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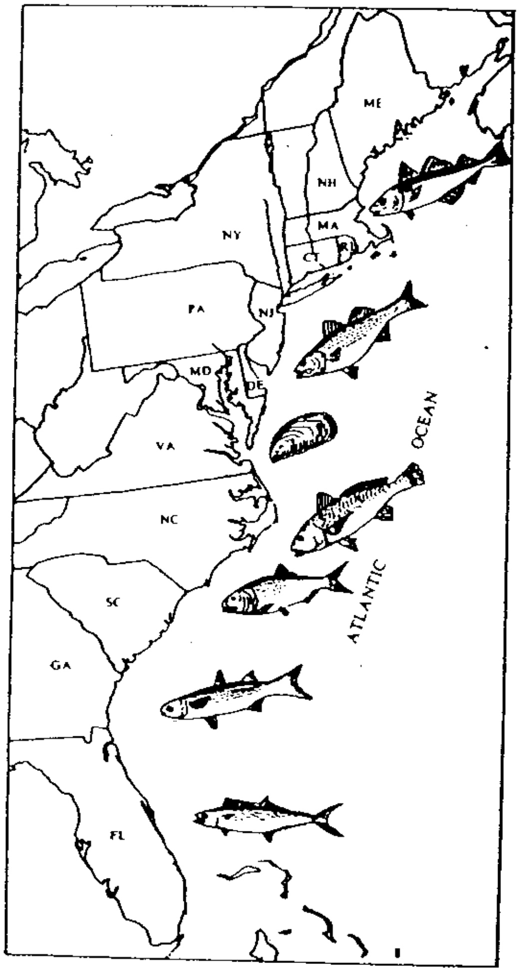

INTERSTATE
FISHERIES
MANAGEMENT
PLAN
FOR
THE
STRIPED
BASS

October 1981

Atlantic States Marine Fisheries Commission

Interstate Fisheries Management Plan for the Striped Bass of the Atlantic Coast from Maine to North Carolina

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SUMMARY

1. Executive Summary

The striped bass, also known as rockfish, is one of the most important recreational and commercial fishes in the region from Maine through North Carolina. Its population levels, as indicated by reported commercial landings, have declined steadily from the high levels experienced from the late 1950s through mid- 1970s. The species is anadromous and undertakes extensive seasonal migrations between its spring spawning and nursery areas in south and mid- Atlantic estuaries, its summer feeding grounds along the mid- and north Atlantic coast and overwintering areas along the coast adjacent to the south and mid- Atlantic breeding areas. Three major stocks comprise the striped bass population under consideration for management. They originate from the Hudson River, Chesapeake Bay, and Roanoke River. In 1975 estimates of the relative contributions of these stocks to the coastal population were calculated to be 6.5%, 90.8%, and 2.7%, respectively (Berggren and Lieberman, 1978). Management of this species is complicated by its complex life history, by major variations in regulations between states and by competition between recreational and commercial fishermen. In recent years the striped bass has become a focal point of public attention in issues of environmental pollution, power plant siting and management of interjurisdictional fisheries.

The striped bass supports an important fishery along the Atlantic coast, especially from Massachusetts through North Carolina; over 90% of the harvest derives from the Territorial Sea (Table 12). Reported commercial landings of striped bass for the region as a whole show a generally rising trend from about 1933 through 1973 (Table 16). The total commercial landings, which averaged approximately 9.5 million lbs between 1958 and 1976 and peaked at 14.7 million lbs in 1973, fell to 3.1 million pounds in 1979. In 1970, with landings of 11.6 million lbs valued at $2.5 million, the striped bass ranked 10th in volume and 8th in value among over 100 finfish species landed on the Atlantic coast. In addition to this decline in landings, the relative share of the total commercial catch taken by individual states has shifted. Figure 15 shows a general trend toward the reduction of Maryland's contribution to the total commercial landings while Massachusetts' has increased. Striped bass of 12-17" total length (TL) comprise the majority of Maryland's (Table 19) catch while fish over 24" TL (about 6 lbs) dominate Massachusetts' landings (Table 20); thus, the data of Figure 15 indicate a shift in the population's age/size composition toward older and larger individuals.

Reliable recreational harvest data for the Atlantic Coast stock is limited. From Maine to the east coast of Florida, in 1979, 39.2 million marine recreational fishing trips produced 1.2 million striped bass. The states from Maine to North Carolina produced 99% of the catch. Although the available data are too discontinuous to describe trends, the sport fishermen's harvest of striped bass has likely suffered the same magnitude of loss as that experienced by commercial fishermen despite indications that the number of anglers has increased during this period. Completion of the data analysis of the National Marine Fisheries Service's (NMFS) 1980 national creel survey will provide further reliable and detailed information regarding the recreational striped bass fisheries. Optimum utilization of this species requires more extensive knowledge of the recreational fishing effort and economic importance.

An analysis of revenues is important for better understanding of the striped bass fisheries in different regions. Despite the reduction in landings since 1973, fishermen in the New England and mid- Atlantic states actually derived greater revenue from their efforts due to a rapid increase in the actual price of striped bass since 1974. In the Chesapeake and south Atlantic fisheries, however, the increased value of the catch has not compensated for the reduced volume, resulting in an overall decline in revenues of about 25% (Strand et al. 1980). The high prices paid for striped bass provide strong incentive to continue fishing despite the reduced numbers of fish available. This fact could make self-regulation of this fishery questionable.

Overall commercial catch records of striped bass correlate strongly with the relative abundance of juveniles produced in Chesapeake Bay (Koo 1970). The factors governing reproductive success are imperfectly understood; although freshwater flow, winter temperatures, and other natural factors likely account for most of the variation in the year class strength (Ulanowicz and Polgar 1980). Man-induced influences such as pollution and large-volume water intakes cannot be discounted. If the latter are significant, management for optimum yield may require their appraisal and control. Natural environmental factors and large-scale human impacts may present the greatest challenge in manipulating for the purpose of striped bass management.

The Atlantic coastal migratory stock is subject to the varying laws and regulations of twelve states and two interstate commissions. Given the particular public interests and stock characteristics within each state, defining measures for management of this common resource requires that concessions be made on all sides. The management goal can be stated as: To perpetuate the striped bass resource in fishable abundance throughout its range and generate the greatest possible net economic and social benefits from its harvest and utilization over time. Component objectives which will lead to attainment of the goal have been proposed and management strategies have been developed to achieve the objectives.

An appropriate management strategy to achieve the established objective of reducing the variation in annual abundance available for harvest is to reduce fishing mortality so as to distribute the catch over a greater number of years than has historically occured. Since a reduction of fishing mortality of small (immature) fish would increase the numbers surviving to maturity, management measures to protect this age class are being recommended. In addition, this would increase the numbers of mature fish that return to the spawning grounds at least once, with possible additional benefit to recruitment. Establishing minimum size limits for producing and coastal areas will increase the yield per recruit by taking advantage of the species innate growth potential. The recommended spawning area closures in the producing areas will prevent excessive exploitation of mature fish and assure that substantial numbers will be available for return to the coastal migratory stock.

These strategies have been translated into recommended management measures which the affected states will be responsible for implementing. It must be recognized that each state's social and political climate and fisheries differ and that each state will act within their constraints to adopt these recommended management measures:

1. Size limitations are recommended in order to achieve the management objectives of maintaining a spawning stock and reducing variations in annual abundance.

a. Minimum in inland waters - As an immediate step, striped bass caught in Albemarle Sound, Chesapeake Bay, Delaware Bay and their tributaries and the Hudson River may not be retained if they are less than 14 inches TL (or equivalent FL). This minimum length is considered as an interim step in reaching the defined goal of 15 inches TL (or equivalent FL) in as reasonable time as possible.

b. Minimum in coastal waters - Striped bass caught in coastal waters, other than the inland waters identified in 1.a, may not be retained if they are less than 24 inches TL, (or equivalent FL), except:

I. No more than four fish which are less than 24 inches TL (or equivalent FL) and at least that minimum length as set forth in 1.a above may be retained by each fisherman daily if the fish were caught by hook and line, or

II. No more than five percent of a total daily catch of striped bass may consist of striped bass less than 24 inches TL (or equivalent FL) and at least that minimum length as set forth in 1.a above if the catch was made by net.

c. Maximum size limits - In those states that have an established maximum size limit for protection of broodstock it is recommended that this size limit be retained.

2. Area closures are recommended in order to achieve the objective of maintaining a spawning stock by preventing excessive exploitation of mature fish in the spawning area.

Major spawning areas or rivers, as defined by the appropriate states will be closed to fishing during striped bass spawning activity.

3. Data Collection and Monitoring Programs are recommended in order to achieve the objective of effectively monitoring and assessing the success of management efforts relative to the overall goal.

a. In order to identify user groups, all persons who sell or buy striped bass will be required to obtain a permit from the appropriate state agency.

b. In order to obtain catch per unit effort information, a data collection/catch monitoring program should be implemented by the states that will compile commercial and recreational fishery statistics by area, season and gear type and amount.

c. In order to obtain catch per unit effort information, a data collection/catch monitoring program should be implemented by the states (concurrent with b. above) that will collect biological samples reflecting age, sex and size composition of the catch.

Regardless of management measures pursued, management of striped bass will require continuous, long-term monitoring programs supplying information about the status and characteristics of the stocks. Specific areas included within this category are, in order of priority:

- catch/statistics records - commercial and recreational, including expended effort and distribution by area, season, and gear.
- mortality rates - natural and fishing
- recruitment rates - year class strength by area
- stock composition/migration patterns and rates - differentiated by age, sex, and size
- socio-economic characteristics of the fisheries

In addition to the above, special research efforts should be directed toward further understanding the factors affecting the abundance and distribution of early life stages. The correlation between Maryland's recruitment survey and subsequent commercial catches indicates that year class strength is determined at or before the juvenile stage. Therefore, attention should be focused on factors controlling reproductive success up to and including the post-finfold larval stage. First of all, the physical loss of spawning areas, due to shoreline development, power plant intakes, pollution, or sedimentation should be evaluated. The condition of the spawning stock, especially the females, should be monitored. Monitoring the viability of the eggs produced is one of the more important areas of effort. Studies on the Roanoke River indicate that egg viability there has dropped considerably in recent years. Perhaps the best approach to quantifying the effects of chemical contaminants is to identify chemicals of concern occuring in the field and then perform laboratory studies to determine their effects. It is important also to develop further understanding of interspecies interactions as limiting factors. These interactions include distribution and abundance of food organisms, predation on larval stages, and competition with other species (e.g. white perch and bluefish). Climatological factors operating throughout the entire early life history stages must be considered as well. Evidence is accumulating which indicates that reproductive success is determined to a large degree by such abiotic environmental factors as spring freshwater flow and variable spring temperatures (Kernehan et al.1981).

The relative abundance of the species from the mid- 1950s through the early 1970s effectively ended earlier efforts to manage striped bass on a regional basis (see Neville, 1942). Because of the species' status as a preferred game fish as well as a food fish, public awareness of and concern over its recent decline is unusually widespread. Management of this fishery is necessary to (1) ensure the species' abundance is not reduced so far as to adversely affect reproductive ability; (2) provide data describing the stock's structure, value, dynamics, exploitation, and other factors required for comprehensive management; and (3) determine the feasibility of reducing variation in catches and increasing stock size. The present magnitude and efficiency of both the commercial and recreational fisheries may deplete the resource to levels from which recovery is slow or impossible. To be effective, management will require close cooperation between the twelve states whose territorial seas are home to striped bass.

INTRODUCTION

INTERSTATE FISHERY MANAGEMENT PLAN

for the

Striped Bass of the Atlantic Coast,

Maine to North Carolina

2. Introduction

The striped bass is one of America's most highly esteemed game and food fishes, especially throughout its range from Maine through North Carolina. The precise value of this resource is difficult to assess, particularly in regard to the recreational fishery. However, the magnitude of the striped bass harvest is suggested by available data. From Maine through the east coast of Florida, in 1979, 5.9 million recreational fishermen caught 1.2 million striped bass (NMFS 1980). The states from Maine through North Carolina produced 99% of the catch. That same year, the Maine to North Carolina commercial fishery produced 3.1 million pounds of striped bass. In 1973, landings of 14.7 million pounds of striped bass were reported by commercial fishermen alone, an apparent all- time record. Contributing to this peak in landings was recruitment of the extraordinary 1970 year class produced in Chesapeake spawning grounds, combined with older and larger striped bass surviving from a succession of dominant year classes during the late 1950's and the 1960s.

Since 1973, however, commercial landings of striped bass have steadily declined for the coast as a whole. The 1979 commercial landings (3.1 million pounds) are the lowest reported in the last 30 years (1949, first year of complete records) for the Maine to North Carolina fishery. The average landing for the 30 year period was 7.8 million pounds. The major Chesapeake spawning areas have not produced a dominant year class of the species since 1970, though reproductive success is considered average in relation to previous years (Figure 12). Despite the decreased availability of striped bass, pressures on this limited resource are strong and increasing due to the high market value of striped bass and growth of the recreational and commercial fishing industry.

In order to define the problem, assess the extent of public concern, and explore possible solutions, the State of Maryland and the National Marine Fisheries Service (NMFS) sponsored a Striped Bass Management Workshop in Baltimore, Maryland on September 22-23, 1977. Attending this workshop were striped bass-oriented researchers, fishery managers, environmentalists, and recreational and commercial fishermen. The workshop's participants strongly recommended that the States and the Federal Government undertake a cooperative effort to manage striped bass on a regional basis (Grice 1977). As a result, the Northeast Marine Fisheries Board, a body of State and Federal resource agency administrators which oversees NMFS's State/Federal Fisheries Management Program, established a program addressing the species as a unit stock throughout its migratory range from Maine to North Carolina.

PROJECT ORGANIZATION

Because the species and its fisheries occur predominantly within three miles of the coast management jurisdiction for striped bass resides with the States rather than the Federal Government. NMFS organized the State/Federal Fisheries Management Program (SFFMP) in 1972 to coordinate interstate management of such high value species as American lobster, surf clam, Atlantic menhaden, and northern shrimp. The SFFMP was a forerunner of the Magnuson Fisheries Conservation and Management Act (MFCMA) of 1976; however, the MFCMA is directed at fisheries outside of the Territorial Sea, in the zone from 3 to 200 miles. In September 1980, the NMFS State/Federal Fisheries Management Program was restructured, in the Northeast Region, resulting in the formulation of the Atlantic States Marine Fisheries Commission's (ASMFC) Interstate Fishery Management Program. The National Marine Fisheries Service Northeast Regional Office entered into a Cooperative Agreement with the Atlantic States Marine Fisheries Commission, under which the Commission is responsible for coordinating the development and implementation of management plans for important fisheries of interjurisdictional nature along the Atlantic Coast. Thus, management officials considered the Interstate Fisheries Management Program (ISFMP) as the most appropriate vehicle for continuation of a striped bass management effort.

The organizational framework of the Striped Bass Management Project under ASMFC includes a Striped Bass Fisheries Management Board, Scientific and Statistical Committee, Project Manager, and Regional Citizens' Advisory Committee (RCAC). Development of this Striped Bass Management Plan is the joint task of the Project Manager, Scientific and Statistical Committee, and Regional Citizens' Advisory Committee, under the direction of the Striped Bass Board. The Striped Bass Board is composed of the administrators of the marine resource management agencies of the twelve states from Maine to North Carolina, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and the Atlantic States Marine Fisheries Commission. Members of the Scientific and Statistical Committee are fishery managers assigned by the same agencies. ASMFC awarded a contract for completion of the Striped Bass Fishery Management Plan to the State of Maryland and the Project Manager is an employee of that State.

Each State's marine resource management agency, assembled a Citizens Advisory Committee (CAC) composed of citizens interested in striped bass. Each State's CAC elected from its members a representative to the Regional Citizens Advisory Committee. Representatives from the RCAC provide the imput of the needs, concerns, and values of all users of the striped bass resource.

PLAN DEVELOPMENT

The Atlantic States Marine Fisheries Commission, an interstate compact responsible for the administration of the Interstate Fishery Management Program on the Atlantic coast, developed a generalized framework for formulating and implementing management strategies for the territorial sea fisheries. Once the unit stock is defined, a workshop is convened to determine the status and needs of the fishery and a project is organized. The plan format is similar to that prescribed for the development of Fishery Management Plans (FMP) by the Regional Fishery Management Councils, established by the Magnuson Fishery Conservation and Management Act of 1976. The FMP, once prepared, is subject to review and revision both before and after implementation. Routine stock assessments and population dynamics studies may be conducted on a long term basis for input into the management plan.

The Striped Bass Project has proceeded on a slightly different course of action than that outlined above. Because of the fishermen's concern over their declining catches of the species, the Project's initial efforts were concentrated on developing interim regulations to provide for immediate management guidance. These interim regulations, to be imposed uniformly throughout the region, would encourage conservation of remaining striped bass stocks through a combination of larger minimum sizes in producing areas, creel limits, and mandatory licenses for anyone selling the fish. With the conclusion of this effort in October, 1979, development of the management plan began in earnest.

PLAN IMPLEMENTATION

The Interstate Fishery Management Program is not the first attempt at managing striped bass on a regional basis. This issue was important in the creation of the Atlantic States Marine Fisheries Commission (ASMFC) in 1942. Based on the research of Daniel Merriman and others during the 1930's, the

U.S. Fish and Wildlife Service attempted to implement a uniform size limit of 16" FL (fork length) in each of the Atlantic Coast states. Although this particular size limit was thought to maximize the yield per recruit, by 1942 only 6 states had implemented the recommendation. William Neville of the Fish and Wildlife Service addressed the ASMFC at its first annual meeting on September 15, 1942 seeking the Commission's assistance in obtaining more widespread acceptance of the 16" FL size limit for striped bass. His report, entitled "The Striped Bass Problem" (Neville 1942) makes rather interesting reading. Comparing the situation then with the present, few significant changes in striped bass management or in the users' perception of the resource and its use are evident.

Much of the complexity in striped bass management lies with the large number of regulatory agencies necessarily involved in any regional effort, and the variety of mechanisms through which the states regulate their resources. Twelve different states and two Federal agencies are involved in the present striped bass management effort. In several of these states, management is effected by legislation; in others, a more responsive and flexible regulatory system prevails. Section 6 contains detailed information on the regulations and regulatory/statutory processes in each state.

Regulations and statutes are determined by the characteristics of the resource in the area of jurisdiction and by the needs and values of the users in that area. Underlying the variety of striped bass regulations is the complex nature of the species' life history, which encompases resident stocks as well as migratory elements, each characterized by different ages and sexes according to the season. For example, consider just the size limits currently specified for the striped bass. In one state no minimum size limit is specified; the minimums in other states include 12" TL (total length), 12" FL (fork length), 14" TL, 16" FL, and 18" TL. In addition, three of the twelve states specify maximum size limits, all different: 32" TL, 40" TL, and 20 lbs.

The formation of the Interstate Striped Bass Fishery Management Project has not changed the diversified nature of striped bass management. The Project has no authority to implement or enforce a regional management plan for the species. It does, however, provide a forum for resource users, fishery managers, and marine resource agency administrators of the States and Federal government to cooperate in the development of a management plan for the major Atlantic Coast stocks of striped bass. There are several options available for implementation of a plan:

* voluntary implementation, state by state, of the management measures recommended by a species project.
* implementation via Amendment One of the Atlantic States Marine Fisheries Compact (P.L. 77-539). Two or more states "may designate the Atlantic States Marine Fisheries Commission as a joint regulatory agency with such powers as they may jointly confer . . . with respect to specific fisheries in which such States have a common interest". The State/Federal management plan for northern shrimp, involving the States of Maine, New Hampshire, and Massachusetts, was implemented through this mechanism.
* implementation via the appropriate Regional Fishery Management Councils under the authority granted in the Magnuson Fishery Conservation and Management Act of 1976. The State/Federal management plan for surf clams was referred to the Regional Fishery Management Council for implementation because a majority of the resource is harvested in the Fishery Conservation Zone (FCZ).
* implementation via special territorial seas legislation. The involved States grant regulatory authority over specific fisheries

to the ASMFC or some other non-partisan organization. Several models of territorial seas legislation have been proposed; none as yet has inspired any degree of consensus among the states.

RESEARCH

Though the body of information concerning striped bass is considerable, a number of informational gaps exist which must be resolved if the species and its fisheries are to be managed effectively. Areas of research given high priority by the Scientific and Statistical Committee (SSC) include:

* developing uniform programs for monitoring the catch and expended effort of both the commercial and recreational fisheries.
* assessing the viability of eggs and larvae from different ages and different stocks of striped bass, to determine the most valuable portion of the brood stock.
* estimating the rates of natural and fishing mortality, through tagging programs and/or studies of age-class and sex ratios in the catch.
* evaluating the effects of natural, physical and environmental factors on the variations in year class strength from year to year and area to area.
* estimating the annual recruitment in spawning areas and the relative annual contribution of each spawning area to the migratory stocks.
* describing the migratory patterns in different areas differentiated according to age and sex.
* evaluating the social and economic characteristics of the striped bass fisheries.

The Striped Bass FMP Project has only limited funds available to support the initial research required for comprehensive description and management of the fisheries. Work thus far supported by the Project's research funds includes a striped bass library, analysis of economic data needs for the management of the striped bass fisheries, and consultation with population dynamics specialists for management strategies and data needs.

To the extent possible, all studies undertaken by the Project will be coordinated with other State and Federal programs to ensure maximum productivity of effort. The basic organization of the Project itself, which brings together representatives of the principal State and Federal agencies responsible for managing anadromous fish resources, will facilitate research coordination.

The Project's present resources are too limited to address, simultaneously and in-depth, all of the questions surrounding the striper and its fisheries. Recognizing this, the Project's participants - particularly the RCAC - helped support the Emergency Striped Bass Act of 1979 (the Anadromous Fish Conservation Act Amendment - Public Law 96-118) sponsored by U.S. Senator John Chafee of Rhode Island. The Striped Bass FMP Project funding is independent of Chafee funds.However, the two Federal agencies charged with administering the Chafee studies are also involved in the Striped Bass FMP Project. Results derived from Chafee funded research will be used in formulating management recommendations in the Plan. Further, the Chafee Bill specifies that the Project's Advisory Committees will be consulted in its administration. The Emergency Striped Bass Act of 1979 and the Striped Bass FMP Project are expected to complement each other.

The overall objective of the Striped Bass Fishery Management Project is to obtain the greatest possible net benefit from this limited resource, while reconciling the demands of user groups and the biological restraints of the stocks. The nature of the fish and its fisheries is highly complex and a number of issues must be addressed. Some of these are biological; for example, what are the recruitment and mortality rates of the various stocks, and what factors affect the survival of eggs and larvae? Other questions, equally important to management, are the social relationships; for example, who fishes for striped bass, and how valuable is the species to them? Regions, states, and sport and commercial fishermen express opposing views regarding the status of the striped bass stocks, causes of their decline, and optimum conservation practices. Different philosophies of management exist: some states protect the larger, more fecund females to ensure an adequate reproduction, while others allow the young fish a greater period of growth. There is a great sense of urgency among some fishermen compelling them to seek immediate implementation of strict management measures, to prevent what they fear to be imminent extinction of the species. In contrast, many others believe the decline in landings is simply a downturn in a natural cycle of abundance. Education of the public regarding the striper's life history and the needs and values of fishermen throughout the species' range is an important part of the program. The Interstate Striped Bass Fishery Management Project, under the administration of the ASMFC, provides the best hope for effective regional management of the species. The following Plan was developed by the ISFMP to be implemented by the individual States with the assistance (and oversight or monitoring) of the ASMFC. It will require time and continued cooperative effort to be successful.

THE SPECIES

3.1 Summary of General Characteristics

The accepted common and scientific names for the species are striped bass, Morone saxatilis (Walbaum) (American Fisheries Society 1980). In the New England and mid-Atlantic regions it is also called striper, linesider, or just plain bass, while from the Chesapeake Bay region southward it is more familiarly known as rockfish or rock.

The general body shape is perch-like, elongated and moderately compressed with a slightly arched back (Figure 1). The species coloration is its most distinctive feature. The sides are silvery with 7 or 8 narrow, black or sooty, longitudinal stripes which follow the scale rows. One of these stripes always follows the lateral line, with 3 or 4 others above it and 3 below. Striped bass are relatively long-lived and capable of attaining moderately large size. Fish weighing 50 or 60 lbs. are not exceptional. In general, female striped bass grow considerably larger than males; reported maximum lengths are 152.4 cm FL (60.0") and 115.6 cm FL (45.5"), respectively.

Striped bass are anadromous, ascending coastal streams and brackish estuaries in early spring to spawn, afterward returning to ocean waters and migrating along the coastline in late spring and early summer. The Atlantic coastal population ranges from the St. Lawrence River, Canada to the common border of Georgia and Florida, (Setzler et al. 1980). Individuals from all spawning areas north of Cape Hatteras contribute to the coastal migratory stock, (Merriman 1941; Raney et al. 1954; Alperin 1966; Schaefer 1968; Berggren and Lieberman 1978).

Merriman (1941) stated that striped bass probably spawned in all larger rivers along the Atlantic coast prior to the construction of dams and pollution in many spawning rivers. Those remaining Mid Atlantic Coastal rivers where striped bass spawn are shown in Figure 2. The major spawning areas for the stocks of striped bass from Maine to North Carolina are the Chesapeake Bay, Hudson River and Roanoke River.

The exact percentage contribution of fish from the major spawning areas to the Atlantic coastal stock is not known precisely. Chesapeake Bay spawners constitute the largest, though fluctuating, proportion of the stocks while the Hudson and Roanoke contribute respectively less (Klauda et al 1980; Van Winkle et al. 1979; Berggren and Liberman 1978). In the northern and southern extremes of the area addressed by this plan, there may be some small contribution from minor spawning areas in Canada and South Carolina respectively.

The beginning of the spawning season varies with latitude, beginning as early as mid-February in Florida's St. John River or as late as early July in the St. Lawrence River (Hardy 1978). On the major spawning grounds of North Carolina, Virginia, and Maryland, the extreme range of the spawning season extends from late March through early June. However, most activity occurs in one or more peaks between mid-April and mid-May. On the Hudson River, the other major spawning and nursery area on the East Coast, the season runs somewhat later, generally from mid-May through mid-June (Hardy 1978). Water temperatures conducive to spawning range from 10.0C to 25.0C. However, spawning generally does not commence until the water temperature reaches 14.4C; peak activity occurs between 15.6C and 19.4C, while temperatures of 21.1C to 22.2C usually bring a halt to the season (Hardy 1978).

Sexual maturation of striped bass appears related to ambient regional temperatures. Fish from southern waters generally mature at an earlier age than those from regions to the north. Most males are mature at age 3 and by age 4 all participate in the spawning runs. Although a significant proportion of females may spawn at age 3, the majority do not mature until age 4 (ca. 494 mm or 19.5" FL). Table 1 summarizes data on age and size of males and females at maturity.

There are indications that some older striped bass females may not spawn every year. Merriman (1941) reported that large, unripe females are regularly taken from Connecticut waters in late spring and early summer during the regular spawning period. Lewis (1962) noted that some fish in the Roanoke River, age seven and older, did not spawn annually. Jackson and Tiller (1952) reported curtailment of spawning in about 1/3 of the age 10 and older fish taken from Chesapeake Bay, though they also found striped bass up to age 14 in spawning condition. Hollis (1967), however, found no evidence of senility in the fish he sampled. There is a strong positive correlation between the length, weight and age of a female striped bass and the number of eggs it produces.

The smaller males, the non-migratory residents of the area, precede the females onto the spawning grounds several weeks before the season actually begins. During the spawning there is little or no feeding by males or females, although they may feed heavily both before and after (Raney 1952). Each female probably finishes spawning within several hours (Lewis and Bonner 1966) shedding all of her eggs during a single spawning event (Hardy 1978).

Striped bass eggs are broadcast at the surface, but afterward may be found anywhere in the water column from surface to bottom depending upon current velocity and, to a lesser extent, salinity. At current velocities less than about 30.5 cm/second (Albrecht 1964), the eggs will concentrate near the bottom. The eggs are spherical, non-adhesive, and nearly transparent (Figure 7); they have a large perivitelline space and range in size from 2.5 to 4.0 mm in diameter. Incubation times are highly dependent on the ambient temperature, ranging from 80 hours at 12.2C to 30 hours at 22.2C (Hardy 1978) (Table 4). Egg survival is adversely affected by low current velocities, high salinities, low levels of dissolved oxygen, soft substrates, temperatures below about 11C or above 22C, high concentration of dissolved solids, extremely high levels of suspended sediments and rapid changes in temperature.

Upon hatching, striped bass prolarvae or yolk sac larvae average 3.1 mm long and are slender and tadpole-like (Figure 9). Nourishment is derived from a large yolk sac with a large oil globule (Mansueti 1958, 1964). The yolk sac stage ranges from 7-14 days depending on temperature (Doroshev 1970). At the time of yolk sac absorption the larvae are 6.0 - 7.0 mm long and are unable to swim continuously and require some turbulence in order to remain suspended in the water column. Active feeding begins between 4 - 10 days (Hardy 1978).

Larval striped bass initially feed only on small, mobile, pelagic planktonic forms. Toward the end of the larval stage, however, benthic forms such as Mysid shrimp and Chironomid larvae may also be taken (Doroshev 1970). The availability of large concentrations of suitable prey is critical at the onset of feeding; their early strike efficiencies are low, while energy expenditures for swimming are high prior to the air bladder's inflation. Westin and Rogers (1978) reported that newly feeding larvae, still carrying the oil globule at 7 mm standard length (SL), at 22C consumed 25% of their body weight in live *Artemia* nauplii; at temperatures of 18 - 24°C, post larvae 8.4 mm SL required 200 - 300 *Artemia* nauplii per day for growth. However, Rogers and Westin (1981) and Rogers (1978) also found that postlarvae are relatively resistant to food deprivation in the laboratory and survived without food up to 22 (at 24C) or 32 (at 15C) days after hatching. However starved larvae in the wild would be more susceptible to disease, predation and parasitism and probably would not survive (Setzler - Hamilton et al 1981).

By the time they reach 30 mm (Westin and Rogers 1978) or 36 mm (Raney 1952), young striped bass have acquired most of the features of adult fish and are considered juveniles. At this time, at least 3-4 weeks after hatching, the body is well covered with scales and the fins and fin rays are fully developed. During the years of life prior to attaining sexual maturity, juvenile striped bass generally remain on or near the nursery areas where they were spawned. At a size of 50-80 mm, some 80-90 days after hatching, striped bass fingerlings are very mobile and exhibit definite schooling behavior. Initially, young striped bass feed almost entirely on invertebrates. During their second summer (Doroshev 1970) they begin to include small fish in their diet, and by the following fall are eating fish and invertebrates in equal number. By the third year, they have become predominantly piscivorous (Westin and Rogers 1978).

In Table 6, Westin and Rogers (1978) summarized data comparing the growth of striped bass from various areas. Growth rates of striped bass are variable, depending on a combination of the season, location, sex, age, and competition. Vladykov and Wallace (1952) reported that there is little growth during the winter, that April usually marks the resumption of growth, and that small striped bass accomplish almost 50% of their yearly growth between late April and early July.

Growth (in length) is more rapid during the second and third years of life, before reaching sexual maturity, than during later years. Thereafter, the rate drops sharply at age four and remains nearly constant at 6.5-8.0 cm per year up to about age 8. The growth rate probably decreases even further after the 8th year.

Prior to maturity, male striped bass grow at a slightly faster rate than females. Although the growth rates of both sexes are reduced after maturation, female striped bass grow in length at a faster rate than males and weigh more than males at any given length.

Merriman (1941) noted that striped bass of the 1934 year class were smaller in average size than fish of the previous and following year classes. He suggested that this may be attributable to competition for food among the many members of that year class, although environmental factors such as the relatively low spring and summer temperatures in 1934 may have been a factor as well.

After many years of fish tagging studies, examination of commercial catch records and analysis of recreational fishing creel census data, it is well documented that Middle Atlantic migratory striped bass make seasonal movements of considerable magnitude. Recruitment to this migratory portion is from various stocks spawned and developed in rivers and estuaries along the Atlantic coast. The major spawning areas which contribute to the coastal migratory stock are the tributaries of the Chesapeake Bay and the Roanoke and Hudson Rivers. Berggren and Lieberman (1978) estimated each area's relative contribution to the coastal stock in 1975 to be 6.5% from the Hudson, 90% from the Chesapeake and 2.7% from the Roanoke. Tagging studies have shown that the contribution of Chesapeake fish has a significant effect on striped bass relative abundances in other areas, (Schaefer 1968; Klauda et al. 1980; Berggren and Lieberman 1978).

A basic migratory pattern, dependent upon age, sex and degree of maturity, is evident for striped bass spawned in the Chesapeake Bay. Fish less than two years of age generally do not join the coastal migration, while about 50% of the three year old females migrate and a smaller portion of two and four year females migrate. The migrating Chesapeake population generally moves northerly along the coast in early spring, along the south shore of Long Island in May and June, and some continue up the New England Coast. In the fall these migrants move southward and overwinter in deeper coastal waters. In the spring, mature females move to their natal rivers to spawn.

The basic migratory patterns of Hudson River striped bass are similar to those of the Chesapeake stocks. Many Hudson River fish will begin a northerly migration after spawning while others apparently stay within the river. In the late fall and winter prespawning striped bass of mixed ages enter the Hudson to overwinter. Larger fish move into the river in the spring and may overwinter elsewhere. In the spring and summer there is a migration into Long Island Sound of Hudson fish from the west and Chesapeake fish from the east (Austin and Custer 1977). The stocks mix on the Long Island summer feeding grounds and Chesapeake fish migrate out through the eastern passage in the fall.

In the Roanoke River, North Carolina, during the latter week of March and the first weeks of April, male striped bass ascend to the spawning grounds in fresh water near Weldon, North Carolina. Females follow in latter April and May and spawning occurs in mid to late May (Trent and Hassler 1968). After spawning, adults of both sexes return to the feeding grounds in Albemarle Sound and coastal waters. Trent and Hassler (1968) concluded that the migratory population in the Roanoke River is relatively restricted to Albemarle Sound and adjacent coastal waters. Holland and Yelverton (1973) hypothesize that the inshore zone of the coast serves as a wintering ground for a large percentage of the coastal migratory stock.

By understanding the differences in migratory patterns and fishing pressures on certain age groups and sexes, regulations could be more specifically structured so that all striped bass stocks may be optimally exploited (McLaren et al. 1981).

The migratory and spawning behavior of striped bass is an adaptive behavior which maximizes the species survival potential. Spawning occurs in the spring. This coincides with the begining of high levels of primary and secondary productivity and with the migration of the spawners out of the spawning areas. This migration insures that intraspecies competition in the nursery grounds will be minimized and the developing juveniles will have an adequate food supply.

The northward summer post-spawning migration of the Chesapeake Bay striped bass stocks corresponds with the northward migration of the adult menhaden which is an important item on their spring and early summer diet. In addition to menhaden, striped bass also eat a range of invertebrate and vertebrate prey. Given the wide range of food habits, the migratory nature of the adults may be an adaptation to take advantage of seasonal high pulses of available food along the coast and to reduce competition within nursery areas.

Bluefish migrations follow the pattern of both menhaden and striped bass and bluefish are probably a formidable competitor with striped bass. The weakfish also have comparable coastal migratory habits spatially and temporally, although their spawning takes place in the near-shore and estuarine zones along the coast. Their diet preferences also overlap those of both bluefish and striped bass. Despite the presence of large numbers of bluefish, weakfish and many other competing species on the coastal feeding grounds, there is no evidence that fluctuations in abundance of any one species have affected levels of the other.

The larval stage is the critical period in the life of the striped bass. Survival during this stage determines the number of fish which will be recruited into the fishery (Polgar 1977). Factors controlling larval survival may be density dependant factors such as cannabalism predation and competition with other species in the nursery area (Christensen et al. 1977). The availability of suitable zooplankton prey in sufficient quantity may be the controlling factor in survival of the larvae (Setzler-Hamilton et al. 1981; Kernehan et al. 1981). The growth and distribution of these prey is dependant on such environmental factors of water temperature, salinity, detrital food sources, current patterns and cropping by various species of preditors.

Striped bass are thought to be a species geared to persistence rather than maximum production (Ulanowicz and Polgar 1980). By releasing a large number of eggs over a wide area and a protracted period, the nonselective, wide range, feeding strategy of juveniles and the broad range of habitats are evidence that a species is geared to persistance. Despite the natural ability of this species to persist throughout natural environmental variations it is not adapted to withstand commercial and recreational fisheries that continue to grow despite declining stocks. In light of these pressures, as well as the unquantified effects of man induced environmental pertubations, it is best to adopt a resource conservative approach and not rely entirely on the natural resilience of the species to rebuild the stocks.

3.2 The Environment

.1 Habitat Requirements

Spawning areas are fresh to brackish waters and, if tributary to an estuary, located within the first 25 miles of freshwater in the river. Salinities range from 0-5 ppt (Tresselt 1952).

Striped bass spawning areas are characteristically turbid. The spawning period corresponds with high spring runoff and occurs in areas where some degree of natural turbidity would be expected. A necessary condition for successful spawning is a current or tidal flow of sufficient velocity to maintain the semibuoyant eggs suspended in the water column (Albrecht 1964).

Doroshev (1970) reported that developing striped bass eggs should be maintained suspended in the water. In natural spawning grounds the flow rate is between 0.1 and 1.5 m/sec. It is believed that 0.3 m/sec. is the optimum flow rate for egg development (Albrecht 1964).

Water temperatures conducive to spawning range from 10.0 to 25.0C. Spawning usually does not commence until the temperature reaches 14.4C, while the peak occurs between 15.6C and 19.4C, usually declining as the temperature approaches 21.1 to 22.2C (Hardy 1978).

The optimum temperature range for the survival of striped bass eggs and larvae appears to be 16-19C (61-66 F).

The relation to water salinity is an important aspect in the early development of striped bass. Albrecht (1964) found that low salinities enhance egg survival while salinities over about 4.7 ppt are detrimental to hatching success. The salinity tolerance range is greatly increased in young striped bass.

Another critical aspect in the early development of striped bass is the amount of dissolved oxygen in the water. Doroshev (1970) listed 5-8 ppm dissolved oxygen (DO) as optimum and 2-3 ppm DO as the minimum for larvae and young survival.

The adult striped bass is definitely coastal in its habitat and is seldom found more than several miles from shore. However, its adaptability permits it to live in salt, brackish or even fresh water. Except for eggs and larvae, salinity does not seem to be a critical factor for survival, as evidenced by the range of salinities the fish must pass through during spawning migrations.

The species can tolerate low temperatures as evidenced by its existance in Nova Scotia, New Brunswick, and St. Lawrence River. The majority of striped bass overwinter in deep holes or channels in bays, estuaries, delta regions or rivers (Talbot 1966). Murawski (1969) observed striped bass overwintering habit and noted that they remained tightly schooled and moved little when water temperatures were 1C or less.

.2 Environmental Impacts

Physical

The contributions of at least two spawning areas, of great importance in the past, have been reduced to a fraction of their former magnitude as a result of human modifications to the environment. In earlier times the Susquehanna River may have been the greatest single spawning area for striped bass in the Chesapeake Bay (Dovel 1971). Because of the construction of numerous dams, only ten miles of the lower Susquehanna River remain as viable striped bass spawning grounds.

The widening and deepening of the Chesapeake and Delaware Canal in 1973 is thought to have contributed to increased flushing of spawned eggs and larvae into the high salinity waters of Delaware Bay. These saline waters are lethal to the young (Kernehan et al. 1981).

Intensive human development has also severely reduced the water quality in many rivers.

The effects of power plants in striped bass spawning and nursery areas is also being examined. Discharge of heated cooling waters, discharge of cooling waters with biofouling control chemicals, entrainment of eggs and larval stages and impingement of juveniles on water intake screens are the detrimental factors associated with plants using natural waters for cooling.

For the proposed Douglas Point plant in the Potomac River, it was predicted that the most probable yearly entrainment loss of striped bass spawn in the Potomac would be 0.6%; it was unlikely to exceed 1.2%. This translated to a most probable yearly loss of approximately 0.6% of the surviving Potomac River spawn or 29,000 pounds of adult fish.

From the Hudson River studies Klauda et al. (1980) noted that "although power generation on the Hudson increased exponentially during the 1970's we, Texas Instruments Inc., have not seen evidence that losses of young striped bass via entrainment and impingement at power plants are related to variations in year class success, either because power plant effects are not important, have not been manifested yet, or are being swamped out by larger variations in the natural environment."

Chemical

Striped bass require suitable levels of DO, salinity and pH for successful spawning, egg development, and hatching and larval and juvenile development. In addition to these regularly measured parameters of the natural environment, the species requires an environment relatively free of chemical substances which either alter these critical parameters or interfere with the organism's physiological processes. Although concentrations of introduced chemicals may be relatively low in the water, these substances can be biomagnified to harmful levels in the striped bass from uptake through the gills or ingestion of contaminated prey.

Spawning and early life stages occur in watersheds bordered by agricultural areas, urban development or industry. Point and non-point source pollution by a variety of metals and organic and inorganic chemicals are the results of this development. The tolerances of bass larvae and juveniles to a variety of chemical substances is found in Tables 9 and 10.

There is no direct evidence that chemicals introduced into the environment have been responsible for the decline of the Atlantic coastal migratory stock. Examination of fish captured on spawning runs in San Francisco Bay have yielded high levels of zinc and petrochemicals in livers and ovaries. Fecundity and viability of eggs were reduced in fish which were in poor condition and/or with a high pollutant content.

The role of chemicals influencing striped bass reproduction is still unclear. Research, currently being conducted through the funds provided by the Emergency Striped Bass Act amendment to the Anadromous Fish Conservation Act, may provide some answers. Preliminary results from work done at Columbia National Fisheries Research Laboratory shows a correlation between bone strength in young of the year striped bass and the amount of contaminants present in the fish. The NMFS Northeast Fisheries Center is studying the effects of contaminants on survival and growth of larvae. The results from these two studies will contribute substantially to assessing the impacts of chemicals on striped bass populations.

Climate

Interannual variations in striped bass abundance have been empirically linked to winter temperatures (Merriman 1941), river flow (Hassler 1958; Turner and Chadwick 1972; Stevens 1977) and fluctuations in availability of forage (Hollis 1952). Heinle et al. (1976) noted that the detrital feeding copepod *Eurytemora affinis* was most abundant following cold winters and they hypothesized that the higher than normal detrital loads available in the rivers due to intertidal ice scouring were what accounted for the population fluctuations. The relationship could also explain the larger than normal striped bass year classes following cold winters noted by Merriman (1941). Boynton et al. (1977) noted that the survival of later spawners was better than for the earlier spawn. This may be accounted for in the "match" of the young bass with the bloom of *E. affinis*. By examining winter temperature anomalies previous to spawning, and spring run-off the year of spawning, Kohlenstein (1980) was able to account for 82% of the interannual variability in year class strength. Klauda et al. (1980) examined a number of factors in several combinations and concluded that some combination of freshwater flow and water temperature just prior to and during spawning are the key environmental factors indirectly or directly influencing year class success in the Hudson.

Biological

The beds of submerged aquatic vegetation (SAV) that were once so prominent in the Chesapeake Bay system have declined drastically over the past decade (Stevenson and Confer 1978). These beds, used by juvenile striped bass, produce dissolved oxygen, reduce solar heating of the water, serve as food for other organisms, stabilize sediments, provide attachment surfaces for organisms and provide cover and feeding areas for numerous species.

There may be some relationship between SAV and striped bass abundance. Decreases in abundance of both were observed in the early 1930's. In the mid 1930's increases occurred. Moderately high levels of abundance of both were observed from the late 1950's through the early 1970's at which time both declined precipitously back to low population levels.

THE STOCKS

4.1 The Description of the stocks

.1 The Chesapeake

.1 Distribution

The major segment of the Northeast striped bass stocks are produced in the Chesapeake Bay. Sampling of coastal populations indicate that as much as 90.8 percent of the coastal migratory stock may have originated in the Bay system in 1975 (Berggren and Libberman, 1978). The Roanoke and the Hudson contribute to these stocks and are significant contributors in more localized fisheries. The percentage contribution of these three spawning systems varies according to the degree success of production in each. Fingerling production data indicates that for a given year reproduction can be very successful in one of these areas while being low in the others.

In order to examine distribution, it is necessary to divide the populations into three basic management units:

Adult Coastal. The Chesapeake component of the migratory stock is approximately 90% females, both mature and immature, and 10% mature males. The Chesapeake component joins the coastal stock and migrates as far north as New Brunswick, Canada. The most heavily utilized feeding areas are in Massachusett's waters. Wintering areas are ill defined, but in recent years, the stocks have used areas located off the Virginia, and more frequently, North Carolina capes.

The size of these fish is generally six to ten pounds or more and five to six years of age and older.

Immature Coastal. This segment of the migratory population consists of 80% immature female striped bass and 20% mature males that travel with them. These fish are two to six years of age and range in size from one to two pounds to the adult population size of six to ten pounds.

These fish migrate in a pattern similar to the adults and feed northward to Maine. The wintering pattern for this group is less well defined than for the adult stock. Some of these individuals periodically spend their winters off the more northern coasts while many continue south to winter off the Virginia and Carolina capes. Some of these fish may return to winter in the deeper waters of the Chesapeake prior to resuming a coastal migration during the spring. The male component participates in spawning activities before leaving.

Estuarine. The members of this group are those young striped bass that reside in the estuaries until they enter the migratory stocks or establish themselves as residents.

Sex ratios within these age classes are generally half male and half female until the female population begins to migrate. Kohlenstein (1981) estimated that approximately 50% of the age III females migrate.

These resident fish feed and winter in the bay. The males enter the spawning run generally as two year olds.

.2 Abundance

Two major factors determining the number of individuals available for harvest are fishing mortality and the continuous success of juvenile production in the estuaries, principally the Chesapeake, and most importantly, Maryland's portion of the system. Figure 12 shows the production of young striped bass in Maryland waters as an index of relative abundance. The index relates closely to subsequent commercial harvest.

The important feature of this information is that it shows that occasional years produce numbers of young striped bass well above the average. These years of exceptional recruitment are generally known as dominant year classes. The contribution of dominant year classes to striped bass populations and fishing success cannot be over-emphasized. The commercial harvest of striped bass over the last 20 years, has been geared to a half dozen dominant year classes. The importance of this fact had not been appreciated until the present 10 year span without a dominant year class.

For example, Figure 12 shows that striped bass reproduction since the most recent dominant year class of 1970 has been mathematically average -- and actually better than during many years when harvest was very high. Nonetheless, it is evident that the numbers of catchable size fish available from these years of "average" reproduction (1971-1975) could not arrest declining Maryland landings once harvest and migration reduced the 1970 year class.

Additional data supporting the fisheries dominance of the 1970 year class was accumulated during a 1974-1977 study of Potomac River striped bass spawning stock by the Chesapeake Biological Laboratory of the University of Maryland. Gill net sampling during each spawning run indicated that although at least eleven year classes were present, members of the 1970 year class predominated--representing 60 percent, 75 percent, and 55 percent by number of the total spawning stock during 1974, 1975, and 1976 respectively (Jones et al. 1977a).

The conclusion is that the striper fishery as we know it has been a product of dominant year classes. This means that without an occasional dominant year class, striped bass landings will subside to a low level.

The number of individual fish that attain harvestable size and are then subsequently subject to removal by the fishery is difficult to determine. The inconsistency of the Coastal State's statutes and regulations make a reasonable determination of recruitment impossible. As an individual fish moves across political boundaries, its harvestable status changes due to different minimum size limits. This determination is made more complicated by the establishment of maximum size limits in some states. Thus, when a fish reaches a certain size, it is no longer available for legal harvest.

.3 Trends

Harvest figures for the coastal striped bass stocks are one indication of population levels. Gross figures of commercial harvest (Figure 13) have fluctuated, from a low of 3.1 million pounds in 1979 to a high of 14.7 million pounds in 1973. Differences in survey methodology prevents any comparison between recreational striped bass catches estimated in 1970, 1975 and 1979. The most accurate survey made in 1979 estimated a catch of 3.3 million pounds in the states from Florida to Maine (NMFS 1980).

