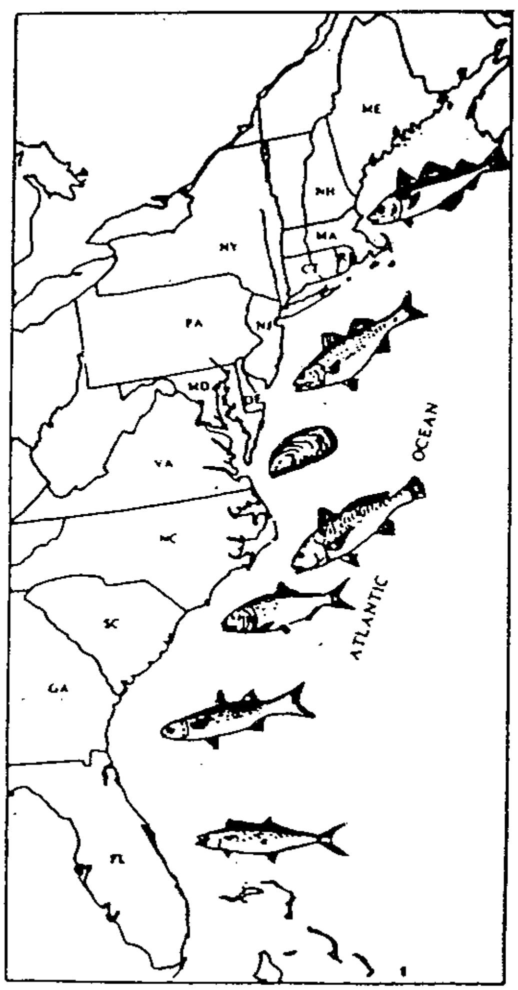
Fisheries Management Report No. 7

of the

ATLANTIC STATES MARINE FISHERIES COMMISSION



FISHERY MANAGEMENT PLAN FOR WEAKFISH

October 1985

FISHERY MANAGEMENT PLAN

FOR THE

WEAKFISH (*Cynoscion regalis*) FISHERY

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Special Scientific Report No. 46

This plan was prepared in cooperation with the Sciaenid Technical Committee and Sciaenid Board, as part of the Interstate Fishery Management Program administered by the Atlantic States Marine Fisheries Commission.

Funds provided by Southeast Region, National Marine Fisheries Service, National Oceanic and Atmospheric Administration under Cooperative Agreement No. SF-13 and by Northeast Region, National Marine Fisheries Service, National Oceanic and Atmospheric Administration under Cooperative Agreement No. NA-80-FA-H-00017.

200 copies of this public document were printed at a cost of $837.38 or $4.19 per copy.

2.0 TABLE OF CONTENTS

Page

1.0 EXECUTIVE SUMMARY

The weakfish is an important fishery resource along the Atlantic coast, particularly between New York and North Carolina. Weakfish migrate seasonally, moving north and inshore in spring and summer to spawning and feeding areas, and returning south and offshore in fall. While inshore, weakfish 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 weakfish are caught offshore in the trawl and gill net fisheries. Commercial catch statistics indicate that weakfish landings have fluctuated widely, increasing from a recent low of 1,397 mt (3.1 million lb) in 1967 to 16,293 mt (35.9 million lb) in 1980. Recreational landings also peaked in 1980 at 21,064 mt (46.4 million lb). Results of a weakfish stock assessment indicate that weakfish from Maryland to North Carolina may have experienced both growth and recruitment overfishing in recent years; however, these conclusions are uncertain due to weaknesses in the data set used in the analyses and lack of knowledge of weakfish stock structure.

The major problem addressed in this management plan is the lack of biological and fisheries data necessary for effective management of the weakfish resource. Despite the importance of weakfish as both a commercial and recreational resource, little is known about its population structure and dynamics. Investigations on life history and fisheries for weakfish 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. Additional problems include the incidental by-catch and discard mortality of small weakfish in nondirected fisheries and commercial-recreational user conflicts.

Weakfish are subject to the varying laws and regulations of the Atlantic coastal states. Several states have minimum size limits ranging from 9 to 12 in. for commercially and/or recreationally-caught weakfish. Because weakfish is a migratory species a cooperative interstate effort is needed to effectively manage this species. The goal of this management plan is to perpetuate the weakfish 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 weakfish.

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 gears used.

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 weakfish resource.

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

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 (TED) through demonstration in the southern shrimp fishery, and fish separators in the finfish trawl fishery.

2. Promote increases in yield per recruit, particularly in northern areas, through delaying entry to weakfish 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 a recruitment index and examine the relations between parental stock size and environmental factors on year-class strength.

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

3.0 INTRODUCTION

3.1 Development of the Plan

This weakfish fishery management plan 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 weakfish (Mercer 1983, Section 12.0). 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 Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, the National Marine Fisheries Service (NMFS) Northeast Fisheries Center (NEFC) Sandy Hook Laboratory, NMFS Southeast Fisheries Center (SEFC) Beaufort Laboratory, NMFS Northeast Region Management Division, and ASMFC provided technical expertise in the development of this plan. General guidance and policy were provided by the Sciaenid Board, consisting of senior administrators of the state marine fisheries agencies and NMFS.

3.2 Problems Addressed by the Plan

The relative abundance of weakfish and status of the fisheries are not well known. Historically, weakfish landings have been highly variable. Reported commercial landings of weakfish have fluctuated between <1 and 19,000 mt (<1,000-41 million lb) from 1880 to 1984. Peaks in landings occurred in the early 1900s, the early 1930s, the mid-1940s, and in 1980. Periods of high landings have generally been followed by sudden and precipitous declines in catch, the causes of which are not known. Commercial and recreational catches have both declined since their peaks in 1980. The relationship between landings and abundance cannot be determined without effort data which are insufficient from both the commercial and recreational fisheries. A recent assessment of the status of weakfish on the Atlantic coast suggests that weakfish from Maryland to North Carolina may have been experiencing growth overfishing and recruitment overfishing in recent years (Boreman and Seagraves 1984). However, the conclusions of this assessment are uncertain, due to weaknesses in the data set upon which the yield-per-recruit and eggs-per-recruit analyses were based, and assumptions made in those analyses.

The incidental bycatch and discard mortality of small weakfish in nondirected fisheries such as the southern shrimp fishery and the scrap catch of weakfish from the pound net, long haul seine, and trawl fisheries have frequently been cited as potentially having significant impacts on weakfish stocks (Section 12.5.1.5). The magnitude of this problem needs to be determined, as well as possible solutions such as use of trawl efficiency devices (TED) in the shrimp fishery.

The weakfish resource is shared by recreational and commercial harvesters, and conflicts have arisen out of competition for the resource both within and between the user groups, through the use of different gear, by fishing during different seasons of the year and in different areas along the coast. Because weakfish is a migratory species harvested by a variety of gears, a cooperative interstate approach to management is essential.

The major problem addressed in this management plan is the lack of biological and fisheries data necessary for effective management of the weakfish resource. Continuous, long-term stock assessment is needed to provide information about the status and characteristics of the stocks. The question of the existence of one or more coastal stocks of weakfish needs to be resolved. Basic data requirements include information on recruitment, age, size, and sex composition of the stock(s), and how these characteristics vary over time. Basic biological data must be supplemented by accurate catch and effort statistics from both commercial and recreational fisheries to assess the impact of fishing activities on weakfish.

4.0 DESCRIPTION OF STOCK

4.1 Species Distribution

Weakfish occur along the Atlantic coast of the United States from southern Florida to Massachusetts, straying occasionally to Nova Scotia and into the eastern Gulf of Mexico (Bigelow and Schroeder 1953; Weinstein and Yerger 1976). The center of abundance for weakfish is from North Carolina to New York.

Weakfish migrate seasonally along the Atlantic coast, moving south and offshore during the autumn and winter, and north and inshore during the spring and summer. During the autumn migration, younger weakfish (less than 4 years of age) tend to stay inshore, moving southward to the inner shelf waters from North Carolina to Florida. Larger and older weakfish move south but offshore, probably no farther than North Carolina, and then return to their northern inshore grounds during spring. The largest weakfish tend to congregate in the northern parts of their range during the summer months (Nesbit 1954; Wilk 1979; Shepherd and Grimes 1983). Adult weakfish utilize estuaries in spring and summer as spawning and feeding grounds; however, a greater proportion of the adults spend summers in oceanic waters than in sounds and bays. Larval weakfish have been collected from within estuaries to 70 km offshore. Juveniles are euryhaline and move from high to low salinity waters throughout the summer, return to higher salinity waters, and generally leave the estuaries by winter.

4.2 Abundance and Present Condition

Reported commercial landings of weakfish increased from a low of 1,397 mt (3.1 million lb) in 1967 to 16,293 mt (35.9 million lb) in 1980, the highest recorded catch of weakfish since 1945 [18,785 mt (41.4 million lb)]. The distribution of peak weakfish landings has shifted from the Middle Atlantic and Chesapeake regions in the 1940s to the South Atlantic region. North Carolina landings account for 98% of the South Atlantic landings. This shift in landings is probably more a reflection of the increased mobility of the North Carolina fishing fleet with a concomitant shift in center of landings to North Carolina, rather than an actual shift in distribution of weakfish (Wilk 1981).

Recreational weakfish landings increased from 1,700 to 7,100 mt (3.7 to 15.7 million lb) from 1960 to 1970. The 1980 estimated recreational catch of weakfish was 21,064 mt, (46.4 million lb) followed by sharp declines to 6,619 mt (14.6 million lb) in 1981 and 2,918 mt (6.4 million lb) in 1982.

Stratified random bottom trawl surveys have been conducted by NMFS NEFC off the northeastern U.S. coast since 1963 in offshore waters [>27 m (15 fm) depth] and since 1972 in inshore waters [<27 m (15 fm) depth]. Catches of weakfish in these surveys have been limited principally to fish <30 cm TL in the autumn inshore surveys. Catch-per-tow indices of young-of-the-year and yearling weakfish ranged from 263.3 fish per tow in 1978 to 29.6 fish per tow in 1982 with no discernable trend. These values were significantly correlated ($r = 0.89$, $df = 6$, $P < 0.01$) with total (recreational and commercial) coastwide landings of weakfish two years later; however, the correlation may be spurious due to the strong influence of one data point (1978 index vs 1980 catch). Without this data point, the relationship remains positive, but is non-significant ($r = 0.56$, $df = 5$, $P < 0.05$) (Boreman and Seagraves 1984).

Various states have conducted estuarine surveys which provide insight into seasonal trends and differences among juvenile weakfish in the various estuaries along the Atlantic coast. None of the juvenile abundance indices in state waters appear to coincide with one another or with the NMFS inshore survey abundance index, suggesting that the factors that control year class strength of weakfish in the individual coastal areas are different, or the same set of factors have different effects (Boreman and Seagraves 1984).

4.3 Ecological Relationships

The following information is summarized from the weakfish profile (Section 12.0):

Reproduction - Weakfish begin to mature at age I throughout the range and all are mature by age II. Males attain sexual maturity at a smaller size [157-182 mm (6-7 in) TL] than do females [175-230 mm (7-9 in) TL] in North Carolina (Merriner 1976). Total lengths at 50% maturity for weakfish collected north of Chesapeake Bay were 256 mm (10.0 in) for females and 251 mm (9.9 in) for males (Shepherd and Grimes 1984). Spawning, hatching, and early larval development take place in the nearshore and estuarine zones along the coast from March to October with peak juvenile production from late April through June.

Age and Growth - Mean back-calculated lengths at age I are similar throughout the range [173-219 mm (7-9 in) TL] (Table 12-4). After age I differences in growth of weakfish between areas and times of collection are considerable. Mean lengths at age of northern weakfish were greater than southern weakfish and maximum mean lengths at age were also greater in the north [81 cm (32 in) TL at age 11] and became progressively smaller towards the south [42 cm (17 in) TL at age 4] (Shepherd and

Grimes 1983). Increased growth rates were reported for weakfish in Delaware in 1979 compared with 1956 (Seagraves 1981) and in the New York area in 1980 compared with 1952 and 1929 (Shepherd and Grimes 1983).

Food and Feeding - Weakfish is a fast swimmer that feeds in the upper to middle water column by sight. Young weakfish feed primarily on mysid shrimp and anchovies, while older weakfish feed mainly on the clupeid species that are abundant in a given area and anchovies (Merriner 1975; Michaels 1984).

Competitors and Predators - Weakfish have food habits similar to other top predators such as bluefish and striped bass. Weakfish are preyed on by bluefish, striped bass, and larger weakfish.

Seasonal Activity - Weakfish migrate seasonally. Photoperiod and temperature may act to trigger the northern spring migration and southern fall migration.

Parasites, Diseases, Injuries, and Abnormalities - Parasites of weakfish were listed by Linton (1905) and Merriner (1973). Mahoney et al. (1973) reported weakfish, especially juveniles, to be one of the most susceptible species to the "fin rot" disease of marine and euryhaline fishes in the New York Bight. This disease has also been observed in weakfish from Delaware Bay and Georgia.

4.4 Estimate of Maximum Sustainable Yield

Two analyses were performed to examine the effects of various fishing strategies on harvest and reproductive capacity of weakfish: 1) a yield-per-recruit analysis was undertaken to determine the level of instantaneous fishing mortality (F) that would result in maximum yield per fish for a given age at entry (t_c) to the fishable stock; and 2) an eggs-per-recruit analysis was performed to relate the effects of changes in F and t_c on the reproductive capacity of the stock (Boreman and Seagraves 1984). Results of the yield-per-recruit analysis are expressed as values of F_{max} and $F_{0.1}$ for a given age at entry to the fishable stock, where F_{max} is the level of F that produces the highest yield per recruit and $F_{0.1}$ is the level of F that corresponds to a point at which the marginal yield per recruit from an additional unit of effort is 0.1 the marginal yield per recruit at very low levels of fishing and thus a point beyond which there is little reward in increasing fishing.

If current values of F for the weakfish fishery along the Atlantic coast are higher than estimates of F_{max}, then growth overfishing is occurring. Values of F were calculated from available estimates of instantaneous total mortality (Z=F+M), which range from 0.38 to 0.42 for weakfish north of Maryland, and from 0.65 to 1.14 for weakfish from Maryland to North Carolina (Table 4.1). Two levels of instantaneous natural mortality (M) were selected, M=0.25 and M=0.35, based on a previous analysis by Murawski (1977) (Boreman and Seagraves 1984). Results of the yield per recruit analysis indicate that at t_c = 1, weakfish south of Maryland may be undergoing exploitation at a level higher than F_{max},

Table 4-1. Estimates of total instantaneous mortality rates (Z) corresponding estimates of instantaneous fishing mortality (F) for weakfish along the Atlantic coast (Modified from Merriner 1973 and Mercer 1983) (from Boreman and Seagraves 1984).

Region	Z	F		Source
		M=0.25	M=0.35	
Cape Cod, Ma. - Ocean City, Md.	0.42	0.17	0.07	Shepherd (1982)
New York	0.66	0.41	0.31	Perlmlutter et al. (1956)
N. New Jersey	0.51	0.26	0.16	Nesbit (1954)
Wildwood, New Jersey	0.52	0.27	0.17	Nesbit (1954)
Cape May, N.J.	0.38	0.13	0.03	Shepherd (1982)
Ocean City, Md. - Virginia Beach, Va.	0.93	0.68	0.58	Shepherd (1982)
Chesapeake Bay	0.76	0.51	0.41	Nesbit (1954)
	0.66	0.41	0.31	Massman (1963)
Exmore, Virginia	0.71	0.46	0.36	Nesbit (1954)
Virginia Beach, Va. - Cape Fear, N.C.	1.14	0.89	0.79	Shepherd (1982)
North Carolina	0.62	0.37	0.27	Nesbit (1954)
North Carolina (pound nets)	0.76 (ages 2-5) 0.97 (ages 3-5)	0.51 0.72	0.41 0.62	Merriner (1973)
North Carolina (otter trawls)	0.65	0.40	0.30	Merriner (1973)

while weakfish north of Maryland are being exploited at a level near or below F_{max} (Table 4-2). Maximum yield per recruit, with M = 0.25 and M = 0.35, would occur at t_c = 4. Delaying age at entry from age 1 to age 2 will increase yield per recruit by 25 and 29% respectively, at M = 0.25 and M = 0.35 and F_{max}. Delaying age at entry from age 1 to age 4 will increase yield per recruit by 64 and 70% at F_{max} and M = 0.25 and M = 0.35, respectively.

The eggs-per-recruit analysis compares the expected lifetime fecundity of an age 1 female recruit (EPR = eggs per recruit) under varying levels of fishing mortality (F) to that female's maximum expected lifetime fecundity (EPR_{max}) when F=0. Values of F were varied between 0 and 1, values of M were 0.25 or 0.35, t_c was varied between 0.5 and 4 years, and the oldest age in the population was equal to 15. Two fecundity schedules were used: Merriner's (1976) fecundity relationship for weakfish in North Carolina and Shepherd's (1982) fecundity relationship for weakfish from Cape Cod to Maryland (Table 4-3). For weakfish north of Maryland, estimates of eggs per recruit (EPR) are 38-71% of EPR_{max} for t_c =1, and 44-75% of EPR_{max} at t_c =2. For weakfish south of Maryland, estimates of EPR are less than 20%, and may be as low as 10%, of EPR_{max} at t_c =1. Delaying age at entry to the fishery in North Carolina until an age of 2 years would raise the estimate of EPR to 20-30% of EPR_{max}. The minimum egg production per recruit necessary to maintain stock levels cannot be estimated from available data. Analyses done on other species (silver hake, haddock, and cod) (Gabriel et al. 1984) indicate that 20-40% of the maximum spawning stock biomass per recruit is necessary to maintain stock size for those species. The percent of maximum spawning stock biomass per recruit is equivalent to percent of maximum eggs per recruit if fecundity and biomass are linearly related, as is the case for weakfish (Merriner 1976).

The results of these yield-per-recruit and eggs-per-recruit analyses cannot be used to confidently predict stock response to imposition of management measures because of weaknesses in the data base and the unknown stock structure of weakfish. The analyses assumed that there is only one stock of weakfish on the Atlantic coast; however, results of several studies on morphometrics and meristics, scale sculpturing, growth rates, and limited tag returns of weakfish suggest that there are two or more weakfish stocks on the Atlantic coast. The arbitrary values of natural mortality (M) used in the analyses appear to be within the expected range for weakfish in the northern region; however, the analyses need to be expanded over a wider range of values for M to reflect the possibility of different stocks. The estimates of total mortality (Z) and the fecundity relationships were calculated during different time periods (1960s for North Carolina and 1970s for the mid-Atlantic area), and may reflect differences in stock structure, density and age-group composition, and gear biases. In addition, the eggs-per-recruit analysis assumes that survivorship of each year class is constant which may not be true.

4.5 Probable Future Condition

Weakfish landings have fluctuated greatly. Landings peaked in 1980 and subsequently declined. Data are not available to make predictions of future stock abundance or landings trends.

Table 4-2. Results of yield-per-recruit analysis for weakfish (from Boreman and Seagraves 1984).

	Age at Entry to Fishery (tc)							
	0.5	1	1.5	2	2.5	3	3.5	4
M = 0.25								
F_{max}	0.198	0.214	0.249	0.312	0.371	0.521	0.628	*
F0.1	0.138	0.146	0.164	0.189	0.211	0.243	0.267	0.303
M = 0.35								
F_{max}	0.240	0.267	0.323	0.442	0.546	1.087	1.230	*
F0.1	0.166	0.179	0.206	0.246	0.279	0.333	0.368	0.423

*Undefined (yield-per-recruit curve has no maximum value)

Table 4-3. Life history parameters for weakfish along the Atlantic coast* (from Boreman and Seagraves 1984).

Age	Average Length (mm TL)	Average Weight (kg)	Percent Mature	Fecundity (millions of eggs)	
				N.C.	MA-MD
1	192	0.06	50	0.15	0.00
2	345	0.33	100	0.75	0.05
3	461	0.79	100	1.68	0.21
4	548	1.32	100	2.73	0.47
5	615	1.86	100	3.75	0.80
6	666	2.35	100	4.68	1.16
7	704	2.78	100	5.47	1.50
8	733	3.14	100	6.12	1.82
9	756	3.44	100	6.66	2.09
10	773	3.67	100	7.08	2.33
11	785	3.86	100	7.42	2.51
12	795	4.00	100	7.68	2.66
13	802	4.11	100	7.88	2.78
14	808	4.20	100	8.03	2.87
15	813	4.27	100	8.15	2.94

*Average lengths based on Shepherd and Grimes (1983); average weights based on length-weight relationship derived by Shepherd (1982); percent maturity from Wilk (1979); and fecundity based on relationships between fecundity and length derived by Merriner (1976) for North Carolina weakfish, and by Shepherd (1982) for weakfish from Cape Cod to Ocean City, Maryland. [1 mm = .04 in., 1 kg = 2.20 lb]

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 2500-square mile system of large interconnecting sounds behind the Outer Banks of North Carolina (Freeman and Walford 1974c; 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 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 1974c; 1976b,c).

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 weakfish 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. 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). In the Atlantic coast states (Maine-Florida), containing 3,152,800 acres of estuarine habitat, an estimated 129,700 acres (4.1%) were lost to dredging and filling from 1954-1968 (Section 12.7.2). 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 shore line 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 12-20.

Federal Programs

The Coastal Zone Management Act of 1972, 16 USC 1451

The 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

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

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. Also requires that documents must be available to the public and their comments 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 provisions 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 on 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 1972, 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. Also protects the habitat of marine mammals, including food sources.

Deepwater Port Act of 1974, 33 USC 1501-1524

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

Establishes a fishery conservation and management regime to be implemented by the Secretary of Commerce. Establishes 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

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 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 Fishery Conservation Zone (FCZ), 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 FCZ.

6.3 Federal Laws, Regulations, and Policies

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

6.4 State Laws, Regulations, and Policies

All states have the power to regulate or enact laws pertaining to the taking of weakfish. Those that have regulatory powers are Rhode Island, Connecticut, New Jersey, North Carolina, and Florida. Those that must adopt legislation are New York, Delaware, Maryland, South Carolina, and Georgia. Virginia has the power to regulate size limits but must enact laws pertaining to area closures. State laws and regulations are summarized in Table 12-18.

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 weakfish fishery.

7.0 DESCRIPTION OF FISHING ACTIVITIES

7.1 History of Exploitation

A commercial fishery for weakfish has existed since the late 19th century, with the first recorded landings in 1880 (Table 7-1). Tremendous fluctuations in the apparent levels of abundance of weakfish have been reported throughout the history of the fishery (Bigelow and Schroeder 1953; McHugh and Bailey 1957; Perlmutter 1959; McHugh 1977). Total landings between 1880 and 1983 ranged from a high of 18,784 mt (41.4 million lb) in 1945 to a low of <1 mt (<2,200 lb) in 1896 and 1909. However, records prior to 1929 are incomplete, with one or more regions with no reported landings. Weakfish landings exceeded 9,000 mt (20 million lb) per year between 1929 and 1940. Landings records are incomplete for 1941 to 1944 and 1946 to 1949 but suggest lower landings during World War II. Landings declined during the next two decades reaching a low of 1,397 mt (3.1 million lb) in 1967. Catches increased steadily throughout the 1970s and peaked at 16,293 mt (35.9 million lb) in 1980, the highest recorded catch of weakfish since 1949. Weakfish landings have steadily declined since 1980 with the catch in 1984 estimated at 8,948 mt (19.7 million lb) (Table 7-1).

The distribution of weakfish landings has shifted historically from one geographic area to another (Wilk 1980) (Table 7-1). Middle Atlantic (New York, New Jersey, and Delaware) landings of weakfish between 1880 and 1908 were greater than landings in other regions. Landings from the Chesapeake Bay region (Virginia and Maryland) generally exceeded all

Table 7-1. Historic record of weakfish landings on the Atlantic coast by region and total landings from 1880 to 1981 (metric tons).

