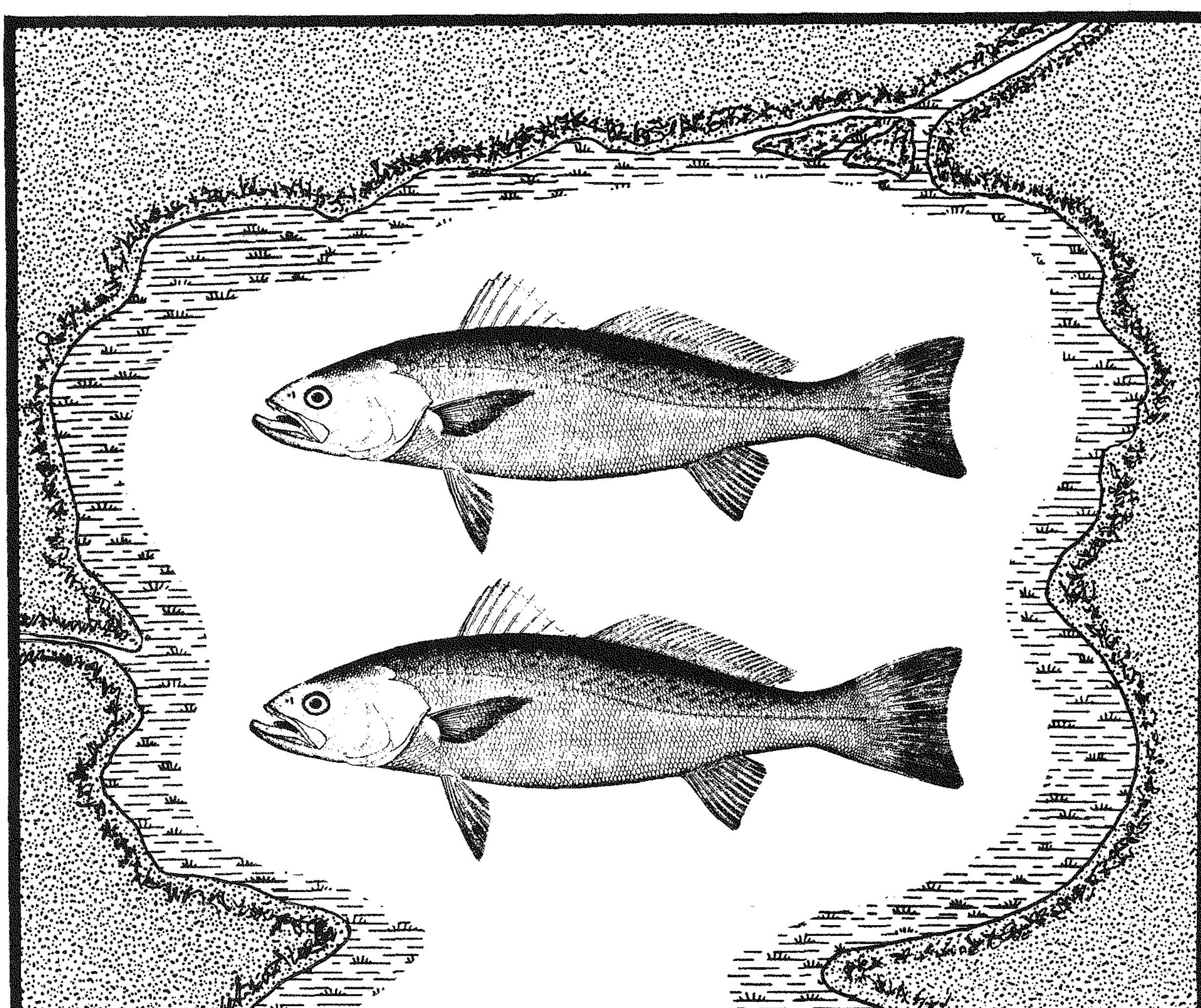
Biological Report 82(11.109)
August 1989

TR EL-82-4

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

WEAKFISH



Coastal Ecology Group
Waterways Experiment Station

Fish and Wildlife Service

U.S. Department of the Interior

U.S. Army Corps of Engineers

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

WEAKFISH

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by

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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.

Millikin and Williams (1984) previously published a review of the nomenclature, taxonomy, morphology, distribution, life history, population structure and dynamics, and the fishery of the blue crab.

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

Information Transfer Specialist
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1010 Gause Boulevard
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U.S. Army Engineer Waterways Experiment Station
Attention: WESER-C
Post Office Box 631
Vicksburg, MS 39180.

CONVERSION FACTORS

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

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

I am grateful to Stuart Wilk and Tony Pacheco of the National Marine Fisheries Service, Sandy Hook, New Jersey, for their reviews of the manuscript and helpful suggestions.

