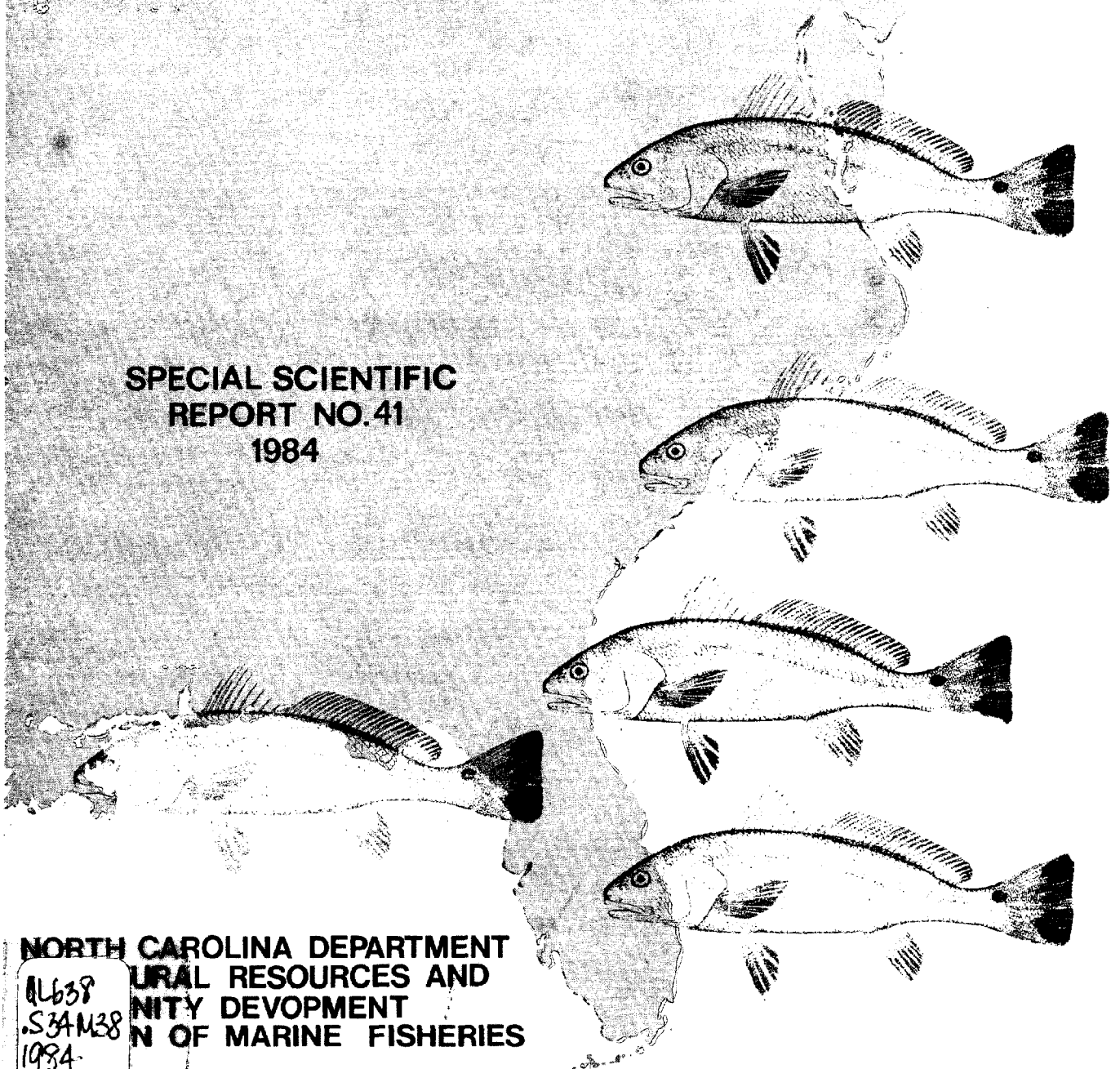
A BIOLOGICAL AND FISHERIES PROFILE OF RED DRUM, *SCIAENOPS OCELLATUS*



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A BIOLOGICAL AND FISHERIES PROFILE OF

RED DRUM, *Sciaenops ocellatus*

by

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and Community Development

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PREFACE

In the early 1970s, state marine fisheries management agencies and the National Marine Fisheries Service (NMFS) began a cooperative program to prepare and implement fishery management plans for coastal migratory species and shared fisheries resources occurring in the Territorial Sea along the Atlantic Coast of the United States. This effort, called the State-Federal Fisheries Management Program, resulted in cooperative management plans for species such as the American lobster, surf clam, striped bass, Atlantic menhaden, penaeid (southern) shrimp, pandalid (northern) shrimp, and summer flounder, as well as development of a cooperative statistics program in the Southeast Region of the United States. Several of these plans have been adopted and implemented by regional Fisheries Management Councils under the Magnuson Fishery Conservation and Management Act of 1976 (PL 94-265). Funding for the overall program has been provided by NMFS through the Atlantic States Marine Fisheries Commission. Since 1980, this coordination has been formally conducted under the Commission's Interstate Fisheries Management Program. This red drum profile represents the initial step in preparation of plans for cooperative management of important sciaenid species occurring along the Atlantic Coast.

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1. IDENTITY

1.1 Nomenclature

The valid name for red drum is *Sciaenops ocellatus* (Linnaeus) 1766 (Figure 1). The following synonymy is after Jordan and Evermann (1896):

Perca ocellata Linnaeus, 1766
Lutjanus triangulum Lacepede, 1802
Sciaena imberbis Mitchill, 1815
Corvina ocellata Cuvier and Valenciennes, 1830
Johnius ocellatus Girard, 1859
Sciaena ocellata Gunther, 1860

1.2 Taxonomy

Classification follows Greenwood et al. (1966). Taxa higher than superorder are not included.

Superorder: Acanthopterygii
  Order: Perciformes
    Suborder: Percoidei
      Family: Sciaenidae
        Genus: *Sciaenops*
          Species: *Sciaenops ocellatus*

Red drum is one of 22 members of the family Sciaenidae found along the Atlantic and/or Gulf coasts of the United States (Robins et al. 1980). This family is commonly known as the drums since many of its members, including red drum, produce drumming sounds by vibrating their swim bladders with special muscles (Jordan and Evermann 1896; Bigelow and Schroeder 1953; Fish and Mowbray 1970; Guest and Lasswell 1978). Chao (1978) assessed the phylogenetic relationships of all western Atlantic genera of Sciaenidae on the basis of swim bladder, otoliths (sagitta and lapillus), and external morphology, and presented a tested key to species and genera. The genus *Sciaenops* is monotypic.

Red drum is the common name given *Sciaenops ocellatus* by the American Fisheries Society (Robins et al. 1980). Other common names include channel bass, puppy drum, redfish, bull redfish, bass, red bass, sea bass, spotted bass, spottail, rat red, pescado colorado, drum, and branded drum (Smith 1907; Jordan et al. 1930; Hildebrand and Schroeder 1928; Shiino 1976).

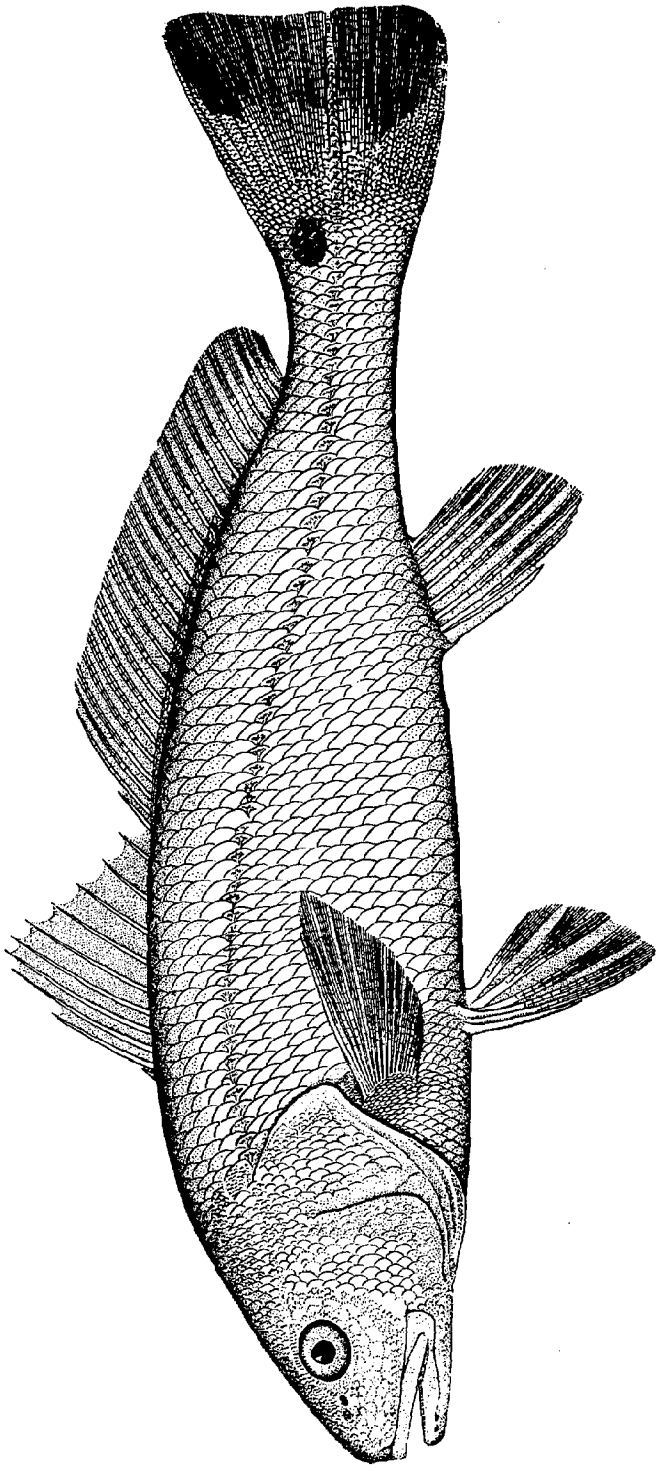

Figure 1. Red drum, Sciaenops ocellatus (Linnaeus), 1766 (illustration by H. L. Todd from: Goode 1884).

1.3 Morphology

The following description is that of Johnson (1978), summarized from Jordan and Evermann (1896), Hildebrand and Schroeder (1928), Topp and Cole (1968), Simmons (1969), Miller and Jorgenson (1973), and Chao (1976).

> D. X-I, 23-25; A. II, 7-8; C. 9+8, procurrent rays 8-10+7-10; V. I, 5; scales 40-45 in a lateral series; vertebrae 10+15, pleural ribs 8, epipleural ribs 7; gill rakers 4-5+7-9; branchiostegals 7; teeth small conical in jaws, set in bands, outer row teeth of upper jaw slightly enlarged; lower jaw teeth subequal; no teeth on vomer, palatines, or tongue.
>
> Head 2.8-3.3, depth 3.3-3.9 in SL; snout 3.3-3.8, eye 3.1-4.7, maxillary 2.5, interorbital 3.7-4.6, pectoral fin 1.5-1.8 in head.
>
> Body elongate, rather robust, not much compressed; back moderately arched; ventral outline nearly straight; head rather long and low; snout conical; mouth horizontal, lower jaw included; lower jaw with five pores, without barbels; maxillary almost reaching below posterior margin of eye. Scales rather large, strongly ctenoid; no scales on soft dorsal fin; scales of breast embedded, cycloid. Dorsal fin continuous, with a deep notch between the spinous and soft portions; dorsal spines rather stiff, pungent; second anal spine thick, much shorter than longest soft rays; posterior margin of caudal fin straight to slightly concave; pectoral fin as long as pelvic fin. Preopercular margin serrate in smaller specimens, becoming entire in specimens of about 9-13 kg.
>
> Pigmentation: May be silvery, grayish, bronze, coppery, yellow, and sometimes almost black; often silvery or copperish in Gulf, darker in muddy bays; each scale with a dark center, forming rather obscure, irregular, undulating brown stripes along scale rows; one to several (most frequently 1) jet black spots at base of caudal and below the soft dorsal fin above lateral line; dorsal and caudal fins dusky; anal and pelvic fins white; outer part of pectoral fin bright rusty.

Topp and Cole (1968) described the osteology of Sciaenops based on a study of 21 specimens (30 mm SL-195 mm skull length). Powles and Stender (1978) described morphometric and meristic development of nine larval red drum (4.1-7.9 mm SL) from South Carolina estuaries and the Cape Fear River estuary, North Carolina. Standard length-total length relationships were determined for red drum in Georgia (Jorgenson and Miller 1968), Texas (Harrington et al. 1979), Louisiana (Hein et al. 1980), and Mississippi (Overstreet 1983) (Table 1).

Table 1. Standard length-total length relationships for red drum as reported in the literature.

Location	Reference	Size range (mm TL)	N	Relationship	r
Georgia	Jorgenson and Miller (1968)	16-40	5	TL = 0.469 + 1.247 SL	-
				SL = -0.290 + 0.799 TL	-
Texas	Harrington et al. (1979)	92-937	8982	TL = 12.870 + 1.177 SL	0.995
Louisiana	Hein et al. (1980)	14-1135	302	SL = -2.0520 + 0.8369 TL	0.9996
Mississippi	Overstreet (1983)	175-1138	861	TL = 7.3032 + 1.1712 SL	0.9975
				SL = -3.4416 + 0.8495 TL	0.9975

2. DISTRIBUTION

2.1 General distribution

Red drum have been reported from the Gulf of Maine off Massachusetts to Key West, Florida, on the Atlantic coast but are rare north of New Jersey (Smith 1898; Yokel 1966; Lux and Mahoney 1969). Commercial landings of red drum have generally declined along the Middle Atlantic coast and none have been reported north of Chesapeake Bay since 1950 (Yokel 1980). Red drum occur in the Gulf of Mexico from extreme southwest Florida continuously along the Gulf coast to Zamora, Vera Cruz, Mexico (Yokel 1966; Castro Aguirre 1978).

2.2 Differential distribution

2.21 Spawn, larvae, and juveniles

Observations of gravid and spent adults and collections of larvae indicate that red drum spawn in the ocean along beaches and in the vicinity of inlets and passes (Pearson 1929; Miles 1950; Simmons and Breuer 1962; Yokel 1966; Hein and Shepard in press). Red drum eggs were observed being carried into seagrass beds by tidal currents in Redfish Bay, Texas (S. Holt and Arnold 1982). Collections of red drum larvae (2.0 mm NL-5.2 mm SL) from eelgrass beds on the eastern shore side of Chesapeake Bay, approximately 37 km from the bay entrance,[1] and observations of gravid adults in Tampa Bay, Florida[2] suggest that some spawning may occur within estuaries.

In the Gulf of Mexico red drum larvae (< 7 mm TL) and postlarvae (7-42 mm TL) have been collected in nearshore oceanic waters, passes and inlets to estuarine waters, and within estuaries (Pearson 1929; Miles 1950; Yokel 1966; Jannke 1971; King 1971; Sabins and Truesdale 1974; Richardson and Laroche 1982; Robison in press). Within estuaries young red drum are generally found in quiet shallow waters with grassy or slightly muddy bottoms that

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[1] Unpublished data on file at the Virginia Institute of Marine Science, Gloucester Point, Virginia.

[2] M. Murphy and R. Taylor, Florida Department of Natural Resources, St. Petersburg, Florida, personal communication.

are not greatly affected by tides (Perret et al. 1980). A study of the distribution of young red drum (6-27 mm SL) among different shoal-grass (Halodule wrightii) beds in Texas found that the ecotone between seagrass and nonvegetated bottom had significantly more red drum than did homogeneously vegetated sites. No red drum were found on large (>5 m across) nonvegetated sites (Holt, Kitting, and Arnold 1983). In Tampa Bay young red drum (8-20 mm SL) were collected along the shoreline over soft mud to sandy bottom, often with submerged grasses or shore grasses and little current. Larger individuals (20-40 mm SL) were collected in bayous and backwaters with low salinity, muddy bottom, little or no submerged vegetation and usually some detritus. Juveniles (40-90 mm SL) were found in semiexposed areas such as river mouths with mud to moderately sandy bottoms, little or no cover, and moderately low salinities and currents. Larger fish (160-250 mm SL) were found in exposed areas of embayments and rivers with moderate currents, sand/mud or rubble bottoms, and moderate salinities.[3]

Most juvenile or immature red drum (<700-750 mm TL) remain in Gulf of Mexico estuaries throughout the year, but move into deeper waters of bays during winter (Pearson 1929; Miles 1950; Simmons and Breuer 1962; Breuer 1973; Loman 1978; Osburn et al. 1982). Young-of-the-year moved out of the seagrass beds in Redfish Bay, Texas in late November with the onset of cold (<16°C) water temperatures (S. Holt and Arnold 1982). Tagging studies have shown that there is very little inter-bay movement of immature red drum in Texas (Simmons and Breuer 1962; Osburn et al. 1982) or Florida (Ingle et al. 1962; Topp 1963). Immature red drum (100 mm-460 mm TL) have also been collected in the Gulf surf zone in summer (Gunter 1958; Simmons and Hoese 1959; McFarland 1963; Heffernan 1973), and Gulf-to-bay movement of red drum (203-254 mm TL) in Texas was noted by Simmons (1951).

