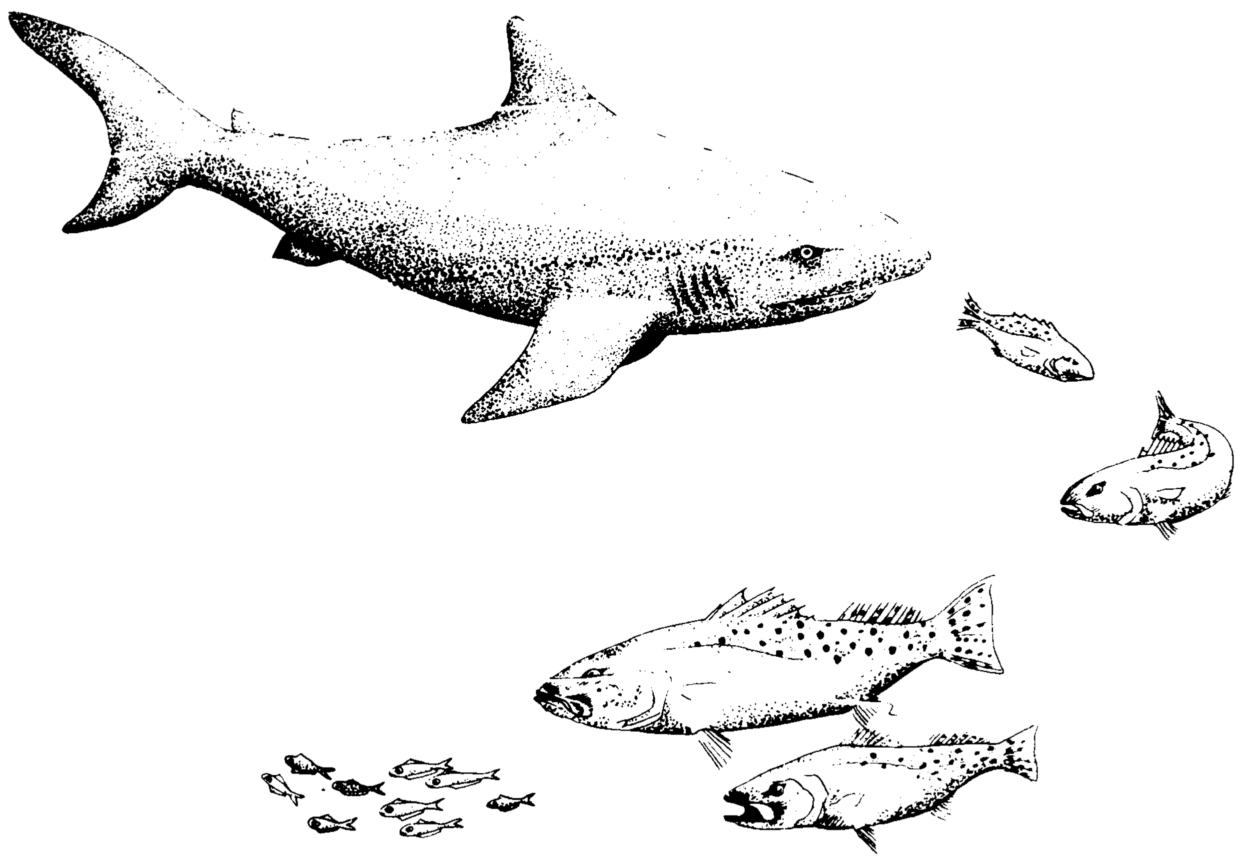
Biological Services Program

FWS/OBS-81/51
March 1982

Life History Requirements of Selected Finfish and Shellfish in Mississippi Sound and Adjacent Areas



MOBILE DISTRICT
U.S. ARMY CORPS OF ENGINEERS
Fish and Wildlife Service

U.S. Department of the Interior

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FWS/OBS-81/51
March 1982

LIFE HISTORY REQUIREMENTS OF SELECTED FINFISH AND SHELLFISH IN MISSISSIPPI SOUND AND ADJACENT AREAS

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PREFACE

The Mississippi Sound and Adjacent Areas Study was authorized by congressional resolutions of 1 February 1977 and 10 May 1977. The main purpose of the study, as stated in the resolutions, is to determine whether the present and proposed dredged material disposal methods for maintenance and construction of the various projects in Mississippi Sound should be modified in any way, in the interest of economic efficiency and environmental quality. The resolutions request an investigation by the U.S. Army Corps of Engineers of various dredging techniques and the possibility of developing a coordinated program for the region, with appropriate consideration of ecological factors. The region under study is defined to include the body of water and adjacent land and estuarine areas extending from Chandeleur Sound and Lake Borgne, on the west, along the Mississippi and Alabama coasts, to the eastern shore of Mobile Bay, on the east. It is bounded on the north by Interstate Highway 10 and on the south by the 120-ft bottom contour of the Gulf of Mexico (Figure 1).

As part of the Mississippi Sound and Adjacent Areas Study, the U.S. Fish and Wildlife Service's National Coastal Ecosystems Team performed a survey of literature on nursery, spawning and migratory activities of 41 finfish and shellfish species previously identified as numerically abundant or important for sport and/or commercial value in the study area. The synopses were prepared from published and unpublished reports on data collected in the northeast Gulf of Mexico or, when applicable, from other regions. They describe the uses, abundance, and importance of the species in the area, seasonal distribution of life stages, habitat and environmental requirements, food habits, and data deficiencies.

A computerized data base including references and supplemental map overlays showing temporal utilization of the region have been prepared in conjunction with this report. A COASTAL*FISH User's Guide, a Finfish/Shellfish Information Base for Mississippi Sound and Mobile Bay has been prepared to explain how to use the computerized data base. The map overlays were prepared utilizing National Oceanic and Atmospheric Administration/National Ocean Survey (NOAA/NOS) United States - Gulf Coast charts: Number 11360 - Cape St. George to Mississippi Passes (1:456,394) for offshore distribution; Number 11371 - Lake Borgne and Approaches, Cat Island to Point Aux Herbes (1:80,000); Number 11373 - Mississippi Sound and Approaches, Dauphin Island to Cat Island (1:80,000); and Number 11376 - Mobile Bay (1:80,000).

This information will be utilized by the U.S. Army Corps of Engineers in developing a regional dredging plan for the Mississippi Sound and vicinity. During planning, consideration will be given to the impacts of removal and placement of dredged material on each of the 41 species. The analyses will include: (1) effect of time of dredging operations on the various life stages of a particular species, (2) effect of dredging operations on habitat utilization by a species, and (3) effect of dredging operations, either direct or indirect, on the abundance and areal distribution of a species.

M. SUSAN IVESTER, U.S. Army Engineer District, Mobile
September 1981

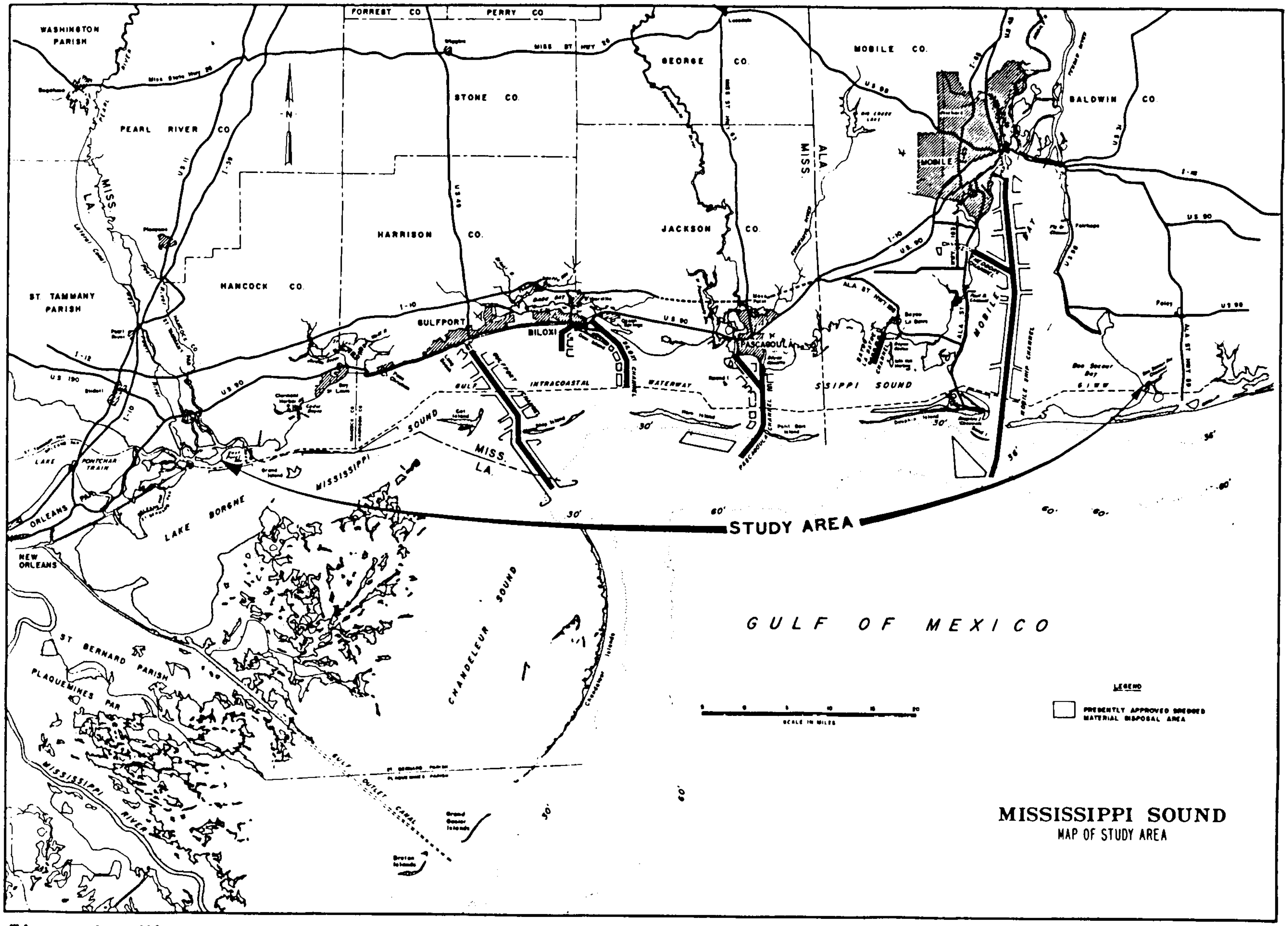

Figure 1. Mississippi Sound and adjacent area (from Mobile District, U.S. Army Corps of Engineers).

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ACKNOWLEDGMENTS

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The following persons prepared the species (in parentheses) synopses: Dr. Paul Wagner, Burke and Associates, New Orleans, Louisiana (white shrimp, pink shrimp, Atlantic spadefish, Florida pompano, red snapper, lane snapper, gray snapper, crevalle jack); Dr. Robert Shipp and Mr. S. Branstetter, University of South Alabama, Mobile, Alabama (blacktip shark, spinner shark, Atlantic sharpnose shark); Dr. Edward Harrison, Mr. Christopher Lagarde, and Mrs. Teresa Heaton, Mississippi State University, National Space Technology Laboratories, Mississippi (Atlantic croaker, southern kingfish, sea catfish, spot); Dr. Sally Richardson, Dr. Thomas McIlwain, Mrs. Harriet Perry, Mr. Richard Waller, and Mr. Dave Ruple, Gulf Coast Research Laboratory, Ocean Springs, Mississippi (blue crab, lesser blue crab, short squid, Atlantic thread herring, striped anchovy, bay anchovy, pinfish, Atlantic stingray); and Mr. John Parsons, Dr. Harold Loyacano, and Dr. Norman G. Benson, U.S. Fish and Wildlife Service, Slidell, Louisiana (gulf menhaden, southern flounder, gulf flounder, tidewater silversides, striped mullet, king mackerel, Spanish mackerel, Atlantic cutlassfish, bluefish, cobia, striped bass, tripletail, sheepshead, southern kingfish, black drum, red drum, sand seatrout, spotted seatrout).

We thank the National Marine Fisheries Service Laboratory, Panama City, Florida, for the opportunity to review their species data bank reports.

The draft manuscript was reviewed for scientific content by R.D. Nester, J.R. Wilson, G.L. Coffee, and M.S. Ivester, Mobile District Corps of Engineers, and members of the Mississippi Sound and Adjacent Areas Biological Group.

CHAPTER 1. MOLLUSCA

SHORT SQUID

Lolliguncula brevis

INTRODUCTION

The short squid (Lolliguncula brevis Blainville) is the most abundant squid in Mississippi Sound and Mobile Bay as well as in other estuaries and nearshore marine waters along the Gulf coast (Gunter 1950; Swingle 1971; Franks et al. 1972; Christmas and Langley 1973). Most short squid live in estuaries from spring to fall, but they winter in warmer, deeper offshore waters.

Most of the data on short squid in Mississippi waters were collected and compiled as part of a continuing research project on commercial fish species in Mississippi Sound waters (Mississippi Annual Reports, undated). This study, now 8 years old, provided data on the distribution, abundance, environmental preferences, and growth. Information on short squid in offshore areas and Mobile Bay is minimal.

DISTRIBUTION AND BEHAVIOR

Christmas and Langley (1973) and Perry and Boyes (1978) provided data on the areal distribution of short squid in Mississippi as did Swingle (1971) in Alabama. Short squid are most abundant in estuarine areas of relatively high salinity (outer Mississippi Sound and lower Mobile Bay). All of the above authors found the highest short squid abundances around barrier island areas south of the Gulf Intracoastal Waterway, and in deeper, higher salinity ship channels. Some squid were collected year-round in areas seaward of the barrier islands at depths between 9 and 18 m (30 and 59 ft) (Franks et al. 1972). Gunter (1950) noted that squid were more common in shallow Gulf waters than in bays in Texas.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Water temperatures apparently govern the migration and abundance of short squid in Mississippi coastal waters (Christmas and Langley 1973; Perry and Boyes 1978). Most squid spend the winter (December-March) in the deeper warmer waters of the Gulf (Franks et al. 1972), and migrate into the estuaries, principally Mississippi Sound and Mobile Bay, as waters therein warm in the spring. Maximum abundance in estuaries is reached in summer and early fall (Christmas and Langley 1973; Perry and Boyes 1978). Most squid seek offshore waters in the late fall, but when winter is particularly cold (as in 1975 and 1976), they move even further into deep waters (Perry and Boyes 1978).

Squid have been collected in Mississippi Sound at temperatures ranging from 5.0° to 34.9°C (41° to 95°F), but catches were highest at temperatures from 13° to 16°C (55° to 61°F) (Swingle 1971). Small squid (under 10 mm mantle length) were most abundant at temperatures above 15°C (59°F) (Perry and Boyes 1978).

In Mississippi and Alabama coastal waters, short squid have been taken at salinities ranging from 10.0 to 35.5 ppt (Christmas and Langley 1973) and from 5.0 to 34.9 ppt (Swingle 1971). The largest catches were at salinities above 15 ppt (Christmas and Langley 1973), including small squid with less than 10-mm mantle length (Perry and Boyes 1978), and between 13 and 16 ppt (Swingle 1971). None were taken at salinities below 10 ppt.

REPRODUCTION

Eggs are laid on soft sandy bottoms in estuaries and are susceptible to sedimentation (Edward T. LaRoe, U.S. Fish and Wildlife Service). Based on the capture of short squid larvae (<10 mm long), this species spawns from spring through early winter (Perry and Boyes 1978). Peak catches of juveniles in Mississippi coastal waters were in late summer and early fall. Short squid with a mantle length of 6 to 10 mm were reported in June, July, August, October, and December in Alabama waters (Swingle 1971). Christmas and Langley (1973) reported the collection and hatching of short squid eggs in the summer from Dog Keys Pass, Mississippi, and from shallow waters seaward of the Mississippi barrier islands.

Short squid mature at a small size (32-mm mantle length for males and 63-mm for females) according to Dragovich and Kelly (1963). These data, when taken in concert with growth data from Perry and Boyes (1978), suggest males mature at 6 months of age and females at 10 months (Perry and Boyes 1978). Females with mantle lengths ranging from 63 to 107 mm spawn from 1,400 to 3,900 eggs (Dragovich and Kelly 1963).

FOOD HABITS

Dragovich and Kelly (1963) reported that short squid feed on fragments of seagrasses, planktonic crustaceans, benthic crustaceans, and fish. Mud and sand particles were also in the stomachs.

USES BY MAN

The short squid is seldom harvested commercially although there is a small frozen bait market for squid along the Gulf coast. As bait, they are very effective for taking seatrout, red drum, other sciaenids, cobia, and offshore bottom fish including snappers and groupers. Hixon (1980) reported on the commercial potentials of squids in the Gulf of Mexico and concluded that many fishing and marketing problems must be resolved before squid will support a viable fishery. The short squid is an important forage species for commercial and game fish.

CHAPTER 2. CRUSTACEA

BROWN SHRIMP

Penaeus aztecus

INTRODUCTION

The brown shrimp is the most important commercial shrimp species in the Mississippi Sound and Mobile Bay area. The average annual catch (1968-77) in the study area was 4,347 metric tons (mt) or 82% of the total study area shrimp harvest, according to the National Marine Fisheries Service (NMFS 1981a). An extensive data base has been developed on life history stages and distribution of the brown shrimp; but information on some environmental requirements has not been defined, probably because of the wide distribution of the species. Changes in annual abundance do not indicate any significant trends, and the size of the resource appears to be environmentally controlled (Van Lopik et al. 1979). For example, catches for a given year are independent of the previous year's catch, and variations in abundance are closely related to stream inflow (Gunter and McGraw 1973). Brown shrimp are harvested in Mississippi Sound and Mobile Bay from May to August and are trawled offshore from June to November (Van Lopik et al. 1979).

DISTRIBUTION AND BEHAVIOR

Adults spawn offshore (30-120 m or 98-394 ft) from about November to April and most postlarvae (10-14 mm) move into the estuaries from February to April (Figure 2). Movement is toward soft bottom shallow areas of estuaries, usually in or near marshes (Christmas et al. 1966, 1976). Apparently, most movement takes place at night near the surface.

Some postlarvae may spend considerable time offshore before they move inshore (Kutkuhn 1962). The nursery period in the estuaries coincides with the time of peak marsh productivity (Gosselink 1980). The postlarvae grow rapidly when temperatures exceed 18°C (64°F). The abundance of postlarvae is used as an index of abundance for management purposes (Van Lopik et al. 1979).

The migration of juveniles (60-70 mm) from shallow parts of estuaries and adults (90-110 mm) from deeper estuarine areas to offshore areas extends from about May to July. Most shrimp movement is during ebb tides (Copeland 1965; Trent 1966). A major segment of the estuarine shrimp fishery is during this migration. Parker (1970) concluded that migrants take a direct route from

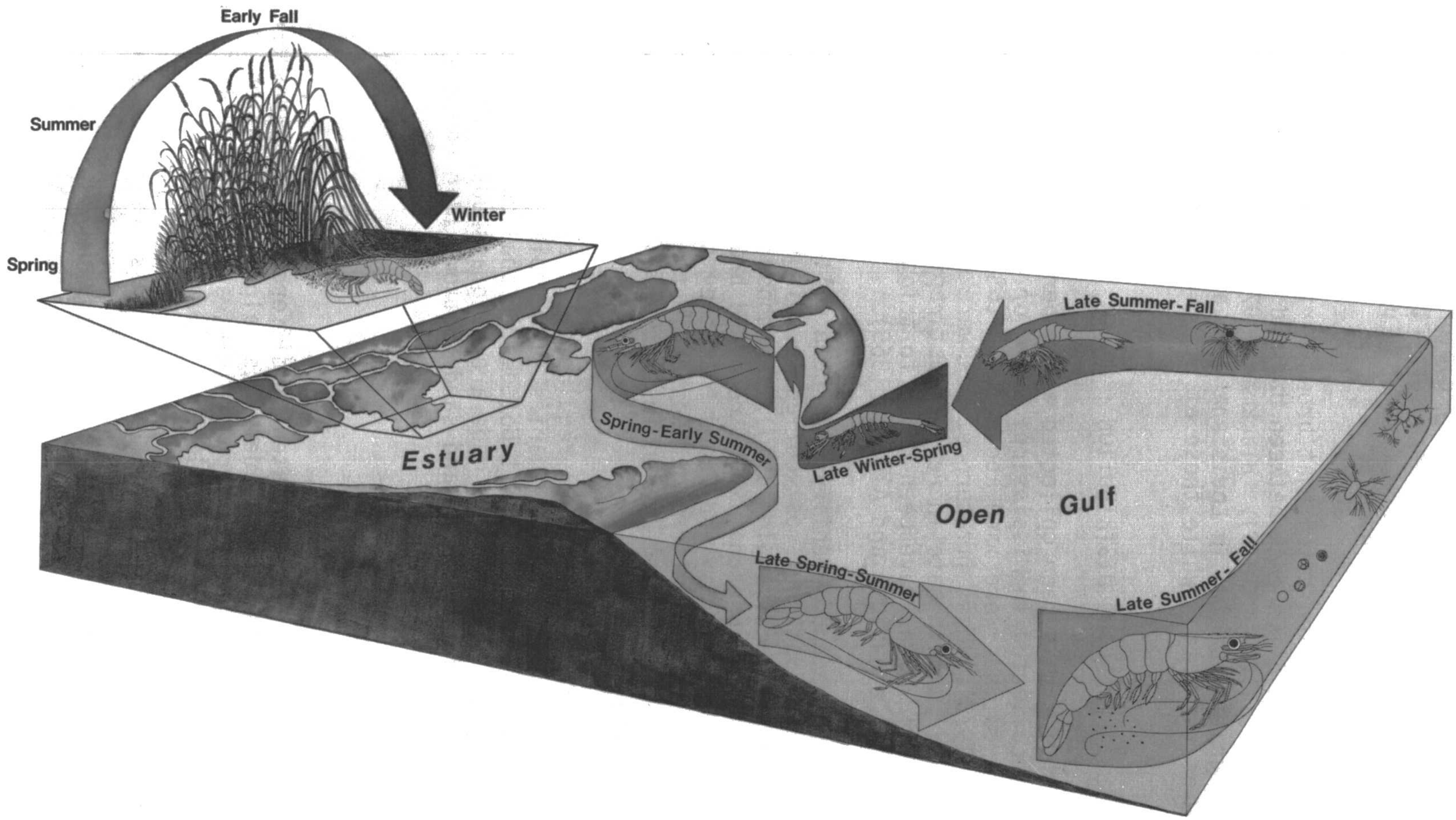

Figure 2. Sketch of brown shrimp seasonal movements between the Gulf and estuaries. Brown shrimp occurrence in marsh nursery areas is simultaneous with maximum production of food from adjoining marshes (from Gosselink 1980).

nursery grounds to tidal passes and that seaward currents influence the time of migration. Migrating brown shrimp are commonly captured in the navigation channels during June and July, presumably because of the faster currents. A mark-recapture study showed some longshore movement (up to 314 km or 195 mi) in the offshore area (Cook and Lindner 1970).

Although earlier studies indicated that brown shrimp migrated at night, recent studies found little difference between day and night catches (e.g., Kutkuhn 1966; Clark and Caillouet 1975). Blackman (1974) observed that the highest catches of migrating shrimp in Louisiana were at twilight; peak catches during the day were at the bottom while those at night were near the surface.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Although brown shrimp have been collected at temperatures as low as 2°C (36°F), few have been collected in Mississippi Sound or Mobile Bay below 10°C (50°F) and the largest catches were made above 20°C (68°F) (Swingle 1971; Christmas and Langley 1973). Most immature stages were collected between 15° and 35°C (59° and 95°F). Growth rate increases most rapidly between 17° and 25°C (63° and 77°F). Cold waves have been known to trigger migrations from estuaries to deep water (Zein-Eldin and Aldrich 1965).

Brown shrimp postlarvae and juveniles have been collected in salinities ranging between 0.2 to 35.5 ppt, but most collections in Mississippi Sound were taken above 5 ppt (Christmas and Langley 1973), and those in Alabama (Swingle 1971) were as low as 0.2 ppt. Loesch (1976b) reported brown shrimp in salinities as low as 0.2 ppt in Mobile Bay and found that they tolerated a wider range of salinity (5 to 30 ppt) in the hotter months than in the cooler months (10 to 15 ppt). Adult brown shrimp have been taken in the Gulf of Mexico waters ranging from 20 to 39 ppt salinity.

