B. STRIPED BASS STOCK ASSESSMENT FOR 2013

B1.0 CONTRIBUTORS

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B2.0 TERMS OF REFERENCE (TOR) FOR STRIPED BASS

1. Investigate all fisheries independent and dependent data sets, including life history, indices of abundance, and tagging data. Discuss strengths and weaknesses of the data sources. Evaluate evidence for changes in natural mortality in recent years.

2. Estimate commercial and recreational landings and discards. Characterize the uncertainty in the data and spatial distribution of the fisheries.

3. Use the statistical catch-at-age model to estimate annual fishing mortality, recruitment, total abundance and stock biomass (total and spawning stock) for the time series and estimate their uncertainty. Provide retrospective analysis of the model results and historical retrospective. Provide estimates of exploitation by stock component, where possible, and for total stock complex.

4. Use the Instantaneous Rates Tag Return Model Incorporating Catch-Release Data (IRCR) and associated model components applied to the Atlantic striped bass tagging data to estimate F and abundance from coast wide and producer area tag programs along with the uncertainty of those estimates. Provide suggestions for further development of this model.

5. Update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, SSB_{MSY}, F_{MSY}, MSY). Define stock status based on BRPs.

6. Provide annual projections of catch and biomass under alternative harvest scenarios. Projections should estimate and report annual probabilities of exceeding threshold BRPs for F and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach covering a range of assumptions about the most important sources of uncertainty, including potential changes in natural mortality.

7. Review and evaluate the status of the Technical Committee research recommendations listed in the most recent SARC report. Indentify new research recommendations. Recommend timing and frequency of future assessment updates and benchmark assessments.

B3.0 EXECUTIVE SUMMARY

B3.1 Major findings for TOR 1 – Fisheries-dependent and fisheries-independent data sets, and evidence for changes in M.

Strict quota monitoring is conducted by states through various state and federal dealer and fishermen reporting systems, and commercial landings are compiled annually from those sources by state biologists. Few states collect reliable information on the discarding of striped bass in commercial fisheries. Information on harvest and release numbers, harvest weights, and sizes of harvested bass from 1982-2003 come from the National Marine Fisheries Service's Marine Recreational Fisheries Statistics Survey (MRFSS/MRIP).

States provided age-specific and aggregate indices from fisheries-dependent and fisheries-independent sources that were assumed to reflect trends in striped bass relative abundance. A formal review of age-2+ abundance indices was conducted by ASMFC at a workshop in July of 2004. The 2004 workshop developed a set of evaluation criteria and tasked states with a review of indices. Both the Striped Bass Technical Committee and the Management Board approved of the criteria and of the review. The resulting review led to revisions and elimination of some indices used in previous stock assessments. The following sources were used as tuning indices in the current stock assessment:

MRFSS/MRIP Total Catch Rate Index
Maryland Gillnet Survey
New York Ocean Haul Seine Survey
Northeast Fisheries Science Center Bottom Trawl Survey
　　Young-of-the-Year Indices from the Delaware River, Hudson River, and MD and VA portions of
　　　　the Chesapeake Bay
Age 1 Indices from the Hudson trawl survey and MD seine survey
Connecticut Bottom Trawl Survey
New Jersey Bottom Trawl Survey
Delaware Electrofishing Spawning Stock Survey
Virginia Pound Net Survey

Tagging data suggest that natural mortality has increased in recent years; however, uncertainty in the tagging model make definitively separating changes in M from changes other input parameters such as reporting rate difficult. See Section B8 for details.

B3.2 Major findings for TOR 2 - Commercial and recreational catch including landings and discards

Commercial landings in the Atlantic striped bass fishery increased from roughly 313 mt (800,000 pounds) in 1990 to 3,332 mt (7.3 million pounds) in 2004. Since 2005, landings have fluctuated about an average of 3,162 mt (6.97 million pounds); however, landings have declined slightly in recent years to about 2,952 met in 2012. In 2011 and 2012, the commercial coast-wide harvest was comprised primarily of ages 4-10 striped bass, while harvest in Chesapeake Bay fisheries (Maryland, Virginia, and the PRFC) was comprised mostly of ages 3-6.

The estimates of dead commercial discards were 625,631 and 795,675 fish for 2011 and 2012. The highest discard losses occurred in anchor gill net, pounds net, and hook-and-line fisheries. Most commercial dead discards since 2004 were fish of ages 3-7. Total commercial striped bass removals (harvest and dead discards) were 1.55 million and 1.63 million fish in 2011 and 2012, respectively. Commercial harvest has generally exceeded dead discards since the mid 1990s.

Recreational harvest increased from 1,010 mt (2.2 million pounds) in 1990 to 14,082 mt (31 million pounds) in 2006. Since 2006, harvested declined through 2012 to 8,740 mt (19 million pounds). Coast-wide recreational harvest was dominated by the 2003 (age 8) year-class in 2011 and 2004 (age 8) year-class in 2012. Ages 5-10 comprised >75% of the coast-wide harvest, and ages 8+ comprised >55% in both years. Recreational harvest from the coast (includes Delaware Bay) was comprised mostly of ages 6-10, while harvest in Chesapeake Bay was dominated by ages 4-8.

The number of striped bass that die due to catch and release increased from 132 thousand fish in 1990 to 1.2 million fish in 1997. Dead releases have remained around 1.2 million fish through 2003, but increased to the series maximum of 2.1 million fish in 2006. Since 2006, dead releases have declined substantially to 459,954 fish. Ages of coast-wide recreational dead releases ranged from 0 to 15+, but most dead releases were ages 2-6. Recreational dead releases from the coast (includes Delaware Bay) were comprised of fish ages 2-6 and from Chesapeake Bay were composed of ages 1-4. Total recreational striped bass removals (harvest and dead discards) in 2011 and 2012 were 2.76 million fish and 1.96 million fish, respectively. See Section B5 for details.

B3.3 Major findings for TOR 3 – Use the statistical catch-at-age model to estimate annual fishing mortality, recruitment, total abundance and stock biomass (total and spawning stock) for the time series and estimate their uncertainty. Provide retrospective analysis of the model results and historical retrospective.

Fully-recruited fishing mortality in 2012 for the Bay, Coast and Commercial Discard fleets was 0.055, 0.133, and 0.039, respectively, and was generally highest in the Coast fleet. The maximum F at age in 2012 was 0.188 for ages 10-11. Average fishing mortality on ages 3-8, which are generally targeted in producer areas (Chesapeake Bay, Delaware Bay, and Hudson River), was 0.13. Striped bass total abundance (age 1+) increased steadily from 1982 through 1997 when it peaked around 251 million fish. Total abundance fluctuated without trend through 2004. From 2005-2010, age 1+ abundance declined to an average around 135 million fish. Total abundance increased to 215 million by 2012, due primarily to 2011 year class from Chesapeake Bay. Abundance of striped bass age 8+ increased steadily through 2004 to 11.7 million, but has since declined to 7.6 million fish in 2010. A small increase in 8+ abundance occurred in 2011 as the 2003 year class became age-8. Female SSB grew steadily from 1982 through 2003 when it peaked at about 81 thousand mt. Female SSB has declined since then and was estimated at 61 thousand mt in 2012. Slight retrospective bias was evident in estimates of fully-recruited F, SSB, and age 8+ abundance of SCA suggesting F is slightly overestimated and abundance estimates are slightly underestimated. An ASAP model confirmed the general trend and magnitudes of fishing mortalities. See Section B7 for details.

B3.4 Major findings for TOR 4–Instantaneous Rates Tag Return Model and estimates F and abundance from coast-wide and producer area tag programs along with the uncertainty of those estimates.

The 2011 estimates of F for fish ≥ 28 inches among the coastal area programs ranged from 0.10 (NYTRWL) to 0.15 (NJDB and NCCOOP) which resulted in an unweighted average F of 0.13.   The 2011 F estimates for the producer area programs ranged from 0.06 (VARAP) to 0.18 (DE/PA) and averaged (weighted) 0.11. The 2011 estimates of F for fish ≥ 18 inches among the coastal areas showed little variation, ranging from 0.11 (MADFW) to 0.15 (NCCOOP) which resulted in an unweighted average of 0.13. The average F value varied without trend ranging from 0.09 to 0.13 since 1995.   The estimates of F for the producer area programs showed more variation, ranging from 0.04 (VARAP) to 0.12 (MDCB) and averaged of 0.10. Stock size estimates for fish age 7+ (≥ 28 inches) steadily increased from 11 million fish in 2000 to a peak of 19.3 million fish in 2007. The 2011 estimate of stock size was 19.1 million fish which was the second highest of the time series. The stock size estimates for fish ≥ 18 inches (age 3+) exhibited a rapid increase from 38.6 million fish in 2000 to a peak of 54.9 million fish in 2007. Estimates decreased annually through 2010 but the 2011 estimate showed a slight increase to 35.7 million fish.

In the Chesapeake Bay specific analysis, F estimates obtained using the IRCR model varied depending on model structure. Bay-wide estimates of F were all below the target value of 0.27. Fishing mortality increased from near-zero values during the moratorium period to 0.13 in 1992, peaked at 0.16 in 1998, and then declined to 0.05 in 2010. The 2011 estimate of F for the Chesapeake Bay was 0.09. These low values of F in recent years are not consistent with the high levels of harvest in the Chesapeake Bay. The assumption that 18-28 inch males are all resident fish may be incorrect. If the fish are emigrating from the Bay at a smaller size and the tags are not recovered or not used in the analysis, the emigration will result in an over-inflated estimate of natural mortality. This in turn will lead to an underestimated fishing mortality, as will overestimating the reporting rate. See section B8 for additional details.

B3.5 Major findings for TOR 5 – Update Biological Reference Points and determine stock status.

Biological reference points for striped bass calculated in the last assessment and currently used as thresholds in management are F_{MSY} (0.34) and an SSB proxy which is equivalent to the 1995 spawning stock biomass. The SSB target was calculated as 125% of the 1995 SSB, and the F target was defined as an exploitation rate of 24% or F=0.3. The estimate for F_{MSY} was derived using the results of the 2008 SCA assessment in which four stock-recruitment models were considered; a Ricker, a log-normal Ricker model, a Shepherd and a log-normal Shepherd model. The TC used a model averaging approach among the four results, producing an estimate of F_{MSY} = 0.34 (range of 0.28-0.40).

For this assessment, the SSB_{Target} and $SSB_{Threshold}$ definitions remained the same, but F reference points were chosen to link the target and threshold F with the target and threshold SSB. Using a stochastic projection drawing recruitment from empirical estimates and a distribution of starting population abundance at age, fishing mortality associated with the SSB target and threshold were

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determined. This resulted in an SSB_{Target} of 72,380 mt (160 million pounds) with an associated F_{Target} = 0.175, and an $SSB_{Threshold}$ of 57,904 mt (128 million pounds) with an associated $F_{Threshold}$ = 0.213.

Stock status of Atlantic striped bass in 2012 was not overfished or experiencing overfishing. Female spawning stock biomass (SSB) was estimated at 61.5 thousand mt, above the SSB threshold of 57,904 mt, but below the SSB target of 72,380 mt. Total fishing mortality was estimated at 0.188, below the F threshold of 0.213 but above the F target of 0.175. Under the F reference points from the previous assessment, overfishing is not occurring; F_{2012} is below both the $F_{Threshold}$ (0.34) and the F_{Target} (0.3).

B3.6 Major findings for TOR 6 – Provide numerical annual projections. Projections should estimate and report annual probabilities of exceeding threshold BRPs for F and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach covering a range of assumptions about the most important sources of uncertainty.

If the fully-recruited fishing mortality that produces the current average F for ages 8-11 (0.186) is maintained during 2013-2017, the probability of the spawning stock biomass going below the SSB reference point passes 0.50 in 2014 and peaks at 0.78 by 2015; after 2016, the probability is expected to decline. If the current catch (3.59 million fish) is maintained during 2013-2017, the probability of F exceeding the Fmsy threshold remains low in 2013 but increases rapidly starting in 2014 and reaches near 1.00 by 2015. The projection results were unchanged if an empirical distribution of recruits per SSB from 2001-2011 were used to randomly drawn recruitment for each year.

Regulatory action will be delayed most likely until 2014-2015. By delaying action, the probability of SSB being below the SSB reference is 0.59 for 2014 and 0.61 for 2015 compared to 0.43 for 2014 and 0.49 for 2015 if the reduction of F started in 2013. Even if F in 2014 was reduced to zero, the probability of SSB in 2014 being below the SSB reference point would decline to only 0.52, but it would drop precipitously in the following years as SSB grows rapidly. By delaying action until 2015, the probability of SSB being below the SSB reference is 0.59 for 2014 and 0.76 for 2015 compared to 0.43 for 2014 and 0.49 for 2015 if the reduction of F started in 2013. Even if F in 2015 was reduced to zero, the probability of SSB in 2015 being below the SSB reference point would decline to only 0.74, but it would drop precipitously in the following years as SSB grows rapidly.

B3.7 Major findings for TOR 7 - Review and evaluate the status of the TC research recommendations listed in the most recent SARC report.

The SA committee was able to address several of the recommendations from the most recent SARC report. These include incorporating error in the catch estimation into the model, re-evaluating key parameters including natural mortality, release mortality rates, and tag reporting rates, treating landings and discards as separate fleets, improving SCA model fit diagnostics, incorporating the stock-recruit relationship into the SCA and reference point models, and exploring different models for selectivity in the plus group. Additional work was done on scale-otolith comparisons, and the SCA model now allows for ageing error to be incorporated directly.

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The SA committee also attempted to explicitly model the spatial dynamics of the striped bass stock within the SCA model. This attempt was ultimately fruitless, as the available data were not sufficient to estimate age-specific immigration rates into the bays. However, the SA committee did make progress in addressing the spatial dynamics of the stock by splitting total removals into three "fleets": a coastal fleet, a Chesapeake Bay fleet, and a commercial discard fleet. Incorporating tagging data and improving the spatial modeling of the stock remain high priorities for future work.

Other research priorities that the Technical Committee identified include additional work on mycobacteriosis and its effects on Chesapeake juvenile production and recruitment success, improved estimates of discard mortality and poaching rates, and development of a coastwide fishery independent index for adult striped bass.

The Striped Bass Technical Committee recommends that preferred model be updated after peer review with the finalized 2012 data before it is presented to the Management Board. In addition, should the Board decide to take management action for the 2015 fishing year, the assessment should be updated in 2014, so the most recent stock status information is available. Subsequently, the assessment should be updated every two years.

The Striped Bass Technical Committee recommends that the next benchmark stock assessment be conducted in five years in 2018, which will allow progress to be made on issues like state-specific scale-otolith conversion factors and incorporating tagging data into the SCA model.

B4.0 Management and Assessment History

B4.1 Management History

Striped bass (*Morone saxatilis*) 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 1940s 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 1970s 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 (FMP) in 1981 to increase restrictions in commercial and recreational fisheries. Two amendments were passed in 1984 recommending management measures to reduce fishing mortality. To strengthen the regulations, a federal law was passed in late 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 first enforceable version of the ASMFC plan to restore striped bass was Amendment 3, which was approved in 1985. Amendment 3 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, therefore, a 36 inch size limit by 1990. However, estuaries have traditionally been considered producer areas and smaller size limits were permitted in these producer areas than elsewhere along the coast. This is allowed because the migration of fish out of the producer areas after spawning reduces the availability of larger fish in these areas. However, 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.

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 1970s due to PCB contamination. In addition to the restrictions, Amendment 3 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 for the fourth time 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. Amendment 4 to the FMP allowed an increase in the target F once the spawning stock biomass (SSB) was restored to levels estimated during the late 1960s and early 1970s. The dual size limit concept was maintained with a 28 inch minimum size limit in coastal jurisdictions and 18 inches in

producer areas. A recreational trip limit and commercial season was implemented to reduce the harvest to 20% of that in the historic period of 1972-1979. Amendment 4 and its four addenda aimed to rebuild the resource, rather than maximize yield. Based on the results of a model simulation of the increase in spawning stock biomass, striped bass were declared restored by the ASMFC in 1995. The model, known as the SSB model, was a life history model resulting in a relative index of SSB (Rugolo and others 1994). When the time series of SSB crossed the level comparable to the 1960-1972 average, the stock reached the criteria for a restored stock.

Under Amendment 5 (adopted in 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. Regulations were developed to allow 70% of the historic harvest (based on the historic period of 1972-1979) and achieve the target F, although states were allowed to submit proposals for alternative regulations that were conservationally equivalent. Amendment 5 retained the two fish per day at 28 inches minimum size limit in coastal waters, but allowed two fish per day at 20 inch in producer areas[1]. States could adjust the minimum size, as long as the size change was compensated with a change in season length, bag limits, commercial quota, or a combination of changes. However, no size limit could be less than 18 inches.

Amendment 6 was approved in 2003. It addressed five limitations within the previous management program: potential inability of the management program contained in Amendment 5 to prevent the exploitation target in Amendment 5 from being exceeded; perceived decrease in availability or abundance of large striped bass in the coastal migratory population; a lack of management direction with respect to target and threshold biomass levels; inequitable impacts of regulations on the recreational, commercial, coastal, and producer area sectors of the striped bass fisheries; and excessively frequent changes to the management program.

Amendment 6 established a control rule that sets both a target and a threshold for the fishing mortality rate and female spawning stock biomass. Based on the targets and threshold, as well as juvenile abundance indices, Amendment 6 implemented a list of management triggers, which if any (or all) are reached in any year will require the Management Board to alter the management program to ensure achievement of the Amendment 6 objectives. A planning horizon established the beginning of 2006 as a time at which any management measures established by the Management Board would be maintained by the states for three years, unless a target or threshold is violated.

	FISHING MORTALITY RATE	FEMALE SPAWNING STOCK BIOMASS
TARGET	F = 0.30*	125% of threshold
THRESHOLD	F = 0.34	Estimate of 1995 SSB

The target fishing mortality rate for the Chesapeake Bay and Albemarle-Roanoke stock is F=0.27

The recreational striped bass fisheries are constrained by minimum size limits meant to achieve target fishing mortalities, rather than annual harvest quotas or caps. Most recreational fisheries are constrained by a two fish creel limit and a 28 inch minimum size limit, with no closed season. Through Management Program Equivalency, the Albemarle Sound/Roanoke River and Chesapeake Bay are granted the ability to employ different creel limits and smaller minimum size limits (18 inches) with the penalty of a target fishing mortality rate of 0.27.

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

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The commercial striped bass fisheries are constrained by minimum size limits and state-by-state quotas. The same size standards regulate the commercial fisheries as the recreational fishery, except for a 20 inch size limit in the Delaware Bay shad gillnet fishery. Amendment 6 restores the coastal commercial quotas to 100% of the average reported landings from 1972-1979, except for Delaware's coastal commercial quota, which remains at the level allocated in 2002. The Chesapeake Bay and Albemarle Sound commercial fisheries are managed to not exceed the 0.27 fishing mortality target.

States are granted the flexibility to deviate from these standards by submitting proposals for review by the Striped Bass Technical Committee and Advisory Panel and contingent upon the approval of the Management Board. Alternative proposals must be "conservationally equivalent" to the management standards, which has resulted in some variety of regulations among states (Table B4.1). These management measures were intended to maintain the fishing mortality rate (F) at or below the target F (0.30).

Fishing in the Exclusive Economic Zone (EEZ) was closed in 1990 and has remained closed to the harvest and possession of striped bass by both commercial and recreational fishermen.

B4.2 Management Unit Definition

The management unit includes all coastal migratory striped bass stocks on the East Coast of the United States, excluding the Exclusive Economic Zone (3-200 nautical miles offshore), which is managed separately by NOAA Fisheries. The coastal migratory striped bass stocks occur in the coastal and estuarine areas of all states and jurisdictions from Maine through North Carolina. Inclusion of these states in the management unit is also congressionally mandated in the Atlantic Striped Bass Conservation Act (PL 98-613) (Figure B4.1).

The Chesapeake Bay management area is defined as the striped bass residing between the baseline from which the territorial sea is measured as it extends from Cape Henry to Cape Charles to the upstream boundary of the fall line (Figure B4.2). The striped bass in the Chesapeake Bay are part of the coastal migratory stock and is part of the coastal migratory striped bass management unit. Amendment 6 implements a separate management program for the Chesapeake Bay due to the size availability of striped bass in this area.

The Albemarle-Roanoke stock is currently managed as a non-coastal migratory stock by the state of North Carolina under the auspices of ASFMC. The Albemarle-Roanoke management unit is defined as the striped bass inhabiting the Albemarle, Currituck, Croatan, and Roanoke Sounds and their tributaries, including the Roanoke River. The Virginia/North Carolina line bound these areas to the north and a line from Roanoke Marshes Point to the Eagle Nest Bay bounds the area to the south. The Bonner Bridge at Oregon Inlet defines the ocean boundary of the Albemarle-Roanoke management area.

There has been some debate in recent years whether to continue to include the Albemarle-Roanoke stock of striped bass in the management unit based on the argument that historical tagging studies have suggested very limited migration of this stock into the Atlantic Coastal area. With such little mixing of Albemarle-Roanoke fish with other coastal migratory stocks, it is difficult to include the Albemarle-Roanoke stock in current coast-wide stock assessment because methods used assume that fish from various stocks are equally mixed on the coast. However, fish tagged on the spawning

grounds of Chesapeake Bay, Hudson River, and Delaware River have been recovered in the Albemarle Sound–Roanoke River area (USFWS tagging data), and recent tagging work suggests that most large Albemarle Sound–Roanoke River striped bass (>800 mm TL) are indeed migratory (Callihan et al., in review). This argues for having the stock remain within the management unit.

B4.3 Assessment History

B4.3.1 Past Assessments

The first analytical assessment of Atlantic striped bass stocks using virtual populations analysis (VPA) was conducted in 1997 for years 1982-1996 and reviewed by the 26th Stock Assessment Review Committee at the Northeast Fisheries Science Center. The results of the review were reported in the proceedings of the 26th Northeast Regional Stock Assessment Workshop (26th SAW): SARC Consensus Summary of Assessments (NEFSC Ref. Document 98-03). Subsequent to this peer review, annual updates were made to the VPA based assessment, and in 2001 estimates of F and exploitation rates using coast-wide tagging data were incorporated into the assessment. The tagging data analysis protocol was based on assumptions described in Brownie and others (1985) and the tag recovery data was analyzed in program MARK (White and Burnham 1999). Adjusted R/M ratios (recovered tags/total number of tags released) were used to calculate exploitation rates.

The stock status and assessment procedures were reviewed once again at the 36th SAW in December 2002 and this time included review of the tag based portion of the assessment in addition to the ADAPT VPA portion of the assessment. Since then, annual updates to the assessment were conducted from 2003 through 2005.

In the 2005 assessment, Baranov's catch equation was used with the tagging data to develop estimates of F. By using the Z values from the Brownie models and µ from R/M (recovered tags/total number of tags released), F estimates could be developed for the first time without the assumption of constant natural mortality._This approach was used because of high and increasing estimates of F from the tag analysis when M was assumed constant. This conflicted with other estimates of exploitation and F in the bay from tag programs, and it coincided with the development of an epidemic of mycobacteriosis in the Bay. Also, estimates of abundance could be made.

In addition, two changes were made to the VPA input data. Modifications were made to the suite of tuning indices used in the VPA following a comprehensive review of the various indices. In addition, current and historical estimates of recreational harvest during January and February in North Carolina and Virginia were added to the catch at age matrix.

In the 2004 and 2005 ASMFC assessments of striped bass, the ADAPT VPA model produced high estimates of terminal-year fishing mortality. The consensus of the Technical Committee members was that the ADAPT estimates were likely overestimated given the uncertainty and retrospective bias in the terminal year estimate, especially the F on the older ages which are compared to the overfishing reference point. A recent run with data updated through 2006 showed even worse overestimation of terminal F (at age 10, F =2.2). As an alternative to ADAPT, an age-structured forward projecting statistical catch-at-age (SCA) model for the Atlantic coast migratory stocks of striped bass was constructed and used to estimate fishing mortality, abundance, and spawning stock biomass during 1982-2006 in the 2007 benchmark assessment. This was considered the preferred model over ADAPT.

Also in 2007 benchmark assessment, the instantaneous tag return models of Jiang et al. (2007) were used for the first time. These type of tag models allow recaptured fish that are subsequently released alive without the tag to be incorporated in the estimation of fishing and natural mortality rather than using an ad hoc approach to adjust for release bias like the Smith et al. (1998) method used with the MARK models.

B4.3.2 Current Assessment and Changes from Past Assessments

Based on recommendations by the 2007 SARC and SA committee discussions, the SCA model has been generalized to allow specification of multiple fleets, different stock-recruitment relationships, year- and age-specific natural mortality rates, different selectivity functions for fleets and surveys with age composition data, ageing errors, standardized residual plots, qqnorm plots of residuals, and various management reference points. The catch data have been split into 3 regional "fleets" (Chesapeake Bay, Coast (includes Delaware Bay and Hudson River), and Commercial Discards) in attempt to better model changes in regional selectivity caused by changes in management regulations over time. In addition, age-specific natural mortality values are incorporated for the first time. Historical recreational data (2004-2010) were also updated due to changes in the MRIP estimation methodology.

For the tag data analyses, the age-independent, harvest/catch-release instantaneous tag return (IRCR) model was the preferred methodology. The catch equation and MARK modeling methodologies were eliminated. Only three MARK models are now run as a double check on the IRCR model results. Instead of assuming constant reporting rates, year-specific report rates were estimated and used for 2001-2011.

B4.4 Fishery Descriptions

Commercial fisheries operate in eight of the 14 jurisdictions regulated by the Commission's FMP (Massachusetts, Rhode Island, New York, Delaware, Maryland, Virginia, Potomac River, and North Carolina; Table B4.1). Commercial fishing for striped bass is prohibited in New Jersey, Pennsylvania, Connecticut, New Hampshire, Maine and the District of Columbia. The predominant gear types in the commercial fisheries are gillnets, pound nets, and hook and line. In a few states, the trap gear is an important part of this fishery. Massachusetts allows commercial fishing with hook-and-line gear only, while other areas allow net fisheries. Most commercial fisheries are seasonal in nature because of bass movements and management regulations. Following the reopening of striped bass fisheries in 1990, a rebuilding management strategy remained in effect until 1995, when the stock was considered recovered. Subsequently, management constraints were relaxed to the extent that states were afforded increases in commercial quotas (Table B4.1)

Recreational fisheries operate in all 14 jurisdictions regulated by the Commission's FMP. The predominant gear type is hook and line (Table B4.1). Following the reopening of striped bass fisheries in 1990, state fisheries were limited to a 2-fish possession limit, 28-inch minimum size limit (except "producer" areas, such as the Chesapeake jurisdictions, were allowed to implement 18-inch minimum size limits) and modest open fishing seasons. By 1995, coincident with the recovered status of striped bass, open fishing seasons were extended, with some states establishing year-round open seasons (Table B4.1). In Chesapeake Bay, recreational caps have been established for specific seasonal fisheries.

B5.0 Investigate all fisheries independent and dependent data sets, including life history, indices of abundance, and tagging data. Discuss strengths and weaknesses of the data sources. Evaluate evidence for changes in natural mortality in recent years. (TOR #1)

B5.1 Fishery Dependent and Independent Indices of Abundance

States provide age-specific and aggregate indices from fisheries-dependent and fisheries-independent sources that are assumed to reflect trends in striped bass relative abundance. A formal review of age-2+ abundance indices was conducted by ASMFC at a workshop in July of 2004 (Appendix A4). Young of-the-year and age 1 indices had been reviewed and validated (ASMFC 1996). The 2004 workshop developed a set of evaluation criteria and tasked states with a review of indices. Both the Striped Bass Technical Committee and the Management Board approved the criteria and the review. The resulting review led to revisions and elimination of some indices formerly used in ADAPT (Appendix A4). For the 2007 benchmark assessment, based on the review of survey programs and Technical Committee recommendations (see Section 6.0), major changes were made to the suite of indices. The NEFSC spring inshore survey, originally age-specific, was reduced to an aggregate index (ages 2-9) and was truncated at 1991 due to missed sampling of inshore survey strata prior to 1991. The Massachusetts commercial CPUE, originally age-specific harvest-per-trip indices, were redeveloped as age-specific (ages 2-13+) total catch-per-hour indices. The New Jersey trawl, originally an aggregate index, was further apportioned into age-specific mean indices for age 2-13+. The New York ocean haul seine survey indices for ages 8-13+ were aggregated into an 8+ index. Connecticut age-specific recreational catch indices for ages 10-13+ were aggregated to 10+. The Virginia pound net survey, a single fixed station, commercial pound net index, was eliminated from the input because few analyses conducted could support its continued use as an index that reflected striped bass abundance. Two new surveys were added: age-specific (ages 2-13+) Delaware River electrofishing spawning stock indices and the coast-wide MRFSS aggregate (2-13+) total catch rate index. In 2013, the Virginia pound net index was re-introduced based on arguments provided by VIMS after elimination of the index in 2005.

Since the 2007 benchmark assessment, changes to sampling methodologies, vessel use, and reporting requirements have impacted the generation of some aggregate and age-specific fisheries-independent and -dependent indices.

Massachusetts Commercial CPUE Index

This index has been eliminated because analyses after the workshop showed that the index reflected changes in angler behavior targeting aggregations, not relative abundance. In addition, starting in 2009, the format of the reporting forms changed and the information required to generate the index in no longer collected.

Connecticut Recreational CPUE Index

This index has been removed from the assessment for several reasons. The original investigator who generated this index retired in 2011 and the replacement biologist has not been able to replicate this index even after talks with the original investigator, suggesting there may have been an error in

the original calculations. In addition, the index covered only a small portion of the stock, and was based in part on the MRFSS/MRIP data. To avoid double-counting the MRFSS/MRIP CPUE data in the model, the CT index with its smaller geographical range was dropped.

New York Ocean Haul Survey

This survey (see below) was stopped in 2007 due to state changes in contract relationships with private fishermen. The index remains in the assessment because it provides abundance trends for 1987-2006.

NEFSC Trawl Survey

The original vessel for this survey was replaced in 2009 with a larger vessel that cannot sample the inshore strata where most striped bass were caught. The index is still used in the assessment because it provides abundance trends for 1991-2008.

Descriptions of the current survey indices are given below and reflect changes to surveys following the formal review. A summary of index information is provided in Table B5.1.

B5.1.1 Fisheries-Dependent Catch Rates

B5.1.1.1 MRIP Total Catch Rate Index

An aggregate index of relative abundance for 1988 to present is generated from MRFSS/MRIP intercept data. Generalized linear modeling (McCullagh and Nelder, 1989) is used to derive annual mean catch-per-hour estimates by adjusting the number of caught fish per trip for the classification variables of state, year, two-month sampling wave, number of days fished in the past 12 months (as a measure of avidity), and number of hours fished. In the analyses, only data from anglers who reported that they targeted striped bass is used to insure methods used among anglers are as consistent as possible and to identify those targeting anglers that did not catch striped bass (zero catches). Also, only data from private boats fishing in the Ocean during waves 3-5 is used.

A delta-lognormal model (Lo *et al.* 1992) was selected as the best approach to estimate year effects after examination of model dispersion (Terceiro, 2003) and standardized residual deviance versus linear predictor plots (McCullagh and Nelder, 1989). In the delta-lognormal model, catch data is decomposed into catch success/failure and positive catch per trip (y > 0) components. Each component is analyzed separately using appropriate statistical techniques and then the statistical models are recombined to obtain estimates of the variable of interest. The catch success/failure was modeled as a binary response to the categorical variables using multiple logistic regression. The *glm* function in R is used to estimate parameters, and goodness-of-fit was assessed using concordance measures and the Hosmer-Lemeshow test. Positive catches, transformed using the natural logarithm, is modeled assuming a normal error distribution using the *glm* function in R. Any variable not significant at $\alpha=0.05$ with type-III (partial) sum of squares is dropped from the initial GLM model and the analysis is repeated. First-order interactions were considered in the initial analyses but it was not always possible to generate annual means by the least-square methods with some interactions included (Searle and others 1980); therefore, only main effects are considered. The annual index of striped bass total catch rate is estimated by multiplying together the prediction of the probability of

obtaining a positive catch and the least-squares mean estimate of the positive catch from the *glm* models.

B5.1.1.2 Virginia Pound Net (VAPNET)

Since 1991, Virginia Marine Institute of Science has conducted the Virginia pound net survey. The pound net survey takes place on the striped bass spawning grounds in the Rappahannock River between river miles 44-47. VIMS has the option of sampling up to four commercial nets. The upper and lower nets are used for this survey and the middle nets are used for tagging. VIMS alternates sampling between the upper and lower nets. The sampling occurs from March 30 to May 3, when the females are on the spawning ground. The pound nets are checked twice a week, but are fishing constantly. When the samples are collected, the fish are sexed and measured, scales are taken from every fish, and a subsample of otoliths.

B5.1.2 Fisheries-Independent Survey Data

B5.1.2.1 Connecticut Trawl Survey (CTTRL)

Connecticut provides an aggregate (ages 4-6) index of relative abundance from a bottom trawl survey. The Connecticut DEEP Marine Fisheries Division has conducted a fisheries–independent Trawl Survey in Long Island Sound since 1984. The Long Island Sound Trawl Survey (LISTS) provides fishery independent monitoring of important recreational species, as well as annual total counts and biomass for all finfish taken in the Survey. Most species are measured on all tows including striped bass. The Long Island Sound Trawl Survey encompasses an area from New London, Connecticut (longitude 72° 03') to Greenwich, Connecticut (longitude 73° 39'). The sampling area includes Connecticut and New York state waters from 5 to 46 meters in depth and is conducted over mud, sand and transitional (mud/sand) sediment types. Long Island Sound is surveyed in the spring (April-June) and fall (September-October) periods with 40 sites sampled monthly for a total of 200 sites annually.

The sampling gear employed is a 14 m otter trawl with a 51 mm codend. To reduce the bias associated with day-night changes in catchability of some species, sampling is conducted during daylight hours only (Sissenwine and Bowman 1978). LISTS employs a stratified-random sampling design. The sampling area is divided into 1.85 x 3.7 km (1 x 2 nautical miles) sites, with each site assigned to one of 12 strata defined by depth interval (0 - 9.0 m, 9.1 - 18.2 m, 18.3 - 27.3 m or, 27.4+ m) and bottom type (mud, sand, or transitional as defined by Reid et al. 1979). For each monthly sampling cruise, sites are selected randomly from within each stratum. The number of sites sampled in each stratum was determined by dividing the total stratum area by 68 km2 (20 square nautical miles), with a minimum of two sites sampled per stratum. Discrete stratum areas smaller than a sample site are not sampled. The CTTRL index is computed as the stratified geometric mean number per tow.

B5.1.2.2 Northeast Fisheries Science Center Bottom Trawl Survey (NEFSC)

The Northeast Fisheries Science Center provides an aggregate (2-9) index of relative abundance from the spring stratified-random bottom trawl survey. The survey covers waters from the Gulf of Maine to Cape Hatteras, NC. Only data from inshore strata from 1991-2008 are used.

B5.1.2.3 New Jersey Bottom Trawl Survey (NJTRL)

New Jersey provides age-specific (2-9+) geometric mean indices of relative abundance for striped bass from a stratified-random bottom trawl initiated in 1989. The survey area consists of NJ coastal waters from Ambrose Channel, or the entrance to New York harbor, south to Cape Henlopen Channel, or the entrance to Delaware Bay, and from about the 3 fathom isobath inshore to approximately the 15 fathom isobath offshore. This area is divided into 15 sampling strata. Latitudinal boundaries are identical to those which define the sampling strata of the National Marine Fisheries Service (NMFS) Northwest Atlantic groundfish survey. Exceptions are those strata at the extreme northern and southern ends of NJ. Where NMFS strata are extended into NY or DE waters, truncated boundaries were drawn which included only waters adjacent to NJ, except for the ocean waters off the mouth of Delaware Bay, which are also included. Samples are collected with a three-in-one trawl, so named because all the tapers are three to one. The net is a two seam trawl with forward netting of 12 cm (4.7 inches) stretch mesh and rear netting of 8 cm (3.1 inches) stretch mesh. The codend is 7.6 cm stretch mesh (3.0 inches) and is lined with a 6.4 mm (0.25 inch) bar mesh liner. The headrope is 25 m (82 feet) long and the footrope is 30.5 m (100 feet) long. Trawl samples are collected by towing the net for 20 minutes. The total weight of each species is measured with hanging metric scales and the length of all individuals comprising each species caught, or a representative sample by weight for large catches, is measured to the nearest cm total length is measured and only data from April are used for striped bass.

B5.1.2.4 New York Ocean Haul Seine Survey (NYOHS)

New York provides age-specific geometric mean indices of relative abundance for striped bass generated from an ocean haul seine survey from 1987 - 2006. Since 1987, NY DEC has been sampling the mixed coastal stocks of striped bass by ocean haul seine. Sampling is conducted annually during the Fall migration on the Atlantic Ocean facing beaches off the east end of Long Island. A crew of commercial haul seine fishermen is contracted to set and retrieve the gear, and assist department biologists in handling the catch. The survey seine measures approximately 1,800 feet long and is composed of two wings attached to a centrally located bunt and cod end. The area swept is approximately ten acres. The seine is fifteen feet deep in the wings and twenty feet deep in the bunt.

Under the original design, sampling dates were selected at random to create a schedule of thirty dates. For each date selected, two of ten fixed stations were chosen at random, without replacement, as the sampling locations for that day. Since this design was difficult to implement due to weather-related delays, the sampling design was altered in 1990. Instead of randomly selecting thirty days, sixty consecutive working days were identified during the fall. One station was randomly selected, without replacement, for each working day until six "rounds" of ten hauls had been scheduled. Hauls that were missed due to bad weather or equipment failure were added to the next scheduled sampling day. No more than three hauls were attempted for any given day so that sampling was evenly distributed over time. Sixty hauls were scheduled for each year.

Since 1995, the survey team has been prohibited from gaining access to several of the fixed stations. Instead of the original ten stations, two of the original stations plus three alternate sites have been used to complete the annual survey. These alternate stations occur within the geographic range

of the original standard stations. Also since 1995, funding delays have resulted in a one-month delay in the commencement of field sampling activities. Between 1987 and 1994 field sampling began in early September. Since 1995, sampling has begun in late September to early October. In addition, decreases in funding have led to reductions in annual sampling effort from sixty seine hauls to forty-five seine hauls per season since 1997. The time series of catch and catch-at-age has been standardized by date for the entire time series.

B5.1.2.5 Maryland Spawning Stock Survey (MDSSN)

Maryland provides spawning stock age-specific (2-13+) mean indices of relative abundance for striped bass in Chesapeake Bay from a gillnet survey initiated in 1985. Multi-panel experimental drift gill nets are deployed in spawning areas in the Potomac River and in the Upper Chesapeake Bay during the spring spawning season in April and May. There are generally 20-25 sampling days in a season. Ten mesh panels 150 feet long that range from 8 to 11.5 feet deep are used. The panels are constructed of multifilament nylon webbing in 3.00- to 10.00-inch stretch-mesh. In the Upper Bay, the entire suite of 10 meshes is fished simultaneously. In the Potomac River, two suites of 5 panels are fished simultaneously. Overall, soak times for each mesh panel range from 15 to 65 minutes. In both systems, all 10 meshes are fished twice daily (20 sets) unless weather or other circumstances prohibit a second soak. Sampling locations are assigned using a stratified random survey design. Each sampled spawning area is considered a stratum. One randomly chosen site per day is fished in each spawning area. The Potomac River sampling area consists of 40 0.5-square-mile quadrants and the Upper Bay sampling area consists of 31 1-square-mile quadrants. The Choptank River was also sampled between 1985-1996. A sub-sample of striped bass captured in the nets is aged. Scales are removed from two-three randomly chosen male striped bass per one cm length group, per week, for a maximum of ten scales per length group over the entire season. Scales are taken from all males over 700 mm TL and all females regardless of total length.

CPUEs for individual mesh sizes and length groups are calculated for each spawning area. Mesh-specific CPUEs ($CPUE_{i,j}$) are calculated by summing the catch in each length group across days and sets, and dividing the result by the total effort for each mesh. Sex-specific mesh selectivity coefficients are then used to correct the mesh-specific length group CPUE estimates. Sex-specific models are used to develop selectivity coefficients for fish sampled from the Potomac River and Upper Bay. Model building and hypothesis testing has determined that male and female striped bass possess unique selectivity characteristics, but no differences are evident between the Upper Bay and the Potomac River. Therefore, sex-specific selectivity coefficients for each mesh and length group are estimated by fitting a skew-normal model to spring data from 1990 to 2000 following the procedure presented in Helser and others. (1998). Model residuals are re-sampled 1,000 times to generate a population of 1,000 mesh- and size class-specific selectivity coefficients for each year, sample area, and sex. The CPUE for each size class and mesh are then divided by the appropriate selectivity coefficient to generate 1,000 replicate matrices of mesh- and length-specific corrected catch frequencies. A vector of selectivity-corrected length-group CPUEs for each spawning area and sex is then developed. The selectivity-corrected CPUEs are averaged across meshes, using a mean that is weighted by the capture efficiency of the mesh. Finally, area- and sex-specific estimates of relative abundance are pooled to develop Bay-wide estimates of relative abundance.

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B5.1.2.6 Delaware Spawning Stock Electrofishing Survey (DESSN)

Delaware provides spawning stock age-specific (2-13+) mean indices of relative abundance for striped bass in the Delaware River from an electroshock survey initiated in 1996. Striped bass are sampled in the Delaware River from the vicinity of Big Timber Creek and League Island near river kilometer 152 located between Central Philadelphia downstream to the Delaware Memorial Bridge below Wilmington, DE at river kilometer 110. A stratified-random sampling design is used and a Smith-Root model 18-E boat electrofisher is used to collect striped bass. Typically, sampling is conducted with the boat moving in the direction of the tidal flow and in a zigzag pattern. Only striped bass approximately >200 mm total length are collected. Sampling is conducted weekly during mid-April to May (two days per week) and seven 12-minute timed samples are made per day. Length, weight, and sex are recorded and scales are collected from each fish.

B5.1.2.7 New York Young-of-the-Year and Yearling Survey (NYYOY and NY Age 1)

New York provides an index of relative abundance for young-of-the year striped bass in the Hudson River for years 1980 to present. The beach seine survey samples fixed stations between Tappan Zee to Haverstraw Bay area using a 61-m, 5-mm stretched mesh bag and 6 mm stretched mesh wing. A total of 33 fixed stations are sampled. Twenty-five stations are sampled biweekly from mid-July through early November. The geometric mean is used as the relative index.

New York also provides an index of relative abundance for yearling striped bass in western Long Island sound. The beach seine (61-m) survey samples fixed stations during May-October. The geometric mean is used as the relative index.

B5.1.2.8 New Jersey Young-of-the-Year Survey (NJYOY)

New Jersey provides an index of relative abundance for young-of-the year striped bass in the Delaware River for years 1980 to present. A bagged beach seine is used at fixed and random stations, which are sampled biweekly from August-October. About 256 samples are taken per year. Relative abundance index for striped bass is calculated as the mean geometric number of young-of-the-year captured per seine haul.

B5.1.2.9 Virginia Young-of-the-Year Survey (VAYOY)

Virginia provides an index of relative abundance for young-of-the-year bass in the Virginia portion of Chesapeake Bay. Begun in 1980, the fixed station survey is conducted in the James, York, and Rappahannock river systems. Eighteen index stations are sampled five times a year on a biweekly basis from mid-July through September. Twenty auxiliary stations provide geographically expanded coverage during years of unusual precipitation or drought when the normal index stations do not yield samples. A bagged beach seine (30.5 m long) is set by hand with one end fixed on the beach and the other fully extended perpendicular to the beach. The seine is swept with the current. Two hauls are made at each site. Abundance indices are computed as the geometric mean number of young-of-the-year or yearling bass per haul.

B5.1.2.10 Maryland Young-of-the-Year and Yearlings Surveys (MDYOY and MD Age1)

Maryland provides an index of relative abundance for young-of-the-year and yearling striped bass in the Maryland portion of Chesapeake Bay. Begun in 1954, the fixed station survey is conducted in the Upper Bay, Choptank, Nanticoke, and Potomac Rivers. Each station is sampled once during each monthly round performed during July, August, and September. A bagless beach seine (30.5 m long) is set by hand with one end fixed on the beach and the other fully extended perpendicular to the beach. The seine is swept with the current. Two hauls are made at each site. Abundance indices are computed as the geometric mean number of young-of-the-year or yearling bass per haul.

B5.2 Comparison of Fisheries-Dependent and Fisheries-Independent Indices

Time series of each index used in the current assessment are shown in Table B5.2-B5.3. The coast-wide MRFSS index suggests a decline in abundance from 1998 to 2003, a steady rise through 2006, and then a declined through 2011 (2012 is unavailable because the intercept data were not available) (Figure B5.1). The VA pound net index showed variable but level trends prior to 1999, an increase in 1999 and 2000, a decline through 2002, an increase through 2004, and then a variable but level trend through 2010 (Figure B5.1). A decline occurred in 2011 and 2012.

The fishery-independent indices for combined ages generally indicate an increase in population abundance from the early 1990s through the mid 1990s, and relatively stable levels through 2007 (Figure B5.2). The New Jersey and Connecticut trawl indices showed declines after 2008 (Figure B5.2) The Maryland gillnet survey showed a relatively stable spawning stock biomass population since the mid 1980s (Figure B5.2). The Delaware electrofishing index exhibited a slight decline in spawning stock through 2009, but an increase through 2011 (Figure B5.2).

Young-of-the-year and age-1 indices in Chesapeake Bay were variable but declines were observed during 2004-2010 and in some years close to low values not observed since 1990 (Figure B5.3). In Delaware Bay, recruitment of YOY increased from 2007 through 2009, but it declined slightly during 2010-2011, while recruitment in the Hudson River declined from 2007-2011 (Figure B5.3). Strong year-classes were evident in 1993, 1996, 2001, 2003 and 2011 in Chesapeake Bay (Maryland and Virginia), and in 1993, 1995, 1999, 2003 and 2009 in Delaware Bay, in 1997, 1999, 2001 and 2007 in Hudson River (Figure B5.3). The lowest YOY index value in the Chesapeake Bay time series was observed in 2012.

B5.3 Atlantic Coast Striped Bass Tagging Data

Eight tagging programs have traditionally participated in the USFWS Atlantic coast-wide striped bass tagging program and each have been in progress for at least 18 years. As striped bass are a highly migratory anadromous species, the tagging programs are divided into two categories, producer area programs and coastal programs. Most programs tag striped bass primarily ≥ 18 inches total length (TL) during routine state monitoring programs.

Producer area tagging programs primarily operate during spring spawning on the spawning grounds. Several capture methods are used such as pound nets, gill nets, seines and electroshocking. The producer area programs are:

- Hudson River (HUDSON) - fish tagged in May;

- Delaware and Pennsylvania (DE/PA) - fish tagged in the Delaware River primarily in April and May;

- Maryland (MDCB) - fish tagged in the Potomac River and the upper Chesapeake Bay primarily in April and May; and

- Virginia (VARAP) - fish tagged in the Rappahannock River during April and May.

Coastal programs tag striped bass from mixed stocks during fall, winter, or early spring. Gears include hook & line, seine, gill net, and otter trawl. The coastal tagging programs are:

- Massachusetts (MADFW) - fish tagged during fall months;

- New York ocean haul seine survey (NYOHS) - fish tagged during fall months. This survey changed to a trawl survey (NYTRL) in 2008 – fish tagged in November. Due to differences in length frequency and gear types, it is not possible to combine the surveys into one data series. When data are presented in the report (NYOHS/TRL), numbers with * are from the trawl.

- New Jersey Delaware Bay (NJDB) - fish tagged in March and April; and

- North Carolina winter trawl survey (NCCOOP) - fish tagged primarily in January.

Tag release and recapture data are exchanged between the USFWS office in Annapolis, MD, and the cooperating tagging agencies. The USFWS maintains the tag release/recovery database and provides rewards to fishermen who report the recaptures of tagged fish. From 1985 through January 2013, a total of 507,097 striped bass have been tagged and released, with 91,440 recaptures reported and recorded in the USFWS database (Ian Park, personal communication).

Release data, recorded at time of tagging, include:

- tag number,
- total length,
- sex (if available),
- release date,
- release location,
- gear, and
- other physical data.

Recapture data are obtained directly from fishermen and include:

- tag number,
- total length,
- disposition,
- recapture date,
- recapture location,
- gear; and

• personal information.

These data are used to develop the following descriptive statistics of reported fish:
• length frequency distributions of releases, measured as total length (TL);
• age frequency distributions of recaptures based on the aged subsample; and
• annual exploitation rates.

Tagging data were available through 2011.

B5.4 Life History and Biology

B5.4.1 Geographic Range

Atlantic coast migratory striped bass 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). Stocks which occupy coastal rivers from the Tar-Pamlico River in North Carolina south to the St. Johns River in Florida are believed primarily endemic and riverine and apparently do not presently undertake extensive Atlantic Ocean migrations as do stocks from the Roanoke River north (ASMFC 1990), although at least one individual tagged in the Cape Fear River recently did so, being recaptured at Montauk Lighthouse, New York. Striped bass are also naturally found in the Gulf of Mexico from the western coast of Florida to Louisiana (Musick and others 1997). Striped bass were introduced to the Pacific Coast using transplants from the Atlantic Coast in 1879. Striped bass also were introduced into rivers, lakes, and reservoirs throughout the US, and to foreign countries such as Russia, France and Portugal (Hill and others 1989). The following life history information applies to the Atlantic coast migratory population.

B5.4.2 Age

The age of a fish is frequently used as a milestone in characterizing many aspects of the fish's life history such as age of maturity. Atlantic striped bass have been aged using scales for over 70 years (Merriman, 1941). Scales of striped bass collected in North Carolina show annulus formation taking place between April and May in the Albemarle Sound and Roanoke River (Trent and Hassler 1968; Humphreys and Kornegay 1985). Annuli form on scales of striped bass caught in Virginia between April and June, or during the spawning season (Grant 1974).

Age data has also been fundamental to VPA- and SCA-based stock assessments of striped bass. Since 1996, catch-at-age models have used scale age, principally because the time series of catch data extends back to 1982 and scales have been the only consistent collected age structure, even in more recent years. However, it is generally recognized that after a certain point, scales underestimate striped bass ages compared to otoliths and known age fish (Secor *et al.* 1995, Appendix B10). ASMFC is working with states to facilitate collection of otoliths for 800 mm striped bass or larger as the state ageing programs have shown high precision in scale ageing striped bass up to age 10.

Generally, longevity of striped bass has been estimated as 30 years, although in recent years, a striped bass was aged as 31 years based on otoliths (Secor 2000). This longevity suggests that striped bass populations can persist during long periods of poor recruitment due to a long reproductive

lifespan, and may have also conferred resiliency against an extended period of recruitment overfishing in the Chesapeake Bay (Secor 2000). Based on SCA estimates, young fish dominate the age composition of striped bass, but recent estimates of older striped bass (age-8 or older) indicate this grouping averaged 10% of striped bass age-1 or older, since 2000. This amount represents nearly a doubling of the proportion of age-8 and older striped bass during the decade of the 1990s.

B5.4.3 Growth

As a relatively long-lived species, striped bass are capable of attaining moderately large size, reaching as much as 125 lbs (Tresselt 1952). Fish weighing 50 or 60 lbs are not exceptional, and several fish harvested in North Carolina and Massachusetts, recorded in excess of 100 pounds, were estimated to have been at least 6 feet long (Smith and Wells 1977). Females do grow to a considerably larger size than males; striped bass over about 30 lbs are almost exclusively female (Bigelow and Schroeder 1953). Both sexes grow at the same rate until 3 years old; beginning at age 4, females grow faster and larger than males.

Growth occurs during the seven-month period between April and October. Within this time frame, striped bass stop feeding for a brief period just before and during spawning, but feeding continues during the upriver spawning migration and begins again soon after spawning (Trent and Hassler 1966). From November through March, growth is negligible.

Growth rates of striped bass are variable, depending on a combination of the season, location, age, sex, and competition. For example, a 35 inch striped bass can be anywhere from 7 to 15 years of age and a 10 lb striped bass can be from 6 to 16 years old (ODU CQFE 2006). Growth (in length) is more rapid during the second and third years of life, before reaching sexual maturity, than during later years. Merriman (1941) observed that striped bass of the 1934 year-class showed their greatest growth during the 3rd year, at which age migratory movements begin. Thereafter the rate dropped sharply at age 4 and remained nearly constant at 6.5-8.0 cm per year up to about age 8. The growth rate probably decreases even further after the 8th year.

Compensatory growth, in which the smaller fish in a year-class, growing at an accelerated pace, reduce or eliminate the size differences between themselves and other larger members of that age group, has been shown to occur in age 2 striped bass in Chesapeake Bay (Tiller 1942) and in age 2 and 3 fish from Albemarle Sound (Nicholson 1964).

B5.4.4 Reproduction and Recruitment

Striped bass are anadromous, ascending coastal streams in early spring to spawn, afterward returning to ocean waters. Spawning takes place in the shallow stretches of larger rivers and streams, generally within about the first 40 km of freshwater in rivers flowing into estuaries (Tresselt 1952). The actual distance upstream of the center of spawning varies from river to river and even within the same river from year to year. Striped bass spawning areas characteristically are turbid and fresh, with significant current velocities due to normal fluvial transport or tidal action. Tributaries of Chesapeake Bay, most notably the Potomac River, and also the James, York, and most of the smaller rivers on the eastern shore of Maryland, are collectively considered the major spawning grounds of striped bass, but other rivers (Hudson and Delaware) make substantial contributions to the population along the

middle Atlantic coast. The spawning population is made up of males 2 years or older and females 4 or more years old.

The spawning season along the Atlantic coast usually extends from April to June, but it begins as early as January or February in Florida, and is governed largely by water temperature (Smith and Wells 1977). Striped bass spawn at temperatures between 10 and 23° C, but seldom at temperatures below 13 to 14°C. Peak spawning activity occurs at about 18° C and declines rapidly thereafter (Smith and Wells 1977).

The number of mature ova in female striped bass varies by age, weight, and fork length. Jackson and Tiller (1952) found that fish from Chesapeake Bay produced from 62,000 to 112,000 eggs/pound of body weight, with older fish producing more eggs than younger fish. Raney (1952) observed egg production varying with size, with a three-pound female producing 14,000 eggs and a 50-pound specimen producing nearly 5,000,000. A recently updated maturation and fecundity schedule for the Albemarle-Roanoke stock found that 28.6% of females were mature at age 3, 96.8% were mature at age 4 and were 100% mature by age 5. Fecundity for the Albemarle-Roanoke stock increased about 50,000-100,000 eggs per year for fish ≤6 years old and 150,000-250,000 for fish >6 years old; the relationship between fecundity and age was statistically linear (r^2=0.86) but somewhat variable. Potential annual fecundity, estimated gravimetrically, ranged from 176,873 eggs for age-3 females (n=4) to 3,163,130 eggs for a single age-16 female. The average number of eggs per gram of ovarian tissue decreased with age (Boyd 2011).

When ripe, the ovaries are greenish-yellow in color (Scofield 1931). After fertilization, the semi-buoyant eggs of striped bass are transported downstream or, if spawned in slightly brackish water, back and forth by tidal circulation. Hatching occurs in about 70-74h at 14-15°C, in 48h at 18-19°C, and in about 30h at 21-22°C (Bigelow and Schroeder 1953).

Newly hatched bass larvae remain in fresh or slightly brackish water until they are about 12 to 15mm long. At that time, they move in small schools toward shallow protected shorelines, where they remain until fall. Over the winter, the young concentrate in deep water of rivers. These nursery grounds appear to include that part of the estuarine zone with salinities less than 3.2 $^0/_{00}$ (Smith 1970).

Maryland data suggest that full maturity of females is not achieved until age 8. Maryland data were accepted as valid and were used to guide changes in size limits needed to meet the management requirements of Amendment 3 to the FMP (i.e., to protect 95% of females of the 1982 and subsequent year classes until they had an opportunity to spawn at least once). Maryland maturity data were also incorporated into modeling work performed in order to develop management regimes specified in Amendment 4 to the FMP (ASMFC 1990).

There are indications that some older striped bass may not spawn every year (Raney 1952). Merriman (1941) reported that large, ripe females are regularly taken from Connecticut waters in late spring and early summer, during the regular spawning period. Jackson and Tiller (1952) reported curtailment of spawning in about 1/3 of the fish age 10 and older taken from Chesapeake Bay, though they also found striped bass up to age 14 in spawning condition.

Striped bass, like many fish populations, shows high interannual variability in recruitment (Figure B5.3). Martino and Houde (2012) found density-dependent effects on growth and mortality in the

upper Chesapeake Bay for age-0 striped bass, where growth rates were higher and mortality rates lower in years with lower juvenile density. Kimmerer *et al* (1998) found similar results for striped bass on the Pacific coast. Environment effects have also been shown to be correlated with recruitment success in striped bass, including over-winter temperatures, hydrological conditions, and zooplankton prey availability (Hurst and Conover, 1998; Martino and Houde, 2010, 2012).

The Maryland recruitment index reached its lowest values during the early 1980s, when the stock was heavily overfished. Recent years of lower recruitment (during a period of high SSB) has led to speculation that a Ricker curve might be appropriate to describe the striped bass stock-recruitment relationship. However, the mechanism behind that kind of overcompensation is unclear for this species. The classically accepted mechanism is cannibalism, and while it has been documented in striped bass, it is a rare event occurrence, and even in studies conducted after the stock recovery, conspecifics make up only a tiny fraction of striped bass diet (Table B4.2).

B5.4.5 Movements and Migration

Migration of striped bass may occur at both juvenile and adult stages, although migratory patterns for all life stages vary by location. In general, juveniles migrate downstream in summer and fall, while adults migrate upriver to spawn in spring, afterwards returning to the ocean and moving north along the coast in summer and fall, and south during the winter (Shepherd 2007). As young and as adults, striped bass move in schools, except for larger fish, which either travel alone or with a few others of similar size.

Juvenile striped bass move down river in schools from their parent stream to low salinity bays or sounds when a year old (Richards and Rago 1999, Smith and Wells 1977). The timing of this juvenile migration varies by location. In Virginia, Setzler-Hamilton and others (1980) observed the movement downstream during summer. In the Hudson River, striped bass begin migrating in July, as documented through an increase in the number of juvenile striped bass caught along the beaches and a subsequent decline in the numbers in the channel areas after mid-July. Downstream migration continues through late summer, and by the fall, juveniles start to move offshore into Long Island Sound (Raney 1952). Juveniles infrequently complete coastal migrations, but even though fish that are under the age of two are largely non-migratory, many do leave their birthplaces when they are two or more years old.

Most adult striped bass along the Atlantic coast are involved in two types of migrations: an upriver spawning migration from late winter to early spring, and coastal migrations that are apparently not associated with spawning activity. Not all fish take part in the coastal migrations. Otolith microchemical analysis of striped bass from the Hudson River and from the Roanoke River, indicate that individuals in these populations exhibited multiple life history strategies (Morris and others 2003, Zlokovitz and others 2003). In both populations, some individuals were permanent residents of the river, while others exhibited varying degrees of migratory behavior beginning at varying ages.

From Cape Hatteras, North Carolina, 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 and others 1989). Larger striped bass (>800 mm TL), most of which are females, tend to migrate farther distances (Callihan *et al*., in review). However, striped bass are not usually found more than 6 to 8 km offshore (Bain and Bain 1982). Recently, Welsh and others (2007) determined from tag recovery locations that striped bass tagged off North Carolina and Virginia in winter migrated northward during summer as far as Maine, although the largest numbers were recovered from New York to Massachusetts, as well as waters of Maryland. During spring months (April, May, and June), the largest numbers of tagged striped bass were caught within waters of Maryland (Chesapeake Bay) and New York (Hudson River). Although usually beginning in early spring, the time period of migration can be prolonged by the migration of bass that are late-spawning.

Some areas along the coast are used as wintering grounds for adult striped bass. The inshore zones between Cape Henry, Virginia, and Cape Lookout, North Carolina, serve as the wintering grounds for the migratory segment of the Atlantic coast striped bass population (Setzler-Hamilton and others 1980). There are three groups of fish that are found in nearshore ocean waters of Virginia and North Carolina between the months of November and March, the wintering period. These three groups are bass from Albemarle and Pamlico Sounds, North Carolina, fish from the Chesapeake Bay, and large bass that spend the summer in New Jersey and north (Holland and Yelverton 1973). Based on tagging studies conducted under the auspices of the ASMFC and Southeast Area Monitoring and Assessment Program (SEAMAP; Welsh and others 2007) each winter since 1988, striped bass wintering off Virginia and North Carolina range widely up and down the Atlantic Coast, at least as far north as Nova Scotia, and represent all major migratory stocks (Welsh and others 2007).

B5.4.6 Stock Definitions

The anadromous populations of the Atlantic coast are primarily the product of four distinct spawning stocks: a Albemarle Sound/Roanoke River 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 the Chesapeake Bay and in the Hudson and Delaware rivers. Historically, tagging data indicated very little mixing between the Albemarle Sound/Roanoke River stock and the coastal population. 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. However, recent tagging work indicates that most large AR striped bass (>800 mm TL) are indeed migratory (Callihan et al., in review), suggesting more work on the relative contributions of current populations is needed. The current Atlantic coast management unit, excluding the fisheries on the Albemarle Sound/Roanoke River stock, is the basis of this stock assessment.

The Chesapeake Bay stock of striped bass is widely regarded as the largest of the four major spawning stocks (Goodyear and others 1985, Kohlenstein 1980, Fabrizio 1987). However, during

most of the 1970s and 1980s, juvenile production in the Chesapeake Bay was extremely poor, causing a severe decline in commercial and recreational landings. The poor recruitment was probably due primarily to overfishing; but poor water quality in spawning and nursery habitats likely also contributed (Richards and Rago 1999).

Recent tag-recovery studies in the Rappahannock River and upper Chesapeake Bay show that larger and older (ages 7+) female striped bass, after spawning, move more extensively along the Atlantic coast than stripers from the Hudson River stock (ASMFC 2004). Tag recoveries of Chesapeake stripers from July through November have occurred as far south as Virginia to as far north as Nova Scotia, Canada. Like the Hudson River stock, nearly all tag recoveries from mature female stripers from the Chesapeake Bay stock have taken place during winter (December and February) off Virginia and North Carolina (Crecco 2005).

Following extensive pollution abatement during the mid-1980s, striped bass abundance in the Delaware River, as measured by juvenile seine surveys, rose steadily thereafter to peak abundance in 2003 and 2004 (Tom Baum, NJ BMF, pers. comm.). Like the Chesapeake Bay and Hudson stocks, spawning migration in the Delaware River begins during early April and extends through mid-June (ASMFC 1990). Recent tagging studies in the Delaware River show that larger and older (ages 7+) female striped bass undergo extensive migration northward into New England from July to November that spatially overlap the migratory range of Chesapeake striped bass (ASMFC 2004). Like the Hudson River and Chesapeake Bay stocks, many tag recoveries from mature female stripers from the Delaware River have taken place between December and February off Virginia, North Carolina, New England, and Long Island (Crecco 2005). The Delaware River stock was officially declared restored in 1998 (Kahn and others 1998).

B5.4.7 Predators and Prey

Bluefish, weakfish, and other piscivores prey on juvenile striped bass (Hartman and Brandt 1995b; Buckel et al. 1999; Gartland et al. 2006). Gartland et al. (2006) reported that striped bass in age-0 bluefish diets was the secondary important prey (10.7% in %W) in the lower Chesapeake Bay and coastal ocean of Virginia in June of 1999 and 2000.

Adult striped bass consume of a variety of fish (e.g., *Brevoortia tyrannus*, *Anchoa mitchilli*, *Mendia* spp.) and invertebrates (e.g., *Callinectes sapidus*, *Cancer irroratus*, *Homarus americanus*), but the species consumed depends upon predator size, time of year, and foraging habitat (Schaefer 1970; Hartman and Brandt 1995a; Nelson et al. 2003; Nemerson and Able 2003; Watler et al. 2003a; Rudershausen et al. 2005; Costantini et al. 2008; Overton et al. 2008; Ferry and Mather 2012).

Several previous studies examined and discussed possible historical shifts in diets of striped bass in Chesapeake Bay (Griffin and Margraf 2003; Pruell et al. 2003; Walter and Austin 2003; Overton et al. 2009). Griffin and Margraf (2003) compared the diets of striped bass collected in 1950s to those published since 1999. They found that small striped bass (a mean FL of 276 mm) consumed more invertebrates while large striped bass (a mean FL of 882 mm) more relied on small pelagic fish prey (such as bay anchovies and age-0 clupeids) in current years than in 1950s. Pruell et al. (2003) examined $\delta^{13}C$ in striped bass scales collected from Chesapeake Bay between 1982 and 1997 and suggested that enrichment of $\delta^{13}C$ through years could due to a historical diet shift from fish prey to invertebrate prey. Although Walter and Austin (2003) and Overton et al. (2009) did not directly

examine historical diets of striped bass, by comparing their findings to the results from previous studies, both studies concluded that striped bass consumed more benthic prey (such as blue crabs). However, all the studies interpreted their conclusions of the historical diet shifts with caution. They believed that other confounding factors, such as ontogenetic development, environmental change, and feeding locations could also contribute their findings.

Uphoff (2003) described the direct relationship between consumption of menhaden by striped bass and stock assessment and management of striped bass with consumption per recruit analysis in Chesapeake Bay. Their simulations indicated that consumption of menhaden decreased with increasing fishing mortality of striped bass and decreasing striped bass entry age. They suggested that striped bass could exceed their carrying capacity, which might be responsible for dramatic declines of menhaden abundance in Chesapeake Bay from 1980 to 1999. Costantini et al. (2008) found that hypoxic area at the bottom of Chesapeake was no longer refuge for fish prey, enhancing striped bass predation efficiency and causing negative effect on fish prey abundance.

B5.4.8 Natural Mortality and Disease

Striped bass are a long-lived species, with a maximum age of approximately 30 years, suggesting natural mortality is relatively low. Previous assessments have assumed an age-constant M of 0.15, consistent with Hoenig's (1983) regression on maximum age. In the current assessment, age-specific Ms for ages 1-6 were derived from a curvilinear model fitted to tag-based Z estimates (assuming Z=M) for fish ≤age3 from NY and tag-based M estimates (Jiang et al., 2007) for striped bass from MD made for years prior to 1997 (see Appendix B5 for more details).

The epizootic of mycobactiosis was first detected in the Chesapeake Bay in 1997 (Heckert et al 2001; Rhodes et al. 2001). However, a retrospective examination of archived tissue samples by Jacobs et al. (2009a) suggested that mycobacteriosis was apparent in Chesapeake Bay striped bass as early as 1984. A rise in Mycobacterium disease in Chesapeake Bay could be causing increases in natural mortality (Pieper 2006; Ottinger and Jacobs 2006). Two primary hypotheses have emerged regarding the mechanism for increased natural mortality (Vogelbein et al. 2006). One is that elevated nutrient inputs to the Bay, with associated eutrophication, results in loss of thermal refugia for striped bass, forcing them into suboptimal and stressful habitat during the summer. A second is that alternations in trophic structure and starvation have resulted due to over-harvest of key prey species such as Atlantic menhaden (*Brevoortia tyrannus*) and reductions in the forage base in Chesapeake Bay.

Prevalence of the disease ranges from ~50% as determined through standard histological methods (Overton et al. 2003), to up 75% with molecular techniques (Kaattari et al. 2005). Prevalence is dependent on the age class sampled with prevalence increasing with age to approximately age 5 and then decreasing in older ages (Kaattari et al. 2005; Gauthier et al. 2008). The decline in prevalence with older ages is likely due to increased mortality in fish which have contracted the disease and do not live to older ages as there appears to be limited ability of striped bass to resolve the disease once it is contracted (Matt Smith, *unpublished data*). Mycobacteriosis appears to be much less prevalent in other producer areas such as the Delaware Bay (Ottinger *et al.* 2006) and the Albemarle Sound/Roanoke River (Overton *et al.* 2006, Matsche *et al.* 2010).

Although fish who are infected with the disease show overall decreased health (Overton et al. 2003), the slow progression of the disease may take years to become lethal in infected fish, thus allowing for multiple spawning opportunities, making determination of the population level impacts of the disease difficult (Jacobs et al. 2009b).   However, recent estimates of annual survival of diseased fish relative to non-diseased fish range have been made. Gauthier et al. (2008) estimated relative survival of diseased fish was 0.69 (0.55 – 0.84) and Smith (*unpublished* data) estimated relative survival of diseased fish was 0.59 to 0.94 depending on the severity of the disease. By combining estimates of the prevalence and progression of the disease, mycobacteriosis may be responsible for a 16% reduction in the Chesapeake Bay age 3 – 8 population of striped bass (Matt Smith, VIMS, *unpublished data*).

Tagging data suggest there has been an increase in M in recent years (Kahn and Crecco 2006; Section B8 of this report). However, some of that increase may be a function of misspecification of parameters such as tag reporting rates, which makes the absolute estimates of natural mortality less reliable (see Section B8 for more discussion).

B6.0 Estimate commercial and recreational landings and discards. Characterize the uncertainty in the data and spatial distribution of the fisheries (TOR #2)

B6.1 Commercial Data Sources

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 (Appendix B1). Commercial harvest in some states is recorded in pounds and is converted to number of fish using conversion methods (Appendix B1). Biological data (e.g., length, weight, etc.) and age structures (scales) from commercial harvest are collected from a variety of gear types through state-specific port sampling programs (Appendix B1). Harvest numbers are apportioned to age classes using length frequencies and age-length keys derived from biological sampling. Sample sizes for lengths and age structures are summarized by state for 2000-2012 in Table B6.1.

B6.2 Commercial Landings

B6.2.1 Commercial Total Landings

Historically, annual commercial harvest of striped bass peaked at almost 6,804 mt (15 million pounds) in 1973, but through management actions, it declined by 99 percent to 63 mt (140,000 pounds) in 1986. Commercial landings have increased from 313 mt (800,000 pounds) in 1990 to 3,332 mt (7.3 million pounds) in 2004 (Table B6.2; Figure B6.1) following liberalization of fishery regulations. Since 2005, landings have fluctuated about an average of 3,162 mt (6.97 million pounds); however, landings have declined in recent years (2011-2012)(Table B6.2; Figure B6.1).

B6.2.2 Commercial Landings in Numbers

Commercial harvest of striped bass was over one million fish from 1997 through 2000 and near one million fish through 2006 (Table B6.3). Since 2007, numbers of fish landed have declined (Table B6.3). In 2012, only 838,636 fish were harvested. The Chesapeake Bay jurisdictions (Maryland, Virginia, and the Potomac River Fisheries Commission) usually account for a major portion of the coast-wide commercial harvest. In 2012, Chesapeake Bay jurisdictions accounted for 64% of the striped bass harvest, by weight, and 80% of the numbers of striped bass harvested.

B6.2.3 Commercial Landings Age Composition

The age structure of commercial harvest varies by state due to size regulations and season of the fisheries. In 2011 and 2012, the commercial harvest was comprised primarily of ages 4-10 striped bass (Table B6.4). Harvest in Chesapeake Bay fisheries (Maryland, Virginia, and the PRFC) was comprised mostly of ages 3-6 (Table B6.4). The coast-wide time series of commercial-harvest age composition is provided in Table B6.5.

B6.3 Commercial Discards

B6.3.1 Estimation of Discards

Few states collect reliable information on the discarding of striped bass in commercial fisheries. Direct measurements of commercial discards of striped bass are generally only available for fisheries in the Hudson River Estuary and were available from Delaware Bay during 2001-2003 (Clark and Kahn, MS). 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:

$$CD = RD*(CT/RT)$$
where:
CD = unadjusted estimate of the number of fish discarded by commercial fishery,
RD = number of fish discarded by recreational fishery, estimates provided by the NOAA
     Marine Recreational Fisheries Survey (MRFSS),
CT = number of tags returned from discarded fish by commercial fishermen,
RT = number of tags returned from discarded fish by recreational fishermen.

Tag return data by gear for 2011 and 2012 are given in Table B6.6. Starting in 1998, the Technical Committee attempted to improve the estimate of commercial discards by calculating tag return ratios and discards separately for Chesapeake Bay and the coast. A separate estimate for Delaware Bay was added in 2004. The ratios of tags from fish discarded by commercial fishermen to tags returned from fish discarded by recreational fishermen are shown in Table B6.7 for 2011 and 2012.

Expanding recreational discards to commercial discards based on reported tag returns assumes equal reporting tag rates in commercial and recreational fisheries but in fact this is not true. To correct for this bias, 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 (Table B6.7). The adjusted correction factors and estimates of total discards for 2011 and 2012 are shown in Table B6.7. Total discards in 2011 and 2012 were estimated to be 3.4 million and 4.5 million fish, respectively.

B6.3.2 Estimation of Dead Discards

Total discards are allocated to fishing gears based on the relative number of tags recovered by each gear (Tables B6.6). Discards by fishing gear were multiplied by gear specific release mortalities and summed to estimate total number of dead discards in a given year (Table B6.8). The estimates of dead discards are 625,631 and 795,675 fish for 2011 and 2012, respectively. The highest discard losses occurred in anchor gill net, pound net, and hook-and-line fisheries (Table B6.8).

B6.3.3 Age Composition of Commercial Dead Discards

Commercial discard proportions at age were obtained by applying age distributions from fishery dependent sampling or independent surveys that used comparable gear types (Table B6.9). Gear specific proportions at age were applied to discard estimates by gear and expanded estimates summed

across all gears (Table B6.10). Most commercial discards since 2004 were fish of ages 3-7 (Table B6.11).

B6.4. Total Removals by Commercial Fisheries

Total commercial striped bass removals (harvest and discards) were 1.55 million and 1.63 million fish in 2011 and 2012, respectively (Figure B6.2). Peak removals were observed in 2005 and 2012 (Figure B6.2). Harvest has generally exceeded dead discards since the mid 1990s (Figure B6.2). Commercial losses in 2011 and 2012 were dominated by the 2006 and 2007 year classes (ages 4 and 5 in 2011, and ages 5 and 6 in 2012 respectively; Figure B6.3).

B6.5 Recreational Data Sources

Information on harvest and release numbers, harvest weights, and sizes of harvested bass from 1982-2003 come from the National Marine Fisheries Service's Marine Recreational Fisheries Statistics Survey (MRFSS/MRIP). The MRFSS/MRIP data collection consisted of a stratified intercept survey of anglers at fishing access sites that obtains numbers of fish harvested and released per angler trip, and a telephone survey that derives numbers of angler trips. Estimates of harvest and release numbers are derived on a bi-monthly basis. Total number of interviews, total number of striped bass interviews, numbers of harvested striped bass measured, estimates of numbers harvested and released with proportional standard errors by state and years 2005-2012 are listed in Table B6.12.

In response to a peer review of the MRFSS program (National Resource Council 2006), NMFS established the Marine Recreational Information Program (MRIP) to improve recreational data collection and estimation methodologies. The timeline of MRIP changes can be found at http://www.st.nmfs.noaa.gov/recreational-fisheries/in-depth/making-improvements-mrip-initiative/history-timeline/index. MRIP estimates are now calculated assuming intercepts at a site represent a cluster of samples, and sample sites are weighted by their probability of selection, which is a function of fishing pressure. The MRFSS estimation procedure assumed that each intercept was an independent observation and that all sites were equally likely to have been sampled. Re-estimation of catch and harvest from 2004-2010 using the new methodology occurred in 2011 and is the standard used presently. However, the additional site metadata needed to replicate the MRIP estimation method are not currently available prior to 2004; therefore, estimates of catch for 1982–2003 are based on the MRFSS methodology.

Anecdotal evidence had suggested that North Carolina, Virginia, and possibly other states had sizeable wave-1 fisheries beginning in 1996 (wave-1 sampling that began in 2004 in North Carolina waters and large wave-1 tag return data for North Carolina and Virginia supported this contention). However, MRFSS/MRIP did not sample in January and February (wave-1) prior to 2004; therefore, there was little information for the winter fishery (Jan, Feb) that had developed off of North Carolina and Virginia. Harvest in wave 1 for these fisheries was estimated back to 1996 using observed relationships between landings and tag returns (Appendix B2). For North Carolina, the ratio of estimated landings to tag returns in wave-1 of 2004 and annual tag returns in wave-1 were used to estimate annual landings from tag returns in January and February of 1996-2003. For Virginia waters, the 1996-2004 mean ratio of landings and tag returns in wave-6 and annual tag returns in wave-1 were used to estimate landings from tag returns in January and February of 1996-2004. Estimates of wave-1 harvest for both Virginia and North Carolina in 1996-2004 are listed in

Appendix B3. For 2005-2012, MRFSS/MRIP wave-1 estimates of harvest for the winter fishery in Virginia waters were still unavailable; therefore, they were estimated. The approach used to estimate wave-1 harvest in prior years was abandoned because correlation between wave 6 harvest and tag returns off Virginia weakened significantly. New methods were developed during 2005-2006, 2007-2008, and 2009-2010 (Appendix B2). In 2012, the regression method of Nelson was updated to include the new MRIP NC wave 1 estimates of harvest and 2012 MRIP and tag data, and the wave 1 estimates from 2005-2012 were re-estimated (Appendix B2). Dead releases for the winter recreational fishery in North Carolina or Virginia were not estimated.

Most states use the length frequency distributions of harvested striped bass measured by the MRFSS. The MRFSS measurements are converted from fork length (inches) to total length (inches) using conversion equations. Proportions-at-length are calculated and multiplied by the MRFSS harvest numbers to obtain total number harvested-at-length. The sample sizes of harvested bass measured by MRFSS may be inadequate for estimation of length frequencies; therefore, some states use harvest length data collected from other sources (e.g., volunteer angler programs) to increase sample sizes (Table B6.12). Full descriptions of state-specific programs are presented in Appendix B3.

Data on sizes of released striped bass come mostly from state-specific sampling or volunteer angling programs (Table B6.12). Proportions-at-length are calculated and multiplied by the MRFSS dead releases numbers to obtain total number dead releases-at-length. For those programs that do not collect data on released fishes, the lengths of tagged fish released by anglers participating in the American Littoral Society's striped bass tagging program or from state-sponsored tagging programs are used. Details on calculations are given in Appendix B3.

Many states collect scale samples during state sampling programs designed to collect information on harvest and released striped bass from the recreational fishery (Table B6.12). Age-length keys are usually constructed and applied to harvest and dead release numbers-at-length. When sampling of the recreational fishery does not occur, age-length keys are constructed by using data on age-length from commercial sampling, fisheries-independent sampling or striped bass tagging programs. For those states that do not collect scale samples, age-length keys are usually borrowed from neighboring states. Detailed descriptions of how age samples are collected, processed, and aged are given in Appendix B3.

Age composition of the January/February recreational fishery in North Carolina and Virginia was estimated from length-frequency data collected by MRFSS/MRIP and appropriate state age-length keys. Length-frequencies for the North Carolina winter harvest of 2004 came from data in wave-6 of 2003 and wave-1 of 2004. Length-frequencies for the winter harvests of 1996-2003 came from wave-6 of year t-1. Lengths were converted to age for North Carolina with a combined age-length key from New York and North Carolina. Length-frequencies for the Virginia winter harvest in 1996-2012 came from MRFSS/MRIP data in wave-6 of year t-1. We converted the Virginia lengths to age with a Virginia age-length key.

B6.6 Recreational Landings and Releases

B6.6.1 Recreational Total Landings

Figure B6.1 traces the impressive growth of the Atlantic coast recreational fisheries from 1982 through 2012. Harvest increased from 1,010 mt (2.2 million pounds) in 1990 to 14,082 mt (31 million pounds) in 2006 (Table B6.2). Following the peak in 2006, harvest declined through 2012 to 8,740 mt (19 million pounds)(Figure B6.1).

B6.6.2 Recreational Landings in Numbers

In numbers of fish, recreational harvest of striped bass was greater than 1.4 million fish from 1997 through 2006, and more than 2.4 million striped bass during 2003-2006 (Table B6.13). Harvest was generally highest in Virginia, Maryland, New Jersey, and Massachusetts (Table B6.13). Coast-wide harvest of striped bass has since declined to 1.5 million fish in 2012. The annual Atlantic coast harvest (in numbers) has been a small fraction of the catch (harvest and releases, combined) since the 1980s because the releases (B2s) have accounted for 85 to 90% of the annual catch in most years (see Section B6.6).

B6.6.3 Age Composition of Recreational Landings

Coast-wide recreational harvest was dominated by the 2003 (age 8) year-class in 2011, and by the 2004 (age 8) year-class in 2012 (Table B6.14). Ages 5-10 comprised >75% of the coast-wide harvest, and ages 8+ comprised >55% in both years (Table B6.14). Recreational harvest from the coast states (includes Delaware Bay) was comprised mostly of ages 6-10, while harvest in Chesapeake Bay (MD and VA) was dominated by ages 4-8 (Figure B6.4). Time series of harvest numbers-at-age are given in Table B6.15.

B6.6.4. Estimation of Releases

The number of striped bass that are caught and released (B2) is estimated by MRFSS/MRIP (Table B6.16) . The releases have accounted for 85 to 90% of the annual catch in most years (Figure B6.5).

B6.6.5 Estimation of Dead Releases

The number of releases that die due to the capture and release process is estimated by multiplying the total release numbers (B2) by an estimate of hooking mortality. While much work has been done on striped bass release mortality, the majority of it has been done in freshwater, where release mortality is higher than in saline water (RMC 1990, Lukacovic and Uphoff 2007). Since the recreational catch estimated by MRFSS/MRIP is taken in ocean or bay waters, the SA committee reviewed studies conducted in saltwater or estuarine water (salinity > 5 ppt). Estimates of overall hooking mortality from these studies included 2% (RMC 1990), 9% (Diodati and Richards 1996; Caruso 2000), and 11% (Lukacovic and Uphoff 2007). However, hooking mortality was affected by factors such as temperature, salinity, hook type, hooking location, and angler experience. Lukacovic and Uphoff (2007) and Diodati and Richards (1996) found mortality rates of 26-27% under the worst conditions in their studies.

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A meta-analysis of hooking mortality as a function of water temperature and salinity for studies conducted in salt and estuarine waters was attempted, but the available data were not informative enough to effectively model hooking mortality. For this assessment, the SA committee chose to use the overall 9% hooking mortality rates estimated by Diodati and Richards (1996), which was conducted in saltwater and covered a range of hook types, hooking locations, and angler experience levels. The 9% rate is also consistent with the other studies reviewed.

Estimates of the number of dead releases are presented in Table B6.17. The numbers of fish released dead increased from 132 thousand fish in 1990 to 1.2 million fish in 1997. Releases remained around 1.2 million through 2003, but increased to the series maximum of 2 million fish in 2006. Since 2006, releases have declined substantially (Table B6.17). In 2012, releases declined to about 78% of the peak releases in 2006. The numbers of fish released dead are generally highest in Massachusetts, Maryland and New York (Table B6.17).

B6.6.6 Age composition of Dead Releases

Ages of coast-wide recreational dead releases ranged from 0 to 15+, but most dead releases were ages 2-6 (Table B6.18; Figure B6.6). The dead releases were dominated by ages 1-4 in MD and VA and 2-6 in coast states (includes Delaware Bay) (Table B6.18; Figure B6.6).

B6.6.7 MRFSS vs. MRIP Estimates

MRFSS estimates of total coastwide catch differed by less than 10% from the MRIP estimates, and there was no consistent pattern in the differences (Figure B6.7). At the state level, the differences were greater in some years, although almost all point estimates from MRFSS were within the 95% confidence intervals of the MRIP estimates (Figure B6.8). Most states did not show a pattern in the direction of the differences (Figure B6.9).

Because of the small scale and the lack of a pattern or bias in the differences between the two estimation methods, the Technical Committee did not attempt to correct the MRFSS estimates for 1982-2003.

B6.6.8 Unreported Catch From Inland Waters

The MRFSS/MRIP survey is a marine fishery survey, and thus does not cover the full extent of striped bass recreational fisheries that occur in rivers. For example, known inland striped bass fisheries occur in the Connecticut, Housatonic, and the Thames Rivers in Connecticut but are not surveyed by MRFSS/MRIP inland of I-95. Similarly, the recreational fishery for striped bass in the Hudson River in New York occurs up to rkm 254, but MRFSS/MRIP stops at rkm 74. There is not an equivalent survey that covers the inland portion of these fisheries on an annual basis, thus estimates of recreational catch are biased low because they only include the marine portion of the catch.

To examine the potential magnitude of this bias, the SA committee examined periodic creel surveys conducted by state natural resource agencies and universities in the Connecticut River (Davis 2011), the Hudson River (NAI 2003, 2007), and the Delaware River (Volstad 2006). Estimates of unreported catch for the years each survey was conducted were compared to estimates of catch from MRFSS/MRIP for the equivalent years.

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This analysis suggested the bias is very low. At the individual state level, omitting the river harvest and loss made less than a 5% difference in estimates of total removals (harvest and dead discards) (Table B6.19.A-C). Bias to model inputs is even less when considering recreational losses in combination with commercial losses.

B6.7 Total Removals by Recreational Fisheries

Total recreational striped bass removals (harvest and dead discards) in 2011and 2012 were 2.76 million and 1.96 million fish, respectively (Table B6.20; Figure B6.10). Recreational removals in 2006 were the highest of the time series but removals have since declined (Figure B6.10). Total removals were highest in New York, New Jersey, Massachusetts and Maryland (Table B6.20). In 2011, the harvest and dead releases combined were dominated by ages 4-8 in Maryland and Virginia and ages 6-8 in coast states (Figure B6.11). In 2012, the harvest and dead releases combined were dominated by ages 1-7 in Maryland and Virginia and ages 6-10 in coast states (Figure B6.11).

B6.8 Incidental Removals

Some states collect information on the number of striped bass killed for other purposes such as scientific research. These are tabulated by age and year in Table B6.21.

B6.9 Total Removals By Commercial and Recreational Fisheries

Combined losses showed that the recreational fishery removed the largest number of striped bass in 2011 and 2012 (Figure B6.12). Historically, the recreational fishery has been the dominant source of fishing removals since 1991 (Figure B6.13). The above components were totaled by year to produce the overall catch at age matrix (Table B6.22). Total removals have been declining since 2006 (Table B6.22; Figure B6.13). The total removals of striped bass in 2011 (4.32 million fish) and 2012 (3.60 million fish) declined by 29% and 41%, respectively, compared to the peak in 2006 (6.11 million) (Figure B6.13). Ages 5 (2006 year-class) in 2011 and 8 (2004 year-class) in 2012 sustained the highest losses (Table B6.22; Figure B6.14). Ages 1+ total removals peaked in 2006 and declined through 2012, while ages 8+ total removals peaked in 2007 and declined thereafter (Figure B6.15).

B6.10 Catch Weight at Age

Catch mean weight at age data, which is used to calculate total biomass and spawning stock biomass, was calculated for the period 1998-2002 using all available weight data from MA, NY, MD, VA, NH, and CT (1998-2001) and adding data from RI and DE in 2002 (NOAA 46th SAW Striped Bass Assessment Report - Appendix A5). Mean weights at age for the 2003-2012 striped bass catches were determined as a result of the expansion of catch and weight at age. Data came from Maine and New Hampshire recreational harvest and discards; Massachusetts recreational and commercial catch; Rhode Island recreational and commercial catch; Connecticut recreational catch; New York recreational catch and commercial landings; New Jersey recreational catch; and Delaware, Maryland, Virginia, and North Carolina recreational and commercial catch. Weighted mean weights at age were calculated as the sum of weight at age multiplied by the catch at age in numbers, divided by the sum of catch at age in numbers. Details of developing weights at age for 1982 to 1996 can be found in NEFSC Lab Ref. 98-03. Weights at age for 1982-2012 are presented in Table B6.23.

B6.11 Use of Preliminary Data

The SA committee stresses that the fishery data for 2012 used in the assessment are still preliminary. Total commercial and recreational landings had not been finalized when the model was run, and some states had not finished ageing their 2012 samples and had to borrow age-length data from other years. However, the SA committee does not expect significant changes to total catch and catch-at-age when the data are finalized, and felt it was important to include the most recent available data in the assessment.

B7.0 Use the statistical catch-at-age model to estimate annual fishing mortality, recruitment, total abundance and stock biomass (total and spawning stock) for the time series and estimate their uncertainty. Provide retrospective analysis of the model results and historical retrospective. Provide estimates of exploitation by stock component, where possible, and for total stock complex. (TOR #3)

B7.1 SCA Operational Model

The striped bass statistical catch-at-age (SCA) model used since 2007 has been generalized to allow specification of multiple fleets, different stock-recruitment relationships, year- and age-specific natural mortality rates, different selectivity functions for fleets and surveys with age composition data, and ageing errors (and bias), standardized residual plots, qqnorm plots of residuals, and various management reference points. The changes in model structure and additions are based on recommendations of the 2007 benchmark review committee (NEFSC 2008). The 2013 SCA model is used to estimate fishing mortality, abundance, and spawning stock biomass of striped bass during 1982-2012 from total removals-at-age and fisheries-dependent and fisheries-independent survey indices.

B7.2 Description of Generalized Model Structure

The structure of the population model is aged-based and projects the population numbers-at-age forward through time given model estimates of recruitment and age-specific total mortality. The population numbers-at-age matrix has dimensions Y x A, where Y is the number of years and A is the oldest age group. The time horizon for striped bass is 1982-present since complete catch data are only available back to 1982. However, there are relative abundance data (e.g., Maryland young-of-the-year indices) available for earlier years. To use those earlier data, the dimensions of population numbers-at-age are expanded to Y+A-1 x A matrix (Figure B7.1).

Population numbers-at-age ($a<A$) are calculated through time by using the exponential cohort survival model

$$\hat{N}_{y,a} = \hat{N}_{y-1,a-1} \exp^{-\hat{F}_{y-1,a-1}-M_{y-1,a-1}}$$

where $\hat{N}_{y,a}$ is abundance of age a in year y, $\hat{N}_{y-1,a-1}$ is abundance of age $a-1$ in year $y-1$, $F_{y-1,a-1}$ is the instantaneous fishing mortality rate for age $a-1$ in year $y-1$, and $M_{y-1,a-1}$ is the instantaneous natural mortality (assumed constant across years and ages). For the plus group (A), numbers-at-age are the sum of survivors of $A-1$ in year $y-1$ and survivors from the plus group in year $y-1$:

$$\hat{N}_{y,A} = \hat{N}_{y-1,A-1} \exp^{-\hat{F}_{y-1,A-1}-M_{y-1,A-1}} + \hat{N}_{y-1,A} \exp^{-\hat{F}_{y-1,A}-M_{y-1,A}}$$

The initial population abundance-at-age for 2-A in the first year is calculated by using $\hat{N}_{y,1}$ and assuming $F_{styr,a-1}$:

$$\hat{N}_{y,a} = \hat{N}_{y,a-1} \exp^{-\hat{F}_{styr,a-1}-M_{styr,a-1}}$$

where *styr* is the first year of catch data.

Recruitment Estimation

The two methods of modeling recruitment are provided:

1. Mean method: recruitment (numbers of age-1 bass) in year y ($N_{y,1}$) is estimated as a log-normal deviation from average recruitment:

$$\hat{N}_{y,1} = \bar{\hat{N}}_1 \cdot \exp^{\hat{e}_y - 0.5\hat{\sigma}_R^2}$$

where $N_{y,1}$ is the number of age 1 fish in year y, $\hat{N}_1$ is the average recruitment parameter, e_y are independent and identically distributed normal random variables with zero mean and constant variance and are constrained to sum to zero over all years, and σ_R is the standard deviation for the log recruitment residuals which is calculated as:

$$\hat{\sigma}_R = \sqrt{\frac{\sum\limits_{y}(\hat{e}_y - \bar{\hat{e}})^2}{n-1}}$$

where n is the number of estimated recruitment deviations.

2. Recruitment model method: recruitment in year y ($N_{y,1}$) is estimated by using one of three stock-recruitment equations and log-normal deviations from the deterministic predictions:

Beverton-Holt equation:

$$\hat{N}_{y,1} = \exp^{\left(\log_e(\hat{\alpha})+\log_e(SSB_{y-1})-\log_e\left(1+\frac{SSB_{y-1}}{\hat{\beta}}\right)+\hat{e}_y-0.5\hat{\sigma}_R^2\right)}$$

Ricker equation:

$$\hat{N}_{y,1} = \exp^{\left(\log_e(\hat{\alpha})+\log_e(SSB_{y-1})-\frac{SSB_{y-1}}{\beta}+\hat{e}_y-0.5\hat{\sigma}_R^2\right)}$$

Shepherd equation:

$$\hat{N}_{y,1} = \exp\left(\log_e(\hat{\alpha}) + \log_e(SSB_{y-1}) - \log_e\left(1 + \left(\frac{SSB_{y-1}}{\hat{\beta}}\right)^{\gamma}\right) + \hat{e}_y - 0.5\hat{\sigma}_R^2\right)$$

where SSB_{y-1} is the female spawning stock biomass in year $y-1$, α, β, and γ are parameters and other parameters are defined above. If a recruitment model is used, $N_{y,1}$ in the first year is estimated as a separate parameter, but is forced to follow the stock recruitment equation by using a penalty constraint:

$$P_{n1} = \lambda_{n1}(\hat{N}_{y,1} - N^e_{y,1})^2$$

where $N^e_{y,1}$ is the recruitment value estimated from the stock recruitment model by using the SSB from the first year and λ_{n1} is a user-specified weight. The penalty function is included in the total likelihood.

The term $-0.5\sigma^2_R$ is a lognormal bias-correction to ensure that average or deterministic prediction is equal to the mean recruitment. This term can be switched-off in the model. If the bias correction factor is used, then the following penalty function is included in the total likelihood and is used to help constrain the recruitment deviations:

$$P_{rdev} = \lambda_R \sum_y \log_e(\hat{\sigma}_R) + \frac{\hat{e}_y^2}{2\hat{\sigma}_R^2}$$

where λ_R is a user-specified weight (Maunder and Deriso, 2003). If the bias correction factor is not used, then the penalty function is:

$$P_{rdev} = \lambda_R \sum_y \hat{e}_y^2$$

Fishing and Total Mortality Estimation

Estimation of fishing mortality-at-age for each fleet is accomplished by assuming that fishing mortality can be decomposed into yearly and age-specific components (separability):

$$\hat{F}_{f,y,a} = \hat{F}_{f,y} \cdot \hat{s}_{f,a}$$

where $F_{f,y}$ is the fully-recruited fishing mortality for fleet f in year y and s_{ya} is the selectivity of age a in fleet f. The dimensions of each F-at-age matrix are Y x A. $F_{f,y}$s are modeled as separate parameters. For years earlier than *styr*, the fishing mortality-at-age is assumed equal to the values for *styr*. Total fishing mortality at year y and age a is calculated as:

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$$\hat{F}_{y,a} = \sum_f \hat{F}_{f,y} \cdot \hat{s}_{f,a}$$

Following Brodziak (2002), a fishing mortality penalty is imposed to ensure that extremely small Fs are not produced during the early phases of the estimation process:

$$P_{f_{add}} = \begin{cases} \text{phase} < 3, & 10 \cdot \sum_y (F_{f,y} - 0.15)^2 \\ \\ \text{phase} \geq 3, & 0.000001 \cdot \sum_y (F_{f,y} - 0.15)^2 \end{cases}$$

For ease of computation, total mortality-at-age (Z) is calculated as

$$Z_{y,a} = F_{y,a} + M_{y,a}$$

and fills a matrix of dimension Y x A. For years earlier than *styr*, Z is assumed equal to the Z values in *styr*.

Fleet Selectivity Estimation

There are multiple functions included for modeling fleet selectivity. They are:

Gompertz equation:

$$\hat{s}_a = \exp^{(-\exp^{-\hat{\beta}(a-\hat{\alpha})})}$$

Logistic equation:

$$\hat{s}_a = \frac{1}{1 + \exp^{-\hat{\beta}(a-\hat{\alpha})}}$$

Gamma equation:

$$\hat{s}_a = a^{\hat{\alpha}} \exp^{\hat{\beta} \cdot a}$$

Thompson (1994)'s exponential-logistic equation:

$$\hat{s}_a = \frac{1}{1-\hat{\gamma}} \cdot \left(\frac{1-\hat{\gamma}}{\hat{\gamma}} \right)^{\hat{\gamma}} \frac{\exp^{\hat{\alpha}\hat{\gamma}(\hat{\beta}-a)}}{1 + \exp^{\hat{\alpha}(\hat{\beta}-a)}}$$

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Double Logistic equation:

$$\hat{s}_a = \frac{1}{1 + \exp^{-\hat{\beta}(a-\hat{\alpha})}} \cdot \left(1 - \frac{1}{1 + \exp^{-\hat{\gamma}(a-\hat{\delta})}}\right)$$

where α, β, γ, and δ are parameters to be estimated. To ensure at least one age had a maximum selectivity of 1, s_a is divided by the maximum of s_a. Based on visual inspection of residuals, an exponential selectivity

$$\hat{s}_a = \alpha \exp^{\beta a}$$

was used for commercial dead discards of ages 2-4 and a fixed selectivity of 1 for older ages was based on visual inspection.

Total Catch and Age Composition of Fleets

Total catch and the age composition (proportions-at-age) from each fleet are the primary data from which fishing mortalities, selectivities, and recruitment numbers are estimated. Given estimates of F, M, and population numbers, predicted catch-at-age is computed from Baranov's catch equation (Ricker, 1975):

$$\hat{C}_{f,y,a} = \frac{\hat{F}_{f,y,a}}{\hat{F}_{f,y,a} + M_{y,a}} \cdot (1 - \exp^{-\hat{F}_{y,a} - M_{y,a}}) \cdot \hat{N}_{y,a}$$

where $\hat{C}_{f,y,a}$ is the predicted catch of age a in fleet f during year y and other variables are as defined above. All predictions are stored in matrices of dimension Y x A.

Predicted catch-at-age data are then compared to the observed total catch and age composition through the equations:

Predicted Total Catch

$$\hat{C}_{f,y} = \sum_a \hat{C}_{f,y,a}$$

Predicted Proportions of Catch-At-Age

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$$\hat{P}_{f,y,a} = \frac{\hat{C}_{f,y,a}}{\sum_a \hat{C}_{f,y,a}}$$

where $\hat{C}_{f,y}$ is the predicted total catch in year y and $P_{f,y,a}$ is the predicted proportions of age a in the catch during year y.

Aggregated Indices of Relative Abundance

Single-age or aggregated-age indices of relative abundance are incorporated into the model by linking them to corresponding age abundances and time of year:

$$\hat{I}_{t,y,\Sigma a} = \hat{q}_t \cdot \sum_a \hat{N}_{y,a} \cdot \exp^{-p_t \cdot Z_{y,a}}$$

where $\hat{I}_{t,y,a}$ is the predicted index of survey t for single-age a or aggregated-ages (sum over a) in year y, q_t is the catchability coefficient of index t, $N_{y,a}$ is the abundance of age a in year y, p is the fraction of total mortality that occurs prior to the survey, and $Z_{y,a}$ is the total instantaneous mortality rate. All qs are estimated as free parameters. Because age-0 abundance is not modeled, YOY and yearling indices must be lagged ahead one year and linked to age 1 and age 2 abundances, respectively.

Indices of Relative Abundance with Age Composition Data

Indices of relative abundance with age composition data (AC surveys) are incorporated into the model by linking them to age abundances and the time of year:

$$\hat{I}_{t,y} = \hat{q}_t \sum_a \hat{s}_{t,a} \cdot \hat{N}_{y,a} \cdot \exp^{-p_t \cdot \hat{Z}_{y,a}}$$

where $s_{t,a}$ is the selectivity coefficient for age a in survey t. For these surveys, multiple selectivity equations are available for modeling: Gompertz, logistic, gamma and Thompson's function as stated above (the double logistic is unavailable), and a user-defined pattern can be specified. All selectivity estimates are divided by the maximum selectivity at age to ensure at least one age had a maximum selectivity of 1. Total index by year is calculated by summing age-specific indices across age classes. The survey age composition is calculated by dividing the age-specific indices by the total index for a given year. The predicted age composition (proportions-at-age) of each survey is calculated as

$$\hat{I}_{t,y,a} = \hat{q}_t \cdot \hat{s}_{t,a} \cdot \hat{N}_{y,a} \cdot \exp^{-p_t \cdot \hat{Z}_{y,a}}$$

and predicted age composition is calculated as

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$$\hat{U}_{t,y,a} = \frac{\hat{I}_{t,y,a}}{\sum_a \hat{I}_{t,y,a}}$$

Female Spawning Stock Biomass

Female spawning stock biomass (metric tons) in year y is calculated as

$$SSB_y = \sum_{a=1}^{A} N_{y,a} \cdot sr_a \cdot m_a \cdot sw_{y,a} / 1000$$

where sr_a is the female sex ratio-at-age, m_a is the proportion mature at age for females, and $sw_{y,a}$ is Rivard weights-at-age (kilograms). Jan-1 Rivard weights were adjusted to match the weights at the time of spawning by averaging the Jan-1 Rivard weight-at-age and the catch weight-at-age for the current year.

Ageing Error

The model allows ageing error matrices to be incorporated if errors (or bias) in ages are suspected. An error matrix can be entered for each fleet and survey with age composition data. The ageing error matrix must be calculated as

$$p_{i,j} = \frac{n_{i,j}}{\sum_j n_{i,j}}$$

where $p_{i,j}$ is the proportion of samples within true age i that were classified as age j and $n_{i,j}$ are the number of samples of true age i that were classified as age j. The ageing matrix is applied to the proportions-at-age for each fleet and survey with age composition data calculated from population dynamics model before they are compared to the observed proportions-at-age. The adjustment is done by:

$$\hat{P}_y^A = A \cdot \hat{P}_y^u$$

where P_y^u is the vector of unadjusted proportions-at-age in year y, A is the ageing error matrix, and P_y^A is the vector of adjusted proportions-at-age- in year y.

Likelihood for Total Catch and Survey Indices

For total catch and survey indices, lognormal errors are assumed throughout and the concentrated likelihood, weighted for variation in each observation, is calculated. The generalized concentrated negative log-likelihood ($-L_l$)(Parma 2002; Deriso et al. 2007) is

$$-L_l = 0.5 * \sum_i n_i * \ln\left(\frac{\sum_i RSS_i}{\sum_i n_i}\right)$$

where n_i is the total number of observations and RSS_i is the weighted residual sum-of-squares from dataset i. The weighted lognormal residual sum-of-squares (RSS_f) of total catch for fleet f is calculated as

$$RSS_f = \lambda_f \sum_y \left(\frac{\ln\left(C_{f,y}+1e^{-5}\right)-\ln\left(\hat{C}_{f,y}+1e^{-5}\right)}{CV_{f,y}}\right)^2$$

where $C_{f,y}$ is the observed catch of fleet f in year y, $\hat{C}_{f,y}$ is the predicted catch in year y, $CV_{f,y}$ is the coefficient of variation for observed catch in year y, and λ_f is the relative weight (Parma 2002; Deriso et al. 2007).   Similarly, the weighted lognormal residual sum-of-squares (RSS_t) of relative abundance index t is calculated as

$$RSS_t = \lambda_t \sum_y \left(\frac{\ln\left(I_{t,y}+1e^{-5}\right)-\ln\left(\hat{I}_{t,y}+1e^{-5}\right)}{\delta \cdot CV_{t,y}}\right)^2$$

where $I_{t,y}$ is the observed index t in year y, $\hat{I}_{t,y}$ is the predicted index in year y, $CV_{t,y}$ is the coefficient of variation for the observed index in year y, δ is the CV weight, and λ_t is the relative weight.

Likelihood for Age Composition Data

For the catch and survey age compositions, multinomial error distributions are assumed throughout and the negative log-likelihood for the fleet age composition is calculated as

$$-L_f = \lambda_f \sum_y -n_{f,y} \sum_a P_{f,y,a} \cdot \ln\left(\hat{P}_{f,y,a}+1e^{-7}\right)$$

where $n_{f,y}$ is the effective number of fish for fleet f aged in year y, $P_{f,y,a}$ is the observed proportion-at-age, and $\lambda_{f,p}$ is the relative weight. The age composition negative log-likelihood for survey t is

$$-L_t = \lambda_t \sum_y -n_{t,y} \sum_a U_{t,y,a} \cdot \ln\left(\hat{U}_{t,y,a}+1e^{-7}\right)$$

where $n_{t,y}$ is the effective sample size of fish aged in year y from survey t, and $U_{t,y,a}$ and $U_{t,y,a}$ are the observed and predicted proportions of age a in year y from survey t.

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Estimation of Effective Sample Sizes for Age Composition Data

The effective sample sizes (ESS) for the catch and survey age composition data can be estimated two ways. First by using the manual, iterative method of McAllister and Ianelli (1997). Predicted average effective sample size ($\hat{\bar{t}}$) is calculated as:

$$\hat{\bar{t}} = \frac{\sum_y \hat{t}_y}{d_y}$$

and $\hat{t}_y$ is defined as

$$\hat{t}_y = \frac{\sum_a \hat{c}_{a,y}(1-\hat{c}_{a,y})}{\sum_a (o_{a,y}-c_{a,y})^2}$$

where $\hat{c}_{a,y}$ is the predicted proportion-at-age a in year y from the catch or survey, $o_{a,y}$ is the observed proportion-at-age, and d_y is the number of years of data for catch or survey series. The effective sample sizes for catch and survey proportions should be repeatedly adjusted until the predicted sample sizes stabilize. The second method uses the equation 1.8 method of Francis (2011). If desired, the multiplier is applied to the input ESS and then input ESSs are replaced with the new computed values. The ADMB code for this method was taken from the NMFS ASAP program.

Total Log-likelihood of the Model

The total log-likelihood of the model is

$$f = -L_l - \sum_f L_{f,p} - \sum_t L_t^U + P_{rdev} + P_{n1} + P_{fadd}$$

The total log-likelihood is used by the autodifferentiation routine in AD Model Builder to search for the "best" selectivity parameters, recruitment parameters (average or equation parameters and recruitment deviations), fishing mortality, and catchability coefficients that minimize the total log-likelihood. AD Model Builder allows the minimization process to occur in phases. During each phase, a subset of parameters is held fixed and minimization is done over another subset of parameters until eventually all parameters have been included. The phases are specified under the "Controls" tab of the GUI. The estimation proceeds by first calculating $F_{f,a,y}$ using initial starting values for $F_{f,y}$ and $s_{f,a}$ (initial parameters estimates are used for the selectivity equations) for each fleet and, with M and initial values of average recruitment by year, the abundance matrix is filled (Figure B7.1). Note that recruitment is actually estimated back to 1970 in order to provide more realistic estimates of N in the first year of data (1982). Also, this allowed the incorporation of indices (e.g., Maryland young-of-the-year index) back to 1970. All predicted values were calculated using the equations described above.

Diagnostics

Model fit for all components is checked by using standardized residuals plots, and root mean square errors. Standardized residuals (r) for log-normal errors were calculated as:

$$r_y = \frac{\log I_y - \log \hat{I}_y}{\sqrt{\log_e (CV_y^2 + 1)}}$$

Root mean square error for lognormal errors was calculated as:

$$RMSE = \sqrt{\frac{\sum_y r_y^2}{n}}$$

For age composition (multinomial) data, standardized residuals were calculated as:

$$r_{y,a} = \frac{P_{y,a} - \hat{P}_{y,a}}{\sqrt{\frac{\hat{P}_{y,a}(1 - \hat{P}_{y,a})}{\hat{n}_y}}}$$

where n_y is the average effective sample size. For catch and indices, qqnorm plots (Faraway 2005) are provided. In addition, the Akaike Information Criterion (AIC) is calculated as:

$$AIC = 2 * f + 2 * K$$

where K is the number of parameters estimated in the model.

Reference Points

Spawning stock biomass-per-recruit (SPR) and yield-per-recruit (YPR) analyses are conducted following Gabriel et al. (1989). The user-specified inputs of % maximum SPR, year of estimates to use, and range of fishing mortality (F) are used in the calculations to provide the % maximum SPR at each F, yield-per-recruit at each F, and estimates of F_{max} and $F_{0.1}$ from YPR. If a S-R model is used to estimate recruitment, the methods of Shepherd (1982) are used to calculate MSY, F_{msy}, and SSB_{msy}. F_{med} is always produced by using the recruits and SSB estimates, and the SPR results.

Summary of Model Structure Used in 2013 Assessment

A summary of the model structure used in this assessment is listed in Table B7.1.

B7.2.1 Data Inputs

Plus Group

As in the 2007 benchmark, an age 13+ plus-group was used for catch and indices data as an attempt to address the increase in scale-ageing bias after ages 12 or so.

Catch Data

Total removals (recreational and commercial harvest numbers plus number of discards that die due to handling and release) and the proportions of catch-at-age of striped bass fisheries are the primary data used in the model. The removals data were partitioned into three "fleets" in an attempt to account for more realistic patterns in fishing selectivity known to have occurred as management measures changed over time. All selectivity time blocks corresponded to Amendment changes. Removals data were split into *Chesapeake Bay*, *Coast* and the *Commercial Dead Discards* (Table B7.1). The latter was a separate fleet because commercial discards were from a multitude of gears that do not necessarily target striped bass and the mixed gear types may have a unique selectivity over time. In addition, the data prior to 1996 could not be separated into regions. The Chesapeake Bay fleet includes commercial and recreational harvest and recreational dead discards taken in the Bay by MD, VA, and the PRFC. The Coast fleet includes commercial and recreational harvest and recreational dead discards taken in the coastal regions, Delaware Bay and Hudson River by ME, NH, MA, NY, NJ, DE, MD, VA and NC. The observed total removals and catch age compositions were generated from all state reported landings-at-age, and recreational dead discards-at-age. The total removals and age composition by region are given year (Table B7.2).

Total catch CVs for the Chesapeake Bay and Coast fleets were assumed equal to the PSEs of MRIP total harvest plus dead discards for the inclusive states since it is assumed that only the estimates of recreational harvest and dead discards have error (Table B7.2). The CV of the combined harvest and dead discards estimates for each year was calculated as

$$CV = \frac{\sqrt{(PSE_H/100*H)^2 + (0.09^2 *(PSE_R/100*R)^2)}}{H + R*0.09}$$

For the commercial dead discards, Monte Carlos simulation was used to estimate the CVs. For each region (Chesapeake Bay, Delaware Bay, and Coast), recreational landings and releases for the years 2009-2012 were randomly drawn from normal distributions parameterized with regional-annual estimates and respective standard deviations. The commercial landings were assumed errorless. The number of tag returns for each year categorized by commercial kill, recreational kill, commercial releases, and recreational releases were drawn randomly from a multinomial distribution parameterized with the total number of tag returns and the proportions of each tag category based on observation data. With the new catch and tag data, the number of commercial dead discards was calculated following section B6.3.1. The simulation was repeated 10,000 times for each region. The mean and standard deviation of the 10,000 resamples were calculated to obtain the CV (sd/mean). The average CV (0.35) was used across all years.

Young-of-the-Year and Age 1 Indices

Young-of-the-year (YOY) and yearlings indices from New York (Hudson River YOY: 1980-2012; West Long Island Sound Age 1: 1986-2012), New Jersey (Delaware Bay YOY: 1981-2012), Maryland (Chesapeake Bay YOY and Age 1: 1970-2012), and Virginia (Chesapeake Bay YOY: 1983-2012) were incorporated into the model by linking them to corresponding age abundances and time of year. Because age 0 striped bass are not modeled, the YOY and yearling indices were advanced one year and are linked to age 1 and age 2 abundances, respectively, and are tuned to

January 1st (p=0;Table B7.3). All YOY and yearling indices are geometric means and corresponding CVs. More information on these surveys can be found in ASMFC (1996).

Aggregate and Age-Species Indices

The aggregate indices (no or borrowed age data or other reasons) from the Marine Recreational Fisheries Statistics Survey (MRIP: 1988-2012) and Northeast Fisheries Science Center (NEFSC spring bottom trawl survey: 1991-2008) are used in the model by linking them to aggregate age abundances and the time of year (Table B7.3). All aggregate indices are geometric means of the survey estimate. The annual CVs for the MRIP index were calculated by dividing model estimates of standard errors by the index. CVs for the NMFS survey was estimated from survey data.

The age-aggregated indices and age composition data from New York (ocean haul seine: 1987-2006), New Jersey (bottom trawl: 1989-2012), Maryland (gillnet: 1985-2012), and Delaware (electrofishing: 1996-2012) surveys are incorporated into the model by linking them to age abundances and the time of year (Table B7.3). The Gompertz equation is used to estimate the selectivity pattern for the Delaware spawning stock survey because theory indicates that vulnerability to electric fields increases with surface area of the fish (Reynolds, 1983). Because MD survey estimates are corrected for mesh-size selectivity, it was determined by trail-and-error that only the selectivity value for age 2 had to be estimated; for ages $\geq$ 3, selectivity was set to 1. For the New York ocean haul survey, the Thompson's exponential-logistic model is used to estimate the selectivity pattern. For the New Jersey survey, a gamma function is used to estimate the selectivity pattern.

Starting Values

Initial starting values for all parameters are given in Table B7.4 and were selected based on trial-and-error. Based on the coast-wide age samples, the starting effective sample sizes for the age proportions in each fleet were set at 50.

Used as starting values, the average effective sample size for each survey with age composition data was calculated in the 2007 benchmark (http://www.nefsc.noaa.gov/publications/crd/crd0803/) by using methods in Pennington and Volstad (1994) and Pennington and others (2002). In essence, effective sample size was estimated by first calculating the length sample variance using the simple random sampling equation and dividing into it the cluster sampling variance of mean length derived through bootstrapping, assuming each seine/trawl haul, gillnet set, or electrofishing run was the sampling unit. The average of the annual effective sample sizes was used as starting values in each survey multinomial error distribution (NJ Trawl = 23; NYOHS = 56; DESSN = 68; MDSSN=68; VAPNET = 68).

Sex Proportions-at-age

Female sex proportions-at-age are used to apportion the numbers-at-age to female numbers-at-age for calculation of female spawning stock biomass. The sex proportions were derived from available state catch datasets. The proportions used were:

Age	1	2	3	4	5	6	7	8	9	10	11	12	13+
Proportion female	0.53	0.56	0.56	0.52	0.57	0.65	0.73	0.81	0.88	0.92	0.95	0.97	1.00

Female Maturity

The proportions mature-at-age for females were derived from literature values and field samples.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13+
Proportion mature	0.00	0.00	0.00	0.04	0.13	0.45	0.89	0.94	1.00	1.00	1.00	1.00	1.00

Natural Mortality

In previous assessments, M of 0.15 was assumed constant across ages. In the current assessment, age-specific Ms for ages 1-6 were derived from a curvilinear model fitted to tag-based Z estimates (assuming Z=M) for fish ≤age3 from NY and tag-based M estimates (Jiang et al., 2007) for striped bass from MD made for years prior to 1997 (Appendix B5). The age-specific M estimates used in the base model are:

Age	1	2	3	4	5	6	≥7
M	1.13	0.68	0.45	0.33	0.25	0.19	0.15

B7.2.2 Model Specification

Phases

Model parameters were solved in phases. The parameters solved in each phase were:

1.   Yr 1, Age 1 N or Avg N (log)
2.   recruitment deviations and fishing mortality
3.   stock-recruitment parameters
4.   catch selectivity parameters
5.   survey selectivity parameters
6.   catchability coefficients of survey indices

Catch Selectivity Functions

In the 2007 model, the time period from 1982-2006 was split into four time blocks (1982-1984, 1985-1989, 1990-1995, and ≥1996) and the Gompertz function was used to estimate the catch selectivity in each time block (NOAA 2007). Each period designates a major change in management regulations of striped bass. In the current formulation, the same time blocks were used for each fleet. However, the usefulness of adding another time period (2003-2012: under Amendment 6) for each fleet was considered by comparing the AIC values of model fits with the additional period (each fleet added sequential) against the model fits without the extra period. Only the addition of the period for commercial dead discards improved model fit. In addition, the three-parameter Thompson exponential-logistic equation was applied to allow more flexible estimation of the selectivity pattern in each time block. If a resulting selectivity pattern was flat-topped, the Thompson function was replaced with a Gompertz function to save one parameter from being estimated.

Stock-Recruitment Curve

Based on literature reviews and committee opinion, the Beverton-Holt equation was selected as the appropriate stock recruitment relationship for striped bass. (See Section B5.4.4 for more discussion.)

Data Weighting

Data weighting was accomplished by first running the model with all initial starting values, lambda weights = 1, and index CV weights = 1. The lambda weights for the total removal data were increased for the Bay, Coast, and Commercial Discards to force the model to better fit the data if needed. After the model was re-run, the index CV weights were adjusted to obtain index RMSE values within the 95% confidence bound of RMSE for a given sample size assuming a normal distribution $(N(0,1))$. The model was re-run several times to adjust the RMSE values. Next, the initial effective sample sizes were adjusted once by using the Francis multipliers and the model was re-run. The RMSE index values for the indices were checked again to ensure the RMSE values still fell in the 95% confidence bounds; if not, the index CV weights were adjusted again and the model re-run.

B7.3 Code Checking

The accuracy of the original model code was checked in 2007 by simulating a virtual population of striped bass in EXCEL and catch numbers, catch age composition, one age-1 index, one aggregate index and one survey index with age composition data were generated using the above model equations and known values of fishing mortality, natural mortality, recruitment, catch and survey selectivities, and catchability coefficients. The catch and survey data and known parameters were then input into the model and the model was run without minimization to check if the code produced the exact values of the simulated population. The model was then run with minimization to check estimation. Both trials showed that the model duplicated the simulated population quantities. Changes to the 2013 model code pertained mostly to the addition of fleet specific-data and estimation, and the addition of multiple recruitment models. The accuracy of the new code was checked by comparing model output to known input values and no errors were identified. Code used for method 1.8 of Francis (2011) was copied from the NMFS ASAP model. All code is presented in Appendix B6.

B7.4 Base Model Configuration and Results

Based on the above analyses and recommendations from the ASMFC's striped bass stock assessment and technical committees, the final model contained four catch selectivity periods for the Bay and Coast fleets, but 5 periods for the Commercial Discard fleet. All indices were used. The lambda weights of total catch for the Bay, Coast and Commercial Discard fleets were increased by 2 to force the model to better fit the data in the early part of each time series. Initial starting values for all parameters are given in Table B7.4; there were 198 parameters estimated in the model. Except for the lambda weight of the total catch series, no other lambda weights were increased. The index CV weights, however, were adjusted and are shown in Table B7.5 along with the index RMSEs and 95% confidence bounds of the RMSE assuming $N(0,1)$. The effective sample sizes from the Francis

(2011) adjustment for catch and index age compositions were: Bay – 31.7, Coast – 42.2, Commercial Discards – 21.5, NYOHS – 14.8, NJTrawl – 5.1, MDSSN – 23.4, DESSN – 25.4 and VAPNET - 10.8.

B7.4.1 Results

Resulting contributions to total likelihood are listed in Table B7.6. The converged total likelihood was 9,779.1 (Table B7.6). Estimates of fully-recruited fishing mortality for each fleet, total fishing mortality, recruitment, parameters of the selectivity functions for the selectivity periods, catchability coefficients for all surveys, and parameters of the survey selectivity functions are given in Table B7.7 and are shown graphically in Figures B7.2-7.5. Graphs depicting the observed and predicted values and residuals for the catch age composition, survey indices, and survey compositions are given in Appendix B7. The model fit the observed total catches (Figure B7.3) and catch age compositions well except for ages 1 and 13+ for the Coast and Commercial Discard fleets, and the YOY, age 1, CTTrawl, and NEFSC indices reasonably well (Appendix B7). The predicted trends matched the observed trends in age composition survey indices (except MDSSN and NYOHS), and predicted the survey age composition reasonably well (MDSSN) to poorly (NJ Trawl) (Appendix B7).

B7.4.1.1 Fishing Mortality

Fully-recruited fishing mortality in 2012 for the Bay, Coast and Commercial Discard fleets was 0.055, 0.134, and 0.039, respectively (Table B7.7) and was generally highest in the Coast fleet (Figure B7.2). The maximum total F-at-age in 2012 was 0.188 (Table B7.8), which occurred on ages 10-11 (Table B7.9). Average fishing mortality on ages 3-8, which are generally targeted in producer areas, was 0.13 (Table B7.8; Figure B7.6). An average F weighted by N was calculated for comparison to tagging results since the tag releases and recaptures are weighted by abundance as part of the experimental design. The 2012 F weighted by N for ages 7-11 (age 7 to compare with tagged fish ≥28") was 0.181 (Table B7.8; Figure B7.6). An F weighted by N for ages 3-8, comparable to the direct enumeration estimate for Chesapeake Bay, was equal to 0.095 (Table B7.8; Figure B7.6).

Fishing mortality-at-age in 2011 and 2012 for the three fleets is shown in Figure B7.7. Fishing mortality-at-age peaked at age 5 in the Chesapeake Bay and Commercial Discards fleets and age 13+ in the Coast fleet. The highest fishing mortality was attributed to the Coast fleet at ages ≥6 (Figure B7.7).

B7.4.1.2 Population Abundance (January 1)

Striped bass abundance (1+) increased steadily from 1982 through 1997 when it peaked around 251 million fish (Table B7.10, Figure B7.5). Total abundance fluctuated without trend through 2004. From 2005-2010, age 1+ abundance declined to around 135 million fish. Total abundance increased to 215 million by 2012 (Figure B7.5). The increase in 2012 was due primarily to the abundant 2011 year class from Chesapeake Bay (Table B7.10). Total abundance is expected to drop in 2013 as the very small 2012 year-class from Chesapeake Bay recruits to the population (Figure B7.5). Abundance of striped bass age 8+ increased steadily through 2004 to 11.7 million, but declined to 7.6 million fish through 2010 (Table B7.10; Figure B7.5). A small increase in 8+ abundance occurred in 2011 as the 2003 year class became age 8 (Figure B7.5).

B7.4.1.3 Spawning Stock Biomass, Total Biomass and Stock-Recruitment Relationship

Weights-at-age used to calculate spawning stock biomass were generated from catch weights-at-age and the Rivard algorithm described in the NEFSC's VPA/ADAPT program. Female SSB grew steadily from 1982 through 2003 when it peaked at about 81 thousand mt (Table B7.11, Figure B7.8). Female SSB has declined since then and was estimated at 61.5 thousand metric tons (95% CI: 45,686-77,400) in 2012 (Table B7.11; Figure B7.8). The SSB point estimate in 2012 remained above the threshold level of 57.9 thousand metric tons (1995 SSB value) and indicates that the striped bass are not overfished. However, given the error associated with the 1995 and 2012 values, there is a probability of 0.28 that the female spawning stock biomass in 2012 is below the threshold. The spawning stock numbers (Figure B7.8) declined more rapidly than the spawning stock biomass.

Total biomass (January 1) increased from 18,609 metric tons in 1982 to its peak at 221,774 metric tons in 1999 (Figure B7.8). Total biomass declined through 2011, but increased in 2012 due to the strong 2011 year-class (Figure B7.8).

The stock-recruitment data derived in the model along with the deterministic fit of Beverton-Holt equation is shown in Figure B7.9.

B7.4.1.4 Retrospective Analysis

Retrospective analysis plots and percent difference plots between the 2012 and peels of the retrospective analysis are shown in Figure B7.10. Moderate retrospective bias was evident in the more recent estimates of fully-recruited total F, SSB, and age 8+ abundance of SCA (Figure B7.10). The retrospective analysis of age-1 recruits showed that the terminal year estimate of age-1 abundance is most uncertain and there is likely over-estimate (Figure B7.10). The retrospective pattern suggests that fishing mortality is likely slightly over-estimated (between 8 and 11% since 2007) and could decrease with the addition of future years of data. Similar retrospective trends have been observed in the previous assessment of striped bass using the ADAPT VPA (ASMFC 2005), the 2007 benchmark, and supporting ASAP model presented in the current assessment.

B7.4.2 Sensitivity Analyses
B7.4.2.1 Starting Values

Starting values for the minimization routine are important to achieve proper convergence at the global minimum. The starting values were selected based on trial-and-error. Many runs were conducted to find values that appeared to be reliable and for which the global minimum was reached consistently. To further check the convergence properties of the model, 100 model runs were made, and for each run, starting values were randomly permuted by $\pm50\%$. A plot of total fully-recruited F in 2012 and corresponding total log-likelihoods assessed convergence stability. The runs demonstrated that the starting values selected produced the smallest total likelihood (9779.13) (Figure B7.11).

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B7.4.2.2 Natural Mortality

Since the use of age-specific Ms is new to the striped bass assessment, the model was also run with a constant M of 0.15 for all ages and years. The model with constant M produced higher fully-recruited Fs and lower female spawning stock biomass (Table B7.12; Figure B7.12).

The SA committee was also interested to see the impact of age-specific Ms generated by using the unscaled Lorenzen equation and weights-at-age (Appendix B5). The Lorenzen equation produced age-specific Ms that ranged from 0.64 at age 1 to 0.20 at age 13+. Lower total fully-recruited fishing mortality and higher female spawning stock biomass were produced using the Lorenzen Ms (Table B7.12; Figure B7.13).

To determine if the potential impact of higher M due to the *Mycobacterium* outbreak in Chesapeake Bay, M for ages 3-8 after 1996 was increased. Smith and Hoenig (MS 2012) estimated that M on ages 3-8 in Chesapeake Bay had increased from an assumed base-level of 0.15 to 0.27 (difference=0.12). This difference was added to the age-specific Ms for ages 3-8 and years 1997-2012. Increasing M produced lower estimates of fully-recruited F and higher estimates of female spawning biomass (Table B7.12; Figure B7.14).

B7.4.2.3 Effects of Deleting Survey Dataset

The contribution of each survey data source to the results of the final model configuration was investigated by removing each dataset one-at-a-time and re-running the model. Changes in the time series of F estimates for 1982-2012 between base run (all indices) and each one removed one-at-a-time were minor except when the MRFSS and MDSSN indices were removed (Table B7.13; Figure B7.15). Without the MRFSS index, the fully-recruited F decreased after 2005-2006 and declining trend in female spawning stock biomass after 2006 became less steep (Figure B7.15). Without the MDSSN, the magnitude of fully-recruited F increased after 1996 and the magnitude of the female spawning stock biomass decreased (Table B7.13; Figure B7.15).

B7.4.2.4 Effects of Effective Sample Sizes of Catch and Survey Multinomial Distributions

The influence of the magnitude of average effective sample sizes of the catch and survey multinomial likelihoods on the estimates of average fishing mortality for ages 8-11 and female spawning stock biomass was investigated. When the average effective sample sizes were increased or decreased by 20% of the original values, fully-recruited F and female spawning stock biomass changed very little (Table B7.12; Figure B7.16).

B7.4.3 Model Comparisons

B7.4.2.5 Comparison of One Fleet Model

In past assessments, all catch data were combined and modeled as one fleet. For historical comparison, a one-fleet model using the all catch data combined, the same indices, starting values, and natural mortality estimate was developed. The Thompson selectivity function was used for the four selectivity blocks and the same data weighting procedure was used. In the one fleet model, the total catch weight lambda was set to 5 to force the model to better fit removals during the early 1980s (in the 2007 benchmark, the weight was set to 10). Comparison of the fully-recruited F and female

spawning stock biomass to the results of the 2012 base model showed that the one fleet model produced lower fishing mortality estimates and higher spawning stock biomass estimates for years 1997-2012 (Figure B7.17).

B7.4.2.6 Comparison of 2011 Assessment Results to 2012 Base Model Results

As a historical retrospective of model results, the estimates of fully-recruited fishing mortality and female spawning stock biomass from the 2011 assessment are compared to the results of the 2012 base model in Figure B7.18. The fully-recruited F estimates in the 2011 assessment were higher than the estimate from the 2012 base model, but the difference was much larger during 1982-1997 than from 1998-2012 (Figure B7.18). Because age-specific Ms were used in the 2012 base model, the 2012 female spawning stock biomass estimates were much higher than estimates from the 2011 assessment (Figure B7.18). The 2012 base model estimated spawning stock biomass increased faster during the early part of the time series than the 2011 assessment. However, the decline in biomass during 2006-2010 from the 2011 assessment model was less steep than the decline estimated in the 2012 base model for the same period (Figure B7.18).

B7.4.2.5 Comparison to Results with Age Data Bias-Corrected for Scale Ageing

Ages derived from scales of striped bass are known to be biased past ages 10-12 or so. Age bias can impact the results of the stock assessment (Liao et al. 2012). The SA committee wanted to start correcting for scale bias by using scale age-otolith age conversion keys (assuming the otolith is the true age) but questions have arisen about the appropriateness of applying conversion keys from one state (mainly Virginia) to the scale ages derived by other states that don't age striped bass using otoliths. A recent scale exchange study has shown that similar scale ageing bias is produced by personnel of fisheries agencies of Mid-Atlantic states reading scales samples from Virginia, but not by personnel in New England. Applying Virginia conversion keys to New England age samples would incorrectly fix the bias.

Another observation that the scale bias at a particular otolith age is not consistent from year to year; thus, annual conversion keys are needed. Only Virginia has conversion keys from 1999-present. Massachusetts has paired scale-otolith data from 2002-2004 and 2010-2012 but annual sample sizes aren't large enough to produce annual conversion keys. Until these issues are resolved the SA committee did not want to officially correct the age composition of catches or surveys in this assessment.

The SA committee did think it would be educational to see the consequences of attempting to correct the scale bias. Two models were constructed: one that used the same inputs as the 2012 base model and an age 13 plus group, and a second one that used the same inputs, but had an age 15 plus group. The Virginia conversion keys were applied to age composition of catches and surveys from New York through North Carolina from 1999-2012, and a combined conversion key from Massachusetts was applied to the same data types from New England. No data prior to 1999 were corrected for scale aging bias. The results are shown in Figure B7.19. The bias corrected models produced lower estimates of fully-recruited F (the age 13 plus-group model produced the lowest estimates) and higher estimates of female spawning stock biomass (the age 13 plus-group model produced the highest estimates) than the 2012 base model, although the trends were similar (Figure

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B7.19)   Recruitment estimates from the bias-corrected models were in general larger than the estimates from the 2012 model, but usually when large year-classes were evident (Figure B7.19).

B7.5 Comparison of SCA Model Results to Tagging Model Results

Total mortality estimated from tagging data of 8 coast-wide tagging programs are provided in section B8.0 (see below). The average values for the Coast and Producer areas are plotted with the total mortality from the SCA model in Figure B7.19.   Increasing trends in total mortality (Z) were similar between the tag-based and SCA models, although the SCA Z estimates were slightly lower in magnitude through 2006 (Figure B7.20). All model Z estimates indicated a decline in total instantaneous mortality after 2006 (Figure B7.20). An important aspect of these comparisons is that the estimates of total mortality made from different datasets and models are similar in magnitude and trend, verifying the results of the SCA model.

B7.6 Comparison of SCA Model Results to ASAP Models Results

As a confirmatory check of the SCA model output, an ASAP statistical catch-at-age model (Appendix B8) was applied to the catch-at-age data and relative abundance indices. The biggest difference between the SCA and ASAP models is that the latter does not allow index data to be used prior to the time catch data are not available. In the following ASAP model, the time series of catch data started in 1985 instead of 1982 to explore the absence of early data during a period when regulations changes dramatically between years. The estimates of average F for ages 8-11 and female spawning stock biomass are compared in Figures B7.21.   In general, the ASAP model produced the fully-recruited F and female spawning stock biomass estimates similar to the SCA model (Figure B7.21). However, the ASAP Fs and female spawning stock biomass estimates were slightly lower during 2000-2005 and during 1994-1999, respectively.

B7.7 Sources of Uncertainty in SCA

Accurate estimates of catch at age require that we know the total loss in numbers and that we apportion this loss correctly to age. The best data on loss comes from the directed recreational and commercial fisheries. Estimates of Virginia wave-1 recreational harvest are estimated by using North Carolina harvest and tag returns, and Virginia tag returns, because MRIP sampling is not conducted during this time. Recreational harvest data are lacking from large river systems such as the Connecticut River and Hudson River where striped bass are known to be harvested. There is less confidence in estimates of discards in commercial and recreational fisheries because little of the data is measured directly. Moreover, gear specific discard/release mortalities are assumed to be constant even though mortalities may vary with season and with changes in gear specifics such as increased use of circle hooks.   The quality of data on age composition varies among fisheries and region. In most cases, fish in catches or discards are measured and length frequencies are converted to age frequencies with age length keys. States with large harvests usually sample fisheries directly and develop age length keys from the fishery and time of year of the fishery. However, states with small fisheries must often rely on length data from small samples or fishery independent collections or use age length keys developed by neighboring jurisdictions. Finally, the assignment of age to scales samples becomes less certain with increasing fish age ($\geq$ age 10).

Estimates of F and population size from the catch at age analyses at the beginning of the time series, not the terminal year, are the most uncertain estimates. However, retrospective analysis indicated that the terminal year estimates are slightly, positively biased and may decrease somewhat with an additional year of data.

B8.0 Use the Instantaneous Rates Tag Return Model Incorporating Catch-Release Data (IRCR) and associated model components applied to the Atlantic striped bass tagging data to estimate F and abundance from coast wide and producer area tag programs along with the uncertainty of those estimates. Provide suggestions for further development of this model. (TOR#4).

B8.1 Introduction

This report summarizes the results of the United States Fish and Wildlife Service's (USFWS) Atlantic coast-wide striped bass tagging program through the 2011 tagging year. The Striped Bass Tagging Subcommittee (SBTS) of the ASMFC Striped Bass Technical Committee analyzes the data collected by the tagging program. The subcommittee is comprised of members from participating state agencies, the National Marine Fisheries Service (NMFS) and the USFWS.

The SBTS estimates rates of survival (S) and fishing mortality (F) using the USFWS Atlantic coast-wide striped bass tagging data. In previous assessments rates of S and F have been estimated with various modeling approaches: Seber (1970) and Brownie models (Brownie et al. 1985) using the software MARK (White and Burnham 1999), a variation of the Baranov's catch equation, and an instantaneous rates model (Hoenig et al. 1998). Since 1998, the SBTS has analyzed tag recovery data with the program MARK (White and Burnham 1999), where survival rates were derived from a suite of Seber (1970) models and assumptions followed Brownie et al. (1985). Additional calculations accounted for catch and release fishing. Then mortality (Z as $-\log_e$ S) was partitioned into fishing (F) and natural (M) mortalities using a biologically-based constant value of M = 0.15 (Smith et al. 2000). The use of this method produced estimates of F that were sometimes nonsensical, particularly for coastal tagging programs, and occasionally countered other indicators of stock status. Therefore, in 2004, the post-model partitioning of Z was also accomplished using a formulation of Baranov's catch equation (Ricker 1975) proposed by Pollock et al. (1991), in which the value of M is not assumed a priori. However, in some cases, the catch equation method also produced nonsensical results. This caused the SBTS to explore a new approach for the 2006 assessment – a formulation of Jiang et al.'s (2007) instantaneous (mortality) rates, catch and release model (IRCR). The IRCR method is simpler and more intuitive than the alternative methods because S, F, and M are estimated without a need for additional analysis methods to account for catch and release fishing (Jiang et al. 2007). In most cases, results from MARK, Baranov's catch equation, and IRCR model have been similar and consistent. Because IRCR modeling has consistently performed well in the analysis of striped bass tagging data, the SBTS has chosen to use the IRCR model as the primary model for this assessment to estimate S, F, and M. While Baranov's catch equation will no longer be utilized, results from MARK will be presented to compare to estimates of survival (S) obtained by the IRCR model.

B8.2 Description of Atlantic Coast-wide Striped Bass Tagging Program

Eight tagging programs have traditionally participated in the USFWS Atlantic coast-wide striped bass tagging program and each have been in progress for at least 18 years. As striped bass are a highly migratory anadromous species, the tagging programs are divided into two categories, producer area programs and coastal programs. Most programs tag striped bass primarily $\geq$ 18 inches total length (TL) during routine state monitoring programs.

Producer area tagging programs primarily operate during spring spawning on the spawning grounds. Several capture methods are used such as pound nets, gill nets, seines and electroshocking. The producer area programs are:

- Hudson River (HUDSON) - fish tagged in May;

- Delaware and Pennsylvania (DE/PA) - fish tagged in the Delaware River primarily in April and May;

- Maryland (MDCB) - fish tagged in the Potomac River and the upper Chesapeake Bay primarily in April and May; and

- Virginia (VARAP) - fish tagged in the Rappahannock River during April and May.

Coastal programs tag striped bass from mixed stocks during fall, winter, or early spring. Gears include hook & line, seine, gill net, and otter trawl. The coastal tagging programs are:

- Massachusetts (MADFW) - fish tagged during fall months;

- New York ocean haul seine survey (NYOHS) - fish tagged during fall months. This survey changed to a trawl survey (NYTRL) in 2008 – fish tagged in November. Due to differences in length frequency and gear types, it is not possible to combine the surveys into one data series. When data are presented in the report (NYOHS/TRL), numbers with * are from the trawl.

- New Jersey Delaware Bay (NJDB) - fish tagged in March and April; and

- North Carolina winter trawl survey (NCCOOP) - fish tagged primarily in January.

Tag release and recapture data are exchanged between the USFWS office in Annapolis, MD, and the cooperating tagging agencies. The USFWS maintains the tag release/recovery database and provides rewards to fishermen who report the recaptures of tagged fish. From 1985 through January 2013, a total of 507,097 striped bass have been tagged and released, with 91,440 recaptures reported and recorded in the USFWS database (Ian Park, personal communication).

Release data, recorded at time of tagging, include:

- tag number,
- total length,
- sex (if available),
- release date,
- release location,
- gear, and
- other physical data.

Recapture data are obtained directly from fishermen and include:

- tag number,

- total length,
- disposition,
- recapture date,
- recapture location,
- gear; and
- personal information.

These data are used to develop the following descriptive statistics of reported fish:

- length frequency distributions of releases, measured as total length (TL);
- age frequency distributions of recaptures based on the aged subsample; and
- annual exploitation rates.

Annual exploitation rates (μ) were developed for both ≥ 18 inch fish and ≥ 28 inch fish and were estimated as follows:

$$\mu = ((R_k + R_L(0.09)) / \lambda_h) / M$$

where:

$R_k =$ the number of killed recaptures;
$R_L =$ the number of recaptures released alive;
$0.09 =$ release mortality rate estimated by Diodati and Richards (1996);
$\lambda_h =$ reporting rate of harvested fish and
$M =$ the number of fish initially tagged and released;

After the 2011 tagging estimates were completed, the Striped Bass Stock Assessment Subcommittee updated the release mortality rate from the previous value of 0.08 to 0.09 to match the value published by Diodati and Richards (1996). Maryland recalculated some of their estimates with the 0.09 value and the differences were negligible. Due to the minimal affect on estimates, and time constraints, 0.08 was used in the calculations of the 2011 estimates.

The SBTS defined two categories of tag recoveries for the analysis: a) fish harvested and tag reported and, b) fish caught, tag reported, and fish released. Only first recapture events were used. Tag recovery matrices for each program used in the current assessment are presented in Appendix B9.

B8.3 Instantaneous Rates Model

Hoenig et al. (1998) first described a model which replaced the Brownie model (1985) survival estimate with an instantaneous rates formulation. In this model, observed recovery matrices from harvested fish were compared to expected recovery matrices to estimate model parameters using a maximum likelihood approach. Jiang et al. (2007) published an expanded version of the instantaneous rates model that accounted for the re-release of caught, tagged fish. Since many of the tagging programs do not age all tagged fish, the SBTS elected to use an age-independent form of the "instantaneous rates – catch and release" (IRCR) model by Jiang et al. (2007). The model was programmed in AD Model Builder (ADMB) by Gary Nelson (MA DMF) and tested using data provided in Jiang (2005). A user-interface in EXCEL creates the required ADMB input file. Details of model algorithms are provided in Jiang et al. (2007) and ADMB code is available in Appendix B9.

Several biologically-reasonable candidate models were formulated based on historical changes in striped bass management (Table B8.1). These models are analogous in structure to the models previously used in the program MARK but estimate instantaneous fishing (F) and natural mortality (M) rates instead of survival (S), although the IRCR also estimates S. The output from the IRCR model consists of estimates of S, F, F' (mortality on tags recaptured and released), M and associated standard errors for each of the candidate models.

Candidate models are fit to the tag recovery data and arranged in order of fit by an overdispersion-corrected second-order adjustment to the Akaike's information criterion (Akaike 1973, Anderson et al 1994, QAICc, Burnham and Anderson 2003). Parameters of the models define various patterns of mortality as follows:

- The global model: i.e., the fully parameterized model which is a time-saturated model with fishing and tag mortalities estimated annually and natural mortality estimated in two periods described below;

- Regulatory period models: three models parameterize mortalities as constant within time periods that are based on regulatory changes to the striped bass fishery between 1987 and 2011 (regulatory periods are explained in Table B8.2);

- Terminal and penultimate year models: versions of the regulatory period models that estimate mortalities separately for the terminal year or constant for the terminal and penultimate year.

There is evidence that natural mortality has increased within striped bass stocks in Chesapeake Bay (Kahn and Crecco 2006, Ottinger 2006, Panek and Bobo 2006, Pieper 2006, and Sadler et al. 2008). The increase in natural mortality has been linked to mycobacterial infections, but declining forage fish populations and water quality may also contribute.

In the 2009 assessment, the SBTS developed an approach for adapting the IRCR model to determine if a time scenario of two natural mortality periods would better fit the data for each of the coastal and producer area programs. When the constant M and two-M suite of models were run concurrently, the suite of two-M models were consistently given the highest weights, while the constant M models almost unanimously received zero weighting. Results of this analysis can be found in Appendix F of the 2011 Striped Bass Assessment Update. Based on these results, all programs run two M periods in their suite of IRCR models with the exception of the NY Trawl (Table B8.3).

B8.3.1 Assumptions and Structure of the Model

Jiang (2005) provided model assumptions based on an age-dependent IRCR. Assumptions are modified below for an age-independent IRCR model as follows:

1) the sample is representative of the target population;
2) lengths of individuals are correctly measured;
3) there is no tag loss;
4) tagging induced mortality is negligible;
5) the year of tag recovery is correctly tabulated;

6) all individuals behave independently;
7) all tagged fish within the length category have the same annual survival and recovery rates;
8) natural mortality rate does not vary by fish length; and
9) the tag reporting rate does not vary by fish length.

Similar to Hoenig et al. (1998), observed recovery matrices for the harvested, as well as caught and released fish, are compared to expected recovery matrices to estimate model parameters. The expected number of tag returns from harvested ($R_{i,y}$) and caught-and- released (R'_{iy}) fish follow a multinomial distribution so that the full likelihood is the product multinomial of the cells (Hoenig et al. 1998). Tagged fish are assumed to be fully recruited to the fishery.

The expected number of tag returns from fish tagged and released in year i and harvested in year y is:

$$\hat{R}_{i,y} = N_i \hat{P}_{i,y}$$

where:

N_i = the number of fish tagged and released in year i; and

$\hat{P}_{i,y}$ = the probability that a fish tagged and released in year i will be harvested and its tag reported in year y.

$\hat{P}_{i,y}$ is defined as:

$$\hat{P}_{i,y} = \begin{cases} \left(\prod_{v=i}^{y-1}\hat{S}_v\right)\left(1-\hat{S}_y\right)\dfrac{\hat{F}_y}{\hat{F}_y + \hat{F}'_y + M}\hat{\lambda}_h & (when\ y > i) \\[3ex] \left(1-\hat{S}_y\right)\dfrac{\hat{F}_y}{\hat{F}_y + \hat{F}'_y + M}\hat{\lambda}_h & (when\ y = i) \end{cases}$$

where

$S_y = e^{-\hat{F}_y - \hat{F}'_y - M}$,

and:

$\hat{F}'_y$ = instantaneous rate of fishing mortality on fish harvested in years y;

$\hat{F}'_y$ = instantaneous rate of fishing mortality on fish caught and released in years y;

$\hat{\lambda}_h$ = tag reporting rate given that a tagged fish is harvested; and

$\hat{S}_y$ = annual survival rate in year y for tags on fish alive at the beginning of year y.

B8.3.2 Model Diagnostics

Model adequacy is a major concern when deriving inference from a model or a suite of models. Over-dispersion, inadequate data (such as low sample size) or poor model structure may cause a lack of model fit. Over-dispersion is expected in striped bass tagging data, given that a lack of independence may result from schooling behavior.

The post-model adjustments of F and M for each program followed similar procedures previously used in the MARK modeling. Over-dispersion was corrected with a c-hat estimate calculated by dividing the pooled Pearson chi-square statistic by pooled degrees of freedom. The pooled Pearson chi-square was calculated by pooling expected cells (observed cells were pooled to match the expected cells) until the value was >2.

B8.4 Coast-wide Tagging Assessment

B8.4.1 Reporting Rate

The reporting rate used throughout these calculations is the proportion of recaptured fish whose tag is reported to the USFWS. Prior to this assessment, a constant value of 0.43 was used, based on a high-reward tag study conducted on the Delaware River stock (Kahn and Shirey 2000), but employing tag returns from the whole Atlantic coast. A high reward tagging study was conducted in 2007 and 2008 by the four producer area programs with the goal of estimating the current tag reporting rate for USFWS tags used in the striped bass tagging program. Data analysis revealed two major findings: tag reporting rate estimates varied widely by region of tag release and were dramatically different for commercial and recreational fishers. The results led the SBTS to conclude that it was no longer appropriate to use a single time-invariant tag reporting rate for all tagging programs. Rather, tag reporting rates would be calculated using the new information on fishery specific differences in tag reporting rate and regional differences in fishery composition. The method used to calculate current fishery sector-specific reporting rates allows for less than 100% of the high reward tags to be reported. This methodology (detailed in Appendix B9) contains additional sources of uncertainty that could influence the harvest and catch and release reporting rates used in the IRCR.

B8.4.2 Methods for Estimation of S, F and M

Estimates of survival, fishing mortality, tag mortality, natural mortality, and the associated standard errors from each IRCR run were calculated as a weighted average across all models and the corresponding variance was calculated as a weighted average of unconditional variances (conditional on the set of models) in an EXCEL spreadsheet. Estimates were provided for fish $\geq$ 18 inches (minimum size in Chesapeake Bay) and for fish $\geq$ 28 inches (minimum size standard for coastal fisheries).

Area fishing mortalities were calculated as mean values for the coastal and producer areas. Coastal F was calculated as the arithmetic mean of the coastal programs' values. The producer area F was calculated as a weighted mean of the producer area programs' values. The weights were based on each program area's proportional contribution to the coast-wide stock. The values are:

- Hudson (0.13);
- Delaware (0.09); and
- Chesapeake Bay (0.78), subweighted with MD (0.67) and VA (0.33).

Variance associated with the area mean F estimates were calculated as additive variances. The additive variance for the unweighted coastal mean F was calculated as:

$$\mathrm{var}(\bar{x}_{coast}) = \sum w_i^2 \, \mathrm{var}(\bar{x}_{state})$$

where:

$w_i = (1 \,/$ number of coastal programs; will be equal for each program);
$\mathrm{var}(\bar{x}_{state})$ = individual state's variance of mean F.

The additive variance for the weighted producer area mean F was calculated as:

$$\mathrm{var}(\bar{x}_{producer}) = \sum w_i^2 \, \mathrm{var}(\bar{x}_{state})$$

where:

$w_i = 0.09$ for Delaware;
$w_i = 0.13$ for Hudson;
$w_i = 0.78$ for Chesapeake Bay; with 0.67 for Maryland and 0.33 for Virginia;
$\mathrm{var}(\bar{x}_{state})$ = individual state's variance of the mean F.

95% confidence intervals were subsequently developed for each area's F.

The coast-wide fishing mortality was calculated as the arithmetic mean of the coastal and producer area means. No associated variance was calculated.

B8.4.2 Methods for Estimation of Stock Size

Stock size was estimated for fish $\geq$ 18 inches TL, corresponding roughly to 3-year-old and older striped bass and for fish $\geq$ 28 inches TL, corresponding roughly to 7-year-old and older fish. Estimates were developed using the IRCR model results for F and a form of Baranov's catch equation:

average stock size = catch / F

Since F was based on an exploitation rate that included discard mortality from released fish, total catch was used.

B8.5 Coast-wide Results and Discussion

B8.5.1 Data

The data inputs for the IRCR model are the observed recovery matrices from harvested fish and released fish (Appendix B9). The number of twice-recaptured fish was examined to ensure that this phenomenon did not cause a bias in model results. Of 91,440 recaptured fish in the database, only 3,455 fish were recorded as twice recaptured. Since this was less than 5%, it was considered inconsequential. Datasets used in the analyses included only first recapture events.

Length frequencies (mm total length at the time of tagging) of fish tagged in 1987 through 2011 were tabulated by program (Table B8.4). The majority (83%) of tagged coastal fish ranged from 450-799 mm while the majority (55%) of producer area tagged fish ranged from 450-649 mm. More fish ≥ 800 mm were tagged by the producer areas (20%) than the coastal areas (11%).

Age distributions of fish released during the entire time series and recaptured in 2011 were tabulated by program (Table B8.5). Ages are based on a subsample of the total number of tagged fish since all programs do not age all tagged fish. Ages are read from scales taken at time of tagging. Coastal ages ranged from 3 to 19 and producer area ages ranged from 2 to 19 years.

Geographic distributions of recaptures from fish tagged and released during the full time series were organized by state and month for each tagging program (Table B8.6). Striped bass tagged in the coastal programs were primarily recaptured in May through July along the Northeast coast. The recaptures generally shift south from their areas of release starting in October. Fish tagged by all of the coastal programs, other than New York, predominantly have recaptures in New Jersey and south through the fall and winter.

Striped bass tagged by the producer area programs were a mixture of resident and migratory stocks. Thus, resident striped bass were most often recaptured in the producer area where they were tagged and recaptured there year-round (i.e. Maryland and Virginia fish were recaptured in Chesapeake Bay, DE/PA fish were recaptured in New Jersey and Delaware, and HUDSON fish were recaptured in New York). The migratory component tagged in the producer areas followed similar patterns as were observed in the coastal programs with recaptures in New England in summer and North Carolina in winter.

B8.5.2 Reporting Rates

Fishery sector-specific tag reporting rates were estimated to be 0.11, 0.85 and 0.55 for commercial fishers, recreational fishers and unidentified fishers, respectively (Appendix B9). Separate, annual harvest and catch and release tag reporting rates were calculated by estimating fishery composition for each fish disposition (harvest or catch and release). Year specific tag reporting rates were highly variable and required further data aggregation (Table B8.21).

Annual variability in tag reporting rate estimates resulted from a combination of sampling error and real differences in the annual fishery composition. Tag returns for most of the programs have been historically low and have continued to decline in recent years. Use of a three year moving

average was implemented to smooth the estimated time series of tag reporting rates in order to better capture the temporal trends in fishery composition and tag reporting rate (Table B8.21).

A single time series of rates was used for the coastal program because preliminary analysis produced very similar results for the individual coastal tagging programs of Massachusetts (MADFW), New Jersey/Delaware Bay (NJDB), New York (NYTRL), and North Carolina (NCCOOP). It was originally determined that each producer area program would generate a separate time series of harvest and catch and release tag reporting rates but results were noisy, due primarily to low sample sizes tied to a severe lack of tagging study cooperation from the commercial fishing sector. Data from Virginia (VARAP), Maryland (MDCB) and Delaware (DE/PA) were pooled to boost sample size because these three regions all have significant exposure to commercial fisheries and the time series trends of their individual tag reporting rates showed similar patterns (Figure B8.6). The New York producer area program (HUDSON) used reporting rates generated from their own tagging data because their data showed an opposite trend for the catch and release reporting rate (Table B8.22).

Tag reporting rates are known to have asymmetric errors, such that even small errors in our ability to estimate fishery sector-specific tag reporting rates are propagated into large errors in the harvest and catch and release tag reporting rate estimation. The fishery sector-specific estimates obtained are dependent on the assumptions of recreational high reward tag reporting rate as well as the weighting scheme used to estimate commercial recoveries, both of which could be incorrectly specified. This represents a significant source of error especially surrounding the commercial tag reporting rate since it is so low. Second, extrapolation of estimates of tag reporting rate through time can introduce two other potential sources of error. Behavior of the fishery sectors to tagging studies may change and the composition of the fishery may change. The method described above allows for the latter source of uncertainty, changes in the composition of the fishery, to be accounted for during extrapolation. Changes in behavior of the fishery sectors cannot be accounted for, however, and would require the use of periodic high reward tagging studies to re-estimate the fishery sector-specific tag reporting rates.

To investigate the affects of using reporting rate that is too high on estimates of S, F and M, sensitivity runs were conducted using Maryland fish $\geq$ 18 inch data from 2000 to 2011, the years that correspond to the new reporting rates. Harvest and catch and release reporting rates were reduced by 10%, 25% and 50% in the IRCR. Results from fish $\geq$ 28 inches were similar and are not presented.

B8.5.3 Model Diagnostics

The Akaike weights assigned to the candidate models are presented in Table B8.7 for fish $\geq$ 28 inches and fish $\geq$ 18 inches. For fish $\geq$ 28 inches multiple models were averaged for every program except MADFW, NJDB and DE/PA. The weighting of the coastal programs was typically dominated by the regulatory period F models while the producer programs were dominated by the terminal years F models.

Model selection for fish ≥ 18 inches differed from the ≥ 28 inch fish for most programs with the exception of MADFW, VARAP, HUDSON and DE/PA. Predominate weight of one model occurred in all but NCCOOP, HUDSON and DE/PA.

B8.5.4 Exploitation Rates

The exploitation rates for fish ≥ 28 inches are presented by program and as an unweighted coast-wide mean (Table B8.8). The 2011 estimates of exploitation ranged from a maximum of 0.18 (NCCOOP) down to 0.06 (MADFW). While exploitation rates reached peak levels between 1997 and 2000, depending on the program, annual estimates of exploitation rates since then have declined for every program. The unweighted coast-wide mean peaked in 1997 at 0.26 but has also declined since then. The 2011 overall coast-wide mean exploitation rate was 0.11, which has remained constant since 2007. The MADFW estimates tended to be the lowest among the tagging programs, while the exploitation rates were generally higher in the producer areas.

The average exploitation rates for fish ≥ 18 inches (Table B8.9) were slightly lower than those for fish ≥ 28 inches, ranging from 0.05 (NYOHS/TRL) to 0.17 (NCCOOP). The interannual pattern of the exploitation estimates were similar to the ≥28 inch estimates, generally declining from a peak mean coast-wide exploitation rate of 0.14 in 1997. The 2011 mean rate of 0.09 was a slight increase from the 2010 rate. As with the ≥28 inch fish, the exploitation rates were generally higher for the producer area programs located in the Chesapeake and Delaware Bays than in the other tagging programs.

B8.5.5 Survival Rates

The 2011 estimates of survival produced by the IRCR model for striped bass ≥ 28 inches ranged from 0.62 (NCCOOP) to 0.90 (NYTRWL) among the coastal programs (Tables B8.10 and B8.12). The unweighted average of these survival estimates was 0.74 and has varied from 0.66-0.74 since 2000. The 2011 survival estimates for the producer areas ranged from 0.60 (VARAP) to 0.67 (DE/PA). The 2011 weighted average was 0.64, similar to annual survival rates since 2001 which have only ranged from 0.63-0.66.

The 2011 estimates of survival for striped bass ≥ 18 inches ranged from 0.54 (NCCOOP) to 0.73 (MADFW) among the coastal programs (Tables B8.11 and B8.13). The unweighted average of these survival estimates was 0.63 and is consistent with previous years' estimates which have varied from 0.63-0.68 since 2000. The 2011 survival estimates for the producer areas ranged from 0.53 (VARAP) to 0.64 (HUDSON) and the weighted average of 0.57 has varied from only 0.55-0.58 since 2000.

In previous assessments, the program MARK was used to estimate S. We have included MARK estimates of S for comparison to IRCR estimates. For this comparison, three models were parameterized in MARK: s(t) r(t), s(p6) r(t), and s(last2) r(p6), and results are provided in Tables B8.14 and B8.15, Figures B8.1 and B8.2. The results from MARK and IRCR were comparable for the ≥ 18 inch and ≥ 28 inch fish.

The SAS converted the tagging estimates of S to Z and compared them to output from the SCA model (Figure B7.20). Results were similar from the two approaches indicating that the total mortality estimates from the IRCR are reliable. Producer area Z estimates were higher than the SCA estimate, and coastal program Z estimates were lower than the SCA. Producer area means are weighted heavily towards Chesapeake Bay, so these higher estimates are reasonable, with increased natural mortality noted in other studies (Kahn and Crecco 2006, Ottinger 2006, Panek and Bobo 2006, Pieper 2006, and Sadler et al. 2008).

The 2011 estimates of Z for fish $\geq$ 28 inches were 0.30 for the coastal tagging programs and 0.45 for the producer area programs. Values increased for fish $\geq$ 18 inches to 0.46 for the coastal programs, which was the highest of the time series, and 0.56 for the producer area programs. Overall, Z showed an increasing trend during the time series for all fish in both programs, but the increase was not as strong for the $\geq$ 28 inch coastal fish as in the other programs. (Figures B8.8 and B8.9).

Due to concerns with the reporting rates described previously, sensitivity runs were conducted with varying reductions in reporting rates. S and Z estimates were minimally affected by reductions in reporting rate, even if the true reporting rate was 50% lower (Figure B8.10). These sensitivity runs demonstrate that the estimates of S and Z are fairly robust to misestimation of reporting rate.

B8.5.6 Fishing Mortality

The 2011 estimates of F for fish $\geq$ 28 inches among the coastal area programs ranged from 0.10 (NYTRWL) to 0.15 (NJDB and NCCOOP) for an unweighted average F of 0.13 (Tables B8.10 and B8.16). The average annual estimate of F peaked at 0.23 in 1998, but has only varied between 0.12-0.16 since 2000. The 2011 F estimates for the producer area programs ranged from 0.06 (VARAP) to 0.18 (DE/PA) with a weighted average of 0.11. The producer area estimates of F were influenced by the regulatory period models. The highest levels of fishing mortality were estimated in the late 1990's after the stock was declared recovered and have been declining beginning in 2000 (Figure B8.3).

The 2011 estimates of F for fish $\geq$ 18 inches among the coastal areas showed little variation, ranging from 0.11 (MADFW) to 0.15 (NCCOOP) for an unweighted average of 0.13 (Tables B8.11 and B8.17). The average F value varied without trend ranging from 0.09 to 0.13 since 1995. The estimates of F for the producer area programs showed more variation, ranging from 0.04 (VARAP) to 0.12 (MDCB) for a weighted average of 0.10. Since the reopening of many of the fisheries in 1991, the average F increased, peaking in value (0.21) in 1998. It has declined since then and varied without trend between 0.10 and 0.15 since 2000 (Figure B8.4).

The SBTS thinks that some estimates of F are unrealistically low (0.06, 0.04 VARAP) when other stock indicators, such as harvest, are considered. The sensitivity runs demonstrated that reporting rate greatly influenced the partitioning of Z into F and M, in a non-linear fashion. When reporting rate is reduced by 10%, Maryland tagging data showed, on average, an 11% increase in F. When reporting rate was reduced by 50%, the F estimate doubled, on average (Figure B8.11). Due to the uncertainty of these estimates, they should be viewed with caution.

B. Striped bass

B8.5.6 Natural Mortality

The 2011 average estimates of natural mortality were all well above the value of 0.15 used in the previous methods. For fish ≥ 28 inches, the weighted average from producer area programs was 0.34 and the unweighted average from coastal programs was 0.24 (Tables B8.10 and B8.18). Coastal programs estimates ranged from 0.19 (MADFW) to 0.32 (NCCOOP). Estimates from the NYTRWL were unrealistically low (0.01) and were not included in the coastal average. This is likely due to the short time series for the trawl survey and low sample sizes compared to previous years, particularly for fish ≥ 28 inches. The range of M values from the producer area programs was 0.21 (DE/PA) to 0.45 (VARAP). These mortality estimates were higher for the Chesapeake Bay programs (VARAP and MDCB) where mycobacteriosis is believed to be most prevalent.

Average natural mortality estimates for fish ≥ 18 inches were higher than the ≥ 28 inches for both the coastal and the producer area programs (Tables B8.11 and B8.19). The unweighted average for the coastal programs was 0.34 and the weighted average M for the producer areas was 0.46. Estimates from the coastal programs ranged from 0.20 (MADFW) to 0.46 (NCOOP) and producer area estimates were from 0.32 (HUDSON) to 0.59 (VARAP). As with the fish ≥ 28 inches, the highest natural mortality estimates were from the Chesapeake Bay producer area programs.

The values of M in the second natural mortality period for both size groups are much higher than the previously assumed, biologically based value of M=0.15. While the large inter-period variation and large estimates of M should be viewed with caution, the fact that all of the tagging programs show an increase in M between periods suggests that M has increased in the stock. However, the magnitude of the inter-period variation could be affected by a misestimation of reporting rate. Sensitivity runs using Maryland data showed that a 10% reduction in reporting rate decreased the M estimate by 5%. The 50 % reduction resulted in a 40% decrease in M (Figure B8.12).

B8.5.7 Stock Size

The stock size estimates for fish ≥ 28 inches (age 7+) steadily increased from 11 million fish in 2000 to a peak of 19.3 million fish in 2007 (Table B8.20 and Figure B8.5). The 2011 estimate of stock size was 19.1 million fish which was the second highest of the time series. The stock size estimates for fish ≥ 18 inches (age 3+) exhibited a rapid increase from 38.6 million fish in 2000 to a peak of 54.9 million fish in 2007. Estimates decreased annually through 2010 but the 2011 estimate showed a slight increase to 35.7 million fish.

B8.6 Chesapeake Bay Tagging Assessment

Amendment 6 implemented a separate management program for the Chesapeake Bay due to the size availability of striped bass in this area. It also specified a separate fishing mortality target of 0.27 (ASMFC 2003). The striped bass fishery in Chesapeake Bay exploits the pre-migratory/resident striped bass population that consists of smaller fish (TL < 28 inches), mostly ages 3 through 6. Fishing mortality in Chesapeake Bay was calculated using data from the same Maryland and Virginia tagging programs described above. The migration rates reported by Dorazio et al. (1994) suggest that striped bass between 18 and 28 inches TL are predominantly resident fish. Maryland data have shown that males comprise 80-90% of the resident fish population. Therefore, the data were limited

to male striped bass between 18-28 inches TL that were recaptured within Chesapeake Bay to estimate fishing mortality on resident fish.

B8.6.1 Methods for Estimation of F, M and S

Fishing mortality, natural mortality, and survival rates for resident striped bass in Chesapeake Bay was estimated using the same IRCR methods previously described. Prior to conducting the analysis, release and recapture data from Maryland and Virginia were combined to produce Baywide harvest and release input matrices for the IRCR (Appendix B9) and estimate a Baywide exploitation rate.

B8.6.2 Reporting Rate

Two high-reward tagging studies have been conducted in the Chesapeake Bay to determine a Bay-specific reporting rate. In 1993, a rate of 0.75 was estimated by Rugolo et al. (1994). The study was repeated in 1999 and resulted in a slightly lower estimate of 0.64 (Hornick et al. 2000). The value of 0.64 is used for the Chesapeake Bay analysis because it is the most recent area-specific value. Due to low sample sizes, a new Chesapeake Bay-specific reporting rate could not be calculated from the 2007-2008 high reward tagging study.

