Northeast Fisheries Science Center Reference Document 13-16

57th Northeast Regional Stock Assessment Workshop (57th SAW)

Assessment Report

by the Northeast Fisheries Science Center

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NOAA Fisheries, Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543

U.S. DEPARTMENT OF COMMERCE
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Northeast Fisheries Science Center
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Foreword

The Northeast Regional Stock Assessment Workshop (SAW) process has three parts: preparation of stock assessments by the SAW Working Groups and/or by ASMFC Technical Committees / Assessment Committees; peer review of the assessments by a panel of outside experts who judge the adequacy of the assessment as a basis for providing scientific advice to managers; and a presentation of the results and reports to the Region's fishery management bodies.
Starting with SAW-39 (June 2004), the process was revised in two fundamental ways. First, the Stock Assessment Review Committee (SARC) became smaller panel with panelists provided by the Independent System for Peer Review (Center of Independent Experts, CIE). Second, the SARC provides little management advice. Instead, Council and Commission teams (e.g., Plan Development Teams, Monitoring and Technical Committees, Science and Statistical Committee) formulate management advice, after an assessment has been accepted by the SARC. Starting with SAW-45 (June 2007) the SARC chairs were from external agencies, but not from the CIE. Starting with SAW-48 (June 2009), SARC chairs are from the Fishery Management Council's Science and Statistical Committee (SSC), and not from the CIE. Also at this time, some assessment Terms of Reference were revised to provide additional science support to the SSCs, as the SSC's are required to make annual ABC recommendations to the fishery management councils.

Reports that are produced following SAW/SARC meetings include: An *Assessment Summary Report* - a summary of the assessment results in a format useful to managers; an *Assessment Report* – a detailed account of the assessments for each stock; and the SARC panelist reports – a summary of the reviewer's opinions and recommendations as well as individual reports from each panelist. SAW/SARC assessment reports are available online at

http://www.nefsc.noaa.gov/nefsc/publications/series/crdlist.htm. The CIE review reports and assessment reports can be found at *http://www.nefsc.noaa.gov/nefsc/saw/*".
The 57th SARC was convened in Woods Hole at the Northeast Fisheries Science Center, July 23-26, 2013 to review benchmark stock assessments of: summer flounder (*Paralichthys dentata*) and striped bass (*Morone saxatilis*). CIE reviews for SARC57 were based on detailed reports produced by NEFSC Assessment Working Groups. This Introduction contains a brief summary of the SARC comments, a list of SARC panelists, the meeting agenda, and a list of attendees (Tables 1 – 3). Maps of the Atlantic coast of the USA and Canada are also provided (Figures 1 - 5).

Outcome of Stock Assessment Review Meeting:

Text in this section is based on SARC-57 Review Panel reports (available at http://www.nefsc.noaa.gov/nefsc/saw/ under the heading "SARC-57 Panelist Reports").

Regarding **summer flounder**, all eight of the stock assessment Terms of Reference (TORs) were met. The stock is neither overfished nor experiencing overfishing in 2012. Fishing mortality has decreased since 1997, and is below the new F_{MSY} proxy.

SSB in 2012 was 82% of the biomass target. The population was modeled with ASAP, a forward projecting age-structured model. A variety of fishery-independent and fishery-dependent surveys were available to characterize the stock. Annual projections were provided for 3 years with no retrospective adjustment.

Regarding **striped bass**, six of the seven stock assessment TORs were met and one TOR which dealt with Biological Reference Points was partly completed. The stock is not overfished and overfishing is not occurring. A variety of fishery-independent and fishery-dependent surveys were available to characterize the stock. The present assessment uses a statistical catch-at-age (SCA) model to estimate F, recruitment, total abundance and stock biomass. There was a slight retrospective pattern. The SARC Panel encourages development of a sex-disaggregated model. Management of striped bass has a long history and ad hoc reference points, such as SSB_{1995}.

SARC-57 concluded that each of the assessments (**summer flounder** and **striped bass**) was effective in delineating stock status, determining BRPs and proxies, and in projecting probable short-term trends in stock biomass, fishing mortality, and catches.

Table 1. 57th Stock Assessment Review Committee Panel.

SARC Chairman (MAFMC SSC):

Dr. Cynthia Jones
Center for Quantitative Fisheries Ecology, Director
Old Dominion University
Virginia
USA
cjones@odu.edu

SARC Panelists (CIE):

Dr. Robin Cook
Senior Research Fellow,
MASTS Population Modelling Group
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Glasgow
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Dr. John Simmonds
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Aberdeenshire
UK
Email: ejsimmonds@gmail.com

Dr. Henrik Sparholt
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DK-1553
Copenhagen V
Denmark
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Table 2. Agenda, 57th Stock Assessment Review Committee Meeting.

July 23-26, 2013

Stephen H. Clark Conference Room – Northeast Fisheries Science Center
Woods Hole, Massachusetts

AGENDA* (version: 16 July 2013)

TOPIC	PRESENTER(S)	SARC LEADER	RAPPORTEUR

Tuesday, July 23

10 – 10:30 AM
Welcome — **James Weinberg**, SAW Chair
Introduction — **Cynthia Jones**, SARC Chair
Agenda
Conduct of Meeting

10:30 – 12:30 PM Assessment Presentation (A. Summer flounder)
Mark Terceiro TBD **Brian Linton**

12:30 – 1:30 PM Lunch

1:30 – 3:30 Assesssment Presentation (A. Summer flounder)
Mark Terceiro TBD **Brian Linton**

3:30 – 3:45 Break

3:45 – 5:45 SARC Discussion w/ Presenters (A. Summer flounder)
Cynthia Jones, SARC Chair **Charles Adams**

5:45 – 6 Public Comments (A. Summer flounder)

Wednesday, July 24

9 – 10:45 AM Assessment Presentation (B. Striped bass)
Gary Nelson TBD **Jessica Blaylock**
Heather Corbett
Alexei Sharov

10:45 – 11 AM Break

11 – 12:30 PM (cont.) Assessment Presentation (B. Striped bass)
Gary Nelson TBD **Jessica Blaylock**
Heather Corbett

Alexei Sharov

12:30 – 1:45 PM	Lunch	
1:45 – 3:30	SARC Discussion w/presenters (B. Striped bass) **Cynthia Jones,** SARC Chair	**Toni Chute**
3:30 – 3:45	Public Comments (B. Striped bass)	
3:45 -4	Break	
4 – 6	Revisit with presenters (A. Summer flounder) **Cynthia Jones**, SARC Chair	**Kiersten Curti**
7	**(**Social Gathering **)**	

Thursday, July 25

8:30 – 10:15 AM	Revisit with presenters (B. Striped bass) **Cynthia Jones**, SARC Chair	**Anthony Wood**
10:15 – 10:30	Break	
10:30 – 12:45	Review/edit Assessment Summary Report (B. Striped bass) **Cynthia Jones**, SARC Chair	**Anthony Wood**
12:45 – 2 PM	Lunch	
2 – 2:45	(cont.) edit Assessment Summary Report (B. Striped bass) **Cynthia Jones**, SARC Chair	**Toni Chute**
2:45 – 3	Break	
3 – 6	Review/edit Assessment Summary Report (A. Summer flounder) **Cynthia Jones**, SARC Chair	**Julie Nieland**

Friday, July 26

9 AM – 5 PM	SARC Report writing. (closed meeting)

*All times are approximate, and may be changed at the discretion of the SARC chair. The meeting is open to the public, except where noted.

Table 3. 57th SAW/SARC, List of Attendees

Name	Affiliation	Email
Adams Charles	NEFSC	charles.adams@noaa.gov
Blaylock Jessica	NEFSC	Jessica.Blaylock@noaa.org
Bochenek Eleanor	NEFSC	bochenek@hsrl.rutgers.edu
Brooks Liz	NEFSC	liz.brooks@noaa.gov
Celestino Michael	NJ DFW	Mike.celestino@dep.state.nj.us
Cook Robin	University of Strathclyde	melford@clara.co.uk
Corbett Heather	NJ DFW	heather.corbett@dep.state.nj.us
Curti Kiersten	NEFSC	kiersten.curti@noaa.gov
Dancy Kiley	MAFMC	kdancy@mafmc.org
Diodati Paul	MA DMF	paul.diodati@state.ma.us
Drew Katie	ASMFC	kdrew@asmfc.org
Hasbrouck Emerson	Cornell Marine Program	ech12@cornell.edu
Jones Cynthia	ODU	cjones@odu.edu
Karp Bill	NEFSC	bill.karp@noaa.gov
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Richards Anne	NEFSC	anne.richards@noaa.gov
Serchuk Fred	NEFSC	fred.serchuk@noaa.gov
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Sosebee Kathy	NEFSC	katherine.sosebee@noaa.gov
Sparholt Henrik	ICES	henriks@ices.dk
Terceiro Mark	NEFSC	mark.terceiro@noaa.gov
Waine Mike	ASMFC	mwaine@asfmc.org
Weinberg James	NEFSC	James.Weinberg@noaa.org
Wood Tony	NEFSC	anthony.wood@noaa.gov

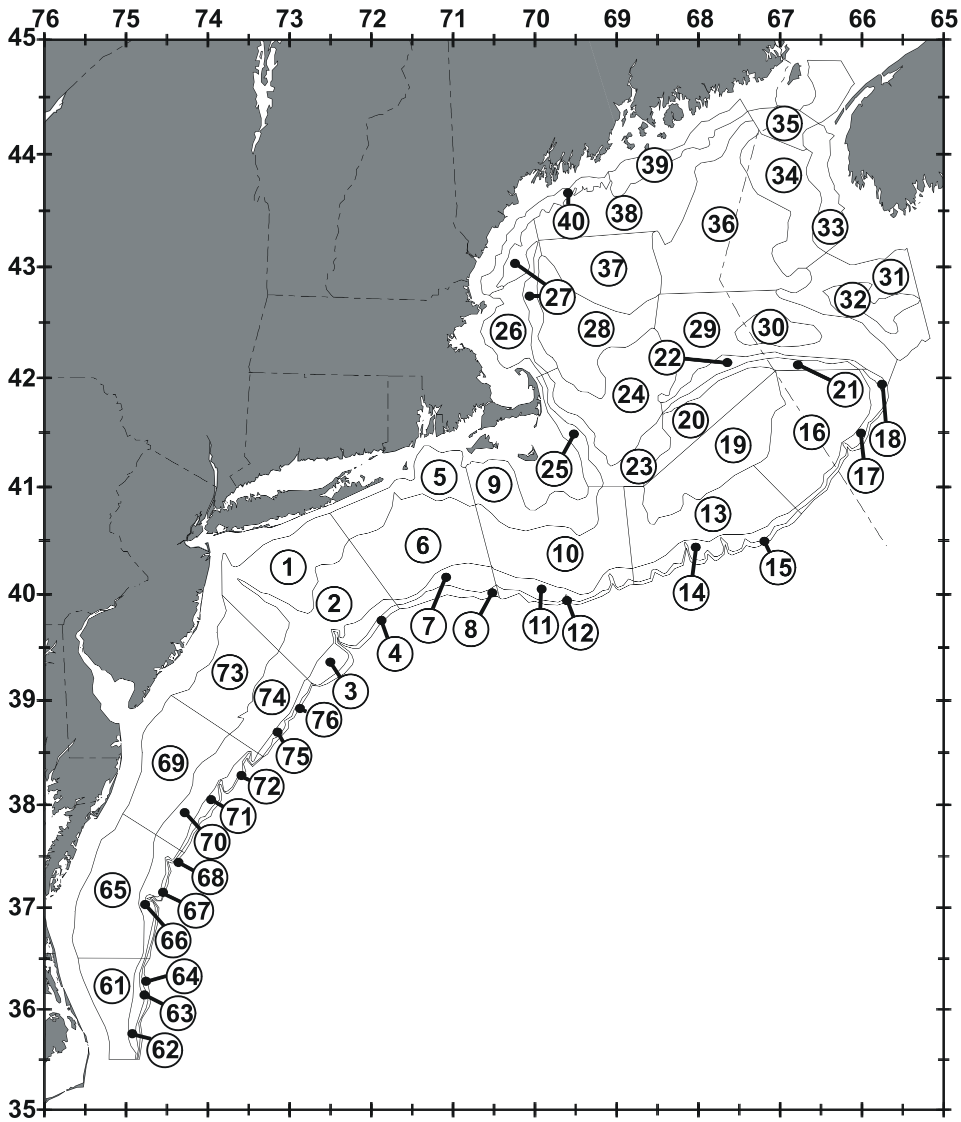

Figure 1. Offshore depth strata that have been sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.

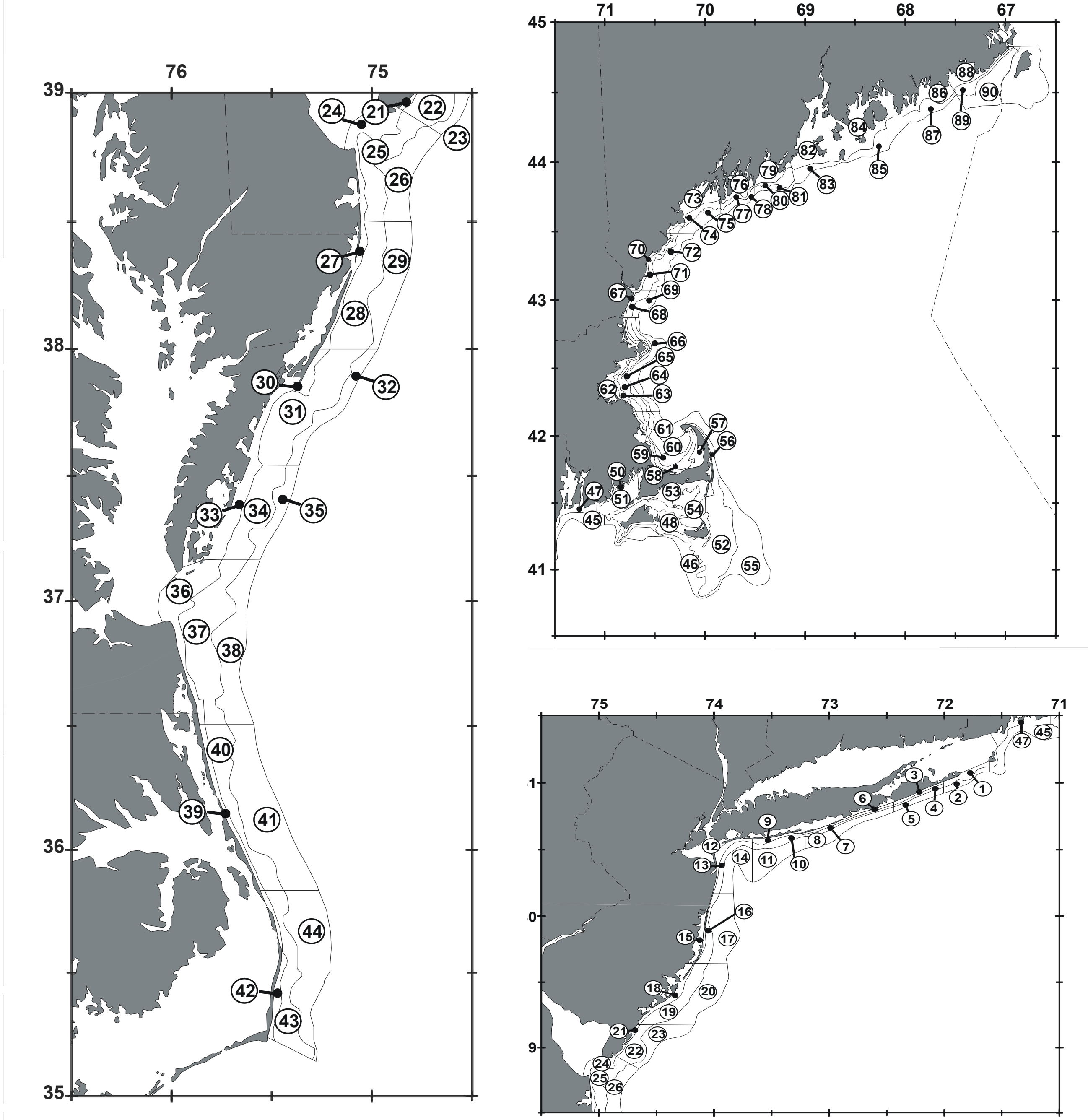

Figure 2. Inshore depth strata that have been sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.

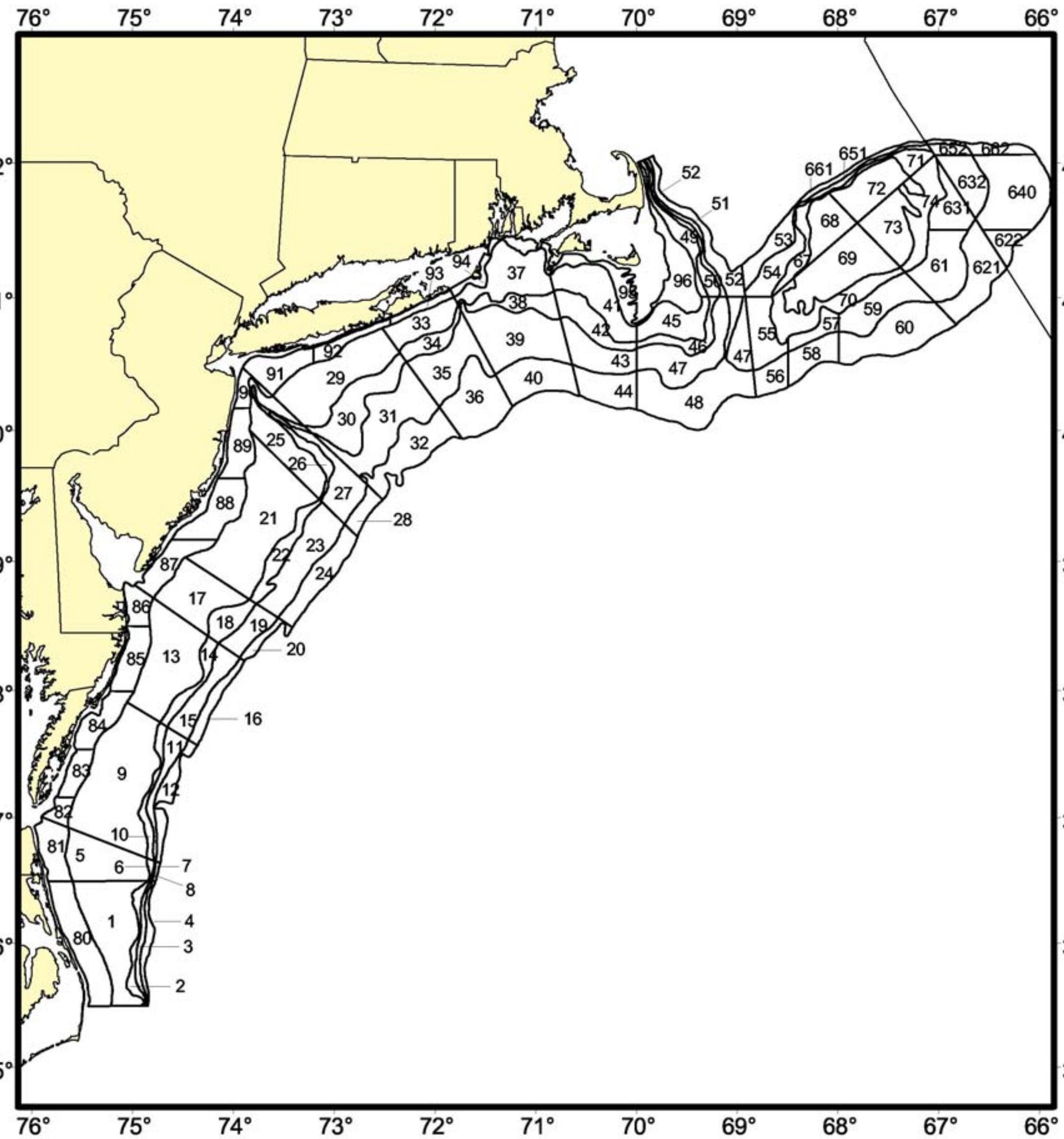

Figure 3. Depth strata sampled during Northeast Fisheries Science Center clam dredge research surveys.

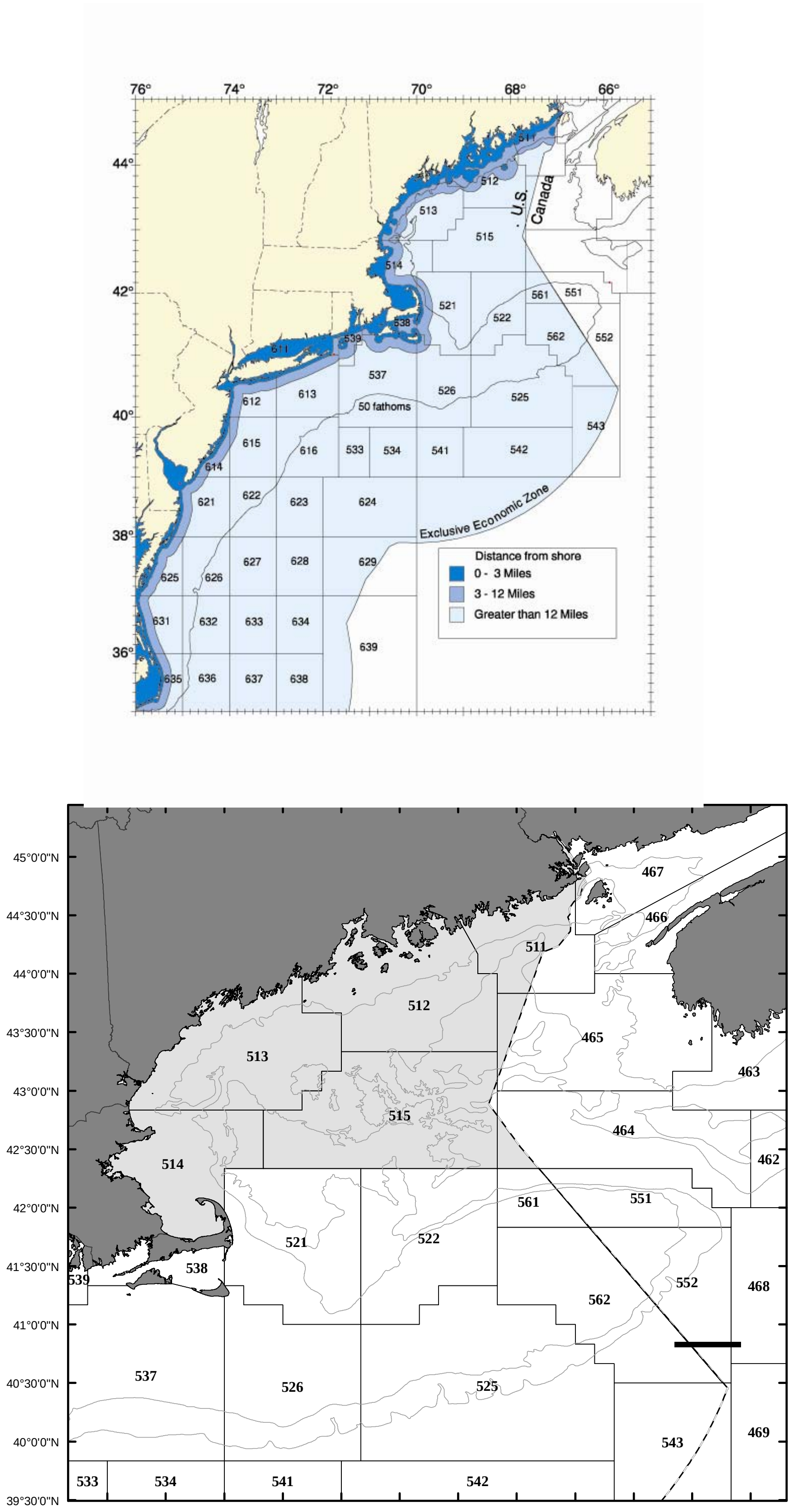

Figure 4. Statistical areas used for reporting commercial catches.

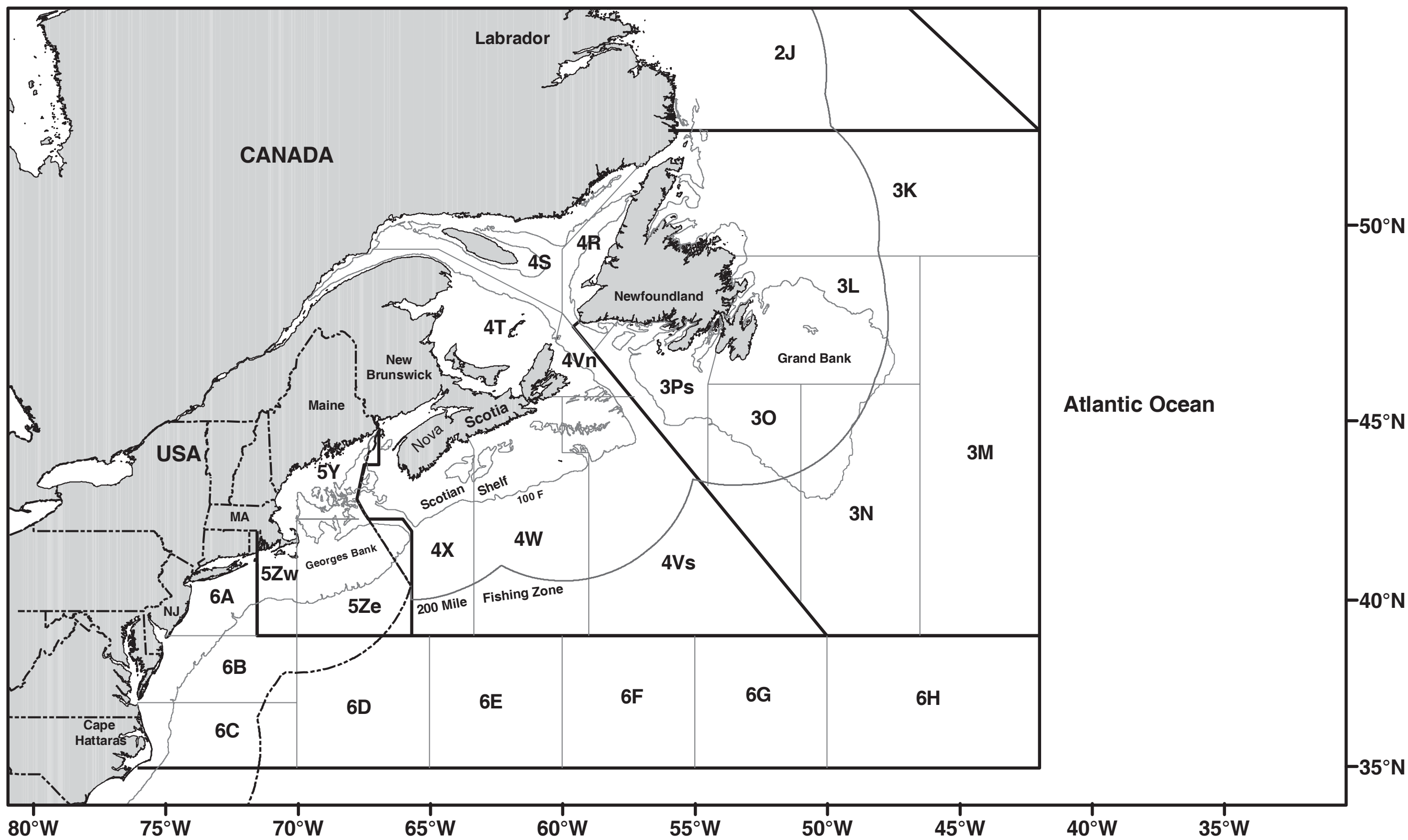

Figure 5. Catch reporting areas of the Northwest Atlantic Fisheries Organization (NAFO) for Subareas 3-6.

A. SUMMER FLOUNDER STOCK ASSESSMENT FOR 2013

Stock Assessment Terms of Reference (TORs) for Summer Flounder

1. Estimate catch from all sources including landings and discards. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize the uncertainty in these sources of data.

2. Present the survey data available for use in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.), and explore standardization of fishery-independent indices*. Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data. Describe the spatial distribution of the stock over time.

3. Review recent information on sex-specific growth and on sex ratios at age. If possible, determine if fish sex, size and age should be used in the assessment*.

4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from TOR-3), and estimate their uncertainty. Explore inclusion of multiple fleets in the model. Include both internal and historical retrospective analyses to allow a comparison with previous assessment results and previous projections.

5. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

6. Evaluate stock status with respect to the existing model (from previous peer reviewed accepted assessment) and with respect to a new model developed for this peer review.

   a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.

   b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-5).

7. Develop approaches and apply them to conduct stock projections and to compute the statistical distribution (e.g., probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).

   a. provide annual projections (3 years). For given catches, each projection 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 in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).

b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.
c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports, as well as MAFMC SSC model recommendations from 2012. Identify new research recommendations.

(*: Completion of specific sub-task is contingent on analytical support from staff outside of the NEFSC.)

EXECUTIVE SUMMARY

TOR 1. Estimate catch from all sources including landings and discards. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize the uncertainty in these sources of data.

Total landings peaked in 1983 at 26,100 mt. During the late 1980s and into 1990, landings decreased, reaching 4,200 mt in the commercial fishery in 1990 and 1,400 mt in the recreational fishery in 1989. Total landings were only 6,500 mt in 1990. Total commercial and recreational landings in 2012 were 8,900 mt = 19.621 million lbs and total commercial and recreational discards were 1,533 mt = 3.380 million lbs, for a total catch in 2012 of 10,433 mt = 23.001 million lbs. Reported 2012 landings in the commercial fishery were 6,047 mt = 13.331 million lbs, about 5% over the commercial quota. The commercial landings are assumed to be reported with minimal error. The uncertainty of the reported landings due to assignment to statistical area equates to a Coefficient of Variation (CV) of 0.3% during 1995-2012. Estimated 2012 landings in the recreational rod-and-reel fishery (as estimated by the MRIP) were 2,853 mt = 6.290 million lbs, about 26% under the recreational harvest limit. The average annual CV of the recreational landings is 6% in numbers and 7% in weight during 1982-2012. The time series of commercial fishery discards was revised for this assessment. Commercial discard losses in the otter trawl and scallop dredge fisheries have accounted for about 14% of the total commercial catch, assuming a discard mortality rate of 80%. The average annual CV of the commercial discards is 15% during 1989-2012. Recreational discard losses have accounted for about 12% of the total recreational catch, assuming a discard mortality rate of 10%. The average annual CV of the recreational discards is 8% during 1982-2012. Commercial landings have accounted for 54% of the total catch since 1982, with recreational landings accounting for 34%, commercial discards about 8%, and recreational discards about 5%.

Catch data from both recreational and commercial fisheries vessel trip reports (VTRs) as well as observer reports were summarized to determine spatial trends in catch and effort within the fishery in recent decades. A northerly trend of offshore commercial catches (and by inference, effort) has developed during the present decade with the largest catches now south of Rhode Island. Commercial catches of summer flounder at its southern extent are reduced after 2005. The fishery observer data show a much larger presence of large summer flounder catches on Georges Bank after 2005. Recreational fishing catch (and by inference, effort) distribution from party and charter boats is relatively unchanged throughout the 1990s and 2000s.

The SARC 57 Review Panel concluded that Term of Reference 1 was met.

TOR 2. Present the survey data available for use in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.), and explore standardization of fishery-independent indices*. Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data. Describe the spatial distribution of the stock over time. (*: Completion of specific sub-task is contingent on analytical support from staff outside of the NEFSC.)

Research survey indices of abundance are available from the NEFSC, MADMF, RIDFW, CTDEP, NYDEC, NJDFW, DEDFW, MDDNR, VIMS, VIMS ChesMMAP, VIMS NEAMAP, and NCDMF surveys. All available fishery independent research surveys except for the NCDMF trawl survey in Pamlico Sound were used in model calibration.

The NEFSC trawl surveys have a survey design that was randomized and the survey extends throughout the range of the species. Rather than developing a model to standardize, the survey design serves the purpose of standardizing the dataset. For these reasons, it was felt that standardization was not needed for the NEFSC trawl surveys. The same argument can be made for the VIMS NEAMAP survey, which is a new dataset used in the stock assessment. The Rhode Island fixed station monthly trawl survey (RIDFW RIX survey) was examined as an example of state surveys for the usefulness and applicability for standardization. The conclusion of this portion of the discussion was that the state surveys would be appropriate to standardize, were this to be a procedure the SDWG or ASMFC Technical Committee wished to perform.

The earliest years (1968-1990) of NEFSC fish trawl surveys showed the largest catches of summer flounder in inshore waters from Long Island to Cape Hatteras, with intermittent catches of summer flounder in the Georges Bank-Great South Channel strata or in the Gulf of Maine. The lowest catches occurred during the early 1990s, before increasing slowly in the late 1990s. During the rebuilding period of the 2000s, larger catches of summer flounder began appearing in northern areas, particularly south of Rhode Island and Massachusetts. Nearly all summer flounder caught north of Hudson Canyon are >30 cm in size. This divide appears to stretch further south during the rebuilding period during the 2000s. Survey catches during the earliest years of the time series were focused around the Delaware-Maryland-Virginia region where the majority of the catch, particularly in inshore strata surrounding Delaware and Chesapeake Bay, were fish <30 cm. Some smaller fish begin to re-enter catches north of Hudson Canyon as Mid-Atlantic Bight and Southern New England regions have become the new areas of greatest summer flounder abundance. The annual alongshelf center of biomass of summer flounder increases (moves North) from the late 1960s to the mid-1980s, then declined (moves South) in the mid 1990s, before reaching high levels again around 2007. For both the spring and fall fish trawl surveys the average alongshelf position of summer flounder increases with increasing size. The length predicted alongshelf center of biomass declines from the late 1960s to the early 1990s, increases until around 2008 and subsequently declines slightly. The relationship of the center of summer flounder biomass to either surface or bottom temperature is minimal in the spring and moderate in the fall. Summer flounder larval distribution has changed little over the past four decades. While *many factors may be causing changes in spatial distribution of summer flounder over the last few decades, their general increased abundance northward and expansion eastward on Georges Bank is apparent. Spatial expansion is also more apparent in years of greater abundance. This kind of response may be evident in summer flounder as expansion in both the spatial distribution and size structure has developed since about 2000, after the period of heavy exploitation during the 1980s and 1990s.*

The SDWG evaluated the utility of the fishery dependent landings- and catch-per unit effort based indices as measures of abundance in the summer flounder stock assessment. The SDWG concluded that the calculation of effort in the fishery dependent data is problematic. For the commercial data, the effort information is dependent on the accurate recording by the fishermen themselves, and the collection of this data is not a focus of their operation, therefore metrics like the recording the fishing time or length of tow may not be completely accurate and could affect the calculation of the CPUE index. There is a lack of consistency in the reporting requirements for parts of the commercial VTR time series; the instructions for how effort is reported have changed. For the recreational data, the calculation of effort is even more problematic. In this analysis, all trips which caught summer flounder were used; there are different ways to define summer flounder trips. However, there is variation in the number of rods and reels (gear quantity) and the time of fishing for each trip. The catch is also inconsistently reported in the for-hire recreational VTR with it being provided in numbers or pounds on these self-reported forms. In total these elements make the calculation of effort challenging when working with fishery dependent data time series. The SDWG noted that over the long term, and especially since fishery quotas were instituted in the early 1990s, there have been a number of regulatory changes which are different in timing and magnitude for each state (primarily seasonal closures, seasonal trip/possession limits, and minimum size limits). This information is not part of the commercial and recreational catch databases and so must be developed independently and integrated within the Generalized Linear Model. This information could not be modeled adequately as covariates or classification variables within the generalized model framework (i.e., inability to develop a model which converges and produces valid parameter estimates) for the commercial fishery data. Of the commercial fishery standardized indices, only the Dealer report LPUE series indicates an increasing trend in abundance comparable to the NEFSC seasonal trawl surveys (an increase of about 80% since 1990). The recreational fishery data indices, for which inclusion of regulatory measures in the models were successful, indicated recent decreasing trends in abundance that were inconsistent with the trends indicated by most state and federal research survey index trends. The modeling difficulties call into question the utility of both the nominal and model-based fishery dependent CPUE as indices of summer flounder abundance. While the commercial trawl indices do indicate increasing trends, the SDWG felt the standardization procedure was still subject to an unknown, likely negative, bias. In addition, the SDWG felt the multiple fishery-independent surveys available to this assessment had sufficient spatial coverage, such that inclusion of the fishery-dependent indices was not necessary, as might be the case for an assessment that lacked adequate fishery independent sampling. Based on these concerns, the SDWG recommended that the fishery dependent standardized indices of abundance not be used in the summer flounder assessment model.

The SARC 57 Review Panel concluded that Term of Reference 2 was met.

TOR 3. Review recent information on sex-specific growth and on sex ratios at age. If possible, determine if fish sex, size and age should be used in the assessment*. (*: Completion of specific sub-task is contingent on analytical support from staff outside of the NEFSC.)

The NEFSC survey data show trends in the most recent years of decreasing mean length and weight at age in all seasons and for both sexes, a trend in von Bertalanffy parameters that indicates 'slower growth' (smaller predicted length at age), and a trend of delayed maturity. There are no trends in length-weight relationship parameters or condition factor that suggest a trend of reduced 'condition' for summer flounder. There are trends in sex ratio that indicate a decreasing proportion of females (and therefore an increasing proportion of males) for ages 2 and older. Statistically significant differences in growth were found between sexes, between Northern and Southern regions (as split at the NEFSC statistical area associate with the Hudson Canyon off the continental margin of New York and New Jersey), and between early and late time periods (1900s and 2000s).

A data collection program was conducted during 2010-2011 with dual goals of 1) data collection and 2) an evaluation of the adequacy of summer flounder sex-at-age and sex-at-length keys developed from NMFS-NEFSC ocean trawl surveys in describing the sex ratio in recreational and commercial landings. The program continued until two full years of data were collected in each targeted region. Efforts were directed toward key ports in states from Massachusetts to North Carolina where summer flounder landings were high. Sex and length data were collected from over 30,000 summer flounder landed in the commercial (CF) and recreational (RF) fisheries and approximately 20,000 of those fish were aged by the NMFS-NEFSC. Minimum sampling goals were exceeded in nearly all regions. Differences in sex ratio between commercial/recreational landings and the NMFS-NEFSC ocean trawl survey were identified using a generalized linear model with a logit-link function and a binomial error distribution, commonly referred to as logistic regression. Analysis of these data showed that summer flounder sex-at-length and sex-at-age keys developed from NMFS-NEFSC ocean trawl data would not be appropriate for describing the sex ratio of recreational landings. However, that sex-at-length of summer flounder landed in the commercial fishery was well described by data collected on the NMFS-NEFSC trawl survey, and the best approach could be to 1) apply a NMFS-NEFSC sex-at-length key to commercial landings length data, and then 2) apply a commercial landings length-at-age key to arrive at an accurate measure of sex-at-age in the commercial fishery. Variation in sex ratio in both the recreational and commercial fisheries was observed to occur at fine spatial scales and perhaps over short time periods. The work further concluded that if a desire exists to accurately define sex ratio in either fishery with empirical data collection, this spatiotemporal variability might require a regular and spatially extensive sampling program in the future.

The SARC 57 Review Panel concluded that Term of Reference 3 was met.

TOR 4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from TOR-3), and estimate their uncertainty. Explore inclusion of multiple fleets in the model. Include both internal and historical retrospective analyses to allow a comparison with previous assessment results and previous projections.

Fishing mortality rates and stock sizes were estimated using the ASAP statistical catch at age model. In the summer flounder ASAP model an age-specific instantaneous natural mortality rate providing an average M = 0.25 was assumed for all years. Seasonal survey indices and all survey recruitment (age-0) indices were compared to population numbers of the same age at the appropriate season of the same year. A multinomial distribution was assumed for fishery catch at age and for survey catch at age when required. A number of additional initial model settings including specification of likelihood component emphasis factors (lambdas), size of deviation factors expressed as standard deviations, and penalty functions for extreme fishing mortality estimates. These were set at consensus values by the 2013 SDWG after multiple sensitivity runs to evaluate a range of inputs. An 'internal' retrospective analysis was conducted to examine the stability of the model estimates as data were removed from the last years of the time series. Retrospective runs were made for terminal years back to 2005. The summer flounder stock assessment has historically exhibited a retrospective pattern of underestimation of F and overestimation of SSB; the causes of this previous pattern have not been determined. In the current assessment model, however, no persistent retrospective patterns are evident. 'Historical' retrospectives indicate that general trends of fishing mortality, stock biomass, and recruitment have been consistent since the 1990s assessments.

Fishing mortality on the fully selected age 4 fish ranged between 0.790 and 1.745 during 1982-1996. The fishing mortality rate has decreased from 0.849 in 1997 to 0.285 in 2012. There is a 90% probability that the fishing mortality rate in 2012 was between 0.213 and 0.343. Spawning stock biomass (SSB) decreased from 24,300 mt in 1982 to 5,521 mt in 1989, and then increased to a peak of 53,156 mt by 2010. SSB was 51,238 mt in 2012, about 82% of the new reference point SSBMSY proxy = SSB35% = 62,394 mt. There is a 90% probability that SSB in 2012 was between 45,781 and 61,297 mt. The average recruitment from 1982 to 2012 is 43 million fish at age 0. The 1982 and 1983 year classes are the largest in the assessment time series, at 62 and 76 million fish; the 1988 year class is the smallest at only 10 million fish. The 2012 year class is currently estimated to be about 37 million fish.

The SARC 57 Review Panel concluded that Term of Reference 4 was met.

TOR 5. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

The 2008 SAW47 recommended proxies for FMSY and SSBMSY were F35% = 0.310 and the associated MSY (13,122 mt = 28.929 million lbs) and SSBMSY (60,074 mt = 132.440 million lbs) estimates from long-term stochastic projections. These 2008 SAW47 BRPs were subsequently adopted by the NMFS and MAFMC in the 2009 fishery regulation specification process, were retained in the 2009-2012 updated assessments to evaluate stock status, and are the existing (old) reference points for summer flounder.

The 2013 SDWG recommends that the updated (new) proxies for FMSY and SSBMSY are F35% = 0.309 (CV = 15%) and associated estimates from long-term stochastic projections of MSY = 12,945 mt (28.539 million lbs; CV = 13%) and SSBMSY = 62,394 mt (137.555 million lbs; CV = 13%; Table A92). The new biomass threshold of one-half SSBMSY is estimated to be 31,197 mt (68.8 million lbs; CV = 13%).

The SARC 57 Review Panel concluded that Term of Reference 5 was met.

TOR 6. Evaluate stock status with respect to the existing model (from previous peer reviewed accepted assessment) and with respect to a new model developed for this peer review.

a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.

b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-5).

a) A model with data through 2012, but with the same configuration and settings as the old (existing) 2012 model with data through 2011, provides estimates appropriate to compare with the old (existing) reference points, which are FMSY proxy = F35% = 0.310 and SSBMSY proxy = SSBMSY35% = 60,094 mt (TOR 6a). This model indicates that F in 2012 = 0.180 and SSB in 2012 = 60,905 mt, so the stock was not overfished and overfishing was not occurring.

b) The final model adopted by the 2013 SDWG for the evaluation of stock status indicates the summer flounder stock was not overfished and overfishing was not occurring in 2012 relative to the new biological reference points established in this 2013 SAW 57 assessment. The fishing mortality rate was estimated to be 0.285 in 2012, below the new threshold fishing mortality reference point = FMSY = F35% = 0.309. SSB was estimated to be 51,238 mt = 112.960 million lbs in 2012, 82% of the new biomass reference point = SSBMSY = SSB35% = 62,394 mt (137.555 million lbs).

The SARC 57 Review Panel concluded that Term of Reference 6 was met.

TOR 7. Develop approaches and apply them to conduct stock projections and to compute the statistical distribution (e.g., probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).

a. Provide annual projections (3 years). For given catches, each projection 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 in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).

b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.

c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

a) Stochastic projections were made to provide forecasts of stock size and catches in 2014-2016 consistent with the new (updated) 2013 SAW 57 biological reference points. The projections assume that recent (2010-2012) patterns of fishery selectivity, discarding, maturity at age and mean weight at age will continue over the time span of the projections. Future recruitment at age 0 was generated randomly from a cumulative density function of the updated recruitment series for 1982-2012 (average recruitment = 43 million fish). If the 2013 Annual Catch Limit (ACL) of 10,133 mt = 22.339 million lbs is taken, the 2013 median (50% probability) dead discards are projected to be 1,735 mt = 3.825 million lbs, and the median landings are projected to be 8,398 mt = 18.514 million lbs. The median F in 2013 is projected to be 0.250, below the new fishing mortality threshold = FMSY proxy = F35% = 0.309. The median SSB on November 1, 2013 is projected to be 56,662 mt = 124.918 million lbs, below the new biomass target SSBMSY proxy = SSB35% = 62,394 mt = 137.555 million lbs.

If the stock is fished at the new fishing mortality threshold = FMSY proxy = F35% = 0.309 in 2014, the median landings are projected to be 9,961 mt = 21.960 million lbs, with median dead discards of 2,177 mt = 4.799 million lbs, and median total catch = 12,138 mt = 26.760 million lbs. This projected median total catch would be the Overfishing Limit (OFL) for 2014, and is less than the new MSY proxy = 12,945 mt (28.539 million lbs; 10,455 mt = 23.049 million lbs of median landings plus 2,490 mt = 5.490 million lbs of median dead discards). The median SSB on November 1, 2014 is projected to be 57,140 mt = 125.972 million lbs, 92% of the new biomass target of SSBMSY proxy = SSB35% = 62,394 mt = 137.555 million lbs. The projected catch estimates in the following table are medians of the catch distributions for fixed F in 2014-2016.

Total Catch (OFL), Landings, Dead Discards, Fishing Mortality (F) and Spawning Stock Biomass (SSB) in 2014-2016
Catches and SSB in metric tons

Year	*Total Catch*	*Landings*	*Discards*	*F*	*SSB*
2014	*12,138*	*9,961*	*2,177*	*0.309*	*57,140*
2015	*11,785*	*9,497*	*2,288*	*0.309*	*58,231*
2016	*11,914*	*9,527*	*2,387*	*0.309*	*59,268*

If the MAFMC risk policy is applied by the SSC assuming a typical level 3 stock, given the size of the SSB relative to SSBMSY, assumed OFL CV = 100%, and the potential OFL at F = 0.309 for each year, the following Acceptable Biological Catch (ABC) results:

ABC Total Catch, Landings, Dead Discards, Fishing Mortality (F) and Spawning Stock Biomass (SSB) in 2014-2016
Catches and SSB in metric tons

Year	*Total Catch*	*Landings*	*Discards*	*F*	*SSB*
2014	*8,071*	*6,649*	*1,422*	*0.197*	*60,581*
2015	*9,992*	*8,117*	*1,875*	*0.237*	*63,969*
2016	*10,729*	*8,681*	*2,048*	*0.245*	*66,469*

For the projections at fixed FMSY proxy = F35% = 0.309, there is by definition 0% probability of exceeding the fishing mortality threshold and 0% probability of falling below the biomass threshold during 2014-2016. For the ABC projections, there is a less than an annual 13% probability that fishing mortality will exceed the threshold and 0% probability that biomass will fall below the threshold.

b, c) All of the projection results presented have a realistic probability of being achieved, and the summer flounder stock has a low vulnerability to becoming overfished, given recent trends in stock productivity and the management regime in place.

The SARC 57 Review Panel concluded that Term of Reference 7 was met.

TOR 8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports, as well as MAFMC SSC model recommendations from 2012. Identify new research recommendations.

Major data and analytical needs for summer flounder assessments have been identified in the 2002 SAW 35 peer review, the 2003 assessment update, the 2005 SAW 41 assessment update, the SDWG 2006 assessment update and subsequent NOAA Fisheries Science and Technology peer review, the SDWG 2007 assessment update, the 2008 SAW 47 *benchmark assessment, the 2012 MAFMC SSC, and by the 2013 SDWG for this current benchmark assessment. Research recommendations "never die" and are retained in these documents until they are addressed (completed). Therefore, these remaining recommendations have been subset as 8.1) completed, in progress, or to be addressed, and 8.2) new (identified by the SDWG SAW Working Group for this assessment). Fifteen 'old' recommendations remain and 13 'new' recommendations have been developed.*

The SARC 57 Review Panel concluded that Term of Reference 8 was met.

SAW WORKING GROUP PROCESS

The Stock Assessment Workshop (SAW) Southern Demersal Working Group (SDWG) prepared the assessment. The SDWG met during June 3-5 and 17-19, 2013 to develop the benchmark stock assessment of summer flounder (fluke) through 2012. The following scientists and managers constituted the 2013 SDWG:

Jeff Brust	New Jersey Division of Fish and Wildlife (NJDFW)
Paul Caruso	Massachusetts Division of Marine Fisheries (MADMF)
Jessica Coakley	Mid-Atlantic Fishery Management Council (MAFMC), SDWG Chair
Kirby Rootes-Murdy	Atlantic States Marine Fisheries Commission (ASMFC)
Chris Legault	National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC) Assessment Methods Task Leader
Jason McNamee	Rhode Island Division of Fish and Wildlife (RIDFW), ASMFC Technical Committee Chair
Jason Morson	Rutgers University
Eric Powell	University of Southern Mississippi Partnership for Mid-Atlantic Fisheries Science (PMAFS)
Mark Terceiro	NMFS NEFSC Demersal Resources Task Leader Summer Flounder Assessment Lead
Tom Wadsworth	North Carolina Division of Marine Fisheries (NCDMF)

In addition to the SDWG, the following scientists and managers participated to varying degrees in the discussions:

Charles Adams	NMFS NEFSC
Jessica Blaylock	NMFS NEFSC
Eleanor Bochenek	Rutgers University
Liz Brooks	NMFS NEFSC
Kiersten Curti	NMFS NEFSC
Kiley Dancy	MAFMC
Jon Deroba	NMFS NEFSC
Charles Fildani	NMFS NEFSC
Emerson Hasbrouck	Cornell Marine Program
Katerine Kaplan	Cornell University
John Maniscalco	New York Dept. of Environ. Conservation (NYDEC)
Katey Marancik	NMFS NEFSC
Mark Maunder	Inter-American Tropical Tuna Commission (IATTC)
Richard McBride	NMFS NEFSC
David McElroy	NMFS NEFSC
Alicia Miller	NMFS NEFSC
Tim Miller	NMFS NEFSC
Paul Nitschke	NMFS NEFSC
Loretta O'Brien	NMFS NEFSC

Mike Palmer	NMFS NEFSC
David Richardson	NMFS NEFSC
Eric Robillard	NMFS NEFSC
Fred Serchuk	NMFS NEFSC
Gary Shepherd	NMFS NEFSC
Kathy Sosebee	NMFS NEFSC
Pat Sullivan	Cornell University
Vic Vecchio	NMFS Northeast Regional Office (NERO)
Allison Watts	Virginia Marine Resources Commission (VMRC)
Jim Weinberg	NMFS NEFSC
Susan Wigley	NMFS NEFSC
Mike Wilberg	University of Maryland
Greg Wojcik	Connecticut Dept. Environ. Protection (CTDEP)
Richard Wong	Delaware Department of Fish and Wildlife (DEDFW)

STOCK UNIT

The definition provided by Wilk et al. (1980) of a unit stock extending from Cape Hatteras north to New England has been accepted in this and previous assessments. A consideration of summer flounder stock structure incorporating tagging data concluded that most evidence supported the existence of stocks north and south of Cape Hatteras, with the stock north of Cape Hatteras possibly composed of two distinct spawning aggregations, off New Jersey and Virginia-North Carolina (Kraus and Musick 2001). The current assessment stock unit is consistent with the conclusions of Kraus and Musick (2001). The Mid-Atlantic Fishery Management Council (MAFMC) and Atlantic States Marine Fisheries Commission (ASMFC) joint Fishery Management Plan (FMP) defines the management unit for summer flounder as extending from the southern border of North Carolina north to the U.S.-Canadian border. The management unit is consistent with the conclusions a summer flounder genetics study that revealed no population subdivision at Cape Hatteras (Jones and Quattro 1999).

As part of this assessment, Kajajian et al. (2013 MS; WPA12) evaluated whether otolith chemistry could be used to determine if there are chemical differences in juvenile otoliths that can subsequently be used as a natural tag to discern summer flounder nursery habitats and quantify stock structure and movement along the U.S. east coast. They used State natural resource agency and university collections of juvenile summer flounder collected (n = 138) in fall 2011 with bottom trawls from estuarine habitats along the US East Coast: Long Island Sound, Delaware Bay, Chesapeake Bay, Pamlico Sound, and the coastal inshore waters of South Carolina and Georgia. They noted that in fish that are not bilaterally symmetrical, such as summer flounder, the left and right sagittal otoliths often exhibit divergent growth patterns and mass, and may have differences in chemical composition. Prior to the analysis of area-scale differences in juvenile otolith signatures, they investigated the assumption of sagittal equivalence. Kajajian et al. (2013 MS) found there were significant mass and overall otolith chemistry differences between the left and right sagittae, originating from $\delta^{13}C$, $\delta^{18}O$, Li, Mg, and Sr.

Left sagittae were used to compare area-scale differences, and Kajajian et al. (2013 MS) found strong differences between the nurseries: Delaware Bay, Chesapeake

Bay, North Carolina, and the South-Atlantic Bight provided sufficient samples for analysis. All studied elements were significantly different between areas, thus they used the all-possible combinations approach to uncover the models that produced the highest classification success, finding that a five-variable model using $\delta^{13}C$, $\delta^{18}O$, Li, Mg, and Y produced the highest classification accuracy at 93% with the fewest variables. Kajajian et al. (2013 MS) concluded that, due to the lack of equivalence within the sagittal pair, the choice of otolith impacted subsequent analyses in the summer flounder, and that otolith chemistry can be used successfully to investigate summer flounder population structure and connectivity.

HISTORY OF MANAGEMENT AND ASSESSMENT

An overview of the history of the summer flounder FMP and assessment is provided in this section and the text box below. Management of the summer flounder fishery began through the implementation of the original Summer Flounder FMP in 1988, a time that coincided with the lowest levels of stock biomass for summer flounder since the late 1960s. The MAFMC and ASMFC cooperatively develop fishery regulations, with the National Marine Fisheries Service (NMFS) serving as the federal implementation and enforcement entity. Cooperative management was developed because significant catch is taken from both state (0-3 miles offshore) and federal waters (3-200 miles offshore).

Amendment 1 to the FMP in 1990 established the overfishing definition for summer flounder as equal to Fmax, initially estimated as 0.23 (NEFC 1990). Amendment 2 in 1992 established target fishing mortality rates for summer flounder for 1993-1995 as F = 0.53, and Fmax = 0.23 for 1996 and beyond. Regulations enacted under Amendment 2 to meet those fishing mortality rate targets included 1) an annual fishery landings quota with 60% allocated to the commercial fishery and 40% to the recreational fishery based on the historical (1980-1989) division of landings, with the commercial allocation further distributed among the states based on their share of commercial landings during 1980-1989, 2) a commercial minimum landed fish size limit at 13 in (33 cm), 3) a minimum mesh size of 5.5 in (140 mm) diamond or 6.0 in (152 mm) square for commercial vessels using otter trawls that possess 100 lbs (45 kg) or more of summer flounder, with exemptions for the flynet fishery and vessels fishing in an exempted area off southern New England during 1 November to 30 April, 4) permit requirements for the sale and purchase of summer flounder, and 5) annually adjustable regulations for the recreational fishery, including an annual harvest limit, closed seasons, a 14 in (36 cm) minimum landed fish size, and possession limits.

The results of stock assessments conducted in the mid 1990s indicated that summer flounder abundance was not increasing as rapidly as projected when Amendment 2 regulations were implemented. In anticipation of the need to drastically reduce fishery quotas in 1996 to meet the management target of Fmax, the MAFMC and ASMFC modified the fishing mortality rate reduction schedule in 1995 to allow for more stable landings between years while slowing the rate of stock rebuilding. Amendment 7 to the FMP set target fishing mortality rates of 0.41 for 1996 and 0.30 for 1997, with a target of Fmax = 0.23 for 1998 and beyond. Total landings were to be capped at 8,400 mt (18.519

million lbs) in 1996-1997 unless a higher quota in those years provided a realized F = 0.23.

Amendment 12 in 1999 defined overfishing for summer flounder as occurring when the fishing mortality rate exceeded the threshold fishing mortality rate of FMSY. Because FMSY could not be reliably estimated for summer flounder, Fmax = 0.24 was used as a proxy for FMSY. FMSY was also defined as the target fishing mortality rate. Under Amendment 12, the stock was defined to be overfished when total stock biomass fell below the biomass threshold of one-half of the biomass target, BMSY. Because BMSY could not be reliably estimated, the biomass target was defined as the product of total biomass per recruit and contemporary (1982-1996) median recruitment, at that time estimated to be 153,350 mt (338 million lbs), with the biomass threshold defined as 76,650 mt (169 million lbs). In the 1999 stock assessment (Terceiro 1999) the reference points were updated using new estimates of median recruitment (1982-1998) and mean weights at age (1997-1998), which resulted in a biomass target of 106,444 mt (235 million lbs) and minimum biomass threshold of 53,222 mt (118 million lbs). The Terceiro (1999) reference points were retained in the 2000 and 2001 stock assessments (NEFSC 2000, MAFMC 2001a) because of the stability of the input data. Concurrent with the development of the 2001 assessment, the MAFMC and ASMFC convened the Summer Flounder Overfishing Definition Review Committee to review these biological reference points. The work of this Committee was later reviewed by the MAFMC Scientific and Statistical Committee (SSC) in August 2001. The SSC recommended that using the FMSY proxy for Fmax = 0.26 was appropriate and should be retained for 2002, and endorsed the recommendation of SARC 31 (NEFSC 2000) which stated that "...the use of Fmax as a proxy for FMSY should be reconsidered as more information on the dynamics of growth in relation to biomass and the shape of the stock recruitment function become available" (MAFMC 2001b).

The 2002 SAW 35 assessment (NEFSC 2002a) indicated the summer flounder stock was overfished and overfishing was occurring relative to the biological reference points. The fishing mortality rate had declined from 1.32 in 1994 to 0.27 in 2001, marginally above the overfishing reference point (Fthreshold = Ftarget = Fmax = 0.26). Total stock biomass in 2001 was estimated at 42,900 mt (94.578 million lbs), or 19% below the biomass threshold (53,200 mt; 117.286 million lbs). The 2002 SAW35 Review Panel concluded that updating the biological reference points was not warranted at that time (NEFSC 2002a). Subsequent updates to the stock assessment were completed in 2003 (Terceiro 2003a) and 2005 (NEFSC 2005). While the 2003 assessment found the summer flounder stock was not overfished and no overfishing was occurring, the 2005 assessment found the stock again experiencing overfishing. The 2005 SAW 41 assessment provided updated values for the fishing mortality and stock biomass reference points (NEFSC 2005).

A peer review of the assessment occurred in 2006 by the NMFS Office of Science and Technology (S&T) (Terceiro 2006a, 2006b). This review made several recommendations, including modification of the definition of the overfished stock from the original definition under Amendment 2 to the FMP. Instead of using January 1 total stock biomass (TSB), the stock was considered overfished when November 1 spawning stock biomass (SSB) fell below one-half SSBMSY = 44,706 mt (98.6 million lbs). Further, the overfishing reference point was revised to be Fthreshold = Ftarget = Fmax =

0.28. The 2006 S&T assessment concluded that the stock was not overfished, but that overfishing was occurring relative to the updated reference points (Terceiro 2006b).

The 2007 assessment update (SDWG 2007) found that relative to the 2006 S&T assessment biological reference points, the stock was overfished and overfishing was occurring. The fishing mortality rate estimated for 2006 was 0.35, a significant decline from the 1.32 estimated for 1994 but still above the threshold of 0.28.

The most recent peer review of the assessment occurred at the 2008 SAW 47 (NEFSC 2008a). In the 2008 SAW 47 assessment, the age-structured assessment model changed from an ADAPT virtual population analysis (VPA) model to a forward projecting, ASAP statistical catch at age (SCAA) model, and the fishery catch was modeled as two fleets: totals landings and total discards. A new value for the instantaneous natural mortality rate (M) was adopted, changing from a constant value of M = 0.20 to age- and sex-specific values that resulted in a mean value of M = 0.25. Biological reference points were therefore also revised; the proxy for FMSY changed from Fmax to F35%, and F40% was recommended as Ftarget. The assessment concluded that the stock was not overfished and overfishing was not occurring in 2007, relative to the revised biological reference points. Fishing mortality calculated from the average of the fully recruited ages (3-7+) ranged between 1.143 and 2.042 during 1982-1996. The fishing mortality rate was estimated to be 0.288 in 2007, below the fishing mortality reference point = F35% = FMSY = 0.310. SSB was estimated to be 43,363 mt (95.599 million lbs) in 2007, about 72% of the biomass target reference point of SSB35% = SSBMSY = 60,074 mt (132.441 million lbs). The assessment exhibited a consistent retrospective pattern of underestimation of F and overestimation of SSB, but no consistent retrospective pattern in recruitment.

The last assessment update in 2012 (Terceiro 2012) indicated that the stock was not overfished and overfishing was not occurring in 2011 relative to the biological reference points established in the 2008 SAW 47 assessment. The fishing mortality rate (F) was estimated to be 0.241 in 2011, below the fishing mortality threshold reference point = FMSY = F35% = 0.310. Spawning Stock Biomass (SSB) was estimated to be 57,020 metric tons (mt) = 125.708 million lbs in 2011, 5% below the biomass target reference point = SSBMSY = SSB35% = 60,074 mt = 132.440 million lbs. The NMFS determined in November 2011 that the summer flounder stock reached the biomass target (i.e., was rebuilt) in 2010, based on the 2011 assessment update (Terceiro 2011). This 2013 SAW 57 benchmark assessment incorporates commercial and recreational fishery catch data, research survey indices of abundance, and the analyses of those data through 2012.

Summary of the history of the Summer Flounder, Scup, and Black Sea Bass FMP.			
Year	**Document**	**Plan Species**	**Management Action**
1988	Original FMP	summer flounder	- Established management plan for summer flounder
1991	Amendment 1	summer flounder	- Established an overfishing definition for summer flounder
1993	Amendment 2	summer flounder	- Established rebuilding schedule, commercial quotas, recreational harvest limits, size limits, gear restrictions, permits, and reporting requirements for summer flounder - Created the Summer Flounder Monitoring Committee
1993	Amendment 3	summer flounder	- Revised the exempted fishery line - Increased the large mesh net threshold - Established otter trawl retention requirements
1993	Amendment 4	summer flounder	- Revised state-specific shares for summer flounder quota allocation
1993	Amendment 5	summer flounder	- Allowed states to combine or transfer commercial summer flounder quota
1994	Amendment 6	summer flounder	- Set criteria for allowance of multiple nets on board commercial vessels for summer flounder - Established deadline for publishing catch limits, commercial mgmt. measures for summer flounder
1995	Amendment 7	summer flounder	- Revised the F reduction schedule for summer flounder
1996	Amendment 8	summer flounder and scup	- Incorporated Scup FMP into Summer Flounder FMP and established scup measures including commercial quotas, recreational harvest limits, size limits, gear restrictions, permits, and reporting requirements
1996	Amendment 9	summer flounder and black sea bass	- Incorporated Black Sea Bass FMP into Summer Flounder FMP and established black sea bass measures including commercial quotas, recreational harvest limits, size limits, gear restrictions, permits, and reporting requirements
1997	Amendment 10	summer flounder, scup, and black sea bass	- Modified commercial minimum mesh requirements, continued commercial vessel moratorium, prohibited transfer of fish at sea, and established special permit for party/charter sector for summer flounder
1998	Amendment 11	summer flounder, scup, and black sea bass	- Modified certain provisions related to vessel replacement and upgrading, permit history transfer, splitting, and permit renewal regulations
1999	Amendment 12	summer flounder, scup, and black sea bass	- Revised FMP to comply with the SFA and established framework adjustment process
2001	Framework 1	summer flounder, scup, and black sea bass	-Established quota set-aside for research for all three species

2001	Framework 2	summer flounder	- Established state-specific conservation equivalency measures for summer flounder
2003	Amendment 13	summer flounder, scup, and black sea bass	- Addressed disapproved sections of Amendment 12 and included new EIS
2003	Framework 3	scup	- Allowed the rollover of winter scup quota - Revised start date for summer quota period for scup fishery
2003	Framework 4	scup	- Established system to transfer scup at sea
2004	Framework 5	summer flounder, scup, and black sea bass	- Established multi-year specification setting of quota for all three species
2006	Framework 6	summer flounder	- Established region-specific conservation equivalency measures for summer flounder
2007	Amendment 14	scup	- Established rebuilding schedule for scup
2007	Framework 7	summer flounder, scup, and black sea bass	- Built flexibility into process to define and update status determination criteria - Scup GRAs modifiable by framework adjustment

AGEING

Historical studies of summer flounder age and growth include those of Poole (1961), Eldridge (1962), Powell (1974), Smith and Daiber (1977), Henderson (1979), and Shepherd (1980). A summer flounder aging workshop held in 1980 (Smith *et al.* 1981) noted that these early studies provided differing interpretations of the growth zones on summer flounder scales and otoliths. After comparative study by fisheries biologists from along the Atlantic coast, the workshop concluded that both structures followed the generalized temperate waters pattern of rapid growth during early summer through early winter. Scales were identified as the better structure for ageing, being preferred over otoliths due to the possibility of poor otolith calcification and/or resorption. Spawning was noted to occur to from early September in the north through the following March in the south. For uniformity, January 1 was considered the birthday, with fish not considered one year old until passing their first summer, to eliminate the possibility of fall spawn fish being classified as age 1 the following January. The 1980 workshop effectively set the first coast-wide conventions for ageing summer flounder, and importantly concluded that the minimum observed mean length of age 1 fish should be at about 17-18 cm and of age 2 fish at about 28-29 cm (Smith *et al*. 1981).

A second summer flounder ageing workshop was held in 1990 (Almeida *et al.* 1992) in response to continuing confusion among summer flounder biologists over the proper interpretation of the conventions established by the 1980 workshop (Smith *et al.* 1981). Several issues were addressed, including the differences in processing and interpreting scales and otoliths, the age classification of the first distinct annulus measured from the focus, and consideration of new studies completed since the 1980 workshop. The 1990 workshop agreed to accept the summer flounder ageing criteria provided in Dery (1988), and in particular noted that first annulus formation for a given cohort could occur after 18-21 months of growth for fish spawned in the north in the fall, and after 10-16 months of growth for fish spawned in the south early the following spring. The latter conclusion was based on a review of the work of Szedlmayer and Able (1992), which validated the first year growth assumption and interpretation of the first annulus. The 1990 workshop most importantly concluded that there was consistency in ageing techniques and interpretation and that first year growth for summer flounder was extremely rapid. The workshop noted the potential for fish born early in the calendar year and inhabiting estuarine areas of the mid-Atlantic to reach 30 cm by their first winter and be classified as age 0, in support of the Poole (1961) and Szedlmayer and Able (1992) conclusions (Almeida *et al.* 1992).

Work performed in preparation for the Stock Assessment Workshop (SAW) 22 stock assessment (NEFSC 1996b) indicated a major expansion in the size range of 1-year old summer flounder collected during the 1995 and 1996 Northeast Fisheries Science Center (NEFSC) winter bottom trawl surveys. The work also brought to light developing differences between ages determined by NEFSC and North Carolina Division of Marine Fisheries (NCDMF) fishery biology staffs. Age structure (scale) exchanges were performed prior to the SAW 22 assessment to explore these differences. The results of the first two exchanges were reported at SAW 22 (NEFSC 1996b) and indicated low levels of agreement between age readers at the NEFSC and NCDMF (31 and 46%). During 1996, research was conducted to determine inter-annular distances and to back-calculate mean length at age from scale samples collected on all NEFSC bottom trawl surveys (winter, spring and fall) for comparison with NCDMF commercial winter trawl fishery samples. While mean length at age remained relatively constant from year to year, inter-annular distances increased sharply in the samples from the 1995-1996 winter surveys, and increased to a lesser degree in samples from other 1995-1996 surveys. As a result, further exchanges were suspended pending the resolution of an apparent NEFSC ageing problem.

Age samples from the winter 1997 bottom trawl survey, aged utilizing both scales and otoliths by only by one reader, subsequently indicated a similar pattern as the previous two winter surveys (i.e., several large age 1 individuals), and some disagreement between scale and otolith ages obtained from the same fish. Because of these problems, a team of five experienced NEFSC readers was formed to re-examine the scales aged from the winter survey. After examining several hundred scales, the team determined that re-ageing all samples from 1995-1997 would be appropriate, including all winter, spring, and fall samples from the NEFSC and Massachusetts Division of Marine Fisheries (MADMF) bottom trawl surveys and all samples from the commercial fishery. The age determination criteria remained the same as those developed at the 1990 workshop (Almeida *et al.* 1992) and described in the ageing manual utilized by NEFSC staff (Dery 1988, 1997). Only those fish for which a 100% agreement of all team members was attained were included in the revised database. The data from the re-aged database were used in analyses in the SAW 25 assessment (NEFSC 1997).

A third summer flounder ageing workshop was held at the NEFSC in 1999, to continue the exchange of age structures and review of ageing protocols for summer flounder (Bolz et al. 2000). Participants at this workshop concluded that the majority of ageing disagreements in recent NEFSC-NCDMF exchanges had arisen from inconsistency among readers in the interpretation of marginal scale increments due to highly variable timing of annulus formation and in the interpretation of first year growth patterns and classification of the first annulus. The workshop recommended regular samples exchanges between NEFSC and NCDMF, and further analyses of first year growth. Subsequently, Sipe and Chittenden (2001) concluded that sectioned otoliths were the best structure for ageing summer flounder over the age range from 0 to 10 years. Since 2001, both scales and otoliths have routinely been collected in all NEFSC trawl surveys for fish larger than 60 cm.

An exchange of NEFSC and NCDMF ageing structures for summer flounder occurred again in 2006, after the SAW Southern Demersal Working Group (SDWG) listed the age sample exchange as a high research priority. This exchange examined samples from fish aged 1 to 9 (23-76 cm total length) and determined that the consistency of ageing between NCDMF and the NEFSC was at an acceptable level. During 2006-2011, overall summer flounder ageing precision, based on sample-size weighted intra- and inter-reader ageing agreement, has averaged 86% with an overall Coefficient of Variation (CV) of 3%. The degree of precision is very similar for structures sampled from surveys and the commercial fisheries. Figures A1-A2 show the intra-ager age bias and percent agreement for the 2011 NEFSC trawl survey age samples, and Figures A3-A5 the intra-ager age bias and percent agreement for the 2011 NEFSC commercial fishery age samples.

GROWTH

Trends in NEFSC survey mean length and weight at age: 1976-2012

The NEFSC winter, spring and fall trawl survey sample data were examined for trends in mean length and weight by sex and age. Age collections for the spring and fall series begin in 1976; the winter survey was conducted during 1992-2007. Data are generally presented here for ages 0 through age 7; samples for ages 8 and older are sporadic and highly variable, although they are more numerous and consistent since 2001.

The spring and winter series indicate no trend in the mean lengths of ages 1-2 for sexes combined. For ages 3-6, there is an increasing trend in mean length from 1976 to about 1990, and a decreasing trend since then, and a slight decreasing trend in the winter survey for ages 7-8 (Figures A6-A7). In the fall series, there is no obvious trend for ages 0-1, but there are relatively strong decreasing trends in mean length for combined sexes for ages 2 and older since the 1990s (Figure A8).

Individual fish weight collection on NEFSC trawl surveys began in spring 1992. In general, the patterns in mean weight reflect those in mean length, with a decreasing trend in mean weight evident for ages 3 and older (Figures A9-A11). Trends in mean weights at age in the total, combined sexes fishery catch (landings plus discards) exhibit a comparable pattern, with strongest declining trends since the 1990s for ages 3 and older (Terceiro 2012).

Trends by sex and age for all three seasonal survey series follow comparable patterns. There are no trends in the mean lengths for ages 0-1, with a weak declining trend since the 1990s for ages 2 and older. Mean lengths of ages 3 and older show decreasing trends for both sexes (Figures A12-A14).

von Bertalanffy Parameters

Early estimates of summer flounder age and growth were limited in spatial and temporal scope, and include those of Poole (1961), Eldridge (1962), Smith and Daiber (1977) and Henderson (1979). Smith and Daiber (1977) used data from 319 fish sampled from Delaware Bay during 1966-1968 to estimate the von Bertalanffy asymptotic length parameter, Linf, for males of 62 cm and for females of 88 cm, although their observed maximum ages were only age 7 for males and age 8 for females. Henderson (1979) estimated Linf for sexes combined to be 92 cm and the von Bertalanffy growth rate parameter, k, to be 0.21, based on fish sampled from the commercial fishery in 1976 with a maximum age of 10.

Fogarty (1981) used data from the NEFSC spring and fall trawl surveys for 1,889 scale samples obtained during 1976-1979 to estimate von Bertalanffy growth parameters. Fogarty concluded that female summer flounder attained a significantly larger asymptotic size than males, but that there was not a significant difference in the growth rate coefficient k. Fogarty (1981) estimated that the parameters for males were Linf = 72.7 cm, k = 0.18, with maximum age of 7; the parameters for females were Linf = 90.6 cm, k = 0.16, with maximum age of 10.

Pentilla et al. (1989) provided information on mean lengths at age for both sexes of summer flounder sampled during NEFSC trawl surveys during 1975-1988; the summer flounder ages have since been corrected to be one year younger (Almeida *et al.* 1992; JM Burnett III, NMFS NEFSC, personal communication 1997; Bolz *et al.* 2000). The data from Pentilla et al. (1989) provide parameters for males of Linf = 72.7 cm, k = 0.18, with maximum age of 11; parameters for females of Linf = 90.7 cm, k = 0.16, with maximum age of 11; and parameters for sexes combined of Linf = 81.6, k = 0.17, with maximum age of 11.

In the current work, the NEFSC trawl survey data for 1976-2012 were used to estimate growth parameters for males, females, and sexes combined for the full time series and for seven multi-year bins. The full time series data provide parameters for males (n = 18,850) of Linf = 73.5 cm, k = 0.14, with maximum length of 67 cm (age 6) and age of 12 (length 63 cm); parameters for females (n = 18,495) of Linf = 80.9 cm, k = 0.18, with maximum length of 82 cm (age 11) and age of 14 (length 76 cm); and parameters for sexes combined (n = 38,173, including small fish of undetermined sex) of Linf = 87.2, k = 0.14, with maximum age of 14 (table below, Figure A15).

Study	N fish	Max age (M, F)	Linf (M, F, B)	k (M, F, B)
Smith & Daiber (1977)	319	7,8	62,88	n/a
Henderson (1979)	n/a	10	92	0.21
Fogarty (1981)	1,889	7,10	72.7, 90.6	0.18, 0.16
Pentilla et al. (1989)	n/a	11,11	72.7, 90.7, 81.6	0.18, 0.16, 0.17
Current assessment	38,173	12,14	73.5, 80.9, 87.2	0.14, 0.18, 0.14

The seven multi-year (mostly five year) bins were for the years 1976-1980, 1981-1985, 1986-1990, 1991-1995, 1996-2000, 2001-2005, and 2006-2012. Von Bertalanffy parameters were estimated for males, females, and sexes combined. For the bins with more limited age ranges, the asymptote of the von Bertalanffy function is not well defined, and so the Linf estimates tend to be unrealistically high and the k estimates tend to be low (e.g., 1990-1995, with maximum ages of only 5 for males and 7 for females, sexes combined Linf = 157.3, k = 0.069), and in some cases the model did not converge to provide realistic model parameter estimates, although the predicted lengths over the observed age range were still realistic (e.g., 1976-1980 and 1991-1995 for males). The multi-year bin growth curves are tightly clustered through age 5 for females, with some divergence at older ages (in part due to the lack of older ages as noted above), with the most recent bin (2006-2012) indicating smaller predicted lengths at age than in previous years (Figure A16). The growth curves are more dispersed for males, and therefore for sexes combined, with the most recent 2006-2012 curve indicating smaller predicted lengths for older males and for all ages when sexes are combined (Figures A16-A17).

Length-Weight parameters

The length-weight parameters used to convert commercial and recreational fishery landings and discards sampled lengths (cm) to weight (kg) are taken from the work of Lux and Porter (1966; L&P), which used individual fish lengths and weights from 2,051 fish collected during 1956-1962 to compute the parameters by calendar quarters. Wigley *et al.* (2003; Wigley) updated the length-weight parameters used in audits of the NEFSC trawl survey data, using individual length and weight information from 9,373 fish for 1992-1999.

In the current work, individual length and weight information from 28,250 fish for 1992-2012 were used to estimate length-weight parameters for comparison with the earlier studies to judge whether changing from the historical Lux and Porter (1966) parameters would be justified. Parameters were estimated for the entire 1992-2012 time series, for 4 multi-year blocks (1992-1995, 1996-2000, 2001-2005, 2006-2012), and by survey seasonal time series (winter 1992-2007, spring 1992-2012, and fall 1992-2012).

A comparison among these alternative compilations indicates very little difference in the estimated length-weight relationships from Lux and Porter (1966), Wigley *et al.* (2003), and the current examination for the NEFSC trawl survey data. The relationships are virtually identical through a total length of 62 cm (the combined surveys mean length of age 7 fish; age 7 and older fish compose the assessment 'plus group'), a threshold below which over 95% of the fishery catch has occurred (see the 'SVs Age 7 xl' vertical line in Figures A18-A19). Above 62 cm, the quarterly length-weight curves of Lux and Porter (1996) bracket the Wigley *et al.* (2003) and survey multi-year bin curves in the expected way, with first quarter, pre-spawning fish larger in weight at length than fourth quarter, post-spawning fish (Figure 18). In a comparison with survey seasonal curves, the curves are again nearly identical through 62 cm (Figure A19). Above 62 cm, the quarterly length-weight curves of Lux and Porter (1996) align with the survey seasonal curves in the expected way, with the seasonal winter (post-spawning) and spring (pre-spawning) curves close to the Lux and Porter first quarter curve, with the fall survey (September; nearest to peak spawning) curve closest to the Lux and Porter third quarter curve (Figure A19). Based on the consistency of the L-W relationship over these comparisons, the Lux and Porter (1966) commercial fishery quarterly length-weight parameters were retained for this assessment.

K Condition Factor

Fulton's condition factor, K, is a measure of the relationship between fish length and weight that attempts to quantify the 'condition' of an individual or group of fish. Nash *et al.* (2006) note that it was Heincke (1908) who first used K as a measure of 'condition,' building on the 'cubic law' of growth in weight first introduced by Fulton (1904; K = x*weight / length**3, where x is a constant to scale K near 1). Nash *et al.* (2006) further point out that it was Ricker (1954) who first attributed the factor K to Fulton and coined the name 'Fulton's condition factor.'

The NEFSC winter, spring and fall trawl survey sample data were examined for trends in condition factor by season and sex. Individual fish weight collection began on NEFSC surveys in spring 1992; the winter survey was conducted during 1992-2007. There are no long-term trends in condition factor by season or sex (Figures A20-A22).

MATURITY

Morse (1981) examined the reproductive characteristics of summer flounder using a special collection sampled during the 1974-1979 NEFSC trawl surveys (2,910 total fish). Morse (1981) estimated that the length at 50% maturity (L50%) was 24.7 cm for males and 32.2 cm for females. O'Brien *et al.* (1993) used NEFSC fall trawl survey data for 1985-1989 (875 total fish) and estimated L50% to be 24.9 cm for males and 28.0 cm for females. Work for this assessment used NEFSC fall trawl survey data for 1992-2012 (9,430 fish) and estimated the time series value of L50% to be 26.8 cm for males and 31.0 cm for females.

The maturity schedule at age for summer flounder used in the 1990 SAW 11 and subsequent stock assessments through 1999 was developed by the 1990 SAW 11 SDWG using NEFSC fall survey maturity data for 1982-1989 (NEFC 1990; Terceiro 1999). The 1990 SAW 11 work indicated that the median length at maturity (50^{th} percentile, L_{50}) was 25.7 cm for male summer flounder, 27.6 cm for female summer flounder, and 25.9 cm for the sexes combined. Under the ageing convention used in the 1990 SAW 11 and subsequent assessments (Smith *et al.* 1981, Almeida *et al.* 1992, Szedlmayer and Able 1992, Bolz *et al.* 2000), the median age of maturity (50^{th} percentile, A_{50}) for summer flounder was determined to be age 0.1 years for males and 0.5 years females (i.e., fish about 13-17 months old, based on the actual spawning month and the January 1 ageing convention relative to fall sampling). Combined estimated (logistic regression) maturities indicated that at peak spawning time in the fall (November 1), 38% of age 0 fish are mature, 72% of age 1 fish are mature, 90% of age 2 fish are mature, 97% of age 3 fish are mature, 99% of age 4 fish are mature, and 100% of age 5 and older fish (age 5+) are mature. The maturities for combined sexes age 3 and older (age 3+) were rounded to 100% in the 1990 SAW 11 and subsequent assessments through 1999.

The NEFSC maturity schedules are based on simple gross morphological examination of the gonads, and it was suggested in the early 1990s that they may not have accurately reflected (i.e., overestimated) the true spawning potential of the summer flounder stock, especially for age-0 and age-1 fish. It was also noted, however, that spawning stock biomass (SSB) estimates based on age-2 and older fish showed the same long term trends in SSB as estimates which included age 0 and 1 fish in the spawning stock. A research recommendation that the true spawning contribution of young summer flounder to the SSB be investigated was included in research recommendations beginning with the SAW 16 assessment in 1993 (NEFSC 1993).

Research at the University of Rhode Island (URI) by Drs. Jennifer Specker and Rebecca Rand Merson (hereafter referred to collectively as the "URI 1999" study) attempted to address the issue of the true contribution of young summer flounder to the spawning stock. The URI 1999 study examined the histological and biochemical characteristics of female summer flounder oocytes to determine if age-0 and age-1 female summer flounder produce viable eggs and to develop an improved guide for classifying the maturity of summer flounder collected in NEFSC surveys (Specker *et al.* 1999, Merson *et al.* 2000, Merson *et al.* MS 2004). The URI 1999 study examined 333 female summer flounder (321 aged fish) sampled during the NEFSC winter 1997 survey (February 1997) and 227 female summer flounder (210 aged fish) sampled during the NEFSC fall 1997 survey (September 1997) using radio-immunoassays to quantify the biochemical cell components characteristic of mature fish. In light of the completion of URI 1999 study to address the long-standing research recommendation, the maturity data for summer flounder for 1982-1998 were examined in the 2000 SAW 31 assessment (NEFSC 2000) to determine if changes in the maturity schedule were warranted.

The NEFSC 1982-1998 and URI 1999 maturity determinations disagreed for 13% of the 531 aged fish, with most (10%) of the disagreement due to NEFSC mature fish classified as immature by the URI 1999 histological and biochemical criteria. The URI 1999 criteria indicated that 15% of the age-0 fish were mature, 82% of the age-1 fish were mature, 97% of the age-2 fish were mature, and 100% of the age 3 and older fish were mature. When the proportions of fish mature at length and age were estimated by logistic regression, median length at maturity (50^{th} percentile, L_{50}) was estimated to be 34.7 cm for females, with the following proportions mature at age: age-0: 30%, age-1: 68%, age-2: 92%, age-3: 98%, and age-4: 100%. Median age of maturity (50^{th} percentile, A_{50}) was estimated to be about 0.5 years. Based on this new information, the 2000 SAW 31 (NEFSC 2000) considered 5 options for the summer flounder maturity schedule for the 2000 stock assessment:

1) No change, use the maturity schedule for sexes combined as in the 1990 SAW 11 and subsequent assessments (rounded to 0.38, 0.72, 0.90, 1.00, 1.00, and 1.00 as in the 1997 SAW 25 and 1999 assessment analyses)

2) Consider only age-2 and older fish for sexes combined in the SSB

3) Knife edged, age-1 and older maturity for sexes combined. This would eliminate age-0 fish of both sexes from the SSB, and assume that the proportions mature at age-1 "round" to 100%

4) NEFSC 1982-1989, 1990-1998 for sexes combined, assuming a 1:1 sex ratio in deriving a combined schedule

5) NEFSC 1982-1989, 1990-1998 for males, URI 1999 for females, assuming a 1:1 sex ratio in deriving a combined schedule.

SAW 31 concluded that some contribution to spawning from ages 0 and 1 should be included, eliminating options 2 and 3. The differences among remaining options 1, 4, and 5 were considered to be relatively minor, and so the 1990 SAW 11 schedule (Option 1) was retained for subsequent assessments. SAW 31 recommended that more biochemical and histological work should be done for additional years to determine if the results of the URI 1999 study would be applicable over the full assessment time series. SAW 31 (NEFSC 2000) also noted the need for research to explore whether the viability of eggs produced by young, first time spawning summer flounder was comparable to the viability of eggs produced by older, repeat spawning summer flounder.

In the 2005 SAW 41 work (NEFSC 2005), the maturity schedule was updated and broadened to include data from 1992-2004, covering the year range for individually measured and weighed fish sampled in NEFSC research surveys. The resulting sexes combined maturity schedule (age 0: 38%; age 1: 91%; age 2: 98%; age 3+: 100%) was retained in the 2006 assessment and 2006 NMFS Science and Technology reference point peer review (Terceiro 2006a, b).

The 2008 SAW 47 SDWG examined the proportions mature at age from 1982-1991 as well as the new NEFSC sampling protocol, individual fish information on length and age at maturity from 1992-2007. Using NEFSC fall survey maturity data from 1992-2007 and logistic regression, the median length at maturity (50^{th} percentile, L_{50}) was estimated at 27.0 cm for males, 30.3 cm for females, and 27.6 cm for sexes combined. The median age of maturity (50^{th} percentile, A_{50}) was determined to be 0.1 years for males, 0.4 years for females, and 0.2 years for sexes combined. These findings were consistent with the findings of the 1990 SAW 11, the URI 1999 study, the 2000 SAW 31, and the 2005 SAW 41. An examination of the proportions of mature age-0 and age-1 fish did not indicate any trend which would warrant modification of the maturity schedule, and so the 2008 SAW 47 concluded that it was appropriate to again retain the maturity schedule from the 2005 SAW 41 assessment (NEFSC 2008a). The 2005 SAW 41 combined sex maturity schedule was also retained in the subsequent 2009-2012 updated assessments (Terceiro 2012).

Since the 2008 SAW 47 assessment, the NEFSC's general approach to the estimation of maturity schedules has advanced, mainly from work conducted for Northeast groundfish assessments in 2008 and subsequent years (NEFSC 2008b, 2012). The new approach involves the evaluation of both observed and logistic regression estimated maturity schedules to look for periodicity and/or trends. Sometimes the number of samples taken for a given year, season, or sex is not sufficient for estimation, or the observed and estimated maturity shows high inter-annual variability due to small sample sizes, and so different year-bin combinations (e.g., annual, discrete multi-year blocks, multi-year moving windows, and time series) were examined.

For this benchmark assessment of summer flounder, the standard NEFSC fall trawl survey 1982-2012 (31 years) maturity data have therefore been re-examined. The current data set consists of 6,088 males from age 0 to 11 and 4,985 females from age 0 to 12, for a total of 11,173 fish. For the entire time series, the observed percent mature of males is 43% at age 0, 95% at age 1, 99% at age 2, and 100% for age 3 and older. The observed percent mature of females is 28% at age 0, 84% at age 1, 96% at age 2, and 100% for age 3 and older. The observed percent mature of sexes combined for the time series is 37% at age 0, 91% at age 1, 98% at age 2, and 100% for age 3 and older (Figure A23). Estimated maturity ogives for the time series indicate the maturity of males to be 40% at age 0, 95% at age 1, and 100% at ages 2 and older; of females to be 28% at age 0, 95% at age 1, and 100% at ages 2 and older; and for sexes combined to be 36% at age 0, 90% at age 1, 99% at age 2, and 100% at ages 3 and older (Figure A24). The median length at maturity (50^{th} percentile, L_{50}) was estimated at 26.0 cm (95% CI from 25.7 to 26.3 cm) for males, 29.2 cm (95% CI from 28.7 to 29.6 cm) for females, and 26.8 cm (95% CI from 26.5 to 27.0 cm) for the sexes combined. The median age of maturity (50^{th} percentile, A_{50}) was estimated to be age 0.1 for males, age 0.4 for females, and age 0.2 for sexes combined (i.e., fish about 13-16 months old, based on the actual spawning month and Jan 1 ageing convention relative to fall sampling).

The NEFSC Fall survey data were pooled into three year blocks (except for the last, four year block of 2009-2012) to look for trends or abrupt changes in the observed proportions mature over time. For many of the bins, the male and female patterns are very similar, generally with age 0 observed maturity at 40-50% and age 1 at 90%. For some of the blocks (1991-1993, 1997-1999, 2006-2008) there is more divergence between the sexes at ages 0 and 1. The most recent 2009-2012 block shows the greatest divergence, with observed proportion mature for females of about 5% at age 0, 50% at age 1, and 90% at age 2 (Figures A25-A28).

Estimated maturity ogives by year (annual) and sex suggest a long term, decreasing trend in proportion mature at ages 0 and 1 for males and females, and for females at age 2. Fish of age 3 and older are generally all very close to 100% mature. The annual proportions for ages 0, 1 and 2 are variable, however, and for several years are poorly estimated with wide confidence intervals (Figures A29-A31). The next step was to estimate maturity ogives for three-year moving windows, in an attempt to stabilize the inter-annual variability and improve precision. Estimated three-year proportions mature for ages 0, 1, and 2 by sex provided a smoother inter-annual pattern and more precise estimates than the annual estimates (Figures A32-A34).

Finally, in keeping with the approach from the previous benchmark assessment (NEFSC 2008a), a sexes combined three-year moving window ogive was compiled from the NEFSC 1982-2012 fall survey data. The three-year moving window approach provides a) well-estimated proportions mature at age, b) estimated maturities at age that transition smoothly over the course of the time series, and c) reflect the recent trend of decreasing maturity at ages 0, 1, and 2. The sexes combined, three-year moving window estimates are presented in Figure A35 and in the table below. The 1982-2012 mean percent maturities at age (un-weighted, simple arithmetic average of annual values at age) are 34% at age 0, 90% at age 1, 99% at age 2, and 100% at ages 3 and older; these averages are 4% lower at age 0, 1% lower at age 1, 1% higher at age 2, and the same at ages 3 and older, compared to the 2005 SAW 41 values used in the 2005 and subsequent assessments. Changing to the proposed updated values will represent the use of the most comprehensive data set available.

MAT3	0	1	2	3	4	5	6	7+
1982	0.35	0.94	1.00	1.00	1.00	1.00	1.00	1.00
1983	0.37	0.95	1.00	1.00	1.00	1.00	1.00	1.00
1984	0.30	0.93	1.00	1.00	1.00	1.00	1.00	1.00
1985	0.40	0.94	1.00	1.00	1.00	1.00	1.00	1.00
1986	0.41	0.92	1.00	1.00	1.00	1.00	1.00	1.00
1987	0.50	0.93	0.99	1.00	1.00	1.00	1.00	1.00
1988	0.58	0.95	1.00	1.00	1.00	1.00	1.00	1.00
1989	0.51	0.97	1.00	1.00	1.00	1.00	1.00	1.00
1990	0.46	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1991	0.44	0.98	1.00	1.00	1.00	1.00	1.00	1.00
1992	0.46	0.97	1.00	1.00	1.00	1.00	1.00	1.00
1993	0.48	0.95	1.00	1.00	1.00	1.00	1.00	1.00
1994	0.45	0.92	0.99	1.00	1.00	1.00	1.00	1.00
1995	0.44	0.86	0.98	1.00	1.00	1.00	1.00	1.00
1996	0.40	0.85	0.98	1.00	1.00	1.00	1.00	1.00
1997	0.26	0.87	0.99	1.00	1.00	1.00	1.00	1.00
1998	0.19	0.84	0.99	1.00	1.00	1.00	1.00	1.00
1999	0.18	0.84	0.99	1.00	1.00	1.00	1.00	1.00
2000	0.23	0.85	0.99	1.00	1.00	1.00	1.00	1.00
2001	0.29	0.94	1.00	1.00	1.00	1.00	1.00	1.00
2002	0.26	0.97	1.00	1.00	1.00	1.00	1.00	1.00
2003	0.23	0.98	1.00	1.00	1.00	1.00	1.00	1.00
2004	0.31	0.92	1.00	1.00	1.00	1.00	1.00	1.00
2005	0.28	0.89	0.99	1.00	1.00	1.00	1.00	1.00
2006	0.28	0.83	0.98	1.00	1.00	1.00	1.00	1.00
2007	0.14	0.86	1.00	1.00	1.00	1.00	1.00	1.00
2008	0.18	0.85	0.99	1.00	1.00	1.00	1.00	1.00
2009	0.25	0.78	0.98	1.00	1.00	1.00	1.00	1.00
2010	0.33	0.79	0.97	1.00	1.00	1.00	1.00	1.00
2011	0.32	0.76	0.95	1.00	1.00	1.00	1.00	1.00
2012	0.27	0.81	0.98	1.00	1.00	1.00	1.00	1.00

Incorporating the McElroy et al. (2013; WPA9) histological results

Subsequent to completion of the above work on maturity, McElroy et al. (2013 MS) produced a working paper (WPA9) detailing their examination of the sources of variability in summer flounder female maturity rates: whether they are dependent on method, or year, or both, and if so, to what magnitude. They compared at-sea and histological maturity assignments made during recent NEFSC resource surveys, and compared female maturity schedules derived from ovarian histology to those from earlier studies (noted above). McElroy et al. (2013 MS) studied 266 female summer flounder sampled during September through November of five years, 2008–2012, as part of the NEFSC fall bottom trawl survey. They also studied female summer flounder sampled as part of the Enhanced Biological Sampling of Fish (EBSF) project supported by the NEFSC, Northeast Cooperative Research Program (NEFSC–NCRP). A total of 935 mature females were collected either in monthly sampling from December 2009 to May

2011 or targeted sampling during the primary spawning season September to November (2011 and 2012) as well as March and April when spawning has also been reported (2012 and 2013 only). Catches were sampled from commercial vessels participating in the NEFSC–NCRP's Study Fleet or other NEFSC-NCRP research studies while fishing in southern New England waters (NMFS statistical areas 537, 539, and 611). These commercial fishery sampled data were used to aid in the interpretation of gonad histology; specifically, to identify the pattern and progression of oocyte maturation (reproductive seasonality).

McElroy et al. (2013 MS) concluded that "… at-sea assignments have a high rate of agreement with microscopic classifications (89%). During this season, the majority of mature females were developing or even actively spawning; regenerating (spent) fish were rare. The largest of immature fish were difficult to classify correctly using macroscopic criteria, as some of these fish were preparing to spawn next year, for the first time; these fish were incorrectly classified at sea as resting, similar misclassifications have also been noted for winter flounder (McBride et al. 2013). An earlier study on summer flounder (NEFSC 2000) using gonad histology reported a similar misclassification rate between at-sea and histological assignments (13% vs. 11% in the current study). The non-matching maturity assignments were concentrated at the ages where the process of maturation was active (age 1 and age 2). Maturity in female summer flounder is rapid with 99% maturity achieved by age 4, using either histology or macroscopic methods. Most of the errors were for immature fish identified as resting at sea. Removing the resting fish from the dataset improved the rate of agreement (95%) between at-sea and histological classifications, and it resulted in overlapping CI's for the maturity ogives between the classification methods. This may be one way to reduce observational error in the at-sea maturity ogives. Otherwise, macroscopic classification remains an effective and cost efficient method for tracking female summer flounder maturity" and "The temporal trend using histology indicated that recently the declines in proportion mature at age for age 1 and age 2 fish were even greater than were evident in the macroscopic data (WPA1), which are the ages with the most misclassifications."

Given the McElroy et al. (2013 MS; WPA9) results, and after direct consultation with McElroy, the NEFSC Fall survey maturity data for summer flounder were re-analyzed here. McElroy et al. (2013 MS) found that most of the macroscopic classification errors were for immature females misclassified as resting (T) mature in the age 0-2 range, which were actually 'IFM' fish - first time maturing females that likely would not effectively spawn until the next year. It is not clear that the same misclassification problem occurs for resting (T) males, as the maturity stage is less ambiguous in them. The new maturity analysis removed the resting (T) females from the NEFSC Fall survey 1982-2012 data. This action removed 1,866 resting females from the initial 11,073 fish (of both sexes), or 17% of the initial sample. This change, when maturities at ages are calculated for sexes combined, resulted in about an average decrease (un-weighted average of annual maturities over the 1982-2012 series) in maturity of 4% for age 0, 2% for age 1, and no change for ages 2 and older.

Sexes combined

Age	0	1	2	3	4	5	6	7+
average	0.34	0.90	0.99	1.00	1.00	1.00	1.00	1.00
std	0.11	0.06	0.01	0.00	0.00	0.00	0.00	0.00
CV	0.33	0.07	0.01	0.00	0.00	0.00	0.00	0.00

Sexes combined - no T Females

Age	0	1	2	3	4	5	6	7+
average	0.30	0.88	0.99	1.00	1.00	1.00	1.00	1.00
std	0.10	0.07	0.01	0.00	0.00	0.00	0.00	0.00
CV	0.32	0.08	0.01	0.00	0.00	0.00	0.00	0.00

The new combined sexes, no T females, 3-year moving window maturities (MAT3-noTF) in the table below and in Figure A36 are recommended by the SDWG for use in the 2013 SARC 57 assessment.

MAT3-noTF	0	1	2	3	4	5	6	7+
1982	0.32	0.93	1.00	1.00	1.00	1.00	1.00	1.00
1983	0.34	0.94	1.00	1.00	1.00	1.00	1.00	1.00
1984	0.26	0.91	1.00	1.00	1.00	1.00	1.00	1.00
1985	0.38	0.92	1.00	1.00	1.00	1.00	1.00	1.00
1986	0.38	0.90	0.99	1.00	1.00	1.00	1.00	1.00
1987	0.47	0.92	0.99	1.00	1.00	1.00	1.00	1.00
1988	0.49	0.94	1.00	1.00	1.00	1.00	1.00	1.00
1989	0.42	0.96	1.00	1.00	1.00	1.00	1.00	1.00
1990	0.39	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1991	0.39	0.97	1.00	1.00	1.00	1.00	1.00	1.00
1992	0.42	0.96	1.00	1.00	1.00	1.00	1.00	1.00
1993	0.42	0.94	1.00	1.00	1.00	1.00	1.00	1.00
1994	0.36	0.89	0.99	1.00	1.00	1.00	1.00	1.00
1995	0.34	0.79	0.97	1.00	1.00	1.00	1.00	1.00
1996	0.31	0.80	0.97	1.00	1.00	1.00	1.00	1.00
1997	0.24	0.84	0.99	1.00	1.00	1.00	1.00	1.00
1998	0.17	0.81	0.99	1.00	1.00	1.00	1.00	1.00
1999	0.14	0.81	0.99	1.00	1.00	1.00	1.00	1.00
2000	0.18	0.81	0.99	1.00	1.00	1.00	1.00	1.00
2001	0.22	0.92	1.00	1.00	1.00	1.00	1.00	1.00
2002	0.23	0.95	1.00	1.00	1.00	1.00	1.00	1.00
2003	0.18	0.97	1.00	1.00	1.00	1.00	1.00	1.00
2004	0.28	0.89	0.99	1.00	1.00	1.00	1.00	1.00
2005	0.25	0.86	0.99	1.00	1.00	1.00	1.00	1.00
2006	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
2007	0.13	0.82	0.99	1.00	1.00	1.00	1.00	1.00
2008	0.17	0.83	0.99	1.00	1.00	1.00	1.00	1.00
2009	0.24	0.76	0.97	1.00	1.00	1.00	1.00	1.00
2010	0.32	0.77	0.96	0.99	1.00	1.00	1.00	1.00
2011	0.30	0.73	0.95	0.99	1.00	1.00	1.00	1.00
2012	0.26	0.78	0.97	1.00	1.00	1.00	1.00	1.00

Age	0	1	2	3	4	5	6	7+
average	0.30	0.88	0.99	1.00	1.00	1.00	1.00	1.00
std	0.10	0.07	0.01	0.00	0.00	0.00	0.00	0.00
CV	0.32	0.08	0.01	0.00	0.00	0.00	0.00	0.00

INSTANTANEOUS NATURAL MORTALITY RATE (M)

The instantaneous natural mortality rate (M) for summer flounder was assumed to be 0.2 in early summer flounder assessments (SAW 20; NEFSC 1996a). In the SAW 20 work, estimates of M were derived using methods described by a) Pauly (1980) using growth parameters derived from NC-DMF age-length data and a mean annual bottom temperature (17.5^{o}C) from NC coastal waters, b) Hoenig (1983) using a maximum age for summer flounder of 15 years, and c) consideration of age structure expected in unexploited populations (5% rule, 3/M rule, e.g., Anthony 1982). The SAW 20 (NEFSC

1996a) concluded that M = 0.2 was a reasonable value given the mean (0.23) and range (0.15-0.28) obtained from the various analyses, and this value for M was used in all subsequent assessments until 2008.

For the 2008 SAW 47 assessment (NEFSC 2008a) longevity- and life-history based estimators of M were reviewed. Sex and age-specific estimates of M were calculated from 1976-2007 summer flounder age and growth data from the NEFSC trawl surveys. Longevity based estimators of M are sensitive to critical underlying assumptions which include the value of p, or the small proportion of the population surviving to a given maximum age, and the maximum observed age under no or low exploitation conditions. Using a maximum age of 15 years for summer flounder, and the methods of Hoenig (1983) and Hewitt and Hoenig (2005), longevity based estimates of M for combined sexes ranged from 0.20 to 0.36 depending on whether a p=1.5% or p=5% was assumed. Other life-history based approaches were used, including those from Pauly (1980), Jensen (1996), Gunderson and Dygert (1988), and Gunderson (1997), with resulting estimates ranging from 0.20 to 0.45. Age-specific and size variable estimates of M, based on the work of Peterson and Wroblewski (1984), Chen and Watanabe (1989), Lorenzen (1996), and Lorenzen (2000), ranged from 0.19 to 0.90, with the highest values associated with age 0-1 fish (fish at smaller lengths).

While the 2008 SAW 47 work provided a wide range of methods and M estimates to be considered, each estimate involved a suite of underlying assumptions which were debated. In addition, the modeling frameworks of ADAPT virtual population analysis, ASAP statistical catch-at-age analysis, and SS2 statistical catch-at-age analysis used in the SAW 47 assessment allowed for log-likelihood profiling of M to determine which M estimate provides the best model fits. Based on an exercise using the base cases, the M that minimized the log-likelihood was 0.35, 0.20, and 0.25 under the models ADAPT, ASAP, and SS2, respectively. The estimate of M that resulted in the lowest residual or likelihood was found to be sensitive to model selection and configuration, as the data input configurations were very similar across the three models.

The SAW 47 considered the different methods of estimating M and after lengthy discussion assumed a natural mortality rate (M) of 0.20 for females and 0.30 for males, based mainly on recently observed maximum ages in the NEFSC survey data of 14 years (76 cm, in NEFSC Winter Survey 2005) for females and 12 years (63 cm, in NEFSC Spring Survey 2007) for males, and the expectation that larger and older fish are likely if fishing mortality rates were maintained at low rates in the future. A combined sex M-schedule at age was developed by assuming these initial M rates by sex, an initial proportion of females at age 0 of 40% derived from the NEFSC Fall survey indices by age and sex, and population abundance decline over time at the sex specific M rates. The final abundance weighted combined sex M-schedule at age ranged from 0.26 at age 0 to 0.24 at age 7+, with a mean of 0.25 (NEFSC 2008a). The 2008 SAW 47 M-schedule (mean M = 0.25) was retained in the subsequent 2009-2012 updated assessments (Terceiro 2012).

The 2013 SDWG discussed the results of Maunder and Wong (2011), WPA10 Maunder (2013a MS; WPA10), and Morson *et al.* (2013 MS; WPA13) with regards to the value of M to be used in the current assessment. The Maunder and Wong (2011) (which reiterated their 2008 SAW 47 work and added new simulation work) and Maunder (2013a MS; WPA10) work concluded that average M was likely higher than

0.25, with males having a mean M of about 0.30 and females a mean M of about 0.50, which would provide a combined mean M = 0.40. However, the SDWG presentation of Morson *et al.* (2013 MS; WPA13) noted that the sampling program described had identified males of ages 13 and 14, equal to the oldest females yet found in any NEFSC commercial fishery or survey sampling, lending support to the idea that M might be towards the lower end of the range of M values under consideration. Objective function profiles over a range of fixed M values in the F57_BASE model runs indicated best fits for mean M of 0.15-0.25 (see TOR 4). The 2013 SDWG concluded that the 2008 SAW47 mean M = 0.25 should be used in the 2013 SAW 57 assessment BASE model run. Sensitivity runs with mean M=0.1, 0.2, 0.3, 0.4 were provided for comparison purposes (see TOR4).

PREDATORS AND PREY

The NEFSC trawl survey foods habits 1973-2011 database was investigated to identify the most frequent predators and prey of summer flounder, relevant to Research Recommendation 10 (see TOR8). Summer flounder was identified to species as a prey item in 65 predator stomachs. Spiny dogfish was the predator in 35 cases (54%), followed by monkfish (11 cases, 17%), winter skate (7 cases, 11%). and bluefish (4 cases, 6%), with other fish species accounting for the other 9 cases and 12%, including 1 case (2%) of summer flounder cannibalism. The data are insufficient to calculate total absolute predator consumption of summer flounder.

The database contains information from 18,862 summer flounder stomachs sampled on 5,365 tows, over 70% of which were found to be empty. ‘Other fish’ (fish which could not be identified to family) were found in about 10% of the stomachs, followed by squids (6%), decapod shrimp (4%), ‘animal remains’ (3%; partially digested stomach contents), anchovies (2%), and other gadids, porgies, mysids, and other small crustaceans (Figure 50). The data were summarized into 4 multi-year blocks to look for temporal patterns. The frequency of ‘Other fish’ and decapod shrimp consumption by summer flounder decreased by about 50% over the time series, while the frequency of consumption of squid slightly increased. The frequency of consumption of anchovies peaked in the 1980s (Figures A37-A39). These results generally confirm those found by Link et al. (2002), who reported on the feeding ecology of flatfish in the northwest Atlantic. The calculation of total absolute consumption of prey by summer flounder has not been attempted here.

NEFSC TRAWL SURVEY ENVIRONMENTAL DATA

Some of the NEFSC winter, spring and fall trawl survey environmental data were summarized for the summer flounder strata sets to investigate the correspondence between the environmental factors and the distribution of summer flounder (relevant to TORs 1-2). The environmental factors were surface air temperature in degrees Celsius (also a proxy for surface water temperature), bottom water temperature in degrees Celsius, and bottom water salinity in parts per thousand (PPT). Valid bottom temperature data on a per tow basis are generally available for the entire 1968-2011/2012 time series for the summer flounder survey strata (Great South Channel to Cape Hatteras) in both spring and fall, with the exception of fall 2008, for which large numbers of observations are missing. Air temperatures are generally missing during the 1970s in both spring and fall. Bottom salinities are generally available for 1997 and later years, except for 2008.

First, the cumulative distributions of the summer flounder survey catches (expcatchnum) and the three environmental factors were compiled for the spring (offshore strata 1-12, 61-76) and fall (offshore strata 1-2, 5-6, 9-10, 61, 65, 69, 73) long time series (1968-2011/2012) strata sets. For this simple compilation, the cumulative totals are not weighted by stratum area. In the spring survey strata, over the full 1968-2012 time series, summer flounder were in general caught at stations (tow sites) that had a warmer bottom temperature (Figure A40; median [50^{th} %ile] catch at 9.0^{o}C, median tows at 7.2^{o}C), higher bottom salinity (Figure A41; median catch at 34.0 PPT, median tows at 33.6 PPT), and warmer air temperature (Figure A42; median catch at 7.0^{o}C, median tows at 6.5^{o}C) than the average environment of the strata set. In the fall survey strata, summer flounder were in general caught at stations (tow sites) that had a warmer bottom temperature (Figure A43; median catch at 15.8^{o}C, median tows at 12.3^{o}C), lower bottom salinity (Figure A44; median catch at 32.4 PPT, median tows at 32.8 PPT), but cooler air temperature (Figure A45; median [50^{th} %ile] catch at 17.8^{o}C, median tows at 18.4^{o}C) than the average environment of the strata set.

In a second compilation, the annual stratified mean values of the environmental factors for positive summer flounder catch tows (expcatchnum > 0) were compared with the annual stratified mean values of the environmental factors for all tows to investigate trends over time. Figure A46 shows that the mean bottom temperature on NEFSC spring survey tows with positive summer flounder catches (FLK_bottemp) was generally warmer than the mean bottom temperature of all tows (All_bottemp) from 1968 through the 1980s. Since 1990, these mean temperatures are more similar. The solid blue trend line shows that the mean bottom water temperature of all tows in the spring strata set has increased over time by a few tenths degree Celsius. Figure A47 shows the pattern for NEFSC fall survey tows, with the bottom temperature on tows with positive summer flounder catches generally warmer than the mean bottom temperature of all tows over the entire series. The solid red trend line shows that the mean bottom water temperature of all tows in the fall strata set has increased over time by about one-half degree Celsius.

Figure A48 shows that the mean bottom salinity on NEFSC spring survey tows with positive summer flounder catches (FLK_botsalin) was generally higher than the mean salinity of all tows (All_botsalin) since 1997. The solid blue trend line shows that the mean bottom salinity of all tows in the spring strata set has increased by about one-percent (about 0.25 PPT) since 1997. Figure A49 shows the pattern for NEFSC fall survey tows, with the bottom salinity on tows with positive summer flounder catches generally lower than the mean salinity of all tows since 1997. The solid red trend line shows that the mean salinity of all tows in the fall strata set has no trend.

Figure A50 shows the mean air temperature on NEFSC spring survey tows with positive summer flounder catches (FLK_airtemp) was generally comparable to the mean air temperature of all tows (All_airtemp) over the series. The solid blue trend line shows that the mean air temperature of all tows in the spring strata set has decreased over time by about one-half degree Celsius. Figure A51 shows the pattern for NEFSC fall survey tows, with the air temperature on tows with positive summer flounder catches generally warmer than the mean bottom temperature of all tows during the 1980s and generally cooler since the late 1990s. The solid red trend line shows that the air temperature of all tows in the fall strata set has increased over time.

GENERAL BIOLOGICAL TRENDS

The NEFSC survey data show trends in the most recent years of decreasing mean length and weight at age in all seasons and for both sexes, a trend in von Bertalanffy parameters that indicates 'slower growth' (smaller predicted length at age), and a trend of delayed maturity. A comparison of mean length at sex and age by survey season indicates there is no significant correlation between the survey mean lengths at ages 0-7 and survey bottom temperatures from the spring and fall series, except for age 1 males in the spring, for which the relationship is negative (r = -0.41; df = 33, rcritical for alpha = 5% = 0.34; Rohlf and Sokal 1981). If the expected positive relationship between summer flounder growth and temperature were to hold, this result suggests that the observed decreasing/delayed trend in mean lengths, weights, and maturities at age is not due to increasing habitat temperatures. Further, there are no trends in length-weight relationship parameters or condition factor that suggest a trend of reduced 'condition' for summer flounder. There are trends in sex ratio that indicate a decreasing proportion of females (and therefore an increasing proportion of males) for ages 2 and older.

The previous recent stock assessment update (Terceiro 2012) indicated that ages 2 and older are near to fully selected by the fisheries, and that fishing mortality has decreased substantially since the 1990s. Fully selected instantaneous fishing mortality rates (F) averaged greater than 1.0 (a percentage exploitation rate of about 60%) during 1982-1990, but have decreased to less than 0.5 (about 30%) since 2001 (Terceiro 2012). Trippel (1995), Stokes and Law (2000), and Sinclair et al. (2002a, b), among others, have all noted that varying intensities of size-selective (and therefore age-selective) fishing mortality in highly exploited fish populations can influence the observed size and age structure (and therefore sex-ratio, maturity, and fitness) of those populations, over both short and evolutionary time scales. Stokes and Law (2000) in particular noted: "…(1) there is likely to be genetic variation for traits selected by fishing; (2) selection differentials due to fishing are substantial in major exploited stocks; and (3) large phenotypic changes are taking place in fish stocks, although the causes of these changes are hard to determine unambiguously."

TOR 1. Estimate catch from all sources including landings and discards. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize the uncertainty in these sources of data.

COMMERCIAL FISHERY LANDINGS

Total U.S. commercial landings of summer flounder from Maine to North Carolina peaked in 1979 at nearly 18,000 mt (39.561 million lbs, Table A1, Figure A52). The reported landings in 2012 of 6,047 mt = 13.331 million lbs were about 5% over the final 2012 commercial quota of 5,750 mt = 12.677 million lbs. Since 1980, about 70% of the commercial landings of summer flounder have come from the Exclusive Economic Zone (EEZ; greater than 3 miles from shore). Large variability in summer flounder landings exist among the states, over time, and the percent of total summer flounder landings taken from the EEZ has varied widely among the states. The commercial landings are assumed to be reported with minimal error. The uncertainty of the reported landings due to assignment to statistical area equates to a Coefficient of Variation (CV) of 0.3%.

Northeast Region (NER; Maine to Virginia)

Annual commercial landings data for summer flounder in years prior to 1994 were obtained from detailed trip-level landings records contained in master data files maintained by the Northeast Fisheries Science Center (NEFSC; the "weighout system" of 1963-1993) and from summary reports of the Bureau of Commercial Fisheries and its predecessor the U.S. Fish Commission (1940-1962). Prior to 1994, summer flounder commercial landings were allocated to NEFSC 3-digit statistical area according to interview data (Burns et al. 1983). Beginning in 1994, landings estimates were derived from mandatory dealer reports under the current NMFS Northeast Region (NER) summer flounder quota monitoring system. Beginning in 1994, the dealer landings have been allocated to statistical area using fishing dealer and fishing Vessel Trip Reports (VTR data) in a multi-tiered allocation procedure at the fishing-trip level (Wigley et al., 2007). Three-digit statistical areas 537-539 (Southern New England), 611-616 (New York Bight), 621, 622, 625, and 626 (Delmarva region), and 631 and 632 (Norfolk Canyon area) have generally accounted for over 80% of the NER commercial landings since 1992 (Table A2).

A summary of length and age sampling of summer flounder landings collected by the NEFSC commercial fishery port agent system in the NER is presented in Table A3. For comparability with the manner in which length frequency sampling in the recreational fishery has been evaluated, sampling intensity is expressed in terms of metric tons (mt) of landings per 100 fish lengths measured. The sampling is proportionally stratified by market category (jumbo, large, medium, small, and unclassified), with the sampling distribution generally reflecting the distribution of commercial landings by market category. Overall sampling intensity has improved since 1995, from 165 mt per 100 lengths to less than 100 mt per 100 lengths, and temporal and geographic coverage has generally improved as well.

The age composition of the NER commercial landings for 1982-1999 was generally estimated semi-annually by market category and 1-digit statistical area (e.g., area 5 or area 6), using standard NEFSC procedures (market category length frequency samples converted to mean weights by length-weight relationships; mean weights in turn divided into landings to calculate numbers landed by market category; market category numbers at length apportioned to age by application of age-length keys). For 2000-2002, sampling was generally sufficient to make quarterly estimates of the age composition in area 6 for the large and medium market categories. Since 2003, sampling has generally been sufficient to make quarterly estimates of the age composition in areas 5 and 6 for the jumbo, large, and medium market categories. The proportion of large and jumbo market category fish (generally of ages 3 and older) in the NER landings has increased since 1996, while the proportion of small market category landings (generally of ages 0 and 1) has become very low (Table A4). The mean size of fish landed in the NER commercial fishery has been increasing since 1993, and has averaged about 1 kg (2.2 lbs) since 2007, typical of an age 4 summer flounder (Table A5).

North Carolina

The North Carolina winter trawl fishery accounts for about 99% of summer flounder commercial landings in North Carolina. A separate landings at age matrix for this component of the commercial fishery was developed from North Carolina Division of Marine Fisheries (NCDMF) length and age frequency sample data. The NCDMF program samples about 10% of the winter trawl fishery landings annually, most recently at rates of less than 10 metric tons of landings per 100 lengths measured (Table A6). All length frequency data used in construction of the North Carolina winter trawl fishery landings at age matrix were collected in the NCDMF program; age-length keys from NEFSC commercial data and NEFSC spring survey data (1982-1987) and NCDMF commercial fishery data (1988 and later) were combined by appropriate statistical area and semi-annual period to resolve lengths to age. Fishery regulations in North Carolina also changed between 1987 and 1988, with increases in both the minimum mesh size of the codend and minimum landed fish size taking effect. It is not clear whether the change in regulations or the change in keys, or some combination, is responsible for the decreases in the numbers of age-0 and age-1 fish estimated in the North Carolina commercial fishery landings since 1987. Landed numbers at age and mean weight at age from this fishery are shown in Tables A7-A8.

COMMERCIAL FISHERY DISCARDS

Background and Previous Estimation Method

In the 1993 SAW 16 assessment, an analysis of variance of Northeast Region (NER) Fishery Observer Program data (OB) was used to identify stratification variables for an expansion procedure to estimate summer flounder total landings and discards from the observer data kept (K) and discard (D) rates in the commercial fishery. Initial models included the main effects of year, quarter, fisheries statistical division (2-digit area), area (divisions north and south of Delaware Bay), and tonnage class. Quarter and division consistently emerged as significant main effects without significant interaction with the year (NEFSC 1993). This discard estimation procedure expands transformation bias-corrected geometric mean catch rates (kept and discards per day fished; K/DF and D/DF) in year, quarter, and division strata by total days fished (DF). Days fished are defined as the hours fishing on trips landing any summer flounder by any mobile gear, including fish trawls and scallop dredges. The use of fishery effort as the expansion factor (multiplier) allows estimates of landings from the fishery observer data to be compared with dealer reported landings, to help judge the potential accuracy of the procedure. For strata with no observer sampling, catch rates from adjacent or comparable strata are substituted as appropriate (except for Division 51, which generally has very low catch rates and negligible catch). Estimates of discard are stratified by 2 gear types (scallop dredges and fish trawls) for years when data were adequate (1992 and later).

Observer data were used to develop estimates of commercial fishery discards since 1989. However, adequate data (e.g., interviewed trip data, survey data) are not available to develop summer flounder discard estimates for 1982-1988. Discard numbers were assumed to be very small relative to landings during 1982-1988 (because of the lack of a minimum size limit in the EEZ), but to have increased since 1989 with the implementation of fishery regulations in the EEZ. It is recognized that not accounting directly for commercial fishery discards in 1982-1988 likely results in a small underestimation of fishing mortality and population sizes in these years.

As recommended by SAW 16 (NEFSC 1993), a commercial fishery discard mortality rate of 80% was applied to develop the final estimate of discard mortality from live discard estimates. The SAW 47 assessment (NEFSC 2008a) considered some preliminary information from a 2007 Cornell University Cooperative Extension study. This study conducted ten scientific trips on inshore multispecies commercial trawling vessels to determine discard mortality rates relative to tow duration, fish size, and the amount of time fish were on the deck of the vessel. The median mortality for all tows combined was 78.7%, very close to the estimated overall discard mortality of 80% used in the assessment. Another study (Yergey *et al.* 2012) conducted by Rutgers University using acoustic telemetry to evaluate both on-deck and latent discard mortality found total discard mortality in the trawl fishery to be 81.7%, again very close to the estimated overall discard mortality of 80% used in the assessment. This discard mortality rate is applied to the live discard estimate regardless of the discard estimation method used.

Current Observer (OB) and Vessel Trip Report (VTR) Data and Previous Estimates

The Observer (OB) sample data aggregated on an annual basis are summarized in Table A9. Discard rates of summer flounder in the scallop dredge fishery are generally much higher (recently >90%) than in the trawl fishery (generally <50%), purportedly because of closures, trip limits, and the higher economic value of kept scallops compared to kept summer flounder. The OB sample data indicated that prior to statistical transformation and stratified expansion, the overall percentage of live discards to total catch has ranged from 6% in 1995 to 59% in 2007, with an un-weighted annual average percentage (rate) of 25% over the 1989-2011 time series. The percentage in 2011 was 21% (Table A9, Figure A53 [OB Raw]; note this work was completed before the 2012 data were available).

Commercial fishery catch rate information is also reported in the NER Vessel Trip Report (VTR) data since 1994 (Table A10). As in the OB data, discard rates of summer flounder reported in the VTR data for the scallop dredge fishery are generally much higher than in the trawl fishery. A comparison of live discard to total catch percentage for the OB and VTR data sets for trawl and scallop dredge gear indicates similar discard rates from the two data sources through the 1990s. Since about 2004, overall OB and VTR discard to total catch ratios have diverged, with the OB data generally indicating higher discard rates. The VTR data indicate that prior to statistical transformation and stratified expansion, the overall percentage of live discards to total catch has ranged from 7% in 1995 to 41% in 2003, with an un-weighted average rate of 21% over the 1989-2011 time series. The percentage in 2011 was 7% (Table A10, Figure A53 [VTR Raw]).

The live discard estimates using the previous estimation method (Assess; D/DF) are summarized in Figure A54. Commercial fishery live discard in weight was highest in 1990 and 1999 (ranging from 1,315 to 1,935 mt of live discards), and lowest in 2009 (148 mt of live discards). Since 2000 the assessment estimate of total live discard has been less than 1,000 mt and less than 10% of total catch. Scallop dredge fishery discard to landed rates are much higher than trawl fishery rates. Although the scallop dredge landings of summer flounder are less than 5% of the total, the scallop dredge discards of summer flounder have generally been about 50% of the trawl fishery discards. During 1994-2011, scallop discards averaged 166 mt while trawl discards averaged 378 mt (Figure A55).

Table A11 and Figure A56 present a comparison of commercial fishery Dealer reported landings of summer flounder (i.e., the “true landings”; Dealer) with estimates of summer flounder commercial landings (using the previous Assess method, but for ‘K*DF’ [{K/DF}*DF]) from landings rates of NEFSC OB sampling and commercial fishing effort (days fished) reported on NER VTRs, as a means of verification of the potential accuracy of the discard estimates. Estimates of landings from combined OB / VTR data has ranged from +53% (1999) to -81% (2011) of the Dealer reported landings in the fisheries, with discards ranging from 38% (1990) to 2% (2011) of the Dealer reported landings. Since 2004, the estimate of landings from the combined OB / VTR data has averaged only about 37% of the Dealer reported landings.

For the trawl fishery, the observed discard per day fished ratio (D/DF) averaged 23 kg/DF during 1989-2003, and 19 kg/DF during 2004-2011 (a rate decrease of 17%), while the observed kept per day fished ratio (K/DF) averaged 151 kg/DF during 1989-2003, and 101 kg/DF during 2004-2011 (a rate decrease of 33%; Figure A57). The resulting observed discard to total catch percentage, however, increased slightly from about 13% during 1989-2003 to 16% during 2004-2011. While this measure of discarding increased, the expansion factor of total trawl fishery days fished (DF) with any summer flounder landings from the VTRs averaged 13,417 during 1989-2003 and 7,612 during 2004-2011, a decrease of 43%. As a result, after statistical transformation and stratified expansion, the absolute estimate of trawl fishery live discard averaged 724 mt during 1989-2003 but only 221 mt during 2004-2011, a decrease of 69% (Figure A58). For the trawl fishery estimates, the days fished expansion factor is the most influential factor on the decrease of recent absolute estimates of live discard.

For the scallop dredge fishery, the observed discard per day fished ratio (D/DF) averaged 39 kg/DF during 1989-2003, and 53 kg/DF during 2004-2011 (a rate increase of

36%), while the observed kept per day fished ratio (K/DF) averaged 7 kg/DF during 1989-2003, and 1 kg/DF during 2004-2011 (a rate decrease of 86%; Figure A59). The resulting observed discard to total catch percentage was therefore about 85% during 1989-2003, increasing to 98% during 2004-2011. While this measure of discarding increased, the expansion factor of total scallop dredge fishery days fished with any summer flounder landings from the VTRs averaged 4,147 during 1989-2003 and 1,468 during 2004-2011, a decrease of 65% (Figure A60). As a result, after statistical transformation and stratified expansion, the absolute estimate of scallop dredge fishery live discard averaged 250 mt during 1989-2003 but only 71 mt during 2004-2011, a decrease of 72%. For the scallop dredge fishery estimates, the days fished expansion factor is also the most influential factor on the decrease of recent absolute estimates of live discard.

The divergence of OB and VTR live discard to total catch percentages compared to the estimated live discard to total catch percentages, and the persistent underestimation of the OB / VTR estimated landings compared to the Dealer reported landings, has raised concern that the live discard might be consistently underestimated since 2004. The underestimation appears to be mainly driven by the days fished effort metric, but it is unclear if the effort metric is simply biased low or if the relationship between effort and catch has somehow changed over time. This concern has prompted a re-examination of the previous discard estimates and consideration of alternative estimation methods. Note that 2012 fishery catch data were not available at the time of this re-examination, and so it is based on data for 1989-2011.

The Standardized Bycatch Reporting Method (SBRM)

The Standardized Bycatch Reporting Methodology (SBRM) Omnibus Amendment to the fishery management plans of the Northeast region was implemented in February 2008 to address the requirements of the Magnuson-Stevens Fishery Conservation and Management Act to include standardized bycatch reporting methodology in all FMPs of the New England Fishery Management Council and Mid-Atlantic Fishery Management Council. The Standardized Bycatch Reporting Method (SBRM) for the estimation of discards (Wigley *et al.* 2008, 2011) has now been adopted for most NEFSC stock assessments that have been subject to a benchmark review since 2009. In this work, SBRM estimates of summer flounder landings and discards are compared with Dealer reported landings and the current estimation approach (Assess) estimates of landings and discards, as part of a re-examination of the estimation of summer flounder commercial fishery discards.

In the SBRM, the sampling unit is an individual fishing trip. Trips were partitioned into fleets using six classification variables: calendar quarter, area fished, gear type, mesh size, fishery access area, and fishing trip category. Calendar quarter was based on the landed date of the fishing trip, and was used to capture seasonal variations in both fishing activity and discard rates. Area fished was based on statistical reporting area; trips where area fished was not recorded or was otherwise unknown were excluded. Two regional areas were defined: New England (NE) comprising statistical reporting areas <'600' (which includes Southern New England, Georges Bank, and the Gulf of Maine), and Mid-Atlantic (MA) comprising statistical areas >='600'. Live discards were estimated using a combined D/K ratio estimator (Cochran 1963) where D = discard pounds of a given species, and K = the kept pounds of all species, or a subset of all species, landed in each trip as reported by VTR or Dealer records. Further computational details are provided in Wigley *et al.* (2011).

