A. STRIPED BASS ASSESSMENT SUMMARY FOR 2007

Status of Stock: The target values and biological reference point thresholds of Atlantic striped bass for fishing mortality (average F of ages 8-11) and spawning stock biomass are F_{target}=0.30 and female spawning stock biomass (SSB_{target})=17,500 mt, and F_{msy}=0.41 and $SSB_{threshold}$=14,000 mt, respectively (ASMFC 2003). The forward projecting statistical catch at age model (SCA) estimated that the fishing mortality rate in 2006 was F=0.31 and the female SSB in 2006 was 24,979 mt (Figure A1). Based on the catch equation method (CEM) using tagging data, fishing mortality rate in 2006 was estimated to be F=0.16 (see Special Comments). Based on the 2006 estimates, Atlantic striped bass are not overfished and overfishing is not occurring.

Female SSB grew steadily through 2003 but has since declined. Fishing mortality estimates from the SCA and CEM models show similar increasing trends from the late 1980s to the late 1990s followed by declines through 2002 (Figure A2). After 2002, Fs from the SCA model increased (see Special Comments) while Fs from the CEM remained relatively flat. Results from retrospective analysis in the SCA suggest that the 2006 F estimate is likely over-estimated and the SSB estimate is likely under-estimated; therefore, F could decrease and SSB could increase with the addition of future years of data.

Forecast for 2007: No forecast was made.

Catch and Status Table (millions of fish): Striped Bass

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Max[1]	Min[2]	Mean[3]
Commercial Landings	1.06	1.22	1.10	1.06	0.94	0.65	0.87	0.91	0.97	1.05	1.22	0.01	0.57
Commercial Discards	0.22	0.33	0.24	0.67	0.31	0.17	0.26	0.52	0.78	0.22	0.78	0.04	0.30
Recreational Harvest	1.65	1.46	1.45	2.03	2.09	1.97	2.55	2.62	2.34	2.78	2.78	0.04	1.04
Recreational Discards	1.27	1.21	1.02	1.36	1.08	1.10	1.19	1.38	1.52	2.07	2.07	0.03	0.68
Catch Used in Assessment	4.19	4.22	3.81	5.10	4.42	3.90	4.86	5.43	5.60	6.11	6.11	0.24	2.58
Female SSB[4]	23.89	21.68	22.83	26.9	28.8	32.2	33.0	30.7	28.1	25.0	33.0	1.4	15.6
Total stock size[5]	65.44	61.94	58.83	54.64	55.19	58.63	54.58	64.82	59.18	55.84	65.44	7.13	39.56
Recruitment (Age 1)[5]	16.49	9.84	9.33	7.42	12.79	15.12	7.70	22.28	8.24	10.04	22.28	1.79	9.44
$F_{age8-11}$ (from SCA)	0.23	0.19	0.16	0.22	0.19	0.18	0.23	0.26	0.28	0.31	0.45	0.08	0.20
$F_{28"+}$ (from CEM)[6]	0.31	0.29	0.29	0.20	0.17	0.18	0.18	0.16	0.17	0.16	0.31	0.04	0.18

1-maximum value from 1982 - 2006
2-minimum value from 1982 - 2006
3-mean value from 1982 - 2006
4-female spawning stock biomass (SSB) from SCA model in metric tons (thousands)
5-millions of fish
6-fully recruited fish (≥28 inches)

Stock Distribution and Identification: Atlantic coast migratory striped bass, *Morone saxatilis*, live along the eastern coast of North America from the St. Lawrence River in Canada to the Roanoke River and other tributaries of Albemarle Sound in North Carolina (ASMFC 1990). The anadromous populations of the Atlantic coast are primarily the product of four distinct spawning stocks: a Roanoke River/Albemarle Sound stock, a Chesapeake Bay stock, a Delaware River stock, and a Hudson River stock (ASMFC 1998). The Atlantic coast fisheries, however, rely primarily on production from the spawning populations in the Hudson and Delaware rivers and in tributaries of Chesapeake Bay. Therefore, the inside fisheries of the Albemarle Sound and Roanoke River are managed separately from the Atlantic coastal management unit, which includes all other migratory stocks occurring in coastal and estuarine areas of all states and jurisdictions from Maine through North Carolina.

From Cape Hatteras, North Carolina (NC), to New England, striped bass coastal migrations are generally northward in summer and southward in winter. Results from tagging 6,679 fish from New Brunswick, Canada to the Chesapeake Bay, during 1959–1963, suggest that substantial numbers of striped bass leave their birthplaces when they are three or more years old and thereafter migrate in groups along the open coast (Nichols and Miller 1967). These fish are often referred to collectively as the "coastal migratory stock," suggesting they form one homogeneous group, but this group is probably, in itself, heterogeneous, consisting of many migratory contingents of diverse origin (Clark 1968).

Coastal migrations may be quite extensive; striped bass tagged in Chesapeake Bay have been recaptured in the Bay of Fundy. They are also quite variable, with the extent of the migration varying between sexes and populations (Hill et al. 1989). Larger bass, typically females, tend to migrate farther; however, striped bass are not usually found more than 6 to 8 km offshore (Bain and Bain 1982). The inshore zones between Cape Henry, Virginia (VA), and Cape Lookout, NC, serve as the wintering grounds for the migratory segment of the Atlantic coast striped bass population (Setzler-Hamilton et al. 1980).

Catch: Total annual removals of striped bass have been dominated by recreational harvest and discard mortality since the early 1990s (Figure A3). Annual catches (both harvested and released fish) by recreational anglers increased rapidly through the early to mid 1990s. From 1998 to 2002, catches fluctuated without trend before undergoing another rapid increase to a peak of more than 27 million fish in 2006 (Figure A4). Due to large size limits and conservation ethics, 85–90% of the fish caught have been released. Since the turn of the century, recreational harvest of striped bass has ranged from roughly 2.0 to 2.8 million fish while discard mortality from released fish has ranged from roughly 1.1 to 2.1 million fish.