	Region				
Year	New England	Middle Atlantic	Chesapeake	South Atlantic	Total
1880	-	5,017	699	829	6,545
1887	-	2,838	743	541	4,123
1888	-	3,053	755	553	4,361
1889	-	*	-	1,116	1,116
1890	-	-	2,158	1,185	3,344
1891	-	-	2,122	-	2,122
1896	-	-	*	-	*
1897	-	5,751	3,230	1,735	10,716
1901	-	6,823	3,832	-	10,655
1902	3,327	-	-	2,290	5,617
1904	-	8,078	3,508	-	11,586
1908	-	11,595	2,577	3,913	18,084
1909	-	-	*	-	*
1915	171	-	*	-	171
1918	-	-	-	2,315	2,315
1919	3	-	-	-	3
1920	-	-	6,892	-	6,892
1921	-	6,666	*	-	6,666
1923	-	-	-	2,385	2,385
1924	46	-	-	-	46
1925	17	-	6,315	-	6,331
1926	1	4,263	-	-	4,274
1927	11	-	-	2,482	2,494
1928	52	-	-	2,904	2,956
1929	73	4,963	5,165	2,805	13,006
1930	84	6,024	8,737	1,337	16,182
1931	104	6,146	5,641	1,364	13,255
1932	60	4,121	6,249	1,656	12,086
1933	167	3,571	6,106	-	9,844
1934	-	-	6,750	3,511	10,260
1935	303	4,600	6,692	-	11,595
1936	-	-	5,301	4,426	9,727
1937	91	5,562	6,212	3,414	15,280
1938	154	3,421	6,175	2,312	12,062
1939	87	3,595	6,149	1,290	11,120
1940	70	2,150	6,201	1,646	10,067
1941	-	-	3,833	-	3,833
1942	48	2,803	3,444	-	6,295
1943	42	2,895	-	-	2,937
1944	146	2,948	5,615	-	8,709
1945	174	5,224	11,223	2,163	18,784
1946	269	*	9,323	-	9,592
1947	178	3,545	8,760	-	12,483
1948	116	2,244	5,879	-	8,239
1949	9	1,819	3,028	-	4,856
1950	2	815	2,087	716	3,621

Table 7-1. (continued)

Year	New England	Middle Atlantic	Chesapeake	South Atlantic	Total
	Region				
1951	1	1,262	1,003	610	2,877
1952	3	1,190	811	756	2,760
1953	11	1,361	1,036	869	3,277
1954	5	1,133	1,082	1,118	3,338
1955	5	1,660	1,924	622	4,212
1956	10	1,438	1,694	839	3,981
1957	20	1,590	1,070	1,016	3,696
1958	5	434	805	1,744	2,988
1959	1	272	359	1,340	1,971
1960	1	283	490	1,046	1,820
1961	1	274	668	1,084	2,028
1962	5	381	763	996	2,146
1963	1	257	541	834	1,633
1964	*	330	800	944	2,075
1965	1	404	1,023	1,035	2,463
1966	*	209	540	957	1,706
1967	1	224	311	862	1,397
1968	1	272	577	1,136	1,987
1969	6	900	474	766	2,146
1970	10	1,024	1,117	1,241	3,392
1971	83	1,977	1,237	1,718	5,015
1972	79	2,456	1,296	3,423	7,069
1973	82	1,889	2,557	2,916	7,293
1974	229	1,993	1,575	2,806	6,476
1975	187	2,734	2,257	3,103	8,281
1976	160	3,311	1,999	3,993	9,350
1977	158	2,386	2,063	3,976	8,584
1978	134	2,637	2,003	4,972	9,694
1979	221	3,854	3,126	6,744	13,994
1980	131	3,765	3,088	9,309	16,293
1981	181	2,793	1,226	7,745	11,946
1982	112	1,973	1,102	5,545	8,782
1983	90	1,780	1,390	4,697	7,957
1984	91	1,822	1,101	5,933	8,948

- information not available
* <1 mt reported

other regions from 1920 to 1950. Since 1958 South Atlantic (primarily North Carolina) landings have exceeded one or both of the northerly regions. The shift in catch to the South Atlantic region is probably more a reflection of the increased mobility of the North Carolina fishing fleet with a concomitant shift in center of landings to North Carolina, rather than an actual shift in distribution of weakfish.

Weakfish have also been important to the recreational fishery since at least the 1800s (Goode 1884). Unlike commercial landings data, recreational catch statistics were not collected on a coast-wide basis until 1960 (Table 7-2). Although results of the 1960, 1965, and 1970 surveys cannot be compared with those of the 1979-1984 surveys, due to changes in survey methodology, trends in recreational landings have generally paralleled commercial landings. Recreational weakfish landings increased from 1,700 to 7,100 mt (4-16 million lb) from 1960 to 1970. The estimated catch increased from 6,500 mt (14.3 million lb) in 1979 to an all-time high of 21,064 mt (46.4 million lb) in 1980, and then declined to 6,619 mt (14.6 million lb) in 1981 and 2,918 mt (6.4 million lb) in 1982. Recreational landings approximately doubled in 1983 to 5,988 mt (13.2 million lb) and then declined again in 1984 to 3,527 mt (7.8 million lb) (Table 7-2). The Mid-Atlantic subregion (New York-Virginia) accounted for 80-97% of the total estimated recreational catch for each of the survey years.

7.2 Domestic Commercial and Recreational Fishing Activities

Commercial Fishery

The commercial fishery consists of the inshore summer fishery, employing haul seines, pound nets, gill nets, and trawls, and the offshore winter fishery which is a trawl and gill net fishery. In addition, weakfish are commercially caught by purse seines, floating traps, trammel nets, fyke nets, hoop nets, and hand lines. These fisheries can be classified as mixed opportunistic fisheries which may concentrate directly on weakfish for brief periods of time.

The principal methods used to harvest weakfish for foodfish have essentially remained the same, but there have been significant shifts in the contribution which trawls and pound nets have made during the past 40 years. During the period 1940-1949, pound nets, haul seines, gill nets, and trawls took approximately 63, 11, 3, and 23% of the total catch, respectively. During the 10-year period 1970-1979, the contribution of these same four gear types was 20, 11, 9, and 60%, respectively. A significant innovation in commercial harvesting methods occurred in the mid-1970s with the use of a high speed pelagic trawls in the form of paired trawls and midwater trawls (Wilk 1981).

Recreational Fishery

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,c,d). The salt-water angling surveys indicate that weakfish are caught mainly by private/rental boats

Table 7-2. Estimated number and weight of weakfish caught by recreational fishermen, 1960-1984 (*indicates none reported).

Year	North Atlantic #	North Atlantic wt (kg)	Mid Atlantic #	Mid Atlantic wt (kg)	South Atlantic #	South Atlantic wt (kg)	All Regions #	All Regions wt (kg)
	- - - - - -	- - - - - -	- - - - - -	T H O U S A N D S	- - - - - -	- - - - - -	- - - - - -	- - - - - -
1960[1]	295	240	3,308	1,501	*	*	3,603	1,741
1965[2]	332	205	1,467	822	*	*	1,799	1,027
1970[3]	745	746	9,397	6,368	*	*	10,142	7,114
1979[4]	98	279	5,157	5,793	1,069	428	6,324	6,500
1980[4]	89	326	14,570	20,544	371	194	15,030	21,064
1981[5]	36	133	8,833	6,397	273	89	9,142	6,619
1982[5]	12	56	1,064	2,717	266	145	1,342	2,918
1983[6]	91	320	5,779	5,397	592	271	6,462	5,988
1984[6]	9	33	3,671	3,377	833	117	4,513	3,527

[1]Clark 1965
[2]Deuel and Clark 1968
[3]Deuel 1973
[4]Anonymous 1984
[5]Anonymous 1985a
[6]Anonymous 1985b

Table 7-3. Estimated total number of weakfish caught by marine recreational fishermen by area and mode for each subregion, 1979-1984 (*denotes none reported).

Year	Area of Fishing			Mode of Fishing			
	Ocean (<3 mi)	Ocean (>3 mi)	Inland	Private/ rental	Party/ charter	Man-made	Beach/ bank
	---------- THOUSANDS ----------						
1979 (Revised)[1]							
North Atlantic	70	4	99	82	4	12	*
Middle Atlantic	986	751	3,407	3,916	1,099	69	73
South Atlantic	147	51	871	938	1	130	*
1980[1]							
North Atlantic	*	1	75	75	8	3	3
Middle Atlantic	4,256	2,549	7,459	6,677	6,467	1,343	83
South Atlantic	7	26	254	254	*	109	8
1981[2]							
North Atlantic	11	3	21	22	14	*	*
Middle Atlantic	6,529	1,193	1,389	5,007	595	3,598	6
South Atlantic	176	10	83	124	*	117	28
1982[2]							
North Atlantic	1	20	13	14	*	*	*
Middle Atlantic	1,323	283	385	1,314	648	84	4
South Atlantic	49	*	140	174	*	22	20
1983[3]							
North Atlantic	11	*	25	66	*	*	
Mid-Atlantic	1,180	577	3,635	4,826	819	47	86
South Atlantic	97	35	445	492	6	64	30
1984[3]							
North Atlantic	36	*	3	2	1	3	32
Mid-Atlantic	2,168	1,028	461	3,184	286	185	16
South Atlantic	76	*	755	555	17	33	228

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

in all subregions (Table 7-3). Anglers caught more weakfish in inland waters (sounds, rivers, and bays) or ocean waters <3 mi from shore, than from ocean waters >3 mi from shore in all subregions and years from 1979 to 1984 (Table 7-3). Numbers of anglers participating in this fishery have increased from a little less than 200,000 in 1965 to over 500,000 in 1974 (Deuel and Clark 1968; Deuel, pers. commun.).

7.3 Foreign Fishing Activities

There is no reported foreign catch of weakfish.

8.0 DESCRIPTION OF ECONOMIC CHARACTERISTICS OF THE FISHERY

8.1 Domestic Harvesting Sector

Historical records of weakfish landings indicate that a successful commercial fishery for weakfish has been operating since the 1880s. Weakfish contribute the most to the total value of U.S. sciaenid landings followed by croaker, spotted seatrout, spot and red drum. Food landings of weakfish were valued at 8.9 million dollars in 1981.

Average dockside prices were fairly stable throughout the 1950s and 1960s, and increased in the 1970s. Highest price per pound occurred in 1981 in all regions. Adjusting prices for inflation indicates that the real (deflated) price of weakfish has gradually increased since 1967. Prices in the South Atlantic have been consistently lower than in the other two regions.

Economic impact analyses of the commercial gill net fishery for weakfish in Delaware was presented by Seagraves and Rockland (1983a). In 1982, 588 mt of weakfish, worth $757,240 at dockside, were landed by Delaware gill netters. The total primary impact, which consists of the purchases and employment where the expenditure initially takes place, was $1,461,607. This included four sectors: the commercial fishermen ($657,736); the wholesalers ($230,335); the retailers ($237,642); and the restaurants ($335,894). The survey showed that packers generally mark up the fish twenty cents per pound and the weighted average retail mark-up is 117.6%. When the primary effects were multiplied by the relevant multipliers from the input-output model, a total output of $2,172,511 was estimated for weakfish. This amount involved 87.79 jobs which resulted in $846,871 in wages. The value resulting from the sale of weakfish was $1,303,481.

8.2 Domestic Processing Sector

Weakfish is primarily a fresh fish product, although small quantities are processed as frozen fillets.

8.3 International Trade

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

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

9.1 Relationship Among Harvesting and Processing Sectors

Most sciaenids are sold for food through local fish houses (Cato 1981), although at one time most weakfish were sold through large wholesale markets such as Fulton Fish Market in New York City (Taylor 1951). Traditional markets for weakfish extend from the Carolinas to New York, primarily along the coast. Weakfish are also shipped to the Gulf states, primarily from New Jersey and North Carolina. Some weakfish are also marketed throughout the Midwest in retail stores. Most weakfish are sold freshly iced, whole, although small quantities are processed as fresh and frozen fillets (Pileggi and Thompson 1980b). Commercially-caught Delaware weakfish were moved via one of three possible routes: 1) iced, packed, and sent out-of-state; 2) iced, packed, and retailed within the state to the consumer; and 3) iced, packed, retailed within the state to a restaurant and then sold to the consumer (Seagraves and Rockland 1983a). The large seafood markets of Ocean City, Rock Hall, Secretary, Baltimore, Philadelphia, and New York serve as the primary out-of-state outlets for Delaware fish. An estimated 90% of the total catch is sold through the packers. The remaining 10% is sold directly by fishermen to restaurants or out-of-state.

Out-of-state marketing channels and inland channels of distribution of weakfish in North Carolina were analyzed by Summey (1977, 1979). Of the total fresh iced weakfish handled by North Carolina dealers in 1974, 80.4% were sold inside North Carolina, the majority in coastal areas. The major in-state markets were retail fish markets (68.3 percent), wholesalers and distributors (27.6%), and direct retail sales (3.1%). The largest out-of-state customer was New York, followed by Virginia and Maryland. Out-of-state sales of weakfish went mostly to wholesalers and distributors.

9.2 Fishery Cooperatives or Associations

There are five active fishermen's cooperatives in the Massachusetts to North Carolina area. Although some purchasing of expendable equipment for fishing vessels is undertaken, their main business is marketing members' landings. Cooperative operations are typical of the region's packing or dock practice, supplying fuel, ice, water and trip service to members. Three of the cooperatives are located in New Jersey: the Belford Seafood Cooperative Association, Inc., the Point Pleasant Fishermen's Dock Cooperative, Inc., and the Cape May Fishery Cooperative. A fourth cooperative is the Pt. Judith Fishermen's Cooperative in Rhode Island, and the fifth is the Shinnecock Fishermen's Cooperative in New York.

9.3 Labor Organizations

Labor organizations identified with the harvesting and processings sectors of the fisheries in the New England area and North Carolina have not been specifically described; however, some of the participants in the weakfish fishery in these areas 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 weakfish. 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 almost entirely limited 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 United Food and Commercial Workers 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 unions' 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 rulings 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 DESCRIPTION OF SOCIAL AND CULTURAL FRAMEWORK OF DOMESTIC FISHERMEN AND THEIR COMMUNITIES

Uniform socio-economic data on fishing communities are not available.

11.0 GOAL STATEMENT

The goal of this management plan is to perpetuate the weakfish 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.

11.1 Specific Management Objectives

The following objectives have been adopted for achievement of the goal:

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

   Objective 1 is a recognition that there is a lack of data necessary for weakfish management and a need to improve the data base 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.

   Objective 2 is a recognition that weakfish abundance fluctuates widely over time and the factors which determine year-class strength and recruitment to the fishery are unknown.

3. Optimize yield per recruit.

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

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

   Objective 4 is a recognition of the need for improved catch and effort statistics from both the commercial and recreational fisheries.

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 weakfish resource.

   This objective recognizes that weakfish is a migratory species with a wide distribution in state waters and in the FCZ and that effective management can only be accomplished through cooperation between the States and Federal government.

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

   This objective is a recognition of the need for continual collection of data throughout the range of weakfish to achieve effective management.

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

   Objective 7 is a recognition that maintaining environmental quality is of critical importance to maintaining maximum natural production of weakfish.

11.2 Specific Management Measures

The following management measures are identified as appropriate for implementation:

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

2. Promote increases in yield per recruit, particularly in northern areas, through delaying entry to weakfish fisheries to ages greater than one.

11.3 Research and Data Collection Programs

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 described below.

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

   The necessity of defining the unit stock for fisheries stock assessment is well established (Cushing 1975; Gulland 1983). Few species form single homogeneous populations and most can be divided into several more or less distinct stocks, reacting to fishing more or less independently (Gulland 1983). Much work has been done on weakfish stock identification (Alperin 1953; Nesbit 1954; Perlmutter et al. 1956; Seguin 1960; Russell and Jeffrey 1979; Shepherd 1982; Crawford and Grimes 1983); however, the results of these studies are inconclusive and conflicting. In addition, none of these studies examined weakfish from the entire geographic range.

   A variety of methods have been used in stock discrimination studies of marine fishes, including tagging and migration, meristics, parasites, serology, and biochemical genetic differences from electrophoresis (Templeman 1983). A study to identify weakfish stocks and determine ocean distribution and mixing has been proposed by Chittenden[1]. The proposed methodology includes collection of young-of-the-year weakfish from estuarine nursery areas throughout the entire range and stock identification using parasites as natural tags and mitochondrial DNA analysis to refine and extend parasite analyses. A pilot study is recommended to evaluate a variety of techniques for distinguishing weakfish stocks using young-of-the-year weakfish from the extremes of the range (Florida and Rhode Island) where the greatest stock separation would be expected. Approximately 100-200 juvenile weakfish should be collected from each area and be preserved appropriately for examination by the following techniques: parasites, electrophoresis, scale circumference analysis, and mitochondrial DNA analysis. The estimated time for completion of this pilot study using experts in the techniques is approximately 6 months. Based on the results of this study, it is recommended that a comprehensive 4-5 year stock identification study should be conducted using the most successful techniques determined by the pilot study.

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 pounds and value of species landed, type of gear used, waterbody of capture, and distance caught from shore. Nominal effort data, such as the number of fishing trips, is collected for some fisheries, and 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 catch estimates, 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 weakfish. Minimum biological data needed from both the commercial and recreational fisheries include size and age composition of the catch. Pound nets, a relatively nonselective gear used throughout much of the weakfish range (Rhode Island to North Carolina), are recommended as a target gear for the development of a coastwide

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[1]Pers. commun. Mark Chittenden, Virginia Institute of Marine Science, Gloucester Point, Virginia.

sampling program to collect catch, effort, and biological data for weakfish 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 data bases.

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

The relationship between adult weakfish abundance and subsequent recruitment is not known. An analysis of 5 years of NMFS/NEFC fall groundfish survey data revealed a significant positive correlation between the survey catch-per-tow index of young-of-the-year and yearling weakfish and total (commercial and recreational) coastwide landings of weakfish two years later; however, the correlation may be spurious due to the strong influence of one data point (1978 index vs 1980 catch) (Boreman and Seagraves 1984). Data on juvenile weakfish abundance are also available from various state estuarine surveys (Mercer 1983; Boreman and Seagraves 1984). The design and methodology of these surveys vary considerably among states. None of the juvenile indices appear to coincide with one another, possibly because different factors control year class strength differ along the coast, or the same set of factors have different effects (Boreman and Seagraves 1984).

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. The first step in the development of a uniform sampling scheme will be for each state to provide 1984 juvenile weakfish data to the chairman of the Sciaenid Technical Committee (R. Seagraves, Delaware) for preliminary analysis.

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 recent scientific program proposed by the Food and Agricultural Organization in 1979 which identified five variables (temperature, turbulence, transport, food, and predation) were most likely to determine recruitment levels (Sullivan 1982). Present indices of weakfish 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 weakfish, including size at sexual maturity, fecundity, and spawning periodicity.

   Aspects of the reproductive biology, including size at maturity and fecundity, have been reported for weakfish in North Carolina during the late 1960s (Merriner 1976) and in the New York Bight for 1980-81 (Shepherd and Grimes 1984). Reproductive strategies apparently differ between northern and southern weakfish (smaller sizes at maturity and higher fecundity for weakfish in North Carolina as compared with larger sizes and lower fecundity for weakfish from Delaware Bay north) and may result from varying environmental demands. Shepherd and Grimes (1984) suggest that the consequences of area specific reproductive characteristics may be a reduced population stability for weakfish in the northern end of the range. In order to effectively manage the weakfish resource, geographic variations in reproductive potential need to be considered. Data on fecundity, size at 100% sexual maturity, and spawning periodicity, collected concurrently on a coastwide basis, are needed to determine future management strategies for weakfish.

12.0 A BIOLOGICAL AND FISHERIES PROFILE OF WEAKFISH, *Cynoscion regalis*

12.1 Identity

12.1.1 Nomenclature

The valid name for weakfish is *Cynoscion regalis* (Bloch and Schneider) 1801 (Figure 12-1). The following synonymy is after Jordan and Evermann (1896):

Johinus regalis, Bloch and Schneider, 1801
Roccus comes, Mitchill, 1814
Labrus squeteague, Mitchill, 1815
Otolithus regalis, Cuvier and Valenciennes, 1830
Cynoscion regale, Gill, 1862
Cestreus regalis, Jordan and Eigenmann, 1889

12.1.2 Taxonomy

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

- Superorder: Acanthopterygii
  - Order: Perciformes
    - Suborder: Percoidei
      - Family: Sciaenidae
        - Genus: *Cynoscion*
          - Species: *Cynoscion regalis*

The weakfish belongs to the drum family, Sciaenidae, so called because of the drumming sounds most members produce by vibrating their swim bladders (Bigelow and Schroeder 1953). Recently Chao (1978) assessed the phylogenetic relationships of all western Atlantic Sciaenidae genera on the basis of swim bladder, otoliths, and external morphology. He also provided a tested key to all species and genera of western Atlantic sciaenids which includes approximate ranges of distribution and some meristics for each species. A key to larval and juvenile sciaenids was presented by Hildebrand and Cable (1934). Amino acid compositional studies of parvalbumins from three species of sciaenids (weakfish, spot, and southern kingfish) and bluefish indicated that parvalbumins may serve as excellent phylogenetic indicators (Sullivan et al. 1975).

There are three other members of the genus *Cynoscion* found along the Atlantic and Gulf coasts of the United States; these are the spotted seatrout, *Cynoscion nebulosus*; the silver seatrout, *C. nothus*; and the sand seatrout, *C. arenarius* (Robins et al. 1980). Taxonomic relationships among these four species have been investigated by morphometrics and meristics (Ginsburg 1929), osteology (Mohsin 1973), and acrylamide gel electrophoresis (Weinstein and Yerger 1976). Ginsburg (1929) recognized *C. arenarius* and *C. regalis* as cognate species. Mohsin (1973) placed *C. arenarius* and *C. nebulosus* in one phyletic line, and *C. regalis* and *C. nothus* in another. Weinstein and Yerger (1976) rejected the phylogeny proposed by Mohsin (1973), concluding that *C. nebulosus* is the most divergent of the four forms and

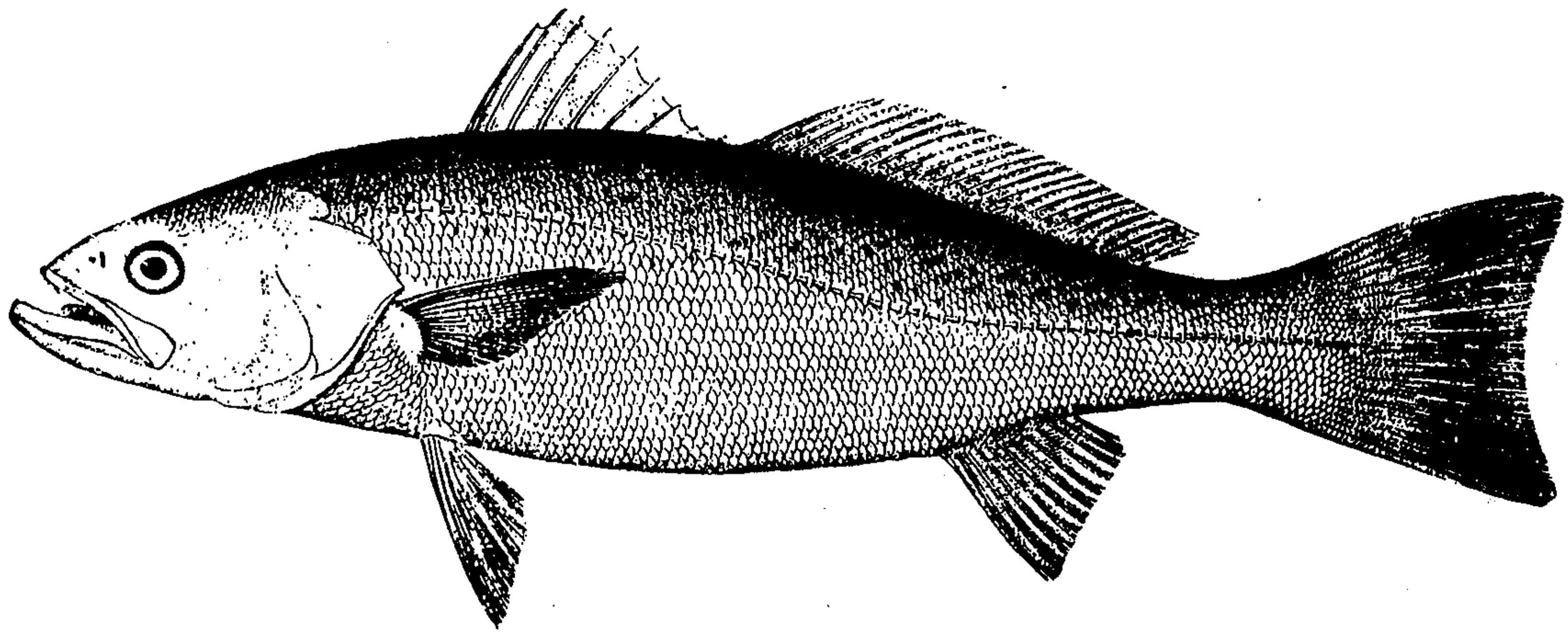

Figure 12-1. Weakfish, Cynoscion regalis (Bloch and Schneider), 1981 (illustration by H. L. Todd from: Goode, 1884).

that C. arenarius should be recognized as a subspecies of C. regalis. Population studies of weakfish using gel electrophoresis indicated that the populations sampled were genetically homogeneous (Russell and Jeffrey 1979; Crawford and Grimes 1983).

Weakfish is the common name given Cynoscion regalis by the American Fisheries Society (Robins et al. 1980). Other common names are weakie, squeteague, trout, seatrout, squit, squitee, sheantts, chickwick, succoteague, drummers, saltwater trout, gray seatrout, tide runner, gray trout, sun trout, shad trout, yellow-finned trout, yellowmouth trout, and summer trout (Goode 1884; Jordan and Evermann 1896; Smith 1907; Jordan et al. 1930; Hildebrand and Schroeder 1928; Bigelow and Schroeder 1953; Leim and Scott 1966; Shiino 1976; Wilk 1979).

12.1.3 Morphology

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 (1963a), Tagatz (1967), Miller and Jorgenson (1973), and Chao (1978).

> D. X-I, 24-29 (modally 27); A. II, 10-13 (modally 12); C. 9+8, procurrent rays 7-9+5-9; V. I, 5; scales 76-86 in a lateral series, about 10 rows between anal origin and lateral line; vertebrae 13+12; gill rakers 4-5+10-12 (typically 5+12); branchiostegals 7; a pair of large canine-like teeth at tip of upper jaw and a distinctly enlarged row from central to posterior position in lower jaw.
>
> Head 2.9-3.3, depth 3.5-4.2 in SL. Snout 4.8-5.1, eye 3.1-5.6, interorbital 3.1-5.6, maxillary 2.1-2.4, pectoral fin 1.6-1.9 in head.
>
> 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, the spines flexible, third and fourth longest; anal fin relatively small, its base ending a little in advance of that of dorsal; caudal fin emarginate in specimens less that 300 mm, the change from a biconcave to an emarginate condition occurring at 250-300 mm; pectoral fin not reaching to tip of pelvic fin.
>
> Pigmentation: Dark olive green above with the back and sides variously burnished with purple, lavender, green, blue, golden, or coppery, 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, chalky or silvery, sometimes somewhat irridescent; 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.