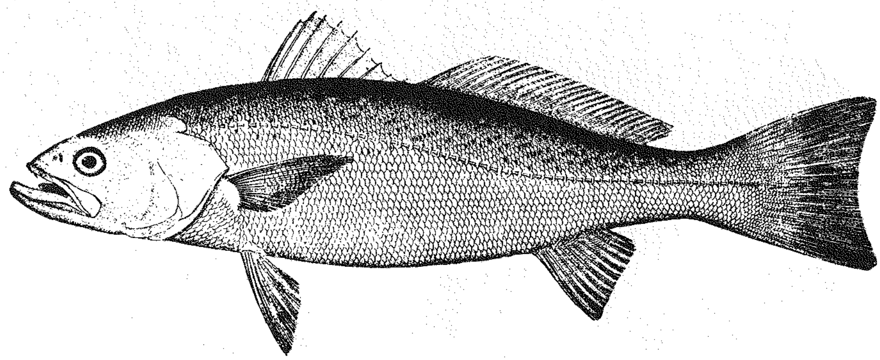

Figure 1. Weakfish (Cynoscion regalis) (from Goode 1884).

WEAKFISH

NOMENCLATURE/TAXONOMY/RANGE

Scientific name . . . . . . Cynoscion regalis
Preferred common name . . . . Weakfish (Figure 1)
Other common names . . . . Gray trout, squeteague, sea trout, trout, tide-runner
Class . . . . Osteichthyes
Order . . . . Perciformes
Family . . . . Sciaenidae

Geographical range ....Weakfish occur along the Atlantic coast of the United States from southern Florida to Massachusetts Bay, straying occasionally to Nova Scotia and into the eastern Gulf of Mexico (Goode 1884; Hildebrand and Schroeder 1928; Bigelow and Schroeder 1953; Guest and Gunter 1958; Leim and Scott 1966; Struhsaker 1969; Weinstein and Yerger 1976; Chao 1978). They are most abundant from North Carolina to New York (Figure 2).

MORPHOLOGY/IDENTIFICATION AIDS

The following description is that of Johnson (1978), summarized from Jordan and Evermann (1896), Eigenmann (1901), Hildebrand and Schroeder (1928), Ginsburg (1929), Perlmutter (1939), Massmann (1963), Tagatz (1967), Miller and Jorgenson (1973), and Chao (1978).

Dorsal rays 24-29, modally 27. Anal rays 10-13, modally 12. Vertebrae 25. Gill rakers 4-5 upper,10-12 lower, and typically 5 + 12. A pair of large canine-like teeth at the tip of upper

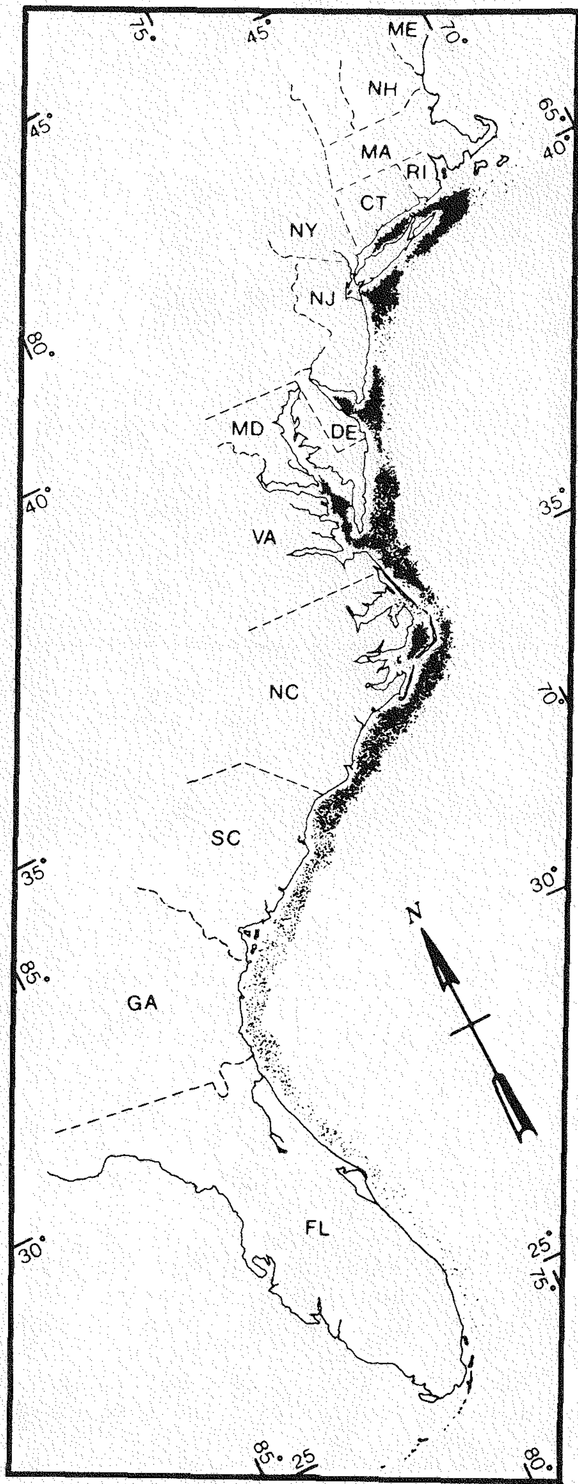

Figure 2. General distribution of the weakfish along the Atlantic coast of the United States (from Wilk 1976).

jaw and a row of distinctly enlarged teeth in the lower jaw. Body elongate, moderately compressed. Head long, snout pointed. Mouth large, oblique, lower jaw projecting, maxillary reaching to posterior margin of pupil or beyond. Dorsal fin with a deep notch between the spinous and soft portions. Caudal emarginate in individuals less than 300 mm total length (TL). Color dark olive green above with the back and sides variously burnished with purple, lavender, green, blue, gold or copper, and marked with a large number of small dark spots which appear as oblique streaks running along scale rows above lateral line. Lower surface forward to tip of jaw white or silvery, sometimes iridescent. Dorsal fins dusky, the lower edge yellowish at base. Pelvic and anal fins yellow; pectoral fin olive on outer side, usually yellow on inner side.