There are no data on dissolved oxygen requirements, but brown shrimp postlarvae are captured in turbid areas in estuaries (Van Lopik et al. 1979). In the estuaries postlarval shrimp prefer soft bottoms in shallow areas, preferably in or near marshes. Highest catches were made around grassbeds. In the offshore area brown shrimp are found in mud and sandy bottoms (Van Lopik et al. 1979).

FOOD HABITS

Brown shrimp are omnivores. Foods eaten at different life stages are: larvae - algae, zooplankton; postlarvae - detritus, algae, zooplankton, and microorganisms; juveniles - detritus, microorganisms; adults - detritus, algae, copepods, and ostracods (Van Lopik et al. 1979).

Laboratory studies of food conversion, growth, and survival rates of postlarval and juvenile brown shrimp showed maximum efficiency at 26°C (79°F) and low efficiency below 21°C (70°F) or above 31°C (88°F) (Venkataramaiah et al. 1972). These studies have been supported by field observations (St. Amant et al. 1963).

VALUE TO MAN

The brown shrimp is the principal component of the commercial shrimp fishery in the Gulf of Mexico. Loesch (1976a) estimated, from experimental trawling, that the standing crop of brown shrimp available for commercial shrimp trawling in Mobile Bay in June through August ranged from 52 to 135 mt. The commercial bait shrimp fishery in Mississippi Sound sold almost 590,000 live shrimp in July and in August in 1971 (Christmas et al. 1976).

The brown shrimp is preyed upon by at least 14 fish species of importance to man (Gunter 1945; Darnell 1958). Van Lopik et al. (1979) described a comprehensive plan for the management of brown shrimp in the Gulf of Mexico which emphasizes the importance of maintaining suitable freshwater inflow and low salinity to help assure high production. Christmas et al. (1976) described the use of postlarvae abundances in the spring months as a method for predicting harvest during the year.

WHITE SHRIMP

Penaeus setiferus

INTRODUCTION

The white shrimp is abundant in Mississippi Sound and Mobile Bay in the summer and fall. In recent years, the commercial catch of white shrimp in Alabama-Mississippi coastal waters has declined, primarily in the offshore area. From 1968 to 1977 the average annual catch of white shrimp in the study area averaged 828 mt or 16% of the area shrimp harvest (NMFS 1981a). An abundance of information is available on the distribution, environmental preferences, and life history of this species, but data deficiencies exist on the effects of temperature, salinity, dissolved oxygen, and depth on early life history stages.

DISTRIBUTION AND BEHAVIOR

Adults spawn in the Gulf and the eggs hatch into free-swimming larvae from March to October (Van Lopik et al. 1979). Eggs are demersal, but larvae occupy all layers in the water column (Subrahmanyam 1971). Adults spawn in areas where the depth ranges between 8 and 34 m (26 and 112 ft). The postlarvae are carried into the shallow bays on flood tides entering the estuaries through deep passes. In Mississippi and Alabama, postlarval recruitment to the estuaries extends from May through October (Christmas et al. 1966; Loesch 1976a). During the postlarval and juvenile stages, the shrimp are in the shallow, muddy bottom areas of estuaries, usually near marshes, and are benthic feeders (Van Lopik et al. 1979). After living several months in the shallow nursery areas, the maturing juvenile shrimp move to deeper waters of the estuary and become vulnerable to the fishery. The fishery in Mobile Bay extends from July to November (Loesch 1976a). The offshore migration is between June and November at night near the surface during ebbing tides (Russell 1965). Adult shrimp in offshore waters live primarily on the bottom, but during migration they have a tendency to school. Loesch (1976a) also reported that larger shrimp enter lower Mobile Bay during the early part of the year, but most leave by June.

Tides, temperature, salinity, light, and turbidity affect white shrimp behavior. Tides and changes in water temperature have a major influence on shrimp migration. Flood tides carry postlarval shrimp into the estuaries in the spring and summer (Lindner and Anderson 1956). Falling tides and falling water temperatures stimulate offshore migration in the fall. Temperature and salinity greatly influence growth and mortality rates, and time of spawning. Growth rates are highest when temperatures warm above 20°C (68°F), and spawning is stimulated by a sudden warming of offshore waters in the spring (Lindner and Anderson 1956). White shrimp are normally active at night, but diurnal activity is highly variable. Turbidity in the spawning and larval habitats of the white shrimp usually is low, but postlarvae, juveniles, and adults tolerate relatively high turbidities in estuaries (Linder and Anderson 1956).

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

White shrimp seek deeper and warmer water as water temperatures decrease in the fall and winter, and enter shallow waters when coastal water temperatures rise in the spring (Lindner and Anderson 1956). Postlarvae have been observed at temperatures ranging from 12° to 32°C (54° to 90°F) and juveniles from 12° to 36°C (54° to 97°F) (Perez-Farfante 1969). Postlarvae normally enter major bays when temperatures are above 25°C (77°F) which is apparently near the optimum for growth and survival (Baxter and Renfro 1967). Adults have been observed at water temperatures between 4° and 31°C (39° and 88°F) (Perez-Farfante 1969); winter kills may occur below 4°C (39°F).

Juvenile white shrimp have been collected in waters ranging from less than 1 ppt (Gunter et al. 1964) to 48 ppt salinity (Hildebrand 1958). Juvenile white shrimp are more abundant in low salinities (< 10 ppt) than are brown or pink shrimp. Loesch (1976b) found that white shrimp were most plentiful at low salinities (below 5 ppt) during the warm months in Mobile Bay. During the winter a wide range of salinities was utilized. Adult white shrimp have been taken over a salinity range from 0.1 ppt to over 40 ppt (Gunter et al. 1964). Optimum salinities appear to be between 10 and 15 ppt (Gunter 1961).

White shrimp spawn in waters between 8 and 34 m (26 and 112 ft) deep and some have been taken in 50 m (164 ft) of water (Russell 1965). While in the estuaries, they sometimes are taken in habitats less than 1 m (3 ft) deep, but as they mature, they gradually move to deeper waters of the estuaries.

In estuaries, juvenile white shrimp prefer a soft mud or peat bottom containing large quantities of decaying organic matter or vegetation (Van Lopik et al. 1979). In the Gulf, white shrimp live in muddy or silty bottoms, and on clay or sand with fragments of shell.

Currents partially control the spring inshore and fall offshore migrations of the white shrimp. Tidal currents through the passes are vital to inshore postlarval distribution. Longshore currents in the offshore waters help direct the movement of shrimp toward the Mississippi River Delta south of the Mississippi barrier islands (Lindner and Anderson 1956).

FOOD HABITS

White shrimp are omnivores. Postlarval shrimp in estuaries feed mainly at the marsh-water interface or in submerged grassbeds. As they grow, the shrimp move to deeper waters and become more predatory. Foods eaten at different life stages are as follows: larvae - algae, zooplankton; postlarvae - algae, flagellates, nauplii, copepods, detritus; juveniles - detritus, microorganisms; adults - detritus, forams, copepods, insect larvae, mollusks, ostracods (Van Lopik et al. 1979).

VALUE TO MAN AND ECOLOGICAL ROLE

White shrimp (along with the brown and pink shrimp) contribute substantially to the commercial food fishery in the Gulf of Mexico. There is also a large recreational fishery for white shrimp. Loesch (1976a) estimated that the monthly standing crop in Mobile Bay available to trawls from July to November ranged from 30 to 121 mt. The white shrimp is also harvested for the bait market (Christmas et al. 1976).

The white shrimp is preyed upon by a large number of fishes and birds. It is an extremely important component in the marine-estuarine food web and constitutes a large portion of the diet of many fishes. Gunter (1945) and Darnell (1958) listed 14 species of fish that often feed on penaeid shrimp.

PINK SHRIMP

Penaeus duorarum

INTRODUCTION

The pink shrimp is a relatively uncommon decapod crustacean in Mississippi Sound and Mobile Bay (Christmas et al. 1966). From 1968 to 1977 the average annual commercial catch from the study area was 98 mt or about 2% of the total shrimp catch (NMFS 1981a). Within the study area 73% were taken offshore, 22% in Mississippi Sound, and 5% in Mobile Bay. In the Dry Tortugas area off southwest Florida, the pink shrimp dominates the commercial shrimp catch. Its life history is much the same as brown and white shrimp, but there are differences in the time that various life history stages reach maximum abundance. Because of its lesser importance in the Missisippi Sound-Mobile Bay fishery, it has not been investigated much in this area. There are life history studies on the pink shrimp in Florida and Texas and much of the environmental data on pink shrimp have been derived from these areas (Perez-Farfante 1969).

DISTRIBUTION AND BEHAVIOR

Adults spawn in the Gulf and the pelagic eggs develop into free-swimming larvae from May to November (Van Lopik et al. 1979). Spawning occurs at depths between 4 and 52 m (13 and 171 ft). Larvae pass through a series of molts that last approximately 2 weeks. During the postlarval stage, tidal currents carry the young shrimp through deep passes into estuarine nursery grounds. In Mississippi, postlarval recruitment to the estuaries extends from May through November (Christmas et al. 1966). Once in the estuaries, the shrimp occupy firm sand or mud bottom habitats and become bottom feeders (Van Lopik et al. 1979).

After several months in the estuaries, the maturing juvenile shrimp migrate offshore in April-September at night near the surface during ebbing tides (Russell 1965). During migrations, pink shrimp have a tendency to school. The pink shrimp is primarily nocturnal (Hoese et al. 1968).

Tides, temperature, salinity, light, and turbidity affect pink shrimp behavior. Tides and water temperature changes have a major influence on shrimp migration. For example, rising tides are important for carrying postlarval shrimp into the estuaries in the summer and early fall. Falling tides and falling temperatures stimulate offshore migration in the fall. Temperature and salinity largely determine growth and mortality rates and time of spawning. Growth rates accelerate when temperatures warm above 20°C (68°F) and spawning is initiated by the sudden warming of offshore waters in the spring (Lindner and Anderson 1956). Pink shrimp are normally active in the water column at night, and they burrow in the bottom during the day (Gehring 1971). Turbidity in the spawning, larval, and adult habitats of the pink shrimp is relatively low, but juveniles tolerate moderate turbidity while they are in the estuarine nursery grounds.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Pink shrimp seek warmer and deeper water as water temperatures drop in the fall and winter and enter shallow water when temperatures rise in the spring (Costello and Allen 1970). Spawning occurs between 19° and 25°C (66° and 77°F) but larvae have been observed at temperatures as high as 37°C (99°F) (Thorhaug et al. 1971). Juveniles have been taken in waters from 4° to 34°C (39° to 93°F) and adults in waters from 10° to 36°C (50° to 97°F) (Costello and Allen 1970).

Juvenile and adult pink shrimp have been taken in waters ranging from 0 to 70 ppt salinity (Costello and Allen 1970). Adults do not tolerate dissolved oxygen levels less than 4 mg/l (Subrahmanyam 1962).

Pink shrimp spawn at depths from 4 to 52 m. Larvae have been taken in waters from 16 to 60 m deep. In the estuarine nursery grounds, the juveniles occur in very shallow (<1 m) water (Costello and Allen 1970).

Pink shrimp inhabit firm mud or silt bottoms, coral sand bottoms containing a mixture of mollusk shells (Springer and Bullis 1954), and firm sand bottoms (Perez-Farfante 1969). In the Dry Tortugas area off southwest Florida, pink shrimp prefer calcareous sediments.

FOOD HABITS

Pink shrimp are omnivores. In offshore waters, larval pink shrimp feed mainly on algae and zooplankton in the open water column. Postlarvae feed on algae and crustacean nauplii. Within the estuary, juveniles feed mainly on detritus algae, diatoms, dinoflagellates, forams, other microorganisms, nematodes, polychaetes, mollusks, copepods, isopods, amphipods, mysids, and fish. Adults feed on decaying organic matter, plants, and animals (Van Lopik et al. 1979).

ECOLOGICAL ROLE AND USES BY MAN

The pink shrimp (along with the brown and white shrimp) comprise the most valuable commercial fishery in the Gulf of Mexico. In Misssissippi Sound, brown and white shrimp predominate. The pink shrimp make up only about 2% of the catch, but have been an important component of the spring fishery. The center of the pink shrimp fishery is in the Dry Tortugas area off southwest Florida and the Campeche Banks off the west coast of the Yucatan Peninsula (U.S. Department of the Interior 1969). Pink shrimp sometimes are taken incidentally by sport shrimpers trawling primarily for brown and white shrimp. Methods have been developed for culturing postlarval pink shrimp for use in intensive shrimp farming or for stocking natural areas (Tabb et al. 1972).

The pink shrimp is preyed upon by a large number of fishes and birds. It is an extremely important component in the marine-estuarine food web and constitutes a large portion of the diet of many fishes. Gunter (1945) and Darnell (1958) listed 14 species of fish that fed on penaeid shrimp in significant quantities.

BLUE CRAB

Callinectes sapidus

INTRODUCTION

The blue crab ranges from Nova Scotia to Uruguay and supports important fisheries along the Gulf and Atlantic coasts. Blue crabs, along with the majority of Mississippi and Alabama's commercial seafood species, are estuarine-dependent, spending a portion of their life cycle in coastal waters. Adult females spawn around and south of the barrier islands; the ensuing larvae undergo a period of development in open Gulf waters. They move into the estuary when they have reached the postlarval or megalopal stage.

The blue crab is a migrant, occupying various habitats in local waters, depending upon the physiological requirements of each particular stage in its life history. Salinity, temperature, and availability of food and adequate habitat all influence the distribution of the blue crab.

Some information in this synopsis is taken from unpublished data collected by personnel of the Fisheries Research and Development Section (Gulf Coast Research Laboratory, Ocean Springs, Mississippi) during the course of Project 2-296-R under Public Law 88-309 (Fisheries Monitoring and Assessment). The reader is also referred to Perry (1975, 1980) and Stuck and Perry (1981) from which data were synthesized.

MATING AND SPAWNING

The female blue crab mates only once, at the time of its final molt. Sperm transferred to the female remain viable for a year or more and are used for repeated spawnings (laying of eggs). Mating and spawning occur from March through November, with peak spawning from May through September. Blue crabs usually spawn within 2 months after mating in the spring and summer. Females that mate in the fall may delay spawning until the following spring. Spawning may take place inshore as well as in offshore waters. Crabs that spawn inshore usually move to higher salinity waters prior to the hatching of the eggs. The eggs are carried beneath the female in a mass known as a "sponge" or "berry." The number of eggs in a sponge may approach two million (Churchill 1919). The eggs hatch in about 2 weeks. According to Sandoz and Rogers (1944), optimal salinities for hatching are between 23 and 30 ppt. Hatching in their study occurred over a wide range of salinity (9 to 32 ppt). Eggs hatch successfully at temperatures between 19° and 29°C (66° and 84°F). The upper temperature range for hatching in northern Gulf waters is probably somewhat higher (32°C or 90°F).

By using the ovarian stages described by Hard (1942), the seasonal reproductive characteristics of the blue crab in Mississippi can be defined. Recently mated females (Stage I) and crabs with developing ovaries (Stage II) are observed in the spring, summer, and fall. Females with mature ovaries (Stage III) occur throughout the year. The appearance of berried females (Stage IV) in March and April indicates that overwintering Stage II females spawn when water temperatures begin to rise in the spring. Stage IV crabs are most abundant during the middle and late summer, corresponding with the influx of mature female crabs from offshore waters. Stage V crabs (spent females) appear during the summer and provide evidence that some females spawn twice in local waters.

DISTRIBUTION OF ZOEAE AND MEGALOPAE

After hatching, crab larvae pass through the zoeal and megalopal stages. The zoeal stage lasts from 31 to 47 days during which it undergoes seven molts. Peak numbers of Callinectes spp. zoeae are collected in Mississippi waters in the summer and early fall. Zoeae have been found in temperatures from 19° to 32°C (66° to 90°F) and in salinities from 21 to 32 ppt. Optimal salinity and temperature ranges for zoeal ecdysis are from 21 to 28 ppt and 20° to 29°C (68° to 84°F), respectively (Sandoz and Rogers 1944). Zoeal stages are rarely found in Mississippi Sound in salinities below 21 ppt. Zoeae are distributed throughout the water column.

Megalopae can survive a broad range of temperature and salinity from early spring to late fall. Megalopae have been collected in Mississippi waters in temperatures ranging from 13° to 32°C (55° to 90°F) and in salinities ranging from 5 to 37 ppt. Seasonally, they are most abundant in the late spring-early summer and in the late summer-early fall. Abundance peaks over a salinity range of 15 to 25 ppt. Megalopae exhibit wide areal distribution, not only in plankton samples near the barrier islands, but also in beam net samples taken in shallow nearshore waters. The megalopal stage normally lasts from 6 to 9 days. Metamorphosis to the first crab stage takes place in inshore waters.

JUVENILE DISTRIBUTION

Juvenile blue crabs live in estuarine nursery grounds throughout the year. They congregate in channels with soft mud sediments and in the marshes that fringe the bays and coastline. Substrate as well as salinity is an important factor in the distribution of the juveniles. Most young crabs in Mississippi and Alabama live in mud bottoms.

Juvenile crabs live in water temperatures ranging from 4° to 37°C (39° to 99°F) and in salinities from 0 to 32 ppt. They are most abundant in salinities from 5 to 15 ppt and in temperatures between 20° and 26°C (68° and 79°F).

FOOD HABITS

The meroplanktonic zoeae are filter feeders, straining microscopic plants and animals from the water. Megalopae have well-developed chelae, which they use to capture food much the same as the adult crab. While in the plankton, they feed upon other zooplankters. Once they drop to the bottom, they become opportunistic benthic omnivores. Juvenile and adult blue crabs also are opportunistic benthic omnivores feeding on clams, mussels, oysters, snails, fish, algae, seaweeds, marsh grasses, and detrital material (Darnell 1958).

GROWTH

Crabs are able to increase in size only by shedding their chitinous exoskeleton. After each molt, a crab may increase in width as much as 25% of its initial size. The entire molting process is completed in a matter of hours. Female crabs cease to molt after they become sexually mature, but males continue to molt and grow after gonadal maturation. Small crabs shed every few days, but the time interval between molts increases as crabs grow. A blue crab will undergo approximately 25 molts during its life. Growth rates for crabs in Mississippi, estimated from width-frequency distributions, averaged 24 to 25 mm/month. Blue crabs reach commercial size within a year following hatching.

ADULT DISTRIBUTION AND MIGRATION

Adult crabs exhibit a differential distribution of males and females in relation to salinity. Male crabs tend to remain in low salinity areas and females in waters with salinities above 20 ppt. Maximum availability of females occurs in the spring and summer and is associated with the movement of over-wintered crabs in coastal waters. Adult females are conspicuously absent during the winter in all areas of Mississippi Sound east of the Gulfport Channel (Figure 1). The migration of females to the Gulf with decreasing water temperatures during the summer may account for this absence.

The two major movements of blue crabs into Mississippi Sound are in the late fall and in the summer. A tagging program in 1971 documented the fall migration of crabs into western Mississippi Sound from Lakes Pontchartrain and Borgne, Louisiana, with the advent of cold weather. Winter crabbing in the Sound is centered in this area. Most are mated females that seek high salinity water when temperatures begin to drop. These crabs remain in the Cat Island-Pass Marianne area through the winter, moving into coastal waters in the spring. Many of the early spring spawners in Mississippi Sound are part of this population.

The winter distribution of mature female crabs that move into Mississippi Sound in the late spring and summer is unknown. Most of these crabs are females that have had one or more sponges. Many are fouled with barnacles and heavily parasitized, which is evidence that these crabs have been in high salinity water prior to their movement into the Sound.

Crabs tagged in coastal bays in the summer showed little lateral movement or migratory patterns.

COMMERCIAL FISHERY

Commercial fishing for blue crabs in Mississippi began in the late 1880's with landings of 17,100 kg (37,699 lb) recorded for the year 1887 (Lyles 1969). The use of more efficient gear, greater fishing effort, and market demand have increased Mississippi's landings to an average of 706,875 kg (1,558,393 lb) a year for the 10-year period from 1970 to 1979 (U.S. Department of Commerce 1970-1979). Yearly landings during this period varied from a high of 912,343 kg (2,011,372 lb) in 1979 to a low of 511,470 kg (1,127,598 lb) in 1975. Landings approaching 900,000 kg (1,984,160 lb) were recorded in 1977 and 1978.

The sex ratio of crabs landed in Mississippi depends on the area and season fished. During the winter, fishing is centered in the Cat Island-Pass Marianne area where gravid females make up a large portion of the catch. During the spring and summer catches are mixed. Males are more abundant in areas of low salinity (coastal bays and bayous) and females predominate in intermediate and high salinity waters. A large percentage of the females taken in July and August are "berried." Tatum (1981) provided a detailed overview of the Alabama fishery.

RECREATIONAL FISHERY

Sport crabbers in Mississippi took about 22,500 kg (49,600 lb) of crabs in 1971 (Herring and Christmas 1974). In addition to the sport catch, many licensed commercial fishermen keep crabs caught in shrimp trawls. Many licensed blue crab fishermen do not sell their catch commercially. Landings of blue crabs by these individuals amounted to 64,115 kg (141,349 lb) in 1974, 35,172 kg (77,541 lb) in 1975, and 44,279 kg (97,618 lb) in 1976 (Fisheries Research and Development Section, Gulf Coast Research Laboratory, Project 2-217-R, unpublished data).

CAUSES OF FLUCTUATIONS IN ABUNDANCE

Great interest has been expressed in determining the cause of observed fluctuations in blue crab populations. The size of natural populations generally tends to be stable and regulated despite some fluctuations in abundance. Density-dependent factors (changes in meteorological and/or hydrological conditions) may greatly influence population size. The vulnerability of blue crabs to changing environmental conditions is greatest during the larval and early juvenile stages of their life cycle. The microscopic blue crab larvae are found in open Gulf waters and are thus subject to offshore currents for a period of up to 1 month. This type of larval dispersal mechanism helps to insure wide distribution of the species; however, it may be a limiting factor in determining the success of a year class or part of a year class if currents that normally move the larvae toward the estuary are altered. The larvae also are very susceptible to changes in temperature and salinity; e.g., the larvae will not develop and molt successfully in salinities below 20 ppt.

Once the late stage larvae (megalopae) have reached the estuary, the major concerns for the survival of future stocks are related to the maintenance of adequate habitat (density-dependent factor) and favorable biological and environmental conditions (density-independent factor) on the nursery grounds. Blue crabs not only compete with each other for space, but with other estuarine-dependent and endemic species. Any loss of marshland and tidal habitat decreases the available areas where they can feed and grow.

DATA GAPS

Although much of the life history of the blue crab in the northern Gulf is well known, additional data are still needed in many areas. Precise information is lacking on the seasonal, areal, and vertical distribution of larvae in Gulf waters and mechanisms of larval transport. Although managed separately by individual States, blue crabs are not restricted by boundaries and move freely through the waters of the north central Gulf. Cooperative tagging programs are needed to identify and separate blue crab stocks. Monitoring and assessment studies should be encouraged to further elucidate the effects of environmental conditions on populations of young blue crabs. Data are also needed on parasites and diseases that affect natural populations.

LESSER BLUE CRAB

Callinectes similis

INTRODUCTION

The lesser blue crab is abundant in northern Gulf waters. Young individuals closely resemble *C. danae* and *C. ornatus*, and species referred to in previously published accounts of the northern Gulf probably were *C. similis*.

The lesser blue crab, of no economic or food value, has received little scientific study. Much of the information reported here was taken from unpublished data collected by personnel of the Fisheries Research and Development Section (Gulf Coast Research Laboaratory, Ocean Springs, Mississippi) during the course of Project 2-296-R under Public Law 88-309 (Fisheries Monitoring and Assessment).

LIFE HISTORY

Callinectes similis lives year round in the offshore waters of Mississippi and is seasonally abundant in Mississippi Sound. Highest catches in the Sound are in the late spring-early summer and in the fall. They have been collected in Mississippi waters in temperatures ranging from 6° to 37°C (43° to 99°F). Early juveniles may be found on inshore nursery grounds in all but the coldest months. Lesser blue crabs have been taken in salinities from 0 to 37 ppt; however, they are most abundant in salinities over 24 ppt. Catches of small *C. similis* in the Sound are often mixed with young blue crabs, *C. sapidus* (Perry 1975). Mixed catches occur frequently on inshore nursery grounds of intermediate salinities.