New SBRM Estimates of Commercial Fishery Discards

For summer flounder, total discards and landings (in weight) by fleet were derived by multiplying the estimated discard or kept rate in that fleet by the corresponding fleet landings from the Dealer reports. Estimates were developed by calendar quarter, gear (fish trawl and scallop dredge), and mesh strata (large => 5.5 in codend, small < 5.5 inch codend). The catch rate denominator and expansion factor landings considered were a) summer flounder (fluke) landings (flk), b) the sum of summer flounder (fluke), scup, and black sea bass landings (fsb), and c) all species landings (all).

The SBRM alternatives are compared with the current assessment estimates of landings (K*DF Assess) in Table A12 and Figure A61 Note that the "flk" alternative is not compared, since the OB kept/"flk" landings rate is always 1, providing a trivial result when raised by the Dealer reported summer flounder landings. As noted above, over the time series the K*DF cumulative estimate of landings averages about 80% of the Dealer reported landings, but has averaged only about 40% or less during 2004-2011. The weighted (by annual landings) CV of the K*DF estimated landings averaged 17% during 1989-2011, and 4% during 2004-2011.

The SBRM K*Kall approach consistently overestimates the 1992-1996 Dealer reported landings by 1.5 to 6 times (several hundred percent). The relatively large variability and occasional large estimated landings are due to comparable variability in the Kall landings expansion factor. Over the time series, the K*Kall cumulative estimate of landings averages about 1.6 times the Dealer reported landings, but has averaged only 7% above during 2004-2011. The weighted (by annual landings) CV of the K*Kall estimated landings averaged 15% during 1989-2011, and 11% during 2004-2011.

The SBRM K*Kfsb approach provided the most consistent match with the Dealer reported landings. Over the time series, the K*Kfsb cumulative estimate of landings averages about 93% of the Dealer reported landings, and has averaged 97% during 2004-2011. The weighted (by annual landings) CV of the K*Kfsb estimated landings averaged 4% during 1989-2011, and 5% during 2004-2011. The landings "verification" exercise suggests that the K*Kfsb estimator would provide the most accurate and precise discard estimate, since it best matched the Dealer reported landings and provided the most precise landings estimates. However, consideration of the estimated discards for the alternatives provides a different conclusion.

The three SBRM alternatives are compared with the current assessment estimates of discards (D*DF [Assess]) in Table A13 and Figure A62. Over the time series, the D*DF (Assess) cumulative estimate of discards has averaged 671 mt with CV of 18%; since 2004 the average is 284 mt with CV of 5%. As noted above, the landings verification exercise suggests that D*DF discard estimates since 2004 may be biased low by about 60%.

The SBRM D*Kflk estimates of discards has averaged 4,148 mt (about 6 times the current assessment estimate) with CV of 68%. Since 2004 the average is 5,484 mt (about 19 times the current assessment estimate) with CV of 35%. As noted above, the landings verification exercise for the K*Kflk estimator provides trivial results since the K*Kflk ratio is always 1.

The SBRM D*Kall estimates of discards has averaged 1,481 mt (about 2 times the current assessment estimate) with CV of 15%. Since 2004 the average is 1,852 mt (about 7 times the current assessment estimate) with CV of 9%. As noted above, the landings verification exercise suggests that D*Kall estimates since 2004 may be biased high by about 10%.

The SBRM D*Kfsb estimates of discards has averaged 8,824 mt (about 13 times the current assessment estimate) with CV of 45%. Since 2004 the average is 6,748 mt (about 24 times the current assessment estimate) with CV of 31%. As noted above, the landings verification exercise suggests that D*Kfsb estimates since 2004 may be biased low by about 6%.

Both the SBRM D*Kflk and D*Kfsb estimator time series contain instances when very large annual discard amounts are estimated, sometimes accompanied by high annual CV, but sometimes not. For the D*Kflk series, the notably large estimates occur for 1993, 2000, 2007, and 2010; for the D*Kfsb series they occur for 1993, 1996, 1997, 2000, 2007, and 2010. The time series for both estimators are characterized by highly variable annual CVs, and high overall CV. In contrast, the D*Kall time series is much less variable, with no obviously infeasible estimates.

In the D*Kflk and D*Kfsb series, for example, the 2010 total discard estimates (11,892 mt for the D*Kflk estimator; 13,297 mt for the D*Kfsb estimator) are driven by the discard ratio in the quarter 3, scallop dredge, Mid-Atlantic stratum. The scallop dredge discard ratio for both estimators is 1166:1, from data sampled on 68 observed trips. Minor expansion factor and computational differences in the estimation procedure result in quarter 3, scallop dredge, Mid-Atlantic stratum discard estimates of 7,950 mt for the D* Kflk estimator (67% of the total annual discard estimate) and 8,143 mt for the D*Kfsb estimator (61% of the total annual discard estimate). Similar, common, single stratum influences on the total annual discard estimator occur for these estimators the years 1993, 2000, and 2007.

The year 1996 provides different circumstances, however, that further illustrate the uncertainties associated with fishery discard estimation. The D*Kflk estimator provides a total discard estimate of 1,142 mt (CV = 29%) and the D*Kfsb estimator an estimate of 80,171 mt (CV = 1%). The D*Kflk 1996 discard ratio is 0.19:1 (the ratio of discards of summer flounder to kept of summer flounder), based on 8,111 kg of summer flounder discards and 41,904 kg of summer flounder landings observed on 222 trips, expanded by 3,711 mt of summer flounder landings (note the impact of stratification and computational correction factors provides a different estimate than the simple aggregate product of 0.19*3,711 = 705 mt – this applies to all aggregate estimates). The D*Kfsb 1996 discard ratio is 0.16:1 (the ratio of discards of summer flounder to kept of summer flounder plus scup plus black sea bass [fsb]), based on the same 8,111 kg of summer flounder discards and 51,031 kg of fsb landings observed on the same 222 trips, expanded by 6,518 mt of fsb landings.

The large difference in the two annual estimates of discards is due to the influence of a single fishery stratum, the 1996 quarter 4 large mesh trawl fishery in New England. The discard ratio for the D*Kfsb estimator is 674:1, based on 611 kg of summer flounder discards and <1 kg of fsb landings from 6 observed trips, expanded by 117 mt of fsb landings. These data provide a discard estimate for the stratum of about 79,000 mt, 98% of the annual discard estimate. In contrast, the discard ratio for the D*Kflk estimator was undefined, because no summer flounder were kept on the 6 observed trips; in fact only 26 of the 117 mt of the fsb landed in the 1996 quarter 4 large mesh trawl fishery in New England were summer flounder. Thus, the D*Kflk estimate of summer flounder discard for that stratum was zero.

Over the 1989-2011 time series, the D*Kflk estimator has a 0.38:1 discard ratio (the ratio of discards of summer flounder to kept of summer flounder), with a time series CV of 70%. The D*Kfsb estimator has a 0.35:1 discard ratio (the ratio of discards of summer flounder to kept of summer flounder plus scup plus black sea bass), with a time series CV of 45%. In contrast, the D*Kall estimator has a 0.007:1 discard ratio (the ratio of discards of summer flounder to kept of all species), with a time series CV of 18%.

Conclusion for Discard Estimation

The consideration of three SBRM discard estimators of summer flounder landings and discards and comparison with the current effort (days fished) based methods and estimates indicates that the estimator based on the ratio of summer flounder discard to all species kept (D*Kall) provides the best overall combination of a feasible estimate of the summer flounder landings based on the landings verification exercise (Table A13, Figure A61) and a feasible and sufficiently precise time series of discard estimates (Table A14, Figures A62-A63). The SBRM D*Kall estimates of discards in live weight average 1,481 mt (1,185 mt dead) during 1989-2011, about 2.2 times the Assess D*DF live average of 671 mt (537 mt dead; Table A13). A comparison of the Dealer reported landings and the SBRM D*Kall estimated discards shows the live discards average of 1,481 mt compared to the landings average of 5,342 mt results in a time series average of live discards to total catch percentage of about 22% (Table A14 and Figure A64). The D*Kall estimate is more in line with the aggregate OB sample data (31%) and the aggregate VTR data (20%) time series averages, compared to the current (Assess) live discards to total catch time series average percentage of 10%. The SDWG recommended that the SBRM D*Kall summer flounder discard estimate time series be used in the 2013 SAW 57 benchmark summer flounder assessment.

*SBRM D*Kall Discard Estimates at age*

Observer length frequency samples were converted to sample numbers at age and sample weight at age frequencies by application of NEFSC survey length-weight relationships and Observer, commercial fishery, and survey age-length keys. Sample weight proportions at age were next applied to the raised fishery discard estimates to derive fishery total discard weight at age. Fishery discard weights at age were then divided by fishery observer mean weights at age to derive fishery discard numbers at age. Classification to age for 1989-1993 was done by semiannual periods using Observer age-length keys, except for 1989, when first period lengths were aged using combined commercial landings (quarters 1 and 2) and NEFSC spring survey age-length keys. Since 1994, only NEFSC survey age-length keys were used, since Observer age-length keys were not yet available and commercial landings age-length keys contained an insufficient number of small summer flounder (<40 cm = 16 inches) that comprise most of the discards. For comparability with the manner in which length frequency sampling in the recreational fishery has been evaluated, sampling intensity is expressed in terms of metric tons (mt) of SBRM 'D*Kall' live discards per 100 fish lengths measured. The sampling has been stratified by gear type (fish trawl and scallop dredge) since 1994. Overall sampling intensity has improved since 1999, from 152 mt per 100 lengths to less than 20 mt per 100 lengths since 2004 (Table A15).

The final comparison between discard estimation methods was made for the SBRM D*Kall estimates apportioned to length and age (dead discards including the 80% discard mortality rate) with those using the Assess D*DF estimates of discards. The SBRM D*Kall estimates in numbers average 2.324 million fish per year during 1989-2011, about 1.8 times the Assess estimate of 1.303 million. Since 2004, the SBRM D*Kall estimate averaged about 1.3 million more fish (about 6 times) than the Assess estimate. The largest difference in absolute numbers was for 1992, with the SBRM D*Kall estimate about 6.1 million fish larger than the Assess estimate; the smallest difference in absolute numbers was for 1989, with the SBRM D*Kall estimate about 17,000 fish larger than the Assess D*DF estimate (Table A16).

The largest difference in proportions at age was in 1995 at ages 0 and 1, due to differences in the distribution of discards during the year (Figure A65). In Assess D*DF estimates, 63% of the discards were estimated in the first half of the year and 37% in the second half, with about 38% of the annual total in the trawl fishery, which tends to discard smaller/younger fish compared to the scallop dredge fishery. In the SBRM D*Kall estimates, although 82% of discards were estimated in first half of the year and 18% in the second half, about 60% of the annual total was in the trawl fishery. When these respective discard estimates in weight were apportioned to length and age in numbers, the result was SBRM D*Kall discards apportioned as 62% age 0, 19% age 1, 18% age 2, and 1% age 3 and older, compared to Assess D*DF discards apportioned as 18% age 0, 53% age 1, 27% age 2, and 2% age 3 and older. Since 2004, the largest difference in proportion at age was in 2007 at age 2, with the SBRM D*Kall estimate 14% smaller than the Assess D*DF estimate. Estimates of SBRM D*Kall discarded numbers at age and mean weight at age are summarized in Tables A17-A18.

The reasons for discarding in the fish trawl and scallop dredge fisheries have been changing over time. During 1989 to 1995, the minimum size regulation was recorded as the reason for discarding summer flounder in over 90% of the observed trawl and scallop dredge tows. In 1999, the minimum size regulation was provided as the reason for discarding in 61% of the observed trawl tows, with quota or trip limits given as the discard reason in 26% of the observed tows, and high-grading in 11% of the observed tows. In the scallop fishery in 1999, quota or trip limits was given as the discard reason in over 90% of the observed tows. During 2000-2005, minimum size regulations were identified as the discard reason in 40-45% of the observed trawl tows, quota or trip limits in 25-30% of the tows, and high grading in 3-8%. In the scallop fishery during 2000-2005, quota or trip limits was given as the discard reason for over 99% of the observed tows. During 2006-2012, minimum size regulations were identified as the discard reason in 15-20% of the observed trawl tows, quota or trip limits in 60-70% of the tows, and high grading in 5-10%. In the scallop fishery during 2006-2012, quota or trip limits was given as the discard reason for about 40% of the observed tows, with about 50% reported as "unknown." As a result of the increasing impact of trip limits, fishery closures, and high grading as reasons for discarding, the age structure of the summer flounder discards has also changed, with a higher proportion of older fish being discarded.

RECREATIONAL FISHERY LANDINGS

Summary landings statistics for the summer flounder recreational fishery (catch type A+B1) as estimated by the NMFS Marine Recreational Fishery Statistics Survey (MRFSS 1982-2003) and Marine Recreational Information Program (MRIP 2004-2012) are presented in Tables A19-A20. Recreational fishery landings increased 20% by number and 8% by weight from 2011 to 2012 to 2,853 mt (6.290 million lbs) and were about 26% under the 2012 recreational harvest limit. The un-weighted average annual CV of the recreational landings is 6% in numbers and 7% in weight is 7% during 1982-2012.

The commercial fishery VTR system provides an alternative set of reported recreational landings by the party/charter boat sector. A comparison of VTR reports and MRFSS estimates indicates that MRFSS estimates are higher by a factor of 2-3 for the 1995-2012 period, with a generally increasing trend through 2009, but decreasing since then, and ranging from a factor of 0.95 in 2012 to 5.45 in 2007 (Table A21). It is unclear if this is due mainly to under-reporting of party/charter boat recreational landings in the VTR system, or a systematic positive bias of MRFSS/MRIP landings estimates for the party/charter boat sector.

Length frequency sampling intensity for the recreational fishery was calculated by MRFSS sub-regions (North - Maine to Connecticut; Mid - New York to Virginia; South - North Carolina) based on a metric tons of landings per hundred lengths measured basis (Burns *et al.* 1983; Table A22). To convert the recreational fishery length frequencies to age, MRFSS sample length frequency data, NEFSC commercial and survey age-length data were examined in terms of number of fish measured/aged on various temporal and geographical bases. Correspondences were made between MRFSS intercept date (quarter), commercial quarter, and survey season (spring and summer/fall), and between MRFSS sub-region, commercial statistical areas, and survey depth strata to integrate data from the different sources. Based on the number, size range, and distribution of lengths and ages, a semi-annual, sub-regional basis of aggregation was adopted for matching of commercial and survey age-length keys with recreational length frequency distributions to convert lengths to ages. Limited MRFSS length sampling for larger fish resulted in a high degree of variability in mean length for older fish, especially at ages 5 and older during the first decade of the time series. Attempts to estimate length-weight relationships from the MRFSS biological sampling data provided unsatisfactory results. As a result, the commercial fishery quarterly length (mm) to weight (g) relationships from Lux and Porter (1966) were used to calculate annual mean weights at age from the estimated age-length frequency distribution of the landings.

The recreational landings historically were dominated by relatively young fish. During 1982-1996, age 1 fish accounted for over 50% of the landings by number and fish of ages 0 to 3 accounted for over 95% of landings by number. No fish from the recreational landings were determined to be older than age 7. With increases in the minimum landed size since 1996 (to 14.5 in [37 cm] in 1997, 15 in [38 cm] in 1998-1999, generally 15.5 in [39 cm] in 2000, and various state minimum sizes from 14.0 [36 cm] to 21 in [53 cm] in 2001-2012) and a trend to lower fishing mortality rates, the age composition of the recreational landings now includes mainly fish at ages 3 and older, at mean weights of greater than 1 kg per fish (Tables A23-A24).

RECREATIONAL FISHERY DISCARDS

MRFSS/MRIP estimates of the percentage of live discard (catch type B2) to total catch (catch types A+B1+B2) in the recreational fishery for summer flounder has varied from about 18% (1985) to about 94% (2010) of the total catch (Table A25). To account for all removals from the summer flounder stock by the recreational fishery, some assumptions about the biological characteristics and discard mortality rate of the recreational live discard need to be made, because biological samples are not routinely taken of MRFSS/MRIP catch type B2 fish. In previous assessments, data available from NYDEC surveys (1988-1992) of New York party boats suggested that nearly all (>95%) of the fish released alive from boats were below the minimum regulated size (during 1988-1992, 14 in [36 cm] in New York state waters), that nearly all of these fish were age 0 and age 1 summer flounder, and that these age 0 and 1 summer flounder occurred in about the same proportions in the live discard as in the landings. It was therefore assumed that all B2 catch would be of lengths below regulated size limits, and be either age 0 or age 1 in all three sub-regions during 1982-1996. Catch type B2 was allocated on a semi-annual, sub-regional basis in the same ratio as the annual age 0 to age 1 proportion observed in the landings during 1982-1996. Mean weights at age were assumed to be the same as in the landings during 1982-1996.

The minimum landed size in federal and most state waters increased to 14.5 in (37 cm) in 1997, to 15.0 in (38 cm) in 1998-1999, and to 15.5 in (39 cm) in 2000. Applying the same logic used to allocate the 1982-1996 recreational released catch to size and age categories during 1997-2000 implied that the recreational fishery released catch included fish of ages 2 and 3. Investigation of data from the CTDEP Volunteer Angler Survey (VAS) for 1997-1999 and from the American Littoral Society (ALS) for 1999, and comparing the length frequency of released fish in these programs with the MRFSS data on the length frequency of landed fish below the minimum size, indicated this assumption was valid for 1997-1999 (MAFMC 2001a). The CTDEP VAS and ALS data, along with data from the NYDEC Party Boat Survey (PBS), was used to validate this assumption for 2000. For 1997-2000 all B2 catch was assumed to be of lengths below regulated size limits, and therefore comprised of ages 0 to 3. Catch type B2 was allocated on a sub-regional basis in the same ratio as the annual age 0 to age 3 proportions observed in the landings at lengths less than 37 cm in 1997, 38 cm in 1998-1999, and 39 cm in 2000.

In 2001, many states adopted different combinations of minimum size and possession limits to meet management requirements. Examination of data provided by MD sport fishing clubs, the CTDEP VAS, the Virginia Marine Resources Commission

(VAMRC) VAS, the ALS, and the NYDEC PBS indicated that the assumption that fish released are those smaller than the minimum size remained valid since 2001, and so catch type B2 was characterized by the same proportion at length as the landed catch less than the minimum size in the respective states. The differential minimum size by state has continued since 2001, and increased samples of the recreational fishery discards by state agency Volunteer Angler Surveys, the MRFSS/MRIP For Hire Survey (FHS), and the American Littoral Society has allowed direct characterization the length frequencies of the discards from sample data and presumably a more accurate estimate of the discard in weight (Table A26).

Studies conducted to estimate recreational fishery discard mortality for striped bass and black sea bass suggest a rate of 8% for striped bass (Diodati and Richards 1996) and 5% for black sea bass (Bugley and Shepherd, 1991). Work by the states of Washington and Oregon with Pacific halibut (a potentially much larger flatfish species, but otherwise morphologically similar to summer flounder) found "average hooking mortality...between eight and 24 percent" (IPHC, 1988). An unpublished tagging study by the NYDEC (Weber MS 1984) on the survival of released sublegal summer flounder caught by hook-and-line suggested a total, non-fishing mortality rate of 53%, which included discard plus tagging mortality as well as deaths by natural mortality. Assuming deaths by natural mortality to be about 18%, (an instantaneous natural mortality rate of 0.20), an annual discard plus tagging mortality rate of about 35% can be derived from the NYDEC results.

In the 1997 SAW25 (NEFSC 1997) and earlier assessments of summer flounder, a 25% discard mortality rate was assumed for summer flounder released alive by anglers. However, two subsequent investigations of summer flounder recreational fishery discard, or hooking, mortality suggested that a lower rate was more appropriate. Lucy and Holton (1998) used field trials and tank experiments to investigate the discard mortality rate for summer flounder in Virginia, and found rates ranging from 6% (field trials) to 11% (tank experiments). Malchoff and Lucy (1998) used field cages to hold fish angled in New York and Virginia during 1997 and 1998, and found a mean short term mortality rate of 14% across all trials. Given the results of these studies conducted specifically for summer flounder, a 10% discard mortality rate was adopted in the Terceiro (1999) stock assessment and has been retained in all subsequent assessments. Ten percent of the total B2 catch at age is therefore the basis of estimates of summer flounder recreational fishery discard mortality at age presented in Table A27. The un-weighted average annual CV of the recreational discards is 8% during 1982-2012. The mean weights at age of the recreational fishery discards are presented in Table A28.

MRIP ESTIMATES OF RECREATIONAL FISHERY CATCH

The NMFS Marine Recreational Fishery Statistics Survey (MRFSS) was replaced by the Marine Recreational Information Program (MRIP) in 2012 to provide improved recreational fishing statistics. The MRIP implemented a new statistical method for calculating recreational catch estimates, with many survey elements related to both data collection and analysis updated and refined to address issues such as data gaps, bias, consistency, accuracy, and timeliness. As part of the implementation of the MRIP, recreational fishery catch estimates for 2004-2011 have been directly replaced by those using the MRIP estimation methods. For earlier years, a constant "ratio of means" of the MRFSS and MRIP estimates has been used to adjust the recreational catch estimates. For 2012, only MRIP estimates area available. Note that MRFSS estimates, and therefore a comparison, are unavailable for 2012.

For the recreational fishery harvest number (catch types A + B1), the largest change was for the state of NJ, with a cumulative 2004-2011 decrease of about 995,000 fish, or about -11%. The largest absolute increase was for the state of NY with a cumulative 2004-2011 increase of about 444,000 fish, or about +9%. The state of NH had the largest cumulative percentage decrease at -50%; however, NH's cumulative harvest (now about 1,300 fish) is less than 0.1% of the coastal total. The commonwealth of MA had the largest cumulative percentage increase at +20%, a cumulative increase of about 210,000 fish. Over all states, the cumulative harvest in numbers decreased by about 702,000 fish (about -3%), ranging from a decrease of 285,000 fish in 2007 (-8%) to an increase of 49,000 fish in 2011 (+3%; Tables A29-A30). Therefore, for the years 1981-2003 recreational harvest in numbers was decreased by 3% for this assessment update.

For the recreational fishery harvest weight (catch types A + B1), the largest change was for the state of NJ, with a cumulative 2004-2011 decrease of about 1,229 mt, or about -11%. The largest absolute increase was for the state of NY with a cumulative 2004-2011 increase of about 967 mt, or about +12%. The state of NH had the largest cumulative percentage decrease at -50%; however, NH's cumulative harvest (now about 1 mt) is less than 0.1% of the coastal total. The commonwealth of MA had the largest cumulative percentage increase at +8%, a cumulative increase of about 115 mt. Over all states, the cumulative harvest in weight decreased by about 384 mt (about -1%), ranging from a decrease of 434 mt in 2007 (-8%) to an increase of 130 mt fish in 2005 (+3%; Tables A31-A32). Therefore, for the years 1981-2003 recreational harvest in weight was decreased by 1%.

For the recreational fishery live releases in numbers (catch type B2), the largest change was for the state of NJ, with a cumulative 2004-2011 decrease of about 4 million fish, or about -6%. The largest absolute increase was for the state of NY with a cumulative 2004-2011 increase of about 513,000 fish, or about +1%. The state of MD had the largest cumulative percentage decrease at -28%, a cumulative increase of about 2.3 million fish. The state of ME had the largest cumulative percentage increase at +59%, a cumulative increase of about 24 fish; the next largest increases were for MA (+17%, 331,000 fish) and NH (+17%, 522 fish). Over all states, the cumulative live release in numbers decreased by about 6.5 million fish (about -4%), ranging from a decrease of 2.2 million fish in 2007 (-11%) to an increase of 411,000 fish in 2011 (+2%; Tables A33-A34). Therefore, for the years 1981-2003 recreational live release and discard mortality estimates were decreased by 4%.

TOTAL CATCH COMPOSITION

NER commercial fishery landings and discards at age, North Carolina winter trawl fishery landings and discards at age, and MRFSS/MRIP recreational fishery landings and discards at age totals were summed to provide a total fishery catch at age matrix for 1982-2012 (Table A35; Figure A66). The percentage of age 3 and older fish in the total catch in numbers has increased during the last decade from only 4% in 1993 to

72% in 2008, 68% in 2009, 69% in 2010, and 80% in 2011. Overall mean weight at age in the total catch was calculated as the weighted mean (by number in the catch at age) of the respective mean value at age from each fishery component (Table A36; Figure A67).

Commercial landings have accounted for 56% of the total catch since 1982, with recreational landings accounting for 35%, commercial discards about 7%, and recreational discards about 5%. Since 2008 the comparable percentages are 58%, 29%, 12%, and 11%. Commercial discard losses in the fish trawl and scallop dredge fisheries have accounted for about 20% of the total commercial catch since 2008, assuming a discard mortality rate of 80%. Recreational discard losses have accounted for 20%-30% of the total recreational catch since 2008, assuming a discard mortality rate of 10% (Figure A68). Table A37 provides a tabulation of total catch in weight using the MRFSS and MRIP estimates of the recreational fishery catch with the changes noted above.

SPATIAL AND TEMPORAL DISTRIBUTION OF LANDINGS AND DISCARDS

Catch data from both recreational and commercial fisheries vessel trip reports (VTRs) as well as Observer reports were summarized to determine spatial trends within the fishery in recent decades. Resulting trends were used to assess the future need for research to understand any major changes in the spatial distribution of the stock. Both commercial (limited to fish trawlers and scallop dredges) and recreational gear catches were summarized in ~5 year intervals from the VTRs for 1994-2012. These data include both landed and discarded catch weights for commercial trips and catch numbers for recreational trips. Additional detail on commercial catch recorded by fisheries observers was also summarized for comparison. Although misreporting of the catch in VTR reports is considered low, the 'rough' accuracy of reported catch location is evident when comparing the spatial range being reported in observer records. Significant uncertainty in the validity of some VTRs exists, particularly for catches reported in areas well off the shelf and in inshore areas of SNE. Determining precise terms for removing VTR data due to misreporting of catch location is difficult, therefore all data is presented with reference to the aforementioned caveat regarding the validity of reported catch location.

Commercial Data

The available VTR time series begins in 1994, just when summer flounder populations began rebuilding. Heaviest commercial catches (and by inference, effort) are reported just off of Cape Hatteras, concentrated around the entrances to Hudson Bay and Narragansett Bay, and offshore along the shelf edge from the Chesapeake Bay entrance through SNE (Figure A69; yellow to brown squares). Combined fall and spring NEFSC bottom trawl surveys for this time period (also plotted, in blue circles) do not reflect these larger offshore catches, however fishing occurs year-round. These areas of higher abundance along the shelf are reflected in the winter survey catches during this time period which was occurring during the same time of year when the fishing season commenced with heavy offshore trawling. Overfishing had also been occurring for previous decades, and Figure A69 reiterates the disparity between abundance levels seen on the survey and the amount of fish being landed by fishermen at that time. Large catches of summer flounder continued along the shelf from 2001-2005 with concentrations slightly farther north off DelMarVa (Figure A70). This northerly trend of offshore commercial catches continued through the present decade with the largest shelf catches now in SNE just south of Rhode Island. While a few inshore hot spots still remain (mainly at the entrance to Delaware and Chesapeake Bays and down the coast to Cape Hatteras), VTR reported commercial catches of summer flounder at its southern extent are reduced after 2005 (Figures A71-A72).

Observer trip reports confirm similar spatial trends within the commercial fishery, though offshore outliers are mostly removed due to more accurate locations reported by observers. Recorded catch weights are reduced due to limited observer coverage, particularly in earlier years when the focus of the Observer program was directed mainly towards documentation of protected species (Figures A73-A74). Catch densities from Observer trips begin resembling a sub-sample of the commercial VTR catch data after 2000 (Figures A75-A77). Although displayed on different scales, the Observer data show a much larger presence of large summer flounder catches on Georges Bank after 2005.

Recreational Data

Recreational fishing catch (and by inference, effort) distribution from party and charter boats is relatively unchanged throughout the duration of the VTR database (Figures A78-A81). One exception is a reduced catch south of the Chesapeake Bay that becomes almost entirely absent after 2005. The highest density of recreational catch occurs in inshore waters from Delaware Bay along the coast to Narragansett Bay. Dominated by summer tourism, the high density of recreational catch follows the migratory pattern of larger fluke returning to inshore waters. Analogous with the survey trends, the majority of large adult summer flounder are seen in highest densities along the New Jersey coastline, across the south coast of Long Island, Rhode Island and extending to the south coast of Massachusetts. While catches of summer flounder do exist south of Delaware Bay, they are not appearing in higher densities and, based on survey lengths, the larger, more desirable fish for charter fishing are congregating in inshore waters farther north.

It is also important to note that this recreational catch data is from only party and charter boat trip reports and does not include recreational fishing on the private, individual angler level. While there may be a strong recreational component to summer flounder south of New Jersey, it may not be well represented at the individual level in these data. Management actions may also be an influential factor. The recreational fishery for summer flounder has been managed under a Recreational Harvest Limit (RHL) since 1993 and has been undergoing changes in an effort to provide equitable regulations among states. These efforts have been particularly focused on the liberalization of quotas and other regulations in states outside of New Jersey and New York, which dominate the recreational fishery.

The SARC 57 Review Panel concluded that Term of Reference 1 was met.

TOR 2. Present the survey data available for use in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.), and explore standardization of fishery-independent indices (completion of specific sub-task is contingent on analytical support from staff outside of the NEFSC.) Investigate the utility of commercial or recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data. Describe the spatial distribution of the stock over time.

RESEARCH SURVEY INDICES OF ABUNDANCE

NEFSC

The NEFSC stratified random bottom trawl surveys were first implemented in the fall of 1963 to sample the Gulf of Maine (GOM) waters off Maine and Nova Scotia southward to Hudson Canyon off New Jersey (NEFSC offshore strata 1-40 [depths equal to or greater than 27 meters = 15 fathoms]). Since 1968, the spring and fall trawl surveys have sampled the waters that encompass the summer flounder stock from the southern Gulf of Maine (GOM) off Massachusetts to Cape Hatteras, North Carolina, with the addition of offshore strata 61-76 (Clark 1979). Consistently sampled inshore strata 1-90 (depths generally ≤27 meters [15 fathoms], except in the GOM) were added to the trawl survey sampling in the fall of 1975. Both the spring and fall surveys were conducted using a Yankee 36 haddock net with roller sweep aboard the FSVs Albatross IV and Delaware II from 1963-2008, and then using a 4-seam, 3-bridle net using a rock-hopper sweep aboard the FSV Henry B. Bigelow since 2009. The NEFSC winter (flatfish) survey began in 1992 and ended in 2007, generally sampling offshore strata 1-18 using a flatfish net with a cookie sweep. For this assessment, the SDWG undertook a re-consideration of the strata included in indices for all three seasonal surveys. After examination of alternative strata set times series trends and precision, the SDWG decided to retain the winter, spring, and fall survey strata sets used in the assessments since 2002 (Miller and Terceiro 2013 MS; WPA8).

NEFSC spring and fall survey indices suggest that total stock biomass peaked during 1976-1977 and again during 2003-2007 (Tables A38-A39, Figure A82). The Fisheries Survey Vessel (FSV) *Albatross IV* (ALB) was replaced in spring 2009 by the FSV *Henry B. Bigelow* (HBB) as the main platform for NEFSC research surveys, including the spring and fall bottom trawl surveys. The size, towing power, and fishing gear characteristics of the HBB are significantly different from the ALB, resulting in different fishing power and therefore different survey catchability. Calibration experiments to estimate these differences were conducted during 2008 (Brown 2009), and the results of those experiments were peer reviewed by a Panel of three non-NMFS scientists during the summer of 2009 (Anonymous 2009, Miller *et al.* 2010). The Terms of Reference for the Panel were to review and evaluate the suite of statistical methods used to derive calibration factors by species before they were applied in a stock assessment context. Following the advice of the August 2009 Peer Review (Anonymous 2009), the methods proposed in Miller *et al.* (2010), and the precedents set in peer-reviews of stock assessments for haddock (Van Eeckhaute and Brooks 2010), yellowtail flounder (Legault *et al.* 2010), silver and red hake (NEFSC 2011a), and winter flounder

(NEFSC 2011b), length-based calibration factors have been used to convert 2009-2011 spring and fall HBB survey catch number and weight indices to ALB equivalents for use in the 2011-2012 updates and in the 2013 SAW 57 assessment.

The aggregate, spring calibration factors from Miller *et al.* (2010) are 3.2255 for numbers (the HBB caught ~3 times more summer flounder numbers in aggregate than the ALB in the calibration experiment), and 3.0657 for weight. The aggregate, fall calibration factors from Miller *et al.* (2010) are 2.4054 for numbers and 2.1409 for weight. The effective total catch number length-based calibration factors vary by year and season, depending on the characteristics of the HBB length frequency distributions. The effective length-based calibration factors have ranged from 1.825 to 1.994 in the spring (average = 1.887) and from 1.814 to 1.964 in the fall (average = 1.876; Tables A40-A42).

Age composition data from the NEFSC spring surveys indicate a substantial reduction in the number of ages in the stock between 1976-1990 (Table A43, Figure A83). For the period 1976-1981, fish of ages 5-8 were captured regularly in the survey, with the oldest individuals aged at 10-12 years. From 1982-1986, fish aged 5 years and older were only occasionally observed in the survey, and by 1986, the oldest fish observed in the survey were age 5. In 1990 and 1991, only three age groups were observed in the survey catch, and there was an indication that the 1988 year class was very weak. Since 1996, the NEFSC spring survey age composition has expanded significantly, with generally increasing abundance of age-3 and older fish up to age 12 for males and age 14 for females. Mean lengths at age from the NEFSC spring survey are presented in Table A44.

Summer flounder are frequently caught in the NEFSC fall survey at stations in inshore strata (< 27 meters = 15 fathoms = 90 feet) and at offshore stations in the 27-55 meter depth zone (15-30 fathoms, 90-180 feet) at about the same bathymetry as in the spring survey. NEFSC fall aggregate and at-age indices are presented in Tables A38-A40 and A42. The NEFSC fall survey catches age-0 summer flounder in abundance, providing an index of summer flounder recruitment (Table A45, Figure A84). NEFSC fall survey indices suggest improved recruitment since the late 1980s, and an increase in abundance of age-2 and older fish since 1996. Mean lengths at age from the NEFSC fall survey are presented in Table A46.

A series of NEFSC winter trawl surveys was initiated in February 1992 to provide improved abundance indices for flatfish, including summer flounder. The surveys targeted flatfish concentrated offshore during the winter. A modified trawl was used that differed from the standard trawl employed during the NEFSC spring and fall surveys in that long trawl sweeps (wires) were added before the trawl doors to better herd fish to the mouth of the net, and the large rollers used on the standard gear were replaced on the footrope with a chain "tickler" and small spacing "cookies." The design and conduct of the winter survey (timing, strata sampled, and the use of the modified trawl gear) resulted in greater catchability of summer flounder compared to the other surveys. Most fish were captured in survey strata 61-76 (27-110 meters; 15-60 fathoms) off the Delmarva and North Carolina coasts. Other concentrations of fish were found in strata 1-12, south of the New York and Rhode Island coasts, in slightly deeper waters. Significant numbers of large summer flounder were often taken along the southern flank of Georges Bank (strata 13-18).

Indices of summer flounder abundance from the winter survey indicate stable stock size during 1992-1995, with catch per tow values ranging from 10.9 in 1995 to 13.6 in 1993 (Table A47). For 1996, the winter survey index increased by 290% over 1995, from 10.9 to 31.2 fish per tow. The largest increases in 1996 occurred in the Mid-Atlantic Bight region (offshore strata 61-76), where increases up to an order of magnitude occurred in several strata, with the largest increases in strata 61, 62, and 63 off the northern coast of North Carolina. Most of the increased catch in 1996 consisted of age-1 summer flounder from the 1995 year class. In 1997, the index dropped to 10.3 fish per tow, due to the lower numbers of age-1 (1996 year class) fish caught. From 1998-2003, the winter trawl survey indices increased; with the 2003 winter survey number and weight per tow indices being the highest in the time series at 27.58 kg/tow (Figure A82). The winter survey index was lower from 2004-2007, and values ranged from 10.3 to 15.9 fish per tow. Similar to the other NEFSC surveys, there is strong evidence since the mid-1990s of increased abundance of age-3 and older fish relative to earlier years in the time series (Tables A48-A49). The NEFSC winter survey series ended in 2007.

Massachusetts DMF

Spring and fall bottom trawl surveys conducted by the Massachusetts Division of Marine Fisheries (MADMF) show a decline in abundance in numbers of summer flounder from high levels in 1986 to record lows in the early 1990s. Both the MADMF spring and fall indices then increased to record high levels in the mid-2000s, and have been relatively stable since then (Tables A50-A51, Figure A85). The MADMF also captures a small number of age-0 summer flounder in a seine survey of estuaries, and these data constitute an index of recruitment (Table A52, Figure A86).

Rhode Island DFW

Standardized spring and fall bottom trawl surveys have been conducted by the Rhode Island Department of Fish and Wildlife (RIDFW) since 1979 in Narragansett Bay and the state waters of Rhode Island Sound. Indices of abundance at age for summer flounder have been developed from the fall survey data using NEFSC fall survey age-length keys. The fall survey reached a time series high in 2009 and near high in 2011 (Table A53, Figure A87). An abundance index has also been developed from a set of fixed stations sampled monthly since 1990, which also reached a time series high in 2009 (Table A54, Figure A87). Recruitment indices are available from both the fall (Figure A86) and monthly fixed station surveys.

University of Rhode Island Graduate School of Oceanography (URIGSO)

University of Rhode Island Graduate School of Oceanography (URIGSO) has conducted a standardized, year-round, weekly two-station trawl survey at Fox Island in Narragansett Bay and at Whale Rock in Rhode Island Sound since the 1950s, with consistent sampling since 1963. Irregular length-frequency samples for summer flounder indicate that most of the survey catch is of fish from ages 0 to 3. The average aggregate numbers-based index decreased from the 1959 until 1972, increased to a peak in the mid-

1970s, decreased to a second low in 1990, and then increased to a time series peak in 2011 (Table A55, Figure A87). The URIGSO indices, developed since the last benchmark assessment in 2008, have not previously been included in the calibration of the ASAP population model.

Connecticut DEP

Spring and fall bottom trawl surveys are conducted by the Connecticut Department of Environmental Protection (CTDEP). The CTDEP surveys show a decline in abundance in numbers of summer flounder from 1986 to record lows in 1989. The CTDEP surveys indicate recovery since 1989, and evidence of increased abundance at ages 2 and older since 1995. The 2011 spring and 2002 fall indices were the highest in the respective time series. Due to vessel engine failure, no complete fall survey was conducted in 2010 (Tables A56-A57, Figure A88). An index of recruitment is available from the fall series (Figure A84).

New York DEC

The New York Department of Environmental Conservation has conducted a small-mesh otter trawl survey in the Peconic Bay estuary at the eastern end of Long Island, New York since the mid-1980s; valid data for summer flounder are available since 1987. The NYDEC survey mean number per tow indices and length frequency distributions were converted to age using the corresponding annual NEFSC fall survey age-length keys (Table A58, Figure A88). The NYDEC indices, developed since the last benchmark assessment in 2008, have not previously been included in the calibration of the ASAP population model.

New Jersey DFW

The New Jersey Division of Fish and Wildlife (NJDFW) has conducted a standardized bottom trawl survey since 1988, and indices of abundance for summer flounder are compiled from data collected from April through October (Table A59, Figure A89). The NJDFW survey mean number per tow indices and length frequency distributions were converted to age using the corresponding annual NEFSC fall survey age-length keys. The NJDFW index peaked in 2002 and has decreased since then. Over the last decade, most year classes are at or below average; however, the index of the 2005 year class was above average (Figure A90).

Delaware DFW

The Delaware Division of Fish and Wildlife (DEDFW) has conducted a standardized bottom trawl survey with a 16 foot head-rope trawl since 1980 and with a 30 foot head-rope trawl since 1991, although due to a previously undocumented un-calibrated vessel change it was determined in this assessment that only the indices from 2003 and later are directly comparable. Recruitment indices (age 0 fish; one index from the Delaware estuary proper for 1980 and later, one from the inland bays for 1986 and later) have been compiled from the 16 foot trawl survey data (Tables A60-A61, Figure A90). Indices for age-0 to age-4 and older summer flounder have been compiled from the 30 foot head-rope survey (Table A62, Figure A89). The indices use data collected from June through October (mean number per tow) with age 0 summer flounder separated from older fish by visual inspection of the length frequency.

Maryland DNR

The Maryland Department of Natural Resources (MDDNR) has conducted a standardized trawl survey in the seaside bays and estuaries around Ocean City, MD since 1972. Samples collected during May to October with a 16 foot bottom trawl have been used to develop a recruitment index for summer flounder (Table A63, Figure A91). This index suggests that weakest year class in the time series recruited to the stock in 1988 and 2005, and the strongest in 1972, 1983, 1986, 1994, and 2009.

Virginia Institute of Marine Science

The Virginia Institute of Marine Science (VIMS) has conducted a juvenile fish survey using trawl gear in Virginia rivers since 1955. An index of recruitment developed from the VIMS survey suggests weak year classes (<0.2 fish per trawl) recruited to the stock in 1955, 1959, 1961-1962, 1966, 1968, 1970, and 1975, with strong year classes (>2.0 fish per trawl) recruiting in 1956-57, 1963, 1971, 1979-1983, 1990-1991, and 1994. Recruitment indices since 1994 have been below average (Table A64, Figure A91).

The VIMS Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMap) was started in 2002, providing research survey samples from Chesapeake Bay. The ChesMMap samples are dominated by age 0-2 summer flounder. The ChesMMAP indices, developed since the last benchmark assessment in 2008, have not previously been included in the calibration of the ASAP population model (Table A65, Figures A92-A93).

The VIMS Northeast Area Monitoring and Assessment Program (NEAMAP) was started in Fall 2007, providing research survey samples along the Atlantic Coastal waters from Rhode Island to North Carolina, in depths of 20-90 feet (9-43 meters). The NEAMAP indices, developed since the last benchmark assessment in 2008, have not previously been included in the calibration of the ASAP population model (Tables A66-A67, Figures A92-A93).

North Carolina DMF

The North Carolina Division of Marine Fisheries (NCDMF) has conducted a stratified random trawl survey using two 30 foot head-rope nets with 3/4" mesh cod-end in Pamlico Sound since 1987. An index of recruitment developed from these data suggests the weakest year class recruited to the stock in 1988, with the strongest year classes in 1987, 1996, 2001, and 2002 (Table A68, Figure A91). The survey normally takes place in mid-June, but in 1999 was delayed until mid-July. The 1999 index is therefore inconsistent with the other indices in the time series, and so the 1999 value has been excluded.

Standardization of fishery-independent indices (Completion of specific sub-task is contingent on analytical support from staff outside of the NEFSC)

The Rhode Island fixed station monthly trawl survey (RIDFW RIX survey) was examined for the usefulness and applicability for standardization. This is a spatially limited, fixed station trawl survey that takes place in RI state waters that began in 1990. Abundance data in numbers of fish was the data that was analyzed. The first procedure was to test some different models to find the appropriate functional form for the data. The final chosen model was a negative binomial generalized linear model. This model was applied to the data using depth and temperature as the covariates against which to model the data. Once the model was produced, diagnostics were performed to test the appropriateness of the model. The functional form appeared appropriate given the histogram of the catch data, there did not appear to be an issue with multi-collinearity, and the model did not have an issue with heteroskedasticity.

The model output was then taken and an annual index was created. The standardized annual index was compared to the nominal index of catch per tow. The effect of the standardization was to scale the existing trend and catch magnitude downward, but the general trend and interannual variation was very similar to the nominal index. The exercise was a first cut and additional work will be needed to complete the modeling exercise, but this analysis was an examination to satisfy the term of reference and to initiate discussion by the group. Additional work including the examination of station as another important covariate would be needed to fully standardize the dataset.

The discussion of the SDWG about this work had multiple elements to it. The first item for discussion had to do with which surveys a standardization procedure would be appropriate for. The NEFSC trawl surveys have a survey design that was randomized and the survey extends throughout the range of the species. Rather than developing a model to standardize, the survey design serves the purpose of standardizing the dataset. For these reasons, it was felt that standardization was not needed for the NEFSC trawl surveys. The same argument can be made for the VIMS NEAMAP survey, which is a new dataset used in the stock assessment.

There are also multiple state surveys that are used in the model. Many of these models also have a randomized design, some do not. Despite the randomization, one of the main features of the state surveys is that many of them are seasonal in timing and are limited to state waters, so do not extend throughout the species range. The group thought there could be some benefit to standardizing these surveys to dampen down some of the variability inherent in them but to also apply the correct functional form when analyzing the data and to make the surveys comparable from state to state by using similar data metrics to model the datasets. The conclusion of this portion of the discussion was that the state surveys would be appropriate to standardize, were this to be a procedure the SDWG or ASMFC Technical Committee wished to perform.

NEFSC Trawl Survey Catch Spatial Patterns

The summer flounder NEFSC spring trawl survey data were summarized into regional groups of strata to investigate spatial distributions of the spawning stock biomass (SSB) over time. The spring series was selected for investigation of the SSB distribution, as the fall series tends to have fewer older fish, and more of the stock is in state waters and therefore less available to NEFSC surveys. The offshore survey strata were grouped into three broad regions: SNE (Southern New England, offshore strata 5-12), MAB (Mid-Atlantic Bight, offshore strata 1-4 & 73-76), and DMV (the Delaware-Maryland-Virginia region, offshore strata 61-72; Figure A94). Survey data were compiled as indices at age in weight (kg), and then summed ages 2-12+ to create proxy SSB indices. The decreasing trend in survey SSB from the late 1970s to a low point around 1990 is common to all three regions. Likewise, the strong increasing trend since 1990 follows a similar pattern in all three regions (Figure A95).

Similar trends in abundance were seen on a finer spatial scale. Catch number per tow in ~5 year increments was summarized for the NEFSC spring (1968-2012), fall (1968-2012), and winter (1992-2007) surveys. Summer flounder demonstrate seasonal movement patterns, with adults migrating offshore to the outer continental shelf waters in October/November for the winter and returning inshore in April/May while juveniles maintain an inshore habitat year-round (Packer and Hoff 1999). Tagging studies confirmed a homing instinct of adult fish to natal estuary waters with occasional straying to the north and east (Poole 1962). There is a tendency for fish migrating offshore north of Hudson Canyon to become more permanent residents of SNE (Lux and Nichy 1981) while fish of New Jersey origin often remain south of Hudson Canyon (Poole 1962).

NEFSC trawl survey data was also summarized by stratum using the average annual minimum swept area of abundance (*N*) as a metric:

$$N = \frac{a_i}{\bar{a}_t} \times \frac{\sum c_i}{t_i}$$

where a_i is the area of stratum i, $\bar{a}_t$ is the average swept area of a standard survey tow, $\sum c_i$ represents the sum of the number of fish caught in a given stratum, and t_i is the total number of tows in stratum i. Abundance was divided into fish less than and greater than 30 cm, the approximate cutoff between age 0 and age 1 fish.

Spring

Plots of the spring (March-May) survey catches for multi-year time blocks reveal offshore aggregations of fish along the shelf edge that are caught during the early part of the spring survey (the southward March survey legs) and more inshore aggregations caught later (during the northward April survey legs) (Figures A96-A104). The earliest years showed the greatest presence of summer flounder in tows from inshore waters from Long Island to Cape Hatteras. These earlier time blocks through the 1990s, when the spring strata set for the early analytical assessments was developed, generally show only intermittent catches of summer flounder in the Georges Bank-Great South Channel strata or in the Gulf of Maine. From 1976-1980, higher catches occurred south of the Delaware Bay, both inshore and offshore through Cape Hatteras with a greater presence of summer flounder in offshore stations moving north along the shelf break through SNE. This spatial pattern continued throughout the 1980s and 1990s, with a reduction in the number of summer flounder compared to the late 1970s. The lowest catch numbers in the time series were seen during the early 1990s just before increasing slowly in the late 1990s. During the rebuilding period of the 2000s, larger catches of summer flounder began appearing in SNE waters, particularly south of Rhode Island and Massachusetts in offshore strata. More summer flounder were also present along the southern edge of Georges Bank. A few small occurrences of summer flounder appear in tows in Massachusetts and Cape Cod Bays and around outer Cape Cod throughout the time series.

Spatial abundance trends for length data summarized by stratum (Figures A105-A113) are similar to the raw survey catch data, however these maps illustrate the spatial and temporal abundance in large versus small summer flounder, are summarized by stratum, and expanded by swept area. Across the entire time series it is evident that smaller fish (< 30 cm, age 1 in the spring) are inhabiting areas in the southern range while fish in the northern range are nearly all >30 cm (mainly age 2 and older). Summer flounder less than 30 cm tend to make up the majority of the catch in spring inshore strata south of the Chesapeake Bay. This is not atypical since juvenile summer flounder tend to remain inshore for the first year before migrating offshore the following winter. Over time, these southern strata, both inshore and offshore, begin to contain a greater proportion of large summer flounder.

Fall

Plots of the fall (September-October) survey catches for multi-year time blocks reveal aggregations of fish mostly in inshore waters along the inner-half of the shelf and into the bays and estuaries. However in periods of higher abundance (1968-1975), a greater presence of summer flounder reaches farther offshore, particularly south of Delaware Bay (Figure A114). The earliest time block of 1968-1975 shows little or no catch of summer flounder in the Georges Bank-Great South Channel strata or in the Gulf of Maine. The second block of 1976-1980, however, shows more substantial catches over Georges and in mid-shelf offshore stratum 10 (Figure A115). Years of lower abundance (the 1980s and early 1990s) show summer flounder aggregating more tightly in inshore strata while catches in the Georges Bank, Great South Channel, and mid-shelf offshore strata (2, 6, 10) declined (Figures A116-A118). From RI waters to the southwest, most of the catches are confined to the inshore strata and the inner-most band of offshore strata (9, 5, 1, 61, 65, 69, 73; moving east to west/southwest). Abundance over time is similar to the spring with higher catches initially in the time series, dropping in the 1980s and 1990s, before increasing in recent years. By the late 1990s, catches of summer flounder were highest in the southern range, especially surrounding the Chesapeake Bay area (Figure A119). During the rebuilding period since 2000, larger catches began occurring more frequently in the MAB and approaching SNE. An increased presence in central Georges Bank is also noticeable in later years of greater abundance, where it was nearly absent in the 1968-1975 time period. Additionally, existence of summer flounder in survey catches in Massachusetts Bay and around Cape Cod has increased throughout the time series and was not present prior to the 1980s (Figures A120-A122).

Fall survey average annual minimum swept area abundances show an even more definitive line spatially dividing fish of sizes less than 30 cm (mainly ages 0 and 1 in the fall) and greater than 30 cm (ages 1 and older; Figures A123-A131). Nearly all summer flounder caught north of Hudson Canyon are >30 cm in size. This divide appears to stretch further south during the rebuilding period during the late 1990s and early 2000s. Survey catches during the earliest years of the time series were focused around the DMV region where the majority of the catch, particularly in inshore strata surrounding Delaware and Chesapeake Bay, were fish <30 cm. Some smaller fish begin to re-enter catches north of Hudson Canyon as MAB and SNE strata become the new areas of greatest summer flounder abundance.

Winter

While winter trawl surveys existed for 6 sporadic years from the mid 1960s until the early 1980s, the survey effort was not consistent across time and space. During the 1960s the survey did not extend to strata south of Hudson Canyon and during the 1970s and 1980s, coverage was patchy. Survey coverage during the later, consecutive years of the winter flatfish survey time series (1992-2007) was more typical of the spring and fall trawl surveys though excluded inshore strata south of Hudson Canyon, strata south of Cape Hatteras, and all of the Gulf of Maine including the Great South Channel and the majority of northern Georges Bank. Throughout the time series, survey catches of summer flounder remain tightly bound to stratum depth contours, remaining farther offshore in waters surrounding large freshwater output sources (Figures A132-A135). This pattern seems more apparent from Delaware Bay and north; summer flounder appear in shallower offshore strata (depth range 27-55 m) to the south of Delaware Bay, while are more restricted to waters 50 m and deeper to the north. Due to the large number of positive tows and the abbreviated time period, it is difficult to decipher any drastic spatial changes over time resulting from the winter survey catches. A northerly shift is apparent as larger catches occurring in the southern strata from 1992-1995 do become present in SNE in later years, while still occurring in southern strata.

Interpolative mapping of NEFSC fish trawl and ichthyoplankton surveys

Introduction

Richardson (2013a, b MS; WPA15 and WPA16) presented descriptive figures and analyses of patterns in summer flounder distribution from NEFSC fish trawl and ichthyoplankton survey catches. The objectives of this work were to present an analysis describing alongshelf shifts in distribution in the fall and spring and to evaluate the extent to which these shifts in distribution can be explained by environmental factors and by changes in the length structure of the population combined with length-specific distribution patterns and analyze of shifts in larval and mature adult distributions to examine potential shifts in spawning.

The maps of fish distribution by multi-year period were produced using an inverse-distance weighting interpolation procedure that includes a distance penalty for depth differences between the interpolated point and the sample station. This interpolation procedure is intended to produce interpolated maps that better represent the distributions of species that are associated with bathymetric features. This mapping procedure requires a parameter that converts bottom depth differences into an equivalent distance measure in kilometers. We optimized this parameter using bottom temperature data due to the difficulty in quantitatively evaluating the parameter using fish data. Specifically, we performed a leave-one-out procedure on bottom temperature to evaluate the increase in accuracy of predicted versus measured bottom temperatures for different parameter values. The depth-informed interpolation procedure performed substantially better than an interpolation procedure that does not incorporate depth. The interpolative mapping procedure was also used to create distribution maps for specific size classes of summer flounder. Changes in fishing mortality rates and natural mortality rates will affect the size-structure of a population. If the species exhibits length-specific distributions this change in size structure may also result in a change in aggregate distribution (e.g. the mean center of biomass) that is not associated with environmental factors.

The distributions of larval and mature adult summer flounder were examined over the last four decades to explore potential shifts in spawning distribution. Ichthyoplankton data was collected during the MARMAP (1977 – 1987) and ECOMON (1999 – 2009) programs, and data from the same time periods for mature adults were examined from the NEFSC spring and fall bottom trawl surveys. All datasets were aggregated spatially based on the current ECOMON strata. Both MARMAP and ECOMON were designed as multi-species surveys, and sampling effort covered the entire northeast U.S. shelf from Cape Hatteras, North Carolina, to Cape Sable, Nova Scotia four to six times per year. MARMAP used primarily a fixed station design covering the sample area of each survey approximately evenly. ECOMON samples the same spatial extent of the shelf as MARMAP, but uses a random-stratified design based on the NEFSC bottom trawl survey design to collect samples from 47 strata. The area encompassed by each stratum determined the number of samples in each stratum. The number of stations sampled during an ECOMON survey is approximately 30 % less than that of MARMAP.
The relative proportion (percent of annual sum) of estimated absolute number of larvae and mature adults within each of 47 strata were used to examine changes in distribution. Larval abundance (larvae • 10 m^{-2}) was calculated for each station. The absolute number of larvae was estimated by multiplying the mean abundance (larvae • 10 m^{-2}) of stations within a stratum by the stratum area (m^2). The relative larval proportion of absolute number of larvae within each stratum was calculated by year and bimonthly season (January – February, March – April, May – June, July – August, September – October, November – December). The absolute number of mature adults was estimated by multiplying mean number of fish > 28 cm in length for each station within a stratum by the stratum area (m^2). The length of 28 cm was chosen based on the estimated median size at maturity (50 %) of 27.6 cm for both males and females from the 47th SAW assessment. The relative mature-adult proportion within each stratum was calculated for the spring and fall surveys. Significant differences in stratum larval and mature adult proportions between MARMAP years (n = 11) and ECOMON years (n = 11) were

examined among the strata that made up at least 99 % of the empirical cumulative distribution from south to north using a Kruskal-Wallis chi-square test. For larvae, the early (September – October), peak (November – December), and late (January – February) larval seasons were tested. The spring and fall bottom trawl surveys were tested for mature adults. Linear regression was used to analyze the along-shelf change in larval and mature adult distributions from south to north. The distance (km) north of Cape Hatteras was calculated for the center of each of the 47 strata. Kruskal-Wallis H values were set to negative if the relative proportion for a stratum was greater during MARMAP and positive if the proportion was greater during ECOMON. A linear regression was run for the along-shelf distance and Kruskal-Wallis H value for each stratum tested for the three larval seasons combined and the two bottom trawl surveys combined.

Adult fish distributions

The spring and fall distributions of summer flounder for 8 multi-year time periods are presented in Figures A136-A137. For both seasons the 1968-1972 time period was characterized by a southerly distribution of the sampled biomass. The recent time period had a more northerly distribution. The spring and fall distributions of summer flounder by length class averaged over the entire time series are shown in Figures A138-A139. A progressive northward shift in distribution is evident with increases in length.

The alongshelf grid used in the subsequent analyses is shown in Figure A140 part A and Figure A141 part A. For both the spring and fall the average alongshelf position of summer flounder increases with increasing size. On the spring survey the alongshelf position is around 200 km for fish <25 cm and is about 580 km for fish >40 cm. On the fall survey a similar pattern is evident, though the alongshelf position does not level off until fish are >50 cm. The spring survey annual alongshelf Center of Biomass of summer flounder increases (moves North) from the late 1960s to the mid-1980s, then declines (moves South) to the mid 1990s before reaching high levels again around 2007. The length predicted alongshelf center of biomass declines from the late 1960s to the early 1990s, increases until around 2008 and subsequently declines slightly. The residuals of the Observed COB from the length-predicted COB show a substantial increase in the early 1970s and a subsequent leveling off (Figure A140 part D). For the fall similar patterns emerge, although the 2005-2012 period does have fish in their most northeasterly position of the time series for both actual and residual COB (Figure A141 part D, Table A69). The residuals of the COB were minimally related (r=0.12) to either the annual SST or bottom temperature in the spring. In the fall a moderate relationship (r=0.37) to SST was evident (Figures A142-A143).

Shifts in the larval and mature adult distributions

Summer flounder larval distribution changed little over the past four decades, even as adult distributions significantly shifted northwards (Figures A144-145). Most change in relative larval proportions among stratum occurred during the early larval season (Figure A145 part A; September – October), with greater proportions in four strata ranging from off Chesapeake Bay to Georges Bank from 1999 to 2009. However, no significant change in along-shelf distance occurred (Figure A145 part D). Over the same time period, mature adults increased in relative proportions of the inner shelf strata of southern New England and northwest side of Georges Bank, primarily in the fall (Figure A145 part E, F). These shifts in relative proportion resulted in a significant northward along-shelf change in the mature adult distribution (Figure A145 part G). The time series of larval indices from the MARMAP and ECOMON programs, proposed as indices of summer flounder spawning stock biomass, are presented in Table A69.

GENERAL SPATIAL TRENDS

The heaviest commercial fishery catches (and by inference, effort) in the 1990s were reported just off of Cape Hatteras, concentrated around the entrances to Hudson Canyon and Narragansett Bay, and offshore along the shelf edge from the Chesapeake Bay entrance through SNE. Large catches of summer flounder continued along the shelf during the early 2000s with concentrations slightly farther north off the Delaware-Maryland-Virginia coast. This northerly trend of offshore commercial catches continued through the present decade with the largest catches now south of Rhode Island. Commercial catches of summer flounder at its southern extent are reduced after 2005. Fishery observer data show a much larger presence of large summer flounder catches on Georges Bank after 2005. Recreational fishing catch (and by inference, effort) distribution from party and charter boats is relatively unchanged throughout the 1990s and 2000s. One exception is reduced catch south of the Chesapeake Bay that becomes almost entirely absent after 2005. The highest density of recreational catch occurs in inshore waters from Delaware Bay along the coast to Narragansett Bay.

The earliest years (1968-1990) of NEFSC fish trawl surveys showed the largest catches of summer flounder in inshore waters from Long Island to Cape Hatteras, with intermittent catches of summer flounder in the Georges Bank-Great South Channel strata or in the Gulf of Maine. The lowest catches occurred during the early 1990s, before increasing slowly in the late 1990s. During the rebuilding period of the 2000s, larger catches of summer flounder began appearing in northern areas, particularly south of Rhode Island and Massachusetts. Nearly all summer flounder caught north of Hudson Canyon are >30 cm in size. This divide appears to stretch further south during the rebuilding period during the 2000s. Survey catches during the earliest years of the time series were focused around the Delaware-Maryland-Virginia region where the majority of the catch, particularly in inshore strata surrounding Delaware and Chesapeake Bay, were fish <30 cm. Some smaller fish begin to re-enter catches north of Hudson Canyon as Mid-Atlantic Bight and Southern New England regions have become the new areas of greatest summer flounder abundance.

The annual alongshelf center of biomass of summer flounder increases (moves North) from the late 1960s to the mid-1980s, then declined (moves South) in the mid 1990s, before reaching high levels again around 2007. For both the spring and fall fish trawl surveys the average alongshelf position of summer flounder increases with increasing size. The length predicted alongshelf center of biomass declines from the late 1960s to the early 1990s, increases until around 2008 and subsequently declines slightly. The relationship of the center of summer flounder biomass to either surface or bottom temperature is minimal in the spring and moderate in the fall. Summer flounder larval distribution has changed little over the past four decades.

While many factors may be causing changes in spatial distribution of summer flounder over the last few decades, their general increased abundance northward and expansion eastward on Georges Bank is apparent. Spatial expansion is also more apparent in years of greater abundance. This may be more than a coincidence as fishing pressure has been shown to enhance changes in spatial distribution due to the environment (Hsieh *et al.* 2006, 2008; Planque *et al.* 2010). One reason for this may be that higher levels of exploitation can lead to reduced heterogeneity in age structure, particularly a reduction in older age fish, making the stock more sensitive to shifts in the environment (Hsieh *et al.* 2006, 2008; Planque *et al.* 2010). This kind of response may be evident in summer flounder as expansion in both the spatial distribution and size structure has developed since about 2000, after the period of heavy exploitation during the 1980s and 1990s. Teasing out the mechanism(s) driving this trend and the resulting increase in SSB that followed in the 2000s may be difficult, but warrants continuing research.

FISHERY DEPENDENT INDICES OF ABUNDANCE

Fishery dependent catch rate data were modeled using generalized linear models in SAS software version 9 (SAS 2011) to developed standardized indices of abundance for summer flounder. The response variables were the continuous variable total landings or catch per day fished (for commercial trips) or per angler trip (for recreational trips), while the classification factors considered were the discrete variables year (the 'year' effect that in a main classification factors only model serves as the index of abundance), and various temporal, spatial, and vessel classification characteristics.

The SAS GENMOD procedure fits generalized linear models that allow the mean of a population to depend on a linear predictor through a nonlinear link function and allow the response probability distribution to be specified from a number of probability (error) distributions. These include the normal, lognormal, binomial, Poisson, gamma, negative binomial (negbin), and multinomial (McCullagh and Nelder 1989). SAS PROC GENMOD was used to model the fishery dependent catch rate data using lognormal (for ln-tranformed rates), gamma, Poisson, and negative binomial (for untransformed rates) probability distributions. The GENMOD procedure fits a generalized linear model to the data by maximum likelihood estimation. There is generally no closed form solution for the maximum likelihood estimates of the parameters, so the procedure estimates the parameters of the model numerically through an iterative fitting process, with the covariances, standard errors, and p-values computed for the estimated parameters based on the asymptotic normality of maximum likelihood estimators (SAS 2011).

The estimates of- and changes in several goodness of fit statistics were used to evaluate the goodness of fit of the model and the significance of the classification factors: a) the ratio of the deviance (twice the difference between the maximum attainable log likelihood and the log likelihood of the model) to the degrees of freedom (DF); this statistic is a measure of "dispersion" and of fit of the expected probability distribution to the data (closer to 1 is better) and is comparable across models, b) the value of the log-likelihood (a measure of model fit), c) the computed AIC (a measure of model fit and performance, valid for a sequence of models within each distribution, and across models with the same type of data), d) whether or not the model converged (whether the negative of the Hessian matrix was positive definite, allowing valid estimation of the parameters and their precision), and e) the significance of the classification factors as indicated by the log-likelihood ratio statistics at the 5% level (SAS 2011, Terceiro 2003b, Dick 2004, Maunder and Punt 2004).

A sequence of models, including from one factor to many factors, were fit and the differences/changes in the goodness of fit diagnostics used to determine the best model under each probability distribution assumption. A Type III analysis was used since it does not depend on the order in which the classification factors are specified. For the discrete variable Poisson and negative binomial error distributions, individual trip catch rate values were rounded to integer values.

Dealer Landings Reports LPUE

Dealer report trawl gear landings rate (LPUE) data for summer flounder were modeled to compile standardized indices of abundance for summer flounder (Terceiro 2013a MS; WPA3). Descriptive statistics indicated that the Dealer report Trawl gear landings rate distribution is overdispersed in relation to a normal distribution, as the mean is larger than the mode, the variance is several orders of magnitude larger than the mean, and skewness is larger than zero. Simple visual inspection indicates the untransformed, interval-binned distribution is likely not normal, but rather a gamma, Poisson or negative binomial. However, the distribution of the ln-transformed landings rates suggests that a lognormal assumption could be appropriate for these data.

The distributions of the observed total landings were examined for three candidate classification variables – calendar quarter (QTR; 1 = Jan-Mar, 2 = Apr-Jun, etc), 3-digit statistical area (AREA), and vessel tonnage class (TC; binned for vessels < 5 gross registered tons [TC = 1], 5-50 [TC = 2], 51-150 [TC = 3], 151-500 [TC = 4], 501-1000 [TC = 5], and 1001 and larger [TC = 6]), expressed as the cumulative sum of the total landings for each class level. The distribution by QTR indicated that about 40% of the landings were taken in the first calendar quarter. The distribution by statistical area indicated that about one-half of the total landings were taken in 5 areas: area 537 off RI and MA, area 616 off northern NJ and western Long Island, NY in the Hudson Canyon area; areas 621 and 622 off southern New Jersey and Delaware Bay, and area 626 off Delmarva. The distribution by tonnage class (TC) indicated that about 70% of the landings were taken by tonnage class 3 vessels. Total reported landings (lbs), trips, days fished, and nominal annual LPUE (landings lbs per DF), and LPUE scaled to the time series mean are presented in Table A70.

Given that the examination of the total landings lbs per day fished frequency distributions indicated that the assumption of a negbin probability (error) distribution was most appropriate for the untransformed landings rate data and that the Deviance/DF (dispersion) statistic for the negbin model was closest to 1.0, the negbin four-factor YEAR-QTR-AREA-TC model is suggested as the best model for the Dealer Report trawl gear landings rate data for summer flounder. The YEAR estimated parameters (re-transformed and bias-corrected to linear scale) serves as the “year effect” index of abundance, and are compared to the nominal index in Figure A146, with all series scaled to their respective time series means to facilitate comparison. All model configurations have a strong smoothing effect on the nominal indices from 1964 until about 2000, and then generally indicate a steeper increase in stock biomass since 2000 than does the nominal index. The lognormal model smoothed the nominal series most strongly through about 2000, but indicated the greatest increase in biomass since 2000. The gamma and negbin models provided nearly identical results, although the negbin diagnostics indicated a better fitting model. The best-fitting negbin indices and their 95% confidence intervals are therefore compared with the nominal index in Figure A147, with the series scaled to their means to facilitate comparison. The negbin annual indices, the annual Coefficents of Variation (CVs), and the 95% confidence intervals are presented in Table A71.

The data and analyses described above include only the data available from the NEFSC Dealer Report landings database. In developing these models, it was recognized that the inclusion of external information on the pattern of commercial fishery management regulations, which are known to affect both the rate of catch and behavior of fishermen, could impact the results. To that end, information on each state's open season (expressed as open or closed for each year-month) and commercial fishery trawl trip limits (expressed as the limit in lbs for each year/month) was added to the LPUE data set. For years prior to 1993, seasons were coded as open and trip limits were set at 100,000 lbs (the highest observed). This information was modeled both as covariates and as explicit classification variables. Unfortunately, attempts to develop valid model incorporating this external information failed, likely due to the lack of contrast of the cell means across classification strata. Most models failed to converge, and those that did 'converge' (i.e., stopped iterating due to the minimum residual step being attained) failed to provide valid parameter estimates for many of the classification variables.

Vessel Trip Report (VTR) CPUE

Fish Trawl Gear

Vessel Trip Report (VTR) fish trawl gear catch rate (landings plus discards; CPUE) data for summer flounder were modeled to compile standardized indices of abundance for summer flounder (Terceiro 2013b MS; WPA4). Descriptive statistics indicate that the VTR trawl gear catch rate distribution is overdispersed in relation to a normal distribution, as the mean is larger than the mode, the variance is several orders of magnitude larger than the mean, and skewness is larger than zero. Simple visual inspection indicates the untransformed, interval-binned distribution is likely not normal, but rather a gamma, Poisson or negative binomial. However, the distribution of the ln-transformed landings rates suggests that a lognormal assumption could be appropriate for these data.

The distributions of the observed total catch were examined for four candidate discrete classification variables – calendar quarter (QTR; 1 = Jan-Mar, 2 = Apr-Jun, etc.), 3-digit statistical area (AREA), vessel tonnage class (TC; binned for vessels < 5 gross registered tons [TC = 1], 5-50 [TC = 2], 51-150 [TC = 3], 151-500 [TC = 4], 501-1000 [TC = 5], and 1001 and larger [TC = 6]), and net mesh size category (MSH; LG [large] => 5 inches; SM [small] < 5 inches), expressed as the cumulative sum of the total catch for each class level. The distribution by QTR indicated that about half of the catch is taken in the first calendar quarter. The distribution by statistical area indicated that about one-third of the total catch was taken in just 3 areas: area 616 off northern NJ and western Long Island, NY in the Hudson Canyon area; area 537 off RI and MA, and area 626 off Delmarva. The distribution by tonnage class (TC) indicated that about two-thirds of the catch was taken by tonnage class 3 vessels. The distribution by mesh size indicated that large mesh trips accounted for 88% of the reported landings and 71% of the reported discards; the nominal reported discard rate (discards to total catch lbs) was 2% for large mesh trips and 6% for small mesh trips. Total catch, trips, days fished, nominal annual total catch lbs per day fished (CPUE), and CPUE scaled to the time series mean is presented in Table A72; there is an increasing trend evident in the nominal series since 1994 (Figure A148).

Given that the examination of the total catch lbs per day fished (CPUE) frequency distributions indicated that the assumption of a negbin probability (error) distribution was most appropriate for the untransformed catch rate data and that the deviance/DF (dispersion) statistic for the negbin model was closest to 1.0, the negbin five-factor YEAR-QTR-AREA-TC-MSH model is indicated as the best model for the VTR trawl gear catch rate data for summer flounder. The YEAR estimated parameters (re-transformed and bias-corrected to linear scale) serves as the "year effect" index of abundance for all three distributions, and are compared to the nominal index in Figure A148, with all series scaled to their respective means to facilitate comparison. All model configurations have a moderate smoothing effect on the nominal indices. The negbin indices and their 95% confidence intervals are compared with the nominal index in Figure A149, again with the series scaled to their means. The negbin annual indices, the annual Coefficients of Variation (CVs), and the 95% confidence intervals are presented in Table A73.

Recreational Party/Charter Boat

Vessel Trip Report (VTR) Party and Charter (P/C) boat catch rate (landings plus discards in numbers per trip; CPUE) data for summer flounder were modeled to compile standardized indices of abundance for summer flounder (Terceiro 2013c MS; WPA5). Descriptive statistics indicate that the VTR P/C boat catch distribution is overdispersed in relation to a normal distribution, as the mean is larger than the mode, the variance is 5-6 times larger than the mean, and skewness is larger than zero. Simple visual inspection indicates the untransformed distributions are likely not normal, but rather a gamma, Poisson or negative binomial. However, the distributions of the ln-transformed individual trip catch rates suggest that a lognormal assumption could be appropriate for these data.

The distributions of the observed total catch were examined for three candidate discrete classification variables – calendar month (MON), 3-digit statistical area (AREA), and VTR trip category (BOAT; Charter or Party boat) - expressed as the cumulative sum of the total catch for each class level. The distribution by QTR indicated that little of the catch is taken in the first or last calendar quarters, and that about 80% is taken during June, July, and August. The distribution by AREA indicated that about 65% of the total catch was taken in area 612 off northern NJ and western Long Island, NY; other areas with significant catch were 539 off RI and MA, 611 off eastern Long Island, NY, 614 off southern NJ, and 621 off Delmarva. The distribution by BOAT class indicated that about

77% was taken aboard Party boats, with the share between Party and Charter varying over time. Total catch, trips, anglers, nominal annual catch per trip (CPUE), and CPUE scaled to the time series mean for the boat types combined (P/C Boat) is presented in Table A74; there is a declining trend evident in the nominal series (Figure A150).

Initial reviews of the work suggested that the inclusion of external information on the pattern of recreational fishery management regulations, which are known to affect both the rate of catch and behavior of fishermen, could impact the results. To that end, information on each state's minimum retention size (SIZE) and possession (BAG) limit for each year from 1994-2012 was added to the basic VTR CPUE data set. In addition, the classification variable AREA (3-digit statistical area) was dropped in favor of the STATE variable in the negbin model, to better correspond to the pattern of the regulatory information. Most of the P/C Boat total catch is reported by boats from NY and NJ, and about 10% of the observations did not include state information and were dropped. First through third level interaction terms with YEAR (e.g., year*state, year*state*size, year*state*size*bag) were also added to the model to determine if those terms were estimable and/or significant (which has consequences for the use of the YEAR main effect as the index of abundance). The addition of the SIZE and BAG information to the YEAR-MON-STATE-BOAT model results in an improved model fit. The addition of interaction terms resulted in a converged model with improved fit, but many of the interaction term coefficients were inestimable. Therefore, the six factor YEAR-MON-STATE-BOAT-SIZE-BAG model (ST-SZ-BG) emerged as the best fitting, usable model. The six-factor ST-SZ-BG negin modeled series indicates no trend in stock abundance, in contrast to the decreasing trend of the nominal and earlier modeled series (Figure A150). The six-factor ST-SZ-BG negbin indices and their 95% confidence intervals are compared with the nominal index in Figure A151, with the series scaled to their means to facilitate comparison. The six-factor SIZE-BAG negbin annual indices, the annual Coefficents of Variation (CVs), and the 95% confidence intervals are presented in Table A75.

Fishery Observer (OB) CPUE

Fish Trawl Gear

Northeast Fishery Observer Program (NEFOP) catch rate (landings plus discards in pounds per trip; CPUE) data for summer flounder taken in observed fish trawl gear trips were modeled to compile standardized indices of abundance for summer flounder (Terceiro 2013d MS; WPA6). Descriptive statistics indicate that the observed trawl gear catch rate distribution is overdispersed in relation to a normal distribution, as the mean is (relatively) much larger than the mode, the variance is much larger than the mean, skewness is much larger than zero, and there is a high proportion of low total catch per trip observations (trips with <250 lbs per trip compose 50% of the observations).

The distributions of the observed total catch were examined for three candidate classification variables – calendar quarter (QTR), 3-digit statistical area (AREA), and vessel tonnage class (TC; binned for vessels < 5 gross registered tons [TC = 1], 5-50 [TC = 2], 51-150 [TC = 3], 151-500 [TC = 4], 501-1000 [TC = 5], and 1001 and larger [TC = 6]), expressed as the cumulative sum or proportion of the total catch for each class level.

The distribution by QTR indicated that about half of the total catch was observed in the first quarter (Jan-Mar), while only 11% was observed in quarter 2 (Apr-May). The distribution by statistical area indicated that about 65% of the total catch was observed in areas 525, 537, 612, 616, 622, and 626, with no other areas accounting for more than 4%. The distribution by vessel tonnage class indicated that about 67% was observed aboard tonnage class (TC) 3 vessels. Total observed trips, hauls, catch, days fished, nominal annual catch per day fished (CPUE), and CPUE scaled to the time series mean are presented in Table A76; there is not a strong trend in the nominal series (Figure A152).

The AICs for the gamma and negbin models (directly comparable because they are based on untransformed catch rates) were very close (gamma slightly lower/better). However, given that the examination of the total catch frequency distributions indicated that the assumption of a negbin probability (error) distribution was most appropriate for the untransformed catch rate data, and the Deviance/DF (dispersion) statistic for the negbin model was closest to 1.0, the negbin four-factor YEAR-QTR-AREA-TC model is indicated as the best model for the observed trawl gear catch rate data for summer flounder. The YEAR estimated parameters (re-transformed and bias-corrected to linear scale) serves as the "year effect" index of abundance for all three distributions, and are compared to the nominal CPUE in Figure A152, with all series scaled to their respective means to facilitate comparison.

All modeled series indicate a steeper increase in stock biomass than the nominal series. The Poisson series is the most variable over time, while the lognormal, gamma, and negbin series are less variable and match fairly closely. The negbin indices and their 95% confidence intervals are compared with the nominal index in Figure A153, with the series scaled to their means to facilitate comparison. The negbin annual indices, the annual Coefficients of Variation (CVs), and the 95% confidence intervals are presented in Table A77.

Scallop Dredge Gear

Northeast Fishery Observer Program (NEFOP) catch rate (landings plus discards in pounds per trip; CPUE) data for summer flounder taken in observed fish trawl gear trips were modeled to compile standardized indices of abundance for summer flounder (Terceiro 2013d MS; WPA6). Descriptive statistics indicate that the observed scallop dredge gear catch distribution is overdispersed in relation to a normal distribution, as the mean is (relatively) much larger than the mode, the variance is much larger than the mean, skewness is much larger than zero, and there is a relatively high proportion of low total catch per trip observations.

The distributions of the observed total catch were examined for three candidate classification variables – calendar quarter (QTR), 3-digit statistical area (AREA), and vessel tonnage class (TC; binned for vessels < 5 gross registered tons [TC = 1], 5-50 [TC = 2], 51-150 [TC = 3], 151-500 [TC = 4], 501-1000 [TC = 5], and 1001 and larger [TC = 6]), expressed as the cumulative sum of the total catch for each class level. The distribution by QTR indicated that most of the observed total catch was distributed about equally between quarters 1, 2, and 4, with only about 10% observed in the third quarter. The distribution by statistical area indicated that about half of the total catch was observed in areas 616 and 622. The distribution by vessel tonnage class indicated that about 75% of the total catch was observed aboard tonnage class (TC) 4 vessels. Total trips, hauls, catch, days fished, nominal annual CPUE, and CPUE scaled to the time series mean are presented in Table A78; the nominal series low occurred in 1998 and the high in 2007 (Figure A154).

Given that the examination of the total catch frequency distributions indicated that the assumption of a Poisson/negbin probability (error) distribution was most appropriate for the untransformed catch rate data and the Deviance/DF (dispersion) statistic for the negbin model was closest to 1.0, the negbin four-factor YEAR-QTR-AREA-TC model is suggested as the best model for the observed scallop dredge gear catch rate data for summer flounder. The YEAR estimated parameters (re-transformed and bias-corrected to linear scale) serves as the "year effect" index of abundance for all three distributions, and are compared to the nominal CPUE in Figure A154, with all series scaled to their respective means to facilitate comparison.

All modeled series provide a comparable degree of smoothing of the nominal CPUE index and indicate a steeper increase in stock biomass than the nominal series. The negbin indices and their 95% confidence intervals are compared with the nominal index in Figure A155, with the series scaled to their means to facilitate comparison. The negbin annual indices, the annual Coefficients of Variation (CVs), and the 95% confidence intervals are presented in Table A79.

MRFSS/MRIP (REC) CPUE

Recreational fishery Marine Recreational Fishery Statistics Survey (MRFSS) / Marine Recreational Information Program (MRIP) catch rate from the intercept (field creel survey) sample data were modeled to compile standardized indices of abundance for summer flounder (Terceiro 2013e MS; WPA7). Descriptive statistics indicate that the MRFSS/MRIP intercept catch distribution is over-dispersed in relation to a normal distribution, as the mean is larger than the mode, the variance is 7 times larger than the mean, and skewness is larger than zero. Simple visual inspection indicates the untransformed distributions are likely not normal, but rather a negative binomial. For these data, only negative binomial models were fit.

The distributions of the intercept total catch were examined for four candidate discrete classification variables – wave (2-month sampling intervals, e.g., January-February, Mar-April, etc. WAVE), state of landing (ST), fishing area (state or EEZ waters; AREA), and fishing mode (shore-based, private/rental boat, party/charter boat; MODE) - expressed as the cumulative sum of the intercept total catch for each class level. The first wave of the year (January-February) is not sampled from North Carolina to the north. The distribution by wave indicated that just over half of the catch was sampled in wave 4 (July-August), and that 97% is taken during May through October. The distribution by state indicated that about 30% of the total catch was sampled from NJ, 20% in NY, 17% in VA, 11% in DE, and 8% in RI, with less than 5% sampled in each of the other states. The distribution by fishing area indicated that about 93% was sampled from state water and 7% in the EEZ. The distribution by fishing mode indicated that about 76% was sampled from private rental boats, 18% from party/charter boats, and 6% from shore-based anglers. Total catch in numbers, trips, nominal annual CPUE (totcal catch per trip), and CPUE scaled to the time series mean for the intercept catch types combined (total catch) are presented in Table A80; there is an increasing trend evident in the nominal series since the late 1980s, although the 2012 CPUE was the lowest since 1995 (Figure A156).

Initial reviews of the work suggested that the inclusion of external information on the pattern of recreational fishery management regulations, which are known to affect both the rate of catch and behavior of fishermen, could impact the results. To that end, information on each state's minimum retention size (SIZE) and possession (BAG) limit for each year from 1981-2012 was added to the CPUE data set. First through third level interaction terms with YEAR (e.g., year*state, year*state*size, year*state*size*bag) were also added to the model to determine if those terms were estimable and/or significant (which has consequences for the use of the YEAR main effect as the index of abundance).

The addition of the SIZE and BAG information to the YEAR-WAVE-STATE-BOAT model results in an improved model fit. The addition of interaction terms resulted in a converged model with improved fit, but many of the interaction term coefficients were not significant and/or inestimable. Therefore, the six factor YEAR-WAVE-STATE-BOAT-SIZE-BAG model (ST-SZ-BG) emerged as the best fitting, usable model. The six-factor ST-SZ-BG negbin modeled series indicates a stronger decreasing trend over the last decade than the nominal and earlier modeled series. The six-factor ST-SZ-BG negbin indices and their 95% confidence intervals are compared with the nominal index in Figure A156, with the series scaled to their means to facilitate comparison. The six-factor SIZE-BAG negbin annual indices, the annual Coefficients of Variation (CVs), and the 95% confidence intervals are presented in Table A81.

2013 SDWG Conclusion on Utility as Indices of Abundance

The SDWG evaluated the utility of the standardized fishery dependent landings- and catch-per unit effort based indices as measures of abundance for the summer flounder stock assessment. The SDWG concluded that the calculation of effort in the fishery dependent data is problematic. For the commercial data, the effort information is dependent on the accurate recording by the fishermen themselves. The collection of this data is not a focus of their operation, however, and therefore metrics like the fishing time or length of tow may not be accurate and could therefore provide a biased CPUE index. There is a lack of consistency in the reporting requirements for parts of the commercial VTR time series; the instructions for how effort is reported have changed. For the recreational data, the calculation of effort is even more problematic. In this analysis, all trips which caught summer flounder were used; there are different ways to define summer flounder trips. However, there is variation in the number of rods and reels (gear quantity) and the time of fishing for each trip that may not be completely or accurately reported. The catch is also inconsistently reported in the for-hire recreational VTR with it being provided in numbers or pounds on these self-reported forms. In total these elements make the calculation of effort challenging when working with commercial and recreational fishery data time series.

The SDWG noted that over the long term, and especially since fishery quotas were instituted in the early 1990s, there have been a number of regulatory changes which are different in timing and magnitude for each state (primarily seasonal closures, seasonal trip/possession limits, and minimum size limits). This information is not part of the commercial and recreational catch databases and so must be developed independently and integrated within the Generalized Linear Model. This information could not be modeled adequately as covariates or classification variables within the generalized model framework (i.e., inability to develop a model which converges and produces valid parameter estimates) for the commercial fishery data.

The three commercial trawl standardized indices generally indicate increasing trends in abundance comparable to the NEFSC seasonal trawl surveys (an increase of about 80% since 1990). The recreational fishery standardized indices, for which inclusion of regulatory measures in the models were successful, indicated recent decreasing trends in abundance that were inconsistent with the trends indicated by most state and federal research survey index trends.

Figure A157 compares the time series trends of the fishery dependent indices of abundance, scaled to the terminal year (2012) to facilitate comparison; Figure A158 makes the same comparison including the three NEFSC seasonal trawl surveys. The modeling difficulties call into question the utility of both the nominal and model-based fishery dependent standardized indices as unbiased measures of summer flounder abundance. While the commercial trawl indices do indicate increasing trends, the SDWG felt the standardization procedure was still subject to an unknown, likely negative, bias. In addition, the SDWG felt the multiple fishery-independent surveys available to this assessment had sufficient spatial coverage, such that inclusion of the fishery-dependent indices was not necessary, as might be the case for an assessment that lacked adequate fishery independent sampling. Based on these concerns, the SDWG recommended that the fishery dependent standardized indices of abundance not be used in the summer flounder assessment model.

The SARC 57 Review Panel concluded that Term of Reference 2 was met.

TOR 3. Review recent information on sex-specific growth and on sex ratios at age. If possible, determine if fish sex, size and age should be used in the assessment (completion of specific sub-task is contingent on analytical support from staff outside of the NEFSC.)

NEFSC SURVEY DATA

Growth

As noted above in the introductory GROWTH section, trends in growth by sex and age for all three NEFSC seasonal survey series follow comparable patterns. There are no trends in the mean lengths for ages 0-1, with a weak declining trend since the 1990s for ages 2 and older. Mean lengths of ages 3 and older show decreasing trends for both sexes. Von Bertalanffy growth curves estimated for five-year bins from 1976-2012 are tightly clustered through age 5 for females, with some divergence at older ages, with the most recent bin (2006-2012) indicating smaller predicted lengths at age than in previous years (Figure A16). The growth curves are more dispersed for males, and therefore for sexes combined, with the most recent 2006-2012 curve indicating smaller predicted lengths for older males and for all ages when sexes are combined (Figure A17).

Sex Ratio in NEFSC Survey Raw Sample Data

The NEFSC seasonal trawl survey raw sample data (not the stratified indices by sex and age, although they generally show similar patterns) were examined for trends in sex ratio by season and age, expressed as the proportion of females at age. The spring and fall series have sufficient data for the compilation beginning in 1976. The winter survey was conducted from 1992-2007.

In the winter survey, the proportion of females showed no trend for age 1 and the mean proportion was 49%. For ages 2 and 3, the proportion decreased from about 0.7-0.8 in the early 1990s to 0.4-0.6 in the mid-2000s. For ages 4 to 6, the proportion decreased from about 0.8-1.0 in the early 1990s to about 0.7 in the mid-2000s. For ages 7 and older that compose the 'plus group,' the proportion ranged from 0.8 to 1.0 over the series (Figures A159-A161).

In the spring survey, the proportion of females showed no trend for age 1 and the mean proportion was 41%. For ages 2 and 3, the proportion decreased from about 0.6-1.0 in the early 1990s to about 0.5 since 2000. For ages 4 and 5, the proportion decreased from a range of 0.8 to 1.0 in the early 1990s to about 0.5 in the mid-2000s. For age 6 the proportion ranged from 0.5 to 1.0 with no trend. For ages 7 and older that compose the 'plus group,' the proportion has been variable, but generally near 1.0 with no trend over the series (Figures A162-A164).

In the fall survey, the proportion of females shows no trend for age 0 and the mean proportion was 33%. For ages 1 and 2, the proportion decreased from about 0.5-0.6 in the 1980s to 0.4-0.5 by 2010-2011. The proportions at ages 3 to 5 strongly decreased from about 0.8 through the late 1990s to about 0.5 by 2010-2011. For ages 6 and older the proportions have been variable with no trend (Figures A165-A167).

Sex Ratio in NEFSC stratified mean indices

NEFSC stratified mean abundance indices (numbers per tow) were calculated for the winter (1992-2007), spring and fall (1976-2012) series. The spring and fall FSV HB Bigelow 2009-2012 indices were calibrated to FSV Albatross IV equivalents using calibration factors at length described under TOR2, above. The male and female indices generally follow similar trends over time (Figures A168-A169).

As in the raw sample data, the sex ratio in the NEFSC stratified indices has changed over the last decade, with generally decreasing proportions of females at ages 2 and older. In the winter indices, the proportion of females showed no trend for age 1 and the mean proportion was 46%. For ages 2, 3, and 4, the proportion has decreased from about 0.6-0.8 in the early 1990s to about 0.4-0.5 by 2007. For ages 5 and 6, the proportion has decreased from about 0.8-1.0 in the early 1990s to about 0.6-0.7 by 2007 (Figure A168). For ages 7 and older that compose the 'plus group,' the proportion has ranged from 0.8 to 1.0 over the series.

In the spring indices, the proportion of females has an increasing trend for age 1 from about 0.3 to 0.5, and the mean proportion was 40%. For ages 2, 3, and 4, the proportion has decreased from about 0.6-0.7 in the late 1970s to about 0.4-0.5 since 2000. For ages 5 and older, the indices during the 1980s-1990s are generally very small values (often < 0.001 fish per tow, and so round to 0 and appear 'missing' in the figures) and the proportion of females over the series is variable without a strong trend. Recently the proportion of females at ages 5 and older has ranged from 0.4-0.9 (Figure A170).

In the fall survey, the proportion of females shows no trend for age 0 and the mean proportion was 33%. For ages 1 and 2, the proportion has decreased from about 0.5-0.6 in the 1980s to 0.4-0.5 by 2010-2012. The proportions at ages 3 to 7 have strongly decreased from about 0.8 through the late 1990s to about 0.4-0.7 by 2010-2012 (Figure A171).

Variation in Growth by Sex, Time, and Area

Sullivan (2013 MS; WPA11) conducted a statistical analysis of the variations in length at age by sex, area and time using data collected from NEFSC survey catch of summer flounder (*Paralichthys dentatus*) over the years 1976 through 2010. A von Bertalanffy growth model was used to systematically assess the similarity of growth patterns between sexes, areas and time periods. Statistically significant differences in growth were found between sexes, between Northern and Southern regions (as split at the NEFSC statistical area associated with the Hudson Canyon off the continental margin of New York and New Jersey), and between early and late time periods (1900s and 2000s).

Sullivan (2013 MS) found there appear to be measurable (statistically significant) differences in the length-age relationship between sexes, areas and times. The three parameter von Bertalanffy model was used to systematically compare different data stratifications. Models that include stratification by sex appear to show the greatest level of significance, followed by area and time (Figures A172-A177). Sullivan concluded that once the appropriate stratification of the data is found age-length keys should be developed based on these stratifications alone and independently of the models. Statistical significance indicated that with the sample sizes available differences in model fit between strata are measurable. Sullivan (2013 MS) concluded that whether these differences result in statistically significant or biologically relevant differences in assessment model outputs will need further examination.

COMMERCIAL AND RECREATIONAL FISHERY DATA

Morson *et al.* (2013 MS; WPA13) conducted a data collection program beginning in 2010 with dual goals of 1) data collection and 2) an evaluation of the adequacy of summer flounder sex-at-age and sex-at-length keys developed from NMFS-NEFSC ocean trawl surveys in describing the sex ratio in recreational and commercial landings. The program continued until two full years of data were collected in each targeted region. Efforts were directed toward key ports in states from Massachusetts to North Carolina where summer flounder landings were high (Figures A178-A179). Sex and length data were collected from over 30,000 summer flounder landed in the commercial (CF) and recreational (RF) fisheries and approximately 20,000 of those fish were aged by the NMFS-NEFSC. Minimum sampling goals were exceeded in nearly all regions. The exception was in the DE/MD/VA/NC area where total samples fell well short of goals in the CF. The CF season in this region is short and already heavily sampled by other research programs so obtaining fish proved difficult, however it should be noted that summer flounder landings in NC/VA come from similar statistical areas as those fish landed in NJ.

For each visit to a commercial dock or packing house, scientists collected data haphazardly from up to 100 fish in each market category available from a given fishing trip. For each fish, total length was measured to the nearest centimeter and sex was determined. Summer flounder cannot be sexed using external characteristics. To avoid a reduction in market, a minimally invasive technique was employed for determining sex that reduced damage to the fish and preserved market integrity. A one-inch incision was made on the pigmented side of the fish in an area halfway between the anterior end of the anal fin and the center of the pectoral fin. Using forceps, the gonads were pulled out through this incision. Orange eggs of female fish and the white of testes tissue could be observed even if sampling did not occur during the spawning season. Minimally five scales were removed from all fish from an area just above the lateral line, anterior to the caudal peduncle. In addition, otoliths were taken from fish greater than 60 cm. To remove the otolith without compromising market value, the operculum was pried open and held back. A cut was made into the gill arches underneath the operculum and the gill arches were scraped away to expose the otic capsule. The tip of a sharp knife was used to open the otic capsule and expose the otolith inside. After removal with a pair of forceps, the operculum was laid back into its original position, leaving little or no evidence of the sampling procedure.

Sampling of summer flounder landed in the recreational fishery was conducted at participating docks and marinas from Massachusetts to Virginia. Scientists went to each port once per week to collect racks (filleted carcasses) of all summer flounder caught that day on all participating boats that were filleted. Boat captains and crew saved fish racks in a bin and when the scientist arrived at the dock they collected the racks and recorded the date and port landed. In addition, in order to increase the number of fish available for collection, freezers were placed at each port. Bags and waterproof tags were provided to the fishermen and were available near the freezers so that samples could be accurately labeled with relevant information. On days scientists were not present, participating boats were asked to deposit all fish racks from the day's catch in these tagged bags and place the bags in the freezers. Freezers were emptied when scientists arrived to collect fresh racks. To ensure a representative sample of summer flounder sex, length, and age, all fish caught on a fishing trip were sampled without regard to size. Total length (cm) was measured on all fish and sex was determined by macroscopic investigation of exposed gonad on filleted fish carcasses. Over ninety-nine percent of all fish collected had reproductive organs intact and readily visible to the naked eye. As the fish were already filleted, scales could not be collected. Otoliths were therefore collected on all fish by cutting through the skull. Fish were held on a hard surface, pigmented side up, head facing left, and a sharp knife was aligned along the preoperculum and rotated a few degrees so that the tip of the knife pointed slightly toward the head of the fish. A deep cut was made through the bones of the head at the anterior end of the otolith capsule, limiting damage to the otoliths inside. The fish was then picked up with both hands and bent along the incision to loosen and expose the otolith for removal using forceps.

To evaluate variability in growth, observed length-at-biological age data were fitted to a von Bertalanffy growth function by non-linear least squares regression. To examine differences in growth parameters, the von Bertalanffy model was fitted by least squares to pooled data and separately to examine differences between sex, and amongst regions and years. To identify spatial differences in growth rates, data were grouped into one of three regions: North, Central, and South. The estimates from the pooled fit were used to parameterize the constrained parameters in the competing growth models. Likelihood ratio tests (Kimura 1980) were used to determine if differences existed between von Bertalanffy parameter estimates between years, regions, and sexes for mean total length-at-age data. Models were developed to assess the following hypotheses 1) separate growth curves among years, regions and sexes; 2) separate growth curves with one growth parameter (Linf, t0, or k) equal; and 3) the alternative hypotheses of no differences in growth curves.

Differences in sex ratio between commercial/recreational landings and the NMFS-NEFSC ocean trawl survey were identified using a generalized linear model with a logit-link function and a binomial error distribution, commonly referred to as logistic regression. For all models, the probability of a fish being female was modeled as the response variable. In addition, to analyze spatial dependence in sex ratio within each fishery, an autologistic model was applied where the autocovariate at a given sampling location was calculated as the inverse distance-weighted average of the fraction of fish that were female at all other sampling locations (Augustin et al. 1996).

When comparing the von Bertalanffy growth model, Morson et al (2013 MS) found differences in growth rates between sexes and areas, with summer flounder north of Cape Hatteras showing different trends in growth than those to the south. Fish grew faster in the Central and North region than in the South region, but there was no significant difference in growth rates between the North and Central regions. Growth differences between areas is consistent with Kraus and Musick (2001) which found latitudinal variation in growth rates and concluded that evidence supported the existence of stocks north and south of Cape Hatteras, with the stock north of Cape Hatteras possibly composed of two distinct spawning aggregations, off New Jersey and Virginia-North Carolina.

That the recreational fishery (RF) lands more females at a given length than the commercial fishery (CF) or the NMFS-NEFSC trawl surveys (NF) is not surprising (Figure A180). Morson *et al.* (2012) found a similarly high fraction female on a more localized scale in the recreational fishery in New Jersey and offered two explanations for why female fish are more common in recreational landings when compared to ocean trawl surveys. First, recreational fishing gear may select for female fish. Lozan (1992) found that female dab flounder (*Pleuronectes limanda*) consumed 73% more food than males of the same size. Recreational fishing depends entirely on the willingness of a fish to attack bait on a line. If female summer flounder eat more and are more aggressive predators, then the RF would land a higher fraction of female fish at a given length than the fraction potentially available in the region. Alternatively, the sex ratio at a given length observed in the RF could be an accurate representation of the sex ratio of summer flounder in the region when and where the fish were landed. In this case, some explanation needs to be advanced for why the sex ratio would be so heavily skewed toward female fish at the location and time of the RF. The RF operates inshore from late spring to early fall. If fewer male fish migrate inshore in the spring, then fewer males would be available to a fishery that takes place primarily inshore during the summer months. In this case, trawl surveys or commercial fishing methods carried out offshore or during other periods of the year might not be appropriate for describing the sex ratio of landings in the RF.

When sex-at-age data are compared among the RF, CF, and NF, Morson *et al.* (2013MS) found it was immediately clear that a population-wide sex-at-age key developed from NF data would not be appropriate to describe sex-at-age in either the CF or the RF (Figures A181-A182). This makes intuitive sense because the size limits in both fisheries will automatically select larger fish at a given age and the faster growth rates of female summer flounder dictate that the sex ratio of these larger fish will be biased toward female. This is further supported when the NF database is sampled to mimic the size restrictions of the RF and CF. While the sex-at-age in the NF begins to resemble the sex-at-age in the RF and CF using this approach, statistically significant differences between sex-at-age in the NF and the landings still remain such that a sex-at-age key developed from NF data would not appropriately describe sex-at-age in either the CF or RF. One approach that could be considered for the CF would be to apply a sex-at-length key developed from NF data followed by a length-at-age key developed from CF data to arrive at an accurate measure of sex-at-age in the CF. However, such an approach would not be advisable in the RF given the disparity in sex-at-length when compared to NF data.

Morson *et al.* (2013 MS) concluded it was difficult to make a defensible recommendation for how often sex ratio data would need to be collected in either fishery with only two years of data to compare, but temporal variation in sex ratio of landings seems likely given that a significant difference was noted in the RF in back-to-back sampling years. Morson *et al.* (2013 MS) found that for both fisheries, the spatial variation in sex ratio was best described by statistical area instead of region, latitude, or a distance-weighted spatial autocovariate. This would suggest that spatial variation in sex ratio happens at fine scales and to most appropriately account for that variation, sex ratio data would need to be collected from all statistical areas where fish are typically landed. Furthermore, in the RF, a clear trend of increasing fraction female with decreasing distance to shore and decreasing latitude was identified. Clearly, male fish are almost entirely absent from the RF south of Long Island, while off the coast of southern New England, male fish are nearly as abundant as in the CF. In bays and estuaries the fraction female is higher than in any statistical area along the coast, even at the highest latitudes. This latitudinal/closeness to shore trend in summer flounder sex ratio was evident on a smaller scale in New Jersey as well (Morson *et al.* 2012). That the fraction male is nearly as high in the RF in the northern statistical areas as in the CF would suggest that hook-and-line fishing does not preferentially target females. This provides evidence for sex-specific movements accounting for differences in sex ratio in the summer flounder RF. Perhaps males only migrate inshore at the most northern latitudes where water temperatures are cooler.

In summary, Morson *et al.* (2013 MS) concluded that summer flounder sex-at-length and sex-at-age keys developed from NMFS-NEFSC ocean trawl data would not be appropriate for describing the sex ratio of recreational landings. They found, however, that sex-at-length of summer flounder landed in the commercial fishery was well described by data collected on the NMFS-NEFSC ocean trawl survey, and that the best approach could be to 1) apply a NMFS-NEFSC sex-at-length key to commercial landings length data, and then 2) apply a commercial landings length-at-age key to arrive at an accurate measure of sex-at-age in the commercial fishery. Variation in sex ratio in both the recreational and commercial fisheries was observed to occur at fine spatial scales and perhaps over short time periods. Morson *et al.* (2013 MS) further concluded that if a desire exists to accurately define sex ratio in either fishery with empirical data collection, this spatiotemporal variability might require a regular and spatially extensive sampling program in the future.

The SARC 57 Review Panel concluded that Term of Reference 3 was met.

TOR 4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series (integrating results from TOR-3), and estimate their uncertainty. Explore inclusion of multiple fleets in the model. Include both internal and historical retrospective analyses to allow a comparison with previous assessment results and previous projections.

2013 MODEL DEVELOPMENT

Background and Existing Model Updated through 2012

Fishing mortality rates and stock sizes were estimated using the Age Structured Assessment Program (ASAP) statistical catch at age model (Legault and Restrepo 1998, NFT 2012a, 2013a). ASAP is an age-structured model that uses forward computations assuming the separability of fishing mortality into year and age components to estimate population sizes given observed catches, catch-at-age, and indices of abundance. The separability assumption is partially relaxed by allowing for fleet-specific computations and by allowing the selectivity-at-age to change in blocks of time. Weights (emphasis factors) are input for different components of the objective function which allows for configurations ranging from relatively simple age-structured production models to fully parameterized statistical catch-at-age models. The objective function is the sum of the negative log-likelihood of the fit to various model components. Catch at age and survey at age compositions are generally modeled assuming a multinomial distribution, while most other model components are assumed to have lognormal error. Specifically, lognormal error distributions were assumed for the total catch in weight, research survey catch at age calibration indices, selectivity parameters, annual fishing mortality parameters, survey catchability parameters, estimated stock numbers at age, and Beverton-Holt stock-recruitment parameters, when estimated. Recruitment deviations are also assumed to follow a lognormal distribution, with annual deviations estimated as a bounded vector to force them to sum to zero (this centers the predictions on the expected stock-recruitment relationship).

In the summer flounder ASAP model an age-specific instantaneous natural mortality rate providing an average M = 0.25 was assumed for all years. Seasonal survey indices and all survey recruitment (age-0) indices were compared to population numbers of the same age at the appropriate season of the same year. A multinomial distribution was assumed for fishery catch at age and for survey catch at age when required. A number of additional initial model settings including specification of the likelihood component emphasis factors (weights or lambdas, L), size of deviation factors expressed as standard deviations (i.e., ln-scale CV), and penalty functions for extreme fishing mortality estimates. These were set at consensus values by the 2013 SDWG after multiple sensitivity runs to evaluate a range of inputs.

The 2013 SAW 57 model development process started with the 2012 updated assessment model run with data through 2011 (Terceiro 2012), which differed from the previous 2008 SAW 47 benchmark assessment ASAP model (NEFSC 2008a) only in the setting of the fleet Effective Sample Size (ESS) and two stock-recruitment (S-R) function priors which were set to zero. The 2008 SAW 47 assessment process had considered models with one, two variations of two fleet, four, and six fishery fleet configurations.

Differences between the two and four fleet models were relatively minor, but convergence problems were encountered for some configurations of the six fleet model. The 2008 and 2012 models included two fleets, one for fishery landings and one for fishery discards. The 2008 and 2012 models estimated fishery landings selectivity using a single logistic two parameter function (forcing asymptotic or 'flat-topped' selection) and fishery discards using a double logistic four parameter function (allowing for domed selection; Fishery Logistic Double Logistic; model acronym FLDL). Two fishery selectivity time blocks were specified for both landings and discards: 1982-1994 and 1995 to the terminal year, with the break roughly corresponding to the full implementation of major management regulations and a major change in the commercial landings reporting system. The fishery selectivities were set with L = 1, in effect specifying a prior on the initial values.

Other 2008 SAW 47 and 2012 model details included 1) total fishery catch L set at 10, to mimic the setting of the 2008 SAW 47 Stock Synthesis model that was also under consideration at the time, 2) landings and discards CV = 0.1, 3) landings fleet age composition ESS = 153 and discards fleet age composition ESS = 100, 4) fishing mortality (F) and stock size (N) in year 1 CV = 0.9 and L = 0.1, and 5) S-R function and population scaler Ls = 0, effectively 'turning off' the influence of the S-R function in the model by setting those likelihood components to zero.

Survey indices in the 2008 and 2012 ASAP models were configured as in an ADAPT VPA, with each survey index-at-age (IAA) entered as an individual time series, with a catchability coefficient (q) is estimated for each index-at-age. As such, there are no survey 'age-compositions,' and no ESS is set or estimated. Table A82 provides a summary of the initial steps in building the 2013 model configuration and settings, while Table A83 provides summary results. Important changes between modeling steps are highlighted with bold text.

Model F57-IAA-IND47-FLDL is the first of the 2013 SAW 57 models, with the same configuration and settings as the 2012 model (which had data through 2011) and data updated through 2012. Surveys are configured as independent indices at age (IAA), the index set included in the model is the same as in the 2008 and 2012 assessments (IND47), and fishery selection is modeled as a single logistic for landings and double logistic for discards (FLDL). As a starting point, the fishery ESS were set at 100 for both fleets. Model F57-IAA-IND47-FLDL provides estimates appropriate to compare with the old (existing) reference points, which are FMSY proxy = F35% = 0.310 and SSBMSY proxy = SSBMSY35% = 60,094 mt (TOR 6a). This model indicates that F in 2012 = 0.180 and SSB in 2012 = 60,905 mt, so the stock was not overfished and overfishing was not occurring (see also TOR 6a). Summary results from the 2008 and 2012 assessments are compared with those from run F57-IAA-IND47-FLDL in Figures A183-A184.

The subsequent model building occurred in two 'phases.' In the first, new (revised) maturity and commercial discard estimates were added to the model, several structural changes were made to fishery selectivity and survey configurations, and several new survey series were added to the model. The end product of phase 1 was the BASE run for subsequent modification. In phase 2, the BASE run was changed to provide improved statistical diagnostics through several 'tuning' steps and a few input data modifications.

Model Building Phase 1

Each model configuration change (step) in phase 1 generally builds on the previous step, unless noted. Step 1 in phase 1 was to revise the maturity schedule with the 3 year moving window, no resting females estimates (model F57-IAA-IND47-FLDL-**MAT3NOT**) described earlier in the MATURITY section. These new maturity data resulted in a small decrease (4-5%) in the most recent estimates of SSB. Next, the revised commercial fishery discard estimates were added to the model (model F57-IAA-IND47-FLDL-MAT3NOT-**NEWDISC**); this change also resulted in relatively small annual changes in the SSB estimates in both directions over the time series, and about 10% increases in the most recent estimates of fishing mortality (Tables A82-A83, Figures A185-A186).

The next two steps changed the model structure in two major ways to follow current standard practice for NEFSC statistical catch at age models. First, the fishery selectivity models for both landings and discards were changed to 'estimates-at-age' (Fishery selectivity at AGE; model acronym FAGE), wherein at least one age is fixed with selection (S) = 1 and other selectivities at age are estimated relative to the reference age or ages. The references ages were age 3 (model age 4) in the first landings time block (1982-1994) and age 4 in the second time block (1995-2012), and ages 1 and 2 in the two discard time blocks. These selectivities were set with L = 1, in effect specifying a prior on the initial values. The changes in the fishery selection models resulted in a moderate dome for the oldest two landed ages in the second time block and a stronger dome for the discards, and corresponding 10-20% decreases in F and similar magnitude increases in SSB (model F57-IAA-IND47-**FAGE**-MAT3NOT-NEWDISC; Tables A82-A83, Figures A185-A186).

In the second structural change, the survey index configuration was modified from individual indices-at-age with separate qs (IAA) to aggregate indices (in numbers) with associated age compositions modeled as proportions that follow the multinomial distribution (MULTI). In this configuration, each aggregate index has a specified input CV and the associated age composition has the 'estimates-at-age' selection pattern either estimated (for surveys with several ages) or fixed = 1 (for single age, young-of-the-year [YOY] age 0 surveys). Survey selectivities were set L = 0 and so were not a component of the objective function. The changes in survey index configuration resulted in 10-20% increases in F and similar magnitude decreases in SSB (model F57-**MULTI**-IND47-FAGE-MAT3NOT-NEWDISC; Tables A82-A83, Figures A185-A186).

The last step in phase 1 was to add several new survey time series to the model: the VIMS ChesMMAP trawl, VIMS NEAMAP spring and fall trawl, the URIGSO trawl, and the NY trawl. The addition of these new surveys resulted in about a 10% decrease in F and comparable increase in SSB in the most recent years (model F57-MULTI-**ALLSV**-FAGE-MAT3NOT-NEWDISC; Tables A82-A83, Figures A185-A186).

Model Building Phase 2

As in phase 1, each change in phase 2 generally builds on the previous step, unless noted, and changes in model setting and results are summarized in Tables A84-A87. Step 1 in phase 2 was to remove the prior (L=1 to L=0) for F and N in year 1 of the model, removing these parameters from the objective function, creating the F57_BASE_1 model which estimated slightly reduced recruitment (R; ~3%) and F (~5-10%) and increased SSB (~7%) in the first selectivity time block.

In step 2, the DEDFW trawl survey index was shortened to 2003 and later years, based on information provided during the SDWG meeting the entire series was not comparable due to an un-calibrated vessel change. This change increased recent SSB (~10-15%) and R (~5-10%) and decreased recent F estimates (~10%; F57_BASE_2).

In F57_BASE_3, the total fishery catch lambda was changed from 10 to 1 (L=1), resulting in a re-scaling of the objective function and a minor decrease in recent SSB.

In F57_BASE_4, the NEFSC MARMAP and ECOMON larval survey indices of SSB, which were submitted for consideration just before the SDWG meeting, were included. These new surveys resulted in a minor decrease in recent SSB.

The first model 'tuning' step was undertaken in run F57_BASE_5. The input aggregate survey CVs, generally the means of the empirical time series averages, are intended to characterize the sampling error of those series. However, it is recognized that additional process (model) error may be present in the survey indices that are not reflected in the input CVs, as diagnosed by the distance of the Root Mean Square Error (RMSE) of each series from 1 (see the ASAP User Manual for ASAP3; NFT 2012b). Examination of the model diagnostics for the survey indices resulted in adjustments to the survey CVs, thereby allowing for larger deviations to bring their respective RMSEs within or close to the expected confidence intervals (CI) for the number of observations. Generally, input CVs of 0.3 (e.g., the NEFSC surveys) were increased to 0.4, input CVs of 0.4 (the state agency surveys) were increased to 0.6, and input CVs of 0.6 (the YOY indices) were increased to 0.9., to account for additional process error in run F57_BASE_5. This changed increased recent F by ~10-15% and decreased recent SSB by a comparable degree, relative to run F57_BASE_4.

Inspection of the F57_BASE_5 diagnostics revealed that a few of the survey RMSE were still outside their expected CIs, and so in a second 'tuning' step the CVs for those series were increased by an additional 0.1, creating run F57_BASE_6. This changed increased recent F by ~10-15% and decreased recent SSB by a comparable degree, relative to run F57_BASE_5.

Run F57_BASE_7 was configured by setting the fishery selectivity lambdas to L = 0, effectively removing the prior and omitting them from the objective function. This change allowed for a more extreme domed selection pattern for both landings and discards in both time blocks, and resulted in slightly lower F and slightly higher SSB in both periods. However, this configuration resulted in a more severe retrospective pattern (increasing the total error range for F by about 10%).

Run F57_BASE_8 retained the fishery selectivity Ls = 0 of run 7, but fixed the fishery landings selection at 1 for ages 3 and older in the first time block and ages 4 and older in the second time block. Forcing flat-topped landings selectivity in this way increased F by ~50-60% early in the time series and by ~15-30% late in the time series, with corresponding but smaller decreases in SSB.

A pattern in fishery age composition residuals for 2008 and later years had persisted through all the BASE run configurations. Run F57_BASE_9 build upon run 6, adding a third fishery selection block for 2008 and later years, with the fishery selection Ls = 1 and S = 1 for age 4 for the landings and age 2 for discards. This change resolved the fishery age composition residual pattern, and the third selection block was retained in subsequent runs.

The NCDMF member of the SDWG expressed a new concern that the NCDMF Pamlico Sound trawl survey YOY index might include a significant contribution of fish from the South Atlantic Bight stock of summer flounder, and so might not provide a valid index of recruitment. The NCDMF YOY survey was therefore removed from run 9, creating run F57_BASE_10, which provided slightly reduced estimates of recruitment (age 0) for the most recent years. With run F57_BASE_10, the modeling of the landings with a domed selectivity pattern was accepted, and it became evident that the average F for all catch also exhibited a domed pattern, such that the expression of 'fully-recruited' F was changed from ages 3-7+ to the F at S = 1 for age 4. Thus, the change in F from run 9 to 10 reflects this reporting change that is carried forward in all subsequent runs.

Inspection of the precision of all the estimated parameters of run F57_BASE_10 revealed that several of the survey selection parameters at age were poorly estimated (either constrained at the bound or with large standard error; although note the survey selectivities are not part of the objective function as L = 0). In run F57_BASE_11, constrained selection parameters at 1 were fixed at S = 1, while poorly estimated selection parameters at age (typically for the youngest or oldest ages in state agency surveys) were fixed near the value of the nearest acceptably estimated age (generally with parameter CV < 0.6). These changes resulted in a 'flatter' selection pattern in the both the landings and discards, higher recent F (as noted above now reported for age 4) and decreased recent SSB (~10%).

Maunder (2013c MS; WPA17) conducted a likelihood profile of run F57_BASE_10 over the population scaling parameter SSB0 (unexploited SSB), and suggested that the SDWG consider down-weighting the fishery and survey age composition data relative to the catch weight and aggregate survey indices. The SDWG therefore applied the Francis (2011) age composition weighting adjustments (calculated internally in ASAP; NFT 2012b) in following this recommendation, creating run F57_BASE_12. In this run, the fishery landings age composition ESS was reduced from 100 to 55, the fishery discards age composition ESS was reduced from 100 to 30, and the various survey age composition ESSs were adjusted from the 'default' 10 to values ranging 53 for the VIMS NEAMAP fall survey to 4 for the MADMF spring survey. This last model 'tuning' step reduced recent F by about 5-10%, reduced recent R by about 5-10%, and reduced recent SSB by about 2% (Tables A86-A87).

The estimation results for F57_BASE runs 1, 2, 6, 9, and 12, between which the largest 'phase 2' changes in estimates occurred, are summarized in Figures A187-A188. F57_BASE_1 is the model that includes all of the new maturity, commercial discards, and survey data, as well as the two major model structural changes to fishery selection-at-age and multinomial survey indices. F57_BASE_2 drops the early part of the DEDFW trawl surveys (uncalibrated vessel change), which exhibited large negative residuals for all ages during early model development. F57_BASE_6 incorporates the two steps of survey CV 'tuning' to better characterize suspected process (model) error. F57_BASE_9 incorporates the third fishery selectivity block for years 2008 and later.

Final run F57_BASE_12 incorporates the Francis (2011) adjustments to fishery and survey age composition ESS. As calibration indices, final run F57_BASE_12 uses a) indices of stock abundance including age compositions from the NEFSC winter, spring, and fall, Massachusetts spring and fall, Rhode Island fall and monthly fixed, Connecticut spring and fall, Delaware, New York, New Jersey, VIMS ChesMMAP, and VIMS NEAMAP spring and fall trawl surveys, b) aggregate indices of stock abundance from the URI GSO trawl survey and NEFSC MARMAP and ECOMON larval surveys, and c) stand-alone recruitment indices (age 0; Young-Of-the-Year, YOY) from surveys conducted by the states of Massachusetts, Delaware, Maryland, and Virginia.

Final 2013 SAW 57 Model: Run F57_BASE_12

Model Fit Diagnostics

Figure A189 shows the distribution of objective function components contribution to total likelihood. Figure A190 shows the RMSE for the aggregate survey indices, with all close to or inside the 95% confidence for RMSE except for the MADMF YOY index, which was still well outside the confidence interval even with the input CV increased to 1.0. The aggregate landings and discards catch and age composition fit diagnostics and residuals are presented in Figures A191-A199. The addition of the third selectivity block for 2008 and later largely eliminated a residual pattern in the fishery age composition residuals. The large discards age composition residual in 1995 could not be resolved as it is due to a large and imprecise discard estimate. The aggregate survey index and age composition fit diagnostics and residuals are presented in Figures A200-A237. Patterns in the aggregate survey index residuals and age compositions (e.g., the RIDFW fall [RIF] and monthly [RIX] indices Figures A210-A213; the URIGSO index Figure A235) were addressed by adjusting the SV CV and ESS where applicable as noted above, rather than by removing the surveys from the model.

Likelihood Profile over assumptions for Natural Mortality (M)

Run F57_BASE_12 (age-varying M from 0.26 to 0.24 with a mean of 0.25) was also run with M values from 0.1 to 0.4 (constant at all ages over times) to help judge which assumption for M fit best, given the diagnostic of total minimum log-likelihood (value of the total objective function). Figure A238 indicates equally good model fits for M values ranging from 0.20 to 0.30. Results for sensitivity runs with constant M = 0.2 and constant M = 0.3, bracketing run F57_BASE_12, are presented in Figures A239-A240.

Retrospective Analyses

An 'internal' retrospective analysis for the F57_BASE_12 was conducted to examine the stability of the model estimates as data were removed from the end of the time series. Retrospective runs were made for terminal years back to 2005. The summer flounder stock assessment has historically exhibited a retrospective pattern of underestimation of F and overestimation of SSB; the causes of this previous pattern have not been determined. In the current assessment model, however, no persistent retrospective patterns are evident. Over the last 7 years, the annual retrospective change in fishing mortality has ranged from +22% in 2006 to -5% in 2009 (Figure A241), the annual retrospective change in SSB has ranged from -2% in 2011 to -21% 2006 (Figure A242), and the annual retrospective change in recruitment has ranged from -45 in 2005 to +33% in 2009 (Figure A243).

The 2008 SAW 47 benchmark assessment, the 2009-2012 assessment updates, and final model F57_BASE_12 (2013 SAW 57) results are compared in Figures A244-A246. The ASAP model has been used in the assessment during the 2008-2013 period, but due to changes in fishery selectivity estimation, 'fully-recruited' F is reported for ages 3-7+ in the 2008-2012 assessments, but only for 'peak' age 4 (S=1) in the 2013 assessment. A long-term retrospective look over all assessments dating back to 1990 is provided in Figure A247. It should be noted that the ADAPT VPA model was used for the 1990-2007 assessments, and fully recruited F was reported for age 2-7+. Also, the assumed value for natural mortality (M) changed from 0.2 for all ages in the 1990-2007 assessments to an average value of 0.25 in the 2008-2013 assessments. Despite these changes in model assumptions, configurations, and estimation procedures, the 'historical' retrospectives indicate that general trends of fishing mortality, stock biomass, and recruitment have been consistent since the 1990s assessments.

2013 FISHING MORTALITY RATE AND STOCK SIZE ESTIMATES

In the landings, the selection of age 1 fish decreased from about 0.4 during the first time block of selectivity estimation (1982-1994) to about 0.1 or less during the second and third blocks, 1995-2007 and 2008-2012. The selection of age 2 fish decreased from 1.0 during the first block to about 0.6 during the second block to about 0.2 during the third block. The selection of age 3 fish decreased from 1.0 during the first and second blocks to about 0.6 during the third selection block, 2007-2012. The selection of age 4-6 fish increased from about 0.7 during the first block to 1.0 during the second and third blocks. The selection of age 7+ fish declined from about 0.9 in the first block to about 0.7 in the second and third blocks (Table A87). The decreases in landings selection at ages 1-3 are in line with expectations given changes in commercial and recreational fishery minimum size regulations.

In the discards, the selection of age 0 fish was about 0.1 for all three selectivity time blocks. The selection of age 1 fish decreased from 1.0 during the first block to 0.5-0.6 during the second and third blocks. The selection of age 2 fish increased from about 0.2 during the first block to 1.0 during the second and third blocks. The selection of age 3 fish increased from about 0.1 during the first block to about 0.7 in the second block and to about 0.9 in the third block. The selection of age 4 fish increased from about 0.1 during the first block to about 0.5 in the second block and to about 0.8 in the third block. The selection of age 5-7+ fish increased from about 0.1 during the first block to 0.5-0.6 during the second and third blocks (Table A87). These changes in discards selection are in line with expectations given changes in commercial and recreational fishery regulations, as fish at ages 2 and older became more frequently discarded due to increasing size limits in the recreational fishery and more frequent fishery closures and restrictive trip limits in both commercial and recreational fisheries.

The overall selection pattern has a domed shaped pattern, with the peak in selection (S=1.0) in the third fishery selectivity block occurring for age 4 (model age 5). For this reason, summer flounder are currently considered to be fully recruited to the fisheries at age 4, and fully recruited fishing mortality for comparison with reference points is expressed as the fishing mortality at age 4 (‘full’ F, ‘peak’ F, ‘apical’ F, where selectivity = 1.0).

Summary model results are provided in Table A88, and population number and fishing mortality estimates at age are provided in Tables A89-A90. Fishing mortality on the fully selected age 4 fish ranged between 0.790 and 1.745 during 1982-1996. The fishing mortality rate has decreased from 0.849 in 1997 to 0.285 in 2012 (Figure A248). There is a 90% probability that the fishing mortality rate in 2012 was between 0.213 and 0.343 (Figure A249). Spawning stock biomass (SSB) decreased from 24,300 mt in 1982 to 5,521 mt in 1989, and then increased to a peak of 53,156 mt by 2010. SSB was 51,238 mt in 2012, about 82% of the new reference point SSBMSY proxy = SSB35% = 62,394 mt (Figure A250-A251). There is a 90% probability that SSB in 2012 was between 45,781 and 61,297 mt (Figure A252). The average recruitment from 1982 to 2012 is 43 million fish at age 0. The 1982 and 1983 year classes are the largest in the assessment time series, at 62 and 76 million fish; the 1988 year class is the smallest at only 10 million fish. The 2012 year class is currently estimated to be about 37 million fish (Figures A250-A251).

The SARC 57 Review Panel concluded that Term of Reference 4 was met.

TOR 5. State the existing stock status definitions for “overfished” and “overfishing”. Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY} and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the “new” (i.e., updated, redefined, or alternative) BRPs.

BIOLOGICAL REFERENCE POINTS (BRPs)

Background

The calculation of biological reference points for summer flounder based on yield per recruit analysis using the Thompson and Bell (1934) model was first detailed in the 1990 SAW 11 assessment (NEFC 1990). The 1990 analysis estimated that Fmax = 0.230. In the 1997 SAW 25 assessment (NEFSC 1997) an updated yield per recruit analysis reflecting the fishery selection pattern and mean weights at age for 1995-1996 estimated that Fmax = 0.240. The Overfishing Definition Review Panel (Applegate et al. 1998) recommended that the MAFMC base MSY proxy reference points on yield per recruit analysis and this recommendation was adopted in formulating the FMP Amendment 12 Overfishing Definition (MAFMC 1999). These reference points were based on the 1999 assessment (Terceiro 1999) and followed what would later be described as the ‘non-parametric approach’ (i.e., biomass reference points calculated as the product of biomass per recruit and a reference period recruitment level; NEFSC 2002b). The analysis in the Terceiro (1999) assessment, reflecting fishery selection and mean weights at age for 1997-1998, indicated that Fthreshold = Ftarget= Fmax = 0.263, yield per recruit (Y/R) at Fmax was 0.552 kg/recruit, and January 1 Total Stock Biomass per recruit (TSB/R) at Fmax was 2.813 kg/recruit. The median number of summer flounder recruits estimated from the 1999 assessment for 1982-1998 was 37.8 million age-0 fish. Based on this median recruitment level, maximum sustainable yield (Ymax as a proxy for MSY) was estimated to be 20,897 mt (46.070 million lbs) at a Total Stock Biomass (TSBmax as a proxy for BMSY) of 106,444 mt (234.669 million lbs). The biomass threshold, one-half TSBmax as a proxy for one-half BMSY, was therefore estimated to be 53,222 mt (117.334 million lbs). The Terceiro (1999) reference points were retained in the 2000 SAW 31 assessment (NEFSC 2000) because of the stability of the input data and resulting biological reference point estimates.

The MAFMC SSC conducted a peer review of the summer flounder Overfishing Definition in concert with the 2001 assessment (MAFMC 2001a, b). The 2001 SSC reviewed six analyses estimating biological reference points for summer flounder that were conducted by members of the Summer Flounder Biological Reference Point Working Group. The 2001 SSC decided that although the new analyses conducted by the Working Group had resulted in a wide range of estimates, they did not provide a reliable alternative set of reference points for summer flounder. The 2001 SSC therefore recommended that Ftarget remain at the Terceiro (1999) estimate of Fmax = 0.263 because a better estimate had not been established by any of the new analyses. The 2001 SSC also reviewed the biomass target (BMSY) and threshold (one-half BMSY) components of the Overfishing Definition and concluded that the new analyses did not justify an alternative estimate of the BMSY proxy. The 2001 SSC endorsed the recommendations of the 2000 SAW 31 which stated that 'The use of Fmax as a proxy for FMSY should be reconsidered as more information on the dynamics of growth in relation to biomass and the shape of the stock recruitment function become available' (NEFSC 2000). The 2001 SSC agreed that additional years of stock and recruitment data should be collected and encouraged further model development, including model evaluation through simulation studies. They also encouraged the evaluation of alternative proxies for biological reference points that might be more appropriate for an early maturing species like summer flounder and the development and evaluation of management strategies for fisheries where BMSY is unknown. The 2001 SSC indicated that as the stock size increases, population dynamic processes that could reflect density dependent mechanisms should be more closely monitored and corresponding analyses should be expanded, i.e., rates of size and age, maturity, fecundity, and egg viability should be closely monitored as potential indicators of compensation at higher stock sizes. Finally, the 2001 SSC recommended that potential environmental influences on recruitment, including oceanographic changes and predation mortality, should be reevaluated as additional recruitment data become available. As a result of the 2001 SSC peer review (MAFMC 2001a) the Terceiro (1999) reference points were retained in the 2001 stock assessment (MAFMC 2001b). In the review of the 2002 stock assessment (NEFSC 2002a), SAW 35 concluded that revision of the reference points was not warranted at that time due to the continuing stability of the input data and resulting reference point estimates. The Terceiro (1999) reference points were subsequently retained in the 2003 (Terceiro 2003a) assessment.

