Biological Report 82(11.91) TR EL-82-4
January 1989

Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic)

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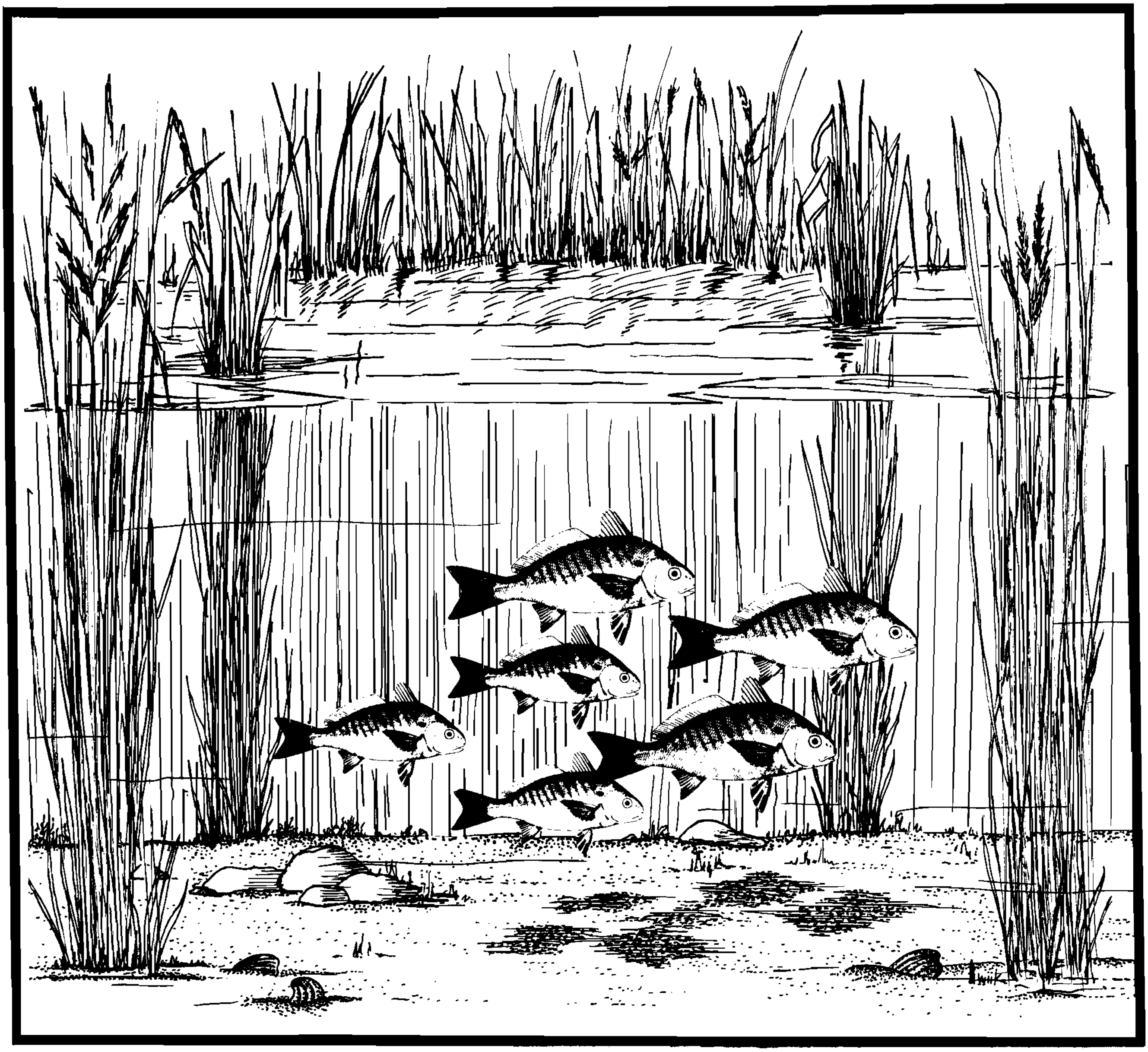

Fish and Wildlife Service
U.S. Department of the Interior

Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (South Atlantic)

SPOT

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PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to one of the following addresses.

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U.S. Army Engineer Waterways Experiment Station
Attention: WESER-C
Post Office Box 631
Vicksburg, MS 39180

CONVERSION TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
meters (m)	0.5468	fathoms
kilometers (km)	0.6214	statute miles
kilometers (km)	0.5396	nautical miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters (m^3)	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons (t)	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees (°C)	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

Multiply	By	To Obtain
inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
statute miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
square miles (mi^2)	2.590	square kilometers
acres	0.4047	hectares
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28350.0	milligrams
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
pounds (lb)	0.00045	metric tons
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees (°F)	0.5556 (°F - 32)	Celsius degrees

CONTENTS

ACKNOWLEDGMENTS

The authors wish to thank Charles Wenner, Marine Resources Institute, Charleston, South Carolina; and William Hettler, National Marine Fisheries Service, Beaufort, North Carolina for reviewing the manuscript. Figure 1 was prepared by Janice Kerr.

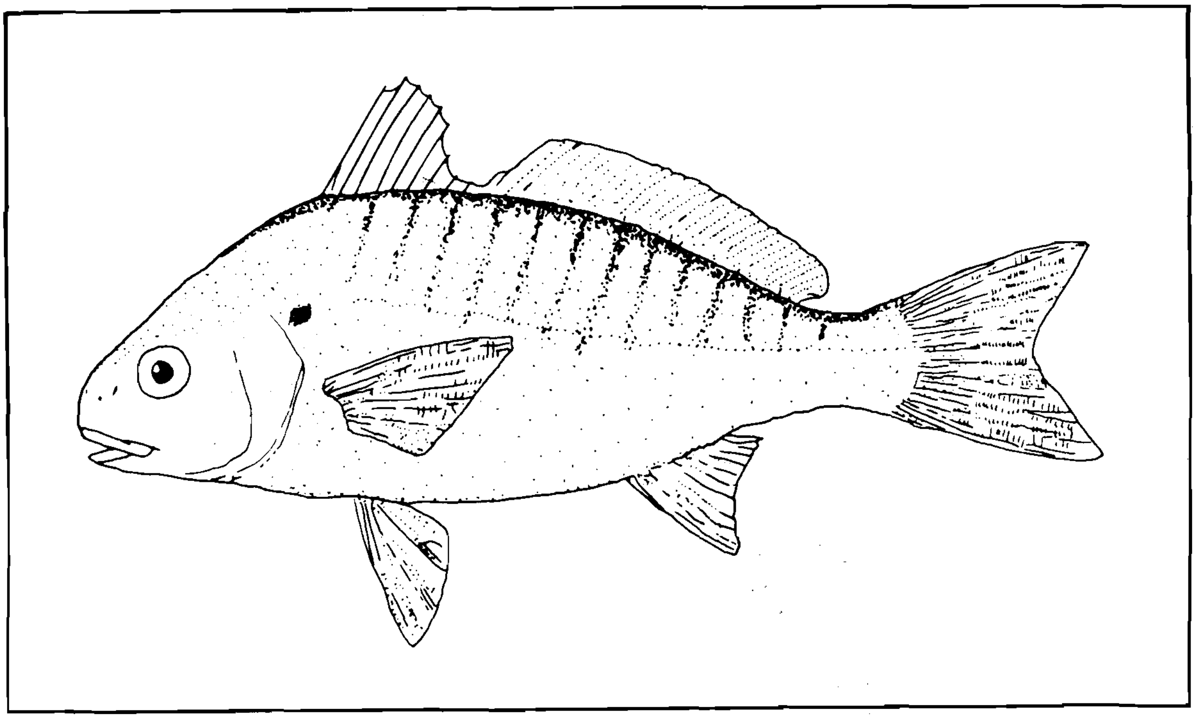

Figure 1. Spot.