B8.6.3 Chesapeake Bay Results and Discussion

B8.6.3.1 Model Diagnostics

The Akaike weights assigned to the candidate models from the IRCR for Maryland and Virginia data combined are presented in Table B8.23. The global model received all the weight for Chesapeake Bay fish, which has been consistent over time.

B8.6.3.2 Exploitation Rates

Exploitation rate estimates for the Chesapeake Bay resident fish have remained relatively stable throughout the time series (Table B8.24). The 2011 exploitation rate was 0.08 which was an increase from the 2010 estimate.

B8.6.3.3 Survival Rates

The Baywide survival estimate for 2011 was 0.40 (Table B8.25). The estimates show a general decline over the time series, but have been fairly stable since 1997, ranging from 0.39 to 0.42.

Three models were run in the program MARK as a check for the survival estimates from IRCR. The IRCR results were comparable to those from MARK for the 18-28 inch fish for most of the time series, however the IRCR survival estimates were slightly higher for the past few years (Table B8.26 and Figure B8.7).

B8.6.3.4 Fishing Mortality

Baywide estimates of F were all below the target value of 0.27. Fishing mortality increased from near-zero values during the moratorium period to 0.13 in 1992, peaked at 0.16 in 1998, and then declined to 0.05 in 2010. The 2011 estimate of F for the Chesapeake Bay was 0.09 (Table B8.25).

These low values of F in recent years are not consistent with the high levels of harvest in the Chesapeake Bay. The assumption that 18-28 inch males are all resident fish may be incorrect. If the fish are emigrating from the Bay at a smaller size and the tags are not recovered or not used in the analysis, the emigration will result in an over-inflated estimate of natural mortality. This in turn will lead to an underestimated fishing mortality, as will an overestimation of the reporting rate.

B8.6.3.5 Natural Mortality

The Baywide estimate of natural mortality for 2011 was 0.82 (Table B8.25). Estimates of natural mortality for Chesapeake Bay fish increased from 0.26 during the first mortality period (1987-1996) to 0.82 during the second mortality period (1997-2011). Both values are substantially higher than the previously assumed, biologically based value of M=0.15. Very large inter-period variation and large estimates of M are not biologically reasonable and should be viewed with caution. Although the values of M for recent years seem excessively high, the overall trend of increasing M is supported by some field observations and the results of the two-period M models by all of the other coastal programs.

B8.7 Sources of Uncertainty in Instantaneous Rates Model

The instantaneous rates approach is a reparameterization of the Brownie models. It has the advantage that it explicitly links the tag recovery rate (f), and annual survival (S) parameters. In the Brownie models, these are allowed to vary independently so that, from one year to the next, the tag recovery rate and the survival rate can both go up. This is unreasonable if the tag reporting rate and the natural mortality rate are constant. An increase in f, and thus exploitation rate, should be accompanied by a decrease in the survival rate, unless the reporting rate or natural mortality rate has changed. In the instantaneous rates model, one specifies the tag reporting rate and estimates F and M, or one specifies that M is constant and estimates F and the reporting rate.

It should be noted that the reporting rate is used mainly to apportion the total mortality into its F and M components. Hence, a modest misestimation of the reporting rate leads to little error in the estimated total mortality, but has a large effect on estimates of F and M. Other factors that may be affecting our tag reporting rates include issues with tag quality, angler fatigue, and commercial reporting. In recent years, members of the SBTS have reported a decline in tag quality, with tags becoming illegible. Angler fatigue may also be an issue as the tagging program has been in effect since 1987 with no change in the reward. Lastly, the number of reported tags has been declining, particularly in the commercial sector. The tagging assessment would benefit from exploring ways to increase commercial cooperation with the tagging programs.

The IRCR model contains the following assumptions:

- The sample is representative of the target population;
- Lengths of individuals are correctly measured;
- There is no tag loss;
- Tagging induced mortality is negligible;
- The year of tag recoveries is correctly tabulated;
- All individuals behave independently;
- All tagged fish within the length category have the same annual survival and recovery rates;
- Natural mortality rate does not vary by fish length; and
- The tag reporting rate does not vary by fish length.

There is a general consensus in the SBTS that effects of potential violations of model assumptions are minor. Reported rates of tag-induced mortality are low (0%, Goshorn et al. 1998; 1.3% Rugolo and Lange 1993). Reported rates of tag loss are also quite low (0% by Goshorn et al.1998, 2% by Dunning et al. 1987, and 2.6% by Sprankle et al. 1996), but members of the SBTS feel it should be reevaluated with more up-to-date data.

Other sources of uncertainty include the calculation of the 95% confidence intervals and the weighting of models each year. The confidence intervals for the area F estimates were calculated without inclusion of the covariance terms which could not be estimated from these data. However, though the magnitude of these terms was unknown, they were assumed to be negligible. In addition, the IRCR may choose and weight the candidate models differently each year as that year's data are added to the recovery matrices.

B9.0 Update or redefine biological reference points (BRPs; point estimates or proxies for B$_{MSY}$, SSB$_{MSY}$, F$_{MSY}$, MSY). Define stock status based on BRPs. (TOR#5)

B9.1 History of Current Reference Points

In the early 1990s, the status of Atlantic striped bass stocks was determined using annual tag-based estimates of survival and the associated fishing mortality. Fishing mortalities that produced a sustainable population were estimated in simulation models developed by Rago and Dorazio, as well as Crecco, and described in the Amendment 4 source document (ASMFC 1990). Subsequent to Amendment 4, a relative index of spawning stock biomass was developed using a forward projecting model of age-0 recruits as determined by the time series of MD juvenile indices (ASMFC 1998). The SSB index served as the basis for developing a biomass threshold for evaluation of the stock rebuilding status. The SSB index increased to a level comparable to historic abundance in the 1960s and consequently, in 1995 striped bass was declared restored. The modeling approach used for the SSB index also served as the basis for the Crecco model for biological reference points, specifically Fmsy (ASMFC 1998). The model applied a combination of minimum sizes (20" in producer areas and 28" on the coast) to define full recruitment to the fisheries. The biological reference point of Fmsy = 0.40 was adopted in Amendment 5 and a target F of 0.31 was established with a subsequent addendum to the FMP. A lower target F of 0.28 for the producer areas was derived based on equivalent SSB/R when the jurisdictions requested a reduction in their minimum size limit from 20 to 18 inches. These values were compared against annual tag based estimates of F for determination of stock status.

In 1997, the ASMFC Technical Committee adopted the results of a VPA model as the method for determination of stock status. Average F was calculated for the ages at full recruitment with age at full F based on the distributions of ages in the catch. The fully recruited F was defined as ages 4–13. Comparisons were made to target F (and F$_{MSY}$) which were products of the Crecco model.

In 2003, the ASMFC adopted Amendment 6 to the Striped Bass FMP. As part of the amendment, new biological reference points (SSB$_{Target}$, SSB$_{Threshold}$, F$_{target}$, and F$_{threshold}$) were established. F$_{MSY}$, estimated using a Shepherd/Sissenwine model, was adopted as F$_{Threshold}$. An exploitation rate of 24%, or F=0.30 was chosen as F$_{Target}$. Target F for the producer area, Chesapeake Bay, was reduced proportionately to 0.27. 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. SSB$_{Target}$ (17,500 mt) was 25% greater than SSB$_{Threshold}$. No biomass targets were chosen specifically for Chesapeake Bay.

These biological reference point definitions were maintained for the 2007 assessment. Point estimates of SSB$_{Target}$ and SSB$_{Threshold}$ were calculated from the SCA model and updated in 2008. The female SSB threshold equals 36,000 mt with a target SSB of 46,101 mt.

The estimate for F$_{MSY}$ was derived using the results of the 2007 assessment, updated in 2008, in which four stock-recruitment models were considered; a Ricker, a lognormal Ricker model, a Shepherd and a lognormal Shepherd model. The TC used a model averaging approach among the four results, producing an estimate of F$_{MSY}$ = 0.34 (range of 0.28-0.40). The F target remained the 24% exploitation rate, F=0.30.

B9.2 Updated Biological Reference Points

The SA committee explored a number of different reference point models. These included YPR/SPR-based estimates for F_{MSY} and SSB_{MSY} (per Gabriel *et al.* 1989), using both a Beverton-Holt and a Shepherd stock-recruitment curve, with and without bias-correcting the recruitment estimates. In addition, SPR-based reference points for F ($F_{30\%}$ and $F_{40\%}$) were calculated.

The type of stock recruitment model chosen in the SCA model as well as the use of the bias correction had significant influence on the biological reference points. An examination of the sensitivity to these factors resulted in a range of values. The Beverton-Holt model without bias correction resulted in a slightly higher estimate of F_{MSY} but a significant decrease in SSB_{MSY} compared to the estimates generated with the bias correction. Similarly if a Shepherd stock-recruitment model with bias correction is chosen, the resulting F_{MSY} is much higher, on par with the current $F_{Threshold}$ estimate. However, if the bias correction is not imposed, F_{MSY} is lower, closer to the Beverton-Holt based estimates. The associated SSB_{MSY} for the Shepherd model with bias correction is approximately half as much as the Beverton-Holt based estimate with bias correction, while the Shepherd model without bias correction was slightly higher than the Beverton-Holt based estimate without bias correction.

The SSB_{MSY} estimate from the Beverton-Holt model with bias correction was also evaluated using a long term projection of the SCA model results at F_{MSY}. Over a 50 year projection the population SSB should reach an equilibrium value equivalent to SSB_{MSY}. The average for a 50 year projection using recruitment randomly selected from the bias corrected stock recruitment model was equivalent to SSB_{MSY}. However, if the empirical recruitment estimates were sampled, the equilibrium SSB was considerably lower. A much lower F_{MSY} as required to produce the appropriate SSB using empirical recruitment values.

Because of the sensitivity to the stock-recruitment model, an alternative approach to link the target and threshold F with the historical proxies for target and threshold SSB was developed. Using a stochastic projection drawing recruitment from empirical estimates and a distribution of starting population abundance at age, fishing mortality associated with the SSB target and threshold were determined. Empirical estimates of recruitment, selectivity, and the starting population came from the SCA model results. Selectivity was calculated as the geometric mean of the last five years of total F at age, scaled to the highest F at age. Estimates of recruitment were restricted to 1990 and later, when the stock was considered restored but not fully rebuilt.

See Appendix B11 for more analyses on this topic requested by the SARC panel at the review.

Estimates of SSB_{1995} from the SCA model were quite consistent across runs with different recruitment functions. The base model estimate results in an $SSB_{Threshold} = SSB_{1995} = 57,904$ mt and an $SSB_{Target} = 125\% \, SSB_{1995} = 72,380$ mt. The projected F to maintain $SSB_{Threshold} = F_{Threshold} = 0.213$, and the projected F to maintain $SSB_{Target} = F_{Target} = 0.175$.

B9.3 Stock Status

Stock status of Atlantic striped bass in 2012 was not overfished or experiencing overfishing under the updated reference points in this assessment. Female spawning stock biomass was estimated at 61.5 thousand mt, above the SSB threshold of 57,904 mt, but below the SSB target of 72,380 mt (Figure B9.1). Total fishing mortality was estimated at 0.188, below the F threshold of 0.213 but above the F target of 0.175 (Figure B9.2).

When compared to the biological reference points currently used in management (ASMFC 2011), the stock is neither overfished nor experiencing overfishing. Female SSB is above both the target (46,101 mt) and the threshold (36,000 mt), and F is below both the target (0.30) and the threshold (0.34).

B. Striped bass

B10.0 Provide numerical annual projections. Projections should estimate and report annual probabilities of exceeding threshold BRPs for F and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach covering a range of assumptions about the most important sources of uncertainty (TOR #6).

B10.1 Female Spawning Stock Biomass

Five-year projections of female spawning stock biomass (SSB) were made by using a population simulation model written in R.   The model projection began in year 2012 and abundance-at-age data with associated standard errors, total fishing-at age, Rivard weights, natural mortality, female sex proportions-at-age, and female maturity-at-age from the model input/output for 2012 were used to parameterize the model and calculate SSB using the abundance and spawning stock biomass equation given in the model structure portion of this document (Section B7.0). For the years greater than 2012, the algorithm in Figure B10.1 was used to project SSB. Total fully-recruited fishing mortality was first specified and multiplied by the average selectivity derived from the average F-at-age values from 2010-2012.   This F-at-age vector is used to project the population in the remaining years.

For each iteration of the simulation, the abundance-at-age in 2012 is first randomly drawn from a normal distribution parameterized with the 2012 estimates of January-1 abundance–at-age and associated standard errors from the stock assessment model, and spawning stock biomass is calculated. For the remaining years, abundance of age 1 recruits is randomly generated using the estimated stock-recruitment Beverton-Holt relationship and applying log-normal errors or using an empirical probability density function created from recruits (1990-2012) per spawning biomass (198-2011) from which random recruits per spawning biomass values are drawn. Abundance-at-age >1 are then calculated using fishing mortality-at-age and natural mortality-at-age for year *y-1* and age *a-1*. An age 13 plus-group was assumed. Female spawning stock biomass is calculated by using average Rivard weight estimates from 2010-2012, sex proportions-at-age, and female maturity-at-age. Each year's SSB estimate is stored in a file and the whole procedure is repeated for the specified number of iterations.

or each year of the projection, the probability of SSB going below the SSB reference point was calculated using SSBs from all iterations of the simulation and an algorithm used to approximate equation 2 in Shertzer et al. (2008). This equation was used to incorporate the associated error of the projected SSB and the associated error of the SSB reference point (1995 value in SCA model). Several F scenarios were investigated.   For years >2012, simulations were performed using the current fully-recruited F, $F_{threshold}$ reference point (=0.213), F_{target} (=0.175), F=0.15, and F=0.10.

The sensitivity of the projection results to differences in the S-R relationship were investigated by using the estimated stock-recruitment Beverton-Holt relationship with random error or using the empirical approach in which R/SSB ratios are re-sampled (and multiplied against SSB in the previous year to get recruitment). The former method assumes the recruitment follows the defined Beverton-Holt relationship, and the latter assumes that the distribution of the R/Bs ratio is stationary and independent of stock size.

In addition, the striped bass management board requested projections that examine the potential impact of increased natural mortality due to Mycobacterium. Projections were made using the full 1990-2012 recruitment time series and the empirical distribution method but 0.12 was added to the natural mortality estimate for ages 3-8.

B10.1.1 Beverton-Holt Stock Recruitment Relationship

If the current fully-recruited F (0.188) is maintained during 2013-2017, the probability of being below the SSB reference point increases to 0.76 by 2015 (Figure B10.2). After 2016, the probability is expected to decline. If the fully-recruited F increases to the current F threshold (0.213) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.89 by 2015 and declines thereafter (Figure B10.2). If fully-recruited F decreases to the F target (0.175) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.68 by 2015 and declines thereafter (Figure B10.2). If fully-recruited F increases to the old Fmsy threshold (0.34) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches a maximum of 0.96 by 2014 and 1.0 thereafter (Figure B10.2). If the fully-recruited F decreases to 0.15 and is maintained during 2013-2017, the probability of being below the SSB reference point reaches a maximum of 0.46 by 2015 and declines thereafter (Figure B10.2). If the fully-recruited F decreases to 0.10 and is maintained during 2013-2017, the probability of being below the SSB reference point reaches a maximum of 0.40 in 2013 and declines thereafter (Figure B10.2).

B10.1.2 Empirical Recruits/SSB ratios

The empirical approach produced results nearly identical to the results obtained using the Beverton-Holt S-R relationship.   If the current fully-recruited F (0.188) is maintained during 2013-2017, the probability of being below the SSB reference point increases to 0.75 by 2015 (Figure B10.3). After 2016, the probability is expected to decline. If the current fully-recruited F increases to F threshold (0.213) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.91 by 2015 and declines thereafter (Figure B10.3). If the fully-recruited F decreases to the current F target (0.175) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.66 by 2015 and declines thereafter (Figure B10.3). If the fully-recruited F increases to the old Fmsy threshold (0.34) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.96 by 2014 and 1.0 thereafter (Figure B10.3). If the fully-recruited F decreases to 0.15 and is maintained during 2013-2017, the probability of being below the SSB reference point reaches a maximum of 0.45 by 2015 and declines thereafter (Figure B10.3). If the fully-recruited F decreases to 0.10 and is maintained during 2013-2017, the probability of being below the SSB reference point reaches a maximum of 0.40 in 2013 and declines thereafter (Figure B10.3).

B10.1.3 Delaying a Decrease in F

To prevent the SSB from dropping below the SSB reference point, a reduction in the fully-recruited F would be required. Based on the above analyses, decreasing the average F to about 0.15 (about 20%) starting in 2013 would allow the SSB from remain above or equal to the SSB reference point with Pr(SSB≤SSBref)≤ 0.50. However, because this stock assessment will not be available until the end of 2013, any regulatory action will be delayed until 2014.

To investigate the impact of this delay, the methods described above using the empirical distribution were used. In the first run, the fishing mortalities-at-age for 2013 were set equal to 2012 and then fishing mortalities-at-age for corresponding the fully-recruited F =0.15 were applied to years 2014-2017. In the second run, the fishing mortalities–at-age for 2013 and 2014 were set equal to 2012 and then fishing mortalities-at-age for corresponding the fully-recruited F =0.15 were applied to years 2015-2017.

The impact of delaying a reduction in F until 2014 is shown in Figure B10.4. By delaying action until 2014, the probability of SSB being below the SSB reference is 0.59 in 2014 and 0.63 in 2015 (Figure B10.4) compared to 0.42 for 2014 and 0.45 for 2015 if the reduction of F started in 2013 (Figure B10.2 or B10.3). Even if F in 2014 was reduced to zero, the probability of SSB in 2014 being below the SSB reference point would decline to only 0.52, but it would drop precipitously in the following years as SSB grows rapidly (Figure B10.4).

For delaying action until 2015, the probability of SSB being below the SSB reference is 0.59 for 2014 and 0.76 for 2015 (Figure B10.5) compared to 0.42 for 2014 and 0.45 for 2015 if the reduction of F started in 2013 (Figure B10.2 or B10.3). Even if F in 2015 was reduced to zero, the probability of SSB in 2015 being below the SSB reference point would decline to only 0.71, but it would drop precipitously in the following years as SSB grows rapidly (Figure B10.5).

B10.1.3 Projections using Short-term Recruitment Series (2002-2012)

To investigate the potential impact of low recruitment on the result of the projections, the analyses in section B10.1.2 using the empirical recruits/SSB ratios method were repeated using a shorter time series (2002-2012). If the current fully-recruited F (0.188) is maintained during 2013-2017, the probability of being below the SSB reference point increases to 0.75 by 2015 (Figure B10.6). After 2016, the probability is expected to decline. If the current fully-recruited F increases to F threshold (0.213) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.93 by 2016 and declines thereafter (Figure B10.6). If the fully-recruited F decreases to the current F target (0.175) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.66 by 2015 and declines thereafter (Figure B10.6). If the fully-recruited F increases to the old F_{MSY} threshold (0.34) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.96 by 2014 and 1.0 thereafter (Figure B10.6). If the fully-recruited F decreases to 0.15 and is maintained during 2013-2017, the probability of being below the SSB reference point reaches a maximum of 0.47 by 2015 and declines thereafter (Figure B10.6). If the fully-recruited F decreases to 0.10 and is maintained during 2013-2017, the probability of being below the SSB reference point reaches a maximum of 0.40 in 2013 and declines thereafter (Figure B10.6).

B10.1.4 Increasing M on ages 3-8

If the current fully-recruited F (0.188) is maintained during 2013-2017, the probability of being below the SSB reference point increases to 0.89 by 2014 and near 1 thereafter (Figure B10.7). If the current fully-recruited F increases to F threshold (0.213) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.90 by 2014 and near 1.0 thereafter (Figure B10.7). If the fully-recruited F decreases to the current F target (0.175) and is maintained

during 2013-2017, the probability of being below the SSB reference point still reaches 0.90 by 2014 and near 1.0 thereafter (Figure B10.7). If the fully-recruited F increases to the old Fmsy threshold (0.34) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.90 by 2014 and 1.0 thereafter (Figure B10.7). If the fully-recruited F decreases to 0.15 and is maintained during 2013-2017, the probability of being below the SSB reference point still reaches 0.90 by 2014 but declines slightly thereafter (Figure B10.7). If the fully-recruited F decreases to 0.10 and is maintained during 2013-2017, the probability of being below the SSB reference point still reaches 0.90 by 2014, but it declines through 2017 to 0.82 (Figure B10.7).

B10.1.5 SARC Additional Analyses

Reviewers of the stock assessment recommended that the Beverton-Holt non-bias-corrected equation be used in place of the bias-corrected B-H equation. In addition, they recommended that only recruitment empirical data be used (instead of the R/SSB ratios) in order to keep the data consistent with the projection method used to develop the $F_{Threshold}$ reference points. The above analyses are repeated in the following section. Results did not different greatly from the approaches used above.

B10.1.5.1 Non-bias-corrected Beverton-Holt Stock Recruitment Relationship

If the current fully-recruited F (0.188) is maintained during 2013-2017, the probability of being below the SSB reference point increases to 0.74 by 2015 (Figure B10.8). After 2016, the probability is expected to decline. If the fully-recruited F increases to the current F threshold (0.213) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.93 by 2015 and declines thereafter (Figure B10.8). If fully-recruited F decreases to the F target (0.175) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.61 by 2015 and declines thereafter (Figure B10.8). If fully-recruited F increases to the old Fmsy threshold (0.34) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches a maximum of 0.93 by 2012 and 1.0 thereafter (Figure B10.8). If the fully-recruited F decreases to 0.15 and is maintained during 2013-2017, the probability of being below the SSB reference point reaches a maximum of 0.30 by 2015 and declines thereafter (Figure B10.8). If the fully-recruited F decreases to 0.10 and is maintained during 2013-2017, the probability of being below the SSB reference point reaches is maximum in 2012 and declines thereafter (Figure B10.8).

B10.1.5.2 Empirical Recruitment

The empirical approach of using only the recruitment values produced results nearly identical to the results obtained using the non-bias corrected Beverton-Holt S-R relationship. If the current fully-recruited F (0.188) is maintained during 2013-2017, the probability of being below the SSB reference point increases to 0.73 by 2015 (Figure B10.9). After 2016, the probability is expected to decline. If the current fully-recruited F increases to F threshold (0.213) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.92 by 2015 and declines thereafter (Figure B10.9). If the fully-recruited F decreases to the current F target (0.175) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.61 by 2015 and declines thereafter (Figure B10.3). If the fully-recruited F increases to the old Fmsy threshold (0.34) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.92 by 2013 and 1.0 thereafter (Figure B10.9). If the fully-recruited F decreases to 0.15 and is

maintained during 2013-2017, the probability of being below the SSB reference point reaches a maximum of 0.31 by 2015 and declines thereafter (Figure B10.9). If the fully-recruited F decreases to 0.10 and is maintained during 2013-2017, the probability of being below the SSB reference point reaches is maximum (0.28) in 2012 and declines thereafter (Figure B10.9).

B10.1.5.3 Delaying a Decrease in F

To prevent the SSB from dropping below the SSB reference point, a reduction in the fully-recruited F would be required. Based on the above analyses, decreasing the average F to about 0.15 (about 20%) starting in 2013 would allow the SSB from remain above or equal to the SSB reference point with Pr(SSB≤SSBref)≤ 0.50. However, because this stock assessment will not be available until the end of 2013, any regulatory action will be delayed until 2014.

To investigate the impact of this delay, the methods described above using the recruitment values were used. In the first run, the fishing mortalities-at-age for 2013 were set equal to 2012 and then fishing mortalities-at-age for corresponding the fully-recruited F =0.15 were applied to years 2014-2017. In the second run, the fishing mortalities–at-age for 2013 and 2014 were set equal to 2012 and then fishing mortalities-at-age for corresponding the fully-recruited F =0.15 were applied to years 2015-2017.

The impact of delaying a reduction in F until 2014 is shown in Figure B10.10. By delaying action until 2014, the probability of SSB being below the SSB reference is 0.54 in 2014 and 0.59 in 2015 (Figure B10.10) compared to 0.41 for 2014 and 0.45 for 2015 if the reduction of F started in 2013 (Figure B10.8 or B10.9). Even if F in 2014 was reduced to zero, the probability of SSB in 2014 being below the SSB reference point would decline to only 0.49, but it would drop precipitously in the following years as SSB grows rapidly (Figure B10.10).

For delaying action until 2015, the probability of SSB being below the SSB reference is 0.58 for 2014 and 0.74 for 2015 (Figure B10.11) compared to 0.41 for 2014 and 0.45 for 2015 if the reduction of F started in 2013 (Figure B10.8 or B10.9). Even if F in 2015 was reduced to zero, the probability of SSB in 2015 being below the SSB reference point would decline to only 0.69, but it would drop precipitously in the following years as SSB grows rapidly (Figure B10.11).

B10.1.5.4 Projections using Short-term Recruitment Series (2002-2012)

To investigate the potential impact of low recruitment on the result of the projections, the analyses in section B10.1.5.2 using the empirical recruitment values were repeated using a shorter time series (2002-2012). If the current fully-recruited F (0.188) is maintained during 2013-2017, the probability of being below the SSB reference point increases to 0.73 by 2015 (Figure B10.12). After 2016, the probability is expected to decline. If the current fully-recruited F increases to F threshold (0.213) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.90 by 2016 and declines thereafter (Figure B10.12). If the fully-recruited F decreases to the current F target (0.175) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.66 by 2015 and declines thereafter (Figure B10.12). If the fully-recruited F increases to the old Fmsy threshold (0.34) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.96 by 2014 and 1.0 thereafter (Figure B10.12). If the fully-recruited F decreases to 0.15 and is maintained during 2013-2017, the probability of being

below the SSB reference point reaches a maximum of 0.44 by 2015 and declines thereafter (Figure B10.12). If the fully-recruited F decreases to 0.10 and is maintained during 2013-2017, the probability of being below the SSB reference point reaches a maximum of 0.40 in 2013 and declines thereafter (Figure B10.12).

B10.1.5.5 Increasing M on ages 3-8

If the current fully-recruited F (0.188) is maintained during 2013-2017, the probability of being below the SSB reference point increases to 0.87 by 2014 and near 1 thereafter (Figure B10.13). If the current fully-recruited F increases to F threshold (0.213) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.94 by 2014 and near 1.0 thereafter (Figure B10.13). If the fully-recruited F decreases to the current F target (0.175) and is maintained during 2013-2017, the probability of being below the SSB reference point still reaches 0.85 by 2014 and near 1.0 thereafter (Figure B10.13). If the fully-recruited F increases to the old F_{MSY} threshold (0.34) and is maintained during 2013-2017, the probability of being below the SSB reference point reaches 0.99 by 2014 and 1.0 thereafter (Figure B10.13). If the fully-recruited F decreases to 0.15 and is maintained during 2013-2017, the probability of being below the SSB reference point still reaches 0.79 by 2014 and increases thereafter (Figure B10.13). If the fully-recruited F decreases to 0.10 and is maintained during 2013-2017, the probability of being below the SSB reference point still reaches 0.72 by 2015, but it declines through 2017 (Figure B10.13).

B10.2 Fully-recruited Fishing Mortality

Five-year projections of fully-recruited F were made by using a population simulation model written in R. The model projection began in year 2012 and abundance-at-age data with associated standard errors, total catch-at-age, Rivard weights, natural mortality, female sex proportions-at-age, and female maturity-at-age from the model input/output were used to parameterize the model for 2012 and the catch equation was solved iterative to obtain fishing-mortality-at-age. For the years greater than 2012, the algorithm in Figure B10.14 was used to project fully-recruited F.

For each iteration of the simulation, the abundance-at-age in 2012 is first randomly drawn from a normal distribution parameterized with the 2012 estimates of January-1 abundance–at-age and associated standard errors from the stock assessment model, F-at-age is solved, and then spawning stock biomass is calculated. For the remaining years, abundance of age 1 recruits is randomly generated using the estimated stock-recruitment Beverton-Holt relationship and applying log-normal errors or using an empirical probability density function created from recruits (1990-2012) per spawning biomass (1989-2011) from which random recruits per spawning biomass values are drawn, and the SSB in the previous year. Abundance-at-age >1 are then calculated using fishing mortality-at-age and natural mortality-at-age for year *y-1* and age *a-1*. An age 13 plus-group was assumed. F-at-age for each year is then solved using the equation. The female spawning stock biomass is calculated by using average Rivard weight estimates from 2010-2012, sex proportions-at-age, and female maturity-at-age. The fully recruited F is then calculated and saved and the whole procedure is repeated for the specified number of iterations.

For each year of the projection, the probability of the fully-recruited F going above the F reference point of 0.213 was calculated using fully-recruited F from all iterations of the simulation

and an algorithm used to approximate equation 2 in Shertzer et al. (2008). This equation was used to incorporate the associated error of the fully-recruited F and associated error of the F threshold value. Several constant catch scenarios were investigated. For years >2012, simulations were performed using the 2012 total catch, 80% of the 2012 catch, and 50% of the 2012 catch.

The sensitivity of the projection results to differences in the S-R relationship were investigated by using the estimated stock-recruitment Beverton-Holt relationship with random error or using the empirical approach in which R/SSB ratios are re-sampled (and multiplied against SSB in the previous year to get recruitment). The former method assumes the recruitment follows the defined Beverton-Holt relationship, and the latter assumes that the distribution of the R/Bs ratio is stationary and independent of stock size.

B10.2.1 Beverton-Holt S-R Relationship

If the current catch (3.59 million fish) is maintained during 2013-2017, the probability of the fully-recruited F being above the F threshold remains low but increases rapidly starting in 2013 and reaches near 1 by 2014 (Figure B10.15). If 80% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold rapidly increases to 0.89 starting in 2015 and reaches 1 by 2017. (Figure B10.15). If 50% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold is near zero (Figure B10.15).

B10.2.2 Empirical Recruits/SSB ratios

The empirical approach produced results nearly identical to the results obtained using the Beverton-Holt S-R relationship. If the current catch (3.59 million fish) is maintained during 2013-2017, the probability of the fully-recruited F being above the F threshold remains low but increases rapidly starting in 2014 and reaches near 1 by 2015 (Figure B10.16). If 80% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold rapidly increases starting in 2015 and reaches 1 by 2017. (Figure B10.16). If 50% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold is near zero (Figure B10.16).

B10.2.3 Projections using Short-term Recruitment Series (2002-2012)

If the current catch (3.59 million fish) is maintained during 2013-2017, the probability of the fully-recruited F being above the F threshold is low in 2013 but rapidly reaches 0.92 in 2014 and near 1 by 2015 (Figure B10.17). If 80% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold rapidly increases starting in 2015 and reaches 1 by 2017. (Figure B10.17). If 50% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold is near zero (Figure B10.17).

B10.2.4 SARC Additional Analyses

Reviewers of the stock assessment recommended that the Beverton-Holt non-bias-corrected equation be used in place of the bias-corrected B-H equation. In addition, they recommended that only recruitment empirical data be used (instead of the R/SSB ratios) in order to keep the data consistent with the projection method used to develop the $F_{threshold}$ reference points. The above analyses are repeated in the following section. Results did not different greatly from the approaches used above.

B10.2.4.1 Non-bias-corrected Beverton-Holt S-R Relationship

If the current catch (3.59 million fish) is maintained during 2013-2017, the probability of the fully-recruited F being above the F threshold remains low but increases rapidly starting in 2013 and reaches near 1 by 2014 (Figure B10.18). If 80% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold rapidly increases to 0.86 starting in 2015 and reaches 1 by 2017. (Figure B10.18). If 50% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold is near zero (Figure B10.18).

B10.2.2 Recruitment Values

The empirical approach produced results nearly identical to the results obtained using the Beverton-Holt S-R relationship. If the current catch (3.59 million fish) is maintained during 2013-2017, the probability of the fully-recruited F being above the F threshold increases rapidly starting in 2013 and reaches near 1 by 2015 (Figure B10.19). If 80% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold rapidly increases starting in 2015 and reaches 1 by 2017. (Figure B10.19). If 50% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold is near zero (Figure B10.19).

B10.2.3 Projections using Short-term Recruitment Series (2002-2012)

If the current catch (3.59 million fish) is maintained during 2013-2017, the probability of the fully-recruited F being above the F threshold is low in 2013 but rapidly reaches 0.92 in 2014 and near 1 by 2015 (Figure B10.20). If 80% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold rapidly increases starting in 2015 and reaches 1 by 2017. (Figure B10.20). If 50% of the 2012 catch is maintained during 2013-2017, the probability of fully-recruited F being above the F threshold is near zero (Figure B10.20).

B11.0 Review and evaluate the status of the Technical Committee research recommendations listed in the most recent SARC report. Indentify new research recommendations. Recommend timing and frequency of future assessment updates and benchmark assessments. (TOR #7)

B11.1 Fishery-Dependent Priorities

High

- Continue collection of paired scale and otolith samples, particularly from larger striped bass, to facilitate development of otolith-based age-length keys and scale-otolith conversion matrices.

Moderate

- Develop studies to provide information on gear specific discard morality rates and to determine the magnitude of bycatch mortality.[1]
- Improve estimates of striped bass harvest removals in coastal areas during wave 1 and in inland waters of all jurisdictions year round.
- Evaluate the percentage of fishermen using circle hooks.[2]

B11.2 Fishery-Independent Priorities

Moderate

- Develop a refined and cost-efficient, fisheries-independent coastal population index for striped bass stocks.

B11.3 Modeling / Quantitative Priorities

High

- Develop a method to integrate catch-at-age and tagging models to produce a single estimate of F and stock status.[3]
- Develop a spatially and temporally explicit catch-at-age model incorporating tag based movement information.[4]
- Review model averaging approach to estimate annual fishing mortality with tag based models. Review validity and sensitivity to year groupings.[5]
- Develop methods for combining tag results from programs releasing fish from different areas on different dates.
- Examine potential biases associated with the number of tagged individuals, such as gear specific mortality (associated with trawls, pound nets, gill nets, and electrofishing), tag induced mortality, and tag loss.[6]
- Develop field or modeling studies to aid in estimation of natural mortality or other factors affecting the tag return rate.

Moderate

- Develop maturity ogives applicable to coastal migratory stocks.
- Examine methods to estimate annual variation in natural mortality.[7]
- Develop reliable estimates of poaching loss from striped bass fisheries.
- Improve methods for determining population sex ratio for use in estimates of SSB and biological reference points.
- Evaluate truncated matrices and covariate based tagging models.

Low

- Examine issues with time saturated tagging models for the 18 inch length group.
- Develop tag based reference points.

B11.4 Life History, Biological, and Habitat Priorities

High

- Continue in-depth analysis of migrations, stock compositions, etc. using mark-recapture data.[8]
- Continue evaluation of striped bass dietary needs and relation to health condition.[9]
- Continue analysis to determine linkages between the mycobacteriosis outbreak in Chesapeake Bay and sex ratio of Chesapeake spawning stock, Chesapeake juvenile production, and recruitment success into coastal fisheries.

Moderate

- Examine causes of different tag based survival estimates among programs estimating similar segments of the population.
- Continue to conduct research to determine limiting factors affecting recruitment and possible density implications.
- Conduct study to calculate the emigration rates from producer areas now that population levels are high and conduct multi-year study to determine inter-annual variation in emigration rates.

Low

- Determine inherent viability of eggs and larvae.
- Conduct additional research to determine the pathogenicity of the IPN virus isolated from striped bass to other warm water marine species, such as flounder, menhaden, shad, and largemouth bass.

Additional Habitat Research Recommendations

- Passage facilities should be designed specifically for passing striped bass for optimum efficiency at passing this species.
- Conduct studies to determine whether passing migrating adults upstream earlier in the year in some rivers would increase striped bass production and larval survival, and opening downstream

bypass facilities sooner would reduce mortality of early emigrants (both adult and early-hatched juveniles).

- All state and federal agencies responsible for reviewing impact statements and permit applications for projects or facilities proposed for striped bass spawning and nursery areas shall ensure that those projects will have no or only minimal impact on local stocks, especially natal rivers of stocks considered depressed or undergoing restoration.[10]

- Federal and state fishery management agencies should take steps to limit the introduction of compounds which are known to be accumulated in striped bass tissues and which pose a threat to human health or striped bass health.

- Every effort should be made to eliminate existing contaminants from striped bass habitats where a documented adverse impact occurs.

- Water quality criteria for striped bass spawning and nursery areas should be established, or existing criteria should be upgraded to levels that are sufficient to ensure successful striped bass reproduction.

- Each state should implement protection for the striped bass habitat within its jurisdiction to ensure the sustainability of that portion of the migratory stock. Such a program should include: inventory of historical habitats, identification of habitats presently used, specification of areas targeted for restoration, and imposition or encouragement of measures to retain or increase the quantity and quality of striped bass essential habitats.

- States in which striped bass spawning occurs should make every effort to declare striped bass spawning and nursery areas to be in need of special protection; such declaration should be accompanied by requirements of non-degradation of habitat quality, including minimization of non-point source runoff, prevention of significant increases in contaminant loadings, and prevention of the introduction of any new categories of contaminants into the area. For those agencies without water quality regulatory authority, protocols and schedules for providing input on water quality regulations to the responsible agency should be identified or created, to ensure that water quality needs of striped bass stocks are met.[11]

- ASMFC should designate important habitats for striped bass spawning and nursery areas as HAPC.

- Each state should survey existing literature and data to determine the historical extent of striped bass occurrence and use within its jurisdiction. An assessment should be conducted of those areas not presently used for which restoration is feasible.

B11.5 Management, Law Enforcement, and Socioeconomic Priorities

Moderate

- Examine the potential public health trade-offs between the continued reliance on the use of high minimum size limits (28 inches) on coastal recreational anglers and its long-term effects on enhanced PCB contamination among recreational stakeholders.[10, 12]

- Evaluate striped bass angler preferences for size of harvested fish and trade-offs with bag limits.

B11.6 Striped Bass Research Priorities Identified as Being Met or Well in Progress

- ✓ Continue improvements to the statistical catch-at-age model as recommended by the 46th SARC (e.g., include error from catch estimates, fit each sector of removals individually, run

additional diagnostics, account for spatial differences in indices, incorporate stock-recruitment relationship).
- ✓ Evaluate to what extent rising natural mortality among Chesapeake Bay striped bass affects the existing F and SSB thresholds, which are based on a fixed M assumption (M = 0.15)
- ✓ Develop simulation models to look at the implications of overfishing definitions relative to development of a striped bass population that will provide "quality" fishing. Quality fishing must first be defined.
- ✓ Evaluate the overfishing definition relative to uncertainty in biological parameters.

B11.7   Timing of Assessment Updates and Next Benchmark Assessment

The Striped Bass Technical Committee recommends that preferred model be updated after peer review with the finalized 2012 data before it is presented to the Management Board. In addition, should the Board decide to take management action for the 2015 fishing year, the assessment should be updated in 2014, so the most recent stock status information is available. Subsequently, the assessment should be updated every two years.

The Striped Bass Technical Committee recommends that the next benchmark stock assessment be conducted in five years in 2018, which will allow progress to be made on issues like state-specific scale-otolith conversion factors and incorporating tagging data into the SCA model.

Footnotes

[1] Literature search and some modeling work completed.

[2] Work ongoing in New York through the Hudson River Angler Diary, Striped Bass Cooperative Angler Program, and ACCSP e-logbook.

[3] Model developed, but the tagging data overwhelms the model. Issues remain with proper weighting.

[4] Model developed with Chesapeake Bay and the rest of the coast as two fleets. However, no tagging data has been used in the model.

[5] Work ongoing by Striped Bass Tagging Subcommittee to evaluate the best years to use for the IRCR and the periods to use for the MARK models.

[6] Gear specific survival being examined in Hudson River.

[7] Ongoing work by the Striped Bass Tagging Subcommittee

[8] Ongoing through Cooperative Winter Tagging Cruise and striped bass charter boat tagging trips. See Cooperative Winter Tagging Cruise 20 Year Report.

[9] Plans for a stomach content collection program in the Chesapeake Bay by the Chesapeake Bay Ecological Foundation.

[10] Ongoing in New York.

[11] Significant habitat designations completed in the Hudson River and New York Marine Districts.

[12] Samples collected from two size groups ($\geq$ 28 inches and 20-26 inches) in Pennsylvania and processed by the Department of Environmental Protection to compare contamination of the two size groups.

B12.0 ACKNOWLEDGEMENTS

B13.0 REFERENCES

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TABLES

Table B4.1. Atlantic Coast Fisheries Regulations, 2012
Commercial

STATE	SIZE LIMITS	SEASONAL QUOTA	OPEN SEASON & POSSESSION LIMITS
ME	Commercial fishing prohibited		
NH	Commercial fishing prohibited		
MA	34" min.	1,159,750 lb. (minus any overage from previous year) Hook & line only	7.12 until quota reached; 5 fish/day on Sun; 30 fish/day Tues-Thurs
RI	Floating fish trap: 26" min. General category (mostly rod & reel): 34" min.	Total: 239,963 lb. *(minus any overage from previous year) Split 39:61 between trap and general category. Gill netting prohibited.	Trap: 1.1 until quota reached; if 80% quota harvested before 8.26, a 500 lb/trap/day limit is imposed; from 8.27–12.31, 10,000 lb. quota set-aside available. General Category: 6.1-8.31 or 75% quota; 9.13-12.31 or 100% quota; 5 fish/day Sun-Thu. Closed Fri/Sat throughout.
CT	Commercial fishing prohibited		
NY	24–36" - Ocean only (Hudson River closed to commercial harvest)	828,293 lb.^ (minus any overage from previous year). Pound nets, gill nets (6-8"stretched mesh), hook & line.	7.1 – 12.15 Gill nets (6 to 8" stretched mesh), pound nets, and Hook and Line only. Gillnets with mesh <6 or >8" stretched mesh allowed a 7 fish limit; trawl vessels allowed a 21 fish trip limit.. No gill nets allowed Great South Bay, South Oyster Bay, or Hempstead Bay.
NJ	Commercial fishing prohibited+		
PA	Commercial fishing prohibited		
DE	28" minimum except 20" spring gillnet in DE Bay/River & Nanticoke River (5.5" max mesh & 0.28mm max twine)	193,447 lb. (minus any overage from previous year)	Gillnet: 2.15-5.31 (3.1-31 for Nanticoke) & 11.15-12.31; drift nets only 2.15-28 & 5.1-31; no fixed nets in DE River Hook and Line: 4.1 – 12.31 Spawning areas closed 4.1-5.31

Table B4.1 cont.
Commercial

STATE	SIZE LIMITS	SEASONAL QUOTA	OPEN SEASON & POSSESSION LIMITS
MD	Bay and Rivers: 18–36" Ocean: 24" min	Bay and River: 2,254,831 lbs (part of Baywide quota)^ Gear specific quotas and landing limits Ocean: 126,396 lb. (minus any overage from previous year)	Bay Pound Net: 6.1-11.30, Mon-Sat 12am-6pm Bay Haul Seine: 6.7-11.30, Mon-Fri Bay Hook & Line: 6.7-11.30, Mon-Thu Bay Drift Gill Net: 1.1-2.28, 12.1-12.31, Mon-Fri 3am-6pm Ocean Drift Gill Net & Trawl: 1.1-4.30, 11.1-12.31, M-F
PRFC	18" min all year 36" max 2.15–3.25	835,960 lbs (part of Baywide quota)	Hook & line: 2.15-3.25, 6.1-12.31 Pound Net & Other: 2.15-3.25, 6.1-12.15 Gill Net: 1.1-3.25
DC	Commercial fishing prohibited		
VA	Bay and Rivers: 18" min, 28" max & complimentary gill net mesh size limit 3.26–6.15 Ocean: 28" minimum	Bay and Rivers: 1,538,022 lbs in 2010 (part of Baywide quota) Ocean: 184,853 lb. (minus any overage from previous year)	Bay and Rivers: 2.1-12.31 Ocean: 2.1-12.31
NC	Albemarle Sound: 18" Ocean: 28"	Albemarle Sound: 275,000 lb Ocean: 480,480 lb.** (minus any overage from previous year) split 160,160 lbs each to beach seine, gill net & trawl	Albemarle Sound: 1.1-4.30, 10.1-12.31; daily trip limit ranging from 5 to 15 fish; striped bass cannot exceed 50% by weight of total finfish harvest; season and daily trip limits set by proclamation. Ocean: gear requirements; open days and trip limits for beach seine, gill net, and trawl set via proclamation

^ Beginning in 2003, NY and MD quotas reduced due to conservation equivalency; MA and RI quotas reduced in 2003 due to quota overages in previous year.
* Beginning in 2007, RI quota reduced due to conservation equivalency.
+ NJ quota applied to recreational bonus fish program
** NC harvests and quotas are for the December 1 to November 30 fishing year

Table B4.1 cont.
Recreational

STATE	SIZE LIMITS	BAG LIMIT	OTHER	OPEN SEASON
ME	20 – 26" OR ≥40"	1 fish	Hook & line only; No gaffing	All year, except spawning areas are closed 12.1 – 4.30 and catch and release only 5.1 – 6.30. Spawning area includes Kennebec watershed.
NH	1 fish 28–40" & 1 fish >28"	2 fish	No netting or gaffing; must be landed with head and tail intact; no culling. No sale.	All year
MA	28" min	2 fish	Hook & line only	All year
RI	28" min	2 fish		All year
CT	28" min, except Connecticut River Bonus Program: 22-28"	2 fish, except CR Bonus: 1 fish	CR Bonus Quota: 4,025 fish	All year, except CR Bonus 5.4-6.30 (limited to I-95 bridge to MA border)
NY	Ocean Private: 1 fish 28-40" & 1 fish > 40" Ocean Charter: 28" min Hudson River: 18" min DE River: 28" min	Ocean: 2 fish Hudson R.: 1 fish DE River: 2 fish	Angling or spearing only	Ocean: 4.15 – 12.15 Hudson River: 3.16 – 11.30 Delaware River: All year
NJ	28" min	2 fish, plus 1 additional through Bonus Program	Bonus program quota: 321,750 lb. No netting. Non-offset circle hooks required 4.1-5.31 in DE River if using natural bait.	Atlantic Ocean no closed season. DE River & tribs open 3.1-3.31 & 6.1-12.31. All other marine waters open 3.1-12.31
PA	Non-tidal DE River: 28" min; Delaware Estuary: 28" min. except 20-26" from 4.1-5.31	2 fish		Year round
DE	28" min. except 20-26" from 7.1-8.31 in Del. River, Bay & tributaries	2 fish	Hook & line, spear (for divers) only. Circle hooks required in spawning season.	All year except 4.1-5.31 in spawning grounds (catch & release allowed)

Table B4.1 cont.
Recreational

STATE	SIZE LIMITS	BAG LIMIT	OTHER	OPEN SEASON
MD	Susquehanna Flats (SF): 18-26" Chesapeake Bay Trophy: 28" min Chesapeake Bay Regular: 18" min with 1 fish > 28" Ocean: 28" min	SF: 1 fish Chesapeake Bay Trophy: 1 fish Chesapeake Bay Regular: 2 fish Ocean: 2 fish	SF: non-off set circle hook if baited hooks & gap>0.5" Chesapeake Bay Quota: 2,956,463 lbs (part of Baywide quota; includes Susquehanna Flats harvest, excludes trophy harvest)	SF: 3.1-5.31; catch & release only 3.1-5.3 Chesapeake Bay Trophy: 4.18-5.15 (most tribs closed) Chesapeake Bay Regular: 5.16-12.15 (most tribs closed until 6.1) Ocean: All year
PRFC	Trophy: 28" Regular: 18" min with 1 fish > 28"	Trophy: 1 fish Regular: 2 fish	Quota: 683,967 lbs. (part of Baywide quota; excludes trophy harvest)	Trophy: 4.18 -5.15 Regular: 5.16-12.31
DC	18" min with 1 fish > 28"	2 fish	Hook & line only	5.16-12.31
VA	Bay/Coastal Trophy: 32" min (28" Potomac tribs) CB Spring: 18-28"; 1 fish >32" CB Fall: 18–28"; 1 fish >34" Potomac Tribs: 18-28"; 1 fish >28" Ocean: 28"	Bay/Coastal Trophy: 1 fish CB Spring: 2 fish CB Fall: 2 fish Potomac Tribs: 2 fish Ocean: 2 fish	Hook & line, rod & reel, hand line only Chesapeake Bay Quota: 1,538,022 lbs in 2010 (part of Baywide quota; excludes trophy harvest)	Bay Trophy: 5.1-6.15 (open 4.18 Potomac tribs) Coastal Trophy: 5.1-5.15 CB Spring: 5.16-6.15 (no fish >32" in spawning areas) CB Fall: 10.4-12.31 Potomac Tribs: 5.16-12.31 Ocean: 1.1-3.31, 5.16-12.31
NC	Roanoke River: 2 fish 18-22" OR 1 fish 18-22" and 1 fish >27" Albemarle Sound: 18" min. Ocean: 28" min	Roanoke River: 2 fish Albemarle Sound: 3 fish Ocean: 2 fish	Roanoke River quota: 137,500 lb. Albemarle Sound quota: 137,500 lb.	Roanoke River: 3.1 – 4.30 (single barbless hook required 3.1-6.30 from Roanoke Rapids dam downstream to US 258 bridge) Albemarle Sound: Spring 1.1 – 4.30; Fall 10.1-12.31 Ocean: All year

Table B4.2. Summary of striped bass (*Morone saxatilis*) diet studies examined for evidence of cannibalism in striped bass. n = total number of stomachs examined, Sizes in the size range, n_{MS} = the number of striped bass stomachs containing striped bass, n_{MA} = the number of striped bass stomachs containing white perch (*Morone americana*), and %MS = the percentage of striped bass stomachs with striped bass. If a paper gave the number of fish found in the stomachs, the value is present in parentheses under n_{MS} and n_{MA}.

Citation P/A	Years	n	Sizes (mm)	n_{MS}	n_{MA}	%MS or
Bay of Fundy, Canada						
Rulifson and McKenna (1987)	1985	80	69-520 FL	0	0	0.00%
U.S. Atlantic Coast						
Merriman (1941) - CT	1936-1937	550	650-1150 TL	A[1]	P[1]	A
Schafer (1970) - LI Sound	1964	367	275-950 FL	0	0	0.00%
Nelson et al. (2003) - MA	1997-2000	3006	290-1162 TL	0	0	0.00%
Overton et al. (2008) –VA/NC	1994-2007	1154	373-1250 TL	0	0	0.00%
Ferry and Mather (2012) - MA	1999	797	375-475 TL	0[2]	0[2]	0.00%
Hudson River						
Gardinier and Hoff (1982)	1974-1977	894	76-275 TL	4	6	0.45%
Dew (1988)	1973-1975	510	>400 TL1 (2)	6	0	0.20%
Delaware Bay						
Nemerson and Able (2003)	1996-2000	369	<139-500 TL	A[1]	A[1]	A
Chesapeake Bay						
Hollis (1952)	1936-1937	1736	195-785 TL[3]	0	22	0.00%
Hartman and Brandt (1995)	1990-1992	1222[4]	Ages 1-3+	A[1]	P[1]	A
Griffin and Margraf (2003)	1955-1959	916	170-1218 TL	2	0	0.22%
Walter and Austin (2003)	1997-1998	1225	458-1151 TL	1 (1)	19 (24)	0.08%
Overton et al. (2009)	1988-2001	2703	150-2400 TL	A[1]	P[1]	A
Albemarle Sound/Roanoke River, North Carolina						
Trent and Hassler (1966)	1963-1964	1070	Pspawn Adults	A[1]	A[1]	A
Manooch (1973)	1970-1971	1094	125-714 TL	2(2)	8(10)	0.18%
Cooper et al. (1998)	1988-1992	522	35-160 TL	0	0	0.00%
Rudershausen et al. (2005)	2002-2003	1399	121-620 TL	A[1]	P[1]	A

[1] Absence or Presence from list of species-specific prey weight percentages or list of prey species names
[2] Kristen Ferry's thesis from which the paper originated was also checked.
[3] Length range not given in paper, but specific fish of lengths 195 and 785 were mentioned in the diet analysis
[4] Number of stomachs containing food

Table B5.1. Summary of surveys currently available for use in stock assessment models.

State	Index	Design	Time of Year	What Stock?	Ages
Marine Recreational Fisheries Survey	Total Catch Rate Index	Stratified Random	May-Dec	Mixed	Aggregate (3-13+)
Connecticut Trawl Survey	Mean number per tow	Stratified Random	April-June	Mixed	Aggregate (2-4)
NEFSC Trawl Survey	Mean number per tow	Stratified Random	March-May	Mixed	Aggregate (2-9)
New Jersey Trawl Survey	Mean number per tow	Stratified Random	April	Mixed	2-13+
New York Ocean Haul Seine Survey	Mean number per haul	Random	Sept-Nov	Mixed	2-13+
Delaware Electrofishing Survey	Mean number per hour	Lattice	April-May	Delaware	2-13+
New York YOY Seine Survey	Mean number per haul	Fixed	July-Nov	Hudson	0
New York W. Long Island Seine Survey	Mean number per haul	Fixed	May-Oct	Hudson	1
New Jersey YOY Seine Survey	Mean number per haul	Fixed/Random	Aug-Oct	Delaware	0
Virginia YOY Seine Survey	Mean number per haul	Fixed	July-Sept	Chesapeake	0
Maryland YOY and Age 1 Seine Survey	Mean number per haul	Fixed	July-Sept	Chesapeake	0-1
Maryland Gillnet Survey	Mean number per set	Stratified Random	April-May	Chesapeake	2-13+
Virginia Pound Net Survey	Mean number per set	Fixed	March-May	Chesapeake	1-13+
Virginia Gillnet	Mean number per set	Fixed	March-May	Chesapeake	1-13+
Tag-based N Index	Number	None	June	Mixed	7+

Table B5.2. Available indices of striped bass relative abundance, 1982–2012.

| | Multi-age | | | | | | Age-specific | | | | | | | | | |
| | MRIP | | NEFSC | | CTTRL | | NYOHS | | NJTRL | | MD SSN | | DE SSN | | VAPNET | |
Year	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV
1982																
1983																
1984					0.02	1.00										
1985					0.01	1.00					4.88	0.25				
1986					0.01	1.00					10.07	0.25				
1987					0.05	0.40	3.83	0.11			7.15	0.25				
1988	0.37	0.79			0.04	0.50	3.60	0.10			3.27	0.25				
1989	0.24	0.85			0.06	0.33	2.58	0.13	0.23	0.61	3.96	0.25				
1990	0.22	0.77			0.16	0.27	3.50	0.18	1.13	0.60	5.04	0.25				
1991	0.40	0.38	0.23	0.17	0.15	0.21	3.28	0.19	1.41	0.67	4.61	0.25			18.75	0.25
1992	0.72	0.24	0.24	0.34	0.22	0.25	3.00	0.19	0.65	0.70	6.29	0.25			8.45	0.25
1993	0.57	0.21	0.48	0.21	0.27	0.16	3.32	0.11	0.67	0.53	6.25	0.25			21.72	0.25
1994	0.84	0.16	1.39	0.22	0.30	0.19	2.90	0.15	1.47	0.40	5.13	0.25			13.87	0.25
1995	1.11	0.14	0.95	0.20	0.60	0.13	2.84	0.18	4.21	0.14	4.62	0.25			14.52	0.25
1996	1.33	0.12	0.60	0.20	0.63	0.14	5.11	0.10	5.66	0.20	7.59	0.25	3.38	0.10	12.3	0.25
1997	1.35	0.13	1.18	0.13	0.85	0.13	4.84	0.14	5.82	0.21	3.87	0.25	4.10	0.09	20.1	0.25
1998	1.66	0.10	0.73	0.15	0.97	0.13	5.01	0.15	5.01	0.10	4.79	0.25	3.73	0.12	14.85	0.25
1999	1.66	0.11	0.45	0.23	1.10	0.12	3.46	0.16	3.51	0.12	3.97	0.25	2.59	0.12	29.89	0.25
2000	1.48	0.12	1.27	0.19	0.84	0.14	4.36	0.11	5.31	0.13	3.52	0.25	2.05	0.16	39.7	0.25
2001	1.20	0.12	0.62	0.26	0.61	0.15	3.47	0.15	1.58	0.36	2.83	0.25	1.88	0.18	18.63	0.25
2002	1.01	0.14	0.98	0.14	1.30	0.10	3.23	0.20	2.13	0.17	4.00	0.25	1.60	0.15	5.23	0.25
2003	0.88	0.15	0.77	0.24	0.87	0.09	4.24	0.19	6.83	0.10	4.55	0.25	2.47	0.12	15.65	0.25
2004	0.93	0.14	0.33	0.25	0.56	0.09	4.88	0.09	6.05	0.15	6.11	0.25	2.89	0.12	31.64	0.25
2005	1.15	0.14	0.29	0.20	1.17	0.10	3.91	0.14	6.41	0.12	4.96	0.25	1.77	0.14	18.14	0.25
2006	1.32	0.13	0.63	0.29	0.61	0.09	4.37	0.14	2.61	0.28	4.92	0.25	2.22	0.18	22.14	0.25
2007	0.70	0.15	0.74	0.13	1.02	0.10			3.50	0.32	2.14	0.25	1.78	0.33	31.52	0.25
2008	0.61	0.15	0.65	0.17	0.57	0.09			1.38	0.33	4.37	0.25	1.72	0.12	18.32	0.25
2009	0.67	0.15			0.60	0.10			2.24	0.34	5.70	0.25	1.25	0.17	22.96	0.25
2010	0.66	0.15			0.40	0.21			0.73	0.53	4.53	0.25	2.69	0.21	34.89	0.25
2011	0.57	0.15			0.48	0.21			2.07	0.28	4.58	0.25	3.25	0.20	8.96	0.25
2012					0.43	0.17			3.48	0.20	2.64	0.25	1.94	0.19	17.44	0.25

Table B5.2 cont.

								Unlagged				
		YOY							Age 1			
	NY		NJ		MD		VA		NY		MD	
Year	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV
1969					2.81	0.34					0.25	0.50
1970					12.52	0.26					0.13	0.50
1971					4.02	0.28					1.36	0.38
1972					3.26	0.30					0.46	0.42
1973					2.32	0.34					0.46	0.34
1974					2.63	0.32					0.26	0.38
1975					2.81	0.28					0.22	0.46
1976					1.58	0.30					0.13	0.70
1977					1.60	0.30					0.06	0.76
1978					3.75	0.26					0.18	0.46
1979	2.15	0.30			1.78	0.28					0.29	0.46
1980	6.08	0.24			1.02	0.28					0.18	0.44
1981	8.86	0.22			0.59	0.32					0.02	1.02
1982	14.17	0.19	0.10	1.22	3.57	0.27	2.71	0.50			0.02	1.16
1983	16.25	0.23	0.07	1.48	0.61	0.33	3.40	0.40			0.32	0.40
1984	15.00	0.20	0.37	0.71	1.64	0.28	4.47	0.46			0.01	2.00
1985	1.92	0.20	0.03	2.05	0.91	0.36	2.41	0.41	0.61	0.71	0.16	0.50
1986	2.92	0.19	0.32	0.55	1.34	0.32	4.74	0.37	0.30	0.55	0.03	0.94
1987	15.90	0.25	0.53	0.47	1.46	0.33	15.74	0.34	0.21	0.59	0.06	0.92
1988	33.46	0.17	0.35	0.41	0.73	0.39	7.64	0.32	0.81	0.52	0.07	0.58
1989	21.35	0.20	1.07	0.36	4.87	0.34	11.23	0.29	1.78	0.41	0.19	0.48
1990	19.08	0.22	1.05	0.32	1.03	0.29	7.34	0.31	0.37	0.46	0.33	0.42
1991	3.60	0.18	0.47	0.26	1.52	0.32	3.76	0.33	1.26	0.38	0.20	0.44
1992	11.43	0.15	1.18	0.23	2.34	0.32	7.35	0.36	1.34	0.38	0.15	0.52
1993	12.59	0.20	1.78	0.24	13.97	0.25	18.11	0.23	0.75	0.39	0.19	0.50
1994	17.64	0.16	0.96	0.24	6.40	0.27	10.48	0.27	1.43	0.44	0.78	0.36
1995	16.23	0.16	1.98	0.25	4.41	0.24	5.45	0.32	1.29	0.39	0.12	0.56
1996	8.93	0.16	1.70	0.23	17.61	0.25	23.00	0.29	1.54	0.44	0.08	0.78
1997	22.30	0.22	1.01	0.24	3.91	0.25	9.35	0.30	1.00	0.49	0.26	0.46
1998	13.39	0.18	1.31	0.26	5.50	0.25	13.25	0.29	2.10	0.48	0.17	0.50
1999	26.64	0.24	1.90	0.23	5.34	0.30	2.80	0.34	2.05	0.34	0.37	0.36
2000	3.16	0.21	1.78	0.26	7.42	0.23	16.18	0.31	1.56	0.43	0.26	0.40
2001	22.98	0.26	1.20	0.23	12.57	0.28	14.17	0.32	2.16	0.34	0.32	0.36
2002	12.32	0.18	0.53	0.29	2.20	0.27	3.98	0.37	2.53	0.30	0.79	0.32
2003	17.36	0.20	2.47	0.24	10.83	0.26	22.89	0.28	1.19	0.29	0.07	0.66
2004	8.81	0.16	1.13	0.26	4.85	0.25	12.70	0.27	2.41	0.30	0.74	0.36
2005	8.61	0.25	1.22	0.22	6.91	0.25	9.09	0.28	0.64	0.50	0.28	0.44
2006	3.82	0.13	0.67	0.25	1.78	0.29	10.10	0.28	2.02	0.36	0.28	0.42
2007	35.02	0.19	1.41	0.21	5.12	0.27	11.96	0.30	0.58	0.44	0.07	0.60
2008	13.86	0.20	1.26	0.24	1.26	0.31	7.97	0.33	1.24	0.37	0.31	0.40
2009	9.73	0.24	1.92	0.24	3.92	0.23	8.42	0.30	0.33	0.43	0.12	0.54
2010	12.90	0.21	1.30	0.21	2.54	0.25	9.07	0.35	0.45	0.42	0.17	0.45
2011	7.30	0.26	1.41	0.26	9.57	0.24	27.09	0.26	2.00	0.14	0.02	1.02
2012	5.68	0.24	0.34	0.24	0.49	0.32	2.68	0.29	0.9	0.26	0.35	0.34

Table B5.3. Age composition of surveys

NY Ocean Haul Seine

Year							Age						
	1	2	3	4	5	6	7	8	9	10	11	12	13+
1987		0.0318	0.1949	0.3591	0.2787	0.0883	0.0349	0.0067	0.0017	0.0000	0.0006	0.0000	0.0028
1988		0.2255	0.2687	0.1945	0.1660	0.0851	0.0218	0.0144	0.0039	0.0021	0.0007	0.0000	0.0137
1989		0.1833	0.2690	0.1478	0.1596	0.1025	0.0936	0.0217	0.0030	0.0020	0.0030	0.0020	0.0108
1990		0.0608	0.2957	0.3063	0.1139	0.0985	0.0557	0.0444	0.0158	0.0058	0.0010	0.0000	0.0023
1991		0.2070	0.3666	0.2439	0.0519	0.0166	0.0253	0.0416	0.0230	0.0063	0.0020	0.0036	0.0115
1992		0.0792	0.4166	0.2577	0.1211	0.0329	0.0143	0.0170	0.0250	0.0175	0.0032	0.0058	0.0096
1993		0.1563	0.3868	0.2908	0.0701	0.0328	0.0094	0.0090	0.0115	0.0131	0.0070	0.0025	0.0082
1994		0.1410	0.2705	0.1562	0.1346	0.0832	0.0546	0.0375	0.0222	0.0406	0.0127	0.0241	0.0203
1995		0.2450	0.2695	0.2542	0.0720	0.0658	0.0352	0.0123	0.0054	0.0123	0.0115	0.0031	0.0084
1996		0.0832	0.7475	0.1142	0.0328	0.0094	0.0073	0.0027	0.0013	0.0007	0.0000	0.0005	0.0003
1997		0.2063	0.2425	0.4508	0.0669	0.0184	0.0037	0.0037	0.0039	0.0017	0.0007	0.0009	0.0006
1998		0.1876	0.2969	0.1714	0.2855	0.0366	0.0091	0.0058	0.0029	0.0002	0.0010	0.0015	0.0011
1999		0.0697	0.6277	0.1722	0.0594	0.0438	0.0050	0.0032	0.0046	0.0035	0.0039	0.0007	0.0046
2000		0.1273	0.1930	0.4338	0.1541	0.0364	0.0368	0.0041	0.0039	0.0016	0.0018	0.0010	0.0044
2001		0.0524	0.4553	0.1474	0.2129	0.0735	0.0274	0.0194	0.0032	0.0039	0.0011	0.0000	0.0025
2002		0.3225	0.2261	0.1843	0.0805	0.0735	0.0572	0.0198	0.0198	0.0013	0.0048	0.0018	0.0057
2003		0.2022	0.3647	0.1251	0.0922	0.0406	0.0646	0.0506	0.0227	0.0177	0.0126	0.0009	0.0049
2004		0.0501	0.5698	0.2734	0.0628	0.0222	0.0076	0.0061	0.0036	0.0011	0.0014	0.0017	0.0002
2005		0.2444	0.1280	0.4126	0.1370	0.0336	0.0138	0.0035	0.0090	0.0065	0.0035	0.0037	0.0045
2006		0.0639	0.6359	0.0728	0.1610	0.0424	0.0144	0.0057	0.0025	0.0003	0.0010	0.0000	0.0000

Table B5.3 cont.

NJ Trawl

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1989	0.0000	0.2780	0.4440	0.0060	0.1370	0.0520	0.0110	0.0160	0.0000	0.0560	0.0000	0.0000	0.0000
1990	0.0000	0.0610	0.1820	0.0200	0.4140	0.1320	0.0290	0.0970	0.0050	0.0610	0.0000	0.0000	0.0000
1991	0.0000	0.2770	0.2840	0.0210	0.0200	0.1480	0.1320	0.0170	0.0340	0.0460	0.0210	0.0000	0.0000
1992	0.0000	0.2580	0.4780	0.0610	0.0640	0.0550	0.0740	0.0100	0.0000	0.0000	0.0000	0.0000	0.0000
1993	0.0000	0.2380	0.3530	0.1500	0.0870	0.1230	0.0240	0.0250	0.0000	0.0000	0.0000	0.0000	0.0000
1994	0.0000	0.2870	0.3700	0.1550	0.0900	0.0480	0.0310	0.0100	0.0090	0.0000	0.0000	0.0000	0.0000
1995	0.0000	0.6580	0.1720	0.0670	0.0450	0.0320	0.0120	0.0070	0.0040	0.0030	0.0000	0.0000	0.0000
1996	0.0000	0.1620	0.5800	0.1600	0.0610	0.0210	0.0130	0.0040	0.0000	0.0000	0.0000	0.0000	0.0000
1997	0.0000	0.1870	0.4090	0.2360	0.1130	0.0350	0.0120	0.0050	0.0010	0.0030	0.0000	0.0000	0.0000
1998	0.0000	0.4420	0.1930	0.0430	0.1300	0.0860	0.0540	0.0250	0.0140	0.0110	0.0020	0.0010	0.0000
1999	0.0000	0.0770	0.3200	0.1810	0.2560	0.1150	0.0320	0.0110	0.0050	0.0030	0.0000	0.0010	0.0000
2000	0.0000	0.1520	0.1400	0.1570	0.2740	0.1670	0.0730	0.0270	0.0060	0.0020	0.0010	0.0000	0.0000
2001	0.0000	0.1480	0.1670	0.1990	0.2990	0.1030	0.0420	0.0230	0.0130	0.0060	0.0010	0.0000	0.0000
2002	0.0000	0.0050	0.0230	0.0710	0.2060	0.3590	0.2300	0.0760	0.0240	0.0040	0.0000	0.0000	0.0000
2003	0.0000	0.3040	0.2380	0.0410	0.1260	0.0970	0.1220	0.0490	0.0150	0.0060	0.0010	0.0010	0.0000
2004	0.0000	0.1820	0.5190	0.0900	0.0400	0.0580	0.0430	0.0360	0.0210	0.0080	0.0040	0.0010	0.0000
2005	0.0000	0.4928	0.2179	0.0610	0.1055	0.0473	0.0418	0.0193	0.0090	0.0025	0.0018	0.0004	0.0007
2006	0.0000	0.0605	0.1003	0.0549	0.2475	0.2560	0.1001	0.0690	0.0456	0.0447	0.0129	0.0073	0.0012
2007	0.0000	0.0287	0.0405	0.2849	0.1571	0.2686	0.0905	0.0325	0.0250	0.0232	0.0204	0.0193	0.0101
2008	0.0000	0.0126	0.0542	0.1013	0.4130	0.0979	0.1441	0.0902	0.0269	0.0158	0.0110	0.0196	0.0118
2009	0.0000	0.1092	0.0085	0.0339	0.1526	0.4425	0.0972	0.0936	0.0374	0.0169	0.0039	0.0034	0.0008
2010	0.0000	0.0272	0.0165	0.0035	0.0448	0.1776	0.4689	0.0912	0.0955	0.0532	0.0212	0.0004	0.0000
2011	0.0000	0.0998	0.0867	0.0706	0.0215	0.0954	0.1651	0.2748	0.0888	0.0472	0.0258	0.0059	0.0183
2012	0.0029	0.1942	0.0929	0.0413	0.0819	0.0460	0.1051	0.1715	0.2066	0.0473	0.0084	0.0018	0.0000

Table B5.3 cont.

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MD Spawning Stock Gillnet Survey

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1985		0.2879	0.6259	0.0653	0.0098	0.0027	0.0045	0.0001	0.0008	0.0001	0.0001	0.0008	0.0020
1986		0.2286	0.2593	0.4942	0.0040	0.0053	0.0020	0.0029	0.0028	0.0000	0.0000	0.0000	0.0009
1987		0.1989	0.3609	0.1610	0.2463	0.0250	0.0031	0.0036	0.0003	0.0000	0.0000	0.0000	0.0009
1988		0.1246	0.2370	0.2178	0.1741	0.2279	0.0040	0.0000	0.0001	0.0133	0.0000	0.0000	0.0011
1989		0.0837	0.3908	0.2034	0.1150	0.1233	0.0831	0.0004	0.0002	0.0001	0.0000	0.0000	0.0000
1990		0.1550	0.3140	0.2391	0.0959	0.0681	0.0636	0.0592	0.0017	0.0002	0.0002	0.0010	0.0020
1991		0.1593	0.4148	0.1351	0.1023	0.0580	0.0566	0.0418	0.0231	0.0009	0.0033	0.0000	0.0049
1992		0.0435	0.3515	0.2440	0.0932	0.1111	0.0682	0.0463	0.0218	0.0111	0.0052	0.0000	0.0039
1993		0.0655	0.2112	0.2994	0.1411	0.0816	0.0830	0.0593	0.0361	0.0118	0.0050	0.0014	0.0047
1994		0.0523	0.2016	0.1908	0.2296	0.1159	0.0662	0.0835	0.0343	0.0167	0.0061	0.0024	0.0006
1995		0.1082	0.2538	0.1457	0.1319	0.1122	0.0871	0.0543	0.0429	0.0252	0.0210	0.0076	0.0101
1996		0.0052	0.4852	0.1346	0.0458	0.0916	0.0849	0.0557	0.0467	0.0221	0.0200	0.0062	0.0021
1997		0.1050	0.1197	0.3477	0.1189	0.0560	0.0510	0.0668	0.0577	0.0319	0.0311	0.0097	0.0046
1998		0.0753	0.2983	0.0684	0.3118	0.0675	0.0276	0.0387	0.0362	0.0314	0.0190	0.0207	0.0052
1999		0.0177	0.4392	0.2019	0.1432	0.0890	0.0287	0.0166	0.0279	0.0132	0.0128	0.0067	0.0031
2000		0.0290	0.1437	0.3053	0.1427	0.1652	0.0773	0.0399	0.0229	0.0225	0.0220	0.0138	0.0157
2001		0.0167	0.1384	0.1852	0.1826	0.0822	0.1007	0.1345	0.0466	0.0421	0.0348	0.0196	0.0166
2002		0.2407	0.1037	0.0961	0.2081	0.0849	0.0747	0.0790	0.0568	0.0185	0.0102	0.0135	0.0138
2003		0.0390	0.2418	0.1051	0.0815	0.1352	0.1248	0.0676	0.0604	0.0756	0.0217	0.0232	0.0240
2004		0.0512	0.2932	0.1992	0.0671	0.0539	0.0719	0.0761	0.0609	0.0432	0.0447	0.0133	0.0254
2005		0.1353	0.2111	0.1477	0.1941	0.0486	0.0516	0.0434	0.0548	0.0408	0.0350	0.0226	0.0152
2006		0.0174	0.5259	0.0817	0.0969	0.0599	0.0297	0.0253	0.0366	0.0425	0.0265	0.0212	0.0366
2007		0.0376	0.1067	0.3553	0.0691	0.0710	0.0626	0.0343	0.0417	0.0464	0.0742	0.0371	0.0640
2008		0.0074	0.1989	0.2486	0.2574	0.0385	0.0520	0.0445	0.0254	0.0272	0.0227	0.0317	0.0457
2009		0.0704	0.0739	0.2684	0.0905	0.2425	0.0370	0.0398	0.0547	0.0158	0.0277	0.0212	0.0579
2010		0.0166	0.3305	0.1113	0.1435	0.1115	0.1212	0.0148	0.0307	0.0225	0.0088	0.0113	0.0777
2011		0.0500	0.1600	0.2700	0.0990	0.1250	0.0830	0.0980	0.0220	0.0200	0.0170	0.0170	0.0390
2012		0.0574	0.1965	0.0876	0.0895	0.0674	0.0872	0.0854	0.0946	0.0281	0.0624	0.0512	0.0926

Table B5.3 cont.

DE Spawning Stock Electrofishing Survey

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1996		0.0060	0.4170	0.1920	0.0610	0.0850	0.0760	0.0640	0.0580	0.0150	0.0090	0.0090	0.0090
1997		0.0930	0.0740	0.3910	0.1370	0.0510	0.0640	0.0730	0.0320	0.0300	0.0230	0.0090	0.0230
1998		0.0400	0.0870	0.0980	0.3470	0.0900	0.0610	0.1050	0.0950	0.0340	0.0250	0.0080	0.0110
1999		0.0000	0.1050	0.1440	0.1770	0.2350	0.0720	0.0540	0.0760	0.0580	0.0510	0.0140	0.0140
2000		0.0360	0.0360	0.2100	0.1710	0.1380	0.2230	0.0660	0.0300	0.0390	0.0320	0.0100	0.0100
2001		0.0060	0.1150	0.1000	0.1850	0.1100	0.1400	0.2000	0.0500	0.0150	0.0400	0.0200	0.0200
2002		0.0340	0.0710	0.1910	0.1780	0.1570	0.1130	0.0890	0.0970	0.0260	0.0160	0.0100	0.0180
2003		0.0200	0.0970	0.0970	0.1340	0.0890	0.1110	0.1250	0.1050	0.1210	0.0340	0.0280	0.0380
2004		0.0070	0.1660	0.2310	0.0980	0.0680	0.0540	0.1120	0.0780	0.0810	0.0440	0.0140	0.0470
2005		0.0960	0.1570	0.1680	0.1980	0.0810	0.0460	0.0300	0.0360	0.0610	0.0360	0.0460	0.0460
2006		0.0595	0.2007	0.0967	0.1413	0.1413	0.0706	0.0520	0.0409	0.0483	0.0483	0.0372	0.0632
2007		0.0061	0.0887	0.3700	0.1804	0.1009	0.0734	0.0306	0.0245	0.0306	0.0275	0.0398	0.0275
2008		0.0299	0.0329	0.1257	0.3024	0.1467	0.1317	0.0449	0.0359	0.0359	0.0269	0.0449	0.0419
2009		0.1296	0.1014	0.0930	0.1803	0.1352	0.0901	0.0789	0.0366	0.0338	0.0169	0.0282	0.0761
2010		0.1469	0.2041	0.1204	0.1143	0.1224	0.0898	0.0469	0.0429	0.0245	0.0224	0.0204	0.0449
2011		0.0220	0.0550	0.1890	0.1720	0.1300	0.0950	0.1140	0.0950	0.0450	0.0300	0.0120	0.0410
2012		0.1538	0.2985	0.2062	0.0308	0.0338	0.0185	0.0677	0.0338	0.0185	0.0154	0.0554	0.0677

Table B5.3 cont.

VA Pound Net

Year	Age												
	1	2	3	4	5	6	7	8	9	10	11	12	13+
1991	0.0231	0.0182	0.1970	0.4403	0.1469	0.0919	0.0275	0.0138	0.0275	0.0000	0.0000	0.0138	0.0000
1992	0.0245	0.0613	0.0736	0.1963	0.3374	0.1411	0.0368	0.0491	0.0245	0.0552	0.0000	0.0000	0.0000
1993	0.0056	0.0267	0.0487	0.1678	0.4470	0.1710	0.0305	0.0197	0.0272	0.0216	0.0342	0.0000	0.0000
1994	0.0000	0.1082	0.0361	0.0999	0.3449	0.1668	0.0864	0.0443	0.0391	0.0248	0.0248	0.0248	0.0000
1995	0.0029	0.2184	0.3448	0.0718	0.1609	0.0489	0.0431	0.0489	0.0287	0.0057	0.0201	0.0057	0.0000
1996	0.0000	0.0426	0.3314	0.2387	0.1361	0.1052	0.0743	0.0309	0.0309	0.0075	0.0000	0.0000	0.0025
1997	0.0000	0.0306	0.1990	0.4133	0.0638	0.0026	0.0357	0.0408	0.0765	0.0510	0.0510	0.0179	0.0179
1998	0.0000	0.0132	0.1492	0.4393	0.1027	0.0028	0.0361	0.0486	0.0541	0.0618	0.0618	0.0153	0.0153
1999	0.0000	0.0269	0.3932	0.3918	0.0951	0.0037	0.0170	0.0147	0.0109	0.0123	0.0133	0.0147	0.0065
2000	0.0000	0.0008	0.3964	0.4604	0.0848	0.0028	0.0127	0.0127	0.0102	0.0074	0.0094	0.0013	0.0013
2001	0.0000	0.0038	0.1471	0.4020	0.2303	0.0054	0.0311	0.0467	0.0467	0.0435	0.0242	0.0140	0.0054
2002	0.0000	0.0000	0.0975	0.2753	0.2639	0.0478	0.1300	0.0784	0.0535	0.0363	0.0115	0.0000	0.0057
2003	0.0000	0.0000	0.0486	0.1917	0.2128	0.0236	0.1169	0.0895	0.1086	0.0914	0.0722	0.0211	0.0236
2004	0.0000	0.0000	0.1111	0.1783	0.1889	0.1120	0.0714	0.1332	0.0746	0.0535	0.0320	0.0352	0.0099
2005	0.0000	0.0034	0.1037	0.3076	0.1569	0.0402	0.0436	0.0958	0.0958	0.0533	0.0391	0.0323	0.0283
2006	0.0000	0.0041	0.3606	0.2925	0.1449	0.0064	0.0233	0.0416	0.0393	0.0535	0.0105	0.0091	0.0142
2007	0.0000	0.0010	0.0799	0.2713	0.1957	0.0362	0.0355	0.0479	0.0600	0.0850	0.1206	0.0225	0.0444
2008	0.0000	0.0093	0.2402	0.3930	0.1779	0.0278	0.0328	0.0311	0.0158	0.0235	0.0235	0.0251	0.0000
2009	0.0000	0.0031	0.0826	0.2215	0.3028	0.0939	0.0533	0.0533	0.0520	0.0520	0.0293	0.0162	0.0402
2010	0.0000	0.0069	0.0787	0.1945	0.3121	0.1266	0.0458	0.0308	0.0380	0.0530	0.0329	0.0209	0.0598
2011	0.0000	0.0090	0.0516	0.1211	0.1547	0.1076	0.0886	0.0987	0.1076	0.1166	0.0706	0.0280	0.0460
2012	0.0000	0.0000	0.0824	0.1882	0.2235	0.1247	0.0612	0.0541	0.0753	0.0494	0.0565	0.0259	0.0588

Table B5.3 cont.

VA Gill Net

Year	Age												
	1	2	3	4	5	6	7	8	9	10	11	12	13+
1991	0.0023	0.0269	0.1816	0.4507	0.2131	0.0785	0.0313	0.0048	0.0109	0.0000	0.0000	0.0000	0.0000
1992	0.0000	0.0373	0.0520	0.1260	0.3927	0.2220	0.0813	0.0520	0.0133	0.0233	0.0000	0.0000	0.0000
1993	0.0000	0.0099	0.0296	0.1696	0.5010	0.2051	0.0316	0.0079	0.0079	0.0099	0.0217	0.0000	0.0059
1994	0.0000	0.0505	0.0465	0.1494	0.5010	0.1494	0.0384	0.0080	0.0304	0.0122	0.0040	0.0102	0.0000
1995	0.0000	0.1373	0.2136	0.0574	0.2365	0.1373	0.0879	0.0534	0.0421	0.0229	0.0076	0.0000	0.0040
1996	0.0000	0.0391	0.4115	0.2346	0.1173	0.0720	0.0514	0.0309	0.0329	0.0062	0.0041	0.0000	0.0000
1997	0.0000	0.0061	0.2185	0.6148	0.1061	0.0210	0.0161	0.0050	0.0087	0.0037	0.0000	0.0000	0.0000
1998	0.0000	0.0020	0.2122	0.5961	0.1273	0.0142	0.0242	0.0060	0.0060	0.0060	0.0020	0.0040	0.0000
1999	0.0000	0.1811	0.5542	0.1641	0.0495	0.0124	0.0186	0.0077	0.0015	0.0031	0.0031	0.0015	0.0031
2000	0.0000	0.0284	0.3496	0.4104	0.1118	0.0346	0.0386	0.0122	0.0062	0.0041	0.0021	0.0021	0.0000
2001	0.0000	0.0145	0.1527	0.4341	0.2846	0.0338	0.0241	0.0161	0.0177	0.0145	0.0016	0.0016	0.0048
2002	0.0000	0.0159	0.0349	0.2794	0.3238	0.1460	0.1111	0.0381	0.0317	0.0095	0.0095	0.0000	0.0000
2003	0.0000	0.0515	0.1679	0.3053	0.2405	0.0878	0.0802	0.0305	0.0248	0.0095	0.0000	0.0000	0.0019
2004	0.0000	0.0476	0.2526	0.1881	0.1246	0.1160	0.1197	0.0879	0.0318	0.0195	0.0074	0.0049	0.0000
2005	0.0000	0.0131	0.1311	0.3869	0.2164	0.0787	0.0623	0.0459	0.0426	0.0066	0.0098	0.0033	0.0033
2006	0.0000	0.0120	0.2763	0.2462	0.1471	0.0841	0.0330	0.0571	0.0480	0.0541	0.0120	0.0240	0.0060
2007	0.0000	0.0148	0.2504	0.3769	0.0956	0.0740	0.0485	0.0309	0.0309	0.0242	0.0282	0.0027	0.0230
2008	0.0000	0.0000	0.0920	0.2299	0.2452	0.0881	0.0843	0.0536	0.0345	0.0613	0.0536	0.0421	0.0153
2009	0.0000	0.0000	0.0693	0.1472	0.1602	0.1645	0.0779	0.1342	0.0693	0.0476	0.0606	0.0087	0.0606
2010	0.0000	0.0105	0.1032	0.1453	0.2800	0.2211	0.0905	0.0421	0.0253	0.0147	0.0168	0.0084	0.0421
2011	0.0000	0.0052	0.0681	0.1780	0.1466	0.0681	0.0838	0.1518	0.0995	0.0524	0.0262	0.0157	0.1047
2012	0.0000	0.0041	0.0249	0.1494	0.2241	0.1618	0.1577	0.0539	0.0664	0.0290	0.0415	0.0332	0.0539

Table B6.1. State-specific summaries of commercial harvest and biological samples collected by gear type and quarter. 2012 data are preliminary.

		Hook and Line				
		Harvest		No. Permits	Length	Samples
State	Year	Pounds	Number	Fishing	Samples	Aged
MA	2000	779,736	40256	3,283	481	481
	2001	815,054	40248	4,219	540	193
	2002	924,890	44897	4,598	544	197
	2003	1,055,439	55433	4,867	628	249
	2004	1,206,305	60632	4,376	855	249
	2005	1,104,737	59473	4,159	742	251
	2006	1,312,168	69986	3,980	607	306
	2007	1,040,328	54266	3,906	328	328
	2008	1,160,122	61076	3,821	330	330
	2009	1,138,291	59258	4,020	321	321
	2010	1,224,356	62898	3,951	357	357
	2011	1,235,631	64454	3,965	414	358
	2012	1,219,665	61509	-	760	299

Doesn't include fish taken for personal consumption

		Trap					Rod & Reel				
		Harvest			Length	Samples	Harvest			Length	Samples
State	Year	Pounds	Number	Effort	Samples	Aged	Pounds	Number	Effort	Samples	Aged
RI	2000				0	0				0	0
	2001	54,312	6,075		139	135*	109,431	5,848		0	0
	2002	63,375	6,586		0	0	107,798	5,814		197	185*
	2003	66,870	6,874		314	314*	171,155	9,150		185	185*
	2004	78,559	7,681		244	157	166,645	8,211		319	82
	2005	68,219	6,446		412	412	174,084	8,366		492	490
	2006	63,827	6,562		425	188	174,970	8,867		424	0
	2007	70,866	7,654		132	132	169,761	6,280		350	0
	2008	89,828	9,659		296	0	156,160	6,940		366	0
	2009	95,091	11,003		371		139,277	5,797		348	
	2010	93,830	10,086		589		155,690	5,601		405	
	2011	93,864	8,373		265	125	134,299	5,970		360	48
	2012	91,871	8,590		163	96	148,042	6,363		89	48

*= value indicates the number of scales that were collected; the number that were actually processed for ageing is not known

Table B6.1 cont.

		Mixed Gear Types				
		Harvest			Length	Samples
State	Year	Pounds	Number	Effort	Samples	Aged
NY	2000	542,659	54,895		814	814
	2001	633,095	58,296		839	839
	2002	518,573	47,143		508	508
	2003	753,261	68,354		524	524
	2004	741,668	70,367		481	481
	2005	689,821	70,560		185	185
	2006	687,204	73,528		580	580
	2007	729,743	78,287		753	734
	2008	653,100	73,263		1154	1144
	2009	789,891	82,574		655	655
	2010	782,402	81,896		388	381
	2011	854,731	87,349		535	534
	2012	671,754	66,224		353	

		Hook and Line					Gillnet landings					Discards from gill nets	
		Harvest		Effort	Length	Samples	Harvest		Effort	Measured	Samples	Length	Samples
State	Year	Pounds	Number	(man-days)	Samples	Aged	Pounds	Number	(yard-days)	Bass	Aged	Samples	Aged
DE	2000	4,800	857	100	80	79	135,835	24,331	384,846	537	356	188	139
	2001	5,732	957		56	56	193,070	33,416	278,675	374	137	721	310
	2002	6,883	1,130		32	32	153,677	25,397	279,974	336	336	621	215
	2003	6,922	1,183		35	34	181,467	30,347	263,672	593	521	235	235
	2004	4,571	287		32	32	177,403	28,119	293,177	179	179		
	2005	2,956	353		6	6	170,859	25,983	1,216,370	144	144		
	2006	5,787	459		2	2	173,676	29,753	416,201	397	372		
	2007	8,398	728		21	21	180,270	30,362	30,500	394	385		
	2008	7,841	626		28	28	180,878	31,227	205,930	227	227		
	2009	10,378	727		144	10	176,741	20,383	159,989	221	221		
	2010	6,996	536		82	79	172,078	19,300	200,285	286	286		
	2011	7,123	488		82	82	181,497	20,029	144,800	148	148		
	2012	11,153	855		63	63	183,171	14,883		150	146		

Table B6.1 cont.

State	Year	Hook and Line					Poundnet/haul seine				
		Harvest	BOATDAYS*TOT(		Length	Samples	Harvest	FISHDAY*NUMI		Length	Samples
		Pounds	Number	Effort	Samples	Aged	Pounds	Number	Effort	Samples	Aged
MD	2000	745,988	211,226	22,442	1,932	209	462,250	102,362	13,038	633	209
	2001	371,854	107,128	14,340	1,693	226	652,606	155,568	17,557	1,115	226
	2002	359,344	97,725	10,888	1,697	217	471,393	176,183	27,241	1,080	217
	2003	373,192	106,961	9,831	1,777	182	602,748	122,611	8,547	1,290	182
	2004	355,629	119,755	16,661	1,965	256	507,110	136,604	7,974	853	156
	2005	283,803	87,096	8,478	2,158	201	513,519	149,711	7,130	1,159	210
	2006	514,019	169,864	11,777	2,106	196	672,698	215,845	6,776	944	196
	2007	643,598	237,800	16,539	1,680	147	528,683	146,518	4,015	1,187	142
	2008	432,139	150,480	11,322	1,626	148	559,298	170,422	4,654	884	170
	2009	650,207	183,568	18,053	2,260	160	566,898	152,058	4,251	1,087	160
	2010	519,117	142,063	15,512	1,790	157	651,916	198,253	4,227	1,528	158
	2011	441,422	129,475	14,212	1,431	149	648,113	167,034	4,411	1,128	149
	2012*	424,657	133,563		1,988	198	565,600	141,558		788	198

State	Year	Gillnet					atl trwlgill				
		Harvest	BOATDAYS*TOT(		Length	Samples	Harvest	BOATDAYS*TOT		Length	Samples
		Pounds	Number	Effort	Samples	Aged	Pounds	Number	Effort	Samples	Aged
MD	2000	993,982	243,571	5,219,125	4,071		95,849	12,035	400,331	0	0
	2001	586,685	115,494	3,432,064	3,772	184	91,786	11,087	92,108	0	0
	2002	662,677	216,780	3,953,989	4,091	165	89,386	12,071	101,657	0	0
	2003	744,768	193,415	2,775,249	2,810	262	98,149	9,516	70,061	0	0
	2004	921,317	190,118	3,556,289	3,591	193	113,104	13,798	193,508	0	0
	2005	1,267,217	178,079	3,894,514	3,381	142	46,871	6,105	83,788	0	0
	2006	929,540	245,467	2,669,277	2,974	183	91,093	10,535	136,732	560	127
	2007	1,068,304	202,616	2,771,074	3,063	183	96,301	11,561		252	202
	2008	1,216,581	259,749	3,785,631	3,621	211	118,005	14,004		244	119
	2009	1,050,188	269,950	2,827,079	3,734	117	127,327	12,500		176	133
	2010	934,742	238,869	3,160,716	3,108	119	44,802	5,369		107	242
	2011	865,537	192,388	2,429,742	3,442	126	21,401	2,072		208	117
	2012*	861,174	190,523		3,800	122	77,551	6,873		629	210

*Data is preliminary

Table B6.1 cont.

State	Year	Gill Net (Chesapeake Bay Area) Harvest Pounds	Number	Effort	Length Samples	Samples Aged	Gill Net (Coastal Area) Harvest Pounds	Number†	Effort	Length Samples	Samples Aged
VA	2000	681,895	84,585	3,495	392	835	905,446	57,586	1,351	1,024	502
	2001	701,773	79,925	3,074	439	443	767,583	45,413	1,429	588	1,585
	2002	708,127	63,938	2,863	608	1,544	690,107	49,541	1,194	371	2,180
	2003	1,442,770	114,111	3,353	1,773	6,358	159,786	9,387	397	207	1,436
	2004	1,311,453	114,054	2,903	515	3,224	155,393	7,989	453	72	600
	2005	1,408,425	84,043	2,737	1,668	7,826	182,294	11,318	390	500	4,022
	2006	1,004,551	73,300	3,268	1,744	4,066	192,299	12,296	368	867	2,431
	2007	1,138,519	98,960	3,125	734	3,311	159,225	10,716	387	293	1,794
	2008	1,274,062	82,702	3,433	857	4,640	159,818	9,981	265	517	4,729
	2009	1,210,607	102,121	3,447	1,444	3,947	139,083	7,878	369	392	3,387
	2010	1,161,461	121,650	3,395	1,902	4,021	122,203	9,066	271	445	2,829
	2011	1,110,061	109,115	3,604	2,884	3,817	158,538	10,079	292	314	2,957
	2012*	1,184,161	88,989	3,525	1,302		171,679	8,126	264	343	

State	Year	Hook and Line (Chesapeak Bay Area) Harvest Pounds	Number†	Effort	Length Samples	Samples Aged	Hook and Line (Coastal Area) Harvest Pounds	Number	Effort	Length Samples	Samples Aged
VA	2000	91,096	16,067	712	40	51	17,762	1,130	64	3	
	2001	70,599	4,971	541	154	915	8,465	501	34		
	2002	116,445	8,682	521	189	1,015	15,716	1,128	70		
	2003	134,035	10,392	598	83	513	598	35	7		
	2004	110,038	13,373	575	65	382	1,544	79	10		
	2005	73,501	5,317	411	108	199	1,633	101	3	1	1
	2006	140,141	10,887	699	143	683	1,253	80	6	4	4
	2007	131,691	7,054	793	77	770	3,117	210	8		
	2008	170,233	7,024	798	44	345	3,284	205	8		
	2009	91,956	8,420	562	229	547	1,337	76	13		
	2010	59,656	7,285	357	119	264	5,633	418	6		
	2011	79,981	5,300	536	395	874	273	17	5	1	1
	2012*	83,113	4,820	507	144		32	2	1		

Table B6.1 cont.

State	Year	Pound Net Harvest Pounds	Number	Effort	Length Samples	Samples Aged	Fyke net Harvest Pounds	Number	Effort	Length Samples	Samples Aged
VA	2000	166,075	27,463	1,722	484	446	8,230		56	22	22
	2001	108,027	21,991	1,221	801	2,239	11,214		60		
	2002	66,808	15,167	1,067	653	2,036					
	2003	96,978	19,761	964	458	940	5,224		68		
	2004	67,999	11,164	776	563	2,055	4,295		20		
	2005	66,062	9,784	792	408	1,097	7,758		31		
	2006	60,466	10,653	602	292	534	871		21		
	2007	90,157	16,759	905	455	1,089	4,419		70		
	2008	97,072	18,919	894	194	429	3,563		60		
	2009	89,097	18,106	802	368	748	8,217		115		
	2010	79,868	14,602	673	346	390	6,129		111		
	2011	72,973	14,640	570	795	445	7,171		70		
	2012*	62,440	11,392	544	405		6,724		136		

State	Year	Haul Seine Harvest Pounds	Number	Effort	Length Samples	Samples Aged	Other Harvest Pounds	Number	Effort	Measured Bass	Samples Aged
VA	2000	13,013		39			339		23		
	2001	7,703	1,688	20	13		105		16		
	2002	7,377	1,614	24	2		113		15		
	2003	17,110	1,298	14	7	52	330		15		
	2004	17,570	6,327	31	31	114	15		3		
	2005	6,574		13					1		
	2006	10,556	679	15	53	337	3,777		12		
	2007	3,908		24			518		37		
	2008	6,337	2,312	35	29	112	49		7		
	2009	13,404	3,848	40	18	24	53		12		
	2010	5,783	1,577	38	48	306	116		12		
	2011	7,698	2,442	26	27	59	28		4		
	2012*	1,355		2			42		8		

*Data are preliminary

†Average ocean striped bass weight used to calculate all gears.

Table B6.1 cont.

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| | | Ocean beach haul seine | | | | | Ocean gillnet | | | | |
| | | Harvest | | | Length | Samples | Harvest | | | Length | Samples |
State	Year	Pounds	Number	Effort	Samples	Aged	Pounds	Number	Effort	Samples	Aged
NC	2000	58,147	2,528		281	281	No fishery due to overage previous year				
	2001	93,580	4,925		161	161	120,336	5,232		69	69
	2002	237,983	12,525		288	288	111,070	5,846		83	83
	2003	No fishery due to overage previous year					140,793	7,544		170	170
	2004	180,640	9,507		178	178	204,046	9,275		211	211
	2005	331,341	13,805		299	299	231,177	12,167		186	186
	2006	No fishery due to overage previous year					56,341	2,561		154	154
	2007	10,471	464		64	64	270,623	11,980		232	101
	2008	75,711	3,510		53	53	138,581	6,425		92	92
	2009	4,856	231		0	0	51,677	2,457		28	28
	2010	4,097	192		0	0	71,664	3,363		98	67
	2011	6,646	293		0	0	139,377	6,148		163	98
	2012	0	0		0	0	5,101	223		21	21

| | | Ocean trawl | | | | |
| | | Harvest | | | Length | Samples |
State	Year	Pounds	Number	Effort	Samples	Aged
NC	2000	102,167	5,108		270	270
	2001	167,199	7,270		103	103
	2002	84,795	4,469		160	160
	2003	108,141	5,692		239	239
	2004	220,166	10,150		285	285
	2005	37,598	1,979		33	33
	2006	17,797	803		115	115
	2007	98,344	4,353		461	204
	2008	74,118	3,436		142	142
	2009	133,430	6,343		151	151
	2010	200,674	9,417		359	225
	2011	100,343	4,426		226	121
	2012	2,180	100		0	0

Table B6.2. Total harvest (metric tons) of striped bass along the Atlantic Coast, 1982–2012. 2012 data are preliminary.

Year	Commercial	Recreational	Total	Year	Commercial	Recreational	Total
1947	2,085	-	2,085	1982	992	1,144	2,136
1948	2,726	-	2,726	1983	639	1,224	1,863
1949	2,543	-	2,543	1984	1,104	582	1,686
1950	3,128	-	3,128	1985	431	376	807
1951	2,444	-	2,444	1986	63	52	115
1952	2,148	-	2,148	1987	63	388	451
1953	1,960	-	1,960	1988	117	578	695
1954	1,759	-	1,759	1989	91	336	427
1955	1,906	-	1,906	1990	313	1,010	1,323
1956	1,686	-	1,686	1991	668	1,653	2,321
1957	1,619	-	1,619	1992	650	1,830	2,480
1958	2,266	-	2,266	1993	794	2,563	3,357
1959	3,317	-	3,317	1994	86	3,083	3,169
1960	3,524	-	3,524	1995	1,555	5,709	7,264
1961	4,042	-	4,042	1996	1,541	6,040	7,581
1962	3,567	-	3,567	1997	2,679	7,336	10,015
1963	3,879	-	3,879	1998	2,936	5,850	8,786
1964	3,558	-	3,558	1999	2,963	6,335	9,298
1965	3,278	-	3,278	2000	3,038	8,060	11,098
1966	3,820	-	3,820	2001	2,843	8,880	11,723
1967	3,924	-	3,924	2002	2,740	8,449	11,189
1968	4,169	-	4,169	2003	3,199	10,405	13,604
1969	4,912	-	4,912	2004	3,332	13,238	16,570
1970	3,999	-	3,999	2005	3,240	13,709	16,949
1971	2,890	-	2,890	2006	3,073	14,082	17,155
1972	4,012	-	4,012	2007	3,192	12,245	15,437
1973	5,888	-	5,888	2008	3,281	13,878	17,159
1974	4,536	-	4,536	2009	3,281	10,404	13,686
1975	3,416	-	3,416	2010	3,203	10,430	13,633
1976	2,494	-	2,494	2011	3,077	12,354	15,430
1977	2,245	-	2,245	2012	2,952	8,740	11,692
1978	1,764	-	1,764				
1979	1,290	-	1,290				
1980	1,895	-	1,895				
1981	1,744	-	1,744				

Table B6.3. Commercial landings (numbers) of striped bass along the Atlantic Coast by state, 1982–2012

Year	ME	NH	MA*	RI	CT	NY	NJ	DE	MD	PRFC	VA	NC	Total
1982			26,183	52,896	207	74,935		12,794	189,089	54,421	14,905	3,200	428,630
1983			9,528	48,173	83	66,334		5,806	147,079	63,171	15,962	1,405	357,541
1984			5,838	8,878	192	70,472		12,832	392,696	372,924	6,507	532	870,871
1985	90		7,601	7,173	350	52,048		1,359		82,550	23,450		174,621
1986			3,797	2,668						10,965	251		17,681
1987			3,284	23						9,884	361		13,552
1988			3,388							19,334	10,588		33,310
1989			7,402										7,402
1990			5,927	784		11,784		698	534	38,884	56,222	803	115,636
1991			9,901	3,596		15,426		3,091	31,880	44,521	44,970	413	153,798
1992			11,532	9,095		20,150		2,703	119,286	23,291	42,912	1,745	230,714
1993			13,099	6,294		11,181		4,273	211,089	24,451	39,059	3,414	312,860
1994			11,066	4,512		15,212		4,886	208,914	25,196	32,382	5,275	307,443
1995			44,965	19,722		43,704		5,565	280,051	29,308	88,274	23,325	534,914
1996			38,354	18,570		39,707		20,660	415,272	46,309	184,495	3,151	766,518
1997			44,841	7,061		37,852		33,223	706,847	87,643	165,583	25,562	1,108,612
1998			43,315	8,835		45,149		31,386	790,154	93,299	204,911	16,040	1,233,089
1999			40,838	11,559		49,795		34,841	650,022	90,575	205,143	21,040	1,103,812
2000			40,256	9,418		54,894		25,188	627,777	91,471	202,227	6,480	1,057,712
2001			40,248	10,917		58,296		34,373	549,896	87,809	148,346	22,936	952,820
2002			48,926	11,653		47,142		30,440	296,635	80,300	127,211	15,784	658,091
2003			61,262	15,497		68,354		31,531	439,482	83,091	161,777	13,823	874,817
2004			66,556	15,867		70,367		28,406	461,064	91,888	147,998	31,014	913,160
2005			65,332	14,949		70,560		26,336	569,964	80,615	119,244	26,573	973,572
2006			75,062	15,429		73,528		30,212	655,951	92,288	109,396	2,799	1,054,664
2007			57,634	13,934		78,287		31,090	598,495	86,695	140,602	16,621	1,023,358
2008			65,330	16,616		73,263		31,866	594,655	81,720	134,603	12,903	1,010,955
2009			63,875	20,725		82,574		21,590	618,076	89,693	138,303	8,675	1,043,512
2010			65,277	17,256		81,896		19,830	584,554	90,258	159,197	12,670	1,030,938
2011			63,309	14,344		87,349		20,517	490,969	96,126	148,063	10,814	931,490
2012			66,394	14,953		66,626		15,738	472,331	90,616	111,839	323	838,820

* Includes fish taken for personal consumption
2012 data are preliminary.

Table B6.4. Age structure of commercial harvest in 2011 and 2012 by state.

2011							Age									
State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
MA	0	0	0	35	132	562	4,933	11,321	11,953	11,888	4,367	5,148	4,550	4,927	3,493	63,309
RI	0	0	0	92	544	1,569	2,673	2,752	1,739	1,462	696	756	816	795	450	14,344
NY	0	0	0	5,254	3,280	17,193	22,244	27,449	5,398	3,918	1,306	980	327	0	0	87,349
DE	0	0	0	0	541	1,759	3,937	4,503	5,142	3,063	1,205	227	43	18	79	20,517
MD	0	0	42,782	80,375	144,116	137,283	59,336	16,680	6,445	2,212	733	422	307	175	104	490,969
PRFC	0	0	0	25,777	37,591	19,870	4,833	2,148	2,685	2,685	0	537	0	0	0	96,126
VA	0	788	6,810	16,328	13,682	19,364	18,891	25,435	10,178	15,325	6,680	4,007	3,477	3,237	3,861	148,063
NC	0	0	0	0	0	923	1,227	2,781	1,949	2,075	598	431	830	0	0	10,814
																931,490

2012							Age									
State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
MA	0	0	0	37	138	1,308	5,582	16,616	13,353	7,676	5,671	7,015	3,089	3,359	2,550	66,394
RI	0	0	12	399	1,102	2,105	2,574	2,520	1,922	999	709	833	542	705	530	14,953
NY	0	0	0	7,418	4,175	13,431	15,208	18,732	3,846	2,291	750	600	175	0		66,626
DE	0	0	0	0	0	1,082	2,820	3,813	3,511	2,438	1,417	349	205	103	0	15,738
MD	0	6,959	49,218	66,050	181,941	98,053	53,022	7,075	8,175	839	664	256	35	11	33	472,331
PRFC	0	958	6,125	11,892	38,342	19,856	10,991	1,098	1,261	34	50	10	0	0	0	90,616
VA	0	610	2,920	7,167	11,809	7,170	9,645	10,497	20,464	10,467	16,915	5,252	3,952	2,410	2,562	111,839
NC	0	0	0	0	0	0	0	15	154	46	62	15	15	0	15	323
																838,820

2012 data are preliminary.

Table B6.5. Time series of coast-wide commercial harvest numbers-at-age, 1982-2012.

							Age									
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1982	0	45,129	200,221	117,158	22,927	5,035	3,328	2,861	1,871	4,407	5,837	7,639	2,509	2,810	6,898	428,630
1983	0	54,348	120,639	120,999	38,278	7,416	1,954	677	607	1,690	1,314	2,375	2,656	1,856	2,733	357,541
1984	0	478,268	270,140	55,598	30,580	21,688	6,441	1,744	1,020	771	146	279	1,096	1,042	2,058	870,871
1985	0	53,699	45,492	7,545	9,448	19,248	21,569	6,581	3,692	1,514	466	607	493	894	3,373	174,621
1986	0	639	6,020	3,207	180	703	1,425	1,199	546	182	105	220	288	963	2,004	17,681
1987	0	0	3,087	4,265	1,618	252	1,104	1,075	448	233	95	273	302	235	565	13,552
1988	0	0	2,086	3,961	15,491	6,469	2,803	539	541	218	266	108	250	41	537	33,310
1989	0	0	0	0	0	139	1,111	959	1,007	631	475	164	343	444	2,129	7,402
1990	0	650	12,551	48,024	29,596	15,122	3,111	2,357	1,147	519	272	130	428	322	1,407	115,636
1991	0	2,082	22,430	44,723	41,048	21,614	8,546	4,412	4,816	1,163	269	125	80	553	1,937	153,798
1992	0	640	32,277	58,009	46,661	41,581	22,186	11,514	8,746	6,314	1,062	464	169	346	745	230,714
1993	0	1,848	21,073	93,868	87,447	42,112	32,485	13,829	8,396	6,420	3,955	763	184	76	404	312,860
1994	0	1,179	22,873	71,614	101,512	48,269	28,530	14,886	8,902	5,323	2,513	1,250	198	68	326	307,443
1995	0	6,726	35,190	114,519	134,709	98,471	38,918	34,191	37,324	21,827	8,364	3,166	997	363	149	534,914
1996	0	557	50,102	127,825	179,031	161,361	120,693	51,995	29,907	18,864	11,663	9,674	2,264	1,134	1,449	766,518
1997	0	1,843	37,754	342,867	213,454	206,836	102,034	76,149	54,989	30,373	17,813	13,813	4,873	3,125	2,688	1,108,612
1998	0	6,124	54,375	267,791	411,067	184,209	94,726	75,915	63,592	31,809	19,948	12,110	5,149	2,574	3,700	1,233,089
1999	0	7,591	94,342	211,645	264,460	221,773	92,992	66,837	63,357	35,916	20,939	14,180	4,611	2,549	2,621	1,103,812
2000	0	244	51,876	203,457	284,772	194,336	121,949	72,841	51,768	37,496	19,263	11,391	4,041	1,850	2,430	1,057,712
2001	0	165	86,190	189,602	241,867	140,555	89,963	95,580	34,026	31,547	22,172	12,853	5,027	2,582	692	952,820
2002	0	184	39,914	133,965	130,689	107,219	68,875	45,032	56,146	28,715	20,386	12,252	7,430	3,341	3,942	658,091
2003	0	3,932	59,027	156,836	171,626	132,005	96,662	76,612	70,049	59,722	20,916	15,944	6,647	2,366	2,472	874,817
2004	1,221	18,069	83,780	173,546	123,717	102,815	94,480	97,849	73,246	57,207	43,534	22,876	13,844	3,906	3,068	913,160
2005	0	145	43,488	239,748	252,020	102,076	57,072	56,939	75,306	50,440	41,629	25,937	19,435	4,598	4,738	973,572
2006	0	81	90,820	192,639	335,889	150,133	48,304	43,705	46,313	61,550	39,664	23,017	13,656	5,447	3,448	1,054,664
2007	0	0	4,711	305,597	207,826	190,053	78,099	51,494	64,579	51,397	32,964	20,498	9,282	3,006	3,853	1,023,358
2008	0	0	12,506	233,419	311,903	125,702	92,605	60,928	42,177	41,351	35,246	29,726	15,626	5,848	3,920	1,010,955
2009	0	69	19,745	190,560	356,448	191,280	68,995	69,342	41,636	31,813	27,531	18,630	16,438	6,490	4,534	1,043,512
2010	0	7,178	46,448	219,450	247,340	177,935	133,809	58,962	45,183	30,091	21,540	17,394	14,386	5,165	6,055	1,030,938
2011	0	788	49,592	127,860	199,887	198,523	118,074	93,069	45,488	42,628	15,586	12,507	10,349	9,153	7,987	931,490
2012	0	8,527	58,276	92,963	238,589	144,744	100,834	60,065	51,612	23,769	25,169	14,187	7,910	6,485	5,690	838,820

2012 data are preliminary.

Table B6.6. Tag returns of striped bass by commercial gear in 2011 and 2012.

2011

		Anchor Gillnet	Drift Gillnet	Hook & Line	Other	Pound Net	Seine	Trawl	Total
Number	DE Bay	2	1	1	0	0	0	0	4
	Chesapeake Bay	9	4	6	0	10	0	1	30
	Coast	2	1	28	2	4	0	2	39

		Anchor Gillnet	Drift Gillnet	Hook & Line	Other	Pound Net	Seine	Trawl
Proportions	DE Bay	0.50	0.25	0.25	0.00	0.00	0.00	0.00
	Ches Bay	0.30	0.13	0.20	0.00	0.33	0.00	0.03
	Coast	0.05	0.03	0.72	0.05	0.10	0.00	0.05

2012

		Anchor Gillnet	Drift Gillnet	Hook & Line	Other	Pound Net	Seine	Trawl	Total
Number	DE Bay (used 2011)	2	1	1	0	0	0	0	4
	Chesapeake Bay	7	3	13	1	2	0	1	27
	Coast	0	2	35	4	2	0	0	43

		Anchor Gillnet	Drift Gillnet	Hook & Line	Other	Pound Net	Seine	Trawl
Proportions	DE Bay	0.50	0.25	0.25	0.00	0.00	0.00	0.00
	Ches Bay	0.26	0.11	0.48	0.04	0.07	0.00	0.04
	Coast	0.00	0.05	0.81	0.09	0.05	0.00	0.00

	Anchor Gillnet	Drift Gillnet	Hook & Line	Other	Pound Net	Seine	Trawl
Release Mortality	0.4275	0.08	0.08	0.2	0.05	0	0.35

Table B6.7. Landings and tag recapture ratios (commercial: recreational) used in estimating total commercial discards for the Atlantic Coast in 2011 and 2012. The correction factors (CF) are used to adjust the tag return ratios for underreporting.

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2011

		Chesapeake Bay				Coast				DE Bay			
		Com	Rec	Ratio	CF	Com	Rec	Ratio	CF	Com	Rec	Ratio	CF
2009	landings	825,281	722,161	1.14		196,642	1,134,803	0.17		20,696	82,741	0.25	
	Discards		1,722,000				5,991,361	0.00			257,452	0.00	
	Killed tags	44	226	0.19	5.87	53	475	0.11	1.55	1	44	0.02	11.01
	discard tags	9	54	0.17		8	346	0.02		2	48	0.04	
2010	landings	820,159	515,632	1.59		194,003	1,342,983	0.14		18,562	99,517	0.19	
	Discards		1,632,669				4,424,709				200,702		
	Killed tags	20	129	0.16	10.26	32	514	0.06	2.32	3	44	0.07	2.74
	discard tags	3	48	0.06		6	277	0.02		2	29	0.07	
2011	landings	722,489	541,797	1.33		182,975	1,553,364	0.12		20,517	110,729	0.19	
	Discards		1,264,123				4,424,994				243,363		
	Killed tags	18	141	0.13	10.45	30	429	0.07	1.68	1	54	0.02	10.01
	discard tags	12	45	0.27		8	194	0.04		3	37	0.08	

	Ches Bay	Coast	DE Bay	
Mean Correction Factor	8.858299	1.852594	7.915696	
Estimated Comm Discards(no.)	2,986,128	338,050	156,194	3,480,372

2012

		Chesapeake Bay				Coast				DE Bay			
		Com	Rec	Ratio	CF	Com	Rec	Ratio	CF	Com	Rec	Ratio	CF
2010	landings	820,159	515,632	1.59		194,003	1,204,970	0.16		18,562	45,846	0.40	
	Discards		1,632,669				4,131,861				125,675		
	Killed tags	20	129	0.16	10.26	32	514	0.06	2.59	3	44	0.07	5.94
	discard tags	3	48	0.06		6	277	0.02		2	29	0.07	
2011	landings	722,489	541,797	1.33		182,975	1,553,364	0.12		20,517	110,729	0.19	
	Discards		1,264,123				4,424,994				243,363		
	Killed tags	18	141	0.13	10.45	30	429	0.07	1.68	1	54	0.02	10.01
	discard tags	12	45	0.27		8	194	0.04		3	37	0.08	
2012	landings	659,684	288,752	2.28		158,113	1,086,034	0.15		15,738	63,800	0.25	
	Discards		2,248,637				2,693,827				168,135		
	Killed tags	20	97	0.21	11.08	31	349	0.09	1.64	1	38	0.03	9.37
	discard tags	5	29	0.17		11	149	0.07		1	31	0.03	

	Ches Bay	Coast	DE Bay	
Mean Correction Factor	10.60	1.97	8.44	
Estimated Comm Discards(no.)	4,107,694	391,751	45,772	4,545,218

Table B6.8. Estimate of total and dead commercial discards of striped bass by gear and area.

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2011 — **Total Discards**

Area	Anchor Gillnet	Drift Gillnet	Hook & Line	Other	Pound Net	Trawl	Total
Coast	17,336	8,668	242,703	17,336	34,672	17,336	338,050
Ches Bay	895,838	398,150	597,226	0	995,376	99,538	2,986,128
Del Bay	78,097	39,048	39,048	0	0	0	156,194
							3,480,372

Release Mortality Rate

Anchor Gillnet	Drift Gillnet	Hook & Line	Other	Pound Net	Trawl
0.4275	0.08	0.09	0.2	0.05	0.35

Dead Discards

Area	Anchor Gillnet	Drift Gillnet	Hook & Line	Other	Pound Net	Trawl	Total
Coast	7,411	693	21,843	3,467	1,734	6,068	41,216
Ches Bay	382,971	31,852	53,750	0	49,769	34,838	553,180
Del Bay	33,386	3,124	3,514	0	0	0	40,025
							634,421

2012 — **Total Discards**

Area	Anchor Gillnet	Drift Gillnet	Hook & Line	Other	Pound Net	Trawl	Total
Coast	0	18,221	318,867	36,442	18,221		391,751
Ches Bay	1,064,958	456,410	1,977,779	152,137	304,274	152,137	4,107,694
Del Bay	22,886	11,443	11,443				45,772
							4,545,218

Release Mortality Rate

Anchor Gillnet	Drift Gillnet	Hook & Line	Other	Pound Net	Trawl
0.4275	0.08	0.09	0.2	0.05	0.35

Dead Discards

Area	Anchor Gillnet	Drift Gillnet	Hook & Line	Other	Pound Net	Trawl	Total
Coast	0	1,458	28,698	7,288	911	0	38,355
Ches Bay	455,269	36,513	178,000	30,427	15,214	53,248	768,671
Del Bay	9,784	915	1,030	0	0	0	11,729
							818,756

Table B6.9. Data sources for estimating striped bass age structure of commercial discards and discard mortality estimates applied to gear types in 2011 and 2012.

Area	Gear	Data Source	Data Type	Conversion to Age
Coastal	Anchor Gillnet	MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings - 2011 & 2012	length-frequency	state age-length key
	Drift Gillnet	MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings - 2011 & 2012	length-frequency	state age-length key
	Hook & Line	MA Hook & line discards at age from compliance report - 2011 & 2012	age structure	
	Pound Net	RI float trap CAA from compliance report - 2011 & 2012	age structure	
	Otter Trawl	NY mixed fishery with trawl landings and NC comm trawl landings CAA - compliance report 2011 & 2012	age structure	
	Other	Average of all gears	age structure	
Chesapeake Bay	Anchor Gillnet	Fisheries-independent sampling, James & Rappahannock Rivers - VA Compliance report, 2011 & 2012	age structure	
	Drift Gillnet	MD discards-at-age estimates in Bay Gillnet fishery - MD compliance report, 2011 & 2012	age structure	
	Hook & Line	MD commerical hook & line harvest at age - MD compliance report, 2011 & 2012	age structure	
	Pound Net	Fisheries-independent sampling, Rappahannock River - VA compliance report, 2011 & 2012	age structure	
	Other	Average of Anchor, drift, H&L and Pound	age structure	
Delaware Bay	Anchor Gillnet	DE gillnet landings harvest-at-age in spring - DE compliance report, 2011 & 2012	age structure	
	Drift Gillnet	DE gillnet landings harvest-at-age in spring - DE compliance report, 2011 & 2012	age structure	
	Hook & Line	DE Hook & line harvest-at-age - DE compliance report 2012	age structure	

Table B6.10. Commercial dead discards apportioned into age classes, 2011 and 2012.

2011		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
Ches Bay	Anchor Gill	-	3,016	48,851	83,831	89,259	39,202	22,315	23,521	17,490	14,474	7,840	7,840	7,840	7,237	6,634	603	3,016	382,971
	Drift Gill	-	-	1,890	4,996	10,752	8,833	3,576	1,451	237	81	29	7	-	-	-	-	-	31,852
	H&L	-	-	4,933	8,425	13,892	13,210	5,980	749	434	83	28	22	22	-	-	-	-	47,778
	Pound	-	465	2,558	6,047	7,675	5,349	4,419	4,884	5,349	5,814	3,488	1,395	233	930	465	233	465	49,769
	Trawl	0	0	0	1006	628	4042	5249	9223	4600	4712	1281	1372	803	667	453	179	625	34,838
	Other	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sub-Total	0	3481	58232	104305	122206	70636	41538	39827	28109	25166	12667	10637	8898	8835	7552	1014	4105	547208
DE Bay	Anchor Gill	-	-	-	-	908	2,953	6,586	7,495	8,517	4,997	1,703	227	-	-	-	-	-	33,386
	Drift Gill	-	-	-	-	85	276	616	701	797	468	159	21	-	-	-	-	-	3,124
	H&L	-	-	-	-	-	-	78	234	430	547	351	586	273	117	273	156	78	3,124
	Sub-Total	-	-	-	-	993	3,229	7,281	8,430	9,743	6,011	2,214	834	273	117	273	156	78	39,634
Coast	Anchor Gill	-	-	-	-	14	53	600	1,588	1,186	1,796	799	380	435	294	111	118	36	7,411
	Drift Gill	-	-	-	-	1	5	56	149	111	168	75	36	41	28	10	11	3	693
	H&L	-	241	591	1,323	2,195	4,707	5,764	3,717	650	158	61	7	4	-	-	-	-	19,416
	Pound	0	0	0	48	53	314	290	606	121	199	63	20	0	16	0	3	0	1,734
	Trawl	-	-	-	175	109	704	914	1,606	801	821	223	239	140	116	79	31	109	6,068
	Other	0	8	21	85	113	378	530	842	379	507	199	105	96	92	49	33	32	3,467
	Sub-Total	0	249	612	1,632	2,485	6,159	8,154	8,507	3,248	3,649	1,420	786	716	546	250	196	180	38,789
	Total	-	3,730	58,844	105,937	125,685	80,024	56,973	56,764	41,100	34,826	16,301	12,257	9,888	9,498	8,075	1,367	4,364	625,631

2012		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
Ches Bay	Anchor Gill	0	1,889	11,335	68,007	102,011	73,674	71,785	24,558	30,225	13,224	18,891	15,113	1,889	9,445	0	11,335	1,889	455,269
	Drift Gill	0	0	492	4,170	16,988	8,638	5,107	461	621	10	26	0	0	0	0	0	0	36,513
	H&L	0	5,624	28,486	26,576	53,645	28,522	12,522	1,624	1,114	70	0	40	0	0	0	0	0	158,222
	Pound	0	0	1,253	2,864	3,401	1,897	931	823	1,146	752	859	394	251	286	179	179	0	15,214
	Trawl	0	0	0	5,900	3,321	10,682	12,096	14,910	3,181	1,859	645	490	152	0	12	0	0	53,248
	Other	0	302	2,288	4,715	9,523	5,350	3,331	996	1,261	602	751	451	157	301	89	279	32	30,427
	Sub-Total	0	7,815	43,853	112,231	188,888	128,764	105,772	43,373	37,547	16,516	21,172	16,487	2,448	10,033	281	11,792	1,921	748,894
DE Bay	Anchor Gill	0	0	0	0	675	1,754	2,362	2,227	1,484	877	202	135	67	0	0	0	0	9,784
	Drift Gill	0	0	0	0	63	164	221	208	139	82	19	13	6	0	0	0	0	915
	H&L	0	0	0	0	59	162	236	133	192	89	44	0	0	0	0	0	0	915
	Sub-Total	0	0	0	0	797	2,081	2,819	2,568	1,815	1,048	266	148	74	0	0	0	0	11,615
Coast	Anchor Gill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Drift Gill	0	0	0	1	49	56	97	134	340	168	203	122	114	100	37	19	17	1,458
	H&L	0	232	1,222	2,072	4,148	5,866	5,723	4,068	1,979	173	21	4	0	0	0	0	0	25,509
	Pound	0	0	1	42	117	222	247	172	82	17	3	2	1	2	1	0	1	911
	Trawl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other	0	13	72	350	613	1,095	1,249	1,184	1,011	424	430	261	233	204	74	39	35	7,288
	Sub-Total	0	245	1,295	2,466	4,928	7,239	7,316	5,558	3,413	782	657	389	348	307	111	58	53	35,167
	Total	-	8,060	45,149	114,698	194,613	138,085	115,906	51,499	42,775	18,346	22,095	17,023	2,870	10,340	392	11,851	1,974	795,675

2012 data are preliminary.

Table B6.11. Time series of commercial discards-at-age from 1982-2012.

							Age									
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1982	0	31,645	3,644	11,456	5,623	1,291	2,397	1,014	369	92	85	0	0	7	0	57,624
1983	0	24,067	1,453	2,878	7,761	2,311	610	610	262	174	0	0	0	0	0	40,127
1984	0	33,575	1,611	5,812	9,734	11,272	2,815	117	586	66	0	52	0	0	0	65,639
1985	0	7,728	30,472	5,939	10,891	3,395	2,742	1,045	261	131	131	0	0	0	0	62,734
1986	0	5,841	20,758	100,067	27,989	13,315	4,295	1,415	346	0	0	0	0	0	0	174,024
1987	0	4,206	14,382	28,597	51,389	16,940	6,520	1,319	1,011	395	111	86	111	0	0	125,066
1988	0	6,142	22,593	36,616	70,959	71,694	23,232	9,116	3,110	1,653	218	195	24	0	0	245,552
1989	0	13,854	50,240	49,029	83,396	82,757	33,479	15,502	6,342	705	1,409	1,409	663	41	0	338,827
1990	0	14,526	68,713	80,935	111,888	115,702	71,600	36,256	5,948	1,539	1,401	1,503	0	0	0	510,011
1991	79	12,632	37,009	64,210	77,335	56,894	36,912	24,857	6,610	4,071	6,542	16	0	0	0	327,167
1992	117	3,698	34,218	36,746	44,412	34,688	14,798	11,179	3,398	2,356	991	0	0	0	0	186,601
1993	0	7,449	50,160	79,011	95,116	63,487	20,941	15,351	9,270	4,606	1,651	536	260	0	0	347,839
1994	0	31,770	47,169	45,081	88,122	84,570	39,229	12,524	6,223	3,674	712	415	30	0	0	359,518
1995	0	72,822	75,520	53,551	94,158	121,592	61,447	19,083	7,569	4,269	2,290	2,346	807	0	0	515,454
1996	0	27,133	114,085	76,336	61,884	58,787	30,835	14,916	6,148	3,989	159	502	50	0	0	394,824
1997	476	7,108	64,352	61,871	30,602	20,951	14,002	6,592	1,963	4,309	2,658	801	1,060	0	0	216,745
1998	0	13,233	53,899	98,510	83,288	29,197	12,970	12,591	7,860	4,372	3,891	2,419	3,311	124	367	326,032
1999	984	58,076	49,894	43,744	55,740	14,477	5,213	3,704	1,980	1,304	648	612	240	3	0	236,619
2000	196	178,457	189,933	157,291	62,699	33,918	26,938	7,831	4,111	3,876	801	863	41	17	25	666,997
2001	0	2,638	58,079	77,958	88,808	29,410	18,877	11,613	9,664	6,371	4,778	1,957	737	10	0	310,900
2002	1,700	20,888	42,641	21,409	28,791	23,720	12,381	6,854	5,645	2,255	1,522	149	173	33	43	168,201
2003	1,512	6,227	28,061	54,464	56,728	19,866	30,850	18,633	16,410	13,572	8,164	3,207	2,894	165	1,222	261,974
2004	2,943	52,810	80,275	75,711	61,636	47,285	50,715	40,057	23,187	9,747	10,346	2,350	430	892	12	458,398
2005	432	11,456	103,594	244,697	168,622	68,032	53,795	43,376	43,305	22,961	16,102	8,439	5,216	2,008	1,463	793,498
2006	0	544	25,559	28,683	36,026	26,447	14,217	15,729	12,170	12,792	7,159	4,352	5,186	0	0	188,864
2007	288	6,276	17,910	87,979	95,757	137,620	76,994	47,593	42,024	30,344	22,250	19,923	11,803	0	0	596,763
2008	0	97	2,789	43,823	70,088	56,841	43,496	21,224	13,575	12,969	12,576	14,221	10,976	0	0	302,676
2009	0	1,645	80,587	166,064	122,265	89,464	29,830	37,602	20,328	16,330	15,678	7,649	18,236	0	0	605,677
2010	0	1,335	16,052	75,408	63,492	45,601	19,217	9,339	6,464	4,065	3,111	1,785	6,007	0	0	251,875
2011	0	3,730	58,844	105,937	125,685	80,024	56,973	56,764	41,100	34,826	16,301	12,257	9,888	9,498	13,805	625,631
2012	0	8,060	45,149	114,698	194,613	138,085	115,906	51,499	42,775	18,346	22,095	17,023	2,870	10,340	14,217	795,675

2012 data are preliminary.

Table B6.12. MRFSS total number of interviews, total number of striped bass interviews, numbers of harvested striped bass measured, estimates of numbers harvested and released by state and for years 2000-2006. VAP=volunteer angler program, ALS=American Littoral Society.

State	Year	Total Interviews	Striped Bass Interviews	Striped Bass Harvested	PSE	Harvest Length Samples By MRFSS	Additional Harvest Length Samples By VAP/State/ALS	Striped Bass Released Alive	PSE	Released Bass Length Samples Measured By VAP/State/ALS	Number of Samples Aged (Har.+Rel.)	Notes
ME	2000	1,717	450	62,186	14.3	92	882	942,593	15.2	7,133	Uses	1
	2001	2,549	616	59,947	12.2	154	987	870,522	12.6	8,186	MA age-length	1
	2002	2,167	726	71,907	11.4	117	500	1,392,200	10.2	4,819	Key	1
	2003	1,601	396	57,765	16.2	81	600	846,708	15.0	6,129		1
	2004	1,580	382	36,886	17.0	75	615	748,388	14.9	7,238		1
	2005	1,653	592	68,838	15.8	94	576	3,024,291	15.3	8,613		1
	2006	1,357	648	73,385	18.4	58	383	4,070,305	13.8	7,684		1
NH	2000	2,302	339	4,262	23.1	16	190	209,606	14.7	5,354	Uses	2
	2001	2,390	278	15,291	17.0	52	603	164,336	13.7	4,269	MA age-length	2
	2002	2,421	407	12,857	14.5	69	467	238,003	12.6	5,971	Key	2
	2003	2,888	340	24,878	15.9	96	239	260,167	13.7	3,544		2
	2004	2,889	344	10,359	19.7	46	228	196,806	15.5	3,714		2
	2005	2,992	414	26,026	21.2	50	178	512,771	15.1	3,868		2
	2006	2,667	817	14,760	19.8	25	288	567,921	12.9	4,317		2
MA	2000	5,708	1,732	181,295	9.2	62	0	7,382,031	6.4	961 (ALS)	1,805	3
	2001	6,735	1,754	288,032	5.9	199	0	5,410,899	5.3	1,398 (ALS)	286	3
	2002	5,296	1,417	308,749	6.7	262	0	5,718,984	5.9	2,093	661	4
	2003	5,963	1,404	407,100	7.0	224	382	4,361,710	6.9	1,898	875	4
	2004	4,493	1,125	400,252	9.6	138	367	5,891,661	8.0	2,448	735	4
	2005	4,593	1,127	368,422	8.1	334	326	4,839,752	8.0	1,943	773	4
	2006	5,043	2,038	345,105	8.8	250	149	8,662,771	6.6	1,241	655	4
RI	2000	3,573	593	95,496	12.6	50	0	541,516	12.4	2,818	Uses	5
	2001	4,103	499	80,125	10.5	132	0	377,474	12.3	2,349	MA-NY age-length	5
	2002	4,232	583	78,190	9.4	175	0	530,402	14.2	2,262	keys	5
	2003	5,545	876	115,471	8.8	215	0	448,707	9.2	2,457		5
	2004	5,193	719	84,814	10.4	125	0	669,975	13.6	2,544		5
	2005	4,076	693	112,418	12.8	106	0	741,022	13.6	3,306		5
	2006	3,442	1,036	75,279	13.4	38	0	1,357,084	15.2	4,306		5
CT	2000	2,031	415	53,191	16.0	48	352	926,367	17.5	-	Uses NY	6
	2001	2,553	395	54,165	14.5	60	305	1,107,707	15.3	-	age-length	6
	2002	2,287	341	51,060	17.3	36	269	696,976	13.6	3,382	keys	6
	2003	3,228	642	95,983	12.1	189	328	843,037	16.8	2,370		6
	2004	2,171	502	75,244	16.6	83	215	1,079,304	18	2,679		6
	2005	1,917	490	114,965	22.8	87	297	1,713,541	15.9	3,296		6
	2006	1,478	240	83,776	16.3	63	271	1,683,242	18.9	4,360		6

Table B6.12 cont.

State	Year	Total Interviews	Striped Bass Interviews	Striped Bass Harvested	PSE	Harvest Length Samples By MRFSS	Additional Harvest Length Samples By VAP/State/ALS	Striped Bass Released Alive	PSE	Released Bass Length Samples Measured By VAP/State/ALS	Number of Samples Aged (Har.+Rel.)	Notes
NY	2000	2,730	488	270,798	10.2	52	781*	1,373,069	9.5	5576 (ALS)	3,856	7
	2001	4,188	452	189,714	8.7	72	909*	824,278	9.7	6037 (ALS)	2,263	7
	2002	3,119	255	202,075	11.7	81	860*	588,155	12.3	5655 (ALS)	2,188	7
	2003	4,990	444	313,761	7.9	174	684*	1,083,808	11.1	5235 (ALS)	2,385	7
	2004	3,927	426	242,623	10.6	233	630*	1,492,703	21.4	4667 (ALS)	2,827	7
	2005	3,919	506	298,387	12.1	366	777*	1,348,377	12.2	5595 (ALS)	2,417	7
	2006	3,823	861	310,441	10.2	283	667*	1,578,073	11.9	6995 (ALS)	3,316	7
NJ	2000	3,107	189	402,302	14.6	79	12,401	885,289	17.6	14,003	2,171	8
	2001	7,180	592	560,208	7.5	360	21,514	965,650	11.1	19,254	1,570	8
	2002	5,370	401	416,455	10	232	24,067	715,099	13.5	22,659	1,537	8
	2003	7,156	526	391,842	8.3	347	26,101	925,885	11.3	26,905	2,952	8
	2004	6,179	562	448,524	9.2	371	15,670	1,323,535	11.5	22,131	2,101	8
	2005	5,644	623	327,616	11	351	8,871	1,197,440	11.6	18,527	1,875	8
	2006	4,844	1,021	489,501	11.2	197	16,100	2,100,560	11	44,470	1,558	8
DE	2000	3,293	261	39,543	16.0	126	0	151,838	14.6	0		
	2001	3,859	288	41,195	16.8	141	0	162,677	18.3	0		
	2002	4,493	385	29,149	13.6	181	0	114,650	11.6	0		
	2003	4,687	283	29,522	14.5	146	0	169,012	13.2	0		
	2004	4,324	372	25,178	15.4	284	0	151,179	12.8	106		
	2005	5,178	386	19,955	21.2	194	0	224,841	15	139		
	2006	4,211	542	18,679	18.1	108	0	245,304	13.8			
MD	2000	4,020	866	506,462	9.7	456	1,099	3,244,731	10.0	2,892	592	9
	2001	3,629	753	382,557	10.0	348	406	2,890,054	11.2	835	880	9
	2002	4,196	838	282,429	11.1	445	731	2,928,589	9.9	256	525	9
	2003	4,355	1,167	525,191	8.1	837	1,349	4,652,800	9.1	1,305	615	9
	2004	4,045	1,043	380,461	8.5	790	479	3,738,523	10.6	597	662	9
	2005	4,054	999	490,275	9.5	1,250	1,023	3,753,328	12.1	809	715	9
	2006	3,573	930	660,462	8.3	1,211	10,340	3,905,212		6,088	771	9
VA	2000	3,174	350	335,259	12.8	293	0	1,022,040	12.8	0		
	2001	5,511	737	301,153	9.9	861	0	620,947	10.9	0	Uses commercial	
	2002	4,695	497	321,470	11.7	624	0	706,729	13.0	0	age-length keys from	
	2003	4,368	494	401,945	9.5	478	0	970,554	12.4	0	hook-and-line	
	2004	4,645	756	477,402	8.4	708	0	1,767,596	10.3	0	augments with	
	2005	3,600	469	367,801	13.1	502	0	1,484,540	13.0	0	data from gillnet	
	2006	3,693	1,121	528,190	9.5	661	0	1,695,963	13.0	0		

Table B6.12 cont.

State	Year	Total Interviews	Striped Bass Interviews	Striped Bass Harvested	PSE	Harvest Length Samples By MRFSS	Additional Harvest Length Samples By VAP/State/ALS	Striped Bass Released Alive	PSE	Released Bass Length Samples Measured By VAP/State/ALS	Number of Samples Aged (Har.+Rel.)	Notes
NC	2000	17,849	282	12,908	24.4	201	0	129,729	15.7	0	0	
	2001	21,305	285	40,016	20.3	375	0	49,953	17.7	0	0	
	2002	17,840	293	33,610	31.2	486	0	63,269	20.6	0	0	
	2003	16,021	440	48,513	26.0	794	0	48,945	31.9	0	0	
	2004	15,703	776	278,270	17.6	2,131	0	230,356	19.2	0	0	
	2005	13,817	438	104,997	19.4	1,264	0	109,535	19.8	0	0	
	2006	15,227	417	90,820	21.7	557	0	82,973	19.9	0	0	

1 Volunteer Angler Program

2 released VAP measurements are both released & harvested combined; Harv. VAP # measured derived by multipling 0.42 by the # of 28"+ fish measured (32"+ fish for 2000)

3 from Diet/Tagging Studies using Rod&Reel

4 from VAP/Tagging Study

5 Released bass length dist from ALS; ALK is combined MA-NY

6 VAP

7 * - VAP samples, not segregated by kept/released

8 Lengths (both harvested and released) from VAP and party/charter boat logbooks
  Ages from harvested fish, spring gill net survey, ocean trawl survey

9 Lengths (both harvested and released) from VASand party/charter boat logbooks as well as creel survey
  Ages from all spring gill net and harvested fish from creel survey, and sub-legals from poundnets

Table B6.13. Total recreational harvest (numbers, includes wave-1 harvest estimates for VA and NC) of striped bass along the Atlantic Coast by state, 1982–2012. Data from 2012 are preliminary estimates.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	Total
1982	929		83,933	1,757	50,081	21,278	58,294	0	984	0	0	217,256
1983	7,212	4,576	39,316	1,990	42,826	43,731	127,912	135	31,746	0	0	299,444
1984	0	0	3,481	1,230	5,678	57,089	13,625	16,571	16,789	0	0	114,463
1985	11,862	0	66,019	670	15,350	23,107	13,145	0	2,965	404	0	133,522
1986	0	0	29,434	3,291	1,760	27,477	36,999	0	14,077	1,585	0	114,623
1987	0	90	10,807	2,399	522	14,191	9,279	0	4,025	2,442	0	43,755
1988	0	647	21,050	5,226	2,672	20,230	12,141	0	133	24,259	367	86,725
1989	738	0	13,044	4,303	5,777	12,388	1,312	0	0	0	0	37,562
1990	2,912	617	20,515	4,677	6,082	24,799	44,878	2,009	736	56,017	0	163,242
1991	3,265	274	20,799	17,193	4,907	54,502	38,300	2,741	77,873	42,224	391	262,469
1992	6,357	2,213	57,084	14,945	9,154	45,162	41,426	2,400	99,354	21,118	967	300,180
1993	612	1,540	58,511	17,826	19,253	78,560	64,935	4,055	104,682	78,481	264	428,719
1994	3,771	3,023	74,538	5,915	16,929	87,225	34,877	4,140	199,378	127,945	7,426	565,167
1995	2,189	3,902	73,806	29,997	38,261	155,821	254,055	15,361	355,237	149,103	11,450	1,089,182
1996	1,893	6,461	68,300	60,074	62,840	225,428	127,952	22,867	337,415	244,746	17,136	1,175,112
1997	35,259	13,546	199,373	62,162	64,639	236,902	67,800	19,706	334,068	518,483	96,189	1,648,127
1998	38,094	5,929	207,952	44,890	64,215	166,868	88,973	18,758	391,824	383,786	45,773	1,457,062
1999	21,102	4,641	126,755	56,320	55,805	195,261	237,010	8,772	263,191	411,873	65,658	1,446,388
2000	62,186	4,262	181,295	95,496	53,191	270,798	402,302	39,543	506,462	389,126	20,452	2,025,113
2001	59,947	15,291	288,032	80,125	54,165	189,714	560,208	41,195	382,557	355,020	58,873	2,085,127
2002	71,907	12,857	308,749	78,190	51,060	202,075	416,455	29,149	282,429	411,248	109,052	1,973,171
2003	57,765	24,878	407,100	115,471	95,983	313,761	391,842	29,522	525,191	455,812	127,727	2,545,052
2004	48,816	8,386	445,745	83,990	102,844	263,096	424,208	25,429	368,682	548,768	230,783	2,550,747
2005	83,617	24,940	340,743	110,490	141,290	376,894	411,532	20,438	533,929	293,161	104,904	2,441,938
2006	75,347	13,521	314,987	75,811	115,214	367,835	509,606	20,159	669,140	547,482	79,023	2,788,125
2007	53,694	6,348	315,409	101,400	118,549	474,062	289,656	8,465	765,169	353,372	37,376	2,523,500
2008	59,152	5,308	377,959	51,191	108,166	685,589	309,411	26,934	415,403	401,155	25,750	2,466,018
2009	62,153	8,587	344,401	71,427	60,876	356,311	283,024	19,539	501,845	326,867	5,650	2,040,680
2010	17,396	5,948	341,045	70,108	92,806	538,374	320,413	16,244	457,898	102,405	23,778	1,986,415
2011	18,105	32,704	255,507	88,635	63,288	674,844	393,194	18,023	445,171	146,603	94,182	2,230,256
2012	11,541	14,410	379,717	60,351	63,098	431,425	161,919	25,434	221,144	134,042	0	1,503,081

Table B6.14. Total recreational harvest (numbers) of striped bass along the Atlantic Coast by age and by state, 2011 and 2012.

2011

State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
ME	0	0	1,346	3,528	5,429	5,838	449	0	43	111	304	324	397	186	151	18,105
NH	0	0	0	1,043	2,796	9,538	7,477	6,269	1,400	1,047	510	761	717	840	307	32,704
MA	0	0	0	2,561	14,523	44,610	53,023	52,623	29,985	24,297	11,667	8,779	7,336	4,153	1,950	255,507
RI	0	0	0	2,036	6,099	21,372	20,836	20,161	6,076	3,416	1,829	2,199	1,736	1,683	1,192	88,635
CT	0	0	0	262	1,790	10,776	10,705	23,107	3,539	7,966	3,091	1,317	159	418	159	63,288
NY	0	0	49	3,595	17,209	108,477	116,018	230,497	39,868	53,045	26,476	22,793	18,549	27,307	10,961	674,844
NJ	0	0	0	782	6,365	17,919	73,153	123,530	54,015	33,723	20,595	8,761	17,367	19,810	17,174	393,194
DE	0	0	16	500	864	997	1,455	2,476	2,914	1,738	1,986	2,102	802	368	1,805	18,023
MD	0	0	23,474	61,759	112,462	94,594	55,840	39,978	17,218	15,883	8,911	5,618	3,235	1,826	4,373	445,171
VA	0	8,101	9,028	13,484	9,072	12,297	16,882	22,975	12,710	12,872	3,556	4,599	6,061	3,715	11,251	146,603
NC	0	0	0	0	0	3,903	5,152	20,632	18,538	20,595	5,358	6,158	3,849	3,468	6,528	94,182
Total	0	8,101	33,913	89,551	176,608	330,321	360,990	542,248	186,305	174,692	84,284	63,411	60,207	63,773	55,850	2,230,256

2012

State	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
ME	0	0	1,833	3,223	5,044	1,041	254	0	0	32	43	27	27	11	5	11,541
NH	0	0	0	538	1,725	3,111	3,551	2,825	1,649	361	197	177	92	110	76	14,410
MA	0	0	0	3,546	17,864	49,306	71,183	88,639	69,559	27,568	19,595	14,399	6,796	7,019	4,243	379,717
RI	0	0	0	1,596	4,599	11,248	15,443	10,616	6,386	2,817	2,449	2,241	1,192	1,002	762	60,351
CT	0	0	57	1,423	1,741	9,525	9,248	20,232	3,708	8,891	2,829	1,689	443	295	3,017	63,098
NY	0	0	132	3,199	8,084	46,579	50,403	126,827	23,732	68,503	31,680	27,469	11,908	19,794	13,114	431,425
NJ	0	0	0	1,208	4,448	10,210	20,628	31,015	41,307	17,988	10,712	7,501	5,057	6,978	4,866	161,919
DE	0	0	18	671	1,470	2,518	2,808	5,988	4,088	1,314	1,905	2,658	1,461	435	99	25,434
MD	748	4,237	27,776	22,503	52,599	33,164	21,637	14,050	22,039	6,880	8,828	2,522	988	1,669	1,505	221,144
VA	758	1,848	5,485	7,303	3,620	4,257	6,229	8,462	19,292	13,193	9,652	11,692	8,009	8,114	26,128	134,042
NC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1,506	6,085	35,301	45,211	101,194	170,958	201,385	308,654	191,760	147,548	87,890	70,376	35,973	45,425	53,814	1,503,081

2012 data are preliminary.

Table B6.15. Time series of recreational harvest numbers-at-age, 1982-2012.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1982	0	5,721	36,125	81,725	24,916	10,963	16,943	11,960	8,970	5,980	4,983	5,980	997	997	997	217,257
1983	4,617	25,001	50,976	62,840	95,870	27,371	15,035	3,338	1,799	1,799	2,699	2,699	1,799	1,799	1,799	299,443
1984	2,021	22,316	24,474	15,610	16,528	15,288	8,034	2,548	0	849	849	0	849	2,548	2,548	114,463
1985	225	3,305	13,315	22,732	36,208	19,572	18,593	9,786	1,957	1,957	0	0	0	0	5,872	133,522
1986	11,002	5,426	9,354	12,136	12,339	13,473	12,285	18,427	7,020	4,387	2,632	877	877	877	3,510	114,623
1987	1,083	1,370	3,822	2,596	4,838	3,756	3,756	2,817	3,756	1,878	939	1,878	2,817	1,878	6,573	43,756
1988	1,023	8,195	5,116	5,120	6,135	11,214	10,191	12,225	9,169	3,056	3,056	3,056	2,037	3,056	4,075	86,725
1989	0	0	3,130	2,087	4,174	6,260	7,304	4,174	2,087	2,087	1,043	0	1,043	1,043	3,130	37,562
1990	627	7,933	17,317	39,534	22,708	22,980	16,657	15,810	7,680	3,009	1,797	899	1,797	1,797	2,696	163,242
1991	1,368	21,382	38,339	61,798	27,957	13,322	24,432	26,848	23,268	9,293	4,159	937	937	1,405	7,025	262,470
1992	1,881	15,923	61,295	52,925	54,507	20,325	13,805	23,488	23,613	18,849	3,854	1,943	971	2,428	4,371	300,179
1993	2,209	18,044	53,461	93,539	68,083	49,704	18,614	20,458	36,054	35,685	19,855	4,461	2,012	503	6,037	428,719
1994	2,112	43,976	138,180	95,461	91,957	47,419	29,827	23,833	34,809	29,999	13,650	8,815	855	427	3,846	565,167
1995	562	134,922	222,570	183,276	105,211	164,461	64,387	81,839	59,042	34,224	24,276	6,888	4,634	1,144	1,745	1,089,181
1996	531	129,149	257,038	214,669	109,367	116,156	137,033	80,275	58,041	27,210	18,534	19,437	5,627	1,535	512	1,175,113
1997	1,837	2,837	74,549	240,321	185,350	213,594	217,940	290,961	183,150	120,586	58,005	32,037	14,960	7,718	4,280	1,648,125
1998	0	20,368	133,541	229,441	168,884	164,613	134,977	153,529	163,905	96,099	87,690	41,837	31,341	14,855	15,983	1,457,063
1999	0	2,307	39,471	141,735	166,527	282,809	200,750	168,942	155,988	108,584	87,820	42,054	29,505	13,081	6,813	1,446,388
2000	0	503	37,950	255,084	402,268	367,123	423,409	201,142	120,257	97,670	53,095	28,375	17,434	10,132	10,671	2,025,112
2001	1,036	559	60,048	169,642	340,240	403,155	379,607	314,763	150,791	92,207	80,417	44,978	26,295	13,149	8,239	2,085,127
2002	0	1,530	33,823	141,000	266,095	405,275	334,964	249,670	237,566	107,817	86,338	46,611	33,558	12,795	16,128	1,973,171
2003	0	36,600	76,642	198,625	295,548	362,028	463,663	336,910	275,724	218,321	123,058	72,670	46,796	25,286	13,182	2,545,052
2004	427	214	94,601	207,895	211,670	268,011	301,427	435,274	331,997	265,634	210,003	103,959	54,859	39,501	25,272	2,550,745
2005	0	322	40,333	245,135	337,585	282,138	285,659	240,402	308,962	233,801	232,352	100,482	67,791	32,149	34,826	2,441,938
2006	0	8,326	112,441	209,402	372,824	335,684	245,484	289,948	249,576	341,499	248,790	158,204	107,653	41,432	66,863	2,788,125
2007	0	73	25,068	333,424	269,399	403,913	267,964	239,743	269,469	267,806	182,806	133,849	62,176	35,214	32,598	2,523,500
2008	0	246	7,036	74,691	340,359	211,584	473,211	359,388	200,562	243,217	197,085	156,271	103,591	36,841	61,936	2,466,018
2009	0	970	15,868	103,386	228,968	429,381	221,964	309,080	169,576	122,503	132,590	111,295	104,868	38,709	51,521	2,040,680
2010	0	8,973	25,576	141,402	156,928	288,769	487,688	201,524	215,001	155,490	81,649	79,440	58,948	37,431	47,595	1,986,415
2011	0	8,101	33,913	89,551	176,608	330,321	360,990	542,248	186,305	174,692	84,284	63,411	60,207	63,773	55,850	2,230,256
2012	1,506	6,085	35,301	45,211	101,194	170,958	201,385	308,654	191,760	147,548	87,890	70,376	35,973	45,425	53,814	1,503,081

2012 data are preliminary.

Table B6.16. MRFSS estimates of release (B2) numbers of striped bass by year and state, 1982-2012.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	Total
1982	687	0	6,441	2,551	643,187	12,297	87,648	0	30,376	0	0	783,187
1983	0	0	34,018	5,444	0	1,469	117,807	0	213,487	11,997	0	384,222
1984	1,887	0	98,405	85,135	31,176	40,469	52,930	0	104,095	8,775	0	422,872
1985	81,153	93	12,360	40,567	26,946	57,540	5,524	702	147,103	2,598	0	374,586
1986	4,379	0	442,298	2,014	10,494	123,842	0	0	390,063	7,528	0	980,618
1987	18,106	435	93,660	63,849	78,434	253,986	56,697	16,988	118,395	7,611	0	708,161
1988	4,528	6,699	209,632	23,347	25,532	92,611	486,306	2,455	132,250	5,631	0	988,991
1989	16,028	4,822	193,067	38,007	125,370	365,712	265,958	4,807	114,269	72,766	0	1,200,806
1990	12,542	15,518	339,511	67,509	89,490	265,099	254,384	14,411	420,084	175,046	0	1,653,594
1991	67,490	6,559	448,735	30,975	301,476	756,663	166,198	38,334	1,036,011	208,350	256	3,061,047
1992	31,177	27,613	779,814	120,410	292,259	799,149	413,506	36,932	749,959	115,899	679	3,367,397
1993	373,064	14,979	833,566	100,993	271,318	694,107	308,253	89,543	1,556,848	100,374	1,524	4,344,569
1994	363,703	43,501	2,102,514	138,989	489,967	1,132,707	568,047	103,992	2,785,392	197,022	5,005	7,930,839
1995	505,758	285,486	3,280,882	356,324	507,124	1,209,585	694,889	115,363	2,401,277	370,949	16,225	9,743,862
1996	1,626,705	292,820	3,269,746	314,336	1,051,612	1,436,091	776,165	99,372	2,545,238	759,916	116,667	12,288,668
1997	1,417,976	279,298	5,417,751	606,746	722,708	1,018,892	736,734	130,073	4,019,987	1,232,323	135,853	15,718,341
1998	691,378	243,301	7,184,358	613,421	1,026,192	884,626	488,319	185,016	2,641,680	796,372	173,704	14,928,367
1999	649,816	145,730	4,576,208	360,121	704,025	1,228,628	1,152,682	105,696	2,387,615	940,755	263,445	12,514,721
2000	942,593	209,606	7,382,031	541,516	926,367	1,373,069	885,289	151,838	3,244,731	1,022,040	129,729	16,808,809
2001	870,522	164,336	5,410,899	377,474	1,107,707	824,278	965,650	162,677	2,890,054	620,947	49,953	13,444,497
2002	1,392,200	238,003	5,718,984	530,402	696,976	588,155	715,099	114,650	2,928,589	706,729	63,269	13,693,056
2003	846,708	260,167	4,361,710	448,707	843,037	1,083,808	925,885	169,012	4,652,800	970,554	48,945	14,611,333
2004	693,400	225,777	4,979,075	525,936	826,724	2,709,246	1,502,694	155,655	3,479,634	1,732,890	222,302	17,053,333
2005	2,985,203	572,633	3,988,679	633,871	1,761,628	1,412,191	1,218,893	251,049	3,855,552	1,295,768	103,432	18,078,899
2006	4,000,309	460,615	7,809,777	834,953	986,700	1,722,386	1,890,294	247,653	3,711,343	1,655,007	24,262	23,343,299
2007	1,115,068	257,372	5,331,470	677,851	984,638	1,677,717	1,789,294	248,689	3,064,928	949,158	13,838	16,110,023
2008	465,003	77,237	3,649,415	416,373	3,104,779	1,346,385	1,309,453	260,677	1,338,728	532,161	10,776	12,510,987
2009	263,512	57,443	2,282,601	398,686	1,161,278	1,073,467	800,510	145,586	1,423,332	358,991	5,407	7,970,813
2010	193,743	51,833	1,671,437	183,112	670,534	1,068,672	690,340	65,048	1,508,647	134,350	20,365	6,258,081
2011	142,505	98,693	973,192	214,302	612,367	1,506,080	884,013	110,085	1,127,511	153,582	110,150	5,932,480
2012	213,277	63,231	967,056	244,993	266,289	594,650	399,785	110,973	2,147,438	101,334	1,574	5,110,600

2012 data are preliminary.

Table B6.17. Estimates of dead releases from the striped bass recreational fishery by year and state, 1982-2012

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	Total
1982	62	0	580	230	57,887	1,107	7,888	0	2,734	0	0	70,487
1983	0	0	3,062	490	0	132	10,603	0	19,214	1,080	0	34,580
1984	170	0	8,856	7,662	2,806	3,642	4,764	0	9,369	790	0	38,058
1985	7,304	8	1,112	3,651	2,425	5,179	497	63	13,239	234	0	33,713
1986	394	0	39,807	181	944	11,146	0	0	35,106	678	0	88,256
1987	1,630	39	8,429	5,746	7,059	22,859	5,103	1,529	10,656	685	0	63,734
1988	408	603	18,867	2,101	2,298	8,335	43,768	221	11,903	507	0	89,009
1989	1,443	434	17,376	3,421	11,283	32,914	23,936	433	10,284	6,549	0	108,073
1990	1,129	1,397	30,556	6,076	8,054	23,859	22,895	1,297	37,808	15,754	0	148,823
1991	6,074	590	40,386	2,788	27,133	68,100	14,958	3,450	93,241	18,752	23	275,494
1992	2,806	2,485	70,183	10,837	26,303	71,923	37,216	3,324	67,496	10,431	61	303,066
1993	33,576	1,348	75,021	9,089	24,419	62,470	27,743	8,059	140,116	9,034	137	391,011
1994	32,733	3,915	189,226	12,509	44,097	101,944	51,124	9,359	250,685	17,732	450	713,776
1995	45,518	25,694	295,279	32,069	45,641	108,863	62,540	10,383	216,115	33,385	1,460	876,948
1996	146,403	26,354	294,277	28,290	94,645	129,248	69,855	8,943	229,071	68,392	10,500	1,105,980
1997	127,618	25,137	487,598	54,607	65,044	91,700	66,306	11,707	361,799	110,909	12,227	1,414,651
1998	62,224	21,897	646,592	55,208	92,357	79,616	43,949	16,651	237,751	71,673	15,633	1,343,553
1999	58,483	13,116	411,859	32,411	63,362	110,577	103,741	9,513	214,885	84,668	23,710	1,126,325
2000	84,833	18,865	664,383	48,736	83,373	123,576	79,676	13,665	292,026	91,984	11,676	1,512,793
2001	78,347	14,790	486,981	33,973	99,694	74,185	86,909	14,641	260,105	55,885	4,496	1,210,005
2002	125,298	21,420	514,709	47,736	62,728	52,934	64,359	10,319	263,573	63,606	5,694	1,232,375
2003	76,204	23,415	392,554	40,384	75,873	97,543	83,330	15,211	418,752	87,350	4,405	1,315,020
2004	62,406	20,320	448,117	47,334	74,405	243,832	135,242	14,009	313,167	155,960	20,007	1,534,800
2005	268,668	51,537	358,981	57,048	158,547	127,097	109,700	22,594	347,000	116,619	9,309	1,627,101
2006	360,028	41,455	702,880	75,146	88,803	155,015	170,126	22,289	334,021	148,951	2,184	2,100,897
2007	100,356	23,163	479,832	61,007	88,617	150,995	161,036	22,382	275,844	85,424	1,245	1,449,902
2008	41,850	6,951	328,447	37,474	279,430	121,175	117,851	23,461	120,486	47,894	970	1,125,989
2009	23,716	5,170	205,434	35,882	104,515	96,612	72,046	13,103	128,100	32,309	487	717,373
2010	17,437	4,665	150,429	16,480	60,348	96,180	62,131	5,854	135,778	12,092	1,833	563,227
2011	12,825	8,882	87,587	19,287	55,113	135,547	79,561	9,908	101,476	13,822	9,913	533,923
2012	19,195	5,691	87,035	22,049	23,966	53,519	35,981	9,988	193,269	9,120	142	459,954

2012 data are preliminary.

Table B6.18. Total recreational dead discards (numbers) of striped bass along the Atlantic Coast by age and by state, 2011 and 2012.

2011 — Age

State	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
ME	0	0	316	1,126	1,962	1,947	2,709	2,355	1,398	336	218	115	124	102	77	39	12,825
NH	0	0	156	920	1,763	2,064	1,755	1,436	496	102	70	37	32	26	17	8	8,882
MA	0	0	14,312	17,614	14,071	7,365	9,664	9,541	6,726	2,694	1,937	1,047	981	856	591	188	87,587
RI	0	0	1,253	2,770	2,505	2,027	3,234	2,988	2,394	709	399	214	257	203	196	139	19,287
CT	2	2,747	4,900	6,605	17,789	4,151	7,927	3,613	4,463	616	1,188	420	308	148	55	182	55,113
NY	0	6,191	19,708	34,709	45,748	6,938	7,477	3,743	5,404	823	1,600	969	906	628	520	184	135,547
NJ	0	14	1,510	6,503	9,597	4,695	34,453	8,821	8,295	2,376	1,111	621	215	415	320	616	79,561
DE	0	0	253	1,367	1,963	1,617	1,795	740	813	562	374	167	84	128	5	39	9,908
MD	0	24,369	18,145	27,800	12,254	5,875	4,569	4,221	2,098	700	805	311	157	65	50	56	101,476
VA	0	3,403	2,589	3,548	1,205	997	834	778	239	98	70	26	19	5	5	5	13,822
NC	0	80	170	525	943	1,207	1,595	1,363	1,726	649	585	286	181	161	139	306	9,913
Total	2	36,803	63,312	103,487	109,801	38,884	76,011	39,600	34,050	9,666	8,356	4,214	3,264	2,735	1,977	1,761	533,923

2012 — Age

State	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
ME	0	0	1,607	2,733	1,683	2,965	2,825	2,820	2,396	1,429	310	167	113	55	56	36	19,195
NH	0	0	2,100	1,723	395	499	304	279	208	113	25	14	12	6	8	5	5,691
MA	0	0	20,857	20,416	6,917	9,219	6,622	7,674	7,426	4,524	1,289	803	530	215	308	236	87,035
RI	0	0	6,020	5,117	2,554	2,570	1,648	1,567	1,038	581	257	223	204	109	91	69	22,049
CT	0	1,996	4,375	5,305	6,914	1,126	1,500	745	1,099	160	409	175	89	32	23	18	23,966
NY	0	2,444	7,781	13,704	18,063	2,739	2,952	1,478	2,134	325	632	383	358	248	205	72	53,519
NJ	0	0	5,287	8,052	5,387	6,482	2,119	1,659	1,827	1,703	561	608	535	298	818	644	35,981
DE	0	0	352	1,514	1,907	1,597	1,965	662	767	613	268	156	97	56	9	26	9,988
MD	0	54,955	49,314	39,511	12,095	7,638	6,739	9,215	4,172	4,504	1,191	1,764	761	334	595	481	193,269
VA	0	2,590	2,324	1,863	571	363	320	437	197	213	56	83	36	16	28	23	9,120
NC	0	3	5	9	12	22	19	18	17	12	8	5	4	2	3	3	142
Total	0	61,988	100,022	99,946	56,500	35,221	27,013	26,552	21,282	14,177	5,006	4,380	2,737	1,370	2,145	1,614	459,954

2012 data are preliminary.

Table B6.19.A. Estimates of unreported recreational catch from inland waters of the Connecticut River.

Year		Connecticut River		MRFSS/MRIP CT	Corrected State Total	(Percent)[a] Bias
		Partial Year Estimate	Full Year Estimate			
1997	Catch	25,941	38,530			
	Harvest	1,965	2,345	64,639	66,984	3.5
	Discards		36,185			
	Discard Loss		2,895	57,817	60,712	4.8
	Total Kill		5,239	122,456	127,695	4.1
1998	Catch	42,095	62,524			
	Harvest	1,225	1,462	64,215	65,677	2.2
	Discards		61,062			
	Discard Loss		4,885	82,095	86,980	5.6
	Total Kill		6,347	146,310	152,657	4.2
2008 - 2009	Catch		39,699			
	Harvest		2,112	112,972	115,084	1.8
	Discards		37,587			
	Discard Loss		3,007	189,776	192,783	1.6
	Total Kill		5,119	302,748	307,867	1.7

[a] Calculated as (unreported inland losses/total unreported and reported losses)*100
Discard loss estimated using 8% release mortality.

Table B6.19.B. Estimated harvest and discard losses of striped bass in the recreational fisheries of New York State in 2001 and 2005.

Year		Hudson River > rkm 74	MRFSS/MRIP NY	Corrected State Total	Percent[a] Bias
2001	Catch	35,018			
	Harvest	6,693	189,714	196,407	3.4
	Discards	28,325			
	Discard Loss	2,266	65,942	68,208	3.3
	Total Kill	8,959	255,656	264,615	3.4
2005	Catch	45,022			
	Harvest	8,827	298,387	307,214	2.9
	Discards	36,195			
	Discard Loss	2,896	107,870	110,766	2.6
	Total Kill	11,723	406,257	417,980	2.8

[a] Calculated as (unreported inland losses/total unreported and reported losses)*100
Discard loss estimated using 8% release mortality.

Table B6.19.C. Estimated harvest and discard losses of striped bass in the recreational fisheries of New Jersey and Delaware in 2002.

Year		DE River	MRFSS / MRIP			Corrected State Total	Percent[a] Bias
			NJ	DE	States Combined		
2002	Catch	47,671					
	Kill	582	416,455	29,149	445,604	446,186	0.1
	Discards	47,089					
	Discard Loss	3,767	57,208	9,172	66,380	70,147	5.4
	Total Kill	4,349	473,663	38,321	511,984	516,333	0.8

[a] Calculated as (unreported inland losses/total unreported and reported losses)*100
Discard loss estimated using 8% release mortality.

Table B6.20. Total recreational harvest and dead discards (numbers) of striped bass along the Atlantic Coast by age and by state, 2011 and 2012.