REASON FOR INCLUSION IN THE SERIES

The weakfish is one of the most abundant fishes in the estuarine and nearshore waters of the Atlantic coast (Wilk 1979). It is a valuable recreational species and a major component of the gill-net, pound-net, haul-seine, and trawl fisheries along the coast (Hildebrand and Schroeder 1928; Wilk 1981). Periods of high landings have generally been followed by sudden and precipitous declines in catch, the causes of which are not known. Overfishing and habitat alterations have been suggested as possible causes.

LIFE HISTORY

Spawning

Weakfish mature at age I throughout their geographic range; however, length at maturity differs between northern weakfish (Delaware Bay and north) and weakfish from North Carolina. In northern fish, females matured at 256 mm and males at 251 mm TL (Shepherd and Grimes 1984); in North Carolina females spawned at 230 mm and males at 180 mm TL (Merriner 1976).

Weakfish spawn in the nearshore and estuarine areas of the coast after the spring inshore migration (Welsh and Breder 1923; Hildebrand and Schroeder 1928). The spawning season of weakfish is earlier and somewhat longer in North Carolina than in areas to the north; it extends from March to September, and peaks from April to June (Merriner 1976). In the New York Bight (Delaware Bay to New York), the season extends from May to mid-July (Shepherd and Grimes 1984). Two spawning peaks are reported for weakfish in New York Bight estuaries: the earlier mid-May peak, attributed to the largest individuals or "tide-runners," is followed by a June peak developed by smaller fish (Shepherd and Grimes 1984).

Fecundity

Estimates of fecundity for southern weakfish differ from those for fish from the New York Bight. A weakfish 500 mm TL from North Carolina produced 2,051,080 ova, whereas a northern fish of the same length produced only 306,159 ova (Merriner 1976; Shepherd and Grimes 1984). The following relationships between fecundity (F) and standard length (SL) in millimeters, total length (TL) in millimeters, weight (W) in grams, and gutted weight (GW) in grams, where ln is the natural logarithm and r is the coefficient of determination, were presented for weakfish in North Carolina (Merriner 1976):

$$\ln F = -2.154 + 2.776 \ln SL; \quad r^2 = 0.85$$

$$\ln F = -1.884 + 2.642 \ln TL; \quad r^2 = 0.86$$

$$F = 21{,}198 + 1{,}279\ W; \quad r^2 = 0.88$$

and the New York Bight (Shepherd and Grimes 1984):

$$\ln F = -16.322 + 4.659 \ln TL; \quad r^2 = 0.835$$

$$\ln F = 1.975 + 1.542 \ln GW; \quad r^2 = 0.839.$$

Larvae

The embryology and larval development of weakfish were described by Welsh and Breder (1923), Pearson (1941), Harmic (1958), Scotton et al. (1973), Lippson and Moran (1974), Johnson (1978), and Powles and Stender (1978). Hatching occurs in 36-40 hours at 20-21 °C (Welsh and Breder 1923). Weakfish larvae range from 1.5 to 1.75 mm TL at hatching and become demersal by 8 mm TL (Welsh and Breder 1923; Pearson 1941). Weakfish larvae have been collected in nearshore waters to 70 km offshore in coastal ichthyoplankton surveys (Berrien et al. 1978).

Juveniles

The use of estuarine areas as nursery grounds by weakfish is well documented. Juveniles are collected most frequently in trawl sampling of the deeper waters of rivers, bays, and sounds, rather than in beach seine collections from shoal areas (Greeley 1939; Massmann et al. 1958; Schwartz 1961, 1964a; Richards and Castagna 1970; Thomas 1971; Chao and Musick 1977).

Extensive sampling of North Carolina sounds revealed that juvenile weakfish were most abundant in areas designated by the North Carolina Division of Marine Fisheries as secondary nursery areas (usually shallow bays or navigation channels characterized by moderate depths, slightly higher salinities, and presence of sand and/or sand-grass bottoms) rather than in primary nursery areas (shallow tributaries of low salinity and mud and/or mud-grass bottom) (Spitsbergen and Wolff 1974; Purvis 1976). In Chesapeake Bay and Delaware Bay juvenile weakfish migrate from high to low salinity areas throughout the summer, return to high salinity waters in fall, and leave the estuaries by December (Hildebrand and Schroeder 1928; Massmann et al. 1958; Thomas 1971; Chao and Musick 1977).

Juvenile weakfish are distributed along the coast from Long Island to North Carolina at depths of 9-26 m in late summer and fall (Clark et al. 1969). Young-of-the-year weakfish were caught in ocean trawl surveys along the coast of North Carolina in 1968-1981 at depths of 9-18 m during fall and winter, and from North Carolina to Florida at depths of 9-11 m in winter and early spring (Wilk and Silverman 1976).

