Fishery Management Report No. 34
of the

Atlantic States Marine Fisheries Commission

Source Document to Amendment 5 to the Interstate Fishery Management Plan for Atlantic Striped Bass

January 1998

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edited by

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This document was prepared in cooperation with the Atlantic States Marine Fisheries Commission's Striped Bass Technical Committee, Striped Bass Stock Assessment Subcommittee, and the Striped Bass Tagging Committee.

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This document is a collation of nearly the entire time-series of data on Atlantic striped bass collected by state and federal agencies since systematic monitoring of the species began in the 1950s. The text, figures, and tables were prepared with the assistance of many scientists working within the Commission process. Mr. Gary Shepherd (National Marine Fisheries Service) and Mr. Najih Lazar (Rhode Island Department of Environmental Management) served as principal authors and editors of contributed text and data, and submitted this information for peer review in the 26th Stock Assessment Workshop held in Woods Hole, Massachusetts in December 1997.

The Commission's Striped Bass Technical Committee, Stock Assessment Subcommittee, and Tagging Committee met several times to review and discuss this Source Document during its preparation. The Technical Committee and Stock Assessment Subcommittee were chaired by Dr. Victor Crecco, Connecticut Department of Environmental Protection (1994-1996), Mr. Mark Gibson, Rhode Island Department of Environmental Management (1996-1998), and Mr. Gary Shepherd, National Marine Fisheries Service (1998-1999). The Tagging Committee was chaired by Mr. Andy Kahnle, New York Division of Marine Fisheries (1985-1998) and Dr. Desmond Kahn, Delaware Division of Fish and Wildlife (1998-1999). The Cooperative Interstate Tagging Program for striped bass was coordinated by Mr. Jorgen Skjeveland and Ms. Tina McCrobie, U.S. Fish and Wildlife Service.

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Preface

The stock assessment for Atlantic striped bass was completed in accordance with a request for review at a meeting of the 26th Northeast Fisheries Science Center Stock Assessment Review Committee. The meeting was held December 1-5, 1997 in Woods Hole, Massachusetts. Terms of reference for the review were:

a. Assess the status of the Atlantic coast striped bass stock complex through 1996 by means of virtual population analysis and characterize the variability of estimates of stock abundance and fishing mortality rates.

b. Provide projected estimates of catch and spawning stock biomass for 1998 and 1999 at various levels of fishing mortality incorporating uncertainty in recruitment and stock size estimates.

c. Estimate fishing mortality rates for specific components of coastal stock complex using tagging data.

d. Review the estimation of Fmsy, defined as the overfishing definition by the ASMFC Striped Bass Management Board.

e. Review the historical SSB model concept and its use in defining stock reconstruction.

f. Review the current SSB model methodology for estimating TACs under ASMFC management.

ASMFC Technical Committee, Stock Assessment Committee, and Tagging Working Group members involved in development of the assessment were:

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[1] Technical Committee member
[2] Assessment Committee member
[3] Tagging working group member

Introduction

Atlantic striped bass, *Morone saxatilis*, is an anadromous species distributed from Texas to the Canadian Maritime Provinces. Striped bass are also present on the west coast of the United States as the result of stocking in the late 1800's. Spawning occurs in brackish to freshwater portions of estuaries where juveniles remain for several years before emigrating to coastal waters. North of Cape Hatteras, striped bass undergo seasonal migrations between their estuarine spawning grounds and the Atlantic coast. Coastal migrations generally proceed northward during the spring and summer, with larger fish moving as far north as the Bay of Fundy. In the fall, the direction of migration reverses and the fish move south to overwintering areas. Although overwintering striped bass have been found from the Gulf of Maine to North Carolina, the major areas of concentration appear to be in the New York Bight and along the coast of North Carolina. In March to April, mature striped bass migrate to estuarine spawning grounds where spawning occurs over the course of several weeks. After spawning, they return to coastal waters and the feeding migration begins again.

Atlantic coastal stocks of striped bass are primarily the product of four distinct spawning stocks; a Roanoke River/Albermarle Sound stock, a Chesapeake Bay stock, a Delaware River stock and a Hudson River stock. Historically the Roanoke stock was believed to have contributed to the mixed coastal group but tagging records over the last several decades suggest emigration during that period has been minimal. The largest producer area is the Chesapeake Bay and includes most of the rivers and estuaries within the bay. The second largest producer is the Hudson River followed by the Delaware River (ASMFC 1990)

Striped Bass Management History

Striped bass have been the focus of fisheries from North Carolina to New England for several centuries and have played an integral role in the development of numerous coastal communities. Striped bass regulations in the United States date to pre-Colonial times when striped bass were prohibited from being used as fertilizer (circa 1640). During the 20th century initial attempts at regulation were made by states during the 1940's when size limits were imposed. Minimum size limits ranged from 16 inches for many coastal states to 10 inches in some southern states. By the 1970's it became increasingly evident that stronger regulations would be needed to maintain stocks at a sustainable level. Recruitment in the Chesapeake Bay stock had reached an all time low, as determined by a juvenile survey conducted by Maryland Department of Natural Resources since 1954. In response to the decline, the Atlantic States Marine Fisheries Commission (ASMFC) developed a fisheries management plan to increase restrictions in commercial and recreational fisheries. To strengthen the regulations, a federal law was passed in 1984 which mandated that coast wide regulations already implemented would be adhered to by Atlantic states between North Carolina and Maine (for striped bass management, the areas under the jurisdiction of ASMFC include coastal waters of North Carolina, Virginia, the Potomac River Fisheries Commission, the District of Columbia, Maryland, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine).

The final version of the ASMFC plan to restore striped bass called for size regulations to protect the 1982 year class, which was the first modest size cohort since the previous decade. The objective was to increase size limits to allow at least 95% of the females in the cohort to spawn at least once. This required an increase in the size limit as the cohort grew, and resulted in a 36 inch size limit by 1990. Several states, beginning with Maryland in 1985, opted for a more conservative approach and imposed a total moratorium on striped bass landings. By 1989, Massachusetts was the only state with an active commercial fishery. Fishing in the EEZ was closed in 1989 and has remained closed to all recreational and commercial striped bass fishing.

Most of the restrictive regulations were intended to restore production in Chesapeake Bay. The Hudson stock did not suffer the same decline in production, in part because the fishery in the river was closed in the 1970's due to PCB contamination. There was no indication of any significant production from the Delaware River stock during the 1970's and early 1980's.

In addition to the restrictions, the management plan contained a trigger mechanism to reopen the fisheries when the 3 year moving average of the Maryland juvenile index exceeded an arithmetic mean of 8.0. That level was attained with the recruitment of the 1989 year class. Consequently the management plan was amended to allow state fisheries to reopen in 1990 under a target fishing mortality of 0.25 which was half the 1990 F_{msy} estimate of 0.5.

The management plan has been amended several times since 1990 to allow states increased flexibility in regulating fisheries. Traditionally, estuaries have been considered producer areas and have been managed under different minimum sizes than coastal waters. The rationale is that the migration of fish out of the producer areas after spawning reduces the availability of larger fish. Therefore producer areas had a minimum size of 18" while coastal states had a 34" standard.

The management plan (Amendment 4 to the FMP (ASMFC 1989)) implemented to control the reopening of the fishery in 1990 allowed an increase in the target F once the spawning stock biomass (SSB) was restored to levels estimated during the late 1960's and early 1970's. In 1995, striped bass were declared restored by the ASMFC. The basis was the results of a model simulation of the increase in spawning stock biomass. The model, known as the SSB model (Appendix I), was a life history model which resulted in a relative index of SSB (Rugolo, Crecco and Gibson 1994). The basis of the model was the relationship between the Maryland juvenile indices and subsequent stock size. This relationship has been demonstrated by several studies, most notably Goodyear (1985). Growth coefficients were applied to the juvenile indices and the cohorts allowed to grow over a 20 year period. Fishing mortality rates for Chesapeake Bay fisheries were applied to each cohort. An emigration rate at age was applied to each cohort which allowed fish to enter the fishing mortality regime imposed by coastal fisheries. A constant natural mortality rate at age was used. Maturity at age, by sex, was applied to surviving fish and the sum of mature striped bass across cohorts resulted in an index of relative spawning stock biomass. When the time series of SSB crossed the level comparable to the 1960-1972 average, the stock reached the criteria for a restored stock. Consequently, under Amendment 5 (1995), target F was increased to 0.31, midway between the initial F (0.25) and F_{msy}, which was revised to equal 0.4.

Amendment 5 retained the same size regulations in coastal waters (28" minimum size, two fish per day and commercial quota) but two fish per day at 20" and commercial quota in producer areas[1]. Commercial fisheries have operated under quotas based on state allocations during the period 1972-1979 (with the exception of Maryland, which calculated quotas based on estimated biomass). States may adjust the minimum size, as long as the size change is compensated with a change in season length, bag limits, commercial quotas or a combination of changes. A chronology of commercial and recreational minimum sizes are summarized in tables 1 and 2.

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[1] Size limits on the coast were increased to 34" in 1994, but reduced to 28" in 1995.

Fishery Data

Commercial Fishery

Landings reached 5,888 mt in 1973 then dropped sharply to a low of 63 mt in 1987. Since the reopening of the fishery in 1990, landings have been controlled by quota with the highest landings in 1996 of 2,178 mt (Table 3, Figure 1).

The predominant gear types in the commercial fisheries are gillnets, pound nets and hook and line. Commercial fisheries operate in 8 of the 14 jurisdictions regulated by the ASMFC management plan. Commercial fishing for striped bass is prohibited in New Jersey, Pennsylvania, Connecticut, New Hampshire, Maine and the District of Columbia. Massachusetts allows commercial fishing with hook and line gear only, while other areas allow net fisheries.

The largest commercial landings are from Maryland, Virginia, PRFC, New York and Massachusetts. Since 1990, the Chesapeake Bay jurisdictions have accounted for 64% of the total followed by Massachusetts (18%) and New York (11%) (Table 4, Figure 2).

Recreational Fishery

Striped bass recreational landings and discards were estimated using the Marine Recreational Fisheries Statistics Survey (MRFSS). This survey, administered by the National Marine Fisheries Service (NMFS), combines a telephone survey and field intercept to estimate catch and effort for the major recreational fisheries along the Atlantic coast. The precision on the estimated catch, expressed in percent standard error (PSE), is a function of the intensity of the survey coverage for each state. Most states add field intercepts for striped bass, in addition to the MRFSS allocation, in order to improve the estimates of catch and effort. Overall, the PSEs of landings and discards ranged from 39% in earlier years (1981-1985) to as low as 6.5% for the period 1990-1996[2].

Recreational landings from Maine to North Carolina have risen steadily since 1990, from a harvest (A + B1) in 1990 of 1,010 mt to 6,620 mt in 1996 (Table 5, Figure 1). This represents a 30% increase from the 1995 catch estimate of 5,080 mt and a 114% increase from the 1994 estimate of 3,084 mt. According to the MRFSS survey, more fish were caught in the last two years (1995-1996) than during the 1982-1993 combined. In 1994, the coastal recreational fishery operated under a one-fish bag limit and a 34 inch minimum size. This was an increase over the 28 inch minimum size in effect in 1993 (Table 2). A number of states, however, opted for the

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[2] Under the FMP, states with substantial recreational fisheries are required to augment the number of intercepts, if necessary, to produce PSE's on landings of < 20%.

larger minimum size of 36 inches. Producer areas, other than Maryland, were permitted a size limit of 18 inches and a one-fish bag limit, but harvest was capped. Maryland harvest was based on a harvest control model calculation (Rugolo and Jones, 1989). Since 1995, coastal states have a 28 inch minimum size and 2 fish bag limit and producer areas are allowed 2 fish at 20 inches (Chesapeake Bay jurisdictions opted for an 18 inch minimum with a reduced season length). The total harvest estimate in numbers in 1996 was 1.29 million fish, representing 63% of the total landings and the record catch since 1979.

Recreational landings were highest in Maryland, followed by New York and Virginia (Figure 3). In the North Atlantic sub-region the majority of the landings occurred in the summer and fall (wave 3-5), however most of the harvest in the Mid-Atlantic sub-region took place in waves 5 and 6 (Salz, 1997). Chesapeake Bay states (MD and VA) harvested about 21% of the total landings by weight and 53% of the total harvest by number in 1996. The private/rental boat mode accounted for 68% of the total catch and 64% of the total harvest in 1996. Shore mode angling accounted for 19% of the total striped bass caught, but only 2% of this catch was harvested. The party-boat/charter mode accounted for 32% of the total harvest in 1996.

Overall, the percent discards (B2/(A+B1+B2)) increased from an average of 71% for the period 1982-85 to 90% in 1986-96 as the minimum size increased during the mid-1980s. The number of fish released increased significantly when Amendment 5 of the striped bass FMP was implemented in 1995 and reached a record 12.6 million fish in 1996. Massachusetts accounted for the greatest proportion of the total discards in 1996 (26%), followed by Maryland (22%) and New York (13%) (Table 6, Figure 4).

Catch at age

Age data was assembled from commercial, recreational and research samples collected since 1982. Semi-annual age-length keys were developed on a regional basis. Region 1 was applied to length frequencies for the area of coastal New Jersey through Massachusetts; region 2 was Hudson River; region 3 was Delaware Bay; region 4 was coastal Delaware to North Carolina; and region 5 was the Chesapeake Bay. Age-length keys were audited for outliers. Missing age data at length were interpolated based on the numbers at age of adjacent lengths. Sample sizes of age-length keys are presented in Table 7.

Data were generally collected in pounds and converted to metric measure in the data summaries.

Commercial Landings

Development of the striped bass commercial catch data involved expansion of landings data, stratified by state, gear and six month periods. The years included in the analysis were 1982-1996. Harvest taken in the EEZ prior to the closure (1989) were included with the state of landing regardless of the location of capture, since that information was not available. Landings were compiled from NEFSC landings data by state and gear, for 1982-1989. Landings have been more closely monitored by state agencies since 1990. Since the reopening of the fishery in 1990, New York, Delaware, Maryland and Virginia and the Potomac River Fisheries Commission, North Carolina and Rhode Island have required commercial fishermen to tag individual fish prior to sale. Massachusetts has a weekly dealer reporting system and fishermen's logbooks while Rhode Island and North Carolina also require weekly dealer reports.

Biological samples (total length measured in inches) from striped bass commercial landings were collected by state agencies for a variety gear types. When length data by strata were not available, the length frequency most closely associated with the missing strata were applied. Length-weight equations from the nearest strata were used to expand length frequency to total landings.

New England

Landings for Maine in 1985 were combined with 1985 Massachusetts landings. No commercial landings were reported for New Hampshire during 1982-1996. Massachusetts landings were predominately by hook and line (>98%), with small contributions from other gears such as trawls. Landings from other gears were assumed to have the same age distribution as the hook and line landings. Annual length frequencies from 1982-1995, supplied by MA DMF, were sampled from July to December which corresponded with the majority of the landings. Annual autumn age/length keys were applied to the length data.

Rhode Island landings were primarily from trapnet, gillnet and hook and line fisheries. Length frequencies from 1982-1986 were available from the spring trapnet fisheries and were expanded using annual spring age keys. Gillnet and hook and line landings were expanded, assuming the same age distribution as New York spring landings from the same gear type. Length data for 1990-1995 were available from RI gillnet and hook/line fisheries and were expanded using annual spring and autumn age keys, respectively.

Although Connecticut prohibits commercial fishing in state waters, landings of 1-3 mt were reported between 1982 and 1985. The age composition from New York for the same year/season/gear combination was used and prorated based on the relative weight of the landings.

Mid-Atlantic

New York coastal fishery length frequencies, by gear, were available from 1982-1984 and 1990-1995. No length frequencies were available for 1985 or 1989. No landings were reported for 1986-1988. Lengths were converted to weight using a length-weight equation provided by New York DEP. Commercial hook and line landings from 1985 accounted for 26% of total landings and were expanded using the NY volunteer angler length data. The remaining 1985 landings, dominated by haul seine, were expanded, assuming the same age distribution as the hook and line landings. The age distribution of landings from 1990-1995 were based on random sampling of landings as reported in the annual state fishery reports. Percent at age in the samples was expanded to total landings in number. The Hudson River commercial fishery has been closed since the 1970's.

New Jersey/Delaware landings were divided into coastal or Delaware Bay landings. Landings from northern New Jersey estuaries were assumed to have the same length distribution as the coastal landings. Delaware landings were combined with New Jersey for the period 1982 to 1986. No commercial length frequencies were available from 1982 to 1985. Gillnet landings in 1982 and 1983 were divided by age, based on the length/age composition of New York gillnet landings. Ocean trawl landings for 1982 and 1983 were expanded based on New York pound net or haul seine length data. For 1984, trawl landings were expanded using trawl length data from New York. New Jersey had no commercial landings after 1986, and no landings were recorded for Delaware from 1986 until 1990. In the 1990's, the age composition of Delaware landings sampled by DE DFW were expanded to total number landed.

Chesapeake Bay

Maryland provided age composition of total landings (combined gears) for the period 1982-1984, based on random sampling by gear and expansion to the total catch. A moratorium occurred from 1985 to 1990 and no landings were reported. For the period 1990 to 1995, Maryland provided the expanded numbers at age by gear and fishery based on random sampling of landings. The reported number landed in the commercial fishery were redistributed to coincide with calendar year rather than fishing year. Fisheries where no age data were available were divided based on the age composition of all fisheries combined. These represented less than 5% of the total landings. Catch at age for 1996 was estimated using 1996 length frequencies and a 1995 age-length key.

Striped bass harvest during the 1980's recorded by the Potomac River Fisheries Commission were partitioned from landings, by gear, attributed to Virginia and Maryland.

Virginia length frequencies of legal size fish, by gear and season, were applied to PRFC landings. The extended size structure of landings in 1982 and 1983 was due to spring landings from anchor gillnets. The associated Virginia age data were applied. In subsequent years, landings were primarily from fall fisheries which target smaller non-migratory fish. PRFC landings in the 1990-1996 period were partitioned by age, based on samples collected by the commission and supplemented with Virginia samples.

Virginia landings at age were based on sampling done by the Virginia Institute of Marine Sciences (VIMS) during the 1980's and by the Virginia Marine Resources Commission (VMRC) in the late 1980's and the 1990's. For the period 1982-1988, length frequencies by gear were applied to seasonal landings. For landings with no associated length data, either the overall age composition was applied or a gear type with similar characteristics was used. Landings at age data for the fishery from 1990 to 1996 were supplied by VMRC.

North Carolina

North Carolina landings from Albermarle Sound/Roanoke River were excluded from this analysis. Coastal landings from 1982 to 1985 were expanded based on length and age data collected by NC Division of Marine Fisheries. The catch at age for the 1990-1992 and 1994-1995 landings were expanded based on age data provided by NC DMF. No length frequencies were available for the landings from 1993, therefore age composition of fisheries independent samples greater than the minimum commercial size were used. Length data for landings in 1996 were also unavailable, so the age composition for coastal landings was assumed to reflect the age structure of the mixed stock wintering off North Carolina.

Catch at age of commercial landings are summarized in table 8.

Adequacy of Commercial Length Sampling

Commercial length sampling was evaluated by year and gear type (Table 9). Sampling generally reflected the fisheries directed at striped bass. Overall, the sampling intensity was highest for gillnets and pound nets, particularly in recent years. Sampling has ranged from 2.2 mt per sample (assuming a sample is equivalent to 100 lengths) to 59.2 mt per sample. A subjective benchmark for samples in the NEFSC has been 200 mt per sample, so striped bass sampling has been comparatively intensive.

Commercial Discards

Striped bass are not routinely encountered in fisheries sampled by the NEFSC Sea

Sampling program. Sea sampling by state agencies occurs infrequently and does not provide adequate samples to estimate discards in the entire coastwide fishery. An alternative procedure was used involving tag return data, which would allow estimation of discard losses in non-directed fisheries.

The cooperative striped bass tagging program was developed to provide a database of releases and recoveries of striped bass integrated across a variety of state and federal programs. Since 1986, nearly 300,000 striped bass have been released using an internal anchor tag supplied by the U.S. Fish and Wildlife Service (FWS). The FWS maintains the database which contains recapture information from researchers, commercial fishermen and recreational fishermen. Recapture records contain information on the disposition of the catch (killed or released) and the type of gear used.

The total number of commercial discards was estimated using the ratio of discards between commercial and recreational fisheries in the tag return data. Equal tag reporting rates between commercial and recreational fisheries was assumed. The ratio of tag recoveries was calculated for 1987 to 1996 for all areas combined. Sample sizes of tag returns from striped bass discarded in commercial fisheries ranged from 200 in 1987 to 2,064 in 1990 (Table 10). The 1988 sample size of recoveries was unusually low (n=47), so an average of 1987 and 1989 recoveries was used. The ratio of commercial to recreational by-catch tags ranged from 0.76 in 1990 to 0.09 in 1996. The variation in ratios likely reflects the changes in ratios of commercial to recreational striped bass effort since 1990.

Recapture data included all size categories, since discards of legal size fish occurred during closed commercial fishing seasons. Recaptures from pound nets in Virginia were eliminated because of biased recapture rates (pound net fishermen using nets adjacent to the tag release area were recapturing fish and reporting tags often within a matter of days). Other trap-based tag recoveries were restricted to fish at large for longer than 20 days. Since tag return data began in 1987, ratios for 1982 to 1986 were hindcast using the trend in ratios between 1987 and 1990. Subsequent to 1990 management regulations changed the size structure of discarded striped bass which biased these ratios relative to the period prior to strict regulations. The hindcast estimated a declining ratio back through time as would have been expected, given the lower size limits in the early fishery and lack of commercial quotas. The resulting ratios are presented in Table 10.

The tag ratios were multiplied by the MRFSS estimate of total recreational discards to estimate total commercial discards. Total commercial by-catch per year was estimated as :

(# tags from commercial discards /# tags from recreational discards) * total B2 estimates

The result of the expansion was total number of fish discarded in the commercial fishery per year among all areas combined. This total was subdivided by gear, based on the ratio of tag recoveries among gear types (Table 11). Gear categories included anchor gillnets, drift gillnets, trap nets (includes pound nets), seines, fyke nets, hook and line, trawls, and other. From 1993 to 1996, the relative contribution of discards from traps, as calculated from tag recaptures, was considered biased high due to the proximity of the gear to the released fish. Therefore, the average recapture percentage by gear, for the period 1987 to 1992, was substituted for the 1993-1996 period. Similarly, discards for 1982 through 1986, by gear type, were calculated using the average ratio from 1987 to 1992. Total discards by year and gear are presented in table 12.

Various discard mortality rates were applied to each gear type (Table 13). A 42.75% mortality was applied to anchor gillnet discards (average of 47% (Seagraves and Miller, 1989) and 38.5% (MD DNR)), 8.6% to drift gillnets (Seagraves and Miller, 1989), 8% to hook and line (Diodati and Richards 1996), 35% for trawls (Crecco 1990), 5% for trap and pound nets, 15% for seines and 5% in other categories (fyke nets, etc.) based on consensus opinion of the Technical Committee. The MRFSS survey does not cover the Hudson River, so no B2 estimates were available for expansion. Discard losses from by-catch in the Hudson River shad fishery were estimated by NY DEC based on weekly at sea sampling of the shad fishery then expansion to total shad gillnet effort. Total discard losses were the sum of estimates from tag recoveries and Hudson River estimates.

The sum of the resulting coast-wide estimates ranged from 37,600 fish in 1983 (47.7 mt) to 511,000 fish in 1995 (1,139.9 mt) (Tables 13 and 14). The partial sum of estimated commercial by-catch losses reported by states were the same order of magnitude. In 1992, the year with the most complete estimates, the sum of available state estimates was 163,780 fish compared to a tag-based estimate of 178,737 fish. From 1986 to 1994, when strict commercial quotas were implemented, discards exceeded the landings. The highest estimated percentage of discards was from anchor gillnets.

The age structure of the discards was estimated by year and gear type. Percent at age from anchor gillnet discards was a composite of Maryland, Virginia, Delaware and Hudson sampling of commercial catches or fisheries independent surveys, using commercial gear between 1982 and 1996. An average percent at age was estimated, with equal weighting among all gillnet samples. Hook and line samples were based on logbook data collected by MA DMF between 1990 and 1996. Prior to 1990, age composition of hook and line discards was not estimated. Age composition of pound net by-catch was based on sampling of Virginia pound net catches from 1982-1995. Pound net discards at age for 1996 were assumed the same as 1995. Hudson River by-catch in the gillnet fisheries was estimated from at-sea sampling of by-catch during the shad fishery. Total annual discards by gear were expanded by the percent at age. Discards with no associated age data were assumed to have the same age composition as the overall estimate. The catch at age of commercial discards are summarized in table 8.

Recreational Fishery

The recreational catch was determined using the MRFSS landings and discard data. In addition to the MRFSS, New Hampshire, Rhode Island, Connecticut, New York, and Maryland conducted volunteer angler survey programs for several years; NH(1993-1996), RI(1990-1996), CT(1979-1996), MD(1995-1996) and NY(1985-1996). The general purpose of these programs is to provide basic catch and effort data in addition to length frequency data. In some programs anglers were asked to fill out log books indicating whether a fish was kept or released . This data was used to characterize the length distribution of discards (B2). Information from the American Littoral Society (ALS) tagging program was also used to characterize the lengths of recreational discards. This program was initiated in the early 1960's to study patterns of seasonal migration and stock delineation of striped bass. Data from this program were available since 1983 (records of striped bass tags prior to that were not available). Lengths of tagged and recaptured fish from 1983 were used for 1982 length data. The MRFSS length frequencies in fork length were converted to total length using the following relationship from Vecchio and Greco (1997):

$$\ln(TL) = \ln(FL)*0.985+0.162.$$

North Carolina landings and discards were from coastal areas only.

The age/length keys from the North Atlantic were used to substitute for missing age/length keys from the Bay jurisdictions and North Carolina coastal waters.

Recreational Landings

The MRFSS, ALS, and CT volunteer angler survey length distributions were used to characterize the total harvest of the North Atlantic sub-region for 1982 to 1984. For 1985 to 1990, lengths from NY volunteer angler program were added to the MRFSS, ALS, and CT volunteer angler program length data. The length samples from RI volunteer program were combined for 1990 to 1995 to characterize the landings. In 1996 additional samples from New Hampshire were added to characterize the New Hampshire and Maine landings. Pooled annual length frequencies were applied to each state's annual harvest taking into account the minimum size in effect of that state (Table 2). Recreational landings were dominated by ages 1-5 from 1982-86. Then as the legal size increased in most states in 1987, these young age classes only represented about 11% of the total catch.

Pooled MRFSS and ALS length frequencies from Delaware, Maryland and Virginia were used for 1982 to 1988 to characterize the recreational landings in Chesapeake Bay. Additional lengths from Maryland's recreational/charter fisheries for fall and spring were used from 1990 to 1995. For the 1995-96 landings, lengths from Maryland's volunteer angler survey were added for the spring, summer, and fall harvests. Recreational landings in this area were dominated by relatively young fish because of the small legal sizes allowed in the Chesapeake Bay. Over the 1982-1996 period, ages 1-5 accounted for over 85% of the landings by number. The recreational catch at age is summarized in table 15.

Adequacy of Recreational Sampling

Sampling intensity was calculated as metric tons of landings per hundred lengths measured by sub-region for the portion of the recreational harvest (Table 16). Sampling intensity since 1990 averaged 102 and 52 mt of landings per 100 lengths in the North Atlantic and the mid-Atlantic sub-regions, respectively. The subjective criteria of 200 mt per 100 lengths was used as a benchmark for an adequate sample size. Based on this criterion, length frequency samples were adequate for both sub-regions, with the exception of 1982-84 in the Maine-New Jersey sub-region.

Recreational Discards

A hooking mortality rate of 8% was used for all areas and years (Diodati and Richards 1996). Length data from volunteer angler programs show that a significant portion of the legal catch is released. However, this varies from state to state. In Connecticut, over 60% of the legal catch was released during 1996. Similar proportions were observed in Rhode Island. However, in New York and Maryland, these proportions were as low as 8% in 1995 and 1996. Because of this variation and the potential bias in the level of experience and conservation ethic of the participants, lengths below legal size were applied. With the exception of the MRFSS lengths, the same lengths used to characterize the landings were used for discards (B2) but below legal size by state and season. The sampling intensity was calculated as a ratio of lengths measured to total discard weight (Table 16). Overall the proportion of fish sampled was less than 10 mt per sample for the North Atlantic area but 1 to 220 mt per sample in the Bay areas and North Carolina. Discard catch at age is summarized in table 15.

Hudson River

The Hudson River has a recreational striped bass fishery which is not sampled under the MRFSS program. Estimates of catch were supplied by NY DEC.

Estimates of recreational catch, landings, and discards in number and weight at age from the Hudson River were made in several steps. The recreational fishery for striped bass in the Hudson River occurs in the spring and targets pre-spawning and spawning fish. Most fish are taken from private boats and shore.

Estimates of the number of striped bass caught by boat anglers in 1991-1995 were made by multiplying reported catch rates by estimated effort. The estimated catch was then partitioned into released fish and creeled fish. Data on catch rates, percent creeled, and length of creeled and released fish were obtained from volunteer anglers. Effort was estimated by expanding observed effort during the spring at the center of the fishing reach with reported estuary and season wide effort from volunteer anglers. Effort estimates were periodically corroborated by areal overflights of the entire estuary. The 1996 estimate was from an access creel survey of boat and shore anglers combined with areal overflights for counts of effort. Results from 1996 were then used to expand the 1991 through 1995 boat estimates to account for catches by both boat and shore anglers. Catch and landings in 1980 - 1990 were estimated from the relationship between abundance, as measured in the by-catch of the commercial shad gill net fishery, and catch and landings in 1991-1996. Discards losses were estimated by applying an 8% release mortality to B2 estimates.

Age composition of harvested and released fish in 1990 - 1991 was estimated from scale samples obtained from volunteer anglers. Age composition for 1980 - 1990 and 1992-1996 was estimated from age frequency of the fall recreational harvest in Connecticut advanced a year to the following spring. The data showed a positive correlation with empirical data for the 1990-1991 Hudson spring fishery.

Weight at Age

Commercial Landings

Weight at age (kg) estimated from length frequency data and length-weight equations was calculated by year, period and state (Table 17). Total weight at age was the average among states, weighted by number at age.

Weight at age in the landings varied through time depending on the changes in management. For instance, in 1982 all fisheries were open and minimum sizes were 12-16".

The weight at age 6 was 4.1 kg. By 1989 Massachusetts was the only commercial fishery and was operating at a 36" minimum size. Consequently the weight at age 8 was 7.5 kg. When other fisheries reopened in 1990, weight at age 8 dropped back to 3.3 kg.

Commercial Discards

Weight at age from commercial discards was estimated from several sources. Length data of tag returns between 1987 and 1996 were subset to include fish captured then discarded in commercial fisheries. The subset was divided among gear groups. Length frequencies were expanded and weighted by total discard losses by gear. An age-length key for spring mixed stock fisheries were applied and length at age was calculated. The length-weight equation was a composite equation from MA, RI, NY and VA :

$$\ln wt\ (lb) = -7.7105 + (\ln length\ (in) * 2.9400)$$

Due to a bias in size of released fish, these weights at age (converted to kg) were only used for fish less than age 5, from 1987 to 1996, for age 5 from 1990 to 1996 and age 6 from 1991 to 1996. Weight at age in the Hudson River by-catch were applied to fish older than age 8. Weight at age of recreational catch was used for fish less than age 8 from 1982 to 1986 (Tables 17 and 20).

Recreational Landings and Discards

Length-weight relationships from Massachusetts fall sampling for 3 blocks of years 1982-1986 , 1987-1991, and 1992-1996 were used to calculate annual mean weights at age, from the estimated age-length frequency distribution for the North Atlantic (Table 18). Similar relationships from Virginia and Maryland samples were used for the Bay states and North Carolina (Tables 19 and 20).

Mean weight at age from striped bass in the Hudson River recreational fishery was estimated from length, weight, and age data collected from annual surveys of the spring spawning stock, 1985-1995(Table 18).

Virtual Population Analysis

Catch at Age Development

Striped bass fisheries exploit native stocks within producer areas and mixed stocks along the coast. Since stock specific catch estimates were not available from the coastal component, a VPA was developed for a mixed stock. Maximum age in the catch matrix was 23 years, but the matrix was truncated to a 15+ age group (Table 21). Minimum size along the coast in the late

1980's was 36 inches, so the Technical Committee felt that estimating a plus group at a younger age might compromise the ability of the VPA to estimate the age at full recruitment. Less than 1% of the total catch was included in the plus group. The age data used in the analysis were based on scale readings. Recent evidence suggests that scales may be underestimating the true age beyond age 12, based on comparison to otolith ages and known age fish (Secor et al 1995). The catch beyond age 12 comprised only 1-3% of the total catch, so the ageing error would be a relatively minor problem. It is clear however that further research needs to be done on the age analysis for striped bass.

Fishery Independent Indices

Fishery independent indices were evaluated for inclusion as tuning indices in the VPA. Indices (collected prior to 1982) available were :

Maine Division of Marine Fisheries

A young of year index from the Kennebec River was calculated based on a beach seine survey conducted in late spring 1987-1996. The index was not included as a tuning index because of the low number of striped bass sampled.

Massachusetts Division of Marine Fisheries

Catch per unit effort from a striped bass tagging program, October 1991-1995, was evaluated. The index was not included in the VPA due to a suspected bias, resulting from targeting striped bass.

Rhode Island Division of Fish and Wildlife

A young of year index of striped bass in Narragansett Bay, spring 1986-1995, was evaluated. The index was excluded from the VPA due to low sample sizes and possible bias in the index created by sampling young of year in an area not considered a primary spawning ground.

Connecticut Division of Environmental Protection

An index of combined age classes was available from a stratified random trawl survey of Long Island Sound during the summer of 1984-1996. The index was not used for tuning because of low sample sizes.

Hudson River Utilities

Indices of striped bass abundance, collected in the Hudson River by the utility industry, were available and included: an index of post-yolk sac larval abundance from spring 1982-1995, a young of year index from a beach seine survey, 1982-1995, and an estimate of age 2 and age 3 absolute abundance based on a Hudson River tagging program, 1986-1996. These were not included due to lack of information to fully evaluate the representativeness of the sampling.

New York Department of Environmental Conservation

An index of young of year striped bass in the Hudson River, 1982-1996, was included as a tuning index (Table 22, Figure 5). The directed striped bass survey uses a 200' beach seine with a 5 mm stretched mesh bag. Sampling is conducted bi-weekly from mid-August to early November at 25 fixed stations selected from a pool of 33 stations. A GM mean number per tow of age 0 was calculated. The index has been validated with the abundance of age 1 fish in Long Island Sound and age 2 estimates from Hudson River Utilities data. An index of age one striped bass from the beach seine survey was not included. Instead, an index of age one striped bass sampled in western Long Island Sound using a beach seine during spring/summer 1985-1996 was included (Table 23, Figure 6).

Each fall since 1987, a survey of coastal migrating striped bass has been conducted from beaches of southwestern Long Island using a 1800' ocean haul seine. A minimum of 10 fixed stations are sampled, and 54 to 60 hauls are conducted from September to November. Indices of abundance at age, calculated as mean number per haul, were included as tuning indices for ages 4-15+ (Table 24, Figure 6).

New Jersey Department of Environmental Protection

An index of young of the year striped bass in the Delaware River is calculated as mean catch per haul from a beach seine survey conducted since 1982 (Table 22, Figure 7). The survey samples 16 stations bimonthly within the Delaware River. The design uses both fixed and random station selection and samples from mid-July to mid-November using a 100' seine with 1/4" mesh. Indices since 1982 were included as tuning indices in the VPA.

A stratified random trawl survey has been conducted within state waters along the coast of NJ since 1988. The index of abundance was not used as a tuning index because of low sample sizes of striped bass.

Delaware Division of Fish and Wildlife

A stratified random trawl survey has been conducted during the spring in Delaware Bay since 1989. An index of young of the year striped bass, calculated as mean number per tow, was used as a tuning index (Table 22, Figure 7). A separate stratified random trawl survey index (ages combined), 1982-1984, 1990-1996 was not included. In addition, an index of female abundance in Delaware River (catch per hour from electrofishing, ages combined) for the spring 1994-1995 was not included due a question about its representativeness and short time series.

Pennsylvania Fish and Boat Commission

An index of female cpue from Delaware River (catch per hour electrofishing, ages combined), for spring 1994-1995 was not included due a question about the representativeness and short time series.

Maryland Department of Natural Resources

An index of production based on presence/absence of eggs in Chesapeake Bay tributaries was available for 1982-1996. The index was not included as a tuning index due to problems tuning a biomass index in an aged based analysis.

A survey of young of the year striped bass in Maryland waters of the Chesapeake Bay has resulted in an annual abundance index since 1954. The survey is conducted at fixed stations; seven stations in the Upper Bay and Potomac River, four stations each in the Nanticoke River and Choptank River. Sampling is conducted monthly from July through September, using a 30.5 m beach seine. A validation of the index is described in Goodyear (1985). The index, calculated as geometric mean number per haul, was included as a tuning index (Table 22, Figure 8). In addition, an index of age one striped bass from the same survey was used in tuning (Table 23, Figure 8).

A survey of striped bass spawning areas was conducted in the Maryland tributaries of the Chesapeake Bay (Choptank River, Upper Bay and Potomac River) during April and May of 1985-1997. A multiple mesh gillnet, with mesh sizes (inches) of 3.0, 3.75, 4.5,5.25, 6.0, 6.5, 7.0, 8.0, 9.0 and 10.0 was set daily, 10 to 20 times per month at stratified random stations. Catch per unit effort (number of fish per hour) was adjusted for selectivity differences between mesh sizes using the method described in Stagg (1996). In 1994 the Potomac River was not sampled and in 1995 the Choptank River was not sampled. A composite bay-wide index was developed using a weighted sum of the CPUE. The weighting factors were based on nursery area (Hollis 1967); with a Choptank weighting of 0.04, Potomac River weighting of 0.37, and the Upper Bay weighting of 0.59. Combined indices of abundance at ages 2-15+ were used as tuning indices in the analysis (Table 25, Figure 8).

Virginia Institute of Marine Science

A survey of striped bass young of the year in Virginia waters of the Chesapeake Bay was done annually since 1980. Eighteen fixed stations on the James, York, and Rappohannock Rivers were sampled with a 30.5 m beach seine 5 times a year on a bi-weekly basis from mid-July through September. An index of abundance, number of striped bass per haul, was used as a tuning index (Table 22, Figure 8).

A trawl survey of Virginia rivers and parts of Chesapeake Bay has been conducted since 1955. A young of year index from this data was not used due to variations in gear over the time series.

Further details of specific juvenile surveys are available in ASMFC Special Report #48, 'Report of the Juvenile Abundances Indices Workshop' (Rago et al, 1995).

<u>Fisheries Dependent Indices</u>

MRFSS

An index of abundance based on recreational angler cpue (catch per angler trip) was calculated for 1982-1996. The committee did not use this index since the recreational catch data was already a major component of the catch matrix.

New Hampshire Fish and Wildlife

NHFW has conducted a creel survey, independent of the MRFSS survey, in 1982, 1984, and 1986-1995. The index of abundance was not used as a tuning index because of the low sample sizes of striped bass.

Massachusetts

CPUE and length frequency data from Massachusetts commercial anglers were available since 1989. Catch per hour fished (autumn 1989-1996) was subdivided for ages 6 to 14 based on the associated age/length data. Indices of abundance for ages 7 to 14 were used as VPA tuning indices (Table 26, Figure 6). Age 6 striped bass were not considered fully recruited to the fishery.

Connecticut

Since 1979 CT DEP has collected recreational striped bass CPUE data using volunteer angler logbooks. The CPUE (catch per trip) was subdivided into ages 1-15+ using the associated length data applied to an age/length key. The indices of abundance were used as tuning indices (Table 27, Figure 6). The fishery is prosecuted in summer/fall and was considered as a fall tuning index.

New York

CPUE of striped bass in the Hudson River commercial shad gillnet fishery (number caught per yd^2 x hrs x 10^{-3}, ages 6-15+) was available for the period 1982-1996. The abundance was estimated based on CPUE determined from sea sampling trips expanded to total effort in the shad fishery. Indices of abundance for ages 6-8 were used as tuning indices (Table 28, Figure 5). Other ages were not considered due to the selectivity of the shad gillnets on larger striped bass.

Data from a New York volunteer angler program on Long Island was available since 1989. CPUE (number caught per hour fished) calculated for ages 1-15+ were not included due to the length of the time series and changes that have occurred in the program during the time series. The age and length data were used in expansion of hook and line caught striped bass from recreational and commercial fisheries in the region.

New Jersey

A fall fishery for large striped bass, using the commercial quota allocated to NJ, has occurred since 1991. CPUE (number caught per trip) from mandatory catch reports was available but not included as a tuning index due to sample size.

<u>VPA Input</u>

A VPA for striped bass was run using the software ADAPT (Parrack 1986, Gavaris 1988, Conser and Powers 1990). The program provides the best estimate for an objective function (the difference between observed and predicted indices) using non-linear least squares methods. The model structure assumes the catch at age matrix is determined without error and tuning indices are representative of population abundance. The time series of the catch at age matrix was 1982 to 1996. Ages used in the VPA estimation were 1 to 14 with 15 as a plus group (all ages equal or greater than 15). A total of 103 age dis-aggregated indices were input. The VPA indices were tuned to stock sizes as of January 1 and indices were adjusted to reflect stock size as of January 1. Spring indices were considered indicative of stock size for January 1 of that year. Fall indices were adjusted forward one year to tune to stock size at the beginning of the next year; e.g. indices of age 1 fish in the fall of 1982 better reflected stock sizes of age 2 fish on January 1, 1983 than January 1, 1982. All young of the year indices in year *i* were transformed to age 1 indices in year *i+1* (i.e. yoy index for 1985 = age 1 index in 1986).

Spawning was assumed to occur in April and 33.3% of the natural mortality occurred prior to spawning, while 10% of fishing mortality was assumed to occur prior to spawning. Natural mortality was set at 0.15. Maturity at age was: age 1 (0), age 2 (0), age 3 (0), age 4 (0.04), age 5 (0.13), age 6 (0.45), age 7 (0.89), age 8 (0.94), age 9 and older (1.0) (Rugolo and Jones 1989). Sex ratio at age was assumed equal to 50:50. Full recruitment, since 1994, ranged from ages 5 to 10 but the peak age in the catch varied between ages 2 and 4 (Figure 9). Therefore fishing mortality of the oldest true age was based on ages 4 - 14. Fishing mortality on the plus group was equivalent to F at age 14. Partial recruitment was set at 0.005 age 1, 0.05 age 2, 0.22 age 3, 0.52 age 4, 0.70 age 5, 0.75 age 6, 1.0 age 7 and greater, based on preliminary runs of the VPA.

Initial runs of the VPA included all tuning indices. Following examination of the adequacy of the tuning indices and evaluation of the diagnostic information, the set of tuning indices were reduced to 58. An iterative re-weighting of the indices was used due to the mixed stock nature of the catch at age data and tuning indices.

Diagnostic Evaluation of VPA

The evaluation of the VPA output presented unique problems for striped bass. The input data consisted of catch from three stocks. Historically population abundance, based on juvenile indices and landings, has varied among stocks. The Chesapeake stock was severely depleted by the early 1980's, the Delaware stock was almost completely extirpated by the 1970's, while the Hudson stock maintained a relatively stable production during the 1980's and 1990's. As a result, a stock specific index may not be linearly related to overall population abundance, as indicated from the catch at age matrix. The residual patterns, as diagnostic indicators, reflect the adequacy of the indices for tuning as well as the relative contribution of that stock to the overall stock mixture. For instance, the Delaware River young of the year index has increased exponentially since the mid 1980's, at a much greater rate than the overall mixed stock growth. As a result, the residuals have a negative trend in early years and a positive trend in later years. The decision was made to reject indices based on the overall contribution to the residual sums of squares rather than time trends in specific indices. In addition, indices were rejected if the index was not considered representative due to gear bias or other factors.

VPA Results

The final VPA model resulted in an overall mean square residual of 0.010 (Table 29). The coefficient of variation on the population estimates ranged from 0.20 for age 4 to 0.33 at age 13, with an overall average of 0.26. The correlation among abundance estimates showed a moderate positive correlation for ages 8-13. This may be due to 'smearing' among age groups, as a result of increased aging errors in older fish.

Population abundance (January 1 stock sizes) increased steadily from a low of 5.3 million fish in 1982 to a high of 40.1 million in 1997 (Figure 10). Strong year classes occurred in 1989, 1993 and 1996 (Figure 11). The 1982 year class, which was the focus of early FMP's, was of average size coastwide, although juvenile indices in Chesapeake Bay suggested an above average 1982 year class. Abundance increased significantly in 1994 and 1997 due to the large 1993 and 1996 year classes. The strong 1982, 1989, 1993, and 1996 year classes are evidence through the time series of stock number at age (Figure 12).

Fishing mortality rates decreased in the mid-1980's, probably as the result of management restrictions. With the reopening of the fisheries in 1990 fishing mortalities increased but were still at or below the target F (Figure 13). In recent years highest mortality occurred on fish greater than age 5 which are the age groups susceptible to fisheries in both coastal and producer area fisheries. Full F in 1996 (ages 5-13) was 0.31 which corresponds with the target F of 0.31. An approximation of fishing mortality in producer areas is F on ages 3-8, which was 0.26 in 1996. An overall F on ages 4-13 was equal to 0.30.

The VPA estimates of fishing mortality in 1982-1984 were lower than expected. Historical tagging estimates of F from the Chesapeake Bay during that period indicated an F possibly approaching 0.9. This uncertainty about F in the converged portion of the VPA may be the result of several factors. First, there are fewer tuning indices for the early years of the time series. Consequently, any index which overestimates relative abundance would have a greater influence in overestimating population abundance and underestimating fishing mortality. Second, estimates of recreational landing in Chesapeake Bay prior to 1985 may have been underestimated (Table 5). Although Maryland increased the number of intercepts in the MRFSS survey during the early 1980's, Virginia landings of 0 fish seems unrealistic. A sensitivity analysis was made by increasing the recreational catch of ages 2-4, from 1982-1985, proportional to the commercial landings. The total catches were increased by a factor of 3.6, 3.1, 7.3, and 2.8 times in 1982-1985, respectively. The result was an increase in F for ages 3-8 (approximation of ages in the producer area fisheries) from 0.22 to 0.36 (1982), 0.25 to 0.28 (1983), 0.21 to 0.91

(1984) and 0.17 to 0.40 (1985). The changes in catch in 1982-1985 decreased the estimates of fully recruited F in the terminal year from 0.31 to 0.23. A more modest (and probably realistic) underestimation of catch (a factor of 2x) in the early years of the time series had little influence on the estimates of fishing mortality in 1982-1985 and in the terminal year. Third, the VPA estimates for the mixed stock may also poorly reflect geographic variation in F. The Chesapeake stock, as referenced by the MD juvenile index) was at its lowest point in the early 1980's while production in the Hudson was relatively stable. Since the fishery within the Hudson River was closed, fishing mortality on that component of the stock may have been low to moderate. Consequently if the proportion of Hudson fish in the mixed stock was high, the high F in the Bay would have been diluted relative to the overall mortality estimate.

The trend in partial recruitment has followed the trends in management regulations (Figure 14). At the beginning of the time series, the minimum size was generally 12 to 16 inches. During this period, full recruitment occurred around ages 3-5. During the mid to late 1980's the minimum sizes in coastal fisheries were steadily increased until reaching a 36 inch minimum in 1990, at which point full recruitment was reached by age 9. Age at full recruitment remained between 9 and 12, until 1996. With liberalization of management restrictions in 1996 and increased effort associated with the large 1993 year class, full recruitment was reduced to age 5.

Spawning stock biomass of females increased from a low of 2,400 mt in 1983 to a 1996 level of 13,100 mt (Figure 11). The spawning biomass is expected to increase even further with the maturation of the 1993 and 1996 year classes.

Precision Estimates of F and SSB

Uncertainty in the results of the terminal year estimates of F and SSB in the VPA was evaluated using a bootstrap procedure (Table 30) (Efron 1982). Two hundred iterations were made to obtain standard errors, coefficient of variations (CVs) and bias estimates for ages 1-13 stock size estimates at the start of 1997 and for ages 4-13 Fs in 1996. Results indicate an 80% probability that 1996 F was between 0.27 and 0.34 (Figure 15). The estimate of bias was less than 5% for ages 1-13. The bootstrap mean of the fully recruited F in 1996 was 0.32 with less than 5% bias and a cv of 0.14. The 1996 SSB of females was between 11,800 mt and 14,300 mt (Figure 16) with a probability of 80%. The bootstrapped mean SSB in 1996 was 12,918 mt with a percent bias of 0.4% and a CV of 0.1.

Tagging Estimates of Mortality

Estimates of 1996 fishing mortality were made using tag recovery data from several tagging programs. Since the 1980's, striped bass have been tagged on the spawning grounds in the Delaware River, Hudson River and tributaries of the Chesapeake Bay, during the fall coastal migration along Long Island, during the fall sport fishery in southern Massachusetts and on the overwintering grounds of coastal North Carolina. In addition, Maryland has conducted a tagging program since 1992 and Virginia and PRFC since 1994 to determine fishing mortality during the autumn fisheries. These fisheries have traditionally targeted smaller fish which constitute the pre-migratory component of the stock. The release and recovery information is maintained by the Fish and Wildlife Service office in Annapolis, MD.

Survival estimates have been made using the Brownie tag recovery model (Brownie et al. 1985). Recently, new software was developed called MARK (White and Burnham, 1997) which was used to analysis the tag recovery matrix (Appendix II). The resulting estimates of fishing mortality (calculated from survival estimates assuming M=0.15) were 0.31 from the Delaware tag releases and 0.34 from the Hudson releases. The estimate of F from the 1996 autumn fishing season in Chesapeake Bay was 0.33.

In 1995 and 1994, the estimated fishing mortality rate calculated from a bootstrap median of all tag estimates, was equal to 0.25 compared with a VPA estimate of 0.24 and 0.27 in 1994 and 1995, respectively. The 1996 VPA estimate of F for ages 3 to 8 (an approximation of ages recruited to fisheries in producer areas, which includes the Hudson River, Delaware and Chesapeake Bays) was 0.26 compared to the tag estimate within the Chesapeake Bay of 0.33.

Biological Reference Points

The Striped Bass Management Board adopted F_{msy} as the definition of overfishing. The current target fishing mortality is 0.31. The overfishing definition and target apply to all striped bass stocks under management by ASMFC. An estimate of F_{msy} (0.40) was made in 1990 when the fishery was reopened in all jurisdictions. In 1997, the estimate of natural mortality used in the assessment was changed from 0.20 to 0.15 as a result of new information about the maximum age of striped bass. Consequently, F_{msy} was re-estimated as 0.38.

The estimation of F_{msy} involves a Shepherd S/R model (Shepherd 1982) and a Thompson-Bell yield per recruit model (Thompson and Bell 1934). Prior to development of the VPA, stock recruitment data was not directly available for the coastal migratory stock of striped bass. The model incorporated information from other stocks of striped bass or related species, and estimates of potential stock growth based on trends in abundance indices, to define parameters in the Shepherd S/R model. The yield model incorporated migratory schedules of fish moving from the minimum sizes in Chesapeake Bay fisheries to the minimum size in the coastal fisheries. The resulting estimate of F_{msy} was 0.38.

Short Term Projections

A stochastic projection of total coastwide landings, discards and spawning stock biomass was made for 1997 to 1999 (Brodziak and Rago 1994). One hundred simulations were made using a target fishing mortality rate of 0.31. A distribution of initial stock sizes (ages 1-15+) was the results of 200 iterations in the VPA bootstrap procedure. Recruitment in 1996 was the highest in the time series. Therefore, the bootstrapped recruitment estimates were not used to characterize age 1 recruitment in 1998 and 1999. The distribution of recruitment was based on the relationship between the VPA recruitment estimates (age 1) and the Maryland juvenile indices for 1981-1996. The relationship was defined by the linear regression:

$$\text{recruits} = 2737.66 + 763.37(\text{MD ji}) \qquad r^2=0.86$$

The regression was used to estimate recruitment strength from juvenile indices for 1955-1977 and 1989-1996. Recruitment during years when stock size may have been substantially lower than current conditions (1978-1988) was not included. Recruitment at age 1 for 1998 and 1999 used in the projection model were randomly selected from the 31 values. Recruitment of age 1 striped bass in 1997 was based on bootstrap values from the VPA.

The results of the stochastic projection indicate a steady rise in average female SSB, reaching 15,297 mt in 1999 (Table 31). Average recruitment ('000s) ranges from 15,760 to 6,400 between 1997 and 1999. Landings would decrease to 7,803 mt in 1997 but increase to 8,515 mt by 1999. Similarly, discards would increase to 3,844 mt by 1999.

Stochastic projections were made under a range of target fishing mortalities for 1998 and 1999. The relationship suggests that an increase in landings beyond 10,000 mt would exceed the F associated with the over-fishing definition (Figure 17). The rate of increase in F relative to landings is greater in 1999 than in 1998.

Conclusions

The Atlantic coastal stocks of striped bass are at high level of abundance and are being exploited at a sustainable level. The estimates of fishing mortality in 1996 were at the target level (0.31) and below the level of F_{msy} (0.38). Record high levels of recruitment from the 1993 and 1996 year classes should approach full recruitment by 1998 and 2001, respectively. Spawning stock biomass should continue to increase over the short term under current levels of exploitation.

Sources of Uncertainty

1. Relative stock contributions to catch from the three major stocks.
2. Migration rates from the three major producer areas.
3. Age estimation using scales rather than otoliths.
4. Age distribution and estimation of commercial discards.
5. Discard mortality rates among various types of commercial gear and various environmental conditions (e.g. temperature and salinity).
6. Bias estimators in the tag-recapture models remain poorly defined.
7. Tag reporting differences between commercial and recreational fisheries.

Research Recommendations

1. The committee recommends that further study be done on the discrepancy in ages between scale based ages and otolith based ages. Particular emphasis should be placed on comparisons with known age fish determined from coded wire tags. Comparisons should be made among age readers and areas.
2. An evaluation of the overfishing definition should be made relative to uncertainty in biological parameters. There is uncertainty in the maximum age, annual repeat spawning among females, age specific natural mortality, maturity ogives, and migration rates.
3. Simulation models should be developed to look at the implications of overfishing definitions relative to development of a striped bass population which will provide 'quality' fishing. Quality fishing must first be defined.
4. Examination of the tag-recapture models and development of a standard method for estimating bias.
5. Refine quota calculation methods which will allow better estimates among various components of the fishery.
6. Increase sea sampling of commercial fisheries, such as the dogfish gillnet fishery, which may have high levels of discards.
7. Examine the mechanisms which may contribute to density dependence in striped bass as modeled in the stock-recruitment relationship.

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Table 1. Commercial striped bass minimum sizes (inches) of jurisdictions under the striped bass FMP, by season 1982-1996.

Commercial Minimum Sizes (inches)

	1982		1983		1984		1985		1986		1987		1988		1989	
state	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall
ME	16" FL						24" TL		33" TL						36" TL	
MA	24" FL								30" TL		33" TL				36 " TL	
RI	16" FL					18" TL		24" TL		33" TL					34" TL	36" TL
NY	18" TL				24" TL					0	0	0	0	0	0	0
NJ	18" TL							24" TL			0					
DE	12" FL				14", 24" TL		0									
MD, bay	12/14-32" TL			14-32" TL			0									
ocean	24" TL						0									
PRFC	12-32" TL		14-34" TL				18 - 34" TL		24-34" TL						0	
VA, bay	14" TL						18 - 40" TL		24" TL						0	
ocean	24" TL								30" TL				33" TL		0	
NC ocean	16" TL				24" TL											0

	1990		1991		1992		1993		1994		1995		1996	
state	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall
ME											33" TL			
MA											34" TL			
RI	18-26",40" TL										20-26",37" TL			
NY	0	24-29" TL				24-39" TL		24-36" TL			24-36" TL			
NJ											0			
DE	28" TL		18-28" TL								18-28" TL			
MD, bay		18-36" TL		18-36" TL		18-36" TL		18" TL		18" TL		18" TL		18" TL
ocean	28" TL										24" TL			
PRFC	18-36" TL										18" TL			
VA, bay	18-36" TL										18" TL			
ocean	28-36" TL										28" TL			
NC ocean	28" TL										28" TL			

Table 2. Recreational striped bass minimum sizes (inches) of jurisdictions under the striped bass FMP, by season 1982-1996.

