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ESTUARINE PLANT AND ANIMAL LIFE

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PREFACE

This paper, which briefly describes the estuarine plant and animal life of the Lewes-Rehoboth Bay area, was prepared from a more detailed report compiled by the College of Marine Studies, University of Delaware. Copies of this more detailed report may be obtained from the Delaware State Planning Office.

Due to the nature of the subject matter, many technical terms are unavoidably used in this working paper. A glossary of these terms can be found in the rear of this paper.

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COASTAL VEGETATION (FLORA)

ALGAE AND PHYTOPLANKTON

The majority of marine plants belong to the group known as the algae. Seaweed, a form of algae, is usually found attached to rocks, shells, pilings, or on the grass and mud surfaces of the marshes. It can, however, be found unattached and free-floating like the microscopic algae, phytoplankton.

All types of algae are extremely important to wetlands ecosystems. Algae are essential primary producers that capture large amounts of sunlight and convert it into organic material. The algae are then consumed by a large number of organisms, and help form the base of estuarine food web. Health and well-developed algal populations are necessary for the development and maintenance of adequately functioning and growing estuarine animal populations. Very little is known about the microscopic algae, phytoplankton in the Lewes-Rehoboth Bay area.

EMERGENT GRASSES

The emergent grasses represent the most important group of primary producers in the marsh and dune communities. Upon death and decomposition of the grasses, the organics are broken down by microorganisms to form organic nutrients. It is the organic nutrients which are vital in maintaining the phytoplankton and zooplankton of the estuaries, which in turn act as food for other higher level organisms. Grasses also play a role in the development of peat and the formation and maintenance of marshes. Little specific knowledge is known about the dune grasses regarding the nutrient and production cycles of the dune communities in Delaware, although they are an essential element in the maintenance of the physical structure of the dunes. While there are several different species of grasses in the dunes and wetlands, most of the Lewes-Rehoboth Bay area is dominated by a few species. The marshes contain predominantly cordgrass, salt hay and spike grass while the dunes are dominated by a single species, American beachgrass. Marsh vegetation is discussed in greater detail in working paper number 9, Wetlands.

MARSH ANIMAL LIFE (FAUNA)

ZOOPLANKTON

Zooplankton is a general term applied to all microscopic planktonic (swimming, floating) animals. Zooplankton includes those animals which are microscopic throughout their life cycle as well as those organisms which are the eggs and larval forms of larger animals. The ichthyoplankton, for example, which are the eggs and larvae of fishes, are important components of the zooplankton.

The zooplankton is important as food for larger animals such as the herring and it is the abundance of zooplankters in estuaries which makes estuaries important to the success of higher-level animals. Zooplankters consume vast amounts of plant material and provide the link between the primary-producers and those species of animals utilized by man. A healthy, well-developed zooplankton community is then, a necessity for a healthy, well-developed estuarine biological ecosystem.

While zooplankton is occasionally sampled as part of studies investigating other organisms, few comprehensive zooplankton studies have been completed in the Lewes-Rehoboth Bay area. The majority of individuals found in the area represent only a few species. The copepods and possibly the mysid shrimp are considered the dominant zooplankton organisms from the Bay and Ocean areas near Cape Henlopen. Many of these species probably exist in Rehoboth Bay. All of the zooplankters mentioned serve as a food source for other organisms, such as flounder, herring, shad, anchovies, spot, croakers, striped bass and weakfish.

ICHTHYOPLANKTON

Ichthyoplankton is a term that refers to egg and larval forms of fishes that are commonly found suspended or floating in the water. The prefix "ichthyo" means "fish"; the suffix "plankton" means "small organisms that float".

Many species of fish use the coastal areas of the State as spawning and nursery grounds. See Figures 1 through 10. During the spring and summer when most spawning activity occurs, large numbers of eggs and larvae can be found in Delaware Bay, the small bays and in the tidal creeks.

Several studies have shown the importance of the Lewes-Rehoboth area as a nursery ground for fish populations. At least fifteen species of fish use Rehoboth Bay during their larval stages. In a 1970 study, three fish species dominated the surface plankton in Rehoboth Bay, comprising 87% of the total larval fishes caught. These species were the bay anchovy, Atlantic silverside, and naked goby.

Similar studies made in Canary Creek in 1962 and 1963 showed that fish eggs were most abundant in June while the fish larvae reach maximum numbers in late June and July.

In three monthly 1970 collections, researchers identified five species of larval fishes in the Broadkill River. A large part of Delaware Bay is used as a spawning area for the weakfish. While some spawning activity was noted in most parts of the Bay, the principle spawning area seems to be located in the lower southwest quarter of the Bay off of the Lewes and Broadkill Beaches.

There is no data available for the Lewes-Rehoboth Canal, Breakwater Harbor, or Harbor of Refuge. And, only four studies have been made in the entire Lewes-Rehoboth Bay area. Although the general concept of the importance of estuaries

in the lives of finfish is known, it is difficult to construct a clear and precise picture of the source and distribution of the eggs, the specific role of each river, bay and tributary in the maintenance of the eggs, larvae and juveniles or of the role of ichthyoplankton in the estuarine food chain based on four studies.

Since it has been shown that little or no spawning takes place in Canary Creek yet large numbers of eggs and larvae are found there, studies of the composition of ichthyoplankton in the Harbor of Refuge and Breakwater Harbor might indicate where the eggs and larvae are originating. A study of the Lewes-Rehoboth Canal might show whether ichthyoplankton is entering Rehoboth Bay via the Canal, from Delaware Bay or vice-versa. However, it is known that there is little water exchange between Roosevelt Inlet and Rehoboth Bay. A knowledge of these processes would add significantly to the understanding of the role of the estuary and wetlands in the lives of estuarine fishes.

FINFISH

Monitoring the relative health of the finfish community is important for several reasons. In some cases, scientists and land use planners can determine how water quality effects the populations of nearshore fishes such as silversides, menhaden and anchovies. Many species of shore zone fishes are sensitive to environmental degradation and reduced populations or "kills" associated with these species are indicative of problem areas. By keeping track of fish catches in the Bay, the distribution and abundance of certain species of fish could be predicted. Such questions as; why did the menhaden leave?; or, why are the hardhead (croakers) coming back? could be answered. Marine biologists can only make educated guesses to these queries now in the absence of any regular monitoring program.

Many species of estuarine and marine fishes frequent the Lewes-Rehoboth Bay area. At one time a leader in commercial fisheries, the area is now becoming an increasingly popular sport fishing center. It is the protected shores inside Cape Henlopen along Lewes Beach into Canary Creek and the shallow waters of Rehoboth Bay that act as the spawning and nursery grounds for a host of fishes, whether residents or migrants, forage feeders or carnivores. Here, the fish that will someday enter the sports catch are spawned and pass through their larval and juvenile stages. Fortunately, a great deal of information concerning fisheries exists for the Lewes-Rehoboth Bay area. The following is a brief synopsis of the major studies to date.

In 1975, finfish were sampled near Hen and Chickens Shoal by otter trawl. Twenty-five species of fishes were collected. Two species, the red Hake and the silver Hake comprised 52% of the individuals captured. Highest abundances were found at night in the spring and summer. Other important species based on numbers of individuals caught were the spot, the sea robin, the clearnose skate and the weakfish.

The clearnose skate is generally a summer skate, entering the estuary when the temperature increases above 9°C. Its diet consists of the sand shrimp, the opposum shrimp, the razor clam and the marsh crab. The little skate replaces the clearnose skate in the estuary when the temperature falls below 9°C. It has principally the same diet as the clearnose skate. No skates are found in the Bay at salinities less than 20%.

The sea trout has been found to be principally a Bay spawner. In Delaware Bay, the majority of the spawning activity occurs in the southwest portion of the Bay including the Breakwater Harbor area. Spawning peaks in late June through July. The eggs are bouyant but the larvae are found near the bottom. Both eggs and larvae can tolerate wide ranges in temperature and salinity provided there is no rapid change.

In 1967, sixty trawls were made in the Delaware Bay including the Breakwater Harbor area to determine the distribution of fishes in the Bay. Forty-seven species were captured with weakfish and hogchokers making up 50% of the total catch. Changes from the summer species to the winter species occur in October when the temperature drops below 18°C. Most of the fish caught were juveniles and young adults indicating the importance of the estuary as a breeding and nursery ground. Summer flounder populations peak in July and September. Few are present in November through April. The summer flounder feeds predominantly on small weakfish. 1969 trawl catches in the same area found that of 43 species identified, weakfish, hogchokers, clearnose skates and windowpanes dominated the catch.

In the Harbor of Refuge area, a catch of 34 species were dominated by hogchokers, spot, weakfish and windowpanes.

A 1954 sampling on Lewes Beach, ranked the species caught based on percentage of the total at the station multiplied by the rate of occurrence. In twenty-two collecting days, Atlantic silverside ranked first, the anchovy, the blueback herring third and tidewater silverside fourth.

A Roosevelt Inlet sampling, conducted along the jetty northeast of Bayside Laboratory and near the old barge on Beach Plum Island found fifty species totalling over 730,000 individuals. The catches were dominated by silversides, bay anchovies, sand perch and sheepshead minnows.

Forage fish such as silversides, anchovies, mullet, mummichogs and spot are present in the lower Broadkill.