Catches of lesser blue crabs in the Sound are predominately juveniles. Adult females are occasionally taken, but are more common south of the islands. Ovigerous (egg-carrying) females rarely occur in inside waters. Older juveniles and adults inhabit high salinity waters of the Sound throughout the year, especially in deep channels.

This crab spawns offshore possibly year round; ovigerous females have been observed in all months. The megalopae are seasonally abundant (February through April) in waters near the barrier islands (Stuck and Perry 1981), with maximum numbers occurring in temperatures between 17° and 20°C (63° and 68°F). They have been collected in temperatures ranging from 8° to 32°C (46° to 90°F). Megalopae are most abundant in salinities above 24 ppt, but some live in salinities as low as 11 ppt. Data are lacking on the areal and vertical distribution of zoeal stages.

CHAPTER 3. CHONDRICHTHYS

BLACKTIP SHARK

Carcharhinus limbatus

INTRODUCTION

The literature on sharks of the western North Atlantic, including the Gulf of Mexico, consists primarily of synopses of data gathered during general shark surveys. Biological knowledge of sharks of the Gulf of Mexico is based largely on surveys of southern Florida or Texas waters, or on interpolations of data from the Atlantic coast of the United States (Radcliffe 1916; Springer 1938, 1940; Bigelow and Schroeder 1948; Baughman and Springer 1950; Clark and von Schmidt 1965; Dodrill 1977). Portions of Springer's data were from the northern Gulf but were not analyzed separately. Two recent keys (Hoese and Moore 1977; Boschung 1979) indicated that blacktip shark live in the northern Gulf, and Branstetter (in press, a) discussed the biological data of 650 sharks of 18 species taken from the north central Gulf. Records are numerous, but some are questionable due to the blacktip's close resemblance to the spinner shark (*C. brevipinna*) (Branstetter in press, b).

REPRODUCTIVE BIOLOGY

The mating season of the blacktip shark is from early June through early July; the gestation period is about 10 to 12 months (Clark and von Schmidt 1965; Branstetter in press, a). In May and June the females bear 3 to 10 pups about 50 to 60 cm (20 to 24 inches) total length (TL) (Radcliffe 1916; Bigelow and Schroeder 1948; Baughman and Springer 1950; Springer 1960; Clark and von Schmidt 1965; Branstetter in press, a). Males are usually mature between 130 and 135 cm (51 and 53 inches) TL, and females reach maturity when 150 to 155 cm (59 to 61 inches) TL (Bigelow and Schroeder 1948; Springer 1960; Clark and von Schmidt 1965; Branstetter in press, a).

SEASONAL DISTRIBUTION AND ABUNDANCE IN THE NORTHERN GULF

The blacktip shark was the second most abundant species taken in studies by Branstetter (in press, a) and the most common shark taken in Alabama coastal waters. Branstetter took them regularly and in good number from February through October throughout the northern Gulf. Similar seasonal abundance was reported off Englewood (Springer 1938, 1940) and Sarasota, Florida (Clark and von Schmidt 1965). These specimen records include new-born pups to breeding adults. The coastal waters of eastern Louisiana, Mississippi, Alabama, and northwest Florida are a nursery area for C. limbatus (Branstetter in press, a).

SPATIAL DISTRIBUTION IN THE NORTHERN GULF

Springer and Bullis (1956) reported captures of blacktip shark off the coast of Louisiana and Mississippi, and Springer (1960) reported a number of specimens taken near the mouth of the Mississippi River. Branstetter (in press, a) took juveniles and adults in Mobile Bay, Mississippi Sound, and adjacent coastal waters. Older juveniles and adults were taken throughout the continental shelf waters of the north central Gulf, and at the surface of waters over 800 m (2,625 ft) deep near the DeSoto Canyon. This species is ubiquitous in the Gulf of Mexico, and is cosmopolitan in warm temperate and tropical waters.

ENVIRONMENTAL CONDITIONS AFFECTING DISTRIBUTION

Sharks tend to leave the shallows during hot weather (Springer 1963) and move to deeper and warmer waters in winter (Springer 1960). S. Branstetter (University of South Alabama, Mobile; personal communication) stated that blacktip sharks were not collected in the northern Gulf if water temperatures for the upper 50 m (164 ft) were below 18°C (64°F). This may be due to the fact that many fish which are staple foods for sharks tend to move offshore in winter, and sharks may follow this food source.

Blacktip sharks usually inhabit offshore waters of the Gulf where salinities are 30 ppt or more, but adults and juveniles have been collected from lower Mobile Bay in brackish water (Branstetter in press, a). Blacktip sharks are taken in coastal waters, continental shelf waters, and open pelagic waters.

Blacktip sharks are most abundant near the Mississippi River or in areas influenced by river discharges (see Springer 1960; Branstetter in press, a), but they apparently show little preference for substrate.

FOOD HABITS

The literature on the food habits of blacktip shark agrees that fish is the major food. Feeding apparently increases during crepuscular and nocturnal periods, but like most sharks this species feeds day and night.

ECOLOGICAL ROLE AND USES BY MAN

The population of blacktip sharks in the northern Gulf is large enough to substantially contribute to the commercial shark fishery. The marketability of meat is good, and the large fins are processed for food (Springer 1979). Its size and peculiar trait of leaping completely from the water when hooked make the blacktip shark an acceptable sport fish for anglers, but the number of anglers who actively fish for sharks in the northern Gulf of Mexico is small.

All of the carcharhinid sharks are apex predators. It is possible that the blacktip shark is numerous enough to have a measurable effect on the populations of prey species of fish.

SPINNER SHARK

Carcharhinus brevipinna

INTRODUCTION

The general literature on the spinner shark is the same as that for the blacktip shark. Valid records for the spinner shark in the Gulf and elsewhere are scarce because it is often confused with the morphologically, zoogeographically, and ecologically similar blacktip shark, *C. limbatus* (Branstetter in press, b).

REPRODUCTIVE BIOLOGY

Springer (1938, 1940) reported only adult male spinner sharks off Englewood, Florida. Bigelow and Schroeder (1948) examined a gravid female (190.5 cm or 75 inches total length) with 10 embryos from Florida (east or west coast unknown). Springer (1960) wrote that newborn pups were 60 to 75 cm (24 to 30 inches) long (TL), that 10 mature males were 175 to 225 cm (69 to 89 inches) long, and that 12 mature females were 188 to 244 cm (74 to 96 inches) long. Clark and von Schmidt (1965) took 20 spinner sharks (juveniles of both sexes, and subadult and adult males) near Sarasota, Florida. A small number of juveniles was examined by Hoese (1965) at Port Aransas, Texas, and 35 specimens from the north central Gulf were examined by Branstetter (in press, a), including 2 mature males (171 and 181 cm or 67 and 71 inches long), and 7 gravid females (191 to 225 cm or 75 to 89 inches long). Branstetter reported that mating was from mid-June through mid-July, and the gestation period was 11 to 12 months. Parturition usually is in late May and early June. Most females bear 6 to 12 pups, 60 to 70 cm (24 to 28 inches) long. The northern Gulf coastal waters are a nursery area for this species.

SEASONAL DISTRIBUTION AND ABUNDANCE IN THE NORTHERN GULF

In Louisiana waters, Springer and Bullis (1956) reported the capture of four spinner sharks during June-August 1953 through 1955, and Springer (1960) reported several captures off Louisiana in August 1947. The National Marine Fisheries Service (NMFS) in Pascagoula, Mississippi, has three records of spinner sharks (one each in January, February, and August) for the north central Gulf of Mexico (Elmer Gutherz, NMFS, Pascagoula; pers. comm.). Branstetter (1980) took spinner sharks in every month except January and March. He reported that the population of spinner sharks inhabiting the northern Gulf was small compared to that of other carcharhinid sharks of the area (but they did occur regularly from spring through early winter), and that portions of the population may overwinter in the northern Gulf shelf waters. Sexual segregation may occur in winter as the records of Springer (1960) and Clark and von Schmidt (1965) indicated males predominated the catch of spinners from the central Florida Gulf coast. The winter records of Branstetter (1980), however, included two mature females and one immature male.

SPATIAL DISTRUBTION IN THE NORTHERN GULF

Spinner sharks are apparently more common west of 88°W in the northern Gulf (see below). Moran (1972) reported examining one set of jaws taken from a specimen captured near Cape San Blas, Florida. Branstetter (1980) reported captures of 2 spinner sharks off Santa Rosa Island, Florida, and captures of 32 spinner sharks between the mouth of Mobile Bay and the mouth of the Mississippi River on the continental shelf. Springer and Bullis (1956) and Springer (1960) reported that exploratory or commercial longliners took spinner sharks only off the coast of Louisiana out to waters over 1400 m (4,593 ft) deep. Branstetter (1980) reported juveniles were mainly taken in shallow coastal waters, but subadults and adults were taken in waters greater than 40 m (131 ft) deep, especially in areas with a "shelly" substrate.

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

Sharks tend to leave the shallows during hot weather (Springer 1963), and move to deeper and warmer waters in winter (Springer 1960). Branstetter (1980) reported that spinner sharks were not collected in the northern Gulf if water temperatures for the upper 50 m (164 ft) were below 18°C (64°F). Because many fish which are eaten by sharks move offshore in winter, the sharks may follow.

Spinner sharks usually inhabit offshore waters where salinities are greater than 30 ppt, and low salinities in inshore estuaries may be a barrier to spinner sharks. Branstetter (1980) did not take any spinner sharks in Mobile Bay or Mississippi Sound waters. Springer and Bullis (1956) reported captures of spinner sharks near Petit Bois Island (Figure 1). R. Lukens (Gulf Coast Research Laboratory, Ocean Springs, Mississippi; pers. comm.) reported sighting specimens near Petit Bois Island, but this area is not greatly affected by freshwater influence.

Most captures of *C. brevipinna* are from continental shelf waters less than 200 m (656 ft) deep, but this may be due to a lack of sampling in deeper waters. The area west of 88°W in the northern Gulf changes from a sand to a sandy silt-clay mosaic with increased amounts of silt and clay towards the Mississippi River (Branstetter 1980). As discussed earlier, many spinner sharks have been recorded from the Mississippi Delta area, and this alluvial substrate may have been associated with the captures. Other factors (food abundance, nursery area) may also be important.

FOOD HABITS

The literature on spinner shark lists fish as the major food. Branstetter (1980) reported that this species will take available food throughout the day and night.

ECOLOGICAL ROLE AND USES BY MAN

The population of spinner sharks in the northern Gulf is probably not large enough to support a commercial fishery, but it might be a valuable contribution if combined with other sharks in the fishery. Springer (1979) lists the marketability of the hides, fins, and meat as excellent. The size and peculiar trait of leaping completely from the water when hooked make the spinner shark an exciting challenge to sport fishermen, but few spinner sharks are sought.

Spinner sharks, as all carcharhinids, are apex predators, but the effects on prey fish stocks are unknown.

ATLANTIC SHARPNOSE SHARK

Rhizoprionodon terraenovae

INTRODUCTION

The Atlantic sharpnose shark is one of the most common shark species in the northern Gulf of Mexico (Hoese and Moore 1977; Parsons 1981). This small shark, often a part of the incidental catch of commercial fishermen, is considered a nusiance to sport fishermen. Until recently, most of the information concerning this species in the northern Gulf of Mexico was in a few generalized studies (Springer 1938, 1940, 1950; Baughman and Springer 1950; Clark and von Schmidt 1965; Dodrill 1977). V. Springer (1964) revised the genus *Rhizoprionodon* and included a few comments on sharpnose life history. The life history of the Atlantic sharpnose shark has been recently described (Parsons 1981). There are no data available on trends in population size.

SEASONAL DISTRIBUTION

The migrations of the sharpnose shark are primarily limited to inshore/offshore movements. During summer, juveniles, subadults, and adults inhabit shallow inshore waters (Parsons 1981). Springer (1938) observed large schools of sharpnose sharks in Mississippi Sound in summer, but found no sharks there in winter. Sharpnose sharks migrate to offshore waters in the fall and concentrate in deeper offshore waters during the winter. Large schools of adult female sharpnose sharks inhabit offshore waters of the northern Gulf in fall, particularly winter and spring (Parsons 1981). Sharpnose sharks begin to move inshore again in mid- to late spring.

SPATIAL DISTRIBUTION

In the northern Gulf of Mexico, Parsons (1981) reported captures of sharpnose sharks between 87° and 91°W longitude (Pensacola, Florida, to the Louisiana delta area). Springer (1938) reported captures from Mississippi Sound as well as from waters near Englewood, Florida. Clark and von Schmidt (1965) obtained data from 22 sharpnose sharks captured in the Sarasota, Florida, area. Springer (1964) reported that sharpnose sharks are found throughout the eastern Gulf of Mexico and to the Yucatan Peninsula in the western Gulf.

REPRODUCTIVE BIOLOGY

The following account is from Parsons (1981). Male sharpnose sharks mature between 75 and 80 cm (30 to 31 inches) TL, and females mature between 80 and 85 cm (31 and 33 inches) TL. Mating probably peaks in July, and by August all gravid females contain embryos ranging from 5 to 11 cm (2 to 4 inches) TL. Embryos require 10 to 11 months gestation. Adult female sharpnose sharks move from offshore water to inshore nursery grounds in early summer to "pup." Females produce from three to seven pups a year. Pups average 32 cm (13 inches) long at birth.

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

Sharpnose sharks begin moving to offshore waters in the fall (Parsons 1981) when northern Gulf coastal water temperature drops to about 20° to 23°C (68° to 73°F). Sharpnose sharks return inshore in May and June when surface water temperatures around Dauphin Island, Alabama, have increased to about the same values. Sharks leave shallow areas during hot weather (Springer 1963).

In the Mobile Bay-Dauphin Island area, Alabama, sharpnose sharks were rarely encountered in salinities below about 20 ppt (Parsons 1981). Because of relatively high uniform salinities in Gulf of Mexico offshore waters, salinity likely has little effect on their distribution there.

Sharpnose sharks often are encountered in the littoral zone in summer and are captured at depths of 90 m (295 ft) in winter (Parsons 1981). The sharpnose shark lives in marine and brackish waters at depths as great as 280 m (919 ft) (Springer 1964).

Since sharpnose sharks have been reported over a wide geographical area, it is likely that they exhibit little substrate specificity; however, sharpnose sharks appear to be more common west of the Mobile Bay drainage (Benny Rohr, National Marine Fisheries Service, Pascagoula, Mississippi; pers. comm.). This may indicate an affinity for alluvial substrates.

FOOD HABITS

Bigelow and Schroeder (1948) reported that sharpnose sharks chiefly feed on small fish such as menhaden and parrotfish. Clark and von Schmidt (1965) examined stomach contents from 22 sharpnose sharks and found whiting, herring, menhaden, eels, and shrimp.

ECOLOGICAL ROLE AND USES BY MAN

In the northern Gulf of Mexico the Atlantic sharpnose shark has no commercial importance. This small shark is frequently caught by sport fishermen, but is usually released even though the flesh is good to eat. The sharpnose shark is an important predator in the northern Gulf of Mexico, and significant reductions in the size of its population could affect the stocks of many commercially important fish species.

ATLANTIC STINGRAY

Dasyatis sabina

INTRODUCTION

The Atlantic stingray is the most common ray of the northern Gulf coast (Gunter 1941; Swingle 1971; Christmas and Waller 1973). It is most abundant in Mississippi Sound and Mobile Bay from spring through fall. Most overwinter in the warmer offshore waters (Funicelli 1975) and in the deeper waters of the Mobile ship channel (Bault 1972). This ray was taken in fish collections in all months in Mississippi Sound except December-February (Christmas and Waller 1973), and in all months in Mobile Bay, especially in the winter and spring (Swingle 1971).

The Atlantic stingray has not been studied extensively because it has little or no economic value. Some data have been gathered on distribution, environmental requirements, growth of interuterine embryos, and morphology, but life history data are generally deficient. The Gulf Coast Research Laboratory has maintained a monitoring program for commercial species in Mississippi coastal waters since 1973, during which specimens of this species were collected routinely (Mississippi Annual Reports, undated).

DISTRIBUTION AND BEHAVIOR

Both adults and juveniles frequent estuaries and surf zones. Atlantic stingrays are essentially euryhaline, and their movements seem random except for migration to and from offshore areas in the fall and spring. Although they are common in the bays of Mississippi Sound, a majority were taken in fish samples along the beaches and near the barrier islands (Christmas and Waller 1973; Duda 1978). Catches of this species are not good measures of their abundance because they cover themselves with thin layers of substrate and are not easily captured in trawls and seines.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Water temperatures usually govern the seasonal abundances of the Atlantic stingray in the coastal waters (Christmas and Waller 1973). The abundance of stingrays increases inshore as the waters warm in the spring and decreases as waters cool in the fall. They live in small numbers in inshore waters during the winter months. Funicelli (1975) noted that bottom temperatures offshore of Mississippi were 6°C higher on the average than in Mississippi inshore waters in November and December, and remained higher through March; a sufficient difference to trigger migrations to offshore waters in the fall. He reported catches of this species in offshore waters of Mississippi in November and December.

Atlantic stingrays are euryhaline and generally are distributed throughout brackish waters. Christmas and Waller (1973) took stingrays at temperatures ranging from 15° to 34.9°C (59.0° to 94.8°F) and in salinities ranging from 4.0 to 29.9 ppt. Swingle (1971) reported catches in salinities from 2 to 30 ppt.

REPRODUCTION

Atlantic stingrays breed in the winter and pups are born in spring, summer, and fall. Newly born pups have a disc width between 100 and 120 mm (Murray and Christmas 1968). The rate of birth is highest in June to August in Mississippi waters, but catches of small rays have been made in all seasons. Mature females as small as 218-mm disc width, and mature males as small as 190-mm disc width were examined by Funicelli (1975). Lack of corresponding growth data precludes determining age at maturation, but these small sizes suggest that maturation may occur near the end of the first year.

FOOD HABITS

Decapod and stomatopod crustaceans are the most important food item of the Atlantic stingray in offshore waters. Larger rays also feed on bony fish, squid, bivalve mollusks, and polychaetes (Funicelli 1975). In a study in Mississippi Sound, amphipods, decapod crustaceans, fish, and broken-up shell materials were identified in Atlantic stingray stomachs (Murray and Christmas 1968). Funicelli (1975) found that some large inshore stingrays had gorged on anchovies and small croakers and speculated that these fish were discards from shrimp trawlers. He also suggested that the Atlantic stingray has a larger mouth than other rays which accounts for the greater diversity of food items in its diet.

ECOLOGICAL ROLE

The Atlantic stingray has no sport or commercial value, but it plays an important ecological role because of its abundance and food habits. Atlantic stingrays have been reported as food for sharks and cobia (Richard Heard, Gulf Coast Research Laboratory, Ocean Springs, Mississippi; pers. comm.).

CHAPTER 4. OSTEICHTHYES

ATLANTIC THREAD HERRING

Opisthonema oglinum

INTRODUCTION

The Atlantic thread herring (Opisthonema oglinum: Clupeidae) is a pelagic schooling fish which occurs widely in the western Atlantic from the Gulf of Maine to southern Brazil (Berry and Barrett 1963). It is one of the largest clupeid fishes in the Gulf of Mexico. The largest population apparently is in the eastern Gulf off the Florida coast.

DISTRIBUTION AND ABUNDANCE

Adult Atlantic thread herring usually inhabit waters less than 50 m (164 ft) deep throughout the year. In the vicinity of Mississippi Sound, most larvae and adults probably occur south of the barrier islands, and the species is the third most abundant clupeid fish in the Sound area (Perry and Boyes 1978). It is the most abundant in the Mississippi Sound in the late summer and fall. Nearly all larvae collected off the west coast of Florida were taken at depths less than 50 m (164 ft) (Houde 1977). Juveniles and adults occur in coastal waters, but some have been known to enter estuaries and bays in the summer.

Data on the distribution and behavior of the Atlantic thread herring in the Mississippi Sound area are sparse. They have been reported off Louisiana (Perret et al. 1971) and Mississippi (Perry and Boyes 1978). Most of the available information on the life history and ecology of the species has been obtained from studies on the Atlantic coast and the west coast of Florida.

In the eastern Gulf of Mexico, Atlantic thread herring spawn from February to September. Based on catches of eggs and larvae, spawning peaks from April to August at depths of less than 30 m (98 ft), usually within 50 km (31 mi) of shore (Houde 1977). The buoyant eggs of the Atlantic thread herring hatch in less than 24 hours at temperatures of 25° to 30°C (77° to 86°F). Most of the pelagic larvae were collected over the inner continental shelf at depths less than 50 m (164 ft) along the west coast of Florida (Houde 1977). This inshore open ocean area apparently serves as a nursery ground for the Atlantic thread herring. Juveniles live in the same areas as adults and larvae, but are also taken in estuaries in July and August (Reintjes 1979a). Adult and juvenile Atlantic thread herring form schools near the surface, often with other clupeids. Off the west coast of Florida the schools increase in size during the fall prior to their winter migration somewhat further offshore, but usually within 10 km (6 mi) of shore. Pristas and Cheek (1973) suggested north-south seasonal movements along the coastline of the Southeastern Atlantic States at a rate of 10 to 11 km (6 to 7 mi) per day. A southerly movement of the population in the fall was observed in this area. The adults apparently concentrate offshore in large schools in the fall and winter before dispersing in the spring and summer (Fuss et al. 1969).

ENVIRONMENTAL REQUIREMENTS

Houde (1977) collected Atlantic thread herring eggs when surface temperatures ranged from 22.5° to 30.3°C (72.5° to 86.5°F) and when surface salinities ranged from 32.4 to 36.8 ppt. Larvae ($\leq$ 5.0 mm standard length [SL]) were collected at surface temperatures from 18.5° to 30.9°C (65.3° to 87.6°F) and at surface salinities from 27.3 to 36.9 ppt. Most eggs and small larvae were taken when surface temperatures and salinities exceeded 25°C (77°F) and 35 ppt, respectively. Juveniles are most abundant in salinities above 15 ppt and temperatures exceeding 20°C (68°F) (Perret et al. 1971). Most adults apparently prefer salinities of 32 to 34 ppt and temperatures of 26° to 29°C (79° to 84°F) (Kinnear and Fuss 1971). The majority of Atlantic thread herring reported by Perry and Boyes (1978) off Mississippi were taken near the barrier islands in salinities greater than 25.0 ppt.

FOOD HABITS

All life stages of Atlantic thread herring feed on planktonic copepods and larval crustaceans. Detritus and larval benthic organisms are also utilized as food for adults (Hildebrand 1963a; Fuss et al. 1969).

ECOLOGICAL ROLE AND USES BY MAN

The Atlantic thread herring stock in the Gulf of Mexico represents an essentially untapped resource. Currently it is marketed fresh, frozen, or salted in relatively small quantities, but its greatest potential value is probably in the fish meal industry. The total Atlantic thread herring catch in the western Atlantic was 12,016 mt in 1974 of which 2,434 mt were landed by U.S. fishermen (Houde 1977). Some thread herring are landed as incidental catches by both the Atlantic and Gulf of Mexico menhaden fleets. In 1967 an attempt was made to establish a thread herring fishery off the western Florida coast. This preliminary effort lasted only 4 months even though 5,000 mt were landed (Houde 1977). Kinnear and Fuss (1971) estimated that the Atlantic thread herring stock along the Florida coast was about 686,000 mt. Houde (1977) projected a potential yield of at least 54,692 to 109,384 mt along the Florida coast based on the mean of biomass estimates in 1971 and 1972.

The primary ecological role of the species in the Gulf of Mexico is its high value as a forage species. Atlantic thread herring are situated near the base of the food chain and have been reported as food for both sport and commercial fishes, including king mackerel, Spanish mackerel, bluefish, seatrout, red drum, tuna, snook, dolphin, wahoo, and crevalle jacks (Reintjes 1979a).

GULF MENHADEN

Brevoortia patronus

INTRODUCTION

Presently, the Gulf menhaden supports the largest commercial fishery by weight in the United States; the Gulf of Mexico harvest in 1980 was 711,000 mt (NMFS 1981b). The Gulf menhaden purse seine industrial fishery dates back to 1900, but it did not become a large fishery until sufficient processing plants were constructed after World War II. The fishery in the study area takes place primarily in Mississippi Sound although some purse seine vessels venture outside the barrier islands. The entire catch is recorded by the National Marine Fisheries Service as being taken from Mississippi Sound (NMFS 1981a; grid zone 11.1). The catch increased until the mid-1970's, but has leveled off in recent years (NMFS 1981a). The data base on all life stages of the Gulf menhaden is strong, but data on some environmental parameters are not clearly defined, probably because of the ubiquitous distribution of the species.