	1982		1983		1984		1985		1986		1987		1988		1989	
state	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall
ME	16" FL						24" TL		33" TL						36" TL	
NH	16" FL						28" TL		33" TL						34 " TL	36" TL
MA	24" FL								30" TL		33" TL				36 " TL	
RI	18" TL				24" TL					33" TL						36" TL
CT	18" TL				26" TL						33" TL					36" TL
NY	18" TL				24" TL				0	0	33" TL					36" TL
NJ	18" TL							24" TL				33" TL				36" TL
DE	12" FL				14" TL	24" TL	0									
MD, bay	12"/14" - 32" TL			14-32" TL									0			
ocean	24" TL												0			
VA, bay	14" TL						18 - 40" TL		24" TL						0	
ocean	24" TL								30" TL				33" TL		0	
NC ocean	12" TL				16" TL		24" TL				33" TL					36" TL

	1990		1991		1992		1993		1994		1995		1996	
state	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall	spring	fall
ME											33" TL			
NH											32" TL			
MA							34" TL							
RI	28" TL						34" TL					28" TL		
CT							34" TL					28" TL		
NY	38" TL	36" TL										28" TL		
NJ	28" TL								34" TL			28" TL		
DE	28" TL													
MD, bay		18-36" TL	36" TL	18-36" TL	36" TL	18-36" TL	36" TL	18" TL	34" TL		32"/26" TL	18" TL	32"/26" TL	18" TL
ocean	28" TL													
VA, bay		18-36" TL							18" TL		18-32" TL			
ocean	28" TL										28" TL			
NC ocean	28" TL										28" TL			

Table 4. Striped bass commercial landings by state (mt). Landings by calendar year. New Jersey commercial landings from the recreational fishery.

	ME	NH	MA	RI	CT	NY	NJ	DE	MD	PRFC	VA	NC	Total
1982			291.7	122.6	2.7	213.6	4.7	11.7	216.8	61.7	24.4	41.9	991.8
1983			101.6	89.1	1.0	140.4	8.9	3.1	171.9	74.5	24.7	23.9	639.1
1984			48.6	24.7	0.9	270.0	4.0	16.8	370.1	355.2	7.0	6.6	1104.0
1985	0.3		53.9	27.8	2.5	212.8	5.5		0.9	100.8	27.0		431.8
1986			44.1	5.0		0.5	4.5			13.3	0.5		68.1
1987			35.7	0.2						26.3	1.0		63.2
1988			36.1							52.3	28.2		116.5
1989			90.7										90.7
1990			67.1	1.8		37.2	-	3.0	1.3	76.7	121.4	4.4	313.0
1991			106.6	12.7		47.6	-	9.6	86.7	98.4	95.8	2.8	460.2
1992			108.4	17.7		103.0	-	8.1	250.6	57.6	92.7		638.0
1993			119.3	18.1		49.4	-	12.7	415.8	64.9	96.9		777.2
1994			90.5	18.1		77.0	-	15.4	401.4	68.0	92.6	42.0	805.0
1995			354.7	68.7		227.2	-	17.5	388.5	90.0	253.0	155.9	1555.4
1996			316.1	71.7		225.7	1.8	53.3	691.0	156.5	636.4	25.3	2177.9

Table 5. Striped bass recreational landings by state (A+B1 number). Includes NC Atlantic Ocean landings.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	Total (000's)
1982	929	0	83,933	1,757	50,082	21,305	58,294	0	984	0	0	217
1983	7,242	4,576	39,316	1,990	42,826	43,773	127,912	135	31,746	0	0	300
1984	0	0	3,482	1,230	5,678	57,484	13,624	16,571	16,788	404	0	115
1985	11,862	0	66,019	670	15,351	23,251	13,145	0	2,965	0	0	133
1986	0	0	29,434	3,291	1,760	27,590	36,999	0	14,077	1,584	0	115
1987	0	90	10,807	2,399	522	14,824	9,279	0	4,025	2,442	0	44
1988	0	647	21,050	5,226	2,672	21,105	12,141	0	188	24,259	367	88
1989	708	0	13,043	4,303	5,778	14,787	1,312		0	0	0	40
1990	2,911	617	20,515	4,677	6,082	26,431	44,878	2,009	75,236	56,017	0	239
1991	3,266	274	20,799	17,193	4,908	55,488	38,300	2,742	118,529	42,225	391	304
1992	6,356	2,213	57,083	14,945	9,154	47,446	41,426	2,308	169,162	21,118	967	372
1993	612	1,539	58,511	17,827	19,253	83,678	64,936	4,056	177,208	78,481	264	506
1994	3,771	3,022	74,538	5,914	16,929	95,616	34,877	4,139	193,793	127,945	7,426	568
1995	2,029	4,405	70,114	29,755	38,903	153,811	171,014	12,570	482,032	148,386	11,491	1,125
1996	2,061	6,921	72,980	60,785	64,167	279,864	119,259	28,129	406,933	235,340	16,431	1,293

Table 6. Striped bass recreational discards by state (B2 number, 000's). Includes NC Atlantic Ocean discards.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	Total
1982	0.7	0.0	6.4	2.6	643.2	12.3	87.6	0.0	30.4	0.0	0.0	783.2
1983	0.0	0.0	34.0	5.4	0.0	1.5	117.8	0.0	213.5	12.0	0.0	384.2
1984	1.9	0.0	98.4	85.1	31.2	40.5	52.9	0.0	104.1	8.8	0.0	422.9
1985	81.2	0.1	12.4	40.6	26.9	57.5	5.5	0.7	147.1	2.6	0.0	374.6
1986	4.4	0.0	442.3	2.0	10.5	123.8	0.0	0.0	390.1	7.5	0.0	980.6
1987	18.1	0.4	93.7	63.8	78.4	254.0	56.7	17.0	118.4	7.6	0.0	708.2
1988	4.5	6.7	209.6	23.3	25.5	92.6	486.3	2.5	132.3	5.6	0.0	989.0
1989	16.0	4.8	193.1	38.0	125.4	365.7	266.0	4.8	114.3	72.8	0.0	1200.8
1990	12.5	15.5	339.5	67.5	89.5	265.1	254.4	14.4	420.1	175.0	0.0	1653.6
1991	67.5	6.6	448.7	31.0	301.5	756.7	166.2	38.3	1036.0	208.4	0.3	3061.0
1992	31.2	27.6	779.8	120.4	292.3	799.1	413.5	36.9	750.0	115.9	0.7	3367.4
1993	373.1	15.0	833.6	101.0	271.3	694.1	308.3	89.5	1556.8	100.4	1.5	4344.6
1994	363.5	43.5	2102.5	139.0	490.0	1132.7	568.0	104.0	2785.4	197.0	5.0	7930.6
1995	505.5	302.3	3245.7	359.2	632.3	1163.5	678.6	106.4	2250.6	369.9	16.6	9630.6
1996	1623.7	269.0	3347.6	309.5	1042.3	1582.9	766.3	99.4	2756.6	734.2	112.1	12643.5

Table 7. Striped bass age samples by area, 1982-1996. Period 1 is January to June, period 2 is July to December.

	Period 1					Period 2					
	Area					Area					
year	1	2	3	4	5	1	2	3	4	5	Total
1982	1,818	217			570	1,396				374	4,375
1983	599	342			644	520				189	2,294
1984	296	263			35	1,040				814	2,448
1985	663	183			1,745	757				1,898	5,246
1986	1,221	254	69		4,160	112				2,686	8,502
1987	1,779	338	160		3,612	2,698				2,010	10,597
1988	2,773	407	102		3,569	2,080				3,533	12,464
1989	1,541	245			3,625	1,314				2,286	9,011
1990	842	176	468		2,863	2,925				848	8,122
1991	4,385	26	3,204		4,044	1,981				3,922	17,562
1992	1,145	253	871		4,166	2,570				2,105	11,110
1993	1,119	268	1,730		3,661	3,241				2,011	12,030
1994	1,971	202	1,177		2,087	2,651				1,163	9,251
1995	2,025	142	876	544	4,028	524				363	8,502
1996	242		824			620				418	2,104
										total	123,618

Area 1=New Jersey north, coastal
Area 2= Hudson River
Area 3=Delaware Bay
Area 4= Delaware south, coastal
Area 5 = Chesapeake Bay

Table 8. Commercial catch at age, 000's, 1982-1996. Maine to coastal North Carolina.

Landings	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.0	45.1	200.2	117.2	22.9	5.0	3.3	2.9	1.9	4.4	5.8	7.6	2.5	2.8	6.9
1983	0.0	54.3	120.6	121.0	38.3	7.4	2.0	0.7	0.6	1.7	1.3	2.4	2.7	1.9	2.7
1984	0.0	478.3	270.1	55.6	30.6	21.7	6.4	1.7	1.0	0.8	0.1	0.3	1.1	1.0	2.1
1985	0.0	53.7	45.5	7.5	9.4	19.2	21.6	6.6	3.7	1.5	0.5	0.6	0.5	0.9	3.4
1986	0.0	0.6	6.0	3.2	0.2	0.7	1.4	1.2	0.5	0.2	0.1	0.2	0.3	1.0	2.0
1987	0.0	0.0	3.1	4.3	1.6	0.3	1.1	1.1	0.4	0.2	0.1	0.3	0.3	0.2	0.6
1988	0.0	0.0	2.1	4.0	15.5	6.5	2.8	0.5	0.5	0.2	0.3	0.1	0.3	0.0	0.5
1989	0.0	0.0	0.0	0.0	0.0	0.1	1.1	1.0	1.0	0.6	0.5	0.2	0.3	0.4	2.1
1990	0.0	0.7	12.6	48.0	29.6	15.1	3.1	2.4	1.1	0.5	0.3	0.1	0.4	0.3	1.4
1991	0.0	2.1	22.4	44.7	41.0	21.6	8.5	4.4	4.8	1.2	0.3	0.1	0.1	0.6	1.9
1992	0.0	0.6	32.3	58.0	46.7	41.6	22.2	11.5	8.7	6.3	1.1	0.5	0.2	0.3	0.7
1993	0.0	1.8	21.1	93.9	87.4	42.1	32.5	13.8	8.4	6.4	4.0	0.8	0.2	0.1	0.4
1994	0.0	1.2	22.9	71.6	101.5	48.3	28.5	14.9	8.9	5.3	2.5	1.3	0.2	0.1	0.3
1995	0.0	6.7	35.2	114.5	134.7	98.5	38.9	34.2	37.3	21.8	8.4	3.2	1.0	0.4	0.1
1996	0.0	0.6	50.1	127.8	179.0	161.4	120.7	52.0	29.9	18.9	11.7	9.7	2.3	1.1	1.4

Discards	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.0	31.6	3.6	11.5	5.6	1.3	2.4	1.0	0.4	0.1	0.1	0.0	0.0	0.0	0.0
1983	0.0	24.1	1.5	2.9	7.8	2.3	0.6	0.6	0.3	0.2	0.0	0.0	0.0	0.0	0.0
1984	0.0	33.6	1.6	5.8	9.7	11.3	2.8	0.1	0.6	0.1	0.0	0.1	0.0	0.0	0.0
1985	0.0	7.7	30.5	5.9	10.9	3.4	2.7	1.0	0.3	0.1	0.1	0.0	0.0	0.0	0.0
1986	0.0	5.8	20.8	100.1	28.0	13.3	4.3	1.4	0.3	0.0	0.0	0.0	0.0	0.0	0.0
1987	0.0	4.2	14.4	28.6	51.4	16.9	6.5	1.3	1.0	0.4	0.1	0.1	0.1	0.0	0.0
1988	0.0	6.1	22.6	36.6	71.0	71.7	23.2	9.1	3.1	1.7	0.2	0.2	0.0	0.0	0.0
1989	0.0	13.9	50.2	49.0	83.4	82.8	33.5	15.5	6.3	0.7	1.4	1.4	0.7	0.0	0.0
1990	0.0	14.5	68.7	80.9	111.9	115.7	71.6	36.3	5.9	1.5	1.4	1.5	0.0	0.0	0.0
1991	0.1	12.6	37.0	64.2	77.3	56.9	36.9	24.9	6.6	4.1	6.5	0.0	0.0	0.0	0.0
1992	0.1	3.7	34.2	36.7	44.4	34.7	14.8	11.2	3.4	2.4	1.0	0.0	0.0	0.0	0.0
1993	0.0	7.4	50.2	79.0	95.1	63.5	20.9	15.4	9.3	4.6	1.7	0.5	0.3	0.0	0.0
1994	0.0	31.8	47.2	45.1	88.1	84.6	39.2	12.5	6.2	3.7	0.7	0.4	0.0	0.0	0.0
1995	0.0	72.8	75.5	53.6	94.2	121.6	61.4	19.1	7.6	4.3	2.3	2.3	0.8	0.0	0.0
1996	0.0	27.1	114.1	76.3	61.9	58.8	30.8	14.9	6.1	4.0	0.2	0.5	0.0	0.0	0.0

Table 9. Sampling intensity of commercial landings (mt), 1982-1996.

	Hook & Line		Trap/Pound net		Gillnet		Fyke net	
Year	Number Sampled	Landings mt	Number Sampled	Landings mt	Number Sampled	Landings mt	Number Sampled	Landings mt
1982	978	407	1118	94	1381	364		0
1983	790	196	1059	78	1364	288		0
1984	524	194	313	173	495	540		11
1985	1230	156	631	112	534	49		0
1986	199	55	18	3	102	6		0
1987	238	31	8	10	231	13		0
1988	352	36	48	26	867	55	4	0
1989	224	90	1322	0	583	0		0
1990	1494	97	1485	62	3033	145	17	1
1991	1498	179	8168	80	5426	178		1
1992	996	160	7604	105	6518	354	129	2
1993	1041	187	6228	123	9044	452		0
1994	886	63	5082	146	10148	444	112	0
1995	1060	543	6251	276	10228	559	1077	6
1996	1072	459	1773	391	3750	1261	27	8

	Haul Seine		Otter Trawl		Other Gear			
Year	Number Sampled	Landings mt	Number Sampled	Landings mt	Number Sampled	Landings mt	Total Lengths	mt / 100 lengths
1982	985	64		20		1	4462	21.3
1983	338	27		24		2	3551	16.0
1984	306	146	97	33		0	1638	59.2
1985		97		17		1	2395	15.4
1986	23	0		4		68	342	20.0
1987		0		9		0	477	15.7
1988	598	0		0		0	1869	6.9
1989	239	0		1		0	2368	2.3
1990	214	2		2		309	6243	5.0
1991	719	6		13		0	15811	2.2
1992	451	7		10		0	15698	3.9
1993		10		5		0	16313	3.8
1994	138	12		9		89	16366	4.7
1995	207	7		9		0	18823	6.7
1996	433	18		15		1	7055	28.5

Table 10. Commercial by-catch estimated from ratio of recreational a commercial tag return data.

Year	Tag Returns n	Ratio of commercial to recreational By-catch	Recreational B2	Estimated Commercial By-catch
1982		***0.20***	783,187	157,421
1983		***0.27***	387,794	105,480
1984		***0.34***	426,402	146,256
1985		***0.41***	392,590	162,532
1986		***0.49***	993,009	481,609
1987	200	0.55	721,427	397,064
1988	47	0.63	990,481	623,733
1989	1,357	0.71	1,203,905	853,651
1990	2,064	0.76	1,654,199	1,256,514
1991	1,728	0.31	3,067,385	935,969
1992	1,640	0.17	3,373,883	572,742
1993	1,585	0.22	4,349,278	965,761
1994	1,938	0.13	7,935,579	1,000,593
1995	1,486	0.15	9,645,613	1,432,717
1996	1169	0.09	12554314	1,097,588

* bold & italic forecasts from 1987-1990 values based on the changes in regulations and no quota

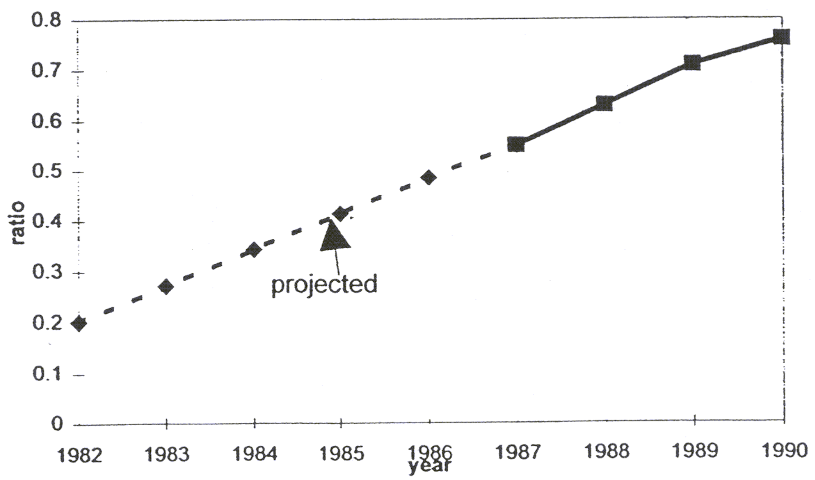


Table 11. Percent tag return data by gear type and year. Excludes VA trap recaptures and recaptures at large < 20 days.

Year	Anchor gillnet	Drift gillnet	Hook & Line	Trawl	Trap/ pound n	Haul Seine	Other
1982	0.79	0.10	0.04	0.01	0.07	0.01	0.01
1983	0.79	0.10	0.04	0.01	0.07	0.01	0.01
1984	0.79	0.10	0.04	0.01	0.07	0.01	0.01
1985	0.79	0.10	0.04	0.01	0.07	0.01	0.01
1986	0.79	0.10	0.04	0.01	0.07	0.01	0.01
1987	0.63	0.19	0.04	0.01	0.11	0.00	0.01
1988	0.87	0.02	0.05	0.01	0.05	0.00	0.00
1989	0.87	0.04	0.03	0.00	0.02	0.02	0.01
1990	0.92	0.01	0.02	0.00	0.04	0.01	0.00
1991	0.75	0.09	0.05	0.02	0.08	0.01	0.01
1992	0.67	0.18	0.03	0.00	0.10	0.01	0.01
1993	0.79	0.10	0.04	0.01	0.07	0.01	0.01
1994	0.79	0.10	0.04	0.01	0.07	0.01	0.01
1995	0.79	0.10	0.04	0.01	0.07	0.01	0.01
1996	0.79	0.10	0.04	0.01	0.07	0.01	0.01

Table 12. Total number of striped bass commercial discards (000's) by year, gear type.

Year	Anchor Gillnet	Drift Gillnet	Hook & Line	Trawl	Trap / Pound Net	Haul Seine	Other
1982	124.7	15.2	5.7	0.9	10.3	1.3	1.1
1983	83.6	10.2	3.8	0.6	6.9	0.8	0.8
1984	115.9	14.1	5.3	0.9	9.5	1.2	1.1
1985	128.7	15.7	5.9	1.0	10.6	1.3	1.2
1986	381.5	46.5	17.4	2.9	31.4	3.8	3.5
1987	251.7	75.4	15.9	4.0	44.7	0.0	5.6
1988	542.6	15.0	29.7	6.2	29.7	0.0	0.0
1989	746.0	33.4	25.6	3.1	19.7	15.2	10.6
1990	1153.1	15.5	25.1	1.3	44.0	15.5	0.8
1991	702.0	83.0	46.8	15.9	74.9	5.3	8.8
1992	383.7	101.0	17.2	1.4	58.1	6.9	4.1
1993	765.0	93.3	34.8	5.8	63.0	7.7	7.0
1994	792.6	96.7	36.1	6.0	65.3	8.0	7.3
1995	1134.9	138.4	51.7	8.6	93.5	11.4	10.4
1996	869.4	106.1	39.6	6.6	71.6	8.8	8.0

Table 13. Total number (000's) of striped bass mortalities from commercial discards by year and gear type

Year	Anchor Gillnet	Drift Gillnet	Hook & Line	Trawl	Trap / Pound net	Haul Seine	Other	Total
1982	53.3	1.3	0.5	0.3	0.5	0.2	0.1	56.2
1983	35.7	0.9	0.3	0.2	0.3	0.1	0.0	37.6
1984	49.5	1.2	0.4	0.3	0.5	0.2	0.1	52.2
1985	55.0	1.4	0.5	0.3	0.5	0.2	0.1	58.0
1986	163.1	4.0	1.4	1.0	1.6	0.6	0.2	171.8
1987	107.6	6.5	1.3	1.4	2.2	0.0	0.3	119.3
1988	232.0	1.3	2.4	2.2	1.5	0.0	0.0	239.3
1989	318.9	2.9	2.0	1.1	1.0	2.3	0.5	328.7
1990	493.0	1.3	2.0	0.4	2.2	2.3	0.0	501.3
1991	300.1	7.1	3.7	5.6	3.7	0.8	0.4	321.5
1992	164.0	8.7	1.4	0.5	2.9	1.0	0.2	178.7
1993	327.0	8.0	2.8	2.0	3.2	1.2	0.4	344.5
1994	338.8	8.3	2.9	2.1	3.3	1.2	0.4	357.0
1995	485.2	11.9	4.1	3.0	4.7	1.7	0.5	511.1
1996	371.7	9.1	3.2	2.3	3.6	1.3	0.4	391.6

Bycatch loss rates		source
Anchor	avg	0.39
	0.43	Seagraves and Miller 47%
Drift	0.08	Seagraves and Miller
Hook	0.08	Diodati and Richards
Trawl	0.35	Crecco, 1990
Trap	0.05	consensus opinion
Seine	0.15	NYDEP estimate
Other	0.05	consensus opinion

Table 14. Commercial and recreational landings and discard total weight (mt), 1982-1996.

Commercial

	Landings	Discard	Proportion Discarded
1982	991.8	69.2	0.07
1983	639.1	47.7	0.07
1984	1104.0	99.8	0.08
1985	431.8	97.1	0.18
1986	68.1	359.2	0.84
1987	63.2	283.5	0.82
1988	116.5	703.5	0.86
1989	90.7	905.0	0.91
1990	313.0	1356.6	0.81
1991	460.2	859.3	0.65
1992	638.0	454.0	0.42
1993	777.2	823.5	0.49
1994	805.0	853.5	0.51
1995	1555.4	1139.9	0.42
1996	2177.9	807.6	0.27

Recreational

	Landings	Discard	Proportion Discarded
1982	1144	83.7	0.07
1983	1217	15.4	0.01
1984	579	30.0	0.05
1985	372	30.4	0.08
1986	501	123.3	0.20
1987	388	115.1	0.23
1988	570	177.8	0.24
1989	332	235.6	0.42
1990	1010	268.5	0.21
1991	1651	587.5	0.26
1992	1823	634.1	0.26
1993	2563	829.5	0.24
1994	3084	1495.0	0.33
1995	5080	1659.9	0.25
1996	6620	1541.1	0.19

Table 15. Recreational catch at age, 000's, Maine to coastal North Carolina, 1982-1996.

Landings

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0	5	36	82	25	11	17	12	9	6	5	6	1	1	1
1983	3	15	46	67	103	29	16	3	2	2	3	3	2	2	2
1984	1	18	21	17	19	18	9	3	0	1	1	0	1	3	3
1985	0	2	12	23	37	20	19	10	2	2	0	0	0	0	6
1986	9	3	5	11	13	15	14	21	8	5	3	1	1	1	4
1987	1	1	3	2	5	4	4	3	4	2	1	2	3	2	7
1988	1	8	5	5	6	11	10	12	9	3	3	3	2	3	4
1989	0	0	3	2	4	6	7	4	2	2	1	0	1	1	3
1990	0	3	19	51	31	33	28	31	15	6	4	2	4	4	6
1991	1	13	30	58	28	15	32	41	42	16	6	2	2	3	15
1992	2	15	56	50	57	25	20	39	43	36	7	4	2	5	9
1993	0	9	43	88	66	52	24	32	63	64	36	8	4	1	12
1994	1	28	96	67	68	40	33	40	67	61	28	18	2	1	9
1995	0	87	171	145	91	160	73	103	87	54	34	10	7	1	3
1996	0	0	143	242	139	145	244	132	101	48	30	38	11	3	1

Discards

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	2	24	17	11	5	2	2	1	0	0	0	0			
1983	1	16	10	2	1	0	0	0	0	0	0	0			
1984	4	13	10	4	1	1	0	0	0	0	0	0			
1985	1	9	14	3	1	0	0	0	0	0	0	0			
1986	2	12	32	19	8	3	1	2	0	0	0	0			
1987	1	5	17	16	9	4	2	1	1	0	0	0			
1988	1	16	15	16	14	8	4	2	1	0	0	0			
1989	1	23	27	16	18	7	3	1	1	0	0	0			
1990	3	36	35	23	9	10	8	5	2	1	0	0			
1991	0	50	63	50	19	10	18	17	10	4	2	0			
1992	1	32	93	55	40	13	9	12	8	5	1	0			
1993	0	57	82	82	51	35	13	8	8	6	3	1			
1994	5	85	183	107	110	58	33	18	17	11	4	3			
1995	4	247	165	124	65	81	27	30	15	6	6	1			
1996	1	71	351	218	171	111	60	16	5	0	2	0			

Table 16 Sampling intensity for striped bass recreational landings and discards, 1982-1996.

Landings (A+B1)	Maine - New Jersey			Chesapeake & Delaware Bay		
Year	Landings (mt)	Lengths	mt / 100 lengths	Landings (mt)	Lengths	mt / 100 lengths
1982	1,144	410	279.0	3	113	2.7
1983	1,149	519	221.4	68	102	66.7
1984	496	166	298.8	83	69	120.3
1985	367	469	78.3	6	65	9.2
1986	497	726	68.5	4	82	4.9
1987	360	175	205.7	28	86	32.6
1988	488	264	184.8	82	126	65.1
1989	332	353	94.1	0	0	
1990	795	676	117.6	215	496	43.3
1991	1,281	1,323	96.8	370	663	55.8
1992	1,448	1,434	101.0	375	837	44.8
1993	1,949	1,678	116.2	614	1037	59.2
1994	2,131	1,463	145.7	921	2213	41.6
1995	3,600	4,708	76.5	1399	2195	63.7
1996	4,939	8,230	60.0	1559	3010	51.8

Discards (B2)	Maine - New Jersey			Chesapeake & Delaware Bay		
Year	Discards (mt)	Lengths	mt / 100 lengths	Discards (mt)	Lengths	mt / 100 lengths
1982	83.1	994	8.4	0.7	123	0.6
1983	10.3	954	1.1	5.1	123	4.1
1984	26.2	825	3.2	3.8	373	1.0
1985	22.7	1,918	1.2	7.6	135	5.6
1986	76.1	2,593	2.9	47.2	115	41.0
1987	93.1	4,402	2.1	22.1	63	35.1
1988	159.6	5,555	2.9	18.2	71	25.6
1989	192.0	7,250	2.6	43.6	24	181.7
1990	193.2	10,325	1.9	75.3	108	69.7
1991	338.5	12,743	2.7	249.0	112	222.3
1992	452.1	15,652	2.9	182.1	145	125.6
1993	489.9	14,444	3.4	339.6	198	171.5
1994	974.6	14,383	6.8	520.4	575	90.5
1995	1176.4	12,854	9.2	483.5	676	71.5
1996	1155.0	17,363	6.7	386.0	1940	19.9

Table 17. Commercial mean weights (kg) at age for landings and discards, 1982-1996.

Landings

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982		0.81	1.20	1.78	2.40	4.06	5.93	7.83	8.65	11.26	12.38	12.63	13.90	14.23	16.09
1983		0.64	1.07	1.63	2.33	2.97	4.21	6.85	8.70	10.08	12.77	12.36	12.29	12.11	11.67
1984		0.60	1.79	2.68	3.22	4.16	4.32	5.12	7.51	7.94	11.09	13.77	11.02	13.27	16.80
1985		0.00	1.14	2.21	3.24	3.98	5.26	6.55	7.87	9.49	11.36	11.57	11.67	14.48	15.54
1986		0.91	1.43	2.55	5.99	5.34	6.41	8.21	9.15	9.12	10.43	12.44	14.48	13.02	15.55
1987			2.38	2.28	5.18	6.41	6.67	7.39	8.71	9.42	10.74	12.64	14.72	14.58	16.44
1988				1.97	2.59	4.74	5.27	7.54	9.52	9.12	12.94	14.58	14.50	14.92	17.80
1989						7.51	7.84	8.04	8.64	10.46	12.40	13.22	15.43	14.41	17.93
1990		1.04	1.46	1.93	2.51	3.32	5.10	7.52	7.40	8.11	11.10	12.56	14.76	17.08	18.94
1991		1.09	1.34	2.22	2.46	2.93	4.18	7.43	8.75	8.80	9.18	9.17	9.28	14.50	17.23
1992		0.82	1.28	1.97	2.62	3.30	4.28	5.66	7.35	9.59	9.88	11.19	13.50	16.41	18.01
1993		0.63	1.57	2.12	2.95	3.70	4.38	6.52	8.02	9.05	9.82	10.24	12.62	13.43	16.42
1994		1.27	1.51	2.22	3.04	4.01	5.11	6.86	7.96	8.64	9.31	9.83	10.76	17.59	18.20
1995		1.15	1.58	2.05	2.71	3.56	4.84	6.25	7.17	8.56	9.59	9.86	12.74	14.70	21.53
1996		0.97	1.20	1.39	1.86	2.54	4.43	7.71	7.74	8.47	9.01	12.03	11.07	11.57	17.40

Discards

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982		0.44	0.68	1.52	2.44	3.64	3.78	4.75	5.35	5.67	6.44			8.40	
1983		0.37	0.67	1.37	2.38	3.36	3.78	4.75	5.35	5.67					
1984		0.62	0.87	1.54	2.14	2.89	3.78	4.75	5.35	5.67		7.38			
1985		0.68	1.02	1.56	2.01	3.29	3.78	4.75	5.35	5.67	6.44				
1986		0.55	1.41	1.93	2.43	3.07	3.78	4.75	5.35						
1987		0.59	0.98	1.83	2.43	2.88	3.78	4.75	5.35	5.67	6.44	7.38			
1988		0.42	0.85	1.49	3.20	3.34	3.78	4.75	5.35	5.67	6.44	7.38	8.49		
1989		0.75	0.91	1.09	3.06	3.34	3.78	4.75	5.35	5.67	6.44	7.38	8.49	8.40	
1990		0.53	0.76	1.51	1.98	3.88	3.78	4.75	5.35	5.67	6.44	7.38	8.49		
1991	0.41	1.00	1.23	1.63	2.30	2.81	3.78	4.75	5.35	5.67	6.44	7.38			
1992	0.09	0.61	1.14	1.48	2.06	3.46	3.78	4.75	5.35	5.67	6.44				
1993		0.36	1.22	1.51	2.18	2.97	3.78	4.75	5.35	5.67	6.44	7.38			
1994		1.11	1.31	1.70	2.15	2.60	3.78	4.75	5.35	5.67	6.44	7.38	8.49		
1995		0.38	0.85	1.57	2.16	2.74	3.78	4.75	5.35	5.67	6.44	7.38	8.49		
1996		0.64	0.66	1.71	2.31	3.28	3.78	4.75	5.35	5.67	6.44	7.38	8.49		

Total

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982		0.66	1.19	1.55	2.41	3.97	5.03	7.03	8.11	11.14	12.30	12.63	13.90	14.22	16.09
1983		0.56	1.06	1.37	2.34	3.06	4.11	5.86	7.69	9.67	12.77	12.36	12.29	12.11	11.67
1984		0.60	1.78	1.64	2.96	3.73	4.16	5.10	6.72	7.76	11.09	12.77	11.02	13.27	16.80
1985		0.61	1.10	1.85	2.58	3.88	5.10	6.30	7.70	9.19	10.28	11.57	11.67	14.48	15.54
1986		0.59	1.42	2.53	2.45	3.18	4.44	6.34	7.67	9.12	10.43	12.44	14.48	13.02	15.55
1987		0.59	1.23	2.22	2.51	2.93	4.20	5.94	6.38	7.06	8.42	11.37	14.72	14.58	16.44
1988		0.42	0.78	1.92	3.09	3.46	3.94	4.91	5.97	6.07	10.01	9.95	12.89	14.92	17.80
1989		0.75	0.91	1.97	3.06	3.35	3.91	4.94	5.80	7.93	7.94	7.99	14.83	13.90	17.93
1990		0.55	0.87	1.78	2.09	3.82	3.84	4.92	5.68	6.29	7.19	7.79	10.63	17.08	18.94
1991	0.41	1.02	1.27	1.98	2.36	2.84	3.86	5.16	6.78	6.37	6.54	8.96	9.28	14.50	17.23
1992	0.09	0.64	1.20	1.67	2.35	3.38	4.08	5.21	6.79	8.52	8.22	11.19	13.50	16.41	18.01
1993		0.41	1.32	1.79	2.55	3.26	4.15	5.59	6.62	7.64	8.83	9.06	12.62	13.43	16.42
1994		1.11	1.38	1.90	2.63	3.11	4.34	5.90	6.89	7.43	8.67	9.22	9.43	17.59	18.20
1995		0.44	1.08	1.72	2.48	3.11	4.19	5.71	6.87	8.08	8.91	8.80	12.19	14.70	21.53
1996		0.65	0.83	1.59	1.97	2.74	4.29	7.05	7.33	7.98	8.97	11.80	9.91	11.57	17.40

Table 18. Length weight equations for the striped bass used in calculations of recreational catch.

<u>Maine - New Jersey</u>

1982-1986	Length (in) = 0.0002 * Wt (lbs) ^ 3.12
1983-1991	Length (in) = 0.0003 * Wt (lbs) ^ 3.08
1983-1991	Length (in) = 0.0004 * Wt (lbs) ^ 2.97

<u>Delaware - North Carolina</u>

1982-1986	Length (in) = 0.00036 * Wt (lbs) ^ 3.01
1983-1991	Length (in) = 0.00024 * Wt (lbs) ^ 2.87
1983-1991	Length (in) = 0.00052 * Wt (lbs) ^ 2.35

Table 19. Striped bass mean weights at age (kg) from the recreational fishery, 1982-1996.

Coastal landings (A+B1)

Year	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982		0.96	1.47	1.99	2.93	5.54	6.40	6.88	7.21	8.80	9.99	11.53	12.78	12.36	12.67
1983	0.33	0.63	1.00	2.08	3.02	4.26	5.48	5.53	6.23	8.01	8.28	13.45	11.82	13.07	11.56
1984		0.85	1.28	2.42	3.42	4.44	5.16	5.25	9.55	5.59	7.70		11.51	13.27	14.85
1985		1.05	2.00	2.57	3.34	4.33	5.92	6.27	6.90	6.63	5.30	5.89			18.73
1986			2.72	2.92	4.38	5.16	6.44	7.56	7.89	7.77	7.67	11.83	14.42	12.67	17.36
1987			3.02	3.03	3.81	4.78	6.08	7.11	8.69	9.40	11.96	10.77	16.60	15.75	18.08
1988		1.93	1.93	2.01	4.24	5.95	6.64	7.57	8.71	9.13	11.22	11.36	13.31	12.95	18.88
1989		1.31	1.82	3.16	5.46	7.79	8.76	9.88	10.96	13.74	16.54	18.30	15.57	18.27	18.41
1990		1.85	1.91	2.79	3.55	4.39	6.17	7.93	8.48	9.43	11.59	12.85	14.28	17.41	18.85
1991		0.98	1.30	3.08	3.88	5.34	6.40	7.52	8.77	8.72	9.47	10.83	12.73	15.33	19.18
1992		0.93	1.29	2.33	3.62	4.75	5.90	7.13	8.32	9.42	9.75	12.37	13.72	15.65	19.22
1993		0.84	1.33	2.39	3.60	4.76	6.00	7.31	7.92	8.67	9.50	9.82	14.54	13.93	16.31
1994			2.95	3.42	3.98	5.18	6.63	7.76	8.40	9.27	9.76	11.04	10.94	17.42	19.77
1995			1.74	3.26	3.66	4.52	6.13	7.18	8.03	9.15	8.85	10.97	14.67	17.70	20.31
1996			1.76	2.92	3.96	5.25	6.57	7.82	8.70	9.77	10.78	12.31	13.78	16.53	18.86

Bay landings (A+B1)

Year	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.22	0.22	0.22												
1983	0.06	0.35	0.69	1.74	3.34	4.95	5.80	7.64	6.61	7.83	6.81	9.13			
1984	0.48	0.59	0.75	1.43	1.78	1.77	8.79								
1985	0.10	0.42	0.55	1.43	1.59	1.51	1.83								
1986	0.07	0.23	0.68	1.64	1.55	2.23									
1987	0.35	0.65	0.87	1.07	1.14	1.36	1.36								
1988	0.39	0.73	1.45	2.26	3.06	3.28	3.39	3.41	3.46	3.86					
1989															
1990		0.99	1.95	2.81	3.50	3.78	4.06	4.20	3.93	3.69	4.30				
1991	0.09	1.05	1.73	2.43	3.20	3.61	3.97	4.18	4.24	4.39	3.93	4.15	6.00	20.40	20.40
1992	0.20	0.54	1.53	2.32	3.36	4.24	4.88	5.19	5.90	6.42	5.88	15.59	16.71		16.71
1993		1.03	1.56	2.32	3.17	3.81	4.84	6.04	7.16	7.84	8.30	8.01	16.21	15.59	17.61
1994	0.29	1.13	1.56	2.19	2.95	3.90	4.65	5.72	6.39	7.14	7.43	7.33	7.34		
1995		1.04	1.45	2.32	3.25	4.24	5.56	5.82	7.28	10.41	6.96	10.22	15.02	15.59	
1996			1.69	2.46	3.30	3.99	4.72	5.25	6.19	6.71	7.91	9.90	12.31	14.26	15.64

Coastal discards (B2)

Year	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.10	0.33	0.68	1.86	3.10	4.62	5.42	6.22	6.85	6.99	7.68	11.83	13.84	15.83	17.19
1983	0.08	0.25	0.67	1.20	1.92	2.96	3.61	7.15	8.47	10.03	5.35	10.66	10.66		9.10
1984	0.18	0.65	0.94	1.38	2.03	3.13	4.94	5.70	10.34	5.07	9.08	9.86	10.23	11.07	11.51
1985	0.08	0.75	1.00	1.51	2.09	2.60	3.45	5.93	7.07	9.68	11.74	12.03	12.59	13.00	13.75
1986	0.10	0.55	1.14	1.83	2.17	2.86	4.62	6.11	7.44	8.28	6.82	12.44	13.24	12.62	14.55
1987	0.23	0.66	1.12	1.87	2.81	3.32	3.95	4.77	5.29	6.08	6.39	9.09	11.82	13.90	14.85
1988	0.22	0.84	1.50	2.08	2.89	3.77	4.20	4.40	4.92	5.40	7.90	10.00	12.42	12.01	14.89
1989	0.21	0.74	1.69	2.93	3.74	4.55	4.83	6.32	5.00	9.26	15.15	15.55	13.95	15.34	14.77
1990	0.25	0.68	1.27	2.18	3.06	3.89	4.96	5.88	5.48	5.57	6.91	9.26	14.07	15.55	15.86
1991	0.28	0.78	1.15	1.91	3.04	4.07	4.66	5.30	6.09	5.67	5.09	6.20	6.93	14.89	14.96
1992	0.19	0.61	1.23	1.97	2.94	4.14	5.28	5.74	6.43	6.92	6.34	10.45	12.73	15.14	16.02
1993	0.10	0.66	1.18	1.98	2.81	3.67	4.90	5.77	6.49	7.09	7.66	7.08	11.44	13.60	14.34
1994	0.42	0.71	1.15	2.06	2.87	3.76	4.50	5.64	6.19	6.69	6.87	7.13	6.92	16.58	15.70
1995	0.24	0.64	1.24	2.16	2.91	3.91	5.19	5.76	7.19	8.62	6.96	9.44	13.22	14.32	
1996	0.22	0.70	1.23	2.00	2.80	3.66	4.64	5.62	6.51	7.04	8.09				

Bay discards (B2)

Year	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.20	0.26	0.34	0.53	1.09										
1983	0.33	0.26	0.31	0.45	1.25	1.25									
1984	0.29	0.42	0.49	0.90	1.33	2.21	2.82	2.82							
1985	0.06	0.51	0.55	0.75	1.02	4.72	7.06	7.06	7.06	7.06				7.06	
1986	0.09	0.53	1.10	1.33	1.62	2.03	4.02	5.89				15.35		17.28	17.13
1987	0.20	0.72	1.28	1.71	1.96	2.04	2.02	2.12	1.98			15.35	15.35	15.35	15.35
1988	0.63	0.64	1.53	1.96	2.62	2.87	3.03	3.14	3.19	3.54					
1989	0.42	0.65	1.98	3.32	3.98	4.57	4.24	4.97	3.61	6.45					
1990	0.08	0.55	1.04	2.36	2.98	3.46	4.42	5.65	4.59	4.66	3.95				
1991	0.46	0.77	1.05	2.04	3.00	3.83	4.44	5.18	5.99	5.72	5.78	5.76	12.86	14.32	14.32
1992		0.69	1.35	2.07	2.99	3.85	4.81	5.18	6.96	9.03	8.79	11.93	9.10	12.40	12.40
1993	0.20	0.71	1.12	2.09	2.90	3.60	4.38	4.93	6.14	8.06	9.20	9.46	16.31	12.40	17.29
1994	0.25	0.80	1.41	1.99	2.58	3.26	3.79	5.14	5.74	6.71	7.02	6.37	7.95		
1995	0.31	0.61	1.30	2.11	2.94	3.90	5.17	5.79	6.69	7.68	5.91	8.18			
1996	0.28	0.63	1.30	2.19	2.95	3.62	4.24	4.95	5.31	6.43		8.29			

Table 20. Total (landings and discards combined) mean weights at age (kg) for commercial, recreational and total fishery, 1982-1996.

Commercial

YEAR	AGE 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982		0.72	1.20	1.55	2.41	3.97	5.40	7.19	8.17	11.17	12.34	12.63	13.90	14.22	16.09
1983		0.62	1.06	1.37	2.34	3.06	4.10	6.01	7.68	9.74	12.77	12.36	12.29	12.11	11.67
1984		0.60	1.78	1.64	2.96	3.73	4.66	5.18	7.00	7.92	11.09	12.71	11.02	13.27	16.80
1985		0.60	1.08	1.85	2.58	3.88	5.18	6.31	7.70	9.20	10.44	11.57	11.67	14.48	15.54
1986		0.62	1.08	2.53	2.45	3.18	4.43	6.41	7.62	9.12	10.43	12.44	14.48	13.02	15.55
1987		0.59	1.23	2.22	2.51	2.93	3.83	5.66	6.34	7.43	9.04	11.84	14.72	14.58	16.44
1988		0.42	0.78	1.92	3.09	4.03	4.42	4.79	5.73	5.91	10.83	11.80	13.54	14.92	17.80
1989		0.75	0.91	1.97	3.06	4.53	5.39	6.26	6.15	9.34	9.38	9.82	15.07	13.92	17.93
1990		0.55	0.87	1.78	2.09	3.82	4.91	6.01	5.91	6.41	7.88	9.25	12.19	17.08	18.94
1991	0.41	1.02	1.27	1.98	2.36	2.84	4.74	5.83	7.32	6.72	9.46	9.06	9.28	14.50	17.23
1992	0.09	0.64	1.20	1.67	2.35	3.38	4.65	5.73	7.22	9.14	9.82	11.19	13.50	16.41	18.01
1993		0.41	1.32	1.79	2.55	3.26	4.64	6.25	7.45	8.57	9.73	10.47	12.62	13.43	16.42
1994		1.11	1.38	1.90	2.63	3.11	4.98	6.49	7.43	8.15	9.41	10.06	13.03	17.59	18.20
1995		0.44	1.08	1.72	2.48	3.11	5.25	6.21	7.19	8.62	9.07	9.79	12.55	14.70	21.53
1996		0.65	0.83	1.59	1.97	2.74	4.55	7.31	7.56	8.30	9.01	11.93	12.51	11.57	17.40

Recreational

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.13	0.44	0.68	1.52	2.44	3.64	4.66	5.38	5.74	6.84	9.03	9.40	10.47	11.16	14.93
1983	0.20	0.37	0.67	1.37	2.38	3.36	3.72	5.08	5.33	6.47	8.28	8.97	9.69	10.26	10.33
1984	0.24	0.62	0.87	1.54	2.14	2.89	5.43	5.96	6.12	7.65	7.70	7.03	10.27	11.26	13.18
1985	0.06	0.68	1.02	1.56	2.01	3.29	4.57	4.82	5.26	5.84	7.16	8.26	7.09	8.59	16.24
1986	0.14	0.55	1.41	1.93	2.43	3.07	3.77	4.89	5.21	5.99	7.67	8.62	9.26	10.64	15.95
1987	0.20	0.88	1.57	1.92	2.43	2.88	3.35	4.25	5.30	6.26	7.58	9.33	10.94	11.25	16.46
1988	0.31	1.04	1.60	2.08	3.20	3.97	4.32	4.63	5.07	5.48	8.26	10.25	11.26	11.26	16.88
1989	0.16	0.88	1.73	2.92	3.06	4.52	5.31	6.15	5.76	8.33	8.36	9.43	10.86	8.40	16.59
1990	0.08	1.02	1.54	2.53	3.27	3.88	4.90	5.91	5.62	5.84	7.26	8.96	9.08	10.27	17.36
1991	0.21	0.90	1.31	2.36	3.28	4.21	4.87	5.55	6.27	6.12	9.47	8.26	9.63	16.23	17.07
1992	0.10	0.69	1.35	2.17	3.23	4.25	5.22	5.81	6.90	7.95	9.75	12.58	13.07	10.80	17.62
1993	0.07	0.81	1.30	2.20	3.12	3.96	5.03	6.01	6.93	7.92	9.50	10.80	14.63	13.88	15.33
1994	0.24	1.03	1.77	2.42	3.10	4.03	4.89	6.06	6.68	7.45	9.77	10.74	11.25	8.50	17.74
1995	0.28	0.77	1.43	2.46	3.19	4.14	5.51	6.14	7.30	8.97	7.17	9.70	14.30	15.87	20.31
1996	0.25	0.67	1.50	2.39	3.25	4.13	5.04	5.91	6.68	7.49	8.93	10.17	13.05	15.39	17.25

Total

YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.13	0.64	1.09	1.54	2.42	3.75	4.83	5.79	6.20	8.68	10.80	11.20	12.97	13.26	15.91
1983	0.20	0.55	0.94	1.37	2.37	3.29	3.77	5.35	6.01	8.10	9.57	10.39	11.11	11.10	11.12
1984	0.24	0.60	1.69	1.61	2.67	3.39	5.07	5.65	6.76	7.76	8.41	12.65	10.65	11.75	14.75
1985	0.06	0.61	1.07	1.65	2.19	3.59	4.91	5.46	6.77	7.45	9.00	10.69	11.42	14.34	15.98
1986	0.14	0.57	1.27	2.40	2.44	3.12	3.95	5.05	5.44	6.09	7.75	9.15	10.97	11.55	15.83
1987	0.20	0.77	1.41	2.11	2.50	2.91	3.61	4.74	5.52	6.49	7.77	9.78	11.38	11.62	16.46
1988	0.31	0.91	1.10	1.98	3.11	4.02	4.38	4.70	5.24	5.62	8.58	10.39	11.50	11.31	17.00
1989	0.16	0.83	1.22	2.23	3.06	4.53	5.37	6.23	6.03	8.68	8.94	9.74	13.04	9.93	17.11
1990	0.08	0.89	1.14	2.05	2.35	3.83	4.91	5.96	5.70	5.97	7.44	9.08	9.36	10.80	17.65
1991	0.21	0.92	1.29	2.17	2.62	3.17	4.81	5.64	6.46	6.24	9.46	8.30	9.62	15.96	17.09
1992	0.10	0.69	1.30	1.93	2.81	3.67	4.90	5.79	6.96	8.15	9.77	12.44	13.10	11.15	17.65
1993	0.07	0.76	1.31	1.99	2.77	3.58	4.80	6.11	7.03	8.00	9.53	10.76	14.45	13.85	15.36
1994	0.24	1.05	1.69	2.21	2.85	3.50	4.94	6.20	6.79	7.53	9.73	10.69	11.37	9.06	17.75
1995	0.28	0.70	1.35	2.18	2.77	3.65	5.38	6.16	7.27	8.86	7.57	9.73	13.97	15.65	20.37
1996	0.14	1.05	1.47	2.32	3.22	4.52	6.39	7.11	7.81	9.20	9.31	10.09	11.36	12.45	17.30

Table 21. Striped bass catch at age in 000's, 1982-1996, Maine to coastal North Carolina.

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	1.8	105.4	256.7	221.0	58.4	19.2	24.2	16.8	11.7	10.6	11.0	13.7	3.4	4.1	0.8
1983	3.6	110.1	178.2	193.2	150.2	39.3	18.7	4.1	2.9	3.7	4.6	5.7	4.9	4.1	4.6
1984	5.6	542.5	302.7	82.5	60.5	51.8	18.4	4.7	2.1	2.1	0.7	0.3	2.2	4.3	4.7
1985	1.3	72.4	101.7	40.3	58.7	43.1	43.6	17.3	6.4	3.4	1.0	0.8	0.5	0.9	8.9
1986	11.4	21.0	63.7	132.8	49.9	32.0	20.4	24.1	9.2	5.3	3.4	1.6	0.9	2.5	6.7
1987	1.4	10.9	37.8	51.2	66.9	25.0	13.2	6.6	6.4	3.0	1.5	2.0	3.4	2.1	7.7
1988	2.6	30.7	41.9	63.2	105.9	97.1	40.5	24.5	13.9	5.7	3.6	3.2	2.4	3.0	4.1
1989	0.8	36.8	80.7	67.0	104.7	95.2	45.5	20.8	10.4	3.7	3.3	2.0	1.9	1.6	5.4
1990	2.7	54.3	135.2	202.8	181.4	173.9	111.4	75.3	24.1	8.4	5.8	3.9	4.8	4.2	7.6
1991	1.9	77.8	151.9	216.5	165.5	103.3	95.1	87.3	62.6	25.6	14.6	2.9	2.8	3.5	17.6
1992	3.3	50.9	216.3	200.6	187.6	113.6	65.6	73.3	63.9	49.1	10.1	4.4	1.9	5.5	10.4
1993	0.1	74.7	195.9	342.4	299.1	193.0	89.3	69.7	89.3	81.7	44.9	10.0	5.0	1.3	13.0
1994	5.6	145.7	349.4	290.4	367.5	231.3	134.1	86.0	99.3	80.5	35.3	22.0	2.9	1.1	9.8
1995	3.7	413.2	446.0	437.0	385.0	461.2	200.6	185.7	147.6	85.9	50.5	16.0	9.2	1.9	3.3
1996	0.5	98.2	658.1	664.8	550.8	476.2	455.9	215.5	142.6	70.8	43.7	47.8	13.2	4.6	2.6

Table 22. Young of year striped bass indices by system.

Year	Kennebec River (ME)	Hudson River (NY DEP)	Hudson River (NY UTIL)	Delaware River (DE)	Delaware River (NJ)	Chesapeake Bay (MD)	Chesapeake Bay (VA)
1981		8.86	6.61		0.00	0.59	1.57
1982		14.17	3.83		0.12	3.54	2.71
1983		16.25	6.58		0.03	0.61	3.40
1984		15.00	5.06		0.29	1.64	4.47
1985		1.92	1.07		0.02	0.91	2.41
1986		2.92	1.62		0.28	1.34	4.74
1987	0.35	15.90	12.82		0.41	1.46	15.74
1988	0.04	33.46	4.91		0.35	0.73	7.64
1989	0.01	21.35	5.66	0.42	1.03	4.87	11.23
1990	0.06	19.05	6.41	0.11	1.00	1.03	7.34
1991	0.25	3.60	5.03	0.18	0.47	1.52	3.76
1992	0.01	11.43	3.68	1.13	1.19	2.34	7.32
1993	0.01	12.59	7.50	1.14	1.78	13.97	18.12
1994	0.33	17.64	5.83	0.19	0.96	6.40	10.48
1995	0.02	16.23	6.04	0.42	1.98	4.41	5.45
1996		9.30		1.36	1.70	17.56	23.05
1997						3.91	

Table 23. Indices of age one striped bass by system.

Year	Hudson River (NY)	Western LI (NY)	Chesapeake Bay (MD)
1981	0.25		0.02
1982	0.84		0.02
1983	0.08		0.32
1984	0.68		0
1985	1.23	0.61	0.15
1986	0.33	0.3	0.03
1987	0.16	0.21	0.05
1988	0.45	0.77	0.06
1989	0.64	1.73	0.15
1990	0.35	0.37	0.33
1991	0.65	1.24	0.19
1992	0.53	1.34	0.11
1993	0.51	0.72	0.19
1994	0.43	1.37	0.76
1995	0.9	1.26	0.12
1996	0.17	1.52	0.08
1997		0.71	

Table 24. Indices at age from New York Ocean Haul Seine Survey, 1987-1996.

Year	Age 2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982														
1983														
1984														
1985														
1986														
1987	0.73	5.98	8.71	7.71	2.89	1.13	0.28	0.15	0.00	0.01	0.00	0.01	0.03	0.00
1988	3.29	4.73	4.86	4.49	2.65	0.90	0.45	0.13	0.07	0.02	0.00	0.07	0.01	0.09
1989	1.40	2.20	1.27	2.03	1.42	1.18	0.32	0.09	0.11	0.02	0.01	0.01	0.01	0.04
1990	1.85	6.49	4.38	1.93	2.12	1.60	1.28	0.47	0.19	0.04	0.00	0.01	0.01	0.00
1991	3.95	7.49	5.12	1.64	0.77	1.05	1.46	0.80	0.36	0.09	0.08	0.02	0.08	0.02
1992	0.99	4.68	3.58	1.93	0.62	0.41	0.70	0.63	0.41	0.16	0.09	0.01	0.02	0.06
1993	2.97	7.92	6.65	2.75	1.80	0.74	0.46	0.57	0.45	0.31	0.12	0.04	0.02	0.03
1994	2.10	6.70	3.22	3.15	1.91	1.29	0.56	0.56	0.58	0.28	0.32	0.06	0.06	0.02
1995	4.91	3.51	2.34	0.70	0.76	0.39	0.21	0.14	0.16	0.14	0.05	0.06	0.01	0.01
1996	6.81	46.91	7.70	2.97	0.96	0.83	0.37	0.16	0.12	0.01	0.11	0.01	0.01	0.00

Table 25. Maryland spawning stock survey indices at age, all systems combined for males and females combined, 1985-1997.

	Age													
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982														
1983														
1984														
1985	72.83	243.05	41.79	19.02	8.88	8.25	1.44	1.83	2.19	0.39	1.74	1.31	0.31	7.01
1986	62.72	164.74	467.30	7.10	4.44	3.16	2.63	0.94	0.73	0.00	0.00	0.94	0.65	2.22
1987	60.93	204.10	128.14	335.33	3.72	2.95	3.48	0.12	0.00	0.00	0.00	0.00	7.25	4.94
1988	32.21	67.75	73.47	72.33	107.36	2.16	0.00	0.00	0.73	0.00	0.02	0.00	0.08	1.86
1989	15.52	121.59	100.51	71.51	91.10	59.62	0.38	0.00	0.37	0.00	0.19	0.00	0.00	0.34
1990	25.63	182.33	204.18	88.67	68.95	67.02	52.92	0.46	0.18	0.02	0.24	0.26	0.05	0.39
1991	40.31	186.40	72.20	68.43	40.60	38.94	35.44	14.97	0.43	0.30	0.00	0.11	0.10	0.45
1992	17.40	240.64	199.49	63.24	84.36	59.62	41.81	19.13	8.79	0.15	0.00	0.03	1.09	0.72
1993	33.40	130.16	222.42	98.53	60.37	57.34	46.52	22.28	7.92	3.27	0.33	0.31	0.46	0.35
1994	11.12	37.90	67.64	98.17	37.34	20.90	30.06	12.22	3.34	0.63	0.36	0.09	0.00	0.05
1995	42.90	110.10	71.81	72.13	56.29	49.63	33.55	41.38	17.83	24.86	8.21	2.14	0.00	0.34
1996	8.38	510.92	140.80	47.65	93.05	109.70	85.01	66.80	34.79	16.59	5.05	1.66	0.00	0.00
1997	4.12	110.98	121.94	71.85	62.03	68.00	42.58	27.36	18.80	12.53	3.32	1.46	0.00	0.00

Table 26. Massachusetts commercial striped bass CPUE at age

	Age									
Year	6	7	8	9	10	11	12	13	14	15+
1982										
1983										
1984										
1985										
1986										
1987										
1988										
1989										
1990	0.01	0.56	2.30	0.92	0.43	0.28	0.12	0.44	0.35	1.60
1991	0.00	0.86	3.51	4.99	0.92	0.31	0.31	0.07	0.25	1.79
1992	0.00	0.38	3.17	5.89	4.78	0.51	0.22	0.06	0.26	0.74
1993	0.00	0.19	1.97	6.41	8.59	5.33	0.86	0.17	0.07	0.43
1994	0.00	0.43	3.74	9.74	6.26	2.18	1.03	0.10	0.10	0.43
1995	0.11	1.13	5.62	9.13	6.75	2.84	1.08	0.27	0.05	0.05
1996	0.00	0.90	4.81	6.12	5.58	4.68	2.47	0.75	0.28	0.13

Table 27. Connecticut Volunteer Angler CPUE at age, 1981-1996.

