time after hatching, and were taken at the surface in the evening, in large numbers."[1]

According to White,[2] the common Shrimp are in spawn on the English coast during the entire summer; "the ova are of a dirty white color."

We have no published data as to the duration of the spawning season upon our coast, but "the young are hatched in the neighborhood of Vineyard Sound in May and June, and arrive at the adult form before they are more than four or five millimeters long. Specimens of this size were taken at Wood's Holl, at the surface, on the evening of July 3. Later in the season much larger specimens were frequently taken at the surface both in the evening and daytime.

"The young of the different kinds of Shrimp, *Crangon vulgaris, Palæmonetes vulgaris*, and *Virbius zostericola*, when hatched from the egg, are free-swimming animals, similar in their habits to the young of the Lobster. In structure, however, they are quite unlike the larvæ of the Lobster, and approach more the zoëa stages of the Crabs. When they first leave the egg, they are without the five pairs of cephalo-thoracic legs, the abdomen is without appendages, and much as it is in the first stage of the young Lobster, while the maxillipeds are developed into long locomotive appendages, somewhat like the external maxillipeds of the first stage of the young Lobster. While yet in the free-swimming condition the cephalo-thoracic legs are developed, the maxillipeds assume the adult form, and the abdominal limbs appear. The young of these Shrimp are very much smaller than the young of the Lobster, but they remain for a considerable time in this immature state, and were very frequently taken at the surface in the towing-net."[3]

Although *Crangon vulgaris* may be common in the southern part of its range (New York to North Carolina), it has not been often recorded from that region, and in fact we know much more about it on the New England coast, along the entire extent of which it is very abundant, though somewhat less so north of Massachusetts Bay. About Halifax, Nova Scotia, it is again abundant and of large size from low-water mark to eighteen fathoms, on sandy, muddy, stony, and rocky bottoms. *It is common everywhere in shallow water and at low-water mark on most sandy* beaches in the Gulf of Saint Lawrence. It also occurs in the Straits of Belle Isle. Since this report was in manuscript, *Crangon vulgaris* has been found by the Fish Commission to occur in different parts of Chesapeake Bay in immense numbers and of unusually large size.

The common Shrimp attains a length of over two inches, exclusive of the anterior appendages, but is generally smaller. In the neighborhood of New York and about New Bedford, Mass., it is taken as food. Northward from there it is, so far as we know, only utilized to a slight extent, and for bait only. It may perhaps be taken on the southern coasts, where it occurs, in connection with *Penæus*, which is sent in large quantities to New York, but from all the information we have been able to obtain, no notice is taken of it south of New York.

Mr. W. N. Lockington states that *Crangon vulgaris* is very abundant upon the Pacific coast of North America, ranging from Alaska (Mutiny Bay) to San Diego, California. It is smaller than *C. franciscorum*, with which it is found associated; and it is also less abundant in the San

[1] VERRILL: Vineyard Sound Report, p. 339, 1871–'72.
[2] Popular History of British Crustacea, 1857, p. 107.
[3] S. I. SMITH: Vineyard Sound Report, pp. 528, 529, 1871–'72.

Francisco markets, although comprising no inconsiderable part of the total catch of Shrimp, and at some seasons it is more common than its congener. The average length of the specimens taken on the Pacific coast is said to be about two and a quarter inches, but large examples exceed three inches in length. This form, which is a sort of color variety, is easily distinguished from *C. franciscorum* by its black tail, and the large proportion of black upon its body, as well as by the different form of the hand, the movable finger of which is much shorter and folds transversely across the tip of the hand. From its black coloring it has received the name of "Black-tailed Crab."

This Shrimp is taken on the west coast in connection with *C. franciscorum*, and is sold fresh in the markets as well as boiled and dried for exportation to China.

The California Shrimp—Crangon franciscorum, Stimpson.

According to notes furnished by W. N. Lockington, this is the largest species of Shrimp on the Pacific coast of the United States, and is the Shrimp *par excellence* of the San Francisco markets, where large quantities are sold during nearly every month of the year.

The total length of the body, in the adults, ranges from three to three and a half inches, while in the same the length of the carapax is about seven-eighths of an inch.

From the Pacific coast variety of *Crangon vulgaris* this species can be distinguished by its larger size; by the absence of the black tail and large black spots, characteristic of the former; by the small dots of dark tint which mottle the surface; and most readily by the much greater length of the movable finger of the hand, which folds parallel with the side of the hand instead of across its extremity.

Crangon franciscorum has a somewhat limited range, not being known from north of Puget Sound, nor south of Point Conception, California. In San Francisco Bay and Tomales Bay it is exceedingly abundant, frequenting especially the sandy coves along their shores. Not only is this Shrimp largely consumed upon the coast when fresh, but it is also taken by the Chinese in immense quantities and shipped to China after boiling and drying. The Shrimp industry affords employment to a large number of Chinese, and constitutes an important factor in the export trade of San Francisco. The Shrimp are usually caught in purse-nets, which are conical in shape, about twenty-five feet long and ten feet across the mouth; they taper to the lower end, which is opened and closed by means of a "puckering string." It is said that no diminution in the number of Shrimp results from the continuous fishing, although the edible species of fish are nearly exterminated in San Francisco Bay.

A species of *Hippolite* (*H. brevirostris*), of a uniform light crimson or scarlet color, occurs at the Straits of Fuca, in San Francisco Bay, and probably along the intervening coast. In San Francisco Bay it is taken with the *Crangons* for food.

The common Prawn—Palæmonetes vulgaris, Stimpson.

The common American Prawn, which closely resembles the English species, although occurring in great abundance along some portions of our Atlantic coast, does not rank among our food invertebrates on account of its small size. It frequently makes up for that deficiency, however, by its great abundance.

The average length of specimens is about one and one-half inches. The body is translucent, almost colorless, but is "marked with irregular, ill-defined, dark blotches and spots, which admirably adapt it for concealment among the discolored and dead leaves of eel-grass, at or near the bottom," in which localities it is most abundant. The American Prawn differs from the

English, among other things, in the character of its rostrum and in its smaller size. The rostrum of the latter is divided or double at the tip, and specimens range in length from three to five inches.

P. vulgaris ranges from Massachusetts Bay to Northern Florida. North of Cape Cod, however, it is rare. It is very common among eel-grass, etc., in Vineyard Sound, Buzzard's Bay, Fisher's Island Sound, and Long Island Sound. Thence it has been recorded from the south side of Long Island, and from numerous points along the coast of New Jersey and the Southern States, as far south as Saint John's River, Florida. The localities inhabited by this species are described as follows by Professor Verrill:[1]

"The common Prawn has its true home among the eel-grass (in brackish water), and here it occurs in countless numbers. . . . It is also very abundant in the pools and ditches (of the muddy shores in brackish water), even where the water is but little salt, and also occurs in immense numbers on the muddy bottoms."

It likewise abounds on the muddy bottoms in pure salt water. On sandy bottoms in both salt and brackish water it often occurs associated with *Crangon vulgaris*, but not in large numbers.

THE RIVER SHRIMPS—PALÆMON OHIONIS, Smith; PALÆMONETES EXILIPES, Stimpson.

Only two species of river Shrimp have yet been described from the United States east of the Mississippi River, and they seem to be used as food in only a few localities. At New Orleans, however, one species, the *Palæmon ohionis*, is very much esteemed.

In this species, the carapax or anterior part of the body is smooth, stout, and considerably swollen, with a short rostrum. Specimens from the Ohio River measured in total length of body from two to three and one-fourth inches, the carapax occupying about one-fourth of this length. The original specimens from which the species was described were from the Ohio River at Cannelton, Indiana, where it is taken for food. Since then it has been found over a larger area, including the vicinity of New Orleans.

Palæmonetes exilipes is a much smaller species than the above, measuring only about an inch and a half in total length. It has been recorded from Sandusky Bay, Lake Erie; Ecorse, Michigan; Somerville, South Carolina; and from fresh-water streams in Florida. It is probably quite widespread in its distribution, but we are not aware of its ever having been used as food, probably on account of its small size.

THE DEEP-WATER PRAWNS—PANDALUS BOREALIS, Kröyer; LEPTOCEROS, Smith; MONTAGUI, Leach; PROPINQUUS, Sars.

These species of Prawns, which resemble one another very closely in appearance and structure, are exceedingly abundant in the deeper waters of Massachusetts Bay, the Gulf of Maine, and elsewhere off the coast of New England, the British Provinces, and southward as far as Virginia, at least.

Pandalus borealis grows to a much larger size than the other three species, but all are large enough to serve as food, and sufficiently abundant in the localities where they occur. Unfortunately they never approach the shore, and the ordinary methods of taking shrimp in shallow water will not answer for their capture. If some means of taking them easily could be devised, they would undoubtedly find a ready sale in the Boston and New York markets, for they have an exceedingly good flavor.

Pandalus borealis attains a length of seven inches. As to color, it is, according to Professor Verrill, "thickly sprinkled with small, red, stellate spots, which, from closer aggregation, make the

[1] Vineyard Sound Report, 1871–'72.

tail deeper in color than the rest of the body. The spermaries are purplish-red, the outer membrane golden, ovaries blue, eggs ultramarine blue." Females carrying eggs were taken in August and September, 1877 and 1878, in and off Massachusetts Bay and off Cape Ann. The localities where this species has been found are as follows: Massachusetts Bay, off Salem, forty-five to fifty fathoms, mud, very abundant; Gulf of Maine, forty to one hundred and sixty fathoms, muddy bottoms, very abundant in some places. In the Gulf of Maine, it was found to be especially common in a region about fourteen miles southeast from Cape Ann, in fifty to about one hundred fathoms. It was also encountered twenty to thirty miles off Cape Sable, Nova Scotia, in depths of fifty-nine to eighty-eight fathoms, and thirty miles off Halifax in eighty-five to one hundred and ten fathoms. Beyond our seas it has been recorded from Greenland, Norway, and Bering Sea.

Pandalus Montagui and *leptoceros* differ from *P. borealis* in coloration, "in having the red more intense and arranged in clearly defined markings, of which those upon the carapax and abdomen are arranged in conspicuous obliquely transverse lines or bars, while the color upon the rest of the body and upon the appendages is collected in distinct specks, blotches, or annulations." The largest specimens which have been examined were from depths of ninety fathoms, off Cape Ann, and measured four and one-half inches in length. Specimens over four inches long have been obtained from several localities. Only a few individuals have so far been seen carrying spawn. They were taken in different places during the months of August, September, and October. These species range all the way from off the mouth of Chesapeake Bay to Greenland, and *P. Montagui* also occurs on the European coast as far south as the British Islands. They are more abundant than *P. borealis*, though of smaller size, and are common in much shallower water, as well as in the same deeper places resorted to by *P. borealis*.

In Massachusetts Bay, they inhabit depths of twenty-two to forty-eight fathoms, where the bottom is gravelly, sandy, and muddy, and have also been found on Stellwagen Bank. In the Gulf of Maine they are widespread and exceedingly abundant in many localities, being often associated with *P. borealis* on muddy bottoms. They live on all kinds of bottom, in depths of ten fathoms downward. They have been found east of George's Bank in a depth of four hundred and thirty fathoms; in the Bay of Fundy, ten to seventy-seven fathoms; off Nova Scotia, sixteen to seventy-five fathoms; in Bedford Basin, Halifax, twenty-six to forty-one fathoms; Gulf of Saint Lawrence, Labrador, etc. South of Cape Cod they range down to depths of two and three hundred fathoms.

Pandalus propinquus, which has been recognized only since this report was first written, occurs associated with the two last species south of Cape Cod.

The United States Fish Commission, in its explorations with the dredge and trawl along the New England coast during the past ten years, has constantly come upon immense schools of these deep-water Prawns, sometimes two or more of the species being associated together, at others occurring separately. It has been no uncommon occurrence for a peck or more to come up in a single cast of the beam trawl, and several such hauls have sometimes been made in a single day. These Prawns apparently move in schools, and it is often impossible to secure more than a single catch in any spot at one time. This fact may result from their moving in a regular body from place to place, and thus coming by chance in the course of the trawl at times, or, if naturally disposed to remain long in a single place, the appearance of the trawl must have the effect of frightening them away. They are active in their movements, and are thus seldom taken in the dredge. It has been the custom on the United States Fish Commission steamer, when a large haul of *Pandali* has been made, after having selected the specimens required for scientific purposes, to turn the

remainder over to the mess, and there are many witnesses to testify to the superior character of the deep-water Prawns as an article of food.

The lobstermen of Biddeford Pool, Maine, who set their pots in the winter from four to six miles from shore, occasionally capture these Prawns, and here may be a suggestion as to the style of apparatus which might be tried advantageously for their capture. The openings would, of course, need to be of much smaller size than those of an ordinary lobster-pot. A light beam trawl of large size might, however, answer still better.

THE CALIFORNIA PRAWN—PANDALUS DANÆ, Stimpson.

According to W. N. Lockington, this is a moderately large species of Prawn, which is now commonly brought to the San Francisco market, and is caught in the open ocean between the Farallone Islands and Point Reyes. The length of the body in the adults, including the rostrum, is about five inches, while the average length of the carapax, excluding the rostrum, is about one and a quarter inches. Fresh specimens are finely marked with transverse zigzag lines of white, separated by bands of red.

Pandalus Danæ has been recorded from the Queen Charlotte Islands and Puget Sound, north of which it is not known; its southern limit is possibly Point Conception, California, the most pronounced point of division between the northern and southern marine faunæ of California, though this fact has not been positively determined. This Prawn has been much more abundant in the San Francisco markets during the past two years than formerly, and the reason assigned is that the fishermen, driven out of San Francisco Bay by the constantly diminishing supply of fish there, have been forced to resort to the open sea between the Farallone Islands and Point Reyes, where the Prawns live in large numbers. It has been noticed with spawn in November, December, and January. A second species of Prawn is occasionally brought to the San Francisco market, along with *P. Danæ*, being obtained in the same places. It is of smaller size than *P. Danæ* and of a uniform light pink color when fresh; it also differs from the latter in the size and shape of the rostrum, appendages, etc., and in the number of the rostral spines.

In 1879, several examples of a large species of Prawn, apparently identical with *Penæus brasiliensis*, of Brazil and the Southern United States, were brought to the San Francisco markets; in 1880 none were observed. This species is also recorded from the west coast of Nicaragua. Adult specimens examined at San Francisco measured seven inches in total length, including the rostrum. Compared with specimens from the Rio Grande, Brazil, no points of difference as regards form or proportion of parts were detected.

THE SOUTHERN SHRIMPS AND PRAWNS—PENÆUS SETIFERUS, M.-Edwards; PENÆUS BRASILIENSIS, Latreille.

These are the large Shrimps or Prawns which occur in such immense numbers on the coasts of the Southern States, and are taken to supply the markets at Charleston, South Carolina; Savannah, Georgia; New Orleans, Louisiana; New York, and elsewhere. The two species are often found associated together, but *Penæus setiferus* is the more abundant, and is, therefore, more commonly seen in the markets. According to Prof. Lewis R. Gibbes, these species may be distinguished apart by the following characters:

"The common Shrimp (*P. setiferus*) has a groove on each side of the large spine that springs from the fore and upper part of the shell or carapax; these run backward and terminate about the middle of the length of the shell. In the same tray in the market will frequently be found other individuals, far less numerous, in which these grooves run the whole length of the shell, terminating just in front of the hinder edge or border of the shell, at the first joint. This form I have referred to the *P. brasiliensis* of Latreille.

"Full-grown individuals of *P. setiferus* measure six or more inches in length, from the tip of the large anterior spine to the tip of the tail spine, and three-fourths of an inch deep and broad in the front or body part. These large specimens of both species are known in the markets as 'Prawns,' or 'Sprawns,' and the half-grown individuals are distinguished as 'Shrimps.' The Prawns appear in our waters generally in March, or in warm seasons as early as the latter weeks of February, and remain in season for two or three months, after which the supply diminishes, and they appear to retire for a time to spawn. To what region or localities they retreat I do not know, nor have I been able to learn anything concerning this matter from the fishermen. I may add that I have never seen one of these Shrimp carrying its eggs. It may be that they ascend our rivers for the purpose of spawning, and friends have called my attention to what they call 'fresh-water Shrimp' that differ in no respect from the common Shrimp, and yet are found in the rivers above the reach of salt water. In June and the succeeding months of summer, the half-grown individuals or 'Shrimps' are in season, and for tenderness of flesh and delicacy of flavor are preferred to the 'Prawns.' In the autumn they all disappear from our waters, and I suppose go southward or else into deeper water. As Prawns and Shrimps die very soon after being taken from the water, they cannot be sent fresh to any distance. They are used both as food and bait."

According to Stimpson, *Penæus brasiliensis* "is often found in brackish water, and even ascends streams to points where the water is nearly or quite fresh. It was thus found in the Croton River at Sing Sing, New York, by Professor Baird, and by myself in a fresh-water creek near Somers Point, New Jersey." From these places it ranges southward to Brazil, and is found more or less continuously along the Southern Atlantic coast, and the Gulf coast to Mexico. *Penæus setiferus* has not been recorded from north of Norfolk, Virginia, but thence southward its range corresponds with that of *P. brasiliensis*, at least so far as regards the coast of the United States.

Mr. T. E. Fisher, of Fernandina, Florida, who has been interested in the Shrimp industry at that place for several years, furnishes the following notes regarding the Shrimps and Prawns, which he distinguishes from one another in the same way as Professor Gibbes: "It is my belief that the Shrimp (smaller individuals) move out into deeper water at the beginning of winter and there remain until about the full moon in March or thereabouts, when they return to the bays and rivers in great quantities as 'Prawns' and ascend the rivers and creeks, I think, to spawn. This is the time when they are taken as food. After spawning, or about May or June, they return to the sea. From May to August the so-called Shrimp, which then appear, are quite small and used principally as fish bait; from August to December they grow quite rapidly. September and October are the best shrimping months of the season, and May and June are the only months when Shrimp are scarce, excepting during the colder months of winter, when they leave the coast for a time." The seasons on the coasts of South Carolina and Eastern Florida, therefore, nearly correspond, excepting that in Florida, the climate being milder, the Shrimp remain upon the coast much later in the season or nearly all winter. Mr. Silas Stearns, of Pensacola, Florida, writes that "Shrimp are abundant on all parts of the Gulf coast, and especially so in the region of Louisiana and Texas. They live on the grassy or sandy flats, and among the weeds on the bottoms of bayous and lagoons, in both salt and brackish water. On the Florida coast they are found throughout the summer months, and appear to breed in the spring or early summer. In the fall they make up in schools, and seem bent on migratory movements. At this time a few are taken in seines and sold to the restaurant keepers of the cities. On the Louisiana and Texas coasts the habit of schooling is much more common, and as the Shrimp

are very abundant at all times during warm weather, they can be profitably caught for the market. Barrataria Bay, of the Louisiana coast, and Galveston and Matagorda Bays, of the Texas coast, are notable places for the shrimp fishery. The fact that these bays afford unusually good feeding grounds and hiding places for the Shrimp will undoubtedly explain their great abundance there. Shrimp of marketable size average about four inches in length. Their color tends to imitate that of the bottom on which they dwell. New Orleans and Galveston are the only cities of the Gulf coast which engage in the shrimp trade."

227. THE MANTIS SHRIMPS—SQUILLIDÆ.

The Mantis Shrimp, or Sea Mantis—Squilla empusa, Say.

"The *Squilla empusa* is a very interesting creature, whose habits are still imperfectly known. It is often thrown on the beaches by the waves, and probably it usually burrows in the mud below low-water mark, but in certain localities it has been found burrowing at or near low-water mark of spring tides, forming large, irregular holes. The very curious, free-swimming young were often taken in the towing-nets. Large specimens are eight or ten inches long and about two broad. The body is not so stoutly built as that of the Lobster, and the carapax or shell is much smaller and softer, while the abdomen is much larger and longer in proportion. The legs and all the other organs are quite unlike those of the Lobster, and the last joint of the great claw, instead of forming a pair of pincers with the next, is armed with a row of six sharp, curved spines, which shut into corresponding sockets, arranged in a groove in the next joint, which also bears smaller spines. By means of this singular organ they can hold their prey securely, and can give a severe wound to the human hand, if handled incautiously. It also uses the stout caudal appendages, which are armed with spines, very effectively. The colors of this species are quite vivid, considering its mud-dwelling habits. The body is usually pale green or yellowish green, each segment bordered posteriorly with darker green and edged with bright yellow; the tail is tinged with rose and mottled with yellow and blackish; the outer caudal lamellæ have the base and spines white, the last joint yellow, margined with black; the inner ones are black, pale at base; the eyes are bright emerald-green; the inner antennæ are dark, with a yellow band at the base of each joint; and the flagellum is annulated with black and white."[1]

This species of *Squilla* ranges from Cape Cod to Florida, but from its habit of remaining most of the time in its burrows it is not very commonly known or met with on the sea-shore, though it is probably very abundant in some localities.

"The Mediterranean species of *Squilla* are generally found at considerable depths; they live in sandy places, where they can easily procure their food, which seems to consist chiefly of annelids and fragments of the *Actinia effæta*. According to Risso, the females when they wish to deposit their eggs, which they have under their abdominal appendages, retire to rocky places. The *Squillæ* are timid, avoiding danger; they swim much after the fashion of Lobsters."[2] In Europe wherever *Squilla* can be found in sufficient numbers it is much esteemed as food, and the American species would probably be as wholesome. On the shores where it abounds it might easily be obtained by digging, and from deeper water by means of the rake dredge.

Two other species of *Squilla*—*Squilla dubia* and *Lysiosquilla glabriuscula*—also occur on the coasts of the Southern States, where one or more of these three species are said to be used as bait to some extent.

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[1] Verrill: Vineyard Sound Report, 1871–'72.

[2] White: Popular History of the British Crustacea, 1857.

228. THE AMPHIPODS.

THE BEACH FLEAS, OR SAND FLEAS—ORCHESTIA AGILIS, Smith; SCUDS—GAMMARUS LOCUSTA, Gould; AND ALLIED FORMS.

The extensive group of *Amphipoda*, to which these species belong, consists entirely of small aquatic animals which, although not of direct importance from an economical point of view, still serve an important purpose in the general economy of nature, and deserve at least some mention here. Besides serving as food for fish, many of the species act as scavengers on the sea-shore, and, despite their small size, are, from their great numbers, able to dispose of a large quantity of dead refuse matter. Some of the species live entirely in the water, while others are exposed to the air during low tide, or even most of the time. The experiment of utilizing these small creatures in the preparation of skeletons for anatomical purposes has been tried with much success. Fish, cleaned of the bulk of their flesh, have been fastened to boards and anchored just below the surface of the water, near the docks in Eastport Harbor, and within the space of a few hours nothing but the bones remained, being cleaned as completely as by any other process, and with but little expenditure of time on the part of the naturalist. Several species upon our coast are abundant enough to act in unison in this way. Some of the deep-water species are as destructive to dead animal matter as are those which live near the shore. The cod and halibut fishermen often suffer from their depredations, as several of the deep-water Amphipods quickly attack the fish which die after being caught on the trawl lines before they are hauled up. The gills of the fish appear to be first devoured, but within a few hours they are able to eat out the entire muscular and visceral matter, leaving only the bones and skin. Cod and hake frequently die upon the trawls, and are thus destroyed, but halibut are more hardy and are seldom much injured.

The number of species of Amphipods upon our coast is very large, but we need refer here to only two or three species to illustrate their principal characteristics.

"These small crustacea are of great importance in connection with our fisheries, for we have found that they, together with the Shrimps, constitute a very large part of the food of most of our more valuable edible fishes, both of the fresh and salt water. The Amphipods, though mostly of small size, occur in such immense numbers in their favorite localities that they can nearly always be easily obtained by the fishes that eat them, and no doubt they furnish excellent and nutritious food, for even the smallest of them are by no means despised or overlooked even by large and powerful fishes that could easily capture larger game. Even the voracious bluefish will feed upon these small crustacea where they can be easily obtained, even when menhaden and other fishes are plenty in the same localities. They are also the favorite food of trout, lake white-fish, shad, flounders, scup, etc., as will be seen from the lists of the animals found in the stomachs of fishes. *One species, which occurs in countless numbers beneath the masses of decaying seaweeds* thrown up at high-water mark on all the shores by the waves, is the *Orchestia agilis* Smith, which has received this name in allusion to the extreme agility which it displays in leaping when disturbed. The common name given to it is 'Beach-flea,' which refers to the same habit. Its color is dark olive green or brown, and much resembles that of the decaying weeds among which it lives, and upon which it probably feeds. It also constructs burrows in the sand beneath the vegetable *débris*. It leaps by means of the appendages at the posterior end of the body.

"A much larger species, and one of the largest of all the Amphipods, is the *Gammarus locusta*, which occurs in great numbers beneath the stones and among the rock-weed near low-

water mark. The males are much larger than the females, and sometimes become nearly an inch and a half long. They cannot leap like their cousins that live at high-water mark, but skip actively about on their sides among the stones and gravel until they reach some shelter or enter the water, when they swim rapidly in a gyrating manner back downward or sideways. But although they can swim they are seldom met with away from the shore or much below low-water mark. The zone of *Fucus* is their true home. This species is abundant on all our shores, wherever rocks and *Fucus* occur, from Great Egg Harbor, New Jersey, to Labrador. Its color is generally olive-brown or reddish-brown, much like that of the *Fucus* among which it lives. The only good English name that I have ever heard for these creatures is that of 'Scuds,' given by a small boy, in reference to their rapid and peculiar motions. . . . Two other related species, of larger size and paler colors, but having the same habit of leaping as the *Orchestia*, though not in such a high degree, occur among the weeds, or burrowing in the sand, or beneath drift-wood, etc., a little below high-water mark. In fact, the sand is sometimes completely filled with their holes, of various sizes. Both these species are stout in form, and become about an inch long when mature. One of them, *Talorchestia longicornis*, can be easily distinguished by its very long antennæ; the other, *T. megalophthalma*, by its shorter antennæ and very large eyes. Both these species are pale grayish, and imitate the color of the sand very perfectly. When driven from their burrows by unusually high tides or storms they are capable of swimming actively in the water. They make dainty morsels for fishes and many shore birds, as well as for certain Crabs, especially *Ocypoda arenaria*."[1]

THE BORING AMPHIPOD—CHELURA TEREBRANS, Phillipi.

This very destructive little crustacean, which is of common occurrence on the European coast, from Southern Norway to the Adriatic Sea, has so far been noticed on the Atlantic coast of the United States at only two places, Wood's Holl and Provincetown, Massachusetts. At both of these localities it was found associated with the "Gribble" (*Limnoria lignorum*), in the submerged piles of old wharves. It is more than possible, however, that it is a common inhabitant of our coast, doing a certain amount of the damage hitherto ascribed to other boring animals. Without a careful examination, it is quite easy for an unskilled eye to confound *Chelura* with *Limnoria*, although they belong to very distinct divisions of the *Crustacea*.

The main characteristics of this animal by which it may be distinguished from all the other Amphipods, as well as crustaceans, are the three pairs of caudal stylets, the last pair being nearly as long as the body proper of the males, although much shorter in the females and young. As to color, the body is semitranslucent and thickly spotted and mottled above with pink.

Professor Allman, of England, who has studied living specimens, describes the habits of this species as follows:[2]

"*Chelura terebrans* is an active little animal, swimming on its back and employing its thoracic legs to adhere to the timber which it has selected for its ravages. . . . Its habits are truly xylophagous, and it excavates the timber not merely for the purpose of concealment, but with the object of employing it as food, which is apparent from the fact that the alimentary canal may be found on dissection filled with minutely comminuted ligneous matter. . . . Timber which has been subject to the ravages of *Chelura* presents a somewhat different appearance from that which has been attacked by *Limnoria lignorum*. In the latter we find narrow cylindrical burrows running deep into the interior, while the excavations of *Chelura* are

[1] VERRILL: Vineyard Sound Report, pp. 313, 314, 1871–'72.

[2] Ann. and Mag. Nat. Hist., xix, p. 361, 1847.

considerably larger and more oblique in their direction, so that the surface of the timber thus undermined by these destructive animals is rapidly washed away by the action of the sea, and the excavations are exposed in the greater part of their extent, the wood appearing plowed up, so to speak, rather than burrowed into. Upon the whole, *Chelura* would seem to be a still more destructive creature than even *Limnoria*."

229. THE ISOPODS.

THE GRIBBLE, OR BORING LIMNORIA—LIMNORIA LIGNORUM, White.

This little crustacean pest, which measures less than one-fifth of an inch in length, is a very common habitant of our Atlantic coast from the Gulf of Saint Lawrence to Florida, and also occurs abundantly on the coasts of Great Britain and of other parts of Europe. In spite of its small size, it is very destructive to all kinds of submarine wood-work, which it rapidly eats away. Its body, which is subcylindrical in shape, consists of fourteen segments, the anterior one being the head; the two ends are rounded and the sides are nearly straight and parallel to one another. The first seven segments, not including the head, bear each a pair of short legs. It makes its burrows by means of stout mandibles or jaws. In color it is grayish, the upper surface of the body being covered with minute hairs, to which more or less dirt usually adheres.