Information on the distribution of juvenile red drum on the Atlantic coast is limited. Postlarval red drum are found over sand and mud bottom in North Carolina,[4] around oyster bars in South Carolina,[5] and over muddy bottoms in

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[3]K. Peters and B. McMichael, Florida Department of Natural Resources, personal communication.

[4]Unpublished data on file at the North Carolina Division of Marine Fisheries, Morehead City, North Carolina.

[5]G. Ulrich, South Carolina Marine Resources Center, Charleston, South Carolina, personal communication.

Florida[6]. In the Cape Fear River estuary, North Carolina postlarval red drum accumulated in greater numbers in the upper reaches of creeks, gradually decreasing in densities downstream (Weinstein 1979). Setzler (1977) demonstrated the transport of red drum larvae from 10.5 km offshore to the lower salinity waters at the head of Doboy Sound, Georgia. In that study significantly higher densities of red drum were caught on flood tides than on ebb tides and larvae collected at inshore stations were significantly larger than those from offshore. Mansueti (1960) speculated that red drum larvae are carried passively into Chesapeake Bay by deep sub-surface high density water currents, and at about 5 mm TL move into shallow water (<1.5 m).

Yokel (1966) stated that juvenile red drum have a more pronounced seasonal pattern of distribution in Chesapeake Bay and North Carolina than in the Gulf of Mexico, moving into deeper areas of estuaries or the sea in the fall and winter. Juveniles (20-90 mm TL) were collected throughout Chesapeake Bay from September to November (Hildebrand and Schroeder 1928; Mansueti 1960). Two juveniles (58 and 66 mm) were collected in November and December in the thermal plume of the Indian River Power Plant, Indian River Bay, Delaware (Wang and Kernehan 1979). Juvenile red drum 15-391 mm TL were collected through December, with young-of-the-year first appearing in September, 1972-1983 in nursery area surveys of Pamlico Sound, North Carolina (Spitsbergen and Wolff 1974; Wolff 1976).[7] Schwartz et al. (1981) listed red drum as occurring year-round in the Cape Fear River estuary. Large numbers of young red drum (up to 8 kg) are occasionally gigged in North Carolina sounds in the winter (Angler gigs 352 puppy drum. 1984). In South Carolina red drum (37-100 mm) have been collected in shallow-waters of marsh-tidal creeks and in tidal impoundments during September through November (Bearden 1967; Smith and Moore 1979). In Georgia red drum were collected by seines in a variety of habitats, including beach, high marsh, tidal canals, and low- and high-salinity tidal pools (Dahlberg 1972). Young and juveniles were usually collected in the shallow shore zones of the Indian River lagoon, Florida (Snelson 1983).

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[6]K. Peters, Florida Department of Natural Resources, personal communication.

[7]Unpublished data on file at the North Carolina Division of Marine Fisheries, Morehead City, North Carolina.

2.22 Adults

Information on the distribution of adult red drum has been obtained from biologists, recreational and commercial fishermen, and menhaden spotter pilots (Yokel 1966; Overstreet 1983). Along the Gulf coast red drum move from the estuaries to the Gulf of Mexico at maturity (>700 mm FL) (Yokel 1966). After spawning some of the adults may move back into bays for a short time (Miles 1951), but on the whole less time is spent in the estuary after maturity (Pearson 1929; Simmons and Hoese 1959). Large schools of red drum have been observed as far as 19 km offshore (Simmons and Breuer 1962). Overstreet (1983) reported that commercial fishermen have observed schools of 150-250 thousand fish (2-30 million kg) in the Gulf. Schools of red drum (5-15 kg) have been observed feeding along the shoreline of islands or the mainland at depths >1.2 m from low tide through flood tide. The schools often occur near black drum, Atlantic tarpon, and pompano and are sometimes caught under schools of blue runner at a depth of 37 m (Anonymous 1982a). Ross et al. (1983) captured 16 adult fish (808-1,050 mm TL) during late autumn, winter and early spring off Freeport, Texas, 88% of which were captured in March and April at depths of 13-22 m. Schools of red drum have been monitored commonly at depths of approximately 40-70 m (Overstreet 1983). During summer schools of red drum are more spread out than during spring and autumn, occurring all over Mississippi Sound and adjacent regions (Overstreet 1983).

Adult red drum migrate seasonally along the coasts of North Carolina and Virginia, moving inshore and north in spring and offshore and south in fall. In Chesapeake Bay red drum are taken from May until October and are most abundant during spring and fall (Hildebrand and Schroeder 1928). Largest catches of citation red drum (≥18 kg) along the Outer Banks of North Carolina are made from late March through May and in October-November.[8] Large schools of red drum have been observed in Pamlico Sound, North Carolina during summer.[9] In winter they have been caught off the coast of North Carolina in the trawl fishery (Pearson 1932; Ross et al. 1983) and in trawl surveys at depths of 10-40 m.[10] Red drum have been

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[8]Unpublished North Carolina Saltwater Fishing Tournament data on file at the North Carolina Office of Travel and Tourism, Raleigh, North Carolina.

[9]J. Brown, North Carolina Division of Marine Fisheries, Morehead City, North Carolina, personal communication.

[10]Unpublished data on file at the North Carolina Divison of Marine Fisheries, Morehead City, North Carolina.

reported off South Carolina in 13-26 m in winter-early spring.[11] In Georgia red drum >4 yr are generally found along the beaches and in offshore waters (Music and Pafford 1984). In the Indian River lagoon area of Florida, red drum were reported as common in the benthic-open shelf habitat and frequent in the surf zone, inlets, and lagoon (Gilmore et al. 1981; Snelson 1983).

2.3 Determinants of distribution

Red drum are euryhaline, having been reported from fresh water to salinities of 50 ppt on the Gulf coast (Gunter 1942, 1945, 1956, 1959; Kilby 1955; Simmons 1957; Briggs 1958; Springer 1960; Springer and Woodburn 1960; Tabb and Manning 1961; Gunter and Hall 1962; Simmons and Breuer 1962; Perret 1971). Simmons and Breuer (1962) reported that the optimum salinity range for red drum was 20-40 ppt. Red drum were collected on the east coast of Florida at salinities from 0-29.9 ppt (Springer 1960; Tagatz 1967). In North Carolina estuaries red drum (10-391 mm TL) were collected over a salinity range of 0-22.3 ppt (Tagatz and Dudley 1961). Yokel (1966) suggested a direct relationship between size and salinity, with juveniles more common at low salinities and large fish preferring higher salinities. This is typical of many species that utilize estuaries as nursery areas (Gunter 1938, 1945).

Crocker et al. (1981) evaluated survival and growth of juvenile red drum in fresh and salt water and found that tolerance to fresh water was size dependent. They found 5% survival in larvae (23-day-old, 6.2 mm SL), 70% for postlarvae (34- and 47-day-old, 16.2-19.7 mm SL), and 95% for juveniles (57-day-old, 56.9 mm SL) subjected to dechlorinated fresh water for 96 hours. Survival in control salinities of 10 ppt was 90% or greater. Wakeman and Wohlschlag (1983) studied osmotic adaptation with respect to blood serum osmolality and oxygen uptake in hatchery-reared (1.3-3.8 g) and wild juvenile red drum. The rapid stabilization of both serum osmolalities and standard metabolic rates indicated that red drum are well adapted to natural rapid salinity changes.

Red drum have been collected over a temperature range of 2-33°C, although they usually move into deeper water at the extremes (Simmons and Breuer 1962). Springer (1960) collected red drum from 2-29°C in the St. Lucie and Indian Rivers, Florida. Red drum (10-415 mm FL) were collected in a North Carolina estuary from 7.5-26.8°C (Tagatz and Dudley 1961).

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[11] C. Wenner, South Carolina Marine Resources Research Institute, Charleston, S.C., personal communication.

Gunter (1947) reported that larger juveniles and adults were more susceptible to the effects of winter cold waves than were smaller fish. High red drum mortality in Texas during freezes was documented by Gunter (1941) and Gunter and Hildebrand (1951). Red drum were killed in three out of nine severe cold spells at Sanibel Island, Florida, but the kills were never severe (Storey and Gudger 1936). Red drum were found dead or dying in the power plant intake canal and on shoals that had iced over in the lower Cape Fear River estuary, North Carolina during the severe winters of 1976 and 1977 (Schwartz et al. 1981).

3. LIFE HISTORY

3.1 Reproduction

Size and age of red drum at sexual maturity are not well known and apparently vary in different areas of the range (Pearson 1929; Gunter 1950; Miles 1951; Simmons and Breuer 1962; Yokel 1966; Hein and Shepard in press) (Table 2). On the Atlantic coast age and size at maturity was determined for the Mosquito Lagoon area of Florida.[12] Males began maturing at age I+ between 470-530 mm FL, and females first matured between ages II and III when 575-760 mm FL. Music and Pafford (1984) collected a single ripening male (755 mm TL, age II) in a Georgia study.

Fecundity of red drum has been estimated from both laboratory-reared and wild caught fish (Table 3). Multiple spawning was reported in laboratory-induced spawning experiments in which three females (9-15 kg) in Texas produced an estimated 6.0×10^7 fertilized eggs in 52 spawns during 76 days (Arnold et al. 1977). In Florida experiments four females (1.68-7.95 kg) produced 8.43×10^6 eggs during 90 days and eight females (1.68-7.95 kg) produced 4.41×10^6 eggs over 100 days (Roberts, Harpster, and Henderson 1978). Overstreet (1983) presented a standard length-fecundity relationship for 22 red drum (294-800 mm SL) in Mississippi as: Log F = 3.6976 + 0.0050 SL ($r = 0.9539$), where F is the number of oocytes 16-300 μm. The maximum estimated numbers of oocytes (16-30 μm) for a 785 mm SL (894 mm TL) red drum in March in that study was 6.20×10^7 (volumetric displacement method) and 9.45×10^7 (gravimetric method). These may be overestimates because red drum are "resting" in March and reserve oocytes

[12] M. Murphy and R. Taylor. Paper presented to the Florida Chapter of the American Fisheries Society, Brooksville, Florida, February 8-9, 1983.

Table 2. Reported size and/or age at maturity for red drum.

Location	Reference	Size	Age
Texas	Pearson (1929)	750-810 mm TL	4 or 5
South Texas	Gunter (1950)	406-432 mm TL	
Texas	Miles (1951)	750 mm	4
Texas	Simmons and Breuer (1962)	700-800 mm SL	3 or 4
Louisiana	Hein and Shepard (in press)	851 mm TL (females) 780 mm TL (males)	
Mississippi	Overstreet (1983)	550-699 mm SL	
Southwest Florida	Gunter (1950)	380 mm TL	
Southwest Florida	Yokel (1966)	630 mm FL	
Tampa Bay, Florida	(1)	430-490 mm FL (males)	1+
		610-670 mm FL (females)	2-3
Mosquito Lagoon area, Florida	(1)	470-530 mm FL (males)	1+
		575-760 mm FL (females)	2-3

[1]M. Murphy and R. Taylor. Paper presented to Florida Chapter of the American Fisheries Society, Brooksville, Florida. Febuary 8-9, 1983.

Table 3. Published fecundity estimates for red drum.

Reference	State	Environment	Size	Number of eggs	Comments
Pearson (1929)	Texas	wild	90 cm TL	3.4×10^6	Determined by volume and weight methods.
Miles (1950)	Texas	wild	750-825 mm (age 5)	2.5×10^6	"Granular stage" of development.
Colura (1974)	Texas	laboratory	26 lb	2.9×10^6	Second natural spawn; estimate was probably high because of investigator's inability to get an even distribution of eggs in aliquot samples.
Arnold et al. (1977)	Texas	laboratory	3 fish (9-15 kg)	6.0×10^7	Fish were subjected to photoperiod and temperature regimes; produced in 52 spawns during 76 days.
Roberts, Harpster, and Henderson (1978)	Florida	laboratory		2.1×10^6	Natural spawn after conditioning; 4 females produced 8.4×10^6 embryos during a 90-day period.
Overstreet (1983)	Mississippi	wild	9,776.7 g	15.8×10^6	Based on number of eggs >16µm by volumetric displacement method.

cannot be distinguished from recruit oocytes. Furthermore, Overstreet (1983) stated that vitellogenesis occurred in oocytes as small as 70 μm but was typically more apparent in those >100 μm.

In the Gulf of Mexico red drum spawn from August to mid-November with a peak in September or October (Pearson 1929; Miles 1951; Springer and Woodburn 1960; Yokel 1966; Christmas and Waller 1973; Sabins and Truesdale 1974; Stuck and Perry 1982; Hein and Shepard in press). Jannke (1971) reported that spawning in southwestern Florida occurred from mid-September through mid-February, peaking in October. Collections of larvae and juveniles indicate that spawning along the Atlantic coast may begin in July or possibly earlier, and continue through December with a peak in late September or October (Hildebrand and Schroeder 1928; Mansueti 1960; Tagatz and Dudley 1961; Yokel 1966; Williams and Deubler 1968; Mahood et al. 1974; Spitsbergen and Wolff 1974; Wolff 1976; Weinstein 1979)[13] (Table 4). Yokel (1966) suggested that spawning may also occur in spring on the Florida east coast, based on reports from anglers, commercial fishermen, and juvenile collections. However, a study of the annual cycle of oocyte development and gonadosomatic indices for red drum from east-central Florida found a discrete spawning season during September and October.[14] Collections of juveniles (35-55 mm FL) in western Pamlico Sound, North Carolina in July (Spitsbergen and Wolff 1974) (Table 4) suggest a late winter or spring spawning in North Carolina.

Red drum spawning has been induced in culture systems by manipulating temperature and photoperiod combinations to simulate optimal conditions or seasonal variations. Spawning occurred under full-winter conditions (9 hr light and 15 hr dark, 22-23°C) after a 7 month recycling through the four seasons (Arnold et al. 1977). Roberts, Harpster, and Henderson (1978) obtained successful spawning at 10 hr 15 min light and 22-26°C after three differing regimes of photoperiod and temperature. Holt, Godbout, and Arnold (1981) reported that red drum stopped spawning in the laboratory when the temperature dropped below 20°C.

Spawning in the laboratory occurred around dusk and was preceded by color changes in the males, drumming, and nudging. Males became dark red to bluish-gray on the dorsum above the lateral line and pale white on the ventrum, while females retained their characteristic reddish color. Drumming began

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[13] Unpublished data, North Carolina Division of Marine Fisheries, Morehead City, N.C.

[14] R. Taylor, Florida Department of Natural Resources, St. Petersburg, Florida, personal communication.

Table 4. Size distribution (mm TL) of young-of-the-year red drum by month from Atlantic coast estuaries.

Author	Mansueti (1960)	Hildebrand and Schroeder (1928)	Tagatz and Dudley (1961)	Spitsbergen and Wolff (1974), Wolff (1976)[1]	Weinstein (1979)	Mahood et al. (1974)
Locality	Chesapeake Bay	Chesapeake Bay	Neuse River, N.C.	Pamlico Sound and tributaries, N.C.	Cape Fear River, N.C.	Georgia
Period	1953-1960	1921	1957-1960	1972-1975 1979-1983		1970-1973
January	-	-	-	-	-	-
February	-	-	-	-	-	-
March	-	-	47	45-88	-	92
April	-	-	57-76	75-145	-	105
May	-	-	-	80-165	-	164
June	-	-	-	95-225	-	-
July	-	165-225	-	35-245	-	-
August	-	-	80-85	230-330	13-15	-
September	20-60	20-52	27-62	12-390	5-30	-
October	20-75	25-53	10-85	15-335	12-40	34
November	30-84	39-90	25-71	15-75	23-47	57
December	-	-	34-37	55-95	23-48	-

[1]Unpublished data, North Carolina Division of Marine Fisheries, Morehead City, N.C.

around dusk and males swam near females and began nudging them near their urogenital opening. Nudging and drumming reached a peak and were followed by the release of eggs and milt. Sound production resumed but decreased after spawning (Chapman 1967; Arnold et al. 1977; Guest and Lasswell 1978; Roberts, Harpster, and Henderson 1978; Holt, Holt, and Arnold 1983). Smith (1907) reported that only males drum.