	Age													
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1981	0.221	0.316	0.163	0.136	0.114	0.056	0.033	0.021	0.015	0.005	0.001	0.002	0.001	0.001	0.002
1982	0.330	0.212	0.109	0.091	0.077	0.037	0.022	0.014	0.010	0.003	0.001	0.001	0.000	0.000	0.001
1983	0.399	0.190	0.080	0.038	0.027	0.009	0.002	0.002	0.000	0.000	0.002	0.000	0.001	0.000	0.000
1984	0.122	0.333	0.226	0.135	0.051	0.037	0.009	0.003	0.000	0.001	0.000	0.001	0.001	0.000	0.000
1985	0.058	0.315	0.222	0.120	0.092	0.041	0.027	0.011	0.001	0.001	0.001	0.001	0.000	0.000	0.000
1986	0.077	0.198	0.466	0.445	0.180	0.051	0.009	0.051	0.023	0.002	0.000	0.000	0.000	0.008	0.000
1987	0.035	0.244	0.342	0.202	0.144	0.064	0.042	0.032	0.027	0.008	0.004	0.002	0.001	0.001	0.001
1988	0.021	0.522	0.280	0.179	0.152	0.118	0.049	0.028	0.007	0.002	0.000	0.000	0.001	0.000	0.000
1989	0.268	0.484	0.468	0.160	0.182	0.126	0.090	0.031	0.015	0.007	0.000	0.000	0.000	0.000	0.000
1990	0.174	0.582	0.555	0.273	0.119	0.126	0.148	0.127	0.053	0.017	0.005	0.005	0.002	0.003	0.003
1991	0.147	0.668	0.431	0.347	0.135	0.066	0.094	0.131	0.087	0.032	0.008	0.002	0.000	0.000	0.001
1992	0.171	0.477	0.574	0.294	0.234	0.107	0.095	0.160	0.145	0.093	0.021	0.004	0.001	0.000	0.002
1993	0.070	0.704	0.623	0.486	0.279	0.220	0.095	0.077	0.110	0.099	0.053	0.013	0.004	0.002	0.007
1994	0.205	0.613	0.877	0.461	0.569	0.355	0.234	0.159	0.195	0.139	0.070	0.052	0.008	0.001	0.003
1995	0.600	1.198	1.343	0.591	0.590	0.322	0.183	0.189	0.186	0.116	0.054	0.018	0.006	0.002	0.000
1996	0.473	1.091	2.393	0.903	0.837	0.375	0.595	0.374	0.233	0.098	0.075	0.101	0.016	0.008	0.007

Table 28. Hudson River Shad gillnet bycatch of striped bass. CPUE at age, 1982-1996.

	Age													
Year	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982		0.006	0.081	0.053	0.012	0.023	0.010	0.004	0.001				0.001	
1983		0.074	0.967	0.641	0.147	0.273	0.116	0.042	0.011					
1984		0.009	0.228	0.379	0.443	0.110	0.005	0.023			0.005			
1985		0.016	0.118	0.272	0.085	0.069	0.026	0.007	0.003	0.003				
1986		0.011	0.233	0.359	0.248	0.080	0.031	0.008						
1987		0.004	0.170	0.490	0.413	0.234	0.055	0.043	0.017	0.004		0.004	0.004	
1988	0.005	0.005	0.100	0.600	0.536	0.327	0.164	0.068	0.036	0.005		0.005		
1989	0.042	0.028	0.056	0.983	1.278	0.562	0.309	0.126	0.014	0.028	0.028		0.014	
1990		0.048	0.254	0.396	0.856	0.682	0.365	0.095	0.032	0.032	0.032			
1991			0.286	0.572	0.477	0.382	0.382	0.095	0.095	0.191				
1992		0.077	0.753	1.430	0.707	0.200	0.354	0.154	0.138	0.077				
1993		0.132	0.823	2.732	2.172	0.790	0.559	0.823	0.494	0.197	0.066			0.033
1994		0.185	0.955	1.509	1.755	1.047	0.277	0.185	0.246	0.031		0.031		
1995	0.026		0.369	1.422	0.869	0.448	0.263	0.105	0.079	0.053	0.079	0.026		
1996														

Table 29. Results of VPA for Atlantic striped bass, 1982-1996.

INPUT PARAMETERS AND OPTIONS SELECTED

Natural mortality is 0.15
Oldest age (not in the plus group) is 14

For all yrs prior to the terminal year (1996), backcalculated stock sizes for the following ages used to estimate total mortality (Z) for age 14: 4 5 6 7 8 9 10 11 12 13 14
This method for estimating F on the oldest age is generally used when a flat-topped partial recruitment curve is thought to be characteristic of the stock.

F for age 15+ is then calculated from the ratios of F[age 15+] to F[age 14] = 1.000

Stock size of the 15+ group is then calculated using the following method: CATCH EQUATION
Partial recruitment estimate for 1996

1	0.0050
2	0.0500
3	0.2200
4	0.5200
5	0.7000
6	0.7500
7	1.0000
8	1.0000
9	1.0000
10	1.0000
11	1.0000
12	1.0000
13	1.0000
14	1.0000

Objective function is SUM w*(LOG(OBS) - LOG(PRED))**2

Indices normalized (by dividing by mean observed value) before tuning to VPA stocksizes

Biomass estimates (other than SSB) reflect mean stock sizes. SSB calculated as in the NEFSC projection program (see note below SSB table for description of the algorithm).

Initial estimates of parameters for the Marquardt algorithm and lower and upper bounds on the parameter estimates:

Par.	Initial Est	Lower Bnd	Upper Bnd
N 1	3.0000000E3	1.0000000E0	1.0000000E7
N 2	3.0000000E3	1.0000000E0	1.0000000E7
N 3 - 8	5.0000000E2	1.0000000E0	1.0000000E6
N 9 - 11	5.0000000E2	1.0000000E0	1.0000000E5
N12 - 13	5.0000000E2	1.0000000E0	1.0000000E4
q indices	1.0000000E-4	0.0000000E0	1.0000000E0

The following indices of abundance were used:

2	HUD YOY
3	NJ YOY
4	DEL YOY
5	MD YOY
6	VA YOY
9	WLI SV 1
10	MD SV 1
12	MD SSB 2
13	MD SSB 3
14	MD SSB 4
15	MD SSB 5
16	MD SSB 6
17	MD SSB 7

18	MD SSB 8
19	MD SSB 9
20	MD SSB 10
21	MD SSB 11
22	MD SSB 12
23	MD SSB 13
24	MD SSB 14
25	MD SSB 15
55	MA COM 7
56	MA COM 8
57	MA COM 9
58	MA COM 10
59	MA COM 11
60	MA COM 12
61	MA COM 13
62	MA COM 14
63	CT CPUE 1
64	CT CPUE 2
65	CT CPUE 3
66	CT CPUE 4
67	CT CPUE 5
68	CT CPUE 6
69	CT CPUE 7
70	CT CPUE 8
71	CT CPUE 9
72	CT CPUE 10
73	CT CPUE 11
74	CT CPUE 12
75	CT CPUE 13
76	CT CPUE 14
81	HUD SHAD 6
82	HUD SHAD 7
83	HUD SHAD 8
92	NY OHS 4
93	NY OHS 5
94	NY OHS 6
95	NY OHS 7
96	NY OHS 8
97	NY OHS 9
98	NY OHS 10
99	NY OHS 11
100	NY OHS 12
101	NY OHS 13
102	NY OHS 14
103	NY OHS 15

Obs Indices (before transformation) by index & yr; with index means

	1982	1983	1984	1985	1986	1987	1988
2	8.860	14.170	16.250	15.000	1.920	2.920	15.900
3	0.000	0.120	0.030	0.290	0.020	0.280	0.410
4	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000
5	0.590	3.540	0.610	1.640	0.910	1.340	1.460
6	1.570	2.710	3.400	4.470	2.410	4.740	15.740
9	-999.000	-999.000	-999.000	0.610	0.300	0.210	0.770
10	0.020	0.320	0.001	0.150	0.030	0.050	0.060
12	-999.000	-999.000	-999.000	72.830	62.720	60.930	32.210
13	-999.000	-999.000	-999.000	243.050	164.740	204.100	67.750
14	-999.000	-999.000	-999.000	41.790	467.300	128.140	73.470
15	-999.000	-999.000	-999.000	19.020	7.100	335.330	72.330
16	-999.000	-999.000	-999.000	8.880	4.440	3.720	107.360
17	-999.000	-999.000	-999.000	8.250	3.160	2.950	2.160
18	-999.000	-999.000	-999.000	1.440	2.630	3.480	-999.000
19	-999.000	-999.000	-999.000	1.830	0.940	0.120	-999.000
20	-999.000	-999.000	-999.000	2.190	0.730	-999.000	0.730
21	-999.000	-999.000	-999.000	0.390	-999.000	-999.000	-999.000
22	-999.000	-999.000	-999.000	1.740	-999.000	-999.000	0.020

23	-999.000	-999.000	-999.000	1.310	0.940	-999.000	-999.000
24	-999.000	-999.000	-999.000	0.310	0.650	7.250	0.080
25	-999.000	-999.000	-999.000	7.010	2.220	4.940	1.860
55	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000
56	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000
57	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000
58	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000
59	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000
60	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000
61	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000
62	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000
63	0.221	0.330	0.399	0.122	0.058	0.077	0.035
64	0.316	0.212	0.190	0.333	0.315	0.198	0.244
65	0.163	0.109	0.080	0.226	0.222	0.466	0.342
66	0.136	0.091	0.038	0.135	0.120	0.445	0.202
67	0.114	0.077	0.027	0.051	0.092	0.180	0.144
68	0.056	0.037	0.009	0.037	0.041	0.051	0.064
69	0.033	0.022	0.002	0.009	0.027	0.009	0.042
70	0.021	0.014	0.002	0.003	0.011	0.051	0.032
71	0.015	0.010	0.000	0.000	0.001	0.023	0.027
72	0.005	0.003	0.001	0.001	0.001	0.002	0.008
73	0.001	0.001	0.002	-999.000	0.001	-999.000	0.004
74	0.002	0.001	0.000	0.001	0.001	-999.000	0.002
75	0.001	0.000	0.001	0.001	-999.000	-999.000	0.001
76	0.003	0.002	0.000	-999.000	0.000	0.008	0.002
81	0.013	0.041	0.408	0.081	0.263	0.478	0.627
82	0.027	0.011	0.103	0.074	0.079	0.270	0.336
83	0.012	0.011	0.004	0.028	0.035	0.047	0.138
92	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	5.980
93	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	8.710
94	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	7.710
95	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	2.890
96	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	1.130
97	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	0.280
98	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	0.150
99	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000
**	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	0.010
**	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000
**	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	0.010
**	-999.000	-999.000	-999.000	-999.000	-999.000	-999.000	0.030

	1989	1990	1991	1992	1993	1994	1995
2	33.460	21.350	19.050	3.600	11.430	12.590	17.640
3	0.350	1.030	1.000	0.470	1.190	1.780	0.960
4	-999.000	0.420	0.110	0.180	1.130	1.140	0.190
5	0.730	4.870	1.030	1.520	2.340	13.970	6.400
6	7.640	11.230	7.340	3.760	7.320	18.120	10.480
9	1.730	0.370	1.240	1.340	0.720	1.370	1.260
10	0.150	0.330	0.190	0.110	0.190	0.760	0.120
12	15.520	25.630	40.310	17.400	33.400	11.120	42.900
13	121.590	182.330	186.400	240.640	130.160	37.900	110.100
14	100.510	204.180	72.200	199.490	222.420	67.640	71.810
15	71.510	88.670	68.430	63.240	98.530	98.170	72.130
16	91.100	68.950	40.600	84.360	60.370	37.340	56.290
17	59.620	67.020	38.940	59.620	57.340	20.900	49.630
18	0.380	52.920	35.440	41.810	46.520	30.060	33.550
19	-999.000	0.460	14.970	19.130	22.280	12.220	41.380
20	0.370	0.180	0.430	8.790	7.920	3.340	17.830
21	-999.000	0.020	0.300	0.150	3.270	0.630	24.860
22	0.190	0.240	-999.000	-999.000	0.330	0.360	8.210
23	-999.000	0.260	0.110	0.030	0.310	0.090	2.140
24	-999.000	0.050	0.100	1.090	0.460	-999.000	-999.000
25	0.340	0.390	0.450	0.720	0.350	0.050	0.340
55	-999.000	-999.000	0.560	0.860	0.380	0.190	0.430
56	-999.000	-999.000	2.300	3.510	3.170	1.970	3.740
57	-999.000	-999.000	0.920	4.990	5.890	6.410	9.740
58	-999.000	-999.000	0.430	0.920	4.780	8.590	6.260

59 □	-999.000	-999.000	0.280	0.310	0.510	5.330	2.180
60 □	-999.000	-999.000	0.120	0.310	0.220	0.860	1.030
61 □	-999.000	-999.000	0.440	0.070	0.060	0.170	0.100
62 □	-999.000	-999.000	1.950	2.040	1.000	0.500	0.530
63 □	0.021	0.268	0.174	0.147	0.172	0.070	0.205
64 □	0.522	0.484	0.582	0.668	0.477	0.704	0.613
65 □	0.281	0.468	0.555	0.431	0.574	0.623	0.877
66 □	0.179	0.160	0.273	0.347	0.294	0.486	0.461
67 □	0.152	0.182	0.118	0.135	0.234	0.280	0.569
68 □	0.118	0.126	0.126	0.066	0.107	0.220	0.355
69 □	0.049	0.090	0.148	0.094	0.095	0.095	0.234
70 □	0.028	0.031	0.127	0.131	0.160	0.077	0.159
71 □	0.007	0.015	0.053	0.087	0.145	0.110	0.195
72 □	0.002	0.007	0.017	0.032	0.093	0.099	0.139
73 □	0.000	-999.000	0.005	0.008	0.021	0.053	0.070
74 □	-999.000	-999.000	0.005	0.002	0.004	0.012	0.052
75 □	0.001	-999.000	0.002	0.000	0.001	0.004	0.008
76 □	-999.000	-999.000	0.003	0.001	0.002	0.008	0.004
81 □	1.359	0.930	0.477	0.980	2.791	2.427	1.106
82 □	0.600	0.689	0.381	0.087	0.751	1.471	0.510
83 □	0.332	0.413	0.381	0.404	0.429	0.221	0.085
92 □	4.730	2.200	6.490	7.490	4.680	7.920	6.700
93 □	4.860	1.270	4.380	5.120	3.580	6.650	3.220
94 □	4.490	2.030	1.930	1.640	1.930	2.750	3.150
95 □	2.650	1.420	2.120	0.770	0.620	1.800	1.910
96 □	0.900	1.180	1.600	1.050	0.410	0.740	1.290
97 □	0.450	0.320	1.280	1.460	0.700	0.460	0.560
98 □	0.130	0.090	0.470	0.800	0.630	0.570	0.560
99 □	0.070	0.110	0.190	0.360	0.410	0.450	0.580
** □	0.020	0.020	0.040	0.090	0.160	0.310	0.280
** □	-999.000	0.010	-999.000	0.080	0.090	0.120	0.320
** □	0.070	0.010	0.010	0.020	0.010	0.040	0.060
** □	0.010	0.010	0.010	0.080	0.020	0.020	0.060

□	1996	1997	AVG.
2 □	1.200	9.300	13.852
3 □	1.980	1.700	0.726
4 □	0.420	1.360	0.619
5 □	4.410	17.560	3.932
6 □	5.450	23.000	8.086
9 □	1.520	0.710	0.935
10 □	0.080	-999.000	0.171
12 □	8.380	4.120	32.882
13 □	510.920	110.980	177.743
14 □	140.800	121.940	147.053
15 □	47.650	71.850	85.689
16 □	93.050	62.030	55.268
17 □	109.700	68.000	42.099
18 □	85.010	42.580	31.318
19 □	66.800	27.360	18.863
20 □	34.790	18.800	8.008
21 □	16.590	12.530	6.527
22 □	5.050	3.320	2.162
23 □	1.660	1.460	0.831
24 □	-999.000	-999.000	1.249
25 □	-999.000	-999.000	1.697
55 □	1.130	0.900	0.636
56 □	5.620	4.810	3.589
57 □	9.130	6.120	6.171
58 □	6.750	5.580	4.759
59 □	2.840	4.680	2.304
60 □	1.080	2.470	0.870
61 □	0.270	0.750	0.266
62 □	0.100	0.412	0.933
63 □	0.600	0.472	0.211
64 □	1.198	0.109	0.448
65 □	1.343	2.393	0.572

66	0.591	0.903	0.304
67	0.590	0.837	0.236
68	0.322	0.375	0.132
69	0.183	0.595	0.108
70	0.189	0.374	0.088
71	0.186	0.233	0.069
72	0.116	0.098	0.039
73	0.054	0.075	0.023
74	0.018	0.101	0.016
75	0.006	0.016	0.003
76	0.002	0.008	0.003
81	-999.000	-999.000	0.856
82	-999.000	-999.000	0.385
83	-999.000	-999.000	0.181
92	3.510	46.910	9.661
93	2.340	7.700	4.783
94	0.700	2.970	2.930
95	0.760	0.960	1.590
96	0.390	0.830	0.952
97	0.210	0.370	0.609
98	0.140	0.160	0.370
99	0.160	0.120	0.272
**	0.140	0.010	0.108
**	0.050	0.110	0.111
**	0.060	0.010	0.030
**	0.010	0.010	0.026

SUMMARY OF WEIGHTING USED IN THE OBJECTIVE FUNCTION:

EXOGENOUS WEIGHTS BY INDEX AND YR (omega) = 1.00
DOWNWEIGHTS BY YEAR (delta) = 1.00

ITERATIVE RE-WEIGHTS BY INDEX (chi)

2	3	4	5	6	9	10	12	13	14
0.0126	0.0026	0.0199	0.0226	0.0703	0.0232	0.0065	0.0076	0.0190	0.0129

15	16	17	18	19	20	21	22	23	24
0.0161	0.0196	0.0202	0.0084	0.0048	0.0078	0.0038	0.0039	0.0061	0.0033

25	55	56	57	58	59	60	61	62	63
0.0042	0.0320	0.0870	0.0729	0.0267	0.0188	0.0086	0.0117	0.0341	0.0076

64	65	66	67	68	69	70	71	72	73
0.0256	0.0665	0.0345	0.0224	0.0284	0.0175	0.0137	0.0030	0.0043	0.0041

74	75	76	81	82	83	92	93	94	95
0.0056	0.0053	0.0067	0.0114	0.0104	0.0074	0.0306	0.0229	0.0113	0.0084

96	97	98	99	100	101	102	103
0.0083	0.0092	0.0112	0.0101	0.0041	0.0050	0.0067	0.0105

CATCH AT AGE (thousands)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	2	4	6	1	11	1	3	1	3	2	3	0	6	4	1
2	106	110	543	73	21	11	31	37	54	78	51	76	146	415	99
3	257	178	303	102	64	38	42	81	136	153	217	198	350	447	659
4	221	193	83	41	133	52	64	69	203	217	201	344	292	438	666
5	58	150	61	59	50	68	106	106	182	166	188	300	369	386	552
6	19	39	52	43	32	25	97	96	174	103	114	194	233	462	477

7	24	19	18	44	20	13	41	46	112	95	66	90	136	201	457
8	17	4	5	17	24	7	25	21	76	88	74	71	87	186	218
9	12	3	2	6	9	7	14	11	24	63	64	90	100	148	143
10	11	4	2	3	5	3	6	4	9	26	49	83	81	86	72
11	11	5	1	1	3	1	4	3	6	15	10	45	36	51	44
12	14	6	0	1	2	2	3	2	4	3	5	10	22	16	48
13	3	5	2	1	1	3	2	2	5	3	2	5	3	9	13
14	4	4	4	1	3	2	3	2	4	3	6	1	1	2	5
15	8	5	5	9	7	8	4	5	8	18	10	13	10	3	3
1+	767	729	1086	401	386	241	445	485	999	1032	1060	1521	1874	2854	3457

CAA summary for ages 3-9 3-13 4-13 5-13

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
3	608	587	523	312	333	209	389	429	907	885	924	1287	1567	2268	3173
3	647	606	529	318	344	219	404	440	930	931	990	1430	1711	2430	3350
4	390	428	226	216	280	181	362	359	795	779	773	1232	1360	1983	2691
5	169	234	143	175	147	129	298	290	591	561	572	888	1069	1545	2025

WT AT AGE (MID-YR) in kg.

	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.130	0.200	0.240	0.060	0.140	0.200	0.310	0.160	0.080
2	0.640	0.550	0.600	0.610	0.570	0.770	0.910	0.830	0.890
3	1.090	0.940	1.690	1.070	1.270	1.410	1.100	1.220	1.140
4	1.540	1.370	1.610	1.650	2.400	2.110	1.980	2.230	2.050
5	2.420	2.370	2.670	2.190	2.440	2.500	3.110	3.060	2.350
6	3.750	3.290	3.390	3.590	3.120	2.910	4.020	4.530	3.830
7	4.830	3.770	5.070	4.910	3.950	3.610	4.380	5.370	4.910
8	5.790	5.350	5.650	5.460	5.050	4.740	4.700	6.230	5.960
9	6.200	6.010	6.760	6.770	5.440	5.520	5.240	6.030	5.700
10	8.680	8.100	7.760	7.450	6.090	6.490	5.620	8.680	5.970
11	10.800	9.570	8.410	9.000	7.750	7.770	8.580	8.940	7.440
12	11.200	10.390	12.650	10.690	9.150	9.780	10.390	9.740	9.080
13	12.970	11.110	10.650	11.420	10.970	11.380	11.500	13.040	9.360
14	13.260	11.100	11.750	14.340	11.550	11.620	11.310	9.930	10.800
15	15.910	11.120	14.750	15.980	15.830	16.460	17.000	17.110	17.650

	1991	1992	1993	1994	1995	1996
1	0.210	0.100	0.070	0.240	0.280	0.140
2	0.920	0.690	0.760	1.050	0.700	1.050
3	1.290	1.300	1.310	1.690	1.350	1.470
4	2.170	1.930	1.990	2.210	2.180	2.320
5	2.620	2.810	2.770	2.850	2.770	3.220
6	3.170	3.670	3.580	3.500	3.650	4.520
7	4.810	4.900	4.800	4.940	5.380	6.390
8	5.640	5.790	6.110	6.200	6.160	7.110
9	6.460	6.960	7.030	6.790	7.270	7.810
10	6.240	8.150	8.000	7.530	8.860	9.200
11	9.460	9.770	9.530	9.730	7.570	9.310
12	8.300	12.440	10.760	10.690	9.730	10.090
13	9.620	13.100	14.450	11.370	13.970	11.360
14	15.960	11.150	13.850	9.060	15.650	12.450
15	17.090	17.650	15.360	17.750	20.370	17.300

WT AT AGE (JAN 1) in kg.

	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.063	0.115	0.151	0.019	0.060	0.094	0.189	0.068	0.024

7	24	19	18	44	20	13	41	46	112	95	66	90	136	201	457
8	17	4	5	17	24	7	25	21	76	88	74	71	87	186	218
9	12	3	2	6	9	7	14	11	24	63	64	90	100	148	143
10	11	4	2	3	5	3	6	4	9	26	49	83	81	86	72
11	11	5	1	1	3	1	4	3	6	15	10	45	36	51	44
12	14	6	0	1	2	2	3	2	4	3	5	10	22	16	48
13	3	5	2	1	1	3	2	2	5	3	2	5	3	9	13
14	4	4	4	1	3	2	3	2	4	3	6	1	1	2	5
15	8	5	5	9	7	8	4	5	8	18	10	13	10	3	3
1+	767	729	1086	401	386	241	445	485	999	1032	1060	1521	1874	2854	3457

CAA summary for ages 3-9 3-13 4-13 5-13

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
3	608	587	523	312	333	209	389	429	907	885	924	1287	1567	2268	3173
3	647	606	529	318	344	219	404	440	930	931	990	1430	1711	2430	3350
4	390	428	226	216	280	181	362	359	795	779	773	1232	1360	1983	2691
5	169	234	143	175	147	129	298	290	591	561	572	888	1069	1545	2025

WT AT AGE (MID-YR) in kg.

	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.130	0.200	0.240	0.060	0.140	0.200	0.310	0.160	0.080
2	0.640	0.550	0.600	0.610	0.570	0.770	0.910	0.830	0.890
3	1.090	0.940	1.690	1.070	1.270	1.410	1.100	1.220	1.140
4	1.540	1.370	1.610	1.650	2.400	2.110	1.980	2.230	2.050
5	2.420	2.370	2.670	2.190	2.440	2.500	3.110	3.060	2.350
6	3.750	3.290	3.390	3.590	3.120	2.910	4.020	4.530	3.830
7	4.830	3.770	5.070	4.910	3.950	3.610	4.380	5.370	4.910
8	5.790	5.350	5.650	5.460	5.050	4.740	4.700	6.230	5.960
9	6.200	6.010	6.760	6.770	5.440	5.520	5.240	6.030	5.700
10	8.680	8.100	7.760	7.450	6.090	6.490	5.620	8.680	5.970
11	10.800	9.570	8.410	9.000	7.750	7.770	8.580	8.940	7.440
12	11.200	10.390	12.650	10.690	9.150	9.780	10.390	9.740	9.080
13	12.970	11.110	10.650	11.420	10.970	11.380	11.500	13.040	9.360
14	13.260	11.100	11.750	14.340	11.550	11.620	11.310	9.930	10.800
15	15.910	11.120	14.750	15.980	15.830	16.460	17.000	17.110	17.650

	1991	1992	1993	1994	1995	1996
1	0.210	0.100	0.070	0.240	0.280	0.140
2	0.920	0.690	0.760	1.050	0.700	1.050
3	1.290	1.300	1.310	1.690	1.350	1.470
4	2.170	1.930	1.990	2.210	2.180	2.320
5	2.620	2.810	2.770	2.850	2.770	3.220
6	3.170	3.670	3.580	3.500	3.650	4.520
7	4.810	4.900	4.800	4.940	5.380	6.390
8	5.640	5.790	6.110	6.200	6.160	7.110
9	6.460	6.960	7.030	6.790	7.270	7.810
10	6.240	8.150	8.000	7.530	8.860	9.200
11	9.460	9.770	9.530	9.730	7.570	9.310
12	8.300	12.440	10.760	10.690	9.730	10.090
13	9.620	13.100	14.450	11.370	13.970	11.360
14	15.960	11.150	13.850	9.060	15.650	12.450
15	17.090	17.650	15.360	17.750	20.370	17.300

WT AT AGE (JAN 1) in kg.

	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.063	0.115	0.151	0.019	0.060	0.094	0.189	0.068	0.024

2	0.528	0.267	0.346	0.383	0.185	0.328	0.427	0.507	0.377
3	0.972	0.776	0.964	0.801	0.880	0.896	0.920	1.054	0.973
4	1.241	1.222	1.230	1.670	1.602	1.637	1.671	1.566	1.581
5	2.076	1.910	1.913	1.878	2.006	2.449	2.562	2.461	2.289
6	3.740	2.822	2.834	3.096	2.614	2.665	3.170	3.753	3.423
7	4.589	3.760	4.084	4.080	3.766	3.356	3.570	4.646	4.716
8	5.683	5.083	4.615	5.261	4.980	4.327	4.119	5.224	5.657
9	5.424	5.899	6.014	6.185	5.450	5.280	4.984	5.324	5.959
10	8.267	7.087	6.829	7.097	6.421	5.942	5.570	6.744	6.000
11	11.011	9.114	8.254	8.357	7.599	6.879	7.462	7.088	8.036
12	11.245	10.593	11.003	9.482	9.075	8.706	8.985	9.142	9.010
13	14.020	11.155	10.519	12.019	10.829	10.204	10.605	11.640	9.548
14	13.114	11.999	11.426	12.358	11.485	11.290	11.345	10.686	11.867
15	15.910	11.120	14.750	15.980	15.830	16.460	17.000	17.110	17.650

	1991	1992	1993	1994	1995	1996	1997
1	0.116	0.036	0.018	0.141	0.145	0.036	0.066
2	0.271	0.381	0.276	0.271	0.410	0.542	0.542
3	1.071	1.094	0.951	1.133	1.191	1.014	2.033
4	1.573	1.578	1.608	1.701	1.919	1.770	2.130
5	2.318	2.469	2.312	2.381	2.474	2.649	3.041
6	2.729	3.101	3.172	3.114	3.225	3.538	3.913
7	4.292	3.941	4.197	4.205	4.339	4.829	5.774
8	5.262	5.277	5.472	5.455	5.516	6.185	8.455
9	6.205	6.265	6.380	6.441	6.714	6.936	8.174
10	5.964	7.256	7.462	7.276	7.756	8.178	8.794
11	7.515	7.808	8.813	8.823	7.550	9.082	10.349
12	7.858	10.848	10.253	10.093	9.730	8.740	9.543
13	9.346	10.427	13.407	11.061	12.220	10.513	11.649
14	12.222	10.357	13.470	11.442	13.339	13.188	12.275
15	17.090	17.650	15.360	17.750	20.370	17.300	17.300

Weights at age at the start of the spawning season are assumed to be the same as the Jan1 weight at age estimates.

PERCENT MATURE (females)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
6	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45
7	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89
8	94	94	94	94	94	94	94	94	94	94	94	94	94	94	94
9	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
11	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
12	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
13	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
14	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
15	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

SEX RATIO (Percent Female) BY YEAR and AGE = 50:50

RESULTS

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

SUM OF SQUARES	6.173218
ORTHOGONALITY OFFSET.........	0.010170
MEAN SQUARE RESIDUALS	0.010038

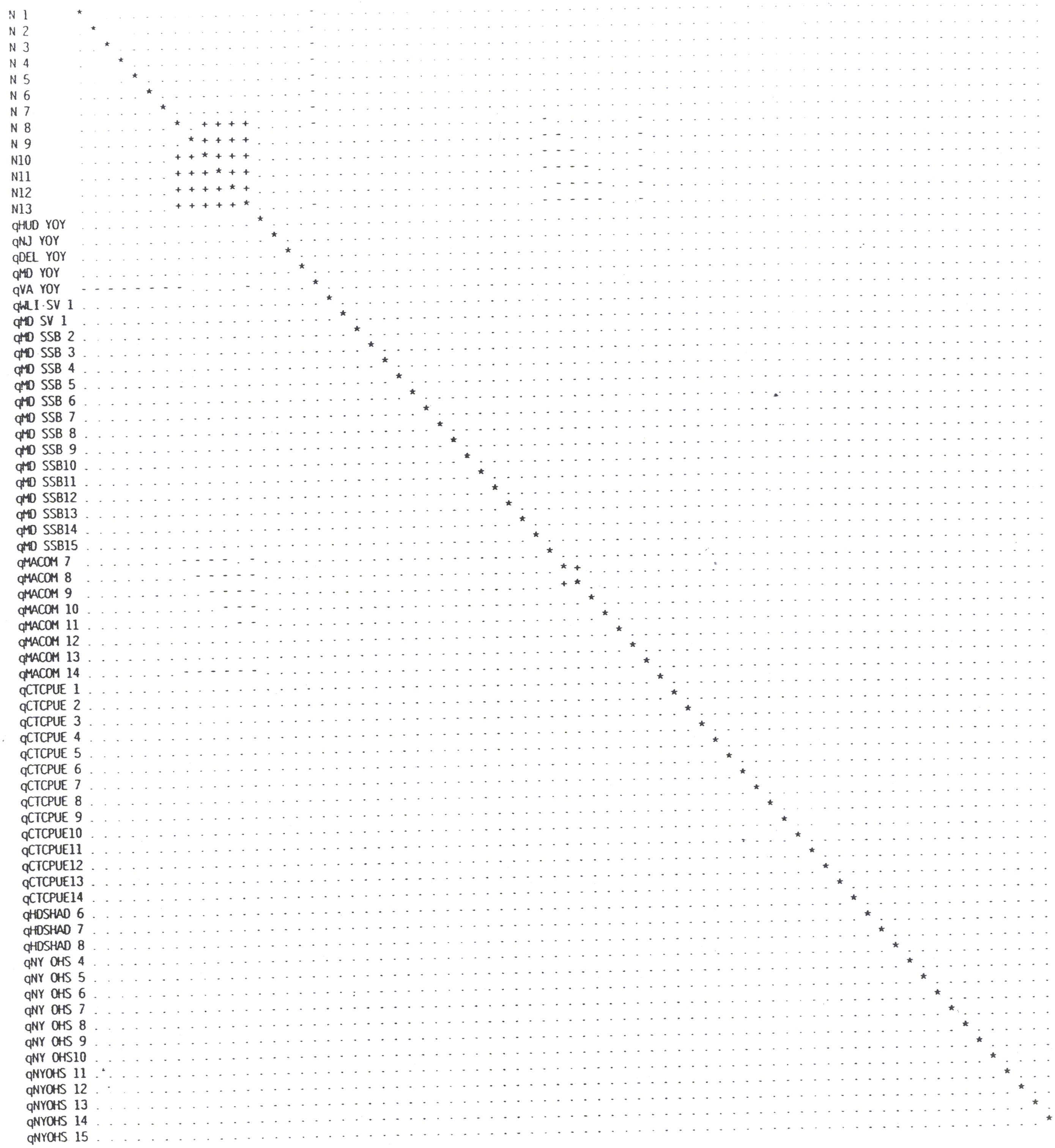
	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 1	1.50988E4	4.14494E3	3.64269E0	0.27
N 2	5.06291E3	1.30217E3	3.88807E0	0.26
N 3	4.01302E3	9.39614E2	4.27092E0	0.23
N 4	9.02464E3	1.80817E3	4.99105E0	0.20
N 5	2.55901E3	5.51230E2	4.64236E0	0.22
N 6	1.29445E3	3.20813E2	4.03490E0	0.25
N 7	1.06829E3	2.65628E2	4.02175E0	0.25
N 8	1.15604E3	2.80570E2	4.12032E0	0.24
N 9	6.52442E2	1.42349E2	4.58339E0	0.22
N10	3.76760E2	8.69735E1	4.33190E0	0.23
N11	1.98092E2	5.32598E1	3.71935E0	0.27
N12	1.12550E2	3.62828E1	3.10202E0	0.32
N13	1.20386E2	3.93350E1	3.06052E0	0.33
qHUD YOY	1.71079E-4	3.94163E-5	4.34031E0	0.23
qNJ YOY	7.38841E-5	3.67004E-5	2.01317E0	0.50
qDEL YOY	9.23405E-5	2.46735E-5	3.74250E0	0.27
qMD YOY	1.19453E-4	2.09618E-5	5.69862E0	0.18
qVA YOY	1.62678E-4	1.76700E-5	9.20645E0	0.11
qWLI SV 1	1.47558E-4	2.86430E-5	5.15163E0	0.19
qMD SV 1	1.16798E-4	3.80749E-5	3.06758E0	0.33
qMD SSB 2	1.77825E-4	5.76924E-5	3.08229E0	0.32
qMD SSB 3	2.51687E-4	5.25603E-5	4.78854E0	0.21
qMD SSB 4	3.46944E-4	8.69673E-5	3.98936E0	0.25
qMD SSB 5	5.05713E-4	1.13836E-4	4.44245E0	0.23
qMD SSB 6	7.53383E-4	1.54924E-4	4.86293E0	0.21
qMD SSB 7	9.49070E-4	1.92898E-4	4.92005E0	0.20
qMD SSB 8	1.09660E-3	3.52329E-4	3.11242E0	0.32
qMD SSB 9	1.16551E-3	5.13938E-4	2.26780E0	0.44
qMD SSB10	2.24183E-3	7.52456E-4	2.97935E0	0.34
qMD SSB11	1.83484E-3	1.01251E-3	1.81217E0	0.55
qMD SSB12	4.41132E-3	2.39801E-3	1.83958E0	0.54
qMD SSB13	1.37625E-2	5.71428E-3	2.40843E0	0.42
qMD SSB14	1.14636E-2	7.09328E-3	1.61612E0	0.62
qMD SSB15	5.77293E-3	2.72715E-3	2.11684E0	0.47
qMACOM 7	1.12179E-3	2.55057E-4	4.39817E0	0.23
qMACOM 8	1.98839E-3	2.99797E-4	6.63246E0	0.15
qMACOM 9	3.38140E-3	5.52267E-4	6.12276E0	0.16
qMACOM 10	5.70647E-3	1.42617E-3	4.00124E0	0.25
qMACOM 11	1.00310E-2	2.94311E-3	3.40829E0	0.29
qMACOM 12	1.81425E-2	7.63808E-3	2.37526E0	0.42
qMACOM 13	3.17848E-2	1.15213E-2	2.75878E0	0.36
qMACOM 14	1.39800E-2	3.11296E-3	4.49090E0	0.22
qCTCPUE 1	2.04476E-4	5.98157E-5	3.41843E0	0.29
qCTCPUE 2	3.28643E-4	5.35320E-5	6.13919E0	0.16
qCTCPUE 3	3.79355E-4	4.00409E-5	9.47418E0	0.11
qCTCPUE 4	6.74898E-4	9.56055E-5	7.05919E0	0.14
qCTCPUE 5	9.66702E-4	1.68282E-4	5.74452E0	0.17
qCTCPUE 6	1.45358E-3	2.27186E-4	6.39818E0	0.16
qCTCPUE 7	1.57129E-3	3.08441E-4	5.09428E0	0.20
qCTCPUE 8	2.41540E-3	5.31970E-4	4.54048E0	0.22
qCTCPUE 9	2.19376E-3	1.02109E-3	2.14845E0	0.47
qCTCPUE10	3.44627E-3	1.34055E-3	2.57078E0	0.39
qCTCPUE11	5.82847E-3	2.55510E-3	2.28111E0	0.44
qCTCPUE12	7.95319E-3	3.00851E-3	2.64357E0	0.38
qCTCPUE13	2.19926E-2	8.49499E-3	2.58889E0	0.39
qCTCPUE14	1.35377E-2	4.68046E-3	2.89239E0	0.35
qHDSHAD 6	7.76914E-4	1.97531E-4	3.93312E0	0.25
qHDSHAD 7	1.31288E-3	3.50692E-4	3.74369E0	0.27
qHDSHAD 8	1.80501E-3	5.70278E-4	3.16515E0	0.32
qNY OHS 4	2.18150E-4	4.17097E-5	5.23019E0	0.19
qNY OHS 5	4.41471E-4	9.65409E-5	4.57289E0	0.22
qNY OHS 6	6.24413E-4	1.90903E-4	3.27084E0	0.31
qNY OHS 7	1.03395E-3	3.64821E-4	2.83413E0	0.35
qNY OHS 8	1.76474E-3	6.25585E-4	2.82094E0	0.35
qNY OHS 9	2.90446E-3	9.78181E-4	2.96924E0	0.34
qNY OHS10	4.48443E-3	1.38429E-3	3.23952E0	0.31

qNYOHS 11	7.84990E-3	2.68817E-3	2.92016E0	0.34
qNYOHS 12	8.84643E-3	4.43982E-3	1.99252E0	0.50
qNYOHS 13	2.05336E-2	1.12716E-2	1.82170E0	0.55
qNYOHS 14	2.98874E-2	1.18418E-2	2.52389E0	0.40
qNYOHS 15	3.04249E-2	9.70250E-3	3.13578E0	0.32

CATCHABILITY ESTIMATES IN ORIGINAL UNITS

	ESTIMATE	STD. ERR.	C.V.
qHUD YOY	2.34881E-3	5.41161E-4	0.23
qNJ YOY	5.36126E-5	2.66309E-5	0.50
qDEL YOY	5.71357E-5	1.52667E-5	0.27
qMD YOY	4.69749E-4	8.24321E-5	0.18
qVA YOY	1.31545E-3	1.42884E-4	0.11
qWLI SV 1	1.37910E-4	2.67702E-5	0.19
qMD SV 1	1.99413E-5	6.50065E-6	0.33
qMD SSB 2	5.84728E-3	1.89706E-3	0.32
qMD SSB 3	4.47356E-2	9.34224E-3	0.21
qMD SSB 4	5.10192E-2	1.27888E-2	0.25
qMD SSB 5	4.33341E-2	9.75456E-3	0.23
qMD SSB 6	4.16383E-2	8.56239E-3	0.21
qMD SSB 7	3.99551E-2	8.12087E-3	0.20
qMD SSB 8	3.43435E-2	1.10344E-2	0.32
qMD SSB 9	2.19847E-2	9.69427E-3	0.44
qMD SSB10	1.79533E-2	6.02592E-3	0.34
qMD SSB11	1.19754E-2	6.60832E-3	0.55
qMD SSB12	9.53825E-3	5.18502E-3	0.54
qMD SSB13	1.14366E-2	4.74857E-3	0.42
qMD SSB14	1.43152E-2	8.85774E-3	0.62
qMD SSB15	9.79823E-3	4.62872E-3	0.47
qMACOM 7	7.13136E-4	1.62144E-4	0.23
qMACOM 8	7.13548E-3	1.07584E-3	0.15
qMACOM 9	2.08680E-2	3.40828E-3	0.16
qMACOM 10	2.71546E-2	6.78655E-3	0.25
qMACOM 11	2.31142E-2	6.78176E-3	0.29
qMACOM 12	1.57839E-2	6.64513E-3	0.42
qMACOM 13	8.44569E-3	3.06138E-3	0.36
qMACOM 14	1.30453E-2	2.90484E-3	0.22
qCTCPUE 1	4.30805E-5	1.26024E-5	0.29
qCTCPUE 2	1.47172E-4	2.39726E-5	0.16
qCTCPUE 3	2.17015E-4	2.29059E-5	0.11
qCTCPUE 4	2.05042E-4	2.90461E-5	0.14
qCTCPUE 5	2.28504E-4	3.97777E-5	0.17
qCTCPUE 6	1.91690E-4	2.99601E-5	0.16
qCTCPUE 7	1.69601E-4	3.32924E-5	0.20
qCTCPUE 8	2.12857E-4	4.68799E-5	0.22
qCTCPUE 9	1.51835E-4	7.06722E-5	0.47
qCTCPUE10	1.34297E-4	5.22397E-5	0.39
qCTCPUE11	1.32441E-4	5.80598E-5	0.44
qCTCPUE12	1.23274E-4	4.66319E-5	0.38
qCTCPUE13	7.00379E-5	2.70533E-5	0.39
qCTCPUE14	4.54035E-5	1.56975E-5	0.35
qHDSHAD 6	6.64872E-4	1.69044E-4	0.25
qHDSHAD 7	5.05366E-4	1.34991E-4	0.27
qHDSHAD 8	3.27481E-4	1.03465E-4	0.32
qNY OHS 4	2.10755E-3	4.02958E-4	0.19
qNY OHS 5	2.11155E-3	4.61755E-4	0.22
qNY OHS 6	1.82953E-3	5.59346E-4	0.31
qNY OHS 7	1.64398E-3	5.80065E-4	0.35
qNY OHS 8	1.68003E-3	5.95557E-4	0.35
qNY OHS 9	1.76882E-3	5.95713E-4	0.34
qNY OHS10	1.65924E-3	5.12186E-4	0.31
qNYOHS 11	2.13692E-3	7.31780E-4	0.34
qNYOHS 12	9.55414E-4	4.79501E-4	0.50
qNYOHS 13	2.28803E-3	1.25598E-3	0.55
qNYOHS 14	8.96621E-4	3.55253E-4	0.40
qNYOHS 15	7.91046E-4	2.52265E-4	0.32

CORRELATION BETWEEN PARAMETERS ESTIMATED (SYMBOLIC FORM)



SYMBOLS: = LARGE NEGATIVE CORRELATION whenever -1 <= R < -L
- MODERATE NEGATIVE CORRELATION whenever -L <= R < -M

.	SMALL CORRELATION	whenever	-M <= R <= +M
+	MODERATE POSITIVE CORRELATION	whenever	+M < R <= +L
*	LARGE POSITIVE CORRELATION	whenever	+L < R <= +1

Where R is the estimated correlation, M is 0.2 and L is 0.5

SUMMMARY OF RESIDUALS

Index 2 HUD YOY
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.4380	-1.4452	0.1122	0.1131	1.1284	1377.762
1983	0.0316	-0.7580	0.1122	0.0886	0.8846	2739.069
1984	0.1686	-0.8716	0.1122	0.1168	1.1653	2444.949
1985	0.0885	-0.6088	0.1122	0.0783	0.7813	3179.704
1986	-1.9672	-0.7688	0.1122	-0.1345	-1.3427	2709.805
1987	-1.5480	-0.5690	0.1122	-0.1099	-1.0967	3308.806
1988	0.1468	-0.3010	0.1122	0.0503	0.5017	4325.852
1989	0.8908	-0.1320	0.1122	0.1148	1.1459	5122.309
1990	0.4415	0.2211	0.1122	0.0247	0.2470	7291.284
1991	0.3275	-0.0942	0.1122	0.0473	0.4724	5319.980
1992	-1.3386	-0.1220	0.1122	-0.1366	-1.3630	5173.921
1993	-0.1833	0.1249	0.1122	-0.0346	-0.3453	6622.860
1994	-0.0866	0.9841	0.1122	-0.1202	-1.1996	15638.497
1995	0.2506	-0.0528	0.1122	0.0341	0.3399	5544.725
1996	0.1673	0.0064	0.1122	0.0181	0.1803	5882.800
1997	-0.3895	0.9490	0.1122	-0.1502	-1.4996	15098.758

Partial variance for this index is 0.00998

Index 3 NJ YOY
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-8.8896	-2.2848	0.0510	-0.3366	-3.3598	1377.762
1983	-1.7996	-1.5976	0.0510	-0.0103	-0.1027	2739.069
1984	-3.1858	-1.7112	0.0510	-0.0752	-0.7501	2444.949
1985	-0.9172	-1.4485	0.0510	0.0271	0.2703	3179.704
1986	-3.5913	-1.6084	0.0510	-0.1011	-1.0087	2709.805
1987	-0.9523	-1.4087	0.0510	0.0233	0.2322	3308.806
1988	-0.5709	-1.1406	0.0510	0.0290	0.2898	4325.852
1989	-0.7291	-0.9717	0.0510	0.0124	0.1234	5122.309
1990	0.3503	-0.6186	0.0510	0.0494	0.4928	7291.284
1991	0.3207	-0.9338	0.0510	0.0639	0.6382	5319.980
1992	-0.4343	-0.9616	0.0510	0.0269	0.2682	5173.921
1993	0.4947	-0.7147	0.0510	0.0616	0.6152	6622.860
1994	0.8973	0.1445	0.0510	0.0384	0.3830	15638.497
1995	0.2799	-0.8924	0.0510	0.0597	0.5963	5544.725
1996	1.0038	-0.8332	0.0510	0.0936	0.9345	5882.800
1997	0.8513	0.1094	0.0510	0.0378	0.3774	15098.758

Partial variance for this index is 0.010682

Index 4 DEL YOY
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1990	-0.3874	-0.3956	0.1410	0.0011	0.0115	7291.284
1991	-1.7272	-0.7108	0.1410	-0.1433	-1.4306	5319.980
1992	-1.2347	-0.7386	0.1410	-0.0700	-0.6983	5173.921
1993	0.6023	-0.4917	0.1410	0.1543	1.5398	6622.860
1994	0.6111	0.3675	0.1410	0.0344	0.3429	15638.497
1995	-1.1807	-0.6694	0.1410	-0.0721	-0.7196	5544.725
1996	-0.3874	-0.6102	0.1410	0.0314	0.3136	5882.800
1997	0.7875	0.3323	0.1410	0.0642	0.6407	15098.758

Partial variance for this index is 0.008962

Index 5 MD YOY
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-1.8969	-1.8044	0.1504	-0.0139	-0.1389	1377.762
1983	-0.1051	-1.1172	0.1504	0.1522	1.5195	2739.069
1984	-1.8636	-1.2308	0.1504	-0.0952	-0.9500	2444.949
1985	-0.8746	-0.9680	0.1504	0.0141	0.1403	3179.704
1986	-1.4636	-1.1280	0.1504	-0.0505	-0.5039	2709.805
1987	-1.0766	-0.9282	0.1504	-0.0223	-0.2228	3308.806
1988	-0.9908	-0.6602	0.1504	-0.0497	-0.4964	4325.852
1989	-1.6840	-0.4912	0.1504	-0.1794	-1.7908	5122.309
1990	0.2138	-0.1382	0.1504	0.0529	0.5285	7291.284
1991	-1.3397	-0.4534	0.1504	-0.1333	-1.3308	5319.980
1992	-0.9506	-0.4812	0.1504	-0.0706	-0.7047	5173.921
1993	-0.5191	-0.2343	0.1504	-0.0428	-0.4276	6622.860
1994	1.2676	0.6249	0.1504	0.0967	0.9650	15638.497
1995	0.4870	-0.4120	0.1504	0.1352	1.3498	5544.725
1996	0.1146	-0.3528	0.1504	0.0703	0.7018	5882.800
1997	1.4963	0.5898	0.1504	0.1364	1.3611	15098.758

Partial variance for this index is 0.010078

Index 6 VA YOY
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-1.6391	-1.4955	0.2652	-0.0381	-0.3801	1377.762
1983	-1.0932	-0.8084	0.2652	-0.0755	-0.7541	2739.069
1984	-0.8664	-0.9220	0.2652	0.0147	0.1471	2444.949
1985	-0.5928	-0.6592	0.2652	0.0176	0.1758	3179.704
1986	-1.2105	-0.8191	0.2652	-0.1038	-1.0362	2709.805
1987	-0.5341	-0.6194	0.2652	0.0226	0.2257	3308.806
1988	0.6660	-0.3514	0.2652	0.2698	2.6933	4325.852
1989	-0.0568	-0.1824	0.2652	0.0333	0.3325	5122.309
1990	0.3284	0.1707	0.2652	0.0418	0.4175	7291.284
1991	-0.0968	-0.1445	0.2652	0.0126	0.1262	5319.980
1992	-0.7657	-0.1724	0.2652	-0.1574	-1.5708	5173.921
1993	-0.0996	0.0745	0.2652	-0.0462	-0.4609	6622.860
1994	0.8069	0.9338	0.2652	-0.0337	-0.3359	15638.497
1995	0.2593	-0.1031	0.2652	0.0961	0.9595	5544.725
1996	-0.3945	-0.0440	0.2652	-0.0930	-0.9281	5882.800
1997	1.0453	0.8986	0.2652	0.0389	0.3883	15098.758

Partial variance for this index is 0.009627

Index 9 WLI SV 1
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 1
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	-0.4267	-0.7567	0.1523	0.0503	0.5016	3179.704
1986	-1.1364	-0.9167	0.1523	-0.0335	-0.3339	2709.805
1987	-1.4930	-0.7169	0.1523	-0.1182	-1.1795	3308.806
1988	-0.1937	-0.4489	0.1523	0.0389	0.3878	4325.852
1989	0.6157	-0.2799	0.1523	0.1364	1.3613	5122.309
1990	-0.9266	0.0731	0.1523	-0.1522	-1.5195	7291.284
1991	0.2827	-0.2421	0.1523	0.0799	0.7976	5319.980
1992	0.3603	-0.2699	0.1523	0.0960	0.9578	5173.921
1993	-0.2609	-0.0230	0.1523	-0.0362	-0.3615	6622.860
1994	0.3824	0.8362	0.1523	-0.0691	-0.6897	15638.497
1995	0.2987	-0.2007	0.1523	0.0760	0.7590	5544.725
1996	0.4863	-0.1415	0.1523	0.0956	0.9542	5882.800
1997	-0.2749	0.8011	0.1523	-0.1638	-1.6353	15098.758

Partial variance for this index is 0.010559

Index 10 MD SV 1
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 1

SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-2.1444	-1.8269	0.0807	-0.0256	-0.2557	1377.762
1983	0.6282	-1.1397	0.0807	0.1427	1.4239	2739.069
1984	-5.1401	-1.2533	0.0807	-0.3136	-3.1306	2444.949
1985	-0.1295	-0.9905	0.0807	0.0695	0.6935	3179.704
1986	-1.7389	-1.1504	0.0807	-0.0475	-0.4740	2709.805
1987	-1.2281	-0.9507	0.0807	-0.0224	-0.2234	3308.806
1988	-1.0458	-0.6827	0.0807	-0.0293	-0.2924	4325.852
1989	-0.1295	-0.5137	0.0807	0.0310	0.3095	5122.309
1990	0.6590	-0.1606	0.0807	0.0661	0.6601	7291.284
1991	0.1069	-0.4758	0.0807	0.0470	0.4694	5319.980
1992	-0.4396	-0.5037	0.0807	0.0052	0.0516	5173.921
1993	0.1069	-0.2568	0.0807	0.0293	0.2929	6622.860
1994	1.4932	0.6024	0.0807	0.0719	0.7175	15638.497
1995	-0.3526	-0.4345	0.0807	0.0066	0.0659	5544.725
1996	-0.7581	-0.3753	0.0807	-0.0309	-0.3083	5882.800

Partial variance for this index is 0.010339

Index 12 MD SSB 2
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	0.7952	-0.9854	0.0874	0.1557	1.5538	2099.191
1986	0.6457	-0.7206	0.0874	0.1195	1.1923	2735.591
1987	0.6168	-0.8846	0.0874	0.1313	1.3102	2321.774
1988	-0.0207	-0.6808	0.0874	0.0577	0.5761	2846.617
1989	-0.7508	-0.4130	0.0874	-0.0295	-0.2948	3720.883
1990	-0.2492	-0.2435	0.0874	-0.0005	-0.0049	4408.070
1991	0.2037	0.1093	0.0874	0.0082	0.0823	6273.161
1992	-0.6365	-0.2059	0.0874	-0.0376	-0.3757	4577.187
1993	0.0156	-0.2340	0.0874	0.0218	0.2178	4450.173
1994	-1.0842	0.0135	0.0874	-0.0960	-0.9579	5700.070
1995	0.2659	0.8724	0.0874	-0.0530	-0.5292	13454.891
1996	-1.3671	-0.1648	0.0874	-0.1051	-1.0491	4768.957
1997	-2.0771	-0.1050	0.0874	-0.1724	-1.7209	5062.909

Partial variance for this index is 0.00974

Index 13 MD SSB 3
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	0.3129	-0.9593	0.1379	0.1754	1.7509	1522.420
1986	-0.0760	-0.8260	0.1379	0.1034	1.0323	1739.437
1987	0.1383	-0.5316	0.1379	0.0924	0.9219	2334.969
1988	-0.9645	-0.6924	0.1379	-0.0375	-0.3745	1988.072
1989	-0.3797	-0.4952	0.1379	0.0159	0.1589	2421.532
1990	0.0255	-0.2263	0.1379	0.0347	0.3466	3168.453
1991	0.0476	-0.0595	0.1379	0.0148	0.1474	3743.592
1992	0.3030	0.2932	0.1379	0.0013	0.0134	5327.089
1993	-0.3116	-0.0206	0.1379	-0.0401	-0.4005	3892.214
1994	-1.5454	-0.0552	0.1379	-0.2055	-2.0509	3759.698
1995	-0.4790	0.1829	0.1379	-0.0913	-0.9109	4770.552
1996	1.0559	1.0360	0.1379	0.0027	0.0274	11195.996
1997	-0.4710	0.0100	0.1379	-0.0663	-0.6619	4013.018