The Gribble generally lives above and just below low-water mark, but has been found at times, though very rarely, as low down as seven to ten fathoms. It gnaws burrows into all sorts of sunken or floating wood near the shore, and lumber or drift-wood left for some time on muddy shores is pretty certain to be attacked by it. The burrows are made to a depth of about half an inch, and when they become numerous enough to reduce the superficial layer of wood to a mere honeycomb, it scales off, leaving a fresh surface, which is at once attacked. Much damage is done by this little creature to the piles of wharves and other submarine wood-work all along our Atlantic coast, and numerous methods of stopping its ravages have been devised. It has been observed attacking the gutta percha of submarine telegraph cables. Professor Verrill describes its habits and the damage it has done on the American coast, as follows:[1]

"It has the habit of eating burrows for itself into solid wood to the depth of about half an inch. These burrows are nearly round, and of all sizes up to about a sixteenth of an inch in diameter, and they go into the wood at all angles and are usually more or less crooked. They are often so numerous as to reduce the wood to mere series of thin partitions between the holes. In this state the wood rapidly decays, or is washed away by the waves, and every new surface exposed is immediately attacked, so that layer after layer is rapidly removed, and the timber thus wastes away and is entirely destroyed in a few years. It destroys soft woods more rapidly than hard ones, but all kinds are attacked except teak. It works chiefly in the softer parts of the wood, between the hard, annual layers, and avoids the knots and lines of hard fiber connected with them, as well as rusted portions around nails that have been driven in, and consequently, as the timbers waste away under its attacks, these harder portions stand out in bold relief. Where abundant it will destroy soft timber at the rate of half an inch or more every year, thus diminishing the effective diameter of piles about an inch annually. Generally, however, the amount is probably not more than half this, but even at that rate the largest timbers will soon be destroyed, especially when, as often happens, the *Teredos* are aiding in this work of destruction. It lives in a pretty narrow zone, extending a short distance above and below low-water mark. It occurs all

[1] Vineyard Sound Report, pp. 379, 380, 1871–'72.

along our shores, from Long Island Sound to Nova Scotia. In the Bay of Fundy it often does great damage to the timbers and other wood-work used in constructing the brush fish-weirs, as well as to the wharves, etc. At Wood's Holl it was found to be very destructive to the piles of the wharves. The piles of the new government wharves have been protected by broad bands of tin-plate covering the zone which it chiefly affects. North of Cape Cod, where the tides are much greater, this zone is broader, and this remedy is not so easily applied. It does great damage also to ship timber floating in the docks, and great losses are sometimes caused in this way. Complaints of such ravages in the navy-yard at Portsmouth, New Hampshire, have been made, and they also occur at the Charlestown navy-yard and in the piles of the wharves at Boston. Probably the wharves and other submerged wood-work in all our sea-ports, from New York northward, are more or less injured by this creature, and, if it could be accurately estimated, the damage would be found surprisingly great.

"Unlike the *Teredo*, this creature is a vegetarian, and eats the wood which it excavates, so that its boring operations provide it with both food and shelter. The burrows are made by means of its stout mandibles or jaws. It is capable of swimming quite rapidly, and can leap backward suddenly by means of its tail. It can creep both forward and backward. Its legs are short and better adapted for moving up and down in its burrow than elsewhere, and its body is rounded, with parallel sides, and well adapted to its mode of life. When disturbed it will roll itself into a ball. The female carries seven to nine eggs or young in the incubatory pouch at one time.

"The destructive habits of this species were first brought prominently to notice in 1811, by the celebrated Robert Stephenson, who found it rapidly destroying the wood-work at the Bell Rock light-house, erected by him on the coast of Scotland. Since that time it has been investigated and its ravages have been described by numerous European writers. It is very destructive on the coasts of Great Britain, where it is known as the 'Gribble.'

"The remedies used to check its ravages are chiefly copper or other metallic sheathing; driving broad-headed iron nails, close together, into the part of the piles subject to their attacks; and applying coal-tar, creosote, or verdigris-paint, once a year or oftener."

THE SALVE BUG—ÆGA PSORA, Kröyer.

This is the largest species of Isopod living upon the New England coast, and attains a length of two inches and a breadth of one inch. It occurs as a parasite on the cod and halibut. In addition to its large size, when adult, it may be readily distinguished by its large eyes, which nearly cover the upper surface of the head, and approach closely together at their anterior extremities. The first three pairs of legs are adapted for clinging to the surface of the fish on which it lives. The body is oval, and broadest just in front of the middle. The Salve Bugs are used as an unguent by the fishermen, who sometimes collect them in large quantities.

230. THE ENTOMOSTRACANS.

This order of crustaceans includes a vast number of small, generally minute, free-swimming forms, frequently called water-fleas, which abound in both fresh and salt waters, and other and generally larger species which occur as parasites on fish and other aquatic animals. The former serve as an important article of food for many fishes, such as the menhaden and mackerel, while the latter are frequently injurious to them, being often strangely modified, and burrowing deeply into the flesh, from which they suck the juices, causing great irritation and at times perhaps death.

231. THE CIRRIPEDIA.

THE BARNACLES—BALANUS EBURNEUS, Gould, AND ALLIED SPECIES.

Several species of Barnacles (which belong to the natural group of *Crustacea*, despite the hard, mollusk-like shell of most of the species) occur upon our coast and serve as food for some of our fishes, but it is mainly their intrusion upon certain of the marine industries that gives them a place in this volume. A large species of Barnacle, *Coronula diadema*, Linné, growing upon the skin of one or more species of whales, is eaten to some extent by the west coast Indians.

In one group of Barnacles the animals are furnished with a fleshy stem or peduncle, by means of which they remain permanently attached to floating objects in the sea. The species of this group bear the general name of "Goose Barnacles." Our commonest species is the *Lepas fascicularis*. The other group of Barnacles, represented upon our coast by the "Rock Barnacle" (*Balanus balanoides*), "Ivory Barnacle" (*Balanus eburneus*), and other species, has no peduncle, but the several valves forming the conical shell are attached directly and permanently to the rocks or wood on which they happen to dwell. Some of the species of both groups grow upon the hulls of ships below the water-line, and in connection with seaweed and other species of marine animals cause the so-called fouling of the bottom, necessitating constant cleaning and scraping of the bottoms of vessels at considerable expense. Barnacles also stand as a serious obstacle in the way of oyster culture, as shown by the recent experiences of the United States Fish Commission. They grow with exceeding rapidity, very much faster than the oyster, and are so hardy as to defy any attempts at extermination. In the spring of 1880, when the experiments in the artificial breeding of oysters were being carried on in Chesapeake Bay, slates coated with plaster were used as collectors. To these the oyster embryos attached themselves in large numbers, and began their growth with good promises of success; but at the same time embryos of the Ivory Barnacle were fully as abundant in the water, and, attaching themselves in even greater numbers, rapidly outgrew the less hardy oysters. In many places they completely crowded the oysters out of place, and soon occupied entire surfaces. In other places, however, they were less numerous and interfered less with the oyster growths. It is very certain that this inconvenience must always remain as a certain check on all oyster-cultural experiments on our coast, and must seriously interfere with any attempts at artificial oyster-breeding. It is to be hoped, however, that future experiments will prove that the Ivory Barnacle cannot entirely destroy the profits of such an important industry, which, in consideration of the greatly impoverished character of some of our formerly rich oyster regions, it is very necessary should be started at once, and, if possible, carried to a high state of perfection.

The Ivory Barnacle ranges from Massachusetts Bay to Florida and the West Indies, while the Rock Barnacle inhabits the entire North Atlantic coasts of both continents. The habitats of our common species are given as follows by Professor Verrill:

"The common Barnacle of the rocky shores, *Balanus balanoides*, is also common on the piles of wharves and bridges, between tides, and also on the bottoms of vessels, etc. It never grows very large, although it may become so crowded together as to form a continuous crust. It is easily distinguished from the other species by its membranous base, which never forms a solid plate like that of the other species. The 'Ivory Barnacle,' *Balanus eburneus*, is also common on all kinds of submerged wood-work, whether fixed or floating. It is usually abundant on the piles and timbers of wharves, buoys, oyster-stakes, bottoms of vessels, etc. It is chiefly found below low-water mark if on fixed objects, and is even more common in the brackish waters of estuaries than in the purer waters outside, and it is capable of living even in pure, fresh water, for Prof.

Jeffreys Wyman has sent me specimens collected by himself about sixty-five miles up the Saint John's River, in Florida, where the water is not at all brackish. This species is sometimes found adhering to the carapax of Crabs, the shell of *Limulus*, and various mollusks. It is easily distinguished from most species on account of its low, broad form and its smooth, white exterior. It has a shelly base. The *B. crenatus*, common on shells and stones in deep water, also occurs on vessels. Other species are often found on the bottoms of vessels that have come from warmer latitudes. Some of them are of large size. One of the most frequent of these is *Balanus tintinnabulum*."

232. THE XIPHOSURA.

THE HORSESHOE CRAB—LIMULUS POLYPHEMUS, Latreille.

The curious form of marine animal called "Horseshoe Crab," "King Crab," and "Horse foot," ranges along our entire Atlantic coast, from Casco Bay, Maine, to Mexico, and gives rise to an important industry in at least one region—Delaware Bay. It is not, however, a true Crab, and its exact position in the animal kingdom is still involved in much obscurity. Some naturalists regard it as a low type of crustacean, while others place it among the *Arachnida*, or scorpions and spiders. Its nearest allies all occur as fossils, through many geological ages down to nearly the oldest of the fossiliferous series. Another species of the same genus, however, still lives upon the eastern coast of Asia.

The carapax of the King Crab is very large, with a regularly rounded outer margin, terminating in a spine at the posterior angles on both sides. The abdomen is much smaller, and from its hinder end, to which it is jointed, runs out a long, tapering spine. The basal portions of the feet on the lower side of the carapax serve as masticating organs.

The King Crab is sluggish in its movements, and spends much of its time more or less buried in the mud and sand of shallow water, coming up occasionally to high-water mark. It is most abundant on the muddy bottoms of shores and estuaries, where it burrows just beneath the surface, and feeds upon various small animals.

"At the breeding season, however, it comes up on the sandy shores to deposit the eggs, near high-water mark. According to the statements of Rev. S. Lockwood, the spawning is done at the time of high tides, during May, June, and July; they come up in pairs, the males, which are smallest, riding on the backs of the females and holding themselves in that position by the short feet, provided with nippers, which are peculiar to the males. The female excavates a depression in the sand and deposits the eggs in it, and the male casts the milt over them, when they again return to deeper water, leaving the eggs to be buried by the action of the waves. In aquaria, under favorable circumstances, the eggs hatch in about six weeks, but in their natural conditions they probably hatch sooner than this; under unfavorable conditions the hatching may be delayed for a whole year. The eggs are very numerous."[1]

From several intelligent observers living on the Delaware Bay side of Southern New Jersey we have received interesting notes on the habits of the King Crab, as exemplified in that region, and which may also hold good for others. While this Crab is comparatively rare on the outer side of Southern New Jersey, on the inner side, along the shores of Delaware Bay, from Cape May to Reed's Island, it is unusually abundant. It is not, however, always present in the very shallow water near shore. During the breeding season, which is mainly confined to the months of May and June, but also extends slightly into July, the males and females approach and ascend the beaches in countless numbers, the latter to lay their eggs, the former to impregnate them. It

[1] VERRILL: Vineyard Sound Report, pp. 340, 341, 1871–'72.

is not an uncommon thing for the female, as she crawls up the beach, to be accompanied by two, three, and even as many as six males, the forward one clinging to the abdomen of the female, and the remainder fastened to one another in the same manner. As a rule, however, each female brings with her only a single male. After the spawning has been accomplished, they retreat from the beach in the same order. King Crabs are not equally abundant at all times during the spawning season, but are most plentiful on the beaches during the spring tides, which occur about the times of the new and full moon. Westerly winds suit them best for spawning, and they will not come ashore in large numbers during an easterly wind. They approach with the flood tide and leave soon after the ebb. The eggs hatch in July and August, at which times the sands become literally alive with the young Crabs. These soon disappear, not to return to the shore until they have attained a considerable size. After the close of the spawning season the adult Crabs are not seen in abundance about the shore, but probably live in slight depths of water near at hand. During the winter they are often taken out in Delaware Bay by the oyster dredgers. They are very much less abundant now than formerly, on account of so many having been caught from year to year for use as a fertilizer. It would appear as though a few years more of indiscriminate capture would result in their being entirely exterminated from the region. The men catch them mainly in their hands, as they come upon the beaches, but they are also captured in pounds and weirs.

The King Crab is rarely used as food for man, but is often fed to swine and poultry, and, after drying, is extensively employed as a fertilizer. It also serves as bait for eels and some species of fish. This species of Crab has been introduced on the west coast of the United States, the young, it is supposed, having been carried over mingled with the spat of the eastern oyster, which has been largely transplanted into the shallow waters of San Francisco Bay. It has also been introduced on the European coast.

Z.—THE WORMS.

233. THE ANNELIDS.

THE MARINE WORMS, BAIT WORMS, ETC.—NEREIS VIRENS, SARS, AND ALLIED SPECIES.

Marine Worms of many different kinds occur in great abundance along the entire Atlantic and Pacific coasts of the United States, and are available as bait, for which purpose a few species are frequently employed by both professional and amateur fishermen. They are generally easily obtained by digging with a spade or trowel into sandy or muddy shores, but are not common on exposed beaches of clear sand. They usually require for their existence a greater or less admixture of mud, gravel, and organic matter, the latter to serve as food. Shores which furnish the common clam (*Mya arenaria*) usually abound in Marine Worms of several varieties, which are overturned in digging for that mollusk. So far as we know, there is no regular trade in this marine product on any part of our coast; but occurring as they do within the convenient reach of most of the shore fishermen, these Worms may be obtained at short notice, and deserve mention here as forming an element of some importance in our marine fisheries. The following account of the habits of Marine Worms in general and of some of our commoner species is extracted from the report of Prof. A. E. Verrill:[1]

"The Marine Worms or Annelids are very numerous under the rocks between tides, and concealed beneath the surface of the gravel and mud that accumulates between and beneath the stones and in crevices. Many kinds also live in the pools, lurking among the roots of the algæ, burrowing in the bottom, or building tubes of their own in more exposed situations. Many of these Annelids are very beautiful in form and brilliant in color when living, while most of them have curious habits and marvelous structures. Several species are of large size, growing to the length of one or two feet. Some are carnivorous, devouring other worms and any other small creatures that they can kill by their powerful weapons; others are vegetarians; but many are mud-eaters, swallowing the mud and fine sand in great quantities, for the sake of the animal and vegetable organisms that always exist in it, as is the case with clams and most of the bivalve shells and many other kinds of marine animals.

"All these Annelids are greedily devoured by most kinds of marine fishes, whenever they can get at them, and, since many of the Annelids leave their burrows in the night to swim at the surface, or do this constantly at the breeding season, they make an important element in the diet of many fishes besides those that constantly root for them in the mud and gravel, like the tautog, scup, haddock, etc. The young of nearly all the Annelids also swim free in the water for a considerable time, and in this state are doubtless devoured in immense numbers by all sorts of young and small fishes.

"One of the largest and most common Annelids found under rocks, burrowing in the sand and gravel, is the *Nereis virens*. It lives both at low-water mark and at a considerable distance farther up. It grows to the length of eighteen inches or more, and is also quite stout in its proportions. The color is dull greenish, or bluish-green, more or less tinged with red, and the surface reflects bright iridescent hues; the large lamellæ or gills along the sides are greenish

[1] Vineyard Sound Report, pp. 317, 318, 341, 342, 1871–'72.

anteriorly, but farther back often become bright red owing to the numerous blood-vessels that they contain. It is a very active and voracious Worm, and has a large, retractile proboscis, armed with two strong, black, hook-like jaws at the end, and many smaller teeth on the sides. It feeds on other Worms and various kinds of marine animals. It captures its prey by suddenly thrusting out its proboscis and seizing hold with the two terminal jaws; then withdrawing the proboscis, the food is torn and masticated at leisure, the proboscis, when withdrawn, acting somewhat like a gizzard. These large Worms are dug out of their burrows and devoured eagerly by the tautog, scup, and other fishes. But at certain times, especially at night, they leave their own burrows, and, coming to the surface, swim about like eels or snakes, in vast numbers, and at such times fall an easy prey to many kinds of fishes. This habit appears to be connected with the season of reproduction. They were observed thus swimming at the surface in the daytime, near Newport, in April, 1872, by Messrs. T. M. Prudden and T. H. Russell, and I have often observed them in the evening later in the season. At Watch Hill, Rhode Island, April 12, I found great numbers of the males swimming in the pools among the rocks at low water, and discharging their milt. This Worm also occurs in many other situations, and is abundant in most places along sandy and muddy shores, both of the sounds and estuaries, burrowing near low-water mark. It occurs all along the coast from New York to the Arctic Ocean, and is also common on the northern coasts of Europe.

"With the last, in this region and southward, another similar species, but of smaller size, is usually met with in large numbers. This is the *Nereis limbata*. It grows to the length of five or six inches, and can easily be distinguished by its slender, sharp, light amber-colored jaws, and by the lateral lamellæ, which are small anteriorly and narrow or ligulate posteriorly. Its color, when full grown, is usually dull brown, or smoky brown or bronze-color anteriorly, with oblique light lines on the sides, and often with a whitish border to each of the rings, which form narrow, pale bands at the articulations; posteriorly the body and lateral appendages are pale red, and the longitudinal dorsal bloodvessel is conspicuous.

"Annelids are quite numerous on the sandy shores where the conditions are favorable. It is evident that these soft-bodied creatures would be quickly destroyed by the force of the waves and the agitation of the sand were they not provided with suitable means for protecting themselves. This is effected mainly in two ways: the sand-dwelling species either have the power of burrowing deeply into the sand with great rapidity, or else they construct long, durable tubes, which descend deeply into the sand and afford a safe retreat. Many of the active burrowing species also construct tubes, but they usually have but little coherence and are not very permanent, nor do they appear to be much relied on by the owners. There is, however, great diversity both in the structure and composition of the tubes of different species, and in the modes by which the rapid burrowing is effected.

"The large green *Nereis* (*N. virens*) is found on the sandy shores in places that are somewhat sheltered, especially if there be an admixture of mud or gravel with the sand to give it firmness and solidity. This species burrows deeply beneath the surface and lines the interior of its large irregular burrows with an abundant mucus-like secretion, which gives smoothness and some coherency to the walls, but does not form a solid tube. With this, and in greater numbers, the smaller species, *Nereis limbata*, is also found, and its habits appear to be essentially the same. Both this and the preceding can burrow rapidly, but much less so than some other worms, and consequently they are not well adapted to live on exposed beaches of moving sands, but prefer coves and harbors. The two large species of *Rhynchobolus* are much better adapted for rapid burrowing. Their heads are very small and acute, and destitute of all appendages, except four

minute tentacles at the end; the body is long, smooth, and tapers gradually to both ends, and the muscular system is very powerful, and so arranged as to enable these Worms to coil themselves up into the shape of an open spiral, like a corkscrew, and then to rapidly rotate themselves on the axis of the spiral. When the sharp head is inserted into the loose mud or sand and the body is thus rotated, it penetrates with great rapidity and disappears almost instantly. Both these species are found on sandy as well as on muddy shores and flats near low-water mark, and also in deeper water. The one usually most abundant is *R. dibranchiatus*. This is readily distinguished by having a simple gill both on the upper and lower sides of the lateral appendages. The other, *R. americanus*, has gills that are more or less branched on the upper side of the appendages, but none on the lower side; the appendages are also longer, especially posteriorly, and differently shaped. The proboscis is remarkably long and large, and when fully protruded it shows four large, black, sharp, fang-like jaws or hooks. Both these Worms are destitute of true bloodvessels, such as most of the allied Worms possess, but have the general cavity of the body filled, between the various organs, with bright red blood, which shows through the skin, giving a more or less red or purple color to the whole body and proboscis."

The principal species of marine Worms which are used as bait are the *Nereis virens*, *Nereis limbata*, *Diopatra cuprea*, *Arenicola marina*, *Clymenella torquata*, *Marphysa sanguinea*, *Arabella opalina*, and *Rhynchobolus dibranchiatus*.

The Earth Worm might also be mentioned in this connection, as it is likewise very commonly used as a fish-bait, especially in fresh waters. All sportsmen, from boyhood up, are acquainted with this simple form of bait, which is more easily obtained than any other. Large quantities are used annually, but no statistics can ever exist to determine the amount, which is irregularly distributed over the country.

234. THE LEECHES.

The American medicinal Leech—Macrobdella decora, Verrill.

Structure of Leeches.—In the true Leeches, which belong to the order *Hirudinea*, the body is flattened, divided into numerous short and indistinctly marked segments, and bears neither bristles nor appendages of any kind. The head is small, with five pairs of minute, simple eyes, and each end of the body terminates in a sucker. "The mouth is armed internally with three pharyngeal teeth arranged in a triradial manner, so that the wound made in the flesh of persons to whom the Leech is applied consists of three short, deep gashes radiating from a common center." The stomach is large, and the nervous system consists of a "brain" and ventral cord. The Leech is hermaphroditic. The eggs, which range from six to fifteen in number, are contained in a sort of spongy, slimy cocoon, from half an inch to an inch in diameter. These are deposited near the water's edge and hatched by the heat of the sun. Respiration in the Leeches is carried on through small apertures arranged along the under surface of the body. The Leech swims with a vertical undulatory motion and moves both in and out of the water by means of its suckers, fastening itself first by one and then by the other, and alternately stretching out and contracting its body.

There are two or three species of Leeches, known as medicinal Leeches, which afford the most convenient means of drawing blood from the human body. They have been used by physicians for this purpose for many years, and have given rise to a very extensive and profitable trade. One of the species belongs to North America.

Distribution and structure of the American Leech.—Although numerous species of Leeches abound in the fresh waters of the United States and are related to the fisheries in various ways,

this region has so far afforded only a single species of true blood-sucking Leech, the *Macrobdella decora* of Verrill. This is, therefore, the only known Leech in our country of economic value. It is very widely distributed in the Northern United States, and was at one time quite extensively used by physicians. Being somewhat inferior in quality to the European Leeches, however, it has, since they have begun to import the latter regularly into this country, ceased to be considered as an officinal Leech excepting in a few places.

The American Leech has, according to Professor Verrill, a large, stout, and broad body, which is considerably compressed throughout. It is strongly annulated, and in extension is much elongated, gradually tapering anteriorly. The larger specimens measure twelve inches or more in length, and have a breadth of upwards of an inch. The head is rounded in front, and is furnished with three stout and prominent maxillæ, having the outer edge denticulate with numerous acute teeth. The eye-spots are ten in number. The breeding season is in the spring. The color above is a dark livid brown or olive green, with a median dorsal row of about twenty to twenty-two bright or pale red spots, which are sometimes obsolete, and a row of rounded black spots near each margin, corresponding in number, and nearly in size, with the red ones. The lower surface is a bright or dark orange red or reddish brown, sometimes with black spots near the margin. "This species is very common, and widely diffused in the fresh waters of the Northern United States. Its range northward and southward is unknown. It is the only true blood-sucking Leech known from the Northern States. It is capable of drawing blood from the human skin, but ordinarily subsists upon fishes, frogs, and tadpoles. It often attaches itself to the throat, and speedily kills them, even when of considerable size."[1]

While the American Leech sometimes attains a length of twelve inches, four to five inches is the average adult size, and the majority of those sold in the shops measure only two to three inches. American Leeches are now seldom used by physicians. The foreign species are so easily obtained, so cheap, and so much more reliable in the majority of cases, that they are now given the preference nearly everywhere. The American Leech was formerly extensively employed, before they began to import the foreign species, and even for some time afterwards, in consequence of the continued high price of the latter. With the gradual decline in the practice of leeching the import trade in Leeches has also fallen off from year to year, the imports for the past few years being less than half those for 1856, and the price about one-fourth what it was then.

Cultivation and economic value of the American Leech.—Attempts have been made to breed and raise the American Leech in artificial ponds after the plan pursued in Europe, but always without success. The Leeches in these inclosures have never thrived well, and, in addition, the slight demand for them has tended to render all the attempts in this direction decidedly unprofitable. Mr. Herman Witte, of New York, has perhaps experimented more extensively in leech-culture in this country than any other person. His ponds, constructed very much like those in France, to be described further on, are located between Winfield and Newtown, Long Island, New York. They are five in number and cover an area of over fifteen acres. At present they serve merely as preservative ponds for surplus supplies of imported Leeches. Other artificial ponds have been started in the State of New Jersey and near Saint Louis, Missouri, but they were all speedily given up. Turtles, snakes, birds, and insects were said to have destroyed great quantities of the Leeches and discouraged operations. American Leeches, when they were in common use, were probably collected to a greater or less extent in most of the regions where they were employed. Eastern Pennsylvania, Bucks and Berks Counties especially, seems, however, to have furnished the principal collecting ground, in past times as at present. Numerous ponds in

[1] VERRILL: Report, U. S. Fish Commissioner for 1872–'73, p. 669.

Eastern Massachusetts, including the southern part of Cape Cod, were formerly noted for the large numbers of Leeches they contained, and during the early part of this century many Leeches were collected from them for medicinal purposes. Philadelphia is now the only large city where American Leeches are used by physicians, who prefer them to the European for certain kinds of treatment. The latter Leech is the more powerful, and extracts the most blood. According to the statements of Philadelphia leechers, about four American Leeches are required to do the work of one European, and the chief merit of the former arises from the fact that they can be used more freely and with less danger to the patient, and can also be employed on the more delicate parts of the body, where the European Leech would act too vigorously. They are especially recommended for the region about the eye, and several are sometimes used, distributed over a wider space, when it is thought best not to extract the blood from a single spot by the aid of an imported specimen. The American Leech does not attach itself as readily as the foreign, and often several specimens have to be tried before one can be found to fasten itself. They bite much less readily out of water than in. The bites of the two Leeches are different; that of the European being deeper and more pronounced and bleeding much longer after the Leech has been detached. The wound of the American Leech generally closes very soon after the Leech has been released, and sometimes immediately.

The European Leech.—The European Leech belongs to a different genus from our own, *Hirudo*, and by some authorities is considered to constitute two distinct species, *H. medicinalis*, the Gray Leech, and *H. officinalis*, the Green Leech. By others the Green Leech and Gray Leech are placed in the one species, *H. medicinalis* of Linnæus. "They are both marked with six longitudinal dorsal ferruginous stripes, the four lateral ones being interrupted or tesselated with black spots. The color of the back varies from a blackish to a grayish green. The belly in the first variety is of a yellowish color, free from spots, and bordered with longitudinal black stripes. In the second it is of a green color, bordered and maculated with black. This Leech varies from two to four inches in length. It inhabits marshes and running streams, and is abundant throughout Europe."

Prior to thirty years ago nearly all the northern countries of Europe contained Leeches, but most of the supplies came from Sweden, Russia, Poland, and Hungary. The swampy regions in which they lived were drained from time to time, for one reason and another, until finally vast areas which had once been profitable became dried up, to the almost entire destruction of the Leeches. Then, and for the first time was the extent of the injury fully realized over all Europe, and strenuous efforts were made to remedy the evil. Several governments, including the French, Prussian, and Hanoverian, offered premiums for successful results in leech-culture, but these efforts were rewarded only in the former country. At present the larger share of the Leeches used in Europe and this country come from the artificial ponds or meadows of Southern France, although many are also raised in Hungary and in other countries of Southern Europe. Paris is the principal receiving center, whence they are sent to England, to the English colonies, and the United States. The export trade to South America and the West Indies is largely carried on through the United States.

Leech culture.—The localities selected for leech-raising are swampy meadows, where the bottom is more or less firm and solid. A certain area having been chosen, it is divided into rectangular plots of different sizes by means of ditches. The breeding season is in June and July. At this time water is admitted only into the ditches, the meadow flats remaining dry. The eggs are laid in the loose, swampy soil at the margins of the ditches, and when the young creep out about six weeks, more or less, afterwards, the meadows are overflowed artificially to a

depth of six to eight inches. Before the young appear, however, as many of the old ones as possible are caught and transferred to other places. Otherwise they would consume too much of the food required for the young. The young Leeches are fed upon the blood of living animals, horses, cattle, etc., which are driven into the shallow water about twice a week and allowed to remain a certain length of time. The Leeches attach themselves merely to the feet, but find in those portions of their prey enough sustenance to cause them to grow rapidly and quickly attain the required size. Fresh blood obtained from the slaughter-houses and deprived of its fibrine by agitation is also supplied to them, or they are placed in it, while it is still warm, for a short time. The feeding is carried on principally in September and October, and again in April and May. During the winter the Leeches remain torpid at the bottom.

Extravagant statements have sometimes been published as to the manner of feeding Leeches in France. It is said that many of the owners of ponds are accustomed to buy up old and diseased horses, drive them into the ponds, and allow them to be overcome by the Leeches, which fasten to all parts of the body and kill them by a slow process of torture. This may occasionally take place, but we are assured by one who has had considerable personal experience in the matter that it is by no means a common practice. The quantity of blood sucked from the feet injures the horses but little; and they are taken out in time to prevent harm. Some single breeding establishments in Southern Europe cover an area of one hundred and twenty hectares. In about three years' time, the young Leeches, without being forced in their growth, attain a good medium size and are suited to the wants of physicians. Medium Leeches are about two inches long, and weigh three and one-half to four pounds to the thousand. The large Leeches weigh about five to five and one-half pounds to the thousand, and this is the preferred size. The European Leeches are graded in the markets as small, medium, and large. Only the medium and large Leeches are used in this country. The very large ones, however, are generally considered too dangerous for use, and are kept for breeding purposes. The foreign Leeches are transported and generally stored in wooden cases or pails, containing swamp earth or mold. The American Leeches, however, are usually kept in glass vessels of water.

American Leech ponds.—Mr. Witte's ponds on Long Island, where he attempted the breeding of American Leeches, occupied about three and one-half acres each, and were divided into five compartments by ditches, like the French ponds. As before stated, his efforts were unsuccessful, or at least unprofitably rewarded. In connection with these large ponds, Mr. Witte has since constructed thirteen others of much smaller size (about twelve by fifteen feet each) for the storage and feeding of Leeches, which are generally imported in larger quantities than are required to supply the immediate demands of the trade. He has had as many as one hundred thousand Leeches in these small ponds at a time, but the number varies.

Use of Leeches.—Leeches are not now used nearly as much as formerly, and the practice of leeching is gradually declining. From year to year the imports have constantly fallen off, and the price of Leeches has rapidly decreased. Whether this will continue until the old custom of leeching is entirely replaced by other methods of treatment or not cannot be predicted. It is evident, however, that in Philadelphia the practice has greatly revived during the past few years, and the best physicians are once more advocating the application of Leeches. About ten years ago the leeching practice reached its minimum in Philadelphia, and it has remained at a low stage until very recently. A well-known Philadelphia leecher says that thirty or forty years ago many more American Leeches were used in that city than European, but during the past year he has applied only about one hundred of the former. Another leecher of the same city states that formerly he applied on an average over three thousand American Leeches a year, while now he uses but a very few.

The varieties of Leeches.—The terms "Spanish Leeches" and "Swedish Leeches" have in this country lost their distinctive meaning. We are informed by a large importer that the Spanish Leech was a small green Leech brought here occasionally, thirty or forty years ago, by sea-captains. They were inferior to other varieties, and during the past twenty years none have been brought into the country, at least not through regular importing houses. The name "Spanish Leech" is, however, still used in the trade, and we have heard it frequently referred to by cuppers and leechers, who are probably ignorant of the real sources of their supplies. As to the Swedish Leeches, they were probably the first variety brought to this country when the import trade began some fifty years ago. They then came from the country whence they derived their name. Since the beginning of leech-culture in France, this same Leech has been raised there artificially, and it is claimed that the American supplies from France are wholly of this kind. The Leeches used in England are also said to be mostly descendants of the Swedish stock raised in France. Having been shipped originally to London by way of Hamburg, they received there the name of Hamburg Leeches, which they still retain. The Leeches used almost exclusively in France come from a native stock, which is now propagated artificially. They are small and of a green color.