DISTRIBUTION AND BEHAVIOR

Gulf menhaden spawn offshore from mid-October through March in 40 to 140 m (131 to 459 ft) of water (Roithmayr and Waller 1963; Lewis and Roithmayr 1981). The larvae move into estuaries from February to May (Fore and Baxter 1972; Christmas and Waller 1973) to low salinity, shallow (0-2 m or 0-6.6 ft deep) sections of the estuary. The larval migrations follow tidal currents through inlets and barrier island passes. Menhaden larvae disperse through the estuary and move primarily into quiet waters near shore. In a northwestern Florida estuary larval menhaden moved into freshwater rivers, but never more than 1.6 km (1 mi) from the freshwater-low salinity zone (Tagatz and Wilkens 1973). In the shallow estuaries, larvae metamorphose into juveniles and change from being carnivores to filter-feeding omnivores. Juveniles move out of the shoreline areas from May to July and form large schools in the open deeper parts of estuaries where they become exposed to the purse seine fishery. The purse seine fishery in Mississippi Sound lasts from May to early October (Lewis and Roithmayr 1981). Juveniles also are present in the surf zone outside the barrier islands (Modde 1980).

Gulf menhaden juveniles and subadults migrate from estuaries into offshore waters from December through February; the exact route and time of movement depend on salinity (Roithmayr and Waller 1963). High salinities in estuaries may delay emigration (Suttkus 1956).

Gulf menhaden (post-spawners and pre-spawners) that move from offshore areas into the estuaries during spring and summer are also exposed to the purse seine fishery (Lewis and Roithmayr 1981). Adults migrate out of the estuary during September-November for the October-March spawning period. Mature fish are sexually inactive in the estuary, but gonads mature for spawning in the offshore area (Lewis and Roithmayr 1981). Spawning stocks consist of fish that have completed two or more complete growing seasons.

Gulf menhaden have been collected every month in Mississippi and Alabama estuaries (Swingle 1971; Christmas and Waller 1973), and only the major migrations are described above.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Little is known about water temperature requirements of larval menhaden before they enter the estuary. In estuaries larval and juvenile menhaden have been captured over a salinity range of 0 to 35 ppt and a temperature range of 5° to 35°C (41° to 95°F). Greatest abundances of larvae and juveniles were in salinities from 5 to 10 ppt and at temperatures exceeding 25°C (77°F) (Christmas and Waller 1973). Juveniles were commonly captured in salinities less than 1 ppt, but adults were only captured above 2 ppt. Adults were most commonly reported in the higher salinity (>25 ppt) parts of the estuary (Christmas and Waller 1973).

Reintjes and Pacheco (1966) reported that laboratory and field studies revealed temperatures as low as 3°C (37°F) inhibited movement into estuaries. Gallaway and Strawn (1974) found that 30°C (86°F) may be near the maximum tolerance limit.

Substrate does not appear to influence distribution since the species feeds in the open water; however, they are most commonly collected over soft bottom in marsh areas of estuaries. Currents control the distribution within the estuary by carrying larvae to quiet water areas. Larval menhaden are commonly found in turbid shallow sections of estuaries, but no turbidity limits have been identified.

Little longshore movement occurs in the northern Gulf of Mexico (Kroger and Pristas 1974), and there is evidence from tagging that commercial catches of Gulf menhaden offshore from or within an estuary depend upon recruitment of juveniles from the same estuary.

FOOD HABITS

Larval Gulf menhaden are particulate-feeding carnivores that feed primarily on microzooplankton. Juvenile and adult menhaden are filter-feeding omnivores; they feed on detritus, and on planktonic plants and animals (Gunter and Christmas 1960). Darnell (1958) found that phytoplankton was the most important food, but the fish also feed on detritus, bacteria, plant fragments, and zooplankton.

ECOLOGICAL ROLE AND USES BY MAN

The Gulf menhaden industrial fish catch is processed into fish meal and oil that is in high demand for poultry feed, swine feed, cosmetics, margarine, and chemicals (Nicholson 1978). Gulf menhaden are an important forage species for red drum, spotted seatrout, sand seatrout, and other predator species. Also, pelicans and other shorebirds feed extensively on Gulf menhaden (Gunter and

Christmas 1960). The Gulf menhaden fishery supported about 78 commercial fishing vessels in 1980. Extensive research is being conducted on methods for forecasting Gulf menhaden catches from catch-effort data and from sampling juvenile fish (e.g., Schaaf et al. 1975; NMFS 1981b).

STRIPED ANCHOVY

Anchoa hepsetus

INTRODUCTION

The striped anchovy (*Anchoa hepsetus*: Engraulidae) ranges from New England to Brazil and is locally common in the northern Gulf of Mexico. It occurs in high salinity bays and estuaries, but it is most abundant offshore where it has been reported at depths down to 73 m (240 ft) (Hildebrand 1963b).

DISTRIBUTION AND ABUNDANCE

Striped anchovy are seasonal inhabitants of coastal waters in the northern Gulf of Mexico. Spawning apparently occurs in the offshore waters of Mississippi from March through August (Christmas and Waller 1973) and at least in March, April, and August off Alabama (Swingle 1971). Adults live offshore all year and are common in Mississippi Sound waters only in the summer and fall. In Mississippi Sound 94% of those collected in fish samples were taken south of the Gulf Intracoastal Waterway (Perry and Boyes 1978). The larvae presumably use both offshore waters and the outer portions of Mississippi Sound as nursery areas in spring, summer, and fall.

Although juvenile and adult striped anchovy are relatively abundant in the Mississippi Sound and associated offshore waters (Christmas and Waller 1973; Perry and Boyes 1978; Shipp 1981; Modde and Ross 1981), much of the data regarding spawning and early life history are speculative. Larvae have been described (Hildebrand and Cable 1930), but available data are inadequate to separate early stages from the other five engraulids occurring in the northern Gulf (*A. cubana*, *A. lyolepis*, *A. mitchilli*, *Anchoviella perfasciata*, and *Engraulis eurostyle*). Much of the early life history data for the species has been based on the tentative identification of small larvae (Hildebrand 1963b; Hoese 1965; Perry and Christmas 1973; Perry and Boyes 1978).

Christmas and Waller (1973) collected juvenile and adult striped anchovy from Mississippi Sound all year except in the winter months and Swingle (1971) collected specimens from May through September off Alabama. Apparently they move to deeper, warmer offshore waters during the winter, although no extensive mass migrations have been reported (Gunter 1945; Christmas and Waller 1973; Reintjes 1979a). Shipp (1981) reported striped anchovy to be one of the most abundant pelagic estuarine forage fish species in the Mississippi Sound estuarine system; it ranked second in abundance in studies in mid-Mobile Bay and fourth in Mobile Bay navigation channels and Mississippi Sound. It was seventh in studies by Christmas and Waller (1973) in Mississippi Sound. Striped anchovy ranked third in numerical abundance from surf zone habitats along the southern shore of Horn Island (barrier island off Pascagoula, Mississippi) in 1976 (Modde and Ross 1981). Although their dominance in the surf zone appears to fluctuate yearly, they may use this habitat for a refuge from predators or for feeding, or both. Adults usually are found in dense schools (Jones et al. 1978).

Striped anchovy probably spawn offshore at depths from 18 to 49 m (59 to 161 ft) (Hildebrand 1963b; Hoese 1965), but some may spawn in shallower water close to the barrier islands if high salinities persist there in spring and summer. Most estimates of spawning season are similar, being based partially on the occurrence of young larvae and early juveniles. Gunter (1945) reported ripening fish in collections off Texas during April and May. Christmas and Waller (1973) suggested that this species spawns offshore of Mississippi from March to August, based on the appearance of young-of-the-year fishes. Most spawning takes place in the early evening (Hildebrand and Cable 1930). The eggs are pelagic and hatch near the surface (Jones et al. 1978). Engraulid larvae were the most abundant larvae collected from Mobile Bay, Mississippi Sound, and the nearshore waters of the Mississippi coast (Williams 1980; Richardson 1981; Ruple 1981). The abundance of striped anchovy larvae, however, is unknown due to the difficulty of identifying larval engraulids. Juveniles have been collected in offshore waters and in the Mississippi Sound, primarily south of the Gulf Intracoastal Waterway, in the spring, summer, and fall.

ENVIRONMENTAL REQUIREMENTS AFFECTING BEHAVIOR

The distribution of all life stages of striped anchovy appears to be limited primarily by salinity. Christmas and Waller (1973) reported this species in salinities ranging from 5.0 ppt to 35.5 ppt. Perry and Boyes (1978) collected 95.6% of their specimens in salinities between 20 and 30 ppt, largely in waters south of the Gulf Intracoastal Waterway. This fish is most abundant at temperatures ranging from 20° to 30°C (68° to 86°F) (Perry and Boyes 1978).

FOOD HABITS

Little is known about the feeding habits of striped anchovy. Hildebrand (1963b) reported that larvae and juveniles feed mainly on copepods, and adults feed on gastropods and copepods.

ECOLOGICAL ROLE

The importance of striped anchovy in Mobile Bay and Mississippi Sound is primarily ecological. No anchovy fishery has been established in the Gulf of Mexico, and harvest by conventional methods would be uneconomical. This anchovy has commercial potential for industrial fishing only (Reintjes 1979b). Ecologically, striped anchovies are an abundant and important pelagic forage fish. They are preyed upon by most carnivorous fishes and many sea birds.

BAY ANCHOVY

Anchoa mitchilli

INTRODUCTION

The bay anchovy (*Anchoa mitchilli*: Engraulidae) is the most abundant species of fish in most nearshore waters of the northern Gulf of Mexico (Perret et al. 1971; Christmas and Waller 1973; Swingle and Bland 1974; Livingston et al. 1976; Naughton and Soloman 1978; Shipp 1981). Gunter (1941) ranked bay anchovy first in "species mass" among fishes in shallow waters of the northern Gulf of Mexico. The species is euryhaline, and individuals are found over a wide range of salinities and temperatures in estuaries and nearshore waters in the western Atlantic from the Gulf of Maine to Yucatan, Mexico.

DISTRIBUTION AND ABUNDANCE

Juvenile and adult bay anchovy live throughout the Mississippi Sound in spring, summer, and fall (Christmas and Waller 1973; Perry and Boyes 1978), but are sparse in the upper Sound in winter (Edwards 1967). The high catches of bay anchovy offshore in the winter are evidence that this species probably migrates to slightly warmer and deeper waters in the fall (Franks et al. 1972; Christmas and Waller 1973; Perry and Boyes 1978). The bay anchovy is generally considered to be the most abundant species in the northern Gulf. While usually the most abundant species collected in the northern Gulf, the bay anchovy ranks only sixth in numerical abundance from the surf zone habitat of Horn Island (Modde and Ross 1981). Greatest numbers in the surf zone occurred during the spring and fall.

Spawning apparently takes place in the outer area of the Sound and offshore Gulf to depths of 20 m (66 ft) (Jones et al. 1978) from February to October (Christmas and Waller 1973). Larvae use the Mississippi Sound and nearshore waters extensively as nursery areas throughout much of the year, but primarily in spring and summer (Perry and Boyes 1978).

Despite the overwhelming dominance of bay anchovy over other fish in the northern Gulf of Mexico, little is known about the life history and ecology of this species. Much of the information about its spawning and early life history is somewhat speculative because of the difficulties in identifying larval stages of the engraulids. Although bay anchovy larvae have been taxonomically described (Kuntz 1914; Hildebrand and Cable 1930; Jones et al. 1978), criteria for the separation of the larval stages of the six species of northern Gulf engraulids (*Anchoa mitchilli*, *A. cubana*, *A. lyolepis*, *A. hepsetus*, *Anchoviella perfasciata*, and *Engraulis eurostyle*) are not possible; consequently some of the early life history data reported for the bay anchovy have been based on the tentative identification of small larvae (Hildebrand 1963b; Hoese 1965; Perry and Christmas 1973; Reintjes 1979a).

The bay anchovy contributed 66.1% of the fish collected in studies of Mississippi Sound (Christmas and Waller 1973). This species was taken throughout the year except January when Franks et al. (1972) reported the greatest number offshore. These observations support the idea of a general offshore movement from shallow, cooler waters to deeper, warmer waters in the winter as suggested by Gunter (1945), Stevenson (1958), and Edwards (1967), and return to the estuaries in the spring. Some specimens were taken offshore throughout the year. Adults have been reported from depths to 36 m (118 ft) (Hildebrand 1963b) and are found in fairly small dense schools near the surface (Reintjes 1979a).

Bay anchovies probably spawn in the lower Mississippi Sound and offshore to depths of 20 m (66 ft) (Reintjes 1979a). They spawn from February to October (Christmas and Waller 1973) and peak in July (Edwards 1967). Bay anchovies may spawn throughout the year in some localities although this was not reported by Ruple (1981) for the Horn Island surf zone, where small engraulid larvae were collected only from March to October. The pelagic eggs are distributed throughout the entire water column, but are most abundant near the surface (Hildebrand 1963b). The eggs hatch in about 24 hours. Engraulid larvae were the most abundant fish larvae collected from lower Mobile Bay (Williams 1980), Mississippi Sound (Richardson 1981), and nearshore waters off the Mississippi barrier islands (Richardson 1981; Ruple 1981), but the relative abundance of bay anchovy is unknown due to the difficulties associated with identification of larval engraulids.

ENVIRONMENTAL REQUIREMENTS AFFECTING BEHAVIOR

Although the distribution of the bay anchovy in Mississippi Sound waters is not greatly affected by differences in salinities, low winter temperatures appear to cause some movement to deeper, warmer offshore waters (Springer and Woodburn 1960; Christmas and Waller 1973). Swingle (1971) found them to be nearly equally distributed in salinities between 5 and 19 ppt in Alabama coastal waters. Highest catches were in salinities ranging from 20.0 to 29.9 ppt. In Mississippi Sound, Christmas and Waller (1973) established no relationships between the distribution of anchovies and salinities above 2 ppt. Perry and Christmas (1973) found larvae in Mississippi waters in salinites ranging from 16.6 to 27.8 ppt. Bay anchovies were taken at temperatures from 5.0° to 34.9°C (41.0° to 94.8°F), but the largest numbers were in water temperatures between 10.0° and 14.9°C (50.0° and 58.8°F) (Christmas and Waller 1973).

FOOD HABITS

Larval and juvenile bay anchovy feed primarily on calanoid copepods which decrease in importance with growth (Sheridan 1978a). Mysid shrimp are important in the diet of adults although calanoid copepods still comprise at least 50% (total dry weight) of the food taken by larger fish ($\geq$ 40 mm SL).

ECOLOGICAL ROLE AND USES BY MAN

The importance of bay anchovy to Mobile Bay and the Mississippi Sound is primarily ecological. No anchovy fishery has been established in the Gulf of Mexico, and harvest by conventional methods would be uneconomical largely due to the relatively small schools and the small size of the fish. Nonetheless, because of their great biomass, bay anchovy offer commercial potential as industrial fish (Reintjes 1979b). Bay anchovy are an important forage fish throughout much of their range. They are preyed upon by most carnivorous fishes and many sea birds. Sand seatrout (*Cynoscion arenarius*) is one of their major predators in Gulf estuaries (Sheridan 1978b).

SEA CATFISH

Arius felis

INTRODUCTION

The sea catfish, commonly called the "hardhead" and "silver cat," is considered a "trash" fish or undesirable species for exploitation (Jackson 1972). It ranges from Cape Cod to Mexico, and it is one of the most abundant, shallow water demersal species in the Gulf of Mexico (Drummond and Pellegrin 1977; Johnson 1978; Lee et al. 1980).

DISTRIBUTION AND BEHAVIOR

Sea catfish often are abundant in trawl hauls from sounds and bays, but are absent in trawls taken in Gulf waters (Lee et al. 1980). Often haul composition may consist of 90% to 100% catfish, indicating schooling by catfish and avoidance of the area by other fish species (Drummond and Pellegrin 1977; Johnson 1978). Highest mean catches per haul are taken in the winter by the industrial fleet.

Catfish are most abundant from April to September in Alabama and from May to October (Perret et al. 1971) and January (Johnson 1978) in Louisiana. Most sources agree that abundance is greatest during the warm months (Gunter 1938; Jackson 1972; Chittenden and McEachran 1976; Adkins et al. 1979). Highest concentrations appear to be located near major estuaries like Breton Sound, Mississippi Sound (Shipp 1981), Biloxi Bay (Jackson 1972), and Mobile Bay (Shipp 1981). Catfish exhibit no specific diurnal or nocturnal activity patterns, but catches are greatest at night (Moore et al. 1970).

REPRODUCTION

Adults migrate to shallow waters (0.6 to 1.2 m or 2 to 3.9 ft) in rivers and bays to spawn in May to August (Merriman 1940; Ward 1957; Jackson 1972; Etchevers 1978; Johnson 1978; Lee et al. 1980). Individual females produce from 10 to 64 mature ova per season (Gunter 1947; Etchevers 1978). Large (14 to 19 mm) demersal eggs (Merriman 1940) are laid in a depression in the sand. There is some question whether the eggs are actually deposited and then picked up again after the male fertilizes them, or whether they are fertilized and then transferred by the modified pelvic fins of the female to the male for oral gestation (Lee 1937; Merriman 1940; Etchevers 1978).

The incubation period (male oral gestation) is about 1 month, and the larvae are retained by the male for an additional 2 to 6 weeks (Merriman 1940; Ward 1957; Hildebrand and Schroeder 1972). From 15 to 30 eggs are held by the male; it eats no food during the 2-month period (Merriman 1940; Gunter 1947). Individuals are sexually mature before 2 years of age, and females may spawn more than once each season (Gunter 1947; Chittenden and McEachran 1976). The life span is about 5 years, but most live only 2 years (Chittenden and McEachran 1976; Etchevers 1978).

Males disperse throughout shallow bays during the incubation and nursery period. Since the fin ray is developed before the yolk is absorbed, there is some question whether a larval stage exists (Johnson 1978). Released juveniles grow in low salinity parts of estuaries and migrate to deeper waters of estuaries in the late fall. Adults overwinter in the Gulf and return to the estuaries in February to March to repeat the cycle (Drummond and Pellegrin 1977).

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

Sea catfish in estuaries in the summer are most abundant in water temperatures from 19° to 25°C (66° to 77°F). Year round, they have been taken in the range of 5.0° to 34.9°C (41.0° to 94.8°F) (Perret et al. 1971; Adkins and Bowman 1976; Drummond and Pellegrin 1977; Johnson 1978). This euryhaline species is common in salinities from 0 to 45 ppt, but some tolerate 60 ppt. A preference of higher salinities has been suggested (Gunter 1947; Johnson 1978; Lee et al. 1980). Breeding occurs in waters having a salinity range of 13 to 30 ppt.

The developmental stage of larvae incubating in the oral cavity may determine the location of the parent male (Harvey 1971). Younger larvae tolerate salinities up to 12.8 ppt, but more developed larvae tolerate salinities of 16.7 to 28.3 ppt (Harvey 1971). Juveniles are most numerous in low salinities (Johnson 1978).

Although minimum dissolved oxygen requirements of sea catfish are not known, this fish sometimes lives in dredged semiclosed and closed canals that are characterized by low oxygen concentrations (Adkins and Bowman 1976). They are found in moderately turbid water (Gunter 1947; Lee et al. 1980).

Sea catfish principally live at depths from 4 to 7 m (13 to 23 ft), but may occupy waters as deep as 36 m (118 ft) (Lee 1937; Johnson 1978). Major substrates are muddy or sandy bottoms rich in nutrients (Etchevers 1978; Shipp 1981).

FOOD HABITS

Catfish are omnivores. They feed on detritus and a wide range of animal organisms. Their diet consists principally of shrimp (Harris and Rose 1968), but other food items are polychaetes, crustaceans, mollusks, algae, coelenterates, and small fish (Lee et al. 1980). Lepidophagy or "scale feeding" has also been recognized in this species (Hoese 1966). Catfish eggs may be an additional food source for females as well as males. Larvae, while in the mouth of the males, obtain nutrition from the yolk sac and zooplankton (Lee et al. 1980).

ECOLOGICAL ROLE AND USES BY MAN

The sea catfish is under-utilized, and many are discarded after capture (Drummond and Pellegrin 1977). A small percentage of catfish landed by trawlers are used by the petfood industry, and consumer reaction to this use has been negative due to regurgitation of catfish spines by pets. The nutritive value of sea catfish compares favorably with croaker, spot, and spotted seatrout, but attempts to market it as human food have been unsuccessful. Minced fish products are dark and often have an offensive odor (Drummond and Pellegrin 1977). The annual commercial harvest of sea catfish in Mississippi Sound, Mobile Bay, and the adjacent offshore area averaged 31 mt from 1968 to 1978; 82% was caught offshore (NMFS 1981a). The commercial catch generally declined from 1968 to 1978.

Sea catfish are a nuisance to sport and commercial fishermen. They take almost any kind of bait and sport fishermen spend much time removing them from their lines (Lee et al. 1980). The poisonous sharp spines have inflicted serious wounds. Commercial fishing problems include difficulties in removing entangled fish from the nets and pump hoses (Drummond and Pellegrin 1977).

SOUTHERN FLOUNDER

Paralichthys lethostigma

INTRODUCTION

The southern flounder is a euryhaline estuarine-dependent bottom fish. It is especially popular as a sport and food fish. The fish are seasonally distributed from deep Gulf waters, up to 110 m (360 ft), to shallow estuaries. The larger flounder range from 30 to 51 cm (12 to 20 inches) long; maximum 76 cm (30 inches) (Nall 1979). Data on behavior and seasonal habits of flounder are scarce.

DISTRIBUTION AND BEHAVIOR

The southern flounder spawns in the winter (September to April but primarily in November to January) over the inner and central continental shelf along the Gulf coast (Gunter 1945; Simmons 1951). They spawn in waters from about 20 to 60 m (66 to 197 ft) deep. The eggs are pelagic. The females may produce up to 100,000 eggs and spawn more than once a year. Most mature in their fourth or fifth year of life, and some live for 10 years (Nall 1979).

The larvae and early juveniles are carried by currents from the open seas to estuaries in winter and spring. The main larval inshore movement is in February. At first they tend to congregate in or near the tidal passes between the barrier islands and in the surf zone of the islands. The young enter the estuaries in the following months (Gunter 1945).

In October-November there is a heavy migration of adults and older juveniles from estuaries to offshore waters where they overwinter (Ginsberg 1952; Fox and White 1969; Stokes 1973).

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

The southern flounder is euryhaline, occurring in waters with salinities from 0 to 60 ppt. The normal range is from about 10 to 31 ppt. They live at water temperatures from 9.9° to 30.5°C (49.8° to 86.9°F), but are most common between 14.5° and 21.6°C (58.1° and 70.9°F) (Stokes 1973). The temperatures and salinities where southern flounder were collected in Mississippi Sound by Christmas and Waller (1973) ranged from 5.0° to 34.9°C (41.0° to 94.8°F) and 0.0 to 29.9 ppt. The juveniles may live in freshwater for short periods.

Juveniles are usually most abundant in shallow areas with aquatic vegetation (shoal grass and other sea grasses) on a muddy bottom. Adults also tend to favor aquatic vegetation such as *Spartina alterniflora*. Some flounders overwinter in the deeper holes and channels of estuaries, but most (adults and second-year juveniles) migrate to Gulf waters in the fall (Gunter 1945).

FOOD HABITS

Larvae eat various forms of zooplankton, and juveniles feed largely on shrimp, crabs, menhaden, croakers, and other flounders (Stokes 1973). Adult food consists largely of fish; some of the more common are striped mullet, anchovies, pinfish, shad, menhaden, and Atlantic croakers (Darnell 1958). In Lake Pontchartrain, fish contributed 87% of the total food volume; anchovies contributed 41%. Other common foods are various species of shrimp, crabs, clams, and gastropods. Adults and older juveniles feed actively day and night (Stokes 1973).

VALUE TO MAN

The commercial landings of flounder in Alabama ranged from 308 to 516 mt in 1965-75 (Swingle 1976). A majority was southern flounder, and about 95% was taken by the shrimp fishery. Sport fishing for flounder is popular in the bays, sounds, and estuaries. Of the total sport catch, 57% was taken by gigging in shallow bays at night. In Alabama in 1975, 377 mt were taken by commercial gear and 55 mt by the sport fishery.

