Atlantic Striped Bass: Stock Status and the Recreational Fishery

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Introduction

The striped bass, *Morone saxatilis*, is one of the premier sportfishes along the U.S. Atlantic coast, prized by both surf fishermen and boat anglers for its large size and fighting qualities. Its appeal has been well described by Sen. John Chafee (1980):

"Americans have 'symbols' which they rally around and which signify some part of the quality of life we all seek. The striped bass is a symbol. It is a worthy species which represents a quest, a test of endurance to fishermen, both recreational and commercial. Its sleek lines, contrasting colors of silver and black, ability to fight, and delectability have made the striper one of the most sought after fish by recreational anglers along the eastern seaboard."

ABSTRACT—The striped bass, Morone saxatilis, *has long been a prized sport fish for anglers along the U.S. Atlantic coast. Betweeen 1960 and 1970, the estimated recreational harvest of striped bass nearly doubled while the number of striped bass anglers increased by almost two thirds. However, since the mid to late 1970's, commercial and recreational harvests of striped bass have decreased to their lowest levels on record. These declines are due primarily to poor production of juveniles by the Chesapeake stock. Although stringent management measures have been implemented to rebuild the stock, juvenile production is unlikely to improve until the protected year classes mature and spawn over the next several years. The future of striped bass fishing depends on successful reproduction by these protected year classes and on management measures which maintain an adequate spawning stock.*

The striped bass has also been credited with being one of four gamefish most responsible for the popularity of surf fishing in America (McClane, 1965).

Native stocks of striped bass occur from Canada to northern Florida and in some tributaries to the Gulf of Mexico; however, the center of abundance is from Massachusetts to North Carolina (Bigelow and Schroeder, 1953). In addition, striped bass have been successfully introduced in many large freshwater lakes and reservoirs, and on the Pacific coast (Setzler et al., 1980). The striped bass is an anadromous species, and is believed to return to its natal river to spawn (ASMFC[1]). Three major stocks of striped bass occur along the Atlantic coast: The Roanoke stock, which spawns in the Roanoke River in North Carolina; the Chesapeake stock, which spawns in Maryland and Virginia tributaries of Chesapeake Bay; and the Hudson stock, which spawns in the Hudson River, N.Y. In the past, the Delaware River was an important spawning area for striped bass; however, for most of this century, production by the Delaware stock has been extremely low. Historically, the Chesapeake stock has been the major producer of striped bass along the Atlantic coast, contributing up to 90 percent of the total catch as recently as 1975 (Berggren and Lieberman, 1978).

Since the mid-1970's, commercial landings of striped bass on the Atlantic coast have declined precipitously (Fig. 1). In 1973, landings from Maine through North Carolina were at an all-time high (6,683 metric tons (t)). Just 10 years later, reported landings reached what was then an all time low (779 t), and they have continued to decrease since then. The recreational catch has experienced a similar decline. The dwindling catches in recent years are primarily a result of decreased juvenile production by the Chesapeake stock (Goodyear et al., 1985) and, to a lesser extent, by the Roanoke stock. The Hudson stock has not experienced a similar decline.

The severe decline in striped bass landings during the 1970's prompted action by state and Federal fisheries agencies, and by the U.S. Congress. In October 1981, the Atlantic States Marine Fisheries Commission (ASMFC) adopted an Interstate Fisheries Management Plan for the Striped Bass (ASMFC, 1981), which applies to the States of Maine through North Carolina. This Plan has been amended several times to incorporate increasingly restrictive management measures. In 1979, Congressional action was taken to establish the Emergency Striped Bass Research Study (ESBS), an amendment to the Anadromous Fish Conservation Act (P.L. 96-118). This law directs the U.S. Fish and Wildlife Service and the National Marine Fisheries Service (NMFS) to monitor the status of the striped bass stocks, identify causes for the decline, and determine the economic impact of the decline. The ESBS is presently authorized to continue through 1987.

[1]ASMFC 1987 Draft interstate fisheries management plan for the striped bass of the Atlantic coast from Maine to North Carolina. Atl States Mar Fish. Comm., Wash., D.C

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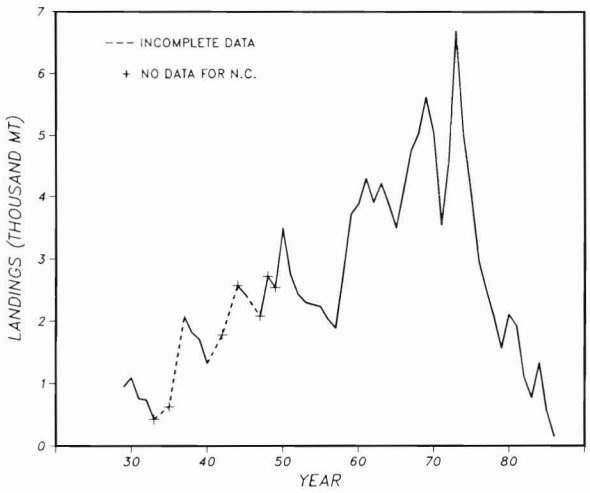

Figure 1.—Commercial landings of striped bass from Maine to North Carolina, 1929-86.