Red drum eggs were described from laboratory spawnings by Johnson et al. (1977) and Holt, Godbout, and Arnold (1981). Vetter et al. (1983) investigated energy metabolism in red drum eggs. Holt, Godbout, and Arnold (1981) reported that laboratory-reared red drum eggs developed successfully to feeding larvae at salinities of 10-40 ppt at 25°C, and best conditions for hatching were 30 ppt salinity and 25°C.

3.2 Pre-adult phase

Red drum larvae were described by Pearson (1929), Jannke (1971), Lippson and Moran (1974), Johnson et al. (1977), Powles and Stender (1978), and Holt, Johnson et al. (1981).

Hatching in the laboratory occurred in 19-20 hr after fertilization at 24°C (Arnold et al. 1977) and about 28-29 hr at 22-23°C (Holt, Johnson et al. 1981). Length at hatching was 1.71-1.79 mm SL (Holt, Johnson et al. 1981). The best conditions for 24-hr larval survival were 30 ppt salinity and 25°C and the survival rate of 2-wk-old larvae was reduced at 20°C (Holt, Godbout and Arnold 1981). Survival rates were greatly increased when larvae were maintained at 25°C through the yolk-sac stage and first feeding (3 days) before being exposed to 20°C (J. Holt and Arnold 1982). Length of the yolk-sac stage varied from 40 hr at 30°C to 84 hr at 20°C (Holt, Johnson et al. 1981). Johnson et al. (1977) reported that red drum larvae began feeding at 60 hr post-hatch (23-25°C). Survival was greater for those larvae offered food on day 3 (14.0%) as compared to day 2 (3.5%) or day 4 (4.0%) (Roberts, Morey et al. 1978).

3.3 Adult phase

Maximum age for red drum has not been determined because of problems with age determination techniques. A maximum age estimate of 33 years for red drum on the east coast of Florida was based on interpretation of banding patterns on otolith sections.[15] However, only the first three bands were

[15] M. Murphy, Florida Department of Natural Resources, St. Petersburg, Florida, personal communication.

adequately validated as annual marks. The maximum known time at liberty shown by tagging is 12 years for a fish tagged at 300 mm and recovered at 18 kg (Simmons and Breuer 1976). The IGFA record is a 40.8 kg fish (Anonymous 1983a) which indicates that red drum longevity is probably greater than 12 years.

Parasites, diseases, mortalities, and abnormal conditions of red drum were reviewed by Yokel (1966), Perret et al. (1980), and Overstreet (1983).

3.4 Nutrition and growth

Crustaceans (crabs and shrimp) and fishes are most important in the diet of red drum in the Gulf of Mexico (Pearson 1929; Gunter 1945; Kemp 1949; Miles 1950, 1951; Knapp 1950; Reid 1955; Darnell 1958, 1961; Inglis 1959; Springer and Woodburn 1960; Simmons and Breuer 1962; Yokel 1966; Fontenot and Rogillio 1970; Boothby and Avault 1971; Bass and Avault 1975; Odum and Heald 1975; Rogillio 1975; Overstreet and Heard 1978; Matlock and Garcia 1983) and on the Atlantic Coast (Linton 1905; Hildebrand and Schroeder 1928; Overstreet and Heard 1978). Large red drum (430-1,020 mm SL) collected off the beach at Sapelo Island, Georgia, fed heavily during summer on echinoderms (five-lunuled sand dollars and sea cucumbers), in addition to crabs and fishes (Overstreet and Heard 1978). A preliminary study of red drum (>3.6-4.5 kg) feeding habits in the Hatteras-Ocracoke area of North Carolina indicated that primary food items were blue crabs (Callinectes sapidus) and various fishes including striped mullet (Mugil cephalus), spot (Leiostomus xanthurus), pinfish (Lagodon rhomboides), and pigfish (Orthopristis chrysoptera).[16]

Changes in food habits with size have been noted. Hildebrand and Schroeder (1928) examined the stomach contents of 15 red drum from Chesapeake Bay (30-1,075 mm) and reported that the small fish fed principally on Gammarus and Mysis and the larger ones on shrimp. Bass and Avault (1975) reported that fish <15 mm SL fed primarily on zooplankton, fish 15-75 mm SL fed mostly on small bottom invertebrates and young of other fish, and fish >75 mm SL ate decapods (crabs and shrimp) and fishes. Inglis (1959) examined fish 30-100 mm and found that about 80% contained fish and 10% contained amphipods. Overstreet and Heard (1978) found that penaeid and palaemonid shrimps occurred in a higher percentage of fish <500 mm SL, whereas blue crabs, the stomatopod Squilla empusa, and fishes were most important in larger fish. Yokel (1966) also found that red drum ate proportionately more crabs as they grew larger, with fish diminishing in importance as food for the largest red drum.

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[16] W. Foster. 1970. Life history aspects of the red drum, Sciaenops ocellata. Progress Report to Sport Fishery Research Foundation.

Dietary items indicate that red drum feed over sandy to muddy bottoms from both shallow and moderately deep water. Grassbeds are also an important feeding area for preadult red drum. Most feeding takes place in the early morning or evening. Red drum have been observed "tailing" in shallow marsh areas, rooting about with heads lowered and tails occasionally out of water (Yokel 1966; Overstreet and Heard 1978).

Growth rates have been reported for red drum in the laboratory (Arnold et al. 1977; Roberts, Morey et al. 1978; Holt, Godbout and Arnold 1981; Lee et al. 1984), in ponds and raceways (Luebke and Strawn 1973; Colura et al. 1976; Trimble 1979; Hein and Shepard 1980; McKee 1980; Crocker et al. 1981; Hysmith et al. 1982), and in the wild (Matlock and Weaver 1979; Perret et al. 1980; Goodrich and Matlock 1983) and were summarized in Swingle et al. (1983) (Table 5). Growth rate estimates for larvae and juveniles range from 0.04-1.7 mm/day. However, the reliability and precision of some estimates are questionable due to small sample sizes, inadequate procedural detail, and absent, incomplete, or inappropriate statistical analyses. The general growth pattern indicated by the reliable estimates is sigmoidal (Swingle et al. 1983). Egg diameter is 1 mm at spawning, and larvae are 2 mm at hatching and grow 0.5 mm before yolk-sac depletion (Johnson et al. 1977). Larvae grow 0.2-0.5 mm/day, juveniles 0.7-1.7 mm/day, and adults 0.5 mm/day (Swingle et al. 1983).

3.5 Behavior

Red drum migrate seasonally along the Atlantic coast (Yokel 1966). Reports from fishermen and menhaden spotter pilots indicate that red drum typically arrive at Cape Hatteras, North Carolina between March and April, some entering Pamlico Sound and others proceeding up the coast. Red drum are expected about a week later at Oregon Inlet (40 miles north of Cape Hatteras) and three weeks to a month later in Virginia, some entering Chesapeake Bay. Apparently in times of high abundance and proper environmental conditions, red drum averaging 13-14 kg were present along the New Jersey coast in summer (May to October) (Welsh and Breder 1923). Red drum leave Virginia in most years by October and fall fishing along the North Carolina coast starts in August and usually ends in November (Yokel 1966). A preliminary tagging study in Pamlico Sound and along the Outer Banks, North Carolina indicated movement of some red drum (337-447 mm TL) out of the sounds and south along the beaches.[17] In a tagging study of red drum (251-600 mm TL) in Georgia, 88.6% (70 fish) of the recoveries

[17] J. Ross, North Carolina Division of Marine Fisheries, Manteo, N.C., personal communication.

Table 5. Published red drum growth rates (where necessary, standard lengths converted to total lengths using Harrington et al. (1979); blanks indicate no estimates given) [from Swingle et al. 1983].

Environment	State and reference	Growing period	Length of growing (days)	Initial size or age	Temperature (°/C)	Salinity (°/oo)	Growth rate (mm TL/day)	Comments
Laboratory	Florida Roberts, Morey, et al. (1978)	Not given	15+	Embryo	23	30	0.36	Found no significant influence of stocking density (2, 10, and 20 embryos/liter) and food density (1,5, and 10 rotifers/ml) on larval growth using two-way analysis of variance.
Laboratory	Texas Holt, Godbout, and Arnold (1981)	Not given	14	Embryo	20 25 30	15-30 15-30 15-30	0.24 0.34 0.46	Found no significant influence of temperature but did find significant influence of salinity on larval growth using two-way analysis of variance.
Laboratory	Texas Arnold et al. (1977)	Not given	570	44 mm TL			0.70-1.14	Growth was 1.14 mm/day in first 180 days and 0.70 mm/day in last 390 days; no other details given.
Laboratory	Texas Lee et al. (1984)	Not given	15	Larvae	24 28	30 30	17.74µg/day 30.25µg/day	Two growth periods; one extending from hatching through depletion of yolk sac, and other beginning at onset of active feeding. Growth in length and weight was significantly greater at 28°C than at 24°C.

Table 5. (continued)

Environment	State and reference	Growing period	Length of growing (days)	Initial size or age	Temperature (°/C)	Salinity (°/oo)	Growth rate (mm TL/day)	Comments
Raceways	Texas Crocker et al. (1981)	July-August 1979	30	72 mm TL		35±2 0	1.7 1.3	Analysis of covariance used to test for differences in growth between salinities, but variance homogeneity assumption apparently violated; conclusion of significant difference is questionable but growth rate exceeded 1.0 mm/day regardless; 93% survival in both treatments.
Ponds	Alabama Trimble (1979)	Oct. 1976-May 1979	136-946	2 days			Not given, presented weight data only	Disease problems rampant; data not statistically analyzed; incomplete detail on procedures used to estimate size at stocking, sampling techniques, and growth in weight estimates.
Ponds	Louisiana Hein and Shepard (1980)	Oct. 1978-Jan. 1979	79	17-42 mm TL	19 (avg)		0.92	Based on 86 fish; a total die off occurred due to cold temperature and low water level.
Ponds	Texas Colura et al. (1976)	Aug.-Nov., 1975	27-37	2-6 days			1.02-1.66	No adjustments for stocking rate variations (156,000 - 880,000 larvae/ha); stocking rate estimating procedures not given; estimating procedures for mean size at stocking or harvest not given; survival in ponds very low (10%); few details given.

Table 5. (continued)

Environment	State and reference	Growing period	Length of growing (days)	Initial size or age	Temperature (°/C)	Salinity (°/oo)	Growth rate (mm TL/day)	Comments
Ponds (received heated power plant effluent)	Texas Luebke and Strawn (1973)	8 June - 6 Nov., 1972	151	272-295 mm TL			0.76-0.85	Estimating procedure not clearly defined; only 13% mortality.
Ponds	Texas Hysmith et al. (1982)	7 Nov., 1975 - 28 April,	108-173	41 mm TL			0.66±0.04 (Fed) 0.35±0.06 (Unfed)	No significant influence of stocking density on growth; significantly higher growth in fish fed artificial diet than in those not fed; no indication of reduced growth in winter; few details on sampling techniques.
Power plant cooling lake	Texas McKee (1980)	Nov. 1975-Nov. 1977	Not given	366-837 mm TL			0.49±0.05	Based on 27 recaptured tagged fish; growth rate (Y) decreased significantly with increased size at tagging, according to Y = 0.75925 - 0.00246 X (X = SL_{mm} at tagging).
Wild	Florida Perret et al. (1980)	1961-1965	Not applicable	282-655 mm TL			0.04-0.66	Data from 12 recaptured tagged fish published by Ingle et al. (1962), Topp (1962), Beaumariage (1964), and Beaumariage and Wittich (1966).

Table 5. (continued)

Environment	State and reference	Growing period	Length of growing (days)	Initial size or age	Temperature (°/C)	Salinity (°/oo)	Growth rate (mm TL/day)	Comments
Wild	Texas Matlock and Weaver (1979)	Nov. 1975-Sep. 1976	Not applicable	275-815 mm TL			0.43±0.08	Based on 110 recaptured tagged fish from Texas bays; no significant difference in growth among bays; no apparent change in growth with increased size at tagging but no statistical analyses conducted; data obtained from fishermen.
Wild	Texas Goodrich and Matlock (1983)	June 1979 May 1980	350	41 mm TL			1.03±0.05	Based on 48 recaptured stocked fish from St. Charles Bay; artificiallly reared juveniles stocked out of phase with wild fish so identifiable by size; fish grew through two summers in first year so growth rate should be greater than wild fish.

were within 25 km of the tagging sites. Five percent (4 fish) exhibited an average northward movement of 112.5 km and 5% (5 fish) exhibited an average southward movement of 112.2 km (Pafford 1981; Music and Pafford 1984). Beaumariage (1969) reported that 91.2% of the red drum recovered during five Schlitz tagging programs in Florida did not move significantly from their release locations.

Tagging studies in Gulf of Mexico estuaries have indicated little movement of subadult red drum. More than 85% of the recaptured red drum from tagging studies in Florida bays moved <10 km from the tagging site (Ingle et al. 1962; Topp 1963; Beaumariage and Wittich 1966; Beaumariage 1969). Simmons and Breuer (1962) reported little intrabay movement of red drum from Aransas Bay, Texas southward. Other Texas tagging studies have indicated broad random movements within bays (Heffernan 1973) with little movement out of bays in which tagged (Osburn et al. 1982). Some movement from the bays to the Gulf along the Texas coast has been noted in fall, with a return in spring (Pearson 1929; Gunter 1945; Miles 1950). Immature red drum have been caught in the Gulf surf zone (Simmons and Hoese 1959; Heffernan 1973) which indicates that not all juveniles enter, or remain in, the bay nursery grounds. Red drum tagged in inshore waters of Louisiana and Mississippi were recaptured inshore (Adkins et al. 1979; Overstreet 1983).

A Mississippi tagging study (Overstreet 1983) and observations by commercial fishermen and menhaden spotter pilots suggest that after leaving the estuaries large red drum undertake extensive migrations in the Gulf of Mexico. There appears to be a general migration along the Gulf coast from off Alabama in April toward the Breton Island and Cameron areas of Louisiana, and by September or October the schools disappear offshore, presumably to spawn. A few spent fish appear along the beaches in October and November. An individual 810 mm SL long, migrated 778 km westward after 752 days and 769 mm SL long fish moved eastward at least 316 km within 399 days (Overstreet 1983). The longest reported migration in the Gulf of Mexico was from Texas to Tampa Bay (Simmons and Breuer 1976).

Carr and Chaney (1976) traced movements of a red drum with an ultrasonic transmitter attached to its caudal peduncle, in the Intracoastal Waterway in Florida. All movement, both north and south, was against the tidal flow, and the fish entered numerous side creeks and moved into a deep hole in a creek at nightfall.

3.6 Contaminants

Red drum were included in a survey of trace elements in fishery resources (Hall et al. 1978). Muscle and liver tissue

from red drum from the North and South Atlantic and Gulf of Mexico were analyzed for the occurrence of 15 elements. No interpretative comments were provided.

Trace metal poisoning was indicated as the possible cause of death of a group of approximately 100 large (7-18 kg) red drum in the Indian River System, Florida between June 14 and July 2, 1980. High levels of copper, zinc, arsenic, chromium, cadmium, and mercury were found in the liver and/or gills, and lesions in the gills resembled those from fish subjected to experimental copper poisoning (Cardeilnac et al. 1981). Commercial fishermen report that large kills of red drum have occurred several times in this area.[18]

A survey of polychlorinated biphenyls (PCBs) in selected finfish species determined that the mean level of PCBs in five red drum from Texas was 0.03 ppm (range: 0.02-0.04 ppm). This level is far below existing (5 ppm) or proposed (2 ppm) maximum permissible levels in foodfish (Gadbois and Maney 1983).

Rabalais et al. (1981) investigated the effects of oil on red drum eggs and larvae from an oil spill in the Bay of Campeche which reached the south Texas coast. High larval mortality resulted when larvae were placed in mixtures of oil and water. When eggs were placed in oil-contaminated water from Port Aransas jetties, over half of the hatched larvae had skeletal anomalies.

4. POPULATION

4.1 Structure

The age/size structure of red drum populations is largely unknown. Length-at-age estimates for the Gulf of Mexico and Atlantic coast vary considerably (Tables 6 and 7) and some are probably overestimates because of failure to consider time of annulus formation, gear selection bias, recaptured tagged fish size data reliability, small sample sizes, and unverified age determination techniques (Swingle et al. 1983).