Commercial harvesters have been under a quota management system since 1990. Annual coastwide landings experienced similar trends to recreational catch in the 1990s, with a steady increase to a peak in 1998 of 1.2 million fish (Figure A5). Since then, annual landings have ranged from 650,000 to 1.1 million fish. Estimates of commercial discard mortality have fluctuated greatly since the early 1990s, ranging from roughly 200,000 to over 700,000 fish, annually (Figure A5).

Data and Assessment: Recreational landings data, length data, and discard estimates were obtained from the National Marine Fisheries Service's Marine Recreational Fisheries Statistics Survey (MRFSS) for waves 2-6 (Mar–Dec). Estimates of recreational discard mortality were derived by applying an 8% discard mortality rate to the MRFSS estimates of live releases (B2s).

Anecdotal evidence suggests that NC and VA had sizeable wave-1 (January–February) fisheries for striped bass beginning in 1996. To account for landings during these months, NC began conducting MRFSS interviews and phone surveys during wave 1 in 2004. Estimates of wave-1 harvest from 1996 to 2003 in NC and 1996 to 2006 in VA were developed using observed relationships between landings and tag returns.

Discard lengths were obtained from various state volunteer angler surveys and lengths of tagged fish released by anglers participating in the American Littoral Society tagging program. Age structures were collected from recreational catches in Massachusetts, New York, New Jersey, and Maryland to develop age-length keys and recreational catch-at-age matrices. Other states used the age-length keys from nearby states or age and length data from state commercial hook and line fisheries to develop catch-at-age matrices for recreational harvest and discard mortality estimates.

Strict quota monitoring is conducted by states through various state and federal dealer and fishermen reporting systems, and landings are compiled annually from those sources by state biologists. Biological data (e.g., length, weight) and age structures from commercial harvest are collected from a variety of gear types through state-specific port sampling programs. Harvest numbers are apportioned to age classes using length frequencies and age-length keys derived from biological sampling.

Direct measurements of commercial discards of striped bass are generally only available for fisheries in the Hudson River Estuary. Discard estimates for fisheries in Chesapeake Bay and coastal locations since 1982 are based on the ratio of tags reported from discarded fish in the commercial fishery to tags reported from discarded fish in the recreational fishery, scaled by total recreational discards. To account for differential tag reporting rates between commercial and recreational harvesters, a correction factor is calculated by dividing the three-year mean of ratios of commercial to recreational landings by the three-year mean of ratios of tags returned by the two fisheries. Estimates of discard mortality were derived by applying gear specific estimates of discard mortality rates to discard estimates.

Atlantic striped bass have historically been assessed using tag data from a coastwide tagging program via estimates of survival from program MARK (Brownie et al. 1985; Smith et al. 2000) and estimates of exploitation rates from mark recapture (R/M) as well as the age-based ADAPT VPA model. In the 2005 assessment, the CEM was first used to develop estimates of F without the assumption of a constant annual value of natural mortality (M=0.15) that is used with program MARK to estimate F and in the ADAPT VPA.

For this assessment, the Striped Bass Technical Committee selected the SCA and CEM as the preferred assessment methods. The SCA was selected as the age-based assessment method for several reasons: the number and form of the selectivity patterns were chosen based on analytical methods and were estimated in the model; estimates of F were robust to the inclusion/exclusion of tuning indices (which was not the case with this years run of ADAPT); and it lacks the assumption the catch-at age is measured without error that is associated with ADAPT. Finally, because SCA is a forward-projecting model, the estimates of F and population size from the catch at age analyses at the beginning of the time series are the most uncertain estimates, not the terminal year as in ADAPT. The CEM was chosen for use with the tagging data because of its ability to estimate F without the assumption of a constant value of M.

In addition, results from several additional models and methods (ADAPT, ASAP, relative F, and catch curves) provide supporting evidence for the trends in F and SSB shown in the SCA and CEM. Further, preliminary runs were presented of two new assessment models: an Instantaneous Rates Tag Return Model Incorporating Catch-Release Data, and a Forward-Projecting Statistical Catch-At-Age Model Incorporating Age-Independent Instantaneous Rates Tag Return Model.

Biological Reference Points: Reference points apply to the entire assessed population. F_{msy} (0.41), estimated using a Shepherd/Sissenwine model, was adopted as $F_{threshold}$ for Amendment 6. An exploitation rate of 24%, or F=0.30 was chosen as F_{target}. Female $SSB_{threshold}$ (14,000 mt) was chosen to be slightly greater than the female spawning stock biomass in 1995 when the population was declared recovered. Female SSB_{target} (17,500 mt) was set 25% greater than $SSB_{threshold}$.

Target F for the producer area, Chesapeake Bay, was set at 0.27 to compensate for the 18-inch size limit that is lower than preferred size limit for Chesapeake Bay under Amendment 6. No biomass targets were chosen specifically for Chesapeake Bay.

Fishing Mortality: Fishing mortality (F) was estimated using the preferred SCA (average F of ages 8-11) and CEM (F on 28 inch plus fish) models as well as with several supporting models. The 2006 estimate of F from the SCA was 0.31 (95% C.I.: 0.23-0.40), while it was 0.16 from CEM. Only the terminal estimate of F from the SCA model (and the supporting ADAPT model) exceeded the target F of 0.30. Results from retrospective analysis in the SCA suggest that the 2006 F estimate is likely overestimated and could therefore decrease with the addition of future data.

Proportional estimates of F by fishery component indicate that recreational harvest is by far the largest component of F for fish age 6 and older followed by commercial harvest (Figure A6). Recreational discards dominate the F on fish age 3 and younger while all four fishery components contribute somewhat equally to the F on age 4 and 5 fish.