The harvest trends and projections for the three previously defined management segments of the coastal population are as follows:

Estuarine. There are several types of fisheries that are directed toward the young striped bass in the Chesapeake. Some begin to harvest the fish as soon as the fall of its second year of life at 12 inches in length. These young fish are harvested all winter in the deeper (usually) wintering areas of the Bay. The most significant harvest usually occurs during the spawning run in spawning areas. The young males are particularly vulnerable because they arrive early, stay for the duration of spawning, and are very active.

A percentage of the young females, age II, III and IV leave the bay and join the immature coastal stocks. The remaining females and males make up the population which is traditionally the mainstay of the estuarine summer recreational fishery. During recent years, under current production/harvest levels, the Chesapeake Bay summer recreational fishery has been much reduced.

The traditional haul seine fishery for these resident fish has all but disappeared and its place has been taken by a summer gill net fishery.

Immature Coastal. During years of high population levels, these fish move as far north as Maine waters and provide a significant recreational fishery. It was the 1970 year class fish that launched many hook-and-line fishermen into commercial activities during 1973 and 1974. The availability and vulnerability of these young fish provided the backbone of the recreational fishery following the dominant year class.

Adult Coastal. These fish provide the mainstay of the coastal recreational/commercial fishery except when dominant year classes temporarily provide large numbers of younger fish. During the 1979 spawning season, the 1970 year class fish accounted for over 80% of the adults in the spawning areas.[1] It is possible that these same fish, 15-28 pounds, predominated in the coastal harvest.

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[1] Age and size range from a sample taken from a Maryland spawning area during the spring of 1979.

Although it is believed that most adults return to the same spawning rivers, they mix freely on the feeding grounds and do not appear to be tied to returning to site specific feeding areas. The occurrence of these exceptional years of production basically determines patterns of harvest. Generally, the older that the individuals in the striped bass stocks become, the more significant the harvest becomes outside the estuaries.

The coastal, as well as the estuarine recreational fishery, has become extremely sophisticated over the last decade. Some of the significant developments that have made hook and line fishing more effective have been: CB and VHF radios, "white line" recording fathometers, the further development and refinement of small boats (the fishing machine), the refinement of fishing techniques and the communication of all these throughout the fishing community by a few quality fishing publications.

Since the coastal fishery depends upon migration from the estuaries the commercial fisheries in these estuaries become very important in determining coastal stock levels. During years of high juvenile production, these fisheries are not as critical. However, during years of normal or low production, their harvest becomes much more significant in determining escapement. This fishing effort remains fairly stable, using traditional methods and gear. A portion of the adult female stocks is protected from the commercial fishery by law in the estuary. Maryland regulations prohibit the keeping of bass greater than 32" TL (32" FL in the Potomac River), while Virginia regulations prohibit the keeping of striped bass greater than 40" TL.

The coastal commercial net fisheries are commonly fisheries of opportunity, and not so much directed to the species. The nature of these net fisheries could allow them to fish on depressed adult striped bass stocks.

The trawl fishery on wintering/migrating adult stocks needs further definition and may warrant close attention. Several factors are coming into play in this fishery: lower parent stock levels, and the rapid improvement of commercial technology. The use of scanning sonar and pair trawling has significantly increased the efficiency of this fishery.

.2 Hudson River

.1 Distribution

The population of striped bass spawning in the Hudson is genetically distinct from the Roanoke or Chesapeake populations. The Hudson River spawning location centers on the Poughkeepsie area and extends from river mile 47 to 77 (Dey 1981). Subsequent to spawning, members of the population disperse throughout the Hudson River and estuary and Long Island Sound. A few members migrate as far as Delaware Bay and the northeastern coast of Massachusetts (McLaren et al. 1981). The areas of greatest summer concentration of Hudson striped bass are within the River, estuary, and western Long Island Sound. Schaefer (1968) and Berggren and Lieberman (1978) concluded that the Chesapeake bass dominates the coastal striped bass stock. Schaefer (1972) demonstrated a mathematical relationship between striped bass young of year production in the Chesapeake and commercial catch in New York three to six years later. The Hudson River stock predominates in the stocks of sublegal fish (less than 16 inches FL) in western Long Island Sound, the New York Bight, and overwintering sublegal fish in Croton Bay.

Austin and Custer (1977) studied the migratory patterns of striped bass as they entered Long Island Sound from both ends. In early summer Hudson River striped bass entered the Sound from the west and Chesapeake fish from the east. They observed a stable summer population and an intra-Sound fall migration as bass along the entire Connecticut Coast migrated to the central part of the Sound, crossed to the Long Island shore and then migrated out via the eastern end of the Sound.

In a more recent tagging study (McLaren et al. 1981) seasonal distribution patterns of age II and older striped bass were determined from recaptures of fish within and outside the river. Maturity, age and sex of the fish was a factor in determining the patterns of pre-spawning and spawning fish.

Prespawning bass entered the Hudson in mid to late fall and remained to overwinter. Both mature and immature bass were located down river from the main spawning grounds in the early spring (March-April). By the end of April, the mature fish began an upriver migration to the spawning grounds while immature fish migrated further downriver. Once spawning was completed, a majority of striped bass left the Hudson River and moved into Long Island Sound and the Atlantic Ocean and generally remained within 50 km of the river mouth (McLaren et al. 1981). From this study, it was impossible to determine what percentage of the Hudson River population remains in the river and what proportion leaves. It was assumed, however, that a majority of the greater than age Class I fish leaves the river and spends the summer and fall within the Sound and New York Bight areas. Juveniles from dominant year classes appear to leave the Hudson nursery and disperse to the western Sound earlier than average or weak year classes (Texas Instruments 1977).

.2 Abundance

The relative contribution of Hudson stock to the coastal fishery is at its maximum (although less than the majority) in the Hudson River, Western Long Island Sound, New York Bight and Northern New Jersey. The relative contribution of Roanoke stock to New York waters ranged from zero to 11.4% during the period from July through October in 1975. These conclusions from Berggren and Liebermann (1978) must be tempered with the recognition that the year of study (1975) was heavily influenced by the large numbers of Chesapeake fish which resulted from the 1970 year class.

The Atlantic coast fishery is no longer dominated by the strong 1970 Chesapeake year class, and it is probable that the Hudson's contribution to the Atlantic Coast migratory stock is now higher than 7 percent (Kumar and Van Winkle 1978). For Long Island Sound fishermen, at least, striped bass from the Hudson may partially compensate for the declining abundance of Chesapeake fish until another dominant year class is produced.

.3 Trends

Landings of striped bass in New York waters from 1939 to 1979 have varied from 169,000 pounds in 1940 to 1.7 million pounds in 1973 (Table 14). The commercial fishery in the Hudson River was closed after the 1975 season due to polychlorinated biphenyl (PCB) contamination of striped bass. This closure along with the decline in Chesapeake migratory stocks caused the 1976 landings to dip below a million pounds for only the second time within the past ten years. It is difficult to separate the relative contribution of the two factors to the decline in commercial catch. Regardless of the absolute decline, New York's percentage share of the coastal catch has increased from an average of 13.6% (1975, 1976, 1977) to 19.5% (1978, 1979, 1980).

The migratory habits of the Hudson striped bass distribute members of the stock most heavily in New York, New Jersey, Connecticut, and Rhode Island waters. With the exception of New York, the trends of commercial catches in each state over the past eight years has been consistently down. Klauda et al. (1980) characterized the Hudson stock as basically healthy as judged by harvest rates, age structure, age at maturity and fecundity. They judged that existing harvest rates could be increased over the present 15 to 25 percent. Longevity of Hudson River striped bass is equal to or greater than other striped bass populations. Age at maturity for Hudson bass does not appear to be decreasing and fecundity is similar to other populations. A dominant year class was produced in 1973 and relatively strong year classes in 1969, 1971, 1977 and 1978.

PCB levels in several species of Hudson River resident fish, as well as American shad and blue crab, have declined since the mid 1970's and may be related to the absence of high floodwaters since 1977 (Armstrong and Sloan 1980). Although their data appeared to show a reduction in relative yearly PCB levels in striped bass, for a variety of reasons, they concluded that striped bass have failed to show a consistent pattern of PCB decline. The size of the striped bass nor the capture location is a reliable indicator of PCB residue levels. Tissue residues in 1979 still exceeded the action level of 5 ppm (Armstrong and Sloan 1980). In spite of the body burden of chemicals, the Hudson population appears to be healthy although it may be too soon to see any detrimental effects (Klauda et al. 1980).

.3 North Carolina

.1 Distribution

Striped bass have supported significant fisheries in coastal North Carolina since colonial times. A report describing striped bass spawning in the Roanoke River was included with other observations on post-Revolutionary America in 1788. The State of North Carolina worked with the U.S. Bureau of Fisheries during the late 1800's to develop techniques for artificially spawning striped bass at several locations in North Carolina.

The commercial and recreational fisheries are most active in the northern portion of the coast, with year-round fisheries in the Albemarle Sound area and seasonal fisheries elsewhere. Over the last decade, principal commercial gears have been anchor gill nets in the estuaries and rivers, beach seines and fish trawls in the ocean.

The age and size ranges of oceanic and estuarine striped bass in North Carolina have been similar in recent years, with fish ranging from 2 to about 12 years of age, and from 1 to about 60 lbs. The mean sizes are quite different, however. Mean weight of striped bass caught in Albemarle Sound is about 2 lbs (age 2-4), while spawning fish in Roanoke River average about 3-4 lbs (age 4). Ocean-caught striped bass average about 10 lbs. Runs of females in the 20 lb class are noted each year in the Roanoke River spawning grounds at Weldon, but very few fish in this size range are captured in North Carolina's rivers and estuaries. Significant numbers of large fish are taken in the beach seine, trawl, and hook and line fisheries along North Carolina's Outer Banks. However, the inshore gill net fisheries are selective for the more abundant smaller fish. Juvenile striped bass remain in the nursery areas throughout their first year. Movements of yearlings are poorly understood since they can usually escape the sampling gear presently being used, and they are not subject to the fishery until near the end of their second growing season.

Recreational fisheries are seasonal; during the fall and spring activity is concentrated in the sounds and rivers, while in the late fall and winter it shifts to the Outer Banks. Hook-and-line fishing in the Cape Fear Neuse and Tar-Pamlico systems is generally limited to small groups of fishermen familiar with the habits of striped bass in their particular areas. Annual recreational landings in these rivers probably total no more than a few hundred fish.

The Albemarle Sound sport fishery is quite extensive, with fishermen concentrating on "school stripers" (12-14 in. FL) during the fall and seeking out larger fish by trolling and plugging later in the season. Fishing along several of the long bridges in the area is productive. Several tributary rivers contain deep holes in which fish concentrate during the winter, and some fishermen make good catches from these locations.

Each of the major rivers of coastal North Carolina appears to support a separate population of striped bass. Relationships among these populations and between the estuarine populations and fish which migrate along the Atlantic coast have not been completely defined. Recaptures of striped bass tagged in offshore waters of North Carolina indicate that possibly only striped bass spawned in the Meherrin River and Roanoke River (Albemarle Sound system) contribute to the Atlantic coastal stock.

Striped bass spawning has been confirmed by capture of eggs and/or larvae in most of the major coastal rivers of North Carolina. Figure 5 shows approximate spawning areas for each river. Spawning generally extends from early April through mid-May in the Northeast Cape Fear River in the southern part of the state to late April through early June in the Roanoke and Meherrin Rivers in the north. (The Meherrin is a major tributary of the Chowan River). Water temperatures are generally in the range of 62-68^{o}F (16-20^{o}C) during this period. Spawning areas in the Meherrin, Roanoke, Tar, and Neuse Rivers are generally characterized by swift currents, with the areas in the first three rivers extending to the fall line. The Northeast Cape Fear River is contained completely within the coastal plain, and the principal spawning area is in tidal freshwater. Juvenile striped bass remain in the nursery areas throughout their first year.

During years of average or below-average juvenile abundance in Albemarle Sound, young fish appear to be restricted to their primary nursery areas in western Albemarle Sound. In years of high abundance, however, they occupy additional nursery areas in Chowan River, central Albemarle Sound, and several tributaries of Albemarle Sound. Young-of-the-year striped bass reach about 5 1/2" FL (140 mm) by their first winter. The minimum legal size for possession is 12" TL (305 mm) in North Carolina; most fish reach this size by October of their second growing season, at which time they enter the fishery. Data currently available do not show any relationship between adult spawning stock, egg production, and subsequent population size, although there appears to be a relationship between juvenile abundance and subsequent adult population levels. Males and females begin spawning at ages 3 and 4 respectively (Trent and Hassler 1968).

Striped bass are found along North Carolina's Outer Banks during the period November - March. Tagging in the ocean during 1968-1971 indicated that migration from the wintering grounds was somewhat size-dependent (Holland and Yelverton 1973). Most of the fish recaptured within North Carolina's rivers and sounds were less than 6 lbs in weight and were taken during December - March. Most Chesapeake Bay returns were also less than 6 lbs, but recaptures extended into the summer. Most of the fish recaptured further north along the Atlantic Coast weighed more than 10 lbs and were taken during May - August. This recapture pattern suggests that relatively small fish from Albemarle Sound and Chesapeake Bay may over-winter along the Outer Banks without taking part in the northerly migration to New England following spawning. However, the absence of recaptures inside Albemarle Sound during late spring-early winter leaves unknown the locations of these fish in North Carolina during this period.

During 1956-1976, Dr. William W. Hassler of North Carolina State University and his associates tagged approximately 9,500 striped bass in the lower Roanoke River. Virtually all recoveries have come from Albemarle and Pamlico Sounds and their tributaries, and the Roanoke River. No confirmed captures have been made from fishermen along the coast north of North Carolina, although a few fish have come from fish markets from Virginia to Pennsylvania. These fish could have been captured in North Carolina and shipped north without the tag being noticed.

Personnel of the North Carolina Division of Marine Fisheries tagged about 500 striped bass in Croatan Sound, near Oregon Inlet, during 1973-75. Only one fish was recaptured in the ocean, a few days after tagging, about 25 miles up the beach from Oregon Inlet. All other recaptured fish came from northern Pamlico Sound, Albemarle Sound, and Roanoke River, including the spawning area. These tagging studies did not demonstrate the degree of contribution of North Carolina bass to the coastal migratory stock. The Berggren and Liebermann (1978) study indicated that in 1975, Roanoke stocks comprised 2.7% of the coastal migratory stock. Data currently available on striped bass populations in the Pamlico - Tar, Neuse, and Cape Fear river systems indicate that these are resident stocks. Migrations are limited to seasonal upstream-downstream movements for spawning and feeding. Predominant age groups in these populations are the same as for the Albemarle Sound-Roanoke River area - II-IV. Occassional fish in the 10-12 year range are captured each year.

.2 Abundance

Sampling for juvenile striped bass is conducted annually in each of the nursery areas, proven or suspected. An index of abundance is available only for the Albemarle Sound area, based on the work of Dr. William Hassler of North Carolina State University and covers the years 1955-1976. During the 22 years of sampling, there have been three dominant year classes - 1956, 1959, and 1967. Above-average classes were apparent in 1961, 1965, 1970, 1975, and 1976. A dominant or above-average year class has been produced at least every five years, although there is no definite pattern.

Prior to the late 1960s, striped bass taken from the ocean along the Outer Banks were predominantly large fish. Large numbers of small fish (2-4 lbs) became available along the Outer Banks about 1967-1971, making possible rapid growth in the commercial and recreational fisheries. Since then, larger fish have apparently become relatively more numerous along the Outer Banks.

During a study covering 1967-69, Dr. Hassler estimated hook-and-line catches of striped bass from the Albemarle Sound area ranged from about 50,000 to about 67,000 fish annually (Hassler and Hogarth 1970). Dr. Hassler has estimated that the annual recreational catch from Roanoke River ranged from 28,000 fish to 65,000 fish during 1970-75. Commercial landings in the river during the same period ranged from 9,000 to 30,000 fish. Annual recreational landings in Roanoke River are at least twice as large as the commercial catch.

.3 Trends

From 1957 through 1966 the average annual commercial landing of striped bass in North Carolina was 723,000 pounds (Table 16). In 1967 landings increased to 1.8 million pounds and remained above one million pounds through 1976 (average 1.5 million). Reductions in catch were proportionately greater in the trawl and beach seine fishery in 1977 and 1978 (Table 13, total landings in Table 16 do not agree with Table 13 because of different methods of data collection). There are no corresponding estimates of effort associated with the landings but, as the decline in the North Carolina ocean fishery coincided, within a year, with the declines in the other coastal states (Table 16), it might be that the ocean fishery was operating primarily on Chesapeake Bay stocks. The 1970 year class of Chesapeake bass helped push many coastal states catches to record levels in the Mid 70's.

Reproduction in the Albemarle System has been relatively good in the 1970's and strong year classes were produced in 1970, 1975 and 1976. The Albemarle Sound fishery operates primarily on smaller fish and the fishery is presently relatively stable.

.4 Delaware

.1 Distribution

In a report on the status of the Delaware stocks, Chittenden (1971) cited reports by Abbott (1878) and Meehan (1896) that documented the abundance of young-of-the-year (YOY) striped bass above Trenton, New Jersey to Port Jervis, New York. Abbott indicated that adult stocks had declined, but that numbers of small fish were still high. Although documentation is scanty, it can be assumed that striped bass were formerly abundant in the Delaware River with the principal spawning grounds in the freshwater portion just upstream of brackish water (i.e. the Philadelphia area). With the advent of the industrial revolution and its accompanying pollution of the lower Delaware River in the later 1800's and early 1900's, the Delaware River striped bass stocks declined precipitously. Raney (1952) described the lower Delaware River as a classic case of destruction of the striped bass spawning grounds through industrial and domestic pollution. Chittenden (1971) attributed the present low status of Delaware River striped bass stocks to the "gross pollution" in the lower 40 miles of the 65-mile long tidal freshwater section of the river and cited the zero and near zero oxygen concentrations noted in much of this zone in the warmest months of the year as the precise cause. This cutting off of such a large portion of the river is most likely the cause of the decline of the species in the tidal portion of the river above the pollution and in the non-tidal zone above Trenton. The existence of a remnant spawning stock in the River in modern times was shown by Murawski (1969). He took striped bass eggs in the Delaware River from Oakwood Beach to Bridgeport, New Jersey, a distance of 21 miles. He found striped bass larvae an additional 46 miles upstream with a 28-mile void in the Philadelphia area.

There have been periodic surveys documenting the presence of juvenile striped bass in the lower Delaware River since the above mentioned reports from the 1800's, beginning with Merriman in 1941, to Daiber (1954), de Sylva (1961), and continuing through the 1960's and 1970's with various power company sponsored surveys and those conducted by the U.S. Fish and Wildlife Service (Miller 1975). Since most of these surveys were conducted with seines or by means of samples removed from power plant intakes, this information is useful for documenting the presence of the species, but is not of a quantitative nature needed for a stock assessment. The best information available concerning the fluctuations in the stocks would be the commercial landings, the State of Delaware intermittant recreational fishing surveys, the abundance data from the power company sponsored surveys, and Delaware Bay trawl surveys conducted by the State of Delaware and University of Delaware (Daiber and Smith 1972; Taylor et al. 1973; Smith 1980). Since the commercial and sport fisheries are addressed elsewhere in this management plan, these data sources will be discussed only briefly.

.2 Abundance

Although there have been many surveys of Delaware estuarine fishes, only a few were of sufficient duration to yield an index of year to year abundance of striped bass.

Icthyological Associates, Inc. has conducted surveys of fish eggs, larvae, and juveniles in the vicinity of Artificial Island (Salem Nuclear Plant) since 1968. Data extracted from annual reports of these studies from 1970 through 1976 is included on the bar graph shown in Figure 6 (from Ichthyological Assoc. 1980). Catch per unit effort (number caught in a 10 minute tow using a 16-ft. semi-balloon bottom trawl) varied from 0.03 per to 1.0 per tow with the peak occurring in 1971. Since the trawl catch was dominated by one-year old fish, the peak catch in 1971 is a reflection of recruitment of the dominant Chesapeake 1970 year class into a size range best sampled by trawling.

Striped bass made up only 0.1% of the total catch by number of fishes caught in surveys made with a 30-foot bottom trawl at selected stations on Delaware Bay from 1966-71 (Daiber and Smith 1972). This survey was reinstituted in 1979 (Smith 1980) so comparisons are possible. The striped bass catch in numbers per 0.1 nautical mile of tow was 0.07 in 1967, 2.39 in 1968, 0 in 1969, 0.09 in 1970, 0.10 in 1971 and 0.18 in 1979. No apparent trend is evident because of the low numbers caught in the trawl.

In a special trawl study of the Chesapeake and Delaware Canal and adjoining Delaware estuary in 1971 and 1972, Taylor et al. (1973) concluded that striped bass biomass was important in the spring when the species was present for spawning, but low and inconsistent the remainder of the year. In related studies using tagging to trace migrations, Smith et al. (1973) were unable to compute a population estimate for spawning stock in the Chesapeake and Delaware Canal due to a lack of recapture data. However, recapture of striped bass tagged in Delaware Bay revealed relatively high levels of fishing mortality (21% and 25% in 1971 and 1973 respectively for combined sport and commercial recaptures up and down the East Coast).

Chesapeake and Delaware Canal

The importance of the Chesapeake and Delaware Canal (hereafter referred to as the Canal) spawning areas for striped bass has been amply demonstrated in recent years (Johnson and Koo 1973; annual reports from 1973 to 1975 by Icthyological Associates concerning the proposed Summit

Power Station in the Canal, Dovel and Edmunds 1971 and Kernehan et al. 1981). These studies have shown that the Canal is a major striped bass spawning area and possibly the principal spawning area in the upper Chesapeake. Indices of abundance for the Canal from 1975 through 1977 ranged from 0.2 to 3.0 young-of-the-year striped bass per ten minute tow with a 10 ft. semi-balloon trawl. Comparable indices in the Delaware River south of the mouth of the Canal ranged from 0 to 0.2 per tow. Since the net flow of water in the Canal is west to east, eggs and larvae should be deposited in the Delaware Estuary in great numbers. The fact that this net flow has not resulted in any particularly abundant juvenile populations of striped bass in the Delaware estuary since 1971 indicates, according to Kernehan in a recent presentation at the 1980 Northeast Fish and Wildlife Conference, that spawning in the C & D Canal was "a wasted resource". Kernehan et al. (1981) found that the net eastward flow of tidal currents in the C & D Canal transported most of the eggs and larvae spawned there to the Delaware River where survival usually was poor. Mean density data and net flow data during April 26- May 20, 1976 and April 18- May 2, 1977 were combined to yield a conservative estimate of nearly 3,300,000,000 eggs, 2,800,000,000 yolk sac larvae, and 150,000,000 post yolk-sac larvae discharged from the C & D Canal into the Delaware River. Survival of these early stages was poor in Delaware River waters.

.3 Trends

According to compilations of Delaware catches and New Jersey catches in counties bordering Delaware Bay from the Fishery Statistics of the United States, landings varied from a low of 5,000 lbs. in 1921 to 361,000 pounds in 1948 with an average of 74,670 lbs. for the period 1967 to 1969. Following the production of a dominant year class in the Chesapeake Bay in 1970, commercial landings for the State of Delaware rose to an all time high of 586,100 pounds in 1973 (Table 15). By 1979 Delaware commercial landings had fallen steadily to 26,300 lbs. For the first time ever in January of 1980, the State of Delaware began collecting detailed information on commercial finfish catch and effort statistics in Delaware Bay instead of relying on the annual visit by a port sampler from the National Marine Fisheries Service for the only record of Delaware commercial finfish landings. Preliminary results of this survey (Richard Seagraves, Delaware Division of Fish and Wildlife, personal communication) showed that from January 1, 1980 to April 30, 1980; 7,757 lbs. of striped bass were taken in 44,774 yards of gill net set by Delaware fishermen in Delaware Bay. The number of net crews (two men per boat) varied by month but peaked at 25 in April. This fishery is not directed solely at striped bass but includes nets set for American shad, white perch, and weakfish.

The striped bass commercial catch since the early 1960's has been almost entirely dominated by gill nets (anchor, stake, and drift). Trawling was outlawed in Delaware Bay in the early 1960's and was phased out more gradually in the 1960's in the Atlantic Ocean within three miles of Delaware's shoreline. Prior to 1960, the trawlers contributed significantly to total striped bass landings. It is evident that in recent years the commercial catch has been steadily decreasing after reaching a peak in 1973. Apparently the large 1970 year-class first influenced the gill net fishery in 1972 and reached a peak in 1973. However, prior to 1972, in the middle and late 1960's the commercial catch was at a level comparable to that being taken now. Although striped bass are important in localized areas of the Delaware Estuary such as near the mouth of the Chesapeake and Delaware Canal, the recreational catches for the estuary or the state as a whole have never been particularly important in the past 25 years. Of the eight surveys conducted since 1955, catches for the Delaware Estuary peaked at 89,529 striped bass (3% of the catch) in 1972. There was no significant difference in 1976 and 1978 recreational striped bass catches in spite of a very real decline in commercial landings from 80,600 lbs. in 1976 to 26,300 lbs. in 1978. The average registered boater caught 0.2 to 0.3 striped bass during the 1976 and 1978 fishing seasons respectively. Striped bass catches by sport fishermen are concentrated in certain locations. Prominent among these are the Chesapeake and Delaware Canal, Port Penn - Augustine Beach area, and in the mouths of the principal Delaware River tributaries south of the C & D Canal, and the mouth of Indian River Inlet.

.5 Maine

.1 Distribution

Striped bass formerly spawned in the State of Maine. Atkins (1887) notes that striped bass used to ascend the Kennebec River as far as Waterville (River mile 57) and the Sebasticook (a major tributary) a short distance above its mouth. He further states "In the winter great numbers of young, 2 or 3 inches long, are found in the rivers, and many of them fall into the bag nets and are captured along with smelts and tom-cods."

Historical reports indicate that spawning populations of striped bass existed in the Kennebec and Androscoggin Rivers. Reports of incidental catches were also recorded on the Saco, Penobscot and St. Croix Rivers. The extent of upstream migration in the Kennebec and Androscoggin Rivers is unknown although fishery records indicate striped bass were found in the Kennebec at least 18 miles above head of tide (about 60 miles above the river mouth). Assuming striped bass could migrate upriver as far as shad and alewive, their upstream limit on the Kennebec would have been approximately 100 miles above the river mouth and on the Androscoggin about 30 miles above the river mouth. The upriver limits of the Saco, Penobscot and St. Croix would have been about 5, 140, and 60 miles above the river mouths, respectively.

All major river systems in Maine capable of supporting resident striped bass populations were developed for water power in the early 1800's. Head of tide on almost all major rivers in Maine is characterized by a natural falls and large water power dams were constructed at these sites almost without exception. These structures were later converted for hydroelectric power generation. The development of the pulp and paper industry in the late 1800's followed by a rapid post World War II industrial expansion lead to severe pollution of all major river systems in Maine. Large discharges from pulp and paper mills on the Androscoggin, Kennebec, Penobscot and St. Croix Rivers resulted in total oxygen depletion in certain river segments and particularly the upper estuaries. The Kennebec and Androscoggin Rivers, sharing a common estuary, were particularly affected and fish kills occurred almost annually from the mid 1950's through the late 1960's. Intensive pollution abatement programs begun in the late 1960's have greatly alleviated this problem and since 1976, water quality on the Kennebec, Androscoggin, Penobscot, and St. Croix Rivers has improved dramatically.

The migratory striped bass resource is distributed seasonally throughout the coastal area from the inshore coastal islands inland to the first upstream barriers on major coastal rivers.

.2 Abundance

From the late 1950's to the present, Maine striped bass catches appear to be of Chesapeake Bay origin because abundance in Maine coincides with abundance of Chesapeake Bay fish two years previous. Surveys of Maine Rivers from 1968-70 and sampling of anglers catches from 1968-1973 failed to yield any striped bass specimens less than two years of age.

The major sportfishery occurs in southwestern Maine adjacent to the large urban areas of Portland, Biddeford, and Saco. Striped bass surf fisheries, with the exception of Head Beach (Cape Small) and Popham Beach are confined to the sandy beaches and rocky promontories south of Portland. The greatest concentration of estuarine striped bass fishermen centers on the Saco River with other large river fisheries in the New Meadows, Kennebec, Sheepscot, Damariscotta, St. George, Penobscot, Narraguagus, Union, and St. Croix Rivers. In years of striped bass abundance the lack of heavy fishing pressure in eastern Maine (Belfast to Calais) is probably due more to low human population density and consequent low fishing pressure rather than lack of striped bass.

In recent times, the relative abundance of migratory striped bass has been highly variable. Otto (1971), estimated that the total 1969 striped bass fishing effort for midcoastal Maine (Kennebunk to Port Clyde) of 176,000 angler hours produced a catch of 23,500 striped bass and a 1970 effort of 114,000 angler hours produced a catch of 6,500 fish. These wide variations in fishing success, typical of the Maine striped bass fishery, are attributable to large fluctuations in migratory stock strength and variations in migratory habits of these stocks.

.3 Trends

Based on landings data of the 19th Century, striped bass were most abundant in the Kennebec River where an intermittent directed commercial fishery occurred from about 1844 to the late 1890's. From 1873 to the early 1900's, a winter gill net fishery for striped bass was carried on in the Sheepscot River estuary which is located just easterly and adjacent to the lower Kennebec River. Although incidental catches of striped bass were made on the Saco, Penobscot and St. Croix Rivers, historical populations of resident striped bass in the Penobscot and rivers to the east were considered to be relatively small and did not support directed commercial fisheries.

Subsequent to 1908, the character of the Maine commercial striped bass fishery changed from an in-river summer fishery in the Kennebec and winter fishery in the Sheepscot to a coastal summer fishery. Sudden increases in coastal landings from 1909 through 1912 suggest a possible influx of fish from distant waters and consequently, during this period, the contribution of resident stocks to the total Maine fishery is unknown. It is felt that the last resident stocks in Maine were probably eliminated from the lower Kennebec River in the early 1930's as a consequence of increasing industrial pollution. The peak commercial landings of striped bass in Maine occurred in 1909 when 111,675 pounds were landed.

The majority of earlier striped bass landings occurred in Sagadahoc and Lincoln counties. The Kennebec and Androscoggin River estuary lies within Sagadahoc County and the upper eastern portions of the Kennebec estuary is in Lincoln county. The Sheepscot River estuary lies wholly within Lincoln County. The upper Sheepscot estuary is characterized by high salinities, a dam at head tide, and limited fresh water under tidal influence. Although limited production of striped bass may have occurred in this system, it is suspected that this river was an important overwintering area for stripers produced in the Kennebec River. Therefore, the Sheepscot River gill-net fishery was probably supported by local stocks produced in the Kennebec River.

In 1969 the commercial net fishery for striped bass was closed. The wide fluctuations in fishing success, typical of the Maine striped bass fishery, are attributable to large fluctuations in migratory stock year class habits of these stocks. The available supply of migratory stocks will probably decline over the next few years due to continued heavy fishing pressue in states south of Maine (Flagg et al. 1976).

4.2 Population Dynamics

The Atlantic Coastal populations of striped bass are characterized by large annual variations in year class strength with the occasional formation of a very large or dominant year class. These dominant year classes are responsible for the peaks in abundance of bass available for harvest and typically predominate in the fishery for several years. There has been an apparent tendancy for such year classes to form approximately every six years beginning in 1934 (Koo 1970) although the 1952 and 1976 year classes failed to follow this apparent trend. The last such year class in the Chesapeake Bay occurred in 1970 and, based on the Maryland young-of-the-year surveys, recruitment has been below the 1954-74 average since 1975. The resulting trend in landings has been a marked decrease since 1973 as the 1970 year class has been harvested.

Selection of a strategy for management of striped bass is constrained by both the existence and the cause of these variations in year class strength. The objective of management for many species is to provide for a sustained yield at some predefined level, commonly either the maximum sustainable (MSY) or some optimum (OSY) that is also consistent with economic and social values. The notion of a sustainable yield is founded on the concept that as a population is depleted from its primitive state by fishing, the reduced density of the survivors causes an increase in growth and/or recruitment to the stock. This increased production is removed by the fishery such that for any given level of fishing mortality there exists an equilibrium stock size and, therefore, an equilibrium yield. The level of this equilibrium yield is determined by the effect of fishing on the size of the stock and the yield extracted. Thus, there exists some relation between the magnitude of the equilibrium, or sustainable yield, and the rate of fishing. Generally, the equilibrium yield increases as the rate of fishing increases to a maximum at some intermediate level of fishing, then declines at higher levels of fishing mortality. Where sufficient data exists, this relationship can be examined empirically. More often, however, surplus production or stock recruitment models are used to characterize the relation between fishing mortality and equilibrium yield.

For species such as striped bass where year class strength is subject to large annual variations, the concept of an equilibrium (i.e., sustainable) yield is less clearly applicable. If the variability is caused by the influence of stock size on recruitment, then the population might undergo regular fluctuations at certain levels of fishing mortality. In this situation, the population size and yield averaged over the period of the fluctuation would be analogous to the corresponding equilibrium. In an analysis of the striped bass landings, Van Winkle et al. (1979) found a significant periodicity of 6 years. This period length is, however, not consistent with the period length that would be expected if the stock density were the causative agent (Van Winkle et al. 1979; Goodyear 1980). In addition, studies of the influence of environmental variables indicate that a large part of the annual variations in year class strength are caused by variations in environmental factors, principally fresh water discharge and water temperature (Kohlenstein 1980; Ulanowicz and Polgar 1980). These observations indicate that the level of recruitment is, at best, only weakly related to the size of the stock. As such, management to achieve a sustainable yield on the basis of a surplus production or stock-recruitment model is inappropriate.

An alternative to managing for a sustainable yield is to manage the resource to assure some optimum allocation of the annual production of recruits to the population while at the same time providing for the preservation or enhancement of the spawning stock. This approach was recommended for striped bass by the participants of workshops on the population dynamics of Atlantic Coast striped bass (Austin 1980). The recommended strategy was to reduce fishing mortality particularly on young fish. The anticipated result was that the longevity of a year class would be extended, thereby reducing the annual variability in landings. In addition, the mean age of the stocks would be increased and along with it there would also be an increase in the production of viable eggs.

The effect of increasing the annual production of viable eggs is uncertain due to the lack of knowledge of the actual mechanisms that determine the strength of a given year class. However, if survival of young is totally dependent on extrinsic environmental factors and unaffected by their density (or any other age class of bass) then, on the average, an increase in the number of eggs will cause a proportional increase in the number of young produced. This is so because the number of young is determined by the initial number of eggs and the survival rate to recruitment. Thus, there would exist a linear relationship between the number of young and the number of eggs cast by spawning females which is independent of the particular set of environmental conditions which determine the survival rate each year.

For the situation where the annual survival rate is totally determined by environmental variables, a reduction in fishing mortality to increase population fecundity will not affect the survival rate. As a consequence, such action will have no effect on the temporal patterns in the occurrence of dominant year classes. It would, however, linearly increase the size of each year class. For example, a doubling of population fecundity would increase the size of a year class by a factor of 2.0. This can be taken to be a small increase when compared to environmentally induced variations in the survival rate which may result in tenfold or greater increase in year class strength when a dominant year class is formed. Such a change in population fecundity would, however, have a substantial effect on the average number of young produced.

These observations are based on the assumption that survival rate is entirely controlled by environmental fluctuations, i.e., that it is not influenced in any manner by the bass population density. If the population itself has an effect on survival either directly or indirectly, then the relationship between the number of eggs and the number of recruits will not be linear. Given the low abundance of the stock, it is impossible to tell whether survival would increase or decrease with increasing population size. At some threshold of population density the survival rate should decline as population density increases. Whether this threshold exists at near zero population size or some much larger population size is unknown. In any event, it is likely that an increase in population fecundity will result in some increased production, albeit small by comparison to the increased production accompanying the formation of a dominant year class. Actual forecasts of the degree to which production may be enhanced are presently impossible because of the lack of understanding of the relationship between stock size and recruitment.

The effect of reducing mortality of small fish on the magnitude and temporal distribution of the yield from a year class can be evaluated through an analysis of the yield obtained from whatever recruitment is produced each year. This type of analysis is usually performed by calculations in terms of yield per recruit (Y/R). Total yield for a year class then is the product of the number of recruits for the year class and the Y/R ratio. The effect of protecting younger fish through modifications of size limits can be evaluated simply on the basis of the yield derived from the average recruit. Such an analysis is presented in Figure 14 based on data collected by Mansueti (1961) and assuming an annual natural mortality rate of 0.15. Note that the yield in biomass per recruit increases for all levels of fishing mortality examined as the length at recruitment increases up to 31 to 38 inches total length. This observation indicates that even substantial increases in minimum size limits would not result in decreases in overall biomass yield. In fact, substantial increases in overall yield would occur with significant increases in the minimum size particularly at high rates of fishing.

This analysis, however, does not address the effect of reducing the mortality of young fish on the allocation of the yield among the various users of the resource. Because of the age and sex specific migratory habits (Goodyear 1978; Kohlenstein 1981) of the bass, a change in size limits might be expected to affect the allocation of the bass produced in the Chesapeake Bay between the Bay and ocean fisheries. Protection of young fish in the Bay would increase the number of fish which join the coastal migratory stock and would thereby reduce the availability of bass (primarily the young females) to the Bay fishermen. This loss would be partly compensated by the greater abundance of older spawning females that would be spared by increased size limits. The possible change in allocation of the yield associated with an increase in minimum size has been examined by Kohlenstein (1981), Polgar (1980) and Cooper and Polgar (1981). Each of these authors determined that decreasing the mortality of young bass in the Chesapeake Bay would increase the yield, but would have little effect on the allocation of the yield. Increases in the minimum size limit in the Bay and in coastal waters would increase yields in both segments of the fisheries.

The increased yield in biomass that would accompany an increased size limit would occur at the expense of some loss in numbers landed because of natural mortality. Increases in the minimum size to 31 to 38 inches total length and eliminating maximum size limits would increase population fecundity by about 5-10 fold, yield in biomass by about 2.5 times, but would reduce the number of fish taken by about 70-80%. These estimates assume no increase in recruitment due to increased population fecundity and that there would be no mortality in excess of natural mortality prior to the fish attaining the minimum size. This assumption is almost certain to be invalid because of noncompliance with the minimum size and inadvertent losses through hooking mortality and by catch of striped bass in fisheries directed at other species. These considerations suggest that the size limits for the optimum distribution of yield would be below those which would maximize the yield per recruit.

The objective of extending the longevity of a year class to reduce the annual variability in landings would best be accomplished by reducing the rate of fishing on all age groups. Assuming an existing conditional fishing mortality rate of above 0.3 to be generally descriptive for the stock as a whole a reduction in the fishing mortality rate would also increase the yield (Figure 14). However, no practical way to reduce fishing mortality across all age categories has yet been identified.

A preliminary analysis of the effect of the proposed increases in minimum size in producing areas to 14 or 15 inches TL and 24 inches TL or 24 inches FL in coastal waters has been performed using a yield per recruit model in which fishing is distributed between the Chesapeake Bay and the ocean (Goodyear 1981). Fishing mortality is considered to be a function of age, length and location and migration is considered to be a function of age and sex. Increasing the minimum sizes from an assumed baseline of 12 inches TL and 16 inches FL for the Bay and ocean, respectively, would increase yield in the Bay by approximately 15% and by approximately 30% in the ocean under 14 inches TL and 24 inches TL minimums. Yields in the Bay and ocean, respectively, would increase by 22% and 47% under 15 inches TL and 24 inches FL minimums (Table 31). These changes in length limits would also affect the fecundity and numbers of fish landed (Table 31). Estimates, presented in Section 6.3 and in Appendix A, of the changes in yield (Kohlenstein 1980) were derived from a mathematical model which does not have the ability to model a change to a 24 inch TL minimum limit in the coastal fishery. Those estimates are different from the above estimates for that reason.

These estimates for the Bay and ocean assume that there will be some incidental commercial and recreational loss of fish of nonlegal lengths but not that a creel limit would be allowed for fish that are outside the otherwise legal size ranges. Such creel limits or incidental catch allowances for commercial fishermen would reduce the benefit in yield that would accrue as a result of the increased size limits but would increase the number of fish taken. The precise influence of the proposed creel limits on the spatial and temporal distribution of yield cannot be readily determined, and was not factored in, because it depends on the level of fishing mortality that will be exerted by anglers on fish within the 14-24" size range.

SOCIO ECONOMIC ASPECTS OF THE FISHERY

5 The Fisheries

.1 Introduction

The striped bass supports important commercial fisheries along the Atlantic Coast, principally from Massachusetts through North Carolina; over 90% of the harvest derives from inland waters and the Territorial Sea (Table 12). As Figure 11 shows, reported commercial landings of striped bass for the region as a whole show a generally rising trend from about 1933 through 1973. The total commercial landings, which averaged approximately 9.5 million pounds between 1958 and 1976 and peaked at 14.7 million pounds in 1973, fell to 3.1 million pounds in 1979. In 1970, with landings of 11.6 million pounds valued at $2.5 million, the striped bass ranked 10th in volume and 8th in value among over 100 finfish species landed on the Atlantic coast.

In addition to the decline in recent commercial landings outlined above, the relative share of the total commercial catch taken by individual states has shifted although Maryland is still the largest producer. Figure 15 shows a general trend toward the reduction of Maryland's contribution to the total commercial landings while Massachusetts' has increased. Striped bass of 12"-17"TL comprise the majority of Maryland's catch (Table 19) while fish over 24" (6 pounds) dominate Massachusetts' landings (Table 20); thus, the data of Figure 15 indicate a shift in the populations's age/size composition toward older and larger individuals.

An analysis of revenues is important for better understanding the striped bass fisheries in different regions. Despite the reduction in landings since 1973, fishermen in the New England and Mid-Atlantic states actually derived greater revenues from their efforts due to a rapid increase in the real price of striped bass since 1974 (Strand et al. 1980). In the Chesapeake and South Atlantic fisheries, however, the increased value of the catch has not compensated for the reduced volume, resulting in an overall decline in revenues of about 25% (Strand et al. 1980). The high prices paid for striped bass provide strong incentive to continue fishing despite the reduced numbers of fish available.

.1 Atlantic Region Commercial Fishery Production and Marketing

The Emergency Striped Bass Study is funding an economic evaluation of the Atlantic coastal striped bass fishery. The University of Maryland is coordinating this study which is scheduled to end in August 1982. The following section, on the commercial fishery, draws heavily upon the interim draft progress report which was circulated in July of 1981 (Smith et al. 1981).

Commercial gears include hand lines, haul seines, fish traps, pound nets, gill nets (both set and drift), and otter trawls. Different gear types predominate as the major means of catching fish in different areas. Also, bass are landed both as a result of directed effort and as bycatch from other fisheries.

The harvested bass are marketed in a number of ways. They are most often sold to a local wholesaler who may pass them along to another wholesaler, retailer, restaurant, or sell them himself, acting as retailer. The fishermen also may sell directly to a retailer, either a fish market or a restaurant. This type of transaction is often the dominant way of selling fish for certain localities at certain times of the year. For both types of sales, the fishermen transport the fish to the buyer, but during the peak fishing seasons, buyers may show up at the docks to purchase fish, paying cash or taking the product on consignment. The buyer may be a wholesaler who owns trucks or it may be a shipping firm, whose only action is to truck seafood products from the dock to larger wholesalers.

Central markets exist in the larger metropolitan areas on the Eastern Seaboard. In the Mid-Atlantic region, striped bass are bought and sold in central markets in Boston, New York City, Philadelphia, and Baltimore (Figure 16). Of these, New York's Fulton market and Baltimore's market account for the majority of the rockfish handled by these large wholesalers. At the next level, the wholesaler may sell to other wholesalers, retailers, shipping firms, restaurants or restaurant purveyors. At certain times of the year, because of changes in seasonal demand and supply, the fish may be transferred back to wholesalers in the producing region.

Generally, the local fishermen sell their catch to local wholesalers. They receive from \$.90 to \$1.50 per pound (whole weight) from the buyer, this ex-vessel price depends on the time of the year, the amount of fish being landed, and on the locality. There is some evidence that buyers price according to the daily or weekly price paid at Fulton Market.

The State of Maryland accounted for 46% of the striped bass landed in 1980. The Chesapeake region (MD, VA) accounts for most of the striped bass landed (56% in 1980). Massachusetts and New York are the next most important producing states (Table 21). Predominant gear used to land the striped bass vary by region. In New England most fish are landed by hook and line (or handline in NMFS terminology). This is the only legal commercial striped bass gear in New Hampshire and Massachusetts. Spearing is allowed in Maine, while traps, pound nets, and gill nets are also allowed in Rhode Island. Commercial fishing for striped bass is illegal in Connecticut waters. (See regulation summary, Section 6.1.4.) There is also some bycatch from draggers (both coastal and offshore) and from gill-netters in Massachusetts. On Long Island, hand lines predominate but gill nets, pound nets, haul seines, and otter trawls also catch substantial numbers of fish. The fish landed in the northern New Jersey fishery are mainly bycatch from draggers while the southern New Jersey and Delaware effort is concentrated in Delaware Bay and is done mostly by gill-netters. Gill netting accounted for over 90% of the total 1980 landings in Chesapeake Bay (Maryland and Virginia combined) and slightly less than 90% in North Carolina (Table 21). Other important gear types in Virginia and North Carolina are pound nets and otter trawls (draggers). Haul seines which are legal in North Carolina account for approximately 2% of the state total. The majority of the commercial striped bass fishermen are located in Chesapeake Bay, although the exact percentage has not been determined at this time (Table 28).

After harvest the fish are taken to local wholesalers and sold. In some cases, a central wholesaler may send his own trucks or those of a contracted transportation firm to the dock to buy the fish directly from the fisherman. This occurred in 1980 in Massachusetts, Rhode Island, Maryland, Virginia, and North Carolina.

The bass are next sold to a larger wholesaler or to a central market; the largest of these is Fulton Market in New York City. Boston, Philadelphia, Baltimore, and Norfolk wholesale markets also handle amounts of striped bass. As can be seen in Figure 16, the Fulton Market is the hub of the distribution network. Approximately 50% (2 million pounds in 1980) of all striped bass landed commercially, pass through this market. (Striped bass is only a small portion of the total fish and shellfish handled by Fulton, for 1980, less than 1% by weight.) Firms in all states ship most of their fish to Fulton. Fulton also takes fish from other central markets when supplies are high. For example, the Baltimore market wholesalers during the winter-spring Chesapeake peak ship a large portion of their bass through to Fulton. Fulton sales tend to set the wholesale price paid for bass throughout the entire Eastern region. The Fulton wholesale market is central to the distribution and marketing of striped bass on the east coast. The amount handled by Fulton and the price at which the markets sell their fish fluctuates widely.

Different regions have different seasonal peaks in landings which are also reflected in the receipts at Fulton. The New England regional fishery tends to have a primary peak during the summer with a lesser secondary peak in September and October. The Mid-Atlantic region (NY, NJ) shows an annual maximum in shipments to Fulton about a month later, that is, October-November. In the Chesapeake and South Atlantic the fishery exhibits two seasonal peaks, one when the fish move inshore at the end of the fall migration and another during the spring spawning season. However, at times when local demand is high and supply is low (for example in July and August in coastal Virginia), Fulton wholesalers sell bass to local wholesalers who were suppliers at other times of the year.

Even though Fulton market is important in the marketing of striped bass, they are bought and sold by many other wholesalers and retailers. Some is sold locally in retail markets, some is sold to larger regional wholesalers, and some is sold to restaurants directly, or indirectly, via restaurant supply houses or purveyors. The number of establishments handling striped bass within a state is roughly related to the catch within the state (Table 29), although heavily influenced by the presence of large central markets.

Subsequent to sale within the wholesale sector (that is, transactions between wholesalers and between wholesalers and purveyors) striped bass is ultimately bought by retailers for final sale. The retail sector was divided into two parts; retail stores and restaurants. In general the retail trade is more important in the Mid-Atlantic than in the New England region. This is due to regional differences in tastes. In the Chesapeake region, for example, most fish markets carry rockfish; in fact, even some of the large grocery chains sell it. There is also substantial retail marketing in New York City but in New England the few fish markets that carry striped bass tend to be either located in areas with large concentrations of individuals from the mid-Atlantic states or in university communities

The restaurant marketing pattern is similar. Most restaurants in the Mid-Atlantic carry rockfish on the menu. As for type of restaurant, in New York and the population centers of the mid-Atlantic, rockfish is found in a large number of French restaurants and in restaurants specializing in seafood. Prices vary a great deal depending on the type of restaurant.