Status of the Stocks

Commercial landings statistics have been widely used as indicators of stock condition in the past (Florence, 1980; ASMFC[1]). Although landings data are influenced by many factors, the close correspondence between striped bass landings and landings per unit of gear (Koo, 1970; VanWinkle et al., 1979) suggests that trends in landings reflect actual changes in abundance of striped bass. However, since 1982, major changes in fishing regulations have restricted harvests; thus, more recent landings data are not indicative of stock abundance.

Commercial landings statistics for Atlantic striped bass are available without major gap since 1930 (Koo, 1970; Boreman and Austin, 1985; ASMFC[1]). Two features are immediately apparent upon examination of the landings data for 1930-86 (Fig. 1):

1) Landings have fluctuated widely, from lows of 497 t in 1934 (estimated by Koo, 1970) and 152 t in 1986, to a high of 6,683 t in 1973, and

2) Striped bass landings have declined steadily since the 1973 peak.

Dominant year classes occurring about every 6 years are thought to have sustained striped bass fisheries during most of this century (Merriman, 1941; Koo, 1970; Florence, 1980). This hypothesis has been supported by spectral analysis of the Maryland landings for 1930-74, which revealed periodicities of 6-8 years, and possibly 20 years (VanWinkle et al., 1979). However, the periodicities were not strongly pronounced, and the authors warned that predictions should not be made on an expectation of 6- to 8-year cycles. Indeed, landings of striped bass have declined steadily in the 12 years since this analysis, with no indication of the appearance of a dominant year class.

Chesapeake Bay Stock

The Chesapeake Bay stock of striped bass has contributed up to 90 percent of the catch in coastal areas prior to the recent decline (Berggren and Lieberman, 1978). Consequently, fluctuations in the Chesapeake stock have a major impact on landings along the entire Atlantic coast.

Sampling programs begun in 1982 have revealed a very low abundance of fish from year classes prior to 1982 in Chesapeake Bay (MDNR, 1985, 1986; Loesch and Kriete, 1984, 1985) and very few females on the spawning grounds in Maryland (MDNR, 1985, 1986). These results suggest that mortality of striped bass spawned in Chesapeake Bay during the 1970's was high enough to essentially remove them from the population by 1982. Estimates of total mortality rates for Chesapeake Bay striped bass from the 1970 year class range from 60 to 70 percent (Kohlenstein, 1980) to 93 percent (MDNR, 1985) per year for males, and 45 percent per year for females (MDNR, 1985). As a result of these high mortality rates, the female component of the striped bass stock in Chesapeake Bay is now composed primarily of year classes that are not fully mature. Restoration of Chesapeake Bay striped bass depends almost entirely upon successful reproduction by the 1982 and subsequent year classes.

The reproductive success of the Chesapeake Bay stock is measured using beach seine surveys for abundance of juvenile fish in nursery areas of the Bay. Two surveys are conducted annually, one in Maryland waters and the other in Virginia waters. The Maryland survey has been conducted since 1954 and has been used extensively to assess the status of the stocks (Schaefer, 1972; Florence 1980; Kohlenstein, 1980; Polgar, 1980; Cohen et al., 1983; Goodyear et al., 1985) and to make management decisions (ASMFC, 1981), on the assumption that the index is a valid predictor of future recruitment to the fishery. This assumption has been supported by analyses relating Maryland commercial landings to the Maryland juvenile index 2, 3, 4, and 5 years previous to the landings (Goodyear, 1985). Changes in the juvenile index accounted for 83 percent of the variation in reported commercial landings from 1964 to 1983. If the commercial landings reflect actual abundance, as the analyses of Koo (1970) and VanWinkle et al. (1979) suggest, these results indicate that the Maryland juvenile index provides a reliable measure of relative year-class strength for striped bass in Maryland waters.

The Maryland juvenile index is a pooled average of samples taken at fixed stations in the Potomac, Choptank, and Naticoke Rivers and in the Upper Bay region (Boone, 1984). The index has fluctuated widely, with a high of 30.4 striped bass per haul in 1970 and a low of 1.2 per haul in 1981 (Fig. 2). Since 1970, the juvenile index has remained low, with values lower than the 1954-70 aver-

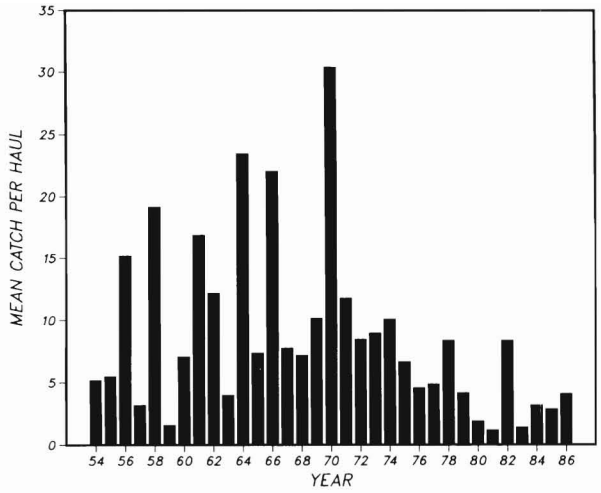

Figure 2.—Maryland juvenile index for striped bass, 1954-86.