The biological reference points for summer flounder were next peer-reviewed by the 2005 SAW 41, using fishery data through 2004 and research survey data through 2004/2005 (NEFSC 2005). The SAW 41 Panel noted that the Beverton-Holt (Beverton and Holt, 1957; Mace and Doonan 1988; BH) model fit the observed stock-recruitment data well, and provided reference points comparable to those derived from a non-parametric (yield and biomass per recruit) approach. The SAW 41 Panel noted, however, that the quantity of observed stock-recruitment data was limited (22 years), and the data during the early part of the time series, when the SSB was at the lowest observed levels, indicated a level of recruitment near the estimated Rmax, and exerted a high degree of leverage on the estimation of the model parameters. This leverage resulted in a high value (0.984) for the calculated steepness (h) of the BH curve, outside of the $\pm$ one standard error interval of the estimate for Pleuronectid flatfish (0.8 $\pm$ 0.1) indicated by Myers et al. (1999). The BH model results suggested that summer flounder SSB could fall to very low levels (<2,000 mt) and still produce recruitment near that produced at SSBMSY. The SAW 41 Panel concluded a) that this result might not be reasonable for the long term, given the recent stock-recruitment history of the stock (i.e., production of a very poor year class in 1988), b) the BH model estimated parameters might prove to be sensitive to subsequent additional years of S-R data, especially if they accumulated at higher levels of SSB and recruitment in the near term, and c) the BH model fit might also be sensitive to the magnitude of recently estimated spawning stock and recruitment, given the recent retrospective pattern of overestimation of stock size evident in the assessment. Given these concerns, the SAW 41 Panel advised that the BH model estimates were not suitable for use as biological reference points for summer flounder, and recommended continued use of reference points developed using the non-parametric model approach. FMP biological reference points from the 2005 assessment were Fmax = FMSY = 0.276, Ymax = MSY = 19,072 mt (42.047 million lbs), TSBmax = BMSY = 92,645 mt (204.247 million lbs), and biomass threshold of 0.5*TSBmax = 46,323 mt (102.125 million lbs; NEFSC 2005).

The biological reference points for summer flounder were peer-reviewed again in 2006 by the National Marine Fisheries Service (NMFS) Office of Science and Technology (S&T) (Methot 2006). The 2006 S&T Peer Review recommended using SSB, rather than TSB as in previous assessments, as the metric for the biomass reference point proxy. The product of the mean recruitment (37.0 million fish) and Y/R at Fmax was 21,444 mt = 47.276 million lbs (as the proxy for MSY); the product of the mean recruitment and SSB/R at Fmax was 89,411 mt = 197.118 million lbs (as the proxy for BMSY; Terceiro 2006a, b). The 2006 S&T Peer Review Panel (Methot 2006) recommended adoption of these biological reference points from the non-parametric approach for summer flounder, advising:

"The low level of recruitment observed in 2005 is essentially the same as the low 1988 recruitment, so it is within the range of recruitment fluctuation used in calculating the expected time to rebuild this stock. The Panel finds that the most representative approach to calculating BRPs and rebuilding rates would be to use the entire set of recruitments from 1982-2005. The average, not median, of these recruitments should be used for calculation of biological reference points because much of the stock's accumulated biomass comes from the larger recruitments. Random draws from this set of recruitments would provide a probability distribution of rebuilding rates that is consistent with the occasional occurrence of small recruitments (1988 and 2005) and large recruitments (1982-1987). There is no documented and obvious reason why recruitments were higher during 1982-1987. If such recruitment levels become more common as the stock rebuilds, then the stock may rebuild to an even higher level than is currently targeted. If such recruitment levels do not occur during the next few years of the rebuilding, then the rebuilding target may be not be achieved by the target time to rebuild. More precise forecasts than this are not feasible."

The two biological reference point estimation approaches previously used in the 2005 SAW 41 (NEFSC 2005) and 2006 S&T Peer Review (Terceiro 2006b) assessments were again applied in the 2008 SAW 47 benchmark assessment work (NEFSC 2008). Objective application of either approach is often compromised by lack of sufficient observation on stock and recruitment over a range of biomass to provide suitable contrast. Thus, it is often necessary to extrapolate beyond the range of observation and to infer the shape of the stock-recruit relationship from limited and variable observations (NEFSC 2002b). The 2001 MAFMC SSC review of summer flounder reference points also noted this concern (MAFMC 2001a).

The non-parametric approach was to evaluate various statistical moments (mean, variance, percentiles) of the observed series of recruitment data and apply the estimated spawning stock biomass and yield per recruit associated with common F reference points to derive the implied spawning stock biomass and equilibrium total yield (landings plus discards). The biomass and yield per recruit models were fit using the NOAA Fisheries Toolbox (NFT) YPR software (NFT 2013b). The full time series of recruitment during

1982-2007 as estimated in the 2008 SAW47 assessment was used in the yield and spawning stock biomass calculations at fishing mortality reference points, as per the 2006 S&T Peer Review Panel recommendation. The non-parametric approach assumes that compensatory mechanisms such as impaired growth, maturity, or recruit survival are negligible over the range of biomass considered (NEFSC 2002b). Once the Fmax reference point (i.e., the Fmax proxy for FMSY) was determined, a long-term (100 year) stochastic projection of stock sizes and catches was done to provide better consistency between the estimated medians of the BRP calculations and shorter-term (e.g., 1-5 year) projections (Legault 2008).

The parametric approach used fitted parametric stock-recruitment models along with yield and spawning biomass per recruit information to calculate MSY-based reference points following the procedure of Sissenwine and Shepherd (1987). Stock-recruitment models were fit using the NFT SRFIT version 6 software (NFT 2008). Since a wide range of models (Beverton-Holt [BH] and Ricker [RK] models, incorporating autoregressive error, and Bayesian priors for various parameters) had been tested in the 2005 SAW 41 work, the 2008 SAW47 parametric model exercise was limited to the simple Beverton-Holt and Ricker models (Beverton and Holt 1957, Mace and Doonan 1988, Ricker 1954).

Old (Existing) Reference Points: 2008 SAW 47 Biological Reference Points (BRPs)

For the 2008 SAW 47 assessment, the ASAP model provided the basis for the 2008 biological reference points and stock status. Average values of mean weights at age in the catch and stock, maturity schedule, and fishery selection pattern for the period 2005-2007 were used as input for ages 0-7+ for BRP calculations. In previous assessments (NEFSC 2005 and earlier) for older aged fish (ages 8-15) with very limited or missing samples, Gompertz functions based on younger ages were used to estimate mean weights for the older ages in the BRP calculations. However, the practice of extending the age structure to age 15 and use of Gompertz weights for the older ages resulted in inconsistency between the BRP biomass estimates based on long-term stochastic projections and shorter-term (e.g., 1-5 year) projections used for Total Allowable Landings (TAL) calculations (NEFSC 2002b, Legault 2008). Therefore, to increase consistency between these two types of projections, the age range of the BRP and projection calculations was set at 0-7+, with 8 additional ages (to age 15) included in the plus group calculation of yield and spawning biomass per recruit. The mean weight at age for the plus group (ages 7+) was updated for the 2008 SAW47 assessment in a new way, by using a weighted average of mean weights for ages 7-15 (observed catch weights for ages 7-10; calculated weights for ages 11-15 as estimated from observed ages 0-10) based on the relative proportions at age given a 2007 total mortality rate of 0.55 (mean M = 0.25 + 2007 F = 0.30; this value is coincidently consistent with the F35% proxy for FMSY). The combined effects of the new assumption for M and the modeling of landings and discards as distinct fleets (which resulted in a slightly domed-shaped combined fishery selectivity pattern) resulted in higher estimates of F reference points, lower estimates of MSY, lower estimates of SSB reference points, and improved stock status with respect to both the F and SSB reference points, as compared to the S&T 2006 assessment.

The reference points estimated from the parametric approach were suspect because the Beverton-Holt function steepness (h) parameters were always very near 1.0. Therefore Fmax, F40%, and F35% (and their corresponding biomass reference points) from the non-parametric approach were considered as candidate proxies for FMSY and BMSY. Fmax had been used in previous assessments as the proxy for FMSY. The estimate of Fmax using mean M = 0.25 and updated fishery selectivity and mean weights at age was relatively high (0.558) and the YPR to F relationship did not indicate a well defined peak. As a result, little gain in YPR (<5%) was realized at fishing mortality rates higher than F35% = 0.310. However, the corresponding decline in SSBR between F35% = 0.310 (~1.48 kg/r) and Fmax = 0.558 (~0.93 kg/r) was about 37%. The 2008 SAW47 concluded that F40% = 0.254 and F35% = 0.310 were candidate proxies that provided sufficient YPR (F40% YPR = 92% of Fmax YPR; F35% YPR = 97% of Fmax YPR) to allow for productive fisheries while also providing for substantial SSBR (F40% SSBR = 176% of Fmax SSBR; F35% SSBR = 155% of Fmax SSBR) to buffer against short-term declines in recruitment. Recommended proxies for FMSY and SSBMSY were F35% = 0.310 and the associated MSY (13,122 mt = 28.929 million lbs) and SSBMSY (60,074 mt = 132.440 million lbs) estimates from long-term stochastic projections. F40% = 0.254 was recommended as a fishing mortality rate target for management. These 2008 SAW47 BRPs were subsequently adopted by the NMFS and MAFMC in the 2009 fishery regulation specification process, and were retained in the 2009-2012 updated assessments to evaluate stock status (Terceiro 2009, 2010, 2011, 2012).

New (Updated) 2013 SAW 57 Reference Points

In developing recommendations for biological reference points, the SDWG reviewed recent work on the subject. Shertzer and Conn (2012) conducted analyses that tested relationships between steepness and two life-history parameters linked to longevity (M and maturity) and found that in neither case was steepness significantly related to the life-history parameter. In Maunder (2012) and Maunder (2013b MS; WPA14) steepness parameters were examined for summer flounder using a Stock Synthesis model and information from the 2008 SAW 47 assessment, and it was proposed that a conservative 0.8 value of steepness suggests a maximum SPRMSY = 30% target proxy and accordingly a lower SPRMSY/SPR0 threshold proxy than the existing F35% proxy would be appropriate. Rothschild at el. (2012) conducted a simulation study of summer flounder biological reference points and also concluded that an SPR proxy less than the existing summer flounder reference points better corresponded to MSY and was appropriate. Mangel et al. (2013) examined fixing steepness and life history parameters for both production and age-structured models and concluded that priors could be used to estimate the S-R function if needed, but that if steepness was 1, the use of other proxies was appropriate. The 2013 SDWG used the NFT programs ASAP (NFT 2013a), YPR (NFT 2013b), and AGEPRO (NFT 2013c) to estimate parametric and non-parametric reference points for summer flounder. Input values for the reference point calculations and projections (see TOR 7) are presented in Table A91. Mean selectivities, mean weights, and mean maturities at age are averages for 2010-2012.

The parametric reference points estimated internally in ASAP for the F57_BASE_12 final model run were suspect because the Beverton-Holt function steepness parameters were always very near 1.0, and the FMSY was estimated to be 3.0, constrained at the estimation boundary (Table A92). Therefore, non-parametric Spawner per Recruit (SPR) reference points such as F40%, F35%, and F30% (and their corresponding biomass reference points) were considered as candidate proxies for FMSY and SSBMSY. Fmax had been used in assessments prior to 2008 as the proxy for FMSY, with the most recent 2008 SAW 47 assessment using F35% as the proxy. The current estimate of Fmax using mean M = 0.25 and updated fishery selectivity and mean weights at age is relatively high (0.48) and the Yield per Recruit (YPR) to F relationship does not indicate a well defined peak.

The SDWG discussed the merits of F30% = 0.378 and F35% = 0.309 as the fishing mortality reference point proxy. F30% provides an increase of about 2% in YPR over F35%, but a corresponding decline in Spawning Stock Biomass per Recruit (SSBR) of 14%. The SDWG recommends that the new (updated) proxies for FMSY and SSBMSY are F35% = 0.309 (CV = 15%) and associated estimates from long-term stochastic projections of MSY = 12,945 mt (28.539 million lbs; CV = 13%) and SSBMSY = 62,394 mt (137.555 million lbs; CV = 13%; Table A92). The new biomass threshold of one-half SSBMSY is estimated to be 31,197 mt (68.8 million lbs; CV = 13%).

The SARC 57 Review Panel concluded that Term of Reference 5 was met.

TOR 6. Evaluate stock status with respect to the existing model (from previous peer reviewed accepted assessment) and with respect to a new model developed for this peer review.

a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.

b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-5).

2013 STOCK STATUS

a. Old (Existing) Model and Reference Points

Model F57-IAA-IND47-FLDL is the first of the 2013 SAW 57 models with data through 2012, but with the same configuration and settings as the old (existing) 2012 model with data through 2011. Surveys are configured as independent indices at age (IAA), the index set included in the model is the same as in the 2008 and 2012 assessments (IND47), and fishery selection is modeled as a single logistic for landings and double logistic for discards (FLDL). Model F57-IAA-IND47-FLDL provides estimates appropriate to compare with the old (existing) reference points, which are FMSY proxy = F35% = 0.310 and SSBMSY proxy = SSBMSY35% = 60,094 mt (TOR 6a). This model indicates that F in 2012 = 0.180 and SSB in 2012 = 60,905 mt, so the stock was not overfished and overfishing was not occurring.

b. New (Updated) Model and Reference Points

Model run F57_BASE_12 is the final model adopted by the 2013 SDWG for the evaluation of stock status. The summer flounder stock was not overfished and overfishing was not occurring in 2012 relative to the new biological reference points updated in this 2013 SAW 57 assessment. The fishing mortality rate was estimated to be 0.285 in 2012, below the new threshold fishing mortality reference point = FMSY = F35% = 0.309. SSB was estimated to be 51,238 mt = 112.960 million lbs in 2012, 82% of the new biomass reference point = SSBMSY = SSB35% = 62,394 mt (137.555 million lbs; Figure A253).

The SARC 57 Review Panel concluded that Term of Reference 6 was met.

TOR 7. Develop approaches and apply them to conduct stock projections and to compute the statistical distribution (e.g., probability density function) of the OFL (overfishing level) and candidate ABCs (Acceptable Biological Catch; see Appendix to the SAW TORs).

a. **Provide annual projections (3 years). For given catches, each projection 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 in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).**

b. **Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.**

c. **Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.**

a) Stochastic projections were made to provide forecasts of stock size and catches in 2014-2016 consistent with the new (updated) 2013 SAW 57 biological reference points (Tables A91-A92). The projections do not explicitly account for the recent retrospective pattern in the assessment, as per the 2006 S&T Peer Review advice (Methot 2006, Terceiro 2006a, 2006b). The projections assume that recent (2010-2012) patterns of fishery selectivity, discarding, maturity at age and mean weight at age will continue over the time span of the projections. One hundred projections were made for each of 1000 Markov Chain Monte Carlo (MCMC) realizations of 2013 stock sizes using AGEPRO version 4.2 (300,000 total iterations with a thinning factor of 300; NFT 2013c). Future recruitment at age 0 was generated randomly from the probability density function of the updated recruitment series for 1982-2012 (average recruitment = 43 million fish).

If the 2013 Annual Catch Limit (ACL) of 10,133 mt = 22.339 million lbs, the 2013 median (50% probability) dead discards are projected to be 1,735 mt = 3.825 million lbs, and the median landings are projected to be 8,398 mt = 18.514 million lbs. The median F in 2013 is projected to be 0.250, below the new fishing mortality threshold = FMSY proxy = F35% = 0.309. The median SSB on November 1, 2013 is projected to be 56,662 mt = 124.918 million lbs, below the new biomass target SSBMSY proxy = SSB35% = 62,394 mt = 137.555 million lbs.

If the stock is fished at the new fishing mortality threshold = FMSY proxy = F35% = 0.309 in 2014, median landings are projected to be 9,961 mt = 21.960 million lbs, with median dead discards of 2,177 mt = 4.799 million lbs, and median total catch = 12,138 mt = 26.760 million lbs. This projected median total catch would be the Overfishing Limit (OFL) for 2014, and is less than the new MSY proxy = 12,945 mt (28.539 million lbs; 10,455 mt = 23.049 million lbs of median landings plus 2,490 mt = 5.490 million lbs of median dead discards). The median SSB on November 1, 2014 is projected to be 57,140 mt = 125.972 million lbs, 92% of the new biomass target of SSBMSY proxy = SSB35% = 62,394 mt = 137.555 million lbs. The projected catch estimates in the following table are medians of the catch distributions for fixed F in 2014-2016.

Total Catch (OFL), Landings, Dead Discards, Fishing Mortality (F)
and Spawning Stock Biomass (SSB) in 2014-2016
Catches and SSB in metric tons

Year	Total Catch	Landings	Discards	F	SSB
2014	12,138	9,961	2,177	0.309	57,140
2015	11,785	9,497	2,288	0.309	58,231
2016	11,914	9,527	2,387	0.309	59,268

If the MAFMC risk policy is applied by the SSC and this assessment is classified as “typical level 3,” given the size of the annual SSB relative to SSBMSY and assuming OFL CV = 100% and an annual OFL corresponding to F = 0.309, then results associated with Acceptable Biological Catch (ABC) follow:

ABC Total Catch, Landings, Dead Discards, Fishing Mortality (F)
and Spawning Stock Biomass (SSB) in 2014-2016
Catches and SSB in metric tons

Year	Total Catch	Landings	Discards	F	SSB
2014	8,071	6,649	1,422	0.197	60,581
2015	9,992	8,117	1,875	0.237	63,969
2016	10,729	8,681	2,048	0.245	66,469

For the projections at fixed FMSY proxy = F35% = 0.309, there is 0% probability of exceeding the fishing mortality threshold and 0% probability of falling below the biomass threshold during 2014-2016. For the ABC projections, there is a less than a 13% probability annually that fishing mortality will exceed the threshold and 0% probability annually that biomass will fall below the threshold.

b, c) All of the projection results presented have a realistic probability of being achieved, and the summer flounder stock has a low vulnerability to becoming overfished, given recent trends in stock productivity and the management regime in place.

The SARC 57 Review Panel concluded that Term of Reference 7 was met.

TOR 8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports, as well as MAFMC SSC model recommendations from 2012. Identify new research recommendations.

Major data and analytical needs for summer flounder assessments have been identified in the 2002 SAW 35 peer review, the 2003 assessment update, the 2005 SAW 41 assessment update, the SDWG 2006 assessment update and subsequent NOAA Fisheries Science and Technology peer review, the SDWG 2007 assessment update, the 2008 SAW 47 benchmark assessment, the 2012 MAFMC SSC review, and by the 2013 SDWG for this current benchmark assessment. Research recommendations are retained in these documents until they are addressed (completed or deemed obsolete). Therefore, these remaining recommendations have been subset as 8.1) completed, in progress, or to be addressed, and 8.2) new (identified by the SDWG SAW Working Group for this assessment).

8.1 Completed, To Be Addressed, or In Progress

1) Develop a program to annually sample the length and age frequency of summer flounder discards from the recreational fishery.

SDWG Response: To date, ongoing programs are in place in the MRFSS/MRIP recreational sampling and the American Littoral Society (ALS). Most states have volunteer angler surveys (NC, VA, MD, NJ, NY, CT, RI, MA) which collects length of fish discarded (and landed) via several different methods (e.g., surveys, e-logbooks, etc.). Some progress has been made, but more synoptic data and potentially less biased data are needed including the length, age, and sex-frequency of discards.

2) A comprehensive collection of otoliths, for all components of the catch-at-age matrix, needs to be collected on a continuing basis for fish larger than 60 cm (~7 years). The collection of otoliths and the proportion at sex for all of the catch components could provide a better indicator of stock productivity.

SDWG Response: Through a PMAFS study, 2 years of data collection has occurred to determine sex ratios in the commercial and recreational landings (Working Paper A13). This is not an ongoing study. One year of data collection has occurred to determine the sex of fish in the NJ state survey, and the MA state survey has had ongoing collection of sex data in their survey (2009-present). The Northeast region fishery sampling program now collects otoliths and scales for commercial landings, and is scheduled to start collecting individual weights.

3) A reference collection of summer flounder scales and otoliths should be developed to facilitate future quality control of summer flounder production aging. In addition, a comparison study between scales and otoliths as aging structures for summer flounder should be completed.

SDWG Response: An exchange of aging structures between NEFSC and NCDMF was completed in Fall 2006 and a report was reviewed by the 2007 SDWG, in response to a 2005 SAW 41 high priority Research Recommendation. An additional exchange occurred between the NC-DMF and the NEFSC in 2009. The SDWG notes that while the exchanges indicate that the current level of aging consistency between NC and NEFSC is acceptable, there is a need to conduct and fund exchanges between all production aging entities (e.g., NC, VIMS, ODU, NEFSC) using scales and otoliths more frequently, on a schedule consistent with benchmark assessments.

4) Collect information on overall fecundity for the stock, as both egg condition and production may be a better indicator of stock productivity than weight.

SDWG Response: This recommendation has not been fully addressed and remains an ongoing data collection need. An ongoing study conducted by Dr. Chris Chambers (NOAA NMFS NEFSC Sandy Hook Laboratory) is examining summer flounder fecundity and egg condition.

5) Investigate trends in sex ratios and mean lengths and weights of summer flounder in state agency and federal surveys catches.

SDWG Response: These trends were examined in great detail for the federal surveys for this assessment (WPA1). MADMF surveys collect sex data. The VIMS NEAMAP surveys collect sex data.

6) Use NEFSC fishery observer age-length keys for 1994 and later years (as they become available) to supplement NEFSC survey data in aging the commercial fishery discard.

SDWG Response: This recommendation has not been addressed by the SDWG, as the age data are not yet available.

7) Consider use of management strategy evaluation techniques to address the implications of harvest policies that incorporate consideration of retrospective patterns (see ICES Journal of Marine Science issue of May 2007).

SDWG Response: Given the retrospective pattern has changed since this recommendation was developed (i.e., smaller and less problematic), this recommendation is no longer considered relevant by the SDWG.

8) Consider treating scallop closed areas as separate strata in calculations of summer flounder discards in the commercial fisheries.

SDWG Response: This recommendation has not been addressed; however, the SDWG does not consider this to be an issue in the current discard estimation methods applied in this assessment.

9) Examine the sensitivity of the summer flounder assessment to the various unit stock hypotheses and evaluate spatial aspects of the stock to facilitate sex and spatially-explicit modeling of summer flounder.

SDWG Response: Progress has been made on aspects of this recommendation in WPA1, WPA8, WPA11, WPA12, and WPA15.

10) Conduct further research to examine the predator-prey interactions of summer flounder and other species, including food habitat studies, to better understand the influence of these other factors on the summer flounder population.

SDWG Response: WPA1 reviewed food habits data available on summer flounder predators and prey. The SDWG concludes that the data are not sufficient to estimate predator consumption of summer flounder and has not attempted to estimate summer flounder consumption of prey.

11) Collect and evaluate information on the reporting accuracy of recreational discards estimates in the recreational fishery.

SDWG response: Some research has been conducted on reporting accuracy in the recreational for-hire fishery (Bochenek et al. 2011); however, comprehensive work across all fishing modes has not been completed.

12) Examine male female ratio at age-0 and potential factors (e.g., environmental) that may influence determination of that ratio.

SDWG: The male female ratio has been updated for the NEFSC surveys. The SDWG reviewed information in Luckenbach et al. 2009 which describes potential environmental factors that may affect sex ratios at age-0.

13) Evaluate potential changes in fishery selectivity relative to the spawning potential of the stock; analysis should consider the potential influence of the recreational and commercial fisheries.

SDWG: Some progress has been made on this topic in a report prepared for the MAFMC SSC describing a MSE for the recreational fishery.

14) Collect data to determine the sex ratio for all of the catch components.

SDWG: Through a PMAFS study, 2 years of data collection has occurred to determine sex ratios in the commercial and recreational landings (WPA13). This is not an ongoing study.

15) Determine the appropriate level for the steepness of the S-R relationship and investigate how that influences the biological reference points

SDWG: The SDWG considered WPA10 and WPA14, Rothschild et al. 2012, Mangel et al. 2013, Shertzer and Conn (2012), and Maunder (2012) in addressing this research recommendation in this assessment.

8.2 New from the July 2012 SSC report (1-5), SAW 57 SDWG (6-13)

1) Evaluate uncertainties in biomass to determine potential modifications to default OFL CV.

2) Evaluate the size distribution of landed and discarded fish, by sex, in the summer flounder fisheries

3) Evaluate past and possible future changes to size regulations on retention and selectivity in stock assessments and projections.

4) Incorporate sex -specific differences in size at age into the stock assessment.

5) Evaluate range expansion and change in distribution and their implications for stock assessment and management.

6) Continued evaluation of natural mortality and the differences between males and females. This should include efforts to estimate natural mortality, such as through mark-recapture programs, telemetry.

7) Further work examining aspects that create greater realism to the summer flounder assessment (e.g., sexually dimorphic growth, sex-specific F, differences in spatial structure [or distribution by size?] should be conducted. This could include:

a) Simulation studies to determine the critical data and model components that are necessary to provide reliable advice, and need to determine how simple a model can be while still providing reliable advice on stock status for management use, and should evaluate both simple and most complex model configurations.

b) Development of models incorporating these factors that would create greater realism.

c) These first steps (a or b) can be used to prioritize data collection, and determine if additional investment in data streams (e.g., collection of sex at age and sex at length and maturity data from the catch, additional information on spatial structure and movement, etc.) are worthwhile in terms of providing more reliable assessment results.

d) The modeling infrastructure should be simultaneously developed to support these types of modeling approaches (flexibility in model framework, MCMC/bootstrap framework, projection framework).

8) Develop comprehensive study to determine the contribution of summer flounder nursery area to the overall summer flounder population, based off approaches similar to those developed in WPA12.

9) Develop and ongoing sampling program for the recreational fishery landings and discards (i.e., collect age, length, sex) to develop appropriate age-length keys for ageing the recreational catch.

10) Apply standardization techniques to all of the state and academic-run surveys, to be evaluated for potential inclusion in the assessment.

11) Continue efforts to improve understanding of sexually dimorphic mortality and growth patterns. This should include monitoring sex ratios and associated biological information in the fisheries and all ongoing surveys to allow development of sex-structured models in the future.

12) Conduct sensitivity analyses to identify potential causes of the recent retrospective pattern. Efforts should focus on identifying factors in both survey and catch data that could contribute to the decrease in cohort abundance between initial estimates based largely on survey observations and subsequent estimates influenced by fishery dependent data as the cohort recruits to the fishery.

13) Develop methods that more fully characterize uncertainty and ensure coherence between assessments, reference point calculation and projections

We recognize that these research priorities will require additional resources and funding to complete and ensure progress in our understanding of summer flounder.

Sources of Assessment Uncertainty and Bias

The SDWG identified the following as ongoing sources of uncertainty and bias in the current assessment.

1) Sex specific differences in life history parameters and in the spatial distribution of summer flounder by size, may have an effect on the assessment model results.

2) The NEFSC research surveys and PMAFS fishery sampling confirm sexually-dimorphic, time varying, spatial differences in growth. These dynamics are not fully accounted for in the stock assessment, because not all fishery and survey catches are independently and adequately sampled.

3) The landings from the commercial fisheries used in this assessment assume no under-reporting of summer flounder landings. Therefore, reported landings and associated effort from the commercial fisheries should be considered minimal estimates.

4) The current assumption for M remains an ongoing source of uncertainty. M is highly influential on the assessment results and has a “rescaling affect” on SSB, F, R, point calculations, and the associated perception of current stock status.

The SARC 57 Review Panel concluded that Term of Reference 8 was met.

2013 SARC 57 Review Panel Special Comments

The benchmark 2008 SAW 47 assessment (NEFSC 2008) was updated annually through 2012 (Terceiro 2012). The summer flounder stock assessment has historically exhibited a consistent retrospective pattern of underestimation of F and overestimation of SSB; the causes of this previous pattern have not been determined. In the current assessment model, however, no persistent retrospective patterns are evident. Over the last 7 years, the annual retrospective change in fishing mortality has ranged from +22% in 2006 to -5% in 2009, the annual retrospective change in SSB has ranged from -2% in 2011 to -21% 2006, and the annual retrospective change in recruitment has ranged from -45 in 2005 to +33% in 2009. The historical retrospective indicates that general trends of fishing mortality, stock biomass, and recruitment have been consistent since the 1990s assessments (Figure A247).

This assessment includes several new research survey time series. The URI GSO trawl, NY trawl, VIMS ChesMMAP trawl, VIMS NEAMAP spring and fall trawl, and the NEFSC MARMAP and ECOMON larval surveys are now tabulated in the assessment and used in the population model calibration.

The NEFSC research surveys and Partnership for Mid-Atlantic Fisheries Science (PMAFS) fishery sampling confirm sexually dimorphic, temporal, and spatial differences in growth of summer flounder. The SAW 57 Southern Demersal Working Group investigated these differences in sex and how it might affect the assessment, but it was not possible to develop a full sex-disaggregated analysis. Sex-specific differences in life history parameters and in the spatial distribution of summer flounder by size may have an effect on the assessment model results and the biological reference point calculations. The assessment model presented to the SARC 57 Review Panel was deemed to provide an acceptable evaluation of stock status. Among potential approaches, simulation studies could be used to identify the critical data and model components and indicate directions for future work.

The Northward shift in the center of biomass for summer flounder may be due in part to the expansion in the age structure and increases in abundance. Environmental or other factors that may have influence on this shift have not been fully quantified.

Some progress has already been made developing a summer flounder assessment model that accounts for sexually dimorphic growth distribution and exploitation rates. Currently it has not been possible to split recreational landings or catch by sexes. The SARC 57 Review Panel would like to encourage further development in this area, with the aim of allowing sexually split assessment to better model summer flounder population. The SARC 57 Review Panel agrees that the development sex-specific sampling of surveys and landings to provide improved model input and sampling of discards and changing the model to include sex-specific parameterization are priorities and may improve the assessment.

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TABLES

Table A1. Summer flounder commercial landings by state (thousands of lb) and coastwide (thousands of pounds (>000 lbs), metric tons (mt)). * = less than 500 lb; na = not available

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	Total '000 lbs	Total mt
1940	0	0	2,847	258	149	1,814	3,554	3	444	1,247	498	10,814	4,905
1941	na	na	na	na	na	na	na	na	183	764	na	947	430
1942	0	0	193	235	126	1,286	987	2	143	475	498	3,945	1,789
1943	0	0	122	202	220	1,607	2,224	11	143	475	498	5,502	2,496
1944	0	0	719	414	437	2,151	3,159	8	197	2,629	498	10,212	4,632
1945	0	0	1,730	467	270	3,182	3,102	2	460	1,652	1,204	12,297	5,578
1946	0	0	1,579	625	478	3,494	3,310	22	704	2,889	1,204	14,305	6,489
1947	0	0	1,467	333	813	2,695	2,302	46	532	1,754	1,204	11,146	5,056
1948	0	0	2,370	406	518	2,308	3,044	15	472	1,882	1,204	12,219	5,542
1949	0	0	1,787	470	372	3,560	3,025	8	783	2,361	1,204	13,570	6,155
1950	0	0	3,614	1,036	270	3,838	2,515	25	543	1,761	1,840	15,442	7,004
1951	0	0	4,506	1,189	441	2,636	2,865	20	327	2,006	1,479	15,469	7,017
1952	0	0	4,898	1,336	627	3,680	4,721	69	467	1,671	2,156	19,625	8,902
1953	0	0	3,836	1,043	396	2,910	7,117	53	1,176	1,838	1,844	20,213	9,168
1954	0	0	3,363	2,374	213	3,683	6,577	21	1,090	2,257	1,645	21,223	9,627
1955	0	0	5,407	2,152	385	2,608	5,208	26	1,108	1,706	1,126	19,726	8,948
1956	0	0	5,469	1,604	322	4,260	6,357	60	1,049	2,168	1,002	22,291	10,111
1957	0	0	5,991	1,486	677	3,488	5,059	48	1,171	1,692	1,236	20,848	9,456
1958	0	0	4,172	950	360	2,341	8,109	209	1,452	2,039	892	20,524	9,310
1959	0	0	4,524	1,070	320	2,809	6,294	95	1,334	3,255	1,529	21,230	9,630
1960	0	0	5,583	1,278	321	2,512	6,355	44	1,028	2,730	1,236	21,087	9,565
1961	0	0	5,240	948	155	2,324	6,031	76	539	2,193	1,897	19,403	8,801
1962	0	0	3,795	676	124	1,590	4,749	24	715	1,914	1,876	15,463	7,014
1963	0	0	2,296	512	98	1,306	4,444	17	550	1,720	2,674	13,617	6,177
1964	0	0	1,384	678	136	1,854	3,670	16	557	1,492	2,450	12,237	5,551
1965	0	0	431	499	106	2,451	3,620	25	734	1,977	272	10,115	4,588
1966	0	0	264	456	90	2,466	3,830	13	630	2,343	4,017	14,109	6,400
1967	0	0	447	706	48	1,964	3,035	0	439	1,900	4,391	12,930	5,865
1968	0	0	163	384	35	1,216	2,139	0	350	2,164	2,602	9,053	4,106
1969	0	0	78	267	23	574	1,276	0	203	1,508	2,766	6,695	3,037
1970	0	0	41	259	23	900	1,958	0	371	2,146	3,163	8,861	4,019
1971	0	0	89	275	34	1,090	1,850	0	296	1,707	4,011	9,352	4,242
1972	0	0	93	275	7	1,101	1,852	0	277	1,857	3,761	9,223	4,183
1973	0	0	506	640	52	1,826	3,091	*	495	3,232	6,314	16,156	7,328
1974	*	0	1,689	2,552	26	2,487	3,499	0	709	3,111	10,028	22,581	10,243
1975	0	0	1,768	3,093	39	3,233	4,314	5	893	3,428	9,539	26,311	11,934
1976	*	0	4,019	6,790	79	3,203	5,647	3	697	3,303	9,627	33,368	15,135
1977	0	0	1,477	4,058	64	2,147	6,566	5	739	4,540	10,332	29,927	13,575
1978	0	0	1,439	2,238	111	1,948	5,414	1	676	5,940	10,820	28,586	12,966
1979	5	0	1,175	2,825	30	1,427	6,279	6	1,712	10,019	16,084	39,561	17,945

Table A1 continued.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	Total '000 lbs	Total mt
1980	4	0	367	1,277	48	1,246	4,805	1	1,324	8,504	13,643	31,216	14,159
1981	3	0	598	2,861	81	1,985	4,008	7	403	3,652	7,459	21,056	9,551
1982	18	*	1,665	3,983	64	1,865	4,318	8	360	4,332	6,315	22,928	10,400
1983	84	0	2,341	4,599	129	1,435	4,826	5	937	8,134	7,057	29,548	13,403
1984	2	*	1,488	4,479	131	2,295	6,364	9	813	9,673	12,510	37,765	17,130
1985	3	*	2,249	7,533	183	2,517	5,634	4	577	5,037	8,614	32,352	14,675
1986	0	*	2,954	7,042	160	2,738	4,017	4	316	3,712	5,924	26,866	12,186
1987	8	*	3,327	4,774	609	2,641	4,451	4	319	5,791	5,128	27,052	12,271
1988	5	0	2,421	4,719	741	3,439	6,006	7	514	7,756	6,770	32,377	14,686
1989	9	0	1,878	3,083	513	1,464	2,865	3	204	3,689	4,206	17,913	8,125
1990	3	0	628	1,408	343	405	1,458	2	138	2,144	2,728	9,257	4,199
1991	0	0	1,124	1,672	399	719	2,341	4	232	3,715	3,516	13,722	6,224
1992	*	*	1,383	2,532	495	1,239	2,871	12	319	5,172	2,576	16,599	7,529
1993	6	0	903	1,942	225	849	2,466	6	254	3,052	2,894	12,599	5,715
1994	4	0	1,031	2,649	371	1,269	2,356	4	179	3,091	3,571	14,525	6,588
1995	5	0	1,128	2,325	319	1,248	2,319	4	174	3,304	4,555	15,381	6,977
1996	8	0	800	1,763	266	936	2,369	8	266	2,286	4,218	12,920	5,861
1997	3	0	745	1,566	257	823	1,321	5	215	2,370	1,501	8,806	3,994
1998	6	0	707	1,712	263	822	1,863	11	224	2,616	2,967	11,190	5,076
1999	6	0	813	1,637	245	804	1,918	8	201	2,196	2,801	10,627	4,820
2000	7	0	789	1,703	240	800	1,848	12	252	2,206	3,354	11,211	5,085
2001	22	0	694	1,800	267	751	1,745	7	223	2,660	2,789	10,958	4,970
2002	1	0	1,009	2,286	357	1,053	2,407	3	327	2,970	4,078	14,491	6,573
2003	0	0	926	2,178	272	1,073	2,384	6	329	3,492	3,559	14,219	6,450
2004	0	0	1,193	3,085	406	1,594	2,831	8	284	3,906	4,834	18,141	8,228
2005	3	0	1,274	2,926	449	1,804	2,529	5	333	3,869	4,059	17,253	7,826
2006	7	0	910	2,120	314	1,262	2,346	4	248	2,669	3,926	13,806	6,262
2007	3	0	660	1,515	207	939	1,698	3	178	2,025	2,669	9,897	4,489
2008	1	0	647	1,469	223	858	1,544	1	199	1,764	2,424	9,133	4,143
2009	0	0	732	1,794	244	1,140	1,799	0	166	1,993	2,819	10,689	4,848
2010	0	0	852	2,289	305	1,364	2,165	0	221	2,625	3,253	13,074	5,930
2011	0	0	1,131	2,825	397	1,513	2,830	1	259	4,783	2,822	16,561	7,511
2012	0	0	892	2,410	620	1,239	2,269	1	141	4,670	1,090	13,332	6,047

Table A2. Distribution of Northeast Region (ME-VA) commercial fishery landings by statistical area.

Area	1992	1993	1994	1995	1996	1997	1998	1999
511	0	0	0	0	1	0	0	0
512	0	0	0	0	1	1	0	0
513	0	3	0	0	2	0	0	2
514	9	11	10	12	3	15	17	11
515	0	0	0	0	0	0	0	0
521	8	3	14	4	16	2	9	2
522	8	8	7	6	13	6	2	3
561	2	1	0	0	1	1	3	2
562	6	4	5	10	1	1	0	3
525	22	35	26	85	140	16	27	28
526	294	242	193	128	45	22	33	17
533	0	0	0	0	6	2	3	5
537	916	557	707	770	553	449	417	354
538	228	255	341	332	273	270	229	275
539	217	157	223	258	248	284	373	418
611	117	35	181	283	170	141	204	230
612	404	393	169	221	353	297	316	403
613	237	167	280	242	188	194	128	171
614	81	97	141	129	18	41	41	13
615	61	15	49	99	20	37	41	44
616	532	476	743	730	474	245	280	122
621	1028	526	258	279	325	266	286	304
622	299	363	323	522	264	53	141	301
623	0	6	0	14	28	0	1	0
625	289	227	122	118	282	227	142	91
626	743	601	821	347	395	94	502	415
631	655	98	219	220	21	174	258	140
632	160	77	60	43	75	30	41	79
635	45	45	77	55	29	418	228	97
636	0	0	0	4	2	27	8	20
Total	6361	4402	4969	4911	3947	3313	3730	3550

Table A2 continued.

Area	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
511	1	0	0	0	1	0	0	0	0	0
512	1	0	0	0	3	0	1	3	0	1
513	0	1	0	1	1	5	1	0	0	2
514	2	1	2	2	3	14	4	3	2	3
515	0	0	3	1	2	0	0	0	0	4
521	4	15	31	12	11	12	3	4	3	5
522	6	5	12	10	18	10	14	3	13	6
561	4	7	8	1	0	1	1	0	0	1
562	8	3	24	9	5	11	3	4	2	1
525	41	29	43	32	67	93	38	40	9	22
526	16	23	23	17	36	75	25	20	7	4
533	10	2	1	2	6	6	4	6	3	2
537	326	337	446	451	875	860	635	475	419	532
538	260	214	257	275	290	223	255	203	182	234
539	455	432	543	551	500	455	386	276	353	272
611	142	155	206	217	317	389	369	299	228	265
612	308	379	613	606	685	611	603	422	414	551
613	170	162	241	240	319	284	304	191	151	205
614	3	11	26	25	30	48	12	33	31	15
615	70	115	90	63	87	68	126	94	69	43
616	384	247	218	359	600	722	524	574	486	426
621	208	274	533	303	397	270	285	179	247	297
622	101	234	153	394	614	424	360	34	203	297
623	8	18	3	14	28	74	22	3	0	62
625	60	129	296	261	156	326	123	121	12	30
626	697	510	648	763	899	880	331	197	174	153
631	185	142	189	119	13	68	13	70	18	97
632	39	41	8	82	39	54	31	12	1	9
635	54	212	99	21	9	1	8	12	16	30
636	1	7	5	4	27	1	0	0	0	1
Total	3564	3705	4723	4835	6036	5985	4481	3278	3043	3570

Table A2 continued.

Area	2010	2011	2012
511	138	0	0
512	0	1	1
513	8	1	5
514	5	22	17
515	0	0	0
521	30	39	21
522	14	19	13
561	0	8	0
562	0	7	0
525	49	72	51
526	10	7	112
533	0	8	0
537	651	974	886
538	161	192	138
539	206	357	271
611	203	413	250
612	519	682	534
613	261	430	560
614	36	106	28
615	76	284	163
616	571	1205	851
621	744	309	814
622	353	443	357
623	0	66	0
625	104	269	83
626	255	387	331
631	33	45	37
632	5	6	1
635	24	17	41
636	1	0	5
Total	4455	6369	5568

Table A3. Summary of sampling of the commercial fishery for summer flounder, Northeast Region (ME-VA); landings in metric tons (mt).

Year	Lengths	Ages	ME-VA Landings (mt)	Sampling Intensity (mt/100 lengths)
1982	8,194	2,288	7,536	92
1983	6,893	1,347	10,202	148
1984	5,340	1,794	11,455	215
1985	6,473	1,611	10,767	166
1986	7,840	1,967	9,499	121
1987	6,605	1,788	9,945	151
1988	9,048	2,302	11,615	128
1989	8,411	1,325	6,217	74
1990	3,419	853	2,962	87
1991	4,627	1,089	4,626	100
1992	3,385	899	6,361	188
1993	3,638	844	4,402	121
1994	3,950	956	4,969	126
1995	2,982	682	4,911	165
1996	4,580	1,235	3,947	86
1997	8,855	2,332	3,313	37
1998	10,055	2,641	3,730	37
1999	10,460	3,244	3,550	34
2000	10,952	3,307	3,564	33
2001	10,310	2,838	3,705	36
2002	7,422	1,870	4,723	64
2003	8,687	2,210	4,835	56
2004	13,970	3,560	6,036	43
2005	17,188	4,903	5,985	35
2006	18,118	5,062	4,481	25
2007	19,581	6,247	3,278	17
2008	14,803	4,661	3,043	20
2009	18,560	4,694	3,570	19
2010	15,185	3,510	4,455	29
2011	16,587	3,121	6,232	38
2012	15,709	2,999	5,568	35

Table A4. Commercial fishery landings at age of summer flounder ('000), Northeast Region (ME-VA).

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
1982	1441	6879	5630	232	61	97	57	22	2	0	0	14421	24
1983	1956	12119	4352	554	30	62	13	17	4	2	0	19109	23
1984	1403	10706	6734	1618	575	72	3	5	1	4	0	21121	10
1985	840	6441	10068	956	263	169	25	4	2	1	0	18769	7
1986	407	7041	6374	2215	158	93	29	7	2	0	0	16326	9
1987	332	8908	7456	935	337	23	24	27	11	0	0	18053	38
1988	305	11116	8992	1280	327	79	18	9	5	0	0	22131	14
1989	96	2491	4829	841	152	16	3	1	1	0	0	8430	2
1990	0	2670	861	459	81	18	6	1	1	0	0	4097	2
1991	0	3755	3256	142	61	11	1	1	0	0	0	7227	1
1992	114	5760	3575	338	19	22	0	1	0	0	0	9829	1
1993	151	4308	2340	174	29	43	19	2	1	0	0	7067	3
1994	119	3698	3692	272	64	12	6	0	5	0	0	7868	5
1995	46	2565	4280	239	39	8	2	1	0	0	0	7180	1
1996	0	1401	3187	798	156	15	3	0	1	0	0	5561	1
1997	0	380	2442	1214	261	69	10	4	0	0	0	4380	4
1998	0	196	1719	2022	437	72	15	1	0	0	0	4462	1
1999	0	123	1569	1522	585	160	26	8	0	0	0	3993	8
2000	0	212	1934	1083	449	119	47	15	6	1	1	3867	23
2001	0	706	1402	1000	331	155	59	16	4	1	2	3676	23
2002	0	406	2706	1375	383	133	75	9	0	1	0	5088	10
2003	0	470	2112	1353	532	255	110	39	17	2	1	4891	59
2004	0	287	2609	1765	748	301	120	58	32	6	4	5930	100
2005	0	506	1373	1629	1091	675	364	182	127	38	24	6009	371
2006	0	375	2221	1110	578	276	132	49	19	3	1	4764	72
2007	0	160	762	1449	485	225	115	43	16	6	4	3265	69
2008	0	135	452	692	951	339	147	70	32	9	4	2831	115
2009	0	164	728	1005	775	521	164	63	29	10	4	3463	106
2010	0	223	704	1203	1210	542	244	95	51	28	8	4308	182
2011	0	101	761	1870	1675	869	326	173	86	28	19	5907	306
2012	0	64	777	1899	1425	673	300	172	94	25	12	5441	303

Table A5. Mean weight (kg) at age of summer flounder landed in the commercial fishery, Northeast Region (ME-VA).

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	0.260	0.420	0.620	1.840	2.330	2.940	2.710	4.040	5.990	0.000	0.000	0.545
1983	0.310	0.460	0.800	1.400	2.350	1.850	2.760	3.300	4.170	4.370	0.000	0.562
1984	0.280	0.390	0.600	1.090	1.430	2.160	3.210	3.620	4.640	4.030	0.000	0.540
1985	0.330	0.440	0.590	1.080	1.730	2.220	2.590	4.710	4.780	4.800	0.000	0.587
1986	0.300	0.440	0.630	1.110	1.760	1.890	3.140	2.960	4.810	0.000	0.000	0.629
1987	0.270	0.450	0.620	1.060	2.000	2.850	3.080	3.020	4.140	0.000	0.000	0.590
1988	0.360	0.460	0.600	1.210	2.070	2.880	3.980	3.910	4.500	0.000	0.000	0.596
1989	0.357	0.554	0.738	1.062	1.833	2.466	3.568	3.592	2.251	0.000	0.000	0.736
1990	0.000	0.518	0.857	1.374	1.835	2.134	3.212	3.915	5.029	0.000	0.000	0.724
1991	0.000	0.482	0.748	1.538	2.257	3.012	3.908	3.873	0.000	0.000	0.000	0.642
1992	0.340	0.500	0.820	1.880	2.680	3.090	0.000	4.590	0.000	0.000	0.000	0.672
1993	0.354	0.488	0.751	1.625	2.099	1.786	2.810	4.136	5.199	0.000	0.000	0.623
1994	0.389	0.552	0.616	1.426	2.266	3.083	3.323	0.000	3.703	0.000	0.000	0.632
1995	0.328	0.542	0.704	1.532	2.373	2.916	3.500	4.094	0.000	0.000	0.000	0.684
1996	0.000	0.544	0.577	1.137	1.881	2.845	3.776	0.000	4.762	0.000	0.000	0.694
1997	0.000	0.544	0.637	0.842	1.310	2.101	2.559	3.429	0.000	4.853	5.004	0.756
1998	0.000	0.550	0.643	0.845	1.386	2.307	2.524	3.983	0.000	0.000	0.000	0.837
1999	0.000	0.523	0.615	0.862	1.359	1.928	2.838	3.618	0.000	0.000	0.000	0.888
2000	0.000	0.566	0.676	0.972	1.459	2.125	2.514	2.600	3.303	3.357	3.707	0.924
2001	0.000	0.588	0.762	1.031	1.721	2.376	2.847	3.566	3.898	3.806	5.499	1.009
2002	0.000	0.596	0.711	1.006	1.652	2.162	2.845	3.601	3.357	2.983	0.000	0.927
2003	0.000	0.611	0.705	0.998	1.414	1.890	2.528	3.181	3.535	3.560	4.964	0.989
2004	0.000	0.555	0.716	0.995	1.427	1.914	2.488	2.984	3.138	3.635	3.911	1.018
2005	0.000	0.556	0.627	0.793	1.056	1.385	1.692	1.989	2.274	3.098	3.375	0.996
2006	0.000	0.580	0.651	0.935	1.319	1.788	2.333	2.828	3.253	3.991	3.727	0.941
2007	0.000	0.559	0.683	0.866	1.202	1.696	2.256	2.424	2.724	3.256	4.183	1.002
2008	0.000	0.563	0.636	0.804	1.103	1.497	1.933	2.265	2.588	2.914	3.425	1.074
2009	0.000	0.536	0.635	0.803	1.051	1.509	1.927	2.523	2.899	3.288	3.670	1.029
2010	0.000	0.436	0.566	0.768	1.036	1.408	2.127	2.493	2.798	3.114	3.831	1.034
2011	0.000	0.475	0.551	0.687	1.015	1.538	1.939	2.453	2.864	3.055	3.819	1.057
2012	0.000	0.550	0.621	0.727	0.985	1.459	1.959	2.015	2.528	2.897	3.552	1.023

Table A6. Summary of North Carolina Division of Marine Fisheries (NCDMF) sampling of the commercial trawl fishery for summer flounder; landings in metric tons (mt).

Year	Lengths	Ages	Landings (mt)	Sampling Intensity (mt/100 lengths)
1982	5,403	0	2,864	53
1983	8,491	0	3,201	38
1984	14,920	0	5,674	38
1985	13,787	0	3,907	28
1986	15,754	0	2,687	17
1987	12,126	0	2,326	19
1988	13,377	189	3,071	23
1989	15,785	106	1,908	12
1990	15,787	191	1,237	8
1991	24,590	534	1,595	6
1992	14,321	364	1,168	8
1993	18,019	442	1,313	7
1994	21,858	548	1,620	7
1995	18,410	548	2,066	11
1996	17,745	477	1,913	11
1997	12,802	388	681	5
1998	21,477	476	1,346	6
1999	11,703	412	1,271	11
2000	24,177	568	1,521	6
2001	19,655	499	1,265	6
2002	21,653	609	1,841	8
2003	17,476	610	1,615	9
2004	20,436	553	2,182	11
2005	20,598	620	1,827	9
2006	20,911	682	1,781	9
2007	26,187	697	1,211	5
2008	27,703	749	1,100	4
2009	19,580	723	1,279	7
2010	23,142	783	1,476	6
2011	16,962	417	1,282	8
2012	7,439	541	495	7

Table A7. Commercial landings at age of summer flounder ('000), North Carolina commercial trawl fishery.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
1982	981	3463	1021	142	52	19	6	4	2	0	0	5690	6
1983	492	3778	1581	287	135	41	3	3	1	0	0	6321	4
1984	907	5658	3889	550	107	18	1	0	0	0	0	11130	0
1985	196	2974	3529	338	85	24	5	1	0	0	0	7152	1
1986	216	2478	1897	479	29	32	1	1	1	0	0	5134	2
1987	233	2420	1299	265	25	1	0	0	0	0	0	4243	0
1988	0	2917	2225	471	227	39	1	6	1	0	0	5887	7
1989	2	49	1437	716	185	37	1	2	0	0	0	2429	2
1990	2	143	730	418	117	12	1	1	0	0	0	1424	1
1991	0	382	1641	521	116	20	2	0.4	0	0	0	2682	0
1992	0	36	795	697	131	21	2	0.03	0	0	0	1682	0
1993	0	515	1101	252	44	1	0.2	0	0	0	0	1913	0
1994	6	258	1262	503	115	14	3	0	0	0	0	2161	0
1995	0	181	1391	859	331	53	2	0	0	0	0	2817	0
1996	0	580	2187	554	132	56	13	1	2	1	0	3526	4
1997	0	17	625	378	18	3	0.2	0	0	0	0	1041	0
1998	18	547	694	230	28	3	0.2	0	0	0	0	1520	0
1999	1	70	504	579	152	88	6	3	0.1	0	0	1403	3
2000	0	50	398	906	345	55	18	1	2	0	0	1775	3
2001	0	79	408	556	334	63	18	5	0.2	0	0	1463	5
2002	0	79	574	1032	460	70	30	3	0.2	0	0	2248	3
2003	0	43	336	712	362	124	50	8	0.456	0	0	1635	8
2004	0	24	608	863	449	238	57	22	2	0.6	0.02	2264	25
2005	0	17	471	832	389	143	44	14	3	0.4	0.04	1913	17
2006	0	18	436	658	447	258	95	26	5	3	0.5	1947	35
2007	0	12	120	581	345	135	54	25	11	2	1	1286	39
2008	0	13	103	272	424	133	83	31	11	1.5	0.4	1072	44
2009	0	3	122	398	443	298	99	24	18	1	1	1407	44
2010	0	19	222	513	403	178	155	43	12	7	1	1553	63
2011	0	0	165	306	529	141	94	86	25	10	4	1360	125
2012	0	2	44	159	124	88	36	18	12	6	3	492	21

Table A8. Mean weight (kg) at age of summer flounder landed in the North Carolina commercial trawl fishery.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	0.340	0.456	0.756	1.284	1.658	2.054	2.116	2.231	2.577	0.000	0.000	0.531
1983	0.319	0.452	0.746	1.140	1.262	1.488	1.729	2.428	2.696	0.000	0.000	0.572
1984	0.331	0.475	0.704	1.059	1.504	2.167	3.482	0.000	0.000	0.000	0.000	0.585
1985	0.377	0.460	0.664	1.203	1.675	2.485	3.073	4.571	0.000	0.000	0.000	0.617
1986	0.360	0.512	0.674	1.092	1.623	1.955	3.398	3.233	3.626	0.000	0.000	0.637
1987	0.334	0.512	0.655	1.086	1.878	2.944	0.000	0.000	0.000	0.000	0.000	0.590
1988	0.000	0.411	0.598	0.926	1.189	1.702	2.241	2.982	3.412	0.000	0.000	0.565
1989	0.118	0.380	0.603	0.988	1.161	2.095	3.086	2.496	0.000	0.000	0.000	0.779
1990	0.079	0.483	0.664	0.867	1.306	2.095	1.897	3.972	0.000	0.000	0.000	0.773
1991	0.000	0.448	0.655	1.072	1.729	2.252	2.508	3.126	4.097	0.000	0.000	0.767
1992	0.000	0.363	0.504	0.851	1.198	1.457	2.302	0.000	0.000	0.000	0.000	0.713
1993	0.000	0.489	0.608	1.128	1.371	2.946	3.406	0.000	0.000	0.000	0.000	0.664
1994	0.272	0.451	0.618	1.270	2.039	2.443	2.888	5.780	0.000	0.000	0.000	0.839
1995	0.038	0.210	0.461	0.853	1.474	2.492	3.792	3.815	0.000	0.000	0.000	0.724
1996	0.000	0.420	0.470	0.730	1.350	1.720	2.290	3.200	2.710	4.510	0.000	0.565
1997	0.000	0.407	0.616	0.760	1.323	2.069	3.248	0.000	0.000	0.000	0.000	0.682
1998	0.405	0.714	0.890	1.237	1.491	2.802	3.381	0.000	0.000	0.000	0.000	0.889
1999	0.144	0.578	0.729	0.919	1.402	1.682	2.609	3.063	3.904	0.000	0.000	0.945
2000	0.000	0.558	0.656	0.801	1.201	1.963	2.590	3.307	3.521	0.000	0.000	0.898
2001	0.000	0.594	0.674	0.758	1.065	1.716	2.388	3.067	4.240	0.000	0.000	0.865
2002	0.000	0.520	0.650	0.760	0.990	1.650	2.200	3.030	4.420	0.000	0.000	0.821
2003	0.000	0.460	0.700	0.890	1.550	2.480	3.250	3.870	4.820	0.000	0.000	1.194
2004	0.000	0.510	0.640	0.820	1.120	1.410	2.140	2.990	3.780	4.020	0.000	0.948
2005	0.000	0.580	0.670	0.870	1.150	1.650	2.430	2.900	3.570	4.298	0.000	0.989
2006	0.000	0.600	0.669	0.815	1.070	1.427	1.842	2.573	3.097	3.803	0.000	1.004
2007	0.000	0.550	0.680	0.780	1.010	1.420	1.730	2.160	2.570	3.720	0.000	0.983
2008	0.000	0.596	0.667	0.834	1.015	1.375	1.551	1.916	2.947	4.856	0.000	1.068
2009	0.000	0.511	0.634	0.765	0.893	1.130	1.507	1.974	1.664	3.285	4.720	0.960
2010	0.000	0.558	0.636	0.791	0.995	1.243	1.483	1.906	2.950	4.881	4.852	1.008
2011	0.000	0.000	0.570	0.670	0.820	1.260	1.490	1.680	2.050	2.300	4.260	0.950
2012	0.000	0.509	0.666	0.775	0.902	1.234	1.636	2.047	1.974	2.628	4.507	1.062

Table A9. Summary NER Fishery Observer sample data for trips catching summer flounder. Total trips (trips are not split for multiple areas), observed tows, total summer flounder catch observed, total summer flounder kept observed, and total summer flounder discard observed, and percentage of summer flounder discard to summer flounder catch observed. All catches in pounds. Includes NER At-Sea Monitoring (ASM) and ASMFC-funded trips for 2010-2012.

Year	Gear	Trips	Tows	Total Catch	Total Kept	Total Discard	Discard: Total (%)
1989	All	57	413	53,714	48,406	5,308	9.9
1990	All	61	463	47,954	35,972	11,982	25.0
1991	All	82	635	61,650	50,410	11,240	18.2
1992	Trawl	66	643	136,632	118,026	18,606	13.6
	Scallop	8	178	1,477	767	710	48.1
	All	74	821	138,109	118,793	19,316	14.0
1993	Trawl	37	410	74,982	67,603	7,379	9.8
	Scallop	15	671	2,967	1,158	1,809	61.0
	All	52	1,081	77,949	68,761	9,188	11.8
1994	Trawl	51	574	174,347	163,734	10,612	6.1
	Scallop	14	651	5,811	435	5,376	92.5
	All	65	1,225	180,158	164,169	15,988	8.9
1995	Trawl	134	1,004	242,784	235,011	7,773	3.2
	Scallop	19	1,051	10,044	2,247	7,778	77.4
	All	153	2,055	252,828	237,258	15,551	6.2
1996	Trawl	111	653	101,389	90,789	10,600	10.5
	Scallop	24	1,083	9,575	1,345	8,230	86.0
	All	135	1,736	110,964	92,134	18,830	17.0
1997	Trawl	59	334	31,707	26,475	5,232	16.5
	Scallop	23	835	5,721	583	5,138	89.8
	All	82	1,169	37,428	27,058	10,370	27.7

Table A9 continued.

Year	Gear	Trips	Tows	Total Catch	Total Kept	Total Discard	Discard: Total (%)
1998	Trawl	53	329	72,396	65,507	6,889	9.5
	Scallop	22	359	1,962	652	1,310	66.8
	All	75	688	74,358	66,159	8,199	11.0
1999	Trawl	56	374	60,733	45,987	14,746	24.3
	Scallop	10	247	3,199	458	2,741	85.7
	All	66	621	63,932	46,445	17,487	27.4
2000	Trawl	115	688	162,015	144,752	17,263	10.7
	Scallop	23	608	8,457	501	7,956	94.1
	All	138	1,296	170,472	145,253	25,219	14.8
2001	Trawl	137	605	109,910	61,625	48,295	43.9
	Scallop	68	1,606	11,622	800	10,822	93.1
	All	205	2,211	121,532	62,425	59,117	48.6
2002	Trawl	175	837	141,246	124,053	17,193	12.2
	Scallop	55	2,522	25,871	887	24,984	96.6
	All	230	3,359	167,117	124,940	42,177	25.2
2003	Trawl	212	1,316	235,685	195,371	40,314	17.1
	Scallop	79	3,248	37,021	2,378	34,643	93.6
	All	291	4,564	272,706	197,749	74,957	27.5
2004	Trawl	546	2,570	561,689	477,634	84,055	15.0
	Scallop	132	4,444	59,787	4,016	55,771	93.3
	All	678	7,014	621,476	481,650	139,826	22.5
2005	Trawl	906	5,993	800,082	580,949	219,133	27.4
	Scallop	136	3,786	38,227	2,805	35,422	92.7
	All	1,042	9,779	838,309	583,754	254,555	30.4

Table A9 continued.

Year	Gear	Trips	Tows	Total Catch	Total Kept	Total Discard	Discard: Total (%)
2006	Trawl	578	4,017	566,458	309,915	256,544	45.3
	Scallop	117	1,488	15,687	1,323	14,364	91.6
	All	695	5,505	582,145	311,238	270,908	46.5
2007	Trawl	682	3,972	759,360	332,373	426,987	56.2
	Scallop	233	4,059	58,865	729	56,136	95.4
	All	915	8,031	818,225	333,102	483,123	59.0
2008	Trawl	559	2,890	482,775	288,182	194,593	40.3
	Scallop	383	8,039	91,826	3,786	88,040	95.9
	All	942	10,929	574,601	291,968	282,633	49.2
2009	Trawl	845	4,450	736,910	506,768	230,142	31.2
	Scallop	300	8,042	69,857	3,382	66,475	95.2
	All	1,145	12,492	806,767	510,150	296,617	36.8
2010	Trawl	982	4,802	1,236,762	973,384	263,378	21.3
	Scallop	221	6,817	75,859	1,788	74,072	97.6
	All	1,203	11,619	1,312,621	975,172	337,450	25.7
2011	Trawl	1,068	6,225	1,283,337	1,069,777	213,560	16.6
	Scallop	258	7,110	78,893	3,192	75,701	96.0
	All	1,326	13,335	1,362,230	1,072,969	289,261	21.2
2012	Trawl	851	4,107	837,902	726,649	111,253	13.3
	Scallop	314	9,541	76,817	5,133	71,683	93.3
	All	1,165	13,648	914,719	731,782	182,936	20.0

Table A10. Summary NER Vessel Trip Report (VTR) data for trips reporting discard of any species and catching summer flounder. Total trips, total summer flounder catch, total summer flounder kept, total summer flounder discard, and percentage of summer flounder discard to summer flounder catch. All catches in pounds.

Year	Gear	Trips	Total Catch	Total Kept	Total Discard	Discard: Total (%)
1994	Trawl	4,267	2,149,332	2,015,296	134,036	6.2
	Scallop	85	70,353	22,877	47,476	67.5
	All	4,352	2,219,685	2,038,173	181,512	8.2
1995	Trawl	3,733	2,444,231	2,332,516	111,715	4.6
	Scallop	113	78,758	25,084	53,674	68.2
	All	3,846	2,522,989	2,357,600	165,389	6.6
1996	Trawl	2,990	1,662,313	1,459,155	203,158	12.2
	Scallop	79	69,557	16,657	52,900	76.1
	All	3,069	1,731,870	1,475,812	256,058	14.8
1997	Trawl	3,044	988,599	851,090	137,509	13.9
	Scallop	51	21,553	4,665	16,888	78.4
	All	3,095	1,010,152	855,755	154,397	15.3
1998	Trawl	3,004	1,128,578	868,706	259,872	23.0
	Scallop	62	23,538	10,323	13,215	56.1
	All	3,066	1,152,116	879,029	273,087	23.7
1999	Trawl	2,884	959,275	772,924	186,351	19.4
	Scallop	41	26,334	14,324	12,010	45.6
	All	2,925	985,609	787,248	198,361	20.1
2000	Trawl	3,140	1,048,791	786,576	262,215	25.0
	Scallop	41	12,183	3,798	8,385	68.8
	All	3,181	1,060,974	790,374	270,600	25.5
2001	Trawl	3,035	1,091,056	783,900	307,156	28.2
	Scallop	71	14,662	1,349	13,313	90.8
	All	3,106	1,105,718	785,249	320,469	29.0

Table A10 continued.

Year	Gear	Trips	Total Catch	Total Kept	Total Discard	Discard: Total (%)
2002	Trawl	3,549	1,164,038	924,590	239,448	20.6
	Scallop	107	23,879	6,913	16,966	71.1
	All	3,656	1,187,917	931,503	256,414	21.6
2003	Trawl	3,008	1,484,076	877,458	606,618	40.9
	Scallop	72	21,190	6,028	15,162	71.6
	All	3,080	1,505,266	883,486	621,780	41.3
2004	Trawl	3,607	1,866,542	1,511,013	355,529	19.0
	Scallop	69	24,814	9,478	15,336	61.8
	All	3,676	1,891,356	1,520,491	370,865	19.6
2005	Trawl	2,475	1,870,302	1,542,640	327,662	17.5
	Scallop	55	11,405	5,364	6,041	53.0
	All	2,530	1,881,707	1,548,004	333,703	17.7
2006	Trawl	2,575	1,373,070	974,264	398,806	29.0
	Scallop	144	17,613	3,091	14,522	82.5
	All	2,719	1,390,683	977,355	413,328	29.7
2007	Trawl	2,633	1,253,778	822,298	431,480	34.4
	Scallop	167	32,937	12,379	20,558	62.4
	All	2,800	1,286,715	834,677	452,038	35.1
2008	Trawl	2,164	1,065,118	807,501	257,617	24.2
	Scallop	109	44,992	11,362	33,630	74.7
	All	2,273	1,110,110	818,863	291,247	26.2
2009	Trawl	2,036	1,051,784	846,685	205,099	19.5
	Scallop	85	19,836	4,166	15,670	79.0
	All	2,121	1,071,620	850,851	220,769	20.6
2010	Trawl	2,230	1,372,669	1,159,710	213,302	15.5
	Scallop	85	18,722	6,306	13,692	73.1
	All	2,315	1,391,391	1,166,016	226,994	16.3

Table A10 continued.

Year	Gear	Trips	Total Catch	Total Kept	Total Discard	Discard: Total (%)
2011	Trawl	2,323	1,866,017	1,744,319	121,778	6.5
	Scallop	67	11,078	2,269	8,904	80.4
	All	2,390	1,877,095	1,746,588	130,682	7.0
2012	Trawl	2,211	1,213,314	1,132,104	93,240	7.7
	Scallop	60	12,270	5,709	7,445	60.7
	All	2,271	1,225,584	1,137,813	100,685	8.2

Table A11. Comparison of commercial fishery dealer reported landings (metric tons; mt) of summer flounder with estimates of summer flounder commercial landings from landings rates of NER Fishery Observer sampling and commercial fishing effort (days fished) reported on commercial Vessel Trip Reports (VTR). Dealer and Landings estimates prior to 1997 do not reflect NC landings and effort.

Year	VTR Days Fished (>000)	Observed Landings Estimate (mt)	Dealer landings Estimate (mt)	Percent Difference (Obs-Dealer)
1989	19,805	7,255	5,817	25
1990	15,980	2,959	2,749	8
1991	26,096	4,123	4,355	-5
1992	18,148	5,343	6,066	-12
1993	19,947	4,032	3,995	1
1994	18,402	6,004	4,968	21
1995	14,168	5,891	4,911	20
1996	10,351	5,024	3,718	35
1997	10,975	2,663	3,994	-33
1998	15,267	3,677	5,076	-28
1999	20,670	7,396	4,820	53
2000	11,268	6,702	5,085	32
2001	11,421	1,509	4,970	-70
2002	12,268	6,609	6,573	1
2003	13,415	5,786	6,450	-10
2004	9,288	4,997	8,228	-39
2005	13,215	3,478	7,826	-56
2006	11,856	1,794	6,262	-71
2007	8,872	1,012	4,431	-77
2008	7,615	1,445	4,143	-65
2009	7,294	1,277	4,848	-74
2010	6,639	2,605	5,930	-56
2011	6,965	1,466	7,511	-81
2012	8,068	1,145	6,047	-81

Table A12. Comparison of summer flounder landings estimates from Dealer reports, the method used in previous assessments (K*DF), the SBRM using all species landings (K*Kall), and the SBRM using all fluke, scup, and black sea bass landings (K*Kfsb).

Year	Dealer Landings	K*DF (Assess)	K*DF CV (Assess)	K*Kall (SBRM)	K*Kall CV (SBRM)	K*Kfsb (SBRM)	K*Kfsb CV (SBRM)
1989	5,817	7,255	0.22	5,878	0.36	3,909	0.13
1990	2,749	2,959	0.21	3,030	0.39	2,080	0.09
1991	4,355	4,123	0.13	2,165	0.16	4,249	0.02
1992	6,066	5,343	0.14	21,483	0.12	7,761	0.05
1993	3,995	4,032	0.21	6,277	0.43	4,074	0.03
1994	4,968	6,004	0.15	17,743	0.08	6,119	0.02
1995	4,911	5,891	0.12	14,085	0.13	6,440	0.01
1996	3,718	5,024	0.33	21,543	0.20	5,690	0.02
1997	3,994	2,663	0.34	2,085	0.49	2,265	0.06
1998	5,076	3,677	0.25	7,380	0.11	3,804	0.06
1999	4,820	7,396	0.25	12,219	0.12	3,516	0.01
2000	5,085	6,702	0.19	7,300	0.05	3,306	0.04
2001	4,970	1,509	0.29	1,476	0.32	2,996	0.07
2002	6,573	6,609	0.18	8,233	0.15	3,847	0.05
2003	6,450	5,786	0.17	7,117	0.21	6,474	0.02
2004	8,228	4,997	0.10	8,757	0.08	5,970	0.04
2005	7,826	3,478	0.09	7,187	0.18	6,487	0.12
2006	6,262	1,794	0.03	6,730	0.26	6,267	0.09
2007	4,431	1,012	0.03	5,972	0.06	5,220	0.02
2008	4,143	1,445	0.03	4,096	0.11	3,053	0.04
2009	4,848	1,277	0.03	7,024	0.08	4,964	0.05
2010	6,067	2,605	0.02	6,927	0.05	7,134	0.01
2011	7,511	1,466	0.02	6,224	0.07	8,909	0.03
mean	5,342	4,046	0.17	8,301	0.15	4,980	0.04
cumulative	122,863	93,047		190,928		114,534	
2004-2011	6,165	2,259	0.04	6,615	0.11	6,001	0.05

Table A13. Comparison of summer flounder discard estimates from the method used in previous assessments (D*DF), the SBRM using fluke (summer flounder) landings (D*Kflk), the SBRM using all species landings (D*Kall), and the SBRM using all fluke, scup, and black sea bass landings (D*Kfsb).

Year	D*DF (Assess)	D*DF CV (Assess)	D*Kflk (SBRM)	D*Kflk CV (SBRM)	D*Kall (SBRM)	D*Kall CV (SBRM)	D*Kfsb (SBRM)	D*Kfsb CV (SBRM)
1989	886	0.22	2,329	1.23	570	0.37	3,607	1.35
1990	1,517	0.21	1,775	1.28	1,122	0.39	3,663	1.28
1991	1,315	0.13	418	0.19	273	0.31	396	0.10
1992	862	0.14	1,345	0.03	2,689	0.19	1,871	0.05
1993	1,057	0.21	9,273	1.49	876	0.35	10,767	1.32
1994	1,019	0.15	5,294	0.89	1,919	0.12	3,263	0.60
1995	385	0.12	931	0.24	1,027	0.15	1,036	0.22
1996	579	0.33	1,142	0.29	1,795	0.23	80,171	0.01
1997	407	0.34	3,097	1.11	1,007	0.20	18,839	1.27
1998	487	0.25	2,549	1.43	793	0.14	2,836	1.41
1999	1,935	0.25	638	0.29	2,075	0.17	921	0.29
2000	907	0.19	16,960	1.04	2,022	0.28	17,598	1.05
2001	584	0.29	1,433	0.48	507	0.16	1,062	0.41
2002	562	0.18	3,230	0.20	1,152	0.13	3,603	0.24
2003	660	0.17	3,891	0.31	1,429	0.13	4,746	0.30
2004	305	0.10	2,060	0.21	2,008	0.10	2,221	0.20
2005	287	0.09	3,209	0.14	1,855	0.06	3,717	0.14
2006	361	0.03	4,773	0.51	1,853	0.11	6,526	0.40
2007	380	0.03	9,988	0.20	2,637	0.11	13,637	0.20
2008	386	0.03	3,285	0.22	1,453	0.08	3,903	0.21
2009	148	0.03	3,184	0.21	1,808	0.06	3,933	0.18
2010	248	0.02	11,892	0.56	1,833	0.07	13,297	0.51
2011	158	0.02	2,704	0.18	1,370	0.07	1,336	0.14
mean	671	0.18	4,148	0.68	1,481	0.15	8,824	0.45
cumulative	15,435		95,398		34,070		202,949	
2004-2011	284	0.05	5,484	0.35	1,852	0.09	6,748	0.31

Table A14. Total Dealer reported landings, recommended new SBRM live discard estimates, recommended new total commercial catch, and discard as a percentage of total catch for summer flounder. Catches in metric tons.

Year	Dealer Landings	D*Kall (SBRM)	D*Kall CV (SBRM)	Total Catch	Live Discard: Catch (%)
1989	5,817	570	0.37	6,387	8.9%
1990	2,749	1,122	0.39	3,871	29.0%
1991	4,355	273	0.31	4,628	5.9%
1992	6,066	2,689	0.19	8,755	30.7%
1993	3,995	876	0.35	4,871	18.0%
1994	4,968	1,919	0.12	6,887	27.9%
1995	4,911	1,027	0.15	5,938	17.3%
1996	3,718	1,795	0.23	5,513	32.6%
1997	3,994	1,007	0.20	5,001	20.1%
1998	5,076	793	0.14	5,869	13.5%
1999	4,820	2,075	0.17	6,895	30.1%
2000	5,085	2,022	0.28	7,107	28.4%
2001	4,970	507	0.16	5,477	9.2%
2002	6,573	1,152	0.13	7,725	14.9%
2003	6,450	1,429	0.13	7,879	18.1%
2004	8,228	2,008	0.10	10,236	19.6%
2005	7,826	1,855	0.06	9,681	19.2%
2006	6,262	1,853	0.11	8,115	22.8%
2007	4,431	2,637	0.11	7,068	37.3%
2008	4,143	1,453	0.08	5,596	26.0%
2009	4,848	1,808	0.06	6,656	27.2%
2010	6,067	1,833	0.07	7,900	23.2%
2011	7,511	1,370	0.07	8,881	23.2%
mean	5,342	1,481	0.15	6,823	21.7%
2004-2011	6,165	1,851	0.08	8,016	23.1%

Table A15. Summary of Observer discard sampling of the commercial fishery for summer flounder, Northeast Region (ME-VA); landings in metric tons (mt); sampling intensity expressed as mt of live discards per 100 lengths.

Year	Gear	Lengths	Ages	Live Discards (mt)	Sampling Intensity (mt/100 lengths)
1989	All	2,337	54	570	24
1990	All	3,891	453	1,122	29
1991	All	5,326	190	273	5
1992	All	9,626	331	2,689	28
1993	All	3,410	406	876	26
1994	Trawl	2,338		1,604	69
	Scallop	660		315	48
	All	2,998	354	1,919	64
1995	Trawl	1,822		618	34
	Scallop	731		409	56
	All	2,553	n/a	1,027	40
1996	Trawl	1,873		1,326	71
	Scallop	854		469	55
	All	2,727	n/a	1,795	66
1997	Trawl	839		502	60
	Scallop	556		505	91
	All	1,395	n/a	1,007	72
1998	Trawl	721		575	80
	Scallop	150		218	145
	All	871	n/a	793	91
1999	Trawl	1,145		1,880	164
	Scallop	216		195	90
	All	1,361	n/a	2,075	152
2000	Trawl	1,470		1,218	83
	Scallop	2,611		804	31
	All	4,081	n/a	2,022	50
2001	Trawl	1,528		257	17
	Scallop	705		250	35
	All	2,233	n/a	507	23
2002	Trawl	3,438		604	18
	Scallop	2,952		548	19
	All	6,390	n/a	1,152	18
2003	Trawl	4,233		795	19
	Scallop	2,594		634	24
	All	6,827	n/a	1,429	21

Table A15 continued.

Year	Gear	Lengths	Ages	Live Discards (mt)	Sampling Intensity (mt/100 lengths)
2004	Trawl	5,760		1,249	22
	Scallop	8,811		759	9
	All	14,571	n/a	2,008	14
2005	Trawl	9,562		1,328	14
	Scallop	4,690		527	11
	All	14,252	n/a	1,855	13
2006	Trawl	8,283		1,476	18
	Scallop	1,911		377	20
	All	10,194	n/a	1,853	18
2007	Trawl	12,725		2,023	16
	Scallop	4,972		614	12
	All	17,697	n/a	2,637	15
2008	Trawl	6,815		888	13
	Scallop	8,211		565	7
	All	15,026	n/a	1,453	10
2009	Trawl	9,441		1,154	12
	Scallop	8,970		654	7
	All	18,411	n/a	1,808	10
2010	Trawl	8,460		1,023	12
	Scallop	7,826		810	10
	All	16,286	n/a	1,833	11
2011	Trawl	8,710		747	9
	Scallop	6,785		623	9
	All	15,495	n/a	1,370	9
2012	Trawl	3,725		457	12
	Scallop	5,156		440	9
	All	8,881	n/a	897	10

Table A16. Difference in absolute numbers between SBRM D*Kall method and Assess D*DF method estimates of discards at age (000s of fish; includes 80% discard mortality rate).

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1989	120	-577	448	21	4	0	0	0	0	0	0	17
1990	-398	-311	30	16	0	0	0	0	0	0	0	-663
1991	-552	-2767	14	0	0	0	0	0	0	0	0	-3305
1992	1675	3888	481	15	0	0	0	0	0	0	0	6059
1993	-353	-101	175	-1	0	0	0	0	0	0	0	-280
1994	220	1855	552	-27	2	1	0	0	0	0	0	2603
1995	1512	82	260	9	5	1	0	0	0	0	0	1868
1996	92	483	808	147	70	22	2	2	2	0	0	1627
1997	30	55	441	153	39	12	1	0	0	0	0	730
1998	56	-24	245	84	55	20	12	2	0	0	0	451
1999	8	51	147	185	67	0	0	-3	0	0	0	456
2000	-9	83	731	215	69	12	9	0	1	0	0	1112
2001	27	126	47	-49	-38	-7	-5	2	1	1	0	104
2002	87	566	377	38	3	-2	9	-4	2	0	0	1075
2003	5	343	438	140	50	27	18	9	7	1	1	1040
2004	19	167	657	315	139	72	43	18	17	4	1	1450
2005	12	169	358	242	144	117	74	40	46	27	12	1240
2006	1	61	568	181	152	81	63	26	22	4	2	1161
2007	13	102	179	616	257	140	102	48	28	8	7	1501
2008	15	137	182	151	199	74	41	9	26	10	5	849
2009	15	172	441	279	183	153	67	37	21	9	2	1379
2010	-3	291	572	400	239	100	54	28	19	9	3	1711
2011	11	108	441	384	178	93	38	23	13	6	4	1300

Table A17. Estimated summer flounder discard at age in the in the commercial fishery. Lengths converted to age using annual NEFSC trawl survey age-length keys. Includes an assumed 80% discard mortality rate. Includes NEFSC OB, ASM, and ASMFC-funded data for 2010-2012.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
1982	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
1984	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
1986	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
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	895	1051	542	21	4	0	0	0	0	0	0	2514	0
1990	1043	2444	97	16	0	0	0	0	0	0	0	3600	0
1991	339	657	14	0	0	0	0	0	0	0	0	1010	0
1992	2830	5432	517	18	0	0	0	0	0	0	0	8797	0
1993	688	1431	354	0	0	0	0	0	0	0	0	2473	0
1994	791	3532	1045	9	2	1	0	0	0	0	0	5380	0
1995	1653	490	466	31	5	1	0	0	0	0	0	2645	0
1996	115	1121	1047	208	70	22	2	2	2	0	0	2588	3
1997	38	304	742	225	39	12	1	0	0	0	0	1360	0
1998	83	150	464	231	55	20	12	2	0	0	0	1018	2
1999	104	1274	1398	460	166	50	4	0	0	0	0	3457	0
2000	13	247	1191	442	161	38	13	3	1	0	0	2110	4
2001	38	225	153	114	34	17	5	3	1	1	0	590	4
2002	100	690	597	123	45	21	19	5	2	0	0	1601	6
2003	7	607	694	196	75	38	28	11	7	1	1	1666	20
2004	21	206	791	368	161	81	49	25	17	4	1	1722	46
2005	16	210	454	294	166	130	84	48	46	27	12	1486	133
2006	5	110	749	233	181	97	73	34	22	4	2	1510	63
2007	22	131	259	709	293	157	114	53	28	8	7	1782	96
2008	18	190	236	193	259	106	62	38	26	10	5	1143	78
2009	17	188	487	301	196	166	73	41	23	10	3	1505	77
2010	11	354	658	455	269	116	63	32	22	11	4	1994	69
2011	14	130	515	439	197	103	43	26	15	7	5	1495	53
2012	9	283	526	364	215	93	51	26	17	9	3	1596	55

Table A18. Estimated summer flounder discard mean weight at age in the in the commercial fishery. Lengths converted to age using NEFSC trawl survey age-length keys.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	0.224	0.404	0.570	1.326	1.846	1.885	2.978	0.000	0.000	0.000	0.000	0.464
1983	0.176	0.370	0.633	0.927	1.194	1.396	0.000	0.000	0.000	0.000	0.000	0.478
1984	0.205	0.364	0.620	0.968	1.771	2.197	4.166	0.000	0.000	0.000	0.000	0.461
1985	0.242	0.398	0.626	1.101	1.748	2.441	0.000	0.000	0.000	0.000	0.000	0.533
1986	0.225	0.447	0.751	1.290	1.740	2.719	3.482	5.960	0.000	0.000	0.000	0.601
1987	0.230	0.412	0.761	1.340	1.839	3.050	4.808	4.640	0.000	0.000	0.000	0.583
1988	0.293	0.488	0.707	1.114	1.921	2.316	0.000	0.000	0.000	0.000	0.000	0.590
1989	0.263	0.512	0.813	1.232	1.784	3.333	1.576	0.000	0.000	0.000	0.000	0.742
1990	0.303	0.460	0.968	1.440	1.677	2.895	6.456	0.000	0.000	0.000	0.000	0.555
1991	0.273	0.433	0.670	1.306	1.372	2.450	0.000	0.000	0.000	0.000	0.000	0.537
1992	0.225	0.504	0.717	1.617	2.279	3.340	0.000	0.000	0.000	0.000	0.000	0.604
1993	0.246	0.518	0.715	1.872	2.442	3.027	0.000	0.000	0.000	0.000	0.000	0.619
1994	0.436	0.583	0.694	1.438	1.923	2.831	3.897	0.000	0.000	0.000	0.000	0.625
1995	0.426	0.575	0.816	1.457	2.603	2.930	3.537	0.000	0.000	0.000	0.000	0.727
1996	0.343	0.532	0.622	1.338	1.341	2.361	3.537	0.000	0.000	0.000	0.000	0.629
1997	0.225	0.487	0.675	0.909	1.153	2.377	0.000	0.000	0.000	0.000	0.000	0.732
1998	0.000	0.525	0.668	0.830	1.257	2.508	2.786	0.000	0.000	0.000	0.000	0.777
1999	0.000	0.508	0.706	0.945	1.549	2.330	2.604	0.000	0.000	0.000	0.000	0.884
2000	0.000	0.760	0.984	1.307	2.388	3.481	3.481	0.000	0.000	0.000	0.000	1.234
2001	0.000	0.621	0.879	1.037	1.539	2.089	2.291	3.738	0.000	0.000	0.000	0.998
2002	0.238	0.488	0.896	1.091	1.519	2.287	2.604	3.200	4.213	0.000	0.000	1.076
2003	0.000	0.677	0.910	1.137	1.597	2.018	2.807	2.714	0.000	0.000	0.000	1.156
2004	0.599	0.635	0.850	1.048	1.412	1.905	2.316	3.002	0.000	0.000	0.000	1.099
2005	0.308	0.571	0.869	1.133	1.408	1.756	2.330	2.357	2.269	0.000	0.000	1.173
2006	0.126	0.619	0.856	1.090	1.344	1.694	2.266	3.310	3.018	3.784	2.964	1.165
2007	0.175	0.492	0.799	1.137	1.467	1.805	2.148	2.878	3.448	3.790	3.065	1.258
2008	0.238	0.445	0.751	1.159	1.397	1.678	1.995	2.103	2.605	2.718	3.054	1.530
2009	0.207	0.424	0.866	1.085	1.265	1.666	2.114	2.507	2.660	3.173	3.641	1.396
2010	0.265	0.450	0.571	0.989	1.236	1.491	1.862	2.158	2.425	2.457	2.473	1.358
2011	0.136	0.393	0.609	0.967	1.173	1.516	1.856	1.994	2.159	2.666	2.123	1.350
2012	0.326	0.433	0.904	0.982	1.188	1.522	1.701	1.799	2.496	2.781	3.650	1.254

Table A19. Estimated total landings (catch types A + B1, [000s]) of summer flounder by recreational fishermen as estimated by the Marine Recreational Fisheries Statistics Survey (MRFSS 1982-2003) and Marine Recreational Information Program (MRIP 2004-2012). SHORE mode includes fish taken from beach/bank and man-made structures. P/C indicates catch taken from party/charter boats, while P/R indicates fish taken from private/rental boats. Proportional Standard Error (PSE) is for the TOTAL landings estimate.

	YEAR										
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
North											
Shore	167	144	62	10	70	39	42	4	16	9	26
P/C Boat	138	201	5	3	48	7	1	1	1	8	1
P/R Boat	1,293	747	568	382	2,562	648	377	137	99	173	211
TOTAL	1,598	1,092	635	395	2,680	694	420	142	116	190	238
Mid											
Shore	682	3,296	977	272	478	251	596	84	96	505	200
P/C Boat	5,745	3,321	2,381	1,068	1,541	1,143	1,134	141	412	589	374
P/R Boat	5,731	12,345	11,764	8,454	5,924	5,499	7,153	1,141	2,658	4,573	3,983
TOTAL	12,158	18,962	15,122	9,794	7,943	6,893	8,883	1,366	3,166	5,667	4,557
South											
Shore	272	523	316	504	689	115	308	91	150	51	50
P/C Boat	53	52	110	81	20	1	1	1	1	1	1
P/R Boat	1,392	367	1,292	292	289	162	348	117	361	159	156
TOTAL	1,717	942	1,718	877	998	278	657	209	512	211	207
All											
Shore	1,121	3,963	1,355	786	1,237	405	946	179	262	565	276
P/C Boat	5,936	3,574	2,496	1,152	1,609	1,151	1,136	143	414	598	376
P/R Boat	8,416	13,459	13,624	9,128	8,775	6,309	7,878	1,395	3,118	4,905	4,350
TOTAL	15,473	20,996	17,475	11,066	11,621	7,865	9,960	1,717	3,794	6,068	5,002
PSE (%)	26	7	8	12	7	5	4	6	4	4	4

Table A19 continued.

	YEAR										
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
North											
Shore	37	47	19	22	27	44	34	61	5	18	26
P/C Boat	14	25	7	5	22	26	19	49	14	21	36
P/R Boat	298	584	388	702	669	970	769	1,448	555	401	487
TOTAL	349	656	414	729	718	1,040	822	1,558	574	440	549
Mid											
Shore	186	217	173	134	195	243	157	467	199	123	145
P/C Boat	999	809	260	650	907	333	281	600	316	238	353
P/R Boat	4,579	4,633	2,330	5,137	5,059	4,972	2,610	4,802	3,878	2,272	3,424
TOTAL	5,764	5,659	2,763	5,921	6,161	5,548	3,048	5,869	4,393	2,633	3,922
South											
Shore	118	183	49	50	33	30	22	41	22	14	32
P/C Boat	1	3	1	5	2	1	<1	1	<1	3	<1
P/R Boat	262	202	99	292	253	360	214	332	304	172	55
TOTAL	381	388	149	347	288	391	237	374	327	189	88
All Regions											
Shore	341	447	241	206	255	317	213	569	226	155	203
P/C Boat	1,014	837	268	660	931	360	301	650	331	262	390
P/R Boat	5,139	5,419	2,817	6,131	5,981	6,302	3,593	6,582	4,737	2,845	3,966
TOTAL	6,494	6,703	3,326	6,997	7,167	6,979	4,107	7,801	5,294	3,262	4,559
PSE (%)	4	4	4	3	4	4	4	3	4	4	4

Table A19 continued.

	YEAR								
	2004	2005	2006	2007	2008	2009	2010	2011	2012
North									
Shore	18	11	18	1	0	6	2	1	14
P/C Boat	22	37	39	65	41	12	17	20	16
P/R Boat	649	541	585	360	541	155	179	250	211
TOTAL	690	589	641	426	582	167	199	271	242
Mid									
Shore	129	77	105	85	62	48	35	28	77
P/C Boat	441	459	277	415	131	165	142	106	77
P/R Boat	2,899	2,801	2,814	2,043	1,531	1,351	1,049	1,364	1,741
TOTAL	3,470	3,338	3,197	2,543	1,724	1,565	1,226	1,498	1,895
South									
Shore	53	16	31	13	17	14	23	10	16
P/C Boat	1	2	1	20	<1	1	1	2	3
P/R Boat	104	83	81	107	26	61	53	50	44
TOTAL	157	101	113	140	44	76	77	61	63
All									
Shore	200	104	154	98	79	63	60	39	106
P/C Boat	464	499	317	501	172	178	160	128	96
P/R Boat	3,652	3,425	3,480	2,510	2,099	1,566	1,282	1,663	1,996
TOTAL	4,316	4,028	3,951	3,109	2,350	1,807	1,502	1,830	2,199
PSE (%)	6	6	7	6	9	7	8	8	8

Table A20. Estimated total landings (catch types A + B1, [mt]) of summer flounder by recreational fishermen as estimated by the Marine Recreational Fisheries Statistics Survey (MRFSS 1982-2003) and Marine Recreational Information Program (MRIP 2004-2012). SHORE mode includes fish taken from beach/bank and man-made structures. P/C indicates catch taken from party/charter boats, while P/R indicates fish taken from private/rental boats. Proportional Standard Error (PSE) is for the TOTAL landings estimate.

	YEAR										
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
North											
Shore	87	59	17	7	25	21	32	2	16	6	20
P/C Boat	85	87	4	2	45	4	<1	<1	<1	6	<1
P/R Boat	875	454	388	328	2,597	582	290	141	89	150	175
TOTAL	1,047	600	409	337	2,667	607	323	144	106	162	196
Mid											
Shore	295	1,254	399	140	293	129	330	52	56	306	126
P/C Boat	3,112	2,196	1,426	609	1,093	1,098	776	125	264	364	267
P/R Boat	3,085	8,389	5,686	4,187	3,521	3,596	4,928	985	1,665	2,673	2,536
TOTAL	6,492	11,839	7,511	4,936	4,907	4,823	6,034	1,162	1,985	3,343	2,929
South											
Shore	87	134	98	230	425	34	113	57	76	25	25
P/C Boat	12	12	23	20	7	1	<1	<1	<1	<1	<1
P/R Boat	629	102	471	142	96	54	163	71	161	80	91
TOTAL	728	248	592	392	528	89	277	129	238	106	117
All											
Shore	469	1,447	514	377	743	184	475	111	148	337	171
P/C Boat	3,209	2,295	1,453	631	1,145	1,103	778	127	266	371	269
P/R Boat	4,589	8,945	6,545	4,657	6,214	4,232	5,381	1,197	1,915	2,903	2,802
TOTAL	8,267	12,687	8,512	5,665	8,102	5,519	6,634	1,435	2,329	3,611	3,242
PSE (%)	25	7	8	11	9	9	4	6	4	4	4

Table A20 continued.

	YEAR										
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
North											
Shore	26	29	14	15	17	56	27	73	6	20	32
P/C Boat	10	14	6	8	17	22	18	43	16	30	35
P/R Boat	214	401	320	518	445	833	738	1,536	695	559	540
TOTAL	250	444	340	541	479	911	783	1,652	717	609	607
Mid											
Shore	94	122	108	78	127	160	136	363	187	135	148
P/C Boat	617	499	179	414	712	274	286	649	349	274	457
P/R Boat	2,833	2,958	1,721	3,246	3,898	4,096	2,461	4,596	3,842	2,517	4,009
TOTAL	3,544	3,579	2,008	3,738	4,737	4,530	2,883	5,608	4,378	2,926	4,614
South											
Shore	61	102	30	26	18	18	13	24	15	9	22
P/C Boat	<1	1	<1	2	1	1	<1	<1	<1	1	<1
P/R Boat	150	105	80	147	147	199	115	185	168	88	35
TOTAL	212	208	111	175	166	218	129	210	184	98	58
All											
Shore	181	253	152	119	162	234	176	460	208	164	202
P/C Boat	628	514	186	424	730	297	305	693	366	305	493
P/R Boat	3,197	3,464	2,121	3,911	4,490	5,128	3,314	6,317	4,705	3,164	4,584
TOTAL	4,006	4,231	2,459	4,454	5,382	5,659	3,795	7,470	5,279	3,632	5,279
PSE (%)	4	4	5	3	4	5	5	4	4	4	4

Table A20 continued.

	YEAR								
	2004	2005	2006	2007	2008	2009	2010	2011	2012
North									
Shore	23	12	25	1	0	1	3	1	17
P/C Boat	28	48	52	86	69	23	32	33	22
P/R Boat	841	646	755	498	843	278	296	361	279
TOTAL	892	705	832	584	912	302	330	395	318
Mid									
Shore	126	90	100	82	100	56	48	36	98
P/C Boat	563	664	362	580	209	261	222	158	105
P/R Boat	3,293	3,405	3,437	2,854	2,439	2,050	1,666	2,009	2,286
TOTAL	3,982	4,158	3,898	3,516	2,748	2,367	1,936	2,203	2,488
South									
Shore	33	11	23	8	11	8	14	8	11
P/C Boat	<1	1	1	16	<1	1	1	1	3
P/R Boat	67	54	50	75	18	39	36	38	32
TOTAL	100	66	73	100	29	48	51	47	46
All									
Shore	181	112	148	91	112	64	65	45	126
P/C Boat	591	713	414	681	278	285	255	192	129
P/R Boat	4,202	4,104	4,242	3,427	3,300	2,367	1,997	2,408	2,597
TOTAL	4,974	4,929	4,804	4,199	3,689	2,716	2,317	2,645	2,853
PSE (%)	6	6	6	7	8	11	13	12	8

Table A21. Comparison of Vessel Trip Report (VTR) reported landings of summer flounder by Party (VTRPB) and charter (VTRCB) boats, with landings estimated by the MRFSS/MRIP for the Party/Charter boat (P/C Boat) sector. Data are numeric landings in thousands of fish.

Year	VTRPB	VTRCB	VTR P/C Boat Total	MRFSS/ MRIP P/C Boat Total	Ratio MRFSS/ MRIP to VTR
1995	189	44	233	268	1.15
1996	289	58	347	660	1.90
1997	302	68	370	931	2.52
1998	281	73	354	360	1.02
1999	190	50	240	301	1.25
2000	208	75	283	650	2.30
2001	105	42	147	331	2.25
2002	104	40	144	262	1.82
2003	123	44	167	390	2.35
2004	101	32	133	464	3.49
2005	80	21	101	499	4.94
2006	42	20	62	317	5.11
2007	64	28	92	501	5.45
2008	40	13	53	172	3.25
2009	32	12	44	178	4.05
2010	32	16	48	160	3.33
2011	62	14	76	128	1.68
2012	80	21	101	96	0.95

Table A22. Recreational fishery sampling intensity of summer flounder landings by MRFSS/MRIP subregion. Includes both MRFSS/MRIP and state agency lengths.

Year	Subregion	Landings (A+B1; mt)	Number Measured	mt/100 Lengths
1982	North	1,047	231	453
	Mid	6,492	2,896	224
	South	728	576	126
	TOTAL	8,267	3,703	223
1983	North	600	311	192
	Mid	11,839	4,712	251
	South	248	170	146
	TOTAL	12,687	5,193	244
1984	North	409	168	243
	Mid	7,511	2,195	342
	South	592	283	209
	TOTAL	8,512	2,646	322
1985	North	337	78	432
	Mid	4,936	1,934	255
	South	392	274	143
	TOTAL	5,665	2,286	248
1986	North	2,667	266	1,003
	Mid	4,907	1,808	271
	South	528	288	183
	TOTAL	8,102	2,362	343
1987	North	607	217	280
	Mid	4,823	1,897	254
	South	89	445	20
	TOTAL	5,519	2,559	216
1988	North	323	310	104
	Mid	6,034	2,865	214
	South	277	743	38
	TOTAL	6,634	3,918	172
1989	North	144	107	135
	Mid	1,162	1,582	73
	South	129	358	36
	TOTAL	1,435	2,047	70

Table A22 continued.

Year	Subregion	Landings (A+B1; mt)	Number Measured	mt/100 Lengths
1990	North	106	110	96
	Mid	1,985	2,667	74
	South	238	1,293	18
	TOTAL	2,329	4,070	57
1991	North	162	189	86
	Mid	3,343	4,648	72
	South	106	820	13
	TOTAL	3,611	5,657	64
1992	North	196	425	46
	Mid	2,929	4,504	65
	South	117	566	21
	TOTAL	3,242	5,495	59
1993	North	250	338	63
	Mid	3,544	4,174	74
	South	212	995	20
	TOTAL	4,006	5,507	63
1994	North	444	621	75
	Mid	3,579	3,834	90
	South	208	1,467	14
	TOTAL	4,231	5,922	69
1995	North	340	501	68
	Mid	2,008	1,470	137
	South	111	485	23
	TOTAL	2,459	2,456	100
1996	North	541	919	59
	Mid	3,738	3,373	111
	South	175	1,188	15
	TOTAL	4,454	5,480	81
1997	North	480	786	61
	Mid	4,736	2,988	159
	South	166	1,026	16
	TOTAL	5,382	4,800	112

Table A22 continued.

Year	Subregion	Landings (A+B1; mt)	Number Measured	mt/100 Lengths
1998	North	911	857	106
	Mid	4,530	3,205	141
	South	218	1,259	17
	TOTAL	5,659	5,321	106
1999	North	783	442	177
	Mid	2,883	1,584	182
	South	129	564	23
	TOTAL	3,795	2,590	147
2000	North	1,652	707	234
	Mid	5,608	1,892	296
	South	210	722	29
	TOTAL	7,470	3,321	225
2001	North	717	351	204
	Mid	4,378	2,963	148
	South	184	933	20
	TOTAL	5,279	4,247	124
2002	North	609	366	166
	Mid	2,925	2,695	109
	South	98	596	16
	TOTAL	3,632	3,657	99
2003	North	607	514	118
	Mid	4,614	3,003	154
	South	58	139	42
	TOTAL	5,279	3,656	144
2004	North	892	1,548	58
	Mid	3,982	2,486	160
	South	100	276	36
	TOTAL	4,974	4,310	115
2005	North	705	551	127
	Mid	4,158	1,994	209
	South	66	269	25
	TOTAL	4,929	2,814	175

Table A22 continued.

Year	Subregion	Landings (A+B1; mt)	Number Measured	mt/100 Lengths
2006	North	831	987	84
	Mid	3,898	1,423	274
	South	73	281	26
	TOTAL	4,804	2,691	179
2007	North	583	1,209	48
	Mid	3,516	1,863	189
	South	100	291	34
	TOTAL	4,199	3,363	125
2008	North	912	906	101
	Mid	2,748	1,022	269
	South	29	65	45
	TOTAL	3,689	1,993	185
2009	North	302	260	116
	Mid	2,367	1,939	122
	South	48	132	36
	TOTAL	2,716	2,331	117
2010	North	330	352	94
	Mid	1,936	1,188	163
	South	51	206	25
	TOTAL	2,317	1,746	133
2011	North	395	252	157
	Mid	2,203	1,759	125
	South	47	191	25
	TOTAL	2,645	2,202	120
2012	North	318	259	123
	Mid	2,488	1,514	164
	South	46	228	20
	TOTAL	2,853	2,001	143

Table A23. Estimated recreational landings at age of summer flounder (000s; catch type A + B1).

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+ N
1982	2,750	8,445	3,498	561	215	1	3	0	0	0	0	15,473	0
1983	2,302	11,612	4,978	1,340	528	220	0	16	0	0	0	20,996	16
1984	2,282	9,198	4,831	1,012	147	4	1	0	0	0	0	17,475	0
1985	1,002	5,002	4,382	473	148	59	0	0	0	0	0	11,066	0
1986	1,170	6,405	2,785	1,089	129	15	28	0	0	0	0	11,621	0
1987	467	4,676	2,085	449	182	1	5	0	0	0	0	7,865	0
1988	429	5,742	3,311	387	88	3	0	0	0	0	0	9,960	0
1989	74	539	946	135	16	2	5	0	0	0	0	1,717	0
1990	353	2,770	529	118	23	1	0	0	0	0	0	3,794	0
1991	86	3,611	2,251	79	40	1	0	0	0	0	0	6,068	0
1992	82	3,183	1,620	90	1	26	0	0	0	0	0	5,002	0
1993	79	3,930	2,323	159	1	2	0	0	0	0	0	6,494	0
1994	790	3,998	1,698	184	28	1	4	0	0	0	0	6,703	0
1995	231	1,510	1,426	116	26	16	1	0	0	0	0	3,326	0
1996	116	2,935	3,468	354	123	1	0	0	0	0	0	6,997	0
1997	4	1,148	4,188	1,465	274	88	0	0	0	0	0	7,167	0
1998	0	768	2,915	2,714	515	63	4	0	0	0	0	6,979	0
1999	0	201	1,982	1,520	325	60	19	0	0	0	0	4,107	0
2000	0	578	4,121	2,284	643	170	5	0	0	0	0	7,801	0
2001	0	838	1975	1781	539	121	36	4	0	0	0	5,294	4
2002	1	194	1327	1204	421	92	20	1	2	0	0	3,262	3
2003	0	237	1674	1751	648	171	62	16	0	0	0	4,559	16
2004	24	213	1554	1720	681	220	120	25	0	0	0	4,557	25
2005	3	184	1197	1539	755	238	99	60	35	0	0	4,110	95
2006	4	72	1412	1319	729	317	135	40	24	0	0	4,052	64
2007	2	70	577	1580	714	286	103	33	28	0	0	3,393	61
2008	1	25	97	437	854	520	213	77	148	0	0	2,372	225
2009	1	20	108	467	661	442	130	54	21	5	1	1,910	81
2010	0	14	49	231	575	376	153	47	23	10	6	1,484	86
2011	1	8	34	254	686	520	170	71	23	8	7	1,782	109
2012	1	8	158	578	772	389	179	85	19	9	1	2,199	114

Table A24. Mean weight (kg) at age of summer flounder landings in the recreational fishery.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	0.224	0.404	0.570	1.326	1.846	1.885	2.978	0.000	0.000	0.000	0.000	0.464
1983	0.176	0.370	0.633	0.927	1.194	1.396	0.000	0.000	0.000	0.000	0.000	0.478
1984	0.205	0.364	0.620	0.968	1.771	2.197	4.166	0.000	0.000	0.000	0.000	0.461
1985	0.242	0.398	0.626	1.101	1.748	2.441	0.000	0.000	0.000	0.000	0.000	0.533
1986	0.225	0.447	0.751	1.290	1.740	2.719	3.482	5.960	0.000	0.000	0.000	0.601
1987	0.230	0.412	0.761	1.340	1.839	3.050	4.808	4.640	0.000	0.000	0.000	0.583
1988	0.293	0.488	0.707	1.114	1.921	2.316	0.000	0.000	0.000	0.000	0.000	0.590
1989	0.263	0.512	0.813	1.232	1.784	3.333	1.576	0.000	0.000	0.000	0.000	0.742
1990	0.303	0.460	0.968	1.440	1.677	2.895	6.456	0.000	0.000	0.000	0.000	0.555
1991	0.273	0.433	0.670	1.306	1.372	2.450	0.000	0.000	0.000	0.000	0.000	0.537
1992	0.225	0.504	0.717	1.617	2.279	3.340	0.000	0.000	0.000	0.000	0.000	0.604
1993	0.246	0.518	0.715	1.872	2.442	3.027	0.000	0.000	0.000	0.000	0.000	0.619
1994	0.436	0.583	0.694	1.438	1.923	2.831	3.897	0.000	0.000	0.000	0.000	0.625
1995	0.426	0.575	0.816	1.457	2.603	2.930	3.537	0.000	0.000	0.000	0.000	0.727
1996	0.343	0.532	0.622	1.338	1.341	2.361	3.537	0.000	0.000	0.000	0.000	0.629
1997	0.225	0.487	0.675	0.909	1.153	2.377	0.000	0.000	0.000	0.000	0.000	0.732
1998	0.000	0.525	0.668	0.830	1.257	2.508	2.786	0.000	0.000	0.000	0.000	0.777
1999	0.000	0.508	0.706	0.945	1.549	2.330	2.604	0.000	0.000	0.000	0.000	0.884
2000	0.000	0.760	0.984	1.307	2.388	3.481	3.481	0.000	0.000	0.000	0.000	1.234
2001	0.000	0.621	0.879	1.037	1.539	2.089	2.291	3.738	0.000	0.000	0.000	0.998
2002	0.238	0.488	0.896	1.091	1.519	2.287	2.604	3.200	4.213	0.000	0.000	1.076
2003	0.000	0.677	0.910	1.137	1.597	2.018	2.807	2.714	0.000	0.000	0.000	1.156
2004	0.599	0.635	0.850	1.048	1.412	1.905	2.316	3.002	0.000	0.000	0.000	1.099
2005	0.308	0.571	0.869	1.133	1.408	1.756	2.330	2.357	2.269	0.000	0.000	1.173
2006	0.126	0.619	0.856	1.090	1.344	1.694	2.266	3.310	3.018	3.784	2.964	1.165
2007	0.175	0.492	0.799	1.137	1.467	1.805	2.148	2.878	3.448	3.790	3.065	1.258
2008	0.238	0.445	0.751	1.159	1.397	1.678	1.995	2.103	2.605	2.718	3.054	1.530
2009	0.207	0.424	0.866	1.085	1.265	1.666	2.114	2.507	2.660	3.173	3.641	1.396
2010	0.265	0.450	0.571	0.989	1.236	1.491	1.862	2.158	2.425	2.457	2.773	1.358
2011	0.136	0.393	0.609	0.967	1.173	1.516	1.856	1.994	2.159	2.666	2.123	1.350
2012	0.326	0.433	0.904	0.982	1.188	1.522	1.701	1.799	2.496	2.781	3.650	1.254

Table A25. Estimated summer flounder recreational landings (catch types A + B1), live discard (catch type B2), and total catch (catch types A + B1 + B2) in numbers (000s), Proportional Standard Error (PSE) of the total catch estimate, and live discard (catch type B2) as a proportion of total catch. Catch type B2 uses estimates for NC from NCDMF (T. Wadsworth, NCDMF, pers. comm.)

Year	A+B1	B2	A+B1+B2	PSE (%)	B2 / (A+B1+B2)
1982	15,473	8,084	23,557	59	0.34
1983	20,996	11,026	32,022	16	0.34
1984	17,475	12,307	29,782	11	0.41
1985	11,066	2,461	13,526	15	0.18
1986	11,621	13,656	25,276	8	0.54
1987	7,865	13,472	21,337	6	0.63
1988	9,960	7,201	17,161	6	0.42
1989	1,717	909	2,625	10	0.34
1990	3,794	5,283	9,077	5	0.58
1991	6,068	9,871	15,938	5	0.62
1992	5,002	7,561	12,542	5	0.60
1993	6,494	17,744	24,235	5	0.73
1994	6,703	12,333	19,035	5	0.65
1995	3,326	13,570	16,894	5	0.80
1996	6,997	13,023	19,984	4	0.65
1997	7,167	13,888	21,021	4	0.66
1998	6,979	16,961	23,939	4	0.71
1999	4,107	17,825	21,940	5	0.81
2000	7,801	18,649	26,444	4	0.71
2001	5,294	24,073	29,343	3	0.82
2002	3,262	13,360	16,648	3	0.80
2003	4,559	15,776	20,335	4	0.78
2004	4,316	15,951	20,336	4	0.79
2005	4,028	21,674	25,806	5	0.84
2006	3,951	17,396	21,404	5	0.82
2007	3,109	17,536	20,736	5	0.85
2008	2,350	20,485	22,899	5	0.90
2009	1,807	22,324	24,097	5	0.93
2010	1,502	22,174	23,736	5	0.94
2011	1,830	20,380	22,266	7	0.92
2012	2,199	14,458	16,657	5	0.87

Table A26. Recreational fishery sample size for summer flounder discard mortality assumption. Includes MRFSS landed fish sampling, American Littoral Society (ALS) reported released lengths, CT Volunteer Angler Survey (CTVAS) reported released lengths, MADMF party boat sampling (MADMF), NYDEC Party Boat Survey sampling (NYPBS), MDDNR Volunteer Angler Logs (MDVAL), and MRF For-Hire Survey (MRF FHS) reported released lengths. Number of MRFSS lengths is for landed fish measured that were less than the state or federal minimum landed size, and assumed to be indicative of the length frequency of the discarded catch. This length frequency was used to characterize the length frequency of the released catch. All other sources of released lengths were used to verify this assumption. In 2002 and 2003, samples of discarded summer flounder from CTVAS and NYPBS used to directly characterize the discard in those states. The MRF FHS began sampling in 2005. B2 mt estimates use NC from NCDMF (T. Wadsworth, NCDMF, pers. comm.)

Year	Source	Discard Mortality (B2; mt)	Number of Lengths	mt/100 Lengths
1982	MRFSS		2,048	
	ALS		1	
	Total	296	2,049	14
1983	MRFSS		2,683	
	ALS			
	Total	376	2,683	14
1984	MRFSS		1,521	
	ALS		1,134	
	Total	415	2,683	15
1985	MRFSS		1,032	
	ALS		695	
	Total	92	1,727	5
1986	MRFSS		976	
	ALS		1,445	
	Total	578	2,421	24
1987	MRFSS		1,164	
	ALS		1,496	
	Total	522	2,660	20
1988	MRFSS		1,065	
	ALS		1,640	
	Total	341	2,705	13
1989	MRFSS		448	
	ALS		171	
	Total	45	619	7

Table A26 continued.

Year	Source	Discard Mortality (B2; mt)	Number of Lengths	mt/100 Lengths
1990	MRFSS		1,588	
	ALS		1,318	
	Total	234	2,906	8
1991	MRFSS		2,230	
	ALS		2,126	
	Total	429	4,356	10
1992	MRFSS		1,401	
	ALS		1,807	
	Total	344	3,208	11
1993	MRFSS		966	
	ALS		3,923	
	Total	910	4,889	19
1994	MRFSS		1,079	
	ALS		3,061	
	Total	687	4,140	17
1995	MRFSS		267	
	ALS		2,307	
	Total	753	2,574	29
1996	MRFSS		639	
	ALS		2,383	
	Total	681	3,022	23
1997	MRFSS		221	
	ALS		2,468	
	Total	556	2,689	21
1998	MRFSS		1,083	
	ALS		3,015	
	Total	734	4,098	18
1999	MRFSS		429	
	ALS		3,688	
	Total	711	4,117	17

Table A26 continued.

Year	Source	Discard Mortality (B2; mt)	Number of Lengths	mt/100 Lengths
2000	MRFSS		421	
	ALS		5,962	
	CTVAS		2,893	
	NYPBS		681	
	Total	952	9,957	10
2001	MRFSS		637	
	ALS		3,453	
	CTVAS		999	
	NYPBS		834	
	MDVAL		2,316	
	Total	1,274	8,239	15
2002	MRFSS		721	
	CTVAS		1,526	
	ALS		2,931	
	NYPBS		1,840	
	MADMF		12	
	Total	777	7,030	11
2003	MRFSS		215	
	ALS		2,466	
	CTVAS		1,407	
	NYPBS		2,167	
	Total	882	6,255	14
2004	MRIP		321	
	ALS		2,153	
	CTVAS		661	
	NYPBS		1,222	
	Total	1,034	4,357	24
2005	MRIP		142	
	ALS		3,398	
	CTVAS		1,199	
	MRF FHS		3,210	
	Total	999	7,949	13

Table A26 continued.

Year	Source	Discard Mortality (B2; mt)	Number of Lengths	mt/100 Lengths
2006	MRIP		180	
	ALS		3,104	
	CTVAS		1,124	
	MDVAL		2,944	
	MRF FHS		2,924	
	Total	795	10,276	8
2007	MRIP		266	
	ALS		4,072	
	CTVAS		1,038	
	MRF FHS		3,364	
	Total	1,130	8,740	13
2008	MRIP		224	
	ALS		5,437	
	CTVAS		843	
	MRF FHS		3,353	
	Total	1,251	9,857	13
2009	MRIP		167	
	ALS		4,873	
	CTVAS		1,023	
	NJVAS		1,918	
	MDVAS		5,466	
	VAVAS		928	
	MRF FHS		3,366	
	Total	1,195	17,741	7
2010	MRIP		147	
	ALS		6,469	
	CTVAS		973	
	NJVAS		2,412	
	MRF FHS		3,722	
	Total	1,079	13,723	8

Table A26 continued.

Year	Source	Discard Mortality (B2; mt)	Number of Lengths	mt/100 Lengths
2011	MRIP		129	
	ALS		5,133	
	NJVAS		2,867	
	MRF FHS		3,404	
	Total	1,074	11,533	9
2012	MRIP		122	
	ALS		4,033	
	NJVAS		1,170	
	MRF FHS		1,677	
	Total	815	7,002	12

Table A27. Estimated recreational fishery discards at age of summer flounder (catch type B2). NC estimates by NCMDF. Discards during 1982-1996 allocated to age groups in same relative proportions as ages 0 and 1 in the subregional catch; during 1997-2000 allocated to age groups in same relative proportions as fish less than the annual EEZ minimum size in the subregional catch; during 2001-2012 allocated to age groups in the same relative proportion as fish less than the minimum size in the respective state catch from MRFSS sampling and as indicated by state agency or ALS sampling of the released catch. All years assume 10% release mortality.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+ N
1982	172	636	0	0	0	0	0	0	0	0	0	808	0
1983	175	932	0	0	0	0	0	0	0	0	0	1107	0
1984	210	1,020	0	0	0	0	0	0	0	0	0	1230	0
1985	40	206	0	0	0	0	0	0	0	0	0	246	0
1986	150	1,217	0	0	0	0	0	0	0	0	0	1367	0
1987	106	1,210	0	0	0	0	0	0	0	0	0	1316	0
1988	55	665	0	0	0	0	0	0	0	0	0	720	0
1989	13	83	0	0	0	0	0	0	0	0	0	96	0
1990	60	470	0	0	0	0	0	0	0	0	0	530	0
1991	24	977	0	0	0	0	0	0	0	0	0	1001	0
1992	17	674	0	0	0	0	0	0	0	0	0	691	0
1993	34	1,740	0	0	0	0	0	0	0	0	0	1774	0
1994	216	1,017	0	0	0	0	0	0	0	0	0	1233	0
1995	189	1,168	0	0	0	0	0	0	0	0	0	1357	0
1996	50	1,249	0	0	0	0	0	0	0	0	0	1299	0
1997	24	820	522	23	0	0	0	0	0	0	0	1389	0
1998	0	685	875	136	0	0	0	0	0	0	0	1696	0
1999	84	587	987	125	0	0	0	0	0	0	0	1783	0
2000	0	587	1097	180	0	0	0	0	0	0	0	1864	0
2001	0	1261	888	239	17	0	0	0	0	0	0	2405	0
2002	75	565	569	190	8	0	0	0	0	0	0	1407	0
2003	49	785	599	194	14	0	0	0	0	0	0	1641	0
2004	85	508	794	307	7	0	0	0	0	0	0	1701	0
2005	254	1153	739	160	8	0	0	0	0	0	0	2314	0
2006	155	552	887	145	13	2	0	0	0	0	0	1754	0
2007	101	667	674	514	65	7	0	0	0	0	0	2028	0
2008	140	807	609	398	246	45	10	3	2	2	0	2262	7
2009	218	897	626	440	162	28	2	1	1	0	0	2375	2
2010	150	808	594	450	194	35	7	2	1	1	1	2243	5
2011	97	481	570	595	241	41	5	3	1	1	1	2036	6
2012	101	165	411	539	197	21	7	3	1	1	0	1446	5

Table A28. Mean weight (kg) at age of summer flounder discards in the recreational fishery.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	0.224	0.404	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.366
1983	0.176	0.370	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.339
1984	0.205	0.364	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.337
1985	0.242	0.398	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.373
1986	0.225	0.447	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.423
1987	0.230	0.412	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.397
1988	0.293	0.488	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.473
1989	0.263	0.512	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.478
1990	0.303	0.460	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.442
1991	0.273	0.433	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.429
1992	0.225	0.504	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.497
1993	0.246	0.518	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.513
1994	0.436	0.586	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.560
1995	0.426	0.575	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.554
1996	0.343	0.532	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.525
1997	0.225	0.394	0.417	0.423	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.400
1998	0.000	0.400	0.453	0.469	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.433
1999	0.127	0.378	0.427	0.455	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.399
2000	0.000	0.478	0.523	0.540	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.510
2001	0.000	0.472	0.570	0.667	0.756	0.000	0.000	0.000	0.000	0.000	0.000	0.530
2002	0.206	0.419	0.665	0.737	0.807	1.893	0.000	0.000	0.000	0.000	0.000	0.552
2003	0.169	0.420	0.645	0.737	1.040	0.000	0.000	0.000	0.000	0.000	0.000	0.537
2004	0.255	0.454	0.678	0.769	1.078	0.000	0.000	0.000	0.000	0.000	0.000	0.608
2005	0.207	0.358	0.550	0.736	1.118	0.000	0.000	0.000	0.000	0.000	0.000	0.432
2006	0.157	0.348	0.523	0.686	0.919	1.389	0.000	0.000	0.000	0.000	0.000	0.453
2007	0.170	0.336	0.593	0.802	1.024	1.483	0.000	0.000	0.000	0.000	0.000	0.557
2008	0.184	0.349	0.558	0.742	0.897	1.162	1.634	2.321	2.506	3.354	0.000	0.553
2009	0.167	0.315	0.549	0.774	0.948	1.167	1.316	1.415	1.405	0.000	0.000	0.503
2010	0.162	0.294	0.466	0.686	0.854	1.156	1.623	2.272	3.203	3.427	2.567	0.481
2011	0.177	0.302	0.479	0.622	0.816	1.154	1.775	2.232	2.683	3.217	2.536	0.527
2012	0.206	0.335	0.486	0.623	0.782	1.283	1.657	1.918	3.260	3.187	4.007	0.564

Table A29. Estimated total landings (catch types A + B1) of summer flounder by recreational fishermen as estimated by the Marine Recreational Information Program (MRIP). SHORE mode includes fish taken from beach/bank and man-made structures. P/C indicates catch taken from party/charter boats, while P/R indicates fish taken from private/rental boats. Proportional Standard Error (PSE) is for the TOTAL landings estimate. MRIP Estimates are currently available only for 2004-2012.

STATE	2004	2005	2006	2007	2008	2009	2010	2011
CT	216,154	156,724	137,521	112,227	145,661	44,944	35,028	53,421
Shore	4,523	2,500	7,193	0	0	0	0	0
P/C Boat	3,155	423	0	2,020	866		436	164
P/R Boat	208,476	153,801	130,328	110,206	144,795	44,944	34,592	53,258
DE	111,362	72,696	88,149	108,264	35,227	87,232	53,512	80,897
Shore	1,271	2,418	4,822	3,565	3,028	2,535	4,748	2,111
P/C Boat	6,318	6,307	4,938	11,840	1,636	11,004	1,220	878
P/R Boat	103,773	63,971	78,388	92,859	30,562	73,693	47,544	77,908
MD	42,261	117,021	37,471	103,849	57,895	64,647	25,215	17,615
Shore	5,105	10,485	1,770	47,280	11,102	9,186	685	6,051
P/C Boat	1,134	1,974	2,537	3,057	3,866	2,072	1,111	2,401
P/R Boat	36,022	104,563	33,164	53,512	42,927	53,389	23,419	9,163
MA	224,729	267,081	238,970	138,071	232,285	50,382	45,156	76,610
Shore	0	4,344	5,819	0	0	633		0
P/C Boat	1,144	4,118	22,544	9,970	1,161	2,703	4,609	1,435
P/R Boat	223,585	258,619	210,607	128,101	231,124	47,046	40,547	75,175
NH	0	0	717	0	562	0	0	0
Shore	0	0	0	0	0	0	0	0
P/R Boat	0	0	717	0	562	0	0	0
NJ	1,616,811	1,300,223	1,556,151	1,067,404	761,843	824,887	552,401	724,828
Shore	37,807	20,662	63,429	19,586	11,171	23,586	19,901	15,294
P/C Boat	147,120	163,348	189,475	195,448	68,163	97,872	85,225	73,260
P/R Boat	1,431,885	1,116,213	1,303,247	852,370	682,509	703,429	447,274	636,275
NY	1,024,670	1,163,329	752,388	865,957	608,925	298,634	334,491	369,962
Shore	60,216	22,407	20,283	0	5,748	8,645	1,588	0
P/C Boat	203,595	283,229	71,959	198,898	53,498	50,505	41,927	24,504
P/R Boat	760,859	857,693	660,146	667,059	549,679	239,483	290,976	345,458
NC	156,967	101,289	113,340	140,296	43,537	75,538	77,431	61,323
Shore	52,899	16,062	31,139	12,842	17,179	13,653	23,347	9,925
P/C Boat	469	2,305	1,383	20,233	27	897	1,271	1,553
P/R Boat	103,599	82,922	80,817	107,221	26,331	60,988	52,813	49,844
RI	248,988	164,909	264,142	175,778	203,745	71,739	118,455	141,312
Shore	13,811	4,055	4,896	459	0	0	1,940	528
P/C Boat	17,807	32,491	16,222	53,383	39,093	9,151	12,287	18,850
P/R Boat	217,371	128,363	243,024	121,936	164,652	62,587	104,228	121,934
VA	674,552	684,272	762,597	397,041	260,221	289,075	260,050	304,289
Shore	24,735	21,364	15,061	14,687	31,111	4,452	7,603	4,775
P/C Boat	83,034	4,496	8,040	5,619	3,668	3,692	12,296	4,655
P/R Boat	566,783	658,412	739,496	376,735	225,442	280,931	240,151	294,859
TOTAL	4,316,495	4,027,544	3,951,446	3,108,887	2,349,901	1,807,077	1,501,739	1,830,258
PSE (%)	6	6	7	6	9	7	8	8

Table A30. Percentage difference in estimated total landings (catch types A + B1) of summer flounder by recreational fishermen as estimated by the MRFSS and MRIP ([MRIP-MRFSS]/MRFSS) by state and fishing mode. Positive value indicates MRIP estimate is larger. SHORE mode includes fish taken from beach/bank and man-made structures. P/C indicates catch taken from party/charter boats, while P/R indicates fish taken from private/rental boats.

MRIP-MRFSS (delta %)

	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL
CT	0%	-26%	28%	3%	26%	-27%	-12%	-15%	-2.6%
Shore	33%	85%	81%			-100%			23.3%
P/C Boat	3%	-77%		23%	1%		-17%	56%	-11.7%
P/R Boat	-1%	-27%	26%	3%	26%	-24%	-12%	-15%	-2.9%
DE	-10%	-20%	-20%	-8%	7%	-5%	-26%	-15%	-13.2%
Shore	18%	-15%	-39%	-40%	32%	-28%	-24%	-19%	-24.3%
P/C Boat	-19%	-27%	7%	15%	-2%	-1%	-10%	3%	-4.8%
P/R Boat	-10%	-19%	-20%	-9%	5%	-5%	-26%	-15%	-13.2%
MD	-36%	37%	-36%	-34%	-35%	-28%	-36%	-39%	-24.2%
Shore	-38%	-18%	-67%	-17%	-26%	71%	104%	52%	-15.1%
P/C Boat	-73%	58%	10%	16%	65%	-37%	-29%	101%	-3.1%
P/R Boat	-33%	47%	-35%	-45%	-41%	-34%	-37%	-62%	-27.0%
MA	-20%	31%	9%	82%	55%	4%	3%	80%	19.7%
Shore	-100%	-73%	25%			-68%			-61.0%
P/C Boat		149%	4%	47%	-42%	26%	-16%	37%	16.7%
P/R Boat	-19%	40%	9%	85%	56%	7%	6%	81%	22.1%
NH			-52%		-46%				-49.7%
Shore									
P/R Boat			-52%		-46%				-49.7%
NJ	-14%	-7%	0%	-20%	-11%	-19%	-4%	-8%	-10.6%
Shore	-50%	-47%	71%	-37%	49%	-12%	14%	-26%	-17.3%
P/C Boat	-32%	-5%	-9%	29%	27%	-17%	32%	12%	-2.8%
P/R Boat	-10%	-6%	-1%	-26%	-14%	-19%	-10%	-9%	-11.4%
NY	9%	1%	-6%	22%	8%	13%	29%	28%	8.9%
Shore	87%	-4%	-2%		-38%	-12%	-22%		22.2%
P/C Boat	-11%	13%	-38%	27%	31%	17%	48%	-5%	4.3%
P/R Boat	13%	-2%	-1%	20%	7%	13%	27%	32%	9.6%
NC	-9%	-21%	-26%	-24%	-18%	30%	-16%	-7%	-15.2%
Shore	15%	8%	22%	-8%	-7%	13%	8%	-23%	6.9%
P/C Boat	-86%	23%	-36%	2%	-94%	-14%	0%	-21%	-12.0%
P/R Boat	-16%	-26%	-35%	-29%	-23%	36%	-24%	-2%	-20.5%
RI	-14%	-12%	0%	-24%	-1%	40%	40%	-1%	-4.7%
Shore	4%	-14%	53%	-76%			23%	-67%	-2.3%
P/C Boat	-20%	15%	-14%	16%	29%	-4%	-4%	13%	7.9%
P/R Boat	-14%	-17%	1%	-34%	-7%	50%	49%	-2%	-6.6%
VA	16%	17%	-12%	-17%	14%	25%	-6%	13%	3.3%
Shore	-4%	-30%	-22%	-72%	81%	-32%	-23%	-44%	-27.0%
P/C Boat	707%	-51%	18%	-24%	-22%	18%	85%	14%	140.3%
P/R Boat	3%	21%	-12%	-10%	9%	26%	-7%	15%	2.7%
TOTAL	-5.3%	-0.2%	-4.5%	-8.4%	2.4%	-5.4%	1.2%	2.7%	-3.0%

Table A31. Estimated total landings (catch types A + B1, metric tons) of summer flounder by recreational fishermen as estimated by the Marine Recreational Information Program (MRIP). SHORE mode includes fish taken from beach/bank and man-made structures. P/C indicates catch taken from party/charter boats, while P/R indicates fish taken from private/rental boats. Proportional Standard Error (PSE) is for the TOTAL landings estimate. MRIP Estimates are currently available only for 2004-2012.