In the German leech trade two kinds of Leeches are recognized, one of which is called the German Leech and the other the Hungarian Leech. The former has a black-spotted belly, while in the latter the belly is uniform in color. The first is a native of Germany, where it has become rare on account of the extent to which it has been caught up. It is now raised artificially. The Hungarian Leech is imported from Hungary, whence come most of the supplies now used in Germany. Other sources of supply are the principalities of the Danube and Plagacz en Posen. The Island of Porto Rico and other islands of the West Indies are said to contain medicinal Leeches. Most of the South American countries, however, on both sides are supplied from Europe via the United States, and Mexico receives some supplies from the same source.

ZA.—THE RADIATES.

235. THE ECHINODERMS.

THE SEA CUCUMBERS, OR TREPANG—HOLOTHURIA FLORIDANA, Pourtales; HOLOTHURIA PRINCEPS; PENTACTA FRONDOSA, Jæger.

The Sea Cucumbers, or Holothurians, are the highest members of the group of Echinoderms, which also includes the Sea Urchins and Star-fishes. They usually have an elongate, cylindrical, *flexible body, covered with a muscular skin, which varies greatly in thickness in the different* species. The mouth is located at one end of the body, and is surrounded by a circle of more or *less complex tentacles or feelers. That division of the Holothurians to which the economic species* belong are furnished with the so-called ambulacral feet, which are sometimes arranged in five *longitudinal rows or series, and at others are scattered without order over the surface of the body.* The body wall frequently contains numerous minute calcareous plates, of various shapes, which are often peculiar to the different species. Many of the species are quite worm-like in external appearance. The Trepang of Chinese commerce is the dried skin of a large species of Holothurian living in the South Pacific Ocean, and used as food in China.

The largest and one of the most conspicuous of the New England Holothurians is the *Pentacta frondosa*, which inhabits the northern Atlantic coasts of both Europe and America, from low-water mark to a depth of one hundred fathoms or more. It is of a brown color, and measures from a few inches to about a foot in length when expanded. The ambulacral feet form five double and irregular rows, and the tentacles are ten in number, and much branched. Dr. William Stimpson remarks concerning this species that, made into a soup, it is very palatable; but it has never been regularly used as food.

Holothuria floridana is a large dark-brown species, with the feet scattered irregularly over the body, and with smaller tentacles than *Pentacta*. It occurs abundantly on the Florida reefs, just below low-water mark, and grows to about fifteen inches in length. *Holothuria princeps* is another large Florida Sea Cucumber. One or both of these species, but more probably the former, gave rise, about 1870, to a limited industry on the Florida coast, to be described hereafter. Large quantities were collected on the reefs, cleaned of their internal organs, boiled, and then dried and shipped to China; but the industry was abandoned after two years' trial, probably having been unprofitable. Chinese coolies assisted in the work.

THE SEA URCHINS—STRONGYLOCENTROTUS DRÖBACHIENSIS, A. Ag.; STRONGYLOCENTROTUS FRANCISCANUS, A. Ag.; ECHINARACHNIUS PARMA, Gray.

The Sea Urchins are related to the Sea Cucumbers, but differ from them in form, and in the character of their external covering. The body is generally somewhat spherical in shape, but more or less flattened below, the mouth being placed near the center of the lower surface. The outer covering is built up of calcareous plates, closely fitting together, from which project a multitude of spines, sometimes of small, sometimes of large size, there being generally a great variation in size in the same individuals. The larger spines are generally arranged in regular series. There is a water system; five double rows of feet, which run from the center above to

the mouth below; and many pedicellariæ. The œsophagus is small and the stomach and intestine somewhat lengthened and curved upon itself. The sexes among Sea Urchins are distinct, the different individuals containing either ovaries or spermaries only. These are five in number, and resemble those of the Star-fish. This portion of the Sea Urchins (the ovaries) are the most important in an economic point of view, the ovaries alone being eaten.

The common or green Sea Urchin (*Strongylocentrotus dröbachiensis*) has a very wide range, and is very abundant upon our northern coast. It extends from New Jersey to the Bay of Fundy, but south and west of the eastern part of Long Island Sound it is rare. Its bathymetrical range is from low-water mark to depths of over four hundred fathoms. Outside of the United States, it ranges from Nova Scotia to the Arctic Ocean; from Spitzbergen to Great Britain; from Bering Strait to the Gulf of Georgia; and along Eastern Siberia to Okhotsk Sea, and De Castries' Bay. This species "feeds partly on diatoms and other small algæ, etc., which it cuts from the rocks with the sharp points of its teeth, and it is also fond of dead fishes, which are soon devoured, bones and all. In return it is swallowed whole, in large quantities, by the wolf-fish and other large fishes." The green Sea Urchin is not now eaten upon our eastern coast, and most Americans would probably regard its use as food with much repugnance, but it was formerly eaten by some of the native east coast Indian tribes, and is still favorably regarded by the Alaskans. Mr. Henry Elliott states that at Saint Paul's Island the villagers, principally Aleuts, search for it at low tide, under the shelter of the bowlders, which stand in the tide pools, on the rocky shores, during nearly all seasons. Usually the shells are broken, the ovaries removed and spread out like raw oysters on a plate, and eaten with salt, pepper, and vinegar. The old women, called "barbies," despise these condiments, however, and suck the Sea Urchins as small boys do eggs. The native Alaskan name for this Sea Urchin is "Repkie."

The common west coast Sea Urchin (*Strongylocentrotus franciscanus*) inhabits the coasts of Southern Alaska, British Columbia, and the United States, as far south as San Diego, California. It attains a much larger size than the green Sea Urchin, and is used as food in some localities. In Southern Europe a related species, *Strongylocentrotus lividus*, is much esteemed as food.

The "Sand Dollar," or "Flat Sea Urchin" (*Echinarachnius parma*), of the New England coast differs so much from the Green Sea Urchin in appearance that it would scarcely appear to belong to the same group of animals, from a superficial examination. Its principal points of difference are its extremely compressed form and very small spines, which are nearly uniform over the entire body. The lower side is perfectly flat, and the upper but slightly convex. Its only importance from an economic standpoint arises from the fact that it furnishes an indelible ink, which might possibly be utilized in the arts, as it now is to a slight extent by the fishermen of some parts of the coast.

The Sand Dollar is commonly met with on sandy shores, but is seldom found living "except at extreme low water of spring tides, when it may sometimes be found on flats or bars of fine siliceous sand in great numbers, buried just beneath the surface, or even partially exposed. It creeps along beneath the sand with a slow gliding motion, by means of the myriads of minute extensile suckers with which it is furnished. It is far more abundant on sandy bottoms at various depths off shore. It has a very wide range, for it is found all the way from New Jersey to Labrador, and also on the North Pacific coast; and in depth it ranges from low-water mark to four hundred and thirty fathoms, off Saint George's Bank, where it was dredged by Messrs. Smith and Harger. When living its color is usually a rich purplish-brown, but it soon turns green when taken from the water. It gives a dark green or blackish color to alcohol, which stains very injuriously any other specimens put in with it. The fishermen on the coast of Maine and New Brunswick some-

times prepare an indelible marking-ink from these 'Sand Dollars,' by rubbing off the spines and skin, and, after pulverizing, making the mass into a thin paste with water. A number of fishes have been found to swallow this unpromising creature for food, and the flounders consume large numbers of them."[1]

THE STAR-FISHES—ASTERIAS VULGARIS, Stimpson; ASTERIAS FORBESII, Verrill.

Only two species of Star-fish merit our attention in this report, not from any good they perform, but from their destructive attacks upon our oyster-beds, which they are said to damage to the extent of perhaps two hundred thousand dollars annually. These two Star-fishes, called *Asterias vulgaris* and *Asterias Forbesii*, are so closely related to one another and so similar in appearance as to require considerable skill at times to point out their differences; but when living the *Asterias Forbesii* can generally be recognized by its bright orange madreporic plate on the upper side of the body, the corresponding plate in *A. vulgaris* agreeing more closely in color with the surrounding portions of its disk. The fishermen do not distinguish between the two species; to them they are both alike, and both are designated under the common but descriptive terms of "Star-fish," "Five-finger," "Sea Star," or simply "Star."

The Star-fish, as its name implies, is a star-shaped animal, consisting of a central disk from which radiate, in the case of the species now under discussion, five elongate arms, which are not marked off or separated in any way from the disk, but exist merely as prolongations from it. The upper and lower sides are quite different from one another. "The upper side presents a rough surface of a greenish, brownish, reddish-green, or purple hue, which when it is dried turns to a yellowish-brown. This is the leathery membrane covering the skeleton of the animal, which consists of small limestone plates, united together at their edges by a sort of cartilage. This forms the framework of the arms and disk, and acts as a chain-armor, encircling and protecting all the soft parts within. On the lower side of the Star-fish this framework terminates in two series of larger plates. This armor is sufficiently flexible to allow the Star-fish to bend himself clumsily over or around anything he is likely to wish to climb upon or grasp." The entire upper surface is covered with many short spines, which are largest and thickest at the edges of the rays and upon the plates bordering the lower sides of the rays. Around the base of each spine there is a circle of curious little claw-like appendages called *pedicellariæ*, which may serve to aid in clearing the upper surface, but whose functions are not satisfactorily made out. Scattered between the spines are little soft water tubes, and at one side of the disk on the back is a sieve-like arrangement, called the madreporic plate, for the admission of water.

The under side of the body is softer than the upper and much lighter in color. The mouth is in the center of the disk; it bears no teeth, but is surrounded by an elastic tube. Five furrows run from the mouth down the center of each arm. They are filled with numerous extensible soft tubes, terminating in a disk and arranged in four rows. These are the so-called feet of the Star-fish, and by means of them it moves about. The majority of the Star-fishes are bisexual, but in the two species under discussion the sexes are distinct.

Our common Star-fishes, and especially the *Asterias vulgaris*, attain a large size, specimens often measuring fifteen inches across, and upwards, on the Maine and Massachusetts coasts. From this extreme we find all the intermediate sizes down to the very smallest. They inhabit various kinds of bottoms, from above low-water mark to twelve or fifteen fathoms and deeper, but it is in shallow water that they do the most damage. They live on muddy, sandy, rocky, and shelly bottoms, and even on the piles of wharves, and are most abundant where they can find the

[1] VERRILL: Vineyard Sound Report, pp. 362, 363, 1871–'72.

greatest amount of food, and it is for the purpose of feeding that they visit the oyster-beds in such large droves. They are not always abundant in the same places, but seem to move about. Professor Verrill thinks "their habit of coming up to the shore may be connected with their reproductive season." They do not enjoy too brackish water, and oysters in such locations are safe from their attacks.

Asterias vulgaris ranges from Long Island Sound to Labrador, and *A. Forbesii* from Massachusetts Bay to the Gulf of Mexico. The former species is, therefore, essentially a northern one, and the latter a southern one, but over a certain region they overlap, and it is through this region and just to the south of it that most of the damage is done. *A. Forbesii* is the shore species where the greater part of the oyster-beds occur, and it must assume most of the blame for the thousands of oysters destroyed on these beds.

236. THE CŒLENTERATES.

The Corals.

Many of the common Florida Corals, from their graceful shapes and delicately sculptured surfaces, are highly prized for ornamental purposes, and have come to possess a certain commercial value. They are regularly kept for sale in most of the larger cities, such as Boston and New York, and unusually fine specimens frequently command a high price. The group of Corals, as popularly understood, includes members of two classes of the Cœlenterata, the Polyp Corals and the Hydroid Corals, both of which, and especially the former, present a great variety of forms. The principal ornamental Corals found on the coast of Florida are as follows: Among the Gorgonians occur the Sea-fans (*Gorgonia flabellum*), and the Sea-feathers or Sea-plumes (*Gorgonia acerosa* and *Gorgonia setosa*). Among the true stony corals are the Stag-horn Corals (*Madrepora cervicornis, prolifera*, and *palmata*); the Brain Corals (*Meandrina labyrinthiformis, clivosa*, and *sinuosa, Diploria cerebriformis*, and *Manicina areolata*); the Fungus Corals (*Agaricia agaricites* and *Mycedium fragile*); the Star Corals (*Orbicella annularis* and *cavernosa*), and many others without common names, such as the *Oculina diffusa* and *Isophyllia dipsacea*. Only a single species of Hydroid Coral is commonly seen in show collections; it is the so-called Finger Coral or Sea Ginger (*Millepora alcicornis*), the latter common name having reference to the smarting sensation which it imparts to the skin, on handling, soon after it is taken from the water. Many foreign species of Corals, belonging to the above groups, are often to be seen in the natural history stores; they come mainly from the West Indies and the Pacific Ocean. Neither the precious Coral (*Corallium rubrum*) nor any other species approaching it in value to the trade occurs in American waters, but large quantities of the former are imported annually from Europe for making into jewelry.

The Jelly-Fishes.

The Jelly-fishes, Sun-fishes, or Medusæ, which are well known to the sea-coast inhabitants as transparent and delicate floating animals, most abundant in the summer months, are, at times, a source of great annoyance to the net fishermen. These watery creatures, whose bodies contain only a very small percentage of solid matter, vary greatly in shape, and belong to several orders of the *Cœlenterata*. They have often been described and figured in popular books on natural history, to which the reader is referred for details concerning their structure and habits. The commoner species found on the New England coast are referred to as follows by Prof. A. E. Verrill.[1]

"A fine, large specimen of the beautiful Jelly-fish *Tima formosa* has been sent me by Mr. V. N. Edwards, who captured it at Wood's Holl, April 30. He states that the same species was very

[1] Vineyard Sound Report, p. 449, 1871–'72.

abundant in February, 1872. It has not been previously recorded as found south of Cape Cod. Among the most common of the larger species in summer were *Mnemiopsis Leidyi*, which occurred in abundance at nearly all hours of the day and evening, and was very phosphorescent at night; *Cyanea arctica*, which occurred chiefly in the daytime, and was here seldom more than a foot in diameter; *Aurelia flavidula*, which was not unfrequently seen in the daytime; *Dactylometra quinquecirra*, which was quite common both by night and day in August and September; and *Zygodactyla grœnlandica*, which was common in July, both in the day and evening, but was seldom seen later in the season. In the winter season the *Mnemiopsis Leidyi* is often abundant in Long Island Sound, and I have also observed it in New York Harbor in February, in large numbers. At Wood's Holl, Mr. V. N. Edwards found the *Pleurobrachia rhododactyla*, both young and nearly full-grown, very abundant in February and March. At Watch Hill, April 13, I found both adult specimens and young ones not more than one-eighth of an inch in diameter. It probably occurs through the entire year, for we frequently met with it in midsummer in Vineyard Sound. Mr. S. I. Smith also found it very abundant at Fire Island, on the south side of Long Island, in September. The *Idyia roscola*, so abundant on the coast of New England north of Cape Cod, was only occasionally met with, and in small numbers, while the *Bolina alata*, which is one of the most abundant species on the northern coast of New England, was not seen at all. The *Aurelia flavidula* is less common than north of Cape Cod, but was found in abundance in Buzzard's Bay, in May, by V. N. Edwards."

Many accounts have been given of the damage done to the nets of the fishermen by Jelly-fishes, when they have congregated together in large numbers. Mr. Fred. Mather, writing from Saybrook, Connecticut, in 1881, says that "the Jelly-fish, called Sun-fish here, are a source of great annoyance this year. They clog up the meshes of the nets, and the tide sweeps away either the net alone, or with its stakes."

The following extract from a letter by Mr. R. H. Stannard, of Westbrook, Connecticut, dated June 1, 1881, refers to the destruction occasioned in former years. "The Jelly-fish have been very destructive to pound fishing several times within the past thirty-five years, and there have been more or less of them every year in the Sound. In 1861, the best part of the season was destroyed, and, in 1868, one-half of the shad-fishing season was destroyed by the Jelly-fish taking away the nets and stakes. In 1878, Jelly-fishes were very plentiful; they stopped the shad fishing with pounds almost entirely, and to such an extent that the company did not pay expenses. This year, 1881, they have destroyed about one-third of the catch or season. If no Jelly-fish had appeared I believe the catch would have been one-third larger than it is."

ZB.—THE PORIFERS.

237. THE SPONGES.

GENERAL CONSIDERATIONS.—The natural group of Sponges with which the public have become familiar, through their constant use of the domestic varieties, remained until comparatively recent times in the much disputed ground between the animal and vegetable kingdoms. The *careful investigations of several distinguished modern naturalists*, however, finally established their animal nature beyond all question, and they were accordingly transferred to the kingdom in which they properly belong. But some years were yet to pass before their true affinities with other animals could be definitely determined, and they were grouped provisionally with the so-called *Protozoa*, a somewhat heterogeneous assemblage of such low forms as did not agree structurally with any of the four great branches or subkingdoms, then recognized as composing the animal kingdom. Still later researches have clearly proved that the Sponges have a much higher organization than the *Protozoa* proper, and propagate by means of eggs, while the members of the latter group do not. Compared as a whole with all the groups above the *Protozoa*, the Sponges appear to be the lowest in structure, and, moreover, they stand apart by themselves as a distinct group, which, in the more recent division of the animal kingdom by most authorities into some seven subkingdoms or branches, in place of the original four, assumes the rank of a subkingdom called *Porifera*, and comes into the plan of classification between the *Protozoa* and the *Cœlenterata*.

The term Sponge conveys to the minds of most people simply the idea of an irregular, soft, flexible mass of open structure, whose exterior is generally much roughened by projecting points, and pierced by numerous holes, leading toward the interior, and whose structure, more closely examined, is seen to consist of a fine net-work of small, horny fibers. This typical Sponge, as we may term it, from its being the form most commonly known and observed, is the ordinary Sponge of commerce, which, though limited in its range to but a few tropical and subtropical regions, is collected in great quantities and sent to all parts of the world. The commercial Sponges, which are the only ones of economical importance to mankind, all belong to a single natural genus, *Spongia*, and form, so far as the number of species are concerned, but a small portion of the entire branch *Porifera*.

As stated above, the general conception of a Sponge is a fibrous skeleton, and nearly all Sponges possess a skeleton or the rudiments of one, but this varies greatly in character in the different divisions of the branch. In the commercial Sponges and their allies, the skeleton is horny and more or less flexible, consisting of fine fibers interwoven and joined together. In another group, the skeleton is composed of horny fibers intermingled with which are many siliceous spicules, causing it to have a much stiffer and harsher structure. In a third group, the so-called siliceous Sponges, the skeleton is entirely made up of siliceous spicules, which may be scattered singly through the soft substance of the Sponge, or joined together in bundles. These spicules vary in shape, some being simple and straight, and others pyramidal, star-shape, or granular. A fourth group, the calcareous Sponges, has a skeleton of calcareous materials, disposed in lines or columns at right angles to the walls. The recent members of this group have the

skeleton made up of calcareous spicules, while the fossil forms referred to the same have calcareous columnar supports, instead of spicular.

The soft and fleshy part of the Sponge, which is the truly organized portion, and upon a knowledge of which we must rely for a perfect understanding of the relations of Sponges, is the most difficult to study, as it is also the least known. It collapses and begins to decay almost on the moment of the Sponge being taken from the water, and alcoholic preparations are of comparatively little value for investigation. The structure of some forms has, however, been sufficiently well made out to give us a tolerably clear idea of what it must be in the entire group. Prof. A. Hyatt describes the general structure of the Sponge as follows:[1]

"They are structurally remarkably uniform, though differing greatly in external aspect. They consist internally of a mass or layer of sarcode or mesoderm, containing a greater or less number of true cells, and have an ectoderm and endoderm of cellular tissue. The majority of the forms are supported by a skeleton of interwoven threads or spicules, or both, of various forms. The exterior is perforated by innumerable pores, leading into channels in the interior, which enlarge and join with groups of neighboring channels, forming large branches. These, in turn, form junctions with other branches, and finally all of them unite into one or several large trunks, which open outwards, like minute craters, on the external surface. These are lined with another membrane, differing from anything else of its kind in the animal kingdom. It is composed of minute cells, furnished on the free side with a long whip or flagellum, surrounded by a collar. Their interiors contain a nucleus and digestive vacuoles, and they, in all respects, resemble the independent animals known as flagellate infusoria. They take in and digest food in the same manner, and eject excrements in great profusion from the area inclosed by the membraneous collar.

"The eggs and spermatozoa are derived from modified cells of the mesoderm, whereas the skeleton is either built up partly from the external membrane, and partly from the sarcode by exogenous growth, or by the transformation of the loose cells of the sarcode into spicules. The function of the smaller external pores is to admit the water, which is thus strained and deprived of its coarser floating material. It is then carried along the canals, by the motion of the cilia, and conveys its load of minute food to the ampullaceous sacs and zoöidal cells. The hydraulic pressure occasioned by the inward flow of the innumerable minute streams forces it through the larger trunks and out at the craters or ostioles with great rapidity."

Their peculiar cellular structure caused the Sponges when they were first carefully studied to be looked upon as compound animals, but this idea has been refuted by more recent studies, and each individual Sponge is now considered, "in its simplest adult form, as homologically a single animal with the internal structure and functions of a colonial organization."

The branch or subkingdom *Porifera* is divided into two classes, the *Calci Spongiæ* (calcareous Sponges) and the *Carneo-Spongiæ* (horny and siliceous Sponges).

The *Calci-Spongiæ* are again divided into two orders, and the *Carneo-Spongiæ* into four orders, the *Halisarcoidea*, *Keratoidea*, *Kerato-Silicioidea*, and *Silicioidea*.

The *Keratoidea* includes all the purely horny Sponges, and the only genus, *Spongia*, of direct importance to mankind. According to Professor Hyatt, the horny Sponges "appear to require for the production of the forms in abundance tropical or subtropical seas, and obtain by far their greatest development in the number of the forms and species in the West Indian seas. The typical forms, the commercial Sponges, are essentially confined to the waters of the Caribbean Islands, Bahama Archipelago, and the southern and western coasts of Florida, in this hemisphere, and to the Mediterranean and Red Seas in the other.

[1] Memoirs Boston Soc. Nat. Hist., ii, 1875–'77.

"Australia affords a few forms, and I have heard, though I cannot substantiate the fact, of some species on the Atlantic coast of Brazil. Bermuda also has a few of the commercial kinds, which, according to Mr. Goode's report, and the suite of specimens forwarded, are much coarser than the Key West, darker in color, and, in fact, just about intermediate between these and those of Australia. They are occasionally found in the stores, but, as a rule, are used only by the fishermen themselves, about their boats, the Bahama Sponges being preferred for domestic purposes by the inhabitants.

"The true *Spongiæ* are all shallow-water forms. In the Mediterranean, according to Ecklel, they are not found below thirty fathoms, and in our own seas about the same, probably, though not fished to greater than five fathoms. The greater part of the fishery is accomplished between the depths of three and twenty feet, according to the report of Dr. Palmer, from whom these remarks are principally derived. The commercial grades coincide very closely here and in Europe, but it is quite easy to show that each of them may be considered a distinct species, if one has an inclination to multiply in this direction. The three grades [of American Sponges]. Glove Sponge (*Spongia officinalis*), subspecies *tubulifera*, Wool Sponge (*Spongia equina*), subspecies *gossypina*, and Yellow and Hard Head, both under the name of (*Spongia agaricina*), subspecies *corlosia*, correspond with remarkable accuracy to the three principal grades of commercial Sponges in Europe. These are the Bath Sponge, *Spongia officinalis*, the Horse Sponge, *Spongia equina*, and the Zimocca Sponge, *Spongia agaricina*. This result, in which three species appear on both sides of the Atlantic, as representing alone the marketable qualities of the genus *Spongia*, becomes of double interest when these varieties, or local species, as they might be called, are compared with one another. It is then found that the aspect of the surface is closely similar in each of the three; that subspecies *tubulifera* represents *Spongia officinalis*, subspecies *gossypina* offsets *Spongia equina* in the same way, and, lastly, subspecies *corlosia* has the same relation to *Spongia agaricina*.

"The whole group of *Keratosa* is confined to seas in which the differences observable between the winter and summer isotherms are not excessive. None are found north of Cape Hatteras and the island of Bermuda, and doubtless a similar limit occurs to the southward of the equator.

"The finer skeletons of the *Keratosa*, those of the genus *Spongia*, are only to be sought in the intermediate zone, where the waters are of equable and high temperature. Again, in examining the species of this genus with relation to each other, it becomes equally evident that they are finest and most numerous in archipelagoes or off coasts which are bordered by large numbers of islands or long reefs, or in sheltered seas.

"The Sponges near Nassau lie on reefs very much exposed to the action of the waves, often thirty miles from land, and always in currents, sometimes running three or four miles an hour. Such currents are usual wherever groups of islands confine the tide water within certain definite channels, and they have also the effect of concentrating the floating food in the channels, or wherever tides meet. Both of these conditions are essential to successful sponge growth, namely, a continuous renewal of aërated water and a plentiful supply of food, and are probably partially the cause of their abundance in such places.

"The shallow-water Sponges are coarser than the deep-water forms. This is probably due, in part, as in other species, to the quantity of sediment, which is, of course, less in deep than in shallow water, as, for example, at Key West in the winter time. I am informed that no fine qualities of any Sponges are found within the limits of the milky water, but all the finer qualities of the marketable kinds in the deepest water in which the species occur, except perhaps in the

case of the Reef Sponge. Glove, Reef, and Hard Head are fished in shallow waters, greatest depth two fathoms, and the other, and generally finer marketable varieties, in from two to five fathoms. This fact also explains in a measure, but not wholly, the greater coarseness of our own Sponges as compared with the European. For though it may be assumed, from the examination of the skeletons, that Mediterranean Sponges are much less exposed to turbid waters, and though it may be shown by the microscope that the primary fibers contain less *débris*, this does not wholly explain their greater fineness and elasticity. I think that we may attribute this either wholly or partly to peculiar climatic conditions.

"The coral reefs afford good holding ground for the bases of the colonies, and protection from the excessive surf of ocean shores, while they grow in water the remarkable clearness of which to a considerable depth is constant subject of remark. These are undoubtedly favorable conditions, as they are common also to the Mediterranean waters. The great quantity of calcareous sediment, however, which is churned by the waves in the winter, on the borders of a coral reef, is not present in the Mediterranean; and the average temperature also, which is very much higher than that under which the finest Sponge skeletons are produced in the Mediterranean, cannot be considered as favorable. These last, then, are probably the direct cause of the inferiority of the skeleton of the commercial varieties found in this association [*i. e.*, many of the American varieties].

"The coarsest quality of all the Mediterranean Sponges, the Gherbis sort and other coarse sorts, grow in localities along the coast, where they are most subject to the action of suspended matter in the water; but all of these are, however, on account of the clearness and medium temperature of the Mediterranean waters, as compared with those of other seas, of much finer quality.

"The coarser kinds of the same variety grow nearest the shore, and the finer kinds in deeper water, and also, according to Nassau spongers, are more apt to occur on marly ground, where the sediment is finer than upon other kinds of bottom. The openness which usually accompanies and appears to correlate with coarseness of the fiber must be considered as one of the elements of inferiority, which invariably accompanies a skeleton having a loose microscopical texture or mesh, and harsh or inelastic or easily torn fibers, but is also, though rarely, found in skeletons of very fine quality, especially at an early age. Thus it may be said that it is undoubtedly a common characteristic of all the inferior qualities of Mediterranean, and of all the Caribbean commercial Sponges without exception, which, though they may have very fine or very coarse or inelastic fibers, are always permeated in the interior and have the surface also cut up by larger and more numerous canals than the corresponding Mediterranean species."

238. THE GENUS SPONGIA AND THE AMERICAN COMMERCIAL SPONGES.

The skeleton of this genus, according to Professor Hyatt, is composed of solid, elastic fibers, the primary ones, those having their origin in the external integuments, being usually, though not invariably, more or less radiatory in their arrangements; but the secondary or connecting fibers are excessively irregular, and generally very closely intertwined. The primary fibers are particularly noticeable on the inner side of the walls of the large or excurrent openings. The skeleton exhibits a very rough surface, due to the development of large projecting masses of the secondary or connecting fibers, which are separated by horizontal channels of greater or less depth. The primary fibers protrude above the surface of the cushions or ridges thus formed, carrying with them more or less of the secondary fiber, and forming a series of superficial tufts, giving the skeleton a peculiarly hirsute aspect. The pores through which the water enters the

Sponges are very numerous, quite permanent in their positions, and irregularly scattered over the sides of the mass, often remaining open even in dried specimens. The cloacal canals are few in number, but exceedingly large, and their apertures are irregularly scattered about, but are almost always on the upper side of the colony. When living, the outer skin is of a dark brown, very dark purple, or a black color. The external layer is usually more or less filled with whatever sediment may be prevalent in the water, and, especially in the West Indies, with the siliceous spicules of other Sponges.

Only four species or six so-called subspecies of commercial Sponges, are recognized from the Florida waters, and these give rise to the five grades, known to the trade, in the order of their importance, beginning with the finest, as Sheepswool, Velvet, Grass, and Glove Sponges. These same grades and subspecies, with one exception, also occur among the Bahama Islands, the sponge fauna of Florida and the Bahamas being more or less identical, but the corresponding grades of these two regions are generally finest in the Florida waters, the Florida commercial Sponges ranking much higher than the Bahama, and commanding higher prices. Commercially, Bahama has two or three times as many grades of Sponges as Florida but these commercial grades are not of specific or even subspecific importance. They result from a division according to quality for the convenience of the trade. Notwithstanding the many Bahama grades, the best of the Bahama Sheepswool Sponges are inferior to the best Florida Sheepswool.

The following descriptions of the several Florida and Bahama commercial Sponges are taken from Professor Hyatt's memoir, "Revision of the North American Poriferæ," with notes on the corresponding Mediterranean species:

THE GLOVE SPONGE—SPONGIA OFFICINALIS, Linn., subspecies TUBULIFERA.