Fishing mortality estimates from the SCA and CEM models show similar increasing trends from the late 1980s to the late 1990s, followed by declines through 2002 (Figure A2). After 2002, Fs from the SCA increase while Fs from the CEM remain relatively flat.

In Chesapeake Bay, the 2006 estimate of F using the CEM is 0.14. F estimates from the CEM have ranged from 0.0 to 0.16 throughout the time series and have remained below the Chesapeake Bay target F of 0.27.

Recruitment: Estimates of abundance from SCA show strong recruitment at age 1 in 1994, 1997, 2002, and 2004, with the 2003 cohort being the strongest in the time series (Figure A7). Since 1990, age 1 abundance has ranged from 7.4 to 22.3 million fish, with the four dominant year-classes mentioned above, all in excess of 15.1 million fish.

The strong year-classes were evident in the Chesapeake Bay (Maryland and Virginia) young-of-the-year surveys during 1993, 1996, 2001, and 2003 (Figure A8). Strong recruitment was also evident in 1993, 1995, 1999, and 2003 in the Delaware Bay juvenile survey and in 1997, 1999, and 2001 in the Hudson River juvenile survey. Striped bass recruitment in the Hudson River has been below the 75th percentile of the survey time series for the past three years (2004-2006).

Spawning Stock Biomass: Female SSB increased from a time series low of less than 1,500 mt in 1984 to a peak of roughly 33,000 mt in 2003 (Figure A1). Female SSB has been in excess of 20,000 mt since 1996, with 2006 estimated at 24,979 mt (95% C.I.: 18,563–32,169).

Stock Abundance: Estimates of age 1+ abundance from the SCA showed a continuous increase from 7.1 million fish in 1982 to a peak of more than 65 million fish in 1997. In subsequent years, abundance declined for a short period before increasing once again to just under 65 million fish in 2004. The 2006 estimate of age 1+ abundance is 55.8 million fish.

Estimates of abundance are also available from the CEM for fish $\geq$28 inches (assumed age 7+) and $\geq$18 inches (assumed age 3+). Abundance of assumed age 7+ fish rose from roughly 2 million fish in the late 1980's to a peak of 14.7 million fish in 2004 before declining slightly in recent years. The SCA shows a similar trend for age 7+ fish with a peak of 12.4 million fish a year in 2003. CEM estimates of assumed age 3+ abundance rose from a low of 7.7 million fish in 1992 to a time series high of 47.9 million fish in 2006.

Special Comments: Fishing in the EEZ was closed in 1990 and has remained closed to harvest and possession by both commercial and recreational fishermen.

Several new models were developed for use in this assessment, including the Forward Projecting Statistical Catch At Age (SCA) model, the Catch Equation Method (CEM), the Instantaneous Rates Tag Return Model Incorporating Catch-Release Data (IRCR), and a Forward-Projecting Statistical Catch-At-Age Model Incorporating Age-Independent Instantaneous Rates Tag Return Model (SCATAG). For this assessment, the ASMFC Striped Bass Technical Committee selected the SCA and the CEM as the preferred assessment methods.

The SARC review panel found that, of the candidate assessment models, the SCA model best estimated parameters that could be judged against the current biological benchmarks, 1995 spawning stock biomass, and fully recruited fishing mortality rate at maximum sustainable yield. With the CEM analysis, the review committee was concerned that fully recruited F was approximated using only tagged fish that were greater than or equal to 28 inches and not all striped bass of these sizes are fully recruited, i.e.; selectivity for striped bass may not be flat-topped. Based on these peer review comments, the SCA model is the preferred model at this time for determining stock status.

The assessment benefits greatly from the large tagging database with extensive spatial and temporal coverage. In addition, fisheries independent and dependent surveys used in the assessment contribute greatly to determining the status of the population.

The CEM uses both the recovery matrix for the entire time series (calculation of survival rates) and the most recent year's recovery vector (calculation of exploitation). Concern has been expressed about the use of two different time scales of the recovery data in the same equation.

While the catch equation provides reasonable estimates of F, there is considerable variation and some nonsensical values in the estimates of M.

The assignment of age from scale samples becomes less certain with increasing fish age ($\geq$ age 10).

Lack of MRFSS estimates from Wave 1 in Virginia and other mid-Atlantic states as well as the lack of coverage in freshwater areas of estuaries adds to the uncertainty in the estimates of recreational harvest and live release.

Retrospective bias was evident in estimates of fully-recruited F and abundance estimates from SCA. It is likely that the 2006 estimate of F is overestimated and female SSB is underestimated.

Sources of Information

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Smith DR, Burnham KP, Kahn DM, He X, Goshorn CJ, Hattala KA, Kahnle AW. 2000. Bias in survival estimates from tag recovery models where catch-and-release is common, with an example from Atlantic striped bass (*Morone saxatilis*). Can J Fish Aquat Sci 57: 886-897.

