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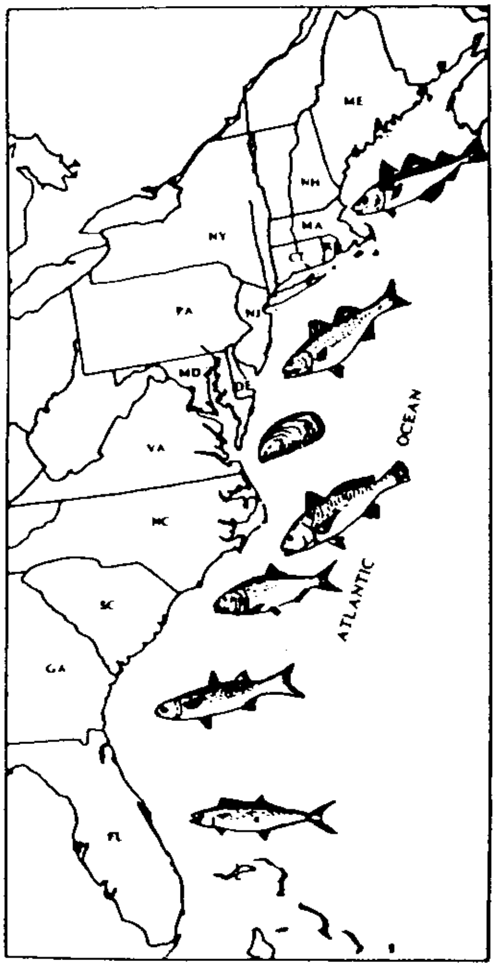

FISHERY MANAGEMENT PLAN FOR SPOT

October 1987

FISHERY MANAGEMENT PLAN

FOR

SPOT (*Leiostomus xanthurus*)

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1.0 EXECUTIVE SUMMARY

The spot is an important fishery resource along the Atlantic coast, particularly from Chesapeake Bay south. Spot migrate seasonally between estuarine and coastal waters. While inshore in bays and sounds, spot are harvested by a variety of commercial gear, including haul seines, pound nets, gill nets, and trawls, as well as by hook and line in the recreational fishery. During winter spot are caught offshore in the trawl and gill net fisheries. Commercial landings statistics indicate that catches have fluctuated widely since 1930 with no apparent long-term trends. Spot landings peaked in 1952 at 6,859 mt (14.5 million lb) and since have fluctuated between 1,767 mt (3.9 million lb) and 5,778 mt (12.7 million lb).

The major problem addressed in this management plan is the lack of biological and fisheries data necessary for stock assessment and effective management of the spot resource. Investigations on life history and fisheries for spot have generally been localized and conducted at differing levels of population abundance. Catch and effort data from both the commercial and recreational fisheries are insufficient to determine the relationship between landings and abundance. An additional potential problem is the incidental bycatch and discard mortality of small spot in nondirected fisheries.

The goal of this management plan is to perpetuate the spot resource in fishable abundance throughout its range and generate the greatest economic and social benefits from its commercial and recreational harvest and utilization over time. The following objectives have been adopted for achievement of the management goal:

1. Conduct cooperative interstate research to understand the coastal biology of, and fisheries for, spot.

2. Maintain a spawning stock sufficient to minimize the possibility of recruitment failure and determine the effects of the environment on year class strength.

3. Optimize yield per recruit.

4. Improve collection of catch and standardized effort statistics and description of fishing gears.

5. Promote harmonious use of the resource among various components of the fishery through the coordination of management efforts among the various political entities having jurisdiction over the spot resource.

6. Promote the cooperative interstate collection of economic, social, and biological data required to effectively monitor and assess management efforts.

7. Promote determination and adoption of the highest possible standards of environmental quality.

The following management measures are identified as appropriate for implementation:

1. Promote the development and use of trawl efficiency devices (TEDs) through demonstration in the southern shrimp fishery, and fish separators in the finfish trawl fishery.

2. Promote increases in yield per recruit through delaying entry to spot fisheries to ages greater than one.

In order to identify additional management measures, which when implemented will result in attainment of the foregoing objectives, a program of research and data collection should be undertaken as follows:

1. Identify stocks and determine coastal movements and the extent of stock mixing.

2. Collect catch and effort data, including size and age composition of the catch, determine stock mortality throughout the range, and define gear characteristics.

3. Develop and maintain a recruitment index and examine the relationships between parental stock size and environmental factors on year-class strength.

4. Define reproductive biology of spot, including size at sexual maturity, fecundity, and spawning periodicity.

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3.0 INTRODUCTION

3.1 Development of the Plan

This fishery management plan for spot, *Leiostomus xanthurus*, was prepared under the Atlantic States Marine Fisheries Commission's (ASMFC) Interstate Fisheries Management Program. The first phase in the development of this plan was the preparation of a profile summarizing available biological and fisheries information on spot (Section 11.0). The formulation of a goal statement, objectives, research needs, and management measures constituted the second phase of the program. The Sciaenid Technical Committee, consisting of scientists from the state marine fisheries agencies of Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, the National Marine Fisheries Service (NMFS) Northeast Fisheries Center, NMFS Southeast Fisheries Center and ASMFC provided technical expertise in the development of this plan. General guidance and policy were provided by the South Atlantic State-Federal Board, consisting of senior administrators of the state marine fisheries agencies and NMFS.

3.2 Problems Addressed by the Plan

Historically, landings of spot, like weakfish, croaker, and other sciaenids, have fluctuated greatly. No long-term trends in abundance are obvious from catch data. Periods of high landings have generally been followed by sudden declines in catch. Commercial landings statistics may indicate trends in abundance of adult spot. However, landings may also reflect changes in fishing effort, area and gear restrictions, as well as market conditions, and are not an accurate measure of abundance. Fluctuations in spot landings, which in most years consist largely of a single year class, appear to be related to variations in climate and fishing pressure (Perlmutter 1959; Joseph 1972).

The incidental bycatch and discard mortality of small spot in nondirected fisheries such as the southern shrimp fishery and the scrap catch of spot from the pound net, long haul seine, and trawl fisheries have been cited as potentially having significant impacts on spot stocks. The magnitude of this problem needs to be determined, as well as possible solutions such as the use of trawl efficiency devices (TEDs) in the shrimp fishery.

The major problem addressed in this plan is the lack of stock assessment data needed for effective management of the spot resource. Basic data requirements are information on recruitment, age, size, and sex composition of the stock(s), and variations in these characteristics in time and space. In addition, accurate catch and effort data are needed from the recreational and commercial fisheries to assess the impact of fishing activities on spot stocks.

4.0 DESCRIPTION OF STOCK

4.1 Species Distribution

Spot range from the Gulf of Maine to the Bay of Campeche, Mexico in estuarine and coastal waters to depths of at least 205 m (Smith and Goffin 1973; Bigelow and Schroeder 1953; Dawson 1958; Springer and Bullis 1958). The area of greatest abundance and center of the commercial fishery on the Atlantic Coast extends from Chesapeake Bay to South Carolina. Spot migrate seasonally between estuarine and coastal waters. They enter bays and sounds during spring where they remain until late summer or fall, and then move offshore to spawn and escape low water temperature (Hildebrand and Schroeder 1928; Roelofs 1951; Dawson 1958; Nelson 1969; Hoese 1973).

4.2 Abundance and Present Condition

Abundance estimates are not available for spot based on stock assessment analysis. Commercial landings data indicate that catches have fluctuated greatly since 1930. Lower landings prior to 1950 are probably due to incomplete statistical records. Spot landings reached an all-time high of 6,587 mt (14.5 million lb) in 1952 and since then have fluctuated between 1,767 mt (3.9 million lb) and 5,778 mt (12.7 million lb) with no apparent long-term trends.

The majority of the commercial foodfish harvest of spot comes from the South Atlantic and Chesapeake Bay areas. Between 1940 and the early 1960s the landings from the two regions were generally almost equal in magnitude; however, from the early 1960s to the present, a dramatic shift in landings from the Chesapeake to the South Atlantic has occurred.

The spot is a short-lived species and year-to-year fluctuations in catch are not surprising since the catch in most years consists largely of a single year class. Environmental differences that prevail on the spawning grounds are most likely responsible for the non-periodic fluctuations in spot landings (Joseph 1972). Other factors which probably affect the commercial landings of spot include changes in fishing effort (including increased recreational effort), habitat degradation, and economic conditions.

4.3 Ecological Relationships

The following information is summarized from Section 11.0.

Reproduction - Spot mature between ages 2 and 3 at a size of 186 to 214 mm TL (7-8 in) on the Atlantic Coast. Maturity is reached at a younger age (1-2) and smaller size (125-200 mm TL, 5-8 in) in the Gulf of Mexico. Spawning takes place offshore from late fall to early spring.

Age and Growth - The spot is a short-lived species, rarely attaining a maximum age of five years. Maximum reported ages were greatest in the northern part of the range; however, age 0-2 spot predominated in populations throughout the range.

Food and Feeding - Spot are opportunistic bottom feeders that mainly eat polychaetes, small crustaceans and mollusks, and detritus. Ontogenetic changes in feeding habits have been reported, from planktivorous feeding as post-larvae to benthic feeding as juveniles and adults.

Competitors and Predators - Differences in spatial and temporal distribution, as well as differences in feeding behavior, reduce competition between spot and croaker, and allow them to coexist in the same area. Reported predators of spot include striped bass, weakfish, flounder, and silky shark.

Seasonal Activity - Spot move into estuaries as post-larvae in winter and early spring, utilizing low salinity tidal creeks where they develop into juveniles. Spot move to deeper areas of higher salinity during summer and early fall and offshore in fall with decreasing water temperatures.

Parasites, Diseases, Injuries, and Abnormalities - Numerous reports of parasites in various life history stages of spot have been cited. A recently reported skin disease, ulcerative mycosis, which primarily affects Atlantic menhaden, has also been observed on spot.

4.4 Estimate of Maximum Sustainable Yield

Maximum sustainable yield has not been estimated for spot.

4.5 Probable Future Condition

There are no obvious long-term trends in abundance of spot based on commercial landings data. Spot landings have fluctuated greatly, and will probably continue to do so, due to such factors as variations in year-class strength and fishing pressure. Increasing fishing effort and habitat degradation and loss could lead to declines in spot abundance.

5.0 DESCRIPTION OF HABITAT

5.1 Condition of the Habitat

Climatic, physiographic, and hydrographic differences separate the ocean region south of Massachusetts to Florida into two distinct areas: the Middle Atlantic area and South Atlantic area, with the natural division occurring at Cape Hatteras. A major zoogeographic faunal change occurs at Cape Hatteras as a result of those differences (Briggs 1974).

The Middle Atlantic area is relatively uniform physically and is influenced by large estuarine areas including Chesapeake Bay (the largest estuary in the United States), Narragansett Bay, Long Island Sound, the Hudson River, Delaware Bay, and the nearly continuous band of estuaries behind the barrier beaches from New York to Virginia. The southern edge of the region includes the estuarine complex of Currituck, Albemarle, and Pamlico sounds, a 2,500-square mile system of large interconnecting sounds behind the Outer Banks of North Carolina (Freeman and Walford 1974; 1976a, b).

The South Atlantic region is characterized by three long crescent-shaped embayments, demarcated by four prominent points of land: Cape Hatteras, Cape Lookout, and Cape Fear in North Carolina, and Cape Romain in South Carolina. Low barrier islands skirt most of the coast south of Cape Hatteras although the sounds behind them are at most only a mile or two wide. Along the coast of Georgia and South Carolina, the barriers become a series of rather large, irregularly shaped sea islands, separated from the mainland by one of the largest coastal salt-water marsh areas in the world, through which cuts a system of anastomosing waterways. The east coast of Florida is bordered by a series of islands, separated in the north by broad estuaries which are usually deep and continuous with large coastal rivers and in the south by narrow, shallow lagoons (Freeman and Walford 1976b, c, d).

At Cape Hatteras, the continental shelf (characterized by water <198 m [108 fm] in depth) extends seaward approximately 32 km (20 mi) and widens gradually to 113 km (70 mi) off New Jersey. The substrata of the shelf in this region is predominantly sand interspersed with large pockets of sand-gravel and sand-shell. South of Cape Hatteras the shelf widens to 132 km (80 mi) near the Georgia-Florida border and narrows to 56 km (35 mi) off Cape Canaveral, Florida and 16 km (10 mi) or less off the southeast coast of Florida and the Florida Keys (Freeman and Walford 1974, 1976b, c, d).

The movements of the oceanic waters along the South Atlantic Coast are not well defined. Portions of the Gulf Stream, which flows northward following the edge of the continental shelf, break off and become incorporated into the coastal water masses. Features of these gyres change seasonally; the inshore flow is northward along the coast to Cape Hatteras in winter and spring and southward in summer and fall. North of Hatteras, surface circulation on the shelf is generally southwesterly during all seasons. There may be a shoreward component to this drift during the warm half of the year and an offshore component during the cold half. This drift, fundamentally the result of temperature-salinity distribution, may be made final by the wind. A persistent bottom drift at speeds of tenths of nautical miles per day extends from beyond mid-shelf toward the coast and eventually into the estuaries. Offshore, the Gulf Stream flows northeasterly (Saila 1973).

5.2 Habitat Areas of Particular Concern

Habitat alterations within estuarine areas are probably damaging to spot stocks since these areas are utilized for nursery grounds. Most estuarine areas of the United States have been altered to some degree by such activities as agricultural drainage, flood control and development. The National Estuary Study, completed in 1970, indicated that 73% of the nation's estuaries had been moderately or severely degraded. Damage and/or destruction of estuaries have largely been by filling, the dredging of navigation channels, and pollution (Gusey 1978, 1981). The Atlantic Coast states (Maine-Florida) contain 3,152,800 acres of estuarine habitat, of which an estimated 129,700 acres (4.1%) were lost to dredging and filling from 1954 to 1968. Unfortunately, the effects of habitat alterations, such as channel dredging, filling of wetlands, increased turbidity associated with dredging, boating, loss of wetlands, and storm runoff, industrial pollutants, and sewage, have rarely been quantified.

5.3 Habitat Protection Programs

In recent years the coastal states have enacted coastal zone management laws to regulate dredge and fill activities and shoreline development. The federal government also regulates dredging and spoil disposal, water pollution, and creation of marine sanctuaries through the U.S. Army Corps of Engineers, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the Environmental Protection Agency.

State Programs

State habitat protection regulations are summarized in Table 11-13.

Federal Programs

The Coastal Zone Management Act of 1972, 16 USC 1451

This Act established a national policy and initiated a national program to encourage state planning for the management, beneficial use, protection and development of the Nation's coastal zones (generally, the submerged lands and waters of the territorial sea and the adjacent shorelands having a direct and significant impact on such waters).

Fish and Wildlife Coordination Act of 1956, USC 742(a)-754

This act established a comprehensive national policy on fish and wildlife resources; authorized programs and investigations that may be required for the development, advancement, management, conservation and protection of the fisheries resources of the United States.

National Environmental Policy Act of 1969, 42 USC 4321-4347

This Act requires detailed environmental impact statements of proposals for legislation and other major Federal actions which may significantly affect the quality of the human environment. Prior to making the detailed statement, the responsible Federal official is required to consult with and obtain the comments of any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. It also requires that documents must be available to the public and their comment must be considered.

The Ports and Waterways Safety Act of 1972, 33 USC 1221-1227

This Act deals with transportation and pollution problems resulting from operation and casualties of vessels carrying oil and other hazardous substances. It is designed to protect coastal waters, living resources, recreational resources and scenic values.