The only comprehensive fish sampling program conducted to date in Rehoboth Bay took place in 1973. The striped killifish, the Atlantic silverside, mummichog, winter flounder and the bay anchovy dominated the samples in both Rehoboth and Indian River Bays. Many of the fishes captured were juveniles, indicating the important role of the small bays in the life cycle of estuarine fishes.

The middle and upper portions of the Broadkill River have never been comprehensively surveyed, nor has the Lewes-Rehoboth Canal. These areas have obviously been disturbed by man but it has not been possible to determine either the direction or the magnitude of the effect on fishes. Rehoboth Bay, similarly a stressed area, has been sampled infrequently and no data exists on Herring Creek or Love Creek, although these areas may be significant nursery grounds for several estuarine species. Figures 1 through 10 indicate probable spawning and nursery areas for major finfish communities.

BENTHIC INVERTEBRATES

Benthic (bottom dwelling) invertebrates include a host of organisms including annelid worms, molluscs and crabs. The worms and other soft-bodied invertebrates comprise the bulk of the bottom community and are important members of the estuarine food web.

Molluscs and crabs are also important members of the benthic community. In 1974, 5.8 million pounds of surf clam meat was landed by commercial clammers in Delaware. In addition, 2.4 million pounds of crab meat was harvested in 1973. No doubt a great deal more crabs and clams were taken from Delaware waters by sport fishermen. From an ecological point of view, these species have well-defined roles in the estuarine ecosystem. Molluscs graze the estuarine waters of plankton and are in turn consumed by a variety of fishes. Crabs are omnivorous opportunistic feeders that are fed on by a variety of fish and waterfowl.

Benthic invertebrates are often good indicators of the relative health of a particular area. Since many estuarine invertebrates are relatively immobile, they must cope with natural stresses and human disruption of their environments. Thus, in stressed and man disturbed areas, it is important to investigate the benthic community in order to assess any changes that may occur. Benthic surveys are also important in monitoring the relative size, health and distribution of commercially valuable shellfish.

Invertebrates at Hen and Chickens Shoal east of Cape Henlopen showed in 1974 one hundred sixty-eight species. The fine sands of the shoal were dominated by the amphipod. In the coarser sand and pebbles, polychaete worms, blue mussel and the amphipod dominated. Highest abundance was found in July and the lowest in April.

While the polychaete worm is present along most of the east coast, the Delaware Bay shoreline between Lewes and Fowler Beach is one of only two areas on the east coast where these worms construct reefs. Individual worms live in tubes made of sand grains, reefs are composed of large numbers of these tubes cemented together. These reefs provide an important habitat for many marine hydroids, bryozoans, tubiculous worms amphipods, xanthid crabs, hermit crabs, gastropods, mussels and oysters. The only ree s in the Lewes-Rehoboth area are near the beach at B yside Laboratory and at Broadkill Beach.

The composition of the fauna by group for the Broadkill River oyster beds is dominated by arthropods and molluscs. In all, sixty-nine species were identified in the Broadkill from eighteen samples.

Unpublished data for Canary Creek lists the most common invertebrates as grass shrimp, blue crabs, mud crabs, fiddler crabs, marsh crabs, mud snails and blue and ribbed mussels.

COMMERCIALLY VALUABLE SHELLFISH

In 1971-72 Delaware Bay including the Lewes Bay area was sampled to determine the condition and distribution of the hard clam. One hundred sixty-nine ten minute dredge tows found only 269 live clams. In general, only the area directly off Beach Plum Island has potential to support a healthy hard clam population. Hard clams were also found in Breakwater Harbor just inside the Inner Breakwall. In addition, the distribution and abundance of invertebrate predators including the horseshoe crab, the whelks, the spider crab and the blue crab were mapped.

In 1969, a comparative study of the American oyster in the Broadkill and Leipsic Rivers was made. Oyster densities were grouped into three density categories and mapped. Although it was estimated that 1.2 million oysters comprise the Broadkill population, the beds were in danger of extinction as population from upstream areas poses a threat to their survival.

The oyster beds of the Broadkill, Leipsic, Murderkill, Mispillion, and St. Jones were sampled and the results reported in 1970-71. The density of oysters in the Broadkill ranked ahead of only one other river, the St. Jones. Collections of oyster spat were made in each river and the Broadkill River ranked last in terms of number collected. The Broadkill is located farthest from the natural seed bed in the Bay; consequently, there is little or no recruitment of spat into the Broadkill River from other areas. It appears that the closing of the former mouth of the Broadkill has had a destructive effect on these oyster beds.

It is estimated that the oyster producing sections of Delaware's tidal streams exist between 3,150-3,600 meters from the river mouths. Secondly, the highest densities of oysters occur on the downstream outer edge of the large meanders in the oyster producing sections of the rivers. A 1968 study estimated the standing crop of hard clams in Rehoboth Bay (9,300 acres) to be approximately 103,827 bushels. However, 19% of these were located in areas closed to shellfishing. Maps of shellfish growing areas, density and distribution by size class are included in the report.

CRUSTACEANS

The crustacean group is represented by many different species although most people are familiar with only a few prominent ones such as the crabs and lobsters.

There are several other important orders of crustaceans, however, which deserve attention.

One of the most important of the crustacean groups from an ecological point are the copepods. Copepods are minute planktonic forms which are common in all the waters of the Lewes-Rehoboth Bay area. These organisms are extremely important as food for the fish of the area and an integral part of the energy-flow system of the estuary (see Zooplankton).

Two other important but generally unfamiliar orders of crustaceans are the amphipods and the isopods. Although much larger than the microscopic copepods, amphipods and isopods are minute forms (up to 3 cm) which are generally confined to the bottoms of the bays and tidal creeks. Some are also prevalent on the surfaces of the marshes among the living and dead grasses. A total of 45 species of amphipods were collected near the Inner Breakwall, Lewes Beach, Broadkill River, Broadkill Beach, Bay and Ocean sides of Cape Henlopen and Rehoboth Bay among others. No quantitative sampling was undertaken but conclusions can be drawn about the species found and their distribution. Generally, the different species are associated with particular habitats such as sand beaches, rock jettys, breakwalls, tidal creeks or oyster beds. Two species of amphipods inhabit the exposed ocean beach at Cape Henlopen. On the bay beaches at Cape Henlopen five species are found, at the Broadkill River oyster beds--7 species, Broadkill Beach--1 specie, at the Inner Breakwater--4 species and in Rehoboth Bay proper--23 species.

As with the amphipods, the isopod species were collected during several benthic invertebrate studies over a period of several years. The sampling stations were similar to those for the amphipods but again no quantitative data is available.

In all, 24 species of isopods were identified in the studies. Most of them are free-living species which are both benthic and planktonic in habitat.

The more conspicuous crustaceans found in the area are the crabs and to a lesser degree, lobsters. Again, only preliminary investigations into these groups have been thus far attempted, mainly because of the difficulties in studying populations of these organisms under field conditions. Their commercial importance, though, dictates that much more study be undertaken.

Lobsters, which were once fairly plentiful in the area, are receiving attention as it appears the populations are beginning to increase. A 1972 study attempted to determine the number and sizes of lobsters present on certain sections of the Outer Breakwall. The average weight per lobster was found to be 1.7 pounds with about 70% of the lobsters studied being at least eight inches in length--the legal size limit.

The crabs studied in the Lewes-Rehoboth Bay area include those of commercial value such as the blue crab, and those of mostly ecological value such as the marsh crab and the fiddler crab.

Through tagging and recapture experiments, it was found that crabs move as much as 50 miles up-bay after wintering in the Cape Henlopen area. It was not possible to determine the origin of the crabs wintering in the Cape area, or whether crabs originating in Delaware Bay move to other estuaries along the east coast during the year. The study does show, however, that the crabs used a large portion of the Bay throughout their lives suggesting that the quality of the blue crab population is dependent on the quality of many areas of Delaware Bay. The population appears to be dominated by young crabs in the winter and spring since juveniles do not seem to be as relegated to the mud banks as do the adults during these seasons. Males occur randomly throughout the Bay while females are more prevalent near the mouth of the Bay in the higher salinity waters.

The highest densities of crabs are generally found near the tributaries of Rehoboth Bay with the lowest densities of crabs in the central and eastern portions of the Bay. This distribution seems to be correlated partially with sediment type. Crabs appear to be more prevalent in areas covered with mud than in areas covered with sand. The study also concluded that populations were lowest in winter but increased in density beginning in February and March, peaking in June or July.

The marsh crabs in Canary Creek consume about five tons of saltmarsh cordgrass every year out of an available 227 tons. While the value seems small, it should be kept in mind that much material is cut by the crabs which is not directly utilized by them. Such material then enters the detrital cycle where it becomes available to other organisms.

In certain areas, burrows made from certain species of marsh crab have been associated with the absence of vegetation along some of the tidal creeks. Where crab activity is the heaviest, they apparently can cause disappearance of the vegetation by cropping the grasses and disturbing the roots. Such bare areas could affect the flooding and erosion patterns in the marshes.

Other crabs receiving study have been the rock crab and the spider crab. These two species were investigated along the Inner Breakwater in 1974. The spider crabs are most prevalent from April through October. They seem to be confined to waters between 15‰ and 32‰ salinity. Rock crabs, on the other hand, are more prominent in the winter months from November to April. Their salinity range (20‰ to 33‰) is somewhat narrower than that of the spider crabs. There is some indication from their seasonal distribution that the rock crab and the spider crab are ecologically equivalent species that perform similar functions at different times of the year. Competition between them is reduced by their seasonality.