Adults

Adult weakfish migrate seasonally between inshore and offshore waters (Welsh and Breder 1923; Merriner 1973; Wilk 1976, 1979, 1980). Warming of coastal waters in spring prompts an inshore and northerly migration of adults from their wintering grounds to sounds, bays, and estuaries (Figure 3). The larger fish move inshore first and tend to congregate in the northern part of the range (Wilk and Silverman 1976; Wilk et al. 1977). Catch records from the pound-net and haul-seine fisheries in Delaware Bay, Chesapeake Bay, and Pamlico Sound indicate that the large fish are followed by a second group of smaller weakfish in summer (Higgins and Pearson 1928; Massmann 1963; Daiber and Smith 1971; Sholar 1979; DeVries 1980, 1981). Shortly after their initial appearance, weakfish return to the larger bays and possibly to the ocean to spawn. In northern areas a

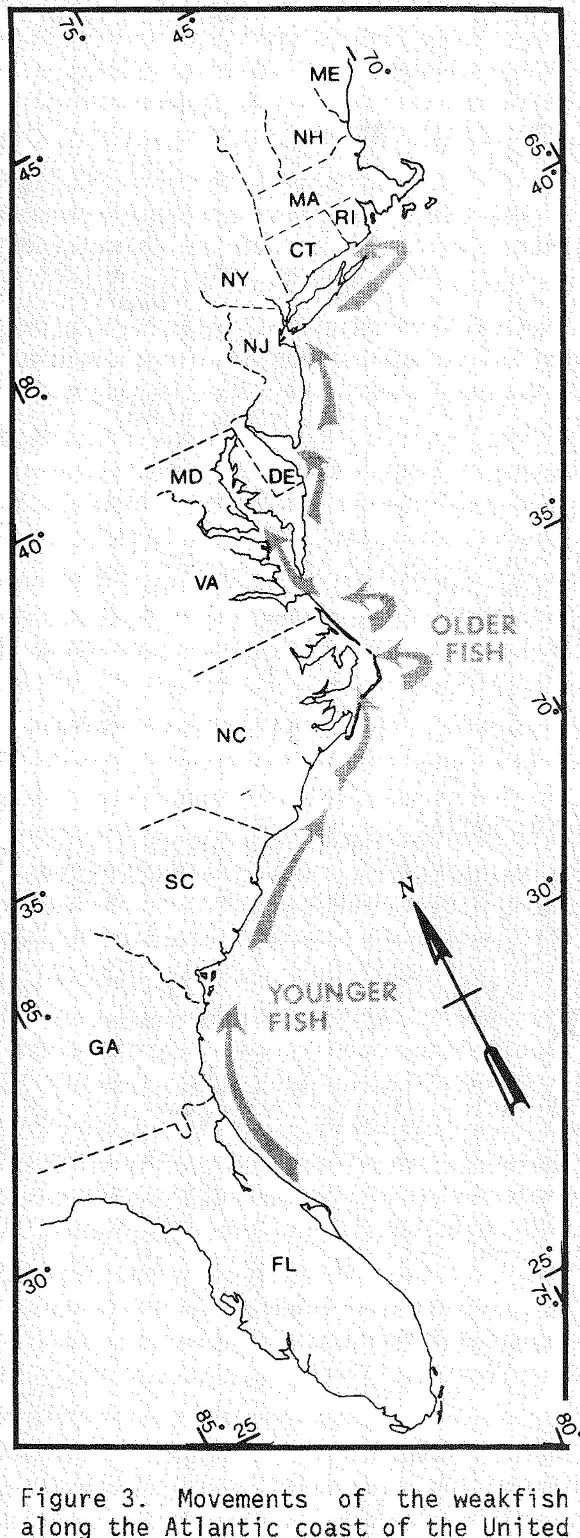

Figure 3. Movements of the weakfish along the Atlantic coast of the United States during spring and summer (from Wilk 1976).

greater proportion of the adults spend the summer in ocean waters rather than in estuaries.

As water temperatures decline in fall, weakfish form aggregations and move offshore and generally southward along the coast (Nesbit 1954; Massmann et al. 1958; Wilk 1976; Wilk and Silverman 1976) (Figure 4). The Continental Shelf from Chesapeake Bay to Cape Lookout, NC, appears to be the major wintering ground for weakfish. A study of the winter trawl fishery off the Virginia and North Carolina coasts indicated that most weakfish were caught in the southern fishing area between *Ocracoke Inlet* and Bodie Island, NC, at depths of 18-55 m (Pearson 1932). Some weakfish may remain in inshore waters throughout the winter from North Carolina southward (Goode 1884; Higgins and Pearson 1928; Hildebrand and Cable 1934).

GROWTH CHARACTERISTICS

Weakfish growth is particularly rapid during the first year. In Delaware Bay, juveniles may grow from 20 to 35 mm/month during June-September (Ichthyological Associates 1980) and may attain lengths ranging from 100 to 175 mm TL throughout the range. The variability of sizes within year classes results from the extended spawning season. Massmann et al. (1958) and Thomas (1971) found two distinct size groups of young-of-the-year weakfish in fall in Chesapeake Bay (45 and 85 mm) and Delaware Bay (30-40 and 110-130 mm). This apparently reflects two separate spawning peaks. Thomas (1971) did not find a bimodal length distribution for adult weakfish which may be due to differential mortality of late-spawned weakfish or to compensatory growth.