Figures

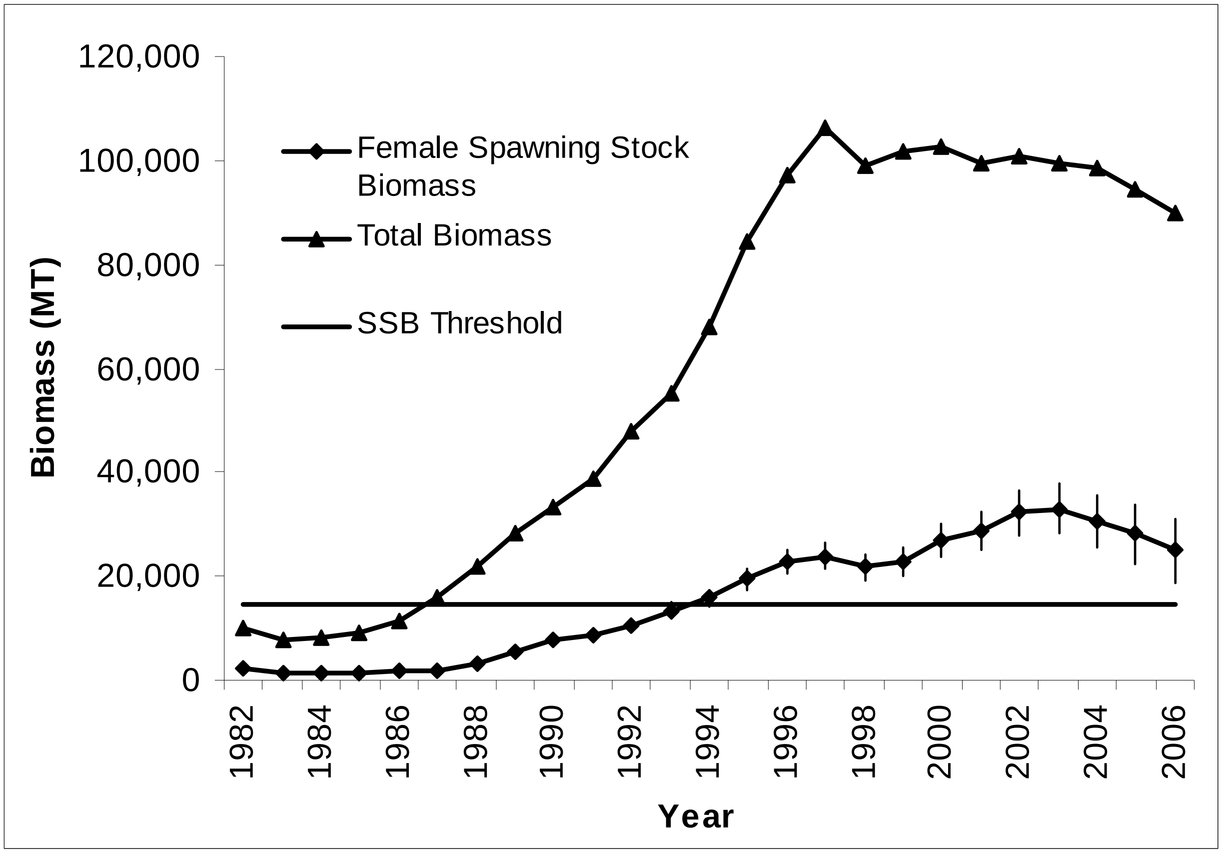


Figure A1. Estimates of Atlantic striped bass female spawning stock biomass (mt) with 95% confidence intervals and January-1 total biomass (mt) from statistical catch at age model (SCA).

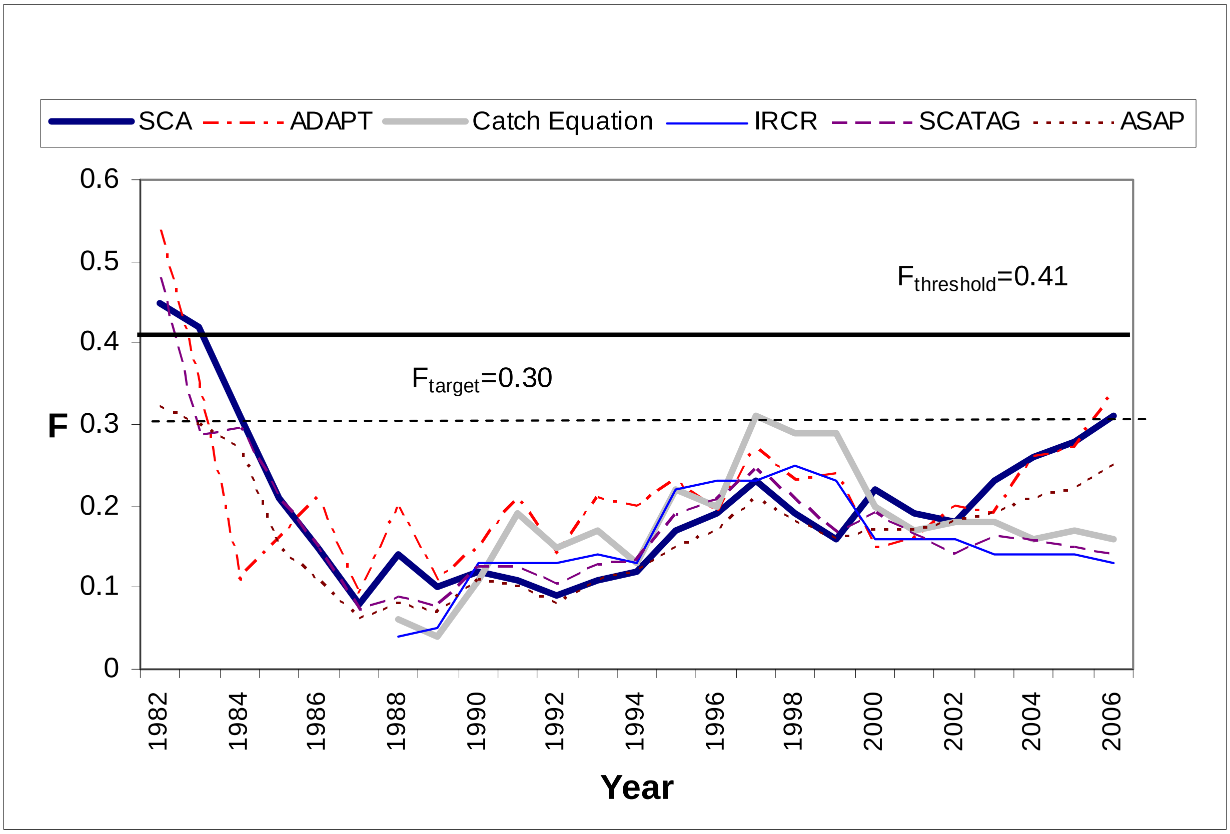


Figure A2. Estimates of instantaneous annual fishing mortality rates (F) for Atlantic striped bass from the catch equation method (CEM), the statistical catch at age model (SCA), and supporting models.