2011

State	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
ME	0	0	316	2,472	5,490	7,376	8,547	2,804	1,398	379	329	419	448	499	263	190	30,930
NH	0	0	156	920	2,806	4,861	11,292	8,913	6,765	1,502	1,117	546	794	742	857	315	41,586
MA	0	0	14,312	17,614	16,632	21,888	54,274	62,564	59,349	32,679	26,234	12,714	9,760	8,192	4,744	2,138	343,094
RI	0	0	1,253	2,770	4,542	8,126	24,606	23,824	22,555	6,785	3,815	2,043	2,455	1,939	1,880	1,331	107,922
CT	2	2,747	4,900	6,605	18,051	5,940	18,703	14,319	27,570	4,155	9,153	3,512	1,626	306	472	341	118,401
NY	0	6,191	19,708	34,757	49,344	24,147	115,954	119,761	235,901	40,691	54,645	27,445	23,698	19,177	27,828	11,144	810,391
NJ	0	14	1,510	6,503	10,379	11,061	52,371	81,975	131,824	56,391	34,833	21,217	8,976	17,782	20,130	17,789	472,755
DE	0	0	253	1,383	2,463	2,482	2,792	2,194	3,290	3,476	2,112	2,152	2,186	930	373	1,844	27,931
MD	0	24,369	18,145	51,273	74,014	118,337	99,164	60,061	42,076	17,918	16,688	9,222	5,775	3,299	1,876	4,429	546,647
VA	0	3,403	10,690	12,576	14,689	10,069	13,131	17,660	23,213	12,808	12,943	3,582	4,618	6,066	3,720	11,256	160,425
NC	0	80	170	525	943	1,207	5,498	6,515	22,358	19,187	21,180	5,644	6,339	4,010	3,607	6,834	104,095
Total	2	36,803	71,413	137,399	199,352	215,492	406,332	400,590	576,298	195,971	183,049	88,498	66,676	62,942	65,750	57,612	2,764,179

2012

State	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
ME	0	0	1,607	4,566	4,907	8,009	3,865	3,074	2,396	1,429	343	210	140	82	67	41	30,736
NH	0	0	2,100	1,723	933	2,224	3,416	3,830	3,033	1,762	385	210	189	98	117	81	20,101
MA	0	0	20,857	20,416	10,463	27,083	55,928	78,857	96,065	74,083	28,857	20,398	14,929	7,011	7,327	4,479	466,752
RI	0	0	6,020	5,117	4,150	7,169	12,896	17,010	11,654	6,967	3,074	2,672	2,445	1,301	1,093	832	82,400
CT	0	1,996	4,375	5,362	8,337	2,868	11,025	9,993	21,331	3,868	9,300	3,003	1,777	475	319	3,034	87,064
NY	0	2,444	7,781	13,836	21,262	10,823	49,531	51,881	128,960	24,057	69,135	32,063	27,827	12,156	19,999	13,186	484,943
NJ	0	0	5,287	8,052	6,596	10,930	12,330	22,287	32,842	43,011	18,549	11,320	8,036	5,355	7,796	5,510	197,900
DE	0	0	352	1,532	2,579	3,067	4,482	3,470	6,755	4,701	1,583	2,061	2,755	1,517	444	125	35,422
MD	0	55,703	53,551	67,287	34,598	60,237	39,903	30,852	18,222	26,542	8,071	10,592	3,283	1,322	2,264	1,986	414,413
VA	0	3,348	4,172	7,347	7,875	3,983	4,577	6,666	8,660	19,505	13,249	9,735	11,728	8,025	8,142	26,151	143,162
NC	0	3	5	9	12	22	19	18	17	12	8	5	4	2	3	3	142
Total	0	63,494	106,107	135,247	101,711	136,414	197,971	227,937	329,936	205,937	152,554	92,270	73,114	37,343	47,571	55,428	1,963,035

2012 data are preliminary.

Table B6.21. Incidental removals-at-age (numbers) of striped bass along the Atlantic coast, 1982-2012

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	64	198	1521	933	396	222	91	45	25	26	19	24	5	6	1	3577
2000	39	96	2125	3439	1255	355	195	101	61	40	33	9	5	1	2	7756
2001	0	15	337	956	660	120	63	56	50	51	21	10	3	1	0	2343
2002	0	9	62	408	508	156	84	36	27	17	7	1	0	0	1	1317
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	1	29	6	6	15	21	25	10	6	2	0	0	0	0	121
2005	0	20	5	5	11	13	15	23	19	8	4	1	1	0	0	125
2006	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
2007	0	3	8	11	8	5	0	0	0	0	0	0	0	0	0	35
2008	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
2009	0	0	17	15	0	0	0	0	0	0	0	0	0	0	0	32
2010	0	0	17	14	1	0	0	0	0	0	0	0	0	0	0	32
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B6.22. Total removals (recreational and commercial harvest and dead discards in numbers) of striped bass along the Atlantic coast, 1982-2012.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1982	0	2,203	108,928	258,714	222,454	58,974	19,491	24,871	16,936	11,210	10,479	10,906	13,619	3,506	3,813	7,895	773,998
1983	0	5,769	121,858	184,594	189,021	143,062	37,098	17,600	4,626	2,668	3,664	4,013	5,074	4,455	3,655	4,532	731,691
1984	0	6,634	549,151	307,758	81,633	57,994	49,401	17,290	4,409	1,606	1,686	995	331	1,945	3,590	4,606	1,089,031
1985	0	1,429	75,568	106,136	39,829	57,751	42,215	42,904	17,411	5,910	3,602	597	607	493	894	9,245	404,590
1986	0	13,236	25,312	71,881	136,636	49,445	30,842	19,122	23,275	7,912	4,569	2,737	1,097	1,165	1,840	5,514	394,584
1987	0	2,221	11,267	40,639	53,668	68,088	25,501	13,656	6,349	6,353	2,505	1,145	2,237	3,230	2,113	7,138	246,109
1988	0	2,178	32,833	47,135	64,193	108,768	98,625	40,850	24,192	13,976	4,927	3,541	3,359	2,311	3,097	4,612	454,596
1989	0	1,114	39,480	83,452	68,942	107,625	96,955	45,236	21,749	10,550	3,422	2,928	1,573	2,050	1,529	5,259	491,863
1990	0	4,009	63,697	138,042	194,424	174,339	165,079	100,388	60,060	17,030	6,195	3,470	2,532	2,225	2,119	4,103	937,712
1991	0	1,447	92,782	169,202	227,417	167,881	103,168	90,297	75,390	46,031	19,062	13,238	1,078	1,017	1,958	8,962	1,018,929
1992	0	3,124	56,313	232,567	209,645	190,645	111,240	60,929	59,701	44,770	33,152	7,034	2,407	1,140	2,774	5,116	1,020,560
1993	0	4,224	91,425	216,884	358,608	307,984	194,653	86,655	58,633	62,714	53,456	28,833	6,884	2,456	579	6,441	1,480,429
1994	0	7,741	172,621	414,248	332,619	405,433	245,557	134,738	71,508	69,073	51,380	21,378	13,858	1,083	495	4,172	1,945,903
1995	0	5,112	495,412	520,954	492,385	408,010	476,654	195,462	169,236	120,996	67,145	41,754	13,538	6,438	1,507	1,894	3,016,496
1996	0	1,055	231,046	818,555	656,361	535,093	453,849	356,203	165,215	100,075	50,718	32,008	29,690	7,940	2,668	1,961	3,442,435
1997	0	44,259	253,142	425,139	1,023,366	610,320	554,128	407,892	442,837	273,849	176,309	85,536	50,876	22,257	11,149	7,074	4,388,133
1998	0	15,640	207,873	555,430	888,552	923,423	508,780	313,037	287,544	258,335	142,871	119,308	58,750	41,444	18,338	20,410	4,359,736
1999	0	3,878	103,029	465,424	650,375	666,648	729,731	376,462	276,602	243,484	160,026	118,633	60,285	35,605	16,315	10,225	3,916,721
2000	0	36,862	340,630	442,388	1,044,044	1,007,957	806,988	730,032	340,411	194,013	151,197	80,370	44,604	23,818	13,098	13,958	5,270,370
2001	0	49,267	144,033	361,425	608,866	908,054	730,083	618,127	530,416	225,959	140,048	117,544	65,350	35,265	16,593	10,166	4,561,195
2002	0	24,423	248,366	309,001	476,341	562,521	750,219	527,255	374,125	341,762	151,130	119,067	64,613	45,012	18,377	20,944	4,033,156
2003	0	2,462	342,392	498,977	578,831	670,481	599,357	699,482	504,371	402,960	325,872	164,618	98,438	62,291	28,730	17,602	4,996,863
2004	94	75,762	190,333	859,094	763,701	522,052	522,505	514,231	638,455	459,315	348,607	277,909	136,564	72,561	46,957	29,084	5,457,223
2005	70	21,753	496,382	440,920	1,135,627	979,289	527,571	445,523	378,346	462,168	325,564	303,539	141,261	95,645	40,498	42,077	5,836,233
2006	14	34,400	221,339	1,182,359	666,688	1,058,629	685,356	356,900	386,775	335,485	446,383	312,237	194,912	130,552	48,760	71,763	6,132,550
2007	62	9,470	128,564	266,611	1,036,926	699,052	892,642	523,269	429,415	471,980	426,840	290,551	212,212	107,310	53,491	45,164	5,593,559
2008	0	18,323	79,331	209,998	556,406	1,077,586	489,355	686,661	480,958	277,229	314,190	259,112	210,673	134,479	44,124	67,214	4,905,639
2009	104	15,986	85,589	212,548	583,013	817,238	871,811	355,438	455,081	248,838	180,688	185,070	144,668	145,740	47,259	58,204	4,407,273
2010	18	1,653	75,231	214,031	515,951	551,702	581,187	710,366	288,557	284,844	200,488	112,423	106,211	84,752	47,411	57,662	3,832,487
2011	2	36,803	75,931	245,835	433,149	541,064	684,879	575,636	726,132	282,559	260,502	120,385	91,439	83,179	84,401	79,404	4,321,300
2012	0	63,494	122,694	238,672	309,372	569,615	480,799	444,677	441,499	300,324	194,669	139,534	104,324	48,124	64,395	75,335	3,597,528

2012 data are preliminary.

Table B6.23. Catch mean weights (kg) at age for striped bass, 1982-2012.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1982	0.13	0.64	1.09	1.54	2.42	3.75	4.83	5.79	6.2	8.68	10.8	11.2	14.05
1983	0.2	0.55	0.94	1.37	2.37	3.29	3.77	5.36	6.01	8.1	9.57	10.39	11.11
1984	0.24	0.6	1.69	1.62	2.67	3.39	5.07	5.65	6.76	7.76	8.41	12.65	12.38
1985	0.06	0.61	1.07	1.66	2.19	3.59	4.91	5.46	6.77	7.45	9	10.69	13.91
1986	0.14	0.57	1.27	2.4	2.44	3.12	3.95	5.05	5.44	6.09	7.75	9.16	12.78
1987	0.2	0.77	1.41	2.11	2.5	2.91	3.61	4.74	5.52	6.49	7.77	9.78	13.15
1988	0.31	0.91	1.1	1.98	3.12	4.02	4.38	4.7	5.24	5.62	8.58	10.4	13.27
1989	0.16	0.83	1.22	2.23	3.06	4.53	5.37	6.23	6.04	8.68	8.94	9.74	13.36
1990	0.08	0.89	1.14	2.05	2.35	3.83	4.91	5.96	5.7	5.97	7.44	9.08	12.6
1991	0.21	0.92	1.29	2.17	2.62	3.17	4.81	5.64	6.46	6.24	9.46	8.3	14.22
1992	0.1	0.69	1.31	1.93	2.81	3.67	4.9	5.79	6.96	8.15	9.77	12.44	13.97
1993	0.07	0.76	1.31	1.99	2.77	3.58	4.8	6.11	7.03	8.01	9.53	10.76	14.55
1994	0.24	1.05	1.69	2.21	2.85	3.5	4.94	6.2	6.8	7.53	9.73	10.69	12.73
1995	0.28	0.7	1.35	2.18	2.77	3.65	5.38	6.16	7.27	8.86	7.57	9.73	16.66
1996	0.14	1.05	1.47	2.32	3.23	4.52	6.39	7.11	7.81	9.2	9.31	10.1	13.7
1997	0.13	0.62	1.18	2.46	2.81	3.64	4.51	5.07	6.73	9.17	9.94	10.24	14.78
1998	0.39	0.77	1.2	1.62	2.25	2.95	4.69	5.66	6.82	7.03	7.76	9.87	11.87
1999	0.62	0.9	1.11	1.44	1.91	2.51	3.36	5.03	6.56	7.85	8.69	9.76	11.98
2000	0.37	0.55	1.1	1.45	1.96	2.79	3.89	5.09	7.11	7.37	9.7	10.7	13.55
2001	0.16	0.38	1.12	1.75	2.21	3.25	4.12	5.02	6.36	7.79	8.65	8.29	10.87
2002	0.12	0.31	1.06	1.51	2.18	3.17	4.19	5.48	6.03	7.56	9.09	9.75	11.52
2003	0.1	0.6	1	1.4	2.2	3.2	4.1	5.2	6.1	7.2	8.5	9.4	11
2004	0.23	0.33	0.84	1.40	2.43	3.11	4.14	5.17	6.07	7.12	8.18	9.03	10.71
2005	0.13	0.50	1.14	1.64	2.22	3.23	4.18	5.64	6.38	7.21	8.51	10.00	12.19
2006	0.18	0.38	0.81	1.35	1.96	2.80	3.84	5.35	6.70	7.41	8.58	9.40	12.05
2007	0.10	0.46	0.94	1.30	2.10	3.07	4.31	5.32	6.89	7.84	9.39	10.12	12.77
2008	0.21	0.45	1.04	1.43	2.14	3.47	5.05	5.51	6.69	8.26	9.19	9.82	12.00
2009	0.26	0.62	1.03	1.41	1.92	3.29	4.49	5.74	6.87	7.73	8.81	9.47	12.24
2010	0.16	0.70	1.11	1.41	1.99	3.34	4.27	5.21	6.27	7.65	8.97	9.15	11.59
2011	0.20	0.52	1.04	1.55	2.00	3.08	4.10	5.13	6.41	7.54	8.20	9.98	13.08
2012	0.31	0.71	1.31	2.23	3.12	3.63	4.36	5.42	6.28	7.78	8.81	9.63	12.14

Table B7.1. Model structure, equation, and data inputs used in this assessment.

General Definitions	Symbol	Description/Definition
Year Index	y	$y = \{1982,...,2012\}$ for catch. $y = \{1970,...,2012\}$ for indices.
Age Index: $a = \{1,..,13+\}$	a	
Fleet Index: $f = \{1$: Chesapeake Bay, 2: Coast, 3: Commercial Dead Discards$\}$	f	
Indices Index: $t = \{1,...,16\}$	t	
Input Data	**Symbol**	**Description/Definition**
Observed Fleet Catch	$C_{f,y}$	Reported number of striped bass killed each year (y) by fleet (f)
Coefficient of Variation for Fleets	$CV_{f,y}$	Calculated from MRIP harvest and dead releases estimates with associated proportional standard errors (commercial harvest from census – no error). CV for commercial dead discards from Monte Carlo simulations.
Observed Fleet Age Compositions	$P_{f,y,a}$	Proportion-at-age (a) for each year (y) and fleet (f)
Observed Total Indices of Relative Abundance	$I_{t,y}$	Reported by various states. YOY and Age 1 Indices: 6 Age-aggregated Indices: 4 (1 fishery-dependent; 3 fishery-independent) Indices with Age Composition: 6 (all fishery-independent)
Coefficient of Variation for Indices	$CV_{t,y}$	Calculated from indices and associated standard errors
Observed Age Compositions of Indices of Relative Abundance	$P_{t,y,a}$	Proportion-at-age (a) for each year (y) and index (t)
Average Effective Sample Size Starting Values	$\hat{n}$	Fleets: 50 Indices: NYOHS – 22, NJ Trawl – 23, MDSSN – 68, DESSN – 68, VAPNET – 68 (calculated from method of Pennington and Volstad, 1995)

Input Data	Symbol	Description/Definition
Catch Weight-at-age (kg)	$w_{y,a}$	Overall average of mean weights-at-age reported for fishery components of states
Rivard Weight-at-age (kg)	$rw_{y,a}$	January-1 weights calculated from catch weights.
SSB Weight-at-age (kg)	$sw_{y,a}$	Adjustment of $rw_{y,a}$ (average of $rw_{y,a}$ and $w_{y,a}$) made to match time of spawning.
Natural Mortality	$M_{y,a}$	Age 1 2 3 4 5 6 $\geq$7 M 1.13 0.68 0.45 0.33 0.25 0.19 0.15 From regression fit to tag estimates of Z for ages 1-3 from Western Long Island Sound, and tag-based estimates of M (Jiang et al., 2007) for ages 3-6 prior to 1997. M for ages $\geq$ 7 from longevity method. M assumed constant across years
Female sex proportions-at-age	sr_a	Calculated from scientific and fishery samples
Maturity-at-age	m_a	Calculated from literature and field samples

Table B7.1 cont.

Population Model	Symbol	Equation
Age-1 numbers	$\hat{N}_{y,1}$	$$\hat{N}_{y,1} = \exp\left(\log_e(\hat{\alpha}) + \log_e(SSB_{y-1}) - \log_e\left(1 + \frac{SSB_{y-1}}{\hat{\beta}}\right) + \hat{e}_y - 0.5\hat{\sigma}_R^2 \right)$$ $$\hat{\sigma}_R = \sqrt{\frac{\sum_y (\hat{e}_y - \hat{\bar{e}})^2}{n-1}}$$ where e_y are independent and identically distributed normal random variables with zero mean and constant variance and are constrained to sum to zero over all years
Abundance-at-Age	$\hat{N}_{y,a}$	First year (ages 2-A in 1970): $\hat{N}_{y,a} = \hat{N}_{y,a-1} \exp^{-\hat{F}_{1982,a-1} - M_{1982,a-1}}$ Rest of years (ages 2-12): $\hat{N}_{y,a} = \hat{N}_{y-1,a-1} \exp^{-\hat{F}_{y-1,a-1} - M_{y-1,a-1}}$
Plus-group abundance-at-age	$\hat{N}_{y,A}$	$\hat{N}_{y,A} = \hat{N}_{y-1,A-1} \exp^{-\hat{F}_{y-1,A-1} - M_{y-1,A-1}} + \hat{N}_{y-1,A} \exp^{-\hat{F}_{y-1,A} - M_{y-1,A}}$
Fishing Mortality	$\hat{F}_{f,y,a}$	$\hat{F}_{f,y,a} = \hat{F}_{f,y} \cdot \hat{s}_{f,a}$ where $F_{f,y}$ and $s_{f,a}$ are estimated parameters
Total Mortality	$\hat{Z}_{y,a}$	$Z_{y,a} = F_{y,a} + M_{y,a}$
Fleet Selectivity	$\hat{s}_{f,a}$	Fleet 1 (Chesapeake Bay): 1982-1984, 1985-1989, 1990-1995, 1996-2012 Fleet 2 (Coast): 1982-1984 Fleet 3 (Commercial Dead Discards): 1985-1989,1990-1995,1996-2002,2003-2012 $$\hat{s}_a = \frac{1}{1-\hat{\gamma}} \cdot \left(\frac{1-\hat{\gamma}}{\hat{\gamma}}\right)^{\hat{\gamma}} \frac{\exp^{\hat{\alpha}\hat{\gamma}(\hat{\beta}-a)}}{1 + \exp^{\hat{\alpha}(\hat{\beta}-a)}}$$ Fleet 2 (Coast): 1985-1989, 1990-1996, 1997-2012 $$\hat{s}_a = \exp^{(-\exp^{-\hat{\beta}(a-\hat{\alpha})})}$$ Fleet 3 (Commercial Dead Discards): 1982-1984 $$\hat{s}_a = \alpha \exp^{\beta a}$$
Predicted Catch-At-Age	$\hat{C}_{f,y,a}$	$$\hat{C}_{f,y,a} = \frac{\hat{F}_{f,y,a}}{\hat{F}_{f,y,a} + M_{y,a}} \cdot (1 - \exp^{-\hat{F}_{y,a} - M_{y,a}}) \cdot \hat{N}_{y,a}$$

Population Model	Symbol	Equation
Predicted Total Catch	$\hat{C}_{y,a}$	$\hat{C}_{f,y} = \sum_{a} \hat{C}_{f,y,a}$
Predicted Proportions of Catch-At-Age	$\hat{P}_{f,y,a}$	$\hat{P}_{f,y,a} = \dfrac{\hat{C}_{f,y,a}}{\sum_{a} \hat{C}_{f,y,a}}$
Predicted Aggregated Indices of Relative Abundance	$\hat{I}_{t,y,\sum a}$	$\hat{I}_{t,y,\Sigma a} = \hat{q}_{t} \cdot \sum_{a} \hat{N}_{y,a} \cdot \exp^{-p_t \cdot Z_{y,a}}$
Predicted Age-Specific Indices of Relative Abundance	$\hat{I}_{t,y,a}$	$\hat{I}_{t,y,a} = \hat{q}_{t} \cdot \hat{s}_{t,a} \cdot \hat{N}_{y,a} \cdot \exp^{-p_t \cdot \hat{Z}_{y,a}}$
Predicted Total Indices of Relative Abundance with Age Composition Data	$\hat{I}_{t,y}$	$\hat{I}_{t,y} = \hat{q}_{t} \sum_{a} \hat{s}_{t,a} \cdot \hat{N}_{y,a} \cdot \exp^{-p_t \cdot \hat{Z}_{y,a}}$
Predicted Age Composition of Survey	$\hat{U}_{t,y,a}$	$\hat{U}_{t,y,a} = \dfrac{\hat{I}_{t,y,a}}{\sum_{a} \hat{I}_{t,y,a}}$
Female Spawning Stock Biomass (metric tons)	SSB_{y}	$SSB_{y} = \sum_{a=1}^{A} N_{y,a} \cdot sr_{a} \cdot m_{a} \cdot sw_{y,a} / 1000$
January-1 Biomass (metric tons)	B_{y}	$B_{y} = \sum_{a=1}^{A} N_{y,a} \cdot rw_{y,a} / 1000$

Table B7.1 cont.

Likelihood	Symbol	Equation
Concentrated Lognormal Likelihood for Fleet Catch and Indices of Relative Abundance	$-L_l$	$$-L_l = 0.5 * \sum_i n_i * \ln\left(\frac{\sum_i RSS_i}{\sum_i n_i}\right)$$ where $$RSS_f = \lambda_f \sum_y \left(\frac{\ln\left(C_{f,y}+1e^{-5}\right)-\ln\left(\hat{C}_{f,y}+1e^{-5}\right)}{CV_{f,y}}\right)^2$$ $$RSS_t = \lambda_t \sum_y \left(\frac{\ln\left(I_{t,y}+1e^{-5}\right)-\ln\left(\hat{I}_{t,y}+1e^{-5}\right)}{\delta_t \cdot CV_{t,y}}\right)^2$$ $CV_{f,y}$ and $CV_{t,y}$ are the annual coefficient of variation for the observed total catch and index in year y, δ_t is the CV weight for index t, and λ_t and λ_f are relative weights
Multinomial fleet catch (f) and index (t) age compositions	$-L_f$ or $-L_t$	$$-L_f = \lambda_f \sum_y -n_{f,y} \sum_a P_{f,y,a} \cdot \ln\left(\hat{P}_{f,y,a}+1e^{-7}\right)$$ $$-L_t = \lambda_t \sum_y -n_{t,y} \sum_a U_{t,y,a} \cdot \ln\left(\hat{U}_{t,y,a}+1e^{-7}\right)$$ where λ_f and λ_t are a user-defined weighting factors and n_y are the effective sample sizes
Effective sample size	$\hat{n}$	The multiplier from equation 1.8 of Francis (2011) was used to adjust the starting values
Constraints Added To Total Likelihood	$P_{n1}, P_{rdev}, P_{fadd}$	$P_{n1} = \lambda_{n1}(\hat{N}_{y,1} - N_{y,1}^e)^2$ - forces $N_{1,1}$ to follow S-R curve $P_{rdev} = \lambda_R \sum_y \log_e(\hat{\sigma}_R) + \frac{\hat{e}_y^2}{2\hat{\sigma}_R^2}$ - for bias correction to constrain deviations $$P_{fadd} = \begin{cases} phase < 3, & 10 \cdot \sum_y (F_{f,y}-0.15)^2 \\ phase \geq 3, & 0.000001 \cdot \sum_y (F_{f,y}-0.15)^2 \end{cases}$$ - avoid small F values at start

Diagnostics	Symbol	Equation
Standardized residuals (lognormal – catch and surveys)	$r_{f,y,a}$ or $r_{t,y,a}$	$r_{t,y} = \dfrac{\log I_{t,y} - \log \hat{I}_{t,y}}{\sqrt{\log_e((\delta_t CV_{t,y})^2 + 1)}}$ $r_{f,y} = \dfrac{\log C_{f,y} - \log \hat{C}_{f,y}}{\sqrt{\log_e(CV_{f,y}^2 + 1)}}$
Standardized residuals (age compositions – catch and surveys)	$ra_{f,y,a}$ or $ra_{t,y,a}$	$ra_{f,y,a} = \dfrac{P_{f,y,a} - \hat{P}_{f,y,a}}{\sqrt{\dfrac{\hat{P}_{f,y,a}(1 - \hat{P}_{f,y,a})}{\hat{n}_f}}}$ $ra_{t,y,a} = \dfrac{P_{t,y,a} - \hat{P}_{t,y,a}}{\sqrt{\dfrac{\hat{P}_{t,y,a}(1 - \hat{P}_{t,y,a})}{\hat{n}_t}}}$
Root mean square error	$RMSE$	Total catch $RMSE_f = \sqrt{\dfrac{\sum_y r_{f,y}^2}{n_f}}$ Index $RMSE_t = \sqrt{\dfrac{\sum_y r_{t,y}^2}{n_t}}$

Table B7.2. Total removals and associated coefficients of variation and age proportions of total removals of striped bass split into Chesapeake Bay, Coast, and Commercial Discard fleet, 1982-2012.

	Chesapeake Bay						Age Proportions								
Year	Total	CV	1	2	3	4	5	6	7	8	9	10	11	12	13+
1982	262,133	0.857	0.00507	0.12678	0.59014	0.23839	0.03160	0.00498	0.00099	0.00089	0.00012	0.00000	0.00029	0.00047	0.00029
1983	277,824	0.224	0.01104	0.28325	0.36483	0.28873	0.03398	0.00918	0.00351	0.00307	0.00086	0.00028	0.00016	0.00032	0.00078
1984	798,853	0.444	0.00557	0.61276	0.33834	0.03751	0.00495	0.00013	0.00068	0.00005	0.00001	0.00000	0.00000	0.00000	0.00000
1985	122,842	0.447	0.01132	0.52144	0.40241	0.04234	0.01142	0.00471	0.00483	0.00153	0.00000	0.00000	0.00000	0.00000	0.00000
1986	56,504	0.516	0.09360	0.28059	0.46742	0.10997	0.01729	0.00595	0.01951	0.00567	0.00000	0.00000	0.00000	0.00000	0.00000
1987	23,170	0.489	0.05059	0.17128	0.40184	0.24355	0.07494	0.00375	0.02876	0.02530	0.00000	0.00000	0.00000	0.00000	0.00000
1988	42,211	0.887	0.02643	0.20139	0.10296	0.10244	0.36728	0.14152	0.05660	0.00138	0.00000	0.00000	0.00000	0.00000	0.00000
1989	16,791	0.285	0.06463	0.56728	0.15406	0.10122	0.07011	0.02801	0.01070	0.00400	0.00000	0.00000	0.00000	0.00000	0.00000
1990	205,740	0.333	0.01873	0.14393	0.18579	0.32698	0.17722	0.10363	0.02839	0.00924	0.00457	0.00152	0.00000	0.00000	0.00000
1991	352,428	0.171	0.00255	0.15667	0.24267	0.25941	0.15361	0.07895	0.05201	0.02952	0.01372	0.00641	0.00448	0.00000	0.00000
1992	383,546	0.156	0.00530	0.09234	0.22350	0.24898	0.18261	0.12646	0.06779	0.03110	0.01392	0.00612	0.00188	0.00000	0.00000
1993	597,071	0.152	0.00278	0.11137	0.16410	0.27782	0.20806	0.11027	0.06903	0.02844	0.01566	0.00797	0.00363	0.00087	0.00000
1994	859,681	0.158	0.00841	0.08882	0.17138	0.19982	0.23514	0.13061	0.08229	0.04048	0.02364	0.01201	0.00506	0.00235	0.00000
1995	1,133,791	0.132	0.00447	0.14701	0.20492	0.22479	0.16855	0.14799	0.04925	0.03082	0.01229	0.00383	0.00414	0.00097	0.00099
1996	1,465,451	0.137	0.00036	0.09842	0.26089	0.18188	0.16817	0.14229	0.08644	0.03241	0.01535	0.00720	0.00462	0.00121	0.00076
1997	1,998,211	0.117	0.02075	0.04500	0.07404	0.32221	0.18116	0.15894	0.08528	0.05664	0.02819	0.01457	0.00648	0.00427	0.00247
1998	1,934,786	0.099	0.00169	0.03597	0.14993	0.25242	0.27003	0.12710	0.06030	0.03604	0.02901	0.01880	0.00978	0.00517	0.00377
1999	1,726,756	0.107	0.00123	0.01763	0.15538	0.22930	0.22668	0.19522	0.07263	0.03593	0.02879	0.01361	0.01137	0.00630	0.00593
2000	2,019,358	0.092	0.01360	0.05297	0.06707	0.24036	0.27401	0.16615	0.09269	0.04241	0.01809	0.01515	0.00751	0.00515	0.00486
2001	1,695,685	0.089	0.02650	0.05998	0.11749	0.19551	0.23594	0.13129	0.08764	0.06882	0.02137	0.01887	0.01455	0.01317	0.00888
2002	1,311,055	0.096	0.01116	0.10412	0.10416	0.19271	0.18460	0.15229	0.10087	0.04483	0.05433	0.01364	0.01389	0.00794	0.01547
2003	2,052,319	0.075	0.00000	0.10428	0.13637	0.17148	0.14837	0.12365	0.09679	0.06315	0.05577	0.05495	0.01998	0.01202	0.01319
2004	1,825,612	0.076	0.03768	0.04394	0.20312	0.20733	0.11058	0.09403	0.08510	0.06536	0.04986	0.03511	0.03521	0.01488	0.01780
2005	1,963,065	0.088	0.00404	0.11522	0.07071	0.24342	0.21513	0.08748	0.05656	0.03891	0.05310	0.03768	0.03703	0.02214	0.01857
2006	2,329,278	0.072	0.01351	0.05082	0.17163	0.17673	0.24904	0.11652	0.04082	0.03479	0.03336	0.04266	0.02650	0.01715	0.02646
2007	2,134,342	0.100	0.00347	0.03161	0.03894	0.34255	0.18042	0.15994	0.05946	0.03628	0.03861	0.03262	0.03410	0.01809	0.02391
2008	1,548,345	0.081	0.00549	0.02349	0.02065	0.20074	0.33928	0.09984	0.08117	0.05211	0.03130	0.03331	0.03126	0.04252	0.03883
2009	1,702,422	0.082	0.00831	0.01123	0.04313	0.18089	0.31257	0.16230	0.06459	0.05332	0.03420	0.02459	0.02821	0.02540	0.05127
2010	1,482,203	0.111	0.00081	0.03521	0.06430	0.25782	0.24658	0.17408	0.09437	0.04192	0.03002	0.01570	0.00713	0.01028	0.02178
2011	1,378,058	0.088	0.02015	0.02148	0.08227	0.15313	0.23472	0.20793	0.11087	0.06843	0.02710	0.02681	0.01204	0.00919	0.02588
2012	1,150,813	0.110	0.05131	0.05757	0.11548	0.11085	0.25704	0.14662	0.09284	0.03334	0.04704	0.02024	0.02561	0.01010	0.03197

Table B7.2 cont.

	Coast							Age Proportions							
Year	Total	CV	1	2	3	4	5	6	7	8	9	10	11	12	13+
1982	454,241	0.366	0.00192	0.09698	0.22097	0.32694	0.09921	0.03720	0.04890	0.03454	0.02380	0.02287	0.02365	0.02971	0.03331
1983	413,741	0.699	0.00653	0.04616	0.19767	0.25603	0.30420	0.07791	0.03870	0.00765	0.00524	0.00825	0.00959	0.01205	0.03003
1984	224,539	0.450	0.00973	0.11611	0.15973	0.20421	0.19731	0.16935	0.06206	0.01893	0.00451	0.00722	0.00443	0.00124	0.04517
1985	219,014	0.679	0.00017	0.01728	0.11977	0.13099	0.20756	0.17460	0.18067	0.07387	0.02579	0.01585	0.00213	0.00277	0.04854
1986	164,055	0.324	0.04844	0.02205	0.15063	0.18503	0.12483	0.10479	0.08366	0.13130	0.04612	0.02785	0.01669	0.00669	0.05193
1987	97,873	0.265	0.01071	0.03159	0.17315	0.19850	0.15288	0.08658	0.06610	0.04540	0.05458	0.02157	0.01056	0.02198	0.12638
1988	166,833	0.326	0.00637	0.10903	0.12105	0.13938	0.13371	0.12561	0.09128	0.09001	0.06513	0.01963	0.01991	0.01897	0.05992
1989	136,245	0.276	0.00021	0.11817	0.22478	0.13368	0.16919	0.10076	0.08498	0.04536	0.03088	0.01995	0.01114	0.00120	0.05969
1990	221,962	0.126	0.00071	0.08812	0.14014	0.20822	0.11709	0.12640	0.10339	0.09868	0.04569	0.01956	0.00932	0.00463	0.03806
1991	339,335	0.144	0.00138	0.07349	0.13753	0.21154	0.10729	0.05437	0.10331	0.11826	0.10193	0.03752	0.01508	0.00313	0.03518
1992	450,413	0.106	0.00216	0.03819	0.25005	0.17186	0.16916	0.06228	0.04469	0.08125	0.08000	0.06316	0.01181	0.00534	0.02005
1993	535,519	0.119	0.00479	0.03264	0.12837	0.21235	0.16552	0.12198	0.04575	0.04911	0.08234	0.08233	0.04671	0.01088	0.01721
1994	726,704	0.074	0.00071	0.08875	0.30239	0.15930	0.15848	0.06702	0.03408	0.03328	0.05852	0.05144	0.02245	0.01571	0.00787
1995	1,367,251	0.099	0.00003	0.18718	0.15586	0.13456	0.08978	0.13697	0.05718	0.08427	0.07277	0.04281	0.02543	0.00738	0.00578
1996	1,582,160	0.067	0.00033	0.03773	0.20362	0.19814	0.14332	0.11791	0.12558	0.06498	0.04515	0.02287	0.01586	0.01732	0.00721
1997	2,173,177	0.055	0.00106	0.07183	0.09794	0.14617	0.10018	0.09920	0.10283	0.14866	0.09919	0.06575	0.03218	0.01912	0.01587
1998	2,098,919	0.064	0.00589	0.05958	0.10075	0.14372	0.15136	0.11133	0.08738	0.09777	0.09259	0.04866	0.04597	0.02207	0.03292
1999	1,953,346	0.062	0.00039	0.00743	0.07537	0.10786	0.11237	0.19360	0.12586	0.10795	0.09818	0.06923	0.05035	0.02498	0.02644
2000	2,584,015	0.064	0.00356	0.02137	0.04529	0.15533	0.15168	0.16933	0.19966	0.09557	0.05935	0.04518	0.02493	0.01290	0.01586
2001	2,554,609	0.045	0.00170	0.01553	0.04076	0.07805	0.16409	0.18713	0.17640	0.15741	0.07048	0.03981	0.03448	0.01607	0.01810
2002	2,553,899	0.052	0.00317	0.03562	0.05083	0.07920	0.11422	0.20629	0.14982	0.12079	0.10372	0.05129	0.03890	0.02117	0.02498
2003	2,682,570	0.047	0.00035	0.04553	0.07122	0.06428	0.11528	0.12142	0.17520	0.13276	0.10143	0.07438	0.04304	0.02630	0.02881
2004	3,173,119	0.063	0.00127	0.01806	0.12858	0.09754	0.08148	0.09566	0.09711	0.15098	0.10876	0.08659	0.06406	0.03374	0.03617
2005	3,079,601	0.055	0.00434	0.08402	0.06446	0.13414	0.12610	0.09345	0.09115	0.08397	0.10216	0.07424	0.06973	0.02901	0.04321
2006	3,614,394	0.051	0.00081	0.02834	0.20945	0.06263	0.12243	0.10721	0.06851	0.08024	0.06795	0.09247	0.06733	0.04167	0.05098
2007	2,862,392	0.052	0.00062	0.01915	0.05785	0.07610	0.07623	0.14451	0.11158	0.10634	0.12142	0.11419	0.06831	0.05369	0.05001
2008	3,054,618	0.059	0.00321	0.01403	0.05737	0.06605	0.15785	0.09098	0.16941	0.12409	0.07045	0.08173	0.06487	0.04276	0.05720
2009	2,099,071	0.055	0.00088	0.03088	0.02788	0.05193	0.07758	0.24108	0.10273	0.15564	0.08113	0.05836	0.05782	0.04468	0.06941
2010	2,098,391	0.058	0.00022	0.01035	0.04893	0.02783	0.05848	0.13228	0.26271	0.10345	0.11146	0.08251	0.04706	0.04250	0.07222
2011	2,317,609	0.054	0.00390	0.01838	0.03177	0.05013	0.03966	0.13735	0.15787	0.24813	0.08807	0.08143	0.03775	0.02870	0.07686
2012	1,651,041	0.074	0.00269	0.02931	0.03672	0.04065	0.04797	0.10538	0.13442	0.21298	0.12320	0.09269	0.05328	0.04584	0.07489

Table B7.2 cont.

	Commercial Discards							Age Proportions							
Year	Total	CV	1	2	3	4	5	6	7	8	9	10	11	12	13+
1982	57,624	0.350	0.00000	0.54917	0.06325	0.19881	0.09759	0.02240	0.04160	0.01760	0.00640	0.00160	0.00148	0.00000	0.00012
1983	40,127	0.350	0.00000	0.59977	0.03620	0.07172	0.19342	0.05759	0.01521	0.01521	0.00652	0.00435	0.00000	0.00000	0.00000
1984	65,639	0.350	0.00000	0.51151	0.02455	0.08854	0.14829	0.17173	0.04288	0.00179	0.00893	0.00100	0.00000	0.00079	0.00000
1985	62,734	0.350	0.00000	0.12319	0.48574	0.09467	0.17361	0.05411	0.04371	0.01665	0.00416	0.00208	0.00208	0.00000	0.00000
1986	174,024	0.350	0.00000	0.03356	0.11928	0.57502	0.16084	0.07651	0.02468	0.00813	0.00199	0.00000	0.00000	0.00000	0.00000
1987	125,066	0.350	0.00000	0.03363	0.11499	0.22866	0.41089	0.13545	0.05213	0.01055	0.00808	0.00315	0.00089	0.00069	0.00089
1988	245,552	0.350	0.00000	0.02501	0.09201	0.14912	0.28898	0.29197	0.09461	0.03713	0.01267	0.00673	0.00089	0.00079	0.00010
1989	338,827	0.350	0.00000	0.04089	0.14828	0.14470	0.24613	0.24425	0.09881	0.04575	0.01872	0.00208	0.00416	0.00416	0.00208
1990	510,011	0.350	0.00000	0.02848	0.13473	0.15869	0.21938	0.22686	0.14039	0.07109	0.01166	0.00302	0.00275	0.00295	0.00000
1991	327,167	0.350	0.00024	0.03861	0.11312	0.19626	0.23638	0.17390	0.11282	0.07598	0.02020	0.01244	0.02000	0.00005	0.00000
1992	186,601	0.350	0.00063	0.01982	0.18337	0.19692	0.23801	0.18589	0.07930	0.05991	0.01821	0.01263	0.00531	0.00000	0.00000
1993	347,839	0.350	0.00000	0.02142	0.14421	0.22715	0.27345	0.18252	0.06020	0.04413	0.02665	0.01324	0.00475	0.00154	0.00075
1994	359,518	0.350	0.00000	0.08837	0.13120	0.12539	0.24511	0.23523	0.10911	0.03484	0.01731	0.01022	0.00198	0.00115	0.00008
1995	515,454	0.350	0.00000	0.14128	0.14651	0.10389	0.18267	0.23589	0.11921	0.03702	0.01468	0.00828	0.00444	0.00455	0.00156
1996	394,824	0.350	0.00000	0.06872	0.28895	0.19334	0.15674	0.14889	0.07810	0.03778	0.01557	0.01010	0.00040	0.00127	0.00013
1997	216,745	0.350	0.00220	0.03279	0.29690	0.28546	0.14119	0.09666	0.06460	0.03041	0.00906	0.01988	0.01226	0.00370	0.00489
1998	326,032	0.350	0.00000	0.04059	0.16532	0.30215	0.25546	0.08955	0.03978	0.03862	0.02411	0.01341	0.01193	0.00742	0.01166
1999	236,619	0.350	0.00416	0.24544	0.21086	0.18487	0.23557	0.06118	0.02203	0.01565	0.00837	0.00551	0.00274	0.00259	0.00103
2000	666,997	0.350	0.00029	0.26755	0.28476	0.23582	0.09400	0.05085	0.04039	0.01174	0.00616	0.00581	0.00120	0.00129	0.00012
2001	310,900	0.350	0.00000	0.00849	0.18681	0.25075	0.28565	0.09460	0.06072	0.03735	0.03108	0.02049	0.01537	0.00629	0.00240
2002	168,201	0.350	0.01011	0.12418	0.25351	0.12728	0.17117	0.14102	0.07361	0.04075	0.03356	0.01340	0.00905	0.00089	0.00148
2003	261,974	0.350	0.00577	0.02377	0.10711	0.20790	0.21654	0.07583	0.11776	0.07112	0.06264	0.05181	0.03116	0.01224	0.01634
2004	458,398	0.350	0.00642	0.11521	0.17512	0.16516	0.13446	0.10315	0.11064	0.08738	0.05058	0.02126	0.02257	0.00513	0.00291
2005	793,498	0.350	0.00054	0.01444	0.13055	0.30838	0.21250	0.08574	0.06780	0.05466	0.05457	0.02894	0.02029	0.01064	0.01095
2006	188,864	0.350	0.00000	0.00288	0.13533	0.15187	0.19075	0.14003	0.07528	0.08328	0.06444	0.06773	0.03791	0.02305	0.02746
2007	596,763	0.350	0.00048	0.01052	0.03001	0.14743	0.16046	0.23061	0.12902	0.07975	0.07042	0.05085	0.03729	0.03338	0.01978
2008	302,676	0.350	0.00000	0.00032	0.00922	0.14479	0.23156	0.18780	0.14370	0.07012	0.04485	0.04285	0.04155	0.04698	0.03626
2009	605,677	0.350	0.00000	0.00272	0.13305	0.27418	0.20186	0.14771	0.04925	0.06208	0.03356	0.02696	0.02588	0.01263	0.03011
2010	251,875	0.350	0.00000	0.00530	0.06373	0.29938	0.25208	0.18105	0.07630	0.03708	0.02566	0.01614	0.01235	0.00709	0.02385
2011	625,631	0.350	0.00000	0.00596	0.09406	0.16933	0.20089	0.12791	0.09106	0.09073	0.06569	0.05566	0.02606	0.01959	0.05305
2012	795,675	0.350	0.00000	0.01013	0.05674	0.14415	0.24459	0.17354	0.14567	0.06472	0.05376	0.02306	0.02777	0.02139	0.03447

Table B7.3. The fraction of total mortality (p) that occurs prior to the survey and ages to which survey indices are linked.

Survey	p	Linked Ages
Age-specific		
NY YOY	0	1 (January 1st)
NJ YOY	0	1 (January 1st)
MD YOY	0	1 (January 1st)
VA YOY	0	1 (January 1st)
MD Age 1	0	2 (January 1st)
NY Age 1	0	2 (January 1st)
Aggregate		
MRFSS	0.5	3-13+
NEFSC	0.333	2-9
CT Trawl	0.333	4-6
Indices with age composition		
NY OHS	0.75	2-13+
NJ Trawl	0.25	2-13+
MD SSN	0.25	2-13+
DE SSN	0.25	2-13+
VA Poundnet	0.25	1-13+

Table B7.4. Starting values for model parameters.

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Parameter(s)	Equation	ADMB Name	Phase	Start Value	Lower Bound	Upper Bound
Yr 1, Age 1 N or Avg N (log)		log_R	1	10	0.27	25
R Deviation (log)		log_R_dev	2	0	-20	20
Fishing Mortality (log)		log_F	2	-1.6	-12	2.31
Aggregate qs (log)		agg_qs	6	-16	-50	0
AgeComp qs (log)		ac_qs	6	-16	-50	0
Catch Selectivity	Gompertz	flgom_a	4	3	-20	150
Catch Selectivity	Gompertz	flgom_b	4	1	-20	150
Catch Selectivity	Thompson	flthom_a	4	-3.81	-20	0
Catch Selectivity	Thompson	flthom_b	4	3	0	150
Catch Selectivity	Thompson	flthom_c	4	0.9	1.00E-28	0.999
Catch Selectivity	Exponential	flexp_a	4	0.1	-150	150
Catch Selectivity	Exponential	flexp_b	4	1	-150	150
AC Selectivity	Gompertz	acgom_a	5	3	-20	150
AC Selectivity	Gompertz	acgom_b	5	1	-20	150
AC Selectivity	Gamma	acgam_a	5	3	0	150
AC Selectivity	Gamma	acgam_b	5	1	0	150
AC Selectivity	Thompson	acthom_a	5	-3.81	-20	0
AC Selectivity	Thompson	acthom_b	5	3	0	150
AC Selectivity	Thompson	acthom_c	5	0.9	1.00E-28	0.999
AC Selectivity	User-Defined	userparms	5	0.6	0	1
S-R Equation	Beverton	BH_a	3	10000	0	100000
S-R Equation	Beverton	BH_b	3	11000	0	100000

Table B7.5. Sample size (n), CV weight (Weight), residual mean square error (RMSE) and 95% confidence bounds for N(0,1) by index.

Index	n	Weight	RMSE	Percentile	
				2.5%	97.5%
NYYOY	33	3.50	1.22	0.761	1.245
NJYOY	30	1.20	1.25	0.748	1.256
MDYOY	43	1.50	1.20	0.792	1.218
VAYOY	30	1.20	1.17	0.748	1.256
NYAge1	27	1.05	1.24	0.733	1.268
MDAge1	43	1.05	1.19	0.792	1.218
MRFSS	24	1.30	1.25	0.716	1.281
CTTRL	29	2.45	1.24	0.743	1.259
NEFSC	18	1.00	1.26	0.669	1.318
NYOHS	20	2.30	1.25	0.687	1.304
NJTRAWL	24	1.90	1.28	0.716	1.281
MDSSN	28	2.30	1.23	0.738	1.263
DESSN	17	2.00	1.28	0.659	1.326
VAPNET	22	1.55	1.26	0.702	1.292

Table B7.6. Likelihood components with respective contributions from base model run.

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Likelihood Components		
Concentrated Log-likelihood	Weight	RSS
Fleet 1 Total Catch:	2	20.9025
Fleet 2 Total Catch:	2	0.612632
Fleet 3 Total Catch:	2	0.150744
Aggregate Abundance Indices		
NYYOY	1	40.1206
NJYOY	1	40.1085
MD YOY	1	56.1552
VA YOY	1	37.8734
NY Age 1	1	38.0402
MD Age 1	1	47.7676
MRFSS	1	36.7304
CTTRL	1	34.2442
NEFSC	1	26.5513
Age Comp Abundance Indices		
NYOHS	1	30.2262
NJ Trawl	1	32.7883
MDSSN	1	36.7345
DESSN	1	26.9383
VAPNET	1	32.5124
Total RSS		538.457
No. of Obs		481
Conc. Likel.		27.1381
Age Composition Data Likelihood		
Fleet 1 Age Comp:	1	1886.81
Fleet 2 Age Comp:	1	3018.14
Fleet 3 Age Comp:	1	1356.09
NYOHS	1	492.357
NJ Trawl	1	242.258
MDSSN	1	1315.91
DESSN	1	974.044
VAPNET	1	501.462
log_R constraint	1	0.287421
Recr Devs	1	13.5802
Total Likelihood		9779.13
AIC		19954.3

Table B7.7. Parameter estimates and associated standard deviations of base model configuration.

Year	Bay Full F	Bay SD	Bay CV	Coast Full F	Coast SD	Coast CV	Commercial Discards Full F	Commercial Discards SD	Commercial Discards CV	Total Full F	Total SD	Total CV		Recruitment	SD	CV
1982	0.8896	0.1317	0.148	0.1674	0.0035	0.021	0.0107	0.0013	0.120	0.9469	0.1287	0.136		18308700	2259540	0.123
1983	0.0738	0.0507	0.687	0.1248	0.0047	0.038	0.0070	0.0059	0.838	0.1599	0.0608	0.380		45416500	4320100	0.095
1984	0.1592	0.0035	0.022	0.0658	0.0040	0.061	0.0090	0.0151	1.681	0.1849	0.0646	0.349		39684200	3926120	0.099
1985	0.0088	0.0166	1.881	0.1081	0.0037	0.034	0.0180	0.0024	0.132	0.1126	0.0601	0.534		39279900	3798770	0.097
1986	0.0036	0.0599	16.644	0.0648	0.0074	0.115	0.0331	0.0054	0.163	0.0709	0.0234	0.330		32458500	3338810	0.103
1987	0.0014	0.0023	1.629	0.0297	0.0056	0.190	0.0175	0.0194	1.108	0.0331	0.0099	0.299		43188300	4034750	0.093
1988	0.0024	0.0639	26.979	0.0411	0.0037	0.090	0.0306	0.0042	0.136	0.0485	0.0116	0.240		56506300	4845150	0.086
1989	0.0008	0.0242	31.077	0.0273	0.0065	0.240	0.0390	0.0061	0.157	0.0484	0.0121	0.250		64927200	5355090	0.082
1990	0.0151	0.0030	0.197	0.0172	0.0062	0.361	0.0565	0.0198	0.351	0.0853	0.0172	0.201		84799400	6469840	0.076
1991	0.0220	0.0032	0.144	0.0225	0.0069	0.305	0.0316	0.0071	0.224	0.0717	0.0108	0.150		70127300	5797160	0.083
1992	0.0204	0.0596	2.917	0.0255	0.0086	0.336	0.0152	0.0071	0.466	0.0563	0.0065	0.115		70488000	5951990	0.084
1993	0.0285	0.0060	0.212	0.0271	0.0069	0.252	0.0244	0.0251	1.031	0.0747	0.0091	0.121		93050800	7218060	0.078
1994	0.0383	0.0015	0.038	0.0338	0.0064	0.190	0.0222	0.0018	0.082	0.0875	0.0095	0.108		183429000	11115800	0.061
1995	0.0458	0.0239	0.523	0.0560	0.0029	0.053	0.0295	0.0076	0.259	0.1207	0.0123	0.102		116771000	8454170	0.072
1996	0.0551	0.0110	0.200	0.0553	0.0071	0.128	0.0098	0.0218	2.222	0.1123	0.0093	0.083		126609000	8908990	0.070
1997	0.0644	0.0006	0.009	0.1473	0.0162	0.110	0.0051	0.0056	1.104	0.1786	0.0175	0.098		153667000	9879520	0.064
1998	0.0586	0.0099	0.169	0.1325	0.0015	0.011	0.0074	0.0054	0.725	0.1623	0.0163	0.101		100332000	7545690	0.075
1999	0.0501	0.0054	0.107	0.1143	0.0056	0.049	0.0052	0.0251	4.868	0.1393	0.0139	0.100		99675100	7374620	0.074
2000	0.0578	0.0016	0.028	0.1443	0.0151	0.105	0.0152	0.0030	0.197	0.1766	0.0174	0.098		79466400	6471350	0.081
2001	0.0508	0.0144	0.283	0.1404	0.0021	0.015	0.0077	0.0069	0.887	0.1660	0.0164	0.099		115700000	8202990	0.071
2002	0.0413	0.0092	0.224	0.1393	0.0050	0.036	0.0044	0.0183	4.122	0.1591	0.0163	0.102		134353000	9183870	0.068
2003	0.0677	0.0002	0.003	0.1481	0.0129	0.087	0.0087	0.0064	0.745	0.1854	0.0170	0.092		76710100	6625090	0.086
2004	0.0601	0.0084	0.140	0.1806	0.0015	0.008	0.0151	0.0078	0.519	0.2177	0.0222	0.102		160129000	10937800	0.068
2005	0.0648	0.0118	0.182	0.1818	0.0052	0.029	0.0260	0.0195	0.751	0.2290	0.0241	0.105		87400000	7548490	0.086
2006	0.0792	0.0041	0.051	0.2227	0.0161	0.072	0.0065	0.0030	0.468	0.2625	0.0281	0.107		82798000	7481950	0.090
2007	0.0730	0.0026	0.035	0.1839	0.0043	0.023	0.0202	0.0075	0.370	0.2312	0.0249	0.108		59054700	6286920	0.106
2008	0.0562	0.0173	0.307	0.2038	0.0045	0.022	0.0109	0.0235	2.160	0.2359	0.0286	0.121		80412800	8273850	0.103
2009	0.0681	0.0035	0.051	0.1461	0.0147	0.101	0.0234	0.0082	0.350	0.1947	0.0226	0.116		55937400	7086020	0.127
2010	0.0648	0.0035	0.055	0.1525	0.0022	0.014	0.0108	0.0073	0.671	0.1897	0.0223	0.118		76555000	10145800	0.133
2011	0.0645	0.0098	0.152	0.1787	0.0039	0.022	0.0288	0.0190	0.661	0.2279	0.0282	0.124		108568000	13204300	0.122
2012	0.0555	0.0030	0.054	0.1337	0.0145	0.108	0.0392	0.0114	0.291	0.1877	0.0259	0.138		143553000	24393100	0.170

Table B7.7 cont.

Catch Selectivtiy Parameters

	Bay				Coasr				Commercial Discards		
	Estimate	SD	CV		Estimate	SD	CV		Estimate	SD	CV
1982-1984				1982-1984				1982-1984			
α	-5.681	0.445	0.08	α	-2.482	0.353	0.14	α	0.016	0.008	0.50
β	2.274	0.064	0.03	β	3.369	0.263	0.08	β	1.247	0.201	0.16
?	0.914	0.022	0.02	?	0.994	0.023	0.02				
1985-1989				1985-1989				1985-1989			
α	-3.828	0.481	0.13	α	5.355	0.674	0.13	α	-2.128	0.248	0.12
β	2.005	0.126	0.06	β	0.416	0.064	0.15	β	4.110	0.400	0.10
?	0.955	0.022	0.02					?	8.84E-01	6.83E-02	0.08
1990-1995				1990-1995				1990-1995			
α	-2.291	0.231	0.10	α	3.133	0.190	0.06	α	-1.899	0.165	0.09
β	3.451	0.245	0.07	β	0.899	0.115	0.13	β	4.652	0.384	0.08
?	0.893	0.037	0.04					?	8.22E-01	6.51E-02	0.08
1996-2012				1996-2012				1996-2002			
α	-1.918	0.123	0.06	α	5.216	0.271	0.05	α	-2.74E+00	5.23E-01	0.19
β	3.766	0.150	0.04	β	0.441	0.033	0.08	β	2.81E+00	2.90E-01	0.10
?	0.941	0.017	0.02					?	9.56E-01	2.94E-02	0.03
								2003-2012			
								α	-2.469	0.352	0.14
								β	3.635	0.212	0.06
								?	9.78E-01	1.76E-02	0.02

Survey Selectivity Parameters			
NYOHS	Estimate	SD	CV
α	-2.95	0.56	0.19
β	2.65	0.18	0.07
ϒ	0.91	0.03	0.03
NJ Trawl			
α	3.14	0.65	0.21
β	0.52	0.14	0.27
DE SSN			
α	3.20	0.18	0.06
β	0.85	0.12	0.14
MDSSN			
s_2	0.14	0.02	0.14
VAPNET			
α	-3.16	0.39	0.12
β	3.15	0.12	0.04
ϒ	0.99	0.01	0.01

Catchability Coefficients			
Survey	Estimate	SD	CV
NY YOY	1.40E-07	1.84E-08	0.13
NJ YOY	1.25E-08	9.45E-10	0.08
MD YOY	4.43E-08	3.70E-09	0.08
VA YOY	1.09E-07	8.96E-09	0.08
NY Age 1	4.46E-08	4.02E-09	0.09
MD Age 1	9.72E-09	9.31E-10	0.10
MRFSS	2.53E-08	1.59E-09	0.06
NEFSC	1.01E-08	1.02E-09	0.10
CTTRL	3.54E-08	2.79E-09	0.08
NYOHS	1.48E-07	1.67E-08	0.11
NJTRL	9.84E-08	1.22E-08	0.12
MDSSN	1.26E-07	1.58E-08	0.12
DESSN	7.76E-08	9.31E-09	0.12
VAPNET	5.42E-07	6.12E-08	0.11

Table B7.8.   Maximum total F-at-age and average total fishing mortality for various age ranges and weighting schemes.

Year	Maximum Total F-at-Age	Unweighted Avg. 3-8	Unweighted Avg. 8-11	N-weighted Avg. 3-8	N-weighted Avg. 7-11
1982	0.947	0.519	0.213	0.807	0.244
1983	0.160	0.145	0.131	0.138	0.134
1984	0.185	0.130	0.080	0.164	0.088
1985	0.113	0.062	0.103	0.032	0.092
1986	0.071	0.051	0.070	0.030	0.068
1987	0.033	0.025	0.033	0.017	0.032
1988	0.048	0.039	0.048	0.030	0.048
1989	0.048	0.037	0.039	0.029	0.043
1990	0.085	0.061	0.042	0.046	0.058
1991	0.072	0.054	0.041	0.042	0.050
1992	0.056	0.044	0.038	0.035	0.042
1993	0.075	0.057	0.046	0.049	0.051
1994	0.088	0.068	0.055	0.060	0.062
1995	0.121	0.096	0.082	0.079	0.092
1996	0.112	0.093	0.097	0.065	0.103
1997	0.179	0.116	0.174	0.078	0.167
1998	0.162	0.107	0.159	0.076	0.153
1999	0.139	0.091	0.136	0.063	0.130
2000	0.177	0.118	0.173	0.094	0.163
2001	0.166	0.105	0.160	0.084	0.152
2002	0.159	0.094	0.151	0.076	0.143
2003	0.185	0.122	0.181	0.091	0.174
2004	0.218	0.135	0.210	0.091	0.201
2005	0.229	0.147	0.223	0.112	0.215
2006	0.263	0.160	0.252	0.102	0.243
2007	0.231	0.150	0.225	0.111	0.216
2008	0.236	0.138	0.224	0.105	0.209
2009	0.195	0.133	0.192	0.112	0.186
2010	0.190	0.123	0.185	0.094	0.176
2011	0.228	0.148	0.222	0.121	0.214
2012	0.188	0.130	0.186	0.095	0.181

Table B7.9. Total fishing mortality-at-age and fishing mortality-at-age by fleet.

Total Fishing Mortality

Year	Age												
	1	2	3	4	5	6	7	8	9	10	11	12	13+
1982	0.003	0.265	0.947	0.708	0.519	0.387	0.304	0.252	0.220	0.199	0.185	0.175	0.174
1983	0.001	0.027	0.116	0.159	0.160	0.149	0.141	0.135	0.131	0.127	0.125	0.122	0.121
1984	0.001	0.050	0.185	0.164	0.136	0.112	0.097	0.087	0.081	0.076	0.073	0.071	0.071
1985	0.001	0.008	0.020	0.039	0.060	0.074	0.085	0.094	0.101	0.106	0.109	0.111	0.113
1986	0.000	0.004	0.014	0.036	0.057	0.063	0.066	0.068	0.070	0.071	0.071	0.071	0.071
1987	0.000	0.002	0.006	0.018	0.028	0.031	0.032	0.032	0.033	0.033	0.033	0.033	0.033
1988	0.000	0.003	0.010	0.029	0.046	0.048	0.048	0.048	0.048	0.048	0.048	0.047	0.046
1989	0.000	0.002	0.009	0.031	0.048	0.048	0.045	0.042	0.040	0.038	0.036	0.035	0.034
1990	0.000	0.004	0.019	0.053	0.085	0.084	0.069	0.055	0.045	0.037	0.032	0.028	0.025
1991	0.000	0.004	0.021	0.051	0.072	0.070	0.059	0.050	0.043	0.038	0.034	0.031	0.029
1992	0.000	0.003	0.019	0.044	0.056	0.055	0.049	0.043	0.039	0.036	0.033	0.031	0.030
1993	0.000	0.004	0.024	0.057	0.075	0.072	0.062	0.054	0.047	0.042	0.039	0.036	0.034
1994	0.001	0.006	0.030	0.070	0.088	0.084	0.073	0.064	0.057	0.051	0.047	0.044	0.041
1995	0.001	0.008	0.042	0.095	0.121	0.117	0.105	0.094	0.085	0.078	0.072	0.068	0.065
1996	0.001	0.007	0.039	0.086	0.110	0.112	0.109	0.104	0.099	0.094	0.090	0.086	0.083
1997	0.001	0.006	0.031	0.081	0.120	0.141	0.156	0.167	0.174	0.177	0.179	0.179	0.177
1998	0.001	0.006	0.030	0.076	0.111	0.130	0.143	0.152	0.158	0.161	0.162	0.162	0.161
1999	0.001	0.005	0.025	0.064	0.094	0.111	0.122	0.130	0.136	0.138	0.139	0.139	0.138
2000	0.001	0.007	0.036	0.085	0.121	0.141	0.156	0.166	0.172	0.175	0.177	0.176	0.175
2001	0.001	0.006	0.029	0.072	0.106	0.127	0.142	0.153	0.160	0.164	0.166	0.166	0.165
2002	0.001	0.005	0.024	0.061	0.093	0.114	0.130	0.142	0.150	0.155	0.158	0.159	0.159
2003	0.001	0.006	0.030	0.085	0.127	0.149	0.164	0.174	0.181	0.184	0.185	0.185	0.184
2004	0.001	0.006	0.031	0.090	0.137	0.164	0.184	0.199	0.209	0.214	0.217	0.218	0.217
2005	0.001	0.007	0.035	0.103	0.153	0.180	0.200	0.213	0.222	0.227	0.229	0.229	0.228
2006	0.001	0.008	0.038	0.106	0.162	0.196	0.221	0.239	0.251	0.258	0.261	0.263	0.262
2007	0.001	0.007	0.036	0.105	0.156	0.184	0.203	0.216	0.225	0.229	0.231	0.231	0.230
2008	0.001	0.006	0.031	0.089	0.137	0.168	0.192	0.210	0.222	0.230	0.234	0.236	0.236
2009	0.001	0.006	0.033	0.096	0.142	0.163	0.177	0.186	0.192	0.194	0.195	0.194	0.192
2010	0.001	0.006	0.030	0.085	0.128	0.151	0.166	0.177	0.184	0.188	0.190	0.189	0.188
2011	0.001	0.007	0.035	0.104	0.155	0.181	0.200	0.213	0.222	0.226	0.228	0.228	0.226
2012	0.001	0.006	0.032	0.097	0.141	0.160	0.172	0.181	0.186	0.188	0.188	0.186	0.184

Table B7.9 cont.

Chesapeake Bay

Age

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1982	0.0017	0.2571	0.8896	0.5549	0.3407	0.2092	0.1284	0.0788	0.0484	0.0297	0.0182	0.0112	0.0120
1983	0.0001	0.0213	0.0738	0.0460	0.0282	0.0173	0.0107	0.0065	0.0040	0.0025	0.0015	0.0009	0.0010
1984	0.0003	0.0460	0.1592	0.0993	0.0610	0.0374	0.0230	0.0141	0.0087	0.0053	0.0033	0.0020	0.0021
1985	0.0003	0.0053	0.0088	0.0076	0.0064	0.0054	0.0046	0.0038	0.0032	0.0027	0.0023	0.0019	0.0016
1986	0.0001	0.0022	0.0036	0.0031	0.0026	0.0022	0.0019	0.0016	0.0013	0.0011	0.0009	0.0008	0.0007
1987	0.0000	0.0009	0.0014	0.0012	0.0010	0.0009	0.0007	0.0006	0.0005	0.0004	0.0004	0.0003	0.0003
1988	0.0001	0.0014	0.0024	0.0020	0.0017	0.0015	0.0012	0.0010	0.0009	0.0007	0.0006	0.0005	0.0004
1989	0.0000	0.0005	0.0008	0.0007	0.0006	0.0005	0.0004	0.0003	0.0003	0.0002	0.0002	0.0002	0.0001
1990	0.0002	0.0011	0.0065	0.0151	0.0148	0.0119	0.0093	0.0073	0.0057	0.0045	0.0035	0.0027	0.0021
1991	0.0002	0.0016	0.0095	0.0220	0.0215	0.0173	0.0136	0.0106	0.0083	0.0065	0.0051	0.0040	0.0031
1992	0.0002	0.0015	0.0088	0.0204	0.0200	0.0160	0.0126	0.0099	0.0077	0.0060	0.0047	0.0037	0.0029
1993	0.0003	0.0021	0.0123	0.0285	0.0279	0.0224	0.0175	0.0137	0.0108	0.0084	0.0066	0.0052	0.0040
1994	0.0004	0.0028	0.0165	0.0383	0.0374	0.0300	0.0236	0.0184	0.0144	0.0113	0.0088	0.0069	0.0054
1995	0.0004	0.0033	0.0197	0.0458	0.0448	0.0359	0.0282	0.0221	0.0173	0.0135	0.0106	0.0083	0.0065
1996	0.0005	0.0028	0.0141	0.0412	0.0551	0.0530	0.0479	0.0428	0.0382	0.0341	0.0305	0.0272	0.0243
1997	0.0006	0.0032	0.0165	0.0482	0.0644	0.0620	0.0560	0.0501	0.0447	0.0399	0.0356	0.0318	0.0284
1998	0.0005	0.0030	0.0151	0.0439	0.0586	0.0565	0.0510	0.0456	0.0407	0.0364	0.0325	0.0290	0.0259
1999	0.0004	0.0025	0.0129	0.0375	0.0501	0.0483	0.0436	0.0390	0.0348	0.0311	0.0277	0.0248	0.0221
2000	0.0005	0.0029	0.0148	0.0432	0.0578	0.0556	0.0502	0.0449	0.0401	0.0358	0.0320	0.0285	0.0255
2001	0.0004	0.0026	0.0130	0.0380	0.0508	0.0489	0.0442	0.0395	0.0353	0.0315	0.0281	0.0251	0.0224
2002	0.0004	0.0021	0.0106	0.0309	0.0413	0.0397	0.0359	0.0321	0.0287	0.0256	0.0228	0.0204	0.0182
2003	0.0006	0.0034	0.0174	0.0506	0.0677	0.0652	0.0589	0.0527	0.0470	0.0420	0.0375	0.0335	0.0299
2004	0.0005	0.0030	0.0154	0.0449	0.0601	0.0578	0.0522	0.0467	0.0417	0.0372	0.0332	0.0297	0.0265
2005	0.0006	0.0033	0.0166	0.0485	0.0648	0.0624	0.0564	0.0504	0.0450	0.0402	0.0359	0.0320	0.0286
2006	0.0007	0.0040	0.0203	0.0593	0.0792	0.0763	0.0689	0.0616	0.0550	0.0491	0.0439	0.0392	0.0350
2007	0.0006	0.0037	0.0188	0.0546	0.0730	0.0703	0.0635	0.0568	0.0507	0.0453	0.0404	0.0361	0.0322
2008	0.0005	0.0028	0.0144	0.0420	0.0562	0.0541	0.0489	0.0437	0.0390	0.0349	0.0311	0.0278	0.0248
2009	0.0006	0.0034	0.0175	0.0509	0.0681	0.0656	0.0592	0.0530	0.0473	0.0422	0.0377	0.0336	0.0300
2010	0.0006	0.0033	0.0166	0.0485	0.0648	0.0624	0.0564	0.0504	0.0450	0.0402	0.0359	0.0320	0.0286
2011	0.0006	0.0032	0.0166	0.0482	0.0645	0.0621	0.0561	0.0501	0.0448	0.0400	0.0357	0.0319	0.0284
2012	0.0005	0.0028	0.0143	0.0415	0.0555	0.0535	0.0483	0.0432	0.0386	0.0344	0.0307	0.0274	0.0245

Table B7.9 cont.

Coast
Age

Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1982	0.0005	0.0058	0.0501	0.1428	0.1672	0.1674	0.1652	0.1628	0.1605	0.1582	0.1559	0.1536	0.1514
1983	0.0004	0.0043	0.0373	0.1065	0.1246	0.1248	0.1232	0.1214	0.1196	0.1179	0.1162	0.1145	0.1128
1984	0.0002	0.0023	0.0197	0.0561	0.0657	0.0658	0.0649	0.0640	0.0631	0.0621	0.0612	0.0604	0.0595
1985	0.0003	0.0020	0.0079	0.0195	0.0353	0.0524	0.0680	0.0807	0.0904	0.0975	0.1024	0.1058	0.1081
1986	0.0002	0.0012	0.0047	0.0117	0.0212	0.0314	0.0407	0.0484	0.0542	0.0584	0.0613	0.0634	0.0648
1987	0.0001	0.0006	0.0022	0.0053	0.0097	0.0144	0.0187	0.0222	0.0248	0.0268	0.0281	0.0291	0.0297
1988	0.0001	0.0008	0.0030	0.0074	0.0134	0.0199	0.0259	0.0307	0.0344	0.0371	0.0390	0.0402	0.0411
1989	0.0001	0.0005	0.0020	0.0049	0.0089	0.0132	0.0171	0.0204	0.0228	0.0246	0.0258	0.0267	0.0273
1990	0.0000	0.0011	0.0056	0.0109	0.0143	0.0160	0.0167	0.0170	0.0171	0.0172	0.0172	0.0172	0.0172
1991	0.0000	0.0014	0.0073	0.0142	0.0187	0.0209	0.0218	0.0222	0.0224	0.0224	0.0225	0.0225	0.0225
1992	0.0000	0.0016	0.0083	0.0161	0.0212	0.0236	0.0247	0.0252	0.0254	0.0254	0.0255	0.0255	0.0255
1993	0.0000	0.0017	0.0088	0.0172	0.0225	0.0252	0.0263	0.0268	0.0270	0.0271	0.0271	0.0271	0.0271
1994	0.0000	0.0021	0.0110	0.0214	0.0281	0.0313	0.0328	0.0334	0.0336	0.0337	0.0338	0.0338	0.0338
1995	0.0001	0.0035	0.0182	0.0354	0.0465	0.0519	0.0543	0.0553	0.0557	0.0559	0.0560	0.0560	0.0560
1996	0.0001	0.0035	0.0179	0.0350	0.0459	0.0513	0.0536	0.0546	0.0550	0.0552	0.0552	0.0553	0.0553
1997	0.0003	0.0024	0.0107	0.0275	0.0506	0.0750	0.0965	0.1135	0.1260	0.1348	0.1407	0.1447	0.1473
1998	0.0002	0.0022	0.0096	0.0248	0.0456	0.0674	0.0868	0.1021	0.1133	0.1212	0.1266	0.1301	0.1325
1999	0.0002	0.0019	0.0083	0.0214	0.0393	0.0582	0.0749	0.0881	0.0978	0.1046	0.1092	0.1123	0.1143
2000	0.0002	0.0024	0.0105	0.0270	0.0496	0.0734	0.0945	0.1112	0.1234	0.1320	0.1378	0.1417	0.1443
2001	0.0002	0.0023	0.0102	0.0262	0.0483	0.0715	0.0920	0.1082	0.1201	0.1285	0.1341	0.1379	0.1404
2002	0.0002	0.0023	0.0101	0.0260	0.0479	0.0709	0.0913	0.1074	0.1192	0.1275	0.1331	0.1369	0.1393
2003	0.0003	0.0025	0.0107	0.0277	0.0509	0.0754	0.0970	0.1141	0.1267	0.1355	0.1415	0.1455	0.1481
2004	0.0003	0.0030	0.0131	0.0337	0.0621	0.0919	0.1183	0.1391	0.1545	0.1652	0.1725	0.1774	0.1806
2005	0.0003	0.0030	0.0132	0.0340	0.0625	0.0926	0.1191	0.1401	0.1556	0.1664	0.1737	0.1786	0.1818
2006	0.0004	0.0037	0.0161	0.0416	0.0766	0.1134	0.1459	0.1716	0.1905	0.2038	0.2128	0.2188	0.2227
2007	0.0003	0.0031	0.0133	0.0344	0.0632	0.0936	0.1205	0.1417	0.1574	0.1683	0.1757	0.1807	0.1839
2008	0.0003	0.0034	0.0148	0.0381	0.0701	0.1037	0.1335	0.1571	0.1743	0.1865	0.1947	0.2002	0.2038
2009	0.0003	0.0024	0.0106	0.0273	0.0502	0.0744	0.0957	0.1126	0.1250	0.1337	0.1396	0.1435	0.1461
2010	0.0003	0.0025	0.0110	0.0285	0.0524	0.0776	0.0999	0.1175	0.1305	0.1395	0.1457	0.1498	0.1525
2011	0.0003	0.0030	0.0129	0.0334	0.0615	0.0910	0.1171	0.1377	0.1529	0.1635	0.1707	0.1756	0.1787
2012	0.0002	0.0022	0.0097	0.0250	0.0460	0.0680	0.0876	0.1030	0.1144	0.1223	0.1277	0.1313	0.1337

Table B7.9 cont.

Commercial Discards

							Age						
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+
1982	0.0006	0.0021	0.0072	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107	0.0107
1983	0.0004	0.0014	0.0047	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070	0.0070
1984	0.0005	0.0017	0.0060	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090
1985	0.0001	0.0005	0.0029	0.0117	0.0180	0.0159	0.0126	0.0099	0.0077	0.0060	0.0047	0.0037	0.0029
1986	0.0001	0.0009	0.0054	0.0215	0.0331	0.0292	0.0232	0.0181	0.0142	0.0111	0.0087	0.0068	0.0053
1987	0.0001	0.0005	0.0029	0.0114	0.0175	0.0155	0.0123	0.0096	0.0075	0.0059	0.0046	0.0036	0.0028
1988	0.0001	0.0008	0.0050	0.0199	0.0306	0.0270	0.0214	0.0168	0.0131	0.0102	0.0080	0.0062	0.0049
1989	0.0002	0.0011	0.0063	0.0254	0.0390	0.0344	0.0273	0.0214	0.0167	0.0130	0.0102	0.0080	0.0062
1990	0.0003	0.0015	0.0070	0.0269	0.0562	0.0565	0.0429	0.0309	0.0221	0.0157	0.0112	0.0080	0.0057
1991	0.0002	0.0009	0.0039	0.0151	0.0315	0.0316	0.0240	0.0173	0.0124	0.0088	0.0063	0.0045	0.0032
1992	0.0001	0.0004	0.0019	0.0073	0.0152	0.0152	0.0116	0.0083	0.0060	0.0042	0.0030	0.0022	0.0015
1993	0.0001	0.0007	0.0030	0.0116	0.0243	0.0244	0.0185	0.0133	0.0095	0.0068	0.0048	0.0035	0.0025
1994	0.0001	0.0006	0.0027	0.0106	0.0221	0.0222	0.0168	0.0121	0.0087	0.0062	0.0044	0.0031	0.0022
1995	0.0002	0.0008	0.0037	0.0141	0.0294	0.0295	0.0224	0.0161	0.0115	0.0082	0.0059	0.0042	0.0030
1996	0.0001	0.0013	0.0072	0.0098	0.0090	0.0080	0.0071	0.0063	0.0056	0.0049	0.0044	0.0039	0.0034
1997	0.0001	0.0007	0.0037	0.0051	0.0047	0.0041	0.0037	0.0033	0.0029	0.0026	0.0023	0.0020	0.0018
1998	0.0001	0.0010	0.0055	0.0074	0.0068	0.0061	0.0054	0.0048	0.0042	0.0037	0.0033	0.0029	0.0026
1999	0.0001	0.0007	0.0038	0.0052	0.0047	0.0042	0.0037	0.0033	0.0029	0.0026	0.0023	0.0020	0.0018
2000	0.0002	0.0020	0.0112	0.0152	0.0140	0.0124	0.0110	0.0097	0.0086	0.0076	0.0068	0.0060	0.0053
2001	0.0001	0.0010	0.0057	0.0077	0.0071	0.0063	0.0056	0.0049	0.0044	0.0039	0.0034	0.0030	0.0027
2002	0.0001	0.0006	0.0032	0.0044	0.0041	0.0036	0.0032	0.0028	0.0025	0.0022	0.0020	0.0017	0.0015
2003	0.0000	0.0002	0.0017	0.0067	0.0087	0.0085	0.0080	0.0076	0.0072	0.0068	0.0065	0.0061	0.0058
2004	0.0000	0.0003	0.0030	0.0117	0.0151	0.0147	0.0140	0.0132	0.0125	0.0119	0.0112	0.0107	0.0101
2005	0.0001	0.0006	0.0052	0.0202	0.0260	0.0254	0.0241	0.0228	0.0216	0.0205	0.0194	0.0184	0.0174
2006	0.0000	0.0001	0.0013	0.0051	0.0065	0.0064	0.0060	0.0057	0.0054	0.0051	0.0049	0.0046	0.0044
2007	0.0000	0.0004	0.0040	0.0157	0.0202	0.0197	0.0187	0.0177	0.0168	0.0159	0.0151	0.0143	0.0135
2008	0.0000	0.0002	0.0022	0.0085	0.0109	0.0106	0.0101	0.0096	0.0091	0.0086	0.0081	0.0077	0.0073
2009	0.0001	0.0005	0.0047	0.0182	0.0234	0.0229	0.0217	0.0206	0.0195	0.0185	0.0175	0.0166	0.0157
2010	0.0000	0.0002	0.0022	0.0084	0.0108	0.0106	0.0101	0.0095	0.0090	0.0086	0.0081	0.0077	0.0073
2011	0.0001	0.0006	0.0057	0.0223	0.0288	0.0281	0.0267	0.0253	0.0239	0.0227	0.0215	0.0203	0.0193
2012	0.0001	0.0008	0.0078	0.0304	0.0392	0.0383	0.0364	0.0344	0.0326	0.0309	0.0293	0.0277	0.0262

Table B7.10. Estimates of population abundance by age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	Total	8+
1982	18,308,700	5,598,360	4,365,980	2,369,580	552,965	178,830	153,168	102,344	77,386	86,409	67,089	131,038	63,681	32,055,530	527,947
1983	45,416,500	5,897,630	2,176,210	1,080,010	838,858	256,387	100,399	97,243	68,442	53,477	60,980	48,002	140,690	56,234,827	468,833
1984	39,684,200	14,657,700	2,908,370	1,235,880	661,984	556,754	182,640	75,063	73,133	51,693	40,523	46,332	143,863	60,318,135	430,607
1985	39,279,900	12,806,400	7,063,710	1,541,390	753,810	450,153	411,548	142,685	59,220	58,066	41,218	32,407	152,517	62,793,024	486,113
1986	32,458,500	12,681,200	6,437,600	4,416,450	1,065,980	553,010	345,804	325,306	111,742	46,057	44,942	31,801	142,246	58,660,637	702,093
1987	43,188,300	10,481,000	6,397,280	4,048,960	3,061,930	784,317	429,490	278,700	261,574	89,707	36,941	36,033	139,573	69,233,805	842,528
1988	56,506,300	13,948,700	5,299,910	4,052,890	2,859,010	2,318,200	628,971	358,140	232,233	217,861	74,700	30,761	146,271	86,673,947	1,059,966
1989	64,927,200	18,248,100	7,045,410	3,344,610	2,829,460	2,127,110	1,826,570	515,741	293,664	190,450	178,722	61,309	145,446	101,733,792	1,385,332
1990	84,799,400	20,968,400	9,226,110	4,451,610	2,331,220	2,099,410	1,676,470	1,503,230	425,625	242,904	157,834	148,358	172,013	128,202,584	2,649,964
1991	70,127,300	27,379,700	10,583,800	5,771,740	3,035,500	1,667,090	1,595,780	1,346,900	1,224,390	350,260	201,401	131,582	268,564	123,684,007	3,523,097
1992	70,488,000	22,644,000	13,817,600	6,610,490	3,942,010	2,200,520	1,285,730	1,294,310	1,102,620	1,009,460	290,303	167,580	334,398	125,187,021	4,198,671
1993	93,050,800	22,762,900	11,431,800	8,645,240	4,548,750	2,901,950	1,722,520	1,053,850	1,066,760	912,709	838,362	241,701	419,121	149,596,463	4,532,503
1994	183,429,000	30,045,100	11,481,100	7,115,940	5,869,360	3,287,680	2,233,280	1,392,920	859,481	875,763	753,042	694,295	549,536	248,586,497	5,125,037
1995	116,771,000	59,222,100	15,138,000	7,103,260	4,769,070	4,187,940	2,500,900	1,786,570	1,124,630	698,970	716,154	618,382	1,025,740	215,662,716	5,970,446
1996	126,609,000	37,695,600	29,774,800	9,260,040	4,642,670	3,292,000	3,079,680	1,938,130	1,400,410	889,519	556,669	573,345	1,323,950	221,035,813	6,682,023
1997	153,667,000	40,873,100	18,954,700	18,254,500	6,108,900	3,239,240	2,433,250	2,377,990	1,503,860	1,091,960	696,775	437,865	1,501,470	251,140,610	7,609,920
1998	100,332,000	49,597,400	20,576,300	11,718,000	12,105,300	4,220,890	2,326,150	1,791,510	1,732,240	1,088,110	787,216	501,625	1,397,450	208,174,191	7,298,151
1999	99,675,100	32,384,700	24,974,100	12,731,100	7,807,490	8,437,100	3,065,130	1,735,090	1,323,940	1,272,720	797,038	576,044	1,391,170	196,170,722	7,096,002
2000	79,466,400	32,176,800	16,323,600	15,532,100	8,585,150	5,534,040	6,246,170	2,334,660	1,310,840	995,082	953,975	596,834	1,474,210	171,529,861	7,665,601
2001	115,700,000	25,647,500	16,183,500	10,035,800	10,252,400	5,922,030	3,972,650	4,600,690	1,702,350	949,797	718,640	688,185	1,495,760	197,869,302	10,155,422
2002	134,353,000	37,347,200	12,917,400	10,025,500	6,714,220	7,180,540	4,314,700	2,967,500	3,399,350	1,248,910	693,979	524,109	1,592,770	223,279,178	10,426,618
2003	76,710,100	43,373,200	18,827,200	8,041,740	6,778,850	4,763,580	5,296,850	3,259,790	2,215,380	2,517,400	920,339	510,058	1,554,070	174,768,557	10,977,037
2004	160,129,000	24,759,100	21,841,200	11,651,900	5,310,090	4,648,410	3,393,820	3,869,660	2,356,710	1,591,220	1,802,050	658,074	1,477,910	243,489,144	11,755,624
2005	87,400,000	51,683,500	12,464,200	13,494,800	7,653,160	3,605,350	3,261,160	2,428,980	2,729,430	1,646,370	1,105,400	1,248,520	1,479,390	190,200,260	10,638,090
2006	82,798,000	28,207,500	26,005,700	7,674,320	8,755,560	5,113,240	2,489,540	2,299,080	1,688,990	1,881,230	1,129,260	756,725	1,868,600	170,667,745	9,623,885
2007	59,054,700	26,718,200	14,179,200	15,967,400	4,962,730	5,797,260	3,475,780	1,718,150	1,558,220	1,131,070	1,250,950	748,327	1,738,530	138,300,517	8,145,247
2008	80,412,800	19,058,200	13,439,400	8,720,580	10,338,600	3,305,270	3,989,750	2,442,660	1,191,220	1,071,100	773,909	854,451	1,700,540	147,298,480	8,033,880
2009	55,937,400	25,954,200	9,593,240	8,304,850	5,738,070	7,019,850	2,309,510	2,832,740	1,703,640	820,819	732,570	527,172	1,737,150	123,211,211	8,354,091
2010	76,555,000	18,053,900	13,065,700	5,919,980	5,421,780	3,878,270	4,932,930	1,665,930	2,024,090	1,210,470	581,702	518,954	1,608,040	135,436,746	7,609,186
2011	108,568,000	24,709,300	9,091,570	8,086,160	3,907,750	3,714,950	2,758,770	3,595,270	1,200,750	1,448,670	863,090	414,185	1,516,020	169,874,485	9,037,985
2012	143,553,000	35,039,300	12,433,200	5,596,410	5,239,380	2,607,240	2,563,120	1,944,400	2,500,480	828,073	994,502	591,478	1,324,350	215,214,933	8,183,283

Table B7.11. Estimates of female spawning stock biomass (metric tons).

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13+	Total	SD
1982	0	0	0	57	80	177	432	415	368	628	649	1,319	837	4,963	1,174
1983	0	0	0	26	120	211	230	363	337	350	509	459	1,470	4,075	991
1984	0	0	0	32	101	469	509	275	388	327	303	501	1,683	4,588	1,053
1985	0	0	0	48	104	409	1,129	549	318	366	320	298	1,996	5,537	1,163
1986	0	0	0	161	160	431	819	1,174	506	250	310	266	1,718	5,795	1,100
1987	0	0	0	140	516	598	921	912	1,179	486	243	306	1,741	7,042	1,185
1988	0	0	0	137	549	2,263	1,530	1,136	989	1,062	538	273	1,839	10,317	1,384
1989	0	0	0	116	527	2,400	5,616	2,123	1,390	1,271	1,282	532	1,843	17,100	1,911
1990	0	0	0	149	366	2,071	4,954	6,290	2,068	1,269	1,100	1,235	2,058	21,559	2,177
1991	0	0	0	198	507	1,338	4,457	5,291	6,464	1,864	1,530	978	3,624	26,250	2,552
1992	0	0	0	214	705	2,028	3,477	5,162	6,074	6,773	2,285	1,792	4,433	32,941	3,044
1993	0	0	0	287	780	2,667	4,751	4,392	5,955	6,154	6,920	2,335	5,784	40,025	3,478
1994	0	0	0	256	1,034	2,957	6,248	5,833	4,739	5,647	6,281	6,629	6,630	46,252	3,767
1995	0	0	0	268	842	3,901	7,394	7,476	6,525	5,036	4,860	5,517	16,157	57,976	4,596
1996	0	0	0	347	917	3,576	10,464	9,217	8,547	6,692	4,587	4,931	17,120	66,399	4,998
1997	0	0	0	731	1,103	3,100	6,684	9,104	8,446	8,275	6,033	3,970	20,749	68,193	5,230
1998	0	0	0	325	1,879	3,336	6,242	6,837	9,043	6,519	5,666	4,505	15,535	59,886	4,658
1999	0	0	0	325	967	5,599	6,089	6,134	6,916	8,329	5,857	4,833	15,644	60,693	4,824
2000	0	0	0	390	1,050	3,804	13,257	7,634	7,036	6,129	7,796	5,499	18,681	71,276	5,608
2001	0	0	0	290	1,377	4,601	9,051	15,464	8,441	6,229	5,311	5,387	15,220	71,370	5,464
2002	0	0	0	260	937	5,649	10,355	10,818	16,153	7,795	5,402	4,506	17,187	79,062	6,100
2003	0	0	0	194	914	3,748	12,387	11,436	10,821	14,905	6,742	4,309	15,973	81,430	6,294
2004	0	0	0	277	757	3,583	7,997	13,411	11,288	9,341	12,632	5,287	14,740	79,313	6,398
2005	0	0	0	346	1,017	2,926	7,673	8,995	13,533	9,732	7,950	10,713	16,776	79,662	6,977
2006	0	0	0	183	1,102	3,639	5,537	8,182	8,853	11,458	8,171	6,239	20,875	74,239	7,061
2007	0	0	0	340	627	4,291	8,149	5,974	8,253	7,296	9,781	6,555	20,649	71,916	7,410
2008	0	0	0	208	1,315	2,733	10,791	8,981	6,164	7,235	6,037	7,481	18,968	69,912	7,419
2009	0	0	0	200	689	5,606	5,907	11,201	9,100	5,255	5,631	4,486	19,851	67,926	7,583
2010	0	0	0	143	667	3,052	12,001	5,953	10,207	7,746	4,460	4,261	17,406	65,895	7,538
2011	0	0	0	213	481	2,768	6,513	12,496	5,986	8,929	6,147	3,632	18,449	65,614	8,068
2012	0	0	0	191	923	2,205	6,227	6,994	12,273	5,274	7,477	4,958	15,022	61,544	8,090

Table B7.12. Sensitivity analysis results for 2013 assessment model.

Year	2012 Base Model		M=0.15		Lorenzen Ms		Increase M after 1996		ESS 20% Increase		ESS 20% Decrease	
	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB
1982	0.947	4,963	1.033	3,923	0.822	9,109	0.822	6,879	0.961	4,824	0.928	5,171
1983	0.160	4,075	0.216	3,190	0.104	7,514	0.104	5,702	0.161	3,959	0.159	4,249
1984	0.185	4,588	0.368	3,560	0.083	8,435	0.083	6,579	0.198	4,464	0.169	4,776
1985	0.113	5,537	0.154	4,277	0.091	10,061	0.091	8,005	0.115	5,381	0.109	5,773
1986	0.071	5,795	0.100	4,423	0.056	10,404	0.056	8,370	0.073	5,622	0.068	6,063
1987	0.033	7,042	0.046	5,383	0.027	12,387	0.027	10,087	0.034	6,812	0.031	7,401
1988	0.048	10,317	0.063	8,161	0.039	17,787	0.039	14,574	0.050	9,968	0.046	10,873
1989	0.048	17,100	0.058	14,062	0.033	28,663	0.033	23,231	0.050	16,536	0.046	18,030
1990	0.085	21,559	0.098	18,176	0.061	34,593	0.061	27,920	0.086	20,888	0.082	22,707
1991	0.072	26,250	0.082	22,368	0.051	40,259	0.051	32,720	0.072	25,460	0.070	27,654
1992	0.056	32,941	0.065	28,449	0.041	48,551	0.041	40,067	0.057	32,022	0.055	34,658
1993	0.075	40,025	0.085	35,129	0.054	57,057	0.054	47,898	0.075	39,045	0.073	41,979
1994	0.088	46,252	0.099	41,309	0.063	64,425	0.063	54,594	0.087	45,301	0.086	48,319
1995	0.121	57,976	0.136	52,198	0.090	78,818	0.090	67,799	0.120	56,921	0.119	60,384
1996	0.112	66,399	0.123	60,854	0.087	90,216	0.087	76,736	0.112	65,540	0.111	68,696
1997	0.179	68,193	0.191	62,526	0.168	91,011	0.168	78,263	0.178	67,423	0.178	70,440
1998	0.162	59,886	0.173	55,088	0.152	81,691	0.152	69,210	0.161	59,527	0.162	61,426
1999	0.139	60,693	0.148	55,886	0.130	83,487	0.130	70,603	0.138	60,538	0.139	61,968
2000	0.177	71,276	0.189	65,806	0.165	98,456	0.165	83,237	0.175	71,328	0.177	72,426
2001	0.166	71,370	0.178	65,974	0.156	100,266	0.156	83,540	0.164	71,735	0.167	72,063
2002	0.159	79,062	0.172	72,950	0.151	110,895	0.151	92,244	0.157	79,696	0.160	79,541
2003	0.185	81,430	0.198	75,098	0.175	113,513	0.175	94,706	0.183	82,286	0.186	81,701
2004	0.218	79,313	0.235	72,813	0.205	110,412	0.205	92,122	0.215	80,309	0.219	79,446
2005	0.229	79,662	0.248	72,503	0.213	111,467	0.213	93,044	0.226	80,777	0.231	79,743
2006	0.263	74,239	0.286	66,934	0.242	105,263	0.242	87,814	0.258	75,410	0.265	74,225
2007	0.231	71,916	0.253	64,221	0.210	104,626	0.210	86,908	0.227	73,191	0.234	71,797
2008	0.236	69,912	0.261	62,059	0.214	103,836	0.214	85,904	0.232	71,244	0.239	69,709
2009	0.195	67,926	0.214	59,837	0.175	102,206	0.175	84,224	0.191	69,365	0.197	67,575
2010	0.190	65,895	0.209	57,924	0.171	99,450	0.171	82,028	0.187	67,358	0.191	65,476
2011	0.228	65,614	0.253	57,245	0.206	98,668	0.206	81,556	0.225	67,138	0.229	65,186
2012	0.188	61,544	0.207	53,357	0.168	93,370	0.168	76,656	0.186	62,936	0.188	61,224

Table B7.13. Estimate of average fishing mortality for ages 8-11 and female spawning stock biomass when surveys are deleted one-at-a-time. Columns represent model results when index was deleted.

| | 2012 Base | | NYOY | | NJYOY | | MD YOY | | VAYOY | | NYAge1 | | MD Age1 | | MRFSS | | CTTrawl | | NEFSC | | NYOHS | | NJTrawl | | MDSSN | | DESSN | | VAPNET | |
Year	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB	Full F	SSB
1982	0.947	4,963	0.962	4,803	0.934	4,981	0.955	4,898	0.939	4,976	0.943	4,990	0.877	4,822	0.964	5,076	0.937	5,141	0.947	4,938	0.994	4,117	0.947	4,993	0.867	6,185	0.945	5,020	0.938	5,023
1983	0.160	4,075	0.163	3,943	0.161	4,085	0.160	4,011	0.160	4,084	0.159	4,097	0.161	3,963	0.158	4,175	0.156	4,226	0.161	4,053	0.177	3,360	0.159	4,102	0.141	5,125	0.160	4,123	0.160	4,124
1984	0.185	4,588	0.186	4,436	0.183	4,591	0.183	4,528	0.185	4,595	0.182	4,613	0.191	4,491	0.180	4,703	0.175	4,765	0.185	4,561	0.228	3,775	0.182	4,619	0.171	5,790	0.184	4,634	0.183	4,636
1985	0.113	5,537	0.116	5,353	0.113	5,537	0.115	5,452	0.113	5,543	0.112	5,570	0.113	5,435	0.111	5,680	0.109	5,761	0.114	5,505	0.136	4,552	0.112	5,578	0.081	6,942	0.113	5,585	0.112	5,588
1986	0.071	5,795	0.074	5,594	0.071	5,790	0.073	5,701	0.071	5,801	0.071	5,834	0.072	5,686	0.069	5,954	0.068	6,045	0.072	5,764	0.088	4,749	0.071	5,844	0.059	7,183	0.071	5,835	0.070	5,841
1987	0.033	7,042	0.034	6,779	0.033	7,032	0.034	6,943	0.033	7,052	0.033	7,094	0.034	6,917	0.032	7,248	0.032	7,362	0.033	7,010	0.041	5,763	0.033	7,114	0.030	8,462	0.033	7,082	0.033	7,086
1988	0.048	10,317	0.050	9,929	0.048	10,310	0.049	10,249	0.048	10,344	0.048	10,399	0.049	10,134	0.047	10,629	0.046	10,794	0.049	10,290	0.058	8,523	0.048	10,454	0.049	11,537	0.048	10,362	0.048	10,354
1989	0.048	17,100	0.049	16,482	0.048	17,121	0.048	17,124	0.049	17,165	0.048	17,247	0.049	16,764	0.047	17,623	0.046	17,910	0.048	17,088	0.055	14,214	0.048	17,379	0.053	17,833	0.048	17,161	0.049	17,120
1990	0.085	21,559	0.086	20,818	0.085	21,610	0.084	21,756	0.086	21,633	0.085	21,753	0.085	21,156	0.083	22,225	0.082	22,600	0.085	21,572	0.093	17,995	0.084	21,950	0.097	21,569	0.086	21,629	0.087	21,547
1991	0.072	26,250	0.073	25,392	0.071	26,322	0.070	26,566	0.073	26,302	0.071	26,508	0.072	25,795	0.070	27,089	0.069	27,558	0.071	26,287	0.076	21,968	0.070	26,749	0.082	25,608	0.072	26,332	0.074	26,170
1992	0.056	32,941	0.057	31,960	0.056	33,034	0.055	33,482	0.057	32,955	0.056	33,304	0.056	32,437	0.055	34,026	0.054	34,617	0.056	33,014	0.059	27,787	0.055	33,596	0.064	31,256	0.057	33,011	0.058	32,718
1993	0.075	40,025	0.075	38,947	0.075	40,153	0.073	40,809	0.076	39,910	0.074	40,489	0.075	39,522	0.073	41,345	0.073	42,052	0.074	40,143	0.076	34,265	0.073	40,866	0.085	37,044	0.076	40,023	0.076	39,557
1994	0.088	46,252	0.088	45,102	0.088	46,421	0.086	47,328	0.088	45,931	0.088	46,743	0.087	45,807	0.086	47,753	0.086	48,547	0.087	46,423	0.088	40,418	0.086	47,289	0.098	41,851	0.090	46,080	0.089	45,457
1995	0.121	57,976	0.121	56,555	0.121	58,200	0.119	59,323	0.121	57,499	0.120	58,524	0.121	57,441	0.120	59,817	0.119	60,766	0.121	58,206	0.121	51,454	0.120	59,292	0.133	51,999	0.125	57,524	0.122	56,903
1996	0.112	66,399	0.113	64,978	0.112	66,590	0.111	68,104	0.113	65,696	0.112	67,031	0.112	65,968	0.111	68,380	0.111	69,350	0.113	66,682	0.114	60,503	0.112	67,859	0.122	58,571	0.117	65,374	0.113	65,154
1997	0.179	68,193	0.180	66,835	0.177	68,417	0.177	70,042	0.179	67,517	0.177	68,778	0.179	67,803	0.176	70,192	0.174	71,098	0.180	68,373	0.183	62,700	0.178	69,602	0.213	59,673	0.189	66,677	0.184	66,929
1998	0.162	59,886	0.163	58,968	0.161	60,158	0.161	61,499	0.163	59,363	0.161	60,390	0.162	59,681	0.160	61,507	0.159	62,134	0.164	59,890	0.165	56,453	0.162	60,924	0.193	51,664	0.172	57,810	0.167	58,760
1999	0.139	60,693	0.140	59,933	0.138	60,964	0.139	62,182	0.140	60,192	0.138	61,244	0.139	60,554	0.137	62,220	0.137	62,713	0.140	60,553	0.141	58,159	0.139	61,559	0.166	51,960	0.147	57,943	0.144	59,486
2000	0.177	71,276	0.177	70,615	0.176	71,626	0.176	72,651	0.177	70,741	0.176	71,933	0.176	71,195	0.172	72,927	0.174	73,255	0.178	70,974	0.178	69,271	0.177	72,003	0.210	61,131	0.184	67,563	0.183	69,825
2001	0.166	71,370	0.167	70,968	0.165	71,625	0.166	72,344	0.167	70,996	0.165	71,983	0.166	71,471	0.161	72,925	0.164	72,777	0.167	70,913	0.167	70,732	0.166	71,722	0.197	61,746	0.172	67,702	0.173	69,869
2002	0.159	79,062	0.159	78,780	0.159	79,136	0.159	79,781	0.160	78,698	0.159	79,737	0.159	79,310	0.153	80,994	0.158	80,280	0.160	78,496	0.159	78,954	0.160	79,206	0.188	68,389	0.164	75,549	0.166	77,150
2003	0.185	81,430	0.186	81,298	0.186	81,310	0.186	81,787	0.186	80,991	0.185	82,049	0.185	81,815	0.177	83,885	0.184	82,275	0.187	80,834	0.185	81,862	0.186	81,346	0.217	70,606	0.188	78,712	0.193	79,096
2004	0.218	79,313	0.218	79,260	0.219	78,953	0.219	79,426	0.219	78,840	0.218	79,743	0.218	79,752	0.205	82,546	0.216	79,774	0.219	78,697	0.217	80,207	0.219	79,070	0.257	68,621	0.220	77,538	0.228	76,611
2005	0.229	79,662	0.229	79,640	0.231	78,922	0.230	79,566	0.231	79,098	0.230	79,912	0.229	80,070	0.213	84,155	0.228	79,868	0.231	78,991	0.229	80,821	0.232	79,255	0.271	68,377	0.230	78,559	0.240	76,528
2006	0.263	74,239	0.263	74,263	0.265	73,132	0.265	73,915	0.265	73,663	0.264	74,267	0.263	74,553	0.240	79,875	0.261	74,257	0.264	73,588	0.263	75,475	0.266	73,622	0.312	63,131	0.263	73,794	0.276	70,980
2007	0.231	71,916	0.231	72,009	0.235	70,513	0.233	71,356	0.234	71,169	0.233	71,710	0.232	72,102	0.207	79,171	0.229	71,866	0.233	71,289	0.232	73,080	0.235	70,966	0.276	60,625	0.231	72,159	0.244	68,463
2008	0.236	69,912	0.236	70,035	0.241	68,277	0.239	69,192	0.240	69,041	0.237	69,480	0.237	69,898	0.208	78,710	0.233	69,810	0.238	69,383	0.237	70,952	0.240	68,584	0.283	59,208	0.235	70,890	0.251	66,392
2009	0.195	67,926	0.194	68,100	0.200	66,020	0.197	67,081	0.199	66,822	0.196	67,386	0.195	67,837	0.169	78,197	0.193	67,945	0.196	67,471	0.195	68,889	0.198	66,334	0.232	57,258	0.193	69,222	0.207	64,185
2010	0.190	65,895	0.189	66,121	0.198	63,585	0.192	64,937	0.195	64,482	0.191	65,317	0.190	65,721	0.162	77,415	0.187	66,042	0.191	65,488	0.190	66,788	0.192	64,227	0.226	55,589	0.188	67,548	0.202	62,038
2011	0.228	65,614	0.227	65,902	0.241	62,730	0.231	64,521	0.236	63,797	0.229	65,012	0.228	65,427	0.192	78,883	0.225	65,916	0.230	65,145	0.228	66,517	0.229	64,067	0.272	55,030	0.226	67,552	0.243	61,323
2012	0.188	61,544	0.187	61,900	0.203	57,912	0.189	60,408	0.196	59,348	0.188	60,937	0.187	61,398	0.157	75,969	0.185	61,978	0.189	61,050	0.187	62,391	0.187	60,375	0.221	51,667	0.188	63,703	0.200	57,209

Table B8.1. Candidate models used in the analyses of striped bass tag recoveries in the IRCR.

Model Number	Model Name	Description
1	Fy; F'y; M(2p)	Global model. F and F' estimated each year, 2 M periods
2	F87-89, F90-94, F95-99, F00-02, F03-06, F07-11; F'y; M(2p)	Constant F for each regulatory period, F' estimated each year, 2 M periods
3	Fy, F'87-89, F'90-94, F'95-99, F'00-02, F'03-06, F'07-11; M(2p)	F estimated each year, constant F' for each regulatory period, 2 M periods
4	F87-89, F90-94, F95-99, F00-02, F03-06, F07-11; F'87-89, F'90-94, F'95-99, F'00-02, F'03-06, F'07-11; M(2p)	Constant F for each regulatory period, constant F' for each regulatory period, 2 M periods
5	F87-89, F90-94, F95-99, F00-02, F03-06, F07-10, F11; F'87-89, F'90-94, F'95-99, F'00-02, F'03-06, F'07-10, F'11; M(2p)	Constant F and F' for each regulatory period with separate estimate for terminal year, 2 M periods
6	F87-89, F90-94, F95-99, F00-02, F03-06, F07-09, F10-11; F'87-89, F'90-94, F'95-99, F'00-02, F'03-06, F'07-09, F'10-11; M(2p)	Constant F and F' for each regulatory period with separate estimate for terminal two years, 2 M periods

Table B8.2. Justification of modeling periods used in candidate model set.

Regulatory Period	Explanation
1987-1989	Partial moratorium and large minimum size limits.
1990-1994	Interim fishery under Amendment 4: Commercial fisheries reopen in some states at 80% of historical harvest. Preferred size limit reduced to 28" on coast and 18" in Hudson and Chesapeake Bay. Combination of size limits, seasons, and bag limits used to attain target fishing mortality rate.
1995-1999	Fully recovered fishery under Amendment 5: Target F=0.33. Recreational fisheries: 20" minimum size, 1 fish creel limit, variable season lengths in the producer areas (Chesapeake Bay, Hudson River,) and 28" minimum size, 2 fish creel limit, 365 day season along the coast. Commercial fisheries: flexible quota, same size limits as the recreational fishery. Establishes quotas based on size limits and has paybacks for quota overages. Target reduced to F=0.31 in 1997, minimum size limits maintained.
2000-2002	Addendum IV to Amendment 5: reduce F on age 8 and older striped bass by 14% through creel and size limits. Credit was given to states already more conservative.
2003-2006	Amendment 6: Target F – 0.30. Coastal commercial quotas increased to 100% of historical harvest. Some states' minimum size limits increased to 28" on the coast.
2007-2011	Change in reporting rate.

Table B8.3. Definition of the two natural mortality periods used by each program in their IRCR analysis.

	striped bass ≥ 28"		striped bass ≥ 18"	
Coast programs	M1	M2	M1	M2
MADW	1992-1998	1999-2011	1992-1998	1999-2011
NYOHS/TRL*	1988-2004	2005-2007	1988-1998	1999-2007
NJDB	1989-2002	2003-2011	1989-2001	2002-2011
NCCOOP	1988-1999	2000-2011	1988-1999	2000-2011
Producer programs	M1	M2	M1	M2
HUDSON	1988-2000	2001-2011	1988-2001	2002-2011
DE/PA	1993-2005	2006-2011	1993-2003	2004-2011
MDCB	1987-2000	2001-2011	1987-1998	1999-2011
VARAP	1990-2003	2004-2011	1990-1997	1998-2011

*NY Trawl = 1M 2008-2011

Table B8.4. Total length frequencies of fish tagged in 1987-2011 by program.
Coast Programs
MADFW

TL (mm)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<199					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-249					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250-299					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300-349					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350-399					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400-449					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
450-499					0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0
500-549					2	5	12	1	0	1	3	0	0	2	2	4	0	0	2	1	0	1	6	0	0
550-599					7	28	33	29	17	8	7	2	2	19	4	13	0	3	12	15	8	10	2	0	3
600-649					27	59	60	42	57	21	27	9	16	50	19	10	3	26	39	35	28	39	27	14	10
650-699					18	119	89	68	76	45	37	16	55	89	58	21	26	93	64	53	68	76	68	42	13
700-749					35	102	97	73	94	38	79	11	75	143	99	60	93	167	80	60	85	78	75	89	59
750-799					56	107	80	72	61	26	60	13	51	140	93	51	167	153	139	83	74	84	85	76	96
800-849					83	159	79	52	69	27	32	11	24	74	81	37	153	98	117	69	88	62	87	44	131
850-899					79	152	81	19	33	19	28	13	8	35	45	15	98	54	64	48	84	48	76	30	98
900-949					45	91	85	10	14	5	19	4	10	20	19	13	54	24	35	19	56	35	48	17	45
950-999					25	38	37	7	13	7	12	5	6	14	18	5	24	15	16	4	26	12	14	11	28
1000-1049					7	19	18	4	6	4	6	3	4	8	10	7	15	15	5	2	7	7	10	4	9
1050-1099					2	5	3	0	2	1	6	0	1	1	8	2	15	3	3	1	2	1	3	0	7
>1099					2	13	4	0	2	0	0	0	1	3	1	0	7	4	0	0	4	2	0	0	5

NYOHS/TRL

TL (mm)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-249	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250-299	0	11	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300-349	14	23	10	1	0	2	0	0	39	5	12	6	1	1	0	2	0	0	1	0	0	0	0	0	0
350-399	19	50	46	8	8	12	11	6	347	138	157	158	18	57	3	46	2	16	39	25	0	0	0	0	0
400-449	64	135	65	116	110	72	172	52	366	745	300	312	261	196	39	346	117	236	229	204	3	0	12	0	0
450-499	119	281	135	193	311	209	488	313	146	540	403	225	543	174	169	249	207	352	188	307	25	1	7	0	0
500-549	205	240	153	262	411	337	519	381	165	352	371	227	285	255	259	118	194	378	191	281	246	44	13	7	0
550-599	272	305	157	351	311	354	284	259	141	160	192	257	118	346	175	116	70	267	188	145	430	132	34	16	1
600-649	517	314	143	372	147	234	183	162	111	107	82	185	63	256	138	98	46	158	95	109	259	74	17	81	4
650-699	401	303	153	242	82	100	162	114	46	65	54	111	48	122	85	88	34	43	43	47	212	31	18	106	11
700-749	215	214	137	175	79	61	114	114	22	26	22	50	10	54	39	57	52	23	17	20	110	21	17	107	31
750-799	84	107	95	139	102	58	95	66	23	17	13	18	11	25	47	39	31	18	15	6	35	8	11	45	26
800-849	17	58	43	79	79	50	58	62	25	11	10	13	6	14	37	36	25	15	4	1	17	5	8	11	32
850-899	11	21	33	62	63	40	43	53	17	12	19	10	7	20		11	23	5	8	2	5	1	6	7	10
900-949	6	7	14	27	43	31	33	43	12	8	6	6	9	2	23	4	18	6	9	2	5	6	6	4	1
950-999	1	2		9	18	17	18	25	10	5	9	8	6	6	11	5	4	2	3	1	2	1	1	3	3
1000-1049	0	1	2	1	5	7	9	24	11	3	11	1	4		3	2	8	2	1	0	0	0	0	0	0
1050-1099	2	3	2	1	2	8	2	12	5	2	3	4	5	2		2	2	1	3	0	0	1	0	0	1
>1099	2	23	7	4	17	13	10	24	4	2	1	0	3	3	4	1	0	2	3	0	0	0	0	0	0

* NY OHS 1988-2007, NY TRL 2008-2012

Table B8.4 cont.

NJDB

TL (mm)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<199			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-249			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250-299			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300-349			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350-399			0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400-449			0	0	2	2	2	11	1	3	6	0	1	2	15	3	1	0	1	1	0	0	0	0	0
450-499			3	0	23	20	45	58	10	23	16	6	16	22	52	17	7	7	9	2	0	2	12	4	1
500-549			29	5	100	61	221	215	38	88	57	95	139	270	148	98	91	50	133	25	7	14	117	30	8
550-599			160	37	82	152	570	545	139	178	79	208	435	698	506	243	357	127	342	190	29	169	376	116	17
600-649			167	40	52	247	501	590	448	382	112	209	682	722	661	523	667	279	335	495	140	357	778	253	54
650-699			78	15	24	188	214	488	524	561	70	148	385	395	363	518	428	448	143	469	395	294	535	379	118
700-749			25	9	9	67	100	281	428	398	33	77	81	181	211	222	296	432	88	153	316	241	224	246	219
750-799			13	3	6	17	14	81	170	213	19	28	29	66	190	85	206	272	59	65	119	146	92	103	225
800-849			8	1	2	12	10	21	37	70	11	21	15	34	117	79	83	164	33	37	35	98	70	38	87
850-899			1	0	0	3	4	10	17	24	8	14	11	5	46	28	35	60	14	18	34	59	26	17	24
900-949			0	0	0	0	1	2	7	5	0	4	3	4	14	11	19	13	5	10	8	25	6	6	2
950-999			0	0	0	0	0	0	1	0	1	0	2	0	2	2	2	3	1	2	5	1	2	3	1
1000-1049			0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	1	0	0	1	0	1	0	0
1050-1099			0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0	0
>1099			0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

NCCOOP

TL (mm)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<199	2	0	0	1	0	0	0	0	0	1	0	1	5	1	8	1	1	1	3	0	0	0	0	0	1
200-249	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
250-299	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0
300-349	0	0	0	0	0	0	0	0	10	0	0	0	3	0	0	0	0	13	1	0	0	0	0	0	0
350-399	0	0	10	0	0	0	30	1	18	0	0	0	85	3	3	0	19	26	0	0	0	0	0	0	0
400-449	3	0	42	0	1	2	201	3	5	3	2	0	1291	40	199	0	173	183	4	0	0	0	0	0	0
450-499	26	0	82	0	25	16	464	9	4	24	63	0	2171	267	787	0	324	697	46	1	0	0	2	0	0
500-549	112	11	211	8	66	42	813	23	6	57	77	1	1587	456	942	2	495	881	310	2	1	0	2	0	0
550-599	291	101	355	44	74	63	994	48	7	98	93	9	429	350	652	22	385	785	612	4	12	2	16	0	0
600-649	381	259	514	228	110	109	813	67	20	121	66	26	117	395	345	77	231	571	609	10	18	3	40	0	0
650-699	242	285	360	477	248	125	575	99	47	134	30	43	90	286	200	146	169	322	527	35	64	15	76	3	0
700-749	121	232	159	448	140	65	319	113	109	180	27	33	75	189	277	385	190	247	512	49	97	21	104	15	0
750-799	50	118	83	283	122	39	118	94	156	250	29	59	38	174	218	474	254	170	421	57	132	28	110	24	0
800-849	19	60	53	153	89	24	52	66	138	217	21	33	24	87	170	351	192	121	472	46	162	23	74	38	0
850-899	8	24	35	55	61	16	32	60	76	123	16	21	20	51	85	199	102	37	409	64	140	26	63	16	0
900-949	5	9	14	17	26	8	17	27	40	56	4	21	11	36	28	92	42	13	212	45	166	10	28	6	0
950-999	1	5	6	2	6	4	8	10	19	21	2	5	6	12	12	51	23	3	85	22	110	6	20	1	0
1000-1049	4	0	4	1	0	0	4	6	4	11	5	4	2	5	6	26	5	0	43	14	51	3	7	0	0
1050-1099	4	3	1	0	0	0	1	2	5	2	2	0	1	1	3	6	1	2	5	7	24	3	5	1	0
>1099	15	4	2	0	0	0	3	0	2	1	1	1	0	1	3	3	3	1	9	3	15	2	0	0	0

Producer Area Programs
HUDSON

TL (mm)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-249	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250-299	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300-349	0	1	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
350-399	0	3	41	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400-449	3	11	45	16	3	6	1	0	2	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
450-499	61	20	35	31	38	34	24	24	53	4	24	35	24	36	78	46	88	129	55	72	111	17	50	6	
500-549	74	33	51	28	91	83	38	25	55	7	31	75	52	80	96	141	120	186	75	65	150	18	85	22	
550-599	134	57	69	35	117	90	40	33	55	10	27	68	89	100	82	169	119	129	96	68	134	22	74	19	
600-649	143	63	74	28	93	111	63	34	81	12	20	52	103	113	48	140	150	135	96	72	146	21	78	17	
650-699	112	90	90	50	84	74	83	44	112	17	51	53	74	126	78	168	122	134	76	63	134	24	87	27	
700-749	80	103	112	73	94	84	86	63	135	20	67	60	69	120	62	156	110	137	114	49	100	33	58	27	
750-799	83	81	114	79	120	94	54	95	188	25	90	91	91	114	47	164	137	150	143	68	131	60	76	50	
800-849	57	75	123	98	168	130	70	108	135	41	92	109	112	118	40	128	126	108	147	108	106	80	100	42	
850-899	33	68	58	69	160	120	86	82	126	46	109	98	118	99	32	93	116	94	148	102	118	99	86	49	
900-949	16	41	41	35	97	76	58	67	78	31	93	56	63	68	16	71	61	55	94	46	58	86	79	38	
950-999	16	22	13	16	35	36	28	37	36	15	52	64	34	51	12	49	67	38	43	21	27	31	44	27	
1000-1049	17	12	3	4	25	6	12	13	13	10	28	24	11	28	5	37	32	17	28	11	12	13	18	8	
1050-1099	2	5	2	6	12	4	3	4	3	2	12	11	7	10	1	8	18	10	14	6	4	2	5	2	
>1099	1	1	2	0	2	2	0	3	0	1	3	3	0	6	1	9	8	3	3	4	5	1	0	3	

DE/PA

TL (mm)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<199					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-249					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
250-299					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
300-349					0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
350-399					0	0	2	20	0	0	0	0	1	0	1	0	1	0	0	1	2	6	0	0	0
400-449					2	0	27	50	34	134	137	64	71	76	68	78	81	62	36	140	133	83	40	86	79
450-499					4	0	46	47	43	93	187	114	91	136	127	105	78	51	73	126	115	114	79	82	139
500-549					4	0	63	76	52	47	113	161	80	144	160	122	79	63	62	133	82	79	67	81	169
550-599					6	0	37	62	78	26	82	122	65	129	179	137	95	47	47	80	46	77	41	72	140
600-649					10	14	32	30	81	38	35	76	46	66	130	71	84	39	24	61	24	54	38	43	71
650-699					22	26	36	28	48	15	19	46	35	51	81	35	44	21	18	20	20	37	26	25	44
700-749					5	8	20	24	57	22	13	38	18	29	66	43	47	16	15	20	10	27	24	31	49
750-799					1	3	13	18	49	32	30	34	14	37	42	29	57	22	14	21	18	24	14	32	40
800-849					0	1	10	14	33	29	21	48	24	24	47	25	64	29	17	29	16	11	24	26	21
850-899					0	0	8	6	19	23	31	37	23	20	34	28	57	40	20	36	24	21	16	21	30
900-949					1	2	6	5	7	6	9	33	17	20	17	9	35	26	14	32	31	20	14	18	18
950-999					0	3	4	10	7	2	1	12	12	14	11	11	16	16	13	21	16	24	21	11	16
1000-1049					0	0	3	3	8	3	2	7	2	5	13	5	8	8	11	14	5	11	8	4	11
1050-1099					0	0	0	0	2	1	4	1	3	1	6	3	5	8	2	4	4	4	5	6	6
>1099					0	0	0	2	1	1	1	2	0	2	2	1	4	4	7	9	2	6	6	4	5

MDCB

TL (mm)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<199	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
200-249	1	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
250-299	1	9	0	6	4	2	2	3	5	0	1	0	2	3	1	3	0	0	8	2	3	3	0	6	2
300-349	46	75	35	9	35	39	22	19	36	23	10	6	23	27	8	21	16	22	87	35	30	18	5	29	20
350-399	124	170	139	13	116	108	105	38	103	160	35	37	56	60	31	34	31	45	84	99	49	29	31	46	46
400-449	248	221	290	43	177	206	229	136	154	260	203	135	102	252	125	71	86	122	188	135	187	117	73	54	140
450-499	322	440	242	99	135	227	351	223	105	265	239	353	221	292	253	254	114	115	311	152	153	117	172	139	220
500-549	501	549	323	117	141	184	400	307	126	148	158	183	132	271	200	291	150	64	155	104	59	69	127	177	260
550-599	377	575	580	168	187	175	241	288	137	121	58	78	38	84	116	129	96	65	48	58	39	41	76	67	179
600-649	173	372	610	232	251	241	201	206	184	120	26	41	24	35	60	96	68	39	37	34	33	31	63	52	117
650-699	46	170	336	238	321	333	332	205	235	149	59	37	21	39	41	46	40	43	26	24	17	38	43	42	56
700-749	17	72	146	139	173	186	264	290	206	254	60	51	12	56	62	49	44	38	31	26	14	26	50	34	66
750-799	7	39	58	43	98	61	102	102	133	287	90	54	23	58	89	53	47	48	58	32	23	16	34	41	93
800-849	1	11	32	32	42	47	49	49	78	156	56	59	38	39	101	56	52	87	62	53	22	19	43	21	48
850-899	0	5	12	39	44	45	84	55	52	63	48	40	30	37	83	63	67	76	68	49	30	28	32	27	23
900-949	0	1	0	32	51	81	83	59	39	52	44	24	33	32	61	52	53	60	57	38	48	32	35	20	15
950-999	1	1	0	9	22	45	59	38	29	47	24	17	21	18	43	42	42	34	28	45	30	19	33	24	26
1000-1049	3	2	0	4	6	13	37	19	37	41	17	9	15	8	28	14	20	14	21	18	17	13	20	17	11
1050-1099	4	3	2	3	4	7	9	4	10	17	7	6	7	5	8	6	6	14	8	12	11	8	16	13	6
>1099	7	16	3	7	6	11	15	2	4	6	3	2	2	2	4	6	3	7	4	8	5	4	3	12	11

VARAP

TL (mm)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
<199																									
200-249																									
250-299																									
300-349																									
350-399																									
400-449																									
450-499		247	80	376	320	0	0	0	82	102	268	241	317	348	118	39	106	155	184	211	368	176	130	256	36
500-549		633	142	209	770	0	0	0	60	59	183	302	259	680	212	83	203	212	198	178	378	137	173	444	46
550-599		407	322	167	502	3	1	1	120	44	39	76	105	325	143	52	123	220	137	80	264	97	205	514	59
600-649		174	233	230	311	62	225	35	132	58	7	5	7	34	39	15	20	153	77	15	109	36	103	324	60
650-699		59	122	152	157	23	150	32	80	38	3	1	3	9	14	3	0	46	37	4	2	2	11	29	18
700-749		24	49	85	90	7	79	18	43	26	4	9	13	53	15	9	30	43	20	16	25	5	19	40	22
750-799		25	27	43	33	5	25	15	29	17	15	13	25	72	41	37	78	179	24	19	78	9	29	74	31
800-849		5	20	68	44	6	14	11	36	22	24	18	29	67	59	26	74	198	71	35	101	12	50	66	41
850-899		2	16	72	105	10	22	23	54	6	40	31	26	61	70	26	75	109	79	36	202	13	43	92	31
900-949		4	5	33	89	8	42	20	29	3	45	24	25	38	38	9	55	82	46	41	220	14	47	78	30
950-999		3	0	21	40	5	43	26	19	1	46	31	19	26	22	6	44	41	29	25	154	15	32	62	23
1000-1049		0	0	5	13	0	15	8	11	0	27	14	11	27	14	8	27	22	15	6	44	4	16	42	11
1050-1099		0	0	2	3	1	3	3	2	0	9	14	5	17	7	2	8	13	2	1	13	2	7	12	1
>1099		1	1	1	4	0	2	3	1	0	2	5	9	8	5	0	9	4	2	1	3	1	2	17	7

Table B8.5. Age range of fish recaptured in 2011 by program. Ages are at time of release.

Coastal Programs	Min. Age at Release	Max. Age at Release
MADFW	3	19
NYTRAWL	3	10
NJDB	4	12
NCCOOP	6	14

Producer Area Programs	Min. Age at Release	Max. Age at Release
DE/PA	5	19
MDCB	3	16
VARAP	4	17
HUDSON	4	13

Table B8.6. Distribution of tag recaptures by state (program) and month.
Coast Programs

MADFW (all recaptures from fish tagged and released during 1992-2011)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
						1	1						2
ME						8	27	22	2	1			60
NH						10	12	6	2	2			32
MA	1				44	135	255	164	73	33	9		714
RI						8	25	10	8	3	7	4	65
CT				4	11	6	9	3	2	10	2	1	48
NY		1	2	9	112	47	15	8	8	32	61	14	309
NJ		1	5	22	50	30	3	1	2	29	103	19	265
PA				1						1			2
DE			6	7	4	1	1			2	10	1	32
MD		6	13	79	59	2		2	2	1	25	20	209
VA	28	21	23	7	8		1		1	1	25	60	175
NC	25	9	1	5					1		9	16	66
UN	3	1	5	4		3	3	4	3	1	1	6	34
Total	57	39	55	138	296	268	337	218	99	120	249	137	2,013

NYOHS/Trawl* (all recaptures from fish tagged and released during 1988-2011)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME	0	0	0	0	1	43	68	28	16	1	0	0	157
NH	1	0	2	12	7	22	22	13	10	4	31	10	134
MA	0	0	0	1	122	274	263	167	144	50	4	0	1,025
RI	1	0	0	5	64	98	70	58	39	30	6	2	373
CT	4	1	9	11	63	67	46	38	26	26	8	2	301
NY	11	5	16	113	319	286	181	126	188	296	299	44	1,884
NJ	7	6	30	128	146	84	36	10	12	86	223	76	844
PA	0	0	0	0	0	0	0	0	0	0	0	0	0
DE	4	7	22	20	9	1	2	0	0	1	9	5	80
MD	7	12	1	39	37	5	0	2	2	2	15	8	130
VA	20	11	18	11	4	1	1	0	1	3	23	41	134
NC	13	5	3	2	1	0	0	0	1	1	5	13	44
Total	68	47	101	342	773	881	689	442	439	500	623	201	5,106

* NY OHS 1988-2007, NY TRL 2008-2012

Table B8.6 cont.

NJDB (all recaptures from fish tagged and released during 1989-2011)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME					6	52	80	34	22	1		1	196
NH					4	33	26	18	4				85
MA	2	1			232	552	611	366	207	70	2	1	2,044
RI				1	82	171	111	91	51	35	10		552
CT			2	3	94	92	87	61	43	32	1		415
NY	2	1	1	30	321	350	221	151	145	249	190	20	1,681
NJ	3	3	34	135	363	173	71	29	45	189	438	93	1,576
PA				5	12	9			1	2	1		30
DE	3	1	29	23	18	9	2	4		9	47	16	161
MD	10	6	25	140	125	7	4	4	6	12	24	12	375
VA	34	37	23	14	12	4			1	2	29	87	243
NC	31	14	5		2						9	25	86
Total	85	63	119	351	1,271	1,452	1,213	759	526	600	750	255	7,444

NCCOOP (all recaptures from fish tagged and released during 1992-2011)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME					3	20	28	16	6				73
NH					1	5	8	10	1	1			26
MA				4	87	237	301	214	101	34	3	1	982
RI				1	23	74	66	33	38	14	3		252
CT				1	32	45	34	27	21	17	3		180
NY				30	162	158	114	54	87	131	55	3	794
NJ	1		2	24	125	85	31	9	6	53	118	5	459
PA					3	5	1						9
DE		1	10	16	13	15	8	7	5	6	11	1	93
MD	7	30	47	236	350	498	257	190	263	453	138	23	2,492
VA	62	77	114	56	101	71	21	24	22	185	335	280	1,348
NC	54	62	47	12	6	9	2	7	3	6	15	37	260
Total	124	170	220	380	906	1,222	871	591	553	900	681	350	6,968

Table B8.6 cont. .

HUDSON (all recaptures from fish tagged and released during 1992-2011)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME					1	9	34	15	11		1		71
NH						5	9	7	2				23
MA			1		8	126	268	161	64	30	1		659
RI					4	77	75	48	29	22	7	1	263
CT		1		1	11	117	131	73	50	33	16		433
NY	1		3	110	562	558	316	179	179	282	218	41	2,449
NJ	6		8	28	37	104	79	20	24	110	256	52	724
PA													0
DE			8	1	1		1			4	14	2	31
MD	3		3	6	4	3	1	1		4	11	7	43
VA	19	18	17	3	1					3	14	41	116
NC	18	14	3	1		1		1			7	15	60
Total	47	33	43	150	629	1,000	914	505	359	488	545	159	4,872

DE/PA (all recaptures from fish tagged and released during 1992-2011)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME					1	2	3	1	2				9
NH						1	2						3
MA					6	37	53	41	19	5			161
RI					4	13	6	13	11	5			52
CT					2	6	1	1	2	2			14
NY					14	18	17	17	8	17	9	2	102
NJ	2	1	7	19	139	168	73	39	35	109	152	22	766
PA			1	8	51	26	5	1	3	2	1		98
DE	1	1	7	14	34	53	51	21	12	25	34	13	266
MD	10	8	6	22	25	63	47	33	36	42	35	17	344
VA	12	9	5	1	2	3			2	2	27	43	106
NC	13	3	3		1						4	4	28
Total	38	22	29	64	279	390	258	167	130	209	262	101	1,949

Table B8.6 cont.

MDCB (all recaptures from fish tagged and released during 1987-2011)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME			1			12	17	7	1	1			39
NH						2	3	2	1				8
MA					26	89	175	123	61	26	2		502
RI					14	34	22	21	14	22	3		130
CT					4	13	17	15	4	4	3		60
NY				2	26	38	25	27	27	38	19		202
NJ			1	2	34	47	10	7	4	36	47	4	192
PA					3	7			1				11
DE			5	7	15	27	10	12	6	9	8	1	100
MD	97	83	62	263	566	763	394	257	443	1,097	353	84	4,462
DC				1	19	4		3			1		28
VA	33	31	43	9	82	95	27	15	13	154	336	261	1,099
NC	34	9	8	2		1	1			1	11	24	91
Total	164	123	120	286	789	1,132	701	489	575	1,388	783	374	6,924

VARAP (all recaptures from fish tagged and released during 1990-2011)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME	0	0	0	0	0	2	13	1	3	0	0	0	19
NH	0	0	0	0	0	5	4	2	0	0	0	0	11
MA	0	0	0	0	19	59	108	68	27	15	0	1	297
RI	0	0	0	0	4	20	11	15	16	10	1	0	77
CT	0	0	0	0	4	10	8	11	9	7	1	0	50
NY	0	0	0	1	31	27	20	16	28	37	11	1	172
NJ	0	0	0	1	31	27	9	2	2	19	33	0	124
PA	0	0	0	0	0	0	0	0	0	0	1	0	1
DE	0	0	1	0	6	9	2	1	0	3	3	0	25
MD	3	6	8	14	56	101	68	56	49	56	25	6	448
VA	26	18	145	445	203	102	45	21	36	176	263	192	1,672
NC	17	6	1	0	1	0	0	0	0	0	4	10	39
Total	46	30	155	461	355	362	288	193	170	323	342	210	2,935

Table B8.7. Akaike weights used to derive model averaged parameter estimates using the IRCR model for striped bass (see Table B8.1 for model descriptions).

≥28 inches

Model	Coast Programs				Producer Area Programs			
	MADFW	NYTRL	NJDB	NCCOOP	HUDSON	DE/PA	MDCB	VARAP
1	0.000	0.018	0.002	0.007	0.000	0.002	0.000	0.000
2	0.000	0.114	0.000	0.131	0.110	0.019	0.001	0.000
3	0.984	0.063	0.998	0.026	0.000	0.007	0.001	0.004
4	0.009	0.304	0.000	0.467	0.652	0.092	0.278	0.063
5	0.005	0.177	0.000	0.185	0.107	0.061	0.260	0.117
6	0.001	0.323	0.000	0.185	0.131	0.820	0.460	0.816

≥18 inches

Model	Coast Programs				Producer Area Programs			
	MADFW	NYTRL	NJDB	NCCOOP	HUDSON	DE/PA	MDCB	VARAP
1	0.000	0.077	0.867	0.005	0.000	0.000	0.036	0.000
2	0.000	0.004	0.053	0.665	0.321	0.002	0.000	0.000
3	0.997	0.194	0.071	0.002	0.000	0.000	0.964	0.005
4	0.001	0.001	0.005	0.127	0.237	0.152	0.000	0.000
5	0.002	0.004	0.002	0.090	0.155	0.217	0.000	0.001
6	0.000	0.719	0.002	0.112	0.287	0.628	0.000	0.995

Table B8.8. R/M estimates of exploitation rates of >28 inch striped bass from tagging programs. Exploitation rate is the proportion of tagged fish that were harvested or killed (adjusted for hooking mortality rate of 0.09 and reporting rate).

Year	MADFW	NYOHS/TRL*	NJDB	NCCOOP	HUDSON	DE/PA	MDCB	VARAP	**MEAN**
1987									
1988		0.05		0.06	0.09		0.07		0.07
1989		0.04	0.02	0.04	0.05		0.04		0.04
1990		0.07	0.04	0.09	0.09		0.09	0.25	0.10
1991		0.13	0.15	0.07	0.09		0.12	0.36	0.15
1992	0.04	0.11	0.02	0.13	0.11		0.12	0.37	0.13
1993	0.05	0.14	0.07	0.11	0.14	0.14	0.12	0.37	0.14
1994	0.04	0.09	0.04	0.08	0.10	0.12	0.12	0.25	0.11
1995	0.04	0.21	0.09	0.14	0.14	0.16	0.21	0.41	0.17
1996	0.08	0.14	0.17	0.11	0.22	0.30	0.17	0.18	0.17
1997	0.17	0.34	0.21	0.18	0.28	0.31	0.23	0.38	0.26
1998	0.07	0.17	0.30	0.20	0.21	0.30	0.23	0.45	0.24
1999	0.09	0.31	0.07	0.24	0.20	0.18	0.21	0.30	0.20
2000	0.12	0.18	0.12	0.06	0.11	0.32	0.17	0.25	0.17
2001	0.07	0.09	0.13	0.14	0.11	0.30	0.11	0.21	0.14
2002	0.07	0.19	0.09	0.10	0.15	0.23	0.10	0.28	0.15
2003	0.09	0.12	0.13	0.09	0.10	0.17	0.11	0.23	0.13
2004	0.08	0.11	0.13	0.11	0.15	0.23	0.08	0.13	0.13
2005	0.05	0.18	0.14	0.06	0.12	0.16	0.11	0.19	0.13
2006	0.07	0.08	0.12	0.11	0.10	0.21	0.14	0.25	0.14
2007	0.04	0.01	0.11	0.16	0.11	0.20	0.09	0.17	0.11
2008	0.06	0.05*	0.12	0.16	0.11	0.12	0.11	0.16	0.11
2009	0.08	0.01*	0.20	0.03	0.14	0.22	0.17	0.07	0.11
2010	0.06	0.09*	0.11	0.06	0.13	0.23	0.10	0.07	0.11
2011	0.06	0.08*	0.11	0.18	0.14	0.12	0.14	0.07	0.11

* NY OHS 1988-2007, NY TRL 2008-2011

Table B8.9. R/M estimates of exploitation rates of ≥18 inch striped bass from tagging programs. Exploitation rate is the proportion of tagged fish that were harvested or killed (adjusted for hooking mortality rate of 0.09 and reporting rate).

Year	MADFW	NYOHS/TRL*	NJDB	NCCOOP	HUDSON	DE/PA	MDCB	VARAP	**MEAN**
1987							0.01		0.01
1988		0.02		0.03	0.04		0.01		0.03
1989		0.03	0.03	0.03	0.03		0.01		0.03
1990		0.03	0.06	0.06	0.06		0.07	0.17	0.07
1991		0.06	0.03	0.08	0.06		0.10	0.14	0.08
1992	0.04	0.05	0.03	0.14	0.07		0.13	0.31	0.11
1993	0.04	0.04	0.02	0.11	0.08	0.14	0.11	0.23	0.10
1994	0.04	0.03	0.03	0.08	0.07	0.12	0.12	0.25	0.09
1995	0.03	0.06	0.05	0.14	0.11	0.14	0.19	0.19	0.11
1996	0.06	0.04	0.08	0.11	0.15	0.15	0.17	0.15	0.11
1997	0.12	0.05	0.07	0.15	0.21	0.14	0.21	0.20	0.14
1998	0.08	0.03	0.10	0.14	0.16	0.15	0.22	0.15	0.13
1999	0.06	0.06	0.05	0.22	0.13	0.11	0.17	0.13	0.12
2000	0.08	0.03	0.06	0.08	0.08	0.15	0.15	0.12	0.09
2001	0.05	0.04	0.08	0.10	0.07	0.15	0.11	0.16	0.09
2002	0.07	0.05	0.05	0.10	0.06	0.14	0.10	0.15	0.09
2003	0.07	0.04	0.06	0.09	0.07	0.15	0.11	0.16	0.09
2004	0.07	0.03	0.10	0.10	0.09	0.15	0.09	0.10	0.09
2005	0.05	0.03	0.08	0.04	0.06	0.11	0.09	0.12	0.07
2006	0.06	0.02	0.05	0.09	0.07	0.12	0.12	0.14	0.09
2007	0.03	0.02	0.09	0.13	0.07	0.08	0.08	0.12	0.08
2008	0.05	0.02*	0.08	0.15	0.06	0.08	0.10	0.08	0.08
2009	0.07	0.04*	0.06	0.04	0.11	0.12	0.15	0.09	0.08
2010	0.05	0.05*	0.06	0.06	0.08	0.09	0.11	0.04	0.07
2011	0.06	0.05*	0.08	0.17	0.11	0.07	0.11	0.06	0.09

* NY OHS 1988-2007, NY TRL 2008-2011

Table B8.10. Parameter estimates of survival (S), instantaneous fishing mortality (F) and instantaneous natural mortality (M), by program, for striped bass ≥28 inches total length.

Coast Programs

Year	MADFW S	MADFW F	MADFW M	NYOHS/TRL* S	NYOHS/TRL* F	NYOHS/TRL* M	NJDB S	NJDB F	NJDB M	NCCOOP S	NCCOOP F	NCCOOP M
1987												
1988				0.81	0.02	0.17				0.81	0.05	0.15
1989				0.81	0.02	0.17	0.93	0.00	0.05	0.81	0.05	0.15
1990				0.75	0.10	0.17	0.84	0.10	0.05	0.76	0.11	0.15
1991				0.73	0.13	0.17	0.66	0.35	0.05	0.76	0.11	0.15
1992	0.87	0.03	0.10	0.74	0.12	0.17	0.93	0.00	0.05	0.76	0.11	0.15
1993	0.84	0.06	0.10	0.72	0.14	0.17	0.83	0.11	0.05	0.76	0.11	0.15
1994	0.83	0.08	0.10	0.74	0.12	0.17	0.89	0.05	0.05	0.76	0.11	0.15
1995	0.82	0.10	0.10	0.67	0.23	0.17	0.84	0.11	0.05	0.72	0.17	0.15
1996	0.75	0.18	0.10	0.66	0.23	0.17	0.76	0.21	0.05	0.72	0.17	0.15
1997	0.74	0.19	0.10	0.64	0.27	0.17	0.77	0.19	0.05	0.72	0.17	0.15
1998	0.76	0.17	0.10	0.64	0.27	0.17	0.68	0.32	0.05	0.72	0.17	0.15
1999	0.68	0.18	0.19	0.63	0.28	0.17	0.77	0.19	0.05	0.72	0.17	0.15
2000	0.69	0.18	0.19	0.70	0.17	0.17	0.81	0.15	0.05	0.64	0.12	0.32
2001	0.75	0.08	0.19	0.70	0.17	0.17	0.79	0.18	0.05	0.64	0.12	0.32
2002	0.72	0.13	0.19	0.70	0.18	0.17	0.81	0.15	0.05	0.64	0.12	0.32
2003	0.72	0.13	0.19	0.69	0.20	0.17	0.67	0.18	0.22	0.64	0.13	0.32
2004	0.74	0.11	0.19	0.71	0.17	0.17	0.67	0.17	0.22	0.64	0.13	0.32
2005	0.75	0.10	0.19	0.59	0.16	0.36	0.66	0.19	0.22	0.64	0.13	0.32
2006	0.75	0.10	0.19	0.60	0.15	0.36	0.71	0.12	0.22	0.64	0.13	0.32
2007	0.77	0.06	0.19	0.60	0.16	0.36	0.69	0.15	0.22	0.62	0.15	0.32
2008	0.75	0.10	0.19	0.91*	0.09*	0.01*	0.67	0.17	0.22	0.62	0.15	0.32
2009	0.74	0.11	0.19	0.90*	0.09*	0.01*	0.65	0.20	0.22	0.62	0.15	0.32
2010	0.76	0.07	0.19	0.89*	0.10*	0.01*	0.67	0.17	0.22	0.62	0.15	0.32
2011	0.74	0.11	0.19	0.90*	0.10*	0.01*	0.69	0.15	0.22	0.62	0.15	0.32

* NY OHS 1988-2007, NY TRL 2008-2011

Table B8.10 cont.

Producer Area Programs

Year	HUDSON			DE/PA			MDCB			VARAP		
	S	F	M	S	F	M	S	F	M	S	F	M
1987							0.85	0.03	0.13			
1988	0.83	0.09	0.08				0.85	0.03	0.13			
1989	0.83	0.09	0.08				0.85	0.03	0.13			
1990	0.77	0.16	0.08				0.76	0.13	0.13	0.67	0.14	0.25
1991	0.77	0.16	0.08				0.76	0.13	0.13	0.67	0.14	0.25
1992	0.77	0.16	0.08				0.76	0.13	0.13	0.67	0.14	0.25
1993	0.77	0.16	0.08	0.73	0.18	0.14	0.76	0.13	0.13	0.67	0.14	0.25
1994	0.77	0.16	0.08	0.73	0.18	0.14	0.76	0.13	0.13	0.67	0.14	0.25
1995	0.71	0.26	0.08	0.66	0.28	0.14	0.68	0.25	0.13	0.62	0.22	0.25
1996	0.71	0.26	0.08	0.65	0.28	0.14	0.68	0.25	0.13	0.62	0.22	0.25
1997	0.71	0.26	0.08	0.65	0.28	0.14	0.68	0.25	0.13	0.62	0.22	0.25
1998	0.71	0.26	0.08	0.65	0.28	0.14	0.68	0.25	0.13	0.62	0.22	0.25
1999	0.71	0.26	0.08	0.65	0.28	0.14	0.68	0.25	0.13	0.62	0.22	0.25
2000	0.80	0.14	0.08	0.66	0.27	0.14	0.78	0.12	0.13	0.70	0.10	0.25
2001	0.66	0.14	0.26	0.66	0.27	0.14	0.63	0.12	0.33	0.70	0.10	0.25
2002	0.66	0.14	0.26	0.66	0.27	0.14	0.63	0.12	0.33	0.70	0.10	0.25
2003	0.65	0.16	0.26	0.72	0.18	0.14	0.63	0.12	0.33	0.70	0.10	0.25
2004	0.65	0.16	0.26	0.72	0.18	0.14	0.63	0.12	0.33	0.58	0.10	0.45
2005	0.65	0.16	0.26	0.72	0.18	0.14	0.63	0.12	0.33	0.58	0.10	0.45
2006	0.65	0.16	0.26	0.67	0.18	0.21	0.63	0.12	0.33	0.58	0.10	0.45
2007	0.65	0.16	0.26	0.69	0.15	0.21	0.63	0.12	0.33	0.58	0.10	0.45
2008	0.65	0.16	0.26	0.69	0.15	0.21	0.63	0.12	0.33	0.58	0.10	0.45
2009	0.65	0.16	0.26	0.69	0.15	0.21	0.63	0.12	0.33	0.58	0.10	0.45
2010	0.65	0.16	0.26	0.67	0.18	0.21	0.64	0.11	0.33	0.60	0.07	0.45
2011	0.65	0.16	0.26	0.67	0.18	0.21	0.65	0.10	0.33	0.60	0.06	0.45

Table B8.11. Parameter estimates of survival (S), instantaneous fishing mortality (F) and instantaneous natural mortality (M), by program, for striped bass ≥18 inches total length.

Coast Programs

Year	MADFW S	MADFW F	MADFW M	NYOHS/TRL* S	NYOHS/TRL* F	NYOHS/TRL* M	NJDB S	NJDB F	NJDB M	NCCOOP S	NCCOOP F	NCCOOP M
1987												
1988				0.78	0.01	0.23				0.79	0.02	0.21
1989				0.78	0.01	0.23	0.86	0.02	0.11	0.79	0.02	0.21
1990				0.75	0.05	0.23	0.83	0.05	0.11	0.72	0.10	0.21
1991				0.75	0.06	0.23	0.82	0.07	0.11	0.72	0.10	0.21
1992	0.86	0.03	0.11	0.75	0.05	0.23	0.85	0.03	0.11	0.72	0.10	0.21
1993	0.84	0.05	0.11	0.75	0.06	0.23	0.85	0.04	0.11	0.72	0.10	0.21
1994	0.83	0.07	0.11	0.75	0.05	0.23	0.86	0.03	0.11	0.72	0.10	0.21
1995	0.83	0.07	0.11	0.73	0.09	0.23	0.82	0.07	0.11	0.70	0.14	0.21
1996	0.78	0.13	0.11	0.73	0.09	0.23	0.78	0.13	0.11	0.70	0.14	0.21
1997	0.76	0.16	0.11	0.73	0.09	0.23	0.76	0.14	0.11	0.70	0.14	0.21
1998	0.77	0.14	0.11	0.73	0.09	0.23	0.74	0.17	0.11	0.70	0.14	0.21
1999	0.71	0.14	0.20	0.63	0.09	0.38	0.79	0.11	0.11	0.70	0.14	0.21
2000	0.71	0.13	0.20	0.64	0.06	0.38	0.79	0.11	0.11	0.56	0.11	0.46
2001	0.76	0.07	0.20	0.64	0.06	0.38	0.78	0.12	0.11	0.56	0.11	0.46
2002	0.72	0.12	0.20	0.64	0.06	0.38	0.68	0.10	0.27	0.56	0.11	0.46
2003	0.73	0.11	0.20	0.64	0.06	0.38	0.67	0.12	0.27	0.56	0.11	0.46
2004	0.74	0.10	0.20	0.64	0.06	0.38	0.66	0.14	0.27	0.56	0.11	0.46
2005	0.74	0.09	0.20	0.64	0.06	0.38	0.66	0.14	0.27	0.56	0.11	0.46
2006	0.75	0.09	0.20	0.64	0.06	0.38	0.68	0.10	0.27	0.56	0.11	0.46
2007	0.77	0.06	0.20	0.64	0.06	0.38	0.67	0.12	0.27	0.55	0.14	0.46
2008	0.75	0.09	0.20	0.62*	0.04*	0.43*	0.67	0.13	0.27	0.55	0.14	0.46
2009	0.74	0.10	0.20	0.62*	0.05*	0.43*	0.68	0.11	0.27	0.55	0.14	0.46
2010	0.76	0.07	0.20	0.57*	0.12*	0.43*	0.67	0.12	0.27	0.55	0.14	0.46
2011	0.73	0.11	0.20	0.58*	0.12*	0.43*	0.67	0.13	0.27	0.54	0.15	0.46

* NY OHS 1988-2007, NY TRL 2008-2011

Table B8.11 cont.

Producer Area Programs

	HUDSON			DE/PA			MDCB			VARAP		
Year	S	F	M	S	F	M	S	F	M	S	F	M
1987							0.83	0.00	0.17			
1988	0.83	0.05	0.13				0.82	0.01	0.17			
1989	0.82	0.05	0.13				0.83	0.00	0.17			
1990	0.78	0.10	0.13				0.77	0.08	0.17	0.62	0.08	0.38
1991	0.78	0.10	0.13				0.74	0.12	0.17	0.62	0.08	0.38
1992	0.78	0.10	0.13				0.69	0.19	0.17	0.62	0.08	0.38
1993	0.78	0.10	0.13	0.68	0.14	0.23	0.71	0.17	0.17	0.62	0.08	0.38
1994	0.78	0.10	0.13	0.68	0.14	0.23	0.71	0.16	0.17	0.62	0.08	0.38
1995	0.71	0.19	0.13	0.67	0.16	0.23	0.66	0.23	0.17	0.61	0.11	0.38
1996	0.71	0.19	0.13	0.67	0.16	0.23	0.68	0.21	0.17	0.61	0.10	0.38
1997	0.71	0.19	0.13	0.67	0.16	0.23	0.64	0.26	0.17	0.61	0.10	0.38
1998	0.72	0.19	0.13	0.67	0.16	0.23	0.63	0.28	0.17	0.50	0.10	0.59
1999	0.71	0.19	0.13	0.67	0.16	0.23	0.50	0.25	0.45	0.50	0.10	0.59
2000	0.79	0.10	0.13	0.68	0.15	0.23	0.52	0.20	0.45	0.51	0.08	0.59
2001	0.79	0.10	0.13	0.68	0.15	0.23	0.54	0.16	0.45	0.51	0.08	0.59
2002	0.65	0.10	0.32	0.68	0.15	0.23	0.56	0.12	0.45	0.51	0.08	0.59
2003	0.65	0.11	0.32	0.69	0.13	0.23	0.54	0.17	0.45	0.50	0.09	0.59
2004	0.65	0.11	0.32	0.60	0.13	0.37	0.56	0.14	0.45	0.50	0.09	0.59
2005	0.65	0.11	0.32	0.60	0.13	0.37	0.57	0.12	0.45	0.50	0.09	0.59
2006	0.65	0.11	0.32	0.60	0.13	0.37	0.55	0.15	0.45	0.50	0.09	0.59
2007	0.64	0.11	0.32	0.62	0.11	0.37	0.57	0.11	0.45	0.51	0.09	0.59
2008	0.64	0.11	0.32	0.62	0.11	0.37	0.56	0.13	0.45	0.51	0.09	0.59
2009	0.64	0.11	0.32	0.62	0.11	0.37	0.54	0.17	0.45	0.51	0.09	0.59
2010	0.64	0.12	0.32	0.61	0.11	0.37	0.56	0.13	0.45	0.53	0.04	0.59
2011	0.64	0.11	0.32	0.62	0.10	0.37	0.57	0.12	0.45	0.53	0.04	0.59

Table B8.12. Summaries of tag-based estimates of survival for striped bass ≥28 inches, using the IRCR model, with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals.

Coast Programs

Year	MADFW	NYOHS/TRL*	NJDB	NCCOOP	Unweighted average	lower 95% CI	upper 95% CI
1987							
1988		0.81		0.81	0.81	0.80	0.82
1989		0.81	0.93	0.81	0.85	0.84	0.86
1990		0.75	0.84	0.76	0.78	0.75	0.82
1991		0.73	0.66	0.76	0.72	0.67	0.76
1992	0.87	0.74	0.93	0.76	0.82	0.76	0.89
1993	0.84	0.72	0.83	0.76	0.79	0.73	0.85
1994	0.83	0.74	0.89	0.76	0.80	0.74	0.86
1995	0.82	0.67	0.84	0.72	0.76	0.69	0.83
1996	0.75	0.66	0.76	0.72	0.72	0.65	0.80
1997	0.74	0.64	0.77	0.72	0.72	0.63	0.80
1998	0.76	0.64	0.68	0.72	0.70	0.62	0.78
1999	0.68	0.63	0.77	0.72	0.70	0.61	0.79
2000	0.69	0.70	0.81	0.64	0.71	0.62	0.80
2001	0.75	0.70	0.79	0.64	0.72	0.65	0.79
2002	0.72	0.70	0.81	0.64	0.72	0.65	0.79
2003	0.72	0.69	0.67	0.64	0.68	0.60	0.75
2004	0.74	0.71	0.67	0.64	0.69	0.63	0.75
2005	0.75	0.59	0.66	0.64	0.66	0.60	0.72
2006	0.75	0.60	0.71	0.64	0.67	0.61	0.74
2007	0.77	0.60	0.69	0.62	0.67	0.61	0.73
2008	0.75	0.91*	0.67	0.62	0.74	0.67	0.81
2009	0.74	0.90*	0.65	0.62	0.73	0.65	0.80
2010	0.76	0.89*	0.67	0.62	0.74	0.67	0.81
2011	0.74	0.90*	0.69	0.62	0.74	0.66	0.82

* NY OHS 1988-2007, NY TRL 2008-2011

Table 8.12 cont.

Producer Area Programs

Year	HUDSON	DE/PA	MDCB	VARAP	**Weighted average***	lower 95% CI	upper 95% CI
1987			0.85		**0.57**	0.56	0.58
1988	0.83		0.85		**0.68**	0.66	0.70
1989	0.83		0.85		**0.68**	0.66	0.69
1990	0.77		0.76	0.67	**0.67**	0.65	0.69
1991	0.77		0.76	0.67	**0.67**	0.65	0.69
1992	0.77		0.76	0.67	**0.67**	0.65	0.68
1993	0.77	0.73	0.76	0.67	**0.73**	0.72	0.75
1994	0.77	0.73	0.76	0.67	**0.73**	0.72	0.75
1995	0.71	0.66	0.68	0.62	**0.67**	0.65	0.68
1996	0.71	0.65	0.68	0.62	**0.67**	0.65	0.68
1997	0.71	0.65	0.68	0.62	**0.67**	0.65	0.68
1998	0.71	0.65	0.68	0.62	**0.67**	0.65	0.68
1999	0.71	0.65	0.68	0.62	**0.67**	0.65	0.69
2000	0.80	0.66	0.78	0.70	**0.75**	0.73	0.77
2001	0.66	0.66	0.63	0.70	**0.66**	0.64	0.68
2002	0.66	0.66	0.63	0.70	**0.66**	0.64	0.68
2003	0.65	0.72	0.63	0.70	**0.66**	0.64	0.68
2004	0.65	0.72	0.63	0.58	**0.63**	0.61	0.65
2005	0.65	0.72	0.63	0.58	**0.63**	0.61	0.65
2006	0.65	0.67	0.63	0.58	**0.63**	0.60	0.65
2007	0.65	0.69	0.63	0.58	**0.63**	0.60	0.65
2008	0.65	0.69	0.63	0.58	**0.63**	0.60	0.65
2009	0.65	0.69	0.63	0.58	**0.63**	0.60	0.65
2010	0.65	0.67	0.64	0.60	**0.63**	0.61	0.66
2011	0.65	0.67	0.65	0.60	**0.64**	0.61	0.66

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA
(0.33).

Table B8.13. Summaries of tag-based estimates of survival for striped bass ≥18 inches, using the IRCR model, with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals.

Coast Programs

Year	MADFW	NYOHS/TRL*	NJDB	NCCOOP	Unweighted average	lower 95% CI	upper 95% CI
1987							
1988		0.78		0.79	0.79	0.78	0.79
1989		0.78	0.86	0.79	0.81	0.80	0.82
1990		0.75	0.83	0.72	0.77	0.75	0.78
1991		0.75	0.82	0.72	0.77	0.75	0.78
1992	0.86	0.75	0.85	0.72	0.80	0.78	0.81
1993	0.84	0.75	0.85	0.72	0.79	0.78	0.80
1994	0.83	0.75	0.86	0.72	0.79	0.78	0.80
1995	0.83	0.73	0.82	0.70	0.77	0.76	0.78
1996	0.78	0.73	0.78	0.70	0.75	0.73	0.76
1997	0.76	0.73	0.76	0.70	0.74	0.72	0.75
1998	0.77	0.73	0.74	0.70	0.74	0.72	0.75
1999	0.71	0.63	0.79	0.70	0.71	0.69	0.72
2000	0.71	0.64	0.79	0.56	0.68	0.66	0.69
2001	0.76	0.64	0.78	0.56	0.69	0.67	0.70
2002	0.72	0.64	0.68	0.56	0.65	0.64	0.67
2003	0.73	0.64	0.67	0.56	0.65	0.63	0.66
2004	0.74	0.64	0.66	0.56	0.65	0.63	0.66
2005	0.74	0.64	0.66	0.56	0.65	0.63	0.67
2006	0.75	0.64	0.68	0.56	0.66	0.64	0.67
2007	0.77	0.64	0.67	0.55	0.66	0.64	0.67
2008	0.75	0.62*	0.67	0.55	0.65	0.61	0.68
2009	0.74	0.62*	0.68	0.55	0.65	0.61	0.68
2010	0.76	0.57*	0.67	0.55	0.64	0.60	0.68
2011	0.73	0.58*	0.67	0.54	0.63	0.59	0.67

* NY OHS 1988-2007, NY TRL 2008-2011

Table B8.13. Continued.

Producer Area Programs

Year	HUDSON	DE/PA	MDCB	VARAP	Weighted average*	lower 95% CI	upper 95% CI
1987			0.83		0.56	0.55	0.56
1988	0.83		0.82		0.66	0.65	0.67
1989	0.82		0.83		0.66	0.66	0.67
1990	0.78		0.77	0.62	0.67	0.66	0.67
1991	0.78		0.74	0.62	0.65	0.64	0.65
1992	0.78		0.69	0.62	0.62	0.61	0.63
1993	0.78	0.68	0.71	0.62	0.69	0.68	0.70
1994	0.78	0.68	0.71	0.62	0.69	0.68	0.70
1995	0.71	0.67	0.66	0.61	0.66	0.64	0.67
1996	0.71	0.67	0.68	0.61	0.66	0.65	0.68
1997	0.71	0.67	0.64	0.61	0.65	0.63	0.66
1998	0.72	0.67	0.63	0.50	0.61	0.60	0.62
1999	0.71	0.67	0.50	0.50	0.54	0.53	0.55
2000	0.79	0.68	0.52	0.51	0.57	0.55	0.58
2001	0.79	0.68	0.54	0.51	0.58	0.56	0.59
2002	0.65	0.68	0.56	0.51	0.57	0.56	0.59
2003	0.65	0.69	0.54	0.50	0.56	0.54	0.57
2004	0.65	0.60	0.56	0.50	0.56	0.54	0.58
2005	0.65	0.60	0.57	0.50	0.56	0.55	0.58
2006	0.65	0.60	0.55	0.50	0.55	0.54	0.57
2007	0.64	0.62	0.57	0.51	0.57	0.55	0.59
2008	0.64	0.62	0.56	0.51	0.56	0.54	0.58
2009	0.64	0.62	0.54	0.51	0.55	0.53	0.57
2010	0.64	0.61	0.56	0.53	0.57	0.55	0.59
2011	0.64	0.62	0.57	0.53	0.57	0.55	0.59

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and
VA (0.33).

Table B8.14. Survival estimates from Program MARK and IRCR for fish ≥ 28 inches

Coastal

MADFW					NYOHS/TRL*				
Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR	Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR
1987					1987				
1988					1988	0.93	1.10	1.05	0.81
1989					1989	1.12	1.05	1.01	0.81
1990					1990	0.70	0.70	0.71	0.75
1991					1991	0.61	0.73	0.74	0.73
1992	0.88	0.88	0.84	0.87	1992	1.13	0.80	0.82	0.74
1993	0.83	0.87	0.83	0.84	1993	0.53	0.71	0.72	0.72
1994	0.94	0.89	0.85	0.83	1994	0.82	0.74	0.75	0.74
1995	0.76	0.76	0.80	0.82	1995	0.84	0.80	0.78	0.67
1996	0.73	0.78	0.82	0.75	1996	0.93	0.84	0.82	0.66
1997	0.84	0.77	0.81	0.74	1997	0.96	0.74	0.73	0.64
1998	0.83	0.78	0.82	0.76	1998	0.40	0.66	0.65	0.64
1999	0.79	0.77	0.80	0.68	1999	0.58	0.71	0.69	0.63
2000	0.61	0.78	0.76	0.69	2000	1.01	0.84	0.87	0.70
2001	0.83	0.79	0.78	0.75	2001	0.75	0.81	0.84	0.70
2002	0.88	0.84	0.82	0.72	2002	0.98	0.82	0.84	0.70
2003	0.75	0.71	0.68	0.72	2003	0.68	0.57	0.56	0.69
2004	0.75	0.71	0.69	0.74	2004	0.33	0.59	0.58	0.71
2005	0.64	0.72	0.70	0.75	2005	0.69	0.57	0.55	0.59
2006	0.76	0.73	0.70	0.75	2006	0.96	0.58	0.56	0.60
2007	0.72	0.72	0.78	0.77	2007	0.83	0.57	0.98	0.60
2008	0.60	0.73	0.79	0.75	2008	0.99*	0.89*	0.94*	0.91*
2009	0.88	0.73	0.78	0.74	2009	0.86*	0.97*	1.03*	0.90*
2010	0.92	0.73	0.81	0.76	2010	0.78*	0.85*	0.91*	0.89*
2011		0.74	0.82	0.74	2011		0.87*	0.93*	0.90*

* NY OHS 1988-2007, NY TRL 2008-2011

Table B8.14 cont.

NJDB					NCCOOP				
Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR	Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR
1987					1987				
1988					1988	1.08	0.87	0.84	0.81
1989	1.15	1.16	1.16	0.93	1989	0.76	0.82	0.78	0.81
1990	1.10	0.87	0.87	0.84	1990	0.70	0.78	0.79	0.76
1991	1.12	1.07	1.06	0.66	1991	0.70	0.79	0.79	0.76
1992	0.84	0.79	0.78	0.93	1992	1.02	0.79	0.80	0.76
1993	0.56	0.76	0.75	0.83	1993	0.79	0.77	0.78	0.76
1994	0.82	0.79	0.78	0.89	1994	0.59	0.77	0.77	0.76
1995	0.88	0.79	0.79	0.84	1995	0.99	0.71	0.71	0.72
1996	0.95	0.78	0.78	0.76	1996	0.62	0.67	0.67	0.72
1997	0.56	0.74	0.74	0.77	1997	0.52	0.69	0.69	0.72
1998	0.65	0.71	0.71	0.68	1998	0.69	0.69	0.69	0.72
1999	0.78	0.80	0.80	0.77	1999	0.96	0.69	0.69	0.72
2000	0.96	0.81	0.81	0.81	2000	0.55	0.72	0.69	0.64
2001	0.90	0.80	0.80	0.79	2001	0.72	0.73	0.70	0.64
2002	0.67	0.80	0.80	0.81	2002	0.78	0.72	0.70	0.64
2003	0.65	0.66	0.65	0.67	2003	0.60	0.62	0.64	0.64
2004	0.51	0.66	0.66	0.67	2004	0.92	0.63	0.64	0.64
2005	0.85	0.69	0.69	0.66	2005	0.45	0.62	0.63	0.64
2006	0.77	0.65	0.64	0.71	2006	0.47	0.63	0.64	0.64
2007	0.69	0.74	0.73	0.69	2007	0.66	0.63	0.65	0.62
2008	0.68	0.72	0.71	0.67	2008	0.94	0.63	0.65	0.62
2009	0.77	0.72	0.72	0.65	2009	0.96	0.62	0.63	0.62
2010	0.70	0.72	0.77	0.67	2010	0.20	0.61	0.64	0.62
2011		0.73	0.77	0.69	2011		0.65	0.67	0.62

Table B8.14 cont.

Producer Areas

		HUDSON					DE/PA		
Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR	Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR
1987					1987				
1988	1.04	0.84	0.83	0.83	1988				
1989	0.74	0.91	0.90	0.83	1989				
1990	0.84	0.80	0.80	0.77	1990				
1991	0.69	0.73	0.73	0.77	1991				
1992	0.79	0.78	0.78	0.77	1992				
1993	0.72	0.75	0.75	0.77	1993	0.56	0.76	0.75	0.73
1994	0.84	0.75	0.75	0.77	1994	0.82	0.79	0.78	0.73
1995	0.74	0.73	0.73	0.71	1995	0.88	0.79	0.79	0.66
1996	0.66	0.71	0.71	0.71	1996	0.95	0.78	0.78	0.65
1997	0.76	0.76	0.76	0.71	1997	0.56	0.74	0.74	0.65
1998	0.66	0.71	0.71	0.71	1998	0.65	0.71	0.71	0.65
1999	0.74	0.73	0.73	0.71	1999	0.78	0.80	0.80	0.65
2000	0.93	0.71	0.71	0.80	2000	0.95	0.81	0.81	0.66
2001	0.52	0.69	0.70	0.66	2001	0.89	0.80	0.80	0.66
2002	0.77	0.72	0.73	0.66	2002	0.67	0.79	0.79	0.66
2003	0.67	0.68	0.67	0.65	2003	0.64	0.65	0.65	0.72
2004	0.69	0.67	0.67	0.65	2004	0.51	0.66	0.66	0.72
2005	0.71	0.67	0.67	0.65	2005	0.85	0.69	0.69	0.72
2006	0.62	0.67	0.67	0.65	2006	0.77	0.65	0.64	0.67
2007	0.65	0.61	0.63	0.65	2007	0.69	0.74	0.74	0.69
2008	0.49	0.61	0.63	0.65	2008	0.68	0.72	0.72	0.69
2009	0.81	0.61	0.64	0.65	2009	0.77	0.72	0.72	0.69
2010	0.60	0.61	0.56	0.65	2010	0.70	0.73	0.77	0.67
2011		0.61	0.56	0.65	2011		0.71	0.76	0.67

Table B8.14 cont.