Weakfish age and growth studies indicated geographic variations in growth, with a pattern of increasing size toward the northern end of the

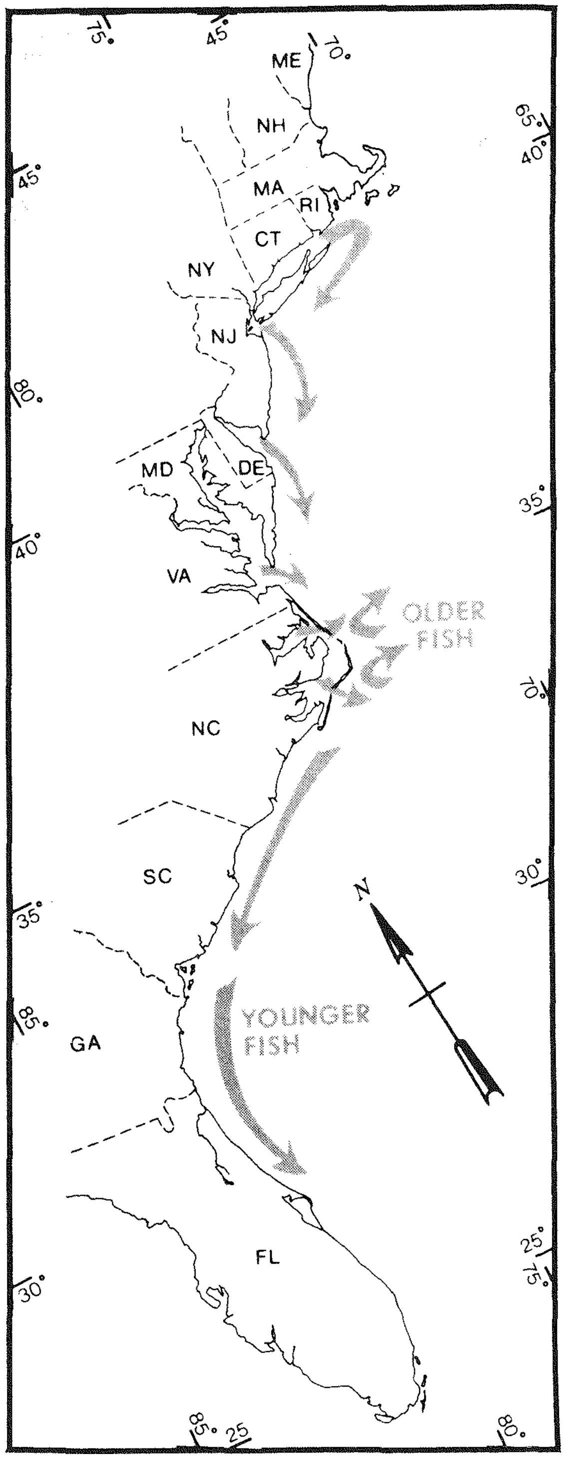

Figure 4. Movements of the weakfish along the Atlantic coast of the United States during fall and winter (from Wilk 1976).

range (Table 1). Shepherd and Grimes (1983) found that northern weakfish collected between Cape Cod, MA, and Ocean City, MD, were largest at each age and attained a greater maximum size and longevity (810 mm TL at age XI). Size at age of weakfish collected between Virginia Beach, VA, and Cape Fear, NC, was lowest (370 mm TL at age III) and similar to that reported by Taylor (1916) and Merriner (1973). In weakfish from Chesapeake Bay (Ocean City, MD, to Virginia Beach, VA) size at age and maximum size were intermediate and were comparable to what Seagraves (1981) reported for Delaware Bay in 1979. Shepherd and Grimes (1983) suggested that these growth variations may result from differing allocations of energy to somatic growth according to environmental and migratory requirements. Growth of weakfish of southern origin may also be limited by prey availability or by genetic differences.

Records of weakfish size at various ages show differences over time (Table 2). A comparison of female weakfish from the New York Bight showed that age-IV females in 1929 averaged 340 mm TL compared to 480 mm TL in 1952 and 580 mm TL in 1980 (Perlmutter et al. 1956; Shepherd and Grimes 1983). Known longevity was 8 yr in 1929, 6 yr in 1952, and 11 yr in 1980. Similar changes in growth and longevity were reported for weakfish in Delaware Bay (Seagraves 1981).

Growth of weakfish was described by the von Bertalanffy growth curve:

$$l_t = L_\infty (1 - e^{-K(t-t_o)}),$$

where l_t is length at age t, L_∞ is the asymptotic length, K is the Brody growth coefficient, t is age, and t_o is the hypothetical age at which the fish would have been zero length. Von Bertalanffy growth parameters showed a trend of decreasing values of L_∞ from north to south, with the exception of Delaware Bay weakfish in 1979 (Seagraves 1981; Shepherd and Grimes 1983) (Table 3). A larger asymptotic length was obtained for Delaware Bay weakfish in 1979 than in 1956.

Length-weight relationships have been developed for weakfish from throughout the Mid-Atlantic Region

Table 1. Mean total lengths (mm) at age of weakfish from three regions (from Shepherd and Grimes 1983).

Age group	Ocean City, MD to Cape Cod, MA 1979-81		Virginia Beach, VA to Ocean City, MD 1979-81		Cape Fear, NC to Virginia Beach, VA 1979-81	
	Male	Female	Male	Female	Male	Female
I	200	200	200	200	220	210
II	310	320	280	300	270	300
III	460	480	450	460	320	370
IV	560	580	560	600		
V	630	640	600	670		
VI	660	680		710		
VII	660	700				
VIII	680	720				
IX	710	730				
X	690	750				
XI	700	810				

Table 2. Mean total lengths (mm) at age of weakfish.