"This subspecies, as compared with other American subspecies, has a skeleton composed of remarkably fine fibers, which bleach out to a whitish brown color. The surface is covered with fine tufts of primary fibers, which are, however, very pliable. The surface is generally quite free from cushions and ridges, and the channels between these when they do occur are neither very deep nor long. The result of these characteristics is a form with a smoother surface and a denser looking skeleton than usual, pierced on the sides by numerous small apertures, very regularly distributed, and at the top by one or more large cloacal oscules. The form is generally dome-like, and is never, so far as I know, cup-shaped, though it may become exceedingly irregular, fistular, or even dendritic. The older specimens show a decided tendency to increase by the prolongation of the parts immediately around the apertures. Thus the main body of the Sponge becomes projected into numerous smaller conical or head-shaped masses like the young of variety *rotunda*, and crested masses like those of variety *disciformis*. At an advanced age the fiber becomes very brittle and unfit for domestic purposes."

This subspecies generally occurs abundantly upon hard bottom. While living its color is black; the largest specimen seen by Dr. Edward Palmer, who collected many specimens for Professor Hyatt, measured about eight inches in height by about twenty inches in circumference. It lives on the coast of Southern Florida (Key West), and among the Bahama Islands (Nassau), upon hard bottoms or reefs, in about six feet of water. Ten varieties are enumerated, all of which inhabit American tropical seas. They are as follows: *pertusa*, *mollis*, *prava*, *disciformis*, *rotunda*, *aperta*, *corlosiformis*, *duplex*, *exotica*, and *solida*.

The Glove Sponge ranks as the poorest of all the Florida commercial grades, and yet belonging to the same species, under the name subspecies *mediterranea*, are the Levant Toilet Sponges, the finest of all Sponges, and the fine-textured Turkey Cup Sponges. The different grades of the

subspecies *mediterranea*, some of which are of an inferior quality, occur on the eastern shore of the Adriatic, on the coast of Greece to Asia Minor, and thence to Tripoli and Tunis.

THE GRASS SPONGE—SPONGIA GRAMINEA, Hyatt.

"This is one of the Grass Sponges of commerce, and is perhaps one of the least variable of all the species. . . . The general structure is coarser than in *tubulifera*, and the interior is *exceedingly open, owing to the large size and central situation of the efferent canals.* The form is that of a truncated cone, fluted by deep furrows on the sides, and either infundibuliform or flat on the truncated surface. The large excurrent orifices are all upon this surface, or in the depression which takes its place. The smaller apertures are situated on the sides, invariably in the depressions between the ridges. The persistency of the former and of the latter ridges, and the situation of the different kinds of orifices, are by far the most characteristic features of this species. Notwithstanding these facts, and though I am obliged to describe this and some other forms as distinct species, I have great doubts of the truth of the assumption. It rests upon the evidence of many specimens, but they are all from one locality."

This species occurs at Key West, Florida, where it grows abundantly on the coral reefs, either on smooth bottoms or attached to corals or other Sponges, in three feet of water and deeper. When living its color is black.

THE SHEEPSWOOL SPONGE—SPONGIA EQUINA, Schm., subspecies GOSSYPINA.

"The typical variety of this species, usually called the Sheepswool Sponge, varies greatly in form. All of these forms, however, are characterized by a peculiar surface. The skeleton rises into large tufts over the entire surface, the larger oscula occupying the depressions between. Sometimes these are very numerous, the whole interior being very cavernous, and sometimes the structure is much denser, with fewer large openings and many small ones scattered between the tufts. Occasionally the depressions are filled up on parts of the Sponge, and a surface is presented having no large tufts, but only the small secondary bundles of fibers, which are especially characteristic of this variety. The result of this structure is to leave great hollows or rather a net-work of deep tunnels under the derm, which are apparent only after the drying of the specimens, when *they become exposed by the universal contraction and cracking of the skin. The color when* living is said by Dr. Palmer to be a shining black."

The habitat of this species is Southern Florida and the Bahama Islands, where it grows in *from three to sixteen feet of water and deeper. The largest specimen examined measured about* nine inches high by thirty inches broad. The following five varieties are recognized by Professor Hyatt: *dendritica*, *porosa*, *alba*, *solitaria*, and *hirsuta*.

This is by far the finest of the American commercial Sponges, ranking much higher than any of the other grades. It is also the one most eagerly sought for, the supply being quite unequal to the demand. It takes the place of the finer Mediterranean grades for most purposes, and, though not so fine in texture, is more durable than the Turkish Sponges. In the same species are placed some of the best-known of the eastern grades, the so-called Horse Sponge, Venetian Bath Sponge, and Gherbis Sponge, *which occur in numerous places in the Mediterranean Sea.*

THE VELVET SPONGE—SPONGIA EQUINA, Schm., subspecies MEANDRINIFORMIS.

"This, the well-known Velvet Sponge of commerce, . . . differs from the preceding in its extreme forms by the absence of the pointed bundles or tufts, and the fibers are also perhaps *slightly finer. The absence of the pointed tufts gives a smoother surface, since, as in the preceding* variety, these are mainly composed of coarse primary fibers loaded with foreign matter, whereas

the connecting or secondary fibers are composed of pure keratose. The surface is also remarkable for the protruding, flattened cushions of fiber, which slightly resemble the convoluted ridges of a *meandrina*. Sometimes these cushions are transformed into long, solid brushes or pencils of fibers."

The localities from which this subspecies has been recorded are as follows: Biscayne Bay and Key West, Florida; Nassau, Bahamas; Havana, Cuba; Mauritius Islands; and the island of Fernando de Noronha, off the coast of Brazil. But one variety of this subspecies has been recognized; it is also in its typical form known commercially as the Velvet Sponge. Professor Hyatt writes of it as follows: "The forms of the specimens in our collection are more spreading than is usual in that variety (*meandriniformis*), and the texture is quite as soft, though denser, perhaps, when the skeleton is dry. The projecting cushions of fiber are similar in form to those of variety *meandriniformis*, but are joined together in larger masses by a tissue of fine superficial threads; also are often less dense and simply bridge the intermediate channels. This and the tortuous and rather shallow character of the channels give the surface a smoother aspect than is common in the skeleton of *meandriniformis*. The oscules are very large and have a peculiar ragged aspect in dried specimens. They look as if some one had made them by repeatedly running a knife into the animal while it was drying, and then omitted to clean out the interior thoroughly, leaving sharp pinnacles of dried sponge cuttings projecting inward, sometimes so as to fill the center, but oftener sticking around the center of the aperture, and more or less completely joined to the wall of the canal, This characteristic ragged look is sometimes also to be seen in the oscules of subspecies *gossypina*. but never so decidedly." This variety is found at Key West, Florida, and Nassau, Bahamas.

This is a fair grade of Sponge, rather rare, and not much in demand; in fact, the dealers often omit it in their enumeration of the American commercial Sponges. It is considered of little value by the trade.

THE GRASS SPONGE—SPONGIA EQUINA, Schm., subspecies CEREBRIFORMIS.

"The aspect of this species, commonly known as one of the 'Grass Sponges,' is very similar to that of *Spongia agaricina*, subspecies *corlosia*, variety *typica*. The difference consists principally in the aspect of the surface. This is broken up by parallel longitudinal ridges of irregular length on the sides, each ornamented with one or two lines of tufts. These ridges extend onto the upper surface, giving them a markedly radiatory arrangement. The larger orifices are situated in rows in the channels between the ridges." Six varieties are enumerated, as follows: *typica*, described above; *plana*, inhabiting Florida and Kingsmill's Islands; *divisa*, found upon hard, irregular bottom or corals, in about two feet of water at low tide, at Key West and Biscayne Bay, Florida, and at Stone's Inlet, South Carolina; *mexicana*, from Vera Cruz, Mexico; *caliciformis*, from Nassau, Bahamas; and *obscura*, from Nassau and the Bermudas. These several varieties differ more or less markedly from the typical specimens, some of them approaching other species in shape and general appearance. This grade is inferior in quality.

THE YELLOW SPONGE—SPONGIA AGARICINA, Pall., subspecies CORLOSIA AND DURA.

"The subspecies *corlosia* resembles very closely in external appearance the *Spongia dura*, or 'Hard Head,' but an examination of a full series of forms showed that very considerable differences exist in the texture, though superficially there is little or no distinction in the aspect of the surface. Dealers can identify these varieties instantly by the color, which is usually lighter than that of the 'Hard Head,' and by the touch, the 'Yellow Sponge' yielding much more readily and feeling less harsh under the fingers. These characters, however, only apply to the normal head-like forms and some of the varieties; many forms cannot be placed in either one or the other of

the two groups with any certainty." This subspecies occurs at the Bahama Islands and Florida. Three varieties are classed with it by Professor Hyatt, *gossypiniformis*, from Nassau; *fusca* and *elongata*, from Biscayne Bay and Key West, Florida; the range in depth is from two feet of water at low tide to thirty feet or more.

This constitutes the second grade of American Sponges, and is very abundant. Although selling at a much lower price than the Sheepswool it forms an important article of commerce. The Mediterranean grade corresponding with it is the so-called Zimocca Sponge.

239. INJURIOUS SPONGES.

THE BORING SPONGE—CLIONA SULPHUREA, Verrill.

This is a common species of siliceous Sponge, which ranges along our Atlantic coast, from Cape Cod to South Carolina, in from one to fifteen fathoms of water. It begins to grow on mussel, clam, or oyster shells, mostly on dead, but also on living specimens, into which, when still very young, it excavates numerous burrows. "As it grows, it penetrates the shell in every direction, forming irregular holes and galleries, which continue to grow as more and more of the substance of the shell is absorbed, until the shells are reduced to a completely honeycombed, brittle mass, or a mere skeleton. Finally the Sponge begins to protrude from the surface, and grows up into mammiliform masses, or small rounded crusts, which continue to grow and spread in every direction, until finally they form masses six or eight inches in diameter. . . . Owing to the remarkable boring habits of this and other allied Sponges, they are very important in the economy of the sea, for they are the principal agents in the disintegration and decay of the shells that accumulate over the bottoms, thus performing the same function in the sea that fungi and insects perform on the land."[1]

There is no question but that the offices of this Sponge are mainly for good, as stated above; but they often attack living shells, burrowing into them as far as the inner layer, and greatly irritating the animal, which will sometimes deposit one or more new coatings of shell structure, so as to cover up the little pores about to open into the inside. They probably also often cause the destruction of oysters. These burrows sometimes appear on the inside as little prominences, scattered over the surface. Masses of this Sponge, when full grown, measure a foot or more in length, and contain stones as large as one's fist, as well as a large quantity of sand. "This species is of a bright sulphur yellow color, and grows into hemispherical or irregular massive forms of firm texture, the surface being covered with scattered, low, wart-like, soft prominences, about an eighth of an inch in diameter, which contract when the Sponge is dried, leaving shallow pits."

Cliona sulphurea has the power of burrowing into submerged limestone as well as shells. A case of this sort was brought to notice in 1878, when a wrecked cargo of marble was discovered off Long Island, having lain there for several years. The pieces of marble taken up were completely riddled by this Sponge to a slight depth.

[1] Vineyard Sound Report, p. 421, 1871–'72.

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INDEX.

	Page.
Aalmutter	247
Abalones	700
Abbott, Dr. C. C., on common Seals	55, 56
habits of the Cray-fishes	814, ~~816~~
spawning and feeding habits of White Perch	432, ~~433~~
Abeona aurora	278
minima	276/278
Aberdeen fish	200
Acantharchus pomotis	405
Acanthuridæ	279
Acanthurus cœruleus	279
nigricans	279
Achigan	401
Achirus lineatus	177
Acipenser brevirostris 660	~~659~~
medirostris 3/	66~~2~~
oxyrhynchus 660	~~659~~
sturio 660	~~659~~
transmontanus 3/	66~~2~~
Acipenseridæ 660	~~659~~
Acrochilus alutaceus	618
Actinophrys sol	734
Acuña, Christopher, on the Pegebuey	120
products of the Pece-Buey	128
Adams, Prof. A. L., on the habits of the Togue	493
Admete Couthouy	693
Aesche	506
African Pompano 329	327,
distribution of	329
Agaphelus gibbosus	31
Agaricia agaricites	841
Agassiz on breeding of Green Turtles	151
breeding seasons and habits of Snapping Turtles	153
range of Soft-shell Turtles	152
rate of growth of Loggerhead Turtle	148
Aglektok	62
Agonidæ	257
Agonus family	257
Aguglia imperiale	358
Aguja	337
Blanca	337
de Palada	337
Prieta	337
Voladora	337
de Casta	337
Agulha	337
Agulhao	337
Alaska Pollack	232
Smelt	544
Albicore	320, 322
Albula vulpes	612
Albulidæ	612
Aleby-trout	236
Alepidosauridæ	547
Alepidosaurus borealis	547
ferox	548 ← Alepocephalidæ 54
Alepocephalus Agassizii	548
Bairdii	548
family	548
Alewife	569, 576, 580
abundance of	582, ~~583~~
food of	586
former abundance of	583, 584
geographical distribution of	584, ~~585~~
history and nomenclature of	579–582
migrations and movements of	585
occurrence of, in New England	~~580~~, 581
reproduction of	586
size of	587
uses of	587
Bay	569
Branch	588
Inland	594
Alfione	277
Allen on Fur Seal pups	93
reproduction of Fur Seal	106
Seals and Walruses	33
swimming of Fur Seal	102
Alligator	141
abundance of	142
economical value of	146
~~the~~ fishery of	146
food and manner of obtaining it	142
geographical distribution of	141
hibernation of	145
mode of capture of	146
mode of life of	144
origin of name of	141
pugnacity of	143
size of	142
voice of	145
Alligator Gar	66~~3~~
Snapper	153
Turtle	153
Allman, Professor, on habits of the Boring Amphipod	825, ~~826~~
Alopias vulpes	~~675~~ 672, 676
Alosa cyanonoton	579
tyrannus	579
Alutera Schoepfii	171
Amauropsis islandica	693

Page.

Amber-fish ... 331
fishes and Leather-jackets ... 331, 332
Ambloplites rupestris ... 404
American Leech ... 834
Lobster ... 781
Soles ... 175
Amia calva ... 658
Amiidæ ... 658
Aminrus ... 626
nebulosus ... 627
Ammodytes lanceolatus ... 244
tobianus ... 248
Ampelisca, sp., found in stomach of Sea-robin ... 256
Amphibians ... 159–162
Amphibious Carnivora ... 33
Amphioxus ... 681
Amphipod, Boriug ... 825, 826
Amphipods ... 824–826
Amphisphyra debilis ... 694
hiemalis ... 694
Amphistichus argenteus ... 278
Amyda ... 152
mutica ... 152
Anachis ... 596
Anarrhicas lepturus ... 249
lupus ... 248, 249
minor ... 249
Anarrhichadidæ ... 248
Anarrichthys ocellatus ... 250
Anchovas ... 544
Anchovies ... 611, 612
Angel-fish ... 171,
Black ... 280
family ... 280
White ... 280
Yellow ... 280
Angelo ... 671
Angler, Marbled ... 173
Anglers ... 169
Anglis ... 171
Anguilla bostoniensis ... 630
marmorata ... 630
megalostoma ... 630
mowa ... 630
texana ... 630
vulgaris ... 629
Angulus tener ... 703
Annelids ... 831–833
Anodonta ... 703
Anonyx, sp., found in stomach of Sea-robin ... 256
Anoplopoma fimbria ... 243, 268
Anspach on habits of the Capelin ... 545
Aolkussa ... 247
Apeltes quadracus ... 457
Aphoristia atricauda ... 175
Apodichthys flavidus ... 251
fucorum ... 251
violaceus ... 251
Aporrhais occidentalis ... 693
Aproplarchus stropurpureus ... 251
Arabella opalina ... 833
Architeuthis Harveyi ... 687
princeps ... 687
Archoplites interruptus ... 276, 405

Page.

Arctic Sea-cow ... 128
extinction of, in historical times ... 128–129
Arctocephalus ... 37
californianus ... 52, 53
monteriensis ... 52, 53
ursinus ... 52
Arenicola marina ... 833
Argina pexata ... 703
Aromochelys odorata ... 154
Artedi on different forms of Ostracion ... 171
Artedius fenestralis ... 259
lateralis ... 259
megacephalus ... 259
notospilotus ... 259
pugettensis ... 259
seriatus ... 259
Ascelichthys rhodorus ... 259
Ashby, Captain, on distribution of Halibut ... 193
food of Halibut ... 195
Halibut Spawn ... 196
migrations of Halibut ... 194
spawning of Mackerel ... 295
Aspidonectes asper ... 152
Emoryi ... 152
nuchalis ... 152
spinifer ... 152
Aspidophoroides inermis ... 258
monopterygius ... 257, 258
Astacus ... 812
leptodactylus ... 812
nigrescens ... 813
nobilis ... 812
torrentium ... 812
Astarte quadrans ... 703
Asterias Forbesii ... 840, 841
vulgaris ... 840, 841
Astyris ... 698
lunata ... 693
rosacea ... 693
Atheresthes stomias ... 188
Atherinidæ ... 456
Atherinops affinis ... 457
californiensis ... 457
Atka Mackerel ... 268
Atlantic Porpoise ... 14
Tom Cod ... 223
Attarak ... 62
Atteitsiak ... 62
Attersoak ... 62
Atwood, Captain, on abundance of Haddock ... 225
abundance of the Plaice ... 178, 180, 181
capture of White Whales in Massachusetts ... 18, 19
distribution of the Lant ... 245, 246
distribution of the Scuppaug ... 387
food of Cod ... 213
food of Mackerel ... 290
geographical distribution of Mackerel ... 281
the habits of the Hake ... 235
habits of the Horned Dogfish ... 672, 673
habits of Horse-Mackerel ... 321, 322
habits of the Lant ... 245
habits of Pollock ... 229

Page.

Atwood, Captain, on the Man-eater Shark 670
movements of Pollock 229
the Nurse Shark 674
rate of growth and size of Mackerel 298
reproduction of Pollock 231
scarcity of the Bone Shark. 668
the Scrag Whale 30
the size of Codfish 220
size of the Halibut 193
spawning of Mackerel 296, 297
the Torpedo 666
the torpidity of the Tautog and the Scup 273
transplanting young Lobsters 804
useful products of Sperm Whale 11
the uses of the Lant 246
Aurelia flavidula 842
Auricula vestita Emersonii 693
Autennaridiæ 173
Auxis Thazard 305
Azia 250
Bacalaos 200
Bacchi 200
Bachelor 407
Baddoch 228
Baggit 468
Bagre 379
Baird, Professor, on abundance of Cod 205
abundance and qualities of Spanish Mackerel 312, 313
the Anchovy 611, 612
capture and uses of Herring. 565, 566
the Common Pompano 327
culture of Lake Trout 492
decrease of Cod-fisheries on New England Coast 221–223
flesh of Little Tunny, when cooked 322
food of Mackerel 291
the food and voracity of Bluefish .....
the habits of the Eel 631 632
the habits of the King-fish .. 375, 376
history and habits of the Lafayette 371
the history and habits of the Scuppang 388–393
the Horse-Mackerel 320
manner of capturing Plaice. 181
migrations of Mackerel 283
movements of Herring Schools 553–555
movements of Mackerel 287
movements and migrations of Bluefish 434, 435
periodicity of abundance of abundance of Herring in Northern Europe 557
periodicity of Bluefish 435–437
Plaice fishing and distribution 178

Page.

Baird, Professor, on pugnacity of Sword-fish 351, 352
reproduction of the Alewife. 586
reproduction of Bluefish 440, 441
size of Bluefish 414, 442
spawning habits of Herring. 562, 563
spawning season of Mackerel. 297
the uses of the Alewife 587, 588
Bairdiella chrysura 375
Bait-bug 779
stealers 273
worms 831
Bakkeljaune 200
Balæna boops 29
gibbosa 29
nodosa 29
Novæ Angliæ 29
vera 29
Balænoptera Davidsonii 30
jubartes 29
velifera 30
Balænopteridæ 29
Balahoo 461
Balanus balanoides 828
crematus 829
eburneus 829
tintinnabulum 829
Baleine jubarte 29
Balistes capriscus 172
Balistidæ 171
Ball-fish 170
Banded Drum 367
Grouper 412
Rudder-fish 331
Bank Cod 201
Lick Bass 406
Banner Pompano 327
Pompano, distribution of 329
Barb 377
Barbot on mode of capture of South American Manatee 127
products of South American Manatee. 127
Bard 247
Bar-fish 406
Barlow, Rev. William, on Mola, Salv. or Sunfish and glue made from it 169
Barnacle Eater 171
Rock 828
Barnacles 828, 829
Barnacles, Goose 828
Barn-door Skate 669
Barracuda 448
Barracouta 448
Barracouta family 448
Barrel-fish 334
Bartram on breeding habits of Alligators 145, 146
pugnacity of Alligators 143, 144
size of the Alligator 142
the voice of Alligators 145
Bashaw 627
Basking Shark 667
Bass, name for Red-fish .....
Bank Lick 406
Black 206
Black 401

	Page.
Bass, Brassy	424
Calico	406
Channel, name for Red-fish	372
family	401
Grass	406
Moss	401
Mud	405
Oswego	401
Otsego	507
Red, name for Red-fish	372
Reef, name for Red-fish	372
Rock	404
Rock	413
School, name for Red-fish	372
Sea	378
Sea	407
Sea, name for Red-fish	372
Silver, name for Moon-eye	612
Spotted, name for Red-fish	372
Strawberry	406
Striped	424, 425
Striped Lake	424
White	428
White Sea	378
Yellow	431
Bastard Cod	268
Halibut	182
Snapper	397
Trout, name for Silver Squeteague	367
Turtle	147
Bat, Sea	255
Bath Sponge	845
Bathymaster signatus	361
Batrachus pardus	251
tau	251
Bavarian char	500
Bay Alewife	569
Porpoise	14
Porpoise, of California, and Marsuin, of Europe, similarity between	14
Seal	62–65
Shark	678
Bdellostoma Dombeyi	182
Beach Clam	708
Fleas	824
Beale on distribution of Sperm Whale	7
habits of Sperm Whale	9
size of Sperm Whale	9
Bean, T. H., on chiroid fishes	268
distribution of the *Halibut*	190
distribution of Starry Flounder	184
the Rough Limanda	184
the Burbot	235
occurrence of Branch Alewife in certain lakes of New York	588–594
Bear, Sea	49
Trout	497
Bearded Seal	63
Beardless Drum	372
Beaver	11
Bécasse de Mer	338
Becker	393
Bedlamers	62
Bedlimers	62

	Page.
Bela decussata	693
harpularia	693
pyramidalis	693
turricula	693
Belknap on the Grampus	14
Bellamers	62
Bellows-fish	173
family	170
geographical distribution of	170
numbers of	170
Bell's Tortoise	157
Belonidæ	458
Beluga	18
Bendire on the Red-fish	478, 479
Benecke, Dr. B., on breeding habits of the brook Lamprey	677, 678
habits of river Lamprey	677
migrations of Eels	633, 634
movements of young Eels	650
reproduction of the Eel	634–638
reproductive habits of Eels	646, 647
the spawning of Lump-fish	254
viviparous nature of Eels	645
breeding habits of the Pike	463
Bergylt	260–273
Bering, Capt. Vitus, death of	129
Bermuda Chub	394
Berried Lobster	783
Berycidæ	361
Beryx family	361
Beshow (Alaska Pollock)	233
(Black Candle-fish)	268
Bezaan fisch	338
Bezuga	370
Bicuda	338
Bielaya ryba	477
Biet on habits of American Manatee	120
products of South American Manatee	127
Big-eyed Herring	580–611
Mackerel	303
Mullet	449
Biggy-head	259
Big-mouth	405
Black Bass	401
Bill-fish	336, 337
name for Gar-pike	662
name for Silver Gar-fish	458
Billard	228
Billet	228
Biocœnosis	734
Bishop Ray	665
Bitter Head	406
Bittium nigrum	693
Bitumen	11
Bivalves	703–710
Black Angel-fish	280
Bass	401
distribution of	401, 402
habits and food of	402
name for Black Rock-fish	266
names of	401
spawning of	402, 403
tenacity of life of	403, 404
transportation of	404

	Page.
Black Bass, Big-mouth	401
Small-mouth	401
Black-bellies	582
Black Biters	201
Candle-fish	268
Black-Coalsoy	228
Black-dotted Flounder	187
Black Drum	367
Black-fin	541
Black-finned Shark	677
Black-fish	268, 269
Black Grouper	411
Grunt	398, 399
Harry	407
Horse	615
Jack	228
Lobster	783
Lungo	487
Mullet	375
Perch	444
Perch, name for Black Surf-fish	278
Black-Pollock	228
Black Rock-fish	266
Rock-fish of Alaska	266
Black Rock-fish, spotted	266
Rockcador	379
Salmon	487
Snapper	397
Snappers, name for Cod	201
Spotted Trout	475
Surf-fish	278
tailed Crab, name for Shrimp	818
Triple-tail	545
Warmouth	405
Whale	11–25
Will	407
Blackfish	17
capture of	13
distribution of	11
food of	12
movements of	12
name for Sea Bass	407
reproduction of	12
schools, stranding of	12
size of	12
time when most abundant	12
used as food	13
useful products of	13
value of	13
Alaska	466, 467
Blackfishes	11
Blackford, on prices of Bull-frogs	161
Blacksmith	276
Blainville, on Sperm Whale in Brittany	9
Blake, J. H., Notes on Sperm Whale Porpoise	18
Blanchera, de la, on Sword-fish in Bay of Biscay	342
Blanquillo	361
Blasius, on distribution of Ringed Seal	65
on geographical distribution of Hooded Seal	70
Bleking Herring	550
Blennidæ	250
Blenny family	250
Blepharis crinitus	326

	Page.
Blepsias cirrhosus	259
Blew-fish	435
Blew Hound-fish	308–435
Blicks	298
Blobs	259
Blockin	228
Blow-fish	418
Blower	170
Blowing Whale	11
Blue-back	582
Salmon	477
Blue Bream	406
Cat-fish	626
Cat-fish (see Cat-fish)	249
Chimæra	662
Cod	268
Crab	775
Crab, distribution of	775
Crab, external character of	775, 776
Crab, habits, uses, &c	776–778
Fin	541
Herring	579
Lumpfish	254
Parrot-fish	274
Perch	277
Perch, name for Cunner	273
Perch, similar in form to Red Perch	260
Pike, name for Pike Perch	417
Shark	669, 671, 675
Snappers	433
Sun-fish	406
Surf-fish	277
Bluefin	541
Bluefish	433
abundance in New Jersey, 1870 and 1881	439, 440
distribution of	433
enemy of Mackerel	299
family	433
food and voracity of	437–440
Girella nigricans	394
movements and migrations of	434, 435
Mummichog	449
name for Chogset	273
name for Sea Bass	407
name for Squeteague	302
names of	433
periodicity of	435–437
reproduction	440, 441
size of	441, 442
uses of	443, 444
Bluesides	62
Blunt-nosed Shiner	322
Boar-fish	335
Boccae	266
Boccaccio	266, 267
Boccone, S. Paulo, on the Sanguisuga, parasite of Sword-fish	354, 355
Bodach	65
Bodieron	267
Boeck, Axel, on distribution and habits of European Lobster	807–810
on process of shedding of European Lobster	793, 794
Bohuslän Herring	550

	Page.
Boldner, Leonhart, on the development of the Lamprey	678
Bolina alata	842
Bone fish, name for Dog-fish	673
name for Lady-fish	612
name for Surgeon-fish	279
Bone Shark	668-670
Bonito	316
abundance of	317
Cuban name for Medregal	331
distribution of	317
as a food-fish	318, 319
name for the Cobia	444
Pacific	319
plain	306
striped	316
Bonnet-headed Shark	671
Bonnet-worm, food of Black Bass	462
Bony fish	569
Boohoo	337
Boregat	267
Boregata	267
Boring Amphipod	825, 826
limnoria	826, 827
sponge	850
Bothragonus Swani	258
Bottle fish	170
Bottle-head Whale	11
Bottle-nose Whale	14
Boundary Herring	550
Bowfin	658
Bowhead and Right Whales, confusion between	20
Bowhead Whale	20
economic importance of	21
feeding habits of	23
food of	23
movements of	21
reproduction of	21
size of	21
Box-fish	170
Box Turtle, Carolina	158
Box Turtles	158
Brachyistius frenatus	278
rosaceus	278
Brail	178
Brain Corals	841
Braize	393
Brama chilensis	335
Brama Raii	335
Bramidæ	335
Branch Alewife	588
capture of	593
economic value of	593
enemies and fatalities of	592, 593
movements of	591, 592
occurrence in certain lakes of New York	588–594
origin of, in Lake Ontario and New York Lakes	590, 591
Branch Alewife, scarcity of in St. Lawrence River	589
Branch Herring	580
Branchiostomidæ	681
Branchiostoma lanceolatum	681
Branded Drum	372

	Page.
Brandt on abundance of South American Manatee	123
the Arctic Sea-cow	134
breeding habits of Manatees	118
Brassy Bass	424
Bream	393, 394
Blue	406
Copper-nosed	406
Salt-water	393
Breeding Harps	62
Brevoort, J. Carson, on names of Codfish	200
uses of the Gurnard	256, 257
Brevoortia patronus	570, 575
pectinata	570
tyrannus	569
tyrannus aureus	570
Bricke	676
Briggs on intestines of embryonic White-fish	516
Brim	406
Brit	550
found in the same locality as the Lant	246
Brochet	462
Brook-fish	466
Pickerels	464
Sucker	614, 615
Trout	475
Brooks, W. K., on anatomy of the Oyster	711, 712, 713, 714
reproduction of the oyster	719, 720, 721
Brosmius brosme	233, 236
Brosmophycis marginatus	244
Brotulidæ	244
Brown Cod	201
Brown on products of Ringed Seals	66
Brown, J. Ross, on Northern Fur Seals	49
Brown, Robert, on geographical distribution of Hooded Seal	69
Brown, Dr. Robert, on similarity of feeding of Whales and Mackerel	294
Brown Rock-fish	264
Snapper	410
Buccinum ciliatum	693
Buccinum undatum	693, 694
Buckland on abundance and value of Gar-fish	459
Buckland, Frank, on chemical composition of European Lobster	811, 812
Buckland, F. T., on gastronomic value of Bull-frogs	160, 161
gastronomic value of Cat-fish	250
the habits of the Lant	244, 245
the Lump-fish	254
mode of capture of Bull-frogs	160
number of eggs in English Lobster	798
on rate of growth and shedding of European Lobster	794, 795
Buckler	776
Buckskin Trout	488
Bug, Salve	827
Buffalo Cod	268
Buffalo-fish	614
Buffalo-fishes	615
Buffalo Jack	324
Bull-frogs	159
breeding habits of	159

Page.