MDCB					VARAP				
Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR	Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR
1987	0.77	0.94	0.90	0.85	1987				
1988	1.02	1.00	0.96	0.85	1988				
1989	1.04	1.03	0.99	0.85	1989				
1990	0.64	0.72	0.73	0.76	1990	0.61	0.71	0.72	0.67
1991	0.65	0.80	0.81	0.76	1991	0.66	0.72	0.73	0.67
1992	0.77	0.76	0.77	0.76	1992	0.79	0.75	0.76	0.67
1993	0.78	0.74	0.75	0.76	1993	1.00	0.69	0.70	0.67
1994	0.83	0.73	0.74	0.76	1994	0.46	0.67	0.68	0.67
1995	0.73	0.70	0.70	0.68	1995	0.95	0.64	0.64	0.62
1996	0.69	0.69	0.69	0.68	1996	0.55	0.60	0.59	0.62
1997	0.73	0.69	0.68	0.68	1997	0.46	0.62	0.61	0.62
1998	0.54	0.68	0.68	0.68	1998	0.86	0.65	0.64	0.62
1999	0.58	0.68	0.68	0.68	1999	0.45	0.63	0.62	0.62
2000	0.92	0.65	0.65	0.78	2000	0.83	0.67	0.72	0.70
2001	0.52	0.65	0.65	0.63	2001	0.51	0.66	0.71	0.70
2002	0.68	0.65	0.65	0.63	2002	0.71	0.67	0.72	0.70
2003	0.79	0.67	0.67	0.63	2003	0.96	0.63	0.60	0.70
2004	0.59	0.66	0.66	0.63	2004	0.36	0.62	0.59	0.58
2005	0.64	0.67	0.66	0.63	2005	0.59	0.61	0.59	0.58
2006	0.72	0.67	0.67	0.63	2006	0.80	0.62	0.59	0.58
2007	0.58	0.59	0.61	0.63	2007	0.72	0.67	0.64	0.58
2008	0.55	0.59	0.61	0.63	2008	0.97	0.66	0.63	0.58
2009	0.95	0.59	0.60	0.63	2009	0.49	0.66	0.63	0.58
2010	0.29	0.59	0.50	0.64	2010	0.25	0.66	0.79	0.60
2011		0.60	0.51	0.65	2011		0.66	0.78	0.60

Table B8.15. Survival estimates from Program MARK and IRCR for fish ≥ 18 inches
Coastal

MADFW					NYOHS/TRL*				
Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR	Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR
1987					1987				
1988					1988	0.62	0.81	0.87	0.78
1989					1989	1.12	0.86	0.92	0.78
1990					1990	0.65	0.81	0.79	0.75
1991					1991	0.88	0.81	0.80	0.75
1992	0.90	0.87	0.84	0.86	1992	1.06	0.80	0.79	0.75
1993	0.82	0.85	0.82	0.84	1993	0.54	0.78	0.76	0.75
1994	0.90	0.88	0.85	0.83	1994	0.77	0.80	0.78	0.75
1995	0.76	0.78	0.80	0.83	1995	0.93	0.76	0.75	0.73
1996	0.88	0.83	0.85	0.78	1996	0.94	0.77	0.76	0.73
1997	0.75	0.80	0.82	0.76	1997	0.76	0.77	0.76	0.73
1998	0.96	0.79	0.81	0.77	1998	0.51	0.76	0.76	0.73
1999	0.73	0.76	0.78	0.71	1999	0.78	0.76	0.76	0.63
2000	0.61	0.78	0.77	0.71	2000	0.65	0.67	0.70	0.64
2001	0.78	0.79	0.79	0.76	2001	0.75	0.68	0.70	0.64
2002	0.94	0.82	0.81	0.72	2002	0.69	0.68	0.70	0.64
2003	0.74	0.71	0.69	0.73	2003	0.72	0.64	0.63	0.64
2004	0.72	0.70	0.68	0.74	2004	0.60	0.64	0.63	0.64
2005	0.67	0.72	0.70	0.74	2005	0.46	0.64	0.63	0.64
2006	0.64	0.72	0.70	0.75	2006	0.95	0.66	0.65	0.64
2007	0.83	0.83	0.80	0.77	2007	0.91	0.41	0.54	0.64
2008	0.64	0.75	0.81	0.75	2008	0.59*	0.59*	0.64*	0.62*
2009	0.86	0.75	0.81	0.74	2009	0.61*	0.62*	0.66*	0.62*
2010	0.87	0.75	0.83	0.76	2010	0.63*	0.61*	0.58*	0.57*
2011		0.76	0.84	0.73	2011		0.59*	0.56*	0.58*

* NY OHS 1988-2007, NY TRL 2008-2011

Table B8.15. Continued.

NJDB					NCCOOP				
Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR	Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR
1987					1987				
1988					1988	1.10	0.89	0.85	0.79
1989	1.00	1.01	1.01	0.86	1989	0.68	0.81	0.77	0.79
1990	0.99	0.72	0.72	0.83	1990	0.60	0.74	0.75	0.72
1991	0.61	0.69	0.69	0.82	1991	0.72	0.76	0.77	0.72
1992	0.67	0.68	0.68	0.85	1992	0.89	0.75	0.76	0.72
1993	0.60	0.69	0.69	0.85	1993	0.87	0.74	0.75	0.72
1994	0.71	0.69	0.69	0.86	1994	0.53	0.73	0.74	0.72
1995	0.90	0.75	0.76	0.82	1995	1.02	0.72	0.72	0.70
1996	0.83	0.76	0.77	0.78	1996	0.60	0.68	0.68	0.70
1997	0.57	0.75	0.76	0.76	1997	0.55	0.70	0.69	0.70
1998	0.79	0.77	0.77	0.74	1998	0.74	0.71	0.71	0.70
1999	0.73	0.74	0.75	0.79	1999	0.99	0.70	0.69	0.70
2000	0.77	0.73	0.71	0.79	2000	0.33	0.53	0.55	0.56
2001	0.83	0.72	0.71	0.78	2001	0.64	0.53	0.55	0.56
2002	0.58	0.71	0.69	0.68	2002	0.56	0.53	0.55	0.56
2003	0.59	0.62	0.63	0.67	2003	0.70	0.58	0.58	0.56
2004	0.72	0.62	0.63	0.66	2004	0.98	0.58	0.58	0.56
2005	0.61	0.62	0.63	0.66	2005	0.26	0.56	0.57	0.56
2006	0.61	0.62	0.63	0.68	2006	0.41	0.58	0.59	0.56
2007	0.68	0.74	0.71	0.67	2007	0.63	0.59	0.59	0.55
2008	0.74	0.74	0.71	0.67	2008	0.96	0.58	0.59	0.55
2009	0.89	0.74	0.72	0.68	2009	0.97	0.57	0.57	0.55
2010	0.61	0.73	0.74	0.67	2010	0.17	0.56	0.52	0.55
2011		0.72	0.74	0.67	2011		0.59	0.56	0.54

Table B8.15 cont.
Producer Areas

HUDSON | | | | DE/PA | | | |

Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR	Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR
1987					1987				
1988	1.03	0.81	0.82	0.83	1988				
1989	0.71	0.85	0.87	0.82	1989				
1990	0.71	0.79	0.79	0.78	1990				
1991	0.80	0.76	0.75	0.78	1991				
1992	0.75	0.77	0.76	0.78	1992				
1993	0.77	0.75	0.74	0.78	1993	0.60	0.69	0.69	0.68
1994	0.79	0.74	0.74	0.78	1994	0.71	0.69	0.69	0.68
1995	0.72	0.73	0.74	0.71	1995	0.90	0.75	0.76	0.67
1996	0.71	0.73	0.74	0.71	1996	0.83	0.76	0.77	0.67
1997	0.75	0.75	0.76	0.71	1997	0.57	0.75	0.76	0.67
1998	0.74	0.72	0.73	0.72	1998	0.79	0.77	0.77	0.67
1999	0.64	0.73	0.73	0.71	1999	0.73	0.74	0.75	0.67
2000	0.94	0.74	0.74	0.79	2000	0.77	0.73	0.71	0.68
2001	0.71	0.71	0.72	0.79	2001	0.83	0.72	0.71	0.68
2002	0.59	0.72	0.73	0.65	2002	0.58	0.71	0.69	0.68
2003	0.73	0.68	0.67	0.65	2003	0.59	0.62	0.63	0.69
2004	0.77	0.67	0.66	0.65	2004	0.72	0.62	0.63	0.60
2005	0.55	0.66	0.66	0.65	2005	0.61	0.62	0.63	0.60
2006	0.68	0.67	0.66	0.65	2006	0.61	0.62	0.63	0.60
2007	0.67	0.61	0.62	0.64	2007	0.68	0.74	0.71	0.62
2008	0.45	0.61	0.62	0.64	2008	0.74	0.74	0.71	0.62
2009	0.94	0.61	0.63	0.64	2009	0.89	0.74	0.72	0.62
2010	0.44	0.60	0.54	0.64	2010	0.61	0.73	0.74	0.61
2011		0.61	0.54	0.64	2011		0.74	0.76	0.62

Table B8.15 cont.

MDCB					VARAP				
Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR	Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR
1987	0.98	0.99	0.92	0.83	1987				
1988	0.85	0.92	0.85	0.82	1988				
1989	1.03	0.91	0.84	0.83	1989				
1990	0.62	0.68	0.71	0.77	1990	0.95	0.66	0.65	0.62
1991	0.76	0.70	0.73	0.74	1991	0.30	0.62	0.61	0.62
1992	0.70	0.72	0.75	0.69	1992	0.94	0.66	0.65	0.62
1993	0.66	0.69	0.72	0.71	1993	0.68	0.63	0.62	0.62
1994	0.71	0.71	0.74	0.71	1994	0.62	0.62	0.61	0.62
1995	0.68	0.64	0.64	0.66	1995	0.72	0.55	0.55	0.61
1996	0.69	0.64	0.64	0.68	1996	0.67	0.55	0.54	0.61
1997	0.64	0.62	0.63	0.64	1997	0.60	0.56	0.55	0.61
1998	0.53	0.63	0.63	0.63	1998	0.43	0.55	0.55	0.50
1999	0.54	0.61	0.61	0.50	1999	0.39	0.55	0.55	0.50
2000	0.62	0.55	0.55	0.52	2000	0.46	0.53	0.55	0.51
2001	0.48	0.53	0.53	0.54	2001	0.49	0.53	0.55	0.51
2002	0.58	0.53	0.53	0.56	2002	0.64	0.52	0.54	0.51
2003	0.60	0.59	0.56	0.54	2003	0.88	0.53	0.52	0.50
2004	0.60	0.58	0.55	0.56	2004	0.36	0.53	0.51	0.50
2005	0.49	0.58	0.55	0.57	2005	0.47	0.52	0.51	0.50
2006	0.64	0.59	0.56	0.55	2006	0.57	0.54	0.52	0.50
2007	0.53	0.49	0.52	0.57	2007	0.62	0.55	0.54	0.51
2008	0.51	0.49	0.52	0.56	2008	0.55	0.54	0.53	0.51
2009	0.48	0.48	0.51	0.54	2009	0.75	0.55	0.54	0.51
2010	0.39	0.49	0.44	0.56	2010	0.11	0.54	0.80	0.53
2011		0.49	0.44	0.57	2011		0.54	0.81	0.53

Table B8.16. Summaries of tag-based estimates of annual instantaneous fishing mortality for striped bass ≥28 inches, using the IRCR model, with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals.

Coast Programs

Year	MADFW	NYOHS/TRL*	NJDB	NCCOOP	Unweighted average	lower 95% CI	upper 95% CI
1987							
1988		0.02		0.05	0.03	0.02	0.05
1989		0.02	0.00	0.05	0.02	0.01	0.04
1990		0.10	0.10	0.11	0.10	0.03	0.17
1991		0.13	0.35	0.11	0.20	0.01	0.38
1992	0.03	0.12	0.00	0.11	0.07	-0.02	0.15
1993	0.06	0.14	0.11	0.11	0.10	0.00	0.21
1994	0.08	0.12	0.05	0.11	0.09	0.00	0.17
1995	0.10	0.23	0.11	0.17	0.15	0.01	0.29
1996	0.18	0.23	0.21	0.17	0.20	0.03	0.37
1997	0.19	0.27	0.19	0.17	0.21	0.03	0.39
1998	0.17	0.27	0.32	0.17	0.23	0.01	0.45
1999	0.18	0.28	0.19	0.17	0.21	0.02	0.40
2000	0.18	0.17	0.15	0.12	0.16	0.01	0.30
2001	0.08	0.17	0.18	0.12	0.14	0.00	0.28
2002	0.13	0.18	0.15	0.12	0.14	0.01	0.28
2003	0.13	0.20	0.18	0.13	0.16	0.01	0.31
2004	0.11	0.17	0.17	0.13	0.14	0.01	0.27
2005	0.10	0.16	0.19	0.13	0.14	0.01	0.28
2006	0.10	0.15	0.12	0.13	0.12	0.01	0.23
2007	0.06	0.16	0.15	0.15	0.13	0.01	0.25
2008	0.10	0.09*	0.17	0.15	0.13	0.02	0.23
2009	0.11	0.09*	0.20	0.15	0.14	0.02	0.26
2010	0.07	0.10*	0.17	0.15	0.13	0.02	0.23
2011	0.11	0.10*	0.15	0.15	0.13	0.03	0.22

* NY OHS 1988-2007, NY TRL 2008-2011

Table B8.16 cont.

Producer Area Programs

Year	HUDSON	DE/PA	MDCB	VARAP	Weighted average*	lower 95% CI	upper 95% CI
1987			0.03		0.02	0.01	0.03
1988	0.09		0.03		0.03	0.01	0.05
1989	0.09		0.03		0.03	0.01	0.04
1990	0.16		0.13	0.14	0.13	0.10	0.15
1991	0.16		0.13	0.14	0.13	0.11	0.15
1992	0.16		0.13	0.14	0.13	0.11	0.15
1993	0.16	0.18	0.13	0.14	0.14	0.12	0.17
1994	0.16	0.18	0.13	0.14	0.14	0.12	0.17
1995	0.26	0.28	0.25	0.22	0.25	0.22	0.27
1996	0.26	0.28	0.25	0.22	0.25	0.22	0.27
1997	0.26	0.28	0.25	0.22	0.25	0.22	0.27
1998	0.26	0.28	0.25	0.22	0.25	0.21	0.28
1999	0.26	0.28	0.25	0.22	0.25	0.21	0.28
2000	0.14	0.27	0.12	0.10	0.13	0.11	0.15
2001	0.14	0.27	0.12	0.10	0.13	0.11	0.15
2002	0.14	0.27	0.12	0.10	0.13	0.11	0.15
2003	0.16	0.18	0.12	0.10	0.13	0.11	0.15
2004	0.16	0.18	0.12	0.10	0.13	0.11	0.14
2005	0.16	0.18	0.12	0.10	0.13	0.11	0.14
2006	0.16	0.18	0.12	0.10	0.13	0.11	0.15
2007	0.16	0.15	0.12	0.10	0.12	0.10	0.15
2008	0.16	0.15	0.12	0.10	0.12	0.10	0.15
2009	0.16	0.15	0.12	0.10	0.12	0.10	0.15
2010	0.16	0.18	0.11	0.07	0.11	0.09	0.14
2011	0.16	0.18	0.10	0.06	0.11	0.09	0.13

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and
VA (0.33).

Table B8.17. Summaries of tag-based estimates of annual instantaneous fishing mortality for striped bass ≥18 inches, using the IRCR model, with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals.

Coast Programs

Year	MADFW	NYOHS/TRL*	NJDB	NCCOOP	Unweighted average	lower 95% CI	upper 95% CI
1987							
1988		0.01		0.02	0.01	0.01	0.02
1989		0.01	0.02	0.02	0.02	0.01	0.03
1990		0.05	0.05	0.10	0.07	0.05	0.09
1991		0.06	0.07	0.10	0.08	0.06	0.09
1992	0.03	0.05	0.03	0.10	0.05	0.04	0.07
1993	0.05	0.06	0.04	0.10	0.06	0.05	0.07
1994	0.07	0.05	0.03	0.10	0.06	0.05	0.07
1995	0.07	0.09	0.07	0.14	0.09	0.08	0.11
1996	0.13	0.09	0.13	0.14	0.12	0.11	0.13
1997	0.16	0.09	0.14	0.14	0.13	0.12	0.15
1998	0.14	0.09	0.17	0.14	0.14	0.12	0.15
1999	0.14	0.09	0.11	0.14	0.12	0.11	0.13
2000	0.13	0.06	0.11	0.11	0.10	0.09	0.12
2001	0.07	0.06	0.12	0.11	0.09	0.08	0.10
2002	0.12	0.06	0.10	0.11	0.10	0.09	0.11
2003	0.11	0.06	0.12	0.11	0.10	0.09	0.11
2004	0.10	0.06	0.14	0.11	0.10	0.09	0.11
2005	0.09	0.06	0.14	0.11	0.10	0.09	0.11
2006	0.09	0.06	0.10	0.11	0.09	0.08	0.10
2007	0.06	0.06	0.12	0.14	0.10	0.08	0.11
2008	0.09	0.04*	0.13	0.14	0.10	0.09	0.11
2009	0.10	0.05*	0.11	0.14	0.10	0.09	0.11
2010	0.07	0.12*	0.12	0.14	0.11	0.10	0.13
2011	0.11	0.12*	0.13	0.15	0.13	0.11	0.15

* NY OHS 1988-2007, NY TRL 2008-2012

Table B8.17. Continued.

Producer Area Programs

Year	HUDSON	DE/PA	MDCB	VARAP	Weighted average*	lower 95% CI	upper 95% CI
1987			0.00		0.00	0.00	0.00
1988	0.05		0.01		0.01	0.01	0.02
1989	0.05		0.00		0.01	0.01	0.01
1990	0.10		0.08	0.08	0.07	0.06	0.08
1991	0.10		0.12	0.08	0.10	0.09	0.11
1992	0.10		0.19	0.08	0.13	0.12	0.14
1993	0.10	0.14	0.17	0.08	0.13	0.12	0.15
1994	0.10	0.14	0.16	0.08	0.13	0.12	0.15
1995	0.19	0.16	0.23	0.11	0.19	0.17	0.21
1996	0.19	0.16	0.21	0.10	0.18	0.16	0.19
1997	0.19	0.16	0.26	0.10	0.20	0.18	0.22
1998	0.19	0.16	0.28	0.10	0.21	0.19	0.23
1999	0.19	0.16	0.25	0.10	0.20	0.18	0.22
2000	0.10	0.15	0.20	0.08	0.15	0.13	0.17
2001	0.10	0.15	0.16	0.08	0.13	0.11	0.15
2002	0.10	0.15	0.12	0.08	0.11	0.09	0.13
2003	0.11	0.13	0.17	0.09	0.14	0.12	0.16
2004	0.11	0.13	0.14	0.09	0.12	0.10	0.14
2005	0.11	0.13	0.12	0.09	0.11	0.10	0.13
2006	0.11	0.13	0.15	0.09	0.13	0.11	0.15
2007	0.11	0.11	0.11	0.09	0.10	0.08	0.12
2008	0.11	0.11	0.13	0.09	0.11	0.09	0.13
2009	0.11	0.11	0.17	0.09	0.13	0.11	0.16
2010	0.12	0.11	0.13	0.04	0.10	0.08	0.12
2011	0.11	0.10	0.12	0.04	0.10	0.08	0.12

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

Table B8.18. Summaries of tag-based estimates of annual natural mortality for striped bass ≥28 inches, using the IRCR model, with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals.

Coast Programs

Year	MADFW	NYOHS/TRL*	NJDB	NCCOOP	Unweighted average	lower 95% CI	upper 95% CI
1987							
1988		0.17		0.15	0.16	0.16	0.17
1989		0.17	0.05	0.15	0.13	0.12	0.14
1990		0.17	0.05	0.15	0.13	0.12	0.14
1991		0.17	0.05	0.15	0.13	0.12	0.14
1992	0.10	0.17	0.05	0.15	0.12	0.11	0.13
1993	0.10	0.17	0.05	0.15	0.12	0.11	0.13
1994	0.10	0.17	0.05	0.15	0.12	0.11	0.13
1995	0.10	0.17	0.05	0.15	0.12	0.11	0.13
1996	0.10	0.17	0.05	0.15	0.12	0.11	0.13
1997	0.10	0.17	0.05	0.15	0.12	0.11	0.13
1998	0.10	0.17	0.05	0.15	0.12	0.11	0.13
1999	0.19	0.17	0.05	0.15	0.14	0.13	0.16
2000	0.19	0.17	0.05	0.32	0.19	0.17	0.20
2001	0.19	0.17	0.05	0.32	0.19	0.17	0.20
2002	0.19	0.17	0.05	0.32	0.19	0.17	0.20
2003	0.19	0.17	0.22	0.32	0.23	0.21	0.24
2004	0.19	0.17	0.22	0.32	0.23	0.21	0.24
2005	0.19	0.36	0.22	0.32	0.27	0.24	0.31
2006	0.19	0.36	0.22	0.32	0.27	0.24	0.31
2007	0.19	0.36	0.22	0.32	0.27	0.24	0.31
2008	0.19	**	0.22	0.32	0.18	0.14	0.23
2009	0.19	**	0.22	0.32	0.18	0.14	0.23
2010	0.19	**	0.22	0.32	0.18	0.14	0.23
2011	0.19	**	0.22	0.32	0.18	0.14	0.23

* NY OHS 1988-2007, NY TRL 2008-2011
** Estimates not included in average.

Table B8.18 cont.

Producer Area Programs

Year	HUDSON	DE/PA	MDCB	VARAP	Weighted average*	lower 95% CI	upper 95% CI
1987			0.13		0.09	0.08	0.10
1988	0.08		0.13		0.10	0.09	0.11
1989	0.08		0.13		0.10	0.09	0.11
1990	0.08		0.13	0.25	0.14	0.13	0.16
1991	0.08		0.13	0.25	0.14	0.13	0.16
1992	0.08		0.13	0.25	0.14	0.13	0.16
1993	0.08	0.14	0.13	0.25	0.16	0.14	0.17
1994	0.08	0.14	0.13	0.25	0.16	0.14	0.17
1995	0.08	0.14	0.13	0.25	0.16	0.14	0.17
1996	0.08	0.14	0.13	0.25	0.16	0.14	0.17
1997	0.08	0.14	0.13	0.25	0.16	0.14	0.17
1998	0.08	0.14	0.13	0.25	0.16	0.14	0.17
1999	0.08	0.14	0.13	0.25	0.16	0.14	0.17
2000	0.08	0.14	0.13	0.25	0.16	0.14	0.17
2001	0.26	0.14	0.33	0.25	0.28	0.26	0.31
2002	0.26	0.14	0.33	0.25	0.28	0.26	0.31
2003	0.26	0.14	0.33	0.25	0.28	0.26	0.31
2004	0.26	0.14	0.33	0.45	0.33	0.30	0.37
2005	0.26	0.14	0.33	0.45	0.33	0.30	0.37
2006	0.26	0.21	0.33	0.45	0.34	0.31	0.38
2007	0.26	0.21	0.33	0.45	0.34	0.31	0.38
2008	0.26	0.21	0.33	0.45	0.34	0.31	0.38
2009	0.26	0.21	0.33	0.45	0.34	0.31	0.38
2010	0.26	0.21	0.33	0.45	0.34	0.31	0.38
2011	0.26	0.21	0.33	0.45	0.34	0.31	0.38

* Weighting Scheme: Hudson (0.13); Delaware (0.09); Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

Table B8.19. Summaries of tag-based estimates of annual natural mortality for striped bass ≥18 inches, using the IRCR model, with the unweighted average for coastal programs, the weighted average for producer areas, and 95% confidence intervals.

Coast Programs

Year	MADFW	NYOHS/TRL*	NJDB	NCCOOP	Unweighted average	lower 95% CI	upper 95% CI
1987							
1988		0.23		0.21	0.22	0.18	0.20
1989		0.23	0.11	0.21	0.19	0.16	0.17
1990		0.23	0.11	0.21	0.19	0.16	0.17
1991		0.23	0.11	0.21	0.19	0.16	0.17
1992	0.11	0.23	0.11	0.21	0.17	0.14	0.16
1993	0.11	0.23	0.11	0.21	0.17	0.14	0.16
1994	0.11	0.23	0.11	0.21	0.17	0.14	0.16
1995	0.11	0.23	0.11	0.21	0.17	0.14	0.16
1996	0.11	0.23	0.11	0.21	0.17	0.14	0.16
1997	0.11	0.23	0.11	0.21	0.17	0.14	0.16
1998	0.11	0.23	0.11	0.21	0.17	0.14	0.16
1999	0.20	0.38	0.11	0.21	0.23	0.21	0.24
2000	0.20	0.38	0.11	0.46	0.29	0.27	0.30
2001	0.20	0.38	0.11	0.46	0.29	0.27	0.30
2002	0.20	0.38	0.27	0.46	0.33	0.31	0.34
2003	0.20	0.38	0.27	0.46	0.33	0.31	0.34
2004	0.20	0.38	0.27	0.46	0.33	0.31	0.34
2005	0.20	0.38	0.27	0.46	0.33	0.31	0.34
2006	0.20	0.38	0.27	0.46	0.33	0.31	0.34
2007	0.20	0.38	0.27	0.46	0.33	0.31	0.34
2008	0.20	0.43*	0.27	0.46	0.34	0.33	0.36
2009	0.20	0.43*	0.27	0.46	0.34	0.33	0.36
2010	0.20	0.43*	0.27	0.46	0.34	0.33	0.36
2011	0.20	0.43*	0.27	0.46	0.34	0.33	0.36

* NY OHS 1988-2007, NY TRL 2008-2012

Table B8.19 cont.

Producer Area Programs

Year	HUDSON	DE/PA	MDCB	VARAP	Weighted average*	lower 95% CI	upper 95% CI
1987			0.17		0.12	0.11	0.12
1988	0.13		0.17		0.13	0.13	0.14
1989	0.13		0.17		0.13	0.13	0.14
1990	0.13		0.17	0.38	0.21	0.19	0.22
1991	0.13		0.17	0.38	0.21	0.19	0.22
1992	0.13		0.17	0.38	0.21	0.19	0.22
1993	0.13	0.23	0.17	0.38	0.23	0.21	0.24
1994	0.13	0.23	0.17	0.38	0.23	0.21	0.24
1995	0.13	0.23	0.17	0.38	0.23	0.21	0.24
1996	0.13	0.23	0.17	0.38	0.23	0.21	0.24
1997	0.13	0.23	0.17	0.38	0.23	0.21	0.24
1998	0.13	0.23	0.17	0.59	0.28	0.26	0.30
1999	0.13	0.23	0.45	0.59	0.42	0.39	0.45
2000	0.13	0.23	0.45	0.59	0.42	0.39	0.45
2001	0.13	0.23	0.45	0.59	0.42	0.39	0.45
2002	0.32	0.23	0.45	0.59	0.45	0.42	0.48
2003	0.32	0.23	0.45	0.59	0.45	0.42	0.48
2004	0.32	0.37	0.45	0.59	0.46	0.43	0.49
2005	0.32	0.37	0.45	0.59	0.46	0.43	0.49
2006	0.32	0.37	0.45	0.59	0.46	0.43	0.49
2007	0.32	0.37	0.45	0.59	0.46	0.43	0.49
2008	0.32	0.37	0.45	0.59	0.46	0.43	0.49
2009	0.32	0.37	0.45	0.59	0.46	0.43	0.49
2010	0.32	0.37	0.45	0.59	0.46	0.43	0.49
2011	0.32	0.37	0.45	0.59	0.46	0.43	0.49

* Weighting Scheme: Hudson (0.13); Delaware (0.09);
Chesapeake Bay (0.78), where MD (0.67) and VA (0.33).

Table B8.20. Coast-wide fishing mortality rates, presented as an unweighted average of producer and coastal programs' means, using the IRCR model, and coast-wide stock size estimates for age 3+ and 7+ obtained via "Kill = F * Stock Size".

Instantaneous Rates Method

Year	Fishing Mortality	Age 3+ Kill includes discards	Total Stock Size Thousands	Year	Fishing Mortality	Age 7+ Kill includes discards	Total Stock Size Thousands
1988	0.01	419.6	30,626	1988	0.03	100.9	3,145
1989	0.01	451.3	37,418	1989	0.03	94.3	3,571
1990	0.07	870.0	12,421	1990	0.12	198.1	1,718
1991	0.09	924.7	10,760	1991	0.16	257.0	1,591
1992	0.09	961.1	10,465	1992	0.10	217.0	2,246
1993	0.10	1,388.6	14,375	1993	0.12	307.6	2,485
1994	0.10	1,765.5	18,549	1994	0.12	367.7	3,180
1995	0.14	2,515.8	17,976	1995	0.20	617.0	3,119
1996	0.15	3,210.3	21,773	1996	0.22	746.5	3,371
1997	0.17	4,090.7	24,613	1997	0.23	1,477.8	6,532
1998	0.17	4,136.2	23,883	1998	0.24	1,260.0	5,263
1999	0.16	3,809.8	24,336	1999	0.23	1,297.6	5,726
2000	0.13	4,892.9	38,611	2000	0.14	1,591.5	11,046
2001	0.11	4,367.9	39,462	2001	0.14	1,759.5	12,946
2002	0.10	3,760.4	36,032	2002	0.14	1,662.3	12,083
2003	0.12	4,652.0	38,463	2003	0.14	2,304.4	16,215
2004	0.11	5,128.9	45,602	2004	0.13	2,451.9	18,235
2005	0.11	5,319.3	48,949	2005	0.13	2,215.1	16,450
2006	0.11	5,874.5	52,813	2006	0.12	2,232.8	17,884
2007	0.10	5,452.1	54,878	2007	0.13	2,458.4	19,317
2008	0.11	4,785.3	45,483	2008	0.13	2,394.5	18,918
2009	0.12	4,305.6	36,893	2009	0.13	1,747.6	13,211
2010	0.11	3,751.6	34,917	2010	0.12	1,882.5	15,795
2011	0.11	4,003.3	35,753	2011	0.12	2,219.6	19,087

Table B8.21. Year specific and three year moving average estimates of tag reporting rate calculated for the four producer area programs. Estimates are displayed based on disposition (harvest or catch and release) of the fish at time of recapture. Tag reporting rate for all producer programs and both recapture dispositions is fixed at 0.43 for all years prior to 2000.

State	Lambda type *	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
						Harvest							
Delaware /	yr.	0.42	0.42	0.43	0.44	0.34	0.38	0.31	0.19	0.34	0.22	0.36	0.85
Pennsylvania	3 yr avg.	0.42	0.43	0.43	0.39	0.38	0.34	0.27	0.26	0.23	0.29	0.30	0.46
Maryland	yr.	0.45	0.49	0.51	0.48	0.46	0.46	0.39	0.36	0.45	0.43	0.44	0.53
	3 yr avg.	0.47	0.48	0.49	0.48	0.47	0.43	0.41	0.39	0.41	0.44	0.47	0.49
New York	yr.	0.47	0.50	0.54	0.59	0.56	0.56	0.66	0.63	0.51	0.57	0.63	0.67
	3 yr avg.	0.49	0.50	0.54	0.56	0.57	0.59	0.61	0.59	0.56	0.56	0.62	0.65
Virginia	yr.	0.48	0.54	0.59	0.64	0.66	0.64	0.74	0.68	0.64	0.53	0.74	0.59
	3 yr avg.	0.51	0.53	0.58	0.64	0.65	0.68	0.69	0.68	0.62	0.62	0.61	0.68

State	Lambda type *	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
						Catch and Release							
Delaware /	yr.	0.46	0.51	0.59	0.50	0.35	0.61	0.80	0.26	0.19	0.85	0.24	0.11
Pennsylvania	3 yr avg.	0.48	0.50	0.52	0.47	0.51	0.57	0.55	0.33	0.35	0.31	0.32	0.21
Maryland	yr.	0.47	0.49	0.56	0.62	0.49	0.57	0.61	0.85	0.85	0.54	0.38	0.66
	3 yr avg.	0.48	0.50	0.55	0.56	0.56	0.55	0.64	0.72	0.74	0.50	0.50	0.49
New York	yr.	0.48	0.52	0.56	0.63	0.67	0.65	0.73	0.59	0.74	0.78	0.85	0.73
	3 yr avg.	0.50	0.52	0.58	0.62	0.65	0.68	0.66	0.69	0.69	0.78	0.79	0.80
Virginia	yr.	0.47	0.51	0.56	0.64	0.55	0.75	0.80	0.52	0.46	0.63	0.60	0.40
	3 yr avg.	0.49	0.50	0.56	0.58	0.62	0.67	0.63	0.57	0.53	0.56	0.57	0.53

* yr. - year specific tag reporting rate
    3 yr avg. - three year moving average

Table B8.22. Estimated tag reporting rates for the combined data of the Delaware / Pennsylvania, Maryland and Virginia producer programs, the New York producer program, and the combined coastal tag programs. Year specific and three year moving average estimates are displayed based on disposition (harvest or catch and release) of the fish at time of recapture. Tag reporting rate for all programs and both recapture dispositions is fixed at 0.43 for all years prior to 2000.

							Harvest						
State	Lambda type *	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
DE/MD/VA	yr.	0.46	0.50	0.53	0.52	0.52	0.51	0.46	0.51	0.51	0.46	0.53	0.61
	3 yr avg.	0.48	0.49	0.52	0.52	0.52	0.50	0.49	0.49	0.49	0.49	0.52	0.56
New York	yr.	0.47	0.50	0.54	0.59	0.56	0.56	0.66	0.63	0.51	0.57	0.63	0.67
	3 yr avg.	0.49	0.50	0.54	0.56	0.57	0.59	0.61	0.59	0.56	0.56	0.62	0.65
Coastal	yr.	0.44	0.45	0.46	0.47	0.48	0.49	0.50	0.51	0.51	0.51	0.51	0.51

							Catch and Release						
State	Lambda type *	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
DE/MD/VA	yr.	0.47	0.50	0.55	0.62	0.51	0.65	0.70	0.58	0.53	0.59	0.42	0.47
	3 yr avg.	0.48	0.50	0.55	0.56	0.59	0.61	0.64	0.61	0.57	0.50	0.48	0.44
New York	yr.	0.48	0.52	0.56	0.63	0.67	0.65	0.73	0.59	0.74	0.78	0.85	0.73
	3 yr avg.	0.50	0.52	0.58	0.62	0.65	0.68	0.66	0.69	0.69	0.78	0.79	0.80
Coastal	yr.	0.47	0.50	0.54	0.57	0.61	0.65	0.68	0.72	0.72	0.72	0.72	0.72

   * yr. - year specific tag reporting rate
     3 yr avg. - three year moving average

Table B8.23. Akaike weights used to derive model averaged parameter estimates using the IRCR model for male striped bass 18-28 inches in Chesapeake Bay (see Table B8.1 for model descriptions).

Model	CB 18-28"
1	**0.999**
2	0.000
3	0.001
4	0.000
5	0.000
6	0.000

Table B8.24. R/M estimates of exploitation (u) of 18-28 inch male striped bass from tagging programs in Chesapeake Bay (adjusted for hooking mortality rate of 0.09 and reporting rate of 0.64).

Year	u
1987	0.01
1988	0.01
1989	0.00
1990	0.03
1991	0.05
1992	0.09
1993	0.07
1994	0.08
1995	0.09
1996	0.08
1997	0.08
1998	0.09
1999	0.06
2000	0.06
2001	0.08
2002	0.07
2003	0.06
2004	0.06
2005	0.05
2006	0.07
2007	0.05
2008	0.05
2009	0.08
2010	0.04
2011	0.08

Table B8.25. Estimates of instantaneous fishing mortality (F), instantaneous natural mortality (M), survival (S) and tag mortality (F') of 18-28 inch male striped bass in Chesapeake Bay using a two-M period (1987-1996 and 1997-2011) IRCR model and a tag reporting rate of 0.64.

Year	F	M	S	F'
1987	0.00	0.26	0.77	0.07
1988	0.01	0.26	0.76	0.06
1989	0.00	0.26	0.77	0.05
1990	0.05	0.26	0.73	0.07
1991	0.08	0.26	0.71	0.06
1992	0.13	0.26	0.67	0.09
1993	0.11	0.26	0.69	0.05
1994	0.10	0.26	0.70	0.07
1995	0.11	0.26	0.69	0.07
1996	0.08	0.26	0.71	0.06
1997	0.12	0.82	0.39	0.06
1998	0.16	0.82	0.37	0.08
1999	0.12	0.82	0.39	0.06
2000	0.11	0.82	0.39	0.09
2001	0.10	0.82	0.40	0.07
2002	0.11	0.82	0.39	0.06
2003	0.12	0.82	0.39	0.05
2004	0.11	0.82	0.39	0.05
2005	0.08	0.82	0.40	0.04
2006	0.11	0.82	0.39	0.06
2007	0.07	0.82	0.41	0.05
2008	0.07	0.82	0.41	0.04
2009	0.12	0.82	0.39	0.04
2010	0.05	0.82	0.42	0.02
2011	0.09	0.82	0.40	0.02

Table B8.26. Survival estimates from Program MARK and IRCR for Chesapeake Bay male fish 18-28 inches.

Chesapeake Bay

Year	s(t) r(t)	s(p6) r(t)	s(last2) r(p6)	IRCR
1987	0.95	0.95	0.86	0.77
1988	0.79	0.90	0.82	0.76
1989	1.01	0.89	0.82	0.77
1990	0.63	0.65	0.69	0.73
1991	0.73	0.66	0.70	0.71
1992	0.65	0.67	0.71	0.67
1993	0.56	0.65	0.69	0.69
1994	0.66	0.67	0.71	0.70
1995	0.54	0.52	0.51	0.69
1996	0.75	0.52	0.51	0.71
1997	0.50	0.50	0.50	0.39
1998	0.36	0.51	0.50	0.37
1999	0.40	0.50	0.49	0.39
2000	0.31	0.40	0.40	0.39
2001	0.40	0.40	0.40	0.40
2002	0.53	0.39	0.39	0.39
2003	0.62	0.39	0.38	0.39
2004	0.24	0.39	0.38	0.39
2005	0.34	0.39	0.38	0.40
2006	0.38	0.39	0.38	0.39
2007	0.32	0.29	0.30	0.41
2008	0.32	0.29	0.30	0.41
2009	0.43	0.29	0.30	0.39
2010	0.14	0.29	0.34	0.42
2011	0.02	0.29	0.34	0.40

FIGURES

Figure B4.1. Coastal migratory striped bass management area [East Coast of the United States, excluding the Exclusive Economic Zone (3-200 nautical miles offshore)]: coastal and estuarine areas of all states from Maine through North Carolina.
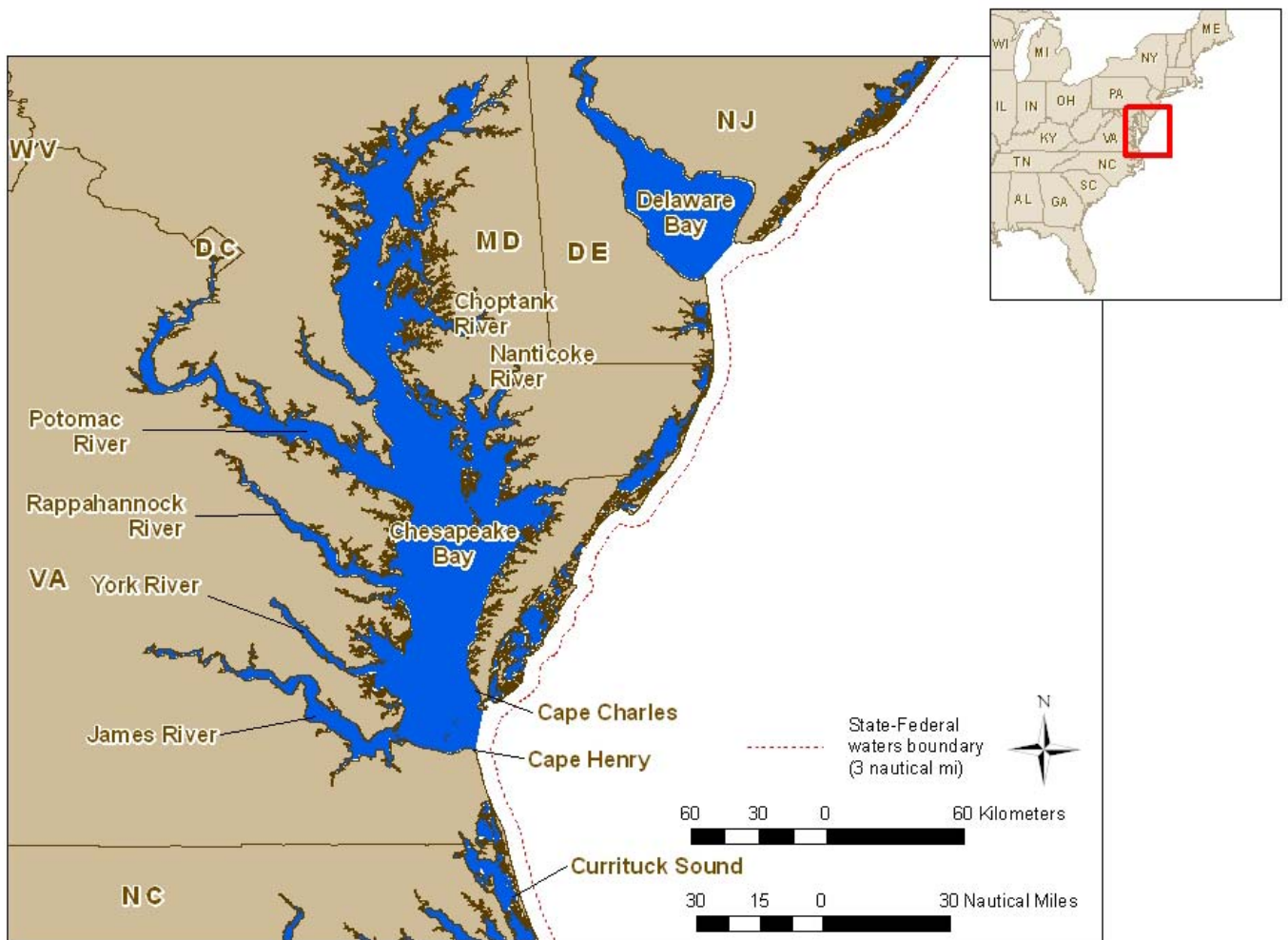
Figure B4.2. Geography of the Chesapeake Bay.
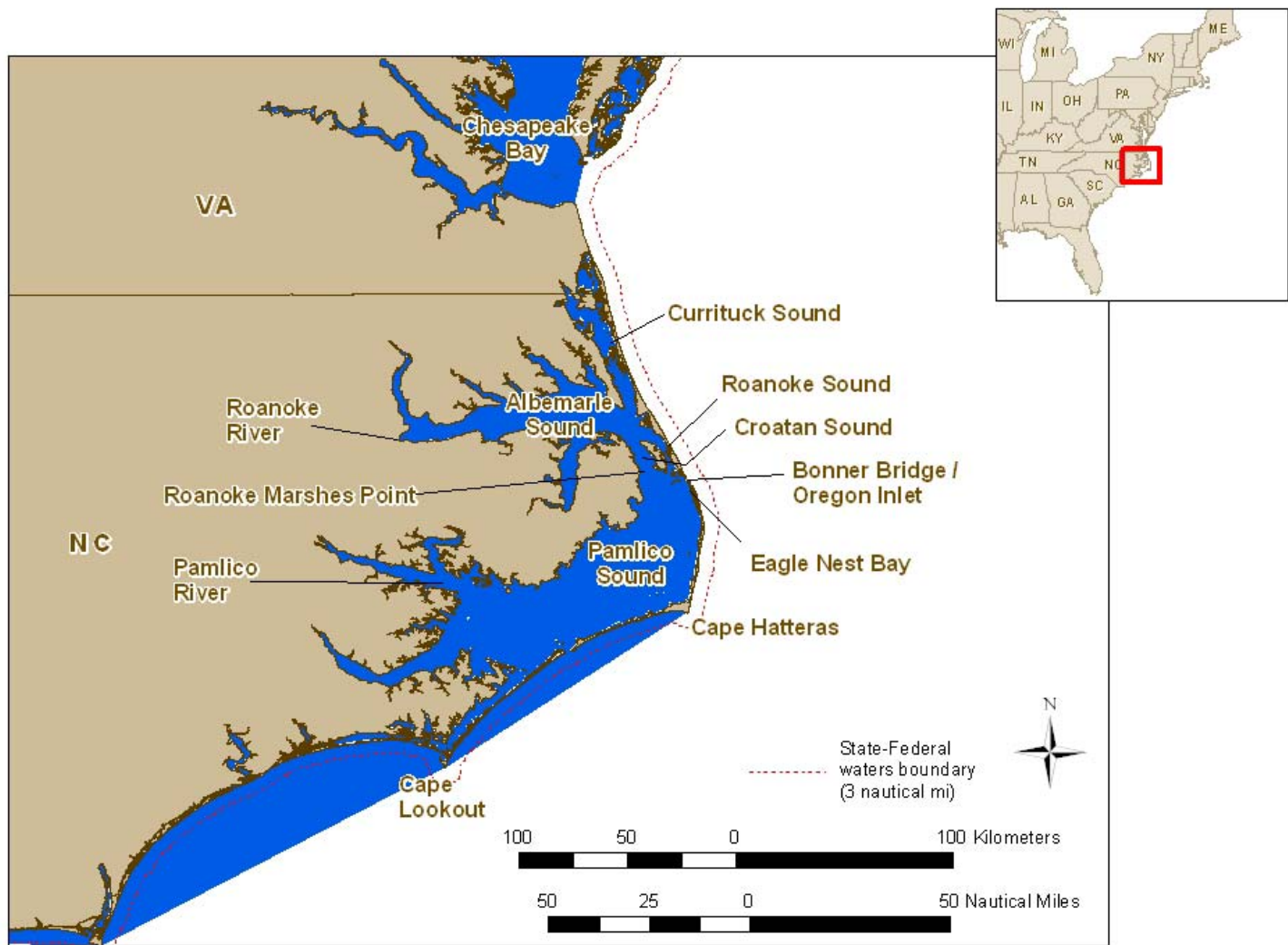
Figure B4.3. Geography of the Albemarle Sound-Roanoke River region.
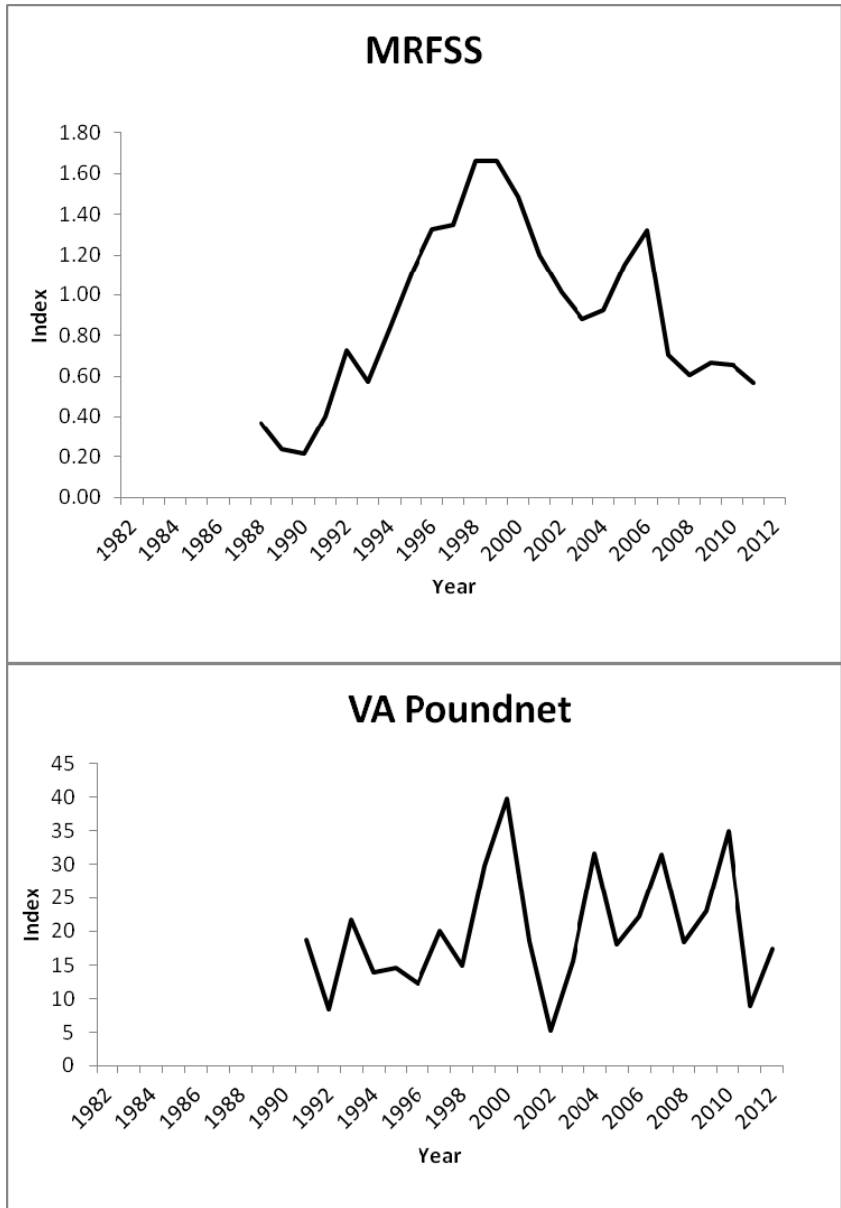
Figure B5.1. Fishery-dependent indices of relative abundance (aggregated), 1982-2012.
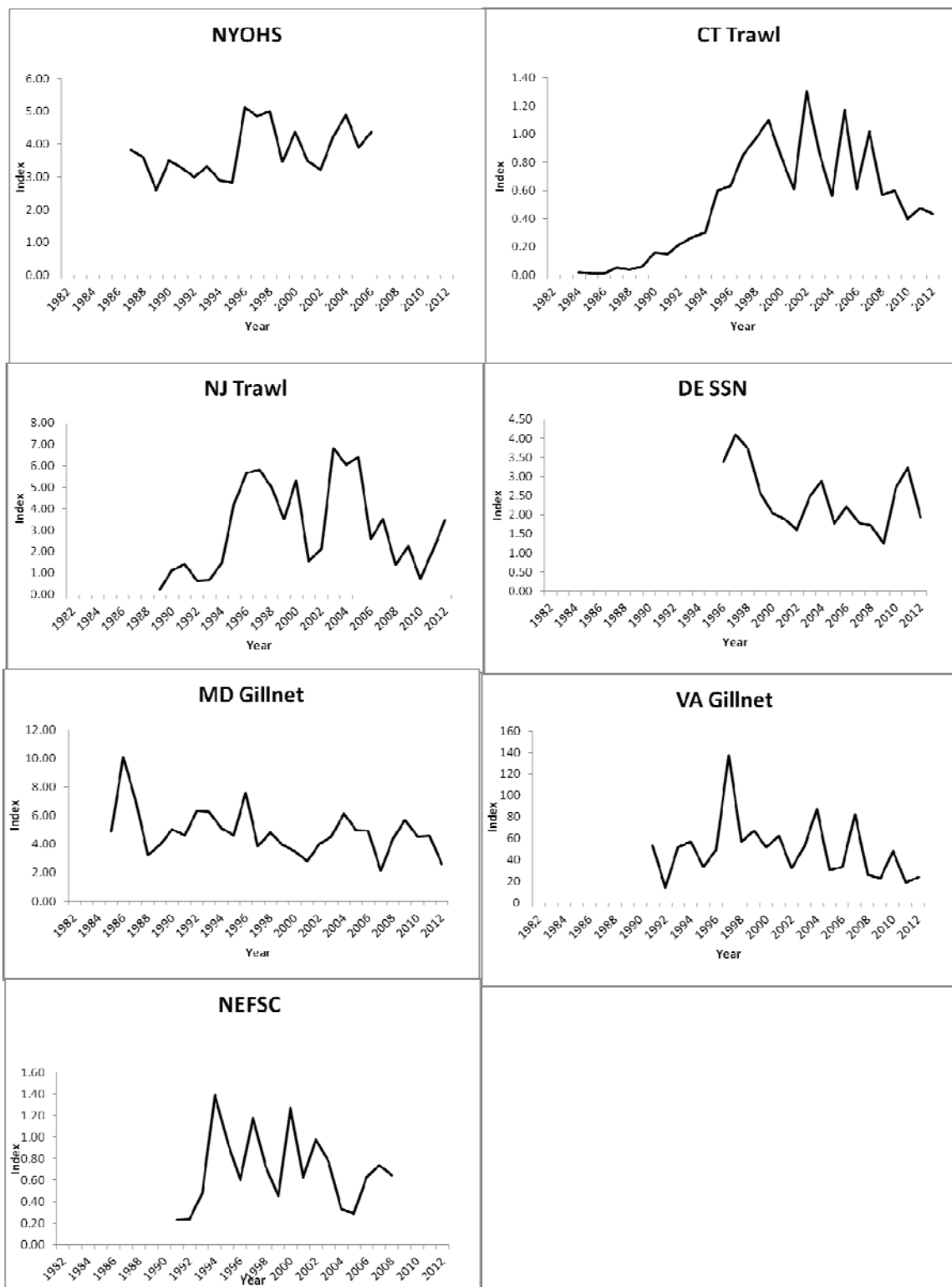
Figure B5.2. Fisheries-independent indices of relative abundance (aggregated), 1982-2012.
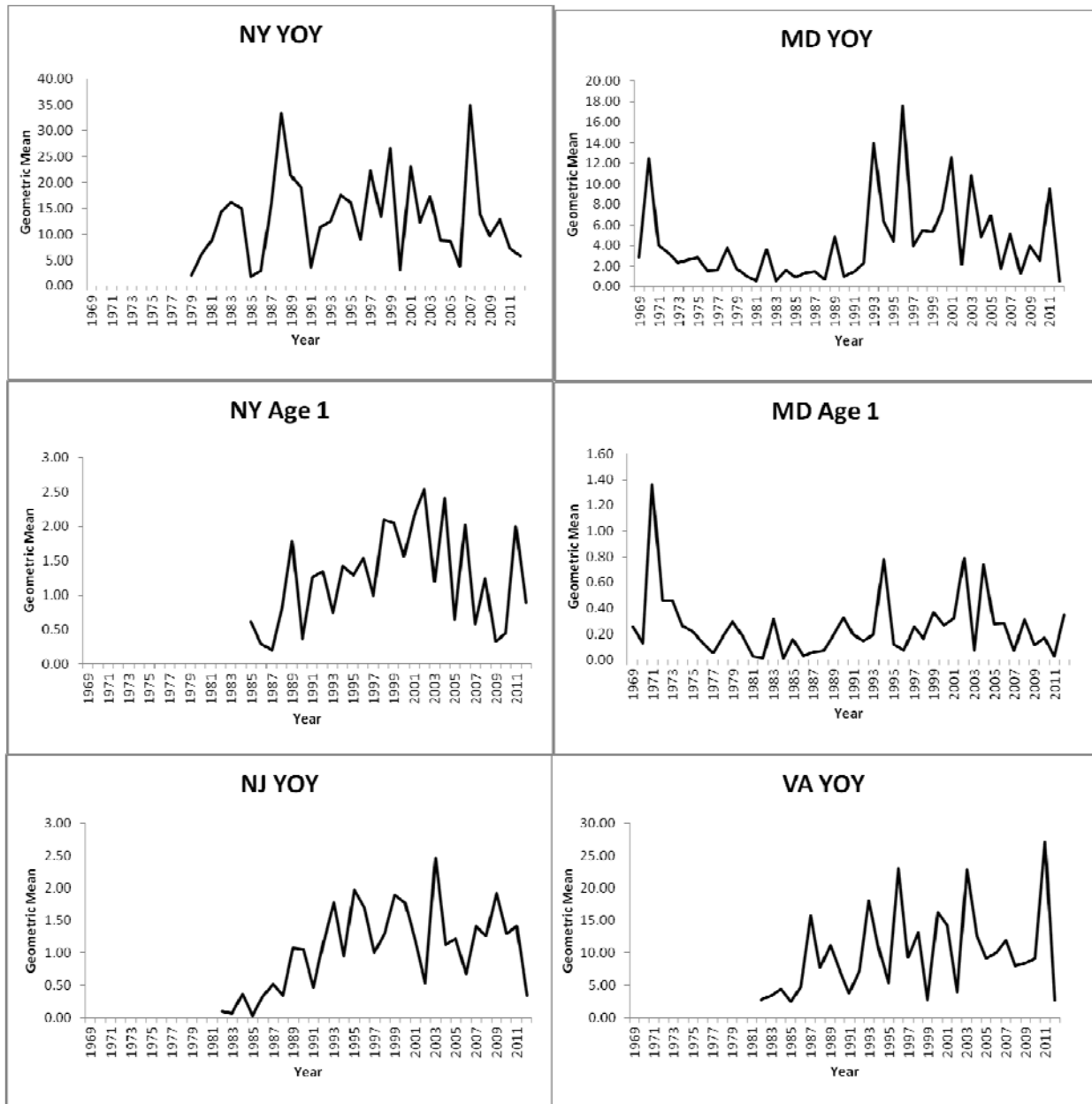
Figure B5.3. Fisheries-independent young-of-the-year and age 1 indices of relative abundance (unlagged), 1982-2012.
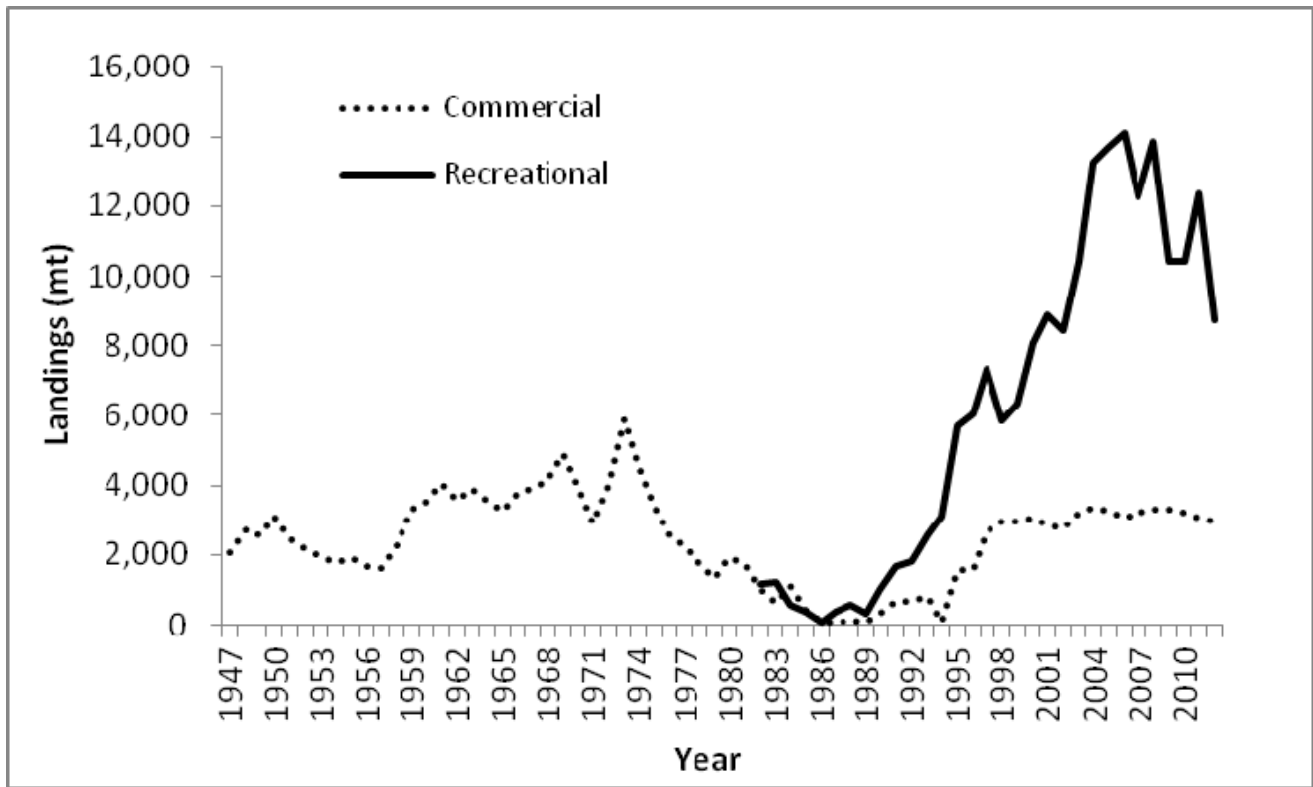
Figure B6.1. Total weight (metric tons) of harvested striped bass by the commercial and recreational fisheries from Maine to North Carolina
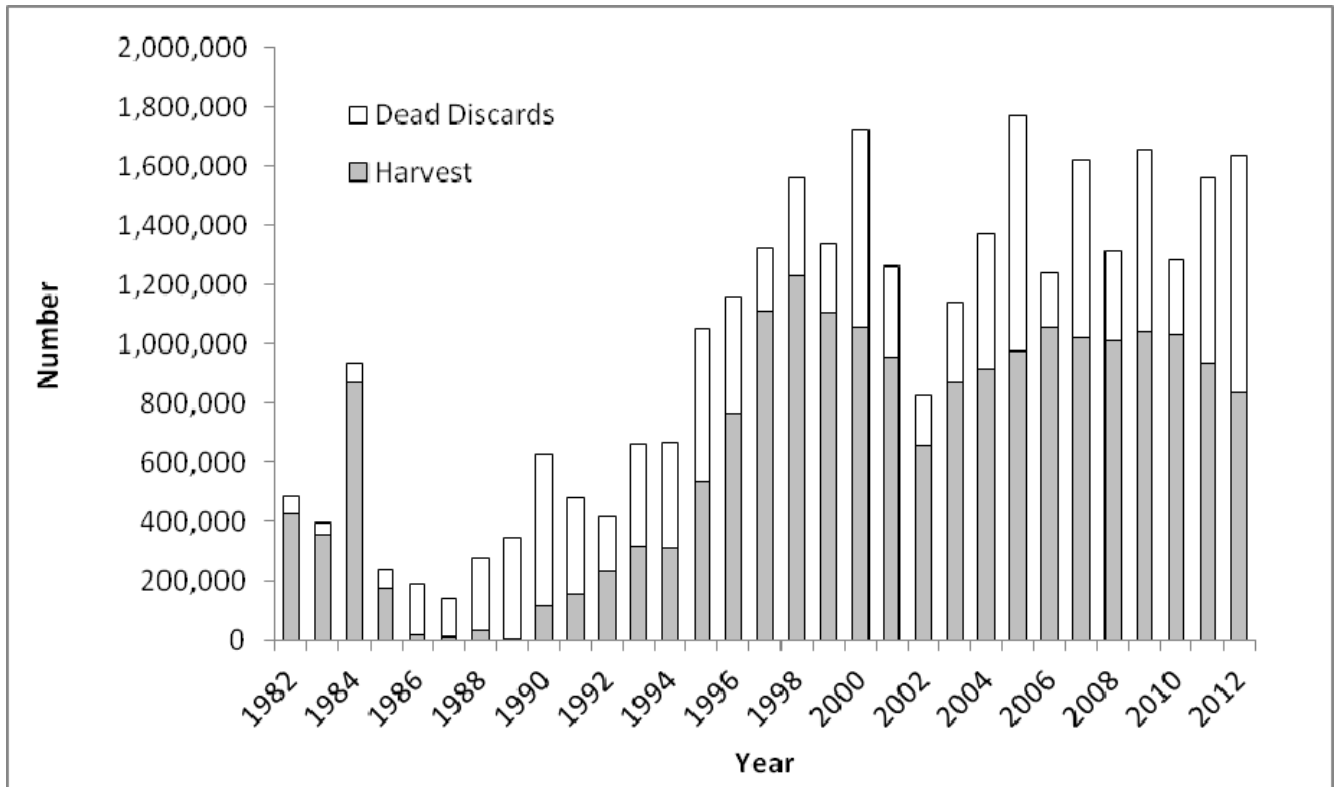
Figure B6.2. Total commercial removals (harvest and dead discards) of Atlantic striped bass, 1982-2012.
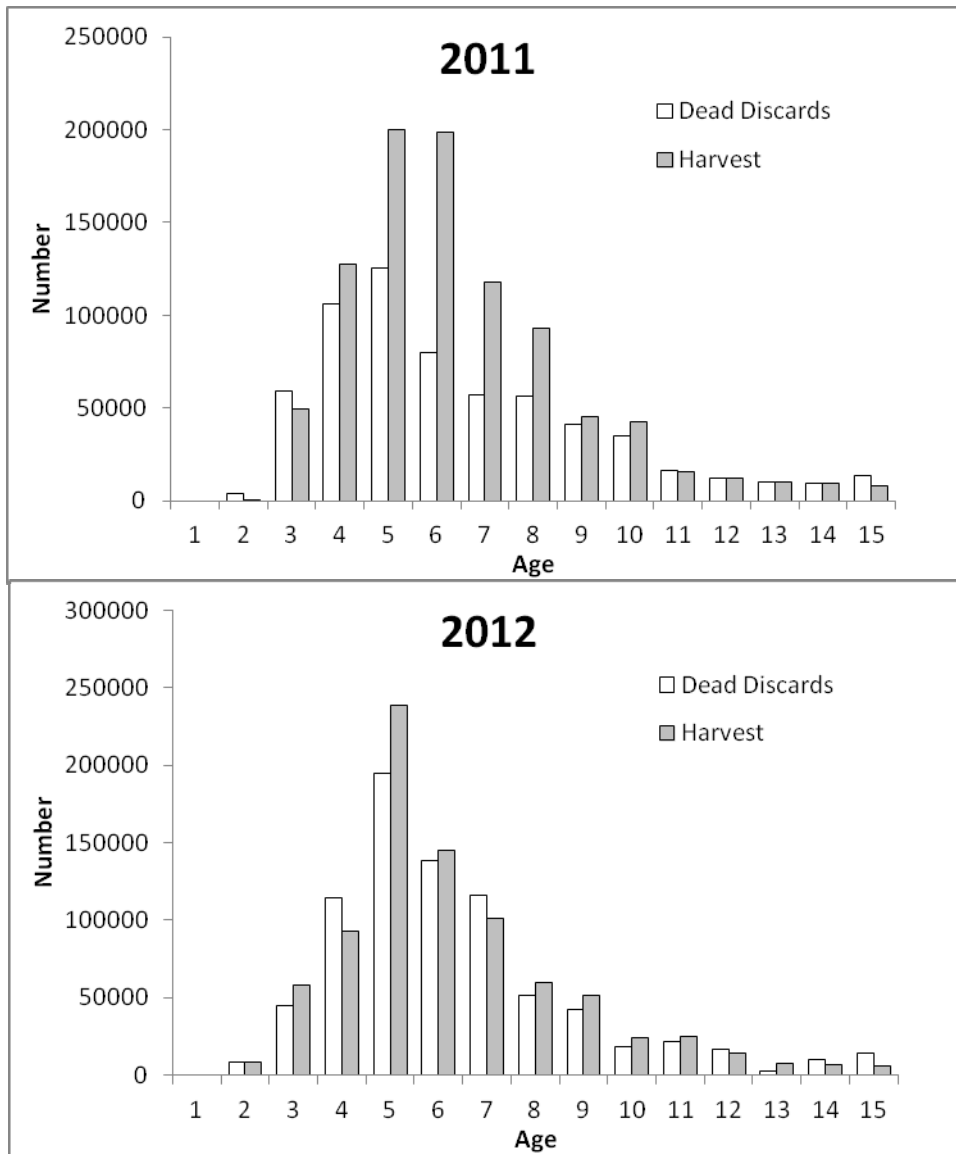
Figure B6.3. Total commercial removals (harvest and dead discards) by age of the Atlantic striped bass, 2011 and 2012
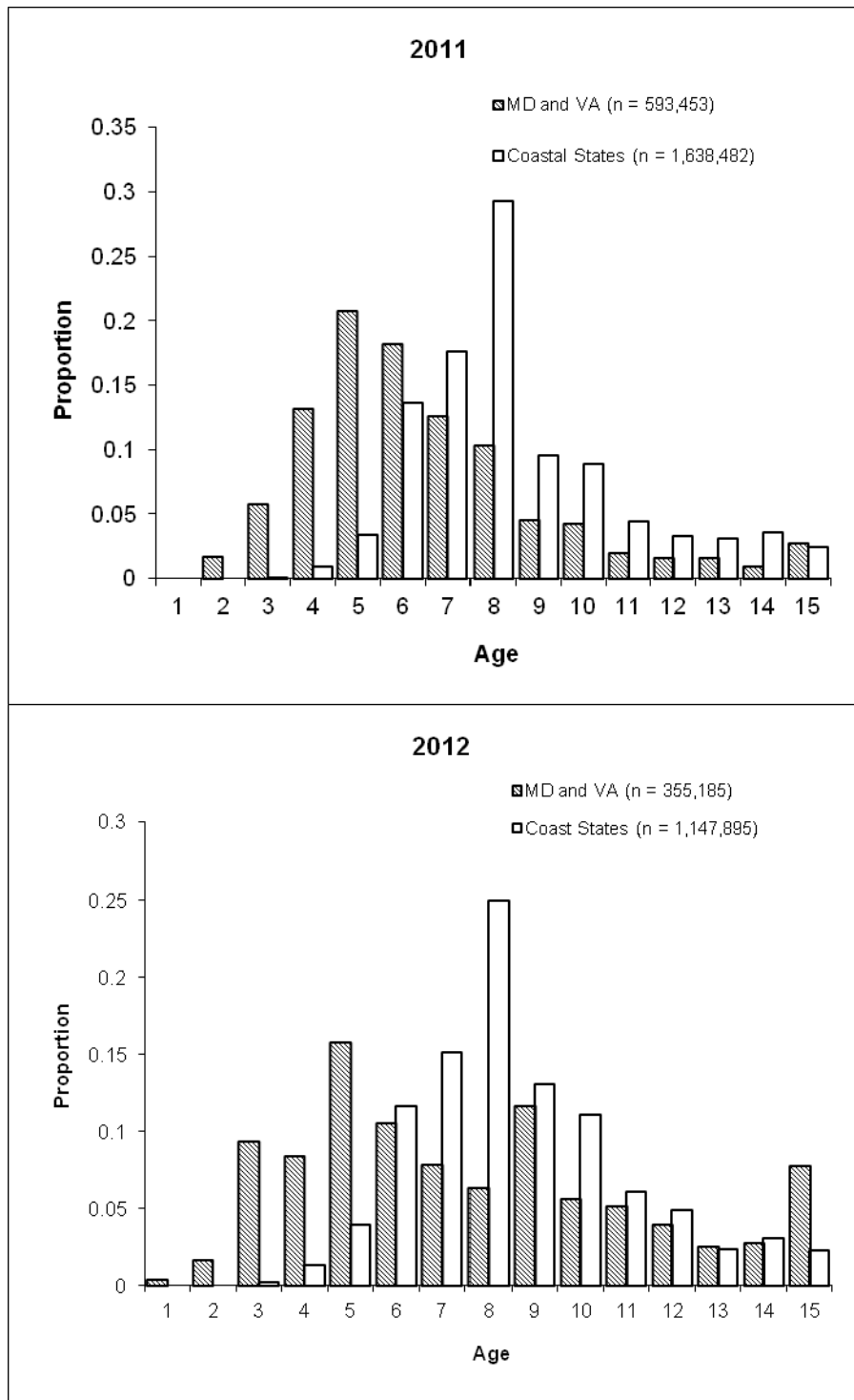
Figure B6.4. Comparison of age compositions from recreational harvest and dead release, 2011 and 2012.
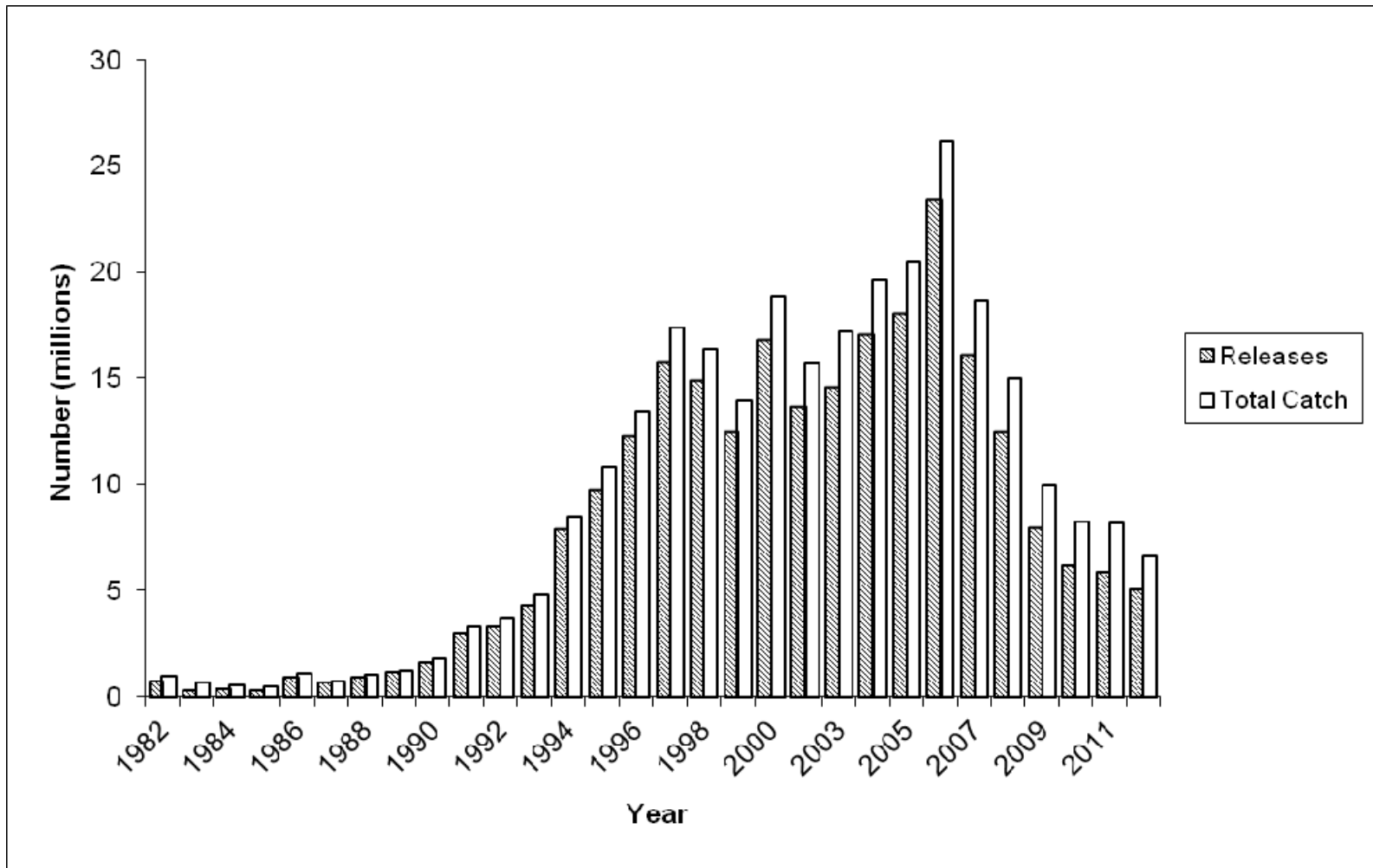
Figure B6.5. Comparison of the numbers of released striped bass to total catch.
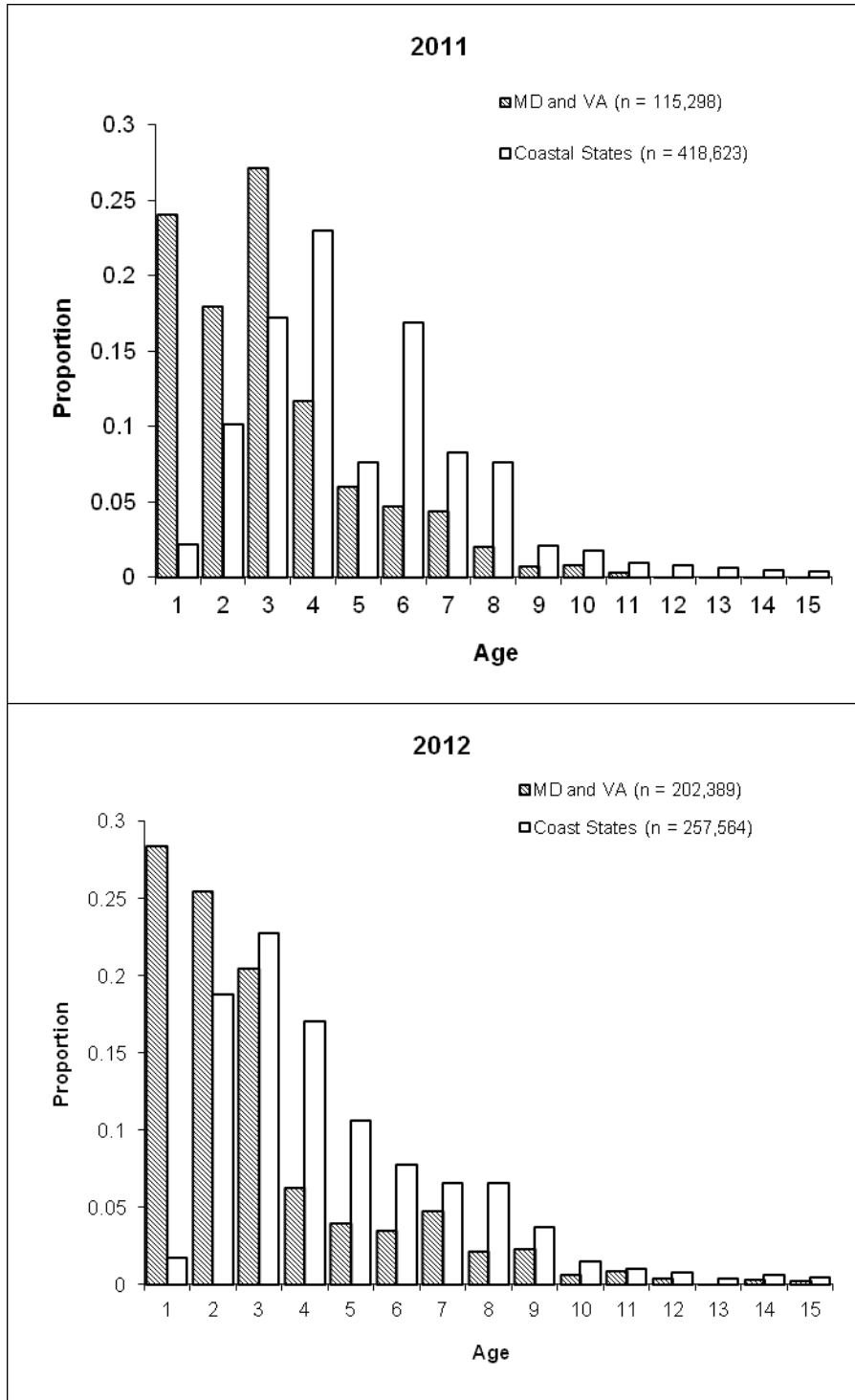
Figure B6.6. Comparison of age compositions of dead recreational discards between coast and Chesapeake Bay in 2011 and 2012.
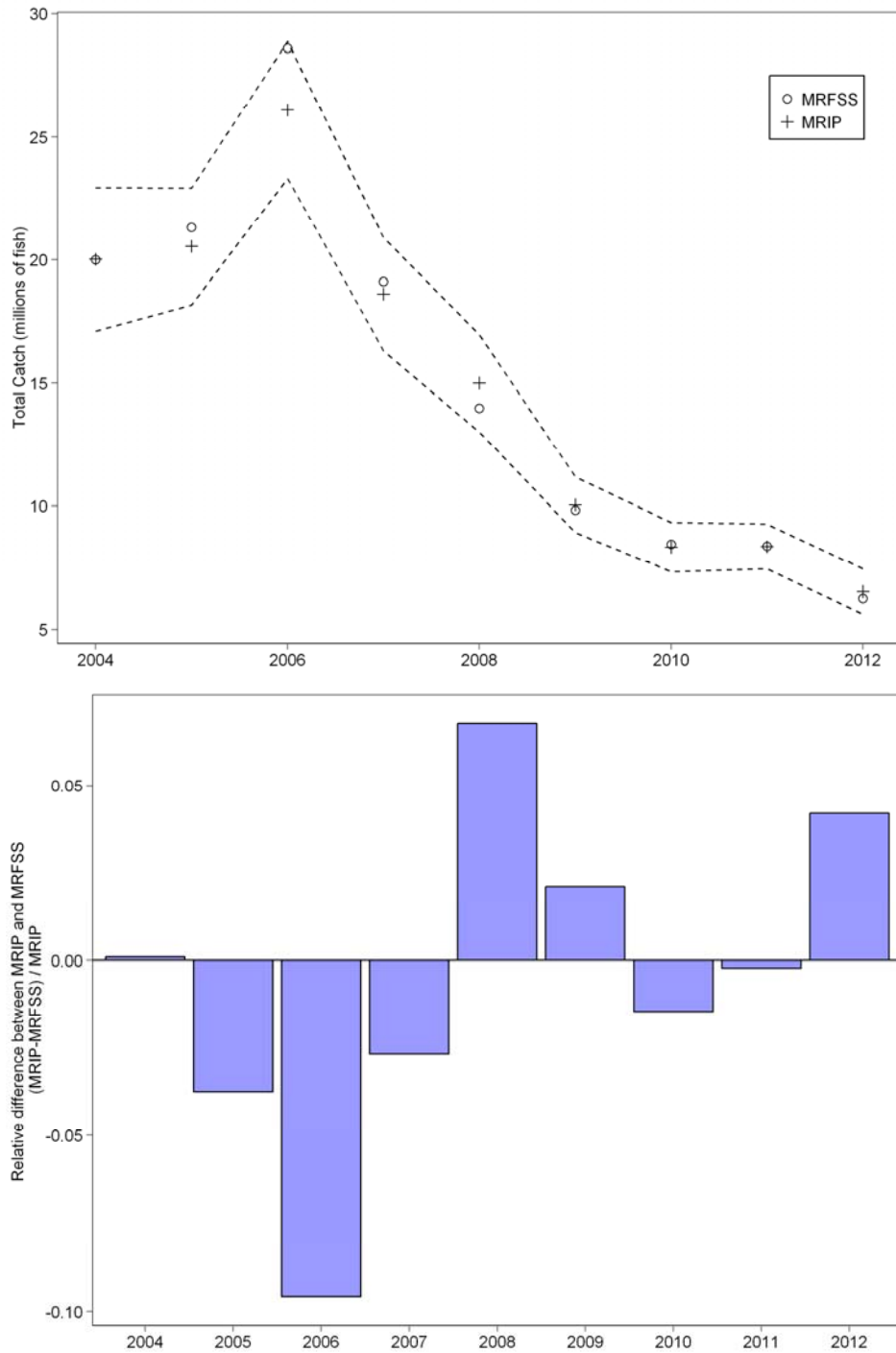
Figure B6.7. MRFSS and MRIP estimates of recreational total catch for the Atlantic coast (top panel) and relative difference between the two estimates (bottom panel). Dashed lines represent 95% confidence intervals for the MRIP estimates.
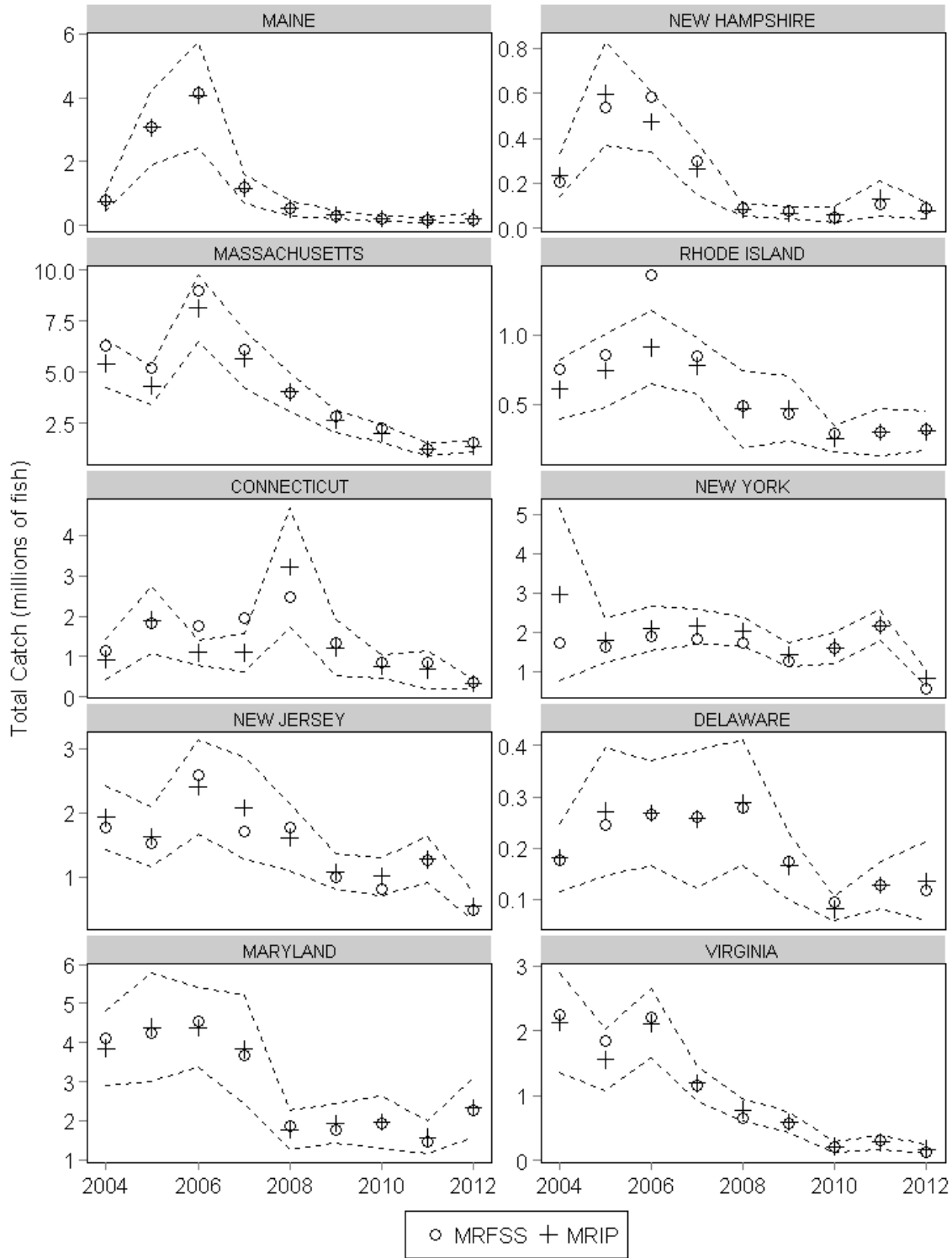
Figure B6.8. MRFSS and MRIP estimates of recreational total catch by state. Dashed lines represent 95% confidence intervals for the MRIP estimates.
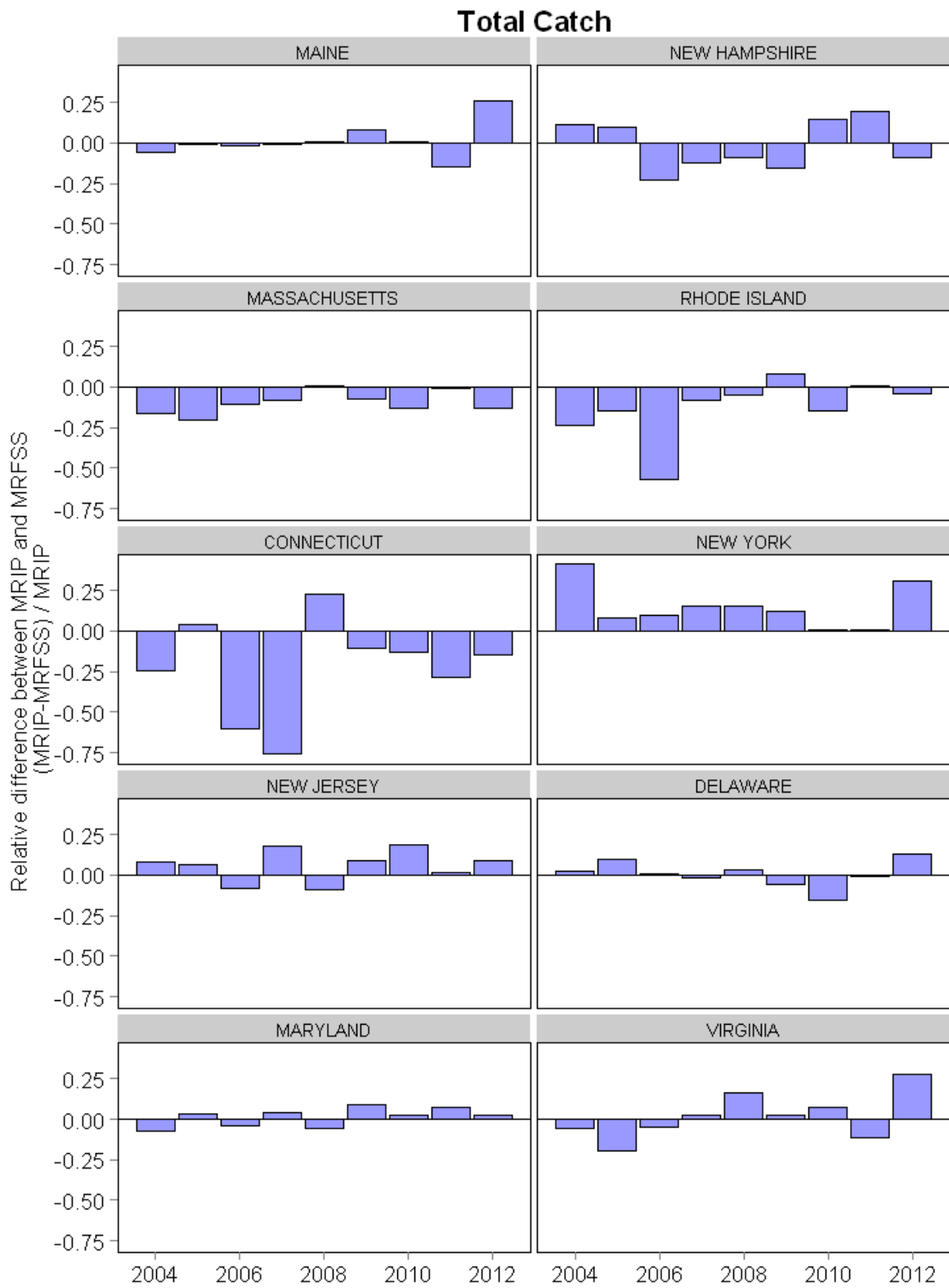
Total Catch

Figure B6.9. Relative differences between MRIP and MRFSS estimates of total recreational catch by state.
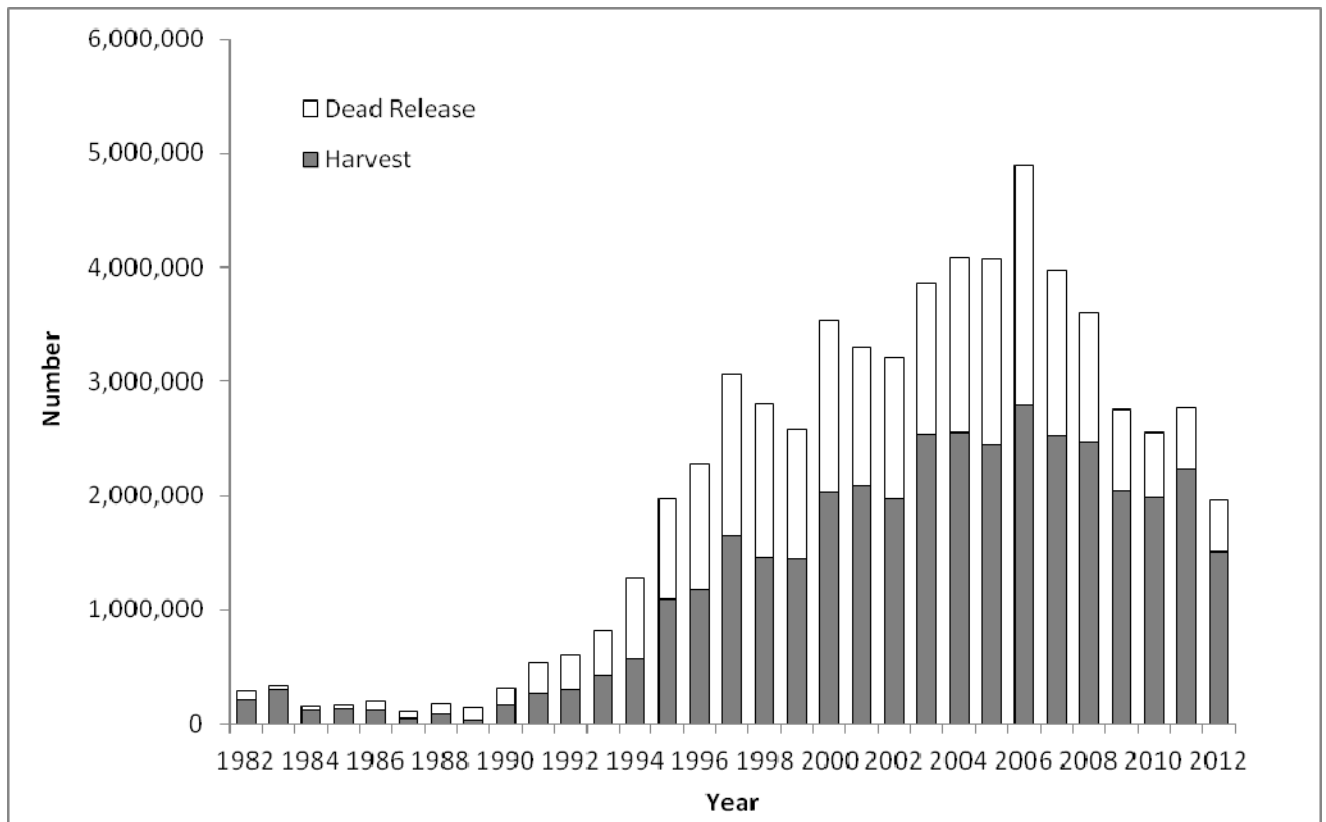
Figure B6.10. Total removals (Dead release and harvest) of striped bass by the recreational fishery, 1982-2012.
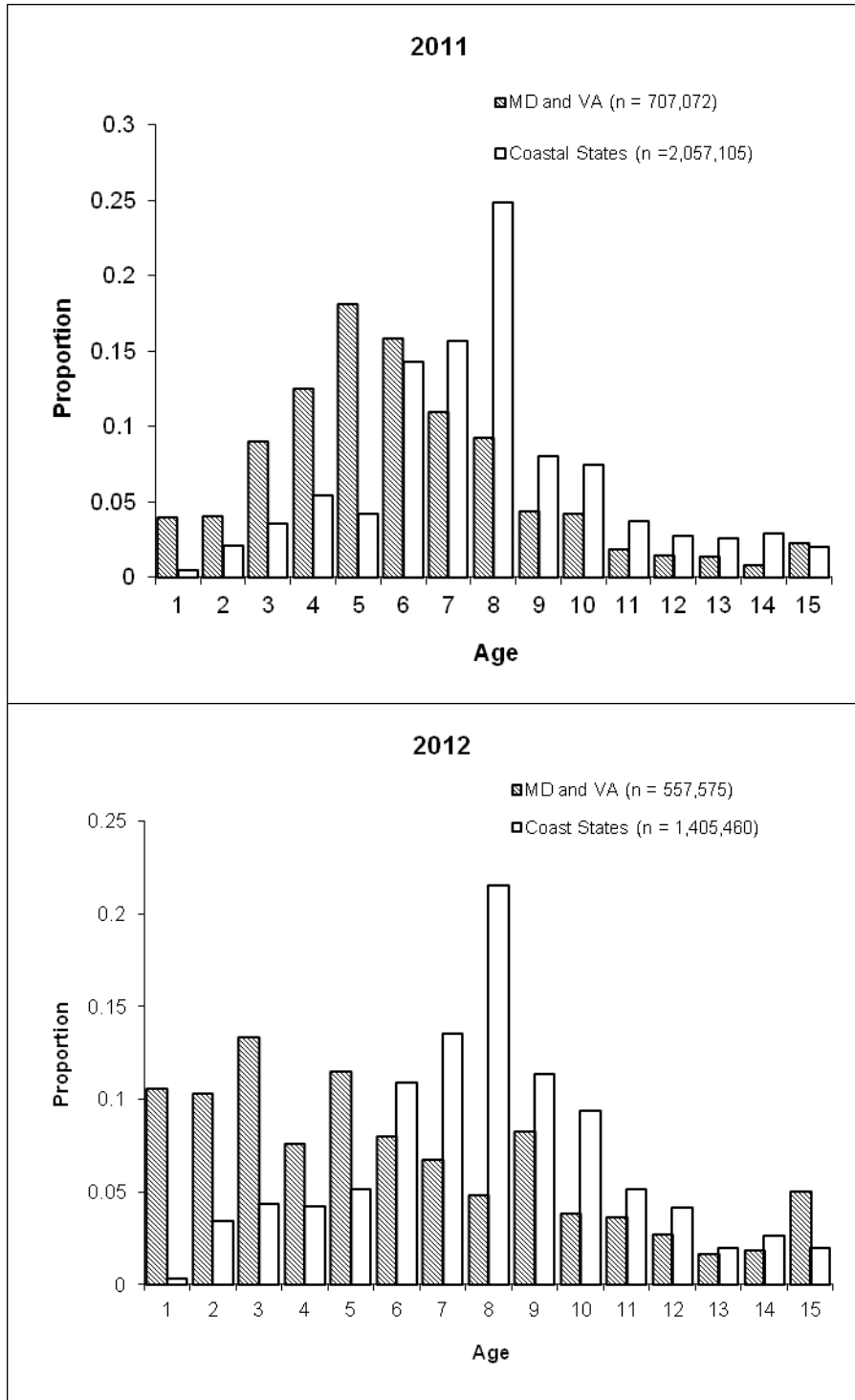
Figure B6.11. Total recreational removals (harvest and dead discards) by age and region, 2011 and 2012.
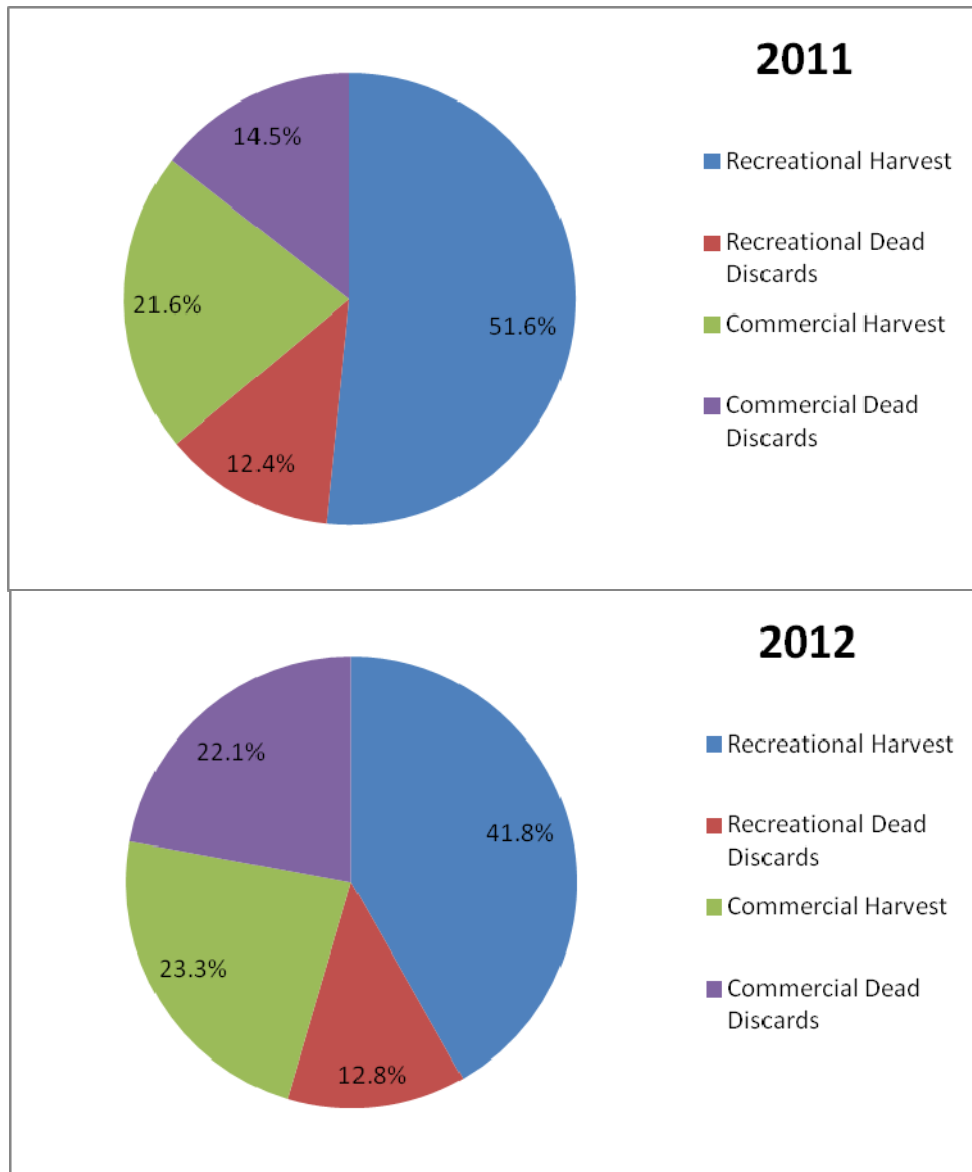
Figure B6.12. Percentage of 2011 and 2012 striped bass mortality by fishery component.
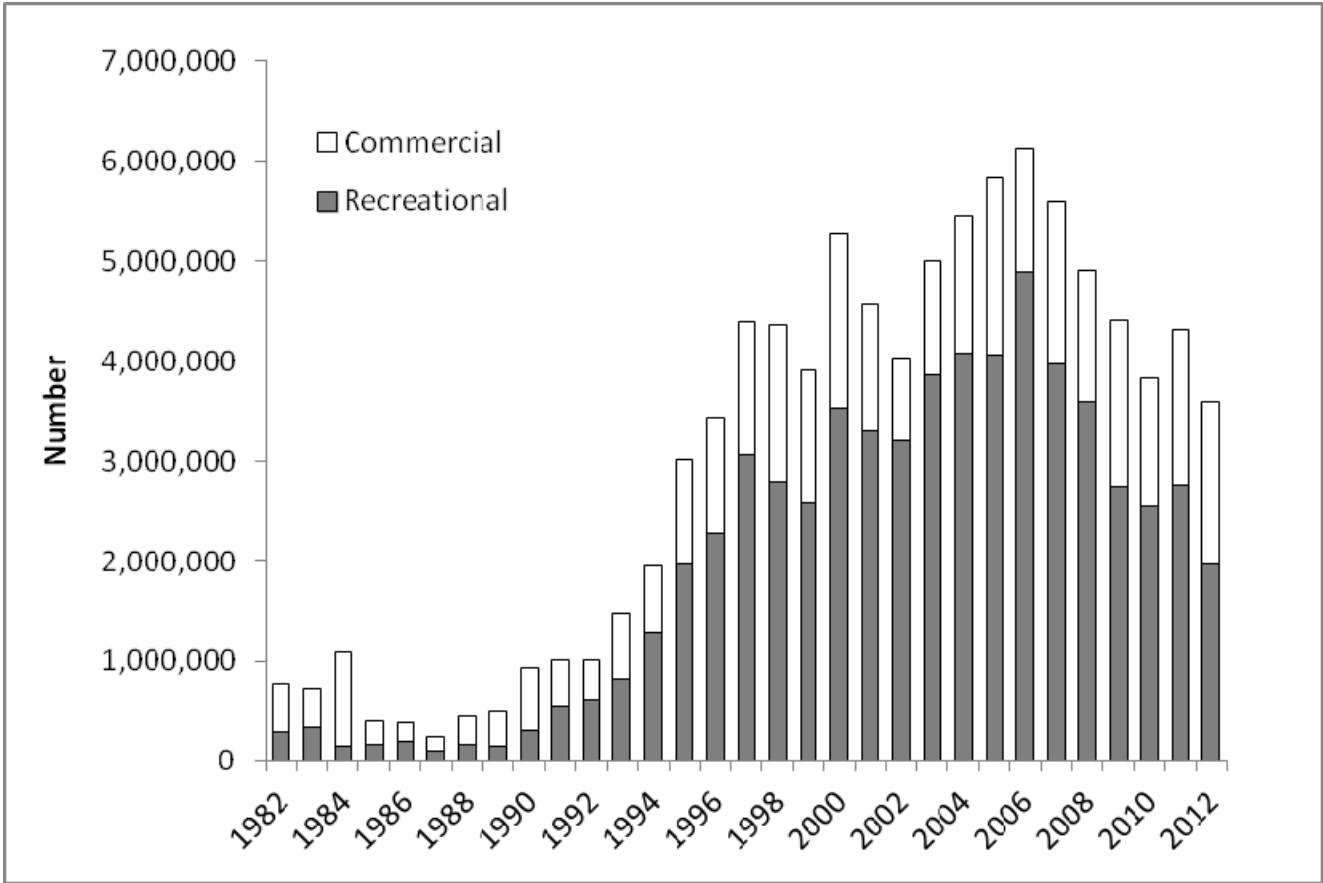
Figure B6.13. Total removals of striped bass partitioned into commercial and recreational contributions, 1982-2012.
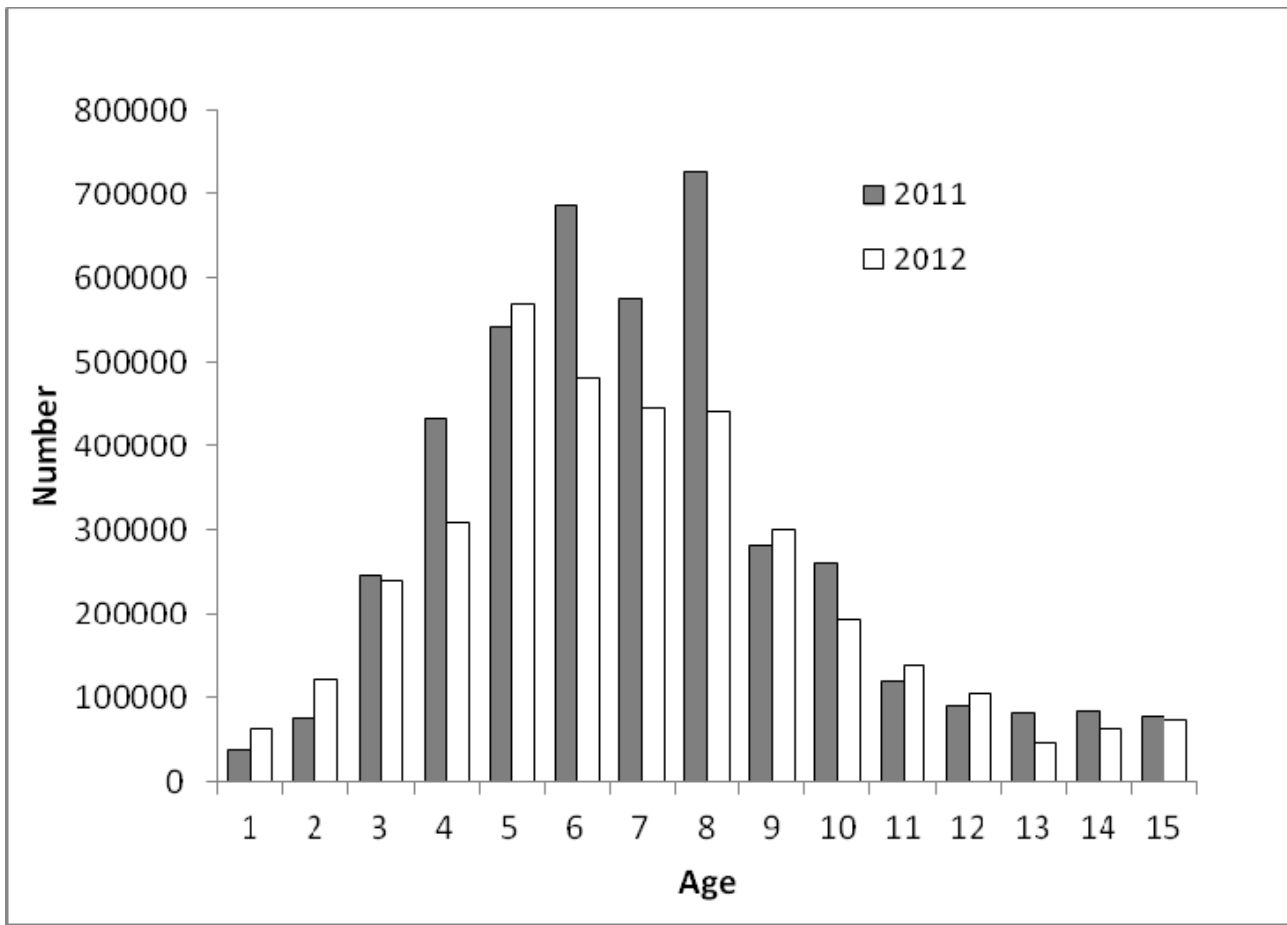
Figure B6.14. Age composition of total removals of striped in 2011 and 2012.
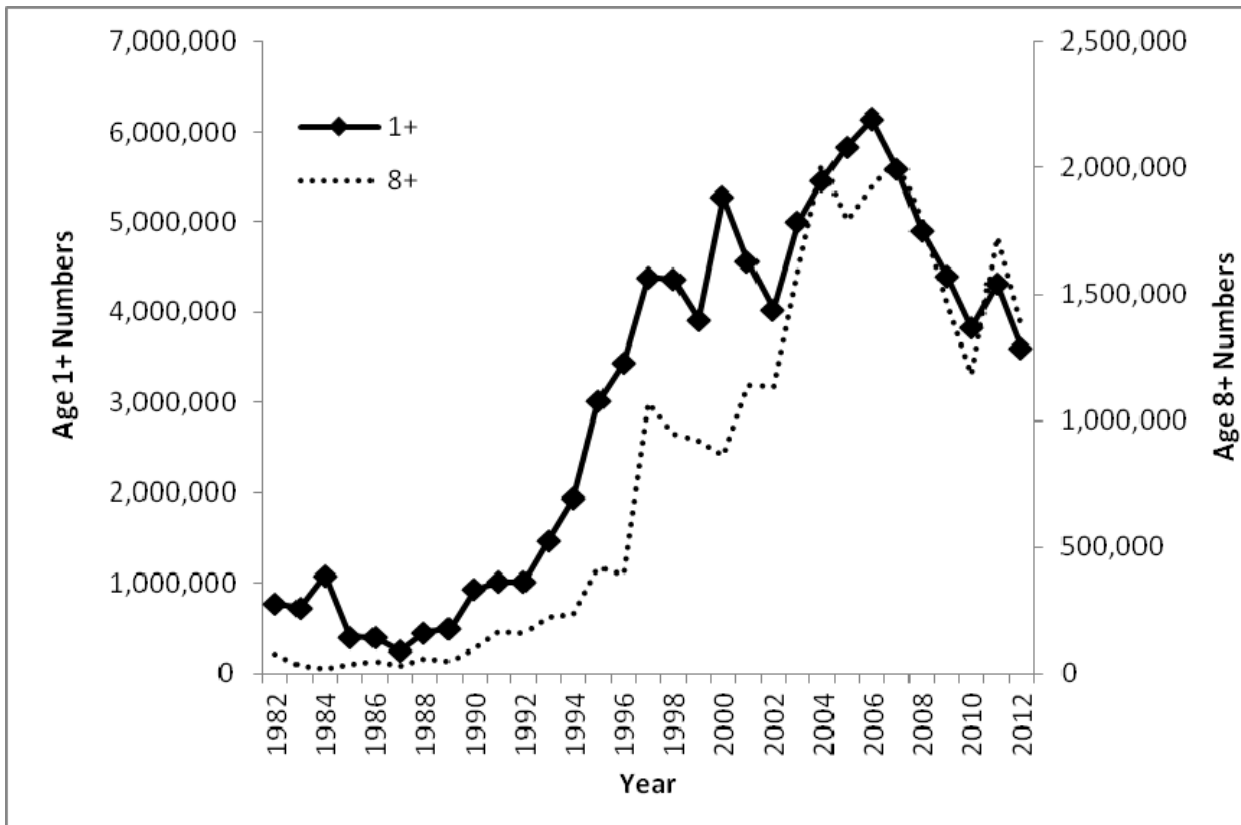
Figure B6.15. Total removals of striped bass by age group, 1982-2012.
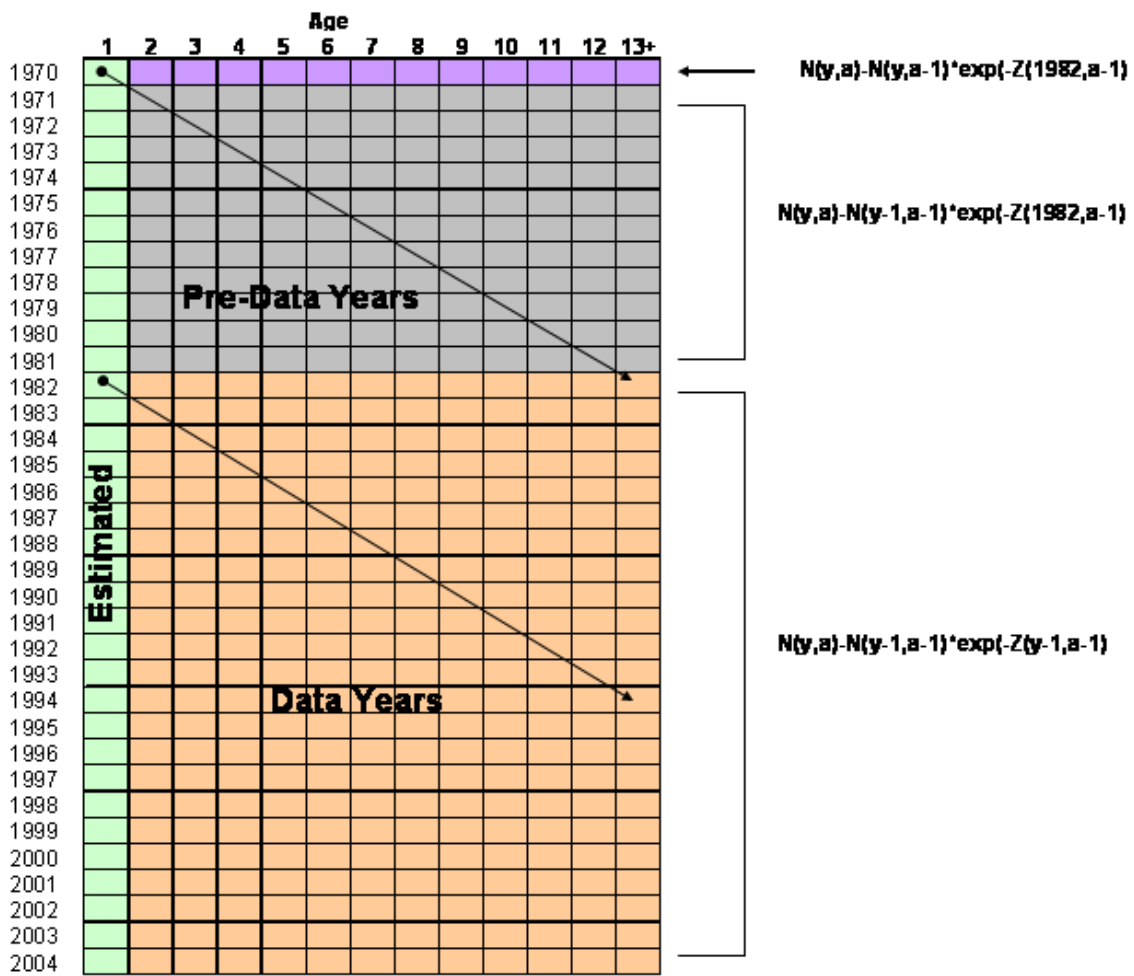
Figure B7.1. Schematic of population abundance-at-age
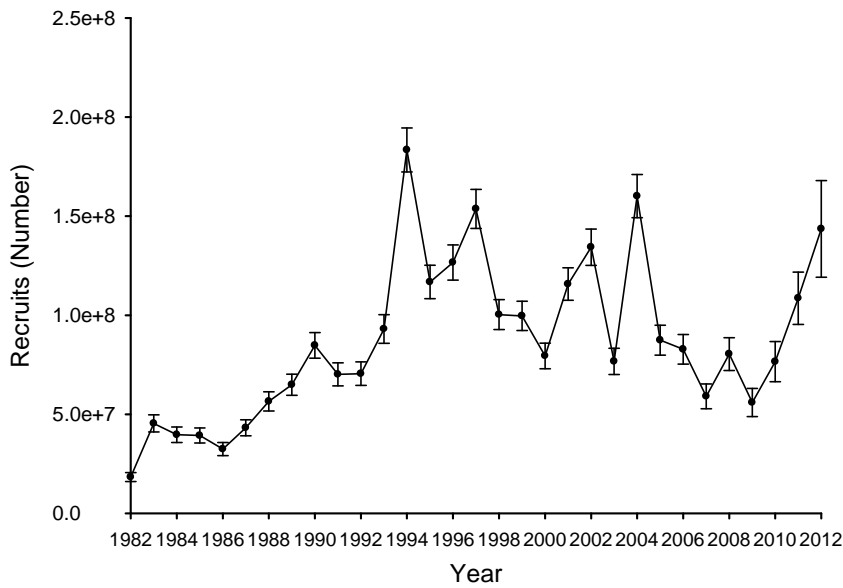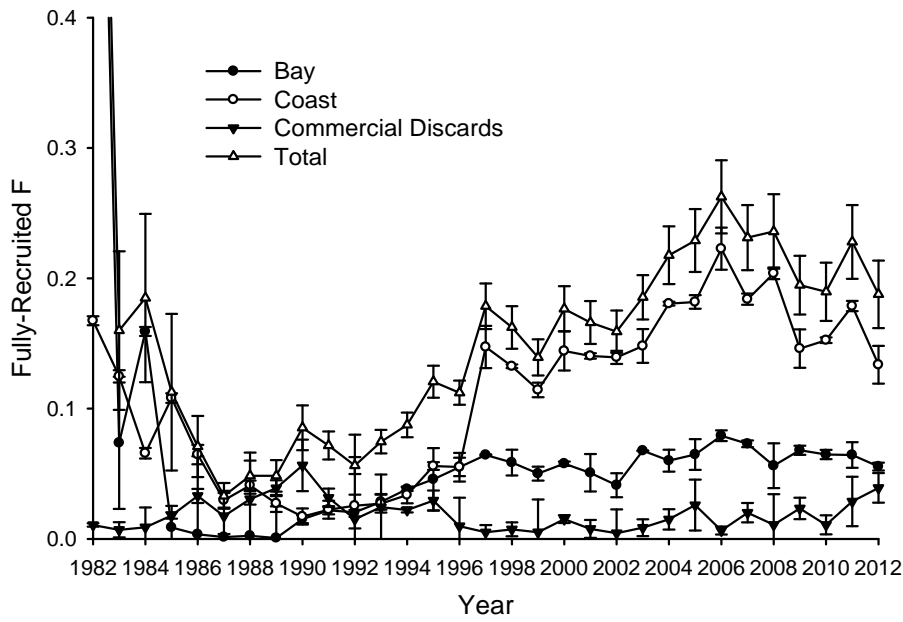
Figure B7.2. Estimates of total and fleet-specific fully-recruited fishing mortality ($\pm$1 SD) and recruitment ($\pm$1 SD) from the SCA base model run.
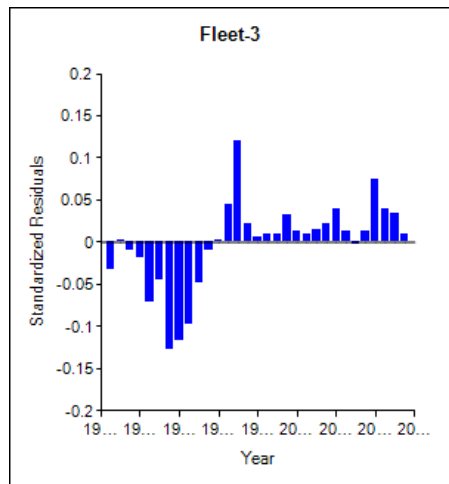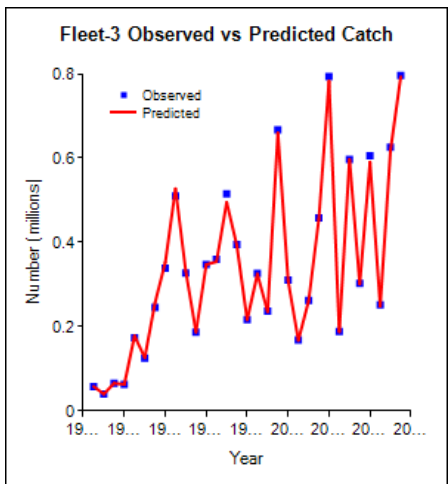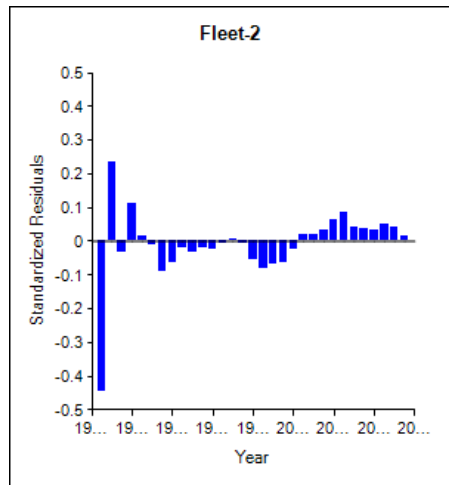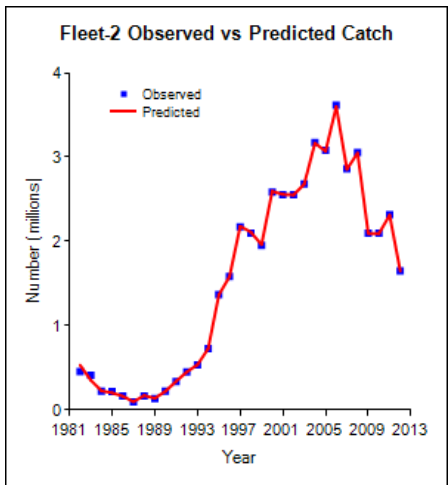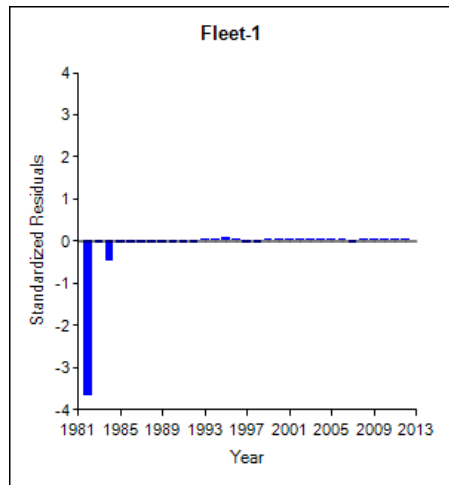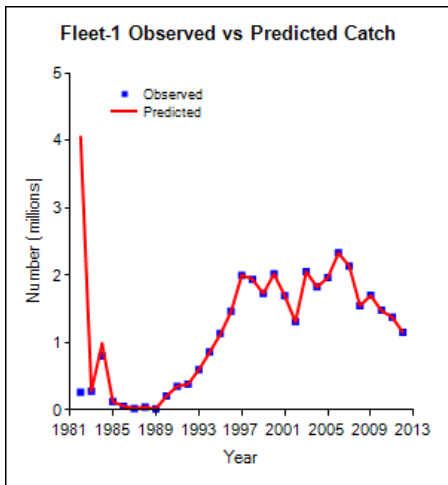
Figure B7.3. Observed and predicted total catch and standardized residuals by fleet.
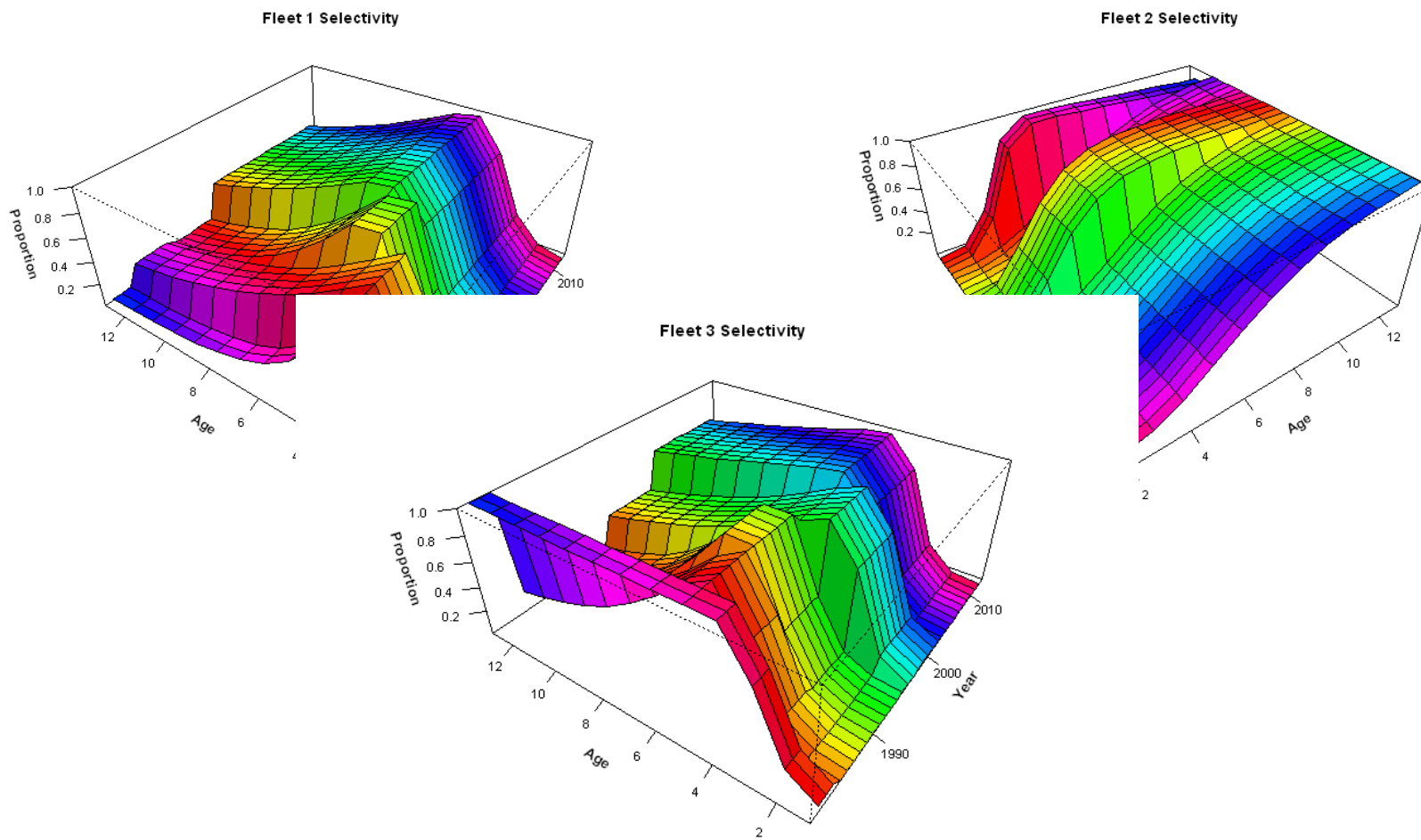
Figure B7.4. Catch selectivity patterns by fleet (Fleet 1 = Bay, Fleet 2 = Coast, Fleet 3 = Commercial Discards).
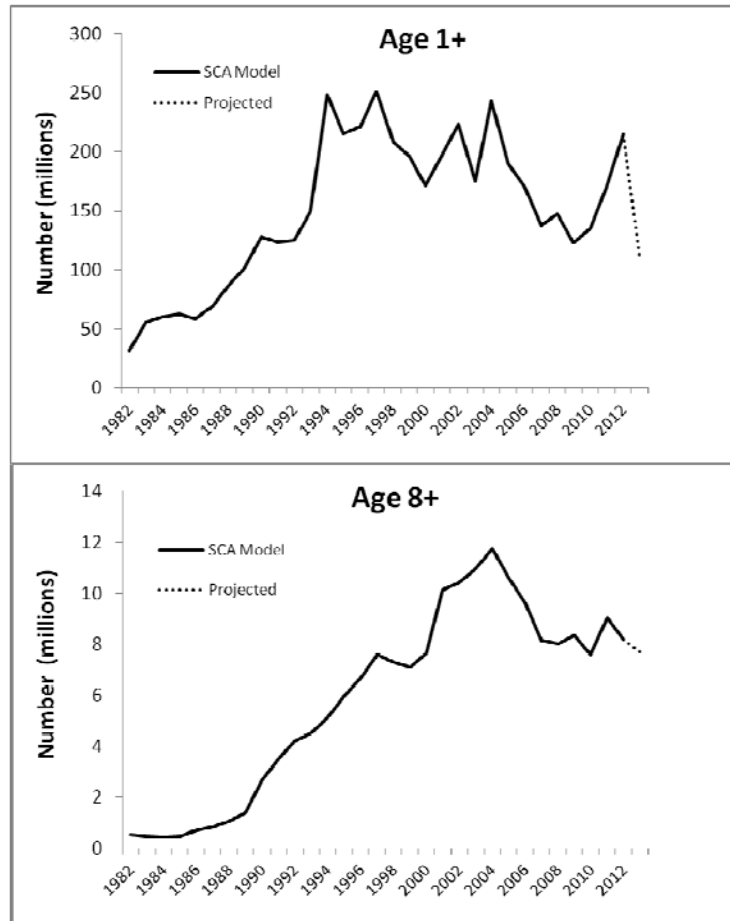
Figure B7.5. Estimates of January-1 total (age 1+) and 8+ abundance for 1982-2013. January-1 abundance for age 1 in 2013 was estimated from the 2012 observed values of the YOY indices and SCA model catchability coefficients, while older ages were projected from January-1 abundances and fishing and natural mortalities-at-age for 2012.
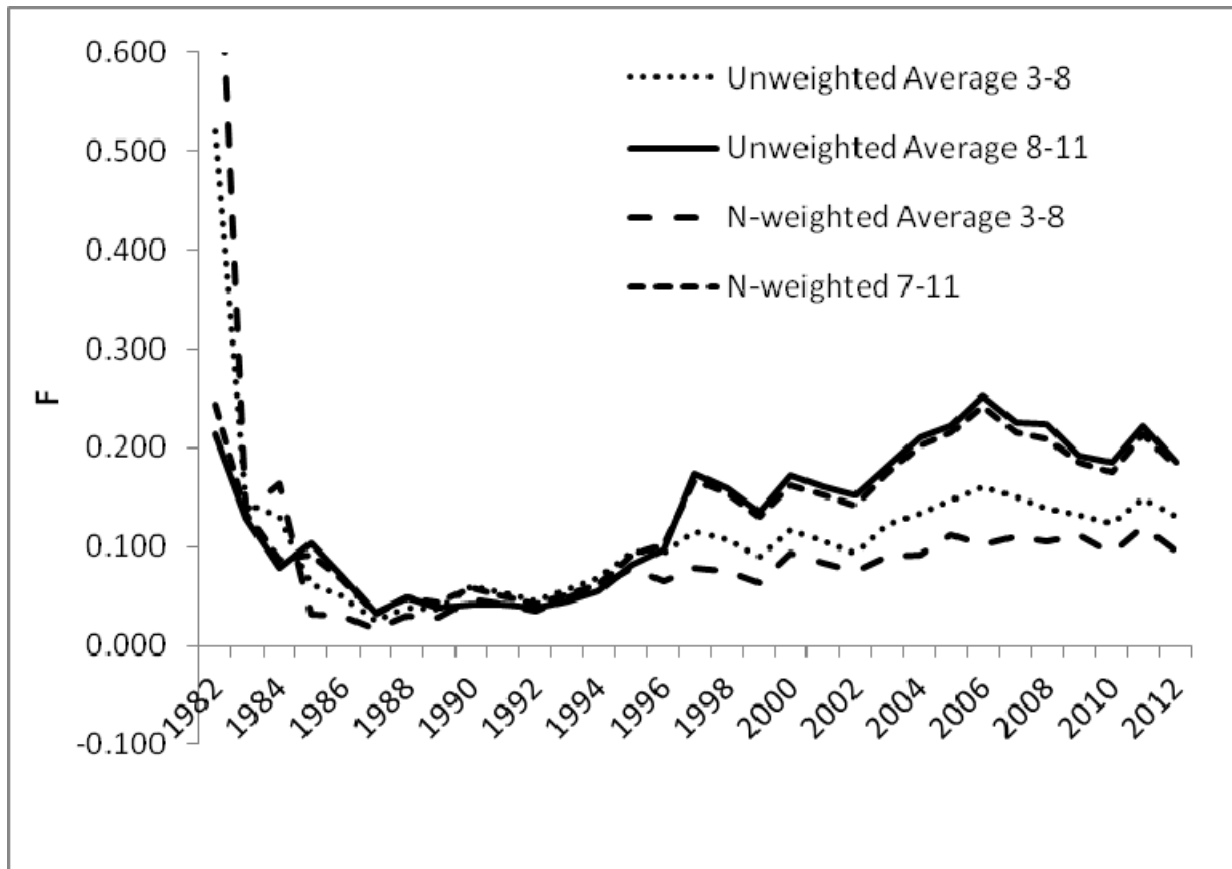
Figure B7.6. Comparison of fishing mortality estimates from the SCA model.
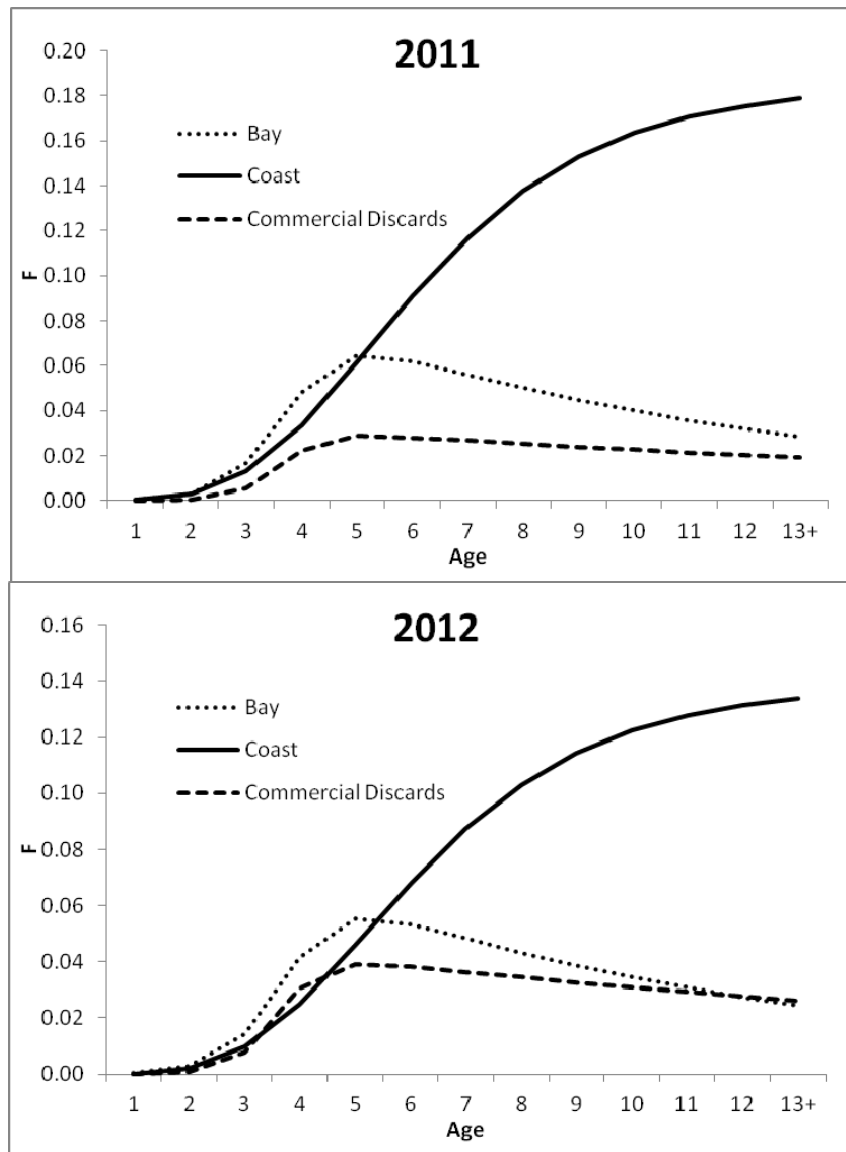
Figure B7.7. Comparison of fishing mortality-at-age in 2011 and 2012 from the SCA model partitioned into fleets
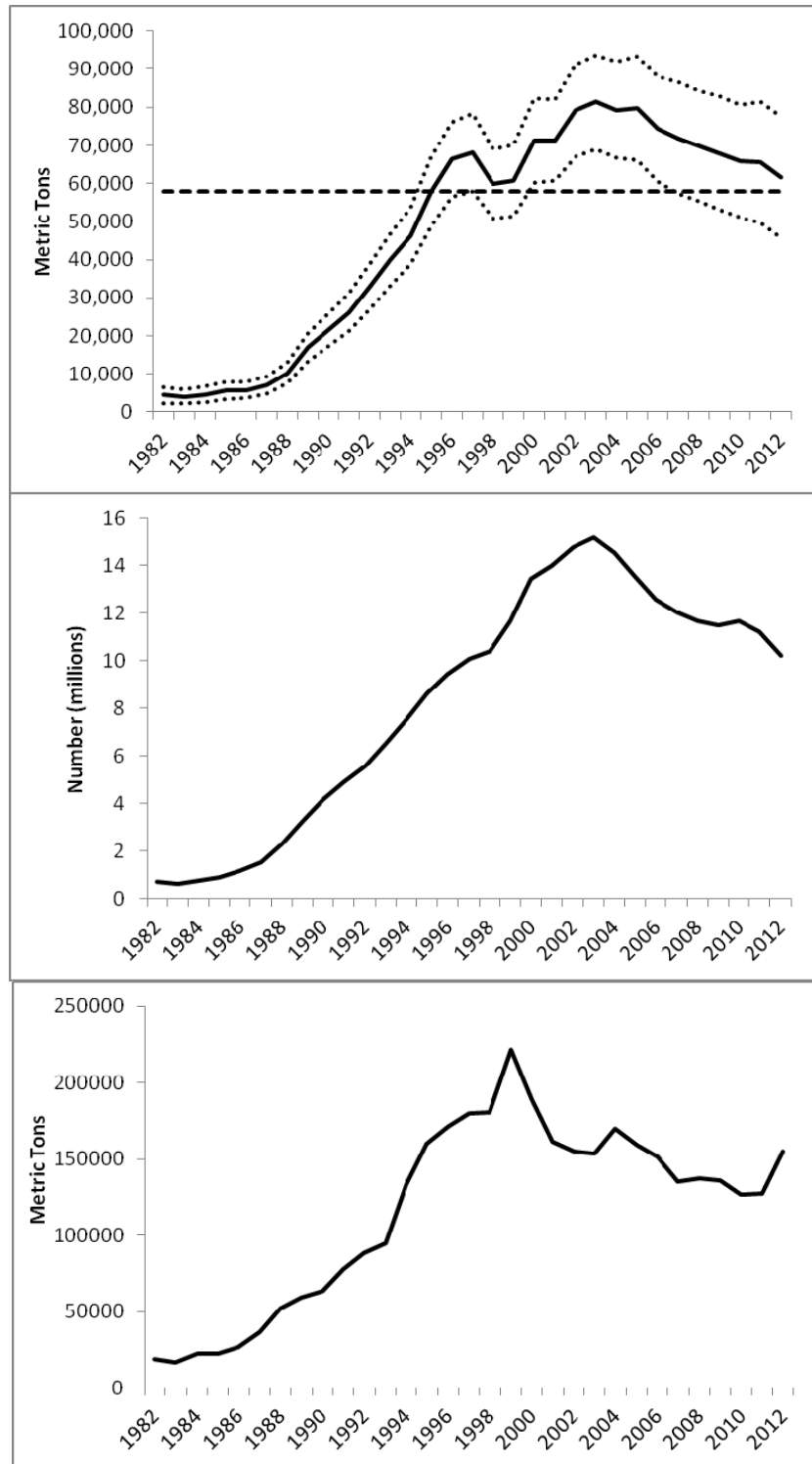
Figure B7.8. Estimates of A) female spawning stock biomass by year (solid line), B) female spawning stock numbers, and C) total January-1 biomass . Dotted lines equal 95% confidence intervals. Dashed line is the female spawning stock reference point (1995 value).
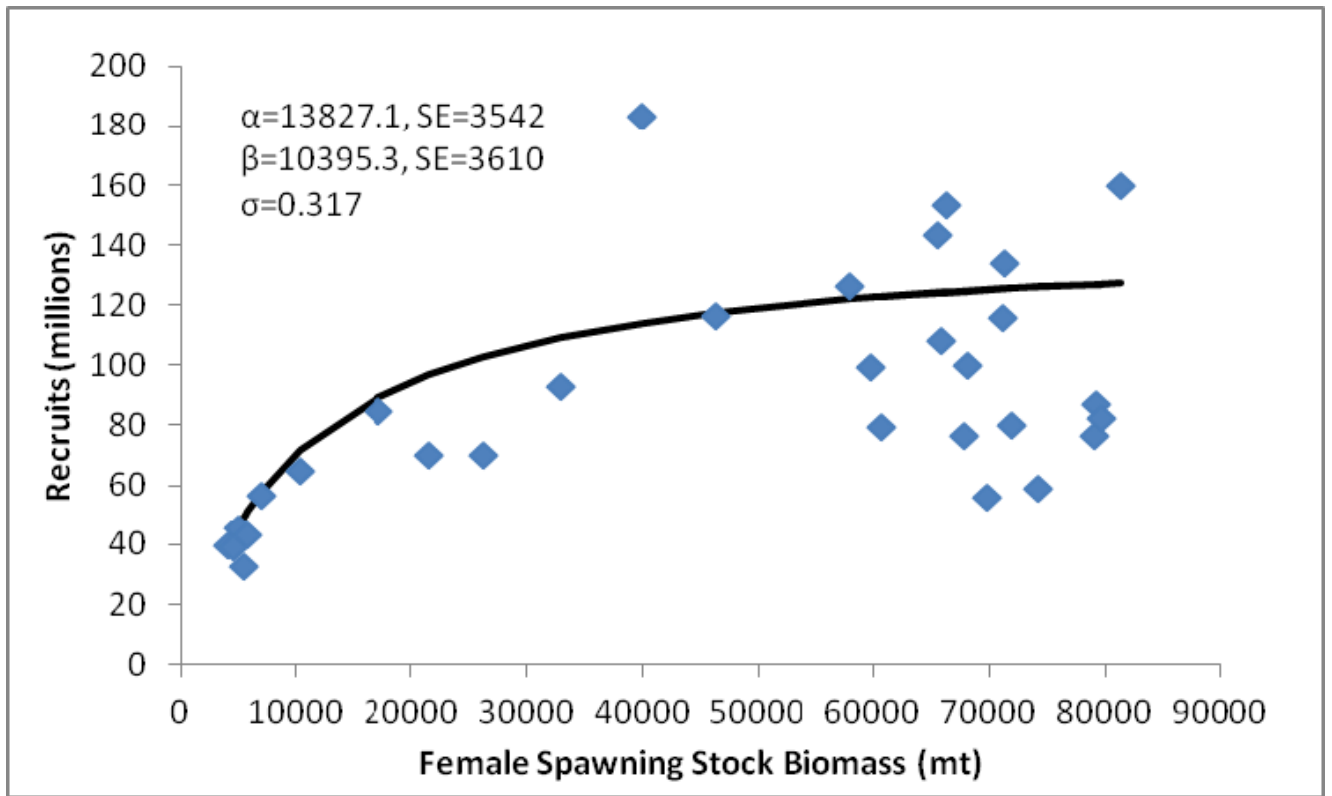
Figure B7.9. Model-estimated stock –recruitment relationship with bias-corrected Beverton-Holt fit (black line).
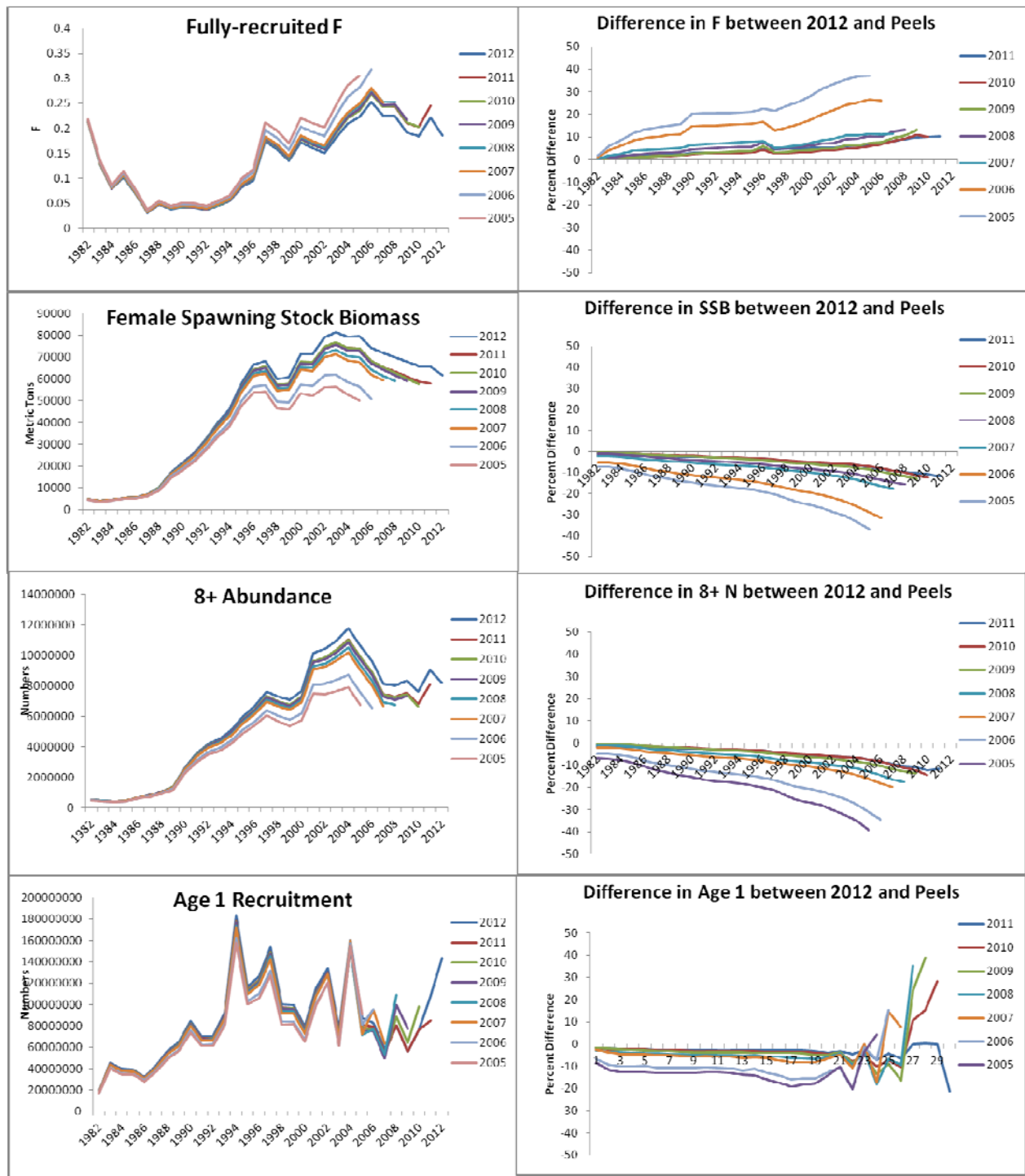
Figure B7.10. Retrospective analysis of fully-recruited F, female spawning stock biomass , 8+ abundance and Age 1 recruits.