Length frequency, scale, and otolith techniques have been used to age red drum (Pearson 1929; Gunter 1945; Miles 1950, 1951; Simmons and Breuer 1962; Theiling and Loyacano 1976; Rohr 1980; Wakefield and Colura 1983; Music and Pafford 1984). The length frequency method is generally only useful for the first

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[18] R. Williams. Florida Department of Natural Resources, St. Petersburg, Florida, personal communication.

Table 6. Published total length-at-age estimates for red drum. (Where necessary, standard lengths converted to total lengths using TL = 12.870 + 1.177 SL (Harrington et al. 1979); blanks indicate no estimates given) [modified from Swingle et al. (1983)].

Location	Reference	AGE - YEARS 1	2	3	4	5	6	7	8	Age determination method
Fernandina, Fla.	Welsh and Breder (1923)			390-590						Scales
Chandeleur and Mississippi Sounds, La.	Rohr (1980)	363	545	670	757	816	858	886	906	Otoliths
Central coast, Tex.	Pearson (1929)	300	530	630	750	840				Length frequency
Central coast, Tex.	Pearson (1929)	420	520	720	780	830				Scales
Laguna Madre, Tex.	Pearson (1929)	350	540	640	740					Length frequency
Aransas Bay, Tex.	Miles (1950)	395								Length frequency
Aransas Bay, Tex.	Miles (1951)	390-435	601	660-710			875	925	975-1,000	Otoliths
Upper Laguna Madre, Tex.	Simmons and Breuer (1962)	325								Length frequency
Central coast, Tex.	Simmons and Breuer (1962)		540	760						Tag recapture
Galveston Bay, Tex.	Wakefield and Colura (1983)	274	453	571	650					Scales
Matagorda Bay, Tex.	Wakefield and Colura (1983)	252	409	548	634	694				Scales
Lower Laguna Madre, Tex.	Wakefield and Colura (1983)	290	462	565						Scales

Table 7. Empirical and back calculated total lengths for red drum collected in South Carolina, Georgia, and Florida.

Location	Reference	Method	Sex	Annuli 1	2	3	4	5	6
South Carolina	Theiling and Loyacano (1976)	otoliths	Combined						
			*Mean length at capture	585	731	825	849	891	849
			Number	15	11	3	3	26	1
Georgia	Music and Pafford (1984)	scales	Combined						
			Mean length at capture	474	718	776			
			Back calculated length	403	653	746			
			Number	24	8	1			
			Males						
			Mean length at capture	475	711	776			
			Back calculated length	435	656	746			
			Number	9	5	1			
			Females						
			Mean length at capture	541	731				
			Back calculated length	412	645				
			Number	12	3				
Florida[1] East Coast		otoliths	Combined						
			+Back calculated length	436	606	695	746		
			Number	328	153	34	8		

*SL converted to TL by TL = 12.870 + 1.177 SL (Harrington et al. 1979)

+Fork length

[1]M. Murphy, Florida Department of Natural Resources, St. Petersburg, Florida, personal communication.

few years of life. Problems with using scales and otoliths to age red drum include circuli disconformities, closely spaced annuli, and intermittent summer and winter annuli on scales, and spawning checks on otoliths, particularly for fish older than age III or IV (Rohr 1980; Music and Pafford 1984).

Mean empirical lengths and back-calculated lengths for red drum from South Carolina, Georgia, and Florida ageing studies are presented in Table 7. The sizes shown are sizes at the annulus, not at the birthdate. A Florida study validated the first three rings on otoliths as annual rings. The first annulus forms at 14-17 months, and then annually for at least the next two years. The regression of fork length on otolith radius was not linear when all age groups were included, but was linear for fish with four or fewer annuli. For older fish the rate of increase in fork length per unit increase in otolith radius declined. The fork length (FL) - otolith radius (OR) relation for fish with four or fewer annuli was: FL = 26.54 + 311.65 OR (mm) (r^2 = 0.8475).[19]

Back-calculated lengths for red drum in Florida were similar to Georgia fish at first annulus, but smaller at successive annuli. The sample size in the Georgia study was small (33 fish) and the method of age determination was not validated. Lengths presented by Theiling and Loyacano (1976) for 62 red drum confined to a saltwater marsh impoundment in South Carolina were mean lengths at capture and therefore were greater than back-calculated lengths. The ageing method was not validated in that study. Bearden (1967) reported that red drum impounded in a brackish water pond in South Carolina averaged 368 mm at age I, 521 mm at age II, and 660 mm at age III, but the method of age determination was not reported. A major research need for red drum is the development of a uniform method of age determination throughout the range.

Von Bertalanffy growth equation parameters were estimated for red drum in South Carolina (Swingle et al. 1983), Florida,[20] Louisiana (Rohr 1980), and Texas (Swingle et al. 1983; Wakefield and Colura 1983) (Table 8). Swingle et al. (1983) based their estimates for South Carolina and Texas on data from Theiling and Loyacano (1976) and Pearson (1929), respectively, using Rafail's (1973) technique.

Numerous equations for the red drum length-weight relationship have been published for the Gulf (Boothby and Avault 1971; Luebke and Strawn 1973; Bass and Avault 1975; Harrington et al. 1979; Hein et al. 1980; McKee 1980; Overstreet 1983) and Atlantic coasts (Theiling and Loyacano 1976; Music and Pafford

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19, 20 M. Murphy, Florida Department of Natural Resources, St. Petersburg, Florida, personal communication.

Table 8. Estimates of von Bertalanffy growth parameters for red drum.

Area	Source	L_∞ (mm TL)	K	t_o
South Carolina (impounded marsh)	Swingle et al. (1983)[1]	945	0.449	-0.324
Florida (Mosquito Lagoon/ Upper Indian River)	(2)	1,043	0.42	-0.149
Florida (Tampa Bay area)	(2)	993	0.46	0.029
Louisiana (Chandeleur and Mississippi Sounds)	Rohr (1980)	950	0.37	-0.33
Texas	Swingle et al. (1983)[3]	1,068	0.295	0.144
Texas (Lower Laguna Madre)	Wakefield and Colura (1983)	717	0.52	-0.01
(Matagorda Bay)		835	0.35	-0.02
(Galveston Bay)		804	0.41	-0.01

[1]Based on data from Theiling and Loyacano (1976).

[2]M. Murphy and R. Taylor, Florida Department of Natural Resources, personal communication.

[3]Based on data from Pearson (1929).

Table 9. Published standard length-weight relationships for red drum [Music and Pafford (1984) and Harrington et al. (1979) are total length-weight relationships]. Weight is in g and length in mm, except cm for Theiling and Loyancano (1976). [from Swingle et al. (1983)].

State	Area	Reference	N	Length range	Log a	b	Calculated weight (g) of 200 mm SL fish
South Carolina	Marsh Impoundment	Theiling and Loyacano (1976)	54	Not given	-1.29596	2.7403	186
Georgia	Estuaries	Music and Pafford (1984)	103	32-1099	-4.220	2.722	111
Mississippi	Mississippi Sound	Overstreet (1983)	480	143-965	-4.7358	3.0053	151
Louisiana	Coastal marsh near Hopedale	Boothby and Avault (1971)	286	240-940	-4.42161	2.83284	125
Louisiana	Salt marsh near Caminada Pass	Bass and Avault (1975)	568	8-183	-7.2052	4.1913	275
Louisiana	Southeastern coast	Hein et al. (1980)	308	14-1135	-5.1197	3.0523	80
Louisiana	Bays and gulf	McKee (1980)	23	483-921	-3.435	2.54	257
Texas	Heated ponds in Galveston Bay system	Luebke and Strawn (1973)	47	283-411	-4.69	2.97	139
Texas	Cooling lake near Corpus Christi; at tagging	McKee (1980)	30	319-720	-3.939	2.71	198
Texas	Bays and gulf	McKee (1980)	45	312-885	-4.058	2.75	186
Texas	Nine bays	Harrington et al. (1979)	8319	49-814	-5.085	3.041	158

1984) (Table 9). Differences in the regression coefficients may be due to sample sizes, length ranges, maturity, and time of sampling. Perret et al. (1980) concluded that the length-weight relationships of Boothby and Avault (1971), Luebke and Strawn (1973), Theiling and Loyacano (1976), Harrington et al. (1979) were similar although no statistical analysis was conducted.

4.2 Abundance, density, mortality, and dynamics

Commercial landings data have been collected from fish dealers in each state since 1880; from 1880 to 1927, the survey was conducted at approximately five year intervals; from 1927 to 1956, annual surveys were conducted; and since 1956, data has been collected on a monthly basis. It should be noted that commercial statistics, when biased, tend to be underestimated, due to failures in reporting which are inherent in their collection. Landings data may reflect changes in effort and market preferences and are not necessarily indicative of trends in stock abundance.

Atlantic coast landings of red drum have always been lower than Gulf of Mexico landings (Figure 2). The highest recorded landings for the Atlantic coast were 788 mt in 1945, compared with 1,594 mt in the Gulf of Mexico for the same year. The highest reported landings in the Gulf were 2,410 mt in 1976. Highest landings on the Atlantic coast in recent years occurred in 1980 (200 mt).

Landings of red drum at the northern extreme of the range have declined since the 1930s (Table 10). No red drum landings have been reported for New York since 1942. A total of 93 mt of red drum were landed in New Jersey from 1926 through 1935, while only 21 mt were caught in the decade ending in 1945. Since 1945 there has been only one commercial landing of red drum (<1 mt) in New Jersey in 1951.

Similar declines in landings have apparently taken place along the coast to the south of New Jersey with the exception of the east coast of Florida (Table 10) (Figure 3). Delaware annual landings have never exceeded 1 mt and were recorded for only six years between 1926 and 1978. Maryland red drum landings have never exceeded 7 mt and only sporadic landings (<1 mt) have been recorded since 1959. Virginia landings were highest in 1950 (83 mt) and did not exceed 9 mt over the past 20 years, except in 1965 (42 mt) and 1983 (22 mt). Red drum landings in South Carolina and Georgia have fluctuated widely and parallel each other. Highest landings in South Carolina were from 1887 to 1908 (23-50 mt), 1936 to 1940 (38-54 mt), and 1950 to 1956 (5-52 mt). South Carolina landings of red drum ranged from <1-6 mt from 1969 to 1982. Georgia landings

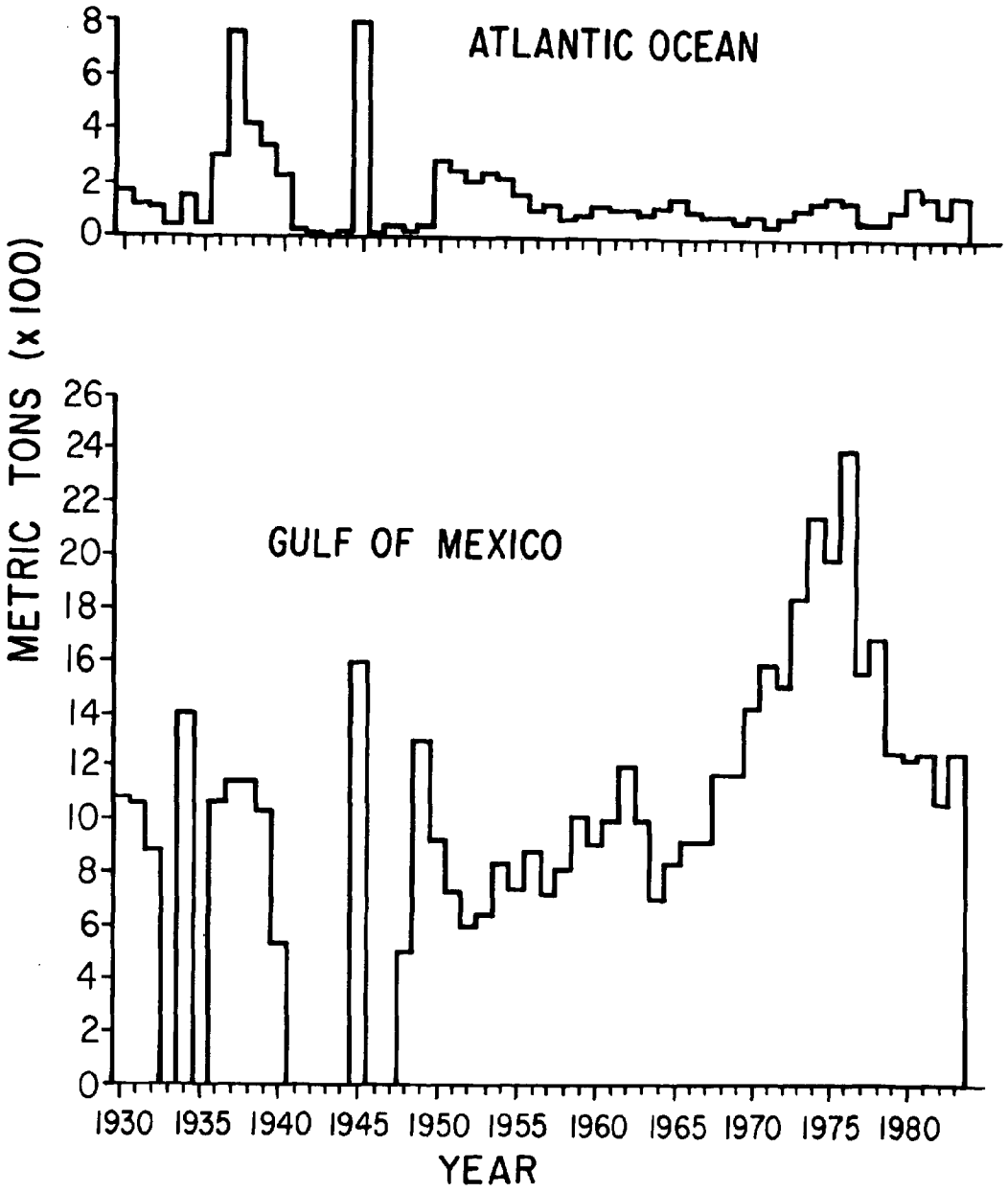

Figure 2. U.S. commercial landings of red drum for the Atlantic coast and Gulf of Mexico, 1930-1983.

Table 10. Commercial landings of red drum by state, 1887-1983 (metric tons).

Year	New York	New Jersey	Delaware	Maryland	Virginia	North Carolina	South Carolina	Georgia	Florida East Coast	Total
1887	-	-	-	-	-	59	25	9	-	93
1888	-	-	-	-	-	64	23	10	-	97
1889	-	-	-	-	-	234	41	15	78	368
1890	-	-	-	-	-	99	40	18	78	235
1897	-	-	-	-	-	81	50	11	107	249
1902	-	-	-	-	-	65	46	16	52	179
1908	-	-	-	-	-	156+	49	69	371	645
1918	-	-	-	-	-	45+	*	1	168	214
1923	-	-	-	-	-	111	14	*	55	181
1925	-	-	-	2	57	-	-	-	-	59
1926	*	6	1	-	-	-	-	-	-	8
1927	-	-	-	-	-	45	3	*	74	123
1928	-	-	-	-	-	108	2	3	92	205
1929	-	12	1	1	4	89	5	2	98	212
1930	-	29	-	7	16	66	4	2	39	163
1931	-	2	-	5	10	39	1	2	52	111
1932	-	22	-	6	11	39	1	1	21	101
1933	-	4	*	3	23	-	-	-	-	31
1934	-	-	-	3	24	60	2	1	65	155
1935	-	18	*	2	16	-	-	-	-	36
1936	-	-	-	2	15	114	47	23	106	307
1937	*	5	-	1	20	200	54	17	37	748
1938	-	2	-	1	61	241	47	12	50	414
1939	*	2	-	2	33	172	38	9	79	335
1940	-	1	-	1	30	61	39	5	84	221
1941	-	-	-	1	18	-	-	-	-	19
1942	*	7	-	1	7	-	-	-	-	15
1943	-	2	-	-	-	-	-	-	-	2
1944	-	*	-	1	15	-	-	-	-	16
1945	-	1	-	*	16	102	22	5	642	788
1946	-	-	-	-	11	-	-	-	-	11
1947	-	-	-	-	38	-	-	-	-	38
1948	-	-	-	-	16	-	-	-	-	16
1949	-	-	-	*	35	-	-	-	-	35
1950	-	-	-	1	83	91	15	9	86	285
1951	-	*	-	2	34	83	52	9	60	240
1952	-	-	1	-	21	101	31	6	52	212
1953	-	-	-	*	9	129	25	6	58	227
1954	-	-	-	2	18	121	5	6	63	215
1955	-	-	-	-	17	61	30	3	44	155
1956	-	-	-	-	9	14	26	1	48	98
1957	-	-	-	-	11	63	*	-	49	123
1958	-	-	-	1	16	8	*	-	46	71
1959	-	-	-	*	15	2	-	-	59	76
1960	-	-	-	*	13	36	-	*	59	108
1961	-	-	-	-	5	41	*	*	52	99
1962	-	-	-	-	3	28	-	-	68	99
1963	-	-	-	-	1	32	-	-	61	94
1964	-	-	-	-	2	46	5	-	54	107
1965	-	-	-	-	42	32	-	-	66	140
1966	-	-	-	*	1	16	*	1	69	88
1967	-	-	-	-	*	6	-	*	73	80
1968	-	-	-	-	*	5	-	2	75	82
1969	-	-	-	*	*	2	*	1	54	58
1970	-	-	-	-	*	3	*	*	67	71
1971	-	-	-	-	*	8	1	1	37	47
1972	-	-	-	-	3	20	1	1	58	83
1973	-	-	-	-	3	32	*	1	76	112
1974	-	-	-	-	7	64	1	1	62	105
1975	-	-	*	-	9	97	6	5	38	155
1976	-	-	-	-	8	76	1	3	48	136
1977	-	-	*	-	*	9	*	2	47	59
1978	-	-	*	-	1	10	2	*	48	61
1979	-	-	-	*	1	58	1	*	43	102
1980	-	-	-	-	*	110	2	1	87	200
1981	-	-	-	-	*	42	*	*	118	161
1982	-	-	-	-	1	24	1	*	63	89
1983	-	-	-	*	22	100	1	*	45	168