The more expensive restaurants charge more for a meal with striped bass on an entree than do the less expensive restaurants. The higher priced establishments also tend to serve bass as a regular menu item and not as a specialty item. Interestingly, these "white tablecloth" restaurants indicated that they would not substitute another item for striped bass regardless of price. The other establishments indicated that possible alternatives to striped bass were salmon or swordfish. In New York, several firms said that they would substitute tilefish, which they can buy for $.50 less than striped bass.

.2 Atlantic Region Recreational Fishery

NMFS conducted a marine recreational fishing survey for the Atlantic and Gulf Coasts from January 1979 through December 1979 (NMFS 1980). The sampling approach was to use complementary fisherman intercept surveys along with a telephone household survey. This approach differed greatly from previous marine surveys and data presented in this report are not directly comparable with previous surveys. This survey is considered to have produced the most accurate and complete data to date. There are a number of cautions to be applied to interpretation of the data, however. For a complete description of methodology and cautions and for the full range of available data the original report should be consulted. Summary tables for this plan were compiled from the full tables in order to focus on the striped bass catch.

In 1979, from Maine through the east coast of Florida, 39.2 million marine recreational fishing trips produced 1.18 million striped bass (Table 22). Of these fish, 478,000 were released alive. The state waters from Maine through North Carolina produced 99% of the catch (Table 23). Maryland produced the majority (55%) of the Maine-North Carolina catch. In contrast to the commercial landings, in which only a small percentage of striped bass catch is made in the ocean outside three miles (Table 12), the recreational landings show 23% and 11% of the striped bass caught in the North Atlantic and Mid-Atlantic, respectively, were made outside three miles (NMFS 1980, Table 18).

In the original report, the catch data are divided into various types (see footnotes to Table 22) and the various arrangements, while seemingly complex, permit further interpretations of the data. The largest striped bass were caught by the North Atlantic fishermen (Table 24). Although most of the North Atlantic states (and New York and New Jersey) have larger minimum size limits than the other Mid-Atlantic states and no maximum size limits, this great difference in calculated average weight is probably not due solely to the difference in regional size regulation. After spawning, the larger Chesapeake Bay fish migrate north to the North Atlantic region and the Chesapeake population contributes the majority of fish to the fishery. The South Atlantic region produced the smallest fish (Table 24) and also the greatest percentage of fish returned to the water. The striped bass is presently a minor part of the total finfish catch along the east coast (Table 24). It ranked 15th and 20th in total catch (Type A+B) in the Mid-Atlantic and North Atlantic catch, respectively. It undoubtedly occupied a much higher place in relative rank and percentage composition of the total catch in the years prior to the stock decline. Whether or not the decline in abundance has reduced the desire of all Atlantic coastal fishermen to catch or their expectation of catching striped bass cannot be determined. In the North Atlantic the striped bass was sought after by six percent of the fishermen (ranked sixth) and by 10 percent (ranked fifth) of the fishermen in the Mid-Atlantic.

Optimum utilization of this species requires more extensive knowledge of the recreational fishing effort and economic importance. Any striped bass management scheme must include careful evaluation of its impact on the recreational fisheries. The recreational user group is very large, diverse, and growing. Aside from the sport fishermen themselves, the coastal communities where they fish and the inland communities where they reside derive considerable economic benefits from the resource. Managers must examine the relative value of striped bass to various user groups in relation to the potential optimum yield.

5.2 The Fisheries of Northern New England

Maine, New Hampshire, Massachusetts

.1 Commercial Fisheries

.1 Historical Perspective

Historical accounts of commercial fisheries in New England make frequent reference to the taking of striped bass with nets commencing as far back as the early 1600's and continuing into the 20th century. While the fishery appears to have been supported largely by coastal migratory stocks, there were localized efforts directed at harvesting over-wintering fish in several river systems. Such was the case in Maine where much of the catch reported from 1848 through 1968 came from a winter gill net fishery in the Kennebec and Sheepscott River estuaries.

Records also allude to periods of great abundance periodically interrupted by periods of extreme scarcity. Most noteworthy in the latter regard was the 30-year period commencing in the late 1800's during which no commercial catches of striped bass were reported from the Massachusetts coastline north of Boston. Oddly enough, it was during this period in the years 1909 through 1912 that Maine recorded its largest catches to date.

Since 1930, Maine commercial landings have been low (Table 15). New Hampshire landings have been similarly low except for the brief period of 1942 through 1945 when they ranged between 7.8 to 19.1 thousand pounds and more recently from 1965 through 1973 when they ranged from 8 to 16 thousand pounds.

Massachusetts landings have been consistently larger but did not reach 200,000 pounds until 1961 although they approached that level in 1944, 1945 and 1946. Between 1962 and 1968 landings ranged from 463,000 to 874,000 pounds and except for 1971, have since exceeded one million pounds annually. It was estimated that 30 to 40% of the 1937 to 1938 commercial catches of striped bass were made with hook and line approximately 40 to 45% were made by pound nets and traps. With the development of more efficient methods of trolling with hook and line from small boats, the hook and line catch reportedly increased to 63 to 75% of the total 1939, 1940 and 1943 catches and to about 89 to 91% of the total 1944, 1945 and 1946 catches, while net and trap catches decreased accordingly.

A minimum legal size of 16 inches (FL) was established in Massachusetts in 1945 as was the law making striped bass a hook and line fish. The latter law allowed retention of incidental catches of bass from fish traps until 1975 when it was amended to eliminate this by-catch provision. The present legal minimum is 24 inches (FL) for commercially caught bass.

New Hampshire's present law establishing a minimum size of 16 inches (FL) and prohibiting the use of nets in the striped bass fishery also was enacted in 1945. Maine passed legislation prohibiting the use of nets for taking striped bass in 1969 but has yet to enact a minimum size law.

.2 Harvest Patterns

Gear is restricted to hook and line fishing in the three northern New England states, which for all intents and purposes translates into a rod and reel fishery. Trolled lures and live bait in the form of alewives, menhaden and eels account for a substantial portion of the commercial catch of striped bass.

Immature, or so-called school bass generally invade waters of southeastern Massachusetts in fishable quantities in late April and have dispersed along the entire northern New England coastline by early to mid-June. The adult component of the migratory stock arrives 2 to 3 weeks later reaching southern Massachusetts by mid-May and moving into Maine waters by mid to late June.

Early October marks the beginning of the fall migration. Striped bass have generally departed northern New England by the end of October with the exception of waters around Nantucket where fishing may continue into mid-November. Small numbers of over-wintering fish are taken outside these dates, particularly in the vicinity of power plant discharges, but their contribution to the commercial catch is small.

Commercial landings reported for the three northern New England states first exceeded one million pounds in 1969 and generally fluctuated thereafter between 1 and 1 1/2 million pounds through 1977 before dropping to the present low level.

During 1979, Massachusetts fishermen purchased 522 commercial permits which are required for the sale of rod and reel caught fish in excess of 100 pounds plus one fish per day. It can be assumed that most of these fishermen acquired the permit to sell striped bass. However, it is not known how many fishermen sold their catch under the 100 pounds exemption clause or how many holders of other commercial fishermen permits utilized them to sell bass. Massachusetts fishermen accounted for 99% of the reported commercial catch from the three state area during the ten year period 1968 through 1977. The Massachusetts catch came largely from the waters of Cape Cod Bay and southward. During 1979, 96.3% of the statewide catch reported to the Division of Marine Fisheries was recorded by dealers located south of Boston.

.3 Marketing

Ex-vessel prices throughout the northeast are set by supply and demand at Fulton Market. Most of the commercial striped bass catch from northern

New England is shipped on consignment, "in the round" to Fulton Market. The small portion (10%) marketed locally is filleted or steaked for distribution through restaurants and fish markets. Processed price reflects approximately a three-fold increase over ex-vessel price.

Approximately 40 Massachusetts dealers buy and ship or distribute striped bass. Fish are graded by size into market categories of small (2 - 5 pounds) medium (5 - 15 pounds) and large (over 15 pounds). Massachusetts landings in 1979 were comprised of 4.2% small fish, 7.6% medium and 88.1% large. Small fish command the highest price per pound. This price has fluctuated less in recent years, in a relative sense, due to the shortage of small fish. Ex-vessel prices fluctuate seasonally but have been generally higher for all market size categories due to the decrease in overall supply. Ex-vessel price for all market size categories averages $1.21 per pound in 1979.

.2 Recreational Fisheries

.1 Historical Perspective

Bigelow and Schroder (1953) noted that as early as 1859, fishing for bass from the rocks with hook and line was a well recognized sport around Massachusetts Bay. Growing ranks of sport fishermen were undoubtedly instrumental in the introduction and passage of legislation that established gear restrictions and minimum size requirements for striped bass in the northeast. It is also apparent that today's fishermen, by virtue of their numbers, more leisure time, better equipment and improved methodology are exerting unprecedented angling pressure on striped bass stocks.

.2 Characteristics

In 1979 776,000 people participated in the Massachusetts marine recreational fishery (NMFS 1980). Total fishing trips numbered 2,743,000.

There is no state estimate of the number of people fishing specifically for striped bass. The Massachusetts fishermen caught 59,000 striped bass (fish kept as well as released, Table 23). In the North Atlantic Region costs averaged $10.60. Number of trips multiplied by this cost would equal 29 million dollars spent on marine recreational fishing in Massachusetts. This figure only represents the money actually spent on the day's activity and does not include the cost of travel, the boat and motor, tackle, or accomodations.

Since both sport and commercial fishermen are restricted to the same gear type, methodology employed by recreational fishermen is essentially the same as that described previously. The sportfishermen places more emphasis on the aesthetics of the fishing experience and hence, is more prone to the use of artificial lures and surf casting and may release some portion of the catch. Distribution of the recreational catch by area and season are also identical to the commercial catch.

In the traditional sense, recreational fishermen provide for their families and neighbors and release fish that are excess to their needs. There is, however, a large and seemingly growing number of participants who sell their catch yet steadfastly defend their recreational fishermen status on the grounds that they are not profiting from the sale but simply defraying the ever increasing costs of going fishing. While this argument is largely one of semantics, the situation confounds existing data collection efforts and needs resolution. In any event, that portion of the "recreational" catch that is sold comprises some unknown part of the commercial landings recorded in the northeast.

The striped bass fishery impacts economically on the entire spectrum of businesses that accommodate travel and equipment needs of striped bass anglers. Major contributors of these services in Massachusetts include approximately 100 bait and tackle dealers located along the coast and approximately 150 charter boats that depend upon striped bass to varying degrees to attract and satisfy their clientele.

5.3 The Fisheries of Southern New England

Rhode Island

.1 Commercial Fisheries

.1 Historical Perspective

Rhode Island landings dated as far back as the 1800's contain reference to striped bass. Currently, the three major gear types for harvesting striped bass are floating traps, gill nets, and hook and line.

There are six companies in Rhode Island which have permits to set fish traps in Rhode Island waters (Holmsen N.D.). Companies are required to have a permit for the location of each trap. Permits for approximately 50 trap locations are maintained by these companies. Permits are valid for a period of 3 years and are issued by the Division of Fish and Wildlife. Depending on the year, as many as 25 locations are used in one season. Only 8 to 10 traps are in the water at one time. The gear is designed for harvesting a mixture of species. Target species are scup, butterfish, squid and fluke. It is considered an indirect fishery for striped bass.

Striped bass are considered an incidental catch in the majority of the gill net catches. Presently, there are only three gill netters involved in a directed fishery for striped bass. Nets are usually 100 fathoms long and 3 fathoms deep and a variety of mesh sizes are used. There are many restricted areas throughout the state where a gill net cannot be used; however, there is potential for gill nets to develop into a significant fishery.

More recently, the hook and line fishery has become an important factor in the commercial landings of striped bass. In order to sell fish taken by hook and line, a $5.00 commercial license is required. There are approximately 200 licensed hook and line fishermen in Rhode Island.

.2 Harvest Patterns

The highest total landings of bass occurred during the years 1972 through 1974 (Table 25). In 1973 over half a million pounds were landed in Rhode Island. There is an apparent recent increasing trend for the hook and line fishery to be the dominant contributor to the commercial landings. Estimates of trap landings are considered to be accurate, the hook and line landings may be an underestimate since the estimates do not include bass which are sold directly to restaurants and fish markets.

Total annual landings decreased sharply in 1976 and continued to decline through 1980 (Table 15). There are, however, no figures on effort, thus total landings may not reflect the relative abundance from year to year. In general, the effort of the trap fishery remains constant. The increases in the landings of the hook and line fishery may suggest a significant increase in hook and line effort. The increase in price has provided a stronger incentive for anglers to sell bass. Seasonal fluctuations in abundance are determined by the migration of striped bass through state waters and are reflected in the monthly recording of commercial catch (Table 26).

.3 Marketing

Most commercially caught striped bass are marketed through the traditional distribution patterns. There are several licensed buyers in the state who buy from local fishermen. Much of the fish are distributed to local markets and restaurants. When striped bass are in large supply, the excess goes to the Fulton Market in New York. Many fishermen find it convenient to sell directly to local markets and restuarants. This has the advantage of eliminating the middle man and provides a better price for both parties. This a perfectly legitimate practice but it does complicate the issue since these sales are not recorded as landings and it tends to bias the estimate for the rod and reel catch.

There are several other problems with estimating rod and reel landings. Dealers in Massachusetts, located close to the Rhode Island state line, claim to be buying fish from Rhode Island fishermen. A similar situation exists at the other end of the state of Rhode Island. During 1979, one buyer claimed to have handled 24,863 lbs. of striped bass. It was estimated that approximately 75% of the sellers were from Connecticut. They contributed over 50% of the landings and possibly the fish were caught in both states.

.2 Recreational Fisheries

.1 Historical Perspective

In the opinion of most Rhode Island recreational fishermen, the striped bass is the state's most popular saltwater gamefish. Since this species primarily inhabits coastal and estuarine areas, it is very accessible both to fishing from the shore and from small boats. It presents the opportunity for almost anyone to take a large gamefish (50 pounds) without the major investments required for tuna and billfish.

Prior to the 1950's, fishing for striped bass was done mostly from shore. However, with the advent of modestly priced outboards and the production of fiberglass boats, many recreational fishermen were allowed the opportunity to pursue their prey afloat. This gave them greater access to the areas beyond the reach of the shore fisherman and allowed the angler to cover more area. Paralleling the growth in the boating industry was an increase in the recreational fishery. This activity appeared to peak in the early 1970's. Several large year classes appeared over a short period of time and striped bass became very abundant along the Rhode Island coast.

Striped bass landed by hook and line have comprised a variable but significant portion of the Rhode Island commercial landings (Table 25). In the late 1970's a commercial license to sell any fish caught by rod and reel was put into effect. Theoretically, a distinction exists between the rod and reel commercial striped bass fisherman and the rod and reel recreational fisherman. This section attempts to deal only with the rod and reel recreational fisherman.

.2 Characteristics

In 1979 430,000 people participated in the Rhode Island marine recreational fishery (NMFS 1980). Total fishing trips numbered 1,631,000. There is no state estimate of the people fishing specifically for striped bass. The Rhode Island fishermen caught 44,000 striped bass (fish kept as well as released, Table 23). In the North Atlantic Region trip costs averaged $10.60. Number of trips multiplied by this cost would equal 17 million dollars spent on marine recreational fishing in Rhode Island. This figure only represents the money actually spent on the day's activity and does not include the cost of travel, the boat and motor, tackle or accomodations.

Recreational fishing for striped bass begins when schools of migrating fish first appear along the coast during late April. The recreational landings and commercial landings are similar in seasonal fluctuation. Peaks of abundance usually occur during the middle of May, as most of the migrants are passing through Rhode Island waters to spend the summer in areas to the north. Fish which remain as summer residents along the Rhode Island Coast are distributed throughout a wide range of habitats. Fishing is very popular in Narragansett Bay, along the south shore beach, the rocky coast and Block Island. In the fall of the year the migratory process reverses itself, with bass increasing in abundance during late September and October.

Fishing clubs both in the past and today are very active. There are over twenty saltwater fishing clubs in Rhode Island, many of which are devoted exclusively to striped bass. In addition, there are many general rod and gun clubs which are also very active in recreational saltwater fishing. Several tournaments are conducted throughout the state each year. The participation of these clubs provides strong competition and generates a considerable amount of interest.

Many Rhode Island recreational fishermen have voiced the opinion that the commercial fishery (floating traps, gill nets, hook and line) is contributing to an overharvest of striped bass in Rhode Island waters. Another area of concern is the relationship between the striped bass and its food source. Some recreational fishermen have long claimed that commercial menhaden fishermen were taking a high percentage of the forage base in Narragansett Bay and that there remained an insufficient food supply for the predator fish, specifically bass and bluefish. Studies conducted by the University of Rhode Island's Graduate School of Oceanography (Oviatt 1977) have indicated that the problem may not be very serious. When menhaden abundances are so low that it is not commercially feasible to catch them they are still sufficiently abundant to be a prime food source for predators.

5.4 The Fisheries of Southern New England

Connecticut

.2 Recreational Fisheries

.1 Historical Perspective

At present, Connecticut does not have a commercial striped bass fishery. In 1940, the Connecticut General Assembly declared the species a game fish and enacted the following statute: "Striped bass less than sixteen inches in length shall not be intentionally taken at any time nor shall any person possess, sell exchange or offer for sale or exchange in this state any striped bass, wherever taken, less than sixteen inches in length, measured from the tip of the snout to the fork of the tail and striped bass taken anywhere in this state shall not be sold or exchanged or offered for sale or exchange. Striped bass shall not be intentionally taken in any of the waters under the jurisdiction of the State of Connecticut except by sport fishing. Any such fish taken contrary to any provision of this section shall be immediately returned without avoidable injury to the waters whence taken."

In 1980 the General Assembly granted regulatory authority to the Department of Environmental Protection for the management of marine commercial and recreational fisheries. The public act granting this authority retained, however, the provision that striped bass be a recreational species and specifies that it be taken only by angling and that striped bass taken in Connecticut waters may not be sold.

Prior to becoming a game fish, striped bass landings in Connecticut were never very significant. From 1893 to 1939 (1939 was the last year for commercial exploitation) a total of only 160,404 pounds were caught by pound net, weir and gill nets (Table 27). The state of Connecticut does not license commercial fishing for striped bass and no bass caught in Connecticut can be sold. However, since there is no prohibition against the sale of fish taken in adjoining states, substantial numbers of striped bass are landed for commercial purposes in Connecticut. The proximity of New York and Rhode Island waters provides for a difficult enforcement problem.

.2 Characteristics

In 1979, 382,000 people participated in the Connecticut marine recreational fishery (NMFS 1980). Total fishing trips numbered 1,590,000. There is no state estimate of the people fishing specifically for striped bass. The Connecticut fishermen caught 65,000 striped bass (fish kept as well as released, Table 23). In the North Atlantic Region, trip costs averaged $10.60. Number of trips multiplied by this cost would equal 17 million dollars spent on marine recreational fishing in Connecticut. This figure only represents the money actually spent on the day's activity and does not include the cost of travel, the boat and motor, tackle or accomodations.

The bass occurs through Long Island Sound and in and around the mouths of all coastal streams entering the Sound (Maltezos 1978). They prefer rocky and reef areas but are caught in good numbers over mussel and oyster beds located in strong tidal currents. There are overwintering groups of bass in the Niantic and Thames Rivers, Connecticut. An active sport fishery exists in the Thames River year-round. The fishing season begins in early April and continues through to November. Seasonal abundance reflects that in neighboring Rhode Island.

It is generally felt that there is a fluctuation in fishing activity which is a result of the relative yearly abundance of fish present in local waters. The volume of business conducted by the boat and tackle trade is usually a reflection of this activity.

5.4 The Fisheries - The Middle Atlantic Region

New York

.1 Commercial

.1 Historical Perspectives

In the early 1800's an established commercial fishery existed in the Hudson River with striped bass being one of the principal species. The bass ranged far upriver prior to the construction of the Albany Dam in 1826. With this construction the commercial and anadromous fisheries for American shad, sturgeon, alewife herring, blueback herring and striped bass disappeared. The commercial catch in the Hudson from 1913 to 1974 ranged from a low of 990 pounds, reported in 1913, to a high of 133,100 pounds in 1960. From 1954 to 1960 the Hudson River landings as a percentage of the New York commercial landings averaged 19%. In 1961, as statewide landings increased, the percentage take dropped to 8% and continued to decline to 2% in 1974 which was two years prior to the commercial closure due to PCB in the Hudson River. The number of fishermen dropped from a high of 95 in 1945 to 10 in 1974 (Sheppard 1976). Number of units of gear and yards of gill net also decreased during this period.

The marine striped bass fishery in New York ranges from the New Jersey coast, around both sides of Long Island, to Montauk Point and involves gill nets, hand lines, haul seines, otter trawls and pound nets. The eastern end of Long Island has traditionally produced the greatest catch of striped bass but, following years of good reproduction in the Hudson River, the western Long Island Sound catch will be large.

.2 Harvest Patterns

Schaefer (1972) found that 70 percent of the variability in annual New York landings of striped bass can be explained by previous annual fluctuations of year-class production in the upper Chesapeake Bay. A good year class produced in the Chesapeake will produce high landings in New York three years later. The Hudson River produced fish are primarily dispersed in western Long Island Sound and around northern New Jersey and are subject to a relatively moderate level of fishing pressure (Klauda et al. 1980). The Chesapeake fish are dispersed along the ocean shore of Long Island and the eastern end of Long Island and Long Island Sound. Since 1970, 69 to 99 percent of the reported New York harvest has been from Suffolk County in eastern Long Island (Hickey 1981).

In 1980, the majority of the catch was made by handline (Table 28). In recent years the commercial harvest during the fall (October-November) has constituted 25 to 66 percent of the annual total while 14 to 38 percent of the annual catch is made in April-June. The greater fall harvest occurs during the southerly migration when the fish are readily available to the gear in the eastern bays and along ocean beaches. During the spring, fewer fish are taken in or near the shore zone and catches are made farther offshore by boat anglers and trawlers.

Prior to the Hudson River closure, the gill net fishery was most productive during the spawning season (April-June). The primary traditional area for the fishery was in the Croton and Haverstraw Bays and the Tappan Zee (McLaren et al. 1981). A fishery on overwintering bass in the Hudson was closed in 1946 to conserve the population.

.3 Marketing

The influence of the Fulton Fish Market, in New York City, on striped bass product flow is large. In 1980, the market handled about 50% of the Massachusetts-North Carolina catch (Table 30). Also about 50% of the New York catch passed through the market in 1980. The marketing flow chart (Figure 16) indicates that Long Island hook and liners and haul seiners sell some portion direct to Long Island retailers and restaurants and avoid intermediate dealers. The remainder, and probably the largest portion of the catch, goes into Long Island primary wholesalers and is then shipped throughout the distribution network. The ex-vessel price varies from $0.90 to $1.50 per pound to the fisherman. In 1980, the majority of the New York catch (as judged by Fulton receipts) is taken in June-July and October-November (Table 30). In the Chesapeake and south Atlantic, the fishery exhibits seasonal peaks in the winter and spring. When the Chesapeake and south Atlantic region demand exceeds local supply, Fulton wholesalers sell bass to local wholesalers who were suppliers at other times of the year.

In the period 1970 to 1978, the New Jersey and New York landings fell 23% while adjusted revenues rose by 88%. Therefore revenues increased despite the substantial decrease in landings. This situation was not true for the Chesapeake region and North Carolina (Strand et al. 1980).

The number of commercial fishermen in New York has not been determined at this time. It is felt that the number of people selling striped bass will fluctuate with the ability of many erstwhile recreational fishermen to catch more fish than they are able to use themselves. The excess will be sold to defray trip expenses and pick up extra money (Schwab 1979).

.2 Recreational Fisheries

.1 Historical Perspectives

In the Hudson River from Troy Dam to Poughkeepsie, a 1936 survey (State of New York, Conservation Dept. 1937) found striped bass to be a popular game fish. The report also expressed concern about pollution of the river. Catches of striped bass are still made up to Troy Dam. In 1972, 1973, and 1974, recreational surveys determined that an average of about 30,000 angler days were expended annually between Troy dam and

Poughkeepsie and an average of 135,000 angler days were expended on the lower Hudson between Poughkeepsie and Tappan Zee.

The lower 35 miles of the Hudson supports the bulk of the Hudson striped bass fishery. Generally angling for bass begins in late March or early April (Schwab 1979). The removal of the Fort Edward Dam in 1973 and the flood of 1976 flushed massive amounts of PCB contaminated sediments into the lower Hudson and resulted in contamination of various species with high levels of PCB's (Klauda et al. 1981). The commercial fishery for striped bass was closed in 1976 although the recreational fishery was not.

The American Indian was the first to settle on Long Island and during the 1600's, the Dutch settled the western end and New Englanders settled the eastern part. Farming and fishing were the predominant ways of life for over two centuries. As New York City's population increased, there was a corresponding increase in the loss of open land to homes, factories, small businesses and roads. Development proceeded from west to east and farmland disappeared as other employment opportunities arose. Following World War I and subsequently World War II, these changes were dramatically accelerated and, while the last decade has witnessed changes at a slower pace, it is a process still in motion and one which will inevitably continue.

Concurrently, but very gradually at first, recreation oriented services developed in response to a growing population's demand for leisure time activities. Since the Island's greatest asset is its marine environment which contains a variety of shell and finfish, an abundance of sheltered harbors and, where there is public access, easily reached beaches, recreation seekers naturally turned to the sea to fulfill their needs.

By the close of the 1930's, Long Island's recreation/tourism industry was well established and businesses catering to the needs of sportfishermen were not only flourishing but contributing substantially to the Island's economy. Following on the heels of World War II, a burgeoning population, technological advances, higher wages and more leisure time rapidly increased growth of the still growing sport fishing industry. Today sport-fishing is a major contributor to the Island's and the state's economy and is the leading outdoor recreational activity within the New York Marine District (Schwab, 1979).

Long Island has about two thirds of the shoreline in New York and it is along the Long Island shoreline that the most productive striped bass waters occur. Along with the growth came a corresponding loss of access for the fishermen from industrial and residential development and conflicts with other users of the beach. A growing number of pleasure fishing and other recreational boats have, at times, produced crowded conditions on the water.

Approximately 60 miles of Long Island's barrier beach from Jones Inlet to Shinnecock Inlet affords some of New York's best sport fishing. Briggs (1962) found the sport fishery from Jones Inlet to Fire Island Inlet to have rapidly expanded from 1956 through 1960 with respect to anglers involved and fish caught. The catches were dominated by northern kingfish, striped bass, and bluefish. Between 1961 and 1963 the area between Jones Inlet and Fire Island consistently attracted more than 70 percent of all the surf anglers during these years (Briggs 1965). In the months of April, May, October and November, striped bass are sought by practically all the surf anglers in this area. The catch and catch per unit effort have always been the highest in the spring (April and May) and fall (September, October and November). Briggs (1962) stated that the Long Island surf fishery was dependant upon striped bass.

By late May, when the bulk of the smaller bass have moved on, there is an increase in the number of larger fish. June marks the peak of the spring and summer seasons. The catch drops sharply by mid-July and bass fishing in general remains reduced well into September. While the shore bound anglers usually take a share of these larger fish in June and early July, fishermen in boats, using worms, chunked and whole baitfish, eels and artificial lures, probably account for a larger percent of the catch. Trolling, casting, chuming, drifting and jigging during the June fishery produces some of the largest fish taken each year.

By mid-September fishing effort and catches of bass begin to increase again. Some of the year's most impressive surf fishing catches occur along the south shore beaches situated just west of the inlets. Normally by the middle of October the fall migration is in full swing as evidenced by the increasing catches of recreational and commercial fishermen. During good years and weather permitting, this migration remains fairly constant and consequently intense fishing effort continues into the first week of November.

The decline in striped bass in New York waters is illustrated by recreational catch data from Schwab (1979). The number of bass per trip caught from a charter boat, which fishes western Long Island Sound and the New Jersey coast, decreased steadily from 1968 through 1978 from 6.6 to 0.38 bass per trip. The declining catch rate was modified by a large catch of three to five pound fish in November of 1976. The bass catch per trip of a charter boat which fishes the eastern sound, went from 20.7 in 1974 to 5.5 in 1978. The catch per trip of a shore based Long Island bass fisherman went from 2.2 bass in 1968 to 0.2 bass in 1978. In all three cases, average weight of the bass increased through the years.

.2 Characteristics

In 1979, 1,351,000 people participated in the New York marine recreational fishery (NMFS 1980). Total fishing trips numbered 7,448,000. There is no state estimate of the people fishing specifically for striped bass. The New York fishermen caught 276,000 striped bass (fish kept as well as released, Table 23). In the mid-Atlantic Region, the average trip cost averaged $13.80. Number of trips multiplied by this cost would equal 103 million dollars spent on marine recreational fishing in New York. This figure only represents the money actually spent on the day's activity and does not include the cost of travel, the boat and motor, tackle or accomodations.

5.4 The Fisheries of the Middle Atlantic

New Jersey

.1 Commercial

.1 Historical Perspectives

The history of striped bass landings in New Jersey has been similar to landings in all coastal states, where the trend has been irregularly upward since the early 1930's. Since 1960, the New Jersey commercial fishery has been primarily an otter trawl fishery in coastal ocean waters in winter. This fishery began when it was discovered that striped bass often spend the winter along the New Jersey coast in relatively shallow ocean waters rather than in bays and estuaries. It is illegal in New Jersey to trawl within two miles of the coast, but enforcement of marine fishery laws is inadequate and illegal fishing occurs. In addition to the trawl fishery, a limited number of stripers are taken in gill nets set for shad in the Delaware Bay.

.2 Harvesting

In the past ten years New Jersey's average annual landings have been around 289,000 pounds (Table 16), with high harvests reported in 1964 of 996,000 pounds and a 1973 high of 766,000 pounds.

In the waters of New Jersey from 1972-1974 approximately 84% of the striped bass are harvested by otter trawl, while about 16% are harvested by gill nets. An average of the fishing years from 1975-1977 show that the months of greatest harvest have been mid-March, April, May, October, November and mid-December, corresponding with migratory patterns.

.3 Marketing

The price for striped bass has varied considerably in the past 40 years. In 1940 it sold for \$.16 per pound, 1950-\$.28, 1960-\$.22, 1970-$.22, and 1978-$.90. It is evident that in years of greater abundance, the price remained low.

.2 Recreational

.1 Historical Perspectives

At the present an 18 inch minimum size limit exists for the hook and line fisherman and a daily bag limit of ten fish. The recreational season extends from March 1 through December 31.

The striped bass is one of New Jersey's most prized game fishes. It is the primary species sought in several surf fishing contests held along the shore.

The striped bass is present in New Jersey waters all year and can be found in near-shore ocean waters, surf, bays and rivers. They are frequently found around underwater structures, jetties, rocky bottoms drop-offs and channels. The most successful hours for fishing are generally at dawn, dusk, or night especially after a fall moon or a mild northeast storm. Depending on the place and time, the methods and baits used vary greatly. During the summer, fishing in the surf, while live lining with menhaden, herring eels or calico crabs, is very successful. During the fall, trolling or drifting in the ocean from a boat is productive. Trolling is done at slow speeds using deep diving lures such as bunker spoons, umbrella rigs, tube lures and large plugs. Drifting live fish or cut baits on the bottom, jigging with bucktails or casting plugs and spoons are all successful fishing methods used.

.2 Characteristics

In 1979, 972,000 people participated in the New Jersey marine recreational fishery (NMFS 1980). Total fishing trips numbered 4,439,000. There is no state estimate of the people fishing specifically for striped bass. The New Jersey fishermen's catch of striped bass (fish kept as well as released, Table 23) cannot be determined from the survey data. In the mid-Atlantic region, trip costs averaged $13.80. Number of trips multiplied by this cost would equal 61 million dollars spent on marine recreational fishing in New Jersey. This figure only represents the money actually spent on the day's activity and does not include the cost of travel, the boat and motor, tackle or accomodations.

5.4 The Fisheries of the Middle Atlantic

Delaware

.1 Commercial

.1 Historical Perspectives

The striped bass has long been an important commercial species in Delaware, although its importance has fluctuated with the fish stocks. Many studies have been conducted over the past thirty years to attempt to assess striped bass relative abundance in Delaware waters. (Daiber and Smith 1972; de Sylva 1961; Murawski 1969; and Raney et al. 1954).

This species once ascended the Delaware to its headwaters (Meehan 1896). Apparently the striped bass was once abundant in non-tidal waters above Trenton and Abbott (1878) reported that large fish had greatly decreased in numbers although there was no noticeable diminution of small ones. Meehan (1896) stated that it was not rare for fishermen to catch far upstream throughout the winter. The anadromous fish stocks have greatly decreased since about 1900.

The lower Delaware River has been described as an example of a classic case of destruction of a striped bass spawning ground through industrial and domestic pollution (Raney 1952). However, there has been some evidence that spawning still occurs in the Delaware River below Chester, Pennsylvania, although to a limited degree in comparison with the eggs, larvae, and juveniles received from the C&D Canal.

.2 Harvest Patterns

As with many marine fisheries, best indicators of relative abundance are the commercial catch statistics compiled by the National Marine Fisheries Service, U.S. Department of Commerce (Table 16). From these statistics it is evident that the commercial catch has been decreasing steadily after having reached a peak in 1973. Apparently, the large 1970 year-class, which was produced in the Chesapeake, first influenced the commercial gill net fishery in 1972 and reached a peak in 1973. However, prior to 1972, in the middle and late 1960s the commercial catch was at a low level comparable to that being taken now.

The striped bass commercial catch since the early 1960s has been almost entirely dominated by gill nets (anchor, stake and drift). Trawling was outlawed in Delaware Bay in the early 1960s and was phased out more gradually in the 1960s in the Atlantic Ocean within three miles of Delaware's shoreline. Prior to the 1960s, the trawlers contributed significantly to total striped bass landings.

.3 Marketing

There are no major fish processors or markets in Delaware. Any striped bass taken are either sold dockside directly to consumers or trucked to dealers in Rock Hall or Baltimore, Philadelphia, Cape May, New Jersey, or New York City.

.2 Recreational

.1 Historical Perspectives

Striped bass have not been a popular species in the recreational catch in the last twenty years. The number taken has fluctuated considerably and is partially a reflection of differences in survey procedures. Of the seven years since 1955 for which creel survey information is available, the catch was highest in 1972 when striped bass comprised 3% of the total number of sport fish taken in the Delaware estuary. Striped bass catches by sport fishermen are concentrated in certain locations. Prominent among these are the Chesapeake and Delaware Canal, Port Penn-Augustine Beach area, in the mouths of the principal Delaware River tributaries south of the C&D Canal, and the mouth of Indian River Inlet.

.2 Characteristics

In 1979, 124,000 people participated in the Delaware Marine recreational fishery (NMFS 1980). Total fishing trips numbered 511,000. There is no state estimate of the people fishing specifically for striped bass. The Delaware fishermen's catch of striped bass (fish kept as well as released, Table 23) cannot be determined from the survey data. In the Mid-Atlantic region, trip costs averaged $13.80. Number of trips multiplied by this cost would equal seven million dollars spent on marine recreational fishing in Delaware. This figure only represents the money actually spent on the day's activity and does not include the cost of travel, the boat and motor, tackle or accomodations.

5.4 The Chesapeake Fisheries

Maryland

.1 Commercial Fisheries

.1 Historical Perspective

The Chesapeake Bay is the center of abundance for the striped bass and its commercial and recreational value in Maryland has been historically greater than any other species of finfish. The value attached to this species can be seen by its inclusion on the Great Seal of Maryland. The species abundance and quality are mentioned in many histories of precolonial and colonial Maryland. The earliest formal catch records in 1887 show a landing of 1.1 million pounds. In efforts to increase the stock in Maryland, hatcheries have a long and disjointed history in Maryland. Efforts range from the 1886 hatchery in Havre de Grace, and the 1921-1924 hatcheries in other rivers of the Upper Bay to the successful 1981 hatchery operation at Cedarville. No demonstrable benefits resulted from the early hatcheries. Intensive research on Chesapeake bass began in the 1930's. So little was known of its habits that a 1936-1937 tagging study (Vladykov and Wallace 1937) concluded that the striped bass was not a coastal migratory species.

After a period of low catches in the early 1930's, the population increased tremendously with the production of large year classes in 1934 and 1940 and thus began a trend toward increasing catches until 1975. The abundance of fish produced from the 1934 and 1940 spawnings and the rapid depletion by fishing of the 1934 year class produced the first stirrings of a committment to management in Maryland as well as coastwide (Neville 1942). Many states adopted larger minimum sizes and other restrictive regulations to conserve the stocks. Maryland instituted a 15 pound maximum in the early 1930's, which was changed to a 32 inch TL maximum in the mid

1970's, but stayed with an 11 inch TL minimum until 1957 when 12 inches TL was instituted. In a package of new and revised striped bass regulations put into effect in 1980, the minimum size in the Upper Bay only was raised to 14 inches TL from June through October.

In 1942, Maryland put into effect the "Maryland Management Plan" which froze the number of licensed fishermen at the 1942 level and placed restrictions on the amount of gear that would be licensed. These measures resulted from the rapid depletion of the 1934 dominant year class in subsequent years of fishing. "Their (1934 year class) tremendous numbers attracted wide notice and, before long, many men throughout tidewater who ordinarily followed other professions, began setting nets for rock. Storekeepers, barbers, clergymen, blacksmiths, bankers, and even doctors bought or shared fishing gears, and soon glutted the market with barely marketable half-pound fish. As a result, in 1937, the big run was seriously depleted, and in 1938 almost all fish of the brood had been caught." (Tiller 1944). In 1975, the last restrictions on the amount of fishing gear which could be licensed in the state were repealed by the Maryland legislature.

This change has allowed many more watermen, both part-time and full time, to enter the fishery. Basically, net effort is restricted now only to how much an individual can fish effectively. The change allowed part-time fishermen to enter the fishery without having to make daily expenses and thus fish where and when full time fishermen could not afford time and gear expense.

There have been numerous changes in fishing gears. There has been a consistent decline in number of pound nets and seines since the end of World War II. The yardage of drift gill net has decreased while stake and anchor net yardage has increased. The hook and line commercial fishery is variable but it presently furnishes only a very small portion of the total landings. In 1979, 93 commercial hook and line licenses were issued but only 37 were issued in 1980. In 1980, 1,491 gill net licenses, 66 haul seines and 54 pound net licenses were issued.

.2 Harvest Patterns

In 1980, 97% of Maryland Chesapeake Bay striped bass landings were made by gill net (Table 21). This emphasis on gill nets as the primary gear extends back for at least the past 30 years. The greatest percentage of catch is made in December through May. Table 30 shows the peak of Maryland transactions at Fulton in December of 1980; however, the high December 1980 catch was caused by a combination of good weather and an unusually heavy concentration of age II bass in areas subject to traditionally heavy fishing effort. The March-April-May fishery usually produces the highest volume of catch. This spring fishery is conducted on the approaches to and directly in Maryland's spawning rivers and areas.

Harvest of any age class in a given year is proportional to the abundance of the year class in the population. Spring commercial fishing effort may also be directed toward a particular size. From 1973 to 1977 the Maryland watermen focused on the 1970 dominant year class. In 1978, the year class had grown past the maximum length limit of 32 inches TL. Present regulations limit the mesh sizes of gill nets to between 2.5 inches to 6 inches stretched mesh. Nets of different mesh sizes can be used to direct effort toward particularly abundant year classes. Generally, the fishery is geared to harvest primarily ages II, III and IV fish.

Due to the differential migratory patterns of male and female bass (Kohlenstein 1980) the sexes are subject to different levels of Chesapeake

Bay fishing mortality. In 1975, in the Potomac River, for ages III and IV approximately 87% of the catch by numbers of fish is male. Males comprised 73% of the age V fish captured but only 26% and 15% of the ages VI and VII fish, respectively, captured in the spring commercial fishery. Survival to age VI may be twice as high for females as for males (Kohlenstein 1980).

.2 Recreational Fishery

.1 Historical Perspective

The Chesapeake Bay in Maryland offers a number of species and a variety of types of fishing opportunities on its 4,412 square miles of Bay and tidewater tributaries. For the fisherman specifically seeking striped bass, the opportunities range from deep trolling for overwintering bass in the lower Bay to summer jigging around the Bay Bridge pilings to fishing among the rocks on the Susquehanna River below Conowingo Dam. At one time or another, the majority of the coastal migratory striped bass are in the Chesapeake.

The earliest attempts to quantify the sport fishery in the Chesapeake were in 1932 and 1933 (Truitt and Vladykov 1936) and 1937 and 1938 (Truitt 1938). They guessed that the number of anglers was between 200,000 and 300,000 in the 1930's. The rate of growth in the number of fishermen, calculated between 1962 and 1976, is about 1.8% annually (Speir et al. 1977).

The early boat sport fishing efforts seems to have been largely charter boats. At Solomons Island and Tilghman Island, the two sport fishing centers in 1932, there were about 75 and 65, respectively, charters for hire. The charter business has become diffuse and there are now at least a dozen charter fishing centers. Solomons and Tilghman centers together listed only a total of 57 Maryland Charter Boat Association members in 1976.

The boat fishing effort presently is concentrated in the small private/rental boat fishery. In 1976 the charter boat fleet made only 18% of the total fishing trips in the middle Maryland Bay (Speir et al. 1977). There is some evidence that the reduction in striped bass has adversely affected the charter boat industry.

The growth in the small boat fishery has come about due to the availability, durability, and convenience of the aluminum or fiberglass trailerable boat and seems to have been a coast-wide occurrance. The fact that the recreational impact is growing cannot be disputed and the effort is such now that competition for the striped bass resource between commercial and recreational is keen.

The relation between commercial catch and recreational catch has been speculated on and calculated for a number of years. Elser (1965) estimated that in 1962 the recreational catch of striped bass (9.3 million pounds) was twice the commercial catch. In 1976 Speir et al. (1977) estimated the recreational catch (2.2 million pounds) to be 1.2 times higher than the commercial catch. Kohlenstein (1980) considered these estimates to be on the high side and estimated that the recreational harvest in 1962 was approximately equal to the commercial harvest and that the 1976 recreational harvest was only about 60% of the reported commercial harvest. In 1962 both fisheries depended heavily on four year olds from the dominant 1958 year class and the sport fishery took significant numbers of the strong 1960 year class as well. In 1976 the recreational fishery took primarily the already heavily fished 1970 year class from around the Bay Bridge. Smaller fish were taken in the other areas (Kohlenstein 1980).

The age classes taken in the recreational fishery are much the same as those described in the commercial section. Catch of the various age classes is proportional to the relative abundance of that age class in the population. Recreational fishermen catch relatively fewer female bass as they are less available in the Bay due to their migratory habits. Recreational effort for larger fish is not as well directed as the commercial fishery with its size selective gears. However a trophy fishery for the large fish is permitted. Beginning in 1962 the sport fisherman was allowed to take one striped bass per day over 15 pounds during the period May 15 to March 1 (presently 32 inches TL, May 1 to March 1). There are some fishermen who do direct their effort toward these larger fish. The best chance for catching a large fish is during the spring runs when the coastal migratory portion is present for spawning in the Bay. Fishing activity begins to pick up in early April and builds to a peak around the first week in September and then drops sharply to a minimum around the first week in November.

In summary, the striped bass, in spite of its relative reduced abundance in the Chesapeake, is still a highly desirable species. In 1976 in the Chesapeake Bay, striped bass ranked second in species preference and was sought by 27% of those fishermen surveyed who had a species preference (Speir 1978). In 1979 the percentage of people specifically fishing for striped bass, during a comparable period of the survey, was 23% (Williams et al. 1981). This indicates that even in times of reduced abundance, people's desire to catch striped bass has not diminished significantly.

.2 Characteristics

In 1979, 913,000 people participated in the Maryland marine recreational fishery (NMFS 1980). Total fishing trips numbered 3,507,000.

There is no state estimate of the people fishing specifically for striped bass. The Maryland fishermen caught 649,000 striped bass (fish kept as well as released, Table 23). In the Mid-Atlantic Region, trip costs averaged $13.80. Number of trips multiplied by this cost would equal 48 million dollars spent on marine recreational fishing in Maryland. This figure only represents the money actually spent on the day's activity and does not include the cost of travel, the boat and motor, tackle or accomodations.

5.5 Fisheries of the Chesapeake

Virginia

.1 Commercial

.1 Historical Perspectives

In a study of the age composition of striped bass catches in Virginia rivers, Grant (1974) provided the following description of the commercial fishery in Virginia. The Virginia commercial fishery for striped bass is scattered and diverse. It includes trawlers, pound nets, fyke nets, haul seines and gill nets. Pound nets are fished at permanent locations and are most consistently used. They are lifted only during brief periods for cleaning, to prevent possible ice damage or because of nuisance factors such as abundant jellyfish. Fyke nets, hung and fished much like small pound nets in Virginia waters, are usually located farther upriver than the pound nets. Catches are relatively small and the gear is employed more sporadically than pound nets. Trawlers are limited to offshore fishing by law. Therefore, striped bass are available to this gear only in winter months, when they are migrating along the coast. Striped bass availability to trawlers increases during severe winters when the river populations migrate to warmer coastal waters (Grant et al. 1970). Gill net mesh size and manner of fishing vary with the season in the striped bass fishery. Small mesh "spot and perch nets" (2 7/8" - 3 1/2" stretch mesh) are anchored in the summer and staked from late fall to winter. Large mesh "shad nets" (5 1/2" stretch mesh) are staked or drifted in late winter and spring. Haul seines are used sporadically throughout the warmer months, but most effectively in the spring.

.2 Harvest

The commercial landings of striped bass in Virginia for the 40 year period 1930-1969 show a nine fold increase from a low of 0.3 million pounds in 1934 to 2.8 million pounds in 1966 (Table 16). The overall trend in landings (and striped bass populations) has been rising during this period. Two definite peaks of abundance are evident, one in the late 1940's and the other in the 1960's. Average commercial landings in the most recent years have declined; continuation or reversal of this decline depends on contributions to subsequent catches by successful year classes such as those of 1966 and 1970 (Grant and Joseph 1969; Grant et al. 1971).

.3 Marketing

The majority of Virginia's commercially harvested striped bass are sold directly to local wholesale dealers. The wholesale products are fresh round fish. A large portion of these are directly shipped to the larger wholesale markets such as Fulton, Baltimore, or Philadelphia. In 1980, approximately 162 thousand pounds of Virginia caught striped bass were shipped to the Fulton Market (Smith et al. 1981). The remaining portion of these striped bass are distributed among the local restaurant/retail trade. The price per pound for these fish varies considerably. It sold for as low as \$.70/lb. in 1977 and for as high as \$1.04/lb. in 1978.

.2 Recreational

.1 Historical Perspectives

Sport fishing for striped bass is intensive in the lower Chesapeake Bay, especially along the Chesapeake Bay Bridge-Tunnel in spring and fall. The recreational fishery extends from the mouth of the Chesapeake Bay to the freshwater regions of major river systems from March through December. Attraction of small striped bass to the numerous lighted piers extends sport fishing beyond daylight hours.

Fishing practices for catching striped bass have changed for sport fishermen with the improvement in boats, outboard engines, and fishing tackle. The general fishing practices have remained basically the same. Deep trolling with weighted lures utilizing wire or lead core line and use of diving planes are common practices. Light weight monofilament line allows spincast jigging of "feathers" and other small "bucktail" lines. Night fishing under lights with live baitfish or "feathers" and bait casting from shore or boat with "peeler crab" is a standard technique used from shore or nearshore at high tides during day or night.

.2 Characteristics

In 1979, 889,000 people participated in the Virginia marine recreational fishery (NMFS 1980). Total fishing trips numbered 2,528,000. There is no estimate of the people fishing specifically for striped bass. The Virginia fishermen' catch of striped bass (fish kept as well as released, Table 23) cannot be determined by the survey data. In the Mid Atlantic Region, trip costs averaged $13.80. Number of trips multiplied by this cost would equal 35 million dollars spent on marine recreational fishing in Virginia. This figure only represents the money actually spent on the day's activity and does not include the cost of travel, the boat and motor, tackle or accomodations.