FOULING ORGANISMS

Fouling organisms represent an artificial grouping of animals that covers many diverse classes. They all have one common attribute; at some time during their life cycle, fouling organisms settle on a hard substrate. The substrate can vary from rocks and shells to jetties and boat surfaces.

There are approximately 2,000 species of fouling organisms which include marine plants barnacles, bivalves and blue mussels.

MICROBIOLOGY

The role of microbes (any small living thing) in the estuary is extremely important but as yet ill defined. Microbes or microorganisms are a diverse group including bacteria, minute fungi, viruses, protozoans, yeast, molds, etc. Collectively, microbes are responsible for breaking down almost all organic matter. They are, therefore, responsible for recycling nutrients by decomposing organics and producing food for detritus feeders. Most importantly, microbes maintain the balance between production and decomposition which is critical in maintaining conditions satisfactory for life in the biosphere. Yet because microbes are so small and indistinguished they are extremely difficult to study.

Microbiological studies undertaken in the Lewes-Rehoboth area can be divided into two types--those aimed at clarifying the role of natural microbial populations in estuarine nutrient cycles, and those aimed at monitoring water quality through observations of microbial populations associated with pollution sources. In both capacities, the studies completed have unfortunately been few in number. Studies investigating microorganisms and nutrient cycles must contend with the difficulties of working with diverse and indistinguishable populations of extremely small organisms. Such difficulties are often not easily overcome. Water quality is generally assessed by monitoring the coliform bacteria yet there has been only moderate impetus in the past to monitor such bacteria in the Lewes-Rehoboth Bay area.

Monitoring the coliform bacteria count in a water system is tantamount to determining the amount of human waste or sewage that is present in the system. Coliform bacteria are found in all human digestive tracts and are deposited in human fecal material. A high coliform count then can be associated with a large output of domestic sewage.

Since water quality data is used to determine the health of shellfish beds, certain areas of Rehoboth Bay and the Broadkill River have received attention regarding the bacterial levels. Increasing usage of all sections of the Lewes-Rehoboth Bay area demands that the sampling program be expanded.

Micro-Organisms and Nutrient Cycling

Scientists know that certain micro-organisms metabolize amino acids, organic acids, plant remains and inorganic compounds and exchange metabolic by-products with the environment. Such exchanges partially control the amounts of some nutrients available in the sediments at any one time. Of particular concern to biologists are the nutrient substances phosphorus and nitrogen for they are critical to the growth and production of both plants and animals.

Through processes known as nitrification and denitrification, bacteria convert nitrogen from one form to another affecting the availabilities of nitrite, nitrate and ammonia. These forms of nitrogen are used in various ways by edaphic algae, phytoplankton and emergent marsh grasses in their growth cycles. Maximal rates of nitrification (production of nitrite and nitrate) were found to occur in the autumn and spring months in the Canary Creek Marsh. The nitrate produced in the fall is probably stored in the sediments and used in conjunction with the nitrate produced in the spring to accommodate the growth needs of the emergent grasses in the spring and summer. The nitrate is then used for the maintenance of the phytoplankton community, a primary food source for the animals of the estuary. Any nitrate the phytoplankton do not utilize might be returned to the marsh surfaces with the flooding tide to be used and recycled by the edaphic algae, the emergent grasses and other micro-organisms. While nitrogen is always available in the estuaries, it is primarily the nitrite and nitrate forms that are used by the plants, so the functions of the micro-organisms in changing other nitrogen forms to nitrite and nitrate are extremely important.

Similar roles are played by micro-organisms in the cycling of phosphorus in the marsh sediments. Phosphorus is another nutrient extremely important for efficient growth of plants of all types. The release of inorganic phosphorus is found to be intimately linked to the concentration levels of other materials in the sediments, notably of iron and sulfur. Several changes in the forms of these elements occur in the sediments and some of these compounds become involved in reactions with organic phosphate producing insoluble salts of phosphorus. In this form, phosphorus is then utilized by the plants of the estuary. The microbial community enters the picture primarily by producing hydrogen sulfide from various sulfate compounds, hydrogen sulfied being a critical element in the reactions leading to the release of inorganic phosphorus. The microbes also transfer phosphorus in the system when they are consumed by other organisms.

Both of these cycles are responsive to changing conditions in the marshes. Introductions of additional sources of nitrogen and phosphorus via sewage discharge or agricultural run-off will have effects on the cycling of these materials in the marshes. Activities such as ditching and impounding, for instance, which affect water flow patterns in the marsh systems will also cause disturbances. The magnitude of the affects of such disturbances are difficult to determine, but it should be made clear that some changes in the cycling of nutrients can be expected following such manipulations.

Micro-Organisms and Water Quality Assessment

As stated, the practice of using microbial populations to monitor water quality is a wide spread and well established one. Coliform bacteria, are isolated from water samples in various ways. The number of organisms present is a reflection of the amounts of certain materials in the water. Bacteria are associated with domestic sewage because their source is primarily the intestinal system of humans.

The bacteria are of themselves not harmful, but their population size can be related to the amount of sewage entering the system. Other materials associated with sewage can cause sickness in humans and, therefore, coliform counts give scientists some indications of the presence of other micro-organisms in the areas sampled.

Work done in the Rehoboth Bay area shows that very variable coliform counts can be obtained depending on the areas sampled and the time of year. Many areas have counts below the levels required by the State Board of Health, inferring that the water quality of these areas is good. Many areas have in fact shown reductions in the coliform levels in the last several years. However, many sections of Rehoboth Bay including some of the tributaries feeding the bay, have coliform levels very much higher than those considered acceptable. The indications are that waters in these areas are receiving heavy sewage loads and might contain materials unsafe for humans. As a result, many shellfish beds are closed to the public since the shellfish possibly contain these harmful materials. Similar situations exist in the shellfish beds in many areas of Delaware Bay including those adjacent to Cape Henlopen.

Those studies made in the Broadkill estuary have found that most of the Broadkill River also contains coliform counts above acceptable levels. This is particularly true in that portion of the river below Milton. Again, the high coliform levels are associated with the introduction of industrial wastes and domestic sewage from the Milton area.

In 1975, as part of a baseline study to help state planners make decisions involving the future locations of sewage outfalls, coliform counts of water and sediments were periodically monitored in the Hen and Chickens Shoal area. It was found that these areas, as might be expected, have very low coliform densities. The use of these areas in the sewage disposal capacity in the past has been light. These levels do give scientists and planners a starting point from which to evaluate the effects of increased usage of offshore areas as sewage disposal sites.

The sewage disposal problem is going to continue to be one of the most pressing problems facing residents of the Lewes-Rehoboth Bay area. It is obvious that the recreational losses to the area because of sewage disposal problems are extensive in the Broadkill, at least, and could increase in other areas if care is not taken to properly handle the disposal of domestic sewage and other organic wastes. Comprehensive data appears to be lacking for the Harbor of Refuge, Rehoboth Bay (including tributaries) and the Lewes-Rehoboth Canal.

WATERFOWL, MARSH AND SHORE BIRDS

While the Lewes-Rehoboth Bay area is not used as heavily by waterfowl and marsh and shore birds as are some of the other coastal areas of the state, waterfowl still play an important role in the ecology of the Lewes-Rehoboth Bay area. The list of species that can be found at various times of the year is a long one. Many of these species are, however, more important than the others, both to the

ecosystem and to the outdoors man.

The greatest populations of waterfowl are present during the fall and winter when species of ducks and geese are migrating from nesting to wintering areas. Rehoboth Bay, Silver Lake and the Broadkill drainage system attract mallards, black ducks, pintails, blue and green-winged teals and Canada and snow geese each year with populations often reaching several thousand. Canvasback and ruddy ducks also appear here as well as large numbers of scaups and surf scoters. The latter fowl are prominent in the offshore areas near Cape Henlopen and in the open areas of Delaware Bay.

All of the marsh in lower Delaware, as well as the fields surrounding the marshes are used by the fowl, primarily as resting and feeding sites. Food sources that attract the birds include fish, grass, seeds, roots, insects and shellfish. It is difficult to determine if any new broods are produced in the spring in this area and, except for a few species like the black duck, it is believed that additions to the parental stock through brooding are insignificant. The resting and feeding functions of the marsh are of great importance to the fowl and careful consideration should be given to any manipulations of the marsh that might impair these two functions.

It should be noted that management practices in many areas of the State have done much to attract waterfowl to Delaware and revitalize declining populations. The benefits of these programs have been reflected in the Lewes-Rehoboth Bay area for the Canada geese and canvasback ducks found there are direct results of these programs. The development and preservation of feeding and watering areas has undoubtedly proven to be a success.

Similarly, pressures which lead to destruction or lowering in quality of marsh areas will have detrimental effects on waterfowl populations. All of Delaware Bay and its associated marsh-wetland areas have been identified as areas of prime importance to the health of all waterfowl populations. Delaware is in the middle of the Atlantic Flyway, one of the prime north-south migratory routes of most waterfowl. Problems associated with oil pollution in the Bay and with alteration of the marsh could seriously affect the health of waterfowl and shore bird populations. To the hunters who harvest 5,000-8,000 waterfowl in Sussex County each season and to the bird enthusiasts who gain pleasure from observing these creatures, the practices implemented will be especially important.

There are problems with waterfowl that should be mentioned. For example, areas such as Silver Lake regularly attract large populations of waterfowl. Large amounts of fecal material deposited by birds in a small system can lead to over-enrichment of the water. The answer to such problems seems not to eliminate the waterfowl from the area, but to create or develop nearby areas which will attract a section of the population and distribute the pressure more evenly.