-Not reported
*Less than 1 metric ton
+Includes black drum

Table 10. (continued)

Year	Florida West Coast	Alabama	Mississippi	Louisiana	Texas	Total
1887	-	-	64	131	456	651
1888	25	-	75	131	429	660
1889	178	29	84	143	483	916
1890	208	25	91	154	503	981
1897	107	97	90	211	519	1,025
1902	501	32	42	201	408	1,184
1908	276	69	111	325	594	1,375
1918	452	10	53	257	607	1,379
1923	635	7	80	302	399	1,422
1925	-	-	-	-	-	-
1926	-	-	-	-	-	-
1927	352	25	108	252	567	1,304
1928	404	22	94	197	468	1,185
1929	450	48	59	202	424	1,183
1930	425	47	55	152	396	1,076
1931	424	28	45	168	392	1,057
1932	326	20	34	128	375	883
1933	-	-	-	-	-	-
1934	396	30	33	223	717	1,399
1935	-	-	-	-	-	-
1936	421	15	40	158	434	1,068
1937	430	30	56	204	433	1,154
1938	459	15	48	237	390	1,150
1939	412	14	75	315	213	1,030
1940	294	12	25	83	120	534
1941	-	-	-	-	-	-
1942	-	-	-	-	-	-
1943	-	-	-	-	-	-
1944	-	-	-	-	-	-
1945	587	118	30	270	589	1,594
1946	-	-	-	-	-	-
1947	-	-	-	-	-	-
1948	*	71	25	115	282	493
1949	758	51	35	218	236	1,298
1950	428	7	24	207	257	923
1951	417	20	14	174	108	733
1952	293	25	19	149	114	600
1953	239	21	28	124	232	644
1954	341	9	28	123	327	828
1955	342	9	26	156	224	757
1956	346	22	32	185	291	877
1957	303	5	25	160	229	721
1958	285	9	30	222	272	816
1959	314	8	32	222	437	1,013
1960	371	4	18	194	320	907
1961	385	11	24	302	280	1,002
1962	593	6	35	257	317	1,209
1963	439	9	27	212	311	998
1964	317	9	23	142	203	693
1965	364	2	15	214	242	836
1966	293	3	17	242	362	916
1967	225	4	44	297	349	918
1968	321	7	98	336	420	1,182
1969	266	23	45	355	493	1,181
1970	303	16	32	358	720	1,429
1971	321	15	27	329	904	1,595
1972	383	35	25	404	666	1,513
1973	433	78	39	538	762	1,850
1974	541	54	40	652	872	2,159
1975	345	34	33	618	962	1,992
1976	411	30	43	1,004	921	2,410
1977	383	30	74	651	432	1,570
1978	408	39	299	553	391	1,690
1979	338	39	88	480	313	1,258
1980	371	24	9	329	506	1,239
1981	513	17	30	408	278	1,248
1982	361	31	18	661	-	1,071
1983	350	27	11	872	-	1,260

-Not reported
*Less than 1 metric ton
+Includes black drum

ranged from 9-69 mt between 1887 and 1908, 5-23 mt from 1936 to 1940, 1-9 mt from 1950 to 1956, and <1-5 mt from 1966 to 1982. Florida and North Carolina contribute the most to east coast landings of red drum. North Carolina landings were highest in 1938 (241 mt) and have fluctuated between 2 and 129 mt since 1950. Florida landings peaked at 642 mt in 1945 and have not fluctuated greatly since 1950, ranging from 37-118 mt through 1983.

Recreational fishery statistics are available from National Marine Fisheries Service salt-water angling surveys conducted at five-year intervals from 1960-1970 (Clark 1962; Deuel and Clark 1968; Deuel 1973), regional surveys in 1974 and 1975, and annual surveys since 1979 (Anonymous 1980; Anonymous in press). Caution should be exercised in interpreting or comparing the results of these surveys (Anonymous 1980). First, estimated catches in the 1960-1970 national surveys and 1974-1975 regional surveys are subject to considerable statistical variability. Second, although the sampling procedures were similar for the 1960-1970 surveys, they were considerably different from the 1974-1975 sampling procedures. In addition, all of these surveys relied on the fisherman's ability to identify the species caught and to recall the numbers and average weight of each species caught, resulting in overestimates of the catch. The magnitude of the overestimation is not known. The sampling design of the 1979-present surveys is significantly different from previous surveys, including both a household survey and creel census. Although the 1979 survey results were published (Anonymous 1980), they are presently being corrected to correspond with 1980 census figures. The 1960-1970 and 1980-1982 survey results are presented here (Tables 11 and 12); however, 1981 and 1982 data are preliminary.[21]

The estimated recreational catch of red drum exceeds commercial red drum landings. The total estimated Atlantic coast recreational catches of red drum exceeded commercial landings by factors of 162 in 1960, 53.3 in 1965, 85.9 in 1970, 2.7 in 1980, 2.1 in 1981, and 4.9 in 1982. Although the 1960-1970 Salt-Water Angling Surveys resulted in overestimates of the catch, the results of the recent annual surveys are generally underestimates (Anonymous 1980).

The estimated weight of the recreational catch of red drum on the Atlantic coast (17,491 mt) exceeded the Gulf coast catch (14,941 mt) in 1960, although twice as many fish were caught in the Gulf. Both the number and weight of red drum caught in the Gulf exceeded the Atlantic coast catch in all other survey

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[21] M. Holliday, National Marine Fisheries Service, Resource Statistics Division, Washington, D.C., personal communication.

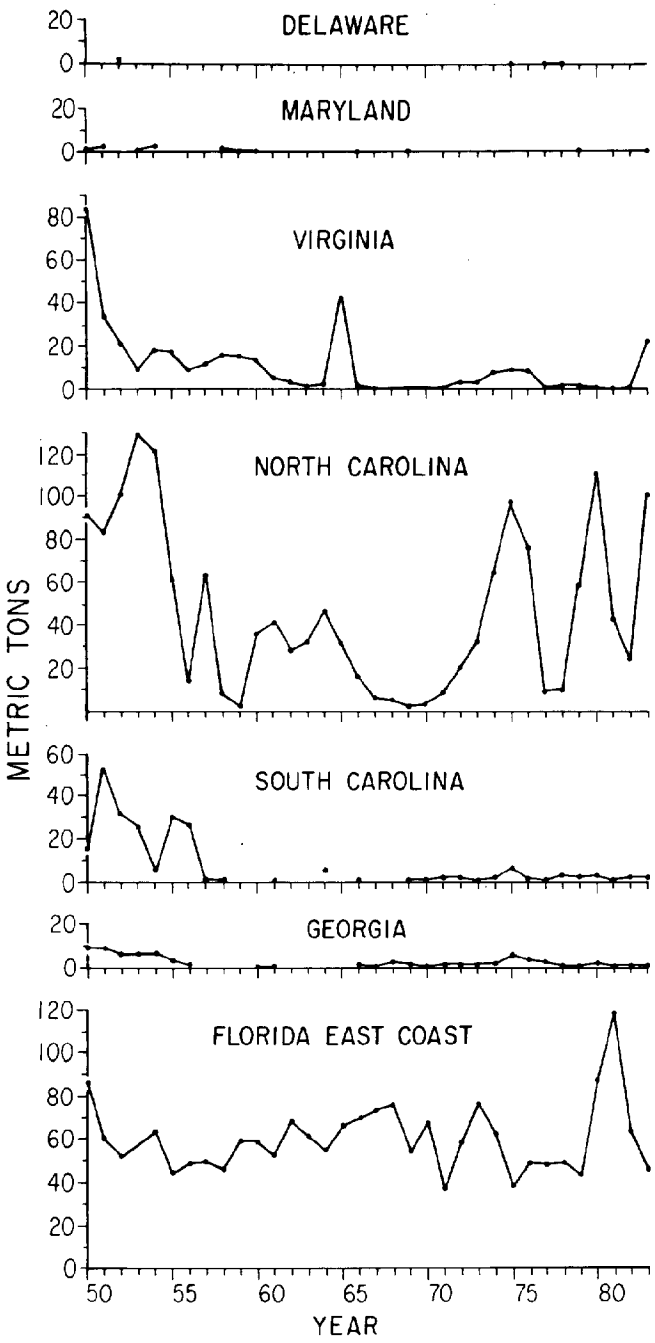

Figure 3. U.S. commercial landings of red drum on the Atlantic coast by state, 1950-1983.

years. Total Atlantic coast landings declined from 1960 to 1970, whereas Gulf coast landings increased over the same period. Although results of the 1980 survey are not directly comparable with previous surveys, they are lower by factors of 11.2 and 4.5 on the Atlantic and Gulf coasts, respectively, raising the question of data set reliability. Preliminary results of the 1981 and 1982 surveys indicate a decline in recreational catch in 1981 and 1982 on both coasts.

Results of the salt-water angling surveys indicate that recreational red drum landings in the Middle Atlantic region (New York to Virginia) declined drastically from 5,176 mt in 1960 to 582 mt in 1965 and 38 mt in 1970 (Clark 1962; Deuel and Clark 1968; Deuel 1973) (Table 11). Red drum were not reported for the Middle Atlantic subregion in the 1980 survey; however, the category "drums" (8.5 mt) may include red drum. Preliminary results of the 1981 and 1982 surveys indicate that 92,000 red drum (223 mt) were caught in 1981 and 52,000 (no weight reported) in 1982 in the Middle Atlantic region (Table 12).

South Atlantic (North Carolina to Florida) catches declined from 1960 (12,331 mt) to 1970 (6,065 mt). In 1980 the estimated recreational catch was 545 mt. Preliminary results of the 1981 and 1982 recreational surveys indicated that 115 mt were caught in 1981 and 438 mt in 1982 in the South Atlantic.

Although the results of the 1983 recreational survey are not yet available there is some indication that red drum abundance is increasing. In 1983 recreational fishermen reported that small red drum (0.7-1.1 kg) returned in unprecedented numbers to Chesapeake Bay and its tributaries, Pamlico Sound, North Carolina, and the surf from Assateague Island to Portsmouth Island. These fish were apparently the result of an excellent spawn during the fall of 1981. Commercial mullet netters in Pamlico Sound reported large numbers of small red drum (10-13 cm) in their nets in May and June, 1983, indicating that perhaps the fall spawn in 1982 was also a good one (The Year of the Puppy Drum. 1983).

There are no mortality estimates for Atlantic coast populations of red drum. Instantaneous natural (M), total (Z), and fishing (F) mortality rates have been calculated for various estuarine populations in the Gulf of Mexico (Matlock and Weaver 1979; Swingle et al. 1983; Green et al. in prep.). Fishing mortality in most Gulf estuarine areas is high relative to natural mortality (Swingle et al. 1983).

There are no estimates of maximum yield per recruit for Atlantic coast populations of red drum. Juvenile populations are growth overfished in Texas and possibly severely growth overfished along the west central coast of Florida, based on estimates of instantaneous fishing mortality (F) from tagging studies (Swingle et al. 1983).

Table 11. Red drum recreational catch and effort statistics from National Marine Fisheries Service Salt-Water Angling Surveys, 1960 - 1970.

Survey Year	Catch Number	Catch Weight lb	Catch Weight kg	Number of Successful Anglers	Average Weight lb	Average Weight kg	Catch per angler Number	Catch per angler Weight lb	Catch per angler Weight kg
	THOUSANDS								
1960[1]									
Middle Atlantic	456	11,400	5,171	35	25.0	11.4	13.0	325.7	147.9
South Atlantic	4,527	27,160	12,320	157	6.0	2.7	28.8	173.0	78.5
Gulf of Mexico	10,294	32,940	14,941	447	3.2	1.5	23.0	73.7	33.5
TOTAL	15,277	71,500	32,432	639	4.7	2.1	23.9	111.9	50.8
1965[2]									
Middle Atlantic	196	1,281	581	68	6.5	2.9	2.9	18.8	8.6
South Atlantic	4,099	15,171	6,881	151	3.7	1.7	27.1	100.5	45.6
Gulf of Mexico	6,900	28,288	12,831	558	4.1	1.9	12.4	50.7	23.0
TOTAL	11,195	44,740	20,294	777	4.0	1.8	14.4	57.6	26.1
1970[3]									
Middle Atlantic	97	83	38	8	0.9	0.4	12.1	10.4	4.8
South Atlantic	4,883	13,358	6,059	164	2.7	1.2	29.8	81.5	37.0
Gulf of Mexico	13,184	53,045	24,061	692	4.0	1.8	19.1	76.7	34.8
TOTAL	18,164	66,486	30,157	864	3.7	1.7	21.0	77.0	34.9

[1]Clark 1962

[2]Deuel and Clark 1968

[3]Deuel 1973

Table 12. Red drum recreational catch statistics from National Marine Fisheries Service Marine Recreational Fishery Statistics Surveys, 1980-1982.

Survey Year	Catch			Average Weight	
	Number	Weight lb	Weight kg	lb	kg
	----------THOUSANDS----------				
1980[1]					
South Atlantic	419	1,202	545	2.9	1.3
Gulf of Mexico	4,893	11,865	5,382	2.4	1.1
1981[2]					
Middle Atlantic	92	491	223	5.3	2.4
South Atlantic	166	254	115	1.5	0.7
Gulf of Mexico	4,194	8,631	3,915	2.0	0.9
1982[2]					
Middle Atlantic	51	-	-	-	-
South Atlantic	516	964	438	1.8	0.8
Gulf of Mexico	7,304	16,169	7,334	2.2	1.0

[1]Anonymous in press.

[2]Preliminary data, M. Holliday, National Marine Fisheries Service, Resource Statistics Division, Washington, D.C., personal communication.

-Not reported.

4.3 Community ecology

Juveniles may spend the first four or five years within estuaries (Pearson 1929) where they compete with other estuarine species for food. Food habits and distributions of red drum were reviewed in earlier sections of this report. Young-of-the-year red drum (15-245 mm TL) in North Carolina estuaries were frequently collected with the bay anchovy (Anchoa mitchilli), inland silverside (Menidia beryllina), Atlantic silverside (M. menidia), sheepshead minnow (Cyprindon variegatus), striped mullet (Mugil cephalus), menhaden (Brevoortia tyrannus), spot (Leiostomus xanthurus), croaker (Micropogonias undulatus), mojarras (Gerreidae), gobies (Gobiidae), summer flounder (Paralichthys dentatus), and southern flounder (P. lethostigma).[22]

Adult red drum occur offshore, often under schools of blue runner (Caranx chrysos) and little tunny (Euthynnus alletteratus) in the Gulf of Mexico. When near shore, schools of red drum often occur near black drum, Atlantic tarpon, and pompano (Overstreet 1983).

5. EXPLOITATION

Matlock (1980) reviewed the history and management of the red drum fishery.

5.1 Commercial Exploitation

5.11 Equipment and trends in equipment

Red drum are harvested in a mixed species fishery by a variety of gear types, including haul seines (common and long), fish trawls, pound nets, gill nets (drift, anchor, set or stake, and runaround), hand lines, trammel nets, and shrimp trawls (Matlock 1980). Purse seine catches of red drum have been reported in the Gulf of Mexico since 1977.