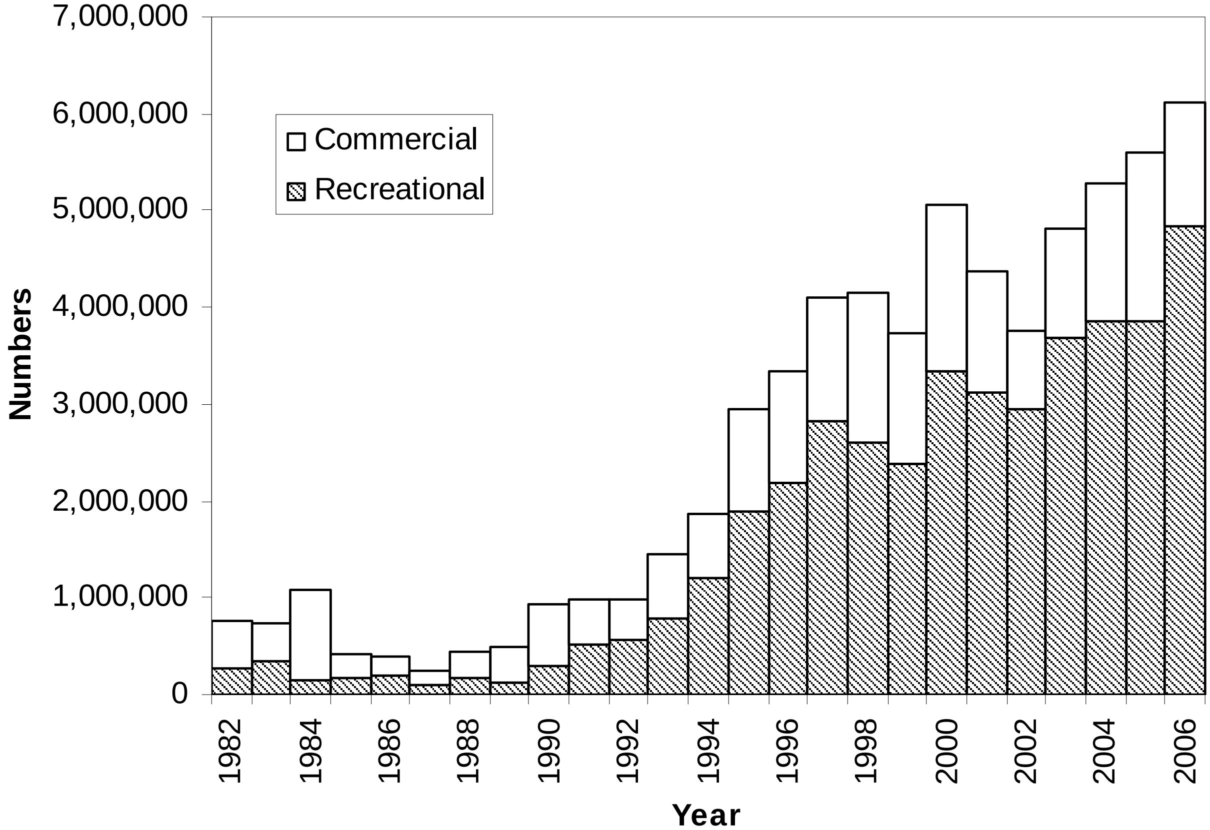


Figure A3. Total removals of Atlantic striped bass partitioned into commercial and recreational contributions, 1982-2006.