Meristic characteristics of weakfish are summarized from Ginsburg (1929), Alperin (1953), Seguin (1960), and Miller and Jorgenson (1973) in Table 12-1. Morphometric data were presented by Crozier and Hecht (1914), Ginsburg (1929), Alperin (1953), and Seguin (1960). Development of larval weakfish (2.7-25.5 mm SL) morphometrics and meristics was described by Powles and Stender (1978). Seagraves (1981) reported the standard length (SL) - total length (TL) relationships for 725 Delaware Bay weakfish as: SL = -10.3 + 0.869 TL and TL = 5.2 + 1.172 SL. The length relations for 29 juvenile weakfish (10-52 mm TL) from coastal Georgia were: TL = 0.070 + 1.290 SL and SL = 0.266 + 0.763 TL (Jorgenson and Miller 1968).

12.2 Distribution

12.2.1 General Distribution

Weakfish occur along the Atlantic coast of the United States from southern Florida to Massachusetts Bay, straying occasionally to Nova Scotia (Goode 1884; Hildebrand and Schroeder 1928; Bigelow and Schroeder 1953; Guest and Gunter 1958; Leim and Scott 1966; Struhsaker 1969; Chao 1978) (Figure 12-2). They are most abundant from North Carolina to New York. The capture of two adult weakfish (266 and 298 mm SL) in the vicinity of Marco Island, Florida validated its occurrence in the eastern Gulf of Mexico (Weinstein and Yerger 1976).

12.2.2 Differential Distribution

12.2.2.1 Spawn, Larvae, and Juveniles

Identification of weakfish eggs is difficult because of the similarity to eggs of several sciaenid species which spawn concurrently (weakfish, silver perch, kingfish, black drum). Weakfish spawning areas have been identified mainly on the basis of collections of spawning adults and larvae. Weakfish spawn in the near-shore and estuarine zones along the Atlantic coast. Ichthyoplankton surveys indicated that the principal spawning area is from Chesapeake Bay to Montauk, Long Island, New York (Colton et al. 1979). Spawning along the coast of Georgia and South Carolina occurs in the deeper waters of the sounds, off the beaches, and in nearshore coastal waters (Lunz and Schwartz 1969; Mahood 1974; Powles and Stender 1978). Weakfish spawn in Pamlico Sound (Merriner 1976) and in or near the various inlets along the coast of North Carolina (Welsh and Breder 1923; Higgins and Pearson 1928; Hildebrand and Cable 1934; Merriner 1976). Spawning activity in coastal waters north of North Carolina was cited by Hildebrand and Schroeder (1928), Pearson (1941), Massmann (1963a), and Olney (1983) for Chesapeake Bay; by Welsh and Breder (1923), Daiber (1954), Harmic (1958), Thomas (1971), and Ichthyological Associates (1980a, b) for Delaware Bay; by Perlmutter (1939), Merriman and Sclar (1952), Nesbit (1954), Perlmutter et al. (1956), Wheatland (1956), and Murawski (1969) for New York and New Jersey waters; by Herman (1963) for Narragansett Bay; and by Bigelow and Schroeder (1953) for the Gulf of Maine. The magnitude of spawning at the northern limit of the range is unknown.

Weakfish larvae have been collected from near shore to 70 km offshore in coastal ichthyoplankton surveys (Hildebrand and Cable 1934; Tathum et al. 1974; Tathum and Swiecicki 1975; Powles and Stender 1976; Swiecicki

Table 12-1. Meristic characteristics of weakfish as reported in the literature (number of specimens examined in parentheses).

	Ginsburg (1929)	Alperin (1953)	Seguin (1960)	Miller & Jorgenson (1973)
Vertebrae				
Total	25 (55)	-	24-26 (742)	25 (10)
Precaudal	-	-	-	13 (10)
Caudal	-	-	-	12 (10)
Dorsal Fin				
Total	-	-	-	11 (10)
Spines	25-29 (189)	-	-	24-28 (10)
Rays	-	35-41 (654)	36-41 (536)	35-39 (10)
Anal Fin				
Spines	-	-	-	2 (10)
Rays	11-13 (189)	-	-	10-12 (10)
Pectoral Fin				
Rays	-	16-20 (655)	-	-
Caudal Fin				
Total	-	-	-	29-33 (10)
Dorsal secondary rays	-	-	-	7-9 (10)
Dorsal primary rays	-	-	-	9 (10)
Ventral primary rays	-	-	-	7-9 (10)
Ventral secondary rays	-	-	-	5-7 (10)
Gill Rakers				
Total	4-7 (187)	-	-	8 (10)
Upper	11-13 (187)	-	10-14 (934)	-
Lower	15-20 (187)	-	-	-

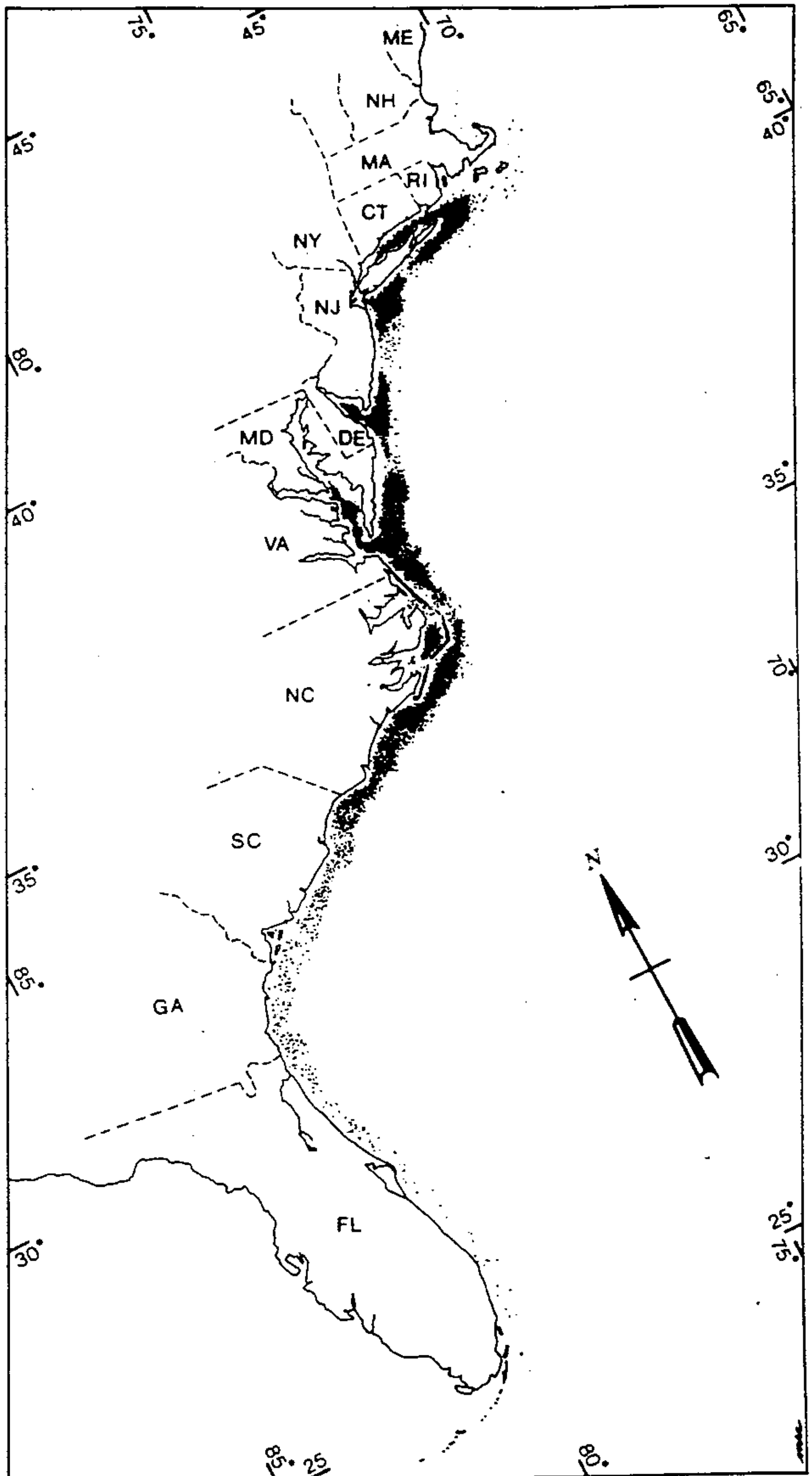

Figure 12-2. General distribution of the weakfish, Cynoscion regalis, along the Atlantic coast of the United States. Density of stippling indicates areas where weakfish tend to congregate (from: Wilk 1976).

1976; Berrien et al. 1978) as well as within estuaries and tidal passes (Welsh and Breder 1923; Hildebrand and Cable 1934; Perlmutter 1939; Pearson 1941; Harmic 1958; Herman 1963; Williams and Deubler 1968; Scotton 1970; Dovel 1971; Hobbie 1971; McDermott 1971; Hoese 1973; Johnson 1973; Powles and Stender 1978; Ichthyological Associates 1980a, b; Collings et al. 1981; Himchak 1981; Olney 1983). Larvae become demersal at 1.5 to 8 mm TL and probably utilize subsurface currents to move to lower salinity nursery grounds (Hildebrand and Cable 1934; Pearson 1941; Harmic 1958).

Juvenile weakfish are euryhaline and have been collected in fresh water (Raney and Massman 1953; Gunter and Hall 1963; Thomas 1971). Juveniles were 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; Dahlberg 1972; Copeland and Birkhead 1973; Ritchie and Koo 1973; Taylor et al. 1973; Mahood 1974; 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, moderate depths, slightly higher salinities, and sand and/or sand-grass bottoms) rather than in primary nursery areas (shallow tributaries, low salinity, mud and/or mud-grass bottom) (Spitsbergen and Wolff 1974; Purvis 1976; Ross 1980; Hawkins 1982; Ross and Carpenter 1983). In Chesapeake Bay and Delaware Bay young-of-the-year 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; Derickson and Price 1973; Taylor et al. 1973; 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, 1968-1981, in depths of 9-18 m during fall and winter[2]. Juvenile weakfish were collected in winter and early spring from North Carolina to Florida at depths of 9-11 m (Wilk and Silverman 1976a).

12.2.2.2 <u>Adults</u>

Merriner (1973) summarized the distribution of adult weakfish as follows:

> The life of the adult weakfish includes estuarine and oceanic residence and an inshore-offshore, north-south migration pattern. Warming of coastal waters in spring prompts an inshore and northerly migration of adults from their wintering grounds. They enter sounds, bays and estuaries in early spring and may either stay there through summer or return to the ocean. Sport and commercial catch records suggest movements of adults from the North

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

Carolina-Chesapeake Bay area to more northerly areas. Summer residence is established throughout coastal systems from Florida to the northern range limit. A greater proportion of the adults spend summers in ocean waters rather than in sounds and bays of northern states. Declining water temperatures of fall are associated with formation of weakfish aggregations and a general southerly movement along the coast. Exact location(s) of wintering grounds for adult weakfish are not known, but existing evidence suggests the continental shelf from Chesapeake Bay to Cape Fear, N.C.

Exploratory fishing between Cape Fear and Cape Hatteras, North Carolina from 1956-1974 revealed that highest catch rates occurred in fall and winter (Bullis and Cummins 1974). Weakfish were caught in trawl surveys along the North Carolina coast from October to May, 1968-1972, at depths less than 18 m.[3] Most fish were <0.2 kg and <265 mm TL. A few weakfish were collected in the fall and winter in the vicinity of a calico scallop bed off the coast of North Carolina (Schwartz and Porter 1977). Samples from the North Carolina winter gill net and trawl fisheries, which operate mostly at depths <37 m, consisted mainly of bait, pan and medium weakfish (111-566 mm TL).[4] Larger weakfish may occur at greater depths and further north (Pearson 1931). Weakfish migrations are discussed further in Section 12.3.5.

12.2.3 Determinants of Distribution

Adult weakfish move inshore to the coast, sounds and bays in spring to spawn. Laboratory tests indicate that optimum hatching of weakfish eggs occurs between 18 and 24°C (Harmic 1958). Weakfish eggs in all stages of development were collected in the Peconic Bay area of New York at temperatures of 12-24°C and salinities of 29-35 ppt (Perlmutter 1939). The young, if not spawned within estuaries, are probably carried there by tidal currents and migrate to low salinity nursery grounds. Thomas (1971) found that upriver movement of juvenile weakfish in the Delaware River was blocked by low oxygen concentrations (1.0-2.3 ppm) and low salinities (<3 ppt). Decreasing water temperatures in the fall appear to initiate movement out of the estuary to deeper waters. Older weakfish apparently move out of the estuaries to deeper water earlier than young-of-the year weakfish (Hildebrand and Cable 1934; Massmann et al. 1958; Thomas 1971). Only a few weakfish of any size have been collected below 10°C in Delaware Bay or Chesapeake Bay (Massmann et al. 1958; Abbe 1967; Thomas 1971). Hildebrand and Cable (1934) found that smaller weakfish (122-182 mm TL) in North Carolina remain in shallow waters except during brief cold snaps. Dead and numb weakfish were observed in shallow waters when water temperatures dropped suddenly to 5°C (Smith 1907; Hildebrand and Cable 1934). Schwartz (1964b) subjected five weakfish collected at 20.7°C to normal winter

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

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

water temperatures. Swimming speed drastically slowed as the water temperature approached 10°C, feeding ceased at 7.9°C, and all fish died at 3.3°C.

12.3 Life History

12.3.1 Reproduction

Weakfish are dioecious, and eggs and milt are expelled into the surrounding water where fertilization takes place. Since they possess no external accessory organs, the sexes cannot be distinguished externally. The male weakfish has drumming muscles along the length of the body which become red and thickened during the spawning season (Merriner 1976). One may be able to differentiate between the male and softer bodied female by applying external pressure on the abdomen (Hildebrand and Schroeder 1928), although this method is not always effective. Only the male makes assorted croaking and drumming sounds (Hildebrand and Schroeder 1928; Fish and Mowbray 1970) which may be an important means of communication during spawning (Thomas 1971).

Merriner (1976) found that male weakfish attain sexual maturity at a smaller size (130-150 mm SL) than do female weakfish (145-190 mm SL) in North Carolina waters. Shepherd (1982) found that size at maturity of weakfish in the New York Bight occurred within the same size range described by Merriner (1973); however, no size differences were found between sexes. Weakfish males and females probably attain sexual maturity as one-year-old fish throughout their geographic range, although smaller members of a year class may not mature until their second year of life.

Weakfish are characterized by high fecundity. Merriner (1976) presented the following fecundity (F) equations for standard length (SL), total length (TL) and weight (W): $F = 0.116\ SL^{2.7755}$ ($r^2 = 0.85$); $F = 0.152\ TL^{2.6418}$ ($r^2 = 0.86$); and $F = 21{,}198 + 1{,}279\ W$ ($r^2 = 0.88$). Using the equation for total length, a 500 mm TL female weakfish will produce slightly over two million eggs. Shepherd (1982) found a much lower annual fecundity for weakfish from the New York Bight; approximately 300,000 eggs for a 500 mm TL fish. The lifetime cumulative fecundity for northern weakfish, however, is nearly the same since they have a greater longevity and ultimate size. The following fecundity relation is from Shepherd (1982): $\ln F = -16.322 + 4.659 \ln TL$ ($r^2 = 0.84$).

Spawning, hatching and early larval development take place in the near-shore and estuarine zones along the coast from March to October with peak juvenile production during late April through June (Welsh and Breder 1923; Hildebrand and Schroeder 1928; Higgins and Pearson 1928; Hildebrand and Cable 1934; Perlmutter 1939; Pearson 1941; Merriman and Sclar 1952; Bigelow and Schroeder 1953; Nesbit 1954; Daiber 1954; Perlmutter et al. 1956; Wheatland 1956; Harmic 1958, Massmann 1963a, b; Tagatz 1967; Murawski 1969; Thomas 1971; Dahlberg 1972; Tathum et al. 1974; Tathum and Swiecicki 1975; Merriner 1976; Powles and Stender 1978; Colton et al. 1979; Shepherd 1982; Olney 1983).

Welsh and Breder (1923) observed large schools of weakfish assembling on the eastern side of Delaware Bay at depths of 5 to 9 m. They reported that spawning took place over mud and sand bottoms chiefly at night, especially in the early evening. A "milling" behavior during spawning has been observed in Great South Bay, Long Island, New York, on the Heckscher Flats.[5] At times, the "milling" occurs simultaneously at many locations on the flats with the dorsal portion of the weakfish breaking the surface. To date, it has not been determined how many individuals are in each "milling" group.

The eggs of weakfish were described by Welsh and Breder (1923), Harmic (1958), and Lippson and Moran (1974). Harmic (1958) found that hatching success of weakfish eggs in the laboratory was reduced by sudden changes in temperature (±6°C) or salinity (±5-6 ppt), turbulence, and dissolved oxygen below 4.3 mg/l. The addition of antibiotics resulted in a four-fold increase in hatching success.

12.3.2 Pre-adult Phase

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) (Figure 12-3). Welsh and Breder (1923) stated that hatching occurs in 36 to 40 hours at 20-21°C. In laboratory experiments hatching occurred within 1000 degree hours over a temperature range of 12 to 13.5°C, with optimum hatching occurring between 18 and 24°C (Harmic 1958). 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). Growth is rapid with the young attaining an average length of 168.8 mm TL by December of their first year (Hildebrand and Cable 1934).

12.3.3 Adult Phase

Weakfish attain a greater maximum size and longevity in the northern part of the range. Shepherd (1982) aged weakfish captured between Cape Fear, North Carolina and Cape Cod, Massachusetts and found maximum ages of 11 (approximately 11.6 pounds) and 4 yr from the northern and southern parts of the sampling range, respectively. Seagraves (1981) reported a maximum age of 9 yr for Delaware Bay and Merriner (1973) reported a maximum age of 6 yr for weakfish from North Carolina waters. Larger and presumably older fish have been recorded: 16 lb (May 1921, Virginia - Hildebrand and Schroeder 1928); 17 lb 8 oz (September 1944, New Jersey - Bigelow and Schroeder 1953); 17 lb 4 oz (May 1980, New York - International Game Fish Association 1982); and 19 lb (May 1983, Chesapeake Bay - Potential World Record Trout Caught 1983). A reported 30 lb weakfish by Welsh and Breder (1923) is highly questionable.

Adult weakfish, owing to their predacious nature, have food habits similar to other top predators such as striped bass and bluefish.

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[5]Pers. commun. John Poole, New York Department of Environmental Conservation, Stony Brook, N.Y.

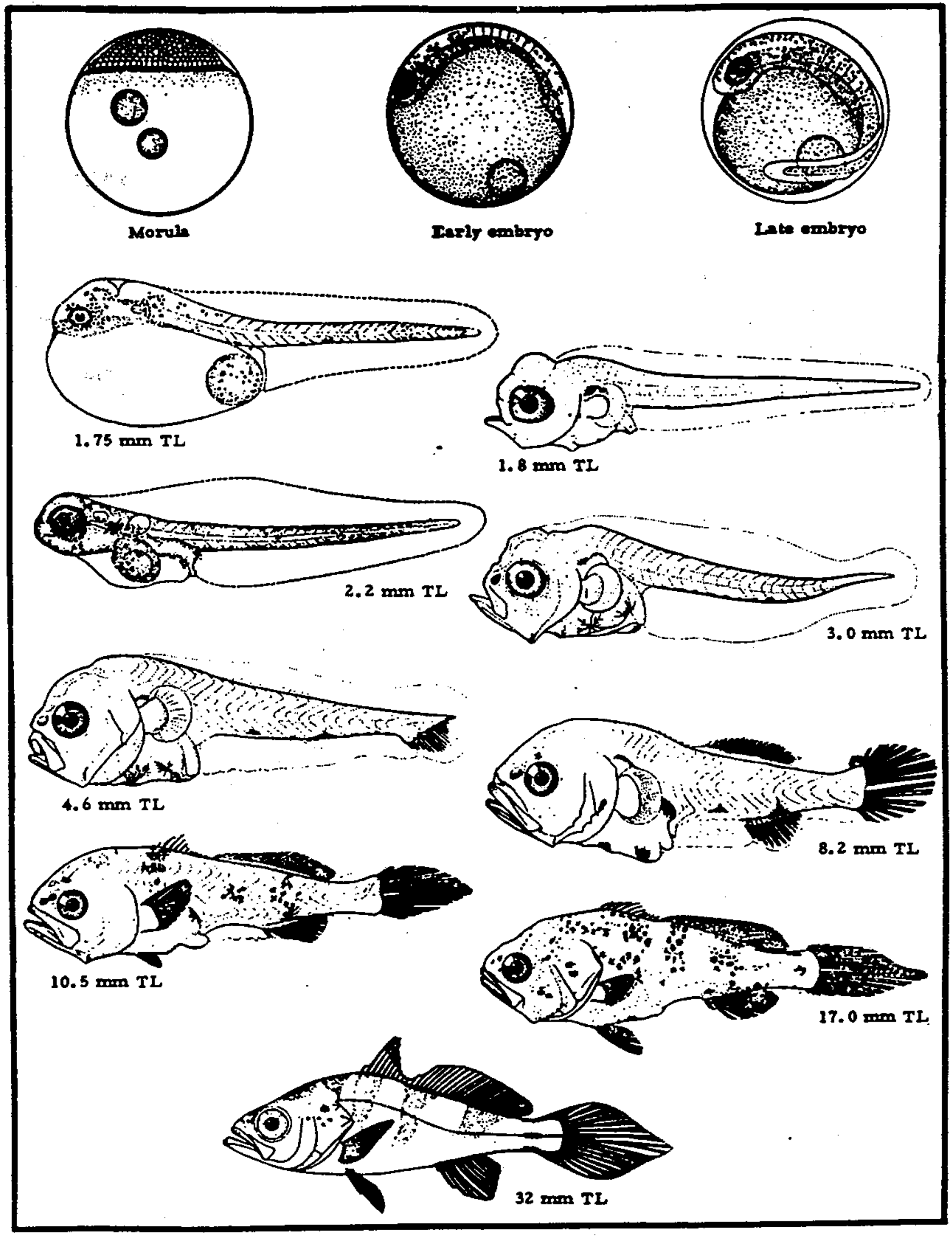

Figure 12-3. States in the development of weakfish, *Cynoscion regalis*, eggs, prolarvae, larvae, and juveniles (illustrations from: Lippson and Moran, 1974) (from: Wilk 1979).

Weakfish are in turn preyed upon by bluefish, striped bass, and larger weakfish (Wilk 1979).

Parasites of weakfish were reported by Linton (1905) and Merriner (1973).

Mahoney et al. (1973) reported weakfish, especially juveniles, to be 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 necrosis 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.[6,7] In spring 1983 numerous weakfish (50-60%) caught in pound nets in the Peconic and Gardiners Bays area of New York were found to be lying on the surface in a moribund condition with red, swollen eyes.[8] Heavy copepod infestations were also noted. No cause for the condition has been determined.

12.3.4 Nutrition and Growth

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). His field data and laboratory behavioral observations suggested that weakfish forage along the periphery of eelgrass beds during low light periods (dusk to dawn). The high percent of occurrence of blue crabs (40%) and spot (18%) in weakfish stomachs indicated that some feeding was occurring in eelgrass beds since these organisms were considerably more abundant there than in adjacent non-vegetated sampling sites. The lack of eelgrass in stomachs, however, and oblique mouth position suggested that weakfish feed pelagically and not deep within the vegetation. In laboratory experiments, weakfish captured fewer prey as the percentage of vegetative cover increased.

Numerous authors have reported on the food habits of weakfish (Peck 1896; Eigenmann 1901; Linton 1905; Smith 1907; Tracy 1910; Welsh and Breder 1923; Nichols and Breder 1926; Hildebrand and Schroeder 1928; Bigelow and Schroeder 1953; DeSylva et al. 1962; Richards 1963; Thomas 1971; Merriner 1975; Stickney et al. 1975; Chao and Musick 1977; Schwartz et al. 1980).

Food habits from different estuarine areas along the coast are presented in Table 12-2. A shift in food with growth was noted by Thomas (1971),

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[6]Pers. commun. Richard Seagraves, Delaware Division of Fish and Wildlife, Dover, Del.

[7]Pers. commun. James Music, Georgia Coastal Resources Division, Brunswick, Ga.

[8]Pers. commun. John Poole, New York Department of Environmental Conservation, Stony Brook, N.Y.

Table 12-2. Stomach contents of weakfish from different estuarine areas along U.S. Atlantic coast (from Chao and Musick 1977).