Federal Water Pollution Control Act, and Amendments of 1972, 33 USC 1251-1376

This Act initiated major changes in the enforcement mechanism of the Federal water pollution control program from water quality standards to effluent limits. Among other things, it requires that permits be issued by the Environmental Protection Agency or the states for discharge of effluents into waters of the United States.

The Marine Protection, Research and Sanctuaries Act of 1972 (The Ocean Dumping Act), 33 USC 1401-1444

This Act regulates the transportation from the United States of material for dumping into the oceans, coastal and other waters, and the dumping of material from any source into waters over which the United States has jurisdiction. The Environmental Protection Agency is empowered to issue permits for transportation or dumping where it will not unreasonably degrade or endanger human health, welfare or amenities, or the marine environment, ecological systems or economic potentialities. Section 106 of the Act provides for the provision of the Fish and Wildlife Coordination Act to apply.

Endangered Species Act of 1973, PL 93-205, 16 USC 1531 et seq.

This Act gives the Departments of Commerce and Interior regulatory and statutory authority over endangered and threatened fauna and flora not included in previous Acts. The purpose of the Act is to conserve endangered and threatened species and the ecosystems upon which they depend.

Marine Mammals Protection Act of 1971, 16 INC 1361-1407

This Act, with certain exceptions, places a moratorium on the taking and importation of all marine mammals and marine mammal products. It makes the Secretary of commerce responsible for protecting whales, porpoises, seals, sea lions; and the Secretary of the Interior responsible for all other marine mammals, specifically sea otters, walruses, polar bears and manatees. It also protects the habitat of marine mammals, including food sources.

Deepwater Port Act of 1974, 33 USC 1501-1524

This Act established procedures for the location, construction and operation of deepwater ports off the coasts of the United States.

Magnuson Fishery Conservation and Management Act of 1976, 16 USC 180

This Act established a fishery conservation and management regime to be implemented by the Secretary of Commerce. It established a fishery conservation zone extending from the limits of the territorial sea of 200 nautical miles from the baseline from which the territorial sea is measured. The Act defines fishery resource to include ". . . any habitat of fish," and enjoins the Secretary to carry out a research program which must include ". . . the impact of pollution on fish, the impact of wetland and estuarine degradation, and other matters. . ."

National Ocean Pollution Research and Development and Monitoring Planning Act of 1978, PL 95-273

The Act designates NOAA as the lead agency in the development of a comprehensive five-year plan for a Federal program relating to ocean pollution research, development and monitoring. This plan is to provide for the coordination of existing Federal programs relating to the oceans and for the dissemination of information emerging from these programs to interested parties. In addition, the plan shall provide for the development of a base of information necessary to the utilization, development and conservation of ocean and coastal resources in a rational, efficient and equitable manner.

NMFS Habitat Conservation Policy of 1983

This Policy will ensure that habitat is fully considered in all NMFS programs and activities, focus NMFS habitat conservation activities on species for which the agency has management or protection responsibilities under the Magnuson Fishery Conservation and Management Act, the Marine Mammal Protection Act, and the Endangered Species Act, lay the foundation for management and research cooperation on habitat issues, and strengthen NMFS partnerships with the states and the regional Fishery Management Councils on habitat issues.

6.0 FISHERY MANAGEMENT JURISDICTION, LAWS, AND POLICIES

6.1 Management Institutions

The Atlantic States Marine Fisheries Commission's (ASMFC) Interstate Fisheries Management Program (ISFMP), comprised of the 15 Atlantic Coast states from Maine to Florida, has the goal of achieving cooperative interstate management of shared territorial sea fisheries of the Atlantic Coast. To achieve this goal, the ISFMP has determined priorities among the territorial sea fisheries for inclusion in the program; developed, monitored, and reviewed management plans for high-priority fisheries; and recommended to the states, and where appropriate, to the regional Fishery Management Councils and the federal government, management measures to benefit territorial sea fisheries.

The U.S. Department of Commerce, acting through the Fishery Management Councils, pursuant to P.L. 94-265 (Magnuson Fishery Conservation and Management Act), has authority to manage stocks throughout the range that are harvested predominantly in the Exclusive Economic Zone (EEZ), which extends from the territorial sea to 200 nautical miles from shore.

6.2 Treaties and International Agreements

Foreign fishing is regulated by P.L. 94-265 pursuant to which Governing International Fishing Agreements are negotiated with foreign nations for fishing within the EEZ.

6.3 Federal Laws, Regulations, and Policies

The only known Federal law that can possibly regulate the management of the spot fishery is P.L. 94-265. There is no Federal fishery management plan for spot.

6.4 State Laws, Regulations, and Policies

All states have the power to regulate or enact laws pertaining to the taking of spot. Those that have regulatory powers are North Carolina and Florida. Those that must adopt legislation are Delaware, Maryland, South Carolina, and Georgia. Once a plan has been approved by the ASFMC, Delaware can issue regulations. Virginia has the power to regulate size limits but must enact laws pertaining to area closures. State laws and regulations are summarized in Table 11-12.

6.5 Local and Other Applicable Laws, Regulations, and Policies

No local or other laws, regulations, or policies are known to exist relative to the spot fishery.

7.0 DESCRIPTION OF FISHING ACTIVITIES

7.1 History of Exploitation

Commercial foodfish landings of spot have fluctuated with short-term sharp increases followed by precipitous declines. Peaks in landings occurred in the 1950s, when landings averaged 4,900 mt (10.8 million pounds), and in the 1970s, when landings averaged slightly more than 4,100 mt (9.0 million pounds). Yearly landings during the past 35 years have fluctuated between 1,800 mt (3.9 million pounds) and 6,600 mt (14.5 million pounds), with an average of 4,000 mt (8.8 million pounds).

Historically, most of the commercial foodfish harvest of spot came from the Chesapeake (Maryland and Virginia) and South Atlantic (North Carolina, South Carolina, Georgia, and Florida) regions (Table 11-5). Since 1960, South Atlantic landings have greatly exceeded Chesapeake landings. Middle Atlantic landings (New York, New Jersey, Delaware) peaked in 1943 and have been insignificant since 1957.

7.2 Domestic Commercial and Recreational Fishing Activities

Commercial Fishery

The commercial foodfish fishery for spot consists of the inshore summer fishery, employing haul seines, pound nets, gill nets, and trawls; and the offshore winter fishery, which consists of trawls and gill nets. These fisheries can be classified as mixed species and opportunistic fisheries which may concentrate directly on spot for brief periods of time, such as in the fall haul seine fishery in North Carolina and South Carolina. In addition, spot are caught by hand lines, and hoop, fyke, and trammel nets. The industrial fishery primarily uses otter trawls, with small amounts taken by haul seines, gill nets, and pound nets.

Recreational Fishery

Anglers take spot from ocean beaches and the banks of bays and rivers, as well as from man-made structures such as piers, bridges, jetties, and causeways (Freeman and Walford 1974, 1976a, b, c, d). They also catch them while fishing estuarine and nearshore waters from anchored or drifting party, charter, private, and rental boats. Spot are usually taken from a few feet below the high tide line to depths of 30 feet or more, over all types of bottoms, by bottom-fishing, chumming, or live-lining. Baits include shrimp, clams, worms, cut fish, and soft or shedder crabs. A few are also taken on small jigs and weighted bucktails which are either cast or jigged from shore or boats.

8.0 DESCRIPTION OF ECONOMIC CHARACTERISTICS OF THE FISHERY

8.1 Domestic Harvesting Sector

Historical records of spot landings indicate that a successful commercial fishery for spot has been operating at least since the late 1880s. Spot ranked fourth behind weakfish, croaker, and spotted seatrout in their contribution to the total value of U.S. sciaenid landings. Food landings of spot were valued at about 2 million dollars in 1987.

8.2 Domestic Processing Sector

Foodfish landings of spot are primarily sold freshly iced, whole. The industrial catch of spot is processed into cat food, frozen crab bait, and recently, surimi.

8.3 International Trade

There are no records of exports of spot from the U.S.

9.0 DESCRIPTION OF THE BUSINESSES, MARKETS AND ORGANIZATIONS ASSOCIATED WITH THE SPOT

9.1 Relationship Among Harvesting and Processing Sectors

Most food sciaenids are sold through local fish houses (Cato 1981). Spot were formerly sold through large wholesale markets such as Fulton Fish Market in New York City, but today are sold principally by local small fish markets. Spot markets are widely distributed along the Gulf coast and from the Carolinas to New York. Attempts have been made in recent years to market spot throughout the Midwest in retail seafood stores and supermarket chains.

9.2 Fishery Cooperatives or Associations

There are seven fishery cooperatives in the South Atlantic and Gulf regions: one in South Carolina, two each in Georgia and Florida, one in Mississippi, and one in Texas. These provide marketing and purchasing, marketing exclusively, and/or other services such as insurance, transportation, purchasing supplies, legislative lobbying, production, processing, and collective bargaining.

9.3 Labor Organizations

Labor organizations identified with the harvesting and processing sectors of the spot fishery have not been specifically described; however, some of the participants in the spot fishery are undoubtedly represented by labor organizations. Labor organizations identified with the harvesting and processing sectors of the fisheries in the Mid-Atlantic area are limited to four organizations: the Seafarers International Union of North America, the International Longshoreman's Association, the United Food and Commercial Workers International Union (UF&CW) of the AFL-CIO, and the International Brotherhood of Teamsters. Information is not available to identify activities that relate directly to spot. The following discussion is related to Mid-Atlantic fisheries generally and was summarized from Development Sciences, Inc. (1980) by Scarlett (1981).

In the Mid-Atlantic area, union involvement is limited almost entirely to onshore seafood handling, processing, and distribution activities. Vessel crews are not organized by any of the identified unions, although some attempts have been made in the past to include fishermen in organized unions. Onshore seafood handling is generally non-unionized, but to the extent that it is, the International Longshoremen's Association is the primary national union involved in seafood handling workers. Most union activity occurs in the region's major urban centers (New York, Philadelphia, Baltimore, and Norfolk) and include handling workers at boat docks and in warehousing facilities located at processing plants. Fish processing workers, (oyster and clam shuckers, fish cleaners and cutters, freezermen, warehousemen, some distribution workers, and wholesale and retail clerks) when unionized, are represented by the UF & CW International Union. Transportation of seafood products, especially from processing facilities to wholesale and retail fish distributors, is organized under the International Brotherhood of Teamsters.

The seafood harvesting, handling, and processing industry is not highly organized in the mid-Atlantic region. Although union activity occurs in all major urban centers, the overall percentage of union members employed in the seafood industry is relatively low. For example, in the Hampton Roads area, only 5% of all workers employed in the seafood harvesting and processing industry are organized by the unions. The reasons for limited union involvement include the low-wage seasonal nature of employment in the processing industry, and the diverse, highly competitive and independent nature of the fishermen, brokers, and processors. In many instances, wages are extremely low, approaching minimum wage in some localities. Fish processing employees are often the lowest paid employees covered by the unions. These employees change employment continuously due to difficult working conditions and unstable employment prospects. Seasonality of employment and constant changeover from shellfish to finfish processing affects steady employment and limits the union's ability to organize onshore workers. Unionization of vessel crews and fishermen is limited by the small size of individual crews and the investor-owner fishing boats. National Labor Relations Board ruling against organization of fishing fleets have added to the organization and administrative problems of including fishermen in national union structures.

9.4 Foreign Investment in the Domestic Fishery

Data on foreign investment in the fishery are not known to exist. It is probable that if investment exists, it is insignificant.

10.0 GOAL STATEMENT

The goal of this management plan is to perpetuate the spot resource in fishable abundance throughout its range and generate the greatest economic and social benefits from its commercial and recreational harvest and utilization over time.

10.1 Specific Management Objectives

1. Conduct cooperative interstate research to understand the biology of, and fisheries for, spot.

   There is a lack of data necessary for effective management of spot stocks. Data on age and growth, reproduction, migration patterns, and stock structure are incomplete. There is a need to improve this database for future refinements of the plan.

2. Maintain a spawning stock sufficient to minimize the possibility of recruitment failure and determine the effects of the environment on year class strength.

   Juvenile recruitment in spot is erratic and dependent upon specific environmental parameters. The effect of spawning stock size on recruitment is unknown. Until the dynamics of the spot population are better understood, a management scheme that preserves at least some minimum spawning stock should be employed.

3. Optimize yield per recruit.

   This objective cannot be fully met until Objective 1 is carried out and data necessary for yield modeling are collected.

4. Improve collection of catch and standardized effort statistics and description of fishing gears.

   There is a need for accurate catch and effort data from the various commercial fisheries which harvest spot and from the recreational fishery. These are basic requirements for stock assessment and population abundance estimates.

5. Promote harmonious use of the resource among various components of the fishery through the coordination of management efforts among the various political entities having jurisdiction over the spot resource.

The spot is a migratory species. Effective management can only be accomplished through cooperative efforts among the states involved in harvesting the resource.

6. Promote the cooperative interstate collection of economic, social, and biological data required to effectively monitor and assess management efforts.

   The need for continual collection of data throughout the range of spot is essential to achieve and maintain effective management.

7. Promote determination and adoption of the highest possible standards of environmental quality.

   Environmental quality is of critical importance to maintaining maximum natural production of spot and sustaining fishable populations of the species.

10.2 Specific Management Measures

The following management measures are identified as appropriate for implementation:

1. Promote the development and use of trawl efficiency devices (TEDs) through demonstration in the southern shrimp fishery, and fish separators in the finfish trawl fishery .

2. Promote increases in yield per recruit through delaying entry to spot fisheries to ages greater than one.

10.3 Research and Data Collection Programs

1. Identify stocks and determine coastal movements and the extent of stock mixing.

   The necessity of defining the unit stock for fisheries stock assessment and management is well established (Cushing 1975; Gulland 1983). Few species form single homogeneous populations, and most can be separated into several more or less distinct stocks, which react to fishing more or less independently (Gulland 1983). A variety of methods have been used in stock discrimination studies of marine fishes, including tagging and migration, meristics, parasites, serology, and biochemical techniques to determine genetic differences (electrophoresis, isoelectric focusing, mt-DNA). Only a few of these methods have been applied to spot stock identification. Aspects of spot life history differ throughout their range and suggest the need for different management strategies.

2. Collect catch and effort data, including size and age composition of the catch, determine stock mortality throughout the range, and define gear characteristics.

   Fisheries stock assessments depend on basic data from the commercial and recreational fisheries including catch, amount of fishing or effort, catch-per-unit-effort, and biological characteristics of the catch (size, age, etc.). From these basic data, estimates of mortality and abundance can be made.

   Commercial and recreational fishery statistics are collected and compiled by the National Marine Fisheries Service in cooperation with various states. Commercial landings data are generally collected on a monthly basis by port samplers, and include pound and value of species landed, type of gear used, water body of capture, and distance caught from shore. Nominal effort data, such as the number of fishing trips, is collected for some fisheries, and the total units of gear fished are recorded on an annual basis. Recreational statistics are collected in two complementary surveys: a telephone survey of households and an intercept survey of fishermen at fishing sites. Data from the two independent sources are combined to produce estimates of catch, total effort, and participation.