.6 The Fisheries of the South Atlantic

North Carolina

.1 Commercial

.1 Historical Perspectives

Most of the commercial fishery for striped bass in North Carolina exists in the Albemarle Sound-Roanoke River systems and adjacent coastal waters (Trent and Hassler 1968) (Figure 13). In the Albemarle Sound and Roanoke River, more striped bass are caught by gill nets than by all other types of commercial gear combined (Lyles 1965; Power 1962). Beach seines and trawls are the major fishing gears used in ocean waters. The landings from the ocean increased significantly in 1967, when the trawl fishery first developed and, except for a decrease in 1969, continued at a level equal to or exceeding the catch in Albemarle Sound. Trawling landings peaked in 1970-71, while beach seine landings have continued at a high level. A majority of these fish caught were no more than three or four years old. Prior to the development of the trawl fishery, the oceanic catch was quite small and was dominated by large fish.

The Albemarle Sound fishery has been pursued since colonial times, first with seines, then beginning during the 1870's with pound nets. Gill nets have become dominant since the development of monofilament nets.

.2 Harvest

Gill net landings in North Carolina, during recent years, are among the highest on record (Table 13 and 16) but effort data are lacking, making it difficult to evaluate reasons for the increased catches.

Although the size composition of striped bass catches taken in the beach net fishery has shifted in recent years, this fishery is also at a very high level (Table 13). Holland and Yelverton (1973) indicated that large numbers of overwintering "jumbo" striped bass are available to the North Carolina oceanic trawl fishery. Holland and Yelverton (1973) stated that, at the present time, this resource was largely unexploited except for those fish caught by New England sports fishermen after the spawning season. The majority of North Carolina trawlers apparently were incapable of fast towing speeds with gear suitable for taking significant numbers. A recently introduced fishing method called "pair trawling", where two trawlers tow one large trawl between the two boats, can attain higher than normal rates of speed. With efficient gear and greater towing speeds, an experimental vessel caught commercially significant quantities of "large" striped bass (mostly large females with roe) while fishing among commercial trawlers taking few or no striped bass. With anticipated developments in increased efficiency of gear and fishing methods, the striped bass population overwintering off the North Carolina coast could be exploited to the extent that the sports fishery for this species from North Carolina to Maine could be seriously affected. The desirability of encouraging an increased commercial effort on large striped bass needs to be explored. An increased effort to obtain reliable catch statistics on a regional basis is necessary to determine if this population of large striped bass is being excessively harvested.

.3 Marketing

In North Carolina, striped bass are generally sold to wholesale dealers. There are approximately 28 fish wholesalers in North Carolina. The product is then distributed to central wholesale markets such as Baltimore, Philadelphia and Fulton. Portions of the catch are also sold to the restaurants and local retailers.

.2 Recreational

.1 Historical Perspectives

The North Carolina recreational fisheries for striped bass are seasonal. During the fall and spring, activities are concentrated in the sounds and rivers, while in the late fall and winter, it shifts to the Outer Banks. Hook and line fishing in the Cape Fear-Neuse and Tar-Pamlico systems is generally limited to small groups of fishermen familiar with habits of striped bass in their particular areas.

The Albemarle Sound sport fishery is quite extensive, with fishermen concentrating on "school stripers" (12"-14" FL) during the fall and seeking out larger fish by trolling and plugging later in the season. Fishing from several of the long bridges in the area is quite productive. Several tributary rivers contain deep holes in which fish concentrate during the winter. Some fishermen make good catches from these locations.

Although fishermen casting from the Outer Bank beaches during the fall and winter concentrate on bluefish, flounder, weakfish and others, striped bass are generally considered as the ultimate prize. Catches of at least several hundred large stripers per season have been noted by fishermen during 1965-66 and 1970-71, but no information is available for other periods.

.2 Characteristics

In 1979, 963,000 people participated in the North Carolina marine recreational fishery (NMFS 1980). Total fishing trips numbered 3,566,000. There is no state estimate of the people fishing specifically for striped bass. The North Carolina fishermen caught 38,000 striped bass (fish kept as well as released, Table 23). In the South Atlantic Region, trip costs averaged $13.60. Number of trips multiplied by this cost would equal 48 million dollars spent on marine recreational fishing in North Carolina. This figure only represents the money actually spent on the day's activity and does not include the cost of travel, the boat and motor, tackle or accomodations.

MANAGEMENT

6.1 Jurisdiction, laws, and policies

The striped bass stocks under consideration for management are rarely found outside the territorial waters of the coastal states from Maine to North Carolina. Thus, there are no (known) international or national laws or policies dealing specifically with striped bass. However, a variety of statutes and regulations have been promulgated by the twelve states and two interstate commissions exercising jurisdiction over the species; county and local ordinances add an additional layer of complexity to the situation. The sections that follow summarize the regulatory processes and significant regulations in effect in the region addressed by this management plan. Table 17 provides a quick reference to the states' principal striped bass regulations.

.1 International

Athough striped bass of American origin may occasionally stray across the border into Canadian waters and vice-versa, the respective stocks are relatively localized and may be considered separate. No conflicts are apparent between U. S. and Canadian fishermen over the striped bass resource in the border region, due in all likelihood to its relative insignificance in quantity and value compared to such species as American lobster, scallops, and the groundfish. Perhaps for these reasons there are no known commissions, alliances, or other institutional arrangements regulating the Atlantic coast striped bass shared by Canada and the United States.

For the sake of comparison, Canadian striped bass regulations are summarized below:

Nova Scotia - striped bass fishery centered in the Annapolis, Gaspereau, and Shubenacadie Rivers size limits - none known (Jessop and Vithayarai 1979)

creel limits - 5 per day (Gasperean and Shubenacadie Rivers)
2 per day (Annapolis River)

seasons - Annapolis River between Hebb's Landing and Lawrencetown Bridge closed to striped bass angling during the period April 1 - June 30.

methods - striped bass taken incidentally in drift nets set for shad in the Shubenacadie River sustain a moderate commercial fishery.

New Brunswick - The striped bass fishery in this province is centered in the St. John River and estuary. The sport fishery depends primarily on migratory striped bass originating along the eastern seaboard of the U. S., while the commercial fishery, conducted mainly during the winter, is supported by fish of local origin (Dadswell 1976).

methods - minimum mesh size for gill nets is 5 1/2".

.2 National

As the striped bass and its fisheries are concentrated almost entirely in the Territorial Sea, management jurisdiction resides with the States rather than the Federal government. No federal regulations governing striped bass are known.

.3 Interstate

The fishery resources of two major river systems, the Delaware and the Potomac, are shared by three and two states, respectively, and regulated by special cooperative arrangements.

6.1.4 STATE

Each state exercises jurisdiction over the striped bass in its waters; both the regulations themselves and the methods of promulgating them vary considerably over the geographic range of the species. Following is a summary of the regulations and regulatory processes in each of the states concerned with this plan, proceeding from north to south along the coast.

Maine The Maine Legislature has sole management authority to set size limits and creel limits for striped bass. The Commissioner of Marine Resources with the advice and consent of the Marine Advisory Council, may establish seasons and locations of fishing for striped bass within the statutory limits.

minimum size limit	-	none
maximum size limit	-	none
creel limit	-	none
season	-	none
methods	-	unlawful to fish for or take striped bass in the coastal waters, except by hook and line or, between sunrise and sunset, by use of a spear.
disposition of catch	-	may be sold.
sport fishing license	-	none.
commercial fishing license	-	if striped bass are sold, a resident or a non-resident commercial fishing license is required.

New Hampshire Rules and regulations, relating to the taking of marine species, may be made by the Director of the Fish and Game Commission, and upon the advice and cooperation of the Advisory Committee of Shore Fisheries. The rules and regulations relating to marine species may regulate (a) the size, number and quantity that may be taken; (b) the areas to be opened or closed to their taking; and (c) the manner of their taking.

minimum size limit	-	16" FL
maximum size limit	-	none.
creel limit	-	none.
season	-	none.
methods	-	illegal to use seine, weir, or net.
disposition of catch	-	may be sold.
sport fishing license	-	none.
commercial fishing license	-	none

Massachusetts Regulatory authority over striped bass is vested in the Director of Marine Fisheries with the approval of the Marine Fisheries Advisory Commission; rules and regulations can be adopted relative to the taking, sale, and possession of striped bass, public hearings are required. Current striped bass regulations are statutory.

minimum size limit	-	24" FL
maximum size limit	-	none.
creel limit	-	no more than 4 fish per day measuring between 16" and 24"FL.
season	-	none
methods	-	hook and line only.
disposition of catch	-	illegal to sell undersized fish. no license required to sell catches if not exceeding 100 lbs plus 1 fish daily.
sport fishing license	-	none.
commercial fishing license	-	license required to sell catches exceeding 100 lbs plus 1 fish daily; fee - $5.00 for rod and reel only.

Rhode Island* Regulatory authority is vested in the Marine Fisheries Council, which can implement regulations in 60 - 90 days; public hearings are required. Current striped bass management control is statutory.

minimum size limit	-	16" FL.
maximum size limit	-	none.
creel limit	-	none.
seasons	-	use of floating fish traps prohibited between December 31 and March 1.
methods	-	generally all methods. in some specific areas at certain times, all methods except hook and line may be restricted or prohibited.
disposition of catch	-	may be sold under standard commercial fishing license or special hook and line license.
sport fishing license	-	none.
commercial fishing license	-	required to operate floating fish traps, gill nets, and trawls. Special $5.00 license for hook and line fishermen allows sale of catch.

*other local restrictions apply which are not listed here.

Connecticut In Connecticut, the Department of Environmental Protection has the authority to promulgate regulations.

minimum size limit	-	16" FL.
maximum size limit	-	none.
creel limit	-	none.
seasons	-	no closed season.
methods	-	angling only - considered gamefish.
disposition of catch	-	may not be sold if caught in State waters.
sport fishing license	-	none.
commercial fishing license	-	not applicable.

New York With the exception of a few emergency powers granted to the Department of Environmental Protection, the control of the striped bass fishery in New york waters is entirely legislative.

minimum size limit	-	16" FL.
maximum size limit	-	none.
creel limit	-	none.
seasons	-	closed during the period December 1 through March 15 in the Hudson and Delaware Rivers. Superceded by the closure order of 1976 prohibiting all commercial fishing in the Hudson River between The Battery and Troy Dam, and all fishing between Troy Dam and Fort Edward.
methods	-	any method.
disposition of catch	-	may be sold (except if taken in Hudson River, per closure order).
sport fishing license	-	required in freshwater, except in Hudson River upstream to Troy Dam.
commercial fishing license	-	none specified or required.

Pennsylvania The Pennsylvania Fish Commission cooperates with the State of New Jersey in managing the resources of the Delaware River. Striped bass in the Pennsylvania portion of the Delaware River are managed by Pennsylvania laws and regulations.

minimum size limit	-	15" TL
maximum size limit	-	none
creel limit	-	2 fish per day per man
seasons	-	none
methods	-	any methods
sport fishing license	-	none
commercial fishing license	-	no commercial fishing permitted

New Jersey Regulatory authority is vested with the Department of Environmental Protection. However, the Marine Fisheries Council has veto power over regulations recommended by the Department. Current striped bass regulations are statutory. The New Jersey portion of the Delaware Bay is managed by New Jersey regulations.

minimum size limit	-	18" TL.
maximum size limit	-	none.
creel limit	-	10 per day.
seasons	-	open season March 1 - December 31.
methods	-	rod and line and goggle fishing (defined as hand propelled spear, dart, arrow, or other missile held while person is completely submerged). netting and other methods illegal.
disposition of catch	-	may be sold if of legal size.
sport fishing license	-	none required for salt water; required for taking striped bass in freshwater.
commercial fishing license	-	none.

Delaware All authority over marine finfish in Delaware is statutory. Striped bass in the Delaware portion of the Delaware River and Bay are managed by Delaware laws.

minimum size limits	-	12" FL.
maximum size limits	-	none (except 20 lbs in Delaware Bay)
creel limits	-	none.
seasons	-	commercial fishing permitted during the period November 1 - April 30, Delaware River and Bay only
methods	-	hook and line, seine and gill nets
disposition of catch	-	may be sold.
sport fishing license	-	none.
commercial fishing license	-	none.

Maryland Most management authority resides with the General Assembly; however, some limited regulatory authority is vested in the Department of Natural Resources. The Sport Fishing Advisory Commission and Tidal Fisheries Advisory Commission supply public and industry input to the Department.

minimum size limit	- 12" TL in most areas at most times. 14" TL during the period June 1 through Oct 31 in Chesapeake Bay and tributaries north of a line drawn from Howell Point to Taylor Island point.
maximum size limit	- 32" TL (except a person may take one striped bass per day over 32" TL if caught by hook and line during the period May 1 to March 1, which may not be sold or offered for sale)
creel limit	- none
seasons	- as noted above for specific size limits. Also, between March 1 and June 1 inclusive, no gill net may be set in striped bass spawning areas or rivers between midnight Friday and midnight Sunday. Also, no restricted gill nets may be set in striped bass spawning areas between March 1 and June 16 inclusive.
methods	- all except purse seine and otter trawls. - use of monofilament gill net webbing prohibited. Minimum-maximum gill net mesh size: 3"-6".
disposition of catch	- may be sold if licensed
sport fishing license	- none
commercial fishing license	- required to sell striped bass (fee $10.00 for rod and reel, $50.00 minimum for nets).

Potomac River The State of Maryland and Commonwealth of Virginia cooperatively manage the fishery resources of the Potomac River via the Potomac River Fisheries Commission (PRFC), an interstate agency with representives of government and industry from both states. The Commission's striped bass regulations are as follows:

minimum size limit	-	12" FL
maximum size limit	-	32" FL
creel limit	-	none
seasons	-	none
methods	-	monofilament nets permitted. maximum gill net mesh size - 7". maximum haul seine length - 2400' pound nets may have 2 heads on 1 leader. hook and line (not licensed), and fyke net.
disposition of catch	-	may be sold if licensed.
sport fishing license	-	none (sport fishing regulated by Maryland)
commercial fishing license	-	Maryland and Virginia residents licensed by PRFC.

Virginia Regulatory authority rests with the Virginia Marine Resources Commission, whose members are appointed by the Governor. The Commission enforces laws made by the General Assembly and can also implement emergency proceedure . Current restrictions on striped bass fishing are both regulatory and statutory.

minimum size limit	-	14" TL
maximum size	-	40" TL,except two per day allowed over this limit.
creel limit	-	as above regarding maximum size limit
seasons	-	none.
methods	-	no trawl or drag nets in inland waters. various restrictions on net sizes.
disposition of catch	-	may be sold
sport fishing license	-	none for tidal water; regular license required for fresh water.

North Carolina The responsibility for striped bass management is vested in the Marine Fisheries Commission; the Division of Fisheries can regulate only through proclamations. Current restrictions on striped bass fishing are regulatory in origin. Various county and local laws may apply for which information is unavailable.

minimum size limit	-	12" TL (except five percent or less of a given catch may be less than this size).
maximum size	-	none
creel limit	-	none in most areas. 25 per day in portions of the Neuse River.
seasons	-	none
methods	-	all methods allowed, except no netting allowed in New Hanover County.
disposition of catch	-	may be sold
sport fishing license	-	none
commercial fishing license	-	no information available

6.2 Management Goal and Objectives

The goal of the parties involved in the preparation of this plan is to perpetuate the striped bass resource in fishable abundance throughout its range and generate the greatest possible net economic and social benefits from its harvest and utilization over time.

Defining a set of objectives for the management of the striped bass resource which will lead to achievement of the goal is a difficult task due to the complex life history and behavior of the fish, the diversity of the fishery, and the lack of an institutional arrangement with jurisdiction over the entire resource. The concept of optimum yield, the ideal to which all fishery management plans ascribe, can be defined most simply as maximizing over time the net value of the resource to the nation. The problem is that there are many components of value - biological, social, political, and economic - each of which may vary in importance between regions and states. Further complicating this issue, these components are measured with different yardsticks (e.g. dollars, recreational experience and aesthetics) which makes their comparison and simultaneous optimization even more difficult. When hard data are lacking, management decisions often must be based on value judgments.

Implied in the goal of optimum yield is balancing the benefits derived from the resource against the inputs of labor and capital. Since few fisheries are directed solely at striped bass, extrapolating relevant harvesting, processing, and marketing costs may be difficult. In the pursuit of efficiency, mandated by the Magnuson Fishery Conservation and Management Act of 1976, expenditures related to research and development, administration, and enforcement must be minimized as well. There are other factors limiting available management options. Much necessary information is poor or unavailable; an example is a description of the stock/recruitment relationship. Some desirable actions may be technically infeasible; for example, manipulating climate to enhance natural reproduction is probably not possible. The objectives chosen should be both flexible, to accomodate new research results, and attainable, given available resources.

In light of the above discussion, the following component objectives for achievement of the goal are proposed:

1. Maintain a spawning stock, minimizing possibility of recruitment failure.
2. Reduce variation in annual abundance available for harvest.
3. Promote harmonious use of the resource among various components of the fishery.
4. Provide for the continued collection of economic, social, and biological data required to effectively monitor and assess management efforts relative to the overall goal.
5. Promote a research program that improves understanding of the striped bass and its fisheries.
6. Promote determination and adoption of standards of environmental quality necessary for the maximum natural production of striped bass.
7. Establish a continuing system for the coordination of management efforts among the various political entities having jurisdiction over the striped bass resource.

6.3 Management Measures

Management authorities may enlist a variety of measures to help them achieve the objectives set forth for a fishery. However, those deciding among these management tools must consider much more than their potential effectiveness in a biological sense. Equally important, perhaps more so in sum total, are the measures' acceptability to recreational and commercial fishermen in all areas where the fish are found, their political palatability, enforceability and cost effectiveness. Considering the very wide range of parochial interests associated with this species and the fact that much remains unknown about its population dynamics, choosing a set of management measures for the Atlantic coast stocks of striped bass that meets all these criteria is a formidable task. Clearly, to meet even limited success in this venture will require a great deal of compromising among all interested parties. A management strategy and management options for striped bass was outlined by Austin (1980). A discussion of potential management measures, which was considered for this Plan, is presented in Appendix A. .The measures considered were:

- minimum size limits
- maximum size limits
- creel limit
- catch quota
- seasonal restrictions
- harvest gear restrictions
- limited entry
- permits and fees
- area closures
- habitat protection
- artifical propagation

6.4 Management Strategy to Achieve Objectives

The striped bass population is characterized by the occasional production of dominant year classes. An appropriate management strategy to achieve the established objective of reducing the variation in annual abundance available for harvest (Section 6.3) is to reduce fishing mortality so as to distribute the catch from a dominant year class over a greater number of years than has historically occured in the fishery. Since a reduction of fishing mortality of small (immature) fish would increase the numbers surviving to maturity, this strategy is also consistent with the objective to maintain a spawning stock. The striped bass population is also characterized by age/sex specific differential migration patterns which result in important geographical differences in the fishery (i.e. in the producing areas and in the coastal areas) which must be considered in the development of regulations for the fishery. However, interrelationships between the stocks in the producing areas and in the coastal areas requires that management measures implemented in the different geographical areas be consistent with the overall strategy of reducing fishing mortality.

To carry out this strategy, a management system is proposed which incorporates separate, but compatible and mutually supportive management regimes for the producing areas and the coastal areas. Specifically, it is proposed that:

1. a minimum size limit of at least 14 inches TL be established for all producing areas to reduce fishing mortality on smaller fish (age II and III) and increase the number of recruits that enter the coastal migratory stocks;

2. a system of daily catch limits be implemented in the coastal areas for fish up to 24 inches TL to minimize exploitation of small (immature) migrant females;

existing maximum size limits and bag limits in producer states be retained and a system of spawning area/seasonal closures be implemented to prevent excessive exploitation of spawning concentrations.

The effects of an increase in minimum size in producer areas are indicated by the population modeling of Chesapeake Bay stocks (Kohlenstein 1980). An increase of the minimum size, only in the Bay, from 12 inches TL to either 14 or 15 inches TL would result in increases in yield while decreasing numbers of fish caught. A 15 inch TL minimum would result in relatively larger yield (pounds) increases and the largest reduction in recreationally caught fish for the Bay (see Appendix A). Goodyear (1981) developed a more sophisticated model which could also account for increases in minimum sizes in the coastal waters of states which fish on Chesapeake stocks (Table 31). Both models show the same trends resulting from increased minimum sizes. Kohlenstein's work indicates the results expected if Maryland alone initiated increases in minimum size while Goodyear's results indicate the increased benefits expected from full, cooperative implementation of this plan's recommended minimum sizes.

Although a 15 inch TL minimum would result in relatively greater increases in yield and benefits to spawners (Table 31), a 14 inch TL minimum in the Chesapeake Bay is seen as more realistically attainable at the present time. An increase is to at least a 15 inch TL minimum length in all producer areas is set as a management goal.

On the basis of this analysis of Maryland catch, it is highly probable that a 14 inch TL minimum size limit in all producing areas will result in further increases in the yield by weight in both producing areas and coastal areas, and substantially increase the numbers of females surviving to maturity.

Since the proposed increase in minimum size limits in producing areas would likely result in greater exploitation of immature fish by coastal fisheries, additional constraints in coastal areas are also necessary. It is recomended, therefore, that a daily bag limit of not more than 4 fish per day less than 24 inches TL and greater than 14 inches TL for hook and line fishermen be implemented in coastal areas. Juvenile fish (school bass) are particularly vulnerable to hook and line fishing and historically have been subject to heavy exploitation in the coastal fishery, with the result that production from a strong year class is depleted within a relatively few years, amplifying the troughs and peaks in the annual abundance available for harvest. The proposed daily catch limits would eliminate the directed commercial fishery on immature fish, while preserving the opportunity for the general public to participate in the large recreational fishery for juvenile fish that had traditionally developed in conjunction with the production of a strong year class. Since small striped bass are taken incidental to commercial fishing for other species, it is also necessary to establish incidental catch limitations for the various net fisheries.

Although the proposed regulations eliminate directed commercial fishing for small fish in the coastal areas, the coastal commercial fishery will ultimately benefit from the proposed management strategy. The increase in the minimum size limits in the producing areas will result in a substantial increase in the numbers of fish that enter the coastal stock. The reduction of fishery mortality of young migrant fish will, in turn, result in a substantial increase in the numbers of fish surviving to maturity when they are available for commercial harvest. In addition, there will be a substantial increase in the numbers of mature fish that return to the spawning grounds at least once, with possible additional benefit to recruitment. Maximum size limitations and season/area spawning closures in the producing areas will prevent excessive exploitation of mature fish and assure that substantial numbers are available for return migration to the coastal fishery.

6.5 Recommended Management Measures

Article IV of the Atlantic States Marine Fisheries Compact states that: "The duty of said commission shall be to make inquiry and ascertain from time to time such methods, practices, circumstances and conditions as may be disclosed for bringing about conservation and the prevention of the depletion and physical waste of the fisheries, marine, shell and anadromous, of the Atlantic seaboard. The commission shall have power to recommend the coordination of the exercise of the police powers of the several states within their respective jurisdictions to promote the preservation of those fisheries and their protection against overfishing, waste, depletion or any abuse whatsoever and to assure a continuing yield from the fisheries resources of the aforementioned states."

The completion of the Interstate Striped Bass Management plan will fulfill this stated duty of the ASMFC. Article IV also states that the commission shall have power to recommend and advise on legislation and regulation and to recommend and coordinate on other fisheries management practices. The role of the ASMFC is clearly advisory and coordinating unless the states wish to designate, under Amendment I of the Compact, ASMFC as the joint regulatory agency. The individual states have ultimate responsibility for implementing those portions of the plan applicable in their jurisdiction.

It must be recognized that each state's social and political climate and fisheries differ and that each state will act within their constraints to adopt these recommended management measures:

1. Size limitations are recommended in order to achieve the management objectives of maintaining a spawning stock and reducing variations in annual abundance.

a. Minimum in inland waters - As an immediate step, striped bass caught in Albemarle Sound, Chesapeake Bay, Delaware Bay and their tributaries and the Hudson River may not be retained if they are less than 14 inches TL (or equivalent FL). This minimum length is considered as an interim step in reaching the defined goal of 15 inches TL (or equivalent FL) in as reasonable time as possible.

b. Minimum in coastal waters - Striped bass caught in coastal waters, other than the inland waters identified in 1.a, may not be retained if they are less than 24 inches TL, (or equivalent FL), except:

I. No more than four fish which are less than 24 inches TL (or equivalent FL) and at least that minimum length as set forth in 1.a above may be retained by each fisherman daily if the fish were caught by hook and line, or

II. No more than five percent of a total daily catch of striped bass may consist of striped bass less than 24 inches TL (or equivalent FL) and at least that minimum length as set forth in 1.a above if the catch was made by net.

c. Maximum size limits - In those states that have an established maximum size limit for protection of broodstock it is recommended that this size limit be retained.

2. Area closures are recommended in order to achieve the objective of maintaining a spawning stock by preventing excessive exploitation of mature fish in the spawning area.

Major spawning areas or rivers, as defined by the appropriate states will be closed to fishing during striped bass spawning activity.

3. Data Collection and Monitoring Programs are recommended in order to achieve the objective of effectively monitoring and assessing the success of management efforts relative to the overall goal.

a. In order to identify user groups, all persons who sell or buy striped bass will be required to obtain a permit from the appropriate state agency.

b. In order to obtain catch per unit effort information, a data collection/catch monitoring program should be implemented by the states that will compile commercial and recreational fishery statistics by area, season, gear type and amount.

c. In order to obtain catch per unit effort information, a data collection/catch monitoring program should be implemented by the states (concurrent with b. above) that will collect biological samples reflecting age, sex and size composition of the catch.

6.6 Implementation

The proposed management action is consistent with stated goals and objectives of the Interstate Striped Bass Management Program and is designed to the extent possible to equitably distribute both short term sacrifices and long term gains among all user groups and geographical areas. Realization of projected benefits is contingent upon a diligent and timely effort by each participating state to implement management measures proposed herein. Failure to act by one or more states, action followed by non-enforcement of new regulations or persistence of regulatory/statutory "loopholes" that circumvent the intent and effectiveness of management measures will be clearly disruptive to the theme of cooperative coast wide management of the striped bass resource.

The management regime proposed herein may require updating or revision as conditions change or new information relevant to striped bass management becomes available. It is essential therefore, that regulations or statutes that implement recommended management measures include provisions for periodic review and timely revision when necessary.

The Emergency Striped Bass Study, funded under the Anadromous Fish Conservation Act, will provide a wealth of information pertinent to this plan. Some findings have been included herein but most will be available subsequent to the submission of the plan for approval. In order to incorporate this information into the Plan and to have the recommended management measures responsive to this and other information, Plan oversight responsibility will be maintained through periodic review by the Striped Bass Board, Scientific and Statistical Committee, and Citizen Advisory Committee. The striped bass program manager employed by the ASMFC, or a contractor of ASMFC under the direction of the program manager, will be responsible for making any necessary changes in the plan.

RESEARCH AND MONITORING

7 Research and Monitoring

7.1 Introduction

The principal characteristics of the striped bass fisheries of the East Coast are as follows: the fisheries thrive on sporadically produced dominant year classes; the fisheries depend for the most part on striped bass derived from the Chesapeake region; and variation in year class strength appears to be related to a large degree to abiotic environmental factors, although brood stock levels may prove to be an important factor. Given the current state of knowledge regarding striped bass and the concerns of commercial and recreational fishermen, the most compatible management alternative is reducing the variability in catches by increasing the mean age of the catch. Accomplishing this requires a reduction in mortality rates in either or both the recreational and commercial fisheries.

Regardless of the strategies pursued, management of striped bass will require continuous, long-term monitoring programs supplying information about the status and characteristics of the stocks. This information is basic to any management program and deserves top priority. Austin (1980) presented the research and monitoring requirements for both the Striped Bass Plan and the Emergency Striped Bass Study as determined by a number of participants at a 1980 workshop. The following section draws heavily on the workshop proceedings.Specific areas of the study are, in order of priority:

* catch statistics/records - commercial and recreational, including expended effort and distribution by area, season, and gear.
* mortality rates - natural and fishing
* recruitment rates - year class strength by area
* stock composition/migration patterns and rates- differentiated by age, sex, and size
* socio-economic characteristics of the fisheries

In addition to the above, special research efforts should be directed toward further understanding the factors affecting the abundance and distribution of early life stages. This research will help to determine whether chance environmental influences or a discrete factor or set of factors have been most influential in the recent decline of the fisheries. Included in the category of special, relatively short term research are, in order of priority:

* inherent viability of eggs and larvae
* mortality factors between egg and post-finfold larva stage, including food availability, predation, and competition.
* spawning stock size and condition, including contaminant loads
* spawning area size and condition, including contaminant loads
* climatological factors

Results of the above special studies conceivably may indicate radical reassessment of management schemes.

In the text following, each of the monitoring programs and suggested areas of research listed above will be discussed in detail. Where appropriate, various techniques will be considered and recommendations made for study designs.

7.2 Routine Data Needs

.1 Catch Statistics

Management's most basic need is data on the volume of catch, the effort expended in its harvest, and its age, size, and sex composition. Therefore,a major recommendation is a coordinated State and Federal effort to obtain improved information on both the commercial and recreational fisheries. Fishermen's reports alone, however, probably cannot provide these data in the desired quality. Managers cannot assume that reported catches are respresentative of the available stocks. Gear selectivity, effort comparison, and incomplete recording pose major problems with use of commercial fishermen's data. Further,the sheer number of recreational fishermen involved necessitates a coastwide creel survey to acquire knowledge of their harvest. Obtaining data on catch is probably best obtained through a program of catch sampling, perhaps combined with experimental fishing in specific areas.

Catch sampling can provide an integrated description of the fisheries if conducted over a wide range of time and space. This approach makes considerable demands on manpower; however, sampling at the market and dealer level would help reduce these requirements. Standard data required in such a program include: the number caught; subsamples of sex and size distribution; subsamples of scales for later age determination; and subsamples of tissues (blood, flesh) for biochemical discriminant analysis. Specific details regarding conducting such a sampling program will vary between areas, thus cannot be discussed further here.

In an experimental fishing study, a location and time must be selected to ensure all members of a stock are present. Spawning areas and seasons would be best, as all age classes of sexually mature fish are available in a relatively limited, bounded geographic area. The benefits expected from a fishing study conducted on the feeding grounds likely would be negligible, because of the magnitude of effort required to sample such a geographically widespread area. Rather than an integrated description of the fisheries, an experimental fishing study provides a 'snapshot' of the stocks available in a particular area.

If both are directed at a single species, experimental fishing will be more cost effective than catch sampling. However, if conducted by State and Federal authorities for other species besides striped bass, catch sampling may prove more efficient than experimental fishing studies. Use of either of these approaches, however, does not negate the need for better catch reporting. Experimental fishing and catch sampling programs, if conducted concurrently, will serve as checks on each other; alone, either will supplement the data obtained through catch reports.

.2 Mortality rates

Though considered in a separate category, mortality rates are closely related to catch statistics. Knowledge of the effects of fishing on the mortality of the stocks is fundamental to management. For the purposes of management, mortality should be partitioned according to age and sex specific components. The study design should allow for differentiation of rates according to season or area; the mortality rates of female striped bass, for example, may be an order of magnitude greater in coastal areas than in spawning areas. Although desirable, obtaining mortality rate estimates by subpopulations would be overly ambitious. There are three approaches to deriving estimates of mortality rates; cohort analysis, mark/recapture studies, and analysis of catch/effort data.

Cohort analysis is probably the best way to obtain data on age specific mortality rates. This approach involves analyzing data describing the age composition of the catch, using this to derive estimates of population size and mortality rates. Because of its reliance on catch age composition data, cohort analysis is complicated by incomplete catch records and other biases built into the harvest data recording process unless these biases can be assumed constant, thus self-canceling. The value of the cohort analysis approach can be improved by using special mark/recapture (tagging) studies as a check; this is recommended. As a bonus, the data necessary for cohort analysis will also allow catch curve analysis.

Mark and recapture or tagging studies can be a useful approach to obtaining mortality rates, especially when used in conjunction with cohort analysis. However, there are major problems associated with tagging programs which must be considered; in particular, obtaining a representative sample for tagging is difficult and tagged fish may be more subject to capture. Good population and mortality estimates require the proper application of reliable tags and measures to ensure good response rates on recaptured fish. In the case of striped bass, the manpower required to tag fish throughout the species' range would be prohibitive. However, striped bass tagged on the spawning grounds, where they are concentrated in time and space, are often recaptured before they have disbursed randomly throughout the population. To counteract this violation of tagging's basic assumption, increasing the sample size and ignoring early tag returns is necessary. Alternately, tagging may be directed at striped bass over-wintering in deeper waters off the coast, where non-selective trawling gear may be used. These stocks, however, are often sorted out by size and/or sex. An additional consideration favoring tagging is that it will also supply needed information regarding migration patterns and rates.

Catch and effort data may be used to obtain information on mortality rates. A basic problem in utilizing commercial landing statistics, however, is standardizing units of effort among the various gear types.

.3 Recruitment

Studies of juvenile abundance such as Maryland's provide an indication of the relative success of reproduction from year to year. Maryland's index correlates well with commercial landings data, indicating that year class strength is established at least by the time the survey is conducted. The data on juvenile abundance is useful also as an indication of the effects of water flows, temperature regimes, and other factors affecting the success of reproduction. Most states producing striped bass have recruitment surveys of some sort; they vary considerably in sampling gear and methods, however. The value of Maryland's survey lies principally in its continuity over time. Its major weakness is its apparent inability to quantify accurately either extremely strong or extremely weak year classes. In addition, a fixed station approach is used; random sampling , if practical, would be somewhat preferable. Finally, there is considerable variation in the size of the samples caught. If management requires a better indication of dominant year classes, or an estimate of absolute numbers rather than an index of density, the number of samples and stations could be increased. The States of New York, Delaware, Maryland, Virginia, and North Carolina should work closely together to standardize sampling gears and methods.

.4 Stock Composition/Migratory Patterns and Rates

Knowledge of the races or subpopulations contributing to the striped bass stocks in various areas at different times is important to management. Regulation of the fisheries in a particular area will depend on the characteristics of the principal stock(s) found there. There are four basic ways to determine the structure of striped bass stocks: tagging, meristics, biochemical analysis, and contaminant load. Which to use depends on the results desired; each has its own strengths and weaknesses.

Tagging is most useful for showing the significance of migrations rather than the racial origin of fish found in a particular area. Although striped bass migratory patterns are generally well known, certain aspects need further attention; for example, the extent of migration of Roanoke River striped bass to the north, and the rates of migration from different regions need further definition. Tagging studies may be used not only to determine which stocks contribute to the New England fishery, but also to ascertain what portion of the stock returns to spawn, and whether the fish spawn each year. Addressing these questions requires tagging 2 and 3 year old fish. If nose tags or similar techniques suitable for tagging pre-recruits can be developed, other information may be obtained. Tagging studies are valuable also as a check on other methods of determining stock structure. A major problem with tagging is the cost and effort required to ensure adequate sample size.

Meristics studies have been used often in the past to discriminate between striped bass stocks. Because of variable results, however, this technique has fallen out of favor.

The biochemical analysis of serum enzymes and proteins is a more promising method of stock differentiation. However, this approach has its own set of complicating factors; enzyme activities vary with the seasons, and the specimens used must be very fresh. An additional problem is determining the origins of the fish; sampling during the spawning season is the best way to circumvent this. Finally the biochemical technique cannot provide quantitative information regarding migratory behavior.

Differentiation by analysis of contaminant load is based on the premise that the chemical composition of a fish reflects that of its habitat. Examples of such chemical "fingerprints" include PCBs in Hudson River striped bass, kepone in bluefish that have spent some time in the James River, and heavy metals in Pacific salmon. The major problems with this technique are the high cost of chemical analyses and the inability to provide quantitative information on migratory behavior.

Regardless of the technique or combination of techniques used, initial studies should be intensive and continuous. After developing confidence in the results, it would be necessary only to conduct the studies periodically; once every five years should be sufficient.

.5 Socio-Ecomonics

Although the capabilities and responsibilities of this group lie principally in the area of biological analysis, we must emphasize the need for a good understanding of the socio-economic characteristics of the striped bass fisheries. The desires of user groups cannot be met if they are not known; management decisions cannot be made unless the costs and benefits of alternatives are estimated. The investigation of the socio-economic data needs of striped bass management now underway will serve as a valuable starting point for further work in this area.

7.3 Special Research

The preceeding discussion concerned data needs requiring more or less continuous commitment of resources. The value of such data increases the longer it is collected, as only with time will trends become evident. The present section concerns studies of a more experimental nature conducted over relatively short periods of time. Once answers are obtained, the study need not be repeated. These special studies would be directed at determining the principal factors contributing to the striped bass' apparent decline in abundance in recent years.

We do not offer in-depth discussion of each of these special research areas; rather, some general observations are made about the subject. Describing and quantifying all mortality factors affecting striped bass would be an enormous undertaking, requiring years of intensive field and laboratory studies costing many millions of dollars. Addressing the decline of striped bass in a realistic manner requires limiting attention to those factors most likely to affect the abundance of any particular life stage. As a fundamental criterion for setting research priorities, only those studies offering the best hope for timely completion should be undertaken.

The correlation between Maryland's recruitment survey and subsequent commercial catches indicates that year class strength is determined at or before the juvenile stage. Therefore, attention should be focused on factors controlling reproductive success up to and including the post-finfold larval stage. First of all, the physical loss of spawning areas, due to shoreline development, power plant intakes, pollution, or sedimentation, should be evaluated. The condition of the spawning stock, especially the females, should be monitored. With estimates of spawning stock size, assessing egg production on the spawning grounds should not be necessary. Monitoring the viability of the eggs produced is one of the more important areas of effort, although the volume of eggs produced each year should be enough to offset any viability problem which may be present in some segment of the polulation. Studies on the Roanoke River indicate that egg viability there has dropped considerably in recent years. Regarding the question of chemical contaminants, perhaps the best approach is to identify chemicals of potential concern occurring in the field, then perform laboratory studies to determine their effects. Drawing relationships between effects observed in the laboratory and events in nature may be a problem, however. It is important also to develop further understanding of interspecies interactions as limiting factors, especially distribution and abundance of food organisms, predation on larval stages, and competition with other species (e.g., white perch). Climatological factors operating throughout the entire early life history stages must be considered as well. Evidence is accumulating which indicates reproductive success is greatly influenced by such abiotic environmental factors as freshwater flow regimes and variable spring temperatures. Thus, in fact there may be little managers can do to ensure maximum reproductive success from one year to the next.

APPENDICES

Appendix A

Alternative Management Measures

.1 Minimum Size Limits

Each state except Maine already specifies some minimum size limit which is set according to both biological and socio-political criteria. The reason for a minimum size limit is to maximize the yield per recruit by taking advantage of the species' innate growth potential and/or to allow the fish to spawn one or more times before becomming subject to harvest. The commercial value of various size categories may also be taken into account. Differentiation may be made between sport and commercial fisheries and between biologically meaningful geographic areas (for example, spawning or wintering areas). Different minimum sizes may be indicated depending on the results desired.

An increased minimum size in the producer areas would allow some level of fishing for the smaller striped bass, which are the traditional mainstay of the producer area fisheries and growth of the remaining smaller fish would produce a larger total yield and an increased number of potential spawners.

14 inch TL or 15 inch TL. Dr. Lawrence Kohlenstein (personal communication July 10, 1981) determined that an increase of the minimum size limit in Maryland from the present 12 inches TL would:

a. increase the weight of the catch of Maryland commercial fishermen by:

- 14% under a 15 inch TL minimum
- 6.5% under a 14 inch TL minimum

b. increase the average coastal harvest in pounds and numbers by:

- 20% under a 15 inch TL minimum
- 10% under a 14 inch TL minimum

c. increase the number of females surviving to maturity by:

- 20% under a 15 inch TL minimum
- 9.5% under a 14 inch TL minimum

d. decrease the Maryland recreational catch in numbers by:

- 50% under a 15 inch TL minimum
- 18% under a 14 inch TL minimum

e. increase the Maryland recreational catch in pounds by:

- Little change under a 15 inch TL minimum
- 4.5% under a 14 inch TL minimum

f. increase the total Maryland catch in pounds by:

- 7% under a 15 inch TL minimum
- 5.5% under a 14 inch TL minimum

A 15 inch TL (14 inch FL) limit would eliminate the fishery for age II striped bass in the Chesapeake Bay. A 14 inch TL limit would eliminate the spring and summer fishery and about one-third of the fall fishery for age II bass in the Chesapeake.

16" FL. Using growth rates and natural and fishing mortality rates estimated from tagging studies, analyses of catch records, and comparisons of the relative values of different market categories Merriman (1941) determined that it was more efficient to begin taking striped bass when they reached 3 (about 16 inches FL) years of age that at any younger or older age. Striped bass less than 3 years old are more plentiful, but weigh less individually and are worth less, while older age classes are being reduced by mortalities faster than they are growing. As a result of his work, many Atlantic coast states implemented a minimum size limit of 16" FL as suggested by Dr. Merriman. Most states in which striped bass spawn, have retained smaller size limits, however, in order to sustain their traditional fisheries. This calculated length for maximum yield per recruit does not correspond with more modern estimates (see Population Dynamics section).

18" FL. Implementing a minimum size limit of 18" FL in coastal waters would postpone recruitment about 3 months compared to the situation under the present 16" FL limit. Slight increases in abundance and biomass of fish age 4 and older---initially about 7% but declining with age---likely would result.

24" TL. The principal benefit associated with a minimum size limit of 24" TL is that it would allow most female striped bass to participate in at least one spawn before becoming subject to harvest. In addition, this size limit would maximize the number of eggs released on the spawning grounds each spring. If striped bass reproductive success is density-independent, there may be no point to increasing the number of eggs spawned unless brood stock levels are at minimal levels. However, if body burdens of contaminants adversely affect reproductive success, the eggs spawned by the younger fish may be significantly more viable than those from larger females. Also, if reproductive success is not entirely independent of stock size, then increasing the number of spawners may increase juvenile recruits. Under these conditions, protecting the younger females may help increase juvenile production.

.2 Maximum Size Limits

Already imposed in Maryland, Virginia and in the Delaware River, the intended effect is the protection of a basic brood stock composed of the most fecund individuals. Regulations limiting maximum size may be applied through all or part of a fish's range or for all or part of the year. Allowances may be made for trophies or fish already dead when landed. However, maximum size limits may accomplish little if fishing mortality is so great that few individuals ever attain the protected state. Further, if the egg viability of the older females is significantly reduced due to senility or increased body burdens of toxic substances, protecting these fish may be a wasted effort.

Without the maximum size limits imposed in Chesapeake Bay, however, it is unlikely that many of the large striped bass which sustain the recreational fisheries to the north would escape capture during their spring spawning runs.

.3 Creel Limits

The ultimate purpose of a creel limit is to reduce the catch of individual fishermen, in order to distribute the benefits of fishing among a larger number of people over a longer period of time. New Jersey's creel limit is 10 fish per day per angler; Maryland allows hook and line fishermen to take only one striped bass per day over 32" TL.

Imposing creel limits on recreational fishermen may be an effective way to reduce total fishing mortality, thereby extending the survival of particular age classes and reducing annual variations in the catch. Without information on distribution of catches among individual fishermen, however, estimating the extent to which a particular creel limit will reduce overall harvests will be difficult. Especially if "10% of the fishermen catch 90% of the fish" as is often said, creel limits may be an effective way of reducing striped bass fishing mortality.

.4 Catch Quotas

An optimum catch in terms of biomass can theoretically be specified for any fish population. Once the quota is reached, further landings are curtailed for the remainder of the particular fishing season. Effective use of quotas requires (a) knowledge of the species' population size, age class, structure, sex ratios, natural mortality, growth rate, and recruitment rate; (b) accurate weekly or monthly landing data; and (c) enforcement capability. Such direct control of catch or effort is the most effective way of regulating population size. It is also the most demanding in terms of biological understanding, data collection, and enforcement.

Limits on the catches of commercial fishermen are often economically, as well as politically, difficult to justify. Rigorous analysis of the costs and benefits involved are required before limits can be imposed which may reduce or eliminate traditional occupations or remove striped bass from the marketplace.

.5 Seasonal Restrictions

Closed seasons may be defined for certain geographic areas and for certain segments of the population. The intent of season closures is to protect all or some segments of the population when and where they are most vulnerable to harvest.

.6 Harvest Gear Restrictions

Allowable methods of harvest may be specified in order to allow escapement of certain portions of the stock and to reduce the overall catch. Net sizes may be controlled, for example, to allow escapement of under or oversize fish. Fishing could be restricted to hook and line only.

Certain angling techniques may be specified to more greatly challenge the sportsman and reduce the overall recreational harvest. From the standpoint of maximizing economic yields, however, the most efficient types of commercial gear should not be discouraged if stocks are at adequate levels or the fishery is not directed at some particularly vulnerable or important segment of the stock.

.7 Limited Entry

Modern technology has greatly increased the efficiency of the gear used to locate and capture fish, while the demand for fresh seafood has caused its price to increase dramatically. The combination of these two factors places tremendous pressures on fish and shellfish resources, making overfishing an ever increasing threat. Limiting the entry of new vessels and individuals into a fishery, by increasing license fees or some other means, may be used both to protect the resource from depletion and to ensure a more stable livelihood for those who harvest it.

.8 Permits and Fees

Expensive, mandatory licenses for the sale of striped bass seem attractive as a means of reducing fishing pressure by eliminating or restricting the opportunistic fisherman. It is commonly held that a license cost of $100 - $500 will exclude all but serious, full-time commercial fishermen. However, the very high value of striped bass in recent years provides such an economic incentive that the desired effect of high license fees may not be realized. On the other hand, the low or non-existent license fees imposed on commercial fishermen in many of the states concerned with this management effort provide little incentive not to fish for and sell striped bass. A permit system also has the advantage of facilitating collection of commercial landing statistics.

.9 Area Closures

Restricting or prohibiting fishing in certain areas at certain times serves to protect all or some segments of the population during some period of vulnerability.

.10 Habitat Protection

The present stocks of striped bass appear meager relative to the abundance of just a few years ago. Contemporary population levels are much less than the hordes of bass described by 17th and 18th century correspondents to their constituents across the Atlantic. Any explanation of the apparent long-term decline in the East Coast's striped bass would have to implicate habitat degration as well as overfishing. Dams now block free upstream movements of anadromous fish in the Susquehanna and many other rivers; few fish of any species can pass the pollution barrier extending along the Delaware River from Trenton to Philadelphia. Fishing is restricted in the Hudson River due to the high levels of PCBs found in its sediments, waters and fish. Fishing is also restricted in the James River where Kepone contaminates the resident species. Spawning areas suffer sewage discharges of various degrees of treatment, non-point source runoff of silt, pesticides, herbicides, and toxic metals, thermal discharges and entrainment and impingement effects from power plants and the wastes of industrial processes. Thousands of acres of marshlands have been drained, dredged, filled, and developed. No one knows the extent to which these phenomena, singly or in combination, have affected the abundance of striped bass or any other species.

No environmental laws or regulations are known which address the protection of particular areas or habitats specifically for the benefit of striped bass; many, however, do so indirectly. Included here would be all

Federal, state and local laws, regulations and ordinances pertaining to water quality standards, land use practices, and environmental protection in general.

.11 Artificial Propagation

Striped bass hatcheries provide invaluable research opportunities and have definite application in programs aimed at restoring or establishing stocks in areas devoid of naturally spawning populations. Stocking may also be an effective enhancement method in certain limited situations. However, hatching and rearing capability sufficient to significantly complement natural reproduction in large systems does not now exist, and may be very costly to develop.