Bull-frogs, culture of 159
discovery of 159
economic uses of 160
how to get spawn of 159
take care of spawn of 159
modes of capture of 160
range of 159
size and mode of life of 159
Bull-head, name for Horned Pout 627
Sculpin 258, 259
Whiting 377
Bull Mackerel 303
Bull-pout 627
Bull Trout 504
Bunch Whale 26
Bunker 569
Burbot 235, 236
abundance of 238
American and European, relation between 237
distribution of 238
economic value of 240
food and feeding habits of 239
information desired concerning the 240
mode of capture of 239
name of 235, 236
popular names of 236
reproduction of 238
size of 237
Burgall 273
Burmeister on range of American Manatee 116
Burr-fish 170
Butterfish 333
Humpbacked 323
Butterfly-fish 257
Butterfly Ray 665
Cabezon 259
Cabrilla 413
Spotted 414
Cachalot 7–10
Caing Whale 11
Calamary, Flying 690
Calamus arctifrons 394
bajonado 394
macrops 394
megacephalus 394
Milneri 394
Calci-Spongiæ 344
Calico Bass 406
California Anchovy 612
Conger Eel 628
Grampus 14
Gray Whale, abundance of 31
capture of 32
distribution of 31
food and reproduction of 32
habits of 31
size of 32
Grunts 400
Hake 243
Herring 568, 569
Pompano 334
Prawn 921
Salmon 479

Page.

California Sardine 569
Sea Elephant 72
general history of 79
geographical distribution of 72
habits of 73
and Southern Sea Elephant, comparison between 74
Sea Lion 44
geographical distribution of 44
habits of 45
Shrimp 818
Smelt 457, 544
Yellow-tail 331
Callinectes hastatus 775
larvatus 775
ornatus 775
tumidus 775
Callista gigantea 708
Callocephalus vitulinus 66
Callorhinus 37, 49
ursinus 49, 52, 53, 77
Cambarus 812
acutus 814
affinis 814, 815
Bartonii 814, 815
Clarkii 814
Diogenes 815
obesus 814
virilis 814
Campbellite 497
Cancer antennarius 771
borealis 769
irroratus 766
found in stomach of Sea-robin 256
magister 770
productus 771
Candle-fish 268, 547
Canestrini on distribution of the Pollock 228
on the Scomber pneumatophorus 303
Cape May Goody 370
Capelin 544
name for Sand Smelt 456
Capelinas 544
Carangidæ 322
Carangoid fishes 322
Caranx chrysos 324
crumenophthalmus 324
fallax 325
hippos 323
Richardii 325
Carassius gibelio 620
Caravina 378
Carcine 322
Carcharias cæruleus 671
glaucus 676
lamella 676
obscurus 671
Carcharodon Atwoodii 670
carcharias 669, 671, 675
Rondeletii 670
Carcinas mænas 774

	Page.
Cardium islandicum	703
pinnulatum	703
Carneo Spongiæ	844
Carnivora, Amphibious	33
Carolina Box Turtle	158
Pompano	326
Carp	618
growth and size of	624-626
habits of	621, 622
races of, their history and habits	618-621
reproduction of	622-624
Leather	619
Mirror	619
Poor Man's	620
Scale	619
Sucker	615
Carpenter, Dr. Philip, on the Cuttles	687
Carpiodes cyprinus	615
Carroll on geographical distribution of Hooded Seal	69
habits of Hooded Seals	58
Cassis madagascariensis	699
Cat-fish	248
Blue	249, 626
Channel, common	626
Flannel-mouth	627
food of	249
Gaff-topsail	627
Great Lake	627
Great Mississippi	626
Mud	627
pugnacity of	249
Salt-water	628
Sea	248, 627
Spotted	249
Stone	627
Yellow	627
Cat-fishes	626
Cat, Sea	51
Shark	67
Cat-thrasher	582
Catesby on the Sword-fish	339
Catostomidæ	614
Catostomus ardens	615
Commersoni	615
fecundus	615
longirostris	615
macrocheilus	615
nigricans	615
occidentalis	615
tahoënsis	615
Caulolatilus anomalus	361
chrysops	360
microps	360
Cavally	323
the Scad and the Jurels	322-326
Cavasina	331
Cayman	141
Caymanes	142
Cebedichthys violaceus	250, 251
Centrarchidæ	401
Centrarchus macropterus	406
Cephalopoda	687
Ceratichthys biguttatus	617
Cero	307, 316
King	307, 316
Spotted	307, 316
Cetacea	33
Cetorhinus maximus	667, 674, 675
Chænobryttus antistius	405
gulosus	405
Chætodipterus faber	445
Chætodontidæ	280
Channel Bass, name for Red-fish	372
Cat, common	627
of the Potomac	627
Cats	626
Chapman on food of Sirenians	118
size of South American Manatee	118
Char	501
Bavarian	500
Chars, distribution and effect of temperature on	502, 503
Chasmistes brevirostris	615
liorus	615
luxatus	615
Chelonia mydas	150
virgata	150
Chelopus	157
guttatus	158
insculptus	158
Muhlenbergi	158
Chelura terebrans	825
Chelydra	153
serpentina	153
Chelydroidæ	153
Cherna	411
Chewagh	504
Chicken Halibut	178, 194
Tortoise	157
Chickwit	362
Chief Mountain White-fish	542
Chilomycterus geometricus	170
Chimæra affinis	663
blue	663
Colliei	663
family	663
Chimæridæ	663
Chinook Salmon	479
Chinquapin Perch	407
Chione succincta	708
Chiridæ	267
Chiton	693
uses of	701
Chogset	273
Chopa blanca	370
spina	393
Chorruy Ryba	466
Chowescha	479
Christmas Flounder	183
Chromis punctipinnis	276
Chrysemys Belli	157
marmoratus	157
picta	157
reticulata	157
Chub, name for Black Bass	269
Fall-fish	617
Lafayette	370
Tautog	269

Page.

Chub, Bermuda 394
Day 618
Eel 236
Mackerel 303–305
Nigger 618
River 617
Salt-water 269
Sucker 614
of Utah Lake 616
Chubby Goby 255
Cicharra 324
Cichlid family 276
Cigar-fish 324
Cinosternoida 154
Cirripedia 828, 829
Cisco 541
Cistudo 158
carolina 158
ornata 158
Citharichthys sordidus 186, 187
Civit-cat 11
Clam 708
Beach 708
Cod 201
Flat 708
Hard 708
Hen 708
Long 707
Painted 708
Round 708
Sea 708
Soft 707
Surf 708
Clark, A. H., on abundance of Frigate Mackerel 306
abundance of Halibut 192
distribution of Cod 202
George, letter on marked White-fish 508
on rate of growth of White-fish 509
Clarke, S. C., on the Black Gronper 411
breeding habits of the Drum 368
the Cobia 444
habits and spawning of Sheepshead 385
mode of life of Alligators 145
names and habits of Whiting 377
the Big-fish 399
size, abundance, and habits of Silver Mullet 453
spawning of Red-fish 373, 374
Cliona sulphurea 850
Clupea æstivalis 579
chrysochloris 594
cœrulea 579
finta 594
halec 579
harengus 584
indigena 579
mattowaca 607
mediocris 607
menhaden 569
mirabilis 568
parvula 579
pusilla 579
sapidissima 594

Page.

Clupea vernalis 579, 588
Clupeidæ, families related to 610–613
Clymenella torquata 833
Coal 228
Coal-fish 228, 233
Coal-Whiting 228
Coalsey 228
Cobia, distribution of 444
Cock-paddle 254
Cock-paidle 254
Cockle 708
Cod 200
family and its kindred 200
Bank 201
Bastard 268
Blue 268
Brown 201
Buffalo 268
Clam 201
Cultus 267
Deep-water 201
fish, name for Cultus Cod 267
Fresh-water 236
Herring 201
Inshore 201
Native 201
Night 214
Pine-tree 201
Rock 200
School 201
Shoal-water 201
Shore 201
Tom 267
Worm 201
Codfish, distribution of 202
food of 211, 212
names of 200
history of, in America 201
reproduction of 214
schooling of the 203
schools, migrations and movements of 207
size of 220
Cœlenterates 841, 842
Cogfard 379
Coho 477
Cojinua 324
Cojumero 116
Colemic 228
Collet on distribution of the Sea Cat-fish 248
Robert, on the Gray Seal 103
Collins, Capt. J. W., on distribution of Mackerel 281
Mackerel-fishing grounds 294
migrations of Mackerel 301, 302
spawning of Mackerel 295
food of Halibut 196
food of Mackerel 292
Halibut spawn 197
migrations of Halibut 194
size of the Halibut 193
Colmey 228
Common Flounder 178
Pompano 327
Seal 55
Sun-fish 405

	Page.
Conch	694, 699
food and destructiveness of	695, 696
uses of	700
Condamine on habits of South American Manatee	121
Coney	412
Conger Eel	655
California	627
Congeree	629
Congo Eel	247
Congrogadidæ	243
Congrogadus, family	243
Conklin on food of Sirenians	119
habits of American Manatee	121
size of Florida Manatee	117
Cony-fish	237
Cooter	158
Florida	155
Cooth	228
Cope on distribution of the Alligator	142
Hooded Seal	71
Terrapins	154
the Wall-eyed Pike	423
Copper-nosed Bream	406
Corallium rubrum	841
Corals	841
Brain	841
Finger	841
Fungus	841
Hydroid	841
Polyp	841
Stag-horn	841
Star	841
Cordeaux, John, on general history of Harbor Seals	58, 59
Coregonus Artedi	541
clupeiformis	507
Hoyi	541
labradoricus	541
nigripinnis	541
quadrilateralis	541
tullibee	541
Williamsoni	542
Corn-cracker	665
Cornide, Don Joseph, on pugnacity of Swordfish	351
Coronula diadema	828
Corsair	265
Spotted	265
Corvina	378
saturna	379
Coryphæna hippurus	332
Coryphænidæ	332
Coste on reproduction of European Lobster on the French coast	803, 804
Cothurnidæ	733
Cottidæ	258
Cottus æneus	258
octodecimspinosus	258
polyacanthocephalus	259
scorpius grœnlandicus	258
Couch, on abundance of Dogfish	673
food of Sperm Whale	10
the habits of the Lant	245
habits of the Silver Hake	242
the habits of the Skipjack	461
Cover	177
Cover-clip	177
Cow-fish	13, 16
Cow-pilot	275
Crab, Black-tailed, name for Shrimp	818
Blue	775
Common edible	770
Common, of Pacific coast	770, 771
Crab-eater	444
Crab, Green	774
Horseshoe	829
Jonah	769
Kelp	778
King	829
Lady	774, 775
Oyster	765, 766
Red	771
Red Rock	778
Rock	766
Rock, of Pacific coast	771, 772
Sand	774
Sea	775
Stone	772–774
Crabs	763–780
Fiddler	763
Hermit	779
Mud	772
Soft	776
Soldier	779
Spider	778
Craibe, Angus W., on habits of Leopard Seal	60, 61
Craig Flounder	198
Crane, Agnes, on habits of South American Manatee	121, 122
Crangon franciscorum	818
vulgaris	816
found in stomach of Sea-robin	256
Crappie	407
Crawfishes	812
Crayfish	780
and Lobster, similarity of shedding and spawning habits	813
Crayfishes	812–816
economic value of	814
habits of	814–816
relations and distribution of	812–814
Creek fish	614
Cremnobates integripinnis	251
Crenella glandula	703
Crenilabrus melops	273
Crepidula fornicata	693
plana	693
Crested Seal	62, 63, 68
Crevallé	323
Horse	324
Croaker	378
name for black Surf-fish	278
fresh-water Drum	370
Crocodile	141
North American	141
Crocodilus acutus	141
Crocus, name for Croaker	379
name for Drum	370
Crustaceans	763–830

	Page.
Cryptodon Gouldii	703
Crytodari siliqua	703
Ctenolabrus adspersus	273
similar in form to Red Perch	260
rupestris	273
Cuban jurel	325
Cubby yew	444
Cuckoo-fish	257
Cucumbers, Sea	838
Cudden	228
Cuddy	228
Cultus Cod	267
Cupleer, similar in form to Rose-fish	260
Cunner	273
Cunners	274
Cusk	233
abundance of	233
Cut-lips	618
Cutlass-fish	335
Cuttle-fishes	687
Cuttles	687–693
Cuvier, on distribution of Sword-fish	340
Cyanea arctica	842
Cybium	307
maculatum, supposed to have been caught at Prince Edward Island	310
Cycleptus elongatus	615
Cyclopteridæ	253
Cyclopterus lumpus	253, 254
orbis	255
Cylichna alba	694
Cymatogaster aggregatus	278
Cynoscion maculatum	365
nobile	378
nothum	367
parvipinne	379
regale	362
Cyprina islandica	703
Cyprnidæ	616
Cyprinodon californiensis	466
Cyprinodontidæ	466
Cyprinus carpio	616–618
carpio communis	619
carpio coriaceus, sive nudus	619
carpio specularis	619
Cystophora angustirostris	74
antillarum	71
cristata	65, 68, 71
falklandica	74
kerguelensis	74
leonina	74
proboscidea	74
Dace	616, 617
Horned	617
Red	617
Dactylometra quinquecirra	842
Dactylopterus volitans	255
Daddy sculpin	258
Dall, on Ambergris	11
Northern Fur Seals	53
reproduction of the Burbot	238
Sword-fish	350
Dallea delicatissima	467
Dallia pectoralis	466
Damalichthys argyrosomus	276, 277
Dampier, on size of South American Manatee	117
Dard	337
Dareste, M. C. M., on the classification of the Eel	629, 630
Dargie	228
Darters	417
Darwin, on local variation in form of Oysters	742, 743
Date-fish	767
Dauphin Blanc	18
Davy, on movements of young Eels	651
Dawson, J. W., on scarcity of Gaspereaux in Saint Lawrence River	589
Day Chub	618
Daylight, name for Sole	177
Spotted Sand Flounder	199
Deal-fish family	449
Decaisne, on cause of green color of Oyster	738
Decapterus macarellus	324
punctatus	324
Deep-Sea Flounder, name for Plaice	178
name for Pole Flounder	198
Deep-water Cod	201
Sculpin	258
Trout	488
Trout, name for Squeteague	364
Whiting	377
DeKay, on abundance of Chub Mackerel	303
Pig-fish	399
distribution of the Chogset	273
Hooded Seal	70, 71
Rose-fish	260
gastronomic value of Cat-fish	250
Harbor Seals	55, 56
the uses of the Silver Hake	243
Delphinapterus catodon	18
Delphinus Bairdii	16
clymenis	16
Demoiselle and Cichlid families	275, 276
Dentalium pretiosum	703
Descourtlitz, on breeding habits of Manatees	118
mode of capture of South American Manatee	127
Devil-fish	31
geographical distribution of	173
habits and form of	173
Devil-fishes	173, 665
Diabasis	397
aurolineatus	398
Plumieri	398
Diamond-back Terrapin	155, 157
breeding habits of	156, 157
characteristics and habits of	156
distribution of	156
economic value of	157
food of	156
Diamond Flounder	185
Diaphana Gouldii	694
Dickie	224
Diffenbach, E., on the Scrag Whale	31
Diodontidæ	170
Diopatra cuprea	833
Diplodus Holbrookii	386

	Page.
Diplodus probatocephalus	380
Diploria cerebriformis	841
Ditrema atripes	277
furcatum	277
Jacksoni	277
laterale	277
Temminckii	276
Doctor-fish	279
Dogfish, name for Shark	670
Shark	670
Dog Salmon	476
Sea	55
Shark	670
Dogfish, enemy of Mackerel	299
name for Bowfin	236
Burbot	658
Horned	672
Smooth	672
Dollar-fish	333
Dollardee	406
Dolly Varden Trout	504
Dolphins	16
(Coryphænidæ)	332
habits of	16
Doré	418
Dormitator	255
Dorosoma lepidcanum	610
Dorosomatidæ	610
Dorset	200
Dory	417–420
family	335
Dotard	58, 65
Douglass, on Alewives	579, 580
products of Sperm Whale	11
Sperm Whale in North America	8
Dowler, Bennet, on the manner in which Alligators obtain food	142, 143
Drill	696
destructiveness of	697
Drum	367
family	362
Banded	367
Beardless	372
Black	367
Branded	372
Fresh-water	370
Little	367
Red	362, 371
Striped	367
Drumfish	15
Drummer, name for Sculpin	259
Drummers	362
Dubertus rhodinsulensis	29
Duck-billed Cat	659
Ducky Shark	671, 672
Dudley, Hon. Paul, on the Scrag Whale	30
Dugong	127
Duméril and Bibron on classification of the Tortoise	147
Dunfish	200
Dunn, Matthias, on spawning of mackerel	297
Du Tertre, on breeding habits of Manatee	118
capture of American Manatee	126
habits of American Manatee	120
Dwarf Salmon	470
Eagle Rays	665
Earll, R. E., on Bluefish in North Carolina	443
food of Cod	213, 214
history of Spanish Mackerel	309, 310
migrations of Codfish	210, 211
movements of *Pollock*	230
Spanish Mackerel	310, 311
reproduction of Codfish	215, 219
Haddock	227
Pollock	230, 231
Spanish Mackerel	313–315
schooling of the Codfish	203–205, 206–207
size of Codfish	220
Easter Mackerel	304
Echeneididæ	446
Echidnoceros setimanus	778
Echinarachnius parma	838, 839
Echinoderms	838–841
Eel	629
classification of	629, 630
discovery of female	636
male, by Syrski	638–640
Conger	655
Conger, California	628
Congo	247
Horned	246
Lamper	247
Maroona	247
Pout	236, 247
Sea	655
Silver	335
Slime	680
Eels, ancient beliefs concerning reproduction of	634–638
external characteristics of	644, 645
geographical distribution of	630, 631
habits of	631, 632
internal characteristics of males and females	640–644
life history of	632, 633
male, do they leave the sea and enter fresh-water?	648
migrations of	633, 634
normal, reproductive habits of	646, 647
supposed to be viviparous	645
young, search for	646
Lamper	676
Egg-fish	170
Égrefin	224
Egypt Herring	460
Eithinyoo-cannooshoeoo	462
Elacate, Canada	444
Elagatis pinnulatus	332
Eleotris	255
El-la-chick	157, 158
Elliott, H. W., on difference between California and Alaska Sea Lions	48, 49
figures of Fur Seals	54
Fur Seals	53, 75–113
Northern Fur Seals	50
peculiar methods of catching Sheepshead	383, 384
Sea Lions	39, 44
size of Northern Fur Seal	50
uses of Pacific Walrus	36

Ducky Shark --- 672

Page.

E-lo-ki-nik 466
Elops saurus 243
Ellwhop 580
Ellwife 580
Embiotocidæ 276
Empereur 337
Emser 133
Emydidæ 154
Emys meleagris 158
English Herring 582
Engraulidæ 611
Enophrys bison 259
Eusatella americana 703, 707
Entomostracans 827
Entz, on green matter in animals 739
Épée de Mer 337
Epialtus productus 778
Epinephelus apua 412
Drummond-Hayi 412
morio 410
nigritus 411
striatus 412
Eretmochelys squamata 149
Erignathus barbatus 63, 107
Erimyzon Goodei 614
sucetta 614
E-ruang-uk 466
Eschricht and Reinhardt on distribution of Bowheads 20
Esox americanus 464
lucius 461
enemy of Alewives 592
nobilior 464
enemy of Alewives 592
reticulatus 462
enemy of Alewives 592
vermiculatus 464
Espada 337
Espadarte 337
Espadón 337
Estes, Dr., on habits of the Bowfin 658, 659
D. C., on habits of Moon-eye 613
Esthcostomatidæ 417
Etzel, Anton von, on distribution of Halibut 192
Eubalæna antipodarum 25
australis 25
biscayensis 24
cisarctica 24
cullamach 25
Eucyclogobius Newberrii 255
Eulachon 547
Eumesogrammus subbifurcatus 213
Eumetopias 37
elongatus 39
Stelleri 38, 39, 49, 82
Eupagurus pollicaris 779
Bernhardus 779
longicarpus 779
pubescens 780
Euplotes 733
European Leech 835
Exocœtus californiensis 459
Rondeletii 459
Exoglossum maxillingua 618

Page.

Expedition, the great Northern 129
Exquemelin, on food of Alligators 142
habits American Manatee 121
name of Manatee 116
Eyebait 246
Fabricius, on habits of Harbor Seal 57
Fair Maid 387
Fall-fish 617
Fan-fish 338
Fat-back, name for Menhaden 569
name for Mullet 449
Fat-head 275
Fat Herring 550
Mullet 451
Fiber canadensis 11
Fiddler Crabs 763
Fierasfer family 243
Fierasferidæ 243
File-fish family 171
geographical distribution 171
number of species—habits 171
Orange 171
File-fishes 169
Finback Whales 24, 27, 28–30
abundance in New England 28
distribution of 28
movements of 28
in the Pacific 28
Finger Coral 841
Mullet 453
Finner, Sharp-headed 30
Finners 24
Fish Ox 120
Fisher, Captain, on spawning of Mackerel 295
Fisher, S. E., on Southern Shrimps and Prawns .. 822, 823
Fishing Frog 173
Fissurella aculeata 701
Five-finger 840
Fjord Herring 551
Seal 62
Fjordskäl 62
Flannel-mouth Cat 627
Flasher 445
Flat Clam 708
back 27
fish 179, 182
fishes 175, 176
Fleas, Beach 824
Sand 824
Fleming, on the range of American Manatee 116
Sperm Whale in Orkney 9
Flétan 191
Fliaum 265
Floe-rat 66
Florida Cooter 155
Flounder 177, 178, 184
Black-dotted 187
Common 178
Craig 198, 237
Deep-Sea 178, 198
Diamond 185
Four-spotted 181
Pole 177, 178, 196
Rusty 197

	Page.
Flounder, Sand, spotted	199
Smooth	183
Starry	184
Turbot	178
Water	199
Winter	179, 182
Flounders	175
Fluke	182
Flower, W. H., on distribution of Ringed Seal	65, 66
Fly-fish	264
Flying Calamary	690
Flying-fish	257
family	459–461
Flying Gurnard	255
Food-fishes	169
Fool-fish, name for File-fish	171
Flounder	183
Forster, J. R., on feeding habits of the Burbot	239
size of Burbot	237
Fortin, P., on abundance and modes of capture of Horse-Mackerel	321
Four-eyed fish	280
Four-spotted Flounder	181
Fox Shark	671
Freia producta	733
Fresh-water Cod	236
Drum	370
Seals	59
Terrapins	152
Friar	456
Frigate Mackerel	305
Frog-fish	173
fishing	173
Frostfish	336
Fulgur carica	694
Fundulus grandis	466
majalis	466
parvipinnis	466
Fungus corals	841
Fur Seals	37
action of reproduction	111
age of female when first pregnant	78
albinos among	105
among the breakers	101
arrival of Cow-seals at rookeries	85
at seal grounds	77
attitudes and coloration of	81, 82
on land	88
battle of the Seals	80, 81
behavior of females on rookeries	88
at night, of	95
change in weight	104
classing the holluschickie by age	*103*
coming in of the bulls	77, 78
comparative size of females and males	103, 104
courage of	87, 88
definition of holluschickie	98
description of adult male	75–77
Cow-Seal	85, 86
the holluschickie	97, 98
pups	89–91
disorganization of rookeries	91, 92
dispersal of the holluschickie	105
distribution in southern seas	38

	Page.
Fur Seals, dolphin, jumps of	101
effects of heat on	83
eyes of the pups	94, 95
fasting at the rookeries	84
fine opportunities for observation	107
general character of	37
genitalia of the male and female	108
gentleness of holluschickie	99
geographical distribution of	37, 38
and migration of	49
habits of	37, 75
hauling-grounds on beaches for hollu-schickie	99
holluschickie	72, 82, 96
holluschickie do not fast	99, 100
hospitals of	93
intestinal worms	84, 85
irregular feeding of the pups	110
leaping out of water	101
life history of	75
locating the hauling-grounds of hollu-schickie	98
mangy cows and pups	92
monstrosities among	105, 106
necessity of understanding the method of reproduction	106, 107
odor of	96
old and young males fighting	79
only one pup born at a time	79
organization of the rookeries	86, 87
paths through the rookeries for hollu-schickie	98, 99
pelagic coition impossible	111
period of gestation	111
podding of the pups	94
power of scent of	96
pre-emption of the rookeries	80
preliminary advances of sexual union	110
range of vision of	95
relative duration of life of	79
reproduction is terrestrial	79
review of statements of *life* in rook-eries	96, 97
rich milk of	110
second change of coat	94
shedding the hair	103
sleeping	89
sleeping afloat	84
small number of barren females	113
speedy birth of pups	108
sports and pastimes of young bache-lors	100
stagey seals	103
sullenness of old males	95
swimming feats of the bachelors	101, 102
taste in the matter of weather	105
unattached males	87
vitality of the male	119
voice of the	82, 83
weight of females	104
where do they die?	106
young Seals learning to swim	93
Northern	40

	Page.
Gädda	402
Gadidæ, unimportant families related to the	243
Gadus	200
chalcogrammus	232
compressus	236
lacustris	235
lota	235
maculosus	236
morrhua	200, 236
periscopus	232
tau	251
Gaff-topsail Cat-fish	627
Pompano	329
Gag	413
Gaillon and Johnson, observations on green color of Oyster	737–738
Galeocerdo tigrinus	672, 673
enemy of Sword-fish	354
Galeorhinus zygopterus	674, 675,
Gammarus locusta	824
Gannet, enemy of Mackerel	299
Gaper	708
Garden, Alexander, on the Sword-fish	339
Gar-fishes, Silver	458
Garibaldi	270
Garman, S. W., on distribution of West Indian Seal	68
Garoupa	411
Gar-pike	662
pugnacity of	663
Alligator	663
Long-nosed	662
Short-nosed	663
Garrick	458
Garrod on size of South American Manatee	118
Garrupa	262
Black and Yellow	264
Flesh-colored	264
Green	265
Red	264
Speckled	263
Gaspereau	580, 589
Gaspergou	370
Gasperôt	580
Gasteropoda	693
Gasterosteidæ	557
Gasterosteus aculeatus	336, 457
biaculeatus	213
microcephalus	458
pungitius	457
Gastrochæna	699
Gawnook	460
Geare, R. I., on the Lake White-fish	507
Geddes, Patrick, on chlorophyl-containing animals	737, 739
Gelasimus minax	763
pugilator	763
pugnax	763
Genyonemus lineatus	379
Geographic Tortoises	152
Geophagus surinamensis	276
George's fish	201
German Leech	837
Gerres argenteus	279
harengulus	279
homonymus	279
Gerridæ	269
Gervais on Sperm Whale in Mediterranean	9
Gherbis Sponge	848
Gibbar	29
Gibbartus	29
Gibbero Dorso	29
Gibbes, L. R., on habits of the Stone Crab	773
the Southern Shrimps	821, 822
Gibbonsia elegans	251
Gila elegans	616
Grahami	616
robusta	616
Gill on distribution of Black Bass	402
history of California Sea Elephant	72
Sperm Whales, Giant and Pigmy	11
Gillichthys mirabilis	255
Gilpin, Dr. Bernard, on geographical distribution of Hooded Seal	69
Gilpin, habits of the Mackerel	285–287, 288
movements of Haddock	224
Gilt-head	273
Girella nigricans	394
Gizzard Shad	610
Glasban	228
Glass-eye	417
Glassock	228
Glattbutt	199
Glaucus	337
Globe-fish	170
Globicephalus intermedius	11
Scammonii	12
swineval	11
Glossan	228
Glossin	228
Glove Sponge	845–847
Glut Herring	582
Glyphidodon saxatilis	275
Glyptocephalus cynoglossus	198, 237
pacificus	186–188
zachirus	188
Gnathodon cuneatus	706
Goat's-head Porgy	393
Gobius glaucofrænum	255
soporator	255
Gobiesocidæ	253
Gobiesox reticulatus	255
Gobiidæ	255
Gobiosoma alepidotum	255
Goblins	259
Goby, Chubby	251, 255
Goggle-eye	404, 405
Goggled-eyed Jack	324
Goggler	324
Gold-fish	276
Golden Shiner	616
Trout	475
Goldsinny	273
Golet	507

	Page.
Goody	370
Cape May	370
Goose Barnacles	828
Goose-fish, appearance	174
eggs—time of spawning	174
geographical distribution of	173
habits and food of	173
palatable for food	174
Goose fishes	173
Gopher Tortoise	158
Gorgonia acerosa	841
flabellum	841
setosa	841
Gottenburg Herring	550
Goujon	627
Gourd-seed Sucker	615
Gråben Herring	550
Grampus	12
color and size of	13
distribution of	13
habits of	14
known to early colonists	14
products of	14
California	14
Mottled	14
White-headed	14
griseus	13
Stearnsii	14
Grande Écaille	611
Grandykye	611
Grass Bass	406
Herring	550
Grass-hopper, name for young Lobster	783
Grass Rock-fish	264
Sponge	848, 849
Gray, on distribution of the Grampus	13
feeding habits of Bowhead	23
Greenland Whales	22
Pilot Whale	11
Sperm Whale in English Channel	9
figures of Fur Seals	54
geographical distribution of the Hooded Seal	70
North American Manatees	114
Northern Fur Seals	52
Gray Back Whale	31
Leech	835
Perch, name for Drum	370
Pickerel	421
Pike	424
Snapper	397
Trout	487
Whale, California	31, 32
Grayling	505
American and European, similarity of	506
distribution of, in Europe	506
name for Salmon	470
Great Herring	550
Great Lake Pike	462
Greedigut	173
Green-bone, name for Mutton-fish	247
Silver Gar-fish	458
Green Crab	773
Green Cod	228
fish	433
Garrupa	265
head	425
Leech	835
Pike	418
Pollock	228
Rock-fish	265, 266
Rock Trout	267
Smelts	456
Sturgeon	662
tail	569
Turtles	147, 150
breeding of	151
distribution of	150
food and feeding habits	150
names of	150
size of	150
uses of	151
North American species of	150
Greenland and Right Whales, Baleen of	21, 22
Turbot	197
Whale	20
Greenlander	258
Grenadier family	244
Grey Gurnard	256
Halibut	194
Grey-lord	228
Grey-Trout, name of Squeteague	362
Gribble	826
Grilse	468
Groper	410
Ground-holders	783
Ground-keepers	201, 213
Ground Pike	424
Shark	674, 675
Tenders	201
Grouper, name for Rock Cod	262
Triple-tail	444
Banded	412
Black	411
Red	410
Grubber	612
Grubbers, name for Cod	212
Grubby	258
Grunt, Black	368, 390
Californian	400
Red-mouth	398
White	399
Yellow	399
Grunter	256
Guard on distribution of the alligator	142
Guasa	411
Gubartas	20
Gundlach on abundance of Florida Manatee	123
Guebucu	337
brasiliensibus	356
Guffer	247
Guichenot on distribution of Sword-fish	340
Gulf Menhaden	575
food of	577
messmates of	576
movements of	576