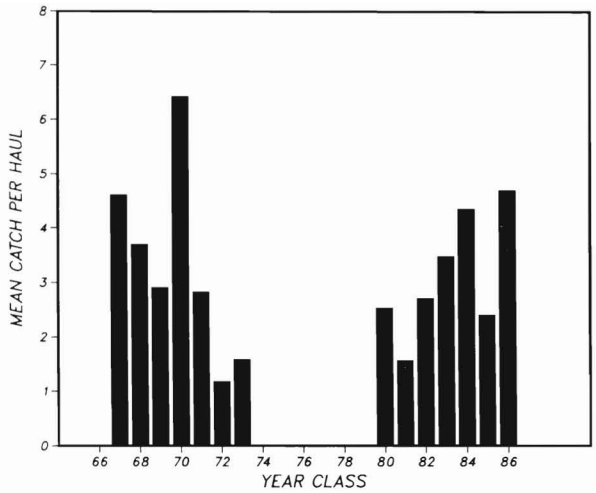

Figure 3.—Virginia juvenile index for striped bass, 1954-86. The juvenile survey was not conducted during 1974-79.

age (11.7) in 15 of the 16 years since 1970. The juvenile index for 1986 increased slightly over the 1985 value, but was only 13 percent of the maximum value in the time series.

The Virginia juvenile index is a pooled average of beach seine surveys conducted in the three major Virginia nursery areas: The James, York, and Rappahannock Rivers. The survey began in 1967, was discontinued during 1974-79, and resumed in 1980. The strong 1970 year class is evident in this series (Fig. 3), as it is in the Maryland series. The Virginia index has generally increased since 1981; however, its reliability in predicting future recruitment to the fishery is unknown.

Taken together, these surveys reveal generally poor reproductive success of the Chesapeake Bay stocks since 1970, with no indication of dominant year classes appearing. Although both indices increased in 1986, the Maryland index remains far below the long-term average. Given the virtual absence of older females on the spawning grounds, the juvenile indices have little potential to increase until significant numbers of the 1982 and subsequent year classes mature and spawn.

Hudson River Stock

In constrast to the Chesapeake Bay stock, the Hudson River stock has not experienced unusual declines in recent years. The Hudson River fishery for striped bass was closed in 1976 due to excessive levels of polychlorinated biphenyls (PCB's). Since the closure, research catches of the overwintering and spawning stocks have been composed mainly of 4- to 8-year-old fish, with ages from 2 to 16 years present (Hoff et al., In press; Kahnle and Brandt, 1985; Stang, 1986; Kahnle and Stang[2]). Estimated total mortality rates were 42 percent per year for 5- to 11-year-old fish (sexes combined) in 1985, and 30 percent per year for 6- to 12-year-old fish in 1986[3]. Although the data are not extensive, the broad age distribution and relatively low mortality rates indicate that the Hudson stock is in good condition.

Indices of juvenile abundance in the Hudson River, based on complementary beach seine and trawl surveys, also suggest that this stock is healthy. Juvenile production has remained high throughout the 1970's and 1980's (Fig. 4). The indices for the two most recent years of the seine survey have been among the lowest of the time series; however, the trawl survey index for 1986 increased while the seine index did not, suggesting a possible shift in local distribution of young striped bass to deeper water[4].

Roanoke Stock

Striped bass from the Roanoke stock appear to have a very limited migratory range (Merriman, 1941; Vladykov and Wallace, 1952; Hassler et al., 1981; Boreman and Lewis, 1987) and thus probably contribute little to fisheries along the coast. All available information on the Roanoke stock indicates that this population is severely depressed. The commercial catch of striped bass in North Carolina, sampled from January to March 1986, consisted mostly of 2-year-old fish, with very few striped bass older than 4 years of age (Winslow and Henry, 1986). The age composition of females on the Roanoke River spawning grounds reflects heavy fishing pressure: Very few females $>$ 4 years old were found on the spawning grounds in 1985 and 1986

[2]Kahnle, A. W., and D. Stang. In prep. Recent changes in survival of Hudson River striped bass. N.Y. Dep. Environ. Conserv., Hudson Riv. Fish. Unit, 21 South Putt Corners Road, New Paltz, NY 12561.