Age group	New York 1929[a] M	New York 1929[a] F	New York 1952[a] M	New York 1952[a] F	Delaware Bay 1965[a] M & F	Delaware Bay 1979[b]* M	Delaware Bay 1979[b]* F	Chesapeake Bay 1929[a] M & F	North Carolina 1916[c] M & F	North Carolina 1967-69[d]* M	North Carolina 1967-69[d]* F
1	200	190	210	200	189	198	196	173	209	185	192
2	260	260	280	280	246	324	327	263	277	264	272
3	300	300	360	360	286	451	455	301	328	323	347
4	320	340	480	480	319	543	553	342	405	384	432
5	360	380	560	560		604	618	386	486	496	509
6	410	410	640	640		681	635	440	479		680
7	440	430					675	489	560		
8	520	440					737		589		
9							762				

a Perlmutter et al. (1956).
b Seagraves (1981).
* TL approximated by: TL = 1.21 SL.
c Taylor (1916).
d Merriner (1973)

Table 3. Von Bertalanffy growth parameters for weakfish (sexes combined) where L_∞ is the asymptotic length in millimeters (SL) (Standard length approximated by: SL=TL/1.21), t_o is the hypothetical age at which the fish would have been zero length, K is the Brody growth coefficient, and W is weight in grams.

Area	L_∞	t_o	K	W(g)
Cape Cod, MA - Ocean City, MD[a]	683	0.031	0.274	5237.0
Ocean City, MD - Virginia Beach, VA[a]	567	0.051	0.350	3026.0
Virginia Beach, VA - Cape Fear, N.C.[a]	331	-1.270	0.550	608.3
Delaware Bay 1956[b]	315	-0.500	0.327	-
Delaware Bay 1979[b]	735	0.084	0.236	-

a Shepherd and Grimes (1983).
b Seagraves (1981).

(Table 4). Merriner (1973) found significant length-weight differences between males and females which he attributed to proportionately greater development of ovarian tissue relative to testicular tissue.

COMMERCIAL AND RECREATIONAL FISHERIES

The principal commercial methods used to harvest weakfish include trawls, pound nets, haul seines, and gill nets. In addition, weakfish are caught in purse seines, floating traps, trammel nets, fyke nets, hoop nets, and hand lines. Generally these fisheries can be classified as mixed opportunistic fisheries that concentrate directly on weakfish for brief periods (Wilk and Brown 1982). During the mid-1970's, high-speed pelagic trawls in the form of paired trawls and mid-water trawls were introduced in the New Jersey-Delaware area.

Although the methods used to harvest weakfish for food have essentially remained the same, there have been significant shifts in the contributions of trawls and pound nets during the past 40 yr (Perlmutter 1959; Merriner 1973; Wilk 1981). During the period 1940-49, pound nets, haul seines, gill nets, and trawls took approximately 63%, 11%, 3%, and 23% of the total catch, respectively. During 1970-79, the contribution of these same four gear types was 20%, 11%, 9%, and 60%, respectively (Wilk 1981).

Commercial landings of weakfish have fluctuated widely since the late 1800's. Two peaks in landings have occurred since 1940, an all-time high of 18,800 t in 1945 and 16,300 t in 1980. The distribution of weakfish landings has shifted historically from one geographic area to another (Wilk 1980) (Figure 5). The Chesapeake Bay region (Maryland and Virginia) contributed most to the total weakfish landings in the 1940's, followed by the Mid-Atlantic Region (New York, New Jersey, and Delaware), and the South Atlantic Region (primarily North Carolina). Weakfish landings remained low in all regions throughout the 1950's and 1960's. Since 1971, South Atlantic Region landings have exceeded those in one or both of the northerly regions. The shift in catch to the South Atlantic Region is probably more

Table 4. Length-weight relationships for weakfish using the equation: log W (g) = log a + b log L (mm), where W is weight in grams, L is length in millimeters (*TL, +SL), and a and b are constant.

Location	Sex	Log a	b	r	n	Length range (mm)
New York Bight[a*]	Combined	-4.877	2.948	0.99	666	59-768
Cape Cod, MA Ocean City, MD[b*]	Combined	-5.030	2.976	0.99	418	
Delaware Bay[c+]	Combined	-4.423	2.861	0.99	182	195-725
North Carolina[d+]	Male	-4.558	2.851	0.99	482	
	Female	-4.343	2.946	0.99	610	
	Combined	-4.374	2.934	0.99	1,650	

a From Wilk (1979). b From Shepherd and Grimes (1983).
c From Seagraves (1981). d From Merriner (1973).