Partial variance for this index is 0.009311

Index 14 MD SSB 4
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	-1.2581	-1.7359	0.1135	0.0542	0.5410	508.000
1986	1.1562	-0.8633	0.1135	0.2291	2.2871	1215.636
1987	-0.1377	-0.6955	0.1135	0.0633	0.6317	1437.771
1988	-0.6939	-0.3783	0.1135	-0.0358	-0.3574	1974.472

1989	-0.3805	-0.5447	0.1135	0.0186	0.1860	1671.720
1990	0.3282	-0.3608	0.1135	0.0782	0.7803	2009.363
1991	-0.7114	-0.1027	0.1135	-0.0691	-0.6893	2601.033
1992	0.3050	0.0665	0.1135	0.0271	0.2701	3080.473
1993	0.4138	0.4194	0.1135	-0.0006	-0.0063	4384.026
1994	-0.7766	0.0941	0.1135	-0.0988	-0.9861	3166.737
1995	-0.7168	0.0098	0.1135	-0.0824	-0.8229	2910.828
1996	-0.0435	0.2474	0.1135	-0.0330	-0.3294	3691.444
1997	-0.1873	1.1414	0.1135	-0.1508	-1.5047	9024.637

Partial variance for this index is 0.009601

Index 15 MD SSB 5
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 5
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	-1.5052	-1.8082	0.1269	0.0385	0.3838	324.190
1986	-2.4906	-1.5991	0.1269	-0.1132	-1.1294	399.573
1987	1.3644	-0.7620	0.1269	0.2699	2.6939	922.918
1988	-0.1695	-0.5083	0.1269	0.0430	0.4292	1189.444
1989	-0.1809	-0.1870	0.1269	0.0008	0.0077	1640.161
1990	0.0342	-0.3634	0.1269	0.0505	0.5038	1374.848
1991	-0.2249	-0.2495	0.1269	0.0031	0.0311	1540.771
1992	-0.3038	0.0297	0.1269	-0.0423	-0.4225	2037.038
1993	0.1396	0.2203	0.1269	-0.0102	-0.1021	2464.633
1994	0.1360	0.5578	0.1269	-0.0535	-0.5344	3454.222
1995	-0.1723	0.2163	0.1269	-0.0493	-0.4923	2455.013
1996	-0.5868	0.0596	0.1269	-0.0821	-0.8190	2098.929
1997	-0.1761	0.2578	0.1269	-0.0551	-0.5498	2559.007

Partial variance for this index is 0.009214

Index 16 MD SSB 6
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 6
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	-1.8284	-2.0063	0.1399	0.0249	0.2484	178.513
1986	-2.5215	-1.7771	0.1399	-0.1042	-1.0396	224.481
1987	-2.6985	-1.4954	0.1399	-0.1683	-1.6802	297.529
1988	0.6640	-0.5956	0.1399	0.1763	1.7592	731.647
1989	0.4998	-0.3610	0.1399	0.1204	1.2021	925.145
1990	0.2212	-0.0104	0.1399	0.0324	0.3234	1313.637
1991	-0.3084	-0.2684	0.1399	-0.0056	-0.0559	1014.865
1992	0.4229	-0.1241	0.1399	0.0765	0.7639	1172.427
1993	0.0883	0.1734	0.1399	-0.0119	-0.1189	1578.694
1994	-0.3921	0.3283	0.1399	-0.1008	-1.0061	1843.099
1995	0.0183	0.6842	0.1399	-0.0932	-0.9299	2630.925
1996	0.5209	0.2794	0.1399	0.0338	0.3373	1755.219
1997	0.1154	-0.0251	0.1399	0.0197	0.1962	1294.450

Partial variance for this index is 0.009581

Index 17 MD SSB 7
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 7
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	-1.6298	-1.2870	0.1422	-0.0487	-0.4864	290.906
1986	-2.5895	-2.2276	0.1422	-0.0514	-0.5134	113.569
1987	-2.6582	-1.8636	0.1422	-0.1130	-1.1274	163.432
1988	-2.9699	-1.5103	0.1422	-0.2075	-2.0710	232.706
1989	0.3480	-0.6696	0.1422	0.1447	1.4438	539.373
1990	0.4650	-0.3986	0.1422	0.1228	1.2252	707.309
1991	-0.0780	-0.0838	0.1422	0.0008	0.0082	968.953
1992	0.3480	-0.3039	0.1422	0.0927	0.9248	777.573
1993	0.3090	-0.1537	0.1422	0.0658	0.6565	903.540
1994	-0.7003	0.1122	0.1422	-0.1155	-1.1528	1178.812
1995	0.1646	0.2627	0.1422	-0.0139	-0.1392	1370.206
1996	0.9577	0.5553	0.1422	0.0572	0.5710	1835.933

1997	0.4795	0.0138	0.1422	0.0662	0.6607	1068.290

Partial variance for this index is 0.011118

Index 18 MD SSB 8
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 8
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	-3.0796	-1.9124	0.0919	-0.1073	-1.0707	134.718
1986	-2.4772	-1.4687	0.0919	-0.0927	-0.9251	209.935
1987	-2.1972	-2.4483	0.0919	0.0231	0.2304	78.824
1989	-4.4118	-1.7241	0.0919	-0.2470	-2.4655	162.626
1990	0.5246	-0.7718	0.0919	0.1191	1.1892	421.473
1991	0.1236	-0.5910	0.0919	0.0657	0.6556	504.972
1992	0.2889	-0.2014	0.0919	0.0451	0.4498	745.571
1993	0.3957	-0.4049	0.0919	0.0736	0.7343	608.311
1994	-0.0410	-0.2729	0.0919	0.0213	0.2128	694.095
1995	0.0688	-0.0259	0.0919	0.0087	0.0869	888.625
1996	0.9986	0.0849	0.0919	0.0840	0.8382	992.685
1997	0.3072	0.2372	0.0919	0.0064	0.0642	1156.038

Partial variance for this index is 0.010693

Index 19 MD SSB 9
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 9
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	-2.3329	-2.2138	0.0695	-0.0083	-0.0826	93.762
1986	-2.9991	-2.1504	0.0695	-0.0590	-0.5888	99.903
1987	-5.0575	-1.6899	0.0695	-0.2341	-2.3366	158.334
1990	-3.7137	-1.9646	0.0695	-0.1216	-1.2136	120.305
1991	-0.2311	-1.0757	0.0695	0.0587	0.5860	292.628
1992	0.0141	-0.8871	0.0695	0.0626	0.6253	353.363
1993	0.1665	-0.4030	0.0695	0.0396	0.3951	573.437
1994	-0.4341	-0.6294	0.0695	0.0136	0.1355	457.244
1995	0.7856	-0.5073	0.0695	0.0899	0.8971	516.606
1996	1.2645	-0.3708	0.0695	0.1137	1.1346	592.194
1997	0.3719	-0.2739	0.0695	0.0449	0.4481	652.442

Partial variance for this index is 0.010769

Index 20 MD SSB10
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 10
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	-1.2966	-2.0484	0.0881	0.0662	0.6609	57.517
1986	-2.3952	-1.7861	0.0881	-0.0536	-0.5354	74.765
1988	-2.3952	-1.2310	0.0881	-0.1025	-1.0234	130.249
1989	-3.0747	-2.4082	0.0881	-0.0587	-0.5859	40.135
1990	-3.7953	-1.9156	0.0881	-0.1655	-1.6523	65.683
1991	-2.9245	-1.7060	0.0881	-0.1073	-1.0711	81.003
1992	0.0931	-0.8351	0.0881	0.0818	0.8160	193.512
1993	-0.0111	-0.6013	0.0881	0.0520	0.5188	244.489
1994	-0.8745	-0.0832	0.0881	-0.0697	-0.6956	410.436
1995	0.8004	-0.3953	0.0881	0.1053	1.0511	300.408
1996	1.4688	-0.3722	0.0881	0.1621	1.6184	307.434
1997	0.8534	-0.1689	0.0881	0.0900	0.8986	376.760

Partial variance for this index is 0.011124

Index 21 MD SSB11
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 11
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	-2.8175	-2.0871	0.0614	-0.0449	-0.4477	67.605
1990	-5.7879	-2.8662	0.0614	-0.1794	-1.7911	31.020
1991	-3.0799	-2.4181	0.0614	-0.0406	-0.4057	48.556
1992	-3.7730	-2.4748	0.0614	-0.0797	-0.7958	45.877

1993	-0.6911	-1.5073	0.0614	0.0501	0.5003	120.727
1994	-2.3379	-1.4086	0.0614	-0.0571	-0.5697	133.245
1995	1.3374	-0.6741	0.0614	0.1235	1.2331	277.747
1996	0.9329	-1.1167	0.0614	0.1259	1.2565	178.407
1997	0.6522	-1.0121	0.0614	0.1022	1.0203	198.092

Partial variance for this index is 0.011517

Index 22 MD SSB12
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 12
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	-0.2173	-1.4476	0.0625	0.0768	0.7670	53.303
1988	-4.6832	-1.5163	0.0625	-0.1978	-1.9743	49.763
1989	-2.4319	-1.4810	0.0625	-0.0594	-0.5928	51.549
1990	-2.1983	-0.9372	0.0625	-0.0788	-0.7861	88.798
1993	-1.8798	-2.0216	0.0625	0.0089	0.0884	30.024
1994	-1.7928	-1.2938	0.0625	-0.0312	-0.3111	62.162
1995	1.3342	-1.0279	0.0625	0.1475	1.4726	81.101
1996	0.8483	-0.1665	0.0625	0.0634	0.6326	191.930
1997	0.4288	-0.7002	0.0625	0.0705	0.7038	112.550

Partial variance for this index is 0.011132

Index 23 MD SSB13
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 13
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	0.4552	-1.0175	0.0779	0.1147	1.1453	26.268
1986	0.1233	-0.4761	0.0779	0.0467	0.4661	45.136
1990	-1.1619	-0.5360	0.0779	-0.0488	-0.4868	42.513
1991	-2.0221	0.0008	0.0779	-0.1576	-1.5733	72.718
1992	-3.3214	-1.5511	0.0779	-0.1379	-1.3768	15.405
1993	-0.9861	-1.2912	0.0779	0.0238	0.2373	19.978
1994	-2.2228	-1.4898	0.0779	-0.0571	-0.5701	16.379
1995	0.9459	-0.7978	0.0779	0.1359	1.3561	32.722
1996	0.6919	-0.2809	0.0779	0.0758	0.7566	54.867
1997	0.5636	0.5049	0.0779	0.0046	0.0456	120.386

Partial variance for this index is 0.010216

Index 24 MD SSB14
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 14
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	-1.3933	-2.4915	0.0576	0.0633	0.6317	7.222
1986	-0.6529	-1.3710	0.0576	0.0414	0.4131	22.145
1987	1.7589	-0.8306	0.0576	0.1492	1.4896	38.014
1988	-2.7479	-0.8313	0.0576	-0.1105	-1.1025	37.988
1990	-3.2179	-0.9859	0.0576	-0.1286	-1.2840	32.547
1991	-2.5247	-1.0014	0.0576	-0.0878	-0.8763	32.046
1992	-0.1360	-0.3744	0.0576	0.0137	0.1371	59.992
1993	-0.9987	-2.0265	0.0576	0.0592	0.5913	11.497

Partial variance for this index is 0.010057

Index 25 MD SSB15
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 15
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1985	1.4183	-0.8888	0.0645	0.1489	1.4859	71.221
1986	0.2685	-1.0737	0.0645	0.0866	0.8644	59.198
1987	1.0683	-0.2190	0.0645	0.0831	0.8291	139.148
1988	0.0916	-1.2070	0.0645	0.0838	0.8363	51.810
1989	-1.6078	-0.7876	0.0645	-0.0529	-0.5283	78.807
1990	-1.4706	-1.0816	0.0645	-0.0251	-0.2505	58.730
1991	-1.3275	-0.0691	0.0645	-0.0812	-0.8105	161.655
1992	-0.8575	-0.4256	0.0645	-0.0279	-0.2782	113.185

1993	-1.5788	-0.4125	0.0645	-0.0753	-0.7512	114.675
1994	-3.5248	-0.7501	0.0645	-0.1790	-1.7870	81.818
1995	-1.6078	-2.2133	0.0645	0.0391	0.3900	18.940

Partial variance for this index is 0.009578

Index 55 MACOM 7
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 8
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1991	-0.1268	-0.5683	0.1790	0.0790	0.7888	504.972
1992	0.3022	-0.1787	0.1790	0.0861	0.8591	745.571
1993	-0.5146	-0.3821	0.1790	-0.0237	-0.2366	608.311
1994	-1.2077	-0.2502	0.1790	-0.1714	-1.7107	694.095
1995	-0.3910	-0.0032	0.1790	-0.0694	-0.6929	888.625
1996	0.5752	0.1076	0.1790	0.0837	0.8355	992.685
1997	0.3476	0.2599	0.1790	0.0157	0.1567	1156.038

Partial variance for this index is 0.009637

Index 56 MACOM 8
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 9
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1991	-0.4448	-0.5415	0.2950	0.0285	0.2847	292.628
1992	-0.0221	-0.3529	0.2950	0.0976	0.9739	353.363
1993	-0.1240	0.1312	0.2950	-0.0753	-0.7515	573.437
1994	-0.5997	-0.0952	0.2950	-0.1488	-1.4854	457.244
1995	0.0413	0.0269	0.2950	0.0043	0.0426	516.606
1996	0.4486	0.1634	0.2950	0.0841	0.8396	592.194
1997	0.2929	0.2603	0.2950	0.0096	0.0961	652.442

Partial variance for this index is 0.00785

Index 57 MACOM 9
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 10
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1991	-1.9033	-1.2950	0.2700	-0.1643	-1.6396	81.003
1992	-0.2125	-0.4241	0.2700	0.0571	0.5704	193.512
1993	-0.0467	-0.1903	0.2700	0.0388	0.3871	244.489
1994	0.0379	0.3278	0.2700	-0.0783	-0.7812	410.436
1995	0.4563	0.0157	0.2700	0.1190	1.1876	300.408
1996	0.3916	0.0388	0.2700	0.0953	0.9510	307.434
1997	-0.0084	0.2421	0.2700	-0.0676	-0.6752	376.760

Partial variance for this index is 0.011374

Index 58 MACOM 10
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 11
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1991	-2.4039	-1.2834	0.1633	-0.1830	-1.8265	48.556
1992	-1.6433	-1.3402	0.1633	-0.0495	-0.4942	45.877
1993	0.0045	-0.3726	0.1633	0.0616	0.6147	120.727
1994	0.5907	-0.2740	0.1633	0.1412	1.4094	133.245
1995	0.2742	0.4606	0.1633	-0.0304	-0.3037	277.747
1996	0.3496	0.0179	0.1633	0.0542	0.5407	178.407
1997	0.1592	0.1226	0.1633	0.0060	0.0598	198.092

Partial variance for this index is 0.011005

Index 59 MACOM 11
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 12
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1991	-2.1077	-1.5513	0.1373	-0.0764	-0.7625	21.132

1992	-2.0060	-1.2677	0.1373	-0.1013	-1.0116	28.062
1993	-1.5081	-1.2001	0.1373	-0.0423	-0.4221	30.024
1994	0.8386	-0.4723	0.1373	0.1800	1.7962	62.162
1995	-0.0554	-0.2064	0.1373	0.0207	0.2068	81.101
1996	0.2090	0.6551	0.1373	-0.0612	-0.6111	191.930
1997	0.7085	0.1213	0.1373	0.0806	0.8046	112.550

Partial variance for this index is 0.010554

Index 60 MACOM 12
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 13
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1991	-1.9810	0.2771	0.0928	-0.2095	-2.0915	72.718
1992	-1.0319	-1.2748	0.0928	0.0225	0.2249	15.405
1993	-1.3749	-1.0149	0.0928	-0.0334	-0.3334	19.978
1994	-0.0116	-1.2135	0.0928	0.1115	1.1133	16.379
1995	0.1688	-0.5215	0.0928	0.0641	0.6393	32.722
1996	0.2162	-0.0046	0.0928	0.0205	0.2045	54.867
1997	1.0435	0.7812	0.0928	0.0243	0.2429	120.386

Partial variance for this index is 0.010922

Index 61 MACOM 13
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 14
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1991	0.5044	0.0184	0.1079	0.0525	0.5235	32.046
1992	-1.3339	0.6454	0.1079	-0.2136	-2.1324	59.992
1993	-1.4881	-1.0067	0.1079	-0.0520	-0.5186	11.497
1994	-0.4466	-0.9185	0.1079	0.0509	0.5084	12.556
1995	-0.9773	-1.0561	0.1079	0.0085	0.0849	10.943
1996	0.0160	-0.4765	0.1079	0.0532	0.5306	19.536
1997	1.0377	0.1060	0.1079	0.1006	1.0037	34.979

Partial variance for this index is 0.011548

Index 62 MACOM 14
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 15
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1991	0.7370	0.8153	0.1847	-0.0145	-0.1443	161.655
1992	0.7821	0.4589	0.1847	0.0597	0.5958	113.185
1993	0.0692	0.4720	0.1847	-0.0744	-0.7423	114.675
1994	-0.6240	0.1344	0.1847	-0.1400	-1.3976	81.818
1995	-0.5657	-1.3289	0.1847	0.1409	1.4066	18.940
1996	-2.2334	-1.8946	0.1847	-0.0626	-0.6244	10.757
1997	-0.8175	-1.3094	0.1847	0.0908	0.9065	19.312

Partial variance for this index is 0.010549

Index 63 CTCPUE 1
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 2
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	0.0478	-1.6219	0.0872	0.1456	1.4529	965.997
1983	0.4487	-1.4183	0.0872	0.1628	1.6245	1184.180
1984	0.6386	-0.7311	0.0872	0.1194	1.1918	2354.198
1985	-0.5464	-0.8458	0.0872	0.0261	0.2605	2099.191
1986	-1.2899	-0.5810	0.0872	-0.0618	-0.6169	2735.591
1987	-1.0066	-0.7450	0.0872	-0.0228	-0.2276	2321.774
1988	-1.7950	-0.5412	0.0872	-0.1093	-1.0910	2846.617
1989	-2.3059	-0.2733	0.0872	-0.1772	-1.7686	3720.883
1990	0.2406	-0.1039	0.0872	0.0300	0.2997	4408.070
1991	-0.1913	0.2490	0.0872	-0.0384	-0.3831	6273.161
1992	-0.3599	-0.0662	0.0872	-0.0256	-0.2556	4577.187
1993	-0.2029	-0.0944	0.0872	-0.0095	-0.0944	4450.173

1994	-1.1019	0.1532	0.0872	-0.1094	-1.0921	5700.070
1995	-0.0274	1.0120	0.0872	-0.0906	-0.9044	13454.891
1996	1.0466	-0.0252	0.0872	0.0934	0.9326	4768.957
1997	0.8066	0.0346	0.0872	0.0673	0.6717	5062.909

Partial variance for this index is 0.00994

Index 64 CTCPUE 2
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 3
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.3486	-1.2327	0.1600	0.1414	1.4118	887.011
1983	-0.7478	-1.4227	0.1600	0.1080	1.0779	733.472
1984	-0.8574	-1.1996	0.1600	0.0548	0.5466	916.811
1985	-0.2962	-0.6925	0.1600	0.0634	0.6328	1522.420
1986	-0.3518	-0.5592	0.1600	0.0332	0.3312	1739.437
1987	-0.8161	-0.2648	0.1600	-0.0882	-0.8805	2334.969
1988	-0.6072	-0.4256	0.1600	-0.0291	-0.2900	1988.072
1989	0.1533	-0.2284	0.1600	0.0611	0.6095	2421.532
1990	0.0777	0.0405	0.1600	0.0060	0.0595	3168.453
1991	0.2621	0.2073	0.1600	0.0088	0.0875	3743.592
1992	0.3999	0.5600	0.1600	-0.0256	-0.2557	5327.089
1993	0.0631	0.2462	0.1600	-0.0293	-0.2923	3892.214
1994	0.4524	0.2116	0.1600	0.0385	0.3846	3759.698
1995	0.3140	0.4497	0.1600	-0.0217	-0.2167	4770.552
1996	0.9840	1.3028	0.1600	-0.0510	-0.5090	11195.996
1997	-1.4121	0.2768	0.1600	-0.2702	-2.6971	4013.018

Partial variance for this index is 0.008889

Index 65 CTCPUE 3
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-1.2555	-1.0120	0.2579	-0.0628	-0.6269	958.182
1983	-1.6579	-1.6132	0.2579	-0.0115	-0.1150	525.213
1984	-1.9672	-1.7333	0.2579	-0.0603	-0.6023	465.796
1985	-0.9287	-1.6466	0.2579	0.1852	1.8482	508.000
1986	-0.9466	-0.7740	0.2579	-0.0445	-0.4443	1215.636
1987	-0.2051	-0.6062	0.2579	0.1035	1.0327	1437.771
1988	-0.5144	-0.2890	0.2579	-0.0582	-0.5805	1974.472
1989	-0.7109	-0.4554	0.2579	-0.0659	-0.6577	1671.720
1990	-0.2008	-0.2715	0.2579	0.0182	0.1820	2009.363
1991	-0.0303	-0.0134	0.2579	-0.0044	-0.0435	2601.033
1992	-0.2831	0.1558	0.2579	-0.1132	-1.1301	3080.473
1993	0.0034	0.5087	0.2579	-0.1303	-1.3009	4384.026
1994	0.0853	0.1834	0.2579	-0.0253	-0.2526	3166.737
1995	0.4273	0.0992	0.2579	0.0846	0.8447	2910.828
1996	0.8534	0.3367	0.2579	0.1333	1.3302	3691.444
1997	1.4311	1.2307	0.2579	0.0517	0.5159	9024.637

Partial variance for this index is 0.008176

Index 66 CTCPUE 4
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 5
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.8038	-1.4417	0.1858	0.1185	1.1828	350.449
1983	-1.2056	-0.8717	0.1858	-0.0620	-0.6189	619.683
1984	-2.0788	-1.6925	0.1858	-0.0718	-0.7163	272.722
1985	-0.8111	-1.5196	0.1858	0.1316	1.3135	324.190
1986	-0.9289	-1.3106	0.1858	0.0709	0.7076	399.573
1987	0.3817	-0.4734	0.1858	0.1588	1.5853	922.918
1988	-0.4081	-0.2197	0.1858	-0.0350	-0.3494	1189.444
1989	-0.5290	0.1016	0.1858	-0.1171	-1.1692	1640.161
1990	-0.6412	-0.0749	0.1858	-0.1052	-1.0501	1374.848
1991	-0.1069	0.0391	0.1858	-0.0271	-0.2707	1540.771
1992	0.1329	0.3183	0.1858	-0.0344	-0.3437	2037.038

1993	-0.0328	0.5088	0.1858	-0.1006	-1.0043	2464.633
1994	0.4698	0.8464	0.1858	-0.0700	-0.6982	3454.222
1995	0.4170	0.5049	0.1858	-0.0163	-0.1631	2455.013
1996	0.6654	0.3482	0.1858	0.0589	0.5880	2098.929
1997	1.0893	0.5464	0.1858	0.1008	1.0065	2559.007

Partial variance for this index is 0.008627

Index 67 CTCPUE 5
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 6
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.7292	-1.6533	0.1495	0.1382	1.3791	198.001
1983	-1.1216	-1.4308	0.1495	0.0462	0.4614	247.361
1984	-2.1696	-0.9655	0.1495	-0.1800	-1.7969	393.927
1985	-1.5336	-1.7570	0.1495	0.0334	0.3333	178.513
1986	-0.9436	-1.5278	0.1495	0.0873	0.8718	224.481
1987	-0.2725	-1.2461	0.1495	0.1456	1.4530	297.529
1988	-0.4956	-0.3463	0.1495	-0.0223	-0.2228	731.647
1989	-0.4415	-0.1117	0.1495	-0.0493	-0.4923	925.145
1990	-0.2614	0.2389	0.1495	-0.0748	-0.7467	1313.637
1991	-0.6947	-0.0191	0.1495	-0.1010	-1.0082	1014.865
1992	-0.5601	0.1252	0.1495	-0.1025	-1.0228	1172.427
1993	-0.0101	0.4227	0.1495	-0.0647	-0.6459	1578.694
1994	0.1694	0.5776	0.1495	-0.0610	-0.6092	1843.099
1995	0.8785	0.9335	0.1495	-0.0082	-0.0821	2630.925
1996	0.9147	0.5287	0.1495	0.0577	0.5760	1755.219
1997	1.2644	0.2242	0.1495	0.1555	1.5523	1294.450

Partial variance for this index is 0.010037

Index 68 CTCPUE 6
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 7
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.8565	-1.7087	0.1687	0.1437	1.4346	124.588
1983	-1.2709	-1.5059	0.1687	0.0396	0.3955	152.608
1984	-2.6846	-1.3612	0.1687	-0.2232	-2.2278	176.353
1985	-1.2709	-0.8607	0.1687	-0.0692	-0.6906	290.906
1986	-1.1683	-1.8013	0.1687	0.1068	1.0657	113.569
1987	-0.9500	-1.4373	0.1687	0.0822	0.8203	163.432
1988	-0.7230	-1.0840	0.1687	0.0609	0.6077	232.706
1989	-0.1112	-0.2433	0.1687	0.0223	0.2225	539.373
1990	-0.0456	0.0277	0.1687	-0.0124	-0.1234	707.309
1991	-0.0456	0.3425	0.1687	-0.0654	-0.6533	968.953
1992	-0.6922	0.1224	0.1687	-0.1374	-1.3714	777.573
1993	-0.2090	0.2726	0.1687	-0.0812	-0.8108	903.540
1994	0.5118	0.5385	0.1687	-0.0045	-0.0450	1178.812
1995	0.9903	0.6890	0.1687	0.0508	0.5072	1370.206
1996	0.8927	0.9816	0.1687	-0.0150	-0.1496	1835.933
1997	1.0451	0.4401	0.1687	0.1020	1.0184	1068.290

Partial variance for this index is 0.009634

Index 69 CTCPUE 7
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 8
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-1.1850	-1.5820	0.1323	0.0525	0.5241	130.822
1983	-1.5905	-2.0169	0.1323	0.0564	0.5629	84.689
1984	-3.9884	-1.7196	0.1323	-0.3001	-2.9951	114.002
1985	-2.4843	-1.5527	0.1323	-0.1232	-1.2299	134.718
1986	-1.3857	-1.1091	0.1323	-0.0366	-0.3652	209.935
1987	-2.4843	-2.0886	0.1323	-0.0523	-0.5224	78.824
1988	-0.9439	-1.6013	0.1323	0.0869	0.8678	128.328
1989	-0.7897	-1.3644	0.1323	0.0760	0.7586	162.626
1990	-0.1817	-0.4121	0.1323	0.0305	0.3041	421.473
1991	0.3157	-0.2314	0.1323	0.0723	0.7221	504.972

1992	-0.1383	0.1583	0.1323	-0.0392	-0.3915	745.571
1993	-0.1277	-0.0452	0.1323	-0.0109	-0.1089	608.311
1994	-0.1277	0.0867	0.1323	-0.0284	-0.2831	694.095
1995	0.7738	0.3338	0.1323	0.0582	0.5808	888.625
1996	0.5279	0.4446	0.1323	0.0110	0.1101	992.685
1997	1.7070	0.5969	0.1323	0.1468	1.4655	1156.038

Partial variance for this index is 0.010982

Index 70 CTCPUE 8
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 9
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-1.4342	-1.4023	0.1172	-0.0037	-0.0374	101.859
1983	-1.8397	-1.4510	0.1172	-0.0455	-0.4545	97.013
1984	-3.7856	-1.7905	0.1172	-0.2338	-2.3334	69.089
1985	-3.3801	-1.4851	0.1172	-0.2220	-2.2163	93.762
1986	-2.0809	-1.4217	0.1172	-0.0772	-0.7709	99.903
1987	-0.5469	-0.9612	0.1172	0.0485	0.4845	158.334
1988	-1.0130	-1.9033	0.1172	0.1043	1.0412	61.721
1989	-1.1466	-1.5528	0.1172	0.0476	0.4751	87.631
1990	-1.0448	-1.2359	0.1172	0.0224	0.2235	120.305
1991	0.3654	-0.3470	0.1172	0.0835	0.8332	292.628
1992	0.3964	-0.1584	0.1172	0.0650	0.6489	353.363
1993	0.5964	0.3258	0.1172	0.0317	0.3165	573.437
1994	-0.1350	0.0993	0.1172	-0.0275	-0.2740	457.244
1995	0.5901	0.2214	0.1172	0.0432	0.4313	516.606
1996	0.7630	0.3579	0.1172	0.0475	0.4737	592.194
1997	1.4455	0.4548	0.1172	0.1161	1.1586	652.442

Partial variance for this index is 0.010731

Index 71 CTCPUE 9
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 10
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-1.5291	-2.0477	0.0544	0.0282	0.2816	58.819
1983	-1.9346	-1.7807	0.0544	-0.0084	-0.0836	76.817
1984	-6.5398	-1.7300	0.0544	-0.2617	-2.6124	80.810
1985	-5.4412	-2.0701	0.0544	-0.1834	-1.8310	57.517
1986	-4.2372	-1.8078	0.0544	-0.1322	-1.3195	74.765
1987	-1.1017	-1.7725	0.0544	0.0365	0.3643	77.452
1988	-0.9413	-1.2527	0.0544	0.0169	0.1691	130.249
1989	-2.2913	-2.4299	0.0544	0.0075	0.0753	40.135
1990	-1.5291	-1.9373	0.0544	0.0222	0.2217	65.683
1991	-0.2669	-1.7276	0.0544	0.0795	0.7934	81.003
1992	0.2287	-0.8568	0.0544	0.0591	0.5896	193.512
1993	0.7396	-0.6230	0.0544	0.0741	0.7400	244.489
1994	0.4633	-0.1049	0.0544	0.0309	0.3086	410.436
1995	1.0358	-0.4170	0.0544	0.0791	0.7891	300.408
1996	0.9886	-0.3939	0.0544	0.0752	0.7509	307.434
1997	1.2139	-0.1905	0.0544	0.0764	0.7628	376.760

Partial variance for this index is 0.010604

Index 72 CTCPUE10
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 11
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-2.0533	-2.1583	0.0654	0.0069	0.0685	33.522
1983	-2.5641	-1.9620	0.0654	-0.0394	-0.3929	40.792
1984	-4.3559	-1.5324	0.0654	-0.1846	-1.8422	62.684
1985	-3.6628	-1.4568	0.0654	-0.1442	-1.4393	67.605
1986	-3.6628	-1.8342	0.0654	-0.1195	-1.1930	46.351
1987	-2.9696	-1.5856	0.0654	-0.0905	-0.9030	59.433
1988	-1.5833	-1.5135	0.0654	-0.0046	-0.0456	63.880
1989	-2.9696	-1.0002	0.0654	-0.1287	-1.2849	106.726
1990	-1.7168	-2.2358	0.0654	0.0339	0.3386	31.020

1991	-0.8295	-1.7878	0.0654	0.0626	0.6252	48.556
1992	-0.1970	-1.8445	0.0654	0.1077	1.0749	45.877
1993	0.8698	-0.8769	0.0654	0.1142	1.1397	120.727
1994	0.9324	-0.7783	0.0654	0.1118	1.1161	133.245
1995	1.2717	-0.0438	0.0654	0.0860	0.8583	277.747
1996	1.0908	-0.4864	0.0654	0.1031	1.0291	178.407
1997	0.9222	-0.3817	0.0654	0.0852	0.8508	198.092

Partial variance for this index is 0.011033

Index 73 CTCPUE11
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 12
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-3.1234	-0.9876	0.0644	-0.1375	-1.3720	63.906
1983	-3.1234	-2.2193	0.0644	-0.0582	-0.5808	18.648
1984	-2.4302	-1.7161	0.0644	-0.0460	-0.4588	30.843
1986	-3.1234	-1.0974	0.0644	-0.1304	-1.3015	57.261
1988	-1.7371	-1.2377	0.0644	-0.0321	-0.3208	49.763
1989	-4.0397	-1.2025	0.0644	-0.1826	-1.8226	51.549
1991	-1.5139	-2.0942	0.0644	0.0373	0.3728	21.132
1992	-1.0439	-1.8106	0.0644	0.0493	0.4925	28.062
1993	-0.0789	-1.7430	0.0644	0.1071	1.0690	30.024
1994	0.8469	-1.0153	0.0644	0.1199	1.1962	62.162
1995	1.1251	-0.7493	0.0644	0.1206	1.2041	81.101
1996	0.8656	0.1121	0.0644	0.0485	0.4840	191.930
1997	1.1941	-0.4216	0.0644	0.1040	1.0379	112.550

Partial variance for this index is 0.011308

Index 74 CTCPUE12
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 13
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-2.0477	-1.6235	0.0748	-0.0317	-0.3165	24.795
1983	-2.6455	-1.0895	0.0748	-0.1163	-1.1611	42.295
1984	-4.3503	-2.4582	0.0748	-0.1415	-1.4118	10.762
1985	-2.7408	-1.5658	0.0748	-0.0878	-0.8768	26.268
1986	-2.5585	-1.0245	0.0748	-0.1147	-1.1446	45.136
1988	-2.0477	-1.4408	0.0748	-0.0454	-0.4529	29.767
1991	-1.1314	-0.5476	0.0748	-0.0436	-0.4356	72.718
1992	-2.0477	-2.0995	0.0748	0.0039	0.0386	15.405
1993	-1.3545	-1.8396	0.0748	0.0363	0.3619	19.978
1994	-0.2559	-2.0382	0.0748	0.1332	1.3299	16.379
1995	1.2104	-1.3461	0.0748	0.1911	1.9076	32.722
1996	0.1495	-0.8293	0.0748	0.0732	0.7304	54.867
1997	1.8743	-0.0435	0.0748	0.1434	1.4310	120.386

Partial variance for this index is 0.011965

Index 75 CTCPUE13
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 14
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-1.1583	-0.7534	0.0731	-0.0296	-0.2953	21.405
1983	-2.0746	-0.9163	0.0731	-0.0846	-0.8447	18.187
1984	-1.6692	-0.3558	0.0731	-0.0960	-0.9578	31.857
1985	-1.8515	-1.8399	0.0731	-0.0008	-0.0084	7.222
1988	-1.2637	-0.1798	0.0731	-0.0792	-0.7905	37.988
1989	-1.3815	-0.6646	0.0731	-0.0524	-0.5229	23.394
1991	-0.5705	-0.3499	0.0731	-0.0161	-0.1609	32.046
1992	-2.3623	0.2772	0.0731	-0.1929	-1.9250	59.992
1993	-1.0630	-1.3750	0.0731	0.0228	0.2275	11.497
1994	0.2527	-1.2868	0.0731	0.1125	1.1227	12.556
1995	0.8698	-1.4243	0.0731	0.1676	1.6731	10.943
1996	0.6822	-0.8448	0.0731	0.1116	1.1136	19.536
1997	1.6143	-0.2623	0.0731	0.1371	1.3686	34.979

Partial variance for this index is 0.01157

Index 76 CTCPUE14
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 15
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-0.1115	-0.5616	0.0818	0.0368	0.3674	42.127
1983	-0.7401	-1.2909	0.0818	0.0450	0.4496	20.315
1984	-2.4141	-0.7550	0.0818	-0.1357	-1.3544	34.720
1986	-2.1264	-0.2214	0.0818	-0.1558	-1.5551	59.198
1987	0.8818	0.6333	0.0818	0.0203	0.2029	139.148
1988	-0.4217	-0.3547	0.0818	-0.0055	-0.0547	51.810
1991	-0.1454	0.7832	0.0818	-0.0759	-0.7580	161.655
1992	-1.1148	0.4268	0.0818	-0.1261	-1.2584	113.185
1993	-0.4682	0.4398	0.0818	-0.0743	-0.7412	114.675
1994	0.9181	0.1022	0.0818	0.0667	0.6660	81.818
1995	0.1249	-1.3610	0.0818	0.1215	1.2130	18.940
1996	-0.6795	-1.9267	0.0818	0.1020	1.0182	10.757
1997	0.8693	-1.3415	0.0818	0.1808	1.8048	19.312

Partial variance for this index is 0.011551

Index 81 HDSHAD 6
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 6
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-4.1871	-1.8719	0.1070	-0.2477	-2.4724	198.001
1983	-3.0384	-1.6493	0.1070	-0.1486	-1.4835	247.361
1984	-0.7408	-1.1840	0.1070	0.0474	0.4734	393.927
1985	-2.3576	-1.9755	0.1070	-0.0409	-0.4080	178.513
1986	-1.1799	-1.7464	0.1070	0.0606	0.6050	224.481
1987	-0.5824	-1.4647	0.1070	0.0944	0.9422	297.529
1988	-0.3111	-0.5649	0.1070	0.0272	0.2711	731.647
1989	0.4625	-0.3302	0.1070	0.0848	0.8466	925.145
1990	0.0832	0.0204	0.1070	0.0067	0.0671	1313.637
1991	-0.5845	-0.2377	0.1070	-0.0371	-0.3704	1014.865
1992	0.1355	-0.0933	0.1070	0.0245	0.2444	1172.427
1993	1.1821	0.2042	0.1070	0.1046	1.0444	1578.694
1994	1.0424	0.3590	0.1070	0.0731	0.7298	1843.099
1995	0.2565	0.7149	0.1070	-0.0490	-0.4896	2630.925

Partial variance for this index is 0.010067

Index 82 HDSHAD 7
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 7
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1982	-2.6572	-1.8105	0.1018	-0.0862	-0.8603	124.588
1983	-3.5552	-1.6077	0.1018	-0.1983	-1.9788	152.608
1984	-1.3183	-1.4630	0.1018	0.0147	0.1470	176.353
1985	-1.6490	-0.9625	0.1018	-0.0699	-0.6975	290.906
1986	-1.5836	-1.9031	0.1018	0.0325	0.3246	113.569
1987	-0.3546	-1.5391	0.1018	0.1206	1.2035	163.432
1988	-0.1359	-1.1858	0.1018	0.1069	1.0667	232.706
1989	0.4439	-0.3451	0.1018	0.0803	0.8017	539.373
1990	0.5822	-0.0741	0.1018	0.0668	0.6668	707.309
1991	-0.0103	0.2407	0.1018	-0.0255	-0.2550	968.953
1992	-1.4871	0.0206	0.1018	-0.1535	-1.5321	777.573
1993	0.6683	0.1708	0.1018	0.0507	0.5056	903.540
1994	1.3406	0.4367	0.1018	0.0920	0.9184	1178.812
1995	0.2814	0.5872	0.1018	-0.0311	-0.3108	1370.206

Partial variance for this index is 0.009861

Index 83 HDSHAD 8
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 8
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize

1982	-2.7160	-1.4434	0.0858	-0.1092	-1.0904	130.822
1983	-2.8030	-1.8782	0.0858	-0.0794	-0.7923	84.689
1984	-3.8146	-1.5810	0.0858	-0.1917	-1.9137	114.002
1985	-1.8687	-1.4140	0.0858	-0.0390	-0.3895	134.718
1986	-1.6455	-0.9704	0.0858	-0.0580	-0.5784	209.935
1987	-1.3507	-1.9500	0.0858	0.0514	0.5134	78.824
1988	-0.2736	-1.4626	0.0858	0.1021	1.0187	128.328
1989	0.6043	-1.2257	0.0858	0.1571	1.5679	162.626
1990	0.8226	-0.2734	0.0858	0.0941	0.9391	421.473
1991	0.7419	-0.0927	0.0858	0.0716	0.7151	504.972
1992	0.8006	0.2970	0.0858	0.0432	0.4315	745.571
1993	0.8606	0.0935	0.0858	0.0658	0.6572	608.311
1994	0.1973	0.2254	0.0858	-0.0024	-0.0241	694.095
1995	-0.7582	0.4725	0.0858	-0.1056	-1.0545	888.625

Partial variance for this index is 0.010095

Index 92 NY OHS 4
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 4
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1988	-0.4797	-0.8423	0.1751	0.0635	0.6336	1974.472
1989	-0.7142	-1.0087	0.1751	0.0516	0.5147	1671.720
1990	-1.4796	-0.8248	0.1751	-0.1146	-1.1443	2009.363
1991	-0.3978	-0.5667	0.1751	0.0296	0.2950	2601.033
1992	-0.2545	-0.3975	0.1751	0.0250	0.2498	3080.473
1993	-0.7248	-0.0446	0.1751	-0.1191	-1.1885	4384.026
1994	-0.1987	-0.3699	0.1751	0.0300	0.2991	3166.737
1995	-0.3660	-0.4541	0.1751	0.0154	0.1540	2910.828
1996	-1.0125	-0.2166	0.1751	-0.1393	-1.3907	3691.444
1997	1.5801	0.6774	0.1751	0.1580	1.5774	9024.637

Partial variance for this index is 0.009234

Index 93 NY OHS 5
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 5
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1988	0.5994	-0.6442	0.1513	0.1881	1.8775	1189.444
1989	0.0160	-0.3228	0.1513	0.0513	0.5115	1640.161
1990	-1.3261	-0.4993	0.1513	-0.1251	-1.2482	1374.848
1991	-0.0880	-0.3854	0.1513	0.0450	0.4489	1540.771
1992	0.0681	-0.1061	0.1513	0.0264	0.2631	2037.038
1993	-0.2897	0.0844	0.1513	-0.0566	-0.5648	2464.633
1994	0.3295	0.4220	0.1513	-0.0140	-0.1395	3454.222
1995	-0.3957	0.0805	0.1513	-0.0720	-0.7189	2455.013
1996	-0.7149	-0.0762	0.1513	-0.0966	-0.9643	2098.929
1997	0.4762	0.1220	0.1513	0.0536	0.5347	2559.007

Partial variance for this index is 0.008792

Index 94 NY OHS 6
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 6
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1988	0.9675	-0.7834	0.1063	0.1861	1.8573	731.647
1989	0.4269	-0.5487	0.1063	0.1037	1.0349	925.145
1990	-0.3670	-0.1981	0.1063	-0.0179	-0.1791	1313.637
1991	-0.4175	-0.4562	0.1063	0.0041	0.0411	1014.865
1992	-0.5803	-0.3119	0.1063	-0.0285	-0.2847	1172.427
1993	-0.4175	-0.0143	0.1063	-0.0428	-0.4276	1578.694
1994	-0.0634	0.1405	0.1063	-0.0217	-0.2163	1843.099
1995	0.0724	0.4964	0.1063	-0.0451	-0.4498	2630.925
1996	-1.4317	0.0917	0.1063	-0.1619	-1.6159	1755.219
1997	0.0136	-0.2129	0.1063	0.0241	0.2402	1294.450

Partial variance for this index is 0.008848

Index 95 NY OHS 7
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 7
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1988	0.5975	-1.4246	0.0916	0.1853	1.8494	232.706
1989	0.5108	-0.5840	0.0916	0.1003	1.0013	539.373
1990	-0.1131	-0.3129	0.0916	0.0183	0.1828	707.309
1991	0.2877	0.0018	0.0916	0.0262	0.2614	968.953
1992	-0.7251	-0.2182	0.0916	-0.0464	-0.4636	777.573
1993	-0.9418	-0.0680	0.0916	-0.0801	-0.7991	903.540
1994	0.1241	0.1979	0.0916	-0.0068	-0.0675	1178.812
1995	0.1834	0.3483	0.0916	-0.0151	-0.1509	1370.206
1996	-0.7382	0.6409	0.0916	-0.1264	-1.2613	1835.933
1997	-0.5046	0.0994	0.0916	-0.0553	-0.5524	1068.290

Partial variance for this index is 0.008351

Index 96 NY OHS 8
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 8
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1988	0.1714	-1.4852	0.0912	0.1510	1.5072	128.328
1989	-0.0562	-1.2483	0.0912	0.1087	1.0847	162.626
1990	0.2147	-0.2960	0.0912	0.0466	0.4647	421.473
1991	0.5192	-0.1153	0.0912	0.0578	0.5773	504.972
1992	0.0980	0.2744	0.0912	-0.0161	-0.1605	745.571
1993	-0.8424	0.0709	0.0912	-0.0833	-0.8310	608.311
1994	-0.2519	0.2029	0.0912	-0.0415	-0.4138	694.095
1995	0.3038	0.4499	0.0912	-0.0133	-0.1329	888.625
1996	-0.8924	0.5607	0.0912	-0.1325	-1.3221	992.685
1997	-0.1371	0.7130	0.0912	-0.0775	-0.7735	1156.038

Partial variance for this index is 0.008291

Index 97 NY OHS 9
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 9
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1988	-0.7770	-1.7189	0.0961	0.0905	0.9031	61.721
1989	-0.3026	-1.3684	0.0961	0.1024	1.0220	87.631
1990	-0.6435	-1.0515	0.0961	0.0392	0.3912	120.305
1991	0.7428	-0.1626	0.0961	0.0870	0.8682	292.628
1992	0.8744	0.0260	0.0961	0.0815	0.8135	353.363
1993	0.1393	0.5101	0.0961	-0.0356	-0.3556	573.437
1994	-0.2806	0.2837	0.0961	-0.0542	-0.5411	457.244
1995	-0.0839	0.4058	0.0961	-0.0470	-0.4695	516.606
1996	-1.0647	0.5423	0.0961	-0.1544	-1.5410	592.194
1997	-0.4983	0.6392	0.0961	-0.1093	-1.0908	652.442

Partial variance for this index is 0.00873

Index 98 NY OHS10
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 10
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1988	-0.9029	-0.5377	0.1057	-0.0386	-0.3851	130.249
1989	-1.0460	-1.7149	0.1057	0.0707	0.7055	40.135
1990	-1.4137	-1.2223	0.1057	-0.0202	-0.2019	65.683
1991	0.2392	-1.0127	0.1057	0.1323	1.3203	81.003
1992	0.7711	-0.1418	0.1057	0.0965	0.9628	193.512
1993	0.5322	0.0920	0.1057	0.0465	0.4643	244.489
1994	0.4321	0.6101	0.1057	-0.0188	-0.1877	410.436
1995	0.4144	0.2980	0.1057	0.0123	0.1228	300.408
1996	-0.9719	0.3211	0.1057	-0.1366	-1.3637	307.434
1997	-0.8383	0.5245	0.1057	-0.1440	-1.4373	376.760

Partial variance for this index is 0.008634

Index 99 NYOHS 11
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 11
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1989	-1.3581	-0.1770	0.1007	-0.1189	-1.1871	106.726
1990	-0.9061	-1.4126	0.1007	0.0510	0.5090	31.020
1991	-0.3596	-0.9645	0.1007	0.0609	0.6080	48.556
1992	0.2795	-1.0213	0.1007	0.1310	1.3073	45.877
1993	0.4095	-0.0537	0.1007	0.0466	0.4656	120.727
1994	0.5026	0.0449	0.1007	0.0461	0.4600	133.245
1995	0.7564	0.7795	0.1007	-0.0023	-0.0232	277.747
1996	-0.5314	0.3368	0.1007	-0.0874	-0.8726	178.407
1997	-0.8191	0.4415	0.1007	-0.1269	-1.2669	198.092

Partial variance for this index is 0.008445

Index 100 NYOHS 12
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 12
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1988	-2.3795	-0.8205	0.0643	-0.1002	-0.9999	49.763
1989	-1.6864	-0.7852	0.0643	-0.0579	-0.5780	51.549
1990	-1.6864	-0.2414	0.0643	-0.0928	-0.9267	88.798
1991	-0.9933	-1.6769	0.0643	0.0439	0.4385	21.132
1992	-0.1823	-1.3933	0.0643	0.0778	0.7767	28.062
1993	0.3930	-1.3257	0.0643	0.1104	1.1023	30.024
1994	1.0544	-0.5980	0.0643	0.1062	1.0597	62.162
1995	0.9527	-0.3320	0.0643	0.0825	0.8239	81.101
1996	0.2595	0.5294	0.0643	-0.0173	-0.1731	191.930
1997	-2.3795	-0.0043	0.0643	-0.1526	-1.5233	112.550

Partial variance for this index is 0.009557

Index 101 NYOHS 13
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 13
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1990	-2.4108	-0.1359	0.0704	-0.1601	-1.5978	42.513
1992	-0.3314	-1.1510	0.0704	0.0577	0.5757	15.405
1993	-0.2136	-0.8911	0.0704	0.0477	0.4758	19.978
1994	0.0741	-1.0897	0.0704	0.0819	0.8174	16.379
1995	1.0549	-0.3976	0.0704	0.1022	1.0202	32.722
1996	-0.8014	0.1192	0.0704	-0.0648	-0.6466	54.867
1997	-0.0129	0.9050	0.0704	-0.0646	-0.6447	120.386

Partial variance for this index is 0.009825

Index 102 NYOHS 14
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 14
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1988	-1.0986	0.1269	0.0816	-0.1001	-0.9987	37.988
1989	0.8473	-0.3578	0.0816	0.0984	0.9820	23.394
1990	-1.0986	-0.0276	0.0816	-0.0874	-0.8727	32.547
1991	-1.0986	-0.0432	0.0816	-0.0862	-0.8601	32.046
1992	-0.4055	0.5839	0.0816	-0.0808	-0.8062	59.992
1993	-1.0986	-1.0682	0.0816	-0.0025	-0.0247	11.497
1994	0.2877	-0.9801	0.0816	0.1035	1.0331	12.556
1995	0.6931	-1.1176	0.0816	0.1478	1.4756	10.943
1996	0.6931	-0.5381	0.0816	0.1005	1.0033	19.536
1997	-1.0986	0.0444	0.0816	-0.0933	-0.9315	34.979

Partial variance for this index is 0.01056

Index 103 NYOHS 15
Index is tuned to the sum of Jan1 full stock sizes (in number) for ages: 14
SORTED BY YEAR

Yr	Observed	Pred	Weight	Wt Res	Std Res	Pred Stocksize
1988	0.1431	0.1448	0.1023	-0.0002	-0.0017	37.988
1989	-0.9555	-0.3400	0.1023	-0.0630	-0.6287	23.394
1990	-0.9555	-0.0098	0.1023	-0.0968	-0.9660	32.547
1991	-0.9555	-0.0253	0.1023	-0.0952	-0.9501	32.046
1992	1.1239	0.6017	0.1023	0.0534	0.5334	59.992
1993	-0.2624	-1.0504	0.1023	0.0806	0.8049	11.497
1994	-0.2624	-0.9623	0.1023	0.0716	0.7149	12.556
1995	0.8362	-1.0998	0.1023	0.1981	1.9775	10.943
1996	-0.9555	-0.5202	0.1023	-0.0445	-0.4446	19.536
1997	-0.9555	0.0622	0.1023	-0.1042	-1.0396	34.979

Partial variance for this index is 0.010138

Percent of total sum of squares by index & yr; with row/column sums

□	1982	1983	1984	1985	1986	1987	1988	1989	1990
2 □	0.21	0.13	0.22	0.10	0.29	0.20	0.04	0.21	0.01
3 □	1.84	0.00	0.09	0.01	0.17	0.01	0.01	0.00	0.04
4 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.00
5 □	0.00	0.38	0.15	0.00	0.04	0.01	0.04	0.52	0.05
6 □	0.02	0.09	0.00	0.01	0.17	0.01	1.18	0.02	0.03
9 □	-99.00	-99.00	-99.00	0.04	0.02	0.23	0.02	0.30	0.38
10 □	0.01	0.33	1.59	0.08	0.04	0.01	0.01	0.02	0.07
12 □	-99.00	-99.00	-99.00	0.39	0.23	0.28	0.05	0.01	0.00
13 □	-99.00	-99.00	-99.00	0.50	0.17	0.14	0.02	0.00	0.02
14 □	-99.00	-99.00	-99.00	0.05	0.85	0.06	0.02	0.01	0.10
15 □	-99.00	-99.00	-99.00	0.02	0.21	1.18	0.03	0.00	0.04
16 □	-99.00	-99.00	-99.00	0.01	0.18	0.46	0.50	0.23	0.02
17 □	-99.00	-99.00	-99.00	0.04	0.04	0.21	0.70	0.34	0.24
18 □	-99.00	-99.00	-99.00	0.19	0.14	0.01	-99.00	0.99	0.23
19 □	-99.00	-99.00	-99.00	0.00	0.06	0.89	-99.00	-99.00	0.24
20 □	-99.00	-99.00	-99.00	0.07	0.05	-99.00	0.17	0.06	0.44
21 □	-99.00	-99.00	-99.00	0.03	-99.00	-99.00	-99.00	-99.00	0.52
22 □	-99.00	-99.00	-99.00	0.10	-99.00	-99.00	0.63	0.06	0.10
23 □	-99.00	-99.00	-99.00	0.21	0.04	-99.00	-99.00	-99.00	0.04
24 □	-99.00	-99.00	-99.00	0.06	0.03	0.36	0.20	-99.00	0.27
25 □	-99.00	-99.00	-99.00	0.36	0.12	0.11	0.11	0.05	0.01
55 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00
56 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00
57 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00
58 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00
59 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00
60 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00
61 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00
62 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00
63 □	0.34	0.43	0.23	0.01	0.06	0.01	0.19	0.51	0.01
64 □	0.32	0.19	0.05	0.07	0.02	0.13	0.01	0.06	0.00
65 □	0.06	0.00	0.06	0.56	0.03	0.17	0.05	0.07	0.01
66 □	0.23	0.06	0.08	0.28	0.08	0.41	0.02	0.22	0.18
67 □	0.31	0.03	0.53	0.02	0.12	0.34	0.01	0.04	0.09
68 □	0.33	0.03	0.81	0.08	0.18	0.11	0.06	0.01	0.00
69 □	0.04	0.05	1.46	0.25	0.02	0.04	0.12	0.09	0.02
70 □	0.00	0.03	0.89	0.80	0.10	0.04	0.18	0.04	0.01
71 □	0.01	0.00	1.11	0.55	0.28	0.02	0.00	0.00	0.01
72 □	0.00	0.03	0.55	0.34	0.23	0.13	0.00	0.27	0.02
73 □	0.31	0.05	0.03	-99.00	0.28	-99.00	0.02	0.54	-99.00
74 □	0.02	0.22	0.32	0.12	0.21	-99.00	0.03	-99.00	-99.00
75 □	0.01	0.12	0.15	0.00	-99.00	-99.00	0.10	0.04	-99.00
76 □	0.02	0.03	0.30	-99.00	0.39	0.01	0.00	-99.00	-99.00
81 □	0.99	0.36	0.04	0.03	0.06	0.14	0.01	0.12	0.00
82 □	0.12	0.64	0.00	0.08	0.02	0.24	0.19	0.10	0.07
83 □	0.19	0.10	0.60	0.02	0.05	0.04	0.17	0.40	0.14
92 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.07	0.04	0.21
93 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.57	0.04	0.25
94 □	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.56	0.17	0.01

95	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.56	0.16	0.01
96	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.37	0.19	0.04
97	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.13	0.17	0.02
98	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.02	0.08	0.01
99	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.23	0.04
**	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.16	0.05	0.14
**	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.42
**	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.16	0.16	0.12
**	-99.00	-99.00	-99.00	-99.00	-99.00	-99.00	0.00	0.06	0.15
**	5.41	3.30	9.26	5.46	4.98	5.99	7.53	6.70	4.82