Appendix B

Review of Striped Bass Biology and Ecology

8 B.1 Preface

A considerable amount of literature concerning the ecology and biology of the striped bass stock from Maine to North Carolina has been published although not all is generally available. Westin and Rogers (1978) and Setzler et al. (1980) each prepared excellent recent synopses which reviewed the literature on taxonomy, morphology, distribution, life history, population ecology, harvesting and culture of the striped bass. During the drafting of this plan, literature review was an important part of the process and resulted in a relatively detailed presentation on striped bass biology. In an effort to present the greatest practical amount of information in the Plan, yet promote ease of reading and usability, a summary of the detailed Section 3 The Species was prepared for the main body of the plan. The following Appendix B contains the detailed presentation and will furnish the reader with a ready reference for the detail necessary for a fuller understanding of the complex life history of the striped bass.

8.B.2.1 General Characteristics

.1 Taxonomy and Nomenclature

The accepted common and scientific names for the species are striped bass, *Morone saxatilis* (Walbaum) (American Fisheries Society 1980). In the New England and mid-Atlantic regions it is also called striper, linesider, or just plain bass, while from the Chesapeake Bay region southward it is more familiarly known as rockfish or rock. Westin and Rogers (1978) and Setzler et al. (1980) list the following as less commonly used vernacular names for the species: green-head, squid-hound, Missuckeke-kequoch, rollers, and sewer trout. Both references cited above provide objective and subjective synonymies for the species; the latter (Setzler et al. 1980) includes a detailed discussion of the history of striped bass systematics. With the last rearrangement of the taxonomic categories of striped bass and its related forms, Gosline (1966) transferred genus *Morone* from the Serranidae (the true sea basses) to the Percichthyidae. The latter is an artificial assemblage of some 17 genera and 40 species representing several unrelated percoid groups (Hardy 1978). The taxonomic affinities of striped bass and its allies are outlined on the following page. Genus *Morone* comprises 4 North American and 2 European species. Westin and Rogers (1978) present a dichotomous key for all 6 and a table of diagnostic osteological characters for 5 of these species.

SUBCLASS	Actinopterygii
SUPERORDER	Acanthopterygii
ORDER	Perciformes
FAMILY	Percichthyidae (Serranidae)
GENUS	Morone

SPECIES	OCCURRANCE
M. americana (Gmelin 1788) - white perch	Atlantic Ocean to fresh water
M. saxatilis (Walbaum 1792)-striped bass	Atlantic, Pacific Oceans, Gulf of Mexico to fresh water
M. chrysops (Rafinesque 1820)-white bass	Freshwater
M. mississippiensis (Jordon & Eigenmann 1877) - yellow bass	Freshwater

.2 Morphology

The following description of adult striped bass is divided into five categories: structural features, pigmentation, size, meristics, and body proportions. The classic illustration of a typical adult appears in Figure 1. Principal sources for the data here presented, in order of relative importance, were Hardy (1978), Westin and Rogers (1978), Hildebrand and Schroeder (1928), and Bigelow and Schroeder (1953).

Structural Features The general body plan is perch-like; the body is elongated and moderately compressed, the back slightly arched. The dorsal fins are clearly separate, their bases approximately equal in length. The first dorsal is spinous, and originates over the posterior half of the pectoral fins; the second dorsal contains only soft rays. The caudal peduncle is fairly deep and keelless; the caudal fin itself is moderately forked. The anal fin is of about the same size and form as the second dorsal fin; it originates below the middle of the latter, and contains three spines which are graduated in length. The pectoral and pelvic fins are of moderate size; the latter possesses a single spine, and is inserted somewhat behind the former. The head is sub-conical and relatively long; the nose is moderately pointed. The mouth is large and obliquely situated; the maxillary extends posteriorly nearly to the middle of the eye, and the mandible is projecting. The teeth are small and present in bands on the jaws, vomer, and palatines; they are found also on the base of the tongue, distributed in two parallel patches. The gill rakers are long and slender. There are two sharp spines on the margin of the opercle, while the margin of the preopercle is serrate. The scales are ctenoid, extending onto all of the fins except the spinous dorsal.

Body Proportions As times contained in standard length: greatest depth, 3.45-4.20; least depth (at caudal peduncle) 9.6; depth at anus, 3.9; head length, 2.9-3.25. As times in head length: length of pectorals, 1.8-2.1; eye diameter, 3.9-4.9 (less in small individuals); interorbital, 3.75-5.4; maxillary, 2.4-2.7. Middle rays of caudal fin 0.6 length of outer rays.

Size Striped bass are relatively long-lived and capable of attaining moderately large size. Fish weighing 50 or 60 lbs are not exceptional. Although the current world record of striped bass caught on hook and line is 73 lbs (set in 1913), the heaviest striped bass on record weighed 125 lbs. In general, female striped bass grow considerably larger than males; reported maximum lengths are 182.9 cm FL (72.0") and 115.6 cm FL (45.5"), respectively.

Pigmentation The species' coloration is its most distinctive feature. The sides are silvery with 7 or 8 narrow, black or sooty, longitudinal stripes which follow the scale rows. Though usually continuous, any one or more of these stripes may be variously interrupted. One of these stripes always follows the lateral line, with 3 or 4 others above it and 3 below. The longer upper stripes extend to the base of the caudal fin. All but the most ventral stripe lie above the level of the pectoral fins. Descriptions of the dorsal surfaces vary from light green, silvery green, or silvery with brassy or coppery reflections, to dark olive green, steel blue, or black; the belly is whitish, creamy, or silvery with brassy reflections. The vertical fins are dusky green to black, the pectorals greenish, and the pelvics white to dusky.

Meristics FIN RAYS (Roman numerals indicate spines, arabic numerals indicate soft rays): 1st Dorsal - VIII-IX; 2nd Dorsal - 9-14 (mode of soft rays = 11 in Hudson River fish, 12 elsewhere); Anal - III, 7-13 (mode = 11); Caudal -17 (upper lobe), 15 (lower lobe); Pectoral 13-19; Ventral - I,5. SCALES: The lateral line scale count ranges from 50 to

72. Scales above and below the lateral line number at mid-body, 9-13 and 13-16, at caudal peduncle 11-13 and 12-15 respectively. GILL RAKERS: The gill rakers are long and slender; older specimens have fewer well-developed gill rakers than younger ones. Total gill rakers on first arch is 19-29, including 6-12 on the upper arm and 12-13 on the lower arm (average values for first gill rakers of Chesapeake Bay striped bass - upper, 9.49-9.77 and lower, 12.61-13.07). BRANCHIOSTEGAL RAYS: 7. VERTEBRAE: total (including hypural), 25 (rarely 24), including 12 abdominal and 13 caudal. See Hardy (1978) for further references to original sources of meristics data.

.3 Reproduction

Much of the following is extracted from Hardy (1978), Westin and Rogers (1978), Raney (1952), Setzler et al. (1980), and Merriman (1941), to which the reader should refer for the more detailed descriptions and references each presents.

Sexuality Striped bass are heterosexual; as with many other fish species, no sexual dimorphism is apparent. Females do, however, grow to a considerably larger size than do males; striped bass over about 13.6 kg (30.0 lbs.) are almost exclusively female (Bigelow and Schroeder 1953). Several cases of hermaphroditism have been reported in striped bass. Westin (1978) described one that had been taken from Rhode Island waters and held in captivity for nearly one year; at the time of examination it measured 52 cm (FL) and weighed 1.6 kg. In their study of Coos Bay, Oregon in 1949 and 1950, Morgan and Gerlach (1950) noted the incidence of hermaphroditism in the striped bass they sampled was almost 3%. Unlike some members of the family Serranidae-the true sea basses among which striped bass were classified until recently- striped bass do not change sex as a normal event in their life cycle. In fact, this is one characteristic used to separate the Percichthyidae from the Serranidae (Gosline 1966). Among the latter, some species of the genera Hypoplectrus and Serranus may be simultaneously male and female.

Maturation Sexual maturation of striped bass appears related to ambient temperatures, fish from southern waters generally mature at an earlier age than those from regions to the north. Most males are mature at age 3 (ca. 370 mm or 14.6" TL)and by age 4 (ca. 480 mm or 18.9" TL) all participate in the spawning runs. Although a significant proportion of females may spawn at age 3 (ca. 420 mm or 16.5" TL), the majority do not mature until age 4 (ca. 500 mm or 19.8" TL). Table 1 summarizes data on age and size of males and females at maturity.

There are indications that some older striped bass may not spawn every year. Merriman (1941) reported that large, unripe females are regularly taken from Connecticut waters in late spring and early summer, during the regular spawning period, indicating not all individuals spawn every year. Lewis (1962) noted that some fish in the Roanoke River, age seven and older, did not spawn annually. Jackson and Tiller (1952) reported curtailment of spawning in about 1/3 of the fish age 10 and older taken from Chesapeake Bay, though they also found striped bass up to age 14 in spawning condition. Hollis (1967), however, found no evidence of senility in the fish he sampled, which included 34 specimens from 20.0 to 63.2 lbs. There are indications that older females spawn earlier in the season, the youngest fish being the last to spawn (Hollis 1967).

Gonads There is a strong positive correlation between the length, weight, and age of a female striped bass and the number of eggs it produces. A summary of data on the relationships between gonad size, fecundity in females, and length, weight, and age of ripe males and females appears in Table 2 (a reproduction of Table V in Westin and Rogers 1978). Table 3, also from Westin and Rogers, relates gonad weight for each sex during separate developmental stages; the data include samples of striped bass from the Hudson, Potomac, and Roanoke Rivers.

Two types of eggs (three, according to Lewis 1962), separated on the basis of size, may be found in the ovary. The smaller, immature ova range in size from 0.07 to 0.125 mm in diameter, while the large ova range in size from 0.22 to 0.76 mm in diameter (Westin and Rogers 1978). The ovaries of immature females contain only small ova, while those of mature fish contain both large and small ova. According to DeArmon (1948), cited by Hardy (1978), the ovaries of a mature fish may contain the eggs for three successive spawning seasons. The two types of eggs are distributed uniformly throughout both ovaries, the large ones accounting for approximately 15% of the total (Jackson and Tiller 1952).

As the spawning season approaches, the large ova ripen, increasing in size to 1.0-1.35 mm at spawning. During the maturation process the eggs and ovaries change color from their normal cream to a pale, grass green (Westin and Rogers 1978).

Spawning Striped bass are anadromous, ascending coastal streams in early spring to spawn, afterward returning to ocean waters and migrating up the coastline in late spring and early summer. Spawning itself takes place in the shallow stretches of larger rivers and streams, generally within about the first 40 km of fresh water in rivers flowing into estuaries (Tresselt 1952). The actual distance upstream of the center of spawning varies from river to river and, within the same system, from year to year. Striped bass spawning areas characteristically are turbid and fresh, with significant current velocities due to normal fluvial transport or tidal action. The usual range of water temperature associated with spawning activities is about 14C- 22C.

Seasons The beginning of the spawning season varies with latitude, beginning as early as mid-February in Florida's St. John River or as late as early July in the St. Lawrence River (Hardy 1978). On the major spawning grounds of North Carolina, Virginia, and Maryland, the extreme range of the spawning season extends from late March through early June. However, most activity occurs in one or more peaks between mid-April and mid-May. On the Hudson River, the other major spawning and nursery area on the East Coast, the season runs somewhat later, generally from mid-May through mid-June (Hardy 1978). Water temperatures conducive to spawning range from 10.0C to 25.0C.

However, spawning generally does not commence until the water temperature reaches 14.4C; peak activity occurs between 15.6C and 19.4C, while temperatures of 21.1C to 22.2C usually bring a halt to the season (Hardy 1978). An important factor contributing to successful reproduction is an uninterrupted, steady rise in the water temperature in early spring. Storms or spells of cold weather may cause sudden drops in water temperature, temporarily halting spawning activity. Early larval stages may be particularly sensitive to such aberrations (Hollis 1967; Kernehan et al. 1981).

Spawning Areas The major spawning areas for the stocks of striped bass found from Maine through North Carolina are the Chesapeake Bay, Hudson River, and Roanoke River (Figure 2). Estimates made in 1975 of the relative contribution of these stocks to the coastal population are 90.8%, 6.5%, and 2.7%, respectively (Berggren and Lieberman 1978). The Chesapeake Bay stock includes a number of smaller, more or less distinct sub-populations associated with specific river systems or areas (Figure 3). These sub-populations may be separated to some degree on the basis of meristic or serological characteristics (Morgan et al. 1973; Koo 1970). In the northern and southern extreme of the area addressed by this plan, there may be some small contribution to available striped bass stocks from minor spawning areas in Canada and South Carolina, respectively. In Canada, these areas include the St. Lawrence and Miramichi Rivers in Quebec, the St. John River in New Brunswick, and the Annapolis and Schubenacadie Rivers in Nova Scotia (Leim and Scott 1966). South Carolina's striped bass spawning areas include the Congaree and Wateree Rivers (May and Fuller 1965).

There is no evidence of successful spawning in coastal areas of New Jersey or Long Island, and very little for rivers of New England (Wallace and Neville 1942 ; Raney 1952). There is, however, evidence of spawning occurring in the Thames Rivers in Connecticut (Maltezos 1960) and Kennebec River in Maine (Towne 1940). In the course of investigations Merriman (1941) found three juveniles of 7.1, 7.6, and 8.5 cm (2.8, 3.0. and 3.3") in the Parker River near Newburyport, Massachusetts, in August of 1937. Regarding the striped bass in Maine, Towne (1940) wrote, in reference to the Mousam River, "I believe that this is a spawning stream for bass. There have been several occasions when fishermen have taken females with ripe eggs in them." Given that the most productive areas for striped bass are those with extensive estuaries (eg. the Hudson River, Chesapeake Bay, Roanoke River - Albemarle Sound), the relative contribution of any New England spawning areas was likely relatively insignificant, except perhaps locally.

Spawning behavior The smaller males, most likely non-migratory residents of the area in question, preceed the female onto the spawning grounds several weeks before the season actually begins. The proportion of male fish on the spawning grounds may range from 55% to 83% (Vladykov and Wallace 1952). During spawning there is little or no feeding by males or females, although they may feed heavily both beforehand and afterward (Raney 1952). There seems to be some separation of females by age, the older ones spawning early in the season while the younger fish (sometimes called "May rock") participate later (Hollis 1967). Mating is promiscuous and sometimes spectacular to observe.

In the phenomenon known as a "rock fight", an individual female may be accompanied by 10 to as many as 50 males, which leap and splash as they fertilize the eggs broadcast by the female at the water's surface (Merriman 1941). Each female probably finishes spawning within several hours (Lewis and Bonner 1966) shedding all of her eggs during a single spawning event (Hardy 1978). Spawning activity seems to be greatest at dusk and dawn, although 'rock fights' and newly spawned eggs may be observed at any time of the day or night (Setzler et al. 1980).

.4 Early Development

This section is divided into four subheadings: eggs, prolarvae (yolk-sac larvae), postlarvae, and juveniles. The material presented herein is largely descriptive; section 2.2.2 of this Appendix contains a more complete discussion of the physical and chemical features of the environment affecting survival at each of these stages. Primary sources for the material that follows were Hardy (1978), Westin and Rogers (1978), and Setzler et al. (1980).

Eggs Striped bass eggs are broadcast at the surface, but afterward may be found anywhere in the water column from surface to bottom depending upon current velocity and, to a lesser extent, salinity. At current velocities less than about 30.5 cm/second (Albrecht 1964), the eggs will concentrate near the bottom. The eggs are spherical, non-adhesive, and nearly transparent (Figure 7); they have a large perivitelline space and range in average size from 2.5 to 4.0 mm in diameter. Incubation times are highly dependent on the ambient temperature, ranging from 80 hours at 12.2C to 30 hours at 22.2C (Hardy 1978) (Table 4). Egg survival is adversely affected by low current velocities, high salinities, low levels of dissolved oxygen, soft substrates, temperature below about 11C or above 22C, high concentration of dissolved solids, extremely high levels of suspended sediments and rapid changes in temperatures.

A description of the immature eggs as they appear in the ovary is presented in this Appendix, section 2.1.3, under the heading 'Gonads'. Yolk begins to coalesce within the maturing eggs at a size of 0.16-0.30 mm (Lewis 1962). As ripening proceeds in the period just prior to the spawning season, the eggs enlarge from about 0.70 mm to between 1.0 and 1.50 mm (Lewis 1962; Raney 1952). There is a gradual shift in the eggs' color during this process; initially cream or creamy yellow, they become a yellowish green and then bright grass green as the time for ovulation approaches (Hardy 1978). There is no perivitelline space prior to the eggs' extrusion and water hardening. Unless released within 30-60 minutes after ovulation into the lumen of the ovary, the eggs may become "overripe" and lose viability. Stevens et al. (1964) believe this mortality of the ova is the result of hypoxia within the ovary; once separated from the ovarian tissues and parental bloodstream, the eggs have no direct source of oxygen until they are released into the water where sufficient oxygen is available.

After release but before water hardening, the eggs range from 1.25 to 1.80 mm (mean: 1.58 mm) in diameter (Mansueti 1964). During the first hour or two after fertilization, the rate depending on temperature, the chorion expands to create a large perivitelline space, which may account for 65-85% of the egg's diameter. Merriman (1941) suggested the large perivitelline space serves to protect the embryo from shock, increasing its chances of surviving the turbulence characteristic of striped bass spawning areas. Ryder (1887; cited in Setzler et al. 1980) believed the perivitelline space might function as a 'breathing' or respiration chamber.

Water-hardened eggs range from 1.30 to 4.6 mm in diameter (Hardy 1978), depending on the size of the female, the genetic stock from which they are derived and the salinities to which they are exposed. Size ranges for eggs taken from various spawning areas and stocks are presented in Figure 8. On the basis of unfertilized egg weights from striped bass representing three spawning areas, Rogers (1978) observed that larger females tend to produce larger (heavier) eggs. Rogers and Westin (1981) found that larger females produced eggs with a greater weight of yolk and oil and young produced from these eggs may be able to withstand food deprivation longer. Eggs spawned in a situation where salinities are high are typically smaller in diameter than those released in fresh water; the chorion's degree of expansion is a function of osmotic pressure. The specific gravity of striped bass eggs ranges from 1.0003 to 1.00065 (average: 1.0005) and appears inversely correllated with egg size (Albrecht 1964).

Fertilized eggs are spherical and non-adhesive; although bright green in color when first spawned, they become transparent and almost invisible as development proceeds. The yolk itself is lightly granulated, greenish or golden green, and ranges from 0.90 to 1.50 mm (mean: 1.18 mm) in diameter. There is a large, amber oil globule measuring 0.4 to 0.85 mm (mean: 0.61) in diameter, and occasionally several smaller oil globules as well (Hardy 1978). The chorion is clear, smooth, and relatively tough despite its thinness. Unfertilized eggs, by comparison, at 12 hours are opaque and more buoyant than developing eggs.

The average dry weight of whole, unfertilized striped bass eggs is 0.3 mg; of this, the chorion comprises 8.17%, the yolk 39.85%, and the oil globule 51.95%. The average caloric value of whole striped bass eggs is 8,031 cal/gm; comparative values of yolk and oil globule material are 5,745 cal/gm and 10,887 cal/gm, respectively (Rogers 1978).

Hardy (1978) presented a rather complete collection of line drawings showing striped bass eggs at various stages of development; a sampling of these are in Figure 6. The duration of the incubation period varies with water temperature, ranging from 80 hours at 12.2C to 30 hours at 22.2C (Hardy 1978). Table 4 presents data on incubation periods at various temperatures for eggs spawned in different areas. Setzler et al. (1980) presented a regression equation describing the relationship between ambient temperature and incubation time:

$$I = -4.60\,T + 131.6$$

where I = time to hatching, in hours, and

T = water temperature in C.

The temperature range for optimal egg survival has been variously reported as 16-23C (Morgan and Rasin 1973) and 15-18C (Rogers et al. 1977). In the range of temperatures normally occuring on the spawning grounds, the incubation period varies from 74 hours at 14.4C to 38 hours at 19.4C (Mansueti 1958). As the embryo develops, its tail separates from the yolk's surface and it may kick about as it floats free within the chorion.

Prolarvae (yolk-sac larvae) Upon hatching, striped bass prolarvae are long, slender, and tadpole-like (Figure 9); they remain essentially colorless and transparent throughout this stage. Nourishment is derived from the large yolk sac and large oil globule (Mansueti 1958, 1964), which is suspended under the forward half of the body. The amber oil globule initially projects at least past the anterior margin of the eye, and usually beyond the head as well. The size at hatching ranges from 2.0 to 3.7 mm, but averages about 3.1 mm (Mansueti 1964).

The rate of absorption of the yolk and oil globule, and thus the duration of the prolarval stage, is quite sensitive to small changes in temperature (e.g. 1.5-2.5C); it varies from 3 days to 23.9C to 6 days at 16.7-17.8C (Albrecht 1964). At the time of yolk absorption the prolarvae generally measure from 5.8-7.0 mm in length (Mansueti and Mansueti 1955; Westin and Rogers 1978.) Although the mouth first becomes evident 2-4 days after hatching at a length of 4.5-5.2 mm, the prolarvae generally do not begin feeding actively until 4-10 days old.

Early yolk sac larvae seem unable to swim continuously, thus requiring some turbulence in order to remain suspended in the water column. In still water they sink to the bottom during their periods of rest, where they may suffer hypoxia or become smothered in silt (Mansueti 1958a; Barkuloo 1970). At 2-3 days of age, however, prolarvae swim continuously and are able to maintain position within the water column (Doroshev 1970).

The following description of prolarvae and their development is extracted from Hardy (1978), who provides more detailed information for the interested reader.

Dorsal and ventral finfolds, the former extending anteriorly to the head, are evident throughout the prolarval stage. The precursor of the caudal fin is spatulate, and developing caudal rays are sometimes seen in prolarvae as small as 6.0 mm. The pectoral fins first become evident at about 4.4 mm, while their supporting rays usually are not noticeable until the prolarval are 6.0 mm long. The number of myomeres increases with age, ranging from a total of 17 initially to a maximum of 25. Of the total myomere count, 8 to 12 (average:10) are preanal while 9 to 15 (average:12) are postanal. Teeth first become evident when the prolarvae reach 3.3 - 5.8 mm, and may number 5 - 7 at a size of 5.8 - 6.5 mm (Doroshev 1970) or 1 - 5 at 6.2 - 6.7 mm (Mansueti 1958). Average proportions of various body measurements relative to the standard length (SL) are given in Table 5.

The eyes are unpigmented at hatching and remain so until about 4.4 mm (Pearson 1938). They are partially pigmented (gray) in prolarvae 4.5 -5.2 mm long, becoming fully pigmented (black) by about the fifth day, at a size of 5.5 - 5.8 mm (Doroshev 1970). Eye mobility becomes apparent about the 8th day at a length of 5.8 - 6.5 mm.

The major divisions of the brain can be clearly seen in prolarvae 4.5 -5.2 mm long. The intestine is clearly evident by the 2nd day, extending downward and back at a sharp angle immediately behind the yolk mass. By the 5th day the intestine has become distinctly folded and peristalsis can be observed. The air bladder is distinguishable as early as 3-4 days after hatching, at a length of 5.2 mm. Inflation of the air bladder occurs somewhat later, however, usually at 5 days or 5.5 -5.8 mm. Colorless or light orange blood cells are evident at 2 - 4 days (4.5 - 5.2 mm), becoming fully pigmented at 5 days (5.5 - 5.8 mm) (Doroshev 1970).

As noted earlier, prolarvae are essentially transparent throughout that state. Scattered melanophores are present at hatching, however, and are primarily associated with the oil globule and yolk sac. Orange chromatophores develop shortly afterward and may be found mixed with the melanophores. The eye is unpigmented initially. Toward the end of the prolarval stage, however, 3 separate pigment areas may be distinguished, which are characteristic of the species. As described by Hardy (1978), these are (a) a series of stellate chromatophores along the posterior two-thirds of the trunk and tail; (b) a heavy concentration of mixed melanophores and chromatophores along the gut, the upper and lower surfaces of the yolk, and the dorsal aspects of the peritoneum; and (c) another heavy concentration of pigment cells associated with the oil globule. Late in the prolarval stage the eye becomes a dark, shiny black.

Postlarvae and larvae The start of the postlarval stage is marked by the disappearance of the yolk-sac and initiation of active feeding. The size and age at which these events occur is variable, depending in large part on temperature; at 17C, the transition to active feeding occurs approximately 8 days after hatching at a larval length of 5.8 - 6.5 mm (Westin and Rogers 1978). Transformation or metamorphosis into post finfold larvae with well-differentiated fins occurs at 13.1 - 15.4 mm approximately 30 days after hatching at an ambient temperature of 24C or 40 days at 18C. In the latter case the size of the larvae at metamorphosis was more variable, ranging from 11.9 - 20.4 mm (Westin and Rogers 1978). The combined duration of finfold and post finfold larval stages is reported as 68 days at 15C, 33 days at 18C, 24 days at 21C, and 23 days at 24C (Setzler et al. 1980).

Larval striped bass initially feed only on small, mobile, pelagic planktonic forms. Toward the end of the larval stage, however, benthic forms such as Mysid shrimp and Chironomid larvae may also be taken (Doroshev 1970). The availability of large concentrations of suitable prey is critical at the onset of feeding; their early strike efficiencies are low, while energy expenditures for swimming are high prior to the air bladder's inflation. Westin and Rogers (1978) reported that newly feeding larvae, still carrying the oil globule at 7 mm SL, at 22C consumed 25% of their body weight in live *Artemia* nauplii; at temperatures of 18-24C, post larvae 8.4 mm SL required 200 - 300 *Artemia* nauplii per day for growth. Rogers and Westin (1977) found that postlarvae are relatively resistant to food deprivation in the laboratory and survived without food up to 22 (at 24C) or 32 (at 15C) days after hatching. However, starved larvae in the wild would be more susceptible to disease, predation and parasitism and probably would not survive (Setzler-Hamilton et al. 1981).

The body is quite slender initially but as development proceeds the relative depth increases. Table 5 presents data on the average proportions of various body measurements relative to the standard length (SL). Although striped bass are generally larger than white perch at similar stages of development, between 6.0 and 8.0 mm the larvae of the two are indistinguishable (Mansueti 1964). The following descriptions of the development of the internal organs, musculature, bony structures, and pigmentation are distilled from Hardy (1978); source references are noted where appropriate. The appearance and development of body parts is more a function of size than of age (Mansueti 1958a). Although inflation of the air bladder may be seen in 5-10% of postlarvae at the time they begin active feeding (about 5-8 mm or 4-8 days after hatching), it is normally delayed 1-3 days in the majority of postlarvae (Doroshev 1970). The stomach is well-developed by the 13th day (Scofield and Bryant 1926).

The total number of myomeres stabilizes after about 5 mm; they are no longer visible after about 13 mm when the larvae become opaque. The total number ranges from 23 to 27 but averages 25; of these, 11-13 (mean: 12) are preanal while 12-13 (mean: 13) are postanal. The vertebrae develop from anterior to posterior, eventually reaching a total of 25 of which 12 are preanal and 13 postanal.

After 6.2 mm the dorsal finfold no longer extends forward to the head; at 8.2 mm the entire finfold is greatly reduced, and at 9.0-12.5 mm has become divided into three distinct regions. At 7-8 mm the anterior dorsal spines and about 1/3 of the soft dorsal rays are evident; the former are still quite rudimentary at 13 mm. At 12-20 mm, the soft dorsal fin is complete, but the full complement of dorsal spines is not present until about 24 mm. The anal fin is first evident at 7 mm, its rudimentary spines and rays at 9 mm, and 2 of the eventual 3 spines at 10-15 mm. The anal fin's full set of rays and spines is established by about 20 mm. Although the pectoral fin buds are discernible at a larval length of 5 mm and their incipient rays by 6 mm, the full complement of 16 rays does not appear before about 30 mm. The pelvic fins are the last to develop, their buds observable at 10-14 mm and their total rays by about 24 mm.

The early larval teeth are slender, conical, and recurved. They develop first on the mandible at a size of about 6 mm, appearing later on the premaxillary at larval sizes of about 8 mm. The mandibular teeth are slightly more numerous than those of the maxillary; the former increase from 6 to 72+ as larval length increases from 8.2-22.0 mm, while the latter multiply from 5 to 66+ over that same period. By about 12 mm, the teeth of both jaws are arranged in two rows (Mansueti 1958a).

At the size of about 12 mm, three poorly defined spines may be seen on the preopercle. In larger individuals these are more numerous, but smaller. The branchiostegal rays first become apparent at a length of 7 mm, with the full complement developed at 8 mm. The upper rays are the first to become ossified. Gill rakers may be easily observed in some specimens but in most cases are too difficult to enumerate reliably. The size at which scales are first seen may vary considerably. Although reported for speciments as small as 10 mm, generally the first scales appear at larval sizes of 20-21 mm (Mansueti 1958a).

Pigmentation varies between individuals, but in all it increases in intensity as development proceeds; at 10-16 mm the larvae become translucent to opaque to the extent that the myomeres are no longer visible. At 22-35 mm the larvae are light gray overall; although all areas are pigmented, there are concentrations on the back, head, and fin bases. At 25 mm, small melanophores covering the body give a diffuse spotted effect, while at 30 mm the abdomen is noticeably less pigmented relative to the rest of the body and fins (Mansueti 1958a). However, evidence of the lateral stripes characteristic of the species is not apparent before about 38 mm (Pearson 1938) or 50 mm (Westin and Rogers 1978).

Juveniles By the time they reach 30 mm (Westin and Rogers 1978) or 36 mm (Raney 1952), young striped bass have acquired most of the features of adult fish and are considered juveniles. At this time, at least 3-4 weeks after hatching, the body is well covered with scales and the fins and fin rays are fully developed. During this stage, which normally covers the first two years of life prior to attaining sexual maturity, juvenile striped bass generally remain on or near the nursery areas where they were spawned. Body proportions for juvenile striped bass fall in or near the ranges reported earlier for adult fish (see section 2.1.2 of this Appendix). The gill raker count averages 24.48 in juvenile striped bass of Chesapeake origin and 24.51 for fish from Albermarle Sound (Mansueti 1958a). Early in this stage, however, the pigmentation consists primarily of numerous small black dots which cover the entire body. In addition, large chromatophores may be found on the top of the head. Pearson (1938) reported that 9 oblique, V-shaped lines may be observed along the lateral line; according to Raney (1952), these are probably blood vessels. By a size of 46 mm, some 50-60 days after hatching, the sides have become silvery, and by 50-80 mm there appear 5 or 6 well-developed longitudinal stripes along the sides. In addition to the stripes, there are 6-10 ill-defined vertical bars, which persist at least faintly into the second year (Westin and Rogers 1978). Also noticeable at 50-80 mm is a heavy stippling of fine dots on the dorsal and caudal fins (Pearson 1938).

Differentiation of gonadal tissues occurs at a size of 130-150 mm FL, sometime between the winter of the first year and the summer of the second (Shubart and Koo 1973). Sexual maturity is generally reached at

2-3 years of age for males and 3-6 years for females. The maturation process is duscussed in more detail in section 2.1.3 of this Appendix, Reproduction.

At a size of 50-80 mm, some 80-90 days after hatching, striped bass fingerlings are very mobile and exhibit definite schooling behavior. Initially, young striped bass feed almost entirely on invertebrates. During their second summer (Doroshev 1970) they begin including small fish in their diets, and by the following fall are eating fish and invertebrates in about equal number. By their third year they have become predominantly piscivorous (Westin and Rogers 1978).

.5 Age and Growth

The age of striped bass may be determined by 1) counting the annuli or growth rings on the scales; 2) studying the distribution of length frequencies in large samples; 3) counting growth bands in the otoliths; and 4) counting growth bands on the opercle or preopercle. Scofield (1931) found all four methods roughly comparable, and capable of determining the age of striped bass up to 8-10 years old with fair accuracy. As a matter of convenience, however, the scale method is most widely used. It's basis is the counting of annuli or growth rings formed on the scales when the fish resume growing in the spring after a period or dormancy during the winter. The problems with using length-frequencies are the large sample sizes required and the overlap in sizes between fast-growing members of one age-class and slow-growing members of the previous age group. Scofield (1931) found that studies of the otoliths yielded the same results as scale analyses, or counting the annual markings discernible on the preopercular and opercular bones after clearing. However, the effort and expense required by these techniques and the fact that the markings past age 3 become irregular and indistinct (Merriman 1941) places them in disfavor compared to the simpler, more accurate, scale method.

In conjunction with their value as relatively accurate indicators of age, scales may also be used to 'back-calculate' the sizes of the fish at the time each annulus was formed, thus providing valuable information about growth rates. Merriman (1941) determined that the growth of scales could be considered proportional to the growth of the fish for striped bass 10.6-67 cm long. In Table 6, Westin and Rogers (1978) summarized data comparing the growth of striped bass from various areas. Growth rates of striped bass are variable, depending on a combination of the season, location, age and competition. Vladykov and Wallace (1952) reported that there is little growth during the winter, that April usually marks the resumption of growth, and that small striped bass accomplish almost 50% of their yearly growth between late April and early July. Growth rates for the young-of-the-year ranged from 0.272 to 0.433 mm per day between June and November in Albermarle Sound (Trent 1962). In the Hudson River the greatest growth rates for young of the year occurred in June and July (Rathjen and Miller 1957). Texas Instruments (1976a) reported instantaneous growth rates in the Hudson River (based on weight) ranged from 0.0311 to 0.047 during July and August and 0.0145 to -0.0157 for October and November. Even within the same river system, growth rates may vary between locations. Chadwick (1966) observed that young-of-the-year and yearlings from the lower Sacramento-San Joaquin Rivers achieved greater total length than fish from the upper sections. Rathjen and Miller (1957) reported similar findings in the Hudson River. This may simply be due to a downstream movement of slightly older bass or the result of better feeding opportunities in those areas.

Growth (in length) is more rapid during the second and third years of life, before reaching sexual maturity, than during later years. Merriman (1941) observed that striped bass of the 1934 year class showed their greatest growth during the 3rd year (Table 7), at which age migratory movements begin. Thereafter the rate dropped sharply at age four and remained nearly constant at 6.5-8.0 cm per year up to about age 8. The growth rate probably decreases even further after the 8th year.

Prior to maturity, male striped bass grow at a slightly faster rate than females. Although the growth rate of both sexes are reduced after maturation, female striped bass grow in length at a faster rate than males and weigh more than males at any given length. Large striped bass, which may reach as much as 125 lbs (Tresselt 1952), are almost exclusively female; the largest male reported in Hudson waters was 85 cm FL (Schaefer 1968). Figure 10 presents data relating age, length, weight, and sex of striped bass.

Merriman (1941) noted that striped bass of the 1934 year class were smaller in average size than fish of the previous and following year classes. He suggested that this may be attributable to competition for food among the many members of that year class, although environmental factors such as the relatively low spring and summer temperatures in 1934 may have been a factor as well. The fish he sampled were later observed to grow at an accelerated rate, which he suggested may have been an example of the "compensatory growth" phenomena but was probably the result of greater food availability at the time. Compensatory growth, in which the smaller fish in a year class, growing at an accelerated pace, reduce or eliminate the size differences between themselves and other larger members of that age group, has been shown to occur in age 2 striped bass in Chesapeake Bay (Tiller 1942) and in age 2 and 3 fish from Albemarle Sound (Nicholson 1964).

.6 Migratory Behavior

Striped bass stocks along the Atlantic Coast can be broadly classified into southern riverine, northern riverine, and Middle Atlantic migratory.

The southern riverine stocks are within several rivers south of about Cape Hatteras and they rarely, if ever, migrate out of their natal river systems. Northern riverine stocks live their entire lives within various river systems north of the United States - Canadian border.

After many years of fish tagging studies, examination of commercial catch records and analysis of recreational fishing creel census data, it is well documented that Middle Atlantic migratory striped bass make seasonal movements of considerable magnitude. Recruitment to this migratory portion is from various stocks spawned and developed in rivers and estuaries along the Atlantic coast. The major spawning areas which contribute to the coastal migratory stock are the tributaries of the Chesapeake Bay and the Roanoke and Hudson Rivers. An estimate of each area's relative contribution to the coastal stock in 1975 was made by Berggren and Lieberman (1978). Their study showed a contribution to the coastal stock of 6.5% from the Hudson, 90% from the Chesapeake, and 2.7% from the Roanoke. While it is recognized that the 1975 Berggren and Lieberman study was influenced by the presence of the dominant 1970 Chesapeake year class, their basic conclusions, that the Chesapeake stock is the major contributor to the Atlantic coast striped bass fishery from southern Maine to Cape Hatteras, North Carolina and a major contributor of legal sized striped bass in the western Long Island Sound and New York Bight, are sound. Schaefer's (1968) tagging studies showed the abundance of striped bass inhabiting the southern Long Island surf area was directly dependent upon the contribution of Chesapeake Bay fish. The relative percentage contribution of Hudson River fish to coastal stocks will vary with the relative abundance of Chesapeake Bay bass (Klauda et al. 1980).

A basic pattern is evident for striped bass spawned in the Chesapeake Bay. Their migration is strongly dependent on age, sex, and degree of maturity. Fish less than two years of age generally do not undertake coastal migration. Approximately 50% of the three year old females migrate and smaller proportions of the two and four year females migrate. However, few males of this age join this coastal migration (Kohlenstein 1981). As a result, the sex composition of these young migratory fish approaches that of the coastal stock in northern waters where 90% of all captured fish are female (Bigelow and Schroeder 1953).

Generally the migrating Chesapeake population moves northerly along the coast in early spring, along the south shore of Long Island in May and June, and some continue up the New England Coast. Larger, older Chesapeake fish may make the most extensive northward migration (Mansueti 1961). These migrating bass are intensively fished off southeastern Long Island, Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine (Setzler et al. 1980). In the fall these migrants move southward and overwinter in deeper coastal waters from New Jersey to North Carolina (Kohlenstein 1981). In the spring, mature females move to their natal rivers to spawn, while immature fish remain downstream of the spawning areas (Jones et al. 1977). Since not all migratory mature females spawn each year, those which do not spawn remain in coastal waters along with migratory immature females.

Schaefer (1968), Raney et al. (1954), Alperin (1966) and Merriman (1941) determined that the basic migratory patterns of Hudson River striped bass are similar to those of the Chesapeake Stocks. Many Hudson River fish will begin a northerly migration after spawning while others apparently stay within the river. Much of the Hudson River information was gained from tagging of mixed Atlantic coast stocks in New York waters and Hudson

River spawned fish were not readily distinguishable. McLaren et al. (1981) tagged a total of 5,219 striped bass on or near the Hudson River spawning grounds in 1976 and 1977. Tag recoveries indicated that the majority of Hudson River fish are confined to the Hudson River estuary and Long Island Sound. Few recaptures were made from Massachusetts, Southern New Jersey and Delaware.

In contrast to the Chesapeake Bay stock, there appears to be no correlation between age and size and the distance traveled. Hudson River males will migrate as readily as females (McLaren et al. 1981). In the late fall and winter prespawning striped bass of mixed ages enter the Hudson to overwinter. Larger fish move into the river in the spring and may overwinter elsewhere. In the spring and summer there is a migration into Long Island Sound of Hudson fish from the west and Chesapeake fish from the east (Austin and Custer 1977). The stocks mix on the Long Island summer feeding grounds and Chesapeake fish migrate out through the eastern passage in the fall. The preponderance of female striped bass in the Long Island Sound and the New York Bight summer population is evidence that the female dominated Chesapeake stock is more abundant than Hudson stock in these areas (Merriman 1941; Schaefer 1968).

In the Roanoke River, North Carolina during the latter week of March and the first weeks of April, male striped bass ascend to the spawning grounds in fresh water near Weldon, North Carolina. Females follow in latter April and May and spawning occurs in Mid to late May (Trent and Hassler 1968). After spawning, adults of both sexes return to the feeding grounds in Albemarle Sound and coastal waters.

Trent and Hassler (1968) concluded that the migratory population in the Roanoke River is relatively restricted to Albemarle Sound and adjacent coastal waters. There appears to be some segregation of sizes of bass within North Carolina waters with smaller fish inhabiting the Sound. Chapoton and Sykes (1961) considered them resident. It may be that the Sound population is premigratory young fish. However, tagging of large striped bass from North Carolina waters by Chapoton and Sykes (1961) showed a northerly migration of large bass. Berggren and Libberman (1978) found that in 1975 North Carolina bass made up 2.7% of the coastal stock. This percentage will vary yearly with the relative year class strength of each spawning population's contribution to the migratory stock. Merriman (1941) believed the southernmost extent of the coastal migratory stock was Chesapeake Bay and that northern stocks did not mix with Cape Hatteras stock. However, Holland and Yelverton (1973) hypothesized that the inshore zone of the coast from Cape Henry, Virginia to Cape Lookout, North Carolina serves as the wintering ground for a large percentage of the coastal migratory stock. This wintering group is composed of Chesapeake Bay, Albemarle and Pamlico Sounds, and New Jersey-north populations.

Migratory patterns of striped bass stocks have important fishery management implications. Knowledge of the origin of the stocks, percent of contribution from each area to the coastal stock and seasonal movements as they relate to levels of exploitations, will aid in the formulation of regulations.

By understanding the differences in migratory patterns and fishing pressures on certain age groups and sexes, regulations could be more specifically structured so that all striped bass stocks may be optimally exploited (McLauren et al. 1981).

.7 Ecological Relationships

The migratory and spawning behavior of the striped bass is an adaptive behavior which maximizes the species survival potential. The spring season marks the beginning of very high levels of primary and secondary productivity which can support the energy demands of great numbers of young fish of all species which are produced seasonally. Migration out of the Chesapeake Bay of most of the spawners and a large proportion of the sexually immature females (Kohlenstein 1981) insures that intraspecies competition in the nursery grounds will be reduced and that an adequate food supply will be available for the development of juveniles. A large proportion of the spawners in the Hudson and Roanoke Rivers also leave the nursery areas. In discussing the difference between migratory behavior of Chesapeake and Hudson stocks McLaren et al. (1981) stated that "... the Chesapeake population which appears to be considerably larger than the Hudson population may better be able to support extensive migration." In an ecological sense, this could perhaps be better stated as: The Chesapeake population is considerably larger than the Hudson population because Chesapeake stocks have adapted to undertake extensive migrations which reduces intra-species competition.

The northward summer post-spawning migration of the Chesapeake Bay striped bass stock coincides with the northward migration of adult menhaden (*Brevoortia tyrannus*) (Nicholson 1971). By mid-June, menhaden are distributed in coastal waters from Florida to Maine. In early September the menhaden move South until by January the majority of the population is again south of Cape Hatteras. This southward migration also corresponds with the striped bass southward migration.

Menhaden are one of the preferred food items of striped bass and it is possible that striped bass have evolved this migratory behavior partly in response to menhaden movements. Striped bass eat a range of invertebrate and vertebrate prey; however, menhaden constitute a large part of the diet. Holland and Yelverton (1973) found menhaden were the most frequently occurring single species of fish in stomachs of large (455-1110 mm) striped bass from North Carolina coastal waters. Dovel (1968) found menhaden to be an important food of overwintering striped bass in Chesapeake Bay.

Merriman (1937) listed silversides, menhaden and shrimp as being common food items of the April - October, 1936 collection of 250 striped bass from Connecticut waters. Hollis (1952) found the summer and fall diet of Chesapeake Bay striped bass was primarily anchovy and menhaden and that striped bass larger than 500 mm did not show any marked difference from smaller bass in food preference. He postulated that seasonal within Bay movements may be governed by food item availability and migration. In contrast to these investigators who found that striped bass were primarily piscivorous, Schaefer (1970) found striped bass caught in the Long Island surf fed primarily on invertebrates. Johnson and Calhoun (1952) found California striped bass fed heavily on shrimp (Neomysis and Crago sp.). They questioned whether these small organisms could be a major food for large striped bass.

Given the striped bass' wide ranging food habits, the migratory nature of the adults may be an adaptation to take advantage of seasonal high pulses of available food along the coast and to reduce competition within the nursery areas.

Bluefish (Pomatomus saltatrix) migrations follow the pattern of both menhaden and striped bass and bluefish are probably a formidable competitor with striped bass. Richards (1976) found squid, anchovy, menhaden and butterfish to be the most common items in the diet of Long Island Sound bluefish. Lack of invertebrate prey other than squid may indicate some niche separation between bluefish and striped bass which allows the two species to coexist on the coastal feeding grounds.

The weakfish (Cynoscion regalis) also have comparable coastal migratory habits spatially and temporally, although their spawning takes place in the near-shore and estuarine zones along the coast. Their diet preferences also overlap those of both bluefish and striped bass.

Despite the presence of large numbers of bluefish, weakfish and many other competing species on the coastal feeding grounds, there is no evidence that fluctuations in abundance of any one species have affected levels of the other. The bluefish has increased in abundance on the Atlantic coast from 1967 through 1978 (Anderson and Almeida 1979). Weakfish have increased in abundance (as measured by commercial catch in the Chesapeake Bay) consistently from 1965 through 1974 (Rothschild et al 1981). During this period of increase of these two species, striped bass produced dominant year classes in 1964, 1966, and 1970 in the Chesapeake Bay (Boone and Florence 1976) and record high catches.

The larval stage is the critical period in the life history of the striped bass. Survival during this stage determines the number of fish which will be recruited into the fishery (Polgar 1977). Factors controlling larval survival may be density dependent factors such as cannabalism, predation and competition with other species in the nursery area (Christensen et al. 1977). Competition for food and space may be less important than the effects of density-independent food availability that is primarily a function of environmental conditions controlling the prey.

The spawning and nursery areas of the striped bass in the Chesapeake, Hudson and Roanoke are shared by large numbers of anadromous blueback and alewife herring, American and hickory shad and semi-anadromous white perch. Young of year blueback herring fed heavily on adult copepods in the James River (Burbidge 1974). Selective predation on larger copepods is apparently heavy enough to change the population structure of the zooplankton community. Carr and Adams (1973) stated that simultaneous occupancy of seagrass beds by the juveniles of many species poses some important problems with regard to partitioning of food reserves.

As striped bass larve begin to feed, at about 7 days after hatching, the availability of suitable zooplankton prey in sufficient quantity may be the controlling factor in survival of the larvae (Setzler-Hamilton et al. 1981; Kernehan et al. 1981). The growth and distribution of these prey is dependent on such environmental factors of water temperature, salinity, detrital food sources and current patterns. The availability of the prey to first feeding larvae will depend upon the non-swimming larvae being spawned in or near these food sources. In the Potomac, striped bass larvae positively select larger cladocerans and copepods (Beaven and Mihursky 1979) which may have patchy distributions. Eldridge et al. (1981) concluded that striped bass larvae need food densities greater than 100,000 per cubic meter of water in order to initiate first feeding. Prey densities could well be affected by the numbers and feeding rates of other species of fish although this question has not yet been addressed. The importance of other larval survival factors, such as a sudden lethal decrease in water temperature (Dey 1981, Kernehan et al. 1981), relative to prey density importance can be defined by further research.

Striped bass apparently are a species geared to persistence rather than maximum production (Ulanowicz and Polgar 1980). By releasing a large number of eggs over a wide area of river and a protracted period, the species insures that some of the eggs or larvae will develop in waters of optimum conditions. This is not very efficient in the short term and results in the cyclical swings in adult populations but it is efficient in perpetuating a species which spawns in the productive but annually variable upper estuary. Boynton et al. (1981) considers the nonselective feeding strategy of juvenile striped bass to be further evidence of a species geared to persistence. Once the critical larval feeding stage is passed, juvenile striped bass are able to feed successfully on a wide range of food items in a broad range of habitats. This adaptability is further illustrated by the development of reproducing freshwater populations from estuarine parent stocks. The current downturn in striped bass population levels may be a natural occurrance but, given the changes in water quality in the spawning and nursery areas and the fishing effort directed toward the species, it is best to adopt a resource conservative approach and not rely entirely on the natural resilience of the species to rebuild the stocks.

8.B.2.2.1 Habitat Requirements

.1 Spawning Habitat

Spawning areas are fresh to brackish waters and, if tributary to a saline estuary, located within the first 25 miles of freshwater in the river. Salinities range from 0 - 1 ppt (Turner and Farley 1971) to 0 - 5 ppt (Tresselt 1952). Hollis (1967) found eggs in waters of 10 ppt. They, however, probably had drifted down from upstream freshwater spawning areas. Like many anadromous fishes, striped bass captured in the more saline lower reaches of an estuary may appear ready to spawn but the actual event probably occurs only after the fish reach freshwater (Raney 1952).