Many other birds use the marshes in the area throughout the year. Great blue herons, green herons, black crowned night herons, clapper rails, Virginia rails, king rails, common egrets, snowy egrets, cattle egrets and willets are

common sights to those who are patient enough to watch for them.

There is a lack of specific information on the cycles of waterfowl and shore birds as they exist in the Lewes-Rehoboth Bay area, but studies done in other areas tell us that much that we do will lead to either disappearance or improvement of them. They are all sensitive to habitat changes, hunting pressures and introductions of pollutants such as pesticides into the water and air. Some fish-eating species--notably some of the herons, egrets and osprey--have experienced significant population reductions in other areas in recent years. Their reductions are linked to the pesticide levels in the food they eat.

Some mention should also be made of the gulls and terns which most people associated with the shore areas of Delaware. Herring gulls, laughing gulls, black-backed gulls, black skimmers, common terns, least terns, gull-billed terns, black terns and sand pipers are some of the common Lewes-Rehoboth Bay shore birds, many of which breed here. They are seen along all the beaches and bays and even in the marshes. Areas particularly important to them are the dune areas of Cape Henlopen where the dune grasses and the isolation they provide form important breeding habitat. Again, very little definite study has been done on these birds in this area but it is known that destruction of such breeding areas seriously affects the success of these species. Gulls and terns are important scavengers, whose functions as consumers of a variety of materials should not be overlooked.

FIGURE 1

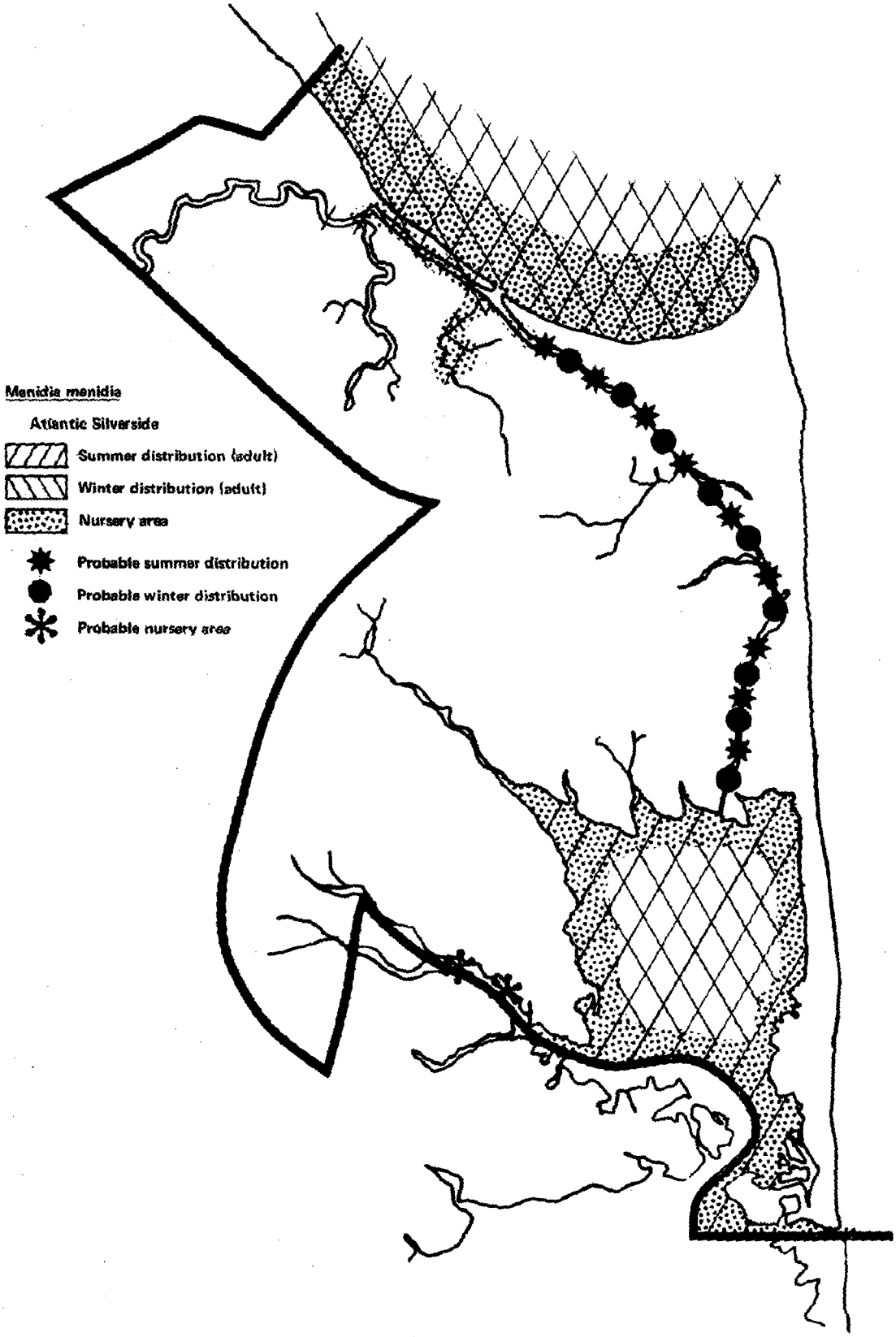

Menidia menidia
Atlantic Silverside
Summer distribution (adult)
Winter distribution (adult)
Nursery area
Probable summer distribution
Probable winter distribution
Probable nursery area

FIGURE 2

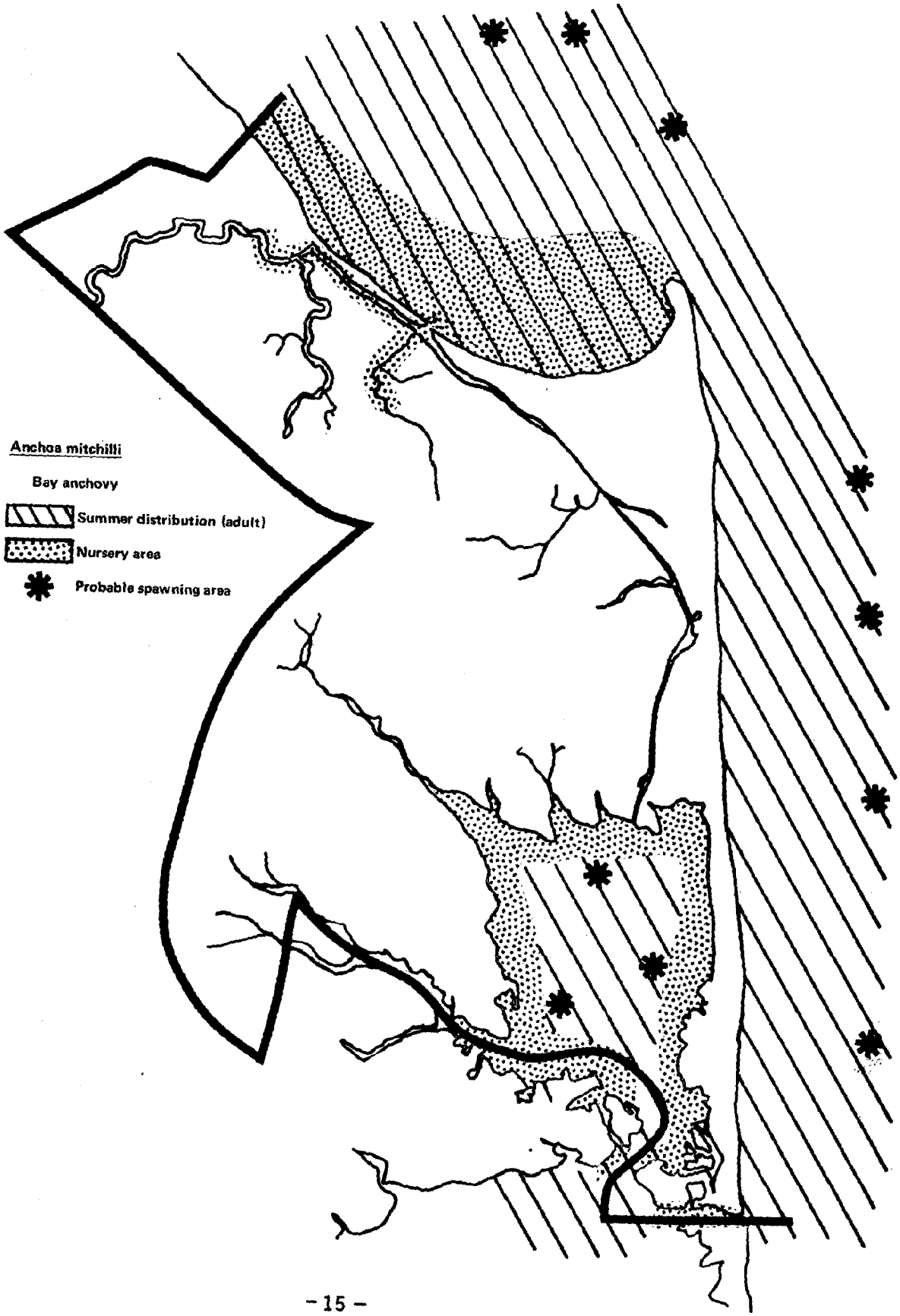

Anchoa mitchilli
Bay anchovy
Summer distribution (adult)
Nursery area
Probable spawning area