	Page.
Gulf Menhaden, popular names of	576
reproduction of	577
Gull-fish	228
Gunnilla, on name of Manatee	116
Günther, on the anatomy of the Mullet	449, 450
classification of the Eel	629
distribution of Rose-fish	260
Fierasferidæ	243
history and habits of the Pilot-fish	330
Lampreys	676
the life history of the Eel	632, 633
movements of the Gar-fishes	458
names of American Burbot	236
rate of growth of Sword-fishes	347, 348
Scopelus family	547
Thread-fish	279
variations of Saibling	501
Gurnard family	255
Gurnard, Flying	255
Grey	256
Red	256
Gurry Shark	674
Gut-pock Herrings	550
Haddie	224
Haddock	223
Haddock, abundance of	225
distribution of	223
food of	226
movements of	224
names of	224
uses of	228
Norway	260
Haddoh	476
Hadow	224
Hadot	224
Hag-fish, enemy of Halibut	182
Hag-fish	682, 680, 681
Hair Seals	37
Hairy-back Shad	610
Hake	234
distribution of	234
habits of	235
names of	234
uses of	235
California	243
Dame	234
King	234
Old English	234
Silver	240
Squirrel	234
White	234
Half Herring	551
Half-beak	461
Half-moon	395
Halibut	177
abnormal individuals among	197
abundance of	193
common names of	190
distribution in N. W. Atlantic	191
food of	195
migrations of	194
size of	193
spawning of	196
Halibut, Bastard	182
Chicken	178, 194
Grey	194
Little	197
Monterey	182
Halichœrus grypus	65
Halicyon richardsi	57
Halisarcoidea	844
Hall on Spawning of Mackerel	296
Hälleflsk	191
Hälleflundra	191
Hallock, Charles, on migration of Sea Bass	408
on distribution of Striped Bass	425
Charles, on habits of the Bowfin	658
on spawning habits of Black Bass	403
Hamlin, on habits of Lake Trout	487
Hammer-head Shark	671, 674
Sucker	615
Handsaw Fish family	547, 548
Hannahills	407
Haploidonotus grunniens	362, 370
Harbin	228
Harbor Porpoise, food of	15
destructiveness of	15
distribution of	14
reproduction of	15
size and movements of	15
uses of	15
Seal	55
general history and synonymy of	55
geographical distribution of	55
habits of	57
Hard Clam	708
Hard-head, name for Salmon	444
Whale	21
Shad, Name for Menhaden	569
Sponge	845
Hard-mouth	618
Hard-tail	324
Harding, Capt. King, on abundance of Mackerel	290
Harding, Capt. King, on food of Mackerel	291
Hare-lip	614
Hare, Sea	18
Harlan, on abundance of Florida Manatee	123
American Manatees	114
size of Florida Manatee	117
Harmer, Thomas, on enumeration of eggs in Mackerel	298
Harp Seal	62, 65
Breeding	62
geographical distribution of	62
hunting, and products	63, 64
Turning	62
Young	62
Hart, M. A., on capture of Lampreys	680
Harvest-fish	333
distribution of	333
Harwood on the nose of the Fur Seal	79
Haul-a-boat	101
Hawk's-bill Turtles	147, 149
as food	150
economic value, grades of shell of	149

	Page.
Hawk's-bill Turtle, food and habits of	149
range of	149
size of	149
Hecht	562
Hector on Sword-fish in New Zealand	341
Heilbot	191
Heiligebutt	191
Helmet-shell	699
Hemdurgan	260
Hemilepidotus spinosus	259
trachurus	259
Hemirhamphus Rosæ	460
unifasciatus	461
Hemitripterus, americanus	258
hispidus	258
Hen Clam	708
Hen-fish family	335
Henshall, J. A., on the Black Bass	401
Heptranchias maculatus	671
Herbert on the peculiarities of the Siscowet	496
Hermes, Dr. Otto, on reproductive organs of Conger-Eel	656, 657
Hermit Crabs	779, 780
Herrard on habits of, American Manatee	119, 120
on products of South American Manatee	127
on the pugnacity of Alligators	143
Herring	549
abundance and importance of	549
artificial propagation of	563
capture and uses of	565, 566
effect of meteorological conditions on capture of	554, 555
fishery, alleged destructiveness of	566–568
food of	563–565
geographical distribution of	551–552
movements and migrations of	552–557
name for Char	501
Gulf Menhaden	576
Menhaden	569
names of	550
periodicity of abundance of, on European coast	557–559
reproduction of	559, 563
Big-eyed	611, 680
Bleking	550
Blue	579
Bohuslän	550
Boundary	550
Branch	580
California	568, 169
Cod	201
English	582
Fat	550
Fjord	551
Glut	582
Gottenburg	550
Grôben	550
Grass	550
Great	550
Gut-pock	550
Half	151
Hogs	14
Kulla	550
Lake	541
Herring, Laid	551
Little	579
Michigan	541
New York	579
Norwegian	550
Norwegian Winter	550
Scotch Dutch	551
Skarp	550
Small	550
Spiced	550
Sprat	579
Spring	579
Summer	579
Tender	551
Tiny	579
Toothed	612
Tribe	549
Wall-eyed	580
Herrings of the Pacific coast	568, 569
River	579
Hessel, Rudolph, on the Carp	618–626
Heterodontus Francisci	673
Heterograpsus nudus	765
oregonensis	765
Heterostichus rostratus	251, 275
Hewlook-Powak	505
Hexagrammus asper	268
decagrammus	267, 268
lagocephalus	267, 268
ordinatus	268
Stelleri	267
Hexanchus corinus	676
Hickory Shad	607
abundance of	608, 609
geographical distribution of	608
names of	607, 608
reproduction of	609
size of	609
Higginson, Francis, on abundance of Mackerel in 1629	289
High-finned Killer Whale	17
Hind, H. Y., on abundance of Herring	549
the causes of irregular movements Mackerel schools	300–1
distribution and abundance of Codfish	209, 210
geographical distribution of Mackerel	281
migrations of the Mackerel	282
movements of Capelin	546
Codfish schools	208
relations between Mackerel and Launce	292, 293
spawning Codfish	209
habits of the Capelin	545, 546
Hind, Spotted	412
Hippa talpoida	779
Hippocampus heptagonus	172
hudsonius	172
ingens	172
Hippoglossoides elassodon	188
exilis	187
Jordani	186, 187
platessoides	197

Page.

Hippoglossus vulgaris 189
Hippolyte brevirostris 818
Hirudo medicinalis 835
officinalis 835
parasite of Sword-fish 355
Histiophorus americanus 336, 337, 356
gladius 336, 357
immaculatus 336
indicus 356
orientalis 336
pulchellus 336
Histriophoca fasciata 63, 67
fasciata 107
Hoe 673
Mother 667
Hog-choker 177
Hogfish 275
name for Log Perch 417
Pigfish 398
Holacanthus ciliaris 280
Holbrook on best fishing-grounds for Sheepshead. 383
breeding of Green Turtles 151
differences between Sea Bass and Black-fish 408
distribution of the Alligator 141
Tautog 269
food and feeding habits of Green Turtles 150
the food of the Loggerhead Turtle. 148
habits of the Crab-eater 444
habits of the Grouper 410
Sheepshead 382
Spanish Mackerel 312
the Squirrel-fish 410
the habits of the Whiting 376, 377
Mobilianer 155
mode of life of Alligators 144
origin of name of Alligator 141
the Pig-fish 399
range of Hawk's-bill Turtles 149
the Red-mouth Grunt 398
size of the Alligator 142
and mode of life of Bullfrog ... 159
Holconotus Agassizi 278
analis 278
argenteus 278
rhodoterus 278
Holia 476
Holibut 191
Holocanthus tricolor 280
Holocentrum pentacanthum 361
Holothuria floridana 838
princeps 838
Holybut 191
Homarus americanus 781
capensis 783
vulgaris 783
Home, Sir Edward, on development of the Lamprey 678
Homer 667
Hone 476
Hooded Seal 65, 68
food of 71

Page.

Hooded Seal, geographical distribution and migrations of 68–71
habits of 71
hunting and products of 71
Hoopid Salmon 477
Horned Dace 617
Dogfish 672
Eel 246
Pout 627
Horness 246
Horny-head 617
Hors 326
Horse Crevallé 323, 324
Horse-fish, name for Blunt-nosed Shiner 322
Sauger 424
Horse-head 323
Horse-mackerel 320
name for Black Candle-fish 268
Bluefish 433
California Hake 243
Jurel 324
Horse, Sea 35
Sponge 845, 848
Horseshoe Crab 829, 830
Horsewhale 35
Houndfish, name for Bluefish 435
Silver Gar-fish 459
Blew 308, 435
Speckled 308, 435
Hubbard on abundance of Sperm Whale 9
distribution of Atlantic Walrus 34
Humañana 474
Humpback Whales 26, 27, 29
food of 26
distribution of 26
migrations of 26
in New England 27
size of 26
Hump-backed Salmon 476
Butterfish 323
Hungarian Leech 837
Hunter and Woods on Sperm Whale in England. 9
Huxley, Prof. T. H., on abundance of Herring ... 549, 550
alleged destructiveness of the Herring fishery ... 567, 568
distribution of the Cray-fishes 812
the functions of the appendages of Cray-fish 782
migration of Herrings ... 553
spawning habits of Herring. 559–562
the structure of the Cray-fish 812, 813
Hya-qua 703
Hyatt, Prof. A., on Florida and Bahama commercial Sponges 846–850
general structure of the Sponge 844
the horny Sponges 844–846
Hydroid Corals 841
Hyodon alosoides 612
selenops 612
tergisus 612
Hyodontidæ 612

Page.

Hyodon tergisus 613
Hyperaodon bidens 18
Hypleurochilus gentilis 251
Hypomesus olidus 544
Hypsopsetta guttulata 185
Hypsurus Caryi 278
Hysterocarpus traski 279
Ichthys Lockingtoni 361
Icosteus æniguaticus 361
family 361
Ictalurus 626
albidus 627
nigricans 626, 627
ponderosus 627
punctatus 627
Ictiobus bubalus 615
carpio 615
cyprinella 615
cyprinus 615
urus 615
Idyia roseola 842
Ikan jegan 338
Ikan-layer 338, 357
Ilyanassa 696
obsoleta 693
Imperador 337
Ingersoll, E., on agencies destructive to Oysters 746–748
on destructive influence of the Drum on Oyster-beds 369
on interference of other animal life with Oysters 748, 749
on Oyster culture 732, 733
Inland Alewife 594
Inshore Cod 201
Isogomphodon maculipinnis 672
Isophyllia dipsacea 841
Isopods 826, 827
Isurus, sp 672
Ivory Barnacle 828
Jack, name for Boccacio 266
Jurel 324
Pickerel 464
Wall-eyed Pike 418
Buffalo 324
Salmon 418
Jackson, J. B. S., on Sperm-Whale grounds 8
Jacobs, Solomon, on migrations of Mackerel 287
Jacoby on discovery of female Eel 636, 638
the external characteristics of Eels 644, 645
natural history of the Eel 652–655
search for young Eels 646
Jelly-fish, food of ocean Sunfish 169
Jelly-fishes 841, 842
Jorker 617
Jew-fish 413
name for Black Grouper 411
Tarpum 611
Jewel-head 370
Joe Rocker 774
John Dory 335
name for Rose-fish 260
Johnny 259
Grindle 658
Verde 413

Page.

Johnson, Capt. G. A., on spawning of Halibut 196
Jonah Crab 769
affinities of 769
distribution and habits 769
economic value of 770
name of 770
Jones, J. Matthew, on abundance of Horse-Mackerel 321
distribution of Sword-fish 341
pugnacity of Spear-fishes 350
Joohoe 337
Jordan, D. S., Prof., on distribution of—
Agonidæ 258
Alaska Pollack 232, 233
Banner Pompano 329
Barracouta 448
Blue Pike 423
California Anchovy 612
Conger Eel 628
Flying-fish 459, 460
Herring 568, 569
Pompano 334
Sardine 569
Smelt 457, 544
Yellow-tail 331
Sparoids 394, 395
Carp family 616–618
Catfish family 626–628
Chub Mackerel 303
Corvinas and Roncadors of the Pacific coast 378–380
Dolly Varden Trout 504, 505
Flat-fishes and Soles of the Pacific coast 184–189
Fresh-water Drum 370
Hag-fishes 681
Inland Alewife 594
King-fish 316
Little Tunny 322
Log Perch 417
Long-finned Tunny 320
Mullet in California 456
Parrot-fish 275
Pacific Bonito 319
Tom Cod 223
Pike Perches 417
Quinnat Salmon 479, 480
Ratfish 662
Rock Cods of the Pacific 262–267
Trouts 267, 268
Salmons of the Pacific 474–479
Sauger 424
Serranoid fishes of the Pacific Coast 413
Sharks of the Pacific Coast 674–676
Sturgeons of California 662
Sucker family 614–616
Sunfishes and their allies 404
Surf-fish family 276–279
Surf Smelt 544
Sword-fish 341
Tile-fish family 361
Wall-eyed Pike 417
Whitefishes 541–543

	Page.
Jorobado	322
Josselyn on the Alewife, 1675	583
size of Mackerel, 1675	299
Joyce, Capt. Hanson B., on migrations of Mackerel	288, 289
Jubaret	29
Jubartes	29
Jubartus	29
Jukes, Professor, on distribution of Ringed Seals	65
food of Hooded Seal	71
Jumper	401
Jumping Mullet	449
June Mullet	451
Jupiter	29
Jupiter Fisch	29
Whale	30
Jupitervisch	29
Jurel	324
Cuba	325
Jurucaa	150
Kabeljaauw	200
Kalleraglik	197
Kapustnik	133
Kaskelot	7
Kassiarsoak	59
Kassigiak	59, 66
Kayko	476
Kazilot	7
Keela Lauk	18
Keethie	173
Keghie	173
Keithok	173
Kelp Crab	778
Kelp-fish of California	275
Kelp Salmon	413
Kemp, R. W., on distribution of West Indian Seal	67, 68
Kemps, Capt. David, on abundance and habits of Mullet	452, 453
Kerato-Silicioidea	844
Keratoidea	844
Kerr, J. W., on food of White-fish	516
spawning of White-fish	523
Kettlemaw	173
Kiel, Peter, on food of White-fish	516
spawning of White-fish	522, 523
Killer Whales	12, 17
annoyance to whalemen	17
destructiveness of	17
habits and distribution of	17
uses of	17
Low-finned	17
Killifish	466
King Cero	307, 316
King Crab	629, 630
King-fish	375
name for Cero	316
Whiting	377
King Hake	234
King Salmon	479
Kipper	468
Kisutch	477
Kirtland, J. P., on breeding habits of the Sunfish	405, 406
habits and value of Grass Bass	407
Kiupmyds	69

	Page.
Klippfisk	200
Knife-handle	707
Knight on food and feeding habits of Green Turtles	151
habits of Yellow-bellied Terrapin	155
Kogia Floweri	11
Köhler	228
Koticlie	82
Krasnaya Ryba	477
Krant	133
Kûla-why	476
Kulla Herring	550
Kulmund	501
Kumlien, L., on Lake Trout	493–496
Muscallonge	464–466
Pike	463, 464
White Bass	428–431
Whitefish	536–540
Yellow Perch	414–417
Ringed Seal	80
Halibut	192
Seals in fresh water	59
Hooded Seal	69, 70
Ringed Seals	664
Salmon in Lake Ontario	473, 47
Kuth	228
Kyack	582
Kyauck	582
Laberdan	200
Lachnolæmus falcatus	275
Lady Crab	774, 775
Lady-fish	612
family	612
Lafayette	370
Lagartos	141
Lagenorhynchus obliquidens	16
perspicillatus	16
Lagocephalus lævigatus	170
Lagodon rhomboides	393
Lake Cusk	236
Herring	541
Salmon	487
Sturgeon	660
Trout	485, 504
Trout, culture of	491–493
enemies of	491
food of	490
importance of	488
names of	488
principal spawning grounds of	489, 490
size of	486
spawning of	488
varieties of	486–488
White-fish	507
Laker	487
Lamantin	116
Lamellaria perspicua	693
Lamellibranchiata	703
Lamna cornubica	670, 676
~~cornubica~~	675
Lamper Eel, name for Mutton-fish	247
Eels	67
Lamplighter	406
Lampreta	676

Page.

Lamprey, economic uses and capture of 679, 680
spawning season of 678
Lampreys 677–680
Lamprididæ 335
Lampris guttatus 335
Lamproie 676
Lancelets 681
Land-snails, edible 701, 702
Lauman, Charles, on capture of White-fish in the Grand Lake 536
economic value of the Burbot 240
feeding habits of the Burbot 239
geographical distribution of Shad 594, 595
on spawning habits of the Capelin 545
value of Capelin 546
varieties of Lake Trout 487
Lant 244
distribution of 245
habits of 244
uses of 246
Lard Herring 551
Latilidæ 360
Launce 244
Lavinia exilicauda 618
Lawyer 236
Leather Carp 619
Leather-jacket 332
habit of stealing bait 172
name for File-fish 172
Leather Turtle 147
Le Baron, J. F., on mode of capturing Manatee .. 124, 125
Leda tenuisulcata 703
Leech, culture of 835, 836
ponds, American 836
structure of 833
use of 836
varieties of 836
American, cultivation and economic value of 834, 835
distribution and structure of ... 833
medicinal 833
European 835
German 837
Gray 835
Green 835
Hungarian 837
Spanish 837
Swedish 837
Leeches 833–837
Legateer 141
Leidy, on cause of green color of Oysters 738
the living Sponge, in Ostrea virginiana. 750
the range of American Manatee 116
Le-Kai 476
Leo marinus 39
Leopard Seal 59, 73
Shark 675
Lepas fascicularis 629
Lepidogobius gracilis 255
Lepidopsetta bilineata 185
Lepidopus caudatus 336

Page.

Lepidosteidæ 662
Lepidosteus osseus 622
platystomus 663
spatula 668
Lepomis cyanellus 406
gibbosus 405
Holbrookii 406
innuatus 406
megalotis 406
notatus 406
pallidus 406
punctatus 406
Leptagonus verrucosus 258
xyosternus 258
Leptocottus armatus 259
Leptocephalus conger 655
Leptops 626
olivaris 626, 627
Lerneans, parasites of Sword-fish 354
Leucorhamphus borealis 16
Peronii 16
Lewis, on abundance of Haddock 225
Libinia dubia 778
emarginata 778
Lienophora Cohnii 734
Limanda aspera 184
ferruginea 184
Rough 184
Limnea 694
Limnoria, Boring 826
lignorum 826
similar to Boring Amphipod. 825
Limulus polyphemus 829
Lindahl, Josua, on periodicity in movements of Herring in Europe 557, 558
Ling, name for Burbot 236
Cobia 444
Cultus Cod 267
Hake 234
Mutton-fish 247
Liocottus hirundo 259
Lion, Sea 37, 38
Liostomus xanthurus 370
Liparididæ 253
Liparis lineatus 253
pulchellus 255
vulgaris 253
Lirus perciformis 334
Little Drum 367
Halibut 197
Herring 579
Mackerel 305
Neck Clam 708
Roncador 379
Smelt 457
Sunny 322
Littorina 693
Ljungman, on annual migrations of Herring schools 555–557
geographical distribution of Herring 551, 552
migrations of Herring 552, 553
names of Herring 550
Lob-Keling 228

Lophius piscatorius ... 173

	Page.
Lobo marino	48
Lobotes surinamensis	444
Lobster	780
American	781
name of	783
Berried	783
Black	783
European, development of	802–804
distribution and habits of	807–811
Rock	780, 783
School	783
Soft-shell	783
Spiny	780
Lobsters	780–812
association of males and females	789–790
average size at present	783–784
bathymetrical range of	787
casting a claw	805–806
character of the bottom preferred by	787–788
color of	785–786
composition of	811–812
decrease in size of	783
deformities and diseases of	806
designations of spawn of	798
destruction by storms	807
development of the young	979
distribution and geographical range of	786–787
enemies of	806–807
extrusion of the eggs, etc	798–799
food of	804–805
in fresh and brackish water	787
growth, shedding, etc., of	791–794
habitats while spawning of	797
large	784–785
migrations of	783
movements of	790–791
number of eggs in	798
off-shore range of	787
parasites of	806
pairing of	797
rate of growth of	794–795
relations and structure of	781–783
reproduction of	795–796
schooling of	789
shedding after spawning	799
size of spawning	797
spawn as food	798
spawning season of	796–797
transplanting the young of	804
winter habits of	790
Lobster's Tail, name for Land Snail	701
Loche	236
Lockee Cod	413
Lockington on the Glyptocephalus zachirus	189
Hippoglossoides Jordani	187
Parophrys ischyrus	185
Lockwood, Rev. Samuel, on habits of Sea-horse	172
tongue of the Drill	696
Lödde	544
Lödde-Fisk	205
Log-fish	334
Log Perch	417
Loggerhead Turtle	147, 153
breeding habits of	148
Loggerhead Turtle, distribution of	147
economic value	148
food of	148
rate of growth	148
size of	148
Loggerheads	147
Pealei	349, 687
Long-boned Shad	279
Long Clam	707
Long-eared Sun-fish	406
Long-finned Sole	188
Tunny	320
Long-nosed Gar-pike	662
Look-down	323
Lopholatilus chamæleonticeps	360
Lophopsetta maculata	179, 199
Losh	236
Lost Salmon	476
Lota brosmiana	236
inornata	236
maculosa	235, 236
enemy of Alewives	592
vulgaris	236
Low-finned Killer-whale	17
Luccio	462
Lucioperca borea	424
canadensis	424
grisea	424
Lump-fish	253
distribution of	254
Lump-suckers	253
Lumpenus anguillaris	251
Lunatia grœnlandica	693
heros	693
heros	700
immaculata	693
Lunge	487
Black	487
Racer	487
Silver	487
Lupton, N. S., on breeding habits of salt-water Cat-fish	628
Luth	147
Lutjanus antolycus	397
Blackfordii	395
campechianus	396
caxis	236
caxis	397
Stearnsii	396
torridus	396
Lütken on distribution of Sword-fish	341
geographical distribution of Rose-fish	261
Luzzo	462
Lybecker on periodicity of Herring in Europe	558
Lycodes family	247
Lycodidæ	247
Lycodopsis microstomus	248
paucidens	248
Lyell, Sir Charles, account of battle between porpoise, and alligators	15
on habits of Cowfish	16
Lyman, Col. Theo., on abundance of Tautog	271
spawning of the Sea-robin	256
Lyon, George, on capture of Lampreys	679–680

	Page.
Lysanger	261
Lysiosquilla glabriusenla	823
Lytle, A. H., on movements of Branch Alewife	592
McDonald, Marshall, on the Hickory Shad	607–609
Shad	594–599
Shad and Alewives	579–588
Machæroplax obscura	693
Mackerel, abundance of	289, 290
and its allies	281, 300
enemies of	299–300
food of	290–294
geographical distribution of	281–282
hibernation of	284
migrations of	282, 283–289
spawning grounds of	302, 303
rate of growth and size of	298, 299
reproduction of	294–298
schools, studies of the movements of	300
Atka	268
Big-eyed	303
Bull	303
Chub	303
Frigate	305
Guide	458
Little	305
Mixed	304
Monterey	316
Shark	6[illegible]
enemy of Mackerel	299
Skip	433
Snapping	433
Spanish	307
Thimble-eye	304
Sinker	304
Yellow	324
Mackinaw Trout	488
Mackinnon, Captain, on Turbot in America	176
Macoma nasuta	708
sabulosa	703
Macrobdella decora	833
Macrochelys	153
lacertina	153
Macrorhinus angustirostris	72
leoninus	73, 74
Macrurida	244
Macrurus Bairdii	244
rupestris	244
Macy, Zaccheus, on former abundance of Sperm Whale	8
on the Scrag Whale	31
Mademoiselle	375
Madrepora cervicornis	841
palmata	841
prolifera	841
Maigre	368
Malacoclemmys geographica	156
Lesueurii	156
palustris	156
Mallotus villosus	207, 544
Malm, on date of capture of Cat-fish	250
Malma	504
Malmgren, on distribution of Hooded Seal	70
habits of Ringed Seals	66
Malthe vespertilio	172
Maltheidæ	173
Manatee, names of	116
mode of capture	123, 124
probability of extinction of	123
products furnished by	127
size and weight of	117
American	114
boundaries of the range of	116
early allusion to habits of, by Columbus	119
Florida, abundance of	122, 123
distribution of	114
size of	117
North American species of	114
South American, abundance of	123
distribution of	115
size and weight of	117
West Indian	115
Manati	116
Manatus antiquus	116
australis	114
inornatus	116
latirostris	115
Manaty	116
Man-eater Shark	669–670, 67[illegible]
Manentine	116
Mangrove Snapper	306, 307
Manicina areolata	841
Manta birostris	666
Mantis, Sea	823
shrimp	823
Manuani	663
Mar, Captain Chester, on food of Mackerel	291–292
migration of Codfish	210
Marbled Angler	173
Margarita argentata	693
cinerea	693
grœnlandica	693
Margate fish	394
Marine Tortoises and Turtles	147
Turtles, species of commercial importance	147
Worms	831
Market fish	394
Maroona Eel	247
Marphysa sanguinea	833
Marse Banker	326
Marshbanker	569
Marsoon	18
Marsuin	14, 18
Marten on distribution of White Whale	18
Marthy	236
Masooka	370
Masters, Peter, on abundance of Mullet at Saint Augustine	453
Matajuelo	361
on the colors of Grayling	507
Mather, Fred., on destructiveness of the Drum	368
Jelly-fish	842
Richard, on abundance of Mackerel in 1635	989
extract from journal	13
Maties	560
Matkah	88
Mattowacca	607

Page.

Maulrush 228
Maximilian, Prince, on distribution of South American Manatee 115
May Sucker 614
Maynard, C. J., on distribution of Florida Manatee 115
Meandrina clivosa 841
labyrinthiformis 841
sinuosa 841
Medialuna 395
Medregal 331
Medusæ 841
Meerbecht 242
Megalops thrissoides 610
Megaptera osphyia 26
versabilis 26
Melampus 694
bidentatus 701
Melanogrammus æglefinus 223
Menhaden 569
abundance of 573
distribution of 570
enemies of 574
food of 573–574
movements of 570–573
names of 569–570
reproduction of 573
uses of 574–575
Gulf 575
Menidia notata 456
Menippe mercenarius 772
Menomonee White-fish 541–542
Menticirrus alburnus 376
littoralis 376
nebulosus 375
undulatus 379
Merchant, Capt. E. W., on abundance of Haddock 225
Pollock 229
Cod-fish schools 205
food of Mackerel 292
the uses of the Hake 235
Merlangus carbonarius 231
vulgaris 241
Merluccio 240, 243
Merlucius bilinearis 240
merlus 240
productus 243
vulgaris 240
Mermaid-fish 171
Mérou 267
Methy 236
Meunier, on overfishing for Sword-fish in the Mediterranean 349
reproduction of Sword-fish 350
Michigan Grayling, artificial propagation of 507
Herring 541
Microgadus proximus 223
tomcod 223
Micropogon undulatus 378
Micropterus Dolomieï 401
enemy of Alewives 592
salmoides 401
enemy of Alewives 592
Microstomidæ 543

Page.