SPOT

NOMENCLATURE/TAXONOMY/RANGE

Scientific name.............Leiostomus xanthurus Lacepede 1803
Preferred common name.............Spot (Robins et al. 1980), Figure 1.
Other common names.......flat croaker, golden croaker, silver gudgeon, goody, Lafayette, chub, roach, Jimmy, oldwife, spot croaker, post croaker, chopa blanca, Norfolk spot, Cape May goody (Dawson 1958)
Class .... Osteichthyes
Order .... Perciformes
Family .... Sciaenidae

Geographic Range: The spot is common in temperate Atlantic coastal waters from Cape Cod southward (Figure 2) and along the Gulf of Mexico to the Bay of Campeche (Bigelow and Schroeder 1953; Springer and Bullis 1956). It occurs rarely in the Florida Keys (Chao 1978) and north of Cape Cod (Bigelow and Schroeder 1953).

MORPHOLOGY AND IDENTIFICATION AIDS

The following general description of spot was summarized from Johnson 1978. The body of the spot is rather deep and compressed, with a strongly elevated back; the head is obtuse and short; mouth is inferior and small, the maxillary extends posteriorly to about the middle of the eye. The dorsal fin is continuous with a notch between the anterior spinous portion (9-11 spines) and the posterior soft portion (29-35 rays); the anal fin has 2 spines and 12-13 rays. There are 72-77 lateral line scales and 24-25 vertebrae. Spot are bluish-gray above

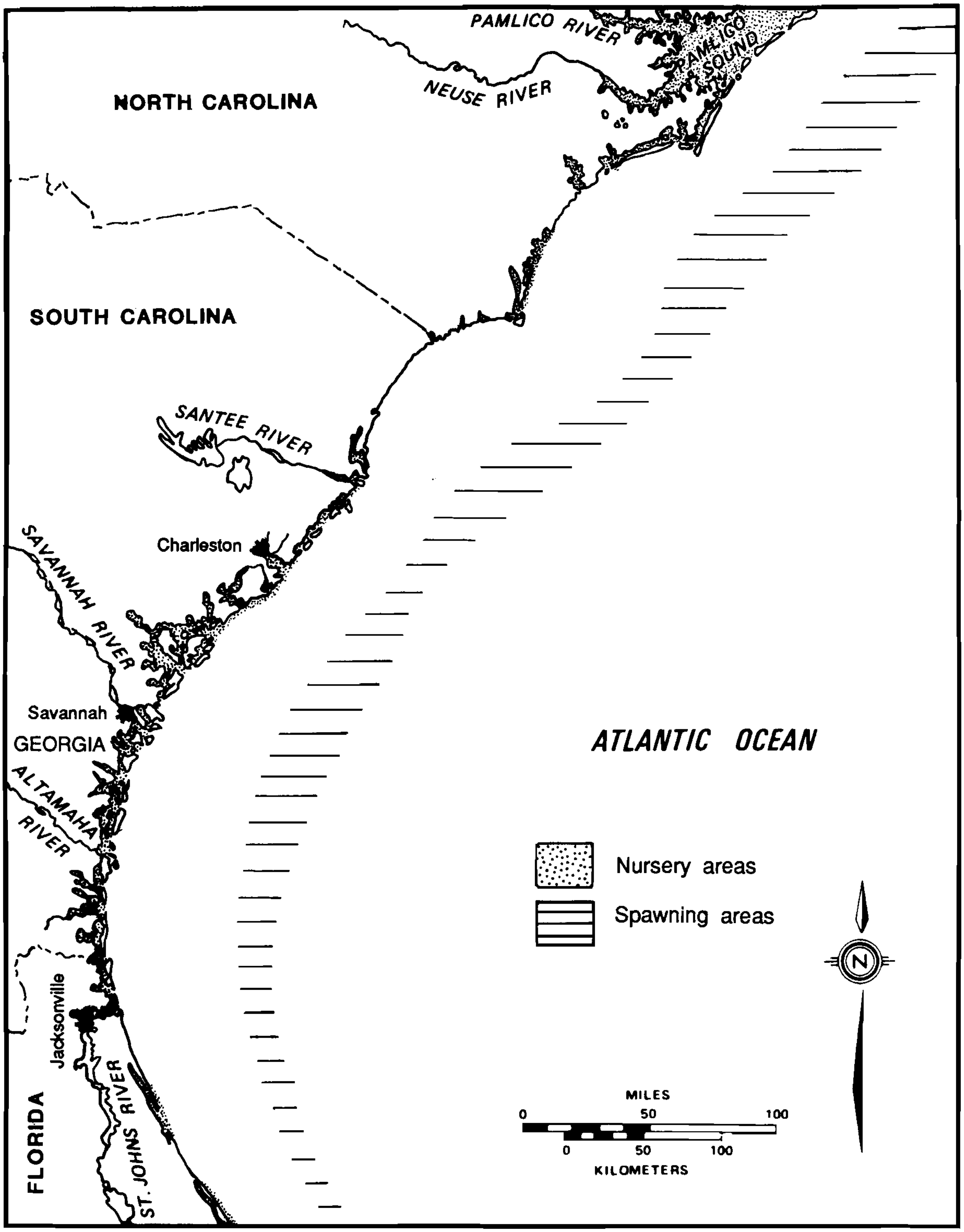

Figure 2. Spawning and nursery areas of the spot in the South Atlantic Region, Southeastern United States.

and somewhat golden below. They have 12-15 oblique dark streaks (these may be indistinct in large specimens), a large black spot above the upper edge of the gill cover, and the fins are generally pale to yellowish.

Adults are not likely to be confused with other species of sciaenids, but juveniles superficially resemble the juveniles of several other species, including the Atlantic croaker, Micropogonias undulatus; the star drum, Stellifer lanceolatus; and the silver perch, Bairdiella chrysoura. The following characteristics distinguish otherwise morphologically similar sciaenids from spot (Chao 1978): the Atlantic croaker has many barbels on the lower jaw and a strongly serrate preopercle; the star drum has a strongly serrate preopercle, well-developed dentition, and a lanceolate caudal fin; the silver perch has well-developed dentition and a rounded caudal fin.