Although striped bass spawning areas are characteristically turbid, there is probably no positive relationship between reproductive success and silt load. Mansueti pointed out that the striped bass egg is preadapted to silt-laden and turbid waters. The spawning period corresponds with high spring runoff periods and spawning reaches are areas where some degree of natural turbidity would be expected. Schubel et al. (1973) found, in the laboratory, fine grained suspended sediments in concentrations of up to 500 mg/l did not significantly affect the hatching success of striped bass eggs, but concentrations of 1000 mg/l did have a negative effect. Survival of larvae of striped bass was significantly decreased by sediment concentrations of 500 mg/l (Auld and Schubel 1974). Concentrations of suspended sediment as great as 500 mg/l are relatively rare in the environment for an extended period. It is doubtful that turbidity is a requirement or that if turbidity is lessened, it would be detrimental.

A necessary condition for successful spawning is a current or tidal flow of sufficient velocity to keep the semibuoyant eggs suspended in the water column (Albrecht 1964). In many spawning areas, egg deposition is centered in rocky areas near the fall line, many miles upstream; the Roanoke River is a good example. The water flow in such areas is quite turbulent, and the eggs produced by the local stocks are characteristically smaller and less buoyant than those of some of the Chesapeake Bay stocks. In the Chesapeake region, spawning is generally concentrated in the upper reaches of the major tidal tributaries; the substrate is mostly sand or mud. Eggs spawned in these areas are kept in suspension through the action of the tides in combination with spring runoff. Since the turbulence produced by these forces is less violent than that found in a river like the Roanoke, the eggs of Chesapeake striped bass tend to be larger and more buoyant. The Hudson River spawning area is quite similar to the Chesapeake spawning rivers (Klauda et al. 1980; Dey 1981).

Water temperatures conducive to spawning range from 10.0 to 25.0 C. However, spawning generally does not commence until the temperature reaches 14.4 C; peak activity occurs between 15.6 C and 19.4 C, declining to a halt as the temperature approaches 21.1 to 22.2 C (Hardy 1978). An uninterrupted, steady rise in water temperatures during the spring contributes greatly to reproductive success. Storms or periods of cold weather may cause sudden drops in water temperatures and temporarily halt spawning activity. Early larval stages of striped bass may be particularly susceptible to such aberrations (Hollis 1967; Kernehan et al. 1981).

.2 Early Development

Doroshev (1970) reported that developing striped bass eggs should be maintained suspended in the water. The specific gravity of swollen striped bass eggs averages 1.005, which is close to the specific gravity of fresh water. Even a slight current will keep the eggs suspended. Under experimental conditions, the yield of larvae from eggs incubated in a suspended state was between 38 and 93%, while the yield from eggs lying on the bottom was between 0 and 27%. In the natural spawning grounds of the striped bass, flow rate is between 0.1 and 1.5 m/sec. It is assumed that the optimum flow rate for egg development should be at least 0.3 m/sec (Albrecht 1964).

Striped bass eggs and larvae have a comparatively narrow temperature range. Under experimental conditions an 85% yield of larvae is observed when eggs are incubated at a temperature of between 14.4 and 22.8 C (Albrecht 1964). The optimum range for survival appeared to be 16-19 C (61-66 F). Temperatures below 10 C (50 F) and above 23 C (73 F) are lethal. Morgan et al. (1981) found, in the laboratory, that temperature is more important than salinity in controlling hatching success and larval length at hatching. Optimal hatching temperature was found to be 18 C. The temperature range of young striped bass is considerably wider than that of larvae (Doroshev 1970).

The relation to water salinity is an important aspect in the life cycle of the striped bass. Since most of the spawning grounds of the striped bass are 10-50 km from the sea, the larvae and even the eggs in the late development stages are in or transported to the brackish water of estuarine areas (Tresselt 1952). Morgan et al. (1981) found that in the laboratory there is a significant interaction of salinity and temperature on hatching success and larval survival. Albrecht (1964) found that low salinities enhance egg survival while salinities over about 4.7% are detrimental to hatching success. The salinity tolerance range is greatly increased in young striped bass. Fish measuring 10 cm readily withstand a sharp alteration of salinity from fresh water to ocean water and back (Tagatz 1961).

Doroshev (1970) listed 5-8 ppm dissolved oxygen (DO) as optimum and 2-3 ppm DO as the minimum for the keeping of larvae and young. Turner and Farley (1971) found that survival of striped bass eggs is directly related to DO levels and that hatching time is longer with lower DO levels. Low DO levels from pollution have been responsible for the elimination of the striped bass spawning area in the Delaware River. The levels of DO in unpolluted spawning areas during spawning would range from 10.8 ppm at 12 C to 9.2 ppm at 20 C (assuming 100% saturation).

.3 Adult

The striped bass is definitely coastal in its habitat and is seldom found more than several miles from shore. Bigelow and Schroeder (1936:333) mentioned the unusual capture of a six pound fish in a gill net on Cod Ledge, 3 or 4 miles off Cape Elizabeth, Maine in 1941. Schroeder also reported the unusual offshore capture of a striped bass about 18 inches long some 70 miles south of Block Island in 70 fathoms of water. According to Schroeder, this was a stray, since the fishermen could not recall having taken another during five years on the offshore fishing grounds. Other departures from the strictly coastal habitat of this species occur during the spring and fall migrations when, for example, the fish cross the open (east) end of Long Island Sound.

The striped bass is at home in salt, brackish, or fresh water. Its extreme adaptability is evident by the now extensive process of stocking the species in freshwater reservoirs all over the United States (Setzler et al. 1980) and establishment of reproducing populations in some.

Except for eggs and larvae, salinity does not seem to be a critical factor. The range of salinities that the fish must pass through in its coastal migration is evidence of this. There is some evidence (Loeber 1951 in Talbot 1966) that juvenile striped bass physiological processes adapt more readily to abrupt transfers from fresh water to salt water than transfers in the other direction. In the East Coast habitat, sharp salinity gradients which might constitute an acutely stressful situation or barrier to movement probably do not exist.

The species can stand low temperatures as evidenced by its existence in Nova Scotia, New Brunswick, and in the St. Lawrence River. Although most of the population appears in the spring and disappears in the fall off the Niantic River, Connecticut, when the water is 6-7.5 C (42.8-45.5 F), it is well known that some fish winter in southern New England estuaries, and netters have been able to take them through the ice in most rivers from New Jersey northward. Off North Carolina, schools have been found moving first when temperatures were 7-8 C (44.6-46.4 F). The majority of striped bass overwinter in deep holes or channels in bays, estuaries, delta regions, or in rivers (Talbot 1966). Murawski (1969) observed bass overwintering in deep areas out of the main current in the upper portion of several New Jersey streams. They remained tightly schooled and moved little when water temperatures were 1 C or less.

Talbot (1966) concluded in his review of environmental factors affecting striped bass that a continued 4 ppm dissolved oxygen (DO) concentration may be too low for continual striped bass production. DO levels below 50% of saturation in certain areas of the Rappahannock River was enough to exclude striped bass from these areas (Massman et al. 1952). The importance of adequate DO to adults is demonstrated by past experiences with excessive oxygen demanding wastes in the Roanoke River (Trent and Hassler 1968) and Delaware River (Chittenden 1971) which resulted in fish kills and habitat elimination.

8.B.2.2.2 Environmental Impacts

.1 Physical

The contributions of at least two spawning areas, of great importance in the past, have been reduced to a fraction of their former magnitude as a result of human modifications of the environment. In earlier times the Susquehanna River may have been the greatest single spawning area for striped bass in the Chesapeake Bay (Dovel 1971). Striped bass were occasionally caught upstream from Berwick, Pennsylvania (river mile, r.m., 160) prior to the construction of feeder dams, and were abundant downstream from Columbia, Pennsylvania (r.m. 43) in the late 1800's (Carlson 1968). Mansueti and Kolb (1953), in their historical review of the shad fisheries of North America, blame the construction of numerous dams for the decline of the Susquehanna River shad fishery; striped bass were similarly affected. By 1820, mill dams prevented the shad from reaching Binghamton, 318 miles from the river's mouth, which was about the northernmost extent of the fishery. Dams were established at Nanticoke, Columbia, Safe Harbor, Middletown, and Duncan's Island between 1830 and 1890 during the active period of canal building; the last three of these have disappeared, however. In 1896, there were major dams at Columbia, Clarks Ferry, Sunberry, and Nanticoke, as well as numerous small dams located between Nanticoke and the New York state line and on the West Branch. The installation of several large hydroelectric facilities on the lower river eliminated what remained of the shad fisheries. The Yorkhaven Dam, completed in 1904, blocked access to the Harrisburg area. Once the Holtwood structure began operations in 1910, only the first 26 miles of the river remained as a spawning area; the Conowingo Dam (1928) reduced this to 10 miles. The latest of the large hydroelectric facilities, Safe Harbor, was completed in 1932; located above the two large dams just mentioned, it had no further effect on shad migrations. Although a fishway was provided at the Holtwood Dam, there was no evidence of its use by shad. No fishway was provided at the Conowingo Dam "primarily because federal and Maryland authorities stated that a successful fishway for shad did not exist" (Mansueti and Kolb 1953). While only 10 miles of the lower Susquehanna River remain as a viable striped bass spawning ground, the northernmost portion of Chesapeake Bay is still considered the most important single spawning and nursery area for this species. Spawning is now concentrated in the Upper Bay between Turkey Point and Worton Point and in the Northeast, Elk, Bohemia, and Sassafras Rivers (Kernehan et al. 1981; Dovel and Edmunds 1971). With the removal of the last lock in 1927 and its widening and deepening in 1973, the Chesapeake and Delaware Canal has become a significant additional spawning area in the head of the Bay. According to Dovel and Edmunds (1971), the area of greatest egg abundance extends from Worton Point, on the Bay proper, to Chesapeake City on the C&D Canal. Enlargement of the canal may have contributed to increased flushing of spawned eggs and larvae into the high salinity waters of Delaware Bay. These saline waters are lethal to the young (Kernehan et al. 1981).

In the past, the Delaware River and its New Jersey tributaries were another important striped bass spawning area (Chittenden 1971). By the late 19th century, however, municipal and industrial wastes associated with intensive human development between Trenton and Wilmington had severely reduced the river's water quality. Especially critical are the levels of dissolved oxygen, which from May through September may be reduced to as little as 0 ppm in the section of the river between 65 and 105 miles above its mouth. The result is a 40 mile-long barrier to the upstream spawning migrations of anadromous species such as striped bass and shad, and to the downstream migrations of their young. Significant runs of American shad have been reestablished in the Delaware River in recent years; however, the life history characteristics of that species may be better suited to present environmental conditions there. Large runs of striped bass could be restored to the Delaware if pollution of the river was reduced (Chittenden 1971).

The effects of proposed and existing power plants in striped bass spawning and nursery areas in the Potomac and Hudson Rivers and the Chesapeake and Delaware Canal were the subject of three large scale studies from which much recent striped bass data has been derived (Jones et al. 1977a, 1977b; McFadden 1977; Warsh 1978).

Discharge of heated cooling waters, discharge of cooling waters with biofouling control chemicals, entrainment of egg and larval stages and impingement of juveniles on water intake screens are the detrimental factors associated with plants using natural waters for cooling. Chadwick (1974) concluded that water temperature of about 32.2 C began to produce mortalities of greater than 50% in striped bass. Loeber (1951) reported the maximum upper temperature tolerated by striped bass juveniles was 35 C. Chlorine is used to control biofouling in cooling water lines and there is often a toxic residual in the discharged water. Middaugh et al. (1977) found that no striped bass embryos exposed to a total residual chlorine concentration (TRC) of 0.21 mg/l hatched. Only 3.5% of the embryos exposed to 0.07 mg/l TRC and 23% of those exposed to 0.01 mg/l hatched. Many of the larvae hatching from these eggs were deformed. Adult and juvenile fish may avoid potentially lethal concentrations. Twenty-four -day old striped bass larvae avoided TRC concentrations of 0.79-0.82 and 0.29-0.32 mg/l but did not avoid potentially lethal concentrations of 0.16-0.18 mg/l TRC (Middaugh et al. 1977).

Impingement is the trapping of weakly swimming organisms on screens that cover water intakes. Survival of impinged fish is usually very low. A variety of screen designs, traveling screens, intake locations and intake velocities have been designed to reduce both impingement and entrainment mortalities. Eggs and larval stages do not have the ability to avoid intake currents. Kerr (1953) concluded that striped bass smaller than 28 mm would have a higher rate of survival if allowed to pass through the power plant cooling system rather than being stopped by impingement on a 5 mm mesh screen. The velocity of the intake current is a prime factor in determining species and life stage impingement. Skinner (1974) found 90% of larval striped bass 12-15 mm able to avoid impingement at velocities of 0.2 foot per second for six minutes or less. Ninety percent of juvenile striped bass 40-50 mm were able to swim for up to six minutes at velocities not exceeding 0.8 foot per second. However almost all fish of this size range were impinged at velocities over 1.6 feet per second.

Entrainment is the incorporation of small organisms into the cooling water flow. Within the intake flow the organisms are subjected to mechanical damage, thermal shock and chemical exposure. Coutant and Kedl (1975) found that in a single passage through a typical power plant condenser tube, mechanical damage of two week old larvae appeared to be minimal. No synergistic effect was apparent between thermal and mechanical effects. In tests simulating pressure changes which would result from entrainment in a pumped storage system, reductions in survival for eggs and larvae ranged from 20% to 80% (Beck et al. 1975).

For the proposed Douglas Point plant in the Potomac River it was predicted that the most probable yearly entrainment loss of striped bass spawn in the Potomac would be 0.6%; it was unlikely to exceed 1.2%. This translated to a most probable yearly loss of approximately 0.6% of the surviving Potomac River spawn or 29,000 pounds of adult fish. The consequences could possibly be less through biological compensating mechanisms (Moon 1976). Conditional mortality rates of young-of-year striped bass due to the operations of seven power plants on the Hudson ranged from an estimated mean of 17.3 to 19.9% (Table 11 and Figure 11 information supplied by Ronald J. Klauda, Johns Hopkins - Applied Physics Lab).

From the Hudson River studies Klauda et al. (1980) noted that "although power generation on the Hudson increased exponentially during the 1970's we, (Texas Instruments Inc.) have not seen evidence that losses of young striped bass via entrainment and impingement at power plants are related to variations in year class success, either because power plant effects are not important, have not been manifested yet, or are being swamped out by larger variations in the natural environment." This large natural environmental variation in both abiotic and biotic factors is a root cause of many of the uncertainties in assessing impacts and judging the relative impacts between different kinds of environmental disturbances. The variability in the baseline data on impingement rates of white perch (*Morone americana*) in the Hudson is so great that (a) 10 additional years of indices of year class strength are not likely to provide a very powerful data set for detecting actual substantial reductions in year class strength; and (b) a number of years greater than the 40 year lifetime of the power plants involved would be required to detect an actual 50% reduction in the mean index of year class strength (Van Winkle et al. 1981).

.2 Chemical

Striped bass require suitable levels of DO, salinity and pH for successful spawning, egg development and hatching and larval and juvenile development. The optimum and tolerated ranges throughout the early life history stages for these parameters are shown in Table 8. In addition to these regularly measured parameters of the natural environment, the organism requires an enviroment relatively free of chemical substances which either alter these critical parameters or interfere with the organisms physiological processes.

Striped bass spawn and the early life stages develop in the lower reaches of coastal rivers. These watersheds are highly developed with large amounts of agriculture, urban development or industry. Point and non-point source pollution by a variety of metals and organic and inorganic chemicals are the results of this development. The tolerances of bass larvae and juveniles to a variety of chemical substances were summarized by Westin and Rogers (1978) and are reproduced here in Tables 9 and 10.

Most of the results are reported as the concentration of substance which was lethal to various life stages. These results can be misleading as the substances may produce undetected chronic effects at sublethal doses. A chemical cannot always be judged totally safe simply because it did not kill at concentrations found in the enviroment. Synergism is the reinforcing of the effects of one chemical in the presence of another, perhaps unrelated, chemical. These synergistic actions are quite difficult to document in the field or to reproduce in the laboratory. In fact, given the variety of substances which end up in the water from both point and non-point sources, chemical effects in the environment may be seen as multiple, singular or synergistic stresses.

There is no direct evidence that chemicals introduce into the environment have been responsible for the decline of the Atlantic coastal migratory stock. Toxic chemicals may have been involved in the loss of the original striped bass populations on the Gulf coast, although no conclusive evidence is available to substantiate this. There is some evidence that toxic chemicals may be affecting striped bass populations in the San Francisco Bay-Delta estuary in California. Fish captured on spawning runs in 1978 were generally in poor condition and heavily burdened with pollutants and parasites (Eldridge 1980). Research during 1978-79 indicated that pre-spawning fish were damaged during their migration through the Bay and that the degree of damage was determined by interaction of the parental genotype with environmental stresses, including chemicals (Whipple 1979). High levels of zinc (up to 90 parts per million (ppm)) and petrochemicals (up to 10 ppm) were found in livers and ovaries of these fish. Fecundity and viability of eggs were reduced in fish which were in poor condition and/or with a high pollutant content. Laboratory studies showed that petrochemical concentrations of 50-300 parts per billion (ppb) affected fish at both short and long exposures (Eldridge 1980). It has been hypothesized that declines in James River striped bass populations are the result of reproductive failure caused by high Kepone residues in the tissues.

McBay et al. (1980) analyzed striped bass collected in 1973 and 1974 from a number of mid and south Atlantic streams for a variety of organic and inorganic compounds and attempted to correlate residues with egg viability. Eggs were found to contain 0.26 to 28.2 mg/kg PCB, 0.18 to 11.1 mg/kg DDT and up to 0.77 mg/kg dieldrin and a number of other chemicals. There was a tendency for residue levels to be associated with a failure of cleavage in fertilized eggs. However, the correlations were not statistically significant. The concentrations of chemicals found were similar to those which caused reproductive failures in other species, e.g., PCB's for Atlantic salmon (Walker 1975) and DDT for lake trout (Burdick et al. 1964) and Atlantic salmon (Locke and Havey 1972). However, Hunt and Linn (1969) found no reproductive depression in striped bass from California which contained 0.5-9.7 mg/kg DDT in the eggs.

McBay et al. (1980) also found mercury, selenium, arsenic, cadmium and lead were widespread contaminants occurring in the brain, muscle, and gonads of all 1973 samples of East Coast striped bass.

Klauda et al. (1980) concluded that the consistently high egg viabilities and hatching rates of Hudson River striped bass made it difficult to conclude that PCB's or other toxic chemicals have had any substantial effects. They also hypothesized that it may be too soon to see any detrimental effects.

The role of chemicals in influencing striped bass reproduction is still open to question. Research now underway, supported by the Emergency Striped Bass Act amendment to the Anadromous Fish Conservation Act, may provide some answers. Preliminary results from work done at Columbia National Fishery Research Laboratory show that bone strength of young-of-year striped bass from the Hudson, Potomac and Nanticoke Rivers may be correlated with the amount of PCB, arsenic, cadmium, lead, selenium and zinc in the fish. At the NMFS Northeast Fisheries Center the effects of contaminants on survival and growth of larvae are being studied. The completion reports from these two studies will contribute substantially to assessing the impacts of chemicals on striped bass populations.

In summary, a number of chemicals in the environment are important to striped bass. Human activities in the watersheds of spawning rivers result in changes in essential chemical parameters of the water or introduce interfering or toxic chemicals. Although concentrations of introduced chemicals may be relatively low in the water, these substances can be biomagnified to harmful levels in the striped bass from uptake through the gills or ingestion of contaminated prey. There are some indications that damage to striped bass has already occurred but conclusive scientific proof of this damage is still lacking. Research which is now in progress will help to judge the question.

.3 Climate

Ecological theory dictates that an organism and its physical environment exist in intimate harmony. Changes in the environment should be reflected by changes in behavior, distribution or abundance and fishery oceanographers have for years been intrigued with the concept that they could forecast stock abundance or distribution by monitoring environmental variability. Life history complexities and the intricacies of the environment have presented such a complex system of organism - environment interactions that most attempts have been thwarted. Only in those cases where a conceptual ecological understanding was apparent did the effort meet with success (Austin and Ingham 1978). Even then the forecasts were off from year to year which lead Cushing (1975) to develop the concept of timing or "match-mismatch". Basically, this hypothesis is that the forcing environmental function--for example, forage for first feeding larvae--may be right but the organism was spawned too soon or too late to take advantage of conditions due to unseasonable warm or cool conditions. In their view of fishery-environmental forecast effort, Austin and Ingham (1978) noted that most successful ocean-fishery forecast models were linked to atmospheric variables. The ocean is, however a more stable habitat than the estuary.

Interannual variations in striped bass *Morone saxatilis* abundance have been empirically linked to cold winters (Merriman 1941), river flow (Hassler 1958; Turner and Chadwick 1972; Stevens 1977) and fluctuations in availability of forage (Hollis 1952). While the statistical relationships between juvenile indices or catch and environmental parameters was good, the exact biological mechanism which the abiotic factors alter or influence have not been identified. Consequently, it has been dangerous to attempt forecasting. Heinle et al. (1976) noted that the detrital feeding copepod *Eurytemora affinis* was most abundant following cold winters, and they hypothesized, based upon energy balance studies, that the higher than normal detrital loads available in the rivers due to intertidal ice scouring were what accounted for the population fluctuations. This relationship, they hypothesized, could also explain the larger than normal striped bass year classes following cold winters noted by Merriman (1941). Further, when spring run-off following a cold winter was higher than normal and carried a heavy detrital load, the young-of- the-year striped bass survival was enhanced. Subsequent studies by Boynton et al. (1977), Setzler et al. (1978), and Ulanowicz et al. (1979) have substantiated these findings. Boynton et al. (1977) noted that the survival of later spawners was better than for the earlier spawn. This may be accounted for in the "match" of the young bass with the bloom of *E. affinis*. A similar relationship was reported by Turner and Chadwick (1972) with cooler Sacramento-San Joaquin River temperatures associated with higher run-off. Much of their run-off is snow melt which may account for the lower temperatures. The lower temperatures would prolong the larval period, increasing the chance for a "match" with the *E. affinis* bloom. Sommani (1972) applied a Ricker spawner/recruit curve to the California stock and added river flow which provided a better fit to the curves. Kohlenstein (1980) reviewed the earlier stock/recruitment and environmental work of others and developed Ricker stock/recruitment curves modified by winter temperature anomalies previous to spawning, and spring (April-May) run-off the year of spawning. He was able to account for up to 82% of the interannual variability in year class strength. He further showed that the relationship was strongest for the years of exceptionally large year classes.

Not only, then, are winter temperatures and run-off important, but they must occur together and during the right water temperature regime. Kohlenstein (1980) goes on to caution however, that while these relationships hold well in the Potomac River they do not for all the Maryland rivers of the Chesapeake Bay. The Potomac, on the other hand, drains the Appalachian mountains while other Maryland Rivers drain the coastal plain. The significance of this is not known, but could be related to the cooler waters (mountain snow melt) of the Potomac, causing better recruitment due to delayed larval development as noted by Boynton et al. (1977). This conflicts with the analyses of McFadden (1977) for the Hudson River, as he suggested a rapid rise in temperature during embryonic development as the causative factor promoting good year class survival. His hypothesis is that the shortened larval period reduces potential predation which appears to be greater in the Hudson than in the Chesapeake Bay system. It is possible then that different factors are at work in the Hudson; as spawning is later, June conditions are the environment encountered by Hudson River post-larvae. Further, first-feeding Hudson larvae depend upon the phytoplankton-grazing copepods *Diaptomus* and *Cyclops*, not the detrital-dependent *E. affinis*.

More recently Klauda et al.(1980) examined a number of abiotic factors (air and water temperatures, freshwater flows) in several combinations, and concluded that some combination of freshwater flow and water temperature just prior to and during spawning are the key environmental factors indirectly or directly influencing year class success in the Hudson. They further stated that forecasting the strength of the year class was still not possible and the important abiotic factors probably change from year to year.

Other than Hassler's (1958) comments concerning the river flow in the Roanoke, there are no reports concerning stock-environmental relationships for the North Carolina striped bass. He postulated that high flows were necessary to stimulate striped bass to migrate upstream.

.4 Biological - Submerged Aquatic Vegetation

The beds of submerged aquatic vegetation (SAV) that were once so prominent in the Chesapeake Bay system have declined drastically over the past decade. (Stevenson and Confer 1978).

There are a number of values associated with SAV. They produce dissolved oxygen, reduce solar heating of the water, serve as food, stabilize sediments, provide attachment surfaces for organisms and provide cover and feeding areas for numerous species of fish. Carr and Adams (1973) found 21 species of fish inhabiting seagrass beds in Florida. Partitioning of food items among the species indicated a variety of microhabitats within the seagrass bed. Detritus was an important dietary component of six species. Odum (1971) concluded that detritus consumers were a key component in the estuarine food web. These consumers included polychaetes, mysids, copepods, amphipods and other invertebrates which are prey species for juvenile striped bass.

There is some circumstantial evidence (at least since the 1930's) that SAV and striped bass abundance may be related. Both were in low abundance in the early 1930's and began increasing in abundance during the mid 1930's. Each was at moderate to high levels of abundance from the late 1950's through the early 1970's at which time both declined precipitiously back to very low population levels. The cycles of abundance of striped bass and SAV may be affected by the same factors or may run parallel, basically independent, courses rather than affect each other directly.

The decline of SAV in the Chesapeake Bay was of sufficient importance to be included in the 1978 EPA funded study which focused in part on determining the causes for decline of SAV and to assess their ecological significance (Boynton et al. 1981). A conceptual ecological value link between SAV and striped bass can easily be made. Striped bass juveniles are found within the SAV beds and do feed upon the invertebrate organisms that inhabit the SAV beds. The striped bass juvenile and adult, however, are so highly adaptable to a range of habitats and prey species that an absolute dependance upon any one parameter within these requirements is difficult to establish. In the Chesapeake Bay, juvenile habitat ranges from tidal fresh mud-bottomed creeks to the rock-bottomed Susquehanna River. Although a change in the basis of primary productivity from SAV to phytoplankton may alter the composition of the zooplankton and vertebrate primary consumer community, the striped bass juvenile can adapt to alterations in prey species.

The larval stage preys upon detritus feeding zooplankton in the upper estuary. Detritus sources may include uplands and emergent wetlands. SAV beds are not generally as numerous in these upper watersheds and probably would not contribute substantially to detrital input in the spawning areas. If SAV beds did exist in or near the spawning areas they would not be fully developed in the early spring and would therefore provide little to no cover for larval striped bass. It can be theorized on this basis that SAV beds would be of most relative value to the juveniles. While substantial information has been developed, through the EPA Study, on certain types of SAV communities, those which occur in the brackish to fresh zone of many estuaries appear to be less well understood. Further research on these communities may demonstrate definite links between SAV and striped bass year class success; at present there appears to be no direct cause and effect relationship between declines of SAV and striped bass.

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TABLES

TABLE 1

AGE AND SIZE AT FIRST MATURITY FOR STRIPED BASS

Area	Age (years)[a] males	Age (years)[a] females	Length (mmFL) males	Length (mmFL) females	Weight (kg) males (based on L-wt eq.)	Weight (kg) females (based on L-wt eq.)	Author
Southern New England	3	5	(350)[b]	570	—	—	Merriman (1941)
Hudson River	4	6	446	558	—	—	McLaren et al. (1981)
Delaware River	3	4	303	—	0.3	—	Bason (1971)
Upper Chesapeake Bay	3	4	330	515	—	—	Pearson (1938)
Potomac River	2	4	330	450	0.6	1.5	Wilson *et al*. (1976)
Roanoke River	3	4	424	518	—	—	Trent and Hassler (1968)
Lakes Marion and Moultrie	-	4	610	—	—	—	Scruggs (1957)
Sacramento-San Joaquin Rivers	-	5	—	535	—	1.8	Scofield (1931)

[a]Age at which at least 50% are mature.

[b]Number in parenthesis is best approximation available from data given by the author.

TABLE 2

RELATIONSHIP OF GONAD WEIGHT, EGG NUMBER, BODY LENGTH AND BODY WEIGHT AMONG STRIPED BASS OF VARIOUS AGES CAPTURED IN A NUMBER OF AREAS

Area and Age	Number in Sample	Gonad Weight total (gm)	Number of Mature Eggs (mean or range)	Body Weight (kg)	Body Length (FL,cm)	Author
Hudson River, New York						
6	2	—	451,000	—	55.1	McLaren et al. (1980)
8	14	—	1,548,000	—	80.9	
10	4	—	1,841,000	—	88.9	
Upper Chesapeake Bay, Maryland						
—	1	—	1,337,000	5.897	70	Pearson (1938)
Chesapeake Bay, Maryland						
4	10	58.5	68,239	1.996	51.2	Jackson and Tiller (1952)
6	7	594.0	856,257	5.897	71.26	
8	13	988.0	1,682,292	7.212	83.0	
10	2	1319.0	2,510,349	9.752	92.1	
males						
($2\frac{1}{2}$)*	16	27.1	—	0.55	34.0	Vladykov and Wallace (1952)
(3-4)	11	89.9	—	1.461	44.2	
females						
($5\frac{1}{2}$)	4	120.0	—	2.50	56.5	
($8\frac{1}{2}$)	3	755.0	—	8.67	83.2	
Nanticoke River, Maryland						
4	3	71.6-154.2	201,000-555,000	1.15-2.09	42.7-53.6	Hollis (1967)
5	3	245.0-336.6	601,000-857,000	3.45-4.63	65.3-69.3	
10	1	1650	2,207,000	14.97	100.3	
Transquaking River, Maryland						
4	3	118-149.7	252,000-416,000	1.81-1.86	49.8-52.3	Hollis (1967)
6	2	427.7-543.9	898,000-1,319,000	4.63-4.76	69.6-71.1	
Elk River, Maryland						
5	2	275.3-347.5	494,000-591,000	3.13-3.31	60.5-61.5	Hollis (1967)
10	1	1897	2,310,000	11.57	90.9	
12-15	7	1966-3476	2,248,000-4,136,000	11.88-25.85	91.9-119.4	
Potomac River, Maryland						
12-14	4	2142-3011	3,257,000-4,864,000	20.14-25.63	108.7-115.6	Hollis (1967)
Roanoke River, Weldon						
—	1	—	14,000	1.361	—	Worth (1904)
—	1	—	265,000	2.041	—	Merriman (1941)
—	1	—	3,220,000	22.68	—	Worth (1904)
Roanoke River, North Carolina						
4	13	—	320,000	1.81-2.22	50.8-53.1	Lewis and Bonner (1966)
6	8	—	454,000	2.73-3.13	55.9-58.2	
10	2	—	1,090,000	6.35-6.76	71.1-73.4	
Offshore, North Carolina						
8	4	126-867	1,044,230-2,221,821	7.3-8.8	80-84	Holland and Yelverton (1973)
9	13	67-1253	1,067,472-3,715,939	7.7-13.6	82-98.1	
10	4	180-2123	1,995,974-4,057,059	9.0-19.0	89.2-109	
12	2	663-914	3,304,497-3,511,038	12.2-12.7	95.0-98.7	

*Numbers in parentheses are best estimates from data given by the author.

TABLE 3

Percent of gonad weight to body weight for each sex during development

stage	Chesapeake M	Chesapeake F	Hudson River M	Hudson River F	Potomac River M	Potomac River F
immature	-	0.7	0.2-1.2	0.4-1.0	0.6-2.3	0.4-0.5
maturing	-	1.7	-	-	3.2-7.3	0.7-5.6
prespawning	5.0	4.8	1.4-11.1	1.1-16.7	1.4-13.6	6.7-10.3
spawning	6.3	8.3			4.1-9.1	11-16
spent	-	1.3			0.7-2.0	3.6-4.8

TABLE 4

HATCHING TIME OF STRIPED BASS EGGS IN RELATION TO WATER TEMPERATURE

Incubation period: Water temperature (^{o}C)	Hatching time (hrs)
At 12.2 C	80 hours
At 14.4 C	54 to 74 hours
At 14.4 to 15.5 C	70 to 74 hours
At 15.0 C	72 to 73 hours
At 15.0 to 16.0 C	48 hours
At 15.5 to 15.6 C	50 to 70 hours
At 15.6 to 17.8 C	48 to 72 hours
At 16.7 to 17.2 C	36 to 48 hours
At 17.2 C	48 hours
At 17.8 to 17.9 C	48 hours
At 18.3 C	43 to 48 hours
At 18.9 to 19.4 C	48 hours
At 19.4 C	38 to 48 hours
At 21.1 C	33 to 48 hours
At 21.6 to 21.7 C	36 hours
At 21.6 to 22.2 C	30 to 44 hours
At 22.2 C	30 hours
At 23.9 C	29 hours

Table 5. Proportions of prolarvae body measurements relative to standard length (SL).

measurement	% of SL	size range (TL) of prolarvae
greatest depth	44.2	2.5 - 3.0 mm
	17.2	5.5 - 6.0 mm
snout to anus	74.1	2.5 - 3.0 mm
	54.7	5.5 - 6.0 mm
eye diameter	7.1	3.0 - 3.5 mm
	6.2	5.5 - 6.0 mm

TABLE 6

COMPARISON OF GROWTH (mm) OF STRIPED BASS FROM VARIOUS AREAS[a] (Westin and Rogers 1978)

Area of Capture		Number in Sample	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	Author
			AGE GROUP																	
Maine, MCFL		216	150	297	408	488	556	617	658	—	—	—	—	—	—	—	—	—	—	Davis (1966)
Massachusetts, MCFL		1056	150	305	437	551	648	737	810	876	927	970	1006	1036	1067	1087	1105	1128	1158	Frisbie (1967)
Rhode Island, MMFL		238	—	—	425	503	576	648	720	863	893	954	997	1001	—	1125	—	—	—	Authors' data
Connecticut, MCFL-4; MMFL-9		25	125	235	365	450	530	610	685	750	820	—	—	—	—	—	—	—	—	Merriman (1941)
Hudson River, N.Y., MCFL[b]	M	98	103	228	339	434	517	592	645	681	666	—	—	—	—	—	—	—	—	Texas Instruments (1974a)
	F	67	104	232	358	459	552	637	708	770	815	855	909	799	846	—	—	—	—	
Delaware Estuary, MCFL		112	102	218	319	430	530	630	708	795	869	919	992	1045	—	—	—	—	—	Buson (1971)
Chesapeake Bay, MCFL	M	224	135	297	381	422	500	595	704	754	831	876	906	—	—	—	—	—	—	Mansueti (1961)
	F[c]	520	124	292	389	467	556	645	724	782	856	899	935	1006	983	1044	—	—	—	
Potomac River, Md., MMFL	M	843	—	331	381	431	508	654	766	784	864	839	—	—	—	—	—	—	—	Wilson, *et al*. (1976)
	F	218	—	338	389	449	549	696	785	829	884	926	936	960	1030	1093	—	—	—	
Nanticoke River, Md., MMFL		75	—	—	376	450	553	579	736	868	865	945	1007	—	—	—	—	—	—	Authors' data
Roanoke River, Va., MCFL[d]		101	132	307	475	587	658	693	724	747	780	800	—	—	—	—	—	—	—	Domrose (1963)
Roanoke River, N.C., MFL	M	2403	—	356	424	465	503	551	594	632	813	—	—	—	—	—	—	—	—	Trent and Hassler (1968)
	F	683	—	—	465	513	544	602	650	671	724	742	762	965	902	—	—	—	—	
North Carolina, offshore, MCFL		277	137	267	392	491	582	667	750	815	868	913	953	998	1054	1098	—	—	—	Holland and Yelverton (1973)
Santee-Cooper Reservoir, S.C.	MCFL	322	216	399	503	582	655	724	767	—	—	—	—	—	—	—	—	—	—	Stevens (1958)
	MCFL[d]	414	170	356	465	528	599	655	719	772	826	—	—	—	—	—	—	—	—	Scruggs (1957)
Savannah River, Ga., MCFL	M	59	147	260	363	431	526	635	695	746	671[e]	711	754	793	823	—	—	—	—	Smith (1970)
	F	213	152	288	386	481	592	688	787	856	914	953	991	—	—	—	—	—	—	
Sacramento-San Joaquin, Calif. MCFL	M	204	106	251	371	445	516	563	612	—	—	—	—	—	—	—	—	—	—	Scofield (1931)
	F	269	106	247	370	460	542	612	680	—	—	—	—	—	—	—	—	—	—	
MMFL	M	314	98	286	373	463	490	541	610	685	805	785	—	—	—	—	—	—	—	
	F	972	97	264	346	458	535	605	686	777	795	870	947	990	1030	1080	—	—	—	
MCFL	M	385	104	249	386	493	566	622	671	726	762	—	—	—	—	—	—	—	—	Robinson (1960)
	F	295	104	249	389	500	594	685	747	800	836	—	—	—	—	—	—	—	—	
Coos River, Ore., MMFL		NA	—	—	368	483	575	635	695	730	760	—	—	—	—	—	—	—	—	Morgan and Gerlach (1950)

[a]MCFL = mean calculated fork length; MMFL = mean measured fork length; MFL = mean fork length; sexes combined unless indicated otherwise.

[b]Converted to fork length (FL = 4.6 + 0.902 TL).

[c]Contains females and bass of unknown sex.

[d]Converted from MCTL by factor of 0.93 (Mansueti, 1961).

[e]This negative growth figure is the result of a single, unusually small specimen for its age being used for the calculation (Smith, 1970).

Table 7. Calculated Monthly Growth Increments of Age 2 and 3 Striped Bass.

Month	Age	FL,cm(in.)	monthly increase, %	Age	FL,cm(in.)	monthly increase,%
June	II	29.0[1] (11.4)	6.64	III	40.5[1] (15.9)	4.61
July	II	30.9 (12.2)	6.64	III	42.2 (16.7)	4.61
August	II	33.0 (13.0)	6.64	III	44.3 (17.4)	4.61
September	II	35.2 (13.9)	6.64	III	46.4 (18.3)	4.61
October	II	37.5[1] (14.8)	0.97	III	48.5[1] (19.1)	0.7
November	II	37.9 (14.9)	0.97	III	48.8 (19.2)	0.7
December	II	38.2 (15.0)	0.97	III	49.2 (19.4)	0.7
January	II	38.6 (15.2)	0.97	III	49.5 (19.5)	0.7
February	II	39.0 (15.4)	0.97	III	49.9 (19.6)	0.7
March	II	39.3 (15.5)	0.97	III	50.2 (19.8)	0.7
April	III	39.7 (15.6)	0.97	IV	50.6 (19.3)	0.7
May	III	40.1 (15.8)	0.97	IV	50.9 (20.0)	0.7

[1]Data points reported by Merriman, 1941.

Table 8

Tolerance and optimum range of some environmental factors for striped bass eggs, larvae, and young

Development Stage	Flow Rate M/Sec	Temp. ^oC	Salinity $^o/oo$	pH	O_2 mg/liter	Author
Eggs	$\frac{0.3-5}{1-2}$	$\frac{14-23}{17-20}$	$\frac{0-10}{1.5-3}$	?	$\frac{1.5-?}{3.7}$	Mansuetti (1958)
Larvae up to 20 mm Long	$\frac{0-5}{0.3-1}$	$\frac{12-23}{16-19}$	$\frac{0-15}{5-10}$	$\frac{6-9}{7-8}$	$\frac{2-20}{5-8}$	Albrecht (1964) Tagatz (1961) Regan (1968)
Young 20-50 mm	$\frac{0-5}{0-1}$	$\frac{10-27}{16-19}$	$\frac{0-20}{10-15}$	$\frac{6-10}{7-9}$	$\frac{3-20}{6-12}$	Bogdanov et al. (1966)
Young 50-100 mm	$\frac{0-5}{0-1}$	$\frac{?-30}{18-23}$	$\frac{0-35}{10-20}$	$\frac{6-10}{7-9}$	$\frac{3-20}{6-12}$	Bogdanov et al. (1966)

Note: $\frac{\text{tolerance}}{\text{Optimum range}}$

Doroshev 1970

TABLE 9

Toxicity of Chemicals to Striped Bass Larvae
(after Westin and Rogers, 1978)

Chemical	96-hour TL_m (mg/l)	Reference
Acriflavine	5.0	Hughes, 1973
Aldrin	0.01	Hughes, 1973
Amifur	10.0	Hughes, 1973
Butyl ester of 2,4-D	0.15	Hughes, 1971
Cadmium	0.001	Hughes, 1973
Chloride	1000	Hughes, 1973
Chlorine	0.20 (24 hr)	Morgan & Prince, 1977
	0.04-0.07 (incipient)	Middaugh *et al.*, 1977
Copper	0.05	Hughes, 1973
Copper	0.31 (48 hr)	O'Rear, 1971
Copper sulfate	0.1	Hughes, 1971
Dieldrin	0.001	Hughes, 1973
Dequat	1.0	Hughes, 1973
Diuron	0.5	Hughes, 1973
Dylox	5.0	Hughes, 1971
Ethyl parathion	2.0	Hughes, 1971
Formaldehyde	10.0	Hughes, 1973
HTH	0.5	Hughes, 1971
Iron	4.0	Hughes, 1973
Karmex	0.5	Hughes, 1971
Malachite green	0.05	Hughes, 1973
Methylene blue	1.0	Hughes, 1973
Methyl parathion	5.0	Hughes, 1971
Potassium dichromate	100	Hughes, 1971
Potassium permanganate	1.0	Hughes, 1971
Roccal	0.5	Hughes, 1973
Rotenone	0.001 (LC_0)	Hughes, 1973
Sulfate	250	Hughes, 1973
Tad-Tox	5.0	Hughes, 1973
Terramycin	50.0 (LC_0)	Hughes, 1973
Zinc	0.1	Hughes, 1973
Zinc	1.18 (48 hr)	O'Rear, 1971

Table 10

Toxicity of Chemicals to Juvenile Striped Bass
(after Westin and Rogers, 1978)

Chemical	Test Temp (°C)	96-hour TL_m (mg/l)	Reference
Abate	13	1.0	Korn & Earnest, 1974
Achromycin	21-22	190	Kelley, 1969
Acriflavin	21	27.5	Hughes, 1973
		16.0	Wellborn, 1971
Aldrin	13	0.0072	Korn & Earnest, 1974
	21	0.075	Hughes, 1973
	20	0.010	Rehwoldt _et al._, 1977
Amifur	21	30.0 (NA)	Hughes, 1973
Ammonium hydroxide	15	1.9-2.85	Hazel _et al._, 1971
	23	1.4-2.8	Hazel _et al._, 1971
Aquathol	21	610	Wellborn, 1971
Bayluscide	21	1.05 (72 hr.)	Wellborn, 1971
Benzene	17.4	10.9 (ul/l)	Meyerhoff, 1975
	16	5.8 (ul/l)	Benville and Korn, 1977
Butyl ester of 2,4-D	21	3.0	Hughes, 1971
	20	70.0	Rehwoldt _et al._, 1977
Cadmium	21	0.002	Hughes, 1973
Carbaryl	17	1.0	Korn & Earnest, 1974
Casoron	21	6,200	Wellborn, 1971
Chlordane	15	0.0118	Korn & Earnest, 1974
Chloride	21	5000	Hughes, 1973
Chlorine	18	0.04 (incipient)	Middaugh _et al._, 1977
Co-Ral	21	62	Wellborn, 1971

Table 10 continued

Chemical	Test Temp (°C)	96-hour TL_m (mg/l)	Reference
Copper	21	0.05	Hughes, 1973
	17	4.3	Rehwoldt *et al.*, 1971
Copper sulfate	21	0.15	Hughes, 1971
	21-22	0.6	Kelley, 1969
	21	0.62	Wellborn, 1969
Cutrine	21	0.1	Hughes, 1973
DDD	17	0.0025	Korn & Earnest, 1974
DDT	17	0.00053	Korn & Earnest, 1974
Dibrom	13	0.5	Korn & Earnest, 1974
Dieldrin	14	0.0197	Korn & Earnest, 1974
	21	0.25	Hughes, 1973
Diquat	21	10.0	Hughes, 1973
	21	80	Wellborn, 1969
Diuron (Karmex)	21	6.0	Hughes, 1973
Dursban	13	0.00058	Korn & Earnest, 1974
Dylox	21	2.0	Hughes, 1971
		5.2	Wellborn, 1969
Endosulfan	16	0.0001	Korn & Earnest, 1974
Endrin	17	0.000094	Korn & Earnest, 1974
E.P.N.	18	0.060	Korn & Earnest, 1974
Ethyl parathion	21	1.0	Hughes, 1971
	15	0.0178	Korn & Earnest, 1974
Fenthion	13	0.453	Korn & Earnest, 1974
Formaldehyde	21	15	Hughes, 1973
	21-22	20	Kelley, 1969
	21	18	Wellborn, 1969
Heptachlor	13	0.003	Korn & Earnest, 1974
HTH	21	0.25	Hughes, 1971

Table 10 continued

Chemical	Test Temp (°C)	96-hour TL_m (mg/l)	Reference
Instant Sea (as Cl)	21	17000 (LC_0)	Hughes, 1973
Iron	21	6.0	Hughes, 1973
Karmex (Diuron)	21	6.0	Hughes, 1971
		3.1	Wellborn, 1969
Lindane	21	0.40	Wellborn, 1971
	13	0.0073	Korn & Earnest, 1974
Malachite green	21	0.2	Hughes, 1973
		0.30 (24 hr.)	Wellborn, 1971
Malathion	21	0.24	Wellborn, 1971
	13	0.014	Korn & Earnest, 1974
	20	0.039	Rehwoldt _et al_., 1977
Methoxychlor	15	0.0033	Korn & Earnest, 1974
Methylene blue	21	12.0	Hughes, 1973
Methyl parathion	21	4.5	Hughes, 1971
	13	0.79	Korn & Earnest, 1974
	20	14.0	Rehwoldt _et al_., 1977
MS-222	21-22	31.5	Kelley, 1969
	22-28	50.0 (24 hr.)	Tatum _et al_., 1966
MS-222 with 20 o/oo	21-22	31.5	Kelley, 1969
Nickel	17	6.2	Rehwoldt _et al_., 1971
Oil field brine	21	16600 (LC_0)	Hughes, 1968
Potassium dichromate	21	75	Hughes, 1971
Potassium permanganate	21	4.0	Hughes, 1971
	21-22	2.6	Kelley, 1969
	21	2.5	Wellborn, 1969
Polyotic	21	>1818	Wellborn, 1969
PMA	21-22	1.1	Kelley, 1969
Quinaldine	21-22	4.5	Kelley, 1969
	22-28	22.0 (24 hr.)	Tatum _et al_., 1965

Table 10 continued

Chemical	Test Temp (°C)	96-hour TL_m (mg/l)	Reference
Quinaldine with 20 o/oo	21-22	5.0	Kelley, 1969
Reconstituted sea water	21-22	35 (o/oo)	Kelley, 1969
Roccal	21	1.5	Hughes, 1973
Rotenone	21	0.001 (LC_0)	Hughes, 1973
Simazine	21	0.25	Wellborn, 1969
Sodium nitrilotriacetic acid (NTA)	20	5500	Eisler *et al.*, 1972
Sulfate	21	3500	Hughes, 1973
Syndet Ch	20	4.6	Eisler *et al.*, 1972
Syndet Ga		8.7	Eisler *et al.*, 1972
Tad-Tox	21	10.0	Hughes, 1973
Terramycin	21	75.0	Hughes, 1973
	21-22	170	Kelley, 1969
	21	178	Wellborn, 1969
		165	Wellborn, 1971
Toluene	16	7.3 (ul/l)	Benville & Korn, 1977
Toxaphene	17	0.0044	Korn & Earnest, 1974
m-xylene	16	9.2 (ul/l)	Benville & Korn, 1977
Zinc	21	0.1	Hughes, 1973
	17	6.7	Rehwoldt *et al.*, 1971
2, 4, 5, T	20	14.6	Rehwoldt *et al.*, 1977

Table 11.