[3]D. Stang, N.Y. Dep. Environ. Conserv., Hudson Riv. Fish. Unit, 21 South Putt Corners Road, New Paltz, NY 12561. Personal commun.

[4]A. Kahnle, N.Y. Dep. Environ. Conserv., Hudson Riv. Fish. Unit, 21 South Putt Corners Road, New Paltz, NY 12561. Personal commun.

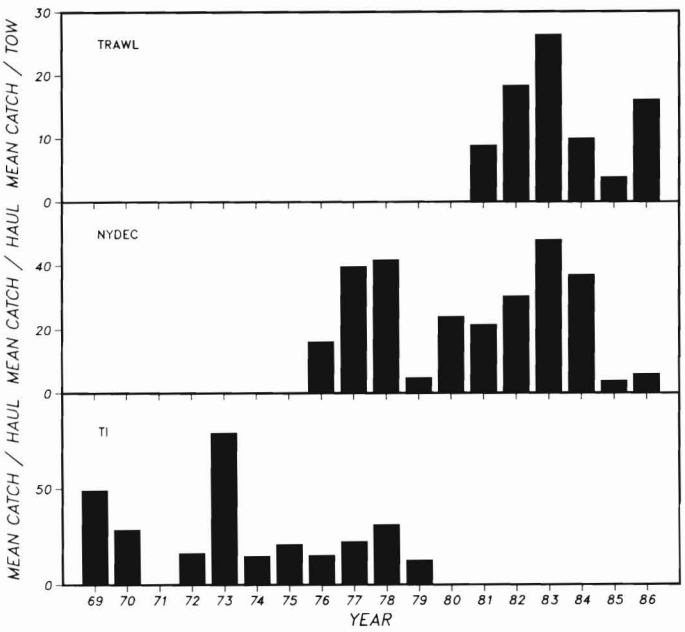

Figure 4.—Hudson River juvenile indices for striped bass. TRAWL is the trawl survey conducted by New York Department of Environmental Conservation (NYDEC) since 1981; NYDEC is the beach seine survey conducted by NYDEC since 1976; TI is a beach seine survey conducted by Texas Instruments from 1969 to 1979.

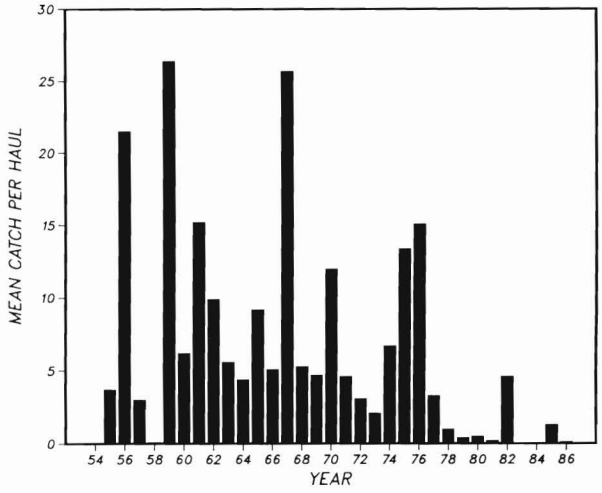

Figure 5.—Albemarle Sound juvenile index for striped bass, 1955-86.

(Winslow and Harriss, 1986; Winslow and Henry, 1986).

Indices of juvenile abundance in the Albemarle Sound nursery areas also reveal the depressed condition of the Roanoke stock. A trawl survey for juvenile striped bass in western Albemarle Sound has been conducted since 1955 (Hassler et al., 1981). The abundance of young-of-the-year striped bass has fluctuated widely over the time period; however, 8 of the 10 lowest indices have occurred in the 9 years since 1977 (Fig. 5). In 1986, the juvenile index (0.14 striped bass per tow) decreased 90 percent compared to 1985, and was only 0.5 percent of the highest index on record (26.4 in 1959). An apparent shift in nursery areas within Albemarle Sound may have caused recent abundance indices to underestimate relative year class strength[5]. However, the low abundance of mature females on the spawning grounds suggests that depressed egg deposition is probably also a factor.

Delaware River Stock

Until this century, the Delaware River system was an important producing area for striped bass. However, severe pollution in the Philadelphia area has caused oxygen depletion which apparently prevents striped bass from reaching their freshwater spawning grounds (Chittenden, 1971). Although restoration efforts are underway, striped bass production remains extremely low. A beach seine survey for juvenile finfish conducted in the Delaware River nursery areas since 1980 has captured few striped bass (Himchak and George, 1986). A slight increase in the index was seen in 1986[6], but juvenile abundance remains very low.