   The effort data presently being collected are generally inadequate for fisheries stock assessment. Standardized measures of effort need to be developed for the various fisheries which harvest spot. Minimum biological data needed from both the commercial recreational fisheries include size and age composition of the catch. Pound nets, a relatively nonselective gear used throughout much of the spot range (Maryland to North Carolina), are recommended as a target gear for the development of a coastwide sampling program to collect catch, effort, and biological data for spot stock assessment, and eventually to monitor the effectiveness of future management strategies. Each state marine fisheries agency should develop a list of pound nets and associated fish processors where biological samples can be collected. Development of a log system, such as has been used by NMFS, to collect accurate catch and effort data and a biological sampling program to collect length, weight, and age data is recommended. In addition, each state marine fisheries agency should document existing commercial and recreational fisheries databases.

3. Develop and maintain a recruitment index and examine the relationships between parental stock size and environmental factors on year-class strength.

   The relationship between adult spot abundance and subsequent recruitment is not known. DeVries (1985) did find a positive correlation between spot catch-per-unit-effort data from a juvenile survey and long haul seine landings of spot three years later. Data on juvenile spot abundance are available from various state estuarine surveys.

The design and methodology of these surveys vary considerably among states. It is recommended that the states develop a uniform random sampling scheme in order to develop a coastwide index of abundance, determine local and seasonal distribution patterns, and determine spawning periodicity. Initially the new survey would be conducted concurrently with established surveys in order to make comparisons and utilize the previously collected data.

It is well documented that the pattern of recruitment to most fish stocks generally bears no obvious relation to the abundance of the parent stock, but rather that year-class strength is determined mostly by environmental factors at some early stage (stages) in the life of that year class (Gulland 1983). The importance of considering environmental influences on marine fish populations is reflected in a scientific program proposed by the Food and Agricultural Organization (FAO) in 1979 which identified five variables (temperature, turbulence, transport, food, and predation) most likely to determine recruitment levels (Sullivan 1982). Present indices of spot year class strength should be analyzed with available environmental data. Additional environmental data needs should be determined as a part of the development of a uniform juvenile sampling program.

4. Define reproductive biology of spot, including size at sexual maturity, fecundity, and spawning periodicity.

Aspects of the reproductive biology of spot have been reported for portions of the range; however, data are incomplete and in some instances, conflicting. Size at maturity may vary throughout the range. Data on fecundity, size at 100% sexual maturity, and spawning periodicity, collected concurrently throughout the range, are needed to determine future management strategies for spot.

11.0 A BIOLOGICAL AND FISHERIES PROFILE OF SPOT, *Leiostomus xanthurus*

11.1 Identity

11.1.1 Nomenclature

The valid name for spot is *Leiostomus xanthurus* Lacepede 1802 (Figure 11.1). The following synonymy is after Jordan and Evermann (1896):

Leiostomus xanthurus, Lacepede, 1802
Mugil obliquus, Mitchill, 1815
Sciaena multifasciata, Lesueur, 1821
Leiostomus humeralis, Cuvier and Valenciennes, 1830
Sciaena xanthurus Gunther, 1860
Leiostomus obliquus, DeKay, 1842
Sciaena obliqua, Gunther, 1860

11.1.2 Taxonomy

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

Superorder: Acanthopterygii
Order: Perciformes
Suborder: Percoidei
Family: Sciaenidae
Genus: *Leiostomus*
Species: *Leiostomus xanthurus*

The spot is one of 23 members of the family Sciaenidae found along the Atlantic and/or Gulf coasts of the United States (Robins et al. 1980; Miller and Woods 1988). The family is commonly known as the drums since many of its members, including spot (males only), produce drumming sounds by vibrating their swim bladders with special muscles (Jordan and Everman 1896; Hildebrand and Schroeder 1928; Bigelow and Schroeder 1953; Dawson 1958; Fish and Mowbray 1970; Hill 1985). Chao (1978) assessed the phylogenetic relationships of all western Atlantic genera of Sciaenidae on the basis of swim bladder, otoliths (sagitta and lapillus), and external morphology, and presented a tested key to species and genera, including meristics and species ranges. The genus *Leiostomus* is monotypic.

Spot is the common name given *Leiostomus xanthurus* by the American Fisheries Society (Robins et al. 1980). Other common names include croaker, silver gudgeon, Lafayette, Jimmy, chub, roach, goody, post-croaker, oldwife, Cape May goody, porgy, and yellowtail (Smith 1907; Hildebrand and Schroeder 1928; Shiino 1976).

11.1.3 Morphology

The following description is that of Johnson (1978), summarized from Jordan and Evermann (1896), Hildebrand and Schroeder (1928), Miller and Jorgenson (1973), Lippson and Moran (1974), and Chao (1976).

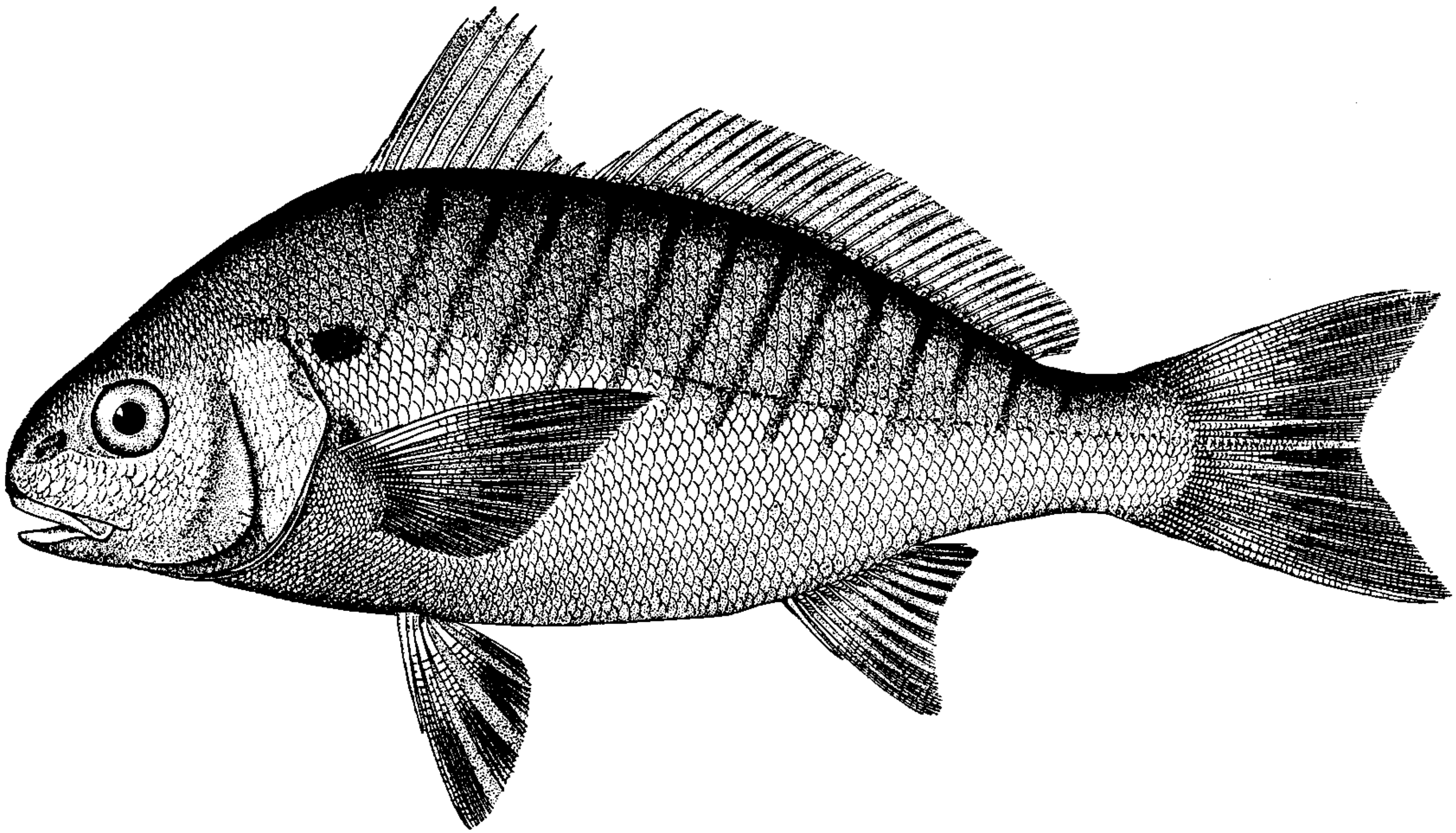

Figure 11-1. Spot, Leiostomus xanthurus Lacepede, 1802 (illustration by H.L. Todd from: Goode, 1884).

D. IX to XI-I, 29-35; A. II,12-13; C. 9+8, procurrent rays 6-8+6-8; V.I, 5; scales 72-77 in a lateral series; vertebrae 10+14 or 10+15; gill rakers 8-12+20-23; branchiostegals 7; teeth small, villiform, set in bands in jaws.

Head 2.9-3.6; depth 2.5-3.6 in SL; snout 2.7-3.4, eye 3.0-3.9, interorbital 3.0-3.8, maxillary 2.6-3.2, pectoral fin 0.9-1.4 in head.

Body rather deep, compressed; back strongly elevated; head short, obtuse; snout blunt; mouth small, inferior; maxillary reaching to about middle of eye; mandible with five pores at the tip. Scales rather small, ctenoid, extending onto base of caudal fin, small scales also present on base of other fins. Dorsal fin continuous, with a notch in between the spinous and soft portions; the spines slender, the third and fourth the longest; caudal fin notably concave, upper rays longest; pectoral fin long, reaching well beyond top of pelvic fin.

Pigmentation: Color bluish gray above with golden reflections below; sides with 12-15 oblique dark streaks (indistinct in very large specimens); a large black spot on shoulder (above the upper end of gill covers); fins generally pale to yellowish.

Recognized by comparatively short compressed body, short obtuse head, small horizontal mouth, oblique bars, and particularly the dark shoulder spot.

Hill (1985) examined the ontogeny of the swimbladder and sonic muscles in spot and found that spot sonic muscle occurred only in males and first appeared at 105 mm SL at approximately 6-7 months of age, before maturation of the gonads. Meristic characters of 15 spot from the Atlantic Ocean were presented by Miller and Jorgensen (1973). Hildebrand and Cable (1930) described the morphometric development of larvae from 1.5 to 50 mm TL and Powles and Stender (1978) described the morphometric and meristic development of 34 spot (4.0-39.0 mm) from South Carolina estuaries and continental shelf waters off the southeastern United States. Length regressions for spot were presented by Dawson (1958), Jorgenson and Miller (1968), and Hata (1985) (Table 11.1).

11.2 Distribution

11.2.1 General Distribution

Spot range from the Gulf of Maine to the Bay of Campeche, Mexico in all depths to at least 205 m (112 fm) (Smith and Goffin 1937; Bigelow and Schroeder 1953; Dawson 1958; Springer and Bullis 1956). On the Atlantic coast of the United States the area of greatest abundance and center of the commercial fishery extends from Chesapeake Bay to South Carolina.

Table 11.1. Length relationships for spot as reported in the literature.

Reference	Location	Range (mm TL)	N	Relationship	r
Dawson (1958)	South Carolina	-	5,162	SL = 2.000 + 1.233 TL	0.996
			546	FL = 8.90 + 1.09 SL	0.991
			546	FL = 6.170 + 0.893 TL	0.997
Jorgenson and Miller (1968)	Georgia	14-111	71	TL = -0.606 + 1.288 SL	0.910
			87	SL = 0.760 + 0.771 TL	0.893
Hata (1985)	Texas	66-275	2,107	TL = 0.907 + 1.305 SL	0.995
			2,107	SL = -0.169 + 0.762 TL	0.995
			2,802	TL = -4.470 + 1.101 FL	0.998
			2,802	FL = 4.367 + 0.906 TL	0.998

11.2.2 Differential Distribution

11.2.2.1 Spawn, Larvae, and Juveniles

Spot eggs have not been identified in ichthyoplankton collections; however, spawning is believed to occur outside of estuaries based on size distributions of larvae collected along the coast, and infrequent collections of fish in spawning condition from offshore. Powell and Gordy (1980) described and illustrated the egg development of spot from laboratory-spawned specimens.

Spot larvae have been collected from within estuaries to the edge of the continental shelf (Hildebrand and Cable 1930; Berrien et al. 1978; Houde et al. 1979; Lewis and Judy 1983; Warlen and Chester 1985; Cowan and Shaw 1988) from October through May. Larvae were smaller and more numerous offshore (34-128 m) than inshore (17-26 m), indicating that more spawning occurs offshore (Berrien et al. 1978; Lewis and Judy 1983; Warlen and Chester 1985). Hildebrand and Cable (1930) reported that spot larvae may be present at any depth but occurred more frequently near the bottom; however, Lewis and Wilkens (1971) found this to be true only at night. Direct across-shelf transport has been suggested as the major transport mechanism for larvae of sciaenids and other species along the mid-Atlantic coast (Nelson et al. 1976; Norcross and Austin 1981; Miller et al. 1984). In contrast, a transport hypothesis of alongshore advection within and just outside the coastal boundary layer in the northwestern Gulf of Mexico has been developed (Shaw et al. 1985; Cowan and Shaw 1988).

Spot larvae entered a North Carolina estuary at an average age of 59 days (range 40-74 days) and an average size of 13.6 mm (range 11.3 to 15.6 mm). Significantly younger and smaller larvae immigrated at the beginning and end of the immigration period. Larvae entered the estuary segregated by age (Warlen and Chester 1985).

Postlarval spot have been collected in estuarine nursery areas as early as December in Texas (Pearson 1929; Simmons 1957) and Louisiana (Sabins and Truesdale 1974), but chiefly in April in Delaware Bay (DeSylva et al. 1962), and in January or February in Chesapeake Bay (Welsh and Breder 1923), North Carolina (Hildebrand and Cable 1930; Tagatz and Dudley 1961; Williams and Deubler 1968; Turner and Johnson 1973; Weinstein 1979; Weinstein and Walters 1981; Lewis and Judy 1983; Warlen and Chester 1985), South Carolina (Shenker and Dean 1979; Bozeman and Dean 1980; Beckman and Dean 1984), Georgia (Music 1974; Music and Pafford 1984), Florida (Welsh and Breder 1923; Townsend 1956; Springer and Woodburn 1960; Wang and Raney 1971; Subrahmanyam and Coultas 1980; Price and Schlueter 1985), Alabama (Nelson 1969; Swingle 1971), Louisiana (Sundararaj 1960; Parker 1971) and Texas (Pearson 1929; Parker 1971).

Low salinity bay waters and tidal marsh creeks with mud and detrital bottoms constitute the primary nursery habitat for juvenile spot in Delaware (DeSylva et al. 1962; Thomas 1971; Johnson 1978; Wang and Kernehan 1979), Virginia (Raney and Massmann 1953; Massmann 1954; Pacheco 1957, 1962a; Richards and Castagna 1970; Merriner et al. 1976; Chao and Musick 1977; Weinstein 1979, 1983; O'Neil 1983; Weinstein and

Brooks 1983; McCambridge and Alden 1984; Weinstein et al. 1984; Cowan and Birdsong 1985), North Carolina (Keup and Bayless 1964; Williams and Deubler 1968; Tagatz and Dudley 1961; Weinstein 1979; Weinstein et al. 1980; Weinstein, Weiss, and Walters 1980; Weinstein and Walters 1981; Epperly 1984; Rozas and Hackney 1984; Ross and Epperly 1985; Rulifson, 1985), South Carolina (Dawson 1958; Shealy et al. 1974; Cain and Dean 1976; Shenker and Dean 1979; Bozeman and Dean 1980), Georgia (Dahlberg 1972; Hoese 1973; Music 1974; Music and Pafford 1984; Rogers et al. 1984), and Florida (Tagatz 1967). Rozas and Hackney (1983) suggested that for spot, some oligohaline wetland habitats may be of equal importance to higher salinity marshes. Juvenile spot are also associated with eelgrass beds in Chesapeake Bay, (Orth and Heck 1980; Weinstein 1983; Weinstein and Brooks 1983) and in North Carolina (Adams 1976); however, by late spring densities in tidal creeks are often several times higher than in nearby seagrass habitats or shoal areas (Weinstein and Brooks 1983; Smith et al. 1984).