FIGURE 3

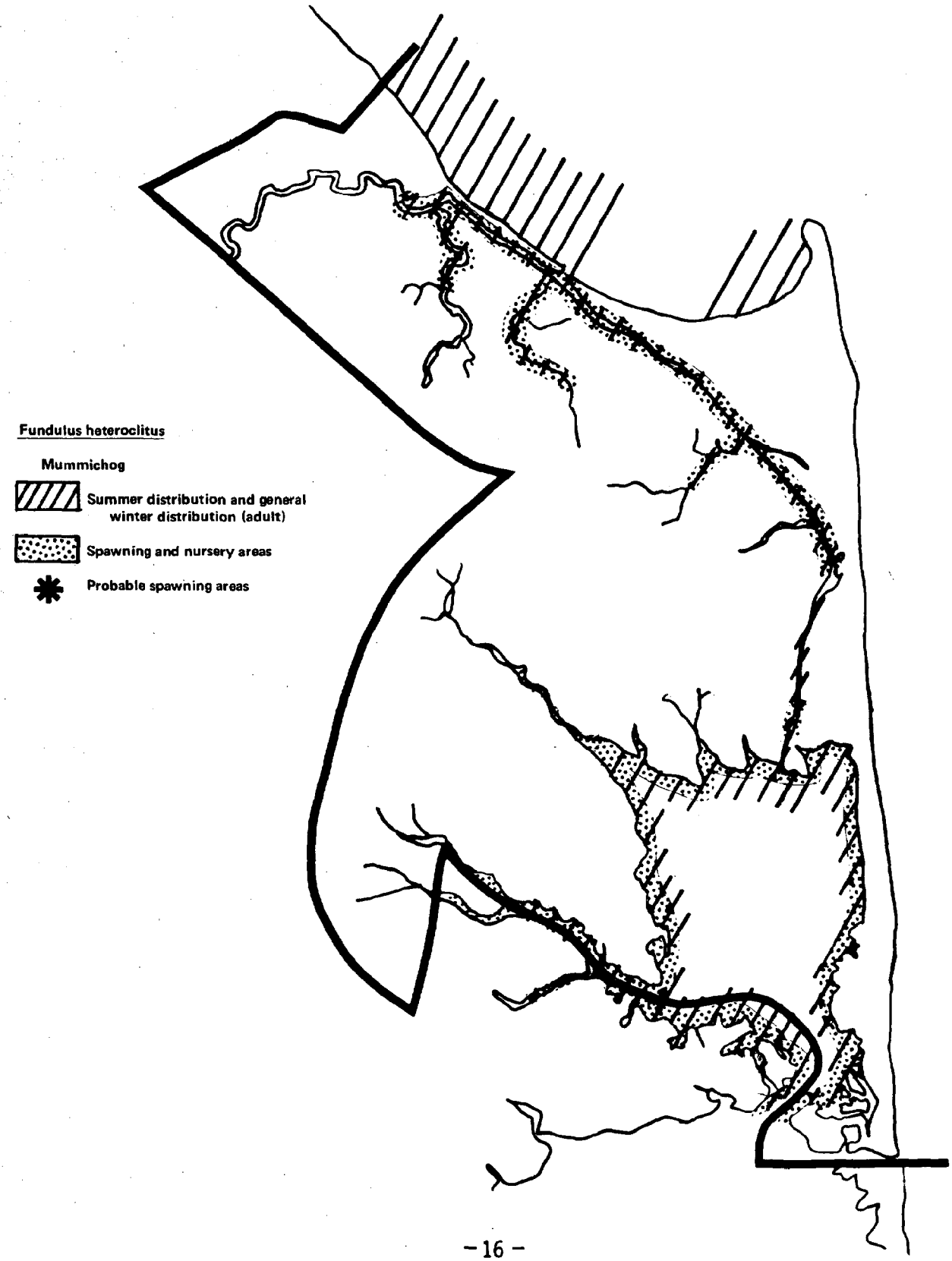

Fundulus heteroclitus
Mummichog
Summer distribution and general winter distribution (adult)
Spawning and nursery areas
Probable spawning areas

FIGURE 4

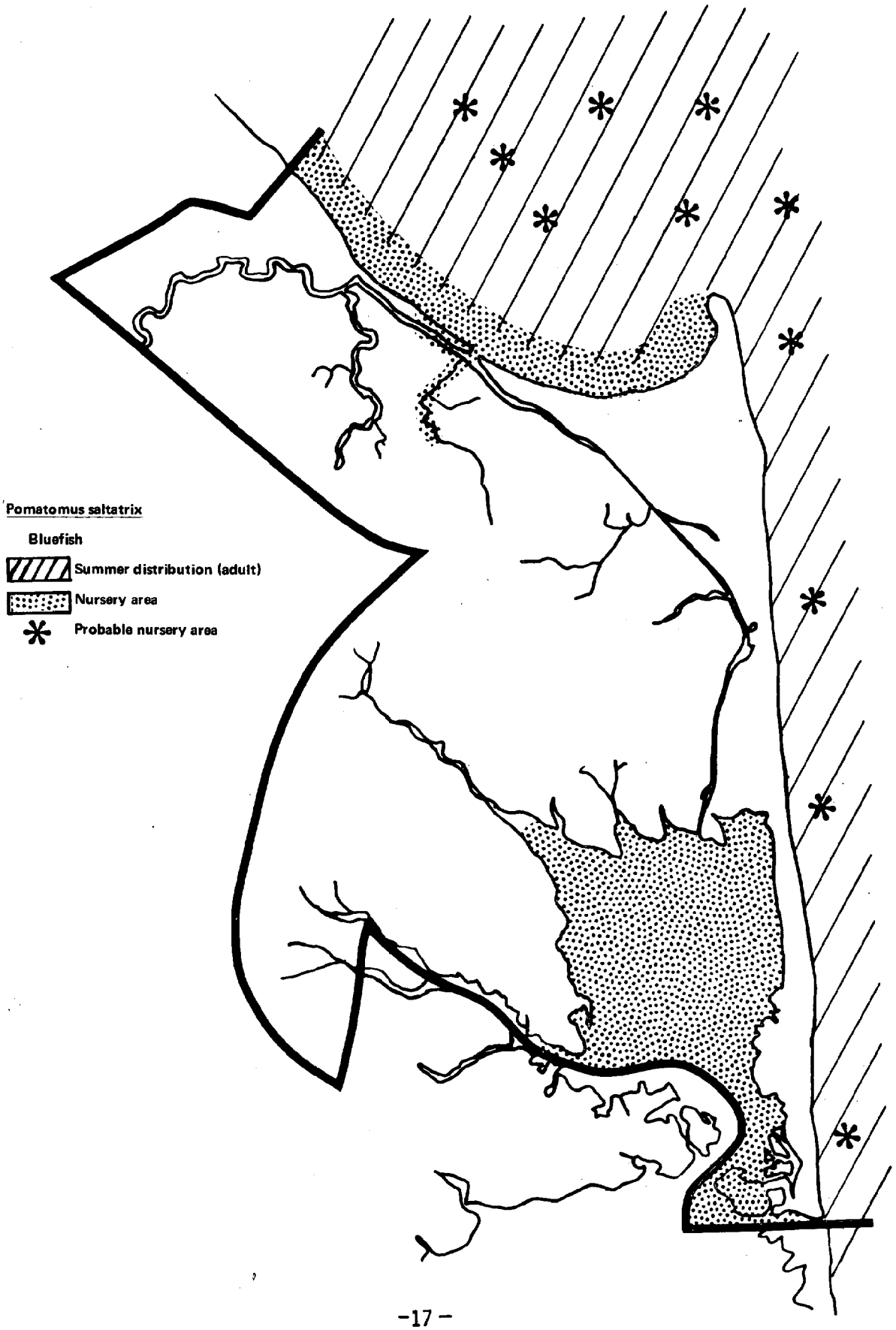

Pomatomus saltatrix
Bluefish
Summer distribution (adult)
Nursery area
Probable nursery area