Although eggs and larvae of most sciaenids are not likely to occur with those of spot (Powles and Stender 1978), the eggs and larvae of the silver seatrout, Cynoscion nothus, Equetus spp., the banded drum, Larimus fasciatus, and the Atlantic croaker may co-occur with spot. The eggs of most sciaenids have not been described, but several characters are useful for distinguishing larval spot from other species (Lippson and Moran 1974; Fruge and Truesdale 1978; Johnson 1978; Powles and Stender 1978; Powell and Gordy 1980). The spot has fewer vertebrae (24-25) than the silver seatrout (26-27), and for fish longer than 5 mm in standard length (SL), the spot has fewer precaudal vertebrae (10) than any other species of Cynoscion. For specimens at least 6 mm SL, spot have more anal fin pterygiophores (14-15) than the banded drum (8-10); individuals shorter than 6 mm SL are not likely to co-occur with small spot larvae. (Pterygiophores are the skeletal elements of fin support.) The larvae of spot have fewer dorsal fin rays (29-35) and more anal fin rays (12-13) than any of the described species of Equetus (36-55 and 5-8 rays, respectively). At about 4 mm SL, spot differ from the Atlantic croaker only in pigmentation. The spot has a large melanophore in the peritoneum anterior to the visceral mass between the cleithra, a triangular or diamond-shaped pigment pattern on the ventral abdomen, and a continuous pigment row along the anal fin base. The pigmentation differences between spot and Atlantic croaker are retained up to about 20 mm SL. Larvae of spot differ from those of Atlantic croaker in a number of other characteristics: by 4.0 mm SL, the eye diameter of spot is larger (>10% of SL); by 7.0 mm SL, spot have more anal fin pterygiophores (14-15 vs. 9-11); by 8.5 mm SL, spot have a shorter preanal length (<5% of SL); by 20-30 mm SL in Atlantic croaker the mandibular barbels are evident in some specimens, and by 50 mm SL they are present in all.

REASON FOR INCLUSION IN SERIES

The spot is one of the most abundant demersal fishes in coastal waters of the South Atlantic Region, and is both commercially and recreationally important. In commercial catch, this species in dollars or pounds has generally ranked among the top five finfish species. In addition, the spot is a popular sport fish, and the recreational catch may exceed the commercial catch. Because of its abundance, the spot is important as prey of other fishes and is a seasonally important component of estuarine and shelf fish assemblages. The spot depends on several different habitats during its life history (Figure 2), and it may provide a direct link for energy exchange between estuarine and nearshore marine environments (see Weinstein 1981).

LIFE HISTORY

Spawning

In the South Atlantic Region, spawning occurs from October to March and peaks in December and January (Townsend 1956; Dawson 1958; Springer and Woodburn 1960; Powles and Stender 1978; Lewis and Judy 1983; Warlen and Chester 1985). This spawning period is later than that in the Mid Atlantic Region (Pacheco 1962; Chao and Musick 1977) and somewhat earlier than that in the northern Gulf of Mexico, where spawning begins in December and peaks in January and February (Pearson 1929; Nelson 1969).

Spot typically migrate offshore to spawn in moderately deep water along the South Atlantic Region (Dawson 1958; Fahay 1975; Powles and Stender 1978; Lewis and Judy 1983). This behavior is similar to that of the species in other parts of its range (Nelson 1969; Fruge 1977; Berrien et al. 1978). A comparison of the frequency distributions of the lengths of spot larvae caught off Beaufort, North Carolina, indicates that spawning occurs over the outer shelf throughout most of the spawning season but over the mid-shelf early and late in the spawning season (Warlen and Chester 1985). Off North Carolina most spawning probably occurs 75-90 km offshore (Warlen and Chester 1985). A limited amount of spawning has been documented in inshore waters (Smith 1907; Pearson 1929; Hildebrand and Cable 1930; Jannke 1971; Music 1974). Spawning apparently occurs at all latitudes throughout the South Atlantic Region, at least as far south as Cape Canaveral, judging from the occurrences of small larvae (Fahay 1975).

Spawning activity begins in fall, when ripening adults collect off beaches (Hildebrand and Cable 1930; Roelofs 1954; Dawson 1958) and then begin to migrate southward shortly before or during their offshore spawning migration. Dawson (1958) suggested that spot migrating southward along South Carolina beaches were the primary source of fish caught in the commercial haul-seine fishery. Spot from more northern waters may use coastal waters of the South Atlantic Region during winter as spawning or feeding grounds (Chao and Musick 1977). Spot tagged in Chesapeake Bay (Pacheco 1962) and Delaware Bay (Pearson 1932) have been recaptured off North Carolina.

There is little published information on the fate of spot after they are spent. Pearson (1929) suggested that few spot survive spawning; however, Gunter (1945) and Dawson (1958) collected spent fish. After spawning, adult spot may remain offshore, but they are rarely taken by bottom trawling in these areas (Wenner et al. 1979a, b, c, d, 1980).

Although the spot spawns in fall and winter, it appears to spawn only in relatively warm water. Hettler and Powell (1981) reported that spot held in a laboratory spawned only at 17.5-25.0 °C. Warlen and Chester (1985) collected young larvae (< 16 days old) only at water temperatures higher than 19.3 °C. Fahay (1975) collected larvae in waters with surface temperatures of 7.4-17.3 °C. The distribution of masses of warm water across the continental shelf may affect the spawning locations of spot during the course of the spawning season.

There are no published accounts of the fecundity of spot in the South Atlantic Region. Dawson (1958) found 77,000 and 84,000 potential ova in two females (unspecified size and state of maturity). Hildebrand and Cable (1930) reported several different sizes of ova in ripening spot and suggested that individual fish may spawn repeatedly over a period of several weeks. The fecundity of spot in other parts of its range is also poorly known (Parker 1971).

Eggs and Larvae

Eggs of the spot are pelagic. At 20 °C they hatch in about 48 h and the yolk sac and oil globule are absorbed within the next 5 days (Powell and Gordy 1980). There are no published accounts of the distribution of eggs from any part of the spot's range. This lack of data is related to the lack of adequate taxonomic descriptions of eggs of spot and other sympatric species of sciaenids.

The larvae of spot are widely distributed along the South Atlantic Region during late fall and early winter; however, the size distribution and relative abundance vary across the continental shelf (Powles and Stender 1978; Lewis and Judy 1983; Warlen and Chester 1985). Although size generally increases (and relative abundance decreases) in nearshore areas (Lewis and Judy 1983; Warlen and Chester 1985), small larvae have been collected in nearshore waters early and late in the spawning season (Warlen and Chester 1985).