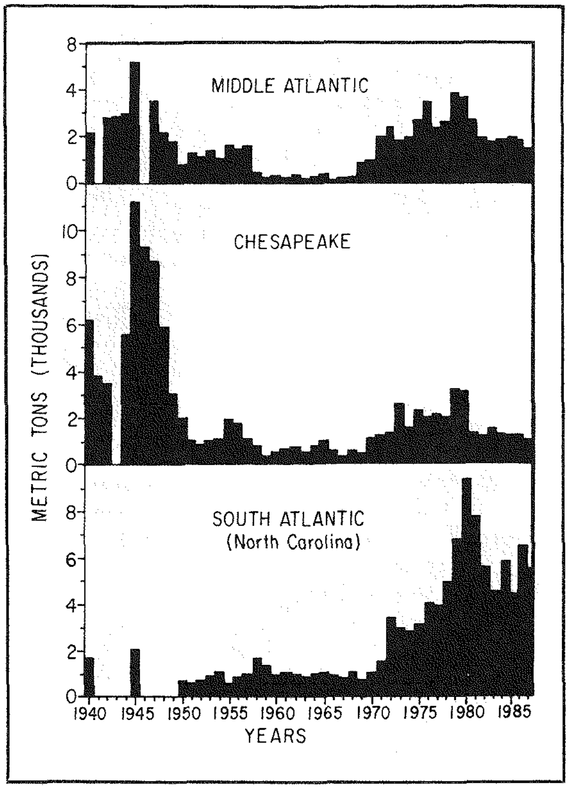

Figure 5. U.S. commercial landings of weakfish by geographic region.

a reflection of the increased mobility of the North Carolina fishing fleet, and a concomitant shift in the center of landings to North Carolina, rather than an actual shift in distribution of weakfish (Wilk 1981).

Weakfish have also been important to the recreational fishery since at least the 1800's (Goode 1884). Anglers take weakfish from boats while trolling and drift fishing, and from boats and shore while casting, live bait fishing, jigging, still fishing, and chumming, primarily during the warmer months of the year (Freeman and Walford 1974a, b, c, 1976a, b). Data from the National Marine Fisheries Service Marine Recreational Fishery Statistics Survey also indicate a peak in recreational landings in 1980 (20,544 t) followed by a sharp decline by 1982 (Table 5).

Table 5. Estimated number and weight of weakfish caught by recreational fishermen in the Mid-Atlantic Region (New York-Virginia) 1979-87. (National Marine Fisheries Service Marine Recreational Fishery Statistics Survey, Atlantic and Gulf Coasts 1979-87).

Year	Number (thousands)	Weight (t)
1979	5,157	5,793
1980	14,570	20,544
1981	8,833	6,397
1982	1,064	2,717
1983	5,779	5,397
1984	3,671	3,377
1985	3,099	3,013
1986*	11,106	6,053
1987	6,982	4,093

* Preliminary data.

ECOLOGICAL ROLE

Food Habits

Weakfish feed predominantly on penaeid and mysid shrimps, anchovies, and clupeid fishes (Welsh and Breder 1923; Thomas 1971; Merriner 1975; Stickney et al. 1975; Michaels 1984). A shift of food habits with growth was reported by Thomas (1971), Merriner (1975), and Stickney et al. (1975). Young weakfish feed mostly on mysid shrimp and anchovies; older weakfish feed on whatever clupeid species are abundant in an area. Michaels (1984) reported that anchovies (rather than clupeids) were the single most important prey fish of weakfish collected offshore (depths > 6 m). Cannibalism was reported to be significant in weakfish (Thomas 1971; Merriner 1975). Weakfish feed primarily between dusk and dawn (Lascara 1981; Michaels 1984). Chao and Musick (1977) correlated feeding structures with the food habits of juvenile sciaenids. The weakfish has an oblique mouth that enables it to capture pelagic prey from above and in front of it. Other adaptations for successful predation include a pair of large canine teeth at the tip of the upper jaw for grasping larger swimming prey and a fusiform body shape for fast pursuit.

A study of fish predator-prey interactions in areas of eelgrass (Zostera marina) in Chesapeake Bay indicated that weakfish are important top carnivores in this habitat (Lascara 1981). Field data and laboratory observations have suggested that weakfish forage along the periphery of eelgrass beds during periods of low light (dusk to dawn). The high percentage of blue crabs (Callinectes sapidus) (40) and spot (Leiostomus xanthurus) (18) in weakfish stomachs indicated that some feeding occurred in eelgrass beds, since these animals were considerably more abundant there than at adjacent non-vegetated sampling sites. The lack of eelgrass in stomachs and the oblique mouth position of the species suggested, however, that weakfish feed pelagically and not deep within the vegetation. In laboratory experiments, weakfish captured fewer prey as the percentage of vegetative cover increased (Lascara 1981).

Community Ecology

Surveys along the Atlantic coast indicated that estuaries provide feeding areas and spawning grounds for adult weakfish and are important nursery areas for the young. Studies in Delaware Bay (Thomas 1971) and Chesapeake Bay (Chao and Musick 1977) showed that several species of sciaenids, including weakfish, silver perch (Bairdiella chrysoura), spot, croaker (Micropogonias undulatus), and black drum (Pogonias **cromis**) were able to coexist in the estuaries; probable reasons include differences in spatial and temporal distribution, relative abundance (abundances of dominant competitors may be reduced by physical disturbance or predation), and food habits. Juveniles of these species enter the estuaries at different times of the year, and within a given period, the highest catches of each species are in different areas and depths. Although weakfish and croaker both prefer the deeper water in or near channels, croaker do not enter estuarine areas until fall after most weakfish have left. Differences in the morphology of the feeding apparatus enable each species to feed at different levels of the water column.