STATE	2004	2005	2006	2007	2008	2009	2010	2011
CT	248	195	197	168	256	89	60	94
Shore	4	3	12	0	0	0	0	0
P/C Boat	4	1	0	3	1	0	1	0
P/R Boat	240	191	185	165	254	89	59	94
DE	137	95	112	148	65	118	73	97
Shore	2	4	5	5	6	3	7	3
P/C Boat	9	8	6	16	3	16	2	1
P/R Boat	126	83	101	127	56	99	64	94
MD	41	126	33	93	71	75	41	24
Shore	6	9	2	37	13	11	1	8
P/C Boat	1	2	2	3	5	2	2	3
P/R Boat	34	115	29	53	53	62	38	14
MA	280	284	278	166	283	56	51	89
Shore	0	4	7	0	0	1	0	0
P/C Boat	1	4	28	12	1	3	6	1
P/R Boat	279	276	243	155	282	52	45	87
NH	0	0	1	0	0	0	0	0
Shore	0	0	0	0	0	0	0	0
P/R Boat	0	0	1	0	0	0	0	0
NJ	1,765	1,449	1,782	1,239	952	1,117	731	928
Shore	32	20	52	22	17	22	24	19
P/C Boat	175	219	245	215	91	135	112	102
P/R Boat	1,559	1,210	1,485	1,002	844	960	595	807
NY	1,252	1,703	1,076	1,442	1,242	645	734	767
Shore	63	33	27	0	6	17	7	0
P/C Boat	259	430	100	338	104	103	86	46
P/R Boat	930	1,240	950	1,103	1,132	524	640	720
NC	100	66	74	100	29	48	51	47
Shore	33	11	23	8	11	8	14	8
P/C Boat	0	1	1	16	0	1	1	1
P/R Boat	67	54	50	75	18	39	36	38
RI	364	227	356	250	372	157	219	212
Shore	19	5	6	1	0	0	3	1
P/C Boat	23	43	23	71	66	20	25	32
P/R Boat	322	179	326	178	306	136	192	180
VA	786	785	894	594	418	413	358	387
Shore	23	24	14	18	59	3	9	7
P/C Boat	119	5	8	7	6	5	20	6
P/R Boat	645	756	872	569	354	405	328	374
TOTAL	4,974	4,929	4,804	4,199	3,689	2,716	2,317	2,645
PSE (%)	6	6	6	7	8	11	13	12

Table A32. Percentage difference in estimated total landings (catch types A + B1, metric tons) of summer flounder by recreational fishermen as estimated by the MRFSS and MRIP ([MRIP-MRFSS]/MRFSS) by state and fishing mode. Positive value indicates MRIP estimate is larger. SHORE mode includes fish taken from beach/bank and man-made structures. P/C indicates catch taken from party/charter boats, while P/R indicates fish taken from private/rental boats.

MRIP-MRFSS (delta%)	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL
CT	-3%	-27%	27%	3%	31%	-33%	-15%	-12%	-3.1%
Shore	33%	72%	173%			-100%			24.9%
P/C Boat	18%	-74%		26%	1%		34%	93%	2.0%
P/R Boat	-4%	-27%	23%	2%	31%	-30%	-16%	-13%	-3.4%
DE	-6%	-20%	-13%	-10%	6%	-2%	-26%	-12%	-10.9%
Shore	6%	42%	-35%	-34%	27%	-28%	-16%	-22%	-15.1%
P/C Boat	71%	-27%	8%	23%	10%	4%	-14%	6%	8.7%
P/R Boat	-10%	-21%	-12%	-12%	4%	-2%	-28%	-11%	-12.0%
MD	-37%	130%	-35%	-34%	-38%	-27%	-36%	-31%	-20.0%
Shore	-32%		-63%	-19%	-40%	77%		75%	-6.0%
P/C Boat	-59%	83%	23%	31%	59%	-29%	-34%	97%	11.7%
P/R Boat	-37%	115%	-34%	-44%	-41%	-34%	-38%	-53%	-23.6%
MA	-23%	30%	-17%	77%	48%	-2%	-7%	52%	8.4%
Shore	-100%	-29%	24%			-73%			-39.1%
P/C Boat		117%	9%	21%	-46%	20%	-13%	26%	11.4%
P/R Boat	-22%	31%	-20%	84%	50%	0%	-6%	53%	8.9%
NH			-56%		-46%				-53.4%
Shore									
P/R Boat			-56%		-46%				-53.4%
NJ	-7%	-5%	-7%	-22%	-15%	-18%	-5%	-8%	-11.0%
Shore	-58%	-48%	78%	-32%	67%	-9%	3%	-24%	-19.3%
P/C Boat	34%	14%	1%	27%	18%	-15%	32%	21%	13.5%
P/R Boat	-8%	-6%	-10%	-27%	-18%	-19%	-10%	-10%	-13.6%
NY	21%	5%	-7%	24%	9%	10%	27%	27%	12.3%
Shore	83%	36%	-4%		-46%	-19%	62%		24.4%
P/C Boat	69%	23%	-37%	44%	36%	18%	70%	-1%	26.7%
P/R Boat	9%	-1%	-3%	19%	8%	10%	23%	30%	9.5%
NC	-10%	-20%	-22%	-24%	-21%	22%	-18%	-5%	-15.2%
Shore	8%	4%	37%	-11%	-12%	2%	1%	-14%	4.9%
P/C Boat	-92%	-20%	-33%	3%	-95%	-18%	30%	-8%	-15.6%
P/R Boat	-13%	-24%	-34%	-29%	-25%	28%	-25%	-3%	-19.9%
RI	-4%	-9%	-8%	-23%	1%	40%	39%	0%	-1.5%
Shore	28%	-7%	332%	-73%			-4%	-74%	16.2%
P/C Boat	65%	13%	-9%	13%	28%	-2%	-3%	12%	13.9%
P/R Boat	-9%	-13%	-10%	-31%	-3%	49%	48%	-1%	-4.0%
VA	19%	18%	-11%	-16%	16%	23%	-6%	8%	3.6%
Shore	-13%	-32%	31%	-64%	117%	-36%	-19%	-45%	-12.1%
P/C Boat	2044%	-53%	11%	-33%	-19%	17%	114%	10%	190.6%
P/R Boat	3%	22%	-12%	-12%	9%	23%	-9%	10%	1.6%
TOTAL	1%	3%	-8%	-6%	3%	-5%	4%	4%	-1.3%

Table A33. Estimated total live releases (catch type B2) of summer flounder by recreational fishermen as estimated by the Marine Recreational Information Program (MRIP). SHORE mode includes fish taken from beach/bank and man-made structures. P/C indicates catch taken from party/charter boats, while P/R indicates fish taken from private/rental boats. Proportional Standard Error (PSE) is for the TOTAL landings estimate. MRIP Estimates are currently available only for 2004-2011.

	2004	2005	2006	2007	2008	2009	2010	2011
CT	269,617	778,857	1,111,460	297,486	990,604	428,159	373,075	319,973
Shore	37,742	15,055	19,236	3,887	1,748	9,817	37,667	8,270
P/C Boat	6,500	963	399	3,416	648		1,282	12
P/R Boat	225,375	762,839	1,091,825	290,182	988,208	418,342	334,127	311,692
DE	737,214	795,130	445,165	1,071,823	604,647	963,700	618,711	601,611
Shore	45,244	64,748	20,179	50,300	65,578	71,566	89,956	73,406
P/C Boat	16,886	32,919	14,060	24,010	9,379	28,762	12,355	3,583
P/R Boat	675,083	697,463	410,926	997,513	529,690	863,372	516,400	524,621
ME							65	
P/C Boat							65	
MD	806,075	360,963	252,483	1,018,330	922,577	816,487	1,225,452	486,095
Shore	178,759	157,364	50,808	335,274	330,253	273,923	573,455	237,207
P/C Boat	34,142	2,523	18,501	22,838	35,510	36,540	29,642	25,500
P/R Boat	593,173	201,077	183,174	660,218	556,814	506,024	622,354	223,388
MA	348,478	358,046	610,373	135,351	273,021	96,356	214,713	221,512
Shore	18,132	128,401	66,200	9,655	2,955	893		45,565
P/C Boat	1,279	9,721	23,359	3,252	1,952	5,171	5,915	2,495
P/R Boat	329,067	219,924	520,814	122,445	268,114	90,292	208,798	173,451
NH	265	1,809	301	218	280	762		
Shore	225			218				
P/R Boat	40	1,809	301		280	762		
NJ	6,701,873	8,939,286	6,739,513	6,192,157	8,959,312	10,414,443	10,564,678	8,247,828
Shore	408,818	779,906	422,346	674,706	460,593	638,629	1,317,649	1,431,155
P/C Boat	412,847	571,270	1,005,129	541,215	486,027	570,680	535,783	550,498
P/R Boat	5,880,207	7,588,110	5,312,038	4,976,236	8,012,692	9,205,133	8,711,246	6,266,174
NY	3,182,287	7,753,367	4,945,661	5,271,601	5,521,407	5,563,769	6,571,251	7,666,674
Shore	100,118	181,011	48,666	184,804	426,756	286,374	273,002	235,356
P/C Boat	475,156	1,108,245	553,581	629,274	502,558	477,480	358,193	586,829
P/R Boat	2,607,013	6,464,111	4,343,415	4,457,523	4,592,093	4,799,914	5,940,055	6,844,489
NC	0	1,755	55,117	4,249	4,411	10,959	15,687	5,417
Shore	0	0	16,886	0	2,364	0	149	403
P/C Boat	0	148	3,562	2,820	2,048	10,959	13,660	4,326
P/R Boat	0	1,608	34,670	1,430	0	0	1,877	689
RI	277,293	280,034	1,129,097	612,107	848,075	382,262	230,311	797,361
Shore	18,088	6,423	58,039	15,812	16,739	7,783	34,806	5,899
P/C Boat	11,841	33,821	45,119	108,834	100,541	38,053	23,161	34,108
P/R Boat	247,364	239,789	1,025,939	487,462	730,796	336,425	172,344	757,354
VA	3,696,609	2,509,013	2,164,118	3,023,421	2,424,687	3,613,064	2,419,838	2,089,498
Shore	849,401	504,097	200,203	444,811	248,877	893,987	282,305	235,368
P/C Boat	75,435	17,274	18,999	26,030	33,536	49,049	40,038	21,261
P/R Boat	2,771,774	1,987,643	1,944,916	2,552,580	2,142,273	2,670,028	2,097,495	1,832,869
TOTAL	16,019,710	21,778,262	17,453,288	17,626,743	20,549,020	22,289,961	22,233,782	20,435,970

Table A34. Percentage difference in estimated total live releases (catch type B2) of summer flounder by recreational fishermen as estimated by the MRFSS and MRIP ([MRIP-MRFSS]/MRFSS) by state and fishing mode. Positive value indicates MRIP estimate is larger. SHORE mode includes fish taken from beach/bank and man-made structures. P/C indicates catch taken from party/charter boats, while P/R indicates fish taken from private/rental boats.

MRIP-MRFSS (delta)

STATE	2004	2005	2006	2007	2008	2009	2010	2011	TOTAL
CT	-26%	-7%	23%	-8%	25%	-22%	-16%	-24%	-1%
Shore	61%	-13%	12%	-56%	52%	-18%	60%	48%	22%
P/C Boat	87%	-74%	12%	18%	32%		-40%	-32%	2%
P/R Boat	-33%	-7%	24%	-7%	25%	-23%	-20%	-25%	-2%
DE	-13%	-5%	-17%	-2%	-16%	-2%	-20%	-16%	-10%
Shore	-42%	-10%	-34%	-23%	-43%	-20%	-36%	-24%	-30%
P/C Boat	-9%	-32%	30%	36%	7%	9%	-7%	-2%	-4%
P/R Boat	-10%	-3%	-16%	-2%	-11%	0%	-17%	-14%	-8%
ME							59%		59%
P/C Boat							59%		59%
MD	-15%	-17%	-51%	-37%	-29%	-21%	-25%	-31%	-28%
Shore	-31%	-23%	-67%	-33%	-15%	12%	3%	-10%	-17%
P/C Boat	-40%	11%	32%	92%	45%	-25%	-30%	19%	-7%
P/R Boat	-7%	-12%	-46%	-41%	-38%	-31%	-40%	-46%	-34%
MA	-10%	16%	10%	37%	51%	-21%	52%	69%	17%
Shore	13%	-18%	50%	6%	-73%	-30%		20%	-1%
P/C Boat	88%	166%	2%	40%	-31%	-4%	-31%	21%	10%
P/R Boat	-11%	48%	6%	40%	60%	-22%	57%	90%	21%
NH	38%	25%	-50%	-48%	35%	220%			17%
Shore	112%			-48%					-16%
P/R Boat	-54%	25%	-50%		35%	220%			23%
NJ	-7%	-10%	-1%	-13%	-4%	-8%	-1%	-1%	-6%
Shore	-34%	11%	60%	12%	34%	-8%	8%	13%	7%
P/C Boat	-3%	8%	5%	31%	37%	4%	14%	3%	10%
P/R Boat	-5%	-13%	-5%	-19%	-7%	-8%	-3%	-4%	-8%
NY	19%	0%	-6%	0%	-10%	-4%	8%	10%	1%
Shore	15%	-62%	-38%	3%	42%	-3%	17%	-30%	-13%
P/C Boat	43%	23%	-42%	51%	0%	13%	9%	-1%	5%
P/R Boat	15%	1%	2%	-4%	-14%	-5%	8%	13%	1%
NC		-3%	-19%	-10%	41%	-16%	-17%	-12%	-16%
Shore			40%		176%		-61%	-71%	35%
P/C Boat		-14%	-14%	-15%	-10%	-16%	-7%	-3%	-11%
P/R Boat		-2%	-34%	3%			-50%	134%	-32%
RI	-7%	-18%	8%	-29%	-12%	10%	7%	-5%	-7%
Shore	10%	-75%	12%	-54%	19%	10%	101%	-8%	-6%
P/C Boat	-12%	13%	-12%	26%	49%	3%	-4%	18%	17%
P/R Boat	-7%	-16%	9%	-35%	-18%	11%	-1%	-6%	-9%
VA	4%	7%	-5%	-11%	-12%	13%	-2%	9%	0%
Shore	32%	17%	-41%	11%	-10%	20%	-6%	-7%	8%
P/C Boat	170%	-31%	39%	-28%	-23%	4%	-11%	-4%	8%
P/R Boat	-3%	5%	1%	-14%	-12%	11%	-1%	12%	-1%
TOTAL	-2%	-4%	-3%	-11%	-7%	-4%	-1%	2%	-4%

Table A35. Total catch at age of summer flounder (000s), ME-NC.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
1982	5344	19423	10149	935	328	117	66	26	4	0	0	36392	30
1983	4925	28441	10911	2181	693	323	16	36	5	2	0	47533	43
1984	4802	26582	15454	3180	829	94	5	5	1	4	0	50956	10
1985	2078	14623	17979	1767	496	252	30	5	2	1	0	37233	8
1986	1943	17141	11056	3783	316	140	58	8	3	0	0	34448	11
1987	1138	17214	10840	1649	544	25	29	27	11	0	0	31477	38
1988	789	20440	14528	2138	642	121	19	15	6	0	0	38698	21
1989	1080	4213	7754	1713	357	55	9	3	1	0	0	15186	4
1990	1458	8497	2217	1011	221	31	7	2	1	0	0	13445	3
1991	449	9382	7162	742	217	32	3	1	0	0	0	17989	1
1992	3043	15085	6507	1143	151	69	2	1	0	0	0	26001	1
1993	952	11924	6118	585	74	46	19	2	1	0	0	19721	3
1994	1922	12503	7697	968	209	28	13	0	5	0	0	23345	5
1995	2119	5914	7563	1245	401	78	5	1	0	0	0	17325	1
1996	281	7286	9889	1914	481	94	18	3	5	1	0	19971	8
1997	66	2669	8519	3305	592	172	11	4	0	0	0	15337	4
1998	101	2346	6667	5333	1035	158	31	3	0	0	0	15675	3
1999	189	2255	6440	4206	1228	358	55	11	0	0	0	14743	11
2000	13	1674	8741	4895	1598	382	83	19	9	1	1	17417	30
2001	38	3109	4826	3690	1255	356	118	28	5	2	2	13428	36
2002	176	1934	5773	3924	1317	316	144	18	4	1	0	13606	23
2003	56	2142	5415	4206	1631	588	250	74	25	3	2	14392	103
2004	130	1238	6356	5023	2046	840	346	130	51	11	5	16174	196
2005	273	2070	4234	4454	2409	1186	591	304	211	66	36	15833	616
2006	164	1127	5705	3465	1948	950	435	149	70	10	4	14027	234
2007	125	1040	2392	4833	1902	810	386	154	83	16	12	11754	265
2008	159	1170	1497	1992	2734	1143	515	219	219	22	9	9680	469
2009	236	1272	2071	2611	2237	1455	468	183	92	26	9	10660	310
2010	161	1401	2224	2989	2682	1232	611	213	104	55	44	11716	416
2011	112	720	2045	3464	3328	1674	638	359	150	54	35	12580	598
2012	111	522	1916	3539	2733	1264	573	304	143	50	19	11173	516

Table A36. Mean weight (kg) at age of summer flounder catch, ME-NC.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
1982	0.255	0.419	0.616	1.447	1.906	2.787	2.668	3.762	4.284	0.000	0.000	0.504	3.831
1983	0.244	0.419	0.716	1.075	1.257	1.495	2.567	3.221	3.875	4.370	0.000	0.522	3.351
1984	0.251	0.398	0.632	1.046	1.500	2.163	3.456	3.620	4.640	4.030	0.000	0.518	3.886
1985	0.290	0.429	0.613	1.109	1.726	2.297	2.671	4.682	4.780	4.800	0.000	0.575	4.721
1986	0.256	0.454	0.668	1.160	1.739	1.994	3.310	2.994	4.415	0.000	0.000	0.613	3.382
1987	0.263	0.446	0.651	1.140	1.941	2.862	3.378	3.020	4.140	0.000	0.000	0.580	3.344
1988	0.319	0.462	0.624	1.130	1.738	2.486	3.888	3.539	4.319	0.000	0.000	0.588	3.762
1989	0.135	0.456	0.689	1.040	1.474	2.248	2.408	2.861	2.251	0.000	0.000	0.650	2.709
1990	0.214	0.421	0.811	1.162	1.538	2.143	3.024	3.944	5.029	0.000	0.000	0.543	4.305
1991	0.166	0.441	0.701	1.186	1.812	2.519	2.975	3.660	0.000	0.000	0.000	0.589	3.660
1992	0.183	0.417	0.718	1.226	1.392	2.687	2.302	4.456	0.000	0.000	0.000	0.512	4.456
1993	0.208	0.482	0.689	1.478	1.671	1.865	2.816	4.136	5.199	0.000	0.000	0.573	4.490
1994	0.310	0.489	0.598	1.349	2.092	2.763	3.399	0.000	3.703	0.000	0.000	0.565	3.703
1995	0.228	0.532	0.675	1.058	1.643	2.645	3.624	4.094	0.000	0.000	0.000	0.631	4.094
1996	0.265	0.496	0.559	1.076	1.629	2.341	2.727	5.363	4.747	4.510	0.000	0.619	4.914
1997	0.204	0.448	0.633	0.862	1.244	2.257	2.609	3.429	0.000	0.000	0.000	0.693	3.429
1998	0.221	0.522	0.643	0.842	1.324	2.444	2.745	3.815	0.000	0.000	0.000	0.758	3.815
1999	0.156	0.340	0.583	0.876	1.423	1.944	2.736	3.467	3.904	0.000	0.000	0.738	3.471
2000	0.094	0.567	0.784	1.079	1.783	2.702	2.645	2.743	3.526	3.357	3.707	0.992	3.025
2001	0.135	0.536	0.766	0.970	1.454	2.171	2.611	3.505	3.893	4.884	5.499	0.893	3.736
2002	0.192	0.438	0.723	0.956	1.382	2.107	2.734	3.567	4.776	2.983	0.000	0.865	3.744
2003	0.171	0.473	0.739	1.026	1.526	2.072	2.794	3.183	3.733	3.598	4.993	0.979	3.357
2004	0.307	0.490	0.720	0.969	1.361	1.788	2.409	3.008	3.450	3.759	3.819	0.979	3.183
2005	0.208	0.425	0.674	0.922	1.187	1.512	1.897	2.168	2.422	3.351	3.377	0.959	2.452
2006	0.156	0.453	0.665	0.964	1.271	1.661	2.240	2.951	3.429	4.020	2.797	0.957	3.138
2007	0.167	0.387	0.681	0.941	1.279	1.734	2.220	2.526	3.172	3.440	3.563	1.025	2.831
2008	0.180	0.372	0.592	0.870	1.162	1.559	1.920	2.221	2.678	3.291	3.362	1.055	2.507
2009	0.167	0.348	0.583	0.837	1.084	1.497	1.943	2.521	2.728	3.492	3.872	0.959	2.703
2010	0.169	0.316	0.503	0.758	1.047	1.398	1.899	2.329	2.860	3.296	3.694	0.912	2.734
2011	0.182	0.327	0.495	0.676	0.998	1.501	1.864	2.197	2.666	2.940	3.482	0.962	2.457
2012	0.202	0.335	0.568	0.742	1.022	1.473	1.845	1.982	2.609	2.998	3.972	0.969	2.328

Table A37. Commercial and recreational fishery landings, revised estimated commercial and recreational dead discard, and total catch statistics (metric tons) as used in the assessment of summer flounder, Maine to North Carolina. Includes MRIP 2004-2012 estimates of recreational catch, and 1982-2003 recreational catch adjusted by the 2004-2011 MRIP to MRFSS ratio for each catch type.

	Commercial			Recreational			Total		
Year	Landings	Discard	Catch	Landings	Discard	Catch	Landings	Discard	Catch
1982	10,400	n/a	10,400	8,163	284	8,447	18,563	284	18,847
1983	13,403	n/a	13,403	12,527	361	12,889	25,930	361	26,292
1984	17,130	n/a	17,130	8,405	399	8,804	25,535	399	25,934
1985	14,675	n/a	14,675	5,594	88	5,682	20,269	88	20,357
1986	12,186	n/a	12,186	8,000	555	8,555	20,186	555	20,741
1987	12,271	n/a	12,271	5,450	502	5,951	17,721	502	18,222
1988	14,686	n/a	14,686	6,550	328	6,878	21,236	328	21,564
1989	8,125	456	8,834	1,417	43	1,460	9,542	499	10,294
1990	4,199	898	5,413	2,300	225	2,525	6,499	1,122	7,938
1991	6,224	219	7,276	3,566	412	3,978	9,790	631	11,254
1992	7,529	2,151	8,219	3,201	332	3,533	10,730	2,483	11,752
1993	5,715	701	6,561	3,956	874	4,830	9,671	1,575	11,391
1994	6,588	1,535	7,494	4,178	660	4,838	10,766	2,195	12,332
1995	6,977	821	7,285	2,428	723	3,152	9,405	1,545	10,437
1996	5,861	1,436	6,324	4,398	656	5,054	10,259	2,092	11,378
1997	3,994	806	4,320	5,314	535	5,849	9,308	1,341	10,169
1998	5,076	634	5,465	5,588	705	6,293	10,664	1,339	11,758
1999	4,820	1,660	6,368	3,747	683	4,430	8,567	2,343	10,798
2000	5,085	1,617	5,811	7,376	915	8,291	12,461	2,532	14,102
2001	4,970	405	5,438	5,213	1,225	6,438	10,183	1,630	11,876
2002	6,573	922	7,022	3,586	746	4,332	10,159	1,668	11,354
2003	6,450	1,144	6,978	5,213	847	6,060	11,663	1,991	13,038
2004	8,228	1,606	8,472	4,974	1,013	5,987	13,202	2,619	14,459
2005	7,826	1,484	8,056	4,929	950	5,879	12,755	2,434	13,935
2006	6,262	1,482	6,550	4,804	768	5,572	11,066	2,250	12,122
2007	4,489	2,110	4,793	4,199	1,002	5,201	8,688	3,112	9,994
2008	4,143	1,162	4,452	3,689	1,154	4,843	7,832	2,316	9,295
2009	4,848	1,446	4,966	2,716	1,140	3,856	7,564	2,586	8,822
2010	5,930	1,466	6,128	2,317	1,066	3,383	8,247	2,532	9,511
2011	7,511	1,096	7,637	2,645	1,093	3,738	10,156	2,189	11,375
2012	6,047	718	6,765	2,853	815	3,668	8,900	1,533	10,433

Table A38. NEFSC research trawl survey indices of abundance for summer flounder. Indices are stratified mean numbers (n) and weight (kg) per tow. Spring indices are for offshore strata 1-12 61-76; fall indices are for offshore strata 1-2, 5-6, 9-10, 61, 65, 69, and 73. Winter indices (1992-2007) are for NEFSC offshore strata 1-3, 5-7, 9-11, 13-14, 16-17, 61-63, 65-67, 69-71, and 73-75. n/a = not available due to incomplete coverage (spring) or end of survey (winter). Note that door and vessel conversion factors for 1967-2008 are not significant; 1967-2008 gear conversion factors have not been included due to limited sample size and extreme violation of underlying assumptions in experimental work.

Year	Spring (n)	Spring (kg)	Fall (n)	Fall (kg)
1967	n/a	n/a	1.35	1.25
1968	0.15	0.16	1.10	1.00
1969	0.19	0.16	0.59	0.61
1970	0.09	0.09	0.15	0.13
1971	0.22	0.28	0.42	0.27
1972	0.47	0.21	0.39	0.27
1973	0.76	0.54	0.87	0.63
1974	1.37	1.26	1.70	1.86
1975	1.97	1.61	3.00	2.48
1976	2.83	2.00	1.14	0.85
1977	2.84	1.74	2.17	1.75
1978	2.55	1.40	0.32	0.40
1979	0.40	0.35	1.17	0.94
1980	1.30	0.78	0.94	0.57
1981	1.50	0.80	0.91	0.72
1982	2.27	1.11	1.57	0.90
1983	0.95	0.53	0.90	0.47
1984	0.66	0.38	0.99	0.65
1985	2.38	1.20	1.24	0.87
1986	2.14	0.82	0.68	0.45
1987	0.93	0.38	0.26	0.28
1988	1.50	0.68	0.11	0.11
1989	0.32	0.24	0.20	0.08
1990	0.72	0.27	0.27	0.19
1991	1.08	0.35	0.51	0.17

Table A38 continued.

Year	Winter (n)	Winter (kg)	Spring (n)	Spring (kg)	Fall (n)	Fall (kg)
1992	12.30	4.90	1.20	0.46	0.85	0.49
1993	13.60	5.50	1.27	0.48	0.11	0.04
1994	12.05	6.03	0.93	0.46	0.60	0.35
1995	10.93	4.81	1.09	0.46	1.13	0.83
1996	31.25	12.35	1.76	0.67	0.71	0.45
1997	10.28	5.54	1.06	0.61	1.32	0.92
1998	7.76	5.13	1.19	0.76	2.32	1.58
1999	11.06	7.99	1.60	1.01	2.42	1.66
2000	15.76	12.59	2.14	1.70	1.90	1.82
2001	18.59	15.68	2.69	2.16	1.56	1.55
2002	22.68	18.43	2.47	2.29	1.32	1.40
2003	35.62	27.48	2.91	2.42	2.00	1.93
2004	17.77	15.25	3.03	2.43	3.00	3.06
2005	12.89	10.32	1.81	1.59	1.57	1.83
2006	21.04	15.93	1.77	1.34	2.10	1.79
2007	16.83	12.89	3.25	3.17	2.21	2.45
2008	n/a	n/a	1.40	1.38	1.38	1.62

Table A39. NEFSC research trawl spring and fall survey indices from the *FSV Henry B. Bigelow* (HBB) and **aggregate calibrated, equivalent indices for the FSV Albatross IV (ALB) time series**. Indices are stratified mean numbers (n) and weight (kg) per tow. Spring indices are for offshore strata 1-12, 61-76; fall indices are for offshore strata 1-2, 5-6, 9-10, 61, 65, 69, and 73. **The aggregate spring catch number calibration factor is 3.2255; the spring catch weight factor is 3.0657; the fall catch number factor is 2.4054; the fall catch weight factor is 2.1409.**

Year	Spring (n) HBB	Spring (kg) HBB	Spring (n) ALB	Spring (kg) ALB
2009	5.672	3.598	1.758	1.174
2010	7.131	4.808	2.211	1.568
2011	8.174	4.929	2.534	1.608
2012	6.612	5.007	1.062	1.633

Year	Fall (n) HBB	Fall (kg) HBB	Fall (n) ALB	Fall (kg) ALB
2009	7.062	5.622	2.936	2.626
2010	3.466	2.941	1.441	1.374
2011	5.663	5.751	2.354	2.686
2012	3.420	3.795	1.422	1.773

Table A40. NEFSC trawl survey spring and fall survey indices from the FSV Henry B. Bigelow (HBB) and **length calibrated, equivalent indices for the FSV Albatross IV (ALB) time series**. Indices are the sum of the stratified mean numbers (n) at length. Spring strata set includes offshore strata 1-12, 61-76. Fall strata set (aged set) includes offshore strata 1, 5, 9, 61, 65, 69, 73, and inshore strata 1-61. The HBB does not sample the shallowest inshore strata (0-18 m, 0-60 ft, 0-10 fathoms). **The length calibration factors are for the lengths observed in the 2008 calibration experiment and include a constant swept area factor of 0.579. The effective total catch number calibration factors (HBB/ALB ratios) vary by year and season, depending on the characteristics of the HBB length frequency distributions.**

Year	Spring (n) HBB	HBB CV	Spring (n) ALB	Effective Factor
2009	5.672	12.1	2.845	1.994
2010	7.131	10.9	3.772	1.891
2011	8.174	15.9	4.448	1.838
2012	6.612	13.9	3.623	1.825

Year	Fall (n) HBB	HBB CV	Fall (n) ALB	Effective Factor
2009	9.509	19.4	5.128	1.854
2010	4.876	16.9	2.688	1.814
2011	7.385	22.1	3.945	1.872
2012	5.573	23.7	2.838	1.964

Table A41. NEFSC trawl survey spring survey indices at age from the FSV Henry B. Bigelow (HBB) and **length calibrated equivalent indices at age for the FSV Albatross IV (ALB) time series.** The spring strata set includes offshore strata 1-12, 61-76. Indices at age are compiled after the application of **length calibration factors including a constant swept area factor of 0.579. The effective catch number at age calibration factors (HBB/ALB ratios) vary by year and season, depending on the characteristics of the HBB length frequency distributions**.

Spring 2009	0	1	2	3	4	5	6	7+	Total
HBB	0.00	1.76	1.54	1.15	0.61	0.41	0.11	0.11	5.67
ALB	0.00	0.72	0.89	0.63	0.32	0.20	0.05	0.04	2.85
HBB/ALB	0.00	2.44	1.73	1.83	1.91	2.05	2.20	2.75	1.99

2010	0	1	2	3	4	5	6	7+	Total
HBB	0.00	1.95	1.87	1.51	0.93	0.47	0.19	0.22	7.13
ALB	0.00	0.95	1.09	0.83	0.49	0.24	0.09	0.08	3.77
HBB/ALB	0.00	2.05	1.72	1.82	1.90	1.96	2.11	2.75	1.89

2011	0	1	2	3	4	5	6	7+	Total
HBB	0.00	1.48	2.44	2.18	1.06	0.63	0.16	0.22	8.17
ALB	0.00	0.72	1.43	1.25	0.56	0.32	0.08	0.09	4.45
HBB/ALB	0.00	2.06	1.71	1.74	1.89	1.97	2.00	2.44	1.84

2012	0	1	2	3	4	5	6	7+	Total
HBB	0.00	0.48	1.07	2.60	1.43	0.59	0.24	0.20	6.61
ALB	0.00	0.24	0.62	1.51	0.76	0.30	0.12	0.07	3.62
HBB/ALB	0.00	2.00	1.73	1.72	1.88	1.97	2.00	2.86	1.83

Table A42. NEFSC trawl survey fall survey indices at age from the FSV Henry B. Bigelow (HBB) and **length calibrated equivalent indices at age for the FSV Albatross IV (ALB) time series.** The fall strata set (aged set) includes offshore strata 1, 5, 9, 61, 65, 69, 73, and inshore strata 1-61. Indices at age are compiled after **the application of length calibration factors including a constant swept area factor of 0.579. The effective catch number at age calibration factors (HBB/ALB ratios) vary by year and season, depending on the characteristics of the HBB length frequency distributions.**

Fall 2009	0	1	2	3	4	5	6	7+	Total
HBB	0.64	3.41	2.27	1.52	0.94	0.42	0.13	0.18	9.51
ALB	0.27	1.97	1.27	0.81	0.48	0.21	0.05	0.06	5.13
HBB/ALB	2.37	1.73	1.79	1.88	1.96	2.00	2.60	3.00	1.85
2010	0	1	2	3	4	5	6	7+	Total
HBB	0.23	1.66	1.28	0.78	0.46	0.27	0.11	0.09	4.88
ALB	0.10	0.96	0.74	0.43	0.24	0.13	0.05	0.04	2.69
HBB/ALB	2.30	1.73	1.73	1.81	1.92	2.08	2.20	2.25	1.81
2011	0	1	2	3	4	5	6	7+	Total
HBB	0.33	1.74	1.99	1.30	0.65	0.48	0.31	0.59	7.39
ALB	0.15	1.01	1.14	0.71	0.33	0.23	0.15	0.23	3.95
HBB/ALB	2.20	1.72	1.75	1.83	1.97	2.09	2.07	2.57	1.87
2012	0	1	2	3	4	5	6	7+	Total
HBB	0.61	0.43	0.78	1.96	1.15	0.32	0.13	0.21	5.57
ALB	0.17	0.25	0.45	1.08	0.60	0.16	0.06	0.07	2.84
HBB/ALB	3.59	1.72	1.73	1.81	1.92	2.00	2.17	3.00	1.96

Table A43. NEFSC spring trawl survey (offshore strata 1-12, 61-76) stratified mean number of summer flounder per tow at age. Coefficient of Variation (CV) in percent.

	Age											
Year	1	2	3	4	5	6	7	8	9	10+	ALL	CV
1976	0.03	1.77	0.71	0.29	0.01	0.01	0.01				2.83	33
1977	0.61	1.31	0.71	0.10	0.09	0.01		0.01			2.84	16
1978	0.68	0.93	0.64	0.19	0.04	0.03	0.03			0.01	2.55	19
1979	0.06	0.18	0.08	0.04	0.03			0.01			0.40	23
1980	0.01	0.70	0.31	0.14	0.02	0.06	0.03	0.02		0.01	1.30	15
1981	0.60	0.54	0.17	0.08	0.05	0.03	0.02	0.01			1.50	16
1982	0.70	1.43	0.12	0.02							2.27	20
1983	0.32	0.39	0.19	0.03	0.01				0.01		0.95	15
1984	0.17	0.33	0.09	0.05		0.01	0.01				0.66	29
1985	0.55	1.56	0.21	0.04	0.02						2.38	22
1986	1.48	0.43	0.20	0.02	0.01						2.14	16
1987	0.47	0.43	0.02	0.01							0.93	15
1988	0.60	0.81	0.07	0.02							1.50	23
1989	0.06	0.23	0.02	0.01							0.32	20
1990	0.63	0.03	0.06								0.72	22
1991	0.79	0.27		0.02							1.08	17
1992	0.77	0.41	0.01		0.01						1.20	18
1993	0.73	0.50	0.04								1.27	18
1994	0.35	0.53	0.04	0.01							0.93	15
1995	0.79	0.27	0.02				0.01				1.09	21
1996	1.08	0.56	0.12								1.76	26
1997	0.29	0.67	0.09	0.01							1.06	15
1998	0.27	0.52	0.32	0.06	0.01	0.01					1.19	21
1999	0.22	0.74	0.48	0.13	0.02	0.01					1.60	22
2000	0.19	1.03	0.63	0.12	0.15	0.02					2.14	15
2001	0.48	0.89	1.02	0.20	0.05	0.04	0.01				2.69	13
2002	0.34	0.89	0.74	0.31	0.10	0.03	0.05	0.01			2.47	16
2003	0.54	1.29	0.59	0.29	0.13	0.06	0.01	0.01			2.91	11
2004	0.30	1.45	0.85	0.27	0.05	0.06	0.04				3.03	22
2005	0.26	0.65	0.58	0.15	0.10	0.05	0.02		<.0.1		1.81	20
2006	0.04	1.04	0.24	0.25	0.09	0.06	0.02	0.01		0.02	1.77	18
2007	0.24	0.52	1.46	0.57	0.18	0.13	0.07	0.04	0.01	0.03	3.25	26
2008	0.22	0.35	0.32	0.29	0.11	0.09	0.02				1.40	15
2009	0.72	0.89	0.63	0.32	0.20	0.05	0.02	0.01	0.01	<0.01	2.85	12
2010	0.95	1.09	0.83	0.49	0.24	0.09	0.05	0.02	0.01	<0.01	3.77	11
2011	0.72	1.43	1.25	0.56	0.32	0.08	0.04	0.03	0.01	0.01	4.45	16
2012	0.24	0.62	1.51	0.76	0.30	0.12	0.04	0.02	<0.01	<0.01	3.62	14

Table A44. NEFSC spring trawl survey (offshore strata 1-12, 61-76) summer flounder mean length (cm) at age.

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11	12
1976	25.9	36.0	43.1	53.5	60.8	70.0	72.0					
1977	25.2	35.0	43.4	51.7	59.6	63.0		74.0				
1978	27.3	34.8	40.9	46.9	53.3	59.5	64.0				65.0	75.0
1979	25.1	37.0	43.2	51.5	54.8			77.0				
1980	29.0	28.8	38.1	44.2	51.1	53.0	67.7	77.0		81.0		
1981	25.3	32.2	39.8	48.9	55.7	62.9	67.8	74.0				
1982	28.6	36.2	47.3	46.7								
1983	25.5	37.7	43.4	53.3	61.4				77.0			
1984	27.1	33.9	41.8	56.7		63.0	56.0					
1985	26.8	36.1	42.8	57.2	54.5							
1986	28.6	36.3	46.0	56.0	63.0							
1987	27.8	37.7	47.3	58.0								
1988	27.7	36.3	47.8	45.0								
1989	30.4	39.2	51.5	60.0								
1990	28.3	47.7	48.6									
1991	27.0	38.8		42.1								
1992	27.9	37.7	57.0		72.0							
1993	27.5	37.9	51.9									
1994	33.0	36.8	48.0	53.1								
1995	29.4	40.0	46.4				72.0					
1996	29.8	36.2	47.2									
1997	29.4	38.3	49.4	54.1								
1998	27.6	39.1	42.7	50.5	50.0	60.0						
1999	28.5	35.8	42.9	49.1	57.7	64.0						
2000	29.5	37.9	44.3	49.4	55.4	60.5						
2001	29.6	39.1	44.9	53.4	60.5	63.8	55.0					
2002	29.7	39.3	45.8	52.7	58.1	63.5	62.1	66.0	54.0	68.0		
2003	32.4	39.3	46.5	51.4	57.5	65.2	51.0	65.0				
2004	29.5	37.6	46.1	50.4	56.9	61.9	63.3					
2005	29.2	39.1	45.1	50.9	55.0	58.3	71.3				73.0	
2006	28.3	36.3	42.1	47.6	51.8	54.0	57.0	63.0		62.0	66.0	
2007	28.3	38.7	43.0	48.2	55.2	53.9	60.4	65.6	61.0	69.4		63.0
2008	32.0	37.3	45.1	49.0	55.9	59.6	57.9					
2009	25.9	36.7	41.3	46.2	52.6	59.9	62.4	63.6	68.2	67.0		
2010	28.4	35.2	41.1	45.5	50.7	56.9	60.5	64.4	65.7	69.5	73.0	68.0
2011	28.3	33.9	37.9	43.6	49.4	56.5	55.7	58.3	64.5	60.4	82.0	
2012	28.8	33.9	37.0	43.3	51.3	57.5	62.3	61.6	64.7	65.2	66.9	

Table A45. NEFSC fall trawl survey (offshore strata <= 55 m [1, 5, 9, 61, 65, 69, 73, inshore strata 1-61]) mean number of summer flounder per tow at age. Coefficient of Variation (CV) in percent.

	Age									
Year	0	1	2	3	4	5	6	7+	ALL	CV
1982	0.55	1.52	0.40	0.03					2.50	25
1983	0.96	1.46	0.34	0.12	0.01	0.01			2.90	13
1984	0.18	1.39	0.43	0.07	0.01	0.01	<0.01		2.09	27
1985	0.59	0.80	0.46	0.05		0.02			1.92	17
1986	0.39	0.83	0.11	0.11		<0.01			1.44	18
1987	0.07	0.58	0.20	0.03	0.02				0.90	15
1988	0.06	0.62	0.18	0.03					0.89	10
1989	0.31	0.21	0.05						0.57	19
1990	0.44	0.38	0.03	0.04		<0.01			0.89	11
1991	0.76	0.84	0.09		0.01	<0.01	<0.01		1.70	14
1992	0.99	1.04	0.25	0.03	0.01	<0.01			2.32	17
1993	0.23	0.80	0.03	0.01			<0.01		1.07	12
1994	0.75	0.67	0.09	0.01	0.01				1.53	12
1995	0.93	1.16	0.28	0.02	0.01				2.40	14
1996	0.11	1.24	0.57	0.04					1.96	15
1997	0.17	1.29	1.14	0.29	0.02	0.01	0.01	<0.01	2.93	16
1998	0.38	2.13	1.63	0.33	0.04	0.01			4.52	20
1999	0.21	1.73	1.49	0.31	0.04	0.01			3.79	14
2000	0.22	1.20	1.22	0.40	0.15	0.06	0.03	0.04	3.32	13
2001	0.12	1.36	0.93	0.37	0.11	0.10		0.01	3.00	18
2002	0.06	1.17	0.86	0.35	0.11	0.03	0.03	0.02	2.63	21
2003	0.18	1.31	1.03	0.25	0.10	0.03	0.07	0.01	2.98	18
2004	0.36	1.49	1.37	0.66	0.19	0.07	0.06	0.04	4.24	19
2005	0.16	1.14	0.54	0.47	0.18	0.10	0.13	0.03	2.75	18
2006	0.31	0.72	1.22	0.35	0.17	0.06	0.07	0.02	2.91	14
2007	0.12	0.84	0.91	0.96	0.31	0.09	0.09	0.04	3.36	29
2008	0.39	0.52	0.59	0.33	0.46	0.16	0.10	0.09	2.64	16
2009	0.27	1.97	1.27	0.81	0.48	0.21	0.05	0.06	5.13	20
2010	0.10	0.96	0.74	0.43	0.24	0.13	0.05	0.04	2.69	17
2011	0.15	1.01	1.14	0.71	0.33	0.23	0.14	0.23	3.94	21
2012	0.17	0.25	0.45	1.08	0.60	0.16	0.06	0.08	2.84	24

Table A46. NEFSC fall trawl survey (offshore strata <= 55 m [1, 5, 9, 61, 65, 69, 73, inshore strata 1-61]) summer flounder mean length (cm) at age.

				Age				
Year	0	1	2	3	4	5	6	7+
1982	28.2	35.1	43.3	47.1				
1983	24.5	33.5	42.7	52.3	60.0	58.0		
1984	23.5	33.6	41.1	46.5	62.6	65.0	70.0	
1985	25.5	35.4	43.1	53.0		63.0		
1986	23.1	35.7	40.8	53.5		57.0		
1987	27.4	34.4	46.0	53.6	47.7			
1988	30.1	35.9	43.4	61.7				
1989	25.8	35.8	48.2	60.0				
1990	24.8	36.0	45.2	54.9	60.0	68.0		
1991	23.2	34.7	43.7	59.0	61.2	67.0	69.0	
1992	25.3	34.4	42.7	51.3	58.8	68.0		
1993	29.9	35.1	44.0	58.1	59.0		70.0	
1994	27.5	38.0	44.3	61.5	57.0			
1995	26.5	36.7	47.4	59.0	65.0			
1996	26.6	35.4	41.6	56.1				
1997	28.4	35.1	40.3	46.5	51.7	59.3	56.0	63.0
1998	24.0	34.7	42.6	50.2	58.2	68.6		
1999	24.1	34.7	40.0	48.5	55.6	56.8		
2000	25.2	35.7	42.1	48.6	53.5	59.9	68.0	66.5
2001	21.8	36.3	42.6	50.0	54.0	62.1		67.0
2002	25.4	36.8	43.8	49.5	55.3	61.4	67.9	69.9
2003	23.2	37.0	43.4	51.8	56.8	59.5	58.5	72.0
2004	23.9	36.8	43.5	48.4	56.2	59.4	60.7	71.2
2005	28.8	34.2	42.2	47.5	51.6	56.4	63.5	63.8
2006	21.5	35.9	41.1	48.1	52.9	55.2	57.6	63.5
2007	22.7	34.2	41.9	46.4	52.4	55.1	58.7	71.0
2008	21.5	35.0	40.4	44.9	48.3	50.9	57.3	63.8
2009	27.7	33.3	39.6	44.2	49.7	53.3	59.2	67.7
2010	28.1	33.0	36.8	41.4	46.9	52.9	57.9	62.8
2011	28.5	33.6	37.3	41.7	47.6	53.2	54.9	59.1
2012	26.2	34.0	36.9	40.9	45.9	54.2	57.8	62.1

Table A47. NEFSC winter trawl survey (offshore strata from 27-185 meters (15-100 fathoms) 1-3, 5-7, 9-11, 13-14, 16-17, 61-63, 65-67, 69-71, 73-75; Southern Georges Bank to Cape Hatteras): mean number and mean weight (kg) per tow. The winter survey ended in 2007.

Year	Stratified mean number per tow	Coefficient of variation (%)	Stratified mean weight (kg) per tow	Coefficient of variation (%)
1992	12.30	16	4.90	15
1993	13.60	15	5.50	12
1994	12.05	18	6.03	16
1995	10.93	12	4.81	12
1996	31.25	24	12.35	22
1997	10.28	24	5.54	17
1998	7.76	21	5.13	17
1999	11.06	13	7.99	11
2000	15.76	13	12.59	13
2001	18.59	11	15.68	13
2002	22.55	16	18.71	16
2003	35.62	19	27.48	19
2004	17.77	14	15.25	15
2005	12.89	15	10.32	20
2006	21.04	14	15.93	14
2007	16.83	13	12.89	15

Table A48. NEFSC winter trawl survey (offshore strata from 27-185 meters (15-100 fathoms) 1-3, 5-7, 9-11, 13-14, 16-17, 61-63, 65-67, 69-71, 73-75; Southern Georges Bank to Cape Hatteras): mean number at age per tow. The winter survey ended in 2007.

Year	Age												
	1	2	3	4	5	6	7	8	9	10	11	12+	Total
1992	7.15	4.74	0.33	0.04	0.01	0.03							12.29
1993	6.50	6.70	0.31	0.05	0.02	0.02							13.60
1994	3.76	7.20	0.82	0.26			0.01						12.05
1995	6.07	4.59	0.25	0.02									10.93
1996	22.17	8.33	0.60	0.12	0.03								31.25
1997	3.86	4.80	1.04	0.43	0.11	0.04							10.28
1998	1.68	3.25	2.29	0.42	0.10	0.01				0.01			7.76
1999	2.11	4.80	2.90	0.84	0.28	0.06	0.04	0.02		0.01			11.06
2000	0.70	6.52	4.96	2.51	0.78	0.17	0.08	0.04	0.01				15.76
2001	3.07	5.33	6.42	2.44	0.80	0.37	0.09	0.05	0.01		0.01	0.01	18.59
2002	2.77	10.74	5.58	2.26	0.85	0.32	0.13	0.02	0.01				22.68
2003	8.17	14.36	8.48	2.67	1.04	0.39	0.32	0.15	0.05		0.01		35.62
2004	1.45	8.68	4.56	1.64	0.62	0.41	0.19	0.16	0.02	0.03	0.01		17.77
2005	2.96	4.03	3.07	1.34	0.70	0.33	0.17	0.13	0.12	0.03		0.01	12.89
2006	2.64	9.06	4.29	2.47	1.32	0.56	0.24	0.22	0.14	0.07	0.01	0.04	21.04
2007	2.77	6.18	5.15	1.54	0.58	0.31	0.16	0.05	0.08	0.01			16.83

Table A49. NEFSC winter trawl survey (offshore strata from 27-185 meters (15-100 fathoms) 1-3, 5-7, 9-11, 13-14, 16-17, 61-63, 65-67, 69-71, 73-75; Southern Georges Bank to Cape Hatteras): summer flounder mean length (cm) at age. The winter survey ended in 2007.

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11	12+
1992	28.0	38.4	48.8	60.0	70.0	69.0						
1993	27.9	37.3	49.4	58.7	58.5	65.0						
1994	28.0	37.5	46.1	56.4			69.0					
1995	27.4	40.2	50.8	59.6								
1996	30.9	38.2	51.4	61.2	63.6							
1997	29.2	37.8	44.5	50.0	57.3	62.5						
1998	28.4	38.0	43.3	52.2	59.7	66.3				64.0		
1999	28.4	36.9	44.5	51.6	59.2	64.1	70.2	68.8		78.0		
2000	28.2	35.9	41.4	49.0	56.3	62.2	68.2	67.1	77.0			
2001	28.3	37.3	43.6	50.2	56.3	61.0	65.3	69.4	58.6		70.0	74.0
2002	30.0	38.5	44.5	51.4	58.1	62.2	66.4	62.7	75.0			
2003	30.8	39.2	45.2	51.4	55.9	61.0	65.6	67.8	67.1		67.0	
2004	28.8	38.6	44.5	50.8	55.0	60.2	65.0	66.6	67.1	72.4	69.0	
2005	27.7	37.6	44.1	48.9	53.3	56.4	60.8	64.1	65.3	70.6		71.5
2006	30.9	36.8	41.0	46.7	51.2	54.6	60.2	61.4	62.1	68.2	65.0	73.3
2007	27.8	38.2	43.5	49.1	53.8	57.3	62.1	63.6	66.0	65.0		

Table A50. MADMF spring survey: stratified mean number per tow at age.

	Age										
Year	0	1	2	3	4	5	6	7	8+	Total	CV (%)
1978		0.102	0.547	0.288	0.232		0.045			1.214	36
1979			0.087	0.090	0.152	0.050	0.011			0.390	31
1980		0.056	0.062	0.053	0.077	0.054	0.056	0.012		0.370	20
1981		0.431	0.593	0.079	0.033	0.046	0.064		0.032	1.278	34
1982		0.350	1.584	0.142	0.042	0.022			0.010	2.150	29
1983		0.051	0.599	0.450	0.024	0.009	0.022		0.012	1.167	17
1984		0.044	0.078	0.067	0.116					0.305	27
1985		0.154	1.260	0.036	0.051	0.004				1.505	20
1986		0.995	0.522	0.185	0.009					1.711	14
1987		0.656	0.640	0.013			0.011			1.320	20
1988		0.211	1.005	0.123	0.014					1.353	18
1989			0.363	0.102			0.011			0.476	22
1990		0.257	0.021	0.081	0.013					0.372	29
1991		0.032	0.050	0.011						0.093	32
1992		0.280	0.342	0.090		0.012	0.011			0.735	21
1993		0.126	0.492	0.065	0.010				0.022	0.715	22
1994		1.860	1.217	0.048	0.023		0.011			3.159	33
1995		0.104	1.302	0.053						1.459	16
1996		0.076	0.686	0.114	0.012					0.888	18
1997		0.544	1.279	0.181	0.116		0.006			2.126	14
1998		0.144	1.212	0.659	0.049	0.050				2.114	20
1999		0.078	0.878	1.112	0.302	0.029		0.016		2.415	19
2000		0.237	1.659	1.205	0.305	0.232	0.054			3.692	17
2001		0.186	1.026	0.730	0.229	0.057				2.228	17
2002		0.151	1.511	0.397	0.102	0.066	0.026	0.014	0.019	2.286	24
2003		0.206	1.440	0.624	0.185	0.118	0.012	0.023		2.608	19
2004		0.027	0.283	0.323	0.061	0.061	0.026	0.023	0.010	0.814	19
2005		0.136	0.351	1.029	0.315	0.132	0.074	0.053	0.107	2.197	19
2006		0.049	2.440	0.975	0.229	0.070	0.086	0.020	0.021	3.890	16
2007		0.254	0.392	1.008	0.102	0.080	0.051	0.012		1.899	13
2008		0.328	0.383	0.167	0.309	0.061	0.016	0.066	0.018	1.348	12
2009		0.251	0.847	0.613	0.146	0.168	0.035	0.040	0.036	2.135	13
2010		0.983	0.670	0.651	0.415	0.043	0.062		0.011	2.835	13
2011		0.150	0.986	0.753	0.144	0.111	0.006			2.148	31
2012		0.109	0.363	1.039	0.315	0.104	0.053	0.011	0.028	2.022	13

Table A51. MADMF fall survey: stratified mean number per tow at age.

					Age						
Year	0	1	2	3	4	5	6	7	8+	Total	CV (%)
1978		0.039	0.442	0.085		0.025				0.591	21
1979			0.050	0.109		0.020				0.179	46
1980		0.123	0.351	0.022	0.022	0.009				0.527	26
1981	0.010	0.400	0.405	0.012						0.827	22
1982	0.038	0.234	1.662	0.019						1.953	15
1983		0.033	0.625	0.154	0.006					0.818	22
1984	0.033	0.485	0.267	0.127		0.011				0.923	23
1985	0.057	0.117	1.895	0.039						2.108	14
1986	0.145	2.316	0.679	0.214	0.008	0.003				3.365	16
1987		1.202	0.663	0.011	0.006					1.882	13
1988		0.474	0.429	0.006	0.007	0.006				0.922	21
1989			0.317	0.016			0.012			0.345	28
1990		0.113		0.011						0.124	33
1991	0.024	0.531	0.288	0.005						0.848	17
1992		1.181	0.186							1.367	27
1993	0.009	0.335	0.478	0.030	0.022					0.874	23
1994	0.052	2.234	0.077							2.363	16
1995	0.011	0.342	0.507							0.860	19
1996		0.761	1.282	0.114	0.006					2.163	23
1997		0.494	1.508	0.351	0.020	0.036				2.409	14
1998		0.012	0.590	0.262	0.018	0.011				0.893	21
1999	0.061	0.347	0.940	0.379	0.037					1.764	15
2000	0.074	1.383	2.303	0.494	0.100	0.092	0.014	0.028		4.488	11
2001	0.011	1.244	1.083	0.307	0.027		0.011	0.017		2.700	20
2002	0.325	2.681	1.302	0.178	0.047	0.036				4.569	13
2003	0.133	3.059	1.254	0.256	0.037	0.028	0.006		0.010	4.783	13
2004	0.026	0.589	1.455	0.136	0.011	0.010				2.227	21
2005		1.557	2.049	1.350	0.446	0.096	0.015	0.015	0.017	5.545	15
2006	0.336	0.586	3.745	0.559	0.043	0.023	0.016			5.308	14
2007	0.399	0.500	0.401	1.039	0.168	0.067	0.016			2.590	20
2008	0.257	1.341	1.238	0.142	0.241	0.045				3.264	16
2009	0.320	0.362	0.784	0.551	0.172	0.126	0.050		0.019	2.383	14
2010	0.078	2.357	0.738	0.459	0.151	0.029	0.031			3.843	20
2011		0.394	1.876	2.200	0.235	0.074	0.011		0.026	4.816	15
2012	0.103	0.216	0.596	1.196	0.249	0.049	0.000	0.000	0.013	2.422	15

Table A52. MADMF seine survey: total catch of age-0 summer flounder.

Year	Total catch
1982	3
1983	3
1984	1
1985	19
1986	5
1987	4
1988	2
1989	4
1990	11
1991	4
1992	0
1993	2
1994	1
1995	14
1996	7
1997	0
1998	13
1999	13
2000	10
2001	1
2002	70
2003	11
2004	4
2005	1
2006	43
2007	38
2008	86
2009	45
2010	4
2011	1
2012	53

Table A53. RIDFW fall trawl survey: stratified mean number per tow at age. RIDFW lengths aged with NEFSC fall trawl survey age-length keys.

	Age										
Year	0	1	2	3	4	5	6	7	8	9+	Total
1981	0.30	0.97	1.74	0.20	0.01	0.00	0.00	0.00	0.00	0.00	3.24
1982	0.02	0.21	0.52	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.83
1983	0.03	0.14	0.42	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.71
1984	0.02	0.74	0.49	0.10	0.00	0.00	0.00	0.00	0.00	0.00	1.35
1985	0.35	0.31	0.28	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.97
1986	0.35	2.45	0.51	0.13	0.00	0.01	0.00	0.00	0.00	0.00	3.46
1987	0.04	0.94	0.37	0.02	0.04	0.00	0.00	0.00	0.00	0.00	1.42
1988	0.00	0.34	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.58
1989	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
1990	0.05	0.67	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84
1991	0.00	0.12	0.08	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.22
1992	0.01	0.77	0.41	0.11	0.07	0.00	0.00	0.00	0.00	0.00	1.38
1993	0.01	0.41	0.22	0.07	0.00	0.00	0.03	0.00	0.00	0.00	0.74
1994	0.04	0.12	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
1995	0.02	0.53	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.76
1996	0.10	0.95	1.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.09
1997	0.03	0.56	0.96	0.30	0.02	0.02	0.00	0.00	0.00	0.00	1.89
1998	0.00	0.09	0.36	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.54
1999	0.02	1.04	1.91	0.35	0.02	0.01	0.00	0.00	0.00	0.00	3.35
2000	0.40	0.50	1.24	0.45	0.14	0.03	0.00	0.00	0.00	0.00	2.76
2001	0.00	1.05	0.63	0.30	0.09	0.07	0.01	0.00	0.00	0.00	2.15
2002	0.44	2.42	1.38	0.40	0.08	0.02	0.03	0.03	0.00	0.00	4.79
2003	0.10	2.35	2.08	0.49	0.12	0.04	0.06	0.00	0.00	0.00	5.24
2004	0.03	0.48	1.30	0.78	0.19	0.06	0.01	0.00	0.00	0.00	2.85
2005	0.01	0.84	1.38	0.69	0.15	0.14	0.01	0.04	0.03	0.00	3.29
2006	0.10	0.14	1.13	0.44	0.16	0.02	0.01	0.00	0.00	0.00	2.00
2007	0.08	0.43	0.86	1.35	0.34	0.13	0.08	0.02	0.00	0.03	3.32
2008	0.12	0.55	1.10	0.62	0.85	0.41	0.16	0.10	0.02	0.00	3.93
2009	0.39	1.05	1.59	1.34	0.77	0.24	0.09	0.01	0.00	0.00	5.47
2010	0.02	0.91	1.24	0.79	0.63	0.45	0.13	0.05	0.03	0.04	4.29
2011	0.02	0.55	1.81	1.77	0.62	0.26	0.07	0.03	0.01	0.03	5.16
2012	0.08	0.14	0.35	1.22	0.85	0.26	0.14	0.03	0.00	0.01	3.09

Table A54. RIDFW monthly fixed station trawl survey: stratified mean number per tow at age. RIDFW lengths aged with NEFSC spring and fall trawl survey age-length keys.

Year	Age										
	0	1	2	3	4	5	6	7	8	9+	Total
1990	0.02	0.17	0.04	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.29
1991		0.07	0.08								0.15
1992	0.01	0.15	0.13	0.04	0.01						0.34
1993	0.01	0.11	0.09	0.04			0.01				0.26
1994	0.04	0.08	0.04		0.01						0.17
1995	0.03	0.02	0.02	0.01							0.08
1996	0.02	0.41	0.40	0.13							0.96
1997	0.04	0.17	0.38	0.13	0.01						0.73
1998		0.07	0.24	0.11	0.01						0.43
1999	0.03	0.26	0.37	0.17	0.05	0.02					0.90
2000	0.09	0.63	1.22	0.49	0.12	0.05	0.01				2.61
2001	0.01	0.42	0.28	0.15	0.06	0.04	0.02				0.98
2002	0.11	0.81	0.63	0.30	0.11	0.05		0.02			2.03
2003	0.05	1.48	1.44	0.45	0.24	0.08	0.04				3.78
2004	0.10	0.54	0.88	0.46	0.13	0.04	0.02				2.17
2005	0.04	0.55	0.98	0.53	0.17	0.16	0.02	0.03	0.01		2.49
2006	0.00	0.24	0.47	0.29	0.23	0.06	0.02	0.01			1.32
2007	0.04	0.25	0.51	0.55	0.20	0.07	0.05	0.01			1.68
2008	0.06	0.36	0.50	0.33	0.46	0.23	0.13	0.04	0.01		2.12
2009	0.12	0.89	1.50	1.28	0.74	0.36	0.12	0.04	0.02	0.01	5.08
2010	0.05	0.50	0.59	0.52	0.40	0.24	0.09	0.03	0.03	0.02	2.47
2011	0.07	0.53	1.16	1.03	0.42	0.24	0.07	0.04	0.02	0.02	3.59
2012	0.02	0.07	0.20	0.53	0.32	0.08	0.03	0.01			1.25

Table A55. University of Rhode Island Graduate School of Oceanography (URIGSO) year-round weekly fixed station trawl survey: mean number per tow.

Year	Fox Is	Whale Rk	Average
1959	2.517	3.347	2.932
1960	1.579	1.583	1.581
1961	3.358	1.492	2.425
1962	1.917	1.063	1.490
1963	0.965	0.083	0.524
1964	1.171	0.246	0.708
1965	1.079	0.679	0.879
1966	1.833	0.567	1.200
1967	0.685	0.135	0.410
1968	0.321	0.042	0.181
1969	0.347	0.033	0.190
1970	0.243	0.071	0.157
1971	0.525	0.067	0.296
1972	0.269	0.000	0.135
1973	1.071	0.322	0.697
1974	3.503	0.581	2.042
1975	2.428	1.272	1.850
1976	8.917	2.674	5.795
1977	2.451	0.350	1.401
1978	1.196	0.528	0.862
1979	1.136	0.590	0.863
1980	0.967	0.100	0.533
1981	4.917	1.284	3.101
1982	2.160	0.835	1.497
1983	1.975	0.629	1.302
1984	0.736	0.451	0.594
1985	0.554	0.432	0.493
1986	1.197	0.889	1.043
1987	1.467	1.842	1.654
1988	1.133	0.713	0.923
1989	0.667	0.096	0.381
1990	0.224	0.078	0.151
1991	1.536	0.188	0.862
1992	0.519	0.228	0.374
1993	0.621	0.083	0.352
1994	0.329	0.163	0.246
1995	0.971	1.258	1.115
1996	1.971	1.713	1.842
1997	1.708	2.071	1.890
1998	2.308	2.258	2.283
1999	4.536	4.475	4.506
2000	4.783	8.161	6.472
2001	4.413	5.367	4.890
2002	6.842	8.375	7.608
2003	5.751	7.786	6.769
2004	4.146	4.921	4.533
2005	2.775	3.958	3.367
2006	2.018	2.956	2.487
2007	5.007	4.422	4.715
2008	6.808	5.725	6.267
2009	6.644	10.771	8.708
2010	6.229	9.192	7.710
2011	11.031	17.889	14.460
2012	6.745	6.142	6.443

Table A56. CTDEP spring trawl survey: summer flounder index of abundance, geometric mean number per tow at age. CTDEP lengths aged with NEFSC spring trawl survey age-length keys.

Year	Age								
	0	1	2	3	4	5	6	7+	Total
1984	0.000	0.314	0.271	0.044	0.000	0.000	0.000	0.000	0.629
1985	0.000	0.015	0.325	0.040	0.058	0.003	0.000	0.000	0.441
1986	0.000	0.753	0.100	0.082	0.008	0.006	0.000	0.000	0.949
1987	0.000	0.951	0.086	0.014	0.004	0.001	0.000	0.001	1.057
1988	0.000	0.232	0.223	0.035	0.009	0.001	0.000	0.000	0.500
1989	0.000	0.013	0.049	0.024	0.016	0.000	0.000	0.000	0.102
1990	0.000	0.304	0.022	0.013	0.006	0.001	0.000	0.001	0.347
1991	0.000	0.392	0.189	0.029	0.028	0.001	0.000	0.000	0.639
1992	0.000	0.319	0.188	0.021	0.004	0.023	0.000	0.000	0.555
1993	0.000	0.320	0.151	0.015	0.018	0.003	0.000	0.001	0.508
1994	0.000	0.496	0.314	0.025	0.018	0.005	0.000	0.002	0.860
1995	0.000	0.199	0.051	0.020	0.005	0.000	0.000	0.006	0.281
1996	0.000	0.578	0.266	0.086	0.023	0.004	0.000	0.004	0.961
1997	0.000	0.391	0.507	0.057	0.036	0.004	0.002	0.002	0.999
1998	0.000	0.064	0.594	0.503	0.116	0.006	0.025	0.002	1.310
1999	0.000	0.245	0.593	0.385	0.139	0.053	0.025	0.000	1.440
2000	0.000	0.321	0.726	0.524	0.074	0.111	0.034	0.000	1.790
2001	0.000	0.841	0.340	0.365	0.120	0.043	0.032	0.007	1.748
2002	0.000	1.057	1.264	0.465	0.233	0.087	0.044	0.035	3.185
2003	0.000	1.608	1.016	0.395	0.232	0.085	0.046	0.039	3.421
2004	0.000	0.259	0.818	0.410	0.194	0.032	0.077	0.048	1.838
2005	0.000	0.253	0.264	0.150	0.033	0.036	0.039	0.029	0.804
2006	0.000	0.038	0.360	0.068	0.065	0.034	0.026	0.022	0.613
2007	0.000	1.152	0.210	0.560	0.316	0.115	0.089	0.065	2.507
2008	0.000	0.601	0.291	0.237	0.263	0.117	0.062	0.043	1.614
2009	0.000	0.777	0.377	0.291	0.180	0.195	0.070	0.040	1.930
2010	0.000	1.867	0.281	0.211	0.144	0.094	0.042	0.049	2.688
2011	0.000	1.002	1.084	0.801	0.382	0.316	0.110	0.153	3.848
2012	0.000	0.468	0.628	0.975	0.635	0.204	0.075	0.076	3.062

Table A57. CTDEP fall trawl survey: summer flounder index of abundance, geometric mean number per tow at age. CTDEP lengths aged with NEFSC fall trawl survey age-length keys. No survey was conducted in 2010.

Year	Age								
	0	1	2	3	4	5	6	7	Total
1984	0.000	0.571	0.331	0.072	0.014	0.004	0.004	0.003	0.999
1985	0.240	0.339	0.528	0.075	0.001	0.008	0.000	0.000	1.191
1986	0.172	1.170	0.298	0.072	0.006	0.001	0.000	0.000	1.719
1987	0.075	1.067	0.223	0.033	0.003	0.000	0.000	0.000	1.401
1988	0.015	0.884	0.481	0.037	0.002	0.001	0.000	0.000	1.420
1989	0.000	0.029	0.095	0.015	0.001	0.000	0.000	0.000	0.140
1990	0.032	0.674	0.110	0.042	0.007	0.005	0.000	0.000	0.870
1991	0.036	0.826	0.340	0.036	0.013	0.005	0.004	0.000	1.260
1992	0.013	0.570	0.366	0.046	0.016	0.009	0.000	0.000	1.020
1993	0.084	0.827	0.152	0.039	0.003	0.001	0.002	0.001	1.109
1994	0.132	0.300	0.085	0.024	0.009	0.000	0.000	0.000	0.550
1995	0.023	0.384	0.117	0.012	0.002	0.001	0.000	0.002	0.541
1996	0.069	0.887	1.188	0.042	0.005	0.000	0.000	0.000	2.191
1997	0.033	0.681	1.373	0.373	0.021	0.014	0.004	0.001	2.500
1998	0.000	0.269	1.054	0.321	0.054	0.021	0.000	0.000	1.719
1999	0.044	0.679	1.484	0.346	0.114	0.011	0.002	0.000	2.680
2000	0.112	0.395	0.871	0.341	0.124	0.043	0.011	0.013	1.910
2001	0.021	2.689	1.137	0.436	0.110	0.018	0.005	0.001	4.417
2002	0.442	3.087	1.930	0.479	0.123	0.031	0.024	0.005	6.121
2003	0.000	1.459	1.319	0.407	0.087	0.091	0.016	0.009	3.388
2004	0.255	0.385	0.755	0.440	0.080	0.024	0.015	0.000	1.954
2005	0.067	1.093	0.744	0.355	0.087	0.032	0.012	0.020	2.410
2006	0.098	0.217	0.592	0.230	0.096	0.044	0.021	0.018	1.315
2007	0.130	0.567	0.387	0.468	0.201	0.078	0.041	0.016	1.888
2008	0.681	0.515	1.155	0.660	0.048	0.013	0.013	0.000	3.085
2009	0.405	0.661	0.888	0.624	0.318	0.133	0.044	0.044	3.117
2010									
2011	0.117	0.693	0.933	0.564	0.123	0.054	0.028	0.084	2.558
2012	0.163	0.459	0.828	1.424	0.585	0.184	0.063	0.030	3.736

Table A58. NYDEC Peconic Bay trawl survey: index of summer flounder abundance. NYDEC lengths aged with NEFSC trawl survey age-length keys.

	Age									
Year	0	1	2	3	4	5	6	7+	Total	CV
1987	0.01	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.05	0.24
1988	0.02	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.09	0.18
1989	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.06	0.20
1990	0.08	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.18	0.13
1991	0.12	0.32	0.04	0.00	0.00	0.00	0.00	0.00	0.48	0.10
1992	0.03	0.16	0.10	0.01	0.00	0.00	0.00	0.00	0.30	0.11
1993	0.08	0.23	0.02	0.00	0.00	0.00	0.00	0.00	0.34	0.11
1994	0.32	0.32	0.04	0.01	0.00	0.00	0.00	0.00	0.70	0.08
1995	0.21	0.18	0.03	0.00	0.01	0.00	0.00	0.00	0.43	0.09
1996	0.05	0.24	0.29	0.04	0.01	0.01	0.00	0.00	0.63	0.08
1997	0.15	0.70	0.43	0.09	0.00	0.00	0.00	0.00	1.38	0.06
1998	0.01	0.26	0.62	0.11	0.01	0.00	0.00	0.00	1.01	0.07
1999	0.04	0.12	0.26	0.12	0.03	0.00	0.00	0.00	0.57	0.09
2000	0.06	0.30	0.33	0.11	0.04	0.02	0.00	0.00	0.85	0.07
2001	0.04	0.29	0.16	0.06	0.02	0.00	0.00	0.00	0.57	0.07
2002	0.29	0.59	0.22	0.06	0.01	0.01	0.00	0.00	1.18	0.07
2003	0.03	0.35	0.23	0.07	0.02	0.00	0.01	0.00	0.72	0.08
2004	0.07	0.24	0.23	0.04	0.00	0.00	0.00	0.00	0.58	0.07
2005	0.06	0.14	0.14	0.11	0.04	0.00	0.00	0.00	0.50	0.13
2006	0.05	0.11	0.22	0.06	0.02	0.00	0.01	0.00	0.47	0.10
2007	0.10	0.11	0.14	0.14	0.04	0.01	0.01	0.00	0.55	0.08
2008	0.43	0.19	0.17	0.06	0.04	0.01	0.00	0.00	0.91	0.10
2009	0.61	0.24	0.19	0.12	0.07	0.02	0.01	0.00	1.24	0.08
2010	0.04	0.10	0.09	0.08	0.06	0.02	0.00	0.00	0.41	0.11
2011	0.05	0.16	0.20	0.14	0.05	0.03	0.02	0.00	0.65	0.09
2012	0.32	0.17	0.16	0.28	0.13	0.02	0.01	0.00	1.11	0.06

Table A59. NJDFW trawl survey, April - October: index of summer flounder abundance. NJDFW lengths aged with NEFSC fall trawl survey age-length keys.

	Age											
Year	0	1	2	3	4	5	6	7	8	9+	Total	CV
1988	0.17	3.06	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.26	0.15
1989	1.00	0.51	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.69	0.23
1990	1.28	1.44	0.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	2.86	0.17
1991	1.00	2.69	0.27	0.02	0.00	0.00	0.00	0.00	0.00	0.00	3.98	0.13
1992	1.10	3.00	0.57	0.06	0.02	0.00	0.00	0.00	0.00	0.00	4.75	0.18
1993	2.55	5.69	0.20	0.01	0.01	0.00	0.00	0.00	0.00	0.00	8.46	0.12
1994	1.66	1.07	0.08	0.00	0.02	0.00	0.00	0.00	0.00	0.00	2.83	0.22
1995	5.12	2.94	0.26	0.07	0.02	0.00	0.00	0.00	0.00	0.00	8.41	0.11
1996	1.66	5.10	2.70	0.18	0.05	0.00	0.00	0.00	0.00	0.00	9.69	0.18
1997	1.65	8.25	5.25	1.02	0.10	0.07	0.01	0.00	0.00	0.00	16.35	0.11
1998	0.67	5.80	2.67	0.29	0.03	0.01	0.00	0.00	0.00	0.00	9.47	0.14
1999	1.03	6.12	3.46	0.65	0.12	0.06	0.00	0.00	0.00	0.00	11.44	0.10
2000	0.99	3.94	1.85	0.46	0.12	0.06	0.04	0.00	0.00	0.00	7.46	0.13
2001	0.62	3.32	1.18	0.41	0.09	0.03	0.02	0.00	0.00	0.00	5.68	0.09
2002	1.51	9.11	4.13	1.28	0.47	0.24	0.05	0.04	0.00	0.00	16.84	0.15
2003	0.60	5.61	2.55	0.57	0.19	0.19	0.07	0.06	0.00	0.00	9.84	0.11
2004	0.90	6.27	2.49	0.57	0.19	0.11	0.10	0.03	0.00	0.00	10.66	0.15
2005	3.11	5.99	1.24	0.53	0.17	0.10	0.03	0.01	0.01	0.00	11.19	0.28
2006	0.81	5.74	3.22	0.48	0.20	0.11	0.08	0.02	0.00	0.00	10.65	0.12
2007	0.64	4.10	2.49	1.22	0.31	0.12	0.09	0.01	0.00	0.00	8.98	0.10
2008	1.31	2.34	1.61	0.45	0.37	0.12	0.07	0.01	0.01	0.00	6.29	0.10
2009	1.68	2.82	2.15	1.02	0.40	0.12	0.08	0.02	0.01	0.00	8.31	0.10
2010	1.28	4.53	2.75	1.48	0.67	0.23	0.09	0.01	0.01	0.02	11.07	0.11
2011	1.05	2.38	1.86	0.97	0.27	0.20	0.07	0.05	0.01	0.01	6.92	0.15
2012	1.88	1.43	1.63	2.15	0.74	0.21	0.09	0.05	0.01	0.00	8.19	0.14

Table A60. DEDFW 16 foot trawl survey: index of summer flounder recruitment at age-0 in the Delaware Bay Estuary.

Year	Geometric Mean number per tow
1980	0.12
1981	0.06
1982	0.11
1983	0.03
1984	0.08
1985	0.06
1986	0.10
1987	0.14
1988	0.01
1989	0.12
1990	0.23
1991	0.07
1992	0.31
1993	0.03
1994	0.29
1995	0.17
1996	0.03
1997	0.02
1998	0.03
1999	0.05
2000	0.18
2001	0.07
2002	0.07
2003	0.09
2004	0.10
2005	0.00
2006	0.02
2007	0.03
2008	0.05
2009	0.31
2010	0.04
2011	0.02
2012	0.02

Table A61. DEDFW 16 foot trawl survey: index of summer flounder recruitment at age-0 in Delaware Inland Bays.

Year	Geometric Mean number per tow
1986	0.317
1987	0.258
1988	0.013
1989	0.139
1990	0.361
1991	0.378
1992	0.368
1993	0.047
1994	0.571
1995	0.301
1996	0.080
1997	0.222
1998	0.390
1999	0.350
2000	0.205
2001	0.142
2002	0.125
2003	0.214
2004	0.268
2005	0.012
2006	0.170
2007	0.170
2008	0.200
2009	0.420
2010	0.130
2011	0.223
2012	0.150

Table A62. DEDFW Delaware Bay 30 foot trawl survey: index of summer flounder abundance. Due to an uncalibrated vessel change, indices for 1991-2002 (*italics*) are not used in the assessment,

Year	0	1	2	3	4	5	6	7	8	Total
1991	*1.44*	*1.13*	*0.18*	*0.04*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*2.79*
1992	*0.47*	*0.28*	*0.08*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.83*
1993	*0.04*	*1.56*	*0.73*	*0.07*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*2.40*
1994	*2.03*	*0.14*	*0.22*	*0.08*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*2.72*
1995	*0.95*	*1.00*	*0.28*	*0.10*	*0.07*	*0.02*	*0.00*	*0.00*	*0.00*	*2.41*
1996	*0.46*	*0.73*	*0.48*	*0.10*	*0.01*	*0.00*	*0.01*	*0.00*	*0.00*	*1.79*
1997	*0.03*	*0.12*	*0.49*	*0.47*	*0.11*	*0.00*	*0.03*	*0.01*	*0.01*	*1.27*
1998	*0.11*	*0.31*	*0.83*	*0.29*	*0.11*	*0.01*	*0.00*	*0.00*	*0.00*	*1.66*
1999	*0.20*	*0.06*	*0.77*	*0.47*	*0.16*	*0.03*	*0.00*	*0.00*	*0.00*	*1.69*
2000	*0.79*	*0.24*	*0.30*	*0.28*	*0.15*	*0.04*	*0.00*	*0.00*	*0.00*	*1.84*
2001	*0.34*	*1.55*	*0.49*	*0.26*	*0.10*	*0.02*	*0.01*	*0.00*	*0.00*	*2.77*
2002	*0.04*	*0.23*	*0.09*	*0.00*	*0.03*	*0.00*	*0.00*	*0.00*	*0.00*	*0.39*
2003	0.15	0.14	0.29	0.15	0.07	0.03	0.02	0.00	0.00	0.85
2004	0.02	0.07	0.06	0.01	0.01	0.01	0.00	0.00	0.00	0.18
2005	0.00	0.30	0.11	0.02	0.01	0.00	0.00	0.00	0.00	0.44
2006	0.41	0.10	0.23	0.07	0.01	0.01	0.00	0.00	0.00	0.83
2007	0.11	0.14	0.83	0.09	0.07	0.02	0.00	0.00	0.01	1.29
2008	0.20	0.35	0.12	0.02	0.01	0.02	0.01	0.00	0.00	0.73
2009	0.45	0.49	0.10	0.09	0.01	0.01	0.00	0.00	0.00	1.16
2010	0.04	0.46	0.35	0.13	0.03	0.01	0.00	0.00	0.00	1.03
2011	0.36	0.24	0.19	0.07	0.05	0.00	0.01	0.00	0.00	0.92
2012	0.24	0.17	0.22	0.03	0.05	0.00	0.00	0.00	0.00	0.71

Table A63. MDDNR Coastal Bays trawl survey: index of summer flounder recruitment at age-0. Geometric mean (re-transformed ln [number per hectare + 1]).

Year	Geo. mean n/tow	Coeff. of Var	Lower 95% CI	Upper 95% CI
1972	34.351	0.54	13.426	87.888
1973	10.321	0.33	5.529	19.267
1974	12.311	0.26	7.516	20.165
1975	3.606	0.18	2.547	5.104
1976	4.207	0.20	2.833	6.246
1977	4.337	0.24	2.728	6.894
1978	5.731	0.19	3.959	8.295
1979	6.715	0.26	4.077	11.060
1980	7.395	0.33	3.953	13.837
1981	8.849	0.24	5.544	14.123
1982	3.408	0.39	1.663	6.983
1983	17.699	144.41	0.031	10223.618
1984	13.310	0.33	7.161	24.738
1985	12.843	0.28	7.472	22.076
1986	59.526	0.59	21.950	161.427
1987	7.584	0.41	3.590	16.018
1988	1.763	0.13	1.371	2.267
1989	2.855	0.15	2.121	3.843
1990	4.733	0.13	3.639	6.156
1991	7.337	0.15	5.508	9.772
1992	8.487	0.15	6.285	11.461
1993	4.145	0.13	3.192	5.383
1994	22.311	0.15	16.486	30.194
1995	13.067	0.15	9.811	17.404
1996	6.493	0.14	4.954	8.509
1997	7.997	0.15	5.948	10.752
1998	14.983	0.14	11.391	19.708
1999	8.565	0.14	6.477	11.326
2000	9.874	0.16	7.272	13.407

Table A63 continued.

Year	Geo. mean n/tow	Coeff. of Var	Lower 95% CI	Upper 95% CI
2001	13.543	0.16	9.945	18.442
2002	5.406	0.14	4.136	7.066
2003	8.180	0.15	6.064	11.035
2004	6.993	0.15	5.230	9.350
2005	2.198	0.11	1.783	2.709
2006	9.658	0.14	7.263	12.843
2007	15.438	0.15	11.588	20.573
2008	12.079	0.14	9.214	15.834
2009	17.887	0.16	13.129	24.368
2010	6.713	0.13	5.170	8.717
2011	4.471	0.13	3.444	5.804
2012	7.705	0.15	5.869	10.117

Table A64. VIMS juvenile fish trawl survey: index of summer flounder recruitment at age-0. Includes all available data and incorporates gear conversion factors from studies conducted in the late 1990s. There was no survey in 1960.

Year	Geometric mean catch per trawl	Lower 95% confidence limit	Upper 95% confidence limit	Coefficient of Variation	Number of stations
1955	0	0	0	0	2
1956	4.44	2.91	6.56	0.24	29
1957	2.14	1.22	3.42	0.30	28
1958	1.48	0.23	4.00	0.85	27
1959	0.06	-0.03	0.15	0.75	27
1960	0	0	0	0	0
1961	0.19	0.12	0.61	1.11	11
1962	0	0	0	0	7
1963	2.07	0.78	4.29	0.54	12
1964	0.65	0.54	0.76	0.08	16
1965	0.74	0.27	1.39	0.44	13
1966	0	0	0	0	17
1967	0.43	-0.17	1.46	1.20	27
1968	0.14	-0.05	0.36	0.79	27
1969	0.20	0.04	0.38	0.45	27
1970	0.04	-0.02	0.10	0.75	29
1971	3.72	3.43	4.04	0.04	129
1972	0.85	0.79	0.92	0.04	84
1973	1.27	0.77	1.89	0.24	94
1974	0.82	0.31	1.51	0.42	32
1975	0.14	0.00	0.30	0.57	22
1976	0.57	0.32	0.86	0.25	68
1977	1.67	1.16	2.31	0.19	36
1978	1.24	0.47	2.40	0.47	36
1979	2.94	2.74	3.15	0.02	50
1980	10.69	6.49	17.25	0.09	70
1981	3.97	2.39	6.31	0.12	67
1982	2.27	1.54	3.21	0.11	64
1983	5.01	3.62	6.82	0.07	60
1984	1.58	0.96	2.39	0.15	41
1985	1.26	0.52	2.37	0.24	27
1986	1.26	0.77	1.89	0.15	53
1987	0.39	0.20	0.63	0.23	52
1988	0.54	0.35	0.75	0.15	143
1989	1.24	0.94	1.58	0.09	162

Table A64 continued.

Year	Geometric mean catch per trawl	Lower 95% confidence limit	Upper 95% confidence limit	Coefficient of Variation	Number of stations
1990	2.54	2.06	3.09	0.06	162
1991	2.79	2.26	3.41	0.06	153
1992	0.92	0.70	1.17	0.09	153
1993	0.52	0.38	0.68	0.12	153
1994	2.54	2.01	3.15	0.06	153
1995	0.71	0.52	0.92	0.11	149
1996	0.81	0.62	1.02	0.09	224
1997	0.89	0.69	1.12	0.09	226
1998	0.73	0.55	0.93	0.10	226
1999	0.53	0.41	0.67	0.10	219
2000	0.57	0.43	0.73	0.11	227
2001	0.47	0.34	0.61	0.12	236
2002	0.77	0.54	1.04	0.12	179
2003	0.44	0.33	0.56	0.11	225
2004	1.30	1.03	1.60	0.07	225
2005	0.35	0.25	0.46	0.13	225
2006	0.80	0.60	1.02	0.10	203
2007	1.00	0.78	1.24	0.08	225
2008	1.35	1.10	1.63	0.07	225
2009	0.75	0.58	0.92	0.09	225
2010	0.55	0.41	0.69	0.11	225
2011	0.17	0.11	0.23	0.18	225
2012	2.03	1.69	2.40	0.09	212

Table A65. VIMS ChesMMAP trawl survey indices for summer flounder. A) Aggregate indices are delta-lognormal model geometric means per tow. B) Aged indices are in numbers, are compiled independently, and are aged using a smoothed age-length key, and so do not total to the aggregate numeric indices.

A)

Year	Number (CV %)	Biomass (CV %)
2002	120.3 (27)	53.6 (24)
2003	35.4 (30)	11.8 (29)
2004	45.8 (25)	17.4 (20)
2005	150.1 (21)	56.1 (19)
2006	176.6 (26)	62.3 (22)
2007	117.0 (34)	38.8 (29)
2008	86.4 (29)	30.4 (25)
2009	35.1 (30)	15.7 (25)
2010	36.6 (29)	15.6 (24)
2011	23.2 (28)	14.1 (26)
2012	3.1 (32)	1.6 (29)

B)

Year	0	1	2	3	4+	Total
2002	62.4	22.7	6.3	4.5	5.0	100.8
2003	19.0	13.1	4.0	2.2	1.7	40.0
2004	28.1	7.4	3.1	2.1	1.7	42.3
2005	65.8	27.2	9.8	5.0	3.9	111.7
2006	100.9	25.4	7.6	4.9	4.0	142.9
2007	87.2	17.2	4.0	2.4	2.2	112.9
2008	54.7	9.3	5.0	3.6	3.3	75.8
2009	18.3	6.9	2.6	1.9	1.7	31.5
2010	20.2	8.2	2.4	1.4	1.1	33.2
2011	6.3	8.2	4.0	2.2	1.4	22.1
2012	1.8	0.6	0.6	0.4	0.3	3.6

Table A66. VIMS NEAMAP trawl survey indices for summer flounder. Indices are calculated as delta-lognormal model stratified geometric mean numbers and biomass (kg) per standard area swept tow.

Season	Number per tow	Number CV (%)	Biomass per tow	Biomass CV (%)
Fall 2007	4.31	7.1	2.65	7.9
Fall 2008	2.76	9.3	1.71	8.5
Fall 2009	4.99	8.9	2.42	7.6
Fall 2010	3.99	8.1	2.02	8.3
Fall 2011	2.55	8.2	1.48	9.1
Fall 2012	3.31	7.5	1.86	7.8
Spring 2008	3.09	8.3	1.93	8.0
Spring 2009	2.56	9.0	1.52	9.0
Spring 2010	2.36	10.0	1.34	9.0
Spring 2011	3.22	8.6	1.68	8.3
Spring 2012	1.22	10.3	0.80	10.0

Table A67. VIMS NEAMAP trawl survey indices at age for summer flounder. Aged indices are in numbers, are compiled independently, and are aged using a smoothed age-length key, and so do not total to the aggregate numeric indices in Table 60.

Spring

Year	1	2	3	4	5	6	7+	Total
2008	0.82	1.18	0.64	0.41	0.25	0.15	0.14	3.59
2009	0.96	0.84	0.46	0.30	0.19	0.11	0.10	2.96
2010	0.88	0.92	0.39	0.24	0.14	0.09	0.09	2.75
2011	1.31	1.45	0.57	0.30	0.15	0.08	0.08	3.94
2012	0.34	0.50	0.25	0.16	0.10	0.06	0.08	1.49

Fall

Year	0	1	2	3	4	5	6	7+	Total
2007	0.75	1.41	0.96	0.67	0.29	0.17	0.08	0.07	4.40
2008	0.47	0.94	0.83	0.49	0.16	0.08	0.04	0.03	3.04
2009	1.31	1.45	0.94	0.60	0.23	0.13	0.06	0.05	4.77
2010	0.99	1.36	0.85	0.47	0.17	0.09	0.04	0.04	4.01
2011	0.38	0.93	0.70	0.40	0.14	0.08	0.04	0.05	2.72
2012	0.71	0.90	0.83	0.59	0.24	0.14	0.07	0.06	3.54

Table A68. North Carolina Division of Marine Fisheries (NCDMF) Pamlico Sound trawl survey: June index of summer flounder recruitment at age-0.

Year	Mean number per tow	CV (%)
1987	19.86	14
1988	2.61	34
1989	6.63	17
1990	4.27	18
1991	5.85	24
1992	9.14	19
1993	5.13	24
1994	8.17	24
1995	6.65	25
1996	30.67	18
1997	14.14	21
1998	10.44	41
1999	n/a	n/a
2000	3.94	21
2001	22.03	15
2002	18.28	18
2003	7.23	24
2004	5.90	20
2005	9.88	22
2006	1.96	22
2007	3.62	22
2008	14.40	22
2009	4.53	22
2010	14.28	22
2011	6.64	22
2012	9.26	22

Table A69. NEFSC Marine Resources Monitoring, Assessment, and Prediction program (MARMAP 1978-1986) and Ecosystem Monitoring Program (ECOMON; 1999-2012) larval survey indices of Spawning Stock Biomass (SSB). n/a = not available.

Year	MARMAP LV	ECOMON LV
1978	43.0	
1979	36.4	
1980	65.3	
1981	n/a	
1982	55.4	
1983	67.9	
1984	87.3	
1985	55.8	
1986	11.0	
1999		213.7
2000		481.9
2001		372.2
2002		495.4
2003		415.3
2004		n/a
2005		170.5
2006		445.7
2007		266.3
2008		323.8
2009		452.0
2010		540.8
2011		713.7
2012		440.4

Table A70. Dealer report trawl gear landings (pounds), effort (days fished), and nominal landings per unit effort (LPUE).

Dealer Report Trawl Gear Landings and Effort					Nominal	Scaled
Year	Landings	Trips	Days Fished	DF/Trip	LPUE	LPUE
1964	1,971,957	3,462	2,937	0.85	671	0.56
1965	4,630,288	8,822	13,277	1.51	349	0.29
1966	536,141	2,599	1,989	0.77	270	0.23
1967	1,070,259	2,550	1,874	0.73	571	0.48
1968	455,888	2,048	1,254	0.61	364	0.31
1969	301,025	1,822	972	0.53	310	0.26
1970	250,785	1,753	996	0.57	252	0.21
1971	302,796	1,927	1,450	0.75	209	0.18
1972	302,564	825	879	1.06	344	0.29
1973	998,819	1,717	1,969	1.15	507	0.43
1974	4,019,594	4,152	4,226	1.02	951	0.80
1975	4,682,706	4,814	4,944	1.03	947	0.80
1976	10,538,429	4,861	6,394	1.32	1,648	1.39
1977	5,243,364	4,259	4,601	1.08	1,140	0.96
1978	9,712,570	6,125	5,708	0.93	1,701	1.43
1979	9,851,462	5,474	5,175	0.95	1,904	1.60
1980	6,283,606	4,803	3,870	0.81	1,624	1.37
1981	7,306,311	5,699	5,084	0.89	1,437	1.21
1982	13,999,253	8,503	8,705	1.02	1,608	1.35
1983	20,046,935	9,289	11,564	1.24	1,734	1.46
1984	21,639,813	9,723	12,287	1.26	1,761	1.48
1985	20,001,037	10,378	12,348	1.19	1,620	1.36
1986	19,205,300	9,895	14,360	1.45	1,337	1.12
1987	19,180,460	9,204	13,093	1.42	1,465	1.23
1988	20,718,050	9,052	13,266	1.47	1,562	1.31
1989	11,176,996	6,704	11,674	1.74	957	0.81
1990	5,463,173	5,571	8,796	1.58	621	0.52
1991	8,611,562	6,393	10,774	1.69	799	0.67
1992	11,924,575	6,855	13,511	1.97	883	0.74
1993	8,305,731	7,335	11,568	1.58	718	0.60
1994	8,879,124	12,566	11,982	0.95	741	0.62
1995	9,562,002	16,007	10,863	0.68	880	0.74
1996	7,650,258	13,823	7,812	0.57	979	0.82
1997	6,244,116	16,505	8,824	0.53	708	0.60
1998	8,061,887	18,242	9,151	0.50	881	0.74
1999	7,461,432	18,534	9,214	0.50	810	0.68
2000	6,780,757	16,472	7,569	0.46	896	0.75
2001	6,654,103	17,484	7,574	0.43	879	0.74
2002	8,331,080	19,595	7,770	0.40	1,072	0.90
2003	8,398,789	18,748	7,833	0.42	1,072	0.90
2004	11,288,176	15,648	6,848	0.44	1,648	1.39
2005	13,326,179	15,079	7,536	0.50	1,768	1.49
2006	11,197,703	14,203	6,716	0.47	1,667	1.40
2007	7,681,053	11,449	5,294	0.46	1,451	1.22
2008	4,928,237	11,129	4,278	0.38	1,152	0.97
2009	8,185,792	12,642	4,901	0.39	1,670	1.40
2010	7,871,289	13,715	4,804	0.35	1,638	1.38
2011	13,858,334	14,491	5,579	0.39	2,484	2.09
2012	11,003,825	13,600	5,804	0.43	1,896	1.59
Total	416,095,585	456,546	349,896	0.77	1,189	1.00

Table A71. Year effect parameter estimates (re-transformed, bias-corrected, annual indices of total stock biomass), index Coefficient of Variation (CV), and Lower and Upper 95% Confidence Intervals (L95CI, U95CI) from the Dealer report trawl gear landings and effort negbin YEAR-QTR-AREA-TC model.

Year	Index	CV	L95CI	U95CI
1964	0.433	0.03	0.412	0.455
1965	0.844	0.02	0.813	0.876
1966	0.374	0.03	0.354	0.395
1967	0.348	0.03	0.329	0.367
1968	0.303	0.03	0.285	0.322
1969	0.267	0.03	0.251	0.284
1970	0.272	0.03	0.255	0.290
1971	0.231	0.03	0.217	0.245
1972	0.379	0.05	0.347	0.415
1973	0.456	0.03	0.428	0.487
1974	0.702	0.02	0.671	0.734
1975	0.509	0.02	0.488	0.531
1976	0.695	0.02	0.666	0.725
1977	0.518	0.02	0.496	0.542
1978	0.635	0.02	0.611	0.660
1979	0.635	0.02	0.610	0.661
1980	0.541	0.02	0.519	0.564
1981	0.617	0.02	0.593	0.642
1982	0.683	0.02	0.659	0.707
1983	0.604	0.02	0.583	0.625
1984	0.608	0.02	0.588	0.629
1985	0.652	0.02	0.631	0.674
1986	0.536	0.02	0.519	0.554
1987	0.481	0.02	0.465	0.497
1988	0.496	0.02	0.479	0.513
1989	0.271	0.02	0.261	0.281
1990	0.185	0.02	0.178	0.193
1991	0.237	0.02	0.228	0.246
1992	0.298	0.02	0.287	0.309
1993	0.297	0.02	0.286	0.308
1994	0.392	0.02	0.380	0.404
1995	0.442	0.01	0.430	0.455
1996	0.526	0.02	0.510	0.542
1997	0.460	0.01	0.447	0.473
1998	0.559	0.01	0.543	0.575
1999	0.586	0.01	0.570	0.603
2000	0.684	0.01	0.664	0.704
2001	0.678	0.01	0.659	0.698
2002	0.855	0.01	0.832	0.879
2003	0.898	0.01	0.873	0.923
2004	1.401	0.01	1.360	1.443
2005	1.433	0.02	1.391	1.476
2006	1.173	0.02	1.138	1.209
2007	1.011	0.02	0.980	1.044
2008	0.911	0.02	0.883	0.941
2009	1.110	0.02	1.077	1.145
2010	1.306	0.02	1.267	1.346
2011	1.365	0.02	1.325	1.407
2012	1.000			

Table A72. Vessel Trip report (VTR) trawl gear catch (landings plus discards in pounds), effort (days fished), and nominal catch per unit effort (CPUE).

VTR Trawl Gear

Year	Total Catch	Trips	Days Fished	Nominal CPUE	Scaled CPUE
1994	5,939,631	9,699	7,965	746	0.59
1995	12,409,699	12,852	12,362	1,004	0.77
1996	10,641,152	12,262	9,185	1,159	0.89
1997	7,162,612	14,276	9,155	782	0.60
1998	9,094,256	16,193	10,678	852	0.65
1999	9,074,878	17,686	11,776	771	0.59
2000	9,660,300	15,854	9,701	996	0.76
2001	9,659,316	16,933	9,496	1,017	0.78
2002	12,866,048	19,778	10,452	1,231	0.94
2003	13,034,298	17,836	8,799	1,481	1.13
2004	16,076,388	18,919	9,327	1,724	1.32
2005	15,901,575	17,045	9,241	1,721	1.32
2006	12,951,765	15,321	8,399	1,542	1.18
2007	9,109,678	14,130	6,697	1,360	1.04
2008	7,711,220	11,502	5,599	1,377	1.05
2009	9,042,244	12,183	5,646	1,602	1.23
2010	11,328,834	13,473	5,821	1,946	1.49
2011	14,426,363	13,425	6,576	2,194	1.68
2012	11,216,765	12,296	6,856	1,636	1.29
Total	207,307,022	281,663	163,732	1,266	1.00

Table A73. Year effect parameter estimates (re-transformed, bias-corrected, annual indices of total stock biomass), index Coefficient of Variation (CV), and Lower and Upper 95% Confidence Intervals (L95CI, U95CI) from the VTR trawl gear negbin YEAR-QTR-AREA-TC-MSH model.

Year	Index	CV	L95CI	U95CI
1994	0.544	0.01	0.529	0.560
1995	0.585	0.01	0.570	0.601
1996	0.664	0.01	0.646	0.683
1997	0.614	0.01	0.598	0.630
1998	0.816	0.01	0.795	0.837
1999	0.801	0.01	0.782	0.822
2000	0.888	0.01	0.866	0.911
2001	0.950	0.01	0.926	0.974
2002	1.117	0.01	1.090	1.144
2003	1.200	0.01	1.170	1.230
2004	1.361	0.01	1.328	1.394
2005	1.378	0.01	1.344	1.413
2006	1.091	0.01	1.063	1.119
2007	1.040	0.01	1.013	1.067
2008	1.027	0.01	0.999	1.055
2009	1.216	0.01	1.183	1.249
2010	1.372	0.01	1.336	1.408
2011	1.439	0.01	1.401	1.478
2012	1.000			

Table A74. Vessel Trip report (VTR) recreational Party/Charter Boat catch (landings plus discards in numbers), effort (trips), and nominal catch per unit effort (CPUE).

VTR P/C Boat Total Catch Numbers Data

Year	Total Catch	Trips	Anglers	Nominal CPUE	Scaled CPUE
1994	774,012	6,538	174,103	118.39	1.49
1995	629,422	6,271	178,203	100.37	1.26
1996	732,093	6,739	179,539	108.64	1.36
1997	674,502	7,326	205,562	92.07	1.16
1998	709,931	8,006	223,802	88.67	1.11
1999	902,077	7,896	218,883	114.24	1.43
2000	723,734	8,443	218,239	85.72	1.08
2001	462,476	7,154	189,689	64.65	0.81
2002	423,902	6,654	177,427	63.71	0.80
2003	443,094	6,982	180,165	63.46	0.80
2004	355,939	6,026	147,862	59.07	0.74
2005	363,276	5,763	141,363	63.04	0.79
2006	282,551	5,698	123,994	49.59	0.62
2007	370,352	6,457	145,792	57.36	0.72
2008	357,833	5,675	127,799	63.05	0.79
2009	402,770	6,274	150,410	64.20	0.81
2010	700,373	7,981	210,684	87.76	1.10
2011	694,609	8,122	211,077	85.52	1.07
2012	498,073	7,875	212,440	63.25	0.79
Total	10,501,019	131,880	3,417,033	79.63	

Table A75. Year effect parameter estimates (re-transformed, bias-corrected, annual indices of total stock abundance), index Coefficient of Variation (CV), and Lower and Upper 95% Confidence Intervals (L95CI, U95CI), from the VTR Party/Charter Boat six-factor negbin YEAR-MON-STATE-BOAT-SIZE-BAG model.

Year	Index	CV	L95CI	U95CI
1994	1.644	0.06	1.466	1.845
1995	1.169	0.06	1.035	1.321
1996	1.399	0.06	1.238	1.581
1997	1.275	0.06	1.128	1.440
1998	1.292	0.06	1.144	1.459
1999	1.299	0.06	1.151	1.467
2000	1.165	0.06	1.033	1.314
2001	1.051	0.03	0.983	1.124
2002	1.005	0.03	0.941	1.074
2003	0.996	0.03	0.941	1.055
2004	0.969	0.03	0.911	1.030
2005	1.030	0.03	0.971	1.093
2006	1.223	0.04	1.126	1.329
2007	1.234	0.03	1.172	1.300
2008	1.202	0.03	1.127	1.281
2009	1.335	0.03	1.257	1.417
2010	1.634	0.03	1.538	1.737
2011	1.600	0.03	1.511	1.694
2012	1.000			

Table A76. Observed trawl gear catch (landings plus discards in pounds), effort (days fished), and nominal catch per unit effort (CPUE).

Observed Trawl Gear catch rate data.

Year	Trips	Hauls	Total Catch (lbs)	Days Fished	Nominal CPUE	Scaled Nominal CPUE
1989	57	415	53,290	37	1,457	0.91
1990	61	467	48,304	37	1,312	0.82
1991	95	724	65,836	67	981	0.62
1992	68	617	124,864	65	1,929	1.21
1993	45	408	74,764	43	1,744	1.09
1994	52	585	177,058	69	2,577	1.62
1995	134	1,016	244,589	114	2,137	1.34
1996	111	658	103,820	64	1,615	1.01
1997	60	349	32,628	38	850	0.53
1998	53	333	74,215	37	2,030	1.27
1999	59	383	57,164	43	1,345	0.84
2000	89	562	144,382	64	2,267	1.42
2001	138	589	106,800	54	1,971	1.24
2002	166	811	139,652	84	1,660	1.04
2003	212	1,328	239,820	151	1,592	1.00
2004	593	3,097	615,564	310	1,987	1.25
2005	1,041	7,646	940,890	924	1,018	0.64
2006	545	4,067	546,202	504	1,085	0.68
2007	634	3,792	710,275	441	1,610	1.01
2008	567	2,952	490,524	332	1,479	0.93
2009	780	4,162	618,329	440	1,406	0.88
2010	660	2,969	835,544	310	2,693	1.69
2011	595	3,540	784,990	381	2,062	1.29
2012	404	2,010	490,391	235	2,087	1.31
Total	7,219	43,480	7,719,893	4,842	1,594	1.00

Table A77. Year effect parameter estimates (re-transformed, bias-corrected, annual indices of total stock biomass), index Coefficient of Variation (CV), Lower and Upper 95% Confidence Intervals (L95CI, U95CI) from the Observed trawl gear Negbin YEAR-QTR-AREA-TC model.

Year	Index	CV	L95CI	U95CI
1989	0.481	0.16	0.350	0.662
1990	0.429	0.16	0.314	0.586
1991	0.578	0.13	0.447	0.748
1992	0.621	0.16	0.459	0.840
1993	0.566	0.18	0.398	0.804
1994	1.169	0.17	0.838	1.629
1995	0.562	0.12	0.448	0.705
1996	0.435	0.12	0.342	0.553
1997	0.287	0.16	0.210	0.391
1998	0.668	0.17	0.481	0.929
1999	0.801	0.17	0.581	1.106
2000	1.672	0.14	1.274	2.193
2001	1.007	0.12	0.804	1.262
2002	1.249	0.11	1.013	1.540
2003	1.238	0.10	1.022	1.498
2004	1.589	0.07	1.373	1.839
2005	1.433	0.07	1.251	1.642
2006	1.351	0.08	1.163	1.569
2007	1.690	0.07	1.460	1.957
2008	1.386	0.08	1.194	1.608
2009	1.713	0.07	1.488	1.971
2010	1.648	0.07	1.427	1.904
2011	1.359	0.07	1.174	1.573
2012	1.000			

Table A78. Observed scallop dredge gear catch (landings plus discards in pounds), effort (days fished), and nominal catch per unit effort (CPUE).

Year	Trips	Hauls	Total Catch Lbs	Days Fished	Nominal CPUE	Scaled Nominal CPUE
1992	9	178	1,477	5	279	1.15
1993	15	671	2,966	19	155	0.64
1994	14	651	5,811	28	210	0.87
1995	19	1054	10,085	45	224	0.93
1996	24	1089	9,609	49	197	0.81
1997	24	959	8,376	41	204	0.84
1998	22	362	1,978	15	129	0.53
1999	10	247	3,199	10	312	1.29
2000	77	1076	12,567	45	281	1.16
2001	69	1643	12,013	68	176	0.72
2002	76	2514	25,739	118	217	0.90
2003	79	3248	37,021	151	246	1.02
2004	168	5651	76,729	255	300	1.24
2005	156	4091	40,010	186	215	0.89
2006	124	2748	35,042	119	296	1.22
2007	195	3549	51,311	142	362	1.50
2008	298	6895	81,232	283	287	1.18
2009	291	7916	72,561	347	209	0.86
2010	187	6102	64,610	275	235	0.97
2011	205	5925	66,294	272	244	1.01
2012	251	7,951	65,937	354	186	0.77
Total	2,313	64,520	684,565	2,827	242	1.00

Table A79. Year effect parameter estimates (re-transformed, bias-corrected, annual indices of total stock biomass), index Coefficient of Variation (CV), Lower and Upper 95% Confidence Intervals (L95CI, U95CI) from the Observed scallop dredge negbin YEAR-QTR-AREA-TC model.

Year	Index	CV	L95CI	U95CI
1992	0.632	0.26	0.383	1.042
1993	0.791	0.20	0.540	1.160
1994	0.898	0.21	0.599	1.347
1995	0.821	0.18	0.581	1.158
1996	0.850	0.16	0.622	1.160
1997	0.723	0.16	0.526	0.995
1998	0.813	0.17	0.589	1.122
1999	1.607	0.24	1.007	2.562
2000	1.502	0.10	1.238	1.822
2001	0.831	0.10	0.679	1.018
2002	1.029	0.10	0.848	1.249
2003	1.137	0.10	0.940	1.374
2004	1.361	0.08	1.170	1.583
2005	1.372	0.08	1.179	1.597
2006	1.357	0.08	1.151	1.600
2007	1.683	0.07	1.461	1.937
2008	1.459	0.07	1.281	1.661
2009	1.214	0.07	1.067	1.382
2010	1.446	0.07	1.255	1.667
2011	1.307	0.07	1.137	1.502
2012	1.000			

Table A80. MRSS/MRIP intercept total catch in numbers, angler trips, and nominal catch per unit effort (CPUE).

MRFSS/MRIP Intercept Total Catch Number Data

Year	Total Catch	Angler Trips	Nominal CPUE	Scaled CPUE
1981	8,595	3,646	2.36	0.95
1982	8,916	3,966	2.25	0.90
1983	13,711	4,518	3.03	1.22
1984	8,418	2,918	2.88	1.16
1985	5,326	3,548	1.50	0.60
1986	14,690	5,250	2.80	1.12
1987	13,775	4,221	3.26	1.31
1988	12,969	5,596	2.32	0.93
1989	4,619	5,366	0.86	0.35
1990	14,655	8,370	1.75	0.70
1991	23,930	11,309	2.12	0.85
1992	21,098	10,125	2.08	0.84
1993	26,326	9,266	2.84	1.14
1994	21,776	10,898	2.00	0.80
1995	15,408	7,126	2.16	0.87
1996	20,989	8,778	2.39	0.96
1997	21,232	8,879	2.39	0.96
1998	25,970	10,105	2.57	1.03
1999	25,408	8,247	3.08	1.24
2000	23,634	8,241	2.87	1.15
2001	35,705	11,573	3.09	1.24
2002	24,141	9,312	2.59	1.04
2003	26,969	10,778	2.50	1.00
2004	23,020	9,767	2.36	0.95
2005	23,356	9,416	2.48	1.00
2006	16,721	4,604	3.63	1.46
2007	21,723	8,856	2.45	0.98
2008	20,132	7,904	2.55	1.02
2009	21,187	7,573	2.80	1.12
2010	22,013	7,781	2.83	1.14
2011	19,232	6,731	2.86	1.15
2012	14,296	6,230	2.29	0.92
Total	599,940	240,898	2.49	1.00

Table A81. Year effect parameter estimates (re-transformed, bias-corrected, annual indices of total stock biomass), index Coefficient of Variation (CV), Lower and Upper 95% Confidence Intervals (L95CI, U95CI) from the MRFSS/MRIP intercept six-factor negbin YEAR-WAVE-STATE-BOAT-SIZE-BAG model.

Year	Index	CV	L95CI	U95CI
1981	1.494	0.09	1.250	1.785
1982	1.474	0.09	1.234	1.761
1983	2.234	0.09	1.871	2.667
1984	2.036	0.09	1.701	2.436
1985	1.091	0.09	0.912	1.305
1986	1.774	0.09	1.488	2.115
1987	2.066	0.09	1.731	2.467
1988	1.542	0.09	1.293	1.839
1989	0.565	0.09	0.473	0.675
1990	1.159	0.09	0.973	1.380
1991	1.376	0.09	1.156	1.638
1992	1.392	0.09	1.169	1.657
1993	1.947	0.09	1.638	2.313
1994	1.366	0.09	1.150	1.623
1995	1.436	0.09	1.205	1.711
1996	1.535	0.09	1.289	1.827
1997	1.564	0.09	1.314	1.862
1998	1.907	0.10	1.559	2.333
1999	2.413	0.07	2.122	2.746
2000	2.330	0.07	2.048	2.651
2001	1.417	0.03	1.339	1.500
2002	1.147	0.03	1.089	1.207
2003	1.152	0.03	1.095	1.212
2004	1.151	0.03	1.092	1.213
2005	1.254	0.03	1.191	1.320
2006	1.710	0.03	1.615	1.811
2007	1.042	0.03	0.991	1.094
2008	1.015	0.03	0.960	1.074
2009	1.151	0.03	1.086	1.219
2010	1.202	0.03	1.133	1.275
2011	1.146	0.03	1.082	1.213
2012	1.000			

Table A82. Summary of ‘phase 1’ 2013 SAW 57 model building settings.

2013 SARC 57	**CODES:**	F57= 2013 SARC 57	FLDL = Fishery selex modeled as Single Logistic-Double Logisitc
ASAP for summer flounder		IAA = Indices configured independently At Age	FAGE = Fishery selex modeled At Age
Ages 0-8+ (coded ages 1-7+)		MULTI = Indices configures as Multinomials	ESS = Effective Sample Size
		IND47 = 2008 SAW 47 index set	ALLSV = all available 2013 SAW57 indices
		L = Lambda (scalar weighting factor)	CV = Coefficeint of Variation; MAT3NOT = New Maturity Schedule
		A50 = age at 50%ile (inflection age)	Y1 = First year of model; NEWDISC = New Commercial Discards

MODEL	**2008** SAW 47	**2012** Update	**F57**-IAA-IND4 -FLDL	F57-IAA-IND47- FLDL-**MAT3NOT**	F57-IAA-IND47 -FLDL-MAT3NOT- **NEWDISC**	F57-IAA-IND47- **FAGE**-MAT3NOT- NEWDISC	F57-**MULTI**-IND47 -FAGE-MAT3NOT- NEWDISC	F57-MULTI-**ALLSV** -FAGE-MAT3NOT- NEWDISC
	terminal Y = **2007**	terminal Y = **2011**	terminal Y = **2012**	terminal Y = 2012	terminal Y = 2012	terminal Y = 2012	terminal Y = 2012	terminal Y = 2012
Years	1982-2007	1982-2011	1982-2012	1982-2012	1982-2012	1982-2012	1982-2012	1982-2012
Mean M	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Fleets	2	2	2	2	2	2	2	2
FISH SELEX								
Time block start	1982; 1995	1982; 1995	1982; 1995	1982; 1995	1982; 1995	1982; 1995	1982; 1995	1982; 1995
Landings Model	Single Log	Single Log	Single Log	Single Log	Single Log	F at Age	F at Age	F at Age
Ascend A50	1	1	1	1	1	n/a	n/a	n/a
Ascend Slope	1	1	1	1	1	n/a	n/a	n/a
Age Fixed S=1	n/a	n/a	n/a	n/a	n/a	3; 4	3; 4	3; 4
Selex L	1	1	1	1	1	1	1	1
Discards Model	Double Log	Double Log	Double Log	Double Log	Double Log	F at Age	F at Age	F at Age
Ascend A50	0	0	0	0	0	n/a	n/a	n/a
Ascend Slope	1	1	1	1	1	n/a	n/a	n/a
Descend A50	2	2	2	2	2	n/a	n/a	n/a
Descend Slope	1	1	1	1	1	n/a	n/a	n/a
Age Fixed S=1	n/a	n/a	n/a	n/a	n/a	1; 2	1; 2	1; 2
Selex L	1	1	1	1	1	1	1	1

EMPHASIS FACTORS								
Catch L	10	10	10	10	10	10	10	10
Landings CV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Discards CV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Landings ESS	173	**153**	100	100	100	100	100	100
Discards ESS	101	**100**	100	100	100	100	100	100
F in Y1 L	1	1	1	1	1	1	1	1
F in Y1 CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
F Dev L	1	1	1	1	1	1	1	1
F Dev CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
N in Y1 L	1	1	1	1	1	1	1	1
N in Y1 CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
All SVs L	1	1	1	1	1	1	1	1
SV q L	0	0	0	0	0	0	0	0
SV q CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
SV q Dev L	0	0	0	0	0	0	0	0
SV q Dev CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
S-R Model								
Rec Dev L	0	0	0	0	0	0	0	0
Rec CV	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Steepness Dev L	0.05	**0**	0	0	0	0	0	0
Steepness CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Scaler Dev L	0.05	**0**	0	0	0	0	0	0
Scaler CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Table A83. Summary of 'phase 1' 2013 SAW 57 model building estimation results.

2013 SARC 57	**CODES:**	F57= 2013 SARC 57	FLDL = Fishery selex modeled as Single Logistic-Double Logisitc	
ASAP for summer flounder		IAA = Indices configured independently At Age	FAGE = Fishery selex modeled At Age	
Ages 0-8+ (coded ages 1-7+)		MULTI = Indices configures as Multinomials	ESS = Effective Sample Size	
		IND47 = 2008 SAW 47 index set	ALLSV = all available 2013 SAW57 indices	
		L = Lambda (scalar weighting factor)	CV = Coefficeint of Variation	MAT3NOT = New Maturity Schedule
		A50 = age at 50%ile (inflection age)	Y1 = First year of model	NEWDISC = New Commercial Discards

MODEL	**2008** SAW 47	**2012** Update	**F57**-IAA-IND47-FLDL	F57-IAA-IND47 -FLDL-**MAT3NOT**	F57-IAA-IND47 -FLDL-MAT3NOT-**NEWDISC**	F57-IAA-IND47 **-FAGE**-MAT3NOT-NEWDISC	F57-**MULTI**-IND47 -FAGE-MAT3NOT-NEWDISC	F57-MULTI-**ALLSV** -FAGE-MAT3NOT-NEWDISC
	terminal Y = **2007**	terminal Y = **2011**	terminal Y = **2012**	terminal Y = 2012	terminal Y = 2012	terminal Y = 2012	terminal Y = 2012	terminal Y = 2012
Objective Function								
Total	4,312.99	5,245.71	5,324.25	5,324.25	5,665.49	5,149.02	7,119.52	7,624.74
Catch	3,507.28	4,037.73	4,168.50	4,168.50	4,255.23	4,251.26	4,247.30	4,247.95
Indices	53.56	270.58	277.43	277.43	290.74	263.20	**668.77**	**991.63**
Fish CAA	666.29	839.99	780.42	780.42	1,017.01	838.42	805.90	811.37
SV CAA	0.00	0.00	0.00	0.00	0.00	0.00	**1,343.95**	**1,519.26**
Fish Selex	25.03	25.13	25.04	25.04	26.22	-12.47	-21.70	-21.44
SV Selex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SV q in Y1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SV q Dev	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F in Y1	1.39	1.49	1.21	1.21	1.24	1.24	1.26	1.26
F Dev	10.00	11.06	11.64	11.64	15.45	15.10	15.57	15.72
N in Y1	58.69	59.72	60.03	60.03	59.61	62.27	58.47	58.99
Rec Dev	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S-R Steepness	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S-R scaler	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FISH SELEX								
Landings (by block)								
Age 0	0.02, 0.01	0.02, 0.01	0.02, 0.01	0.02, 0.01	0.02, 0.01	0.02, 0.01	0.02, 0.01	0.02, 0.01
Age 1	0.42, 0.08	0.43, 0.06	0.43, 0.07	0.43, 0.07	0.42, 0.06	0.43, 0.09	0.42, 0.06	0.42, 0.07
Age 2	0.96, 0.59	0.96, 0.48	0.96, 0.49	0.96, 0.49	0.96, 0.48	1.00, 0.53	1.00, 0.42	1.00, 0.46
Age 3	1.00, 1.00	1.00, 0.93	1.00, 0.93	1.00, 0.93	1.00, 0.93	1.00, 0.92	1.00, 0.83	1.00, 0.87
Age 4	1.00, 1.00	1.00, 0.99	1.00, 0.99	1.00, 0.99	1.00, 0.99	**0.73, 1.00**	0.80, 1.00	0.79, 1.00
Age 5	1.00, 1.00	1.00, 1.00	1.00, 1.00	1.00, 1.00	1.00, 1.00	**0.59, 1.00**	**0.79, 1.00**	0.78, 0.95
Age 6	1.00, 1.00	1.00, 1.00	1.00, 1.00	1.00, 1.00	1.00, 1.00	**1.00, 0.84**	**0.78, 0.86**	0.77, 0.78
Age 7+	1.00, 1.00	1.00, 1.00	1.00, 1.00	1.00, 1.00	1.00, 1.00	**0.98, 0.52**	0.91, 0.60	**0.92, 0.48**
Discards (by block)								
Age 0	0.13, 0.05	0.13, 0.07	0.13, 0.07	0.13, 0.07	0.13, 0.08	0.13, 0.07	0.12, 0.07	0.12, 0.08
Age 1	1.00, 0.66	1.00, 0.71	1.00, 0.70	1.00, 0.70	**1.00, 0.57**	1.00, 0.54	1.00, 0.55	1.00, 0.56
Age 2	0.08, 1.00	0.08, 1.00	0.08, 1.00	0.08, 1.00	**0.18, 1.00**	0.16, 1.00	0.16, 1.00	0.16, 1.00
Age 3	0.00, 0.63	0.00, 0.76	0.00, 0.78	0.00, 0.78	**0.01, 0.93**	**0.06, 0.79**	0.06, 0.83	0.06, 0.81
Age 4	0.00, 0.30	0.00, 0.51	0.00, 0.53	0.00, 0.53	**0.00, 0.80**	**0.08, 0.55**	0.08, 0.66	0.08, 0.62
Age 5	0.00, 0.12	0.00, 0.32	0.00, 0.33	0.00, 0.33	**0.00, 0.67**	**0.09, 0.40**	**0.09, 0.54**	0.09, 0.48
Age 6	0.00, 0.04	0.00, 0.19	0.00, 0.19	0.00, 0.19	**0.00, 0.55**	**0.10, 0.34**	**0.10, 0.55**	0.10, 0.47
Age 7+	0.00, 0.02	0.00, 0.11	0.00, 0.11	0.00, 0.11	**0.00, 0.44**	**0.10, 0.28**	**0.10, 0.48**	**0.10, 0.37**
F, R, SSB								
F 1982	1.20	1.10	1.07	1.07	1.11	**0.90**	**1.06**	1.03
F 1988	2.00	1.98	2.01	2.01	1.97	**1.65**	1.66	1.67
F 2007	0.30	0.25	0.25	0.25	0.26	**0.19**	**0.23**	**0.19**
F 2011		0.24	0.22	0.22	0.24	**0.19**	**0.23**	**0.20**
F 2012			0.18	0.18	0.20	**0.16**	**0.19**	**0.17**
Age 0 1982	73,512	71,569	69,619	69,619	72,774	70,478	71,467	71,357
Age 0 1988	12,831	12,806	12,744	12,744	11,637	11,628	10,377	10,358
Age 0 2007	39,972	42,496	43,435	43,433	46,106	49,644	46,051	47,755
Age 0 2011		25,990	19,104	19,101	22,557	22,925	**17,708**	**19,402**
Age 0 2012			54,667	54,654	49,816	**53,379**	54,202	**37,668**
SSB 1982	24,674	25,006	25,320	24,686	24,456	25,567	**22,726**	23,050
SSB 1989	7,017	7,040	6,734	7,099	6,615	6,830	**6,223**	6,134
SSB 2007	43,364	49,828	48,979	46,026	49,881	**61,776**	**56,637**	**64,978**
SSB 2011		57,050	60,019	57,780	56,674	**67,730**	**58,549**	**66,482**
SSB 2012			60,905	58,971	57,434	**67,652**	**57,526**	**64,384**

Table A84. Summary of 'phase 2' 2013 SAW 57 BASE model building settings for runs 1-6.

MODEL	F57-MULTI-ALLSV-FAGE-MAT3NOT-NEWDISC	F57_BASE_1: remove starting F and N Ls	F57_BASE_2: restrict DE 30 to 2003+	F57_BASE_3: change CAT L 10 to 1	F57_BASE_4: add Larval SVs	F57_BASE_5: tune SV CVs - step 1	F57_BASE_6: tune SV CVs - step 2
Years	1982-2012	1982-2012	1982-2012	1982-2012	1982-2012	1982-2012	1982-2012
Mean M	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Fleets	2	2	2	2	2	2	2
FISH SELEX							
Time block start	1982; 1995	1982; 1995	1982; 1995	1982; 1995	1982; 1995	1982; 1995	1982; 1995
Landings Model	F at Age	F at Age	F at Age	F at Age	F at Age	F at Age	F at Age
Ascend A50	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ascend Slope	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age Fixed S=1	3; 4	3; 4	3; 4	3; 4	3; 4	3; 4	3; 4
Selex Ls	1	1	1	1	1	1	1
Discards Model	F at Age	F at Age	F at Age	F at Age	F at Age	F at Age	F at Age
Ascend A50	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Ascend Slope	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Descend A50	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Descend Slope	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age Fixed S=1	1; 2	1; 2	1; 2	1; 2	1; 2	1; 2	1; 2
Selex Ls	1	1	1	1	1	1	1

EMPHASIS FACTORS							
Catch L	10	10	10	**1**	1	1	1
Landings CV	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Discards CV	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Landings ESS	100	100	100	100	100	100	100
Discards ESS	100	100	100	100	100	100	100
F in Y1 L	1	**0**	0	0	0	0	0
F in Y1 CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9
F Dev L	1	**0**	0	0	0	0	0
F Dev CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9
N in Y1 L	1	**0**	0	0	0	0	0
N in Y1 CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9
All SVs L	1	1	1	1	1	1	1
SV q L	0	0	0	0	0	0	0
SV q CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9
SV q Dev L	0	0	0	0	0	0	0
SV q Dev CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9
S-R Model							
Rec Dev L	0	0	0	0	0	0	0
Rec CV	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Steepness Dev L	0	0	0	0	0	0	0
Steepness CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Scaler Dev L	0	0	0	0	0	0	0
Scaler CV	0.9	0.9	0.9	0.9	0.9	0.9	0.9

Table A85. Summary of 'phase 2' 2013 SAW 57 BASE model building estimation results for runs 1-6.