Current Research

Intensive efforts are presently underway to monitor the status of the stocks of Atlantic striped bass. Under the ESBS, NMFS is mandated to conduct research on striped bass population dynamics. This is done jointly with the states by supplementing on-going stock assessment programs. The overall goal is to assess recruitment, growth, and mortality in the four stocks. Information is being collected primarily through population monitoring conducted independently of fishing activities and through a coastwide tagging effort. At present, a rare opportunity exists to study striped bass stocks which are undergoing limited exploitation.

Fishery-independent monitoring of sub-adult and adult striped bass has been conducted in Chesapeake Bay by the States of Maryland and Virginia since 1982 (MDNR, 1985, 1986; Loesch and Kriete, 1984, 1985) and in the Hudson River by the State of New York since 1976 (Hoff et al., In press; Kahnle and Brandt, 1985; Kahnle and Stang, 1986; Stang, 1986). However, comparable information on the coastal stock is lacking. To provide information on this life-history stage, an additional monitoring program will begin in 1987. Striped bass will be sampled as they migrate along the eastern shore of Long Island during the

[5]H. Johnson, N.C. Div. Mar. Fish., 108 S. Water St., Elizabeth City, NC 27909. Personal commun.

[6]B. Halgren, N.J. Div. Fish, Game Wildl., Bur. Mar. Fish., Nacote Creek Lab., Star Route, Absecon, NJ 08201. Personal commun.

fall. At that time of year, a mixture of Chesapeake and Hudson stocks is present (Fabrizio and Saila, 1986), and thus information on both stocks will be obtained. Stock origins of the sampled fish will be determined to allow stock-specific estimation of population parameters.

A coastwide tagging effort was initiated in 1986 and will be expanded in 1987. Striped bass will be tagged in the spawning areas of North Carolina, Virginia, Maryland, and New York, and along the coast and in wintering areas of Chesapeake Bay. All fish are being tagged with internal anchor tags, which have relatively high retention rates (HRF, 1985) and appear to inflict minimal mortality (Dunning et al., In press). All tag returns are reported to the U.S. Fish and Wildlife Service (FWS) for distribution of rewards and entry into a master data base. At the current low levels of fishing activity, the tagged fish will be at large for a relatively long time. This will allow more complete mixing of tagged and untagged fish, and provide more extensive information on migration patterns, growth rates, and mortality than would be otbatined if fishing pressure were high.

In addition to these monitoring and tagging programs, NMFS is funding two studies which will allow estimates of stock recovery rates to be refined. These are an evaluation of mortality caused by hook and release fishing and an investigation of striped bass maturation rates. Hooking mortality is of concern because striped bass may be subject to hook-and-release fishing for 4-5 years before they reach the present harvestable size of 33 inches TL. If catch and release fishing causes significant mortality, then the advantages gained by raising minimum size limits may be reduced. Information on maturation rates is needed because ASMFC's strategy for rebuilding the Chesapeake stock is based on protecting females until they have reached spawning age. The best available information on age at maturity (Merriman, 1941) is nearly 50 years old and is inadequate for management needs. The current study will provide updated estimates of maturation rates for the Chesapeake and Hudson stocks.

The Recreational Fishery

Striped bass have been sought by recreational fishermen for many years along the Atlantic coast. As early as 1859, striped bass were being caught by hook and line from the rocks around Massachusetts Bay (Bigelow and Schroeder, 1953). The largest reported striped bass weighed about 125 pounds (Bigelow and Schroeder, 1953), though few fish exceed 70 pounds. The all-tackle world record for striped bass is a 78½-pound fish caught by Albert J. McReynolds off New Jersey in 1982 (IGFA, 1985).

Despite the long history of interest in striped bass angling, information on the recreational catch of striped bass has not been available until recent years. The earliest estimates of the U.S. catch by marine recreational fishermen are from the Saltwater Angling Surveys conducted in 1960, 1965, and 1970 (Clark, 1962; Deuel and Clark, 1968; Deuel, 1973). These surveys were based on interviews in which fishermen were asked to report the number and average weight of each species they had caught during the previous year. Due to the lengthy recall period and other problems, these early surveys are thought to overestimate the catch (Hiett and Worrall, 1977). However, the results should be useful for examining changes in catch and effort from 1960 through 1970, because the same design was used in all three surveys.

Since 1979, an annual survey of the marine recreational fishery has been conducted by NMFS (USDOC, 1984, 1985a,b, 1986). Data are collected using two complementary methods: Interviews with fishermen at fishing sites and a telephone survey of households. The on-site interviews provide information on catch per trip, and the telephone interviews provide information on the number of trips. The catch is recorded as 1) whole fish, available for examination by interviewers (catch "Type A"), 2) fish not available in whole form (filleted, used for bait, etc., catch "Type B1"), or 3) fish released alive (catch "Type B2"). This recording method allows an important distinction to be made between harvest and catch in the recreational fishery. The estimated harvest is the sum of catch Type A and catch Type B1, i.e., the number of fish known to have died. The number of fish caught is the sum of Types A, B1, and B2, i.e., the harvest plus fish that were released alive (and whose actual fate is unknown).