The mechanisms by which spot larvae are transported to estuarine nursery areas from the offshore spawning grounds are not known; however, both active behavior and passive transport mechanisms have been demonstrated in other species of fishes (Norcross 1983; Norcross and Shaw 1984). Because the eggs and larvae of spot are buoyant and usually near the surface of the water, the offshore distributions of early life history stages may be affected by Ekman transport, tides, and temperature (see Norcross and Shaw 1984). Wind-induced Ekman transport may initially affect the abundance of larvae in offshore waters; however, larvae become more demersal during later stages (Hildebrand and Cable 1930; Lewis and Judy 1983). As later larval stages settle out of the upper water column, they probably become less affected by Ekman transport and are more affected by other forces (inertia and Coriolis) that occur at greater depths (Lewis and Judy 1983). The limited swimming ability of small sciaenid larvae (0.25-1.0 m/s for brief periods; Lewis and Judy 1983) suggests that spot larvae move into estuaries primarily by drifting.

Larvae 10-24 mm SL first appear in coastal estuaries in January (Hildebrand and Cable 1930; Music 1974; Lewis and Judy 1983), but movement into estuaries probably peaks in February and March (Dawson 1958; Hildebrand and Cable 1930; Music 1974; Weinstein et al. 1980a). Because of the extended spawning season, larval and juvenile spot continue to enter many estuaries throughout the first half of the calendar year. This prolonged spawning and recruitment period may provide a buffering effect against unusual climatic conditions.

Warlen and Chester (1985) found that larvae and postlarvae (fish that have not completed metamorphosis to the juvenile stage, and are still planktonic) entered North Carolina estuaries at ages of 40-74 days (mean = 59 days). They observed little within-sample variation in age, and hypothesized that spot entered the estuary in somewhat distinct age cohorts. In addition, small individuals arrived at the estuary near both the beginning and end of the recruitment period; this occurrence probably is a result of nearshore spawning at both the beginning and end of the spawning season or from more rapid transport mechanisms at these times. Postlarval spot entering Chesapeake Bay appear to be somewhat older (Joseph 1972) than spot migrating into estuaries in North Carolina. This observation provides additional evidence that populations in the Mid Atlantic Region may use the South Atlantic Region for spawning.

Temperature may affect the ingress of larvae and postlarvae to estuaries; however, the roles of temperature and other environmental factors are not well known. Swimming speeds of spot larvae and juveniles have been positively correlated with temperature (Rulifson 1977). In addition, some early workers observed mass mortality of spot during periods of low water temperatures (5-10 °C), although it has been suggested that larvae and postlarvae may be more tolerant than older fish to such temperatures (Hildebrand and Cable 1930; Dawson 1958; Hodson et al. 1981a).

The relative importance of passive and behaviorally mediated transport of larvae within estuaries is poorly understood. Because peak recruitment for winter-spawned larvae in most Atlantic coast estuaries occurs at a time when estuarine thermal stratification and tidal exchange ratios are at a yearly maximum, active migration and use of tidal water movements are believed important in the dispersal of spot and other estuarine species (Weinstein et al. 1980a). During migration in the Cape Fear River (North Carolina) estuary, postlarval and juvenile spot occur in the middle and lower layers of the water column during the day and concentrate near the surface at night (Lewis and Wilkens 1971; Weinstein et al. 1980a). This behavior may enable spot to use tidal currents to augment their lateral movement into the shallow areas of estuaries (Weinstein 1979). In another study, Weinstein et al. (1980b) found that abundance of small spot in ichthyoplankton collections was much lower near the mouths of tidal creeks than in areas closer to the headwaters in the Cape Fear estuary. Spot, thus, appeared to congregate in the shallow-water portions of estuaries. Unfortunately, behavioral mechanisms that augment movement in some estuaries do not always apply in other estuaries having different hydrographic characteristics.

Postlarval spot have been collected in large numbers throughout estuaries and apparently are tolerant of a wide range of physical, chemical, and biotic factors. Similar numbers of spot have commonly been collected during the period of peak recruitment in estuarine areas having very different physicochemical conditions (Weinstein 1979; Bozeman and Dean 1980; Rogers et al. 1984; and Rozas and Hackney 1984). Some studies (Kilby 1955; Reid 1957; Weinstein 1983; Weinstein and Brooks 1983) have suggested that other habitat features such as substrate and sea grass beds are important in determining the distribution of spot in localized areas.

Several investigators have studied the effects of river discharge (especially high water conditions) on the recruitment of spot and estuarine community structure. Weinstein et al. (1980a) reported that, although postlarvae were absent in sections of the main channel of the Cape Fear River during high water, the fish recovered rather rapidly to pre-high water densities. The structural patterns of the shallow-water fish assemblages in the Cape Fear River estuary were not affected by annual differences in river discharge (Weinstein et al. 1980b). Rogers et al. (1984) concluded that recruitment of spot and other fishes may be inhibited during discharge peaks of the Ogeechee River in Georgia, but that upper-estuary nursery areas were used during high water. Kobylinski and Sheridan (1979) found no correlation between the abundance of spot and annual variation in river discharge in Apalachicola Bay, Florida.

Juveniles and Adults

Juvenile spot that have congregated in the shallow water of tidal creeks tend to disperse as they increase in size (Weinstein and Walters 1981); this emigration into deeper waters after growth appears to occur throughout estuaries (Herke 1971; Chao and Musick 1977), and results in the size-specific use of shallow estuarine habitats (Turner and Johnson 1973; Weinstein et al. 1980b; Rogers et al. 1984). Differences in gear bias (Kjelson and Johnson 1978), sampling methods, and experimental design have probably contributed to reports that various size classes of spot are ubiquitous in estuarine areas.

Juvenile spot live in different habitats for different periods of time (Weinstein 1983; Weinstein and Brooks 1983; Rozas and Hackney 1984). Tagged individuals remained in tidal creeks of the York River estuary for an average of 91 days, and the population remained there as long as 6 months (Weinstein 1983). This observation suggests that the exchange of juvenile spot between marsh habitats is relatively minor during the first summer. In another study, Rozas and Hackney (1984) concluded that the period of residency is much shorter in oligohaline marshes of the Cape Fear River. It is not known whether these differences are related to the productivity or structural complexity of the habitat. Older fish may be "tracking" their epibenthic and infaunal food supply in the estuary, or they may be moving to avoid increased predation by wading birds and crabs in shallow water (Weinstein and Brooks 1983).

Large juveniles apparently move into deeper portions of estuaries. Trawling in South Carolina (Shealy et al. 1974) and Georgia (Music 1974) resulted in the capture of large numbers of advanced juveniles in late summer and fall. Young-of-the-year spot overwinter in the deeper portions of most estuaries (Music 1974; Chao and Musick 1977). Relatively little is known about the importance of environmental factors, habitat features, and biological processes in determining the distribution and movements of juveniles.

The distribution patterns of some estuarine fishes have recently been ascribed to differing mortality rates in various parts of estuaries (Polgar 1982). Weinstein and Walters (1981) suggested that a similar phenomenon may explain the distribution of young spot in the Cape Fear estuary. Mortality was higher in polyhaline tidal creeks than in less saline creeks due to the presence of seasonally abundant marine predators.