Randomization of Starting Values (n=100)
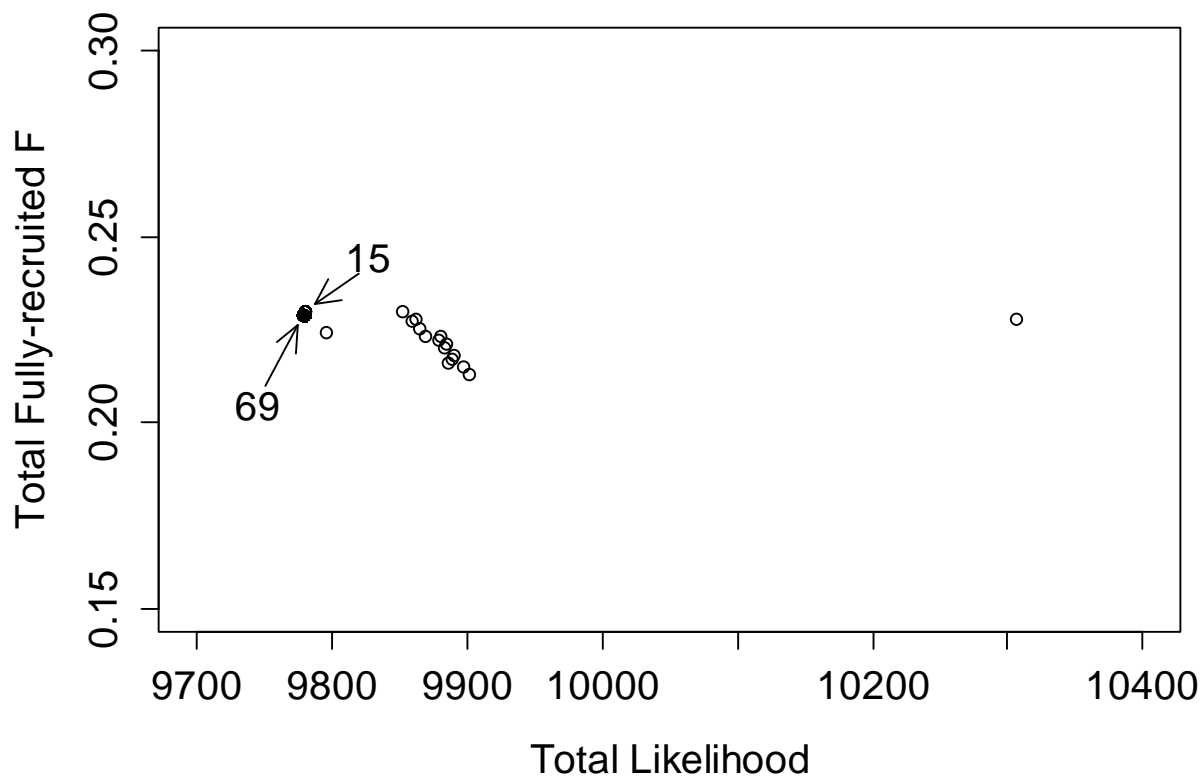
Figure B7.11. Results from 100 SCA model runs in which starting values were randomly permuted by ±50%. Solid dot represents the total likelihood and F produced by the base model and the number 69 represents the number of random runs that converged to base run solution. The second point of the most frequent convergence (n=15) is shown.
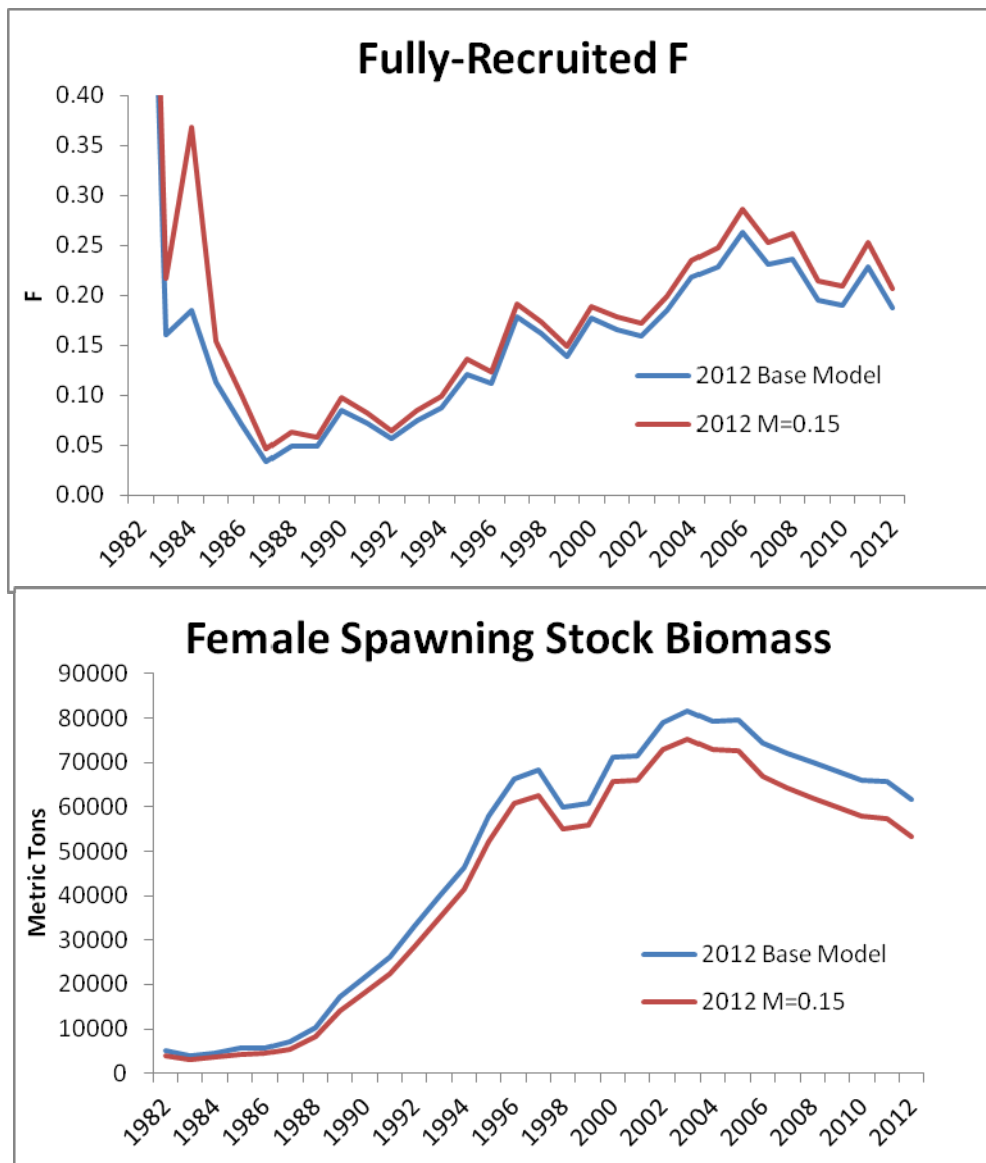
Figure B7.12. Comparison of results from the 2012 base model with age-specific M with results assuming a constant M=0.15.
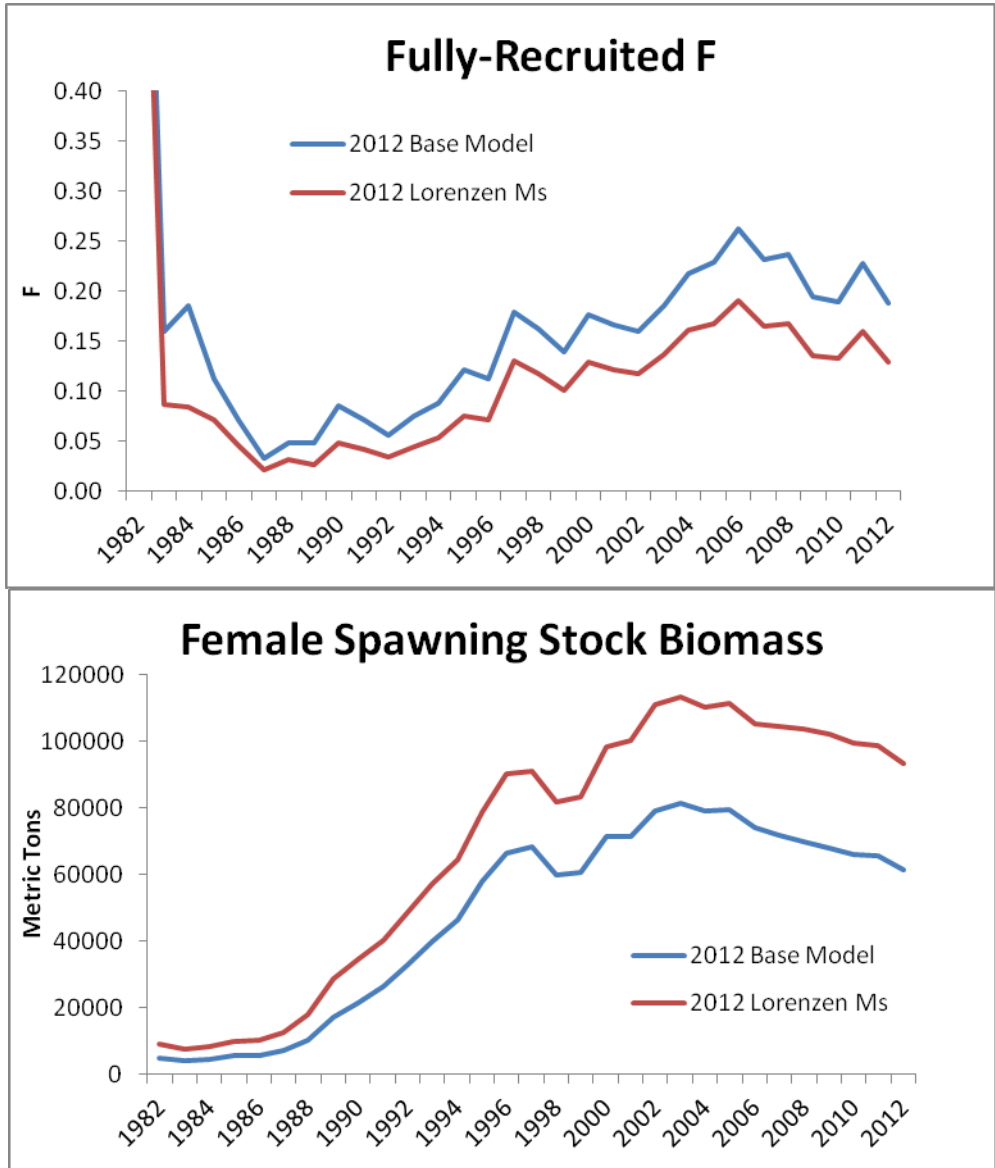
Figure B7.13. Comparison of results from the 2012 base model with age-specific M with results of model using unscaled Lorenzen age-specific M estimates .
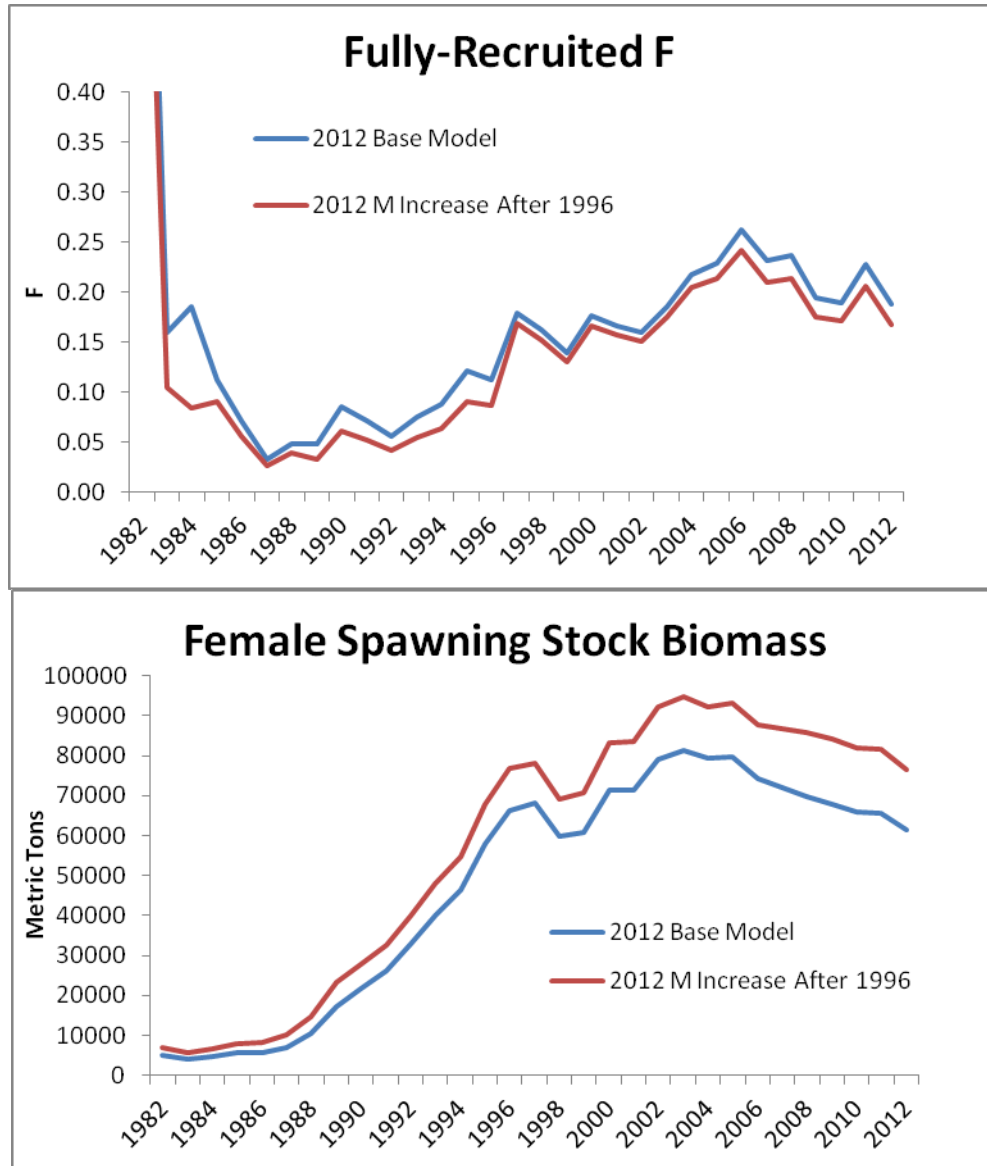
Figure B7.14. Comparison of results from the 2012 base model with age-specific M with results when M is increased on ages 3-8 after 1996.
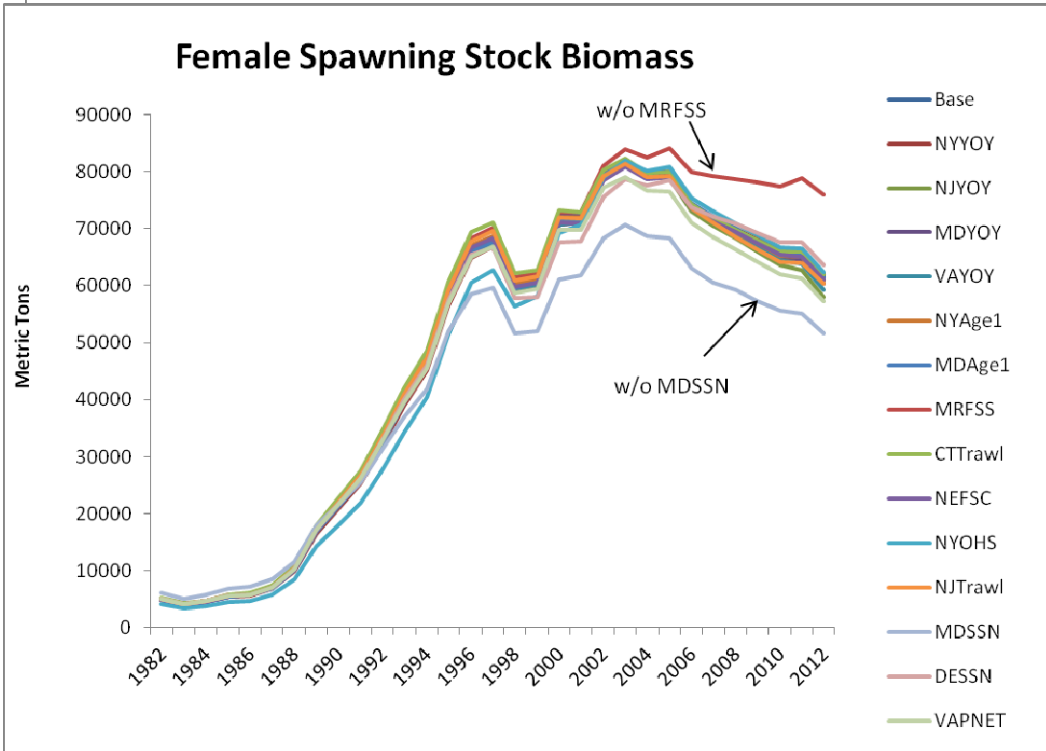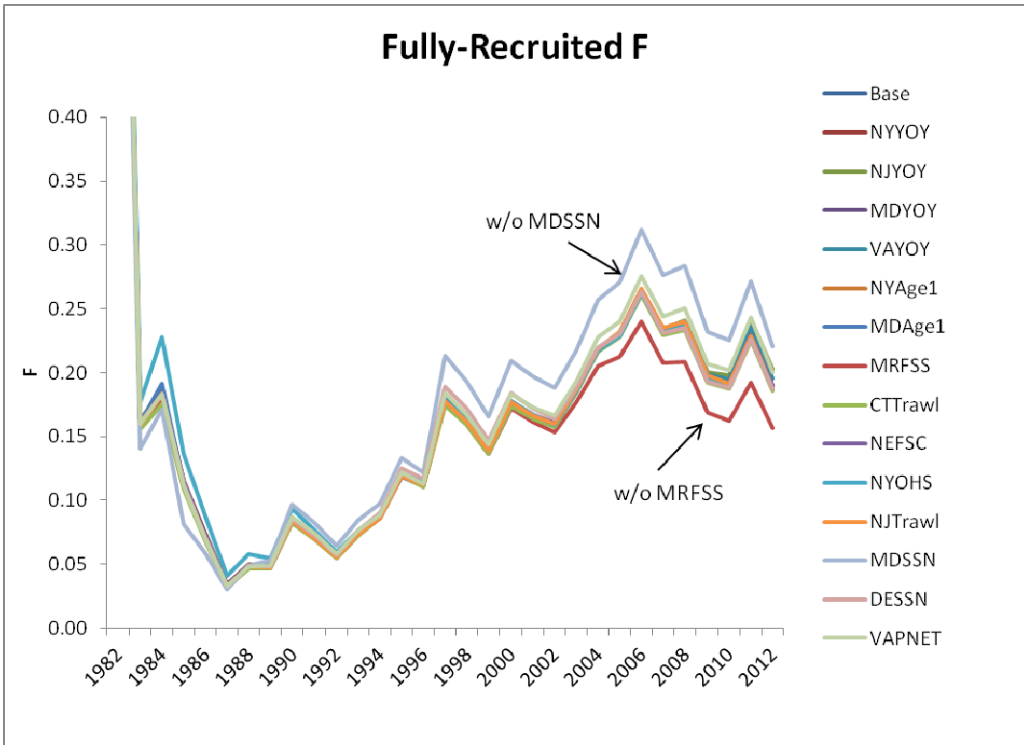
Figure B7.15. Comparison of fully-recruited F estimates when data from each survey were deleted one-at-a-time from the final SCA model configuration.
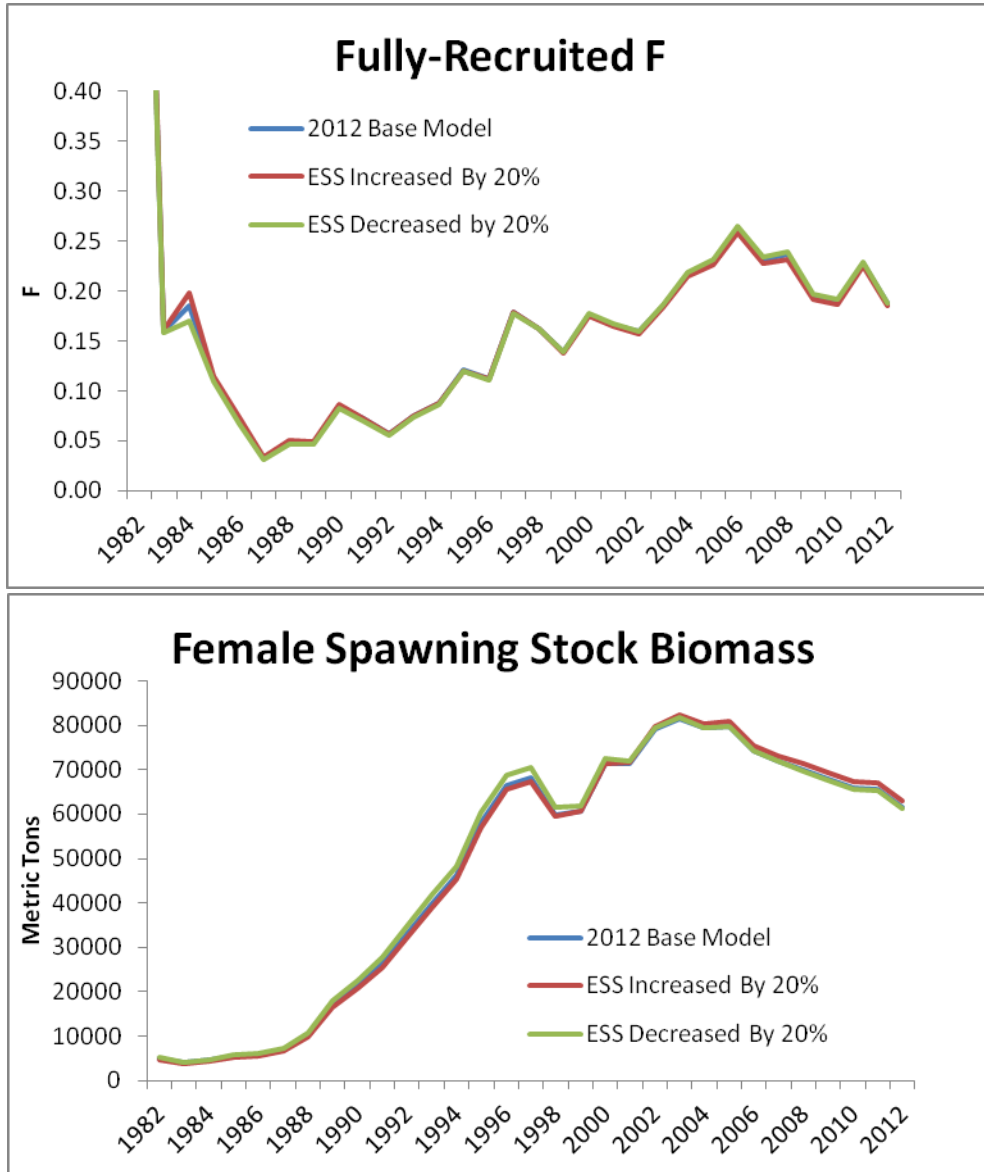
Figure B7.16. Comparison of fully-recruited F and female spawning stock biomass when the average effective sample sizes for the catch and survey multinomial likelihoods were increased and decreased by 20% of the original values.
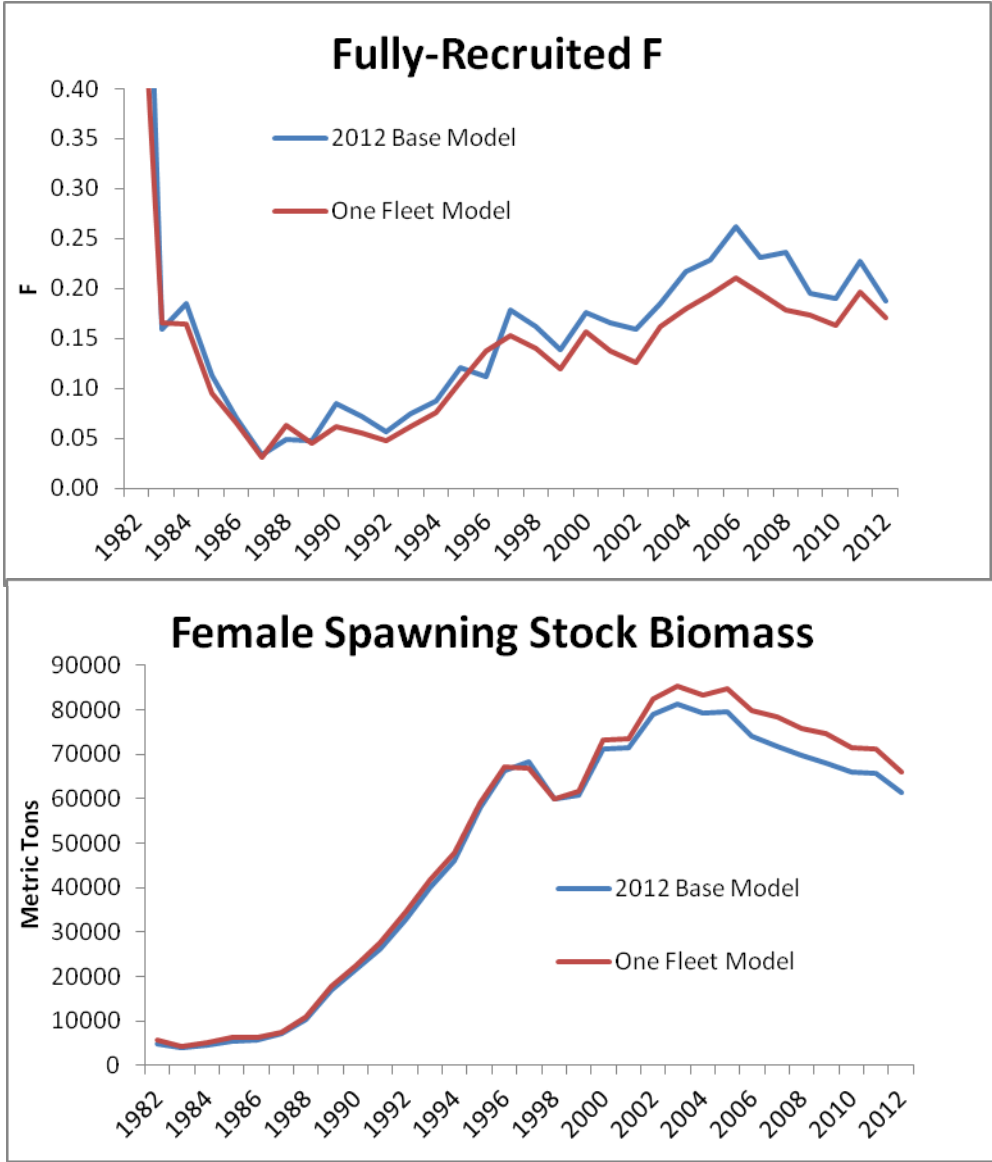
Figure B7.17. Comparison of fully-recruited F and female spawning stock biomass estimates from the 2012 base model and a one fleet model.
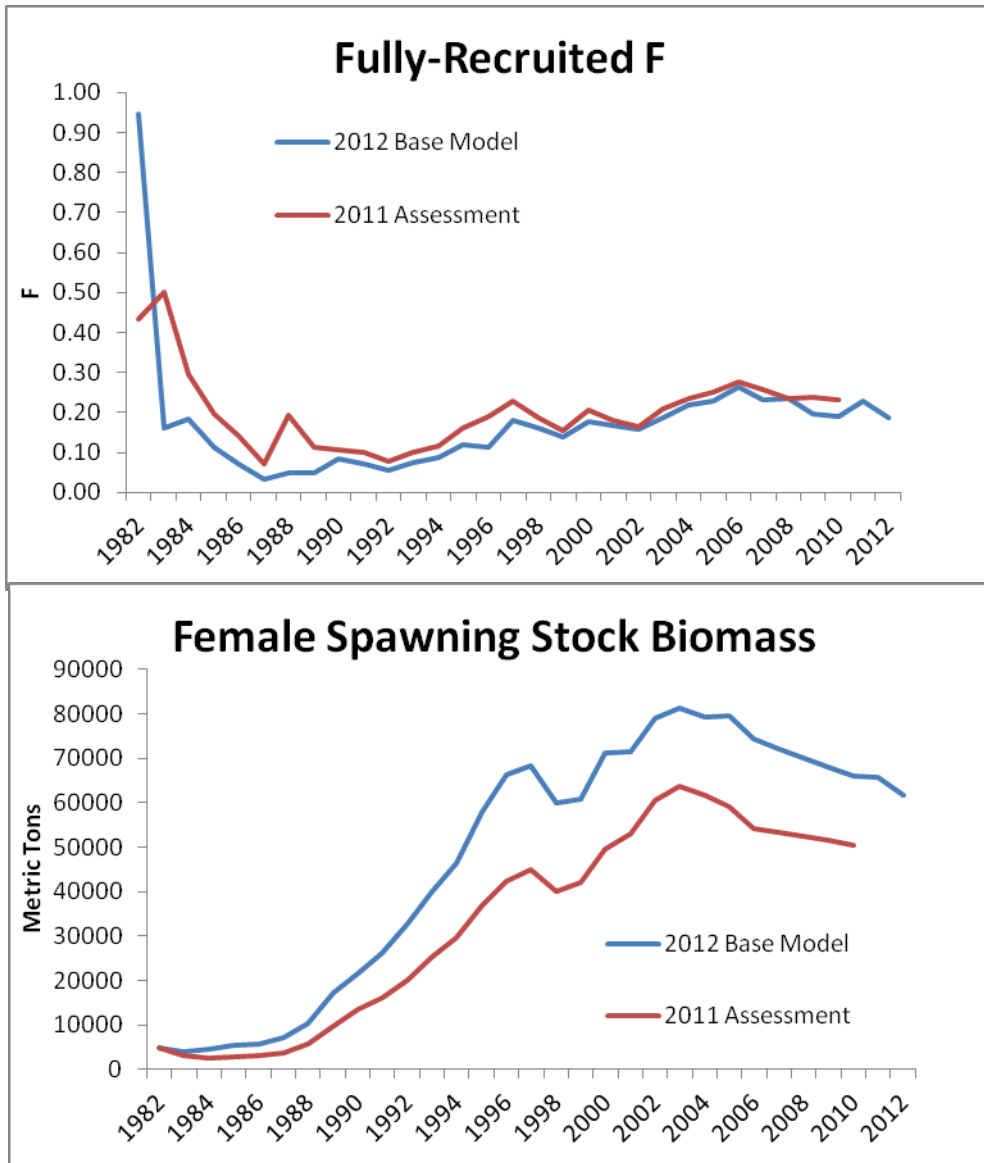
Figure B7.18. Comparison of fully-recruited F and female spawning stock biomass estimates from the 2012 base model and the 2011 assessment.
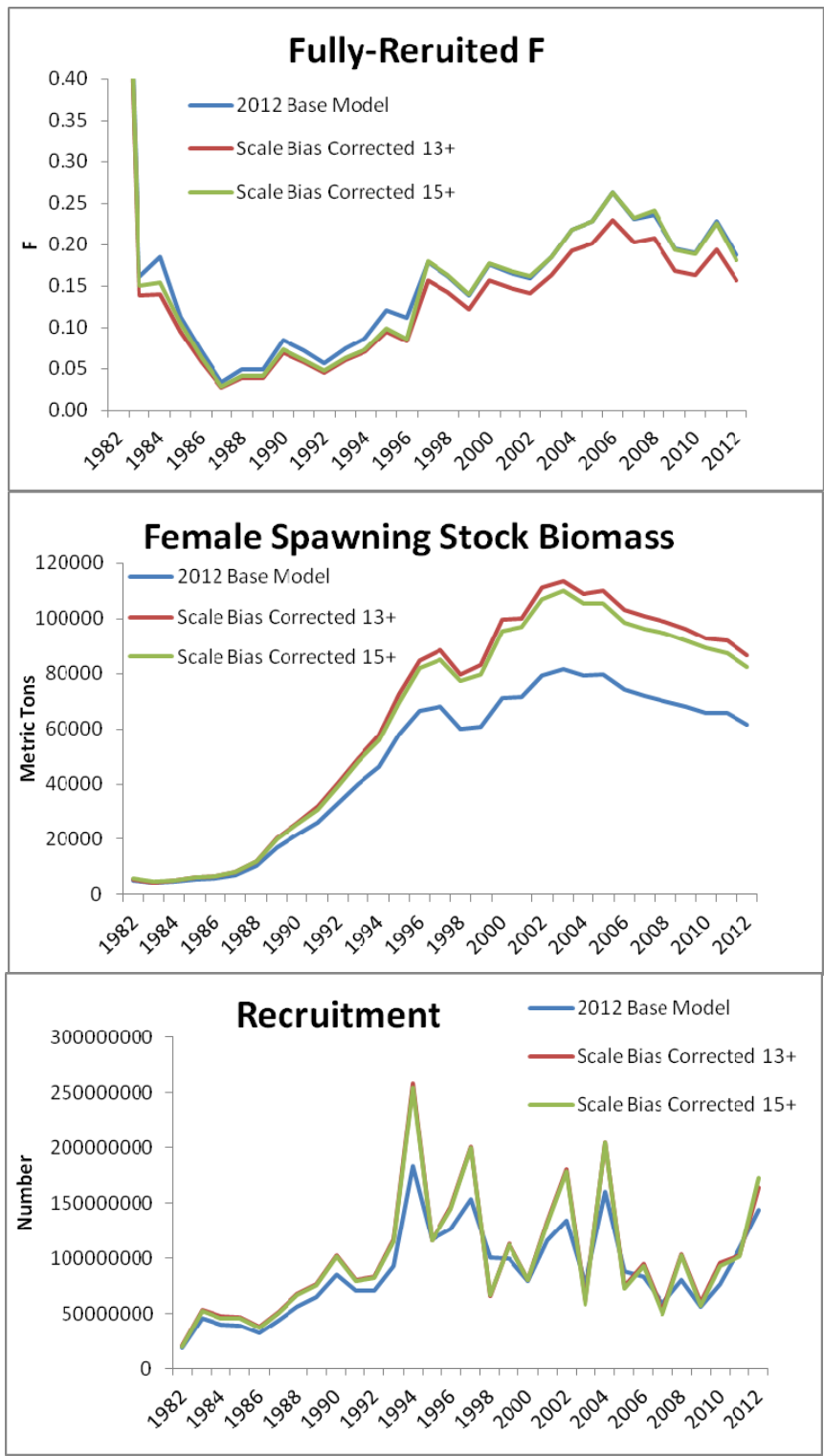
Figure B7.19. Comparison of fully-recruited F, female spawning stock biomass estimates, and recruitment from the 2012 base model and the scale aging bias corrected models with age 13 and 15 plus groups.
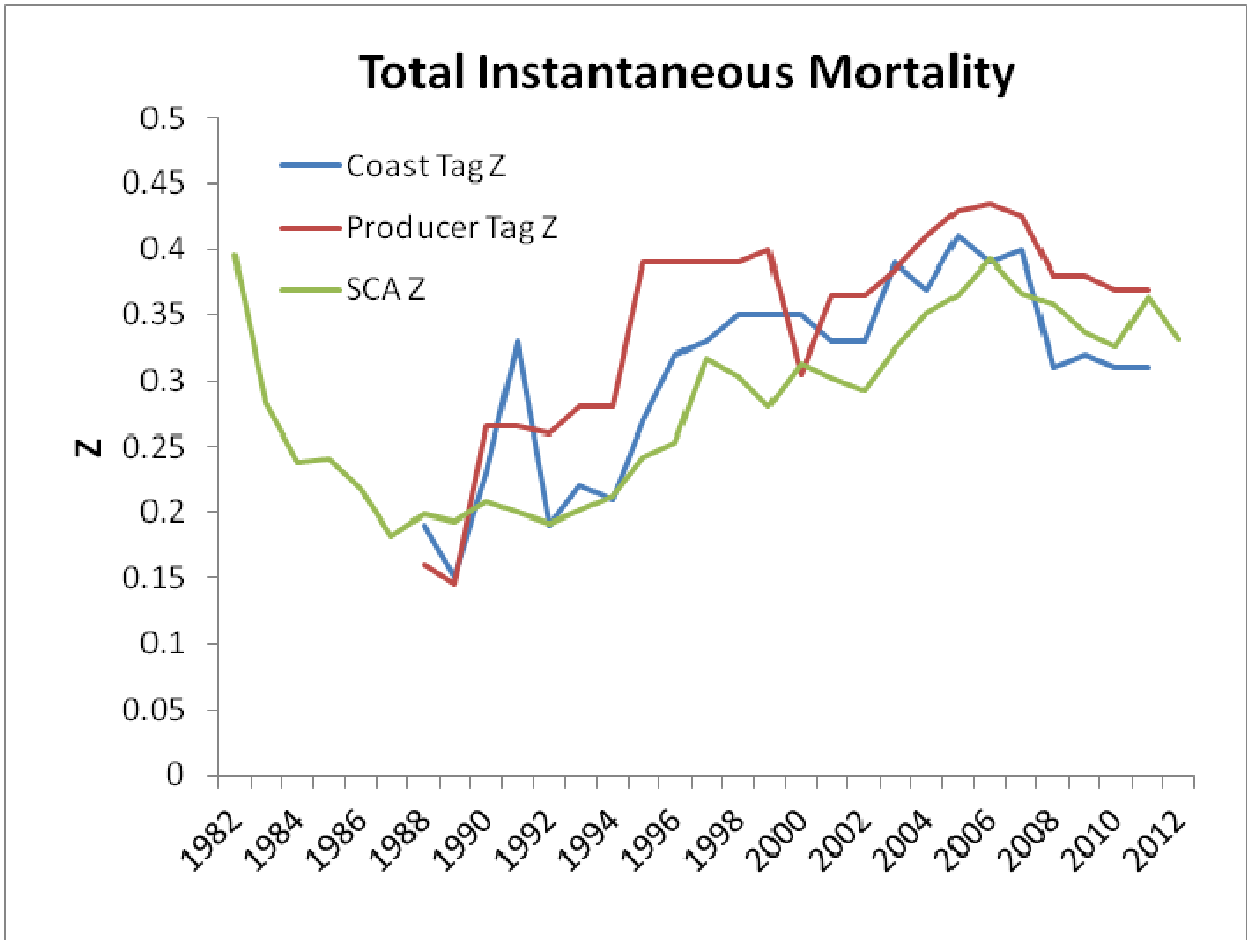
Figure B7.20. Comparison of total instantaneous mortality estimates from the 2012 base SCA and tagging models.
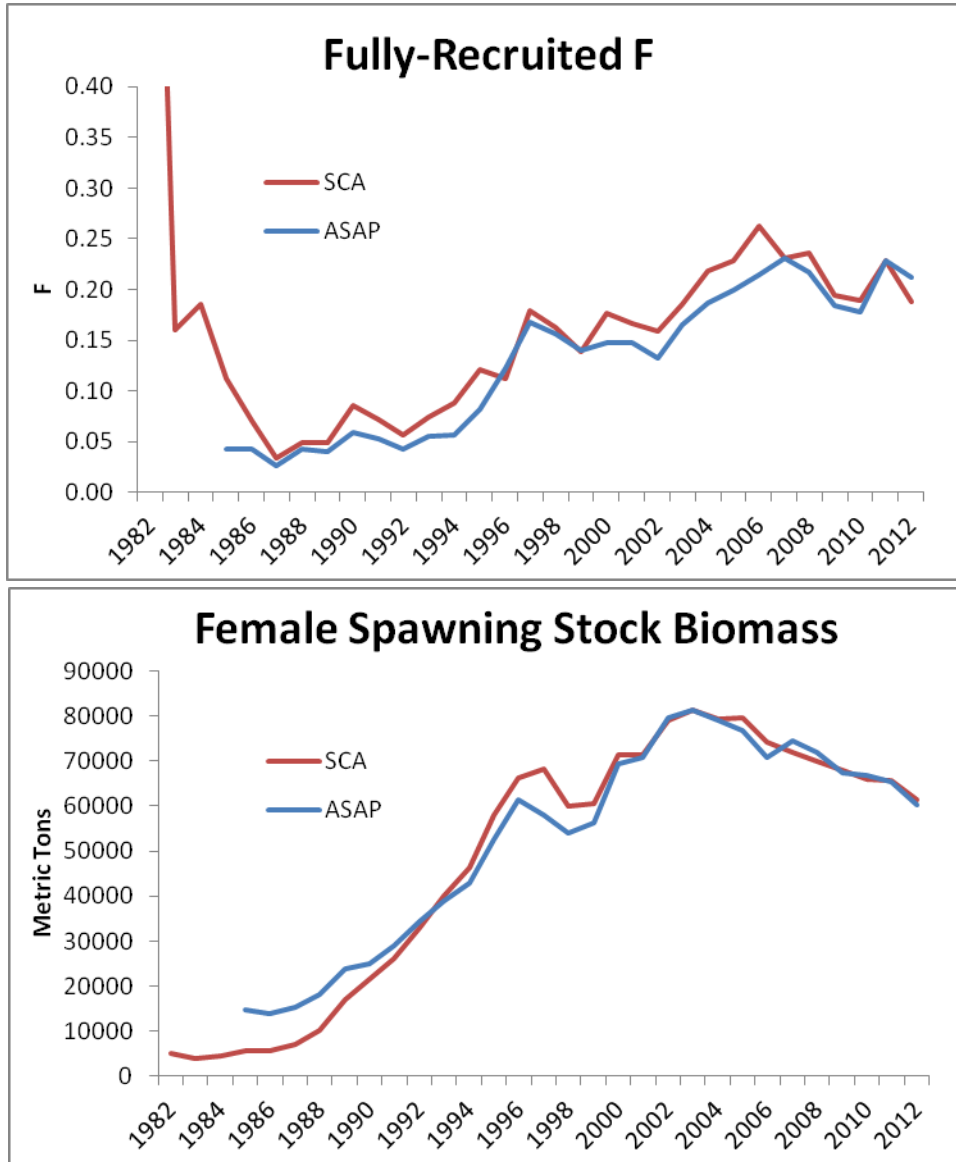
Figure B7.21. Comparison of estimates of fully-recruited F and female spawning stock biomass between the SCA and ASAP models.

Coastal
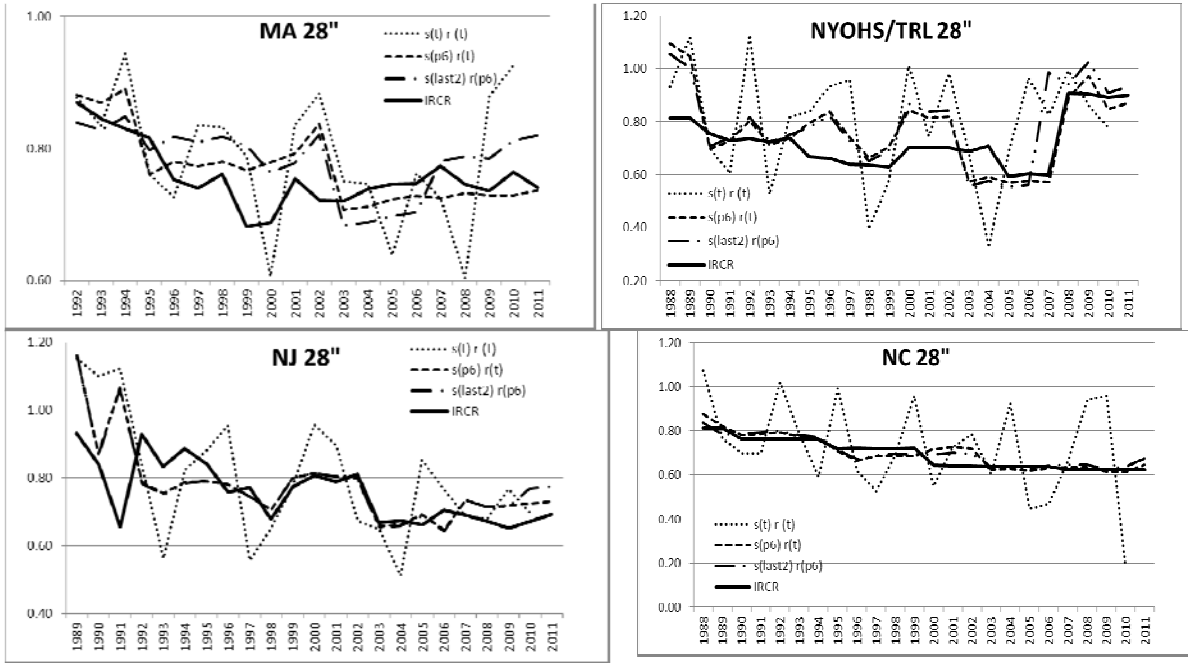
Producer Areas
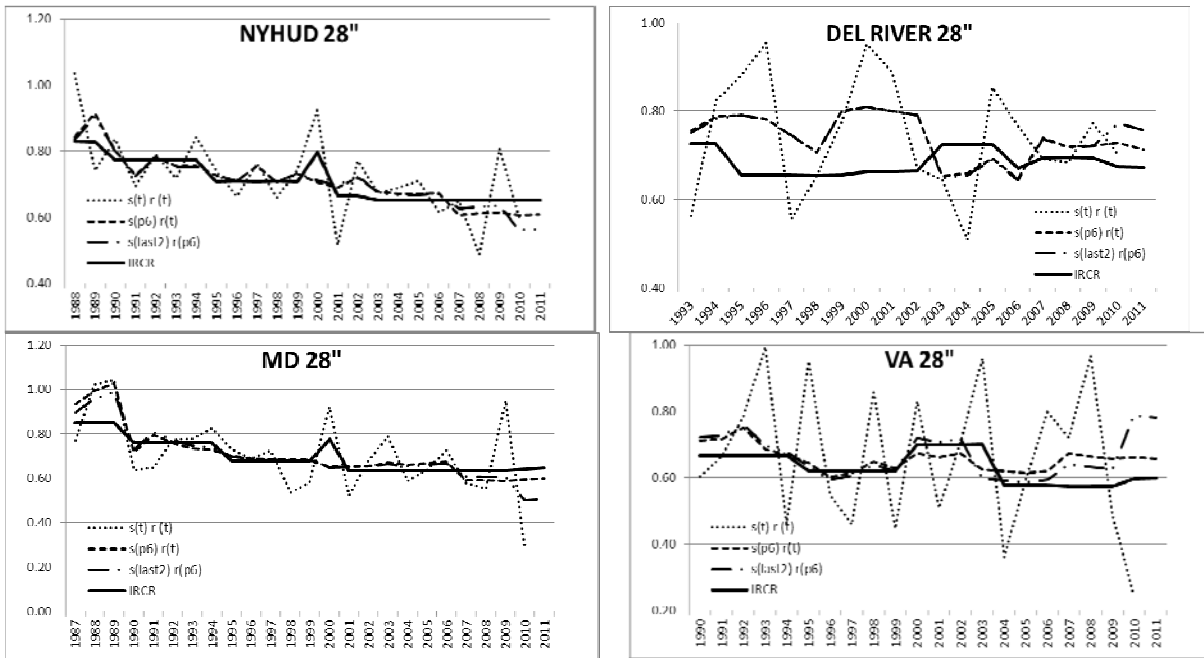
Figure B8.1. Survival estimates from Program MARK and IRCR for fish ≥ 28 inches (note different scales).

Coastal
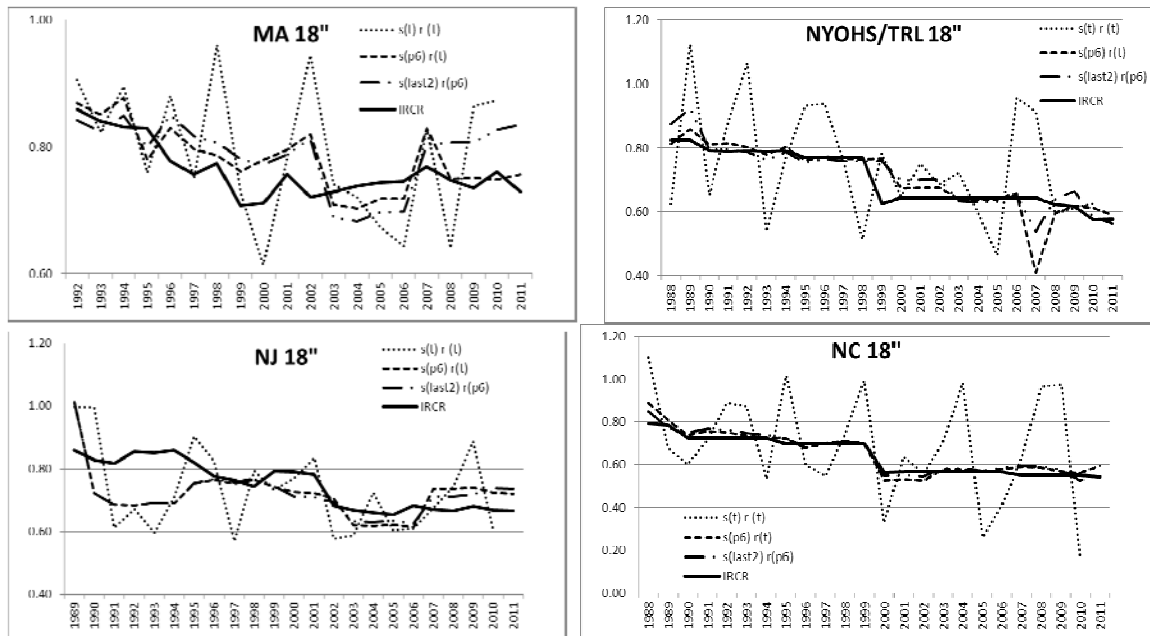
Producer
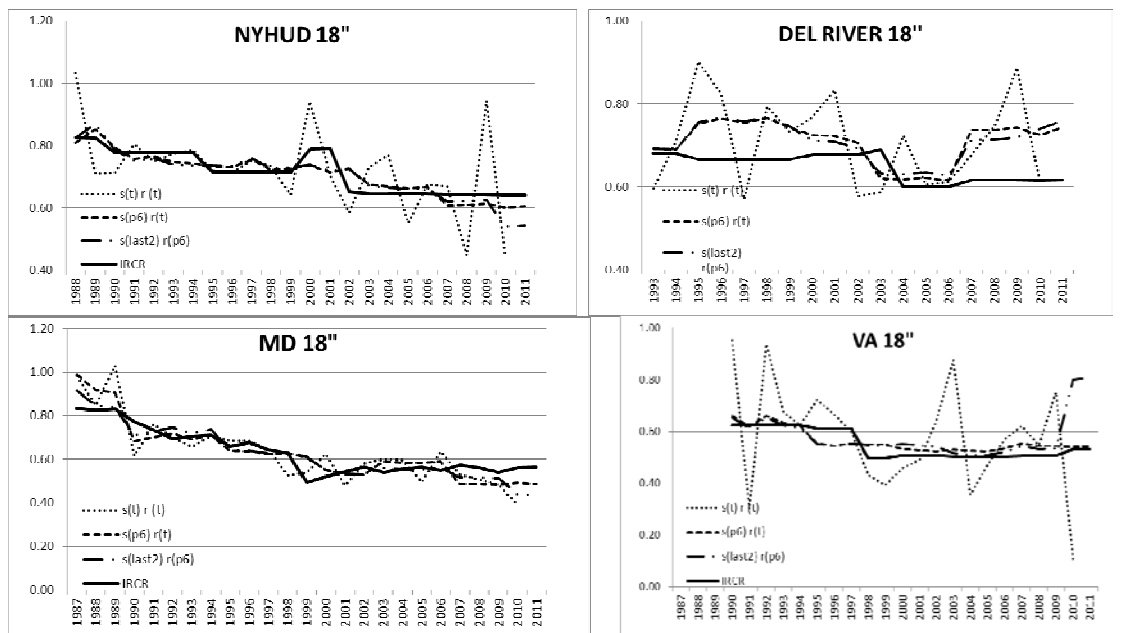
Figure B8.2. Survival estimates from Program MARK and IRCR for fish ≥ 18 inches (note different scales).

Figure B8.3. Comparison of coastal program (unweighted) and producer area (weighted) mean fishing mortality estimates from IRCR, for fish $\geq$ 28 inches with 95% confidence intervals.
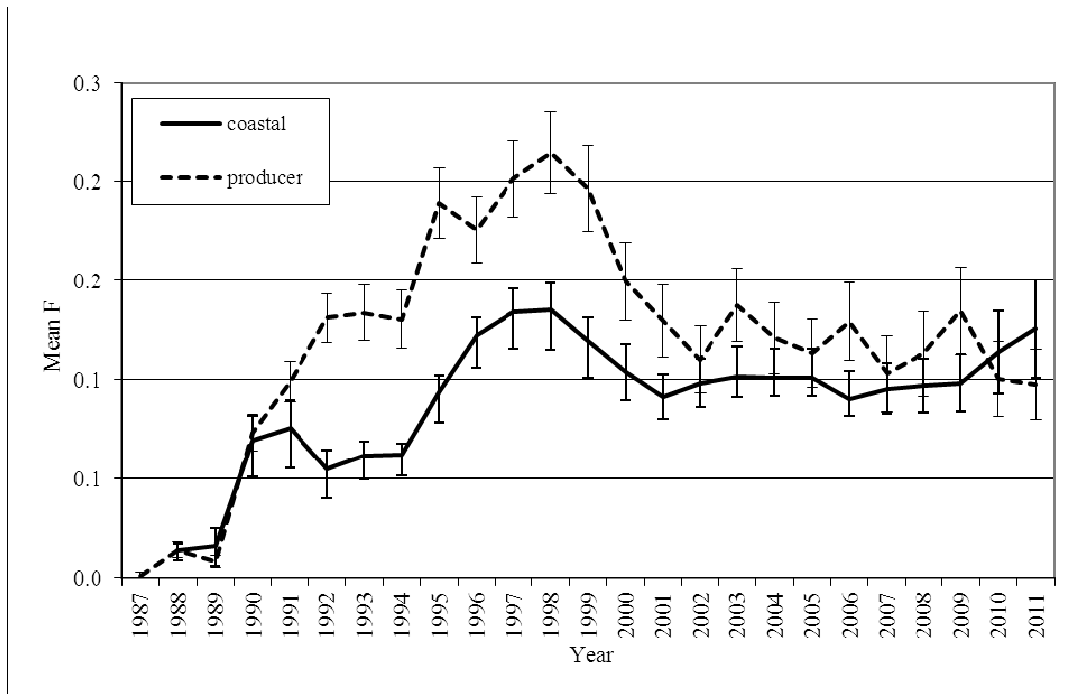
Figure B8.4. Comparison of coastal program (unweighted) and producer area (weighted) mean fishing mortality estimates from IRCR, for fish $\geq$ 18 inches with 95% confidence intervals.
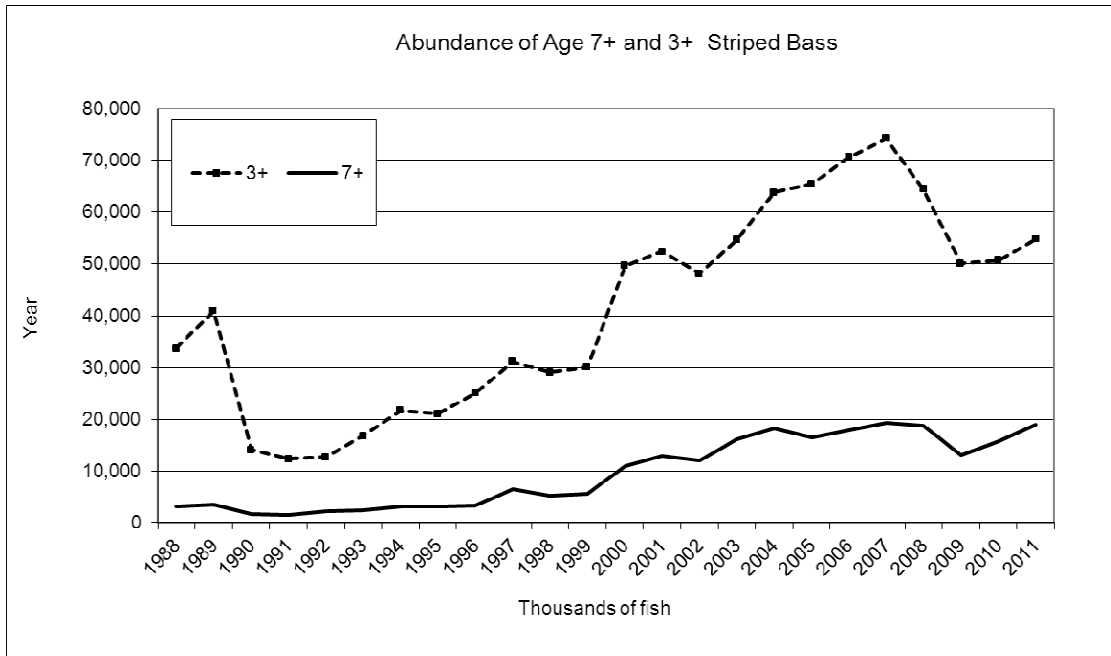
Figure B8.5. Comparison of stock size estimates from IRCR, for fish age seven and older (comparable to fish ≥ 28 inches) and age three and older (comparable to fish ≥ 18 inches). Stock size obtained via "Kill = F * Stock Size".
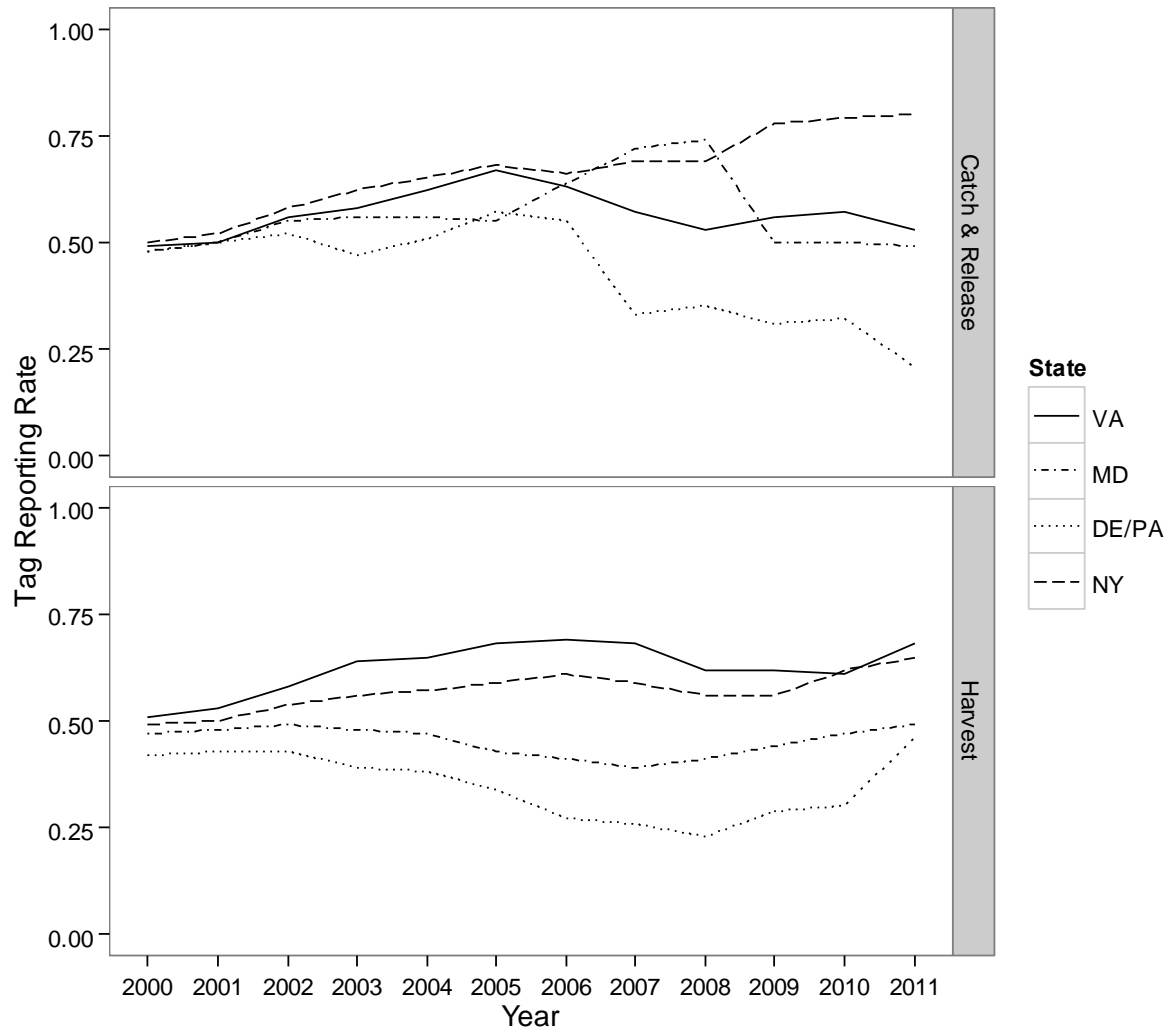
Figure B8.6. Three year moving average estimates of striped bass tag reporting rate for the four producer programs. Results are presented for harvested and catch and release fish. Tag reporting rate for all regions and both recapture dispositions is fixed at 0.43 for all years prior to 2000.
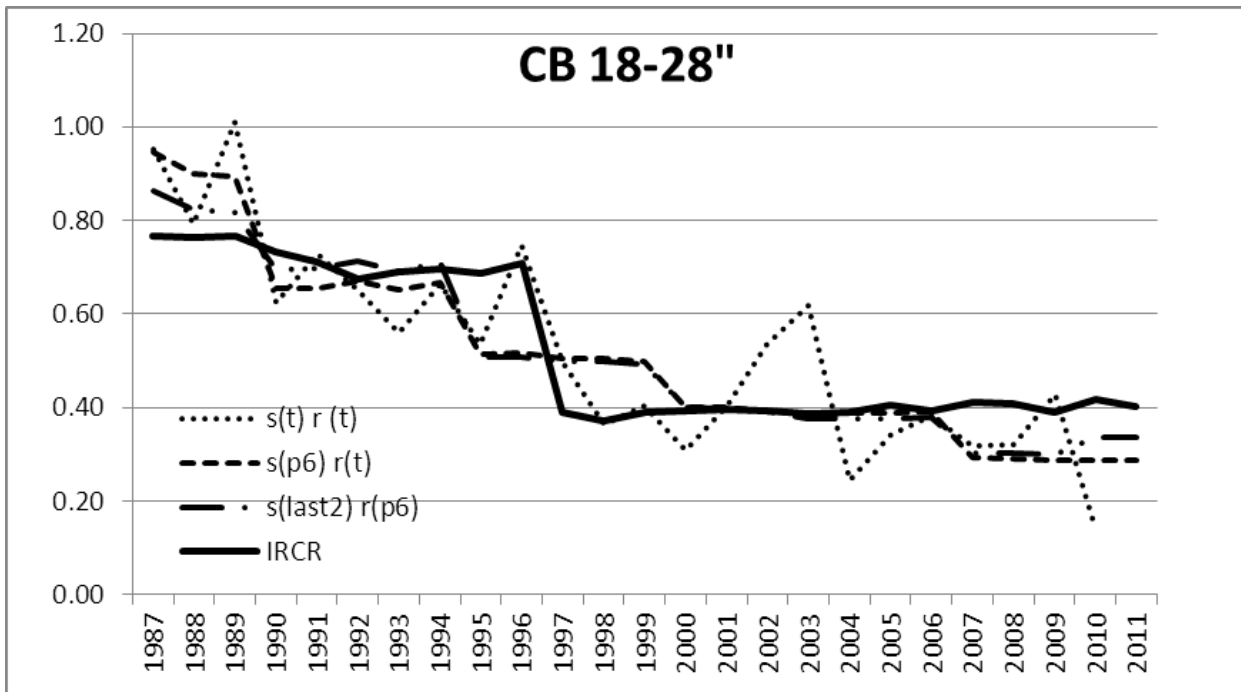
Figure B8.7. Survival estimates from Program MARK and IRCR for Chesapeake Bay male fish 18-28 inches

Z Estimates from Tagged Striped Bass ≥ 28"
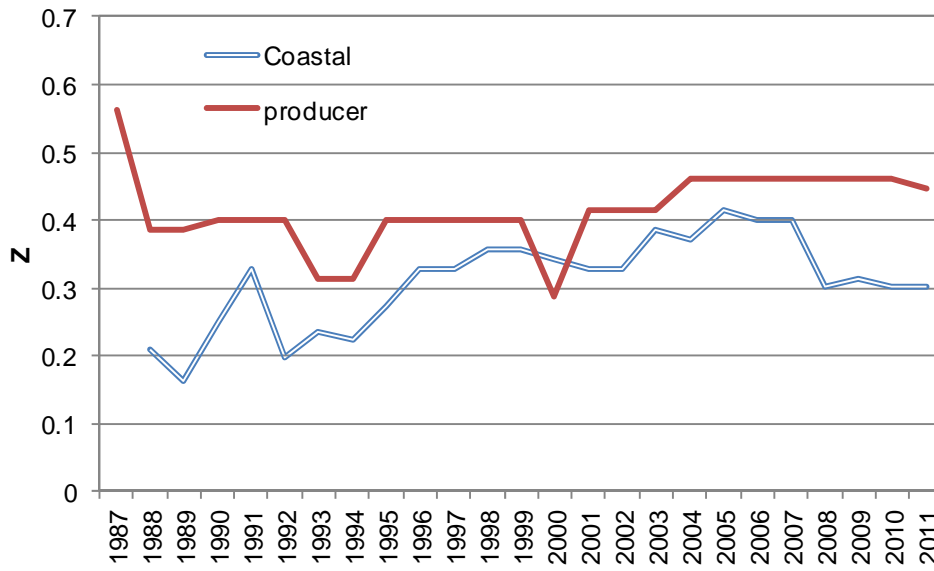
Z Estimates from Tagged Striped Bass ≥ 18"
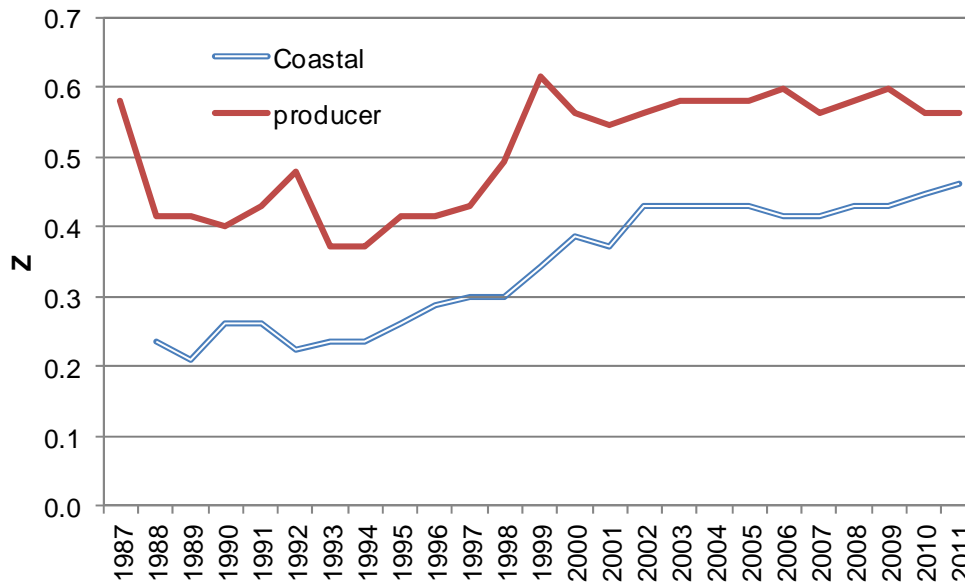
Figure B8.8: Estimates of total mortality (Z) from the IRCR tagging model for coastal and producer areas for fish ≥ 28 inches (top) and ≥ 18 inches (bottom).

Z Estimates from Chesapeake Bay Tagged Striped Bass 18-28"
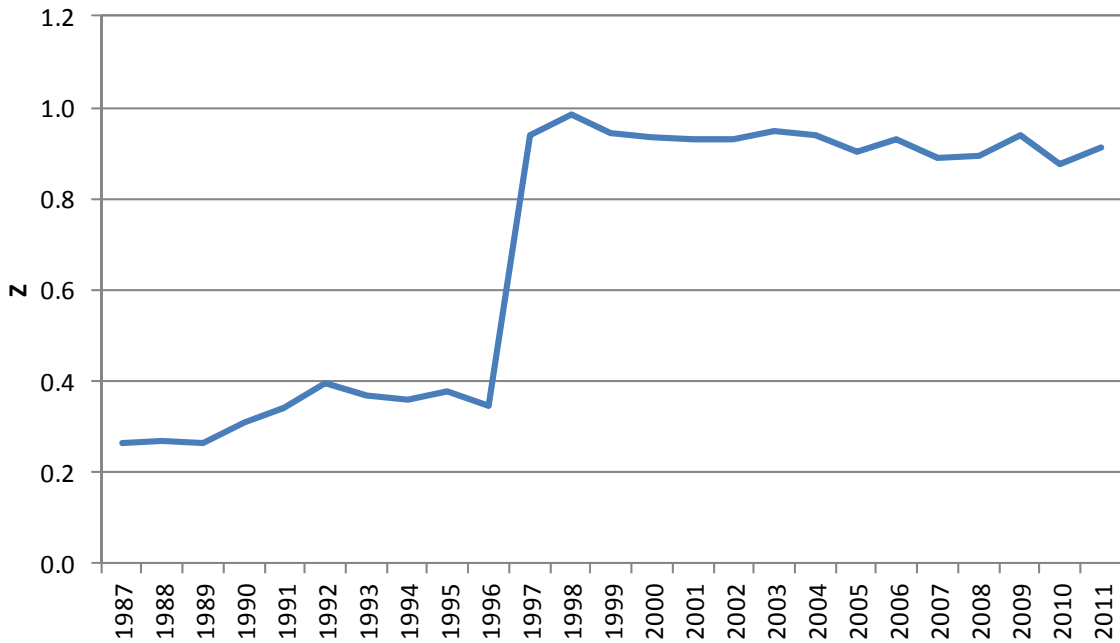
Figure B8.9. Estimates of total mortality (Z) from the IRCR tagging model for Chesapeake Bay fish, 18 – 28 inches.
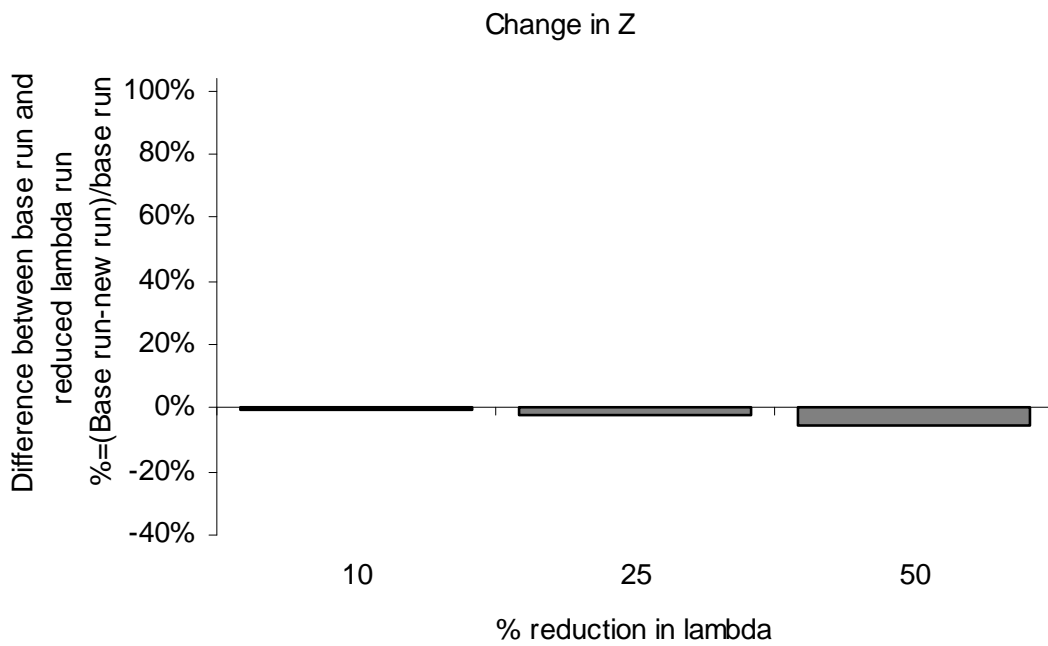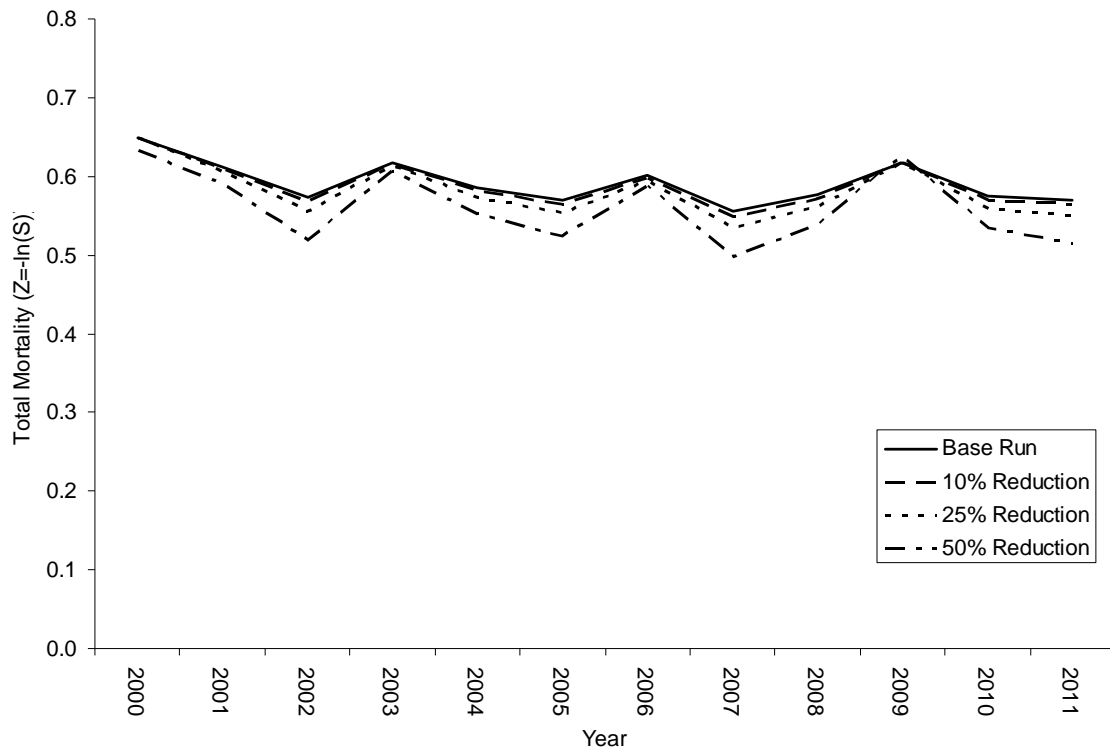
Figure B8.10. Effect of lower reporting rates on estimates of total mortality (Z) from the IRCR tagging model.

Figure B8.10. Effect of lower reporting rates on estimates of total mortality (Z) from the IRCR tagging model.
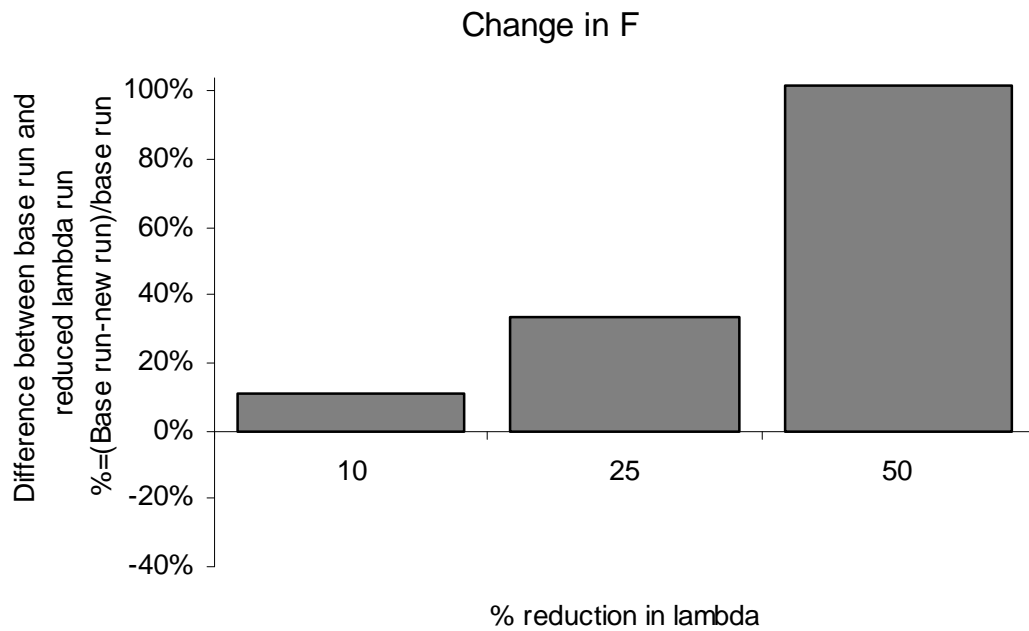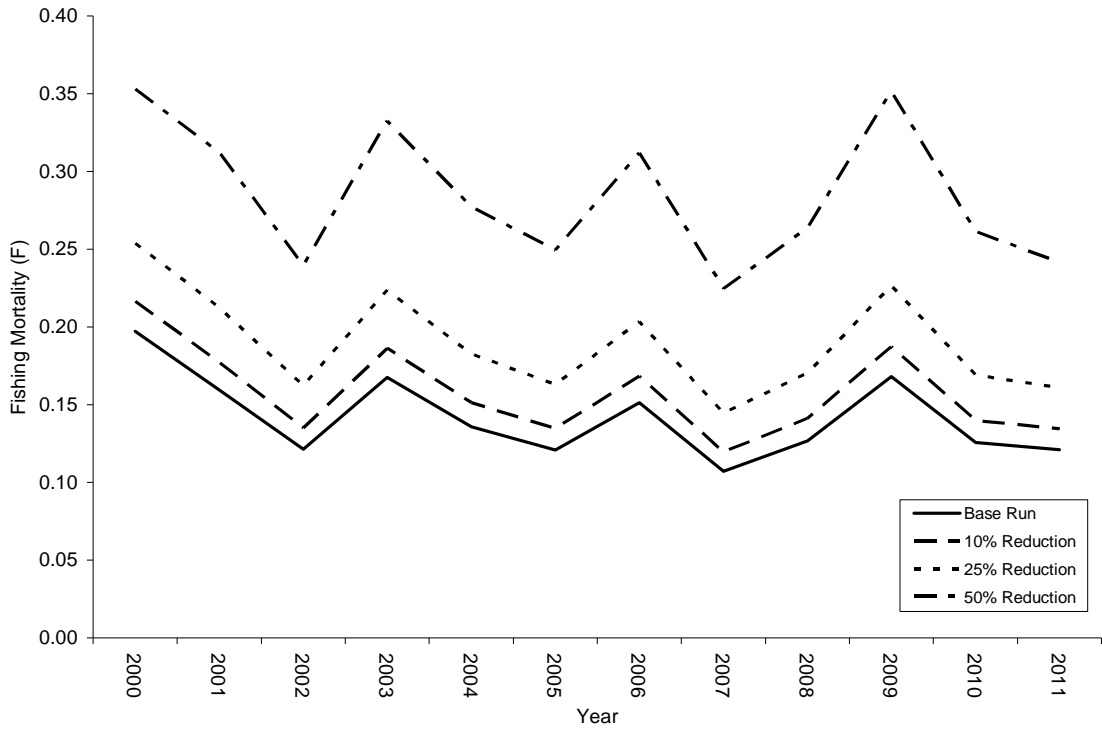
Figure B8.11. Effect of lower reporting rates on estimates of fishing mortality (F) from the IRCR tagging model.
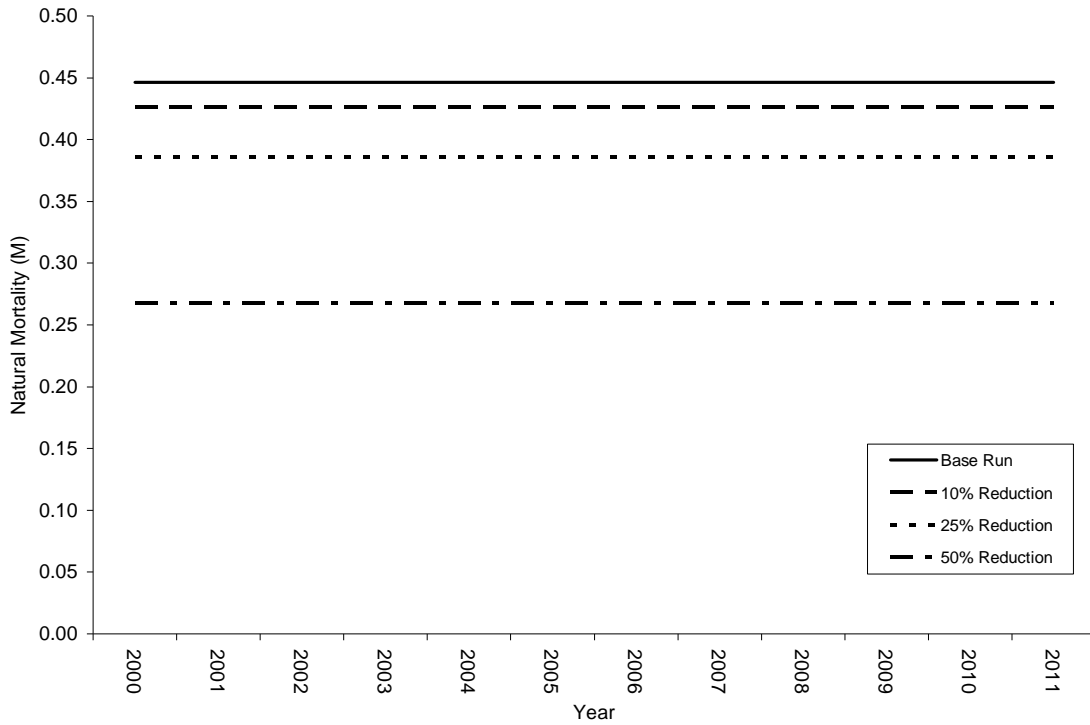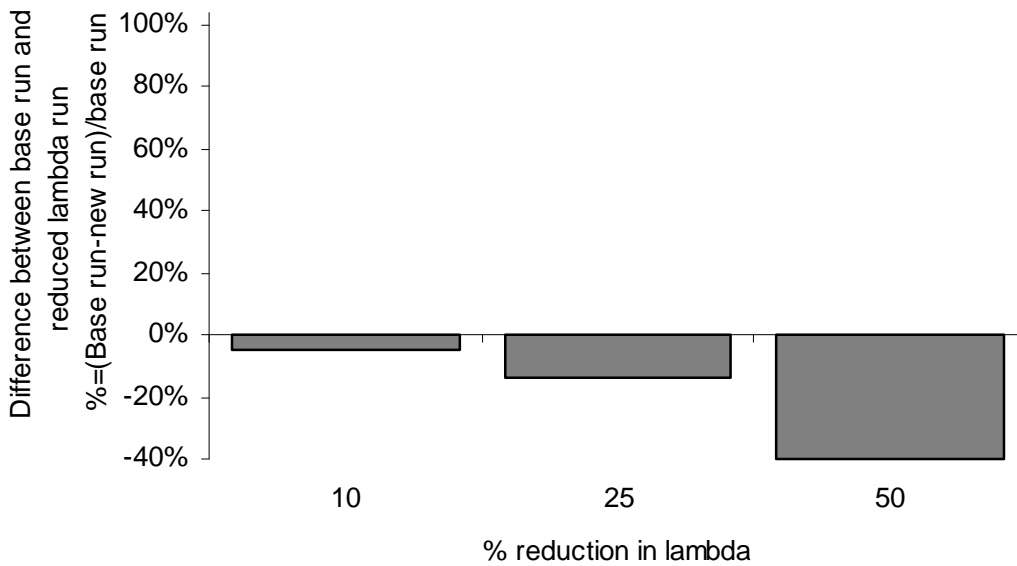
Figure B8.12. Effect of lower reporting rates on estimates of natural mortality (M) from the IRCR tagging model.
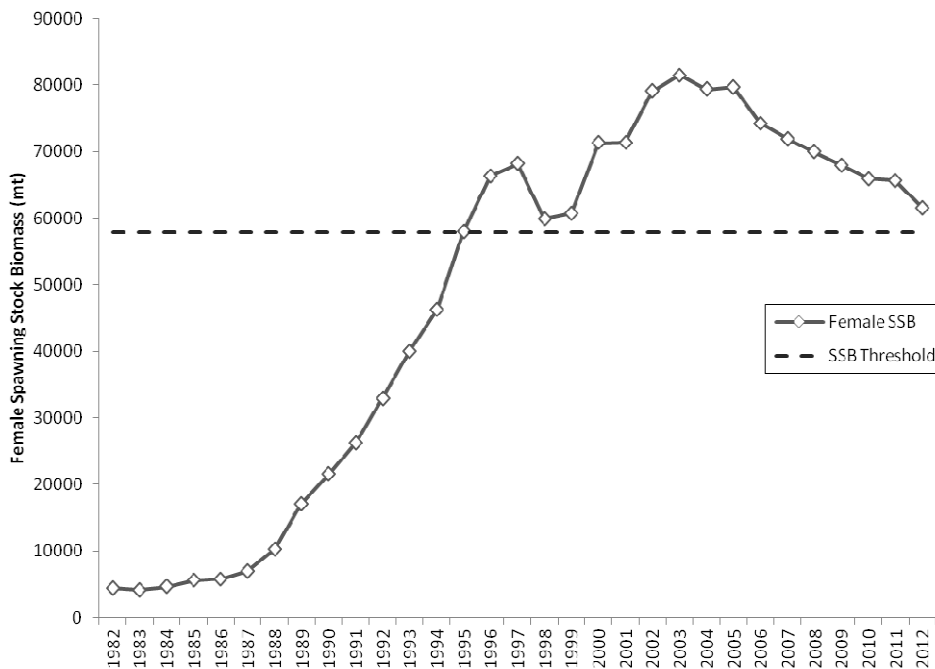
Figure B9.1. Female spawning stock biomass relative to SSB threshold value updated in this assessment.
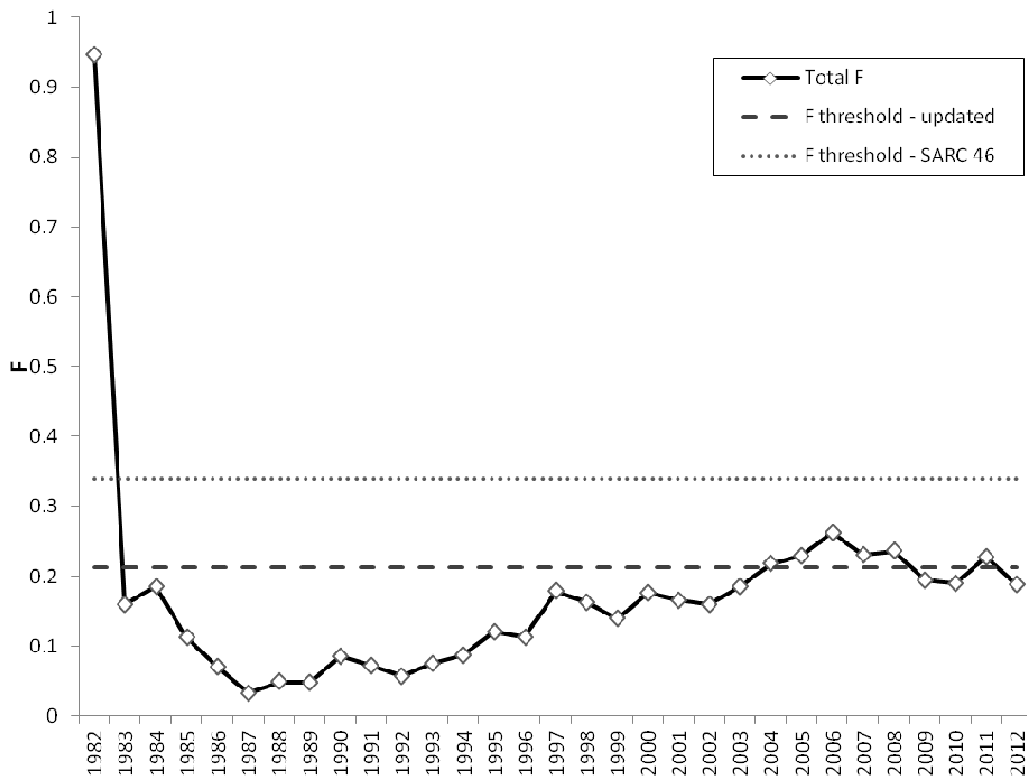
Figure B9.2. Maximum total F at age relative to current (SARC 46) and updated F threshold values.
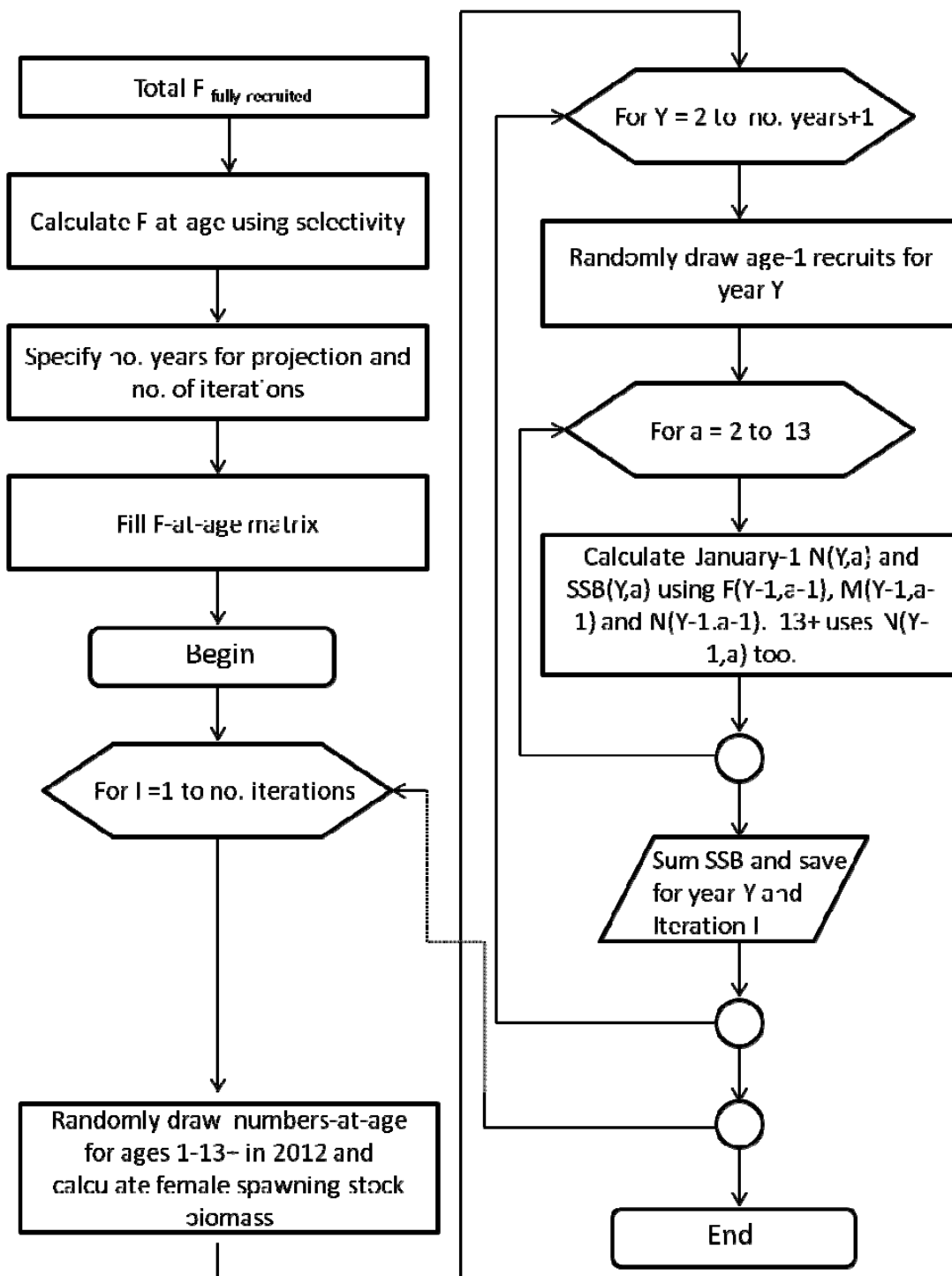
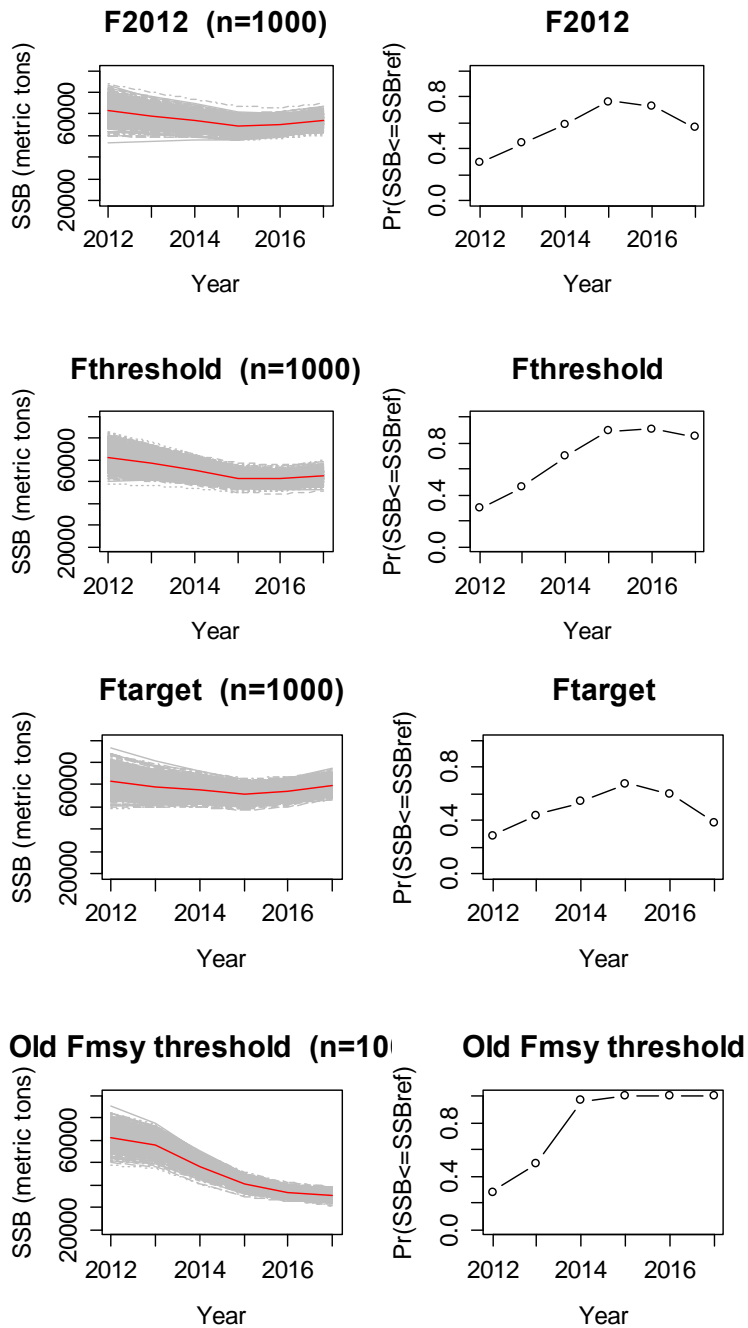Figure B10.1. Flowchart of female spawning stock biomass projection routine written in R.

Figure B10.2. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and assuming the Beverton-Holt S-R relationship. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

F=0.15 (n=1000)
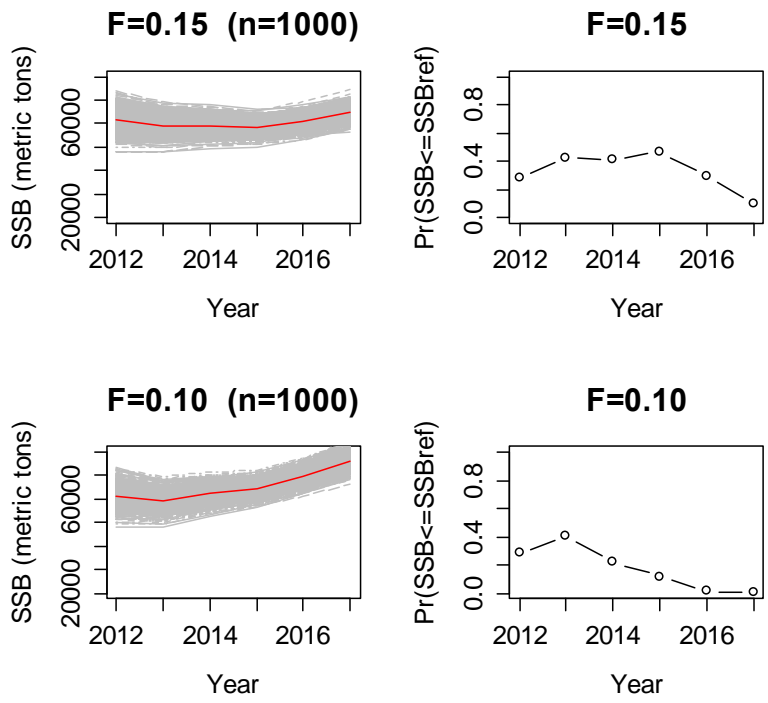
F=0.15

F=0.10 (n=1000)
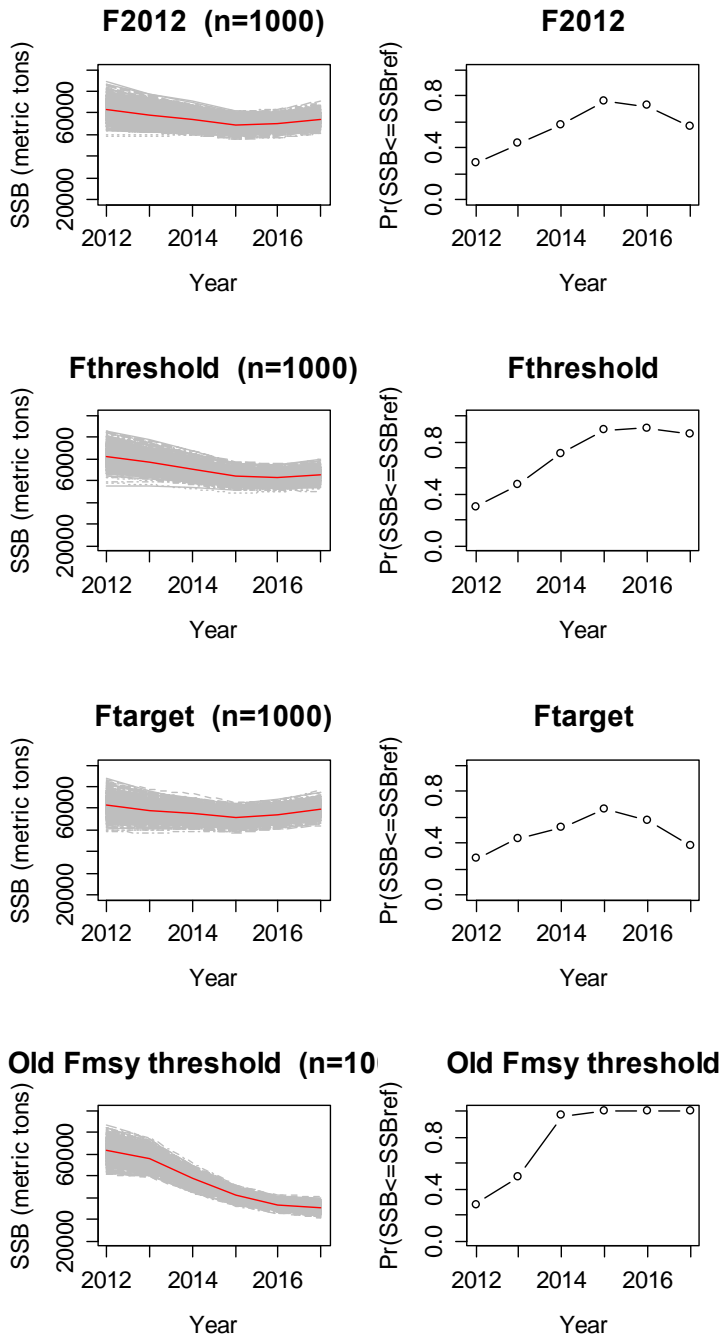
F=0.10

Figure B10.2 cont.

Figure B10.3. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment/SSB ratios from a nonparametric distribution created with the 1990-2012 time series of recruitment and 1989-2011 SSB data. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections

Figure B10.3 cont.
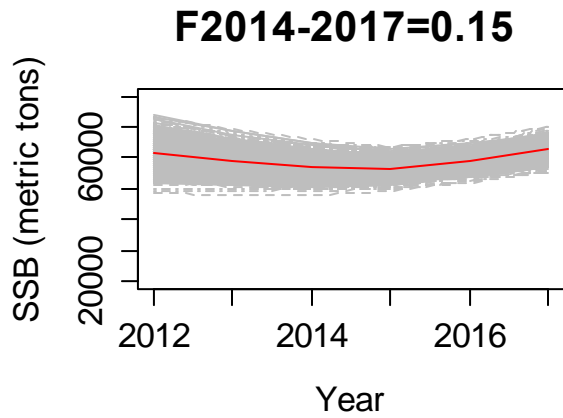
Figure B10.4. Impact of delaying decrease in F until 2014.

Figure B10.5. Impact of delaying decrease in F until 2015.
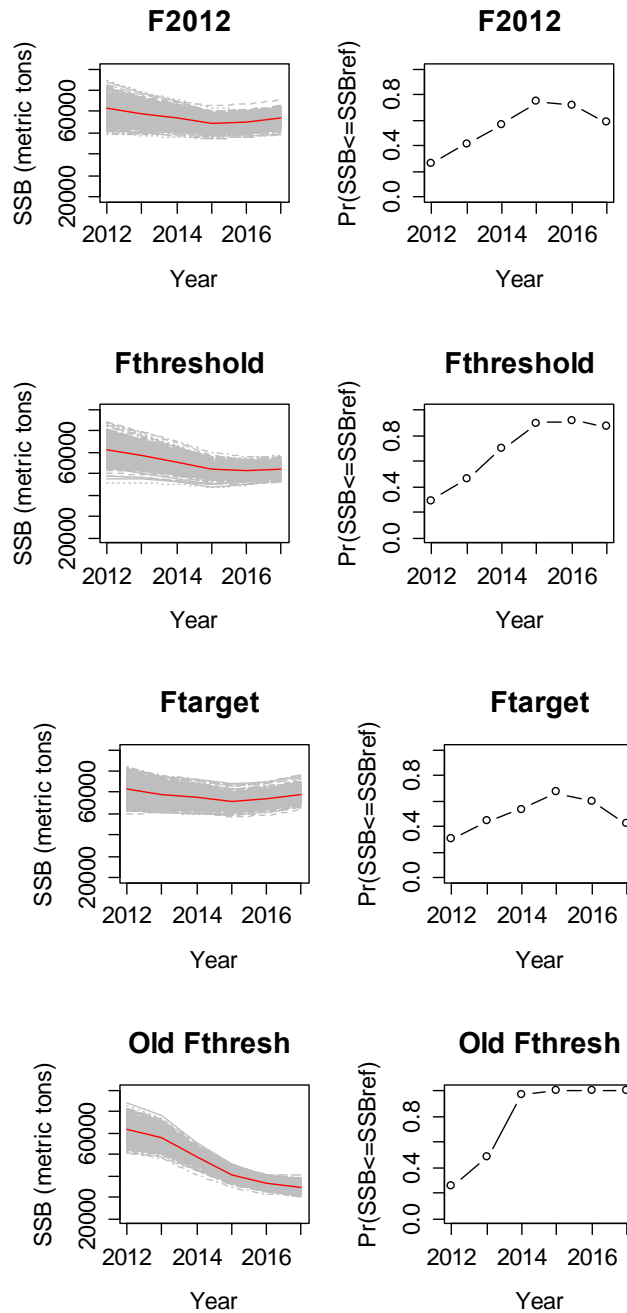
Figure B10.6. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment/SSB ratios from a nonparametric distribution created with the 2002-2012 time series of recruitment and 2001-2011 SSB data. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.
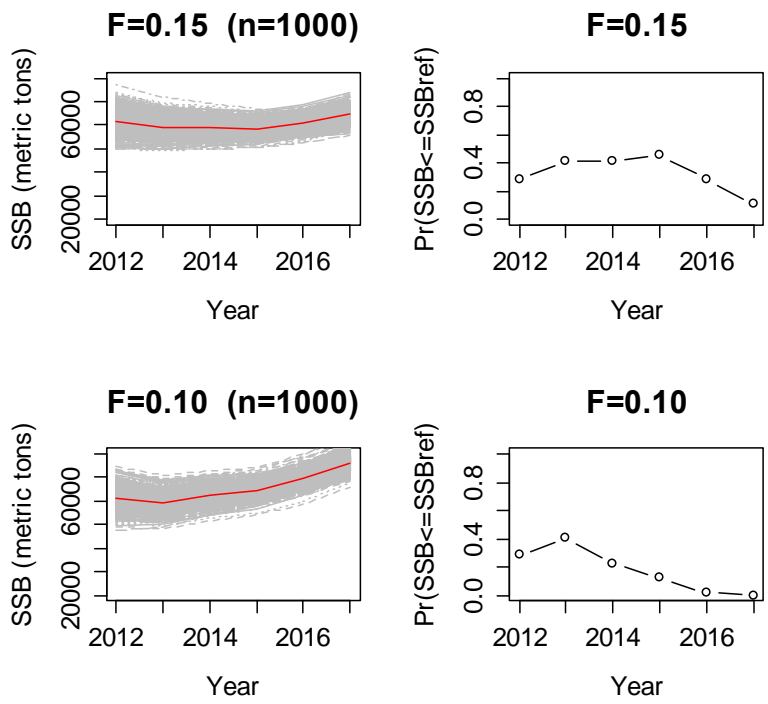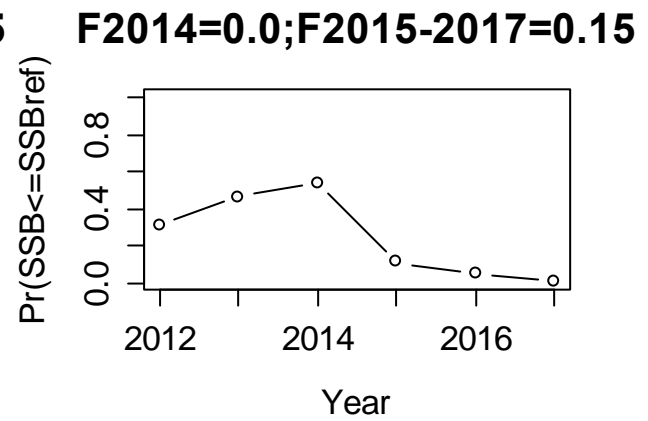
Figure B10.6 cont.

Figure B10.6 cont.

Figure B10.7. Results of the female spawning stock biomass projections using increased natural mortality values on age 3-8 and randomly drawing recruitment/SSB ratios from a nonparametric distribution created with the 1990-2012 time series of recruitment and 1989-2011 SSB data. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.
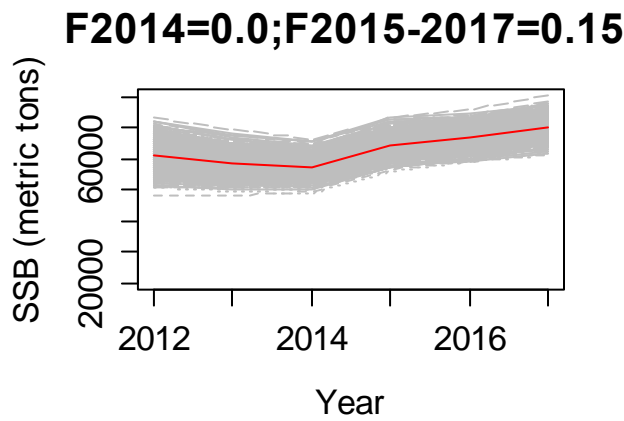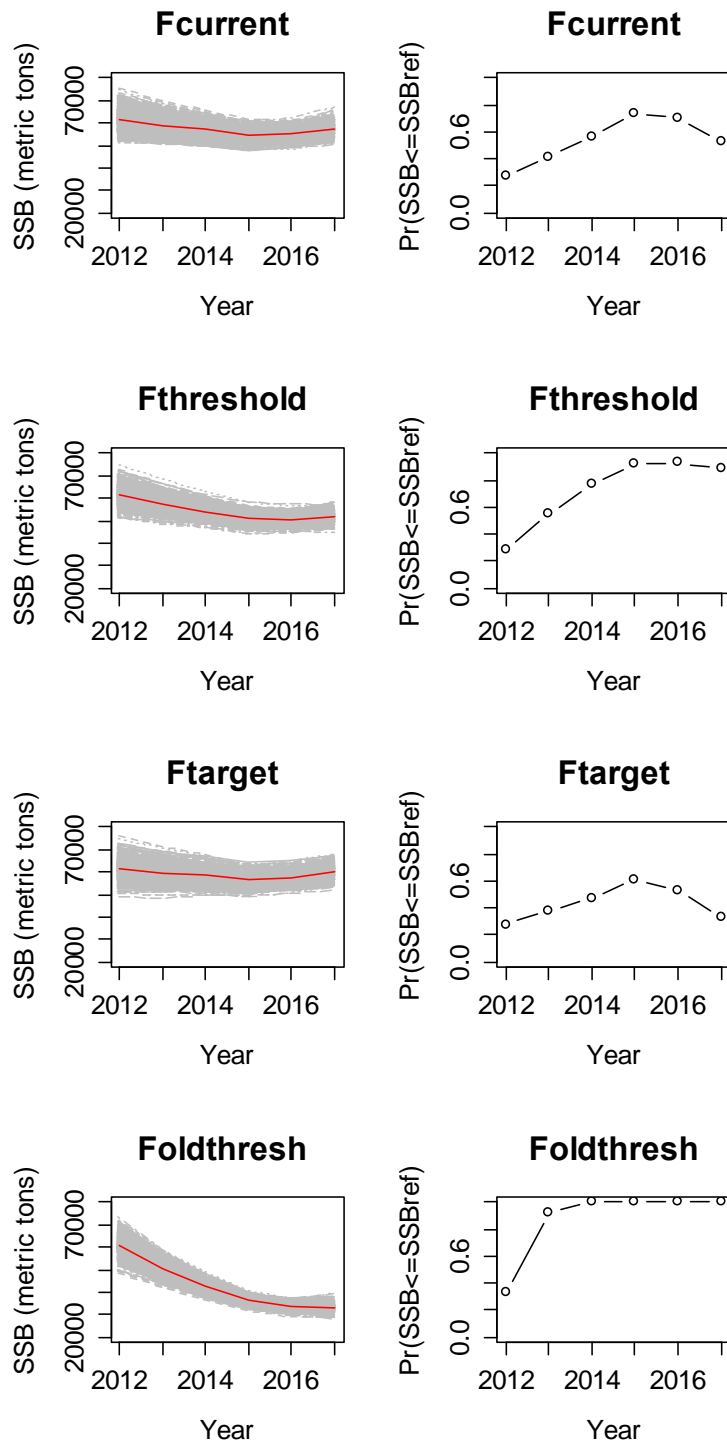
Figure B10.8. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and using the non-bias corrected Beverton-Holt S-R relationship (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.
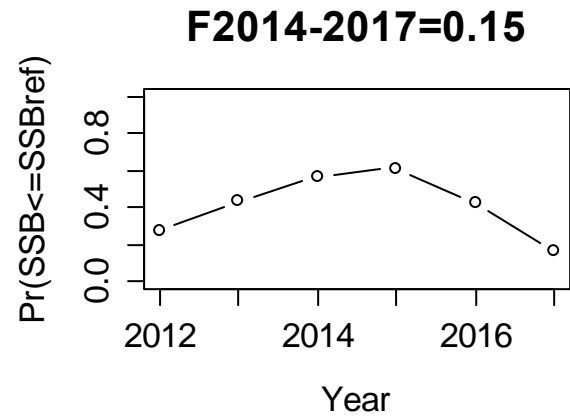
Figure B10.8 cont.

Figure B10.9. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment from the 1990-2012 time series of recruitment (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.
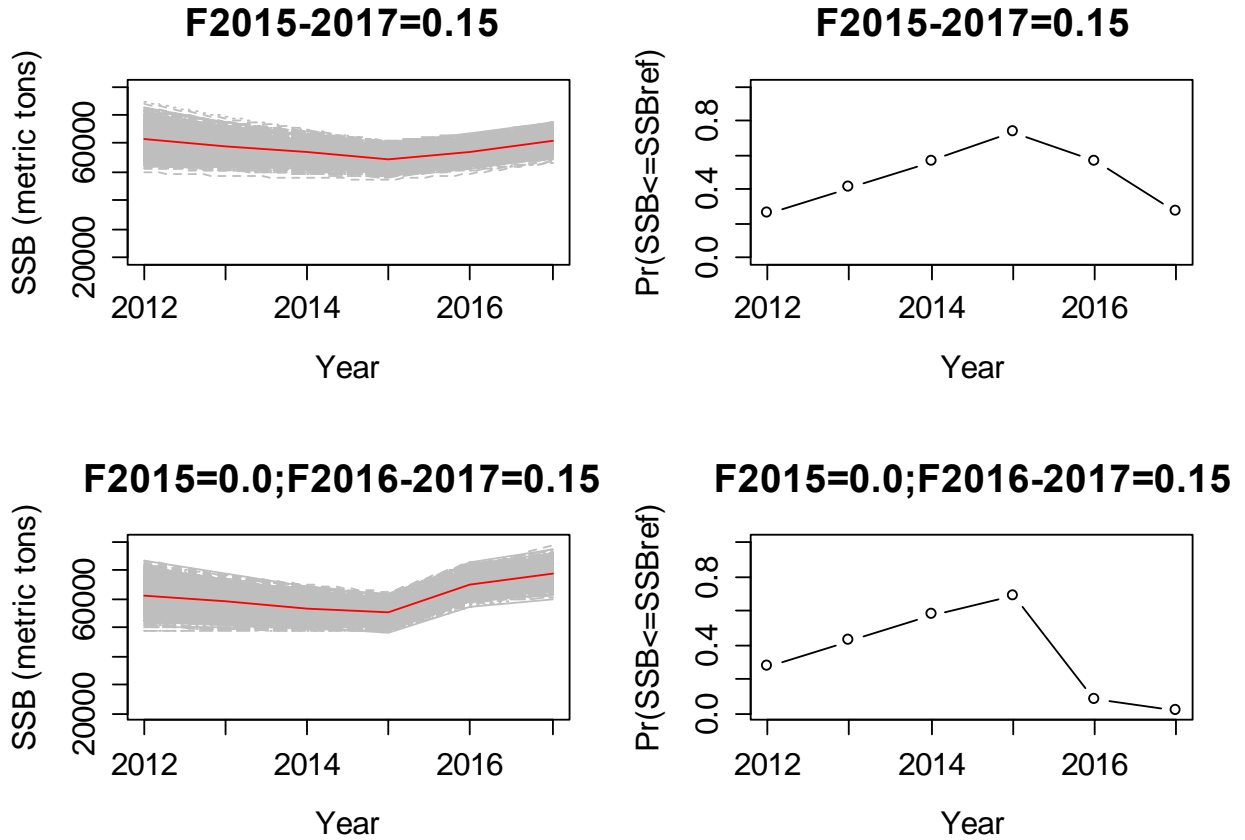
Figure B10.10. Impact of delaying decrease in F until 2014 using empirical recruitment (additional analysis that was completed and peer reviewed during the SARC meeting).
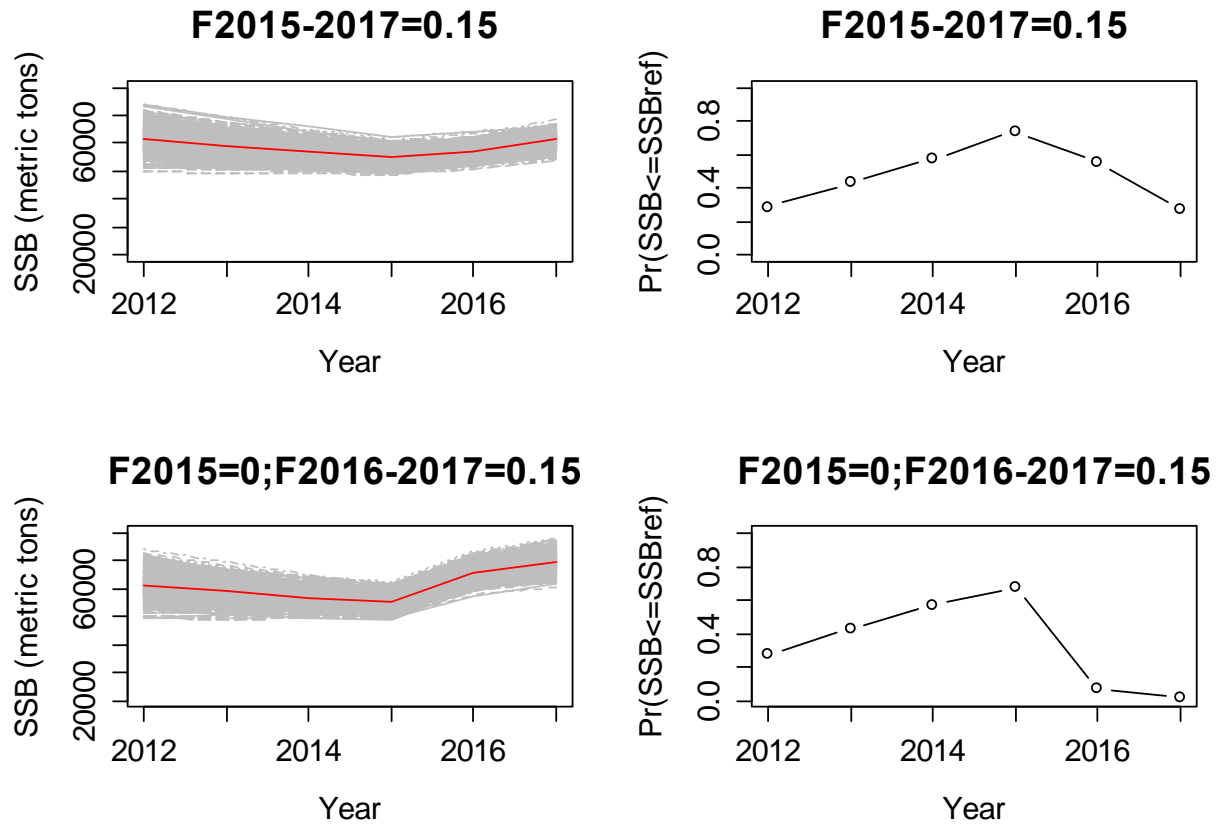
Figure B10.11. Impact of delaying decrease in F until 2015 using empirical recruitment (additional analysis that was completed and peer reviewed during the SARC meeting).

Figure B10.12. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment values from the 2002-2012 time series of recruitment (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.
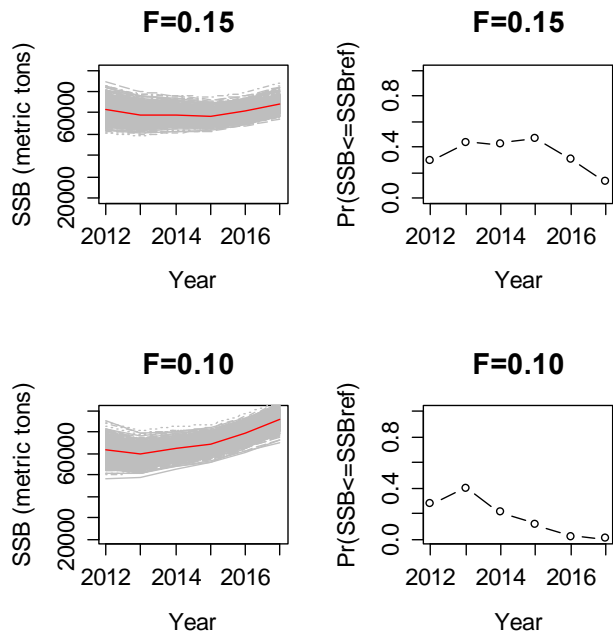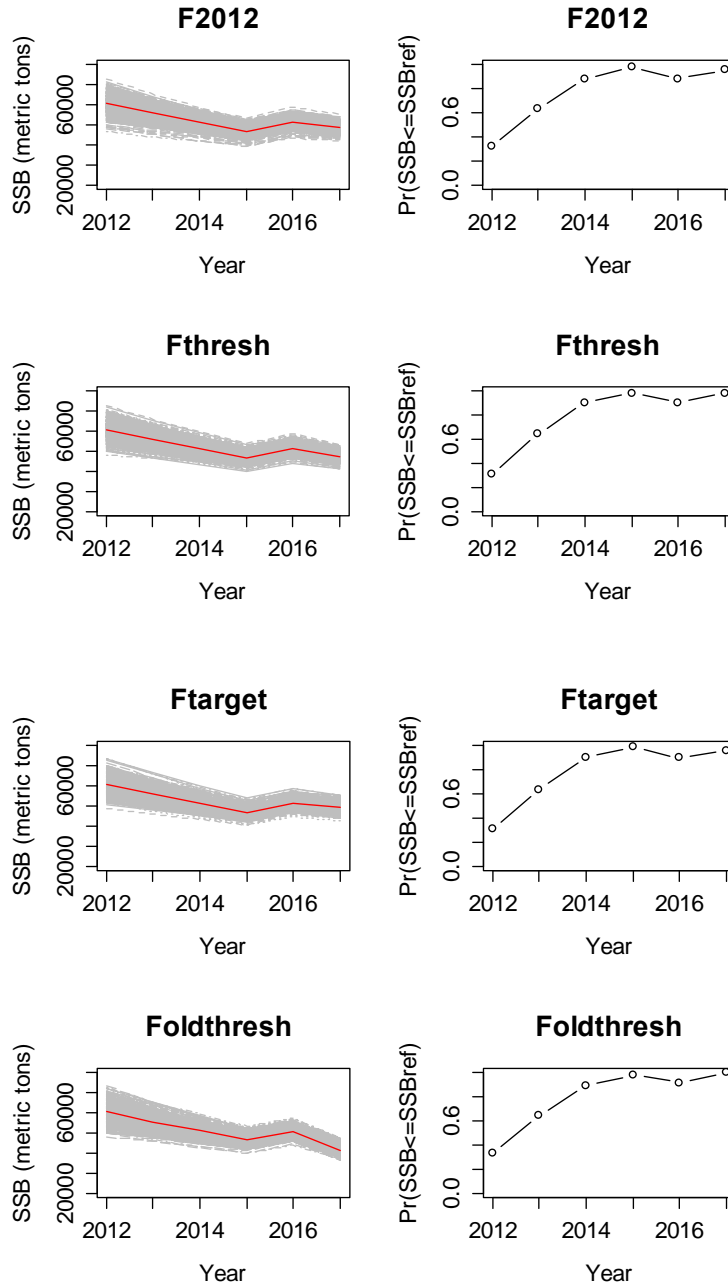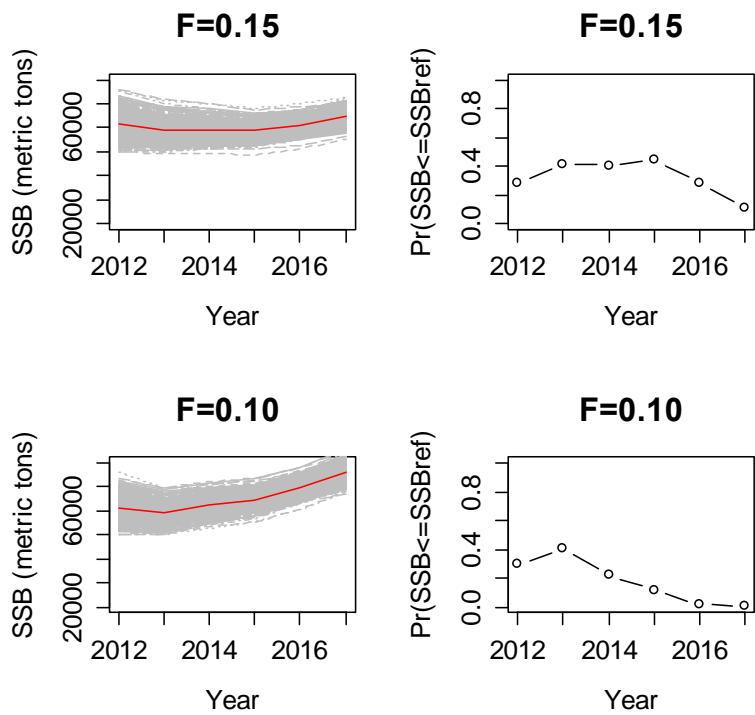
Figure B10.12 cont.
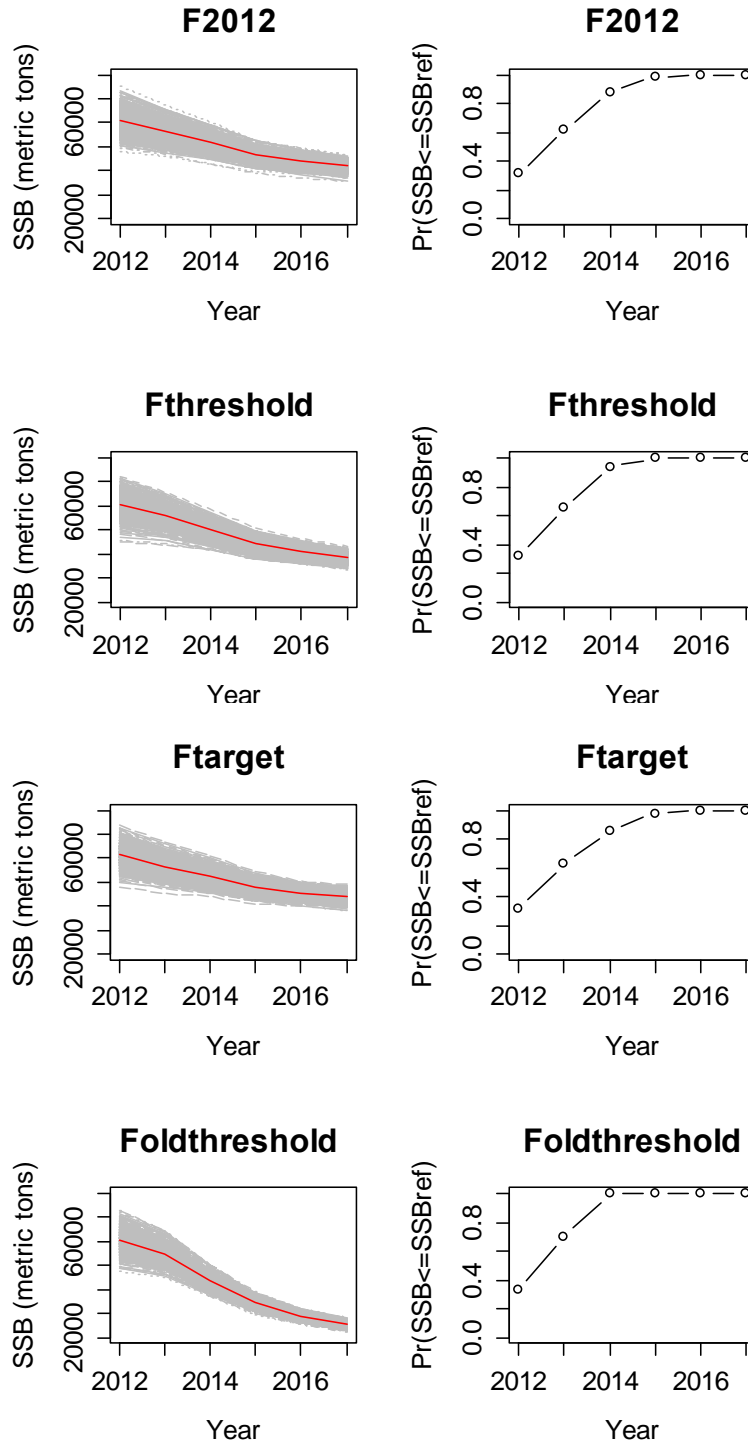
Figure B10.13. Results of the female spawning stock biomass projections using increased natural mortality values on age 3-8 and randomly drawing recruitment values from the 1990-2012 time series (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.
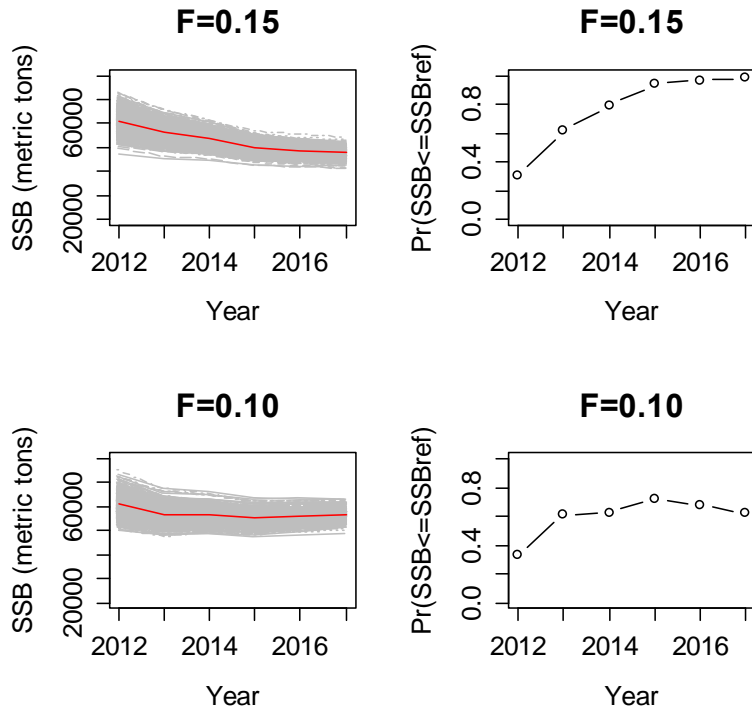
Figure B10.13 cont.
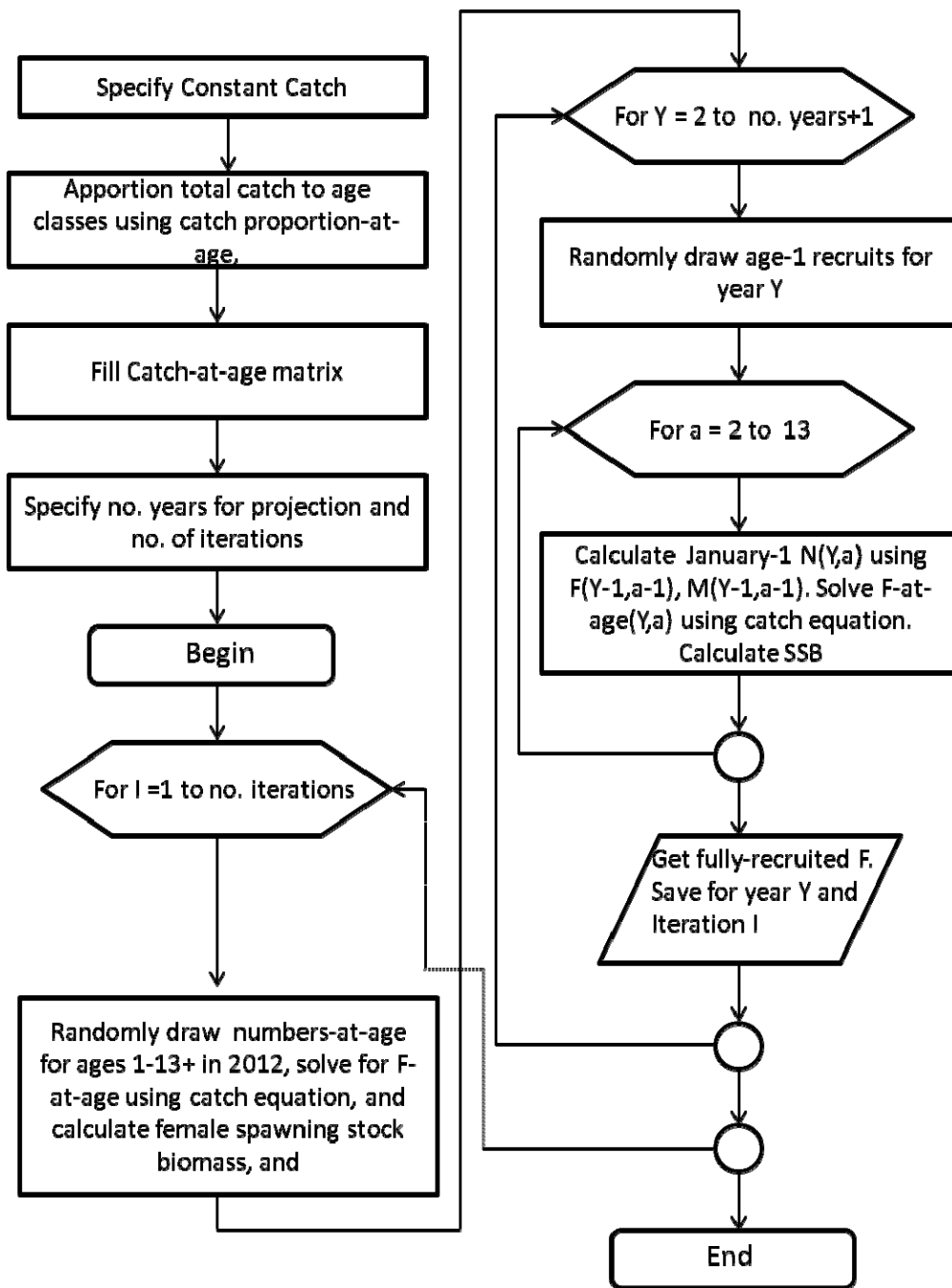
Figure B10.14. Flowchart of the fully-recruited F projection routine written in R.
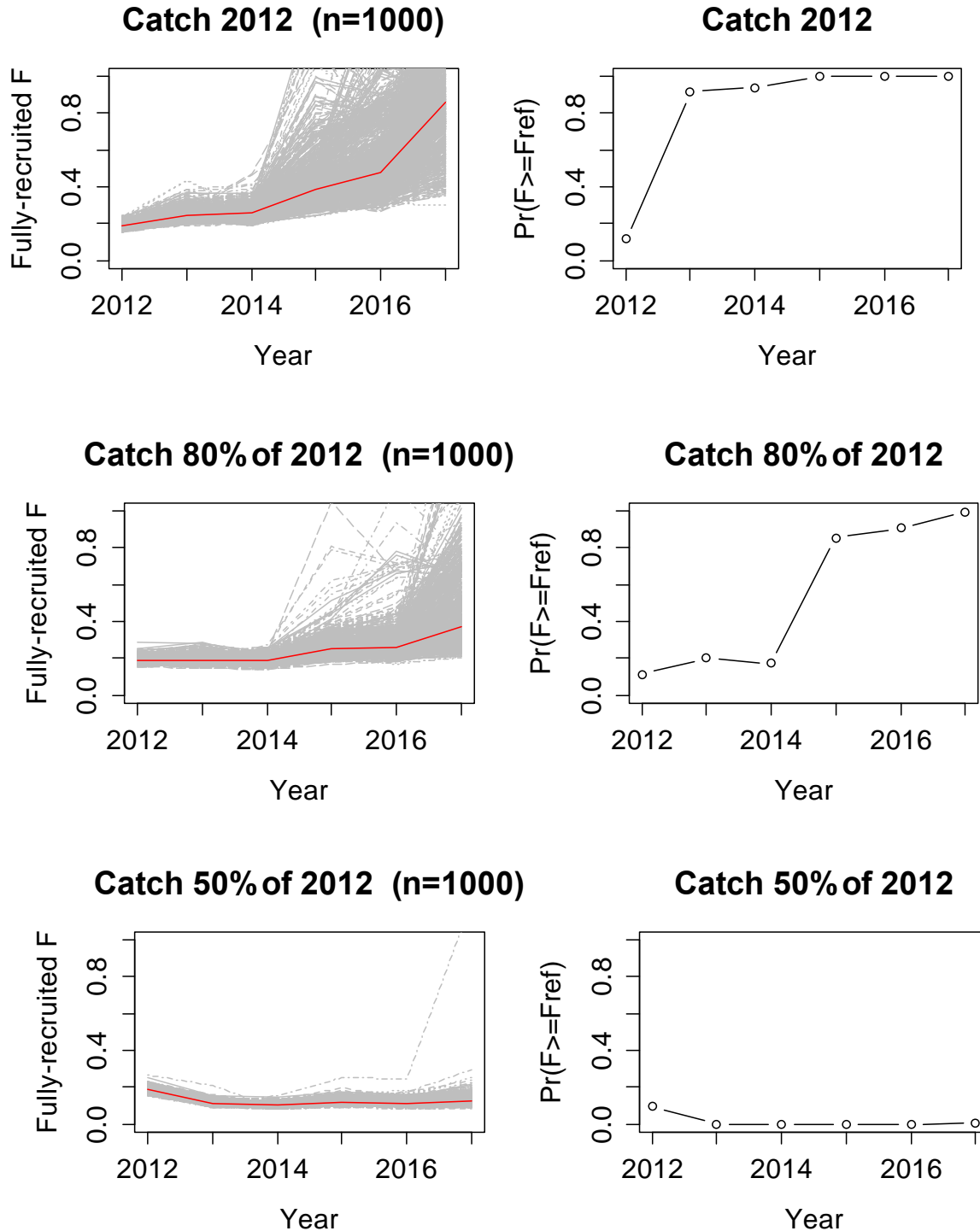
Figure B10.15. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and assuming the Beverton-Holt stock recruitment relationship. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.
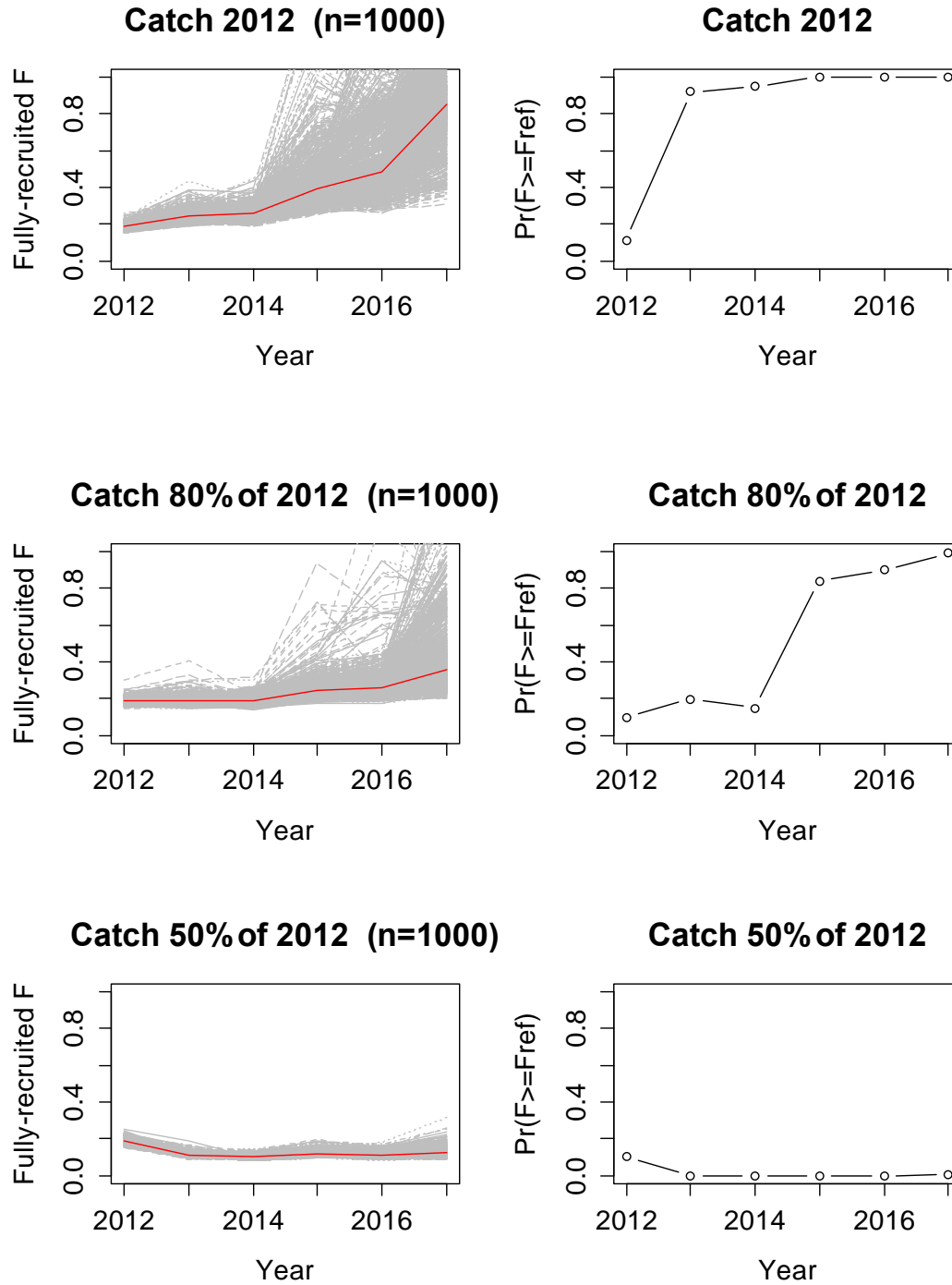
Figure B10.16. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment/SSB ratios from a nonparametric distribution created with the 1990-2012 time series of recruitment and 1989-2011 SSB data. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

Catch 2012 (n=1000)

Catch 2012

Catch 80% of 2012 (n=1000)

Catch 80% of 2012

Catch 50% of 2012 (n=1000)

Catch 50% of 2012

Figure B10.17. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment/SSB ratios from a nonparametric distribution created with the 2002-2012 time series of recruitment and 2001-2011 SSB data. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.
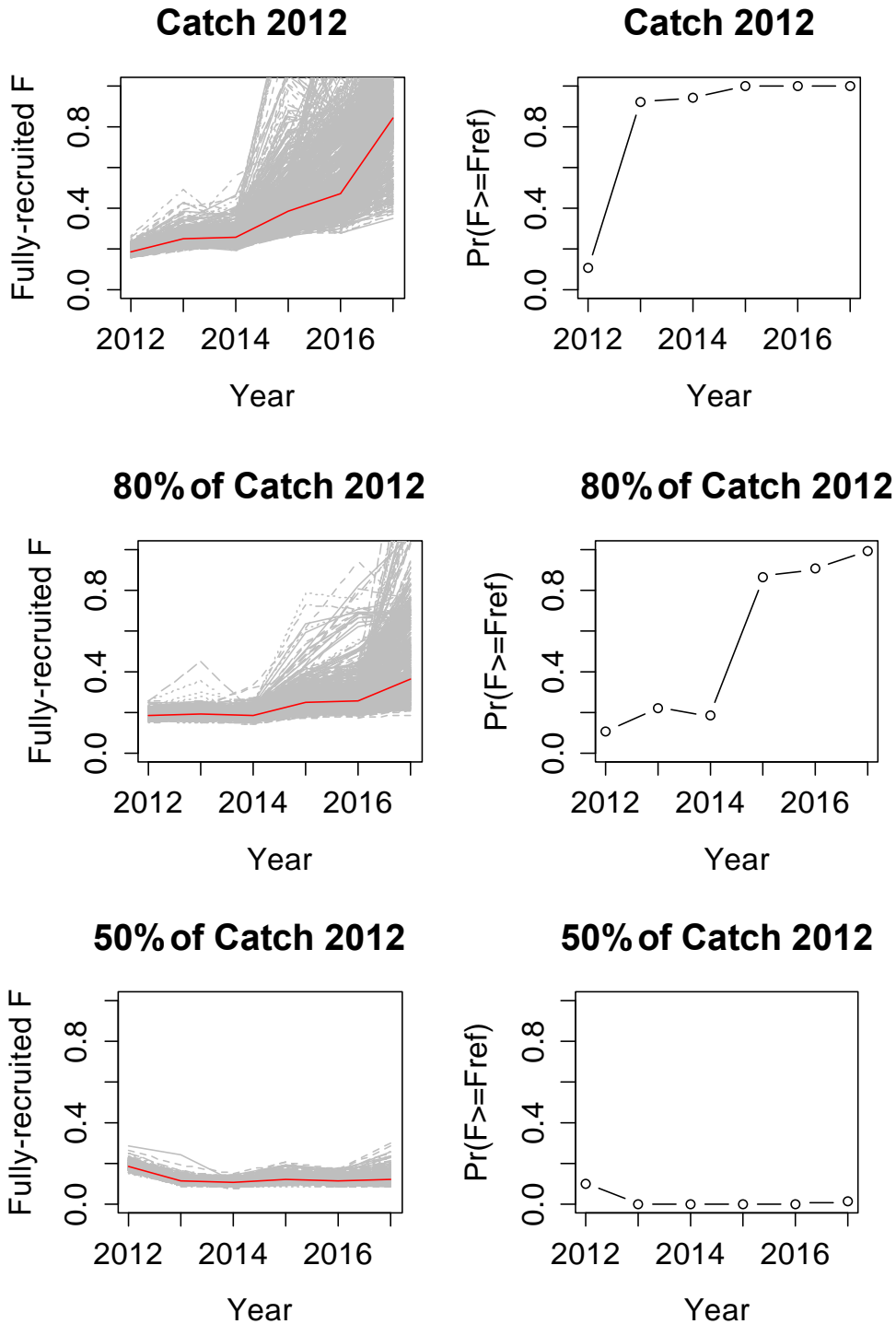
Figure B10.18. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and using the non-bias-corrected Beverton-Holt stock recruitment relationship (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.
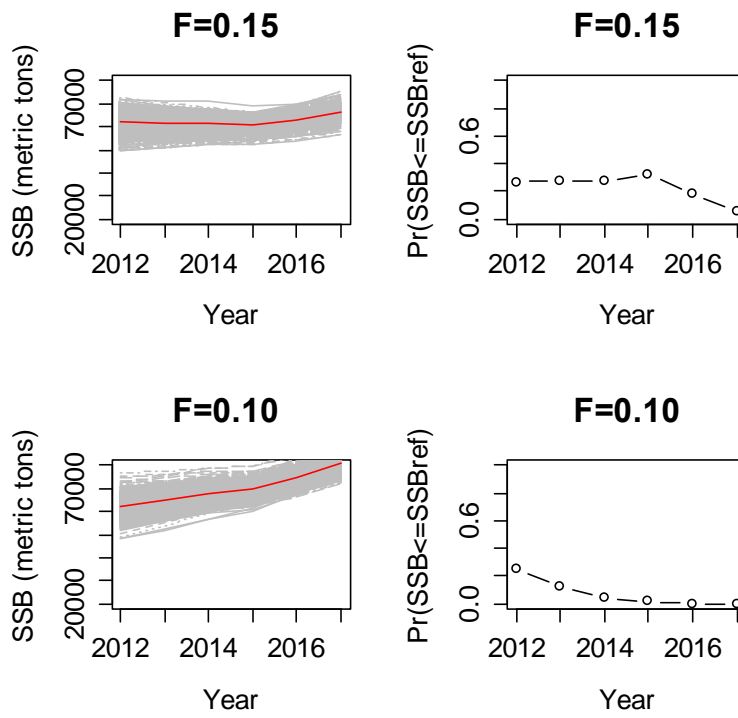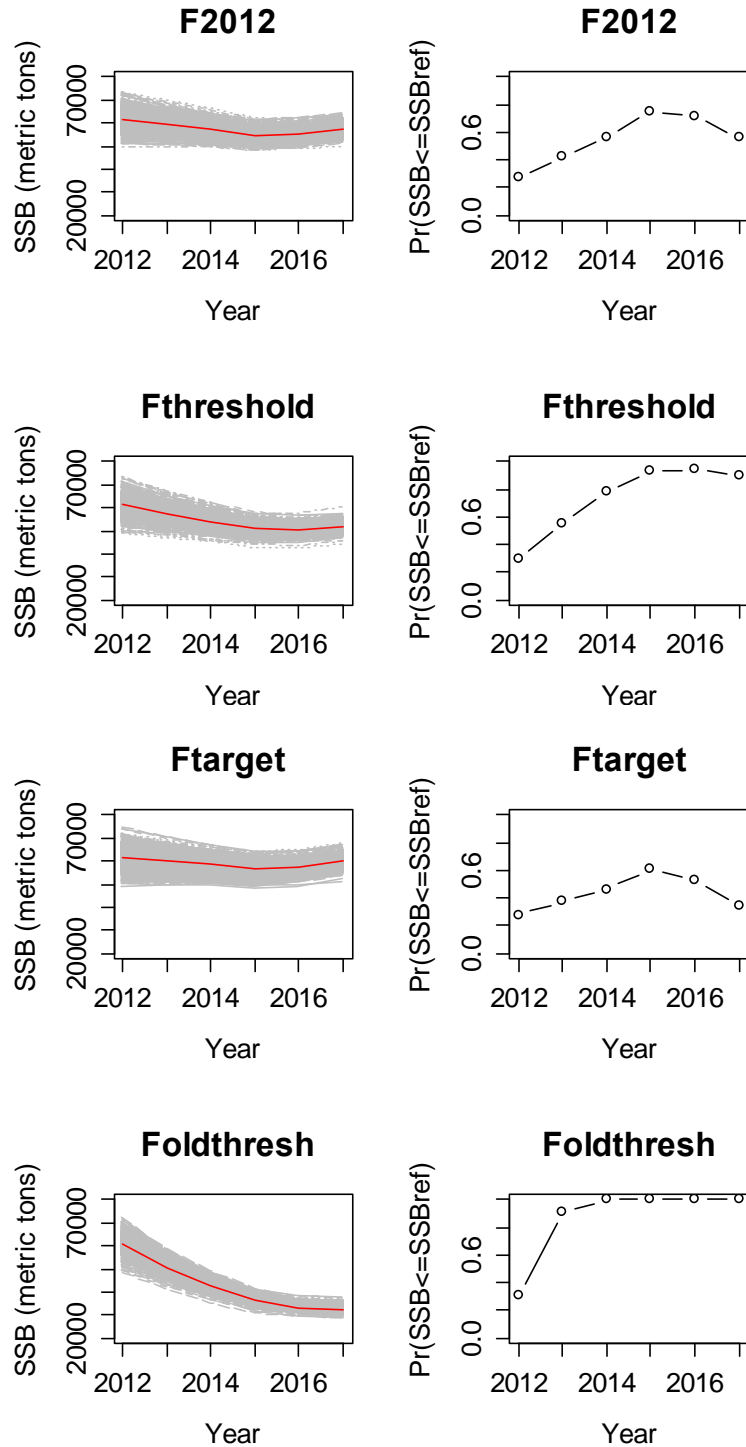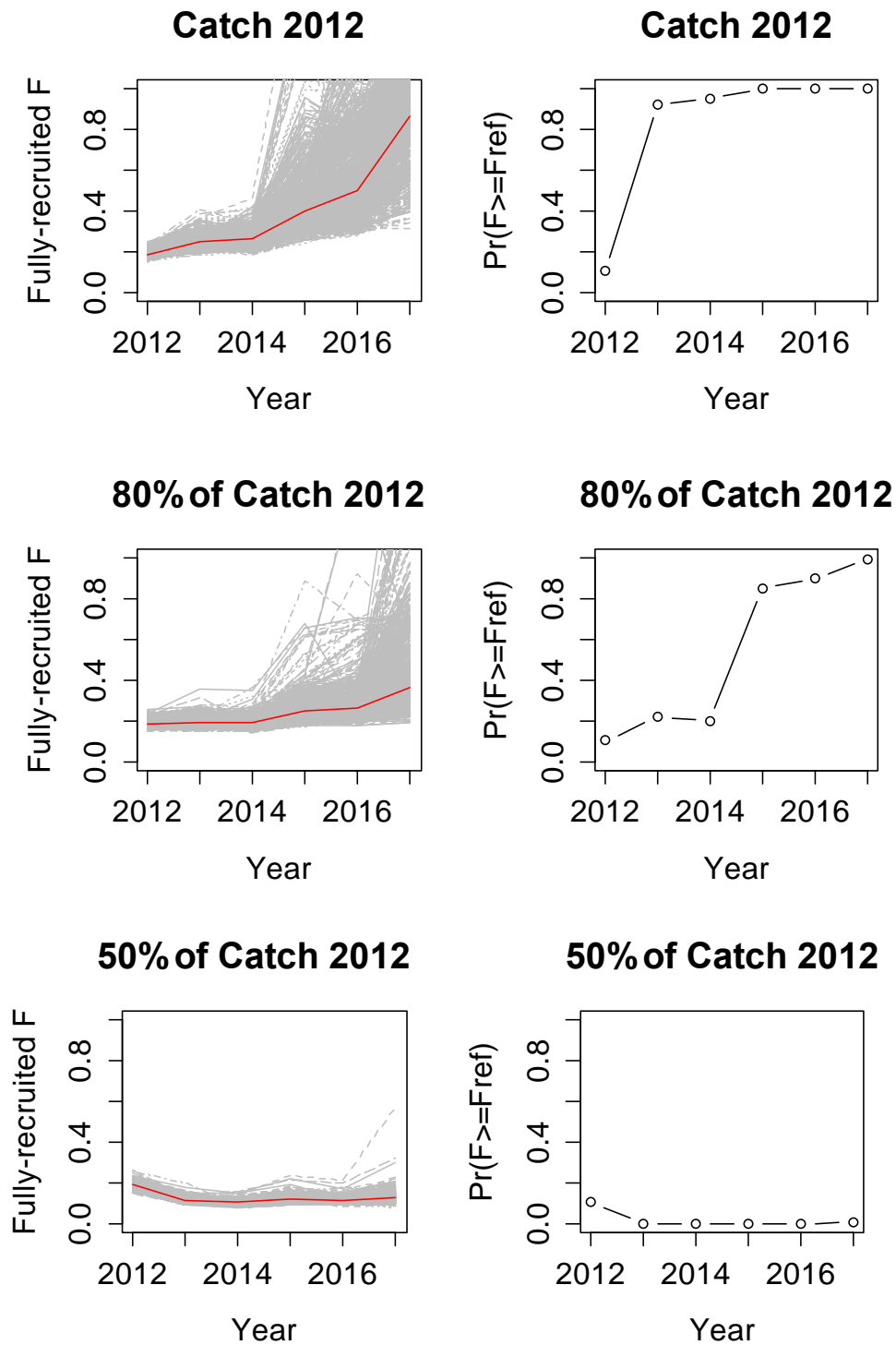
Figure B10.19. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment values from the 1990-2012 time series (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.
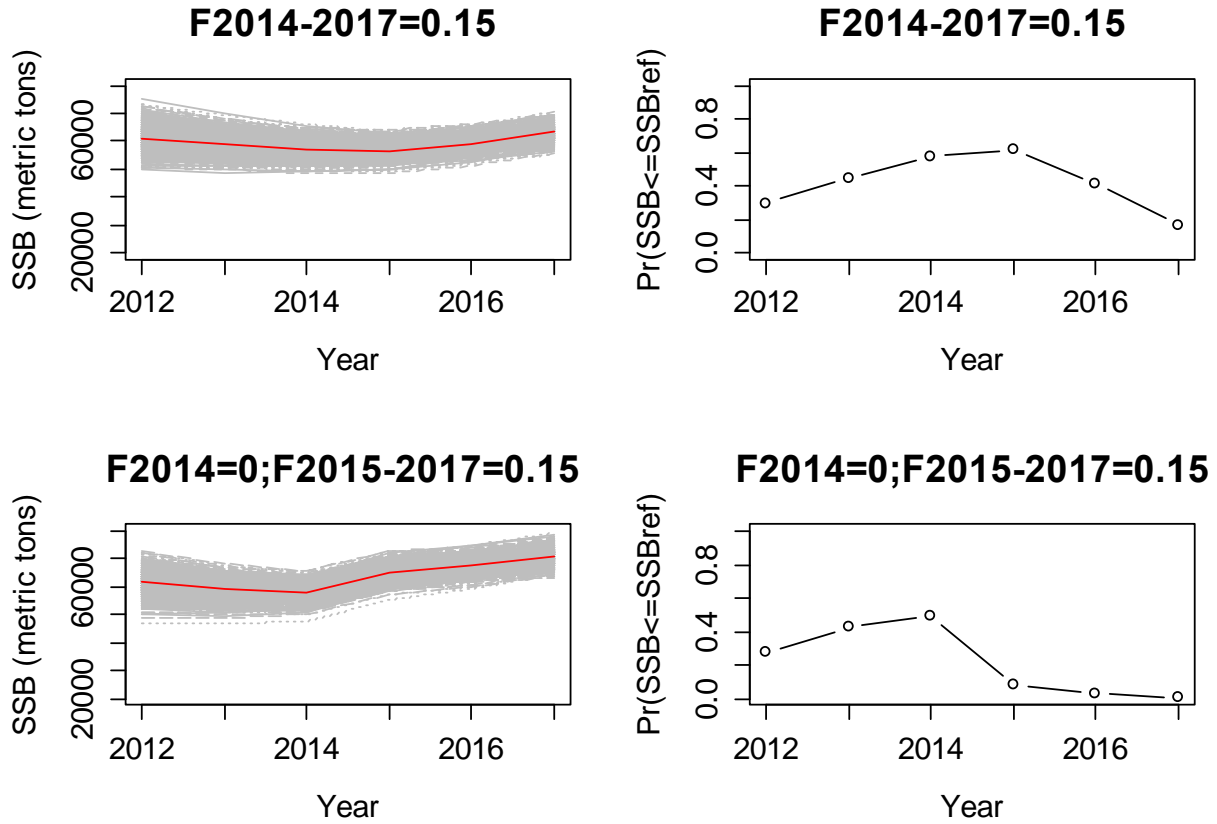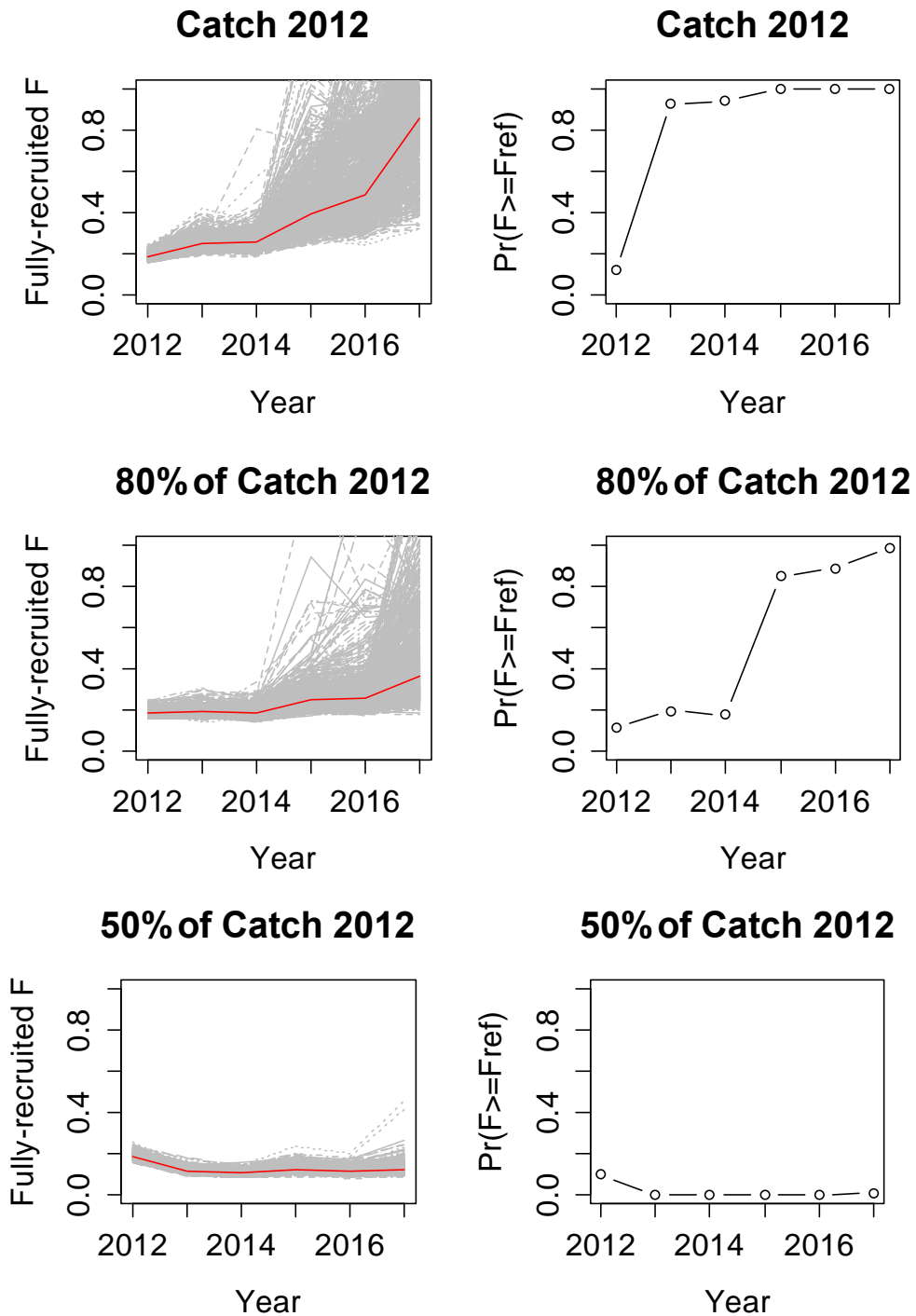
Figure B10.20. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment from the 2002-2012 time series of recruitment (additional analysis that was completed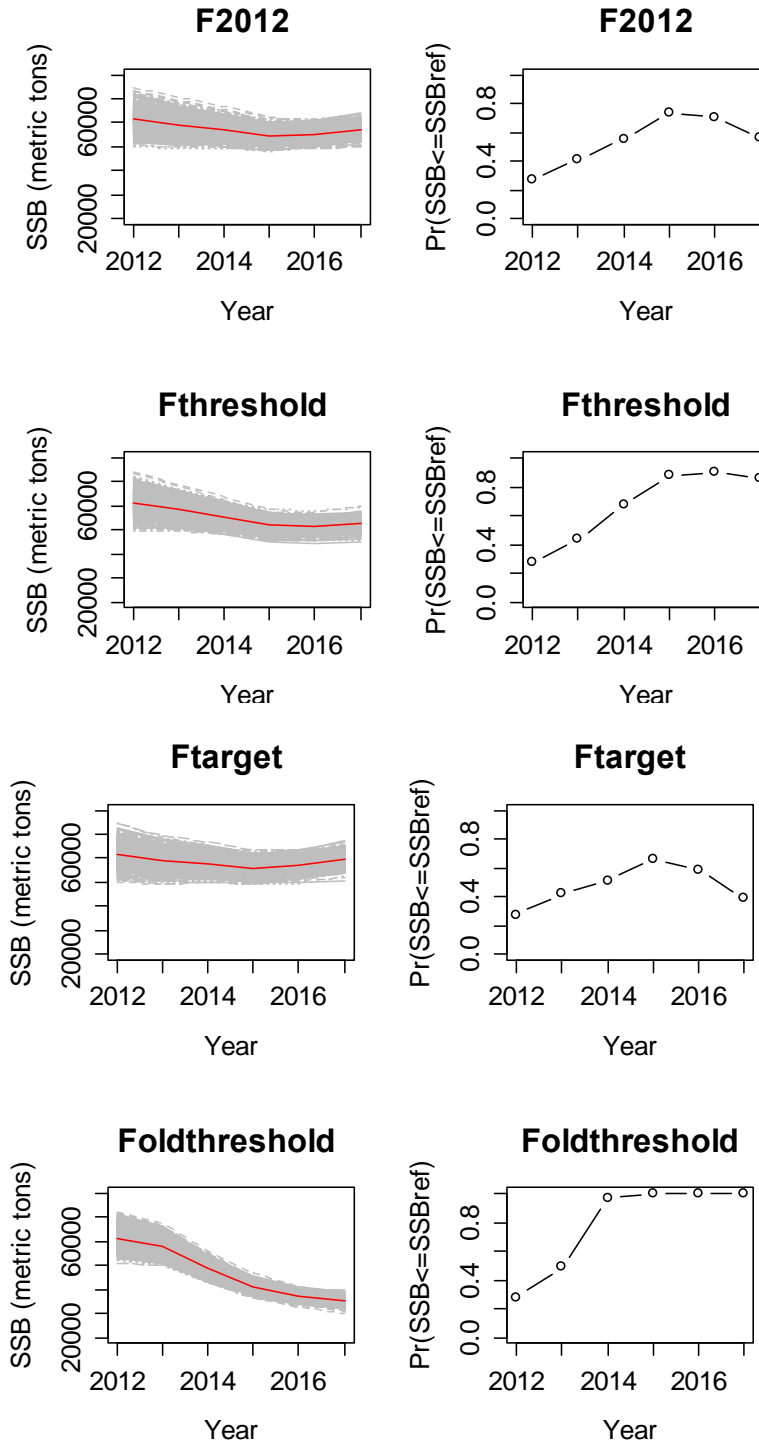 and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.
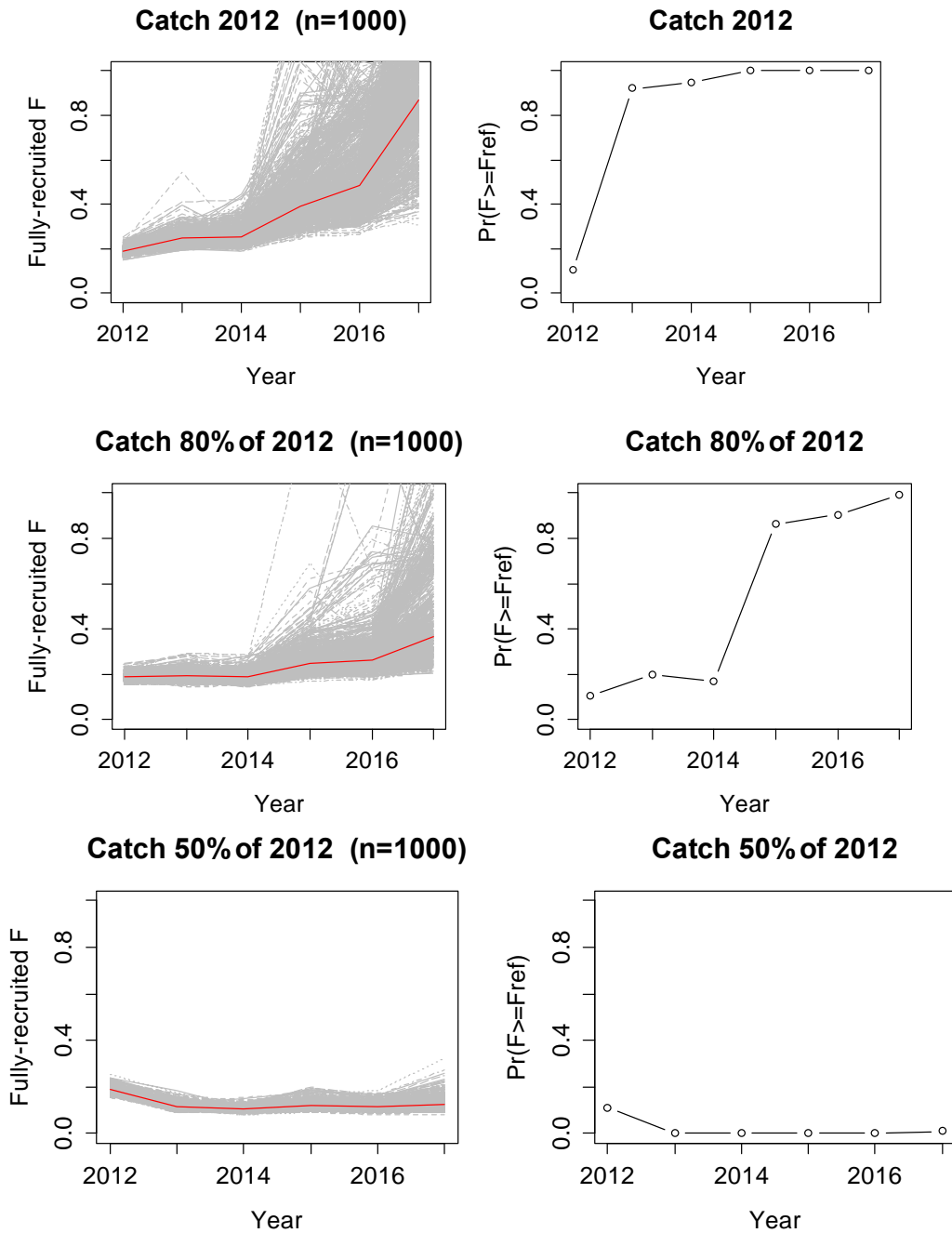
Appendix B1. Commercial Landings Data Sources

State Commercial Landings Monitoring Programs

Massachusetts
Fish dealers are required to obtain special authorization from the Division of Marine Fisheries (DMF) in addition to standard seafood dealer permits to purchase striped bass directly from fishermen. Dealer reporting requirements include weekly reporting to the DMF or Standard Atlantic Fisheries Information System (SAFIS) of all striped bass purchases. If sent to DMF, all harvest information is entered into SAFIS by DMF personnel. Harvest is tallied weekly to determine proximity of harvest to the quota cap. Following the close of the season, dealers are also required to provide a written transcript consisting of purchase dates, number of fish, pounds of fish, and names and permit numbers of fishermen from whom they purchased. Fishermen must have a DMF commercial fishing permit (of any type) and a special striped bass fishing endorsement to sell their catch. They are required to file catch reports at the end of the season, which include the name of the dealer(s) that they sell to and extensive information describing their catch composition and catch rates. If an angler does not file a report, he/she can not obtain a permit in the next year.

Rhode Island
Commercial harvest is reported through Interactive Voice Recording (IVR) and SAFIS. The IVR is a phone-in system designed to monitor quota-managed species, including striped bass. The reported data are aggregated by dealer and include gear, pounds landed, and date landed. SAFIS collects trip level data over the web in accordance with data standards developed by the Atlantic Coastal Cooperative Statistics Survey (ACCSP). Specific data fields include: vessel name, vessel identification (state registration or US Coast Guard Documentation Number), RI commercial license number, port landed, species, reported quantity, unit of measure, date landed, and price. The commercial harvest reported for RI is considered a complete census. The RI Division of Fish and Wildlife (DFW) has a harvester logbook for the commercial finfish and crustacean fishery sectors that collects catch and effort statistics and the associated gear types, gear sets, and areas fished as well as validates data reported by dealers and commercial fishermen.

New York
New York's annual quota (in pounds) is converted into a total number of fish, based on the mean weight of striped bass sampled during state monitoring efforts in the prior year. Each participant in the fishery is issued a fixed number of tags and a set of trip report forms. The regulations governing the fishery require that a commercial harvester tag each legal fish taken within the slot limit for sale, and that report forms are completed whenever any fishing trips are taken. Forms include all the data fields as described in the Rhode Island and Virginia sections of this appendix, as well as fields for area and depth fished, amount of fish harvested in both pounds and count, and specific serial numbers of tags used for each trip. If no trips were taken for an entire month, harvesters must submit a monthly "did not fish" report. All reports are due within 15 days from the end of each month. At the conclusion of the commercial season, any unused tags must be returned to the department. Each participant's harvest records are examined to account for all tags issued. A complete census of the commercial harvest is reported to NMFS each year, and information is also sent to the ACCSP for inclusion to the Data Warehouse.
Delaware

Each fisherman has an Individual Transferable Quota (ITQ), for which they are issued tags by the Division of Fish and Wildlife (DFW). Tags are tamper-proof and serial numbered in accordance with the recommendations of the ASMFC's Law Enforcement Committee. Each harvested fish must be tagged by the fisher and then tagged by a certified weigh station, which must report daily to a real-time quota monitoring system. Fishers must also submit a seasonal catch log.

Potomac River Fisheries Commission (DC)
Mandatory reports of daily activity are submitted on a weekly basis. Failure to report can, and has, resulted in the loss of licenses. Harvest numbers are considered a complete census since all fishermen must report. Each fisherman is given a report book with one sheet for each fishing week at the beginning of the year. He/she records daily harvest (in pounds by market size category and the number of striped bass ID tags used, i.e. the number of fish harvested), amount of gear used (effort), the area of the river where the fish were caught and the port or creek of landing. The buyer records the average selling price and the estimated discards are reported for the week. The reports are mailed to the PRFC weekly and entered into the system and reported to NMFS via the Virginia Marine Resources Commission (VMRC).

Maryland
All commercially harvested striped bass are required to be tagged by the fishermen prior to landing with serial numbered, tamper evident tags inserted in the mouth and out through the operculum. These tags verify the harvester and easily identify legally harvested fish to the public and law enforcement. Each harvest day and prior to sale, all tagged striped bass are required to pass through a commercial fishery check station. Check station employees, acting as representatives of MD Department of Natural Resources (DNR), count, weigh, and verify that all fish are tagged. The check stations are required to call daily and report the total pounds of striped bass checked the previous day, as well as keep daily written logs detailing the activity of each fisherman, which are returned weekly by mail. Individual fishermen are required to report their striped bass harvest on monthly fishing reports and to return their striped bass permit to DNR at the end of the season.

Virginia
All permitted commercial harvesters of striped bass must report the previous month's harvesting activities to VMRC no later than the 5th day of the following month, in accordance with the VMRC regulation that governs the mandatory harvester reporting program. This regulation requires that the monthly catch report and daily catch records shall include the name and signature of the registered commercial fisherman and his license registration number, buyer or private sale information, date of harvest, city or county of landing, water body fished, gear type and amount used, number of hours gear fished, number of hours watermen fished, number of crew on board including captain, species harvested, market category, and live weight or processed weight of species harvested, and vessel identification (Coast Guard documentation number, VA license number or Hull/VIN number). Any information on the price paid for the catch may be provided voluntarily. In addition, all permitted commercial harvesters of striped bass must record and report daily striped bass tag use and specify the number of tags used on striped bass harvested in either the Chesapeake Area or Coastal Area. Daily striped bass tag use on striped bass harvested from either the Chesapeake area or Coastal area, within any month, must be recorded on forms provided by the Commission and must accompany the monthly catch

report submitted no later than the 5th day of the following month. Any buyer permitted to purchase striped bass harvested from Virginia tidal waters must provide written reports to VMRC of daily purchases and harvest information on forms provided by VMRC. Such information shall include the date of the purchase; buyer and harvester striped bass permit numbers, and harvester Commercial Fisherman Registration License number. In addition, for each different purchase of striped bass harvested from Virginia waters, the buyer shall record the gear type, water area fished, city or county of landing, weight of whole fish, and number and type of tags (Chesapeake area or Coastal area) that applies to that harvest. These reports shall be completed in full and submitted monthly to VMRC no later than the 5th day of the following month. In addition, during the month of December, each permitted buyer shall call the VMRC interactive Voice Recording System, on a daily basis, to report his name and permit number, date, pounds of Chesapeake area striped bass purchased, and pounds of Coastal area striped bass purchased.

North Carolina
Commercial harvest is monitored real time through dealer reporting on a daily basis. Dealers report total numbers of fish and total pounds each day. Each fish must have a Division of Marine Fisheries (DMF) tag affixed through mouth and gills upon processing at the fish house. However, the final numbers and pounds used in reports come from the NC DMF trip ticket program. The trip ticket program collects gear data, species data, and total pounds per species each time a commercial fisherman makes a sale at a fish house.

Commercial Harvest Length-Frequencies

Data on length and weight of commercially harvested striped bass are collected through various state-specific sampling programs described below.

Massachusetts
Commercial port samplers visit fish houses throughout the state during the commercial season and measure striped bass being sold. All fish present on a given day are sampled or if there are too many, a sub-sample of totes containing fish are randomly selected. The number measured (TL and FL) and weighted (pounds) is based on the discretion of the port sampler. Approximately, 500-700 fish are measured each season. The length information collected is used the generate length distributions of harvested fish.

Rhode Island
Dockside samples are collected from commercial floating fish trap and rod and reel fisheries. Every individual striped bass observed is measured for fork length (inches) and weighed (pounds). Sampling begins in May or June and continues through October, when the majority of commercial fishing for striped bass in Rhode Island takes place. The low possession limit, especially in the rod and reel fishery, limits the number of striped bass available for sampling on any given day. The proportion of striped bass at length caught in the commercial fisheries is assumed equal to the proportion of striped bass at length sampled from the commercial harvest. The length frequency distributions are estimated separately for the trap and rod and reel fisheries and generally about 185-492 fish are measured per year per gear type. The total number of striped bass commercial harvest is estimated for each fishery by using the sample numbers and

weights to extrapolate to the total weight landed. The estimated total number and the proportions at length are multiplied to compute the estimated number at length for each gear.

New York
Each week during the open season, staff from the Bureau of Marine Resources visit wholesale markets (packing houses), retail markets, or intercept commercial harvesters at marinas or gas docks to sample striped bass caught for commercial purposes. The open geographic area is limited in size, therefore only a few large wholesale markets/packing houses are worth visiting. The information recorded from each fish includes the tag number, fork length, total length, and weight. A sample of scales is collected from each fish. Each year, approximately 1,000 samples are collected.

Delaware
Commercial harvest is sampled at certified, permitted weigh stations.   Real-time quotas are monitored to determine sampling frequency, both temporally and spatially. Random sub-sampling includes fork and total length, weight, sex, and scale sample for age determination. Additionally, striped bass are purchased throughout the commercial season for stomach content analysis and otolith age determination.

Potomac River Fisheries Commission (DC)
A random sample (weekly or monthly) is purchased from local fish buyers. The samples are transported to Virginia Institute of marine Sciences (VIMS), where length, weight, sex and age (scales) are recorded. The recent average monthly harvest is used to establish a target sampling frequency and sample sizes. Samples are processed by professionally trained people at VIMS.

Maryland
Pound net sampling occurs during five rounds from May through October. Each round is 10 to 11 days long. Maryland waters of the Chesapeake Bay are subdivided into three regions; the Upper Bay (Susquehanna Flats south to the Bay Bridge), the Middle Bay (Bay Bridge south to a line stretching between Cove Point and Swan Harbor), and the Lower Bay (Cove Point/Swan Harbor south to the Virginia line. For each round, an optimum number of fish to be sampled is determined for each Bay region. At each net sampled, data recorded includes latitude and longitude, date the net was last fished, depth, surface salinity, surface water temperature, air temperature, secchi depth (m), and whether the net was fully or partially sampled. If the net is fully sampled, all striped bass (including sub-legal fish) are measured for total length (mm TL) and, healthy, legal-size fish ($\geq$457 mm total length) are tagged with USFWS internal anchor streamer tags. If the pound net is partially sampled, legal-size striped bass are targeted for tagging. Check stations across Maryland are randomly sampled for pound net and hook-and-line harvested fish each month from June through November. For pound nets, sample targets of fish per month are established for June through August and for September through November. For hook-and-line, a sample target of fish per month is established over the six-month season.