Milaktok 62
Millepora alcicornis 841
Miller's Thumb 250
Millet on food and voracity of the Sailfish 504
Milner, J. W., on artificial propagation of White-fish 523–528
the Chief Mountain White-fish 542, 543
culture of White-fish 529–535
development and rate of growth of White-fish 519–522
distribution of the Eel 632
enemies of Lake Trout 491
enemies of White-fish 512, 513
food of the Grayling 506, 507
White-fish 513–516
general habits and history of Lake Sturgeon 660, 661
the habitat of the Michigan Grayling 506
habits of the speckled trout 490
importance of Lake Trout 488
improved methods of shipping eggs of White-fish 529–531
the Lamprey as a parasite 679
movements of White-fish in the Great Lakes 509–512
parasites of White-fish 535
size and weight of Lake Trout 491
spawning grounds of Lake Trout 489, 490
spawning habits of Lake Trout 488, 489
Minister 62
Minnilus cornutus 617
Minnow, name for Mummichog 406
Rot-gut 618
Minnows 616
Minny 276, 278
Mirror Carp 619
Mishcuppaug 386
Missouri Sucker 615
Mitchill, on habits of the Sheepshead 382, 383
the Hammer-head Shark 671
history of the Chub Mackerel 303
Spanish Mackerel 308
Sword-fish 340
Tautog 269
Tautog fishing 272, 273
term of continuance of the Sheepshead 380, 381
and Field on abundance of Salmon 469
Mixed Mackerel 304
Mnemiopsis Leidyi 842
Mobilianet Terrapin 155
Möbius, Professor, on food of Herring 505
reproduction of European Oyster 720
Modiola capax 709
hanatus 709
modiolus 703, 709
plicatula 709
Modiolaria discors 703
Moharra 276, 278
family 279
Mongrel White-fish 541

Mustelus vulgaris . . . 673

	Page.
Monk-fish	171, 173
Mola	169
Moll	269
Molligut	173
Mollusks	687
dyes from	699
shells for cameo-cutting	699, 700
Wing-footed	702, 703
Molva Huntia	236
vulgaris	236
Molyneux on Sperm Whale in England	9
Monocanthus setifer	213
Monodon monoceros	19
Monterey Halibut	182
Mackerel	316
Moon-eye	541–613
family	612, 613
Moon-fish	445
name for Blunt-nosed Shiner	322
range of	445
Silver	323
Moore, C. R., on abundance of Spanish Mackerel	312
Moray, speckled	628
Morays	628
Morina	250
Morse	34, 35, 36
Mortimer, C., on pugnacity of Sword-fish	351
Morue	200
verte	200
Moss Bass	401
Mossbunker	569
Mother of Eels	236
Mottled Grampus	14
Mountain Trout	475
name for Black Bass	401
Moxostoma macrolepidotum	614
Mucqua	497
Mud Bass	405
Cat	627
Crabs	772
Mud-dab	182
Mud-fish	659
Mud Shad	610
Suckers	615
Muffle Jaws	259
Mugil albula	449
brasiliensis	449
Müller, August, on the development of the Lamprey	678
great Northern Expedition	129
Mullet, abundance of	450, 451, 452
in California	456
Eastern Florida	450–453
general habits of	449
movements of	451
names of	449
in Saint Mary's River	453
Southeastern Florida	453
value of	452
Big-eyed	449
Black	375
Fat	451
Finger	453
Jumping	449
June	451
Mullet, Roe	451
Sand	449
Sea	453
Silver	449
Striped	449
White	449
Mullets	449
Mummichog	466
family	466
Bluefish	449
Muraena nigra	629
Muraenidæ	628
Murenæides ornatus	251
Murie, Dr., on food of Sirenians	119
size of South American Manatee	117, 118
Murray, Andrew, on Bowhead Whales	20
distribution of Right Whales	25
Sperm Whales	7
Muscallonge	464
abundance of	464–466
Musk Tortoise	152, 154
characteristics of	154
distribution of	154
Musquaw River White-fish	541
Mussel Digger	31
Mussels	709
uses of	710
Mustelis canis	236
Musteius californicus	673
canis	672
Mustèt	244
Musteta	244
Mutton-fish	247
Mya arenaria	703
Mycedium fragile	841
Mycteroperca brunnea	413
falcata	413
microlepis	413
stomias	413
Myctophum crenulare	547
Myers, W. E., on the Mullet in Saint Mary's River	453
Mykiss	474
Myliobatidae	665
Myliobatis californicus	666
Fremenville	665
Mylochilus caurinus	617
Mylopharodon conocephalus	617
Myriolepis zonifer	268
Mytilus edulis	703, 709
Myxine glutinosa	680
Myxinidae	680
Namaycush	485
Narwhal	19
distribution of	19
size, uses, &c	19
Nassulas	733
Natica	696
clausa	693
Native Cod	201
Seal	58, 65
Naucrates ductor	330
Nautichthys oculofasciatus	259
Needle-fish	458
Neill, Mr., on the Mutton-fish	248

	Page.
Neitsek	65, 66
Nejou õgou	676
Nelson, E. W., on the Blackfish of Alaska	466, 467
Neoclinus Blanchardi	251
satiricus	251
Neoliparis mucosus	255
Neptunea despecta	693
Nereis limbata	832, 833
virens	831, 833
Nerimartout	69
Neunaüge	676
Neunaügel	676
Neverita duplicata	700
New England Whiting	240
New Light	407
New York Herring	579
Newfoundland Turbot	177
Nigger Chub	618
Night Cod	214
Nilsson and Muller on Sea-Bears	52
Nine-eye	676
Nippers	273
Nordenskiöld on extinction of Rhytina	135
Norris, Thad., on beauty of young Salmon	472
habits and size of White Perch	432
manner of fishing for Sheepshead	383
the size of the Salmon	473
North, Christopher, on the "perfect fish"	473
Northern Fur Seal	49
figures of	53, 54
general history	51
size of	51
Northwest Whale	24
Norway Haddock	260
Norwegian Herring	550
Winter Herring	550
Nosconoge	466
Notemigonus chrysoleucus	616
Noturus flavus	627
Nucula proxima	703
tennis	703
Nurse-shark	676, 674
Nye, William, on pugnacity of Sword-fish	353
Oar-fish	449
Obispo Ray	665
Ocean Kingfish	337
Sun-fishes	169
Octopus granulatus	687
Oculina diffusa	841
Odobænidæ	33
Odobaenus obesus	34
rosmarus	34
Odontaspis littoralis	676
Odontopyxis trispinosus	258
Odostomia striatula	694
Ogilby on breeding habits of Manatees	118
the Sucking-fish as a fisher	446, 447
Oil Shark	676
Okow	418
Old English Hake	234
Old Man	65
Oligocottus analis	259
globiceps	259
maculosus	259

	Page.
Oligoplites saurus	332
Olivella biplicata	699
dama	699
gracilis	699
Oliver on the habits of the Lant	245
Ombre Chevalier	501
Ommastrephes illecebrosa	687, 690
enemy of Mackerel	299
Oncorhynchus chouicha	479
gorbuscha	476
keta	476
kisutch	477
nerka	477
quinnat	480
Onion-fishes	244
Opah family	335
Ophichthys chrysops	628
ocellatus	628
Ophidiidæ	243
Ophidium marginatum	243
Taylori	244
Ophiodon elongatus	267, 268
Orange File-fish	171
Rockfish	265
Orbicella annularis	841
cavernosa	841
Orca atra	17
gladiator	17
rectipinna	17
Orchestia agilis	824
Orcynus alalonga	320
alliteratus	322
argentivittatus	320
pelamys	316
thynnus	320
enemy of Sword-fish	354
similar to Frigate Mackerel	306
Oregon Finner	30
Ormer-shells	700
Orthagoriscidæ	169
Orthagoriscus mola	169
Orthodon microlepidotus	618
Osmerus dentex	544
eperlanus	543
mordax	543
spirinchus	544
thaleichthys	544
Ostracion bicaudalis	171
quadricornis	171
trigonis	171
triqueter	171
Ostraciontidæ	170
Ostrea edulis	711
virginica	703, 711
rate of growth of	725–729
Oswego Bass	401
Otaria	37
californiana	45
jubata	38, 44
leonina	52
ursina	54
Otaries	37
Otariidæ	33
Otolithus thalassinus	364

Page.

Otsego Bass 507
Ouiachon 547
Oviedo on name of Manatee 116
Owen, Prof. R., on the power of Sword-fishes 345
Owl, Sea 254
Oxyiebius pictus 268
Oyster 711
Oyster-banks, natural and artificial 750–758
characteristics of 750, 751
positions of the spat in 751, 752
Oyster-beds, artificial, establishment of 752, 753
cause of green color of 735–742
experiments at Washington and Philadelphia ... 735
characters of the larval shell 728
coarser anatomy of 711–715
colors in different parts of 740–742
culture, influences of environment on 732, 733
situations best adapted for 731, 732
discrimination of sexes of 722, 723
early stages of development of 726
experiments on, at Saint Jerome's Creek . 727
food of 729–735
observations at Saint Jerome's Creek 729–731
influence of temperature on 743, 744
impregnation of the eggs of 723–725
interference of other animal life with ... 748–750
local variations in form and habits of 742–744
manner of taking on flesh and reproduction of 755–758
methods of distinguishing sexes and taking eggs of 722–725
minute anatomy of 715–719
mud and fry of 747
physical and vital agencies destructive to . 746–750
and its prey, mutual relation between ... 734, 735
rate of growth of 728, 729
sex, sexual products, and difference of sexual habits in American and European 719–722
size of the egg of 725, 726
spat collectors 753, 754
variations in color of 735, 736
the shell of 743
young, food of 728
larval character of 727, 728
Crab 765, 766
development of 745, 746
as a messmate and purveyor 744–746
quadruple commensalism of 744, 745
European experiments upon 740
fish, name for Tautog 269
Toad-fish 251
Raccoon 752
Pacific Bonito 319
Finback 30
Lycodids 248
Tom Cod 223
Walrus, size of 35
distribution of 35
habits of 35, 36

Page.

Packard, Dr., on geographical distribution of Hooded Seal 69
Paddle-fish 69
Pagophilus groenlandicus 70
Painted Clam 708
Palæmon ohionis 819
Palæmonetes exilipes 819
vulgaris 818
Palinurus vulgaris 780
Paludina 694
Pandalus borealis 819, 820
Danæ 821
leptoceros 819, 820
Montagni 819, 820
propinquus 819, 820
Panganaut Tautwock 201
Panopeus depressus 772
Harrisii 772
Herbstii 772
Sayi 772
found in stomach of Sea-robin 256
Pantosteus platyrhynchus 615
Panulirus interruptus 780
Paper-shell 776
Paralepidæ 548
Paralepis borealis 548
coruscans 548
family 548
Paralichthys dentatus 176, 177, 178, 182
maculosus 182
oblongus 181
quadrocellatus 181
stigmatias 182
Parkhurst, on the Capelin 544, 545
Parnell, on economic value of Cat-fish 250
on the Mutton-fish 247
uses of the Lump-fish 254
Red Gurnard 256
Parophrys ischyrus 185
isolepis 186
vetulus 185
Part 228, 468
Parrot-fish, Blue 274
Parrot-fishes and some of their allies 274, 775
Pasture school 201
Paugy 386
Pauly, Dr., on sex of Eels 649
Peacock-fish 338
Peal 468
Pearch 406
Pece-Buey 128
Pecten irradians 703, 709
islandicus 703, 709
tennicostatus 703, 709
Peelers 770
Pega de las Agujas 446
Pegebuey 116
Penæus brasiliensis 821
setiferus 821
Pennant, on abundance of Alewives 584
feeding habits of the Burbot 239
Pensacola Rock Salmon 331
Snappers 396

Page.

Pentacta frondosa 838
Perca americana 239, 414
fluviatilis, enemy of Alewives 592
Perch, name for Black Bass 401
Chogset 273
Drum 370
Surf-fish 276
Black 444
name for Surf-fish 278
Blue 277
Chinquapin 407
Gray, name for Drum 370
Log 417
Pike 417
Red 260
Ringed 414
River 279
Sacramento 405
Silver 375
Striped 417
White 277, 424, 431
name for Drum 370
Yellow 414
Percina caprodes 417
Peristedium miniatum 257
Periwinkle 694
Perley, M. H., on distribution of Halibut 192, 193
the Pollock 228
the habits of the Hake 235
migrations of Mackerel 288
movements of Pollock 230
movements of the Silver Hake 242
names of Hickory Shad 608
the uses of the Lump-fish 254, 255
Permit 329
Pesce-spada 337
prêtre 266
vermiglia 264
Pescerey 275
Peters, on abundance of Salmon 469
Petricola pholadiformis 703
Petromyzon americanus 676
argenteus 679
branchialis 676
fluviatilis 678
marinus 676, 679
Planeri 677, 678
Petromyzonidae 676
Pez Colorado 372
de espada 337
Philine lineolata 694
Phillips, Barnet, a criticism on the essay "First families of the Atlantic" 282, 283
Phoca Ausoni 74
barbata 65
byroni 74
canina 57
dorsata 63
elephantina 74
fœtida 59, 63, 65, 107
groenlandica 62, 63, 65
Isidorei 70
leonina 74

Page.

Phoca nummularis 57
Petrovi 107
proboscidea 74
vitulina 55, 57, 63, 65, 73, 82, 107
Phocæna brachycion 14
Phocarctos Hookeri 38
Phocidæ 33
Pholads 707
Physa 694
Physis blennioides 234
Chesteri 234
chuss 234
Earllii 234
regius 234
tenuis 234
Pickerel 421, 424, 462, 464
Brook 464
Gray 421
Salt 418
Yellow 421
Pickering 424
Pickers 201
Piddocks 707
Piembo, Paul, on prices of Bull-frogs in California 161
Pig-fish 398
name for Sculpin 258
Pig-fishes 397
Pig, Snuffing 14
Pigmy Sculpin 258
Pike 461
family 461–466
Blue, name for Pike Perch 417
Gray 424
Great Lake 462
Green, name for Pike Perch 418
Ground 424
Nicholas, on habits of Spear-fishes 358
Perches 417
Sacramento 617
Sand 424
Spawn 421
Wall-eyed, name for Pike Perch 417
Yellow 421
name for Pike Perch 417
Pilcher 569
Pilot-fish 330
Whales 11
Piltock 228
Pin-fish 346, 355
Pine-barren Terrapin 178
Pine-tree Cod 201
Pinnipedia 33
Pinnipeds 33
Pinnotheres maculatum 766
ostreum 765
Pipe-fish, appearance and size 172
family 172
geographical distribution 172
habits 172
Pipe-fishes 169
Piper 257
Piscator, on Alewife in the Saint Lawrence River 589

Pseudonym of a writer in Forest & Stream.

Page.

Piscator, author of "Practical Angler," on economic value of the Gurnard 257
Piscis Jovis 29
Piso, on the history of the Sail-fish 356
Plaice 176, 178, 186
fishery 179, 180
Plain Bonito 306
Planorbis 694
Platydon cancellatus 707
Platyglossus bivittatus 274
radiatus 274
semicinctus 275
Platygobio gracilis 617
Platyonichus ocellatus 774
food of Mackerel 290
Platypeltis ferox 152
Platysomatichthys hippoglossoides 177, 197
Pleurobrachia rhodactyla 842
Pleurogrammus monopterygius 268
Pleuronectes glaber 183
glacialis 184
stellatus 184
Pleuronichthys cœnosus 189
quadrituberculatus 189
verticalis 189
Pliny, on the Sword-fish 338
Poddlie 228
Podley 228
Podling 228
Podothecus acipenserinus 258
vulsus 258
Poey on distribution of Sword-fish 341
movements of Spear-fishes 358
size of Black Grouper 412
Poggys 21
Poghaden 387, 569
Pogonias chromis 367
fasciatus 367
Pogonichthes macrolepidotus 617
Pogy, name for Menhaden 569
Moon-fish 445
Scup 387
Surf-fish 276
Poisson bœuf 116
rouge 372
Polar Whale 20
Pole Flounder 177, 178, 188
Polistotrema, enemy of Cultus Cod 268
Rock Cod 263
Stouti 691
Pollachius carbonarius 228
chalcogrammus 232
viridis 228
Pollack 228
Polliwogs 160
Pollock 228
distribution of 228
habits and food of 229
reproduction of 230
uses of 231
raw 228
Polynemidæ 279
Polynemus octonemus 279
Polyodon spathula 659

Page.

Polyodontidæ 659
Polyp Corals 841
Pomacentridæ 275
Pomacentrus rubicundus 276
Pomatomidæ 433
Pomatomus saltatrix 433
Pomfret 335
Pomodasys fulvomaculatus 398
Pomoxys annularis 407
sparoides 406
Pompano, African 427, 329
Banner 327, 329
California 334
Carolina 326
Common 327
Gaff-topsail 329
Round 327, 329
Shore 329
Pompanos 326
Pompilus 330
Pond Tortoises 152, 154, 157
Pookagen 569
Porbeagle 669
Porcupine Fish, appearance, habits, voice 170
geographical distribution 170
fishes 170
Porgee 276, 277
name for Moon-fish 445
Three-tail 445
Porgies of the Gulf 394
Porgy, name for Porcupine Fish 170
name for Scup 386
Goat's-head 393
Sheepshead 394
White-boned 394
Porichthys porosissimus 253
Poriferata 843, 844
Porifera 843–850
Porpoise 18
Atlantic 14
Bay 14
Right Whale 16
Skunk 16
Sperm Whale 11
vomerina 14
Harbor 14
Pristipomatidæ 395
Pot-belly Trout 488
Potomac River, observations of temperature taken, 1881 602
Potfisk 7
Potter 154
Pottfisch 7
Pout, Horned 629
Potvisch 7
Prawn, California 821
common 818, 819
Prawns, Deep-water 819–821
Preestl 475
Pricke 679
Prid 679
Pride 679
Prinkle 228
Prionotus 235

	Page.
Prionotus palmipes	255, 256
stephanophrys	258
strigatus	255
Pristidæ	667
Pristipoma Davidsoni	400
Pristis pectinatus	667
Promicrops guasa	412
Prosopion Cousii	542
Psettichthys	186
melanostictus	186, 187
Pseudemys concinna	155
elegans	155
hieroglyphica	155
mobiliensis	155
rugosa	154
scabra	155
Troostii	155
Pseudo-harengus	580
Pseudojulis modestus	275
Pseudopleuronectes americanus	182
Psychrolutes paradoxus	259
Pterophryne histrio	173
Pteroplatea maclura	665
marmorata	666
Pteropoda	702
Ptychochilus Harfordii	617
lucius	617
oregonensis	617
Puckermouth	178
Puff-fish	170
Puffer	14
Puffers	170
Puffing-grubby	258
Pug-nosed Shiner	322
Puit Aal	247
Pumpkin-seed	333, 405
Puncturella noachina	693
Purchas on American Manatees	125, 126
Purple Shore-crab of Pacific coast	765
Purpura	698
lapillus	693, 699
Puysegur on cause of green color of Oyster	738
Pygosteus pungitius	338
Quahaug	708
Qualoch	476
Quassilabia lacera	614
Queen-fish	380
Quill-back	615
Quinnat Salmon	479
development of	481, 482
distribution of	480, 481
names of	480
river ascent of	482, 483
spawning habits of	484, 485
speed of ascent of	483, 484
Quinnault	480
Quoddy Salmon	230
Rabbit Fish	170
size and habits of	170
Rabbit-mouth Sucker	614
Racer Lunge	487
Raccoon Oysters	752
Racochilus toxotes	277
Radiates	838–843

	Page.
Raed-fish	261
Ragged-jackets	62
Raia *binoculata*	667
inornata	667
lævis	667
rhina	667
stellulata	667
Raiæ	664
Raiidæ	666
Rainbow Trout	475
Raleigh on the Alligator	141
pugnacity of Alligators	143
Rana Catesbiana	159
esculenta	161
Rangers	58
Ranzania truncata	170
Rasher	265
Rat-fish of California	662
Rathbun, Richard, on Crustaceans, Worms, Radiates, and Sponges	762
Rat-tail Fish	244
Rattle-snake's Tail	701
Rauning Pollack	228
Raw Pollock	228
Rawlin Pollack	228
Ray, Bishop	665
Butterfly	665
Eagle	665
Sharp-nosed	665
Sting	664
Razor-fish	707
Razor-clam	707
Razor-shell	707
Red Bass, name for Red-fish	372
Red-bellied Snapper	410
Terrapin	154
Red Crab	771
Cusk family	244
Dace	617
Drum	362, 371
Red-eye	404, 405
Red-fender	154
Red-fin	617
Red-fish	371, 372
of California	275
name for Blue-back Salmon	477
Rose-fish	261
Southern	372
Red Grouper	410
Gurnard	256
uses of	256
Red Horse	372, 614
Red Lump-fish	254
Red-mouth Grunt	398
Red Mullet family	361
Perch	260
name for Demoiselle	276
Red Rock-Cod	265
Rock Crab	778, 779
Rock-fish	265
of Alaska	266
Roncador	379
Snapper	395
Snappers, enemies of Turbot	172

	Page.
Red Snappers, value as a food-fish	396
Red-spotted Trout	504
Red Trout	487
Reef Bass, name for Red-fish	372
Sponge	846
Trout	488
Reeks, Henry, on habits of Harbor Seals	58
on the Harbor Seal	62
Regalecus Banksii	449
Reina	266
Remora	446
family	446
brachyptera, parasite of Sword-fish	355
squalipeta, parasite of Sword-fish	355
Remoras, fish parasite	355
Remoropsis brachyptera	446
Repkie	639
Rhachianectes glaucus	31
Rhacochilus toxotes	276
Rhamphocottus Richardsoni	259
Rhinobatus exasperatus	667
productus	666, 677
triseriatus	667
Rhombine	177
Rhombochirus osteochir	446
parasite of Spear-fish	355
Rhomboplites aurorubens	396, 397
Rhombus maximus	199
Rhynchobolus Americanis	833
dibranchiatus	833
Rhynchonella psittacus	703
Rhytina	123
causes of extinction	135, 136
extinction of	134
use to survivors of Northern Expedition	129
gigas	129
Ribbon Seal	67
general history of	67
geographical distribution of	67
habits of	67
Richardson, on biography of the Pike	462
Sir John, on discovery of Thymallus signifer	505
on distribution of Cod	202
distribution of the Sea Cat-fish	248
the Lump-fish	254
reproduction of the Burbot	238
Right Whale Porpoise	16
Whales	824
distribution of affinities of	24
movements of	25
reproduction of	25
sizes and yield of oil of	26
Ringed Perch	414
Seal	56, 63, 65
geographical distribution	65
habits, products, and hunting	66
history and nomenclature	65
Rink, on annual catch of Harp Seals in Greenland	64
distribution of Halibut	191
geographical distribution of Hooded Seal	69
Greenland Turbot	198
Rio Grande Trout	476
Rip Sack	31
Risso, on distribution of Sword-fish	340
River Chub	617
Herrings	579
Perch	279
Rhinoptera quadriloba	665
Roach, name for Fall-fish	617
Spot	370
Robin	393
Sea	255
Round	324
name for Goose Fish	173
Roccus americanus	424, 431
similar to Surf-fish	276
chrysops	424, 428
interruptus	424, 431
labrax	424
lineatus	424, 425
Rochefort, on the habits of Antillean Manatee	120
products of South American Manatee	127
Rock Barnacle	828
Bass	404, 413
Black-fish	410
Rock-cod	200
distribution of	262
names of	262
of Pacific	262
spawning of	262, 263
Red	265
Rock Crab	766
economic value of	767
development of	767
distribution and habits of	766
external characters of	766, 767
of Pacific coast	771, 772
Rock-fish	412, 417, 424, 425
name for Pacific Rock-cod	262
Black-banded	263
Brown	264
Grass	264
Green	265, 266
Red	265
Yellow	265
Yellow-backed	264
Yellow-tail	266
Rock Lobster	780, 783
Salmon	228
Pensacola	331
Seal	62
Rock Toad-fish	258
Rock Trout	267
Green	267
Spotted	267
Rockling	201
Rocky Mountain White-fish	542
Roe Mullet	451
Röding	501
Roncador	379
Black	379
Little	379
Red	379
Stearnsi	379
Yellow-finned	379

Page.

Ronchil 361
Ronco 378
Rorquals 24
Rose-fish 260
food of 261
range and size of 261
uses of 262
Ross, J. C., on distribution of Ringed Seals 65
Rosy Surf-fish 278
Rot-gut Minnow 618
Rotchet 257
Rough dab 197
Limanda 184
Round Robin 324
name for Goose Fish 173
Clam 708
fish 541
Pompano 327
distribution of 329
Roys, Captain, on Sulphur-bottom Whale 27
Rudder-fish 334
family 332
Banded 331
Runner 332
Rusty Flounder 197
Rutty, on Sperm Whale in England 9
Ryder, John A., on the Life-history of the Oyster 711–758
Sabre-fish 335
Sac-à-lait, name for Crappie 407
Mummichog 466
Sacramento Perch 405
Pike 616–617
Saddle-backs 62
Saddlers 62
Sah-Kwey 479
Saibling 500
and Oquassa, resemblance between 503
Sail-fish 356
movements of 357
name for Carp Sucker 615
Bone-Shark 667
Sword-fish ..... —
Sailor's choice 393
name for Pig-fish 398
Saith 231
Saithe 228
Salmarino 501
Salmo chouicha 480
Clarkii 568
confinis 487
fontinalis 498
Gairdneri 468, 474
irideus 468, 475
purpuratus 475
quinnat 480
salar ..... 468, 237.
siscowet 496
stomias 475
spilurus 468, 476
symmetrica 487
toma 487
Salmon 468
abundance of 469
distribution of 468, 469
Salmon, habits of 469, 470
in Lake Ontario 473, 474
movements of 471
name for Pike Perch 418
Squeteague 365
reproduction of 470, 471
spawning habits of 471, 472
young fish of 472
Black 487
Blue-back 477
California 479
Chinook 479
Dog 476
Dwarf 470
Fresh-water 470
Grilse 472
Hump-backed 476
Kelp 413
Kelts 471
Killer 458
King 479
Lake 487
Land-locked 470
Lost 476
Parr 472
Pensacola, Rock 331
Quoddy 230
Rock 228
Sea 230
Silver 477
tribe 468
Trout 474, 485
name for Dolly Varden Trout 504
White 331, 477
Salmonidæ, families related to 547, 548
Salpa 259
Salt Pickerel 418
Salt-water Bream 393
Chub 269
Terrapins 152
Trout, name for Squeteague 362
Salve Bug 827
Salvelinus fontinalis 485, 486, 497, 498
malma 504
namaycush 485
namaycush, enemy of Alewives 592
namaycush var. siscowet 496
siscowet 486
Sand Bug 779
Crab 774
cusk family 243
dab 197
dollar 839, 840
Eel 244
fleas 824
Mullet 449
Pike 424
Piper 676
Shark 670, 671
Smelts 456, 457
Smelts, spawning, of 456, 457
Sanguisuga, parasite of Sword-fish 354
Sarda chilensis 319
Mediterranea 316

	Page.
Sarda pelamys, similar to Frigate Mackerel	306
Sardine, name for Anchovy	611
Gulf Menhaden	576
California	569
Sargo	400
Sarpo	251
Sars, G. O., on Codfish schools	205
development and spawning habits of European Lobster	802, 803
habits of the *Pollock*	229
natural history of Norwegian Lobster	810, 811
process of shedding of European *Lobster*	793
reproduction of Codfish	214, 215
Sauer on extinction of Rhytina	135
Sauger	424
Saury	460
Savanilla	611
Savega	569
Saw-belly	582
Saw-fish	667
Sawyer	658
Saxidomus aratus	708
gracilis	708
Say, on food and habits of Blue Crab	776
Sayrus Camperii	461
Scabbard-fish	335
Scads	326
Scalaria Groenlandica	693
Novangliæ	693
Scale Carp	619
Scallop	709
Scammon, C. M., on abundance California Gray Whale	31, 32
antics of Humpback Whale	26, 27
Blackfish	12
Bowheads	21
California Sea Lions	45–48
Porpoise	14
destructiveness of Killer Whales	17
distribution California Sea Elephant	72
Right Whales	25
Sulphur - bottom Whales	27
figures of Fur Seals	54
habits of California Grampus	14
California Sea Elephant	73
the Leopard Seal	59, 60
motion of Cachalot	10
movements of Right Whales	25
Northern Fur Seals	49–53
Pacific Finback	30
reproduction of Right Whales	25
the Scrag Right Whale	31
size of California Sea Elephant	72
Humpback Whale	26
Sperm Whale	9
Scamp	413

	Page
Scaphirhynchus platyrhynchus	662
Schellfisch	224
Scherer, on extinction of Rhytina	135
Schizothærus nuttalli	708
Schlegel, on distribution of the Cat-fish	248
on spawning of the Cat-fish	249
Schoodic Trout	470
School Bass, name for Red Fish	372
Cod	201
Lobster	783
Schroder, on parmacitty	11
Sciæna aquila	368
ocellata	362, 371
Sciænidæ	362
Scomber Colias	303
diego	303
gladius	356
grex	303
pneumatophorus	303
scombrus	281
Scomberesocidæ	459
Scomberesox saurus	460
Scomberomorus	307
caballa	307, 316
concolor	316
maculatus	307
regalis	307, 316
Scombrolucius brevirostris	460
Scoodled Skulljoe	228
Scopelidæ	547
Scopelus family	547
Scores by on habits of Nurse Shark	674
Seal killing	64
Scorpæna dactyloptera	260
guttata	263
marinus	261
norwegicus	261
porcus	263
regulus	261
scrofa	263
Stearnsi	260
viviparus	261
Scorpænichthys marmoratus	259
Scorpene	263
Scorpina	263
Scorpion	259, 263
Scorpis californiensis	395
Scotch Dutch Herring	551
Scott, G. C., on abundance of the Bonito	318
Spanish Mackerel	308
the best fishing ground for Sheepsheads	383
the Grouper, as a dinner-fish	411
habits of the Bonito	318
reproduction of Spanish Mackerel	313
Scrag Whale	30
Whale, history of	30
Scrod	201
Scrode	201
Sculpin	256
Daddy	258
Pigmy	258
tribe	258
Sculpins of Atlantic coast	258

	Page.
Sculpins, food of Goose Fish	173
of Pacific coast	259
Scup	386
abundance of	389
enemies of	391
food of	388
increasing abundance of	392
movements of	390
spawning of	389
value of	392
Scuppaug	386
Scylliorhinus ventriosus	676
Scytalina cerdale	243
Sea-arrow	690
Sea Bass	407
breeding of	409
geographical range of	408
movements and habits of	409
name for Red-fish	372
size and value of	409, 410
White	378
Sea-bat	173
Sea-boat	701
Sea-Bear	49
Sea-bug	701
Sea Cat	627
name for Northern Fur Seals	51
Sea Cat-fishes	248
Sea-caterpillar	701
Sea-Clam	708
Sea-Cow	114–116
Arctic	128
Sea Crab	775
Sea-craws	783
Sea Cucumbers	838
Sea Devil	173
Sea-dog	55
Sea-ears	700
Sea Eel	655
Sea Elephant	49
California	72
Sea-fans	841
Sea-feathers	841
Sea Ginger	841
Sea-hare	18
Sea-Horse family	172
geographical distribution	172
strange shapes—interesting habits	172
Sea Lawyer	397
Sea Lion	37, 38
general history of	39
geographical distribution	38, 39
California	44
Sea Mantis	823
Sea Mullet	453
Sea-needle	458
Sea-owl	254
Sea-perch	273
Sea-pike	458
Sea-ravens, food of Goose Fish	173
name for Sculpin	258
Sea-robin	251
distribution of	256
spawning of	256
Sea Salmon	230
Sea-serpent	449
Sea-snails	253, 693
Sea-snakes	628
Sea-snipe, name for Silver Gar-fish	488
Sword-fish	338
Sea-star	840
Sea-toad	258
Sea Trout	267
Sea Trout, name for Squeteague	362
White Sea Bass	378
Sea Urchin	838, 839
Seal, Bay	62–65
Bearded	63
Common	55
Crested	62, 63, 68
Fjord	62
Fresh-water	59
Fur	37, 75–113
Northern Fur	49, 54
Hair	37
Harbor	55
Harp	62, 65
Hooded	65, 68
Leopard	59, 73
Native	58, 65
Ribbon	67
Ringed	56, 63, 65
Rock	62
Square Flipper	65
tribe, in general	32, 33
West Indian	67
Sebago Trout	470
Sebastes marinus	260
Sebastichthys atrovirens	265
auriculatus	264
carnatus	264
caurinus vexillaris	264
chlorostictus	264
chrysomelas	264
ciliatus	266
constellatus	265
elongatus	266
entomelas	266
flavidus	264, 266
maliger	264
melanops	266
miniatus	265
mystinus	263, 266
nebulosus	263
nigrocinctus	263
ovalis	266
pinniger	264, 265
proriger	266
rastrelliger	264, 265, 266
rhodochloris	264–265
rosaceus	264, 265
ruber	265
rubrivinctus	265
serriceps	263
umbrosus	265
Sebastodes paucispinis	266
See-catch	77, 81
See-vitchie	40

Shark, Nurse ... 676
— Oil ... 676
— Dog ... 676
— White ... 676

	Page.
Sei	228
Selene argentea	323
setipinnis	322
Semele decisa	708
Semotilus bullaris	617
corporalis	617
Sennet	448
Señorita-fish of California	275
Seomga	474
Sergeant-fish	444
Sergeant Major	276
Seriola carolinensis	331
dorsalis	331
falcata	331
fasciata	331
Lalandii	331
zonata	331
Seriphus politus	380
Serranoid fishes	413
Serranus atrarius	407
clathratus	413
fasciularis	410
maculofasciatus	414
nebulifer	413
trifurcus	410
Sesarma reticulata	763
Sethe	228
Sey	228
Sey Pollack	228
Shad	594
causes influencing rate of movement up rivers	605
effects of water temperatures on migrations	598–599
food of	606–607
geographical distribution of	594–596
hereditary instinct of locality in	597, 598
migrations of	596–597–598
name for Gulf Menhaden	576
Moharra	279
names of	594
observations of, on Saint John's River, Fla.	599
period of river life of	603–606
reproduction of	605–606
size of	606
young, observations of movements in Potomac	603
Gizzard	610
Hard-head, name for Menhaden	569
Hickory	607
Long-boned, name for Moharra	279
Mud	610
School	201
Stink	610
Tailor	608
Trout, name for Squeteague	382
Waiter	541
White-eyed	610
Winter	610
Yellow-tail, name for Menhaden	569
Shark, Basking	667
Black-finned	671
Blue	669, 672
Bone	667
Bonnet-headed	671

	Page.
Shark, Cat	675
Dog-fish	670
Duky	671
Fox	671
Ground	676
Gurry	671
Hammer-head	670
Mackerel	670
Man-eater	669, 676
Nurse	670, 671
Sand	671
Shovel-nosed	675, 676
Thrasher	671
Tiger	670
Sharks	667–671
of Pacific coast	671–676
Sharp-headed Finner	30
Sharp-nosed Ray	665
Shedders	776
Sheepshead	380
distribution of	380
family	380
name for Butter-fish	333
Parrot-fish	275
Porgy	394
Three-tailed	445
Sheepswool Sponge	848
Shiner	617, 618
name for Menhaden	569
Surf-fish	278
Blunt-nosed	322
Golden	616
Pug-nosed	322
Shiners	616
Ship-worm	704
Shoal-water Cod	201
Trout	488
Shoemaker	332
Shoemaker-fish	326
Shore Cod	201
Shore-crab, Purple, of Pacific coast	765
Yellow, of Pacific coast	765
Shore Pompano, distribution of	329
Short-nosed Gar-pike	663
Shovel-nosed Shark	670, 671
Sturgeon	662
Shrimp, California	813
Common	816–818
Mantis	823
Shrimps and Prawns	816–823
Southern	821–823
Shrimps, River	819
Shriver, W. W., letter from, claiming first transportation of Black Bass	404
Sibbald, on Sperm Whale in England	9
Sibbaldius borealis	27
sulfureus	27
tectirostris	28
tuberosus	28, 29
Sidera mordax	628
ocellata	628
Sifo	337
Silicioidea	844
Siliqua patula	707

Shark, Bay ... 676

Page.