The recent surveys provide estimates of catch and effort for all species of finfish; however, the estimates for species occurring frequently in the catch are more reliable than those for infrequently caught species. Striped bass have been relatively scarce since these surveys began; thus, the estimates are not as reliable as those for many other species. An additional source of error exists because striped bass are frequently caught at night in certain coastal areas, while most of the on-site interviews are conducted during the day. Coefficients of variation have ranged from 9 to 45 percent for the estimated catch and from 10 to 50 percent for the estimated harvest of striped bass on the Atlantic and Gulf of Mexico coasts.

The number of striped bass caught on the Atlantic coast increased between 1960 and 1965 and declined slightly in 1970 (Table 1). During the same period, the harvest in pounds increased steadily. This suggests that striped bass caught in 1970 were larger on average than striped bass caught in 1960 or 1965. Between 1979 and 1985, the number of striped bass caught declined 67 percent, while the estimated harvest declined 83 percent (Table 2), reflecting the decrease in striped bass abundance during this time. In 1986, the catch of striped bass doubled compared with 1985, however the harvest decreased by nearly half. These trends in catch and harvest reflect a larger number of striped bass being released alive since 1981, probably because of increased minimum size limits, recreational creel limits, and the scarcity of

Table 1.—Estimated recreational harvest of striped bass along the Atlantic coast, 1960-70. Sources: Clark (1962), Clark and Deuel (1968), Deuel (1973).

	Catch		
Year	Number (thousands)	Weight (t)	Number of anglers (thousands)
1960	9,339	17,014	487
1965	16,718	25,788	721
1970	14,237	33,246	793

larger striped bass. In 1986, 90 percent of all striped bass caught by recreational fishermen were released.

Striped bass accounted for 2.5, 3.7, and 3.1 percent of the total number of fish caught by anglers on the Atlantic coast during 1960, 1965, and 1970 respectively. In constrast, striped bass accounted for less than 1 percent of the total number of fish caught by anglers on the Atlantic coast between 1979 and 1986 (Table 2).

The number of striped bass anglers on the Atlantic coast, estimated as the number of fishermen catching one or more striped bass in a year, increased 63 percent from 1960 and 1970 (Table 1). Estimates of the number of striped bass fishermen have not been available since 1970; however, the estimated total number of marine recreational fishermen in U.S. waters increased 40 percent between 1970 and 1980 (USDOI, 1972; USDOI and USDOC, 1982). The number of striped bass fishermen is likely to have shown a parallel increase, at least through the late 1970's. Since 1979, the percentage of fishermen identifying striped bass as the primary species sought has decreased steadily (Table 3). In 1979, the striped bass ranked third among the 15 primary species sought in the Mid-Atlantic region, but it dropped to tenth by 1985 and below fifteenth in 1986 (Table 3).

Conversion of the recreational harvest from numbers to weight allows the recreational harvest to be compared with the commercial landings. Estimates of the recreational harvest in weight were obtained directly through personal interviews with fishermen in the 1960, 1965, and 1970 surveys. For 1979-86, the weight of recreationally harvested fish can be estimated by assuming that catch Type B1 fish have the same average weight as catch Type A fish. For 1960, 1965, and 1970, respectively, the estimated recreational harvest was 4.4, 7.4, and 6.6 times the commercial harvest. The recreational harvest approximately equalled the commercial landings averaged over 1979-86; although the relationship varied between years. These comparisons are approximate only, as the recreational harvest is overestimated for the 1960s and probably underestimated for 1979-86.

Most striped bass angling occurs in inland waters, however there is considerable variation in the percentage caught in the ocean versus in inland areas (Table 4). A relatively large proportion of the catch in ocean waters occurs within 3 miles of shore. In nearly all years, the catch by boats has exceeded the catch from shore, averaging 67 percent of the total catch from 1979 through 1985 (Table 5). Most boat fishing is from private or rental boats. The catch from party/charter boats averaged only 9 percent of the total catch from 1979 to 1985, and only 2 percent since 1983.

Table 2.—Estimated number of striped bass caught and harvested (in thousands) along the U.S. Atlantic coast, 1979-86. Sources: USDOC (1984, 1985a, b, 1986).

Year	Catch (thousands)	Harvest (thousands)	Percent released alive	Wt. of harvest (t)	Striped bass as % of total recreational harvest
1979	2,014	1,324	34	2,975	0.73
1980	562	417	26	798	0.20
1981	893	798	11	617	0.45
1982	910	243	73	1,584	0.42
1983	572	290	49	1,182	0.22
1984	627	128	80	451	0.25
1985	665	225	66	797	0.28
1986[1]	1,401	141	90	852	0 50

[1]Source: Unpubl. NMFS data.

Table 3.—Percent of recreational fishermen identifying striped bass as the primary species sought, and rank of striped bass among the top 15 species sought in the Mid-Atlantic and North-Atlantic regions, 1979-86. Sources: USDOC (1984, 1985a,b, 1986).