	1991	1992	1993	1994	1995	1996	1997	SUM
2	0.04	0.30	0.02	0.23	0.02	0.01	0.37	2.39
3	0.07	0.01	0.06	0.02	0.06	0.14	0.02	2.56
4	0.33	0.08	0.39	0.02	0.08	0.02	0.07	0.98
5	0.29	0.08	0.03	0.15	0.30	0.08	0.30	2.41
6	0.00	0.40	0.03	0.02	0.15	0.14	0.02	2.30
9	0.10	0.15	0.02	0.08	0.09	0.15	0.43	2.01
10	0.04	0.00	0.01	0.08	0.00	0.02	-99.00	2.31
12	0.00	0.02	0.01	0.15	0.05	0.18	0.48	1.86
13	0.00	0.00	0.03	0.68	0.13	0.00	0.07	1.78
14	0.08	0.01	0.00	0.16	0.11	0.02	0.37	1.83
15	0.00	0.03	0.00	0.05	0.04	0.11	0.05	1.76
16	0.00	0.09	0.00	0.16	0.14	0.02	0.01	1.83
17	0.00	0.14	0.07	0.22	0.00	0.05	0.07	2.12
18	0.07	0.03	0.09	0.01	0.00	0.11	0.00	1.87
19	0.06	0.06	0.03	0.00	0.13	0.21	0.03	1.71
20	0.19	0.11	0.04	0.08	0.18	0.43	0.13	1.94
21	0.03	0.10	0.04	0.05	0.25	0.26	0.17	1.45
22	-99.00	-99.00	0.00	0.02	0.35	0.07	0.08	1.40
23	0.40	0.31	0.01	0.05	0.30	0.09	0.00	1.45
24	0.12	0.00	0.06	-99.00	-99.00	-99.00	-99.00	1.10
25	0.11	0.01	0.09	0.52	0.02	-99.00	-99.00	1.52
55	0.10	0.12	0.01	0.48	0.08	0.11	0.00	0.90
56	0.01	0.15	0.09	0.36	0.00	0.11	0.00	0.73
57	0.44	0.05	0.02	0.10	0.23	0.15	0.07	1.06
58	0.54	0.04	0.06	0.32	0.01	0.05	0.00	1.03
59	0.09	0.17	0.03	0.52	0.01	0.06	0.11	0.99
60	0.71	0.01	0.02	0.20	0.07	0.01	0.01	1.02
61	0.04	0.74	0.04	0.04	0.00	0.05	0.16	1.08
62	0.00	0.06	0.09	0.32	0.32	0.06	0.13	0.99
63	0.02	0.01	0.00	0.19	0.13	0.14	0.07	2.38
64	0.00	0.01	0.01	0.02	0.01	0.04	1.18	2.13
65	0.00	0.21	0.28	0.01	0.12	0.29	0.04	1.96
66	0.01	0.02	0.16	0.08	0.00	0.06	0.16	2.06
67	0.17	0.17	0.07	0.06	0.00	0.05	0.39	2.40
68	0.07	0.31	0.11	0.00	0.04	0.00	0.17	2.31
69	0.08	0.02	0.00	0.01	0.05	0.00	0.35	2.63
70	0.11	0.07	0.02	0.01	0.03	0.04	0.22	2.57
71	0.10	0.06	0.09	0.02	0.10	0.09	0.09	2.54
72	0.06	0.19	0.21	0.20	0.12	0.17	0.12	2.64
73	0.02	0.04	0.19	0.23	0.24	0.04	0.18	2.16
74	0.03	0.00	0.02	0.29	0.59	0.09	0.33	2.28
75	0.00	0.60	0.01	0.20	0.46	0.20	0.30	2.21
76	0.09	0.26	0.09	0.07	0.24	0.17	0.53	2.20
81	0.02	0.01	0.18	0.09	0.04	-99.00	-99.00	2.08
82	0.01	0.38	0.04	0.14	0.02	-99.00	-99.00	2.04
83	0.08	0.03	0.07	0.00	0.18	-99.00	-99.00	2.09
92	0.01	0.01	0.23	0.01	0.00	0.31	0.40	1.31
93	0.03	0.01	0.05	0.00	0.08	0.15	0.05	1.25
94	0.00	0.01	0.03	0.01	0.03	0.42	0.01	1.26
95	0.01	0.03	0.10	0.00	0.00	0.26	0.05	1.19
96	0.05	0.00	0.11	0.03	0.00	0.28	0.10	1.18
97	0.12	0.11	0.02	0.05	0.04	0.39	0.19	1.24
98	0.28	0.15	0.04	0.01	0.00	0.30	0.34	1.23
99	0.06	0.28	0.04	0.03	0.00	0.12	0.26	1.06
**	0.03	0.10	0.20	0.18	0.11	0.00	0.38	1.36

** ▯	-99.00	0.05	0.04	0.11	0.17	0.07	0.07	0.92
** ▯	0.12	0.11	0.00	0.17	0.35	0.16	0.14	1.50
** ▯	0.15	0.05	0.11	0.08	0.64	0.03	0.18	1.44
** ▯	5.65	6.59	3.90	7.42	6.93	6.58	9.48	100.00

-99 in the above table indicates a missing value

Partial variance (and proportion of total) by index

▯	2	3	4	5	6	9
** ▯	0.00998050	0.01068167	0.00896165	0.01007822	0.00962666	0.01055901
** ▯	0.01715479	0.01835998	0.01540356	0.01732277	0.01654661	0.01814915

▯	10	12	13	14	15	16
** ▯	0.01033875	0.00973983	0.00931137	0.00960127	0.00921356	0.00958134
** ▯	0.01777056	0.01674112	0.01600467	0.01650296	0.01583656	0.01646871

▯	17	18	19	20	21	22
** ▯	0.01111807	0.01069255	0.01076888	0.01112361	0.01151662	0.01113247
** ▯	0.01911009	0.01837869	0.01850988	0.01911960	0.01979513	0.01913484

▯	23	24	25	55	56	57
** ▯	0.01021613	0.01005744	0.00957802	0.00963715	0.00784953	0.01137367
** ▯	0.01755980	0.01728705	0.01646300	0.01656463	0.01349201	0.01954941

▯	58	59	60	61	62	63
** ▯	0.01100540	0.01055387	0.01092233	0.01154821	0.01054949	0.00993955
** ▯	0.01891642	0.01814033	0.01877364	0.01984942	0.01813280	0.01708441

▯	64	65	66	67	68	69
** ▯	0.00888899	0.00817626	0.00862695	0.01003655	0.00963354	0.01098197
** ▯	0.01527868	0.01405361	0.01482827	0.01725113	0.01655843	0.01887615

▯	70	71	72	73	74	75
** ▯	0.01073125	0.01060354	0.01103317	0.01130780	0.01196470	0.01156952
** ▯	0.01844520	0.01822569	0.01896416	0.01943620	0.02056531	0.01988606

▯	76	81	82	83	92	93
** ▯	0.01155054	0.01006672	0.00986112	0.01009514	0.00923380	0.00879187
** ▯	0.01985343	0.01730300	0.01694961	0.01735184	0.01587135	0.01511174

▯	94	95	96	97	98	99
** ▯	0.00884841	0.00835145	0.00829116	0.00873015	0.00863390	0.00844544
** ▯	0.01520893	0.01435474	0.01425110	0.01500566	0.01484022	0.01451629

▯	100	101	102	103	********
** ▯	0.00955677	0.00982483	0.01056032	0.01013797	0.58179068
** ▯	0.01642647	0.01688723	0.01815141	0.01742546	1.00000000

STOCK NUMBERS (Jan 1) in thousands

▯	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1 ▯	1378	2739	2445	3180	2710	3309	4326	5122	7291	5320	5174
2 ▯	966	1184	2354	2099	2736	2322	2847	3721	4408	6273	4577
3 ▯	887	733	917	1522	1739	2335	1988	2422	3168	3744	5327
4 ▯	958	525	466	508	1216	1438	1974	1672	2009	2601	3080
5 ▯	350	620	273	324	400	923	1189	1640	1375	1541	2037

6	198	247	394	179	224	298	732	925	1314	1015	1172
7	125	153	176	291	114	163	233	539	707	969	778
8	131	85	114	135	210	79	128	163	421	505	746
9	102	97	69	94	100	158	62	88	120	293	353
10	59	77	81	58	75	77	130	40	66	81	194
11	34	41	63	68	46	59	64	107	31	49	46
12	64	19	31	53	57	37	50	52	89	21	28
13	25	42	11	26	45	48	30	40	43	73	15
14	21	18	32	7	22	38	38	23	33	32	60
15	42	20	35	71	59	139	52	79	59	162	113
1+	5339	6600	7460	8615	9753	11423	13842	16632	21134	22677	23701

	1993	1994	1995	1996	1997
1	6623	15638	5545	5883	15099
2	4450	5700	13455	4769	5063
3	3892	3760	4771	11196	4013
4	4384	3167	2911	3691	9025
5	2465	3454	2455	2099	2559
6	1579	1843	2631	1755	1294
7	904	1179	1370	1836	1068
8	608	694	889	993	1156
9	573	457	517	592	652
10	244	410	300	307	377
11	121	133	278	178	198
12	30	62	81	192	113
13	20	16	33	55	120
14	11	13	11	20	35
15	115	82	19	11	19
1+	26019	36609	35264	33577	40792

Summaries for ages 3-8 3-13 4-13 5-13

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
3	2649	2363	2340	2959	3903	5235	6245	7361	8995	10374	13140	13831
3	2932	2639	2594	3257	4226	5615	6580	7686	9343	10890	13776	14820
4	2045	1905	1677	1735	2487	3280	4592	5265	6175	7147	8449	10928
5	1087	1380	1211	1227	1271	1842	2618	3593	4166	4546	5369	6544

	1994	1995	1996	1997
3	14097	15026	21570	19115
3	15176	16235	22895	20576
4	11416	11464	11699	16563
5	8250	8553	8008	7538

FISHING MORTALITY

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.13	0.11	0.29	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.03	0.02
3	0.37	0.30	0.44	0.08	0.04	0.02	0.02	0.04	0.05	0.04	0.04	0.06	0.11	0.11	0.07
4	0.29	0.51	0.21	0.09	0.13	0.04	0.04	0.05	0.12	0.09	0.07	0.09	0.10	0.18	0.22
5	0.20	0.30	0.27	0.22	0.14	0.08	0.10	0.07	0.15	0.12	0.10	0.14	0.12	0.19	0.33
6	0.11	0.19	0.15	0.30	0.17	0.10	0.15	0.12	0.15	0.12	0.11	0.14	0.15	0.21	0.35
7	0.24	0.14	0.12	0.18	0.22	0.09	0.21	0.10	0.19	0.11	0.10	0.11	0.13	0.17	0.31
8	0.15	0.05	0.05	0.15	0.13	0.09	0.23	0.15	0.21	0.21	0.11	0.14	0.15	0.26	0.27
9	0.13	0.03	0.03	0.08	0.10	0.05	0.28	0.14	0.25	0.26	0.22	0.18	0.27	0.37	0.30
10	0.22	0.05	0.03	0.07	0.08	0.04	0.05	0.11	0.15	0.42	0.32	0.46	0.24	0.37	0.29
11	0.44	0.13	0.01	0.02	0.08	0.03	0.06	0.03	0.23	0.40	0.27	0.51	0.35	0.22	0.31
12	0.26	0.40	0.01	0.02	0.03	0.06	0.07	0.04	0.05	0.17	0.19	0.46	0.49	0.24	0.32
13	0.16	0.13	0.25	0.02	0.02	0.08	0.09	0.05	0.13	0.04	0.14	0.31	0.25	0.37	0.30

14	0.23	0.28	0.16	0.14	0.13	0.06	0.09	0.08	0.15	0.13	0.10	0.13	0.14	0.21	0.30
15	0.23	0.28	0.16	0.14	0.13	0.06	0.09	0.08	0.15	0.13	0.10	0.13	0.14	0.21	0.30

Avg F for ages 3-8 3-13 4-13 5-13

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
3	0.23	0.25	0.21	0.17	0.14	0.07	0.13	0.09	0.15	0.12	0.09	0.11	0.13	0.18	0.26
3	0.23	0.20	0.14	0.11	0.10	0.06	0.12	0.08	0.15	0.18	0.15	0.24	0.21	0.24	0.28
4	0.22	0.19	0.11	0.11	0.11	0.07	0.13	0.09	0.16	0.19	0.16	0.25	0.23	0.26	0.30
5	0.21	0.16	0.10	0.12	0.11	0.07	0.14	0.09	0.17	0.21	0.17	0.27	0.24	0.27	0.31

BACKCALCULATED PARTIAL RECRUITMENT

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.29	0.21	0.65	0.13	0.04	0.05	0.04	0.07	0.05	0.03	0.04	0.04	0.06	0.09	0.07
3	0.86	0.60	1.00	0.25	0.19	0.18	0.08	0.24	0.19	0.11	0.14	0.11	0.22	0.29	0.19
4	0.65	1.00	0.48	0.30	0.58	0.41	0.13	0.30	0.47	0.23	0.23	0.17	0.21	0.48	0.62
5	0.45	0.60	0.62	0.72	0.67	0.86	0.36	0.48	0.63	0.29	0.33	0.27	0.25	0.50	0.96
6	0.25	0.37	0.35	1.00	0.78	1.00	0.55	0.78	0.63	0.28	0.34	0.28	0.30	0.57	1.00
7	0.54	0.28	0.27	0.58	1.00	0.96	0.74	0.64	0.76	0.27	0.30	0.22	0.27	0.46	0.90
8	0.34	0.11	0.10	0.49	0.61	0.99	0.83	1.00	0.88	0.49	0.35	0.26	0.30	0.69	0.78
9	0.30	0.06	0.08	0.25	0.49	0.47	1.00	0.91	1.00	0.63	0.68	0.36	0.55	0.99	0.87
10	0.49	0.11	0.06	0.22	0.37	0.45	0.18	0.71	0.62	1.00	1.00	0.89	0.49	1.00	0.84
11	1.00	0.26	0.03	0.05	0.38	0.29	0.23	0.22	0.95	0.95	0.85	1.00	0.70	0.59	0.90
12	0.60	0.79	0.02	0.05	0.14	0.63	0.26	0.28	0.20	0.40	0.59	0.89	1.00	0.65	0.91
13	0.37	0.26	0.57	0.07	0.10	0.83	0.32	0.35	0.54	0.10	0.44	0.61	0.52	0.99	0.87
14	0.53	0.55	0.36	0.48	0.60	0.64	0.32	0.51	0.61	0.30	0.32	0.25	0.28	0.56	0.87
15	0.53	0.55	0.36	0.48	0.60	0.64	0.32	0.51	0.61	0.30	0.32	0.25	0.28	0.56	0.87

MEAN BIOMASS (MT)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	166	508	544	177	352	614	1245	761	542	1037	480
2	540	575	1145	1167	1442	1656	2392	2853	3619	5324	2916
3	753	554	1170	1459	2011	3031	2008	2695	3278	4388	6292
4	1196	528	629	745	2550	2763	3568	3386	3618	5007	5329
5	716	1181	594	594	844	2059	3271	4501	2787	3532	5053
6	654	690	1152	516	600	768	2535	3675	4338	2824	3788
7	499	499	784	1219	376	524	857	2567	2948	4100	3378
8	655	410	585	636	924	331	501	875	2105	2395	3797
9	550	533	427	568	480	794	263	459	566	1548	2057
10	428	563	574	385	407	457	664	307	338	386	1257
11	274	341	487	561	321	423	493	872	192	354	365
12	586	149	360	525	479	324	464	457	731	150	296
13	277	409	95	276	455	486	304	471	347	636	175
14	236	164	322	90	223	398	382	208	304	447	591
15	557	184	441	986	817	2064	783	1207	896	2415	1764
1+	8087	7288	9309	9903	12281	16694	19730	25292	26607	34545	37539

	1993	1994	1995	1996
1	430	3485	1441	765
2	3112	5483	8604	4599
3	4607	5606	5681	14805
4	7762	6179	5412	7170
5	5925	8618	5777	5359
6	4901	5582	8065	6253
7	3812	5073	6302	9392
8	3233	3726	4499	5764
9	3426	2535	2930	3721
10	1466	2559	2074	2289
11	841	1022	1758	1331

12	242	490	653	1548
13	231	153	357	502
14	139	99	144	196
15	1536	1262	324	150
1+	41666	51872	54022	63844

Summaries for ages 3-8 3-13 4-13 5-13

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
3	4472	3862	4914	5168	7306	9477	12740	17699	19073	22247	27637
3	6587	5857	6856	7483	9447	11961	14928	20264	21247	25321	31788
4	5835	5303	5686	6024	7436	8930	12920	17569	17969	20933	25496
5	4638	4775	5057	5279	4886	6166	9352	14183	14351	15926	20167

	1993	1994	1995	1996
3	30241	34784	35737	48744
3	36448	41544	43509	58134
4	31840	35938	37828	43329
5	24078	29759	32416	36159

CATCH BIOMASS (MT)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0	1	1	0	2	0	1	0	0	0	0	0
2	68	61	327	44	12	9	28	31	48	72	35	58
3	281	168	515	109	81	54	47	99	155	197	282	259
4	342	267	134	67	320	109	127	154	418	473	389	686
5	142	358	163	129	122	169	331	324	428	435	530	833
6	72	130	176	156	100	73	393	435	669	329	419	696
7	118	71	94	215	81	48	178	248	551	459	323	434
8	98	22	27	95	122	31	116	132	452	496	427	438
9	73	17	14	43	50	36	74	63	139	408	449	632
10	92	30	16	25	32	19	33	33	51	161	405	670
11	120	44	6	9	26	12	32	30	45	141	100	432
12	154	60	4	9	15	20	33	20	36	25	56	110
13	44	55	24	6	10	39	28	25	46	27	25	73
14	55	46	51	13	29	24	34	16	45	56	61	18
15	129	51	69	142	106	127	70	92	134	302	184	200
1+	1787	1380	1620	1063	1109	771	1524	1702	3220	3582	3685	5539

	1994	1995	1996
1	1	1	0
2	154	291	104
3	594	605	971
4	646	958	1552
5	1054	1072	1787
6	818	1692	2167
7	673	1086	2936
8	542	1151	1555
9	685	1081	1124
10	615	770	663
11	354	386	413
12	241	157	490
13	39	131	151
14	14	30	59
15	174	67	45
1+	6602	9477	14015

Summaries for ages 3-8 3-13 4-13 5-13

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
3	1053	1016	1108	771	827	485	1192	1393	2674	2389	2370	3346	4325
3	1536	1222	1172	863	961	611	1391	1563	2992	3151	3405	5263	6259
4	1254	1053	656	754	879	557	1344	1465	2837	2954	3123	5004	5666
5	913	786	523	687	559	448	1218	1310	2419	2481	2733	4318	5020

	1995	1996
3	6563	10966
3	9088	13807
4	8484	12836
5	7526	11285

SSB AT THE START OF THE SPAWNING SEASON - females (MT)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	22	12	11	16	37	45	63	50	60	77	92	133
5	44	71	31	37	49	139	187	248	192	218	308	347
6	157	147	235	115	124	168	489	734	948	586	770	1057
7	236	239	301	494	177	230	344	1051	1386	1741	1285	1587
8	327	191	234	312	461	151	231	374	1043	1164	1739	1468
9	259	271	197	274	256	396	142	219	333	841	1030	1708
10	226	258	262	193	227	218	343	127	185	220	647	829
11	168	175	246	268	166	194	225	359	116	167	166	481
12	333	90	161	240	246	151	211	223	379	78	142	140
13	163	221	53	150	232	230	149	220	191	322	75	123
14	130	101	170	42	119	203	203	118	181	184	292	73
15	312	104	240	534	440	1083	415	636	486	1298	940	827
1+	2378	1881	2141	2674	2534	3207	3002	4359	5498	6895	7487	8773

	1994	1995	1996
1	0	0	0
2	0	0	0
3	0	0	0
4	101	104	122
5	502	369	333
6	1210	1779	1284
7	2071	2474	3638
8	1669	2136	2672
9	1363	1590	1896
10	1387	1068	1162
11	540	976	747
12	284	366	773
13	84	183	266
14	67	68	119
15	681	180	86
1+	9961	11293	13097

The above SSBs by age (a) and year (y) are calculated following the algorithm used in the NEFSC projection program, i.e.

$$SSB(a,y) = W(a,y) \times P(a,y) \times N(a,y) \times \exp[-Z(a,y)]$$

where $Z(a,y) = 0.333 \times M(a,y) + 0.1 \times F(a,y)$
$N(a,y)$ - Jan 1 stock size estimates (males & females)
$P(a,y)$ - proportion mature (generally females)
$W(a,y)$ - weight at age at the beginning of the spawning season

The W(a,y) are assumed to be the same as the Jan1 weight at age estimates (see "WT AT AGE" table in input section). Jan1 weights at age are calculated as geometric means in ADAPT from the mid-year weight at age estimates (from the catch) of the cohort in successive years.

MEAN STOCK NUMBERS (thousands)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	1279	2542	2268	2952	2511	3072	4016	4756	6769	4939	4803
2	844	1045	1908	1914	2530	2151	2628	3437	4067	5787	4225
3	690	590	692	1363	1584	2150	1825	2209	2875	3401	4840
4	777	385	391	452	1063	1310	1802	1518	1765	2308	2761
5	296	498	222	271	346	824	1052	1471	1186	1348	1798
6	174	210	340	144	192	264	631	811	1133	891	1032
7	103	132	155	248	95	145	196	478	600	852	689
8	113	77	104	116	183	70	107	140	353	425	656
9	89	89	63	84	88	144	50	76	99	240	296
10	49	70	74	52	67	70	118	35	57	62	154
11	25	36	58	62	41	54	57	97	26	37	37
12	52	14	28	49	52	33	45	47	80	18	24
13	21	37	9	24	41	43	26	36	37	66	13
14	18	15	27	6	19	34	34	21	28	28	53
15	35	17	30	62	52	125	46	71	51	141	100
1+	4567	5755	6369	7799	8865	10489	12633	15205	19127	20544	21483

	1993	1994	1995	1996
1	6150	14519	5147	5463
2	4095	5222	12291	4380
3	3517	3317	4208	10071
4	3901	2796	2483	3091
5	2139	3024	2086	1664
6	1369	1595	2210	1383
7	794	1027	1171	1470
8	529	601	730	811
9	487	373	403	476
10	183	340	234	249
11	88	105	232	143
12	23	46	67	153
13	16	13	26	44
14	10	11	9	16
15	100	71	16	9
1+	23402	33060	31313	29423

Table 30. Bootstrap estimates of precision in striped bass VPA.

SEED FOR THE RANDOM NUMBER GENERATOR: 74747
MAIN LOOP LIMIT IN MARQUARDT ALGORITHM: 50
NUMBER OF BOOTSTRAP REPLICATIONS ATTEMPTED: 200
NUMBER FOR WHICH NLLS CONVERGED: 200
Results from the converged replications are used for computing the statistics that follow. Other replications are ignored.

BOOTSTRAP OUTPUT VARIABLE: Age-specific stock sizes (on Jan 1, 1997) estimated by NLLS

AGE	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1	1.511E4	1.576E4	3.595E3	0.24
2	5.109E3	5.270E3	1.300E3	0.25
3	4.015E3	4.180E3	9.041E2	0.23
4	9.030E3	9.204E3	1.808E3	0.20
5	2.561E3	2.610E3	5.554E2	0.22
6	1.296E3	1.330E3	3.198E2	0.25
7	1.070E3	1.066E3	2.527E2	0.24
8	1.157E3	1.181E3	2.514E2	0.22
9	6.530E2	6.591E2	1.366E2	0.21
10	3.771E2	3.742E2	7.104E1	0.19
11	1.984E2	1.977E2	4.806E1	0.24
12	1.137E2	1.133E2	3.310E1	0.29
13	1.206E2	1.208E2	3.766E1	0.31

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
6.557E2	2.542E2	4.34	1.445E4	0.25
1.615E2	9.193E1	3.16	4.947E3	0.26
1.642E2	6.393E1	4.09	3.851E3	0.23
1.740E2	1.279E2	1.93	8.856E3	0.20
4.874E1	3.927E1	1.90	2.512E3	0.22
3.452E1	2.261E1	2.66	1.261E3	0.25
-3.182E0	1.787E1	-0.30	1.073E3	0.24
2.410E1	1.778E1	2.08	1.133E3	0.22
6.106E0	9.659E0	0.94	6.469E2	0.21
-2.929E0	5.023E0	-0.78	3.800E2	0.19
-6.913E-1	3.398E0	-0.35	1.991E2	0.24
-3.955E-1	2.340E0	-0.35	1.141E2	0.29
1.231E-1	2.663E0	0.10	1.205E2	0.31

BOOTSTRAP OUTPUT VARIABLE: Catchability estimates (q) for each index of abundance used in the ADAPT run. Note that these q's have been re-scaled to original units.

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
2.363E-3	2.361E-3	5.343E-4	0.23
5.356E-5	5.950E-5	2.855E-5	0.53
5.705E-5	5.934E-5	1.644E-5	0.29
4.693E-4	4.713E-4	7.728E-5	0.16
1.314E-3	1.325E-3	1.357E-4	0.10
1.377E-4	1.402E-4	2.248E-5	0.16
1.992E-5	2.129E-5	6.315E-6	0.32
5.840E-3	6.139E-3	1.722E-3	0.29
4.471E-2	4.619E-2	1.014E-2	0.23
5.099E-2	5.262E-2	1.231E-2	0.24
4.331E-2	4.357E-2	9.998E-3	0.23

4.161E-2	4.218E-2	7.747E-3	0.19
3.993E-2	4.117E-2	7.359E-3	0.18
3.432E-2	3.506E-2	1.020E-2	0.30
2.197E-2	2.512E-2	1.114E-2	0.51
1.794E-2	1.890E-2	6.240E-3	0.35
1.196E-2	1.384E-2	7.107E-3	0.59
9.521E-3	1.118E-2	6.134E-3	0.64
1.143E-2	1.208E-2	4.574E-3	0.40
1.431E-2	1.646E-2	9.515E-3	0.67
9.793E-3	1.016E-2	4.374E-3	0.45
7.124E-4	7.369E-4	1.594E-4	0.22
7.128E-3	7.201E-3	1.004E-3	0.14
2.084E-2	2.104E-2	3.029E-3	0.15
2.711E-2	2.864E-2	6.819E-3	0.25
2.307E-2	2.410E-2	5.935E-3	0.26
1.577E-2	1.745E-2	7.365E-3	0.47
8.436E-3	9.213E-3	3.115E-3	0.37
1.303E-2	1.364E-2	2.843E-3	0.22
4.304E-5	4.325E-5	1.196E-5	0.28
1.471E-4	1.477E-4	2.205E-5	0.15
2.169E-4	2.193E-4	2.166E-5	0.10
2.049E-4	2.040E-4	2.930E-5	0.14
2.284E-4	2.326E-4	3.963E-5	0.17
1.916E-4	1.965E-4	3.073E-5	0.16
1.695E-4	1.747E-4	3.287E-5	0.19
2.127E-4	2.190E-4	4.689E-5	0.22
1.517E-4	1.663E-4	7.443E-5	0.49
1.342E-4	1.432E-4	5.255E-5	0.39
1.323E-4	1.483E-4	5.796E-5	0.44
1.232E-4	1.301E-4	4.365E-5	0.35
6.998E-5	7.330E-5	2.583E-5	0.37
4.537E-5	4.935E-5	1.586E-5	0.35
6.645E-4	6.846E-4	1.523E-4	0.23
5.051E-4	5.235E-4	1.360E-4	0.27
3.273E-4	3.409E-4	9.895E-5	0.30
2.106E-3	2.136E-3	4.007E-4	0.19
2.110E-3	2.124E-3	4.563E-4	0.22
1.828E-3	1.926E-3	5.285E-4	0.29
1.643E-3	1.725E-3	5.323E-4	0.32
1.679E-3	1.815E-3	5.884E-4	0.35
1.767E-3	1.912E-3	6.413E-4	0.36
1.658E-3	1.740E-3	4.884E-4	0.29
2.134E-3	2.240E-3	7.225E-4	0.34
9.538E-4	1.066E-3	5.010E-4	0.53
2.286E-3	2.611E-3	1.368E-3	0.60
8.957E-4	9.760E-4	3.719E-4	0.42
7.902E-4	7.972E-4	2.255E-4	0.29

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
-2.457E-6	3.778E-5	-0.10	2.366E-3	0.23
5.946E-6	2.019E-6	11.10	4.761E-5	0.60
2.296E-6	1.163E-6	4.03	5.475E-5	0.30
2.071E-6	5.464E-6	0.44	4.672E-4	0.17
1.121E-5	9.594E-6	0.85	1.303E-3	0.10
2.441E-6	1.589E-6	1.77	1.353E-4	0.17
1.373E-6	4.465E-7	6.89	1.855E-5	0.34
2.994E-4	1.218E-4	5.13	5.541E-3	0.31
1.484E-3	7.169E-4	3.32	4.323E-2	0.23
1.633E-3	8.705E-4	3.20	4.936E-2	0.25
2.563E-4	7.070E-4	0.59	4.305E-2	0.23
5.712E-4	5.478E-4	1.37	4.104E-2	0.19
1.238E-3	5.204E-4	3.10	3.869E-2	0.19
7.426E-4	7.213E-4	2.16	3.358E-2	0.30
3.151E-3	7.875E-4	14.34	1.881E-2	0.59

9.609E-4	4.412E-4	5.36	1.697E-2	0.37
1.877E-3	5.026E-4	15.69	1.008E-2	0.71
1.660E-3	4.338E-4	17.44	7.861E-3	0.78
6.534E-4	3.234E-4	5.72	1.077E-2	0.42
2.153E-3	6.728E-4	15.05	1.215E-2	0.78
3.667E-4	3.093E-4	3.75	9.426E-3	0.46
2.449E-5	1.127E-5	3.44	6.879E-4	0.23
7.296E-5	7.099E-5	1.02	7.055E-3	0.14
1.953E-4	2.141E-4	0.94	2.065E-2	0.15
1.534E-3	4.822E-4	5.66	2.557E-2	0.27
1.038E-3	4.196E-4	4.50	2.203E-2	0.27
1.682E-3	5.208E-4	10.67	1.408E-2	0.52
7.767E-4	2.203E-4	9.21	7.659E-3	0.41
6.063E-4	2.010E-4	4.65	1.242E-2	0.23
2.130E-7	8.454E-7	0.49	4.282E-5	0.28
6.292E-7	1.559E-6	0.43	1.465E-4	0.15
2.425E-6	1.532E-6	1.12	2.145E-4	0.10
-9.518E-7	2.072E-6	-0.46	2.059E-4	0.14
4.242E-6	2.802E-6	1.86	2.241E-4	0.18
4.959E-6	2.173E-6	2.59	1.866E-4	0.16
5.179E-6	2.324E-6	3.06	1.643E-4	0.20
6.343E-6	3.316E-6	2.98	2.064E-4	0.23
1.455E-5	5.263E-6	9.59	1.372E-4	0.54
9.062E-6	3.716E-6	6.75	1.251E-4	0.42
1.603E-5	4.099E-6	12.12	1.162E-4	0.50
6.943E-6	3.087E-6	5.64	1.162E-4	0.38
3.318E-6	1.826E-6	4.74	6.666E-5	0.39
3.981E-6	1.121E-6	8.77	4.139E-5	0.38
2.011E-5	1.077E-5	3.03	6.444E-4	0.24
1.844E-5	9.615E-6	3.65	4.866E-4	0.28
1.368E-5	6.997E-6	4.18	3.136E-4	0.32
2.974E-5	2.833E-5	1.41	2.076E-3	0.19
1.408E-5	3.226E-5	0.67	2.096E-3	0.22
9.792E-5	3.737E-5	5.36	1.730E-3	0.31
8.228E-5	3.764E-5	5.01	1.560E-3	0.34
1.358E-4	4.160E-5	8.09	1.543E-3	0.38
1.442E-4	4.535E-5	8.16	1.623E-3	0.40
8.297E-5	3.453E-5	5.01	1.575E-3	0.31
1.058E-4	5.109E-5	4.96	2.028E-3	0.36
1.118E-4	3.543E-5	11.72	8.420E-4	0.60
3.255E-4	9.674E-5	14.24	1.960E-3	0.70
8.026E-5	2.630E-5	8.96	8.154E-4	0.46
6.987E-6	1.595E-5	0.88	7.833E-4	0.29

BOOTSTRAP OUTPUT VARIABLE: Full vector of age-specific stock sizes on Jan 1, 1997

AGE	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1	1.511E4	1.576E4	3.595E3	0.24
2	5.109E3	5.270E3	1.300E3	0.25
3	4.015E3	4.180E3	9.041E2	0.23
4	9.030E3	9.204E3	1.808E3	0.20
5	2.561E3	2.610E3	5.554E2	0.22
6	1.296E3	1.330E3	3.198E2	0.25
7	1.070E3	1.066E3	2.527E2	0.24
8	1.157E3	1.181E3	2.514E2	0.22
9	6.530E2	6.591E2	1.366E2	0.21
10	3.771E2	3.742E2	7.104E1	0.19
11	1.984E2	1.977E2	4.806E1	0.24
12	1.137E2	1.133E2	3.310E1	0.29
13	1.206E2	1.208E2	3.766E1	0.31
14	3.507E1	3.396E1	5.173E0	0.15
15	1.936E1	1.875E1	2.859E0	0.15

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
6.557E2	2.542E2	4.34	1.445E4	0.25
1.615E2	9.193E1	3.16	4.947E3	0.26
1.642E2	6.393E1	4.09	3.851E3	0.23
1.740E2	1.279E2	1.93	8.856E3	0.20
4.874E1	3.927E1	1.90	2.512E3	0.22
3.452E1	2.261E1	2.66	1.261E3	0.25
-3.182E0	1.787E1	-0.30	1.073E3	0.24
2.410E1	1.778E1	2.08	1.133E3	0.22
6.106E0	9.659E0	0.94	6.469E2	0.21
-2.929E0	5.023E0	-0.78	3.800E2	0.19
-6.913E-1	3.398E0	-0.35	1.991E2	0.24
-3.955E-1	2.340E0	-0.35	1.141E2	0.29
1.231E-1	2.663E0	0.10	1.205E2	0.31
-1.113E0	3.658E-1	-3.17	3.619E1	0.14
-6.150E-1	2.022E-1	-3.18	1.998E1	0.14

BOOTSTRAP OUTPUT VARIABLE: Full vector of age-specific terminal F's (in 1996).

AGE	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1	9.080E-5	9.376E-5	2.485E-5	0.27
2	2.257E-2	2.273E-2	5.132E-3	0.23
3	6.556E-2	6.686E-2	1.371E-2	0.21
4	2.163E-1	2.209E-1	4.513E-2	0.21
5	3.330E-1	3.401E-1	7.302E-2	0.22
6	3.462E-1	3.621E-1	7.802E-2	0.23
7	3.124E-1	3.180E-1	6.271E-2	0.20
8	2.695E-1	2.766E-1	5.308E-2	0.20
9	3.020E-1	3.124E-1	5.236E-2	0.17
10	2.891E-1	3.033E-1	6.574E-2	0.23
11	3.080E-1	3.304E-1	9.290E-2	0.30
12	3.159E-1	3.388E-1	9.243E-2	0.29
13	2.995E-1	3.133E-1	4.132E-2	0.14
14	2.995E-1	3.133E-1	4.132E-2	0.14
15+	2.995E-1	3.133E-1	4.132E-2	0.14

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
2.961E-6	1.757E-6	3.26	8.784E-5	0.28
1.586E-4	3.629E-4	0.70	2.241E-2	0.23
1.300E-3	9.691E-4	1.98	6.426E-2	0.21
4.633E-3	3.191E-3	2.14	2.116E-1	0.21
7.067E-3	5.164E-3	2.12	3.260E-1	0.22
1.589E-2	5.517E-3	4.59	3.303E-1	0.24
5.570E-3	4.434E-3	1.78	3.068E-1	0.20
7.143E-3	3.753E-3	2.65	2.624E-1	0.20
1.042E-2	3.702E-3	3.45	2.916E-1	0.18
1.419E-2	4.649E-3	4.91	2.749E-1	0.24
2.242E-2	6.569E-3	7.28	2.856E-1	0.33
2.296E-2	6.536E-3	7.27	2.929E-1	0.32
1.379E-2	2.921E-3	4.60	2.857E-1	0.14
1.379E-2	2.921E-3	4.60	2.857E-1	0.14
1.379E-2	2.921E-3	4.60	2.857E-1	0.14

BOOTSTRAP OUTPUT VARIABLE: Fully-recruited (ages 4-13) F in the terminal year (1996)

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
2.995E-1	3.133E-1	4.132E-2	0.14

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
1.379E-2	2.921E-3	4.60	2.857E-1	0.14

BOOTSTRAP OUTPUT VARIABLE: Partial recruitment vector in the terminal year (1996)

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1	2.623E-4	2.197E-4	6.272E-5	0.24
2	6.520E-2	5.334E-2	1.369E-2	0.21
3	1.894E-1	1.569E-1	3.667E-2	0.19
4	6.247E-1	5.186E-1	1.250E-1	0.20
5	9.620E-1	7.890E-1	1.485E-1	0.15
6	1.000E 0	8.382E-1	1.438E-1	0.14
7	9.024E-1	7.415E-1	1.465E-1	0.16
8	7.785E-1	6.503E-1	1.497E-1	0.19
9	8.724E-1	7.288E-1	1.292E-1	0.15
10	8.352E-1	7.062E-1	1.511E-1	0.18
11	8.898E-1	7.629E-1	1.706E-1	0.19
12	9.124E-1	7.821E-1	1.751E-1	0.19
13	8.651E-1	7.286E-1	8.994E-2	0.10
14	8.651E-1	7.286E-1	8.994E-2	0.10
15	8.651E-1	7.286E-1	8.994E-2	0.10

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
-4.261E-5	4.435E-6	-16.25	3.049E-4	0.21
-1.186E-2	9.680E-4	-18.19	7.706E-2	0.18
-3.245E-2	2.593E-3	-17.14	2.218E-1	0.17
-1.061E-1	8.836E-3	-16.98	7.308E-1	0.17
-1.730E-1	1.050E-2	-17.99	1.135E0	0.13
-1.618E-1	1.017E-2	-16.18	1.162E0	0.12
-1.609E-1	1.036E-2	-17.83	1.063E0	0.14
-1.282E-1	1.058E-2	-16.47	9.067E-1	0.17
-1.436E-1	9.133E-3	-16.46	1.016E0	0.13
-1.290E-1	1.068E-2	-15.44	9.642E-1	0.16
-1.269E-1	1.206E-2	-14.26	1.017E0	0.17
-1.303E-1	1.238E-2	-14.29	1.043E0	0.17
-1.365E-1	6.360E-3	-15.78	1.002E0	0.09
-1.365E-1	6.360E-3	-15.78	1.002E0	0.09
-1.365E-1	6.360E-3	-15.78	1.002E0	0.09

BOOTSTRAP OUTPUT VARIABLE: Average partial recruitment over 1994-1996

AGE	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1	7.422E-4	6.669E-4	1.063E-4	0.14
2	6.982E-2	6.264E-2	9.556E-3	0.14

3	2.275E-1	2.043E-1	2.596E-2	0.11
4	3.995E-1	3.597E-1	3.999E-2	0.10
5	4.937E-1	4.441E-1	4.325E-2	0.09
6	5.534E-1	5.001E-1	4.894E-2	0.09
7	4.844E-1	4.363E-1	4.149E-2	0.09
8	5.424E-1	4.911E-1	4.476E-2	0.08
9	7.815E-1	7.096E-1	4.908E-2	0.06
10	7.420E-1	6.764E-1	4.610E-2	0.06
11	7.196E-1	6.605E-1	5.257E-2	0.07
12	8.409E-1	7.731E-1	7.098E-2	0.08
13	7.614E-1	6.937E-1	3.548E-2	0.05
14	5.145E-1	4.651E-1	2.734E-2	0.05
15	5.145E-1	4.651E-1	2.734E-2	0.05

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
-7.536E-5	7.516E-6	-10.15	8.176E-4	0.13
-7.180E-3	6.757E-4	-10.28	7.700E-2	0.12
-2.320E-2	1.836E-3	-10.20	2.507E-1	0.10
-3.975E-2	2.828E-3	-9.95	4.392E-1	0.09
-4.961E-2	3.058E-3	-10.05	5.433E-1	0.08
-5.334E-2	3.461E-3	-9.64	6.068E-1	0.08
-4.815E-2	2.934E-3	-9.94	5.326E-1	0.08
-5.131E-2	3.165E-3	-9.46	5.937E-1	0.08
-7.195E-2	3.471E-3	-9.21	8.535E-1	0.06
-6.563E-2	3.260E-3	-8.85	8.076E-1	0.06
-5.917E-2	3.717E-3	-8.22	7.788E-1	0.07
-6.782E-2	5.019E-3	-8.07	9.087E-1	0.08
-6.773E-2	2.509E-3	-8.89	8.291E-1	0.04
-4.941E-2	1.933E-3	-9.60	5.639E-1	0.05
-4.941E-2	1.933E-3	-9.60	5.639E-1	0.05

BOOTSTRAP OUTPUT VARIABLE: Mean stock biomass during the terminal year (1996)

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
6.391E4	6.477E4	6.679E3	0.10

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
8.580E2	4.723E2	1.34	6.305E4	0.11

BOOTSTRAP OUTPUT VARIABLE: SSB (females) at start of spawning season (1996)

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP STD ERROR	C.V. FOR NLLS SOLN
1.311E4	1.317E4	1.301E3	0.10

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V FOR CORRECTED ESTIMATE
5.340E1	9.198E1	0.41	1.306E4	0.10

Table 31. Input parameters and stochastic projection results of striped bass: landings, discard and spawning stock biomass (female; '000 mt). Starting stock sizes on 1 January 1997 (age 1 -older) as estimated by VPA bootstrap procedure (200 iterations) for ages 1-15+. Recruitment (age 1) level in 1998-1999 selected at random from time series of recruitment equivalents determined from MD juvenile indices (1955-1977, 1989-1996). Fishing mortality pattern, proportion discarded, and mean weights (kg) are weighted (by fishery) average values from 1994-1996. Fishing mortality is the target mortality from the FMP. Percent mortality prior to spawning is 33%.

Age	Partial Recruitment Pattern	Proportion Discarded	Female Proportion Mature	Overall Mean Weight	Mean Weight Landings	Mean Weight Discards
1	0.00	0.94	0.00	0.220	0.290	0.290
2	0.08	0.86	0.00	0.933	1.110	0.690
3	0.30	0.63	0.00	1.503	1.710	1.160
4	0.51	0.46	0.04	2.237	2.470	1.950
5	0.63	0.46	0.13	2.947	3.190	2.630
6	0.72	0.47	0.45	3.890	4.130	3.410
7	0.61	0.39	0.89	5.570	5.400	4.320
8	0.71	0.25	0.94	6.490	6.710	5.240
9	1.00	0.16	1.00	7.290	7.540	5.960
10	1.00	0.12	1.00	8.530	8.680	6.690
11	1.00	0.12	1.00	8.870	8.850	6.770
12	1.00	0.12	1.00	10.170	10.390	7.690
13	1.00	0.04	1.00	12.233	12.070	8.930
14	1.00	0.00	1.00	15.670	15.670	-
15+	1.00	0.00	1.00	18.820	18.820	-

Year	Recruitment		SSB		Landings		Discards	
	Average ('000)	Median ('000)	Average (mt)	Median (mt)	Average (mt)	Median (mt)	Average (mt)	Median (mt)
1997	15,760	15,621	13,096	12,975	7,803	7,725	3,246	3,198
1998	6,443	5,226	13,481	13,336	8,211	8,129	3,543	3,508
1999	6,500	5,226	15,297	14,993	8,515	8,393	3,844	3,815

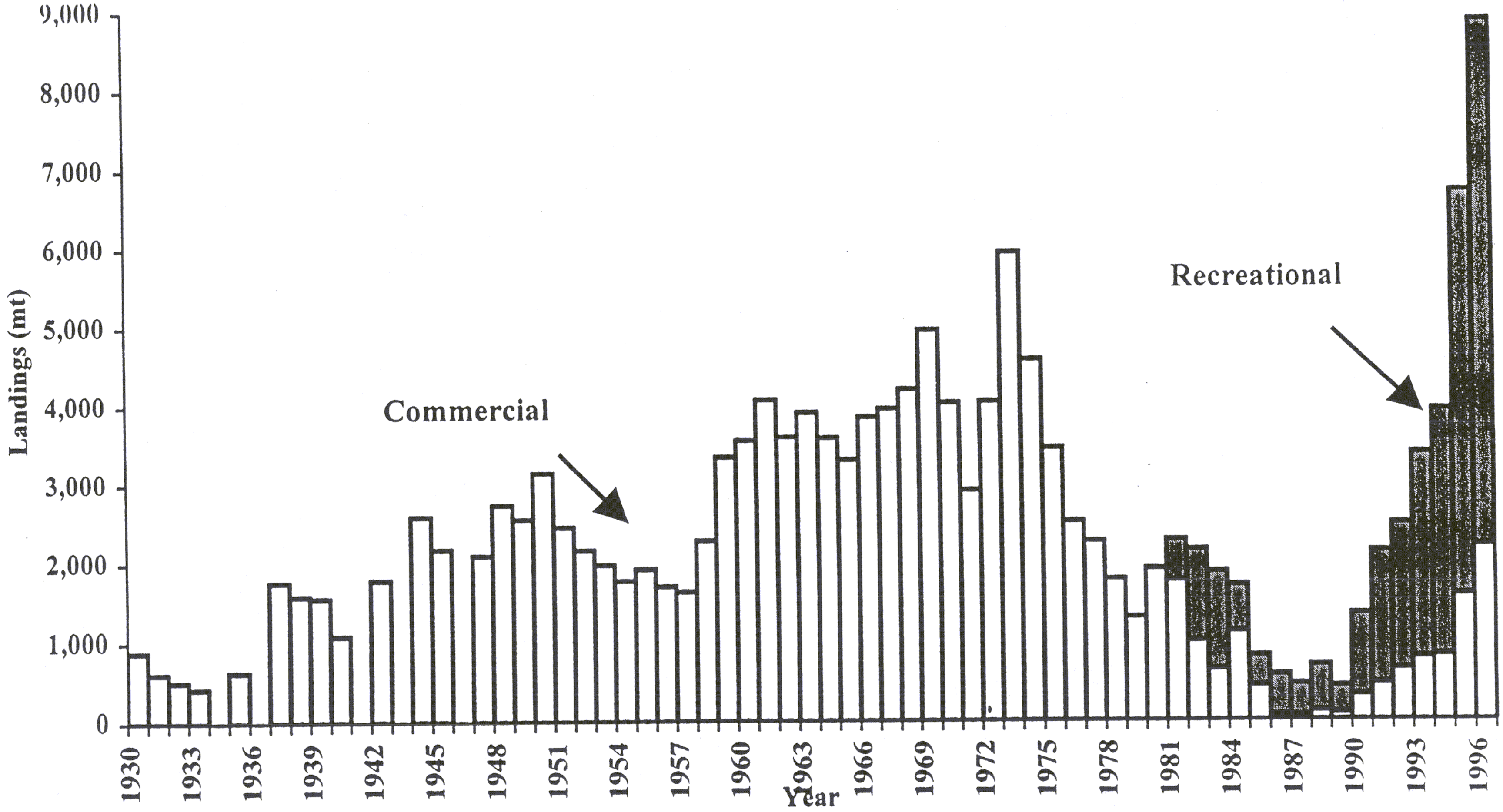
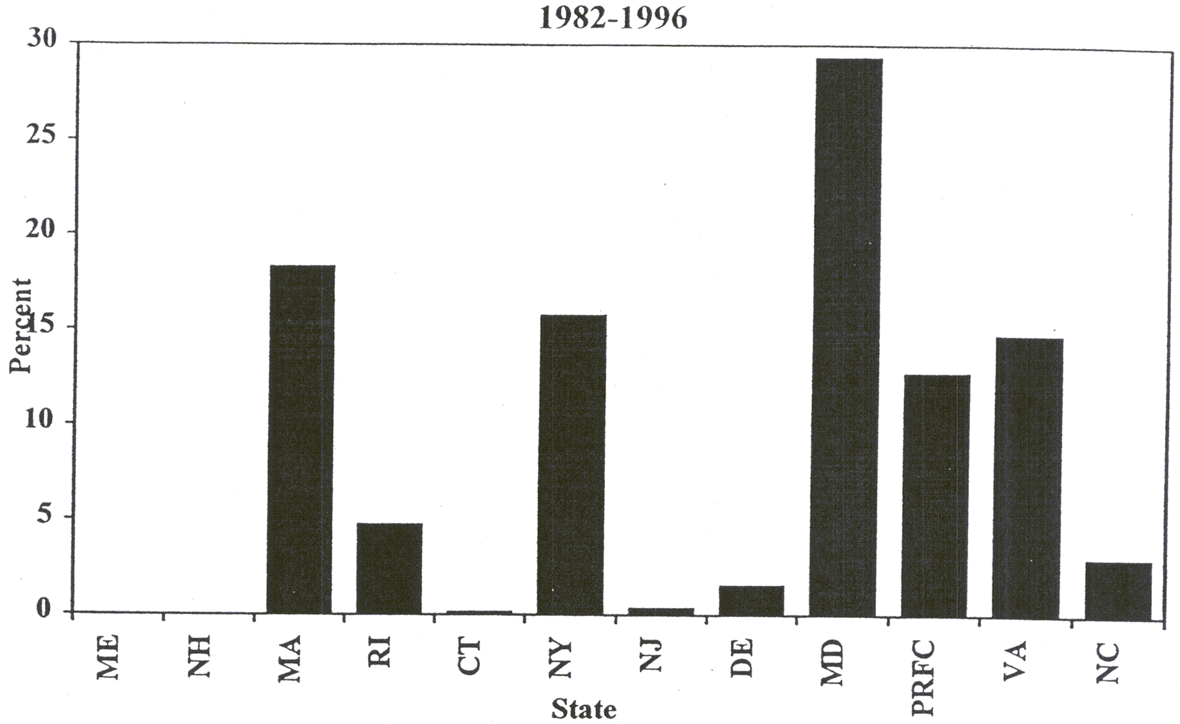


Figure 1. Striped bass commercial and recreational landings, Maine to coastal North Carolina, 1930-1996.



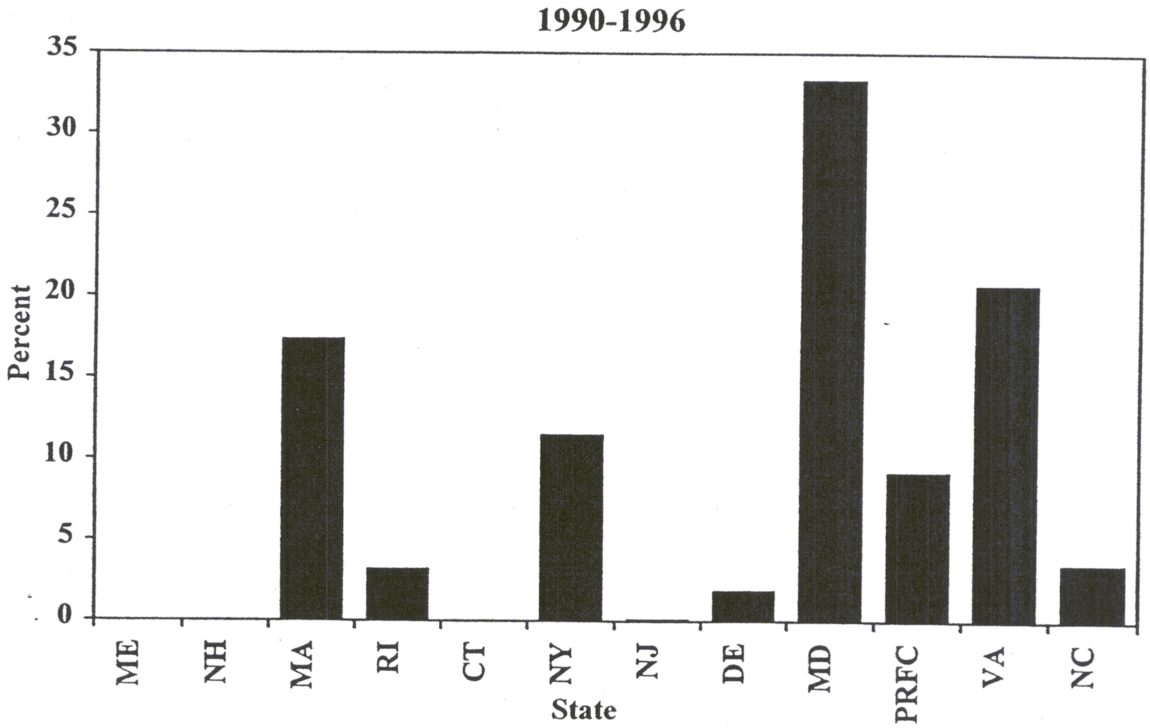


Figure 2. Percentage commercial striped bass landings in weight, by state for 1982-1996 and 1990-1996.

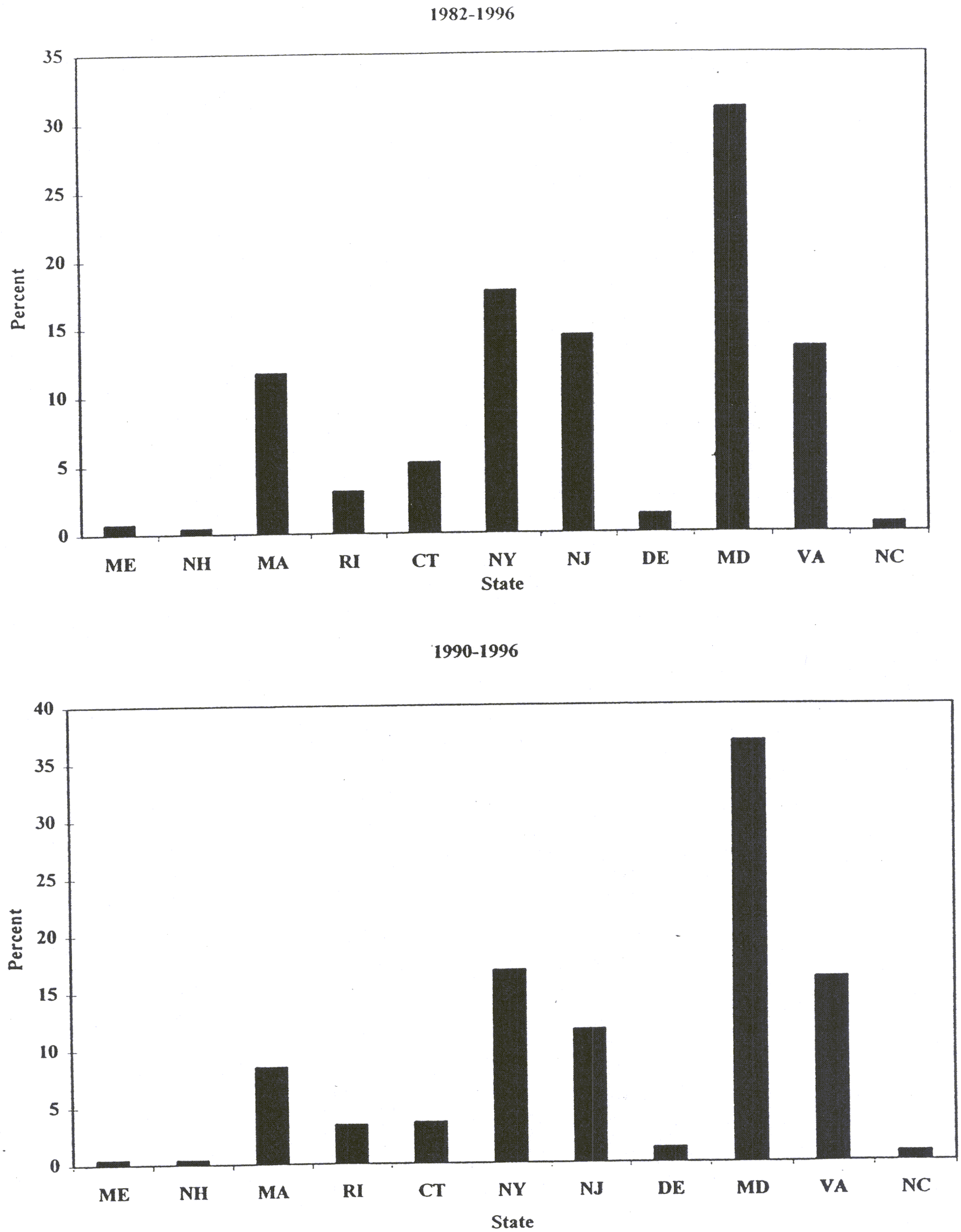


Figure 3. Percentage of striped bass recreational landings in number by state, 1982-1996, 1990-1996.