GULF FLOUNDER

Paralichthys albigutta

INTRODUCTION

The gulf flounder is relatively common on the continental shelf (up to 50 m or 164 ft deep) and in larger bays and sounds of the Gulf of Mexico. Only larvae and first-year juveniles in the spring and summer inhabit Mobile Bay or the Mississippi Sound (Walker and Nelson 1964; Swingle 1971). The fish is smaller (0.5 to 1.0 kg or 1.1 to 2.2 lb) than the southern flounder and prefers a firmer bottom. The species often is called the sand flounder. It ranges from North Carolina to southern Texas and in the Bahamas (Hoese and Moore 1977). The abundance of this species appears to vary greatly throughout its range (Christmas and Waller 1973); consequently, there is confusion concerning its distribution and abundance. This possibly is the cause of the scarcity of data and conflicting reports on this species.

DISTRIBUTION AND BEHAVIOR

In general, the gulf flounder is much more abundant in Florida waters than in the Alabama-Mississippi Gulf area (Reid 1954). It is the most abundant flounder in the Tampa Bay area, but relatively scarce in the shallow Gulf of Texas (Miller 1965). The fish spawn on the inner continental shelf from November to February, and most of the larvae and first-year juveniles migrate into bays, sounds, and estuaries. Males grow faster than females, and fish 2 to 3 years old usually live in the Gulf. Females range from 36 to 42 cm (14 to 17 inches) at the end of their third year of life (Nall 1979).

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

Most adults live in salinities exceeding 30 ppt and depths probably exceeding 20 m (66 ft) over hard sand bottoms (Ginsburg 1952). In the estuaries the young live in grass flats. Fish have been collected from waters with temperatures ranging from 10.8° to 31.0°C (51.4° to 87.8°F), and salinities ranging from 6 to 36 ppt.

FOOD HABITS

Juveniles feed primarily on crustaceans, but they become more piscivorous as they grow older. Flounders over 10 cm (4 inches) long feed almost entirely on fish, primarily in the daytime (Stokes 1977).

USES BY MAN

The gulf flounder is infrequently taken by anglers and most of the commercial catch is taken by shrimp trawlers. It contributes only a small percentage to the total flounder catch in Alabama (Swingle 1971). In commercial and sport catch reports, the southern and gulf flounder are combined and not reported separately.

TIDEWATER SILVERSIDES

Menidia peninsulae

INTRODUCTION

The former species *Menidia beryllina* has been recently split into two species: *M. peninsulae*, the tidewater silversides, and *M. beryllina*, the inland silversides (Robins 1980). Both species are thought to occur in Mississippi Sound, and the data base probably includes both species (Dr. Sally Richardson, Gulf Coast Research Laboratory, Ocean Springs, Mississippi; pers. comm.). The tidewater silversides is a small minnow-sized fish of the Gulf coast that is common in the shallow estuaries, especially along the shore. Sometimes it enters freshwater streams. The life span is about 16 months to 2 years; few exceed 5 cm in length, and some mature at 5 months. See Martin and Drewry (1978) for an extensive literature review.

DISTRIBUTION AND BEHAVIOR

This fish inhabits the shorelines of bays, estuaries, marshes, and sounds (Hoese and Moore 1977). It shows little preference for either sand or mud bottom. It is particularly abundant near submerged vegetation and often associated with some sort of shelter such as islands, piers, and oyster bars (Martin and Drewry 1978). It is nonmigratory and is rarely found outside the barrier islands (Parker 1965). The fish usually does not live in waters over 2 m (7 ft) deep and tends to stay near the surface. It probably overwinters in the deep parts of bays and estuaries. The fish probably spawns in most months of the year, especially in the spring and fall (Gunter 1945; Swingle 1971). The tidewater silversides spawns among dead leaves, tree roots, and vegetation, primarily in tidal freshwater or brackish waters. The eggs are demersal, adhering to various types of substrate including concrete structures.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Within its normal habitat range, the location of silversides is more dependent on habitat than on salinity (Swingle 1971). The fish often enters freshwater streams and is not usually abundant at salinities higher than 20 ppt. Specimens have been collected at water temperatures in the Gulf from 8° to 34°C (46° to 93°F). Ripe females have been found at water temperatures ranging from 19° to 33°C (66° to 91°F), and spawning was observed at a temperature of 26°C (79°F) (Martin and Drewry 1978).

FOOD HABITS

The silversides is omnivorous and feeds on copepods, amphipods, detritus, chironomid larvae, polychaetes, and terrestrial insects, but is an aggressive predator on small arthropods and small fish. Sometimes the species resorts to cannabalism (Levine 1980).

ECOLOGICAL ROLE AND USES BY MAN

This small fish is fed upon by a number of sport and commercial fish. Some are captured in nets and seines and used as fish bait.

STRIPED MULLET

Mugil cephalus

INTRODUCTION

The striped mullet is a euryhaline estuarine-dependent species that is distributed worldwide in subtropical and tropical climates. It inhabits environments from fresh to hypersaline waters, and from shallow estuaries to deep areas of the Gulf of Mexico. It is abundant throughout Mississippi Sound and Mobile Bay and supports a sizable commercial fishery and a moderate sport fishery. Mullet have been observed in Alabama inland as far as 607 km (377 mi) from the Gulf (Boschung and Hemphill 1960). As Baughman (1950) observed, "*Mugil cephalus* is almost too common to deserve notice." The taste of mullet from Florida waters is claimed to be superior to that of mullet from the western Gulf. Some striped mullet grow up to 75 cm (30 inches) in length, but most range from 30 to 45 cm (12 to 18 inches) long, according to the U.S. Bureau of Fisheries (USBF 1937). Their movements are mostly inshore-offshore rather than along the coast.

DISTRIBUTION AND BEHAVIOR

The striped mullet has a protracted spawning season, from October to May (Gunter 1945; Kilby 1955). Apparently some females spawn more than once in a spawning season (Moore 1973). Large numbers leave the bays and estuaries in the fall to spawn and overwinter in deeper Gulf of Mexico waters (Broadhead 1954; Thompson 1966; Hoese and Moore 1977) as far as 80 km (50 mi) offshore (Martin and Drewry 1978) and as deep as 1,385 m (4,544 ft), close to the edge of the continental shelf. The eggs, which hatch in about 48 hours at 22°C (72°F), are somewhat buoyant but tend to sink. The larvae show vertical diurnal movement. In the spring, dense schools of larvae (up to 24 days old) and fry (up to 25 mm) are carried by currents into the shallow estuaries. They usually stay close to the shoreline. Young juveniles first appear in the surf zone and lower bays, but they soon spread over the shallow areas of the sound and bays (Gunter 1945; Moore 1973). They spend most of their first 2 years of life in the estuaries (Etzold and Christmas 1979) and usually avoid large open waters.

Mullet live in freshwater and as far out as 80 km (50 mi) from the coast (Etzold and Christmas 1979). The water temperature ranges from 4.5° to 37.0°C (40.1° to 98.6°F). Mullet often swim and feed on or near the surface, and their penchant for randomly jumping out of the water is well known (USBF 1937). Fish mature when about 20 cm (8 inches) long at age 1 or 2 years, and some fish live 8 years (Martin and Drewry 1978).

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

Striped mullet live in fresh water and in salinities up to 75 ppt. In Texas estuaries the mullet were about equally distributed in water of all salinities (Gunter 1945). They have been taken in Mississippi in salinities ranging from 0.0 to 35.5 ppt (Christmas and Waller 1973).

Fish less than 3.6 cm (1.4 inches) long are most abundant in salinities from 0.0 to 14.9 ppt. Juveniles (up to 7.9 cm or 3.1 inches long) prefer lower salinities and warmer waters than larger fish. Juveniles are mostly taken in salinities from 0 to 10 ppt when temperatures range from 25° to 30°C (77° to 86°F). Fish up to 11 cm (4 inches) long are abundant at salinities from 0 to 20 ppt at temperatures of 7° to 30°C (45° to 86°F) (Etzold and Christmas 1979). Highest catches in samples from Mississippi Sound were in the range of 7° to 20°C (45° to 68°F). Mullet are often killed in water temperatures less than 5°C (41°F) (J.C. Parker 1971), and they tend to aggregate in sheltered areas before the arrival of cold weather.

FOOD HABITS

Mullet feed largely upon various forms of plankton, epiphytic algae, littoral diatoms, invertebrates, small particles of vascular plants, and finely divided organic detritus scraped from the surface of shallow mud flats or from the surface of rocks and other objects (Odum 1976). The presence of planktonic crustacea and surface algae indicates that some plankton straining must take place, especially among younger fish (Etzold and Christmas 1979). The mullet move on and off tidal flats to feed during the day and most of the night (Darnell 1958).

USES BY MAN

Mullet have always contributed substantially to the Alabama and Mississippi commercial landings, but their unit value historically has been low. The mullet fishery is a specific fishery and is not made up of incidental catches in shrimp trawls. In 1975, the sport catch was 36 mt in Alabama and the commercial catch was 734 mt (Swingle 1976). The mean annual catch of mullet in 1968-78 was 874 mt in Alabama and 243 mt in Mississippi with the majority taken in Mississippi Sound (NMFS 1981a).

Mullet are taken, sometimes in abundance, by anglers. Most are taken near the surface on small hooks and worms in shallow bays and estuaries (USBF 1937). Mullet are sometimes used as cut bait for inshore fishing, or as bait in crab traps (Broadhead 1954).

KING MACKEREL

Scomberomorus cavalla

INTRODUCTION

The king mackerel, a marine species, is probably the most popular offshore sport fish in the Gulf of Mexico (Hoese and Moore 1977). The fish may weigh over 33 kg (73 lb) and averages between 7 and 9 kg (15 and 20 lb) (USBF 1937). Because they are not estuarine dependent, few fish show up in the samples of coastal fishery investigations, and data are scarce for the Mississippi Sound and Mobile Bay.

DISTRIBUTION AND BEHAVIOR

The king mackerel winter in Florida waters and migrate in large schools in the spring to areas offshore of Mississippi Sound and States westward to spawn (Williams and Sutherland 1978). They spawn in May to September over the continental shelf, and only rarely do the early juveniles move into estuaries. One 8-cm (3-inch) fish was reported from Mobile Bay in September by Swingle (1971). Most adults migrate in the fall to Florida waters and the Keys and occasionally to the U.S. South Atlantic (Sutherland and Fable 1980). Sport fishermen report a winter population of older larger fish off the coast of Louisiana. The females grow larger than the males and may live as long as 14 years. At the end of the first year they are about 45 cm (18 inches) long and after 7 years about 76 cm (30 inches) long.

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

King mackerel larvae are more abundant over the middle and outer continental shelf (> 35 m or 115 ft) than over the inner continental shelf (< 35 m), according to McEachran et al. (1980). Larvae are captured over a temperature range of 19.6° to 29.8°C (67.2° to 85.6°F) and a salinity range of 27.3 to 37.4 ppt over the outer continental shelf (42 to 183 m or 138 to 600 ft). Larvae are most abundant in September (McEachran et al. 1980). Water temperatures over 16°C (61°F) seem to be preferred (Berrien and Finan 1977a). King mackerel of all ages occasionally enter waters with salinities as low as 5 ppt. Mackerel apparently prefer clean sand bottoms in waters less than 80 m (262 ft) deep.

FOOD HABITS

The king mackerel feeds heavily on fish, primarily herring, menhaden, and sardines, as well as squid and shrimp. Along the South Atlantic, Atlantic menhaden and Atlantic thread herring were dominant in mackerel stomachs in the spring and summer (DeVane 1978). Food was much more variable in the other seasons.

USES BY MAN

In the northeast Gulf of Mexico, the king mackerel is taken in large numbers as a sport fish in offshore waters, but rarely is taken commercially (Swingle 1976). It is common along the Gulf beaches and further offshore and was the most important marine species in the sport fishery in Alabama in 1975 (463 mt) and other years. The best fishing is during the fall migration, but there is a winter fishery for large king mackerel near oil and gas rigs off the coast of Louisiana. Most are caught from private boats and piers.

SPANISH MACKEREL

Scomberomorus maculatus

INTRODUCTION

The Spanish mackerel, a prized food and sport fish, is a common, highly migratory, pelagic species of the Gulf of Mexico. It is most abundant along the western coast of Florida (Trent and Anthony 1978). Adults from these stocks apparently migrate in schools to Alabama and Mississippi waters, and farther west, to spawn in the spring and summer, and return in the fall (Sutherland and Fable 1980). Although Spanish mackerel freely enter tidal estuaries, the species apparently is not estuarine dependent (Parker 1965). Spanish mackerel usually inhabit shallower water than the king mackerel.

This fish may weigh as much as 11 kg (24 lb), but most of the larger fish are 4 to 5 kg (9 to 11 lb), and most of those taken for the market or by the sport fishery weigh 0.7 to 1.8 kg (1.5 to 4 lb) (USBF 1937). Except for fall migrations along the Gulf coast, the Spanish mackerel are not usually found in estuaries, and data on their life history and migration are limited.

DISTRIBUTION AND BEHAVIOR

The Spanish mackerel migrates seasonally throughout much of the Gulf. The longshore movement is far more extensive than the inshore-offshore movements of estuarine-dependent species. This mackerel spawns in May through September while it is in the northern Gulf. The fish apparently spawn at night in inner (< 35 m or 115 ft), middle (< 50 m or 165 ft) and outer (> 50 m) continental shelf waters at depths of 12 m (39 ft) to possibly 200 m (656 ft) and water temperatures exceeding 22°C or 72°F (21° to 31°C, seldom below 18°C [70° to 88°F, seldom below 64°F]). Eggs are buoyant and hatch within 24 hours. Larvae are most abundant in September (McEachran et al. 1980) and in June (Dwinnel and Futch 1973).

Although most eggs, larvae, and juveniles are found in Gulf waters, the occurrence of fingerlings in Mobile Bay and Mississippi Sound (Swingle 1971) near Dauphin Island (Christmas and Waller 1973) indicates that at least some Spanish mackerel use estuaries during their early life stages. Conceivably, some could spawn there. Early fingerlings also have been caught in the shallow waters off Mustang Island and near river mouths in Texas (Baugham 1947). Most Spanish mackerel mature in their third year of life when 25 to 34 cm (10 to 13 inches) long.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

According to Hoese and Moore (1977), Spanish mackerel in the northern Gulf usually spawn at salinities between 30.0 to 35.5 ppt and at water temperatures exceeding 25°C (77°F). Larvae in Texas waters live in a temperature range of 19.6° to 29.8°C (67.3° to 85.6°F) and at salinities ranging from 28.3 to 37.4 ppt (McEachran et al. 1980). Another source reports that preferred water temperatures are from 21° to 27°C (70° to 81°F) (Berrien and Finan 1977b). Most early juveniles caught in sampling gear were in salinities exceeding 10 ppt. Preferred bottom habitat for young mackerel seems to be clean sand.

FOOD HABITS

Older juveniles and adults feed on fish (usually herring and shad) according to Berrien and Finan (1977b). Knapp (1949) found that the stomachs of Spanish mackerel contained 61% fish, 23% shrimp, 11% squid, and 5% crabs.

USES BY MAN

Adult mackerel, particularly in the fall as they migrate along the Gulf coast, are often taken by anglers from shore, especially near barrier islands, and from piers and boats. Occasionally some are caught in estuaries. Anglers may be successful in Alabama and Mississippi from March to November (Springer and Pison 1958). Some anglers in Louisiana catch mackerel throughout the year, so apparently not all mackerel leave the Mississippi Sound area in the winter (Christmas and Waller 1973). In Alabama, where Spanish mackerel have an average weight of 1 kg (2.2 lb), they are the second most important marine sport fish, according to the Alabama Department of Conservation and Natural Resources (ADCNR 1976).

Most of the commercial landings of Spanish mackerel are from shrimp trawl catches in offshore waters (Swingle 1976). In Alabama in 1975 only 4.2 mt were taken commercially while 436.3 mt were taken by anglers. The mean annual commercial catch in 1968-78 was 30.1 mt in Alabama and 75.8 mt in Mississippi (NMFS 1981a).

ATLANTIC CUTLASSFISH

Trichiurus lepturus

INTRODUCTION

This species is abundant in northern Gulf waters and sometimes contributes to industrial bottom-fish production. The fish is scaleless, eel-like, with large jaws and teeth which make it unattractive as a food and sport fish (Dawson 1967; Hoese and Moore 1977). The cutlassfish prefers moderate to high salinities (Parker 1965). Some adults may reach 1.8 m (6 ft) long, but most are 0.6 to 0.9 m (2 to 3 ft).

DISTRIBUTION AND BEHAVIOR

The cutlassfish inhabits inshore waters up to 500 m (1,640 ft) deep, but usually less than 60 m (197 ft) deep in the northern Gulf. They apparently spawn in June through August at depths from 22 to 60 m (72 to 197 ft) (Dawson 1967). The pelagic larvae and early juveniles are carried by currents into shallow waters, sometimes into estuaries. Older juveniles move into estuarine nursery grounds in the summer and return to the Gulf of Mexico in the fall. Spawning in the Gulf has also been reported for January-February (Dawson 1967), May-June (Miller 1965), and May-July (Hoese 1965), based on the appearance of eggs (buoyant), larvae, and early juveniles in the sampling gear. Early juveniles were taken at depths from 30 to 60 m (98 to 197 ft) off the coast of Louisiana, but as they grew older (in spring and summer) they became more abundant at depths of 7 to 15 m (23 to 49 ft) (Dawson 1967) which suggests an inshore movement. The cutlassfish tends to remain near the bottom during the day and comes near the surface at night.

Cutlassfish reach a mean length of 25 cm (10 inches) by the end of the first year, 40 cm (16 inches) in the second year, and 70 cm (28 inches) by the end of the third year. About 40% of the cutlassfish mature at the end of their first year of life, and all are mature at 5 years (Fritzsche 1978).

ECOLOGICAL FACTORS INFLUENCING DISTRIBUTION

In Alabama most fish are captured in inshore coastal waters and Mississippi Sound. Few were captured in Mobile and Perdido Bays (Swingle 1971). The salinity range for the species is 5 to 30 ppt. About one-half of the catches were in salinities from 5.0 to 9.9 ppt (Swingle 1971). Gunter (1945) found no cutlassfish in salinities less than 13 ppt. In Mississippi, cutlassfish were taken at water temperatures between 10.0° and 34.9°C (50.0° and 94.8°F) and at salinities between 5.0 and 35.5 ppt. The highest catches were between 20.0° and 24.9°C (68.0° and 76.8°F) and 25.5 and 29.9 ppt (Christmas and Waller 1973).

FOOD HABITS

The cutlassfish feeds on a wide range of fish species as well as squid, shrimp, and isopods. It apparently feeds most heavily near dawn and dusk (Portsev 1978) and near the surface at night (Springer and Woodburn 1960). In the Gulf of Mexico, cutlassfish eat fish, principally anchovies, detritus, mysid shrimp, penaeid shrimp, larval crustaceans, and squid (Mericas 1981).

USES BY MAN

Most cutlassfish are caught by shrimp trawlers, but some are taken in the groundfish trawl fishery. Even as an industrial fish, cutlassfish are not in great demand; they are landed only when caught in great abundance. Cutlassfish are marketed for food in the Orient and parts of the Caribbean (Dawson 1967). Recent immigrant Orientals are now utilizing cutlassfish for food along the northern Gulf coast.

The cutlassfish contributed 1,814 mt to the annual industrial bottom fish production of the Gulf States, based upon 1959-62 catch statistics (Dawson 1967). In the summer most were taken at depths of 18 to 40 m (59 to 131 ft), but the highest catch was at 15 m (49 ft).

FLORIDA POMPANO

Trachinotus carolinus

INTRODUCTION

The Florida pompano is a common marine fish along the barrier islands bordering Mississippi Sound and Mobile Bay. It often inhabits inlets and surf zones, but migrates in the fall and early winter to deeper offshore waters (Johnson 1978). No data are available on trends in abundance; however, the biological data base for the Florida pompano is reasonably adequate.

DISTRIBUTION AND BEHAVIOR

Florida pompano prefer the sand beach and surf zone habitat along the barrier islands bordering Mississippi Sound and Mobile Bay. They are common in spring and summer in the surf zone (Modde and Ross 1981). Modde (1980) collected juvenile pompano from April to August in the surf zone of Horn Island, but they were most abundant in May.

Florida pompano spawn offshore from May to October (Johnson 1978), and the larvae develop offshore and move into the beach and surf zone where the juveniles mature from April to September (Swingle 1971; Christmas and Waller 1973). With cooler weather in the fall, pompano move to deeper offshore waters. This species is a schooling fish that feeds on the bottom (McClane 1965) and is most active during the daytime. Modde and Ross (1981) collected the most juvenile pompano in the early afternoon and early evening in the surf zone of Horn Island in 1976.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Young and adults apparently do not tolerate the low water temperatures associated with estuaries and surf zones during the winter (McClane 1965). Pompano are normally in the upper salinity ranges and seldom move into low salinity water (Finucane 1969; Johnson 1978).

Juveniles have been taken in waters with temperatures ranging from 10° to 34°C (50° to 93°F), and adults from 17° to 32°C (63° to 90°F) (Johnson 1978). Optimum larval salinities range from 10 to 35 ppt; optimum juvenile salinities range from 20 to 35 ppt, and optimum adult salinities range from 10 to 35 ppt (Johnson 1978).

The Florida pompano inhabit shallow waters near beaches in the spring and summer and much deeper waters in the winter (Berry and Iversen 1966). This species is normally found over firm sand bottoms and is attracted to submerged reefs and oil platforms (Bellinger and Avault 1970).

FOOD HABITS

This carnivore feeds largely on small pelagic and benthic invertebrates (McClane 1965). Larval pompano feed on polychaetes, gastropod larvae, amphipods, copepods, and insects (Fields 1962). Juveniles feed on polychaetes, shrimp, clams, mysids, and blue crab larvae (Bellinger and Avault 1971). Adults feed on fish, crabs, shrimp, amphipods, and mollusks (Berry and Iversen 1966).

USES BY MAN

The Florida pompano is considered to be a food fish without equal and is very popular with sport fishermen. They are fished along beaches in the surf as well as offshore, particularly around oil platforms and artifical reefs.

CREVALLE JACK

Caranx hippos

INTRODUCTION

The crevalle jack, a large pelagic fish, is common in Mississippi Sound and Mobile Bay during the summer. It is a euryhaline fish and moves into fresh water and low salinity bays, particularly in the juvenile stage. Schools of large crevalle jack also occur in the Mobile Delta in late summer and fall (Glen Coffee, Mobile District Corps of Engineers; pers. comm.). In the winter, the larger jacks move into offshore Gulf waters. No data are available on the crevalle jack's trend in abundance.

DISTRIBUTION AND BEHAVIOR

The crevalle jack spawns offshore from March through September (Berry 1959). Adults usually remain offshore, but feed occasionally in shallow estuaries in the summer. Juveniles live in Mississippi Sound and Mobile Bay in the spring and summer (Swingle 1971; Christmas and Waller 1973). Berry (1959) reported a number of inshore areas around the Gulf where juveniles have been collected; however, larvae live offshore. The crevalle jack is most active during the day time in the upper water column (Kwei 1978). The species tends to move in small schools, but some large adults are solitary (McClane 1965).

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Crevalle jack adult movement, growth, and spawning are influenced by temperature. Colder temperatures (below 18°C or 64°F) trigger larger fish to seek deeper, warmer offshore waters; immigration to estuaries begins when temperatures exceed 20°C (68°F) in the spring. Larvae have been recorded from 20° to 29°C (68° to 84°F) and adults from 18° to 34°C (64° to 93°F) (Johnson 1978). Large numbers of juvenile crevalle jack were killed during a January cold period when the temperature reached 10°C (50°F) in Indian River Lagoon, Florida (Gilmore et al. 1978).

This species has a wide salinity tolerance. It is frequently taken in brackish waters and, at times, in coastal rivers (Berry 1959). Larvae have been taken between 35 and 37 ppt salinity, juveniles from 0.1 to 36 ppt, and adults from 0 to 44 ppt. The optimum salinity for adults is above 30 ppt (Johnson 1978).

Crevalle jack live over a wide range of depths, from shallow mud flats in estuaries to offshore waters over the continental shelf. Since this fish is a pelagic schooling fish, it has not been identified with a particular bottom type.