Author	Chao 1976	Welsh and Breder 1923				Merriner 1975	
Locality	York River, Va.	Acushnet River, Mass	Cape Charles, Va.	Winyah Bay, S.C.	Fernandina, Fla.	Pamlico Sound and Morehead City, N.C.	
Period	June-Aug 1973	Sept. 1882	Sept. 1916	July 1915	Mar. 1920	June 1967-Jan 1970	
Source	Original	p. 159	p. 160	p. 161	p.161	Table 1	
Number of specimens	36	28	45	34	105	2,159	
Empty stomachs	2	5	0	5	74	1,342	
Length of specimens	70-183 mm TL	7-11 cm SL	43-11.5 cm SL	2.8-6.2 cm SL	5-17 cm SL	135-481 mm SL	
Quantitative method	% of occurrence	% of volume	% of volume	% of volume	% of volume	% of occurrence	% of volume
Fishes:							
Anchoa mitchilli	72.2					58.1	25.6
Others and remains	8.3	48.0	2.0	9	18	15.7	74.0
Macrozooplankton							
Mysidacea	2.8						
Neomysis americana	63.9					31.0	0.9
Isopoda		0.5		6			
Decapoda (shrimps)		47.0	0.5		46	0.1	
Others and remains			91.0	83	18	1.5	1.2
Microzooplankton							
Copepoda			3.5	2			
Epibenthos:							
Polychaeta		0.5				0.5	
Amphipoda			3.0				0.1
Others and remains						1.5	
Unidentified remains	5.6	4.0			18	96.8	8.2

Table 12-2 (continued)

Author	Thomas 1971					Stickney et al. 1974
Locality	Delaware River, Del.					Savannah River and Ossabaw Sound, Ga.
Period	June 1969	July 1969	Aug. 1969	Sept. 1969	Oct. 1969	May 1972-July 1973
Source	Table 20	Table 20	Table 20	Table 20	Table 20	Table 1
Number of specimens	71	94	94	120	66	120
Empty stomach	10	11	10	18	12	35
Length of specimens	11-76 mm TL	5-123 mm TL	15-180 mm TL	20-180 mm TL	61-180 mm TL	30-169 mm SL
Quantitative method	% of occurrence	% of occurrence	% of occurrence	% of occurrence	% of occurrence	% of occurrence
Fishes:	[1]7.0	[1]14.9	[1]16.0	[1]33.3	[1]34.8	
Anchoa mitchilli	1.4	2.1	1.1	3.3	4.5	2.5
Others and remains	2.8	7.4	13.8	12.5	30.3	31.7
Macrozooplankton						
Mysidacea	74.6	59.6	65.8	66.7		0.8
Neomysis americana						55.0
Isopoda		4.3	2.1	1.7		2.5
Decapoda (shrimps)		2.1	3.2	6.7	10.6	2.5
Others and remains						
Microzooplankton						
Copepoda	19.7	4.3	2.1	3.3		5.0
Calanoid						2.5
Others and remains	9.9	4.3	1.1	0.8	1.5	
Epibenthos:						
Nereis succinea						15.0
Amphipoda						2.5
Gammarus sp.	9.9	58.5	58.5	28.3	28.8	1.7
Others and remains						9.2
Unidentified remains						2.5

[1]All fishes combined

Merriner (1975), Stickney et al. (1975), and Schwartz et al. (1980). Young weakfish feed primarily on mysid shrimp and anchovies while older weakfish feed on the clupeid species that are abundant in a given area. Cannibalism was reported by Thomas (1971) and Merriner (1975). Chao and Musick (1977) described and illustrated in great detail the functional morphology of juvenile weakfish. They found mouth position, dentition, gill rakers, digestive tract, pores, nares, and body shape to be important in locating and ingesting prey in the water column. Young weakfish feed mainly above the bottom and therefore are able to coexist with other species which have more benthic feeding habits.

Growth of juvenile weakfish was reported by Perlmutter (1939) for New York; Welsh and Breder (1923) for New Jersey; Daiber and Smith (1971), Thomas (1971), and Ichthyological Associates (1980a) for Delaware Bay; Pearson (1941), Massmann et al. (1958), and Chao and Musick (1977) for Chesapeake Bay; Higgins and Pearson (1928), Hildebrand and Cable (1934), Spitsbergen and Wolff (1974), Purvis (1976), and Hawkins (1982) for North Carolina; Shealy et al. (1974) for South Carolina; and Mahood (1974) for Georgia. Weakfish growth is particularly rapid during the first year (Table 12-3). In Delaware Bay, juveniles may grow from 20 to 35 mm per month during June-September (Ichthyological Associates 1980a) and may attain lengths ranging from 100 to 175 mm TL throughout the range. The variability of size within year classes (Table 12-3) is due to the extended spawning season throughout the range. Massmann et al. (1958) and Thomas (1971) found two distinct size groups of young-of-the-year weakfish in the fall from Chesapeake Bay (45 mm and 85 mm) and Delaware Bay (30-40 mm and 110-130 mm), respectively. This apparently reflects two separate spawning peaks. Thomas (1971) did not find a bimodal length distribution for adult weakfish which may be due to high mortality of late spawned weakfish or compensatory growth.

Annulus formation on weakfish scales takes place from March through September with the highest incidence in June and July (Taylor 1916; Perlmutter et al. 1956; Massmann 1963b; Thomas 1971; Merriner 1973; Seagraves 1981; Shepherd 1982). Growth of adult weakfish slows during reproduction as energy is shifted to the development of gonads. Somatic growth is rapid after spawning and annulus formation, as indicated by the increase in the scale marginal increment from July to October (Merriner 1973).

Age composition and rate of growth have been estimated from annual rings on scales, otoliths, vertebrae, and from length frequencies (Eigenmann 1901; Tracy 1908; Taylor 1916; Welsh and Breder 1923; Higgins and Pearson 1928; Hildebrand and Schroeder 1928; Hildebrand and Cable 1934; Daiber 1954, 1955, 1956, 1957; Nesbit 1954; Perlmutter et al. 1956; Massmann 1963a, b; McHugh 1960; Thomas 1971; Wolff 1972; Merriner 1973; Feldheim 1975; Seagraves 1981; Shepherd 1982). These estimates vary considerably not only from one investigator to another, but from season to season, year to year, and area to area.

Mean back-calculated lengths at age I are fairly constant through time and space (Table 12-4). Differences in the growth of weakfish after age I are considerable, between areas and years of collection. Weakfish from Virginia Beach and north (Seagraves 1981; Shepherd 1982) are

Table 12-3. Growth of weakfish from different estuarine areas along U.S. Atlantic coast (from Chao and Musick 1977).

Author	Thomas 1971	Pearson 1941		Chao 1976	
Locality	Delaware River, Del.	Lower Chesapeake Bay		York River, Va.	
Period	1969	1929-30		Jan. 1972-Dec. 1974	
Gear	T and S	PL and P		16-ft T	
Source	Table 4	Figure 23		Fig. 10 (present study)	
Length (mm)	Total length	Total length		Total length	
Age group	0	0	1	0	1
January					120-205
February					130-315
March					
April			130-250		65-175
May					155-330
June	5-70				140-385
July	15-125	20-(150)		20-55	105-305
August	15-(185)	30-(160)		10-(195)	100-370
September	70-(185)		(130)-180	70-(110)	115-300
October	40-(175)			35-(135)	140-325
November				65-(140)	140-205
December				95-(170)	

Author	Hildebrand and Cable 1932		Shealy et al. 1974		Mahood 1974	
Locality	Beaufort, N.C.		South Carolina coast		Georgia Coast	
Period	?		Feb. 1973-Jan. 1974		Oct. 1970-Sept. 1973	
Gear	PL, P, and T		20-ft T		40-ft T	
Source	Table 4		Table 32		Table 7	
Length (mm)	Total length		Total length		Total length	
Age group	0	1	0	1	0	1
January		75-204		138-327		68-438
February		105-274				65-388
March		90-230		155		83-358
April		80-284		118-188		48-408
May	4-9	125-224				48-348
June	4-44	95-279	23-(47)	72	13-(128)	(133)-328
July	4-(39)	40-379	23-(52)	(53)-187	18-(173)	(178)-363
August	4-(64)	65-369	23-(72)	(73)-182	23-(203)	(208)-323
September	10-(79)	80-314	23-(67)	(68)-208	18-(213)	(218)-388
October	45-(94)	100-329	28-(72)	(73)-228	28-(223)	(228)-313
November	45-(99)	(100)-329	68-72	78-702	48-(233)	(238)-348
December	85-(94)	(95)-299	88-92	108-197	53-(233)	(238)-348

[1]Gear: P, pound net; PL, plankton net; S, seine; T, trawl.
[2]Age-group: 0 represents smallest groups of young-of-the year taken from January on; other fishes (including overwintering young-of-the-year) are included in age-group 1. Parentheses indicate that the boundary of age-groups 0 and 1 is indistinguishable.

Table 12-4. Mean back-calculated standard lengths (mm) for weakfish as reported in the literature.

Age Group	North Carolina 1916[1] Combined	North Carolina 1967 - 1969[2] Male	North Carolina 1967 - 1969[2] Female	Region 3 Cape Fear, N.C. to Virginia Beach, Va. 1979 - 1981[3] Male	Region 3 Cape Fear, N.C. to Virginia Beach, Va. 1979 - 1981[3] Female	Chesapeake Bay 1929[4] Combined	Delaware Bay 1965[5] Combined	Delaware Bay 1979[5] Male	Delaware Bay 1979[5] Female	Region 2 Virginia Beach, Va. to Ocean City, Md. 1979 - 1981[3] Male	Region 2 Virginia Beach, Va. to Ocean City, Md. 1979 - 1981[3] Female	New York 1929[4] Male	New York 1929[4] Female	New York 1952[4] Male	New York 1952[4] Female	Region 1 Ocean City, Md. to Cape Cod, Ma. 1979 Male	Region 1 Ocean City, Md. to Cape Cod, Ma. 1981[3] Female
I	173	153	159	181	176	143	156	164	162	166	167	170	167	174	180	164	167
	(37)	(423)	(543)	(94)	(100)	(162)	(230)	(330)	(306)	(95)	(76)	(209)	(190)	(341)	(401)	(373)	(327)
II	229	218	225	224	241	217	203	268	270	230	248	230	229	238	247	259	266
	(37)	(167)	(260)	(38)	(58)	(137)	(168)	(214)	(195)	(33)	(31)	(174)	(172)	(136)	(115)	(306)	(275)
III	271	267	287	263	299	249	236	373	376	371	426	258	260	308	314	381	395
	(36)	(78)	(166)	(9)	(15)	(112)	(77)	(44)	(55)	(6)	(7)	(124)	(132)	(47)	(49)	(201)	(201)
IV	335	317	357		304	283	264	449	457	459	541	281	293	370	418	464	477
	(21)	(26)	(50)		(1)	(87)	(9)	(12)	(28)	(1)	(4)	(104)	(114)	(11)	(13)	(88)	(104)
V	402	410	421			319		499	511	497	556	312	331	468	499	517	526
	(15)	(1)	(9)			(62)		(8)	(23)	(1)	(2)	(89)	(91)	(4)	(5)	(53)	(71)
VI	396		562			364		563	525		583	353	355	548	561	541	558
	(6)		(1)			(37)		(1)	(11)		(1)	(67)	(56)	(2)	(1)	(39)	(53)
VII	463					404			558			386	371			548	578
	(3)					(16)			(8)			(35)	(29)			(18)	(39)
VIII	487								609			455	382			558	601
	(1)								(4)			(10)	(7)			(10)	(26)
IX									630							582	625
									(4)							(7)	(15)
X																563	625
																(2)	(9)
XI																580	667
																(1)	(3)

[1] As reported by Taylor (1916).
[2] As reported by Merriner (1973).
[3] As reported by Shepherd (1982).
[4] As reported by Perlmutter, Miller and Poole (1956).
[5] As reported by Seagraves (1981).
All data except from Merriner (1973) and Seagraves (1981) approximated by FL/1.15 or TL/1.21.

larger at each successive age than those collected from North Carolina (Merriner 1973; Shepherd 1982) except for Chesapeake Bay and New York in 1929 (Perlmutter et al. 1956). Perlmutter et al. (1956) suggested that the larger average size of weakfish in New York waters in 1952 indicated that contributions from the slower growing southern stocks were less than in 1929. Seagraves (1981) compared growth of weakfish in Delaware Bay between 1956 and 1979 and found that growth was greater in 1979 for each successive age after age I. These differences in growth between areas and years are discussed further in Section 12.4.

12.3.5 Behavior

Welsh and Breder (1923) observed that weakfish first appear along the Middle Atlantic coast in April and May when there is a run of adult fish into the bays and sounds. Shortly after their initial appearance, the fish return to the larger bays and possibly to the ocean to spawn. Samples of weakfish from the Delaware Bay and Chesapeake Bay pound net fisheries and from the Pamlico Sound pound net and long haul seine fisheries revealed that larger individuals predominated in the spring followed by a second group of smaller weakfish in the summer (Higgins and Pearson 1928; Massman 1963; Daiber and Smith 1971; Sholar 1979; DeVries 1980, 1981a; Ross 1982).

A study of the winter trawl fishery off the Virginia and North Carolina coasts indicated that most weakfish were caught in the southern fishery area between Ocracoke Inlet and Bodie Island, North Carolina at depths of 18 to 55 m (Pearson 1932). Catches of weakfish in the northern fishing area (southeast of Cape Henry, Virginia at depths of 36 to 91 m) increased in March and April, indicating that schools of weakfish were moving northward for the summer. These fish were larger (50-75 cm) than weakfish caught in the southern area (generally less than 50 cm). Weakfish caught in the southern area were the same size as caught in the summer inshore fisheries in North Carolina and Virginia, whereas the larger fish were frequently caught in pound nets along the New Jersey and Long Island coast. Pearson (1932) concluded that in spring a general inshore movement of fish undoubtedly occurs, and the larger and older individuals possibly move farther up the coast to more northern localities while the younger fish (2 to 3 years old) move directly inshore to the North Carolina sounds and Chesapeake Bay. Some weakfish may remain in inshore waters throughout the winter from North Carolina southward (Goode 1884; Higgins and Pearson 1928; Hildebrand and Cable 1934; Anderson 1968; Shealy et al. 1974; Mahood 1974). Wilk (1979) summarized the migratory patterns of weakfish along the Atlantic coast as follows:

> Young weakfish less than four-years-old, move out of the near-shore and estuarine zones and south along the coast in fall and winter, some as far as Florida, and north in spring and summer. The older and larger fish, usually greater than four-years-olds, move south but offshore in the fall, probably no farther than North Carolina, and then return to their inshore northern grounds with the advent of spring warming (Nesbit, 1954; Massmann et al., 1958; Wilk, 1976; and Wilk and Silverman, 1976a) (Figures [12-4] and [12-5]). The larger fish, some larger than 15 pounds, appear to move fastest and

tend to congregate in the northern part of their range (Wilk and Silverman, 1976a; and Wilk et al., 1977).

Weakfish school by size and begin to school as pre-adults (Welsh and Breder 1923; Bigelow and Schroeder 1953; Pearson 1941).

Preliminary unpublished studies of weakfish behavior have been conducted by the National Marine Fisheries Service Sandy Hook Laboratory (Wilk 1979). Weakfish are highly visually oriented when feeding; in addition they have a highly developed chemo-sensing response mechanism. When fright or stress stimuli, such as increased temperature, were introduced schooling became tighter and more frequent. Weakfish exhibited a 35% increase in swimming speed accompanied by tighter and more frequent schooling as temperature was gradually increased (0.05°C/h) from the acclimated temperature range of 19-20°C to almost 29°C. As the fish became acclimated to 29°C their activity decreased to a point similar to that before temperature was increased. This increased activity may serve to move the fish from regions of adverse temperature.

Weakfish exhibited three distinct activity patterns in a laboratory study of predator-prey interactions in eelgrass: resting, observed only at night; swimming, observed at all light intensities and generally throughout the daylight period; and feeding, observed during all lighted periods, but most intense at very low light levels (Lascara 1981). The prey-capture sequence included visual fixation and orientation towards prey, active pursuit, and once within striking distance (20-50 cm), rapid beating of caudal fin, and forward and upward lunge with jaws agape and opercles spread. Weakfish consumed fewer prey as percent area of vegetative cover increased.

12.3.6 Contaminants

Joseph (1972) hypothesized that the widespread use of DDT along the Atlantic coast, beginning in 1945 and 1946 and its continued heavy use for the next few years, might be related to the dramatic decline in weakfish stocks during the 1950s and 1960s. Although it has not been demonstrated that weakfish concentrate DDT, Butler (1969) reported levels of DDT as high as 8 ppm in the gonads of female spotted seatrout and no observed breeding of that species in two years in the lower Laguna Madre, Texas, where pesticide residues were consistently high.

Trace levels of 15 elements were determined in tissues of 204 species of mollusks, crustaceans, and finfish, including weakfish, to provide baseline data to help identify potential problems involving species, elements, or locations (Hall et al. 1978). No interpretative comments were provided.

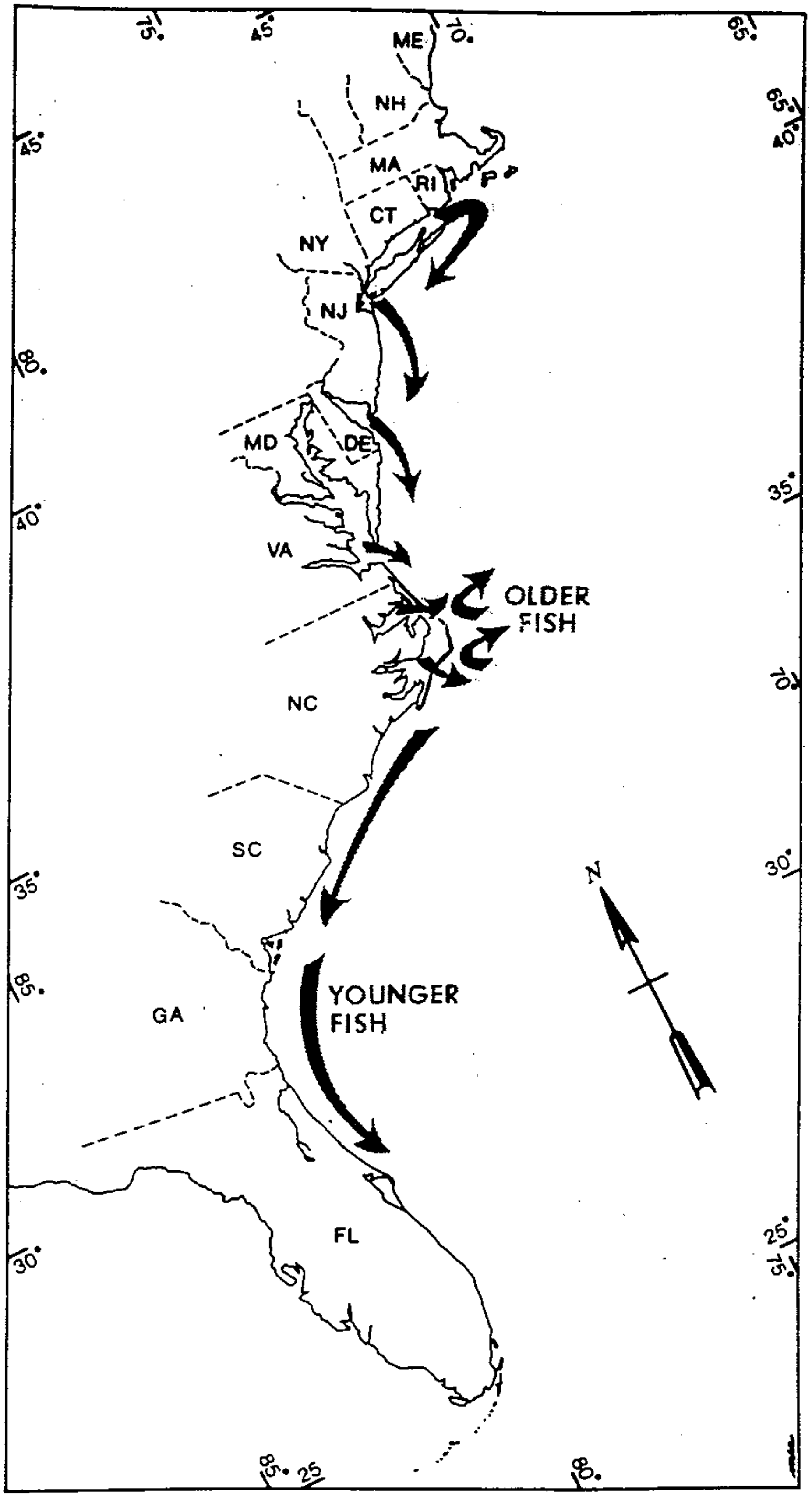

Figure 12-4. Movements of the weakfish, Cynoscion regalis, along the Atlantic coast of the United States during fall and winter (from: Wilk 1976).

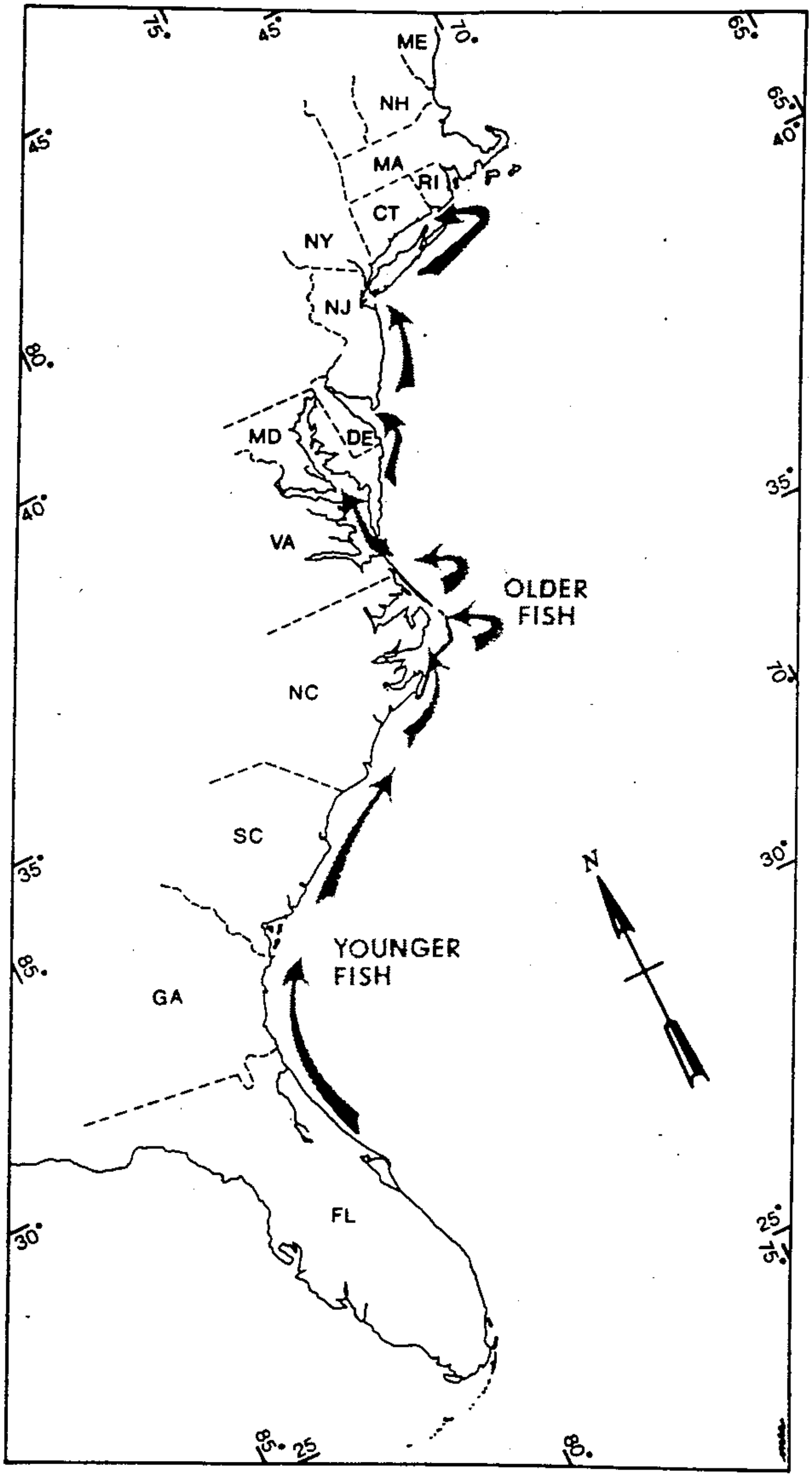

Figure 12-5. Movements of the weakfish, Cynoscion regalis, along the Atlantic coast of the United States during spring and summer (from: Wilk 1976).

12.4 Population

12.4.1 Structure

Two or three population subunits of weakfish have been hypothesized by various investigators. Welsh and Breder (1923) suggested the existence of racial groups based on spring and fall spawning of weakfish and large differences in diameters of eggs stripped from two specimens at Cape May, New Jersey. Pearson (1941) also noted that the eggs fell into two different size groups. Hildebrand and Cable (1934), however, suggested that he may have confused eggs of silver perch and pigfish with weakfish eggs. They also suggested that Welsh and Breder (1923) may have measured eggs spawned in water of unequal density which would have affected egg diameters. Nesbit (1954) concluded that there were northern and southern populations of weakfish based on differences in scale sculpturing in juveniles and on limited tag returns. He believed that the fishery, however, draws on a common stock which chiefly originates in southern waters (south of Delaware Bay but excluding North Carolina sounds). Perlmutter el al. (1956) also supported the idea of northern and southern stocks based on fin ray counts, scale sculpturing, and growth rates. The young of the year of these two segments were separate and identifiable although mixing of adults occurred. Alperin (1953) compared meristic and morphometric characteristics of weakfish from New York and Virginia and found no significant differences. Three major weakfish population subunits were distinguished by Seguin (1960) based on morphometic and meristic characteristics: a northern segment, New York; a central segment, Delaware and possibly Virginia; and a southern segment, North Carolina. Joseph (1972) concluded from available evidence presented in racial studies that if stock separation does exist, the most likely point of differentiation is Cape Hatteras, North Carolina. Shepherd (1982) hypothesized three population subunits based on significant differences in total length-scale size relationships: Region 1, Cape Cod, Massachusetts to Ocean City, Maryland; Region 2, Ocean City, Maryland to Virginia Beach, Virginia; and Region 3, Virginia Beach, Virginia to Cape Fear, North Carolina. He also found differences in growth and longevity between the regions. Preliminary results of an electrophoretic study of young-of-the-year weakfish collected from Long Island Sound, New York, Delaware Bay, Chesapeake Bay, and Pamlico Sound, North Carolina indicated that the populations sampled were genetically homogeneous (Crawford and Grimes 1983).