MODEL	F57-MULTI-ALLSV-FAGE-MAT3NOT-NEWDISC	F57_BASE_1	F57_BASE_2: restrict DE 30 to 2003+	F57_BASE_3: change CAT L 10 to 1	F57_BASE_4: add Larval SVs	F57_BASE_5: tune SV CVs - step 1	F57_BASE_6: tune SV CVs - step 2
Consequence	Lower F, higher SSB	minor increase SSB	Increase SSB	Rescale OF, decrease SSB	Minor decrease SSB	SV RMSEs closer to 1, decrease SSB	SV RMSEs yet closer to 1, less SSB
Objective Function							
Total	7,624.74	7,547.23	7,406.23	3,570.07	3,682.17	3,758.04	3,736.37
Catch	4,247.95	4,247.43	4,247.07	438.82	438.77	435.96	435.79
Indices	991.63	990.66	936.28	922.56	1,034.50	904.29	882.55
Fish CAA	811.37	814.73	811.85	801.26	802.34	798.23	798.29
SV CAA	1,519.26	1,515.34	1,431.59	1,428.19	1,427.43	1,640.65	1,640.88
Fish Selex	-21.44	-20.93	-20.56	-20.76	-20.87	-21.09	-21.14
SV Selex	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SV q in Y1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SV q Dev	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F in Y1	1.26	**0.00**	0.00	0.00	0.00	0.00	0.00
F Dev	15.72	**0.00**	0.00	0.00	0.00	0.00	0.00
N in Y1	58.99	**0.00**	0.00	0.00	0.00	0.00	0.00
Rec Dev	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S-R Steepness	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S-R scaler	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FISH SELEX							
Landings (by block)							
Age 0	0.02, 0.01	0.02, 0.01	0.02, 0.01	0.02, 0.01	0.02, 0.01	0.02, 0.01	0.02, 0.01
Age 1	0.42, 0.07	0.42, 0.07	0.42, 0.07	0.42, 0.07	0.42, 0.07	0.42, 0.07	0.42, 0.06
Age 2	1.00, 0.46	1.00, 0.46	1.00, 0.46	1.00, 0.44	1.00, 0.44	1.00, 0.44	1.00, 0.42
Age 3	1.00, 0.87	1.00, 0.87	1.00, 0.88	1.00, 0.86	1.00, 0.86	1.00, 0.84	1.00, 0.83
Age 4	0.79, 1.00	0.76, 1.00	0.76, 1.00	0.77, 1.00	0.77, 1.00	0.77, 1.00	0.78, 1.00
Age 5	0.78, 0.95	0.71, 0.94	0.71, 0.93	0.71, 0.95	0.72, 0.96	0.72, 0.98	0.72, 1.00
Age 6	0.77, 0.78	**0.71, 0.77**	0.71, 0.75	0.70, 0.78	0.70, 0.79	0.71, 0.83	0.71, 0.85
Age 7+	0.92, 0.48	**0.84, 0.47**	0.84, 0.44	0.84, 0.49	0.83, 0.50	0.85, 0.56	0.85, 0.60

Discards (by block)							
Age 0	0.12, 0.08	0.12, 0.08	0.12, 0.08	0.12, 0.07	0.12, 0.07	0.12, 0.07	0.12, 0.07
Age 1	1.00, 0.56	1.00, 0.56	1.00, 0.56	1.00, 0.55	1.00, 0.55	1.00, 0.55	1.00, 0.55
Age 2	0.16, 1.00	0.16, 1.00	0.16, 1.00	0.16, 1.00	0.16, 1.00	0.16, 1.00	0.16, 1.00
Age 3	0.06, 0.81	0.06, 0.81	0.06, 0.81	0.06, 0.82	0.06, 0.82	0.06, 0.83	0.06, 0.84
Age 4	0.08, 0.62	0.08, 0.62	0.08, 0.61	0.08, 0.63	0.08, 0.63	0.08, 0.65	0.08, 0.66
Age 5	0.09, 0.48	0.09, 0.48	0.09, 0.47	0.09, 0.49	0.09, 0.50	0.09, 0.53	0.09, 0.54
Age 6	0.10, 0.47	0.10, 0.47	0.10, 0.45	0.10, 0.48	0.10, 0.49	0.10, 0.53	0.10, 0.55
Age 7+	0.10, 0.37	0.10, 0.37	0.10, 0.34	0.10, 0.39	0.10, 0.41	0.10, 0.46	0.10, 0.50
F, R, SSB							
F 1982	1.03	**0.88**	0.88	0.93	0.92	0.90	0.91
F 1988	1.67	**1.56**	1.55	1.59	1.59	1.58	1.59
F 2007	0.19	0.19	0.17	0.18	0.18	0.21	0.22
F 2011	0.20	0.20	0.18	0.18	0.19	0.21	0.23
F 2012	0.17	0.17	0.15	0.15	0.16	0.18	0.19
Age 0 1982	71,357	**68,855**	68,957	**63,253**	63,764	66,823	67,206
Age 0 1988	10,358	10,190	10,209	9,710	9,692	**10,068**	10,043
Age 0 2007	47,755	48,038	**51,019**	49,770	49,274	45,486	43,824
Age 0 2011	19,402	19,505	**20,845**	20,849	20,714	20,327	19,897
Age 0 2012	37,668	37,907	**40,707**	40,556	40,307	40,028	42,137
SSB 1982	23,050	24,516	24,627	**22,593**	22,830	23,189	23,160
SSB 1989	6,134	6,141	6,230	5,900	5,867	6,043	6,013
SSB 2007	64,978	65,877	**72,211**	**66,425**	**64,233**	**58,140**	**56,199**
SSB 2011	66,482	67,364	**75,529**	**72,681**	**70,829**	**62,299**	**58,104**
SSB 2012	64,384	65,245	**73,694**	**71,445**	**69,738**	**61,160**	**57,098**

Table A86. Summary of ‘phase 2’ 2013 SAW 57 BASE model building settings for runs 7-12.

MODEL	F57_BASE_7: Fish Selex Ls = 0	F57_BASE_8: Fish Selex Ls =0, Fix Fish Selex = 1 for 3+, 4+	F57_BASE_9: Model 6, Add 3rd Fish Selex Block 2008+	F57_BASE_10: **Drop NCYOY**	F57_BASE_11: **Fix High CV SV Selex Note not in OF**	F57_BASE_12: A**pply All Francis Fish and SV ESS Adjustments**
Years	1982-2012	1982-2012	1982-2012	1982-2012	1982-2012	1982-2012
Mean M	0.25	0.25	0.25	0.25	0.25	0.25
Fleets	2	2	2	2	2	2
FISH SELEX						
Time block start	1982; 1995	1982; 1995	**1982; 1995; 2008**	1982; 1995; 2008	1982; 1995; 2008	1982; 1995; 2008
Landings Model	F at Age	F at Age	F at Age	F at Age	F at Age	F at Age
Ascend A50	n/a	n/a	n/a	n/a	n/a	n/a
Ascend Slope	n/a	n/a	n/a	n/a	n/a	n/a
Age Fixed S=1	3; 4	**3+; 4+**	**3; 4**	3; 4	3; 4	3; 4
Selex Ls	**0**	**0**	**1**	1	1	1
Discards Model	F at Age	F at Age	F at Age	F at Age	F at Age	F at Age
Ascend A50	n/a	n/a	n/a	n/a	n/a	n/a
Ascend Slope	n/a	n/a	n/a	n/a	n/a	n/a
Descend A50	n/a	n/a	n/a	n/a	n/a	n/a
Descend Slope	n/a	n/a	n/a	n/a	n/a	n/a
Age Fixed S=1	1; 2	1; 2	1; 2	1; 2	1; 2	1; 2
Selex Ls	1	1	1	1	1	1

EMPHASIS FACTORS						
Catch L	1	1	1	1	1	1
Landings CV	0.1	0.1	0.1	0.1	0.1	0.1
Discards CV	0.1	0.1	0.1	0.1	0.1	0.1
Landings ESS	100	100	100	100	100	**55**
Discards ESS	100	100	100	100	100	**30**
F in Y1 L	0	0	0	0	0	0
F in Y1 CV	0.9	0.9	0.9	0.9	0.9	0.9
F Dev L	0	0	0	0	0	0
F Dev CV	0.9	0.9	0.9	0.9	0.9	0.9
N in Y1 L	0	0	0	0	0	0
N in Y1 CV	0.9	0.9	0.9	0.9	0.9	0.9
All SVs L	1	1	1	1	1	1
SV q L	0	0	0	0	0	0
SV q CV	0.9	0.9	0.9	0.9	0.9	0.9
SV q Dev L	0	0	0	0	0	0
SV q Dev CV	0.9	0.9	0.9	0.9	0.9	0.9
S-R Model						
Rec Dev L	0	0	0	0	0	0
Rec CV	0.5	0.5	0.5	0.5	0.5	0.5
Steepness Dev L	0	0	0	0	0	0
Steepness CV	0.9	0.9	0.9	0.9	0.9	0.9
Scaler Dev L	0	0	0	0	0	0
Scaler CV	0.9	0.9	0.9	0.9	0.9	0.9

Table A87. Summary of 'phase 2' 2013 SAW 57 BASE model building estimation results for runs 7-12.

MODEL	F57_BASE_7: Fish Selex Ls = 0	F57_BASE_8: Fish Selex Ls =0, Fix Fish Selex = 1 for L1= 3+, L2 = 4+	F57_BASE_9: Model 6, Add 3rd Fish Selex Block 2008+	F57_BASE_10: **Drop NCYOY**	F57_BASE_11: **Fix High CV SV Selex Note not in OF**	F57_BASE_12: **Apply All Francis Fish and SV ESS Adjustments**
Consequence	More dome, worse Retro	Flat selex, substantial decrease SSB	Improved Fish CAA resids, better Retro, increase SSB	Minor R changes	Less Fish Dome, higher recent F, less recent SSB	Less Land Fish Dome, lower recent F, less recent SSB
Objective Function						
Total	3,751.11	3,758.10	3,679.02	3602.24	3,606.67	3,586.51
Catch	436.08	436.18	434.01	433.92	434.53	432.89
Indices	882.78	881.86	878.13	800.74	801.19	802.32
Fish CAA	792.66	795.65	752.97	753.62	754.01	512.33
SV CAA	1,639.59	1,644.41	1,637.15	1637.31	1640.77	1868.50
Fish Selex	**0.00**	0.00	**-23.25**	-23.34	-23.83	-29.52
SV Selex	0.00	0.00	0.00	0.00	0.00	0.00
SV q in Y1	0.00	0.00	0.00	0.00	0.00	0.00
SV q Dev	0.00	0.00	0.00	0.00	0.00	0.00
F in Y1	0.00	0.00	0.00	0.00	0.00	0.00
F Dev	0.00	0.00	0.00	0.00	0.00	0.00
N in Y1	0.00	0.00	0.00	0.00	0.00	0.00
Rec Dev	0.00	0.00	0.00	0.00	0.00	0.00
S-R Steepness	0.00	0.00	0.00	0.00	0.00	0.00
S-R scaler	0.00	0.00	0.00	0.00	0.00	0.00
FISH SELEX						
Landings (by block)						
Age 0	0.02, 0.01	0.02, 0.01	0.02, 0.01, 0.01	0.02, 0.01, 0.01	0.02, 0.01, 0.01	0.02, 0.01, 0.01
Age 1	0.42, 0.06	0.43, 0.06	0.42, 0.08, 0.03	0.42, 0.08, 0.03	0.42, 0.08, 0.03	0.41, 0.08, 0.04
Age 2	1.00, 0.40	1.00, 0.39	**1.00, 0.58, 0.17**	**1.00, 0.58, 0.17**	1.00, 0.56, 0.16	1.00, 0.55, 0.18
Age 3	1.00, 0.80	1.00, 0.79	**1.00, 1.00, 0.56**	**1.00, 1.00, 0.56**	1.00, 1.00, 0.54	1.00, 1.00, 0.55
Age 4	0.74, 1.00	**1.00, 1.00**	**0.78, 1.00, 1.00**	**0.77, 1.00, 1.00**	0.78, 1.00, 1.00	0.74, 1.00, 1.00
Age 5	**0.60, 0.94**	**1.00, 1.00**	**0.72, 0.78, 1.00**	**0.72, 0.78, 1.00**	0.73, 0.84, 1.00	0.67, 0.85, 1.00
Age 6	**0.34, 0.79**	**1.00, 1.00**	**0.71, 0.68, 0.88**	**0.71, 0.68, 0.88**	**0.72, 0.77, 0.95**	**0.70, 0.81, 1.00**
Age 7+	**0.26, 0.50**	**1.00, 1.00**	**0.84, 0.51, 0.45**	**0.84, 0.51, 0.45**	**0.87, 0.63, 0.56**	**0.87, 0.72, 0.73**

Discards (by block)						
Age 0	0.12, 0.07	0.12, 0.07	0.12, 0.07, 0.08	0.12, 0.07, 0.08	0.12, 0.07, 0.08	0.12, 0.07, 0.09
Age 1	1.00, 0.55	1.00, 0.55	1.00, 0.52, 0.58	1.00, 0.52, 0.58	1.00, 0.52, 0.58	1.00, 0.52, 0.57
Age 2	0.16, 1.00	0.16, 1.00	**0.16, 1.00, 1.00**	**0.16, 1.00, 1.00**	0.16, 1.00, 1.00	0.15, 1.00, 1.00
Age 3	0.03, 0.85	0.03, 0.85	**0.06, 0.71, 1.00**	**0.06, 0.71, 1.00**	0.06, 0.72, 1.00	0.08, 0.73, 0.93
Age 4	**0.01, 0.67**	**0.01, 0.72**	**0.08, 0.47, 0.95**	**0.08, 0.47, 0.95**	0.08, 0.50, 0.97	0.09, 0.52, 0.84
Age 5	**0.01, 0.55**	**0.01, 0.61**	**0.09, 0.46, 0.64**	**0.09, 0.46, 0.64**	0.09, 0.50, 0.67	0.10, 0.53, 0.61
Age 6	**0.00, 0.55**	**0.00, 0.68**	**0.10, 0.55, 0.51**	**0.10, 0.55, 0.51**	**0.10, 0.62, 0.56**	0.10, 0.60, 0.55
Age 7+	**0.00, 0.47**	**0.00, 0.78**	**0.10, 0.56, 0.38**	**0.10, 0.56, 0.38**	**0.10, 0.69, 0.47**	**0.10, 0.64, 0.53**
F, R, SSB						
F 1982	**0.67**	**1.09**	0.91	0.87	0.89	0.79
F 1988	**1.16**	**1.93**	1.59	1.52	1.55	1.24
F 2007	0.22	**0.29**	0.21	**0.24**	**0.26**	0.26
F 2011	0.22	**0.27**	0.28	**0.35**	**0.38**	**0.36**
F 2012	0.19	0.22	0.22	**0.28**	**0.30**	**0.28**
Age 0 1982	67,374	66,476	67,284	67,304	66,982	62,672
Age 0 1988	10,048	9,964	10,061	9,982	9,927	9,789
Age 0 2007	44,114	42,135	42,964	**43,672**	42,391	**39,987**
Age 0 2011	20,036	19,702	20,821	**20,274**	19,894	**19,562**
Age 0 2012	42,629	41,697	42,614	**42,275**	41,561	**37,185**
SSB 1982	23,604	22,951	23,202	23,224	22,983	**24,300**
SSB 1989	6,167	5,906	6,025	6,019	5,923	**5,521**
SSB 2007	55,986	**47,378**	**54,698**	**55,340**	**49,361**	**48,540**
SSB 2011	**59,246**	**51,650**	**56,402**	**57,244**	**52,080**	**51,126**
SSB 2012	**58,133**	**51,458**	**56,243**	**56,947**	**52,131**	**51,238**

Table A88. Summary results for Spawning Stock Biomass (SSB) in metric tons (mt); Recruitment (R) at age 0 (000s); Fishing Mortality (F) for fully recruited (peak) age 4.

Year	SSB	R	F
1982	24,300	62,272	0.790
1983	23,221	75,755	1.043
1984	18,627	39,574	1.175
1985	18,435	62,265	1.102
1986	18,344	62,217	1.294
1987	18,917	42,373	1.123
1988	10,110	9,789	1.542
1989	5,521	30,500	1.241
1990	9,312	36,200	0.875
1991	11,297	40,549	1.041
1992	11,483	39,499	1.040
1993	12,802	36,837	0.959
1994	13,846	45,911	0.906
1995	17,675	57,652	1.745
1996	22,638	41,085	1.360
1997	25,234	37,678	0.849
1998	26,370	40,282	0.764
1999	28,493	33,516	0.552
2000	35,347	44,873	0.569
2001	40,672	46,952	0.479
2002	46,523	50,596	0.425
2003	52,635	37,754	0.399
2004	50,659	53,490	0.446
2005	47,583	32,260	0.451
2006	49,233	38,985	0.330
2007	48,540	39,987	0.263
2008	48,942	48,675	0.312
2009	51,578	54,857	0.300
2010	53,156	34,549	0.312
2011	51,129	19,562	0.359
2012	51,238	37,185	0.285

Table A89. January 1 population number (000s) estimates at age.

	Age								
	0	1	2	3	4	5	6	7+	Total
1982	62,272	43,746	23,821	2,360	807	252	172	124	133,555
1983	75,755	46,914	21,351	6,350	636	285	96	103	151,492
1984	39,574	56,644	19,763	4,054	1,220	175	87	52	121,568
1985	62,265	29,486	22,165	3,140	652	293	47	33	118,081
1986	62,217	46,585	12,231	3,887	557	169	84	20	125,750
1987	42,373	46,157	16,902	1,656	533	119	41	23	107,804
1988	9,789	31,581	18,431	2,880	286	135	34	16	63,151
1989	30,500	7,218	10,019	1,788	283	48	26	8	49,890
1990	36,200	21,828	1,995	1,444	267	64	12	8	61,817
1991	40,549	26,555	8,345	472	351	87	22	6	76,386
1992	39,499	30,099	10,552	1,585	91	96	26	8	81,955
1993	36,837	28,233	8,827	1,991	311	25	29	10	76,263
1994	45,911	27,098	10,729	1,866	431	93	8	12	86,148
1995	57,652	33,422	9,641	2,432	436	136	32	6	103,756
1996	41,085	43,743	21,052	2,627	322	59	24	7	108,920
1997	37,678	31,204	28,328	7,037	511	64	14	8	104,844
1998	40,282	28,794	21,649	13,028	2,308	170	24	9	106,263
1999	33,516	30,779	20,053	10,380	4,647	838	69	14	100,295
2000	44,873	25,537	21,282	10,397	4,525	2,084	403	40	109,141
2001	46,952	34,239	17,807	11,094	4,474	1,994	989	214	117,761
2002	50,596	35,966	24,626	10,104	5,280	2,158	1,027	633	130,390
2003	37,754	38,790	26,089	14,481	5,086	2,689	1,164	921	126,975
2004	53,490	28,938	28,133	15,505	7,473	2,659	1,483	1,183	138,863
2005	32,260	40,952	20,774	16,143	7,614	3,727	1,407	1,455	124,332
2006	38,985	24,681	29,254	11,804	7,868	3,777	1,961	1,556	119,885
2007	39,987	29,873	17,934	17,947	6,513	4,404	2,206	2,100	120,964
2008	48,675	30,598	21,590	11,224	10,535	3,898	2,718	2,698	131,936
2009	54,857	37,273	22,545	14,922	7,144	6,003	2,253	3,275	148,272
2010	34,549	42,009	27,470	15,611	9,559	4,120	3,513	3,401	140,232
2011	19,562	26,456	30,950	18,984	9,936	5,448	2,382	4,179	117,897
2012	37,185	14,985	19,540	21,353	11,819	5,405	3,001	3,855	117,141

Table A90. Fishing mortality (F) estimates at age.

	Age							
	0	1	2	3	4	5	6	7+
1982	0.023	0.457	1.062	1.061	0.790	0.715	0.743	0.919
1983	0.031	0.605	1.402	1.400	1.043	0.943	0.980	1.212
1984	0.034	0.678	1.580	1.578	1.175	1.063	1.105	1.366
1985	0.030	0.620	1.481	1.480	1.102	0.997	1.036	1.281
1986	0.039	0.754	1.739	1.737	1.294	1.171	1.217	1.504
1987	0.034	0.658	1.510	1.507	1.123	1.016	1.056	1.305
1988	0.045	0.888	2.073	2.071	1.542	1.395	1.450	1.793
1989	0.075	1.026	1.677	1.652	1.241	1.127	1.171	1.440
1990	0.050	0.702	1.182	1.166	0.875	0.794	0.825	1.016
1991	0.038	0.663	1.401	1.395	1.041	0.943	0.980	1.210
1992	0.076	0.967	1.408	1.379	1.040	0.946	0.982	1.206
1993	0.047	0.708	1.294	1.281	0.959	0.870	0.904	1.114
1994	0.057	0.773	1.224	1.205	0.906	0.823	0.855	1.051
1995	0.016	0.202	1.040	1.771	1.745	1.500	1.442	1.297
1996	0.015	0.174	0.836	1.388	1.360	1.172	1.129	1.019
1997	0.009	0.106	0.517	0.865	0.849	0.731	0.704	0.635
1998	0.009	0.102	0.475	0.781	0.764	0.659	0.636	0.575
1999	0.012	0.109	0.397	0.580	0.552	0.482	0.472	0.435
2000	0.010	0.101	0.391	0.593	0.569	0.496	0.483	0.442
2001	0.007	0.070	0.307	0.492	0.479	0.414	0.401	0.364
2002	0.006	0.061	0.271	0.436	0.425	0.367	0.355	0.322
2003	0.006	0.061	0.260	0.411	0.399	0.345	0.335	0.305
2004	0.007	0.071	0.295	0.461	0.446	0.387	0.375	0.342
2005	0.008	0.076	0.305	0.469	0.451	0.392	0.381	0.348
2006	0.006	0.059	0.229	0.345	0.330	0.288	0.280	0.257
2007	0.008	0.065	0.209	0.283	0.263	0.233	0.230	0.214
2008	0.007	0.045	0.109	0.202	0.312	0.298	0.294	0.224
2009	0.007	0.045	0.108	0.195	0.300	0.286	0.282	0.215
2010	0.007	0.046	0.110	0.202	0.312	0.298	0.294	0.224
2011	0.007	0.043	0.111	0.224	0.359	0.346	0.343	0.259
2012	0.005	0.032	0.085	0.176	0.285	0.276	0.273	0.205

Table A91. Input values for 2013 SAW 57 YPR and SSBR reference point estimates and stock projections. Values are averages for 2010-2012.

2013 SAW 57

Mean Natural Mortality (M) = 0.25

Proportion of mortality before spawning = 0.83

Age	Fishery Selex	Fishery Selex CV	M	M CV	Jan 1 Stock Weights	Jul 1 Catch Weights	Nov 1 SSB Weights	Weights CV	Maturity	Mat CV
0	0.02	0.20	0.26	0.10	0.147	0.184	0.219	0.26	0.380	0.33
1	0.13	0.20	0.26	0.10	0.240	0.326	0.382	0.14	0.910	0.07
2	0.32	0.20	0.26	0.10	0.414	0.522	0.574	0.11	0.980	0.01
3	0.63	0.20	0.25	0.10	0.602	0.725	0.812	0.18	1.000	0.01
4	1.00	0.20	0.25	0.10	0.860	1.022	1.158	0.18	1.000	0.01
5	0.96	0.20	0.25	0.10	1.233	1.457	1.579	0.20	1.000	0.01
6	0.95	0.20	0.25	0.10	1.644	1.869	2.227	0.20	1.000	0.01
7+	0.72	0.20	0.24	0.10	3.300	3.300	3.561	0.20	1.000	0.01

Table A92. Biological reference point estimates for the 2008 SAW 47 (old = existing) and 2013 SAW 57 (new = updated) assessments. In both assessments, the non-parametric references points (**BOLD**) are used to evaluate stock status.

Assessment Model	**2008_SAW47 ASAP SCAA**	**2013_SAW57 ASAP SCAA**
NON-PARAMETRIC	(deterministic)	(stochastic)
	M=0.25	M=0.25
Median R (000s)	41,553	40,237
FMSY Proxy	F35%	F35% (5%ile, 95%ile)
FMSY	**0.310**	**0.309 (0.247,0.390)**
Y/R (kg)	**0.358**	**0.303 (0.256, 0.358)**
SSB/R (kg)	**1.443**	**1.449 (1.165, 1.856)**
MSY (mt)	**13,122**	**12,945 (10,387; 15,997)**
SSBMSY(mt)	**60,074**	**62,394 (50,044; 77,273)**
PARAMETRIC		
Internal Beverton-Holt	L = 0.05	L = 1
R0	39,140	40,993
SSB0	189,729	140,382
Steepness	0.999	0.998
FMSY	0.420	3.000 (n/a)
MSY	14,686	13,841 (11,143; 16,539)
SSBMSY	43,898	11,423 (8,452; 14,412)

FIGURES

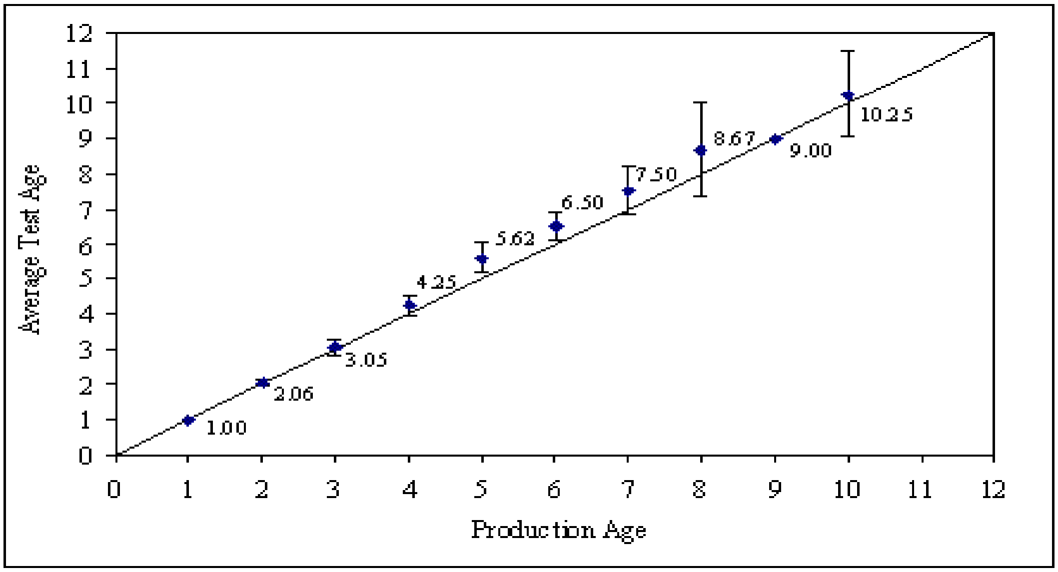


Figure A1. Age bias plot for NEFSC 2011 spring survey ages, 75% agreement.

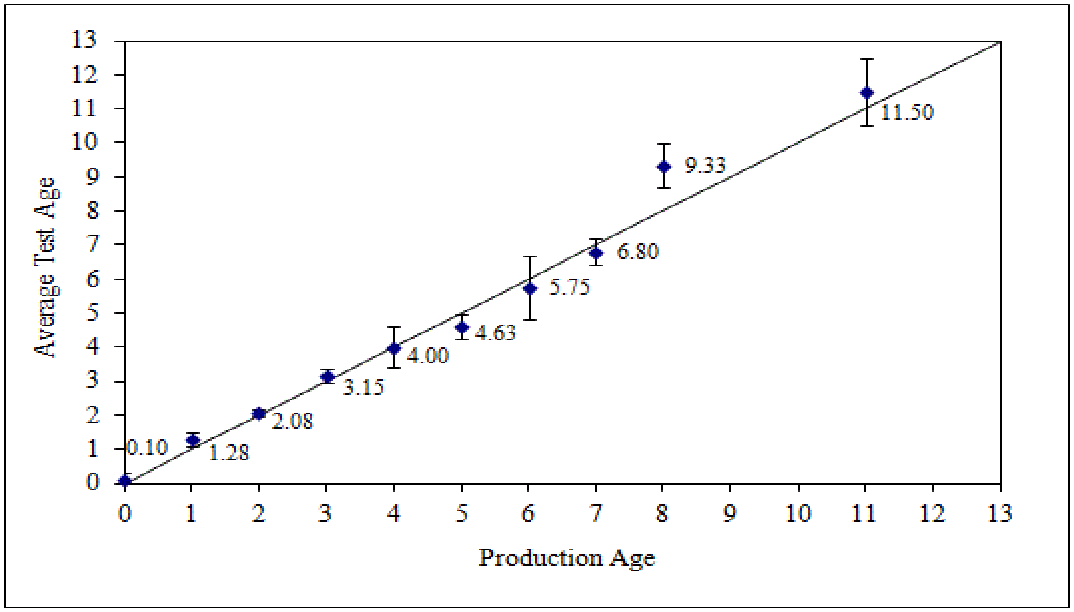


Figure A2. Age bias plot for NEFSC 2011 fall survey ages, 73% agreement.

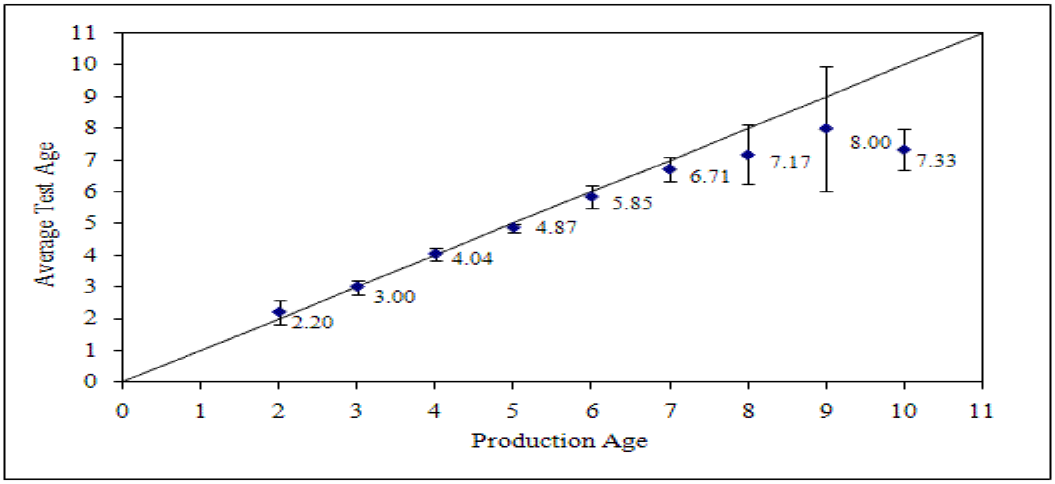


Figure A3. Age bias plot for NEFSC 2011 quarter 1 commercial ages, 69% agreement.

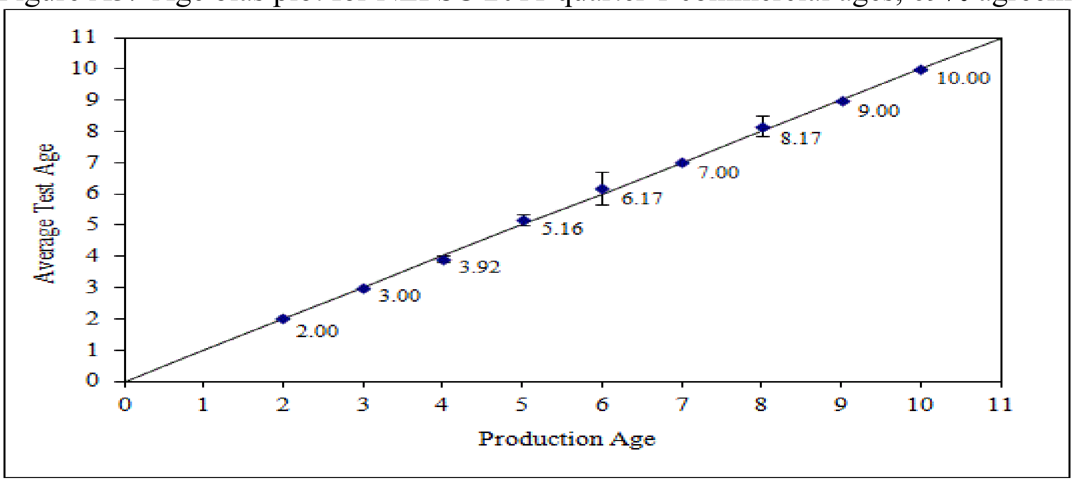


Figure A4. Age bias plot for NEFSC 2011 quarter 2 commercial ages, 92% agreement.

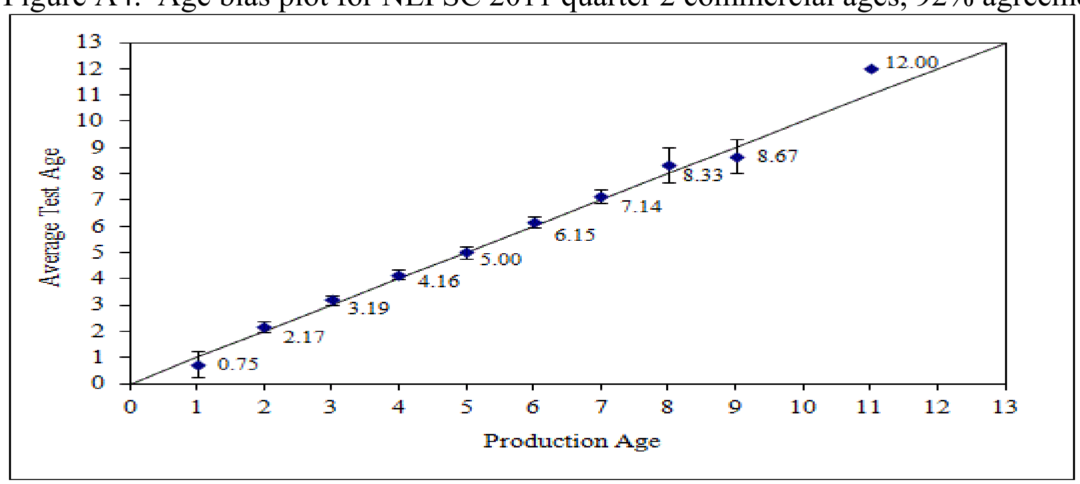


Figure A5. Age bias plot for NEFSC 2011 quarter 3-4 commercial ages, 80% agreement.

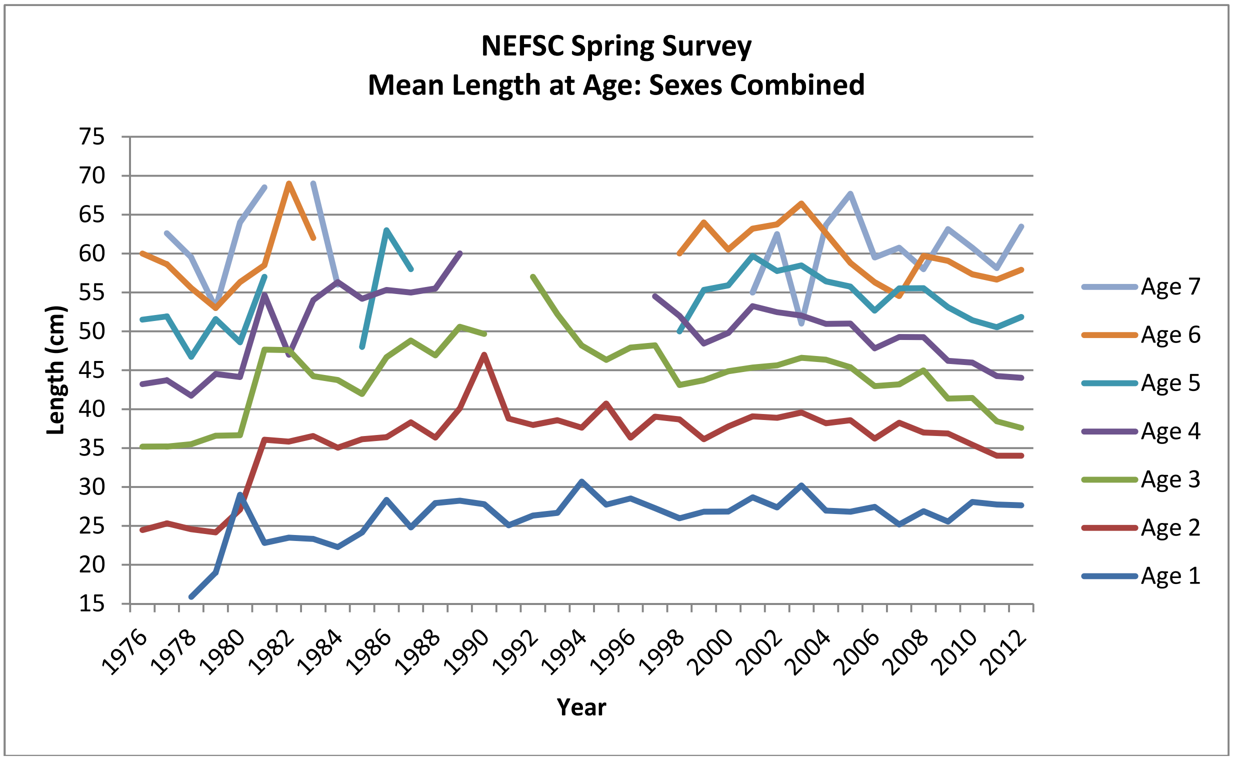


Figure A6. Trend in mean length at age for fish sampled in the NEFSC spring trawl survey: sexes combined.

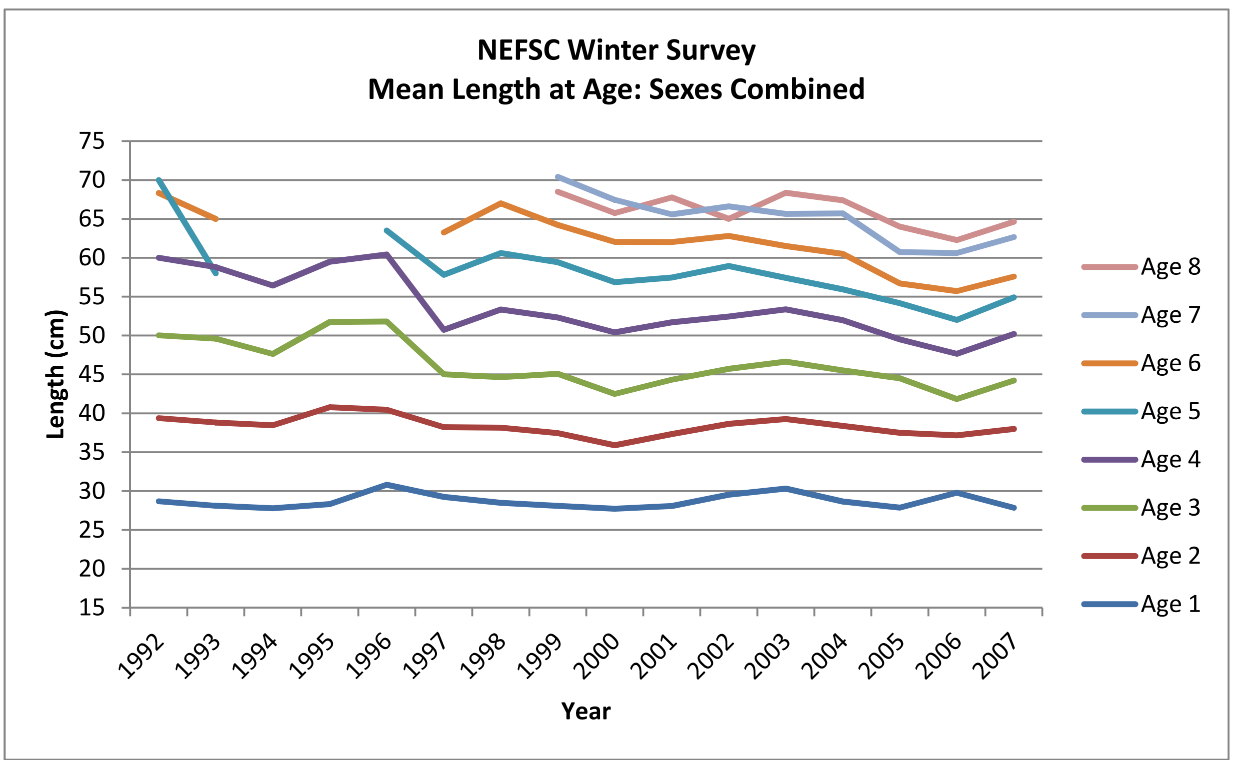


Figure A7. Trend in mean length at age for fish sampled in the NEFSC winter trawl survey: sexes combined.

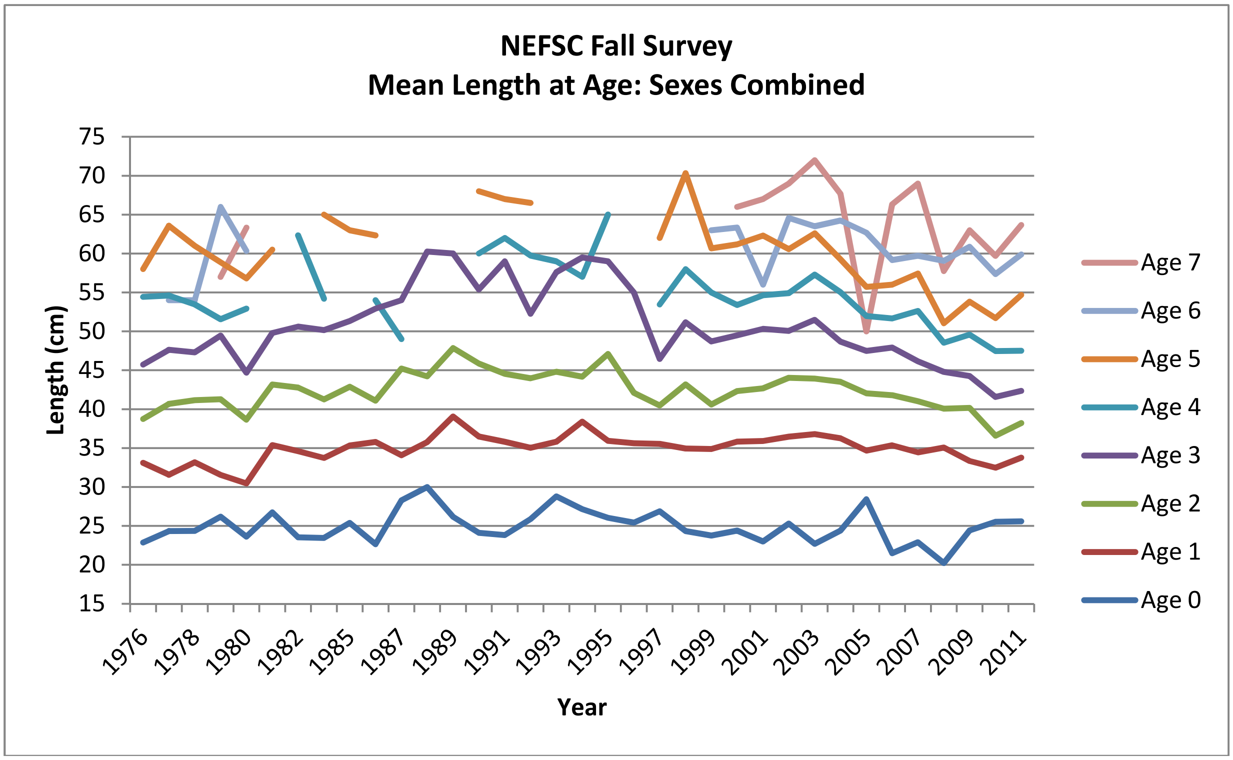


Figure A8. Trend in mean length at age for fish sampled in the NEFSC fall trawl survey: sexes combined.

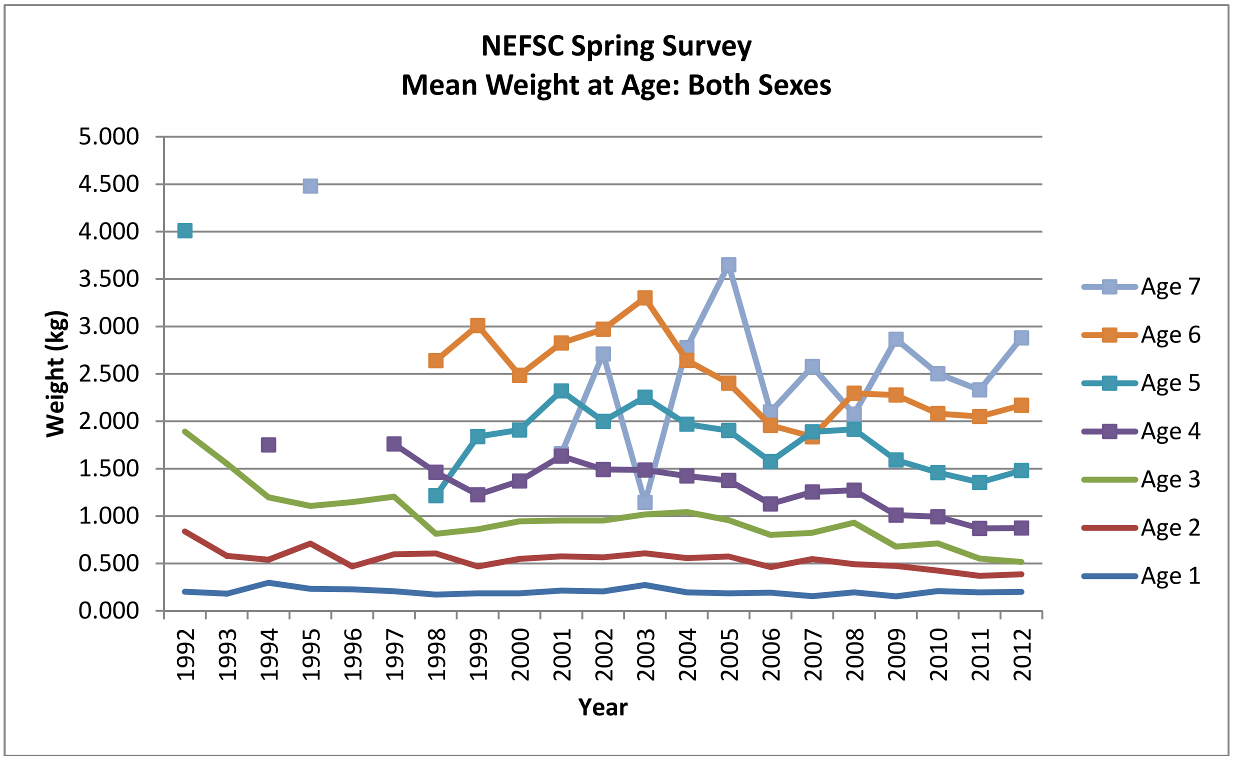


Figure A9. Trend in mean weight at age for fish sampled in the NEFSC spring trawl survey: sexes combined.

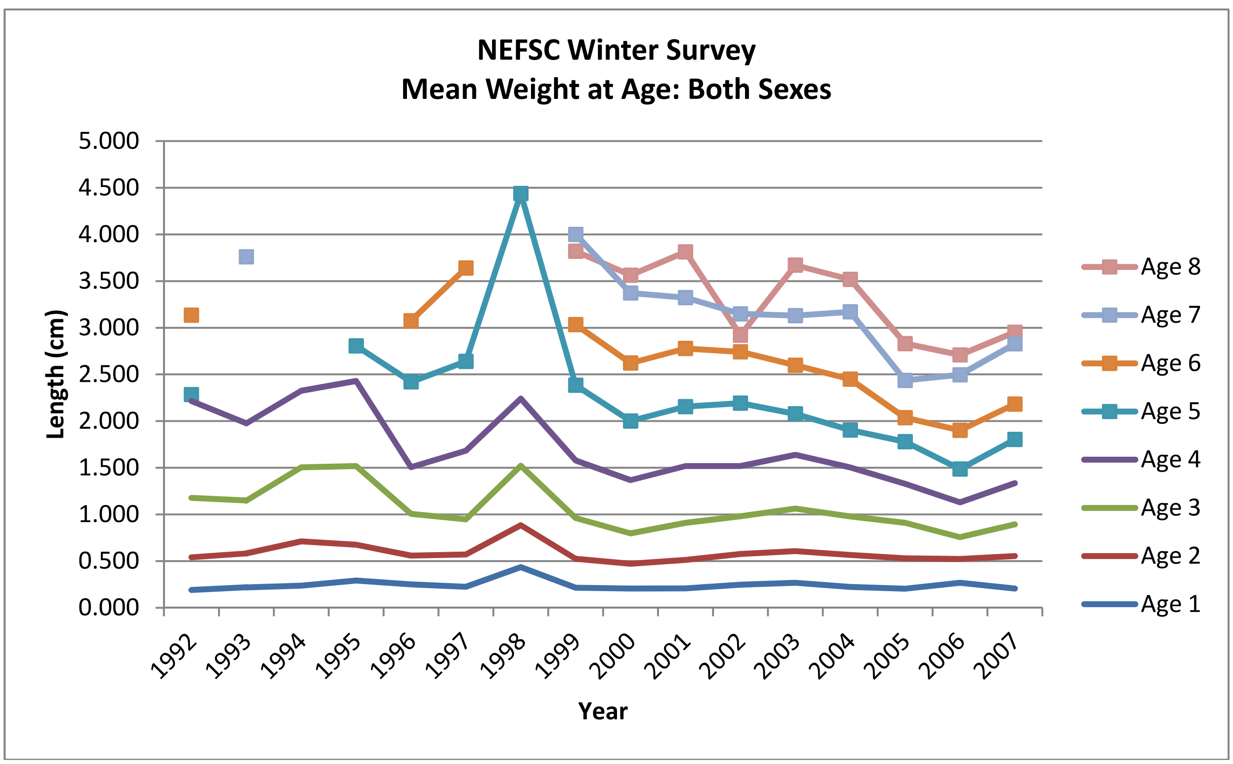


Figure A10. Trend in mean weight at age for fish sampled in the NEFSC winter trawl survey: sexes combined.

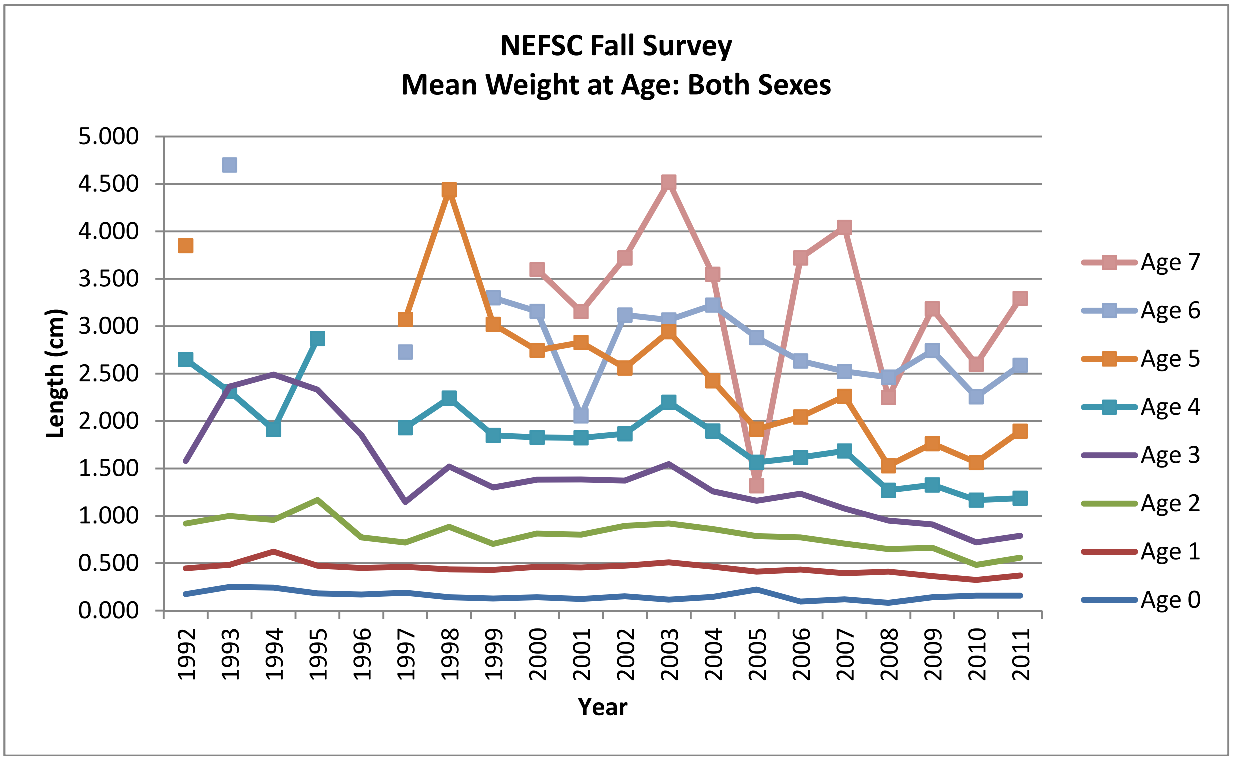
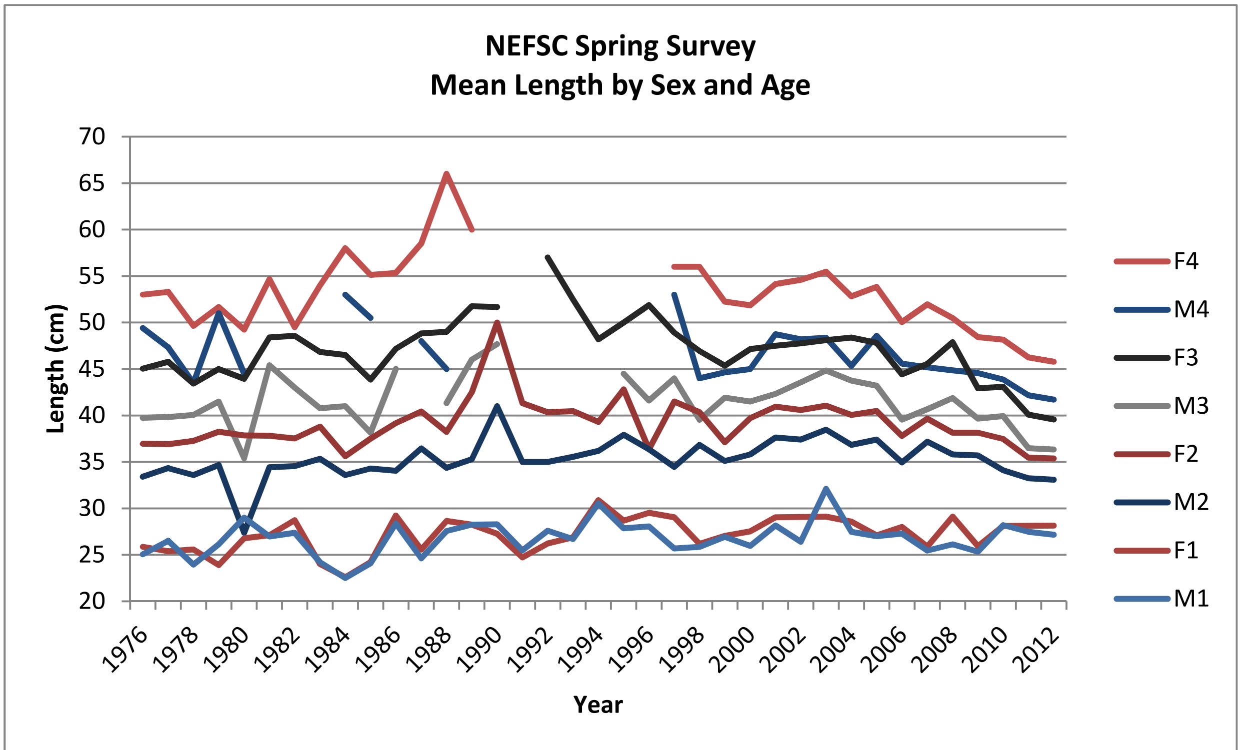


Figure A11. Trend in mean weight at age for fish sampled in the NEFSC fall trawl survey: sexes combined.



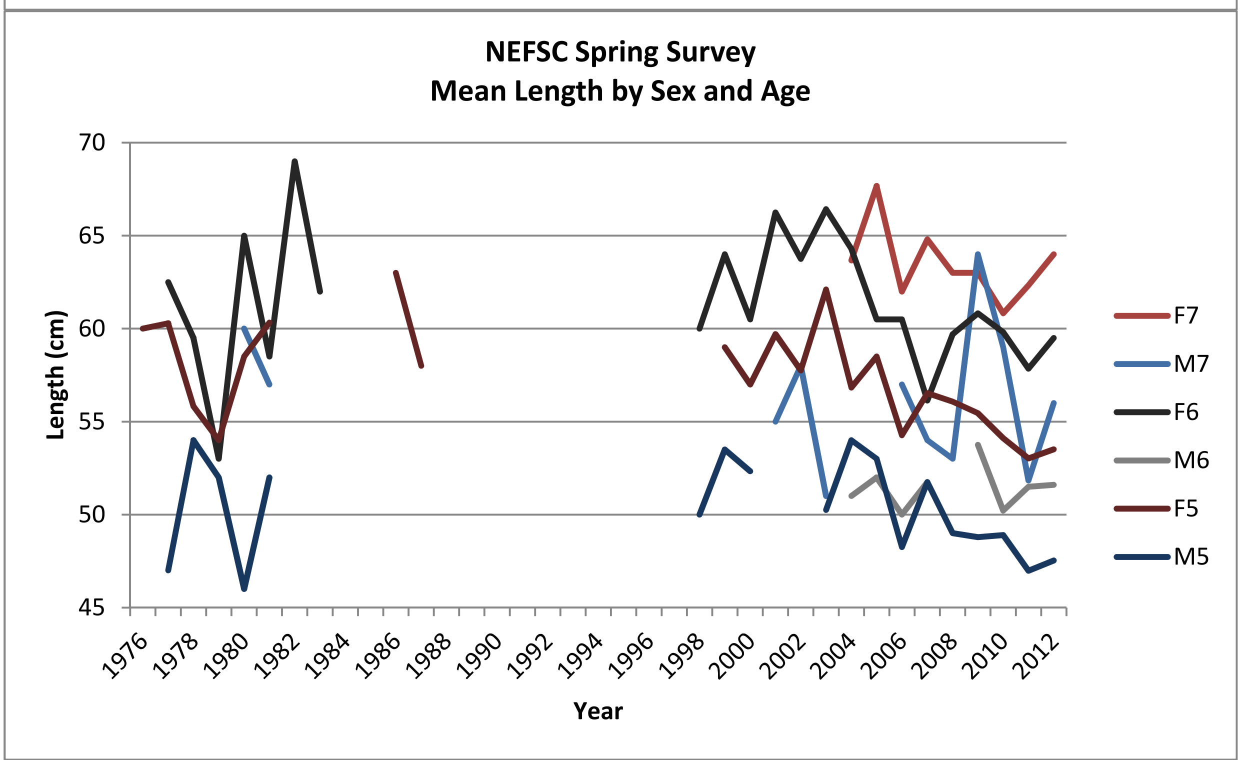


Figure A12. Trend in mean length at age for fish sampled in the NEFSC spring trawl survey: by sex and age; e.g., M1 = age 1 males, F7 = age 7 females.

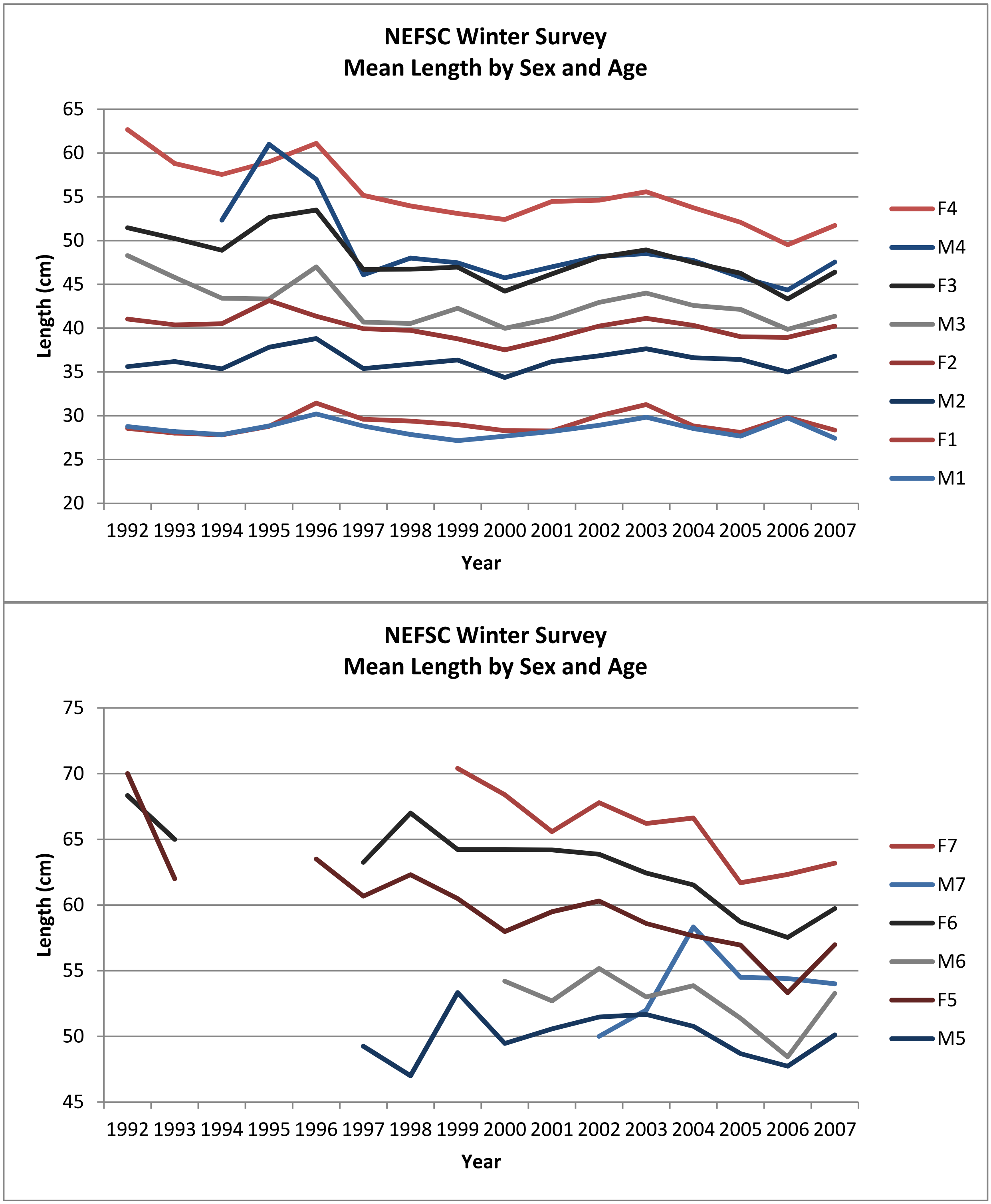


Figure A13. Trend in mean length at age for fish sampled in the NEFSC winter trawl survey: by sex and age; e.g., M1 = age 1 males, F7 = age 7 females.

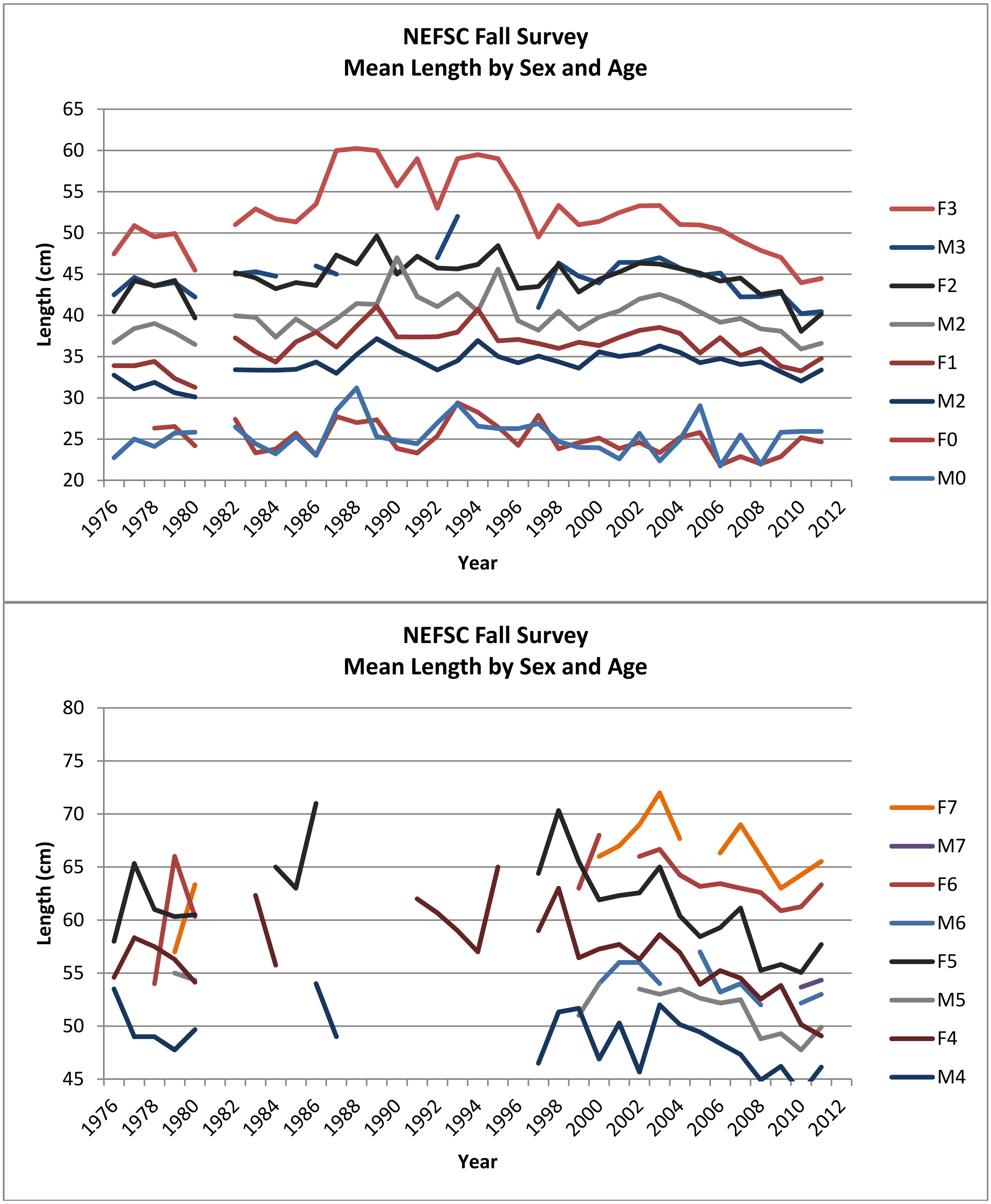


Figure A14. Trend in mean length at age for fish sampled in the NEFSC fall trawl survey: by sex and age; e.g., M0 = age 0 males, F7 = age 7 females.

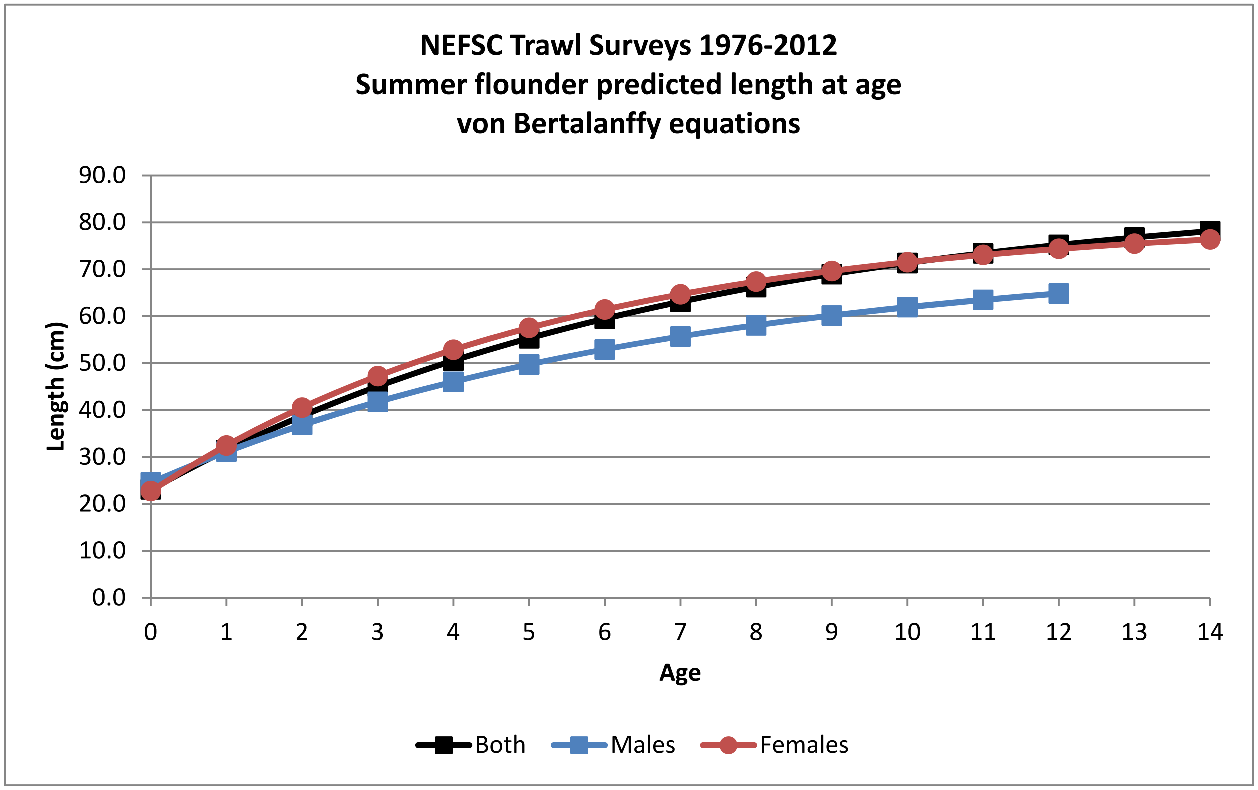
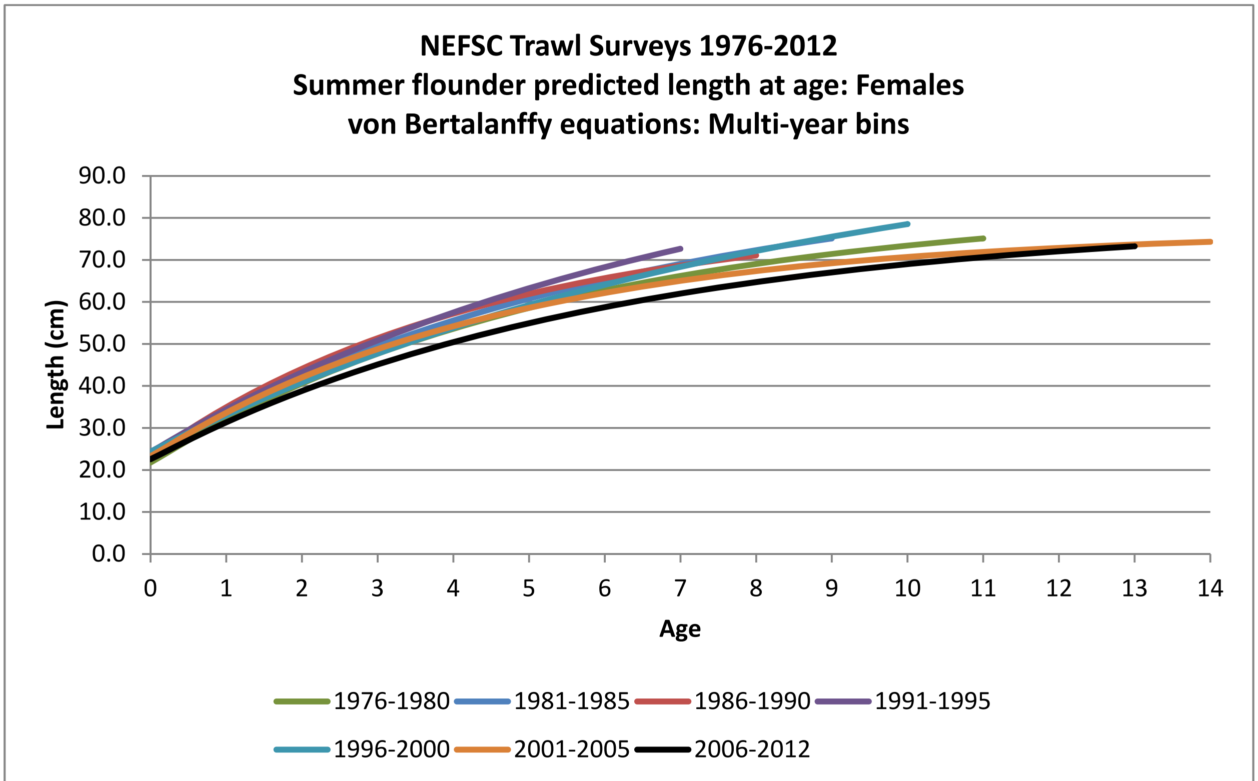


Figure A15. Predicted length at age from von Bertalanffy equations parameters estimated from NEFSC trawl survey data for 1976-2012. Maximum observed age for males is age 12; for females is age 14.



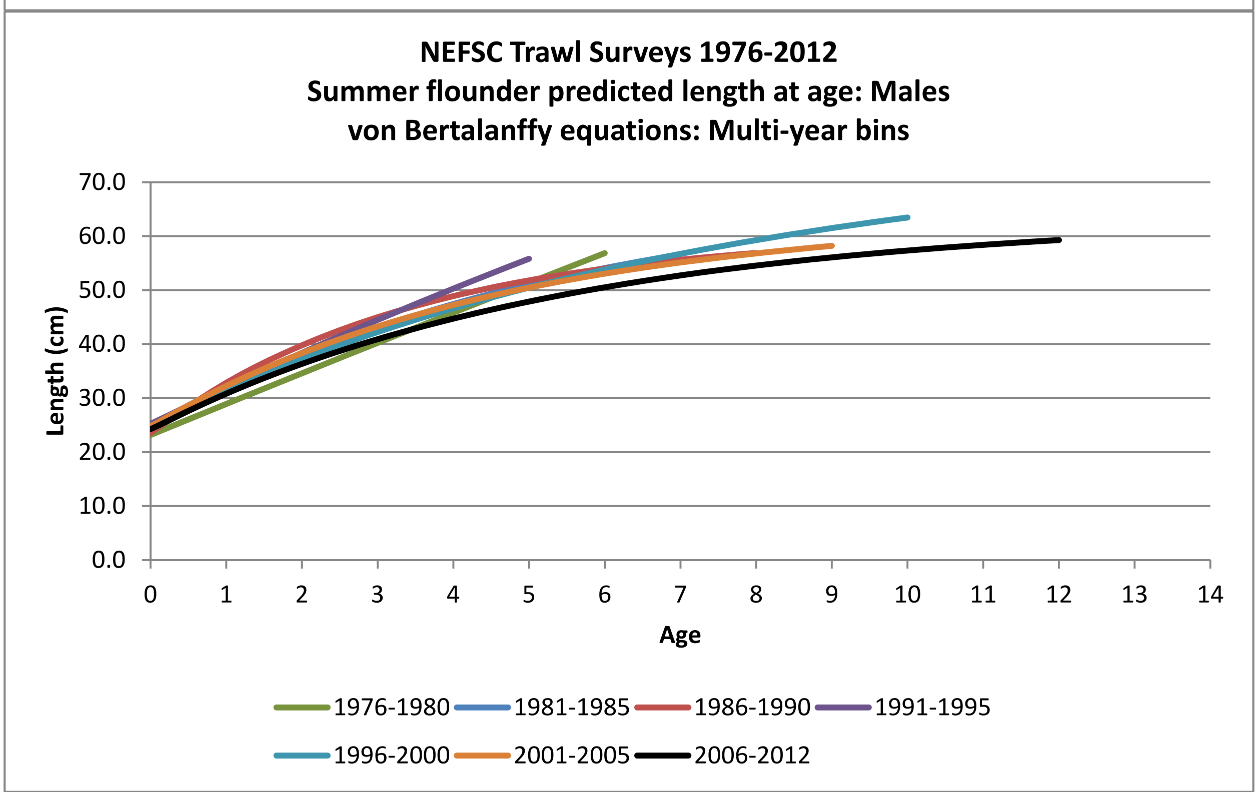


Figure A16. Predicted length at age from von Bertalanffy equations parameters estimated from NEFSC trawl survey data for multi-year bins by sex. Curves plotted through the maximum observed ages for each bin and sex.

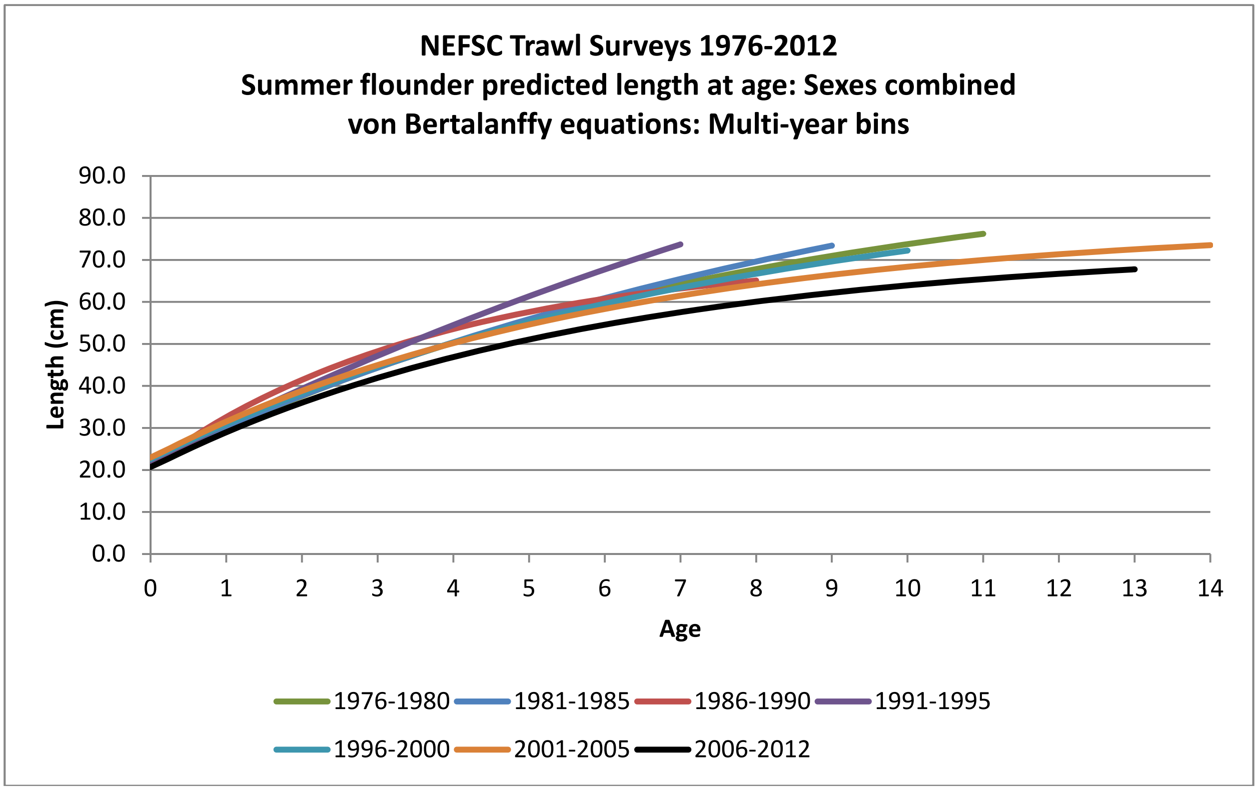


Figure A17. Predicted length at age from von Bertalanffy equations parameters estimated from NEFSC trawl survey data for multi-year bins by sexes combined. Curves plotted through the maximum observed ages for each bin.

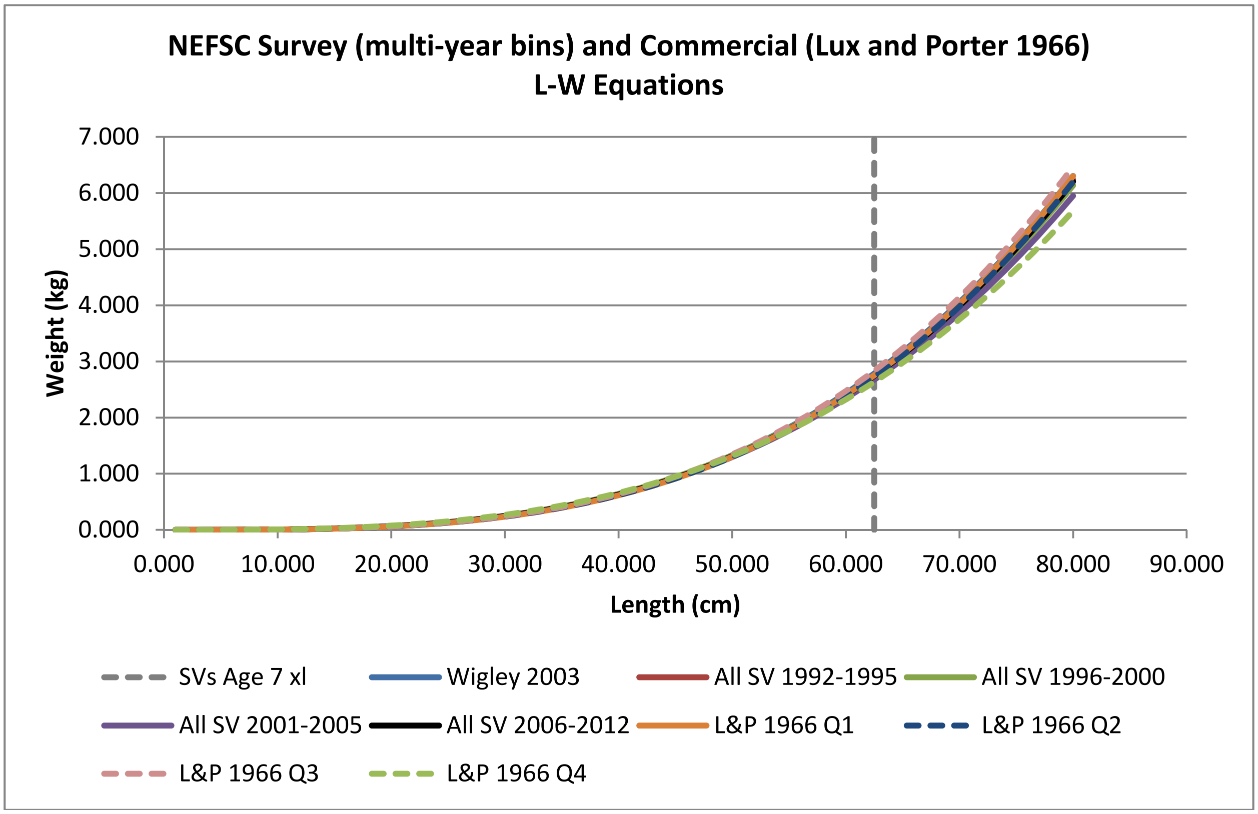


Figure A18. Length-weight relationships from the works of Lux and Porter (1966; L&P), Wigley et al. (2003; Wigley), and the current work (all surveys combined multi-year bins: 1992-1995, 1996-2000, 2001-2005, and 2006-2012). Vertical gray line is the mean length of age 7 in NEFSC surveys.

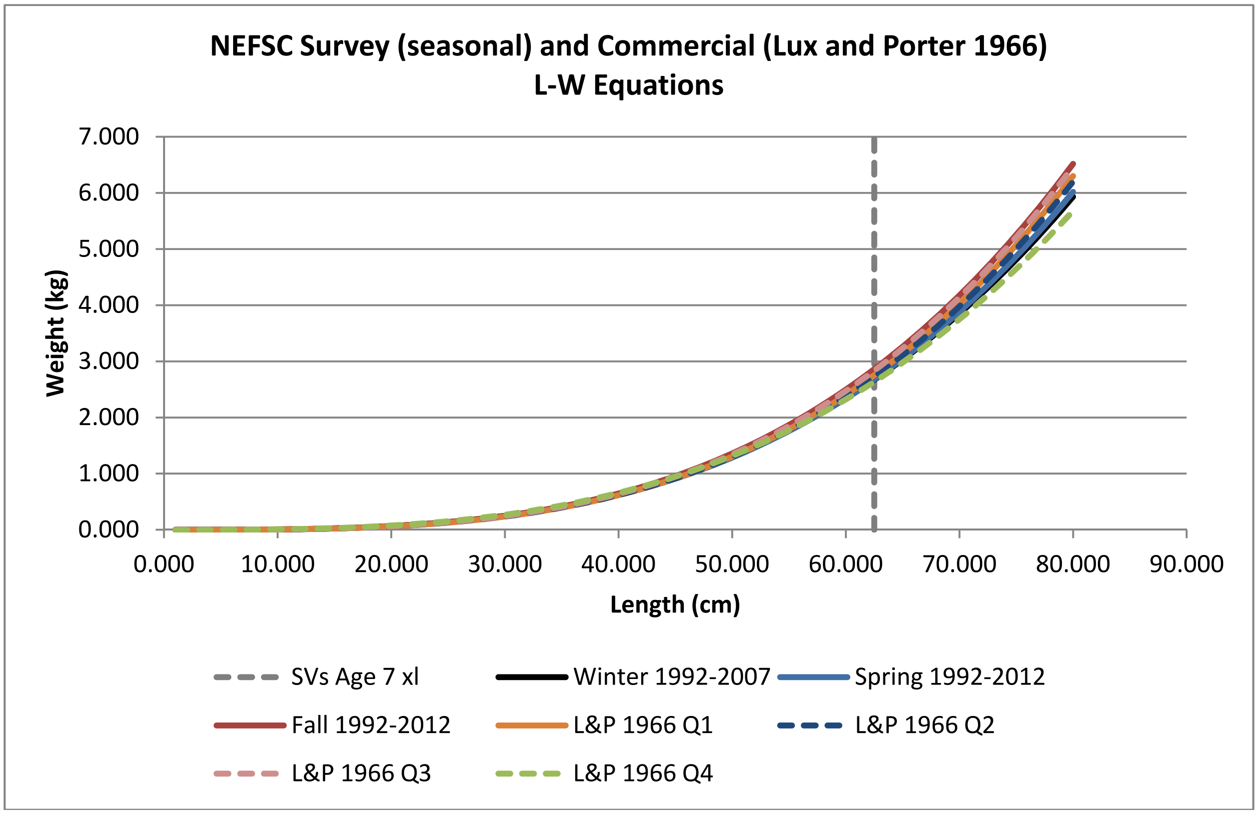


Figure A19. Length-weight relationships from the works of Lux and Porter (1966; L&P) and the current work (seasonal surveys: winter 1992-2007, spring 1992-2012, fall 1992-2012). Vertical gray line is the mean length of age 7 in NEFSC surveys.

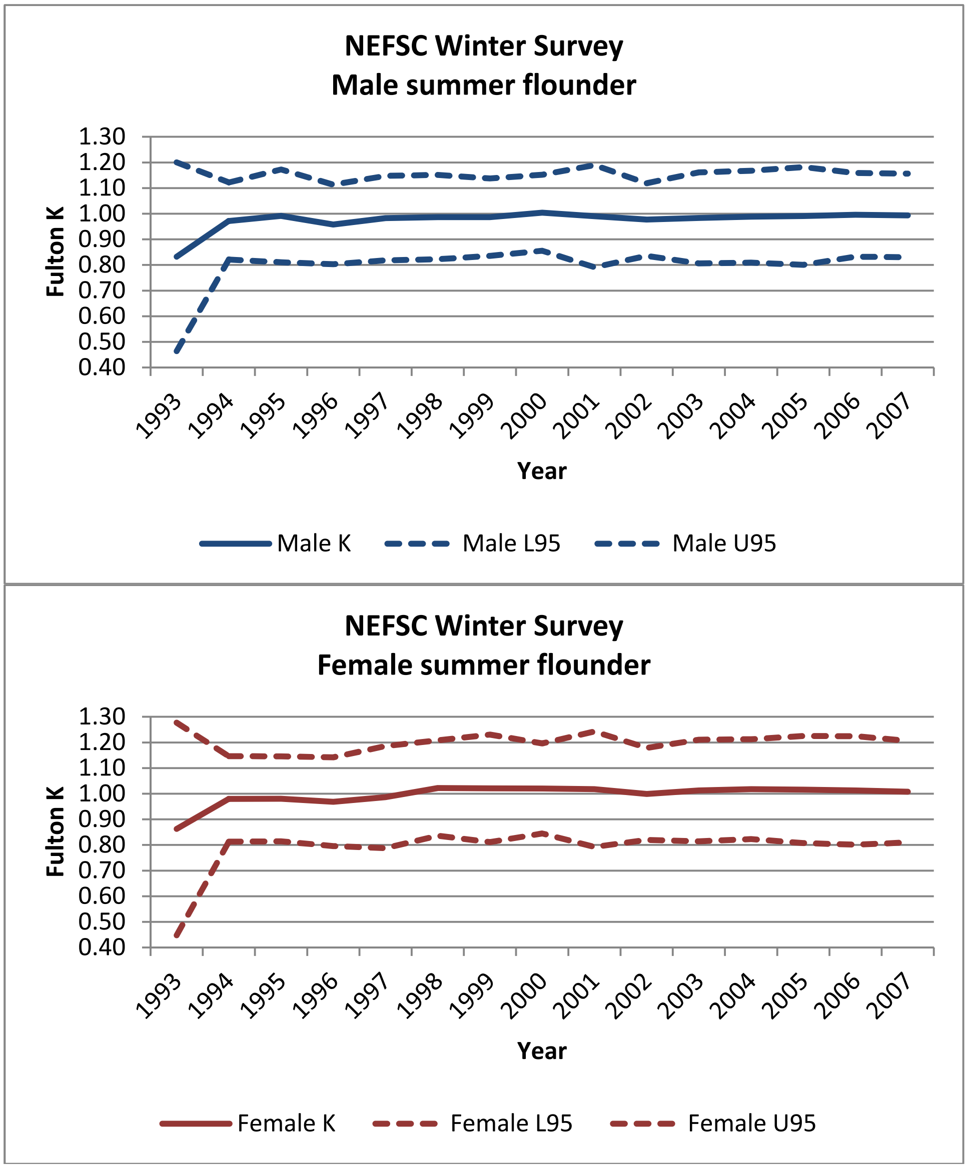


Figure A20. Seasonal condition factor of summer flounder: NEFSC winter survey by sex.

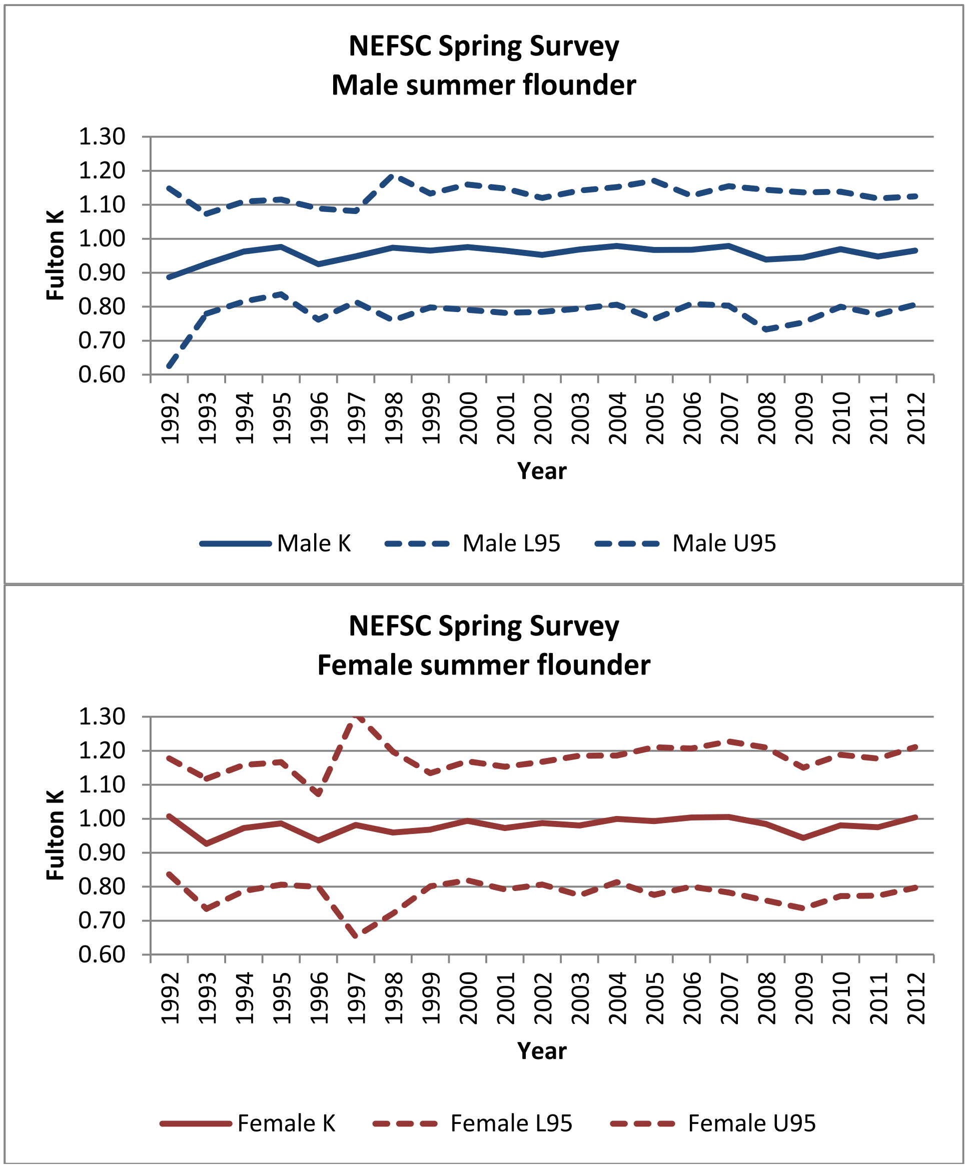


Figure A21. Seasonal condition factor of summer flounder: NEFSC spring survey by sex.

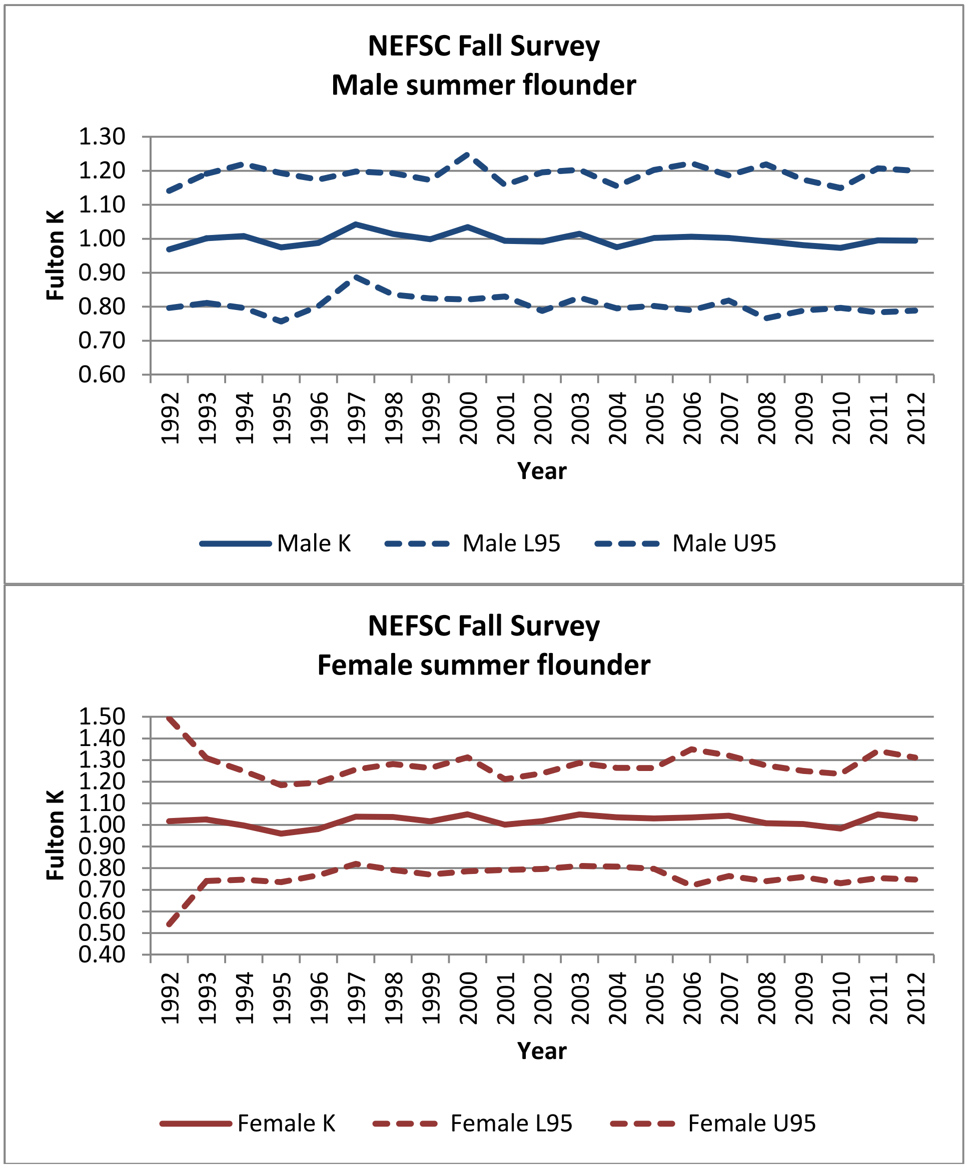


Figure A22. Seasonal condition factor of summer flounder: NEFSC fall survey by sex.

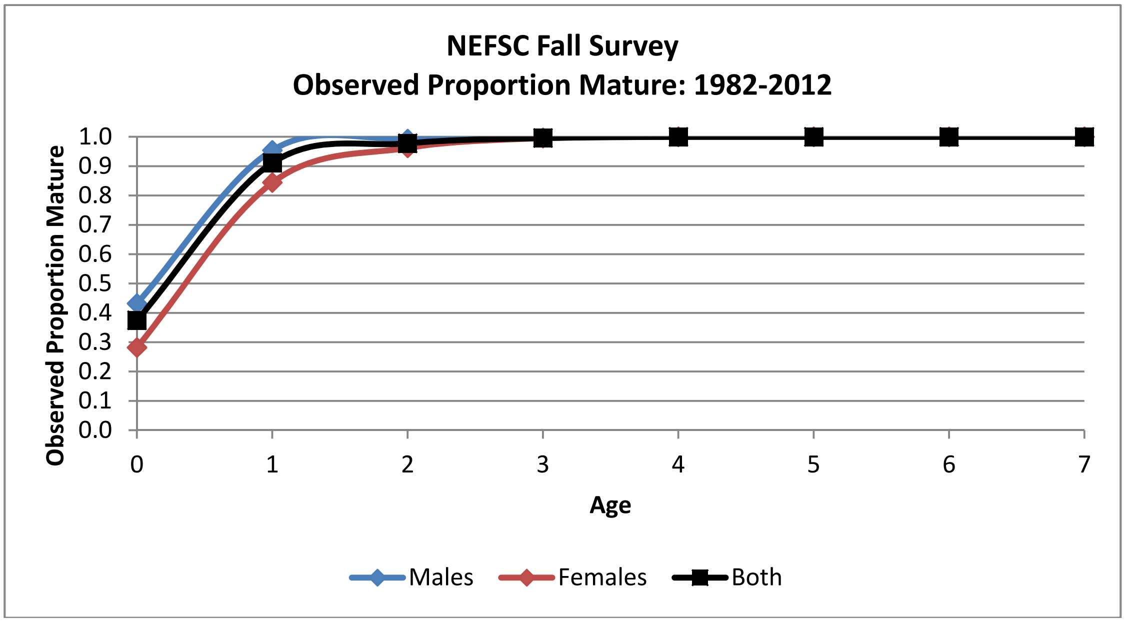


Figure A23. Observed proportion mature at age and sex from the NEFSC Fall survey time series.

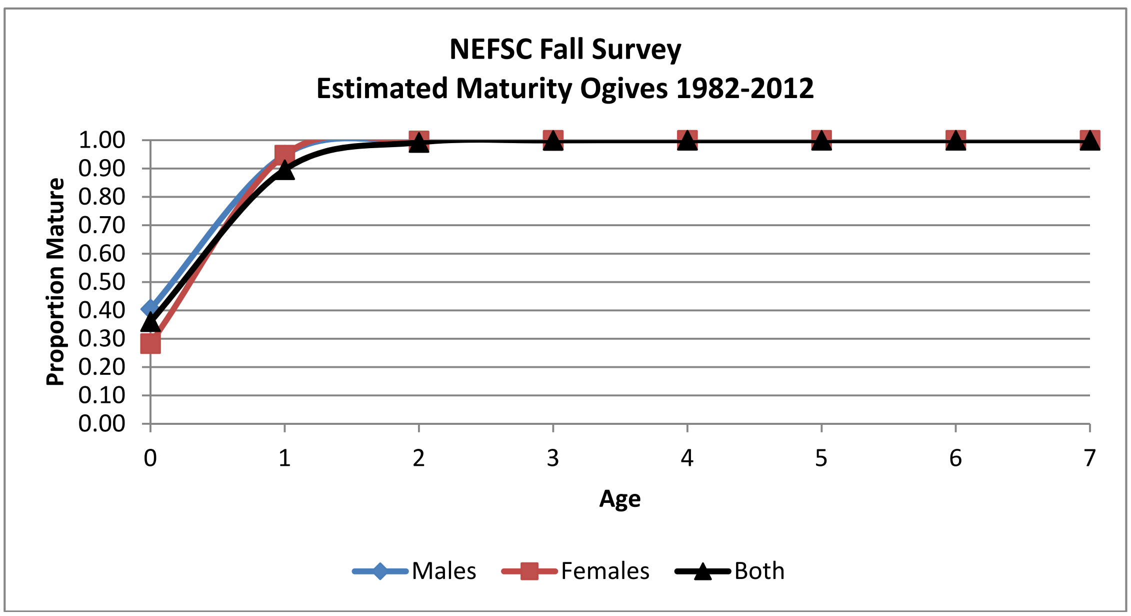


Figure A24. Estimated proportion mature at age and sex from the NEFSC Fall survey time series.

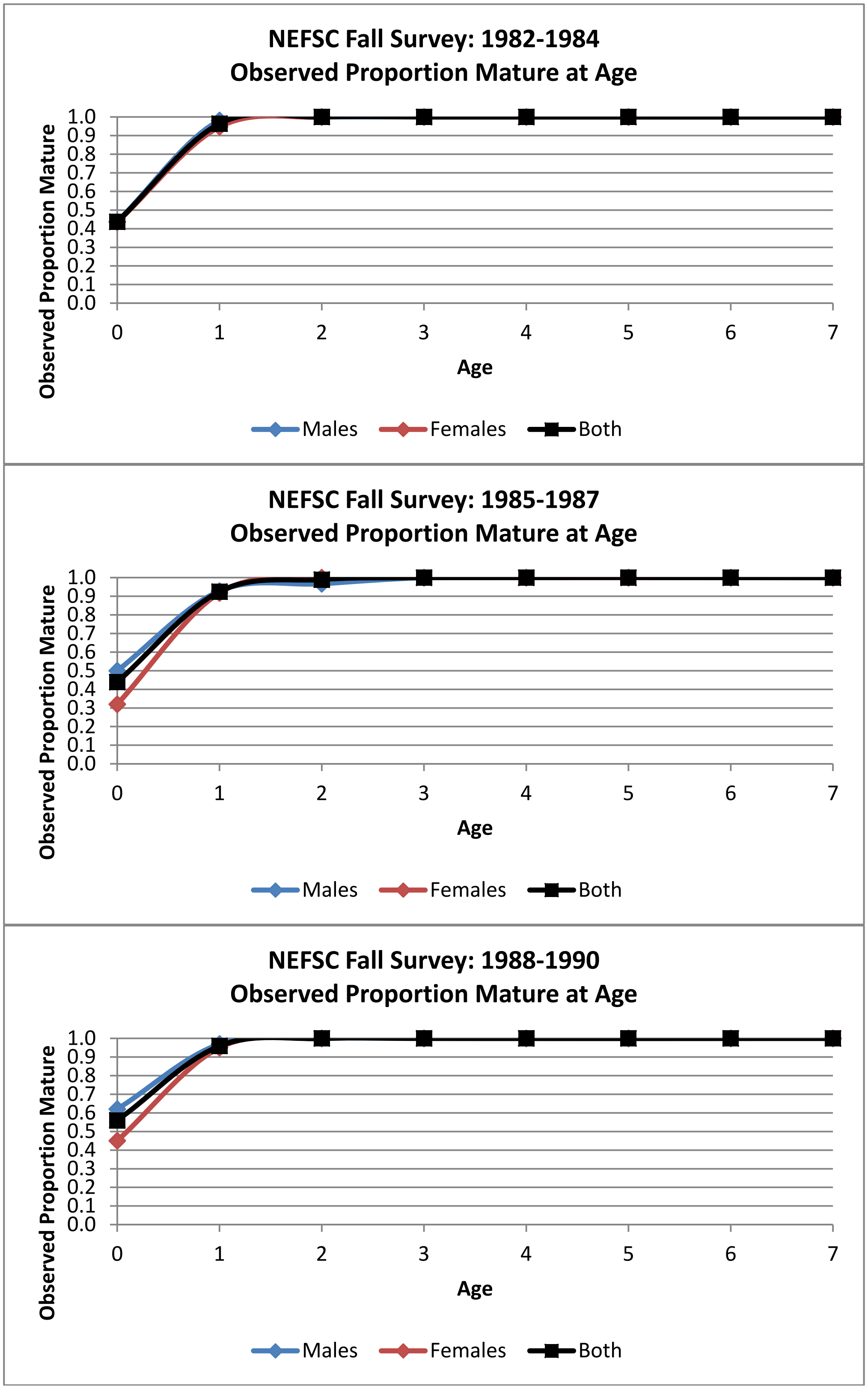


Figure A25. NFESC fall survey observed proportion mature at age: 3 year time blocks.

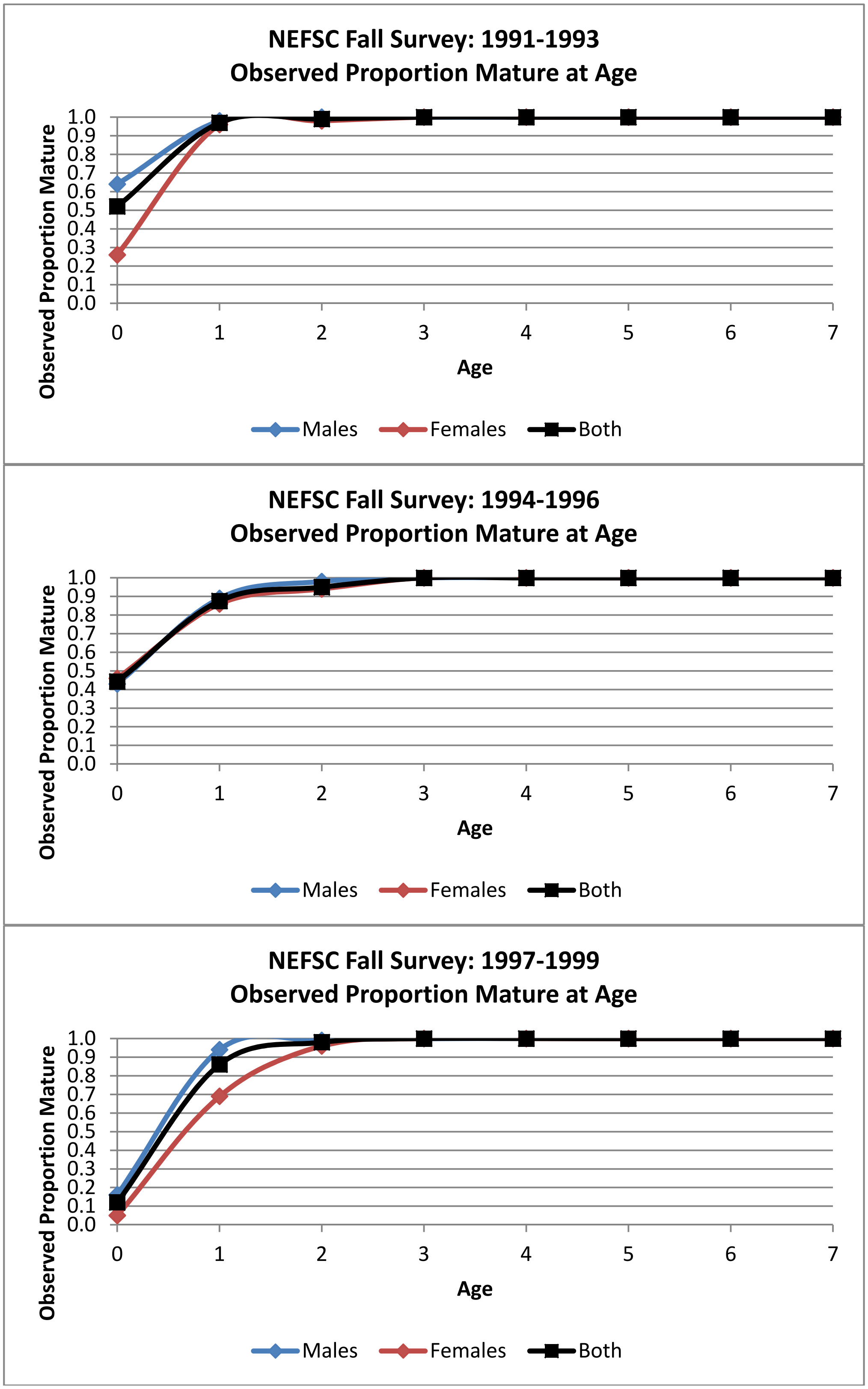


Figure A26. NFESC fall survey observed proportion mature at age: 3 year time blocks.

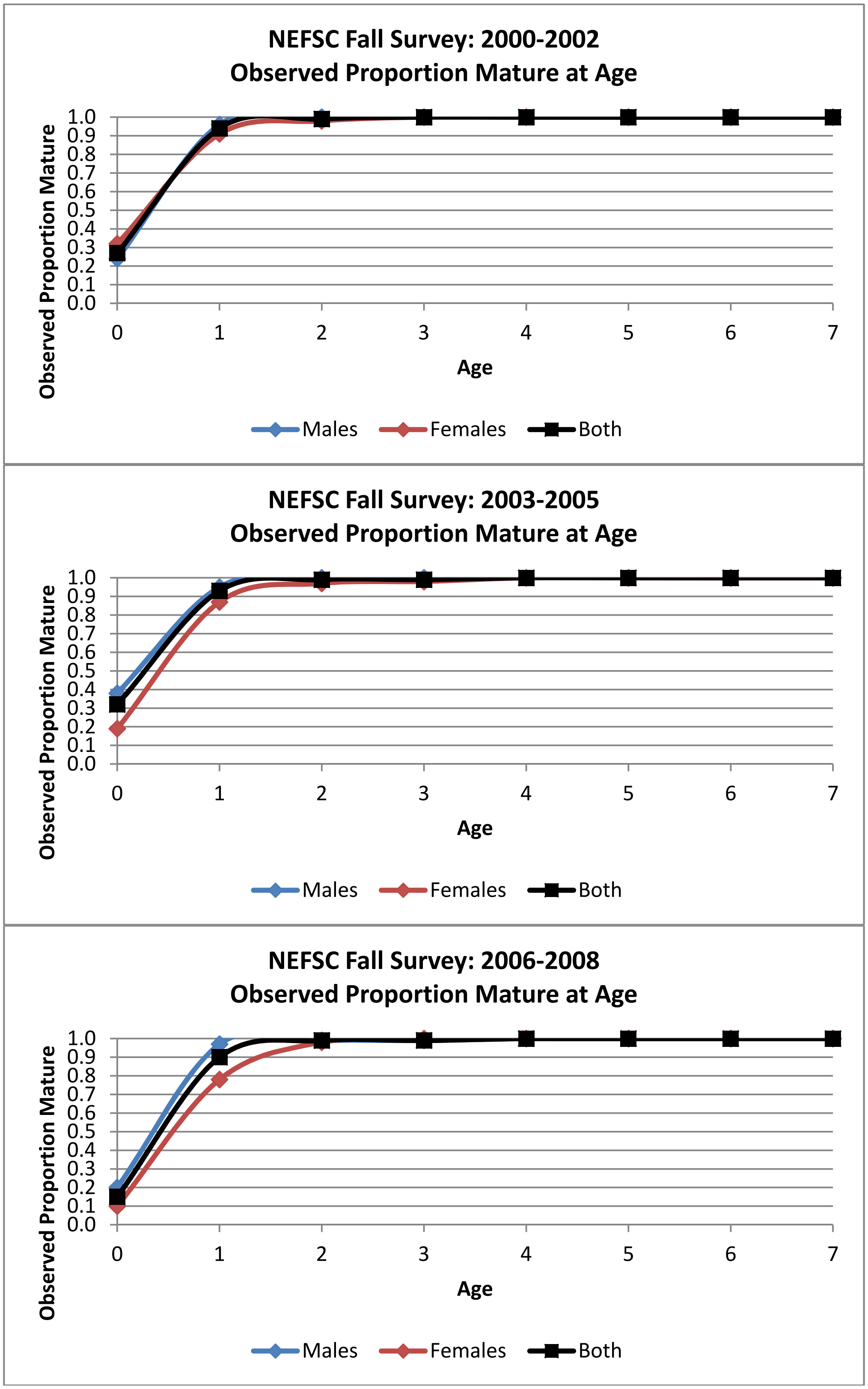


Figure A27. NFESC fall survey observed proportion mature at age: 3 year time blocks.

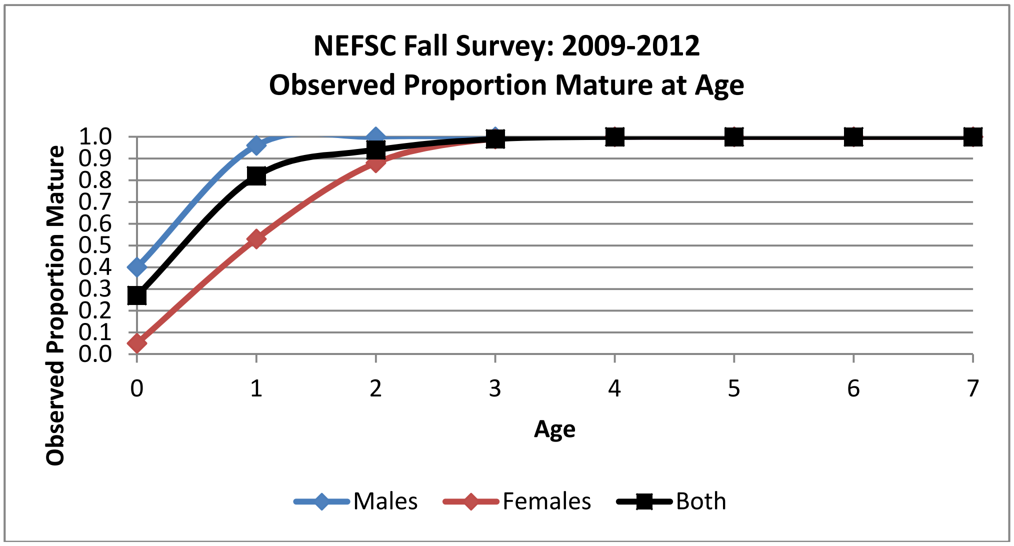


Figure A28. NFESC fall survey observed proportion mature at age: most recent year time block, 2009-2012.

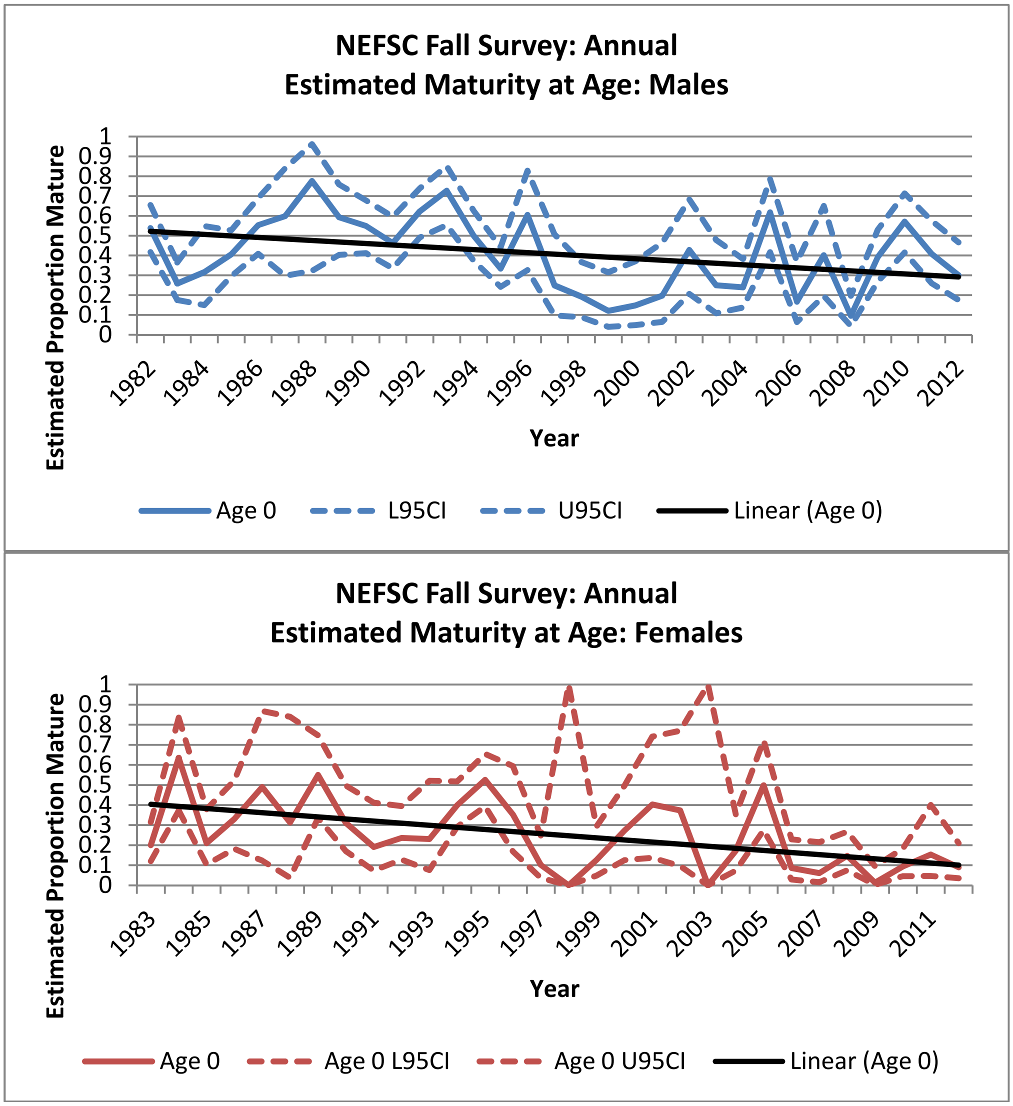


Figure A29. Estimated maturity at age 0, by year and sex. Solid line is a fit linear trend.

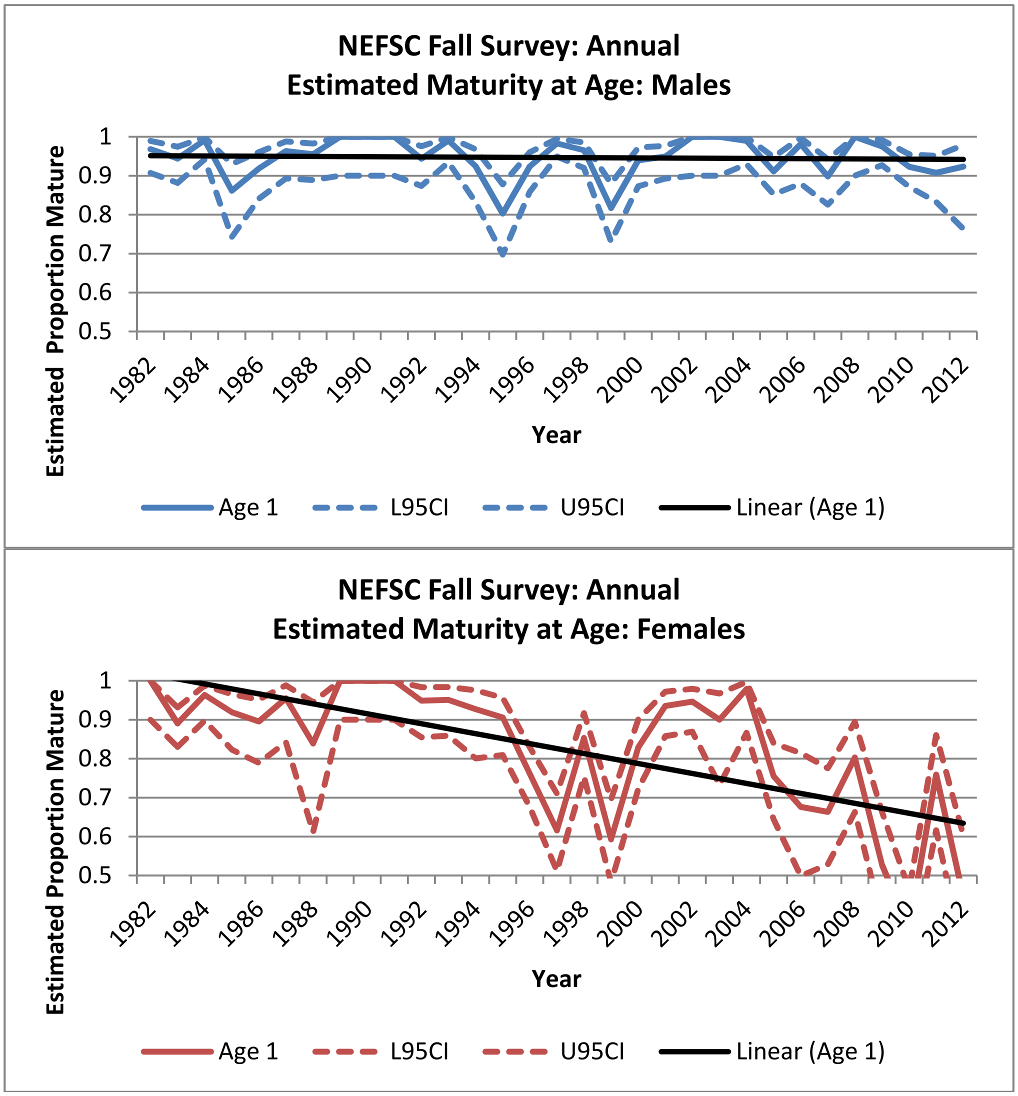


Figure A30. Estimated maturity at age 1, by year and sex. Solid line is a fit linear trend.

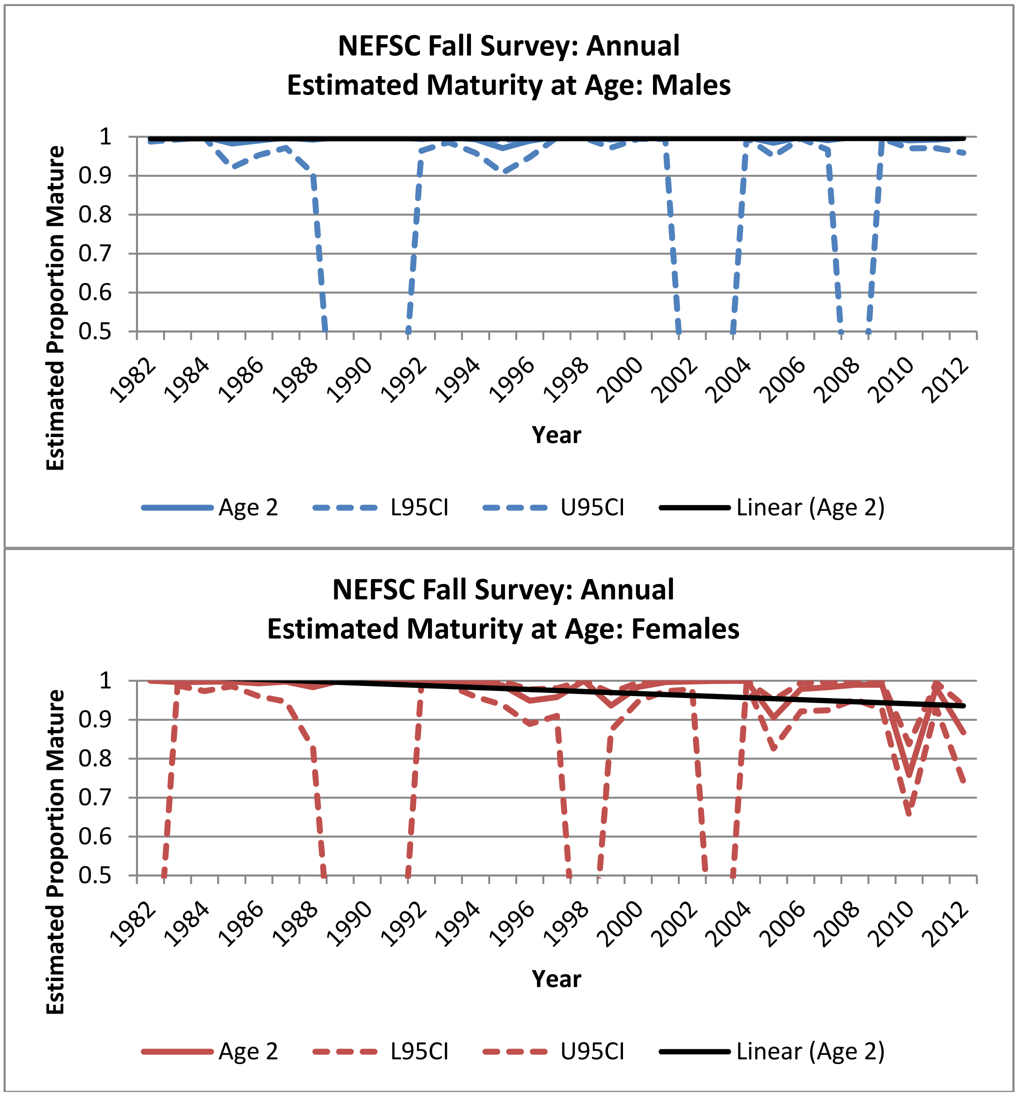


Figure A31. Estimated maturity at age 2, by year and sex. Solid line is a fit linear trend.