FIGURE 5

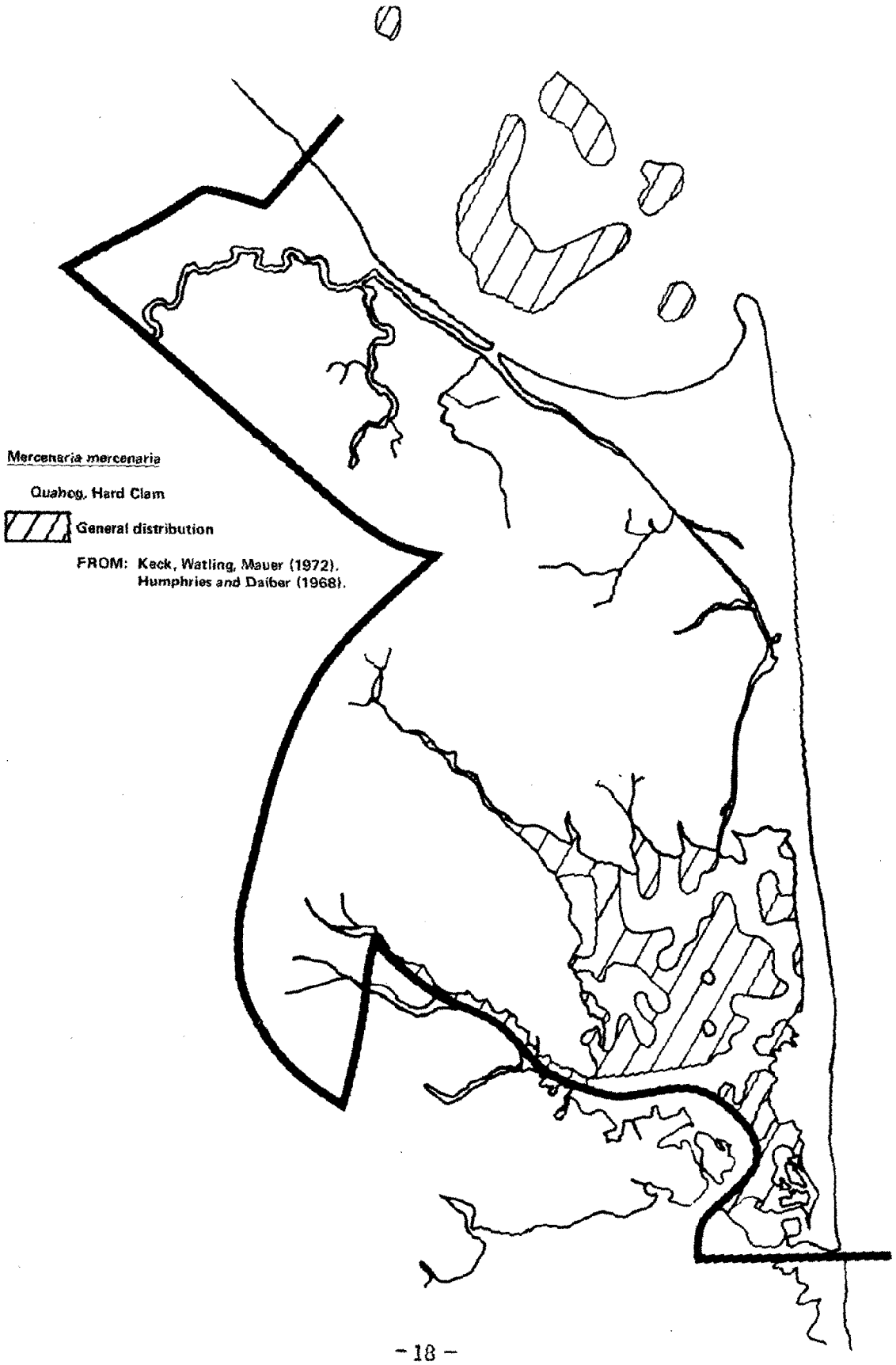

Mercenaria mercenaria
Quahog, Hard Clam
General distribution
FROM: Keck, Watling, Mauer (1972).
Humphries and Daiber (1968).

FIGURE 6

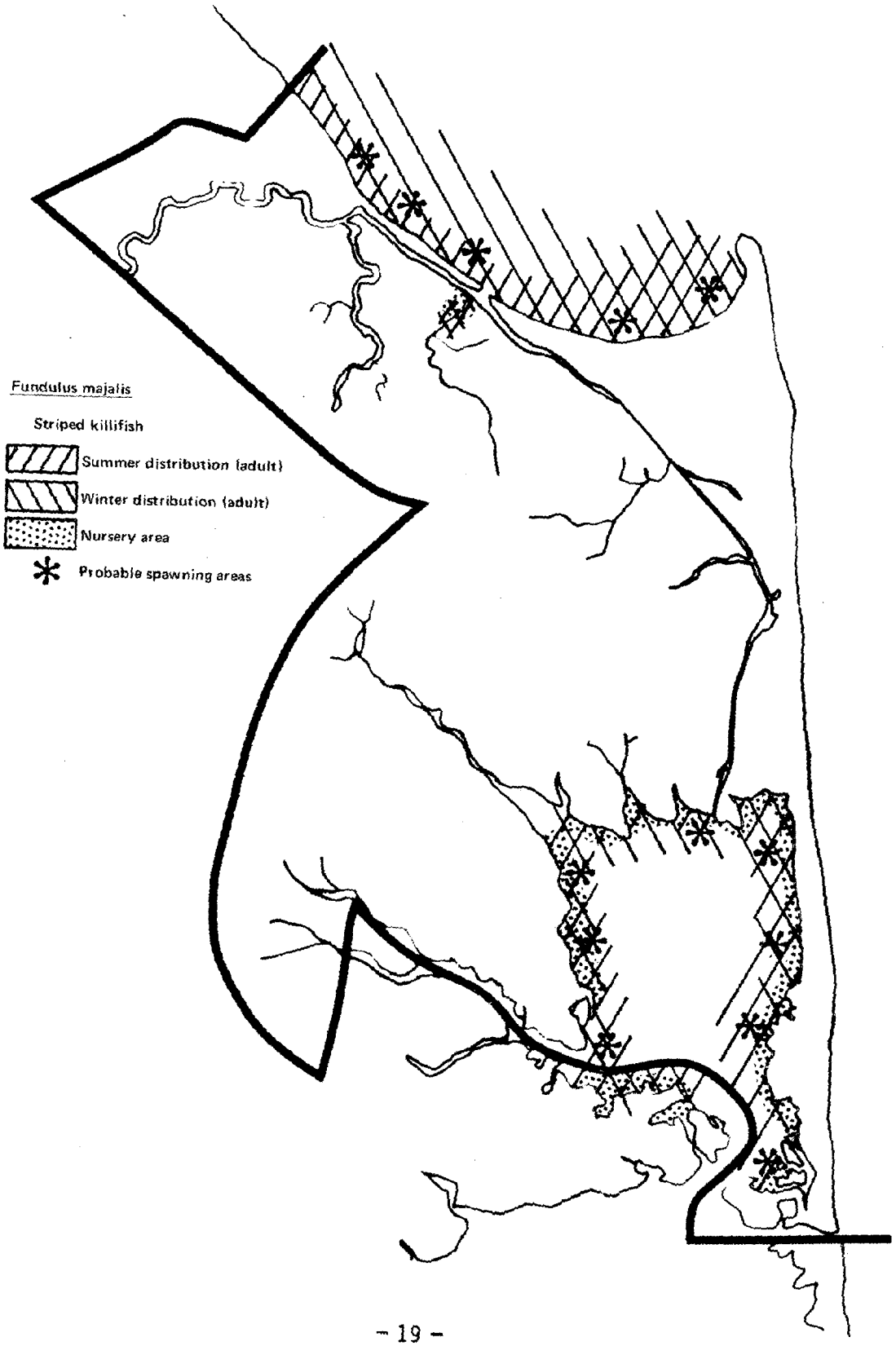

Fundulus majalis
Striped killifish
Summer distribution (adult)
Winter distribution (adult)
Nursery area
Probable spawning areas

FIGURE 7

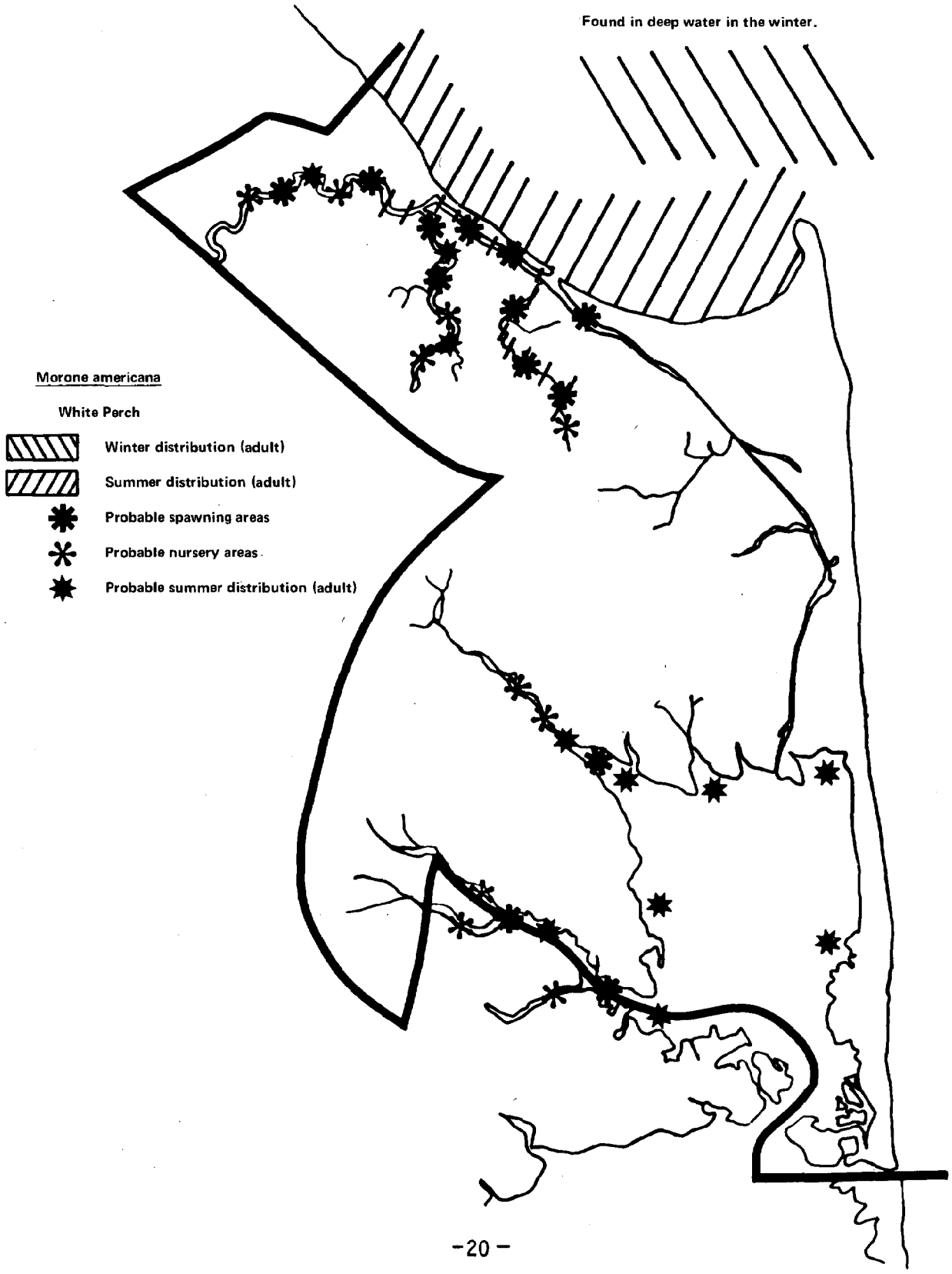

Found in deep water in the winter.
Morone americana
White Perch
Winter distribution (adult)
Summer distribution (adult)
Probable spawning areas
Probable nursery areas
Probable summer distribution (adult)