Age and growth studies as well as fishery analyses indicate different growth characteristics, harvest rates, juvenile survival rates, and probable mixing between subgroups (Merriner 1973). The identification of weakfish populations, mapping of their distribution, measurements of their respective abundance and determination of the contribution of each to the fishery, require further studies of age and growth, fecundity, movements and migrations, scale and chemical characteristics, meristic and morphometric variations, made continuously over the entire range of the species for several years (Wilk 1979).

National Marine Fisheries data from 1968-1976 indicated that the sex ratio of weakfish at each age remained essentially the same from area to area and from year to year. There were equal numbers of males and females at all ages and weakfish did not appear to school by sex during any time of life (Wilk and Silverman 1969a, b; Wilk et al. 1977). Shepherd (1982) reported that while the overall population ratio of males to females approached equality, there were significant differences from 50:50 at various length intervals due to differences in growth between the sexes. Mean lengths at age were greater for females after age I in all regions, except for age VI males in Delaware Bay, represented by a single male (563 mm SL) (Seagraves 1981) and ages II, VII, and VIII males from New York, 1929 (Perlmutter et al. 1956) (Table 12-4).

The age composition of weakfish populations between Cape Cod, Massachusetts and Cape Fear, North Carolina varied between areas as well as historically (Table 12-4). Although part of this variation may be due to sampling gear bias, weakfish longevity is apparently greater in the northern extreme of the range. Shepherd (1982) identified 11 age groups in Region 1, six in Region 2, and four in Region 3. Nine age groups were identified in Delaware Bay (Seagraves 1981), seven in Chesapeake Bay (Perlmutter et al. 1956), and six in North Carolina (Merriner 1973). Older weakfish were found in New York in 1979-1981 (age XI) (Shepherd 1982) than in either 1952 (age VI) or 1929 (age VIII) (Perlmutter et al. 1956) and older fish were found in 1929 than in 1952. Seagraves (1981) found older weakfish in Delaware Bay in 1979 (age IX) than in 1956 (age IV). Older weakfish were found in North Carolina in 1916 (age VIII) (Taylor 1916) than in 1967-1969 (age VI) (Merriner 1973) or 1979-1981 (age IV) (Shepherd 1982).

Age/size composition of the commercial fisheries varies with location, gear type and season. Shepherd (1982) reported that landings from the spring mid-water trawl fishery operating out of Cape May, New Jersey consisted of fish from ages I-X with the majority of fish greater than 55 cm TL and age V. The fall commercial otter trawl fishery, however, landed primarily one year olds, with occasional fish as old as age VII. Young-of-the-year weakfish were culled from the catches. National Marine Fisheries Service groundfish survey data revealed that July-August otter trawl catches consisted primarily of age I weakfish (20-30 cm TL) and young of the year predominated in September-October samples. Catch curves for weakfish from North Carolina fisheries indicated that weakfish were fully recruited to the trawl fishery after one growing season and to the pound net fishery at age II (Merriner 1973). Samples from the North Carolina long haul seine and pound net fisheries indicated that age of recruitment varied from age I to age II annually (Sholar 1979; DeVries 1980, 1981a), possibly due to differences in year-class strength. Weakfish were fully recruited to the Chesapeake Bay pound net fishery at age II (Massmann 1963a; Joseph 1972).

Weakfish age and growth studies indicate geographic variations in growth (Table 12-4). Lengths at age I were similar throughout the range. Shepherd (1982) found that northern weakfish in Region 1 were largest at each age beyond age I. Growth of weakfish in Region 3 was lowest and similar to that reported for North Carolina by Taylor (1916) and Merriner (1973). Region 2 weakfish had intermediate growth comparable to Delaware Bay weakfish in 1979 (Seagraves 1981). Growth variations have been attributed to density dependent mechanisms, temperature, variable energetic costs of migration and spawning, variable prey availability, and to genetic differences. Shepherd (1982) stated that there are no data to indicate large variations in weakfish density, and seasonal migrations occur in conjunction with movements of the 16-24°C isotherms. He hypothesized that northern weakfish have evolved the growth strategy of increased somatic growth and longevity to maximize chances of surviving long migrations and producing gametes. The growth strategy of southern weakfish, which have little distance to migrate, is possibly shifted to increased gonad growth. This is indicated in the greater fecundities at length for southern weakfish (Section 12.3.1). Maximum size of southern origin weakfish may also be limited by prey availability (Shepherd 1982); however, Merriner (1973) stated that growth of weakfish is probably not limited by prey availability since weakfish utilize a variety of food sources. The existence of genetically distinct weakfish population subunits with different growth rates has not yet been established.

Historic variations in growth rates are apparent in Table 12-4. Weakfish lengths at age in the New York area increased between 1929, 1952, and 1979-1981 (Perlmutter et al. 1956; Shepherd 1982). Seagraves (1981) noted an increased growth rate for Delaware Bay weakfish from 1956 to 1979. Ages V and VI weakfish in North Carolina were larger in 1967-1969 (Merriner 1973) than in 1916 (Taylor 1916). Lengths at age were similar for Chesapeake Bay and New York in 1929 (Perlmutter et al. 1956) and less than reported North Carolina lengths (Taylor 1916; Merriner 1973; Shepherd 1982). These variations in growth rates and the fluctuations in weakfish abundance have suggested density induced growth compensation (Seagraves 1981; Shepherd 1982).

Von Bertalanffy growth parameters for weakfish are presented in Table 12-5. Shepherd (1982) did not find significant differences in L_∞ for males and females. Values of L_∞ increased from south to north; however, growth curves between regions were not compared statistically because of the large variance around parameters in Regions 2 and 3. Seagraves (1981) reported a higher L_∞ for males in Delaware Bay, probably due to the single large (563 mm SL) age VI male. The combined L_∞ for Delaware Bay was higher than that reported for Region 2 by Shepherd (1982). A larger asymptotic length was obtained for Delaware Bay weakfish in 1979 than in 1956.

Length-weight relationships for weakfish, were reported for North Carolina (Merriner 1973; Schwartz et al. 1979a, b, c, d, e, f), Delaware Bay (Daiber 1957; Seagraves 1981), and New York (Wilk et al. 1975, 1978; Shepherd 1982) (Table 12-6). Length-weight coefficients approached the cubic power of fish length (2.67-2.98) for both males and females. Merriner (1973) found significant differences between males and females which he attributed to proportionately greater development of ovarian tissue relative to testicular tissue. No significant differences were found in the other studies.

Table 12-5. Von Bertalanffy growth parameters for weakfish as reported in the literature.

Area	Sex	L_∞ (mm SL)	t_0	K	W(g)
Cape Cod. Ma - Ocean City, Md (Region 1)[1]	Combined	683	0.031	0.274	5237.0
Ocean City, Md - Virginia Beach, Va (Region 2)[1]	Combined	567	0.051	0.350	3026.0
Virginia Beach, Va - Cape Fear, N.C. (Region 3)[1]	Combined	331	-1.270	0.550	608.3
Delaware Bay 1956[2]	Combined	315	-0.500	0.327	-
Delaware Bay 1979[2]	Female	752	0.013	0.237	-
	Male	869	-0.228	0.171	-
	Combined	735	0.084	0.236	-

[1]As reported by Shepherd and Grimes (in press).

[2]As reported by Seagraves (1981).

*Standard length approximated by TL/1.21.

Table 12-6. Length-weight relationships for weakfish as reported in the literature $\log W$ (g) = $\log a + b \log L$ (mm).

Location	Sex	Log a	b	r	n	Size range
New York Bight[1] *	Combined	-4.877	2.948	0.99	666	59-768 mm TL
Cape Cod, Mass. Ocean City, Md.[2] *	Combined	-5.030	2.976	0.99	418	
Delaware Bay[3] +	Combined	-4.423	2.861	0.99	182	195-725 mm SL
North Carolina[3] +	Male	-4.558	2.851	0.99	482	
	Female	-4.343	2.946	0.99	610	
	Combine	-4.374	2.934	0.99	1,650	

[1]From Wilk (1979)
[2]From Shepherd (1982)
[3]From Seagraves (1981)
[4]From Merriner (1973)
*L = Total Length
+L = Standard Length

12.4.2 Abundance, Density, Mortality, and Dynamics

Catches of weakfish throughout the species range have fluctuated widely since the late 1800s (Goode 1884). Historical summaries of the commercial and recreational fisheries for weakfish were presented by Merriner (1973), McHugh (1980) and Wilk (1981). Regional analyses of recorded weakfish landings include Perlmutter (1959), McHugh (1976, 1977, 1981) and Seagraves (1981) for the Middle Atlantic region; Nesbit (1954), McHugh and Bailey (1957), Massmann (1963a), Richards (1965), Joseph (1972), and Rothschild et al. (1981) for the Chesapeake Bay region; and Higgins and Pearson (1928), Roelofs (1951b), Wolff (1972), and Merriner (1973) for North Carolina.

Commercial landings data have been collected from fish dealers in each state since 1880; from 1880-1927 the survey was conducted on the average of once every five years; from 1927 to 1956, annual surveys were conducted; and since 1956, data has been collected on a monthly basis (Fiedler 1943, 1945; Anderson and Power 1946, 1947, 1948, 1949, 1950a, 1950b, 1951, 1955, 1956a, 1956b, 1957; Anderson and Peterson 1952, 1953, 1954; Power 1958, 1959, 1960, 1961, 1962, 1963; Power and Lyles 1964; Lyles 1965, 1966, 1967, 1968, 1969; Wheeland 1971, 1972, 1973a, 1975; Thompson 1974a; Pileggi 1976, 1978; Wise 1977; Pileggi and Thompson 1980b). Commercial landings are presently collected by individual states. It should be noted that in general commercial statistics, when biased at all, tend to be somewhat underestimated due to failures in reporting which are inherent in their collection. Seagraves and Rockland (1983b) noted that the large increase in estimated landings of weakfish in Delaware from 1979 (212 mt) to 1980 (403 mt) may be due to an improved estimate of catch rather than a major increase in the size of the fishery. It is not known how landings prior to 1980 compare with those since then.

Total commercial foodfish landings of weakfish during the past 40 years reveal two peaks, one during the 1940s and another during the 1970s (Wilk 1981) (Figure 12-6). Although records through 1928 are largely incomplete, they do indicate high catches of weakfish between 1897 and 1908 (Table 12-7). Weakfish landings exceeded 9,000 mt per year between 1929 and 1940. Incomplete records from 1941 to 1944 and 1946 to 1949 suggest lower landings during World War II. Weakfish landings reached an all-time high of 18,800 mt in 1945 followed by a decline to 2,800 mt in 1952. Total catch fluctuated between 2,700 and 4,100 mt through 1958, followed by a decline to 1,400 mt in 1967, the lowest level since 1924. Landings increased steadily from 3,400 mt in 1970 to peak at 16,300 mt in 1980, the highest recorded catch of weakfish since 1945. Total weakfish landings declined in 1981 to less than 12,000 mt and again in 1982 to less than 8,800 mt.

Regional commercial landings of weakfish between 1880 and 1957 indicate that the Chesapeake Bay region contributed most to the total landings, followed by the Middle Atlantic region and the South Atlantic region (Tables 12-7 and 12-8) (Figure 12-7). New England landings (including Maine, Massachusetts, Rhode Island, and Connecticut) have never exceeded 320 mt. Catches in excess of 45 mt from that area coincide with peak landing periods farther to the south, perhaps indicating a wider

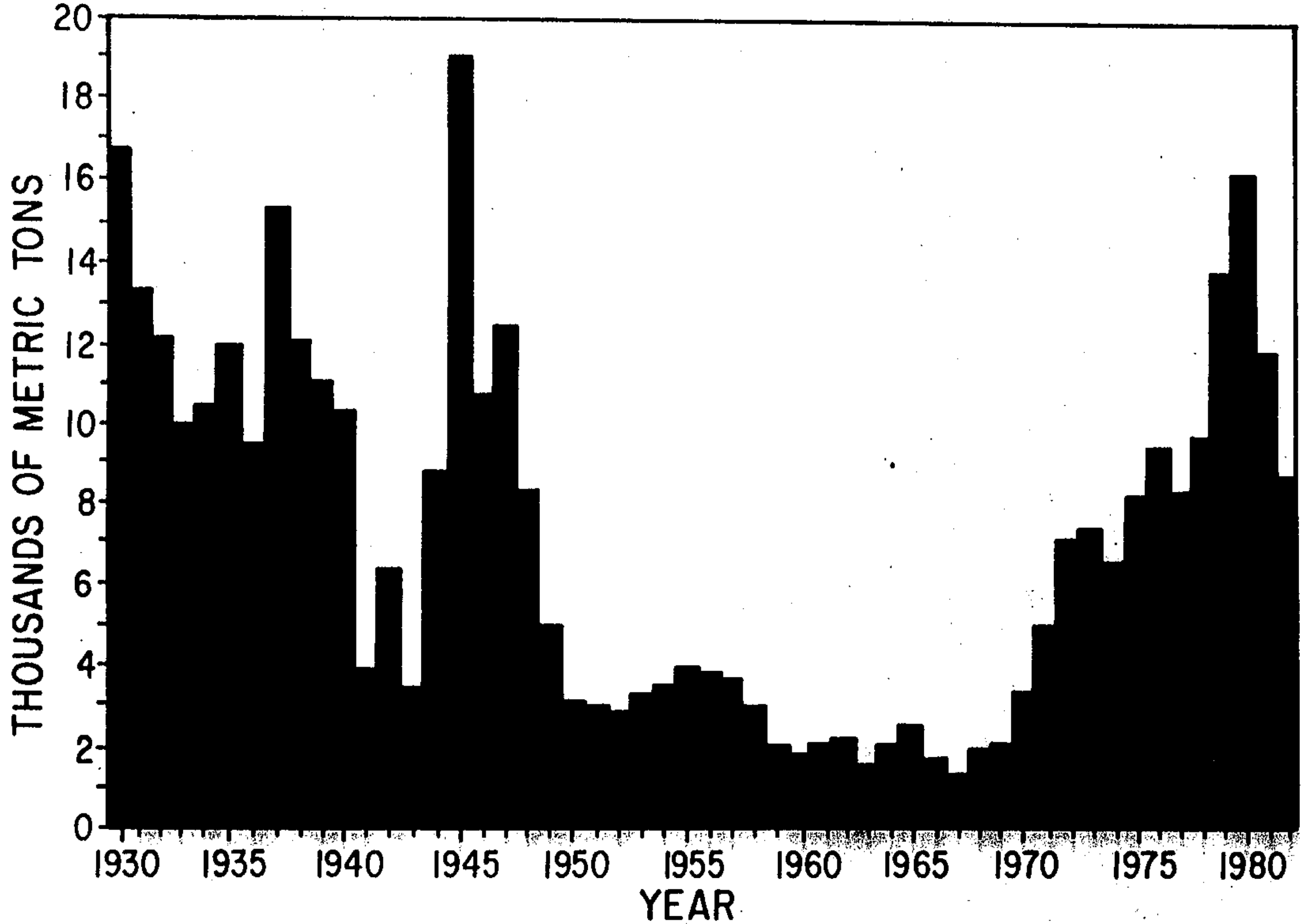

Figure 12-6. U. S. commercial landings of weakfish, <u>Cynoscion regalis</u> 1930-1982.

Table 12-7. Historic record of weakfish landings on the Atlantic coast by region and total landings from 1880 to 1981.

Year	Region				
	New England	Middle Atlantic	Chesapeake	South Atlantic	Total
1880	-	5,017	699	829	6,545
1887	-	2,838	743	541	4,123
1888	-	3,053	755	553	4,361
1889	-	*	-	1,116	1,116
1890	-	-	2,158	1,185	3,344
1891	-	-	2,122	-	2,122
1896	-	-	*	-	*
1897	-	5,751	3,230	1,735	10,716
1901	-	6,823	3,832	-	10,655
1902	3,327	-	-	2,290	5,617
1904	-	8,078	3,508	-	11,586
1908	-	11,595	2,577	3,913	18,084
1909	-	-	*	-	*
1915	171	-	*	-	171
1918	-	-	-	2,315	2,315
1919	3	-	-	-	3
1920	-	-	6,892	-	6,892
192	-	6,666	*	-	6,666
1923	-	-	-	2,385	2,385
1924	46	-	-	-	46
1925	17	-	6,315	-	6,331
1926	1	4,263	-	-	4,274
1927	11	-	-	2,482	2,494
1928	52	-	-	2,904	2,956
1929	73	4,963	5,165	2,805	13,006
1930	84	6,024	8,737	1,337	16,182
1931	104	6,146	5,641	1,364	13,255
1932	60	4,121	6,249	1,656	12,086
1933	167	3,571	6,106	-	9,844
1934	-	-	6,750	3,511	10,260
1935	303	4,600	6,692	-	11,595
1936	-	-	5,301	4,426	9,727
1937	91	5,562	6,212	3,414	15,280
1938	154	3,421	6,175	2,312	12,062
1939	87	3,595	6,149	1,290	11,120
1940	70	2,150	6,201	1,646	10,067
1941	-	-	3,833	-	3,833
1942	48	2,803	3,444	-	6,295
1943	42	2,895	-	-	2,937
1944	146	2,948	5,615	-	8,709
1945	174	5,224	11,223	2,163	18,784
1946	269	*	9,323	-	9,592
1947	178	3,545	8,760	-	12,483
1948	116	2,244	5,879	-	8,239
1949	9	1,819	3,028	-	4,856
1950	2	815	2,087	716	3,621

Table 12-7. (continued)

Year	Region				
	New England	Middle Atlantic	Chesapeake	South Atlantic	Total
1951	1	1,262	1,003	610	2,877
1952	3	1,190	811	756	2,760
1953	11	1,361	1,036	869	3,277
1954	5	1,133	1,082	1,118	3,338
1955	5	1,660	1,924	622	4,212
1956	10	1,438	1,694	839	3,981
1957	20	1,590	1,070	1,016	3,696
1958	5	434	805	1,744	2,988
1959	1	272	359	1,340	1,971
1960	1	283	490	1,046	1,820
1961	1	274	668	1,084	2,028
1962	5	381	763	996	2,146
1963	1	257	541	834	1,633
1964	*	330	800	944	2,075
1965	1	404	1,023	1,035	2,463
1966	*	209	540	957	1,706
1967	1	224	311	862	1,397
1968	1	272	577	1,136	1,987
1969	6	900	474	766	2,146
1970	10	1,024	1,117	1,241	3,392
1971	83	1,977	1,237	1,718	5,015
1972	79	2,456	1,296	3,423	7,069
1973	82	1,889	2,557	2,916	7,293
1974	229	1,993	1,575	2,806	6,476
1975	187	2,734	2,257	3,103	8,281
1976	160	3,311	1,999	3,993	9,350
1977	158	2,386	2,063	3,976	8,584
1978	134	2,637	2,003	4,972	9,694
1979	221	3,854	3,126	6,744	13,994
1980	131	3,765	3,088	9,309	16,293
1981	181	2,793	1,226	7,745	11,946
1982	112	1,973	1,102	5,545	8,782
1983	64	1,780	1,305	4,696	7,845

Table 12-8. Commercial landings of weakfish by state, 1930-1982 (metric tons). A dash (-) indicated information not available or no catch reported, and an asterisk (*) indicates less than 1 metric ton taken.

Year	ME	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA	FL (East Coast)	Total
1930	-	*	64	20	431	5,033	560	1,702	7,035	1,058	11	1	272	16,187
1931	*	68	24	13	665	5,299	181	979	4,662	1,358	2	-	11	13,261
1932	*	26	26	8	307	3,766	48	819	5,430	1,649	1	1	10	12,091
1933	-	130	29	9	374	3,141	56	523	5,583	-	-	-	-	9,845
1934	-	-	-	-	-	-	-	670	6,080	3,505	1	-	5	10,260
1935	-	118	17	13	744	3,662	194	595	6,096	-	-	-	-	11,440
1936	-	-	-	-	-	-	-	608	4,067	1	-	-	-	9,370
1937	-	58	29	4	661	8,431	132	494	5,717	3,413	3	-	*	15,280
1938	-	123	29	3	480	2,852	89	485	5,690	2,311	2	-	-	12,062
1939	-	56	26	5	646	2,761	187	662	5,487	1,288	1,	*	*	11,120
1940	-	49	17	4	684	1,353	136	620	5,581	1,646	1	-	-	10,090
1941	-	-	-	-	-	-	-	553	3,280	0	0	0	0	3,833
1942	-	2	24	8	821	1,905	78	666	2,778	-	-	-	-	6,281
1943	-	10	21	11	950	2,300	99	-	-	-	-	-	-	3,391
1944	-	17	98	31	684	2,140	123	938	4,677	-	-	-	-	8,709
1945	-	20	135	19	956	4,138	130	1,074	10,149	2,149	-	-	15	18,785
1946	-	19	181	68	1,045	-	-	1,028	8,295	-	-	-	-	10,637
1947	-	27	148	31	700	2,581	254	743	8,017	-	-	-	-	12,511
1948	-	6	72	39	454	1,499	290	503	5,376	-	-	-	-	8,239
1949	-	*	7	2	184	1,142	471	278	2,749	-	-	-	-	4,833
1950	-	*	2	*	64	491	260	268	1,819	-	-	-	-	2,906
1951	-	-	*	1	69	887	302	106	897	573	-	-	37	2,876
1952	-	-	1	2	76	987	127	127	684	737	-	-	20	2,761
1953	-	-	8	3	49	980	332	114	922	860	-	-	9	3,277
1954	-	-	4	1	58	908	167	119	962	1,080	12	-	27	3,338
1955	-	*	2	3	93	851	716	187	1,737	615	-	*	7	4,212
1956	-	-	5	5	96	908	434	216	1,478	835	-	*	3	3,981
1957	-	-	10	10	90	918	581	154	916	1,002	5	-	9	3,696
1958	-	-	4	1	4-	248	147	95	711	1,728	3	-	13	2,989
1959	-	-	*	*	20	169	83	49	309	1,321	3	-	15	1,971
1960	-	-	1	*	40	239	4	123	367	1,016	6	-	24	1,820
1961	-	-	*	1	24	190	61	127	541	1,047	11	0	26	2,028

Table 12-8. (Continued)

Year	ME	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA	FL (East Coast)	Total
1962	-	-	3	2	22	295	65	88	675	980	5	-	12	2,146
1963	-	-	1	*	39	151	67	43	498	799	3	*	33	1,633
1964	-	-	*	*	25	247	58	78	722	892	3	-	49	2,074
1965	-	-	2	*	33	270	100	112	910	888	10	1	135	2,463
1966	-	-	*	-	12	156	41	68	472	860	13	*	83	1,706
1967	-	-	1	-	14	207	4	39	272	802	1	*	58	1,397
1968	-	-	1	-	29	241	2	69	508	1,037	*	*	99	1,987
1969	-	-	6	-	53	848	10	79	395	698	3	*	65	2,156
1970	-	-	10	-	134	889	67	146	971	1,107	2	*	132	3,392
1971	-	-	83	-	580	1,397	97	184	1,058	1,653	-	-	65	5,022
1972	-	-	79	-	830	1,442	184	142	1,154	3,343	*	-	79	7,069
1973	-	1	81	-	575	1,162	151	245	2,312	2,822	1	*	93	7,293
1974	-	22	208	-	647	1,218	127	186	1,389	2,746	1	-	59	6,476
1975	-	3	211	-	620	1,982	132	402	1,855	3,050	1	1	51	8,177
1976	-	6	148	-	610	2,589	112	196	1,803	3,952	*	-	40	9,344
1977	-	5	149	-	775	1,461	151	94	1,962	3,932	-	*	43	8,573
1978	-	11	115	8	748	1,753	136	238	1,765	4,920	-	-	52	9,746
1979	-	16	290	15	686	2,956	212	304	2,821	6,694	*	*	49	13,944
1980	-	10	105	15	723	2,220	822	258	2,831	9,226	6	-	78	16,293
1981	-	15	166	-	615	1,701	477	141	1,086	7,661	-	-	84	11,946
1982	-	10	102	-	569	1,039	365	127	975	5,466	*	*	79	8,732

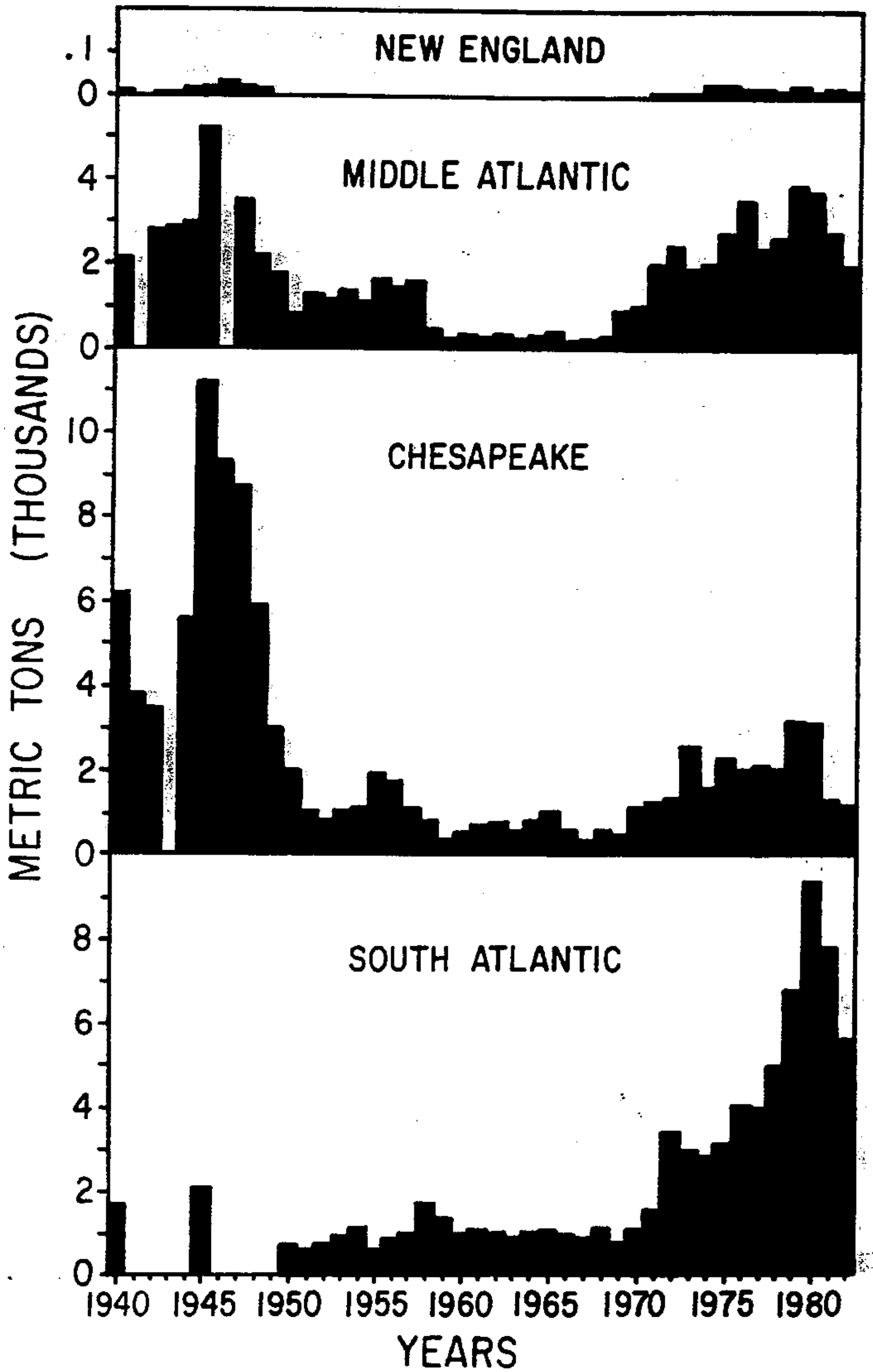

Figure 12-7. U. S. commercial landings of weakfish, *Cynoscion regalis*, by geographic region, 1940-1982

distribution of the species during periods of high abundance (Wilk 1981). Middle Atlantic landings (New York, New Jersey, and Delaware) of weakfish exceeded other regions between 1880 and 1908, reaching a high of 11,600 mt in 1908. Landings from this region fluctuated between 1,800 mt and 6,200 mt from 1929 to 1949, and declined to a low of less than 230 mt in 1966. Weakfish landings in the Middle Atlantic region increased from 910 mt in 1969 to a high of over 3,600 mt in 1979 and 1980. New Jersey landings account for 74% of Middle Atlantic landings from 1930 to the present, followed by New York (18%) and Delaware (8%). Chesapeake Bay landings (Maryland and Virginia) exceeded all other regions between 1929 and 1950. Highest weakfish landings for this region were 11,230 mt in 1945, followed by a decline to 820 mt in 1952. Landings increased in the 1970s to 3,100 mt in 1979 and 1980, the highest since 1948. Virginia landings account for 88% of the total Chesapeake Bay catch. South Atlantic landings of weakfish fluctuated between 590 and 1,700 mt between 1950 and 1971. Landings in this region reached an all-time high of 9,300 mt in 1980, exceeding the combined catch of the other three regions for that year. North Carolina landings accounted for 98% of the South Atlantic landings from 1930 to 1981.