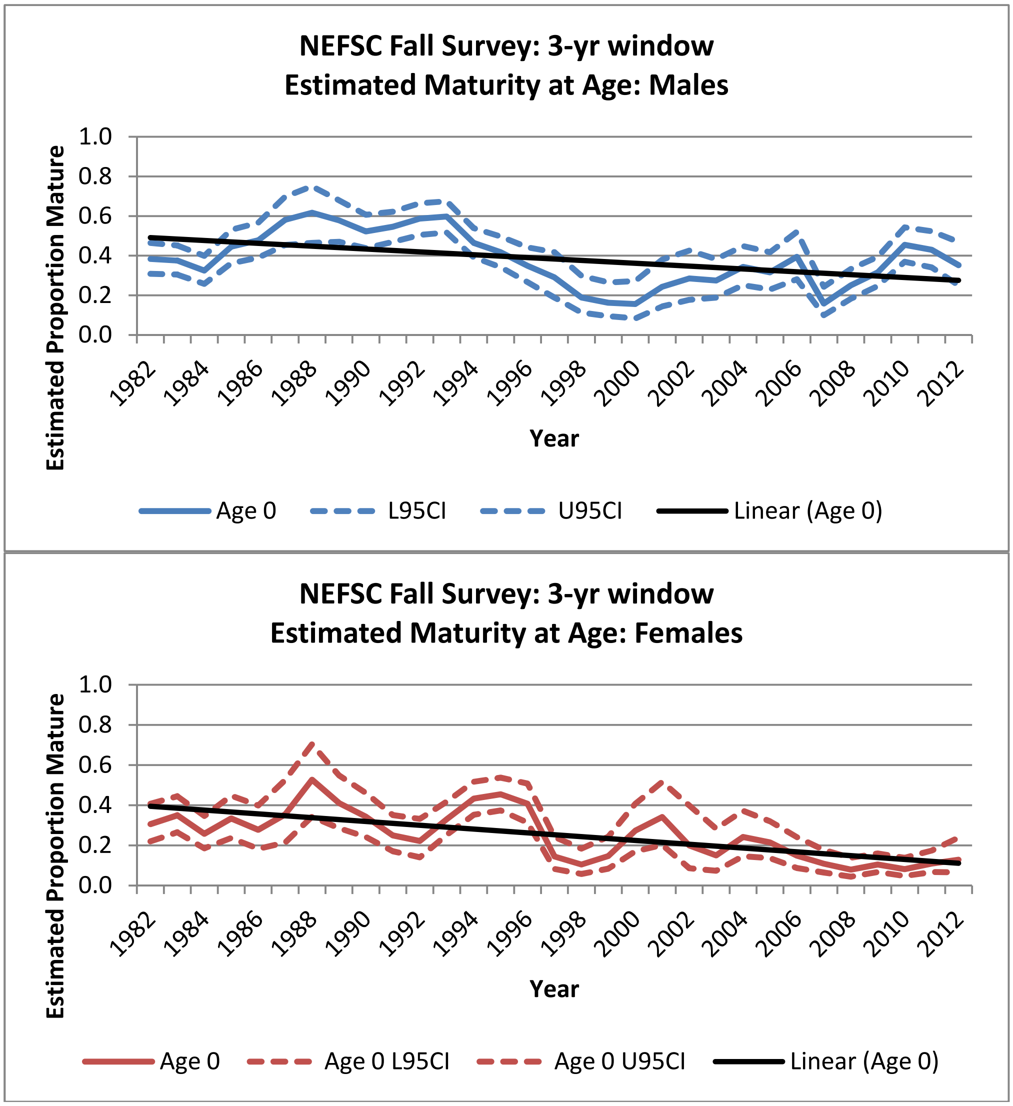


Figure A32. Estimated maturity at age 0, by 3-year moving window and sex. Solid line is a fit linear trend.

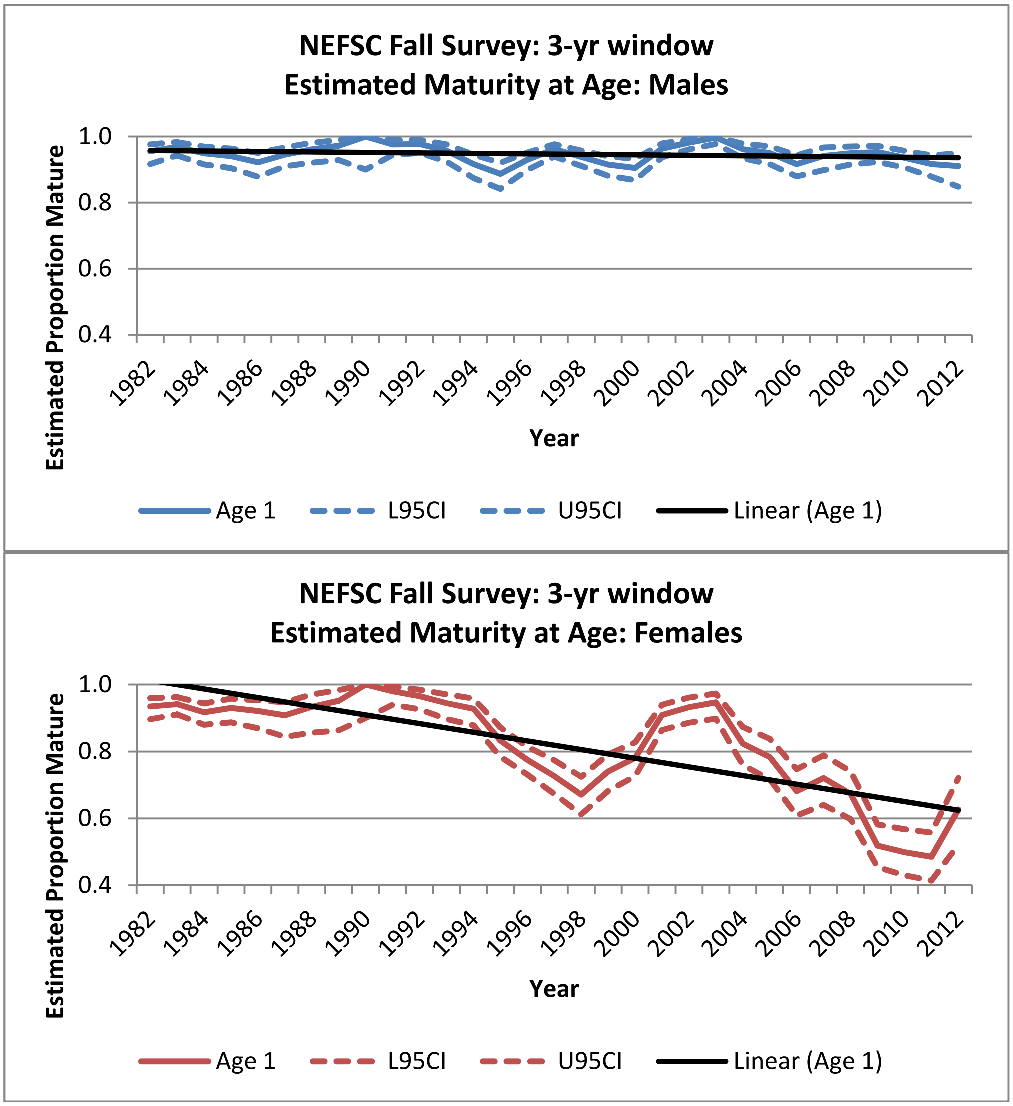


Figure A33. Estimated maturity at age 1, by 3-year moving window and sex. Solid line is a fit linear trend.

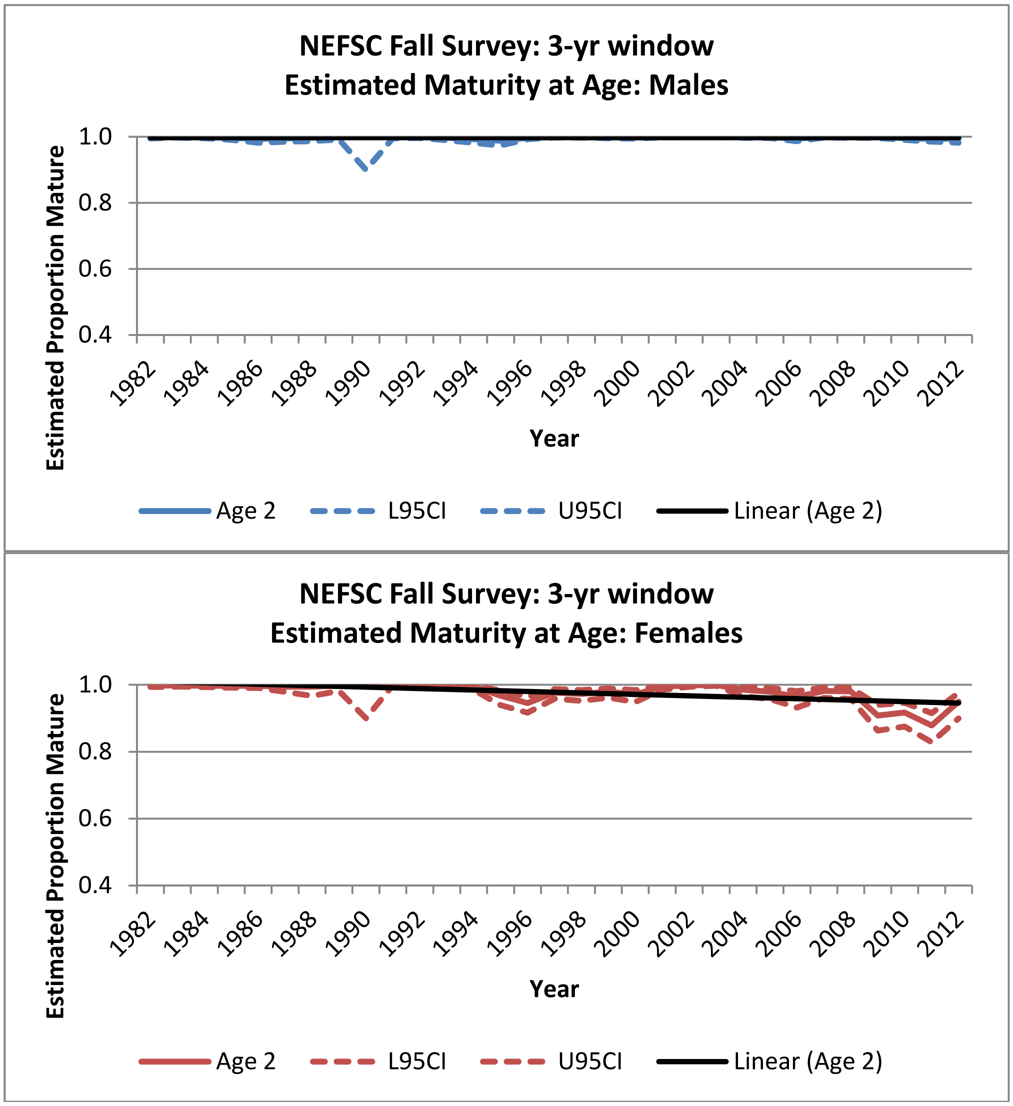


Figure A34. Estimated maturity at age 2, by 3-year moving window and sex. Solid line is a fit linear trend.

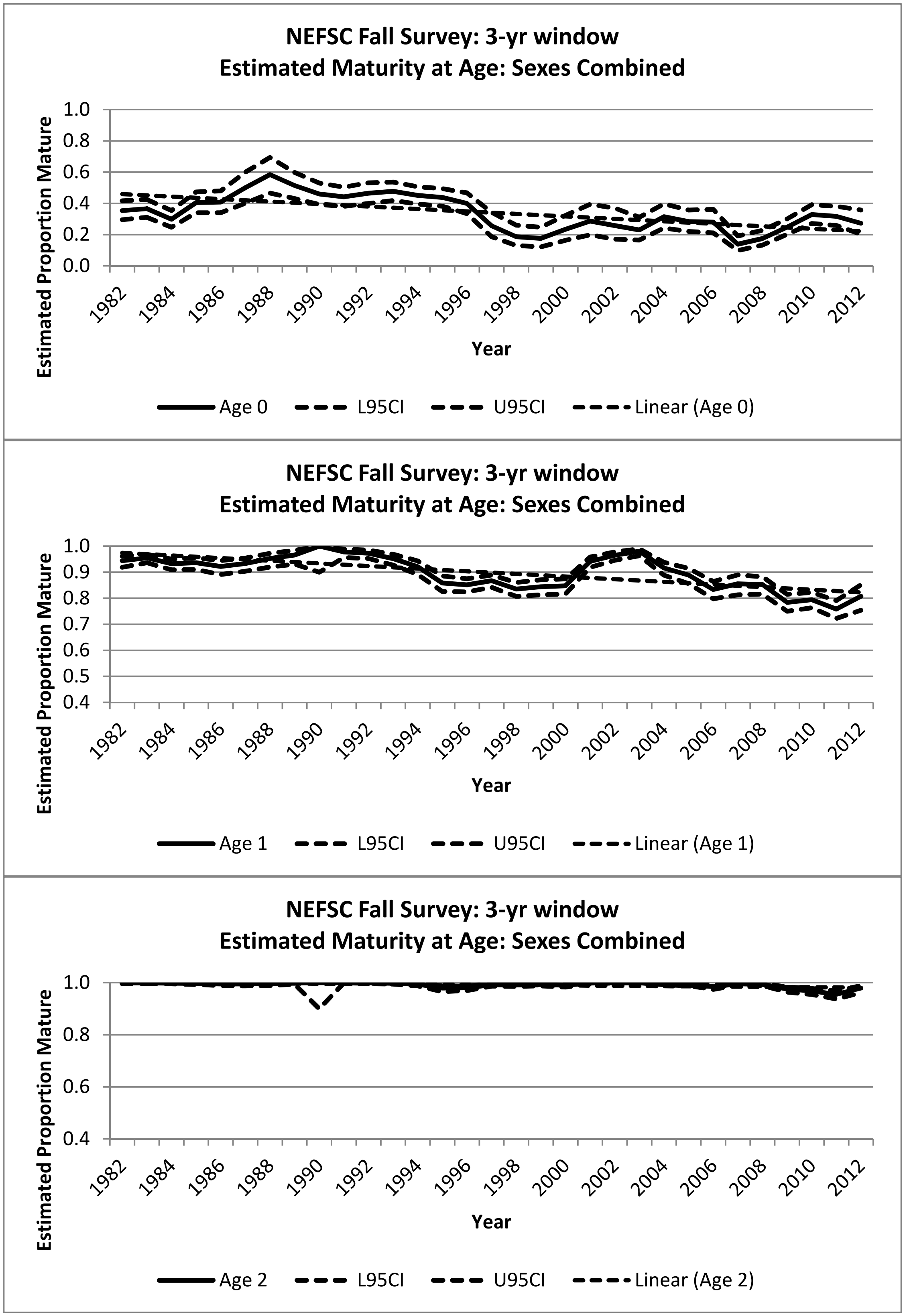


Figure A35. Estimated maturity at ages, 0, 1, and 2, for sexes combined by 3-year moving window. Straight dashed lines are fit linear trends.

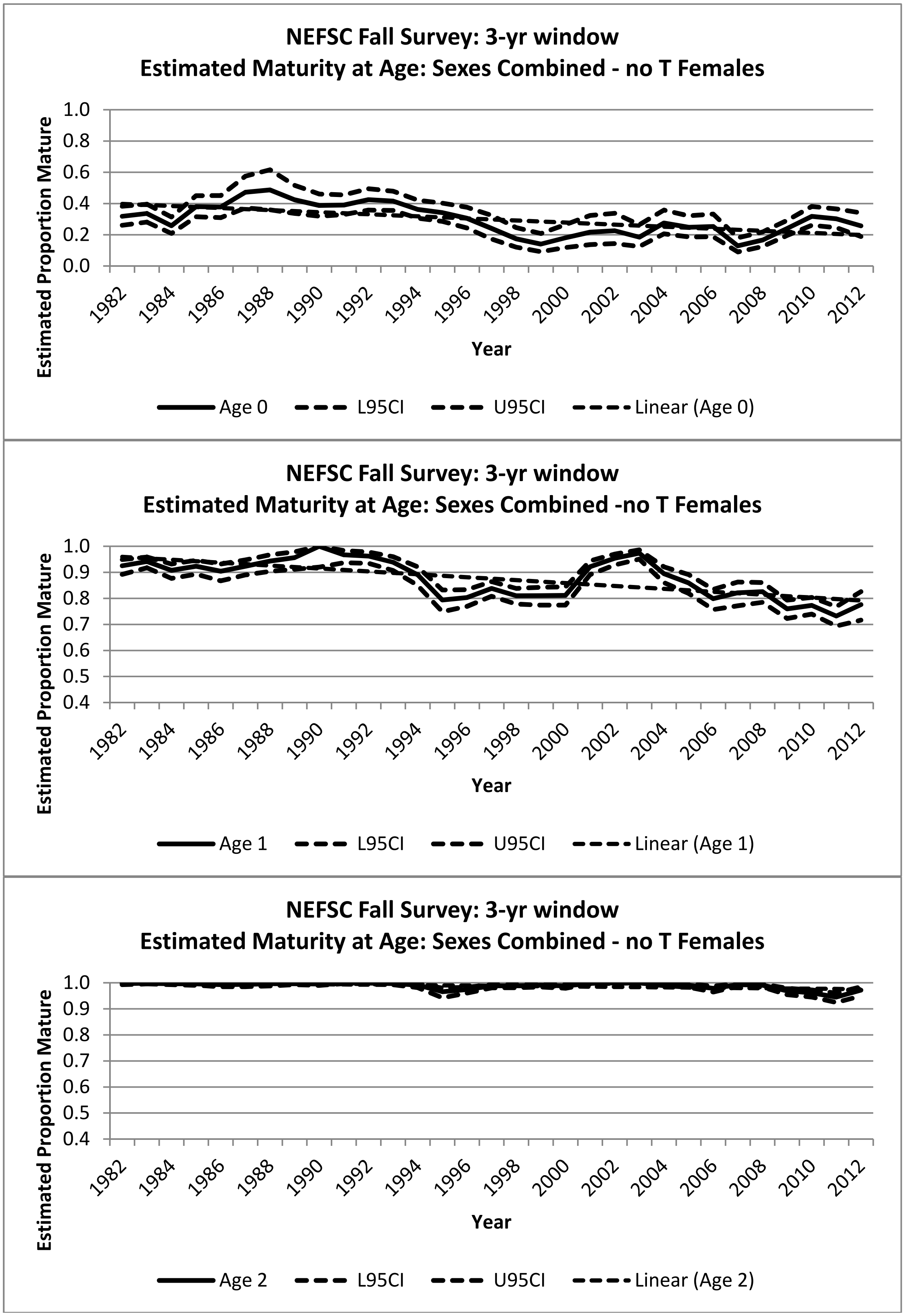


Figure A36. Estimated maturity at ages, 0, 1, and 2, for sexes combined by 3-year moving window, resting (T) females removed. Straight dashed lines are fit linear trends.

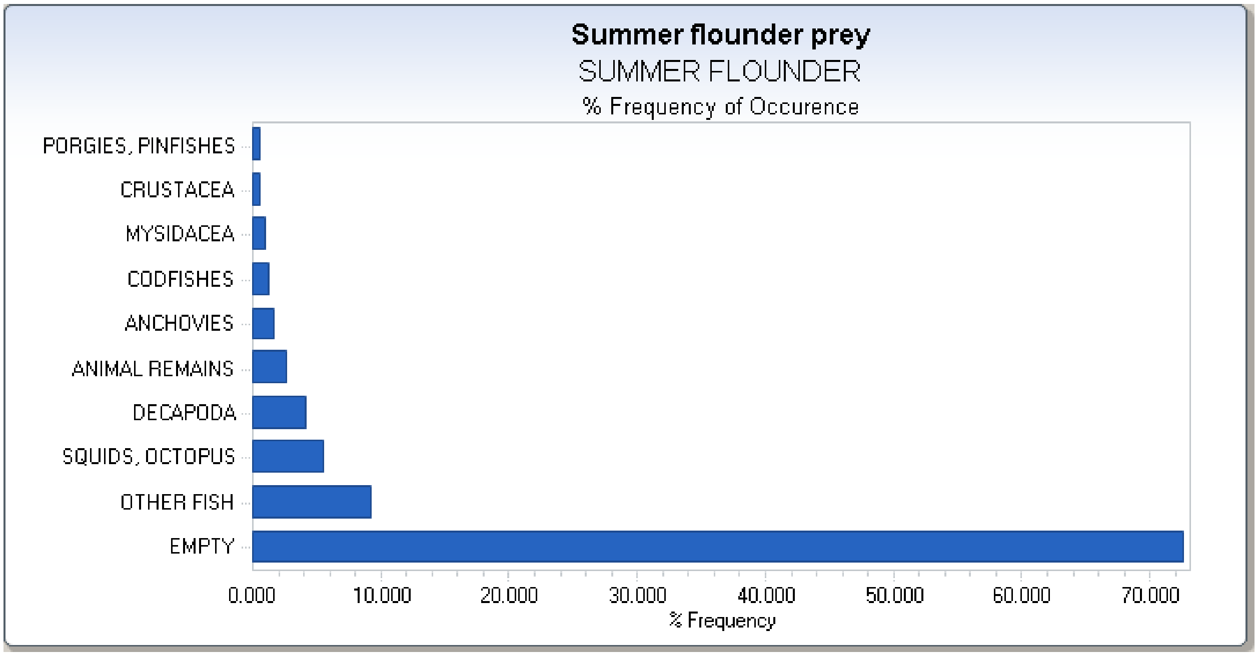


Figure A37. NEFSC trawl survey food habits data: percent frequency of occurrence of prey consumption by summer flounder.

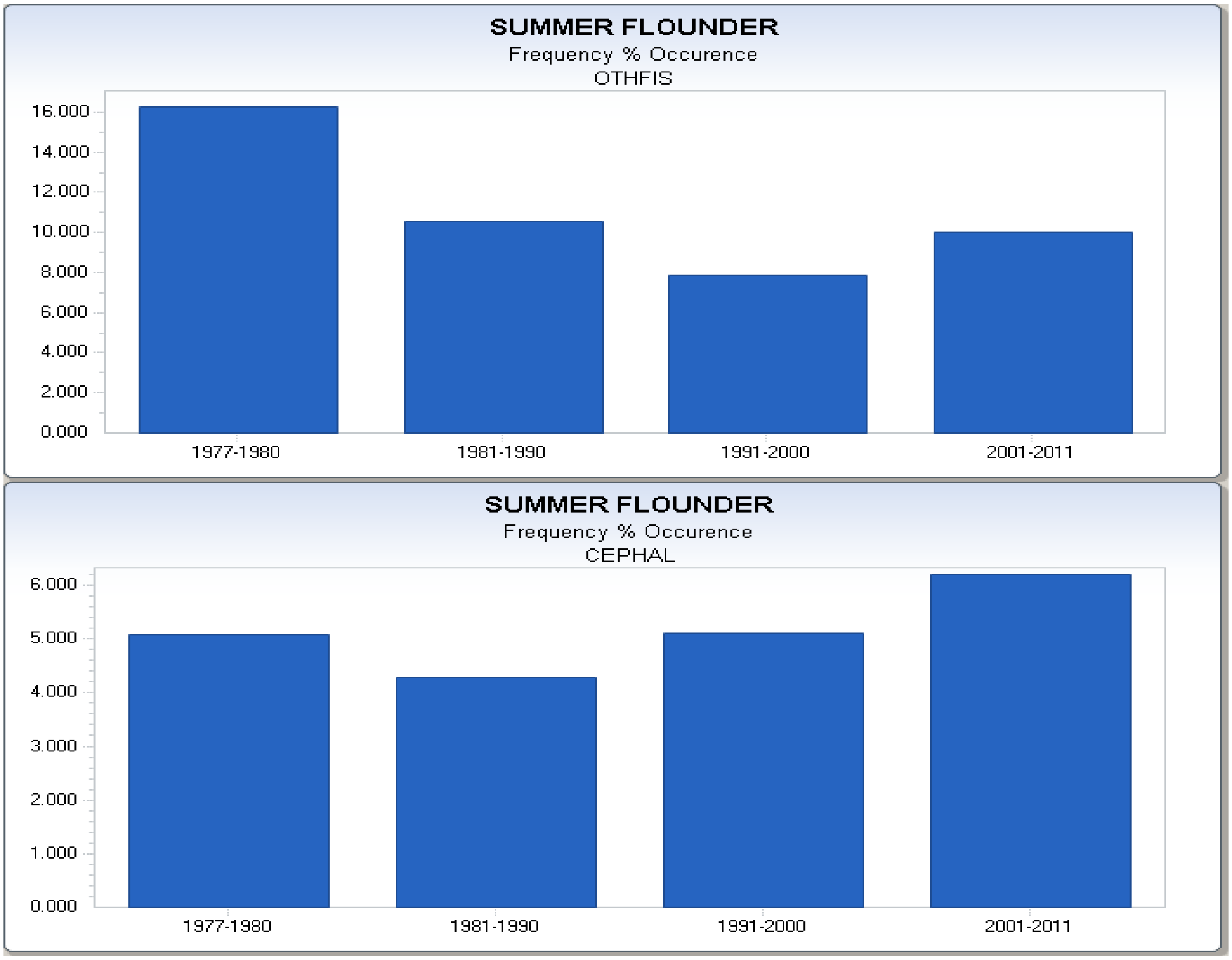


Figure A38. NEFSC trawl survey food habits data: temporal pattern in percent frequency of occurrence of prey consumption by summer flounder for 'Other Fish' (top) and cephalopods (squid; bottom).

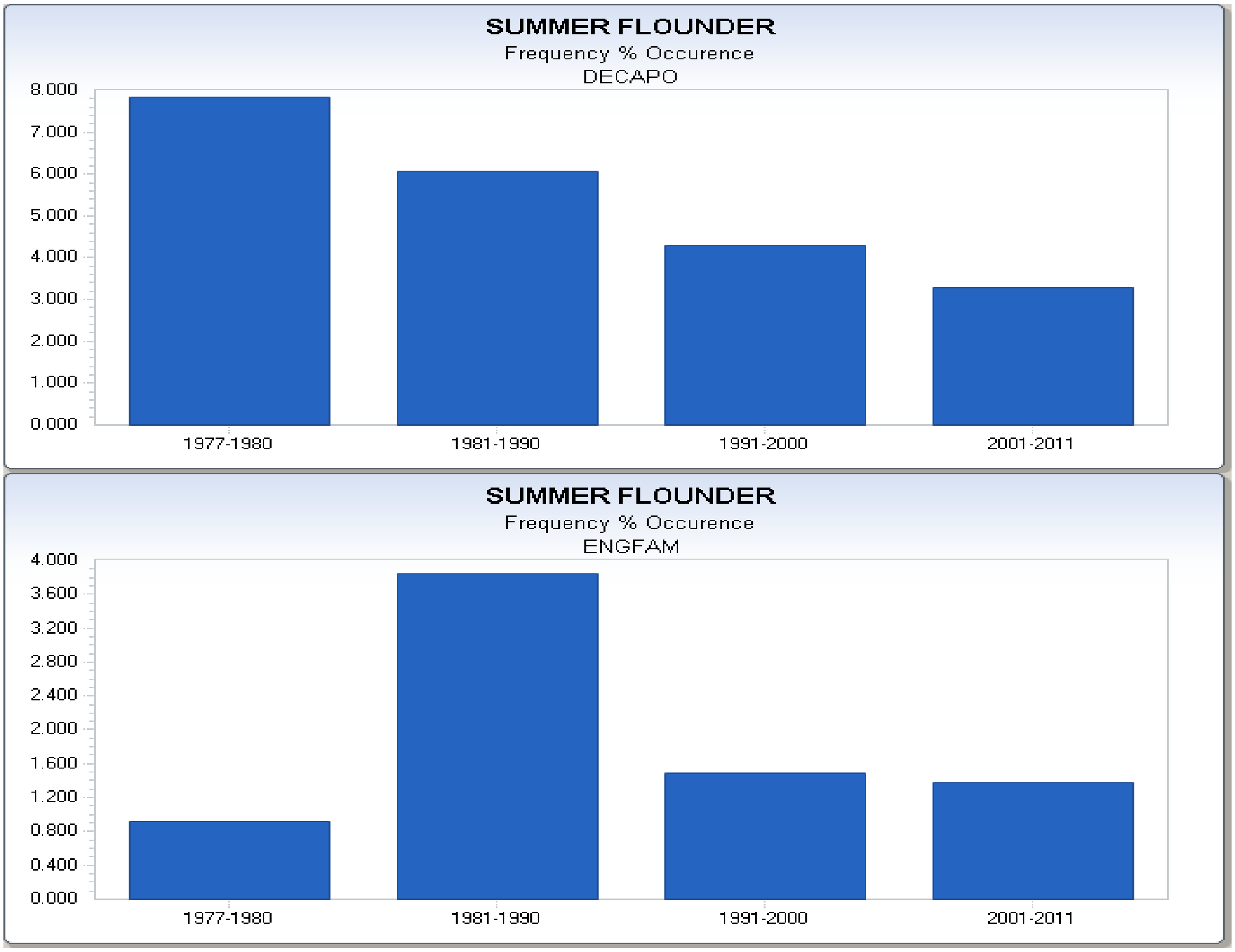


Figure A39. NEFSC trawl survey food habits data: temporal pattern in percent frequency of occurrence of prey consumption by summer flounder for decapods (shrimp; top) and engraulids (anchovies; bottom).

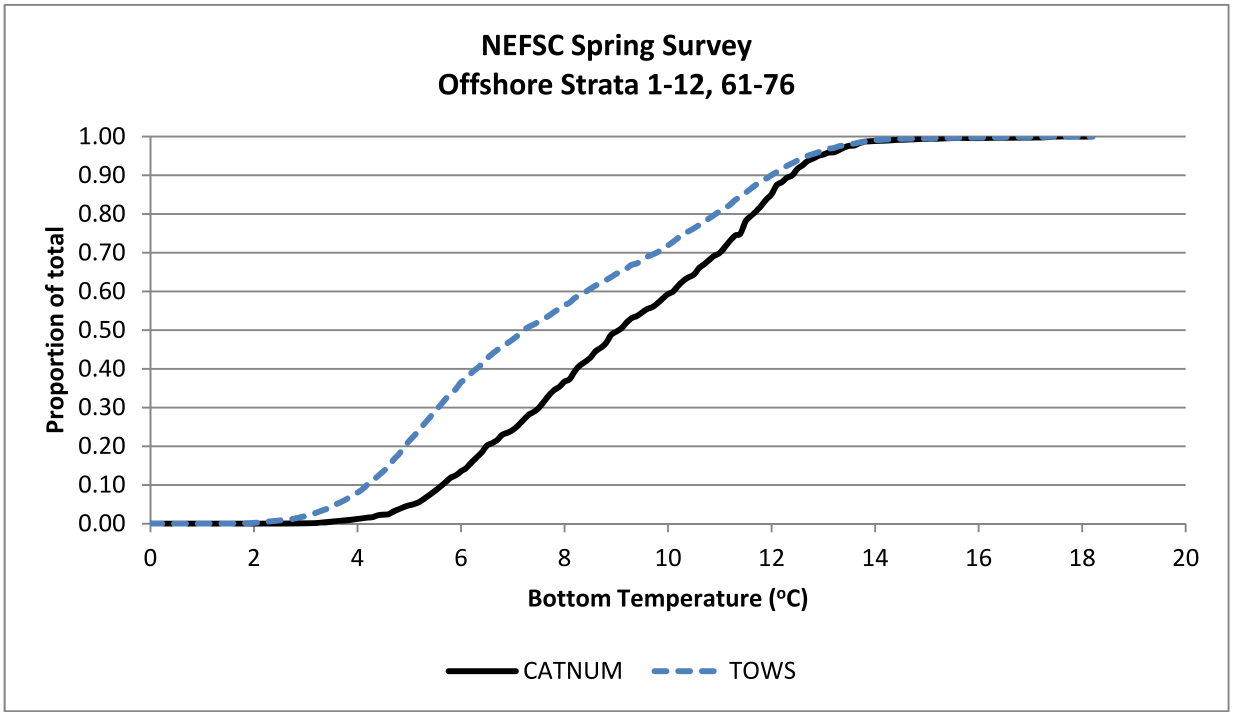


Figure A40. Cumulative proportion of total (expanded catch number per tow or number of tows) by bottom temperature for survey stations in the NEFSC spring survey strata set (1968-2012).

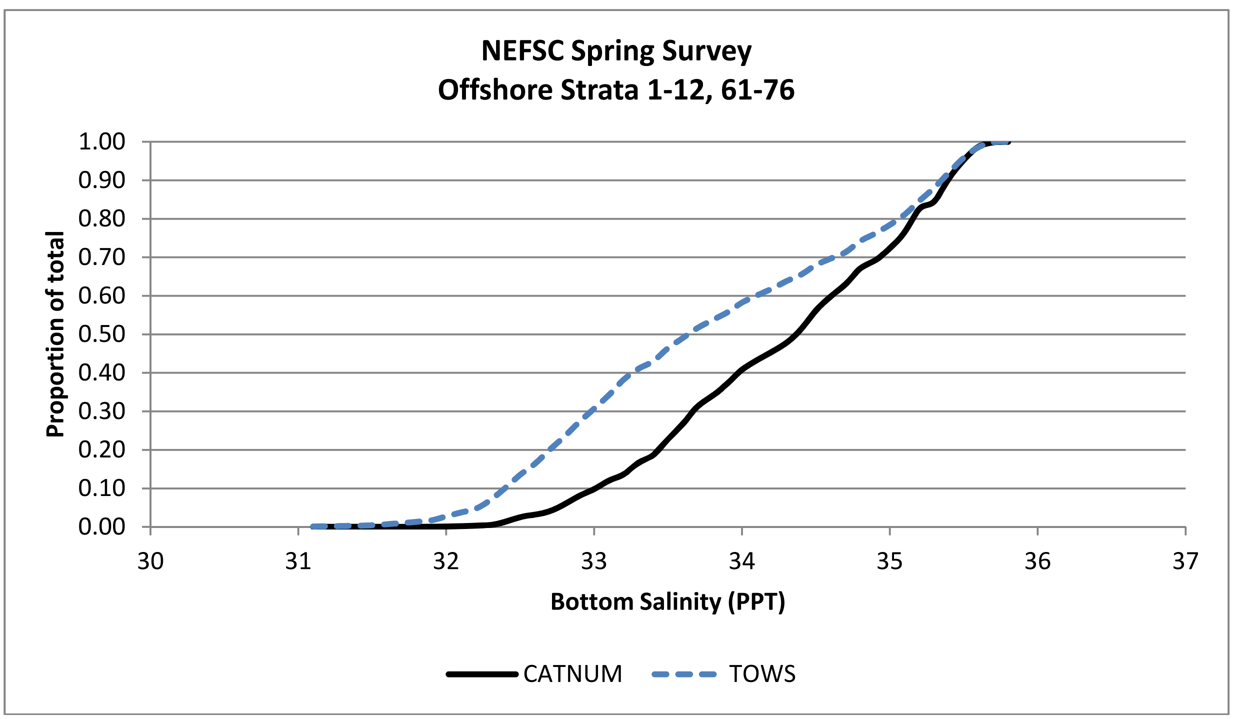


Figure A41. Cumulative proportion of total (expanded catch number per tow or number of tows) by bottom salinity for survey stations in the NEFSC spring survey strata set (1968-2012).

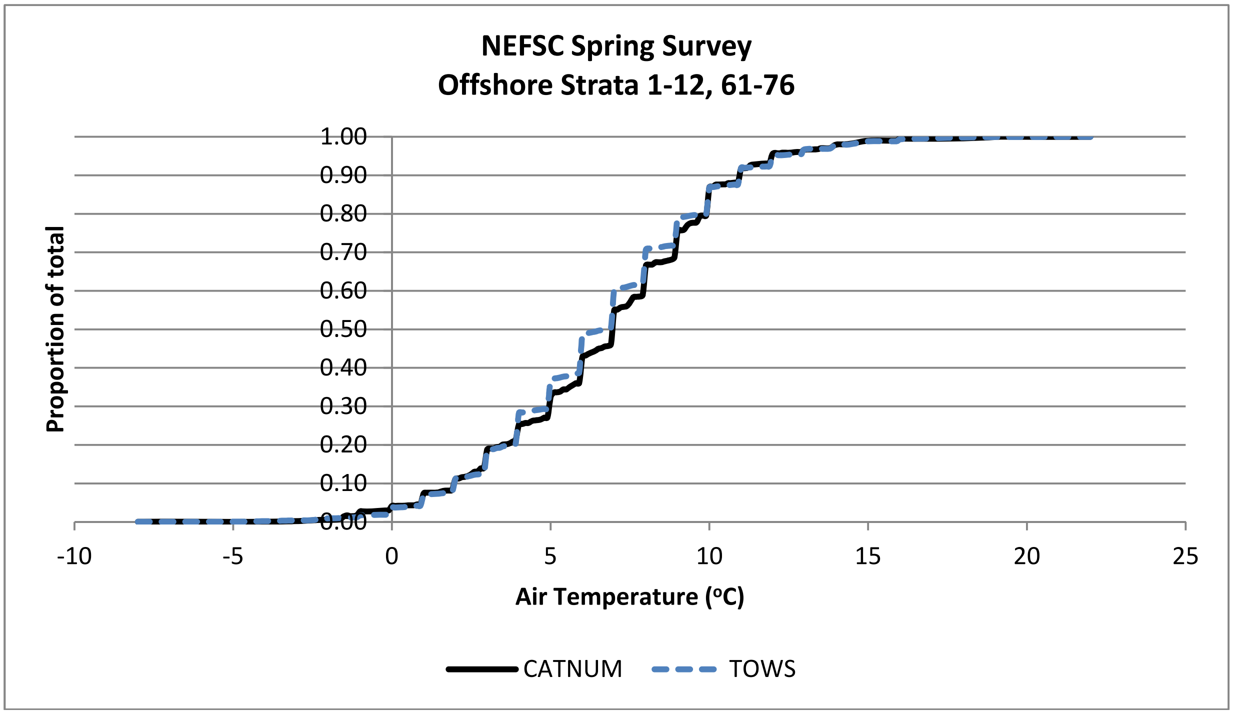


Figure A42. Cumulative proportion of total (expanded catch number per tow or number of tows) by air temperature for survey stations in the NEFSC spring survey strata set (1968-2012).

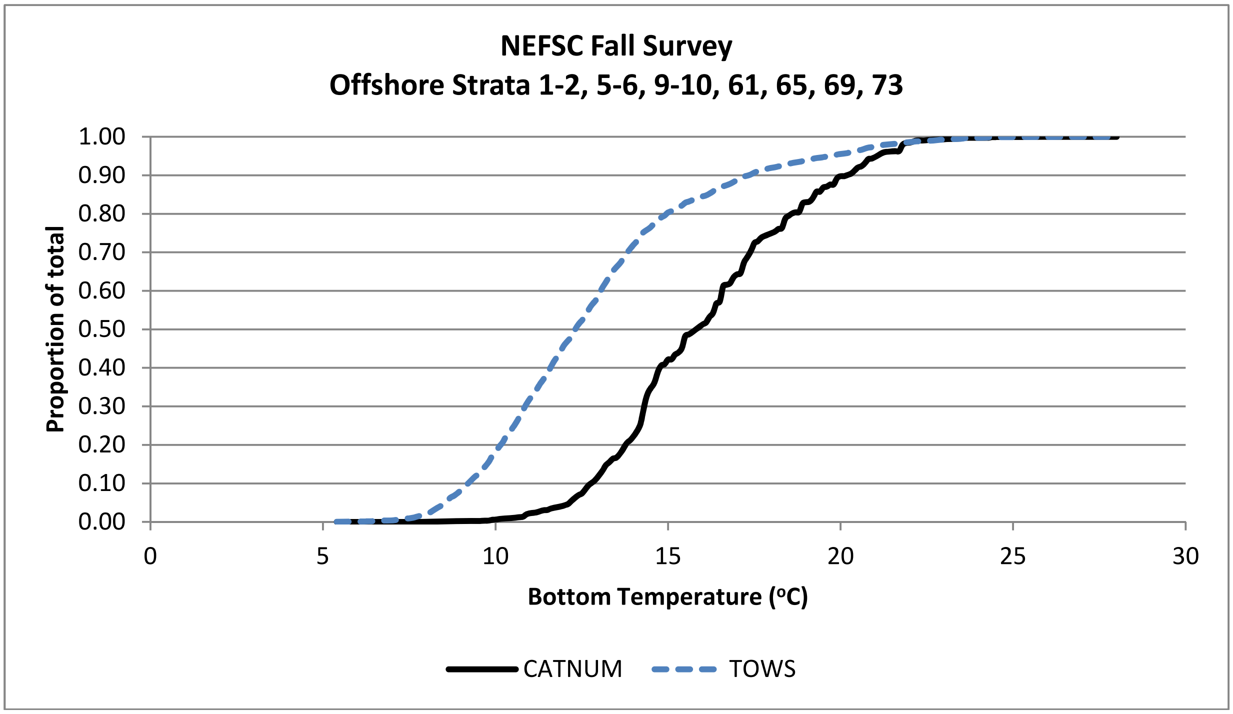


Figure A43. Cumulative proportion of total (expanded catch number per tow or number of tows) by bottom temperature for survey stations in the NEFSC fall survey strata set (1968-2012).

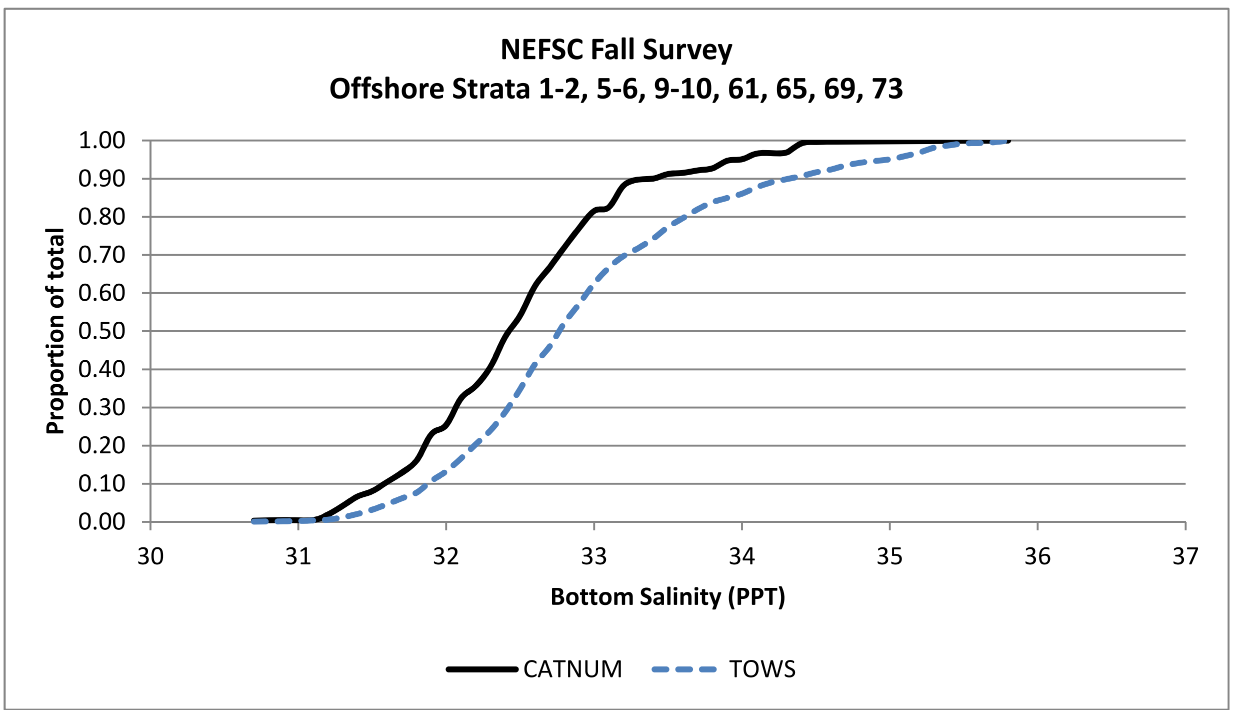


Figure A44. Cumulative proportion of total (expanded catch number per tow or number of tows) by bottom salinity for survey stations in the NEFSC fall survey strata set (1968-2012).

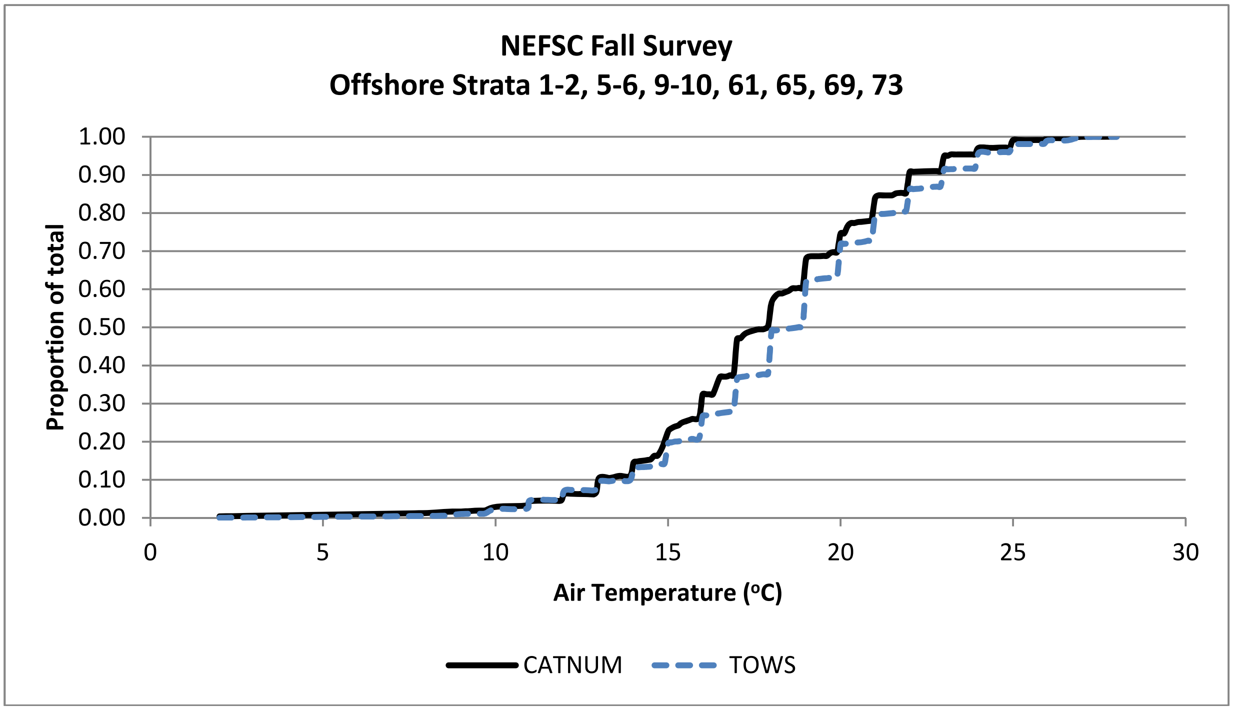


Figure A45. Cumulative proportion of total (expanded catch number per tow or number of tows) by air temperature for survey stations in the NEFSC fall survey strata set (1968-2012).

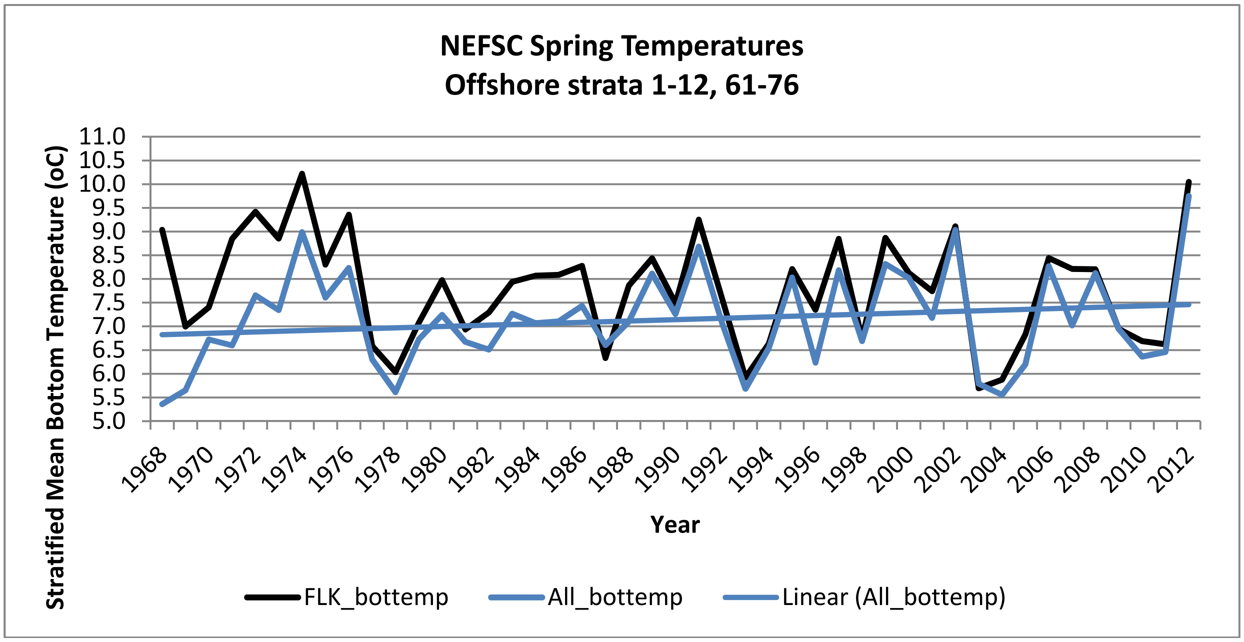


Figure A46. Annual stratified mean values of the bottom temperature for spring positive summer flounder catch tows (expcatchnum > 0; FLK_bottemp) was compared with the annual stratified mean values for all tows (All_bottemp).

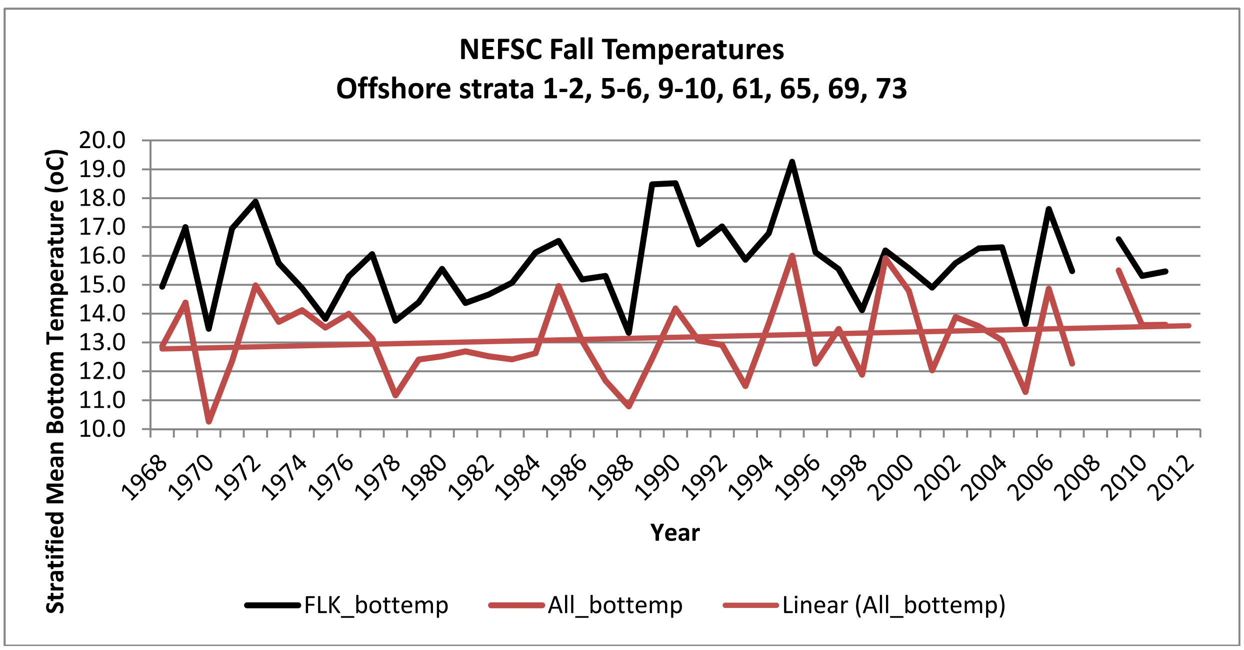


Figure A47. Annual stratified mean values of the bottom temperature for fall positive summer flounder catch tows (expcatchnum > 0; FLK_bottemp) was compared with the annual stratified mean values for all tows (All_bottemp).

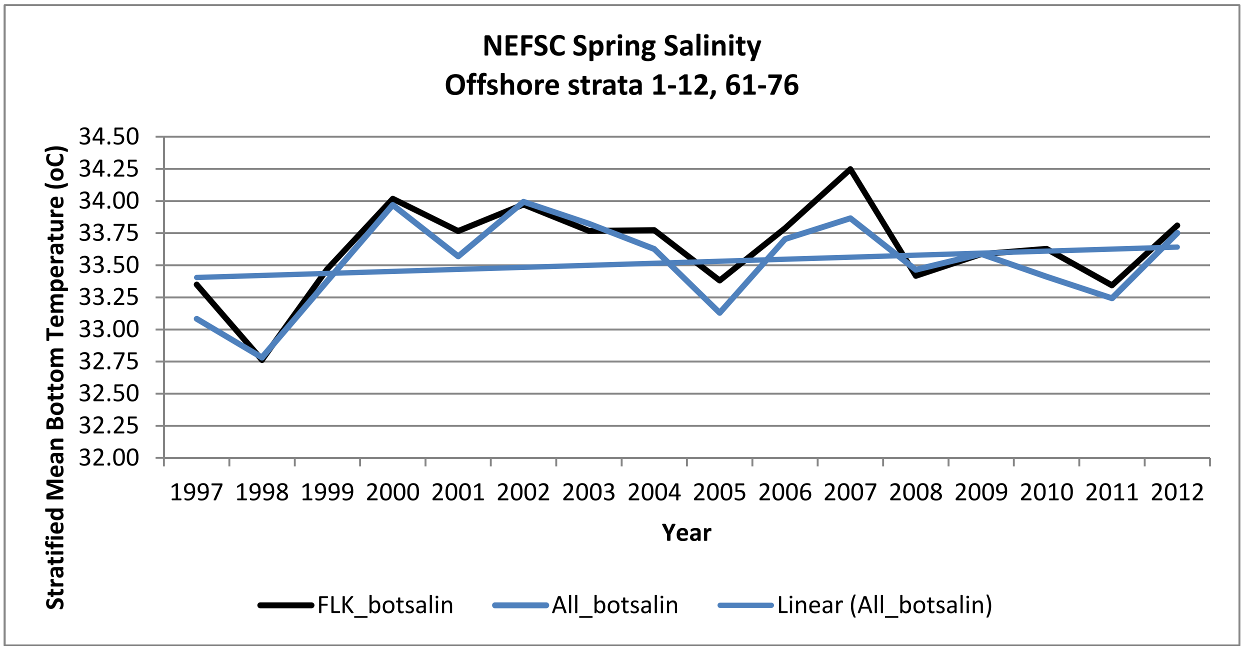


Figure A48. Annual stratified mean values of the bottom salinity for spring positive summer flounder catch tows (expcatchnum > 0; FLK_botsalin) was compared with the annual stratified mean values for all tows (All_botsalin).

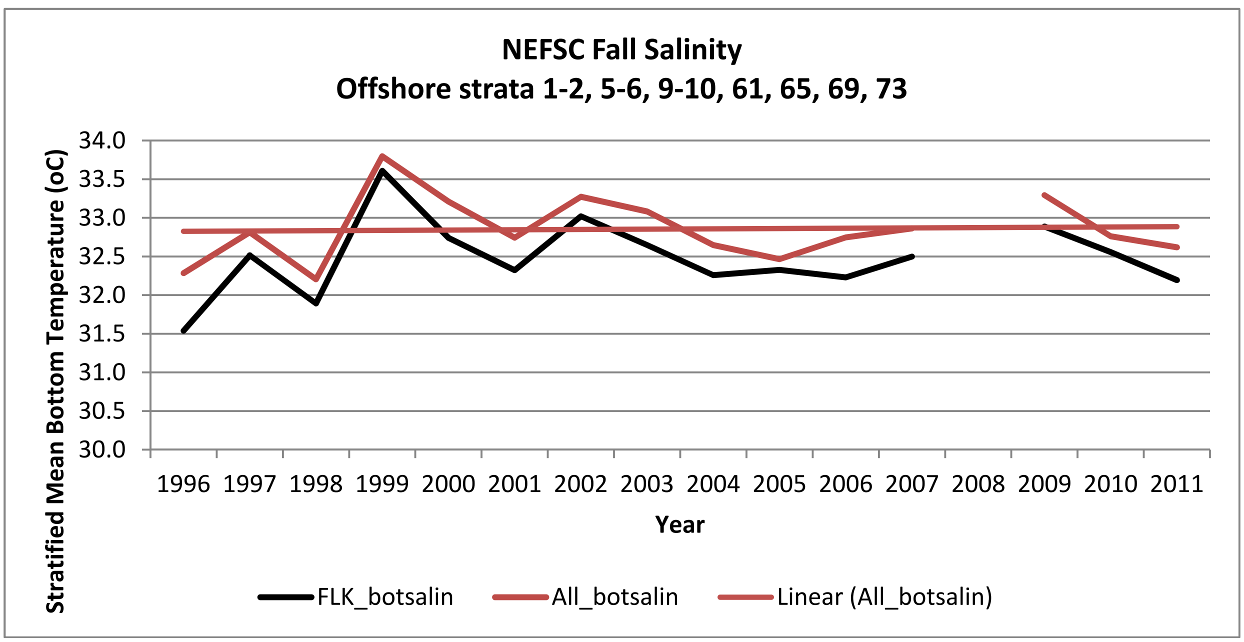


Figure A49. Annual stratified mean values of the bottom salinity for fall positive summer flounder catch tows (expcatchnum > 0; FLK_botsalin) was compared with the annual stratified mean values for all tows (All_botsalin).

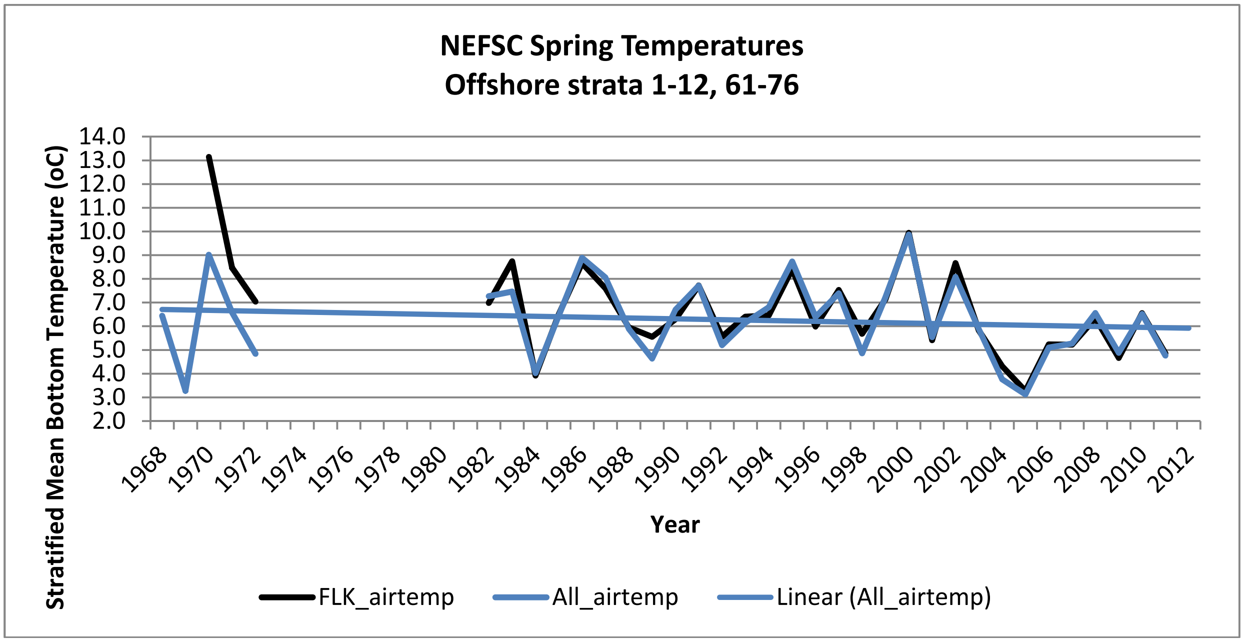


Figure A50. Annual stratified mean values of the air temperature for spring positive summer flounder catch tows (expcatchnum > 0; FLK_airtemp) was compared with the annual stratified mean values for all tows (All_airtemp).

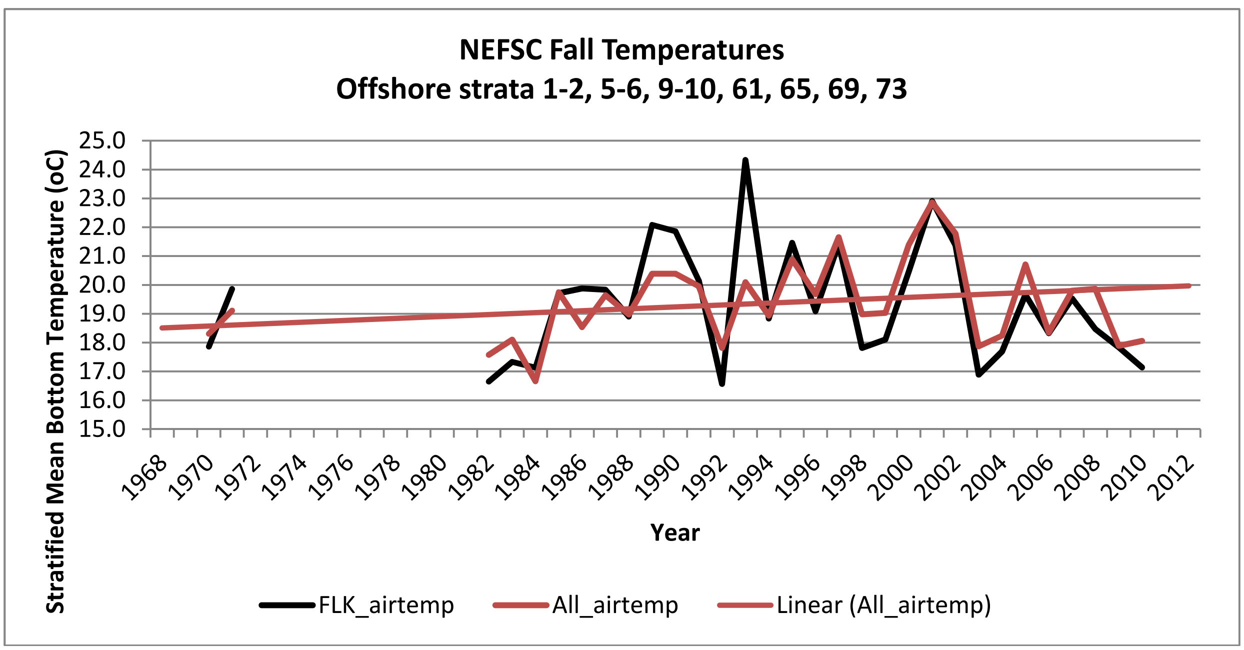


Figure A51. Annual stratified mean values of the air temperature for fall positive summer flounder catch tows (expcatchnum > 0; FLK_airtemp) was compared with the annual stratified mean values for all tows (All_airtemp).

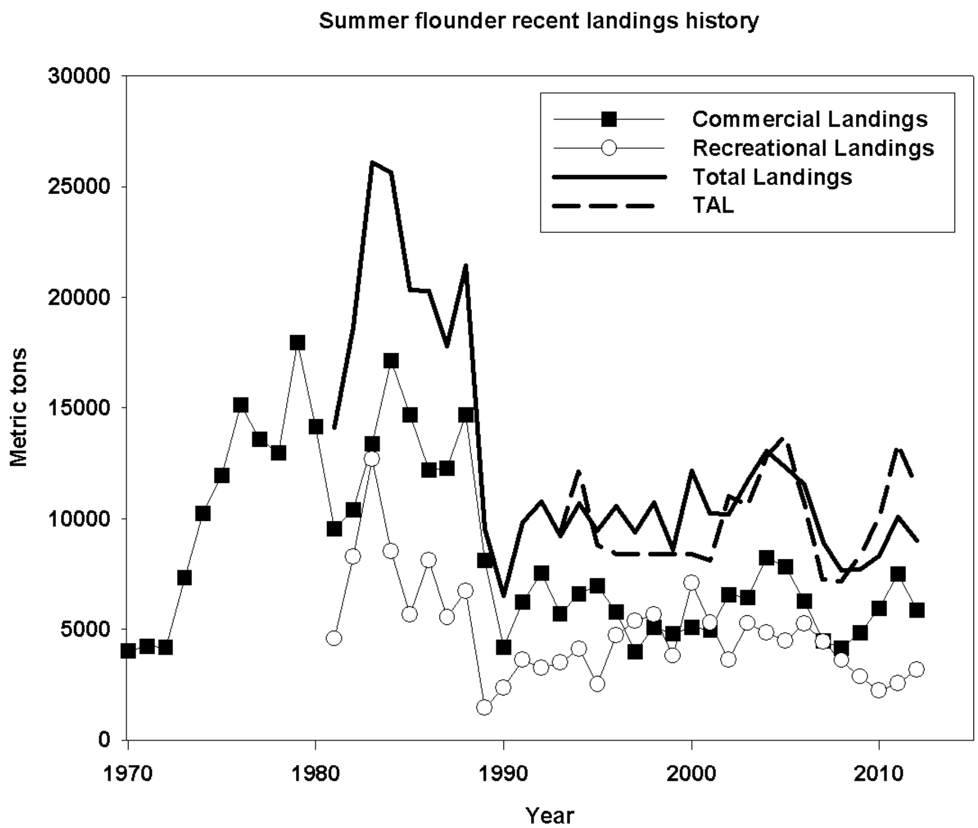


Figure A52. Summer flounder recent commercial (1970-2012), recreational (1981-2012), total fishery (1981-2012) landings, and the corresponding fishery Total Allowable Landings (TAL).

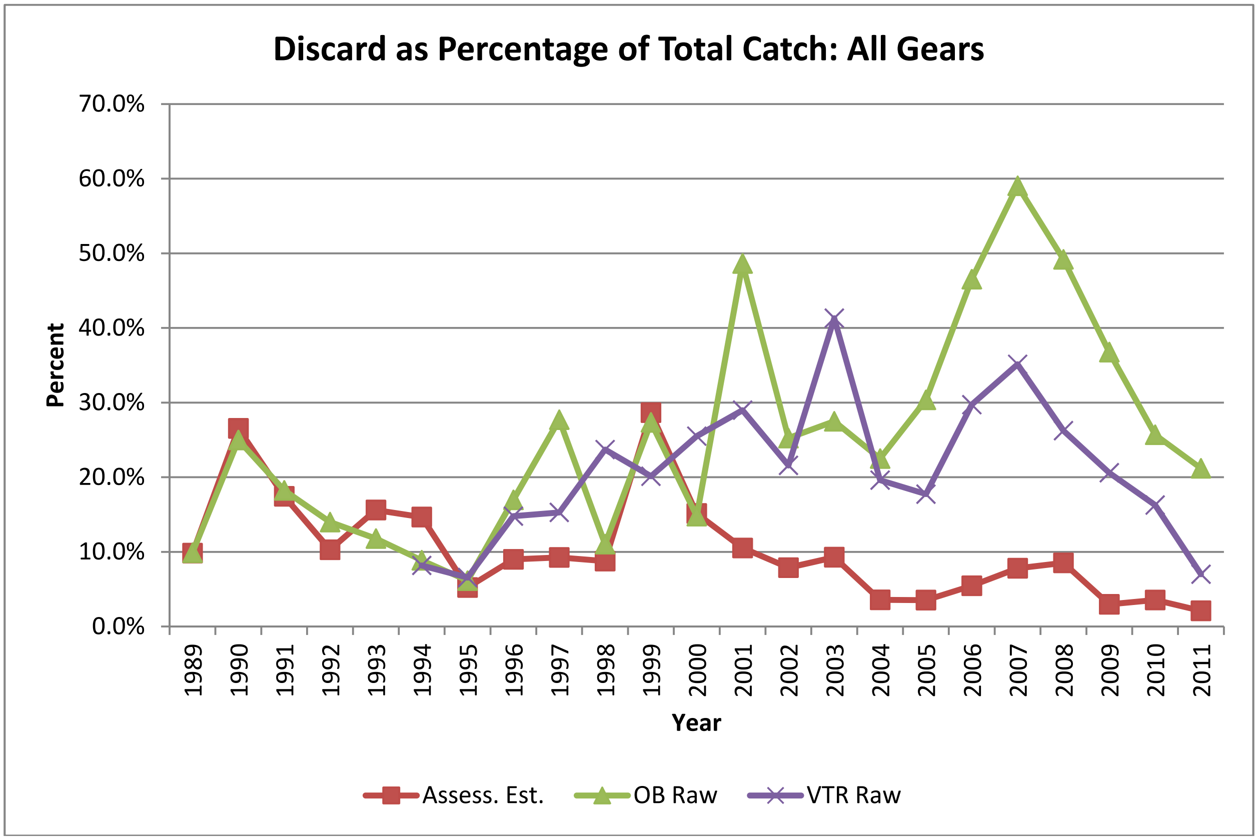


Figure A53: Discard as a percentage of total catch for all fishing gears combined: as previously estimated in the assessment (Assess Est.), as compiled from Observer data (OBRaw) and as compiled from Vessel Trip Report data (VTR Raw).

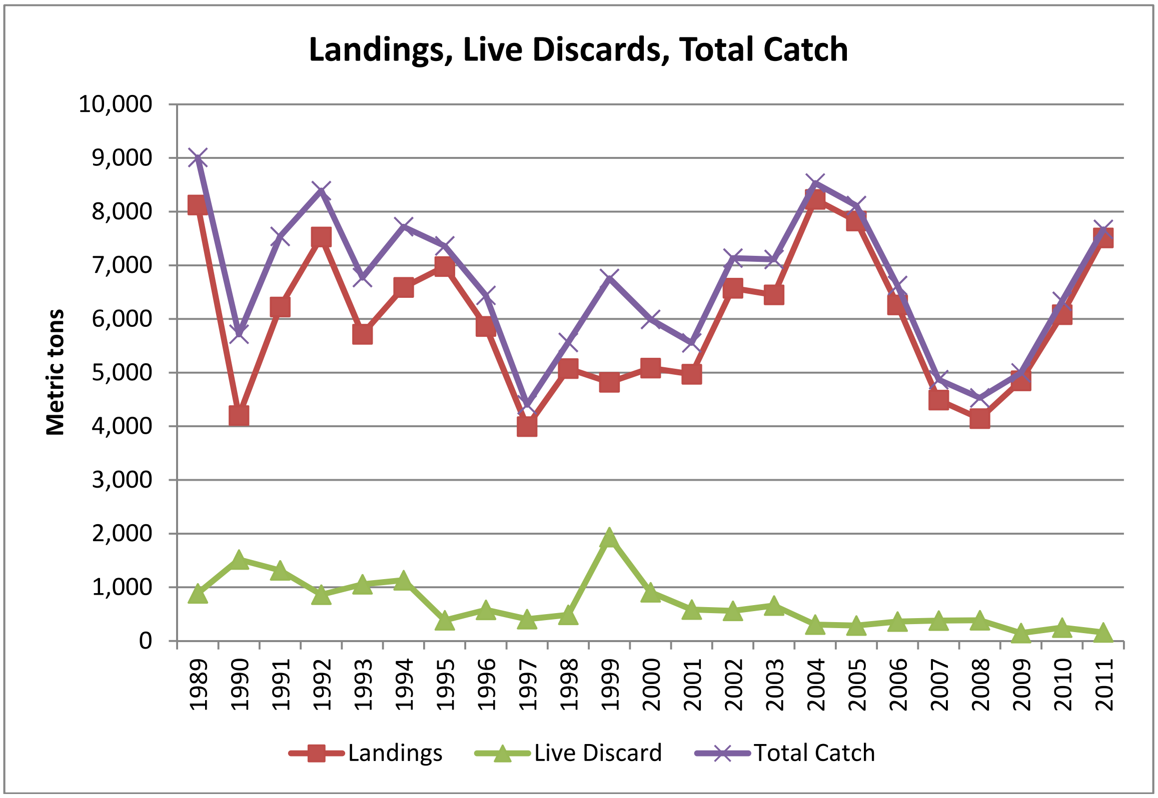


Figure A54. Dealer reported landings, live discards using the previous estimation method (Assess; D/DF), and total catch.

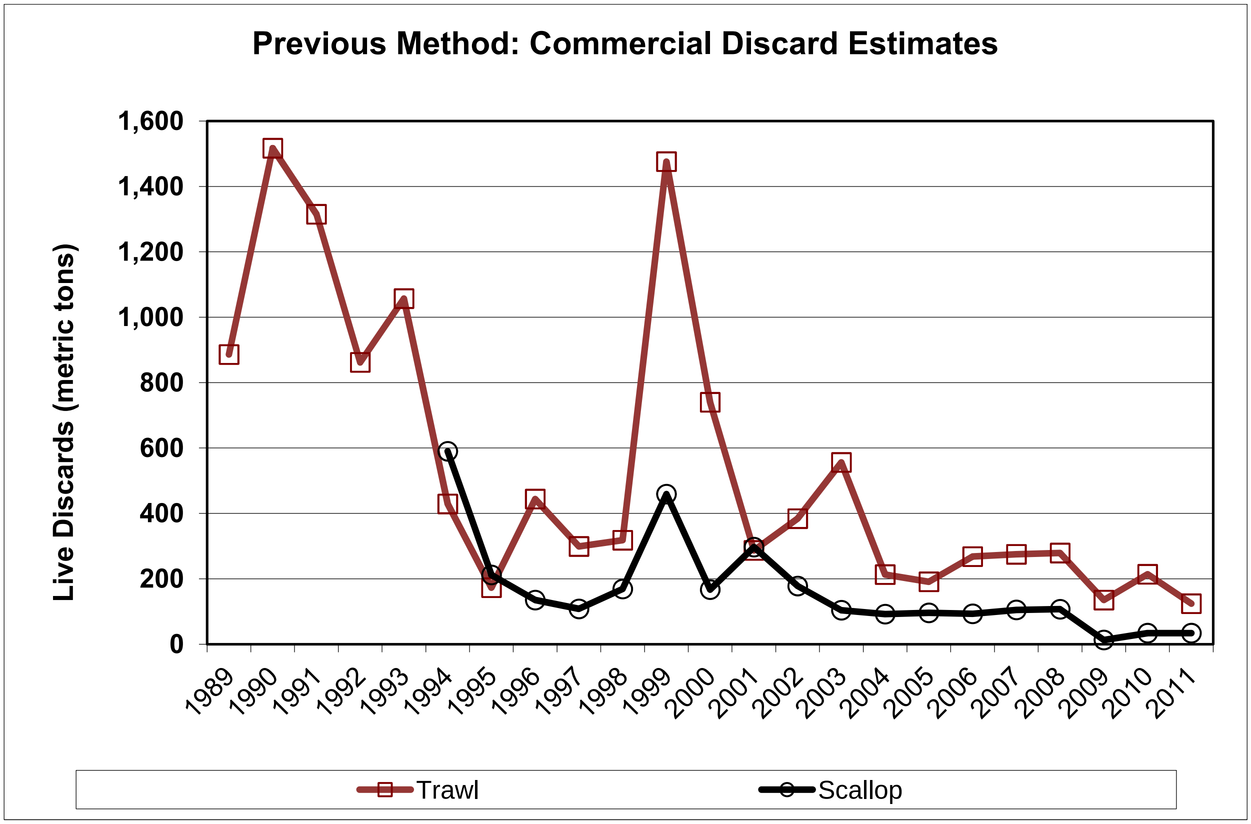


Figure A55. Live discards by gear type using the previous estimation method (Assess; D/DF).

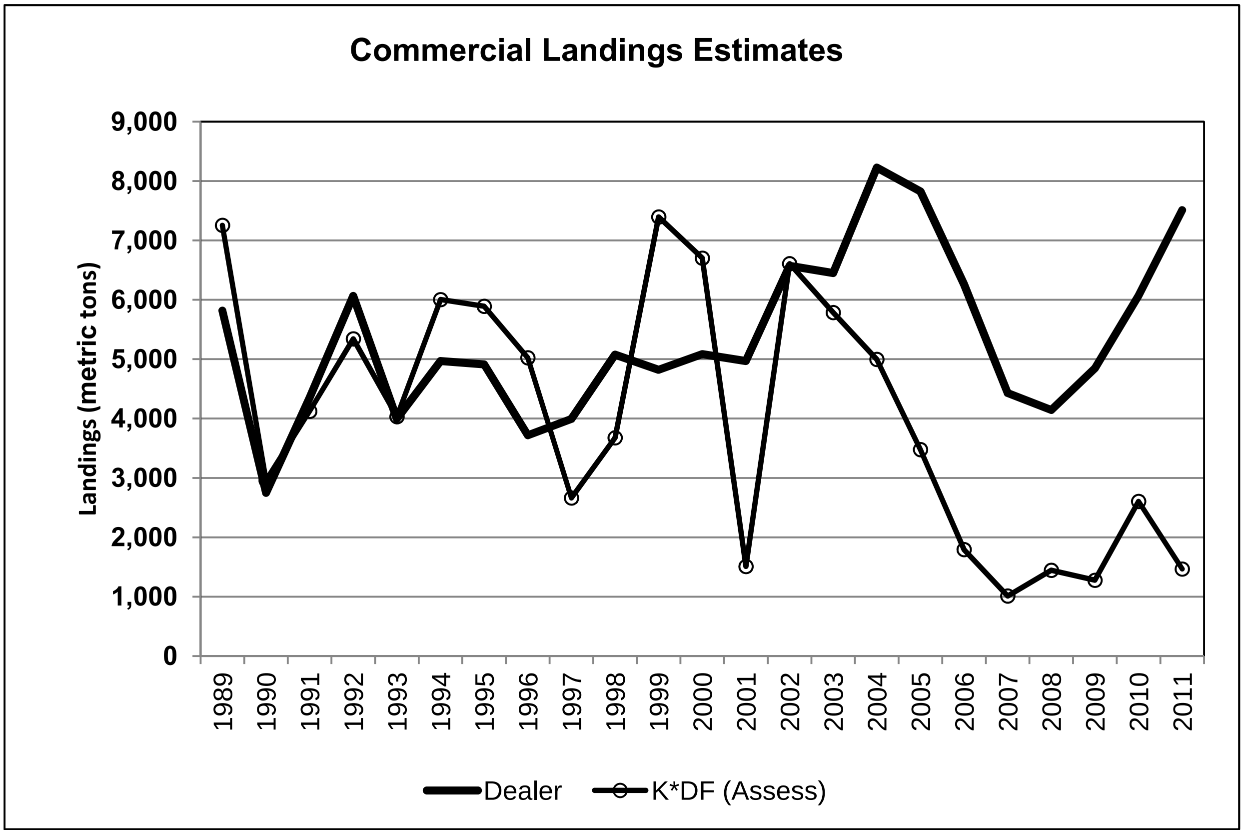


Figure A56. Comparison of commercial fishery Dealer reported landings of summer flounder (i.e., the “true landings”; Dealer) with estimates of summer flounder commercial landings using the previous Assess method, but for ‘K*DF’ [{K/DF}*DF].

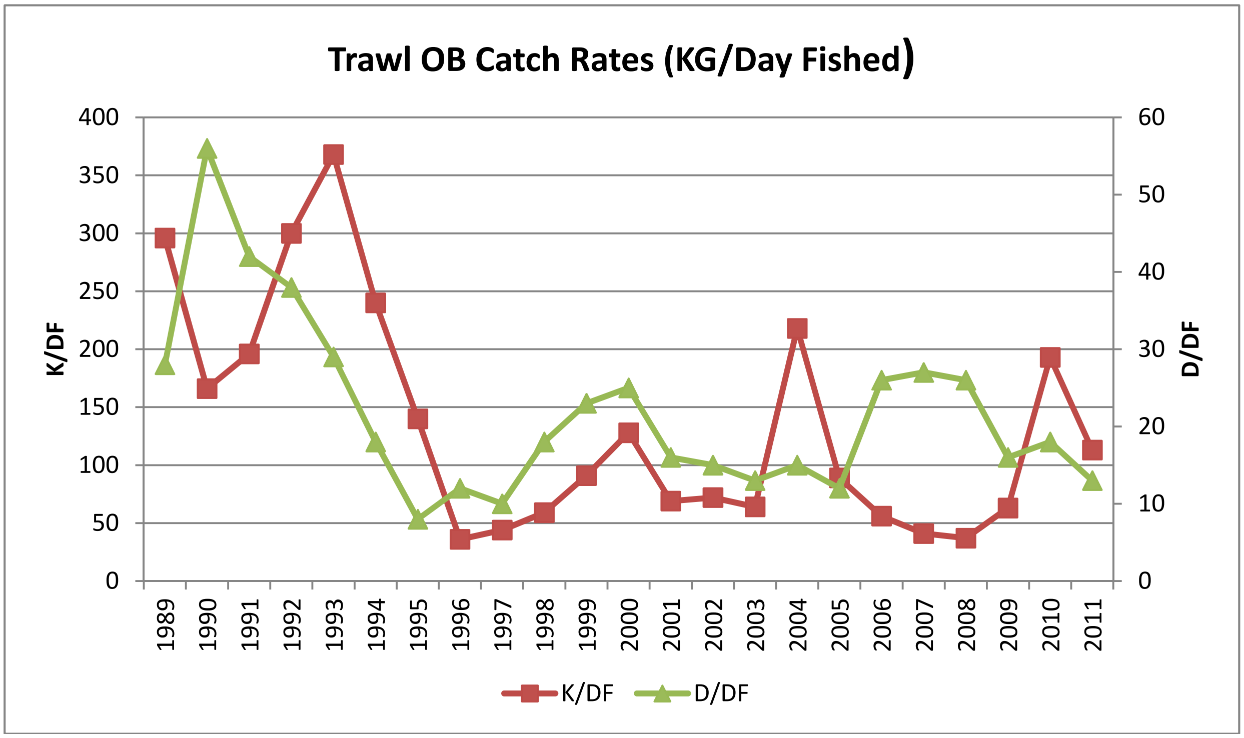


Figure A57. Observed Discard per Day Fished (D/DF) and Kept per Day Fished (K/DF) catch rates for fish trawl gear.

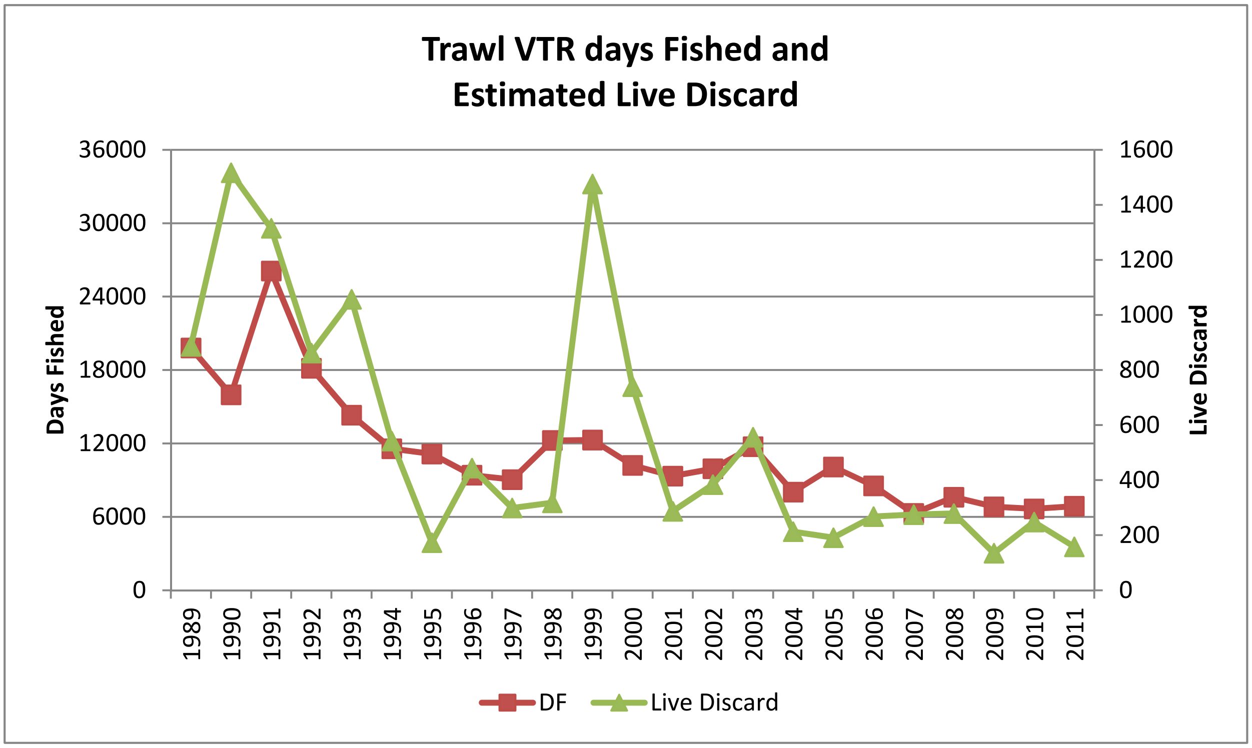


Figure A58. Fish trawl gear VTR Days Fished and previous estimation method (Assess) estimated live discard.

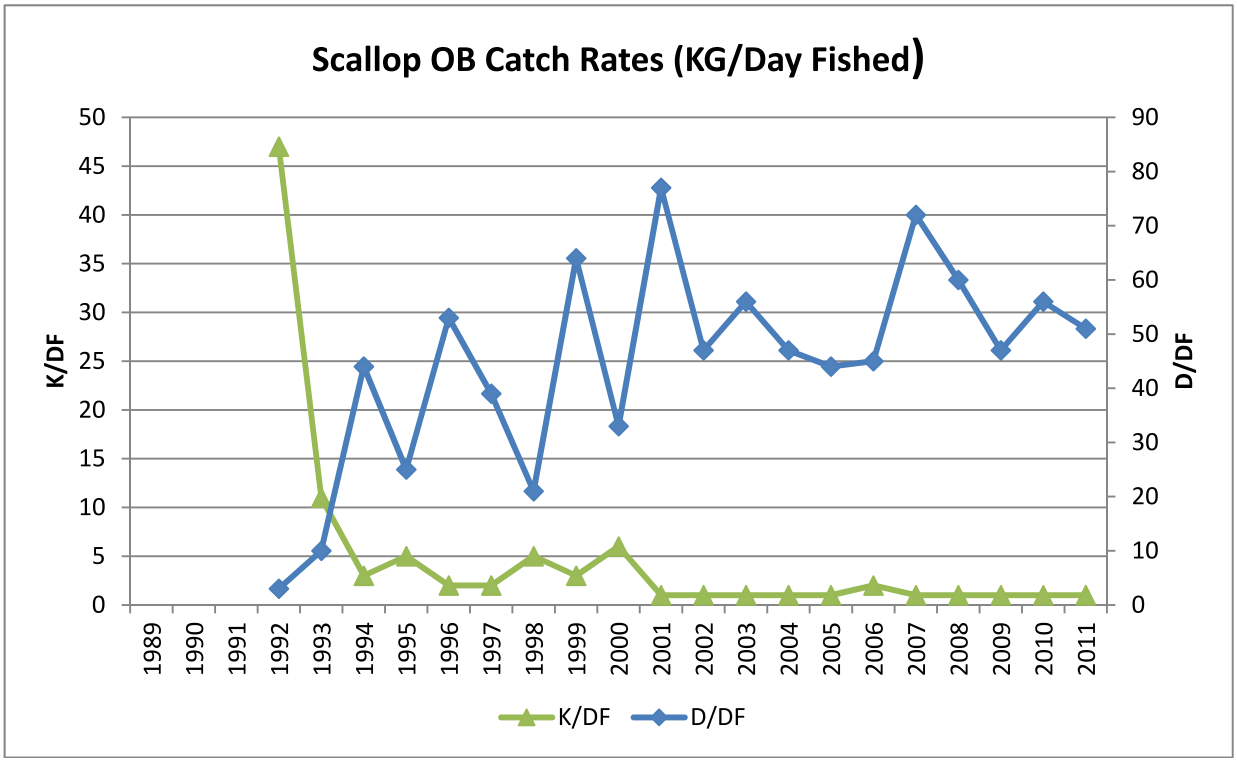


Figure A59. Observed Discard per Day Fished (D/DF) and Kept per Day Fished (K/DF) catch rates for scallop dredge gear.

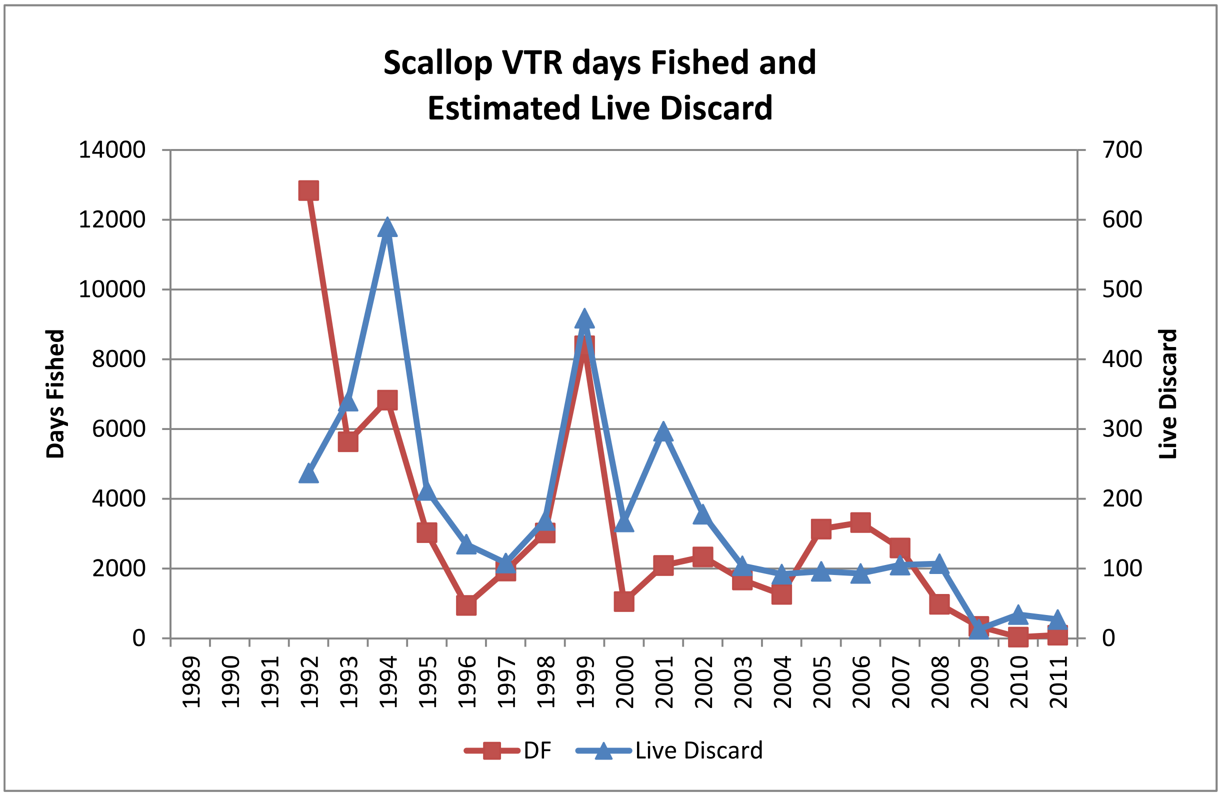


Figure A60. Scallop dredge gear VTR days fished and previous estimation method (Assess) estimated live discard.

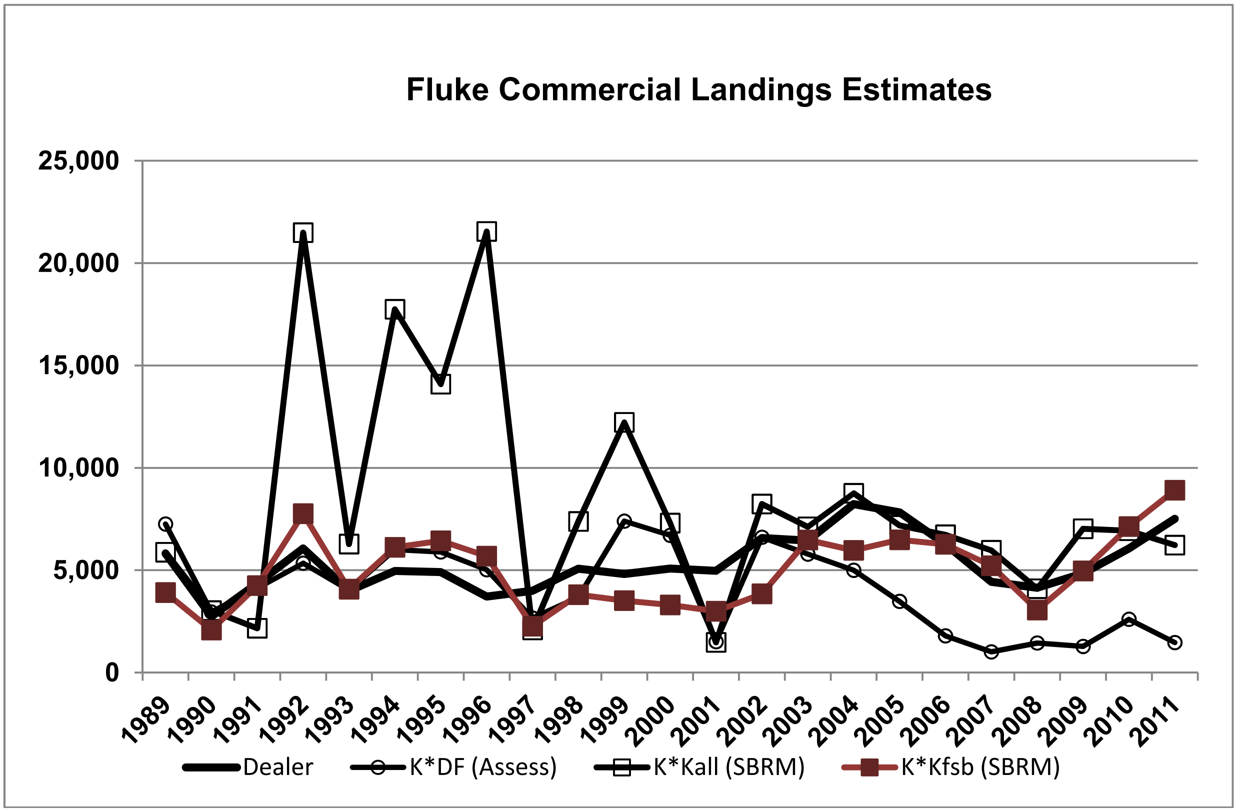


Figure A61. Comparison of summer flounder landings estimates from Dealer reports, the method used in previous assessments (K*DF), the SBRM using all species landings (K*Kall), and the SBRM using all fluke, scup, and black sea bass landings (K*Kfsb).

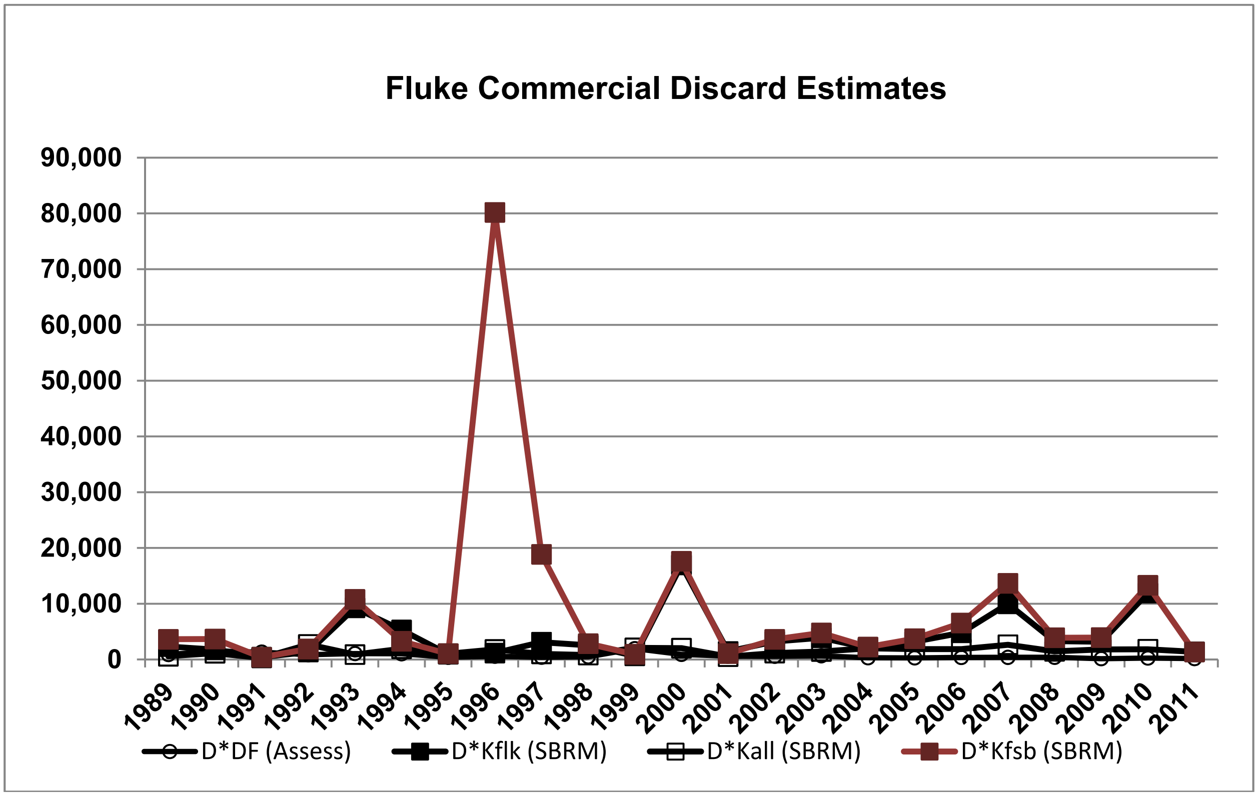


Figure A62. Comparison of summer flounder discard estimates from the method used in previous assessments (D*DF), the SBRM using fluke (summer flounder) landings (D*Kflk), the SBRM using all species landings (D*Kall), and the SBRM using all fluke, scup, and black sea bass landings (D*Kfsb).

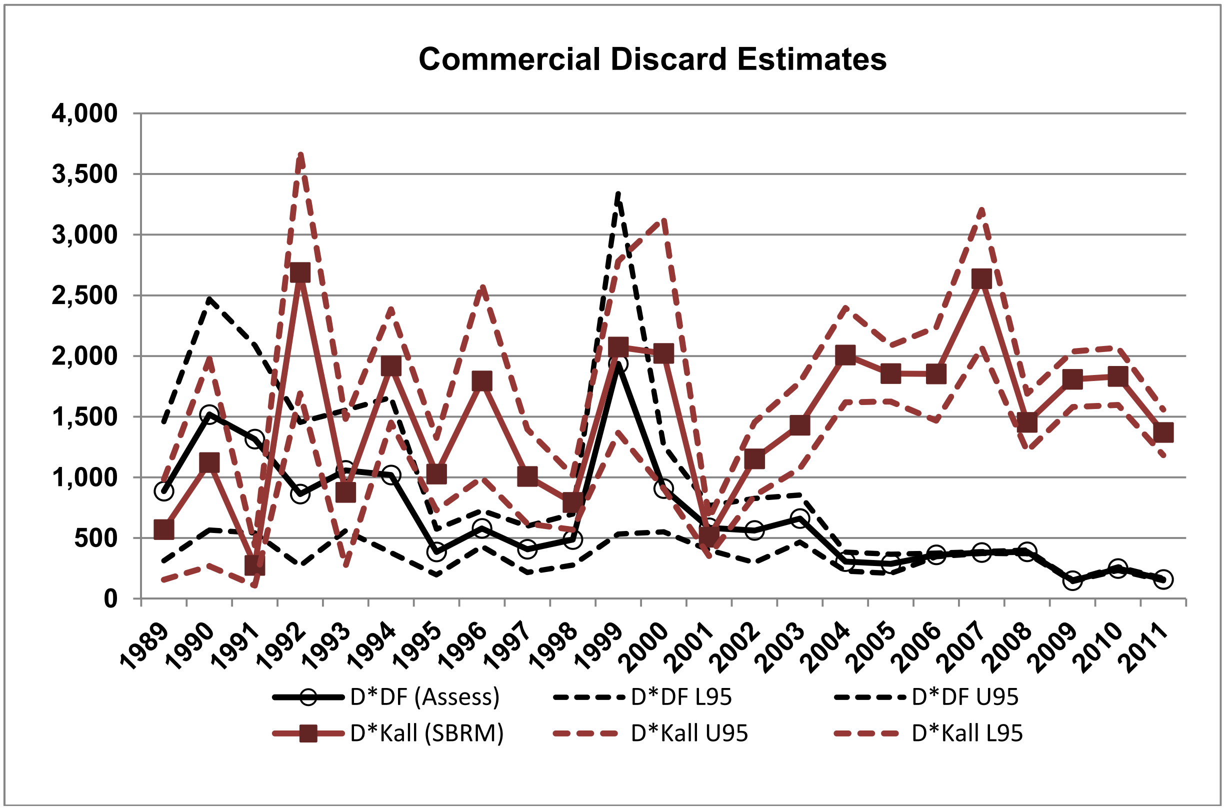


Figure A63. Comparison of summer flounder discard estimates and 95% confidence intervals from the method used in previous assessments (D*DF) and the SBRM using all species landings (D*Kall).

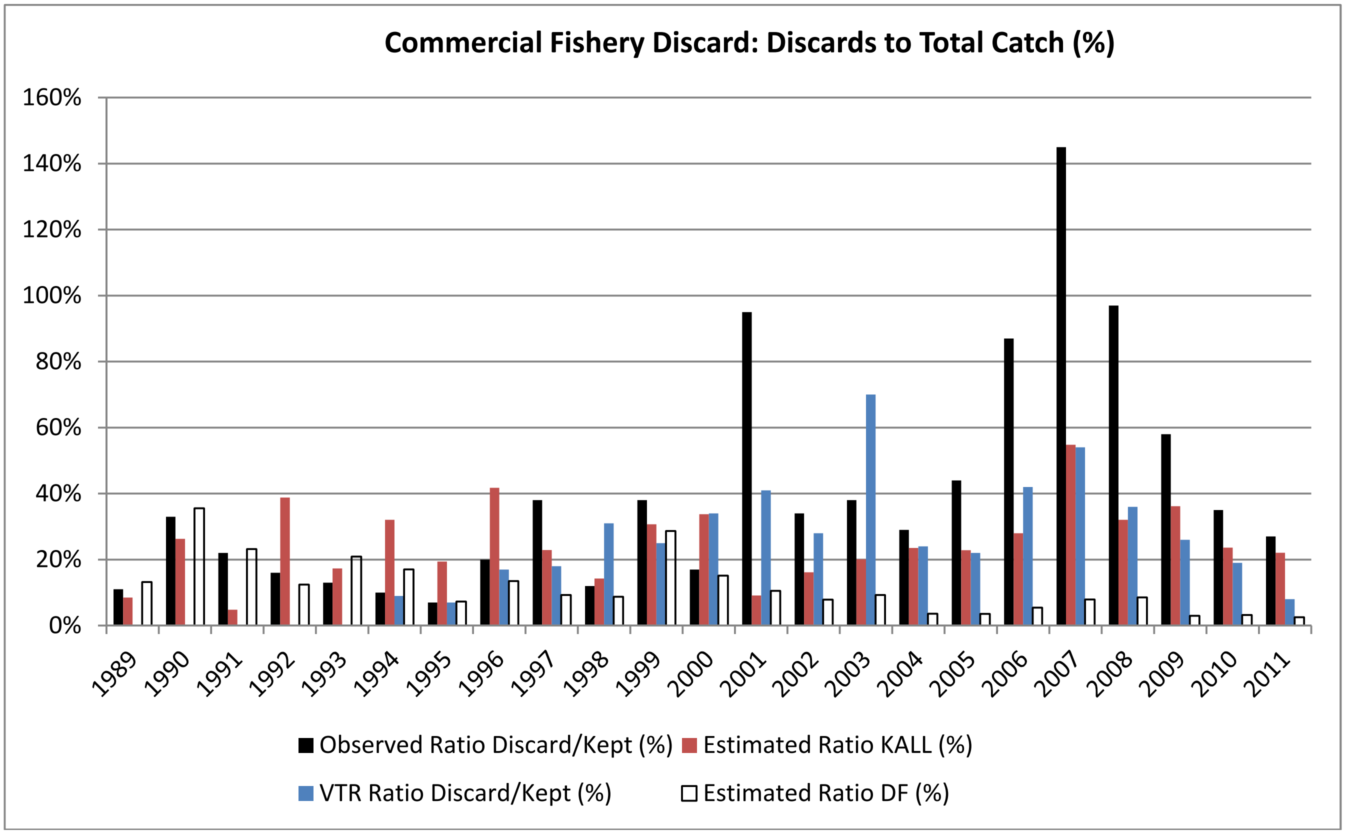


Figure A64. Comparison of summer flounder discard ratios (discard to total catch in percent) from the raw Observer data (black), the SBRM D*Kall estimates (estimated discards and Dealer reported landings; red), the raw VTR data (blue), and the method used in previous assessments (D*DF; estimated discards and Dealer reported landings).

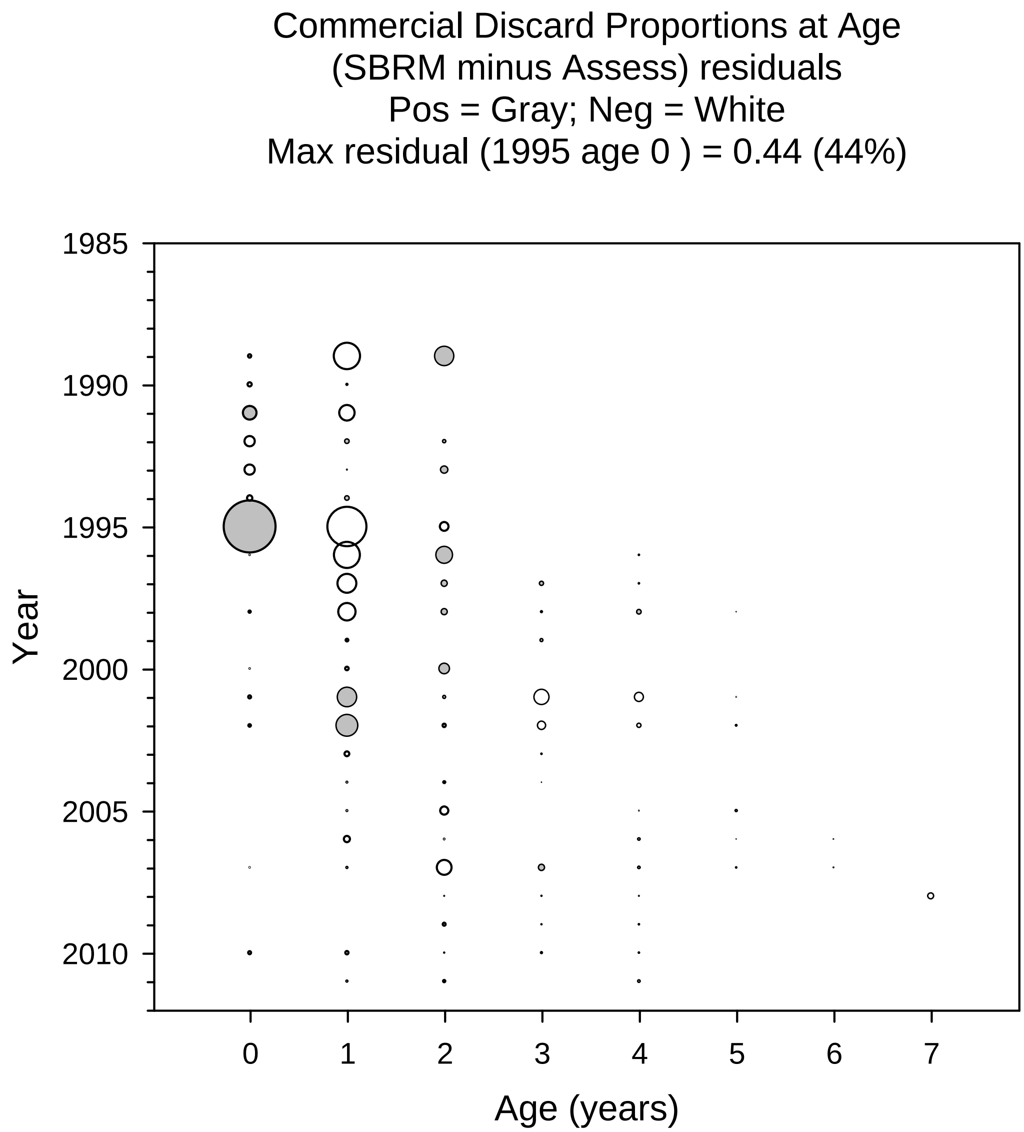


Figure A65. Comparison of SBRM D*Kall and Assess D*DF estimates of discards at age: residuals (differences) in estimated proportion at age by year.

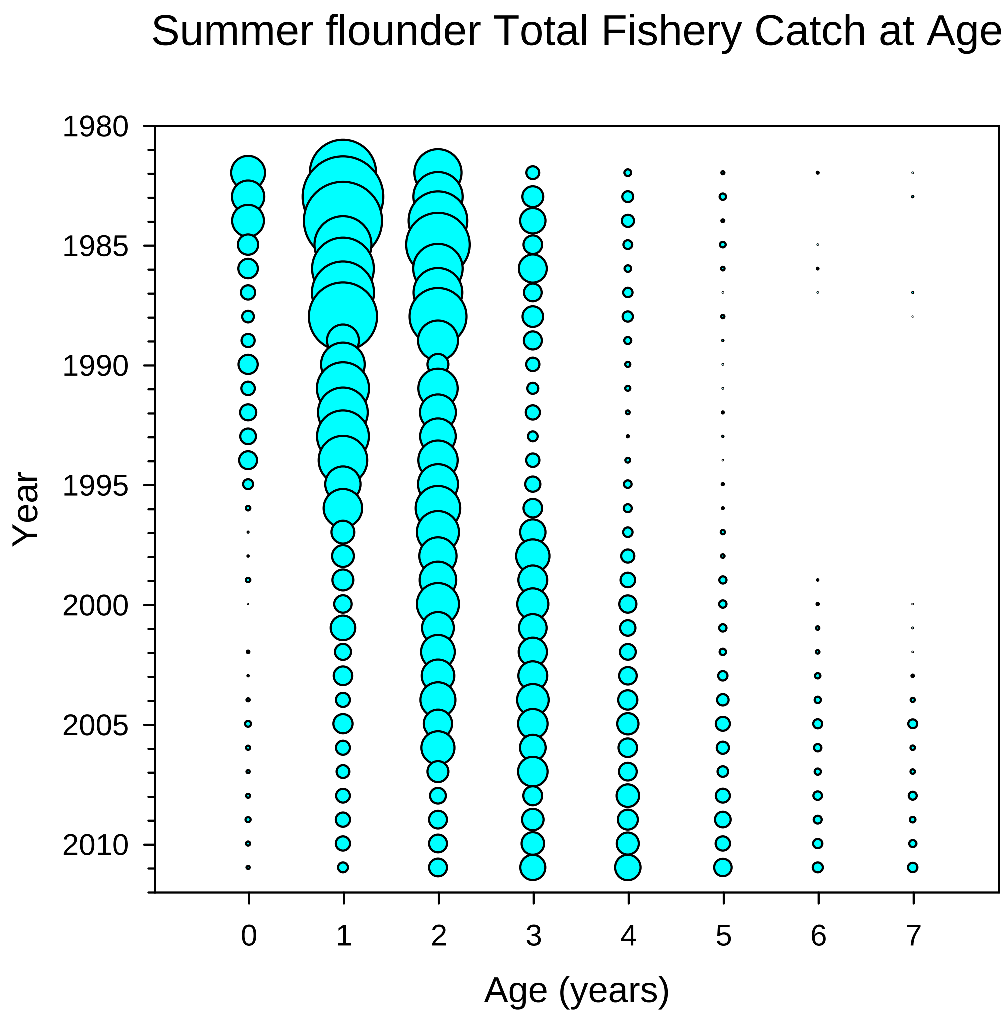


Figure A66. Total fishery catch at age for summer flounder.

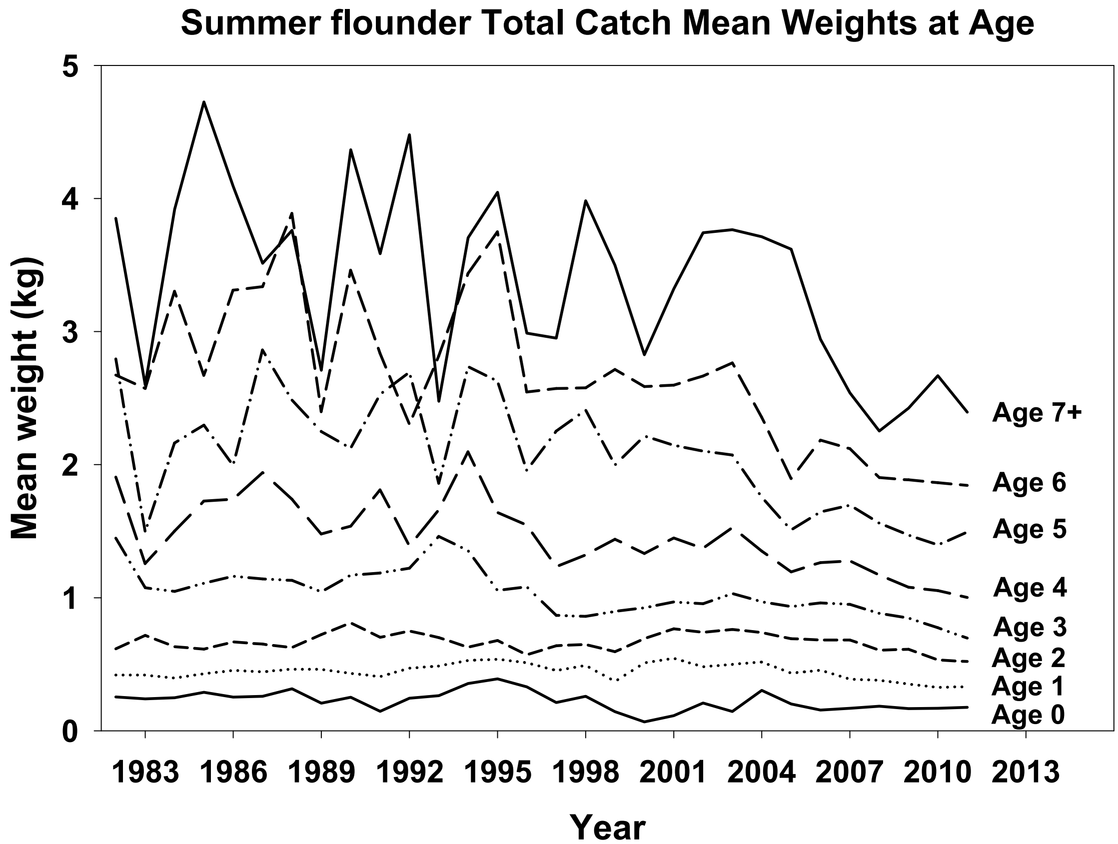


Figure A67. Mean weight at age in the total fishery catch of summer flounder.

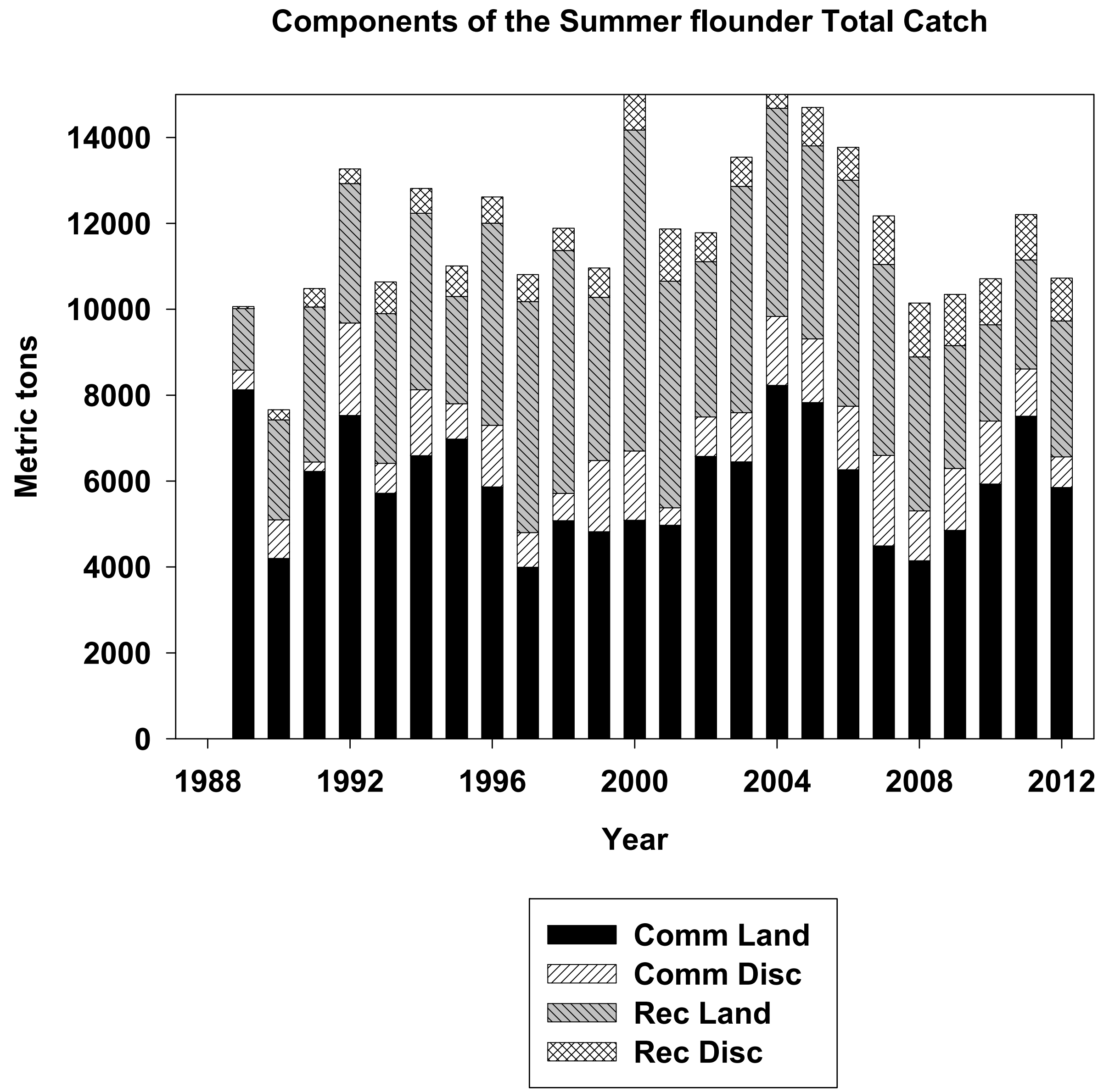


Figure A68. Components of the summer flounder fishery catch.

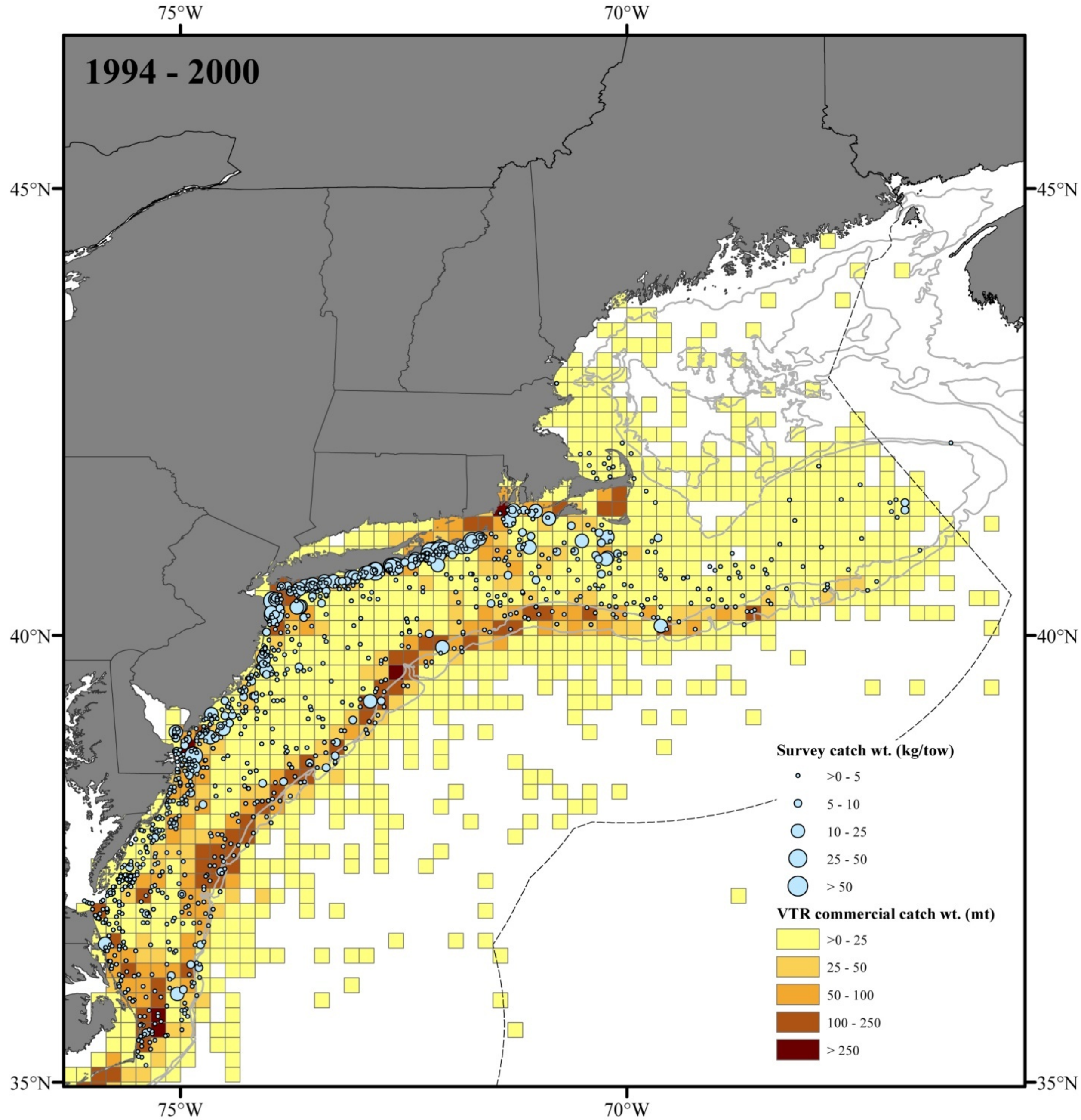


Figure A69. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and commercial VTR-reported catch weight (landings and discards) binned to ten minute squares from 1994-2000.

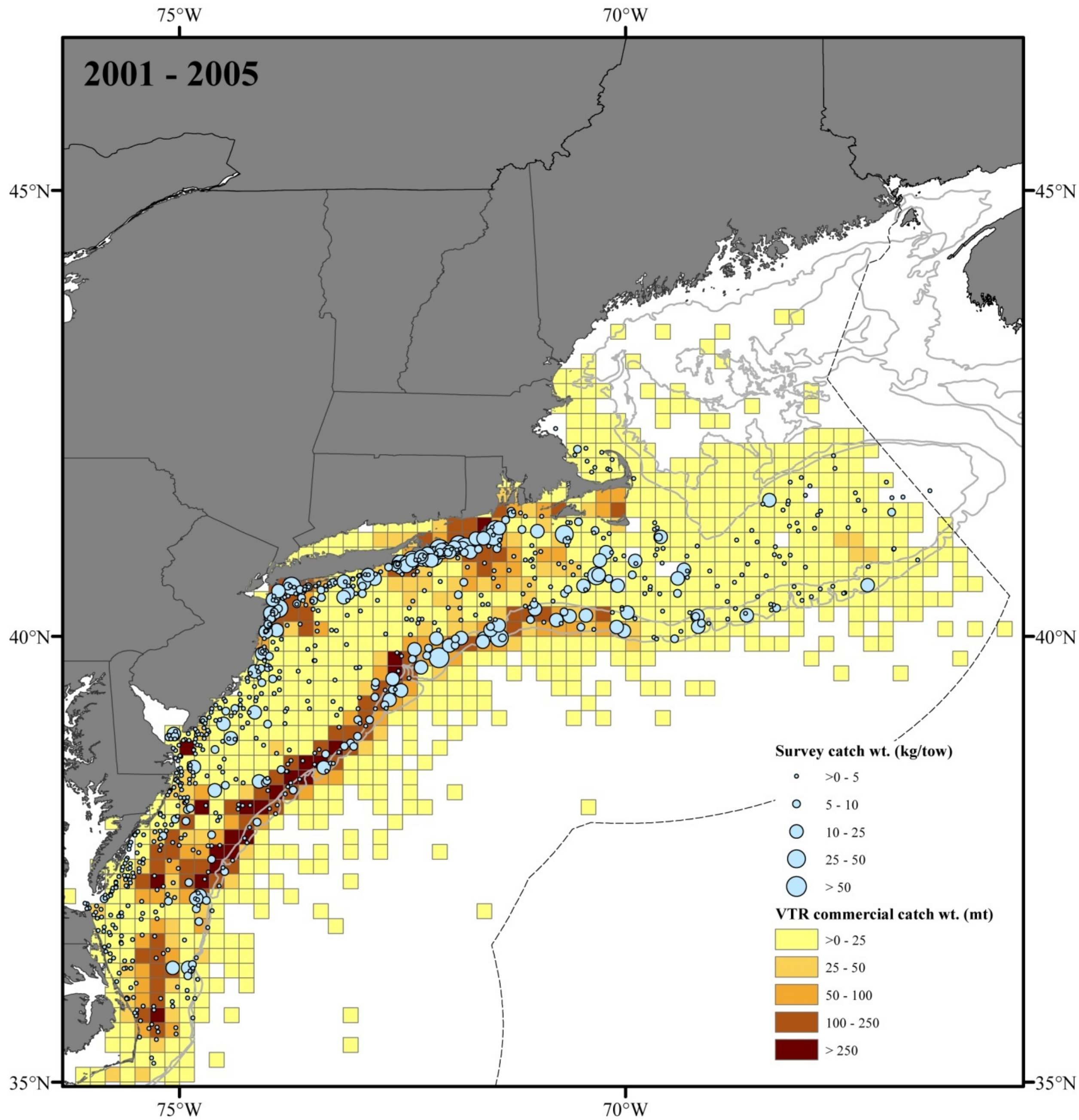


Figure A70. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and commercial VTR-reported catch weight (landings and discards) binned to ten minute squares from 2001-2005.