Virginia
VMRC has been collecting striped bass biological data since 1988. The field sampling program is designed to sample striped bass harvests, in general proportion to the extent and timing of these harvests within specific water areas. Since 2003, VMRC has managed its Coastal Area and Chesapeake Area harvests by two different ITQ systems, and data collections procedures are

intended to ensure adequate representation of both harvest areas. Samples of biological data are collected from seafood buyers' place of business or dockside from offloaded striped bass caught by pound nets or haul seines. Infrequently, some gill net or commercial hook-and-line fishermen's harvests may be sampled directly. At a majority of the sites, striped bass are sampled from a 50-pound box that was previously boxed and iced. At other sites, recently landed fish are randomly sampled directly from the culling table. For each specimen, length is measured using an electronic fish measuring board (FMB), with the accuracy of +/- 2.5 millimeters, and weight is recorded directly to the FMB, from an Ohaus scale, accurate to the nearest 0.01 pound. A sub-sample of fork lengths are taken, but all striped bass are measured for total length (natural) from the tip of the fish snout to the end of its caudal fin. Sub-samples of sex information and fish hard parts (scales and otoliths) are also collected, on a 1-inch interval basis. Generally, only 40-50% of striped bass sampled for scales are also sampled for otoliths. Supplementary data is collected for each biological sample, such as date of collection, harvest location, market grade, harvest area, and gear type.

North Carolina
Samples are collected by DMF personnel at the fish houses or on the beach for the beach seine fishery. DMF sets a target to collect length, weight, sex (Sykes method), and scale samples from 300 fish per gear type, which is usually about 6% of the total harvest.

Commercial Age Samples

The primary ageing structures for striped bass are scales. All states with commercial striped bass fisheries collected samples on a routine basis. Descriptions of the sampling programs are below.

Massachusetts
Commercial port samplers visit fish houses throughout the commercial season and collect scale samples from striped bass being sold. Generally, scale samples from 500-800 fish are collected each season. The proportion that each age comprised the total samples is estimated from a sub-sample of 250-350 fish which guarantees a precision of $\pm$7-10% at α= 0.05. Weighted proportions at age are generated by weighting the age proportions sampled in each county by county harvest. Scales are impressed in plastic using a heated press and aged by projecting impressions on a microfiche machine.

Rhode Island
Scales are removed from the first 25 striped bass that are weighed and measured in a given sample in the commercial dockside sampling program. A sample of scales (typically seven or more) is removed from the area behind the pectoral fin and then cataloged for ageing. The number of age samples taken range from 185 to 492 per year per gear type.

New York
A sample of scales is collected from each fish sampled by staff from the Bureau of Marine Resources (as described in the previous New York section). Each year, approximately 1,000 age samples are collected. Scales are pressed into clear acetate and age assignment is completed by a minimum of two readers. Age assignments are compared for agreement. Disagreements are settled by a group reading or repress of the sample. Samples for which no agreement can be reached are discarded from the set.

Delaware
Commercial harvest is sampled at certified, permitted weigh stations. Real-time quotas are monitored to determine sampling frequency, both temporally and spatially. Random sub-sampling includes fork and total length, weight, sex, and scale sample for age determination. Additionally, striped bass are purchased throughout the commercial season for stomach content analysis and otolith age determination.

Potomac River Fisheries Commission (DC)
A random sample (weekly or monthly) is purchased from local fish buyers. The samples are transported to VIMS, where length, weight, sex and age (scales) are recorded. The recent average monthly harvest are used to establish a target sampling frequency and sample sizes. The sample is 'worked-up' by professionally trained people at VIMS.

Maryland
Age composition of the pound net and hook-and-line fisheries is estimated via two-stage sampling (Kimura 1977, Quinn and Deriso 1999). The first stage refers to total length samples taken during the surveys, which was assumed to be a random sample of the commercial harvest. In this case, the length frequencies from hook-and-line and pound net check stations were combined with the pound net tagging length frequency. In stage 2, a random sub-sample of scales was aged which were selected in proportion to the length frequency of the initial sample. The total number of scales to be aged was determined using a Vartot analysis which is a derived index measuring the precision of an age-length key (Kimura 1977, Lai 1987). Regardless of the sample size indicated by the Vartot analysis, 10 fish in each length category over 700 mm TL were aged. Year-class was determined by reading acetate impressions of the scales placed in microfiche readers, and age was calculated by subtracting year-class from collection year. The resulting ages were used to construct an age-length key.

Virginia
VMRC has been collecting striped bass biological data since 1988. The field sampling program is designed to sample striped bass harvests, in general proportion to the extent and timing of these harvests within specific water areas. Since 2003, Virginia has managed its Coastal Area and Chesapeake Area harvests by two different ITQ systems, and data collections procedures are intended to ensure adequate representation of both harvest areas. Samples of biological data are collected from seafood buyers' place of business or dockside from offloaded striped bass caught by pound nets or haul seines. Infrequently, some gill net or commercial hook-and-line fisherman's harvests may be sampled directly. At a majority of the sites, striped bass are sampled from a 50-pound box that was previously boxed and iced. At other sites, recently landed fish are randomly sampled directly from the culling table. For each specimen, length is measured using an electronic fish measuring board (FMB), with the accuracy of +/- 2.5 millimeters, and weight is recorded directly to the FMB, from an Ohaus scale, accurate to the nearest 0.01 pound. A sub-sample of fork lengths are taken, but all striped bass are measured for total length (natural) from the tip of the fish snout to the end of its caudal fin. Sub-samples of sex information and fish hard parts (scales and otoliths) are also collected, on a 1-inch interval basis. Generally, only 40-50% of striped bass sampled for scales are also sampled for otoliths. Supplementary data is collected for each biological sample, such as date of collection, harvest location, market grade, harvest area, and gear type.

North Carolina
Scales are obtained from striped bass above the lateral line and below the dorsal fin, pressed on acetate sheets using a Carver heated hydraulic press and read by DMF personnel on a microfiche reader. Age is assigned using ASMFC striped bass ageing guidelines. A sub-sample of 15 fish per sex per 25 mm size group are aged. Year class is then assigned to the remainder of the sample.

Commercial Harvest-At-Age

Commercial harvest at age are usually estimated by applying corresponding length-frequency distributions and age-length keys to the reported number of fish landed by the commercial fisheries in each state. State-specific descriptions of the estimation procedures are below.

Massachusetts
The proportion that each age comprises the total samples of harvested fish is estimated from a sub-sample of 250-350 fish which guarantees a precision of $\pm 10\%$ at $\alpha = 0.05$. Weighted proportions at age are generated by weighting the age proportions sampled in each county by county harvest. The number of fish harvested is then multiplied by the proportions-at-age to get numbers harvested-at-age.

Rhode Island
Gear-specific age-length keys are computed based on the length and age samples collected from the commercial dockside sampling program. In years when no RI age data is available, a combined Ma and NY age-length key is used. The keys are applied to the commercial length frequencies to estimate the catch-at-age for each gear. The numbers at age are summed over gear types to provide an estimate of the total commercial catch-at-age for the year.

New York
Since sampling is conducted weekly throughout the open season and open geographic area, it is assumed that the annual sample is representative of the harvest. The number of fish harvested is disaggregated by the length and age frequency of the monitoring samples. No effort has been made to apportion the release data to length or age classes because no physical samples are collected.

Delaware
The DFW develops age-length keys by commercial gear type. Landings in the commercial hook and line commercial fishery comprise a very low proportion of the total commercial landings. Therefore, age samples from this fishery are supplemented with age samples from recreational hook and line striped bass to formulate an age-length key specific to harvest from this gear type.

Potomac River Fisheries Commission (DC)
Harvest is apportioned via ageing of the commercial samples. No age data (except fish < 18") are collected for released fish. Also included is information on the For-Hire fisheries, as the PRFC considers party, charter, guide and other such boats as commercial operations that carry recreational fishermen. PRFC requires a commercial license for the captain and requires him to

have a sport fishing decal (license) for his boat that exempts his passengers from needing to be individually licensed. Captains use a logbook system to report their boats' catch and estimates of the released fish. PRFC also cooperates with the NMFS "For-Hire" Survey by providing a monthly list of boats and captains licensed to carry fee-paying passengers in the Potomac. This allows NMFS to include the PRFC boats in their database and to survey them. At present, NMFS is unable to produce a separate catch and release estimate for the Potomac, but the information on the total harvest is included in the MD and VA estimate. Since, the PRFC, MD and VA all share in one overall Chesapeake Bay F-base management system, there is no immediate need for a Potomac River sub-total for the "For-Hire" fishery.

Maryland
The harvest-at-age for each fishery is calculated by applying the age-length key developed from the hook-and-line and pound net data to the length frequencies observed in each fisheries and expanding the resulting age distribution to the harvest.

Virginia
Harvest data are apportioned to age classes by using an area-specific (Chesapeake Area or Coastal Area), seasonal age-length key (if possible) or annual key. Collected lengths and the age-length key are inputs, along with the harvest weight, into the template that has been used for 3 years to determine catch at age.

North Carolina
Total pounds landed is obtained from trip ticket program. Then year classes are apportioned to harvest based on the percentage of pounds per year class as observed in the sample taken from fish houses. Numbers of fish per year class are then assigned using the average weight per fish per year class as observed in the sample.

Appendix B2. Estimation of Virginia and North Carolina Wave-1 Harvest, 1996-2004

DT: 7/11/2005

TO: ASMFC Striped Bass Technical Committee

FR: Joseph Grist, ASMFC

RE: MRFSS North Carolina Wave-1 2004 harvest

Introduction

During the March 2005 Striped Bass Technical Committee (STB TC) meeting, the results for the 2004 wave-1 North Carolina (NC) harvest were reported. This was the first time wave-1 was directly sampled by the Marine Recreational Fisheries Statistics Survey (MRFSS), and the results were both predictable and a cause for concern. A total of 177,288 striped bass (equivalent to 3,615,670 lb) were harvested during wave-1 in North Carolina.

Anecdotal knowledge has suggested that North Carolina, Virginia, and possibly other states had a sizeable wave-1 fishery. The 2004 wave-1 harvest values for North Carolina and the wave-1 tag return data (Figure 1) for North Carolina and Virginia support this suggestion. However, information is still lacking on what the previous annual harvest rates were, as well as the level of exploitation in Virginia and elsewhere during wave-1. The STB TC requested an examination of the data that included suggestions for how to incorporate these data efficiently into the coastwide STB assessment.

The goal of this analysis is to determine if tag return data during wave-6 and wave-2 are correlated with the reported total harvest and, if so, if a proxy ratio may be utilized to back-calculate wave-1 data for North Carolina and Virginia.

Data

Striped bass tag return data from North Carolina and Virginia were provided by the U.S. Fish and Wildlife Service (USFWS). Data were queried from the MRFSS website (http://www.st.nmfs.gov/st1/recreational/queries/effort/effort_time_series.html) on July 11, 2005 for North Carolina and Virginia, having selected variables by harvest (A+B1), all oceans combined, and all modes combined.

Methods

Tag return and MRFSS data were merged by wave and by year and were analyzed for each state. SAS 9.1 was utilized to calculate Pearson's correlation coefficient (PROC CORR), generate linear regressions, and conduct ANOVA or analysis of variance (PROC REG) to test for similarities between tag return and total harvest data by wave. Only wave-6 (November and December) and Wave-2 (March and April) data were analyzed.

Results

North Carolina

Tag returns were positively correlated with total harvest (0.5828) during wave-6 (Figure 2). ANOVA indicated significant evidence (*p*-value = 0.0366) that total harvest could explain the proportion of tag returns during wave-6.

Tag returns were positively correlated with total harvest (0.9518) during wave-2 (Figure 3). ANOVA indicated significant evidence (*p*-value < 0.0001) that total harvest could explain the proportion of tag returns during wave-2.

Virginia

Tag returns were positively correlated with total harvest (0.5827) during wave-6 (Figure 4). Although ANOVA did not indicate statistically significant evidence (*p*-value = 0.0599) that total harvest could explain the proportion of tag returns during wave 6, the given p-value indicates suggestive, but inconclusive, evidence that the null hypothesis is false, possibly representing biological significance.

Tag returns were slightly negatively correlated with total harvest (-0.4007) during wave-2 (Figure 5). ANOVA did not indicate significant evidence (*p*-value = 0.4311) that total harvest could explain the proportion of tag returns during wave-2. However, the tag return data were not consistent from year to year and a negative correlation was expected.

Estimates of Wave-1 Harvest 1996-2004

Based on the above analyses and suggestion from the Striped Bass TC, Table 1 contains estimates for total harvest for each state.

North Carolina: Wave-1 total harvest for 1996-2003 is based on the NC specific 2004 wave-1 ratio of tag returns to MRFSS total harvest numbers. There were 47 tags returned during the wave-1 fishery period for the ocean fishery. The MRFSS reported harvest (A+B1) was 177,288 striped bass during the same period. This resulted in a 2004 ratio tags to harvest of 0.000265. This ratio was applied to the wave-1 tag returns for the NC ocean fishery to provide a back-calculated total harvest for wave-1 in NC.

Virginia: Unlike NC, a 2004 wave-1 total harvest was not reported. However, analysis of the tag returns suggested that a winter fishery similar to that of North Carolina occurred off VA during 2004. The July 11th report to the TC did indicate that VA wave-6 tag returns were positively correlated to harvest and implied biological significance, though wave-2 analysis did not. Personal communication with Sara Winslow (NCDMF) confirmed that the winter fishery begins in the latter half of wave-6 and continues into wave-1 in northeastern NC, and similar trends would be expected for southeastern VA. Anecdotally, this suggested that wave-6 and wave-1 harvest would show some level of correlation in fishing activity. Using known wave-1 tag returns, a mean ratio (0.000167) of tag returns to harvest for VA wave-6, 1996-2004, was utilized to back-calculate the total wave-1 harvest.

Summary

The 2004 wave-1 total harvest for North Carolina corresponds with observed recreational effort that begins during wave-6 and continues into wave-1 throughout the coastal waters of northeastern North Carolina and southeastern Virginia (Sara Winslow, NCDMF, personal communication).

Analysis indicates that tag return data can be used to explain total harvest in wave-6 and wave-2 in North Carolina. If the assumption that wave-1 follows a similar trend is acceptable by the STB TC, then wave-1 data before 2004 could be back-calculated for North Carolina striped bass harvest. There are two possible methods for back-calculation (Figure 6). One would be using the direct 2004 ratio of tag returns to reported total harvest. The other would be to use the combined ratio of tag returns to total harvest for both wave-6 and wave-2.

Correlation analysis for Virginia did indicate total harvest could be explained by tag returns, although ANOVA did not provide strong evidence for or against the reported correlation. However, tag return evidence does show a wave-1 striped bass fishery is occurring in Virginia (Figure 1), and using the wave-6 mean ratio of tag returns to reported total harvest for 1996-2004 could be utilized to back-calculate the wave-1 striped bass recreational fishery (Figure 7).

Table 1. Estimates of wave-1 harvest by the winter striped bass recreational fisheries off Virginia and North Carolina.

Year	Total harvest values (projected)	
	NC	VA
1996	18,860	5,985
1997	49,037	83,793
1998	15,088	89,778
1999	18,860	107,734
2000	7,544	53,867
2001	18,860	53,867
2002	75,442	89,778
2003	79,214	53,867
2004	177,288*	155,616

*actual harvest
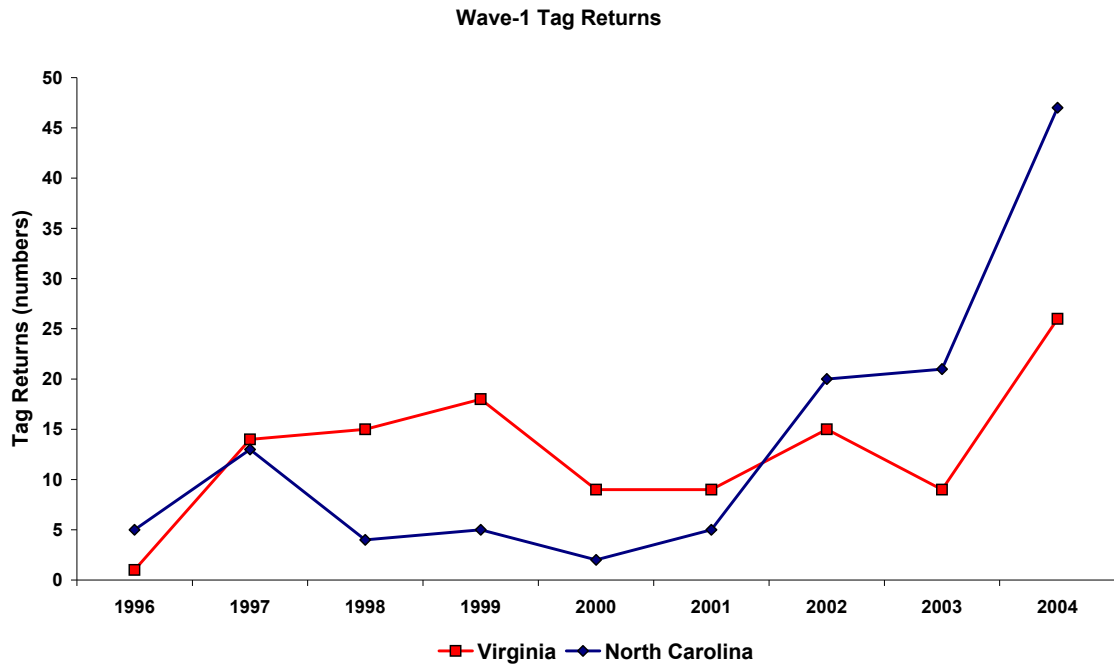
Wave-1 Tag Returns

Figure 1. Wave-1 tag returns for Virginia and North Carolina.

Wave 6: North Carolina
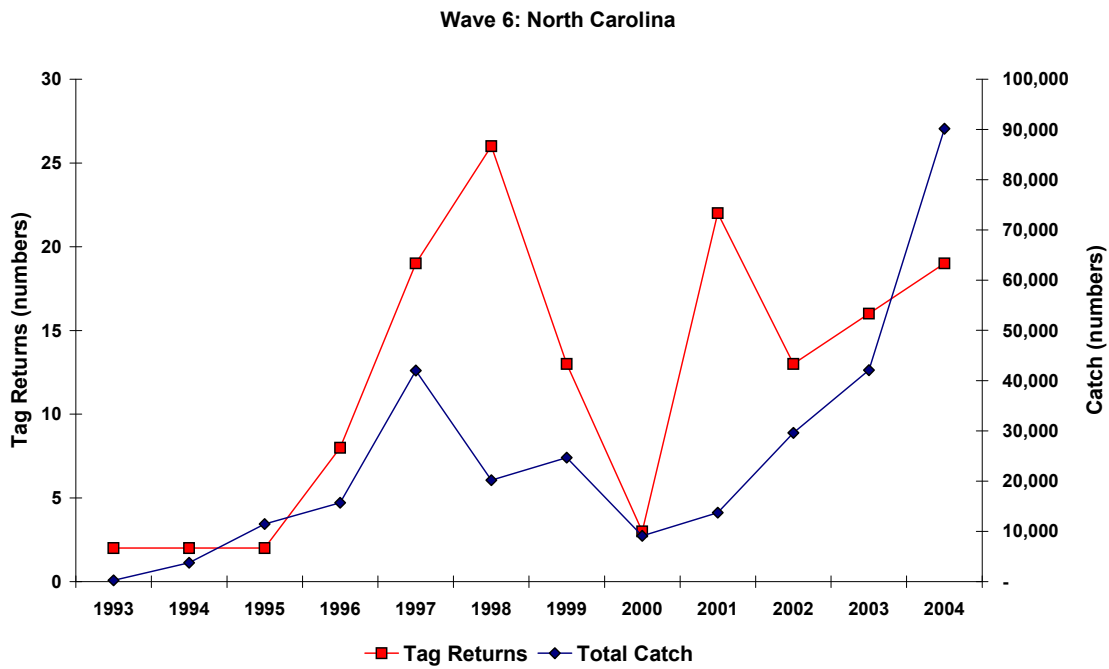
Figure

2. Wave-6 tag returns versus total harvest for North Carolina.

Wave 2: North Carolina
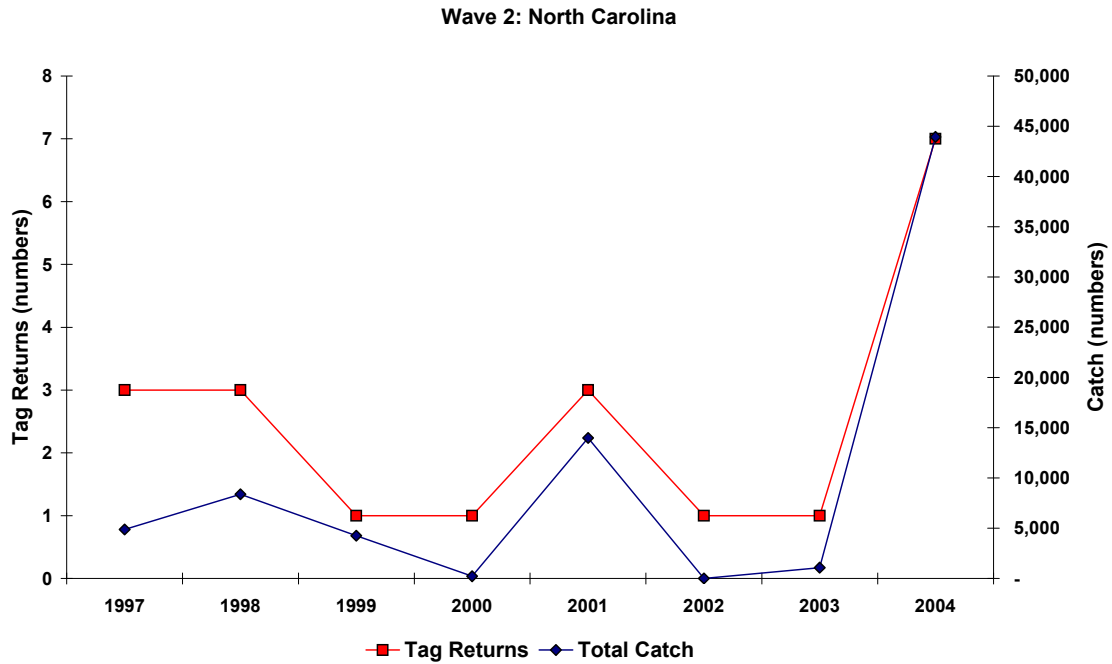
Figure 3. Wave-2 tag returns versus total harvest for North Carolina.

Wave 6: Virginia
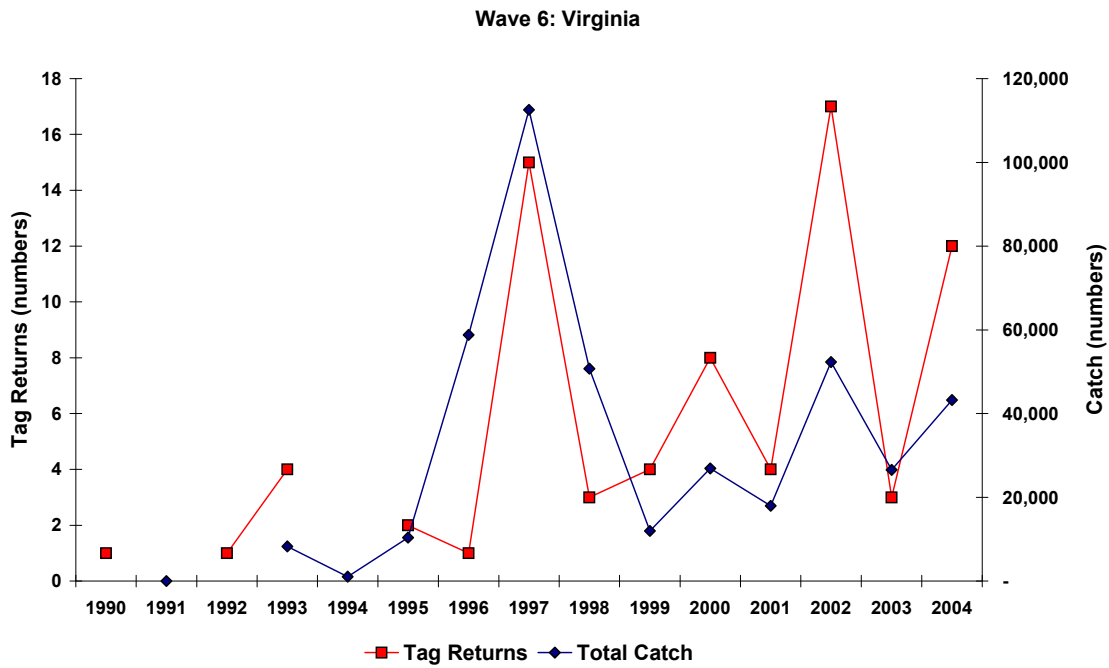
Figure

4. Wave-6 tag returns versus total harvest for Virginia.

Wave 2: STB
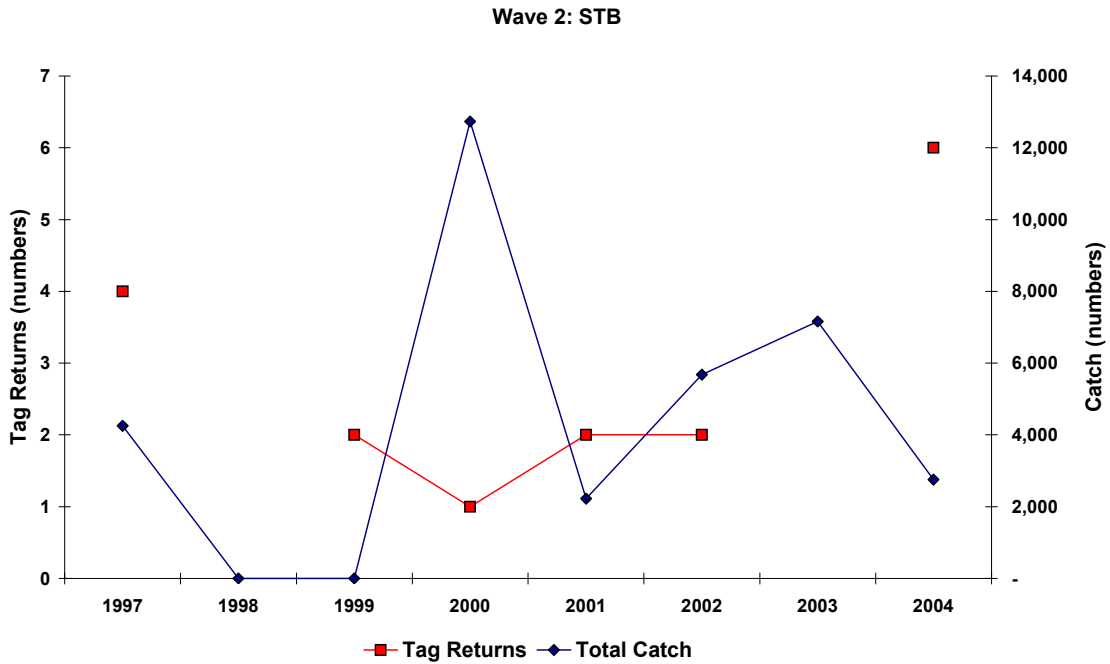
Figure 5. Wave-2 tag returns versus total harvest for Virginia.

Catch Projection: North Carolina Wave-1
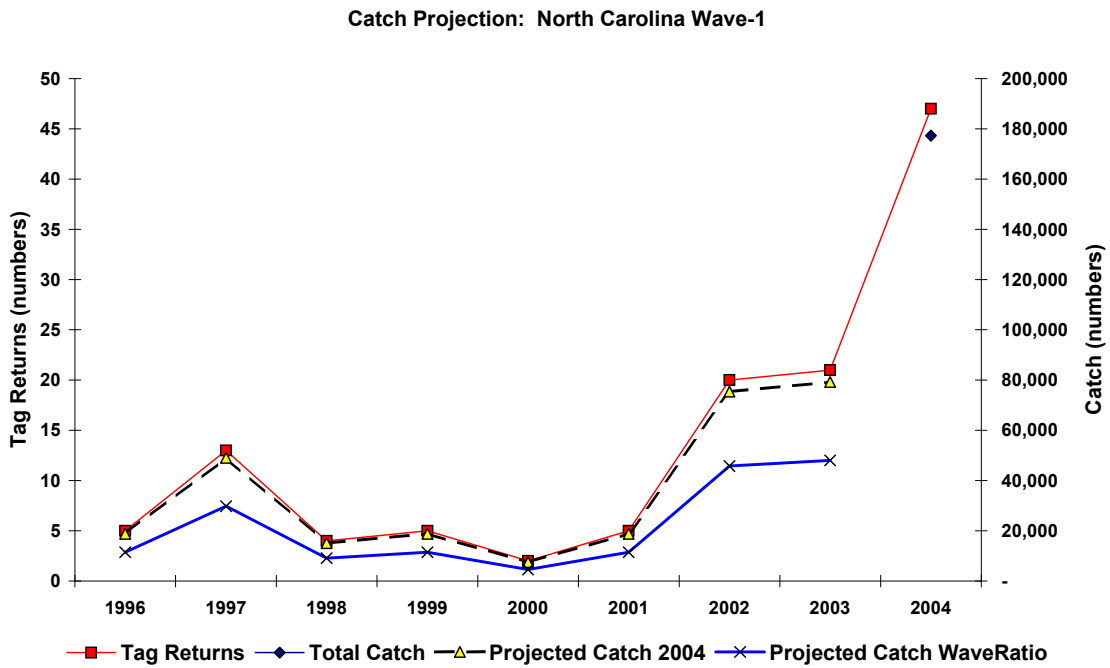
Figure 6. Comparison of harvest projections for North Carolina wave-1.
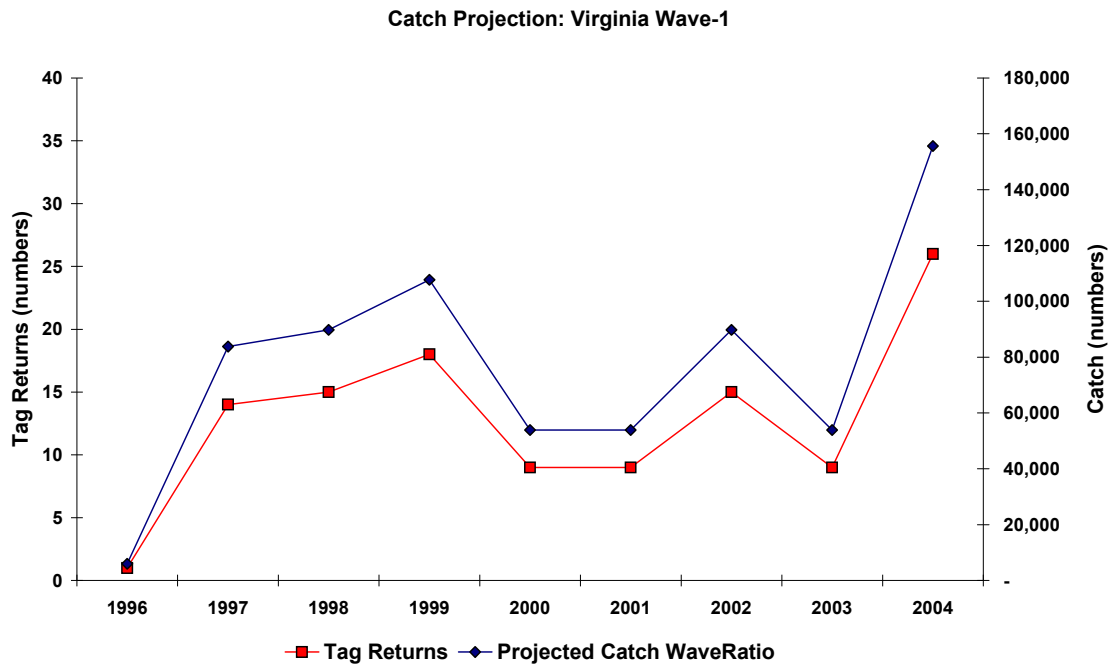
Figure 7. Harvest projection for Virginia wave-1.

Estimation of Virginia Wave 1 Harvest in 2005 and 2006

In Appendix C of the 2005 stock assessment, a memo from Joe Grist states "Personal communication with Sara Winslow (NCDMF) confirmed that the winter fishery begins in the latter half of wave-6 and continues into wave-1 in northeastern NC, and similar trends would be expected for southeastern VA." If the fisheries are similar because of their close proximity, it follows that complete information on harvest from NC in 2005 and 2006 could be used to provide more realistic estimates of harvest in Virginia during wave 1.

If it is assumed that the number of tags returned from killed fish is proportional to the numbers of fish harvested regardless of location, the ratio of the NC harvest in wave 1 to tag returns from NC harvested fish will provide a means by which harvest in Virginia can be estimated in the same wave using Virginia wave 1 tag returns:

VA harvest = NC harvest/NC tag returns*VA tag returns

"Killed" tag numbers from only recreational anglers fishing were extracted from the USFWS tag database using the following codes:

Region = "COAST",
disposition="K"
recapturertype="H" or "S",
event=1
capmonth =1 or 2
capyear=2005 or 2006
State = "NC" (or "VA")

To match the tag data, estimates of wave 1 NC harvest from charter/private boats in the state territorial seas for 2005 and 2006 were extracted from the MRFSS website.

Estimates of harvest are given below

| | Wave 1 | | | | Wave 1 | |
| | NC | NC | Ratio | | VA | Est. |
Year	Harvest	Tag Returns	(har/tags)		Tag Returns	Harvest
2005	71981	14	5141.50		7	35991
2006	84144	23	3658.43		23	84144

Estimation of Virginia Wave 1 Harvest in 2007 and 2008

TASK 4 (Comments from Laura Lee)

In Task 4, the Board asked how the winter wave 1 fishery off NC and VA affects the age structure of the population. Gary Nelson computed the percentage of harvest that this fishery comprised of the total harvest for the stock using data from 2006. The estimated percentages at age were presented in the TC report to the board under task 4 (report attached, see page 8).

The Board did not specifically request updated harvest estimates for wave 1 from VA. Gary suggested that if we do calculate an estimate, that we include it in the annual compliance report and spreadsheet due in June. The VA wave 1 estimates for 1996 through 2004 were derived based on a correlation of tag returns to harvest. The calculation of estimates for 2005 and 2006 was tasked to Gary. Since the original correlation fell apart, he simply used the ratio of NC wave 1 harvest to NC wave 1 tag returns multiplied by VA wave 1 tag returns to estimate the wave 1 harvest for Virginia. Joe Grist provided the USFWS data to me, and, using Gary's approach, I computed the following estimates for VA's wave 1 harvest (number of fish) in 2007 and 2008:

2007   369,090
2008   879,225

However, the number of tag returns in NC during wave 1 in these years was low relative to other years (2005/06) and the method (Harvest $_{NC}$ / Tag Returns$_{NC}$ * Tag Returns$_{VA}$ is questionable

Year	NC Harvest (N)	NC Tag Returns	VA Tag Returns	Estimated VA Harvest (N)
2005	71,962	14	8	41,121
2006	85,884	23	22	82,150
2007	36,382	**3**	30	363,820
2008	41,741	**2**	41	855,690

We looked at average harvests (2005/06) / average tag returns for the same years, and 19 was the average tag returns, for the 2 years. We used that avg. harvest:average tag return (2005/06) proportion, and determined that the average (2007/08) harvest of 39,061 fish would correspond to an average of 9 tags in NC for 2007/08. That average tag return (9) was used to estimate the 2007 and 2008 Virginia harvests (numbers of striped bass).

Year	NC Harvest (N)	NC Tag Returns	VA Tag Returns	Estimated VA Harvest (N)
Avg. 2005/06	78,923	19		
2007	36,382	**9**	30	121,273
2008	41,741	**9**	41	190,153

Comparison of Wave 6 harvest (numbers), of striped bass, by recreational fisheries, in Virginia and North Carolina. Included are North Carolina ocean recreational harvests of striped bass, for Wave 1, 2005-08.

Year	: From: 2004 To: 2008		Year	: From: 2004 To: 2008		Year	: From: 2005 To: 2008	
Wave	: 6		Wave	: 6		Wave	: 1	
Species	: STRIPED BASS		Species	: STRIPED BASS		Species	: STRIPED BASS	
Geographic Area: VIRGINIA			Geographic Area: NORTH CAROLINA			Geographic Area: NORTH CAROLINA		
Fishing Mode : ALL MODES COMBINED			Fishing Mode : ALL MODES COMBINED			Fishing Mode : ALL MODES COMBINED		
Fishing Area : ALL OCEAN COMBINED			Fishing Area : ALL OCEAN COMBINED			Fishing Area : ALL OCEAN COMBINED		
Type of Catch : HARVEST (TYPE A + B1)			Type of Catch : HARVEST (TYPE A + B1)			Type of Catch : HARVEST (TYPE A + B1)		
Information:			Information:			Information:		
NUMBERS OF FISH			NUMBERS OF FISH			NUMBERS OF FISH		
Year	HARVEST	NumPSE	Year	HARVEST	NumPSE	Year	HARVEST	NumPSE
2004	44,948	19	2004	92,276	18	2005	71,982	26
2005	53,922	23	2005	31,139	28	2006	85,884	23
2006	114,336	15	2006	4,869	30	2007	36,382	27
2007	18,139	20	2007	4,878	25	2008	41,741	26
2008	39,752	18	2008	2265	36			

VA Wave 1 Harvest Estimates in 2009-2010

Three methods were used to calculate the 2009 and 2010 wave 1 harvest estimates.
Method 1 (Old Nelson): VA harvest$_i$ = NC harvest$_i$/NC tag returns$_i$*VA tag returns$_i$
 "Killed" tag numbers from only recreational anglers fishing are extracted from the USFWS tag database using the following codes:

Region = "COAST", disposition="K"
recapturertype="H" or "S",
event=1
capmonth =1 or 2
capyear=2009 or 2010
State = "NC" (or "VA")

Method 2 (Lee):
Adj. NC tags (2009/10) = NC avg. harvests (2005/06) / NC avg. tag returns (2005/06) * NC avg. harvest (2009/10)

VA harvest$_i$ = NC harvest$_i$/Adj. NC tag (2009/10)*VA tag returns$_i$

This method was developed because the Old Nelson method produced unrealistic estimates for 2007 and 2008. The Adj. NC tags returns for 2009/10 is 3.

Method 3 (New Nelson):
A linear equation was fitted to the NC harvest and NC tag returns to develop an relationship between harvest and tag returns (see below). The equation was then used to calculate the VA harvest by using the values of the VA wave 1 tag returns.

$$H_{NC} = 16849.68 + 2923.72 * Tags_{NC}$$
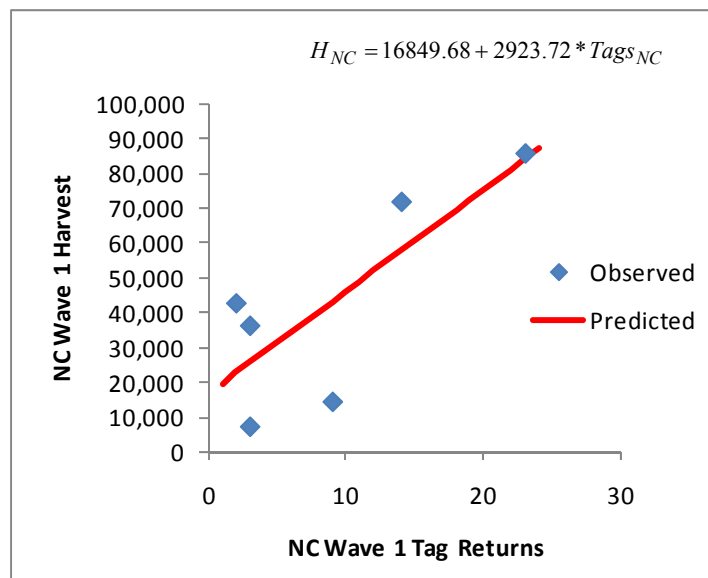
The historical and current data are:

Year	NC Wave 1 Harvest	PSE	NC Tag Retuns	VA Tag Returns
2005	71,982	25.5	14	8
2006	85,884	22.9	23	22
2007	36,382	26.6	3	30
2008	42,833	27.6	2	41
2009	7,375	32.4	3	26
2010	14,523	35.2	9	6

The estimates of VA wave 1 harvest are:

Year	New Nelson	Old Nelson	Lee
2005	40,239	41,121	
2006	81,172	82,150	
2007	104,561	363,820	121,273
2008	136,722	878,077	195,128
2009	92,866	63,917	63,917
2010	34,392	9,682	29,046

The New Nelson Method was used in 2009-2010.

New VA Wave 1 Estimates for 2005-2011 MRIP Updated

The regression method of Nelson was updated to include the new MRIP NC wave 1 estimates of harvest and 2011 MRIP and tag data. A linear equation was fitted to the NC harvest and NC tag returns to develop a relationship between harvest and tag returns (see below). The equation was then used to calculate the VA harvest by using the values of the VA wave 1 tag returns.

Year	NC Wave 1 Harvest	PSE	Tag Releases	Tag Releases (w/o NY)	NC Tag Retuns	VA Tag Returns
2005	77,594	28	12564	9655	14	8
2006	76,031	50	12365	9142	23	22
2007	32,198	42.2	8759	5981	3	30
2008	24,129	40.5	7225	5044	2	41
2009	5,650	47.5	6369	5333	3	26
2010	12,901	46.8	7023	5550	9	6
2011	94,093	31.2	5241	4014	21	5

Additional analyses were conducted to determine if a better covariate might be the ratio of tags returned to the total number of fish released with tags by all tagging programs since tag returns are likely to be dependent on the total number released.

NC Harvest Versus Tag Returns

Tags Returns Only

$$H_{NC} = 8504.4 + 3507.5 * Tags_{NC}$$
$$r^2 = 0.75, \; p = 0.011$$
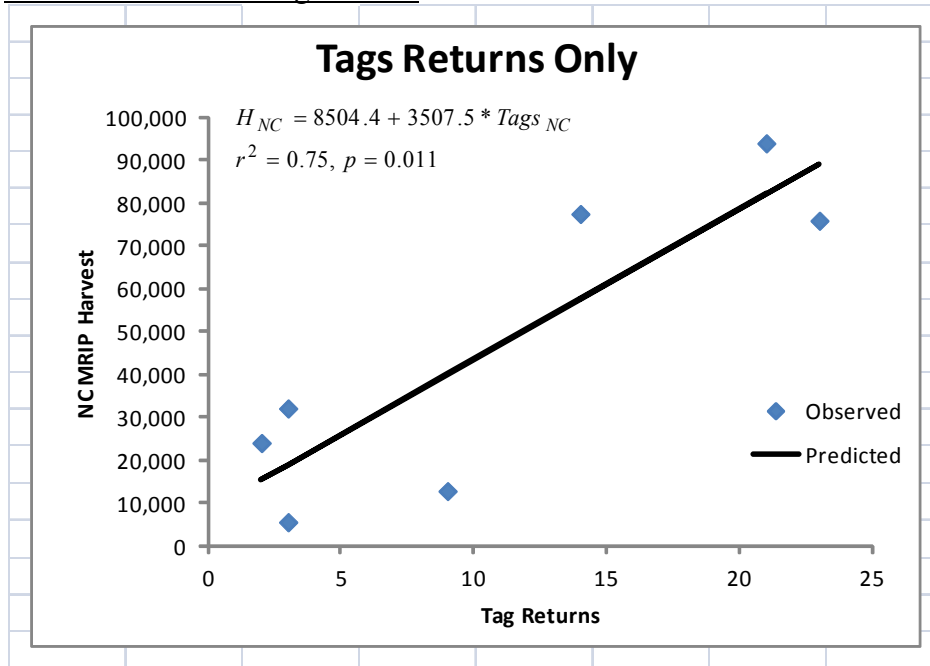
There was a strong linear relationship between MRIP harvest and tag returns for NC. The r^2 for the regression was fairly high (0.75).

NC Harvest Versus Ratio of Tags Returned/Tags Released

All Tag Programs

$$H_{NC} = 18789.7 + 20428318.1 * Ratio_{NC}$$
$$r^2 = 0.57, \; p = 0.051$$
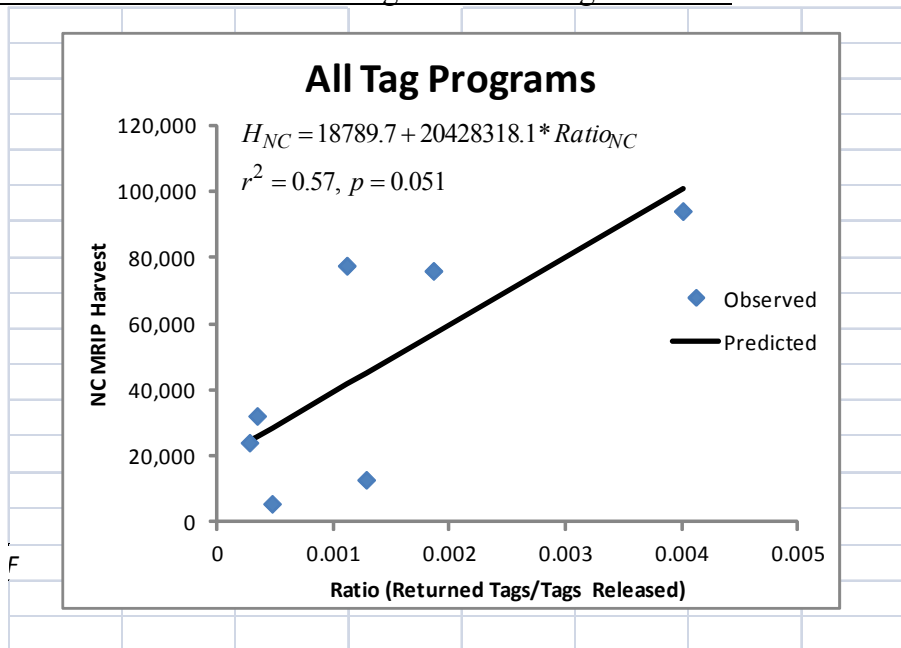
There was a moderate linear relationship between MRIP harvest and ratios for NC. The r^2 for the regression was lower (0.57) than the r^2 for the harvest-tag return regression (0.75).

Because few fish tagged in NY migrate south of New Jersey, the regression analysis was repeated with the total number of releases for NY deleted .

All Tag Programs (w/o NY)

$$H_{NC} = 182050 + 15892782 * Ratio_{NC}$$

$$r^2 = 0.56, \, p = 0.045$$

NC MRIP Harvest

Ratio (Returned Tags/Tags Released)

Observed

Predicted

F
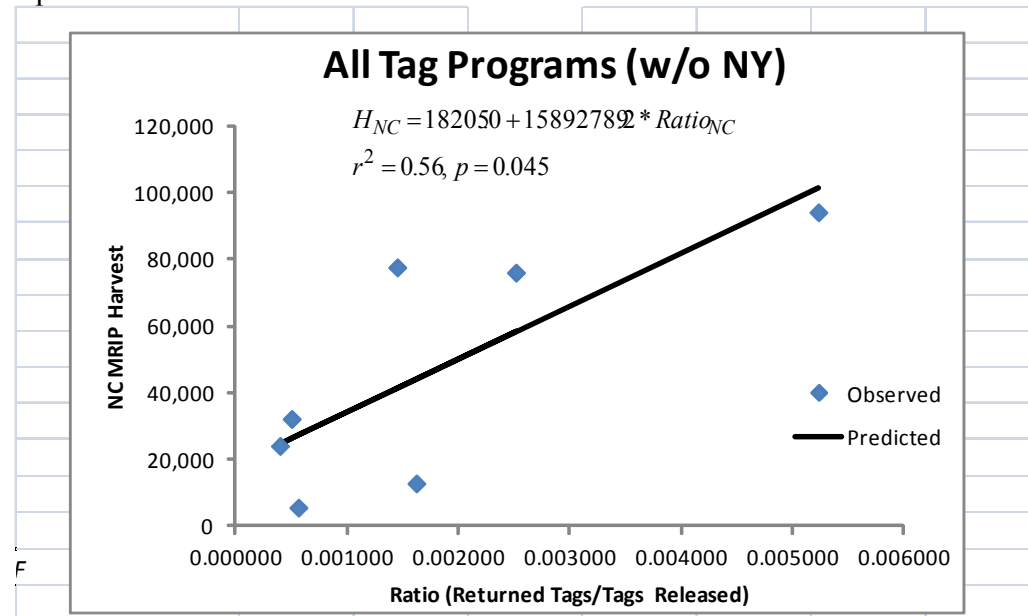
There was a moderate linear relationship between MRIP harvest and ratios for NC. The r^2 was lower (0.56) than the r^2 for the harvest-tag return regression (0.75). Using the number of releases did not produce better predictive relationships with harvest.

Comparison of New Updated Estimates for VA wave 1 with Previous Methods

	MRIP	MRFSS		
Year	New Nelson	New Nelson ('05-'10)	Old Nelson	Lee
2005	36,565	40,239	41,121	
2006	85,670	81,172	82,150	
2007	113,730	104,561	363,820	121,273
2008	152,313	136,722	878,077	195,128
2009	99,700	92,866	63,917	63,917
2010	29,550	34,392	9,682	29,046
2011	26,042	31,468		
		MRFSS 2011 data for wv 1		
		unavailable		

The New Nelson method is used for 2005-2011.

New VA Wave 1 Estimates for 2005-2012 MRIP Updated

The "New Nelson" regression method was updated to include the new MRIP NC wave 1 estimates of harvest and 2012 MRIP and tag data. A linear equation was fitted to the NC harvest and NC tag returns to develop a relationship between harvest and tag returns (see below). The equation was then used to calculate the VA harvest by using the values of the VA wave 1 tag returns.

Year	VA Wave 1 Estimates (no. fish)
2005	35,308
2006	86,386
2007	115,573
2008	155,706
2009	100,980
2010	28,011
2011	24,363
2012	64,495

Appendix B3. Recreational Fishery Monitoring Programs

Recreational Harvest and Releases

Information on harvest and release numbers, harvest weights, and sizes of harvested bass from 1982-2003 come from the National Marine Fisheries Service's Marine Recreational Fisheries Statistics Survey (MRFSS/MRIP). The MRFSS/MRIP data collection consisted of a stratified intercept survey of anglers at fishing access sites that obtains numbers of fish harvested and released per angler trip, and a telephone survey that derives numbers of angler trips. Estimation of harvest and catch per trip from intercept data considered intercepts at a location as independent samples. Estimates of harvest and release numbers are derived on a bi-monthly basis . With the establishment of the Marine Recreational Information Program (MRIP), estimates are now made assuming intercepts at a site represent a cluster of samples. Re-estimation of catch and harvest from 2004-2010 using the new methodology occurred in 2011 and is the standard used presently. The timeline of MRIP changes can be found at http://www.st.nmfs.noaa.gov/recreational-fisheries/in-depth/making-improvements-mrip-initiative/history-timeline/index.

Recreational Length-Frequencies of Harvested Fish

Most states use the length frequency distributions of harvested striped bass measured by the MRFSS/MRIP. The MRFSS/MRIP measurements are converted from fork length (inches) to total length (inches) using conversion equations. Proportions-at-length are calculated and multiplied by the MRFSS/MRIP harvest numbers to obtain total number harvest-at-length. The sample sizes of harvested bass measured by MRFSS/MRIP may be inadequate for estimation of length frequencies; therefore, some states use length data from other sources (e.g., volunteer angler programs) to increase sample sizes. Descriptions of these programs are below.

Maine
A volunteer angler program targets avid striped bass fishermen as a means of collecting additional length data. Though this has increased the sample size of the MRFSS, it still overlooks lengths and weights on sub-legal or released stripers. Because many anglers opt for catch and release, field interviewers actually see limited numbers of fish. An angler using the Volunteer Angler Logbook (VAL) records information about fish harvested or released during each trip for themselves and any fishing companions. Information about each trip is also recorded, including time spent fishing, area fished, number of anglers, and target species. At the end of the season each angler mails his/her logbook to the Department of Marine Resources (DMR), which is then copied and sent back to the angler.

Massachusetts
For released and harvested fish, volunteer recreational anglers are solicited to collect length and scale samples from striped bass that they captured each month (May-October). Each person is asked to collect a minimum of 5 scales from at least 10 fish per month, place the scales in marked coin envelopes, and record the disposition of each fish (released or harvested), fishing mode (boat or shore-based fishing), and location. Over 1,200 samples are received each year from over 30 anglers. Starting in 2005, DMF began using the MRFSS/MRIP length data and the volunteer angler harvest length data to estimate the length structure of harvested fish. This is

done by first generating the percentages-at–length from MRFSS/MRIP and volunteer program by fishing mode and then averaging the proportions-at-length across programs. DMF then estimates the harvest by fishing mode and applies the numbers to the correct proportions-at-length to get harvest numbers at length and fishing mode, and then sums across modes to get total numbers harvested-at-length. The volunteer angler data adds about 200-400 extra measurements to estimate harvest length distributions.

Connecticut
The Volunteer Angler Survey (VAS) is designed to collect fishing trip and catch information from marine recreational (hook and line) anglers who volunteer to record their angling activities via a logbook. VAS anglers contribute valuable fisheries-specific information concerning striped bass, fluke, bluefish, scup, tautog, and other important finfish species used in monitoring and assessing fish populations inhabiting Connecticut marine waters. The survey logbook is easy to fill out. Each participating angler is assigned a personal code number for confidentiality. Recording instructions are provided on the inside cover of the logbook. Upon completion, anglers tape the pre-postage paid logbook shut and drop it off in the mail. Anglers that send in logbooks are rewarded with a VAS cooler and updated results of the program. After all the logbooks are computer entered and error checked, the logbooks are returned to each participant for their own records. The CT Fisheries Division has annually supplemented the MRFSS/MRIP survey with about 2,000-3,000 length measurements from the angler survey.

New York
Prior to 2011, the MRFSS/MRIP length data were not used in any fashion. Instead, the American Littoral Society's (ALS) release data were used to estimate length distribution of both harvested fish (>28") and released fish (B2 sub-legal <28"). The sample sizes are about 5,000 fish each year.

New Jersey
New Jersey collects information on harvested fish through the Striped Bass Bonus Program (SBBP). NJ's historical commercial quota forms the basis of this program where a recreational angler can apply online for a non-transferrable permit to harvest one additional striped bass per day measuring not less than 28 inches. Upon harvest and prior to transportation, the angler is required to immediately fill out a non-transferable permit with the following information: date, location, caught, and length. This harvest information is submitted online (mandatory harvest reporting) to the NJ Bureau of Marine Fisheries for monitoring and analysis.

Maryland
There are two additional sources for size frequency data: a volunteer angler survey and the DNR creel survey during the spring trophy season. Neither of the additional surveys employ statistical design. The volunteer angler survey is described in the next MD section. The DNR creel survey was initiated in 2002. The survey samples access sites (docks and marinas) with the largest volume of recreational angler traffic during the spring trophy season (mid-April to mid-May). The number of intercepted boats has varied from 137 to 181, number of anglers from 180 to 461, and the number of examined fish from 460 to 510. Biological data collected during the survey includes total length, weight, sex, spawning condition, and age (both scales and otoliths are collected). Other fishing statistics are collected, such as number of hours fished, number of lines fished, boat type, number of anglers per boat, number of fish kept, and number of fish released.

Recreational Length-Frequencies of Released Fish

Data on sizes of released striped bass come mostly from state-specific sampling programs. Proportions-at-length are calculated and multiplied by the MRFSS/MRIP dead discard numbers to obtain total number released dead-at-length. Descriptions of these programs are below.

Maine
Release data are collected through the Volunteer Angler Survey, as described in the previous Maine section. DMR has annually supplemented the MRFSS survey with about 1200 - 9200 length measurements from the Volunteer Angler Survey.

New Hampshire
The Fish and Game Department (FGD) uses a striped bass volunteer angler survey for anglers fishing in New Hampshire. Roughly 30-50 volunteer anglers per year report information about each striped bass fishing trip they take that originates in NH. They are asked to measure every striped bass they catch (both harvested and released fish) to the nearest inch. Volunteers report on roughly 500-1700 trips each year and provide usable measurements on 1000-7000 fish each year. About 95% of the measured fish are released.

Massachusetts
For released and harvested fish, volunteer recreational anglers are solicited to collect length and scale samples from striped bass that they captured each month (May-October). Each person is asked to collect a minimum of 5 scales from at least 10 fish per month, place the scales in marked coin envelopes, and record the disposition of the each fish (released or harvested), and fishing mode. Over 2,200 samples are received each year from over 100 anglers. Approximately 1,000-1,500 lengths of released striped bass are reported each year.

Rhode Island
The size structure of striped bass released from Rhode Island's recreational fishery is based on the American Littoral Society's (ALS) release data for Rhode Island by year.

Connecticut
Release data come from the Volunteer Angler Survey, as described in the previous Connecticut section. About 2000-3000 length measurements of released fishes are obtained each year.

New York
The ALS release data are used to estimate length distribution. The ALS tags are released all around the marine district of New York all year long. Because fish can be tagged at any size, the Bureau of Marine Resources gets both legal and sub-legal length distributions, both within and outside NY's open recreational season. Thus, the length distribution for harvested fish is from the fish >28 in, and the length distribution for the released fish is from the sub-legal (i.e., <28).

New Jersey
Lengths of released striped bass are collected through a volunteer angler survey (VAS), as described in the previous New Jersey section. It is important to note that, although the VAS is primarily administered through the SBBP, the VAS and the SBBP are independent data sources. Someone does not need to harvest a Bonus fish or have a Bonus Permit in order to participate in,

fill out, and submit their logbooks. There is a broad range of participant avidity and apparent skill level – from someone that fishes once or twice a year and does not catch/harvest a single bass to someone that fishes 100 days of the year. The only 'screening/removal' of logbooks for analysis the Bureau of Marine Fisheries conducts is to ensure the logbooks are filled out correctly and contain the proper information. Information on the size composition of harvested and released fish as well as effort (by trip and even hours), CPUE and fishing mode are available by region. (The state is broken down into 26 different regions and each location provided by the fisherman is assigned to one of those areas.)   The VAS survey was initiated in 1990 when the NJ Fish and Wildlife initiated the SBBP. VAS provides about 500-1500 length measurements on released fish per year.

In addition to the VAS, length information is also collected through Party/Charter Boat Logbooks, administered through the SBBBP. Each boat that signs up to participate in the SBBP is mailed a logbook as well as the instructions on how to fill it out properly. A Private/Charter boat does not need to use or harvest any SBBP fish to fill out or participate in the logbook survey but they do need to be a participant in the SBBP. Boat owners are asked to fill out a daily trip logbook for each trip they take when targeting striped bass, even if no striped bass are caught; they are not asked to record striped bass information when they are making trips targeting other species. They are asked to record the date, location fished, number of patrons, number of hours fished, lengths of released fish (longest length to the nearest inch), number of released fish, lengths of harvested fish, and number of harvested fish. Logbooks must be completed even if no Bonus Cards are used or all bonus cards have been used for the year. All logbooks are returned by the end of the season. Private/Charter Boat Logbooks were first collected in 1997 and have continued ever since. Much of this data has never been looked at closely or analyzed but all of the information has been entered, checked, and screened for incorrect information.

Delaware
Number at length of recreational discards are acquired annually from the American Littoral Society's tag release database for Delaware River, Delaware Bay, and the near shore waters of the Atlantic Ocean adjacent to Delaware Bay.

Maryland
There are two additional sources for size frequency data: a volunteer angler survey and the DNR creel survey during the spring trophy season. Neither of the additional surveys employs statistical design. The DNR creel survey is described in the previous MD section. Maryland DNR has conducted a volunteer angler survey to obtain information on size structure of kept and released striped bass in the recreational fishery since 2000. The areas and time periods covered are defined by the number of responses received from anglers. Anglers are asked to provide information on the date of fishing, number of hours fished, number of anglers in the party, and method of fishing. Anglers also record the total number of striped bass kept and the total number of striped bass released and measure and record the length for the first twenty striped bass caught. A separate form is filled for each trip even if no fish are caught. If more than one survey participant is fishing on the same boat, only one designated individual is asked to fill out the survey form for the group for that day to avoid duplication. The data are submitted to MD DNR either on paper forms or via internet entry. Participation varies from year to year, which is reflected in the total number of entries. The number of reported trips varies between 200 and 300 and the total number of measured fish varies approximately from 600 to 2000 per year.

Volunteer angler survey data are combined with the MRFSS/MRIP information and MD DNR Spring Trophy Survey to characterize size frequency distribution of recreational harvest by wave. Volunteer survey data are the only source for the characterization of the discards. The volunteer survey does not provide age information.

Virginia
Data on releases are derived from the MD DNR Volunteer Logbook Survey described above.

North Carolina
North Carolina does not collect information on size of releases. Usually, release length frequency data that reflect the release sizes in NC are borrowed from other states.

Recreational Age Data

Many states collect scale samples during state sampling programs designed to collect information on harvest and released striped bass from the recreational fishery (described above). For those states that do not collect scale samples, age-length keys are usually borrowed from neighboring states. Detailed descriptions of how age samples are collected are given below.

Massachusetts
For released and harvested fish, volunteer recreational anglers are solicited to collect length and scale samples from striped bass that they capture each month (May-October). Each person is asked to collect a minimum of 5 scales from at least 10 fish per month and record the disposition of the each fish (released or harvested) and fishing mode. Over 2,200 samples are received each year from over 100 anglers. The size frequency of released fishes by mode are used to allocate MRFSS/MRIP release numbers by mode among size classes. A sub-sample of all scale samples collected (about 450-520 fish/yr) are aged and combined with commercial samples (250 fish/yr) and tagging samples (about 150-300 fish/yr) to produce an age-length key used to convert the MRFSS/MRIP size distribution into age classes. Recreational scale samples are selected using a weighted random design based on the total number of striped bass caught in each wave and mode stratum (as determined by MRFSS/MRIP).

New York
An age-length key is created using data from NY's combined projects: the cooperative angler survey, western Long Island beach seine survey, and a fall Ocean Haul Seine/Ocean Trawl survey. The cooperative angler (fishery-dependent) data is from both kept and released fish, but the geographical distribution of the samples are biased towards the Western Long Island Sound. Samples are at the pleasure of the cooperating fishers, collected - nearly all year long. Each year, anglers contribute anywhere from 500 to 5,000 samples, over a fairly wide range of sizes. The Western Long Island beach seine survey is a multi-species, fishery-independent survey conducted at fixed sampling sites in bays around the north and south shores of Long Island. Most of the samples are of small juvenile fish, but some larger adult fish are caught. Each year the beach seine survey contributes approximately 1,000 length/age samples collected over the months of April through November. The fall Ocean Haul seine survey is a fishery-independent survey conducted at fixed survey sites. The geographic distribution of sampling is biased towards the eastern South Shore of Long Island, during the months of September through December. The Ocean Trawl Survey replaced the Ocean Haul Seine Survey in 2007. It covers the geographic

area of the entire south shore of Long Island, during the month of November. Each year, about 1,000 samples are collected. The survey samples the adult coastal migratory mixed striped bass stocks. The age-length key created is applied to both legal and sub-legal fish (assumed harvest and discards), broken down into two six-month seasonal keys.

New Jersey
New Jersey collects age (scale) samples from harvested and released fish through a biological sampling program. In 2010, New Jersey instituted new protocols for targeting fishing tournaments and party/charter boats in the spring and fall in order to streamline the collection process and eliminate duplicate data or data not being used for the coastal assessment. A recent decrease in sample sizes necessitated a change in the methods used to collect samples resulting in the development of a new long-term plan. This information is collected, monitored, entered and analyzed by the NJ Bureau of Marine Fisheries.

Delaware
Recreational age data is compiled from directed fishery sampling in the summer slot season (July 1 – Aug 31) and the fall recreational fishery. Length, sex, scales, and otoliths are acquired from each fish, and when available, weight.

Maryland
Direct age data are available from the creel survey of the trophy fishery only. Both scales and otoliths are collected from the fish examined in creel survey. For periods not covered by the creel survey, an age-length key developed from the samples of commercially harvested fish is applied to recreational length frequency to characterize age structure of the recreational harvest.

Virginia
Most age data are collected from the commercial fishery. The sampling group will sometimes sample from one or more recreational tournaments, but not in every year. In 2004, there were two length and age samples; no sampling of tournaments occurred in 2005.

5.1.2.5 Recreational Harvest-At-Age

Recreational harvest-at-age is usually estimated by applying corresponding length-frequency distributions expanded to total numbers of harvest-at-length and age-length keys to the MRFSS/MRIP number of fish harvested by the recreational anglers in each state. State-specific descriptions of the estimation procedures are below.

Maine
DMR uses age-length data collected by MA DMF. The age-length key is applied to the Volunteer Angler Survey lengths, which is then applied to MRFSS/MRIP estimates of harvested fish.

New Hampshire
FGD uses age-length data collected by MA DMF. The age-length key is applied to the Volunteer Angler Survey lengths, which is then applied to MRFSS/MRIP estimates of harvested fish.

Massachusetts
Harvest numbers-at-age are generated by applying total numbers of harvested fish by length to the age-length key as described above.

Rhode Island
Age-length data collected by NY DEC and MA DMF are combined to create annual age-length keys. The combined NY-MA age-length key is applied to the expanded length frequencies from RI's recreational fishery to estimate recreational harvest-at-age on an annual basis.

Connecticut
The Fisheries Division uses age-length keys from Long Island Sound provided by NY DEC and applies the numbers-at-length obtained from the volunteer angler survey.

New York
The MRFSS/MRIP numbers of harvest and releases by wave are disaggregated by the ALS length frequency distribution (calculated by wave). The numbers at length are added by wave together into two seasonal length distributions. The seasonal length distributions are multiplied by the seasonal length/age keys created (see above) for legal (i.e., >28 inches, harvest) and sub-legal (i.e., <28 inches, releases) fish. The length distributions are adjusted, due to the conversion of ALS data from fork length to total length and the "gaps" which result, by averaging the values before and after the interval with no observed frequency. Next, the numbers are added for each season. Occasionally there is a need to re-adjust for the actual numbers of harvest or releases from MRFSS/MRIP due to the adjustments and rounding.

New Jersey
New Jersey uses the length frequency information gained from the Striped Bass Volunteer Angler Survey to characterize the length structure of NJ's recreational harvest of striped bass and the MRFSS harvest data by season (fall and spring) to expand the length frequency data. A variety of age sources are then used to develop NJ's age-length key by season. For the spring key, age data from NJ's Delaware Bay Striped Bass Tagging Survey (occurs in March – May), NJ's January, April and June cruises of the Ocean Trawl Survey, and spring harvested and released striped bass from tournament and party/charter boat biological sampling are used. To develop NJ's fall age-length key, age data from the August and October cruises of the Ocean Trawl Survey and fall harvested and released fish from the tournament and party/charter boat biological sampling are utilized. The appropriate seasonal age-length key is then expanded to the length frequency information to develop NJ's striped bass harvest by age and season.

Delaware
Delaware's recreational harvest at age data is developed from the known harvest of 3 distinct sectors of the fishery. Spring landings numbers, lengths, and weights are acquired from MRIP Wave 2 and 3 reports. Age at length is derived from the DFW's spawning stock survey in April and May. Delaware's summer slot (20" - 26") landings numbers, lengths, and weights are acquired from MRIP Wave 4 reports. Age at length is derived from DFW's sampling of harvested slot fish during July and August. Recreational harvest (landings, weight, and lengths) for the remainder of the calendar year is acquired from MRIP Wave 5 and 6 reports. Age at length data is derived from DFW sampling of recreationally caught fish during October through December.

Potomac River Fisheries Commission (DC)
Length and age data collected from the commercial fisheries are used to generate recreational numbers-at-age.

Maryland
Length frequency of recreational harvest is characterized using MRFSS/MRIP, VAS, and creel survey length data. The age-length key derived from the spring spawning survey is applied to length frequency for waves 2 and 3. For waves 4–6, an age length key derived from samples of commercial harvest is used.

Virginia
A catch-at-age matrix is developed, starting with an age-length key from the commercial samples of length and weight and proportions of harvested striped bass at length from MRFSS/MRIP.

North Carolina
The NY age-length key is used along with length frequencies to apportion harvest numbers into age classes.

Recreational Dead Discards-at-Age
The number of dead discards-at-age is usually estimated by applying corresponding total numbers of dead discards-at-length to age-length keys. State-specific descriptions of the estimation procedures are below.

Maine
DMR uses age-length data collected by MA DMF. These data are applied to the Volunteer Angler Survey lengths, which is then applied to the dead discard estimates.

New Hampshire
FGD uses age-length data collected by MA DMF. These data are applied to the Volunteer Angler Survey lengths, which is then applied to the dead discard estimates.

Massachusetts
Dead discards-at-age are generated by applying total numbers of discards-at-length to the age-length key described above.

Rhode Island
Age-length data collected by NY DEC and MA DMF are combined to create annual age-length keys. The combined NY-MA age-length key is applied to the expanded length frequencies from Rhode Island's recreational fishery to estimate recreational releases-at-age on an annual basis.

Connecticut
The Fisheries Division uses age-length keys from Long Island Sound provided by NY DEC and applies the dead discards numbers-at-length.

New York
The MRFSS/MRIP numbers of harvest and releases by wave are disaggregate by the ALS length frequency distribution (calculated by wave). The numbers at length are added by wave together into two seasonal length distributions. The seasonal length distributions are multiplied by the seasonal age-length keys created (see previous NY section) for legal (i.e., >28 inches, harvest) and sub-legal (i.e., <28 inches, releases) fish. The length distributions are adjusted, due to the conversion of ALS data from fork length to total length and the "gaps" which result, by averaging the values before and after the interval with no observed frequency. Once complete, the numbers are added for each season. Occasionally there is a need to re-adjust for the actual numbers of harvest or releases from MRFSS/MRIP due to the adjustments and rounding.

New Jersey
New Jersey uses the length frequency information gained from the Striped Bass Volunteer Angler Survey to characterize the length structure of NJ's recreational harvest of striped bass and the MRFSS harvest data by season (fall and spring) to expand the length frequency data. A variety of age sources are then used to develop NJ's age-length key by season. For the spring key, age data from NJ's Delaware Bay Striped Bass Tagging Survey (occurs in March – May), NJ's January, April and June cruises of the Ocean Trawl Survey, and spring harvested and released striped bass from tournament and party/charter boat biological sampling are used. To develop NJ's fall age-length key, age data from the August and October cruises of the Ocean Trawl Survey and fall harvested and released fish from the tournament and party/charter boat biological sampling are utilized. The appropriate seasonal age-length key is then expanded to the length frequency information to develop NJ's striped bass harvest by age and season.

Delaware
Dead discards at age for Delaware are calculated as 8 percent (assumed mortality) of the total discard numbers from MRIP wave reports by season (spring and fall). For the spring, age at length is derived from DFW's spawning stock survey in April and May. For the fall, age at length is derived from DFW's recreational sampling conducted during the months of October through December. Age at length of sub-legal discards caught during the fall is derived from the DFW's trawl survey and the spring spawning stock survey.

Potomac River Fisheries Commission (DC)
Length and age data collected from the commercial fisheries are used to generate recreational numbers-at-age.

Maryland
Length frequency of recreational releases is characterized using MRFSS/MRIP, VAS, and creel survey length data. The age-length key derived from the spring spawning survey is applied to length frequency for waves 2 and 3. For waves 4–6, an age-length key derived from samples of commercial harvest is used.

Virginia
Release numbers (discards from the recreational fishery by spring (Waves 2,3) and summer-fall (Waves 4,5,6)) are apportioned to age classes, using the MD DNR Volunteer Angler Survey

proportion of discards-at-age and proportion of discards-at-length, expanded according to seasonal harvest in numbers.

North Carolina
The NY age-length key is used, along with length frequencies, to apportion release numbers into age classes.

Appendix B4. Report of the Striped Bass VPA Indices Workshop

Baltimore, MD
July 28 & 29, 2004

List of Participants

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Workshop Purpose

Impetus: "An objective discrimination of which tuning indices to include or withhold from the model should be integrated in the next assessment." 36th SAW Advisory

Goal: Develop criteria for the inclusion/exclusion of current and future indices for aggregate or age-specific ($\geq$age 2+) used in the striped bass virtual population model.

Objectives: Critically evaluate the survey design and precision of the index, and validate each index by comparing it to other area indices. If applicable, determine how the survey design should be modified to be more valuable.

Background: The Role of Indices in the VPA

Indices are used in the tuning process as a relative index of abundance (abundance at age). Some surveys provide an aggregrate index and others provide an age specific index. Some may be appropriate for aggregation due to precision; others are more precise as an age-specific index.

ADAPT uses the entire time series to determine relative abundance of the cohort in the terminal year. The longer the time series the more information the model has to produce an estimate. After the model produces the estimate, the stock assessment subcommittee evaluates the correlation of the index to the known abundance as the VPA has estimated it.

Evaluation Criteria

The Workshop participants began the discussion with the some suggested guidelines provided by Gary Nelson prior to the meeting. The guidelines are as follows:

  a. Have a sampling design
  b. Have an acceptable level of precision (if applicable)
  c. Has it been validated? (i.e., is it correlated with indices of abundance of other life stages, etc.)

The sampling design should be appropriate to achieve the objectives of the survey. Additionally, the sampling design should produce a precise estimate. Further indication of a good index is the validation of the survey, comparing it to another index that shows similar trends. There should be a correlation between indices sampling similar portions of the coastwide stock. If an age class can be followed through time, it is also indicative of a good survey.

Taking Gary's suggestions a step further, John Hoenig developed a set of discussion points regarding the index. The following list includes the John points plus additional comments from other participants.

  1) Correlation of an index with the VPA is not an appropriate evaluation criterion unless the index pertains to the whole stock. (If substocks in the North go up, as reflected in three indices, and substocks in the South go down, as reflected in one index, you'd get a biased

picture if you eliminated the southern index just because it disagreed with the average (which is dominated by the North)).

2) Validity of sampling design can be used to determine inclusion. An index should not be evaluated based on an inappropriate variance. The appropriate variance can be determined based on the survey's sampling design. For example, if one site is sampled repeatedly (e.g., a pound net) the sample size is one (i.e., one site).

3) The number of sites and the number of days sampled may be useful criteria; a minimum number of fish sampled might be appropriate *in combination* with other factors (number of sites, etc.)

4) All indices should be treated "equally" to be "fair".
    a. If you evaluate one index you should evaluate all of them.
    b. You can kick out indices but there must be a way to reinstate them and there must be a way to introduce new indices that is "fair" in the sense of holding the index to the same standards as other indices.

5) If you want to make a change to the set of indices, it is important to do two assessments in parallel – one the old way and one the new way for several (e.g., 3) years. Otherwise, you can't distinguish between changes in stock perception due to methodology and changes due to stock dynamics.

6) If an index represents only a portion of the stock complex then it should receive a weight less than one. The stock assessment subcommittee has typically weighted the indices according to how well they fit the VPA, e.g., using iteratively reweighted least squares.

7) If an index is unique in representing a particular portion of the stock complex, then it may be desirable to retain the index even if it is not perfect.

8) The primary criterion thus would appear to be whether an index tracks weak and strong year classes well. An index can be considered poor if year-to-year changes in catchability obscure abundance trends.
    a. In looking for year effects, it is not appropriate to look at the residuals from the VPA unless the index being evaluated pertains to the whole stock.
    b. If one plots age-specific indices versus time, then synchronous peaks and valleys (all indices going up and down together) is problematic.

9) If age-specific indices are problematic, the program might still provide an aggregate index

10) Validation of one index against another index from the area provides support for the two indices.

Some of the indices used in the VPA assessment are age-specific and some are age-aggregated indices. It might be necessary to develop different criteria for the two kinds of indices. Before eliminating an age-specific index, the survey should be considered as an aggregated index. The problem with the index may be the ageing. It could still track the stock appropriately as an aggregate.

The Stock Assessment Subcommittee currently uses iterative reweighting for the surveys, meaning the survey weighting is based on how well the index fits the estimate produced by the VPA. The VPA is currently used to derive a single estimate of the fishing mortality on the coastal migratory stock. Ideally, there would be stock specific VPAs that are combined into one coastwide assessment.

If you believe that the particular index gives you reliable representation of the dynamics and abundance of the species in the particular area, then an estimate of variability of the index is needed. Also, you need to know if the same index is representative of the stock coastwide because we are looking for an ideal index of relative abundance that would be truly representative of the stock coastwide. An alternative to the VPA's iterative reweighting would be to assign weights to each index based on an assumed contribution to the overall coastwide migratory stock.

There is some concern about apriori weighting because an index may represent the local stock accurately. Also, as the stocks have rebuilt over time the contribution to the coastal stock has increased. There is uncertainty as to how this can be accounted for in the apriori weighting.

Review of Sampling Program and Indices

The participant agreed to many of the points in John Hoenig's list, but not all. The group decided to continue with a review of the sampling programs. The evaluation criteria would be further refined as the surveys are reviewed.

Massachusetts – Commercial CPUE Index (Gary Nelson)
The Massachusetts Commercial catch per unit effort index has been used in the VPA assessment since the Striped Bass Stock Assessment Subcommittee has used the VPA. The unit of effort has changed over the course of the time series. The method for calculating the CPUE has changed over time with different MA DMF personnel. The time series has been recalculated using a consistent methodology.

The index is really a measure of commercial harvest per effort or an estimate of the number of fish sold per trip. It uses the weight of the fish reported by the dealer and the average weight of the fish measured in the fish house. The average is then weighted by the total fish (whole fish) landed in each county. The total weight reported is an absolute (no variance), but the average weight is estimated so the variance is included. The number of trips comes from the required catch reports. Fishermen must submit catch reports to receive a license for the following year. Catch reports include information such as hours fished, number of fish sold and released by month, and dealer transactions. This survey is used as an age aggregated index and age-specific index.

The sampling design is not ideal for this index because the sampling is dependent on which fish house lands striped bass. Three counties in Massachusetts make up about 80% of the total landings. The information gathered in the fish house does not provide information about the trip, whether it was landed as a direct or indirect take. Most of the Massachusetts striped bass fishermen are weekend warriors.

There are a few problems with the survey design. Permits are issued to the boat, not individuals. Therefore, an average trip per boat is estimated not per fishermen. The number of fishermen is not collected. In Massachusetts, this fishery is hook and line only and has a trip limit of 40 fish per day. There could be five guys on a boat for one hour catching 40 fish or one guy out there all day catching 40 fish.

The catch per effort per trip is not well defined because the information is not collected. There are over 4,300 people permitted but Massachusetts only receives 100-200 voluntary logs with trip dates, numbers caught, hours fished per trip. The average hours fished is estimate from the logbooks. Average hours fished contributes to variability in the survey. There can be hours fished with zero catch. Even though commercial fishermen are required to submit catch reports, not all submit the report despite the penalty of losing the permit in the next year. So Gary has to impute the fish caught using the information he does have. Additional information may be available through the VTR data for commercial fishermen holding a federal permit.

This survey has a multiple stage sampling design, meaning it needs a randomly sample a fish house and then randomly sample the fish. The variance estimate is conditional on assumption of random sample, but sample may not be representative. The fish that end up in the fish houses are random, but the selection of which fish house is sampled is not random. Therefore, we do not know if the sample is representative of all the catch because it is not random. Bootstrapping does not confer validity on an index.

The group discussed the difficulty of setting one standard for all the surveys – the protocol for variation estimation will depend on the survey design, therefore will not be consistent across all surveys. The index should not be thrown out because it's not perfect, especially if there is not another index to replace it and its representative of the area.

The number of trips is declining because the quota is filling more quickly. There is a jump in the CPUE from 1994-1995 because there was a change in the minimum size and the commercial quota also increased. The group is not confident that the CPUE represents the population, particularly the fishery has capped out the quota since 2000. Also, in a representative catch, the cohorts can be followed through the samples. The 1993 yearclass was strong and it cannot be followed through the MA CPUE. One suggestion was to apply a length frequency to the ageing samples for a more representative sample.

For an age-specific index, Massachusetts could randomly pick a fish box to collect samples. The proportion of ages in a sample could be applied to the aggregate index. Massachusetts had to cut down on the sizes of age samples from the fish house due to personnel cut backs.

Connecticut Recreational CPUE and Trawl Survey
Connecticut submitted information regarding the trawl survey, but did not provide information on the recreational catch per unit effort. Additionally, there was no representative from Connecticut in attendance at the Workshop. The Connecticut surveys were not reviewed at this time.

New York Long Island Ocean Haul Seine Survey (Vic Vecchio)

Originally, the survey had 10 sampling locations that consisted of inshore sandy sites. The locations were randomly sampled from October to November. After the commercial striped bass fishery reopened, commercial trawls were prohibited from state waters. Some localities prohibit NY DEC from accessing traditional sampling sites. In New York, fishermen are not allowed to use ocean haul seine survey to commercially catch striped bass, but can use to fish for other species. The estimates derived from 10 sampling locations were compared to the results with fewer sampling locations. There was no difference in the ages in the catch. Additionally, funding has been reduced impacting the sampling dates and actual survey catch. The dates of the older survey have been standardized.

In reviewing the time series, it is interesting to note that the catch jumped in 1996-1998 due to the 1993 and 1996 yearclasses. Also, in some cases the coefficient of variance exceeded the catch. Bootstrapping would be appropriate for the New York data.

Age samples are taken from every fish measured in the survey. New York is able to produce an estimate of geometric mean catch at age for each survey year. The CV is then calculated for the catch at age and an averaged from 1997-2003 is produced. The survey is not very good at catching the larger fish, so the sample sizes for the older fish are pretty small.

The survey samples a mixed stock. To evaluate the survey, the ocean haul seine survey was correlated to the YOY index. Out of 13 age groups, 11 had positive correlation, but only 6 had a significant correlation.

New Jersey Trawl Survey (Tom Baum)

The New Jersey trawl survey has a stratified random sampling design. The survey occurs in April and October. Decreases in funding have led to reductions in annual sampling effort, from 60 to 45 seine hauls. New Jersey's survey was not designed to sample striped bass survey; it was originally for sampling groundfish. Striped bass are tagged when feasible.

In a typical year, there are 30-40 tows in 18 strata, which comes out to about 2 tows per site. The CVs are pretty low in the later half of the time series. The high CVs in the latter half of the time series could be attributed to low sample sizes at each stratum. The standard error should be checked to determine if it was calculated for a stratified random design.

The survey is used as an age aggregated index, aggregating ages from 2-13. April and October are used as separate age aggregated indices because the length frequencies differ significantly, representing different stock composition. April survey is more consistent and therefore probably the better candidate for an age-specific index. New Jersey has an age-length key for every year, so most of the information is available for switching over to an age-specific index. If the survey measures all of the fish caught, then it could be used as an age-aggregated index. It is possible to get age specific data, but New Jersey is not likely to produce the data.

To reduce the variance, some of the strata should be thrown out because no striped bass were caught in that location. The strata should only be removed from the index if there were no

striped bass throughout the time series. The variance can be a problem with fixed station trawl surveys because there is no random element to the survey.

Delaware Trawl Survey (Des Kahn)

The Delaware trawl survey began during the 1960's, but the exact start date is not well documented. The survey collects weight rather than numbers of fish (kilograms per tow of striped bass). The time series is disjointed because a different vessel was used in the first two segments of the time series. In 2002, the survey began using a new custom-built stern rig trawler. Comparative tows were conducted to get a handle on the catchability of the two vessels.

The trawl survey uses a fixed sampling scheme. It was selected due to the lack of towable bottom in Delaware Bay. The index was conducted the whole year. Due to the number of zero tows, the data was jackknifed – used for situations were the distribution assumptions may not be true. Jackknife does not deal with the lack of distribution of the data; it does assume that the sample is representative of the population from which it is drawn.

The sample size is the number of months that were sampled. In some years, the trawl survey did not operate in March. In each month, the fixed sites were sample nine times.

The trawl survey is used as an aggregate index in the VPA (age 2-7). There is age data available from 1998 forward. To validate the index, it should be compared to another mixed stock index. The lagged juvenile index is often used to confirm trends.

Delaware Spawning Stock Survey (Greg Murphy)

The Delaware River spawning stock survey collects age, size, sex, and abundance estimates for striped bass. The survey began in 1991 experimenting with three different collection methods and has continued using electrofishing since 1994. The survey divided the Delaware River into two zones based on river access. There are twelve Delaware stations and fourteen Pennsylvania stations. Over time, some of the stations have been lost due to development.

The stations cannot be considered random, but the observations at each station are random. The survey has a multistage lattice design. The strata are sampled independently of another (i.e. sampling does not affect other sites). The lattice survey design imposes a structure to control the number of times each area sampled.

Another challenge that confronts the survey has been the moving salt line, which can restrict the sample areas upstream where electrofishing is effective. Reviewing its correlation to other life stages, such as a juvenile survey, could validate this survey.

Maryland Spawning Stock Survey (Linda Barker)

The objective of the Maryland's spring gillnet survey is to characterize the Chesapeake Bay portion of the spawning stock biomass and provide a relative abundance at age. The survey area at one time covered the Chesapeake Bay, Choptank River and Potomac River, but the Choptank River has since been dropped from the survey. A stratified random design is used to sample the spawning areas.

The group discussed the survey's sampling design to determine if it was truly randomly stratified. Because Maryland DNR samples the same site twice in some days, the design can be referred to as two-stage cluster sampling. It is important to correctly identify the sampling design to properly calculate the variance.

For each sample, all of the striped bass are measured, all females are aged, but only males greater than 700 mm are aged and smaller males are subsampled. Since 2000, approximately 500 fish are aged per year. The group recommended developing area and sex specific age length keys. MD DNR should also look into applying selectivity coefficients.

The survey has revealed that it does not accurately capture the spawning stock biomass as it collects samples of fish ages 2-8. There is a very low variance for ages less than 8 years old and higher variable estimates for ages greater than 8 years old. The number of age 8+ appearing in the survey has increased since the moratorium. The fish caught in the survey are mostly males (age 2-8) and the ages 10 and greater are mostly females. The data is representative of the behavior of the fish, capturing mostly males. The CPUE provides a decent relative abundance at age, but it is not doing a good job of characterizing the spawning stock survey.

Virginia Pound Net Survey (Phil Sadler)

Since 1991, Virginia Marine Institute of Science has conducted the Viginia pound net survey. The pound net survey takes place on the striped bass spawning grounds in the Rappahannock River between river miles 44-47. VIMS has the option of sampling up to four commercial nets. The upper and lower nets are used for this survey and the middle nets are used for tagging. VIMS alternates sampling between the upper and lower nets. The sampling occurs from March 30 to May 3, when the females are on the spawning ground. The pound nets are checked twice a week, but are fishing constantly. When the samples are collected, the fish are sexed and measured, scales are taken from every fish, and a subsample of otoliths.

The sex ratio in the catch tends to be two males to every female. The females captured in the survey are generally ages 4 and older and males are age 3 and older. There appears to be no bias in net catchability.

There are several periods where no fish were caught. By averaging the CPUE data, the estimate is low. To eliminate the zero effect, VIMS could graph CPUE by date and determine the area under the curve.

The Workshop participants had a lengthy discussion on the Virginia pound net survey because it is an example of a survey that was removed in recent stock assessment due to poor performance in the VPA. The Virginia pound net survey provides an estimate of catch in the commercial fishery. If a variance is estimated, it is not an estimate of the striped bass abundance rather it is the variance for the commercial catch. The workshop participants suggested several ways to evaluate the survey. Local juvenile surveys can be used for validation. A longitudinal catch curve can also be applied to investigate year effects, specifically to detect downward trends. The catch curves explain how often the striped bass are seen and if the patterns are explainable.

VIMS should also examine the temporal window and the spatial window to evaluate the survey design.

NEFSC Trawl Survey (Gary Shepherd)

The NEFSC trawl survey uses a stratified random design and assumes that time is irrelevant. The index samples fish from Nova Scotia to North Carolina. It is an eight-week cruise, completed in four two-week legs. Fishing occurs 24 hours per day. The survey did not really start to encounter striped bass until 1991. The survey has shown a general upward trend since 1990. The catch distribution tends to very from year to year and the sizes encountered are also variable.

The NEFSC trawl survey data would be a good candidate for an age-specific index. An age-length key from the New Jersey March-April gillnet survey could be applied to the NEFSC samples. The NEFSC survey is important because it is the only survey to cover the range of the coastal migratory stock. For a good index, the NEFSC would need 400 ageing samples. The fish are encountered in different locations in different years. So the appropriate key needs to applied to the samples. For the fish encountered in the southern range, an age-length key could be derived from the North Carolina Cooperative Cruise.

VPA Output Compared to the Indices

The group reviewed the ADAPT VPA output from last year's assessment to each of the indices reviewed during the workshop. The VPA predicted the indices very well when there weren't many striped bass. As the stock increased, the variance went up with the mean. If one of the criteria for inclusion was the index must follow the same trend as the VPA, then none of the indices would be used. The coastal indices should carry the same signal as the VPA output because they characterize the coastal migratory stock. Some of the indices may not align with the VPA because they were down weighted.

Several of the indices show spikes. The spikes should be compared to other indices to determine if there is correlation. The coastal indices should be reviewed to determine if there are spikes that correlate with one another or the VPA output. To determine the validation of the indices, it would be helpful to know how the VPA weighs the indices.

The stock assessment subcommittee has typically used the bootstrap estimates to determine the variation in the surveys. All of the surveys are entered into the VPA and the bootstrap estimates determine if it is appropriate to include each index.

On the other hand, the VPA produces an estimate of the overall stock complex abundance. To use the VPA to evaluate the indices may mean eliminating an index that does not track the overall stock complex, but tracks local trends accurately. An index should not be removed without a legitimate reason for removing the index. The effect of each index on the VPA should be analyzed.

General Overview of Survey Issues

The sampling design of each survey was a common theme for discussion during the review of the indices. There tends to be two separate types of programs. The first group includes the NEFSC trawl survey and the Maryland Spawning Stock Survey. These two surveys are randomized over space. The second group includes other programs such as MA CPUE, which is a census of commercial catch rates, but fishermen are not fishing over random fish. The New York ocean haul seine survey is not randomized over space. The Virginia pound net survey uses two nets over fixed locations. Delaware is randomized, but only 30% can be sampled.

There is confidence that the Maryland spawning stock survey and the NEFSC trawl survey are catching a representative sample of the population because both surveys are randomized over space. Both surveys can get a valid variance. The sampling design of the other surveys may not be randomized; therefore it cannot be assumed that the surveys are a good representation of the stock. Without randomization, the estimate of variance for each survey may not be appropriate.

The Virginia pound provides a good estimate of the fishermen's catch rate, but the variance is not very useful. The NEFSC survey is not designed to catch striped bass and does catch a lot of striped bass. The variance is only useful for qualitative purposes. Variance estimates are for the survey index.

In addition to variance, age information is collected through the indices, despite some of the ageing error issues. Another important measure for the indices is the ability to track cohorts over time. There needs to be confidence that the survey is tracking cohort abundance in a logical trend. Catchability can influence the ability of a survey to track a cohort over time. If the design of the survey changes, the catchability can change.

A survey could reflect logical trends for 8 of the 10 years, straying from the trend in the remaining two years. Those two years could be eliminated if there was adequate evidence that is was due to abnormal climatic conditions influencing fish abundance.

To verify a cohort trend, the survey can be compared to a local young of the year index. States would need to be careful about using the index to validate the juvenile survey and vice versa. In some areas, a young of the year index may not be available for comparison. In these situations, a catch curve could be applied to the cohort. Longitudinal catch curves could be used, not to estimate mortality rates, but to see if there is trend that is useful.

Ideally, the stock assessment will include the same indices as in previous years and then a separate run is made to remove more questionable indices. There should be some guidelines for removing an index from the model run or at the very least an explanation provided in the assessment report. To evaluate an index for inclusion, one could plot the indices by year for each cohort. If one of the indices has a dramatically different trend, the index is not tracking things well. It is important to remember that an index can be valid for a local area, but not for the stock complex. It may track a different trend or a local stock. For example, Chesapeake Bay recruitment correlates well with the Delaware River recruitment, but not the Hudson River.

Striped bass is a stock complex measured by local indices, but the stock complex abundance is supposed to be annually evaluated.

Recommendations for criteria to evaluate the VPA indices

The Workshop participants developed a list of evaluation steps that should be applied to each index. The state agencies should use the evaluation list for each state survey. Each program should be analyzed to determine if the survey is conducted at the appropriate time of year, i.e. bracketing the correct spawning period. Similarly, the survey design should be reviewed by the state to determine if the sampling area is correct. If the state determines there is a lot of noise in the data, the state should attempt to refine the data. For instance, if some of the stations catch striped bass consistently and others do not, can something be done to refine these data? The states should identify if the indices are sex-specific indices or age-specific due to survey design. Because a self-evaluation by each state could be subjective, the Technical Committee should evaluate the state's program evaluation and make a recommendation to the Striped Bass Stock Assessment Subcommittee.

1. Evaluate design and best method to evaluate uncertainty of index.
2. Assess the index and/or improve the index to get the best signal.
3. Validate the index before use in the VPA.
   a. Sensitivity of the VPA results to the influence each index.
   b. Validate an index to a JAI, where possible.
   c. Longitudinal catch curves, to determine the cohort trends.
   d. Plots of age specific index v. year to see if cohorts are moving in a specific direction.
4. Evaluation by the agency conducting the survey
   a. Rank (weight) index
   b. Criticisms/Supporting Evidence
5. Evaluate by the Striped Bass Technical Committee
   a. Evaluate index based on survey design, precision, and ability to track cohorts or portion of the stock targeted.
   b. Provide recommendations to the Striped Bass Stock Assessment Subcommittee on which indices should be used in the assessment.

The Workshop participants developed a matrix in Excel that includes the important components for evaluating each index (sampling design, time of year, tracking stock or catch, etc.). Also included in the matrix are recommendations to improve and evaluate the survey.

PURPOSE: TO ESTIMATE FINAL YEAR ABUNDANCE							
SURVEY	**SINCE**	**SAMPLING DESIGN**	**TIME OF YEAR**	**STOCK OR CATCH**	**WHAT STOCK?**	**AGES**	**VARIANCE?**
NMFS (TOTAL, REC HARVEST)		SURVEY	ALL	CATCH	MIXED		YES??
NEFSC CRUISE		STRAT RANDOM	SPRING/FALL	STOCK	MIXED		YES
MASS COMM CATCH		NONE	ALL	CATCH/HARVEST	MIXED		
RI - FLOATING TRAPS?							
CONN TRAWL SURVEY				STOCK	MIXED		
CONN REC CATCH				CATCH	MIXED		
NY HAUL SEINE		FIXED STATION	FALL	STOCK	MIXED		
NY HUDSON SPAWN SURVEY		STRAT RANDOM		STOCK	HUDSON	5-10	YES
PA RIVER SURVEY							
NJ TRAWL SURVEY		STRAT RANDOM	SPRING	STOCK	MIXED		YES?
NJ REC CATCH		NONE	ALL	CATCH	MIXED		NO
DEL RIVER SURVEY		CLUSTER??	SPRING	STOCK	DEL		
DEL TRAWL SURVEY		FIXED STATION	ALL	STOCK	MIXED		
MD JI		FIXED STATIONS	SUMMER	STOCK	CBAY		
MD SPRING GILLNET SURVEY	1985	STRAT RANDOM	SPRING	STOCK	CBAY		
VA POUND NETS	1991	FIXED STATIONS		CATCH	RAPP	3+	YES/NO

SURVEY	EVALUATION/CRITERIA	RECOMMENDATIONS
NMFS (TOTAL, REC HARVEST)		Define what an index would be using total catch and effort
NEFSC CRUISE		Age fish samples from trawls; review strata choices
MASS COMM CATCH		Standardize minimum length numbers; compare lengths of subsamples to length of all; examine applying age-length keys; develop index with total catch; adjust index for covariates; examine whether change in week-end warrior composition
RI - FLOATING TRAPS?		see if data is available for development of an index
CONN TRAWL SURVEY		segregate into age-specific indices; use age-length key instead of VB equation
CONN REC CATCH		Describe and evaluate
NY HAUL SEINE	AGAINST TOTAL JI? NY JI?	resestimate precision using bootstrap; compare index at age to Jis individually
NY HUDSON SPAWN SURVEY		Describe and evaluate; generate age-specific indices with appropriate variance
PA RIVER SURVEY		Describe and evaluate
NJ TRAWL SURVEY		Examine strata choices; generate age-specific indices using April data
NJ REC CATCH		determine if development of an index is possible
DEL RIVER SURVEY		investigate area under curve method for possible spatial distribution issues; examine temporal disitribution within strata; compare upper river index to PA survey
DEL TRAWL SURVEY		change biomass index to numbers; generate age-specific indices; compare indices to VPA for age 1
MD JI	AGAINST LAGGED CATCH	
MD SPRING GILLNET SURVEY		examine first vs second set; review impact of sex-specific catchabilities
VA POUND NETS	AGAINST JI, LONG CATCH CURVES, YEAR EFFECTS, CATCH VS. TEMPORAL WINDOW	AGAINST JI, LONG CATCH CURVES, YEAR EFFECTS, CATCH VS. TEMPORAL WINDOW; examine flow regimes; compare index to MDs

Summary of Responses To Workshop Recommendation

Survey	Index Type	In VPA?	Workshop Recommendations	Recommendations Addressed?	PSE Range	Attempted Validation?
NEFSC	Age-specific: ages 3-11	Yes	Age fish samples in trawl;review strata choices	No	No PSEs provided for age-specific indices. Untransformed, aggregate index PSEs (91-04): range= 0.13-0.58, mean=0.29	No
MA Comm Catch	Aggregate and age-specific commercial Index	Yes	Standardize min. length numbers; compare lengths of subsamples to length of all; examine applying age-length keys; develop index with total catch; adjust covariate; examine week-end warrior composition	Yes A total catch index was developed using covariates, making most recommendations moot.	Old index age 7-12 average PSE: 7-0.51,8-0.23,9-0.13, 10-0.13,11-0.18,12-0.23. New Index age7-12 PSE (for 2000): 7- 0.05, 8-0.08, 9-0.10,10-0.11,11-0.15,12-0.22	Yes, correlation of aggregate indices to other aggregate indices (MRFSS, NYOHS, NJ, CT) but no significant correlations of new age indices to other programs; only 1996 YC could be tracked over only three years; influence of age-specific and aggregate index on VPA results increased.
RI – Floating Traps	?	No	See if data is available for development of an index	No	None	No
CT Trawl Survey	Aggregate Index (spring)	Yes	Segregate into age-specific indices using age-length keys instead of VB equation	No	Ln transformed, aggregate index PSEs: range=0.1-0.5, mean=0.20	No

Survey	Index Type	In VPA?	Workshop Recommendations	Recommendations Addressed?	PSE Range	Attempted Validation?
CT Rec Catch	Age-specific: ages 2-11	Yes	Describe and evaluate	No	None	No
NY Ocean Haul Seine	Age-specific Index: ages: 3-13+	Yes	Re-estimate precision using bootstrap; compare index at age to juvenile indices individually	Yes	Aggregate PSEs:mean=0.08; Age-specific PSEs: 2-0.17,3-0.11,4-0.13,5-0.16,6-0.22,7-0.23,8-0.39,9-0.51	Yes, strong correlations between CB juvenile index and indices for ages 2-5; not so for older ages.
NY Hudson Spawn Survey	?	No	Describe and evaluate; generate age-specific indices	No, but survey would be inappropriate	None	No
PA River Survey	Electrofishing survey	No	Describe and evaluate	No	None	No
NJ Trawl Survey	Aggregate Index	Yes	Examine strata choices; generate age-specific indices using April data	No	Aggregate index PSEs (91-03): range 0.18-0.69, average 0.38	No
NJ Rec Catch	RecCatch/Effort	No	Determine if development of an index is possible	No	None	No

Survey	Index Type	In VPA?	Workshop Recommendations	Recommendations Addressed?	PSE Range	Attempted Validation?
DE Spawning stock River Survey	Electrofishing aggregate and age-specific: ages 2-15	No	Investigate area under the curve method for possible spatial distribution issues; examine temporal distribution within strata; compare upper river index to PA survey	Yes – claims multistage lattice design addresses spatial and temporal distribution issues.	Aggregate PSEs (96-03): mean=0.20. Age-specific mean PSEs: 2-0.52,3-0.3,4-0.31,5-0.29,6-0.27,7-0.27,8-0.26,9-0.27,10-0.36,11-0.34,12-0.47, 13-0.46	Yes, compared age-specific indices to NJ juvenile fish index and found 6 out of 14 were significantly correlated. However, only 3 of nine comparisons between DE and PA surveys were significantly correlated.
DE Trawl Survey	Aggregate Index	No	Change biomass index to number; generate age-specific indices; compare indices to VPA for age 1	Some – developed numbers index using GLM	Aggregate mean PSE (91-04): 0.29 (I calculated from Table 3)	No
MD Spring Gillnet Survey	Age-specific 2-13+	Yes	Examine first vs second set;review impact of sex-specific catchabilities	In progress, showed differences in catchability and visibility	Age-specific mean PSEs (91-04):2-0.11, 3-0.02, 4-0.02,5-0.03,6-0.03,7-0.03,8-0.04,9-0.06,10-0.14,11-0.10,12-0.10,13-0.71	No

Survey	Index Type	In VPA?	Workshop Recommendations	Recommendations Addressed?	PSE Range	Attempted Validation?
VA Pound Net Survey	Fixed Pounds Net	No	Validate Index against MD and VA juveniles indices; examine year effects,; use longitudinal catch curves; examine catch versus temporal window, flow regimes.	Yes – no relationship between river flow and index; Mar 30-3May window better for inter-annual assessment of stock	Can't be calculated due to fixed sites	Yes, compared age-specific indices for age 3 8 to VA JI index but found poor correlation; weak correlation for age 9-10; high correlation between age 11-12 index and JI; there were no correlations between index and MD juvenile indices.

Appendix B5. Development of Age-specific Natural Mortality Rates for Striped Bass

Gary Nelson

Massachusetts Division of Marine Fisheries

<u>Lorenzen (1996)</u>

The Lorenzen (1996) M-weight equation was used to generate Ms-at-age. Weights-at-age were estimated by fitting a curvilinear model (W=a*Age^b) to coast-wide mean weights-at-age available from the stock assessment (Figure 1). Since we are interested in obtaining baseline estimates of M, I used only weights-at age from 1991-1996 in the model fitting. The weights were used in the Lorenzen equation (3.0*weight^-0.288) but scaled to grams before use. The resulting unscaled M estimates were then re-scaled to 1.4% survival at the maximum age of 31 using a spreadsheet formulation provided by Doug Vaughan.

<u>Empirical Estimates</u>

I also derived an M-age equation by fitting another curvilinear model to empirical estimates of M for ages 1-6. The New York Western Long Island tagging program provides annual estimates of instantaneous total mortality rates (Z) for ages 1, 2, and 3-4 by using MARK and the bias-correction method for live releases (Table 1). Since fishing mortality is unlikely a large component of Z, I assumed that M=Z. Based on the proportions of fish released alive by anglers (age 1: avg. 0.83; age 2: avg. 0.94; age 3-4: 0.88; max for all ages =1.0), this assumption is not unrealistic. I averaged estimates from 1991-1996 over each age. I also obtained estimates of M for ages 3, 4, 5 and 6 from 1991-1996 using the Jiang et al. (2007) data and age-dependent model. I re-estimated M for each age (Jiang originally estimated M for ages 3-5 combined and age 6 separately) using program IRATE (Table 2). To aid in model fitting, I assumed a constant M at age 7 using either the assumed SASC M=0.15 or the average M prior to 1997 derived by tagging programs for bass >= 28 inches (Table 3). For ages greater than 7, the estimate of M was assumed the predicted M at age 7 since the equations predicted steep drops in M after age 7. The model (M=a+b/age+c/age^2) was fitted assuming log-normal errors and using least-squares.

<u>Results</u>

The Lorenzen unscaled and scaled estimates of natural mortality are shown in Table 4 and are plotted in Figure 2. The unscaled Lorenzen estimates were much lower than the estimates of M from WLI striped bass at ages 1 and 2, were close to the estimates of M for ages 3-6 for WLI and Jiang, and were generally higher than the assumed SASC constant M of 0.15 through age 22. Scaling the Lorenzen estimates lower the estimates of M for ages 1-6 considerably (Table 4; Figure 2). M estimates for ages >10 were lower than the assumed SASC constant of M=0.15.

The equations estimated using the WLI and Jiang data were:

Assuming M=0.15 at age 7,

$$M = -0.108 + \frac{1.919}{Age} + \frac{-0.683}{Age^2}$$

Assuming M=Avg. Tag M at age 7,

$$M = -0.179 + \frac{2.229}{Age} + \frac{-1.005}{Age^2}$$

The equation estimates of M were much higher at ages 1-4 than either Lorenzen method (Figure 2).

The stock assessment committee chose to use the curve fit/M=0.15 estimates in the SCA model because they thought the estimates were more realistic than the Lorenzen estimates and M for ages <7 were based on tag model estimates prior to the suspected increase in Mycobacterium related mortality in Chesapeake Bay.

Table 1. NY West Long Island Z estimates for 1991-1996 using MARK and bias-correction methods.

Year	1	Age 2	3-4
1991	1.17	0.62	0.31
1992	1.20	0.68	0.21
1993	1.15	0.63	0.30
1994	1.19	0.76	0.39
1995	1.16	0.72	0.30
1996	1.16	0.84	0.30
Average	1.17	0.71	0.30

Table 2. Re-estimated age-specific M estimates from Jiang et al. (2007) data and model.

Age	M
3	0.44
4	0.43
5	0.36
6	0.152

Table 3. Estimated M of 28 inch bass and greater (age 7+) for period prior to 1997 by state programs.

State	M
MA	0.10
NYOHS/Trawl	0.10
NJ	0.07
NC	0.16
HUD	0.09
DE/PA	0.10
MD	0.14

Table 4. Resulting M estimates from the Lorenzen and curve fitting methods.

	Lorenzen (1996)		Curve Fit	
Age	Unscaled	Scaled	M=0.15	Avg. Tag M
1	0.64	0.40	1.13	1.11
2	0.47	0.29	0.68	0.71
3	0.39	0.24	0.45	0.47
4	0.34	0.21	0.33	0.33
5	0.31	0.19	0.25	0.24
6	0.28	0.18	0.19	0.17
7	0.26	0.16	0.15	0.13
8	0.25	0.15	0.15	0.13
9	0.23	0.15	0.15	0.13
10	0.22	0.14	0.15	0.13
11	0.21	0.13	0.15	0.13
12	0.20	0.13	0.15	0.13
13	0.20	0.12	0.15	0.13
14	0.19	0.12	0.15	0.13
15	0.18	0.12	0.15	0.13
16	0.18	0.11	0.15	0.13
17	0.17	0.11	0.15	0.13
18	0.17	0.11	0.15	0.13
19	0.17	0.10	0.15	0.13
20	0.16	0.10	0.15	0.13
21	0.16	0.10	0.15	0.13
22	0.15	0.10	0.15	0.13
23	0.15	0.09	0.15	0.13
24	0.15	0.09	0.15	0.13
25	0.15	0.09	0.15	0.13
26	0.14	0.09	0.15	0.13
27	0.14	0.09	0.15	0.13
28	0.14	0.09	0.15	0.13
29	0.14	0.09	0.15	0.13
30	0.13	0.08	0.15	0.13
31	0.13	0.08	0.15	0.13

Figure 1. Observed versus predicted weights-at-age.

Figure 2. Comparison of estimates of age-specific Ms.