	Percent seeking striped bass		Rank of striped bass	
Year	N. Atl.	Mid-Atl.	N. Atl.	Mid-Atl.
1979	4.0	9.6	6	3
1980	3.9	4.5	4	5
1981	3.6	3.0	5	5
1982	3.1	1 5	7	6
1983	3.2	2.6	7	6
1984	2.8	2.9	6	6
1985	2.6	0.9	7	10
1986[1]	2.1	N.A.[2]	8	::15

[1]Source· Unpubl. NMFS data.
[2]Data not available.

Table 4.—Estimated recreational catch of striped bass on the Atlantic coast by area fished, 1979-86. Numbers may not add to total due to rounding. Sources: USDOC (1984, 1985a,b, 1986).

	Catch (thousands of fish)				
Year	Ocean <3 mi.	Ocean >3 mi.	Inland	Undefined	Total
1979	331	88	1,232	364	2,014
1980	14	3	496	48	562
1981	79	12	794	8	893
1982	114	69	723	4	910
1983	286	37	206	44	572
1984	363	1	262	1	627
1985	163	0	500	2	665
1986[1]	820	15	566	—[2]	1,401

[1]Source: Unpubl. NMFS data.
[2]Less than 1,000 fish

Table 5.—Estimated recreational catch of striped bass on the Atlantic coast by mode of fishing, 1979-86. Sources: USDOC (1984, 1985a,b, 1986).

	Catch (thousands of fish)			
Year	From shore	From Party/ charter boats	From Private/ rental boats	Total
1979	128	365	1,520	2,014
1980	84	61	417	562
1981	456	28	409	893
1982	597	56	258	910
1983	282	4	286	572
1984	303	5	319	627
1985	193	29	444	665
1986[1]	614	66	721	1,401

[1]Source: Unpubl. NMFS data.

Management Regulations

The striped bass fishery has a long history of management. The earliest regulation on striped bass, restricting netting in the Hudson River, was enacted in 1892 in New York. The first minimum size limits were instituted in 1912 (Virginia, 10 inches) and 1913 (New Jersey, 12 inches) (ASMFC[1]). In response to a decline in landings during the mid-1930s, the ASMFC recommended that a coastwide 16-inch minimum size limit be instituted (Neville, 1942). This recommendation resulted in adoption of additional regulations during the 1940's by most of the coastal states (see ASMFC[1] for a detailed review).

Between the late 1940's and the late 1970's, few additional regulations were imposed on striped bass fishing. However, in 1979, the ASMFC began preparing an Interstate Fisheries Management Plan for the Striped Bass (ASMFC, 1981) in response to the severe decline in landings in the mid-1970s. When the Plan was adopted in 1981, it called for a minimum size limit of 14 inches TL in the producing areas (Albemarle Sound, Chesapeake Bay and Delaware Bay, and the Hudson River) and 24 inches TL along the coast. However, hook and line

fishermen could retain four fish per day and net fishermen up to 5 percent of their daily catch between the old and new size limits. State-established maximum size limits were retained, and spawning areas were closed to fishing during the spawning season (ASMFC, 1981). The Plan was subsequently amended several times to incorporate increasingly restrictive management measures. The most recent amendment to the Plan was instituted to ". . . prevent directed fishing mortality on at least 95 percent of the 1982 year class females, and females of all subsequent year classes of Chesapeake Bay stocks until 95 percent of the females of these year classes have an opportunity to reproduce at least once." This objective is being met primarily by increasing the minimum size limits to stay ahead of the growth of the 1982 year class. By the summer of 1988, a minimum size limit of 33 inches TL will be required in all areas where striped bass fishing is allowed.

In addition to increased size limits, some states have imposed creel limits, closed seasons, or total closures. Other restrictions have been instituted because of potential health hazards. New York closed the Hudson River fishery in 1976 and the Long Island fishery in 1986 because of PCB contamination. In Rhode Island, sale of striped bass has been prohibited since 1986 for the same reason; however, recreational fishing is allowed with a one fish per day creel limit. Regulations in place as of 31 December 1986 that affect the recreational fishery are summarized in Table 6.

Table 6.—State regulations in place as of 31 December 1986 that affect fishing for striped bass (ASMFC, text footnote 1).

State	Min. size limit (TL)	Daily creel limit	Season	Other
ME	33"	2	No closed season	Hook & line only, no sale.
NH	33"	2	No closed season	Hook & line only.
MA	33"	[1]1	No closed season	Hook & line only, sale permitted.
RI	33"	1	No closed season	No sale due to PCB contamination.
CT				Legislated closure, no possession.
NY				Closure due to PCB contamination.
NJ	24"	5	No closed season	Hook & line only, no sale.
PA	31"	2	No closed season	Hook & line only.
DE				Moratorium, no possession.
MD				Moratorium, no possession.
PRFC[2]	24"	5	Closed 1 Dec. to 31 May	34-inch maximum size limit.
DC	24"	2	Closed 1 Dec. to 31 May	Hook & line only, no sale.
VA	24" (B[3]) 30" (O)	5 2 over 40"	Closed 1 Dec. to 31 May	
NC	14"	3	No closed season	Albemarle Sd.
	16"	3	No closed season	Roanoke R., inland. Atlantic ocean closed.