GROWTH CHARACTERISTICS

Length-Weight Relationship

Dawson (1958) reported the following relationship between weight (W, in grams) and standard length (SL, in millimeters) for spot 45-205 mm long in South Carolina: $\log_{10}W = -4.544 + 2.958 \log_{10}SL$. He also determined that total length (TL) could be calculated from standard length as TL = 1.233 SL + 2.0 mm.

Larvae and Postlarvae

Warlen and Chester (1985) counted daily growth increments on otoliths (sagitta) to determine the age and growth history of larvae and postlarvae collected off Beaufort Inlet, North Carolina, during fall and winter in 1978-1980. Growth of young spot was biphasic; it was rapid in the ocean and appeared to coincide with a winter peak of plankton productivity (Turner et al. 1979; Yoder et al. 1981), slowed during the early months of estuarine residence (until about April), and then accelerated after metamorphosis of larvae to the juvenile stage, at lengths of about 25 mm SL.

Warlen and Chester (1985) found no significant differences in growth rates between years. Age-specific growth rates declined from 5% per day at age 10 days to <1% per day at age 90 days. Back-calculated lengths at each age were significantly greater in older than in younger fish of the same cohort, leading the authors to suggest that size-selective mortality favored survival of faster growing larvae.

Weinstein and Walters (1981) also found that growth rates of postlarvae in the estuary were slow in late winter and early spring. The long recruitment period of spot necessitated a complicated methodology for measuring growth; however, estimated average daily growth rates of 0.14-0.16 mm/day in the Cape Fear River estuary (Weinstein and Walters 1981) were similar to the 0.1% specific growth rate for late larval and early juvenile spot entering Beaufort Inlet estuary (Warlen and Chester 1985). In addition, the sizes of postlarvae collected early in their estuarine residency correspond closely to the asymptote predicted by the Gompertz growth equations for larvae, derived by Warlen and Chester (1985). This observation indicates that larvae may enter estuaries at a similar size throughout the South Atlantic Region.

Juveniles and Adults

In early studies from the Atlantic coast and Gulf of Mexico, somewhat variable estimates of spot growth rates were shown (Table 1). Many studies probably underestimated growth because of the protracted spawning season, the extended recruitment period, size-dependent emigration, and biased sampling methods (Herke 1971). In addition, the use of scales to age spot was admitted to be problematic, or not validated, in some studies (Welsh and Breder 1923; Pacheco 1962).

Estimates of the growth of spot in the South Atlantic Region show good agreement. Using modal analysis of the lengths of fish caught in South Carolina, Dawson (1958) found that spot reached 115-130 mm SL in their first year of growth and 150-175 mm SL in their second year. Using the same method, Music (1974) estimated that spot attained lengths of 140-145 mm TL (about 110-115 mm SL) during their first year in Georgia estuaries. Welsh and Breder (1923) assigned a total length of 140 mm TL to age I spot at Fernandina Beach, Florida. Weinstein and Walters (1981) found that spot reached at least 100 mm SL by September of their first year in the Cape Fear estuary.

Growth rates show seasonal and annual variation. Growth in young juveniles is rapid in late spring and early summer (Weinstein and Walters 1981), but juvenile and adult spot grow very slowly during winter (Dawson 1958; Pacheco 1962). Weinstein and Walters (1981) found that growth of spot in the Cape Fear estuary was rapid in late summer in 1978 but depressed during the summer of 1977. High temperatures in July 1977 reduced feeding and retarded growth to the extent that the ultimate sizes achieved by the spot at the end of the growing season that year may have been comparatively small.

Size and Age at Maturity

The smallest size at which advanced gonadal development was observed was 170-175 mm TL (Dawson 1958; Music 1974). Other researchers indicated that spot reach sexual maturity at sizes of 185-210 mm TL (Hildebrand and Schroeder 1928; Hildebrand and Cable 1930; Gunter 1945; Townsend 1956). Music (1974) indicated that males may mature at a slightly smaller size (170 mm TL) than females (205 mm TL).

Most spot reach sexual maturity in 2 years; but some may require 3 years. Some adults are captured in estuaries throughout the year (Music 1974; Shealy et al. 1974; Chao and Musick 1977). Length frequency distributions of spot caught by trawling led Dawson (1958) to conclude that most fish that spawned off South Carolina were 2 or 3 years old.

Table 1. Total length (mm) of spot at different ages, in different areas.

Area	Age I	Age II	Age III	Source
New Jersey	80-100	165-220	240-290	Welsh and Breder 1923
Chesapeake Bay	127			Hildebrand and Schroeder 1928
Beaufort, North Carolina	140			Hildebrand and Cable 1930
Chesapeake Bay	170-225	195-270		Pacheco 1962
Glynn County, Georgia	191	224	242	Music and Pafford 1984
Fernandina, Florida	140			Welsh and Breder 1923
Alligator Harbor, Florida	120-160	190-230		Townsend 1956
Lake Pontchartrain, Louisiana	140-155	200-210	225	Sundaraj 1960
Lake Borgne, Louisiana	135			Parker 1971
Laguna Madre, Texas	130-140	190-210		Pearson 1929
Galveston Bay, Texas	90-110			Parker 1971

Gunter (1945) and Townsend (1956) reported similar findings for the Gulf of Mexico.

THE FISHERY

History

Historical data available in publications of the U.S. Bureau of Commercial Fisheries and statistical reports of the U.S. Fish and Wildlife Service show that the commercial catch of spot has fluctuated widely since 1939 and was too sporadic to support a well-developed fishery in most states along the Atlantic seaboard. The commercial catch has been consistently high only in the Carolinas and Virginia, where nearly 75% of the total annual catch is made.

Spot are taken in large numbers in fall by haul-seine fishermen along the beaches of North and South Carolina. Catches consist predominantly of maturing adults that are beginning to migrate offshore to spawn. From April to October 1979, spot was the most abundant fish species by number (44%) and weight (40%) caught by long haul-seine fishing in Pamlico Sound, its tributaires, and Core Sound, North Carolina (DeVries 1982). Most of these spot were age I or II. Spot are also taken by shrimp trawlers, but the fish are usually small and useful only for pet food or fish meal; sometimes they are discarded. Spot are sought by sport fishermen because they take bait readily and can be caught near bridges, piers, and wharves. Small-scale commercial gill-netters also catch substantial numbers of spot in fall in South Carolina (E.B. Joseph, South Carolina Wildlife and Marine Resources Department, Charleston, pers. comm.).

In the 1970's, the commercial catch of spot ranged from 3 to 11 million pounds with a value of $400,000 to $1,275,000 (Table 2). Most of this catch was taken with haul seines, and some of it with otter trawls, pound nets, gill nets, and hook-and-line. There has been no steady trend in the catches with time--a feature characteristic of short-lived species. Most of the catch has consisted of 2- and 3-year old fish.