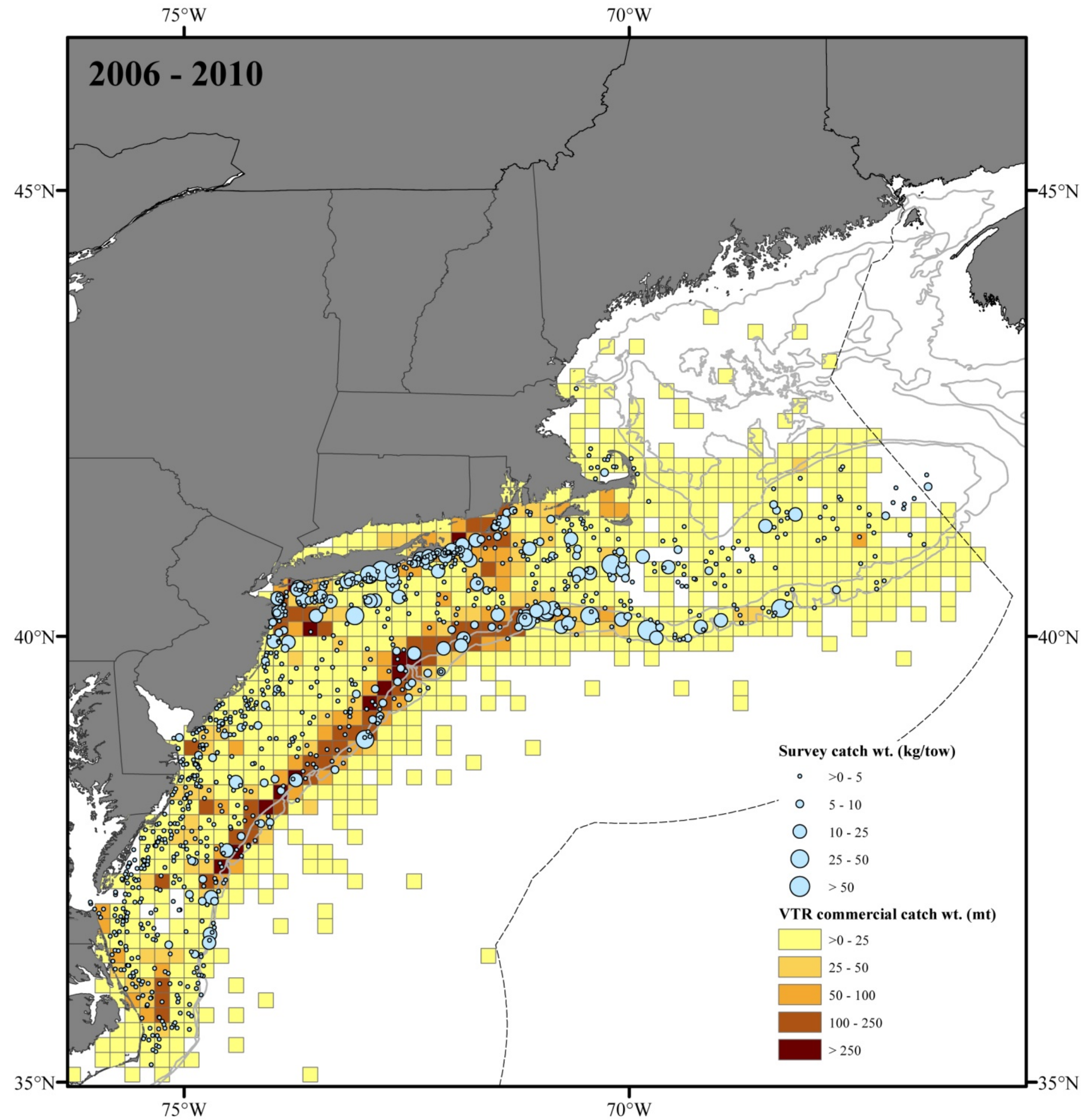


Figure A71. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and commercial VTR-reported catch weight (landings and discards) binned to ten minute squares from 2006-2010.

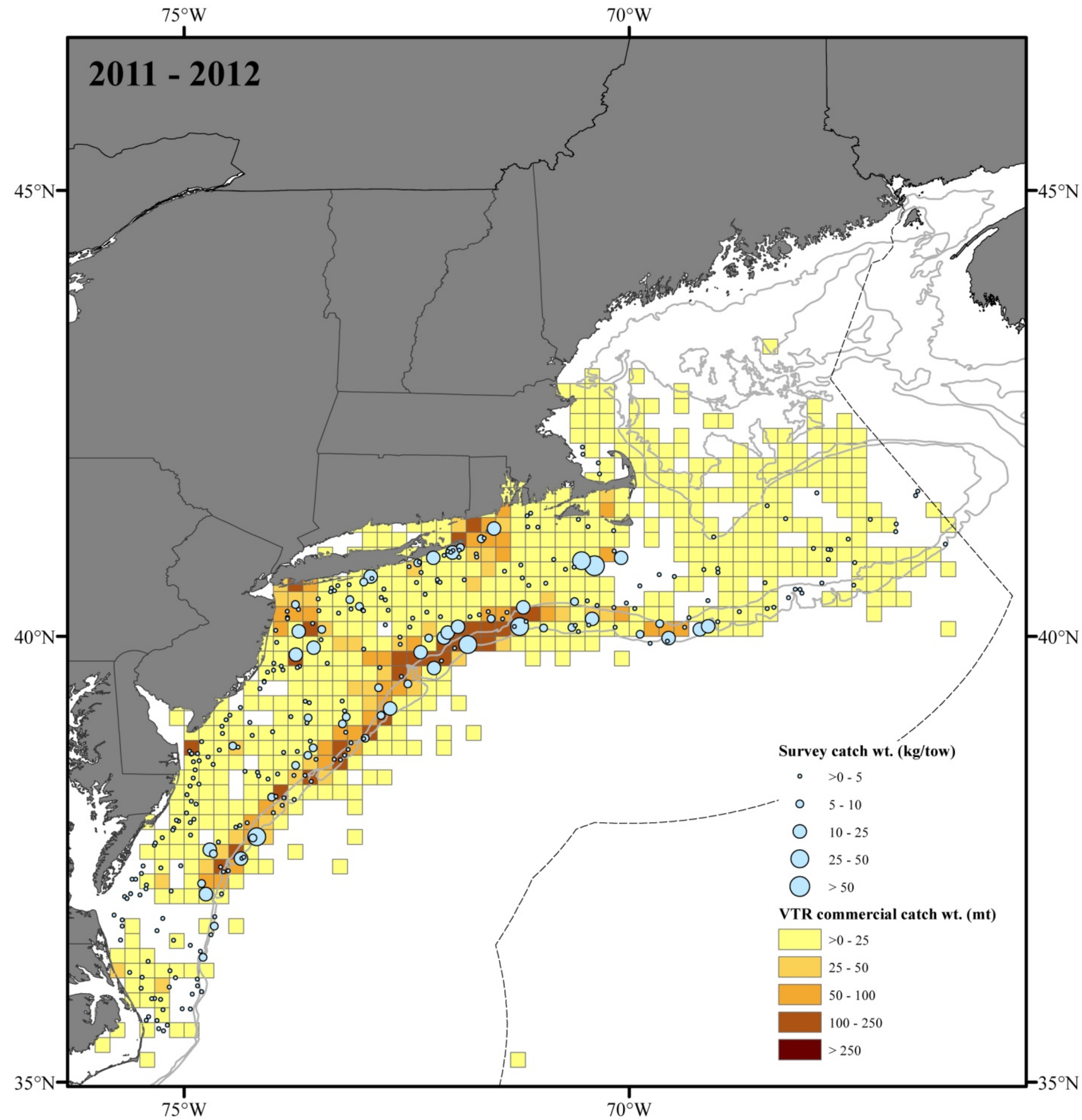


Figure A72. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and commercial VTR-reported catch weight (landings and discards) binned to ten minute squares from 2011-2012.

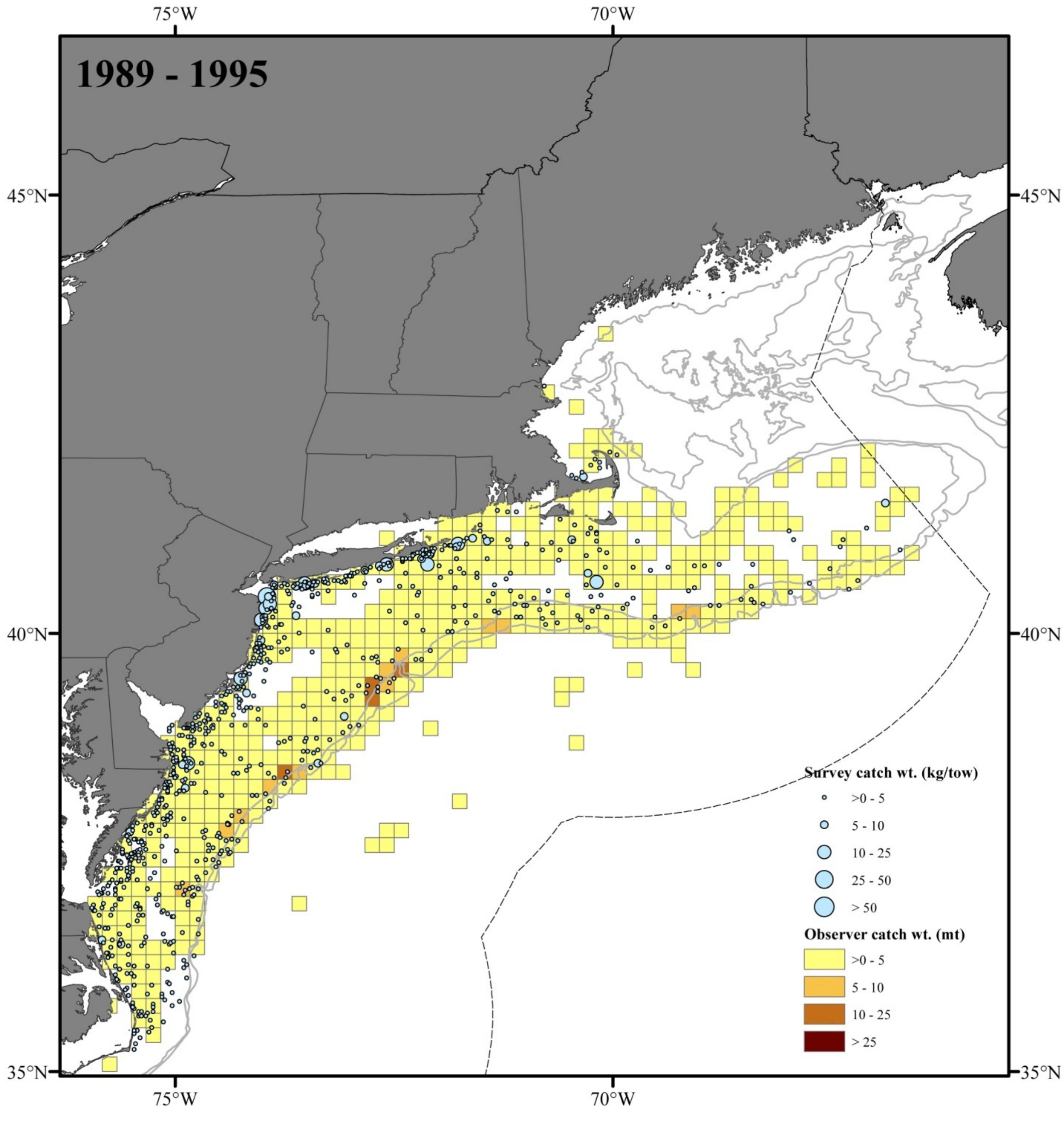


Figure A73. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and total observed catch weight (landings and discards) binned to ten minute squares from 1989-1995.

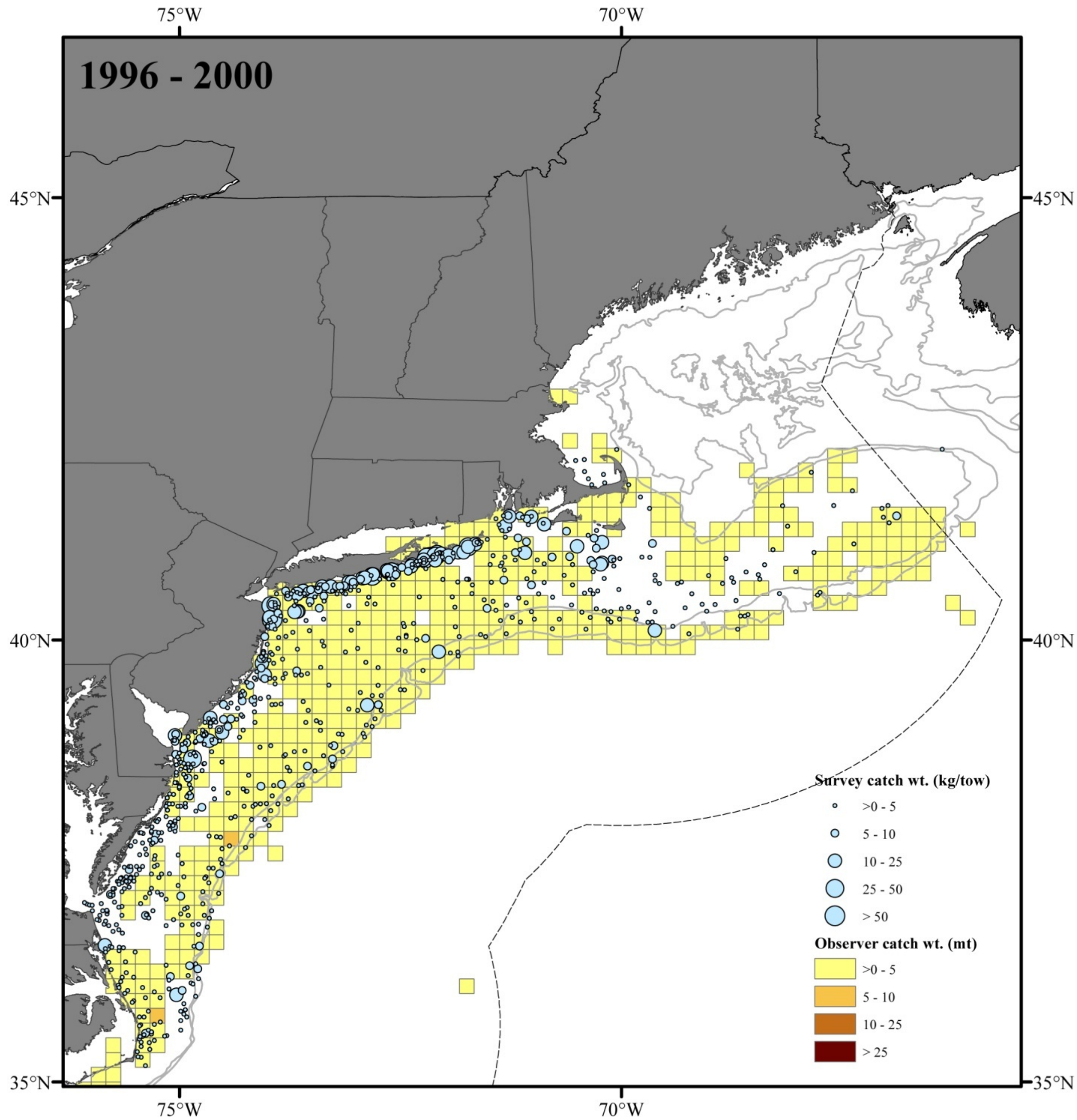


Figure A74. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and total observed catch weight (landings and discards) binned to ten minute squares from 1996-2000.

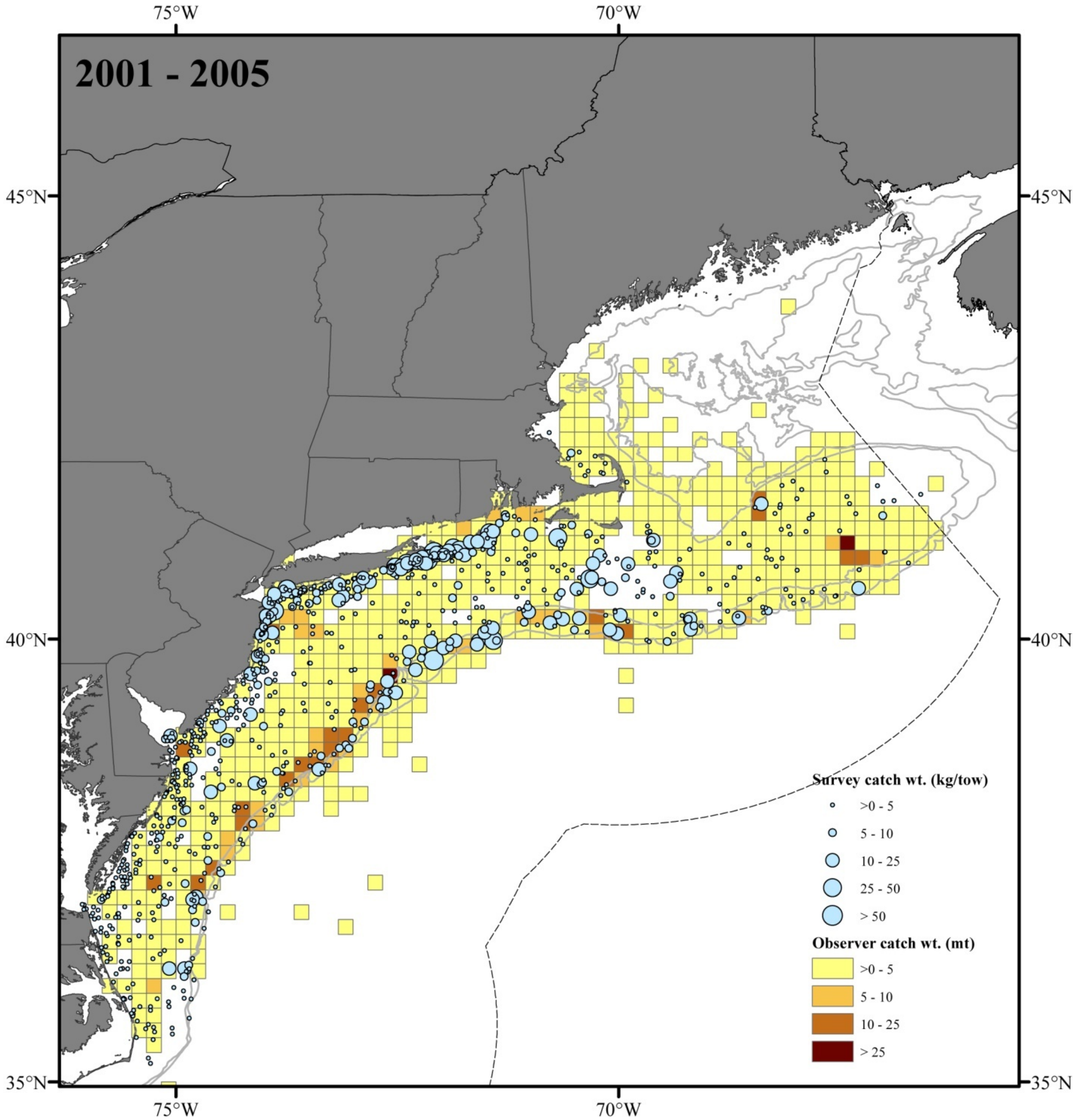


Figure A75. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and total observed catch weight (landings and discards) binned to ten minute squares from, 2001-2005.

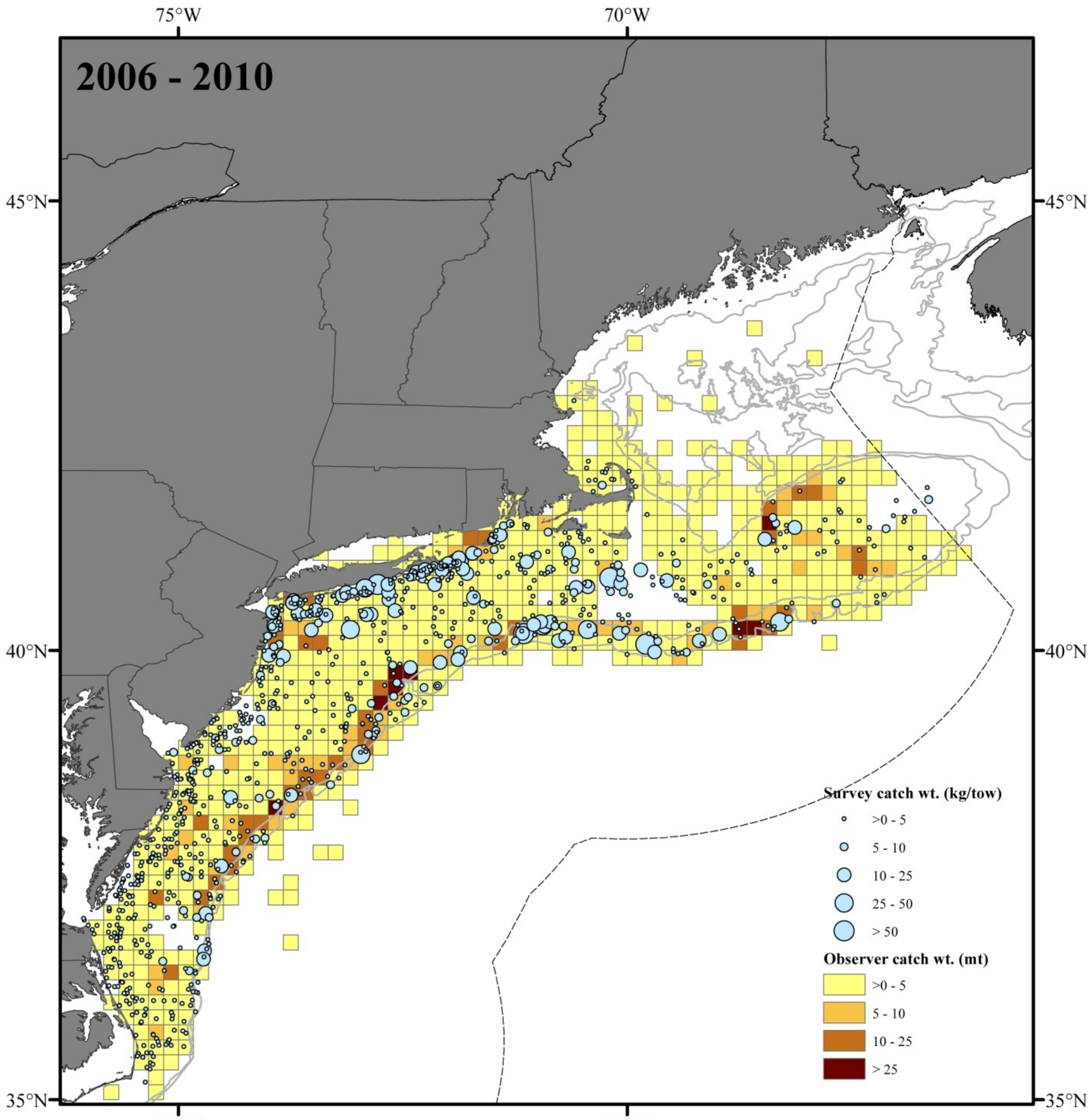


Figure A76. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and total observed catch weight (landings and discards) binned to ten minute squares from 2006-2010.

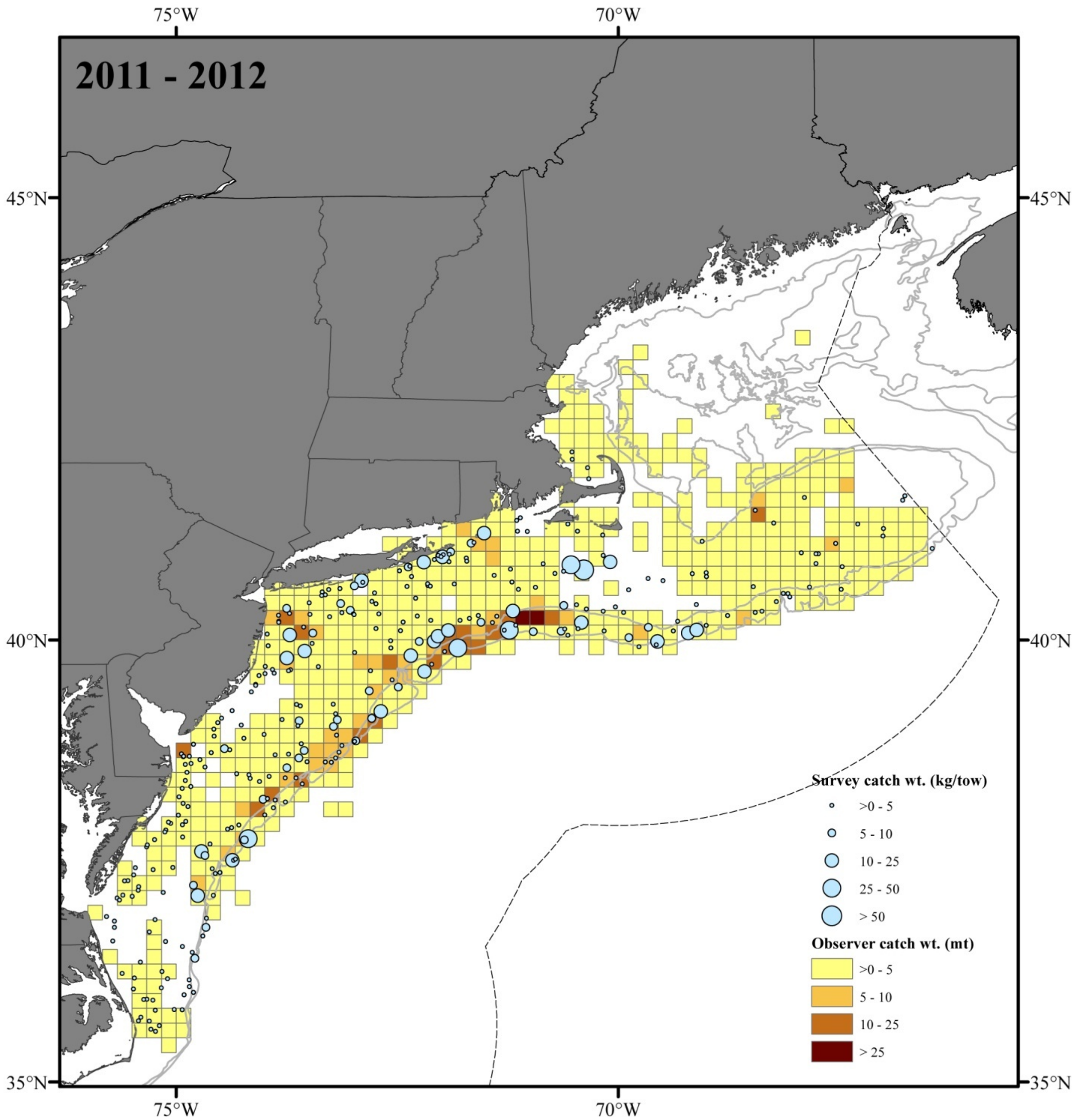


Figure A77. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and total observed catch weight (landings and discards) binned to ten minute squares from 2011-2012.

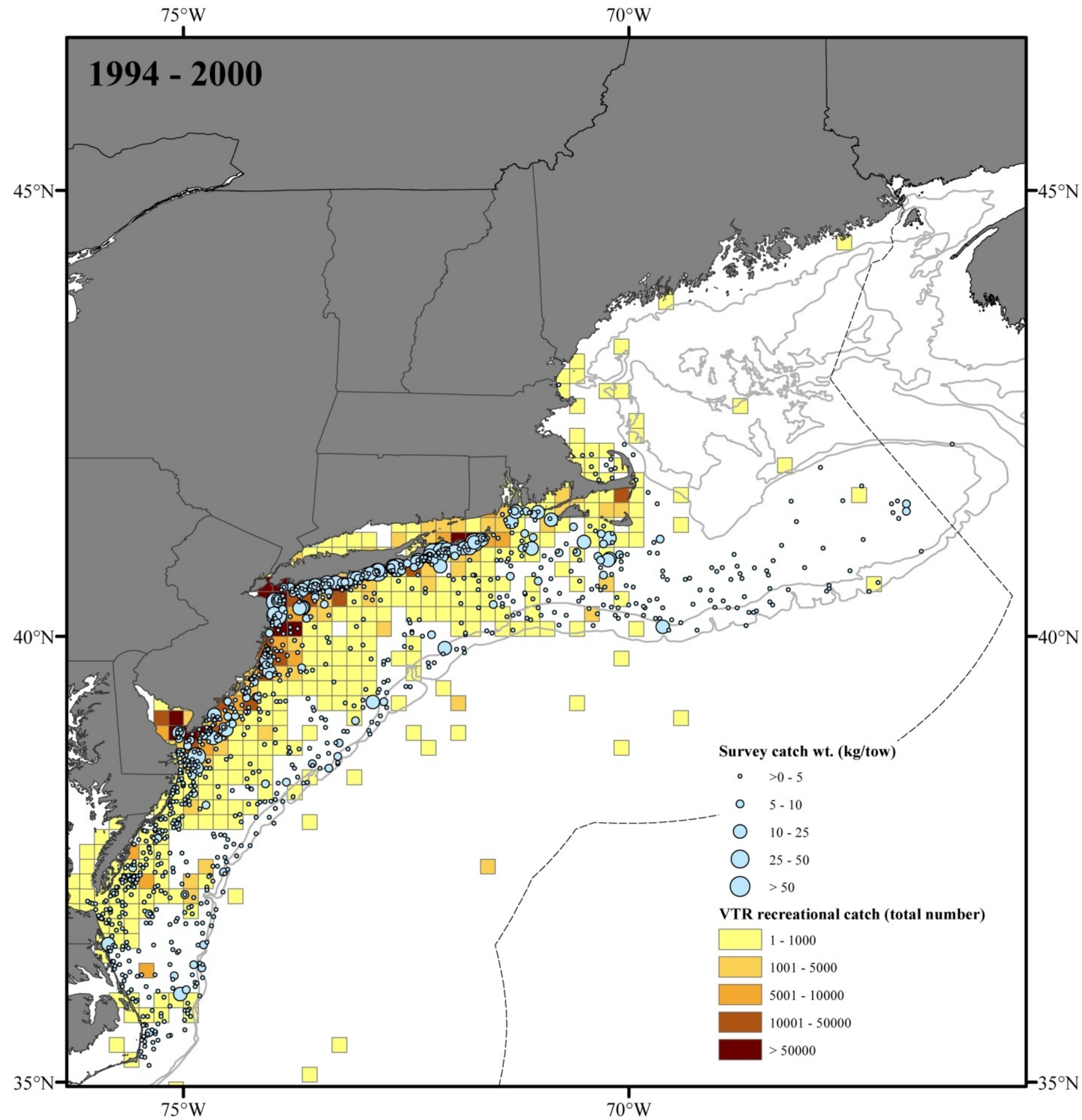


Figure A78. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and recreational (party and charter boat) VTR-reported catch (total number) binned to ten minute squares from 1994-2000.

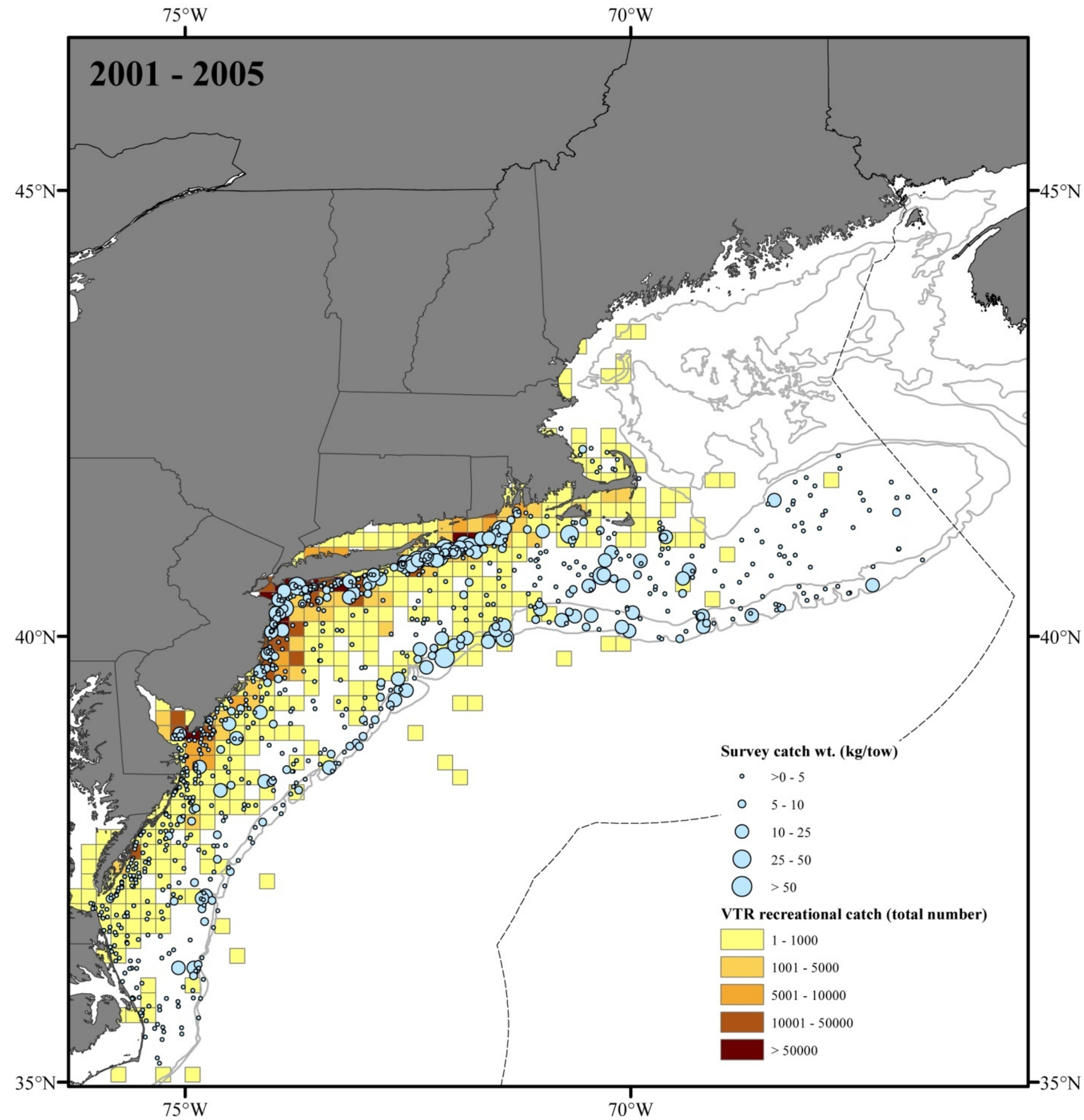


Figure A79. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and recreational (party and charter boat) VTR-reported catch (total number) binned to ten minute squares from 2001-2005.

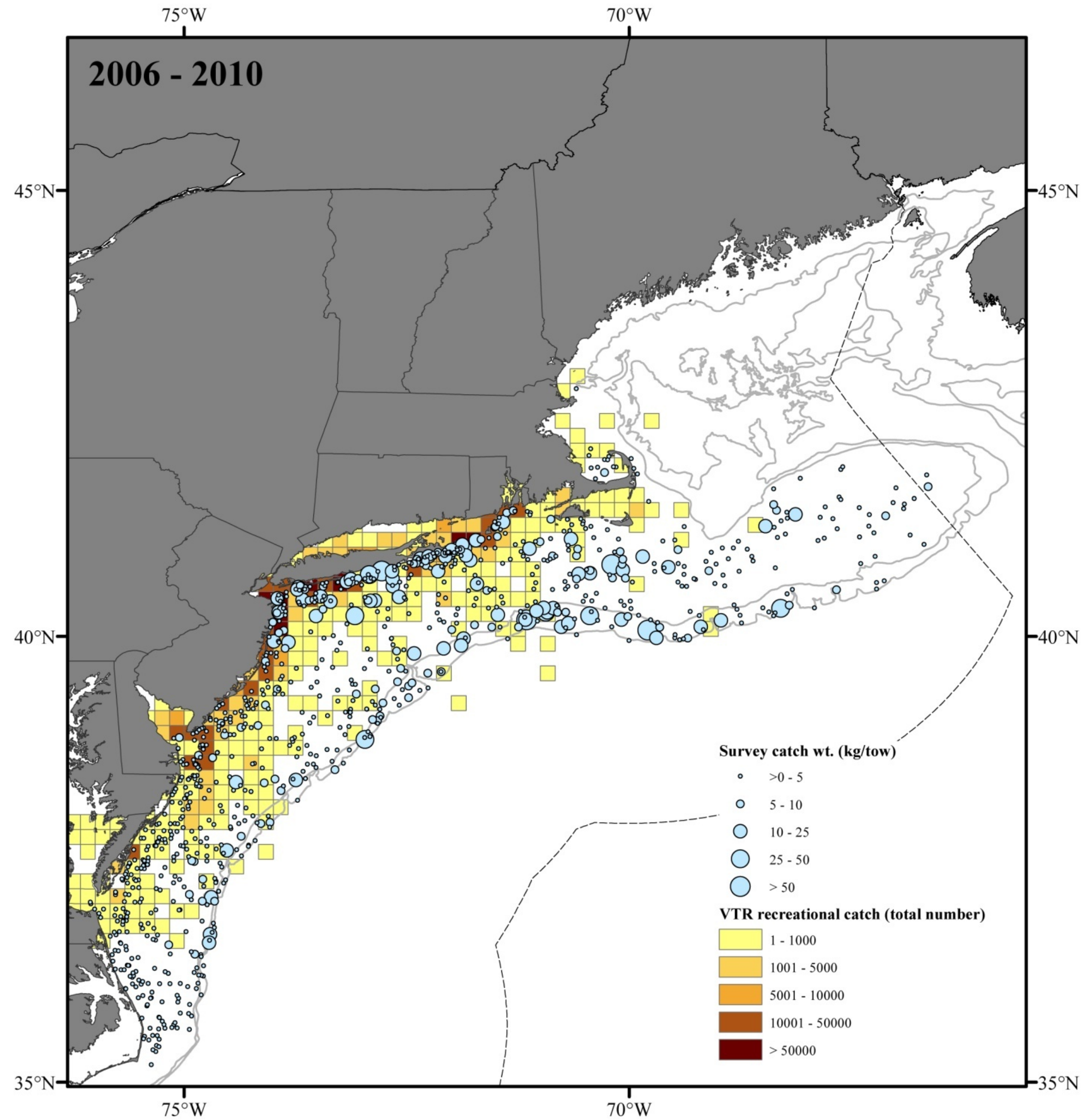


Figure A80. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and recreational (party and charter boat) VTR-reported catch (total number) binned to ten minute squares from 2006-2010.

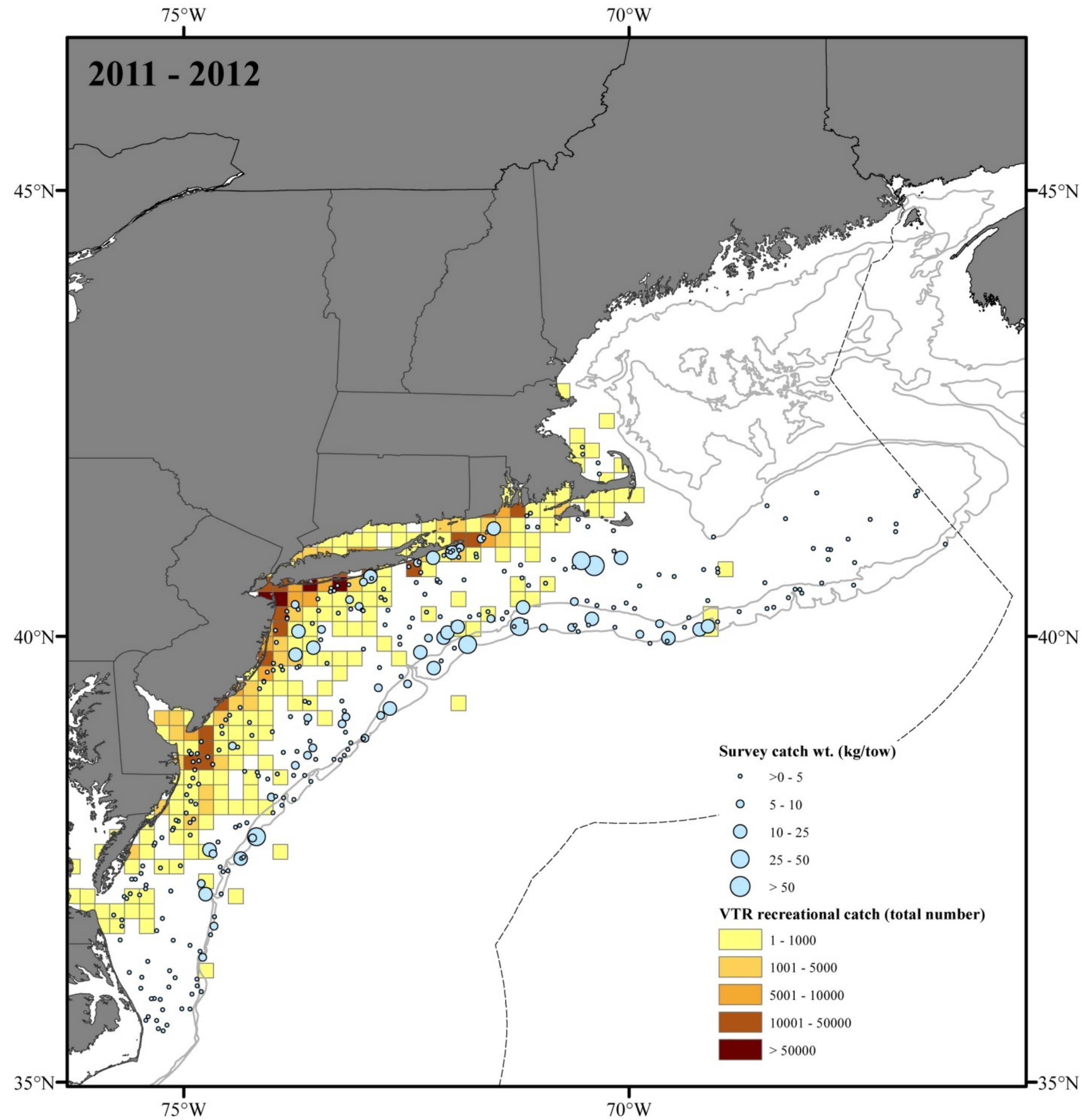


Figure A81. Spatial overlap of NEFSC trawl survey (spring and fall combined) catches (kg/tow) and recreational (party and charter boat) VTR-reported catch (total number) binned to ten minute squares from 2011-2012.

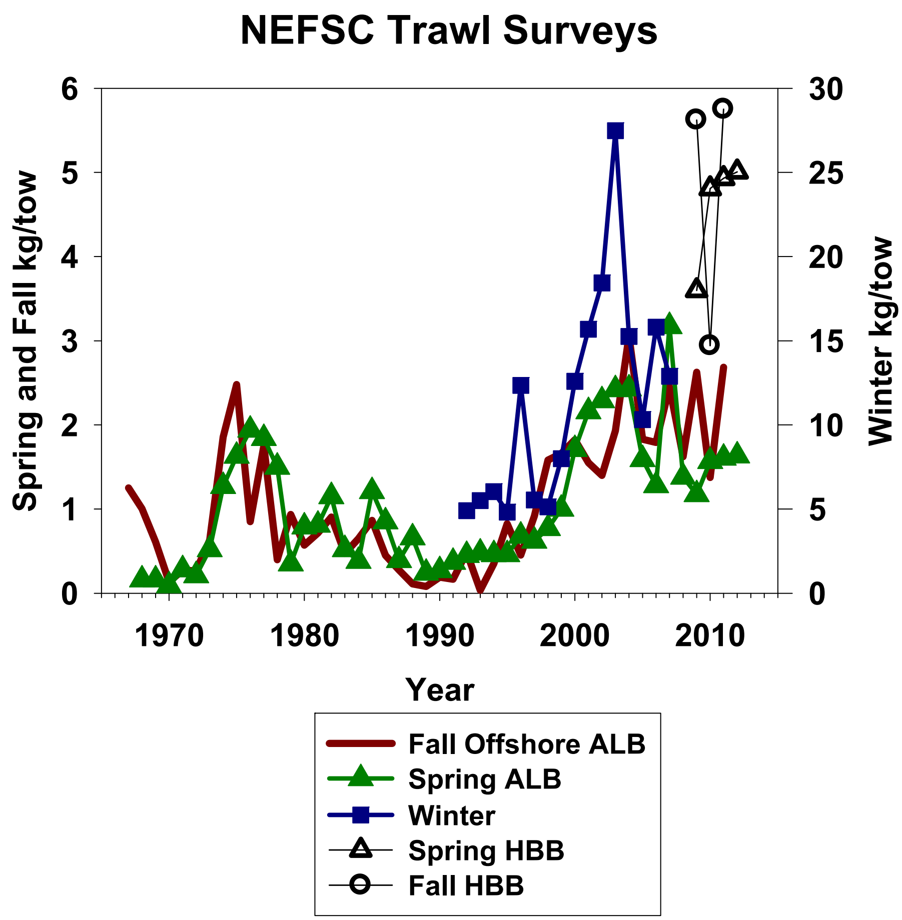


Figure A82. Trends in NEFSC trawl survey biomass indices for summer flounder.

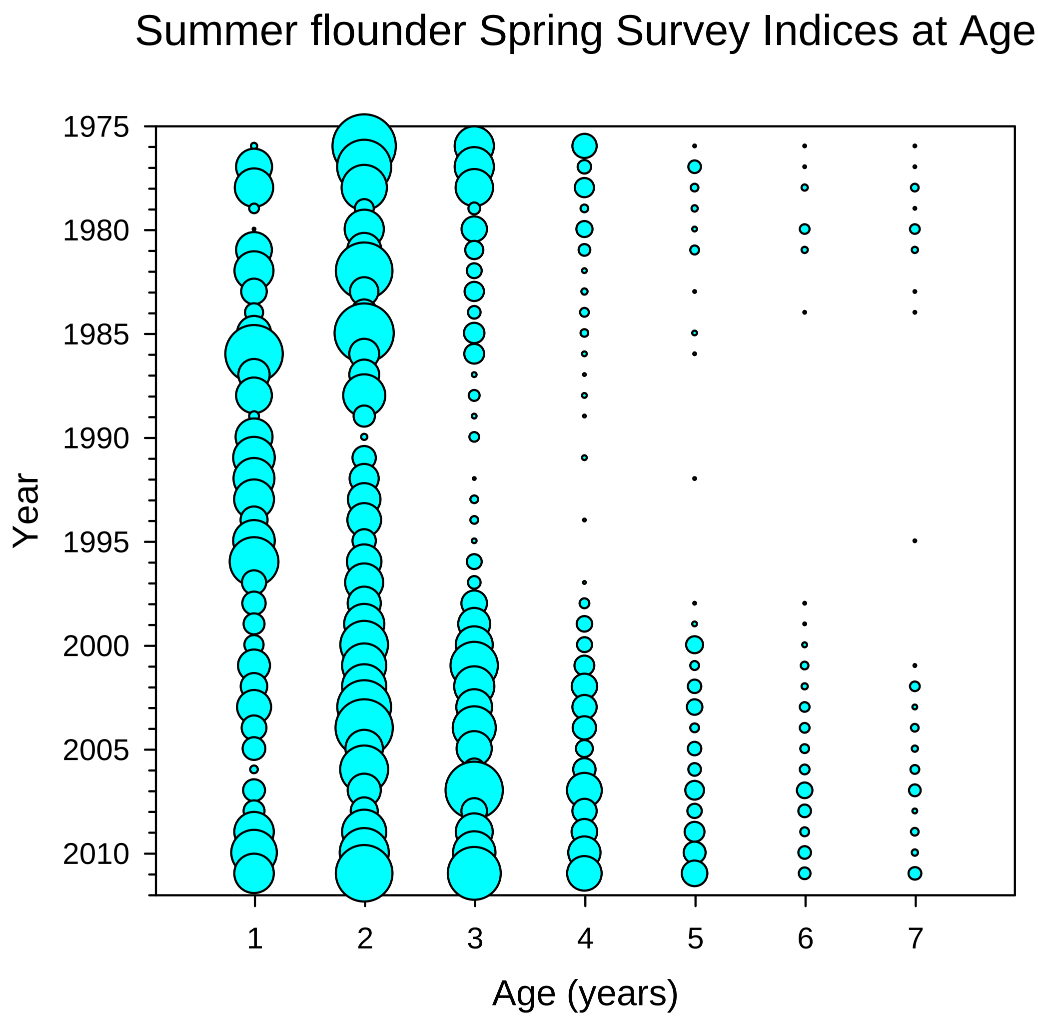


Figure A83. NEFSC spring trawl survey catch at age.

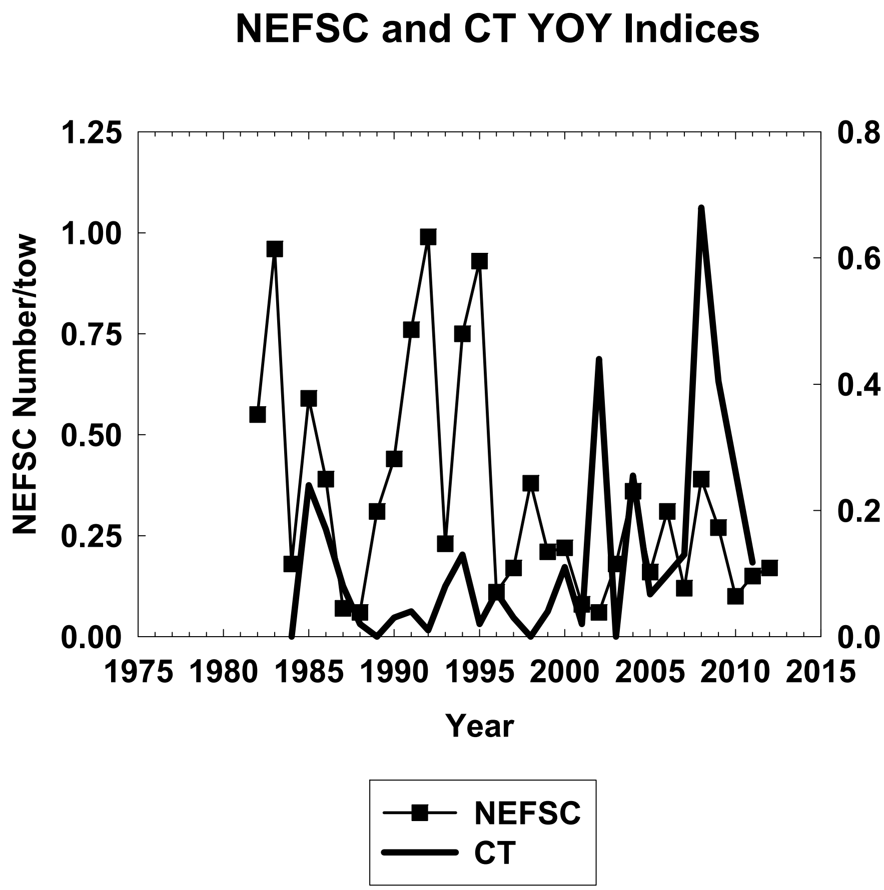


Figure A84. Trends in NEFSC and CT trawl survey recruitment indices for summer flounder.

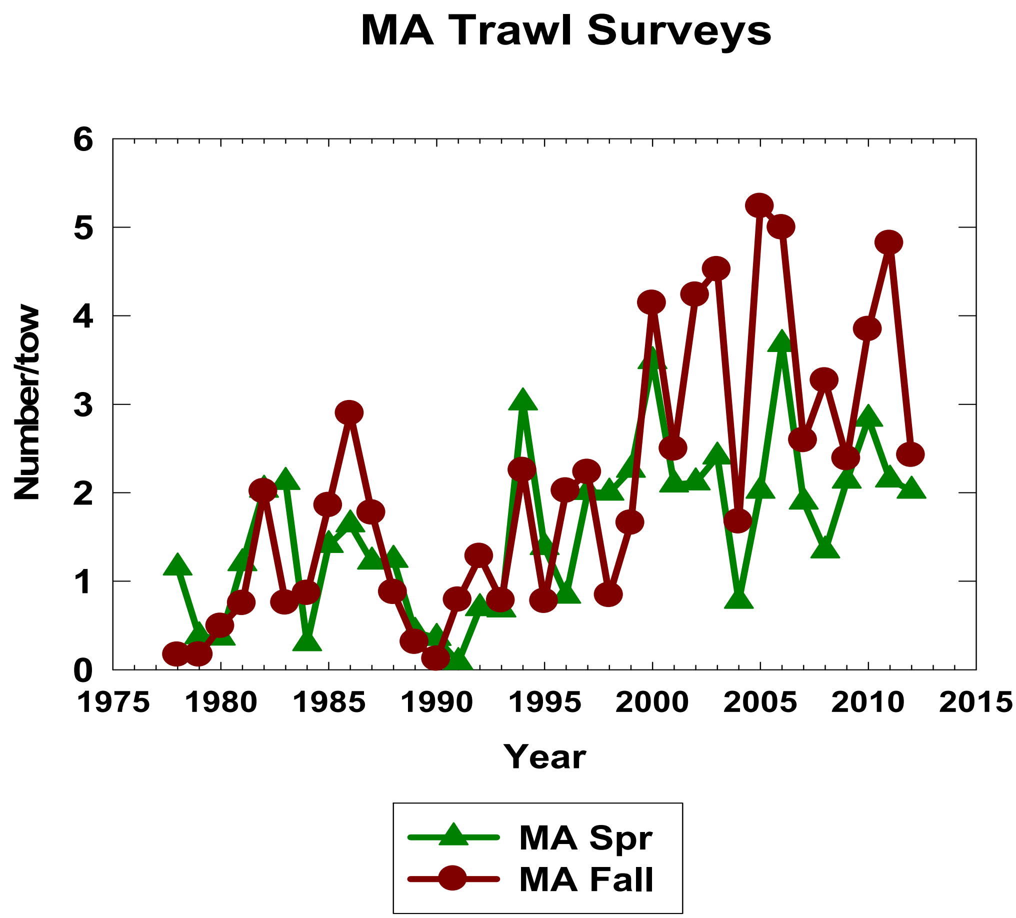


Figure A85. Trends in MA trawl survey abundance indices for summer flounder.

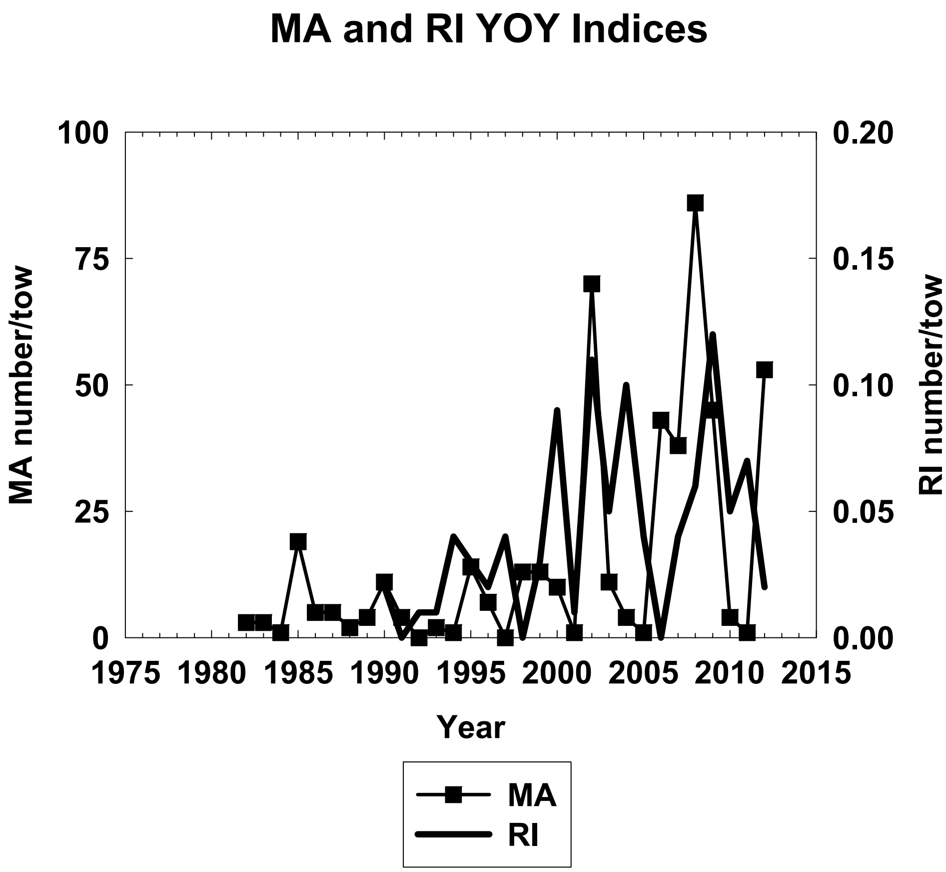


Figure A86. Trends in MA and RI trawl survey recruitment indices for summer flounder.

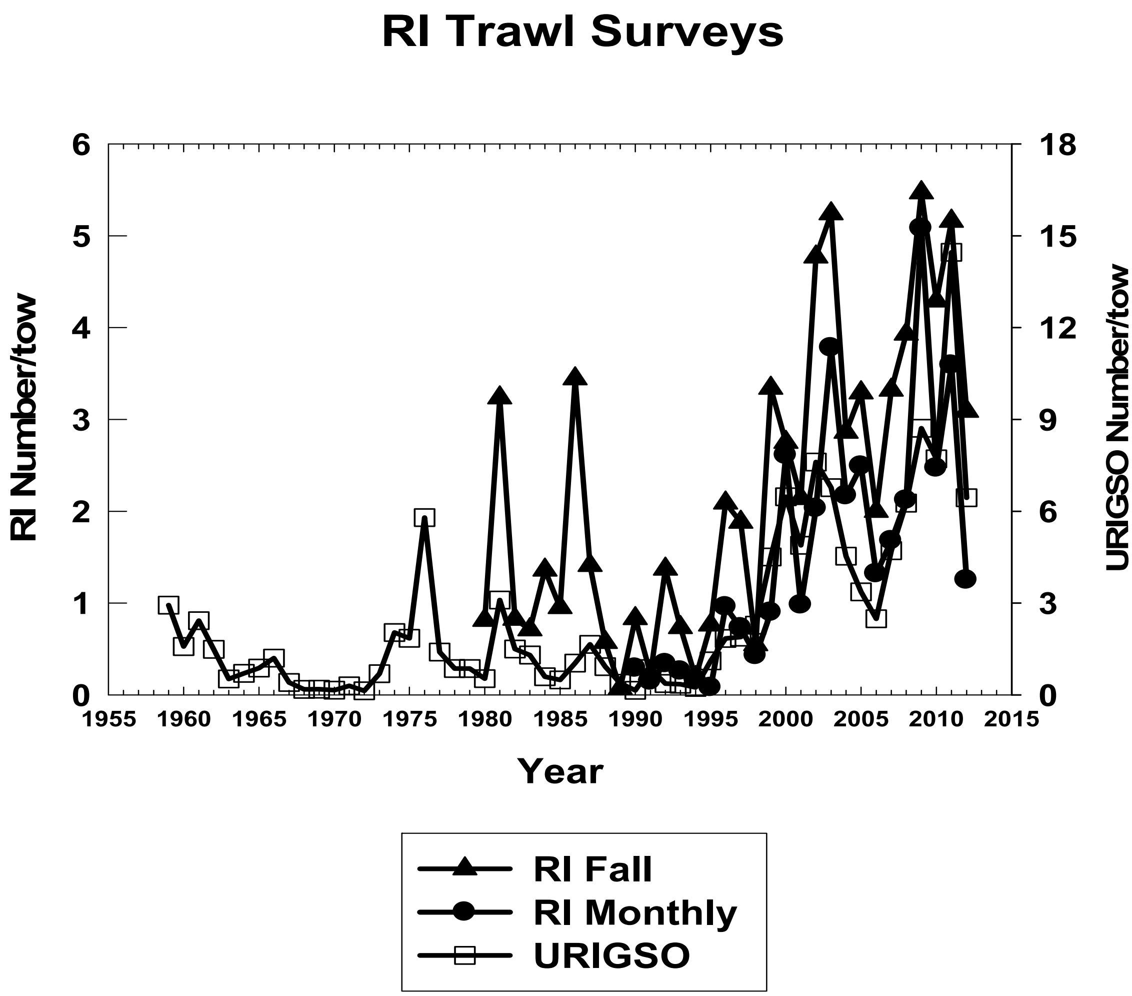


Figure A87. Trends in RI trawl survey abundance indices for summer flounder.

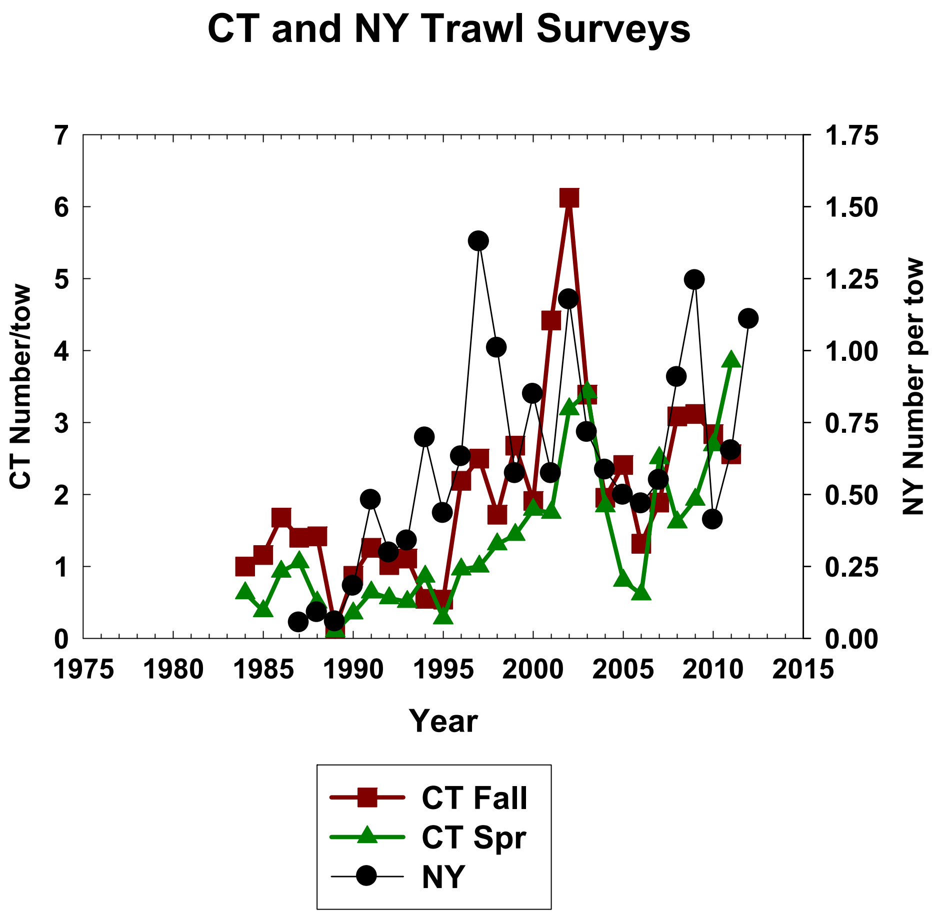


Figure A88. Trends in CT and NY trawl survey abundance indices for summer flounder.

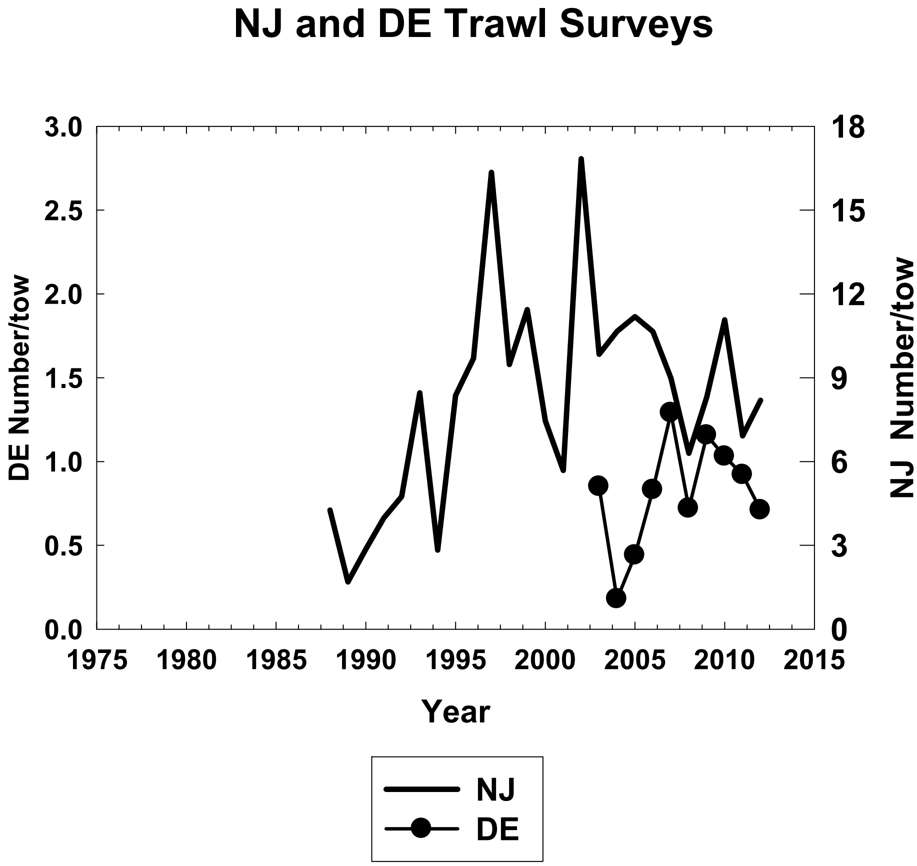


Figure A89. Trends in NJ and DE trawl survey abundance indices for summer flounder.

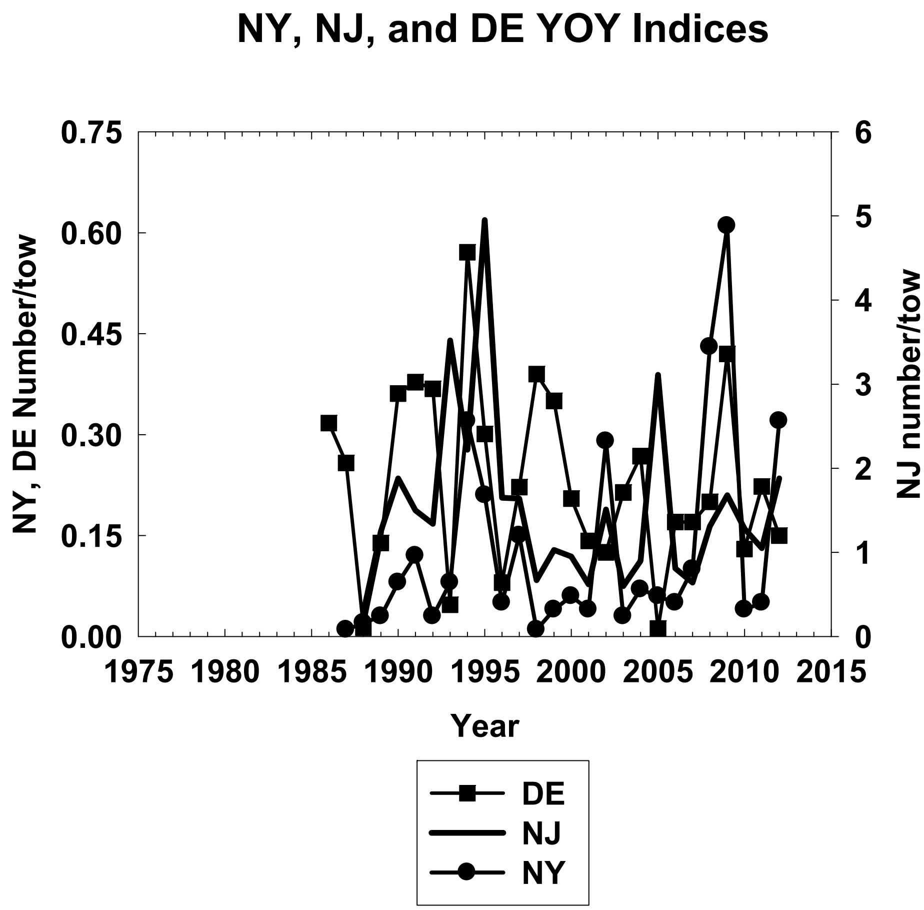


Figure A90. Trends in NY, DE, and NJ trawl survey recruitment indices for summer flounder.

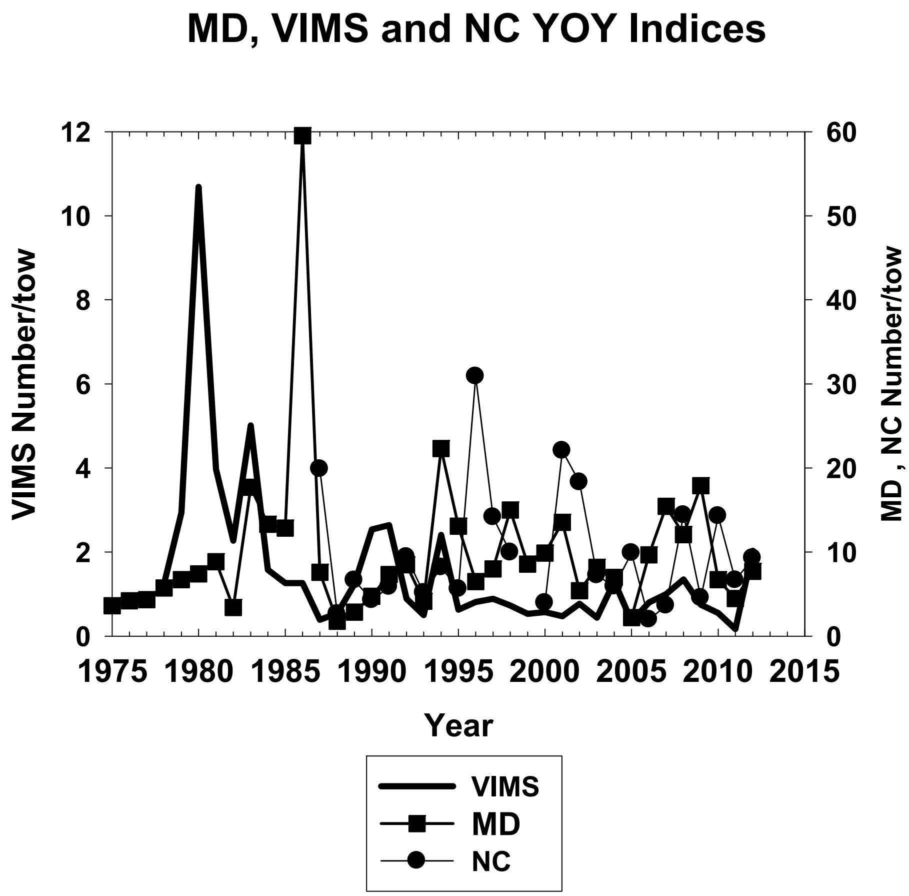


Figure A91. Trends in MD, VIMS and NC trawl survey recruitment indices for summer flounder.

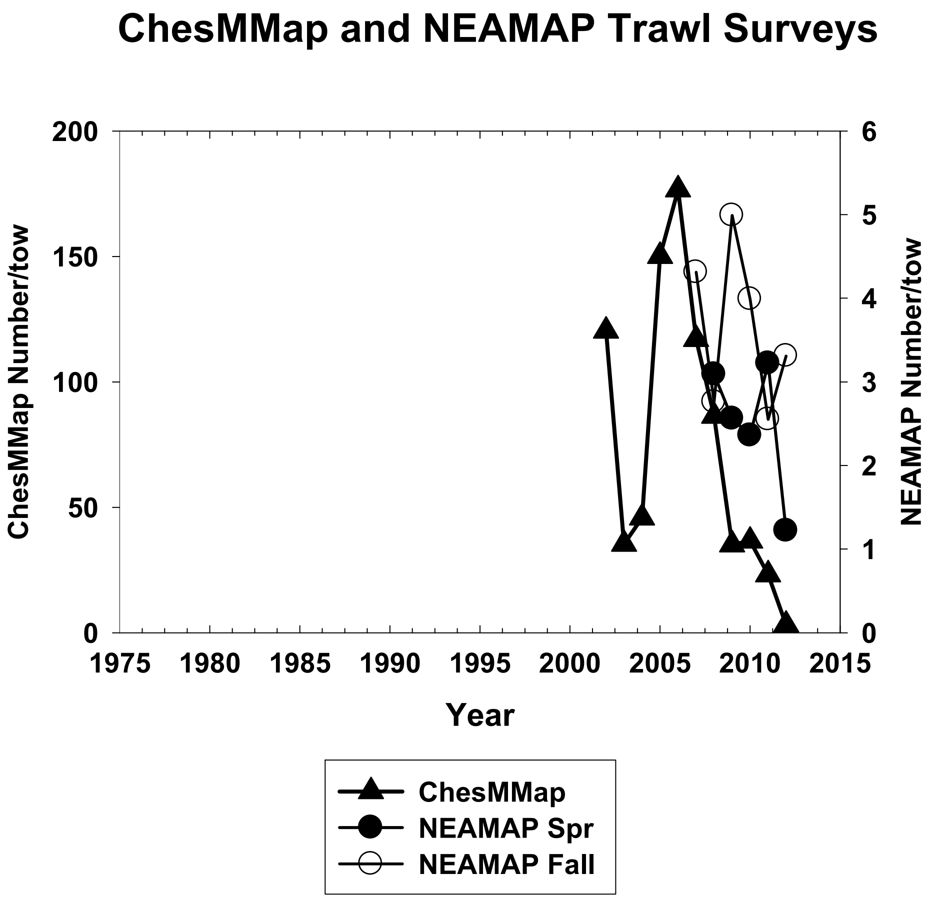


Figure A92. Trends in NEAMAP and ChesMMAP trawl survey abundance indices for summer flounder.

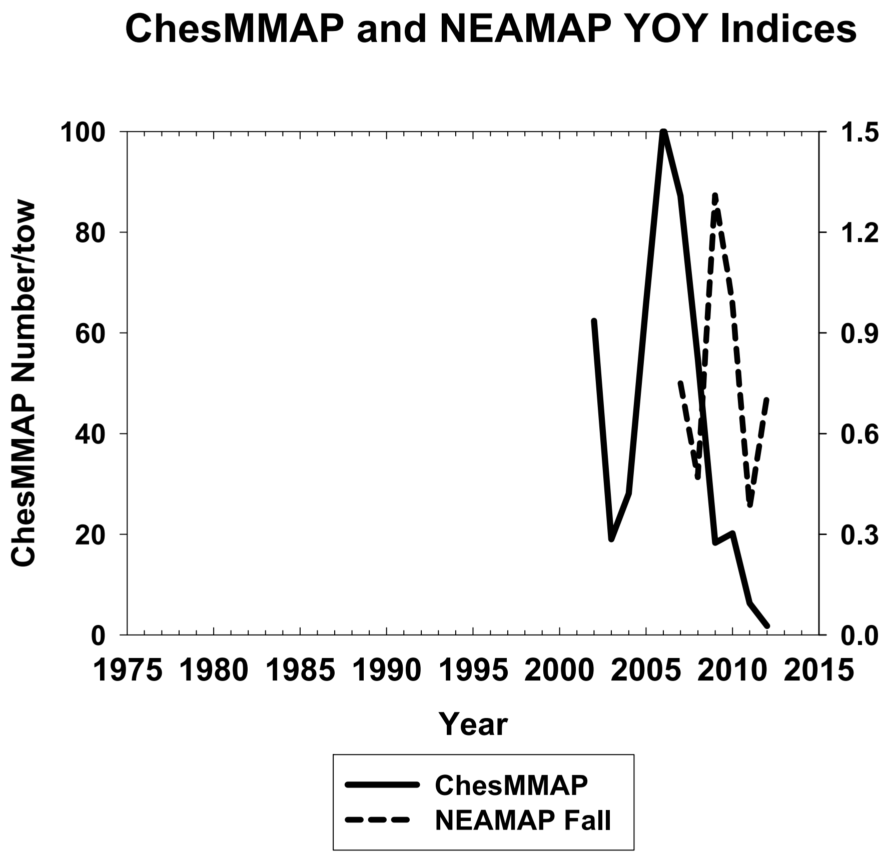


Figure A93. Trends in VIMS ChesMMAP and NEAMAP fall trawl survey recruitment indices for summer flounder.

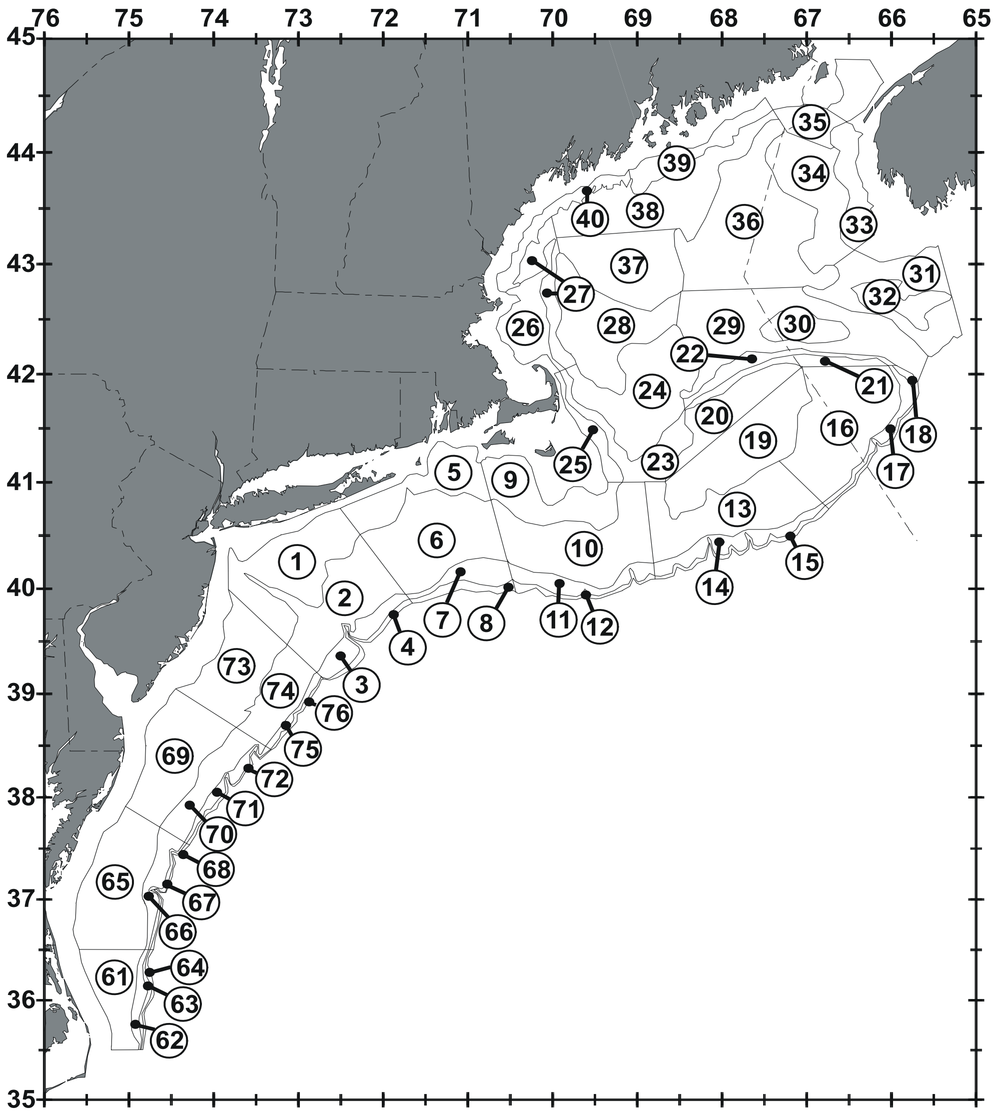


Figure A94. Offshore depth strata (27 meters [15 fathoms] to > 200 meters [109 fathoms]) sampled during Northeast Fisheries Science Center bottom trawl research surveys.

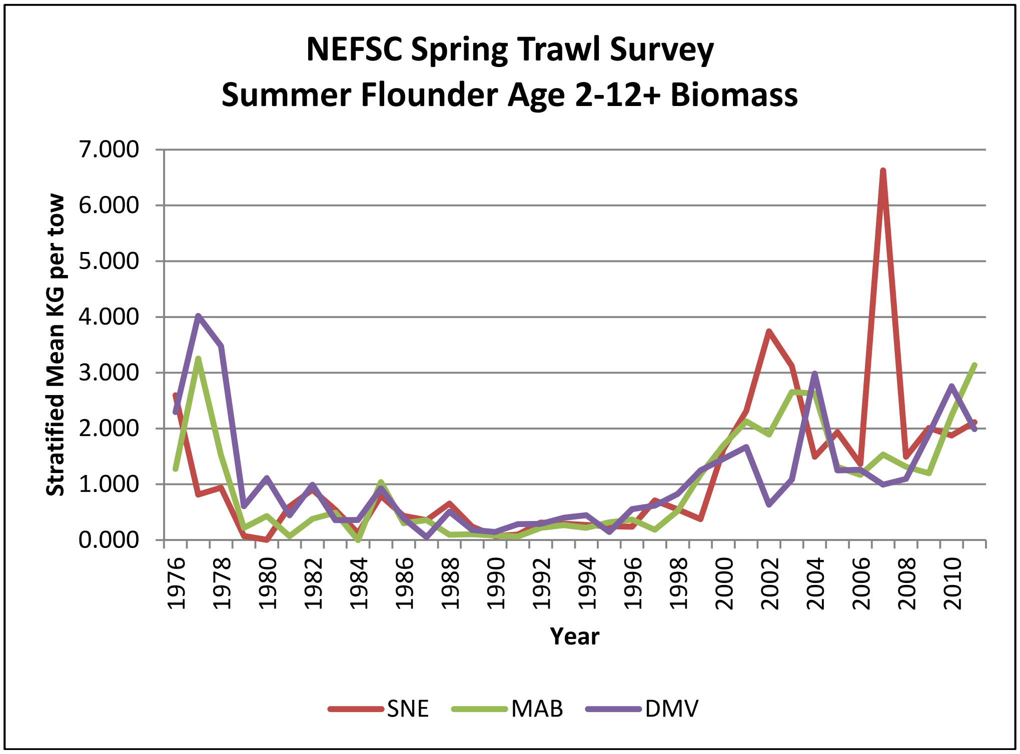


Figure A95. Annual NEFSC spring trawl survey indices of SSB of summer flounder in three distinct regions (Southern New England [SNE], Mid-Atlantic Bight [MAB], and DelMarVa [DMV]) of the northwest Atlantic.

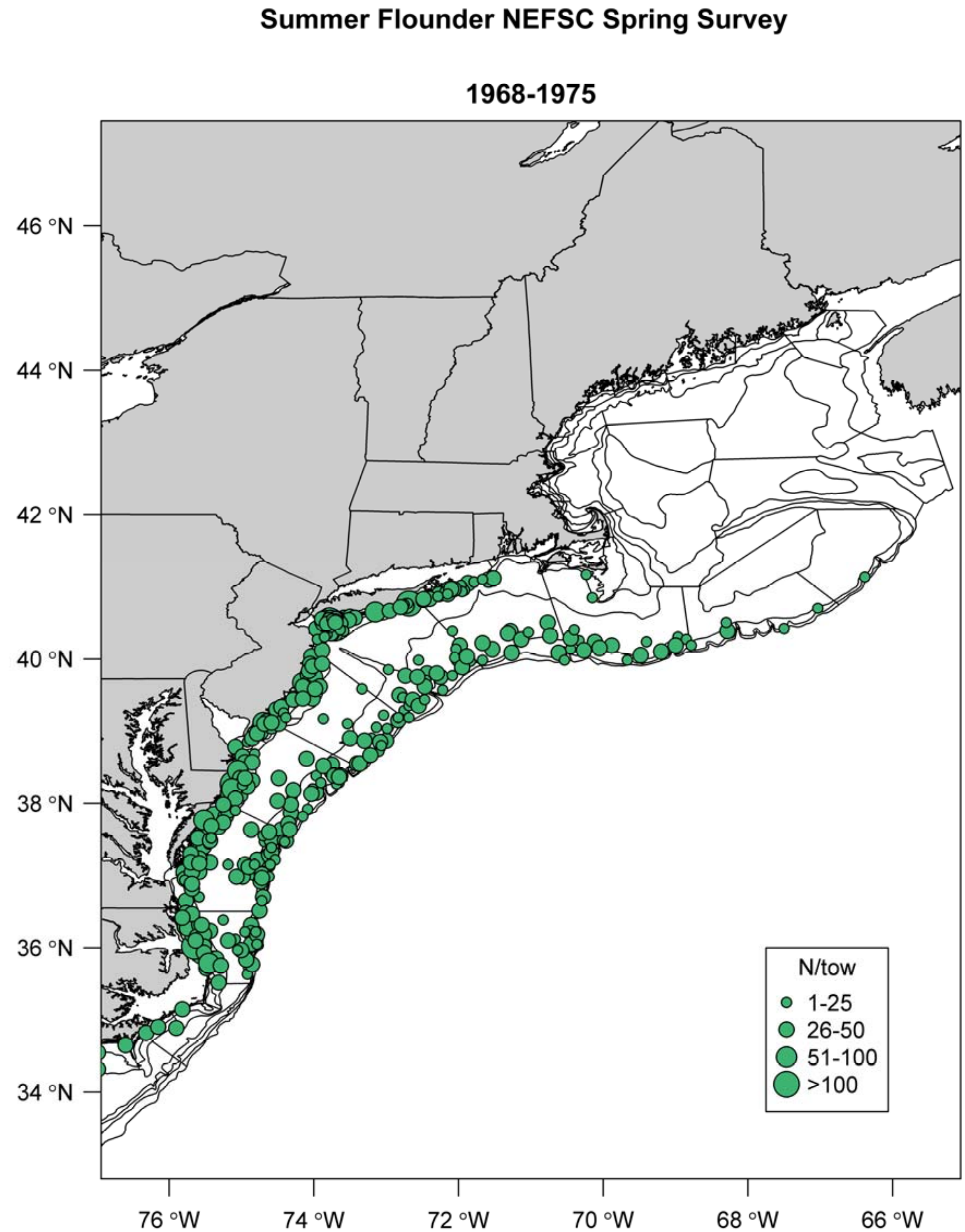


Figure A96. NEFSC spring survey catch numbers per tow, 1968-1975.

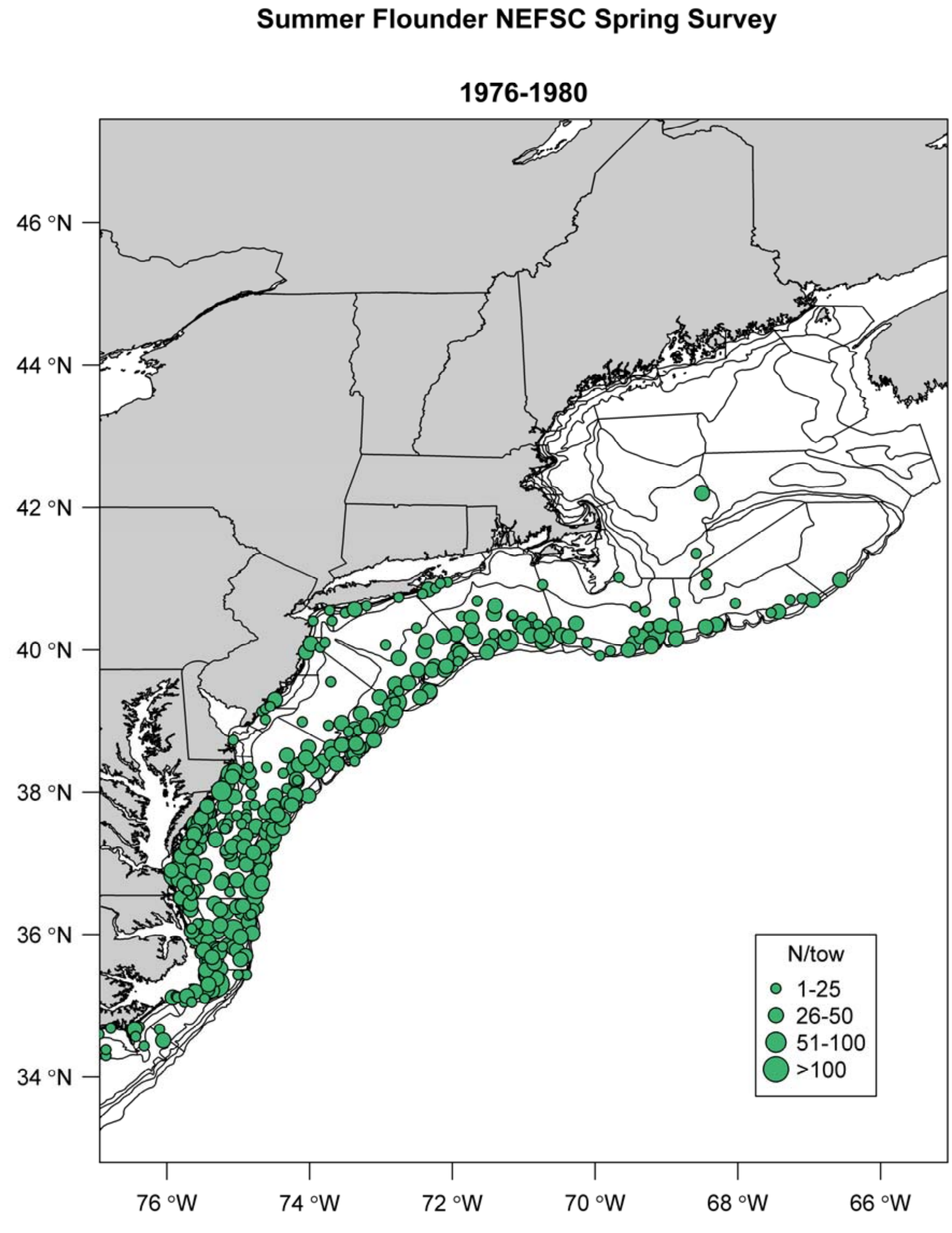


Figure A97. NEFSC spring survey catch numbers per tow, 1976-1980.

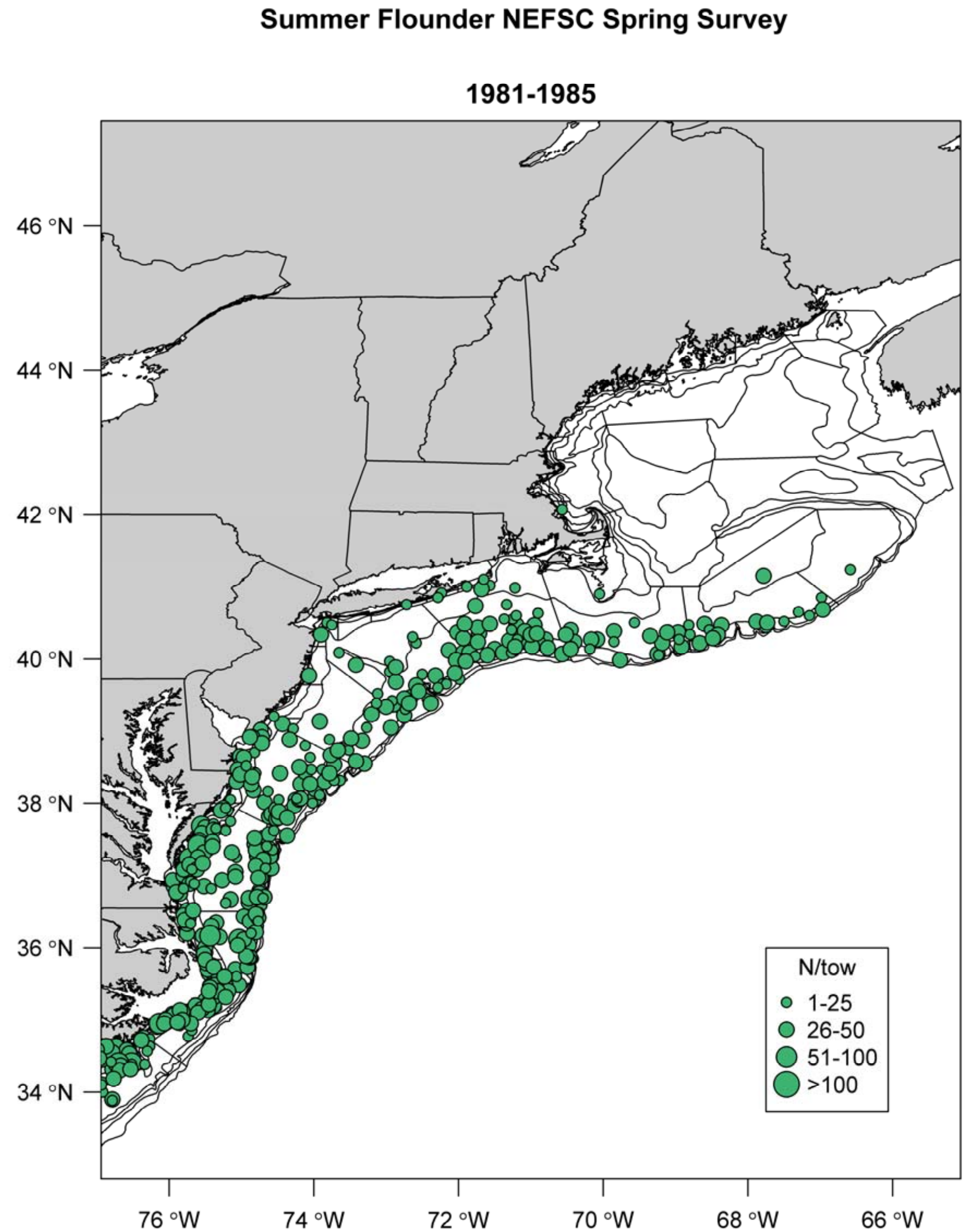


Figure A98. NEFSC spring survey catch numbers per tow, 1981-1985.

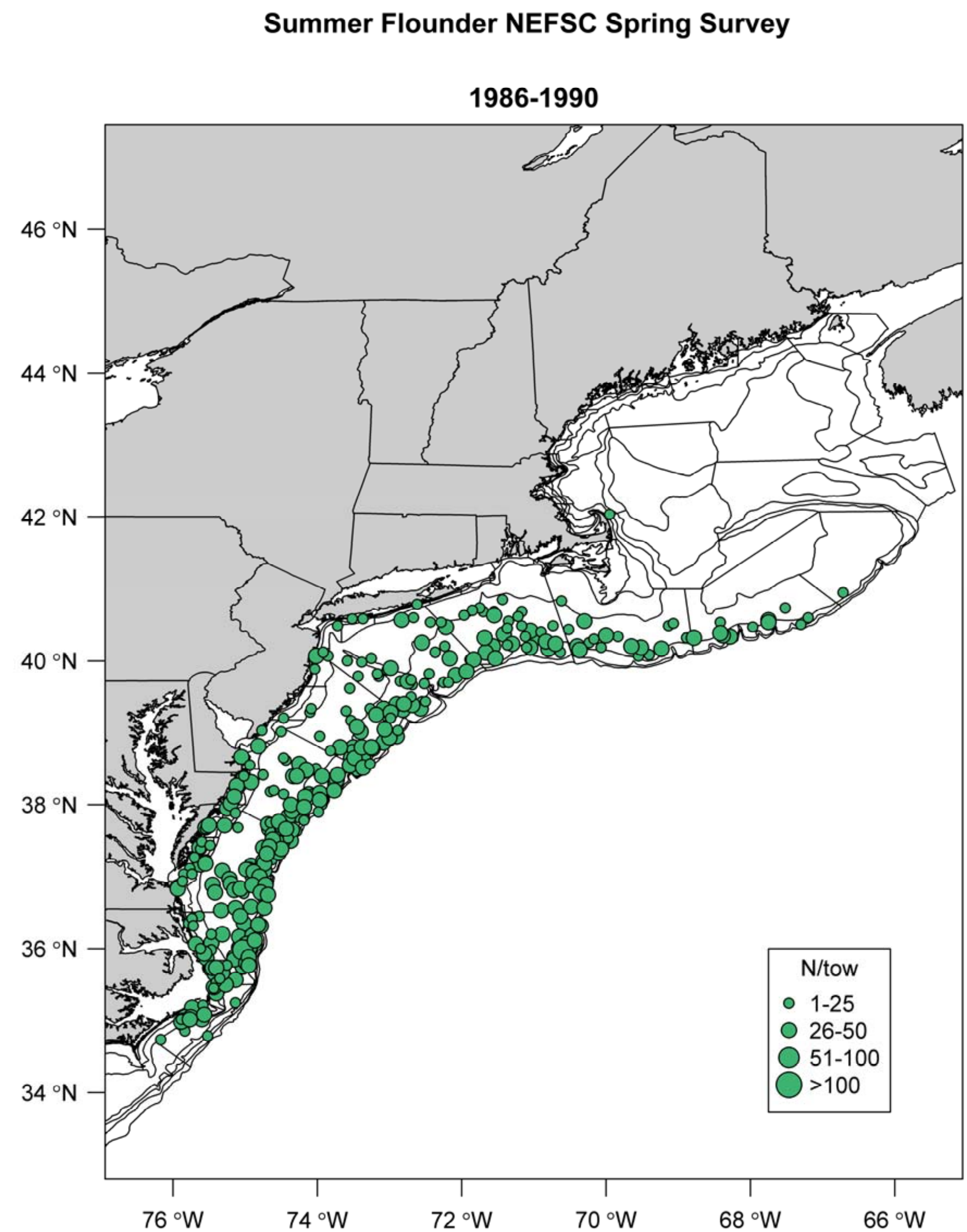


Figure A99. NEFSC spring survey catch numbers per tow, 1986-1990.

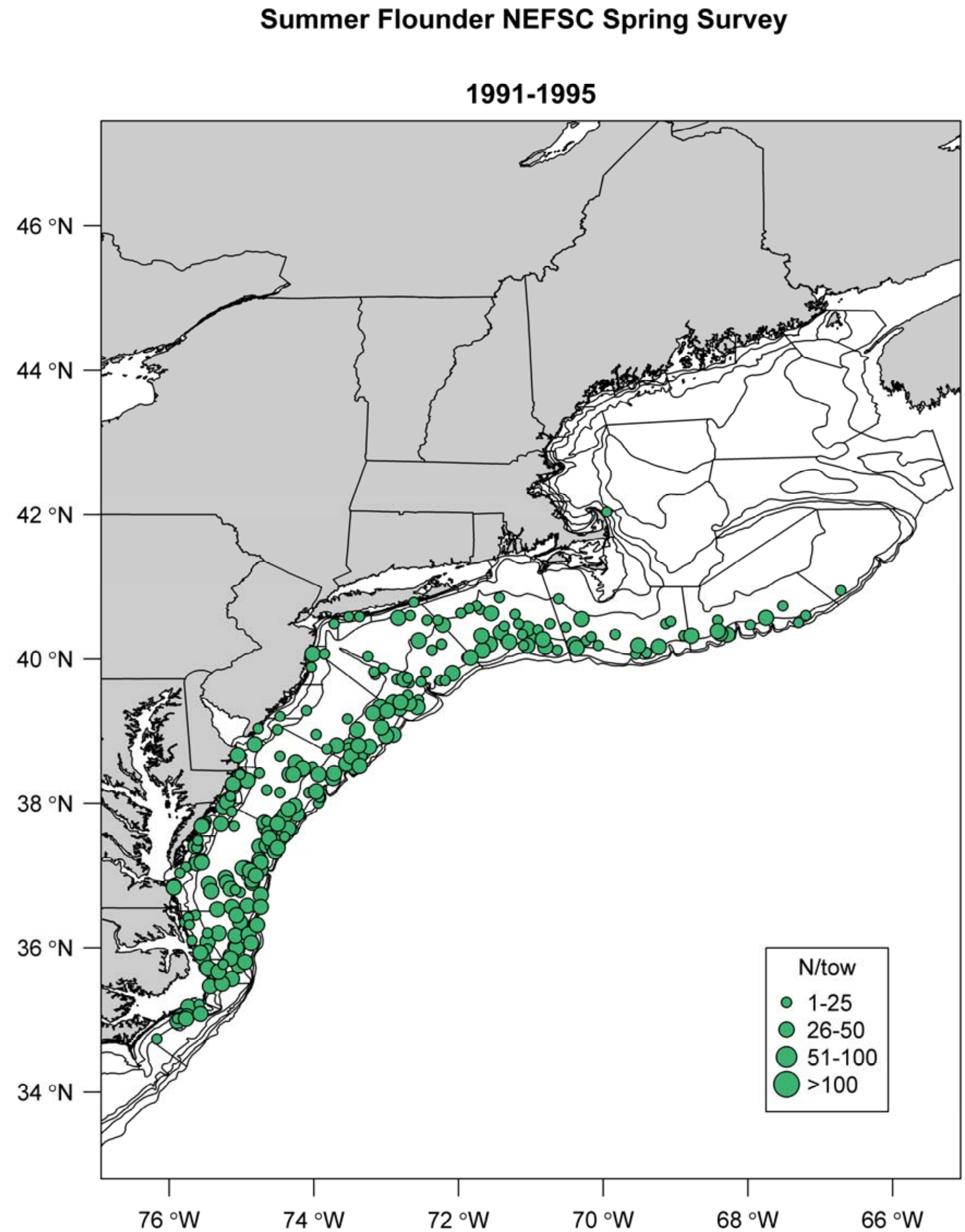


Figure A100. NEFSC spring survey catch numbers per tow, 1991-1995.

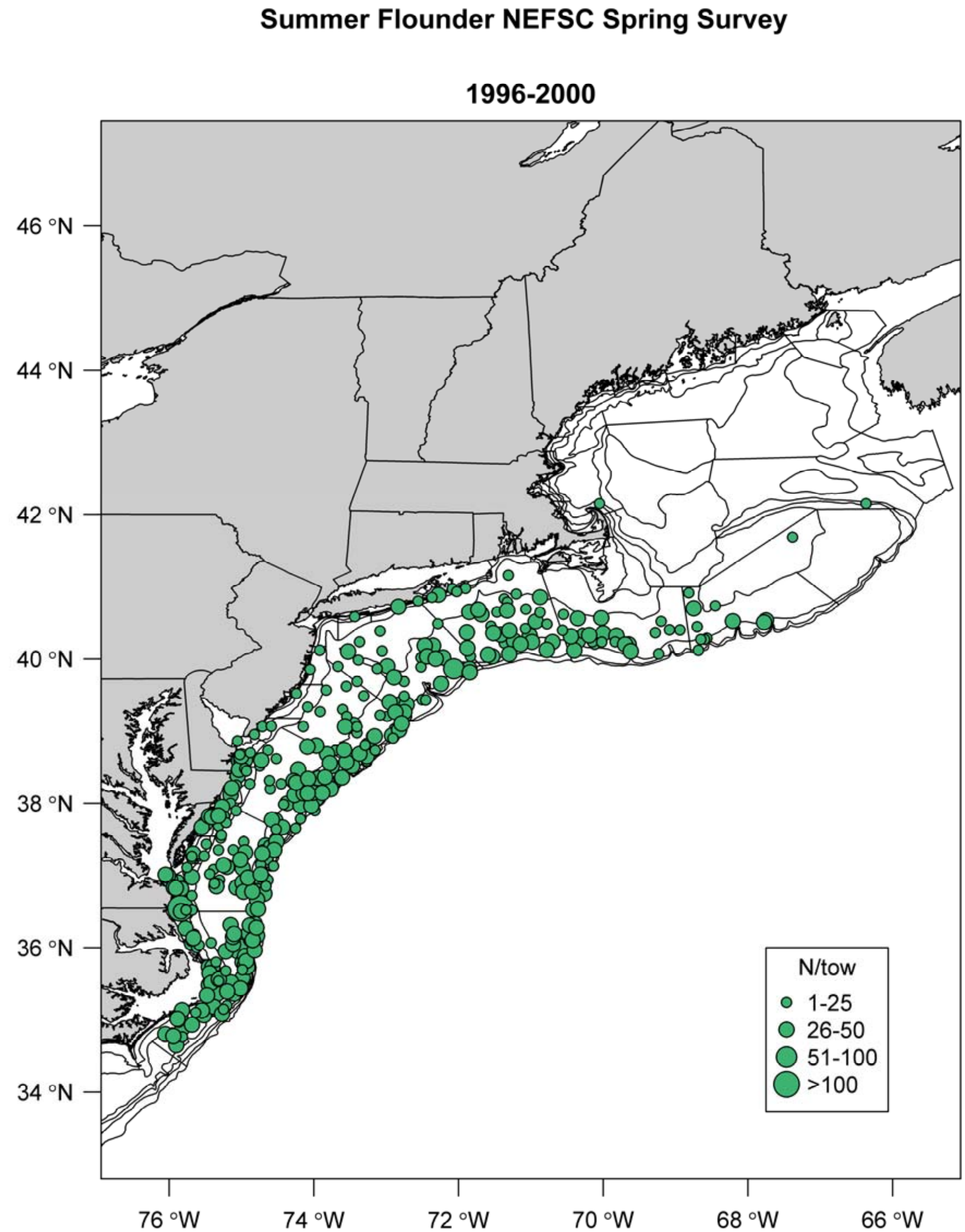


Figure A101. NEFSC spring survey catch numbers per tow, 1996-2000.

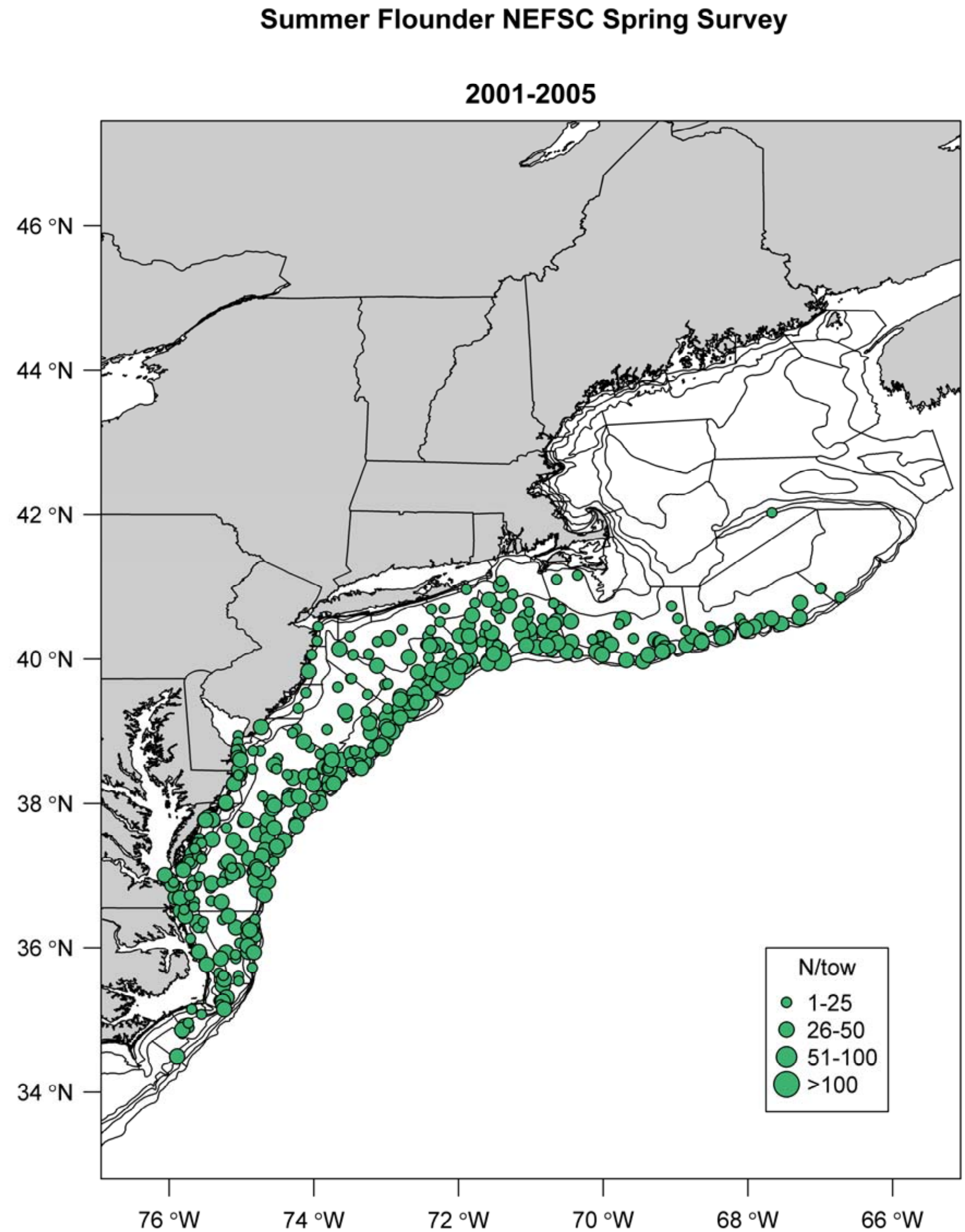


Figure A102. NEFSC spring survey catch numbers per tow, 2001-2005.

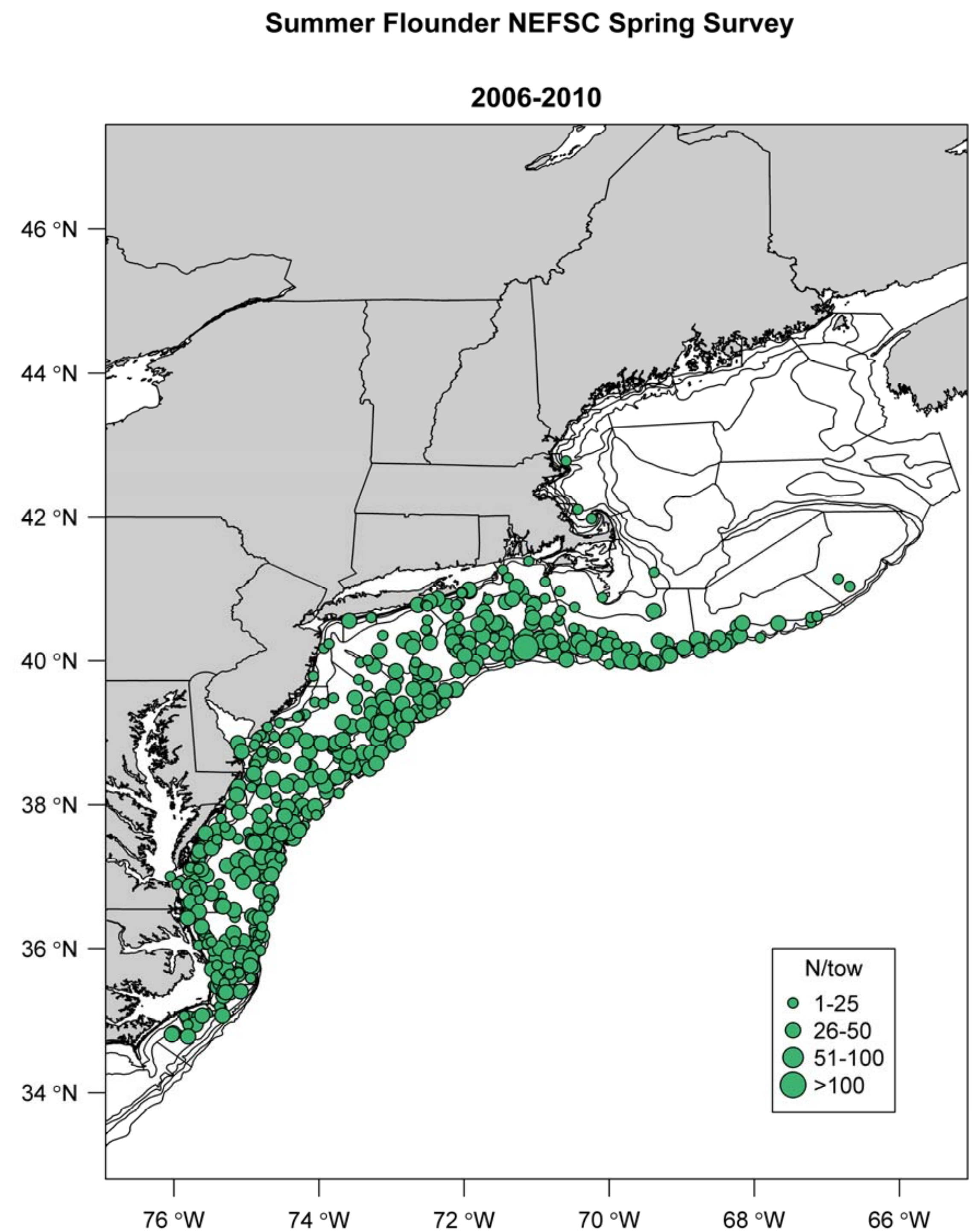


Figure A103. NEFSC spring survey catch numbers per tow, 2006-2010.

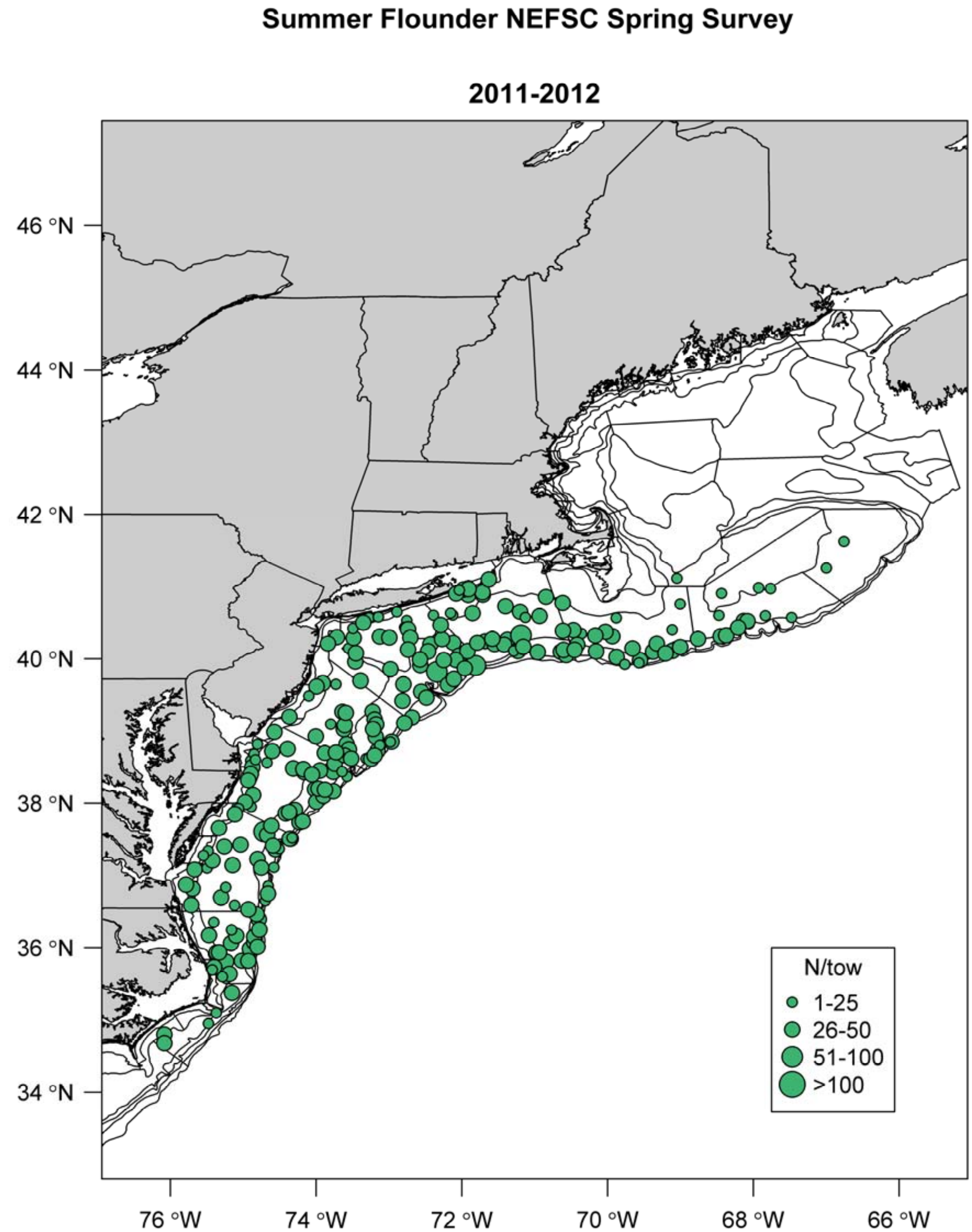


Figure A104. NEFSC spring survey catch numbers per tow, 2011-2012.

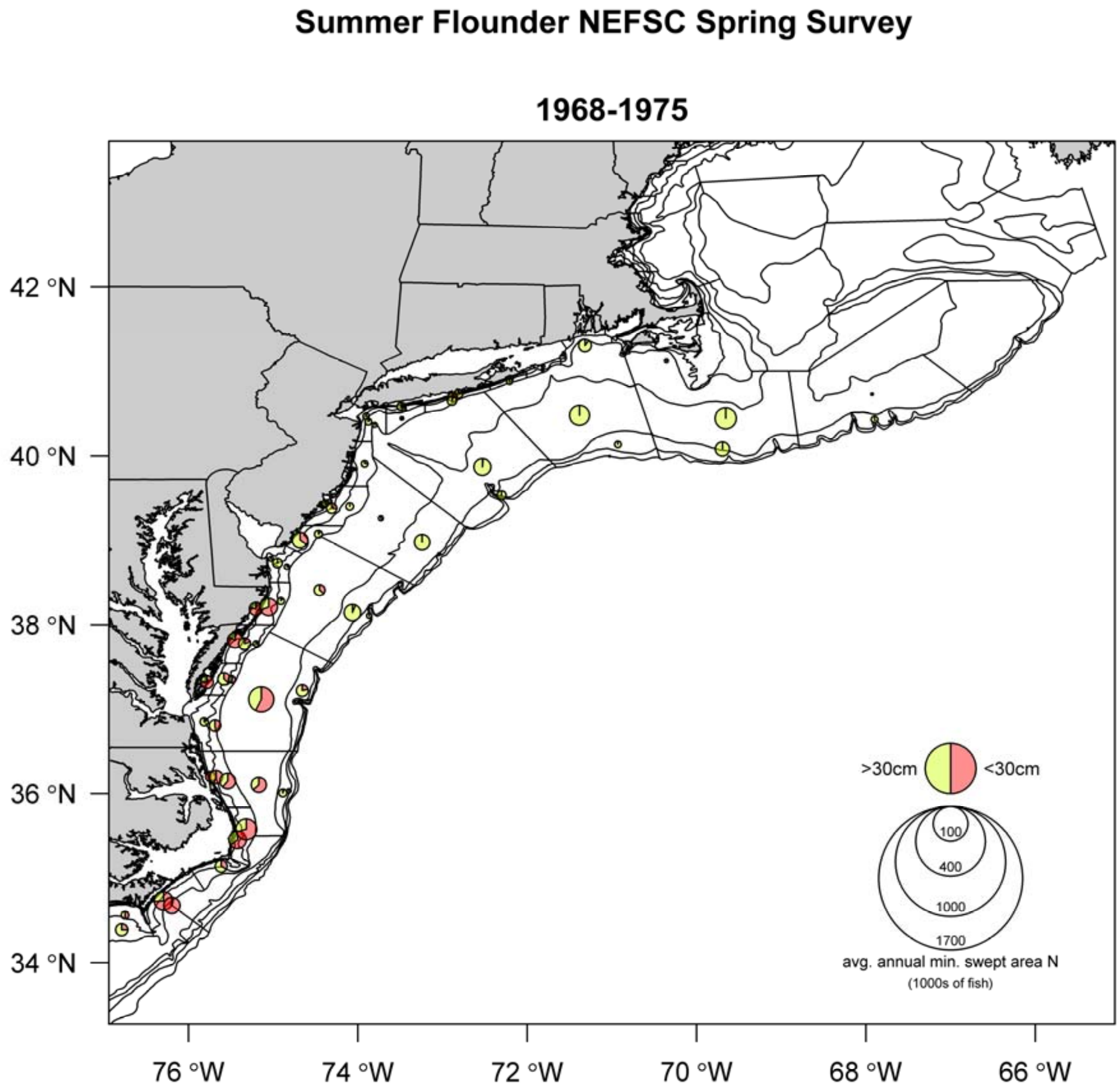


Figure A105. NEFSC spring survey average minimum swept area abundances by strata and size category, 1968-1975.

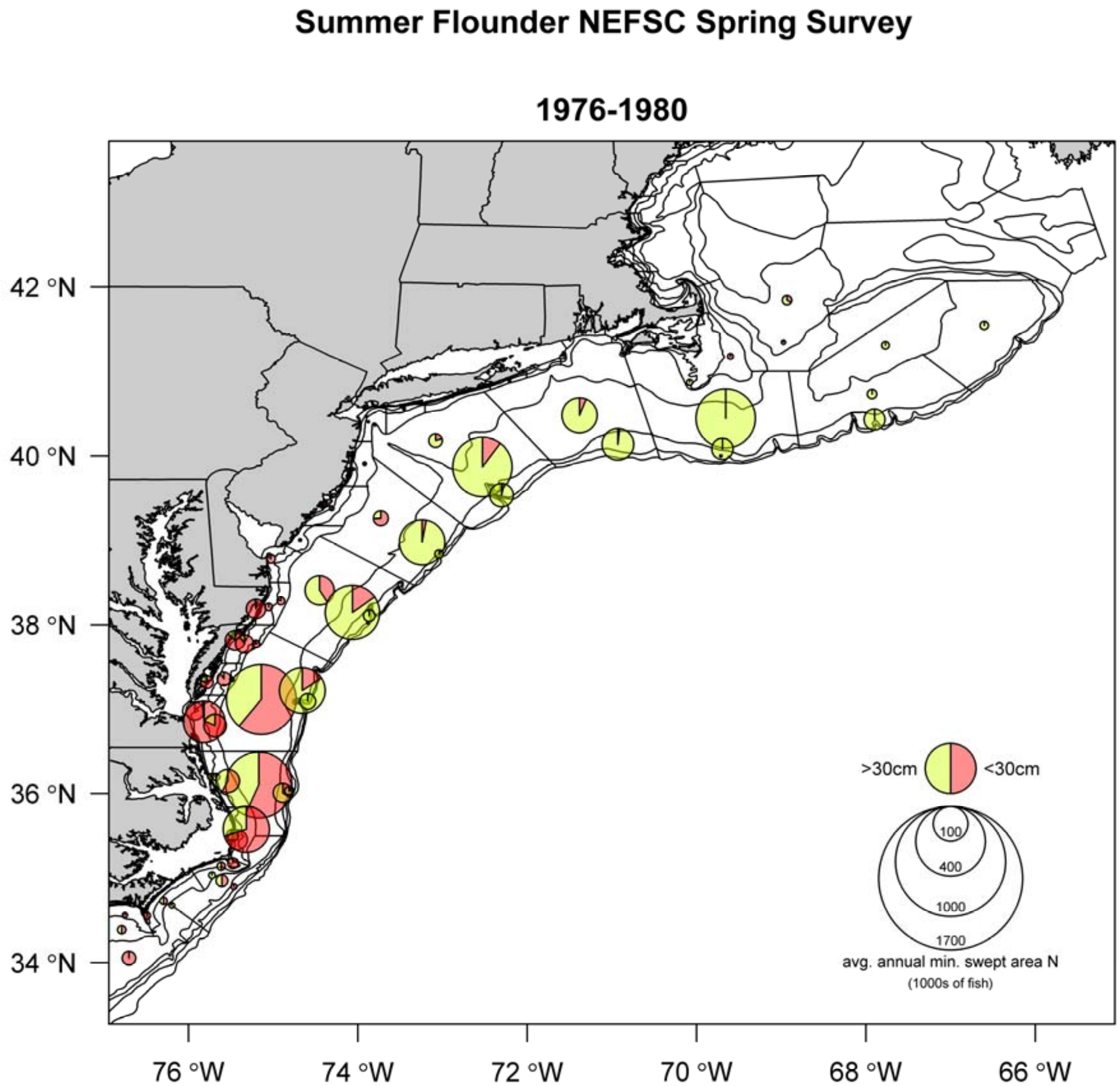


Figure A106. NEFSC spring survey average minimum swept area abundances by strata and size category, 1976-1980.