Recreational fishery statistics are available from National Marine Fisheries Service salt-water angling surveys conducted at five-year intervals from 1960-1970 (Clark 1962; Deuel and Clark 1968; Deuel 1973) and regional surveys in 1974-1975. Annual recreational fishery statistics have been conducted since 1979; however, the results are not yet available. Caution must be exercised in interpreting or comparing the results of these surveys. First, estimated catches in the 1960, 1965, and 1970 national surveys and 1974-1975 regional surveys are subject to considerable statistical variability. Second, although the sampling procedures were similar for the 1960-1970 surveys, they were considerably different from the 1974-1975 sampling procedures. In addition, all of these surveys relied on the fisherman's ability to identify the species caught and to recall the numbers and average weight of each species caught, resulting in overestimates of the catch. The sampling design of the 1979-present surveys is significantly different, including both a household survey and creel census. Only the 1960, 1965, and 1970 angling survey results are presented here.

Recreational weakfish landings increased from 1,700 to 7,100 mt from 1960 to 1970 (Table 12-9). Total commercial landings for 1960 and 1970 were 1,800 and 3,400 mt, respectively. The number of successful anglers apparently doubled over this ten-year period (Table 12-9). Although the survey results may be gross overestimates, catch and effort in the recreational fishery have undoubtedly increased. The estimated average weight of weakfish caught increased from 0.48 kg in 1960 to 0.70 kg in 1970 which agrees with the historical changes in growth noted in age and growths studies (Seagraves 1981; Shepherd 1982) (Section 12.4.1).

Juvenile weakfish abundance data are available for various years from Georgia to Rhode Island. Catch per unit effort (pounds per hour) of weakfish for inside waters of Georgia was nearly the same throughout the year except for large increases in July and August which were due to rapid growth of juveniles (Mahood 1974). Comparison of data from 1970-1973 and 1930-1932 indicates that weakfish entered trawl catches at

Table 12-9. Weakfish recreational catch and effort statistics, as indicated by national and regional saltwater angling surveys, 1960 - 1970.

Survey year	Catch			Number of successful anglers	Average weight		Catch per angler		
	Number	Weight lbs	Weight kg		lbs	kg	Number	Weight lbs	Weight kg
1960[1]	3,603	3,840	1,741	205	1.07	0.48	17.58	18.81	8.44
1965[2]	1,799	2,265	1,029	178	1.26	0.57	10.11	12.74	5.76
1970[3]	10,142	15,684	7,113	406	1.55	0.70	24.98	38.72	17.49

[1]As reported in Clark (1962).

[2]As reported in Deuel and Clark (1968).

[3]As reported in Deuel (1973).

a smaller size and growth was more rapid in 1970-1973. Juveniles were most abundant from July through September in all major estuaries of South Carolina in 1973 (Shealy et al. 1974). Nursery area monitoring in North Carolina sounds from 1978 to 1981 indicated that juvenile weakfish abundance peaks in July and August (Ross 1980; Ross and Carpenter 1983; Hawkins 1982). Catch per unit effort increased each year in both primary and secondary nursery areas. Trawl surveys in the Cape Fear River, North Carolina, 1973-1978 and 1979-1982, indicated that peak recruitment of juvenile weakfish occurred in June or July (Schwartz 1979a, b, c, d, e; Carolina Power and Light 1980, 1981, 1982, 1983). Abundance increased from 1973 to 1976, declined in 1977, and increased in 1978. Juvenile abundance increased from 1979 to 1980 and declined sharply thereafter. An index of juvenile weakfish abundance based on trawl surveys of the York River, Virginia, 1955-1982, indicated that peaks in abundance occurred at approximately ten-year intervals with the highest peak in 1980 (Austin 1981) (Figure 12-8).[9] Increases in commercial pound net catches of weakfish tended to occur two to three years following an increase in juvenile abundance (Figure 12-8). Results of a Maryland blue crab trawl survey, 1980-1982, in upper Chesapeake Bay and Chincoteague Bay indicated that juvenile weakfish catch per unit effort declined from 1980 to 1982 in Chesapeake Bay but increased in Chincoteague Bay, especially in 1982. Peak recruitment occurred in September (Dintaman 1981, 1982, 1983). Thomas (1971) reported that peak abundance of juveniles was reached in late June and early to mid-July in Delaware Bay and the abundance of young weakfish increased steadily from 1968 to 1970. A stock assessment of juvenile fishes in Delaware Bay in 1980 and 1981 indicated that juvenile catch rates peaked in late summer and were similar for both years (Seagraves 1982). Data from recreational surveys and adult trawl surveys in Delaware Bay indicated poor recruitment to adult weakfish populations in the 1970s compared with the late 1960s. In Rhode Island waters, weakfish juveniles have shown an increase in relative abundance from 1979 to 1981.[10]

Merriner (1973) attributed the fluctuations in weakfish abundance and the apparent decline of the resource to: 1) natural fluctuations in year class strength and the aggregate effects of pollution on survival and production of weakfish or food organisms; 2) shift in the center of the fishery from the Middle Atlantic region to the Chesapeake Bay region in the 1930s; 3) exceptionally high landings from Chesapeake Bay region between 1945 and 1948 coupled with the fact that this fishery generally harvests younger weakfish than the northern fishery; 4) growth of sport fishing between World War II and the present with its attendant harvest of adult weakfish; and 5) excessive harvest of juveniles by the commercial fishery along the Atlantic coast.

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

[10]Pers. commun. Christopher Ordzie, Rhode Island Division of Fish and Wildlife, Wickford, RI

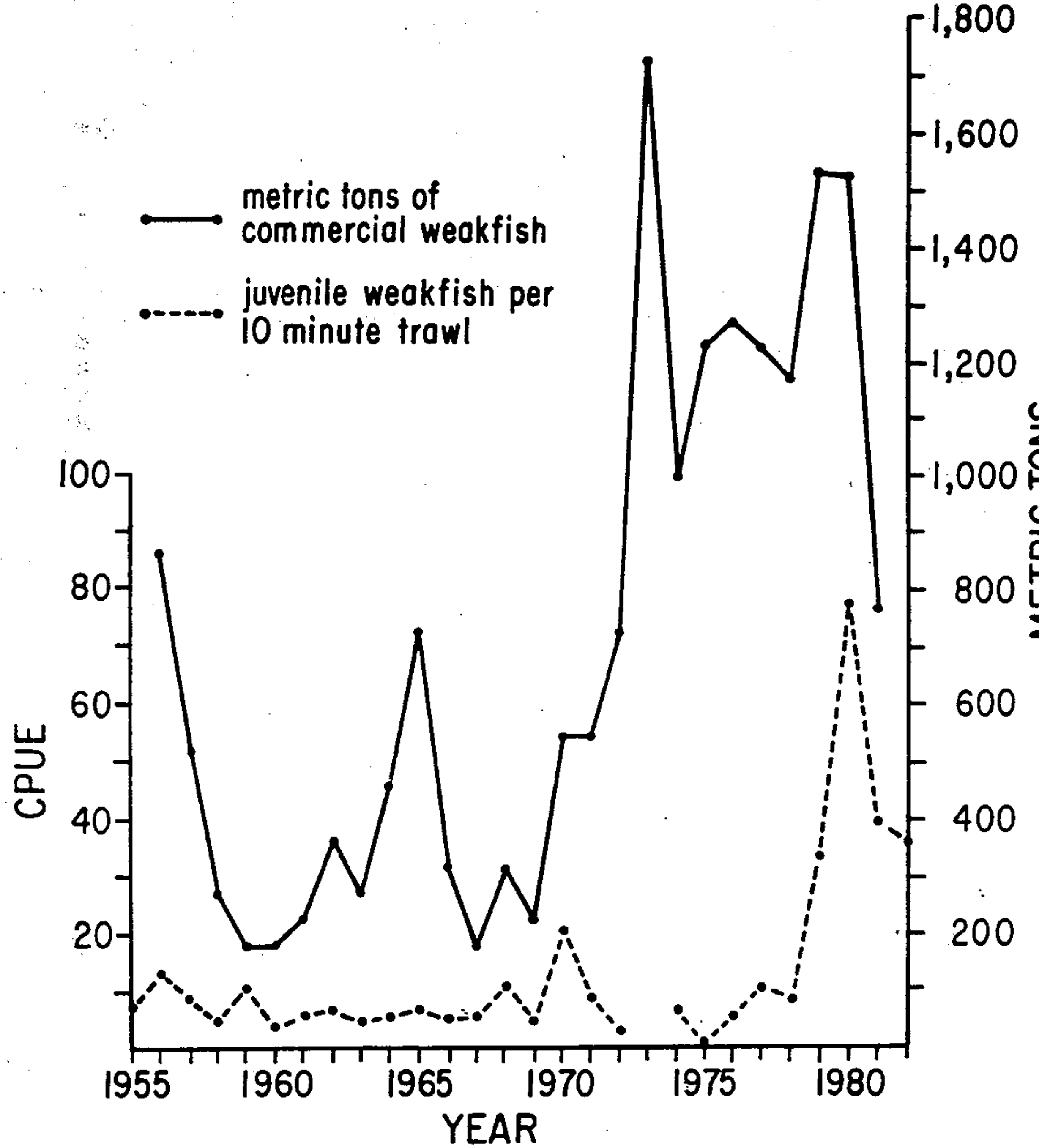

Figure 12-8. Relative abundance of juvenile weakfish in Virginia waters and the commercial pound net catch of weakfish in Virginia, 1955-1982.

Total annual mortality estimates from catch curve analysis of pound net samples in North Carolina indicated that 62% of the weakfish population of age III or older are expected to die each year either from harvest or natural causes (Merriner 1973) (Table 12-10). His estimate compared favorably with mortality estimates he derived from age frequency tabulations of Nesbit (1954), Perlmutter et al. (1956), and Massmann (1963a) (Table 12-11). Mortality rates from catch curve analysis of trawl survey data from Cape Cod, Ma. to Cape Fear, N.C. showed a cline of increasing mortality from north to south (Shepherd 1982) (Table 12-10).

Juvenile weakfish mortality due to power plant entrainment and impingement was investigated in the Delaware River, N.J. and the Cape Fear River, N.C. Estimates of total number of weakfish impinged at the Salem Nuclear Generating Station in the lower Delaware River estuary were 1.9×10^6 in 1977, 8.0×10^6 in 1978, and 0.5×10^6 in 1979 (Public Service Electric and Gas Company 1978; Ichthyological Associates 1980b). Annual survival was 57% in 1977, 44-70% in 1978, and 68% in 1979. Impingement estimates corresponded with biweekly population estimates in the estuary in terms of general trends of increasing and decreasing abundance. Cumulative entrainment estimates of eggs, larvae, and young in 1979 were 1.48×10^5, 2.38×10^6, and 9.19×10^6, respectively. Instantaneous total mortality (Z) and percentage total mortality (A) of the total population were determined by catch curve analysis to be 6.24 and 99.81 in 1979. Cumulative impingement and entrainment losses were estimated to comprise 0.3 and 0.65% respectively, of the total mortality of the 1978 and 1979 year classes. These studies concluded that juvenile weakfish populations were not significantly affected by impingement and entrainment. The mean concentrations of weakfish larvae in entrained water at the Brunswick Steam Electric Plant on the Cape Fear River, N.C., ranged from 250/1000 m^3 to 400/1000 m^3 during periods of peak abundance (May-October) (Hodson et al. 1977; Copeland et al. 1979). Mean entrainment densities were similar to weakfish densities in other parts of the estuary except most channel areas, where densities were higher. Weakfish comprised about 2% of the total entrained catch. The number of weakfish impinged monthly per million cubic meters of water entrained ranged from 0-1457 and was highest from June through October (MacPherson 1977; Carolina Power and Light Company 1979).

A preliminary assessment of weakfish in the Middle Atlantic Bight tentatively indicated that under present harvest conditions the optimum exploitation rate has been reached (Murawski 1977). He concluded that if age at first selection (t_c) was increased from age I to age II for all fisheries, an increase in yield per recruit of approximately 30% could be anticipated (Table 12-12). His results were based on reported commercial and recreational landings for the period 1966-1976, National Marine Fisheries Service groundish survey cruise data 1972-1976, and creel estimates in 1976. The reliability of these results is questionable due to the doubtful accuracy of recreational landings data, gear bias, and lack of information on instantaneous natural mortality. No other data are available on weakfish population dynamics.

Table 12-10. Total annual mortality estimates for weakfish from North Carolina to New York (from catch curves).

Location and gear	Total annual mortality (A)	Total instantaneous mortality (Z)
Cape Cod, Ma.- Ocean City, Md.[1]	0.34	0.42
Cape May, N.J.[1]	0.27	0.38
Ocean City, Md.- Virginia Beach, Va.[1]	0.60	0.93
Virginia Beach, Va.- Cape Fear, N.C.[1]	0.68	1.14
North Carolina[2] (pound net)	0.53 (ages II-V) 0.62 (ages III-V)	0.76 0.97
North Carolina[2] (otter trawl)	0.48	0.65

[1]As reported by Shepherd (1982).

[2]As reported by Merriner (1973).

Table 12-11. Weakfish mortality estimates for areas on the east coast of the United States calculated from age frequency data in the literature (from Merriner 1973).

Source	Area and date of collection		Annual mortality	Number of age groups	Total number of fish
Nesbit (1954)	North Carolina	1934	0.62	6	332
Nesbit (1954)	Chesapeake Bay	1929	0.79	4	96
		1934	0.72	6	316
Massman (1963a)		1956	0.59	4	218,807
		1957	0.71	4	126,448
		1958	0.67	5	221,803
Nesbit (1954)	Exmore, Virginia	1929	0.69	4	22
		1933	0.67	6	946
		1934	0.77	5	419
Nesbit (1954)	Northern New Jersey	1929	0.71	6	1,171
	Wildwood, New Jersey	1928	0.63	5	423
		1934	0.81	6	669
Perlmutter, Miller, and Poole (1956)	New York	1952	0.66	5	742

Table 12-12. Yield-per-recruit (R) for various instantaneous rates of fishing and natural mortality (F,M) and ages at first selection (t_c) for weakfish in the Middle Atlantic Bight* (from Murawski 1977).

	$t_c = 0.5$			$t_c = 1.0$			$t_c = 1.5$			$t_c = 2.0$		
F M=	.2	.3	.4	.2	.3	.4	.2	.3	.4	.2	.3	.4
0.1	243	155	101	255	162	106	264	166	108	269	167	107
0.2	317	208	141	348	228	153	377	244	163	399	255	167
0.3	320	216	150	368	248	172	415	227	189	456	299	200
0.4	296	206	147	356	247	175	418	286	200	474	318	218
0.5	264	188	138	333	236	172	405	284	203	474	324	227
0.6	232	170	127	306	223	166	386	276	202	464	324	230
0.7	203	152	117	280	208	158	366	267	198	450	320	231
0.8	179	137	107	257	195	150	346	257	194	435	314	230
0.9	158	123	97	236	182	143	327	247	189	421	308	228
1.0	140	111	89	218	171	136	311	238	184	407	301	225

*Underlined values indicate Y/R_{max}

12.4.3 Community Ecology

Surveys along the Atlantic coast indicate that estuaries provide feeding areas and spawning grounds for adult weakfish and are important nursery areas for the young. Thomas (1971) found that three species of drums (weakfish, silver perch, and black drum) use the lower Delaware River, a low salinity nursery area, in the summer. A fourth species, croaker, utilizes this area in late fall and early winter. Spot were very abundant during certain years and northern kingfish were occasionally collected in the study area. Weakfish was the most abundant species of drum and second most numerous fish in trawl catches. Thomas (1971) suggested that competition between these species was probably avoided by differences in habitat, food, and time of entry. Black drum arrived in the study area in early June, weakfish in mid-June, silver perch in late June, and croaker in late October. Small weakfish and croaker enter the area through the deeper waters in or near the channel, while small silver perch and black drum move along the shore. Most small weakfish were taken by trawl in the river, juvenile black drum were taken in the mid to upper portions of marsh creeks, and silver perch were generally collected along the shore zone of the river, in ditches, and in the lower portions of marsh creeks. Croaker preferred the deep water habitat of weakfish but did not enter the area until after most weakfish had left. Differences in food habits were due to variations in habitat and morphological and behavioral differences between the species.

Chao and Musick (1977) reported that juvenile sciaenids, including weakfish, silver perch, croaker, and spot, were able to coexist in the York River estuary, Virginia because of differences in spatial and temporal distribution, relative abundance, and food habits. Juveniles of these species entered the estuary at different times of year and, within a given period, the highest catches of each species were in different areas and depths of the York River system. They concluded that differences in the morphology of the feeding apparatus enable these species to utilize food resources from different levels of the water column. Weakfish is a fast swimmer that feeds in the upper to middle water column by sight. In addition, food resources in the study area were abundant and not limiting.

Studies of Chesapeake Bay seagrass systems revealed that eelgrass beds are important foraging grounds for adult weakfish (Lascara 1981) but are not significant spawning areas or nursery grounds for weakfish (Orth and Heck 1980; Meyer 1982). Weakfish was the numerically dominant piscivore taken over eelgrass habitat, whereas bluefish dominated in non-vegetated areas. Weakfish apparently traversed grass beds singly or in small groups rather than in schools, as gill net sets captured only one or two at a time. Highest capture rates occurred between dusk and dawn over grass beds. Weakfish apparently inhabit adjacent channels and holes during daylight hours.

Weakfish are found offshore in winter from North Carolina to Florida. Gill net catches along the North Carolina coast (10-30 m) indicate that weakfish are caught with bluefish, butterfish, croaker, and menhaden.[11]

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

12.5 Exploitation

12.5.1 Commercial Exploitation

The fisheries for weakfish were reviewed by Collins (1887), Pratt (1917), Higgins and Pearson (1928), Pearson (1931), Taylor (1951), Reid (1955), McHugh and Bailey (1957), Perlmutter (1959), Merriner (1973), McHugh (1977, 1980, 1981), Lesser and Ritchie (1979), Wilk (1979, 1980, 1981), Rothschild et al. (1981), and Wilk and Brown (1982).

12.5.1.1 Fishing Equipment

The principal commercial methods used to harvest weakfish include trawls, pound nets, haul seines, and several variations of 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 which may concentrate directly on weakfish for brief periods of time (Wilk and Brown 1982). The most significant innovation in commercial harvesting methods has been the use of high speed pelagic trawls in the form of paired trawls and midwater trawls. This methodology, which began in earnest during the mid-1970s, primarily in the New Jersey-Delaware area of the Middle Atlantic region, harvested over 700 mt annually in 1979 and 1980 (Wilk 1981).

Total effort (counts of gear) and the composition of gear in the coastal fishery of the Atlantic states has changed since 1900 (Merriner 1973). The reported number of pound nets, haul seines, and gill nets have declined in the Chesapeake and Middle Atlantic regions and North Carolina while the number of otter trawls has increased (McHugh and Bailey 1957; Joseph 1972; Merriner 1973; McHugh 1981; Rothschild et al. 1981). The number of otter trawls landing in Virginia increased from 49 in 1972 to 145 in 1978 (DuPaul and Baker 1979). McHugh (1981) reported that weakfish was the mainstay of the haul seine fishery in Delaware and when it was gone the fishery did not survive for long. The last haul seine in Delaware ceased operating in 1971. The Delaware otter trawl fishery ended in 1966 due to pressure exerted by recreational fishermen.

The principal methods used to harvest weakfish for foodfish have essentially remained the same; however, there have been significant shifts in the contribution trawls and pound nets have made during the past 40 years (Perlmutter 1959; Wilk 1981) (Figure 12-9). During the period 1940 to 1949, pound nets, haul seines, gill nets, and trawls took approximately 63, 11, 3, and 23% of the total catch, respectively; however, during the 10-year period 1970-1979, the percent contribution of these same four gear types was 20, 11, 9, and 60%, respectively (Wilk 1981).