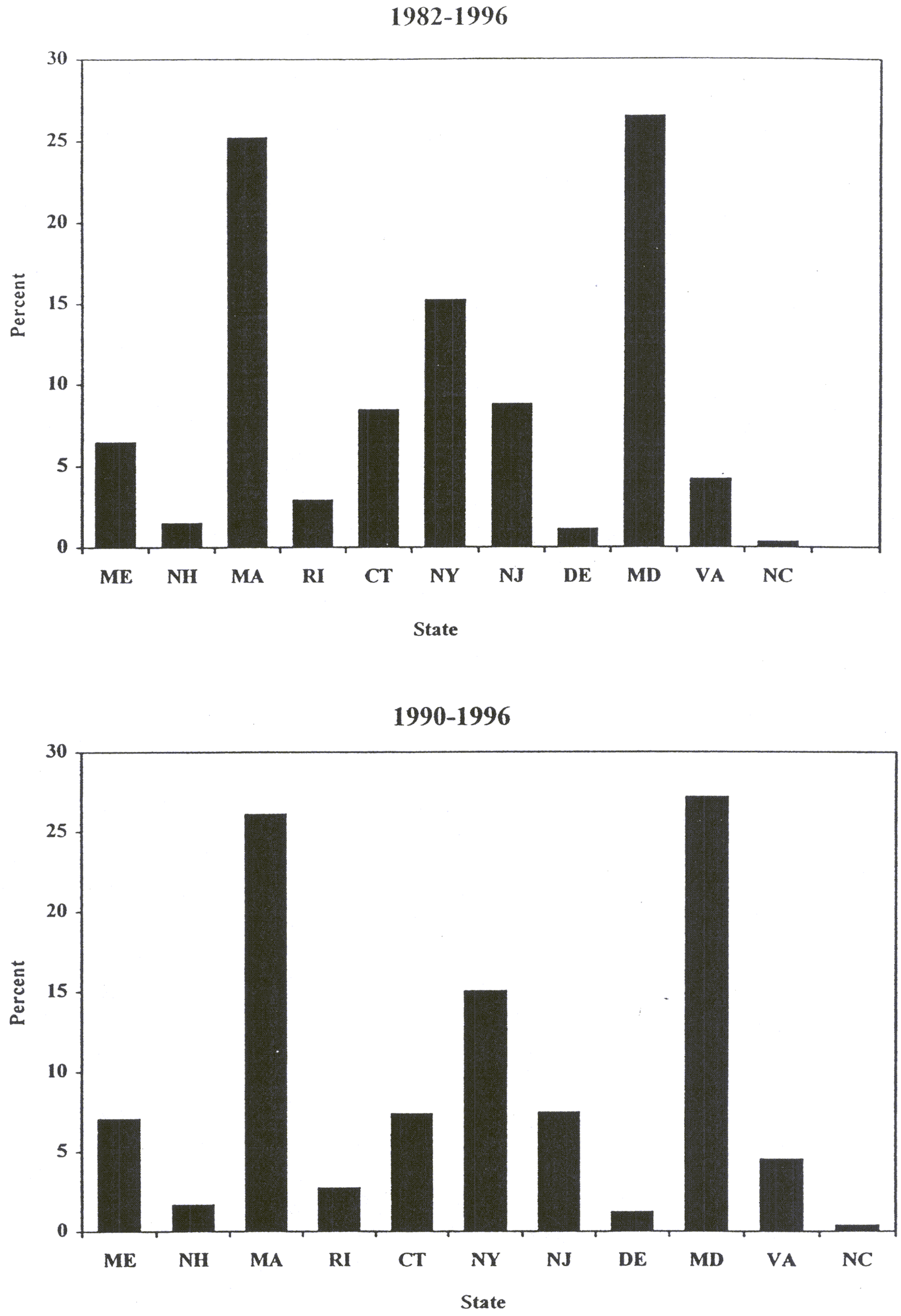


Figure 4. Percentage of striped bass recreational discards in number by state, 1982-1996, 1990-1996.

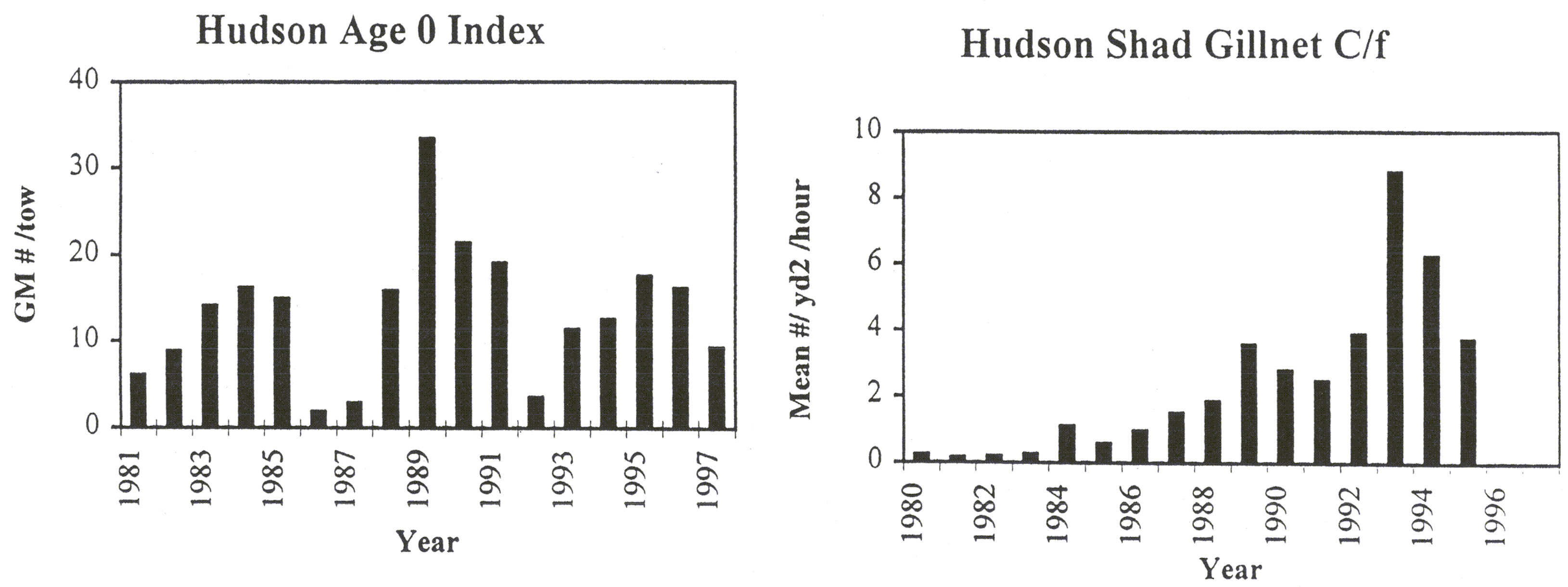


Figure 5. Fisheries independent indices of Hudson River stock of striped bass.

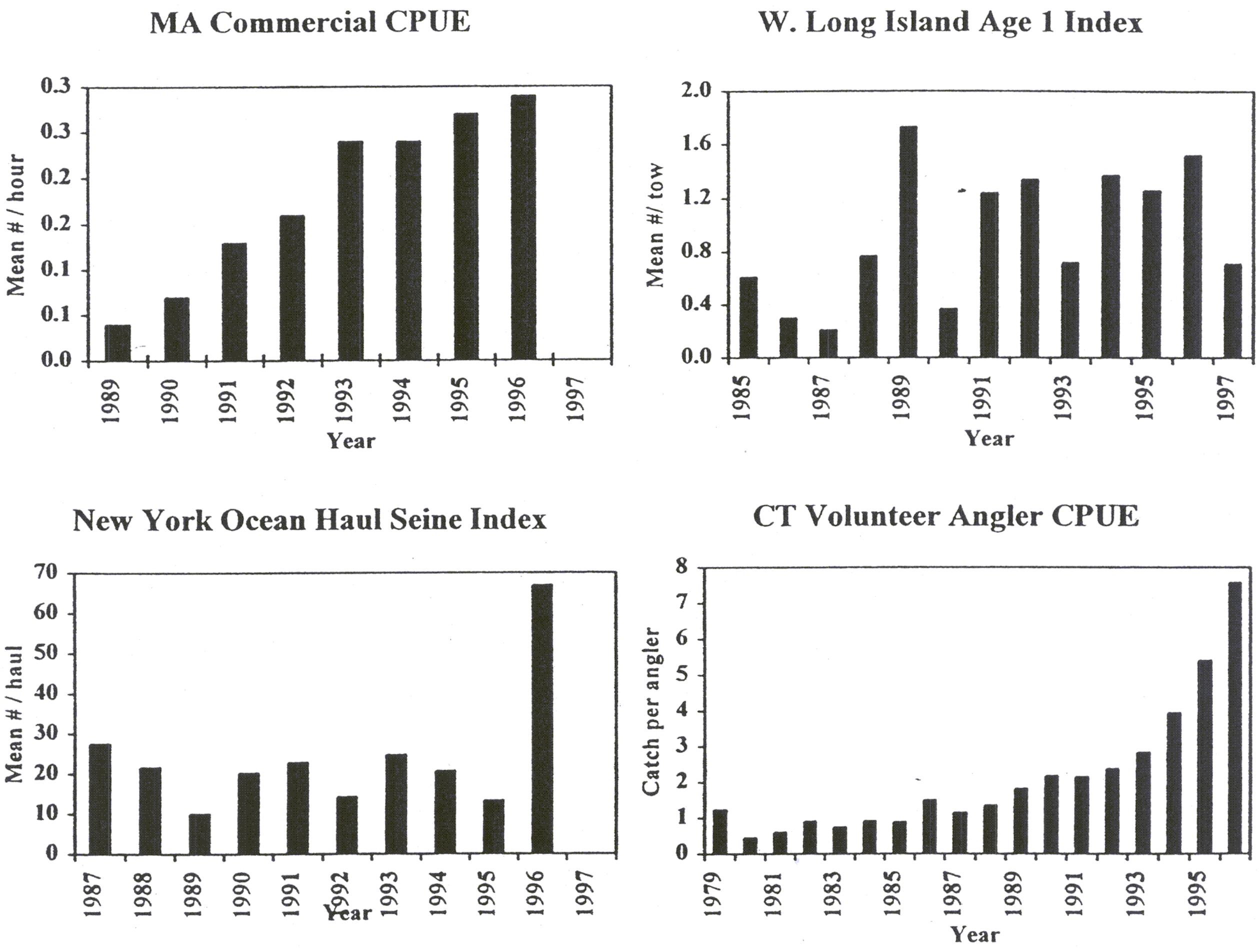


Figure 6. Indices of striped bass abundance in coastal regions.

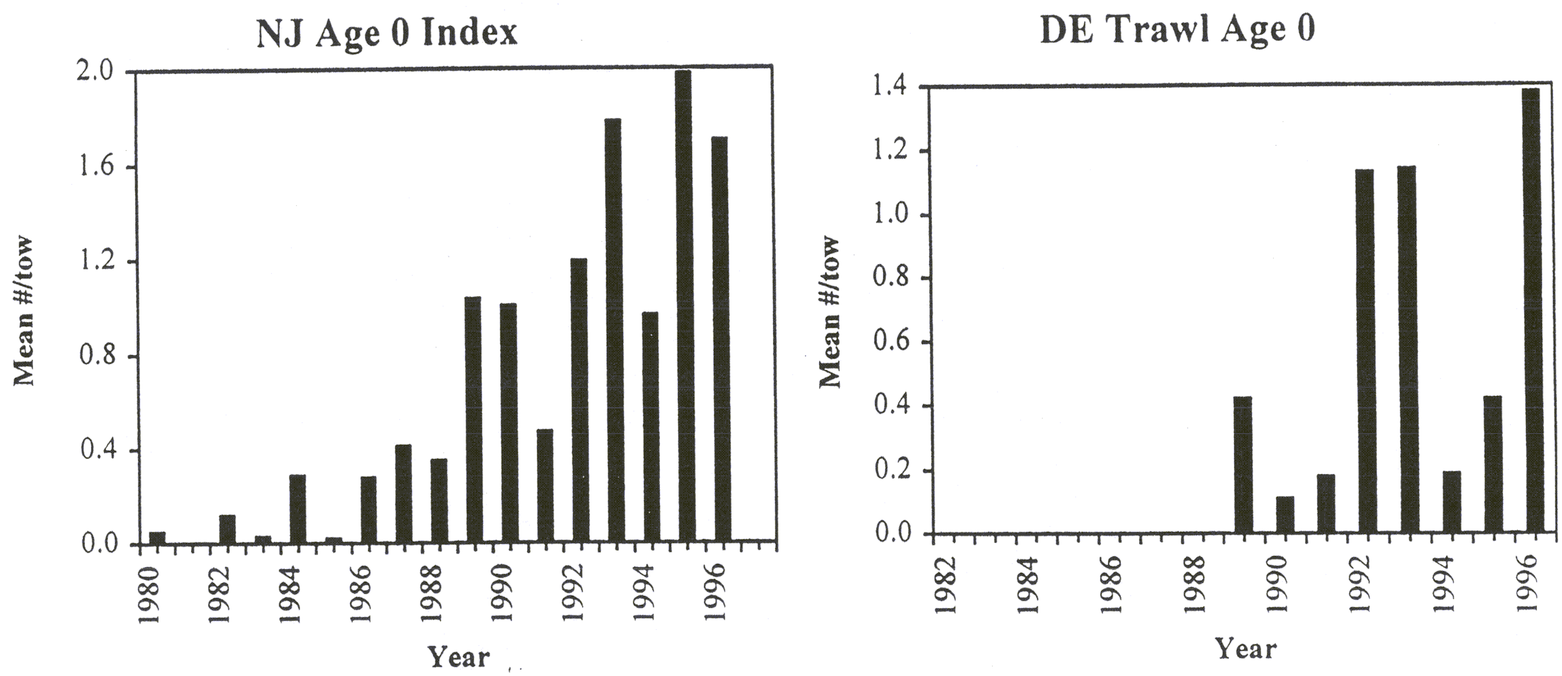


Figure 7. Indices of striped bass abundance for Delaware stock.

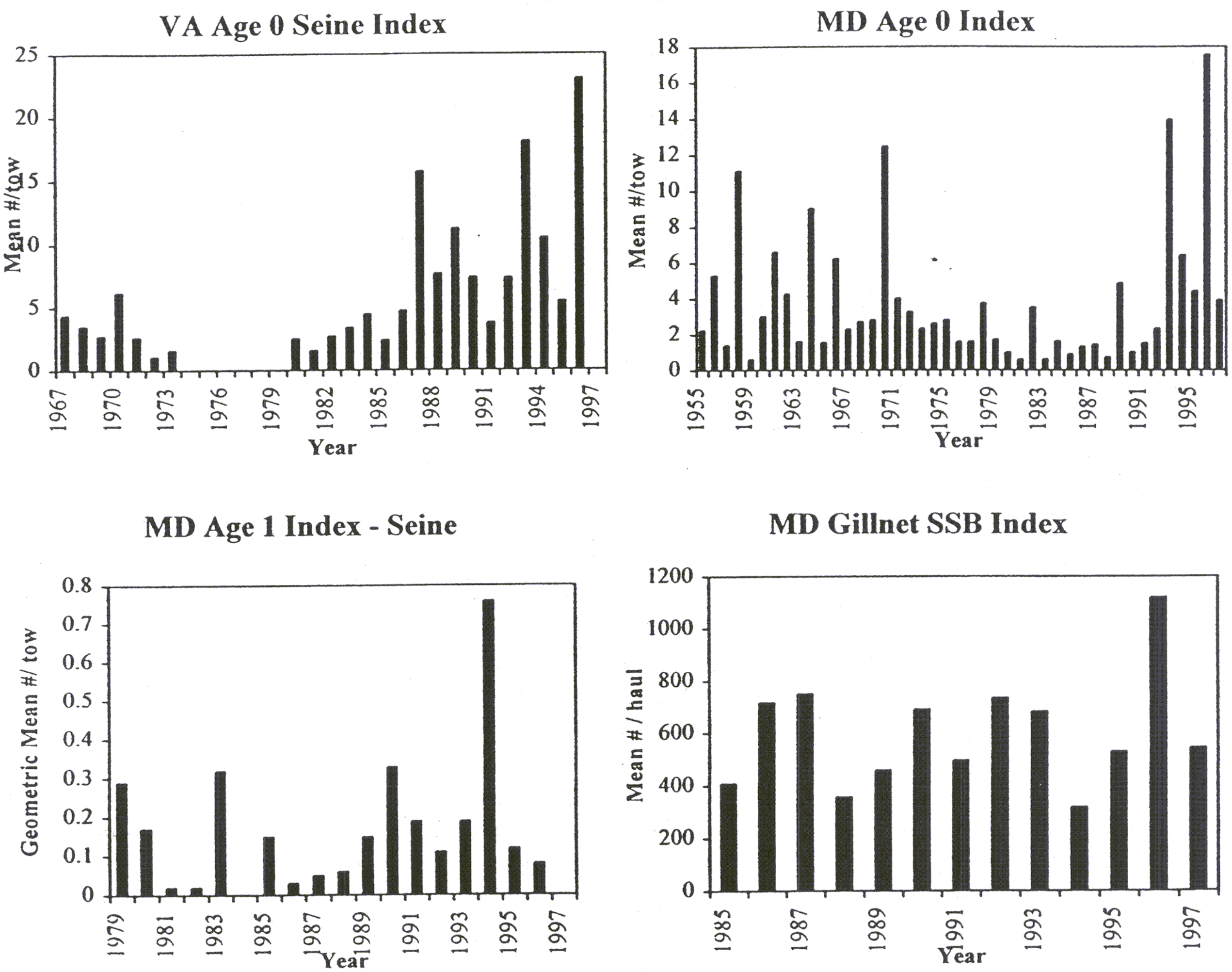


Figure 8. Indices of abundance for striped bass in Chesapeake Bay.

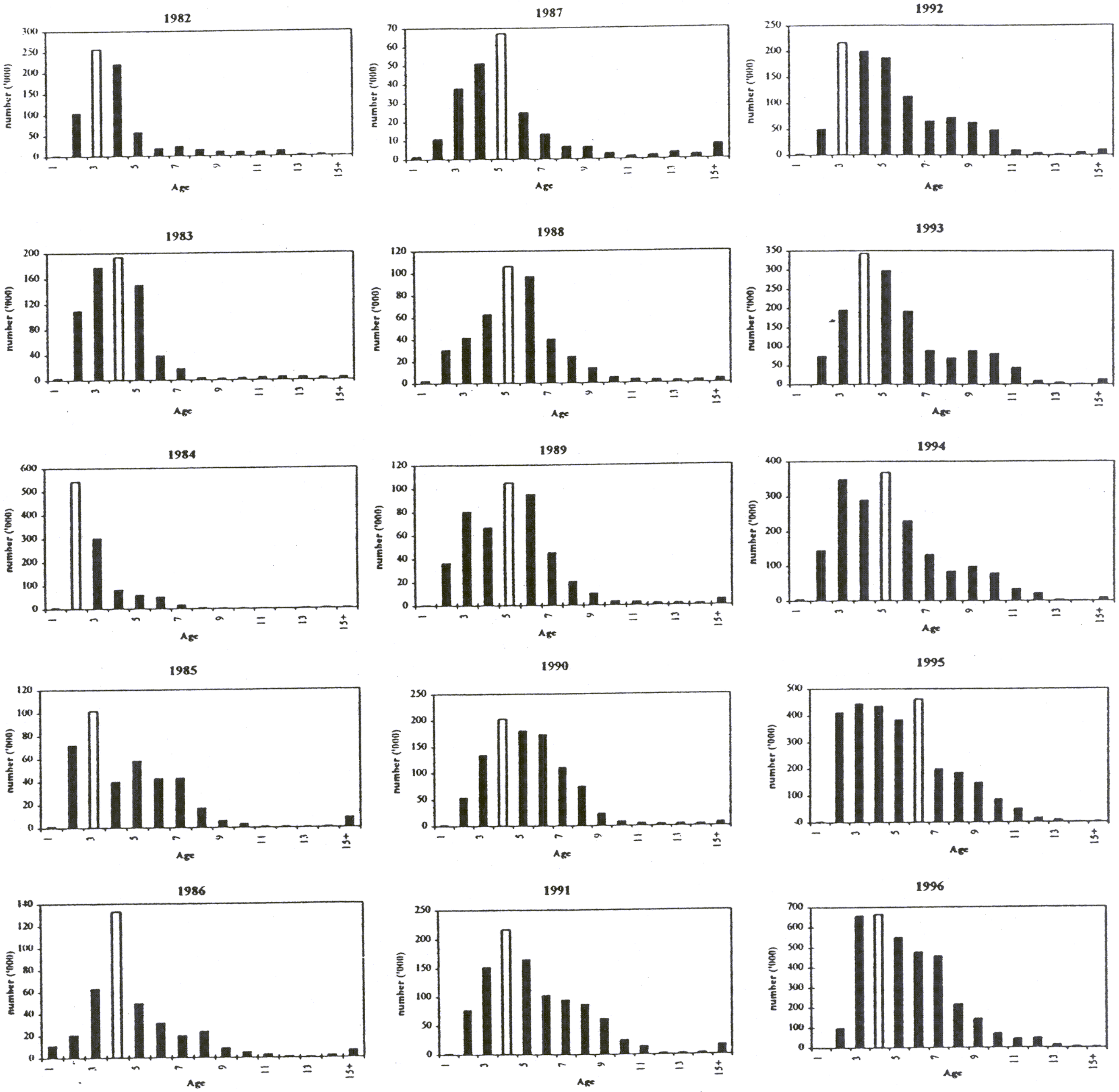


Figure 9. Striped bass catch at age by year, 1982-1996. Empty bar indicates age at maximum recruitment.

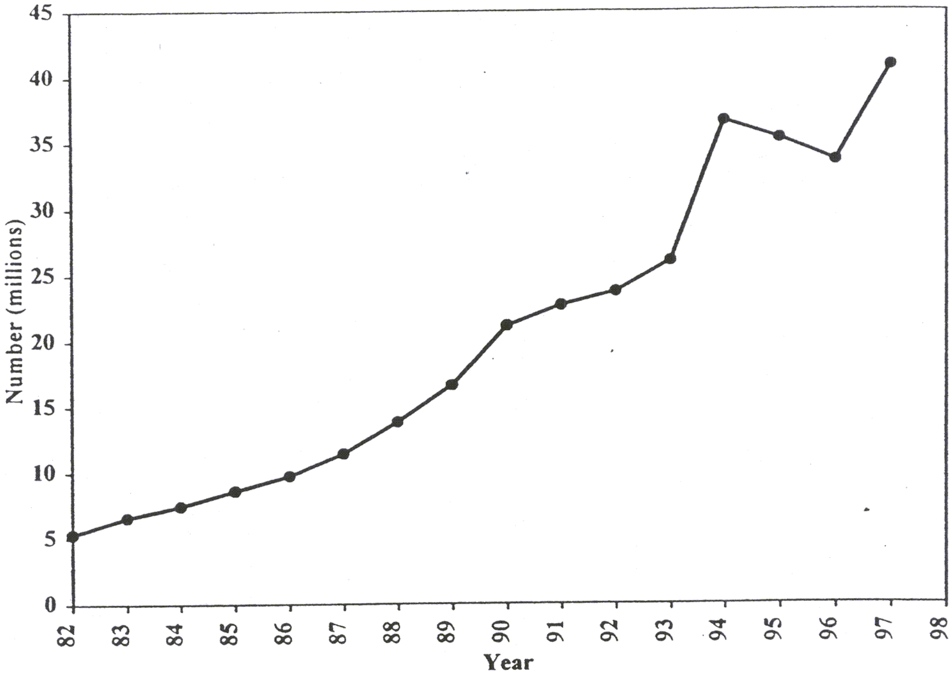


Figure 10. Estimated striped bass abundance, ages 1-15+ in number, Maine to coastal North Carolina estimated in VPA.

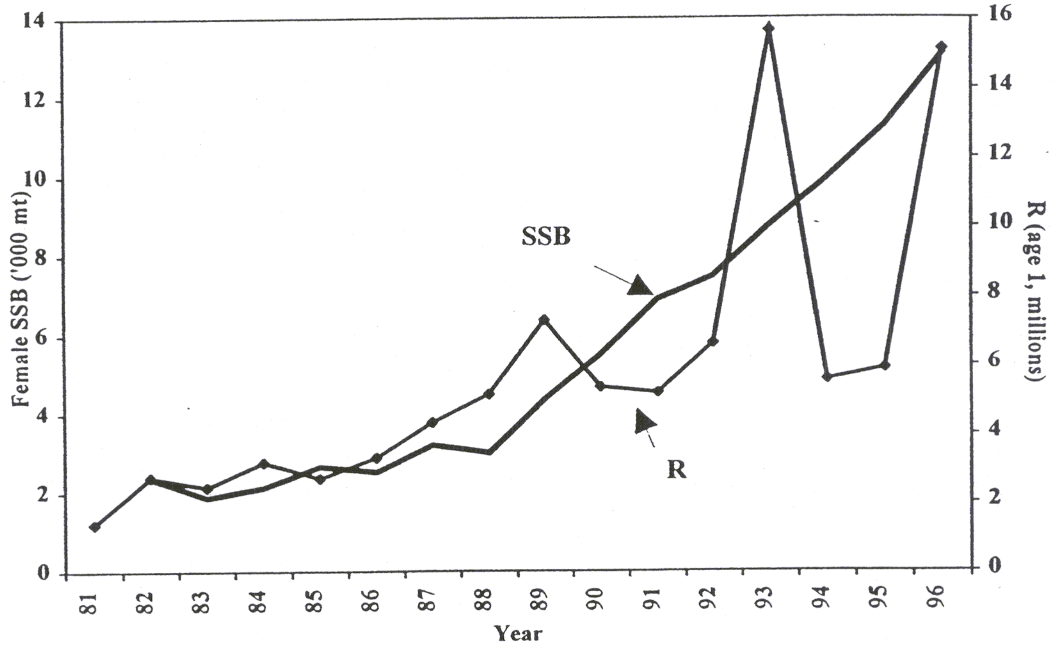


Figure 11. Striped bass spawning stock biomass and age 1 recruitment as estimated from VPA, 1982-1996. Recruitment data corresponds to year class.

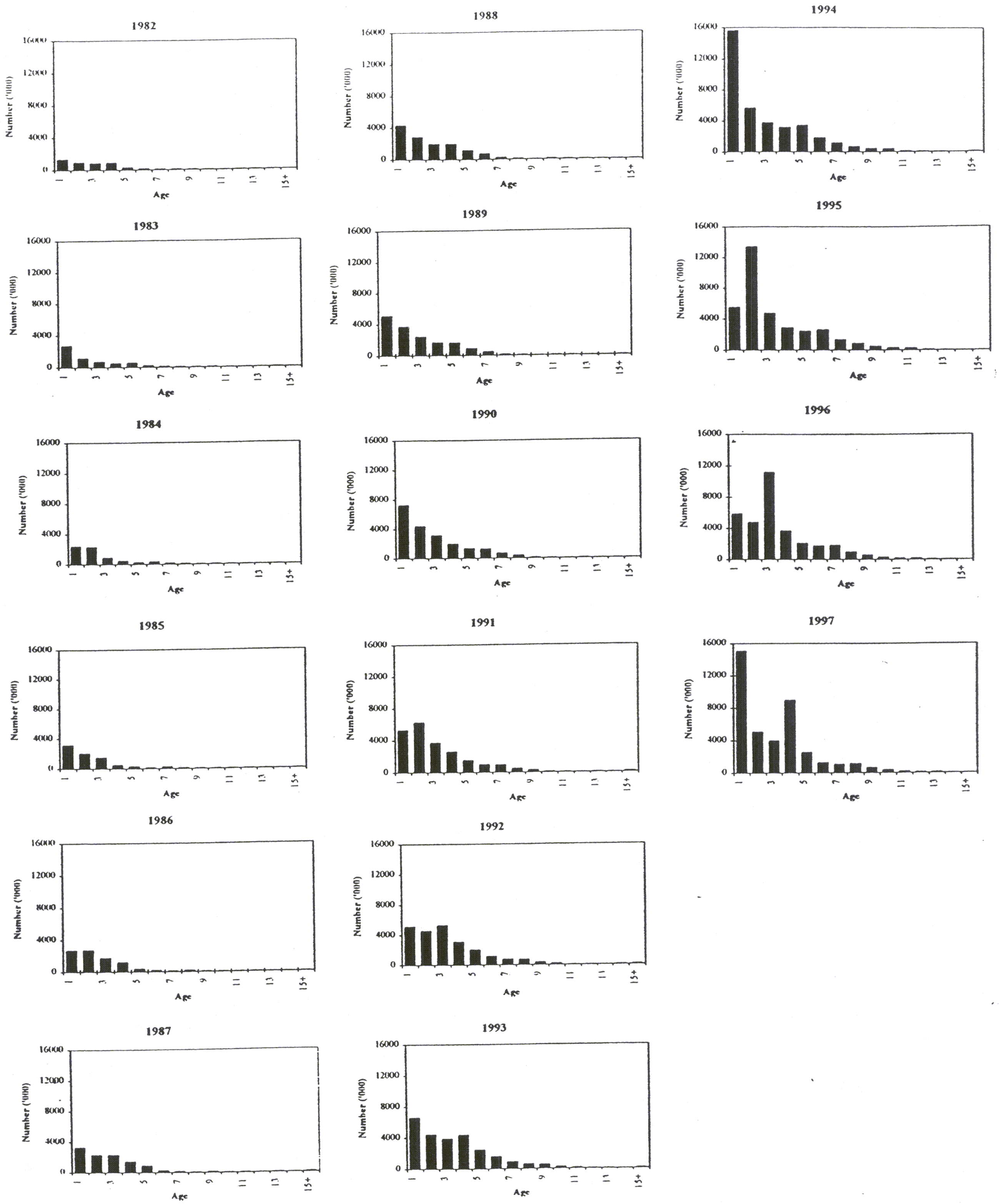


Figure 12. Striped bass population number at age on January 1, 1982-1997. Numbers in 000's.

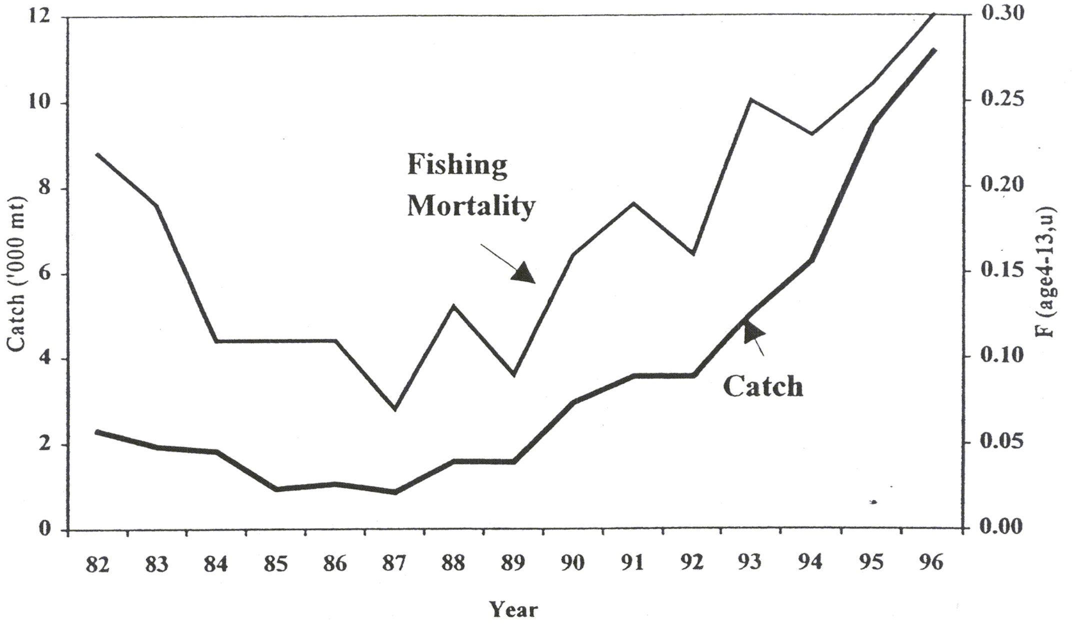


Figure 13. Total catch and fishing mortality of striped bass, Maine to coastal North Carolina, 1982-1996, determined from VPA.

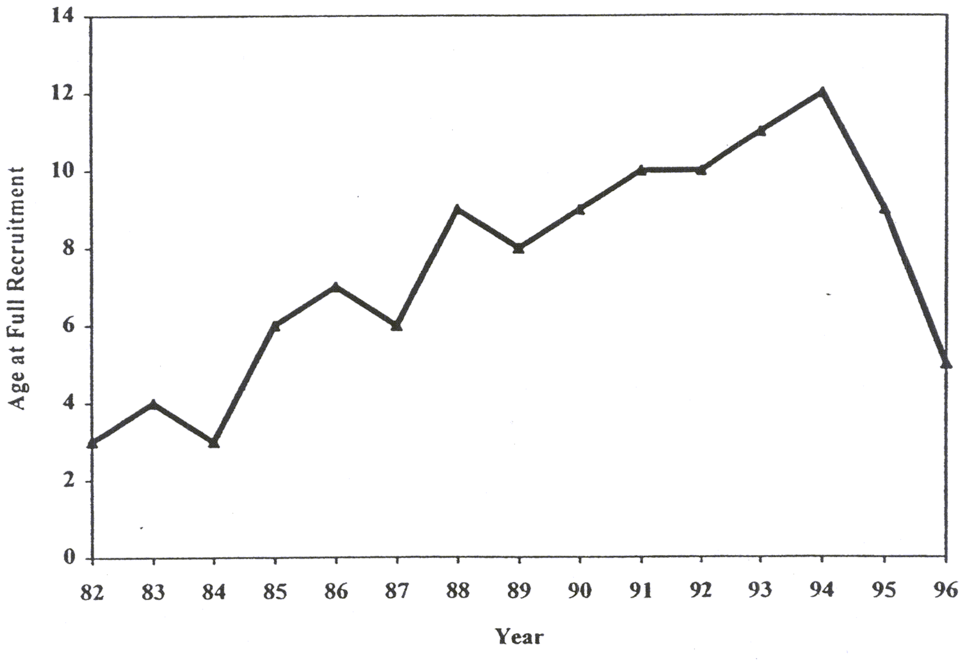


Figure 14. Age at full recruitment of striped bass Maine to North Carolina based on backcalculated partial recruitment in the VPA. 1982-1996.

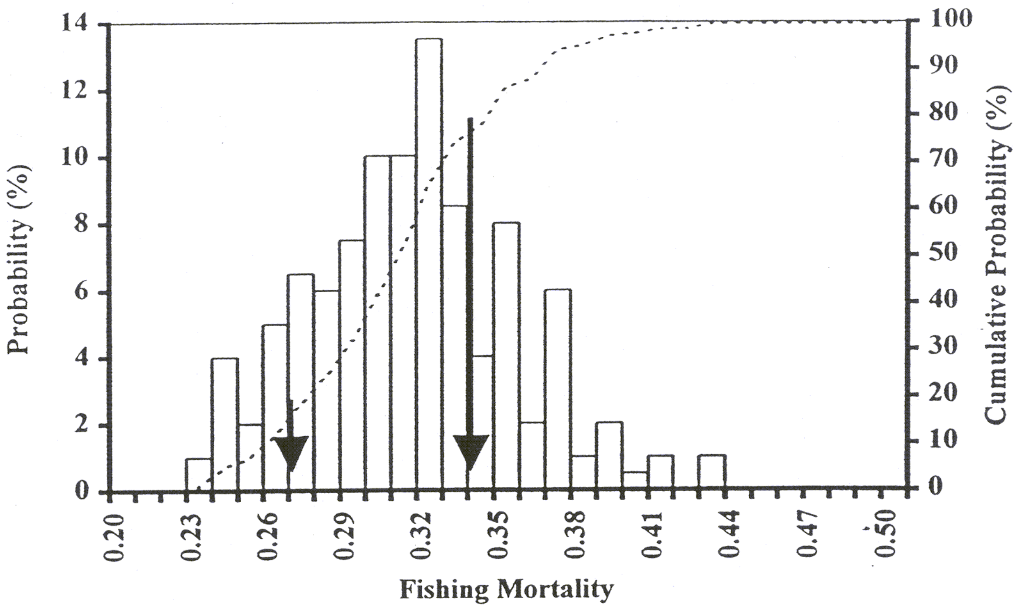


Figure 15. Precision estimate of fishing mortality (ages 4-13) for striped bass. Bars display the range of the bootstrap estimates and the probability of individual values in the range. The dashed line gives the probability that SSB is less than any value along the X axis.

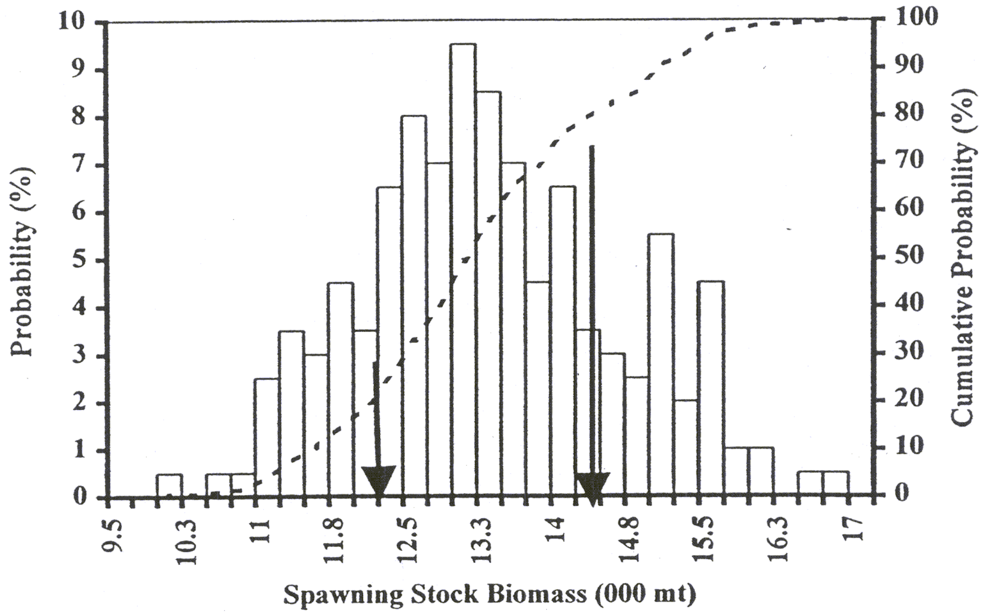


Figure 16. Precision estimate of spawning stock biomass for striped bass. Bars display the range of bootstrap estimates and the probability of individual values in the range. The dashed line gives the probability that SSB is less than any value along the X axis.

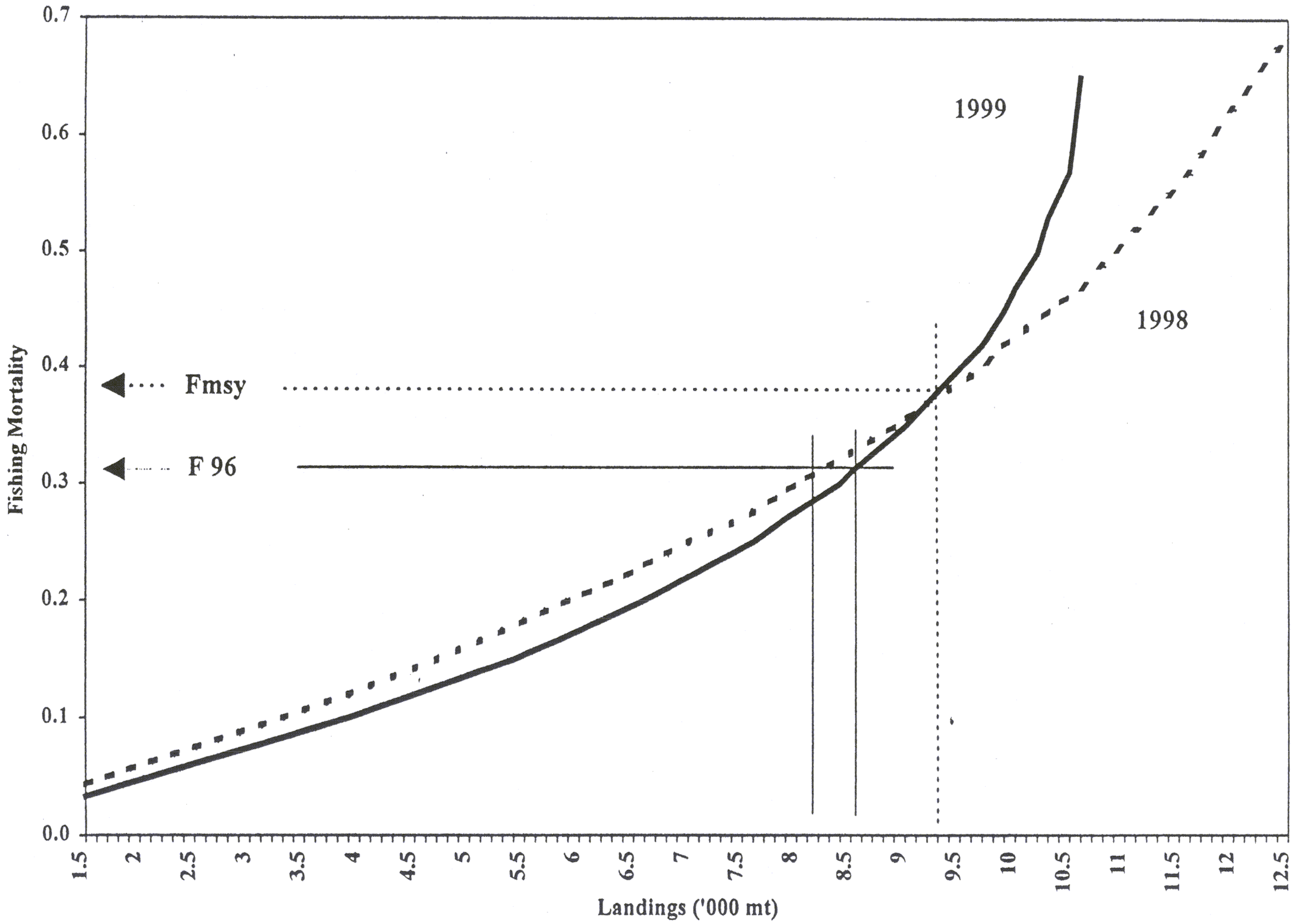


Figure 17. Projected fishing mortalities under varying levels of total striped bass landings for 1998 and 1999.

Appendix I

Use of the Spawning Stock Biomass Model (SSB) to Project Quotas for Atlantic Coast Striped Bass

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INTRODUCTION

The striped bass (*Morone saxatilis*) has supported important commercial and recreational fisheries in the Chesapeake Bay and along the Atlantic coast (Boreman and Austin 1985; Goodyear 1985; ASMFC 1995). Due to the large size of Chesapeake Bay, it is believed that the Chesapeake Bay stock contributes about 60 and 80% of the total striped bass production to the coastal migratory stock (Kohlenstein 1981; Fabrizio 1987). The Hudson River and Delaware River stocks together account for about 20 to 40% of coastwide production. The Chesapeake Bay stock began an alarming decline in spawning biomass and recruitment during the mid-1970's. Because of the highly migratory nature of Chesapeake Bay stripers (Rugolo and Jones 1989), the socioeconomic consequences of the Chesapeake stock decline were experienced along the Atlantic coast by the early 1980's following sharp declines in commercial and recreational landings. Concern over the future of the striped bass resource intensified by 1985 (Goodyear et al. 1985), resulting in the general belief that overfishing was the primary cause of the stock collapse. As a result, by 1987 the coastal states had imposed higher minimum size limits, and attempted to reduce fishing mortality rates (F) through harvest restrictions on the commercial fishery and drastic reductions in the daily creel limit on the recreational fishery. Moreover, in an effort to dramatically reduce Bay F and to ensure rebuilding of the Bay spawning population, the state of Maryland imposed a harvest moratorium on the Bay commercial and sport fisheries from 1985 to 1989.

Although fishing mortality rates (F) on striped bass had dropped abruptly after 1985, the criteria to establish stock restoration had not yet been evaluated. As a measure of stock recovery in the Bay, it was originally thought that simply tracking juvenile production from the historic Maryland Juvenile Survey might provide a sufficient criterion on which to establish stock restoration (Goodyear et al. 1985b). However, since dominant year-classes of striped bass can frequently arise at low spawning stock size, it soon became evident that juvenile indices measure future yield and spawning biomass, but can be misleading measures of current stock conditions. Thus, a scientific consensus was reached that criteria for establishing stock recovery had to based on continued controls of fishing mortality (F) and on rebuilding spawning stock biomass (Crecco 1990).

With the knowledge that the Maryland juvenile indices from 1954 to 1982 could accurately forecast relative changes in future coast-wide landings and stock size (Goodyear 1985), stock modeling work began to focus on an approach to reconstruct relative trends in striped bass spawning biomass from the 1960's to the present. The outcome of this work was a deterministic, non-equilibrium age-structured model known as the Spawning Stock Biomass (SSB) model (Rugolo et al. 1994). A precursor to the SSB model was the Harvest Control Model (HCM) (Rugolo and Jones 1989) which was used to project harvest quotas for the Maryland striped bass commercial fishery from 1990-93. The HCM was used at varying minimum size limits and target fishing mortality rates. The HCM was refined (Rugolo 1994), and a computational method devised, to project both Bay-wide and coastal commercial and recreational quotas which considered recent management changes to the coastal Atlantic fisheries. The SSB simulation modeling framework was the ultimate extension of the concept of expanding initial year class strength to future measures of spawning stock and exploitable stock size (biomass and abundance) for the Chesapeake Bat pre-migratory and coastal Atlantic migratory components of the striped bass stock (Rugolo et al. 1994).

The SSB approach, as described herein, is a deterministic, non-equilibrium age-structured model that projects future harvest quotas under varying minimum size limits, target fishing rates (i.e. F_{int}, F_{20}, F_{msy}) and patterns of age and sex-specific recruitment to the exploitable stock. The purpose of this report is to outline the essential elements of the SSB model, and to provide a real-time example of how striped bass quota projections were made.

METHODS

Model Development

The computer-based (Appendix i) SSB model for striped bass involves the deterministic expansion of the 1954-96 Maryland juveniles indices (Table 1) forward in time, thereby projecting relative stock sizes in future years. These relative stock sizes were expressed in numbers and weight (lbs.) for the exploitable (ESB) and spawning stocks (SSB). The model incorporates historic age-specific fishing patterns (minimum sizes, Bay and coastal F, partial recruitment vector) (Tables 2 and 3) and relevant age-specific life history characteristics (i.e. natural mortality (M), growth, migration and maturity ogives) (Table 4). The major assumption underlying the SSB Model (Rugolo et al 1994), and the earlier Harvest Control Model (HCM) (Rugolo and Jones 1989), is that there is a definable positive relationship between the Maryland juvenile indices and future landings and stock abundance in the Bay and along the coast. This assumption is strongly supported by the significant positive correlations between the Maryland indices and lagged commercial landings reported from several studies (Schaefer (1972); Austin and Hickey (1978); Goodyear (1985); Rugolo and Jones 1989). Moreover, Rugolo and Markham (1996) have reported that trends in predicted (model) SSB levels from the Chesapeake stock between 1985 and 1996 were highly correlated ($r = 0.99$, $P<0.0001$) to female relative stock biomass (CPUE) corrected for gillnet selectivity (Stagg 1995) (Figure 1). The strong coherence between empirical and model-based SSB indicates that the theory and assumptions which underlie the SSB model are sound, thereby providing a reliable approach to predict accurate trends in striped bass spawning biomass.

Due to the dramatic reductions in fishing mortality (F) rates after 1985, the results of the SSB model (Rugolo et al. 1994) predicted a sharp rise in SSB for the Chesapeake Bay stock during the early 1990's (Figure 2). The projected SSB levels would exceed the 1960's SSB levels, a period of relatively stable recruitment (Table 1), by 1995. For this reason, the ASMFC Striped Bass Management Board determined that the Bay striped bass population was fully restored in 1995.

Model Implementation

The SSB model output was expressed in units of relative exploitable stock biomass (ESB) and spawning stock biomass (SSB) per unit of juvenile production for the pre-migrant population in the Bay and for the coastal migratory population. Model output was also expressed separately for male and female stripers. This was necessary because many of the age-specific life history parameters (Table 4) differ between male and female striped bass (Kohlenstein 1980; Jones 1989).

In the model, time variant depletion of initial recruits (ages 2+) from the Bay and coast due to fishing (F), natural mortality (M) and emigration (E) was expressed by a negative exponential equation:

$$N_{t,s} = \sum_{i=0,\, a=2}^{i=1,\, a=15} N_{i,a,t-1,s}(\exp - (F_{i,a,t,s} + M_a) - E_{i,a,s}) \qquad (1)$$

where: i = location (Bay or coast);

t = time (years);

a = age (ages 2 to 15);

s = sex (male or female);

N = juvenile index;

M = natural mortality;

F = fishing mortality:

E = emigration rate (note: not applicable to coastal stock).

In all model runs, partial recruitment to the fishery of ages 0 and 1 stripers was assumed to be zero.

For these model runs, natural mortality (M) was held constant at 0.15 for males and females and for all age groups (ages 2 to 15). Fishing mortality rates (F) from 1959 to 1987 (Table 2) were derived for the Bay and Atlantic coast (Gibson 1993; Shepherd 1994; ASMFC 1990; Sprankle 1994) based on catch curves, tag-recapture and catch-at-age models. The overall trend in fishing mortality (F) between 1969 and 1984 from the historic VPA (Gibson 1993: Shepherd 1994) was very similar to the trend in F derived by tag-recapture (Sprankle 1994). The F estimates from 1988 to 1996 were based on tag-recapture methods and on output from the recent Adapt VPA (Gibson 1995).

In recent years (1985 to 1996), minimum size limits have risen in the Bay (from 12 to 18 in.) and along the coast (from 18 to 36 in.) (Table 3). The SSB model output accounted for sub-legal mortality (C) (age groups below legal size) as a fraction (0.20) of annual F based on our best estimates of hook-release (Diodati and Richards 1996) and poaching mortality. The resulting total mortality (Z) rate among sub-legal stripers was expressed in the model by:

$$Z = M + (C * F) \qquad (2)$$

To estimate average age (Age_a) at each minimum size, the von Bertalanffy growth model (Jones 1989) was re-arranged to estimate average age from length (l_a):

$$Age_a = 1/K * -loge(l_a - 1 / 1) + t_o \qquad (3)$$

Total mortality (Z) for striped bass age groups whose length exceeded the minimum size was expressed by:

$$Z = M + F \qquad (4)$$

The average age of striped bass whose length corresponded to the minimum size often fell between two discrete age groups. In this case, total mortality (Z) was derived by weighted interpolation:

$$Z = (M + (0.20 * F)*frac<l_a) + ((M + F)*frac>l_a) \qquad (5)$$

where: $frac<l_a$ represents the fraction of age_a below the minimum size:

$frac>l_a$ is the fraction of age_a that is equal to or greater than the minimum size limit.

The migration rate (E in equation 1) of Chesapeake Bay stripers to the coastal migratory stock was also expressed explicitly in the SSB model. Age and sex-specific migration rates (Table 4) were derived by Jones and Rugolo (1988) during the moratorium years (1985-1989). An implicit assumption in the model is that once migration to the Atlantic coast has occurred, striped bass remain in the coastal migratory stock until sexual maturity has been attained (Kohlenstein 1980). Age and sex-specific migration was configured in the model during the second half of each year (t).

The model (see Appendix 1) generated exploitable stock (ESB) biomass (ages 2 to 15) by year (t), age (a),sex (s) and location (i) by:

$$ESB_{t,s} = \sum_{i=0,\ a=2}^{i=1,\ a=15} N_{a,i,t,s}(\exp\text{-}(F_{i,t,a} + M_a) - E_{i,a},s) * W_{a,s} \qquad (6)$$

where: $W_{a,s}$ = the mean weight (lbs.) by age (a) and sex (s) based on the von Bertalanffy growth model (Jones 1989).

The model (see Appendix 1) also generated spawning stock biomass (SSB) (ages 2 to 15) by year (t), age (a),sex (s) and location (i) by:

$$SSB_{t,s} = \sum_{i=0,\ a=2}^{i=1,\ a=15} N_{a,i,t,s}(\exp\text{-}(F_{i,t,a} + M_a) - E_{i,a},s) * W_{a,s} P_{a,s} \qquad (7)$$

where: $P_{a,s}$ = mean proportion of mature fish by age (a) and sex (s) based on Jones and Rugolo (1988).

The annual catch in number (C_t) was generated in the model (Appendix 1) by year (t), age (a),sex (s) and location (i) by:

$$C_t = \sum_{i=0,\ a=2}^{i=1,\ a=15} F_{i,t,a} / (F_{i,t,a} + M_a) * (N_{i,t,a}(1\text{-}e - (F_{i,t,a} + M_a)) \qquad (8)$$

Catch in weight (CW) was estimated in the model from the above expression times the age and sex-specific weight term ($W_{a,s}$).

Quota Estimation

It is relatively straightforward to extend the SSB model in order to project Bay-wide and coastal annual quotas. The approach employed here is a natural extension of the Harvest Control Model (HCM)(Rugolo and Jones 1989) which has been used since 1990 to estimate annual harvest quotas for the Maryland commercial and recreational fisheries. The reliability of the HCM approach is demonstrated by the fact that annual Bay commercial quotas based on HCM had risen steadily from 1990 to 1994, but estimated fishing mortality rates (F) on pre-migrant striped bass have remained low (F range: 0.14 to 0.23) and stable (Rugolo and Lange 1993).

The quota estimates given herein should be viewed as a working example and therefore, should not be considered relevant for the current FMP. The current FMP (Amendment 5) has adopted a dual minimum size limit strategy (20 in. size limit for the Bay and 28 in. size limit for the coast) for managing Atlantic coast striped bass at a target fishing mortality rate (F_{int}) of 0.31 (ASFMC 1995). The so-called interim target F (F_{int}) is the fishing mortality rate that fell halfway between F = 0.25 (Amendment 4) and F_{msy}. The current overfishing definition (F_{msy} = 0.38) for striped bass was derived using the Shepherd S-R model and the Thompson-Bell YPR model (Crecco 1994).

Alternative minimum size limits are allowed in the Bay and along the coast with varying target F_{int} levels (Table 5), provided that the alternative size limit produced equivalent conservation based on SSB/R (Crecco 1994) to the preferred option (i.e. 20 in. minimum size limit for the Bay and 28 in. size limit for the coast). The Bay jurisdictions (MD, VA and PRFC) have chosen an 18.0 in. rather than a 20.0 in. minimum size limit. For this reason, the target Fint level for the Bay fishery was reduced from 0.31 to 0.28 based on equivalent SSB/R (Table 5). Since 1996 is the year in which the most current observed fishing mortality rates (F) are available (1996 Bay F = 0.27 and coastal F = 0.37), the SSB model projects harvest quotas based on F and stock size in the reference year (1996) to the years, 1998 and 1999. The 1996 F estimates for the Bay and coastal fisheries used in this example are preliminary and therefore subject to major revision. Since no estimates of F are available after 1996, the 1996 F estimates for the Bay and coast were assumed to occur in the years 1997, 1998 and 1999.

Although ESB levels for the Bay and coast were estimated by equation 6, several modifications to the original model have been made in an attempt to improve model performance. Firstly, the geometric mean juvenile indices from the Maryland survey were used (Table 6) instead of the arithmetic mean. This change was made because the geometric mean is more consistent with the log normal distribution of most survey abundance data. Secondly, since the coastal migratory population of striped bass is actually several discrete stocks (Delaware River, Hudson River and Chesapeake Stocks), we reconfigured the model (see Figure 3) to include the relative stock contribution from the Hudson and Delaware stocks based on annual juvenile surveys of these stocks (Table 6). The three sets of juvenile indices from 1980 to 1996 were re-scaled so that, on average, the Chesapeake Bay stock accounted for 65% of the total coastwide production (Fabrizio 1987), and the Hudson and Delaware stocks comprised an average of 20% and 15%, respectively (Table 7). Since age and sex-specific migration rates have not yet been estimated for Hudson and Delaware Rivers stripers, we assumed that fish from these stocks join the coastal migratory population by age 2+.

Specifically, the SSB model generated exploitable stock biomass (ESB) estimates (see equation 6) in 1996, 1998 and 1999 (Table 8). Since the current minimum size limit in the Bay is 18.0 in., ESB levels generated by the model for the Bay fishery in 1996, 1998 and 1999 reflect the relative stock weight of 18 in.+ pre-migrant striped bass. By contrast, the minimum size limits for the coastal fishery were more variable (20 to 28 in.). For this reason, ESB levels generated for the coastal fishery reflect relative stock weight over a range of sizes from 20 in.+ to 28 in.+ (Table 8). The ESB levels were estimated as a ratio between the ESB levels between the years 1996 and 1998 and between 1996 and 1999 (Table 9).