In the late 1970's, the recreational harvest of spot was about 907 metric tons (2 million pounds annually) (National Marine Fisheries Service 1980, 1984), but the catch may be much larger. In 1982 over 6.7 million spot weighing 559 metric tons (1.2 million pounds) were caught by marine recreational fishermen in the South Atlantic Region (NMFS 1985). Trends are difficult to define because surveys have been inadequate in some years, and methods have occasionally changed. The recreational catch is also composed mostly of 2- and 3-year old fish.

Management

There are no current state or federal restrictions on the commercial or recreational catch of spot.

Population Dynamics

Population levels of spot fluctuate tremendously; such changes are typical of species with short life spans. Year-class strength is probably determined during the larval and postlarval stages (Norcross 1983); however, estimates of mortality for the larval stage have not been reported.

Weinstein and Walters (1981) found that rates of mortality in postlarval and juvenile spot varied among years and among areas. Mortality was significantly higher in 1977 than in 1978 in polyhaline marshes due to predation by the Atlantic silverside, *Menidia menidia*, and the striped killifish, *Fundulus majalis*. High mortality rates observed in 1978 in oligohaline marshes were believed due to extremely high freshwater flows in winter and spring, which displaced spot from their preferred habitats.

No information is available on the status or structure of populations in the South Atlantic Region. Given the short life span of the species, the extensive offshore spawning grounds, and the prolonged spawning period, it is likely that spot inhabiting the South Atlantic Region compose a single population.

ECOLOGICAL ROLE

Food and Feeding Habits

Spot display two distinct feeding modes. Larvae are size-selective

Table 2. Commercial landings (thousands of pounds) of spot, and catch values (thousands of dollars) in the South Atlantic Region from 1969 to 1977 (National Marine Fisheries Service 1972, 1974, 1975a,b, 1976, 1978a,b, 1980, 1984).

	North Carolina		South Carolina		Georgia		Florida	
Year	pounds	value	pounds	value	pounds	value	pounds	value
1969	1488	188	454	43	2	1	875	158
1970	1529	142	368	37	9	1	1398	229
1971	1190	173	1286	83	6	1	2891	474
1972	3902	378	2269	207	33	3	1940	323
1973	5398	676	1455	233	34	4	921	155
1974	5607	625	358	40	16	2	1748	259
1975	8300	861	1491	253	9	1	841	163
1976	2674	348	1013	181	18	3	534	109
1977	3805	469	295	59	7	1	1029	183

plankton feeders, and juveniles and adults are predators on infaunal and epibenthic invertebrates. There have been no studies to date of the feeding habits of larval spot in the South Atlantic Region, but general patterns may be inferred from studies in the northern Gulf of Mexico (Govoni et al. 1983). Larvae initially eat small prey (tintinnid ciliated protozoans, invertebrate eggs, and copepod nauplii) and then eat progressively larger food (larval pelecypods, copepodites, pteropods, and adult copepods) as they grow to 10-15 mm SL. Larvae of all sizes seemingly feed diurnally (Govoni et al. 1983).

Regional differences in the diets of larval spot appear to reflect prevailing hydrographic conditions. Larvae collected near river mouths had fed on taxa typical of estuarine waters and larvae collected offshore had fed on taxa representative of more oceanic areas (Govoni et al. 1983). Regardless of geographic area, major prey categories remained fairly similar.

The zooplankton of the South Atlantic Region sometimes shows tremendous geographic variation (Bowman 1971), due in part to the periodic intrusion of cold-water upwellings onto the continental shelf. The diets of larval spot, therefore, probably vary according to geographic distribution of the zooplankton. Differences in diets associated with upwellings may affect the survival of larval spot; however, the larvae have relatively high assimilation efficiencies, and dependence on zooplankton patches appears to be less than that of some other abundant fishes (Govoni et al. 1982, 1985).

Postlarval spot entering the estuary apparently feed much like larvae. Early accounts showed that individuals up to 25 mm SL fed primarily on planktonic copepods and ostracods (Welsh and Breder 1923; Hildebrand and Schroeder 1928; Hildebrand and Cable 1930). Postlarval spot, 17-24 mm SL, fed mainly on copepods (mostly Harpacticoida, Centropages spp., Temora spp., and Acartia spp.) in the Newport River estuary (Kjelson et al. 1975). Postlarvae feed throughout daylight hours (Kjelson et al. 1975; Peters and Kjelson 1975), but feeding rates are highest in late morning (Kjelson and Johnson 1976). Field and laboratory data have indicated that the size of prey increases with the size of the postlarvae (Kjelson and Johnson 1976).

The transformation from postlarvae to juveniles (at about 25 mm SL) marks a change from a sight-feeding planktivore to a partly olfactory-dependent benthic feeder. The bodies of transforming postlarvae become deeper, their mouths and eyes smaller, and their sensory appendages more developed (Chao and Musick 1977). The diet of large postlarvae and small juveniles reflects this change; small juveniles prey on insect larvae, polychaetes, harpacticoid copepods, and other crustaceans (Welsh and Breder 1923; Hildebrand and Cable 1930; Roelofs 1954; Townsend 1956; Stickney et al. 1975; Sheridan 1979; Hodson et al. 1981b).

Juveniles seemingly switch to nocturnal feeding shortly after transformation, which may be a strategy for predation avoidance (Hodson et al. 1981b). Recent evidence attributes some distribution patterns to differential mortality due to size-selective predation (Polgar 1982). Another possible explanation for nocturnal feeding may involve avoidance of high daytime temperatures in shallow marsh areas (Hodson et al. 1981b). Finally, prey availability may be much greater at night than during the day because many invertebrate prey species are nocturnal.

Plant material and detritus noted in stomachs of juvenile and adult spot probably provide little nutritional value because spot lack cellulase activity in their gut (Stickney and Shumway 1974). However, the microbial flora associated with this material may provide some nutritive value (Cammen et al. 1978). This material is probably ingested incidentally, as juveniles and adults occasionally feed by scooping up or diving into the substrate (Roelofs 1954; Chao and Musick 1977).

Diets of larger juveniles are variable. Studies within the South Atlantic Region (Stickney et al. 1975, Hodson et al. 1981b) showed no pattern in the diet of spot, and similar findings have been reported in other areas (Sheridan 1979). Regional differences in the diets are probably due to differences in the availability of prey in the variety of habitats in which spot live.

The prey of adults in estuarine or coastal waters of the South Atlantic Region has not been reported, but adult spot probably feed much as they do in other areas. Chao and Musick (1977) reported that adult spot in Chesapeake Bay were nocturnal predators on zooplankton, benthic infauna, and epifauna. Organisms most frequently consumed were polychaetes (mostly Pectinaria gouldii, Glycinde solitaria, Amphitrite spp., Nereis succinea, and Nepthys spp.), amphipods (Gammarus spp.), cumaceans, gastropods, pelecypods, nematodes, the mysid Neomysis americana, and several copepods. Livingston (1984) reported similar findings for two populations of spot in the Gulf of Mexico.