Appendix B6. AD Model Builder code for the striped bass statistical catch-at-age model.

```
//--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><>
//
//      Striped bass Statistical Catch-At-Age Model
//      Gary Nelson
//      Massachusetts Division of Marine Fisheries
//      Gloucester, MA 01930
//
//      ADMB code for the calculation of effective sample size using the Francis (2011) method
//                      copied from ASAP written by Chris Legault, NMFS.
//
//      ADMB code for fitting S-R curves was adapted from code written by Erik Williams, NMFS in his
//      Atlantic Menhaden model
//--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><><>--><>
TOP_OF_MAIN_SECTION
 arrmblsize=1000000;
 gradient_structure::set_NUM_DEPENDENT_VARIABLES(300);
GLOBALS_SECTION
 #include <string.h>
 char hh[2];
DATA_SECTION
 init_int styrR;
// STARTING AND ENDING YEAR OF MODEL
 init_int styr;
 init_int endyr;
// NUMBER OF AGES
 init_int nages;
 int y;
 ivector agebins(1,nages);
 LOCAL_CALCS
   for(y=1;y<=nages;y++) agebins(y)=y;
 END_CALCS
 init_matrix M(styr,endyr,1,nages);
 init_vector fsex(1,nages);
 init_matrix fmat(styr,endyr,1,nages);
 init_matrix cwgt(styr,endyr,1,nages);
 init_matrix swgt(styr,endyr,1,nages);
 init_matrix ssbwgt(styr,endyr,1,nages);
 //TOTAL CATCH CVs
 init_number nfleets;
 init_3darray obs_age_comp(1,nfleets,styr,endyr,1,nages);
 init_matrix obs_total_catch(styr,endyr,1,nfleets);
 init_matrix total_catch_CV(styr,endyr,1,nfleets);
 init_matrix ss_age_comp(styr,endyr,1,nfleets);
 init_number nselperiods;
 init_matrix fleetsel(1,nselperiods,1,4);
 init_matrix fleetllw(1,nfleets,1,3);
// AGGREGATE SURVEYS
 init_int agg_surv_num;
 init_vector use_agg(1,agg_surv_num);
 init_vector agg_surv_flag(1,agg_surv_num);
 init_vector agg_surv_ages(1,agg_surv_num);
 init_vector agg_wgt(1,agg_surv_num);
 init_vector agg_index_CV_wgt(1,agg_surv_num);
 init_matrix agg_obs_surv_indices(styrR,endyr,1,agg_surv_num);
 init_matrix agg_surv_CV(styrR,endyr,1,agg_surv_num);
//SURVEYS WITH AGE COMPOSITION
 init_int ac_surv_num;
 init_vector use_ac(1,ac_surv_num);
 init_matrix acsel(1,ac_surv_num,1,6);
 init_matrix acuser(1,ac_surv_num,1,nages);
 init_3darray surv_comps(1,ac_surv_num,styrR,endyr,1,nages);
 init_matrix ac_obs_surv_indices(styrR,endyr,1,ac_surv_num);
 init_matrix ac_surv_CV(styrR,endyr,1,ac_surv_num);
 init_matrix ac_ss(styrR,endyr,1,ac_surv_num);
 init_number pF;
 init_number pM;
```

```
 init_int rivard;
//Recruitment Model
 init_int srmodel;
 int srcnt;
 LOCAL_CALCS
 if(srmodel==1) srcnt=1;
 if(srmodel==2||srmodel==3) srcnt=3;
 if(srmodel==4) srcnt=4;
 END_CALCS
 init_number log_R_con1;init_number log_R_con2;init_number log_R_con3;init_number log_R_con4;
 init_number log_R_dev_con1; init_number log_R_dev_con2; init_number log_R_dev_con3; init_number log_R_dev_con4;
 init_number log_F_con1; init_number log_F_con2; init_number log_F_con3; init_number log_F_con4;
 init_number aggqs_con1;init_number aggqs_con2;init_number aggqs_con3;init_number aggqs_con4;
 init_number acqs_con1;init_number acqs_con2; init_number acqs_con3; init_number acqs_con4;
 init_number flgom_a_con1;init_number flgom_a_con2;init_number flgom_a_con3;init_number flgom_a_con4;
 init_number flgom_b_con1;init_number flgom_b_con2;init_number flgom_b_con3;init_number flgom_b_con4;
 init_number fllog_a_con1;init_number fllog_a_con2; init_number fllog_a_con3; init_number fllog_a_con4;
 init_number fllog_b_con1;init_number fllog_b_con2; init_number fllog_b_con3; init_number fllog_b_con4;
 init_number flgam_a_con1;init_number flgam_a_con2; init_number flgam_a_con3; init_number flgam_a_con4;
 init_number flgam_b_con1;init_number flgam_b_con2;init_number flgam_b_con3;init_number flgam_b_con4;
 init_number flthom_a_con1;init_number flthom_a_con2;init_number flthom_a_con3;init_number flthom_a_con4;
 init_number flthom_b_con1;init_number flthom_b_con2; init_number flthom_b_con3; init_number flthom_b_con4;
 init_number flthom_c_con1;init_number flthom_c_con2; init_number flthom_c_con3; init_number flthom_c_con4;
 init_number fldlog_a_con1;init_number fldlog_a_con2;init_number fldlog_a_con3;init_number fldlog_a_con4;
 init_number fldlog_b_con1;init_number fldlog_b_con2; init_number fldlog_b_con3; init_number fldlog_b_con4;
 init_number fldlog_c_con1;init_number fldlog_c_con2; init_number fldlog_c_con3; init_number fldlog_c_con4;
 init_number fldlog_d_con1;init_number fldlog_d_con2; init_number fldlog_d_con3; init_number fldlog_d_con4;
 // If GOmpertz Plus
 init_number flgomp_a_con1;init_number flgomp_a_con2;init_number flgomp_a_con3;init_number flgomp_a_con4;
 init_number flgomp_b_con1;init_number flgomp_b_con2;init_number flgomp_b_con3;init_number flgomp_b_con4;
 init_number flgomp_c_con1;init_number flgomp_c_con2;init_number flgomp_c_con3;init_number flgomp_c_con4;
 // If Thompson  Plus
 init_number flthomp_a_con1;init_number flthomp_a_con2;init_number flthomp_a_con3;init_number flthomp_a_con4;
 init_number flthomp_b_con1;init_number flthomp_b_con2; init_number flthomp_b_con3; init_number flthomp_b_con4;
 init_number flthomp_c_con1;init_number flthomp_c_con2; init_number flthomp_c_con3; init_number flthomp_c_con4;
 init_number flthomp_d_con1;init_number flthomp_d_con2; init_number flthomp_d_con3; init_number flthomp_d_con4;
 // If Exponential
 init_number flexp_a_con1;init_number flexp_a_con2;init_number flexp_a_con3;init_number flexp_a_con4;
 init_number flexp_b_con1;init_number flexp_b_con2; init_number flexp_b_con3; init_number flexp_b_con4;
 init_number acgom_a_con1;init_number acgom_a_con2;init_number acgom_a_con3;init_number acgom_a_con4;
 init_number acgom_b_con1; init_number acgom_b_con2; init_number acgom_b_con3; init_number acgom_b_con4;
 init_number aclog_a_con1;init_number aclog_a_con2;init_number aclog_a_con3;init_number aclog_a_con4;
 init_number aclog_b_con1; init_number aclog_b_con2; init_number aclog_b_con3; init_number aclog_b_con4;
 init_number acgam_a_con1; init_number acgam_a_con2; init_number acgam_a_con3; init_number acgam_a_con4;
 init_number acgam_b_con1; init_number acgam_b_con2; init_number acgam_b_con3; init_number acgam_b_con4;
 init_number acthom_a_con1;init_number acthom_a_con2;init_number acthom_a_con3;init_number acthom_a_con4;
 init_number acthom_b_con1; init_number acthom_b_con2; init_number acthom_b_con3; init_number acthom_b_con4;
 init_number acthom_c_con1;init_number acthom_c_con2;init_number acthom_c_con3;init_number acthom_c_con4;
 init_number user_con1;init_number user_con2;init_number user_con3;init_number user_con4;
 init_number BH_a_con1;init_number BH_a_con2;init_number BH_a_con3;init_number BH_a_con4;
 init_number BH_b_con1;init_number BH_b_con2;init_number BH_b_con3;init_number BH_b_con4;
 init_number r_a_con1; init_number r_a_con2; init_number r_a_con3; init_number r_a_con4;
 init_number r_b_con1; init_number r_b_con2; init_number r_b_con3; init_number r_b_con4;
 init_number shep_a_con1; init_number shep_a_con2; init_number shep_a_con3; init_number shep_a_con4;
 init_number shep_b_con1; init_number shep_b_con2;init_number shep_b_con3;init_number shep_b_con4;
 init_number shep_c_con1; init_number shep_c_con2; init_number shep_c_con3; init_number shep_c_con4;
 init_number log_R_lam;
 init_number R_dev_lam;
 init_int navgf;
 init_matrix avgftable(1,navgf,1,3);
 init_int pspr;
 init_int Myear;
 init_int Selyear;
 init_int Wgtyear;
 init_int Matyear;
 init_int oldest;
 init_number maxF;
```

```
init_number calcincr;
init_number repincr;
init_number nconver;
init_number convflag;
init_3darray convmatrix(1,nconver,1,nages,1,nages);
init_int cilike;
init_int alike;
init_int biascor;
int cnt;
int p;
int a;
int t;
int realage;
int d;
int total;
int n_parms;
int ncsel;
int nsurvsel;
int df;
int parmFlag;
int devFlag;
int nflparms;
int nacparms;
int nacuserparms;
int nFparms;
int nRparms;
int ndeltaR;
int ndeltaF;
int ndeltaq;
int ndeltaSSB;
int ndeltaFullF;
int fltwogom;
int fltwolog;
int fltwogam;
int flthree;
int flfour;
int flgomp;
int fltp;
int flnexp;
int actwogom;
int actwolog;
int actwogam;
int acthree;
int acfour;
int user;
int cnter;
int cnter2;
int cnter3;
int cnter4;
int cnter5;
int cnter6;
int cnter7;
int iyear;
int nfs;
int ok;
int looper;
int aggdiff;
int acdiff;
int acparms;
int aggparms;

LOCAL_CALCS
 aggdiff=0;
 acdiff=0;
 for(t=1;t<=agg_surv_num;t++){
  if(use_agg(t)==0) aggdiff+=1;
 }
```

```
for(t=1;t<=ac_surv_num;t++){
 if(use_ac(t)==0) acdiff+=1;
}
acparms=ac_surv_num-acdiff;
aggparms=agg_surv_num-aggdiff;
// Calculate the number of fleet selectivity parameters
nfs=ceil(maxF/calcincr);
nflparms=0;
for(t=1;t<=nselperiods;t++){
if(fleetsel(t,4)==1) nflparms+=2;
if(fleetsel(t,4)==2) nflparms+=2;
if(fleetsel(t,4)==3) nflparms+=2;
if(fleetsel(t,4)==4) nflparms+=3;
if(fleetsel(t,4)==5) nflparms+=4;
if(fleetsel(t,4)==6) nflparms+=3;
if(fleetsel(t,4)==7) nflparms+=4;
if(fleetsel(t,4)==8) nflparms+=2;
}
nFparms=nfleets*(endyr-styr+1);
//Count number of each selectivity curve
fltwogom=0;
fltwolog=0;
fltwogam=0;
flthree=0;
flfour=0;
flgomp=0;
fltp=0;
flnexp=0;
for(t=1;t<=nselperiods;t++){
 if(fleetsel(t,4)==1){
   fltwogom+=1;
 }
 if(fleetsel(t,4)==2){
   fltwolog+=1;
 }
 if(fleetsel(t,4)==3){
   fltwogam+=1;
 }
 if(fleetsel(t,4)==4){
   flthree+=1;
 }
 if(fleetsel(t,4)==5){
   flfour+=1;
 }
 if(fleetsel(t,4)==6){
   flgomp+=1;
 }
 if(fleetsel(t,4)==7){
   fltp+=1;
 }
 if(fleetsel(t,4)==8){
   flnexp+=1;
 }
}
if(fltwogom==0) {
  flgom_a_con1=-1;
  flgom_b_con1=-1;
}
if(fltwolog==0){
  fllog_a_con1=-1;
  fllog_b_con1=-1;
}
if(fltwogam==0){
  flgam_a_con1=-1;
  flgam_b_con1=-1;
}
if(flthree==0){
```

```
     flthom_a_con1=-1;
     flthom_b_con1=-1;
     flthom_c_con1=-1;
    }
  if(flfour==0){
     fldlog_a_con1=-1;
     fldlog_b_con1=-1;
     fldlog_c_con1=-1;
     fldlog_d_con1=-1;
    }
  if(flgomp==0){
     flgomp_a_con1=-1;
     flgomp_b_con1=-1;
     flgomp_c_con1=-1;
    }
  if(fltp==0){
     flthomp_a_con1=-1;
     flthomp_b_con1=-1;
     flthomp_c_con1=-1;
     flthomp_d_con1=-1;
    }
   if(flnexp==0){
     flexp_a_con1=-1;
     flexp_b_con1=-1;
    }
  //Age Conp Surveys
   nacparms=0;
   nacuserparms=0;
  if(ac_surv_num>0){
    for(t=1;t<=ac_surv_num;t++){
     if(use_ac(t)==1){
      if(acsel(t,6)==1) nacparms+=2;
      if(acsel(t,6)==2) nacparms+=2;
      if(acsel(t,6)==3) nacparms+=2;
      if(acsel(t,6)==4) nacparms+=3;
      if(acsel(t,6)==5){
        for(a=1;a<=nages;a++){
         if(acuser(t,a)>1) nacuserparms+=1;
        }
       }
      }
     }
    }
   actwogom=0;
   actwolog=0;
   actwogam=0;
   acthree=0;
   user=0;
  //Age Comp Surveys
   for(t=1;t<=ac_surv_num;t++){
    if(use_ac(t)==1){
     if(acsel(t,6)==1){
       actwogom+=1;
      }
     if(acsel(t,6)==2){
       actwolog+=1;
      }
     if(acsel(t,6)==3){
       actwogam+=1;
      }
     if(acsel(t,6)==4){
       acthree+=1;
      }
     if(acsel(t,6)==5){
      for(a=1;a<=nages;a++){
       if(acuser(t,a)>1) user+=1;
      }
     }
```

```
   }
  }
 }
 if(actwogom==0){
  acgom_a_con1=-1;
  acgom_b_con1=-1;
 }
 if(actwolog==0){
  aclog_a_con1=-1;
  aclog_b_con1=-1;
 }
 if(actwogam==0){
  acgam_a_con1=-1;
  acgam_b_con1=-1;
 }
 if(acthree==0){
  acthom_a_con1=-1;
  acthom_b_con1=-1;
  acthom_c_con1=-1;
 }
 if(user==0) user_con1=-1;
 if(ac_surv_num<=0){
  actwogom=1;
  actwolog=1;
   actwogam=1;
  acthree=1;
  user=1;
 }
 //Recruitment model parameters
 if(srmodel==1){
  iyear=styrR;
  nRparms=1+endyr-styrR+1;
  BH_a_con1=-1;
  BH_b_con1=-1;
  r_a_con1=-1;
  r_b_con1=-1;
  shep_a_con1=-1;
  shep_b_con1=-1;
  shep_c_con1=-1;
 }
 if(srmodel==2){
  nRparms=1+(endyr-(styrR+1)+1)+2;
  iyear=styrR+1;
   r_a_con1=-1;
  r_b_con1=-1;
  shep_a_con1=-1;
  shep_b_con1=-1;
  shep_c_con1=-1;
 }
 if(srmodel==3){
   iyear=styrR+1;
  nRparms=1+(endyr-(styrR+1)+1)+2;
  BH_a_con1=-1;
  BH_b_con1=-1;
  shep_a_con1=-1;
  shep_b_con1=-1;
  shep_c_con1=-1;
 }
 if(srmodel==4){
  BH_a_con1=-1;
  BH_b_con1=-1;
  r_a_con1=-1;
  r_b_con1=-1;
  iyear=styrR+1;
  nRparms=1+(endyr-(styrR+1)+1)+3;
 }
  //SEs for log-Recruitment, log-qs, log Fs and SSB
```

```
    ndeltaR=endyr-styrR+1;
    ndeltaq=aggparms+acparms;
    ndeltaF=nfleets*(endyr-styr+1);
    ndeltaSSB=endyr-styrR+1;
    ndeltaFullF=endyr-styr+1;

    // fl selectivty, Fs,qs for agg, qs for ac, ac selecticity parms, recruitment
    df=nflparms+nFparms+acparms+aggparms+nacparms+nacuserparms+nRparms+ndeltaR+ndeltaF+ndeltaq+ndeltaSSB+ndeltaFullF;
    n_parms=nflparms+nFparms+aggparms+acparms+nacparms+nacuserparms+nRparms;
 END_CALCS
 matrix sigma(1,df,1,df+1);
 !! set_covariance_matrix(sigma);
PARAMETER_SECTION
//TEMPORARY VARIABLES
 number adds;
 number pgroup;
 number diff;
 number diff2;
 number sel;
 number sumage;
 number maxs;
 number dodo;
 number dodo1;
 number sumdo;
 number sumdo1;
 number fpen;
 number cl;
 number maxer;
 number dd1;
 number dd2;
 number slope;
 number origslope;
 number sigma1;
 number pgroup1;
 number cl1;
 number maxer1;
 number msy;
 number fmsy;
 number ssbmsy;
 number concll;
 //--------------------INITIATE SCAM ARRAYS------------------------//
//AVERAGE RECRUITMENT
 init_bounded_number log_R(log_R_con3,log_R_con4,log_R_con1);
 number log_R_constraint;
//RECRUITMENT DEVIATIONS
 init_bounded_dev_vector log_R_dev(iyear,endyr,log_R_dev_con3,log_R_dev_con4,log_R_dev_con1);
//FISHING MORTALITY
 init_bounded_matrix log_F(styr,endyr,1,nfleets,log_F_con3,log_F_con4,log_F_con1);
//CATCH SELECTIVITY
 init_bounded_vector flgom_a(1,fltwogom,flgom_a_con3,flgom_a_con4,flgom_a_con1);
 init_bounded_vector flgom_b(1,fltwogom,flgom_b_con3,flgom_b_con4,flgom_b_con1);
 init_bounded_vector fllog_a(1,fltwolog,fllog_a_con3,fllog_a_con4,fllog_a_con1);
 init_bounded_vector fllog_b(1,fltwolog,fllog_b_con3,fllog_b_con4,fllog_b_con1);
 init_bounded_vector flgam_a(1,fltwogam,flgam_a_con3,flgam_a_con4,flgam_a_con1);
 init_bounded_vector flgam_b(1,fltwogam,flgam_b_con3,flgam_b_con4,flgam_b_con1);
 init_bounded_vector flthom_a(1,flthree,flthom_a_con3,flthom_a_con4,flthom_a_con1);
 init_bounded_vector flthom_b(1,flthree,flthom_b_con3,flthom_b_con4,flthom_b_con1);
 init_bounded_vector flthom_c(1,flthree,flthom_c_con3,flthom_c_con4,flthom_c_con1);
 init_bounded_vector fldlog_a(1,flfour,fldlog_a_con3,flthom_a_con4,fldlog_a_con1);
 init_bounded_vector fldlog_b(1,flfour,fldlog_b_con3,fldlog_b_con4,fldlog_b_con1);
 init_bounded_vector fldlog_c(1,flfour,fldlog_c_con3,fldlog_c_con4,fldlog_c_con1);
 init_bounded_vector fldlog_d(1,flfour,fldlog_d_con3,fldlog_d_con4,fldlog_d_con1);
 // GOmpertz Plus
 init_bounded_vector flgomp_a(1,flgomp,flgomp_a_con3,flgomp_a_con4,flgomp_a_con1);
 init_bounded_vector flgomp_b(1,flgomp,flgomp_b_con3,flgomp_b_con4,flgomp_b_con1);
 init_bounded_vector flgomp_c(1,flgomp,flgomp_c_con3,flgomp_c_con4,flgomp_c_con1);
//Thompson Plus
```

```
init_bounded_vector flthomp_a(1,fltp,flthomp_a_con3,flthomp_a_con4,flthomp_a_con1);
init_bounded_vector flthomp_b(1,fltp,flthomp_b_con3,flthomp_b_con4,flthomp_b_con1);
init_bounded_vector flthomp_c(1,fltp,flthomp_c_con3,flthomp_c_con4,flthomp_c_con1);
init_bounded_vector flthomp_d(1,fltp,flthomp_d_con3,flthomp_d_con4,flthomp_d_con1);
//Exponentia;

init_bounded_vector flexp_a(1,flnexp,flexp_a_con3,flexp_a_con4,flexp_a_con1);
init_bounded_vector flexp_b(1,flnexp,flexp_b_con3,flexp_b_con4,flexp_b_con1);

//SURVEY SELECTIVITIES
init_bounded_vector acgom_a(1,actwogom,acgom_a_con3,acgom_a_con4,acgom_a_con1);
init_bounded_vector acgom_b(1,actwogom,acgom_b_con3,acgom_b_con4,acgom_b_con1);
init_bounded_vector aclog_a(1,actwolog,aclog_a_con3,aclog_a_con4,aclog_a_con1);
init_bounded_vector aclog_b(1,actwolog,aclog_b_con3,aclog_b_con4,aclog_b_con1);
init_bounded_vector acgam_a(1,actwogam,acgam_a_con3,acgam_a_con4,acgam_a_con1);
init_bounded_vector acgam_b(1,actwogam,flgam_b_con3,acgam_b_con4,acgam_b_con1);
init_bounded_vector acthom_a(1,acthree,acthom_a_con3,acthom_a_con4,acthom_a_con1);
init_bounded_vector acthom_b(1,acthree,acthom_b_con3,acthom_b_con4,acthom_b_con1);
init_bounded_vector acthom_c(1,acthree,acthom_c_con3,acthom_c_con4,acthom_c_con1);
init_bounded_vector userparms(1,user,user_con3,user_con4,user_con1);
//SURVEY CATCHABILITY COEEFFICIENTS AND PREDICTED INDICESindices
init_bounded_vector agg_qs(1,aggparms,aggqs_con3,aggqs_con4,aggqs_con1);
matrix agg_pred_surv_indices(styrR,endyr,1,agg_surv_num);
matrix resid_agg(styrR,endyr,1,agg_surv_num);
matrix std_resid_agg(styrR,endyr,1,agg_surv_num);
vector RMSE_agg(1,agg_surv_num);
init_bounded_vector ac_qs(1,acparms,acqs_con3,acqs_con4,acqs_con1);
matrix ac_pred_surv_indices(styrR,endyr,1,ac_surv_num);
matrix resid_ac(styrR,endyr,1,ac_surv_num);
matrix std_resid_ac(styrR,endyr,1,ac_surv_num);
vector RMSE_ac(1,ac_surv_num);
matrix p_sel(1,nselperiods,1,nages);
matrix surv_sel(1,ac_surv_num,1,nages);
// If S_RRecruit relationship
init_bounded_number BH_a(BH_a_con3,BH_a_con4,BH_a_con1);
init_bounded_number BH_b(BH_b_con3,BH_b_con4,BH_b_con1);
init_bounded_number r_a(r_a_con3,r_a_con4,r_a_con1);
init_bounded_number r_b(r_b_con3,r_b_con4,r_b_con1);
init_bounded_number shep_a(shep_a_con3,shep_a_con4,shep_a_con1);
init_bounded_number shep_b(shep_b_con3,shep_b_con4,shep_b_con1);
init_bounded_number shep_c(shep_c_con3,shep_c_con4,shep_c_con1);
//PREDICTED SURVE AGE COMPOSITIONS
3darray calc_comps(1,ac_surv_num,styrR,endyr,1,nages);
3darray surv_pred_comps(1,ac_surv_num,styrR,endyr,1,nages);
3darray std_resid_surv_comps(1,ac_surv_num,styrR,endyr,1,nages);
// INDIVIDUAL LIKELIHOOD SAVE VECTORS
vector like_agg(1,agg_surv_num);
vector like_ac_surv(1,ac_surv_num);
vector like_ac_age(1,ac_surv_num);
//CATCH-AT-AGE,PREDICTED TOTAL CATCH, PREDICTED CATCH AGE COMPOSITION, AND SSB
//NUMBERS,F,Z MATRICES
matrix N(styrR,endyr,1,nages);//Population numbers by year and age
3darray Ffleet(1,nfleets,styr,endyr,1,nages);
matrix Z(styrR,endyr,1,nages);
3darray C(1,nfleets,styr,endyr,1,nages);
matrix pred_total_catch(styr,endyr,1,nfleets);
3darray pred_age_comp(1,nfleets,styr,endyr,1,nages);
3darray selbyfleet(1,nfleets,styr,endyr,1,nages);
vector fleet_total_catch_like(1,nfleets);
vector fleet_age_comp_like(1,nfleets);
matrix rwgts(styr,endyr,1,nages);
matrix W2(styr,endyr,1,nages);
matrix jan1bio(styr,endyr,1,nages);
3darray catchbio(1,nfleets,styr,endyr,1,nages);
matrix aceffssyr(styrR,endyr,1,ac_surv_num);
matrix resid_C(styr,endyr,1,nfleets);
matrix std_resid_C(styr,endyr,1,nfleets);
```

```
3darray std_resid_CAA(1,nfleets,styr,endyr,1,nages);
matrix Fcomb(styr,endyr,1,nages);
matrix avgF(styr,endyr,1,navgf);
number FF;
vector partialF(1,nages);
vector Zypr(1,nages);
vector psb(1,oldest);
number maxSPR;
number recvar;
number recsigma;
number recpen;
matrix SSBatage(styr,endyr,1,nages);

vector Neff_stage2_mult_catch(1,nfleets);
vector Neff_stage2_mult_index(1,ac_surv_num);
vector mean_age_obs(styr,endyr);
vector mean_age_pred(styr,endyr);
vector mean_age_pred2(styr,endyr);
vector mean_age_resid(styr,endyr);
vector mean_age_sigma(styr,endyr);
number mean_age_x;
number mean_age_n;
number mean_age_delta;
number mean_age_mean;
number mean_age_m2;

//REPORT STANDARD DEVIATIONS FOR ANNUAL FS,RS, AND CATCHABILITY COEFFICIENTS
//sdreport_vector F_ann(styr,endyr);
sdreport_vector R(styrR,endyr);
sdreport_matrix F(styr,endyr,1,nfleets);
sdreport_vector q_AC(1,acparms);
sdreport_vector q_Agg(1,aggparms);
sdreport_vector SSB(styrR,endyr);
sdreport_vector FullF(styr,endyr);
//likeprof_number AvgF;
objective_function_value f;
INITIALIZATION_SECTION
 log_F log_F_con2;
 agg_qs aggqs_con2;
 ac_qs acqs_con2;
 userparms user_con2;
RUNTIME_SECTION
 maximum_function_evaluations 10000, 10000, 10000;
 convergence_criteria 1e-5, 1e-7, 1e-16;
PRELIMINARY_CALCS_SECTION
 Ffleet.initialize();
 C.initialize();
 calc_comps.initialize();
 like_agg.initialize();
 like_ac_surv.initialize();
 like_ac_age.initialize();
 surv_sel.initialize();
 agg_pred_surv_indices.initialize();
 ac_pred_surv_indices.initialize();
 surv_pred_comps.initialize();
 resid_agg.initialize();
 std_resid_agg.initialize();
 RMSE_agg.initialize();
 resid_ac.initialize();
 std_resid_ac.initialize();
 std_resid_surv_comps.initialize();
 //Starting values
 log_R=log_R_con2;
 if(srmodel>1){
   BH_a=BH_a_con2;
   BH_b=BH_b_con2;
   r_a=r_a_con2;
```

```
  r_b=r_b_con2;
 shep_a=shep_a_con2;
 shep_b=shep_b_con2;
 shep_c=shep_c_con2;
}
for(t=1;t<=nselperiods;t++){
 if(fleetsel(t,4)==1){
   flgom_a=flgom_a_con2;
   flgom_b=flgom_b_con2;
  }
 if(fleetsel(t,4)==2){
   fllog_a=fllog_a_con2;
   fllog_b=fllog_b_con2;
  }
 if(fleetsel(t,4)==3){
   flgam_a=flgam_a_con2;
   flgam_b=flgam_b_con2;
  }
 if(fleetsel(t,4)==4){
   flthom_a=flthom_a_con2;
   flthom_b=flthom_b_con2;
   flthom_c=flthom_c_con2;
  }
 if(fleetsel(t,4)==5){
   fldlog_a=fldlog_a_con2;
   fldlog_b=fldlog_b_con2;
   fldlog_c=fldlog_c_con2;
   fldlog_d=fldlog_d_con2;
  }
 if(fleetsel(t,4)==6){
   flgomp_a=flgomp_a_con2;
   flgomp_b=flgomp_b_con2;
   flgomp_c=flgomp_c_con2;
  }
 if(fleetsel(t,4)==7){
   flthomp_a=flthomp_a_con2;
   flthomp_b=flthomp_b_con2;
   flthomp_c=flthomp_c_con2;
   flthomp_d=flthomp_d_con2;

  }
 if(fleetsel(t,4)==8){
   flexp_a=flexp_a_con2;
   flexp_b=flexp_b_con2;
  }
}
for(t=1;t<=ac_surv_num;t++){
 if(use_ac(t)==1){
 if(acsel(t,6)==1){
   acgom_a=acgom_a_con2;
   acgom_b=acgom_b_con2;
  }
 if(acsel(t,6)==2){
   aclog_a=aclog_a_con2;
   aclog_b=aclog_b_con2;
  }
 if(acsel(t,6)==3){
   acgam_a=acgam_a_con2;
   acgam_b=acgam_b_con2;
  }
 if(acsel(t,6)==4){
   acthom_a=acthom_a_con2;
   acthom_b=acthom_b_con2;
   acthom_c=acthom_c_con2;
  }
 }
}
```

```
   userparms=user_con2;
//Rivard weights
 for(a=2;a<=nages-1;a++){
  for(y=styr+1;y<=endyr;y++){
    W2(y,a)=(log(cwgt(y,a))+log(cwgt(y-1,a-1)))/2;
    }
   }
for(y=styr;y<=endyr-1;y++){
    W2(y,1)=2*log(cwgt(y,1))-W2(y+1,2);
    }
for(a=1;a<=nages-2;a++){
    W2(styr,a)=2*log(cwgt(styr,a))-W2(styr+1,a+1);
    }
W2(styr,nages-1)=(W2(styr,nages-1)+W2(styr,nages-2))/2;
W2(endyr,1)=2*log(cwgt(endyr,1))-W2(endyr,2);
for(y=styr;y<=endyr;y++){
    W2(y,nages)=log(cwgt(y,nages));
    }
for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
    rwgts(y,a)=exp((W2(y,a)+log(cwgt(y,a)))/2); // Added 4-3-2013
  }
 }
PROCEDURE_SECTION
 calc_selectivity();
 calc_mortality();
 calc_biascorrect();
 calc_numbers_at_age();
 calc_catch_at_age();
 calc_predict_indices_agg();
 calc_predict_indices_ac();
 //exit(0);
 scam_likelihood();

 evaluate_the_objective_function();
FUNCTION print
//CALCULATE CATCH SELECTIVITIES VALUES FOR CURRENT PARAMETER ESTIMATES
 cout<<agg_index_CV_wgt<<endl;
FUNCTION calc_selectivity
 cnt=0;
 cnter=0;
 cnter2=0;
 cnter3=0;
 cnter4=0;
 cnter5=0.;
 cnter6=0;
 cnter7=0;
 for(p=1;p<=nselperiods;p++){
  maxs=0.;
   for(a=1;a<=nages;a++){
    if(fleetsel(p,4)==1){
     if(a==1) cnt+=1;
     p_sel(p,a)=mfexp(-1.*mfexp(-1.*flgom_b(cnt)*(double(agebins(a))-flgom_a(cnt))));
     if(p_sel(p,a)<0) p_sel(p,a)=0;
     if(p_sel(p,a)>maxs) maxs=p_sel(p,a);
     }
    if(fleetsel(p,4)==2){
     if(a==1) cnter+=1;
     p_sel(p,a)=1./(1.+mfexp(-1.*fllog_b(cnt)*(double(agebins(a))-fllog_a(cnt))));
     if(p_sel(p,a)<0) p_sel(p,a)=0;
     if(p_sel(p,a)>maxs) maxs=p_sel(p,a);
     }
    if(fleetsel(p,4)==3){
     if(a==1) cnter2+=1;
     p_sel(p,a)=pow(double(a),flgam_a(cnt))*exp(-1.*flgam_b(cnt)*double(a));
     if(p_sel(p,a)<0) p_sel(p,a)=0;
     if(p_sel(p,a)>maxs) maxs=p_sel(p,a);
```

```
          }
       if(fleetsel(p,4)==4){
        if(a==1) cnter3+=1;
        p_sel(p,a)=(1./(1.-flthom_c(cnter3)))*pow((1-flthom_c(cnter3))/flthom_c(cnter3),flthom_c(cnter3))*
          (mfexp(flthom_a(cnter3)*flthom_c(cnter3)*(flthom_b(cnter3)-double(a)))/
          (1+mfexp(flthom_a(cnter3)*(flthom_b(cnter3)-double(a))))));
        if(p_sel(p,a)<0) p_sel(p,a)=0;
        if(p_sel(p,a)>maxs) maxs=p_sel(p,a);
        }
       if(fleetsel(p,4)==5){
        if(a==1) cnter4+=1;
        p_sel(p,a)=(1./(1.+mfexp(-1.*fldlog_b(cnter4)*(double(agebins(a))-fldlog_a(cnter4)))))*
          (1-(1./(1.+mfexp(-1.*fldlog_d(cnter4)*(double(agebins(a))-fldlog_c(cnter4))))));
        if(p_sel(p,a)<0) p_sel(p,a)=0;
        if(p_sel(p,a)>maxs) maxs=p_sel(p,a);
        }
       if(fleetsel(p,4)==6){
        if(a==1) cnter5+=1;
        if(a<nages) p_sel(p,a)=mfexp(-1.*mfexp(-1.*flgomp_b(cnter5)*(double(agebins(a))-flgomp_a(cnter5))));
        if(a==nages) p_sel(p,a)=flgomp_c(cnter5);
        if(p_sel(p,a)<0) p_sel(p,a)=0;
        if(p_sel(p,a)>maxs) maxs=p_sel(p,a);
        }
       if(fleetsel(p,4)==7){
        if(a==1) cnter6+=1;
        if(a<nages){ p_sel(p,a)=(1./(1.-flthomp_c(cnter6)))*pow((1-flthomp_c(cnter6))/flthomp_c(cnter6),flthomp_c(cnter6))*
          (mfexp(flthomp_a(cnter6)*flthomp_c(cnter6)*(flthomp_b(cnter6)-double(a)))/
          (1+mfexp(flthomp_a(cnter6)*(flthomp_b(cnter6)-double(a)))));}
        if(a==nages) p_sel(p,a)=flthomp_d(cnter6);
        if(p_sel(p,a)<0) p_sel(p,a)=0;
        if(p_sel(p,a)>maxs) maxs=p_sel(p,a);
        }
       if(fleetsel(p,4)==8){
        if(a==1) cnter7+=1;
        if(a<4) p_sel(p,a)=flexp_a(cnter7)*mfexp(flexp_b(cnter7)*double(a));
        if(a>=4) p_sel(p,a)=1;
        if(p_sel(p,a)<0) p_sel(p,a)=0;
        if(p_sel(p,a)>maxs) maxs=p_sel(p,a);
        }
      }//age
      p_sel(p)=p_sel(p)/maxs;
     }
//MATCH PERIOD SELECTVITIES TO YEARS AND CALCULATE ANNUAL F AND F-AT-AGE
FUNCTION calc_mortality
 for(t=1;t<=nfleets;t++){
  for(p=1;p<=nselperiods;p++){
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(fleetsel(p,1)==t){
      if (y>=fleetsel(p,2) && y<=fleetsel(p,3)){
       Ffleet(t,y,a)=p_sel(p,a)*mfexp(log_F(y,t));
       selbyfleet(t,y,a)=p_sel(p,a);
      }
     }
    }
   }
  }
 }
 // Combined Fleet Fs at age
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
   Fcomb(y,a)=0;
    for(t=1;t<=nfleets;t++) Fcomb(y,a)+=Ffleet(t,y,a);
   }
  }

 for(y=styrR;y<=endyr;y++){
```

```
   for(a=1;a<=nages;a++){
    if(y<styr)Z(y,a)=Fcomb(styr,a)+M(styr,a);
    if(y>=styr)Z(y,a)=Fcomb(y,a)+M(y,a);
   }
  }

  for(t=1;t<=nfleets;t++){
   for(y=styr;y<=endyr;y++){
    F(y,t)=mfexp(log_F(y,t));
   }
  }

   for(y=styr;y<=endyr;y++){
    FullF(y)=0;
     for(t=1;t<=nfleets;t++){
      FullF(y)+=mfexp(log_F(y,t));
     }
   }
FUNCTION calc_biascorrect
 if(biascor==1) recvar=norm2(log_R_dev(styr,endyr)-(sum(log_R_dev(styr,endyr))/(endyr-styr+1)))/(endyr-styr+1-1.0);
 if(biascor==0) recvar=0;
//CALCULATE AND FILL NUMBERS-AT-AGE MATRIX
FUNCTION calc_numbers_at_age
 // First row of pre-data year
 if(srmodel==1){
   N(styrR,1)=mfexp(log_R+log_R_dev(styrR)-0.5*recvar);//Fill in Recruits in first year and age
  }
 if(srmodel>1){
   N(styrR,1)=mfexp(log_R);//Fill in Recruits in first year and age
  }

  for(a=2;a<=nages;a++){
   N(styrR,a)=N(styrR,a-1)*mfexp(-1.*Z(styrR,a-1));//Fills in top row of matrix
   }
  N(styrR,nages)=N(styrR,nages-1)*mfexp(-1.*Z(styrR,nages-1))/(1.-mfexp(-1.*Z(styrR,nages)));
    sumdo1=0;
    for(a=1;a<=nages;a++){
     if (rivard==1) sumdo1+=N(styrR,a)*mfexp(-1.*(pF*Fcomb(styr,a)+pM*M(styr,a)))*fsex(a)*fmat(styr,a)*rwgts(styr,a);
     if (rivard==0) sumdo1+=N(styrR,a)*mfexp(-1.*(pF*Fcomb(styr,a)+pM*M(styr,a)))*fsex(a)*fmat(styr,a)*ssbwgt(styr,a);
    }
   SSB(styrR)=sumdo1/1000;
   // Constraints on first recruitment to follow S-R curve
   if(srmodel>1){
    if(srmodel==2) log_R_constraint=log(BH_a)+log(SSB(styrR))-log(1+SSB(styrR)/BH_b)-0.5*recvar;
    if(srmodel==3) log_R_constraint=log(r_a)+log(SSB(styrR))-SSB(styrR)/r_b-0.5*recvar;
    if(srmodel==4) log_R_constraint=log(shep_a)+log(SSB(styrR))-log(1+pow(SSB(styrR)/shep_b,shep_c)-0.5*recvar);
    }
  //Rest of data
  for(y=styrR+1;y<=endyr;y++){
   if(srmodel==1) N(y,1)=mfexp(log_R+log_R_dev(y)-0.5*recvar);
   if(srmodel>1){
    if(srmodel==2) N(y,1)=mfexp(log(BH_a)+log(SSB(y-1))-log(1+SSB(y-1)/BH_b)+log_R_dev(y)-0.5*recvar);
    if(srmodel==3) N(y,1)=mfexp(log(r_a)+log(SSB(y-1))-SSB(y-1)/r_b+log_R_dev(y)-0.5*recvar);
    if(srmodel==4) N(y,1)=mfexp(log(shep_a)+log(SSB(y-1))-log(1+pow(SSB(y-1)/shep_b,shep_c))+log_R_dev(y)-0.5*recvar);
    }
   N(y)(2,nages)=++elem_prod(N(y-1)(1,nages-1),(mfexp(-1.*Z(y-1)(1,nages-1))));
   N(y,nages)+=N(y-1,nages)*mfexp(-1.*Z(y-1,nages));//plus group
   if(y<styr){
     sumdo1=0;
      for(a=1;a<=nages;a++){
       if (rivard==1) sumdo1+=N(y,a)*mfexp(-1.*(pF*Fcomb(styr,a)+pM*M(styr,a)))*fsex(a)*fmat(styr,a)*rwgts(styr,a);
       if (rivard==0) sumdo1+=N(y,a)*mfexp(-1.*(pF*Fcomb(styr,a)+pM*M(styr,a)))*fsex(a)*fmat(styr,a)*ssbwgt(styr,a);
      }
      SSB(y)=sumdo1/1000;
    }
    if(y>=styr){
      sumdo1=0;
```

```
          for(a=1;a<=nages;a++){
            if (rivard==1) sumdo1+=N(y,a)*mfexp(-1.*(pF*Fcomb(y,a)+pM*M(y,a)))*fsex(a)*fmat(y,a)*rwgts(y,a);
            if (rivard==0) sumdo1+=N(y,a)*mfexp(-1.*(pF*Fcomb(y,a)+pM*M(y,a)))*fsex(a)*fmat(y,a)*ssbwgt(y,a);
          }
          SSB(y)=sumdo1/1000;
      }

   }
  R=column(N,1);
 //CALCULATE CATCH-AT-AGE MATRIX
 FUNCTION calc_catch_at_age
 for(t=1;t<=nfleets;t++){
  for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    C(t,y,a)=N(y,a)*Ffleet(t,y,a)*(1.-mfexp(-1.*Z(y,a)))/Z(y,a);
   }
  }
 }
 for(t=1;t<=nfleets;t++){
  for(y=styr;y<=endyr;y++){
    sumage=0;
    for(a=1;a<=nages;a++){
     sumage+=C(t,y,a);
    }
    pred_total_catch(y,t)=sumage;
    for(a=1;a<=nages;a++){
      pred_age_comp(t,y,a)=C(t,y,a)/(sumage+0.001);
    }
   if(convflag==1) pred_age_comp(t,y)=convmatrix(t)*pred_age_comp(t,y);
  }
 }
// Calculate Predicted Aggregate Indices
FUNCTION calc_predict_indices_agg
 if(agg_surv_num>0){
  cnt=0;
  for(t=1;t<=agg_surv_num;t++){
   if(use_agg(t)==1){
    cnt+=1;
    adds=0;
    realage=0;
    diff2=0;
    for(y=styrR;y<=endyr;y++){
     if (agg_obs_surv_indices(y,t)>=0.) //Skip missing values (-1)
      {
           realage=(int)floor(agg_surv_ages(t));
           diff2=int(ceil(agg_surv_ages(t)*100)-(floor(agg_surv_ages(t))*100));
           pgroup=0;
           for (a=realage;a<=diff2;a++)
            {
             pgroup+=N(y,a)*mfexp(-1.*agg_surv_flag(t)*Z(y,a));
          }
            agg_pred_surv_indices(y,t)=mfexp(agg_qs(cnt))*pgroup;
      }//agg_surv_indices>=0
     if (agg_obs_surv_indices(y,t)==-1) agg_pred_surv_indices(y,t)=-1;
    }//y loop
    q_Agg(cnt)=mfexp(agg_qs(cnt));
   }
  }//t loop
 }
FUNCTION calc_predict_indices_ac
 //calc survey selectivities
 if(ac_surv_num>0){
  cnt=0;
  cnter=0;
  cnter2=0;
  cnter3=0;
  cnter4=0;
```

```
for(t=1;t<=ac_surv_num;t++){
 if(use_ac(t)==1){
  maxs=0;
 for(a=1;a<nages;a++){
  if(acsel(t,6)==1){
     if(a==1) cnt+=1;
     surv_sel(t,a)=exp(-1.*exp(-1.*acgom_b(cnt)*(double(agebins(a))-acgom_a(cnt))));
     if(surv_sel(t,a)>=maxs) maxs=surv_sel(t,a);
  }
  if(acsel(t,6)==2){
     if(a==1) cnter+=1;
     surv_sel(t,a)=1./(1.+mfexp(-1.*aclog_b(cnter)*(double(agebins(a))-aclog_a(cnter))));
     if(surv_sel(t,a)>=maxs) maxs=surv_sel(t,a);
  }
   if(acsel(t,6)==3){
     if(a==1) cnter2+=1;
     surv_sel(t,a)=pow(double(a),acgam_a(cnter2))*exp(-1.*acgam_b(cnter2)*double(a));
    if(surv_sel(t,a)>=maxs) maxs=surv_sel(t,a);
  }
  if(acsel(t,6)==4){
     if(a==1)  cnter3+=1;
     surv_sel(t,a)=(1./(1.-acthom_c(cnter3)))*pow((1-acthom_c(cnter3))/
        acthom_c(cnter3),acthom_c(cnter3))*(mfexp(acthom_a(cnter3)*acthom_c(cnter3)*(acthom_b(cnter3)-double(a)))/
        (1+mfexp(acthom_a(cnter3)*(acthom_b(cnter3)-double(a)))));
     if(surv_sel(t,a)>=maxs) maxs=surv_sel(t,a);
  }
  if(acsel(t,6)==5){
    if(acuser(t,a)>=0 && acuser(t,a)<=1) surv_sel(t,a)=acuser(t,a);
    if(acuser(t,a)==99){
     cnter4+=1;
     surv_sel(t,a)=userparms(cnter4);
    }
    if(surv_sel(t,a)>=maxs) maxs=surv_sel(t,a);
  }
 }
 surv_sel(t,nages)=surv_sel(t,nages-1);
 surv_sel(t)=surv_sel(t)/maxs;
 }
}
cnt=0;
for(t=1;t<=ac_surv_num;t++){
 if(use_ac(t)==1){
   cnt+=1;
   for(y=styrR;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     calc_comps(t,y,a)=-1;
     if (surv_comps(t,y,a)>=0.){
       calc_comps(t,y,a)=surv_sel(t,a)*mfexp(ac_qs(cnt))*N(y,a)*mfexp(-1.*acsel(t,2)*Z(y,a));
     }
    }//a loop
   }//y loop
  q_AC(cnt)=mfexp(ac_qs(cnt));
 }
}//t loop
for(t=1;t<=ac_surv_num;t++){
 if(use_ac(t)==1){
  for(y=styrR;y<=endyr;y++){
    sumage=0;
    for (a=1;a<=nages;a++){
     if(surv_comps(t,y,a)>=0.) sumage+=calc_comps(t,y,a);
    }
    if(sumage>0.) ac_pred_surv_indices(y,t)=sumage;
    if(sumage<=0.) ac_pred_surv_indices(y,t)=-1;
    for (a=1;a<=nages;a++){
     surv_pred_comps(t,y,a)=-1;
     if(sumage>0.){
      if(surv_comps(t,y,a)>=0.)surv_pred_comps(t,y,a)=calc_comps(t,y,a)/sumage;
```

```
          }
          if(sumage<=0.){surv_pred_comps(t,y,a)=-1;}
        }
      }
      if(convflag==1){
        for(y=styrR;y<=endyr;y++){
          if(ac_pred_surv_indices(y,t)>=0.) surv_pred_comps(t,y)=convmatrix(t+nfleets)*surv_pred_comps(t,y);
        }
      }
    }
  }
 }//if surveys>0
FUNCTION scam_likelihood
 cnt=0;
 //CALCULATE TOTAL CATCH Likelihoods
   for(t=1;t<=nfleets;t++){
    fleet_total_catch_like(t)=0.;
   for(y=styr;y<=endyr;y++){
    if(obs_total_catch(y,t)>=0.){
       fleet_total_catch_like(t)+=square(log((obs_total_catch(y,t)+0.00001)/(pred_total_catch(y,t)+0.00001))/total_catch_CV(y,t));
       cnt+=1;
   }
   }
  }
//CALCULATE CATCH AGE COMP LIKELIHOOD
   for(t=1;t<=nfleets;t++){
    fleet_age_comp_like(t)=0.;
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
      if(obs_age_comp(t,y,a)>=0.){
        fleet_age_comp_like(t)-=ss_age_comp(y,t)*obs_age_comp(t,y,a)*log(pred_age_comp(t,y,a)+1e-7);
      }
     }
    }
   }
//CALCULATE AGGREGATE SURVEY WEIGHTED RESIDUAL SUM OF SQUARES
  if(agg_surv_num>0){
   for(t=1;t<=agg_surv_num;t++){
    like_agg(t)=0;
    if(use_agg(t)==1){
      for(y=styrR;y<=endyr;y++){
             if(agg_obs_surv_indices(y,t)>=0.){

like_agg(t)+=square(log((agg_obs_surv_indices(y,t)+0.00001)/(agg_pred_surv_indices(y,t)+0.00001))/(agg_surv_CV(y,t)*agg_index_CV_wgt(t)))
;
        cnt+=1;
             }
     }
    }
   }
  }
// CALCULATE SURVEY WITH AGE COMPOSITIONS
 if(ac_surv_num>0){
  for(t=1;t<=ac_surv_num;t++){
   like_ac_surv(t)=0;
   if(use_ac(t)==1){
    for(y=styrR;y<=endyr;y++){
     if(ac_obs_surv_indices(y,t)>=0.){
        like_ac_surv(t)+=square(log((ac_obs_surv_indices(y,t)+0.00001)/(ac_pred_surv_indices(y,t)+0.00001))/(ac_surv_CV(y,t)*acsel(t,5)));
        cnt+=1;
    }
    }
   }
  }
  for(t=1;t<=ac_surv_num;t++){
   like_ac_age(t)=0;
   if(use_ac(t)==1){
```

```
        for(y=styrR;y<=endyr;y++){
          for(a=1;a<=nages;a++){
            if(surv_comps(t,y,a)>=0.){
                like_ac_age(t)-=ac_ss(y,t)*surv_comps(t,y,a)*log(surv_pred_comps(t,y,a)+1e-7);
            }
          }
        }
      }
    }
  }
FUNCTION evaluate_the_objective_function
 f=0;
 sumdo1=0;
 recpen=0;
 sumdo=0;
 dodo=0;
 dodo1=0;
  for(t=1;t<=nfleets;t++){
    sumdo+=fleet_total_catch_like(t)*fleetllw(t,2);
    f+=fleet_age_comp_like(t)*fleetllw(t,3);
  }
  for(t=1;t<=agg_surv_num;t++){
    if(use_agg(t)==1){
      dodo+=like_agg(t)*agg_wgt(t);
    }
  }
  for(t=1;t<=ac_surv_num;t++){
    if(use_ac(t)==1){
      dodo1+=like_ac_surv(t)*acsel(t,3);
      f+=like_ac_age(t)*acsel(t,4);
    }
  }
//CONCENTRATED LIKELIHOOD
  concll=0.5*cnt*log((sumdo+dodo+dodo1)/cnt);
  f+=concll;
  if(biascor==0) f+=R_dev_lam*norm2(log_R_dev);
  if(biascor==1){
   if(current_phase()==log_R_dev_con1) f+=norm2(log_R_dev);
   if(current_phase()>log_R_dev_con1){
     for(y=styr;y<=endyr;y++){
       recpen+=log(sqrt(recvar))+square(log_R_dev(y))/2*recvar;
     }
     f+=R_dev_lam*recpen;
   }
  }
  if(srmodel>1) f+=log_R_lam*square(log_R-log_R_constraint);
//CALCULATE PENALTY CONSTRAINT FOR F
  if(current_phase()<3){
   fpen=10.*norm2(mfexp(log_F)-0.15);
  }
  else{
   fpen=0.000001*norm2(mfexp(log_F)-0.15);
  }
 f+=fpen;

REPORT_SECTION
 report <<"Likelihood Components" << endl;
 report <<" "<<endl;
 report <<"                    "<<"\t"<<"Weight"<<"   "<<"RSS"<<endl;
 for(t=1;t<=nfleets;t++){
   report <<" Fleet "<<t<<" Total Catch: "<<"\t"<<fleetllw(t,2)<<"\t"<<setw(10)<<fleetllw(t,2)*fleet_total_catch_like(t)<<endl;
 }
 report <<" Aggregate Abundance Index    " << endl;
 for(t=1;t<=agg_surv_num;t++){
   if(use_agg(t)==1){
    report <<"  Survey "<<t<<"        : "<<"\t"<<agg_wgt(t)<<"\t"<<setw(10)<<agg_wgt(t)*like_agg(t)<<endl;
   }
```

```
    }
  report <<" Age Comp Abundance Indexs   " << endl;
  for(t=1;t<=ac_surv_num;t++){
    if(use_ac(t)==1){
     report <<"  Survey "<<t<<"       : "<<"\t"<<acsel(t,3)<<"\t"<<setw(10)<<acsel(t,3)*like_ac_surv(t)<<endl;
    }
   }
  report<<" "<<endl;
  report <<" Total RSS        "<<"\t"<<" "<<"\t"<<setw(10)<<sum(elem_prod(column(fleetllw,2),fleet_total_catch_like))+
      sum(elem_prod(agg_wgt,like_agg))+sum(elem_prod(column(acsel,3),like_ac_surv))<<endl;
  report <<" No. of Obs        "<<"\t"<<" "<<"\t"<<setw(10)<<cnt<<endl;
  report <<" Conc. Likelihood    "<<"\t"<<" "<<"\t"<<setw(10)<<concll<<endl;
  report<<"Age Composition Data "<<endl;
  for(t=1;t<=nfleets;t++){
    report <<" Fleet "<<t<<" Age Comp: "<<"\t"<<fleetllw(t,3)<<"\t"<<setw(10)<<fleetllw(t,3)*fleet_age_comp_like(t)<<endl;
  }
  for(t=1;t<=ac_surv_num;t++){
    if(use_ac(t)==1){
     report <<"  Survey "<<t<<"       : "<<"\t"<<acsel(t,4)<<"\t"<<setw(10)<<acsel(t,4)*like_ac_age(t)<<endl;
    }
   }
  report <<" "<<endl;
  if(srmodel>1) report <<"log_R constraint "<<"        : "<<"\t"<<log_R_lam<<"\t"<<setw(10)<<log_R_lam*square(log_R-log_R_constraint)<<endl;
  if(biascor==0) report <<"Recr Devs "<<"        : "<<"\t"<<R_dev_lam<<"\t"<<setw(10)<<R_dev_lam*norm2(log_R_dev)<<endl;
  if(biascor==1) report <<"Recr Devs "<<"        : "<<"\t"<<R_dev_lam<<"\t"<<setw(10)<<R_dev_lam*recpen<<endl;
  report <<" "<<endl;
  report <<"Total Likelihood    : "<<"\t"<<" "<<"\t"<<setw(10)<<f<<endl;
  if(biascor==0) report <<"AIC    : "<<"\t"<<" "<<"\t"<<setw(10)<<2*f+2*n_parms<<endl;
  if(biascor==1) report <<"AIC    : "<<"\t"<<" "<<"\t"<<setw(10)<<2*f+2*(n_parms+1)<<endl; // for calculated recvar
  report << " " << endl;

  ofstream ofs36("LLtable.out");
    ofs36 <<"Likelihood Components" << endl;
  ofs36 <<" "<<endl;
  ofs36 <<"             "<<"\t"<<"Weight"<<"\t"<<"  "<<"RSS"<<endl;
   for(t=1;t<=nfleets;t++){
    ofs36 <<"Fleet "<<t<<" Total Catch: "<<"\t"<<fleetllw(t,2)<<"\t"<<setw(10)<<fleetllw(t,2)*fleet_total_catch_like(t)<<endl;
   }
  ofs36 <<" Aggregate Abundance Indices  " << endl;
   for(t=1;t<=agg_surv_num;t++){
    if(use_agg(t)==1){
    ofs36 <<"  Survey "<<t<<"       : "<<"\t"<<agg_wgt(t)<<"\t"<<setw(10)<<agg_wgt(t)*like_agg(t)<<endl;
    }
   }
  ofs36 <<" Age Comp Abundance Indices  " << endl;
  for(t=1;t<=ac_surv_num;t++){
    if(use_ac(t)==1){
     ofs36 <<"  Survey "<<t<<"       : "<<"\t"<<acsel(t,3)<<"\t"<<setw(10)<<acsel(t,3)*like_ac_surv(t)<<endl;
    }
   }
  ofs36<<" "<<endl;
  ofs36 <<" Total RSS        "<<"\t"<<" "<<"\t"<<setw(10)<<sum(elem_prod(column(fleetllw,2),fleet_total_catch_like))+
      sum(elem_prod(agg_wgt,like_agg))+sum(elem_prod(column(acsel,3),like_ac_surv))<<endl;

  ofs36 <<" No. of Obs        "<<"\t"<<" "<<"\t"<<setw(10)<<cnt<<endl;
  ofs36 <<" Conc. Likel.      "<<"\t"<<" "<<"\t"<<setw(10)<<
       0.5*cnt*log((sum(elem_prod(column(fleetllw,2),fleet_total_catch_like))+
      sum(elem_prod(agg_wgt,like_agg))+sum(elem_prod(column(acsel,3),like_ac_surv)))/cnt)<<endl;
  ofs36 <<" "<<endl;
  ofs36<<"Age Composition Data "<<"\t"<<"Likelihood"<<endl;
  for(t=1;t<=nfleets;t++){
    ofs36 <<" Fleet "<<t<<" Age Comp: "<<"\t"<<fleetllw(t,3)<<"\t"<<setw(10)<<fleetllw(t,3)*fleet_age_comp_like(t)<<endl;
  }
  for(t=1;t<=ac_surv_num;t++){
    if(use_ac(t)==1){
     ofs36 <<"  Survey "<<t<<"       : "<<"\t"<<acsel(t,4)<<"\t"<<setw(10)<<acsel(t,4)*like_ac_age(t)<<endl;
    }
```

```
    }
ofs36 <<" "<<endl;
if(srmodel>1) ofs36 <<"log_R constraint"<<": "<<"\t"<<log_R_lam<<"\t"<<setw(10)<<log_R_lam*square(log_R-log_R_constraint)<<endl;
ofs36 <<"Recr Devs "<<        : "<<"\t"<<R_dev_lam<<"\t"<<setw(10)<<R_dev_lam*norm2(log_R_dev)<<endl;
ofs36 <<" "<<endl;
ofs36 <<"Total Likelihood    : "<<"\t"<<" "<<"\t"<<setw(10)<<f<<endl;
ofs36 <<"AIC            : "<<"\t"<<" "<<"\t"<<setw(10)<<2*f+2*n_parms<<endl;
ofs36.close();
report <<"**********************************************************************************************************"<<endl;
report<<"Mortality Rates "<<endl;
report << "Natural" << endl;
report << M << endl;
report<<" "<<endl;
report << "Fishing" << endl;
report << mfexp(log_F)<< endl;
report<<" "<<endl;
report <<"***********************************SCAM Output***********************"<<endl;
 report << "Total Catch" << endl;
report << "Observed" <<endl;
report << obs_total_catch << endl;
report << "Predicted" << endl;
report << pred_total_catch <<endl;
report <<" "<<endl;
report << "Obs Catch Age Comp "<< endl;
report<<obs_age_comp<<endl;
report <<" "<<endl;
report <<"Pred Catch Age comp"<<endl;
report<<pred_age_comp<<endl;
report <<" "<<endl;
report << "Number-At-Age "<< endl;
report << N<<endl;
 report<<"Observed Aggregate Indices"<<endl;
report<<agg_obs_surv_indices<<endl;
report <<" "<<endl;
report<<"Predicted Aggregate Indices"<<endl;
report<<agg_pred_surv_indices<<endl;
report <<" "<<endl;
report<<"Aggregate Survey qs"<<endl;
report<<mfexp(agg_qs)<<endl;
report <<" "<<endl;
report<<"Aggregate Indices CVs"<<endl;
report<<agg_surv_CV<<endl;
report <<" "<<endl;
report<<"Observed Age Comp Indices"<<endl;
report<<ac_obs_surv_indices<<endl;
report <<" "<<endl;
report<<"Predicted Age Comps Indices"<<endl;
report<<ac_pred_surv_indices<<endl;
report <<" "<<endl;
report<<"Age Comps Survey qs"<<endl;
report<<mfexp(ac_qs)<<endl;
report <<" "<<endl;
report<<"Age Comps Indices CVs"<<endl;
report<<ac_surv_CV<<endl;
report <<" "<<endl;
report<<"Observed Survey Age Comps "<<endl;
report<<surv_comps<<endl;
report <<" "<<endl;
report<<"Predicted Survey Age Comps "<<endl;
report<<surv_pred_comps<<endl;
report <<" "<<endl;
report<<"Predicted Survey Age Comps Selectivities"<<endl;
report<<surv_sel<<endl;
report <<" "<<endl;

report<<"Fishing Mortality at age"<<endl;
//report<<F<<endl;
```

```
report <<" "<<endl;
report<<"Female SSB"<<endl;
report<<SSB<<endl;
report <<" "<<endl;

report<<"Rivards Weights(kg)"<<endl;
report<<rwgts<<endl; report <<" "<<endl;
report<<"Catch Weights (kg)"<<endl;
report<<cwgt<<endl; report <<" "<<endl;
report<<"January-1 stock biomass (mt)"<<endl;
report<<jan1bio/1000<<endl; report <<" "<<endl;
report<<"Catch biomass (mt)"<<endl;
report<<catchbio/1000<<endl; report <<" "<<endl;

FINAL_SECTION
// Number of Parameters
 ofstream ofs51("nparms.out");
 ofs51<<n_parms<<endl;
 ofs51.close();
 //Final calculations
 ofstream ofs1("jan1bio.out");
 ofstream ofs2("catchbio.out");
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     jan1bio(y,a)=rwgts(y,a)*N(y,a);
     if(a<nages) ofs1<<jan1bio(y,a)/1000<<" ";
     if(a==nages) ofs1<<jan1bio(y,a)/1000<<endl;
      for(t=1;t<=nfleets;t++){
       catchbio(t,y,a)=cwgt(y,a)*obs_total_catch(y,t)*obs_age_comp(t,y,a)/1000;
     }
     }
   }
   for(t=1;t<=nfleets;t++){
    for(y=styr;y<=endyr;y++){
     for(a=1;a<=nages;a++){
      if(a<nages) ofs2<<catchbio(t,y,a)<<" ";
      if(a==nages) ofs2<<catchbio(t,y,a)<<endl;
    }
   }
  }
 ofs1.close();
 ofs2.close();

// Output Average F
 cnter=0;
 cnter2=0;
 for(t=1;t<=navgf;t++){
  cnter=avgftable(t,1);
  cnter2=avgftable(t,2);
  for(y=styr;y<=endyr;y++){
    sumdo=0;
    cnt=0;
    sumdo1=0;

  if(avgftable(t,3)==1){ //Unweighted
    for(a=cnter;a<=cnter2;a++){
    sumdo+=Fcomb(y,a);
    cnt+=1;
    }
    avgF(y,t)=sumdo/cnt;
  }
  if(avgftable(t,3)==3){ //N-weighted Jan-1
    for(a=cnter;a<=cnter2;a++){
    sumdo+=Fcomb(y,a)*N(y,a);
    sumdo1+=N(y,a);
    }
    avgF(y,t)=sumdo/sumdo1;
```

```
      }
    if(avgftable(t,3)==2){ //B-weighted Jan-1
      for(a=cnter;a<=cnter2;a++){
        sumdo+=Fcomb(y,a)*jan1bio(y,a);
        sumdo1+=jan1bio(y,a);
      }
      avgF(y,t)=sumdo/sumdo1;
    }
  }
}
ofstream ofs3("avgF.out");
  for(y=styr;y<=endyr;y++){
    for(t=1;t<=navgf;t++){
    if(t<navgf) ofs3<<avgF(y,t)<<" ";
    if(t==navgf) ofs3<<avgF(y,t)<<endl;
  }
}
ofs3.close();


//Ouput R and Rsd
ofstream ofs4("R.out");
 d=n_parms+1;
 for(t=styrR;t<=endyr;t++){
    ofs4<<R(t)<<" "<<sigma(d,1)<<endl;
    d+=1;
 }
 ofs4.close();
// Output Fleet Fully-recruited F and Fsd
 for(t=1;t<=nfleets;t++){
    sprintf(hh,"%i",t);
    adstring u=adstring("Fleet")+hh+adstring("FullF.out");
    ofstream ofs5(u);
    for(y=styr;y<=endyr;y++){
    ofs5<<F(y,t)<<" "<<sigma(d,1)<<endl;
      d+=1;
    }
    ofs5.close();
 }


 //Output F-at-age
 ofstream ofs82("Fatage.out");
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
    if(a<nages) ofs82<<Fcomb(y,a)<<" ";
    if(a==nages) ofs82<<Fcomb(y,a)<<endl;
    }
  }
ofs82.close();
//Output Catchability Coefficients of Age-specific and Aggregate Indices
 ofstream ofs6("acqs.out");
 cnt=0;
  for(t=1;t<=ac_surv_num;t++){
   if(use_ac(t)==1){
     cnt+=1;
     ofs6<<mfexp(ac_qs(cnt))<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/mfexp(ac_qs(cnt)))<<endl;
     d+=1;
   }
   if(use_ac(t)==0){
     ofs6<<"0"<<" "<<"0"<<" "<<"0"<<endl;
   }
  }
 cnt=0;
 ofstream ofs7("aggqs.out");
  for(t=1;t<=agg_surv_num;t++){
   if(use_agg(t)==1){
     cnt+=1;
```

```
    ofs7<<mfexp(agg_qs(cnt))<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/mfexp(agg_qs(cnt)))<<endl;
    d+=1;
   }
   if(use_agg(t)==0){
    ofs7<<"0"<<" "<<"0"<<" "<<"0"<<endl;
   }
 }
//Output Female Spawning Stock Biomass
 ofstream ofs8("SSBfem.out");
  for(y=styrR;y<=endyr;y++) {
   if(y>=styr) ofs8<<SSB(y)<<" "<<sigma(d,1)<<endl;
    d+=1;
  }
 ofs8.close();
 //
 //
 // Output Total Fully-Recruited F and Fsd
 ofstream ofs81("FullF.out");
  for(y=styr;y<=endyr;y++){
   ofs81<<FullF(y)<<" "<<sigma(d,1)<<endl;
   d+=1;
  }
 ofs81.close();
 //Output N-at-age
 ofstream ofs9("N.out");
 for(y=styrR;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(a<nages) ofs9<<N(y,a)<<" ";
   if(a==nages) ofs9<<N(y,a)<<endl;
  }
 }
 // Output Predicted Survey Selectivities-at-Age
  ofstream ofs("survsel.out");
   for(a=1;a<=nages;a++){
    for(t=1;t<=ac_surv_num;t++){
     if(t<ac_surv_num) ofs<<surv_sel(t,a)<<" ";
     if(t==ac_surv_num) ofs<<surv_sel(t,a)<<endl;
   }
  }
  ofs.close();
//Output Fleet Catch Age Comp
 for(t=1;t<=nfleets;t++){
   sprintf(hh,"%i",t);
   adstring u=adstring("Fleet")+hh+adstring("CAApred.out");
   ofstream ofs(u);
 for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(a<nages) ofs<<pred_age_comp(t,y,a)<<" ";
   if(a==nages) ofs<<pred_age_comp(t,y,a)<<endl;
  }
 }
 ofs.close();
 }
//Output Catch Age Comp
 for(t=1;t<=nfleets;t++){
   sprintf(hh,"%i",t);
   adstring u=adstring("Fleet")+hh+adstring("CAAobs.out");
   ofstream ofs(u);
 for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(a<nages) ofs<<obs_age_comp(t,y,a)<<" ";
   if(a==nages) ofs<<obs_age_comp(t,y,a)<<endl;
  }
 }
 ofs.close();
 }
//Output Predicted Total Catch
```

```
   for(t=1;t<=nfleets;t++){
   sprintf(hh,"%i",t);
   adstring u=adstring("Fleet")+hh+adstring("Catpred.out");
   ofstream ofs(u);
   for(y=styr;y<=endyr;y++){
     ofs<<pred_total_catch(y,t)<<endl;
   }
  ofs.close();
 }
//Output Observed Total Catch
  for(t=1;t<=nfleets;t++){
   sprintf(hh,"%i",t);
   adstring u=adstring("Fleet")+hh+adstring("Catobs.out");
   ofstream ofs(u);
   for(y=styr;y<=endyr;y++){
    ofs<<obs_total_catch(y,t)<<endl;
   }
   ofs.close();
 }
 // Output Fleet F at age
 for(t=1;t<=nfleets;t++){
   sprintf(hh,"%i",t);
   adstring u=adstring("Fleet")+hh+adstring("Fatage.out");
   ofstream ofs(u);
  for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<Ffleet(t,y,a)<<" ";
    if(a==nages)  ofs<<Ffleet(t,y,a)<<endl;
   }
  }
 ofs.close();
}
//Output Predicited and Observed Indices
  ofstream ofs15("AggPred.out");
   for(y=styrR;y<=endyr;y++){
    for(t=1;t<=agg_surv_num;t++){
    if(t<agg_surv_num) ofs15<<agg_pred_surv_indices(y,t)<<" ";
    if(t==agg_surv_num) ofs15<<agg_pred_surv_indices(y,t)<<endl;
    }
   }
  ofstream ofs16("AggObs.out");
   for(y=styrR;y<=endyr;y++){
    for(t=1;t<=agg_surv_num;t++){
    if(t<agg_surv_num) ofs16<<agg_obs_surv_indices(y,t)<<" ";
    if(t==agg_surv_num) ofs16<<agg_obs_surv_indices(y,t)<<endl;
    }
   }
//Output Predicited and Observed Age Comp surveys
 ofstream ofs17("ACPred.out");
    for(y=styrR;y<=endyr;y++){
    for(t=1;t<=ac_surv_num;t++){
    if(t<ac_surv_num) ofs17<<ac_pred_surv_indices(y,t)<<" ";
    if(t==ac_surv_num) ofs17<<ac_pred_surv_indices(y,t)<<endl;
    }
  }
 ofstream ofs18("ACObs.out");
   for(y=styrR;y<=endyr;y++){
    for(t=1;t<=ac_surv_num;t++){
    if(t<ac_surv_num) ofs18<<ac_obs_surv_indices(y,t)<<" ";
    if(t==ac_surv_num) ofs18<<ac_obs_surv_indices(y,t)<<endl;
    }
  }
 ofstream ofs19("survacpred.out");
   for(t=1;t<=ac_surv_num;t++){
    for(y=styrR;y<=endyr;y++){
      for(a=1;a<=nages;a++){
       if(a<nages) ofs19<<surv_pred_comps(t,y,a)<<" ";
```

```
                   if(a==nages) ofs19<<surv_pred_comps(t,y,a)<<endl;
          }
       }
     }
     ofstream ofs20("survacobs.out");
       for(t=1;t<=ac_surv_num;t++){
         for(y=styrR;y<=endyr;y++){
           for(a=1;a<=nages;a++){
             if(a<nages) ofs20<<surv_comps(t,y,a)<<" ";
              if(a==nages) ofs20<<surv_comps(t,y,a)<<endl;
         }
       }
     }
     ofstream ofs21("calccomps.out");
       for(t=1;t<=ac_surv_num;t++){
         for(y=styrR;y<=endyr;y++){
           for(a=1;a<=nages;a++){
             if(a<nages) ofs21<<calc_comps(t,y,a)<<" ";
              if(a==nages) ofs21<<calc_comps(t,y,a)<<endl;
         }
       }
     }
  //**********************************************************************************************
  // Effective Sample Sizes - McAllister and Ianelli Method
  //**********************************************************************************************
     // Output Average Effective Sample Size for Catch Age Comps
        sumdo1=0;
       dodo1=0;
      for(t=1;t<=nfleets;t++){
       sprintf(hh,"%i",t);
       adstring u=adstring("Fleet")+hh+adstring("ess.out");
       ofstream ofs(u);
      for(y=styr;y<=endyr;y++){
         sumdo=0;
         dodo=0;
         for(a=1;a<=nages;a++){
            if(obs_age_comp(t,y,a)>=0){
             sumdo+=pred_age_comp(t,y,a)*(1-pred_age_comp(t,y,a));
             dodo+=square(obs_age_comp(t,y,a)-pred_age_comp(t,y,a));
            }
            if(obs_age_comp(t,y,a)<0){
             sumdo=0;
             dodo=0;
            }
         }
               if(sumdo>0 && dodo>0) sumdo1+=sumdo/dodo;
        }
       for(y=styr;y<=endyr;y++){
         if (obs_total_catch(y,t)>=0) dodo1+=1;
        }
       ofs<<sumdo1/dodo1<<endl;
       ofs.close();
      }
  //Output Input Fleet Effective Sample
       for(t=1;t<=nfleets;t++){
         sprintf(hh,"%i",t);
         adstring u=adstring("Fleet")+hh+adstring("obseffss.out");
         ofstream ofs(u);
          for(y=styr;y<=endyr;y++){
            ofs<<ss_age_comp(y,t)<<endl;
          }
        ofs.close();
        }
  //Output Survey Age Comps Average Efficitive Sample Size
      ofstream ofs23("acavgeffss.out");
      for(t=1;t<=ac_surv_num;t++){
       if(use_ac(t)==1){
```

```
    sumdo1=0;
    dodo1=0;
    for(y=styrR;y<=endyr;y++){
      sumdo=0;
      dodo=0;
      for(a=1;a<=nages;a++){
        if(surv_comps(t,y,a)>=0){
         sumdo+=surv_pred_comps(t,y,a)*(1-surv_pred_comps(t,y,a));
         dodo+=square(surv_comps(t,y,a)-surv_pred_comps(t,y,a));
         }
        if(surv_comps(t,y,a)<0){
         sumdo=0;
         dodo=0;
         }
        }
            if(sumdo>0 && dodo>0) sumdo1+=sumdo/dodo;
      }
    for(y=styrR;y<=endyr;y++){
      if (ac_obs_surv_indices(y,t)>=0) dodo1+=1;
      }
    ofs23<<sumdo1/dodo1<<endl;
    }
  if(use_ac(t)==0) ofs23<<"0"<<endl;
  }
 //Observed ac effective sample size
 ofstream ofs231("acobseffss.out");
 for(y=styrR;y<=endyr;y++){
   for(t=1;t<=ac_surv_num;t++){
    if(t<ac_surv_num) ofs231<<ac_ss(y,t)<<" ";
    if(t==ac_surv_num) ofs231<<ac_ss(y,t)<<endl;
   }
 }
// Catch yearly effective sample size
  for(t=1;t<=nfleets;t++){
   sprintf(hh,"%i",t);
   adstring u=adstring("Fleet")+hh+adstring("yreffss.out");
   ofstream ofs(u);
   for(y=styr;y<=endyr;y++){
     sumdo=0;
     dodo=0;
     for(a=1;a<=nages;a++){
       if(obs_age_comp(t,y,a)>=0){
        sumdo+=pred_age_comp(t,y,a)*(1-pred_age_comp(t,y,a));
        dodo+=square(obs_age_comp(t,y,a)-pred_age_comp(t,y,a));
        }
       if(obs_age_comp(t,y,a)<0){
        sumdo=0;
        dodo=0;
        }
       }
     if(sumdo==0 && dodo==0) ofs<<"-1"<<endl;
            if(sumdo>0 && dodo>0) ofs<<sumdo/dodo<<endl;
     }
   ofs.close();
   }

 //Survey Age Comps Yearly Effective Sample Size
 ofstream ofs25("acyreffss.out");
 for(t=1;t<=ac_surv_num;t++){
  if(use_ac(t)==1){
   for(y=styrR;y<=endyr;y++){
     sumdo=0;
     dodo=0;
     for(a=1;a<=nages;a++){
       if(surv_comps(t,y,a)>=0){
        sumdo+=surv_pred_comps(t,y,a)*(1.-surv_pred_comps(t,y,a));
        dodo+=square(surv_comps(t,y,a)-surv_pred_comps(t,y,a));
```

```
            }
          if(surv_comps(t,y,a)<0){
            sumdo+=0;
            dodo+=0;
          }
        }
      if(sumdo==0 && dodo==0) aceffssyr(y,t)=-1;
          if(sumdo>0 && dodo>0) aceffssyr(y,t)=sumdo/dodo;
      }
    }
  if(use_ac(t)==0) aceffssyr(y,t)=0;

  }
    for(y=styrR;y<=endyr;y++){
      for(t=1;t<=ac_surv_num;t++){
       if(t<ac_surv_num) ofs25<<aceffssyr(y,t)<<" ";
       if(t==ac_surv_num) ofs25<<aceffssyr(y,t)<<endl;
      }

  }
//**********************************************************************************************
 // Effective Sample Sizes - Francis (2011) method equation 1.8
 //**********************************************************************************************
// Compute Francis (2011) stage 2 multiplier for multinomial to adjust input Neff
// Francis, R.I.C.C. 2011. Data weighting in statistical fisheries stock assessment models. CJFAS 68: 1124-1138
// Code from ASAP3
// Catch
 Neff_stage2_mult_catch=1;
for (t=1;t<=nfleets;t++){
 mean_age_obs=0.0;
 mean_age_pred=0.0;
 mean_age_pred2=0.0;
 mean_age_resid=0.0;
 for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(obs_age_comp(t,y,a)>=0.){
     mean_age_obs(y)+=obs_age_comp(t,y,a)*a;
     mean_age_pred(y)+=pred_age_comp(t,y,a)*a;
     mean_age_pred2(y)+=pred_age_comp(t,y,a)*a*a;
   }
  }
 }
 mean_age_resid=mean_age_obs-mean_age_pred;
 mean_age_sigma=sqrt(mean_age_pred2-elem_prod(mean_age_pred,mean_age_pred));
 mean_age_n=0.0;
 mean_age_mean=0.0;
 mean_age_m2=0.0;
 for(y=styr;y<=endyr;y++){
  if (obs_total_catch(y,t)>=0.){
     mean_age_x=mean_age_resid(y)*sqrt(ss_age_comp(y,t))/mean_age_sigma(y);
     mean_age_n+= 1.0;
     mean_age_delta=mean_age_x-mean_age_mean;
     mean_age_mean+= mean_age_delta/mean_age_n;
     mean_age_m2+= mean_age_delta*(mean_age_x-mean_age_mean);
  }
 }
 if ((mean_age_n > 0) && (mean_age_m2 > 0)) Neff_stage2_mult_catch(t)=1.0/(mean_age_m2/(mean_age_n-1.0));
}

//Indices
 Neff_stage2_mult_index=1;
for (t=1;t<=ac_surv_num;t++){
 if (use_ac(t)<=0.) Neff_stage2_mult_index(t)=0;
 if (use_ac(t)>=1.) {
    mean_age_obs=0.0;
    mean_age_pred=0.0;
    mean_age_pred2=0.0;
```

```
     mean_age_resid=0.0;
   for(y=styrR;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(surv_comps(t,y,a)>=0.){
       mean_age_obs(y)+=surv_comps(t,y,a)*a;
       mean_age_pred(y)+=surv_pred_comps(t,y,a)*a;
       mean_age_pred2(y)+=surv_pred_comps(t,y,a)*a*a;
      }
     }
    }
    mean_age_resid=mean_age_obs-mean_age_pred;
    mean_age_sigma=sqrt(mean_age_pred2-elem_prod(mean_age_pred,mean_age_pred));
    mean_age_n=0.0;
    mean_age_mean=0.0;
    mean_age_m2=0.0;
    for(y=styrR;y<=endyr;y++){
      if (ac_obs_surv_indices(y,t)>=0.){
        mean_age_x=mean_age_resid(y)*sqrt(ac_ss(y,t))/mean_age_sigma(y);
        mean_age_n+=1.0;
        mean_age_delta=mean_age_x-mean_age_mean;
        mean_age_mean+=mean_age_delta/mean_age_n;
        mean_age_m2+=mean_age_delta*(mean_age_x-mean_age_mean);
      }
    }
    if ((mean_age_n > 0) && (mean_age_m2 > 0)) Neff_stage2_mult_index(t)=1.0/(mean_age_m2/(mean_age_n-1.0));
   }
  }

  ofstream ofs50("Francis.out");
  for(t=1;t<=nfleets;t++) ofs50<<Neff_stage2_mult_catch(t)<<endl;
  for(t=1;t<=ac_surv_num;t++) ofs50<<Neff_stage2_mult_index(t)<<endl;
  ofs50.close();

  //*************************************************************************
  // Compute Standardized Residuals for Total Catch
  //*************************************************************************
  //Residuals
  for(t=1;t<=nfleets;t++){
     sprintf(hh,"%i",t);
     adstring u=adstring("Fleet")+hh+adstring("std_res_C.out");
     ofstream ofs(u);
     sumdo=0;
    for(y=styr;y<=endyr;y++){
      if(obs_total_catch(y,t)<0.) resid_C(y,t)=0;
      if(obs_total_catch(y,t)>=0.){
       resid_C(y,t)=log(obs_total_catch(y,t)+1e-5)-log(pred_total_catch(y,t)+1e-5);
       sumdo+=1;
      }
    }
//Calculate standardized residuals
   for(y=styr;y<=endyr;y++){
     if(obs_total_catch(y,t)>=0.){
       std_resid_C(y,t)=resid_C(y,t)/sqrt(log(square(total_catch_CV(y,t))+1));
     }
     if(obs_total_catch(y,t)<0.) std_resid_C(y,t)=-99999.0;
    }
   for(y=styr;y<=endyr;y++){
    ofs<<std_resid_C(y,t)<<endl;
    }
   ofs.close();
   }
   //Output RMSE for Fleet Catch
   for(t=1;t<=nfleets;t++){
     sprintf(hh,"%i",t);
     adstring u=adstring("Fleet")+hh+adstring("RMSE.out");
     ofstream ofs(u);
    sumdo=0;
```

```
    for(y=styr;y<=endyr;y++){
      if(obs_total_catch(y,t)<0.) resid_C(y,t)=0;
      if(obs_total_catch(y,t)>=0.){
        resid_C(y,t)=log(obs_total_catch(y,t)+1e-5)-log(pred_total_catch(y,t)+1e-5);
        sumdo+=1;
      }
    }
//Calculate standardized residuals
  for(y=styr;y<=endyr;y++){
    if(obs_total_catch(y,t)>=0.){
      std_resid_C(y,t)=resid_C(y,t)/sqrt(log(square(total_catch_CV(y,t))+1));
    }
    if(obs_total_catch(y,t)<0.) std_resid_C(y,t)=0;
  }
// Calculate RMSE
    adds=0;
    for(y=styr;y<=endyr;y++){
      if(obs_total_catch(y,t)>=0.) adds+=square(std_resid_C(y,t));
    }
    ofs<<sqrt(adds/sumdo)<<endl;
    ofs.close();
  }
//***********************************************************************************
// Compute Standardized Residuals for Aggregate indices
//***********************************************************************************
  sumdo=0;
  for(t=1;t<=agg_surv_num;t++){
    if(use_agg(t)==1){
      sumdo=0;
      for(y=styrR;y<=endyr;y++){
        if(agg_obs_surv_indices(y,t)<0.) resid_agg(y,t)=0;
        if(agg_obs_surv_indices(y,t)>=0.){
          resid_agg(y,t)=log(agg_obs_surv_indices(y,t)+1e-5)-log(agg_pred_surv_indices(y,t)+1e-5);
          sumdo+=1;
        }
      }
//Calculate standardized residuals
  for(y=styrR;y<=endyr;y++){
      if(agg_obs_surv_indices(y,t)>=0.){
        std_resid_agg(y,t)=resid_agg(y,t)/sqrt(log(square(agg_surv_CV(y,t)*agg_index_CV_wgt(t))+1));
      }
      if(agg_obs_surv_indices(y,t)<0.) std_resid_agg(y,t)=-99999.0;
  }
// Calculate RMSE
    adds=0;
    for(y=styrR;y<=endyr;y++){
      if(agg_obs_surv_indices(y,t)>=0.) adds+=square(std_resid_agg(y,t));
    }
    RMSE_agg(t)=sqrt(adds/sumdo);
  }
  }
  ofstream ofs28("RMSE_agg.out");
  for(t=1;t<=agg_surv_num;t++){
   ofs28<<RMSE_agg(t)<<endl;
  }

  ofstream ofs29("std_res_agg.out");
   for(y=styrR;y<=endyr;y++){
    for(t=1;t<=agg_surv_num;t++){
     if(t<agg_surv_num) ofs29<<std_resid_agg(y,t)<<" ";
     if(t==agg_surv_num) ofs29<<std_resid_agg(y,t)<<endl;
    }
  }
//***********************************************************************************
// Compute Standardized Residuals for AC Surveys indices
//***********************************************************************************
  sumdo=0;
```

```
  for(t=1;t<=ac_surv_num;t++){
   if(use_ac(t)==1){
   sumdo=0;
   for(y=styrR;y<=endyr;y++){
      if(ac_obs_surv_indices(y,t)<0.) resid_ac(y,t)=0;
      if(ac_obs_surv_indices(y,t)>=0.){
        resid_ac(y,t)=log(ac_obs_surv_indices(y,t)+1e-5)-log(ac_pred_surv_indices(y,t)+1e-5);
        sumdo+=1;
      }
    }
 //Calculate standardized residuals
   for(y=styrR;y<=endyr;y++){
      if(ac_obs_surv_indices(y,t)>=0.){
        std_resid_ac(y,t)=resid_ac(y,t)/sqrt(log(square(ac_surv_CV(y,t)*acsel(t,5))+1));
        }
      if(ac_obs_surv_indices(y,t)<0.) std_resid_ac(y,t)=-99999.0;
    }
// Calculate RMSE
   adds=0;
   for(y=styrR;y<=endyr;y++){
    if(ac_obs_surv_indices(y,t)>=0.) adds+=square(std_resid_ac(y,t));
    }
   RMSE_ac(t)=sqrt(adds/sumdo);
 }
 }
  ofstream ofs30("RMSE_ac.out");
  for(t=1;t<=ac_surv_num;t++){
  ofs30<<RMSE_ac(t)<<endl;
  }
 ofstream ofs31("std_res_ac.out");
 for(y=styrR;y<=endyr;y++){
  for(t=1;t<=ac_surv_num;t++){
  if(t<ac_surv_num) ofs31<<std_resid_ac(y,t)<<" ";
  if(t==ac_surv_num) ofs31<<std_resid_ac(y,t)<<endl;
  }
 }
//*********************************************************************************************
//   Standardized Residuals for Catch Age Comp
//*********************************************************************************************
  for(t=1;t<=nfleets;t++){
   sprintf(hh,"%i",t);
   adstring u=adstring("Fleet")+hh+adstring("std_res_CAA.out");
   ofstream ofs(u);
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(obs_age_comp(t,y,a)>=0.){
       std_resid_CAA(t,y,a)=((obs_age_comp(t,y,a)+1e-5)-(pred_age_comp(t,y,a)+1e-5))/sqrt(((pred_age_comp(t,y,a)+1e-5)*(1-
(pred_age_comp(t,y,a)+1e-5)))/ss_age_comp(y,t));
     }
     if(obs_age_comp(t,y,a)<0.) std_resid_CAA(t,y,a)=0.;
     if(a<nages) ofs<<std_resid_CAA(t,y,a)<<" ";
     if(a==nages) ofs<<std_resid_CAA(t,y,a)<<endl;
    }
   }
 ofs.close();
 }
//*********************************************************************************************
//   Standardized residuals for Surveys Age Comp
//*********************************************************************************************
 ofstream ofs33("std_res_survey_agecomp.out");
  for(t=1;t<=ac_surv_num;t++){
   if(use_ac(t)==1){
   for(y=styrR;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(surv_comps(t,y,a)>=0.){
       std_resid_surv_comps(t,y,a)=((surv_comps(t,y,a)+1e-5)-(surv_pred_comps(t,y,a)+1e-5))/sqrt(((surv_pred_comps(t,y,a)+1e-5)*(1-
(surv_pred_comps(t,y,a)+1e-5)))/ac_ss(y,t));
```

```
       }
     if(surv_comps(t,y,a)<0.) std_resid_surv_comps(t,y,a)=0.;
     if(a<nages) ofs33<<std_resid_surv_comps(t,y,a)<<" ";
     if(a==nages) ofs33<<std_resid_surv_comps(t,y,a)<<endl;
    }
   }
  }
 }

//*************************************************************************************************
// Output Catch Selectivity Parameters
//*************************************************************************************************
 ofstream ofs34("catsel.out");
  d=nRparms+nFparms+1;
   for(t=1;t<=fltwogom;t++){
    if(flgom_a_con1>0){
      ofs34<<flgom_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/flgom_a(t))<<endl;
      d+=1;
      ofs34<<flgom_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/flgom_b(t))<<endl;
      d+=1;
    }
  }
  for(t=1;t<=fltwolog;t++){
   if(fllog_a_con1>0){
      ofs34<<fllog_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/fllog_a(t))<<endl;
      d+=1;
      ofs34<<fllog_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/fllog_b(t))<<endl;
      d+=1;
    }
  }
   for(t=1;t<=fltwogam;t++){
    if(flgam_a_con1>0){
      ofs34<<flgam_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/flgam_a(t))<<endl;
      d+=1;
      ofs34<<flgam_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/flgam_b(t))<<endl;
      d+=1;
    }
  }
   if(flthom_a_con1>0){
     for(t=1;t<=flthree;t++){
      ofs34<<flthom_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/flthom_a(t))<<endl;
      d+=1;
      ofs34<<flthom_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/flthom_b(t))<<endl;
      d+=1;
      ofs34<<flthom_c(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/flthom_c(t))<<endl;
      d+=1;
     }
   }
   if(fldlog_a_con1>0){
    for(t=1;t<=flfour;t++){
      ofs34<<fldlog_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/fldlog_a(t))<<endl;
      d+=1;
      ofs34<<fldlog_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/fldlog_b(t))<<endl;
      d+=1;
      ofs34<<fldlog_c(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/fldlog_c(t))<<endl;
      d+=1;
      ofs34<<fldlog_d(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/fldlog_d(t))<<endl;
      d+=1;
    }
  }
 ofstream ofs35("surveysel.out");
  for(t=1;t<=actwogom;t++){
   if(acgom_a_con1>0){
      ofs35<<acgom_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acgom_a(t))<<endl;
      d+=1;
      ofs35<<acgom_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acgom_b(t))<<endl;
      d+=1;
```

```
      }
    }
   for(t=1;t<=actwolog;t++){
    if(aclog_a_con1>0){
      ofs35<<aclog_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/aclog_a(t))<<endl;
      d+=1;
      ofs35<<aclog_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/aclog_b(t))<<endl;
      d+=1;
    }
   }
   for(t=1;t<=actwogam;t++){
    if(acgam_a_con1>0){
      ofs35<<acgam_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acgam_a(t))<<endl;
      d+=1;
      ofs35<<acgam_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acgam_b(t))<<endl;
      d+=1;
    }
   }
   if(acthom_a_con1>0){
     for(t=1;t<=acthree;t++){
      ofs35<<acthom_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acthom_a(t))<<endl;
      d+=1;
      ofs35<<acthom_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acthom_b(t))<<endl;
      d+=1;
      ofs35<<acthom_c(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acthom_c(t))<<endl;
      d+=1;
     }
   }

   if(user>0){
   for(t=1;t<=user;t++){
    ofs35<<userparms(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/userparms(t))<<endl;
    d+=1;
   }
  }
 // Output Fleet Catch Selecitivites
 for(t=1;t<=nfleets;t++){
   sprintf(hh,"%i",t);
   adstring u=adstring("Fleet")+hh+adstring("Select.out");
   ofstream ofs(u);
  for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<selbyfleet(t,y,a)<<" ";
    if(a==nages) ofs<<selbyfleet(t,y,a)<<endl;
   }
  }
  ofs.close();
 }
//*******************************************************************************************
// Output Female Spawning Stock Biomass-At-Age
//*******************************************************************************************
 ofstream ofs361("SSBatage.out");
  for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    sumdo1=0;
    if (rivard==1) sumdo1=N(y,a)*mfexp(-1.*(pF*Fcomb(y,a)+pM*M(y,a)))*fsex(a)*fmat(y,a)*rwgts(y,a);
    if (rivard==0) sumdo1+=N(y,a)*mfexp(-1.*(pF*Fcomb(y,a)+pM*M(y,a)))*fsex(a)*fmat(y,a)*ssbwgt(y,a);
    if (a<nages) ofs361<<sumdo1/1000<<" "; //Metric tons
    if (a==nages) ofs361<<sumdo1/1000<<endl;
   }
  }
//*******************************************************************************************
// Output Stock-Recruit Values
//*******************************************************************************************
  ofstream ofs362("predSR.out");
  sumdo=(max(SSB)*1.05)/100;
  sumdo1=0;
```

```
      }
    }
   for(t=1;t<=actwolog;t++){
    if(aclog_a_con1>0){
      ofs35<<aclog_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/aclog_a(t))<<endl;
      d+=1;
      ofs35<<aclog_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/aclog_b(t))<<endl;
      d+=1;
    }
   }
   for(t=1;t<=actwogam;t++){
    if(acgam_a_con1>0){
      ofs35<<acgam_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acgam_a(t))<<endl;
      d+=1;
      ofs35<<acgam_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acgam_b(t))<<endl;
      d+=1;
    }
   }
   if(acthom_a_con1>0){
     for(t=1;t<=acthree;t++){
      ofs35<<acthom_a(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acthom_a(t))<<endl;
      d+=1;
      ofs35<<acthom_b(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acthom_b(t))<<endl;
      d+=1;
      ofs35<<acthom_c(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/acthom_c(t))<<endl;
      d+=1;
     }
   }

   if(user>0){
   for(t=1;t<=user;t++){
    ofs35<<userparms(t)<<" "<<sigma(d,1)<<" "<<fabs(sigma(d,1)/userparms(t))<<endl;
    d+=1;
   }
  }
 // Output Fleet Catch Selecitivites
 for(t=1;t<=nfleets;t++){
   sprintf(hh,"%i",t);
   adstring u=adstring("Fleet")+hh+adstring("Select.out");
   ofstream ofs(u);
  for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<selbyfleet(t,y,a)<<" ";
    if(a==nages) ofs<<selbyfleet(t,y,a)<<endl;
   }
  }
  ofs.close();
 }
//*******************************************************************************************
// Output Female Spawning Stock Biomass-At-Age
//*******************************************************************************************
 ofstream ofs361("SSBatage.out");
  for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    sumdo1=0;
    if (rivard==1) sumdo1=N(y,a)*mfexp(-1.*(pF*Fcomb(y,a)+pM*M(y,a)))*fsex(a)*fmat(y,a)*rwgts(y,a);
    if (rivard==0) sumdo1+=N(y,a)*mfexp(-1.*(pF*Fcomb(y,a)+pM*M(y,a)))*fsex(a)*fmat(y,a)*ssbwgt(y,a);
    if (a<nages) ofs361<<sumdo1/1000<<" "; //Metric tons
    if (a==nages) ofs361<<sumdo1/1000<<endl;
   }
  }
//*******************************************************************************************
// Output Stock-Recruit Values
//*******************************************************************************************
  ofstream ofs362("predSR.out");
  sumdo=(max(SSB)*1.05)/100;
  sumdo1=0;
```

```
  for(y=1;y<=100;y++){
    if(y==1) sumdo1=1;
    if(y>1) sumdo1=sumdo1+sumdo;
    if(srmodel==1) ofs362<<"1"<<" "<<"0"<<endl;
    if(srmodel==2) ofs362<<mfexp(log(BH_a)+log(sumdo1)-log(1+sumdo1/BH_b))<<" "<<sumdo1<<endl;
    if(srmodel==3) ofs362<<mfexp(log(r_a)+log(sumdo1)-sumdo1/r_b)<<" "<<sumdo1<<endl;
    if(srmodel==4) ofs362<<mfexp(log(shep_a)+log(sumdo1)-log(1+pow(sumdo1/shep_b,shep_c)))<<" "<<sumdo1<<endl;
  }
  ofstream ofs363("res_SR.out");
  for(y=styr;y<endyr;y++){
    if(srmodel==1) ofs363<<"0"<<endl;
    if(srmodel==2) ofs363<<log(R(y+1))-(log(BH_a)+log(SSB(y))-log(1+SSB(y)/BH_b))<<endl;
    if(srmodel==3) ofs363<<log(R(y+1))-(log(r_a)+log(SSB(y))-SSB(y)/r_b)<<endl;
    if(srmodel==4) ofs363<<log(R(y+1))-(log(shep_a)+log(SSB(y))-log(1+pow(SSB(y)/shep_b,shep_c)))<<endl;
  }
  ofstream ofs364("SRparms.out");
    if(srmodel==1){
      ofs364<<"1"<<" "<<"0"<<endl;
      ofs364<<"1"<<" "<<"0"<<endl;
    }
    if(srmodel==2){
      ofs364<<BH_a<<" "<<sigma(n_parms-1,1)<<endl;
      ofs364<<BH_b<<" "<<sigma(n_parms,1)<<endl;
    }
    if(srmodel==3){
      ofs364<<r_a<<" "<<sigma(n_parms-1,1)<<endl;
      ofs364<<r_b<<" "<<sigma(n_parms,1)<<endl;
    }
    if(srmodel==4){
      ofs364<<shep_a<<" "<<sigma(n_parms-2,1)<<endl;
      ofs364<<shep_b<<" "<<sigma(n_parms-1,1)<<endl;
      ofs364<<shep_c<<" "<<sigma(n_parms,1)<<endl;
    }
  ofstream ofs365("recvar.out");
    if(biascor==0)  ofs365<<"0"<<endl;
    if(biascor==1)  ofs365<<recvar<<endl;
  ofs365.close();

//***********************************************************************************************
// Reference Points
//***********************************************************************************************
  //!!!!!!!!!!!!!!!!!!!!!    Yield Per Recruit
  ofstream ofs37("ypr.out");
  FF=calcincr;
  maxs=0;
  maxer=0;
  sumdo=0;
  sumdo1=0;
  dodo1=0;
  cnter=nfs/int(ceil(maxF/calcincr));
  cnter2=0;
  for(a=1;a<=nages;a++){
    if(Fcomb(Selyear,a)>=dodo1) dodo1=Fcomb(Selyear,a);
  }
  for(looper=1;looper<=nfs;looper++){
    for(a=1;a<=nages;a++){
      partialF(a)=FF*Fcomb(Selyear,a)/dodo1;
    }
  for(a=1;a<=nages;a++){
    Zypr(a)=partialF(a)+M(Myear,a);
  }
    for(a=1;a<=oldest;a++){
      if(a==1) psb(a)=1;
      if(a>1){
      if(a<=nages) psb(a)=mfexp(-1.*Zypr(a-1));
      if(a>nages) psb(a)=mfexp(-1.*Zypr(nages));
      }
```

```
    }
  //Cumulative product
  for(a=1;a<=oldest;a++){
    if(a==1) psb(a)=psb(a);
     if(a>1) psb(a)=psb(a)*psb(a-1);
  }
  sumdo1=0;
  for(a=1;a<=oldest;a++){
     if(a<=nages) sumdo1+=partialF(a)/Zypr(a)*(1-mfexp(-Zypr(a)))*psb(a)*cwgt(Wgtyear,a)/1000;
     if(a>nages)  sumdo1+=partialF(nages)/Zypr(nages)*(1-mfexp(-Zypr(nages)))*psb(a)*cwgt(Wgtyear,nages)/1000; //change to metric tons
  }
  //get Ymax and Fmax
   if(sumdo1>=maxs){
      maxs=sumdo1;
      maxer=FF;
   }
  if(looper==2) origslope=sumdo1/FF*0.10;
  cnter2+=1;
  if(looper==1) ofs37<<0<<" "<<0<<endl;
  if(cnter2==cnter){
   ofs37<<value(FF)<<" "<<sumdo1<<endl;
   cnter2=0;
  }
  FF+=calcincr;
}
//YPR Reference Points
 ofstream ofs38("yprref.out");
 ofs38<<maxer<<" "<<maxs<<endl;
//F0.1
 sumdo=0;
 sumdo1=0;
 FF=maxer;
 diff=FF/2;
 ok=0;
 dodo=0.000000001;
 dodo1=0;
 for(a=1;a<=nages;a++){
    if(Fcomb(Selyear,a)>=dodo1) dodo1=Fcomb(Selyear,a);
   }
 while(ok==0){
  //Calculate average F ratio for each fleet
   for(a=1;a<=nages;a++){
    partialF(a)=FF*Fcomb(Selyear,a)/dodo1;
   }

   for(a=1;a<=nages;a++){
   sumdo=0;
    Zypr(a)=partialF(a)+M(Myear,a);
   }

   for(a=1;a<=oldest;a++){
    if(a==1) psb(a)=1;
    if(a>1){
     if(a<=nages) psb(a)=mfexp(-1.*Zypr(a-1));
     if(a>nages) psb(a)=mfexp(-1.*Zypr(nages));
    }
   }
  for(a=1;a<=oldest;a++){
   if(a==1) psb(a)=psb(a);
    if(a>1) psb(a)=psb(a)*psb(a-1);
  }
  sumdo1=0;
  for(a=1;a<=oldest;a++){
    sumdo=0;
    if(a<=nages) sumdo1+=partialF(a)/Zypr(a)*(1-mfexp(-Zypr(a)))*psb(a)*cwgt(Wgtyear,a)/1000;
    if(a>nages)  sumdo1+=partialF(nages)/Zypr(nages)*(1-mfexp(-Zypr(nages)))*psb(a)*cwgt(Wgtyear,nages)/1000;//metric tons
  }
```

```
    dd1=sumdo1;
    //Calculate average F ratio for each fleet
    for(a=1;a<=nages;a++){
     partialF(a)=(FF+calcincr)*Fcomb(Selyear,a)/dodo1;
     }

    for(a=1;a<=nages;a++){
      Zypr(a)=partialF(a)+M(Myear,a);
     }
    for(a=1;a<=oldest;a++){
      if(a==1) psb(a)=1;
      if(a>1){
       if(a<=nages) psb(a)=mfexp(-1.*Zypr(a-1));
       if(a>nages) psb(a)=mfexp(-1.*Zypr(nages));
      }
    }
    for(a=1;a<=oldest;a++){
      if(a==1) psb(a)=psb(a);
      if(a>1) psb(a)=psb(a)*psb(a-1);
     }
    sumdo1=0;
    for(a=1;a<=oldest;a++){
      sumdo=0;
      if(a<=nages) sumdo1+=partialF(a)/Zypr(a)*(1-mfexp(-Zypr(a)))*psb(a)*cwgt(Wgtyear,a)/1000;
      if(a>nages)  sumdo1+=partialF(nages)/Zypr(nages)*(1-mfexp(-Zypr(nages)))*psb(a)*cwgt(Wgtyear,nages)/1000;
     }
    dd2=sumdo1;
    slope=(dd2-dd1)/((FF+calcincr)-FF);
    if(fabs(origslope-slope)<=dodo) ok=1;
    if(ok==0){
      if(slope>origslope) FF=FF+diff;
           if(slope<origslope) FF=FF-diff;
            diff=diff/2;
     }
    }
   ofs38<<FF<<" "<<sumdo1<<endl;
   ofs38.close();

//!!!!!!!!!!!!!!!!!!  Spawning Stock Biomass Per Recruit !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
   ofstream ofs39("spr.out");
   //Calculate SPR at F=zero
    sumdo=0;
    sumdo1=0;
    for(a=1;a<=nages;a++){
      Zypr(a)=M(Myear,a);
     }
    for(a=1;a<=oldest;a++){
      if(a==1) psb(a)=1;
      if(a>1){
       if(a<=nages) psb(a)=mfexp(-1.*Zypr(a-1));
       if(a>nages) psb(a)=mfexp(-1.*Zypr(nages));
      }
     }
    for(a=1;a<=oldest;a++){
      if(a==1) psb(a)=psb(a);
      if(a>1) psb(a)=psb(a)*psb(a-1);
     }
    for(a=1;a<=nages;a++){
      Zypr(a)=pM*M(Myear,a);
     }
    maxSPR=0;
    for(a=1;a<=oldest;a++){
     if(rivard==0){
      if(a<=nages) maxSPR+=psb(a)*mfexp(-Zypr(a))*ssbwgt(Wgtyear,a)/1000*fmat(Matyear,a);
      if(a>nages)  maxSPR+=psb(a)*mfexp(-Zypr(nages))*ssbwgt(Wgtyear,nages)/1000*fmat(Matyear,nages);
     }
     if(rivard==1){
```

```
    dd1=sumdo1;
    //Calculate average F ratio for each fleet
    for(a=1;a<=nages;a++){
     partialF(a)=(FF+calcincr)*Fcomb(Selyear,a)/dodo1;
     }

    for(a=1;a<=nages;a++){
      Zypr(a)=partialF(a)+M(Myear,a);
     }
    for(a=1;a<=oldest;a++){
      if(a==1) psb(a)=1;
      if(a>1){
       if(a<=nages) psb(a)=mfexp(-1.*Zypr(a-1));
       if(a>nages) psb(a)=mfexp(-1.*Zypr(nages));
      }
    }
    for(a=1;a<=oldest;a++){
      if(a==1) psb(a)=psb(a);
      if(a>1) psb(a)=psb(a)*psb(a-1);
     }
    sumdo1=0;
    for(a=1;a<=oldest;a++){
      sumdo=0;
      if(a<=nages) sumdo1+=partialF(a)/Zypr(a)*(1-mfexp(-Zypr(a)))*psb(a)*cwgt(Wgtyear,a)/1000;
      if(a>nages)  sumdo1+=partialF(nages)/Zypr(nages)*(1-mfexp(-Zypr(nages)))*psb(a)*cwgt(Wgtyear,nages)/1000;
     }
    dd2=sumdo1;
    slope=(dd2-dd1)/((FF+calcincr)-FF);
    if(fabs(origslope-slope)<=dodo) ok=1;
    if(ok==0){
      if(slope>origslope) FF=FF+diff;
           if(slope<origslope) FF=FF-diff;
            diff=diff/2;
     }
    }
   ofs38<<FF<<" "<<sumdo1<<endl;
   ofs38.close();

//!!!!!!!!!!!!!!!!!!  Spawning Stock Biomass Per Recruit !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
   ofstream ofs39("spr.out");
   //Calculate SPR at F=zero
    sumdo=0;
    sumdo1=0;
    for(a=1;a<=nages;a++){
      Zypr(a)=M(Myear,a);
     }
    for(a=1;a<=oldest;a++){
      if(a==1) psb(a)=1;
      if(a>1){
       if(a<=nages) psb(a)=mfexp(-1.*Zypr(a-1));
       if(a>nages) psb(a)=mfexp(-1.*Zypr(nages));
      }
     }
    for(a=1;a<=oldest;a++){
      if(a==1) psb(a)=psb(a);
      if(a>1) psb(a)=psb(a)*psb(a-1);
     }
    for(a=1;a<=nages;a++){
      Zypr(a)=pM*M(Myear,a);
     }
    maxSPR=0;
    for(a=1;a<=oldest;a++){
     if(rivard==0){
      if(a<=nages) maxSPR+=psb(a)*mfexp(-Zypr(a))*ssbwgt(Wgtyear,a)/1000*fmat(Matyear,a);
      if(a>nages)  maxSPR+=psb(a)*mfexp(-Zypr(nages))*ssbwgt(Wgtyear,nages)/1000*fmat(Matyear,nages);
     }
     if(rivard==1){
```

```
    if(a<=nages) maxSPR+=psb(a)*mfexp(-Zypr(a))*rwgts(Wgtyear,a)/1000*fmat(Matyear,a);
    if(a>nages)  maxSPR+=psb(a)*mfexp(-Zypr(nages))*rwgts(Wgtyear,nages)/1000*fmat(Matyear,nages);
  }
 }
// Calc SPR for F>0
 FF=calcincr;
 maxs=0;
 maxer=0;
 sumdo=0;
 sumdo1=0;
 cnter=nfs/int(ceil(maxF/calcincr));
 cnter2=0;
 dodo1=0;
 for(a=1;a<=nages;a++){
    if(Fcomb(Selyear,a)>=dodo1) dodo1=Fcomb(Selyear,a);
   }
 for(looper=1;looper<=nfs;looper++){
  for(a=1;a<=nages;a++){
   partialF(a)=FF*Fcomb(Selyear,a)/dodo1;
   }
  for(a=1;a<=nages;a++){
   Zypr(a)=partialF(a)+M(Myear,a);
   }
  for(a=1;a<=oldest;a++){
    if(a==1) psb(a)=1;
    if(a>1){
    if(a<=nages) psb(a)=mfexp(-1.*Zypr(a-1));
    if(a>nages) psb(a)=mfexp(-1.*Zypr(nages));
    }
  }
  for(a=1;a<=oldest;a++){
    if(a==1) psb(a)=psb(a);
    if(a>1) psb(a)=psb(a)*psb(a-1);
   }
  for(a=1;a<=nages;a++){
   partialF(a)=pF*FF*Fcomb(Selyear,a)/dodo1;
   }
  for(a=1;a<=nages;a++){
   Zypr(a)=partialF(a)+pM*M(Myear,a);
   }
  sumdo1=0;
  for(a=1;a<=oldest;a++){
   if(rivard==0){
    if(a<=nages) sumdo1+=psb(a)*mfexp(-Zypr(a))*ssbwgt(Wgtyear,a)/1000*fmat(Matyear,a);
    if(a>nages)  sumdo1+=psb(a)*mfexp(-Zypr(nages))*ssbwgt(Wgtyear,nages)/1000*fmat(Matyear,nages);
   }
   if(rivard==1){
    if(a<=nages) sumdo1+=psb(a)*mfexp(-Zypr(a))*rwgts(Wgtyear,a)/1000*fmat(Matyear,a);
    if(a>nages)  sumdo1+=psb(a)*mfexp(-Zypr(nages))*rwgts(Wgtyear,nages)/1000*fmat(Matyear,nages);
   }
  }
 if(looper==1) ofs39<<0<<" "<<maxSPR<<" "<<maxSPR/maxSPR*100<<endl;
 cnter2+=1;
 if(cnter2==cnter){
   ofs39<<value(FF)<<" "<<sumdo1<<" "<<sumdo1/maxSPR*100<<endl;
   cnter2=0;
 }
FF+=calcincr;
 }
 ofs39.close();

// Find F at maxSPR
 sumdo=0;
 sumdo1=0;
 FF=0.5;
 diff=FF/2;
 ok=0;
```

```
    dodo=0.00001;
     dodo1=0;
    for(a=1;a<=nages;a++){
      if(Fcomb(Selyear,a)>=dodo1) dodo1=Fcomb(Selyear,a);
      }
    while(ok==0){
      for(a=1;a<=nages;a++){
      partialF(a)=FF*Fcomb(Selyear,a)/dodo1;
      }
      for(a=1;a<=nages;a++){
       Zypr(a)=partialF(a)+M(Myear,a);
      }
      for(a=1;a<=oldest;a++){
       if(a==1) psb(a)=1;
       if(a>1){
        if(a<=nages) psb(a)=mfexp(-1.*Zypr(a-1));
        if(a>nages) psb(a)=mfexp(-1.*Zypr(nages));
       }
      }
      for(a=1;a<=oldest;a++){
       if(a==1) psb(a)=psb(a);
       if(a>1) psb(a)=psb(a)*psb(a-1);
      }
      for(a=1;a<=nages;a++){
       partialF(a)=pF*FF*Fcomb(Selyear,a)/dodo1;
       }
      for(a=1;a<=nages;a++){
       Zypr(a)=partialF(a)+pM*M(Myear,a);
      }
     sumdo1=0;
     for(a=1;a<=oldest;a++){
      if(rivard==0){
       if(a<=nages) sumdo1+=psb(a)*mfexp(-Zypr(a))*ssbwgt(Wgtyear,a)/1000*fmat(Matyear,a);
       if(a>nages)  sumdo1+=psb(a)*mfexp(-Zypr(nages))*ssbwgt(Wgtyear,nages)/1000*fmat(Matyear,nages);
      }
      if(rivard==1){
       if(a<=nages) sumdo1+=psb(a)*mfexp(-Zypr(a))*rwgts(Wgtyear,a)/1000*fmat(Matyear,a);
       if(a>nages)  sumdo1+=psb(a)*mfexp(-Zypr(nages))*rwgts(Wgtyear,nages)/1000*fmat(Matyear,nages);
      }
      }
     dd1=sumdo1/maxSPR*100;
     if(fabs(pspr-dd1)<=dodo) ok=1;
     if(ok==0){
      if(dd1>pspr) FF=FF+diff;
            if(dd1<pspr) FF=FF-diff;
             diff=diff/2;
     }
    } //ok
    ofstream ofs40("sprref.out");
    ofs40<<pspr<<" "<<FF<<" "<<sumdo1<<endl;
    ofs40.close();

//!!!!!!!!!!!!!!!!!!!!!!!!!!!!   Production Model  !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
 ofstream ofs42("Production.out");
// Calculate Spawning Stock, Yield and Recruits At Equilibrium
   sumdo=0;
   sumdo1=0;
   maxs=0;
   ssbmsy=0;
   fmsy=0;
   msy=0;
   pgroup=0;
    dodo1=0;
    for(a=1;a<=nages;a++){
      if(Fcomb(Selyear,a)>=dodo1) dodo1=Fcomb(Selyear,a);
      }
    for(looper=1;looper<=nfs;looper++){
```

```
  if(looper==1) FF=0;
  if(looper>1) FF+=calcincr;
 //CAlculate SSB
  for(a=1;a<=nages;a++){
   partialF(a)=FF*Fcomb(Selyear,a)/dodo1;
   }
  for(a=1;a<=nages;a++){
    Zypr(a)=partialF(a)+M(Myear,a);
   }
  for(a=1;a<=oldest;a++){
    if(a==1) psb(a)=1;
    if(a>1){
    if(a<=nages) psb(a)=mfexp(-1.*Zypr(a-1));
    if(a>nages) psb(a)=mfexp(-1.*Zypr(nages));
    }
 }
 for(a=1;a<=oldest;a++){
  if(a==1) psb(a)=psb(a);
  if(a>1) psb(a)=psb(a)*psb(a-1);
 }
  for(a=1;a<=nages;a++){
   partialF(a)=pF*FF*Fcomb(Selyear,a)/dodo1;
   }
  for(a=1;a<=nages;a++){
    Zypr(a)=partialF(a)+pM*M(Myear,a);
   }
 sumdo1=0;
 for(a=1;a<=oldest;a++){
  if(rivard==0){
   if(a<=nages) sumdo1+=psb(a)*mfexp(-Zypr(a))*(ssbwgt(Wgtyear,a)/1000)*fmat(Matyear,a);
   if(a>nages)  sumdo1+=psb(a)*mfexp(-Zypr(nages))*(ssbwgt(Wgtyear,nages)/1000)*fmat(Matyear,nages);
  }
  if(rivard==1){
   if(a<=nages) sumdo1+=psb(a)*mfexp(-Zypr(a))*(rwgts(Wgtyear,a)/1000)*fmat(Matyear,a);
   if(a>nages)  sumdo1+=psb(a)*mfexp(-Zypr(nages))*(rwgts(Wgtyear,nages)/1000)*fmat(Matyear,nages);
  }
 }
 dd1=sumdo1;//B/R
 //Y/R
  for(a=1;a<=nages;a++){
   partialF(a)=FF*Fcomb(Selyear,a)/dodo1;
   }
  for(a=1;a<=nages;a++){
    Zypr(a)=partialF(a)+M(Myear,a);
   }
  for(a=1;a<=oldest;a++){
    if(a==1) psb(a)=1;
    if(a>1){
    if(a<=nages) psb(a)=mfexp(-1.*Zypr(a-1));
    if(a>nages) psb(a)=mfexp(-1.*Zypr(nages));
    }
 }
 for(a=1;a<=oldest;a++){
  if(a==1) psb(a)=psb(a);
  if(a>1) psb(a)=psb(a)*psb(a-1);
 }
 sumdo1=0;
 for(a=1;a<=oldest;a++){
  if(a<=nages) sumdo1+=partialF(a)/Zypr(a)*(1-mfexp(-Zypr(a)))*psb(a)*(cwgt(Wgtyear,a)/1000);
  if(a>nages)  sumdo1+=partialF(nages)/Zypr(nages)*(1-mfexp(-Zypr(nages)))*psb(a)*(cwgt(Wgtyear,nages)/1000);
 }
 dd2=sumdo1;//Y/R
 if(srmodel==1){
  ofs42<<"0"<<" "<<"0"<<" "<<"0"<<" "<<"0"<<endl;
  }
 if(srmodel==2){
  maxer =BH_b*(BH_a*dd1-1);//B
```

```
    cl=maxer/dd1; //R
    pgroup=cl*dd2;//Y
    if(pgroup>=msy){
       msy=pgroup;
       fmsy=FF;
       ssbmsy=maxer;
     }
    if(maxer>=0){
      ofs42<<FF<<" "<<maxer<<" "<<cl<<" "<<pgroup<<endl;
     }
   }
  if(srmodel==3){
   maxer =log(r_a*dd1)*r_b;//B
   cl=maxer/dd1; //R
   pgroup=cl*dd2;//Y
    if(pgroup>=msy){
      msy=pgroup;
      fmsy=FF;
      ssbmsy=maxer;
     }
    if(maxer>=0){
      ofs42<<FF<<" "<<maxer<<" "<<cl<<" "<<pgroup<<endl;
     }
   }
  if(srmodel==4){
   maxer =shep_b*pow((shep_a*dd1-1),1./shep_c);//B
   cl=maxer/dd1; //R
   pgroup=cl*dd2;//Y
    if(pgroup>=msy){
      msy=pgroup;
      fmsy=FF;
      ssbmsy=maxer;
     }
    if(maxer>=0){
      ofs42<<FF<<" "<<maxer<<" "<<cl<<" "<<pgroup<<endl;
     }
   }
 }//For looper
ofs42.close();

/// Output Fmsy
 ofstream ofs41("Fmsy.out");
 if(srmodel>1) ofs41<<fmsy<<" "<<ssbmsy<<" "<<msy<<" "<<"99"<<endl;
 if(srmodel==1) ofs41<<"0"<<" "<<"0"<<" "<<"0"<<" "<<"99"<<endl;
 ofs41.close();
```

Appendix B7. Plots of SCA model output

Figure 1. Plots of observed and predicted catch proportions-at-age by year for each fleet.

Figure 1 cont.

Fleet 3 Catch Age Composition By Year
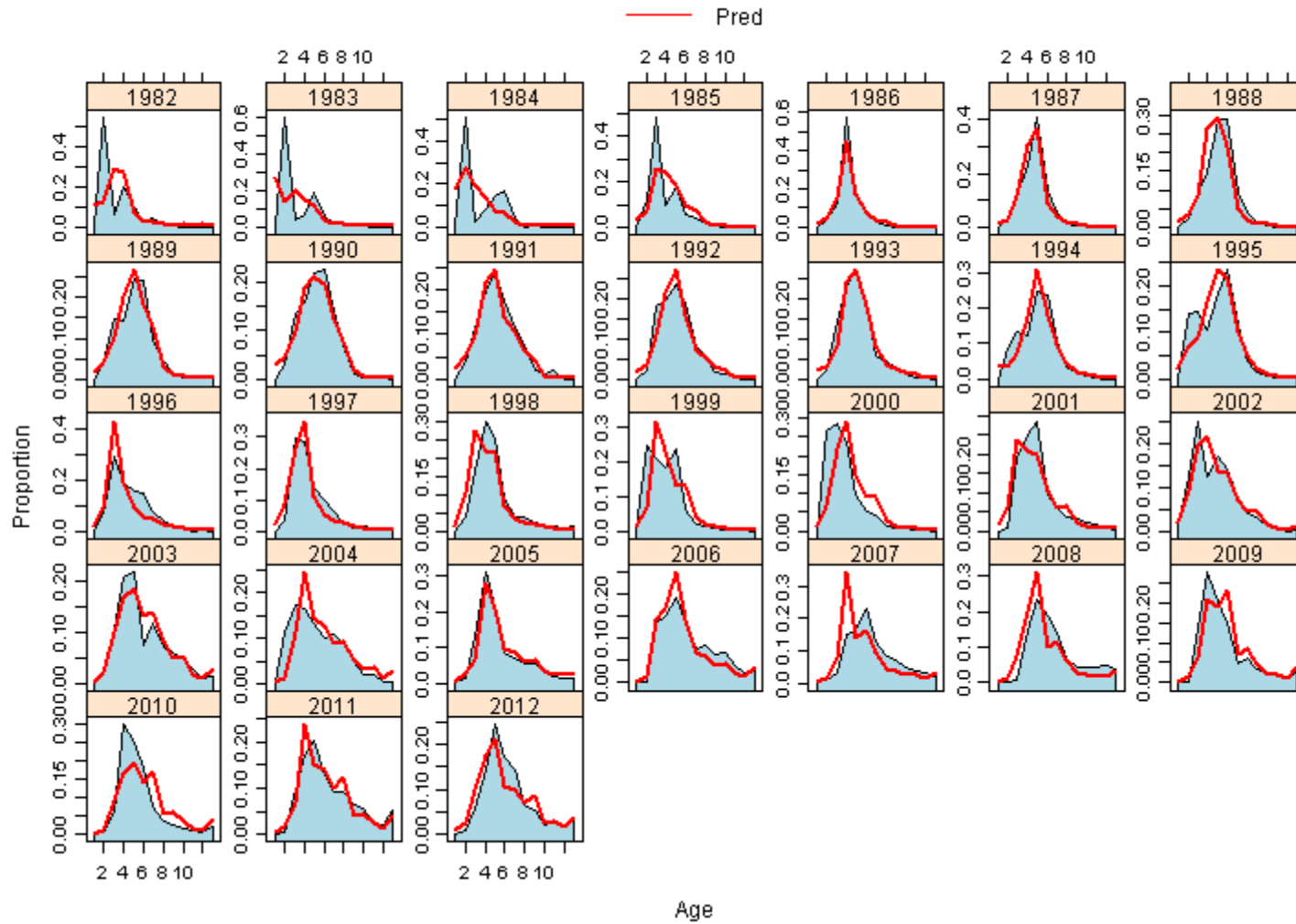
Figure 1 cont.
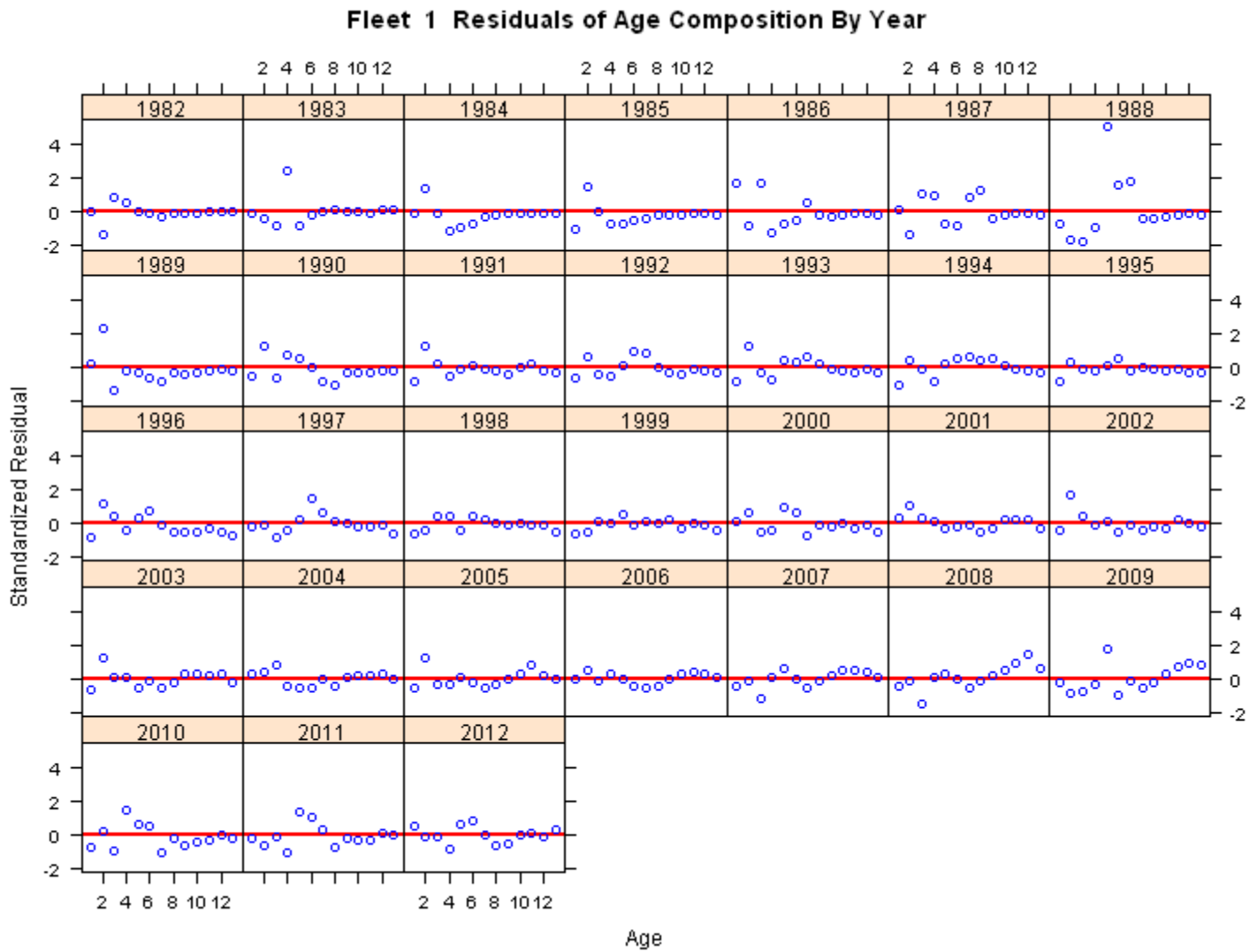
Figure 2. Standardized residuals of catch proportions-at-age by year for each fleet.

Fleet 2 Residuals of Age Composition By Year
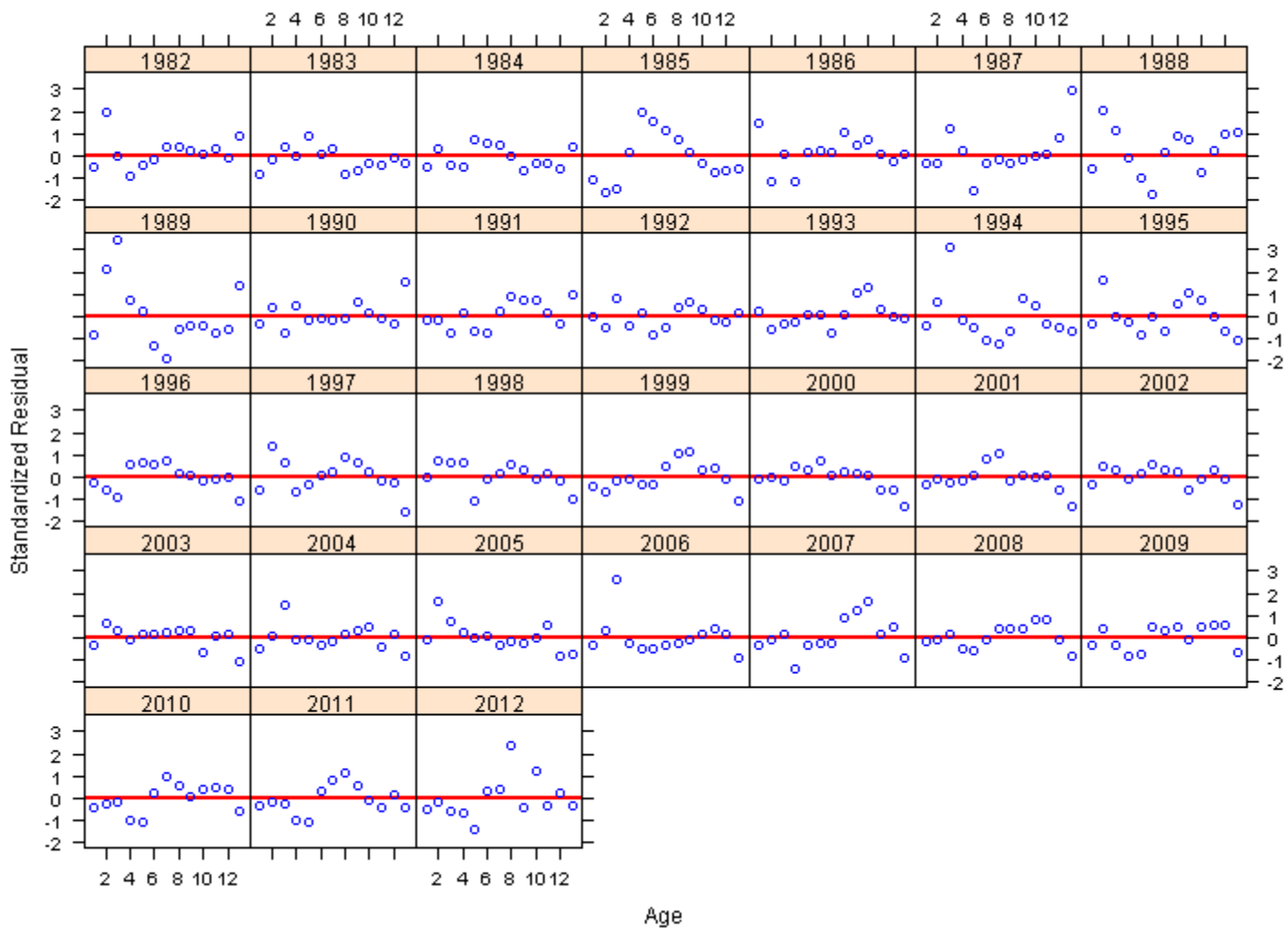
Figure 2 cont.

Fleet 3 Residuals of Age Composition By Year

Figure 2 cont.

Fleet 1 Catch Age Composition By Age
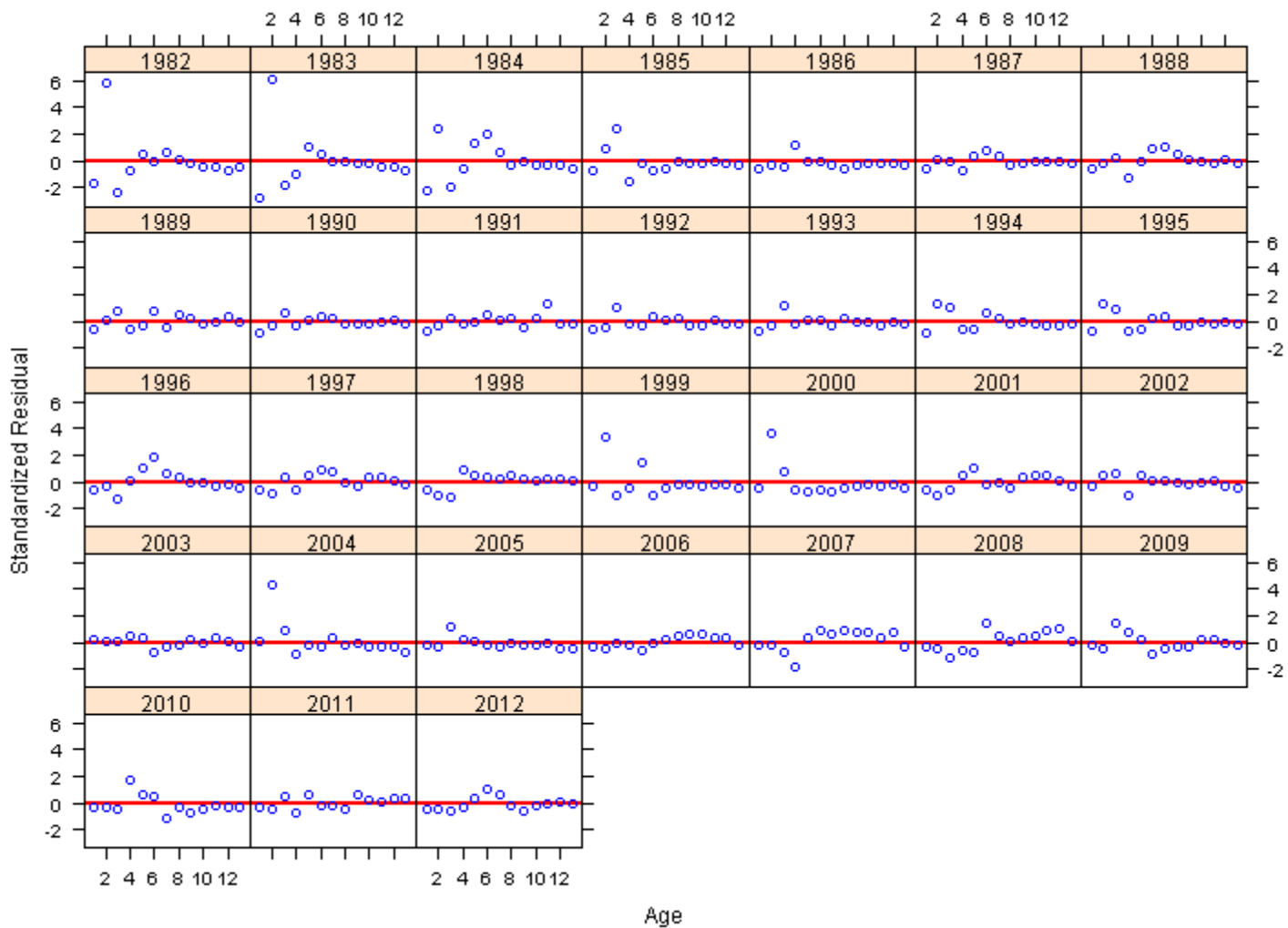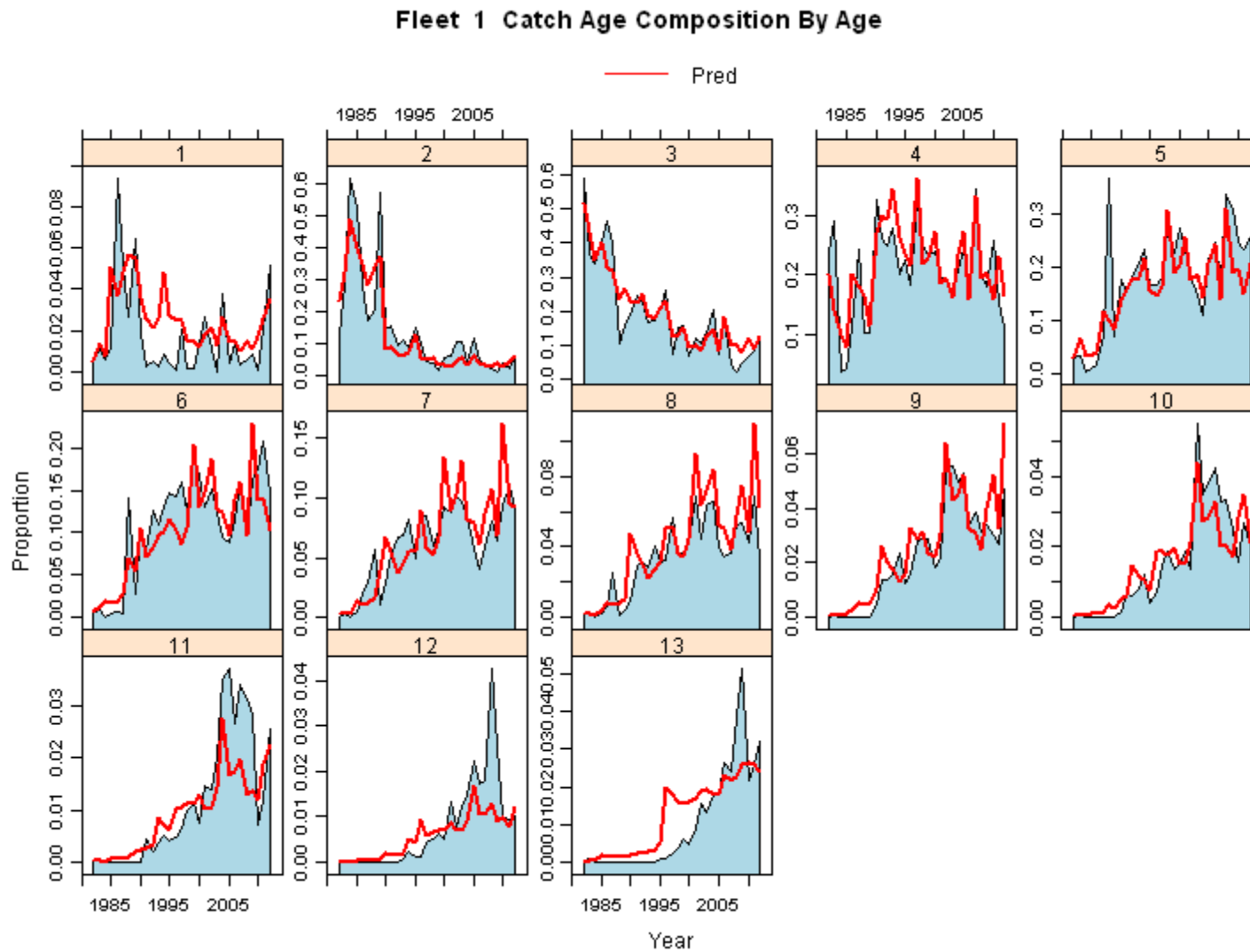
Figure 3 .Observed and predicted catch proportions-at-age by age for each fleet.

Fleet 2 Catch Age Composition By Age
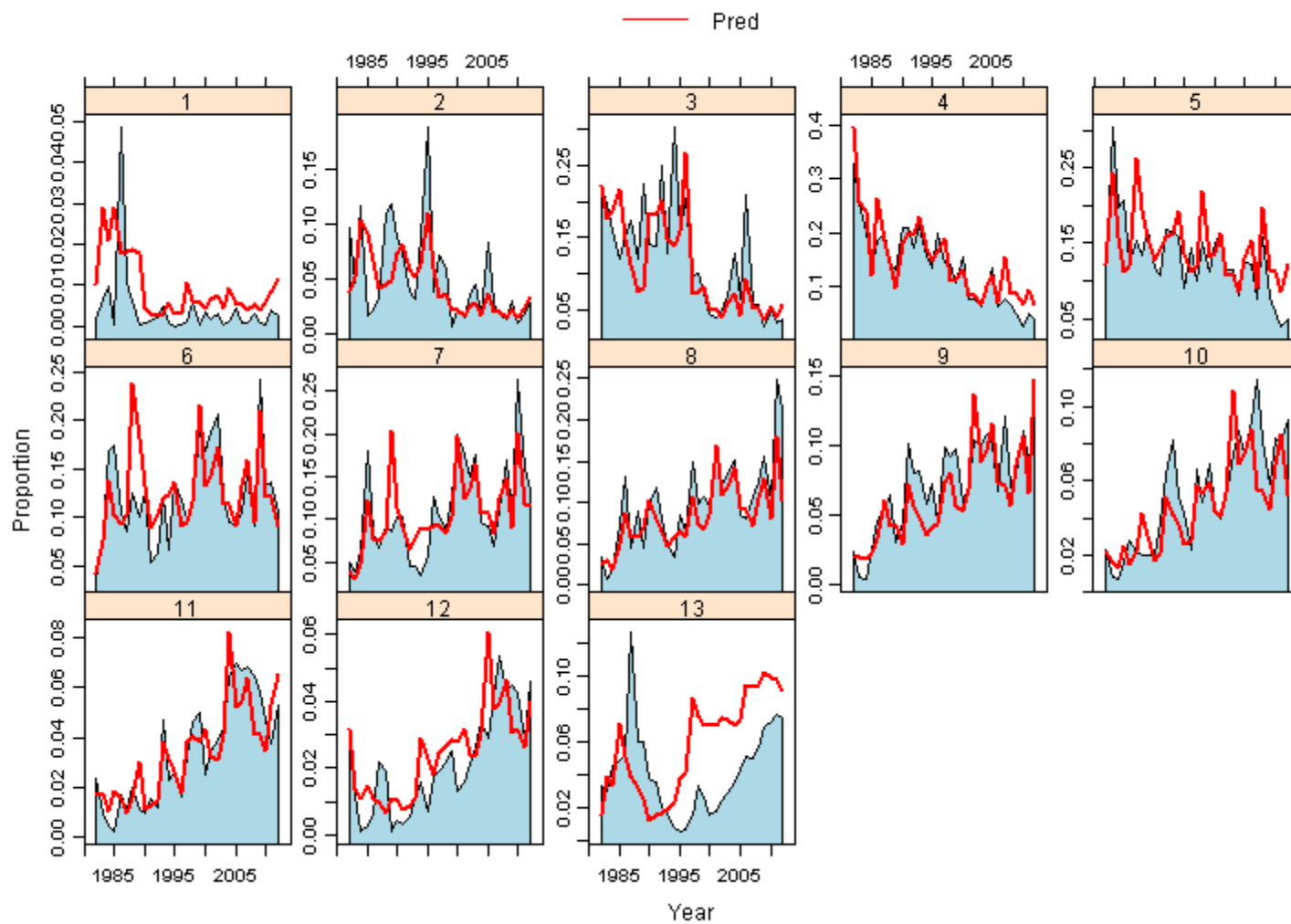
Figure 3 cont.

Fleet 3 Catch Age Composition By Age
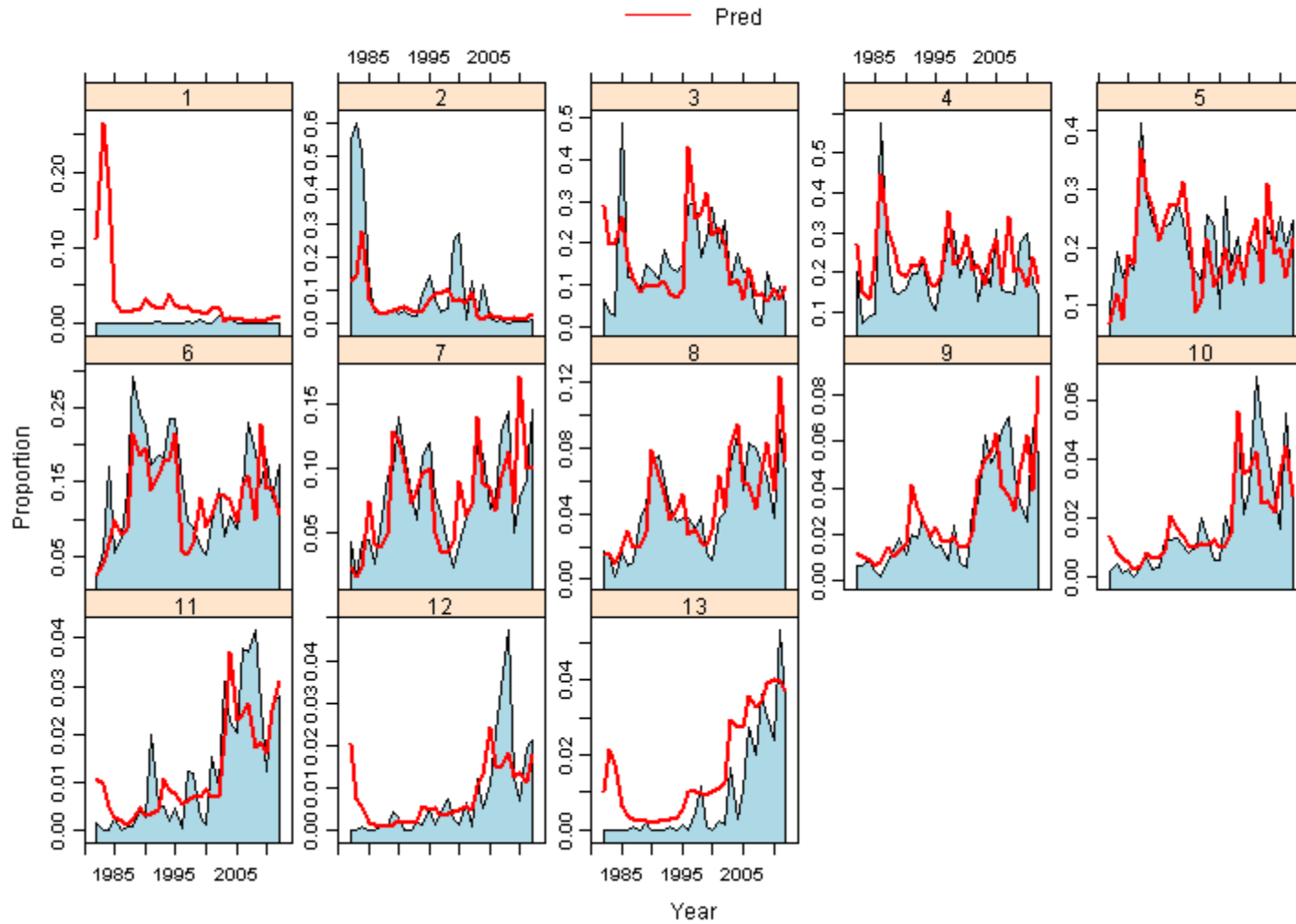
Figure 3 cont.
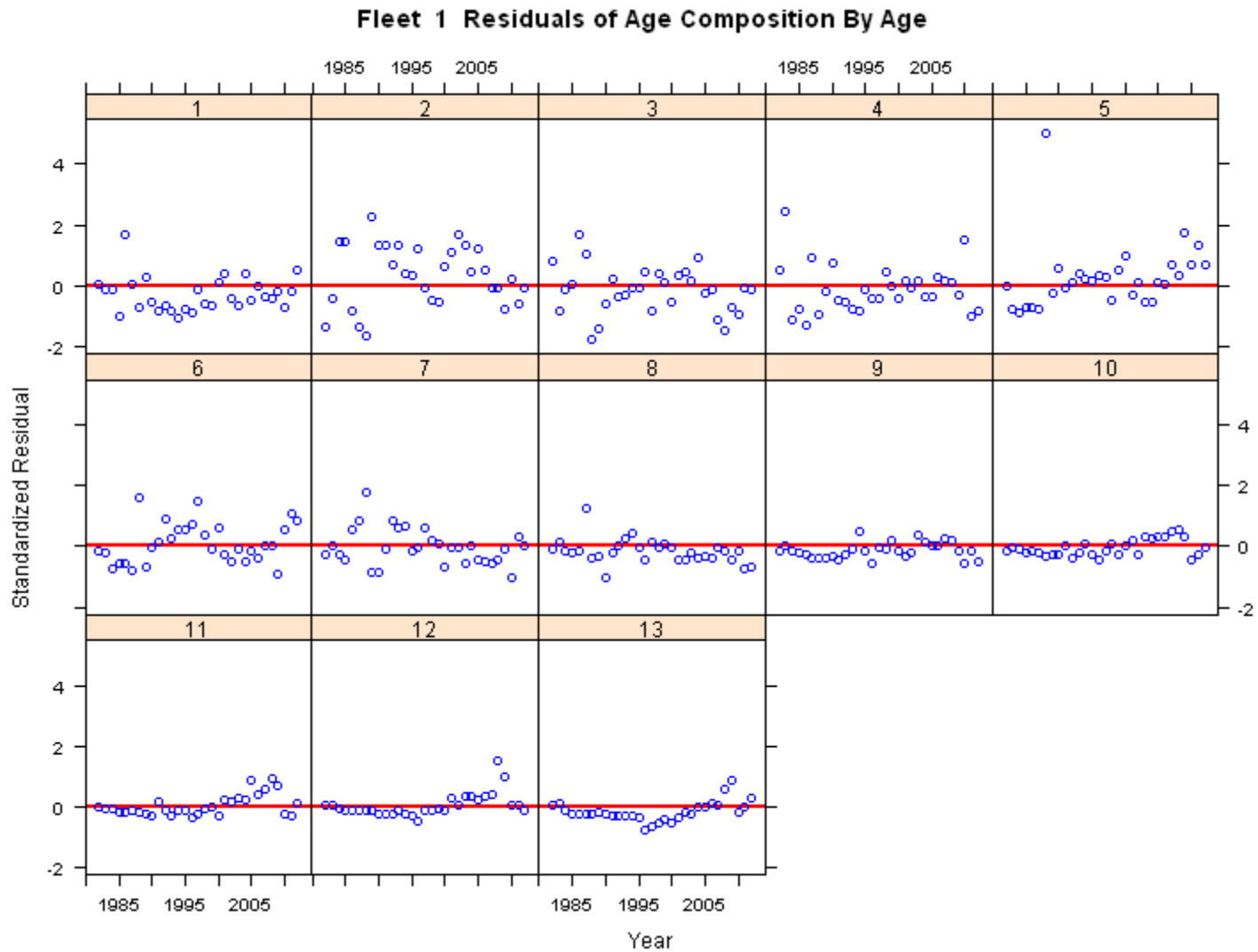
Figure 4. Standardized residuals of catch proportions-at-age by age.

Fleet 2 Residuals of Age Composition By Age
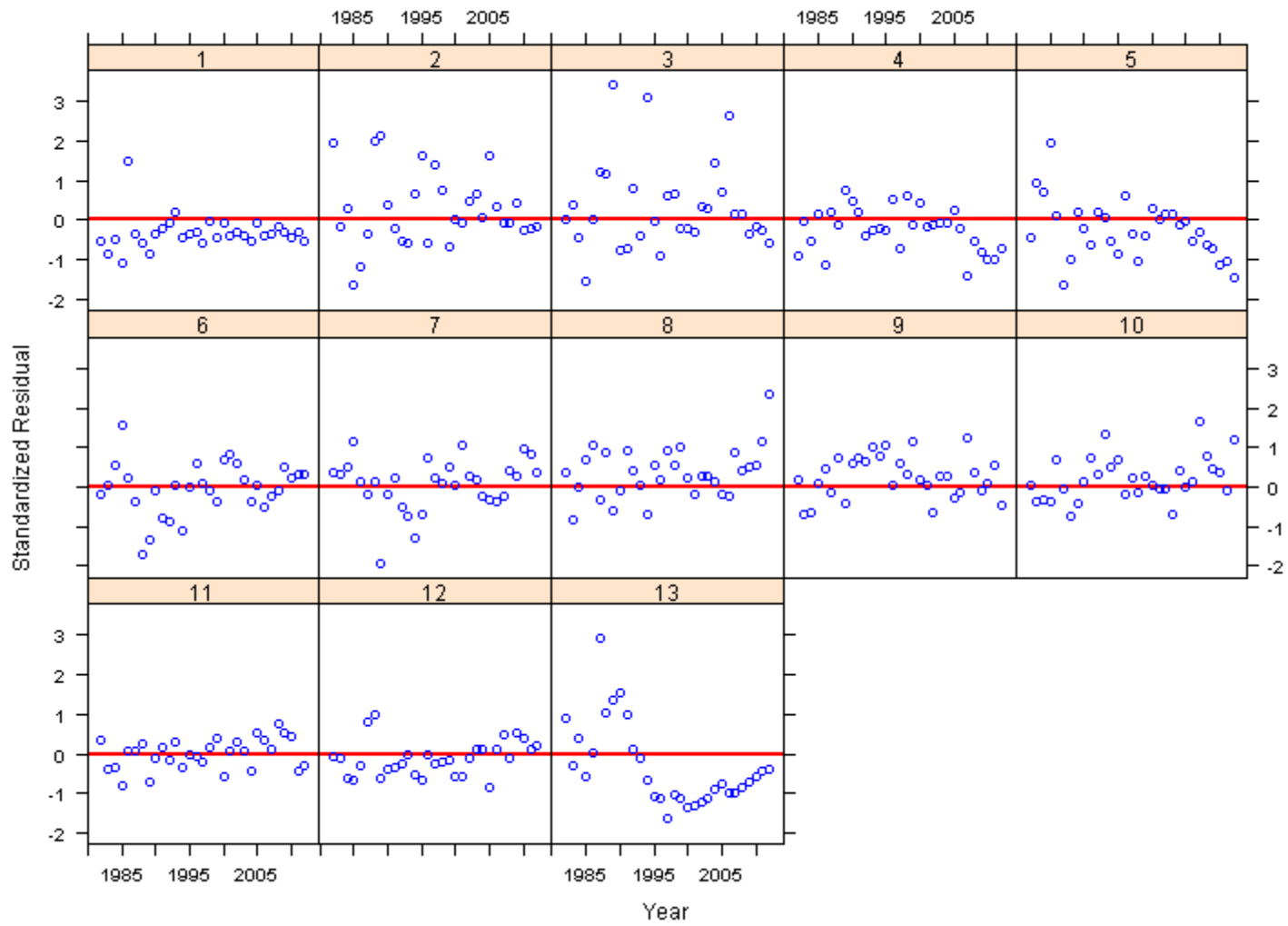
Figure 4 cont.

Fleet 3 Residuals of Age Composition By Age
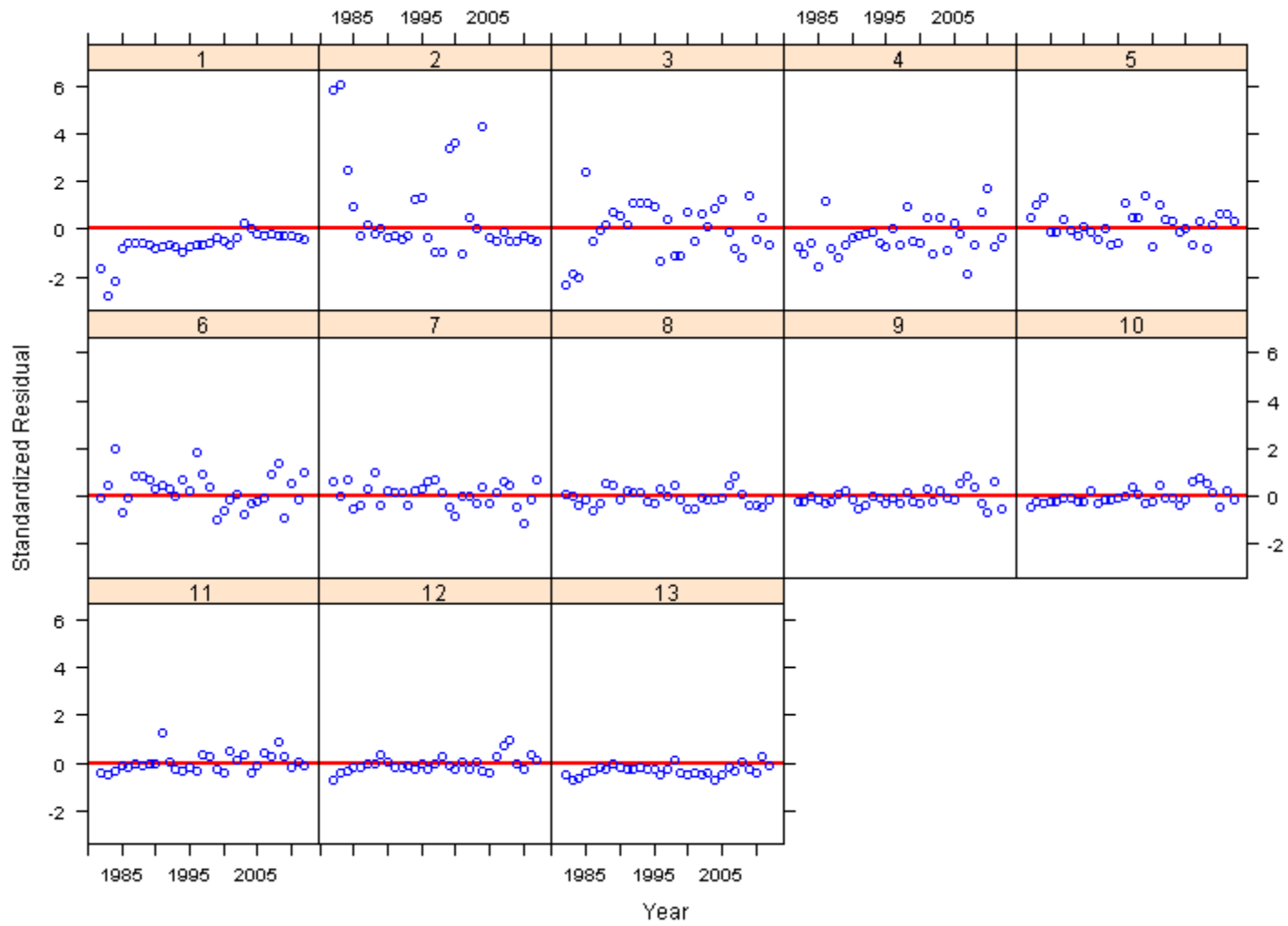
Figure 4 cont.
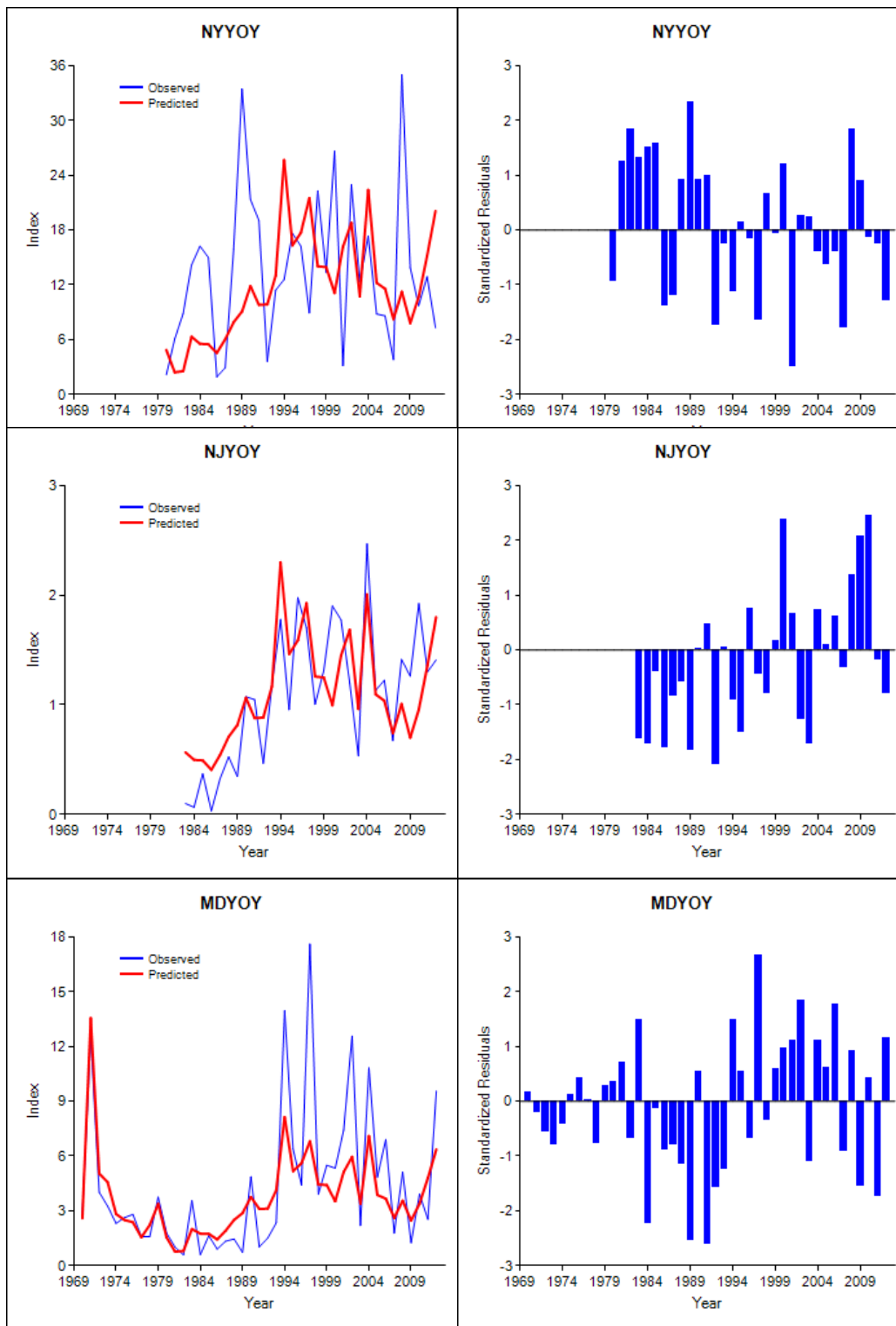
Figure 5. Observed and predicted values and standardized residuals for young-of-the-year and yearling surveys tuned to Age 1 and 2, respectively.
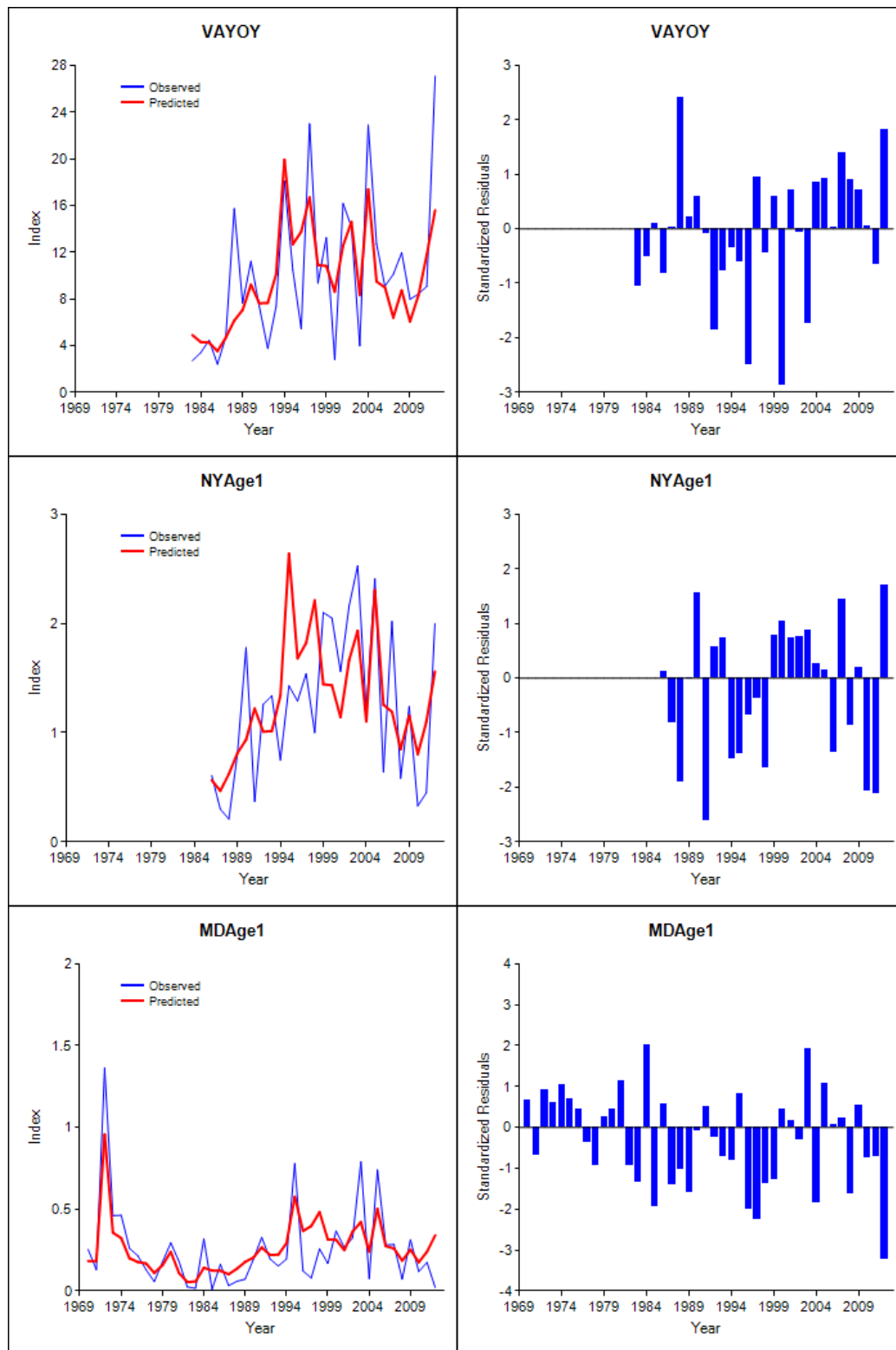
Figure 5 cont.
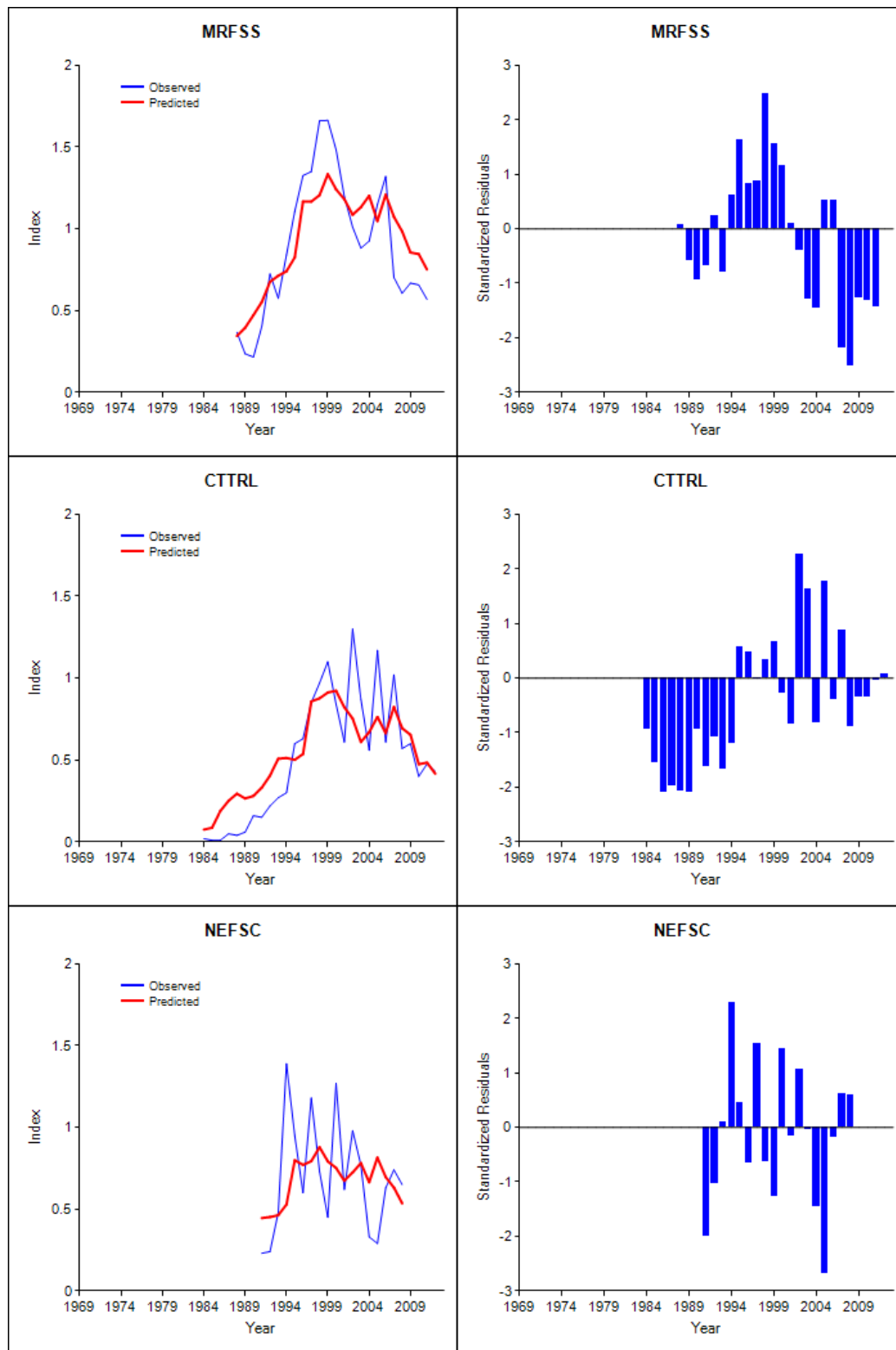
Figure 6. Observed and predicted values and standardized residuals for age-aggregated surveys.
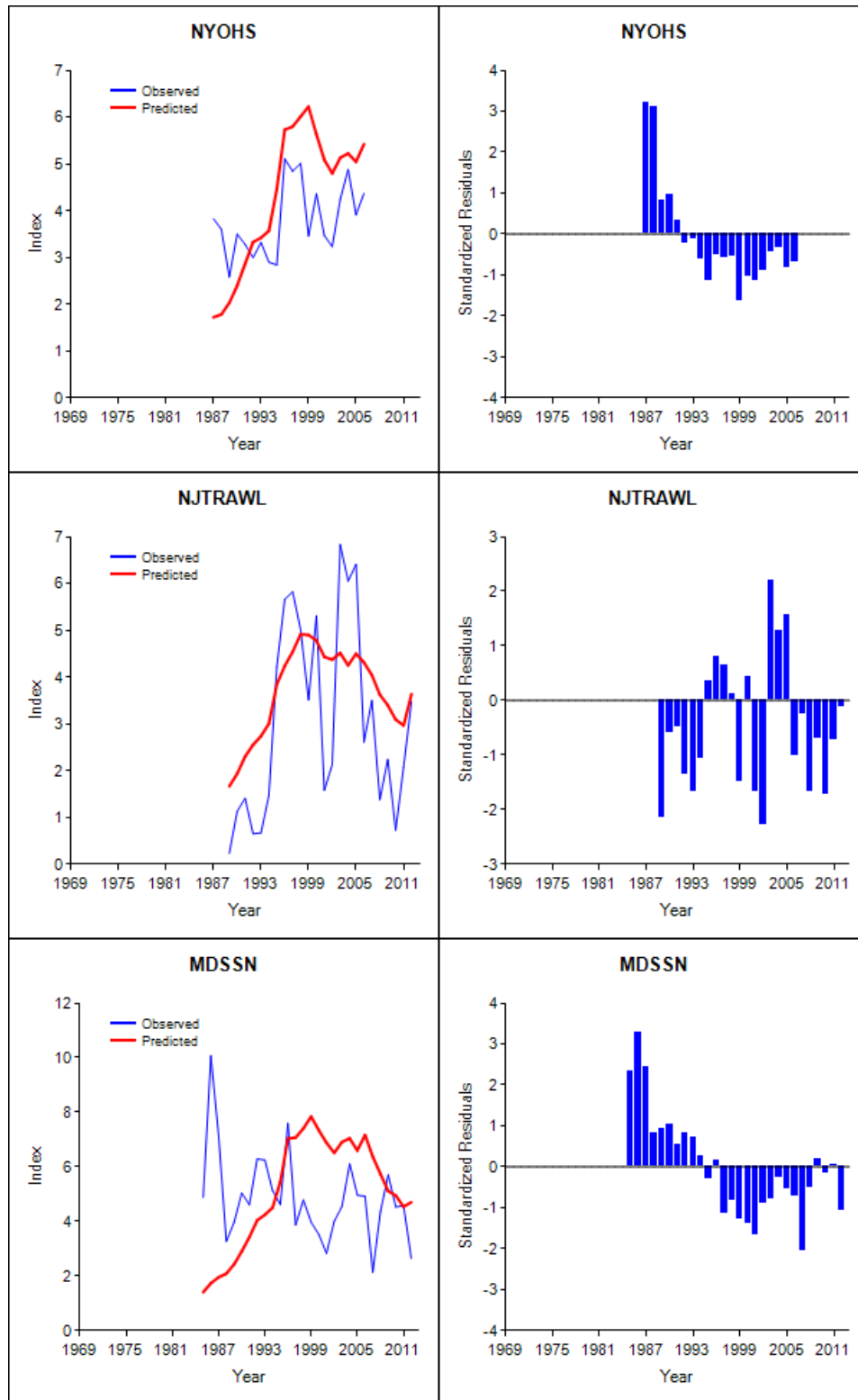
Figure 7. Observed and predicted values of the total index and standardized residuals for surveys with age composition data.
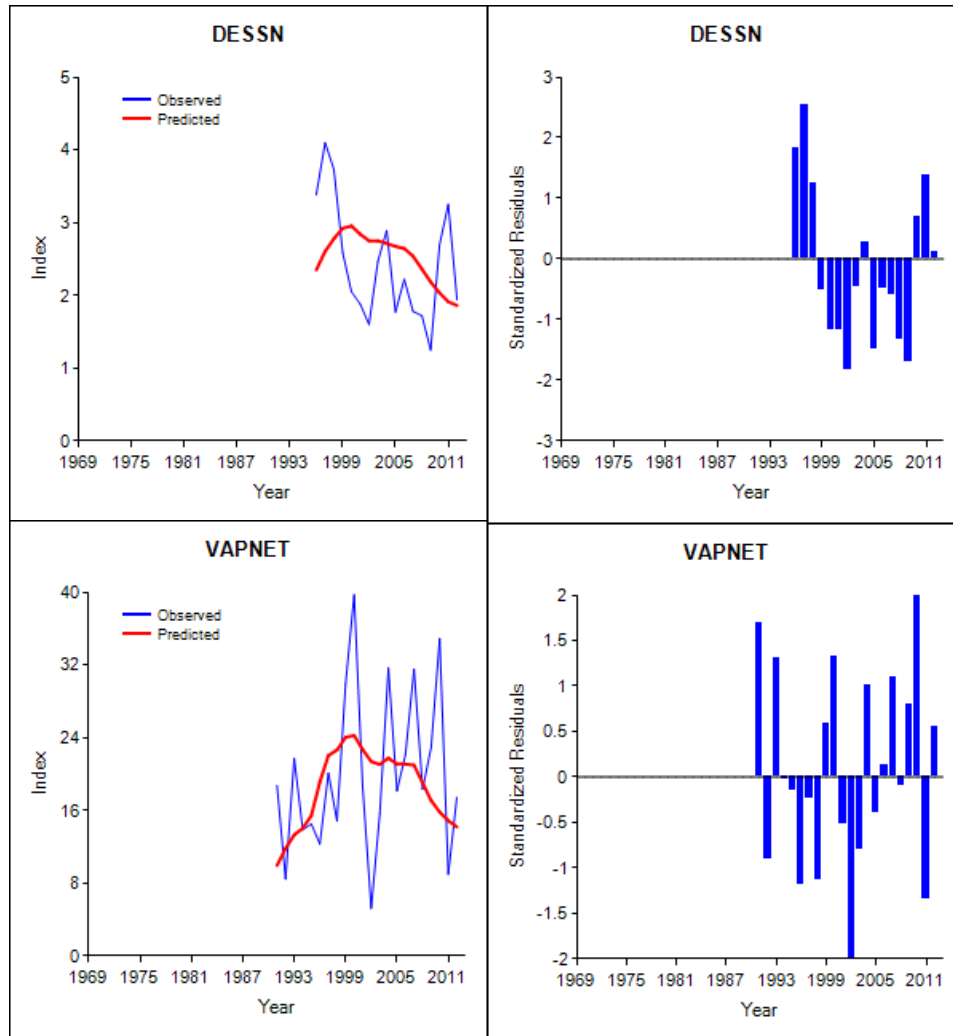
Figure 7 cont.
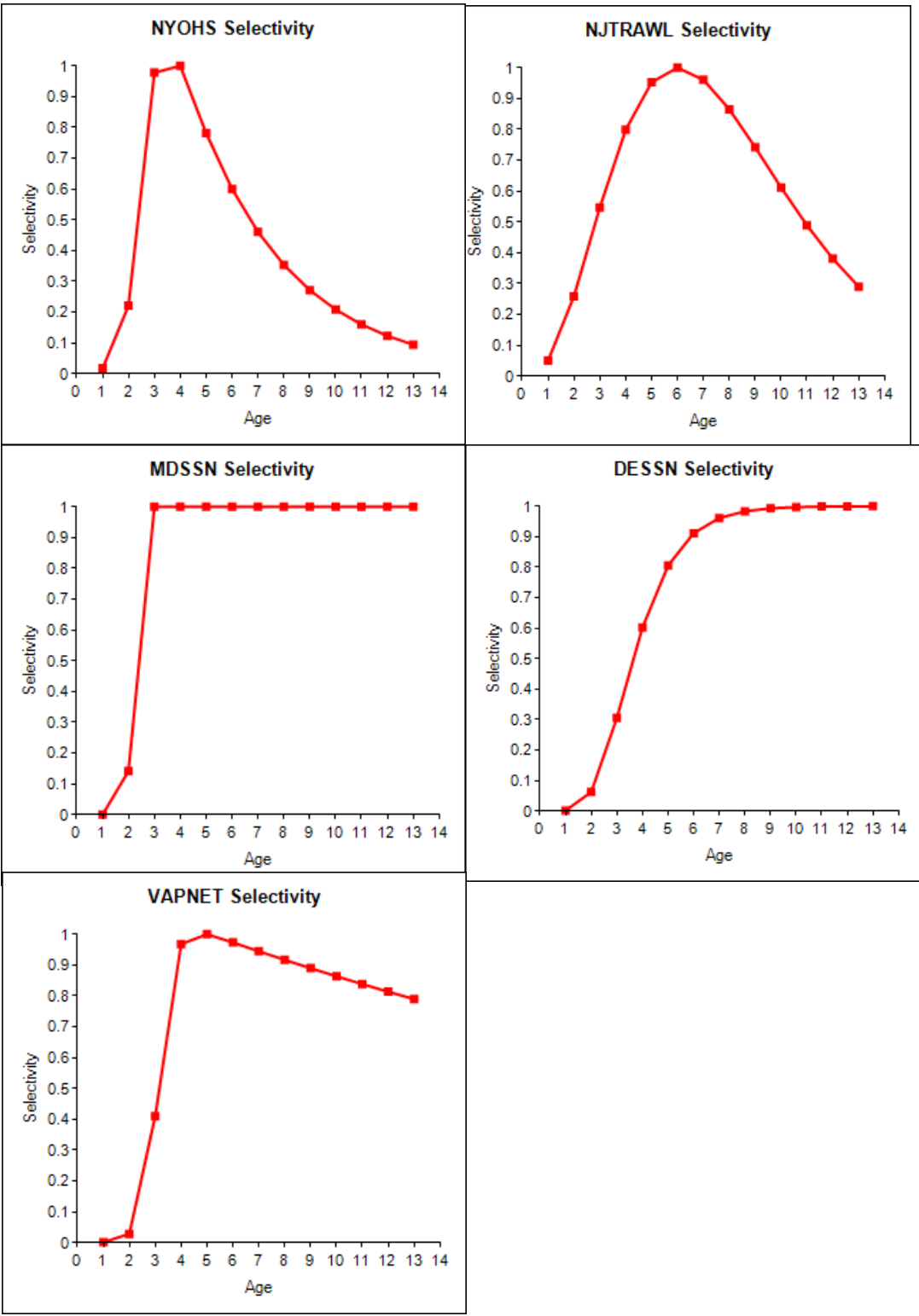
Figure 8. Selectivity patterns estimated for the NYOHS, NJ Trawl, MD SSN, DE SSN surveys and VAPNET.

Figure 9. Observed and predicted proportions-at-age and standardized residual for each year by age for the NYOHS survey.
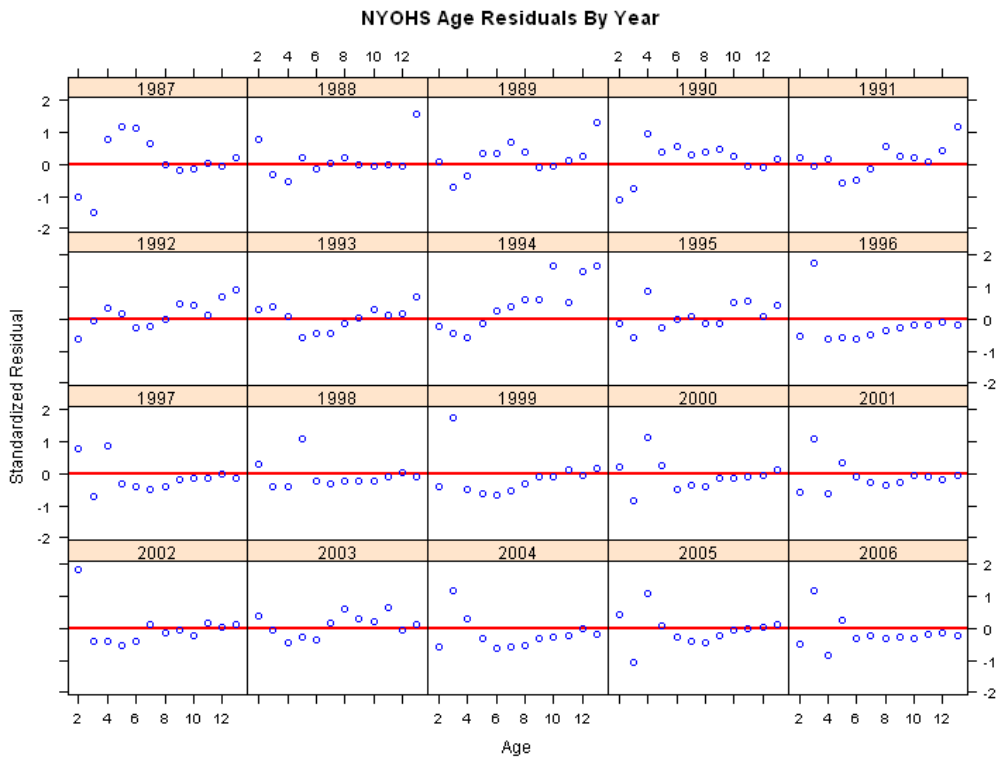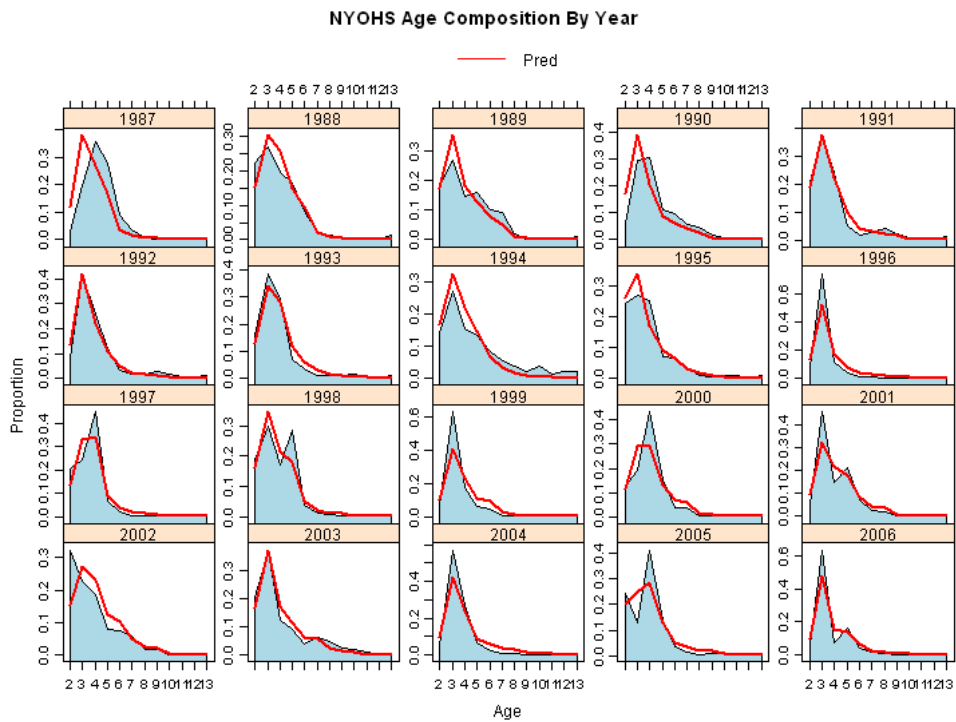
Figure 10. Observed and predicted proportions-at-age and standardized residuals for each age by year for the NYOHS survey.

Figure 11. Observed and predicted proportions-at-age and residuals for each year by age for the NJ Trawl survey.
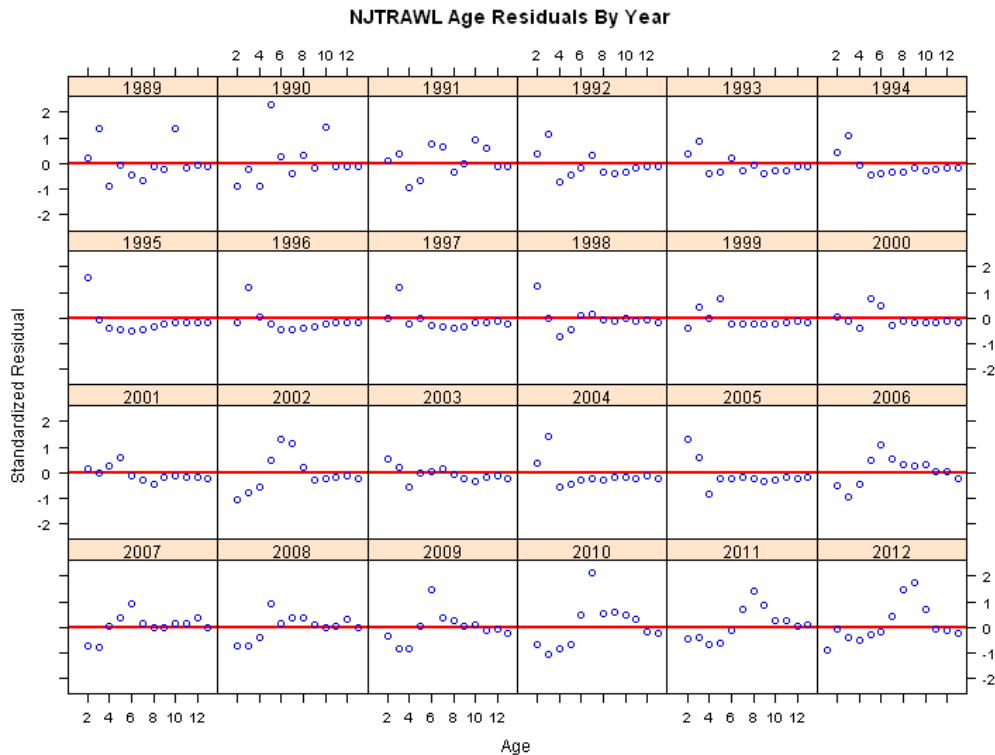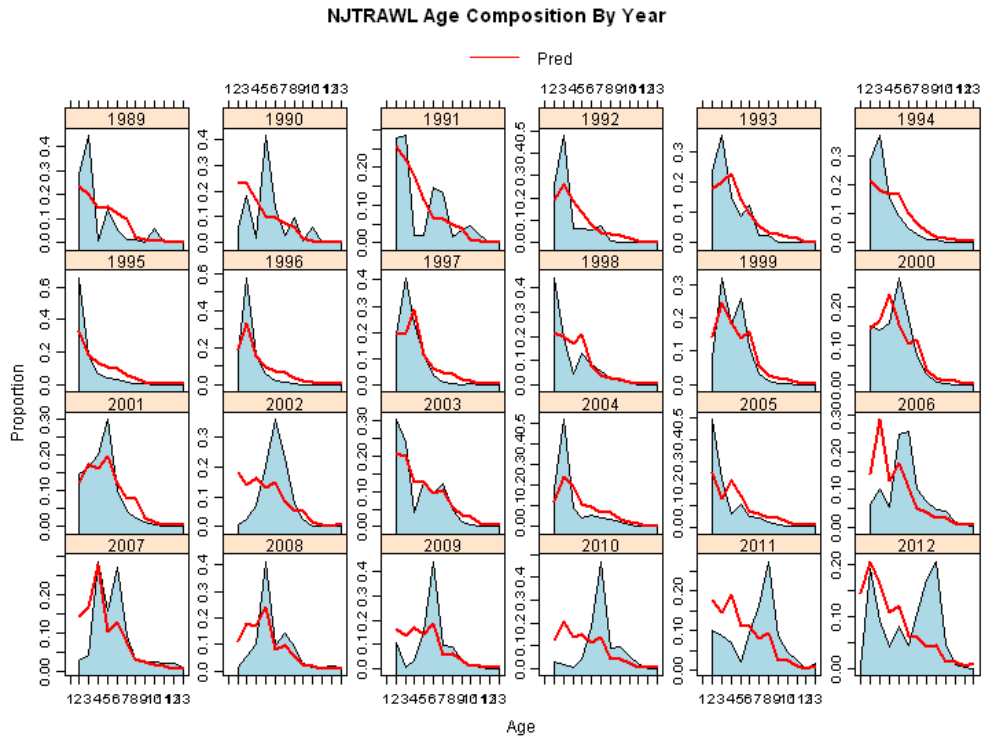
Figure 12. Observed and predicted proportions-at-age and standardized residuals for each age by year for the NJ Trawl survey.
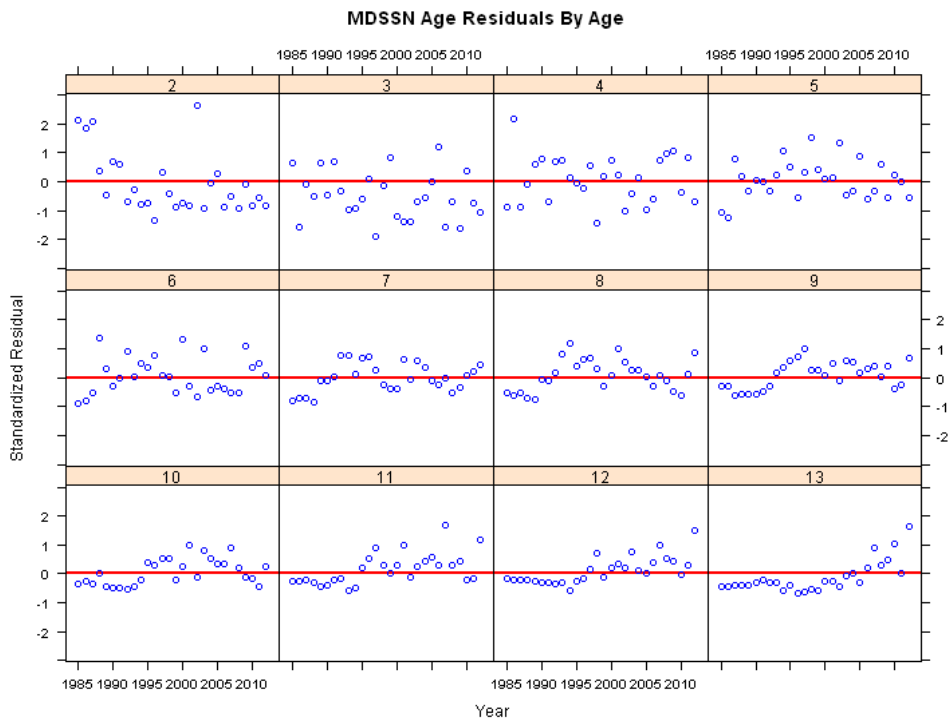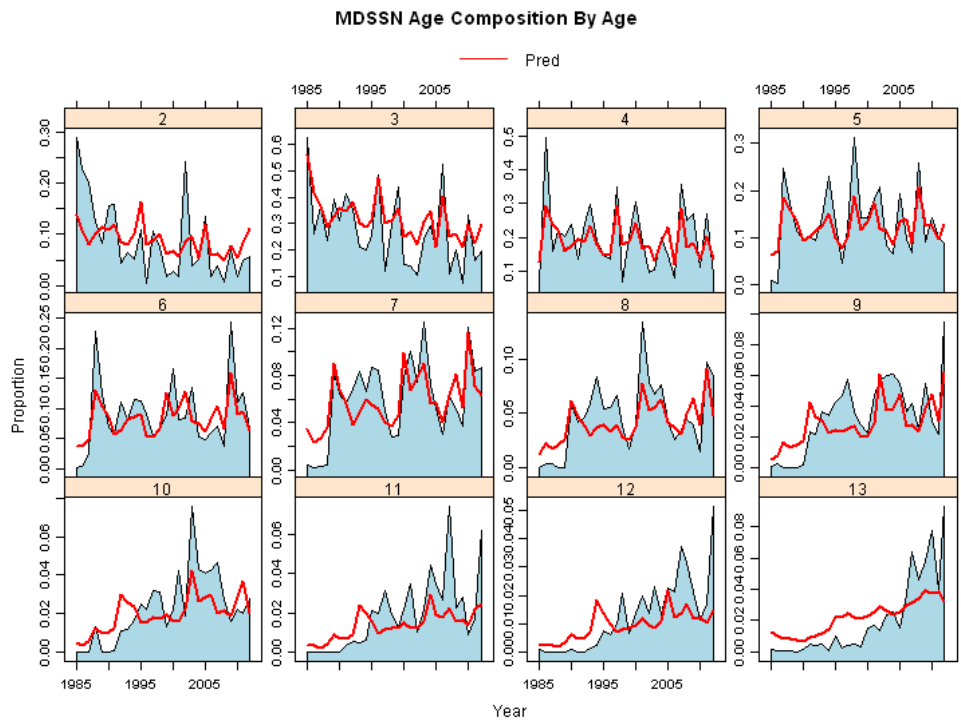
Figure 13. Observed and predicted proportions-at-age and standardized residuals for each year by age for the MD SSN gillnet survey.
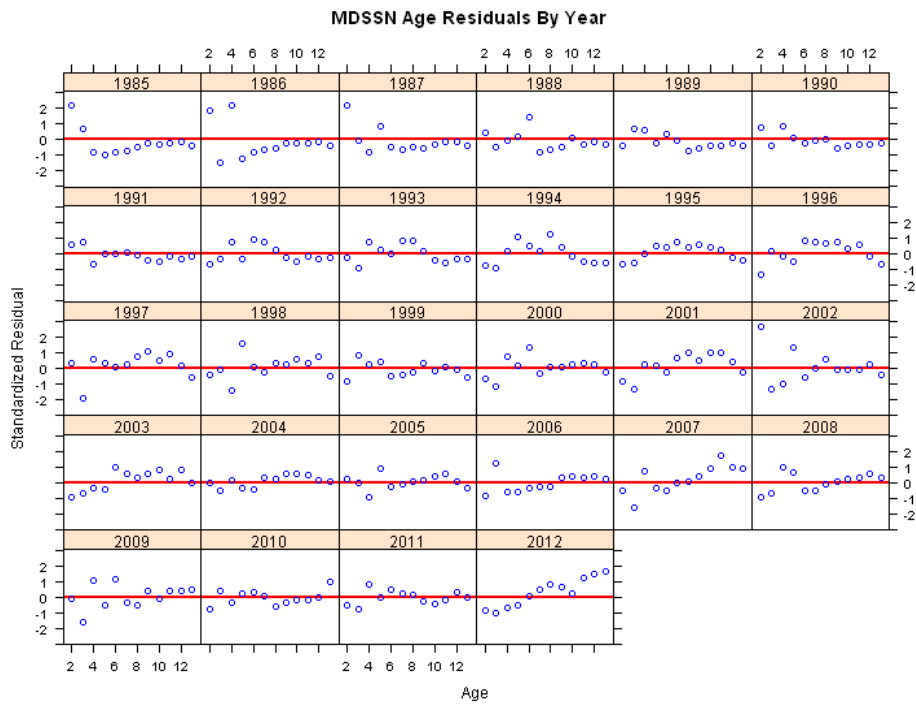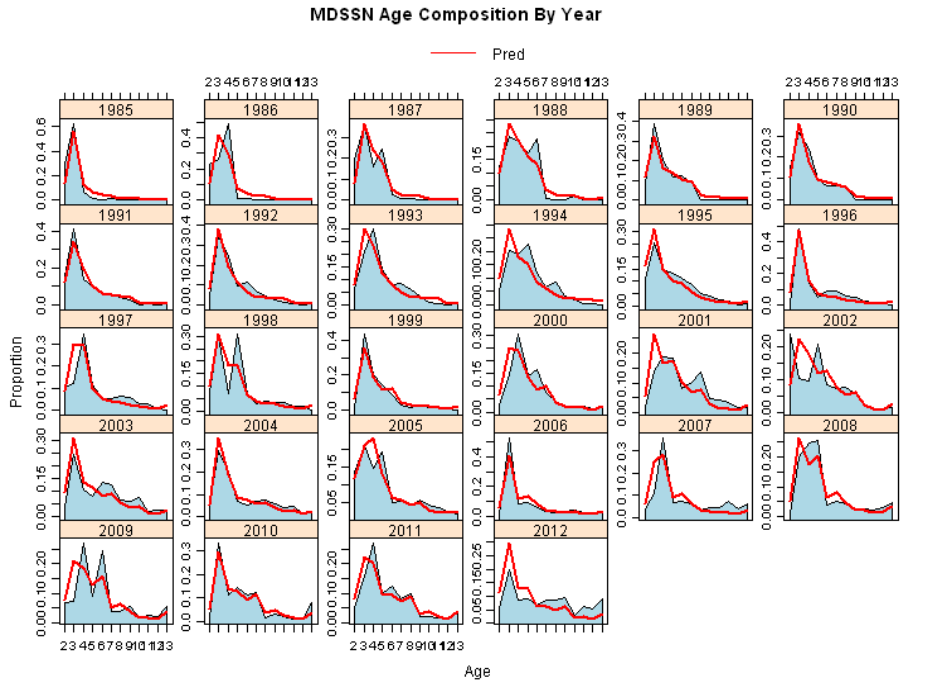
Figure 14. Observed and predicted proportions-at-age for each age by year for the MD SSN gillnet survey.
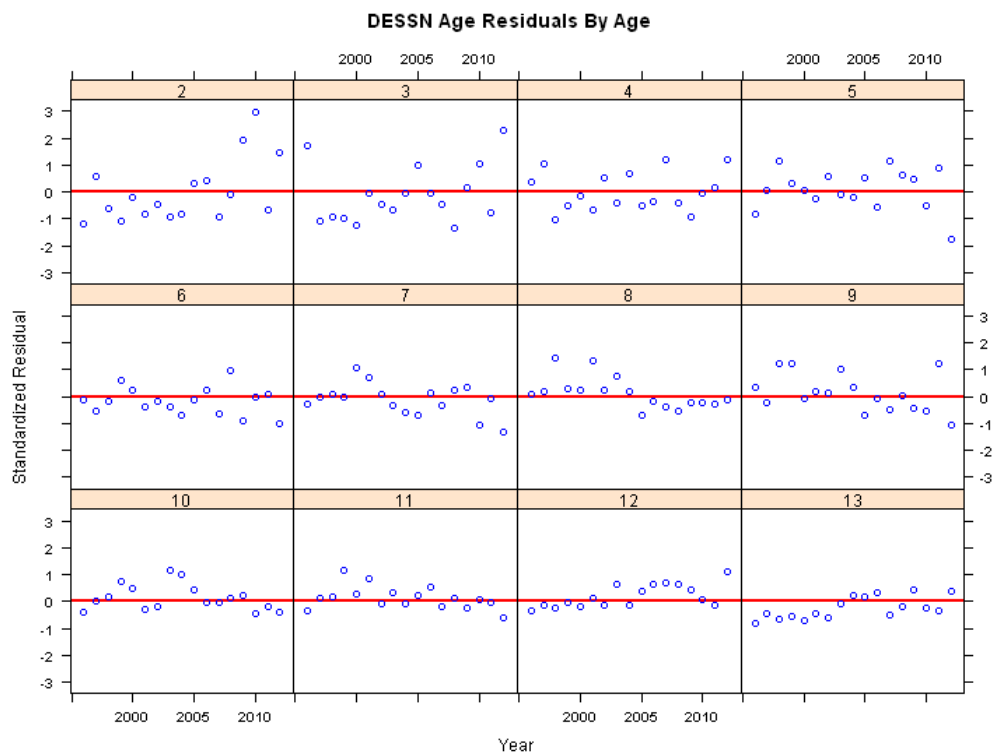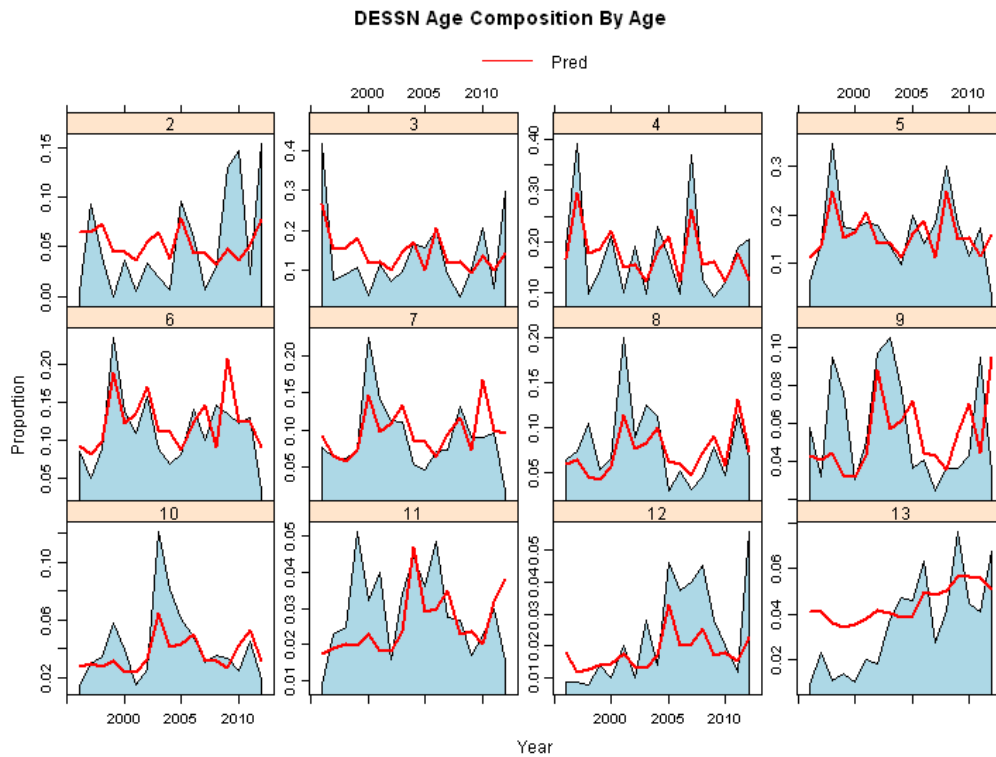
Figure 15. Observed and predicted proportions-at-age and standardized residuals for each year by age for the DE SSN electrofishing survey.
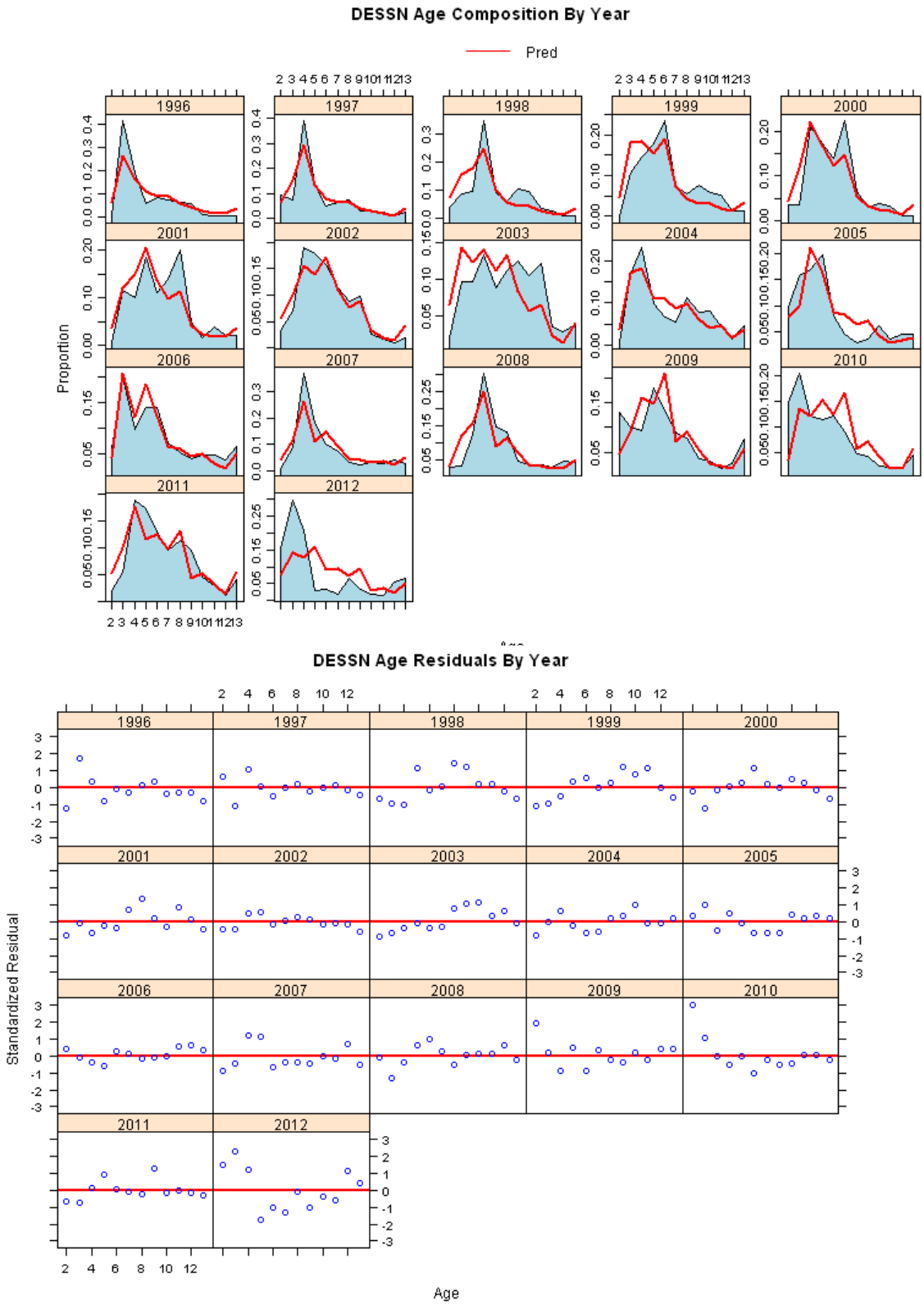
Figure 16. Observed and predicted proportions-at-age and standardized residuals for each age by year for the DE SSN electrofishing survey.
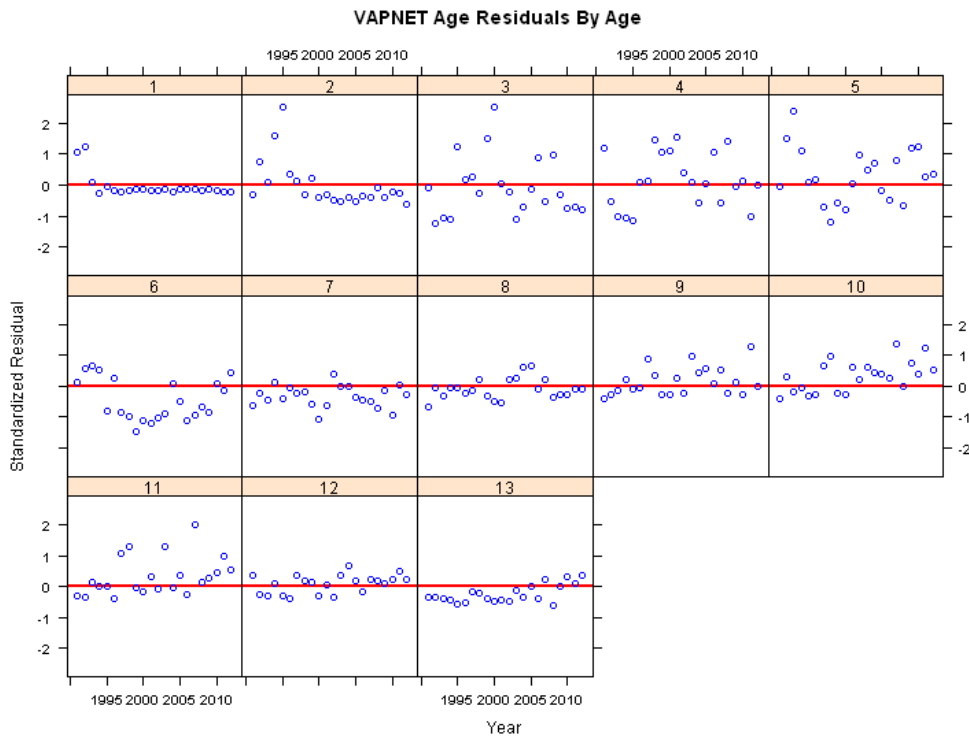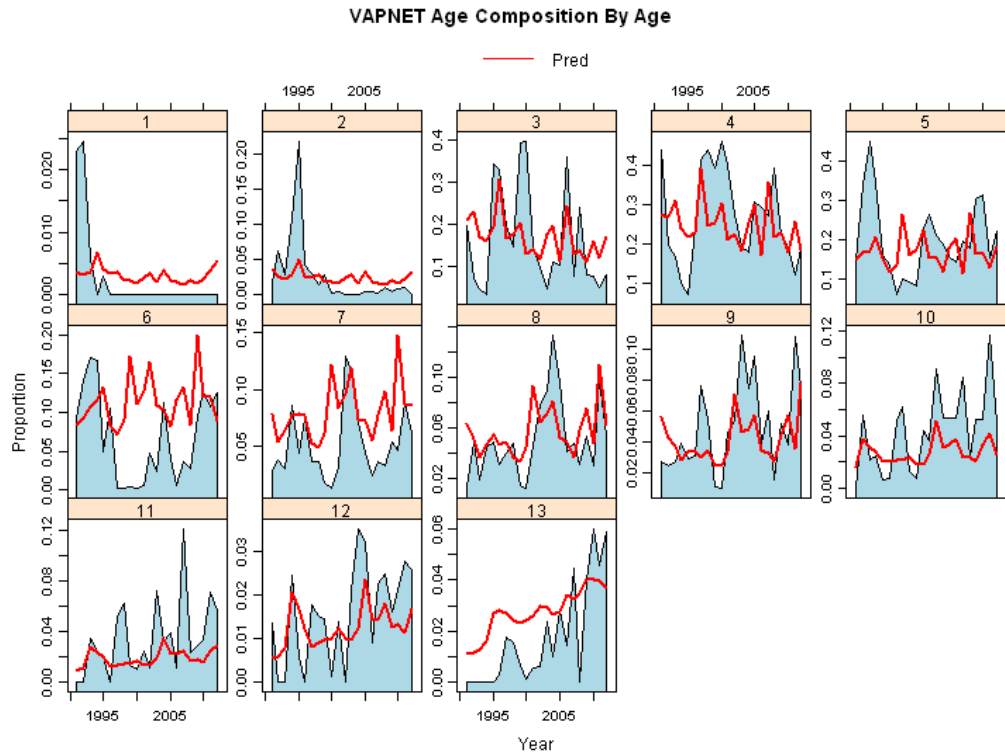
Figure 17. Observed and predicted proportions-at-age and standardized residuals for each year by age for the VAPNET survey.
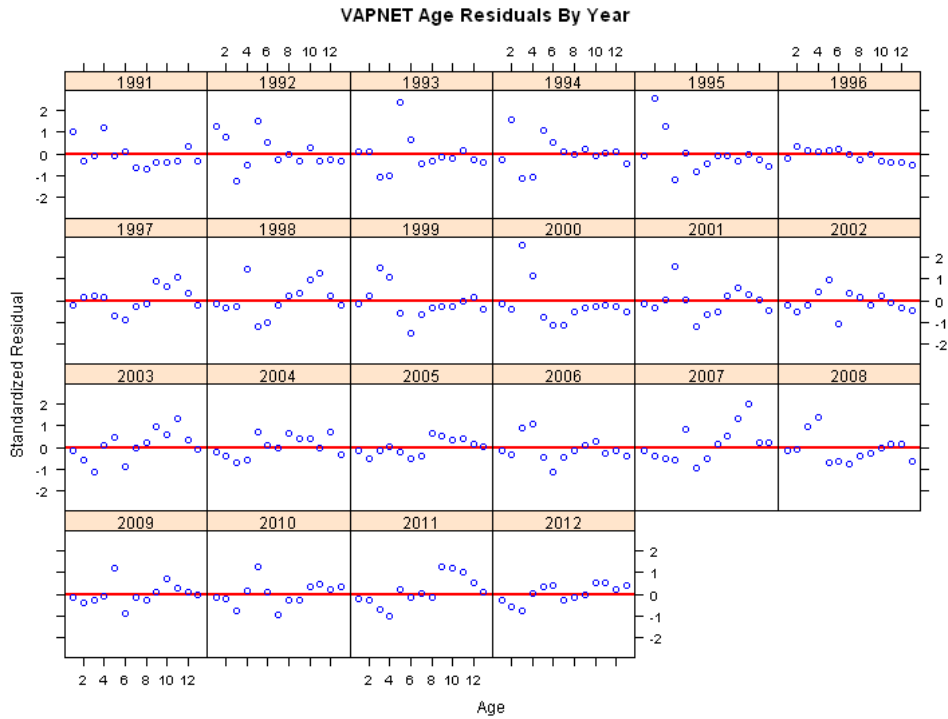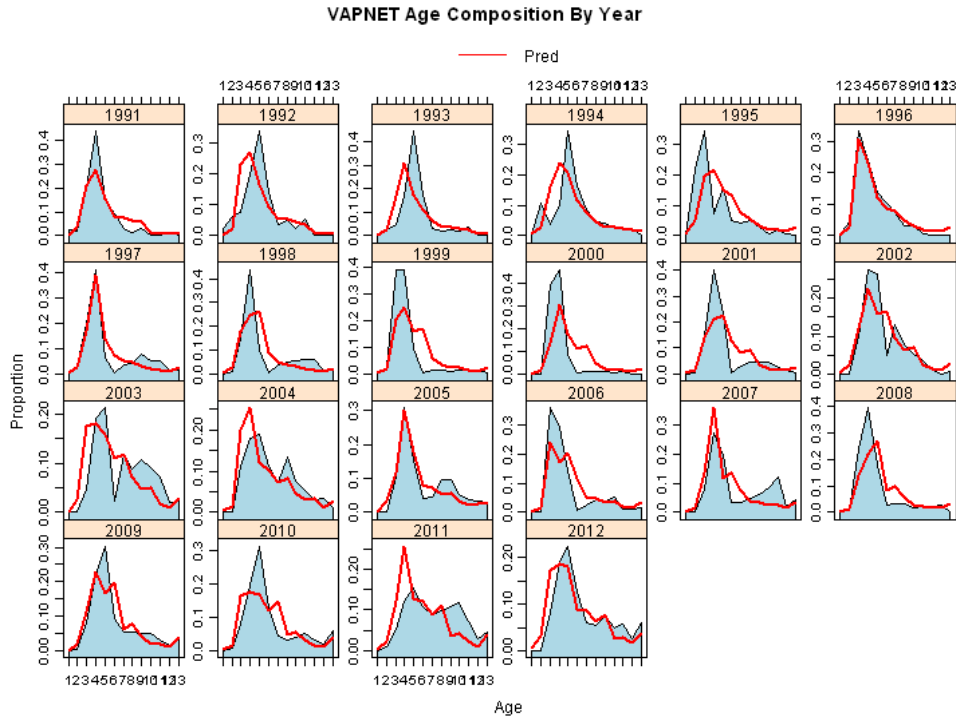
Figure 18. Observed and predicted proportions-at-age and standardized residuals for each age by year for the VAPNET survey.

Appendix B8: Age-Structured Assessment Program (ASAP)

B8.1 Model Structure

As an alternative to the SCA model, an ASAP statistical catch-at-age model (Legault and Restrepo 1998) was applied to the striped bass catch-at-age data and relative abundance indices. The years 1982-1984 experienced unusual selectivity patterns in the fisheries, consequently the time series of catch was begun in 1985, the first year of the Maryland moratorium on striped bass catch. Similar to the SCA, a three fleet model was developed with total weight of each component a function of mean weights-at-age and catch-at-age. Since ASAP cannot account specifically for sex ratio as does SCA, the ASAP maturity input was modified to equal maturity-at-age * sex ratio-at-age, therefore mimicking female only SSB in the subsequent calculations. Selectivity was estimated for each fleet with three time periods: 1985-1989, 1990-1995 and 1996-2012. The selectivity curves were fitted as a double logistic for the Bay fleet and commercial discards (which are primarily within Chesapeake Bay) and a single logistic model for the coastal fleet. The CV for the Bay and Coastal catches was set at 0.05 prior to 1995 and 0.02 from 1995-2012, with commercial discard uncertainty set at 0.1 for the entire time series. Effective sample size was calculated using the Francis method and held constant for the fleet coastal and commercial discard time series but a two-stage estimate in the Bay fleet split at 1995. The configuration of the relative abundance indices was similar to the SCA model, although the survey CVs were increased as necessary to maintain the RMSE around 1.0 to 1.5. However, the CV on the Chesapeake Bay young of year index for 2011 was reduced to the survey estimated value (0.2) in order to force the model to emphasize the most recent strong cohort.

B8.2 Results

The ASAP model was able to produce similar results as the SCA model using the shortened time series. In general the predicted indices from the model followed the trajectory of the observed abundance indices (Figure B8.1), with possible exception of the MD SSN and NY ocean haul seine indices which displayed time trends in the residual patterns (Figure B8.2). The average fishing mortality (ages 8-11) increased steadily between 1987 and 1997, remained stable through 2003, increased again until 2007 (Figure B8.3). Since 2008 F has ranged between 0.19 and 0.23, with 2012 equal to 0.21. Fishing mortality by fleet indicates the largest component of F is from the coastal fishery. Female spawning stock biomass increased steadily between 1986 (11,880 mt) and 2003 (78,020 mt) but has slowly decreased with the 2012 estimated SSB of 58,612 mt (Figure B8.4). Recruitment at age 1 shows large year classes in 1993, 1996, 2003 and 2011 (Figure B8.5). Alternative model configurations in which the CV on the most recent Bay yoy indices was not reduced, 2011 recruitment estimates were about 35% lower (Figure B8.6). The stock and recruitment series provided enough contrast to produce a reasonably well fitted Beverton-Holt stock recruitment model (Figure B8.7). Steepness was estimated was 0.790 with unexploited SSB of 337,205 mt and unexploited R of 121.118 million fish.

The ASAP model results were evaluated for any retrospective problems using a seven year peel. Results suggest an over-estimation of fishing mortality for 2005-2007 (Figure B8.8), with a relative difference in 2005 of 39% (16% in 2007). Between 2008 and 2011 there were no retrospective issues with relative differences ranging from 8.5% to 1.1%. Similarly for SSB, the model estimates tended to under-estimate SSB (Figure B8.9) as much as 31% in 2005 but less

than 9% since 2007. Recruitment estimates tended to be more erratic ranging from -35% to 36% (Figure B8.10). The most recent two years tended to under-estimate recruitment by 15% to 20%. An MCMC run using 500 iterations with a thinning factor of 200 was applied to the ASAP results. The 80% confidence interval for annual total 2012 fishing mortality ranged from 0.165 to 0.238 (Figure B8.11). Similarly, 80% CI for 2012 SSB ranged from 51,240 mt to 66,333 mt (Figure B8.12).

B8.3 Comparison with SCA model

Overall the striped bass catch-at-age and relative abundance indices modeled in the ASAP program produced similar results as the SCA model. The estimate of 2011 recruitment was the largest source of uncertainty depending on the amount of uncertainty attributed to the recent Bay indices. In addition, the initial year estimate of abundance and F were slightly lower in ASAP likely due to the added information in the longer time series used in the SCA model. Another point of difference between the two models is the estimate of F_{MSY}. The SCA makes adjustments for the potential log-retransform bias whereas ASAP does not. The reference point generated from the ASAP model was an F_{MSY} of 0.144 while the SCA model was 0.22.

B8.4 Literature Cited

Legault, C.M amd V.R. Restrepo. 1998. A flexible forward age-structured assessment program. ICCAT. Col. Vol. Sci. Pap. 49:246-253.