Weinstein and O'Neil (1986), concluded from working experiments that young-of-the-year spot recruited into tidal creeks and were largely resident for the duration of warm weather. As temperatures dropped in the fall mass emigrations to deeper estuarine waters or the ocean are apparently stimulated. Hildebrand and Schroeder (1928) reported that some young of the year overwinter in the deeper waters of Chesapeake Bay although other studies only collected spot from April or May through December in the York River and Chesapeake Bay (Pacheco 1962b; Markle 1976). Spot was a dominant species in the winter (November-June) fish community of eelgrass beds in Bogue Sound and the Newport River, North Carolina (Adams 1976). Young spot (<15 cm) are year-round residents of the inshore waters (rivers, sounds and coastal waters) of South Carolina (Shealy et al. 1974). Spot were trawled in Georgia creeks, sounds and outside waters year-round with largest numbers taken in the creeks during winter (Mahood et al. 1974; Music 1974; Music and Pafford 1984).

11.2.2.2 Adults

Adult spot migrate seasonally between estuarine and coastal waters. They enter bays and sounds during spring, but seldom occur as far up-estuary as do the young. They remain in these areas until late summer or fall before moving offshore to spawn or escape low water temperature (Hildebrand and Schroeder 1928; Roelofs 1951; Dawson 1958; Schwartz 1964a; Nelson 1969; Hoese 1973).

Within Chesapeake Bay, adult spot are generally available to commercial and sport fisheries from April through October, the bulk being taken from August to October when spot are moving out of the bay (Pacheco 1962a). During winter spot are taken in the winter trawl fishery operating off Cape Hatteras, N.C. (Pearson 1932). A tagging study in Georgia estuaries indicated offshore movement of spot; the longest distance traveled was 118 km (Music and Pafford 1984).

Spot ranked first both in total number and total weight of all species taken in trawl surveys of groundfish in coastal waters (4.6-9.1 m) of the South Atlantic Bight (Cape Fear, North Carolina to Cape Canaveral, Florida) (Wenner 1987a; Wenner et al. 1987). There was no significant difference in frequency of occurrence between seasons. Mean catch/tow was highest in two strata off Georgia during winter and catches from summer and fall were moderate throughout the region. The stratified mean catch per tow, both in numbers and weight, was highest in spring and lowest in fall. The size frequency distribution indicates that two or possibly three age classes were present, young of the year, age I, and age II.

11.2.3 Determinants of Distribution

The spot is a euryhaline species, recorded from <1°/₀₀ (Gunter 1945; Raney and Massmann 1953; Massmann 1954; Tagatz and Dudley 1961; Keup and Bayless 1964; Dahlberg 1972; Rohde et al. 1979; Schwartz et al. 1981) up to 60°/₀₀ (Simmons 1957). Reports of spot salinity preferences as reflected by their distribution are conflicting. Parker (1971) found spot of all sizes in Galveston Bay, Texas and Lake Borgne, Louisiana to be about equally distributed over broad salinity ranges and concluded that salinity per se has little effect on spot distribution. In two Florida studies, spot abundance was positively associated with salinity (Parrish and Yerger 1973; Mulligan and Snelson 1983). Total densities of young-of-year spot in a polyhaline system were twice that of the meso-oligohaline creek in the York River, Virginia (O'Neil and Weinstein 1987). Reid (1957) observed a marked gradient distribution of young spot in East Bay, Texas, with maximum catches being made in lower salinity.

A significant positive correlation (P=0.05) was reported for juvenile spot/croaker ratios salinity fluctuations in North Carolina marsh creeks (Gerry 1981; Moser 1987; Moser and Gerry in press). The sampling site with the greatest fluctuations had an approximate 2:1 ratio of spot to croaker, while the most stable site had an approximate 1:3 ratio of spot to croaker. The integrated laboratory studies indicated that croaker avoid crossing salinity gradients, significantly more than spot. Moser (1987) reported that large magnitude changes in oligohaline to mesohaline waters are most likely to adversely affect juvenile spot. Sensitivity to salinity fluctuation changes with fish size, based on routine metabolic rates during salinity changes. Oxygen uptake was determined as a function of constant salinity, temperature, and fish size: $\log_{10} O_2$ (mg/g/h) = 0.129 (salinity, ppt) + 1.604 (temperature, °C) - 0.140 (size g) - 2.767.

Spot are apparently tolerant of a wide range of temperatures (1.2-36.7°C); however, extended periods of low temperatures have resulted in stunned and dead spot (Hildebrand and Cable 1930; Gunter and Hildebrand 1951; Lunz 1951, 1958; Dawson 1958). Schwartz (1964b) reported that young spot tolerated a slightly lower temperature (2.2°C) than adults (3.3-4.4°C) in an aquarium study.

Experiments on thermal shock resistance of post larval and juvenile spot revealed no apparent effect of acclimation to selected constant temperatures versus acclimation to diel temperature cycles (Hartwell and Hoss 1979). Postlarvae had lower thermal shock resistance than juveniles when acclimated at the same temperatures. Most mortality occurred within 10 minutes of shock onset. At an average offshore power plant delta-T of 10-12°C and an ambient temperature of 15-16°C, spot eggs may be more affected by heat shock than later as embryos. Larvae could not survive a delta-T of 18° C (Hettler and Clements 1978). Hodson et al. (1981a) estimated that the upper incipient lethal temperature was 35.2°C for postlarval (<25 mm SL) and small juvenile spot. The critical thermal maximum (CTM) value for juvenile spot acclimated at 15°C was 31.0°C (Hoss et al. 1972) Oxygen consumption increased as temperature was raised in 5° increments, and all of the spot died within 5 to 10 minutes at temperatures 15°C above the normal environmental temperature.

Juvenile spot may inhabitat waters with dissolved oxygen concentrations as low as 1.3 to 5.4 mg/l, but most prefer concentrations exceeding 5.0 mg/l (Ogren and Brusher 1977). Oxygen consumption rates of spot (121-204 mm TL) in filtered 20°C Patuxent River water ranged from 5-45.1 mg O_2 h for those swimming at 31.7cm/sec; and from 10.8-93.6 mg O_2 h for those swimming at 49 cm/sec. Respiration rates increased as size increased at all three speeds (Neumann et al. 1981). Respiration data for spot (11g) at 25° C were described best by the relationship: $\log_{10}$ O_2 mg/lg/h)= 2.0 + 0.22 (swimming speed, body lengths/s). This implies that spot have a standard metabolic rate of .100 mg/g/h and an optimum swimming speed of 2 body lengths (Moser 1987).

A habitat suitability index (HSI) model was developed for juvenile spot in estuaries (Stickney and Cuenco 1982). Habitat variables used in the model included dominant sediment type, average summer water temperature, average summer salinity, average minimum summer dissolved oxygen, and average water depth at mean high water.

11.3 Life History

Summaries of information on the life history of spot were presented by Dawson (1958), Johnson (1978), and Darovec (1983).

11.3.1 Reproduction

On the Atlantic coast spot mature at the end of their second year or early in their third year of life (Hildebrand and Cable 1930; Dawson 1958). In the Gulf of Mexico some spot mature as they approach age I (Hata 1985), and others at age II (Pearson 1929; Townsend 1956; Nelson 1969; Hata 1985). Reported sizes at maturity range from 186-214 mm TL on the Atlantic coast and 125-200 mm TL on the Gulf coast.

Dawson (1958) calculated fecundity gravimetrically of two spot (158-187 mm SL) caught off South Carolina. The calculated number of eggs >0.2 mm in diameter was 77,730 and 83,900 but it was not known whether these were representative of fully ripe fish.

The spot is a late fall to early spring spawner. Time of spawning for spot has been estimated from gonadal development and the appearance of larval and postlarval fish. Spawning off Chesapeake Bay is from late fall to early spring (Welsh and Breder 1923; Hildebrand and Schroeder 1928; Lippson and Moran 1974; Colton et al. 1979); from October to March, but principally December-January, off North Carolina and South Carolina (Hildebrand and Cable 1930; Dawson 1958; Berrien et al. 1978; Lewis and Judy 1983; Warlen and Chester 1985); and October to April off

Georgia (Dahlberg 1972; Mahood et al. 1974; Music 1974; Setzler 1977). The spawning season is similar along the Gulf coast: December-March off Florida (Kilby 1955; Townsend 1956; Springer and Woodburn 1960; Herrema et al. 1985); December-February off Alabama (Nelson 1969); December-January off Louisiana (Parker 1971) and October or November-March, peaking in November-February, off Texas (Pearson 1929; Gunter 1945; Simmons 1957; Parker 1971; Hata 1985).

Data indicate that spot spawn further offshore and in deeper waters than other sciaenids. Fall migrations of maturing spot to offshore waters were reported from Chesapeake Bay (Hildebrand and Schroeder 1928), North Carolina sounds (Roelofs 1951), and South Carolina estuaries (Dawson 1958). Ripe spot were collected in depths up to 82 m (45 fm) off South Carolina (Dawson 1958), 8-10 mi off the Georgia coast (Hoese 1973), and in 27 m (15 fm) in the northeastern Gulf of Mexico (Nelson 1969). Smith (1907) stated that in North Carolina spot spawn in the sounds and inlets and Pearson (1929) and Hildebrand and Cable (1930) suggested that spawning occurred in close proximity to passes off Texas and North Carolina, respectively; however, no evidence was offered to support these statements. Larval distributions of spot also indicate that spawning occurs more heavily offshore (26-128 m) than inshore (14.6-20.1 m) (Berrien et al. 1978; Lewis and Judy 1983; Warlen and Chester 1985; Cowan and Shaw 1988).

11.3.2 Pre-adult Phase

Embryonic development of spot was described from laboratory-reared specimens by Powell and Gordy (1980). Spot eggs were pelagic. Egg diameter averaged 0.80 mm and ranged from 0.72 to 0.87 mm. Oil globules ranged in number from one to 12 and coalesced during egg development so that only one globule was present on newly hatched larvae. The eggs hatched in about 48 h at 20°C.

Various sizes of larvae and juveniles were illustrated by Welsh and Breder (1923), Pearson (1929), and Jannke (1971). Hildebrand and Cable (1930) described and illustrated a developmental series from 1.0-50.0 mm. These illustrations were reprinted by Scotton et al. (1973) and Lippson and Moran (1974) who also included original illustrations of larvae (5.6-12.8 mm) by Peter Berrien. Powles and Stender (1978) described the meristic and morphometric development and pigmentation in specimens, 4.0-39.0 mm SL, and discussed previous descriptions. A comparative larval development of spot and croaker, 1.6-10.7 mm SL, including illustrations was presented by Fruge (1977) and Fruge and Truesdale (1978). Powell and Gordy (1980) described and illustrated the egg and larval development of spot and presented meristic characters useful in separating spot larvae from other sciaenids.

11.3.3 Adult Phase

The maximum lifespan of spot appears to be greater on the Atlantic coast from North Carolina and north. DeVries (1982) reported two age V spot (333 and 346 mm FL) from North Carolina, although the typical maximum age in that study was about age III. Welsh and Breder (1923) reported a maximum age of 4.5 years (30 cm TL) from New Jersey and Pacheco (1962b) found two age IV fish (x = 237.5 mm FL) in Chesapeake Bay pound net samples. Maximum spot ages reported for other areas were age III (210-283 mm TL) in Georgia (Music and Pafford 1984), age III (270 mm TL) in Lake Pontchartrain, Louisiana (Sundararaj 1960), and age III 283 mm TL) in the northwestern Gulf of Mexico, with a typical maximum lifespan of one or two years (Hata 1985).

Similarities in diet and habitat have suggested that spot and croaker are in direct competition with one another (Parker 1971; Sheridan 1979); however, other studies indicate that competition is avoided by subtle differences in feeding habits and distribution (Chao and Musick 1977). A study of the life history, feeding habits, and functional morphology of juvenile sciaenid fishes (including spot and croaker) in the York River Estuary, Virginia concluded that juvenile sciaenids are able to coexist in the same area because of differences in spatial and temporal distribution. Young-of-the-year spot entered the estuary in April and left the estuary by December, whereas young-of-the-year croaker were first caught in August and stayed throughout the winter. Croaker fed on the substrate on epifauna, and spot fed more "into" the substrate on infauna (Chao and Musick 1977; Currin 1984). Enclosure studies of food resource partitioning between juvenile spot and croaker revealed that spot increased their consumption of meiobenthos and croaker ate more zooplankton in response to depleted macrobenthic prey (bivalve siphons). These differences in feeding behavior should allow the species to partition food resources during periods of low abundances of preferred prey, and thereby relieve competitive pressures for food (Woodward 1981). Govoni et al. (1983, 1986) reported that spot and croaker larvae collected in the Gulf of Mexico had distinct, non-overlapping diets and were spatially segregated, implying that they do not compete for food. Kobylinsk and Sheridan (1979) concluded that, in general, in Apalachicola Bay, Florida, spot utilize salt marsh and macrophyte habitats, as well as low salinity, high turbidity and color, mud bottom locations. Croaker is more habitat limited, using low to moderate salinity mud bottom regions, especially those influenced by a highly turbid runoff.

Predators of spot include striped bass (Hollis 1952), weakfish (Merriner 1975), silky shark (Dawson 1958), and flounder (Stokes 1977). Knapp (1950) found spot in only 0.2% of 5,946 individuals of 34 species of food and game fishes on the Texas coast.

Parasites of spot were reported by Linton (1904), Chandler (1954), Koratha (1955a,b), Bullock (1957), Hargis (1957), Dawson (1958), Schwartz (1963), and Joy (1974). Govoni (1983) reported helminth infections of spot larvae in the Gulf of Mexico.

11.3.4 Nutrition and Growth

Spot are opportunistic bottom feeders that mainly eat polychaetes, small crustaceans and mollusks, and detritus (Linton 1904; Smith 1907; Welsh and Breder 1923; Hildebrand and Schroeder 1928; Hildebrand and Cable 1930; Gunter 1945; Roelofs 1954; Reid 1954, 1955b; Townsend 1956; Darnell 1958, 1961; Fontenot and Rogillio 1970; Parker 1971; Diener et al. 1974; Weaver and Holloway 1974; Stickney et al. 1975; Chen 1976;

Chao and Musick 1977; Virnstein 1977; Stickney and McGeachin 1978; Kobylinski and Sheridan 1979; Sheridan 1979; Sutherland 1982; Matlock and Garcia 1983); Shipman 1983) (Table 11.2).