[1]Catch and possession.
[2]Potomac River Fisheries Commission.
[3]B = bay, O = ocean.

Future Conditions

Ultimately, the quality of recreational fishing for striped bass will depend on reestablishing conditions which foster successful reproduction and subsequent recruitment to the harvestable stocks. Achieving these goals will depend both on increasing the size of the spawning stocks and on the occurrence of environmental and water quality conditions conducive to survival of larvae and juveniles.

In the immediate future, an increase in the number of striped bass is to be expected as a result of management measures which have substantially protected the 1982 and subsequent year classes from exploitation. By the time members of the 1982 year class reach the minimum size limit of 33 inches TL, they will have been afforded 3-4 years of additional protection compared with year classes that became vulnerable at 12 or 14 inches. As a result, the 1982 year class may actually exceed the abundance of the 1970 year class at these ages (USDOI and USDOC, 1986). In addition, harvesting striped bass at 33 inches TL will maximize the yield from each individual entering the population (Goodyear, 1984). Thus, short term increases in the harvest of striped bass can be expected due to increases in abundance and increased size of the available fish. However, unless these protected year classes are able to reproduce successfully, their contribution to the fishery will be short-lived.

Long-term prospects for striped bass fisheries depend on sustained successful reproduction and subsequent recruitment to the fishable stocks. These in turn hinge critically on the levels of fishing mortality which the stocks are subjected to, and on water quality and environmental conditions in the spawning and nursery areas. All female striped bass in a year class are not mature until the age of 6 years (Merriman, 1941), thus there must be significant escapement of females from fishing to allow them to spawn even once. The scarcity of mature females on the spawning grounds in Maryland since 1982 suggests that fishing mortality during the 1970's was excessive. At the annual fishing mortality rates estimated for Chesapeake Bay females in the 1970's, egg production of female recruits would be decreased by 97 pecent to more than 99 percent compared with an unfished stock (based on Goodyear, 1980).

Adequate egg production clearly does not guarantee adequate recruitment. Survival of eggs and larvae of most highly fecund fish species is extremely variable and results in variable recruitment to fisheries (Sissenwine et al., In press). Much of this variability is thought to be caused by naturally occurring, random fluctuations in environmental conditions. However, the larvae of fish which spawn where human activities contaminate the water must run a further gauntlet. Studies conducted in four Maryland spawning areas since 1984 have shown that river water can be toxic to striped bass larvae and juveniles (Hall, 1984, 1985; Hall et al., 1986; CNFRL[7]). Thus, both natural conditions and contaminant levels must be favorable to permit survival. Although natural environmental variability cannot be controlled, removal of contaminant stress would increase the probability of

[7]CNFRL. 1984, 1986. Impact of contaminants on striped bass in the Chesapeake Bay - a summary of research on pH/contaminant interactions in laboratory and field investigations. U.S. Fish Wildl. Serv., Col. Natl. Fish. Res. Lab., Columbia, Mo. prog. reps., var. pagin.

young striped bass encountering favorable environmental conditions. Further, the probability of young striped bass being present during favorable water quality conditions would be increased by building a spawning stock comprised of several age classes. Young female striped bass spawn later than older ones (Hollis, 1967); thus, the length of the spawning season would be extended by maintaining several age classes in the spawning stock.

Evidence from historical records suggests that striped bass population levels have always fluctuated widely, due most likely to the influence of dominant year classes. Despite the variable nature of production of striped bass, the quality of fishing could be maintained at a more consistent level if fishing mortality were lower than in the recent past. Lower mortality would extend the harvest of a dominant year class over a larger number of years, thus reducing fluctuations in harvest.

In the past, management of striped bass has been based primarily on minimum size limits. Although size limits restrict the harvest of undersized fish, they allow unrestricted harvest of "legal" fish. Thus, excessive harvest of fish can occur despite size limits, potentially resulting in reduced spawning stock size and subsequent recruitment failure. To avoid these problems, fishing mortality must be controlled through additional management measures such as creel limits and seasonal and area closures.

Recent regulations have focused on reducing fishing mortality and increasing the number of spawning females. If and when the stock is restored, these regulations will be relaxed. However, future management will need to be more restrictive than in the past to avoid repeating the experience of the 1970s.

Acknowledgments

We thank John Joyce for preparing the graphics for this paper. John Boreman and Tom Morrissey provided helpful reviews of the manuscript.

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