Figure B8.1. Predicted indices vs. observed indices from ASAP striped bass model.
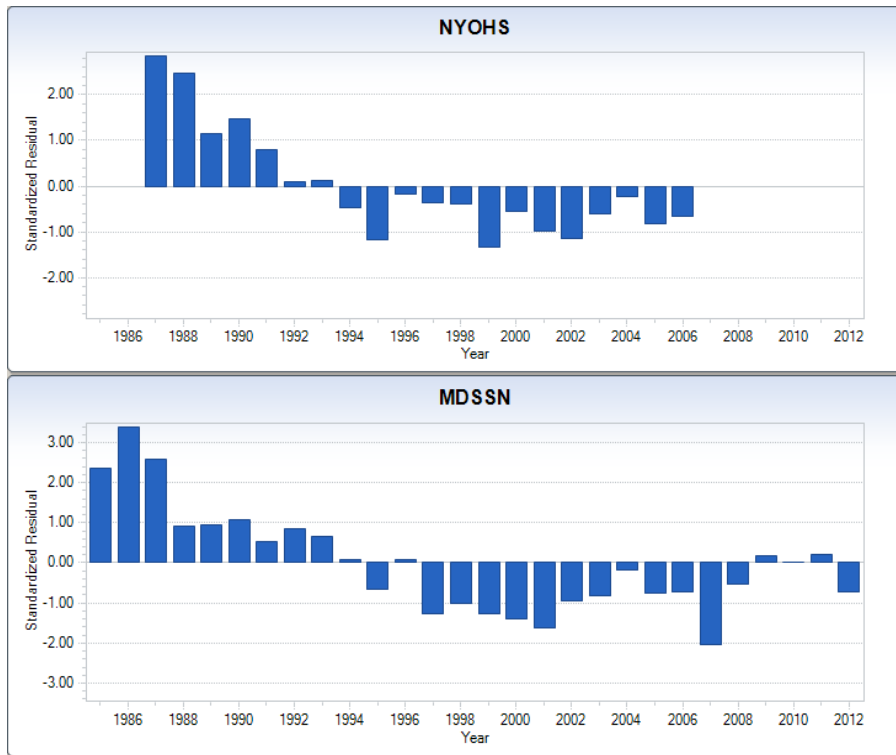
Figure B8.2. Residual patterns from MD spawning stock index and NY ocean haul seine index showing time trended residual patterns.
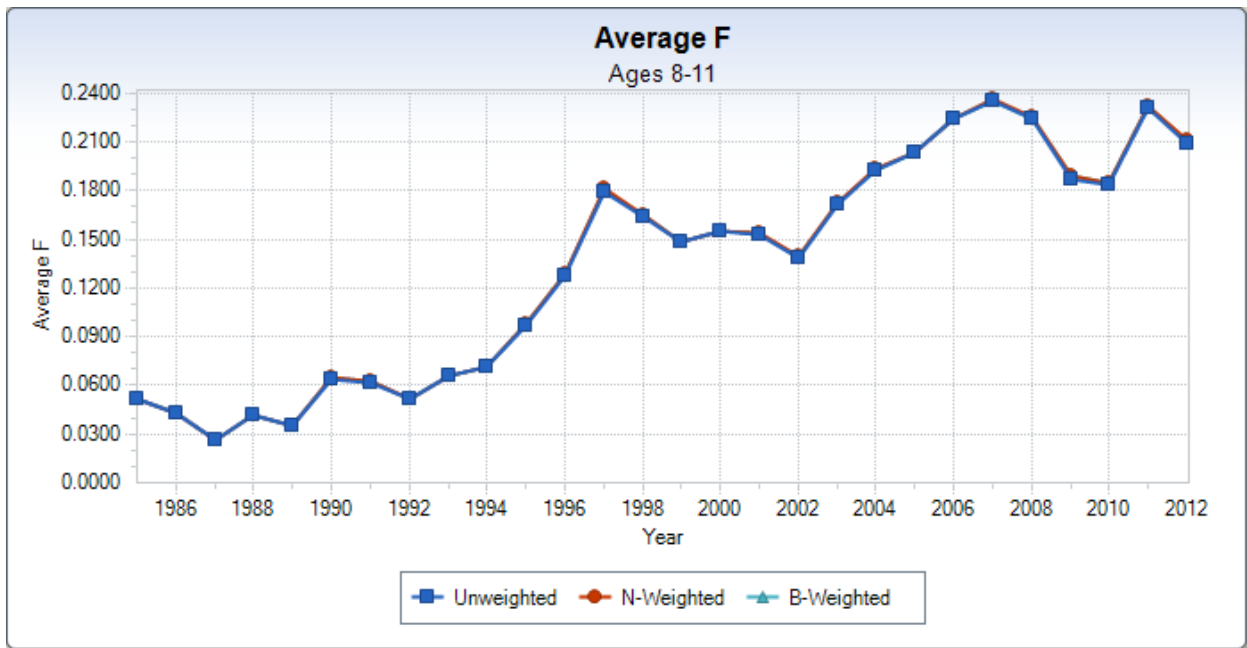
Figure B8.3. Time series of striped bass annual fishing mortality (age 8-11) from ASAP model results.
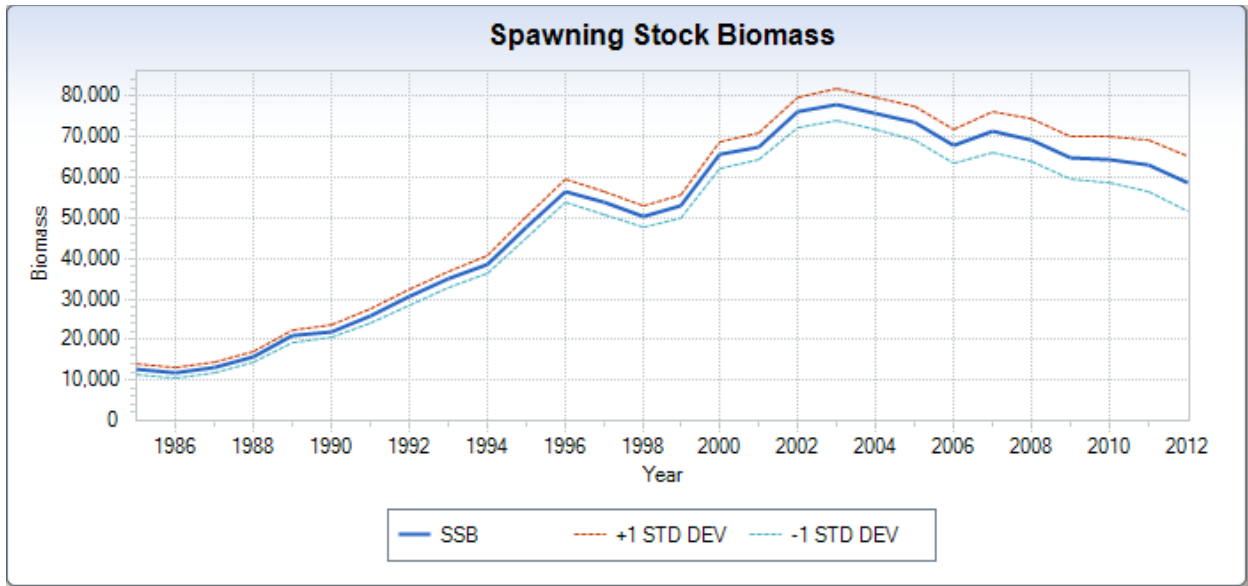
Figure B8.4. Time series of striped bass annual female spawning stock biomass from ASAP model results.
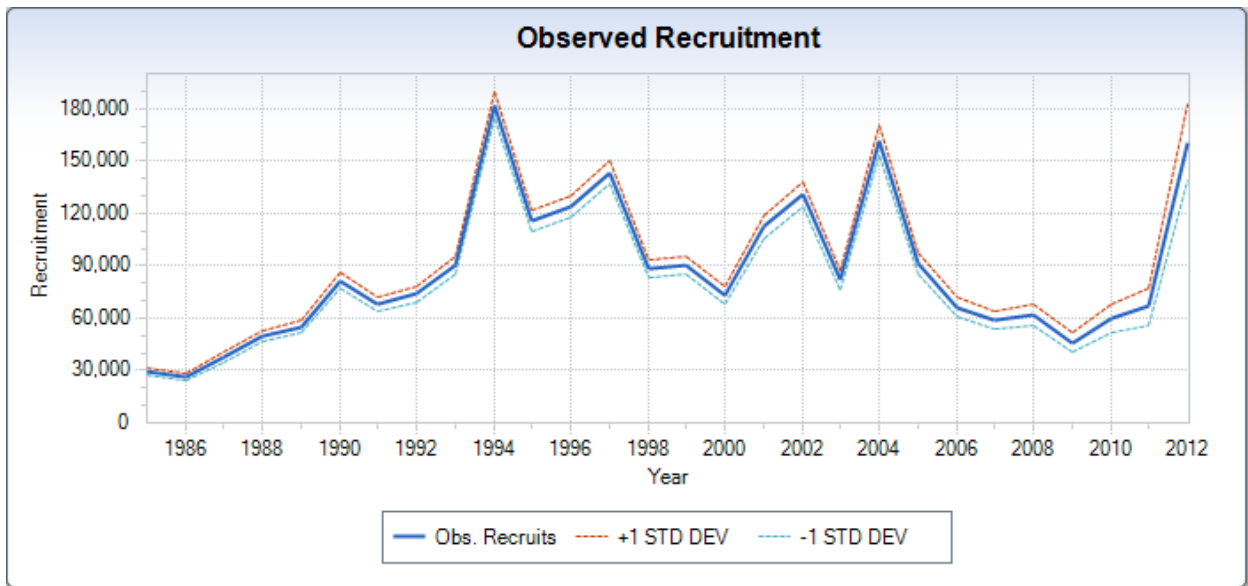
Figure B8.5. Observed striped bass age 1 recruitment estimates from ASAP model.
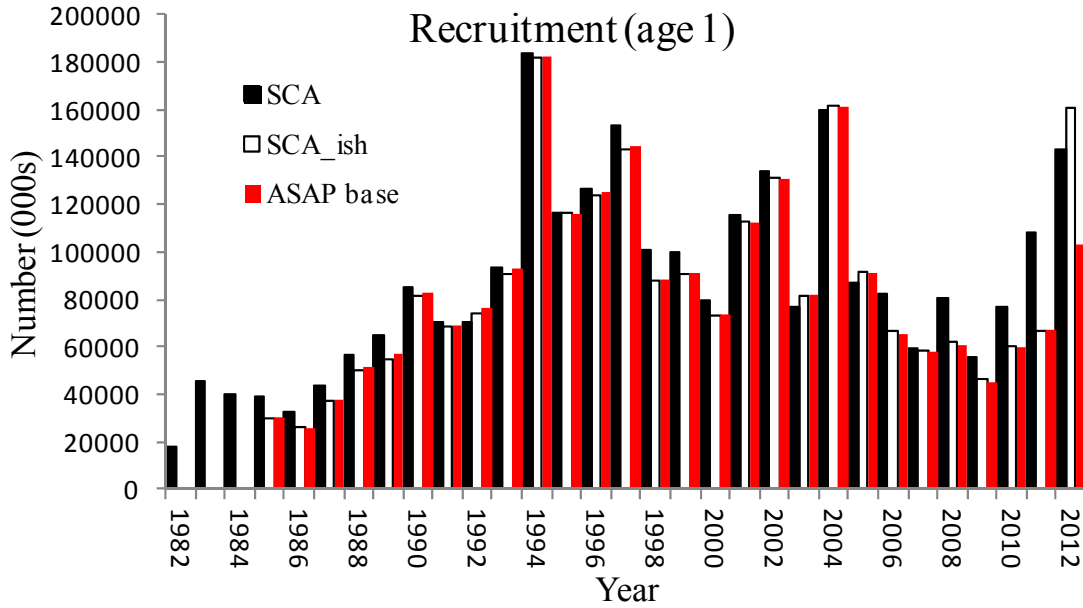
Figure B8.6. Comparison of age 1 recruitment estimates of striped bass from SCA, ASAP run as SCA (SCA_ish) and an alternative model without reduce CV on Chesapeake Bay 2011 yoy index (ASAP base).
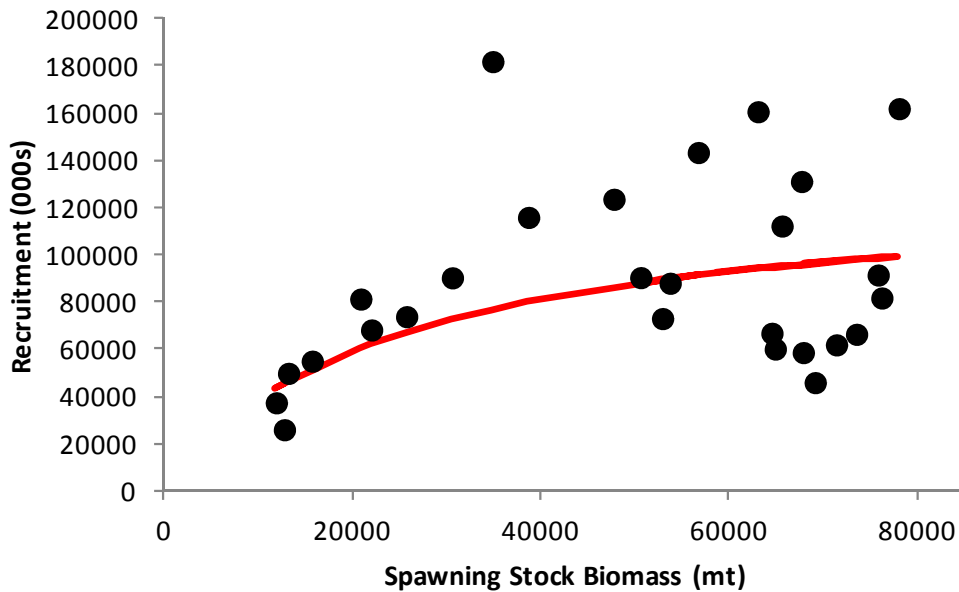
Figure B8.7. Beverton-Holt stock recruitment plot of striped bass generated from ASAP model results.
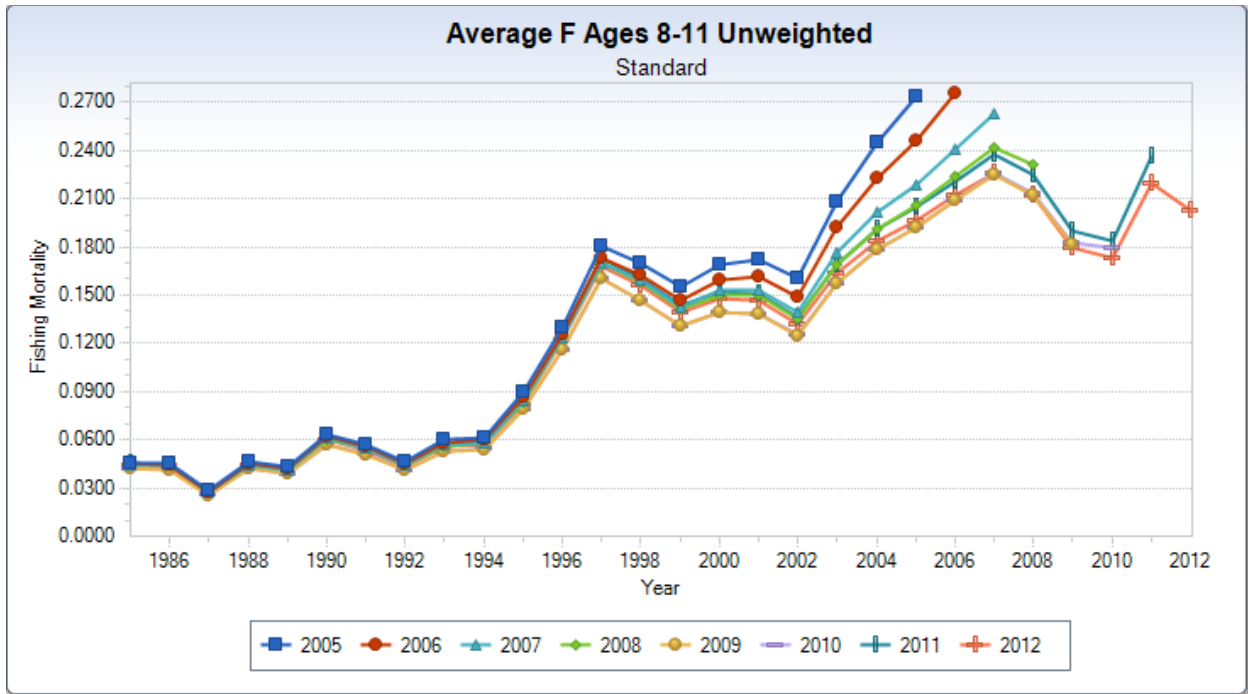
Figure B8.8. Retrospective pattern in striped bass fishing mortality from ASAP model results.
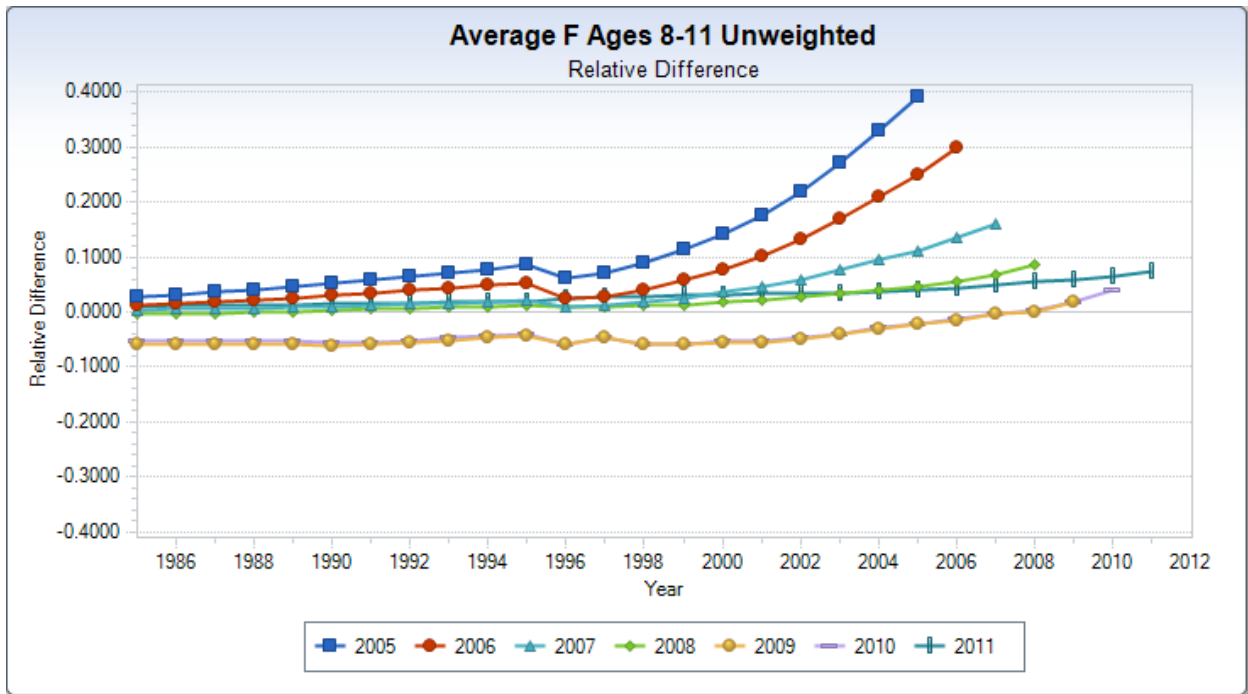
Figure B8.9. Retrospective relative differences in striped bass fishing mortality from ASAP model results.
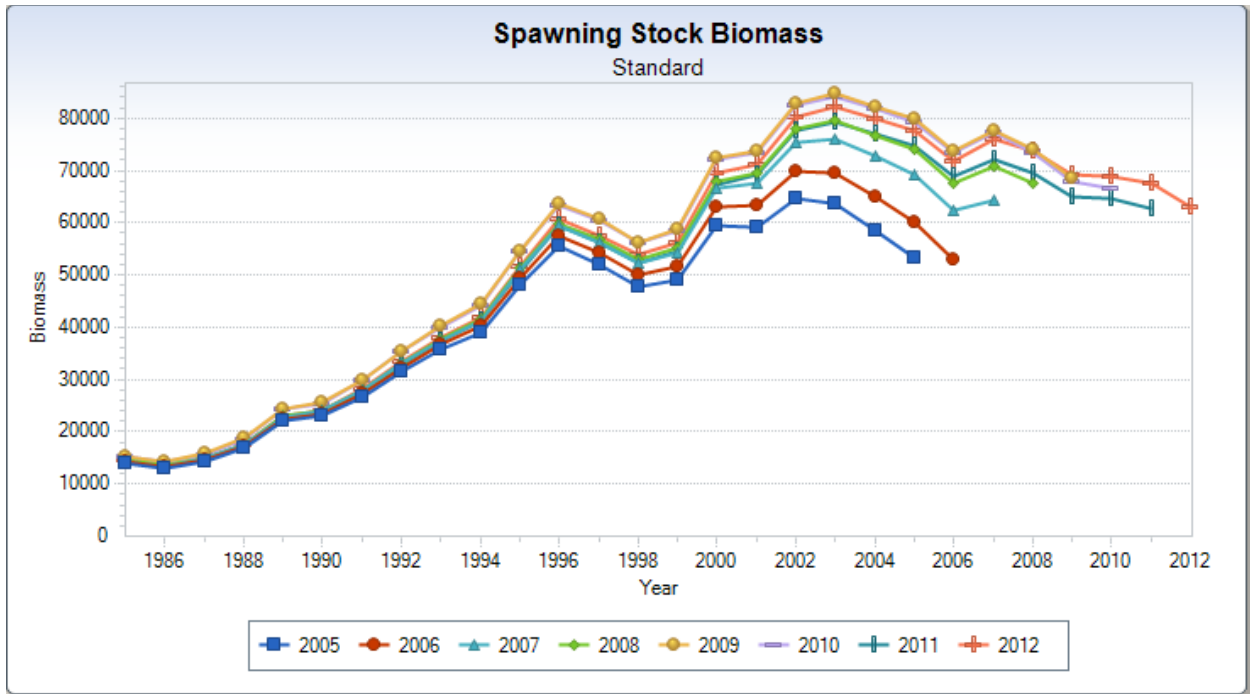
Figure B8.10. Retrospective pattern in striped bass female spawning stock biomass from ASAP model results.
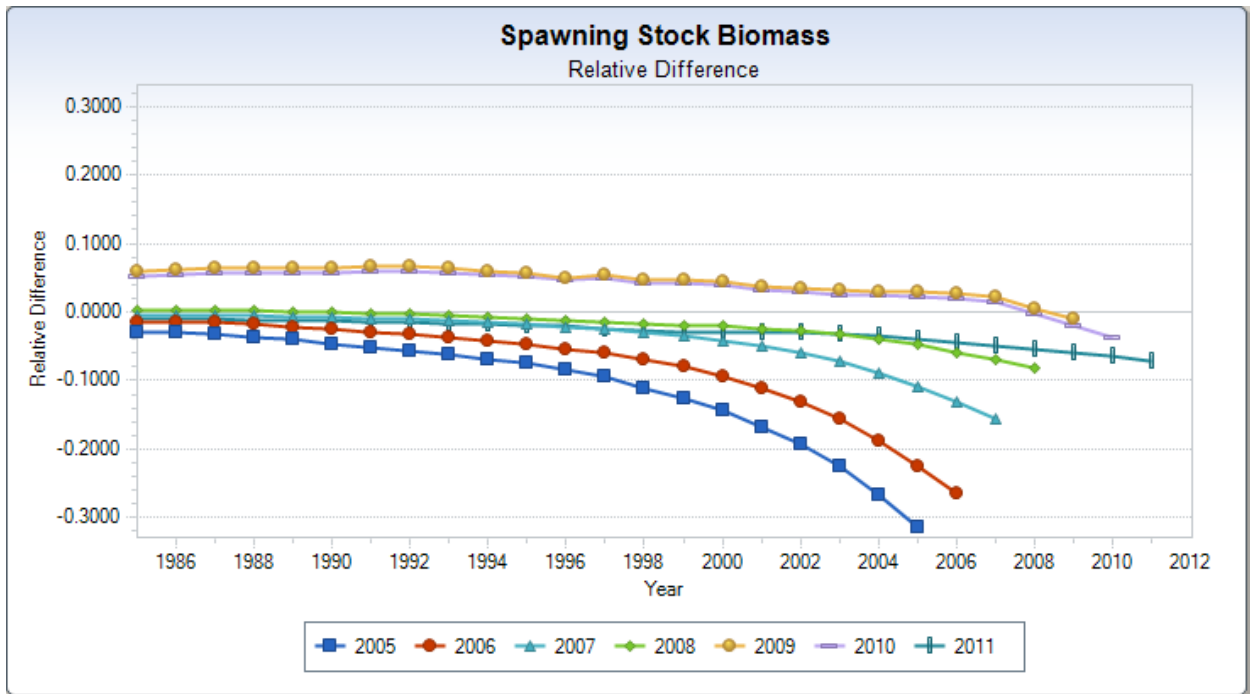
Figure B8.11. Retrospective relative difference pattern in striped bass female spawning stock biomass from ASAP model results.
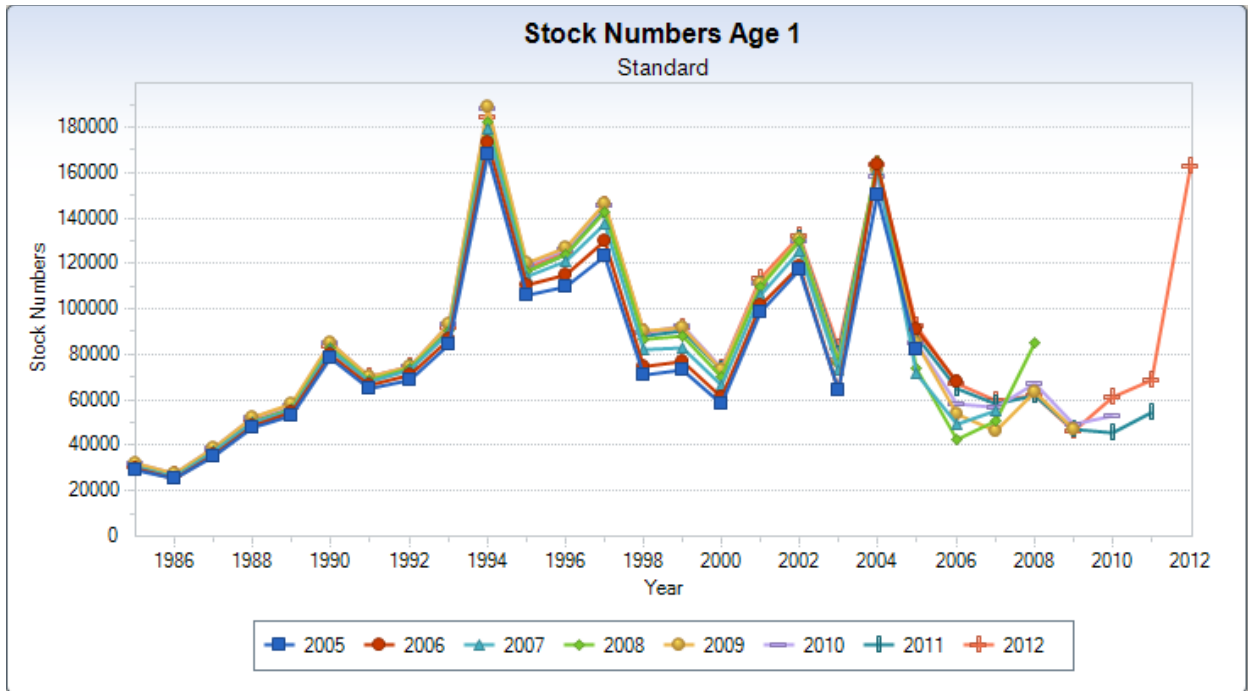
Figure B8.12. Retrospective pattern in striped bass age 1 recruitment from ASAP model results.
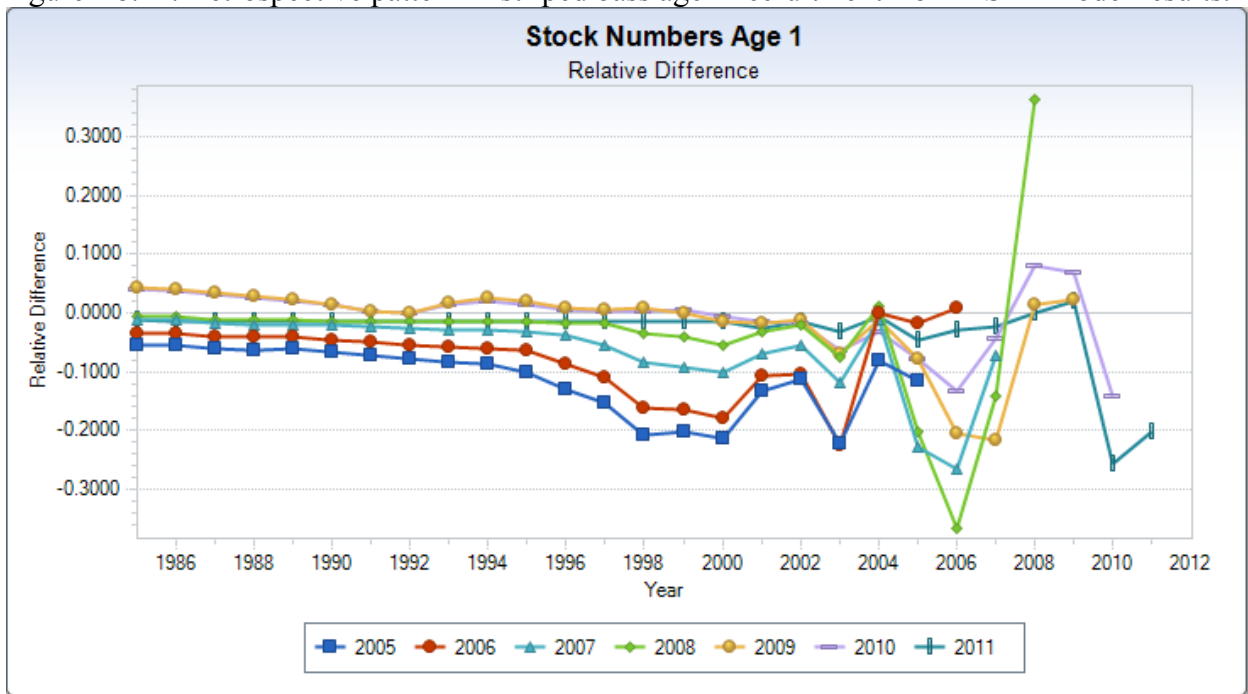
Figure B8.13. Retrospective relative difference pattern in striped bass age 1 recruitment from ASAP model results.
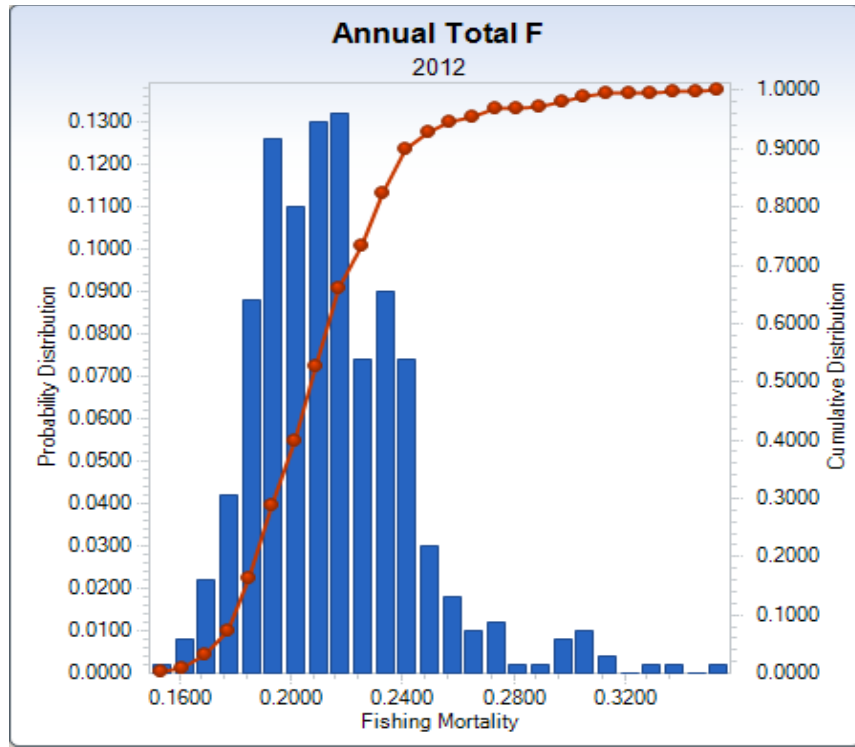
Figure B8.14. MCMC results of total 2012 striped bass fishing mortality from ASAP model results.
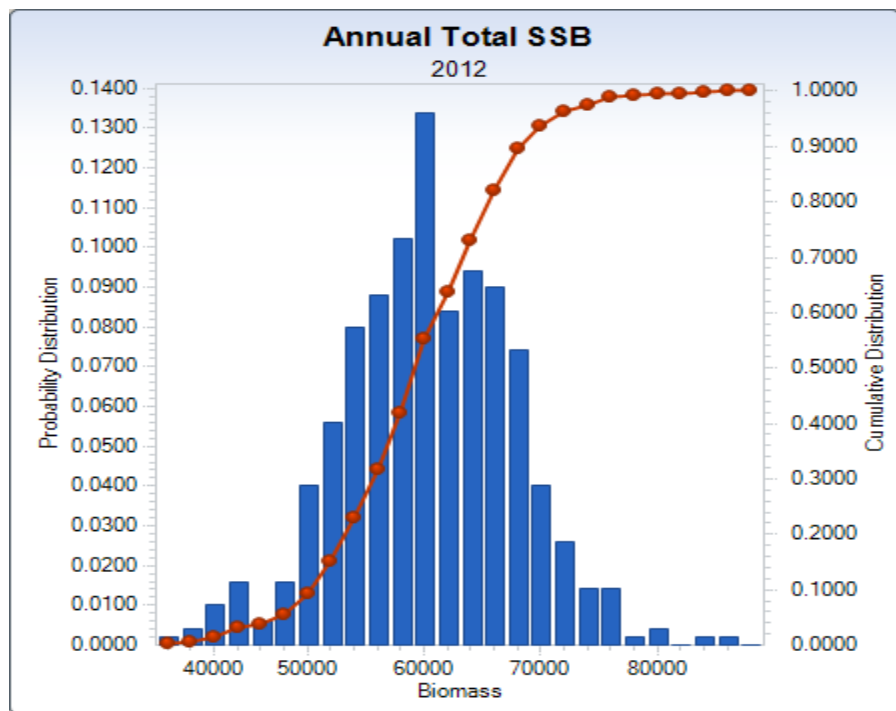
Figure B8.15. MCMC results of total 2012 striped bass female spawning biomass from ASAP model results.

Appendix B9. Estimation of Reporting Rate for Tagging Model, Input Tagging Matrices by Tagging Program, and ADMB Code for IRCR Model

B9.1 Recommendations for striped bass tag reporting rate obtained from a high reward tagging study conducted in 2007 and 2008

Tag reporting rate (λ) is an important parameter in stock assessment tagging models. In the 2011 striped bass stock assessment update, tag reporting rate estimates were used to calculate annual catch rates, live release bias, exploitation rates and survival estimates. A high reward tagging study was conducted in 2007 and 2008 to determine if the tag reporting rate had changed from the previous estimate of 0.43, obtained in 2000. The state agencies of Delaware, Maryland, New York, and Virginia combined to release 5,937 standard tags and 1,244 high reward tags, for this study. Recaptures from this study have resulted in the return of 492 standard tags and 129 high reward tags across all regions. Based on the results of this study, the tagging sub-committee agreed to three main conclusions regarding striped bass tag reporting rate. (1) Tag reporting rate differed greatly depending on which fishery sector recaptured the fish ($\lambda = 0.11$ for commercial fishers, $\lambda = 0.85$ for recreational fishers, $\lambda = 0.55$ unidentified fishers). (2) Tag reporting rate was not homogeneous throughout the striped bass stock. Regional differences in tag reporting rate were determined by the split of harvest among fishery sectors (i.e., the local ratio of commercial to recreational fishing effort drove the regional reporting rate). (3) Tag reporting rates were conditionally independent of fish size given a fishery sector. The tagging sub-committee has agreed to implement a new approach to estimating tag reporting rate. Harvest and catch and release estimates of tag reporting rate will be obtained using fishery sector specific reporting rates and tag return data for the New York producer program, the pooled data of the Delaware, Maryland and Virginia producer programs, and the pooled data of all the coastal programs. A three year moving average will be used to calculated year specific reporting rates. The adoption of this approach will provide tag reporting rates that more closely reflect the regional differences in the striped bass fishery composition

B9.1.1 Introduction

In recent assessments of the striped bass fishery, doubt was raised over the validity of low fishing mortality (F) estimates produced by the tagging models. The low F estimates obtained could reflect reality, or more likely given the recent static management of the fishery, reflect an artifact created by the tag reporting rate (λ) declining or natural mortality rate (M) increasing. Researchers at VIMS and MDDNR have undertaken a study to investigate the effects of the bacterial disease mycobacteriosis on the natural mortality rate of striped bass. Results from this work, as well as the work of several other researchers (Jiang et al. 2007; Gauthier et al. 2008) conclude that M has increased in Chesapeake Bay striped bass coincident with the onset of mycobacteriosis. These findings, while significant by themselves, do not rule out the possibility that λ has also changed in the decade since it was last estimated to be 0.43 (Kahn and Shirey 2000).

High reward tagging studies are a commonly accepted method of determining tag reporting rate in both wildlife and fisheries management (Henny and Burnham (1976); Conroy and Blandin (1984); Pollock et al. (1991); Pollock et al. (2001, 2002)). Several studies have used high reward tagging programs in the past to determine tag reporting rates for striped bass

resulting in estimates of 0.43 for the coastal fishery (Kahn and Shirey 2000), as well as 0.75 and 0.64 for the Chesapeake Bay (Rugolo and Lange 1993; Hornick et al. 2000 respectively) A high reward tagging study was organized by the striped bass tagging sub-committee, funded by NOAA Chesapeake Bay Office, and conducted in 2007 and 2008 by the State agencies of Delaware, Maryland, New York and Virginia to determine if λ had changed.

The initial analysis of the data was completed during the summer of 2009 and did not result in a consensus agreement on a new value of λ. Details of the initial data analysis are described in the 2009 striped bass stock assessment; Appendix D (ASMFC 2009) and in the 2011 striped bass stock assessment; Appendix G (ASMFC 2011). This appendix discusses the results of the 2007 -2008 high reward tagging study and the current recommendations for estimating tag reporting rate.

B9.1.2 Methods

Representatives from Delaware, Maryland, New York, and Virginia tagged and released fish in the spring of 2007 and 2008. These fish were tagged with either a standard Fish and Wildlife Service tag or a high reward tag. Fishers who captured a tag were able to report the tag to the Fish and Wildlife Service and received a hat or t-shirt for reporting a standard tag or $125 for reporting a high reward tag. Prior to the release of tagged striped bass, participating regions undertook extensive advertising campaigns at boat ramps, tackle shops, and angling clubs in order to increase awareness of the high reward tagging study in the general angling public. In addition, information about the study was circulated to all licensed commercial fisherman that would be pursuing striped bass. Any fish released less than 457mm total length was removed from the data set. This was done to ensure that the tagged population was composed of legal sized striped bass and thus representative of the group for which a tag reporting rate estimate was desired. Virginia released fish in close proximity to cooperative commercial fisherman who regularly recapture tagged fish and were believed to report tags at a rate exceeding that of the general commercial fishing sector. Thus, any fish released by Virginia that was recapture within the first week at liberty was removed from the data set. Prior to analysis, chi-square tests of independence were conducted on the raw tag recovery rates between years and between tag types to determine if data pooling was appropriate.

Estimating fishery sector specific tag reporting rates

Two methods were used to estimate fishery sector specific rates. The ratio of ratios method estimated fishery sector specific tag reporting rates using equation 1 (see below) and subsets of the data determined by which fishery sector, recreational or commercial, returned the tag. The multi-component model estimated fishery sector specific tag reporting rates as intermediate steps in the overall tag reporting rate estimation procedure (see below).

Ratio of ratios model

This method was proposed for estimating tag reporting rate in the current high reward tagging study. Estimates were obtained by comparing the rate of return of standard tags and high reward tags (equation 1) under the assumption that 100% of high reward tags encountered were returned (Henny and Burnham 1976; Pollock et al. 2002). This is essentially a ratio of ratios method, and has the form

$$\lambda_{hat} = (R_{std} / N_{std}) / (R_{high} / N_{high}) , \qquad\qquad (1)$$

where λ_{hat} is the estimated tag reporting rate for standard tags, R_{std} is the number of standard reward tags returned, N_{std} is the number of fish marked with standard reward tags, R_{high} is the number of high-reward tags returned and N_{high} is the number of fish tagged with high-reward tags. This method failed to produce credible results as discussed in ASMFC 2009 and ASMFC 2011 and is not discussed further in this appendix.

Multi-component model

The multi-component fishery tagging model proposed by Paulik (1961), Kimura (1976), and Hearn et al. (1999) and described in Pollock et al. 2002 was used. This approach allowed tag reporting rate estimates to be obtained under the more reasonable assumption that 100% of high reward tags encountered by recreational anglers were returned. This approach was further generalized to allow recreational anglers to return less than 100% of high reward tags encountered. The multi-component method produced fishing sector specific tag reporting rates as intermediate steps in the overall reporting rate estimation and can also provide regional tag reporting rate estimates through appropriate data subsetting. The multi-component approach required landings data to be used as a weighting factor. The weights used were the percentage of total landings attributed to the commercial and recreational fisheries obtained using 2007 and 2008 commercial landings data from striped bass compliance reports and MRFSS recreational landings estimates for the same time period (Table 1). Only the landings data from Delaware/Pennsylvania, Maryland, New York and Virginia were used. Information on recreational catch and release numbers was not used in calculating recreational landings as similar discard information is not readily available for the commercial fishery. The steps in calculating the multi-component lambda estimates are described below.

1). Recreational reporting rate for standard tags is calculated using equation 2

$$\lambda_{rechat} = (R_{std} / N_{std}) / ((R_{high} / N_{high}) / X), \qquad\qquad (2)$$

where λ_{rechat} is the estimated recreational tag reporting rate, R_{std} is the number of standard-reward tags returned by recreational anglers, N_{std} is the number of fish marked with standard reward tags, R_{high} is the number of high-reward tags returned by recreational anglers, N_{high} is the number of fish tagged with high-reward tags and X is the assumed percentage of high reward tags returned by recreational anglers.

2). Let Y equal the ratio of the % of total landings do to recreational fishers divided by the % of total landings do to commercial fishers. Then the commercial sector tag reporting rate is calculated using equation 3.

$$\lambda_{comhat} = \lambda_{rechat} * (C_{std} / R_{std}) * Y, \qquad\qquad (3)$$

Where λ_{comhat} is the calculated standard tag reporting rate for commercial fishers, λ_{rechat} is the estimated recreational standard tag reporting rate (equation 2), C_{std} is the number of standard-reward tags returned by commercial fishers, R_{std} is the number of standard-reward tags returned by recreational fishers and Y is as described above.

3). The number of standard tags that should have been recovered in the recreational sector is calculated as

$$R_{true} = R_{std} / \lambda_{rechat} . \qquad (4)$$

4). The number of standard tags that should have been recovered in the commercial sector is calculated as

$$C_{true} = C_{std} / \lambda_{comhat} . \qquad (5)$$

5). The sum of equation R_{true} and C_{true} is the total number of standard tags that should have been reported. The sum of R_{std} and C_{std} is the total number of standard tags that were actually reported. Thus, the overall standard reporting rate is the number of standard tags that were actually reported divided by the number of standard tags that should have been reported.

To explore sensitivity of the method to failure of the assumption of 100% recreational high reward tag return rate, rates of 100%, 95%, 90%, 85% and 80% were used in the analysis (X in equation 1). Fishery sector specific rates were calculated by state of release and with all states combined. To calculate harvest and recreational tag reporting rate, λ_{rechat} was used to estimate the tag reporting rate for recreational fishers, λ_{comhat} was used to estimate the tag reporting rate for commercial fishers and the overall standard reporting rate, calculated in step 5, was used to estimate the tag reporting rate of fishers whose sector was unknown.

Harvest and catch and release tag reporting rate calculation

Data preparation

Tag returns were separated into 457mm and 711mm groups. For each group, annual recaptures were tabulated by fishing sector (recreational, commercial or unknown) and disposition (catch and release or harvested). Recaptures made by researchers were not included when tabulating the data (Fish and Wildlife Service code R). Fish and Wildlife Service recapture code (C) was classified as commercial, (S and H) were classified as recreational and everything else was classified as unknown.

Tag reporting rate calculation

The instantaneous rates tagging model used in the striped bass assessment allows for the use of separate harvest and catch and release tag reporting rates for each year tagging data. For years up to and including 1999, 0.43 was used as the harvest and catch and release (CR) tag reporting rate. This value was estimated in a previous high reward tagging study and had historically been used as the harvest and CR rate in striped bass assessments. Harvest and CR tag reporting rates for the years 2000 - present were calculated as follows. First, an annual total observed tag return value was calculated as the sum of tag returns from the commercial, recreational and unknown fishing sectors accumulated throughout the year. Second, annual expected tag recaptures for each fishing sector were obtained by dividing the annual observed tag returns of each fishing sector by the corresponding annual fishery sector specific tag reporting rate. Third, the total annual expected tag recaptures was calculated by summing the annual expected tag recaptures for each fishing sector.

The annual fishery sector specific tag reporting rates for the years 2000 – present were calculated as follows. Linear interpolation was used to calculate the commercial, recreational and unknown tag reporting rates for the years 2000 to 2006. Linear interpolation was accomplished by assuming the fishery sector specific rates are 0.43 for all sectors in 1999 and 0.11, 0.85 and 0.55 for commercial, recreational and unknown sectors in 2007. A slope was then estimated for each fishery sector and year specific values were predicted. The estimates of 0.11, 0.85 and 0.55 were used as the commercial, recreational and unknown sector specific tag reporting rates for the years 2007 – present.

Year specific tag reporting rates and three year self-weighting moving average tag reporting rates were calculated. The three year moving average (average) rates were calculated to smooth the time series of year-specific tag reporting rate estimates. The average rates were calculated using tag return data from the target year as well as data from one year before and one year after to calculate the target year tag reporting rate. For the year at the beginning of the time series, for which there is no year before, the average rate was calculated using data from the target year and the year after. Likewise, for the year at the end of the time series, the average rate was calculated using the data from the target year and one year before. The average rates are self-weighted because they were calculated using pooled raw data rather than simply averaging three year specific estimates of tag reporting rate. Thus, years with more data contributed more to the average. Once the data from the appropriate years was pooled, the method for calculating the average harvest or catch and release tag reporting rate was identical to the year specific method described above.

B9.1.3 Results

Release recapture data is tabulated by state with release and recapture numbers summed over both years of release and all years of recapture (Table 2). The total number of tags released differs by state, but the percentage of tags released by each state that were high reward was fairly constant, ranging between 16 and 19%.

Chi-square tests of independence

Chi-square tests indicated that the return rate of standard tags was significantly different between 2007 and 2008 (p =0.019). The return rate of standard tags released in 2008 (0.128) was significantly greater than the return rate of standard tags released in 2007 (0.107). Separate tests of the high reward tags and the pooled high reward and standard tags did not show significant differences between the annual return rates for these two groups (p=0.40 and p=0.092 respectively).

Chi-square tests indicated that the return rate of standard tags was significantly different among regions of release (p < 0.001). The return rates for standard tags were 0.14, 0.09, 0.16, and 0.07 for Delaware, Maryland, New York, and Virginia respectively. The return rates of high reward tags were 0.21, 0.14, 0.15, and 0.12 for Delaware, Maryland, New York, and Virginia respectively. Chi-square tests indicate that the high reward tag return rates were marginally significantly different (p= 0.041). This result was likely do to the relatively high return rate for Delaware. The return rates for the pooled standard and high reward tags differed significantly by region of release (p < 0.001). Tests indicate that return rates of tags were not independent of

region and should not be pooled across this factor. Pooling across years appeared to be acceptable.

Fishery sector specific tag reporting rates

Tag reporting rates, for the recreational and commercial fishery as well as an overall rate where all tags were combined, were estimated using the multi-component model. Sensitivity to the failure of the 100% recreational high reward tag-return rate assumption was explored and a consensus was reached to use 90% as the high reward tag return rate assumption for recreational anglers. Using the total data from table 2, the multi-component model estimated an overall standard tag reporting rate of 0.55, a recreational standard tag reporting rate of 0.85 and a commercial standard tag reporting rate of 0.11. Regional analysis of the data was done and the assumption of 90% high reward tag return rate for recreational anglers was used for this analysis as well. Standard tag reporting rate estimates for recreational anglers were fairly consistent among Delaware (0.83), Maryland (0.70), and Virginia (0.75), with New York standing out with an estimate of 102% standard tag reporting rate for recreational anglers (Table 3). Standard tag reporting rate by the commercial fishery was consistently low with an estimated 2% reported in Delaware, 11% reported in Maryland, 34% reported in New York, and 28% reported in Virginia (Table 3). Overall standard tag reporting rate varied widely by region, with estimated reporting rates of 26% in Delaware, 39% in Maryland, 91% in New York, and 62% in Virginia (Table 3).

Harvest and catch and release tag reporting rates

Linear interpolation of fishery sector specific rates between 1999, where all rates are fixed at 0.43 and 2007 where the rates are fixed at 0.55, 0.85 and 0.11 for other, recreationally, and commercially caught tags respectively, are presented in Table 4. Year specific and average estimates of tag reporting rate were obtained for harvested and catch and release fish for each state that participated in the high reward tagging study (Table 5 and Figure 1). Average rates, for all individual States, were much less volatile than the year specific rates. Data sets from Delaware, Maryland and Virginia were combined to bolster sample size especially for commercial returns (Table 6). Tag reporting rate trends for New York suggested that they would be better served estimating their own tag reporting rate. Estimates for the coastal programs (Massachusetts, North Carolina, New Jersey and New York) have yet to be obtained using this method; however, preliminary results obtained using coastal program tag return data from 2007 and 2008 shows that a single harvest and catch and release tag reporting rate can be used for all coastal tagging programs (Table 7). Estimates obtained from the preliminary study of 0.72 for catch and release and 0.51 for harvested fish will be used as the tag reporting rates in then Instantaneous rates model for the years 2007 and beyond. For years prior to and including 1999, the coastal programs will use 0.43 as the tag reporting rate for both harvest and catch and release. For the years 2000 – 2006 the coastal program will use values calculated using linear interpolation between 0.43 and the harvest and catch and release values for 2007 presented above (Table 6).

B9.1.4 Discussion

The analysis of the high reward tagging study data revealed four important findings. (1) The assumption of 100% reporting of high reward tags was clearly violated as evidenced by preliminary estimates of standard tag reporting rate exceeding 100% for New York, (2) Estimates of standard tag reporting rate varied widely when the data from the four producer programs were analyzed separately (3) Estimates of harvest and catch and release tag reporting rate were similar among the four coastal area tagging programs and (4) Regardless of location (producer or coastal tagging program), the tag reporting rates of standard reward tags were dramatically different for the commercial and recreational fishing sectors.

Annual variability in harvest and catch and release tag reporting rate estimates resulted from a combination of sampling error and real differences in the annual fishery composition. Tag returns for most of the programs have been historically low and have continued to decline in recent years. This has likely only served to inflate the magnitude of the sampling error. Use of a three year moving average was implemented to smooth the estimated time series of tag reporting rates in order to better capture the temporal trends in fishery composition and tag reporting rate. It was originally determined that each producer area program would generate a separate time series of harvest and catch and release tag reporting rates and a single time series would be used for the coastal program. A single time series of rates was used for the coastal program because preliminary analysis produced very similar results for the individual coastal tagging programs of Massachusetts, New Jersey/ Delaware, New York, and North Carolina. Individual producer area program results were noisy, due primarily to low sample sizes tied to a severe lack of tagging study cooperation from the commercial fishing sector. Data from Virginia, Maryland and Delaware were pooled to boost sample size because these three regions all have significant exposure to commercial fisheries and the time series trends of their individual tag reporting rates showed similar patterns. New York used reporting rates generated from their tagging data and the coastal programs used the single reporting rate time series generated with their data.

There are two main sources of error in the estimation of tag reporting rates as outlined above. First, the fishery sector specific estimates of tag reporting rate may be incorrect. The estimates obtained are dependent on the assumptions of recreational high reward tag reporting rate as well as the weighting scheme used to estimate commercial recoveries, both of which could be incorrectly specified. This represents a significant source of error especially surrounding the commercial tag reporting rate since it is so low. Second, extrapolation of estimates of tag reporting rate through time can introduce two other potential sources of error. Behavior of the fishery sectors to tagging studies may change and the composition of the fishery may change. The method described above allows for the latter source of uncertainty, changes in the composition of the fishery, to be accounted for during extrapolation. Changes in behavior of the fishery sectors cannot be accounted for and would require the use of periodic high reward tagging studies to re-estimate the fishery sector specific tag reporting rates.

The extremely low tag reporting rate of commercial fishing sector represents a significant source of error in this analysis. Tag reporting rates are known to have asymmetric errors, such that even small errors in our ability to estimate the commercial tag reporting rate are propagated into large errors in the harvest and catch and release tag reporting rate estimation. The accuracy of this approach to estimating tag reporting rate would benefit greatly from increased commercial cooperation with tagging studies. The entirety of the tagging assessment methodology would benefit from exploring ways to either increase commercial cooperation with

the tagging programs or pursue methods by which estimates of fishing mortality rates could be obtained in the absence of tagging data from the commercial fishery.

B9.1.5 Acknowledgments

B9.1.6 Literature cited

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Table 1. Recreational and commercial landings of striped bass, in number of fish. Recreational data was obtained from MFRSS including wave 1 estimates and commercial data was obtained from state annual compliance reports.

	Recreational Landings				Commercial Landings			
Year	DE	MD	NY	VA	DE	MD	NY	VA
2007	10,096	679,024	370,722	366,964	30,717	598,495	78,287	140,602
2008	16,994	442,280	448,271	396,950	31,866	594,655	73,263	134,603

Table 2. Numbers of releases and recaptures of standard and high reward tags included in the high reward tagging data analysis. Tag numbers for DE represent releases of animals by both Delaware and Pennsylvania.

	Standard tags			High reward tags		
		Recaptures			Recaptures	
State	Releases	Commercial	Recreational	Releases	Commercial	Recreational
DE	734	4	72	141	1	15
MD	742	8	50	173	3	15
NY	1991	12	196	448	4	39
VA	2470	18	132	482	21	31
Total	5937	42	450	1244	29	100

Table 3. Estimated fishery specific tag reporting rates for the commercial, recreational and unknown fishing sectors. Combined estimate was obtained by pooling raw tag return data from the four States.

Data set	Commercial	Recreational	Unknown
Delaware	0.02	0.83	0.26
Maryland	0.11	0.70	0.39
New York	0.34	1.02	0.91
Virginia	0.28	0.75	0.62
Combined	0.11	0.85	0.55

Table 4. Annual fishery specific tag reporting rates calculated using linear interpolation. For each fishery sector a slope was calculated using the values for 1999 and 2007. All values were rounded to the nearest $1/100^{th}$ of a percent.

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007
Comm.	0.43	0.39	0.35	0.31	0.27	0.23	0.19	0.15	0.11
Rec.	0.43	0.48	0.54	0.59	0.64	0.69	0.75	0.80	0.85
Other	0.43	0.45	0.46	0.48	0.49	0.51	0.52	0.54	0.55

Table 5. Year specific and three year moving average estimates of tag reporting rate calculated for the four producer area programs. Estimates are displayed based on disposition (harvest or catch and release) of the fish at time of recapture. Tag reporting rate for all producer programs and both recapture dispositions is fixed at 0.43 for all years prior to 2000.

| | | Harvest | | | | | | | | | | | |
State	Lambda type *	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Delaware /	yr.	0.42	0.42	0.43	0.44	0.34	0.38	0.31	0.19	0.34	0.22	0.36	0.85
Pennsylvania	3 yr avg.	0.42	0.43	0.43	0.39	0.38	0.34	0.27	0.26	0.23	0.29	0.30	0.46
Maryland	yr.	0.45	0.49	0.51	0.48	0.46	0.46	0.39	0.36	0.45	0.43	0.44	0.53
	3 yr avg.	0.47	0.48	0.49	0.48	0.47	0.43	0.41	0.39	0.41	0.44	0.47	0.49
New York	yr.	0.47	0.50	0.54	0.59	0.56	0.56	0.66	0.63	0.51	0.57	0.63	0.67
	3 yr avg.	0.49	0.50	0.54	0.56	0.57	0.59	0.61	0.59	0.56	0.56	0.62	0.65
Virginia	yr.	0.48	0.54	0.59	0.64	0.66	0.64	0.74	0.68	0.64	0.53	0.74	0.59
	3 yr avg.	0.51	0.53	0.58	0.64	0.65	0.68	0.69	0.68	0.62	0.62	0.61	0.68

| | | Catch and Release | | | | | | | | | | | |
State	Lambda type *	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Delaware /	yr.	0.46	0.51	0.59	0.50	0.35	0.61	0.80	0.26	0.19	0.85	0.24	0.11
Pennsylvania	3 yr avg.	0.48	0.50	0.52	0.47	0.51	0.57	0.55	0.33	0.35	0.31	0.32	0.21
Maryland	yr.	0.47	0.49	0.56	0.62	0.49	0.57	0.61	0.85	0.85	0.54	0.38	0.66
	3 yr avg.	0.48	0.50	0.55	0.56	0.56	0.55	0.64	0.72	0.74	0.50	0.50	0.49
New York	yr.	0.48	0.52	0.56	0.63	0.67	0.65	0.73	0.59	0.74	0.78	0.85	0.73
	3 yr avg.	0.50	0.52	0.58	0.62	0.65	0.68	0.66	0.69	0.69	0.78	0.79	0.80
Virginia	yr.	0.47	0.51	0.56	0.64	0.55	0.75	0.80	0.52	0.46	0.63	0.60	0.40
	3 yr avg.	0.49	0.50	0.56	0.58	0.62	0.67	0.63	0.57	0.53	0.56	0.57	0.53

* yr. - year specific tag reporting rate
3 yr avg. - three year moving average

Table 6. Estimated tag reporting rates for the combined data of the Delaware / Pennsylvania, Maryland and Virginia producer programs, the New York producer program, and the combined coastal tag programs. Year specific and three year moving average estimates are displayed based on disposition (harvest or catch and release) of the fish at time of recapture. Tag reporting rate for all programs and both recapture dispositions is fixed at 0.43 for all years prior to 2000.

| | | | | | | | Harvest | | | | | | |
State	Lambda type *	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
DE/MD/VA	yr.	0.46	0.50	0.53	0.52	0.52	0.51	0.46	0.51	0.51	0.46	0.53	0.61
	3 yr avg.	0.48	0.49	0.52	0.52	0.52	0.50	0.49	0.49	0.49	0.49	0.52	0.56
New York	yr.	0.47	0.50	0.54	0.59	0.56	0.56	0.66	0.63	0.51	0.57	0.63	0.67
	3 yr avg.	0.49	0.50	0.54	0.56	0.57	0.59	0.61	0.59	0.56	0.56	0.62	0.65
Coastal	yr.	0.44	0.45	0.46	0.47	0.48	0.49	0.50	0.51	0.51	0.51	0.51	0.51

| | | | | | | Catch and Release | | | | | | | |
State	Lambda type *	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
DE/MD/VA	yr.	0.47	0.50	0.55	0.62	0.51	0.65	0.70	0.58	0.53	0.59	0.42	0.47
	3 yr avg.	0.48	0.50	0.55	0.56	0.59	0.61	0.64	0.61	0.57	0.50	0.48	0.44
New York	yr.	0.48	0.52	0.56	0.63	0.67	0.65	0.73	0.59	0.74	0.78	0.85	0.73
	3 yr avg.	0.50	0.52	0.58	0.62	0.65	0.68	0.66	0.69	0.69	0.78	0.79	0.80
Coastal	yr.	0.47	0.50	0.54	0.57	0.61	0.65	0.68	0.72	0.72	0.72	0.72	0.72

    * yr. - year specific tag reporting rate
      3 yr avg. - three year moving average

Table 7. Summary of coastal tagging program tag return data from 2007 and 2008 and results of tag reporting rate analysis for harvested and catch and release fish. Adj. Comm and Adj. Rec values were obtained by dividing Comm. Recaps and Rec. recaps by the fishery specific tag reporting rate estimates of 0.11 and 0.85 respectively. Reporting rates are calculated as Obs. Recaps divided by Adj. Recaps.

Catch and Release

	MA	NY	NJ/DE	NC	Total
Comm. Recap	1	0	1	3	5
Rec. recap	26	9	65	75	175
Obs. recaps	27	9	66	78	180
Adj. Comm	9	0	9	27	45
Adj. Rec	31	11	76	88	206
Adj. recaps	40	11	85	115	251
Reporting rate	0.68	0.82	0.78	0.68	0.72

Harvest

	MA	NY	NJ/DE	NC	Total
Comm. Recap	16	4	19	26	65
Rec. recap	91	24	190	217	522
Obs. recaps	107	28	209	243	587
Adj. Comm	145	36	173	236	590
Adj. Rec	107	28	224	255	614
Adj. recaps	252	64	397	491	1204
Reporting rate	0.42	0.44	0.53	0.49	0.51
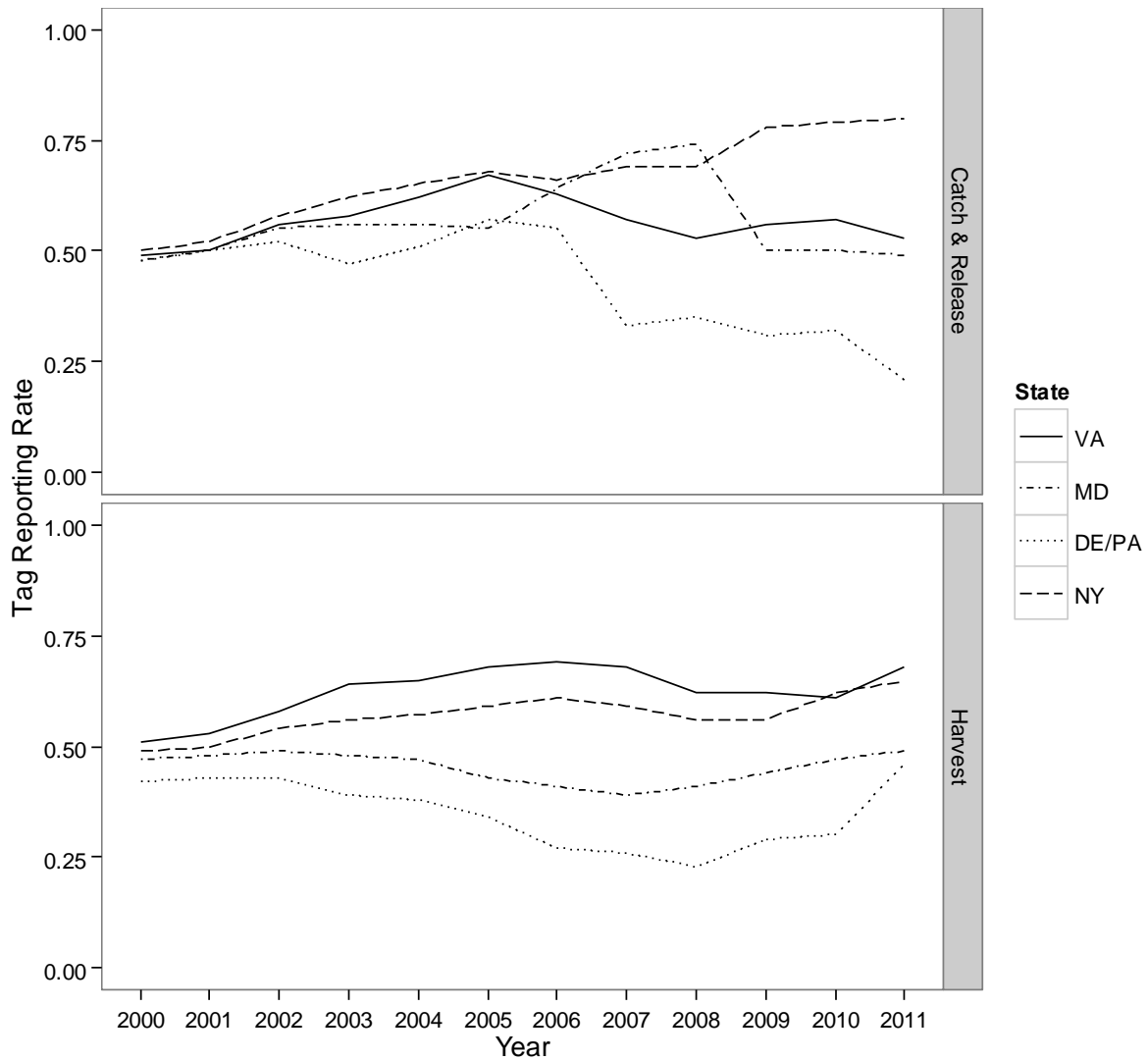
Figure 1. Three year moving average estimates of striped bass tag reporting rate for the four producer programs. Results are presented for harvested and catch and release fish. Tag reporting rate for all regions and both recapture dispositions is fixed at 0.43 for all years prior to 2000.

B9.2 Input Matrices for Tagging Model

Coastal Programs
MADFW - ≥ 28"

Release Number	Year	Harvested recaptures																			
		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
329	1992	4	9	9	10	8	4	1	2	3	1	1									
651	1993		12	20	13	21	20	12	9	3	1	3	2	1							
461	1994			6	14	26	17	13	7	2	2	2	1		1			1			
218	1995				3	9	8	4	2	2	1		2			1		1			
271	1996					8	8	13	6	8	1	2	2		2						
118	1997						8	4	2	3	1	1		1		1	1				
219	1998							6	14	5	4	4	4								
59	1999								2	3	1	2							1		2
163	2000									9	3	5	3	3		1	1		1		1
411	2001										12	18	10	9	9	3		1	2	1	2
352	2002											10	12	11	6	4	3	2	1		
172	2003												8	3	5	4			5		
613	2004													24	18	9	9	6	5		4
541	2005														15	20	9	13	3	2	4
509	2006															19	9	13	11	11	1
322	2007																7	15	10	1	4
480	2008																	15	19	13	7
385	2009																		17	9	17
457	2010																			14	17
308	2011																				10

Release Number	Year	Released (Event 1 only)																			
		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
329	1992	12	13	5	3				1												
651	1993		15	16	12	5	1	3	2	1											
461	1994			13	6	5	4	4			1										
218	1995				11	4	1	1	2	2											
271	1996					12	5	3	2	2	1										
118	1997						7	4	1			1									
219	1998							8	6	3	2		1		1						
59	1999								2	1											
163	2000									1	2	3		1							
411	2001										6	5	6	2	1	1		3			
352	2002											14	2	3	3	3	1				
172	2003												1	1	1	2					
613	2004													6	7	4	3	1	1		1
541	2005														8	5	2	1			
509	2006															11	4	1	3		
322	2007																3	4		1	
480	2008																	6	5	3	1
385	2009																		4	3	7
457	2010																			7	3
308	2011																				6

NYOHS/TRL - ≥ 28"

Harvested recaptures

Release Number	Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
214	1988	2	3	4	7	2	3	2		2			2												
342	1989		2	9	10	8	10	4	3	1	2	1			2										
246	1990			5	7	5	3	3		1	1	2													
281	1991				15	9	6	3	4	1	4	2	1	1											
287	1992					13	11	6	13	3	3	4	1		1			1							
236	1993						13	8	11	4	5		1												
254	1994							8	11	17	15	5	4	1	3	1	1								
353	1995								31	26	17	14	6	5	1	1	4	1							
110	1996									6	4	7	5	1				1	1						
70	1997										10	4	4		1	1	1		2						
82	1998											6	4	3			1								
85	1999												12	4	3			4							
56	2000													3	5	2	3	1							
93	2001														4	5	7	3	1						
176	2002															17	8	3		3		3	3		1
146	2003																10	4	6	1		1	2		1
154	2004																	8	2	2	1	2	1		1
64	2005																		7	2	1	4	1		
57	2006																			3	5	5			1
25	2007																							1	
144	2008*																					4	7	8	3
26	2009*																							1	1
38	2010*																							2	2
142	2011*																								6

Released (Event 1 only)

Release Number	Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
214	1988	21	10	9	2	2	3	1	1																
342	1989		30	17	14	5	3	3																	
246	1990			16	9	4	3																		
281	1991				17	10	4	2	1	1	2	1													
287	1992					25	10	8	4	2		2													
236	1993						14	3	3	2															
254	1994							17	6	3	5	1	1			1									
353	1995								23	10	6		1					2							
110	1996									8		6					1						1		
70	1997										3					1									
82	1998														1	1									
85	1999												2	1	1		1								
56	2000													4	1		1	1							
93	2001														4	1	2								
176	2002															13	1	2							
146	2003																4	1					1		
154	2004																	8	2	1					
64	2005																		2						
57	2006																				2				
25	2007																					3			
144	2008*																					4	4	3	
26	2009*																						2		
38	2010*																								1
142	2011*																								2

* NY OHS 1988-2007, NY TRL 2008-2011

NJDB - ≥ 28"

Harvested recaptures

Release Number	Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
38	1989		2	4		1	1																	
9	1990			1																				
15	1991			1					1	1														
76	1992					1		1																
91	1993					3	1	2	2	3		1												
308	1994						5	9	10	11	9	4	3	2	1	1								
552	1995							22	30	18	16	10	5	3	3	4	2	1	2	1	1			
589	1996								47	18	30	12	6	5	3	3	6	2		1			2	
68	1997									7	2	1	1		3									
126	1998										19	5	5	2		4	1	1						
101	1999											3	3	5	1		1	3	1					
233	2000												13	15	8	9	6	4		1	1		1	1
522	2001													33	26	21	14	6	5	1	4		1	
359	2002														16	12	11	9	2	3	2		3	
564	2003															34	13	19	5	7	4	4	1	1
847	2004																52	30	17	17	15	11	4	3
180	2005																	12	5	7	3	4	5	
225	2006																		13	7	9	6	2	1
434	2007																			23	22	11	11	6
518	2008																				30	27	18	12
337	2009																					33	10	9
339	2010																						18	13
525	2011																							27

Released (Event 1 only)

Release Number	Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
38	1989	4	1	5	2					1														
9	1990		2					1																
15	1991			2		1				1														
76	1992				7	5	5			1														
91	1993					5	3	3								1								
308	1994						24	16	9	6	2	1	1			1								
552	1995							34	23	18	13	4	1	3			1							
589	1996								36	17	17	2	6	1	2	2	2						1	
68	1997									5														
126	1998										2	5	3	1			1							
101	1999											6	3	2	4	2								
233	2000												10	5	4	4	1	1						
522	2001													20	13	4	3	3	1	1				
359	2002														12	13	6	2		1			1	
564	2003															26	17	10	4	1	3	1		
847	2004																50	19	5	2	3		1	
180	2005																	12	6	5		1	3	1
225	2006																		12	5	4	1		1
434	2007																			16	7	11	3	3
518	2008																				18	7	9	3
337	2009																					10	6	3
339	2010																						8	10
525	2011																							20

NCCOOP - ≥ 28"

Harvested recaptures

Release Number	Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
191	1988	4	3	4		6	3	2			1														
411	1989		6	7	7	11	4	2	2	1	1		1												
322	1990			11	6	11	5	1	2	2	2	2	1												
856	1991				23	19	23	20	16	5	11	7	1	1	1	1									
433	1992					22	11	7	10	7	6	7	5	2											1
142	1993						6	3	5	3	2	1													
480	1994							14	16	7	6	5	6	1	3	1	2	2							
372	1995								21	13	16	11	5	2	2	5	1	1	2			1			
557	1996									26	17	12	3	3	3	4		3	1	1					
869	1997										67	31	16	9	11		3	3	1		1		1		
106	1998											9	7		2	1	1					1			
179	1999												18	5	5	2		2	2	1	1		2		
164	2000													4	6	1	2	3	2	1					
515	2001														32	18	11	3	9	6	1				
789	2002															39	31	20	13	7	3	1			1
1,578	2003																75	53	29	16	12	7	6	4	3
784	2004																	40	18	15	11	5	3	2	4
557	2005																		17	16	9	5	4	1	1
2,113	2006																			107	80	46	25	22	11
305	2007																				24	20	9	3	6
923	2008																					73	39	27	15
121	2009																						2	3	1
411	2010																							12	9
103	2011																								9

Released (Event 1 only)

Release Number	Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
191	1988		8	5	2	3	1	3					1												
411	1989		17	13	11	3	3	1							1										
322	1990			14	11	5	3	1																	
856	1991				45	18	23	14	2	2	1	1													
433	1992					23	17	7	4	1	2	3		1											
142	1993						8	2		1															
480	1994							26	8	1	4	1													
372	1995								22	2	1	3		1											
557	1996									8	3	3	2	2	1										
869	1997										18	13	9	5	1			1				2			
106	1998											3	4							1					
179	1999												3	3				1				1			
164	2000													4		1	1								
515	2001														11	3	4	1	2	2		2			
789	2002															12	11	1	5	3	1	1			
1,578	2003																27	12	8	9	3			1	1
784	2004																	17	8	10	5	1	1		
557	2005																		8	5	1	2	1		
2,113	2006																			44	23	11	6	5	1
305	2007																				7	2	2		
923	2008																					23	11	4	5
121	2009																						2		
411	2010																							3	
103	2011																								5

Producer Area Programs

HUDSON - ≥ 28"

Release Number	Year	Harvested recaptures																							
		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
277	1988	11	9	7	9	6	3	2	1	4		1													
387	1989		9	13	9	4	5	7	4						1		1								
445	1990			17	14	11	8	4	4	1	3	1													
364	1991				14	14	8	5	9	5	2	1					1			1	1				
699	1992					34	27	16	11	11	10	7	3	2	1			1							
536	1993						33	16	10	16	10	5	5		1				1						
381	1994							17	24	21	8	6	4	4	4	2	2								
461	1995								27	23	20	18	10	1	1	1	1	1	1						
681	1996									63	43	27	12	2	7	2	3	3	1	1					
184	1997										22	7	8	5	3	2	1		1	1					
530	1998											47	29	13	7	13	5		1	2		1			
503	1999												43	13	21	9	12	4	2	3	1	3	1		1
485	2000													27	17	13	8	8	6	3	3			1	
576	2001														32	23	12	6	5	8	1	3			
196	2002															16	8	7	2	5	3	1	2	1	
677	2003																39	35	25	10	11	3	1		4
649	2004																	55	25	24	14	5	2	4	1
574	2005																		40	29	16	8	4	7	
707	2006																			44	30	28	9	7	8
399	2007																				26	20	10	5	6
540	2008																					33	26	19	8
396	2009																						31	25	13
458	2010																							37	19
242	2011																								22

Release Number	Year	Released (Event 1 only)																							
		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
277	1988	14	21	11	2	4	2	2		1						1									
387	1989		33	16	7	5	1	2																	
445	1990			45	16	16	4	4							1										
364	1991				23	17	5	4			3			1											
699	1992					54	30	18	10	2	3	3	2												
536	1993						42	20	13	4	5	2	2												
381	1994							26	8	5	2		2	1											
461	1995								23	11	10	3	1	3		1									
681	1996									26	24	6	6	1	2	2		1	2		1				
184	1997										7	4	4	1			1								
530	1998											19	16	4	2	7	1								
503	1999												20	9	6	3	2	3	1	1					
485	2000													18	6	9	10	5							
576	2001														16	16	2	1	1	2	1		1		
196	2002															4	3	2	2	2	1	1	1	1	
677	2003																25	9	10	7	2	1			
649	2004																	19	9	10	4	2		1	2
574	2005																		19	15	5	6			
707	2006																			17	10	7	4		1
399	2007																				9	7	5	2	2
540	2008																					16	8	3	2
396	2009																						13	11	4
458	2010																							12	10
242	2011																								5

DE/PA - ≥ 28"

Release Number	Year	Harvested recaptures																		
		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
52	1993	3	6	1	4	3	2		1											
81	1994		4	6	4	1	2	1												
173	1995			11	7	2	6	2	4	1										
110	1996				14	3	5	2	2	2	1	1	1					1		
107	1997					14	5	4		4								1		
206	1998						26	7	5	2	4	3	1	1	1		2			
107	1999							8	10	2	2	3	1				1			
148	2000								20	10	2	3		3		1				
220	2001									28	10	9	6	5	3		2	3	1	1
139	2002										14	4	2	3	1	2		1		
286	2003											20	13	10	6	2		3	2	4
168	2004												16	7	5	3		1	2	4
110	2005													7	7	1	1	2	1	1
180	2006														16	7	3	2	2	4
125	2007															8	4	1	1	
140	2008																6	5	2	1
127	2009																	12	6	10
147	2010																		14	7
185	2011																			9

Release Number	Year	Released (Event 1 only)																		
		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
52	1993	2	2																	
81	1994		3	4	2															
173	1995			8	5	5		1												
110	1996				4	3	3		2											
107	1997					2	1	1												
206	1998						6	2	1	1	1									
107	1999							2	2											
148	2000								4	2	2	1		1						
220	2001									3	4									
139	2002											8		2						
286	2003											13	8	3		2			1	
168	2004												3	2	1	1				
110	2005													5	2	1				
180	2006														4	1	1			
125	2007															3			1	
140	2008																1	2	1	
127	2009																	3		
147	2010																		7	6
185	2011																			5

MDCB - ≥ 28"

Harvested recaptures

Release Number	Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
29	1987						2	1				1														
129	1988		2	1	3	7	2		1	1																
220	1989			3	7	3	3	2	1	5	2															
305	1990				10	8	5	3	1	3		3	1													
395	1991					19	10	13	3	7	3	4	1			2										
436	1992						21	15	11	14	4	8	6	3	2	1										
627	1993							31	25	30	13	14	7	8	1	3	2									
548	1994								25	27	20	16	10	8	4	2			1							
529	1995									45	24	19	12	4	5	2	2	3			2		1			
862	1996										61	35	36	14	6	7	2	1	1							
335	1997											33	19	15	1	2	1	1								
242	1998												23	13	2	3	2			1		1				
177	1999													16	5	6	2	1	2	1		1	1			
248	2000														18	12		4	4	1		2	1		2	
469	2001															21	10	10	5	2	3		1		1	
324	2002																13	18	5	6		3		1		
324	2003																	14	9	8	6	2	3			
367	2004																		13	7	9	2	3	1	1	2
334	2005																			16	11	6	4	2	1	1
235	2006																				14	4	4	4	3	
154	2007																					6	4	3	2	1
128	2008																						6	3	3	3
255	2009																							18	7	1
198	2010																								8	
285	2011																									17

Released (Event 1 only)

Release Number	Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
29	1987			2		1																				
129	1988		4	7	4	7	3	1	2																	
220	1989			6	10	14	3	2	2																	
305	1990				13	8	7	2	1	1			1													
395	1991					26	13	7	2	2		1														
436	1992						23	15	8	2	3	2		2												
627	1993							29	18	11	2	2	1	1												
548	1994								27	15	4		5	2		1		1		1						
529	1995									18	7	6	3	3	1											
862	1996										36	19	7	3	2											
335	1997											8	7	2	1				1							
242	1998												7	3	1	2										
177	1999													3	3	2	1									
248	2000														3	4	4	1								
469	2001															10	9	1	1	1						
324	2002																5	2	1	1	2					
324	2003																	8	2	1	2	2				
367	2004																		4	2	2	1	1		1	1
334	2005																			5	4	1		1		
235	2006																				3	2	2			1
154	2007																					2	1			
128	2008																						1		1	
255	2009																							3	4	1
198	2010																								3	3
285	2011																									3

VARAP - ≥ 28"

Harvested recaptures

Release Number	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
301	1990	10	1	6	1	3	5	1			1	1			1								
390	1991		19	10	12	9	2	1	2		2				1								
40	1992			2	1	1	1				1												
212	1993				11	11	5	2	3														
123	1994					4	4	4	1														
210	1995						18	6	5	2	1	1	2		1								
67	1996								3	1			1										
212	1997								11	12	6	2		1	1	1							
158	1998									16	9	1	3	1									
162	1999										13	2	1	2	1							1	
365	2000											13	11	6	5	3	3		1				
269	2001												9	8	2	6	1						
122	2002													7	3	5	1		1	1			
400	2003														23	13	3	1	2	2	1	2	
686	2004															21	8	8	3	3	1	1	
284	2005																12	7	5	1	3		
175	2006																	10	3	3	2	1	4
840	2007																		33	22	11	2	4
75	2008																			5	1		
241	2009																				5	3	
483	2010																					11	5
190	2011																						7

Released (Event 1 only)

Release Number	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
301	1990	15	8	8			1			1													
390	1991		20	13	4	2	1																
40	1992			2	1	1																	
212	1993				10	7	1		1			1											
123	1994					4	1			1													
210	1995						7	2	3	1		1											
67	1996							1															
212	1997								2	1	2	1											
158	1998									6	4			1									
162	1999										3	3		1									
365	2000											9	7	4	2								
269	2001												7	4	2		1		1				
122	2002													2	2			1					
400	2003														8	8	3						
686	2004															16	2	5	1		1		
284	2005																4	4	1		1		
175	2006																	2	1	1	1		
840	2007																		12	7	1	1	
75	2008																						
241	2009																				1	1	
483	2010																					5	1
190	2011																						1

Coastal Programs – 18" fish

MADFW - $\geq$ 18"

Release Number	Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
												Harvested recaptures								
388	1992	5	11	9	10	10	4	2	2	4	1	2									
897	1993		14	22	13	26	22	14	11	4	4	3	2	1							
675	1994			9	15	27	23	16	8	3	2	3	2		2			1			
376	1995				4	10	14	7	4	3	2		4	1		1		1			
443	1996					9	10	14	7	13	2	4	4	1	2						
202	1997						9	4	3	3	1	1		2		1	1				
315	1998							10	14	5	5	4	5	2		1					
87	1999								2	3	2	2		1					1		2
251	2000									9	5	8	3	3		1	2		1		2
598	2001										12	24	13	11	14	5		1	2	2	3
456	2002											15	13	12	8	4	5	2	2	1	
239	2003												8	3	5	7	1		5		
652	2004													24	18	9	9	6	5		4
610	2005														16	20	10	15	3	2	5
574	2006															19	9	13	12	11	2
389	2007																7	15	14	3	4
530	2008																	15	19	13	9
457	2009																		17	10	21
500	2010																			14	18
326	2011																				11

Release Number	Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
											Released (Event 1 only)										
388	1992	15	14	5	3				1												
897	1993		21	24	18	9	2	4	2	1				1							
675	1994			24	10	15	4	5			1										
376	1995				17	13	2	1	2	3	1										
443	1996					24	12	9	5	2	2										
202	1997						13	6	2	1		2									
315	1998							11	8	4	2	1	2	1	1						
87	1999								2	1											
251	2000									2	3	4		1		1					
598	2001										10	6	8	3	1	2		3			
456	2002											15	3	4	5	4	2				
239	2003												3	2	1	2			1		
652	2004													6	8	4	3	1	1		1
610	2005														11	5	3	1			
574	2006															12	5	1	3		
389	2007																4	8	2	2	1
530	2008																	7	7	3	1
457	2009																		6	3	7
500	2010																			9	3
326	2011																				7

NYOHS/TRL - ≥ 18"

Harvested recaptures

Release Number	Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1,623	1988	3	4	12	18	7	13	8	9	6	2	3	4	1		1	1								
1,611	1989		7	19	17	10	25	12	10	4	6	3	2	2	2			1							
808	1990			7	14	6	5	4	2	4	3	3	1												
987	1991				22	11	16	8	11	9	10	6	2	2	2	1	1	1		1					
1,000	1992					15	14	9	19	8	9	11	4	1	1			3		1					
1,250	1993						18	10	15	8	12	4	7	3	1	1	1		1						
1,657	1994							13	19	34	32	21	22	6	7	2	2	2	1	1					
1,506	1995								32	37	31	26	13	9	2	7	6	4				1			
659	1996									9	9	17	12	1		2			3	1					
1,084	1997										17	11	12	3	4	3	3	3	2						1
1,100	1998											10	15	8	5	4	4	1	3	2					
1,049	1999												24	16	23	15	5	9	2	2					
1,003	2000													9	14	6	16	5	4	2	1	3		2	1
1,203	2001														20	22	22	11	6	8	4	1	6	3	1
971	2002															24	16	10	3	7	1	6	3	1	1
758	2003																16	7	14	9	1	1	3		2
664	2004																	9	5	3	5	2	3	2	2
1,152	2005																		16	7	10	9	5	3	4
686	2006																			7	12	16	10	2	4
871	2007																				4	4	7	5	7
1,340	2008																					14	20	26	15
268	2009																						5	6	4
119	2010																							3	3
364	2011																								10

Released (Event 1 only)

Release Number	Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1,623	1988	101	53	42	18	16	11	5	2																
1,611	1989		148	89	53	19	17	10	4	1		1	2							1					
808	1990			55	21	9	7	3		1															
987	1991				50	31	21	11	3	5	6	2	1												
1,000	1992					63	26	16	10	3	2	2													
1,250	1993						52	20	11	10	2		1	1	1										
1,657	1994							101	31	22	18	2	5			1	1								
1,506	1995								67	42	28	8	5		2	2	1	2							
659	1996									37	11	11	1	2	1	1							1		
1,084	1997										64	16	8	5	2	1									
1,100	1998											54	17	4	4	3	2								
1,049	1999												40	13	14	2	1	1	1						
1,003	2000													42	15	12	4	2							
1,203	2001														50	20	10	4	1	1					
971	2002															53	10	7	2	1					
758	2003																30	13	7	2			1	1	
664	2004																	29	12	8	1				
1,152	2005																		60	15	11		1		
686	2006																			43	12	2	1		1
871	2007																				45	13	3	3	
1,340	2008																					55	31	10	
268	2009																						19	3	
119	2010																							6	2
364	2011																								13

* NY OHS 1988-2007, NY TRL 2008-2011

NJDB - ≥ 18"

Harvested recaptures

Release Number	Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
483	1989	4	7	11	1	7	4	4	1		3	3	1	1										
110	1990		2	1		1	2								1									
297	1991			2	2		3	2	5	1	1			1								1		
765	1992				8	10	2	7	8	4	5	3	2		2									
1,680	1993					11	8	33	32	23	15	10	7	4	1	1	2	1	1	1				
2,287	1994						21	45	69	51	45	24	20	6	8	6	1	4	2	1		1		
1,819	1995							38	63	59	40	30	13	10	8	7	4	3	3	3	2		1	1
1,941	1996								64	55	59	34	24	22	10	7	11	2	1	1	1		2	1
405	1997									11	6	4	2	3	5	1			3					
811	1998										37	17	29	22	9	7	4	5	1	1				
1,796	1999											34	56	47	29	23	17	20	10	4	2		1	
2,397	2000												65	89	52	60	34	19	9	10	5	2	4	3
2,305	2001													80	65	64	30	30	14	5	6	2	1	1
1,828	2002														40	40	42	24	14	8	8	3	3	3
2,190	2003															61	58	52	19	21	16	9	4	3
1,856	2004																83	54	39	28	27	17	7	3
1,162	2005																	38	25	25	13	11	10	1
1,466	2006																		33	38	37	28	14	12
1,090	2007																			47	40	23	26	15
1,407	2008																				48	50	46	32
2,239	2009																					57	62	51
1,195	2010																						33	27
756	2011																							29

Released (Event 1 only)

Release Number	Year	1988	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
483	1989	47	34	22	9	5	5	1	2	2														
110	1990		16	1	3	2	1	1																
297	1991			20	8	6	4	1	1	1	1													
765	1992				56	33	22	6		2	1	1	1		1									
1,680	1993					112	60	34	32	16	7	6	1		1	1				1				
2,287	1994						153	93	92	35	20	7	6	2	3	3								
1,819	1995							128	107	50	41	9	5	8		1	1		2	1				1
1,941	1996								142	83	48	14	15	4	4	2	5		1				1	
405	1997									35	12	9	2	2		3	1	1						
811	1998										63	22	18	8	6	4		3						
1,796	1999											100	56	27	19	8	5	5	3	1				
2,397	2000												149	63	26	16	10	2	2	3	1			
2,305	2001													138	53	30	12	11	1	3	1			1
1,828	2002														70	56	21	11	4	3	1	1	1	1
2,190	2003															129	73	30	15	4	7	1	2	
1,856	2004																122	53	18	6	7	2	3	
1,162	2005																	79	24	13	7	1	4	2
1,466	2006																		83	38	19	6	6	5
1,090	2007																			60	18	19	6	5
1,407	2008																				72	29	18	8
2,239	2009																					140	58	20
1,195	2010																						46	26
756	2011																							29

NCCOOP - ≥ 18"

Harvested recaptures

Release Number	Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1,323	1988	12	3	17	35	21	16	9	10	4	3	2							1						
1,153	1989		10	11	10	12	6	2	2	2	4			1											
1,946	1990			44	46	31	24	7	11	8	7	3	6	3	1										
1,779	1991				55	45	40	32	29	14	19	7	3	2	2	1									
1,007	1992					55	36	19	20	11	10	8	7	3											1
527	1993						22	9	9	8	7	5	2					1							
4,341	1994							132	101	72	52	45	24	8	6	1	5	2	3	1	3				
639	1995								35	15	23	17	8	3	2	6	1	1	3			1			
661	1996									29	17	13	3	4	3	4		3	1	1					
1,347	1997										86	42	19	11	13			3	3	1		1	1		
460	1998											26	12	6	9	2	5					1			
271	1999												24	8	5	3		2	2	2	1		2		
4,539	2000													146	60	35	17	12	6	4	1	1	1		
2,387	2001														109	57	46	17	16	9	3	1	2		1
3,813	2002															186	109	54	26	16	8	4	3	2	1
1,906	2003																85	57	30	15	13	8	7	4	4
2,468	2004																	119	63	35	19	8	5	2	4
3,960	2005																		91	40	21	7	8	2	1
4,453	2006																			186	120	67	44	33	19
370	2007																				24	22	10	3	6
1,033	2008																					78	42	29	15
146	2009																						3	3	1
566	2010																							16	9
107	2011																								9

Released (Event 1 only)

Release Number	Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1,323	1988	3	44	28	15	16	4	4					1	1											
1,153	1989		38	27	19	7	3	3							1										
1,946	1990			83	47	19	19	7	2	3	1				1										
1,779	1991				78	40	40	23	4	5	2	2													
1,007	1992					48	22	14	8	2	3	3		1		1									
527	1993						22	13	8	2	3	1	2												
4,341	1994							184	80	22	15	10	6		1		1	1							
639	1995								27	5	2	5		2											
661	1996									10	5	4	2	2	1										
1,347	1997										34	22	9	6	2			1				2			
460	1998											21	14	2	2		1		1						
271	1999												7	5				1				1			
4,539	2000													133	28	10	6								
2,387	2001														62	24	14	6	2	5	2	2	1		
3,813	2002															85	34	12	6	4	1	3			
1,906	2003																34	14	8	11	3	2		1	1
2,468	2004																	59	23	16	6	2	1	1	
3,960	2005																		37	18	4	5	2		
4,453	2006																			115	50	20	9	6	2
370	2007																				10	2	2		
1,033	2008																					23	11	4	5
146	2009																						2		
566	2010																							4	
107	2011																								5

Producer Programs

HUDSON - ≥ 18"

Release Number	Year	Harvested recaptures																							
		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
826	1988	13	11	12	14	7	6	3	6	5	1	2													
669	1989		10	16	10	4	7	9	4	2					1		1								
783	1990			19	17	11	10	4	6	2	4	1	1		2										
546	1991				14	15	8	7	9	6	3	1		1		1	2		1	1					
1,135	1992					36	31	16	12	18	14	11	6	3	2			1			1				
940	1993						34	22	16	24	13	8	5	3	1	1	2		1						
643	1994							20	25	27	13	9	5	4	4	3	1	2			1				
628	1995								30	25	23	19	11	2	1	1	2	1	1						
1,069	1996									67	47	40	18	2	9	5	3	5	2	1	1				
241	1997										22	7	8	6	3	2	1		1	1					
698	1998											49	35	14	8	14	5	1	1	4	1	1			
798	1999												45	18	25	10	15	6	4	3	1	3	1	1	1
846	2000													32	19	23	13	12	9	5	4			1	
1,069	2001														38	30	15	13	9	9	1	4			1
597	2002															19	11	11	6	6	5	4	4	1	1
1,379	2003																54	56	35	16	15	6	3	3	4
1,273	2004																	65	38	32	18	5	4	5	3
1,325	2005																		46	34	22	9	8	10	
1,130	2006																			46	33	33	14	10	8
755	2007																				29	31	15	7	6
1,236	2008																					42	37	32	10
507	2009																						31	26	13
840	2010																							40	24
337	2011																								24

Release Number	Year	Released (Event 1 only)																							
		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
826	1988	41	49	32	11	11	8	4			4					1									
669	1989		49	30	12	8	3	4	1																
783	1990			71	30	22	11	6						1	1										
546	1991				42	29	7	6	2	1	3			1											
1,135	1992					76	38	27	14	5	6	4	2	1											
940	1993						66	38	20	8	9	4	2												
643	1994							39	16	7	5	1	4	2											
628	1995								30	16	12	4	1	3	1	1									
1,069	1996									53	36	16	10	3	2	2	2	1	3		1				
241	1997										10	6	5	1			1								
698	1998											25	20	4	2	8	2			1					
798	1999												29	17	7	4	2	4	2	1					
846	2000													42	13	12	16	8	2	2			1		
1,069	2001														44	31	10	3	3	2	1				
597	2002															26	9	8	2	4	2	1	1	1	
1,379	2003																66	28	19	12	3		1	1	
1,273	2004																	53	25	15	9	2	1	1	2
1,325	2005																		57	30	14	9		1	1
1,130	2006																			36	28	12	7	1	1
755	2007																				22	19	9	2	2
1,236	2008																					48	21	13	4
507	2009																						20	14	5
840	2010																							26	15
337	2011																								10

DE/PA - ≥ 18"

Release		Harvested recaptures																		
Number	Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
265	1993	15	9	5	9	4	3		2	1										
313	1994		15	11	8	7	3	3				1				1				
477	1995			25	13	4	10	3	6	1	1									
313	1996				18	7	7	3	7	2	3	1	2		1			1		
513	1997					29	12	8	5	6	2	2	1	1				1		
716	1998						43	14	11	9	6	7	2	1	1	1	2			
407	1999							18	14	5	5	4	2		1		1			
651	2000								40	22	9	6	3	4		2				
902	2001									56	22	26	10	8	3	2	3	4	1	2
616	2002										36	21	5	7	3	3		1	1	
657	2003											40	20	12	7	3		5	3	3
384	2004												24	8	6	3		1	4	3
326	2005													13	7	2	3	3	1	1
583	2006														27	11	8	4	4	4
393	2007															9	7	1	3	
484	2008																13	8	6	5
375	2009																	17	7	9
447	2010																		18	12
746	2011																			17

Release		Released (Event 1 only)																		
Number	Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
265	1993	14	10	3	3	1	1	2												
313	1994		18	13	8															
477	1995			34	20	10	2	5												
313	1996				19	10	5	1	4			1								
513	1997					27	22	12	2	1										
716	1998						40	8	6	3	2									
407	1999							17	10	4	1	4								
651	2000								33	20	8	8	3	2	1					
902	2001									39	17	12	3	4	1					
616	2002										16	20	4	5						
657	2003											33	14	6		2		1	1	
384	2004												12	5	3	2				
326	2005													28	9	5				
583	2006														33	8	4	3	2	1
393	2007															15	4	2	2	
484	2008																25	12	5	3
375	2009																	23	4	3
447	2010																		27	13
746	2011																			44

MDCB - ≥ 18"

Harvested recaptures

Release Number	Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1,409	1987	1	9		21	21	24	20	8	8	6	3	2	1												
2,240	1988		7	3	30	41	48	25	14	19	7	10	1	1												
2,343	1989			4	53	65	64	34	22	18	11	4	1	2		1										
1,365	1990				35	37	34	16	11	7	4	10	3			1										
1,452	1991					57	56	44	14	22	10	10	5	1	3											
1,615	1992						85	57	40	26	12	11	8	10	2	1										
2,154	1993							98	83	63	39	33	19	15	3	4	2									
1,824	1994								90	94	45	39	28	17	7	2			2						1	
1,353	1995									106	61	40	20	11	8	3	2	5		1	2		1			
1,680	1996										116	69	63	22	10	8	2	1	1							
841	1997											72	42	23	6	2	1	1				1				
919	1998												84	28	10	7	5	1	1	1		1				
592	1999													42	23	10	3	1	2	1		1	1			
931	2000														64	23	11	7	7	2	1	2	1		2	
1,104	2001															55	21	20	8	2	3		1		1	
1,134	2002																55	48	16	7	1	4		2		
791	2003																	43	24	11	9	2	4			1
682	2004																		28	15	10	2	3	1	2	2
876	2005																			40	26	10	5	3	1	1
525	2006																				30	9	5	6	3	
381	2007																					14	8	4	2	2
360	2008																						17	8	4	4
718	2009																							52	11	6
668	2010																								37	11
1,098	2011																									66

Released (Event 1 only)

Release Number	Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1,409	1987	52	34	25	21	21	23	9	2	3		1														
2,240	1988		84	59	56	35	23	18	8	4	1	2														
2,343	1989			74	73	47	33	15	11	5	2	1														
1,365	1990				48	31	28	9	4	2	1		1													
1,452	1991					57	50	20	17	9	1	1			1			1								
1,615	1992						81	39	24	17	8	5		2												
2,154	1993							71	61	31	17	7	4	1												
1,824	1994								87	45	22	8	9	4		2		1		1						
1,353	1995									62	31	11	7	5	1	2										
1,680	1996										83	38	13	3	2											
841	1997											36	17	2	2	1		1		1						
919	1998												45	11	9	2										
592	1999													18	13	4	3									
931	2000														42	8	6	2								
1,104	2001															37	11	3	2	2						
1,134	2002																29	12	5	1	2	1				
791	2003																	20	6	4	3	2				
682	2004																		17	5	3	1	2		1	1
876	2005																			16	6	2		2		
525	2006																				16	5	2			1
381	2007																					8	4		1	
360	2008																						6	1	2	
718	2009																							9	5	2
668	2010																								14	4
1,098	2011																									16

VARAP - ≥ 18"

Harvested recaptures

Release Number	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1,464	1990	21	20	24	10	8	9	2			1	1			1								
2,481	1991		48	38	22	14	3	1	2	1	4				1								
130	1992			7	4	1	3				1												
621	1993				18	17	12	5	4	1													
195	1994						6	7	4	1	2												
698	1995						24	12	9	4	1	1	2		1								
376	1996							3	10	3	2	1	1	1			1						
712	1997								26	17	10	2		1	1	1							
784	1998									28	16	1	3	1									
853	1999										30	7	4	2	2							1	
1,765	2000											44	23	11	7	4	5	1	1				
797	2001												31	14	5	7	1						
315	2002													10	4	6	1	1	1	1			
852	2003														32	20	5	3	3	2	1	2	
1,477	2004															45	14	8	4	3	1	1	
921	2005																27	17	6	1	4	1	
668	2006																	27	4	5	5	3	4
1,961	2007																		63	34	16	3	5
523	2008																			17	4		
867	2009																				26	7	2
2,050	2010																					29	7
416	2011																						13

Released (Event 1 only)

Release Number	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1,464	1990	76	28	18	9	1	1		1	2													
2,481	1991		93	33	24	10	2	1															
130	1992			6	3	3		1		1													
621	1993				26	16	3	1	1	1	1		1										
195	1994					6	1		3	1													
698	1995						20	7	8	1			1										
376	1996							10	7	3													
712	1997								14	6	4	1											
784	1998									21	7												
853	1999										22	12	1	2									
1,765	2000											49	23	7	3								
797	2001												20	6	7		1		1				
315	2002													7	3	2			1				
852	2003														12	11	3	1	1				
1,477	2004															25	5	5	1		1		
921	2005																14	8	2	1		1	
668	2006																	19	6	1	1		
1,961	2007																		34	10	1	1	
523	2008																			7	2	2	
867	2009																				16	2	
2,050	2010																					14	2
416	2011																						5

Chesapeake Bay (MD and VA combined) - 18-28" males

Harvested recaptures

Release Number	Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1,308	1987	1	6		18	19	21	17	6	7	4	2	2													
1,852	1988		4	2	23	26	37	23	10	12	6	6														
1,916	1989			1	39	51	57	30	19	9	6	3		1												
1,171	1990				22	28	26	11	10	4	3	6	2													
1,089	1991					34	43	29	9	10	4	5	3		1											
1,149	1992						62	41	26	9	5	2		2												
1,628	1993							66	54	34	18	15	10	2												
1,255	1994								58	63	19	16	15	8	3											
1,129	1995									61	31	16	7	5	2	1		1								
982	1996										48	31	24	6	4	1										
955	1997											48	25	10	5											
1,274	1998												69	22	6	4	2	1	1							
1,075	1999													39	20	7	1	1								
2,032	2000														75	21	16	5	3	2						
1,120	2001															54	17	10	3							
996	2002																42	26	12	1	1	1				
900	2003																	35	21	5	5	1	1			
1,070	2004																		36	12		1				
1,136	2005																			38	25	4	1	2		
747	2006																				30	5	1	5	1	
1,304	2007																					37	14	6	1	
660	2008																						22	7	1	1
1,018	2009																							53	7	7
1,935	2010																								46	13
997	2011																									53

Released (Event 1 only)

Release Number	Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1,308	1987	49	31	18	18	16	21	8	1			1														
1,852	1988		64	42	37	25	18	11	5	3	1	1														
1,916	1989			53	50	26	24	8	8	5	2	1														
1,171	1990				40	20	17	6	2	1	1															
1,089	1991					38	31	15	12	4																
1,149	1992						57	17	12	13	5	3														
1,628	1993							41	42	18	11	5	4													
1,255	1994								54	27	14	4	3	2		1										
1,129	1995									67	19	9	4	1		2										
982	1996										46	20	5													
955	1997											38	12	1	1											
1,274	1998												48	12	7		1	1								
1,075	1999													29	18	3	3									
2,032	2000														73	17	3	2								
1,120	2001															38	4	7	1	1						
996	2002																30	8	4							
900	2003																	16	6	3	1					
1,070	2004																		22	4	1		1			
1,136	2005																			20	5	2		1		
747	2006																				26	7				
1,304	2007																					27	6		1	
660	2008																						13	2	3	
1,018	2009																							19	1	1
1,935	2010																								20	2
997	2011																									13

B9.3 AD Model Builder code for the instantaneous rates catch/release model (IRCR).

```
//--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>
//
//  Jiang et. al  Instantaneous rates model for catch and release
//  Age-Independent model
//
//
//  Gary Nelson, Massachusetts Division of Marine Fisheries
//  Version 2.0 6/29/2012
//--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>--><<>
DATA_SECTION
// Starting and ending year of the release year
 init_int styrR;
 init_int endyrR;
//Starting and ending year of recovery years
 init_int styr;
 init_int endyr;
 //Total Releases by Year
 init_vector N(styrR,endyrR);
//Recapture Matrix for harvest fish
 init_imatrix rh(styrR,endyrR,styr,endyr);
//Recapture Matrix for releases fish
 init_imatrix rr(styrR,endyrR,styr,endyr);
 //---Reporting Rate for harvested fish----------
 init_vector lh(styr,endyr);
 //---Initial probability of tag shedding and tag-induced mortality for harvested fish--
 init_vector phih(styr,endyr);
 //---Reporting Rate for released fish----------
 init_vector lr(styr,endyr);
 //---Initial probability of tag shedding and tag-induced mortality for released fish--
 init_vector phir(styr,endyr);
 //Hooking Mortality
 init_vector h(styr,endyr);
//Number of Natural Mortality Periods and Beginnng Years
 init_int mp;
 init_ivector mp_int(1,mp);
 int pp;
//Number of Fishing  Mortality Periods and Beginning Years
 init_int fp;
 init_ivector fp_int(1,fp);
 int qq;
//Number of Tag Mortality Periods
 init_int fap;
 init_ivector fap_int(1,fap);
 int ss;
 int tp;
 LOCAL_CALCS
 pp=mp+1;
 qq=fp+1;
 ss=fap+1;
 tp=mp+fp+fap+(4*(endyr-styr+1));
END_CALCS
matrix sigma(1,tp,1,tp+1);
!! set_covariance_matrix(sigma);
//looping variables
int y;
int t;
int a;
int d;
int cnt;
int total;
int Ntags;
int looper;
int df_r;
```

```
 int df_h;
 int hless;
 int rless;
PARAMETER_SECTION
 number dodo;
 number dodo1;
 number probs;
 number AIC;
 number AICc;
 number K;
 number up_df;
 number up_count;
 number up_chi;
 number up_chat;
 number p_chi;
 number p_df;
 number p_chat;
 //-------------F estimates-----------------------------
 init_bounded_vector e_F(1,fp,-30.,1.6,1);
 vector F(styr,endyr);
 vector fp_yr(1,qq);
 //-------------M estimates-----------------------------
 init_bounded_vector e_M(1,mp,-30.,1.6,1);
 vector M(styr,endyr);
 vector mp_yr(1,pp);
//--------------Tag Mortality----------------------------
 init_bounded_vector e_FA(1,fap,-30.,1.6,1);
 vector FA(styr,endyr);
 vector fap_yr(1,ss);
//------------------Tag Number of Tags-------------------
 vector tags(styrR,endyrR);
//-----------------Mortality Calculations------------
 matrix s(styrR,endyrR,styr,endyr);
 matrix u_h(styrR,endyrR,styr,endyr);
 matrix u_r(styrR,endyrR,styr,endyr);
 vector S_fish(styr,endyr);
//---------Predicted Cell recoveries-------------
 vector sum_prob_h(styrR,endyrR);
 vector sum_prob_r(styrR,endyrR);
 matrix s_prob(styrR,endyrR,styr,endyr);
 matrix exp_prob_h(styrR,endyrR,styr,endyr);
 matrix ll_h(styrR,endyrR,styr,endyr);
 matrix exp_prob_r(styrR,endyrR,styr,endyr);
 matrix ll_r(styrR,endyrR,styr,endyr);
 vector ll_ns(styrR,endyrR);
 matrix exp_r_h(styrR,endyrR,styr,endyr);
 matrix exp_r_r(styrR,endyrR,styr,endyr);
 matrix pool_r(styrR,endyrR,styr,endyr);
 matrix pool_h(styrR,endyrR,styr,endyr);
 matrix pool_r_e(styrR,endyrR,styr,endyr);
 matrix pool_h_e(styrR,endyrR,styr,endyr);
 matrix chi_r(styrR,endyrR,styr,endyr);
 matrix chi_h(styrR,endyrR,styr,endyr);
 matrix p_chi_r(styrR,endyrR,styr,endyr);
 matrix p_chi_h(styrR,endyrR,styr,endyr);
 matrix pear_r(styrR,endyrR,styr,endyr);
 matrix pear_h(styrR,endyrR,styr,endyr);
 matrix stdres_r(styrR,endyrR,styr,endyr);
 matrix stdres_h(styrR,endyrR,styr,endyr);
 vector exp_ns(styrR,endyrR);
 vector chi_ns(styrR,endyrR);
 vector pear_ns(styrR,endyrR);
 vector stdres_ns(styrR,endyrR);
 sdreport_vector S(styr,endyr);
 sdreport_vector FM(styr,endyr);
 sdreport_vector FT(styr,endyr);
```

```
sdreport_vector NM(styr,endyr);
//----------Likelihood Values------------------------------------
number f_tag;
objective_function_value f;
INITIALIZATION_SECTION
e_F -1.6;
e_FA -1.6;
e_M -1.6;
RUNTIME_SECTION
maximum_function_evaluations 100, 500, 5000;
convergence_criteria 1e-5, 1e-7, 1e-16;
PRELIMINARY_CALCS_SECTION
F.initialize();
FA.initialize();
M.initialize();
PROCEDURE_SECTION
calc_number_tags();
calc_M_vector();
calc_F_vector();
calc_FA_vector();
calc_fish_surv();
calc_s();
calc_s_prob();
calc_u_h();
calc_u_r();
calc_exp_prob_h();
calc_exp_prob_r();
calc_LL();
calc_Chisquare();
calc_pooled_cells();
evaluate_the_objective_function();
FUNCTION calc_number_tags
 cnt=0;
 for (t=styrR;t<=endyrR;t++)
  {
   Ntags=0;
   for (y=styr+cnt;y<=endyr;y++)
    {
      Ntags+=rh(t,y)+rr(t,y);
    }
     tags(t)=Ntags;
     cnt+=1;
  }
FUNCTION calc_M_vector
 for(t=1;t<=mp;t++)
  {
          mp_yr(t)=mp_int(t);

  }
     mp_yr(pp)=endyr+1;

for(t=styr;t<=endyr;t++)
  {
   for(d=1;d<=mp;d++)
    {

     if(t>=mp_yr(d) && t<mp_yr(d+1))
          { M(t)=mfexp(e_M(d));
      NM(t)=M(t);
     }
    }
  }

FUNCTION calc_F_vector
 for(t=1;t<=fp;t++)
  {
```

```
                fp_yr(t)=fp_int(t);

    }
        fp_yr(qq)=endyr+1;

   for(t=styr;t<=endyr;t++)
    {
      for(d=1;d<=fp;d++)
        {

         if(t>=fp_yr(d) && t<fp_yr(d+1))
                  { F(t)=mfexp(e_F(d));
           FM(t)=F(t);
          }
        }
     }

   FUNCTION calc_FA_vector
    for(t=1;t<=fap;t++)
     {
              fap_yr(t)=fap_int(t);

     }
        fap_yr(ss)=endyr+1;

   for(t=styr;t<=endyr;t++)
    {
      for(d=1;d<=fap;d++)
        {

         if(t>=fap_yr(d) && t<fap_yr(d+1))
                  { FA(t)=mfexp(e_FA(d));
           FT(t)=FA(t);
          }
        }
     }

   FUNCTION calc_fish_surv
    for (t=styr;t<=endyr;t++)
     {
      S_fish(t)=mfexp(-1*(F(t)+h(t)*FA(t)+M(t)));
      S(t)=S_fish(t);

     }

   FUNCTION calc_s
    cnt=0;
   for (t=styrR;t<=endyrR;t++)
    {
     for (y=styr+cnt;y<=endyr;y++)
      {

       if(t==y){s(t,y)=1;}
       if(t!=y)
        {

         s(t,y)=mfexp(-F(y-1)-FA(y-1)-M(y-1));

        }
      }
       cnt+=1;
    }
   FUNCTION calc_u_h
    cnt=0;
   for (t=styrR;t<=endyrR;t++)
    {
```

```
   for (y=styr+cnt;y<=endyr;y++)
    {

    u_h(t,y)=(F(y)/(F(y)+FA(y)+M(y)))*(1-mfexp(-F(y)-FA(y)-M(y)));
    }
    cnt+=1;
  }

FUNCTION calc_u_r
 cnt=0;
 for (t=styrR;t<=endyrR;t++)
  {
   for (y=styr+cnt;y<=endyr;y++)
    {
    u_r(t,y)=(FA(y)/(F(y)+FA(y)+M(y)))*(1-mfexp(-F(y)-FA(y)-M(y)));
    }
    cnt+=1;
  }
FUNCTION calc_s_prob
 cnt=0;
 for (t=styrR;t<=endyrR;t++)
  {
   looper=0;
   for (y=styr+cnt;y<=endyr;y++)
    {
            probs=1;

            for(a=y-looper;a<=y;a++)
      {
       probs=probs*s(t,a);
      }
      s_prob(t,y)=probs;
      looper+=1;
    }
   cnt+=1;
  }
FUNCTION calc_exp_prob_h
 cnt=0;
 for (t=styrR;t<=endyrR;t++)
  {
   dodo=0;
   for (y=styr+cnt;y<=endyr;y++)
    {
     exp_prob_h(t,y)=lh(y)*phih(y)*s_prob(t,y)*u_h(t,y);
            dodo+=exp_prob_h(t,y);
    }
   sum_prob_h(t)=dodo;
   cnt+=1;
  }

FUNCTION calc_exp_prob_r
 cnt=0;
 for (t=styrR;t<=endyrR;t++)
  {
   dodo=0;
   for (y=styr+cnt;y<=endyr;y++)
    {
     exp_prob_r(t,y)=lr(y)*phir(y)*s_prob(t,y)*u_r(t,y);
            dodo+=exp_prob_r(t,y);
    }
   sum_prob_r(t)=dodo;
   cnt+=1;
  }

FUNCTION calc_LL
 cnt=0;
```

```
for (t=styrR;t<=endyrR;t++)
 {
  for (y=styr+cnt;y<=endyr;y++)
   {
    ll_h(t,y)=0;
    ll_r(t,y)=0;
     if(rh(t,y)!=0)
      {
       ll_h(t,y)=rh(t,y)*log(exp_prob_h(t,y));
      }
     if(rr(t,y)!=0)
      {
       ll_r(t,y)=rr(t,y)*log(exp_prob_r(t,y));
      }
   }
   cnt+=1;
  }
for (t=styrR;t<=endyrR;t++)
 {
  ll_ns(t)=(N(t)-tags(t))*log(1-(sum_prob_h(t)+sum_prob_r(t)));
 }

FUNCTION evaluate_the_objective_function
 f_tag=0;
 cnt=0;
 for (t=styrR;t<=endyrR;t++)
  {
   for (y=styr+cnt;y<=endyr;y++)
    {
     f_tag+=ll_h(t,y)+ll_r(t,y);
    }
   cnt+=1;
  }

  for (t=styrR;t<=endyrR;t++)
   {
    f_tag+=ll_ns(t);
   }
 f=f_tag*-1.;

FUNCTION calc_Chisquare
 cnt=0;
 up_count=0;
 for (t=styrR;t<=endyrR;t++)
  {
   for (y=styr+cnt;y<=endyr;y++)
    {
     up_count+=1;
    }
    cnt+=1;
  }
 cnt=0;
 for (t=styrR;t<=endyrR;t++)
  {
   for (y=styr+cnt;y<=endyr;y++)
    {
     exp_r_r(t,y)=exp_prob_r(t,y)*N(t);
     exp_r_h(t,y)=exp_prob_h(t,y)*N(t);
    }
   cnt+=1;
  }
 cnt=0;
 for (t=styrR;t<=endyrR;t++)
  {
   for (y=styr+cnt;y<=endyr;y++)
    {
```

```
       chi_r(t,y)=square(rr(t,y)-exp_r_r(t,y))/exp_r_r(t,y);
       chi_h(t,y)=square(rh(t,y)-exp_r_h(t,y))/exp_r_h(t,y);
       pear_r(t,y)=(rr(t,y)-exp_r_r(t,y))/sqrt(exp_r_r(t,y));
       pear_h(t,y)=(rh(t,y)-exp_r_h(t,y))/sqrt(exp_r_h(t,y));
       stdres_h(t,y)=(rh(t,y)-exp_r_h(t,y))/sqrt(exp_r_h(t,y)*(1.-exp_r_h(t,y)/N(t)));
       stdres_r(t,y)=(rr(t,y)-exp_r_r(t,y))/sqrt(exp_r_r(t,y)*(1.-exp_r_r(t,y)/N(t)));
      }
    cnt+=1;
   }
  for (t=styrR;t<=endyrR;t++)
  {
      exp_ns(t)=N(t)*(1-(sum_prob_h(t)+sum_prob_r(t)));
  }

  //Not seen chi
  for (t=styrR;t<=endyrR;t++)
  {
      chi_ns(t)=0;
      chi_ns(t)=square((N(t)-tags(t))-exp_ns(t))/exp_ns(t);
      pear_ns(t)=((N(t)-tags(t))-exp_ns(t))/sqrt(exp_ns(t));
      stdres_ns(t)=((N(t)-tags(t))-exp_ns(t))/sqrt(exp_ns(t)*(1.-exp_ns(t)/N(t)));
  }
  //total chi square
  up_chi=sum(chi_r)+sum(chi_h)+sum(chi_ns);
  K=fap+mp+fp;
  up_df=up_count*2-K;
  up_chat=up_chi/up_df;
  AIC=-1.*2*f_tag+2*K;
  AICc=AIC+(2*K*(K+1))/(sum(N)-K-1);
FUNCTION calc_pooled_cells
// Pool harvested cells
 cnt=0;
 for (t=styrR;t<=endyrR;t++)
 {
     for(y=styr+cnt;y<=endyr;y++)
     {
        pool_h_e(t,y)=0;
        pool_h(t,y)=0;
        pool_h_e(t,y)=exp_r_h(t,y);
        pool_h(t,y)=rh(t,y);

     }
    cnt+=1;
 }
cnt=0;
hless=0;
for(t=styrR;t<=endyrR;t++)
 {
  for(y=endyr;y>=styr+cnt;y--)
    {
      if(pool_h_e(t,y)>=2.)
       {
        pool_h(t,y)=pool_h(t,y);
        pool_h_e(t,y)=pool_h_e(t,y);
       }
      if(pool_h_e(t,y)>=0 && pool_h_e(t,y)<2.)
       { if (y!=styr+cnt)
         {
          hless+=1;
          pool_h_e(t,y-1)=pool_h_e(t,y-1)+pool_h_e(t,y);
          pool_h(t,y-1)=pool_h(t,y-1)+pool_h(t,y);
          pool_h(t,y)=0;
          pool_h_e(t,y)=0;
         }
         if (y==styr+cnt) break;
        }
```

```
       }//for
      cnt+=1;
    }//for

// Pool released cells
  cnt=0;
  for (t=styrR;t<=endyrR;t++)
   {
      for(y=styr+cnt;y<=endyr;y++)
       {
          pool_r_e(t,y)=0;
          pool_r(t,y)=0;
          pool_r_e(t,y)=exp_r_r(t,y);
          pool_r(t,y)=rr(t,y);

       }
     cnt+=1;
   }
  cnt=0;
  rless=0;
  for(t=styrR;t<=endyrR;t++)
   {
    for(y=endyr;y>=styr+cnt;y--)
      {
        if(pool_r_e(t,y)>=2.)
          {
           pool_r(t,y)=pool_r(t,y);
           pool_r_e(t,y)=pool_r_e(t,y);
          }
        if(pool_r_e(t,y)>=0 && pool_r_e(t,y)<2.)
          { if (y!=styr+cnt)
            {
             rless+=1;
             pool_r_e(t,y-1)=pool_r_e(t,y-1)+pool_r_e(t,y);
             pool_r(t,y-1)=pool_r(t,y-1)+pool_r(t,y);
             pool_r(t,y)=0;
             pool_r_e(t,y)=0;
            }
            if (y==styr+cnt) break;
          }
      }//for
      cnt+=1;
    }//for
  p_df=up_df;
 //Pooled Chi-square
  cnt=0;
  for (t=styrR;t<=endyrR;t++)
   {
    for (y=styr+cnt;y<=endyr;y++)
     {
       p_chi_h(t,y)=0;
       p_chi_r(t,y)=0;

       if(pool_h_e(t,y)!=0)
        {
         p_chi_h(t,y)=square(pool_h(t,y)-pool_h_e(t,y))/pool_h_e(t,y);
        }
       if(pool_r_e(t,y)!=0)
        {
         p_chi_r(t,y)=square(pool_r(t,y)-pool_r_e(t,y))/pool_r_e(t,y);
        }
     }
     cnt+=1;
   }
  p_chi=sum(p_chi_h)+sum(p_chi_r)+sum(chi_ns);
  p_chat=p_chi/p_df;
```

```
REPORT_SECTION
report<<"Log-L"<<"  "<<"\t"<<"K"<<"\t"<<"AIC"<<"      "<<"AICc"<<"      "<<"Eff. Sample Size"<<endl;
report<<f_tag<<"  "<<"\t"<<K<<"\t"<<AIC<<"\t"<<AICc<<"\t"<<sum(N)<<endl;
report<<" "<<endl;
report<<" "<<endl;
report<<"*******Model Statistics*****************"<<endl;
report<<"Unpooled Chi-square    "<<" "<<up_chi<<endl;
report<<"Upooled df           "<<" "<<up_df<<endl;
report<<"Unpooled c-hat         "<<" "<<up_chat<<endl;
report<<"Pooled Chi-square      "<<" "<<p_chi<<endl;
report<<"Pooled df            "<<" "<<p_df<<endl;
report<<"Pooled c-hat           "<<" "<<p_chat<<endl;
report <<"****************************************"<<endl;
report<<" "<<endl;
report<<" "<<endl;
report << "S for fish" << endl;
report << S_fish << endl;
report<<" "<<endl;
report<<"**********************Observed and Calculated Data*************************************"<<endl;
report << "Obs Recoveries of harvest fish "<< endl;
report<<rh<<endl;
report <<" "<<endl;
report << "Obs Recoveries of release fish "<< endl;
report<<rr<<endl;
report <<" "<<endl;
report << "Total Released "<< endl;
report<<N<<endl;
report <<" "<<endl;
report <<"Total Recovered Tags"<<endl;
report <<tags<<endl;
report<<" "<<endl;
report << "s matrix" << endl;
report <<s<<endl;
report<<" "<<endl;
report << "S_prob matrix" << endl;
report <<s_prob<<endl;
report<<" "<<endl;
report << "Exploitation Rate of harvested fish" << endl;
report <<u_h<<endl;
report<<" "<<endl;
report << "Exploitation Rate of released fish" << endl;
report <<u_r<<endl;
report<<" "<<endl;
report <<"Expected Probability of harvested fish"<<endl;
report<<exp_prob_h<<endl;
report <<" "<<endl;
 report <<"Expected Probability of released fish"<<endl;
report<<exp_prob_r<<endl;
report <<" "<<endl;
report<<"Not Seen Probability"<<endl;
report<<1-(sum_prob_h+sum_prob_r)<<endl;
report<<" "<<endl;
report <<"Expected Number of harvested fish"<<endl;
report<<exp_r_h<<endl;
report <<" "<<endl;
 report <<"Expected Number of released fish"<<endl;
report<<exp_r_r<<endl;
report <<" "<<endl;
report <<"Expected Number of not seen"<<endl;
report<<exp_ns<<endl;
report <<" "<<endl;
report <<"Cell Likelihoods of harvested fish"<<endl;
report<<ll_h<<endl;
report <<" "<<endl;
 report <<"Cell Likelihoods of released fish"<<endl;
```

```
report<<ll_r<<endl;
report <<" "<<endl;
report <<"Cell Likelihoods of unseen"<<endl;
report<<ll_ns<<endl;
report <<" "<<endl;
report <<"Unpooled Chi-squares of Harvested Fish"<<endl;
report<<chi_h<<endl;
report <<" "<<endl;
report <<"Unpooled Chi-squares of Released Fish"<<endl;
report<<chi_r<<endl;
report <<" "<<endl;
report <<"Chi-squares of Not Seen"<<endl;
report<<chi_ns<<endl;
report <<" "<<endl;
 report <<"Pooled Cells of Harvested Fish"<<endl;
report<<pool_h<<endl;
report <<" "<<endl;
report <<"Pooled Expected Cells of Harvested Fish"<<endl;
report<<pool_h_e<<endl;
report <<" "<<endl;
report <<"Pooled Cells of Released Fish"<<endl;
report<<pool_r<<endl;
report <<" "<<endl;
report <<"Pooled Expected Cells of Harvested Fish"<<endl;
report<<pool_r_e<<endl;
report <<" "<<endl;
report <<"Pooled Chi-squares of Harvested Fish"<<endl;
report<<p_chi_h<<endl;
report <<" "<<endl;
report <<"Pooled Chi-squares of Released Fish"<<endl;
report<<p_chi_r<<endl;
report <<" "<<endl;
report <<"Pearson Residuals for released fish"<<endl;
report<<pear_r<<endl;
report <<" "<<endl;
report <<"Pearson Residuals for harvested fish"<<endl;
report<<pear_h<<endl;
report <<" "<<endl;
report <<"Pearson Residuals for not seen"<<endl;
report<<pear_ns<<endl;
 report <<" "<<endl;
FINAL_SECTION
 //Calculate F and sd
 d=mp+fp+fap;
//Calculate S and Sd
 ofstream ofs1("S.std");
 for(y=styr;y<=endyr;y++)
   {
             d+=1;
     ofs1<<S(y)<<"\t"<<sigma(d,1)<<endl;


   }
  ofstream ofs2("F.std");
  for(y=styr;y<=endyr;y++)
   {
             d+=1;
     ofs2<<FM(y)<<"\t"<<sigma(d,1)<<endl;
   }
//Calculate FA and sd
  ofstream ofs3("Ft.std");
  for(y=styr;y<=endyr;y++)
   {
             d+=1;
     ofs3<<FT(y)<<"\t"<<sigma(d,1)<<endl;
   }
//Calculate M and Sd
```

```
  ofstream ofs4("M.std");
 for(y=styr;y<=endyr;y++)
   {
            d+=1;
     ofs4<<NM(y)<<"\t"<<sigma(d,1)<<endl;


   }
//Calculate harvest residuals
 ofstream ofs5("hresid.std");
     ofs5<<stdres_h<<endl;
//Export release residuals
 ofstream ofs6("rresid.std");
     ofs6<<stdres_r<<endl;
//Export not seen residuals
 ofstream ofs7("nsresid.std");
     ofs7<<stdres_ns<<endl;
```

Appendix B10: Scale-Otolith Bias in Ageing Striped Bass

Atlantic striped bass have been aged using scales for over 70 years (Merriman, 1941). Scales have long been a popular ageing structure because their collection does not require the fish to be killed or a market-quality fish to be damaged. However, scales have fallen out of favor with the recognition that that scales can underestimate the age of older fish, a phenomenon which has been documented in striped bass (Secor *et al.*, 1995).

ASMFC convened an ageing workshop for striped bass in 2003 to discuss the scale-otolith issue. Prior to the workshop, an exchange was conducted using 102 scales from known age fish; these fish had been tagged with coded wire tags (CWT) at age-0 and released. State personnel from MA, NJ, DE, VA, MD, and NC read the scales and the results were compared with the known ages.

The known-age scale exchange found general overestimation of year 1 and 2 specimens by one year and good agreement on scale readings from 3-7 years (Figure 1). Ages 9 through 12 (very low sample size was available from these ages) were interpreted reasonably accurately by experienced readers but were underestimated by all other readers. Age 8 was underestimated by all readers, which may have been due to a scale quality issue.

Workshop participants felt that scales were reliable for striped bass up to age 10-12 (about 800mm), but that otoliths should be used for animals older or larger than that (ASMFC 2003). The workshop recommended collecting paired samples from larger fish to better assess the reliability of scales for ageing older animals and the degree of bias between scales and otoliths.

Because of the difficulty and expense of collecting and processing otoliths, most states do not currently have sufficient otolith samples to develop a conversion matrix for their scale ages. Virginia has a large collection of paired samples dating back to 1999, and Massachusetts has samples from 2002-2004 and 2010-2012. Both states tended to age scale samples younger than the corresponding otolith sample for older ages (Figures 2, 3). VA also tended to age scale samples older than otolith samples for the youngest (< 5 years) fish.

The Technical Committee considered using VA's annual conversion matrices to convert scale ages from other states into otolith ages. One concern that was raised was that different states may need different correction factors between scales and otoliths. The comparison of scales and known ages at the 2003 workshop suggested that experienced readers were closer to the true ages and thus would need less of a correction than less experienced readers. To assess the consistency of scale-ageing across states, a set of 256 scale samples from VA was sent to MD, NJ, NY, RI, and MA to be aged by their scale readers prior to the assessment workshop, and the results were compared to VA's scale ages and corresponding otolith ages.

There was a regional pattern in the differences between the ages assigned by VA and the ages assigned by the other states (Figure 4). The mid-Atlantic states of MD and NJ agreed much more

with the ages assigned by VA, while the north Atlantic states of MA and RI tended to underage older fish compared to VA's ages. This may be a function of geographic differences in the scales themselves (due to regional differences in growth that are harder for readers from other regions to interpret), or of differences in preparation, reading technique, or reader experience. Ages assigned by all states using scales underaged the older fish compared to the ages VA assigned using otoliths, and the north Atlantic states again had a lower rate of agreement (Figure 5). However, a separate exchange of MA otoliths between VA and MA found very good agreement between the two states and no evidence of bias (Figure 6), consistent with other observations that otoliths tend to be easier to age precisely than scales.

These results indicated that applying a single correction matrix would likely not fully correct all ages and might introduce additional bias in samples aged by more experienced personnel.

While the use of scales remains a concern in this assessment, the currently available paired samples are not sufficient to convert scales ages on a coastwide basis. The TC recommends that sampling of otoliths, especially of larger fish, continues and more work is done to characterize the scale-otolith bias at the state level for all states that contribute to the age-length keys used in the assessment.

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Secor, D. H., T. M. Trice, and H. T. Hornick. 1995. Validation of otolith-based ageing and a comparison of otolith and scale-based ageing in mark-recaptured Chesapeake Bay striped bass, *Morone saxatilis*. Fish. Bull. 93:186-190.
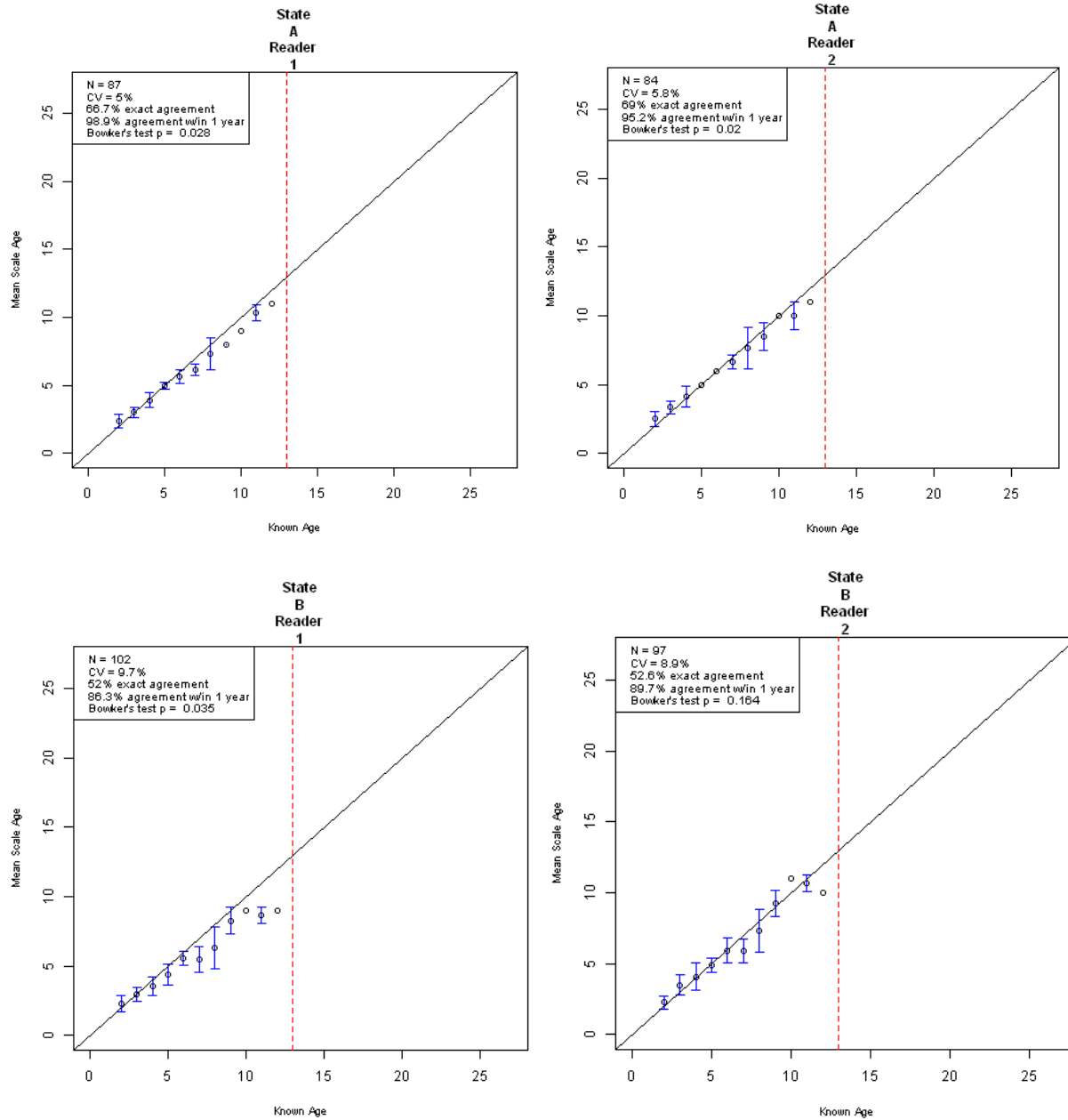
Figure 1: State scale age readings compared to the known age of CWT striped bass. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).
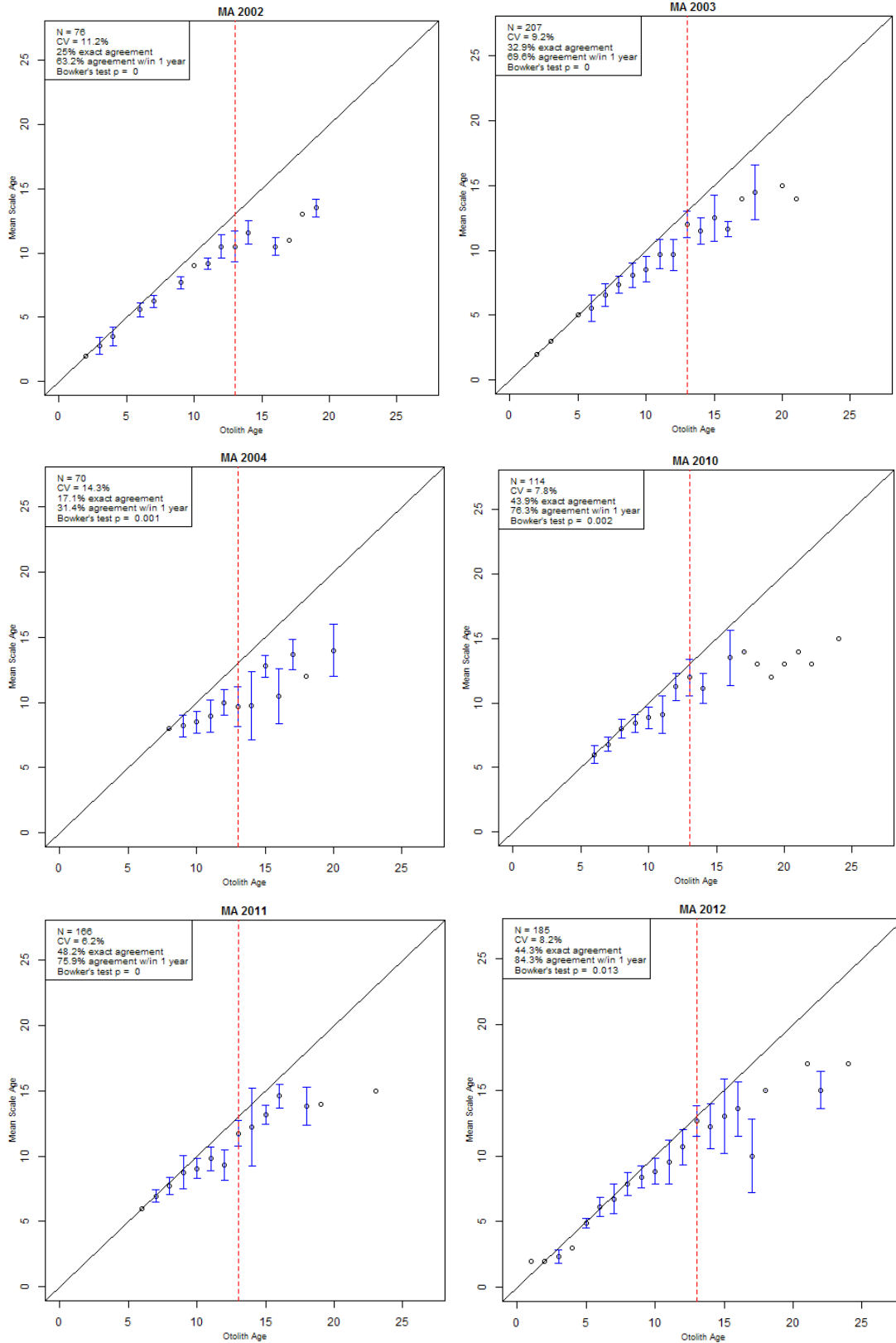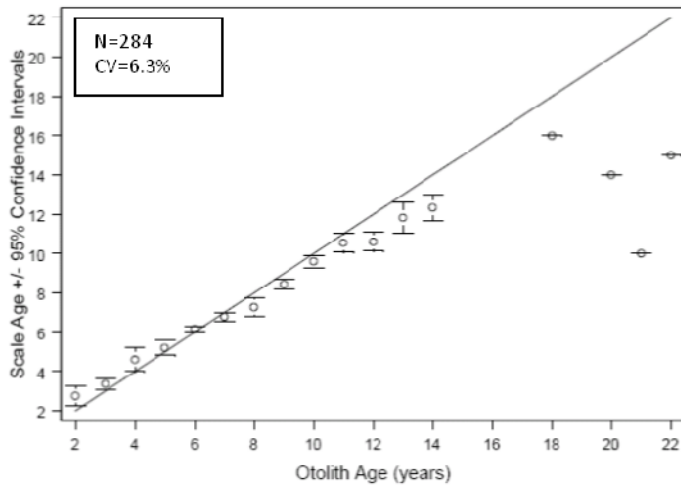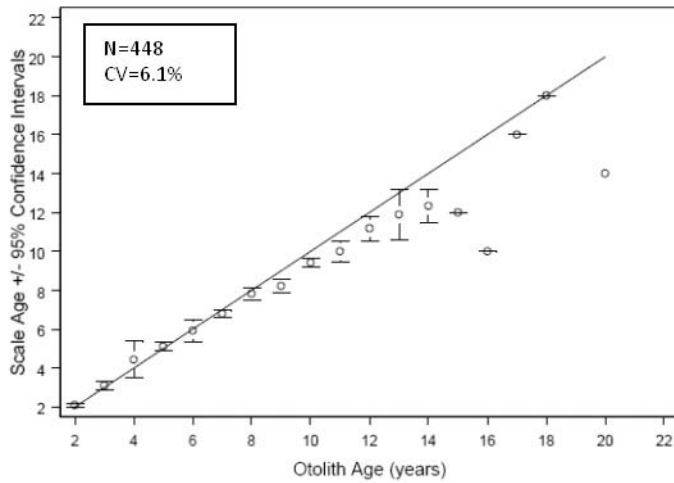
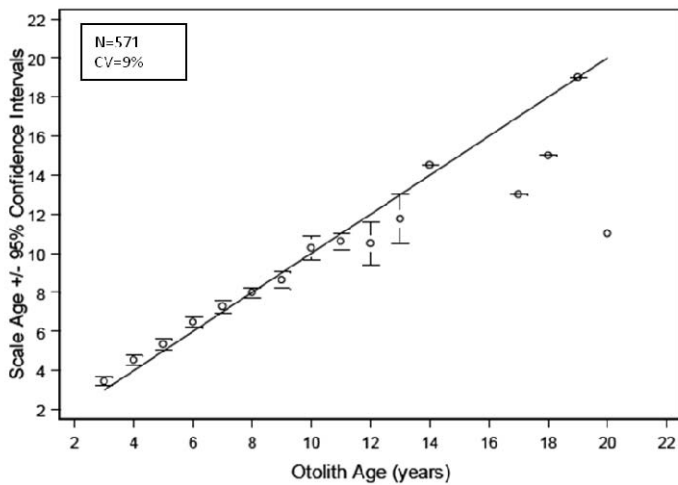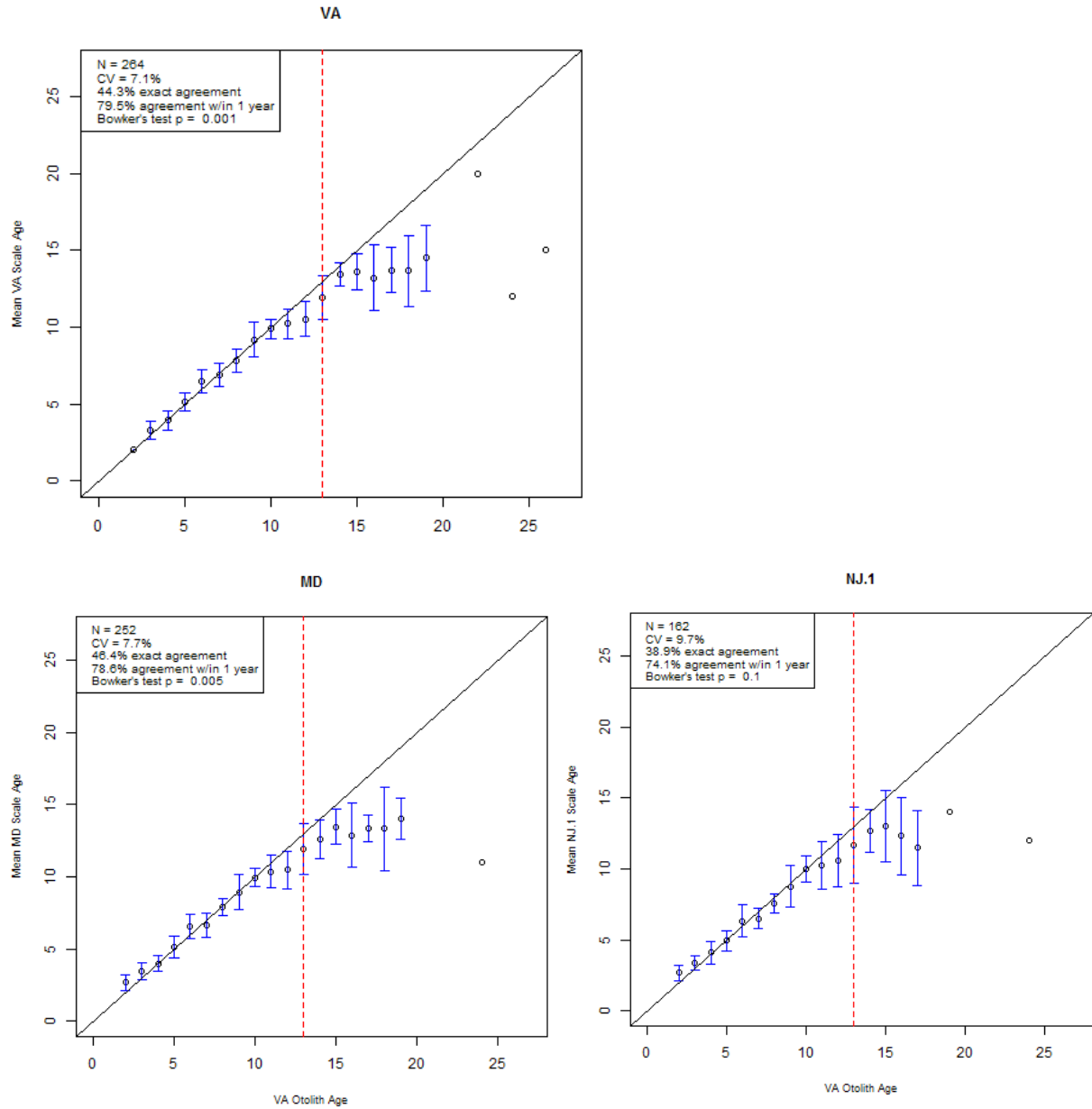Figure 1 (cont.): State scale age readings compared to the known age of CWT striped bass. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).
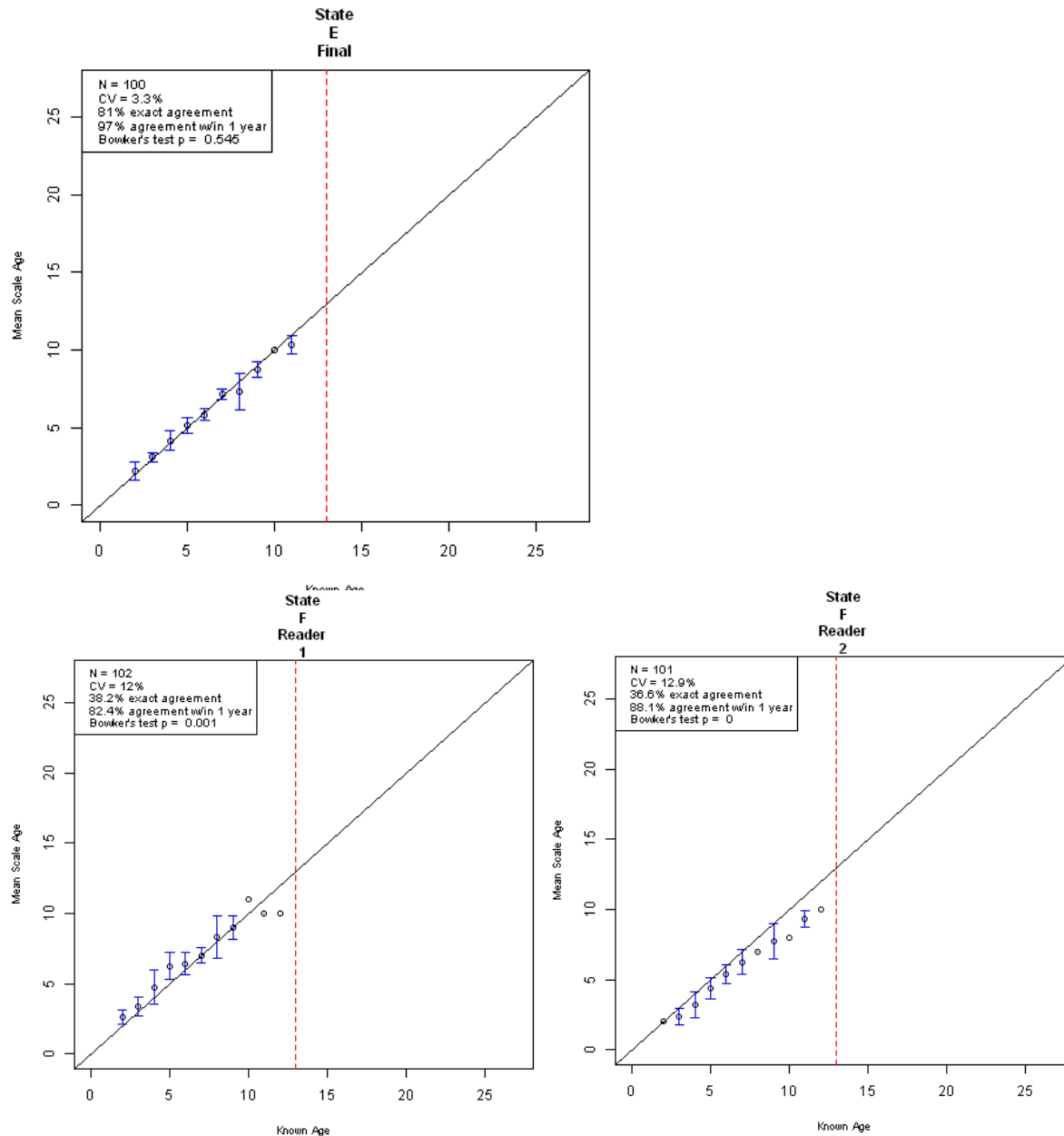
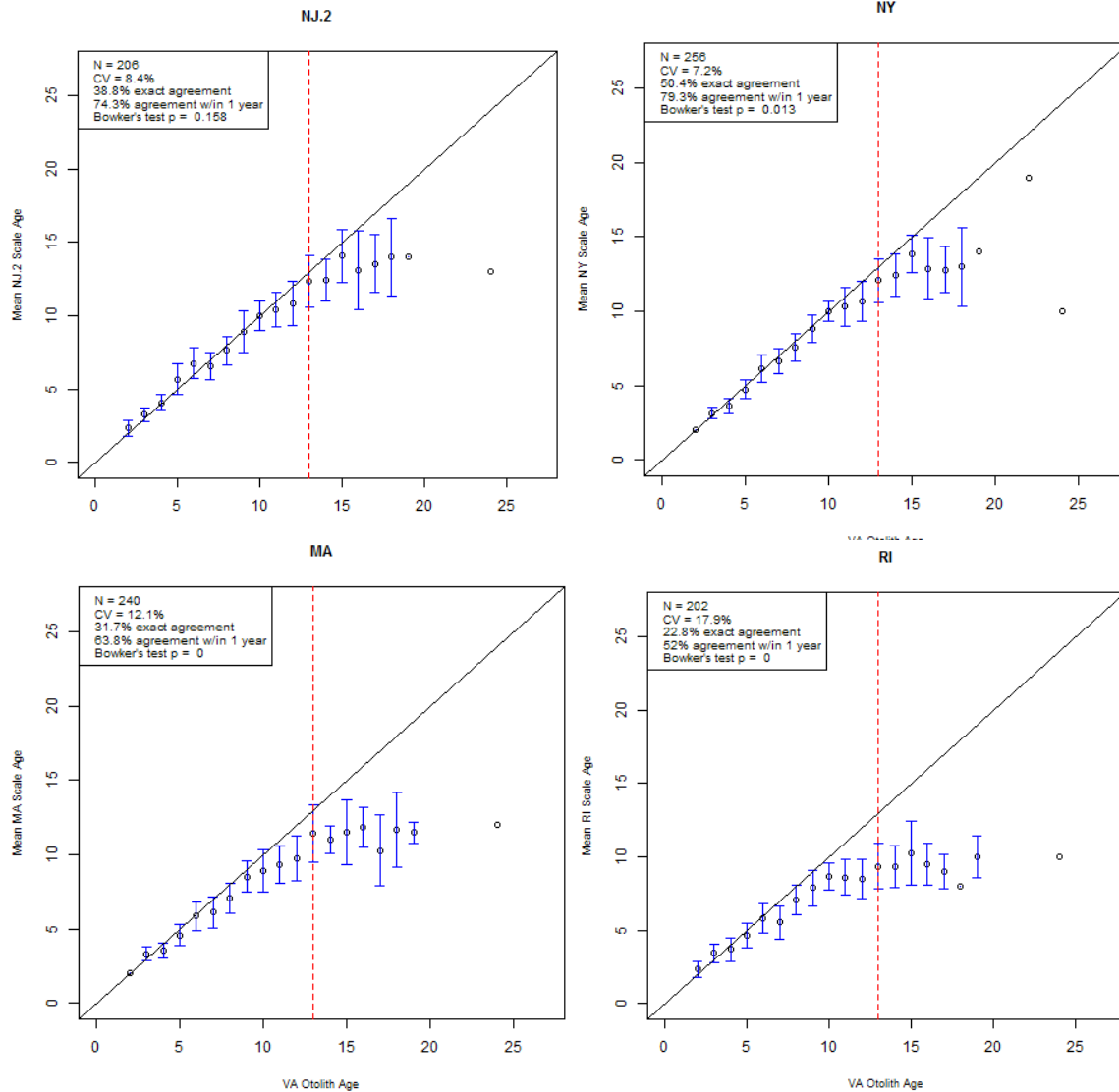Figure 1 (cont.): State scale age readings compared to the known age of CWT striped bass. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).

Figure 2: Massachusetts scale-otolith comparisons by year. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).

Figure 3: Virginia scale-otolith comparisons by year. Error bars indicate 95% confidence intervals. From VMRC Summary Report on Finfish Ageing 2002, 2003, 2004.
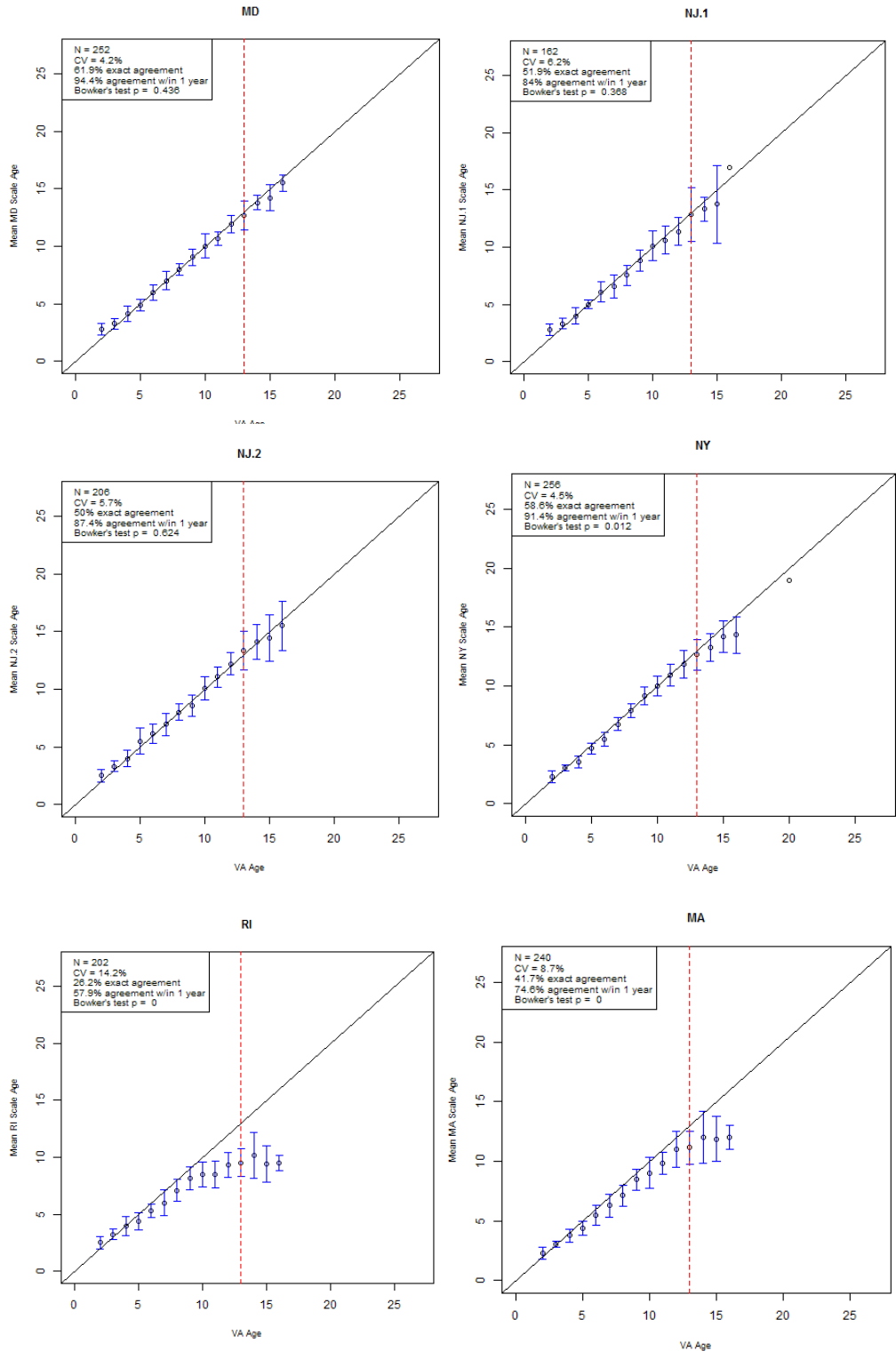
Figure 4: State scale age readings of striped bass compared to the scale ages assigned by Virginia. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).
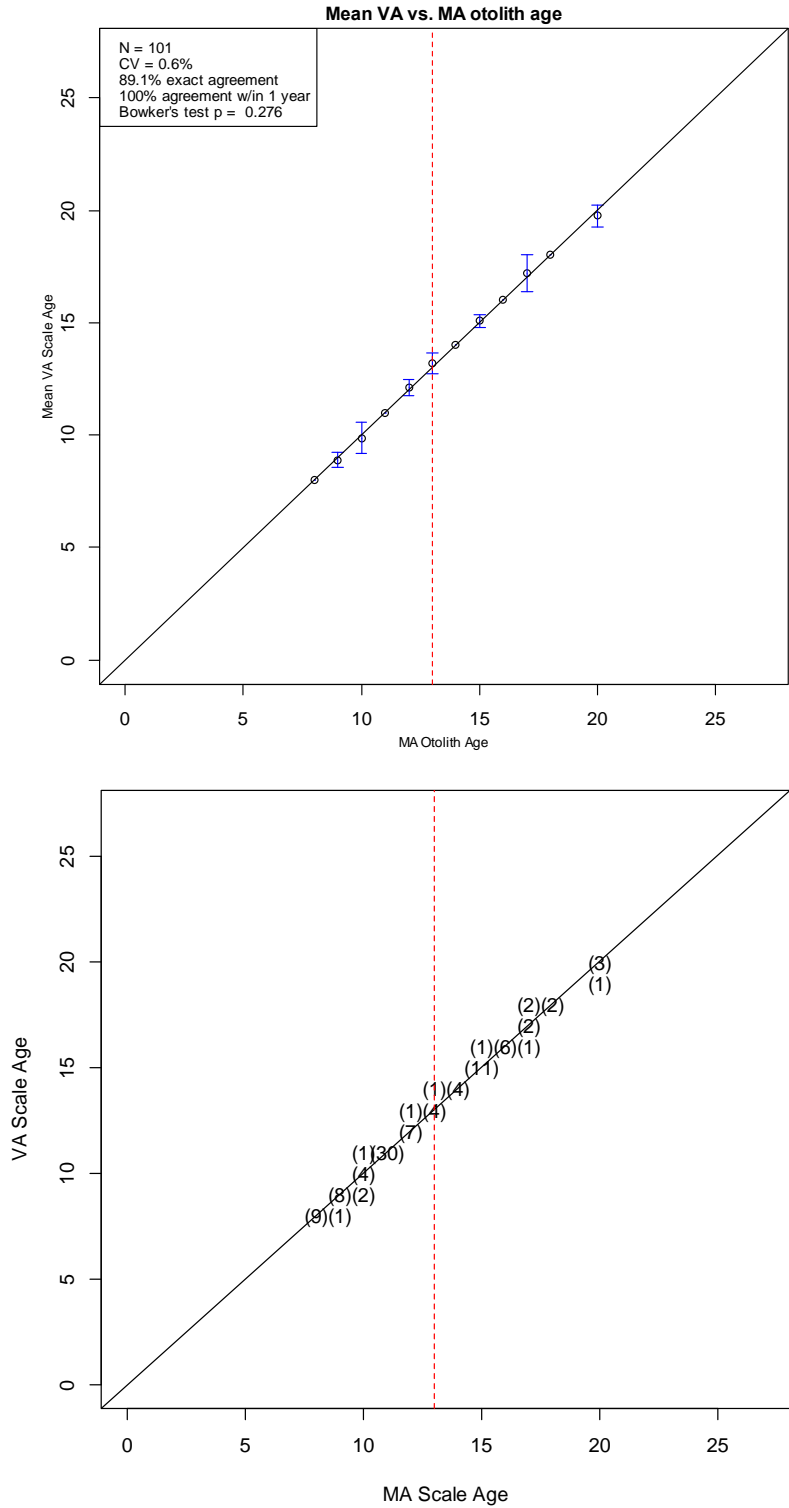
Figure 5: State scale age readings of striped bass compared to the otolith ages assigned by Virginia. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).

Figure 5 (cont.): State scale age readings of striped bass compared to the otolith ages assigned by Virginia. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).

Figure 6: Comparisons of VA and MA otolith ages. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+). Numbers in parentheses indicate sample size.

Appendix B11. Biological Reference Point Calculations Revisited

The Striped Bass Technical Committee developed an alternative, projection-based approach to the fishing mortality reference points that would align with the current spawning biomass reference points (SSB_{1995}). The estimate of F_{MSY}, used as a biological reference point (BRP) in the previous assessment, was sensitive to the choice and parameterization of the stock-recruitment model in the Statistical Catch at Age model (SCA). The proposed fishing mortality reference point was calculated using a stochastic projection by drawing recruitment from empirical estimates and a distribution of starting population abundance at age. The objective was to determine fishing mortality rates that would achieve the historical SSB target and threshold currently used in management. Empirical estimates of recruitment, selectivity, and the starting population came from the SCA model results. Estimates of recruitment were restricted to 1990 and later, when the stock was considered restored.

However, the SARC panel was concerned that projections did not achieve model-based estimates of SSB_{MSY} when the population was fished at F_{MSY}. To address these concerns, additional runs of the projections were completed at the Review Workshop. The major issue appeared to be the mismatch between the projection model assumptions and reference point model recruitment assumptions. The projection model used empirical estimates of recruitment while the model-based reference points predicted recruitment from either a Beverton-Holt or Shepherd stock-recruitment curve.

Accordingly, the projections were run with recruitment calculated from stock-recruitment curves instead of empirical recruitment observations. The striped bass SCA model was used to estimate both the bias-corrected and uncorrected parameters for a Beverton-Holt and Shepherd stock-recruitment curve. When these analyses were redone at the workshop, it was found that the model could not fit the Shepherd curve adequately (parameter estimates were consistently at the bounds), so the Shepherd curve was replaced with a Ricker curve to examine the effects of over-compensation in the stock-recruitment relationship.

Reference points (SSB_{MSY} and F_{MSY}) were calculated using the bias-corrected stock-recruitment curves. The uncorrected stock-recruitment curve with a model estimate of uncertainty was used for the projections. As before, projections were done using the AgePro program from the NOAA Fisheries Toolbox, and empirical estimates of selectivity and the starting population structure came from the SCA model results. The population was projected forward using the model-based estimate of F_{MSY} for 100 years, and the final equilibrium SSB was compared to the model-based estimates of SSB_{MSY}.

Estimates of equilibrium SSB under F_{MSY} were consistent with model-based estimates of SSB_{MSY} when the projections were done with model-based recruitment (Table B11.1). Results indicated that the differences in equilibrium SSB between projections done with empirical recruitment and projections done with model-based recruitment were caused by lower median recruitment in the empirical recruitment projections.

The SARC panel also asked to see a distribution of the projection-based SSB target and threshold values relative to observed recruitment, to ensure that attempting to attain those values would allow the population to persist at levels that could provide robust recruitment. The distribution of equilibrium SSB values obtained by fishing at the proposed empirical F target and threshold is shown in Figure B11.1.

Table B11.1. Comparison of model-based and projection-based BRPs for striped bass.

	Beverton-Holt[1]	Ricker[1]	Empirical Target[2]	Empirical Threshold[2]
F reference point	F_{MSY} = 0.201	F_{MSY} = 0.341	F_{proxy} = 0.175	F_{proxy} = 0.213
SSB_{MSY} (mt)	75,100	42,128	n/a	n/a
Median projected SSB (mt)	69,193	41,534	72,380	57,904

1: Model-based reference points (F_{MSY} and SSB_{MSY}) and projected values using model-based recruitment.

2: Empirical target and threshold F_{proxy} reference points from projections using observed recruitment to attain SSB threshold and target (SSB_{1995} and 125% SSB_{1995}, respectively).

Figure B11.1. Observed recruitment vs. spawning stock biomass plotted with equilibrium SSB values projected from fishing at the target and threshold F rate reference points using empirical recruitment.