Production and Energetics

Because spot migrate offshore in fall, their production may represent a considerable energy exchange between estuarine and shelf ecosystems. Weinstein and Walters (1981) estimated production on a monthly basis from collections in the Cape Fear estuary. Estimates pooled from several sampling sites for the entire 7-month period of marsh residence for young-of-the-year resulted in a value of 0.17 g wet weight/m^2. This was equivalent to 0.05 g dry weight/m^2 or 257 calories/m^2 (Weinstein and Walters 1981). Adams (1976) estimated production for spot in two seagrass (Zostera marina) habitats at Bogue Sound and Phillips Island, North Carolina. His study included all age classes, though it probably emphasized young-of-the-year because of the winter and spring sampling periods. Monthly production estimates ranged from 37 to 356 calories/m^2. These studies suggest that marshes and seagrass beds are similarly productive as nursery areas for spot.

Estimates of the daily ration of postlarvae relative to the fish's wet body weight have ranged from 4.3% to 9.0% (Kjelson et al. 1975; Kjelson and Johnson 1976). The lower ration estimates (4.3%) are less than some predictions of metabolic need based on oxygen consumption requirements (Kjelson et al. 1975; Kjelson and Johnson 1976); the discrepancy between the ration and metabolic need was believed to be due to an inadequate food supply during the sampling period (Kjelson et al. 1975). The higher daily ration estimates (9.0%) were obtained from larvae captured a year later, when the food supply was greater. Such findings support the critical period concept which maintains that year-class strength is determined by the availability of food after the larval yolk supply has been used (see May 1974), and are similar to studies of other marine fishes (Houde 1978). The tremendous fluctuations observed in spot populations in the past (Joseph 1972) may thus be due to variations in survival of larvae. In addition, such estimates indicate that larval and postlarval spot entering estuaries may significantly affect copepod populations (Thayer et al. 1974; Kjelson and Johnson 1976).

Predation and Parasitism

There is little published information about predation on spot. Because of their abundance and wide distribution they are probably preyed upon by a large number of other fishes. Weinstein and Walters (1981) reported that silversides (Menidia spp.) preyed heavily on postlarvae in estuaries; their data suggested that predation affects distribution patterns of postlarvae.

Juvenile and adult spot are eaten by many other fishes, including striped bass, Morone saxatilis; silky shark, Carcharhinus falciformis; seatrout, Cynoscion spp.; bluefish, Pomatomus saltatrix; mackerels, Scomberomorus spp.; longnose gar, Lepisosteus osseus; and flounders, Paralichthys spp. (Hollis 1952; Dawson 1958; DeVane 1978; Rozas and Hackney 1984).

Few external parasites of spot have been reported. The parasitic copepods Lernaeenicus radiatus and Ergasilus lizae (Dawson 1958) have been reported from spot collected off South Carolina and in the Gulf of Mexico, respectively. The marine leech Myzobdella lugubris has been reported from spot (Sawyer et al. 1975).

The spot serves as host to many different types of internal parasites, including a microsporidean, Ichthyosporidium sp.; the monogenetic trematodes Tagia bairdiella, Pedocotyle minima, and Diclidophora caudalis; the digenetic trematode Aphanurus sp.; and the acanthocephalan Telosentis tenuicornis (Koratha 1955; Bullock 1957; Hargis 1957; Schwartz 1963; Sprague 1966; Sprague and Hussey 1980; Govoni 1983).

ENVIRONMENTAL REQUIREMENTS

Temperature, Salinity, and Dissolved Oxygen

Spot occur throughout a wide range of physicochemical conditions; however, relatively little is known about the effects of physicochemical conditions on different stages of spot. In most studies, only the limits of tolerance of a particular life stage to one or two environmental variables have been determined; virtually nothing is known about interactive or chronic effects.

Tolerance to thermal shock and other environmental extremes varies with developmental stage (Hettler and Clements 1978; Hartwell and Hoss 1979; Hodson et al. 1981a). Laboratory studies indicated that spot embryos do not develop at temperatures below 14 °C, but that larvae can tolerate temperatures as low as 5 °C (Hettler and Clements 1978). Burton (1979) reported that ventilation rates indicative of cold stress occurred in juveniles held at 5 °C. Tolerance of spot eggs to thermal shock varies seasonally; the eggs are affected more by heat shock than are early embryos and larvae (Hettler and Clements 1978). The rate of post-shock cooling also affected egg and larval mortality; rapid cooling increased mortality.

Early field observations (Hildebrand and Cable 1930; Dawson 1958) suggested that juveniles may be more tolerant of low temperatures than adults. "Cold shock" has been reported in larval fish returned to acclimation temperatures following thermal shock (Hoss et al. 1974; Hettler and Clements 1978). However, the temperature tolerance of large juvenile and adult spot is not known.

The upper temperature tolerance and the thermal shock tolerance of early life history stages also vary with acclimation temperature (Hoss et al. 1974; Hettler and Clements 1978; Hartwell and Hoss 1979; Hodson et al. 1981a). As acclimation temperatures increase, tolerance to heat shock decreases. The upper temperature tolerance for postlarval and small juvenile spot is about 35 °C, depending on the size of the fish, its condition, and the acclimation temperature (Hodson et al. 1981a).

Hodson et al. (1981a) found that as acclimation temperature increased, critical thermal maxima (CTM) of spot also increased. However, a significant interaction effect was evident between temperature and salinity, such that CTM values increased with decreased salinity at low acclimation temperature (10 °C), but decreased with decreasing salinity at high acclimation temperature (30 °C). Thus because young spot are initially acclimated to cold ocean temperatures, the decrease in salinity as they move into estuaries increases their CTM and tolerance to higher temperatures that often occur there. In addition, spot entrained in power plant cooling water may have an increased chance of survival if that water is of low salinity (Hodson et al. 1981a).

Salinity may affect development of spot. Powell and Gordy (1980) reared spot successfully at 30-35 parts per thousand (ppt), and found only minor differences (probably temperature-related) between laboratory-reared larvae and those collected in the South Atlantic Region and the Gulf of Mexico. Low salinities do not appear to be necessary for development and metamorphosis into juveniles; however, the effects of salinity on survivorship of larvae and indirect effects on later stages are not known. Perez (1969) found that spot were more active at a higher rate of salinity change (10 ppt/h) than at lower rates (5 ppt/h, 1 ppt/h) and suggested that spot may avoid areas with rapidly changing salinity.