Multiplant Conditional Entrainment and Impingement Mortality Rates[a] (%) Calculated for Young-of-Year Hudson River Striped Bass Populations in 1974 and 1975

Source	Year	Entrainment		Impingement		Combined	
		Range	Mean	Range	Mean	Range	Mean
EPA[b]	1974	11.1 - 14.5	12.8	1.1 - 9.2	5.2	12.1 - 22.4	17.3
	1975	18.2 - 18.4	18.3	0.4 - 3.5	2.0	18.5 - 21.3	19.9
Utility[c]	1974	8.1		4.2		11.9	
	1975	11.9		2.3		13.9	

[a]conditional mortality rate defined as the fraction of the young-of-year population at time of initial vulnerability to entrainment/impingement that would be killed by entrainment/impingement during first year of life in the absence of other sources of mortality

[b]includes Bowline, Roseton, Indian Point 1 and 2, Lovett, Danskammer, and Albany power plants (from Boreman et al. 1979, Barnthouse and Van Winkle 1979).

[c]includes Bowline, Indian Point 2 and Roseton power plants only (from McFadden and Lawler 1977).

Table 12 1974-1978 Commercial Landings of Striped Bass by distance caught off U.S. shores; in thousands of lbs. and % of total for each year.

	INSHORE		OFFSHORE								TOTAL
	0-3 miles		3-12 miles		3-200 miles		12-200 miles		> 200 miles		Total
	lbs.	(%)	lbs.	(%)	lbs.	(%)	lbs.	(%)	lbs.	(%)	lbs.
1978	4236	(94.2)			261	(5.8)			-	-	4497
1977	4995	(97.2)			145	(2.8)			-	-	5140
1976	5658	(96.9)	174	(3.0)			6	(0.1)	-	-	5838
1975	8358	(94.4)			494	(5.6)			-	-	8852
1974	9786	88.5	1236	(11.2)			30	(0.3)			11052
mean		(94.2)		(7.2)		(4.7)					

Table 13 Striped bass landings (lb) in North Carolina by gear and area 1965-1979

1965

Gear	Estuarine	Ocean	Total
Beach Seine		59,600	
Trawl			
Gill Net	349,000		
Pound Net	150,500		
Other	71,700		
Total	571,200	59,600	630,800

1966

Gear	Estuarine	Ocean	Total
Beach Seine		30,900	
Trawl			
Gill Net	564,100	600	
Pound Net	47,500		
Other	49,100		
Total	661,300	31,500	692,800

1967

Gear	Estuarine	Ocean	Total
Beach Seine		225,300	
Trawl		56,700	
Gill Net	901,000	462,000	
Pound Net	52,700		
Other	68,600		
Total	1,022,300	744,000	1,766,300

1968

Gear	Estuarine	Ocean	Total
Beach Seine		408,500	
Trawl		30,200	
Gill Net	1,132,400		
Pound Net	92,600		
Other	89,800		
Total	1,314,800	438,700	1,753,500

1969

Gear	Estuarine	Ocean	Total
Beach Seine		18,900	
Trawl		117,900	
Gill Net	881,400		
Pound Net	54,200		
Other	209,000		
Total	1,144,600	136,800	1,281,400

1970

Gear	Estuarine	Ocean	Total
Beach Seine		587,500	
Trawl		665,500	
Gill Net	584,300		
Pound Net	99,700		
Other	246,200		
Total	930,200	1,253,000	2,183,200

1971

Gear	Estuarine	Ocean	Total
Beach Seine		29,800	
Trawl		443,600	
Gill Net	583,900		
Pound Net	82,100		
Other	84,400		
Total	750,400	741,600	1,492,000

1972

Gear	Estuarine	Ocean	Total
Beach Seine		618,200	
Trawl		208,900	
Gill Net	458,900		
Pound Net	54,000		
Other	6,800		
Total	519,700	827,100	1,346,800

Table 13 (Cont.)

1973

Gear	Estuarine	Ocean	Total
Beach Seine		887,600	
Trawl		220,500	
Gill Net	502,100		
Pound Net	63,300		
Other	85,500		
Total	663,900	1,108,100	1,772,000

1974

Gear	Estuarine	Ocean	Total
Beach Seine		432,400	
Trawl		71,300	
Gill Net	445,400	100	
Pound Net	52,100		
Other	34,000		
Total	531,500	503,800	1,035,300

1975

Gear	Estuarine	Ocean	Total
Beach Seine		409,200	
Trawl		169,000	
Gill Net	666,500	6,800	
Pound Net	65,000		
Other	3,800		
Total	735,300	585,000	1,320,300

1976

Gear	Estuarine	Ocean	Total
Beach Seine		172,400	
Trawl		160,000	
Gill Net	638,500		
Pound Net	47,700		
Other	31,900		
Total	718,100	332,400	1,050,500

1977

Gear	Estuarine	Ocean	Total
Beach Seine		37,300	
Trawl	100	15,400	
Gill Net	420,200	38,000	
Pound Net	57,400		
Other	3,000		
Total	480,700	90,700	571,400

1978

Gear	Estuarine	Ocean	Total
Beach seine		17,600	
Trawl	100	139,900	
Gill Net	492,400	7,100	
Pound Net	36,400		
Others	4,600		
Total	533,500	164,600	698,100

Table 14.
New York Striped Bass Landing in Pounds by Gear From 1939 to 1977

Year	Haul Seine	Otter Trawl	Pound Net	Gill Net*	Hand Lines	Total*
1939	81,800 (44.6)	37,400 (20.4)	8,000 (4.4)	28,900 (15.7)	27,500 (15.0)	183,600
1940	110,300 (65.4)	—	9,600 (5.7)	42,800 (25.4)	5,600 (3.4)	168,600
1941	—	—	—	—	—	—
1942	135,900 (51.3)	—	66,300 (25.0)	30,400 (11.5)	32,500 (12.3)	265,100
1943	233,900 (73.9)	400 (0.1)	7,000 (2.2)	26,100 (8.2)	49,200 (15.5)	316,600
1944	281,300 (55.9)	2,900 (0.6)	15,100 (3.0)	46,100 (9.2)	158,000 (31.4)	503,400
1945	116,700 (38.8)	58,500 (19.5)	7,800 (2.6)	22,500 (7.5)	95,100 (31.6)	300,600
1946	366,500 (76.4)	10,700 (2.2)	17,000 (3.5)	12,700 (2.6)	73,000 (15.2)	479,900
1947	146,800 (60.1)	35,600 (14.6)	11,000 (4.5)	7,400 (3.0)	43,500 (17.8)	244,300
1948	246,700 (69.3)	24,500 (6.9)	28,100 (7.9)	22,900 (6.4)	33,600 (9.4)	355,800
1949	592,100 (94.6)	9,800 (1.6)	4,300 (0.7)	2,300 (0.4)	17,500 (2.8)	626,000
1950	483,900 (93.6)	12,100 (2.3)	4,400 (0.9)	10,500 (2.0)	6,200 (1.2)	517,100
1951	566,400 (90.4)	1,700 (0.2)	9,200 (1.5)	13,900 (2.2)	35,000 (5.6)	626,200
1952	431,200 (88.8)	3,300 (0.7)	3,300 (0.7)	30,400 (6.3)	17,500 (3.6)	485,700
1953	409,600 (89.5)	500 (0.1)	5,900 (1.2)	54,700 (11.4)	11,000 (2.3)	481,700
1954	382,000 (87.1)	6,580 (1.5)	1,100 (0.3)	49,200 (11.2)	—	438,800
1955	408,400 (80.7)	4,300 (0.8)	1,300 (0.3)	74,800 (14.8)	17,300 (3.4)	506,100
1956	289,900 (73.4)	200 (0.1)	1,500 (0.4)	91,900 (23.3)	11,700 (3.0)	395,200

*Includes striped bass landed in the Hudson River. (Byron Young 1978)

Table 14 continued

New York Striped Bass Landings in Pounds by Gear from 1939 to 1977, cont.

Year	Haul Seine	Otter Trawl	Pound Net	Gill Net*	Hand Lines	Total*
1957	445,500 (95.2)	3,300 (0.7)	800 (0.02)	—	18,300 (3.9)	467,900
1958	318,000 (80.0)	1,700 (6.4)	1,000 (0.03)	77,100 (19.4)	—	397,800
1959	379,700 (70.6)	8,600 (1.6)	1,500 (0.3)	133,100 (24.7)	15,100 (2.8)	538,000
1960	531,900 (73.8)	46,900 (6.4)	4,200 (0.6)	132,800 (18.2)	15,000 (2.1)	730,800
1961	651,100 (71.6)	133,900 (14.7)	19,800 (1.1)	84,200 (9.3)	30,700 (3.4)	909,700
1962	402,700 (75.0)	83,100 (12.7)	3,200 (0.5)	48,100 (7.3)	29,500 (4.5)	656,600
1963	374,100 (55.6)	177,000 (26.3)	5,000 (0.7)	50,700 (7.5)	66,000 (9.8)	672,800
1964	687,100 (69.1)	193,300 (19.4)	17,300 (1.7)	55,300 (5.6)	42,000 (4.2)	995,000
1965	576,800 (78.0)	49,200 (6.7)	3,700 (0.5)	81,400 (11.0)	28,500 (3.9)	789,600
1966	747,500 (71.1)	85,100 (8.1)	109,500 (10.4)	80,300 (7.6)	27,900 (2.7)	1,050,300
1967	1,042,200 (63.9)	146,400 (9.0)	86,900 (5.3)	268,900 (16.5)	85,700 (5.3)	1,630,100
1968	901,200 (58.1)	51,100 (3.3)	76,500 (4.9)	376,900 (24.3)	144,800 (9.3)	1,550,500
1969	873,000 (56.9)	223,300 (14.5)	104,600 (6.8)	276,400 (17.4)	66,800 (4.4)	1,535,100
1970	906,300 (67.7)	74,400 (5.6)	38,300 (2.9)	176,200 (13.2)	143,100 (10.7)	1,338,300
1971	688,200 (58.1)	105,100 (8.9)	101,200 (8.6)	112,300 (9.5)	176,800 (14.9)	1,183,600
1972	407,300 (48.7)	132,300 (15.8)	148,200 (17.7)	95,400 (11.4)	53,000 (6.3)	863,200
1973	603,200 (34.6)	294,000 (16.9)	439,500 (25.2)	61,800 (3.5)	342,800 (19.7)	1,741,300
1974	427,800 (30.4)	340,700 (24.1)	366,800 (26.0)	38,500 (2.7)	235,200 (16.7)	1,409,000

*Includes striped bass landed in the Hudson River.

Table 14 continued

New York Striped Bass Landing in Pounds by Gear From 1939 to 1977. cont.

Year	Haul Seine	Otter Trawl	Pound Net	Gill Net*	Hand Lines	Total*
1975	228,300 (19.3)	252,800 (21.4)	224,000 (18.9)	76,000 (6.4)	398,600 (33.7)	1,183,700
1976	105,200 (12.4)	100,300 (11.8)	89,700 (10.5)	184,250 (21.7)	371,300 (43.6)	850,750
1977	133,600 (17.4)	56,800 (7.4)	85,700 (11.2)	85,200 (11.1)	404,800 (52.8)	766,100

*Includes striped bass landed in the Hudson River.

Data compiled from Fishery Statistics of the U.S. 1939-1974 and from Automatic Data Processing print outs 1975 - 1977.

Table 15 Total State of Delaware sport catch of striped bass in Delaware

Year	Number	% of Total Sport Catch
1955	400	0.02
1960	4,272	0.78
1968	28,941[a]	2.5[a]
1971	6,255[a]	0.26[a]
1972	89,529[a]	3.04[a]
1973	6,591[b]	0.33[b]
1976	3,829[b]	0.15[b]
1978	4,743[b]	0.28[b]

[a] Figures for Delaware River and Bay only

[b] Boat catch only

Table 16 State by State comparison of commercial landings of striped bass, Maine through North Carolina, 1954-1966 (in thousands of pounds).

YEAR	ME lbs.	NH lbs.	MA lbs.	RI lbs.	CT lbs.	NY lbs.	NJ lbs.	DE lbs.	MD lbs.	VA lbs.	NC lbs.	GRAND TOTAL
1954	-	-	68	116	0.5	439	51	146	2108	951	1122	5002
1955	-	-	72	34	0.5	506	35	88	2572	894	736	4938
1956	-	-	72	26	0.6	394	50	28	2150	995	764	4480
1957	-	-	56	23	1.0	553	132	16	1859	929	597	4165
1958	-	-	51	41	2.7	398	59	22	3105	1317	1096	6093
1959	-	-	80	31	8.0	538	196	12	4349	2097	872	8183
1960	0.3	-	129	77	4.8	731	115	25	4409	2278	782	8550
1961	-	-	210	167	20.0	910	276	66	5408	1854	550	9462
1962	-	-	589	61	32.5	657	494	108	3979	1944	747	8611
1963	1.4	-	480	71	30.0	673	753	48	3748	2747	737	9289
1964	-	-	522	75	35.0	995	996	31	3300	1889	714	8560
1965	-	8	463	60	-	740	761	32	2949	2213	484	7712
1966	-	8	585	250	-	1050	315	64	3347	2803	653	9076

Table 16 continued

State by State comparison of commercial landings of striped bass, Maine through North Carolina, 1967-1980 (in thousands of pounds).

YEAR	ME lbs.	NH lbs.	MA lbs.	RI lbs.	CT lbs.	NY lbs.	NJ lbs.	DE lbs.	MD lbs.	VA lbs.	NC lbs.	GRAND TOTAL
1967	-	8	662	132	-	1630	327	66	4150	1678	1817	10469
1968	5	10	874	98	-	1551	459	49	4532	1614	1912	11105
1969	-	12	1038	132	-	1535	311	42	5088	2671	1568	12398
1970	-	14	1344	84	-	1338	260	54	3978	1782	2318	11172
1971	-	15	749	131	-	1184	290	39	2743	1221	1449	7821
1972	-	16	1174	309	-	836	373	248	3229	2659	1261	10105
1973	-	15	1386	623	-	1741	766	586	4976	2888	1752	14733
1974	-	5	1258	336	-	1409	714	212	3503	2564	1016	11017
1975	0.5	4	1360	306	-	1184	341	106	2897	1331	1303	8832
1976	-	-	1360	153	-	851	137	81	1875	954	1038	6449
1977	0.4	-	1184	108	-	766	125	57	1732	833	572	5377
1978	0.5	-	328	51	-	1108	77	38	1265	443	698	4008
1979	-	-	399	54	-	570	40	26	946	467	614	3116
*1980	0.4	-	817	20	-	572	24	17	2100	503	473	4526

* Preliminary figures

Table 17.

Summary of State Regulations for the Coastal United States, Maine to North Carolina

State	Minimum Size	Daily Creel	Disposition of Catch	Methods Permitted	License Required
Maine	none	none	no restrictions	hand line, rod & reel or spear	none
N.H.	16" FL min.	none	may sell	illegal to use seine, weir, net	none
Mass.	16" FL min.	4/day between 16" - 24" FL	may sell	hook & line legal size fish caught incidental to nondirected trap fishery	rod & reel license required for sale of daily catch over 100 lbs.
R.I.	16" FL min.	none	may sell	hook & line traps between Sept. 1 to Oct. 14	license required for commercial fish traps
Conn.	16" FL min.	none	may not sell	sport fishing only	license required upstream from tidewater
N.Y.	16" FL min.	none	may sell	any method (seines & nets illegal in Hudson, Delaware)	license required when caught in fresh water
N.J.	18" TL min.	10	may sell	rod & line, goggle fishing	license required when caught in fresh water
Del.	commercial fishing legal size range 12"FL to 20 lbs.	none	may sell	hook & line, haul seine, gill net	none
Md.	12" TL min. 32" TL max.	none (1 per day larger than 32" if caught by hook & line)	may sell if licensed	all methods except purse seine and otter trawl	commercial license required to sell
Va.	14" TL min.	none (no more than 2/day over 40")	may sell	all methods	fresh water license for striped bass
N.C.	12" TL min.	none	may sell	any method	none

Table 18.

Striped Bass Measurements

Total Length Conversions to Fork Length [1]

Total length inches	Fork Length inches	Total length Centimeters	Fork Length Centimeters
36.0	34.2	91.440	86.868
35.0	33.2	88.900	84.328
34.0	32.3	86.360	82.042
33.0	31.4	83.820	79.756
32.5	30.9	82.550	78.486
32.0	30.6	81.280	77.724
31.5	30.0	80.010	76.200
31.0	29.5	78.740	74.930
30.5	29.0	77.470	73.660
30.0	28.6	76.200	72.644
29.5	27.9	74.930	70.866
29.0	27.6	73.660	70.104
28.0	26.5	71.120	67.310
27.0	25.5	68.580	64.770
26.0	24.5	66.040	62.230
25.0	23.7	63.500	60.198
24.0	22.5	60.960	57.150
23.0	21.5	58.420	54.610
22.0	20.6	55.880	52.324
21.0	19.6	53.340	49.784
20.0	18.7	50.800	47.498
19.0	17.7	48.260	44.958
18.0	16.8	45.720	42.672
17.5	16.3	44.450	41.402
17.0	15.8	43.180	40.132
16.5	15.3	41.910	38.862
16.3	15.3	41.402	38.862
16.0	14.9	40.640	37.846
15.7	14.6	39.878	37.084
15.5	14.4	39.370	36.576
15.0	14.0	38.100	35.560
14.5	13.5	36.830	34.290
14.0	13.0	35.560	33.020
13.5	12.5	34.290	31.750
13.0	12.1	33.020	30.734
12.7	11.9	32.258	30.226
12.5	11.6	31.750	29.464
12.3	11.5	31.242	29.210
12.0	11.2	30.480	28.448
11.0	10.2	27.940	25.908
10.0	9.3	25.400	23.622
9.0	8.4	22.860	21.336
8.0	7.5	20.320	19.050

[1] Total length = 1.038 (fork length) + .4662
Fork length = .963 (total length) - .445

Table 19. Commercial Landings of Striped Bass in Maryland, by Market Categories, 1959-1978[1,2,3]

	12"-14"			14"-17"			>17"[5]			CLASSIFIED		UNCLASSIFIED		TOTAL
	Lbs.	% of Total Classified	% of Total	Lbs.	% of Total Classified	% of Total	Lbs.	% of Total Classified	% of Total	Sub-Total	% of Total	Sub-Total	% of Total	Lbs.
1959	937244	38.1	22.4	1020019	41.5	24.4	501556	20.4	12.0	2458819	58.7	1727998	41.3	4186817
1960	1488992	52.5	37.2	557424	19.6	13.9	790544	27.9	19.7	2836960	70.9	1166698	29.1	4003658
1961	2115357	55.6	36.9	1087755	28.6	19.0	603444	15.9	10.5	3806556	66.3	1932651	33.7	5739207
1962	775583	37.2	20.9	884259	42.5	23.8	422562	20.3	11.4	2082404	56.0	1636895	44.0	3719299
1963	725714	38.8	20.7	659370	35.3	18.8	485218	25.9	13.9	1870302	53.4	1630920	46.6	3501222
1964	568649	39.1	22.4	512108	35.2	20.2	374003	25.7	14.7	1454760	57.3	1082736	42.7	2537496
1965	378714	32.3	19.1	398962	34.1	20.1	393751	33.6	19.8	1171427	58.9	816453	41.1	1987880
1966	918589	50.1	35.7	416451	22.7	16.2	498683	27.2	19.4	1833723	71.2	742909	28.8	2576632
1967	1155950	63.7	40.4	351607	19.4	12.3	306328	16.9	10.7	1813885	63.4	1047927	36.6	2861812
1968	1636524	63.9	46.2	629461	24.6	17.8	296772	11.6	8.4	2562757	72.3	983037	27.7	3545794
1969	1817757	62.6	45.0	822897	28.3	20.4	264233	9.1	6.5	2904887	72.0	1131100	28.0	4035987
1970	845737	40.9	27.4	840578	40.7	27.2	380442	18.4	12.3	2066757	66.9	1021809	33.1	3088566
1971	726935	47.2	31.0	552354	35.9	23.5	260781	16.9	11.1	1540070	65.6	808196	34.4	2348266
1972	749153	43.1	26.7	604115	34.7	22.1	385678	22.2	13.9	1738946	62.6	1038189	37.3	2777135
1973	2807133	69.8	49.7	779124	19.4	13.8	436795	10.9	7.7	4023052	71.3	1620588	28.7	5643640
1974	433864	33.3	17.2	572239	43.9	22.6	297038	22.8	11.8	1303141	51.6	1224462	48.4	2527603
1975												2317034	100.0	2317034
1976												1477996	100.0	1477996
1977												1615547	100.0	1615547
1978												1049791	100.0	1049791[4]
1979														
1980														
X̄		48.0	31.2		31.7	19.7		20.4	12.7					

[1]data from Maryland Fisheries Administration files [2]1965-1978 Totals do not include Potomac River landings [3]breakdown by market categories not available for 1975-1978 [4]preliminary [5]maximum size limit 32" TL as of July 1, 1977; equivalent to previous maximum size limit of 15 lbs, in effect since July 1, 1941.

Table 20
1979 Massachusetts Striped Bass Landings by Weight Categories (lbs.).

	Small (2-5 lbs.)	Monthly Percent Distribution	Medium (5-15 lbs.)	Monthly Percent Distribution	Large (> 15 lbs.)	Monthly Percent Distribution	Total	Percent Total
May	3,519	7.8	4,159	9.2	37,635	83.1	45,313	11.3
June	4,189	3.1	8,637	6.4	122,260	90.5	135,086	33.8
July	2,622	4.0	6,816	10.3	56,874	85.8	66,312	16.6
August	1,990	4.2	4,621	9.7	40,824	86.1	47,435	11.9
September	2,476	8.4	3,283	11.1	23,746	80.5	29,505	7.4
October	1,536	2.4	2,903	4.6	59,183	93.0	63,622	15.9
November	611	6.7	144	1.6	88,322	91.7	9,077	2.3
December	27	0.8	0	0	3,386	99.2	3,413	0.9
Total	16,970		30,563		352,230		399,763	
Percent Total	4.2		7.6		88.1			

TABLE 21
PRELIMINARY COMMERCIAL STRIPED BASS LANDINGS, BY STATE, REGION, AND GEAR[1], 1980

GEAR / STATE/REGION	Gill Net (lbs)	Gill Net ($)	Pound Net (lbs)	Pound Net ($)	Hand Line (lbs)	Hand Line ($)	Haul Seine (lbs)	Haul Seine ($)	Otter Trawl (lbs)	Otter Trawl ($)	Total (lbs)	Total ($)	Percent of Total East Coast Landings (lbs)	Percent of Total East Coast Landings ($)
New England														
Maine	--	--	--	--	--	--	--	--	--	--	--	--	--	--
New Hampshire	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Massachusetts[2]	--	--	--	--	--	--	--	--	--	--	815,000	1,010,600[3]	17.8	20.8
Rhode Island	33	47	--	--	11,857	26,825	--	--	3,255	4,575	20,113	30,450	.4	.6
Connecticut	--	--	--	--	--	--	--	--	--	--	45,000	59,000	1.0	1.2
Sub-total	33	47	--	--	11,857	26,825	--	--	3,255	4,575	880,113	1,100,050	19.2	22.6
Mid-Atlantic														
New York	112,905	160,997	95,051	149,509	214,497	387,193	79,651	138,050	69,939	93,396	572,043	929,145	12.5	19.2
New Jersey	7,215	8,911	284	354	--	--	--	--	15,832	21,274	23,331	30,359	.5	.6
Sub-total	120,120	169,908	95,335	149,863	214,497	387,193	79,651	138,050	85,771	114,670	595,374	959,684	13.0	19.8
Chesapeake														
Delaware	16,800	15,451	--	--	--	--	--	--	--	--	16,800	15,451	.4	.7
Maryland	2,046,948	1,766,359	23,029	19,679	11,455	13,699	18,287	23,846	1,270	1,520	2,100,989	1,825,103	46.0	37.6
Virginia	413,873	415,804	65,001	57,591	3,183	5,089	131	141	21,062	34,249	503,260	512,880	11	10.6
Sub-total	2,477,621	2,197,614	88,030	77,270	14,638	16,788	18,418	23,987	22,332	35,769	2,621,049	2,353,434	57.4	48.9
South Atlantic														
North Carolina	409,969	351,354	13,826	12,877	18,921	21,359	7,276	7,963	21,359	40,601	471,351	434,154	10.3	9.0
Total East Coast	3,007,743	2,718,923	197,131	240,010	259,913	454,165	105,345	170,000	132,717	195,615	4,567,887	4,847,322	(100)	(100)

1 In addition to the gear shown, floating traps in Rnode Island caught 4968 pounds of striped bass worth $8590. These values are included in the totals.
2 Breakdown of landings by gear type is unavailable. NMFS indicates that 95% and 90% of the catch in Mass. and Conn., respectively, are hand line.
3 Massachusetts Landings (815,000) are from NMFS. Value ($1010,600) is an estimate based on Preliminary 1980 Data.
4 Maryland and Virginia landings include striped bass caught in the Potomac River.
5 Gear Type totals do not include all states.

(Source: Smith et al. 1981)

Table 22. Marine recreational catch of striped bass by catch type for the Atlantic and Gulf coast of the United States. 1979.

	Number by region [2]				
Catch[1] Type	North Atlantic	Mid Atlantic	South Atlantic	Gulf	All Regions
A	43,000	487,000	9,000[3]	1,000[3]	540,000
A+B	185,000	948,000	47,000	1,000[3]	1,181,000
B1	90,000	73,000	0	0	163,000
B2	52,000	387,000	38,000	0	478,000
A+B1	133,000	560,000	9,000[3]	1,000[3]	703,000

1 Catch type
A = catch brought to shore and identified
B = catch not seen by interviewer
B_1 = catch discarded dead, filleted, used for bait
B_2 = released alive

2
N. Atlantic = states of ME, NH, MA, RI, CT
M. Atlantic = states of NY, NJ, DL, MD, VA, DC
S. Atlantic = states of NC, SC, GA, FL (east coast)

3
Interpolated from original tables

Table 23. Marine recreational catch[1] of striped bass from Maine to North Carolina. 1979.

State	Number	State	Number
Maine	17,000[2]	New York	276,000
New Hampshire	none reported	Maryland	649,000
Massachusetts	59,000	New Jersey, Delaware, Virginia	23,000[2]
Rhode Island	44,000		
Connecticut	65,000		
		North Carolina	38,000
		Total	1,171,000

1 Catch Type A+B

2 Interpolated

Table 24. Distribution of catch, by region, of marine recreational catch of striped bass on the Atlantic and Gulf Coast of the U.S. 1979.

	Subregion				
Measurement	North Atlantic	Mid Atlantic	South Atlantic	Gulf	All Regions
Catch type A Striped bass lb.	586,400	1,918,000	15,400[1]	2,200[1]	2,522,100
Regional percent of total striped bass catch (lb.) from all regions	23.3	76.1	0.6	0.1	
Regional percent of total finfish catch (lb.) from all regions	3.2	2.2	<0.1	<0.1	1.3
Average weight (lb.) of individual striped bass	13.6	3.9	1.7	2.2	4.6
Catch type A+B[1] striped bass no.	133,000	560,000	9,000[1]	1,000[1]	703,000
Percent of total striped bass catch (no.)	18.9	79.7	1.3	0.1	
Percent of total finfish catch (no.)	0.1	0.3	<0.1	<0.1	0.4

1 Interpolated

Table 25 A summary of annual landings of striped bass in Rhode Island since 1960. Landings are broken down into gear type.

Year	Total	Value	Price/lb.	Traps	Handline	Misc.
1977	98	77	.78	12	79	7
1976	151	121	.80	13	132	6
1975	305	153	.60	19	263	23
1974	336	114	.34	162	164	10
1973	623	220	.35	365	253	5
1972	309	115	.37	182	109	18
1971	131	39	.29	40	77	14
1970	84	25	.29	18	55	11
1969	132	35	.26	45	74	13
1968	98	22	.22	28	34	36
1967	132	25	.19	68	41	23
1966	250	45	.18	195	42	13
1965	60	11	.18	20	34	6
1964	75	12	.16	20	45	10
1963	71	13	.18	31	22	18
1962	61	10	.16	23	34	4
1961	167	26	.15	126	27	14
1960	77	15	.19	68	8	1

Landing in 1000's of pounds
Value in 1000's of dollars
Price/lb. in dollars
Misc. includes fish taken by dragger and gill nets.

Table 26 Monthly summaries of Rhode Island Commercial Landings of Striped bass for the ten year period 1965-74 . (Thousands of pounds).

Year	M	A	M	J	J	A	S	O	N	D	Total
1974	-	19	18	44	49	13	8	132	52	.8	335
1973	-	3	100	53	52	40	47	218	109	-	622
1972	-	5	8	19	17	32	20	168	39	9	304
1971	-	-	6	13	17	20	17	19	32	-	124
1970	-	-	14	10	10	13	16	13	4	-	80
1969	-	8	16	9	8	15	3	40	14	-	113
1968	-	.7	10	6	3	10	7	30	9	-	75
1967	-	.8	17	6	8	11	8	67	.5	-	117
1966	-	.1	12	15	7	6	12	129	57	-	238
1965	-	-	3	6	8	7	9	11	4	-	48
Average		3.1	20.4	18.1	17.9	16.7	14.7	82.7	32.0	9.8	
%		1.4	9.4	8.4	8.3	7.7	6.8	38.3	14.8	4.5	

Table 27 A summary of commercial landings of striped bass taken in Connecticut waters from 1893-1939.

	Type of Gear			
Year	Pound & Weir	Gill Net 2 1/2" (lbs.)	Total (lbs.)	Value ($)
1893	-	-	2,500	-
1897	-	-	6,547	-
1898	-	-	2,885	-
1901	-	-	13,145	-
1902	-	-	4,402	-
1905	6,070	5,862	11,932	$1210
1906	4,445	1,570	6,015	$ 589
1907	4,371	-	4,371	$1111
1908	2,749	-	2,749	$ 335
1909	3,696	2,949	6,645	$ 822
1910	5,453	3,277	8,730	$1092
1911	4,454	3,327	7,781	$1026
1912	3,141	4,935	8,076	$1049
1913	3,795	3,895	7,690	$ 852
1914	5,528	2,746	8,274	$1368
1915	6,755	2,300	9,055	$1303
1916	3,638	2,836	6,474	$1173
1917	4,285	2,526	6,811	$1194
1918	5,705	2,850	8,555	$2373
1919	-	-	2,023	$ 519
1920	-	-	1,280	$ 599
1924	-	-	1,495	$ 384
1925	-	-	5,227	$1149
1926	-	-	4,629	$1001
1927	-	-	4,167	$1080
1939	-	-	8,946	$1272
Totals	64,085	39,073	160,404	$21501

TABLE 28 COMMERCIAL STRIPED BASS FISHERMAN BY STATE - 1980

State/Region	Estimated Population	Source	Comments--
Massachusetts † North of Cape Cod	333	Massachusetts, Dept. of Natural Resources	Based on commercial licensing of rod and reelers, for the sale of striped bass in excess of 100 pounds per day.
Cape Cod	264	"	"
Connecticut	150 - 200	Connecticut Dept. of Environmental Protection	Commercial harvesting of striped bass is prohibited in Connecticut. D.E.P. officials, however, estimate that of the 45,000 recreational fishermen directing effort towards striped bass, 150-200 could be considered commercial fishermen.
Rhode Island	850	Rhode Island wholesaler	Mostly (80%) hand liners and float trap fishermen, both full and part time.
New York	--	--	Unable to estimate at this time, additional data is needed.
New Jersey	130	New Jersey - Bureau of Shellfisheries	Licensed gill-netters in New Jersey.
Delaware	60	Delaware Division of Fish & Wildlife	Based on landings and effort data from Delaware Division of Fish & Wildlife. These (60) are all gill-netters who focus effort on the striped bass - there are about 150 gill-netters working in Delaware.

† The North of Cape Cod region encompasses all counties north of Plymouth County and Cape Cod Bay.

TABLE 28 (Continued)

State/Region	Estimated Population	Source	Comments--
Maryland †† Northern Chesapeake	268	Maryland Department of Natural Resources	This includes both full and part-time licensed gill-netters. An unknown percentage catch striped bass.
Southern Chesapeake	1287	"	"
Virginia	761 (full time) 2000-3000 (part-time or casual)	Virginia Marine Resources Commission	Includes all licensed gill-netters Part-time fishermen are defined as those spending 50 percent or less of their working effort gill netting.
North Carolina	78	Marine Advisory Service North Carolina State Univ.	Mostly gill netters

(Source; Smith et al. 1981)

†† The Northern Chesapeake includes all counties north of the Bay Bridge - the Southern Chesapeake encompasses all counties south of the Bay Bridge.

Table 29

Estimated Number of Establishments Handling Striped Bass

State	Wholesalers	Restaurants	Retailers
Massachusetts	42	141	51
Connecticut	30	58	52
Rhode Island	12	122	16
New York	211*	145	259
New Jersey	64	24	53
Delaware	4	12	14
Maryland	75	115	89
District of Columbia	5	31	8
Virginia	87	80	65
North Carolina	28	10	6

* Total population for the state, an unknown number handle striped bass.

(Source: Smith et al. 1981)

Table 30. Fulton Street Striped Bass Receipts, by Region, State of Origin, and Month.

State/Region	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
	-(in 1000s of lbs.)-												
New England													
Massachusetts	1.3	-	-	3.8	22.0	250.0	96.8	46.4	69.6	172.3	42.6	6.7	711.5
Rhode Island	-	-	1.2	1.4	6.3	2.8	1.7	.3	.1	1.9	.8	.2	16.7
Connecticut	.5	.1	-	.5	.2	8.3	17.8	13.9	6.5	3.5	3.3	1.4	56.0
Total	1.8	.1	1.2	5.7	28.5	261.1	116.3	60.6	76.2	177.7	46.7	8.3	784.2
Mid Atlantic													
New York	1.2	-	3.9	19.1	18.8	50.3	48.5	35.8	35.6	49.8	150.3	29.7	443.0
New Jersey	-	11.3	2.5	15.7	1	2.8	.3	.1	4.1	2.5	1.3	5.7	47.3
Total	1.2	11.3	6.4	34.8	19.8	53.1	48.8	35.9	39.7	52.3	151.6	35.4	490.3
Chesapeake													
Delaware	-	-	.1	10.3	6.3	-	-	-	-	-	-	-	16.7
Maryland	81.7	71.3	96.8	79.8	22.0	8.4	3.1	-	-	5.9	10.4	136.0	515.4
Virginia	8.8	22.4	44.6	64.1	8.1	1.2	-	-	.3	5.5	3.6	4.1	162.7
Total	90.5	93.7	141.5	154.2	36.4	9.6	3.1	-	.3	11.4	14.0	140.1	694.8
South Atlantic													
North Carolina	32.1	29.2	20.9	24.5	1.5	5.6	2.1	12.0	3.7	5.7	6.4	17.0	160.7
Grand Total	125.6	134.3	170.0	219.2	86.2	329.4	170.3	108.5	119.9	247.1	218.7	200.8	2,130.0
Wholesale† Selling Price	$1.65	$1.10	$ .90	$2.00	$2.40	$1.25	$1.95	$3.00	$2.45	$1.80	$1.85	$1.50	

†Wholesale selling prices are the average ex-market selling prices by month.

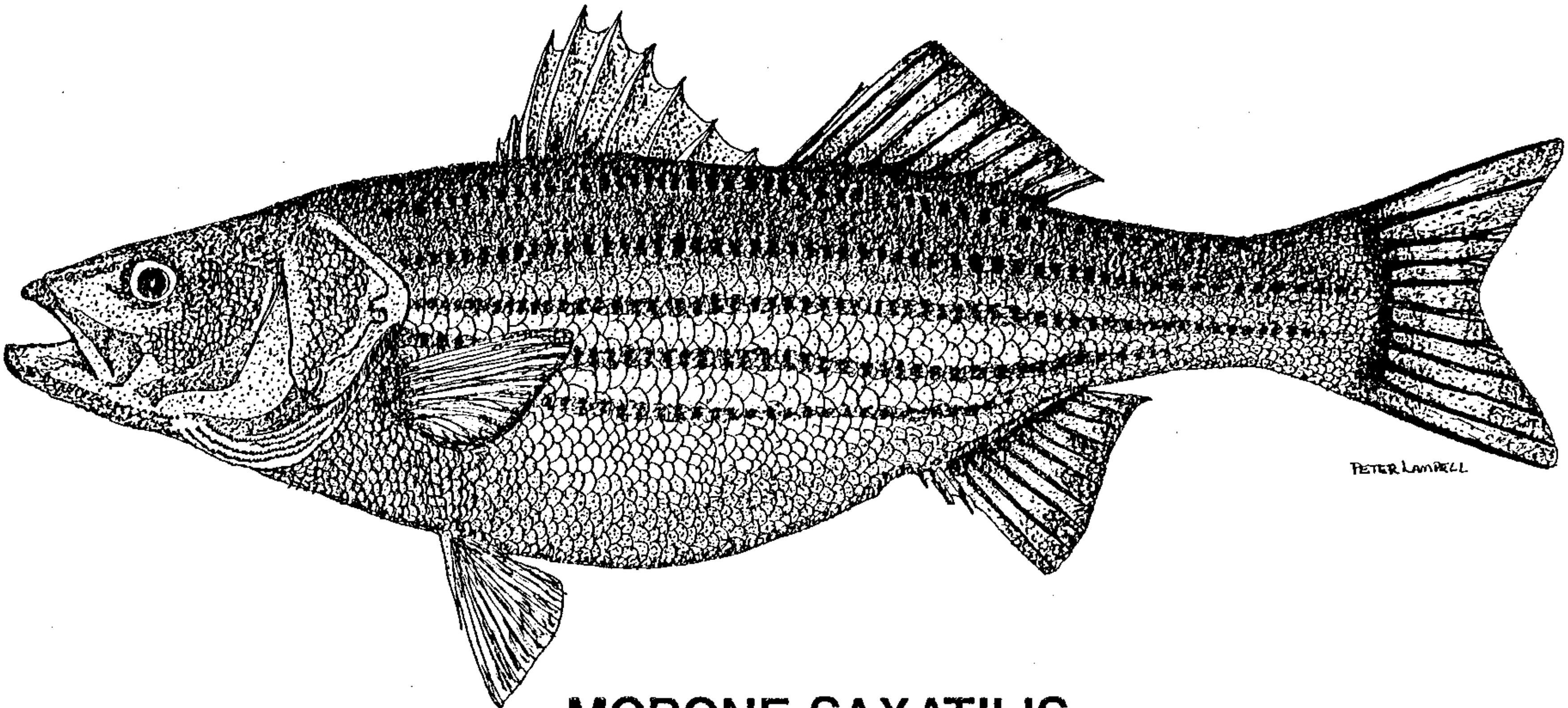
(Source: Smith et al. 1981)

Table 31. Effects of increasing size limits from present baseline, 12 inches TL Bay and 16 inches FL ocean, on striped bass stocks produced in the Chesapeake Bay*

Increased Minimum Size Limits:	Bay Ocean	15" TL min 24" FL min	14" TL min 24" TL min
Effects			
a. Increase average coastal harvest in pounds		47%	31%
b. Decrease average coastal harvest in numbers		37%	33%
c. Increase the number of females surviving to maturity by (Fecundity)		103%	62%
d. Increase the total Md. catch in pounds by		22%	15%
e. Decrease number fish landed in the Bay		16%	7%

* Analysis does not factor in a creel limit on bass 14" - 24"

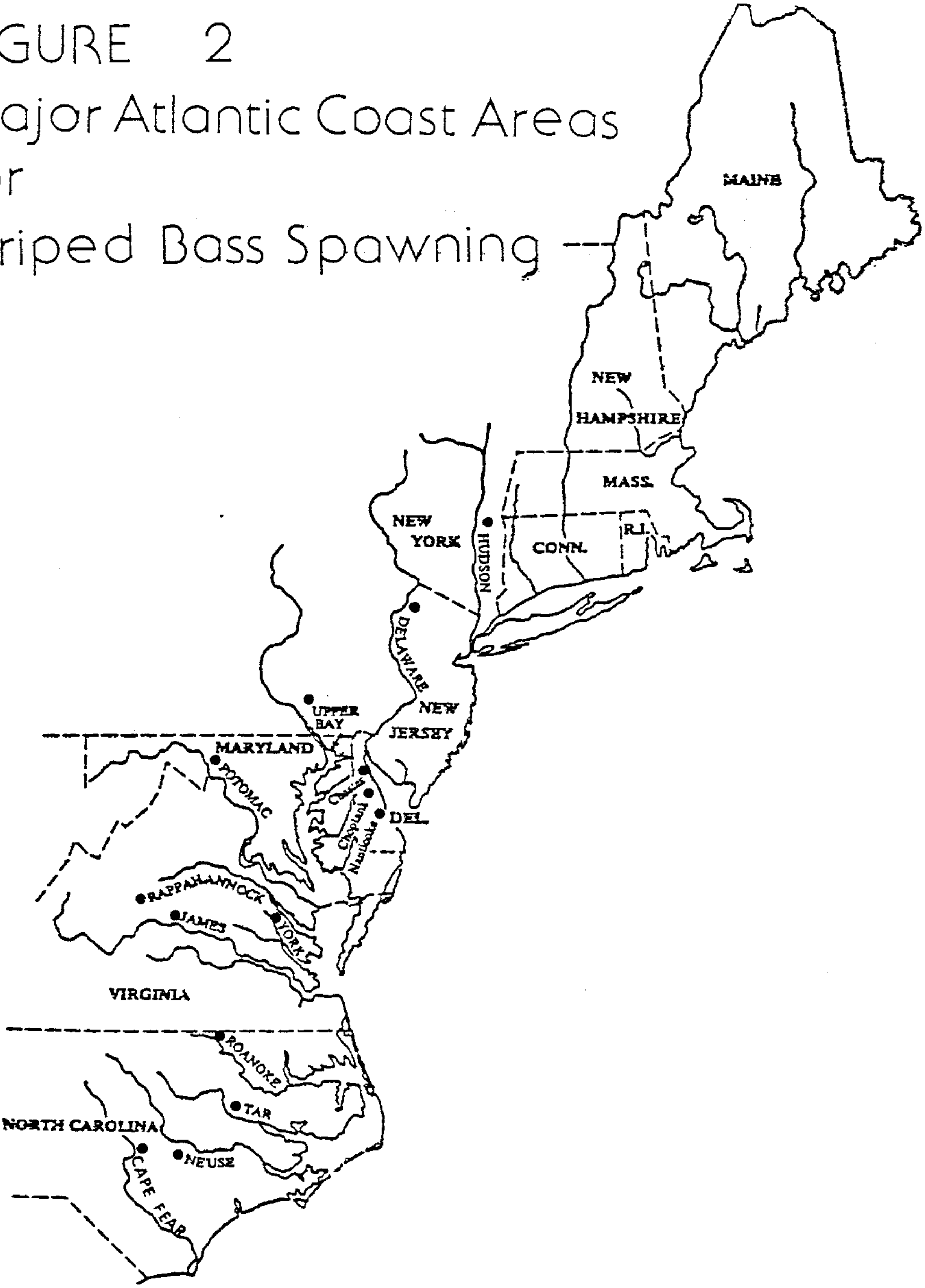
FIGURES



MORONE SAXATILIS

Figure I

FIGURE 2
Major Atlantic Coast Areas for Striped Bass Spawning



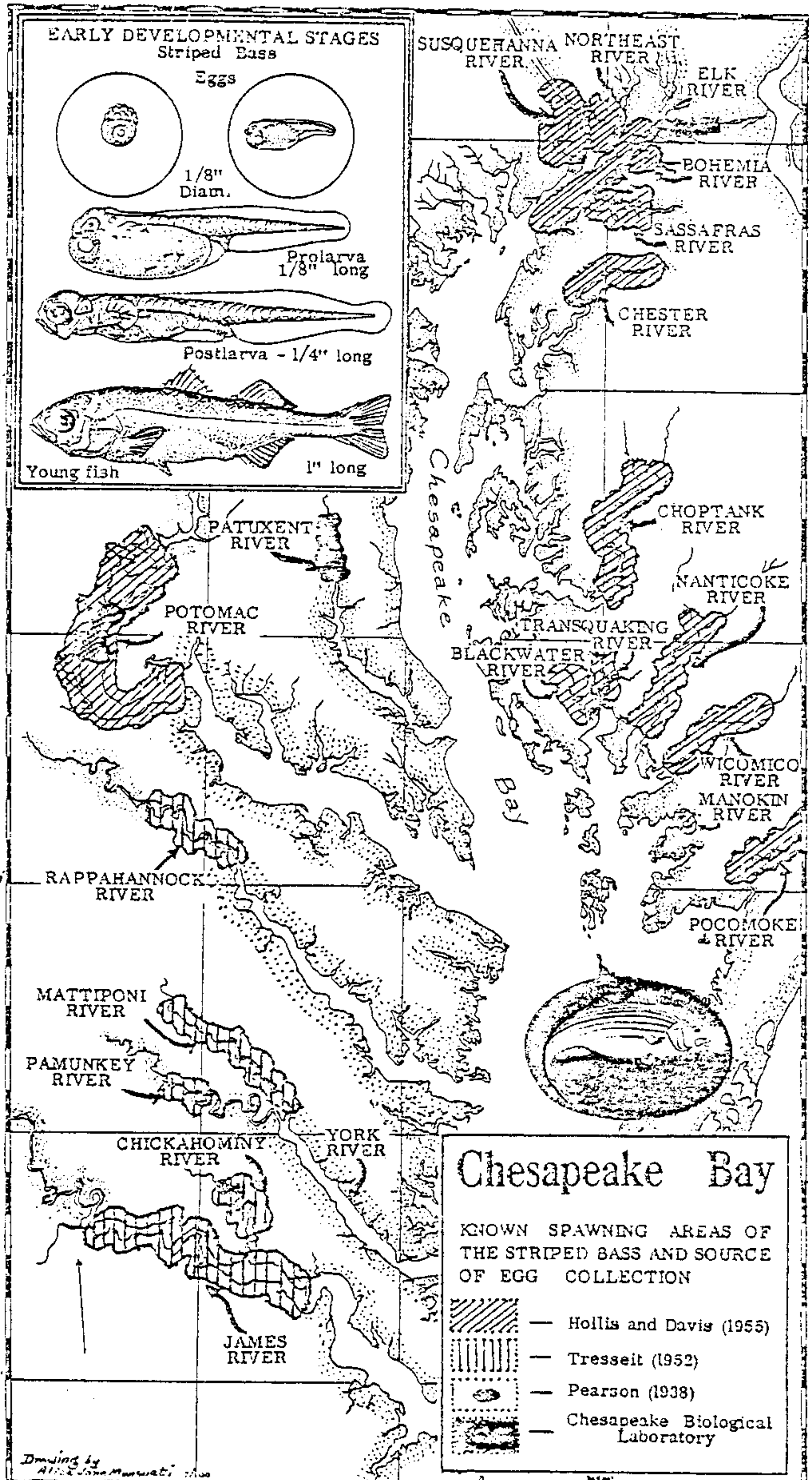
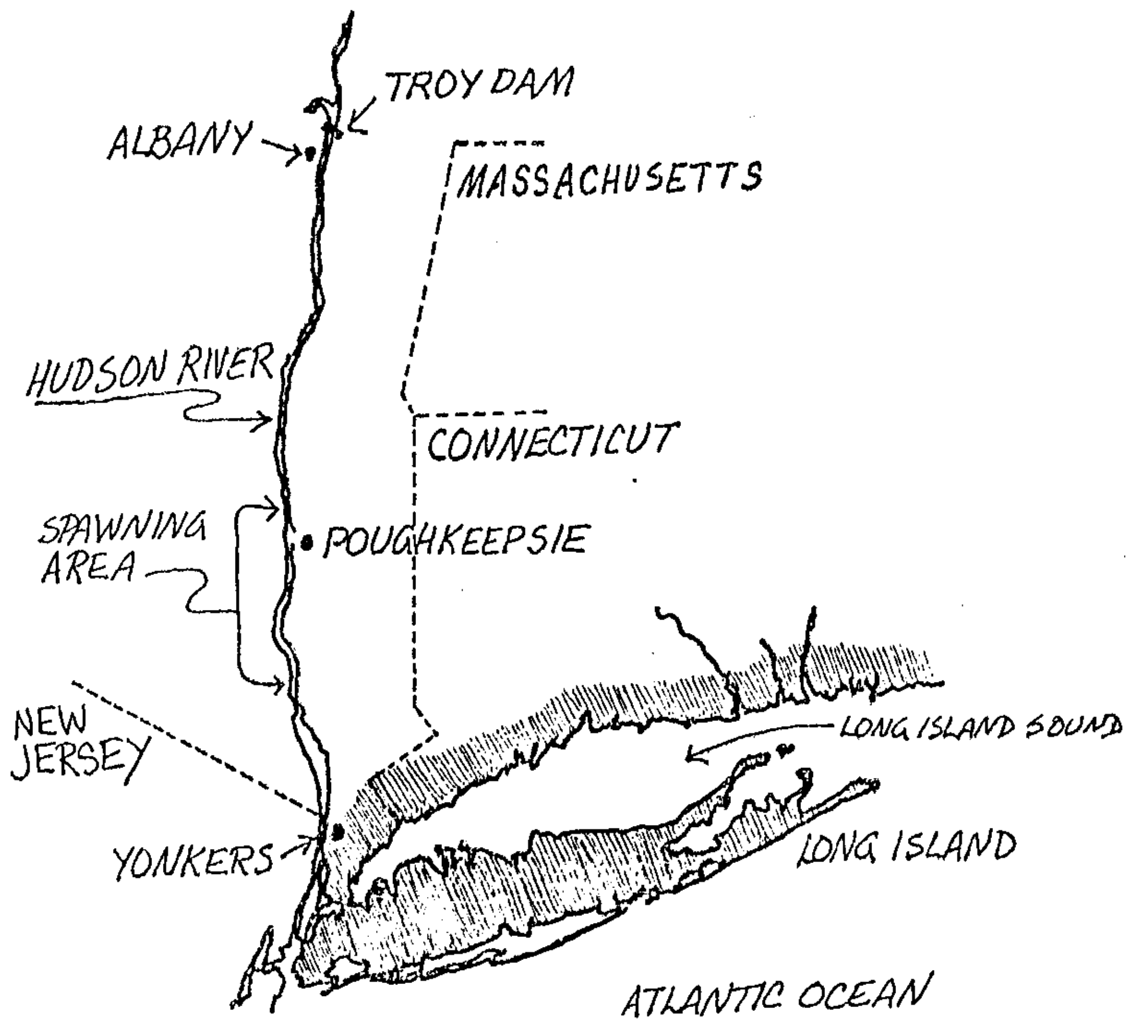


Fig. 3 Ranges and locations of some of the principal spawning areas of striped bass, or rock, in Chesapeake Bay, with illustrations of selected early developmental stages.