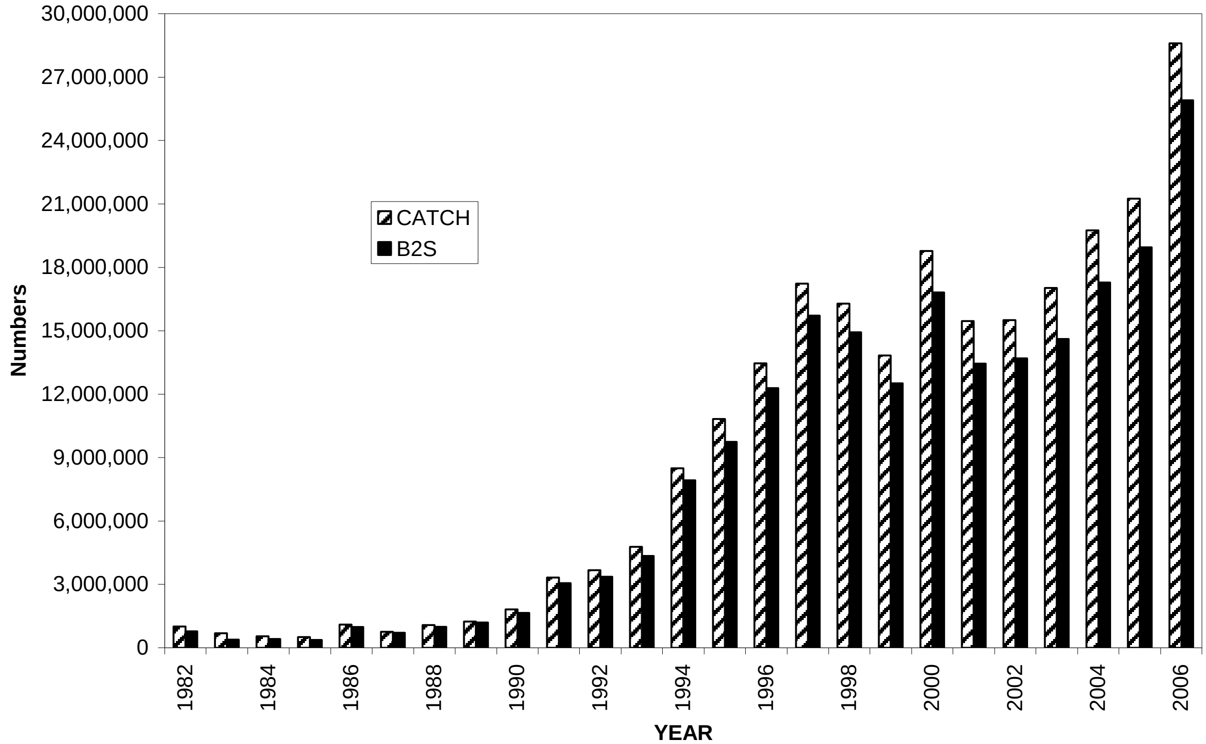


Figure A4. MRFSS estimates of total catch and live releases (B2) of Atlantic striped bass for the US Atlantic coast (ME-NC), 1982-2006.

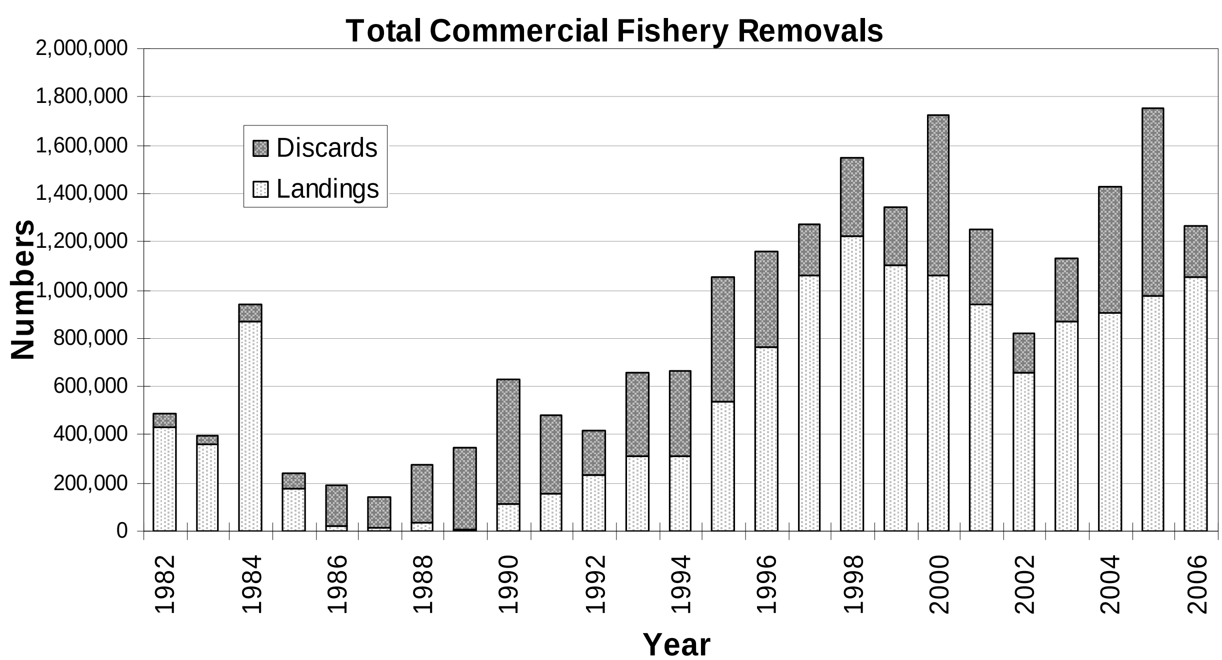
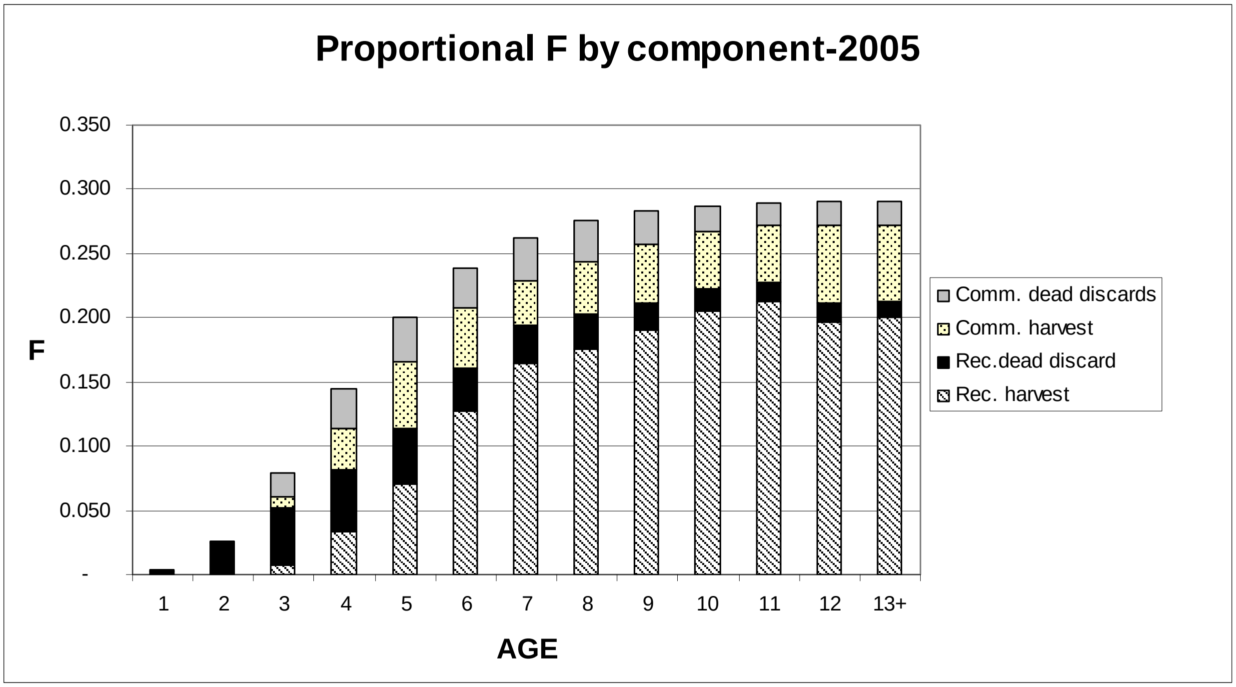