The percentage of Virginia landings of red drum taken by gear type is presented in Table 13. Pound nets and fish trawls have accounted for the major portion of the landings since 1977. Haul seines and gill nets contributed significantly prior to 1977 and again in 1983.

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[22]Unpublished data, North Carolina Division of Marine Fisheries, Morehead City, N.C.

Gill nets have accounted for 31-57% of red drum landings since 1979 in North Carolina (Table 14). Common and long haul seine catches have declined since 1977 and fish trawl and pound net catches have fluctuated. The incidental catch by shrimp trawls ranged from 0.5-15.2% of North Carolina red drum landings from 1978 to 1983.

Red drum are mainly caught by shrimp trawls, hand lines, and gill nets in South Carolina (Table 15). Hand lines have accounted for 100% of Georgia landings since 1978 (Table 16).

Runaround gill nets are the predominant gear in Florida, accounting for 65.5-83.6% of the red drum catch (Table 17). Red drum are also caught by hand lines, haul seine, and trammel nets.

5.12 Areas fished

Red drum are caught in both estuaries and oceanic waters along the Atlantic coast, but the majority of the commercial catch is made in estuaries (Table 18). Juvenile red drum, which remain in or near estuaries for the greater part of their early years, are the basis for the commercial fishery. Estuarine areas generally receive a high level of effort with gear which catch red drum, such as trammel nets, gill nets, haul seines, pound nets, and trot lines (Yokel 1966). Although Florida landings by area of capture were not available,[23] most red drum are caught in the estuaries.

5.13 Seasons

In Virginia red drum are harvested from May until October and are most abundant during spring and fall (Hildebrand and Schroeder 1928). Red drum are taken year-round from North Carolina to Florida. Largest catches in North Carolina are made in fall (October-November). In South Carolina more red drum are landed in late spring and summer and in Georgia in late summer and fall. Highest landings in Florida occur in fall and early winter.

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[23] E. Snell, National Marine Fisheries Service Resource Statistics Office, Miami, Florida, personal communication.

Table 13. Percentage of Virginia red drum landings by gear type, 1970-1983.

Year	Common Haul Seines	Fish Trawls	Pound Nets	Gill Nets	Hand Lines	Sea Scallop Dredges	Fyke & Hoop Nets	Total Landings (kg)
1970	100.0							45
1971	100.0							318
1972	54.2	1.7	30.5	13.6				2,676
1973		17.7	25.8	56.5				2,812
1974	5.7	1.3	79.0	14.0				7,121
1975	19.9	3.1	49.5	27.5				8,890
1976	35.3	5.8	22.6	34.2				8,618
1977		33.3	33.3		33.3			136
1978		14.3	61.9			23.8		953
1979		73.7	26.3					862
1980		25.0	50.0	25.0				181
1981		50.0	50.0					91
1982		56.5	36.9	1.8	2.3		2.4	854
1983	17.8	2.0	42.1	37.9	0.2			18,516

Source: Fishery Statistics of the United States, 1970-1977; NMFS Landings Data, 1978-1983.

Table 14. Percentage of North Carolina red drum landings by gear type, 1970-1983.

Year	Common Haul Seines	Long Haul Seines	Fish Trawls	Pound Nets	Gill Nets	Shrimp Trawl	Hand Lines	Total Landings (kg)
1970	9.3	32.0	9.3	8.0	41.3			3,402
1971	28.5	18.0	8.1	21.5	23.8			7,802
1972	30.5	12.8	2.8	45.2	8.6			19,459
1973	25.9	30.0	11.1	14.2	18.8			31,888
1974	21.0	45.9	0.8	17.9	14.2	T		64,455
1975	17.3	31.3	30.8	11.4	9.2			96,434
1976	8.4	45.6	4.6	13.3	28.1			76,294
1977	17.3	59.9	2.5	T	19.3			8,936
1978	0.9	19.4	65.3		13.9	0.5		9,798
1979		34.0	2.0	7.3	49.5	7.2		57,561
1980	6.9	30.3	17.6	1.3	32.2	3.7	T	106,745
1981	0.5	11.9	15.1	38.8	31.0	2.7		42,375
1982	2.0	13.2	26.4	6.4	46.2	5.7	T	23,841
1983	4.1	9.5	5.5	8.7	57.0	15.2	0.1	99,732

T - Less than 0.1 percent.

Source: Fishery Statistics of the United States, 1970-1977; NMFS Landings Data, 1978-1983.

Table 15. Percentage of South Carolina red drum landings by gear type, 1970-1983.

Year	Shrimp Trawls	Hand Lines	Haul Seines	Gill Nets	Spears	Fyke & Hoop Nets	Total Landings (kg)
1970	100.0						181
1971	53.8	7.7	38.5				590
1972	100.0						544
1973	100.0						272
1974		60.9		39.1			1,043
1975	36.4	52.3		6.8	4.5		1,996
1976		8.3		91.7			544
1977	7.7			53.8		38.5	590
1978		100.0					1,939
1979	7.5			92.5			801
1980	48.9			51.1			1,863
1981			18.8	81.2			367
1982	0.7	11.9		86.7	0.7		1,011
1983	2.1	5.2	8.8	83.8			1,031

Source: Fishery Statistics of the United States, 1970-1977; NMFS Landings Data 1978-1983.

Table 16. Percentage of Georgia red drum landings by gear type, 1970-1983.

Year	Hand Lines	Shrimp Trawls	Gill Nets	Total Landings (kg)
1970		100.0		227
1971	33.3	66.7		544
1972		100.0		1,406
1973		42.4	58.6	1,497
1974	41.9	58.1		1,406
1975	16.0	84.0		4,536
1976	54.8	43.8	1.4	3,311
1977	78.0	12.0	10.0	2,268
1978	100.0			149
1979	100.0			424
1980	100.0			677
1981	100.0			118
1982	100.0			114
1983	100.0			511

Source: Fishery Statistics of the United States, 1970-1977; NMFS Landings Data, 1978-1983.

Table 17. Percentage of Florida East Coast red drum landings by gear type, 1970-1977.

Year	Common Haul Seines	Runaround Gill Nets	Hand Lines	Trammel Nets	Cast Nets	Total Landings (kg)
1970	6.5	76.2	16.6	0.7		66,587
1971		83.6	13.7	2.7		36,696
1972	3.0	74.5	22.4		0.1	58,241
1973	3.7	79.9	15.6	0.9		75,523
1974	8.5	65.5	24.1	1.9		62,278
1975	7.1	68.5	23.3	1.1		37,784
1976	6.3	72.1	21.0	0.6		48,081
1977	8.4	70.1	19.6	1.8		46,947

Source: Fishery Statistics of the United States, 1970-1977.

Table 18. Annual commercial catch of red drum (kg) by state and water area for the Atlantic coast, 1968-1983 and percent caught in the estuaries.

Year	Virginia			North Carolina			South Carolina			Georgia		
	Ocean	Estuary	%	Ocean	Estuary	%	Ocean	Estuary	%	Ocean	Estuary	%
1972	590	2,087	78	7,864	11,641	60	412	109	21	242	1,297	84
1973	499	2,313	82	14,881	16,871	53	0	281	100	508	1,191	77
1974	408	6,713	94	16,070	48,538	75	140	844	86	730	611	45
1975	1,225	7,666	91	49,533	47,643	49	632	4,980	89	272	4,232	94
1976	635	7,802	92	12,639	63,682	83	0	1,160	100	689	2,595	79
1977	45	91	67	2,858	6,078	68	58	296	84	253	1,964	89
1978	363	590	62	6,985	2,812	29	431	1,531	78	0	149	100
1979	635	227	26	12,084	45,303	79	60	741	93	0	424	100
1980	45	136	75	32,275	78,049	71	874	989	53	78	599	88
1981	45	45	50	12,648	29,727	70	23	344	94	0	118	100
1982	483	371	43	13,964	9,877	41	235	775	77	0	75	100
1983	1,836	39,814	96	31,451	64,766	67	15	293	95	0	511	100

Source: NMFS Landings Data, 1972-1983.

5.14 Fishing operations and results

There are no data on fishing effort, selectivity, or yield for the Atlantic coast. Matlock et al. (1977) reported on trends in red drum abundance in Texas bays influenced by commercial netting activities. Catch rates for red drum in areas closed to commercial netting were about twice as high as those from areas open to netting. The effect of commercial netting was local; netting removed red drum from restricted areas but did not appreciably affect adjacent non-netted areas.

In 1984 the Texas Parks and Wildlife Commission banned the use of plastic baits on trotlines because these baits were thought to be selective for small (<500 mm) red drum. Matlock et al. (1979) compared the size of red drum landed by commercial fishermen before (1972-1974) and after (1974-1978) the ban with the size of fish collected during Texas Parks and Wildlife Department trammel net surveys to determine the effect of the ban on either the commercial catch or fish availability. Red drum landed by commercial fishermen were significantly larger after the ban than before. It appears that plastic baits are selective for small red drum and that the ban did affect the size of red drum caught.

5.15 Incidental catches

Red drum were not reported in several studies of fish caught incidental to shrimp trawling (Anderson 1968; Knowlton 1972; Wolff 1972; Keiser 1976). Commercial landings statistics indicate that the percentage of North Carolina landings from shrimp trawls ranged from <0.1% in 1974 to 15.2% in 1983 (Table 14). In South Carolina shrimp trawl landings ranged from 0.7-100.0% of the total (Table 15). Prior to 1978, 12.0-100.0% of Georgia red drum landings were caught by shrimp trawls (Table 16).

Red drum have been reported as a bycatch from shrimp and fish trawls in the Gulf of Mexico (Swingle et al. 1983). Red drum landings in Alabama were predominantly by shrimp trawling, accounting for 48-95% of the landings. In Mississippi red drum were taken as incidental bycatch in the industrial groundfish fishery and the shrimp trawl fishery. The percentage of red drum landings taken by fish and shrimp trawls averaged 8 and 15%, respectively, from 1968 through 1976. Shrimp trawls accounted for a very minor portion of red drum landings in Louisiana and Texas; generally <1% of annual red drum landings.

In the Gulf of Mexico large red drum have been caught by purse seiners fishing for blue runner. Red drum school below blue runner and when the net is set red drum are harvested as a bycatch (Overstreet 1983). From July 1, 1983 to April 16, 1984, 225.4 mt (497,000 lb) of red drum were landed in observed purse seine catches from the northern Gulf of Mexico (off the Mississippi River delta). The catches generally consisted of large red drum (7-8 kg) and were caught 18-22 km offshore at depths of 18-24 m.[24]

5.2 Recreational Exploitation

5.21 Equipment and trends in equipment

Red drum are caught by bottom fishing, jigging, and casting from shore, as well as bottom fishing, casting, live-lining and trolling from boats (Freeman and Walford 1974, 1976a, b, c, d). Baits include soft or shedder crabs, shrimp, clams, squid, and cut mullet, spot, herring or menhaden, as well as artificial lures such as spoons, jigs, weighted bucktails, feathers, plugs, and streamer flies. Red drum are also harvested by gill netting and gigging for home consumption. In South Carolina 94% of the gill-net fishermen who fished in 1978 fished recreationally (Moore 1980).

5.22 Areas fished

The recreational fishery for trophy red drum ($\geq$18 kg) which exists in the South Atlantic has been primarily a surf fishery along the outer beaches of barrier islands (Freeman and Walford 1974, 1976a, b, c, d; Osborne 1981; Wongrey 1981; Ogle 1982; Arrington 1983; Music and Pafford 1984). Small red drum (<8 kg) are caught in the estuaries from Chesapeake Bay to Florida (Freeman and Walford 1976a, b, c, d; Smith and Moore 1979; Osborne 1981; Music and Pafford 1984).

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[24] W. Fable, National Marine Fisheries Service, Southeast Fisheries Center, Panama City Laboratory, Panama City, Florida, personal communication.

The numbers of red drum caught by principal area of fishing in each region in 1965, 1970, and 1980 are presented in Table 19. The salt-water angling surveys indicated that 88% of the red drum caught in the Middle Atlantic region in 1965 were caught in sounds, rivers, and bays, whereas in 1970 only 47% were caught in estuarine waters. More red drum (59%) were caught in the ocean in the South Atlantic in 1965, but in 1970 and 1980 79% and 92%, respectively, were caught in sounds, rivers, and bays. In the Gulf of Mexico more red drum were caught in sounds, rivers, and bays than in the ocean in all survey years.

5.23 Seasons

The fishing season for red drum is all year from Georgia to southern Florida (Freeman and Walford 1976c, d). From Altamaha Sound to Fort Pierce Inlet, best fishing for small fish is August to October inshore, and for large fish, March to May and November to January offshore. Best fishing for small red drum from St. Lucie Inlet to southern Florida is from April to August and from August to November for large ones. Adult red drum generally remain in coastal waters through the coldest months and during late summer move offshore, presumably to spawn.

Most red drum are caught from mid-March or early April to early December between False Cape, Virginia and Georgia. The best fishing for large fish runs from late March to early June and for small fish from late September to November (Freeman and Walford 1976b). Good surf fishing along the North Carolina coast is from March to June and October to November (LaMonte 1951; Osborne 1981; Ogle 1982). The fishing season in Chesapeake Bay is from late April or May to November. The best fishing for large fish is from mid-May to mid-June and from August to October for small fish (Freeman and Walford 1976a). The red drum fishing season from False Cape, Virginia to Delaware Bay extends from April or May to November and the best fishing is from May-June and September-October (Freeman and Walford 1974).

5.24 Fishing operations and results

Red drum catch data by month and year on the Eastern Shore of Virginia were reported for 1955 to 1965. Catch rates were never high but relative highs occurred during 1957 and 1962 at 0.14 fish per man-hour. More fish were

Table 19. Number of red drum caught by U.S. anglers in each region in 1965, 1970, and 1980 by principal area and method of fishing.

Survey year	Region	Principal area of fishing		Principal method of fishing			
		Ocean	Sounds, rivers, and bays	Private or rented boat	Party or charter boat	Bridge, pier, or jetty	Beach or bank
		THOUSANDS					
1965[1]	Middle Atlantic	24	172	7	35	126	28
	South Atlantic	2,436	1,663	1,497	235	1,965	402
	Gulf of Mexico	1,332	5,568	4,841	769	890	400
1970[2]	Middle Atlantic	51	46	46	-	-	51
	South Atlantic	1,032	3,851	3,839	276	287	481
	Gulf of Mexico	5,060	8,124	7,655	1,586	1,694	2,249
1980[3]	South Atlantic	26	313	318	-	43	58
	Gulf of Mexico	467	3,005	4,513	51	388	431

[1]Deuel and Clark 1968
[2]Deuel 1973
[3]Anonymous in press

landed during May and September, but catch rates were highest for April, June, and September. A low of 0.01 fish per man-hour occurred in 1959 (Richards 1965). A 1963 sport fishery survey in the Cape Canaveral area of Florida found that catch per unit effort was highest in October and April north of Cape Canaveral, and highest in April to the south (Anderson and Gehringer 1965). Catch per unit effort data (number and weight) for red drum caught in the Gulf of Mexico was summarized by Perret et al. (1980).

The National Marine Fisheries Service salt-water angling surveys, 1960-1970, indicated that the number of red drum per angler declined in all regions from 1965 to 1970 (Table 11). The average reported weight of fish decreased in both the Middle and South Atlantic regions from 1960 to 1970, but increased in the Gulf of Mexico from 1960 to 1965 and decreased slightly from 1965 to 1970.

Davis (1980) reported that recreational fishermen caught 96% of the red drum landed in Everglades National Park from 1972 through 1977. The mean annual yield of red drum from park waters was 0.17 kg per acre, producing mean annual harvests of 105,370 kg from 1972 through 1977. In the past 20 years, there has been a shift in age structure toward larger, mature fish, with upward trends in catch rates and a marked reduction in the year-to-year variability of catch rates, possibly due to changes in environmental conditions (Davis 1980).

6. SOCIAL AND ECONOMIC IMPLICATIONS

6.1 Values

Cato (1981) reviewed the economic values and uses of the sciaenid fisheries in the South Atlantic and Gulf of Mexico. A comparison of dockside value of commercial landings of important sciaenids revealed that red drum ranks behind weakfish, croaker, spotted seatrout, and spot. Red drum prices increased steadily in the Gulf of Mexico and have been consistently higher there except in 1969, 1980 and 1982 (Figure 4). Atlantic coast prices increased steadily from 1960 but dropped sharply in 1983.

Current prices have increased while deflated prices have remained fairly stable. Red drum exvessel prices vary from state to state. In 1982 prices varied from 23-79 cents per pound in North Carolina and the east coast of Florida, respectively (Table 20).