Ontogenetic shifts in diet have been reported (Darnell 1958, Hodson et al. 1981b; Sheridan and Trimm 1983; Smith et al. 1984; O'Neil and Weinstein 1987). Both small (1.00 to 5.00 mm) and large (5.01 to 10.00 mm) spot larvae selected copepodid and adult copepods, pteropods, and pelecypods (Govoni et al. 1986). A study of the feeding ecology of postlarval spot (17-24 mm) indicated that copepods composed 99% (by volume and number) of the gut contents (Kjelson et al. 1975). Darnell (1958) noted a change in feeding habits from microcrustaceans to bottom material at about 25 mm, as the oblique terminal mouth becomes inferior. Juvenile spot, 40-99 mm, fed on micro-bottom surface animals such as ostracods, harpacticoid copepods, isopods, amphipods, minute gastropods, and foraminifera. Isopods, amphipods, and mollusks predominated in the diet of larger spot (>100 mm). Hodson et al. (1981b) also reported a change from planktivorous feeders as postlarvae to benthic feeders as juveniles. Small spot tended to be selective; larger spot were more opportunistic (O'Neil and Weinstein 1987).

Feeding behavior of spot and croaker in aquaria was observed by Roelofs (1954) and Chao and Musick (1977). Both noted that spot seemed to dive into the bottom sand much more often than croaker, but Chao and Musick (1977) did not observe that the dives by spot were shallower than croaker as stated by Roelofs (1954). Chao and Musick (1977) reported that spot fed more on tubiculous or burrowing species of worms, while croaker fed more on the crawling species of worms.

Feeding periodicity apparently differs between tidal and nontidal systems. No distinct diel feeding periodicity was indicated for spot in a nontidal system (Currin 1984). In the Newport River, North Carolina, a tidal system, postlarval spot (16-24 mm) had the highest food content in their digestive tracts during daylight hours (Kjelson et al. 1975; Peters and Kjelson 1975; Kjelsen and Johnson 1976). Feeding began near dawn and maximum gut fullness was reached near midday. Gut contents of spot contained from 0.5 to 24 copepods/fish and maximum daily feeding rates were estimated at 17 copepods/h. Spot feeding rates in the field decreased as water current velocity increased but in the laboratory were highest when a slight current was present.

Govoni (1980, 1981) described aspects of functional development of the alimentary canal, liver, and pancreas in larval spot in relation to its early life history. Major developmental changes (differentiation of the esophagus, stomach, intestine and rectum) are accompanied by changes in habitat (movement into estuarine nursery areas) and feeding regime (from pelagic calanoid copepod nauplii and copepodites to harpacticord copepods, followed by epifaunal and infaunal invertebrates). Govoni (1987) reported ontogenetic changes in larval spot dentition which co-occurred with changes in habitat, feeding mode, and diet.

Numerous feeding studies have been conducted with larval and juvenile spot. Govoni et al. (1982) assessed short-term carbon assimilation in discrete age cohorts of larval spot and found that carbon utilization and absorption were not significantly related to development as measured

Table 11.2. Stomach contents of spot, Leiostomus xanthurus, from different estuarines areas along U.S. Atlantic and Gilf of Mexico coasts (from Chao and Musick 1977).

Author	Chao 1976	Roelofs 1954	Stickney et al. 1975	Welsh and Breder 1923	Townsend 1956	Parker 1971	
Locality	York River, Va.	North Carolina	Savannah River and Ossabaw Sound, Ga.	St. Vincent Sound, Fla.	Alligator Harbor, Fla.	Lake Pontchar-train, La	Clear Lake, Tex.
Period	June-Aug. 1973	All seasons 1950	May 1972-July 1973	April 1915	June 1955-May 1956	July 1959-Mar. 1961	
Source	Original	Table 1	Table 1	p. 179	Table 3	Table 13	
Number of specimens	77	73	126	50	45	22	457
Empty stomachs	4	0	7	0	9	4	60
Length of specimens	73-302 mm TL	60-140 mm TL	50-149 mm SL	2.1-3.5 cm SL	16-163 mm SL	40-99 mm TL	18-99 mm TL
Quantitative method	% of occurrence	% of occurrence	% of occurrence	% of volume	% of occurrence	% of occurrence	
Fish & remains	8.2	6.8	5.0		11.1	19	14
Macrozooplankton:							
Mysidacea	8.2	4.1				14.5	8.5
<u>Neomysis</u> <u>americana</u>	27.4	7.4					
Isopoda	2.7					7.0	16.0
Decapoda(shrimp)	1.4	5.5	0.8		5.5	19.0	15.0
Insecta	2.7	1.4	1.7			14.0	19.0
Others and remains	1.4	0.8					
Microzooplankton:							
Copepoda	21.9	100		8.0	66.7	3.0	1.0
Cyclopoid	19.2						
Calanoid	13.7		33.1				
Harpacticoid	20.5		88.4				
Ostracoda		2.7	5.8	72.0	2.8	5.0	3.0
Others and remains	1.4	6.8	7.4	1.0		14.5	13.0
Epibenthos:							
Annelids (polychaete)	56.6	32.9	11.6	1.0		14.5	13.0
<u>Nereis</u> <u>succinea</u>	27.4		9.1				
<u>Glycinde</u> <u>solitaria</u>	37.0						
<u>Nephthys</u> sp.	11.0						
Phyllodocid	6.8						

Table 11.2. (continued)

Author	Chao 1976	Roelofs 1954	Stickney et al. 1975	Welsh and Breder 1923	Townsend 1956	Parker 1971	
Locality	York River, Va.	North Carolina	Savannah River and Ossabaw Sound, Ga.	St. Vincent Sound, Fla.	Alligator Harbor, Fla.	Lake Pontchar-train, La	Clear Lake, Tex.
Period	June-Aug. 1973	All seasons 1950	May 1972-July 1973	April 1915	June 1955-May 1956	July 1959-Mar. 1961	
Source	Original	Table 1	Table 1	p. 179	Table 3	Table 13	
Number of specimens	77	73	126	50	45	22	457
Empty stomachs	4	0	7	0	9	4	60
Length of specimens	73-302 mm TL	60-140 mm TL	50-149 mm SL	2.1-3.5 cm SL	16-163 mm SL	40-99 mm TL	18-99 mm TL
Quantitative method	% of occurrence	% of occurrence	% of occurrence	% of volume	% of occurrence	% of occurrence	
Spionid	6.8						
Oligochaeta	4.1						
Cumacea	21.9						
Amphipoda	24.7						
Gammarus sp.	12.3						
Crabs	1.4						
Cnidaria	9.6						
Othera and remains	5.5						
Infauna:							
Pectinaria gouldii	53.4						
Ampharetid	19.2						
Gastropoda	20.5		0.8			4.0	17.0
Pelecypoda	27.4	11.0				1.5	10.0
Nematoda	34.2	71.2			30.6		
Others and remains	5.5		5.0				
Unidentified remains and organic matters	42.5	23.3	35.6	14.0	36.1	14.5	7.0

by age, length, or dry weight. Powell and Chester (1985) presented morphometric indices of nutritional condition and sensitivity to starvation of spot larvae. Age at first feeding was age 3 d at 24°C, 4 d at 22°C, 5 d at 20°C, and 5-6 d at 18°C. An observation of episodic feeding and growth of larval spot in the northern Gulf of Mexico was reported by Govoni et al. (1985). Instantaneous exponential growth rates, estimated from measurements of otolith growth increments, indicated accelerated growth on the day the larvae were collected. A laboratory experiment verified that larval spot respond to an increased ration with accelerated growth that is detectable in otoliths. An estimate of daily ration for juvenile spot was 10.1% of body wt per day. Postlarval estimates were 4.3 and 9.0%. The high variability was attributed to the variability of natural gut contents (Peters and Kjelson 1975; Kjelson and Johnson 1976). A study of the effect of temperature on food evacuation rate in spot (15-50 g) indicated that maximum meal size occurred at 24°C (Peters et al. 1974). Quadratic regressions summarized the effects of temperature on evacuation time of various meal sizes.

Daily growth rates for juvenile spot range from 0.02-0.04 g/g/day (Peters et al. 1978; Warlen et al. 1979; Weinstein 1983; Currin et al. 1984). Food consumption values for spot ranged from about 0.83 to 25.03 g dry wt/m^2/y (Bozeman and Dean 1980; Weinstein and Walters 1981; Weinstein 1983; Currin et al. 1984). Mean daily consumption for spot ranged from 5.89 mg dry wt/m^2/d to 284.4 mg dry wt/m^2/d. Spot Production values ranged from 0.25 to 7.51 g/m^2/y.

11.3.5 Behavior

Behavior, swimming speed, and swimming performance of juvenile spot and implications of the data for predicting impingement and entrainment in power plants have been investigated. Rulifson and Huish (1975) reported that increased water temperature (range: 15-20°C) resulted in increased sustained swimming time (SST), time to impingement (TTI), and maximum swimming speed for juvenile spot (1.7-7.0 cm). Increased water velocity (range 12-48 cm/sec) decreased SST and TTI, and was also related to a decrease in the number of bursts per test. Smaller spot were more rheotactic than larger fish, and swam steadily for longer periods, resulting in increased SST. Larger spot tended to turn and drift with the current to the downstream screen, where they became impinged. These results suggest that reduced water velocity in combination with increased ambient temperature should produce the best conditions for optimum swimming performance of juvenile spot. Hettler (1977) reported a maximum sustained swimming speed of 6 BL/sec (BL=body length) for juvenile spot (mean length 4.3 cm). This was similar to the rate for croaker (5 BL/sec), but much slower than that for pinfish (11 BL/sec), which is similar in body form and size. Perez (1969) found that young spot (56.3-76.3 mm) moved faster in a changing salinity regime of 10 ppt/h than at a fixed salinity of 12 ppt.

11.3.6 Contaminants

Trace element levels were determined for 15 elements in spot to provide baseline data to help identify potential problems involving species, elements, and locations (Hall et al. 1978). No interpretive comments were provided.

Cross et al. (1975) estimated the daily flux of Mn, Fe, Cu, and Zn for spot, menhaden, and pinfish in the Newport River estuary, North Carolina. They concluded that because a significant fraction of the trace metal ingested by the fish is defecated and not assimilated, juvenile fish may have a major role in cycling trace metals in highly productive coastal-plain estuaries. Assimilation efficiencies for spot were: Zn-2%, Fe-0.3%, Mn-0.7%, Cu-1%. Higher concentrations of trace metals were found near heads of estuaries which serve as nursery areas for juvenile spot. Spot in other studies had lower concentrations when taken in higher salinity waters. Cupric ion was found to be toxic to the eggs of spot, causing 50% inhibition of hatch at a pCu of 9.0 and complete suppression at a pCu of 8.0 (Engel and Sunda 1979). Cadium accumulated mainly in the visceral organs of spot and exposure to levels $\geq$ 10 ppm resulted in severe damage to proximal tubule cells of the kidney (Hawkins et al. 1980). Hawkins (1984) examined rodlet cell structure in normal and cadmium-damaged kidney tissues of spot.

Chronic exposure of spot to sublethal concentrations of toxaphene (a chlorinated camphene insecticide) resulted in no significant differences in mortality among control and experimental fish (Lowe 1964). Acute toxicity tests conducted at the end of the experiment resulted in 100% mortality in all groups at 2.0 ppb and indicated that spot did not develop resistance to toxaphene as a result of prolonged exposure. Juvenile spot chronically exposed to 0.1 ppm Sevin (a synthetic carbonate insecticide) in flowing seawater exhibited no symptoms of pesticide poisoning during the 5 month experiment (Lowe 1967). Sublethal concentrations, (0.05 ppb) of endrin (a chlorinated hydrocarbon insecticide) did not appear to affect the general physical condition of spot (Lowe 1965). A study of the rate of dieldrin (a chlorinated hydrocarbon insecticide) uptake and depuration by spot exposed to concentrations of 0.0135-1.35 ug/l for 35 days found that maximum concentrations were attained in 11 to 18 days and depuration was completed in 13 days (Parrish et al. 1974). Tissue alterations, such as subepithelial edema in gill lamellae and sever lysis and sloughing of the small intestine epithelium, occurred in spot exposed to 1.35 ug/l for four days.

Spot has been shown to be sensitive to both chlorinated sewage effluents and to residual chlorine in seawater (Virginia State Water Control Board 1974). Massive fish kills estimated at 5-10 million individuals (spot, bluefish, white perch, weakfish and menhaden) were observed in the James River, Virginia adjacent to two sewage treatment plants. Total residual chlorine (TRC) concentrations ranged from 0.07-0.28 mg/l. Toxicity studies estimated the 96h LC_{50} was 0.09 mg/l TRC. Middaugh et al. (1977) estimated incipient LC_{50} values for juvenile spot (10-20 mm) of 0.12 mg/l TRC at 10°C and 0.06 mg/lTC at 15°C. Histological examination of spot used in the incipient LC_{50} bioassay at 15°C indicated pseudobranch and gill damage in individuals exposed to a measured TRC concentration of 1.57 mg/l TRC. Spot demonstrated temperature-dependent avoidance responses to TRC.

Stehlik and Merriner (1983) reported the effects of accumulated dietary Kepone (chlordecone) on juvenile spot. Lethal concentrations (3.3 ug/g) fed over 28 days resulted in muscular tetany, fractured vertebral centra, abnormally thickened vertebrae, and eventual death. Similar bone damage developed in spot fed lesser concentrations (0.59 and 0.30 ug/g). The 96-h LC50 value for spot exposed to atrazine (a widely utilized herbicide) was 8.5 mg/l compared to 0.094 mg/l for copepods and >30 mg/l for oyster larvae. These values exceed the maximum reported measured concentration of atrazine (0.002 mg/l) in estuarine areas (Ward and Ballantine 1985). PCB (polychlorinated biphenyls) levels in spot from New Jersey and Texas ranged from 0.03 to 0.29 ppm, well below the FDA limit of 5 ppm and the proposed 2 ppm standard (Gadbois and Maney 1983).

11.4 Population

11.4.1 Structure

Spot sex ratios, are generally accepted to be 1:1. Hata (1985) reported that male and female spot appeared equally abundant in the northwestern Gulf of Mexico.

Spot have been aged using scales (Welsh and Breder 1923; Townsend 1956; Pacheco 1957, 1962b; Sundararaj 1960; DeVries 1982; Music and Pafford 1984), otoliths (Sundararaj 1960), and length frequency analysis (Welsh and Breder 1923; Hildebrand and Schroeder 1928; Pearson 1929; Hildebrand and Cable 1930; Townsend 1946; Hata 1985). Barger and Johnson (1980) evaluated marks on scales, otholiths, and vertebrae, and found that the otoliths possessed the highest potential as age determination structures. Marginal increment analysis indicated that spot annuli on scales were formed in October and November in Chesapeake Bay (Pacheco 1957), from March through May in North Carolina (DeVries 1982), from late February through early April in Georgia (Music and Pafford 1984), and in February and early March in Lake Pontchartrain, Louisiana (Sundararaj 1960). Otolith annuli formed from January through March (Sundararaj 1960).

The spot is a short-lived species, rarely attaining a maximum age of five years (Table 11.3). Maximum ages reported in the literature were greatest in the northern part of the range [New Jersey: 4.5 yr by Welsh and Breder (1923); Chesapeake Bay: 4.5 yr by Pacheco (1962b); Core Sound, N.C.: 5 yr by DeVries (1981)]. Age 0-II spot predominated in populations throughout the range (Pacheco 1962b; Joseph 1972; DeVries 1981a, 1982; Music and Pafford 1984). The average age composition of spot in Virginia waters, 1961-1964, by numbers of fish caught, was 36.9% age 0, 60.5% age I, 2.4% age II, and 0.12% age III (Joseph 1972). Percent age composition of the spot catch in the Core Sound, N.C. long haul seine fishery during October 1979 and 1980, respectively, was: age 0, 38.7 and 27.3%; age I, 44.1 and 58.8%; age II, 16.4 and 12.0%; and age III, 0.8 and 1.8%, (DeVries 1982). Winter trawl catches were equally dominated by fish age 0 and I during 1982-83, by age I fish in 1983-84, and by age 0 fish in 1984-85 (Ross et al. 1986).