Sill 550
Sillkung, similar to Deal-fish 449
Sillock 228
Siluridæ 626
Silver Bass, name for Moon-eye 612
Eel 335
Silver-fish 611
Silver Gar-fishes 458
Hake 240
distribution of 240
habits of 242
migrations and movements of 241
uses of 242
Lunge 487
Moon-fishes 322
Mullet 449
Perch 375
Salmon 477
Sides 456
Silver-spotted Tunny 320
Silver Squeteague 367
Surf-fish 278
Trout 475
Simmonds, on gastronomic value of the Cuttlefish. 692
Simpson, A. W., on geographical distribution of Mackerel 281
Singing-fish 253
Sirenia 33
Sirenians 114
food of 118
Siscowet 485, 486
Siskawitz 486, 496
Skarp Herring 550
Skate, Barn-door 668
Skates 668
Skeponopodus guebucu 357
typus 357
Skip Mackerel, name for Bluefish 433
Skipjack 460
name for Bluefish 433
Butter-fish 333
Cutlass-fish 335
Inland Alewife 594
the Jurel 324
Leather-jacket 332
Pacific Bonito 319
Runner 332
Skipper 460
Skopster 460
Skowitz 477
Skrae-fish 228
Skulljoe 228
Skunk porpoise 16
Sleeper Shark 674
Slider 155
Slime Eel 680
Slimskin 73
Slippery Dick 274
Sole 188
Small Herring 550
Small-mouth Black Bass 401
Smelt 543
family 543
name for Lant 244

Page.

Smelt, name for Pacific Tom Cod 223
Alaska 544
California 457, 544
~~Cittle~~ ..... ~~457~~
Green 456
Little 457
Surf 544
Smelts, Sand 456
Smith, on different varieties of Mackerel 308
John on size of Mackerel (1622) 299
Capt. J. B., on spawning of Sand Smelts .. 457
J. V. C., on abundance of Chub Mackerel. 304
Turbots in America 176
S. I., on development of the Shrimp 817
young Lobster. 799, 802
distribution and coloration of common Shrimp 816
growth and development of Rock Cod 767–769
habits and distribution of Jonah Crab 769, 770
Smolt 468
Smooth Black-fish 269
Dog-fish 674
Flounder 183
Smyth & Lowe, on size of South American Manatee 117
Snail-borers 696
Snails 696
Sea 253
Snake-fish family 548
Snapper family 395
name for Rose-fish 260
Alligator 153
Bastard 397
Black 397
Brown, name for Red Grouper 410
Gray 397
Mangrove 396, 397
Pensacola 396
Red-bellied, name for Red Grouper 410
Snappers, food of Mackerel 291
name for Bluefish 433
Black, name for Cod-fish 201
Blue, name for Bluefish 433
Snapping Mackerel, name for Bluefish 433
Turtles 152, 153
breeding seasons and habits of 153
economic value of 153, 154
size of 153
North American species 153
Snooks 444
Snuffing pig 14
Snuffer 14
Social Whale 11
Soft Clam 707
Crab 776
Soft-shelled Tortoises, range of 152
Soft-shell Lobster 783
Turtles, economic value of 152
food of 152
Soglia 187
Soldier Crabs 779
Sole 182, 186, 187

	Page.
Sole, American	175
Californian	185
Long-finned	188
Slippery	188
Solea vulgaris	175
Soleidae	175
Solenoconcha	703
Somniosus microcephalus	675
Sookli	703
Southern Red-fish	372
Spade-fish	445
Spanish Flag	265
Leech	837
Mackerel	303
and its allies	307–316
reproduction of	313
Sparad	278
Sparada	276, 278
Sparidæ	380
Sparling	543
Sparoids	394
Californian	394
Sparus, auratus	393
pagrus	393
Spawn Pike	421
Spear-fish	336, 337, 357
movements of	358
name for Carp Sucker	615
pugnacity of	358
Mediterranean	337
Spearing	612
Spearling	543
Speckled Garrupa	263
Hound-fish	308, 435
Moray	628
Trout	497, 475, 504
culture of	500
distribution of	498
habits of	498, 499
size and food of	500
spawning season and habits of	499
Turtle	158
Sperling	550
Sperm Whale	7–11
in California	9
distribution of	7
in Europe	9
food of	10
former abundance of	8
habits of association, motion, blowing, &c	9
reproduction of	10
size and color of	9
useful products of	11
Porpoise	18
capture of two, in England	18
Sphyræna argentea	448
borealis	448
picuda	448
spet	448
Sphyrænidæ	448
Sphyrna tiburo	671
zygæna	671, 672
Spiced Herring	560

	Page.
Spicer, Capt. William, on pugnacity of Spear-fishes	358, 359
Spider Crabs	778
Spiering	543
Spikes	298
Spiny Lobster	780, 781
Spirialis Gouldii, food of Mackerel	290
Spisula ovalis	703
solidissima	708
Split-mouth Sucker	614
Split-tail	817
American commercial	846
Sponge, Bath	845
Boring	850
general considerations of	843
Gherbis	848
Glove	845, 847
Grass	848, 849
Hard Head	845
Horse	845, 848
injurious	850
Reef	846
Sheepswool	848
Velvet	848
Venetian Bath	848
Wool	845
Yellow	845, 849
Zimocca	845
Sponges	843–846
Spongia, the genus	846
agaricina	845
agaricina, sub-sps. Corlosia and dura	849
equina	845
equina, sub-sp. cerebriformis	849
equina, sub-sp. gossypina	848
equina, sub-sp. meandriniformis	848, 849
graminea	848
officinalis	845
officinalis, sub-sp. tubulifera	847
Spot	379
Spotted Bass, name for Red-fish	372
Black Rock-fish	266
Cabrilla	414
Cat-fish	249
Cero	307, 316
Corsair	265
Hind	412
Rock Trout	267
Sand Flounder	199
Squeteague	365
Tortoise	158
Trout	475
Trout, name for Squeteague	365
Turbot	177
Sprat	277
Herring	579
Spring Herring	579
Squali	669
Squalus gibbosus	616
niger	616
obesus	616
pandora	616
purpureus	616
rhomaleus	616

Page.

Squalus acanthias 672, 674, 675
americanus 204
Square Flipper Seal 65
Squat 674
Squatina 171
angelus 674
Squeteague 362
abundance of 362–364
great catch of, off Rockaway, 1881 ... 363
names of 362
Silver 367
Spotted 365
Squid School 201
Common 687
Squid-fish 11
Squid-hound 425
Squids, enemies of the Lant 345
Squilla dubia 823
empusa 823
Squirrel-fish 410
name for Sailor's Choice 393
Bermuda 361
Squirrel Hake 234
Squit 362
Squitee 362
Stag-horn Corals 841
Stannard, R. H., on destructiveness of the Jelly-fish 842
Star Corals 841
Star-fish, name for Butter-fish 333
Star-fishes 840, 841
Starbuck, Alexander, on former abundance of Sperm Whale 8
Starling 267
Starry Flounder 184
Stay-ships, fish-parasites 355
Stearns, Silas, on abundance and habits of Common Pompano 328, 329
on abundance and habits of the Grouper 410, 411
on abundance and habits of the Sailor's Choice 394
on abundance of Sheepshead 380
and size of the Plaice 179
of Striped Bass in Gulf of Mexico 425
Alligator Gar 664
Angel-fish 280
Black Grouper 411
Bluefish in Gulf of Mexico 442–443
the Crevallé 324
destructiveness of the Drum 368
distribution of Banner Pompano 329
the Cobia 444
Florida Manatees 114
and habits of Red Snappers 395
of Plaice 179
feeding habits of Toad-fish 252
Gray Snapper 397
Gulf Menhaden 575, 577
habits of Amber-fish 331
Blue Crab 777, 778
the Jurel 325

Page.

Stearns, Silas, on feeding habits of Margate fish ... 394
Silver Gar-fish ... 458, 459
Spade-fish ... 445, 446
Spotted Hind ... 412
Spotted Squeteague ... 366, 367
Sting Ray ... 664
history and habits of Southern Red-fish ... 371, 373
the King-fish ... 316
Mangrove Snapper ... 397
manner of capture and value of the Drum ... 369
migrations of Spanish Mackerel in Gulf of Mexico ... 311, 312
movements of Red-fish ... 373
Mullet in the Gulf of Mexico ... 454–456
names of Banded Groupers ... 413
Plaice ... 178
Red-mouth Grunt ... 398
reproduction of Spanish Mackerel ... 315
size and habits of the Pig-fish ... 399, 400
spawning of Red Snappers ... 396
season of Sea Bass ... 409
of Sheepshead ... 385, 386
Toad-fish ... 252
Sucking-fish ... 446
Sarpum ... 611
Shread-fish ... 279
Whipparee ... 665
Stedman on size of South American Manatee ... 117
Steel-head ... 474
Steen-Kobbe ... 62
Steindachner on size of Sword-fish in the Mediterranean ... 347
Steinbutt ... 199
Steller, G. W., on habits of Northern Fur Seal ... 51, 52
Rhytina ... 130
misfortunes of ... 130
on natural history of Sea Cow ... 130–134
Stenlock ... 228
Stenotomus caprinus ... 386
chrysops ... 386
Gardeni ... 386
Stereolepis gigas ... 413
Stickleback family ... 457, 458
four-spined ... 457
ten-spined ... 457
two-spined ... 457
Stimpson on the Kelp Crab ... 778
range of Southern Shrimps ... 822
Sting Ray ... 664
Stingaree ... 664
Stink-pot ... 154
Stink Shad ... 610
Stint ... 543
Stizostedium canadense ... 417, 424
vitreum ... 417
Stomodon narineri ... 665
Stockfisch ... 200
Stokvisch ... 242
Stolephorus Browni ... 611
compressus ... 612

Page.

Stolephorus delicatissimus 612
Mitchilli 611
ringens 612
Stone Cat 627
Stone Crab 772, 774
distribution of 773
Stone-biter 249
Stone, Livingston, on the California Salmon 479–485
Stone-roller Sucker 615
Storer, H. R., on abundance of the Bonito 317
Chub Mackerel 304
Cunners 274
Squeteague 362
amount of oil obtained from Mackerel Shark 669
distribution of Halibut 192
the Scuppaug 387
Tautog 269
economic value of Cat-fish 250
Snapping Turtle 154
Toad-fish 253
Flat-fish 182, 183
gastronomic value of the Tautog 271
the habits of the Lant 245
movements of Haddock 224
Mutton-fish 247
names of Sea Bass 407, 408
spawning of Mackerel 296
Toad-fish 252
uses of the Silver Hake 242, 243
Strawberry Bass 406
Striped Bass 424, 425
abundance of 427, 428
American and European, similarity of 424
family 424
fishing clubs 426, 427
food of 425, 426
geographical distribution of 425
habits of 425
manner of capture, size and shipment of 426
reproduction and growth of 426
uses of 426
Bonito 316, 319
Drum 367
Fish 368
Lake Bass 424
Mullet 449
Perch 417
Stromateidæ 332
Stromateoid fishes 332
Stromateus alepidotus 333
simillimus 334
triacanthus 333
food of Sword-fish 349
Strombas gigas 699
Strömming 550
Strongylocentrotus dröbachiensis 838, 839
franciscanus 838, 839
lividus 839
Sturgeon ..... 669 [illegible]

Page.

Sturgeon, Green ..... 66[illegible]
Lake ..... 66[illegible]
Shovel-nosed ..... 66[illegible]
White ..... 66[illegible]
Sturgeons, Atlantic coast 659–662
California ..... 66[illegible]
Succoteague 362
Sucker, Brook 614
Carp 615
Chub 614
Gourd-seed 615
Hammer-head 615
May 614
Missouri 615
Mud 615
name for the Bagre 379
Rabbit-mouth 614
Stone-roller 615
Sweet 614
Sword-fish, name for Remora 446
White 614
Suckerel 615
Suckers 614
name for Remora 446
Sucking-fishes 446
Sudis ringens 548
Suk-kegh 477
Sulphur-bottom Whales 27, 29
distribution and movements of 27
Summer Flounder 178
Herring 579
Sun-fish 405
name for Blunt-nosed Shiner 322
name for Bone Shark 667
Blue 406
Common 405
Long-eared 406
Sun-fishes, name for Jelly-fish 841
Ocean 169, 170
Sun-squalls 169
Sun Trout, name for Squeteague 362
Sundevall, Carl J., on reproduction of European Burbot 238, 239
Sunny 405
Surf Clam 708
Surf-fish 277
family 276
habits of 276, 277
names of 276
Black 279
Blue 277
Rosy 278
Silver 279
Wall-eye 278
Surf Smelt 544
Whiting 377
Surgeon-fish family 279
Sutherland, P. C., on abundance of Halibut 192
Svine-hval 11
Swedish Leech 837
Sweet Sucker 614
Swell fishes 170
Toad 170

Page.

Sweeny, R. O., on dissimilarity of Siscowet and Namaycush 497, 498
Swine-fish 249
Swingle Tail 671
Sword-fish 336–338
abundance in the past, probability of future decrease 349
abundance of at present 348
absence of ordinary habits of breeding season among 350
in America, allusions by early writers 339, 340
as an article of food 355, 356
distribution on coast of United States 340
distribution in Eastern Atlantic 340
effects of overfishing for in the Mediterranean 348
enemies of 354
entering rivers 342
family 336
geographical distribution and movements of 338
influence of temperatures on movements of 344, 345
invertebrate parasites of 354
large painting of, in Bremen 342
movements of individuals 345
name for Cutlass-fish 335
name for Gar-pike 662
names of 337
nature of food of 349
occurrence in Pacific and Indian Oceans 341
Parasites, Suckers, or Remoras 355
periodical movements of 342, 343, 344
probable winter habitat of 345
pugnacity of 351, 352, 353, 354
rate of growth of 347
reasons of coming of, on our coast 344
reproduction of 349, 350
size of, in the Mediterranean 347
times of arrival and departure of 343, 344
American, maximum, and average size of 346
American, minimum size of 346–347
Sucker 446
Sycotyphus canaliculata 694
Syngnathidæ 172
Synodontidæ 548
Synodus fœtens 548
lucioceps 548
Syrski, discovery of male eel by 638–640
on the ovaries of the eel 641–644
Tailor shad 608
Talorchestia longicornis 825
megalophthalma 825
Tambor 265
Tarpon 611
Tarpum 610
Tartaruga 150
Tauna 322
Tautang 268
Tautog 268, 269
abundance of 271
distribution of 269

Page.

Tautog fishery 271, 272
food of 270
habits of 270
reproduction of 270, 271
Tautogaonitis 268
Tchawytcha 479
Telleus 708
Tender Herring 551
Terebratulina septentrionalis 703
Teredo, destructiveness of 706
dilatata 704
megotara 704
navalis 704
norvegica 704
Thompsoni 704
Terrapin, Diamond-back 155–157
Pine-barren 158
Red-bellied 154
Salt-water 156
Yellow-bellied 155
Terrapins, Fresh-water 154
Tetrapturus albidus 337, 358
albidus, enemy of Swordfish 354
belone 337
imperator 357
indicus 336, 358
Tetrodon turgidus 170
Tetrodontidæ 170
Tetu, D. H., on uses of White Whale 19
Thalassochelys caretta 147
Kempii 147
Thalassophryne maculosa, closely related to Toad-fish 251
Thaleichthys pacificus 547
Thimble-eye Mackerel 303
Thompson, on capture of Harbor Seal 57
Sperm Whale in England 9
J. H., on periodical movements of Sword-fish 343
Thrasher Shark 671
Thread-fish 320
family 279
Thread Herring 610
Thresher Shark 671
Three-tail Porgee 445
Sheepshead 445
Thunder-pumper 370
Thutinameg 173
Thynnallus montanus 505
signifer 505
tricolor 505
vulgaris 506
Thysanopoda, food of Mackerel 290
Tibrie 228
Tiger Shark 672
Tile-fish 360
family 360
Tima formosa 841
Timberello 305
Tinker Mackerel 290, 304
Tinkers 298
Tiny Herring 579
Toad-fish 251
food of 252

Tailor, freshwater .. 608
saltwater .. 608

	Page.
Toad-fish, name for Goose Fish	173
name for Swell Fish	170
Tobias-fish	244
Togue	486
Tom-cod, name for King-fish	375
name for Rock-fish	267
Atlantic	223
Ton	230
Tonicella marmora	693
Tonnina	322
Toothed Herring	612
Torgoch	501
Torpedo	666
californica	667
occidentalis	666
Torsk	200
Tortoise, Bell's	157
Chicken	157
Gopher	158
Musk	152, 154
shell Turtles	149
Spotted	158
Wood	158
Tortoises, Geographic	152
Pond	152, 154, 157
Soft-shelled, food of	152
and Turtles, Marine	147
mode of life of	147
distribution of	147
Tortue franche	150
Trachurus picturatus	326
saurus	326
Trachydermon albus	693
ruber	693
Trachynotus carolinus	326
fasciatus	392
glaucus	327, 329
goreensis	327, 329
ovatus	327, 329
Trachypteridæ	449
Trachypterus altivelis	449
Tree-fish	263
Trepang	836
Triacis Henlei	675
semifasciatus	675
Trichechus latirostris	114, 118
manatus	114, 115
senegalensis	119
Trichiurus haumela	335
lepturus	335, 337
Trichodon Stelleri	253
Trichotropis borealis	693
Triforis nigrocinctus	693
Trigger-fish	172
Trigla	256
cuculus	256, 257
gunardus	256
hirundo	256, 257
lyra	257
Triglidæ	255
Triglopsis Thompsoni, food of Burbot	239
Trionychidæ	152
Triple-tail	444
Black	445

	Page.
Tritia	696
trivittata	693
Trophon clathratus	693
scalariformis	693
Trout	486
in the Great Lakes	493–496
Bastard, name for Silver Squeteague	367
Bear	497
Black Spotted	475
Brook	475
Bull	504
Deep-water	488
name for Squeteague	364
Dolly Varden	504
Gray	487
Grey, name for Squeteague	362
Golden	475
Lake	485
name for Dolly Varden Trout	504
Mackinaw	488
Mountain	475
name for Black Bass	401
Pot-bellie	488
Rainbow	475
Red	487
spotted	504
Reef	488
Rio Grande	476
Rock	267
Salmon	474, 485
name for Dolly Varden Trout	504
Salt-water, name for Squeteague	362
Sea, name for Green Rock Trout	267
Sea Bass	378
name for Squeteague	362
Sebago	470
Schoodic	470
Shad, name for Squeteague	362
Shoal-water	488
Speckled	497
name for Dolly Varden Trout	504
Rainbow Trout	475
Spotted, name for Rainbow Trout	475
name for Squeteague	365
Sun, name for Squeteague	362
White, name for Silver Squeteague	367
True, F. W., on enumeration of eggs in Mackerel	297
the Sirenians	114–136
useful Aquatic Reptiles and Batrachians	141–161
Trumbull, J. H., on abundance of the Bonito	317
letter in the Dubertus	29, 30
Trumpo	9
Trunk Fishes	170
Turtle	147
Trygon dipterurus	666
Tsebarqua	267
Tub-fish	256, 257
Tuladi	486
Tuna	319, 320
Tunny	320
Long-finned	320
Silver-spotted	320
Turbot	177

Trygon centrura . . . 665

	Page.
Turbot in America	175
name for Diamond Flounder	185
File fishes	172
Plaice	178
skin used for cleansing purposes	172
valuable as food	172
Flounder	178
Greenland	199
Spotted	177
Turning Harps	62
Turritella erosa	653
Tusk	233
Tusk-shells	703
Tursiops erebennus	16
gillii	16
Turtle, Alligator	153
Bastard	147
Leather	147
Loggerhead	147, 153
Speckled	158
Trunk	147
Turtles	147
Box	158
Green	147, 150
Hawk's bill	147, 149
Snapping	152, 153
Tortoise-shell	149
Tyee	479
Tyler, E., on abundance of Branch Alewife	591
movements of Branch Alewife	591, 592
Tylosurus caribbæus	459
exilis	459
hians	459
Jonesii	459
longirostris	458
vulgaris	459
Tyrant of the Lake	487
Tyrgon centrura	664
Uhler and Lugger on economical importance of the Drum	368
distribution of Sword-fish	341
Umber	506
Umbrina roncador	379
Uncecola irrorata, found in stomach of Sea-robin	256
Unio	703
Unionidæ	709, 710
Upeneus flavovittatus	361
Uranidea	259
aspera	259
gulosa	259
Urchin, Sea	838
Urolophus halleri	666
Urosalpinx cinerea	697
Ursus marinus	51
Vache marin	116
Vaginicola	733
Valenciennes, on distribution of Sword-fish	340
Velutina lævigata	693
zonata	693
Velvet Sponge	848
Venericardia borealis	703
Venetian Bath Sponge	848
Venus mercenaria	703
Vermilion-fish	264
Verrill on the Amphipods	824, 825
appearance and habits of Lady Crab	774, 775
of Mantes Shrimp	823
breeding habits of King Crab	829
color of Pandalus borealis	819, 820
destructiveness and distribution of the Teredo	706, 707
distribution of the Green Crab	774
Rock Crab	766
habitat of common Prawn	819
habitats of the common Barnacle	828, 829
habits and appearance of Oyster Crab	765
characteristics of Fiddler Crabs	763–765
of common Shrimp	816, 817
and destructiveness of Boring Limnoria	826, 827
of Hermit Crabs	780
Marine Worms	831–833
the Sea-arrow	690–692
Spider Crab	778
and uses of Blue Crab	776
history and breeding habits of the common Squid	687–690
of the Ship-worm	704, 705
the Jelly-fishes	841, 842
Mud Crabs	772
Ophidium marginatum	243
reproduction of the Conch	694, 695
the Sand-dollar	839, 840
Squids, enemies of Mackerel	299, 300
structure of American Leech	834
Vuva	266
Voilier	338
Volator	459
Von Frantzius, on abundance of South American Manatee	123
distribution of Florida Manatees	115
Von Heuglin, on distribution of Hooded Seal	70
Ringed Seals	65
Von Schrenck, on distribution of Ribbon Seal	67
Von Siemann, on movements of young Eels	651
Vorticella	733
Wagner, on distribution of Ringed Seals	65
Sea-bears	52
Waites Shad	541
Walker, S. T., on consumption of Moss by Sheepshead	385
Wall-eye Surf-fish	278
Wall-eyed Herring	580
Pike, abundance of	418
in the Great Lakes	418–423
name for Pike Perch	417
Walrus, Atlantic, distribution of	34
Walruses	33, 34, 35
Atlantic and Pacific species	34
Walton, on the habits of Salmon	469, 470
marked Salmon	470
Warmouth	405
Black	405
Warsaw	411
Water Flounder	199
Weak-fish	302
Webb, Capt. Henry, on spawning of Mackerel	295

White Shark ... 676

	Page.
Weesick	608
Wells, on pugnacity of Alligators	144
Welshman	401
West Indian Seal	67
geographical distribution of	67
Whale, Black	11, 25
Blowing	11
Bowhead	20
Bunch	26
Caing	11
Finback	28, 30
Grayback	31
Gray, California	31, 32
Greenland	20
Humpback	26, 27, 29
Jupiter	30
Killer	12, 17
Northwest	24
Pilot	11
Polar	20
Right	6, 24
Scrag	30
Social	11
Sperm	7–11
Whales, Sulphur-bottom	27, 29
White	15, 18
Whipparee	665
White, on range and habits of Mantis Shrimps	823
uses and destructiveness of the Green Crab	774
Angel-fish	280
Bass	424, 428
White-boned Porgy	394
White-coats	62
White-eyed Shad	610
White-fish	507
abundance of	536–540
artificial propagation of	523–535
capture of	535, 536
development of eggs and embryo	519–521
diseases of	535
embryonic, food of	515, 516
enemies of	512, 513
experiments in hatching eggs of	528
food of	513–516
habits of, at spawning season	516–519
methods of shipping eggs of	528, 529
migrations of	509
name for Bluefish	433
Menhaden	569
Silver Salmon	477
Tile-fish	361
names of	507
rate of growth of	521, 522
size of	507, 508
spawning of	516
Chief Mountain	542
Lake	507
Menomonee	541, 542
Mongrel	541
Musquaw River	541
Rocky Mountain	542
Grunt	399
Hake	234

	Page.
White Mullet	449
Perch	431
Perch, name for Drum	370
Surf-fish	277
similar to Striped Bass	424
Surf-fish	276
Salmon	477
name for California Yellow-tail	331
Sea Bass	378
Sturgeon	662
Sucker	614
Trout, name of Silver Squeteague	367
Whale	15, 18
captures in Massachusetts	18, 19
distribution of	18
habits of	18
historical note of	18
uses of	19
Whiting, name for Harvest-fish	333
King-fish	375
Musquaw River White-fish	541
Tom Cod	223
Bull-head	277
Deep-water	377
New England	240
Surf	377
Whitings	376
Wide Gap	173
Gut	173
Will George	269
Williams, H. S., on the habits of the Cavally	323
Mullet season in the Indian River	453, 454
Red-fish as a game-fish	374, 375
season for Sheepshead	385
Wind fish	173
Window-pane, name for Spotted Sand Flounder	199
Turbot	177
Wing-fish	256
Wing-shells	702, 703
Winkle	694
Winninish	479
Winter Flounder	179, 182
Shad	610
Wittmack, Dr. L., on habits of the Pike in Europe	462, 463
on the habits of the Sabling	503, 504
Dr., on movements of Haddock	225
on reproduction of Haddock	226
Wolf-eel	250
Wolf-fishes	247–249
Wood, on capture of American Manatee	125
Wood-louse	701
Wood Tortoise	158
Woodward, on the Pholades	707
Woohoo	387
Wool Sponge	845
Worm Cod	201
Worms	831–837
bait	831
marine	831
Wrasses	247
Wrinkle	694
Xeniatina californiensis	400
Xerobates Agassizi	159

	Page.
Xerobates Berlandieri	158
polyphemus	158
Xiphias gladius	336, 337
imperator	357
Rondeletii	337
Xiphiidæ	336
Xiphister chirus	251
mucosus	250
Xiphosura	829, 830
Xylophaga dorsalis	704
Xylotrya fimbriata	704, 707
Xystreurys liolepis	188
Yarrell, on distribution of the Sea Cat-fish	248
economic value of Cat-fish	250
Yarrow, H. C., on abundance and size of Spanish Mackerel	312
distribution of Sword-fish	341
the Spotted Squeteague	365, 366
Yellow Angel-fish	280
Bass	431
Yellow-bellied Terrapin	155
Yellow Cat	627
Yellow-finned Roncador	379
Yellow Fish	268
Grunt	399
Mackerel	324
Perch	414
abundance of	414, 415, 416, 417
Pickerel	421
Pike	421
Yellow Pike, name for Pike Perch	417
Rock-fish	265
Shore-crab of Pacific Coast	765
Sponge	845, 849
Yellow-tail	375
name for Menhaden	569
Runner	332
California	331
Rock-fish	266
Shad, name for Menhaden	569
Yoldia limatula	703
myalis	703
sapotilla	703
thraciformis	703
Young Harps	62
Zalophus	37, 38
californianus	39, 44, 45
Zaniolepis latipinnis	268
Zee-snip	338
Zenidæ	335
Zenopsis ocellatus	335
Zeus faber	224
Zeyl-fisch	338
Zimocca Sponge	845
Zirphæa crispata	707
Zoarces anguillaris	236, 247
viviparus	247
Zwaard-fis	337
Zygodactyla grœnlandica	842