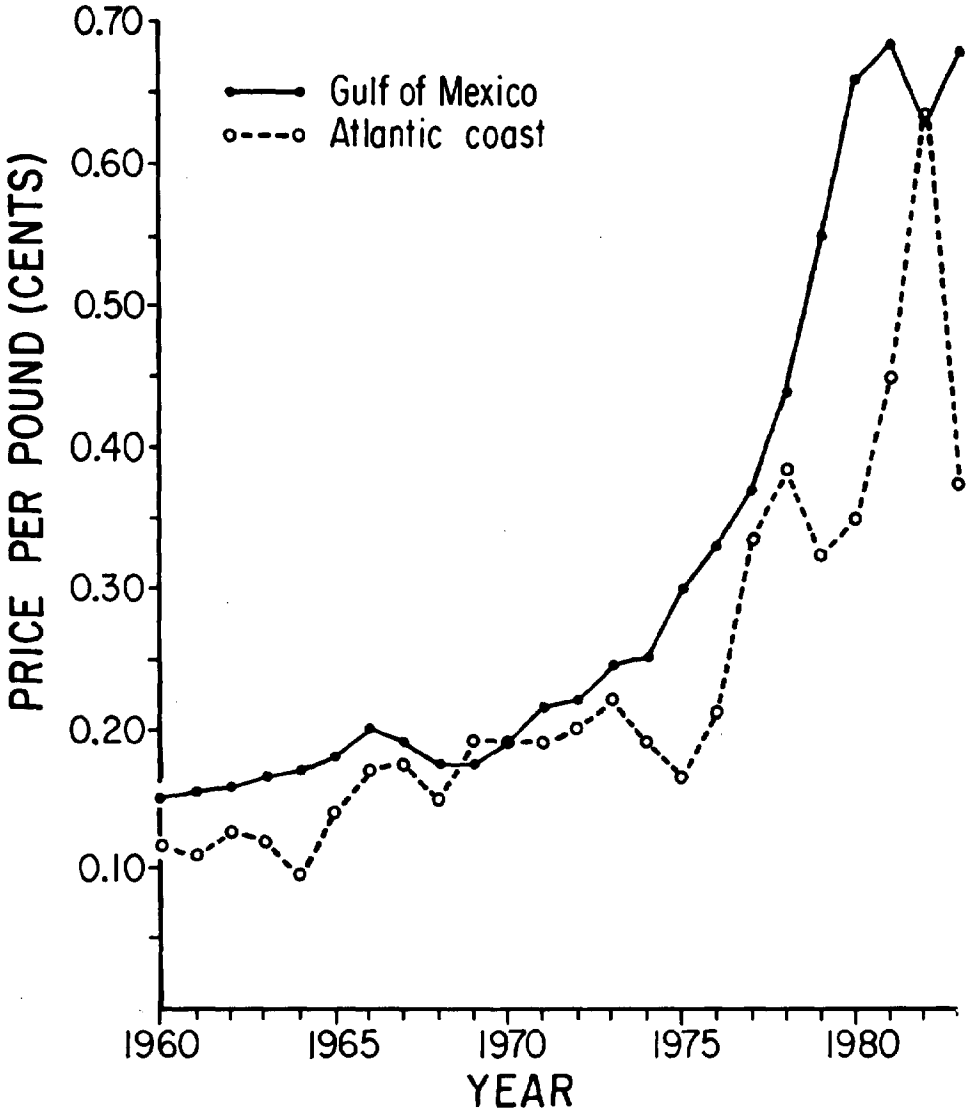

Figure 4. Dockside price of red drum for the Atlantic coast and Gulf of Mexico, 1960-1983.

Table 20. Unadjusted exvessel price of commercially-caught red drum on the Atlantic coast by state, 1960-1982.

Year	Virginia	North Carolina	South Carolina	Georgia	Florida East Coast
	(DOLLARS/POUND)				
1960	.046	.081	-	.150	.147
1961	.092	.081	.250	.150	.137
1962	.084	.081	-	-	.145
1963	.084	.068	-	-	.147
1964	.086	.089	.141	-	.183
1965	.105	.119	-	-	.177
1966	.083	.103	.100	.123	.187
1967	.085	.097	-	.135	.184
1968	.110	.069	-	.222	.152
1969	.060	.085	.157	.190	.193
1970	.060	.085	.157	.190	.193
1971	.037	.100	.181	.209	.208
1972	.079	.122	.268	.202	.228
1973	.113	.111	.258	.210	.271
1974	.150	.111	.258	.210	.271
1975	.100	.101	.286	.299	.322
1976	.083	.128	.283	.329	.340
1977	.110	.136	.335	.414	.372
1978	.063	.114	.345	.649	.448
1979	.084	.172	.264	.553	.532
1980	.150	.194	.262	.643	.555
1981	.240	.201	.418	.709	.541
1982	.139	.234	.602	.669	.791

-None caught

Source: Fishery Statistics of the United States, 1960-1977; NMFS Landings Data, 1978-1982.

6.2 Employment

There is little available information on employment in the fisheries for red drum which are mixed species fisheries. The commercial fishery for coastal finfish in South Carolina is primarily a part-time activity with few, if any, full-time employees, primarily due to major commercial interest in the shrimp, blue crab, and oyster fisheries (Smith and Moore 1979).

6.3 Participation

There is little specific information on participation in the fisheries for red drum. Participation in South Carolina's gig and gill net fisheries, both of which harvest red drum, has increased greatly in the last decade. Gig licenses increased 225% from 1971-1972 (590) to 1977-1978 (1,910) and gill net licenses increased 306% over the same time period (705 to 2,861) (Smith and Moore 1979). Davis (1980) examined changes in the Everglades National Park red drum and spotted seatrout fisheries 1958-1978. The number of commercial fishermen fluctuated between 125 and 276 from 1963 to 1978. Recreational fishing activity increased steadily from 58,000 angler-days in 1959 to 174,000 in 1965, fell slightly in the late 1960s, reached another peak of about 160,000 angler-days in 1973 and 1974, and fell again to less than 100,000 angler-days in 1977.

The 1960-1970 salt-water angling surveys indicate significant growth of marine sport fisheries in the South Atlantic region. The estimated number of anglers increased from 1.0×10^6 in 1960 to 1.7×10^6 in 1965 and 1.8×10^6 in 1970 (Clark 1962; Deuel and Clark 1968; Deuel 1973). Bearden (1969) estimated that there were 240,500 resident anglers in South Carolina in 1968. The number of resident South Carolina participants in a 1974 survey was estimated at 347,000 people (Mabrey et al. 1977). Out-of-state participation appears to be an important segment of South Carolina's sport fisheries. An estimated 261,000 people from North Carolina and 56,000 from Georgia fished in South Carolina in 1974 (Mabrey et al. 1977).

6.4 Processors and product forms

In South Carolina red drum are sold to either local wholesale or retail markets. Gill nets and hook and line were the principal gears used to take coastal finfish for market. A survey of licensed persons engaged in selling finfish indicated that red drum, spotted seatrout, and flounder comprised only 7.2% of the total reported weight of finfish sold (Smith and Moore 1979).

Commercial landings of red drum on the Gulf Coast are mostly sold in local markets as fresh in-the-round or gutted, with a small percentage sold as frozen and gutted, or as fresh or frozen fillets (Perret et al. 1980).

6.5 Import/export

Imports of juvenile red drum from Mexico are substantial and have an impact on Texas, Louisiana, Oklahoma, and perhaps other markets supplied from Texas and Louisiana landings. Imports increased from 1964 (45.1 mt) to 1969 (396.2 mt) and have since decreased (Table 21). The decline in imports from the 1970s to the present is due to the development of seafood markets in Mexico, new fishing regulations in Mexico, and until recently, a declining U.S. dollar. At their peak, imports accounted for 25% of the total U.S. supply of red drum. Most imports are in-the-round and gutted. Frozen fillets were imported between 1978 and 1981, and comprised from 12 (1981) to 29% of imports (1978) (Perret et al. 1980; Swingle et al. 1983).

Exports of red drum from the U.S. have occurred but statistical information is unavailable before 1981 when the National Marine Fisheries Service began inspecting drum exports (include red drum and black drum). Drum are exported to Nigeria, Turkey, and probably Egypt, the Mideast, Venezuela, and Taiwan. The red drum exported are usually adult fish because of a market preference for large fish in the above countries and because it can be marketed at relatively low prices. The product is shipped frozen in-the-round or is gutted (Swingle et al. 1983).

6.6 Gear conflicts

In North Carolina gear conflicts may occur between the long haul seine fishermen and the pound net, crab and eel pot fishermen. Abandoned, broken-off pound net stakes and pound net stakes left in place from season to season exclude long haulers from large areas, especially in Core Sound. A very large increase in the number of crab and eel pot fishermen has resulted in ever increasing friction with haul seiners, who cannot haul in areas filled with pots. Potters are mainly interested in shoal waters, which long haulers need only to bunt or harden up their seine (DeVries 1981).

6.7 Commercial-recreational conflicts

Heffernan and Kemp (1980, 1982) reviewed the conflicts in the red drum fishery, particularly in the Gulf of Mexico.

Table 21. U.S. imports and exports of red drum, 1964-1983 (from Swingle et al. 1983).

Year	Imports			Exports[a]
	Total	In-the-round	Frozen Fillets	
	Metric Tons			
1983	110.8	79.8	30.9	-
1982	128.5	115.9	12.6	-
1981	65.5	57.5	8.1	997.9
1980	162.3	135.2	27.1	N.A.
1979	164.1	133.2	30.8	N.A.
1978	235.6	167.6	67.9	N.A.
1977	254.3	N.A.	N.A.	N.A.
1976	178.6	N.A.	N.A.	N.A.
1975	182.9	N.A.	N.A.	N.A.
1974	217.3	N.A.	N.A.	N.A.
1973	335.6	N.A.	N.A.	N.A.
1972	282.8	N.A.	N.A.	N.A.
1971	272.0	N.A.	N.A.	N.A.
1970	381.6	N.A.	N.A.	N.A.
1969	396.2	N.A.	N.A.	N.A.
1968	101.7	N.A.	N.A.	N.A.
1967	4.0	N.A.	N.A.	N.A.
1966	14.4	N.A.	N.A.	N.A.
1965	49.4	N.A.	N.A.	N.A.
1964	45.1	N.A.	N.A.	N.A.

a - includes red drum and black drum

\- - none exported

N.A. - not available

Source: E. Barry, National Marine Fisheries Service, New Orleans, personal communication; J. Dougherty, NMFS, St. Petersburg, personal communication.

Conservationists and recreational fishermen complained of overharvest of fish by commercial interest prior to 1900, continuing to the present. State legislatures enacted various regulations which closed portions of estuarine areas to the use of nets and seines during seasonal periods with the intent to protect spawning fish. From the 1930s to the 1970s, legislation was directed toward reducing commercial fishing pressure on bay stocks by imposing size limits, opening and closing various bay and Gulf waters, and establishing gear restrictions in relation to mesh sizes, length of nets, and their seasonal use. Growing netting pressure and reported declines in available stocks led to the prohibition of the use of monofilament nets in Louisiana in 1977 and Texas in 1980. The Texas legislature passed a bill in 1981 prohibiting the commercial sale of Texas-caught red drum for two years. Davis (1982) discussed management conflicts in Everglades National Park and Matlock (1982) discussed conflicts between user groups of red drum in Texas. At the urging of recreational fishermen in Florida regulations and legislation have been introduced to ban gill netting for red drum; however, none of it has passed.

7. MANAGEMENT AND PROTECTION

7.1 Regulatory measures

The fisheries for red drum have been conducted almost entirely within the internal waters of the states and in the territorial sea which extends 5.6 km (3 n mi) offshore on the Atlantic coast. Therefore, management has been by individual state regulation. The State of Maryland passed a saltwater angling license bill, May 22, 1984, for fishing in Maryland tidal waters of Chesapeake Bay and tributaries and is the only state on the Atlantic coast that requires saltwater anglers to be licensed. The monies collected by the license will be dedicated for recreational fishing enhancement and anglers will be given the opportunity to have input concerning the content of the fisheries management program adopted by the Maryland Department of Natural Resources. The State of Virginia is also considering a saltwater angling license. Regulations and methods of promulgating them vary among states and are summarized in Table 22. The only regulations specifically dealing with red drum are size limits in North Carolina and Florida, and daily possession limits in Virginia and North Carolina.

The Atlantic States Marine Fisheries Commission (ASMFC) administers a cooperative agreement with the National Marine Fisheries Service (NMFS) entitled the Interstate Fisheries Management Program (ISFMP). This program provides funding to

Table 22. Synoptic overview of present state management systems.

	Rhode Island	Connecticut
Administrative organization	Rhode Island Department of Environmental Management	Connecticut Department of Environmental Protection
Legislative organization	Rhode Island Marine Fisheries Council	Connecticut Commissioner Environmental Protection
Licenses	Commercial	Commercial
Size restrictions	None	None
Limits	None	None
Gear restrictions	None	None
Conservation regulations	None	None

Table 22. Continued

	New York
Administrative organization	New York State Department of Environmental Conservation
Legislative organization	New York Fish and Game Laws, Article 13 Marine and Coastal Resources
Licenses	Commercial non-resident beam and otter trawl
Size restrictions	None
Limits	None
Gear restrictions	Trawl prohibited from Great South Bay, Moriches Bay, Shinnecock Bay; seasonally in Peconic Bays. Gill nets restricted from Peconic Bays; haul seines limited in lengths in these same bays and cannot be fished from midnight Thursday to 6:00 p.m. Sunday. Nets and trawls may not be set in western Long Island Sound Apr. 1 - Nov. 1. Gill nets prohibited in central and western Long Island Sound.
Conservation regulations	None

Table 22. Continued

	New Jersey	Delaware
Administrative organization	New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife, Marine Fisheries Administration, Bureau of Marine Fisheries	Division of Fish and Wildlife Department of Natural Resources and Environmental Control
Legislative organization	New Jersey Statutes, Title 23, Chapter 28	Delaware State Legislature
Licenses	Fyke nets - $1, $4, $30 Haul seines - $25 Bait seines - $3 (50' - 150') Gill nets - anchored - $13 drift - $20 run around - $20 Pound nets - $ 25 - $ 50 - $100 Otter trawl - $100 Beam trawl - $100 Purse seine - $100	None
Size restrictions	None	None
Limits	None	
Gear restrictions	Trawls and purse seines restricted from within 2 miles of coastline. Seasons for gill nets, fyke nets, haul seines.	Trawls prohibited in Delaware Bay. Gill nets, fyke nets and seines allowed. Purse seines prohibited within 3 miles of coast.
Conservation regulations	None	None

Table 22. Continued.

	Maryland	Virginia
Administrative organization	Maryland Department of Natural Resources	Virginia Marine Resources Commission
Legislative organization	Natural Resources Article, Annotated Code of Maryland Title 4, Subtitle 1, Title 08, Subtitle 02, Chapter 05 Fish	Marine Resources of the Commonwealth Code of Virginia of 1950, Title 28.1
Licenses	Otter trawl - $100 Beam trawl - $100 Fyke or hoop nets - $50 Gill nets- ≤200 yds $100 >200 yds $200 Recreational - $5 in Chesapeake Bay	Commercial
Size restrictions	None	None
Limits	None	No more than two ≤32" TL
Gear restrictions	Trawling prohibited within 1 mile of Maryland shoreline in Atlantic Ocean. Numerous gear and area restrictions.	Trawling prohibited in Chesapeake Bay. Pound net mesh <2" (s.m.) and haul seine mesh <3" mesh (s.m.) prohibited. Trawling prohibited within 3-mi. limit from Cape Charles north to Maryland line in Sep. and Oct.
Conservation regulations	Secretary of Natural Resources has authority to adopt rules and regulations relating to taking, possession, transportation, exporting, processing, sale or shipment necessary to conservation.	None

Table 22. Continued

	North Carolina
Administrative organization	North Carolina Department of Natural Resources and Community Development, Division of Marine Fisheries; Marine Fisheries Commission
Legislative organization	North Carolina Administrative Code, Title 15, Chapter 3.
Licenses	Vessels without motors, any length, when used with other licensed vessel - no license Vessels, not over 18' - $1/foot Vessels, over 18' to 38' - $1.50/foot Vessels, over 38' - $3/foot Non-resident vessels - $200 in addition to above fee requirement Finfish processor - $100 Unprocessed finfish dealer - $50
Size restrictions	14" TL minimum
Limits	No more than two >32" TL; in New Hanover County, none $\geq$20 lbs.
Gear restrictions	Trawling for finfish prohibited in internal coastal waters. No purse seine for food fish. Many specific net regulations for areas and seasons.
Conservation regulations	Secretary, acting upon advise of Director of Marine Fisheries, may close area to trawling if in coastal fishing waters, samples become composed primarily of juvenile finfish of major economic important. No person shall remove red drum from any boat hook, gaff, spear, gig, or similar device.