Reported lengths at age I were similar throughout the range with the exception of those reported by Welsh and Breder (1923) and Parker (1971) (Table 11.3). The smaller sizes in those studies may be because larger fish had left the area. DeVries (1982) reported that back-calculated lengths at the first annulus for North Carolina spot with one annulus were bimodally distributed with modes at 94-134 mm TL and 172-206 mm TL.

Table 11.3. The age-length relationship of spot from the Atlantic and Gulf coasts, as reported in the literature [modified from Dawson (1958) and Parker (1971)].

Author	Area	Method	Total length in millimeters at age					
			I	II	III	IV	V	Other
Welsh and Breder (1923)	New Jersey	scales	80-100 median 90	165-220 median 193	240-290 median 275			300 at 4.5 yr
Hildebrand and Schroeder (1928)	Chesapeake Bay	length frequency	127					
Pacheco (1957)	Chesapeake Bay	scales	167-224 mean 196	196-269 mean 246				
Hildebrand and Cable (1930)	Beaufort, N.C.	length frequency	140 mean					
DeVries (1982)	Core Sound, N.C.	scales scales	143 144	222 219	244 252	321 317	369 355	
Dawson (1958)	South Carolina	length frequency	144-162	205-218				
Music and Pafford (1984)	Georgia	scales	128	201	219			
Welsh and Breder (1923)	Fernandina, Fla.	length frequency	140					
Townsend (1956)	Alligator Harbor, Fla.	scales and length frequency	119-161 median 140	187-230 median 209				
Parker (1971)	Lake Borgne, La.	length frequency	133					
Sundararaj (1960)	Lake Pontchartrain, La.	scales otoliths	144 153	200 212	223 225			
Pearson (1929)	Texas	length frequency	130-140 median 130	190-210 median 200				
Parker (1971)	Galveston Bay Texas	length frequency	93-110					
Hata (1985)	northwestern Gulf of Mexico	length frequency	165-200 (spring recruits) 130-150 (winter recruits)	210-255	275-290			

This bimodality may represent two peaks in spawning as length frequencies of trawled age 0 spot from North Carolina estuaries showed a bimodal distribution from June to September (Ross 1980; Ross and Carpenter 1983; Ross and Epperly 1985). Hata's (1985) mean sizes at age I for Winter recruits (130-150 mm) and Spring recruits (165-200 mm) are similar to the two modes at age I reported by DeVries (1982).

Spot reach a greater maximum size in the northern part of the range. Maximum sizes reported in the literature were 330 mm in New Jersey (Welsh and Breder 1923), 345 mm in Chesapeake Bay (Hildebrand and Schroeder 1928), and 346 mm in Core Sound, N.C. (DeVries 1982). Maximum size reported for spot south of North Carolina was 290 mm in the northwestern Gulf of Mexico (Hata 1985).

Length-weight relationships for spot were presented for North Carolina (Hester and Copeland 1975), South Carolina (Dawson 1958), Georgia (Music and Pafford 1984), Mississippi and Louisiana (Dawson 1965), and the northwestern Gulf of Mexico (Hata 1985) (Table 11.4). Hata (1985) reported that length-weight regressions did not differ significantly for male and female fish or for adult and immature fish.

11.4.2 Abundance, density, mortality, and dynamics

Juvenile spot abundance peaks in late spring in various estuarines along the Atlantic coast, with large variations in interannual abundance. Thomas (1971) reported that young spot apparently enter the lower Delaware River in numbers only when large year classes are produced offshore. Numbers collected in trawl samples ranged from eight in 1968 to 954 in 1969, and only one in 1970. A spot index from the Maryland striped bass survey, 1962-1984, indicated that abundance of juvenile spot in the Maryland portion of Chesapeake Bay was highest in 1973, 1975, 1977 and 1984[1]. Annual catch-per-unit-effort (CPUE) indices from a Maryland crab trawl survey from 1980-85 peaked in 1982 and in 1984.[1] Spot was the most abundant species caught in the North Carolina Division of Marine Fisheries juvenile stock assessment survey from 1979 to 1984 (DeVries 1985). Mean monthly CPUE peaked in April each year. Annual CPUE was highest in 1979, 1981, and 1982, with a peak in 1981. No statistically significant positive correlation was found between spot CPUE data and landings.

Commercial landings statistics may sometimes reflect long term trends in abundance of adult spot. However, landings also are the result of changes in fishing effort, area and gear restrictions, as well as market conditions, and thus are not a precise nor accurate measure of abundance. Commercial landings data have been collected since 1880. From 1880-1927 a survey was conducted on the average of once every five years. Annual surveys were conducted from 1927 to 1956, and since then commercial landings statistics have been collected on a monthly basis, It should be noted that commercial statistics, when biased, tend to be underestimated due to reporting failures inherent in their collection. The history of spot landings was reviewed by Joseph (1972) and Wilk (1981). Spot landings have fluctuated greatly since 1930 (Table 11.5).

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[1]Unpublished data on file at the Maryland Department of Natural Resources, Annapolis, Maryland.

Table 11.4. Length-weight relationships for spot (L= total length in mm and W = total weight in grams)

Author	Area	N	Range (mm TL)	Equation
Hester and Copeland	North Carolina	356	25-195	$\log W = -5.230 + 3.221 \log L$
Dawson (1985)*	South Carolina	4,297	45-205	$\log W = -4.54396 + 2.95831 \log L$
Music and Pafford (1984)	Georgia	325	120-283	$\log W = -5.096 + 3.121 \log L$
Dawson (1965)	Mississippi and Louisiana	944	50-175	$\log W = -5.03588 + 3.07255 \log L$
Hata (1985)	Northwestern Gulf of Mexico	2,802	66-275	$\log W = -5.242 + 3.1244 \log L$

*L = standard length

Table 11.5. Commercial landings of spot by state, 1930-1985 (metric tons).

Year	New York	New Jersey	Delaware	Maryland	Virginia	North Carolina	South Carolina	Georgia	Florida coast	Total
1930	2	246	67	57	1,131	1,056	13	5	59	2,635
1931	30	93	91	45	289	778	4	2	55	1,388
1932	12	49	9	21	342	720	5	5	+	1,162
1933	10	215	15	14	325	+	+	+	+	579
1934	+	+	+	28	926	2,172	5	6	37	3,173
1935	-	8	1	8	185	+	+	+	+	202
1936	+	+	7	17	413	3,376	301	5	67	4,185
1937	*	7	1	13	1,351	2,390	111	2	80	3,956
1938	-	83	1	27	1,754	2,603	89	2	45	4,604
1939	18	291	23	78	1,388	2,028	119	3	40	3,987
1940	4	75	24	64	1,003	2,178	137	1	83	3,569
1941	+	+	+	64	825	+	+	+	+	888
1942	19	549	40	63	409	+	+	+	+	1,080
1943	190	596	14	+	+	+	+	+	+	800
1944	111	263	25	85	2,056	+	+	+	+	2,540
1945	1	34	33	95	1,828	2,842	492	-	73	5,397
1946	-	+	+	59	1,858	+	+	+	+	1,917
1947	-	16	*	55	2,054	+	+	+	+	2,126
1948	-	3	29	51	1,795	+	+	+	+	1,879
1949	5	5	12	113	3,815	+	+	+	+	3,950
1950	*	*	5	44	2,040	2,346	132	-	42	4,610
1951	-	58	8	59	2,282	2,093	1,200	*	127	5,828
1952	-	141	55	191	2,683	2,517	826	6	169	6,587
1953	1	39	20	128	1,775	1,277	200	4	156	3,601
1954	1	80	47	117	2,010	1,084	226	6	213	3,784
1955	-	22	103	185	1,791	861	513	47	164	3,686
1956	-	21	89	136	1,455	1,168	1,897	19	221	5,006
1957	3	78	60	267	1,574	979	952	29	154	4,097
1958	-	*	8	269	2,384	1,053	382	18	269	4,383
1959	-	4	9	39	1,703	1,027	835	*	468	4,086
1960	-	*	8	226	1,772	1,184	1,234	*	468	4,892
1961	-	-	-	5	537	933	1,573	*	421	3,469
1962	-	*	-	12	1,066	552	1,422	1	319	3,374
1963	-	-	*	7	669	415	1,233	1	511	2,838
1964	-	*	-	15	1,451	567	1,436	1	432	3,903
1965	-	-	-	*	794	414	533	5	425	2,172
1966	-	-	-	2	523	495	964	2	546	2,533
1967	-	*	-	112	1,929	1,383	1,007	5	407	4,843
1968	-	-	-	21	506	714	931	1	501	2,674
1969	-	3	-	10	476	675	206	1	397	1,767
1970	-	*	0	260	2,664	694	167	4	634	4,423
1971	-	1	-	9	229	540	583	3	1,311	2,676
1972	-	*	-	34	1,339	1,770	1,029	15	880	5,067
1973	-	5	-	12	1,168	2,448	660	15	418	4,727
1974	-	5	-	17	1,021	2,543	162	7	793	4,549
1975	-	27	8	47	870	3,765	676	4	381	5,778
1976	1	1	4	7	541	1,213	460	8	242	2,477
1977	3	9	5	7	847	1,726	134	3	467	3,201
1978	*	5	9	14	1,454	2,213	182	*	450	4,328
1979	*	1	8	5	1,153	3,313	190	*	395	5,064
1980	*	1	2	3	814	3,221	186	1	405	4,633
1981	-	3	5	6	465	1,593	58	4	1,270	3,403
1982	-	1	1	3	461	2,231	29	*	2,010	4,736
1983	-	*	-	59	711	1,339	109	*	1,028	3,245
1984	-	*	-	20	333	1,579	59	*	684	2,676
1985	-	1	8	3	708	1,834	18	*	549	3,121
1986	-	3	39	47	834	1,521	275	*	416	3,135
1987	-	7	64	+	1,484	1,273	18	*	383	3,229

+ = not available - = 0 * = <1 mt

Lower landings prior to 1950 are probably due to incomplete statistical records rather than actual declines in landings. Spot landings reached an all-time high of 6,587 mt (14.5 million lb) in 1952. Since then landings have fluctuated between 1,767 mt (3.9 million lb) and 5,778 mt (12.7 million lb) with no apparent long-term trends.

Most of the commercial foodfish harvest of spot comes from the Chesapeake (Maryland and Virginia) and South Atlantic (North Carolina, South Carolina, Georgia, and Florida) regions. Middle Atlantic landings (New York, New Jersey, and Delaware) peaked in 1943 at 870 mt (1.8 million lb) and have been insignificant since 1957. Chesapeake landings of spot peaked in 1949 at 3,928 mt (8.7 million lb), dropped sharply in the 1960s, and peaked again in 1970 at 2,924 mt (6.4 million lb). The majority of the Chesapeake catch of spot is landed in Virginia (Table 11.5). Prior to 1960 landings from the Chesapeake and South Atlantic regions were similar; however, from the early 1960s to the present South Atlantic landings have greatly exceeded Chesapeake landings. Spot landings have fluctuated greatly in the South Atlantic region with a peak of 4,826 mt (10.6 million lb) in 1975. North Carolina landings increased in the 1970s while South Carolina landings declined. Georgia spot landings are negligible. Florida landings increased in the early 1980s and are presently second to North Carolina landings. Gulf foodfish landings of spot have remained at a low level since the the 1950s.

The estimated recreational catch of spot ranged from 1,871 to 6,034 mt between 1979 and 1986 (Anonymous 1984, 1985a, b, 1986, 1987) (Table 11.6). Highest landings were reported for 1980 with a general decline through 1984. Middle Atlantic catches of spot were higher that South Atlantic catches in all years except 1979.

Year-to-year fluctuations in catch are not surprising since the catch in most years consists largely of a single year class. Joseph (1972) suggested that environmental differences that prevail on spawning grounds are most likely responsible for the non-periodic fluctuations in spot landings. In addition, spot is not generally a targetted commercial species, but is harvested by mixed species gears including trawls, pound nets, and haul seines.

11.5 Exploitation

11.5.1 Commercial Exploitation

Aspects of the commercial fisheries for spot were discussed by Higgins and Pearson (1928), Hildebrand and Schroeder (1928), Hildebrand and Cable (1930), Pearson (1932), Reid (1955b), McHugh (1977a, b; 1981), Wilk (1981), and Ross et al. (1986).

11.5.1.1 Fishing Equipment

Spot are caught by a variety of gears in mixed species fisheries. The principal commercial gears employed to harvest spot for food fish include gill nets, haul seines, pound nets, and otter trawls. In addition, hand lines and hoop, fyke, and trammel nets have accounted for minor landings. The industrial fishery primarily uses otter trawls,

Table 11.6. Spot recreational catch statistics from the Marine Recreational Fishery Statistics Survey, 1979-1987.

Survey year	Catch Number	Catch weight lb	Catch weight kg	Average weight lb	Average weight kg
	- - - - T H O U S A N D S - - - -				
1979[1]					
Middle Atlantic	10,528	4,367	1,981	0.41	0.19
South Atlantic	15,115	6,122	2,777	0.41	0.18
Total	25,644	10,490	4,758		
1980[1]					
Middle Atlantic	17,717	7,743	3,512	0.44	0.20
South Atlantic	10,971	5,560	2,522	0.51	0.23
Total	28,691	13,303	6,034		
1981[2]					
Middle Atlantic	21,131	9,775	4,434	0.46	0.21
South Atlantic	6,947	2,429	1,102	0.35	0.16
Total	28,078	12,204	5,536		
1982[2]					
Middle Atlantic	12,883	3,549	1,610	0.28	0.13
South Atlantic	6,763	2,275	1,032	0.34	0.15
Total	19,646	5,824	2,642		
1983[3]					
Middle Atlantic	22,584	4,979	2,258	0.22	0.10
South Atlantic	8,812	3,108	1,410	0.34	0.16
Total	31,395	8,087	3,668		
1984[3]					
Middle Atlantic	11,194	2,715	1,231	0.24	0.11
South Atlantic	5,817	1,410	640	0.23	0.11
Total	17,011	4,125	1,871		
1985[4]					
Middle Atlantic	12,142	4,371	743	.36	.17
South Atlantic	13,052	4,342	1,958	.33	.15
Total	25,194	8,713	2,701		
1986[5]					
Middle Atlantic	15,738	4,510	2,046	.29	.13
South Atlantic	5,761	1,267	552	.22	.10
Total	21,499	5,777	2,598		
1987[6]					
Middle Atlantic	12,464	5,221	2,368	.42	.19
South Atlantic	4,860	1,652	729	.34	.15
Total	17,324	6,873	3,097		

[1]Anonymous 1984 [2]Anonymous 1985a [3]Anonymous 1985b [4]Anonymous 1986

[5]Anonymous 1987 [6]Preliminary data

with small amounts taken by haul seines, gill nets, and pound nets (Wilk 1981). The total catch of spot by the major gears has not changed dramatically in the proportion each contribute to the fishery. The average contribution of each gear based on 1955 to 1959 data was 70, 13, 11, and 5% for haul seines, gill nets, pound nets, and otter trawls, respectively, compared with an average of 57, 19, 11, and 13% for 1975 to 1979 data (Wilk 1981).