Figure 4

Hudson River and Long Island Sound



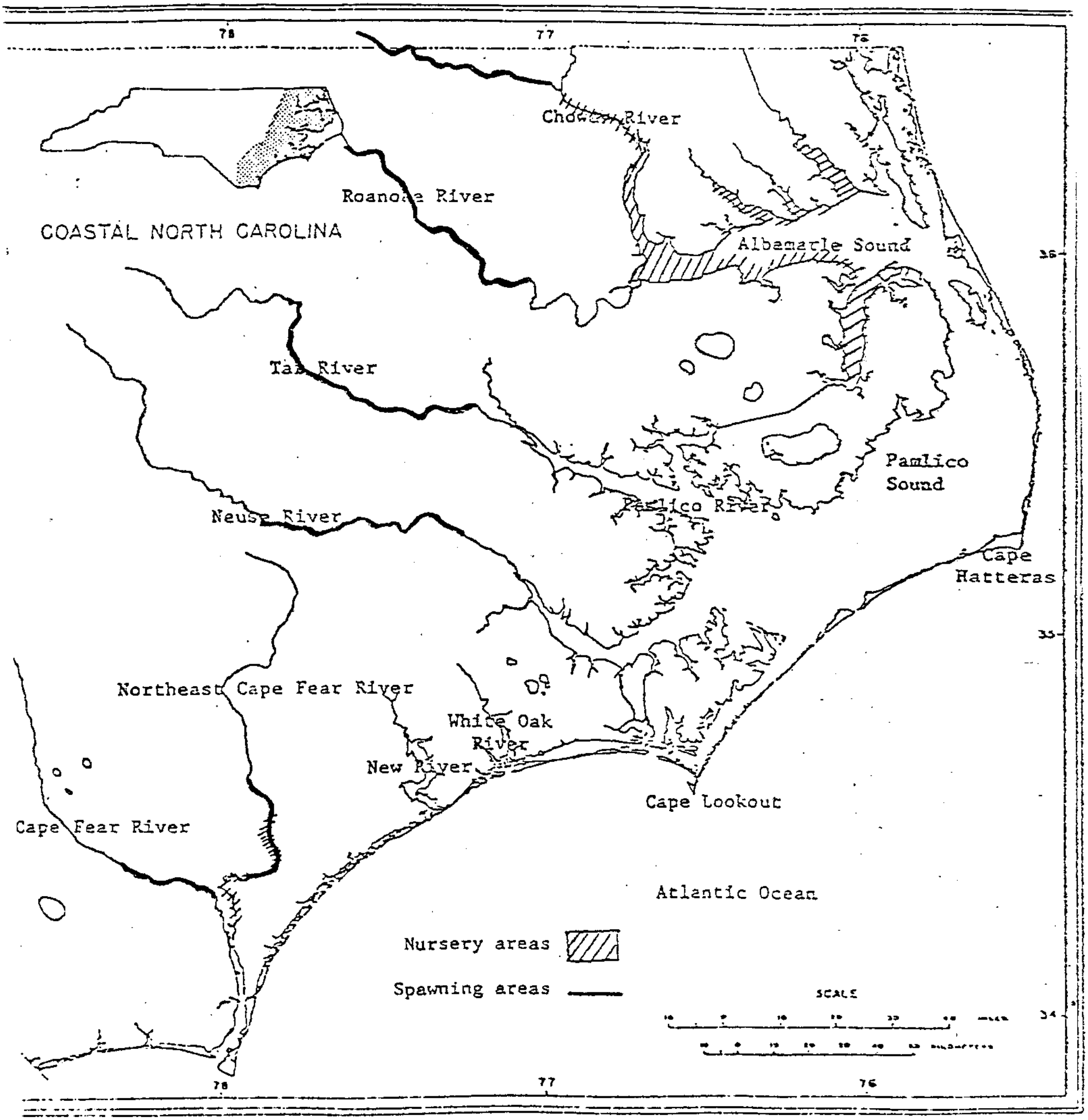


Figure 5 Spawning and nursery areas of striped bass in North Carolina.

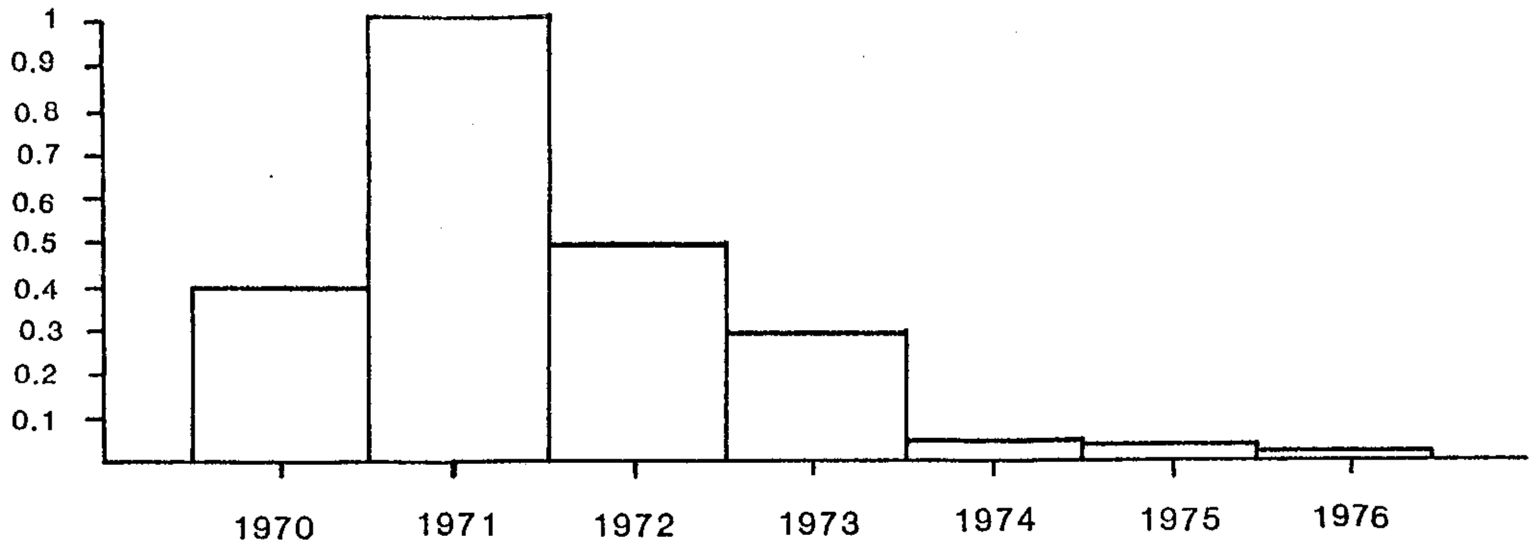


Figure 6 Average annual catch per tow of juvenile striped bass in the Delaware Bay near Artifical Island. 1970-1976.
(Icthyological Associates, 1980)

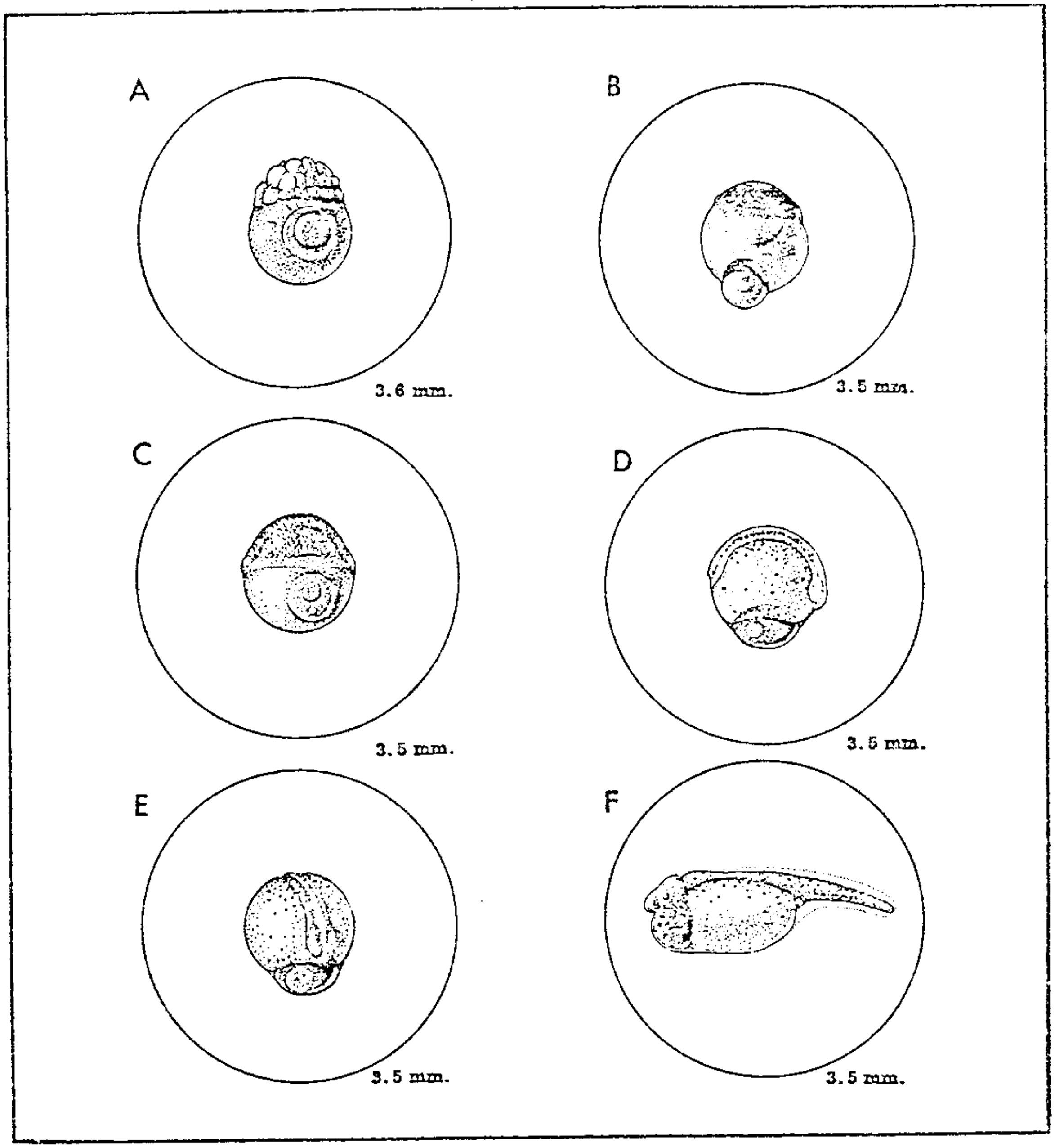
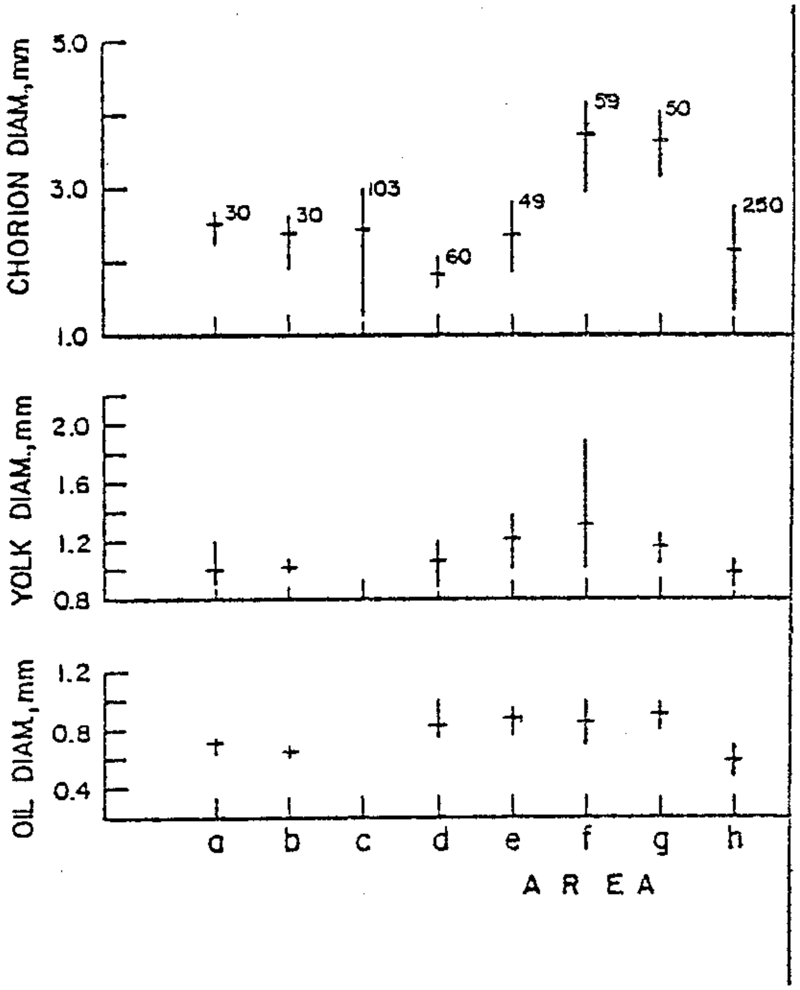


Figure 7 Striped bass eggs. A. fertilized egg, showing 32-cell stage; B. fertilized egg, many-celled stage or early blastoderm; C. fertilized egg, germ ring and embryonic shield stage; D. fertilized egg, early embryonic stage (lateral view); E. fertilized egg, early embryonic stage (dorsal view); F. fertilized egg, fully developed embryo, chorion-3.5 mm, embryo-2.5 mm (from: Mansueti, 1958).

Figure 8



Regional variation in striped bass egg dimensions; chorion, yolk and oil diameters measured in live material from several locations indicated by letters. Number to right refers to the number of eggs measured from each location.

a - Hudson River, hatchery 1975 (Rogers, 1978)
b - Hudson River, hatchery 1976 (Rogers, 1978)
c - Delaware River (Bason, 1971)
d - Blackwater River, Maryland, 1974 (Rogers, 1978)
e - Transquaking River, Maryland, 1974 (Rogers, 1978)
f - Nanticoke River, Maryland, 1974 (Rogers, 1978)
g - Choptank River, Maryland, 1975 (Rogers, 1978)
h - South Carolina, Moncks Corner Hatchery, 1976 (Rogers, 1978)

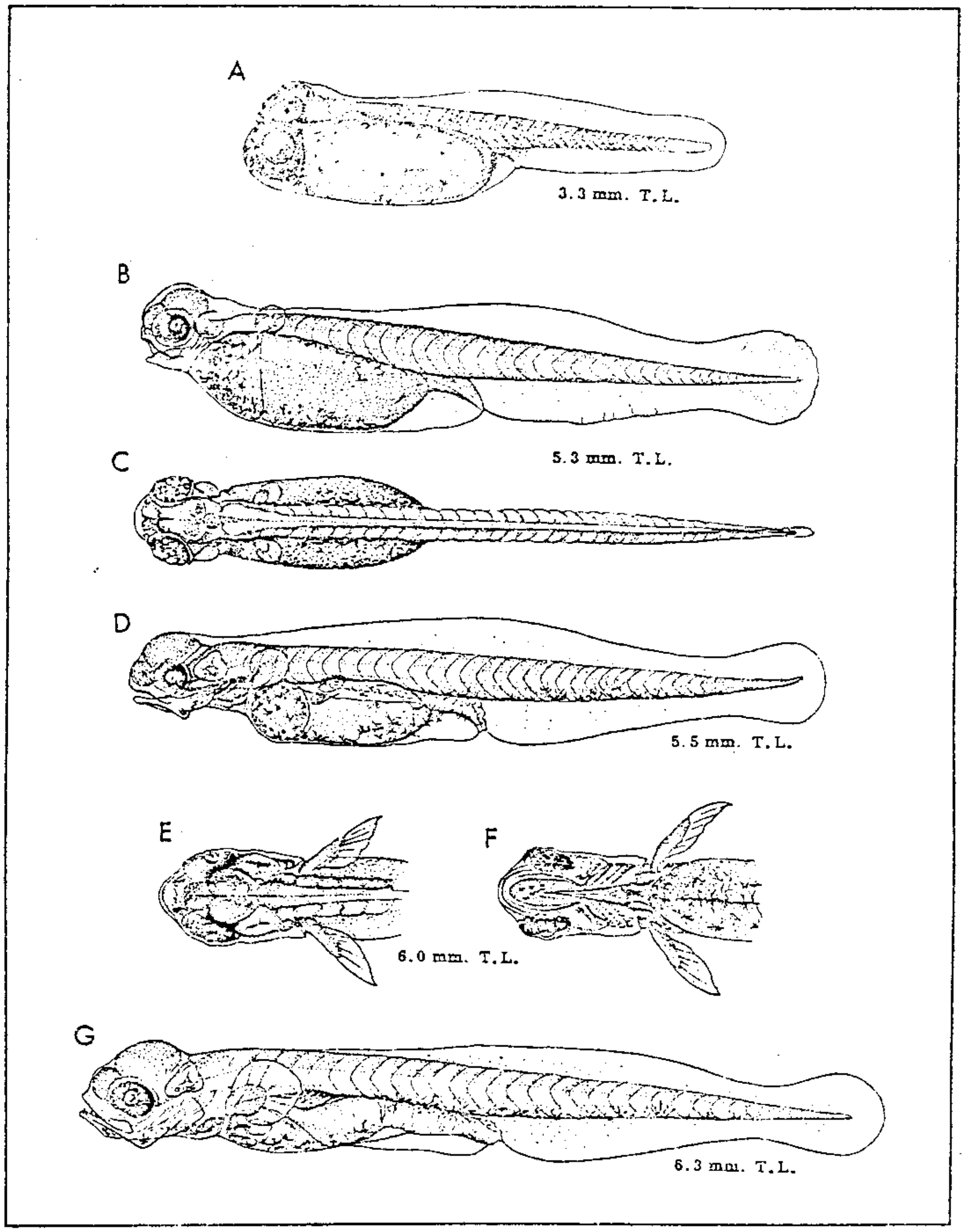


Figure 9 Striped bass prolarvae. A. prolarva, soon after hatching. B. prolarva, lateral view; C. prolarva, dorsal view; D. prolarva, 5.5 mm; E. prolarva, dorsal view; F. prolarva, ventral view; G. prolarva, almost indistinguishable from early postlarva (from: R. Mansueti, 1958).

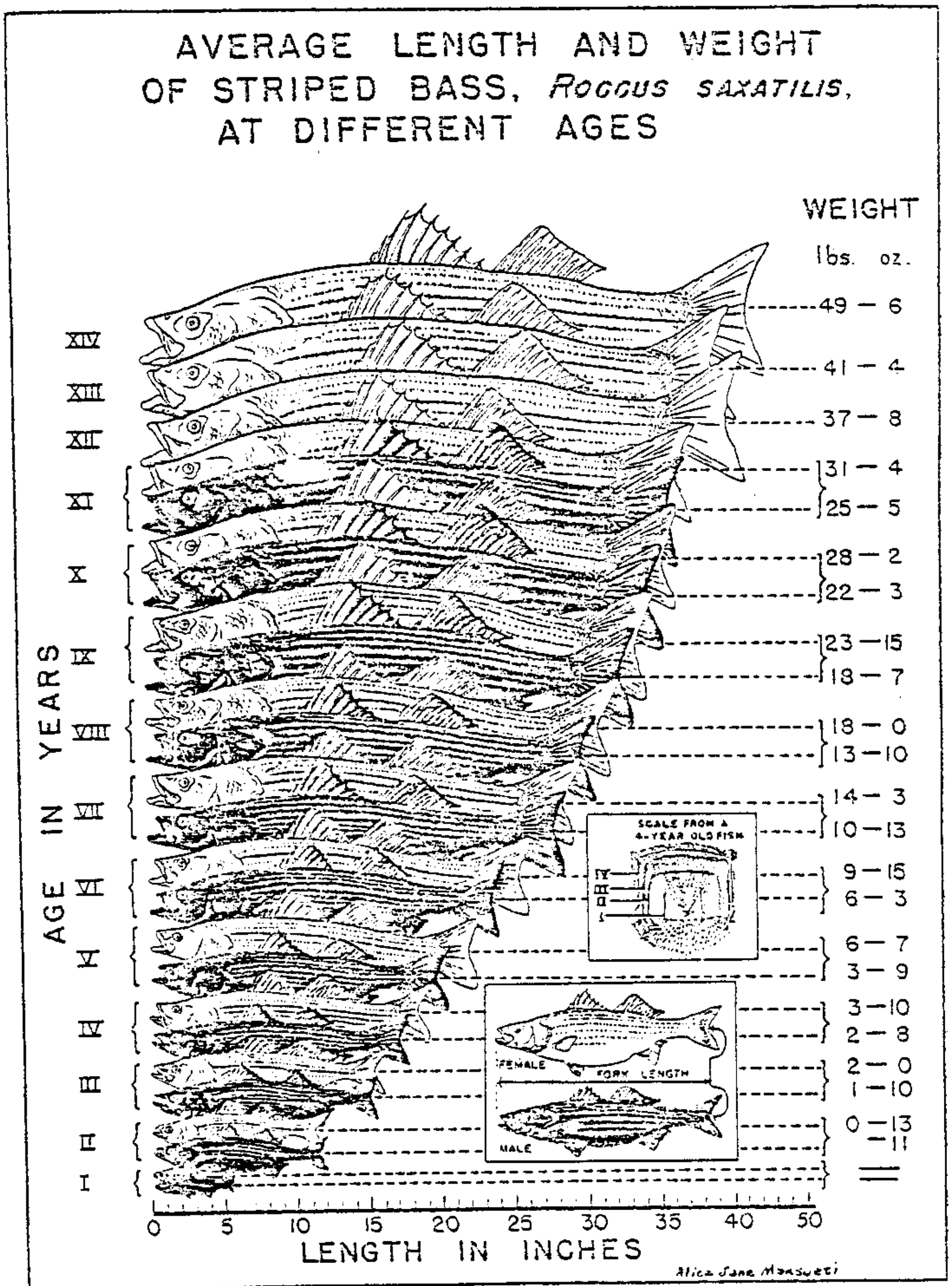


Fig.10 Graphic summary of average lengths and weights of striped bass, or rock, at different ages. This chart highlights two facts: (1) beginning at 3 years of age, the female is larger than the male at the same age; and (2) males do not live as long as females. In this sample of fish very few males over 8 years old were captured; none were found among large fish over 11 years old. Therefore, virtually all "jumbo" striped bass appear to be females. These results are based on calculated data derived from the examination of annular rings of scales taken from striped bass caught in various regions of Chesapeake Bay, during 1957 and 1958. After Mansueti (1961A).

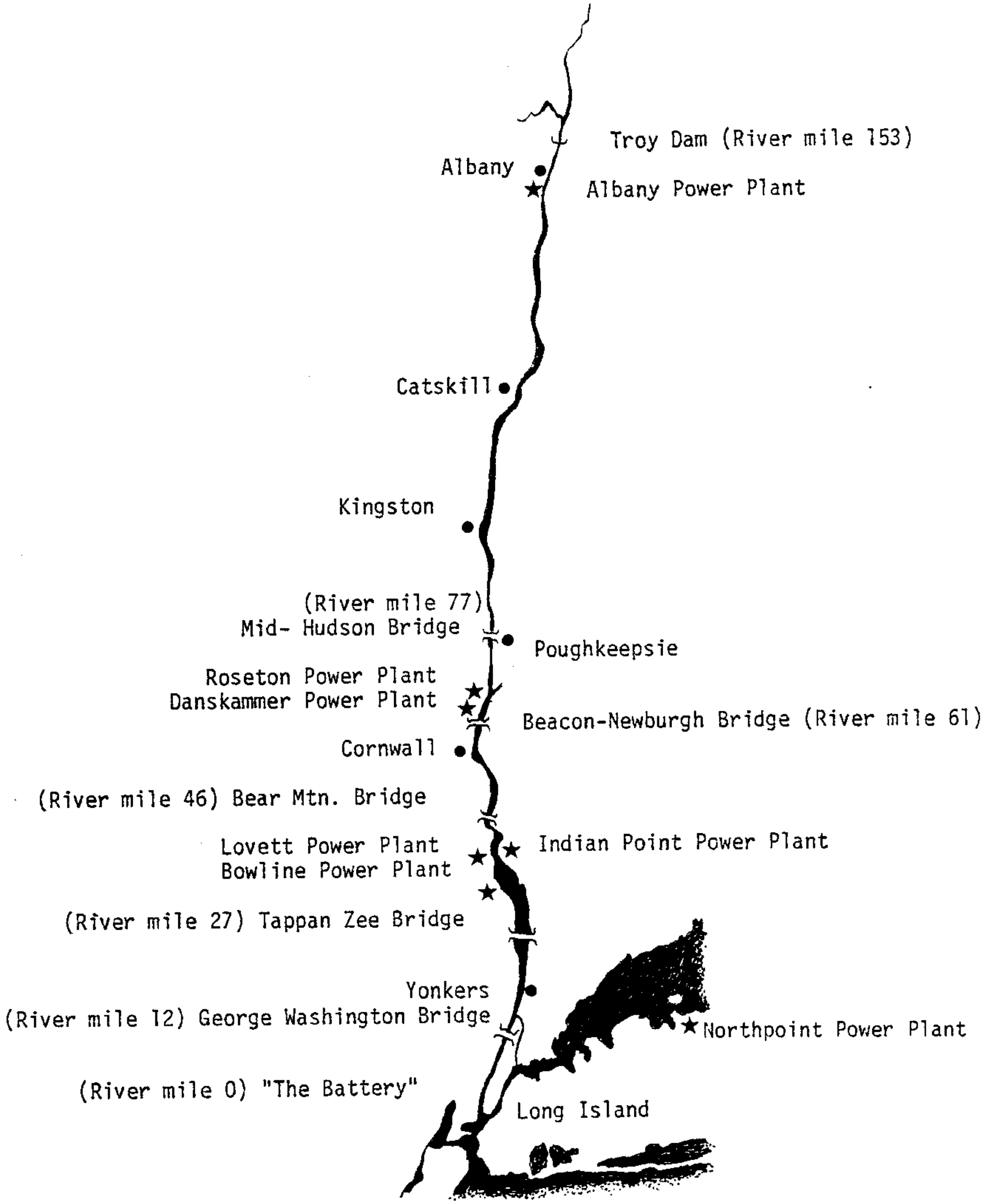


FIGURE 11. Location of Power Plants on Hudson River and Estuary

Figure 12. Relative Annual Abundance of Young-of-Year Striped Bass in Maryland Waters.

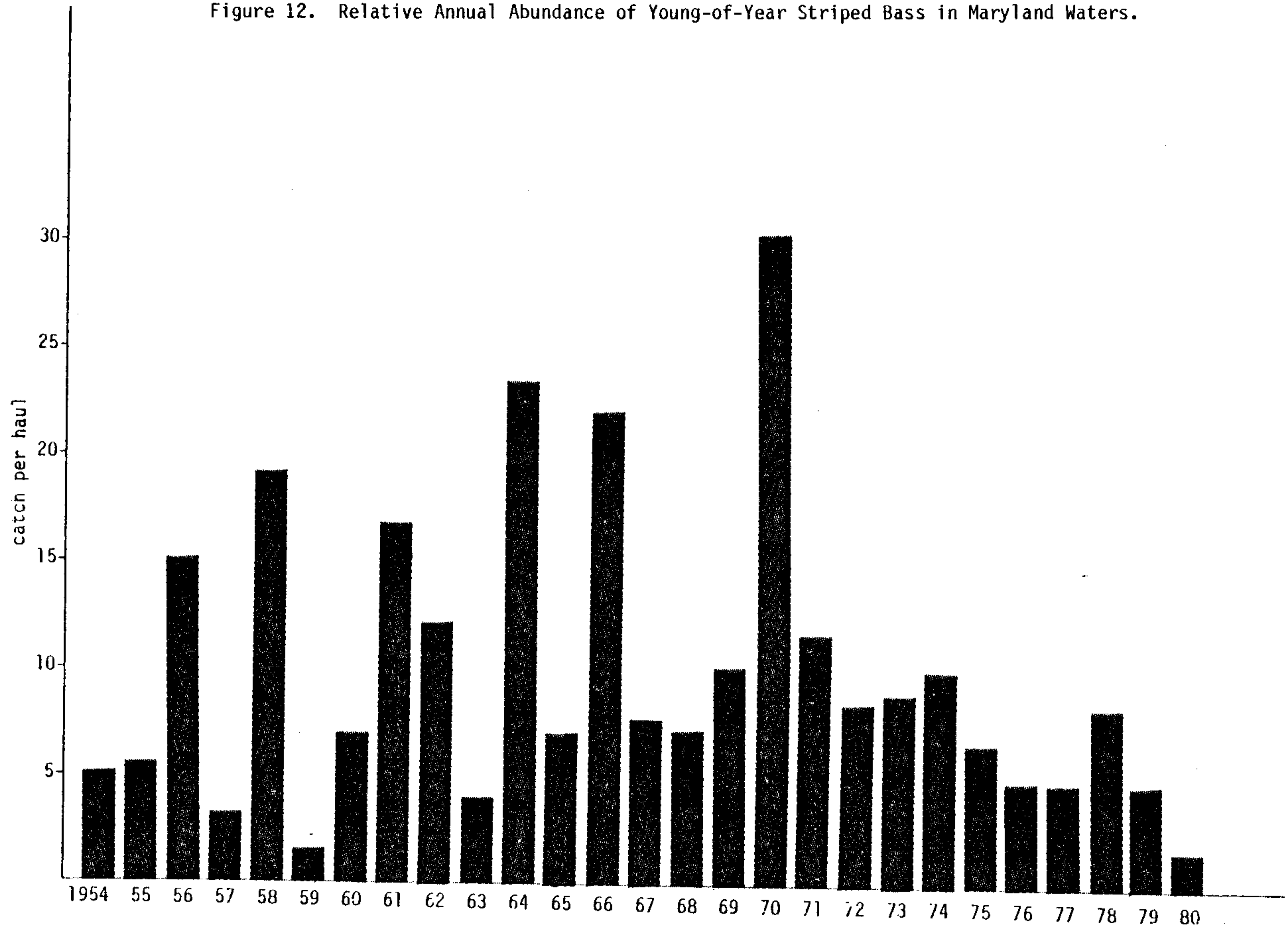
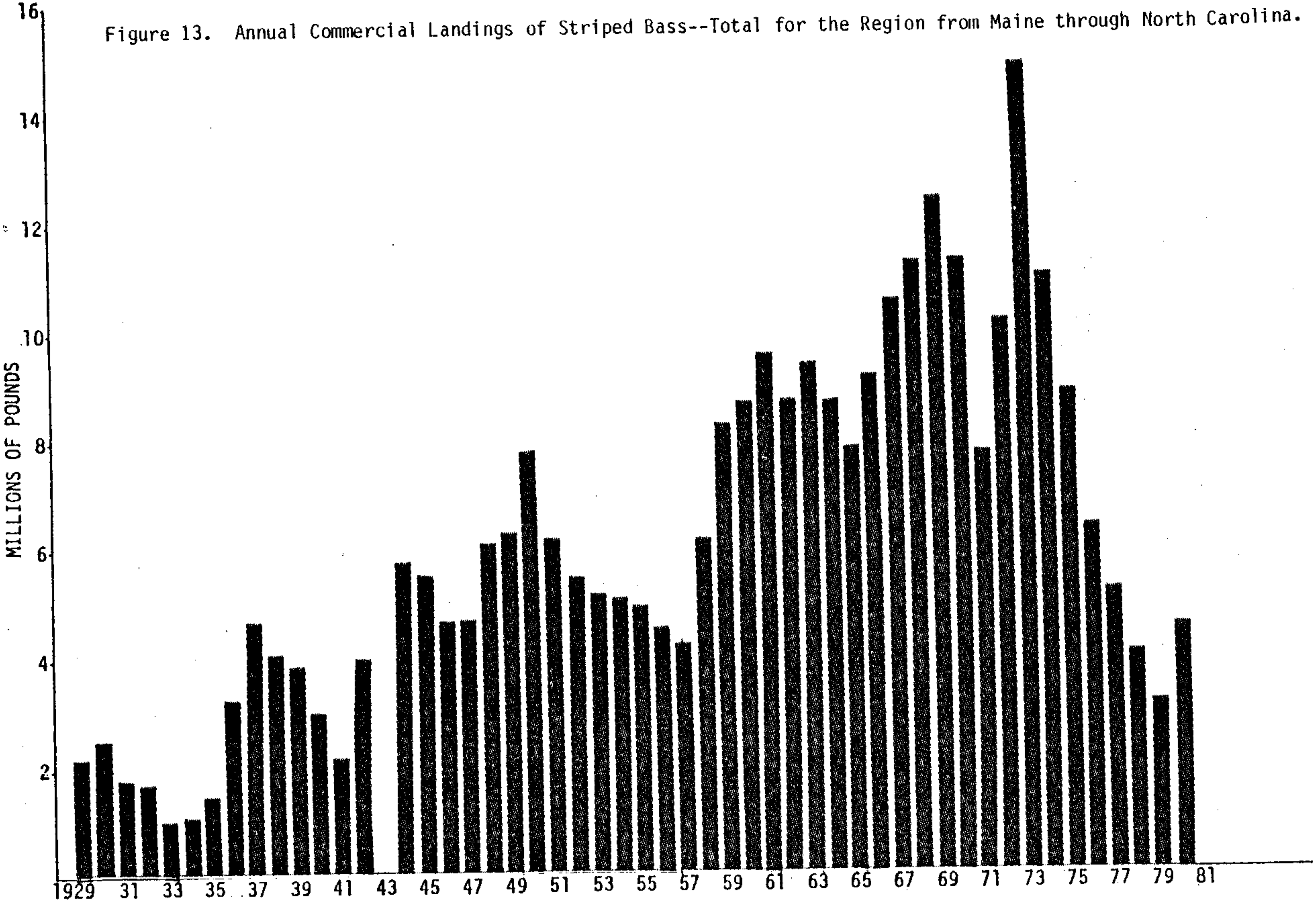


Figure 13. Annual Commercial Landings of Striped Bass--Total for the Region from Maine through North Carolina.



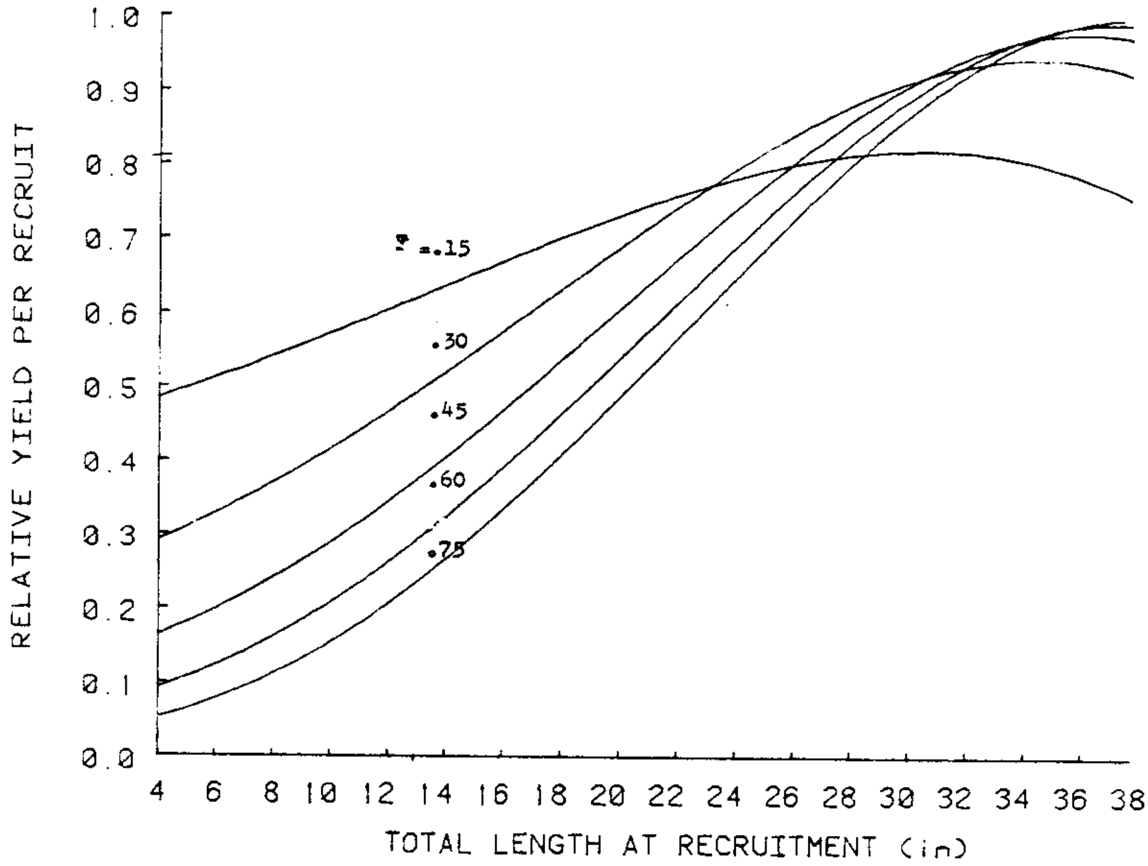
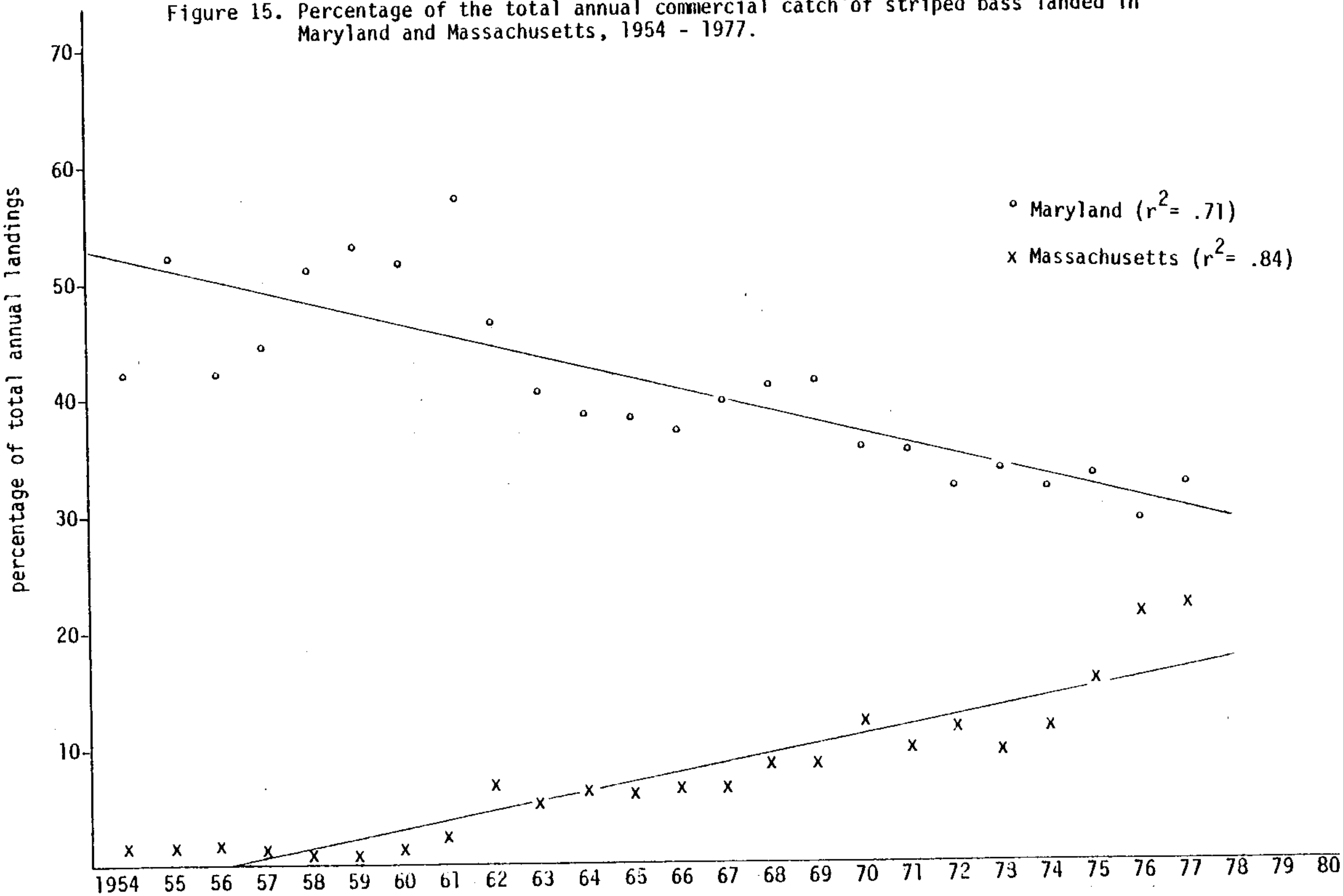


Figure 14 . The relationship between relative yield per recruit and length at recruitment to the fishery for several levels of conditional fishing mortality assuming no upper size limit and a natural mortality rate of 0.15. Computations were performed with the Beverton-Holt yield per Recruit Model with Von Bertalanffy growth parameters estimated from data on female striped bass reported by Mansueti (1961). The results with growth parameters estimated for data on males and both males and females in other studies are similar to those provided here.

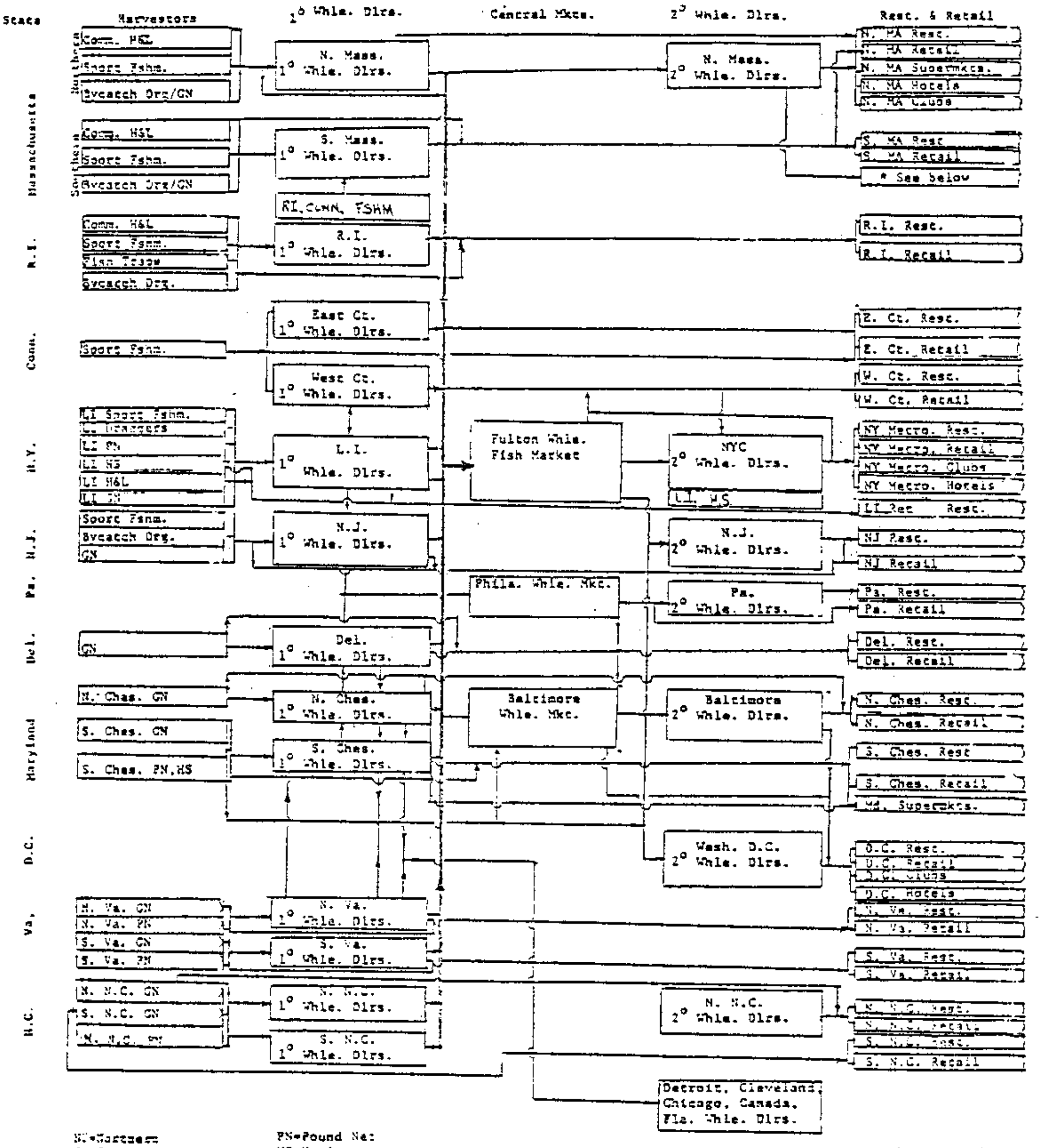
Source: Goodyear 1981.

Figure 15. Percentage of the total annual commercial catch[1] of striped bass landed in Maryland and Massachusetts, 1954 - 1977.



[1]Maine through North Carolina

Figure 16. Striped Bass Marketing Flow, 1980.



N.=Northern
S.=Southern
Drg.=Draggers
H&L=Hook and Line

PN=Pound Net
HS=Haulseine
GN=Gill Net
Comm.=Commercial

*Retail outlets & supermarkets - Buffalo, Rochester, Dallas, West Coast

(Source: Smith et al. 1981)

Interstate Fisheries Management Plan for the Striped Bass

of the Atlantic Coast from Maine to North Carolina