Table 22. Continued

	South Carolina	Georgia
Administrative organization	South Carolina Wildlife and Marine Resources	Georgia Department of Natural Resources
Legislative organization	Section 50-5-20	Georgia Code 27-4-110
Licenses	Land and sell $25 Commercial boat license ≤18' - $20 >18' - $25 Gill nets haul seines - $10/100 yds	Commercial fishing license (personal) - $10.25 for any sales of catch Nontrawler license ≤18' - $5 >18' - $5 + $.50/foot Trawler license - $50 for 18' + $3/additional foot No license for seines ≤300' unless catch is sold.
Size restriction	None	None
Limits	None	None
Gear restrictions	Seine mesh less than 2½" prohibited Purse seining for food fish permitted in ocean greater than 300 yds from beach.	Gill netting prohibited in Georgia waters. Seine mesh restrictions: minimum of 1¼" for seines less than 100'; minimum mesh size of 2½" (stretched mesh) for 100' - 300' maximum length.
Conservation regulations	None	None

Table 22. Continued

	Florida
Administrative organization	Marine Fisheries Commission
Legislative organization	Chapter 370, Florida Statutes; additional 220 state laws that apply on a local level; all local laws will become Rules of the Marine Fisheries Commission by July 1, 1985.
Licenses	License to sell: Resident - $25 annually Non-resident - $100 annually Alien - $150 annually Wholesale seafood dealer Resident - $300 annually Non-resident - $500 annually Alien - $750 annually Retail seafood dealer Resident - $25 annually Non-resident - $200 annually Alien - $250 annually
Size restrictions	12" FL minimum
Limits	None
Gear restrictions	Purse seining and stop netting prohibited. Numerous local gear and area restrictions.
Conservation regulations	None

the Atlantic coastal states to coordinate interjurisdictional fisheries management and develop fishery management plans (FMPs) for species occurring in the territorial sea.

The Magnuson Fishery Conservation and Management Act (MFCMA) provides for the conservation and exclusive management by the Federal government of all fishery resources within the United States Fishery Conservation Zone (FCZ). The FCZ extends from the territorial sea to 370 km (200 n mi) from shore. Fishery management in the FCZ is based on fishery management plans developed by regional Fishery Management Councils (FMC).

The National Park Service retains the authority to manage fish primarily through the establishment of coastal and nearshore national parks and national monuments such as Everglades National Park in Florida.

7.2 Habitat protection

Red drum are dependent on estuaries for at least the first few years of life. Larvae and juveniles are generally found in shallow waters, in areas not greatly affected by tides, with grassy or muddy bottoms and moderate salinities (Section 2.1). Yokel (1966) concluded that red drum abundance varied directly with estuarine size. States which have relatively high annual landings also have large estuaries. North Carolina and the east coast of Flordia are the leading producers of red drum on the Atlantic Coast and they also have the largest estuaries of the states from North Carolina south. There is considerable variation in this relationship, but the general trend supports the supposition of the importance of estuaries and shallow marine areas to the production of red drum (Yokel 1966).

Davis (1980) suggested that changes in the red drum fishery in Everglades National Park 1972-1977, which included a shift in age structure toward larger, mature fish and increased catch rates, resulted from increased salinities from drainage control. The Texas Department of Water Resources has investigated the effects of freshwater inflow upon Texas bays and estuaries. A comparison of annual harvest rates of red drum with seasonal freshwater inflows revealed a positive response between harvest and increased inflow in spring (April-June), fall (September-October), and late fall (November-December). High inflow in winter (January-March) and summer (July-August) was negatively correlated with catch rate (Anonymous 1982b).

Estuarine habitats have deteriorated rapidly since approximately 1940, mostly as a result of industrial and human population growth. The National Estuary Study, completed in 1970, indicated that 73% of the Nation's estuaries had been moderately or severely degraded (Gusey 1978, 1981). Damage

and/or destruction of estuaries has largely been by dredging and filling for waterfront property, dredging of navigation channels, construction of causeways and bridges, installation of ports and marinas, alteration of freshwater flow, and pollution. Unfortunately the effects of habitat alterations have rarely been quantified.

In recent years the coastal states have enacted coastal zone management laws to regulate dredge and fill activities and shoreline developement (Table 23). The Federal government also has some jurisdiction over the estuarine-marine habitat. The Office of Coastal Zone Management (OCZM) has authority through National Marine Sanctuaries, pursuant to Title III of the Marine Protection, Research, and Sanctuaries Act (MPRSA). The OCZM Estuarine Sanctuary program has designated Rookery Bay in Collier County, Florida, and the Apalachicola River and Bay in Franklin County, Florida, as estuarine sanctuaries. The OCZM also sets standards for approving and funding state coastal zone management programs. The Environmental Protection Agency may provide protection to fish communities through the granting of National Pollutant Discharge Elimination System (NPDES) permits for the discharge of pollutants into ocean waters, and the conditioning of those permits so as to protect valuable resources. The U. S. Army Corps of Engineers has jurisdiction over the disposal of dredged material, pursuant to both the Clean Water Act and the MPRSA. The Fish and Wildlife Service, under the Fish and Wildlife Coordination Act, reviews and comments on proposals for work and activities in or affecting navigable waters that are sanctioned, permitted, assisted, or conducted by Federal agencies. The review focuses mainly on potential damage to fish and wildlife, and their habitat.

The Envionmental Assessment Branch of the NMFS is required to assess potential impacts on fishery resources of projects submitted to the Corps of Engineers for permits, and to recommend whether a project should be approved, denied, or modified. Fiscal year 1981 (October 1980 - September 1981) was the first year NMFS quantified the cumulative acreage of habitat involved in the Corps of Engineers permit program in the Southeast Region of the United States. NMFS made recommendations on 1,380 permit applications involving 7,272 ha (17,969 acres); 18% were proposed for dredging, 36% for filling, and 46% for impounding. NMFS did not object to alteration of 1,861 ha (4,598 acres), recommended against altering 5,411 ha (13,371 acres), and recommended that 1,345 ha (3,324 acres) either be restored or modified from upland habitat to mitigate the losses that were permitted. Thus, the NMFS efforts conserved 6,756 ha (16,695 acres) of habitat (Lindall and Thayer 1982). NMFS is also involved in the review of Congressionally authorized Federal projects. NMFS has adopted a new habitat conservation policy which will enhance its overall role in habitat conservation from a previously advisory role based primarily on the policies

Table 23. Summary of state habitat protection regulations, Rhode Island to Florida.

State	Administrative organization	Legislative authorization	Regulations
Rhode Island	Rhode Island Department of Environmental Management and Coastal Resources Management Council	Chapter 279, Public Laws of 1971, Sect. 1, Title 46, General Laws of Water and Navigation. Chapter 23 Coastal Resources Management Council.	Permits required for coastal zone development, aquaculture, dredge and fill operations.
Connecticut	Connecticut Department of Environmental Protection	"The Coastal Management Act" Section 22-a-90 to 22a-96	Permits required to dredge fill or construct structures in both fresh and salt water. Permit required to work in regulated wetland areas.
New York	Department of Environmental Conservation, Bureau of Tidal Wetlands	Environmental Conservation Law Article 25, Tidal Wetlands Act, Part 661. Land use regulations of tidal wetlands.	Regulates activities in and adjacent to tidal wetlands and requires permits for such activities.
New Jersey	Department of Environmental Protection, Division of Coastal Resources	Wetlands Act of 1970 NJSA 13:9A-1 et seq., Coastal Area Facilities Review Act NJSA 13:19-1 et seq., Waterfront Development Law, NJSA 12:5-3, Beaches and Harbors Bond Act of 1977 PL 77-208, Shore Protection Legislation NJSA 12:6A-1	Regulates activities in the coastal zone and requires permits for such activities.

Table 23. (continued)

State	Administrative organization	Legislative authorization	Regulations
Delaware	Delaware Department of Natural Resources and Environmental Control, Division of Environmental Control, Wetlands Section	Sect. 1, Title 7, Delaware Code, Chapter 66. Wetlands.	Regulates use of wetlands and their upland border and provide penalties for violations.
Maryland	Maryland Department of Natural Resources, Tidewater Administration; Maryland Department of Health and Mental Hygiene, Office of Environmental Programs	Natural Resources Article, Code of Maryland	Regulates activities in tidal wetlands areas.
Virginia	Virginia Marine Resources Commission; County wetlands boards	The Wetlands Act Section 62.1-13.20, Code of Virginia	Regulates alterations to tidal marshes, sand and mud flats, subaqueous bottoms, and sand dunes.
North Carolina	North Carolina Department of Natural Resources and Community Development, Office of Coastal Management; Coastal Resources Commission; Coastal Resources Advisory Council	NC Dredge and Fill Law (GS 113-229), Coastal Area Management Act (CAMA) (GS 113A100)	Requires permits to dredge or fill in or about estuarine waters. Establishes areas of environmental concern. Permits required for coastal zone development.
	Division of Marine Fisheries	North Carolina Administrative Code, Chapter 3, Section .1400	Prohibits the use of bottom-disturbing gears and severely restricts or prohibits excavation and/or filling activities in nursery areas for young finfish and crustaceans.
South Carolina	South Carolina Coastal Zone Managment Council	Coastal Zone Management and Planning Act	Directs permit activities in areas of wetlands, beaches, and dunes.

Table 23. (continued)

State	Administrative organization	Legislative authorization	Regulations
Georgia	Georgia Department of Natural Resources, Coastal Resources Division, Coastal Protection Section	Coastal Marshlands Protection Act of 1970 (Gs. L. 1970, p. 939, 1.)	Requires permits to dredge, fill, remove drain, or otherwise alter any marshlands.
		Shore Assistance Act of 1979 (Gs. L. 1979, 1.)	Requires permits for a structure, shoreline engineering activity, or land alteration in beaches, sand bars, and sand dunes in Georgia.
Florida	Florida Department of Natural Resources	Chapter 253, Florida Statutes	Regulates dredge, fill, and structures on state submerged lands (below mean high water). Provides for acquisition of conservation lands and tidally influenced areas.
		Chapter 258, F.S.	Establishes aquatic preserves and regulates activities within preserves.
	Florida Department of Environmental Regulation	Chapter 403, F.S.	Permitting of activities (including dredge and fill) which affect water quality.
	Florida Department of Community Affairs	Chapter 380, F.S.	Administer and set standards for "Development of Regional Impact". Protects regional or statewide resources from poorly conceived development activities.

developed in response to the Fish and Wildlife Coordination Act and the National Environmental Policy Act.[25] The new policy will: (1) ensure that habitat is fully considered in all of NMFS' programs and activities; (2) focus NMFS' habitat conservation activities on species for which the agency has management or protection responsibilities under the MFCMA, the Marine Mammal Protection Act, and the Endangered Species Act; (3) lay the foundation for management and research cooperation on habitat issues; and (4) strengthen NMFS' partnerships with the states and the regional FMCs on habitat issues.

7.3 Stocking

Red drum, a highly sought game and food fish, has been the target of numerous mariculture experiments. Investigations on grow out of red drum were initiated in 1947 and continued intermittently for 20 years in South Carolina ponds tidally stocked with wild fish (Lunz 1951, 1956; Bearden 1967). The red drum portion of the harvested crops was only 15 kg/ha/yr at maximum, but Bearden (1967) noted that the impounded red drum averaged 860 g when 1 year old. In a more recent study, South Carolina ponds yielded 52 kg/ha/yr of red drum with year-old drum averaging 950 g and ranging from 800-1,070 g (Theiling and Loyacano 1976).

Red drum, fed commercial feed or killed forage fish in Texas ponds, exhibited potential for higher yield and survival during grow out. Luebke and Strawn (1973) reported that yield for red drum reached 308 kg/ha with 96% survival and increase in mean weight from 186 g to 641 g. Red drum averaging 0.5 g were produced in Texas by rearing 2- to 6-day-old larvae in ten 0.1-ha ponds for 27 to 60 days with 20% survival and 29.7 kg/ha yield. Red drum stocked at a larger size (638-1,484 g) and given supplemental feed did not grow (Colura et al 1976). Lasswell et al. (1977) reported excellent growth (2 kg/yr) of juveniles stocked in Texas reservoirs.

Juvenile red drum were reared to marketable size (454 g) in 0.08 ha brackish-water ponds in Alabama. The yield when harvested from 394-715 days old ranged from 787-2,292 kg/ha with 1-33% of the drum marketable at harvest. The cost of feed approached the dock value of whole red drum, posing an economic barrier in Alabama for mariculture of red drum (Trimble 1979).

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[25] Federal Register 48(228):53142-53148, November 25, 1983.

The development of spawning techniques (Colura 1974; Arnold et al. 1977; Roberts, Harpster, and Henderson 1978) enhanced the mariculture potential for red drum. Roberts, Morey, et al. (1978) investigated the effects of delayed feeding, stocking density, and food density on survival, growth and production of larval red drum in Florida. The tolerances of eggs, larvae, and postlarvae of red drum to ammonia and nitrite were investigated by Holt and Arnold (1983). Crocker et al. (1981) evaluated survival and growth of juveniles in fresh and salt water.

The use of stocking as a potential management tool in Texas resulted from the declining trend in red drum abundance in Texas and the development of techniques to spawn and rear red drum in captivity (Matlock 1984). During 1975-1982 Texas bays were stocked with over 56 million red drum eggs (15%), fry (80%), and fingerlings (5%). To assess the success of fingerling stockings, 49,194 were tagged. The success of these stockings has not yet been evaluated. With the completion of the John Wilson Hatchery at Corpus Christi, the Texas Parks and Wildlife Department is involved in a comprehensive red drum restoration project (Sasser 1983). The impact of the stocking on the coastal fishery resource will be evaluated in on-going monitoring programs. The Texas Parks and Wildlife Department has recently produced a hybrid cross between the red drum and black drum which may have potential as a freshwater sport fish (Anonymous 1983b).

Historically, stocking of hatchery fish into coastal waters to improve catch has generally been a failure. The value of artificially propogated sciaenids in the management of sciaenid stocks can best be realized through: (1) descriptions of previously undescribed early life stages, (2) bioassay, and (3) introduction of tagged, known-age stocks to determine growth, migratory patterns, and exploitation rate. Stocking of large numbers of sciaenid larvae, fry, or fingerlings into the coastal area is not advocated unless they are stocked in water where they: (1) previously did not exist and an opportunity exists for filling an underutilized niche, (2) had existed but populations had reached such low levels that inadequate spawning stocks remain, (3) habitat alterations had eliminated spawning, growing or fishing grounds, or (4) water quality persistently prevented successful spawning or year-class survival (Tatum 1981).

8. CURRENT RESEARCH

There is little ongoing research on red drum on the Atlantic coast. The Maryland Tidewater Administration, the Virginia Institute of Marine Science, and the North Carolina Division of Marine Fisheries

(NCDMF) conduct juvenile fish surveys in the estuaries to monitor finfish stocks. The NCDMF also samples the commercial fisheries in order to monitor adult finfish stocks and will begin an adult estuarine fish survey in 1984. A tagging study and population assessment of red drum in Georgia estuaries is being conducted by the Georgia Coastal Resources Division. The Florida Department of Natural Resources is completing a study on life history, age and growth, mortality, and yield per recruit of red drum, is examining habitat loss in three Florida estuaries and changes in the fisheries of those estuaries, and is tagging red drum (ages I-IV). The National Park Service monitors juvenile finfish stocks and conducts a creel survey of the recreational fishery in Everglades National Park. The U.S. Fish and Wildlife Service is conducting a two-year resource assessment study of the commercial fishery, which includes red drum, in Everglades National Park. NMFS conducts annual marine recreational fishery statistics surveys and commercial fishery statistics are collected by state and Federal port agents.

9. IDENTIFICATION OF PROBLEMS

The Interstate Fisheries Management Program Sciaenid Technical Committee has identified the following immediate red drum research needs: (1) stock identification; (2) validation of uniform ageing techniques throughout the range; and (3) tagging studies to estimate fishing and total mortality. Improved catch and effort statistics for both the commercial and recreational fisheries are needed to measure stock density. Long-term monitoring needs include: (1) determination of habitat preferences, growth rates, and food habits of larval and juvenile red drum; (2) assessment of the effects of environmental factors on stock density; and (3) yield modeling. The effectiveness of controlling fishing mortality and minimum size in managing the fisheries needs to be examined.

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