FOOD HABITS

The crevalle jack is a voracious carnivore that feeds on a variety of pelagic fishes, especially mullet (Pew 1971). It also feeds on shrimp and crabs. No information is available on larval or juvenile food habits.

USES BY MAN

The crevalle jack does not support much of a commercial fishery in the northern Gulf. The U.S. commercial catch is concentrated in western Florida, where it is the second most important jack (McClane 1965). The taste of smaller fish is rather good, but specimens over 0.3 to 4.5 m (1 to 15 ft) long are reported to be dark and almost tasteless (McClane 1965). The crevalle jack is very popular with sport fishermen because it is a fierce and stubborn fighter. One of the larger predatory fishes in the Gulf, it reaches weights exceeding 25 kg (55 lb) (McClane 1965).

BLUEFISH

Pomatomus saltatrix

INTRODUCTION

The bluefish is a migratory pelagic species that is relatively common in offshore waters of Mississippi Sound and Mobile Bay (Wilk 1977). Juveniles and adults have been captured in nearshore areas of the barrier islands, but they are not commonly abundant in low salinity estuaries (Swingle 1971; Christmas and Waller 1973). In 1970, bluefish was the number one sport fish of U.S. marine coastal waters; an estimated 1.4 million anglers caught about 54,799 mt (Deuel 1973). No identified trends in abundance are apparent in the Gulf of Mexico, and there are no State or Federal regulations for the management of bluefish in Mississippi Sound and Mobile Bay. Published accounts on bluefish in the Gulf of Mexico are rare, and most life history data have been collected on the Atlantic coast. Bluefish are not estuarine dependent, but they move into or near estuaries to feed.

DISTRIBUTION AND BEHAVIOR

Bluefish spawn over, or seaward of, the continental shelf in the Gulf of Mexico from August to April (Barger et al. 1978; Finucane et al. 1980). The juveniles and adults migrate in the spring to nearshore areas and some enter estuaries. The distribution of immature stages of bluefish in the Gulf of Mexico is not well documented. Bluefish are usually caught around the barrier islands and along the island beaches on the Gulf side.

Large bluefish juveniles and adults school, usually separately (Wilk 1977). Adults are active during all daylight hours (Olla and Studholme 1971). Laboratory studies on the Atlantic coast show that temperature had significant influence on swimming activity; when acclimatized at 19° to 20°C (66° to 68°F), stress was indicated when temperatures approached a low of 11.9°C (53.4°F) and a high of 28.8°C (83.8°F) (Olla and Studholme 1971). Movements between offshore and inshore waters in the Gulf of Mexico are irregular, reportedly in response to changes in water temperature (Wilk 1977).

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

Temperature and salinity are the only factors cited by Wilk (1977) as determinants of the distribution of bluefish on the Atlantic coast. Extensive data from egg and larval collections on the outer continental shelf of Virginia showed that maximum spawning occurred at 25.6°C (78.1°F) with none below 18°C (64°F) (Norcross et al. 1974). Minimum spawning temperature is about 14°C (57°F) (Hardy 1978). Bluefish seem to prefer salinities from 26.6 to 34.9 ppt. Limited larvae collections in the Gulf of Mexico were found in a temperature range of 23.2° to 26.4°C (73.8° to 79.6°F) and a surface salinity range of 35.7 to 36.6 ppt (Barger et al. 1978). In estuaries they rarely live in salinities below 10 ppt. Hardy (1978) suggested 7 ppt as the minimum salinity. Lacking are data on the effects of substrate, turbidity, tides, or dissolved oxygen on bluefish distribution. Bluefish activity patterns are highly oriented to vision (Olla and Studholme 1979), however, and bluefish are not likely to frequent turbid areas.

FOOD HABITS

Juvenile and adult bluefish feed voraciously by sight throughout the water column on a large variety of fishes and invertebrates. Major foods are menhaden, silversides, anchovies, spotted seatrout, Atlantic croaker, and spot. Invertebrates include squid, shrimps, crabs, mysids, and annelids (Wilk 1977).

USES BY MAN

The mean annual commercial catch of bluefish from 1968 to 1978 in Mobile Bay was 0.9 mt, and in Mississippi Sound it was 5.4 mt (NMFS 1981a). From 1965 to 1975, 93% of the commercial landings in Alabama were from offshore waters, and the remainder were from inshore waters (Swingle 1976). The sport catch of bluefish in Alabama in 1975 was 412 mt (Swingle 1976). The species is an incidental commercial food species but an important sport species in the area.

COBIA

Rachycentron canadum

INTRODUCTION

The cobia is a relatively large (up to 22 to 45 kg or 49 to 99 lb and 1.8 m or 5.9 ft long) sport fish that inhabits the shallow parts (< 100 m) of the continental shelf of the Gulf of Mexico. The species often is found around pilings, buoys, wrecks, or floating objects (Hoese and Moore 1977). Data on this species are relatively scarce and sometimes contradictory. A review of the literature on life history is best given by Richards (1967).

DISTRIBUTION AND BEHAVIOR

Cobia concentrate and spawn offshore, primarily in April and May but as late as August, in waters less than 20 m (66 ft) deep. The eggs are buoyant, pelagic, and hatch in about 36 hours. In early summer, the adults disperse and tend to concentrate near stationary objects such as oil and gas drilling and production platforms. The species also inhabits open-water inlets and bays, harbors, and reefs (Hardy 1978). Although the young are uncommon in estuaries, some live in high salinity waters of bays in the summer (Parker 1965). Several young have been caught in or near Mobile Bay in the summer and fall (Swingle 1971). On the east coast, juveniles are observed near beaches, bays, shoals, and river mouths (Hardy 1978).

The cobia is not a schooling species, but sometimes groups of three to four fish are observed. Sometimes it associates with sharks, rays, and pilot fishes.

Male cobia mature in their second year of life when about 577 mm fork length (FL) long, and females mature in their third year when about 695 mm FL long. Some fish live as long as 10 years, but a large majority are 5 years old or younger (Richards 1967). Females may lay, sometimes intermittently, as many as 5 million eggs a year. Juvenile cobia rarely have been reported anywhere.

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

Cobia usually live in salinities exceeding 30 ppt (Parker 1965) and at temperatures from 20° to 32°C (68° to 90°F). They tend to be most abundant in northern Gulf waters in March and April (during spawning) and in Gulf waters of Florida in April through August. Apparently large numbers move to the southern Gulf in the winter.

FOOD HABITS

The cobia is highly predaceous, especially on fish and squid.

USES BY MAN

The flesh of the cobia is good eating, and the fish is caught by anglers near oil and gas platforms, and natural and manmade reefs. In Alabama in 1975, 62.5 mt of cobia were caught by anglers, mostly from private boats (Wade 1976). The commercial catch in 1975 was only 3.0 mt (Swingle 1976).

STRIPED BASS

Morone saxatilis

INTRODUCTION

The striped bass, an important commercial and sport fish species along the Atlantic coast, once was common in rivers of the northern Gulf of Mexico (McIlwain 1980). The Atlantic coast populations north of South Carolina have declined greatly in recent years, according to the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration (USFWS and NOAA 1980); and the native Gulf of Mexico stocks are low. Extensive attempts are underway to re-establish striped bass in northern Gulf of Mexico rivers. The native Gulf coast race (or stocks) once ranged from the Suwannee River in Florida to Lake Pontchartrain in Louisiana. Years ago large striped bass sometimes migrated up the Mississippi River as far north as St. Louis, Missouri (Barkuloo 1980), and recently one was caught near Vicksburg, Mississippi. The Gulf stocks can be separated from the Atlantic coast stocks by lateral line scale counts and a combination of fin ray counts (Barkuloo 1970). McIlwain

(1968) suspected that pollution was responsible for the decimation of the Gulf stocks of striped bass in Mississippi rivers.

The only known reproducing population of Gulf stocks of striped bass inhabits the Apalachicola River, Florida. Attempts to culture them were first successful in 1980, and the young fish were reintroduced into the Pascagoula River (Crateau 1980a). The Gulf and Atlantic stocks of striped bass from southern coastal rivers (Florida to South Carolina) are primarily riverine and usually do not undertake coastal migrations (Setzler et al. 1980); however, northern stocks of the Atlantic coast, concentrated in Chesapeake Bay, migrate along the coast as far north as Maine and as far south as North Carolina.

Young fish hatched from Atlantic stocks from North Carolina and Chesapeake Bay and from southern coastal rivers have been stocked in northern Gulf of Mexico rivers. Striped bass from South Carolina rivers have been stocked widely in inland reservoirs and rivers in more than 25 States, and several self-sustaining populations have been established (Setzler et al. 1980).

According to scattered historical records, native striped bass once were taken commercially in small numbers from Apalachicola Bay, Florida, and from Mobile Bay, Alabama (Shell and Kelly 1968). According to Barkuloo (1980), the Gulf stocks of striped bass probably inhabit rivers more than bays and estuaries. Data on the estuarine phase of the Gulf stocks are scarce, and the only information on their riverine phase is from the Apalachicola River, Florida (Crateau 1980a). Setzler et al. (1980) prepared an excellent review of the biology of the striped bass, but much of the review concerned Atlantic stocks.

DISTRIBUTION

Striped bass stocks in coastal rivers of Alabama (Alabama River) and Mississippi (Pascagoula, Pearl, and Biloxi Rivers) are now being maintained by stocking Atlantic stocks of fish. These stocks appear to move into estuaries more than the native stocks (McIlwain 1980). The status of striped bass restoration is discussed in the following paragraphs.

The Apalachicola River, Florida, has both Atlantic and Gulf stocks of striped bass. In this river 39 out of 100 striped bass captured in a fishing tournament in 1979 were from Gulf stocks, and the rest were from Atlantic stocks (Hollowell 1980). The striped bass eggs for fish culture and restoration of the Gulf stocks were collected from this river.

In the Alabama River, Alabama, large numbers of young fish from Atlantic stocks have been introduced. In 1979 only 4 out of 250 of the recaptured striped bass examined were from Gulf stocks. Preliminary plans call for introducing Gulf stocks into Lewis Smith Lake, and the Perdido, Blackwater, and Styx Rivers, Alabama (Crateau 1981). The status of natural reproduction of the Gulf or Atlantic stocks in the Alabama River is unknown.

In Mississippi, fish from Atlantic stocks have been planted in the Pearl, Jourdan, Biloxi, and Pascagoula Rivers. Sizable numbers are now being caught in the lower reaches of these rivers, and some have been taken on the Gulf side of

Ship Island and around the Chandeleur Islands (McIlwain 1980). Fingerlings of Gulf stocks were introduced into the west branch of the Pascagoula River (Bluff Creek) in 1980, but the success of this introduction has not been evaluated (Crateau 1980a). Future plans call for stocking additional fish from Gulf stocks into the Pascagoula River and possibly into the Pearl River (U.S. Fish and Wildlife Service 1981).

Striped bass from Atlantic stocks (as well as striped bass/white bass hybrids) also have been introduced into many Louisiana rivers, and some are being caught in the rivers and off the coast (Hollowell 1980). T. McIlwain (Gulf Coast Research Laboratory, Ocean Springs, Mississippi; pers. comm.) reported that striped bass are occasionally caught at the mouth of the Mississippi River by commercial fishermen.

Current attempts to restore the striped bass in northern Gulf of Mexico rivers appear to be partially successful. There is evidence that fish from Atlantic stocks do not grow as large or as old as the Gulf stocks in the same Gulf coast rivers (Crateau 1980b; McIlwain 1980).

ENVIRONMENTAL REQUIREMENTS

The principal spawning area in the Apalachicola River, Florida, appeared to be the tailwater area of Jim Woodruff Lock and Dam (Crateau 1980a). They spawn from February to May in the temperature range of 10° to 24°C (50° to 75°F). Eggs hatch in about 30 hours at 21° to 22°C (70° to 72°F), 48 hours at 18° to 19°C (64° to 66°F), and 70 to 74 hours at 14° to 15°C (57° to 59°F) (Setzler et al. 1980). Striped bass require a sandy or rubble bottom for spawning. McIlwain (1968) reported that striped bass historically spawned from mid-February to mid-March in Mississippi. The Atlantic stocks may spawn from 5 to 241 km (3 to 150 mi) above the river mouth (Setzler et al. 1980). Some optimal requirements for early life stages are listed below (Setzler et al. 1980).

Habitat factors	Egg	Larvae (up to 20 mm)	Juveniles (20-50 mm)
Flow rate (m/s)	1.0-2.0	0.3-1.0	0-1
Salinity (ppt)	1.5-3.0	5-10	10-15
Temperature (°C)	17-20	16-19	16-19
Dissolved oxygen (mg/l)	>1.5	5-18	6-12

The fish spawn in turbid rivers and suspended sediment concentrations of 550 mg/l had no effect on striped bass eggs. Spawning became more active in the Roanoke River when minimum flows exceeded 1.6 m/sec, and most spawning terminated when flows were less than 1.1 m/sec (Setzler et al. 1980). Precise details on striped bass spawning requirements in Gulf of Mexico rivers are not available.

Because of the differences between Gulf of Mexico and Atlantic coast estuaries, it is not possible to document the expected striped bass behavior in Mississippi and Alabama estuaries.

FOOD HABITS

McIlwain (1980) mentioned threadfin shad, menhaden, and silversides as the primary foods of introduced Atlantic stocks in Mississippi rivers. Adult striped bass in the Apalachicola River utilized threadfin shad, American eel, Atlantic needlefish, and other fishes (Crateau 1980a). Small striped bass of the Atlantic coast feed on small crustaceans, small fish, and insects (Setzler et al. 1980).

USES BY MAN

The striped bass commercial catch off the Atlantic coast was 3,162 mt in 1973, and the estimated 1970 sport catch was 16,623 mt (Setzler et al. 1980). Attempts are underway to restore the striped bass to Gulf coast rivers, and the commercial sale of the species is not permitted (Setzler et al. 1980). The striped bass is the only anadromous fish species of significant sport fishing value in the northern Gulf of Mexico. Although special efforts are being made to re-establish the Gulf stocks, the existing stocks consist predominantly of the Atlantic stocks.

TRIPLETAIL

Lobotes surinamensis

INTRODUCTION

The tripletail is sometimes taken by anglers and commercial fishermen (Hoese and Moore 1977), but little is known about its habits. A few grow as big as 9 kg (20 lb), but most only weigh from 0.5 to 1.0 kg (1.1 to 2.2 lb). Data on distribution, abundance, and life history characteristics are scarce.

DISTRIBUTION AND BEHAVIOR

This fish is relatively common in inshore waters, and in the summer in deeper waters of sounds, bays, and estuaries. It spawns in the summer, May through August, in inshore waters and in grassy areas of large sounds and bays (Baughman 1941, 1943b; Swingle 1971; Hardy 1978). Tripletail often inhabit the upper 1 m (3 ft) of the water column, but they have been taken in fish samples 46 m (151 ft) deep, and on one rare occasion at a depth of 1,573 m (5,161 ft) deep and out from the shore as far as 275 km (171 mi).

Individuals are sluggish and sometimes float on their side on the surface with their head down and tail up (Hardy 1978). Juveniles often are observed in weed beds and near submerged objects in harbors. Tripletails school only during spring-fall migration to and from offshore waters. They mature in their second year by the time the males are 44 cm (17 inches) long and the females are 45.5 cm (18 inches) long.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Factors affecting seasonal abundance in or near estuaries, or affecting the tripletail's survival or habits are little known. The fish apparently is estuarine dependent. Fry 15 to 25 mm long apparently prefer salinities from 10 to 20 ppt.

FOOD HABITS

The food of the tripletail has not been reported in the available literature.

USES BY MAN

The flesh of the tripletail is good eating but bony (Hoese and Moore 1977). The fish has sport value and is included as a category in some of the fishing rodeos along the Gulf coast.

RED SNAPPER

Lutjanus campechanus

INTRODUCTION

The red snapper is a demersal marine fish common over hard bottoms and banks in the Gulf of Mexico. Adults as large as 13.5 kg (29.8 lb) usually stay in deeper offshore waters. Juvenile snappers will move into shallower waters in Mississippi Sound, including channels and grassbeds. The red snapper is found in shallower waters in summer and in deeper waters in winter (Johnson 1978). Over the past 10 years, there has been a measurable decrease in the commercial catch of the red snapper, thought to be partially due to high catch of slow growing juveniles by commercial shrimp trawlers (Bradley and Bryan 1975). Until the mid-1960's, little was known about the red snapper's life history. Since then, several investigations have been made, primarily in Florida and Texas. The data base on the red snapper needs to be enlarged considerably.

DISTRIBUTION AND BEHAVIOR

The red snapper spends much of its life near the bottom in deep offshore waters near coral, hard sand, banks and outcrops, ridges and manmade submerged objects. It spawns offshore over sand and shell bottoms from June to October (Moseley 1966). Spawning depths range from 16 to 37 m (52 to 121 ft) (Bullis and Jones 1976). The larvae live in offshore waters near the bottom, and the juveniles move into shallow waters, natural channels in sounds, and grass beds on sand bottoms (Moseley 1966). A few have been collected in the Mobile ship channel and near the mouth of Mobile Bay (Swingle 1971). Adults migrate into shallow offshore waters in the warmer months and then move to deeper waters in the colder months. The red snapper is a schooling fish and tends to concentrate in large numbers around wrecks or submerged objects. Little published information is available concerning diel distribution except that night fishing has been effective, indicating nocturnal feeding (Carpenter 1965).

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Little data are available on influences of tides, salinity, light, and turbidity on red snapper. From the red snapper's habitat preferences, it is known that it occurs in areas of high salinity (33 to 37 ppt), low light concentrations, and low turbidity.

Red snapper move shoreward as temperatures rise in the spring and summer, and move offshore in the fall as water temperatures drop. Juvenile red snapper have been recorded from 15° to 30°C (59° to 86°F); and adults, from 13° to 31°C (55° to 88°F) (Bullis and Jones 1976).

Red snappers apparently require high salinity because they are seldom, if ever, taken in estuarine waters. Juveniles and adults have been taken in salinities from 24 to 40 ppt. Optimum salinities are from 33 to 37 ppt (Moseley 1966).

Red snappers are common on the banks (100 to 200 m or 328 to 656 ft deep) of the Gulf of Mexico near the edge of the continental slope and shelf. Juvenile red snappers have been taken in waters ranging from 9 to 91 m (30 to 299 ft) (Moseley 1966), and adults have been taken at depths as great as 219 m (719 ft) (Moseley 1966).

Red snappers are most abundant over or near banks, coral reefs and outcrops, submarine ridges, rocks, and manmade structures such as shipwrecks and offshore drilling platforms. They also are found at times over hard sand and shell bottoms (Bullis and Jones 1976).

FOOD HABITS

The red snapper is a carnivore known for its voracious feeding habits. Juveniles feed on shrimp, crabs, other larval crustaceans, fish, cephalopods, tunicates, and chaetognaths. Adults feed on tunicates, crabs, shrimp, fish, and mollusks (Bradley and Bryan 1975).

USES BY MAN

The red snapper is a valuable contributor to the Gulf commercial and sport fishery. In the Gulf, the commercial fishery is centered off the west coast of Florida, off Texas, and on the Campeche Banks off Mexico. The commercial catch has declined in recent years, possibly due to high mortality of juveniles caught incidentally by shrimp trawlers. Sport fishing for red snapper is popular around submerged objects and oil platforms.

LANE SNAPPER

Lutjanus synagris

INTRODUCTION

The lane snapper is a demersal fish relatively uncommon in the Mississippi Sound and Mobile Bay area, but common off southern Florida. Often found in shallow water, the lane snapper is a bottom feeder that occasionally enters low salinity bays as juveniles. Juvenile lane snappers remain in the bays from March to September (Bullis and Jones 1976) and migrate offshore in the winter. No data are available on the trend in abundance, and the data base on the lane snapper is insufficient.

DISTRIBUTION AND BEHAVIOR

Adult lane snappers live exclusively in high salinity offshore waters (Erhardt 1977). They are bottom fish that spawn over offshore sand bottoms from March to September (Starck 1971). The species is active day and night. Juveniles move inshore in the spring and summer, and a few specimens have been collected in Perdido Bay and around Dauphin Island (Swingle 1971). Adults show little movement or migration in offshore waters. Adult habitat is offshore sand bottoms, natural channels, banks, and manmade reefs and structures (Bullis and Jones 1976).

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

The literature on the lane snapper has little information on the influences of tides and turbidity on behavior.

Adult lane snappers have been recorded at water temperatures between 16° and 29°C (61° and 84°F) (Bullis and Jones 1976). They are apparently killed if exposed to low (8° to 10°C or 46° to 50°F) temperatures (Gilmore et al. 1978).

No data were available concerning salinity tolerances of lane snapper other than the facts that adults are always found in high salinity (>30 ppt) waters and juveniles are often found in low (<15 ppt) salinity (Erhardt 1977). Adult lane snappers have been taken at depths from 4 to 132 m (Starck 1971). The lane snapper is primarily found over hard bottoms, including reefs, banks, submarine ridges, and sand bottoms (Bullis and Jones 1976).

FOOD HABITS

Adult lane snappers feed on fish, crustaceans, annelids, mollusks, and algae (Starck 1971). No information is available on larval or juvenile food habits.

USES BY MAN

The lane snapper, common in southern Florida and the Caribbean, is a popular food fish in that area. Along the northern Gulf, it is less common and is taken incidentally in the commercial red snapper fishery.

GRAY SNAPPER

Lutjanus griseus

INTRODUCTION

The gray snapper is a demersal euryhaline fish relatively uncommon in the Mississippi Sound area. It is much more abundant in southern Florida, the Bahamas, and the Caribbean (Johnson 1978). This snapper frequents a variety of habitats and lives in deep channels and offshore reefs as well as in very shallow water around mangroves and tidal bays. It moves into freshwater streams in summer and therefore is one of the few euryhaline lutjanids (Christmas and Waller 1973). Like the red snapper, it moves to deeper offshore waters during the colder months. Juveniles occupy estuarine nursery grounds in shallow water in the summer. Although the gray snapper is taken incidentally in the fishery for red snapper, no data are available on its trend in abundance. Most of the studies on the gray snapper have been in southern Florida. Little information on this species is available in the Mississippi Sound and Mobile Bay area.

DISTRIBUTION AND BEHAVIOR

This fish lives in a variety of habitats--from shallow freshwater rivers and estuaries to deep offshore reefs and banks. It is a bottom schooling fish most active at night (Starck 1971). It spawns offshore over a sand or rock bottom from April to September (Starck 1971). Juveniles utilize the estuarine bays as nursery grounds from May through September, and a few specimens were collected in Mobile Bay (Swingle 1971). Juveniles and adults migrate to deeper offshore waters in the fall.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Little data are available on the effects of tides, salinity, and turbidity on gray snapper behavior. Starck (1971) reported increased activity of adults at night. From the gray snapper's distribution, it can be concluded that this snapper occurs in a wide range of turbidities.

The gray snapper migrates shoreward in the spring and summer and offshore when water temperatures drop. Larval gray snappers have been caught in water temperatures ranging from 16° to 27°C (61° to 81°F); juveniles, from 17° to 36°C (63° to 97°F); and adults, from 11° to 28°C (52° to 82°F) (Starck 1971).

Gray snappers are euryhaline and can tolerate a wide range in salinity. Juveniles live in salinities from 0 to 37 ppt; and adults, from 0 to 48 ppt (Starck 1971).

Gray snappers have been taken in a wide range of depths. Juveniles have been captured in less than 1 m (3 ft) in estuaries; and adults, to 124 m (407 ft) offshore (Starck 1971).

A wide range of substrates are utilized by gray snappers. In estuarine areas, they frequent vegetated shorelines (mangrove roots in Florida) and mud bottoms (Starck 1971). Juveniles are also found around sandy grassbeds. Offshore, adults prefer sand bottoms, reefs, banks, and rocky areas.

Starck (1971) made an extensive study based on underwater observations of the gray snapper in the Florida Keys. He observed that currents affected the schooling and feeding habits of the gray snapper.

FOOD HABITS

The gray snapper is a carnivore and feeds on progressively larger animal foods as it grows from larvae to adult. Starck (1971) and Baughman (1943a) reported the following food items: larvae - copepods, amphipods; juveniles - shrimp, copepods, small fish, annelids, insects; and adults - crabs, shrimp, fish, squid.