11.5.1.2 Areas Fished

Most of the commercial food fish catch of spot comes from the Chesapeake Bay and South Atlantic areas. Prior to 1961, landings from the two regions were almost equal in magnitude; however, from the early 1960s to the present, landings have shifted from the Chesapeake area to the South Atlantic. Lower landings in the Chesapeake area in recent years may be due in part to lower fishing effort during this period (Joseph 1972).

The chief spot fishing grounds in Delaware were the southernmost part of Delaware Bay and the bays behind the barrier islands (Goode 1887). Spot are caught throughout Chesapeake Bay and its tributaries, but the greater part of the annual commercial catch is from the lower part of the bay (Hildebrand and Schroeder 1928; Reid 1955b; McHugh 1960). In North Carolina 60-70% of commercial spot landings are derived from estuarine waters, primarily Pamlico and Core sounds (Higgins and Pearson 1928; DeVries 1981b; Ross et al. 1986). The principal fishery for spot in South Carolina is a haul seine fishery located along the beach in the northern part of the state (Cain 1985). Commercial spot landings in Georgia are derived solely as bycatches from offshore shrimp trawling since commercial pound nets, haul seines, and gill nets (except for shad or sturgeon) are prohibited (Music and Pafford 1984). Spot are primarily caught in estuaries on the east coast of Florida and from 1959 to 1962, 41% of the landings came from Indian and Banana River lagoons in the Cape Canaveral area (Anderson and Gehringer 1965).

11.5.1.3 Fishing Seasons

Spot caught in estuaries during late spring, summer, and fall. As water temperatures decline in fall, spot move offshore and are harvested in the beach seine and winter trawl fisheries.

11.5.1.4 Fishing Operations and Results

Trends in Chesapeake Bay fisheries were presented by Rothschild et al. (1981) and Bonzek and Jones (1984). In terms of fishing effort, there has been a consistent decline in the number of pound nets since 1930 and a decline in the number of haul seines in post-war years. Examination of spot landings as the percent deviation from the mean catch, 1950-1980, revealed that landings have frequently been below average since 1960 (Rothschild et al. 1981). Trends in spot CPUE data for haul seine and pound net catches in Virginia, 1960-1980, based on numbers of haul seines and pound nets, generally paralleled total landings trends (Bonzek and Jones 1984).

Experimental and theoretical 50% retention lengths and selection factors, plus gilling frequencies in experimental pound heads were derived for spot, a major component of the scrap-fish catch in Chesapeake Bay pound nets (Meyer and Merriner 1976) (Table 11.7). The 50% retention lengths increased with mesh size, and selection factors were constant over the size range of spot used. A general trend of increased gilling with increased mesh size occurred, which offsets the benefits of using a larger mesh size to allow escapement of smaller individuals. Roelofs (1950) reported escapement rates for spot (7->16cm) of 12.2, 42.8, and 50.5 %, respectively, from trawls with cod-end mesh sizes of 5.1 cm (2 in), 5.7 cm (2¼in), and 6.4 cm (2½in).

Mark-recapture experiments were conducted to estimate the efficiency of a 4.9 m (16 ft) otter trawl in capturing brown shrimp, Atlantic croaker, and spot in water 1.5 m deep (Loesch et al. 1976). Trawl efficiency was determined to be approximately 30 to 50% for brown shrimp, 26% for croaker, and 6% for spot. These data indicate that the 4.9 m trawl is much less than 100% efficient. Biomass estimates based on swept area using trawl data are therefore minimal and a conversion factor must be applied before estimating the true standing crop.

11.5.1.5 Incidental Catches

Industrial catches of spot, i.e. spot used for animal food, reduction, or bait, are landed in the Chesapeake, South Atlantic, and Gulf regions. Statistics on industrial landings of spot in the Chesapeake and South Atlantic have been reported in the mixed-species category, "unclassified," since 1969 and 1973, respectively. Gulf landings, which are derived from a directed industrial bottomfish trawl fishery (Roithmayr 1965; Gutherz et al. 1975), greatly exceed Atlantic coast industrial landings of spot (Table 11.8).

Atlantic coast industrial landings of spot are undersized fish derived chiefly from the Chesapeake Bay pound net fishery (McHugh 1960; Pacheco 1962b) and the North Carolina finfish trawl, pound net, and long haul seine fisheries (Fahy 1966; Wolff 1972). Pacheco (1962b) reported that spot ranged in size from 100 to 250 mm in the Chesapeake Bay pound net fishery, but generally only spot >170 mm were marketed. He estimated that 30% of the 1956 year-class by numbers which entered the fishery was considered scrap in 1956 and 1957. Fahy (1966) estimated that 95% of North Carolina industrial fish landings were supplied by the finfish trawl fishery operating in sounds and coastal ocean waters, with lesser contributions from the pound net and long haul seine fisheries. Spot was the second most abundant species in 1962 and 1964 trawl scrap catches, comprising 17.0-19.0% by number and 16.2-17.4% by weight. In samples of the 1962 long haul and pound net catches spot comprised only 4.5 and 2.8% of the catch number and weight, respectively. Wolff (1972) reported that trawler landings fell to 73% of the scrap total in 1969-70 and continued to fall to 61% of the total during 1970-71. Spot comprised 13.2% by weight of trawler-landed scrap fish in 1969-1971 and only a few spot, mostly >200 mm, were packed for the food fish market.

Spot is one of the most abundant species in the by-catch of the South Atlantic Bight shrimp trawl fishery. Unlike the scrap catch in the finfish trawl fishery, undersized fish in the shrimp fishery are generally discarded "at sea" rather than landed (Roelofs 1950). Wolff (1972) reported a fish to shrimp discard ratio of 5.4:1 and that spot

Table 11.7. Experimental and theoretical 50% retention lengths and selection factors for spot as a function of pound-head mesh size (from Meyer and Merriner 1976).

Advertised stretched mesh size (mm)	Conditioned stretched mesh size (mm)	Experimental 50% retention lengths (mm)	Experimental selection factors	Theoretical 50% retention lengths (mm)	Theoretical selection factors
51	50.1	148	3.0	139	2.8
57	53.4	161	3.0	152	2.8
64	61.4	176	2.9	168	2.7
70	68.3	204	3.0	189	2.8
76	75.1	ND	ND	212	2.8

ND = no data available

Table 11.8. Industrial catch of spot (from Fisheries Statistics of the United States 1965-1977, NMFS).

Year	Chesapeake (lbs)	Chesapeake (kg)	South Atlantic (lbs)	South Atlantic (kg)	Gulf (lbs)	Gulf (kg)	Total (lbs)	Total (kg)
1965	192	87	1,520	689	7,282	3,303	8,994	4,080
1966	195	88	982	445	5,862	2,659	7,039	3,193
1967	305	138	992	450	7,970	3,615	9,267	4,203
1968	125	57	624	283	7,732	3,507	8,481	3,847
1969	150	68	211	96	7,398	3,356	7,759	3,519
1970			318	144	8,681	3,938	8,991	4,078
1971			325	147	8,100	3,674	8,425	3,822
1972			1,276	579	7,400	3,357	8,676	3,935
1973			1,254	569	15,993	7,254	17,247	7,823
1974					20,120	9,126	20,120	9,126
1975					20,385	9,246	20,385	9,246
1976					16,494	7,482	16,494	7,482
1977					12,706	5,763	12,706	5,763

comprised 38.7% by weight of the discard. He calculated that 32.6 million kg (71.8 million lb) of scrap fish were discarded over a two-year period, 1969-1971, of which 12.6 million kg (27.8 million lb) were spot. Total North Carolina industrial landings of spot for those two years were only 0.3 million kg (0.6 million lb). Spot was the most abundant fish in the South Carolina shrimp by-catch, representing 30.46% of the yearly catch (Keiser 1976). He estimated a fish by-catch of 3.7 to 16.6 million kg in 1975, of which spot comprised 1.1 to 5.5 million kg. Knowlton (1972) estimated a yearly average catch of 16.4 kg (36.1 lb) of spot per hour of shrimp trawling in Georgia's close inshore waters (5-6 miles offshore), representing 28.0% of the average yearly catch of finfish. The average annual catch of spot taken during shrimp trawling from Cape Romain, SC to Cape Canaveral, FL, 1931-1935, was 144 per hour of trawling which represented 8.8% of the total catch (Anderson 1968). Spot were most abundant in South Carolina coastal waters at 466 per hour of trawling, representing 22.3% of the catch.

Great concern from environmentalists has been raised in recent years about the incidental catches and subsequent mortality of sea turtles and the large volume of finfish by-catch in the South Atlantic and Gulf shrimp fisheries. In order to reduce the mortality of threatened and endangered sea turtles, NMFS designed and tested a device, called the Turtle Excluder Device (TED), that was placed in the net in front of the codend to deflect sea turtles out through a trap door in the top of the net. The first TEDs were not well received by the shrimping industry because of their large size and heavy weight. They were redesigned, made lighter in weight, modified to increase their ability to exclude finfish and other organisms caught incidentally to trawling, and renamed to Trawl Efficiency Device. Several models of TEDs have been designed and tested by NMFS, various Gulf of Mexico and South Atlantic states and Sea Grant.

Results of tests conducted on two different TEDs, the NMFS-TED and the Georgia-Jumper, in South Carolina coastal waters were presented by Wenner (1987b). In the July-August brown shrimp portion of the study, the total number of fishes in the by-catch was reduced by 49.7% while the total weight was 54.5% less in the NMFS-TED. Reductions in the catch of spot were 73.2% in number and 74.5% in weight. The Georgia-Jumper showed at 24.8% and 37.2% reduction in finfish by-catch in numbers and weight, respectively. Spot were reduced by 35.4% and 31.4% in number and weight, respectively. Similar results in finfish by-catch reduction were obtained in the October-November white shrimp study. Reductions in the number and weight of spot in the NMFS-TED were 36.8% and 41.9%, respectively. The Georgia-Jumper TED caught 56.0% fewer and 51.2% less weight of spot than the control net.

TEDs have been shown to be effective in eliminating a sizeable portion of the by-catch encountered during shrimp trawling operations. Many finfish species of commercial and recreational interest, including the Atlantic croaker, weakfish, spot, kingfish, summer flounder, bluefish, and Spanish mackerel, were removed; however, the catch of shrimp was reduced by 2.5-15.8% in nets with TEDs. TEDs were also shown to be effective in reducing the catch of blue crabs (28.4-42.5% by weight) and horseshoe crabs (87.9-100% by weight). While TEDs have not been readily adopted by fishermen, mainly because of their expense and handling problems, the results of field tests indicate that TEDs would be effective in reducing the by-catch and mortality of finfishes in the southern shrimp fishery.

11.5.2 Recreational Exploitation

11.5.2.1 Fishing Equipment

Spot are usually caught while bottom fishing from shore and boats with hooks baited with worms, shrimp, clams, soft and shedder crabs, and cut fish. (Freeman and Walford 1974; 1976a, b, c). Spot are also caught in noncommercial gill-net fisheries such as described for South Carolina (Moore 1980). In that study spot accounted for 47% (73.179 kg) of the total harvest of fish by gill-net fishermen who did not sell their catch and 57% (109,953 kg) of the finfish harvested by gill-net fishermen who sold a portion of their catch.

11.5.2.2 Areas Fished

Anglers take spot from ocean beaches, mouths of inlets, and banks of bays and rivers, as well as from man-made structures such as piers, bridges, jetties, and causeways. Spot are taken in nearshore coastal waters and in estuaries over mud, sand, and sand-shell bottom, and especially over shellfish beds (Freeman and Walford 1974; 1976a, b, c). The majority of the Atlantic coast recreational harvest takes place from Delaware Bay south to northern Florida (Wilk 1981). The Marine Recreational Fishery Statistics Survey, 1979-1987, indicates that most spot are caught in inland waters and within three miles of shore (Table 11.9). In the Middle Atlantic region most spot were caught in inland waters except in 1981. In the South Atlantic region more spot were caught in the ocean within 3 mi of the coast. This survey also indicates that most spot are caught from shore or by private/rental boats rather than party/charter boats (Table 11.10).

11.5.2.3 Fishing Seasons

The fishing season from Delaware Bay to False Cape, Virginia, including Chesapeake Bay, extends from May or June to October or mid November, with best fishing in late summer and early fall. (Freeman and Walford 1974, 1976a). From False Cape, Virginia to Altamaha Sound, Georgia, the fishing season extends from late April or May to mid-December, with the best fishing for large spot from September to November or early December (Freeman and Walford 1976b). Most spot are caught from March to December, with best fishing from July to September, south of Altamaha Sound, Georgia (Freeman and Walford 1976c).

11.5.2.4 Fishing Operations and Results

Catch rates for spot were reported for the Virginia portion of Chesapeake Bay and its tributaries, 1955-1960 (Richards 1962). Spot catch rates reached a maximum in late August or early September in the Rappahannock area, and progressively later at points nearer the mouth of the bay. Spot catch rates by year fluctuated and were highest in 1959

Table 11.9. Estimated total number of spot caught by marine recreational fishermen by area of fishing for each subregion, 1979-1987.

Year	Area Of Fishing		
	Inland	Ocean (<3 mi)	Ocean (>3 mi)
	- - - - - - - - - - -THOUSANDS- - - - - - - - -		
1979 (Revised)[1]			
Middle Atlantic	8,344	1,812	37
South Atlantic	3,298	11,707	110
Total	11,642	13,519	147
1980[1]			
Middle Atlantic	12,547	1,010	172
South Atlantic	2,736	2,264	46
Total	15,283	3,275	218
1981[2]			
Middle Atlantic	4,935	13,179	2,410
South Atlantic	708	5,655	36
Total	5,643	18,834	2,446
1982[2]			
Middle Atlantic	6,801	5,912	111
South Atlantic	1,343	5,129	3
Total	8,144	11,041	114
1983[3]			
Middle Atlantic	12,769	4,415	2,954
South Atlantic	1,717	6,348	3
Total	14,486	10,763	
1984[3]			
Middle Atlantic	7,070	2,755	1,370
South Atlantic	2,040	3,443	7
Total	9,110	6,198	1,377
1985[4]			
Middle Atlantic	8,676	3,108	344
South Atlantic	3,992	9,053	7
Total	12,668	12,161	351
1986[5]			
Middle Atlantic	11,126	1,013	182
South Atlantic	1,316	4,421	24
Total	12,442	5,434	206
1987[6]			
Middle Atlantic	11,057	979	428
South Atlantic	2,145	83	
Total	13,202	3,611	511

[1]Anonymous 1984 [2]Anonymous 1985a [3]Anonymous 1985b [4]Anonymous 1986

[5]Anonymous 1987 [6]Preliminary data

Table 11.10. Estimated total number of spot caught by marine recreational fishermen by mode of fishing for each subregion, 1979-1987.