The tolerance of postlarval and juvenile spot to low oxygen concentrations is intermediate in comparison with other estuarine species (Burton et al. 1980; Subrahmanyam 1980; Neumann et al. 1981). Exposure of 90 mm TL spot to a dissolved oxygen concentration of 0.8 mg/l for 96 h at 27 °C resulted in 5% mortality; an oxygen concentration of 0.6 mg/l resulted in 95% mortality (Burton et al. 1980). These results should not be interpreted as indicating safe levels because the chronic effects of depressed oxygen levels on growth and survival are unknown. Concentrations greater than 0.6-0.8 mg/l could be below the tolerance level under conditions of increased activity, higher temperature, or other factors affecting metabolism (Burton et al. 1980). Although the metabolic rate of spot is relatively low, their oxygen requirements (per unit body weight) may render them unfit to survive hypoxia in shallow tidal pools (Subrahmanyam 1980).

Substrate and System Features

Spot use inshore estuarine and offshore marine environments during their ontogeny. Various life history stages are differentially distributed in estuaries and are critically dependent on different habitats. Thus, alterations of the salinity or temperature regimes of an estuary may have significant impacts on the population of spot in any particular estuary. Increased mortality or displacement and subsequent failure to recolonize some estuarine habitats have been observed after periods of altered river flow in North Carolina (Weinstein 1979; Weinstein and Brooks 1983).

Habitat alterations resulting from industrial effluents affect the abundance of spot in coastal seagrass systems (Livingston 1975, 1984). The composition and structure of the benthic community upon which larger spot feed were substantially altered, and the size-specific feeding patterns of spot were changed.

Studies by Kilby (1955), Springer and Bullis (1956), and Simmons (1957) suggested that substrate features are important in affecting the distribution of spot. Data from offshore cruises (Springer and Bullis 1956) showed higher catches over mud and sand bottom than over live bottom (sponge-coral) areas. In estuaries, spot appear to prefer substrates with lower organic content than those preferred by some other species of sciaenids (Weinstein 1979). Because current patterns affect settling of organic and inorganic particulates, alteration of the current patterns in estuaries may alter substrate features and other characteristics sufficiently to affect the distribution of spot and other estuarine species. Not all such changes may be harmful to the population of spot in any particular area; however, the effects in any given area would be difficult to predict.

Contaminants

Many pesticides, herbicides, heavy metals, and chlorination by-products have been found to have significant lethal or sublethal effects on all stages of the life history of spot. Developing eggs and larvae may be especially sensitive to environmental contaminants (Engel and Sunda 1979). Furthermore, because of their relatively long residence period in a particular tidal creek and the adjacent marsh (Weinstein 1983), postlarval and juvenile stages may be repeatedly exposed to various contaminants.

Several heavy metals (copper, lead, cadmium, and mercury) are known to be toxic to various life stages of spot (Engel and Sunda 1979; Hawkins et al. 1980), but no one has investigated the effects of a given metal on all developmental stages. Different metal forms (ions, free metal, etc.)

vary in toxicity and may change within estuaries. Copper ions inhibit hatching and development of spot (Engel and Sunda 1979), and cadmium levels of 10 parts per million (ppm) cause renal failure and death of juveniles (Hawkins et al. 1980). The toxicity of some metals to phytoplankton and invertebrates (Sunda and Guillard 1976; Anderson and Morel 1978; Sunda et al. 1978) may have deleterious effects on early life history stages of spot that rely on these organisms for food.

Many pesticides and herbicides have lethal and sublethal effects on spot (Bahner et al. 1977; Schimmel and Wilson 1977; Stehlik and Merriner 1983). Runoff from agricultural lands has caused widespread as well as localized fish kills in several South Carolina estuaries (J. Settle, South Carolina Wildlife and Marine Resources Commission, Charleston, pers. comm.). Agrochemicals have been implicated in fish kills in many estuarine areas (Stehlik and Merriner 1983). Sublethal quantities accumulating through chronic exposure can produce skeletal deformities. Many of these compounds are relatively persistent in the aquatic environment, as they remain in sediments and animal tissues for long periods. Because spot appear to remain in a particular creek or area of marsh throughout most of the summer growth period, they may be more likely than many other estuarine fishes to suffer from repeated exposure to these compounds.

Chlorine-produced oxidants (CPO) from secondary sewage treatment wastes and electric generating plants also can have significant deleterious effects on juvenile spot (Tsai 1968; Middaugh et al. 1977, 1980). High concentrations (>0.13 mg CPO/liter) were acutely toxic in flowing water tests conducted at 29-31 °C and salinities of 26-31 ppt. Sublethal concentrations (<0.12 mg CPO/liter) depressed feeding during an 8-day period of exposure (Middaugh et al. 1980). It is not known whether such sublethal concentrations affect growth. The toxicity of bromochlorinated seawater to spot appears to be greater than that of chlorinated seawater. At high operating levels, some sewage treatment plants may release quantities of bromochlorinated sewage sufficient to cause death of juvenile spot (Roberts and Gleeson 1978; Roberts 1980). Not all stages of spot have been examined with regard to toxicity, and almost no information is available about the effects of longterm exposure of spot to these compounds.

Other Factors

Spot have significantly slower swimming speeds than other abundant estuarine fishes (Hettler 1979). Small spot (<2.7 cm SL) cannot maintain their orientation in currents exceeding 15 cm/s, and somewhat larger spot (2.5-5.0 cm SL) cannot maintain their orientation in currents exceeding 30 cm/s (Rulifson 1977; Hettler 1979). These low swimming speeds and endurance levels could result in significant mortality of spot caught in intake structures at industrial or power generating plants.

Swimming and orientation behavior of spot vary with size. Spot <5 cm SL orient into weak currents (<15 cm/s), whereas larger spot drift with them. Thus, despite their increased swimming capabilities, the larger spot are also vulnerable to impingement on intake structures (Rulifson 1977). Alterations in the design or careful placement of intake structures may reduce impingement and entrainment of spot.

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16. Abstract (Limit: 200 words)

Species profiles are literature summaries of the life history, distribution, and environmental requirements of coastal fishes and invertebrates. Profiles are prepared to assist with environmental impact assessment. The spot (Leiostomus xanthurus) is an abundant fish in coastal waters of the South Atlantic Region. It is important to commercial and recreational fisheries. In the South Atlantic Region, spot spawn offshore from October to March. The larvae are transported from the offshore spawning grounds to estuarine nursery areas. Juvenile spot initially congregate in shallow tidal creeks, but then disperse into deeper water as they get larger. Spot mature at 2-3 years of age. As larvae, spot feed on plankton, but switch to benthic invertebrates as juveniles and adults. Juvenile and adult spot are eaten by many other fishes. Tolerance to thermal shock and other environmental extremes varies with developmental stage. Alterations of the salinity or temperature regimes of an estuary may affect populations of spot; disturbances that affect the benthic community upon which spot feed may also affect spot abundance. Spot are not strong swimmers and may, therefore, suffer significant mortality due to intake structures at industrial or power generation plants.

17. Document Analysis a. Descriptors

Estuaries
Fishes
Growth
Feeding habits

b. Identifiers/Open-Ended Terms

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Leiostomus xanthurus
Habitat
Salinity requirements
Temperature requirements
Spawning
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c. COSATI Field/Group

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