Harvest quota projections ($H_{t,i}$) for the years 1998-99 were derived by the following expression:

$$H_{t,i} = ((F_{int,i} - F_{nh})/F_{96} - F_{nh}) * H_{ref,i} * ESB_i \qquad (9)$$

where: $F_{int,i}$ = target fishing mortality rates by location (see Table 4);

F_{nh} = the assumed non-harvest fishing mortality rate (F_{nh}=0.10);

$F_{int,i}$ = target fishing mortality by location;

$H_{ref,i}$ = total 1996 commercial and recreational harvest by location (Table 10);

ESB = proportional change in exploitable stock biomass between 1996 and 1998 and between 1996 and 1998 (Table 9).

The non-harvest fishing mortality term (F_{nh}) was included in equation (9) because the landings scalar ($H_{ref,i}$) does not include losses from discard mortality. The 1998 and 1999 quotas were projected by equation (9) by scaling the 1996 harvest ($H_{ref,i}$) by the ratio differences in fishing mortality (current vs. target F) and in ESB between the years 1996 and 1998 and between 1996 and 1999.

Quota Results

The projected 1998 (9.2 million lbs.) and 1999 (9.5 million lbs.) Bay-wide quotas for striped bass (Table 10) were nearly twice the 1996 Bay-wide harvest (5.6 million lbs.). This pronounced increase in Bay-wide quotas largely reflect the influx of harvestable-size fish from the dominant 1993 year-class (Table 7). Since age-specific migration to the coast of pre-migrant stripers is relatively rapid after age 2 (Table 4), under an 18.0 in. minimum size limit, the Bay-wide quotas depend largely on the abundance of ages 4, 5 and 6 year old stripers. It is evident that the magnitude of the Bay-wide quotas depend greatly on recruitment strengths in years t-4, t-5 and t-6. For this reason, the Bay-wide quotas for striped bass are inherently variable across years.

The projected 1998 and 1999 striped bass quotas for the coastal fisheries differed across the range of minimum sizes (20.0 to 28.0 in.) (Table 10). The 1998 and 1999 projected quotas were similar to, or slightly below the 1996 coastal landings (9.8 million lbs.). This modest improvement in the coastal quotas occurred largely because the 1996 F ($F_{96} = 0.37$), used in this example, exceeded the target F levels (Table 5). The quota projections varied by minimum size due to inherent variability in ESB levels (Table 8) and in target F levels (F_{int}) (Table 5) at each of the minimum sizes (20.0 to 28.0 in.). Coastal ESB levels vary to some degree due to annual changes in recruitment strengths from the Hudson, Delaware and Chesapeake Stocks (Table 7). This is further compounded by shifts in ESB levels at each of the minimum size limit combinations (Table 9). Since the exploitable striped bass population on the coast is comprised of fish of three stocks (ie Bay, Delaware and Hudson stocks) between ages 5 and 20, the magnitude of coastal quotas do not depend as much as the Bay quotas on the strength of two to three year-classes. As a result, long-term variability of coastal quotas should be considerably less than that for Bay-wide quotas.

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Table 1. Maryland juvenile striped bass arithmetic mean catch per haul.

Year	Head of Bay	Potomac River	Choptank River	Nanticoke River	Bay-Wide
1954	0.9	5.2	1.2	25.1	5.2
1955	4.4	5.7	12.5	5.9	5.5
1956	33.9	6.2	9.8	8.2	15.2
1957	5.4	2.5	2.1	1.3	2.9
1958	28.2	8.4	19.5	22.5	19.3
1959	1.9	1.6	0.1	1.8	1.4
1960	9.3	4.3	9.0	4.7	7.1
1961	22.1	25.8	6.0	1.5	17.0
1962	11.4	19.7	6.1	6.6	12.2
1963	6.1	1.1	5.4	4.1	4.0
1964	31.0	29.1	10.6	13.3	23.5
1965	2.2	3.4	9.5	21.6	7.4
1966	32.3	10.5	13.6	3.3	16.7
1967	17.4	1.9	5.3	4.1	7.8
1968	13.1	0.7	6.3	9.0	7.2
1969	26.6	0.2	4.8	6.2	10.5
1970	33.1	20.1	57.2	17.1	30.4
1971	23.7	8.5	6.3	2.0	11.8
1972	12.1	1.9	11.0	25.0	11.0
1973	24.5	2.1	1.3	1.1	8.9
1974	19.9	1.5	15.3	3.9	10.1
1975	7.6	7.8	4.7	5.2	6.7
1976	9.9	3.2	2.4	1.7	4.9
1977	12.1	1.9	1.2	1.0	4.8
1978	12.5	7.9	6.0	4.8	8.5
1979	8.3	2.2	2.8	0.9	4.0
1980	2.3	2.2	1.0	1.8	2.0
1981	0.3	1.4	1.3	2.4	1.2
1982	5.5	10.0	13.0	6.2	8.4
1983	1.2	2.0	0.9	1.0	1.4
1984	6.1	4.7	2.8	1.5	4.2
1985	0.3	5.6	3.7	2.1	2.9
1986	1.6	9.9	0.5	2.2	4.1
1987	0.3	6.4	12.1	2.5	4.8
1988	7.3	0.4	0.7	0.4	2.7

Table 1. Maryland juvenile striped bass arithmetic mean catch per haul (continued).

Year	Head of Bay	Potomac River	Choptank River	Nanticoke River	Bay-Wide
1989	19.4	2.2	97.8	2.9	25.2
1990	3.8	0.6	3.1	0.9	2.1
1991	3.9	2.5	12.2	1.1	4.4
1992	1.3	22.1	4.3	4.3	9.0
1993	23.0	36.4	105.5	9.3	39.8
1994	23.4	3.9	19.3	21.5	16.1
1995	4.4	8.7	17.7	10.4	9.3
1996	25.0	48.5	154.4	43.6	59.4
TPA *	17.3	9.2	10.8	8.6	12.0

*TPA (target period average) is the average from 1959 through 1972.

Table 2. Historic time series of instantaneous fishing mortality rates (F) for Chesapeake Bay and Atlantic Coast for years 1954-1994 as derived by Gibson (1993) and Crecco (1993), respectively. (Source: Rugolo et al. 1994).

Year	Bay	Coast
1954	0.45	0.35
1955	0.45	0.35
1956	0.45	0.35
1957	0.45	0.35
1958	0.45	0.35
1959	0.45	0.35
1960	0.60	0.35
1961	0.60	0.35
1962	0.70	0.35
1963	0.65	0.35
1964	0.60	0.35
1965	0.55	0.40
1966	0.55	0.40
1967	0.55	0.40
1968	0.65	0.40
1969	0.80	0.40
1970	0.70	0.45
1971	0.75	0.45
1972	1.45	0.45
1973	1.10	0.45
1974	1.00	0.45
1975	0.90	0.45
1976	0.80	0.45
1977	1.30	0.45
1978	0.90	0.45
1979	1.25	0.45
1980	1.75	0.45
1981	1.80	0.45
1982	1.30	0.45
1983	1.10	0.45
1984	0.60	0.45
1985	0.08	0.40
1986	0.05	0.40
1987	0.05	0.35
1988	0.05	0.35
1989	0.05	0.30
1990	0.12	0.25
1991	0.15	0.25
1992	0.18	0.25
1993	0.18	0.25
1994	0.18	0.25

Table 3. Historic size limits in Chesapeake Bay and along the Atlantic Coast for years 1954-1994. For the Bay, size limits are specific to the resident, pre-migratory stock, and to the coastal migratory stock. Since coastal size limits varied among states during 1990-present, parenthetical values represent the percentage of total annual F on the coastal migratory stock at those limits. Size units are total length in inches (Source: Rugolo et al. 1994).

	Bay		Coast	
Year	Resident	Migratory	Group 1 (%F)	Group 2 (% F)
1954-57	11 - 32	11 - 32	17+ (50)	17+ (50)
1958-82	12 - 32	12 - 32	17+ (50)	17+ (50)
1983	12.7[1] - 32	12.7 - 32	24+ (50)	24+ (50)
1984	14 - 32	14 - 32	24+ (50)	24+ (50)
1985	closed	closed	24+ (50)	24+ (50)
1986	closed	closed	29+ (50)	29+ (50)
1987	closed	closed	31+ (50)	31+ (50)
1988	closed	closed	33+ (50)	33+ (50)
1989	closed	closed	36+ (50)	36+ (50)
1990	18 - 36	closed	28+ (50)	36+ (50)
1991	18 - 36	closed[2]	28+ (35)	36+ (65)
1992	18 - 36	closed[2]	28+ (35)	36+ (65)
1993	18+	34+	28+ (25)	28+ (75)
1994	18+	34+	28+ (25)	34+ (75)

1/ Effective (i.e. weighted) annual size limit = 12-32" TL (1 Jan - 30 June @ 65.18% of landings) + 14-32" TL (1 July - 31 Dec @ 34.82% of landings).
2/Modest directed losses in these years accounted for under total non-compliance loss rate: $Z = M + (C + F')$ where $F' = 0.25$.

Table 4. Emigration and maturity rates by age of striped bass from Chesapeake Bay.

	Emigration		Maturity	
Age	Male	Female	Male	Female
0	0	0	0	0
1	0	0	0	0
2	0.1	0.1	0.75	0
3	0.35	0.5	1.0	0
4	0.35	0.5	1.0	0.05
5	0.35	0.5	1.0	0.15
6	0.35	0.5	1.0	0.45
7	0.35	0.5	1.0	0.75
8	1.0	1.0	1.0	0.95
9	1.0	1.0	1.0	1.0
10	1.0	1.0	1.0	1.0
11	1.0	1.0	1.0	1.0

Table 5. Estimated interim target fishing mortality rates (Fint) for striped bass from the 1998 Bay and coastal fisheries at various minimum size and slot limits and at a natural mortality rate (M) of 0.15. These Fint estimated were based on equivalent conservation of SSB/R for a preferred minimum size of 28.0 in. for coastal and 20.0 in. for Bay fisheries.

	Minimum Size (in. TL)	Fint
Coast		
	20.0	0.24
	22.0	0.25
	24.0	0.27
	26.0	0.28
	28.0	0.31
Bay		
	20.0	0.31
	18.0	0.28

Table 6. Geometric mean juvenile indices of striped bass for the Bay, Hudson River and Delaware River stocks from 1980 to 1996.

Year	Bay Index	Hudson Index	Delaware Index
1980	2.0	6.1	0.05
1981	1.6	8.9	0.00
1982	4.5	14.2	0.12
1983	1.6	16.3	0.03
1984	2.6	15.0	0.29
1985	1.9	1.9	0.02
1986	2.3	2.9	0.28
1987	2.5	15.9	0.41
1988	1.7	33.5	0.35
1989	5.9	21.4	1.03
1990	2.0	19.1	1.00
1991	2.5	3.6	0.47
1992	3.3	11.4	1.19
1993	15.0	12.6	1.78
1994	7.4	17.6	0.96
1995	5.4	16.2	1.98
1996	18.5	9.3	1.70
Mean	4.74	13.29	0.69

Table 7. Adjusted geometric mean juvenile indices of striped bass for the Bay, Hudson and Delaware Rivers from 1980 to 1996. Adjustments made by the ratio of the annual index (INDt) for each stock to the long term (1980-1996) arithmetic mean times the average assumed long term contribution of each stock (Bay = 0.65, Hudson = 0.20, Delaware = 0.15).

Year	Adj. Bay Index[1]	Adj. Hudson Index[2]	Adj. Delaware Index[3]
1980	2.74	0.92	0.11
1981	2.19	1.34	0.00
1982	6.16	2.14	0.26
1983	2.19	2.45	0.07
1984	3.56	2.26	0.63
1985	2.60	0.29	0.04
1986	3.15	0.44	0.61
1987	3.42	2.39	0.89
1988	2.33	5.04	0.76
1989	8.07	3.18	2.24
1990	2.74	2.87	2.17
1991	3.42	0.54	1.02
1992	4.52	1.67	2.59
1993	20.50	1.90	3.87
1994	10.13	2.65	2.09
1995	7.39	2.44	4.30
1996	25.32	1.40	3.70

1 / (Index / 4.75) * 10 * 0.65;
2/ (Index / 13.29) * 10 * 0.20;
3/ (Index / 0.69) * 10 * 0.15;

Table 8. Estimates of exploitable stock biomass (ESB) (male and female biomass combined) at various minimum size limits for the Bay and coastal striped bass fisheries for 1996, 1998 and 1999 using the SSB model. Units of ESB are expressed as lbs./juvenile index.

		Coast	
Minimum Size (in. TL)	ESB96	ESB98	ESB99
20.0	131.37	167.44	176.18
22.0	123.61	156.09	164.93
24.0	112.25	145.21	149.93
26.0	102.84	121.92	131.93
28.0	95.06	84.86	110.49

		Bay	
Minimum Size (in. TL)	ESB96	ESB98	ESB99
18.0	8.54	13.42	13.72

Table 9. Estimates of delta ESB at various minimum size limits for the Bay and coastal striped bass fisheries from 1996 to 1998 and 1996 to 1999 based on the modified SSB model. The ESB values are expressed as ratios between ESB98/ESB96 and ESB99/ESB96 from Table 8.

Coast

Minimum Size (in. TL)	ΔESB98	ΔESB99
20.0	1.27	1.34
22.0	1.26	1.33
24.0	1.29	1.34
26.0	1.19	1.28
28.0	0.89	1.16

Bay

Minimum Size (in. TL)	Δ ESB98	ΔESB99
18.0	1.57	1.61

Table 10. Estimated Bay-wide and coastal quotas (Htotal in lbs * 1000) for the years 1998 and 1999 based on ESB for male and female striped bass, the 1996 bay fishing mortality rate (F96 = 0.27), the interim target fishing mortality rate (Fint = 0.28) and the 1996 Bay-wide (recreational and commercial) landings of striped bass. The 1996 coastal landings (Href) was 9,767.1 lbs.

	Bay Quotas [1]	
Parameters	1998	1999
1996 Landings (Href)	5,557.5 lbs * 1000	
Quota	9,248.8	9,484.4

	Coast Quotas [1]	
Minimum Size (in. TL)	1998	1999
20.0	7,720.2	8,145.8
22.0	8,210.6	9,207.3
24.0	9,500.9	9,868.8
26.0	9,319.6	9,876.3
28.0	7,907.3	10,306.0

1/ $H_{total} = ((F_{int} - F_{nh}) / (F_{96} - F_{nh})) * ESB * H_{ref}$,
where: $F_{nh} = 0.10$

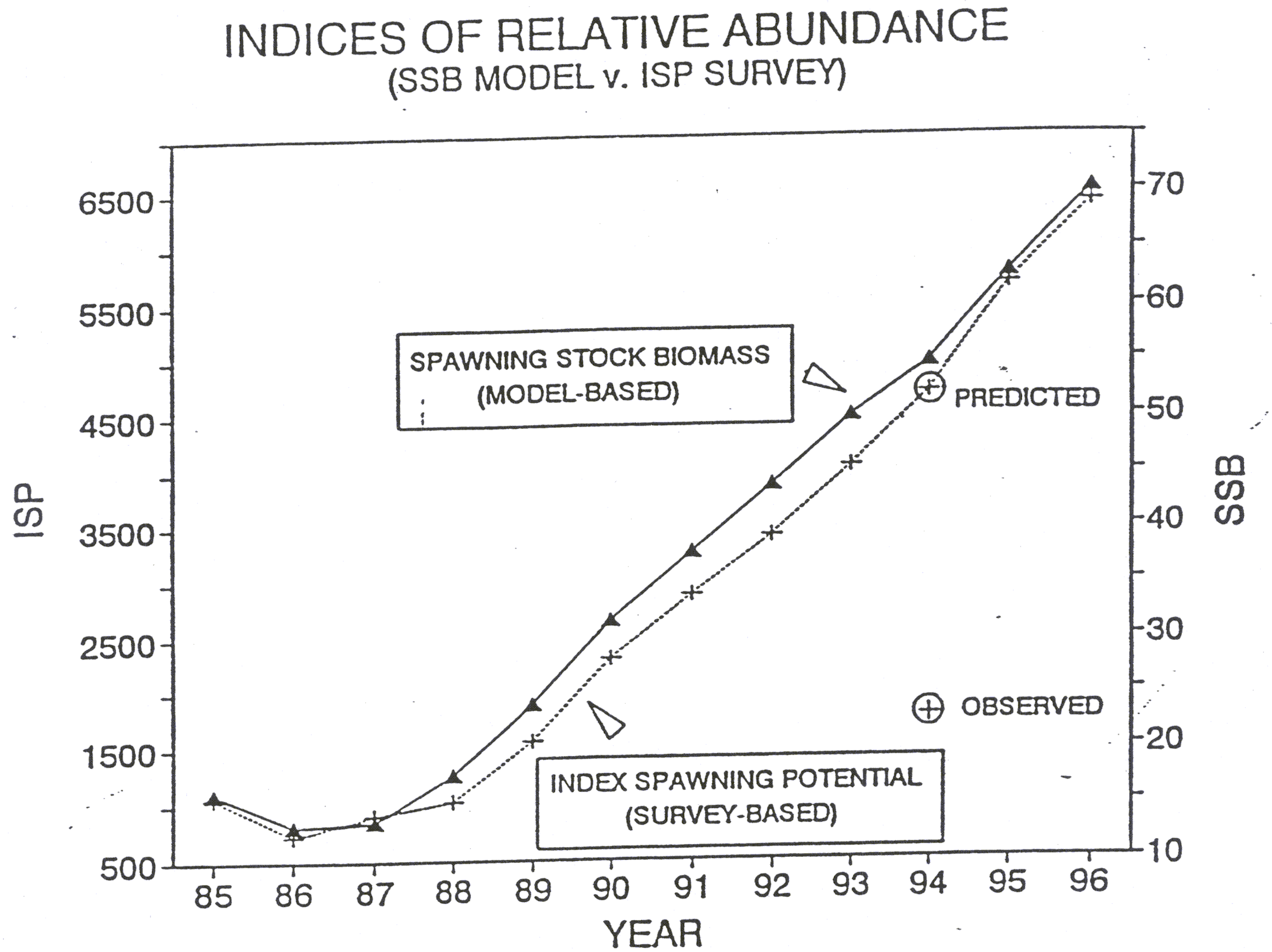

Figure 1. Indices of relative abundance from SSB model compared to calculated Index of Spawning Potential derived from observed survey data.

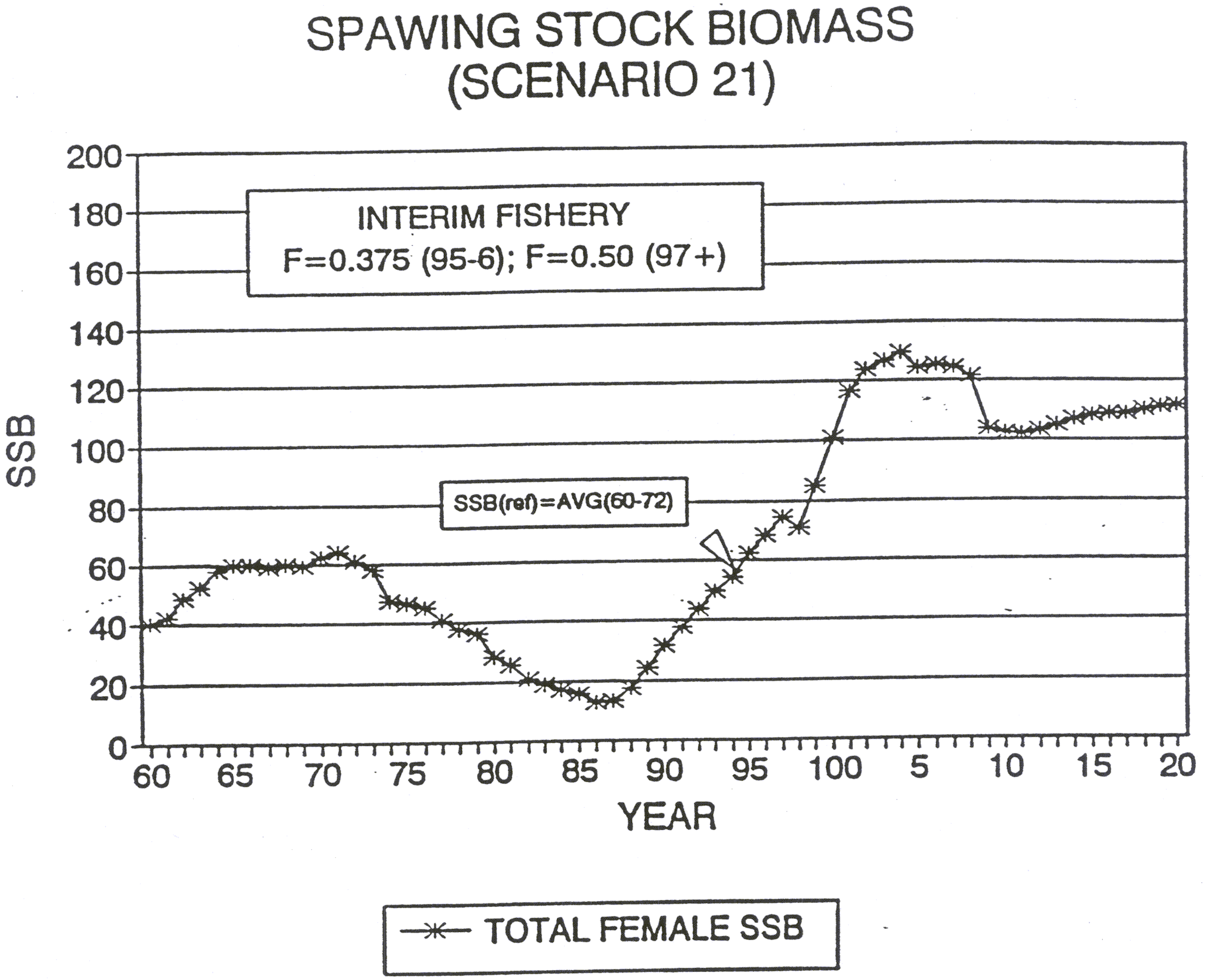

Figure 2. Simulated female spawning stock biomass derived from the SSB model. Based on a fishing mortality of 0.375 from 1995-1996 and 0.5 from 1997 to 2020.

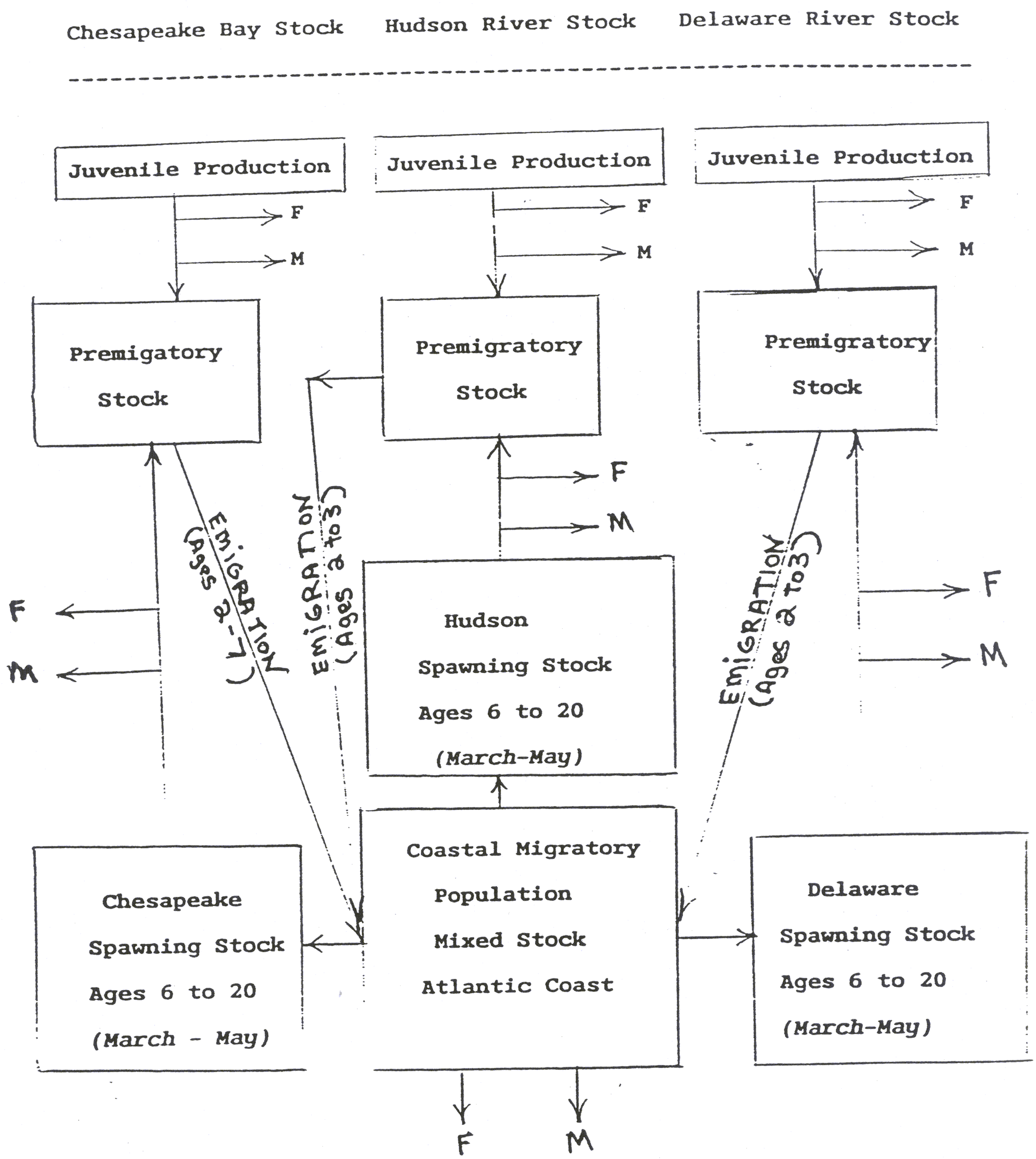

Figure 3. Schematic of striped bass spawning stock biomass model for three spawning stocks.

Appendix i

Comparison of empirical and model-based indices of relative spawning stock biomass for the coastal Atlantic striped bass stock

By

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Report to the
Striped Bass Technical Committee
Atlantic States Marine Fisheries Commission

INTRODUCTION

The overall objective of the inter-jurisdictional fisheries management program for coastal striped bass is the achievement of specific measurable goals deemed characteristic of both stock status, and fishery performance. Principal among these are the measures of juvenile reproduction in the key spawning areas, coast-wide female spawning stock biomass, as well as target fishing mortality rates (Crecco 1994) specified for all jurisdictions that exploit the resource.

Results of juvenile recruitment surveys conducted in the Hudson River, Delaware Bay, Chesapeake Bay and Roanoke River are fundamental to gauging annual reproductive success of each component of the coastal migratory stock. To serve the basis of timely and accurate estimates of annual fishing mortality rate, the assessment process has relied on a variety of data gathering and analytical activities. For coastal Atlantic fisheries, these include the coast-wide cooperative tagging program performed by the states under the aegis of the United States Fish and Wildlife Service (USFWS), and virtual population analysis (VPA). For Chesapeake Bay fisheries, estimates of the rate of exploitation that is directly attributable to the Bay jurisdictional fisheries has been provided in results of a mark-recapture program implemented by the Maryland Department of Natural Resources in 1993, and continued thereafter (Rugolo and Lange 1993, Rugolo et al. 1994, Schaefer and Rugolo 1995).

For the purpose of measuring the status of the coastal adult striped bass stock, Rugolo et al. (1994) developed a simulation model to reconstruct the historical performance of the stock, and to project future stock status under a variety of management regimes for years 1960 - 2020. The aim of this work was to provide answers to three fundamental management questions: (1) what is the measure of stock status indicative of a restored stock - i.e., the so-called reference or target level; (2) what is current stock status relative to this reference level; and (3) what are the consequences on long-term stock status of alternative management strategies under consideration by the management agencies. Based on results of this work, the measure of coast-wide female spawning stock biomass (termed SSB) was proposed as the basis of the *adult stock trigger* specified in Amendment #4 of the Interstate Striped Bass Fisheries Management Plan (ISFMP), and subsequently adopted in Amendment #5 of the plan. Indeed, this measure of spawning stock biomass was one of the principal determinants for declaring the striped bass stock restored as of 1995, and in choosing among the suite of alternative management strategies considered by the respective jurisdictions.

Considering the importance of results of this work, an effort was made to corroborate the model-based trajectory in SSB with independent measures of spawning stock status. In 1993, Rugolo and Lange developed an empirical-based index of spawning stock abundance termed the *Index of Spawning Potential* (ISP) from catch-per-unit-effort data on spawning females collected by the MDNR's spawning grounds gill net survey. Based on survey data from 1985-92, the ISP was shown to be highly correlated ($R^2 = 0.97$) with the model-based projections in SSB (Rugolo et al. 1994, Rugolo 1994). This result strongly suggested that the simulation model provided a reliable measure of annual spawning stock biomass which was suitable to supporting the interstate decision-making process.

In this report, we provide an update of the annual ISP index through 1996, and compare the performance of growth in the coastal stock expressed in the currency of ISP, to projections in SSB for 1985-96. Spawning stock survey data used in this analysis have been corrected for bias resulting from gill net selectivity as derived by Stagg (1995).

METHODS

The MDNR has monitored the status of the resident and migratory adult striped bass stocks since 1981. In particular, the spring spawning stock survey was designed to gather information to monitor stock condition, and to evaluate the effects of coast-wide management actions on the Maryland component of the coastal Atlantic stock. This survey, which commenced in 1982 and was standardized in 1985, is an integral part of the MDNR's annual monitoring program. Insofar as the Chesapeake spawning stock is considered a major contributor to the coastal migratory stock (Berggren and Lieberman 1978), data from this survey provides valuable information on stock condition which is necessary to assess the effectiveness of existing management actions.

1. <u>The Spring Spawning Stock Survey</u>

Experimental drift gill nets are deployed in three of Maryland's four major spawning systems (Hollis 1967) consisting of: the Head-of-Chesapeake Bay (Upper Bay), the Choptank River, and the Potomac River. The Potomac River was not sampled in 1994; nor was the Choptank River in 1995. Customarily, field sampling begins in early April on the Choptank and Potomac Rivers, and in mid-April in the Upper Bay. Survey sampling ends in all systems when daily catches decline to zero. Gill net sizes of 3.00 (3.125 in the Choptank River), 3.75, 4.50, 5.25, 6.00, and 7.00 inch stretched multifilament nylon mesh were fished in each system from 1985 through 1989. Additional mesh sizes of 6.50, 8.00, 9.00, and 10.00 inch were added in 1990 in all sampling areas to accommodate the expanding population of larger fish which resulted from the strict conservation measures imposed by the coastal states under Amendments #4 and #5 of the ISFMP.

Two deployments or sets per mesh size are made each sampling day. All striped bass collected per set are measured in mm total length (TL), sexed by the expression of gonadal products, counted and released. Age structure is determined from scale samples aged subsequent to the termination of sampling. When time and fish condition permit, striped bass are affixed with an internal-anchor external-streamer tag as part of the USFWS cooperative tagging program, and checked for the presence of binary coded wire cheek tags implanted in hatchery released fish. Other data recorded include water temperature, salinity, sample site location, water depth range, net length and width, mesh size, and time the net fished.

2. Index of Spawning Potential

Stagg (1995) estimated the gill net selection characteristics or biases expressed in the measure of catch-per-unit-effort (cpue) of striped bass collected by this survey for each sex and sampling area. Since, overall, relatively few mature female striped bass are captured in this survey, Stagg combined area and year effects in developing female-specific selectivity curves. As a result of changes in mesh sizes deployed in 1990 and thereafter, two separate female selection models were developed and used in this analysis. The first, for females sampled from 1985-89, was applied to correct cpue data in those years. The second, for 1990-95, was applied to data in those years, and in 1996.

Year, area, mesh size, and sex-specific measures of relative abundance were determined for each centimeter length group as the average of ratios catch-per-unit-effort (MDNR 1994). CPUE estimates were then corrected for gill net selectivity by applying the selectivity coefficients derived for each area, mesh size, sex, and centimeter length group cpue estimates.

Because the ISP measures spawning potential, it was necessary to exclude immature female striped bass from the estimate. Berlinsky et al. (1995) determined that female striped bass younger than age 4 were immature. However, cpue and selectivity coefficients are length-based, not age-based, making it problematic to separate under-***aged*** females from the sample. In order to exclude females younger than age four from the index, we used differences in observed length frequency of females collected by this survey and subsequently aged. We observed that, on average, age 3 females had an approximate mean length of 470mm (TL), while females of age 4 had an approximate mean length of 530mm (TL). Accordingly, 500mm (TL) was established as a suitable length of demarcation between these ages. Thus, all females less than 500mm (TL) were excluded from the ISP calculation. For the purpose of making inter-annual comparisons of indices of spawning potential, this decision is non-confounding.

System-specific and aggregate ISP indices were computed for years 1985-96. Individual system indices of spawning potential were derived by converting abundance by length group to an index of biomass using the length-weight regression for Bay female striped bass defined as: $\ln(wt_{lbs}) = [2.965 \times \ln(len_{TL}) - 7.479]$. Specifically, selectivity corrected female catch-per-unit-effort by length group were multiplied by mean weight at length for each area and mesh size to obtain an index of biomass per length group. Length group values were then summed across mesh sizes to obtain the index of spawning potential for each year and system combination.

Estimates of missing river-specific ISP values were made based on the relationship, in 1985-93 and 1996, between that system and the other sampling areas via multiple regression analysis. The 1994 Potomac River ISP was estimated from regressing the Potomac River ISP (ISP_{PR}) on the Upper Bay ISP (ISP_{UB}) and Choptank River ISP (ISP_{CR}) values for these years. Similarly, 1995 ISP_{CR} was estimated from a regression of the Choptank River ISP on the Upper Bay and Potomac River ISP values.

RESULTS

The index of spawning potential presented in this report indicates that spawning stock biomass was at the lowest level in 1986 and has steadily increased, with the exception of 1994, to the highest level in 1996 (Table 1). Multiple regression analyses performed as described estimated the 1994 ISP_{PR} at 225.8 (R^2=0.76; p=0.007), and the 1995 ISP_{CR} at 3285.3 (R^2=0.65; p=0.026).

Figure 1 relates the trends in model-based SSB and survey-based ISP for years 1985-96 inclusive. For 1994, the ISP included on the trend line was estimated from the linear regression of ISP on SSB (R^2=0.992; $p \leq 0.000001$) (Figure 2). The observed 1994 ISP value is also shown in Figure 1.

In 1994, unusually warm ambient conditions in March and early April elevated water temperatures which were measured at 56°F in the Choptank River upon commencement of sampling on April 4. Early spawning fish, usually the larger females, had already spawned and were not available to the gear. The absence of larger females from the sample, in view of their contribution total stock biomass, resulted in a 1994 ISP_{CR} value of only half that projected in the Choptank River based on the multiple linear regression model described above.

In the Upper Bay in 1994, weather conditions did not appear to affect the timing match between sampling and spawning activity which peaks, on average, 2-3 weeks after that of the Choptank River. Water temperatures in the mid-40°Fs were measured when sampling began on April 11; peak spawning temperatures were observed at the beginning of May. Nonetheless, only forty spawning females were sampled by gill nets in 1994. In comparison, the Upper Bay pound net survey sampled almost five times that the number of females, and recorded cpue values comparable to 1992 and 1993 estimates (MDNR 1994). Moreover, the 1994 juvenile recruitment survey recorded the sixth highest geometric mean index in the Upper Bay (JI=12.9) since 1955 (MDNR 1994), which is further suggestive that the Upper Bay spawning stock was sufficiently large to produce a dominant year class in this system for the second straight year. This compelling ancillary evidence suggests that the Upper Bay gill net survey failed to take a representative sample of the magnitude of the spawning stock, hence its spawning potential in 1994.

The last factor which confounded the observed 1994 ISP was the elimination of sampling on the Potomac River that year. Since the multiple regression used to estimate missing system ISP values is based upon the measured ISP of the two other systems, the Potomac River ISP was estimated low, due to low ISP_{CR} and ISP_{UB} as discussed, even though the two previous years (1992 and 1993), and the two following years (1995 and 1996) ISP_{PR} values ranged between approximately 963 and 1,144 biomass units.

Based upon the 1994 survey sampling timing mismatch to spawning activity in the Choptank River, and the uncharacteristically low Upper Bay average cpue, we suspected that the *observed* ISP_{94} was anomalous. A plot of the residuals from the SSB *v* ISP regression indicated that the 1994 residual was approximately 25x greater than that of the next largest negative residual

ISP value. Further, the observed ISP_{94} fell well outside (approximately 2x) the width of the 95% confidence interval of the regression model at the measured value of SSB_{94}. By any objective measure, 1994 is an aberration in terms of the derived ISP. Therefore, the observed ISP_{94}, is considered an outlier resulting from the unique sampling conditions in that year, and excluded from subsequent analyses in this report.

Figure 3 illustrates the result of a non-linear model fit (R^2=0.975) to the trajectory in spawning stock biomass, derived from the simulation model (Rugolo et al. 1994) for years 1985-96. By this approach, SSB is estimated to increase at an approximate rate of 16.5% per year. Similarly, Figure 4 shows the results of an analogous non-linear model fit (R^2=0.979) to the increase in growth of the spawning stock as measured by the index of spawning potential for years 1985-96. Here, the approximate average rate of increase in ISP is 20.5% per year. For the latter, ISP_{94} was not included in the analysis for reasons previously discussed. [By comparison, R^2=0.81 for this model fit with the inclusion of ISP_{94}].

CONCLUSIONS

Overall, the index of spawning potential presented in this report provides an readily accessible and reliable basis for gauging inter-annual changes in the status of the Chesapeake Bay component of the coastal migratory stock. Annual ISP values can be derived within one month of survey completion given timely data entry. On the basis of the demonstrated relationship between the ISP and SSB indices, it may also be possible to develop threshold levels of ISP based on the reference 1960-72 SSB level (i.e., SSB_{REF}) derived in Rugolo et al. (1994).

Results of the comparison of the survey (ISP) and model-based (SSB) relative biomass indices clearly demonstrate the continued coherence in these trajectories of spawning stock growth (R^2=0.992) (Figure 2). The average annual rate of increase in mature female biomass in the Chesapeake Bay component of the coastal stock appears slightly greater based on the ISP than on SSB (20.5% *v* 16.5%, respectively). Absolute differences in these two respective exponentially increasing slopes should not be considered too strictly, however, in the interest of conservation of stock recovery.

Considering the profound relationship between the model-based and empirical-based spawning stock measures (Figures 1 and 2), it is shown that the simulation model derived by Rugolo et al. (1994) provides an eminently reliable measure of coastal migratory spawning stock biomass. Overall, the Chesapeake Bay striped bass spawning stock is judged to be growing at or above the projected rate of increase in SSB, which can be attributed to the coast-wide conservation measures adopted in Amendments #4 and #5 of the interstate fisheries management plan.

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Table 1. Index of spawning potential (ISP) derived from the Maryland gillnet spawning stock survey, and the index of coast-wide spawning stock biomass (SSB) projected by the stock synthesis model (Rugolo et al. 1994) for years 1985 - 1996 inclusive.

YEAR	ISP	SSB
85	1064.8	15.9
86	713.2	13.0
87	895.6	13.4
88	1016.5	17.5
89	1562.6	24.0
90	2296.4	31.5
91	2871.4	37.6
92	3406.5	43.6
93	4028.3	49.9
94*	1754.0	54.7
95*	5666.6	62.7
96	6393.5	70.2

* Note, the Potomac River was not sampled in 1994; nor the Choptank River in 1995. Both these river-specific ISP values were estimated and included in the aggregate ISP value tabled based on the relationship between that system and the other sampling areas via multiple regression modeling for years 1985-93 and 1996.

Figure 1

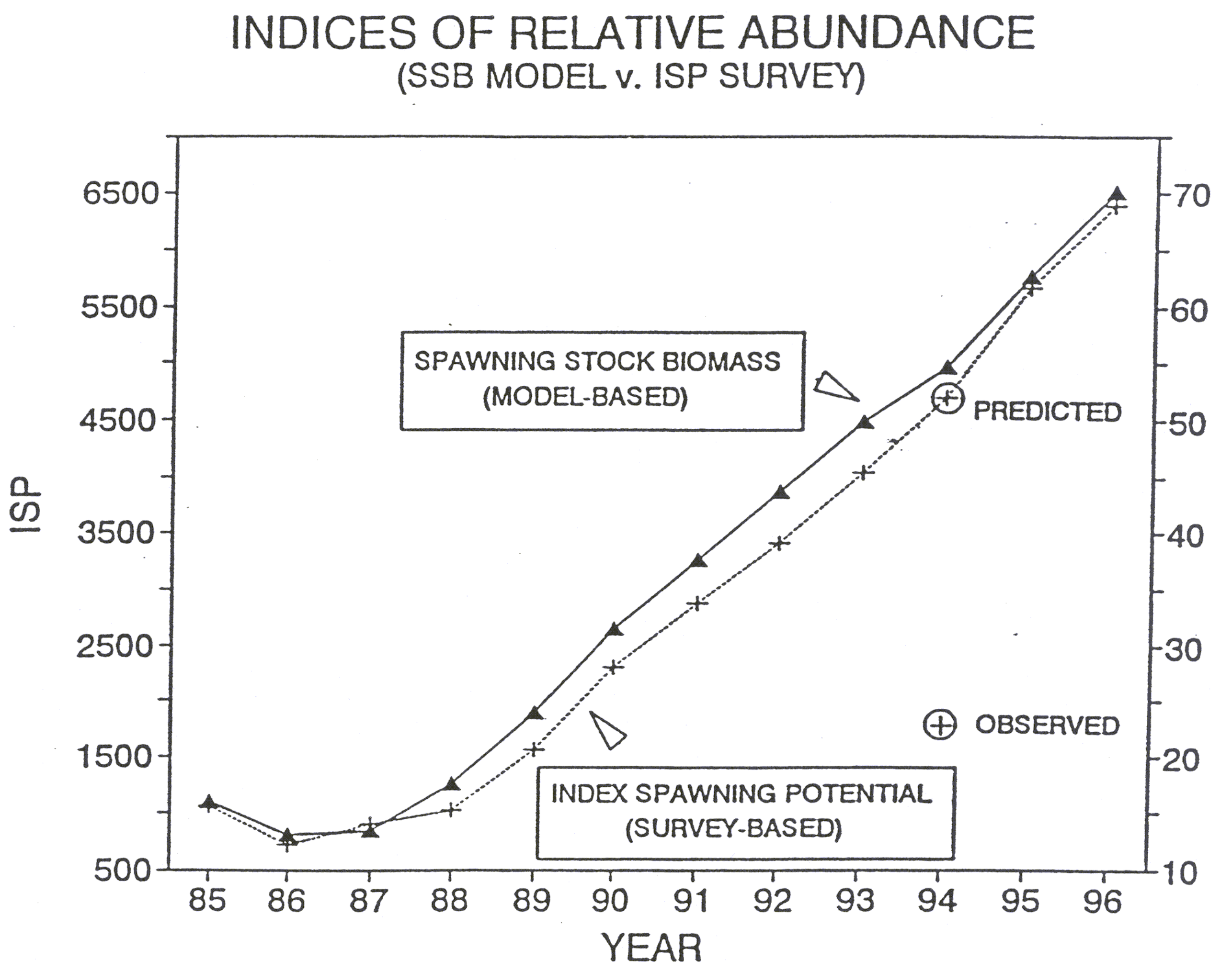

INDICES OF RELATIVE ABUNDANCE
(SSB MODEL v. ISP SURVEY)
SPAWNING STOCK BIOMASS
(MODEL-BASED)
PREDICTED
OBSERVED
INDEX SPAWNING POTENTIAL
(SURVEY-BASED)
ISP
SSB
6500
5500
4500
3500
2500
1500
500
70
60
50
40
30
20
10
85
86
87
88
89
90
91
92
93
94
95
96
YEAR

Figure 2

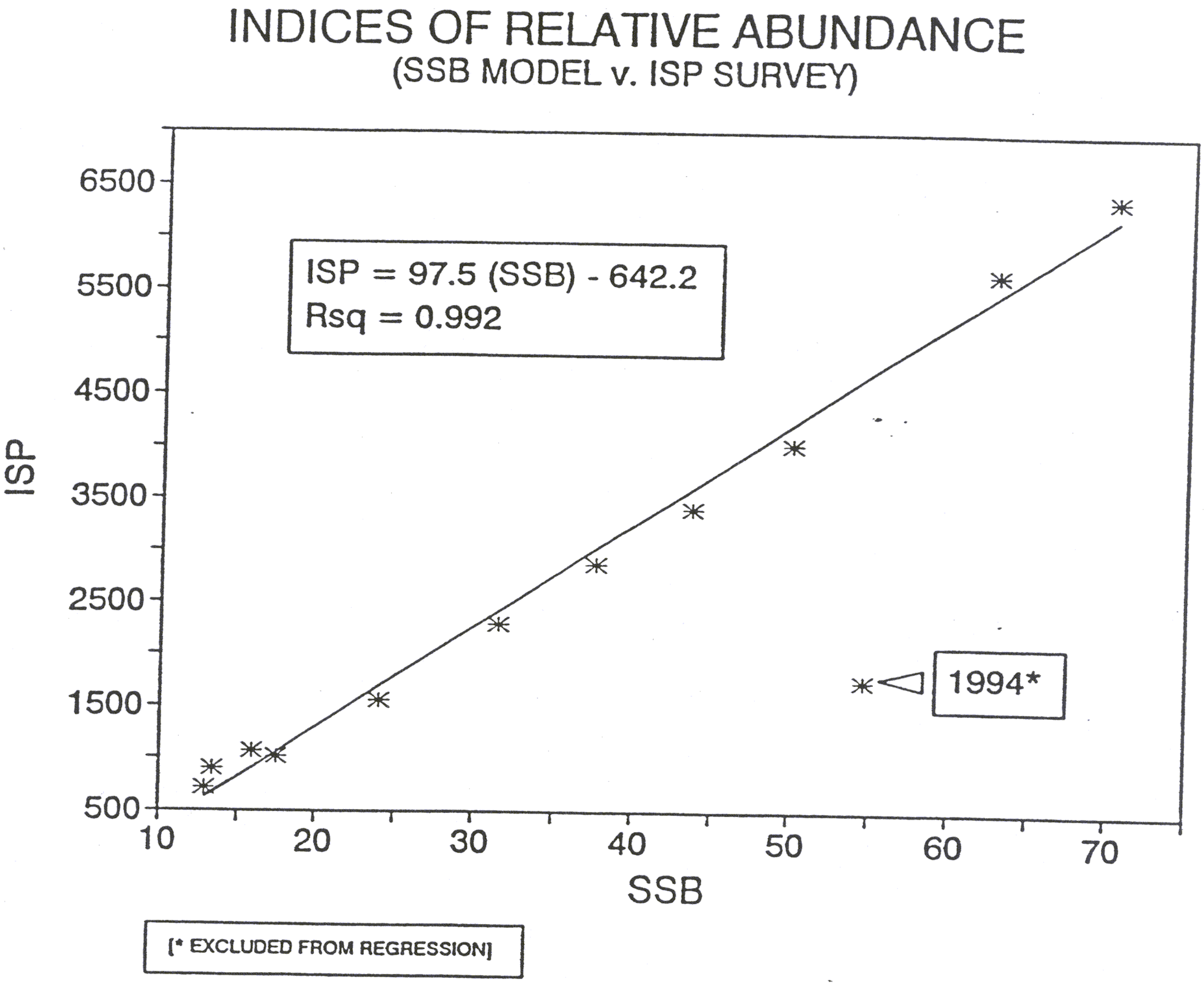
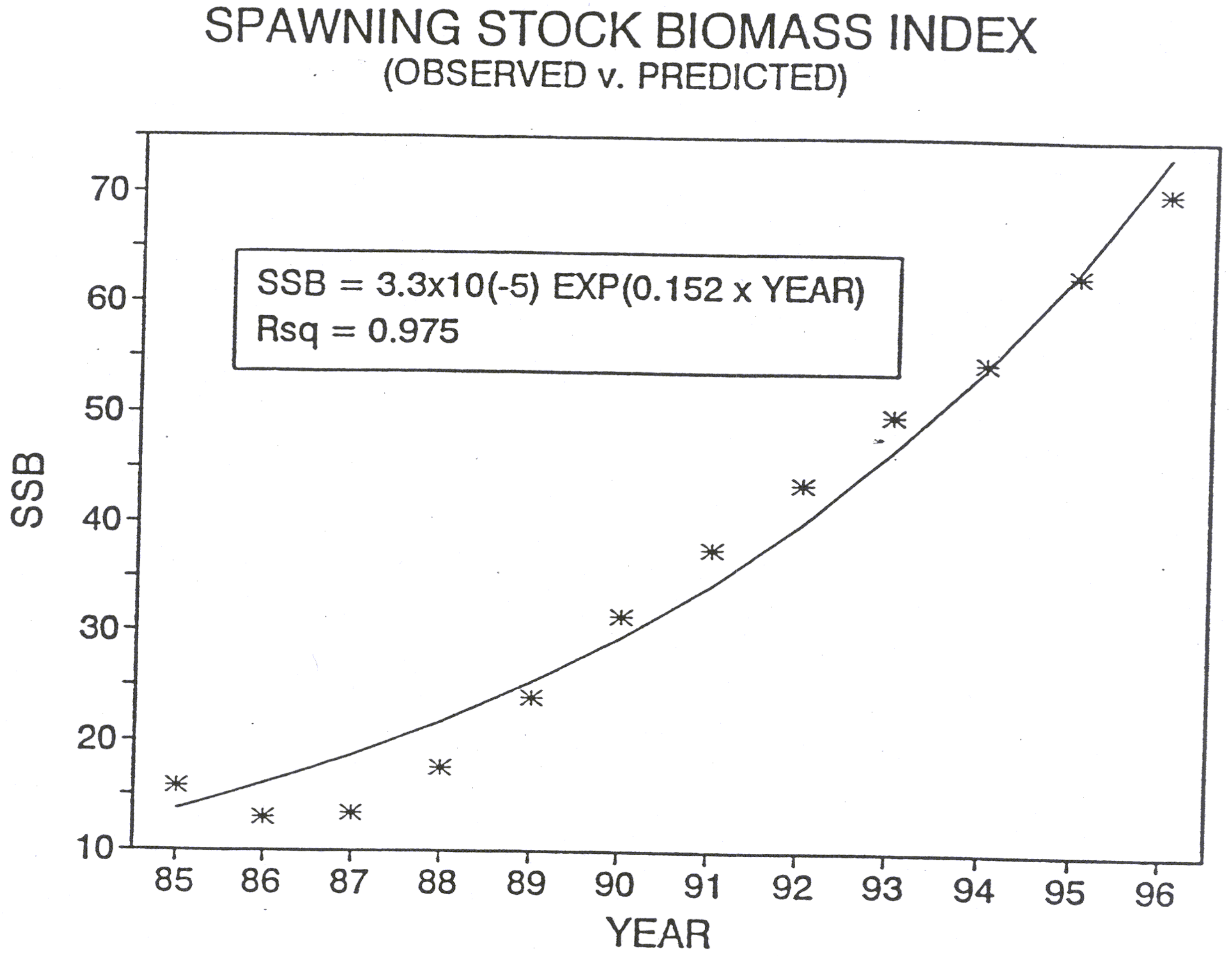
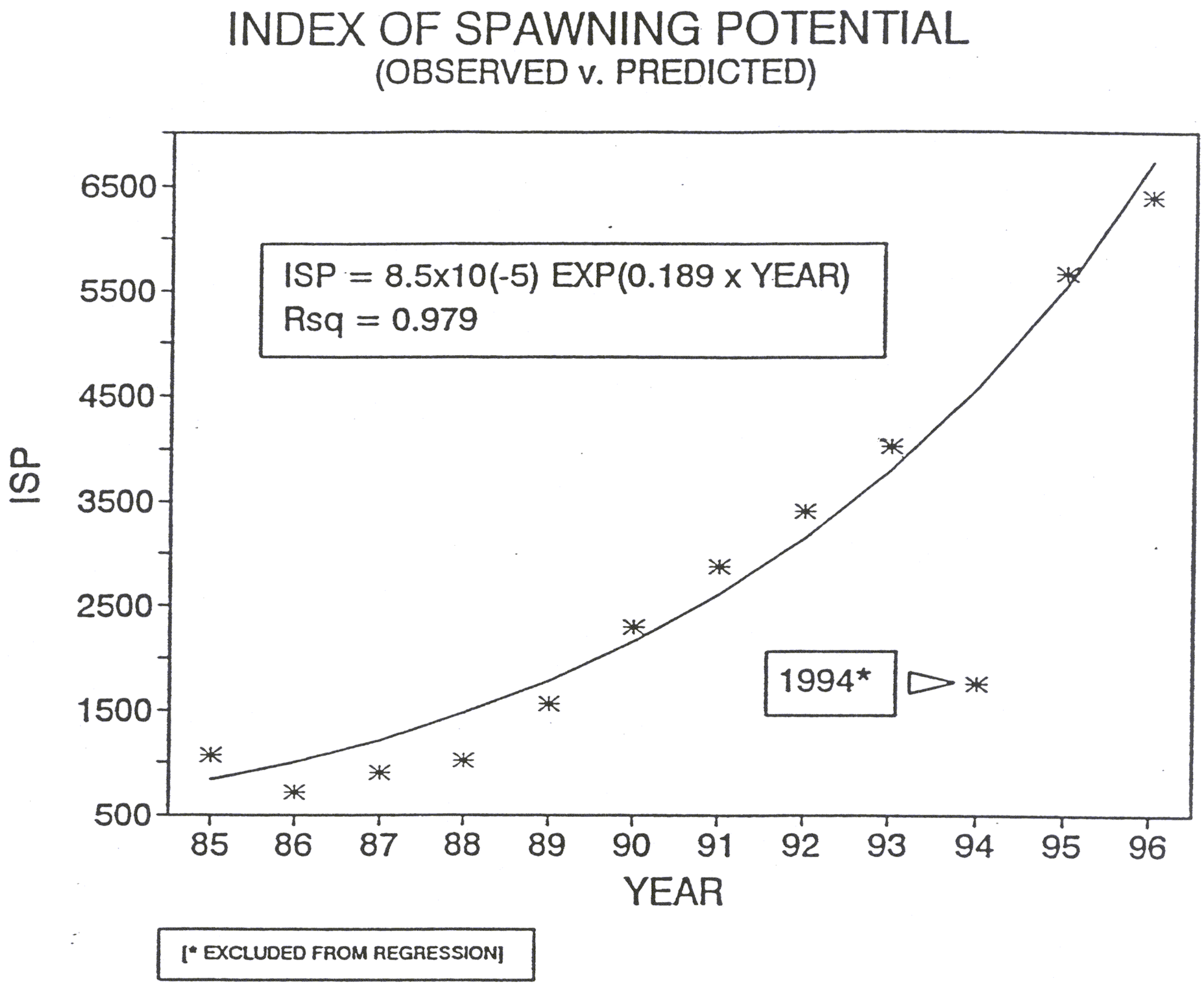

INDICES OF RELATIVE ABUNDANCE
(SSB MODEL v. ISP SURVEY)
ISP = 97.5 (SSB) - 642.2
Rsq = 0.992
6500
5500
4500
3500
2500
1500
500
ISP
10
20
30
40
50
60
70
SSB
1994*
[* EXCLUDED FROM REGRESSION]

Figure 3



SPAWNING STOCK BIOMASS INDEX
(OBSERVED v. PREDICTED)
SSB = 3.3x10(-5) EXP(0.152 x YEAR)
Rsq = 0.975
SSB
70
60
50
40
30
20
10
85
86
87
88
89
90
91
92
93
94
95
96
YEAR


INDEX OF SPAWNING POTENTIAL
(OBSERVED v. PREDICTED)
ISP = 8.5x10(-5) EXP(0.189 x YEAR)
Rsq = 0.979
1994*
ISP
6500
5500
4500
3500
2500
1500
500
85
86
87
88
89
90
91
92
93
94
95
96
YEAR
[* EXCLUDED FROM REGRESSION]

This paper is not to be cited without prior reference to the authors

ASMFC Striped Bass Stock Assessment
Appendix II

AN OVERVIEW OF METHODS TO ESTIMATE ANNUAL MORTALITY OF ATLANTIC STRIPED BASS FROM TAG-RECOVERY DATA

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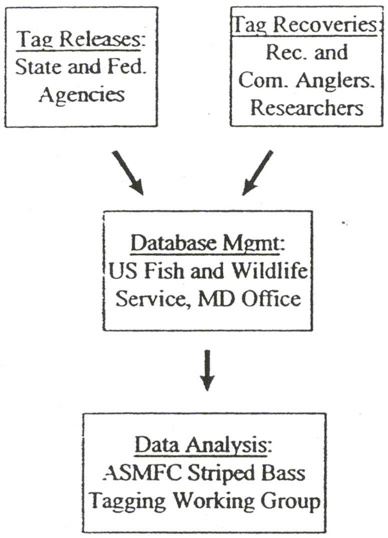
1. Introduction to the Cooperative Striped Bass Tagging Program

The Cooperative Striped Bass Tagging Program is a cooperative effort involving most of the Atlantic coast states, federal agencies, and recreational and commercial anglers (Fig 1). Initially, the purpose of the Cooperative Striped Bass Tagging Program, with its genesis during the mid 1980's, was to evaluate hatchery contribution to restoration efforts (Wooley et al 1988) and monitor mortality and migration of wild stock (Emergency Striped Bass Research Study Report for 1990). Upton (1994) assessed the tagging program's role in hatchery evaluation. In this paper we focus on that part of the tagging program that is directed at monitoring migratory stocks of striped bass.