Figure A5. Total commercial removals (landings and dead discards) of Atlantic striped bass, 1982-2006.



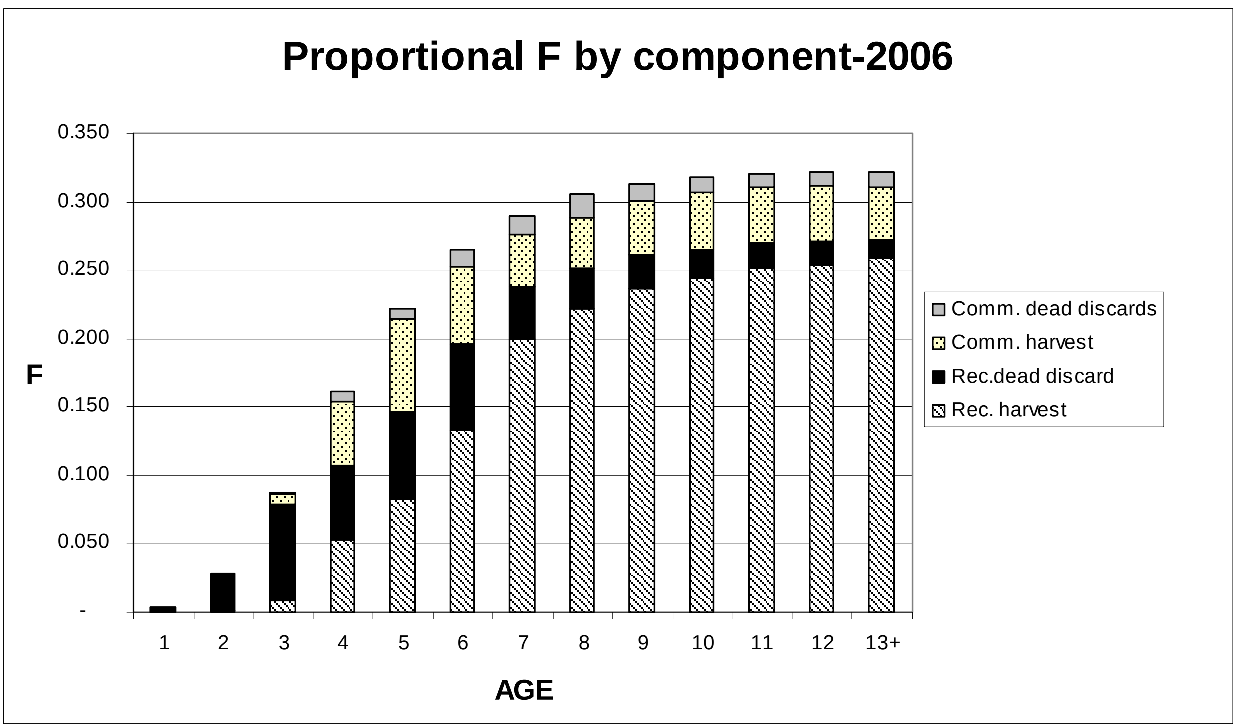


Figure A6. Proportional F at age by fishery component for Atlantic striped bass in 2005 and 2006 as derived from the statistical catch at age model (SCA).