Year	Mode Of Fishing: Private/ rental	Party/ charter	Shore
	----------THOUSANDS	-------	
1979 (Revised)[1]			
Middle Atlantic	5,082	883	4,563
South Atlantic	2,275	*	12,840
Total	7,357	883	17,403
1980[1]			
Middle Atlantic	10,607	180	6,929
South Atlantic	2,666	*	8,305
Total	13,273	180	15,234
1981[2]			
Middle Atlantic	12,715	1,442	6,973
South Atlantic	641	36	6,271
Total	13,356	1,478	13,244
1982[2]			
Middle Atlantic	6,281	488	6,114
South Atlantic	1,004	*	5,759
Total	7,285	488	11,873
1983[3]			
Middle Atlantic	9,543	442	12,598
South Atlantic	1,355	75	7,382
Total	10,898	517	19,980
1984[3]			
Middle Atlantic	8,497	696	2,002
South Atlantic	1,622	19	4,176
Total	10,119	715	6,178
1985[4]			
Middle Atlantic	7,638	2,244	2,260
South Atlantic	3,049	165	9,838
Total	10,687	2,409	12,098
1986[5]			
Middle Atlantic	10,616	2,730	2,391
South Atlantic	934	1	4,826
Total	11,550	2,731	7,217
1987[6]			
Middle Atlantic	9,928	1,066	1,469
South Atlantic	1,885	-	2,975
Total	11,813	1,066	4,444

[1]Anonymous 1984 [2]Anonymous 1985a [3]Anonymous 1985b [4]Anonymous 1986

[5]Anonymous 1987 [6]Preliminary data

for private boats and 1960 for party boats. Marshall and Lucy (1981) also reported that the average number of spot caught per trip in 1979 in the Rappahannock area peaked in September. Results of the Maryland saltwater fishing survey for 1979 indicated that spot CPUE was highest during September-October for beach/bank and structure fishermen but for private/rental fishermen the CPUE was highest in July-August (Williams et al. 1982). In 1980 spot CPUE was highest in July-August for beach/bank fishermen and in September-October for other modes (Williams et al. 1983). In both years the average size of spot caught declined throughout the fishing season.

11.6 Social and Economic Implications

11.6.1 Values

Spot along with croaker, spotted seatrout, weakfish, and red drum constitutes an important part of the food finfish industry of the Atlantic and Gulf coasts (Cato 1981). The dockside value of commercial landings of spot on the United States ranked second behind spotted seatrout in the 1960s but was fourth in the 1950s and 1970s behind croaker weakfish and spotted seatrout. Food landings of spot were valued at about 2 million dollars in 1987. Dockside prices are affected by seasonal quantities of any of the commercially valuable sciaenids landed, volumes going into short-term storage, location of landings relative to the market, import, competing species, and consumer's tastes, preferences, and incomes (Cato 1981).

11.6.2 Employment

There is little information available on employment in the fisheries for spot. Spot are harvested in mixed species fisheries such as the otter trawl, gill net, pound net, and haul seine fisheries which are seasonal fisheries.

11.6.3 Participation

User groups include commercial fishermen, processors, and dealers, food consumers, recreational fishermen, marinas, and bait shops. Little data exists on number of participants in these various user groups. Estimates of participation in marine recreational fishing by residents of the Mid-Atlantic states between 1979 and 1987 fluctuated between 2.0 to 4.3 million residents. Estimates for the South Atlantic ranged from 1.5 to 2.5 million residents for those same years (Anononymous 1984, 1985a, b, 1986, 1987).

11.6.4 Processors and Product Forms

Food fish landings of spot are primarily sold freshly iced, whole through local fish houses (Cato 1981). A study of out-of-state marketing channels for North Carolina fresh seafood in 1974 found that 60.5% of the spot handled by North Carolina coastal dealers were distributed inside North Carolina (Summey 1977). The coastal area received 85% of the amount handled in-state and inland areas received the remaining 15%. A study of inland channels of distribution for fresh iced seafood in North Carolina indicated that the total inland market for spot was small when compared to flounder, weakfish, or croaker (Summey 1979). Of the total sales, 88.8% were sold through retail outlets either by the wholesaler himself (35.6%) or his retailer customer group (53.2%). The restaurant market purchased only 2.5% of this species. Resale to other wholesalers represented 8.2% of sales.

11.6.5 Import/Export

Cato (1981) reported that there was interest in developing new markets for exportation of finfish to Africa. While there is evidence that some of the sciaenids have been exported, it is not anticipated that these will become preferred export species. This market requires extremely large volumes of low-cost fish. Since most sciaenids are produced commercially by small independent fishermen, it is difficult to assemble large volume shipments. High domestic prices also discourage exporting.

11.6.6 Gear Conflicts

A large increase in the number of crab and eel pot fishermen in North Carolina sounds has resulted in confrontation with haul seiners, who cannot haul in areas filled with pots (DeVries 1981b). Similar problems most likely have occurred in other states.

11.6.7 Commercial-Recreational Conflicts

The sciaenid fisheries have been and will continue to be major sources of conflicts or competition among user groups of the resources (Cato 1981). For example, in the Pamlico-Pungo River area of North Carolina a conflict exists with recreational anglers who fear long haulers are depleting stocks of sport fish (DeVries 1981b).

11.7 Management and Protection

11.7.1 Regulatory Measures

Spot occur mainly in the territorial waters of the coastal states from Maryland to Florida. Each state exercises jurisdiction over the fisheries with the waters to three nautical miles from shore. The regulations and methods of promulgating them vary between states and are summarized in Table 11.11. The Maguson Fishery Conservation and Management Act (MFCMA) provides for the conservation and exclusive management of all fishery resources within the U.S. Exclusive Economic Zone (EEZ) which extends from the territorial sea to 200 nautical miles from shore. There are no national or international laws or policies dealing with spot.

11.7.2 Habitat Protection

Spot utilize both estuarine and coastal oceanic waters at various life history stages and times of the year. Habitat alterations within estuarine areas are probably the most damaging to spot stocks since these areas are utilized for spawning and nursery grounds. Most estuarine areas of the United States have been altered to some degree by such activities as agricultural drainage, flood control and development.

Table 11.11. Synoptic overview of present state management systems.

State	Maryland	Virginia
Administrative organization	Maryland Department of Natural Resources	Virginia Marine Resources Commission
Legislative organization	Natural Resources Article, Annotated Code of Maryland Title 4, Subtitle 1, Title 08, Subtitle 02, Chapter 05 Fish	Marine Resources of the Commonwealth Code of Virginia of 1950, Title 28.1
Licenses	Otter trawl - $100 Bean trawl - $100 Fyke or hoop nets - $50 Gill nets - <200 yds $100 >200 yds $200	Commercial
Size restrictions	None	None
Limits	None	None
Gear	Trawling prohibited within 1 mile of Maryland shoreline in Atlantic Ocean. Numerous gear and area restrictions	Trawling prohibited in Chesapeake Bay. Pound net mesh <2" (s.m.) prohibited. 3" mesh (s.m.) requirement for haul seines.
Conservation regulations	Secretary of Natural Resources has authority to adopt rules and regulations relating to taking, possession, transportation, exporting, processing, sale or shipment necessary to conservation.	

Table 11.11. (continued)

State	North Carolina
Administrative organization	North Carolina Department of Natural Resources and Community Development Division of Marine Fisheries
Legislative organization	North Carolina Administrative Code, Title 15, Chapter 3.
Licenses	Vessels without motors, any length, when used with other licensed vessel - no license Vessels, <18'5" - $1.00/foot Vessels, 18'6" to 38'5" - $1.50/foot Vessels, >38'3" - $3/foot Non-resident vessels - $200 in addition to above fee requirement Finfish processor - $100 Unprocessed finfish dealer - $50
Size restrictions	None
Limits	None
Gear restrictions	Trawling for finfish prohibited in internal coastal waters. No purse seine for food fish. Many specific net regulations for areas and seasons.
Conservation regulations	Secretary, acting upon advise of Director of Marine Fisheries, may close any area to trawling if in coastal fishing waters, samples become composed primarily of juvenile finfish of major economic importance.

Table 11.11. (continued)

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

Table 11.11. (continued)

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

The National Estuary Study, completed in 1970, indicated that 73% of the nation's estuaries had been moderately or severly degraded. Damaged and/or destruction of estuaries have largely been by filling, dredging of navigation channels, and pollution (Gusey 1978, 1981). In the Atlantic coast states (Maine-Florida), which contain 3,152,800 acres of estuarine habitat, an estimated 129,700 acres (4.1%) were lost to dredging and filling from 1954-1968 (Table 11.12). Unfortunately, the effects of habitat alterations such as channel dredging, filling of wetlands, increased turbidity associated with dredging, boating, loss of wetlands, and storm runoff, industrial pollutants, and sewage, have rarely been quantified.

In recent years, the coastal states have enacted coastal zone management laws to regulate dredge and fill activities and shoreline development. The federal government also regulates dredging and spoil disposal, water pollution, and creation of marine sanctuaries through the U.S. Army Corps of Engineers, (PL 92-500; 1988 R&H Act), the National Marine Fisheries Service (F&W Coordination Act; PL 92-500), the U.S. Fish and Wildlife Service (F&W Coordination Act; PL 92-500), and the Environmental Protection Agency (PL 92-500). State regulations are summarized in Table 11-13.

11.8 Current Research

Spot research and montoring activities were discussed at the Sciaenid Assessment Workshop (Wilk and Austin 1981) and by the Sciaenid Technical Committee. Several states monitor juvenile and adult abundance of spot in estuarine surveys. The Delaware Division of Fish and Wildlife conducts annual recruitment surveys of sciaenids and adult groundfish surveys in Delaware Bay. Data has also been collected on the recreational fishing in Delaware since 1955. The Maryland Department of Natural Resources has conducted an annual blue crab and finfish population survey in Chesapeake Bay and Chincoteague Bay since 1980. The University of Maryland's Chesapeake Biological Laboratory (CBL) conducted a trawl survey from 1965 to 1975. Juvenile spot abundance in Chesapeake Bay and its tributaries has been monitored in monthly trawl surveys since 1954 by the Virginia Institute of Marine Science (VIMS). Beginning in 1988, VIMS and CBL, under coordination of the Chesapeake Bay Stock Assessment Committee (CBSAC), will undertake a Chesapeake Bay-wide trawl survey using high rise trawls. The Virginia Marine Resources Commission will begin a fishery dependent sampling program in 1988. The North Carolina Division of Marine Fisheries (NCDMF) has collected data on juvenile spot abundance from March through November annually in a trawl survey that was standardized in 1978. A quarterly stratified random survey of fishes of Pamlico Sound was initiated in 1987. The NCDMF also conducts monthly sampling of the major commercial fisheries for size and age composition of the fisheries. A number of studies on recruitment of larval and juvenile spot in Pamlico Sound and its tributaries and food resource partitioning by juvenile spot and croaker have been conducted by Dr. John Miller and graduate students of North Carolina State University. The National Marine Fisheries Service (NMFS) Beaufort Laboratory conducts an annual recruitement survey of larval fishes at two estuarine sites in the vicinity of Beaufort, NC. NMFS conducts an annual coastwide survey of contaminants in estuarine finfish. The Carolina Power and Light Company's Southport Laboratory

Table 11.12. Acres of shoal water habitat and loss in Atlantic coastal states from 1954 - 1968 (from Gusey 1978, 1981).

State	Total Area	Basic area of important habitat	Area of basic habitat lost by dredging and filling	Percent loss of habitat
Massachusetts	207,000	31,000	2,000	6.5
Rhode Island	94,700	14,700	900	6.1
Connecticut	31,600	20,300	2,100	10.3
New York	376,600	132,500	10,800	15.0
New Jersey	778,400	411,300	53,900	13.1
Delaware	395,500	153,400	8,500	5.6
Maryland	1,406,100	376,300	1,000	0.3
Virginia	1,670,000	428,100	2,400	0.6
North Carolina	2,206,600	793,700	8,000	1.0
South Carolina	427,900	269,400	4,300	1.6
Georgia	170,800	125,000	800	.6
Florida, E. coast	525,600	398,100	35,000	8.8
TOTAL	8,290,800	3,152,800	129,700	4.1

Table 11.13. Summary of state habitat protection regulations.

State	Administrative organization	Legislative authorization	Regulations
Maryland	Maryland Department of Natural Resources, Tidewater Administration; Maryland Department of Health and Mental Hygiene, Office of Environmental Programs	Natural Resources Article Code of Maryland	Regulate activities in tidal wetlands areas.
Virginia	Virginia Marine Resources Commission; County wetlands boards	Section 62.1-13.4, Code of Virginia, Wetlands Act.	Regulates alterations to tidal marshes, sand and mud flats, subaqueous bottoms, and sand dunes.
North Carolina	North Carolina Department of Natural Resources and Community Development Office of Coastal Management; Coastal Resources Commission; Coastal Resources Advisory Council	NC Dredge and Fill Law (GS 113-229), Coastal Area Management Act (CAMA) (GS 113A100)	Requires permits to dredge or fill in or about estuarine waters. Established areas of environmental concern. Permits required for coastal zone development.
	Division of Marine Fisheries	NC Administration Code Code, Chap. 3, Sect. .1400	Prohibits the use of bottom -disturbing gears and severly restricts or prohibits excavation and/ or filling activities in nursery areas for young finfish and crustaceans.
South Carolina	South Carolina Coastal Zone Management	Coastal Zone Management and Planning Act	Directs permit activities in areas of wetlands, beaches, and dunes.

Table 11.13. (continued)

State	Administrative organization	Legislative authorization	Regulations
Georgia	Georgia Department of Natural Resources, Coastal Resources Division,	Coastal Marshlands Protection Act of 1970 (GS. L. 1970, p. 939, <1.)	Requies permits to dredge, fill, remove, drain, or otherwise alter any marsh lands.
	Shore Assistance Act of 1979 (Gs. L. 1979, <1.)	Required permits for a structure, shoreline engineering activity, or land alteration in beaches, sand bars, and sand dunes in Georgia.	
Florida	Florida Department of Natural Resources	Chapter 253, Florida Statutes	Regulates dredge, fill, and structures on state submerged lands)below mean high water). Provides for acquisition of conservation lands and tidally influenced areas.
		Chapter 258. F.S.	Established aquatic preserves and regulates activities within perserves.
	Florida Department of Environmental Regulation	Chapter 403, F.S.	Permitting of activities (including dredge and fill) which affect water quality.

Table 11.13. (continued)

State	Administrative organization	Legislative authorization	Regulations
	Florida Department of Community Affairs	Chapter 380, F.S.	Administer and set standards for "Development of Regional Impact". Protects regional or statewide resources from poorly conceived development activities.

conducts a monthly montoring survey of the Cape Fear River. A seasonal coastal groundfish trawl survey from Cape Fear, North Carolina to Cape Canaveral, Florida was recently completed by the South Carolina Marine Resources Research Institute. The Georgia Department of Natural Resources has performed fishery-independent monitoring of finfish abundance in northern, central, and southern sectors of Georgia coastal waters since 1984, including tagging and age and growth studies. The Florida Department of Natural Resources is conducting a food chain study of finfishes in the mangroves. Commercial landings statistics are collected monthly by all states and NMFS and recreational catch statistics are being collected cooperatively between individual states and NMFS.

11.9 Research Needs

Spot research needs, as indicated by this review of the literature, by discussions at the Sciaenid Assessment Workshop (Wilk and Austin 1981), and by the ISFMP Sciaenid Technical Committee, include stock identification, determination of migatory patterns through tagging studies, monitoring long term changes in abundance, growth rates and age structure, and determination of the onshore vs offshore components of the fishery. Continued monitoring of juvenile spot populations in major spawning areas is necessary to predict year-class strength. Improved catch and effort statistics from the commercial and recreational fisheries are needed, along with size and age structure of the catch, in order to develop production models.

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14.0 APPENDIX

14.1 Listing of members of Sciaenid Technical Committee and South Atlantic State-Federal Fisheries Management Board.

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