USES BY MAN

The gray snapper is a common commercial fish in the Caribbean, but is relatively uncommon along the northern Gulf. It is a popular food fish with sportsmen, particularly in Florida.

PINFISH

Lagodon rhomboides

INTRODUCTION

The pinfish (*Lagodon rhomboides*) is the most common member of the family Sparidae in the estuarine waters of the Southeastern United States. In vegetated nearshore habitats it is probably the most abundant fish.

DISTRIBUTION AND BEHAVIOR

In spring and summer, late larval and juvenile pinfish are abundant in shallow grass bed areas. Larger fish usually move to deeper holes and channels in summer before moving offshore where they spawn during the fall and winter.

Pinfish apparently spawn some distance offshore from late fall through early winter (Hildebrand and Cable 1938; Reid 1954; Kilby 1955; Caldwell 1957; Hansen 1970). Caldwell (1957) reported that pinfish spawned from October to March, and peaked in December and January at Cedar Key, Florida. Ruple (1981) suggested a peak in spawning during the fall off the Mississippi coast based on the occurrence of late larvae ($\sim$ 10 mm SL) during December. Spawning probably occurs near the surface (Hansen 1970) where pelagic larvae have been collected (Hildebrand and Cable 1938; Caldwell 1957). Larvae move inshore in the spring and inhabit waters near both high and low energy beaches (Caldwell 1957; Modde and Ross 1981; Ruple 1981) during the winter and spring. In spring and summer late larval and juvenile pinfish are the numerically dominant fish in shallow subtidal seagrass meadows (Hoese and Jones 1963; Hansen 1970). In summer most adults and some juveniles inhabit deeper open waters of estuaries and channel edges (Caldwell 1957). Pinfish generally are free swimming fishes throughout the water column (Caldwell 1957). Migration to the outer portions of the estuary and offshore begins in late summer and fall when fish of the same age may congregate in schools (Hansen 1970).

ENVIRONMENTAL REQUIREMENTS AFFECTING BEHAVIOR

The pinfish tolerates a wide range of environmental conditions. Specimens were collected in Mississippi Sound at water temperatures from 10.0° to 34.9°C (50.0° to 94.8°F) and salinities ranging from 5.0 ppt to 35.5 ppt (Christmas and Waller 1973). They have been taken at depths from several centimeters to 73 m (240 ft). Generally, the larger fish and larvae, which are spawned offshore, occur in relatively deep waters. Pinfish show no apparent preference for bottom types or currents, but adults are not often collected from turbulent surf zones (Caldwell 1957; Modde and Ross 1981).

FOOD HABITS

Pinfish are one of the most important predators on macrobenthic organisms of seagrass meadows and have been shown to play an important role in the organization of faunal assemblages in these areas. Pinfish demonstrate planktivory, omnivory, strict carnivory, and strict herbivory at different times, places, and developmental stages (Stoner 1979). Larvae (< 16 mm SL) are planktivorous, feeding primarily on calanoid copepods. Juveniles (16 to 80 mm SL) feed on harpacticoid copepods, amphipods, and plant matter. Adults feed mostly on plant material, and where plant material is unavailable, bivalves become an important food item (Stoner 1979).

ECOLOGICAL ROLE AND USES BY MAN

Although not generally considered a sport or food fish, large numbers of pinfish are taken by sport fishermen with larger fish sometimes being eaten. Pinfish are used by sport and commercial fishermen as a bait fish for red drum, spotted seatrout, and tarpon (Caldwell 1957). Pinfish are of minimal commercial value in the canned pet food industry, which utilizes mixed catches of "scrap fishes." The prime importance of pinfish in Mississippi Sound is the ecological role they play in the predator-prey relationships of the region, especially in the shallow grass bed habitats.

SHEEPSHEAD

Archosargus probatocephalus

INTRODUCTION

The sheepshead is a relatively common species in the coastal waters of Mississippi Sound and Mobile Bay, but it is not highly regarded as a sport or commercial fish. Commercial landings of sheepshead (most taken incidentally in shrimp trawls) exceeded 450 mt in the Gulf in most years before 1939, but have been low since then because of changes in shrimp fishing methods rather than from depleted stocks (Lyles 1968). Sheepshead weigh as much as 9 kg (20 lb), but most weigh 1.3 to 1.8 kg (2.9 to 4.0 lb). Data on the age, size, and growth of sheepshead are rare.

DISTRIBUTION AND BEHAVIOR

This species spawns in schools in the shallow sandy inshore waters of the Gulf in late winter, spring, and early summer (Johnson 1978). The eggs float and usually hatch in less than 2 days. The larvae migrate into shallow estuaries primarily in March to May and, as juveniles, sometimes congregate in grass beds (Christmas and Waller 1973). Pelagic larvae inhabit surface waters near a sandy shore, and later stages (up to 50 mm long) live in shallow waters over grass beds. As they grow larger and their crushing dentation develops, the young start to occupy habitats and develop food habits similar to those of the adults (Johnson 1978). In summer the adults live in estuarine and inshore waters and tend to associate with muddy shallow waters and inlets. In late fall when water temperatures drop, sheepshead of all ages tend to migrate from estuaries to overwinter in offshore waters. Sheepshead do not typically school, but they commonly form feeding aggregations (Johnson 1978).

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

The sheepshead thrives in a wide range of salinities and water temperatures. Temperatures where sheepshead have been captured range from 16° to 30°C (61° to 86°F) (Gunter 1945) and 12.0° to 32.5°C (53.6° to 90.5°F) (Springer and Woodburn 1960). In separate investigations, sheepshead were reported to live in salinities ranging from 0.3 to 29.9 ppt (Gunter 1945), 3.7 to 29.8 ppt, 5.0 to 35.0 ppt (Herald and Strickland 1949), and 0.0 to 35.0 ppt (Etzold and Christmas 1979). Fry were taken at salinities from 5.0 to 24.9 ppt. Some sheepshead have been caught in salinities as high as 80 ppt (Gunter 1945).

Although this fish may spend most of its time over sand and soft bottoms, fingerlings may use grass beds in shallow waters. Adults tend to associate with hard bottom surfaces, such as oyster beds, wrecks, pilings, and bulkheads.

FOOD HABITS

Except for young fish, sheepshead are bottom feeders. The larvae usually consume copepods, amphipods, and other zooplankton; small juveniles may eat copepods, mysids, polychaetes, and chironomid larvae; larger juveniles and adults eat blue crabs, barnacles, young oysters, clams, other mollusks and crustaceans, and young croakers. The teeth of this species are adapted for capturing and eating barnacles and other shelled animals attached to hard surfaces such as pilings and bulkheads (Johnson 1978).

VALUE TO MAN

Sheepshead support a moderate sport fishery in most months. They are taken commercially almost exclusively by shrimp trawlers while fishing offshore for shrimp, but sometimes they are caught intentionally when they are most available during spawning in March to May. Sheepshead have a low dockside value, and most incidental catches in shrimp trawls are probably discarded.

In Alabama in 1975, 50 mt of sheepshead were taken commercially, and 93 mt were taken by sport fishermen (Swingle 1976). In 1969-78 the average annual commercial catch was 98 mt in Alabama and 30 mt in Mississippi (NMFS 1981a).

SPOT

Leiostomus xanthurus

INTRODUCTION

The spot, Leiostomus xanthurus, is distributed along the Atlantic coast from Massachusetts Bay to the Gulf of Mexico south to the Bay of Campeche, Mexico. The fish has various local common names such as goody, flat croaker, roach, and post croaker (Dawson 1958). It is an abundant estuarine-dependent species in Mississippi Sound and Mobile Bay, and it is used primarily as an industrial fish for pet food manufacture.

ENVIRONMENTAL FACTORS

The spot is a euryhaline fish capable of enduring salinities from 0 to 60 ppt. In Louisiana waters spot were collected in salinities from 0.2 to 30 ppt (Perret et al. 1971), but the largest catches were made at salinities of 10 ppt or higher. Spot were taken in salinities of 0.0 to 33.9 ppt in Mobile Bay and were more abundant at higher (>10 ppt) salinities (Nelson 1969). J.C. Parker (1971) collected more spot than other fish in the high salinity waters of Lake Borgne, Louisiana. Swingle and Bland (1974) collected more spot than croaker at high salinity stations in coastal Alabama waters. They also stated that there was a general trend for the smaller fish to be taken at low salinities (0.0 to 23.5 ppt). In St. Andrew Bay, Florida, spot were captured in the largest numbers in the deeper and higher salinity (12 to 32 ppt) stations (Naughton and Saloman 1978).

Hildebrand and Cable (1930) reported that 5.0°C (41.0°F) was close to the lethal limit for 1-year or older fish at Beaufort, North Carolina, but noted that the young-of-the-year fish were less sensitive to cold than older fish. Dawson (1958) concluded that the lethal minimum temperature for spot is about 5°C (41°F), and it probably fluctuates with the size of the fish, duration of low temperature, and rapidity of the temperature drop. Abundance dropped off sharply below 9°C (48°F); however, some spot were collected in Mobile Bay at 6°C (43°F). Spot were taken in Mobile Bay at 31°C (88°F), the highest temperature recorded in the survey (Nelson 1969).

LIFE HISTORY AND DISTRIBUTION

Spot are 2 years old before reaching sexual maturity (Dawson 1958; Nelson 1969). Spawning apparently takes place offshore during the winter. Spawning in North Carolina may take place in November, but the principal spawning months are December and January with diminished activity in February (Hildebrand and Cable 1930). Nelson (1969) suggested that spawning in coastal waters off Mobile Bay begins in late December or early January and continues through March. Spawning was observed about 24 km (15 mi) offshore of Mobile Bay at a depth of 27 m (89 ft). From the appearance of postlarvae, J.C. Parker (1971) determined the spawning period of spot to be short, extending from December through January for Lake Borgne, Louisiana, and from January through March offshore from Galveston Bay, Texas, area.

Data on spawning habits for spot on the Atlantic coast are of interest because of the scarcity of data on spawning in the Gulf of Mexico. For example, Dawson (1958) found that adult spot move out of the sounds and rivers of South Carolina in the fall. Numbers of large spot with ripe or nearly ripe gonads have been taken off South Carolina at depths to 81 m (266 ft). The spot migrate to deeper waters and spawn largely in December and January. The fertilized eggs and larvae are transported into the estuarine system, but they enter the estuaries later than croakers. Spot larvae were first encountered in the estuaries around December in Mississippi, according to the Gulf of Mexico Fishery Management Council (GMFMC 1981). In South Carolina, postlarvae and juvenile populations appear in the inshore areas as early as February or March (Dawson 1958). Juvenile spot first appeared in collections in early December in North Carolina (Hildebrand and Cable 1930). They disperse into shallows and marsh areas in late winter, but move into open bay waters in the spring (Nelson 1969).

Sundararaj (1960) reported that young were first taken in Lake Pontchartrain, Louisiana, in January. In Lake Borgne, Louisiana, and Galveston Bay, Texas, postlarvae appeared each year shortly after temperatures began to rise. Young spot used nursery areas less than 1.2 m (3.9 ft) deep (J.C. Parker 1971). Dawson (1958) believes that young fish probably remain in the inshore nursery areas with local changes in distribution until the end of their second summer. Those with developing gonads begin a gradual movement back to the sea to spawn. This agrees with the findings of Hildebrand and Cable (1930), Nelson (1969), J.C. Parker (1971), and Music (1974).

FOOD HABITS

Spot feed primarily on small benthic organisms. Small fish (<25 mm) feed entirely on small crustaceans, principally copepods. Thereafter detrital material occurs in the stomachs in increasing abundance along with minute mollusks and annelids (Hildebrand and Cable 1930). The food of the spot in Chesapeake Bay consists mainly of crustaceans and annelids, and small amounts of mollusks and fish (Hildebrand and Schroeder 1972).

Kobylinski and Sheridan (1979) reported that spot eat a wide variety of foods including polychaetes (23.8%), harpacticoid copepods (21.0%), detritus (16.3%), and bivalves (10.4%). Analysis showed three size-related feeding categories: (1) 20- to 29-mm fish feed mostly on insect larvae, harpacticoid copepods, and detritus; (2) 70- to 99-mm fish eat detritus, harpacticoid copepods, and polychaetes; and (3) 100- to 109-mm fish eat bivalves. Larval spot feed most actively in daylight, with maximum activity at noon (Kjelson and Johnson 1976).

USES BY MAN

There is no commercial food fishery for spot in Mississippi and Alabama, but they are caught incidentally by the shrimp fleet, menhaden purse seine fishery, and sport fishermen. The reported average annual commercial catch for food from 1968 to 1978 was 25 mt with 71% being taken offshore (NMFS 1981a). Croaker, spot, sand seatrout, and silver seatrout comprise the bulk of the industrial pet food industry (Lyles 1976).

In a study in Louisiana the spot was the third most abundant commercial finfish and accounted for approximately 10% of the fish collected (Perret et al. 1971). Spot ranked second to the Atlantic croaker in total annual production of industrial bottomfish in the north-central Gulf of Mexico (Roithmayr 1965a).

SOUTHERN KINGFISH

Menticirrhus americanus (Linnaeus)

INTRODUCTION

The southern kingfish, *Menticirrhus americanus*, is also known locally as "ground mullet." In the summer adults inhabit inshore areas such as Biloxi Bay, Mississippi, and Barataria Bay, Louisiana, but in the fall, the fish move into deeper waters in response to low water temperature (Irwin 1970; Etzold and Christmas 1979). No long-term change in abundance was found. Annual catches of kingfish generally decreased from 1968 to 1978 in Mississippi Sound, Mobile Bay, and offshore areas (NMFS 1981a). The average annual catch in these areas from 1968 to 1978 was 217 mt of which 80% were taken offshore (NMFS 1981a). The life history and ecology of the southern kingfish have not been studied adequately, and much remains to be learned about the movements, behavior, and dynamics of the Mississippi Sound population (Etzold and Christmas 1979).

DISTRIBUTION AND BEHAVIOR

Southern kingfish are bottom-dwelling in all life stages (Hildebrand and Cable 1934; Johnson 1978). Hildebrand and Schroeder (1928) reported that spawning in the northern Gulf of Mexico occurs in the fall, but Gunter (1938) found well-developed roe in Gulf fish in April, May, and June. Currently, April to October is accepted as the spawning season (Etzold and Christmas 1979). Spawning probably takes place beyond the barrier islands, but some may spawn in Mississippi Sound. Spawning depths range from about 9 to 26 m (30 to 85 ft) (Johnson 1978). Males mature at age 2 and females mature at age 2 or 3 (Irwin 1970; Johnson 1978).

The eggs and larvae of southern kingfish are transported by currents and tidal action shoreward to estuaries. Johnson (1978) speculated that larvae may be transported upstream in tidal rivers in the salt wedge. Young-of-the-year have been reported from passes in the Mississippi River distributaries (Irwin 1970). Young spend their first summer in shallow-water areas in or near beaches, estuaries, tidal rivers, tidal passes, and river mouths (Johnson 1978). Until they reach a length of about 50 mm, the young seem to prefer sand to soft mud bottoms, with some detritus (Johnson 1978).

As they grow, juveniles gradually migrate seaward. When 50 to 150 mm long, kingfish inhabit shallow waters up to depths of 18 m. Larger individuals (>150 mm) inhabit depths from 9 to 36 m (30 to 118 ft) in the vicinity of the barrier islands (Irwin 1970). In the Mississippi Sound they are widely distributed and inhabit navigation channels and bays to the north and south of the barrier islands (Etzold and Christmas 1979).

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

The Mississippi Sound population of kingfish usually inhabits waters between 10° and 35°C (50° to 95°F) (Etzold and Christmas 1979). Other sources reported temperature ranges of 10.0° to 32.5°C (50.0° to 90.5°F) (Johnson 1978) and 8° to 30°C (46° to 86°F) (Bearden 1963). Irwin (1970) reported them to be most common above 15°C (59°F). As the water cools below 10°C (50°F), the kingfish apparently move to the deeper waters of estuaries and offshore areas.

Estimates of salinity tolerance range from 6.4 to 41 ppt (Irwin 1970), 6.4 to 34.6 ppt (Bearden 1963), and 5 to 35.5 ppt (Etzold and Christmas 1979). Etzold and Christmas (1979) noted that the highest catches in Mississippi waters were made in salinities between 15 and 29.9 ppt; however, Irwin (1970) and Johnson (1978) claimed that the species is most common above 24 ppt.

FEEDING HABITS

Southern kingfish are carnivorous bottom feeders (Bearden 1963). Larvae and juveniles (15 to 80 mm) feed on copepods, small annelids, mysid shrimp, amphipods, and shrimp larvae. Larger individuals (81 to 135 mm or 3 to 5 inches) prefer annelids, amphipods, small penaeids, and small crabs. Adults feed on crustaceans and polychaetes. Bearden (1963) reported that fish are not a major food. This is supported by other authors (Hildebrand and Schroeder 1928; Irwin 1970) who reported that fish rarely exceed 15% of the diet.

USES BY MAN

The southern kingfish is taken commercially throughout much of its geographic range. Most are taken incidentally in the shrimp and industrial fisheries. In the Mississippi Sound and vicinity they contribute a sizable proportion of the total commercial catch (Etzold and Christmas 1979). Frequently they and other demersal species are processed for animal food or fertilizer (Moore et al. 1970). The kingfish is also caught by sport fishermen, but the landings are not well documented.

ATLANTIC CROAKER

Micropogonias undulatus (Linnaeus)

INTRODUCTION

The Atlantic croaker, *Micropogonias undulatus*, also is called the "hardhead," "crocus," and "king billy" (Hildebrand and Cable 1930, 1972). This commercially important demersal species lives in coastal waters from Massachusetts to Mexico (Hildebrand and Cable 1930; White and Chittenden 1976; Johnson 1978). Although individuals may attain a larger size along the U.S. east coast, they are far more abundant in the northern Gulf of Mexico. The Atlantic croaker and other groundfish concentrate in the coastal waters between Mobile Bay, Alabama, and Trinity Shoals, Louisiana. It is these fishing grounds that are most exploited by the industrial bottom fish and food fish fisheries (Gutherz 1976; Roithmayr 1976; Rohr 1977; GMFMC 1981). The Atlantic croaker contributes about 70% of the Gulf groundfish landings (Gutherz 1976; Rohr 1977; GMFMC 1981).

Much research has been conducted on the Atlantic croaker. Sufficient data on their distribution and life history are available, but environmental data are relatively scarce. Wide fluctuations in annual abundance are thought to be influenced by environmental conditions, yet there is little information available on the relation between abundance and environmental changes (GMFMC 1981).

DISTRIBUTION AND LIFE HISTORY

The croaker is characterized by a protracted spawning period, rapid growth, high mortality, and a relatively short life (GMFMC 1981). Croaker rarely live beyond 4 or 5 years (J.C. Parker 1971). Although the distribution or migration of the adults is weakly defined, particularly in winter, it is known that older juveniles and adults tend to school, especially just before spawning (Gutherz 1976). In late fall to early spring (October to April) sexually mature adults, usually about 2 years of age, migrate offshore and spawn in the shallow open sea near passes to the estuaries (Wallace 1940; Bearden 1964; Avault et al. 1969; Adkins and Bowman 1976; White and Chittenden 1976; Johnson 1978; Etzold and

Christmas 1979). Most croakers probably spawn seaward of the Louisiana and Mississippi barrier islands (Gutherz 1976) with November being the peak spawning month. Individual egg counts range from 41,200 to 180,000 (Hildebrand and Cable 1930; Hansen 1970; Etzold and Christmas 1979).

Adults have been taken from depths of 1 to 90 m (3 to 295 ft) (Chittenden and McEachran 1976). An optimum depth of 58 m (190 ft) has been suggested. Spawning may take place in a depth range to 15 to 81 m (49 to 266 ft), but most spawn near 20 m (66 ft) (Bearden 1964; Gutherz 1976; Johnson 1978).

Croaker eggs are pelagic and incubate in less than 1 week. Larvae dwell principally along the bottom (Hildebrand and Cable 1930; Gutherz 1976). Larvae are transported by tidal and wind-generated currents sometimes through channels into estuaries (Wallace 1940). Larvae first enter the Mississippi Sound in October (Gutherz 1976). Schools of young fish move to bays and up rivers and rarely venture beyond 10 m (33 ft) in depth. In the winter, most first-year juveniles live in harbors and shallow areas near freshwater sources (Hildebrand and Cable 1930; Hansen 1970; J.C. Parker 1971). In late spring and early summer juveniles migrate into the Mississippi Sound in waters up to 6 m (20 ft) deep (Gutherz 1976). In late summer and fall most adult croakers migrate into Gulf waters to spawn (Johnson 1978). Few croaker remain in inside waters for more than 1 year.

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

Declining water temperatures in the fall apparently stimulate the migration of older juveniles and adults from the estuaries. Increasing temperatures ($\geq$ 16°C or 61°F) in the spring induce inshore migration (Wallace 1940; Suttkus 1955; Gutherz 1976; Johnson 1978). Juveniles can tolerate lower water temperatures than adults and have been taken at temperatures from 0.4° to 35.5°C (32.7° to 95.9°F) as compared to 5° to 25.5°C (41.0° to 77.9°F) for adults (J.C. Parker 1971). Young grow at temperatures ranging from 6° to 20°C (43° to 68°F) (Hildebrand and Cable 1930). Lethal minimum and maximum temperatures are 0.6° and 38°C (33.1° and 100.4°F) for juveniles and 3.3° and 36°C (37.9° and 96.8°F) for adults. The species is considered euryhaline and inhabits waters with salinities from 0 to 40 ppt and rarely to 75 ppt (Bearden 1964; J.C. Parker 1971; Perret et al. 1971). Larvae and juveniles have been taken in salinities ranging from 0 to 36 ppt. Optimum salinities of 18 to 21 ppt for best growth and survival have been suggested (Swingle 1971; Johnson 1978).

Oxygen requirements of Atlantic croaker are not known, but their presence in poorly oxygenated canals indicates that they can tolerate low levels of dissolved oxygen (Adkins and Bowman 1976). Croakers are ubiquitous in their preference for bottom substrate. Adults live over mud, sand, mud-shell mixtures and mud-sand mixtures; the last is preferred (Gutherz 1976; GMFMC 1981). They also inhabit waters near oyster reefs, sponge and coral reefs and mud-bottomed navigational channels (Johnson 1978). Juveniles live over similar substrates, in deep channels with mud bottoms, and grass beds (Johnson 1978; GMFMC 1981; Shipp 1981).

FOOD HABITS

Croaker larvae eat amphipods, isopods, ostracods, copepods, meiobenthos, and detritus (Roussel and Kilgen 1975; Etzold and Christmas 1979). Juvenile croakers eat detritus, meiobenthos, mysid shrimp, amphipods, annelids, mollusks, grass shrimp, penaeid shrimp, small fish, and small crabs. Plant material was in some stomachs (Hildebrand and Schroeder 1972; Roussel and Kilgen 1975). The adult diet includes all foods listed for juveniles as well as larger fish, shrimp, and crabs (Roelofs 1954; Roussel and Kilgen 1975; Chen 1976).

USES BY MAN

Commercial and sport catches are best from early summer to late fall when the migration of juveniles from the estuaries to offshore waters makes them easier to catch (Hildebrand and Schroeder 1972; GMFMC 1981). Numerous croaker are also caught near offshore oil platforms as well as in inside waters of the sounds and rivers (Gutherz 1976; Rohr 1977). Landings and catch-per-unit-effort (CPUE) of the industrial fleet have declined since 1974 (GMFMC 1981). The financial difficulties resulting from this decline have prompted development of a Federal groundfish fishery management plan. This management plan proposes to increase CPUE by decreasing the numbers landed that are caught incidentally in the shrimp fishery (those caught alive could be thrown back). Proposed alternatives to resolve this problem have met with much opposition from some sport and commercial fishermen. The croaker has no Federal status and remains unregulated although an overall optimum yield (OY) for the entire Gulf coast area of 819,160 mt has been recommended. Currently the estimated maximum sustainable yield (MSY) for this area is 1,070,000 mt (GMFMC 1981).

Croakers are exploited by sport and commercial fishermen for human consumption, and for pet food, fish meal, and bait (Gutherz 1976; GMFMC 1981). The Surimi industry, which produces domestic and foreign oriental Kamaboko (sausage), has been hampered in its development by the shortage of large croaker.