The tagging program is comprised of 4 critical operations: tagging fish, recovery of tags, managing records of releases and recoveries, and analyzing tag-recovery data (Fig. 1). All operations must be functioning for the program to succeed. (It is significant that commitment to all 4 operations has been sustained to date.)

Figure 1. Critical operations of the Cooperative Striped Bass Tagging Program.



With releases spanning a decade and exceeding 167,000, the database has great value for monitoring striped bass and understanding stock dynamics. Tagged striped bass have been released in 10 states by 15 agencies (Appendix). Analysis of tag-recovery data collected over multiple years has provided estimates of year and stock-specific mortality (Dorazio 1993) and migration rates (Dorazio et al.1995). The ASMFC Tagging Working Group regularly estimates stock-specific mortality based on tag-recovery data and reports those estimates to the Stock Assessment Subcommittee and Technical Committee.

Although the tagging program lacks a formal study design, a study plan on "Management of Striped Bass Tag-recapture Database" dated 1988 (on file at Leetown Science Center) outlined that tagging was to occur simultaneously in multiple fisheries to allow estimation of migration and stock-specific mortality. Because a major objective of the tagging program has been stock-specific estimates of mortality, much of the tagging has been conducted in producer areas. These efforts are best represented by decade long spring tagging programs in the Chesapeake Bay and Hudson River and by a more recent tagging program in the Delaware Bay (Table 1). There has also been a substantial effort to target coastal migrants. Migrants are intercepted in large numbers along southeast Long Island, off the coast of North Carolina, and off the coast of Massachusetts. Tagging off the coast of Massachusetts was initiated with the purpose of tagging large (>30 in) striped bass.

Table 1. Organization of tagging effort in the Cooperative Striped Bass Tagging Program.

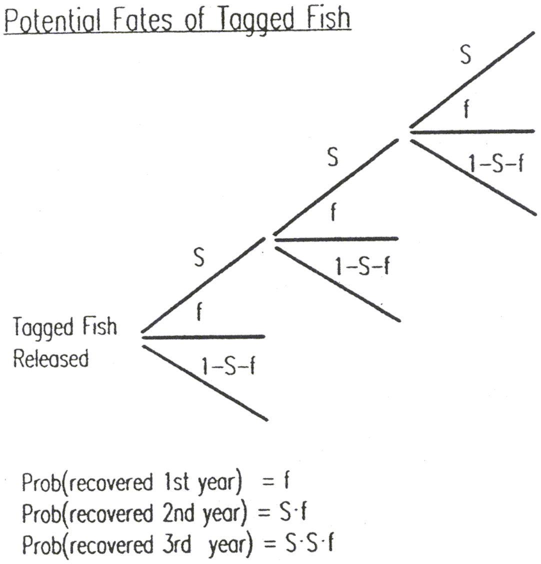
Target	Select locations	Duration
Producer areas	Chesapeake Bay	1987-1997
	Hudson River	1988-1997
	Delaware Bay	1991-1997
Coast migrants	Long Island	1987-1997
	Offshore North Carolina	1989-1997
	Offshore Massachusetts	1991-1997

The purpose of this paper is to discuss the analytical framework used to estimate mortality from tag-recovery data. Probabilistic models provide the basis for estimating mortality from tag-recovery data. Brownie et al. (1985) published an influential handbook which presented methods of tag-recovery modeling and synthesized important early work by George A. F. Seber, George M. Jolly, Douglas S. Robson, Richard M. Cormack, Cavell Brownie, David R. Anderson, and Kenneth P. Burnham. The models presented in Brownie et al. (1985), allowing for time, sex, and age-specific survival and recovery, have been used extensively in estimation of mortality for striped bass. Because of its fundamental importance to modeling striped bass tag-recoveries, in section 2 we introduce the Brownie et al. modeling approach in some detail (those familiar with this modeling approach can skip this section). In section 3 we review advances to the methodology, describe the currently applied approach, and discuss sources of bias in estimation of survival from striped bass tag-recovery data. Finally, in section 4 we illustrate the currently applied approach with an example.

2. The "Brownie et al. Tag-recovery Models"

The backbone of these models is the expected probabilities of tag recovery which are based on potential fates of tagged animals (Fig. 2). The expected probabilities are specified as functions of annual survival (*S*) and recovery (*f*) rates. The recovery rate (*f*), interpreted as a measure of sampling intensity, is a function of the catch rate and the rate at which tags are reported.

Figure 2. Potential fates and expected probabilities for time-specific tag recoveries.



Consider, as an example, the simple model structure where survival and recovery rates are assumed to be constant. This model structure can be represented by the following matrix of expected recoveries where the number of fish tagged in year i is N_i .

	Number tagged	Expected recoveries in year j			
i	in year i	j=1	2	3	4
1	N_1	N_1f	N_1Sf	N_1SSf	N_1SSSf
2	N_2		N_2f	N_2Sf	N_2SSf
3	N_3			N_3f	N_3Sf

Define

R_{ij} = the number of tags recovered in year *j* from the fish tagged in year *i*.

Then the matrix of tag-recoveries can be represented by

i	Number tagged in year i	Expected recoveries in year j			
		j=1	2	3	4
1	N_1	R_{11}	R_{12}	R_{13}	R_{14}
2	N_2		R_{22}	R_{23}	R_{24}
3	N_3			R_{33}	R_{34}

By making certain assumptions, such as the tagged cohorts share the same rates of recovery and survival and fates are independent, the set of recoveries $\{R_{ij}\}$ can be modeled by a product multinomial distribution with likelihood function

$$L(\pi_{ij};R_{ij},N_i) = \prod_{i=1}^{k}\left\{\binom{N_i}{R_{ii},\ldots,R_{il},R_{i,l+1}}\prod_{j=i}^{l}\pi_{ij}^{R_{ij}}\right\} \qquad (1)$$

The π_{ij} in the likelihood function are the cell probabilities from the recovery matrix and are functions of the recovery and survival rates (S_j and f_j). For example, from the constant survival and recovery model shown above, $\pi_{12} = Sf$. Consequently, the maximum likelihood estimates are those values of *S* and *f* that maximize the likelihood function.

The important assumptions underlying these models are listed below (from Brownie et al. 1985. pg 6).

Assumptions relating to study planning, field procedures, and type of species:

1) The sample is representative of the target population:
2) Age and sex of individuals are correctly determined:
3) There is no tag loss:
4) Survival rates are not affected by tagging itself: and
5) The year of tag recoveries is correctly tabulated.

Assumptions relating to the stochastic model component:

6) The fate of each tagged fish is independent of the fate of other tagged individuals;

7) The fate of a given tagged fish is a multinomial random variable.

Assumptions relating to model structure:

8) Cell probabilities are specified correctly;

9) All tagged individuals of an identifiable strata (e.g., species, age, sex) in the sample have the same annual survival and recovery rates;

10) Annual survival and recovery rates may vary by calendar year, and/or by age and sex of individuals (variation by area and population is also possible).

Brownie et al. (1985) develop a series of tag-recovery models each representing a set of tentative assumptions about survival and recovery rates. For instance, compare the tentative assumptions of these 3 competing models:

Model	Tentative Assumptions
1	year-specific survival and recovery rates
2	constant survival, and year-specific recovery rates
3	constant survival and recovery rates

It is important to test these underlying assumptions. If the assumptions are not supported by the data then it is very likely that the estimates from the model will be unreliable. However, if the model appears to fit the data then we consider the model as a possible candidate - along with other models that fit the data.

To test the underlying assumptions and analogously the goodness-of-fit (GOF) of the model we compare the observed recoveries to the expected recoveries based on the tentative model. If the observed and expected recoveries are relatively close then we say the model fits the data.

The GOF test can be developed by first recognizing that a single chi-square value is computed from observed and expected values for each cell in the recovery matrix by

$$\frac{(Observed - Expected)^2}{Expected} = \frac{(O-E)^2}{E}$$

Then an overall GOF test is made by adding the chi-square value over all cells in the recovery matrix.

$$X^2 = \sum_{i=1}^{k} \sum_{j=i}^{l+1} \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \qquad (2)$$

The null hypothesis is that the data fit the model, and the model's assumptions regarding survival and recovery are tenable. If the null hypothesis is rejected (by a relatively large χ^2), the model is considered to be untenable.

The goal of model selection, based on the Principle of Parsimony, is to find the simplest model (i.e., one with the fewest number of parameters) which adequately fits the observed data. So, like Goldielocks in her search for the perfect breakfast, the analyst's task is to find that which is "just right" - a model with not too few nor too many parameters.

Potential consequences in model selection:

(1) Selecting a model with too few parameter (i.e., an overly simple model) risks substantial bias in the estimates. Estimated sampling variances are almost always too small, thus resulting in a highly precise but <u>wrong</u> estimates. Testing hypotheses based on an overly simple model is almost always nonconservative.

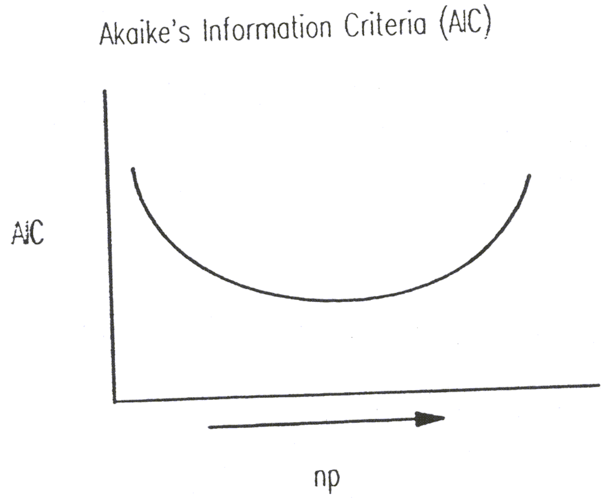
(2) Selecting a model with too many parameters (i.e., an overly general model) results in estimated sampling variances and covariances which are too large, but parameters are still unbiased. Hypotheses based on an overly general model is almost always conservative.

Tools for model selection:

A criteria useful for model selection would reach a minimum (or maximum) for the most parsimonious model. The Akaike's Information Criteria (AIC) attempts to accomplish that ideal and is defined

$$\text{AIC} = -2\ln L + 2np \qquad (3)$$

where $\ln L$ is the natural log of the likelihood and np is the number of model parameters. The AIC can be computed for each model and compared to determine the "best" fitting



model. In general, several models will have similar AIC values and statisticians recommend that further selection among them be based on the biology of the situation and on statistical model comparisons where possible.

The test for model comparison used in tag-recovery analysis is the likelihood ratio test (LRT). The LRT compares a general model to a simple model. The general model will always be as good or better than the simple model. The simple model can never do a 'better' job of modeling the data, but can do as good a job. If the models are equally likely to be responsible for the observed data (i.e., both do a good job of modeling the data) then the test statistic will be non-significant. If you are otherwise indifferent about the choice of the model then you should select the simple model - consistent with the Principle of Parsimony. Thus, if the LRT if not significant then favor the simple model.

If, however, the general model is much more likely to be responsible for the observed data (i.e., does a better job of modeling the data) then the LRT test statistic will be significant. Thus, if the LRT is significant then favor the general model.

3. Advances in Tag-recovery Modeling

Prestratification to Compare Multiple Tag-recovery Matrices

Dorazio (1993) incorporated the advanced modeling techniques presented in Lebreton et al. (1992) with the sex and time-specific models of Brownie et al. (1985) to enhance estimation of stock and time-specific survival and recovery. In this approach, modeling and estimation is done simultaneously on multiple matrices and comparisons of rates are accomplished during model selection. Consider simultaneous tagging of 2 stocks of fish over 3 years. The 2 tag-recovery matrices which result can be represented using the following notation.

		Number tagged	Expected recoveries in year j		
Stock	i	in year i	j=1	2	3
1	1	N_{11}	R_{111}	R_{112}	R_{113}
1	2	N_{12}		R_{122}	R_{123}
1	3	N_{13}			R_{133}
2	1	N_{21}	R_{222}	R_{212}	R_{213}
2	2	N_{22}		R_{222}	R_{223}
2	3	N_{23}			R_{233}

As usual the model structure is determined by the recovery and survival rate parameters (i.e., the fs and Ss). Thus,

Stock	i	Number tagged in year i	Expected recoveries in year j j=1	2	3
1	1	N_{11}	$N_{11}f_{11}$	$N_{11}S_{11}f_{12}$	$N_{11}S_{11}S_{12}f_{13}$
1	2	N_{12}		$N_{12}f_{12}$	$N_{12}S_{12}f_{13}$
1	3	N_{13}			$N_{13}f_{13}$
2	1	N_{21}	$N_{21}f_{21}$	$N_{21}S_{21}f_{22}$	$N_{21}S_{21}S_{22}f_{23}$
2	2	N_{22}		$N_{22}f_{22}$	$N_{22}S_{22}f_{23}$
2	3	N_{23}			$N_{23}f_{23}$

Dorazio (1993) showed how the recovery and survival rates for the i^{th} group and in the j^{th} year (i.e., f_{ij} and S_{ij}) can be formulated as linear combinations of a baseline rate and parameters that measure the effect due to stock and year. In this way, the tag-recovery models allow stock membership and time to affect survival and recovery rates as main, additive, or multiplicative effects (cf. ANOVA).

Advent of Program MARK

Until 1996, the above methods had been implemented using a software program called SURVIV (White 1983). While extremely flexible, SURVIV was difficult to implement when model complexity increased by including large number of years or groups (stock, age, sex) in the analysis. Recently, SURVIV has been superseded by program MARK. Program MARK is a Microsoft Windows-based interface program that allows direct inputs of data, on-screen model specifications, comparisons of models, and viewing and printing results (White and Burnham, 1997). Program MARK computes the estimates of model parameters via numerical maximum likelihood techniques. The number of estimable parameters and model likelihood are used to compute the quasi-likelihood Akaike information criteria value (QAICc) for the model, which is used to measure the distance of the proposed model to a hypothetical "true" model based on information theory (Akaike 1985, Burnham et al. 1995). The smaller the QAICc value, the closer the proposed model to the "true" model.

Two parameters, *r* (reporting rate or reporting probability - the probability that a tag is reported from a recaptured fish (released or harvested) regardless of source of mortality) and *S* (survival rate), can be estimated from the MARK program's parameterization of the Brownie model. These two parameters can be year-specific (i.e. time effect), group-specific (i.e. group effect), or modeled as a function of an independent variable. Interaction effects between years and groups can also be modeled. The time effect does not need to be a single year but can be set over a multiple year time period (i.e. two year or longer time period). Any variables that could affect reporting or survival rates (i.e. environmental variables or catch statistics) can be included in the model as covariate variables via the design matrix. Therefore, many different models (time effects, group effects, covariates, and their interactions) can be included in the analysis.

For the purposes of tag-recovery analysis, MARK represents an advance in 2 important respects:

1) MARK expands the set of tag-recovery models that can be implemented practically by fishery biologists (this includes the previously discussed models and those which specify rates as functions of continuous covariates such as harvest effort (time-specific covariate) or fish length at tagging (individual-specific covariate), and
2) Recovery rate is reparameterized in MARK consistent with a general modeling framework for mark-recapture data. Recovery rate was redefined as $f = (1-S)r$ where *r* is the rate at which tags are reported from dead fish regardless of source of mortality. This new look at recovery rate exposed a bias in estimation of mortality when tag-recoveries from dead and live animals are analyzed using the tag-recovery models. Previously, this bias had been overlooked or ignored (depending on who you talk to). We pick up this issue again in this section under <u>Sources of Bias</u>.

Currently Applied Approach to Model Selection and Estimation

Model selection is integral to estimation of mortality using tag-recovery models. There are 2 recent advances in model selection that we feel warrant changes from the model selection strategy advocated by Brownie et al. (1985). Work by Burnham et al. (1995) has lead us to place greater reliance on AIC (and related measures such as QAICc) over likelihood ratio tests; and methods presented by Buckland et al. (1997) moved us to estimate survival as a weighted average from multiple models, thereby avoiding the selection of a "best" model.

Our current approach to modeling of striped bass tag-recovery data and estimation of survival involves 4 steps.

(1) Prior to data analysis, we identify a set of candidate models.
(2) We fit the models to the tagging data.
(3) We evaluate the model fit using AIC and Goodness-of-Fit diagnostics.
(4) We estimate survival as a weighted average of survival from the best fitting models where the weight is related to model fit (the better the fit, the higher the weight).

Our methods to identify a set of candidate models are based on two criteria. First, the models must be biologically defensible. One example would be that since spatial distributions and migratory patterns are different between the Chesapeake Bay and the Hudson River stocks, survival and reporting rates might be different and therefore the stock effects should be modeled. Second, the models should reflect possible changes in the fishery practices and regulations. For example, we hypothesize that regulatory changes affect survival rates, which suggests a model with survival as a function of regulatory period.

Based on these two criteria, we have the following classes of candidate models.

(1) Models incorporating time effects. This class of models assume that time affects survival and reporting rates. The time effect may be year-specific or due to an effect that changes across time, such as fishery regulation or fishery practice.

(a) Time effects modeled as year-specific. Here a different parameter is estimated for each year with no attempt to explain changes in time.

(b) Time effects determined by changes in the fishery regulations. These models assume that fishery regulations have effects on both survival and reporting rates, and that fishery regulations changed significantly between three time periods: 1988 to 1989, 1990 to 1994, and 1995 to 1996.

(c) Time effects determined by changes in the fishery practice. These models include catches of striped bass as a covariate. The catch statistics can be total annual recreational catches (A+B1+B2) estimated by the Marine Recreational Fisheries Statistics Survey (NMFS). Other fisheries statistics, such as total harvest (commercial, recreational, and by-catch), could also be included.

(2) Models incorporating group effects. This class of models assumes that group membership affects survival and reporting rates. Possible grouping variables are stock, sex, and age. Their inclusion in the models depends on the data sets used in the analysis (grouping variables are not available for all tagging locations).

Time and group variables can be combined so that their possible affect can be modeled simultaneously (cf. Dorazio 1993).

Final estimates of survival rates are obtained by using a recently presented model weighting technique (Buckland et al. 1997),

$$\hat{S}_t = \sum_{i=1}^{M} w_i \hat{S}_{t,i} \tag{4}$$

where $\hat{S}_t$ is estimated survival rate for year t. M is total number of models. $\hat{S}_{t,i}$ is estimated survival rate for year t and model i. and w_i is relative weight for model i. In practice. we set M to the number of models that have ΔQAICc smaller than 7.0, primarily based on the reasoning that models that have ΔQAICc greater than 7.0 have very small influences on the final estimate. (QAICc is a quasi-likelihood version of AIC and $\Delta QAICc_i$ is the difference in QAICc values between the best fitted model and model i, i.e., the best fitted model has ΔQAICc = 0). The weight, w_i, is calculated by,

$$w_i = \frac{e^{-\frac{\Delta QAICc_i}{2}}}{\sum_{j=1}^{M} e^{-\frac{\Delta QAICc_j}{2}}} \tag{5}$$

where $i = 1, \ldots, M$. Thus, the better the model fit, the larger the value of w_i.

An approximate standard error for $\hat{S}_t$, was given by Buckland et al. (1997),

$$\sigma_t = \sum_{i=1}^{M} w_i \left(V_{t,i} + (b_{t,i} - \hat{S}_t)^2\right)^{\frac{1}{2}} \tag{6}$$

where $V_{t,i}$ is estimated variance from model i.

Sources of Bias in Analysis of Striped Bass Tag-recovery Data

We recognize several sources of bias due to small samples, model selection, and violation of assumptions. Small sample bias is not an issue for most of our analyses because the size of the tagged cohort typically exceeds 300. Our current approach of model selection and estimation is geared towards avoiding biases due to model selection. It is clear that we will always make use of incorrect models in estimation because the dimensionality of the "true" model will always exceed our analytical capabilities. Rather we adhere to George Box's opinion that "All models are wrong, but some are useful" (paraphrased here). Our approach to finding "useful" models is to identify a priori a set of realistic models, use objective measures for assessing their fit to the data, and make inference from the set of best fitting models.

We believe violation of assumptions represents the most significant source of bias. We discuss 2 cases where assumptions are violated which we believe to be important (in both cases the result is an underestimate of survival). First, we discuss bias caused by techniques of handling or marking fish, which includes tag-induced mortality and tag loss. While some studies reported that both tag-induced mortality and tag loss were minimal (about 1.3% tag-induced mortality, Rugolo and Lange, 1993), other studies reported that they could be higher. Because of the belief that for striped bass tag-induced mortality and tag loss are minimal we do not attempt to for bias due to these sources.

The second assumption violation that we discuss is specifying incorrect recovery probabilities due to release of live fish. Recall that in the Brownie et al. formulation of the tag-recovery models there was a recovery rate (f). It appeared that it did not matter how a tag was recovered in a given year, just that it was recovered (f simply measured sampling intensity adjusted by reporting rate). With the advent of program MARK it has become clear that $f = (1\text{-}S)r$ where S is the survival rate and r is the rate at which tags from dead fish (including any source of mortality) are reported. Clearly, $(1\text{-}S)r$ indicates that the models assume that a fish must die before the tag is reported. If that is not the case, i.e., some proportion are released alive, then the recovery probabilities are specified incorrectly. Another way to think about this is to consider the extreme case. Suppose you tagged fish but none die from any cause (i.e., $S = 1$), and some are caught but released (tags are recovered and the fish released suffer no ill effect). If you run the resulting releases and recoveries through the tag-recovery models the estimate of S will be < 1 even though S is in fact 1. Heuristically, there is a bias due to release of live fish, and the tag-based estimate is an underestimate.

This bias was assessed recently by Burnham (unpublished manuscript), who found that the bias can be estimated by,

$$\frac{S_t^{\prime}}{S_t} = \frac{1 - \frac{R}{\lambda}}{1 - \frac{R}{\lambda} + 0.92\, P_L \frac{R}{\lambda}} \tag{7}$$

where S_t is fish survival rate, R is the ratio of reported tags over released tags (i.e., the recovery rate, "f", from the original parameterization of Brownie models), λ is the ratio of reported tags over tags caught (most commonly termed reporting rate), P_L is proportion of tagged fish caught and released alive, 0.92 is survival for fish caught and released. The value of 0.92 was derived from the previous study that 8% of fish being caught die due to hooking and handling mortality (Diodati and Richards 1996). While R and P_L can be estimated from the tagging data, λ is unknown. (If we know R, P_L, and λ, we already know fishing mortality rate).

The problem of adjusting for the bias caused by releasing fish alive with tag removed is that the reporting rate (λ) is unknown. One method to estimate λ is to use fishing mortality rates estimated by the VPA, as suggested by Vic Crecco (personal communications). This method, however, would cause the estimated survival rates to be dependent on the VPA analysis, and comparisons of fishing mortality rates between two methods (tagging estimates and VPA) to be less meaningful. Vic Crecco also suggested using an average reporting rate over a multiple years instead of one year, which could reduce dependency between two methods. However to do this, an additional assumption has to be made that reporting rate remains constant between years. Another problem in using the single VPA estimated fishing mortality rate is that additional information, such as relative recruitment from each stock and fishing pressure on the different stocks, would be needed in order to derive stock specific fishing mortality rates for both producer areas.

Xi He (MA Division of Marine Fisheries) derived another method to adjust the bias caused by releasing fish alive is based on the fact that fishing mortality rates estimated by the MARK program after the bias adjusting (F_1) and fishing mortality rate estimated by three parameters, R, λ, and P_L (F_2) should be equal. Since only λ is unknown, an iterative process by choosing different values of λ can be applied to find a λ value where $F_1 = F_2$. The values of F_1 and F_2 were calculated from

$$F_1 \;=\; -\ln(S) - 0.15 \qquad (8)$$

where S is adjusted estimates of survival rate from the tagging data using the MARK program and 0.15 is assumed to be natural mortality rate and

$$F_2 \;=\; -\ln(1 - (1 - 0.92 * P_L)R / \lambda) \qquad (9)$$

where 0.92, P_L, R, and λ were defined previously.

Alternatively, reporting rate could be estimated empirically through use of reward tags. Following previous reward tag studies (e.g., Maryland's reward tag study, Rugolo et al., 1994) tags with various rewards can be distributed. Direct recovery of reward tags can be modeled to estimate reporting rates. This design can be repeated each year so that stock and time-specific changes in reporting rate can be modeled. Initially, new money would be needed to support the change in rewards from the existing reward system. Eventually, a reward system could be put in place with an operating cost in line with the current reward system.

Perhaps the most promising method to adjust the bias caused by releasing fish alive is to modify the Brownie model to include P_L (proportion of fish released alive) in the recovery matrix. Burnham (1991) developed a theory for joint analysis of combined recovery and recapture data, however it did not account for recaptures occurring continuously in time (which happens when anglers are the responsible for reporting tags). Barker (1997) extended Burnham's work and developed models allowing for recaptures and recoveries to occur any time between release periods. However, the Barker model is unlikely to be useful for the striped bass tagging data because anglers routinely remove tags prior to release. Thus, the Barker model does not apply to the striped bass case (Ken Burnham, person. commun.). So it remains unclear if the theory can be extended to encompass the striped bass case. Further studies are needed and if successful, the modified model can be widely applied to other fisheries tagging studies.

4. An example analysis: Chesapeake Bay and Hudson River 1988 to 1996

Here we present estimates of annual survival rates for striped bass 28 inches and greater in total length for the Hudson River and Maryland portion of Chesapeake Bay from 1988 to 1996. We estimated survival from tagging data provided by Maryland Department of Natural Resources (MD DNR), New York Department of Environmental Conservation (NY DEC), and U.S. Fish and Wildlife Service (USFWS).

Data and Methods

Data were provided by MD DNR, NY DEC, and USFWS (Table 2 and 3). All fish had total length equal or greater than 28 inches and were released from March to April in the Hudson River and from April to May in the Chesapeake Bay each year. Two data sets were used in the analysis. The first data set was for the Maryland portion of the Chesapeake Bay producer areas and contained fish released inside the Maryland portion of the Chesapeake Bay (Upper Chesapeake Bay, Choptank River, Potomac River, and Chesapeake and Delaware Canal). However, fish were not taggged and released in each area consistently. The second data set was for the Hudson River producer area and contained fish released in the Hudson River. Recapture data were reported to and maintained by the USFWS (person. commun. T. McCrobie, USFWS).

Annual survival rates for striped bass were estimated using the tag-recovery models (Brownie et al. 1985), and were computed by program MARK (White and Burnham, 1997). We followed the methods outlined above for model selection and estimation (see Currently Applied Approach to Model Selection and Estimation). We adjusted estimated survival using equation (7) and employed the iterative approach to find λ (using equations (8) and (9)).

Table 2. Release and recapture matrix of striped bass for the Chesapeake Bay producer area from 1988 to 1996. Data were provided by the Maryland Department of Natural Resources. Total length of all fish were equal or greater than 28 inches. All fish were released from April to May.

		Number recaptured								
Year of release	Number released	88	89	90	91	92	93	94	95	96
88	129	6	8	7	14	6	1	3	0	0
89	221		9	17	17	6	4	3	5	2
90	304			23	16	11	5	2	4	0
91	396				47	24	20	4	9	3
92	438					44	28	18	16	7
93	628						58	44	40	11
94	545							52	42	22
95	529								61	29
96	862									92

Table 3. Release and recapture matrix of striped bass for the Hudson River producer area from 1988 to 1996. Data were provided by the New York Department of Environmental Conservation. Total length of all fish were equal or greater than 28 inches. All fish were released from March to April.

		Number recaptured								
Year of release	Number released	88	89	90	91	92	93	94	95	96
88	227	25	31	18	11	10	5	4	1	4
89	387		41	29	17	9	6	8	4	0
90	446			62	31	27	14	9	4	1
91	364				38	31	12	10	9	4
92	699					90	58	35	21	13
93	537						73	36	24	18
94	381							43	33	26
95	462								50	34
96	683									88

Results and Discussion

A total of 25 models were included in the analysis (Table 4). Values of QAICc were used to evaluate models. Four models (Model 1 to Model 4), which had the smallest QAICc values and had ΔQAICc values less than 7.0, were then chosen to calculate the weighted averages of the survival rates from 1988 to 1996. The 4 models included group effects for both survival rate and reporting probability (Table 4). Model 1 included the group effects and time effects where time period was determined by regulatory changes (1988-89, 1990-1994, and 1995-96). Model 2 was similar to the Model 1 except that the survival rates for 1995 and 1996 were separately estimated with the justification that 1995 was a transition year. Model 3 was similar to Model 1 except there was no time effect on reporting probability. Model 4 assumed time effect on survival rate at an annual time scale (survival rates differed from year to year) and no time effect on reporting probability.

Table 4. Models used in the analysis. The notations used to describe each model are same as used in the MARK program, where g denotes group, t denote time, a number proceeding t denotes a constraint on time into regulatory periods (see text for details), and REC denotes that the rates are modeled as a function of recreational catch. QAICc is the quasi-likelihood Akaike information criteria value (see text for details). *np* is number of parameters estimated by the model.

Model no.	Notation	QAICc	ΔQAICc	*np*
1	{S{(g*3t) r(g*3t)}	13720.900	0.00	12
2	{S{(g*4t) r(g*3t)}	13722.130	1.23	14
3	{S{(g*3t) r(g)}	13724.220	3.32	8
4	{S{(g*t) r(g)}	13726.080	5.18	20
5	{S(g*t) r(g*t) REC on r only }	13729.880	8.98	22
6	{S{(g*3t) r(g*t)}	13730.160	9.26	24
7	{S(g*t) r(t)}	13734.030	13.13	26
8	{S(g*t) r(g*t)}	13735.760	14.86	34
9	{S(g*t) r(.)}	13736.890	15.99	19
10	{S(t) r(g)}	13739.830	18.93	11
11	{S{(3t) r(3t)}	13748.430	27.53	6
13	{S(g*t) r(g*t) REC on S and r}	13752.180	31.28	8
14	{S(g*t) r(g*t) REC on S only }	13753.700	32.80	22
15	{S(.) r(g)}	13754.490	33.59	3
16	{S{(3t) r(.)}	13755.420	34.54	4
17	{S(g) r(g)}	13755.460	34.56	4
18	{S(.) r(g*t)}	13756.960	36.06	19
19	{S(t) r(.)}	13758.140	37.24	10
20	{S(t) r(t)}	13758.230	37.33	17
21	{S(g) r(g*t)}	13758.570	37.67	20
22	{S(g) r(.)}	13762.120	41.22	3
23	{S(g) r(t)}	13770.830	49.93	11
24	{S(.) r(.)}	13771.750	50.85	2
25	{S(.) r(t)}	13780.570	59.67	10

The time series of annual survival rates for each model and the weighted mean annual survival rates from 4 selected models and their standard errors for both producer areas were listed in Table 5. Three general results can be derived. (1) The survival rates had a decreasing trend for both producer areas from 1988 to 1996. (2) The survival rates decreased much more dramatically for the Chesapeake Bay producer area than those for the Hudson River producer area. (3) The survival rates for the Chesapeake Bay producer area in 1995 and 1996 were among the lowest as compared to other years and to the Hudson River producer area. Standard errors for the terminal year (1996) tend to be higher than other years, particularly for Model 2.

Table 5. Estimated annual survival rates and their standard errors (in parentheses) from the first 4 models listed in Table 4 and weighted mean annual survival rate and their standard errors (in parentheses) for striped bass in two producer areas from 1988 to 1996. Model numbers correspond to the model numbers listed in Table 4.

Year	Model 1	Model 2	Model 3	Model 4	Weighted mean
Hudson River producer area					
88	0.741(0.042)	0.740(0.042)	0.692(0.026)	0.774(0.040)	0.737(0.074)
89	0.741(0.042)	0.740(0.042)	0.692(0.026)	0.647(0.034)	0.731(0.042)
90	0.626(0.016)	0.629(0.017)	0.634(0.015)	0.619(0.029)	0.627(0.017)
91	0.626(0.016)	0.629(0.017)	0.634(0.015)	0.666(0.029)	0.629(0.017)
92	0.626(0.016)	0.629(0.017)	0.634(0.015)	0.616(0.025)	0.627(0.017)
93	0.626(0.016)	0.629(0.017)	0.634(0.015)	0.627(0.027)	0.628(0.017)
94	0.626(0.016)	0.629(0.017)	0.634(0.015)	0.653(0.030)	0.629(0.017)
95	0.663(0.079)	0.630(0.090)	0.641(0.029)	0.656(0.033)	0.651(0.075)
96	0.663(0.079)	0.598(0.136)	0.641(0.029)	0.633(0.036)	0.640(0.082)
Chesapeake Bay producer area					
88	0.951(0.010)	0.951(0.010)	0.847(0.030)	0.869(0.050)	0.937(0.053)
89	0.951(0.010)	0.951(0.010)	0.847(0.030)	0.837(0.036)	0.936(0.053)
90	0.641(0.019)	0.632(0.020)	0.633(0.017)	0.691(0.038)	0.640(0.022)
91	0.641(0.019)	0.632(0.020)	0.633(0.017)	0.568(0.035)	0.635(0.023)
92	0.641(0.019)	0.632(0.020)	0.633(0.017)	0.632(0.033)	0.639(0.022)
93	0.641(0.019)	0.632(0.020)	0.633(0.017)	0.653(0.029)	0.638(0.022)
94	0.641(0.019)	0.632(0.020)	0.633(0.017)	0.657(0.031)	0.638(0.022)
95	0.449(0.059)	0.508(0.079)	0.555(0.040)	0.536(0.042)	0.481(0.074)
96	0.449(0.059)	0.595(0.102)	0.555(0.040)	0.627(0.042)	0.512(0.092)

Table 6. Bias-adjusted estimates of fishing morality F using He's iterative method (described above in section 3 under Sources of Bias in Analysis of Striped Bass Tag-recovery Data). $\hat{S}$ is the estimated survival rate from the MARK program (weighted from 4 models) and has not been adjusted for the bias due to the release of alive fish. F is the adjusted fishing mortality rate assuming natural mortality of 0.15. λ is the estimated reporting rate (proportion of tags reported over tags recovered). R is the first year recovery rate (number of fish recovered and reported in the first year / total number of fish released). P_L is the proportion of fish released alive.

Year	$\hat{S}$	F	λ	R	P_L
Hudson River producer area					
88	0.737	0.044	0.765	0.129	-
89	0.731	0.043	0.705	0.104	0.784
90	0.627	0.091	0.512	0.113	0.739
91	0.629	0.122	0.388	0.136	0.623
92	0.627	0.119	0.475	0.129	0.636
93	0.628	0.143	0.501	0.104	0.550
94	0.629	0.136	0.418	0.139	0.575
95	0.651	0.164	0.425	0.106	0.407
96	0.640	0.218	0.502	0.110	0.257
Chesapeake Bay producer area					
88	0.937	<0	-	0.047	0.667
89	0.936	<0	-	0.041	0.765
90	0.640	0.129	0.295	0.076	0.574
91	0.635	0.129	0.452	0.119	0.585
92	0.639	0.143	0.387	0.100	0.528
93	0.638	0.162	0.357	0.092	0.457
94	0.638	0.157	0.369	0.095	0.476
95	0.481	0.411	0.262	0.115	0.254
96	0.512	0.357	0.263	0.107	0.283

Adjustment of fishing mortality for release of live fish does not change the observed trends (Table 6). A few observations can be made based on these results. (1) It seems that there was a step increase of fishing mortality in the Chesapeake Bay in 1995 and 1996, and in the Hudson River in 1996. Increases of fishing mortality rates in the Chesapeake Bay were much higher than those in the Hudson River. (2) The estimated reporting rates (λ) were consistently higher for the Hudson River than for the Chesapeake Bay, although it is not clear if those reporting rates are within a reasonable range. (3) For both systems, the R values (first year recovery rate) have been pretty constant (excluding 1988-90 in Chesapeake), and the proportions of fish released alive have been decreasing, suggesting that increases in fishing mortality in recent years are mostly due to fish being kept and killed, and not due to increases in fishing effort. (4) Natural mortality of 0.15 may be too high as suggested by negative fishing mortality rates for the Chesapeake Bay in 1988 and 1989. For fish greater than 28 inch, natural mortality could be almost negligible. This suggests that the assumption of 0.15 for natural mortality is not be correct. However, natural mortality of 0.15 is consistent with the VPA analysis.

In conclusion, the time series of the survival rates for both producer areas suggest a decreasing trend from 1988 to 1996. Survival rates for the Chesapeake Bay producer area decreased more dramatically than those for the Hudson River producer area, suggesting higher fishing pressure on the Chesapeake Bay stock than on the Hudson River stock. However, from year to year, fish tagged in the Maryland portion of the Chesapeake Bay were not consistently released at all areas (Upper Chesapeake Bay, Choptank River, Potomac River, and Chesapeake and Delaware Cannal). Whether or not these inconsistencies in release areas affect the estimation of survival rates is unknown. The fitted models also suggest that fishery regulations have significant effects on the survival rates, which show apparent step changes between 1989 to 1990 and 1991 to 1994 for both producer areas, and between 1990 to 1994 and 1995 to 1996 for the Chesapeake Bay producer areas.

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Appendix

Distribution of tagged striped bass released as part of the Cooperative Striped Bass Tagging Program. This summary includes only those releases that have been entered in the database maintained by the US Fish and Wildlife Service including entries up to October 1997. Some 1996 releases and all 1997 releases have not been entered in the database. Seasons were defined by quarters of the year: spring was March-May, summer was June - August, fall was September-November, and winter was December-February.

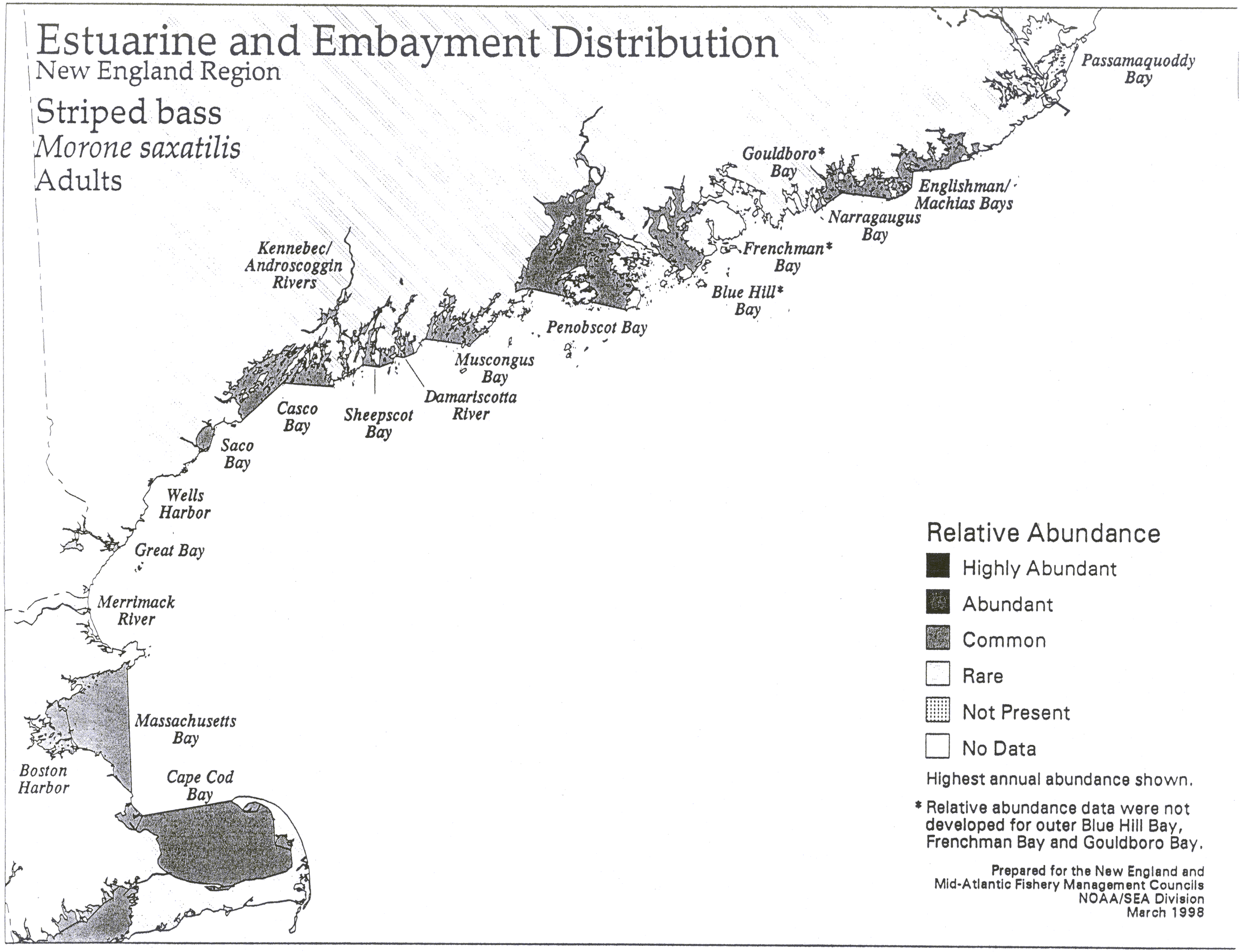
Year	State	Agency	Season	Number tagged
1986	MD	FWS	Summer	45
	MD	MDDNR	Fall	241
	MD	MDDNR	Winter	804
	RI	RIDFW	Fall	4951
1987	MD	MDDNR	Spring	1877
	MD	MDDNR	Fall	140
	MD	MDDNR	Winter	250
	NY	NYDECCST	Spring	13
	NY	NYDECCST	Summer	71
	NY	NYDECCST	Fall	1737
	NY	NYDECCST	Winter	5
	RI	RIDFW	Fall	8741
	VA	VAVIMS	Spring	1986
	VA	VAVIMS	Fall	3319
	NC	FWS	Spring	37
1988	MD	MDDNR	Spring	3287
	MD	MDDNR	Fall	314
	MD	MDDNR	Winter	361
	NC	NCCOOP	Winter	1338
	NY	NYDECCST	Spring	58
	NY	NYDECCST	Summer	254
	NY	NYDECCST	Fall	1832
	NY	NYDECCST	Winter	102
	NY	NYDECHUD	Spring	735
	NY	NYDECHUD	Summer	101
	NY	NYDECHUD	Fall	69
	RI	RIDFW	Fall	1566
	VA	VAVIMS	Spring	2133
	VA	VAVIMS	Summer	72
	VA	VAVIMS	Fall	3892
	VA	VAVIMS	Winter	1964
1989	MA	MADFWELE	Summer	788
	MA	MADFWELE	Fall	39
	MD	MDDNR	Spring	2904
	MD	MDDNR	Fall	44
	MD	MDDNR	Winter	103
	MD	MDOXFORD	Summer	222
	NC	NCCOOP	Winter	1156
	NJ	NJDEP	Spring	545

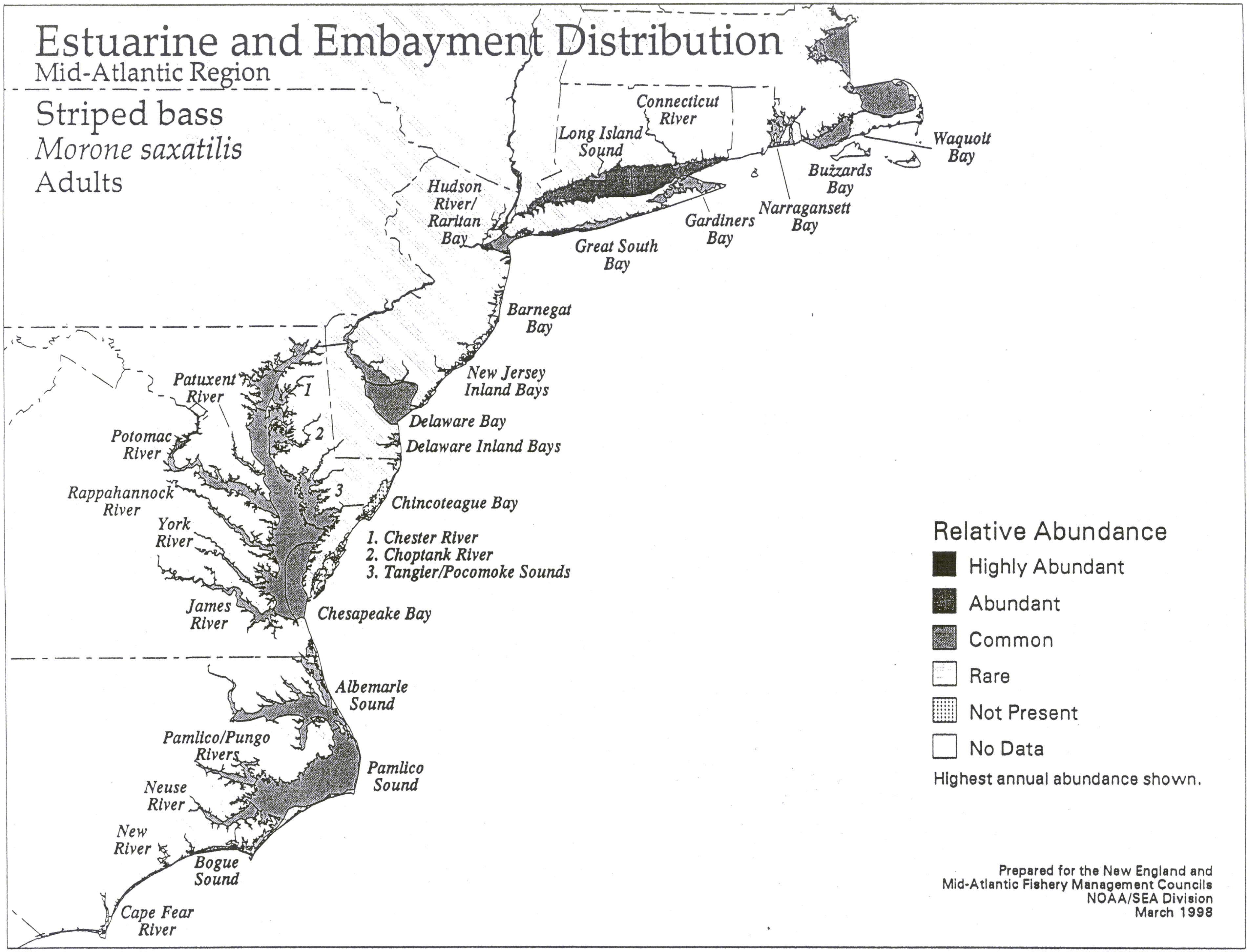
	NJ	NJDEP	Summer	12
	NJ	NJDEP	Fall	4
	NJ	NJDEP	Winter	25
	NY	NYDECCST	Spring	60
	NY	NYDECCST	Summer	694
	NY	NYDECCST	Fall	1041
	NY	NYDECHUD	Spring	539
	NY	NYDECHUD	Summer	157
	NY	NYDECHUD	Fall	60
	VA	VAVIMS	Spring	4677
	VA	VAVIMS	Fall	6203
	VA	FWS	Spring	92
	VA	FWS	Summer	9
1990	MD	MDDNR	Spring	1491
	MD	MDDNR	Fall	197
	MD	MDDNR	Winter	6
	NC	NCCOOP	Winter	1940
	VA	NCCOOP	Winter	70
	NJ	NJDEP	Spring	208
	NJ	NJDEP	Summer	43
	NJ	NJDEP	Fall	56
	NJ	NJDEP	Winter	21
	NY	NYDECCST	Spring	27
	NY	NYDECCST	Summer	375
	NY	NYDECCST	Fall	1093
	NY	NYDECCST	Winter	61
	NY	NYDECHUD	Spring	814
	NY	NYDECHUD	Summer	109
	NY	NYDECHUD	Fall	38
	VA	VAVIMS	Spring	2603
	VA	VAVIMS	Fall	3376
	VA	VAVIMS	Winter	932
	NJ	DEDNREC	Spring	55
1991	DE	FWS	Spring	6
	MD	FWS	Spring	87
	NJ	FWS	Spring	34
	MA	MADFWELE	Fall	388
	MD	MDDNR	Spring	1813
	MD	MDDNR	Winter	147
	NC	NCCOOP	Winter	735
	VA	NCCOOP	Winter	1045
	NC	NCDMF	Spring	76
	NJ	NJDEP	Spring	407
	NJ	NJDEP	Summer	19
	NJ	NJDEP	Fall	46
	NJ	NJDEP	Winter	467
	NY	NYDECCST	Spring	260
	NY	NYDECCST	Summer	660
	NY	NYDECCST	Fall	1096

	NY	NYDECCST	Winter	12
	NY	NYDECHUD	Spring	569
	NY	NYDECHUD	Summer	20
	NY	NYDECHUD	Fall	73
	VA	VAIGFC	Spring	341
	VA	VAVIMS	Spring	5436
	VA	VAVIMS	Fall	2524
	VA	VAVIMS	Winter	111
1992	DE	DEDNREC	Spring	45
	NJ	DEDNREC	Spring	10
	DE	DEDNREC	Summer	2
	MD	FWS	Spring	81
	MD	FWS	Winter	36
	MA	MADFWELE	Fall	895
	MD	MDDNR	Spring	2011
	MD	MDDNR	Fall	3520
	MD	MDDNR	Winter	300
	NC	NCCOOP	Winter	1016
	NJ	NJDEP	Spring	946
	NJ	NJDEP	Summer	31
	NJ	NJDEP	Fall	23
	NJ	NJDEP	Winter	317
	NY	NYDECCST	Spring	14
	NY	NYDECCST	Summer	487
	NY	NYDECCST	Fall	1356
	NY	NYDECCST	Winter	100
	NY	NYDECHUD	Spring	872
	NY	NYDECHUD	Summer	295
	NY	NYDECHUD	Fall	73
	VA	VAIGFC	Spring	509
	VA	VAIGFC	Summer	48
	VA	VAIGFC	Winter	5
	VA	VAVIMS	Spring	1826
	VA	VAVIMS	Fall	317
	VA	VAVIMS	Winter	174
1993	CT	CTDEP	Spring	34
	CT	CTDEP	Summer	93
	DE	DEDNREC	Spring	302
	DE	DEDNREC	Summer	3
	MD	FWS	Spring	41
	MD	FWS	Winter	47
	MA	MADFWELE	Fall	674
	MD	MDDNR	Spring	2585
	MD	MDDNR	Fall	4899
	MD	MDDNR	Winter	350
	NC	NCCOOP	Winter	133
	VA	NCCOOP	Winter	397
	NJ	NJDEP	Spring	1764
	NJ	NJDEP	Summer	6

	NJ	NJDEP	Fall	134
	NJ	NJDEP	Winter	24
	NY	NYDECCST	Spring	22
	NY	NYDECCST	Summer	540
	NY	NYDECCST	Fall	1884
	NY	NYDECCST	Winter	36
	NY	NYDECHUD	Spring	942
	NY	NYDECHUD	Summer	23
	NY	NYDECHUD	Fall	60
	VA	VAIGFC	Spring	717
	VA	VAVIMS	Spring	621
	VA	VAVIMS	Fall	2567
1994	CT	CTDEP	Spring	633
	CT	CTDEP	Summer	87
	CT	CTDEP	Fall	9
	DE	DEDNREC	Spring	325
	PA	DEDNREC	Spring	73
	MD	FWS	Spring	74
	MA	MADFWELE	Fall	375
	MD	MDDNR	Spring	2042
	MD	MDDNR	Summer	1048
	MD	MDDNR	Fall	4738
	NC	NCCOOP	Winter	4365
	VA	NCCOOP	Winter	266
	NJ	NJDEP	Spring	2404
	NJ	NJDEP	Summer	30
	NJ	NJDEP	Fall	49
	NJ	NJDEP	Winter	3
	NY	NYDECCST	Spring	13
	NY	NYDECCST	Summer	1140
	NY	NYDECCST	Fall	1265
	NY	NYDECCST	Winter	352
	NY	NYDECHUD	Spring	637
	NY	NYDECHUD	Summer	23
	NY	NYDECHUD	Fall	47
	VA	VAIGFC	Spring	490
	VA	VAVIMS	Spring	195
	VA	VAVIMS	Fall	2990
1995	CT	CTDEP	Spring	263
	CT	CTDEP	Summer	92
	DE	DEDNREC	Spring	92
	PA	DEDNREC	Spring	264
	PA	DEDNREC	Summer	3
	MD	FWS	Spring	87
	MA	MADFWELE	Fall	434
	MD	MDDNR	Spring	1675
	MD	MDDNR	Summer	1033
	MD	MDDNR	Fall	4672
	MD	MDDNR	Winter	320

	NC	NCCOOP	Winter	644
	NJ	NJDEP	Spring	2212
	NJ	NJDEP	Summer	32
	NJ	NJDEP	Fall	17
	NJ	NJDEP	Winter	71
	NY	NYDECCST	Spring	18
	NY	NYDECCST	Summer	222
	NY	NYDECCST	Fall	1020
	NY	NYDECCST	Winter	365
	NY	NYDECHUD	Spring	618
	NY	NYDECHUD	Summer	33
	NY	NYDECHUD	Fall	87
	NJ	PAFC	Spring	108
	PA	PAFC	Spring	53
	VA	VAIGFC	Spring	343
	VA	VAVIMS	Spring	697
1996	DE	DEDNREC	Spring	186
	PA	DEDNREC	Spring	111
	DE	DEDNREC	Summer	6
	PA	DEDNREC	Summer	8
	MD	FWS	Spring	51
	NJ	NJDEP	Spring	2368
	NJ	NJDEP	Winter	166


Estuarine and Embayment Distribution
New England Region
Striped bass
Morone saxatilis
Adults
Passamaquoddy Bay
Gouldboro* Bay
Englishman/ Machias Bays
Narraguagus Bay
Frenchman* Bay
Blue Hill* Bay
Kennebec/ Androscoggin Rivers
Penobscot Bay
Muscongus Bay
Damariscotta River
Casco Bay
Sheepscot Bay
Saco Bay
Wells Harbor
Great Bay
Merrimack River
Massachusetts Bay
Boston Harbor
Cape Cod Bay
Relative Abundance
Highly Abundant
Abundant
Common
Rare
Not Present
No Data
Highest annual abundance shown.
* Relative abundance data were not developed for outer Blue Hill Bay, Frenchman Bay and Gouldboro Bay.
Prepared for the New England and Mid-Atlantic Fishery Management Councils
NOAA/SEA Division
March 1998



Estuarine and Embayment Distribution
Mid-Atlantic Region
Striped bass
Morone saxatilis
Adults
Connecticut River
Long Island Sound
Hudson River/ Raritan Bay
Great South Bay
Gardiners Bay
Narragansett Bay
Buzzards Bay
Waquoit Bay
Barnegat Bay
New Jersey Inland Bays
Delaware Bay
Delaware Inland Bays
Patuxent River
Potomac River
Rappahannock River
York River
James River
Chincoteague Bay
1. Chester River
2. Choptank River
3. Tangier/Pocomoke Sounds
Chesapeake Bay
Albemarle Sound
Pamlico/Pungo Rivers
Pamlico Sound
Neuse River
New River
Bogue Sound
Cape Fear River
Relative Abundance
Highly Abundant
Abundant
Common
Rare
Not Present
No Data
Highest annual abundance shown.
Prepared for the New England and
Mid-Atlantic Fishery Management Councils
NOAA/SEA Division
March 1998