Diseases

Mahoney et al. (1973) reported that weakfish, especially juveniles, are one of the most susceptible species to the "fin rot" disease of marine and euryhaline fishes in the New York Bight. The consistent and most striking feature of the disease in weakfish is necrosis of the caudal fin followed by involvement on the other fins. Pollution is suspected to have a role in the disease. This disease has also been observed in weakfish from Delaware Bay and Georgia.

ENVIRONMENTAL REQUIREMENTS

Temperature

Weakfish eggs in all stages of development were collected in Peconic Bay, NY, and Narragansett Bay, RI, at temperatures of 12-24 °C (Perlmutter 1939; Herman 1963). Laboratory tests indicated that hatching of weakfish eggs was optimal between 18 and 24 °C (Harmic 1958).

Weakfish have been collected over a temperature range of 9.5 to 30.8 °C (Massmann et al. 1958; Richards and Castagna 1970; Merriner 1976). In areas of highest abundance of juvenile weakfish in Delaware Bay, water temperatures ranged from 28.0 °C in July to 17.2 °C in October (Thomas

1971). Decreasing water temperatures in fall appear to initiate movement of most weakfish out of the estuaries to deeper water. Older weakfish appear to precede the young of the year in moving out of the estuaries (Hildebrand and Cable 1934; Massmann et al. 1958; Thomas 1971).

Only a few weakfish have been collected at temperatures below 10 °C in Delaware Bay or Chesapeake Bay (Massmann et al. 1958; Abbe 1967; Thomas 1971). Hildebrand and Cable (1934) reported that some small weakfish (122-182 mm TL) remained in North Carolina estuaries and nearshore coastal waters year-round except during brief cold snaps. Dead and numb weakfish were seen in shallow waters when water temperatures suddenly dropped to 5 °C (Smith 1907; Hildebrand and Cable 1934).

Schwartz (1964b) subjected five weakfish collected at 20.7 °C to normal winter water temperatures. Swimming speed slowed drastically as the water temperature approached 10 °C, feeding ceased at 7.9 °C, and all fish died at 3.3 °C. Wilk (1979) reported that as temperature was gradually increased (0.05 °C/h) from the acclimated temperature range of 19-20 °C to almost 29 °C, weakfish showed a 35% increase in swimming speed accompanied by tighter and more frequent schooling; however, as the fish became acclimated to 29 °C their activity decreased to a point similar to that before the temperature was increased. This increased activity may help to move the animals from regions of adverse high temperature.

Salinity

Weakfish are euryhaline and have been collected at salinities ranging of 0.1 to 32.3 ppt (Massmann et al. 1958; Richards and Castagna 1970; Wilk and Silverman 1976; Wilk et al. 1977). Harmic (1958) collected eggs and larvae in Delaware Bay at salinities of 12.1 to 31.3 ppt. Juveniles have been taken in salinities from 0.1 to 31.7 ppt, but areas of most abundant catches had salinities of 2.0 ppt in June to 10.8 ppt in August (Massmann et al. 1958; Richards and Castagna 1970; Thomas 1971). Adults were collected over a salinity range of 6.6 to 32.3 ppt (Richards and Castagna 1970; Wilk and Silverman 1976; Wilk et al. 1977).

Dissolved Oxygen

Information on relationships between dissolved oxygen and weakfish tolerance or preferences is scarce. Thomas (1971) reported that upriver movement of juvenile weakfish in the Delaware River was blocked by low oxygen concentrations (1.0-2.3 ppm). In areas of the most abundant catches of juvenile weakfish in Delaware Bay, mean dissolved oxygen ranged from 4.2 ppm in July to 7.4 ppm in October.

Pollution

In a model of the effects of pollution on a multispecies group of coastal fishes, weakfish showed relatively large depressions in abundance in response to chronic or acute pollution, but then recovered relatively quickly (in 6-10 years) (Schaaf et al. 1987).

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16. Abstract (Limit: 200 words)

Species profiles are literature summaries of the taxonomy, morphology, range, life history, and environmental requirements of coastal aquatic species. They are designed to assist in environmental impact assessment. Weakfish are one of the most abundant fishes in the estuarine and nearshore waters of the Atlantic coast. Weakfish mature at age I throughout their range and spawning takes place in coastal and estuarine waters from March to September. Juveniles utilize the deeper areas within estuaries as nursery grounds, migrate from high to low salinity areas throughout the summer, return to high salinity areas in fall, and most leave the estuaries by late fall. Some may remain in estuarine and nearshore coastal waters in winter, particularly in southern areas. Adult weakfish migrate seasonally, north in spring and south in fall and between inshore and offshore waters. Growth rates, maximum size, and longevity of weakfish are higher at the northern end of the range. Weakfish are an important recreational and commercial species in the Mid-Atlantic. Weakfish feed predominantly on mysid shrimp and anchovies as juveniles, and on clupeids and anchovies as adults. Weakfish have been found over a temperature range of 9.5 to 30.8 °C. Juvenile weakfish have been found over a wider salinity range (0.1-31.7 ppt) than adults (6.6-32.3 ppt).

17. Document Analysis a. Descriptors

Estuaries	Temperature	Fishes
Growth	Salinity	Habitat requirements
Life cycles	Dissolved oxygen	
Food habits	Fisheries	

b. Identifiers/Open-Ended Terms

Weakfish
Cynoscion regalis
Spawning

c. COSATI Field/Group

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