12.5.1.2 Areas Fished

Weakfish are caught inshore along the Atlantic coast, especially within bays and sounds during the warmer months of the year and offshore in the South Atlantic region during winter. The centers of abundance of weakfish are North Carolina, Chesapeake Bay, Delaware Bay, New Jersey

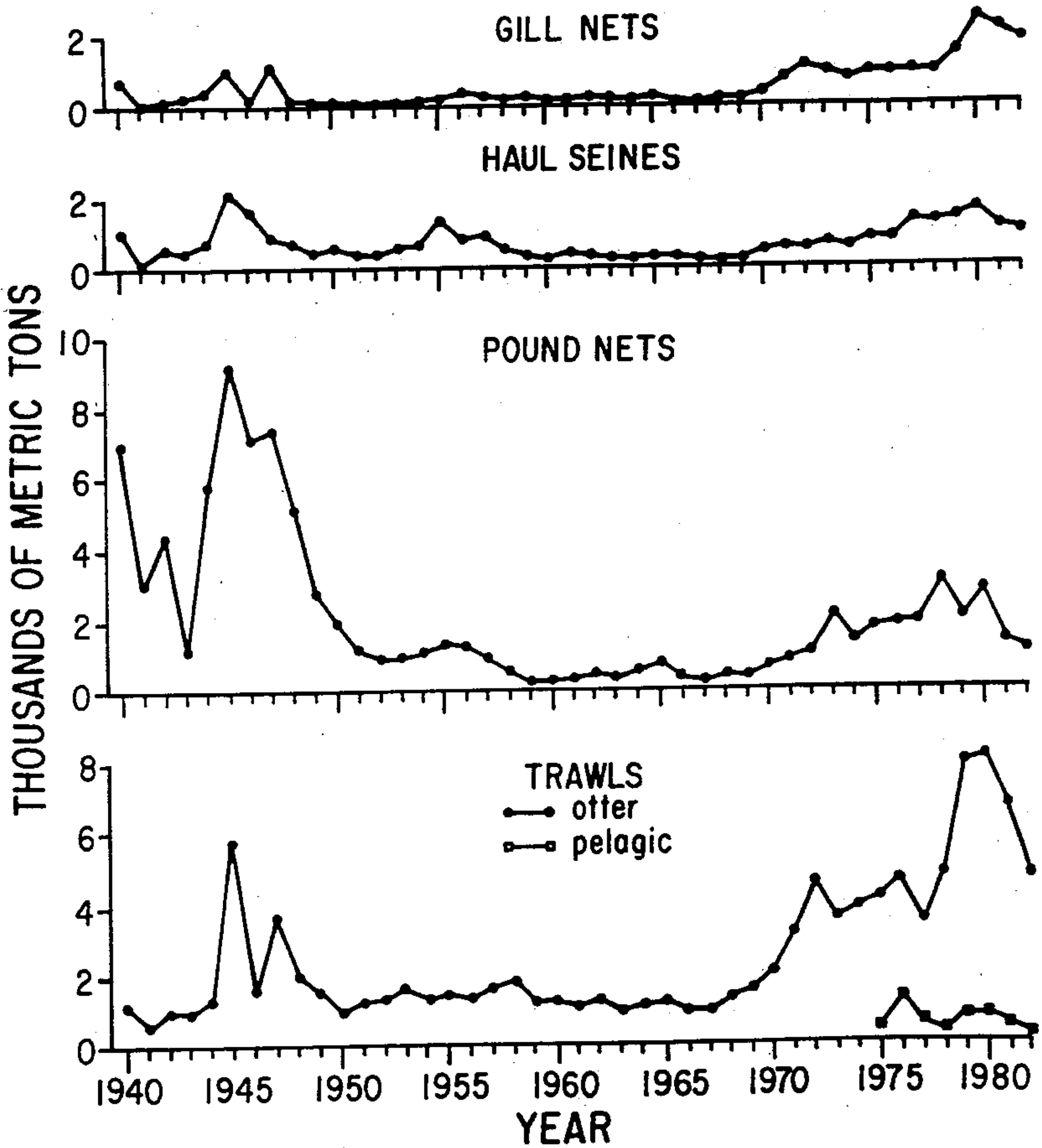

Figure 12-9. Commercial foodfish landings of weakfish by major harvesting methods, 1940-1982.

coastal waters, and Great South Bay and the Peconic Bays of eastern Long Island, New York (McHugh 1980). The majority of fishing effort for weakfish in New Jersey waters occurs in Raritan-Sandy Hook Bay, Delaware Bay, and out to 27 m along the entire coast. The principal gill net areas occur within the 18 meter contour and include lumps and ridges outside the contour that are 18 m or less in depth. Trawling and purse seine fishing take place from the inshore two mile limit to 27 m, and occasionally offshore to 110 m (Long et al. 1982). June and Reintjes (1957) found weakfish to be only a minor species in the otter trawl fishery off Delaware Bay (<27 m). During winter weakfish are taken by otter trawls and gill nets along the coasts of Virginia and North Carolina to depths of 55 m.

The proportion of weakfish caught >6 km offshore increased from 14-16% in 1972-1974 to 35% in 1975 and has exceeded 40% since 1978 (Wheeland 1973b; Thompson 1974b, 1981, 1982, 1983; Wheeland and Thompson 1975; Pileggi and Thompson 1976, 1979, 1980a; Wise and Thompson 1977, 1978) (Table 12-13). Approximately 95% of these offshore catches are landed in New Jersey (24-29%) and North Carolina (66-70%). The New Jersey landings represent weakfish taken by high speed pelagic trawls, whereas the North Carolina landings are from the winter trawl fishery.

The distribution of weakfish landings has shifted historically from one geographic area to another (Wilk 1980). Peak catches during the 1940s were landed primarily in the Middle Atlantic and Chesapeake areas. In 1980 and 1981 North Carolina landings of weakfish exceeded the combined landings from all other states (Table 12-8). This shift in catch to the South Atlantic region (North Carolina) is probably more a reflection of the increased mobility of the North Carolina fishing fleet with a concomitant shift in center of landings to North Carolina, rather than an actual shift in distribution of weakfish.

12.5.1.3 Fishing Seasons

Weakfish landings along the coast coincide with the known north-south migration patterns of this species (McHugh 1980). In South Carolina landings are greatest in January; in North Carolina in February; May and October in Virginia and Delaware; in New Jersey and New York, in May or June and October; and August in Rhode Island and Massachusetts. In Maryland the spring peak is absent and landings peak strongly in late fall. North of Chesapeake Bay the fishing season extends from April or May to November or December (Collins 1887; Barnes 1909; Bigelow and Schroeder 1953; Long et al. 1982; Seagraves and Rockland 1983b). Weakfish are believed to be year-round residents south of Chesapeake Bay and exhibit an inshore-offshore migration pattern (Smith 1907; Hildebrand and Schroeder 1928; Bigelow and Schroeder 1953). Weakfish are harvested throughout the year in North Carolina with highest landings reported from December through March by the offshore trawl fishery. Haul seines and pound nets are used in late spring and summer, and gill nets in late summer and fall (Merriner 1973; DeVries 1981b; Ross 1982). Weakfish are caught year-round off South Carolina, Georgia, and Florida with lowest catches in March (Anderson and Gehringer 1965; Anderson 1968; Mahood 1974).

Table 12-13. Commercial landings of weakfish by distance caught off U.S. shores, 1972 - 1982.

Year	0 - 6 km (0-3 mi)		6 - 370 km (3-200 mi)		Total		% caught 6 km off shore
	mt	$ (x 1000)	mt	$ (x 1000)	mt	$ (x 1000)	
1972	6,010	1,119	1,181	293	7,191	1,412	16
1973	6,383	1,720	1,052	245	7,435	1,965	14
1974	5,633	1,728	973	240	6,606	1,968	15
1975	5,391	1,671	2,965	732	8,356	2,403	35
1976	6,018	1,951	3,462	668	9,480	2,619	37
1977	6,091	2,155	2,396	713	8,487	2,868	28
1978	4,837	2,595	4,886	1,791	9,723	4,386	50
1979	7,056	3,788	6,827	2,494	13,883	6,282	49
1980	9,155	4,859	6,766	2,465	15,921	7,324	42
1981	6,470	5,732	5,505	3,346	11,975	9,078	46
1982	5,074	5,448	3,667	3,461	8,741	8,909	42

12.5.1.4 Fishing Operations and Results

Trends in landings may reflect changes in stock size, total effort in the fisheries, and/or in market incentives. Catch per unit of effort provides a comparative measure of abundance as well as commercial gear effectiveness (Merriner 1973). The available fishing effort statistics, such as total counts of gear used herein, are a very crude estimate of effort but may give a rough view of trends in weakfish abundance.

Trends in catch per unit of effort are similar for all regions (Table 12-14). Since 1940 catch per unit of effort was highest in 1945, declined through the 1950s, and increased from the 1960s to the present. In the Middle Atlantic region, pound nets were the most productive gear in 1940 and 1945, followed by haul seines. Since 1950 trawls have ranked first followed by pound nets and then by haul seines in 1965. In the Chesapeake region trawls have remained the most productive gear from 1940 to the present. Haul seines were the most productive gear in the South Atlantic in 1940, followed by pound nets. The ranking since 1945 has been trawl, haul seine and pound net. Gill nets have been the least productive gear in all regions.

Catch and effort data for the Delaware gill net fishery in 1981 and 1982 were reported by Seagraves (1982) and Seagraves and Rockland (1983b). Total effort in 1981 peaked in May, when 36 fishing units operated fixed gill nets, declined to 5-25 units in the summer drift net fishery, and increased to 13-26 fishing operations in the fall. The average weakfish catch per day during the spring season was 175 kg/day. Catch per unit effort increased in June to 311 kg/day and declined in July and August. Average catch per day of weakfish during the fall was 65 kg/day in 1981. In 1982 total effort peaked in May when 45 fishing units operated fixed gill nets and declined to 35 units in the summer drift net fishery and 12 in the fall. Catch per unit effort increased from 194 kg/day during spring to 230 kg/day in June, and then declined in July (65 kg/day) and August (67 kg/day). Average catch per day of weakfish during the fall increased to 230 kg/day in 1982 (primarily ocean netters). The average daily catch rate increased by 11% in 1982 over 1981 but declined slightly when adjusted for average amount of net fished.

Pound nets have been cited as the cause for declines in the catch of important food species such as the weakfish, due to the destruction of undersized or immature fish (Higgins and Pearson 1928). Retention and escapement characteristics of pound nets as a function of pound-head mesh size were examined by Meyer and Merriner (1976) (Table 12-15). They concluded that the presently used 51 mm (2 in.) stretched mesh in pound-heads is a necessary though wasteful compromise to prevent gilling. However, an escape panel of larger mesh size, located near the bottom of the pound head, would allow escapement of small sciaenids.

Otter trawl mesh selectivity studies in Delaware Bay indicated that escapement of yearling weakfish would be aided by use of a 76 mm (3 in.) mesh cod-end bag (Daiber 1957, 1958). Fifty percent escapement levels were 204 mm for a 76 mm (3 in.) bag, 123 mm for a 64 mm (2.5 in.) mesh bag, and 66 mm for a 51 mm (2 in.) mesh bag (used by commercial fishermen). Fish <185 mm are culled from the catch. Austin (1979)

Table 12-14. Catch per unit of effort (kg per unit of gear) of weakfish for the main gear types within each region (from landings statistics).

Year	Middle Atlantic				Chesapeake				South Atlantic			
	Otter trawl	Haul seine	Pound net	Gill net	Otter trawl	Haul seine	Pound net	Gill net	Otter trawl	Haul seine	Pound net	Gill net
1940	1,135	3,013	4,132	19	21,372	291	2,515	0	0	1,580	181	181
1945	5,625	6,435	8,739	135	84,852	805	3,603	50	7,370	2,868	227	143
1950	1,461	461	1,378	28	6,603	178	797	3	2,356	834	71	23
1955	2,025	9,215	1,263	120	4,463	1,265	728	15	3,362	809	70	10
1960	575	188	203	44	1,598	266	154	2	9,259	902	19	23
1965	1,099	488	68	60	1,157	400	603	16	5,777	743	24	44
1970	3,790	1,326	247	410	2,547	832	585	30	7,314	1,044	30	15
1976	7,527	4,154	2,432	1,088	3,248	263	2,442	55	12,959	5,006	219	26

Table 12-15. 50% retention lengths and selection factors from experimental data plus theoretical 50% retention lengths and selection factors computed from regressions (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	203	4.1	190	3.8
57	53.4	218	4.1	203	3.8
64	61.4	263	4.3	218	3.8
70	68.3	270	4.0	237	3.6
76	75.1	268	3.6	258	3.4

Morphometric data from weakfish (TL = total length, OG = opercular girth, MG = maximum body girth, MD = maximum body depth, and MW = maximum body width):

OG = 8.865 + 0.428 TL n = 210 r^2 = 0.69 (154-258 mm)

MG = 16.957 + 0.442 TL n = 210 r^2 = 0.58 (154-258 mm)

MD = 9.479 + 0.165 TL n = 210 r^2 = 0.44 (154-158 mm)

MW = -0.615 + 0.105 TL n = 210 r^2 = 0.59 (154-258 mm)

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MW = -0.615 + 0.105 TL n = 210 $r^2 = 0.59$ (154-258 mm) recommended a cod end mesh size of 76-83 mm (3-3.5 in.) for weakfish or a mixed species fishery as it would retain maximum yield per recruit weakfish (age III, 330 mm TL).

12.5.1.5 Incidental Catches

Industrial or scrap landings of weakfish were reported from 1965 to 1973 from the Chesapeake and South Atlantic regions (Figure 12-10). Landings peaked at 337 mt in 1965, declined to less than 3 mt in 1969, and were 38 mt in 1973. Since 1973 weakfish are included in the category of "unclassified, for bait, reduction, and animal food." These landings were chiefly derived from the Chesapeake region pound net fishery and the North Carolina finfish trawl, pound net, long haul seine, and beach seine fisheries (McHugh 1960; Joseph 1962; Wolff 1972; Merriner 1973). Demand for scrap fish in Chesapeake Bay and North Carolina is generated by the crab pot fishery and pet food industry, although menhaden and herring are the most desirable species. Estimates of scrap trawler-caught weakfish landings in North Carolina between 1962 and 1971 ranged from 107 to 542 mt a year (Fahy 1965a, b, 1966; Brown and McCoy 1969; Wolff 1972). Length frequencies of culled and unculled finfish trawl samples revealed that weakfish <220 mm TL were discarded as scrap, or approximately 43.3% of the landed weakfish (Wolff 1972). A very conservative estimate of the number of weakfish discarded, based on a cull size of 220 mm (180 g), ranges from 0.6 to 3.0 million fish a year during 1962-1972.

A greater scrap fish problem is the destruction of undersized fish by fisheries that cull the fish "at sea" rather than land them, particularly the South Atlantic shrimp fisheries (Roelofs 1950, 1951a). Wolff (1972) estimated an overall discard ratio for shrimping operations in North Carolina, 1969-1971, of 2.4 kg of fish per 0.5 kg of shrimp. The total discard of weakfish was estimated to be 1,461 mt for two years, an amount 13 times greater than the trawler landed scrap weakfish for the same period. This amount of weakfish discard was approximately 64% of the total North Carolina landings for the same years and consisted of many more individuals since discarded fish were less than market size. Shrimpers in South Carolina, Georgia, and Florida also discard large quantities of fish. Keiser (1976) determined that the overall median fish/shrimp weight ratio was 1.94:1 and that between 110 and 498 mt of weakfish were caught incidental to shrimping in South Carolina in 1975. Total weakfish landings in South Carolina in 1975 were less than 1 mt. From 5.1 to 22.8 million weakfish were discarded, based on Keiser's (1976) reported mean weight of 0.02 kg (133 mm TL). A study of fishes taken during commercial shrimp trawling in Georgia found that the average catch of weakfish was 4.0 kg per hour of trawling (Knowlton 1972). Anderson (1968) reported that 61.4 weakfish per hour of shrimp trawling were taken between Cape Romain, South Carolina and Cape Canaveral, Florida. Catch per unit effort was highest in South Carolina coastal waters (141.4 per hour), followed by Georgia inside and coastal waters (58.6 per hour), and Florida coastal waters (46.2 per hour). The effect of these fisheries on weakfish stocks has not yet been determined; however, these studies suggest that shrimp trawling is a significant factor in mortality of young-of-the-year weakfish.

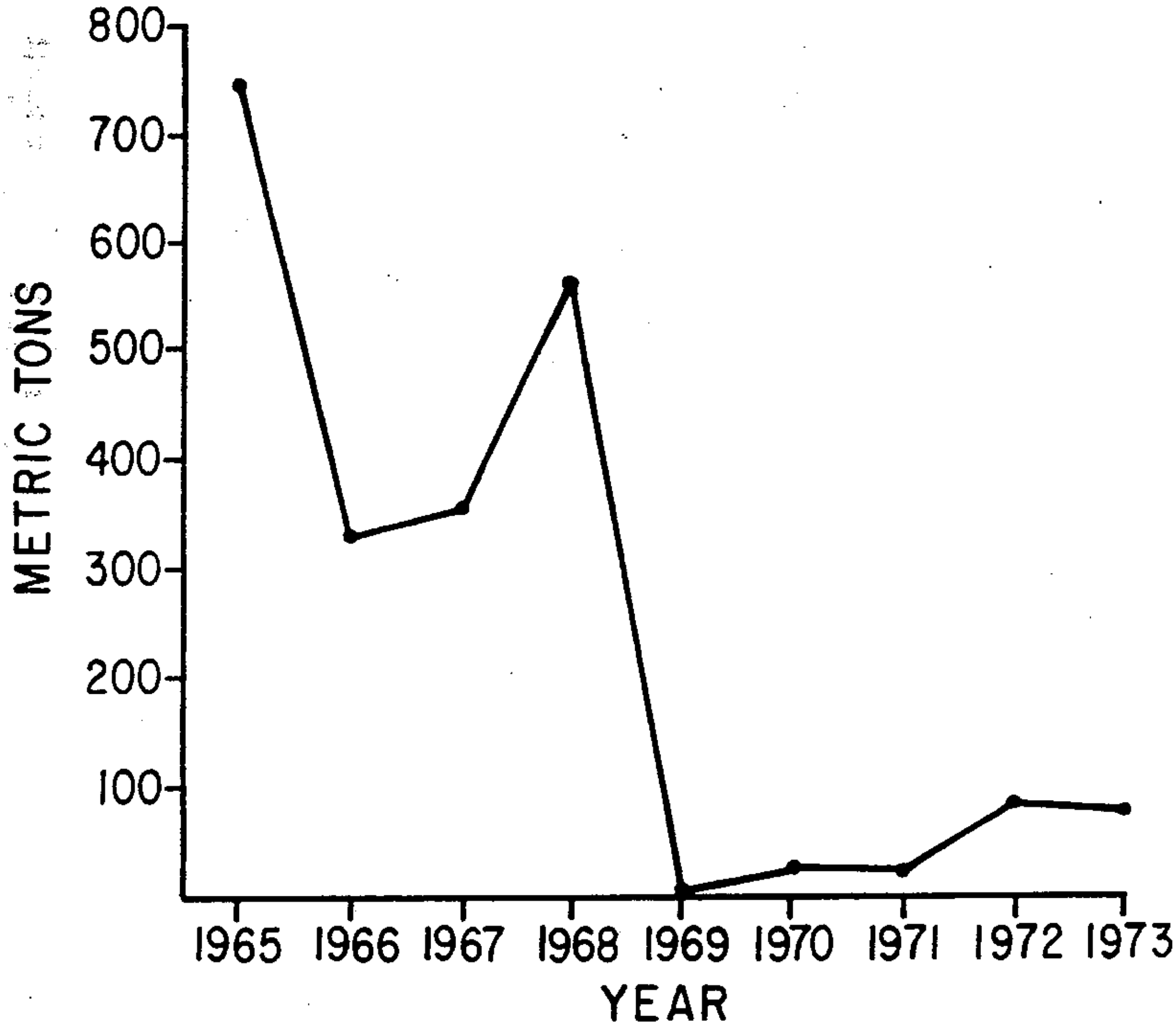

Figure 12-10. Commercial landings of weakfish used for industrial purposes, 1965-1973.

12.5.2 Recreational Exploitation

12.5.2.1 Fishing Equipment

Weakfish are caught from boats while trolling, chumming, casting, live bait fishing, jigging, still fishing, and drift fishing (Freeman and Walford 1974a, b, c; 1976 a, b, c, d). They are also taken from shore as well as man-made structures by casting, still fishing, live bait fishing, jigging and chumming. The salt-water angling surveys of 1965 and 1970 (Deuel and Clark 1968; Deuel 1973) indicated that the principal method of fishing is from private or rented boats followed by party of charter boats, beach or bank fishing, and bridge, piers and jetties (Table 12-16). Principal natural baits used while bait fishing for weakfish include shrimp, worms, cut and whole fish, soft and shedder crabs, and clams (Goode 1884; Freeman and Walford 1974a, b, c; 1976a, b, c, d). In addition, artificial baits (lures) in a myriad of shapes and colors are employed while casting, jigging and trolling from boats and shore (Wilk 1981).

12.5.2.2 Areas Fished

The salt-water angling surveys of 1965 and 1970 indicated that approximately twice as many weakfish were caught in sounds, rivers, and bays as in the ocean (Deuel and Clark 1968; Deuel 1973) (Table 12-16). Weakfish are caught inshore in tide rips, sloughs, holes, salt water creeks, shallow bays, channels, shelving beaches and the surf (McClane 1965; Osborne 1981). They can be caught in the vicinity of lighted bridges and from docks and piers at dusk and at night. Salt marshes are potentially good for weakfishing in fall. They also range offshore in depths up to 18 m, mostly over rocky or mud bottoms. Wrecks, rocks, jetties and bridges have a powerful attraction and can be hotspots.

Specific fishing areas for weakfish along the entire coast are indicated on the charts in Freeman and Walford (1974 a,b,c; 1976 a,b,c,d) and in selected anglers' guide books from various states. The most prolific weakfish grounds in North Carolina are on the eastern side of Pamlico Sound. An analysis of the North Carolina charter boat fishery revealed that weakfish were caught bottom fishing in estuaries (Manooch et al. 1981). Weakfish are caught throughout Chesapeake Bay and its tributaries. Principal centers of activity have shifted from the ocean and bay sides of Eastern Shore (Richards 1962, 1965) to the Chesapeake Bay Bridge Tunnel and in early spring to the deeper waters of the main stem Bay by charter boat and head boat fishermen seeking "jumbo" weakfish prior to their June spawning run at the mouth of the Bay. It is reported, and has been documented by examination of fishing activity and fathometer tracings that large weakfish often school under schools of feeding bluefish.[12] The Eastern Shore charter boat fishery bottom-fishes for weakfish around the Chesapeake Bay Bridge Tunnel and behind the barrier islands from June to September (Marshall and Lucy 1981). From late August to October weakfish are caught in the inlets

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[12] Pers. commun. Herbert Austin, Virginia Institute of Marine Science, Gloucester Point, VA.

Table 12-16. Number of weakfish caught by U.S. anglers in 1965 and 1970, by regions and by principal area and method of fishing.

		Principal area of fishing		Principal method of fishing			
Year	Region	Ocean	Sounds, rivers, and bays	Private or rented boat	Party or charter boat	Bridge pier or jetty	Beach or bank
1965[1]	North Atlantic	-	332	291	-	-	41
	Middle Atlantic	539	928	1,110	225	15	117
1970[2]	North Atlantic	81	664	677	68	-	-
	Middle Atlantic	3,281	6,116	7,159	1,461	265	512

[1]Deuel and Clark (1968)

[2]Deuel (1973)

and in the ocean to 6 km offshore. Large spawning weakfish are caught in sloughs and shoal areas in the lower Delaware Bay during May.[13] These fish then emigrate to oceanic coastal waters, where they are caught for a time in early June before migrating north. Smaller weakfish are caught throughout the late summer in shallow water, especially in the area of the planted oyster beds in Delaware Bay. Weakfish are caught primarily within 5 km of the beach along the entire coast of new Jersey (Long et al. 1982). At times, schools of weakfish may congregate further offshore, usually on lumps and ridges <18 m in depth. A secondary zone of low fishing activity includes many of these lumps and ridges and extends over 32 km offshore around Cape May.

12.5.2.3 Fishing Seasons

The sport fishing season for weakfish varies along the coast. Weakfish are caught year round in southern Florida with best fishing from November to April (Freeman and Walford 1976d). From Altamaha Sound, Georgia to Fort Pierce Inlet, Florida, fishing for weakfish occurs from March to December with best fishing from mid-March through May (Freeman and Walford 1976c). Weakfish are caught from May to December from False Cape, Virginia to Georgia with best fishing in the fall from September to November (Freeman and Walford 1976b). Weakfish are present year round in North Carolina waters but first spotty catches are usually in April with peaks in June through July and September (Osborne 1981). The weakfish fishing season starts in May or June along the coast from False Cape, Virginia to Block Island and runs until October or early November (Freeman and Walford 1974b, c, 1976a). Best fishing in this area is in September and October. Bottom-fishing trips for weakfish by the Virginia headboat fishery begin in May or June (Marshall and Lucy 1981). Weakfish are caught along the southern New England coast from late May or June to mid-October with best fishing in September (Freeman and Walford 1974a).

12.5.2.4 Fishing Operations and Results

The harvest of weakfish by anglers has basically followed the same trends exhibited by commercial landings during the past 20 years (Wilk 1981). The salt-water angling surveys indicated that catches were low in the 1960s and increased in 1970 (Clark 1962; Deuel and Clark 1968; Deuel 1973; Wilk 1981) (Table 12-9). Catch per angler increased from 8.4 kg per angler in 1960 to 17.5 kg per angler in 1970. The number of anglers may have increased from 178,000 in 1965 to 406,000 in 1970. The average weight has ranged from 0.5 kg in 1960 to 0.7 kg in 1970.

Recreational fishing surveys in Delaware indicated a three-fold increase in catch and effort of weakfish from 1968 to 1971 (Table 12-17). Catch per unit of effort declined between 1972 and 1978, increased in 1979 and 1980, and declined in 1981 and 1982 (Lesser 1968; Martin 1973; Miller 1977, 1980; McClain 1981; Seagraves 1982; Seagraves and Rockland 1983a). Seagraves and Rockland (1983a) noted that 1982 marked the first time in

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[13] Pers, commun. Richard Seagraves, Delaware Division of Fish and Wildlife Dover, Del.

Table 12-17. Summary of marine angler surveys conducted by the Delaware Division of Fish and Wildlife (from Seagraves 1981).

Year	Estimated number of weakfish taken in Delaware Bay (c)	Man-days of angling effort (f)	Catch per angler-day (c/f)
1968[a]	805,653	144,851	5.56
1971[b]	2,117,072[e]	300,481	7.05
1972[b]	2,448,391	654,586	3.74
1973[b]	1,086,723	392,171	2.77
1976[c]	1,666,368	420,800	3.96
1978[d]	330,381[f]	156,578	2.12
1979[g]	1,389,000	511,000	2.72

[a]After Lesser, 1978.

[b]After Martin, 1973.

[c]After Miller, 1977.

[d]After Miller, 1980.

[e]1971 data covers only May 30 to September 30.

[f]Does not include catch of party boats.