BLACK DRUM

Pogonias cromis

INTRODUCTION

This estuarine-dependent species is common along the nearshore and estuarine areas of the Gulf of Mexico. It is most abundant in Louisiana and Texas waters, but it has only moderate commercial and sport value. Black drum seem to be most abundant in shallow, turbid, and brackish waters, often less than 1.2 m (3.9 ft) deep (Darnell 1958). No comprehensive study of the black drum has been made.

DISTRIBUTION AND ABUNDANCE

Black drum spawn in February to April in or near tidal passes, and in open bays and estuaries (Etzold and Christmas 1979). The larvae are transported by currents into the shallow estuarine nursery grounds, often over seagrass beds (Johnson 1978). When the juveniles reach about 10 cm (4 inches) in length, some seek deeper waters or occupy the shallow waters of sandy beaches (Pearson 1929). In many instances, the spawning area and nursery area may be one and the same. Adult migration is largely restricted to spring and fall movement through the passes between estuaries and nearshore environments. This fish is predominantly a bay species (Hoese and Moore 1977). The juveniles tend to live in shallow mud-bottom bays. The fish is about 25 cm (10 inches) long at the end of the first year, 35 cm (14 inches) after 2 years, and 58 cm (23 inches) after 5 years (USBF 1937). A large female may produce 6 million eggs. Based on size, some fish may complete 35 years of life.

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

Black drum are euryhaline during all life stages, i.e., they occur in salinities from 0 to 35 ppt. The species is most common at salinities ranging from 9 to 26 ppt (Gunter 1956; Etzold and Christmas 1979), but some inhabit water with salinities as high as 80 ppt. The black drum is usually taken at water temperatures from 12° to 30°C (54° to 86°F). This fish inhabits areas with sand or soft bottoms as well as brackish marshes and oyster reefs (Etzold and Christmas 1979). The preferred habitat of juveniles during the first 3 months are muddy, nutrient-rich, marsh habitats such as tidal creeks.

FOOD HABITS

Black drum are opportunistic benthic carnivores. The larvae feed largely on zooplankton. Postlarvae feed on soft foods, but the juveniles and adults feed on mollusks (e.g., oysters and clams) and crustaceans (e.g., shrimp and crabs) as well as fish (Darnell 1958). In one study the stomach contents of black drum were 74% mollusks, 16% crabs, and 10% fish. The intestines of the larger fish usually contain large amounts of shell debris. Organic detritus is found in many fish. The major food is the clam (*Mulinia lateralis*) in mud-bottomed bays. The drum feeds heavily in salt marshes when the marshes are under water. Drum feed vertically in shallow water with their tails splashing the surface, a behavior called "flagging."

Cave and Cake (1980) reported, from experimental feeding studies, that the black drum is capable of crushing and consuming oysters. They use their chin barbel to help locate oysters, and they will ingest and attempt to crush any oyster that fits into their pharyngeal apparatus. Ingested oysters are normally crushed or rejected within 55 seconds.

VALUE TO MAN

The black drum has only moderate commercial and sport value because of the relatively poor quality of its flesh, particularly among larger fish. It is taken commercially, and usually incidentally, primarily by shrimp trawlers in estuarine and nearshore waters. In Alabama the black drum commercial catch increased from 298 kg (657 lb) in 1965 to 25,737 kg (56,740 lb) in 1973 because of increased catches in shrimp trawls (fishermen began to fish in deeper waters). Nonetheless, most black drum are discarded by the industry (Swingle 1976). In Alabama in 1975 the commercial catch was 7,275 kg (16,039 lb), and the sport catch was 3,891 kg (8,578 lb) (Swingle 1976). The 1969-78 average annual commercial catch was 8,280 kg (18,254 lb) in Alabama and 27,676 kg (61,015 lb) in Mississippi (NMFS 1981a).

Cave and Cake (1980) found that moderate to large captive drum are capable of consuming more than two commercial size oysters per kilogram of body weight per day. Black drum are known to destroy large numbers of oysters on seed reefs and oyster grow-out leases in Louisiana and Mississippi.

Some black drum weigh as much as 15 to 22 kg or 33 to 49 lb (54 kg or 119 lb maximum). The best eating size is less than 50 cm (20 inches). Parasitic tapeworms are common in the flesh of the larger fish (USBF 1937).

RED DRUM

Sciaenops ocellatus

INTRODUCTION

The red drum, also called redfish, is a popular sport and commercial marine fish that inhabits the Gulf coastal areas. It is most abundant in the northern Gulf and has been caught out as far as 22 km (14 mi) from shore at depths up to 40 m (131 ft). It is estuarine dependent and broadly euryhaline. Young red drum, black drum, and spotted seatrout often inhabit the same waters the first year. Small shallow bayous and tidal channels are typical habitats. They often are caught near Gulf reefs. Rather extensive reviews of red drum biology were made by Pearson (1929), Johnson (1978), and Perret et al. (1980). Management was reviewed by Matlock (1980).

DISTRIBUTION AND BEHAVIOR

The red drum spawns in inshore waters (on the Gulf side of barrier islands), usually in or near passes between barrier islands, usually in the fall and winter but primarily in September-November (Pearson 1929; Gunter 1945; Etzold and Christmas 1979). Most larvae (planktonic) and early juveniles are carried by currents in late fall into the shallow estuaries and bays, but many remain near the mouths of the tidal passes until spring and early summer. Young red drum tend to seek out sheltered coves and lagoons where they occupy shallow waters along marsh edges (Tarbox 1974; Bass and Avault 1975). They tend to associate with aquatic grasses in shallow waters over muddy bottoms. Most red drum reside in the bays and estuaries in the summer, but migrate, usually at night, into the Gulf in the late fall. They do not show much longshore migration; most of their movement is inshore-offshore (Simmons and Breuer 1962). After first spawning, red drum spend increasingly more time at sea and less time in bays and estuaries. Some spend extended periods in the surf zone (Johnson 1978).

The adults are largely solitary fish that live in shallow waters in the bays, whereas they tend to school in Gulf waters. The largest, "bull reds," may stay far offshore (Hoese and Moore 1977). The smaller fish (< 2.2 kg), called "rat reds," tend to school and make up much of the sport fishing. They usually remain in or near estuaries until they are 3 years old, but some leave at the end of their first year of life. They often live near the perimeters of marshes in waters less than 2 m (7 ft) deep and, generally, do not occupy open bays. The fall migration to the Gulf is protracted whereas the migration back to the estuaries in the spring is more contracted (Pearson 1929). Tagging studies in Texas (Simmons and Breuer 1962) suggested that some "schools" of red drum are almost permanent residents of the Gulf proper, whereas others rarely leave the bays and estuaries.

Red drum are about 18 cm (7 inches) long at the end of their first year of life. Lengths for older fish are 36 cm (14 inches) for age two, 56 cm (22 inches) for age three, 66 cm (26 inches) for age four, and 76 cm (30 inches) for age five (Perret et al. 1980). Older fish (bull reds) may exceed 13.5 kg (29.8 lb). Males usually mature in their third year, and females in their fourth year or fifth year, when about 71 to 81 cm (28 to 32 inches) long. A bulk of the spawning population is 5-year-old fish.

ENVIRONMENTAL FACTORS AFFECTING DISTRIBUTION

The general salinity range for red drum is 0 to 30 ppt, but some tolerate salinities up to 50 ppt (Theiling and Loyacano 1976). Larvae and juveniles were taken at salinities between 5.0 to 35.5 ppt in one study (Christmas and Waller 1973), but most occur at salinities from 9 to 26 ppt. The larger fish seem to prefer higher salinities. Red drum are most abundant in salinities from 20 to 25 ppt (Etzold and Christmas 1979), and from 25 to 30 ppt (Kilby 1955). Overall, red drum prefer moderate to high salinities.

Red drum have been observed in water temperatures ranging from 2° to 29°C (36° to 84°F). Some young fish were found in a temperature range of 20.5° to 31°C (68.9° to 87.8°F). The highest catches were at temperatures between 20° and 25°C (68° and 77°F) (Etzold and Christmas 1979). Large numbers of red drum have been reported killed in severe cold spells (Adkins et al. 1979).

Red drum thrive in waters over sand, mud, or sandy mud bottoms and occasionally in and among aquatic vegetation.

FOOD HABITS

The food habits of the red drum are intermediate between black drum, which are pure bottom feeders, and spotted seatrout, which are more pelagic feeders (Pearson 1929). Their feeding habits are marine littoral, and they feed on and off the bottom most intensively in early morning and late evening (crepuscular feeding) (Kilby 1955).

The larvae feed on copepods and a number of other zooplankton. The juveniles eat amphipods, mysid shrimp, grass shrimp, penaeid shrimp, small crabs, polychaetes, decapods, oligochaetes, and fish. Adults apparently prefer shrimp, blue crab, menhaden, and other fishes (Boothby and Avault 1971). They may feed on the bottom or in the water column. In one study 99% of the fish examined contained crustaceans, 43% contained fish, and 15% contained polychaetes (Overstreet and Heard 1978a). The larger drum ate more fish. Red drum gorged with sand dollars have been taken in the Mississippi Sound (Etzold and Christmas 1979). Blue crab is the principal food of the red drum in inside (bay) waters, and penaeid shrimp dominate the stomach contents of fish taken in Gulf waters (Gunter 1945; Darnell 1958; Simmons and Breuer 1962). Red drum, like black drum, sometimes feed vertically in shallow waters and often splash the surface with their tails, a habit called "tailing" or "flagging" by fishermen (Perret et al. 1980).

VALUE TO MAN

Red drum are sought by anglers and commercial fishermen throughout their range and in some areas are the most highly prized sciaenid. In Alabama red drum have low value in the local commercial markets. A 9-kg (20-lb) or larger red drum may sell for only $2 to $3, it if sells at all, according to the Alabama Department of Conservation and Natural Resources (ADCNR 1976). Large numbers of red drum migrate from the estuaries to the Gulf in the fall and return in the spring. These "runs" attract large numbers of anglers who commonly catch the larger fish (Hoese and Moore 1977). Large fish also are often taken by surf fishermen (USBF 1937).

Most commercial red drum are taken incidentally by shrimp trawls in offshore waters. In Alabama in 1975, 33,165 kg (73,116 lb) were caught commercially and 374,209 kg (824,990 lb) were taken by anglers (Swingle 1976). The annual mean commercial catch for 1969-78 was 35,100 kg (77,382 lb) in Alabama, and 65,070 kg (143,455 lb) in Mississippi (NMFS 1981a). A high percentage was taken in offshore waters. The potential offshore catch was several times the current sport and commercial landings in 1975 (ADCNR 1976). In 1978, Alabama had a minimum legal length of 35.6 cm (14 inches) for sport and commercial fishermen; Mississippi had the same minimum length for commercial fishermen (Matlock 1980).

SAND SEATROUT

Cynoscion arenarius

INTRODUCTION

The sand seatrout, locally known as "white trout," is a popular sport fish species in Mississippi Sound and Mobile Bay. The early life stages are spent in the estuaries. The adults are found in the estuary and are abundant offshore (Christmas and Waller 1973). They make up a considerable part of the industrial bottomfish fishery in the offshore area (Roithmayr 1965a). The commercial catch data indicate a general decrease in abundance since 1977, but there has been no shift in distribution of the stocks and no indication that the reproductive capacity of the fishery has been impaired (GMFMC 1981). The data base on the sand seatrout is good, but there is little definitive information on early life stages.

DISTRIBUTION AND BEHAVIOR

Sand seatrout apparently move offshore more than most members of the family Sciaenidae. Chittenden and Moore (1977) found that the sand seatrout was the only sciaenid commonly caught in a 110-m (361-ft) bottom contour survey in the Gulf of Mexico. Moore et al. (1970) found that the Atlantic croaker was the most abundant sciaenid in a study of demersal fishes of the 7- to 100-m (23- to 328-ft) depth zone off Louisiana, but sand seatrout also was common.

Spawning takes place from March to September offshore near passes and inlets to estuaries (Gunter 1945). Peak spawning appears to be in March and April or in August-September (Schlossman 1980). This fish spawns in 14 to 40 m (46 to 131 ft) of water (Schlossman 1980). The larvae migrate into shallow areas of the upper estuaries and later move to deeper open bays as they grow. Sand seatrout apparently prefer grass beds and marshes during their early life stages (Conner and Truesdale 1972). Adults also move into the estuary following spawning and commonly concentrate around wrecks, manmade reefs, and bridges. In the fall most adults and juveniles migrate to the offshore waters, but some sand seatrout remain in estuaries all winter.

ENVIRONMENTAL REQUIREMENTS

Larval and juvenile sand seatrout have been collected in the 5° to 34°C (41° to 93°F) water temperature range, but most were caught at temperatures above 10°C (50°F) (Christmas and Waller 1973; Juneau 1975). Sand seatrout are less tolerant of low temperatures than spotted seatrout. Adult sand seatrout apparently prefer water temeratures from 12° to 36°C (54° to 97°F).

Larval and juvenile sand seatrout have been collected in salinities from 0 to 26 ppt and appear to be more tolerant of low salinities than the adults (Christmas and Waller 1973; Juneau 1975). Adults are most commonly collected in the 12 to 35 ppt salinity range, but Gunter (1945) collected them in the 0 to 30 ppt range.

Data on dissolved oxygen as it relates to sand seatrout tolerance and/or preferences are scarce, but Parmer et al. (1971) quoted a study that stated that sand seatrout tend to avoid waters with less than 4.6 to 5.0 mg/l of dissolved oxygen.

Early life stages apparently prefer soft organic bottom (Conner and Truesdale 1972), but adults are found over most substrates in estuaries and offshore.

FOOD HABITS

Juvenile sand seatrout feed on copepods, crab zoeae, mysids, and small fish (Sheridan 1978b). Moffet et al. (1979) found amphipods, penaeid shrimp, mysids, menhaden, anchovies, mullet, and the young of other fishes in sand seatrout stomachs. Adults have similar feeding habits to juveniles; penaeid shrimp, menhaden and anchovies are the predominant foods (Moffet et al. 1979; Sheridan 1979).

VALUE TO MAN

The sand seatrout is an important sport fish species and is caught commercially (usually in shrimp trawls) for food and industrial purposes. Sport fishing is most effective around submerged objects and bridges in estuaries. In 1975, sport fishermen in Alabama caught 235 mt, mostly from private boats (Wade 1977).

SPOTTED SEATROUT

Cynoscion nebulosus

INTRODUCTION

The spotted seatrout, probably the most valued sport species in Mississippi Sound and Mobile Bay, also contributes substantially to the commercial fishery. This euryhaline species rarely leaves the estuary except when it is forced out by water temperature and salinity extremes (Tabb 1966). The life history of spotted seatrout is well known, but there are little data on environmental requirements of early life stages. The commercial catch declined from 1968 to 1978 (NMFS 1981a). However, the sport fish catch is known to exceed the commercial catch; in 1975 the sport catch in Alabama was 361,494 kg (796,958 lb), and the commercial catch, only 19,800 kg (43,652 lb) (NMFS 1981; Wade 1981). The largest spotted seatrout caught in Alabama weighed 4.5 kg (9.9 lb) and in Mississippi, 4.9 kg (10.8 lb), but most caught by sport and commercial fishermen and in sampling gear weighed less than 1.8 kg (4.0 lb) (Lorio and Perret 1980).

DISTRIBUTION AND BEHAVIOR

Spawning is believed to occur at night in deep channels and depressions adjacent to shallow flats, grass beds, and bayous in the estuary (Wade 1981).

Spawning takes place from March to September and peaks in April-July (Perret et al. 1980). Larvae move into the shallow grass bed and marsh nursery areas and begin to school in 6 to 8 weeks (Tabb 1966). Growth is rapid in the nursery areas; larvae and juveniles remain in vegetated nursery areas until late fall when they move to deeper parts of the estuary.

Mature adults and large juveniles concentrate in passes and inlets to feed on migrating penaeid shrimp and small fish in the spring and summer. Adults winter in deep holes or channels in estuaries and may leave the estuary for the near offshore waters when water temperatures are below 7°C (45°F). Spotted seatrout feed at all levels in the water column, but there is no information on diel activity. Adkins et al. (1979) captured the smallest spotted seatrout in the lower salinity (northern) stations of Terrebonne Parish, Louisiana, and the largest fish in high salinity stations bordering the Gulf of Mexico.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

Spotted seatrout spawn at temperatures ranging from 20° to 30°C (68° to 86°F). A laboratory study of survival of spotted seatrout eggs and yolk-sac larvae revealed that the optimum temperature and salinity were 28.0°C (82.4°F) and 28.1 ppt, respectively (Taniguchi 1980). One hundred percent survival rates were predicted for the temperature range of 23.1° to 32.9°C (73.6° to 91.2°F), and the salinity range of 18.6 to 37.5 ppt. Larvae and juveniles have been collected at water temperatures from 5° to 36°C (41° to 97°F) (Tabb 1966; Perret et al. 1980). Optimum adult temperatures are 15° to 27°C (59° to 81°F) (Tabb 1958). When estuarine water temperatures exceed 27°C (81°F) in mid- and late summer, spotted seatrout sometimes move offshore (Mahood 1974). Adult mortalities have been documented when water temperatures decline to 4°C (39°F) (Moore 1976).

Although larval spotted seatrout have been collected in the 0 to 36 ppt salinity range, Tabb (1966) believed that salinities below 5 ppt were intolerable. Juveniles are usually collected in the 10 to 25 ppt salinity range and adults in the 15 to 30 ppt range. In Mississippi Sound, larvae and juveniles were collected in salinities from 2 to 30 ppt (Christmas and Waller 1973). Tabb (1966) found that a common factor in productive spotted seatrout areas was seasonally fluctuating salinities. Spotted seatrout of all ages are most common in waters of low turbidity (Pearson 1929). They feed in the water column and near bottom and are found over all types of substrates in estuaries.

FOOD HABITS

Larval spotted seatrout feed primarily on mysid shrimp and copepods (Miles 1950; Danker 1979). Juveniles feed on amphipods, mysids, penaeid shrimp, anchovies, silversides, and other small fish (Danker 1979). Adults feed on fish (anchovy, menhaden, Atlantic croaker, spot) and shrimp (Perret et al. 1980). Adkins et al. (1979) found that adults fed heavily on polychaetes during low tide stages. Shrimp were most heavily utilized during May and June.

MANAGEMENT AND USES BY MAN

There has been considerable controversy in recent years on how to best manage the sport and commercial fisheries for spotted seatrout (Adkins et al. 1979). Sport fishermen maintain that gill net harvesting has been responsible for the decrease in sport fishing success in some areas, and sport fishing interests have attempted to regulate commercial production. Perret et al. (1980) summarized the management problems as follows: (1) catch and fishing effort statistics on both the commercial and sport fisheries are inadequate; (2) information on population dynamics (stock size, mortality rates, and age and size composition) is lacking; (3) data are relatively scarce on seasonal distribution, migration, and spawning and nursery characteristics; (4) yield models needed for management are lacking; (5) alterations of river inflows and estuarine bottom are known to be important, but the effects have not been measured adequately; and (6) economic and sociological problems have not been clearly identified for making management decisions.

There is a 30.5-cm (12-inch) minimum size limit for fish caught by sport fishermen in Mississippi and Alabama (Merriner 1980). A review of management problems of spotted seatrout emphasized the need for preserving the necessary estuarine habitats threatened by increasing industrial, shipping, and housing development (Merriner 1980).

Larval spotted seatrout are an excellent bioassay subject (Johnson et al. 1979).

ATLANTIC SPADEFISH

Chaetodipterus faber

INTRODUCTION

The Atlantic spadefish is frequently captured around wharves, rockpiles, old wrecks, and other manmade structures in and immediately offshore of Mississippi Sound and Mobile Bay. It is common in the Sound in summer, but migrates to deeper offshore waters in the fall (McClane 1965). In the winter, it does not occur in the Sound (Christmas and Waller 1973). Few studies on the spadefish have been reported, and no data are available on its trends in abundance. Most of the data include relative abundance and distribution in particular estuaries. The data base generally is inadequate for management decisions.

DISTRIBUTION AND BEHAVIOR

Adult spadefish congregate in small schools around rocky patches, reefs, wrecks, pilings, and other structures in Mississippi Sound. Adults seldom move into the bays (e.g., upper Mobile Bay and Bay St. Louis), but small juveniles do in the summer. Within the bays, juveniles are found over clay and mud bottoms and in sandy grass beds (Johnson 1978). Twenty-one juvenile specimens were collected in the Mobile Bay area in salinities above 10 ppt (Swingle 1971). The spadefish spawns offshore from March through August (Christmas and Waller 1973; Johnson 1978). After larval development offshore, the juveniles move into estuarine nursery grounds. This species schools and feeds in the upper portion of the water column. No data are available on the spadefish's diel distribution.

ENVIRONMENTAL FACTORS INFLUENCING DISTRIBUTION

The spadefish is temperature sensitive and avoids shallow cold water. Adults have been taken in waters with temperatures between 10° and 34°C (50° and 93°F) (Johnson 1978). Spadefish have been captured in water with salinities ranging from 4 to 43 ppt, but most seem to prefer salinities nearer 30 ppt (Johnson 1978). This species inhabits the Sound and nearshore waters of the Gulf at depths usually less than 20 m (66 ft).

This fish usually lives over a mud, sand, or rocky bottom in waters near manmade structures.

FOOD HABITS

The spadefish is an omnivore but feeds primarily on crustaceans, ctenophores, jellyfish, and tunicates (Breder 1948; McClane 1965; Johnson 1978). No data were available on larval or juvenile food habits.

USES BY MAN

Although the spadefish is a desirable food fish, few are sought by fishermen in Mississippi Sound. Although sport fishermen catch them occasionally when fishing near wrecks, submerged objects or oil platforms, spadefish are not very popular.

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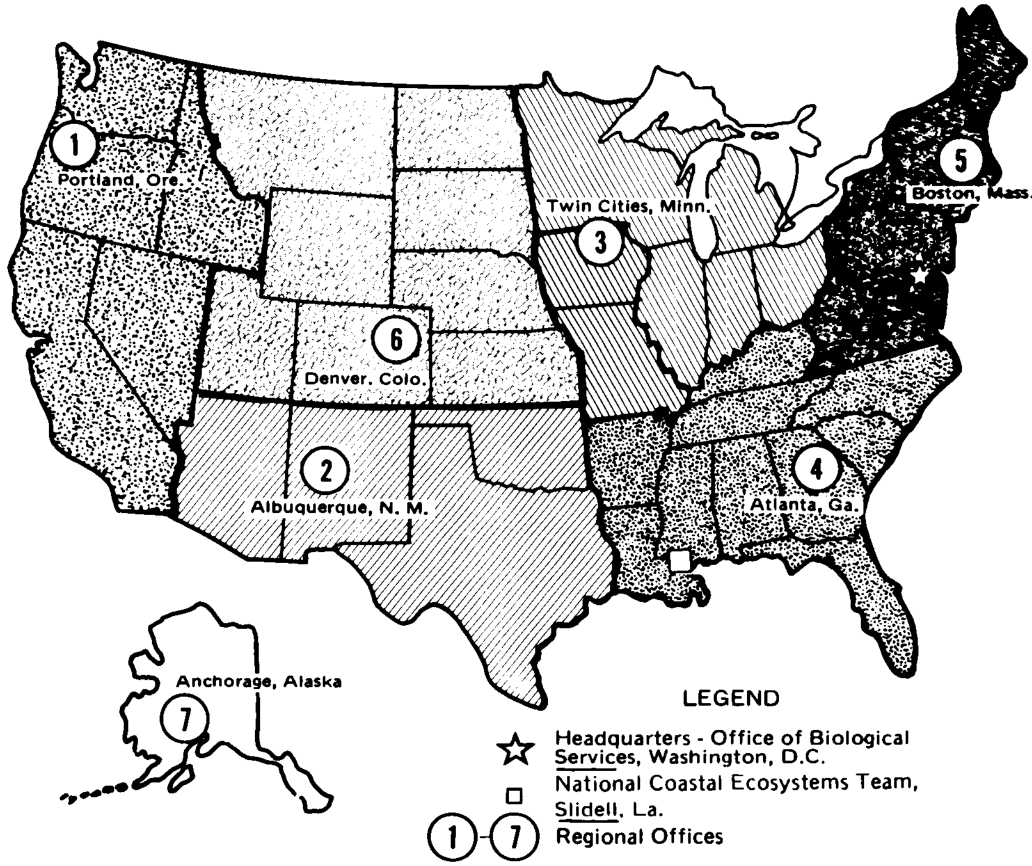

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DEPARTMENT OF THE INTERIOR
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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.