FIGURE 8

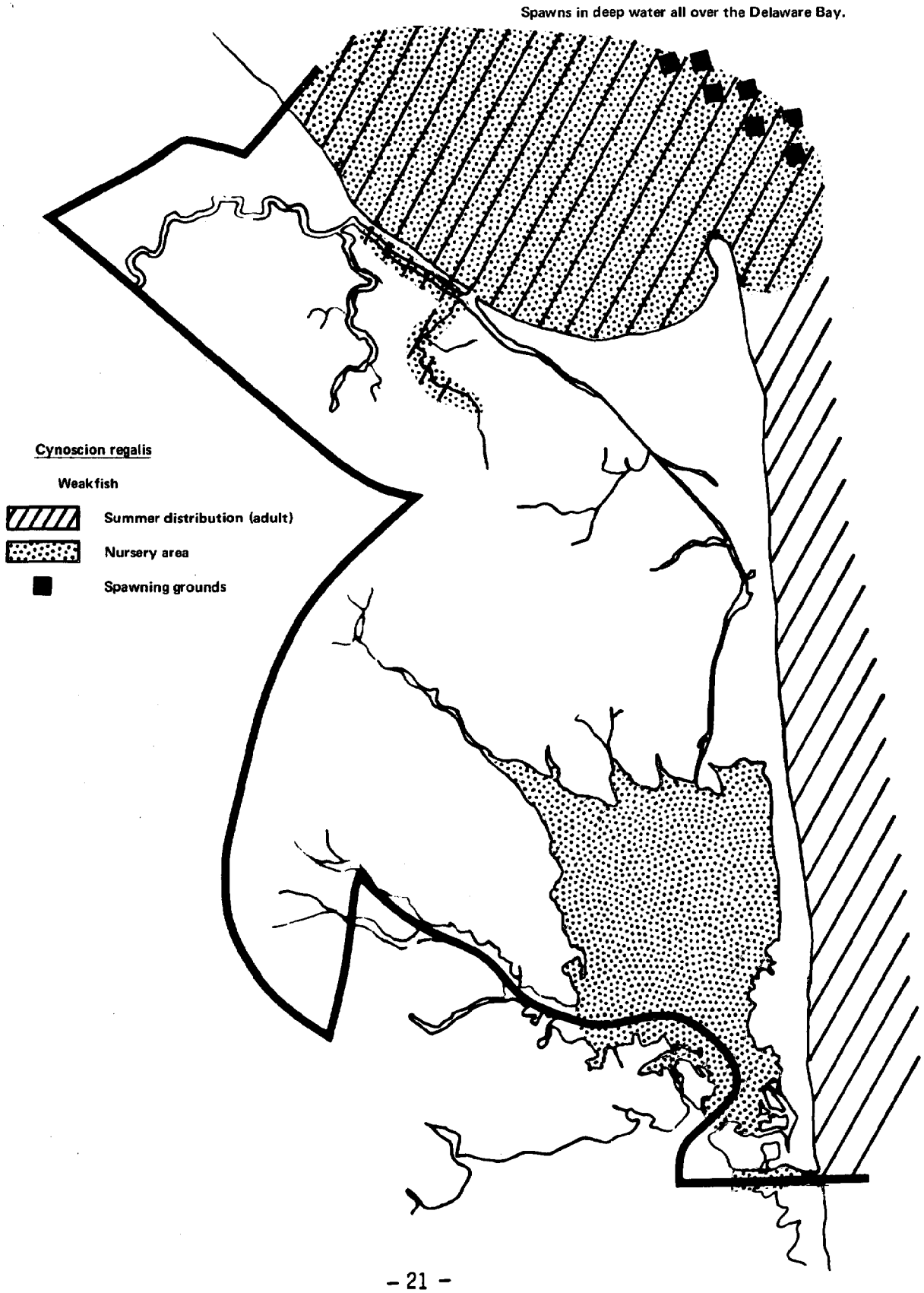

Spawns in deep water all over the Delaware Bay.
Cynoscion regalis
Weakfish
Summer distribution (adult)
Nursery area
Spawning grounds

FIGURE 9

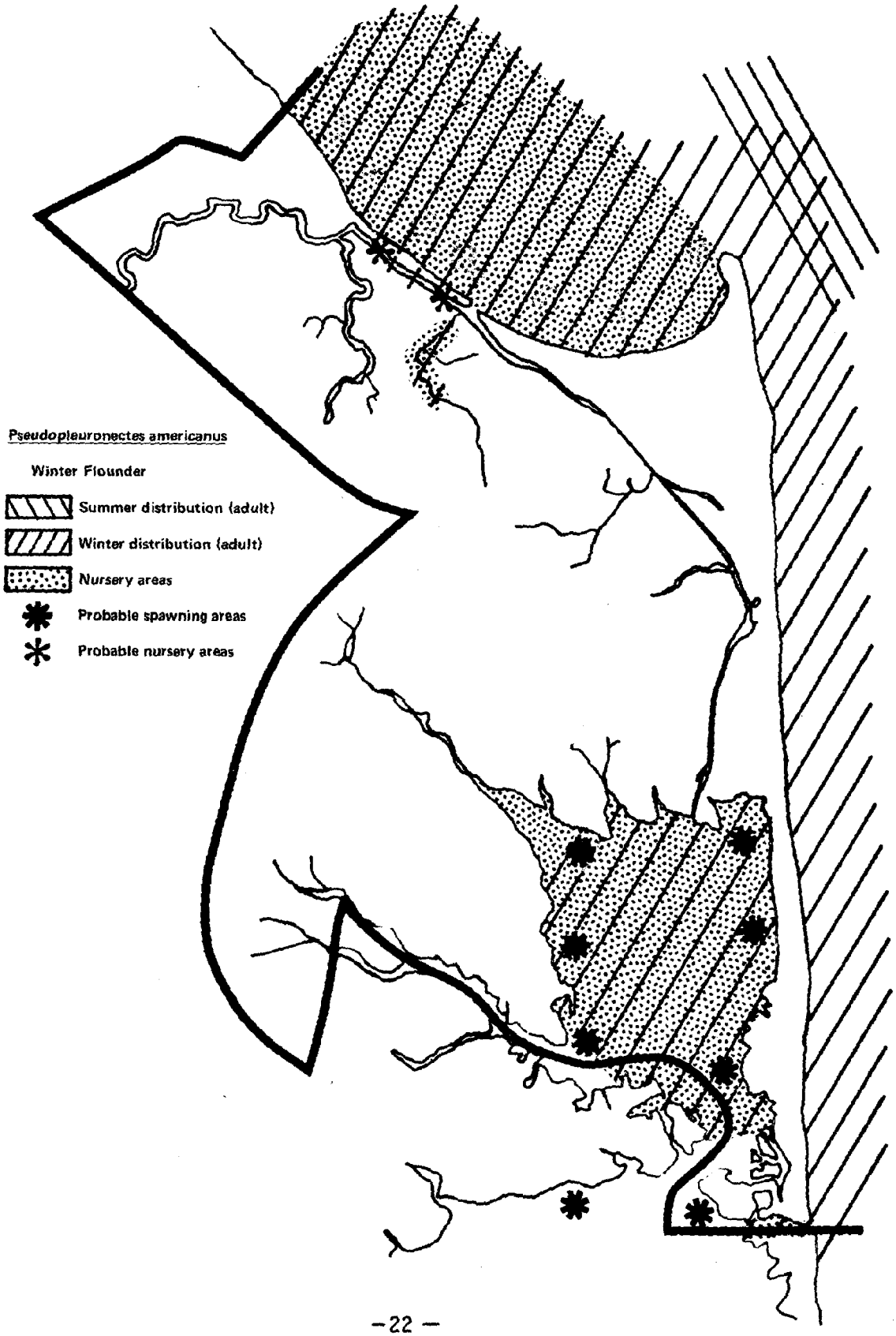
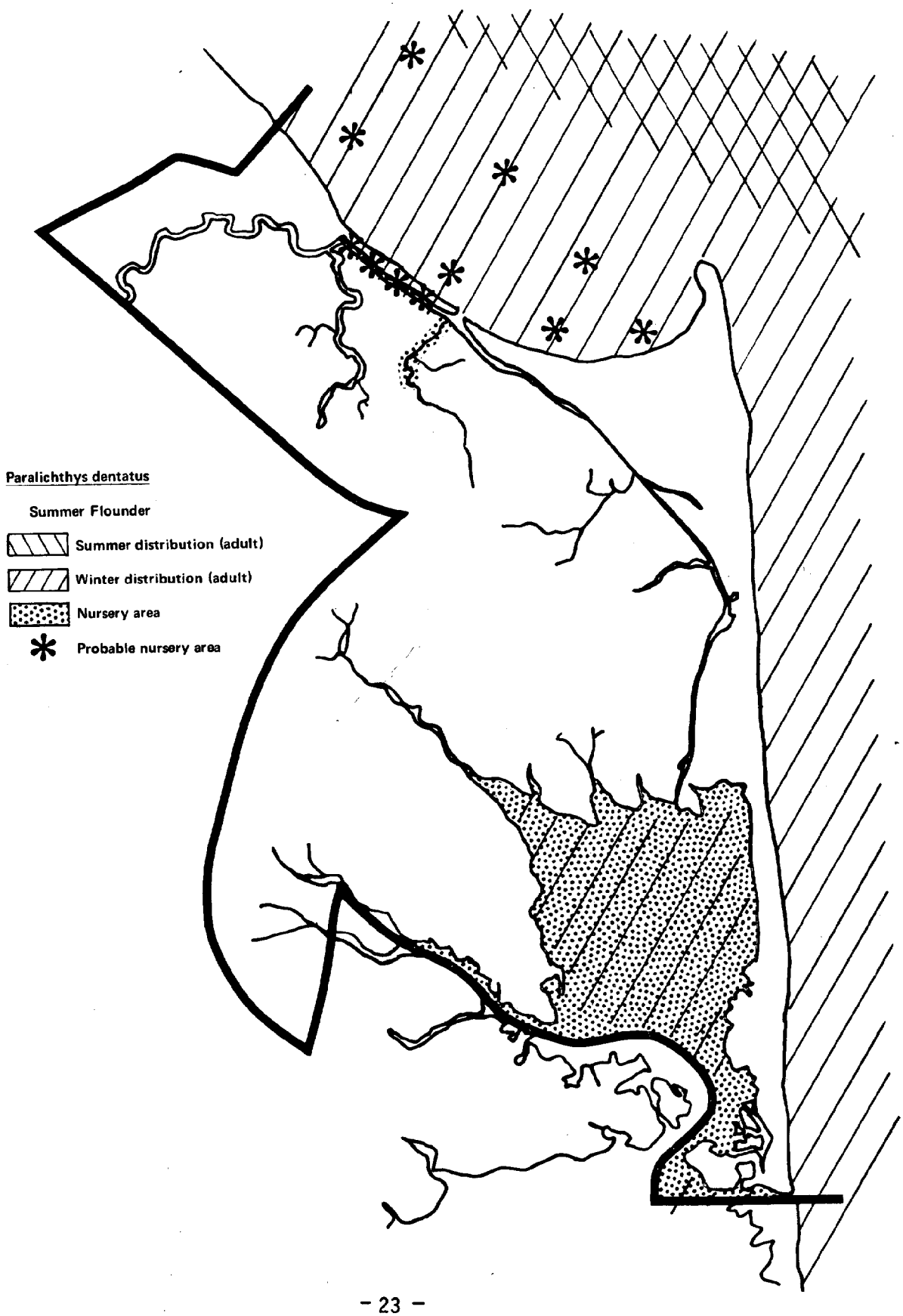