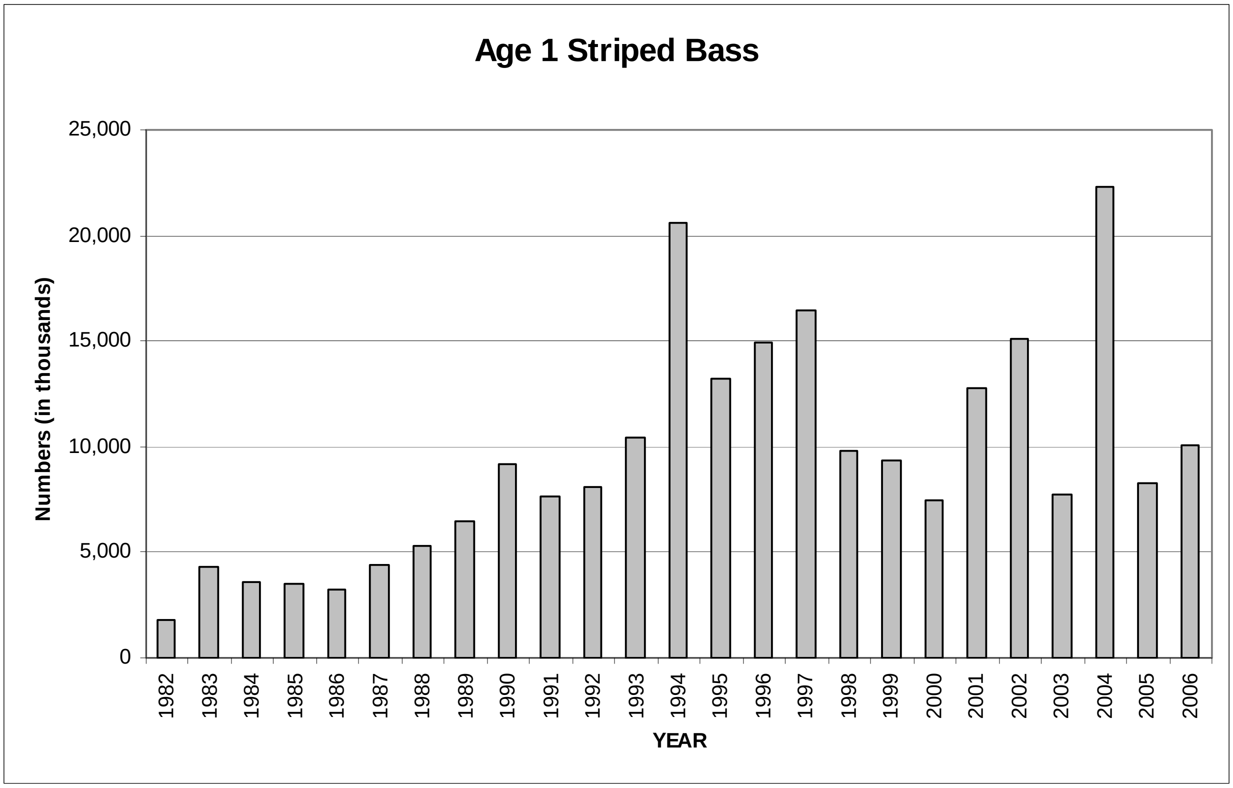


Figure A7. Estimates of age 1 abundance of Atlantic striped bass from the statistical catch at age model (SCA), 1982-2006.

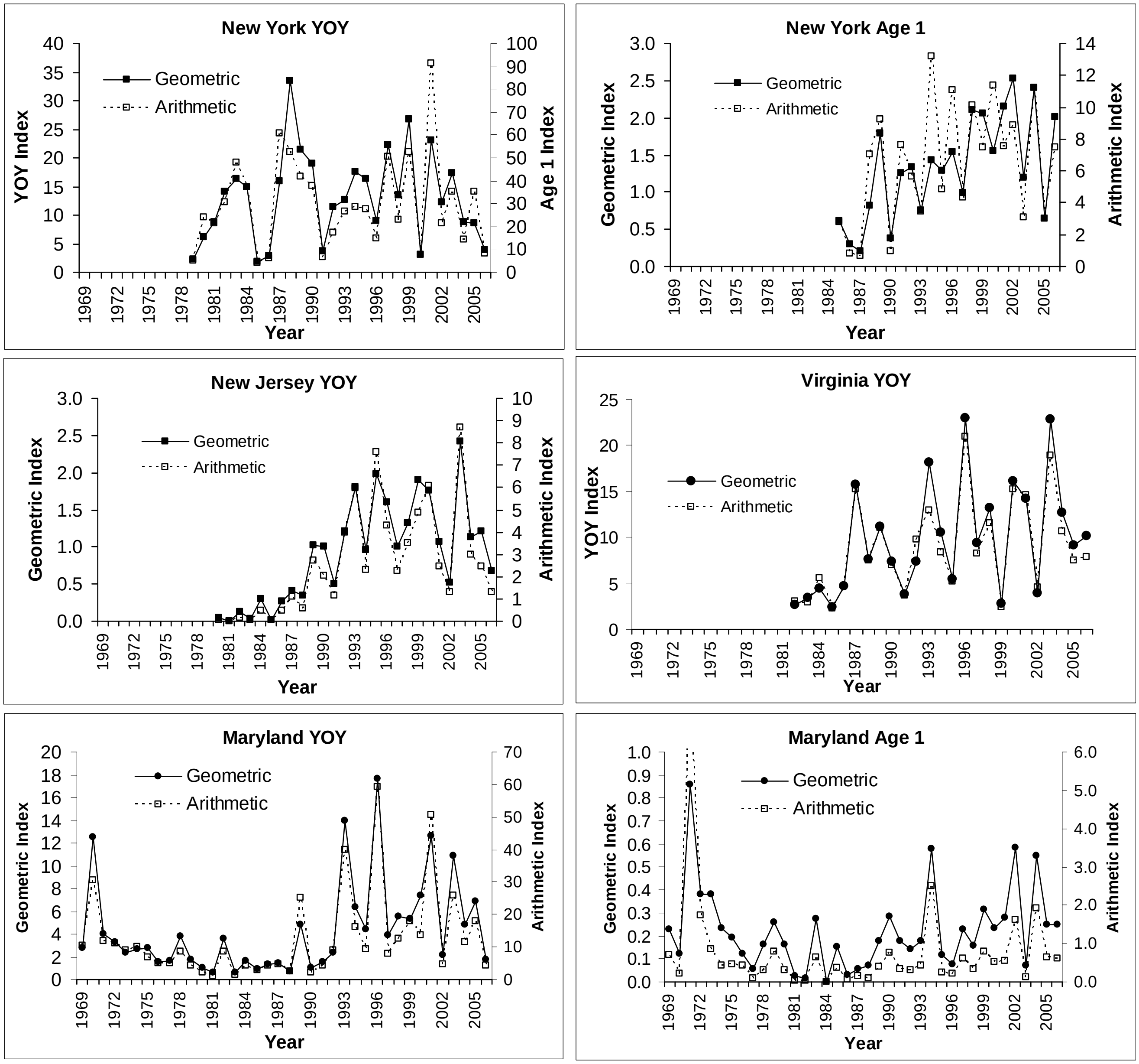


Figure A8. Young-of-the-year and age 1 indices of Atlantic striped bass relative abundance.