[g]After Anonymous, 1980 - includes all Delaware waters.

over a decade that weakfish was not the most frequent fish in the catch of marine anglers in Delaware. An increase in average size of weakfish in Delaware Bay was noted over this same period (Seagraves 1981). The largest weakfish entered in the Delaware Sport Fishing Tournament in 1968 was 2.4 kg (5.2 lb) and 7.5 kg (16.6 lb) in 1980. The minimum entry weight of 1.4 kg (3 lb) in 1968 was raised to 2.3 kg (5 lb) in 1972, 3.2 kg (7 lb) in 1973, and 4.5 kg (10 lb) in 1975. There are two seasonal peaks in catch per unit effort in Delaware Bay.[14] The first occurs during the spring spawning run of large adults (>2 kg). A second peak occurs in late summer as waves of smaller fish move northward and enter Delaware Bay. A minor peak may occur in coastal oceanic waters during the fall as the fish return on their southward migration.

Catch rates from a recreational fishing survey of Virginia's Eastern Shore from 1955 to 1962 indicated that weakfish were most abundant in 1955 (Richards 1965). Catch rates declined to a low in 1958 and increased through 1962. Two peaks in catch per unit effort occurred along the Eastern Shore, May and September-October (Richards 1965). Catch rates of weakfish in Chesapeake Bay have shifted from a single peak in the fall during the 1960s (Richards 1962) to bimodal peaks (spring and fall) in the late 1970s and early 1980s (Marshall and Lucy 1981). The recreational catch of weakfish in Maryland tidal waters (Chesapeake Bay and ocean side bays) declined from 996 mt (572,340 fish) in 1979 to 150 mt (126,780 fish) in 1980 (Williams et al. 1982).[15] The average weight of weakfish caught declined from 1.7 kg to 1.2 kg. Party and charter boat catch rates of weakfish in Maryland waters peaked in fall and private boat catch rates peaked in spring. A sport fishing survey in Albemarle Sound, N.C. found that weakfish catch rates declined from 1.52 kg/hour in 1977 to 0.23 kg/hour in 1978, and 0.07 kg/hour in 1979 (Mullis and Guier 1982).

12.6 Social and Economic Implications

12.6.1 Values

The economic values and uses of the sciaenid fisheries were discussed Cato (1981). Weakfish contribute the most to the total value of United States sciaenid landings followed by croaker, spotted seatrout, spot and red drum. Food landings of weakfish were valued at 8.8 million dollars in 1981 (Figure 12-11). The recreational fishery also probably makes a substantial but unknown contribution to the food fish market. The recent upswing in weakfish landings began in 1971. Maximum regional landings occurred in the South Atlantic (North Carolina) in 1980 at 9,300 mt (Table 12-8). Average dockside prices were fairly stable throughout the 1950s and 1960s and increased in the 1970s (Figure 12-12). Highest price per pound occurred in 1981 in all regions. Prices in the South Atlantic have been consistently lower than in the

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[14]Pers. commun. Richard Seagraves, Delaware Division of Fish and Wildlife, Dover, Del.

[15]Pers. commun. John Williams, Maryland Department of Natural Resources Annapolis, Md.

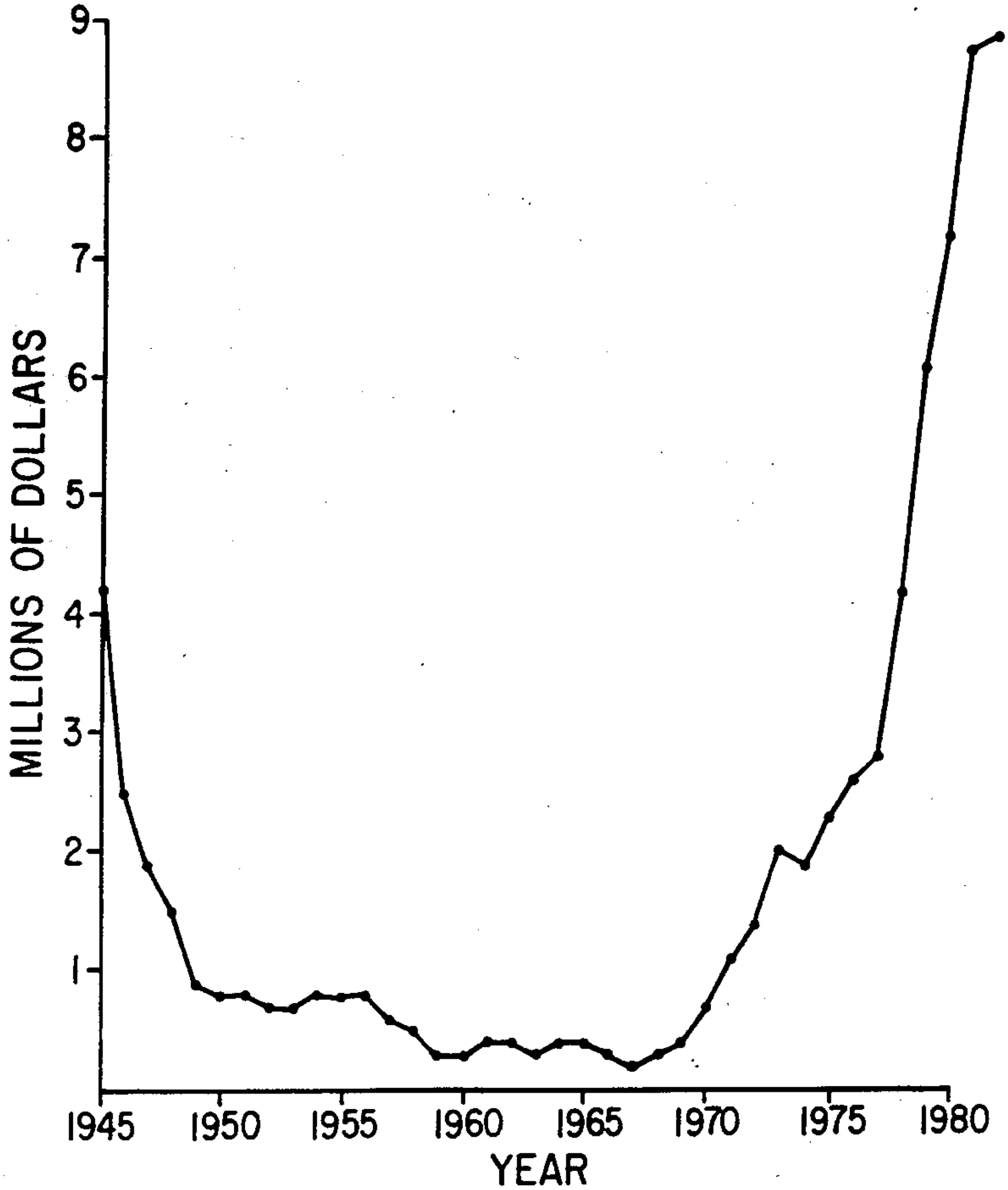

Figure 12-11. Dockside value of U. S. commercial landings for weakfish, 1945-1982.

other two regions. Price movements appear to react inversely to landings (Cato 1981). Adjusting prices for inflation indicated that the real (deflated) price of weakfish has gradually increased since 1967. Real price increases have most likely resulted from increased demand (Cato 1981).

Economic impact analyses of the commercial gill net fishery and the recreational fishery in Delaware were presented by Seagraves and Rockland (1983a, b). In 1982, 588 mt of weakfish, worth $757,240 at dockside, were landed by Delaware gill netters. The total primary impact, which consists of the purchases and employment where the expenditure initially takes place, was $1,461,607. This included four sectors: the commercial fishermen ($657,736); the wholesalers ($230,335); the retailers ($237,642); and the restaurants ($335,894). The survey showed that packers generally mark up the fish twenty cents per pound and the weighted average retail mark-up is 117.6%. When the primary effects were multiplied by the relevant multipliers from the input-output model, a total output of $2,172,511 was estimated for weakfish. This amount involved 87.79 jobs which resulted in $846,871 in wages. The value resulting from the sale of weakfish was $1,303,481. The estimated sport catch of weakfish in Delaware in 1982 was 138 mt. Direct expenditures relating to total sport fishing in Delaware in 1982 were conservatively estimated at approximately 8.9 million dollars and the total economic impact of those expenditures was nearly 13 million dollars. This included 7 million dollars in value added (summation of wages, proprietors income, taxes and dividends), of which 3.5 million dollars was resident income. The resident incomes resulted in 439 full-time equivalent jobs.

12.6.2 Employment

There are no specific data available on employment in the various commercial fisheries for weakfish. The decrease in total units of gear (Section 12.5.1.4) suggests that employment may have declined, although there has probably been an increase in part-time fishermen.

12.6.3 Participation

User groups of sciaenids include commercial fishermen, processors and dealers, food consumers, recreational fishermen, marinas, and bait shops (Cato 1981). Weakfish are harvested seasonally by the pound net, haul seine, gill net, and otter trawl fisheries along the coast (Section 12.5.1.1). The number of anglers in the recreational fishery apparently doubled between 1960 and 1970 and the recreational catches of weakfish may have exceeded commercial landings in 1970 and 1975.

Marine recreational angling surveys in Delaware from 1955 to 1982 indicated that the highest level of participation occurred in 1976, with total effort equaling approximately 826,000 man-days (Seagraves and Rockland 1983a). This represented a 3.4-fold increase in effort over 1960 (239,327) and a 1.8-fold increase over 1968 (452,809). Although total effort declined in 1982 (514,802), it equalled the 27-year average. A survey of sport fishing in Albemarle Sound, N.C. from 1977 to 1980 indicated that fishing effort for weakfish showed a 1.3-fold

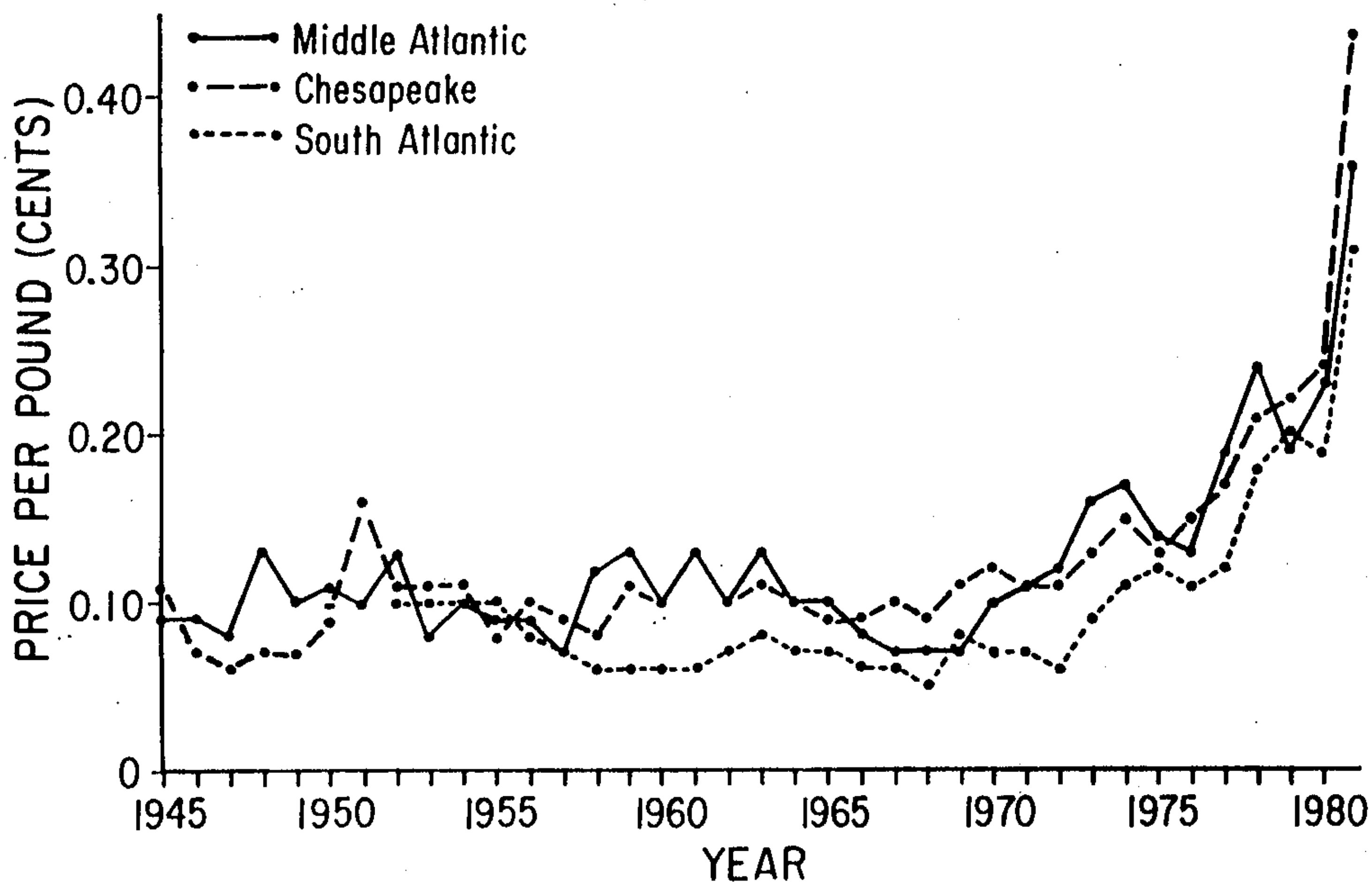

Figure 12-12. Dockside price of weakfish by geographic region, 1945-1982.

increase from 1977 to 1978, followed by a 2.6-fold decrease in 1979 (Mullis and Guier 1982).

12.6.4 Processors and Product Forms

Most sciaenids are sold for food through local fish houses (Cato 1981). At one time most weakfish were sold through large wholesale markets such as Fulton Fish Market in New York City (Taylor 1951). Traditional markets for weakfish extend from the Carolinas to New York, primarily along the coast. Weakfish are also shipped to the Gulf states, primarily from New Jersey and North Carolina.[16] Some weakfish are also marketed throughout the Midwest in retail stores. Most weakfish are sold freshly iced, whole, although small quantities are processed as fresh and frozen fillets (Pileggi and Thompson 1980b). Commercially-caught Delaware weakfish were moved via one of three possible routes: 1) iced, packed, and sent out-of-state; 2) iced, packed, and retailed within the state to the consumer; and 3) iced, packed, retailed within the state to a restaurant and then sold to the consumer (Seagraves and Rockland 1983a). The large seafood markets of Ocean City, Rock Hall, Secretary, Baltimore, Philadelphia, and New York serve as the primary out-of-state outlets for Delaware fish. An estimated 90% of the total catch is sold directly by fishermen to restaurants or out-of-state.

Out-of-state marketing channels and inland channels of distribution of weakfish in North Carolina were analyzed by Summey (1977, 1979). Of the total fresh iced weakfish handled by North Carolina dealers in 1974, 80.4% was sold inside North Carolina, the majority in coastal areas. The major in-state markets were retail fish markets (68.3%), wholesalers and distributors (27.6%), and direct retail sales (3.1%). The largest out-of-state customer was New York, followed by Virginia and Maryland. Out-of-state sales of weakfish went mostly to wholesalers and distributors.

The potential exists to utilize weakfish for surimi (minced fish); however this use has not been fully developed (Angel et al. 1978).

12.6.5 Import/Export

There is some evidence that sciaenids have been exported to Africa, however, it is not anticipated that they will become preferred export species. This market required large volumes of low-cost fish (Cato 1981).

12.6.6 Gear Conflicts

A large increase in the number of crab and eel pot fishermen in North Carolina sounds has resulted in increasing friction with haul seiners, who cannot haul in areas filled with pots (DeVries 1981b). Potters are mainly interested in shoal waters, which long haulers need only to bunt up their seines. An additional gear conflict in North Carolina is with

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[16] Pers. commun. Roger Anderson, Gulf and South Atlantic Fisheries Development Foundation, Tampa, FL.

pound net stakes that are abandoned, broken off or left in place from season to season, and exclude long haulers from large areas, especially in Core Sound (DeVries 1981b).

12.6.7 Commercial-Recreational Conflicts

Wilk and Brown (1982) reported that space conflicts have occurred between private- and party-boat recreational fishermen and gill netters (stationary) who simultaneously exploit large concentrations of spawning fish in the shallow estuaries of the Long Island area of New York. They reported that similar conflicts have taken place between New Jersey and Delaware private-, party- and charter boat fishermen and commercial pelagic trawlers and purse seiners who simultaneously fish large concentrations of sport weakfish which congregate in the shoal waters at the mouth of Delaware Bay during early summer. In 1966 recreational fishermen in Delaware helped to enforce an old law prohibiting the operation of otter trawls in Delaware Bay. Since then weakfish have been taken commercially by fixed and drifted gill nets fished early in spring before the recreational catch enters the market (Seagraves 1981). The commercial gill net fishermen are in spatial conflict all season long with the recreational fishermen who claim that the commercial fishermen are "overharvesting" the weakfish resource in Delaware Bay.[17]

In Chesapeake Bay, significant concern was generated during the spring and summer of 1982 as "high roller" gill net boats from Florida began fishing for large bluefish (4.5-6.8 kg) using large mesh (16.5 cm).[18] While the initial focus was on their use for taking bluefish, an underlying concern was their possible expansion to the weakfish fishery during the spring and summer of 1983. Numerous recreational fishing interests in both Maryland and Virginia created sufficient political furor that the use of the runaround gill net was banned in the Virginia waters of Chesapeake Bay.

A growing problem in the Pamlico-Pungo River area of North Carolina is a conflict with recreational anglers who fear long haulers are depleting stocks of sport fish (DeVries 1981b).

12.7 Management and Protection

12.7.1 Regulatory Measures

Weakfish occur mainly in the territorial waters of the coastal states from Massachusetts to Florida. Each state exercises jurisdiction over the fisheries within its waters to three nautical miles from shore. The regulations and methods of promulgating them vary between states and are summarized in Table 12-18. The Magnuson Fishery Conservation and Management Act (MFCMA) provides for the conservation and exclusive

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[17]Pers. commun. Richard Seagraves, Delaware Division of Fish and Wildlife, Dover, Del.

[18]Pers. commun. Herbert Austin, Virginia Institute of Marine Science, Gloucester Point, Va.

management of all fishery resources within the U. S. Fishery Conservation Zone (FCZ) which extends from the territorial sea to 200 nautical miles from shore. There are no national or international laws or policies dealing with weakfish.

12.7.2 Habitat Protection

Weakfish utilize both estuarine and coastal oceanic waters at various life history stages and times of the year (Section 12.2.2). Habitat alterations within estuarine areas are probably the most damaging to weakfish 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. 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, dredging of navigation channels, and pollution (Gusey 1978, 1981). In the Atlantic coast states (Maine-Florida), containing 3,152,800 acres of estuarine habitat, an estimated 129,700 acres (4.1%) were lost to dredging and filling from 1954-1968 (Table 12-19). 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; 1899 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 12-20.

12.8 Current Research

Current weakfish research was discussed at the Sciaenid Assessment Workshop (Wilk and Austin 1981). Weakfish stocks are assessed in seasonal National Marine Fisheries Service groundfish survey cruises. In addition, several states monitor juvenile and adult weakfish populations in estuarine surveys. The Rhode Island Division of Fish and Wildlife has conducted a random station trawl survey in Narragansett Bay and in Rhode Island and Block Island Sounds during the spring and fall of each year since 1979. The Delaware Division of Fish and Wildlife conducts monthly adult groundfish and annual recruitment surveys in Delaware Bay. Catch and effort data are collected for the commercial and recreational fisheries of Delaware. The Maryland Department of Natural Resources conducts an annual blue crab population survey in Chesapeake and Chincoteague Bays and has documented all finfish, including weakfish, since 1980. Juvenile weakfish abundance in Chesapeake Bay and its tributaries has been monitored in monthly trawl surveys by the Virginia Institute of Marine Science since 1955. The North Carolina Division of Marine Fisheries monitors juvenile weakfish

Table 12-18. Synoptic overview of present state management systems.

State	Rhode Island	Connecticut
Administrative organization	Rhode Island Department of Environmental Management	Connecticut Department of Environmental Protection
Legislative organization	Rhode Island Marine Fisheries Council	Connecticut Commissioner Environmental Protection
Licenses	Commercial	Commercial
Size restrictions	None	12"
Limits	None	None
Gear restrictions	None	None
Conservation regulations	None	None

Table 12-18. (Continued)

State	New York
Administrative organization	New York State Department of Environmental Conservation
Legislative organization	New York Fish and Game Laws, Article 13 Marine and Coastal Resources
Licenses	Commercial non-resident beam and otter trawl
Size restrictions	12" minimum (sport and commercial)
Limits	None
Gear restrictions	Trawl prohibited from Great South Bay, Moriches Bay, Shinnecock Bay; seasonally in Peconic Bays. Gill nets restricted from Peconic Bays; haul seines limited in lengths in these same bays and cannot be fished from midnight Thursday to 6:00 p.m. Sunday. Nets and trawls may not be set in western Long Island Sound Apr. 1 - Nov. 1. Gill nets prohibited in central and western Long Island Sound.
Conservation regulations	None

Table 12-18. (Continued)

State	New Jersey	Delaware
Administrative organization	New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife, Marine Fisheries Administration, Bureau of Marine Fisheries	Division of Fish and Wildlife Department of Natural Resources and Environmental Control
Legislative organization	New Jersey Statutes, Title 23, Chapter 28	Delaware State Legislature
Licenses	Fyke nets - $1, $4, $30 Haul seines - $25 Bait seines - $3 (50' - 150') Gill nets - anchored - $13 drift - $20 run around - $20 Pound nets - $ 25 - $ 50 - $100 Otter trawl - $100 Beam trawl - $100 Purse seine - $100	None
Size restrictions	9" minimum (not more than 5% under if offered for sale)	10" minimum
Limits	None	None
Gear restrictions	Trawls and purse seines restricted from within 2 miles of coastline. Seasons for gill nets, fyke nets, haul seines.	Trawl prohibited in Delaware Bay. Gill nets, fyke nets and seines allowed
Conservation regulation	None	

Table 12-18. (Continued)

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	9" minimum	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 12-18. (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 12-18. (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 1½" for seines <100'; minimum size of 2½" (s.m.) for 100 - 300' maximum length.
Conservation regulations	None	None

Table 18. (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

Table 12-19. 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 12-20. Summary of state habitat protection regulations.

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

Table 12-20. (Continued)

State	Administrative organization	Legislative authorization	Regulations
Delaware	Delaware Department of Natural Resources and Environmental Control, Division of Environmental Control, Wetlands Section	Sect. 1, Title 7, Delaware Code, Chapter 66. Wetlands.	Regulates use of wetlands and their upland border and provide penalties for violations
Maryland	Maryland Department of Natural Resources, Tidewater Administration; Maryland Department of Health and Mental Hygiene, Office of Environmental Programs	Natural Resources Article, Code of Maryland	Regulates activities in tidal wetlands areas.
Virginia	Virginia Marine Resources Commission; County wetlands boards	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. Establishes areas of environmental concern. Permits required for coastal zone development.
	Division of Marine Fisheries	NC Administrative Code Code, Chap. 3, Sect. .1400	Prohibits the use of bottom - disturbing gears and severely restricts or prohibits excavation and/ or filling activities in nursery areas for young finfish and crustaceans.

Table 12-20. (Continued)

State	Administrative organization	Legislative authorization	Regulations
Georgia	Georgia Department of Natural Resources, Coastal Resources Division, Coastal Protection Section	Coastal Marshlands Protection Act of 1970 (Gs. L. 1970, p. 939, §1.)	Requires permits to dredge, fill, remove, drain, or otherwise alter any 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.
South Carolina	South Carolina Coastal Zone Management Council	Coastal Zone Management and Planning Act	Directs permit activities in areas of wetlands, beaches, and dunes.
Florida	Florida Department of Natural Resources	Chapter 253, Florida Statutes	Regulates dredge, fill, and structures on state submerged lands (below mean high water). Provides for acquisition of conservation lands and tidally influenced areas.
		Chapter 258. F.S.	Establishes aquatic preserves and regulates activities within perserves.

Table 12-20. (Continued)

State	Administrative organization	Legislative authorization	Regulations
	Florida Department of Environmental Regulation	Chapter 403, F.S.	Permitting of activities (including dredge and fill) which affect water quality.
	Florida Department of Community Affairs	Chapter 380, F.S.	Administer and set standards for "Development of Regional Impact". Protects regional or statewide resources from poorly conceived development activities.

abundance in its nursery area assessment from March to November. In addition adult weakfish are sampled from the long haul seine, pound net, and winter trawl and gill net fisheries, and an age and growth study is being conducted. An inshore trawl survey for sciaenids occurring between Cape Fear, N.C. and Cape Canaveral, Fla. was recently completed by the South Carolina Marine Resources Research Institute. Weakfish have been tagged in an ongoing Georgia estuarine tagging study.

12.9 Research Needs

Weakfish research needs, as indicated by this review of the literature, by discussions at the Sciaenid Assessment Workshop (Austin 1981), and by the ISFMP Sciaenid Technical Committee, include stock identification, determination of migratory 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 weakfish 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. The optimum utilization (economic and biological) of a long-term fluctuating population such as weakfish needs to be determined.

13.0 ACKNOWLEDGEMENTS

I wish to thank members of the Interstate Fisheries Management Program (ISFMP) Sciaenid Technical Committee for their major contributions to the format and contents of this report. The members of the ISFMP Sciaenid Board and the South Atlantic State Federal Fisheries Management Board provided guidance in the development of the plan's goal and objectives. Membership rosters are included as an appendix to this report (Section 15.0). I thank Michael Street, North Carolina Division of Marine Fisheres, for his advice and review of the manuscript. Funding for the preparation of this report was provided by the National Marine Fisheries Service (NMFS) Southeast Regional Office, NOAA, under State/Federal Cooperative Agreement No. SF-13. Funds for printing were provided by NMFS - Northeast Regional Offices, NOAA, to the ISFMP under Cooperative Agreement No. NO-80-FA-00017. I thank Diana Willis for typing this report.

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15.0 APPENDIX

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