Pseudopleuronectes americanus
Winter Flounder
Summer distribution (adult)
Winter distribution (adult)
Nursery areas
Probable spawning areas
Probable nursery areas

FIGURE 10


Paralichthys dentatus
Summer Flounder
Summer distribution (adult)
Winter distribution (adult)
Nursery area
Probable nursery area

GLOSSARY OF TERMS

Algae - plants commonly found growing in the water. They can be small microscopic forms like diatoms or large macroscopic forms like the seaweeds.

Amphipod - an order of small organisms of the class Crustacea.

Benthic - a term meaning bottom and used in reference to animals or plants living on the bottoms of creeks, bays or the oceans. Clams and oysters are examples of benthic organisms.

Bryozoans - a group of primitive animals producing exoskeletons of calcareous material similar to those formed by corals.

Coliform - type of bacteria commonly found in the intestines of humans and in their fecal material. The number of coliform bacteria present in a system can be related to the amount of domestic sewage present and so coliform sampling has become an important pollution monitoring practice.

Copepods - microscopic crustaceans found in the water column important as food items for larger animals. They compose part of the zooplankton.

Crustacea - a large class of organisms almost all of which are aquatic and marine including the crabs, lobsters, shrimps, sow bugs, barnacles, water fleas, amphipods, isopods, copepods, cladocerans, and many others.

Decapod - having ten legs as is common in many crustaceans.

Denitrification - process by which nitrites and nitrates are transformed into ammonia and free nitrogen, again accomplished by certain bacteria.

Detritus - decaying organic material of both plant and animal origin, usually in small particulate form. In estuaries a large amount of the detritus is made up of dead cordgrass, Spartina alterniflora, that is washed into the water after it dies.

Ecology - the study of the relationships of organisms to each other and to their environment.

Ecosystem - the unit used in ecological study which includes all of the organisms, environments and processes common to a given area that are distinctly related and dependent upon one another. We speak in terms of a wetland ecosystem to refer to the animals, plants, marshes, bays, creeks and rivers existing in a particular drainage system and the processes which join them together.

Edaphic - relating to organisms that grow upon, or in, soil. In our work here, it relates primarily to certain algae that grow on the mud surfaces of the marshes.

Estuary - a confined coastal body of water which has a free connection to the open sea and in which salt water of the oceans is mixed with and diluted by fresh water from the land. Many materials necessary for the existence of organisms become entrained in these systems, and so these areas support large amounts of plant and animal life.

Fouling Organisms - a general term applied to a group of diverse types of organisms that sometime during their life cycle are found attached to hard substrates including pilings, jetties and bottoms of ships, where they are often considered nuisances. Barnacles, tunicates, bryozoans and hydroids are common types of fouling organisms.

Hydroids - a primitive group of jelly-like organisms often found attached to any solitary object such as piers, jetties and boats. Hydroids make up a large part of the fouling organism community.

Invertebrates - animals lacking a backbone or vertebral column, as worms, snakes, clams and oysters and insects.

Isopods - an order of small organisms of the class Crustacea.

Larvae - immature forms of many organisms that change structurally before they become adult-like. Fish, clams, oysters and worms all have larvae which are very much different from the mature adult forms.

Macroscopic - referring to objects which are large enough to be seen with the naked eye.

Marsh - an area of normally wet ground usually surrounding or adjacent to a creek, river or bay.

Microbiology - the study of the biology of microorganisms.

Microorganisms - a general classification of organisms, both plant and animal that are extremely small and invisible to the naked eye. A microscope is needed to identify them. Included in this group are bacteria, fungi, viruses and protozoans among others.

Microscopic - generally referring to anything too small to be seen with the naked eye.

Molluscs - a group of animals including the clams, oysters, snails, welks, squids and octopii.

Morphology - the study of the physical form and structure of organisms.

Nitrification - the process by which free nitrogen or ammonia nitrogen is transformed to nitrite and nitrate nitrogen, usually accomplished by certain bacteria and blue-green algae.

Nitrite - ($NO_2^=$) - a form of nitrogen found in nature and which also classifies as a nutrient.

Nitrogen - an elemental substance of the earth, important to the existence of all living organisms for it is a major component of proteins and genetic materials.

Nutrient - any of a group of chemical materials an organism needs in order to survive. Nitrogen is an example of a nutrient material.

Organic - relating to materials derived from organisms. More inclusively, those materials containing the element carbon, which is a basic element in all living things.

Organism - any plant or animal.

Phosphorus - an elemental substance of the earth and one extremely important to all living organisms. Like nitrogen a critical nutrient in any ecosystem, the amount present partially determining how productive a system will be.

Plankton - microscopic plants and animals that are found floating in the water. The term zooplankton refers to the microscopic, floating animal community and phytoplankton refers to the microscopic, floating plant community. The plankton can be divided further to refer to more specific plankton forms such as the ichthyoplankton-zooplankters which are the eggs and larvae of fish--both small, floating stages in the life cycles of fishes.

Polycheate (oligocheate) - two types of segmented worms.

Primary Producers - green plants of various types which are at the base of all food webs because of their capability of converting sunlight into organic matter. All other organisms in the system ultimately depend on the material first produced by the green plants.

Protozoan - any primitive, single-celled organism.

Salinity - a measure of the amount of dissolved solid material contained in a kilogram of sea water.

Tubicolous worms - tube-building worms.

Turbidity - the term referring to the amount of suspended materials present in water. Waters of high turbidity have large amounts of material in them, and so are not very clear. The suspended materials involved are usually soil and silt particles but can also by phyto- and zooplankton organisms.

Wetlands - the general term applied to the creeks, rivers and bays of Delaware and the land areas surrounding them which are under the influence of these water systems.

Xanthid Crabs - smal crabs of the family Xanthidae which are commonly found on the marsh surfaces. They lack the swimming legs of more water oriented crabs such as the blue crabs.

Zooplankton - see plankton.