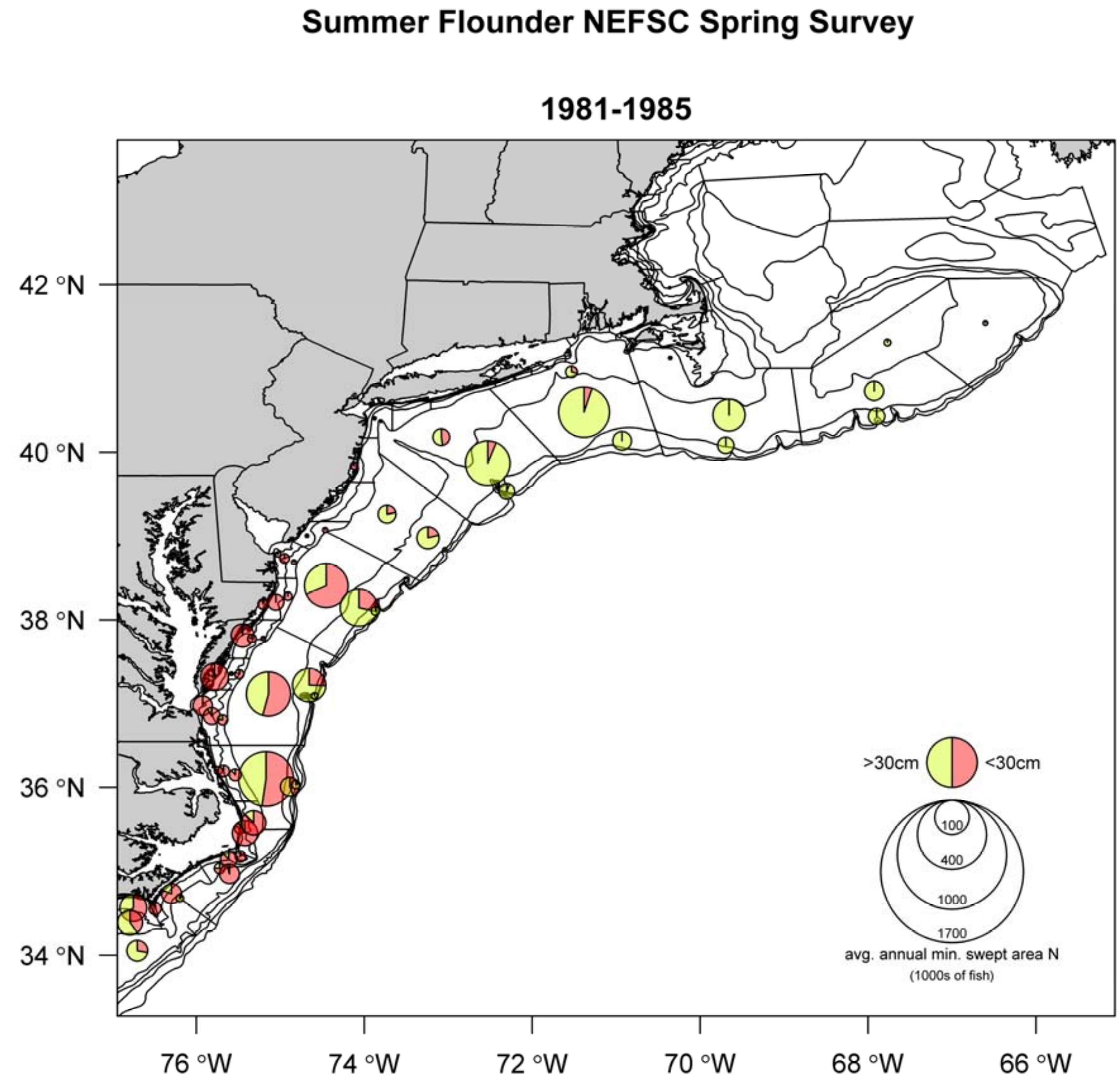


Figure A107. NEFSC spring survey average minimum swept area abundances by strata and size category, 1981-1985.

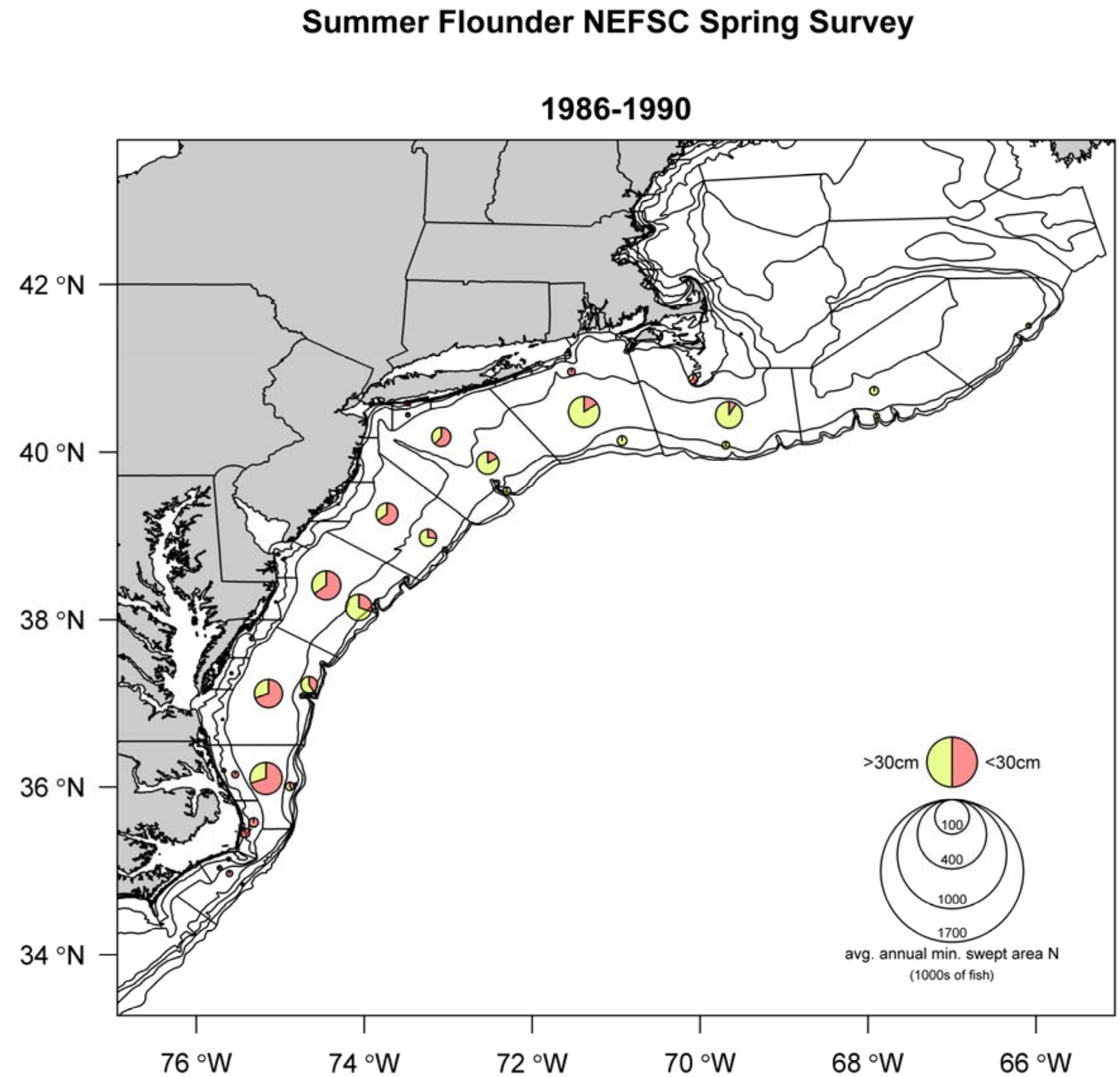


Figure A108. NEFSC spring survey average minimum swept area abundances by strata and size category, 1986-1990.

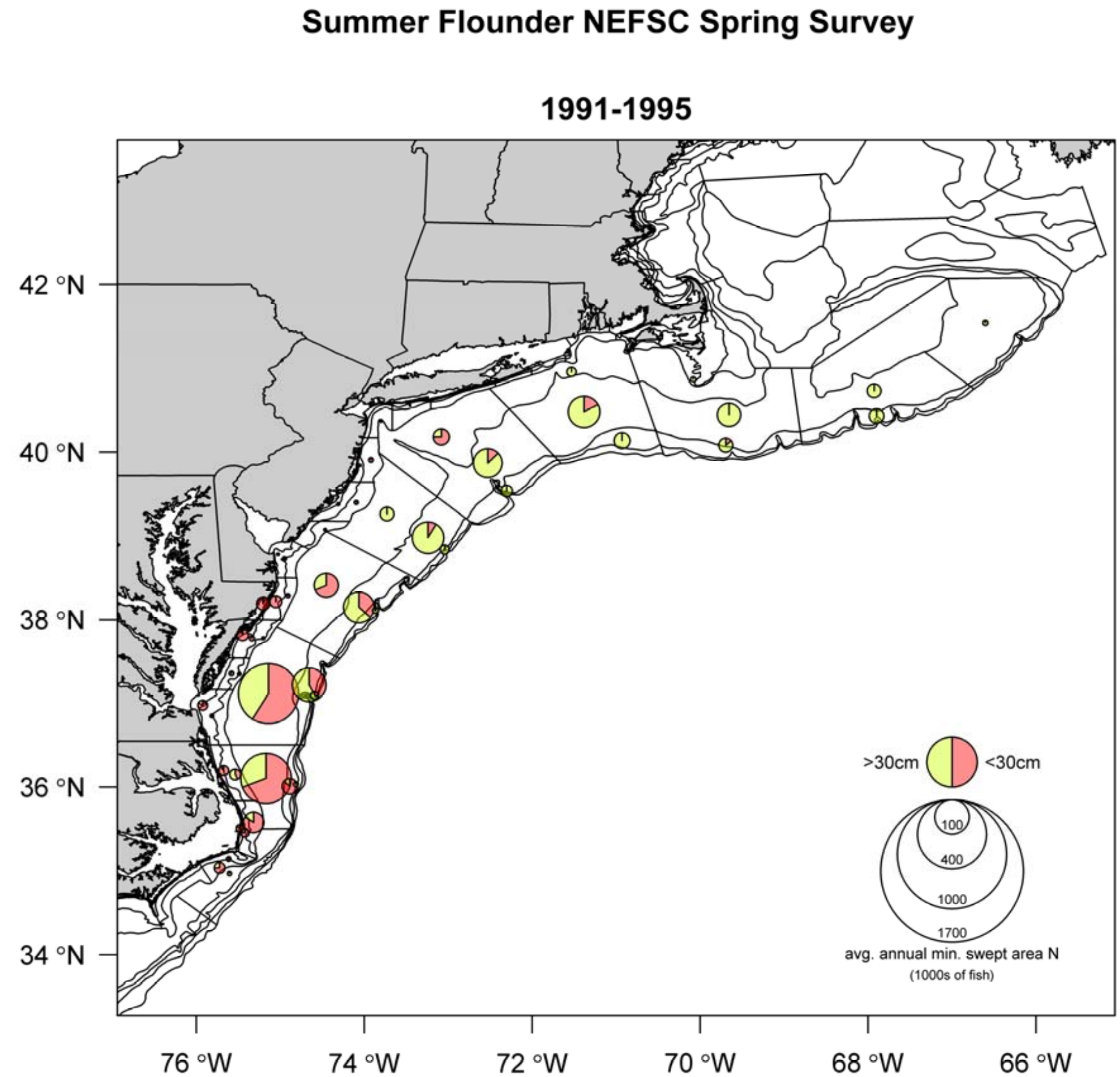


Figure A109. NEFSC spring survey average minimum swept area abundances by strata and size category, 1991-1995.

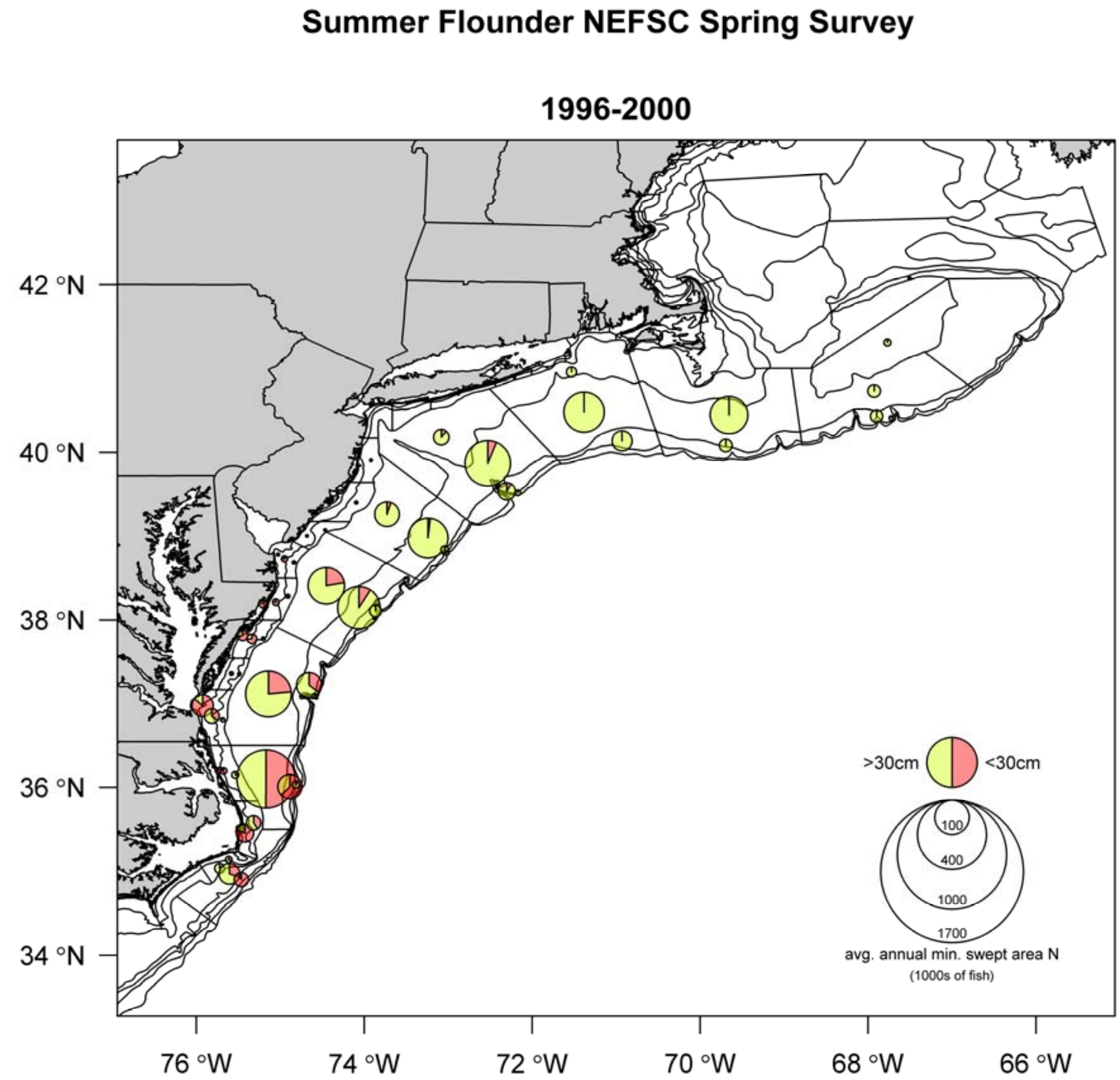


Figure A110. NEFSC spring survey average minimum swept area abundances by strata and size category, 1996-2000.

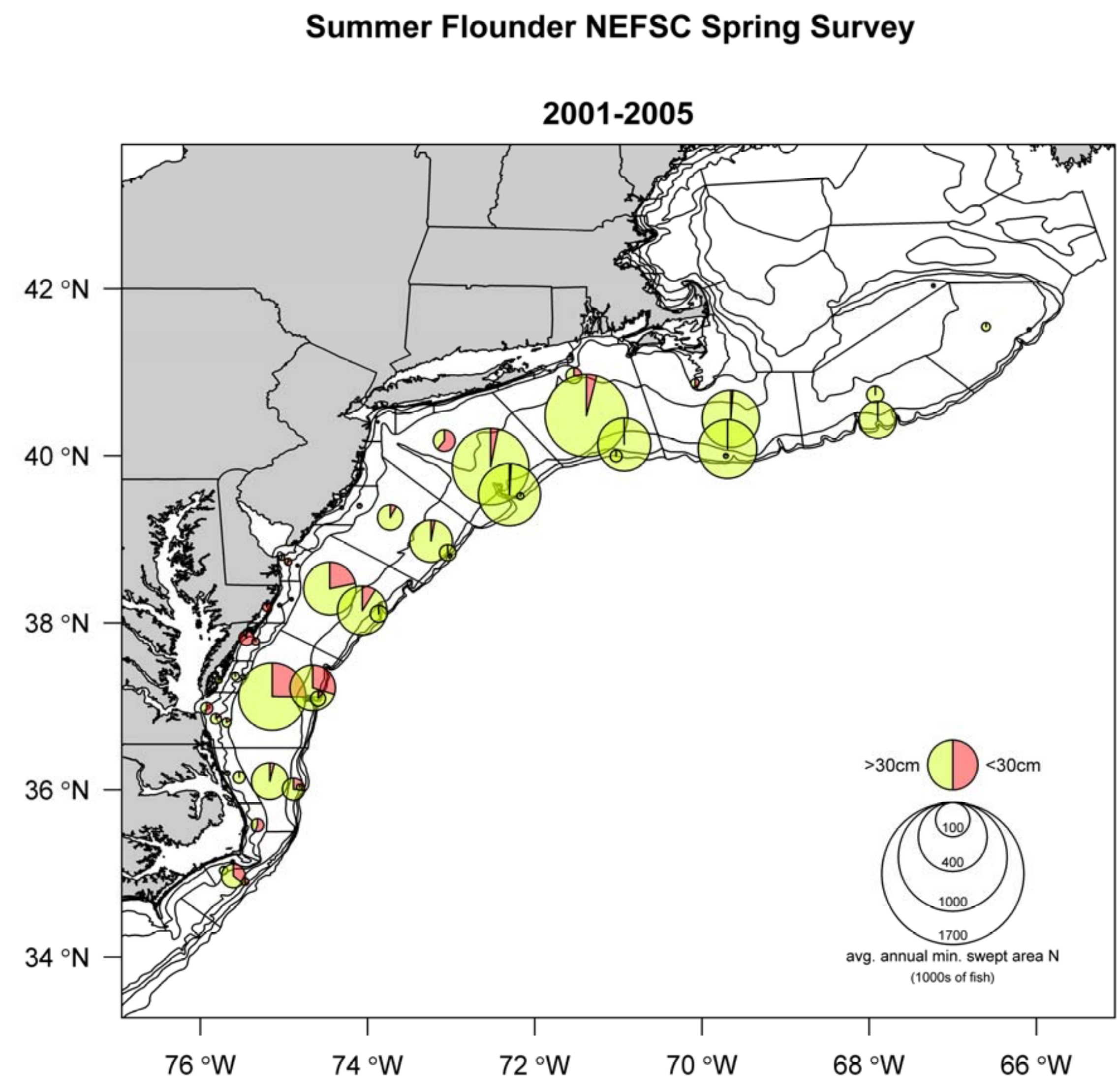


Figure A111. NEFSC spring survey average minimum swept area abundances by strata and size category, 2001-2005.

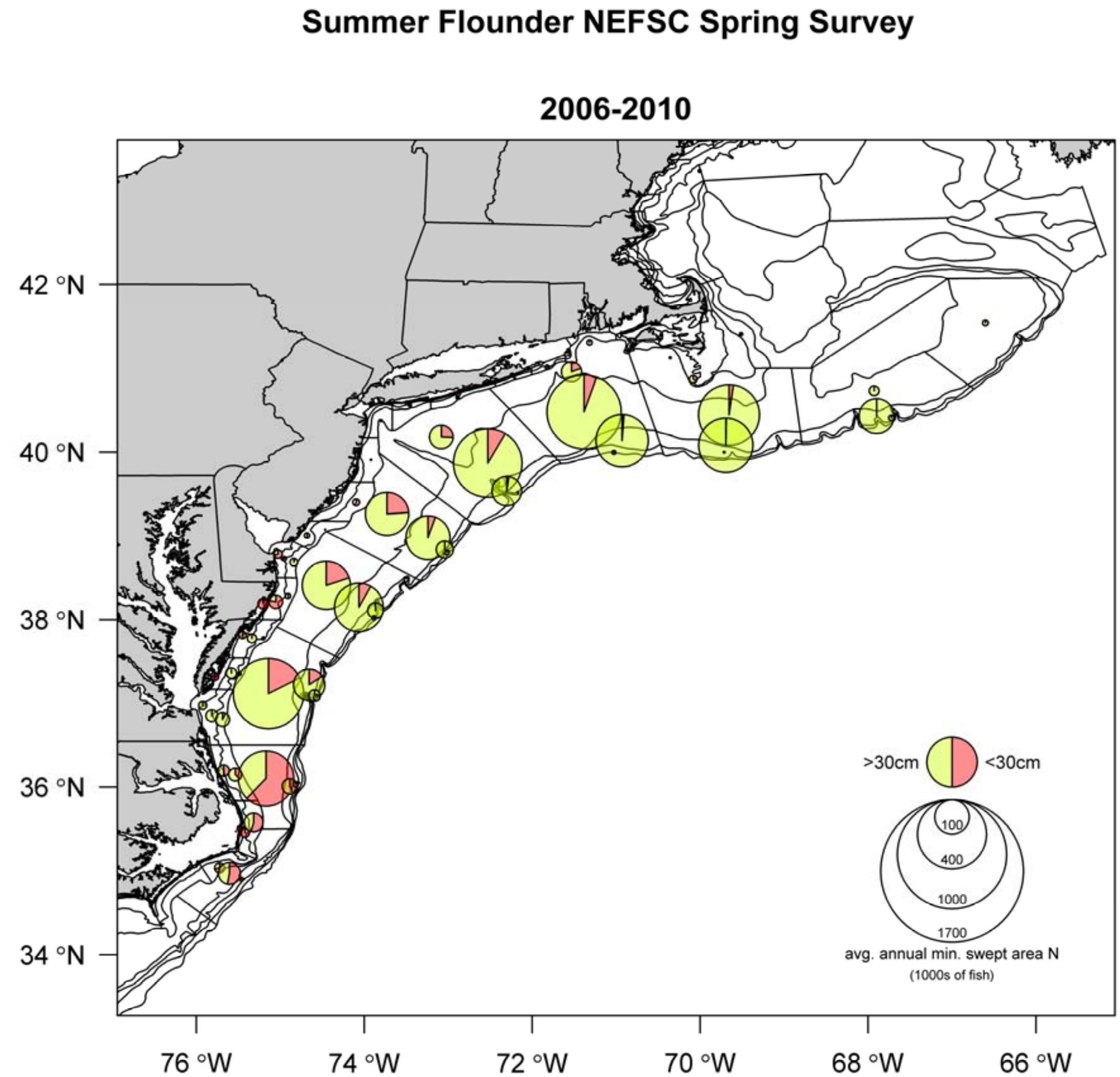


Figure A112. NEFSC spring survey average minimum swept area abundances by strata and size category, 2006-2010.

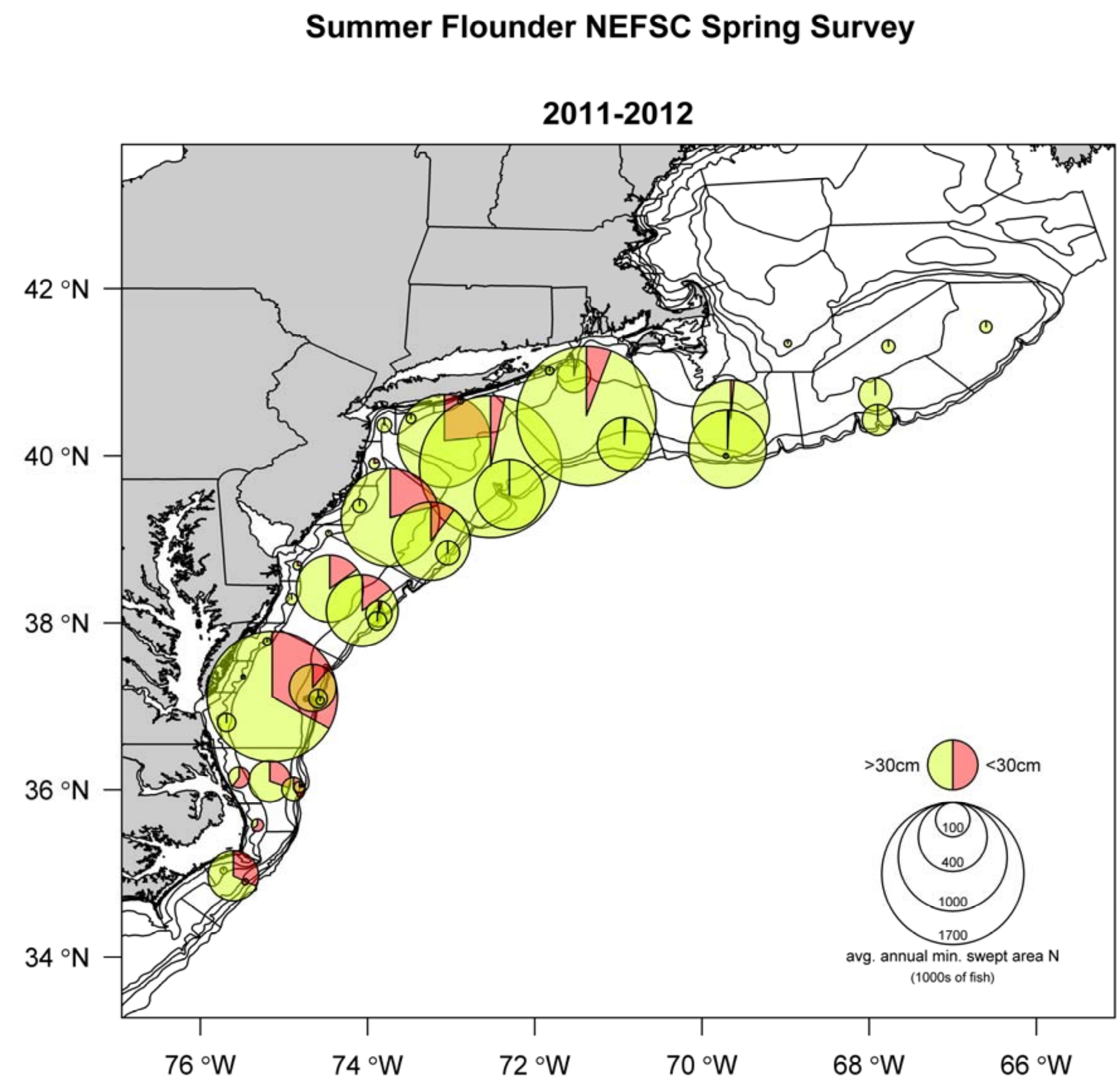


Figure A113. NEFSC spring survey average minimum swept area abundances by strata and size category, 2011-2012.

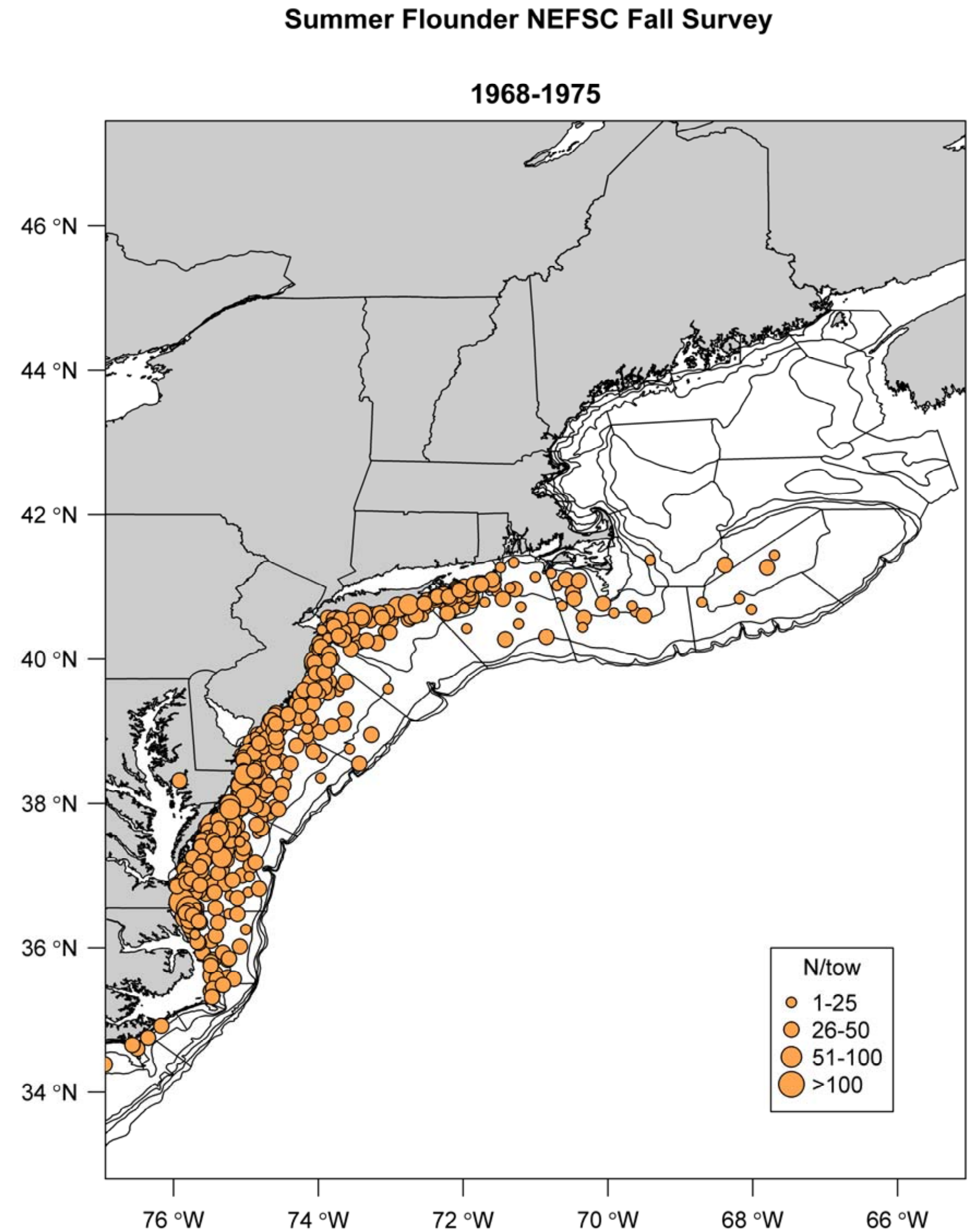


Figure A114. NEFSC fall survey catch numbers per tow, 1968-1975.

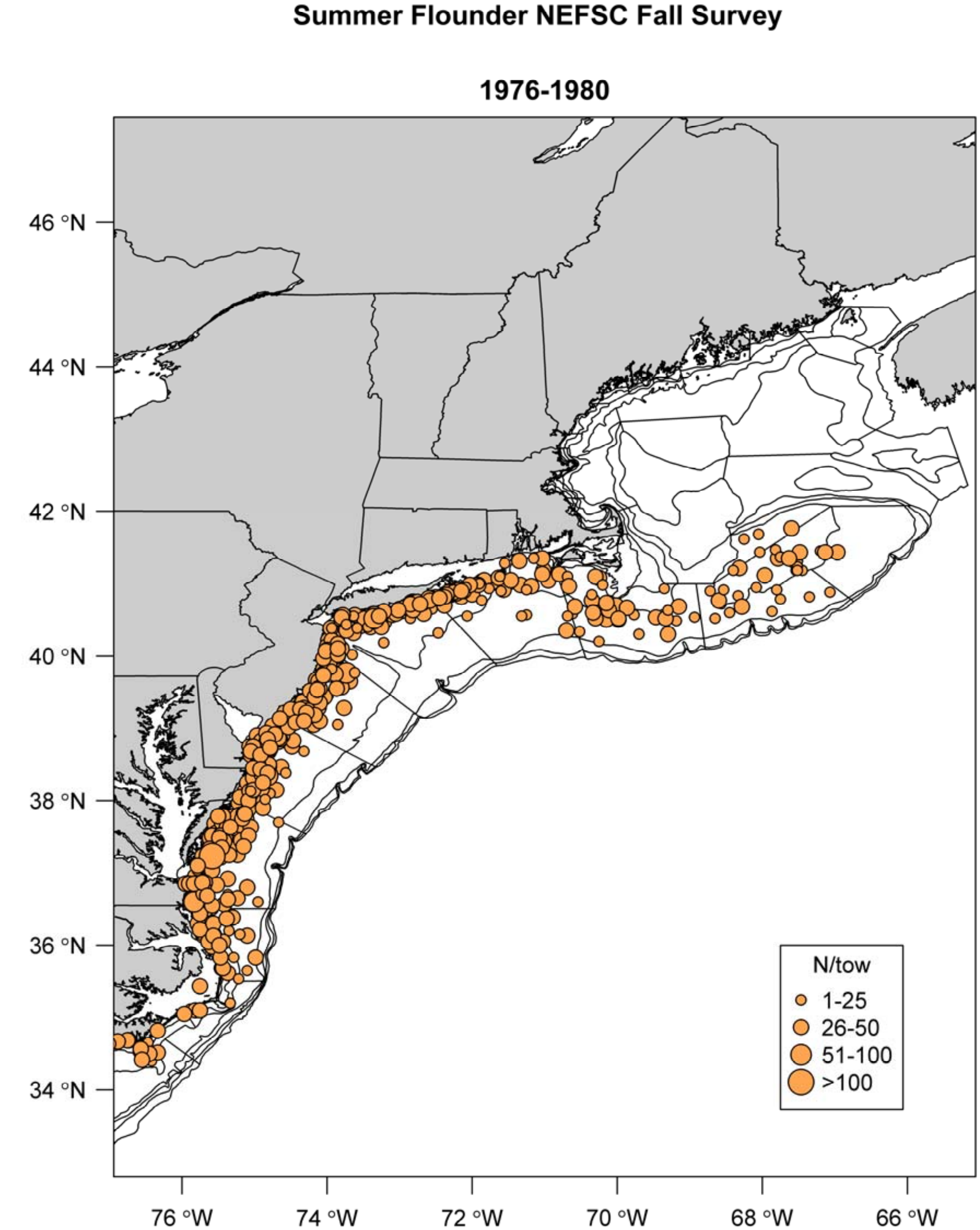


Figure A115. NEFSC fall survey catch numbers per tow, 1976-1980.

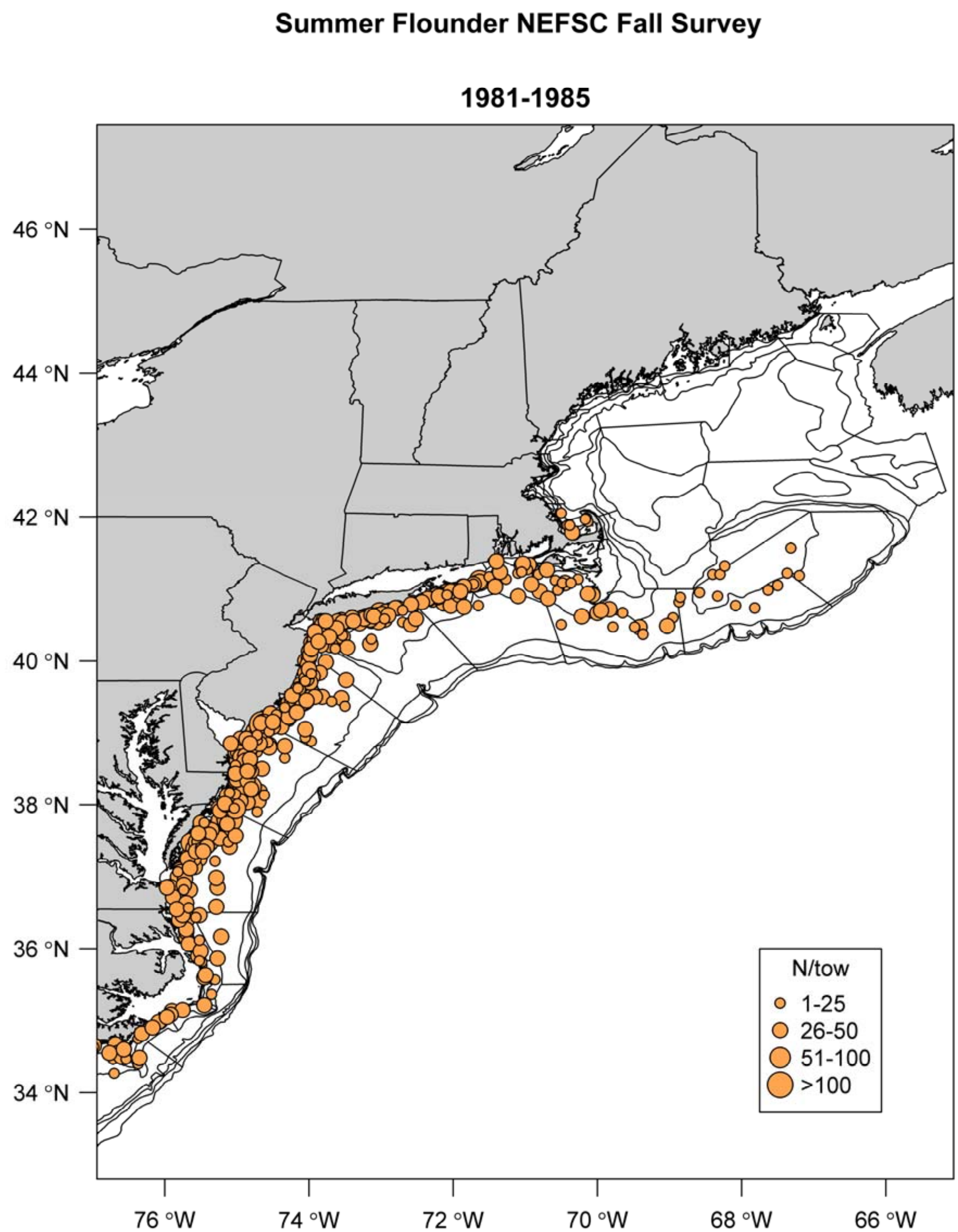


Figure A116. NEFSC fall survey catch numbers per tow, 1981-1985.

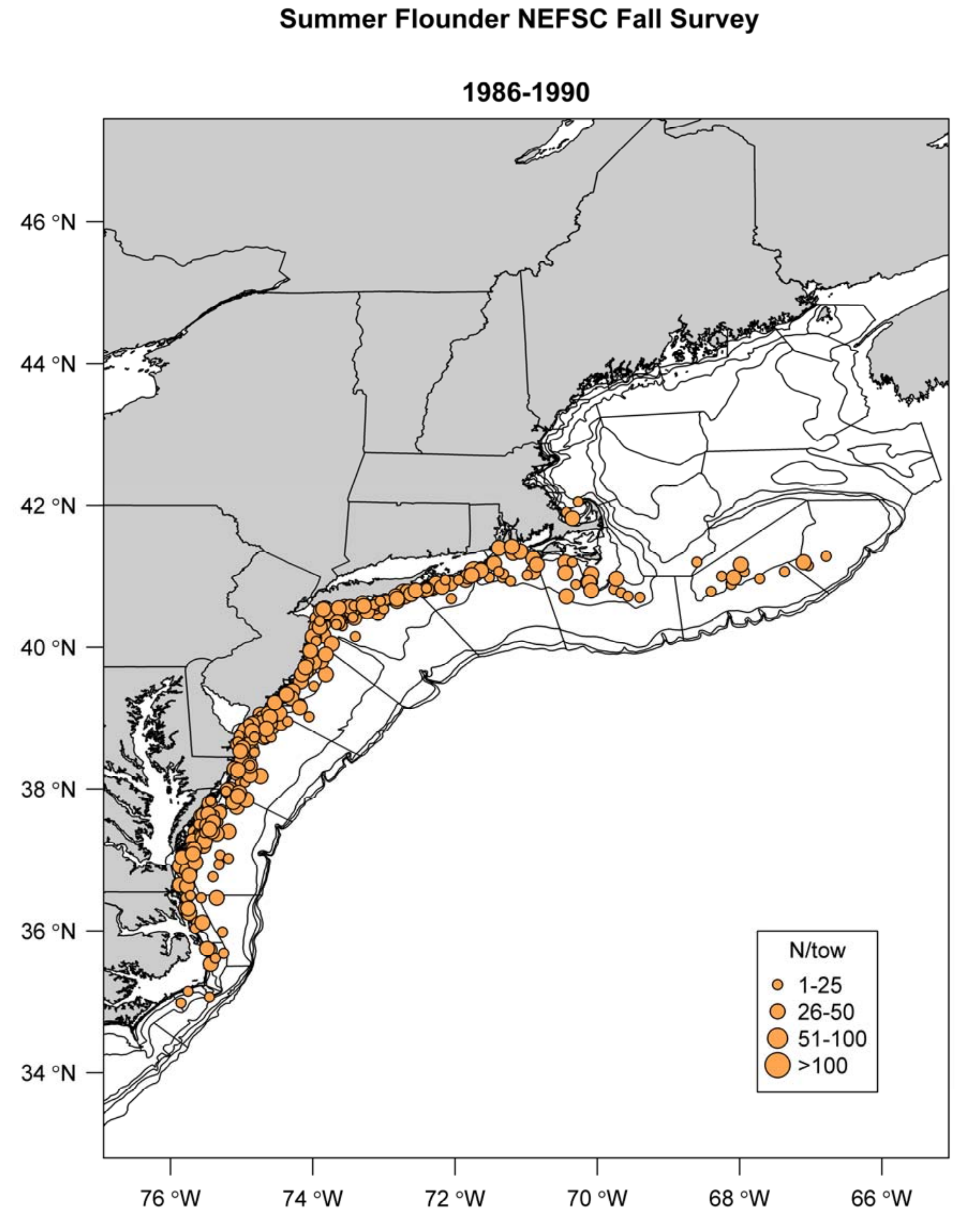


Figure A117. NEFSC fall survey catch numbers per tow, 1986-1990.

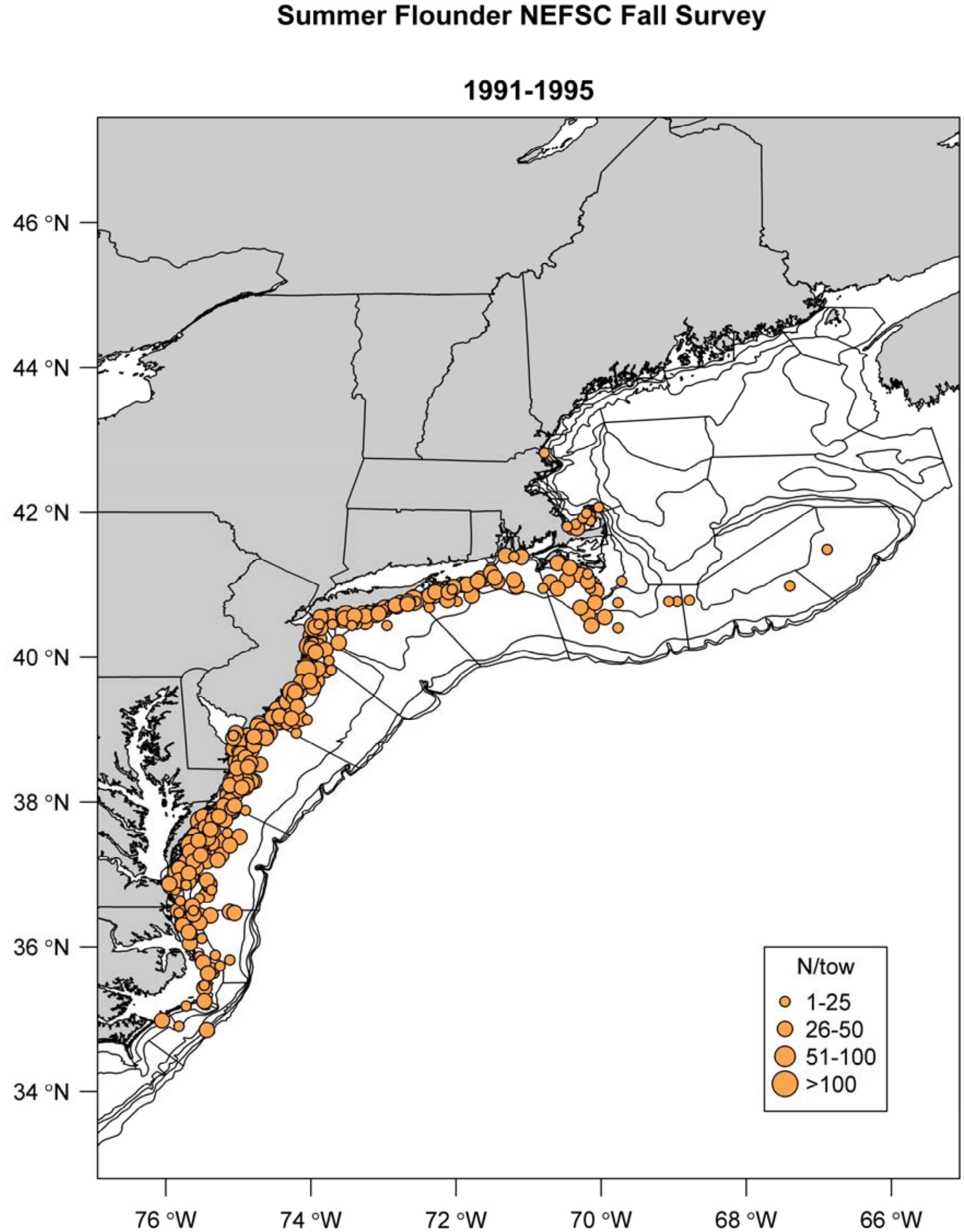


Figure A118. NEFSC fall survey catch numbers per tow, 1991-1995.

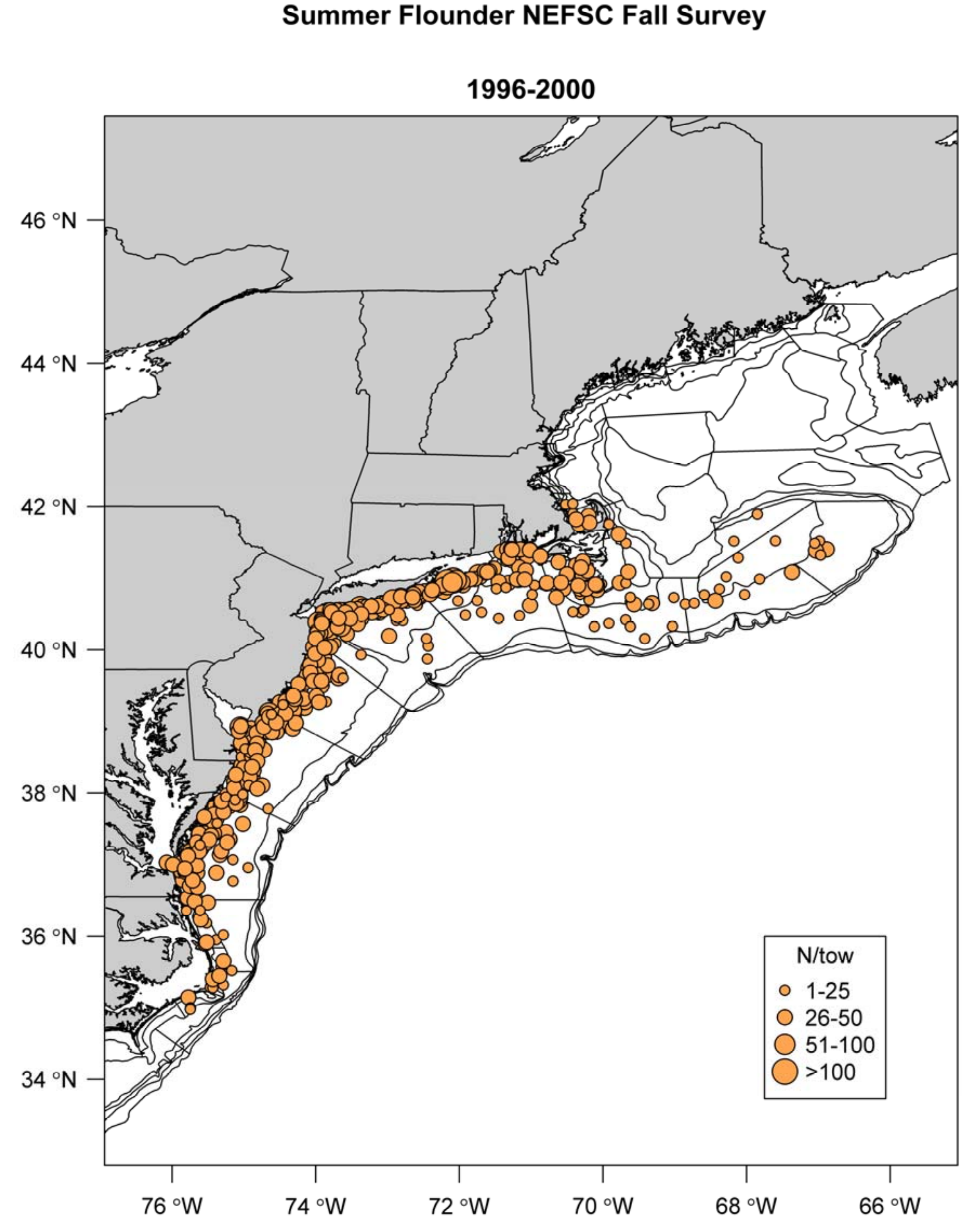


Figure A119. NEFSC fall survey catch numbers per tow, 1996-2000.

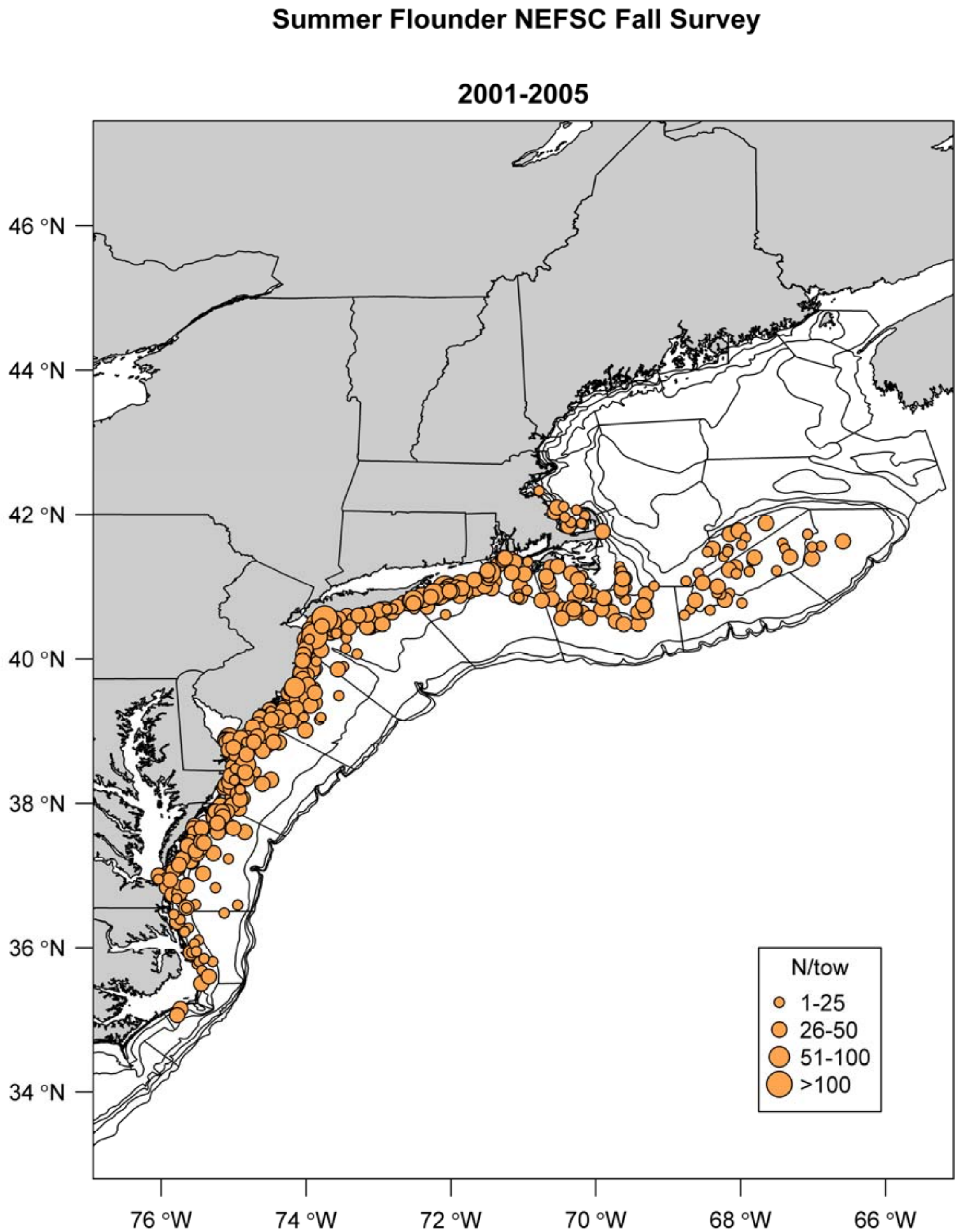


Figure A120. NEFSC fall survey catch numbers per tow, 2001-2005.

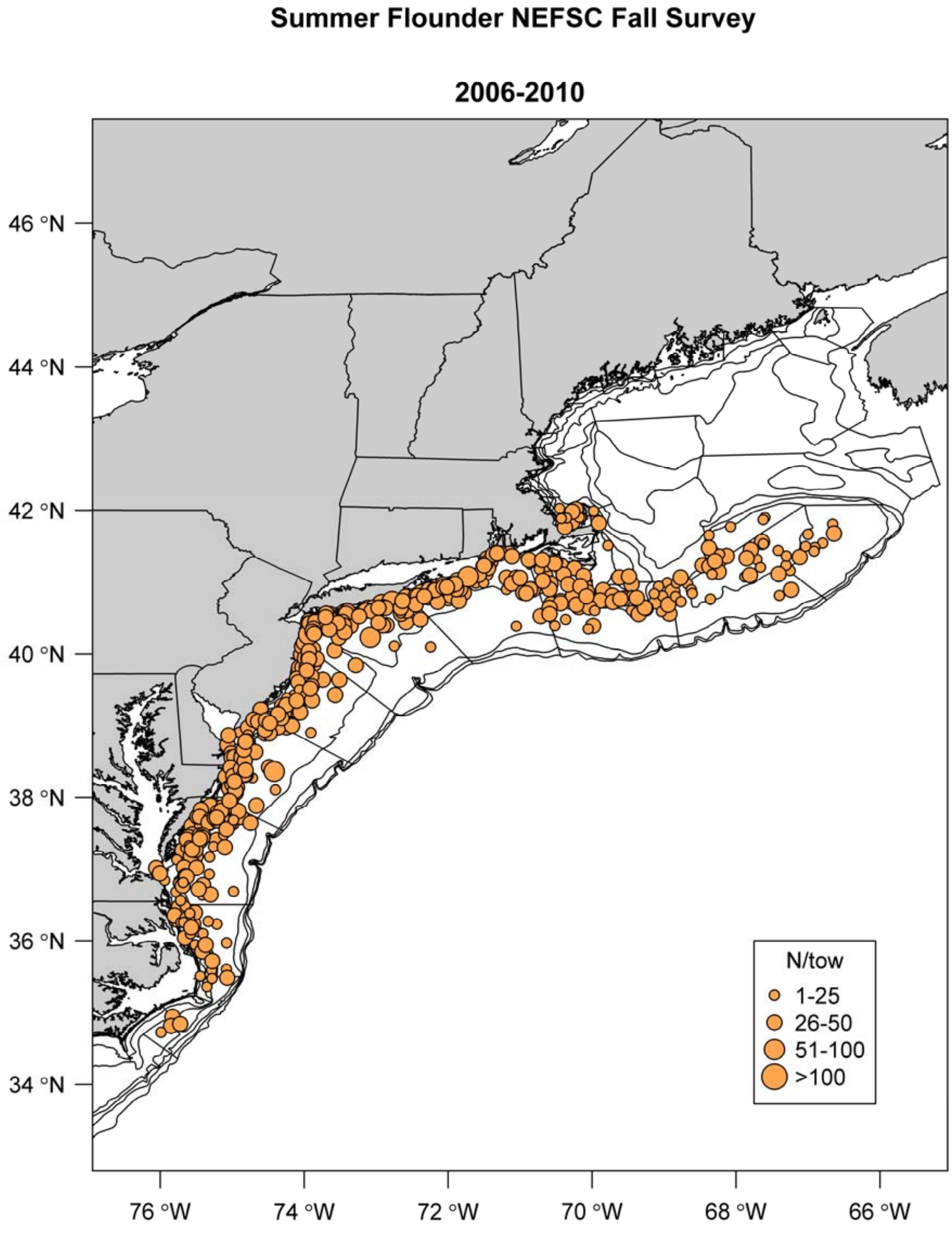


Figure A121. NEFSC fall survey catch numbers per tow, 2005-2010.

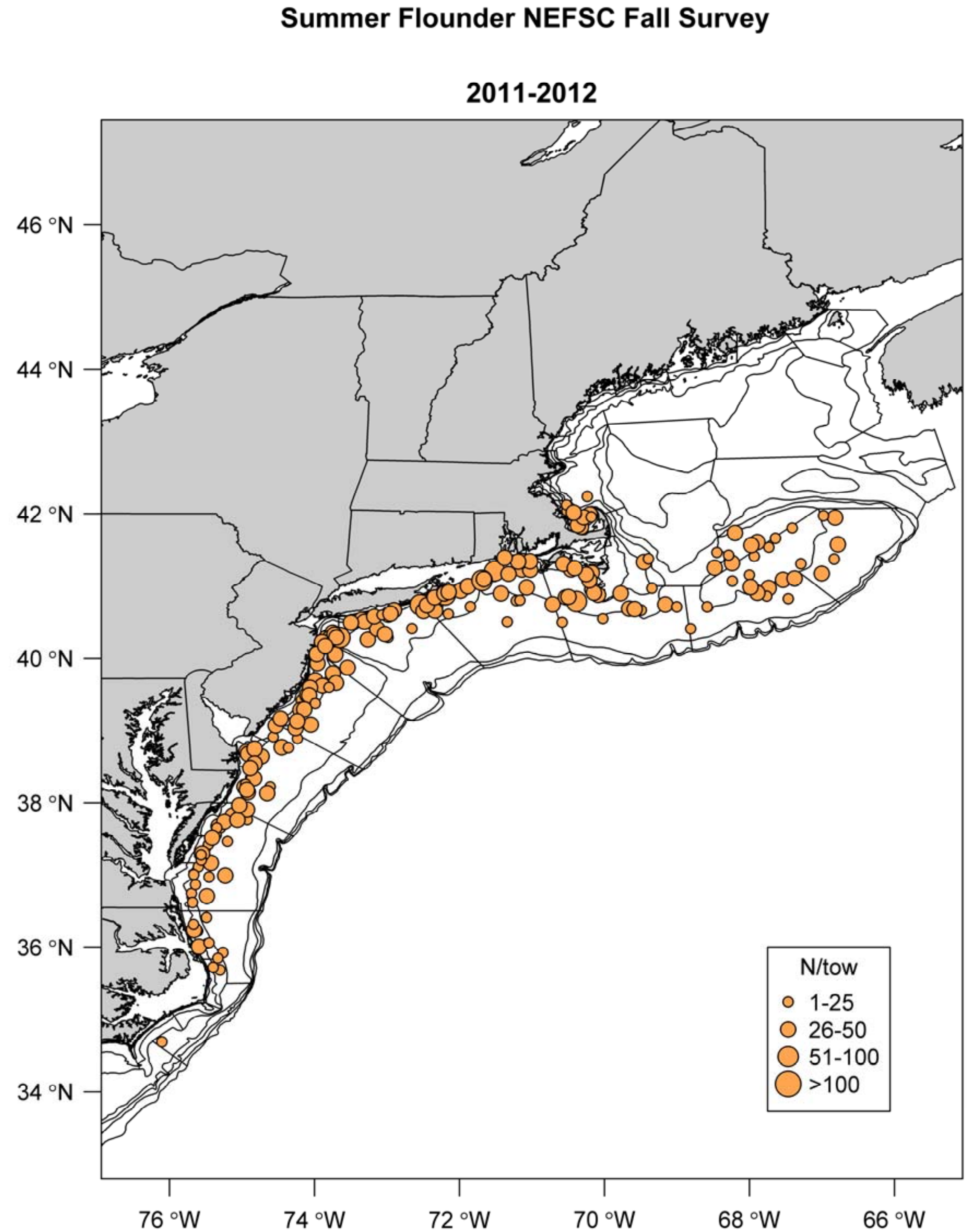


Figure A122. NEFSC fall survey catch numbers per tow, 2011-2012.

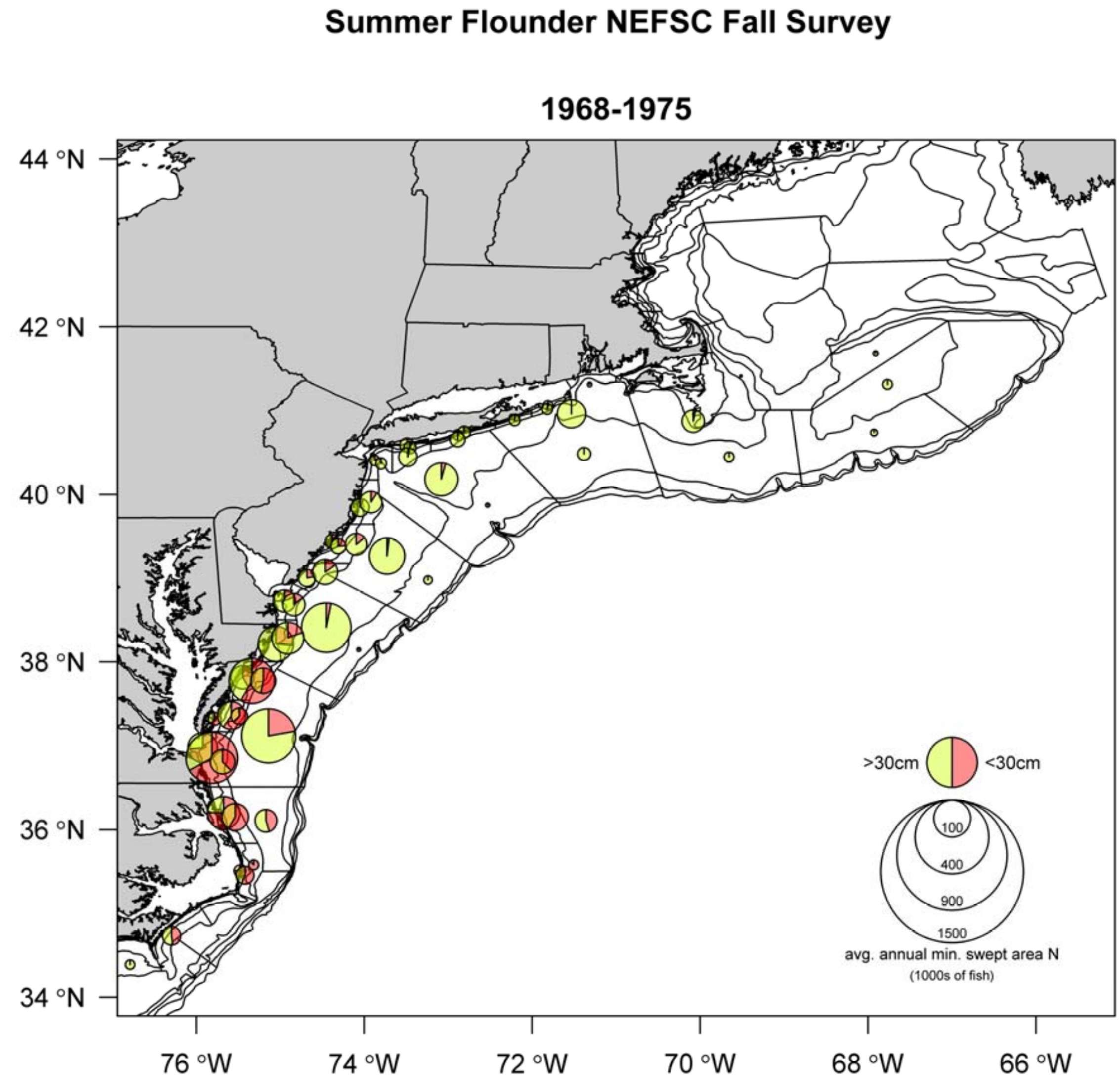


Figure A123. NEFSC fall survey average minimum swept area abundances by strata and size category, 1968-1975.

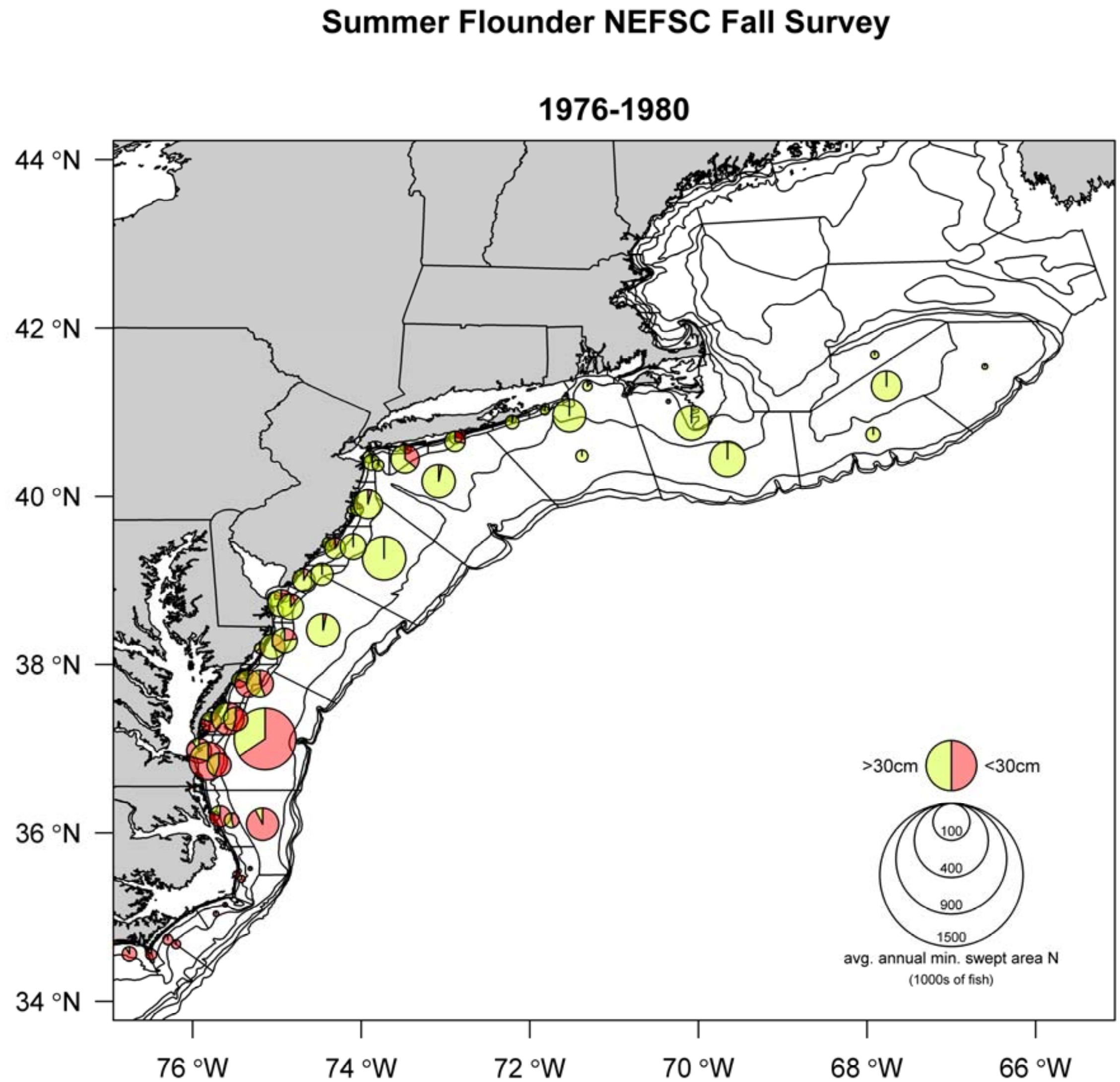


Figure A124. NEFSC fall survey average minimum swept area abundances by strata and size category, 1976-1980.

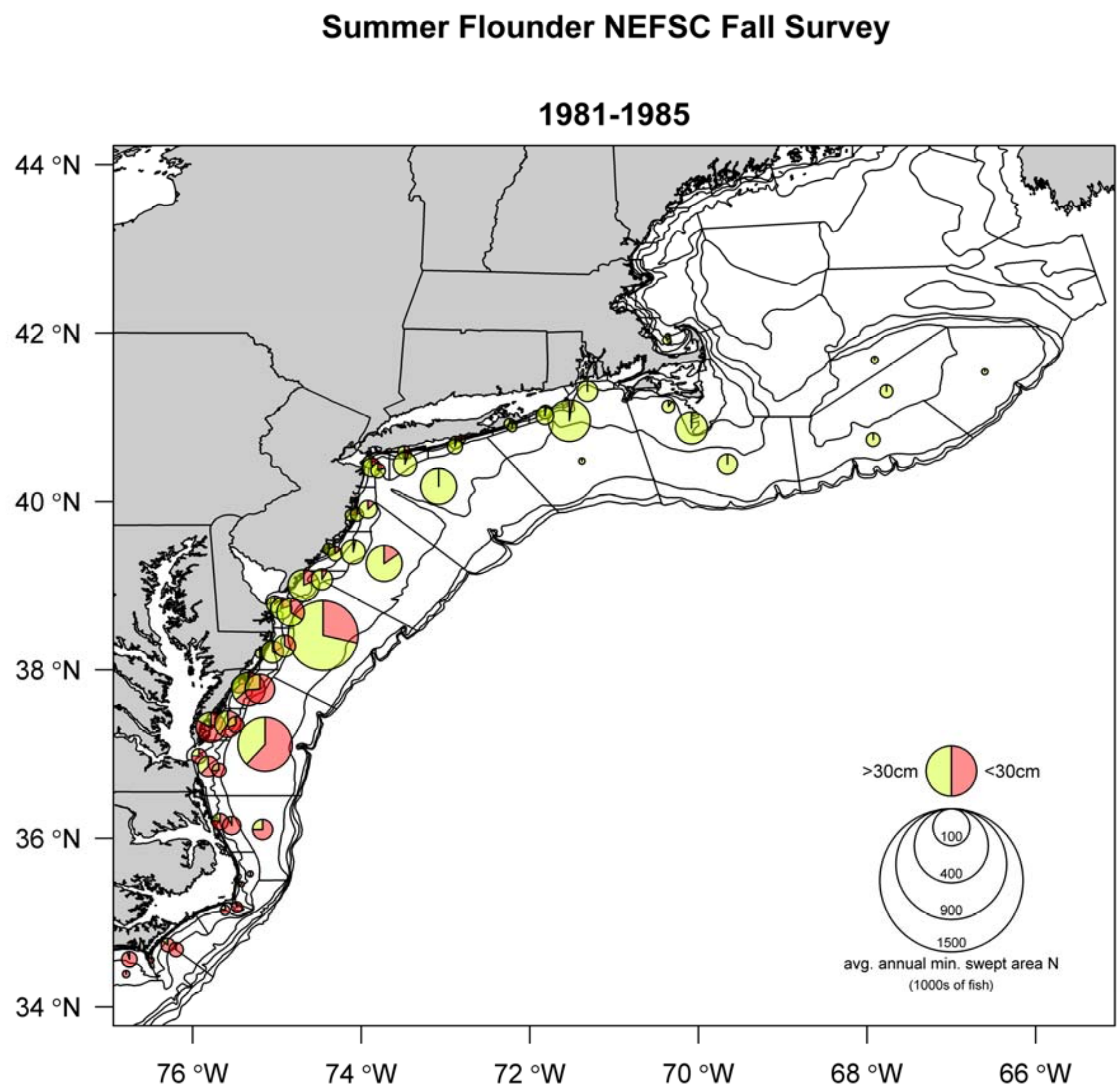


Figure A125. NEFSC fall survey average minimum swept area abundances by strata and size category, 1981-1985.

Summer Flounder NEFSC Fall Survey

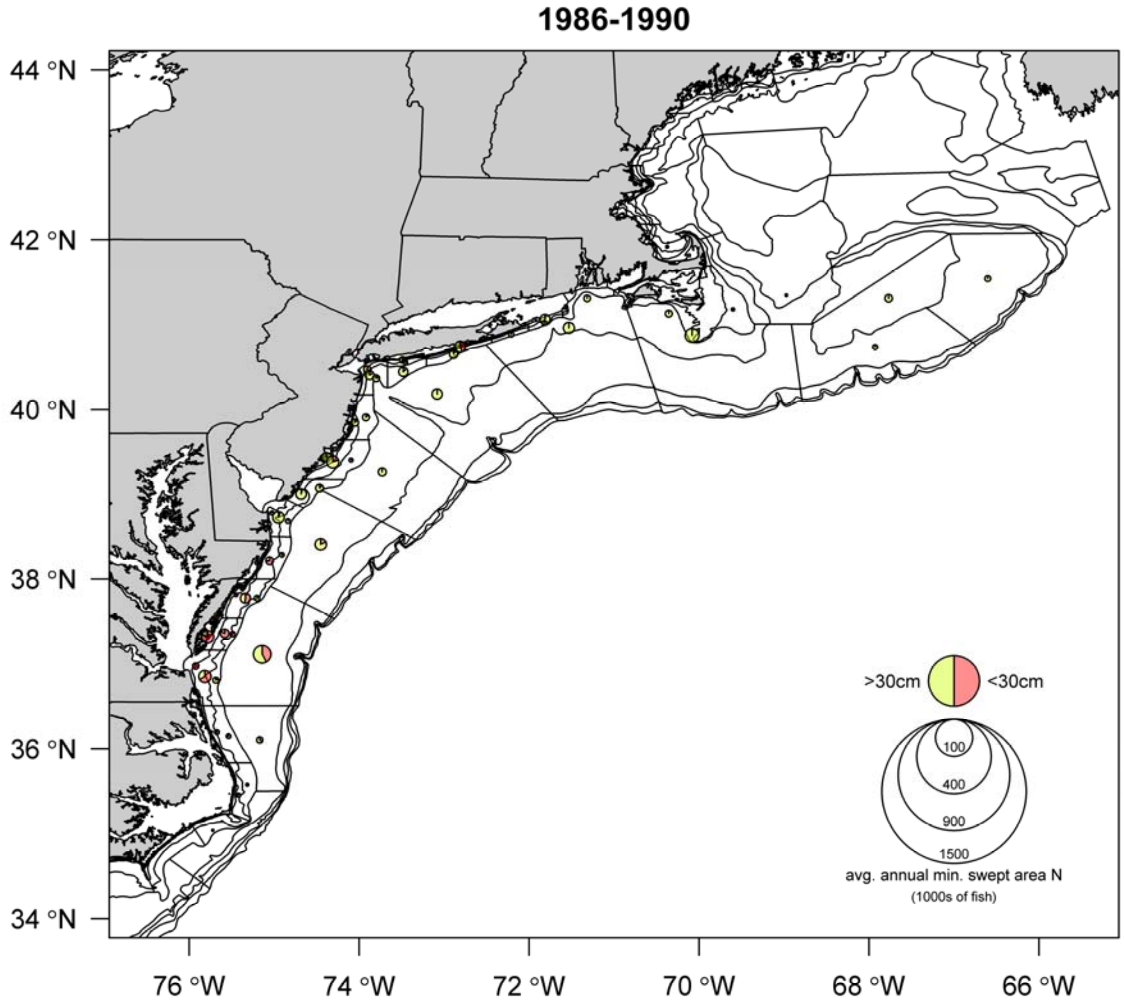


Figure A126. NEFSC fall survey average minimum swept area abundances by strata and size category, 1986-1990.

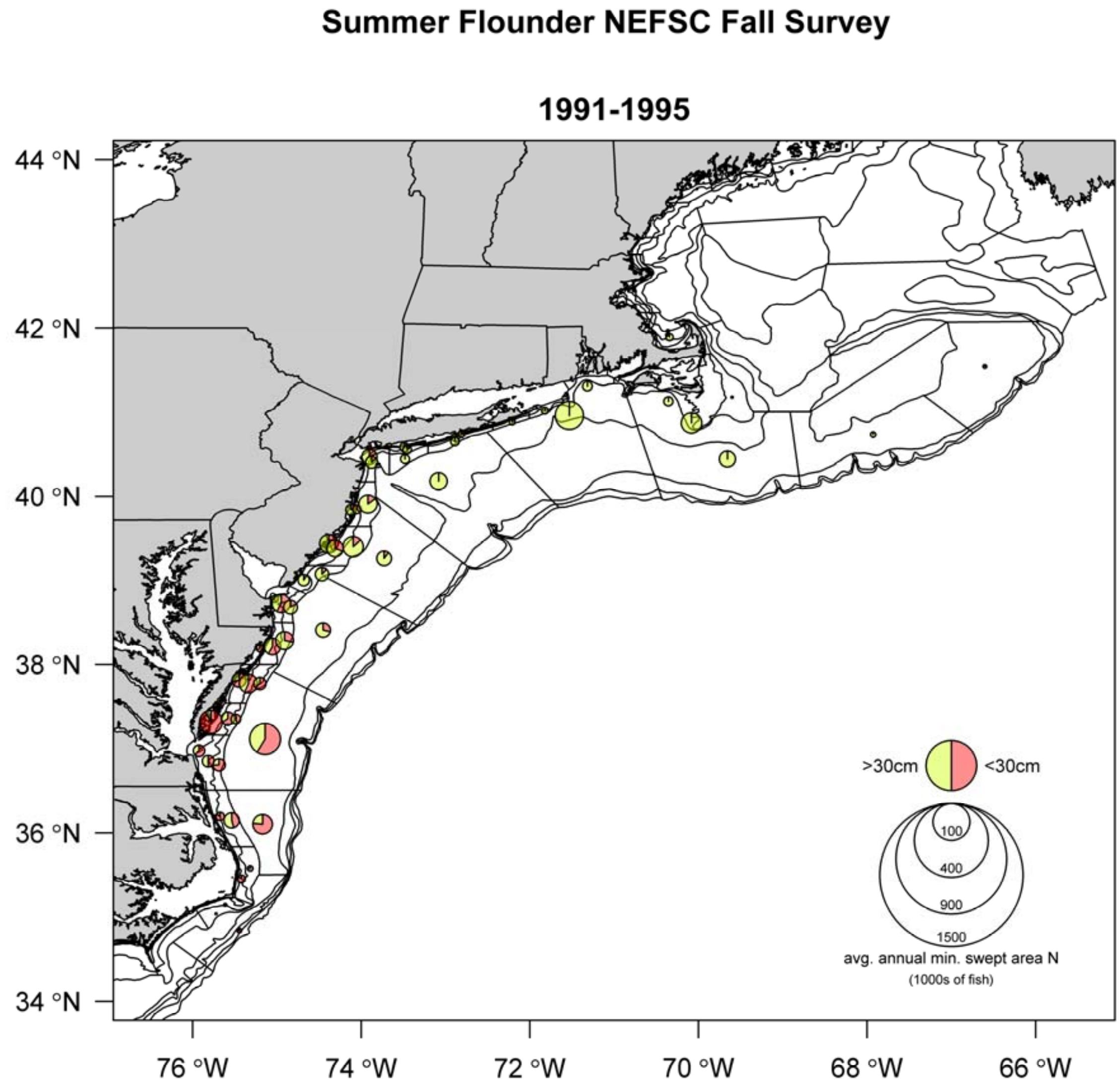


Figure A127. NEFSC fall survey average minimum swept area abundances by strata and size category, 1991-1995.

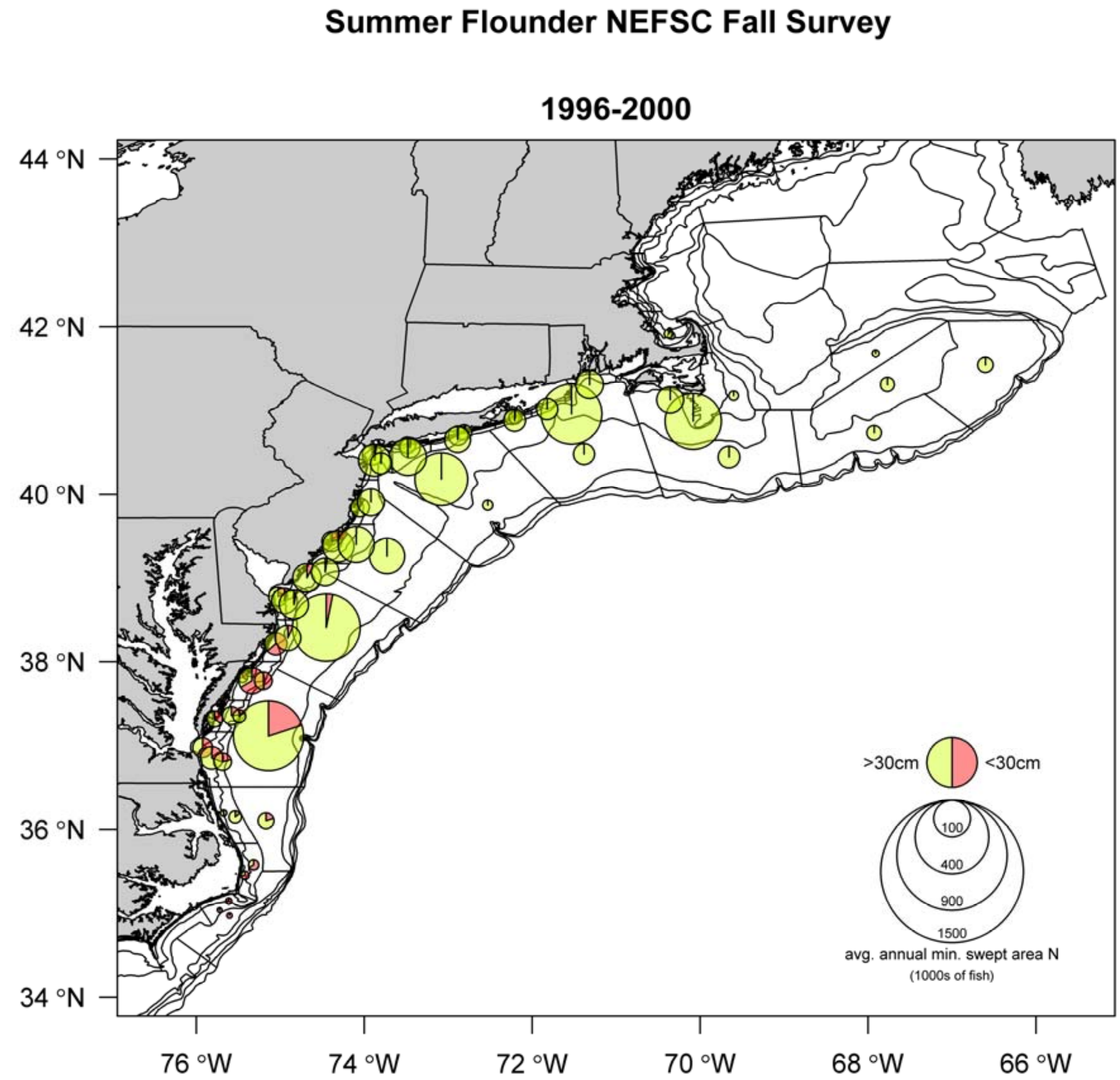


Figure A128. NEFSC fall survey average minimum swept area abundances by strata and size category, 1996-2000.

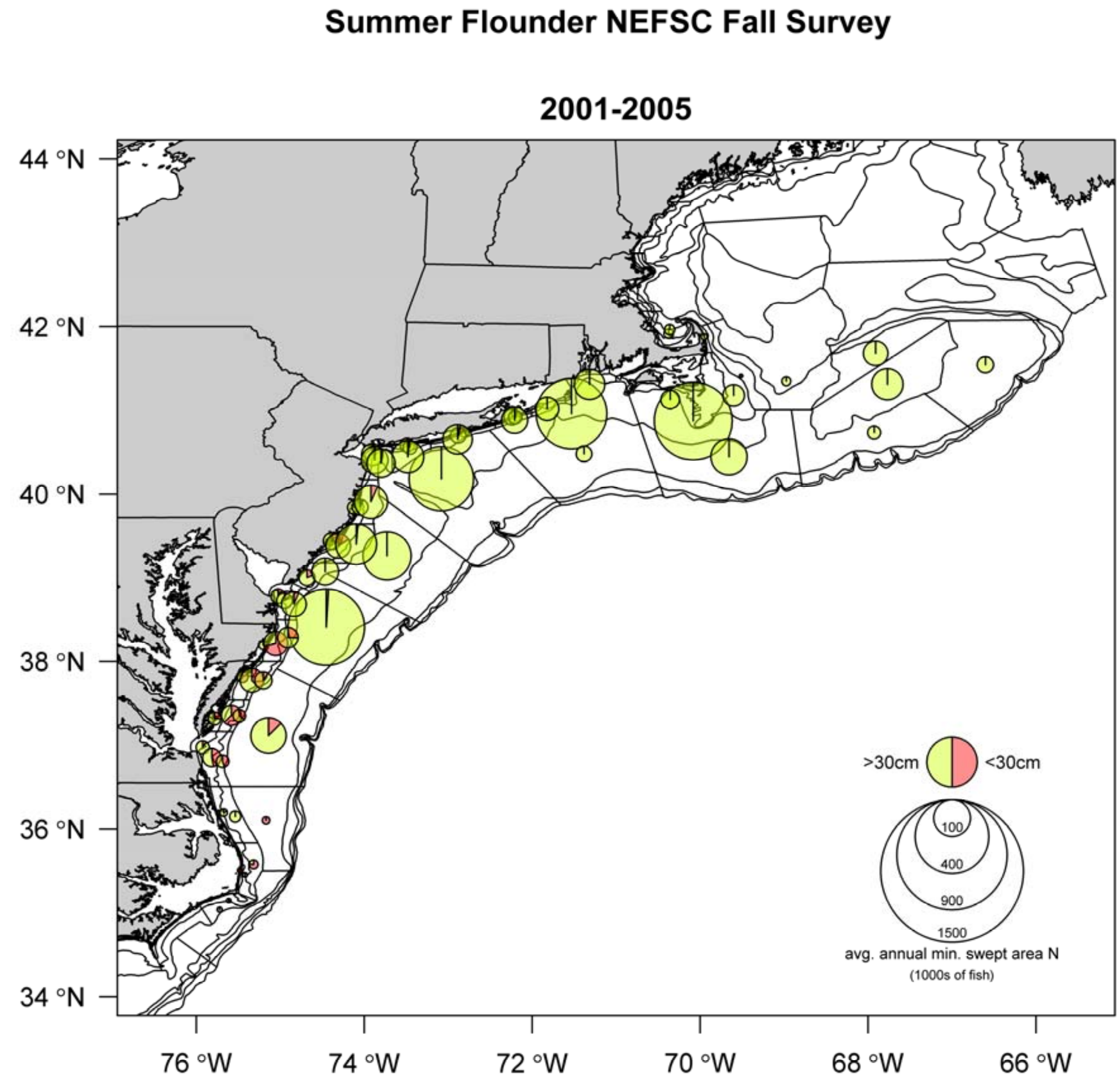


Figure A129. NEFSC fall survey average minimum swept area abundances by strata and size category, 2001-2005.

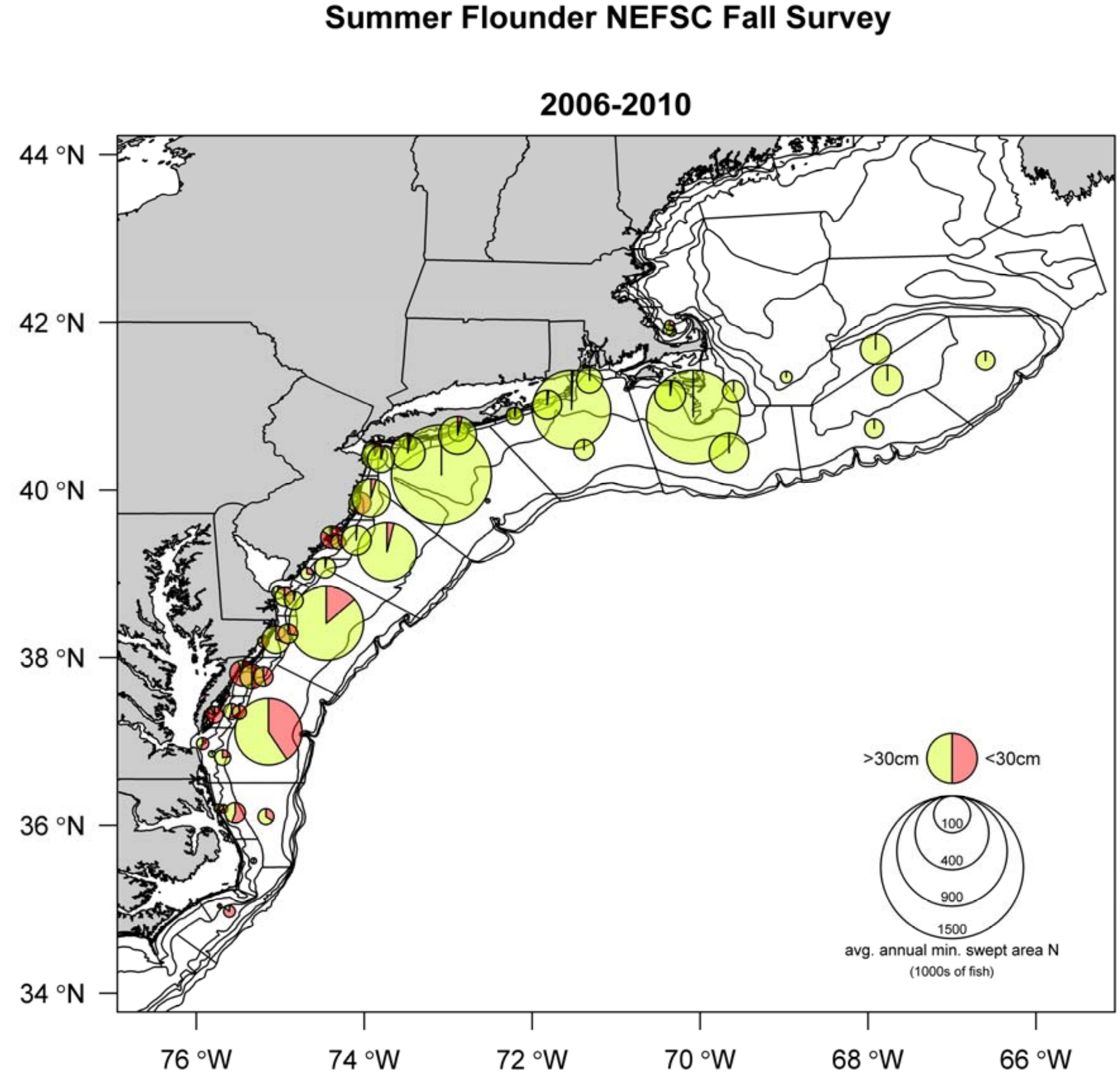


Figure A130. NEFSC fall survey average minimum swept area abundances by strata and size category, 2006-2010.

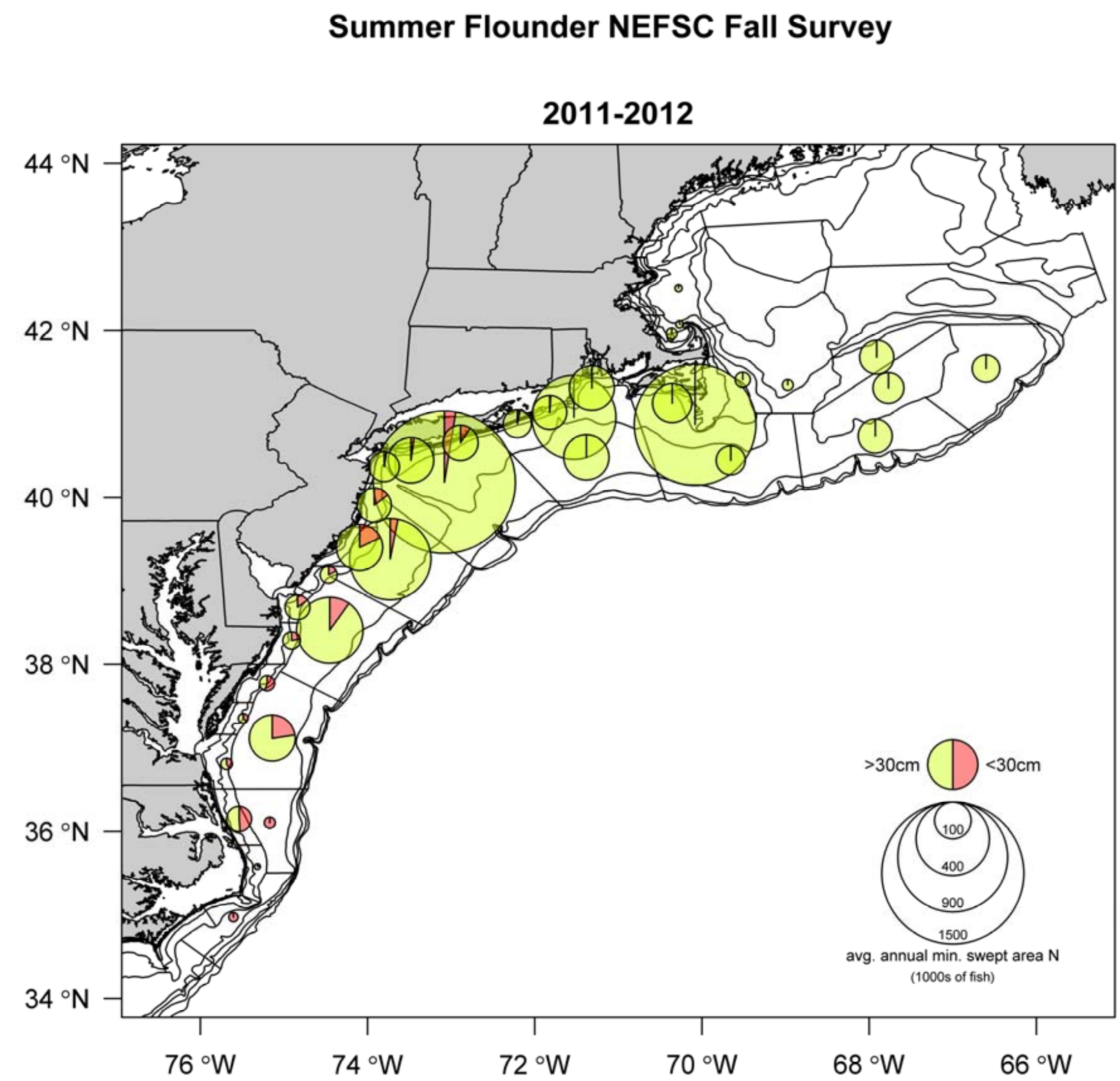


Figure A131. NEFSC fall survey average minimum swept area abundances by strata and size category, 2011-2012.

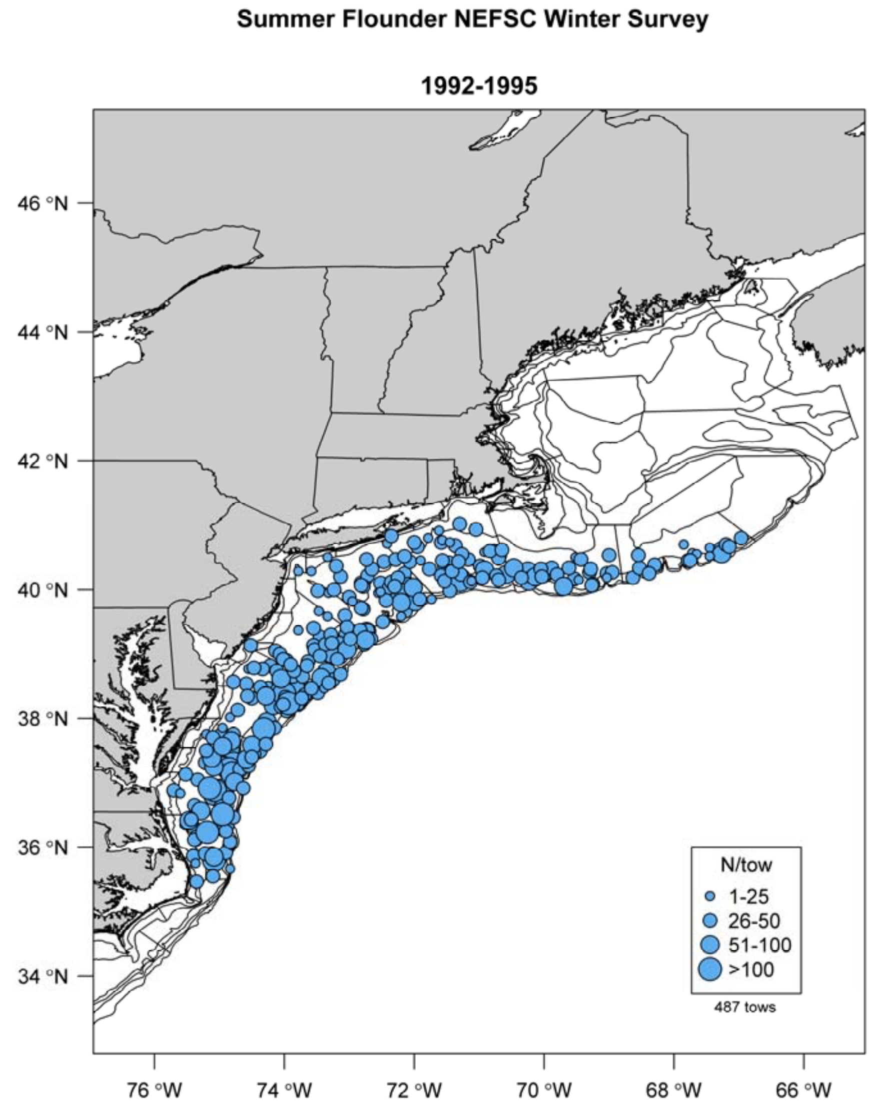


Figure A132. NEFSC winter survey catch numbers per tow, 1992-1995.

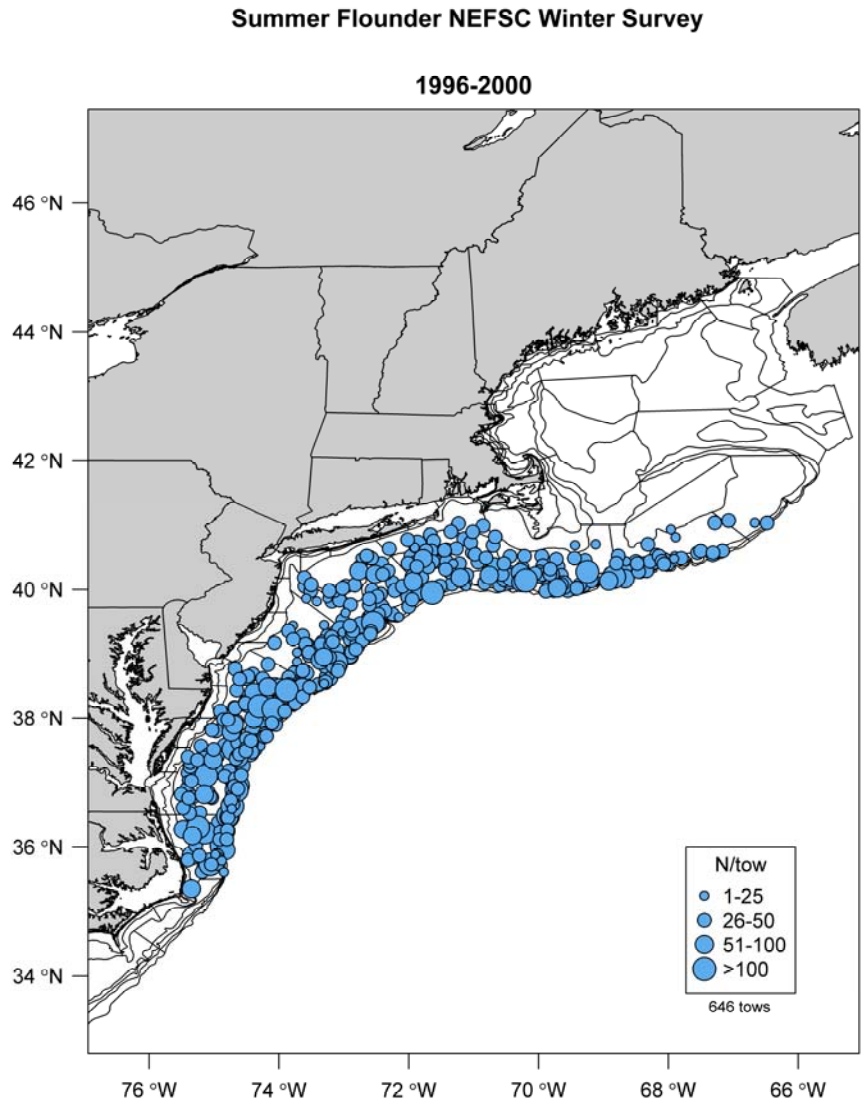


Figure A133. NEFSC winter survey catch numbers per tow, 1996-2000.

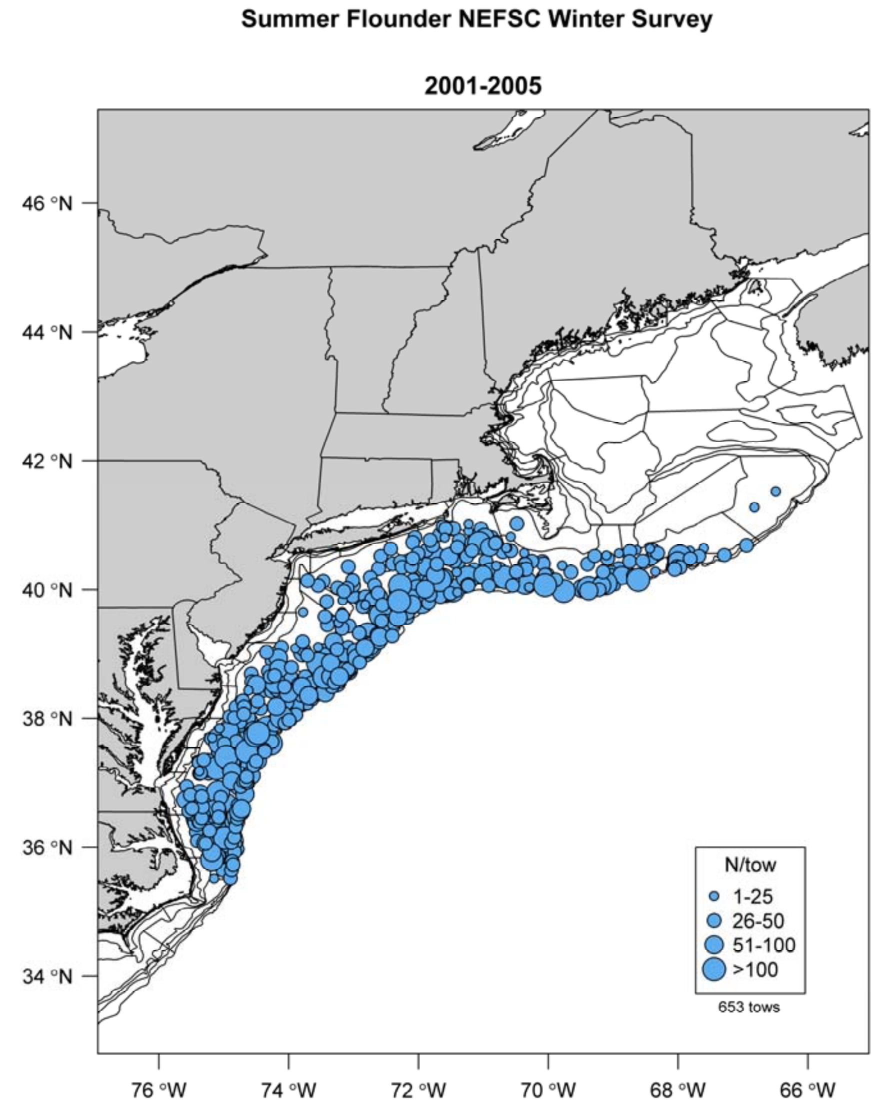


Figure A134. NEFSC winter survey catch numbers per tow, 2001-2005.

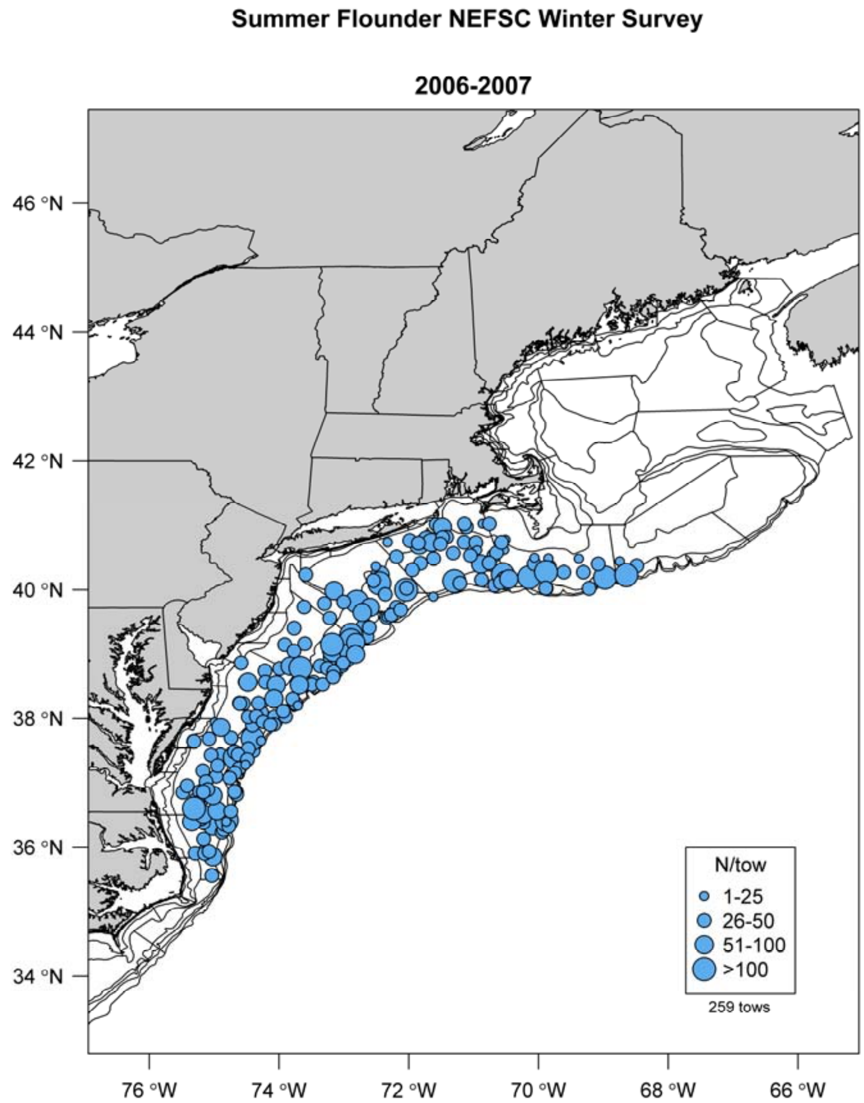


Figure A135. NEFSC winter trawl survey catches (numbers/tow) of summer flounder, 2006-2007.

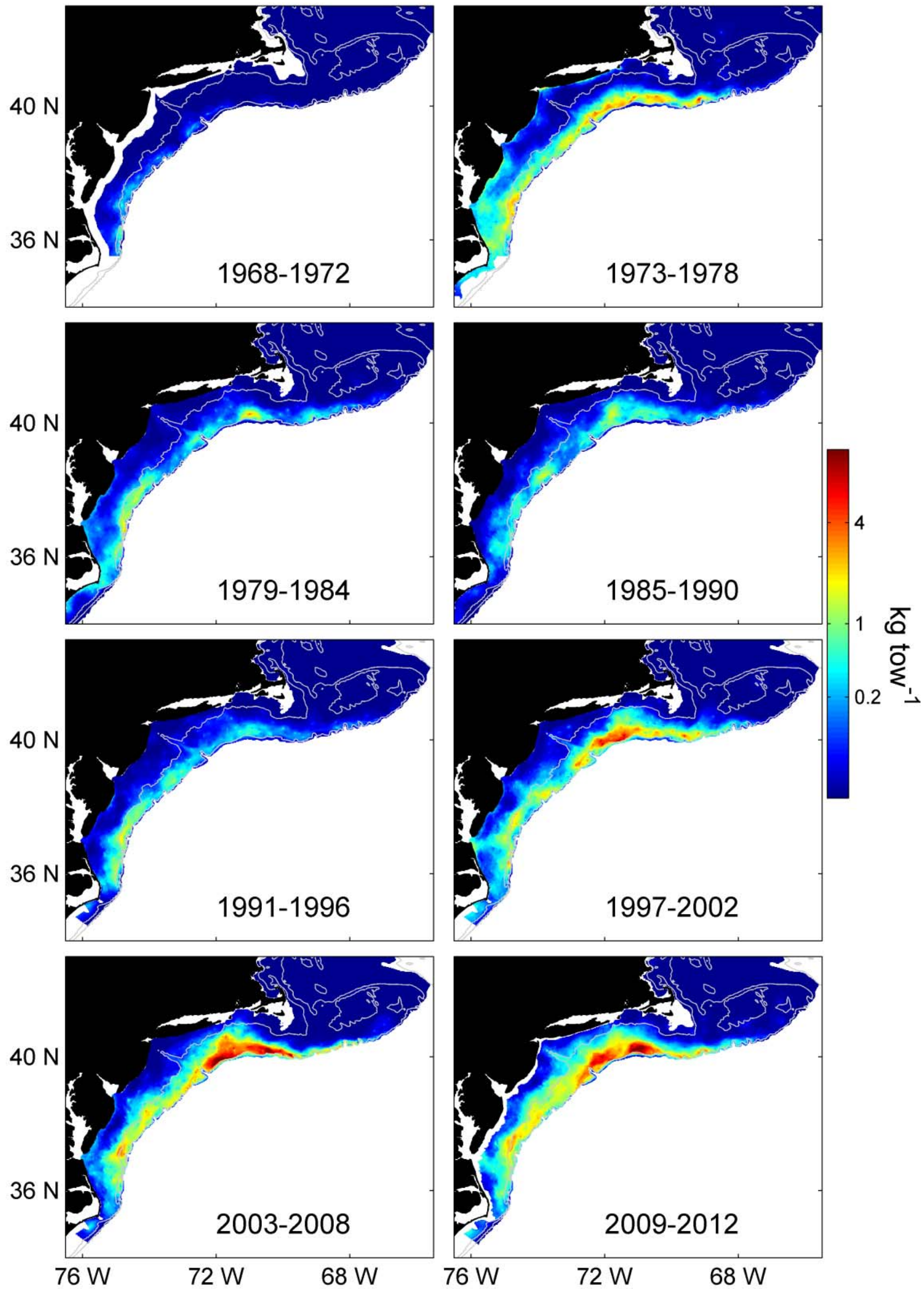


Figure A136. Distribution of summer flounder on the spring trawl survey through time. The scaling for all panels is the same. A weight calibration factor of 3.06 was used to scale the 2009-2012 Bigelow data to the Albatross time series.

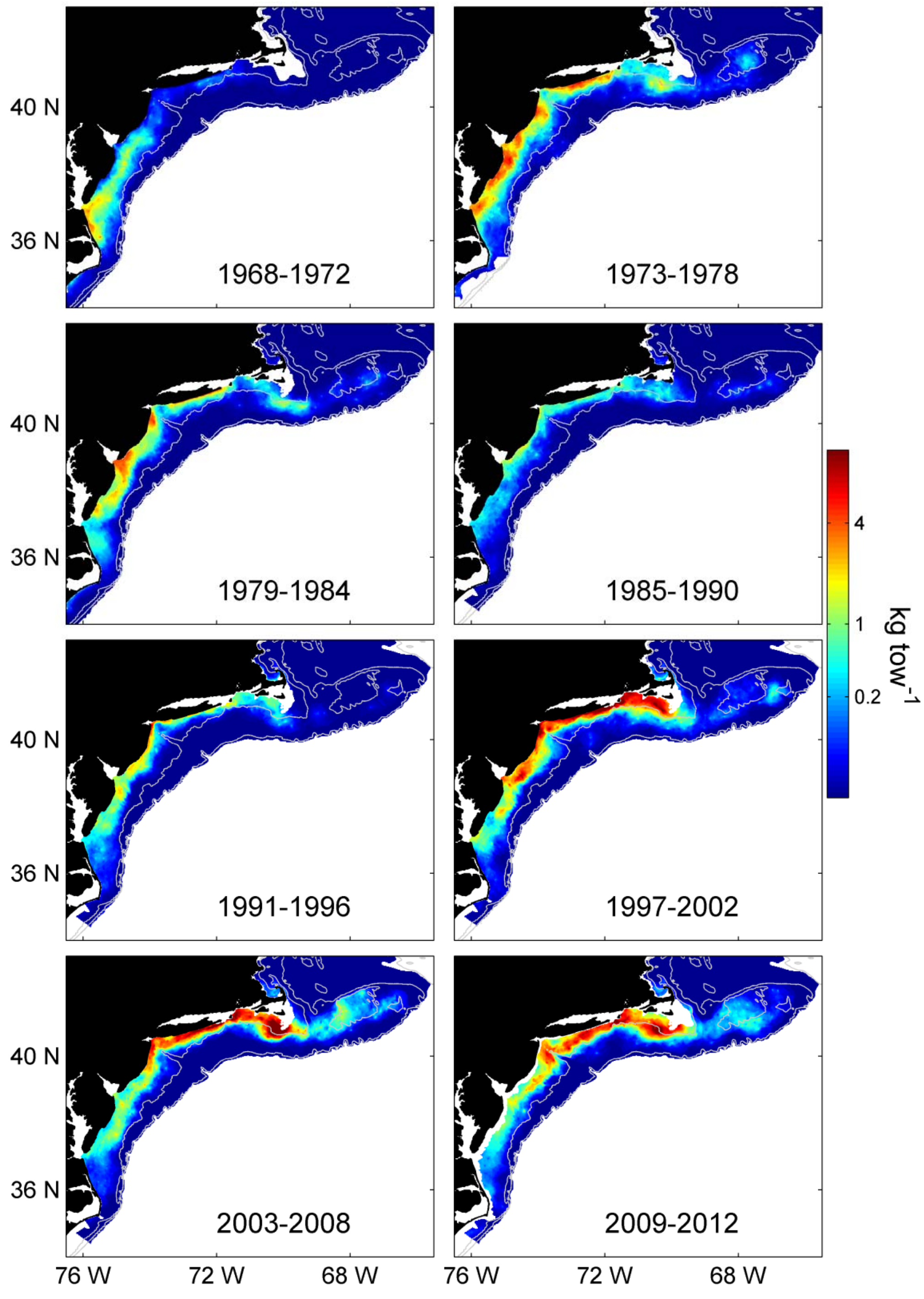


Figure A137. Distribution of summer flounder on the fall trawl survey through time. The scaling for all panels is the same. A weight calibration factor of 2.14 was used to scale the 2009-2012 Bigelow data to the Albatross time series.

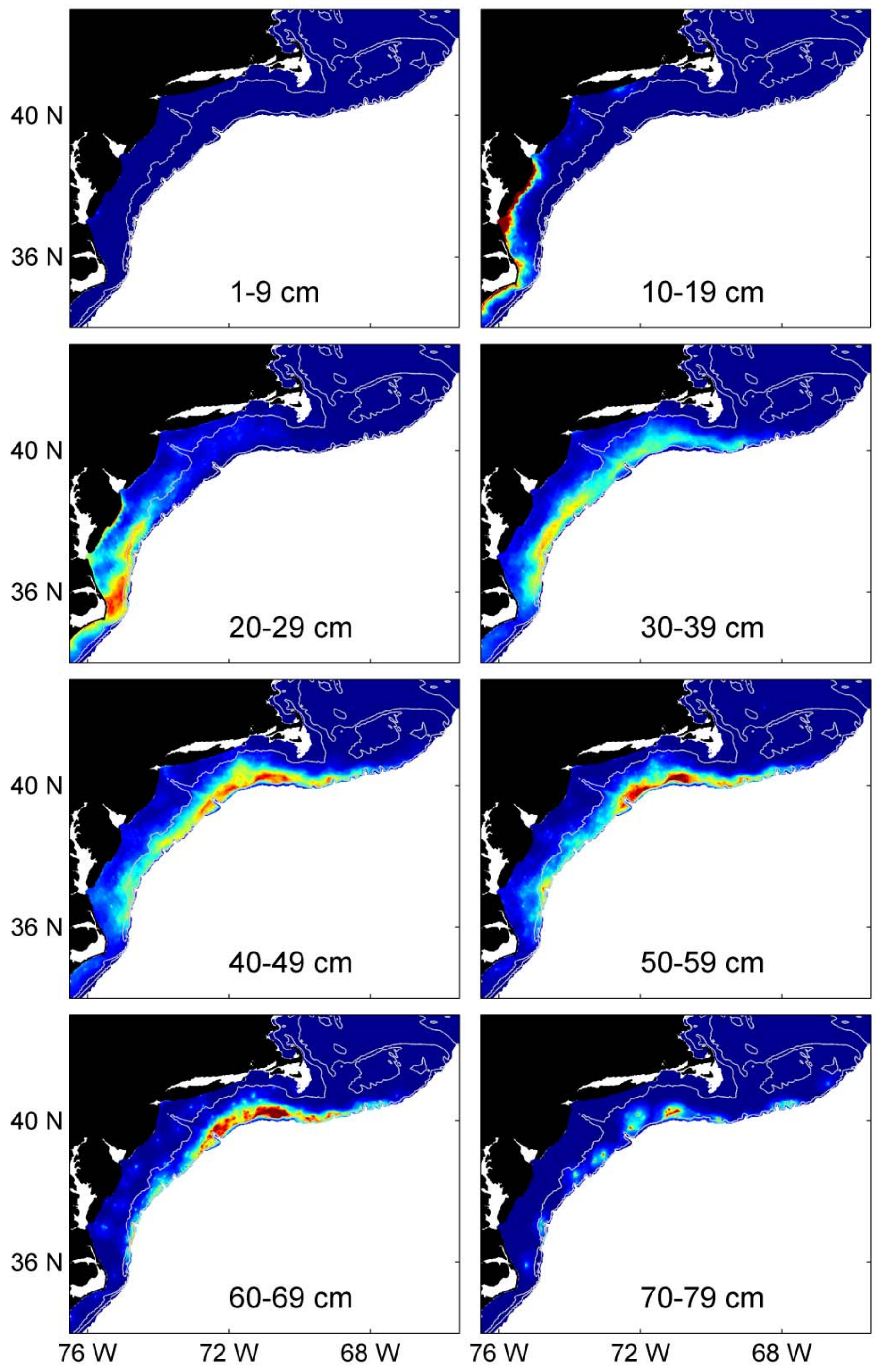


Figure A138. Average Summer Flounder distribution by length class for the 1968-2012 period on the spring trawl survey. The color scale differs by length class to aid in visualization.

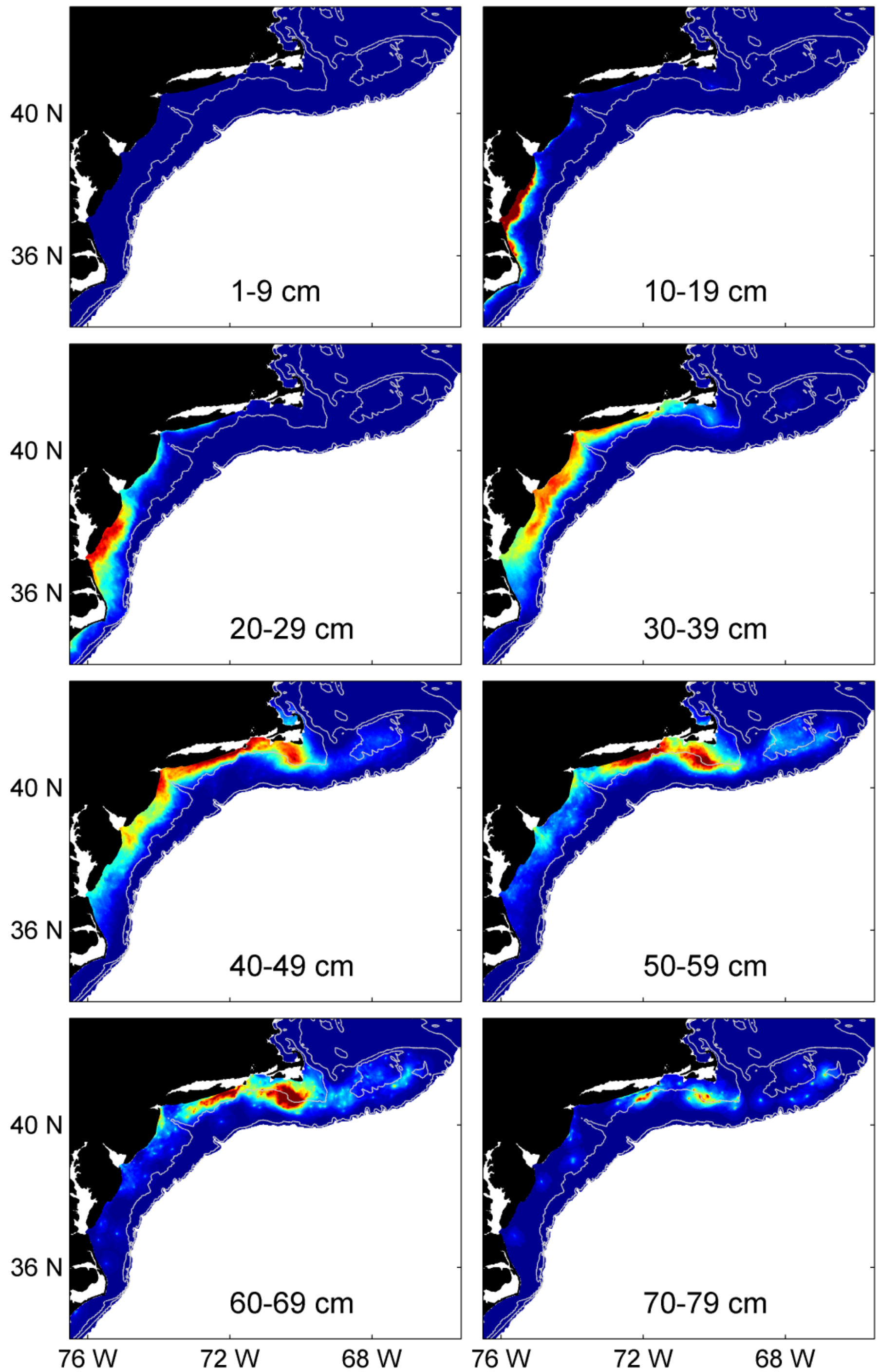


Figure A139. Average Summer Flounder distribution by length class for the 1968-2012 period on the fall trawl survey. The color scale differs by length class to aid in visualization.

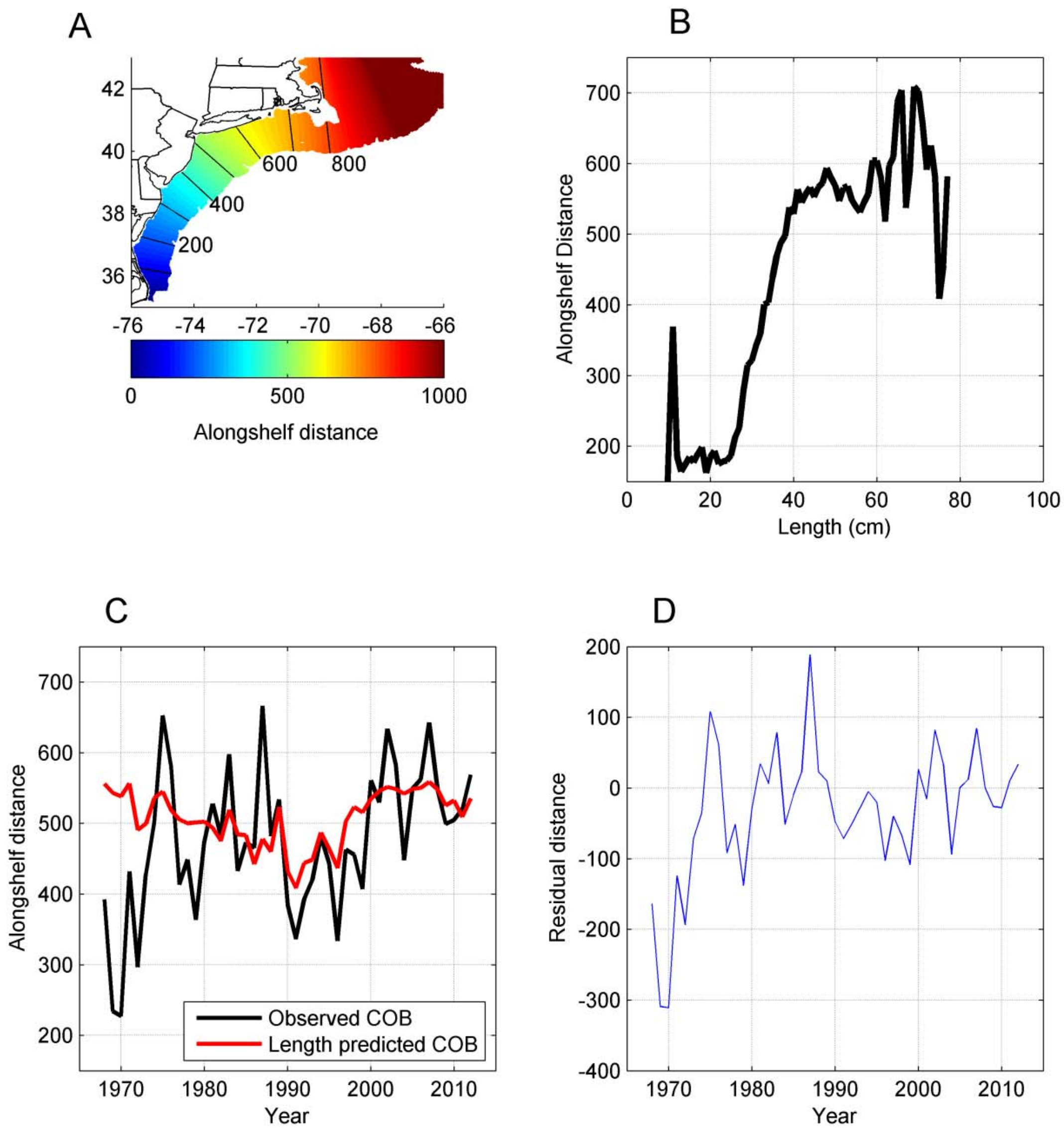


Figure A140. Alongshelf Center of Biomass of Summer Flounder on the Spring trawl survey. A) Map of alongshelf positions with distances in kilometers. B) Average alongshelf center of biomass by cm length class for the 1968-2012 spring time series. C) Annual observed center of biomass on the spring trawl survey (black) and center of biomass predicted solely based on the sampled length structure for that survey and the time-series average alongshelf position by length class. D) Residuals of the observed alongshelf distance and predicted alongshelf distance based solely on length structure. The residuals correspond to the distribution shift not explained by changes in length structure

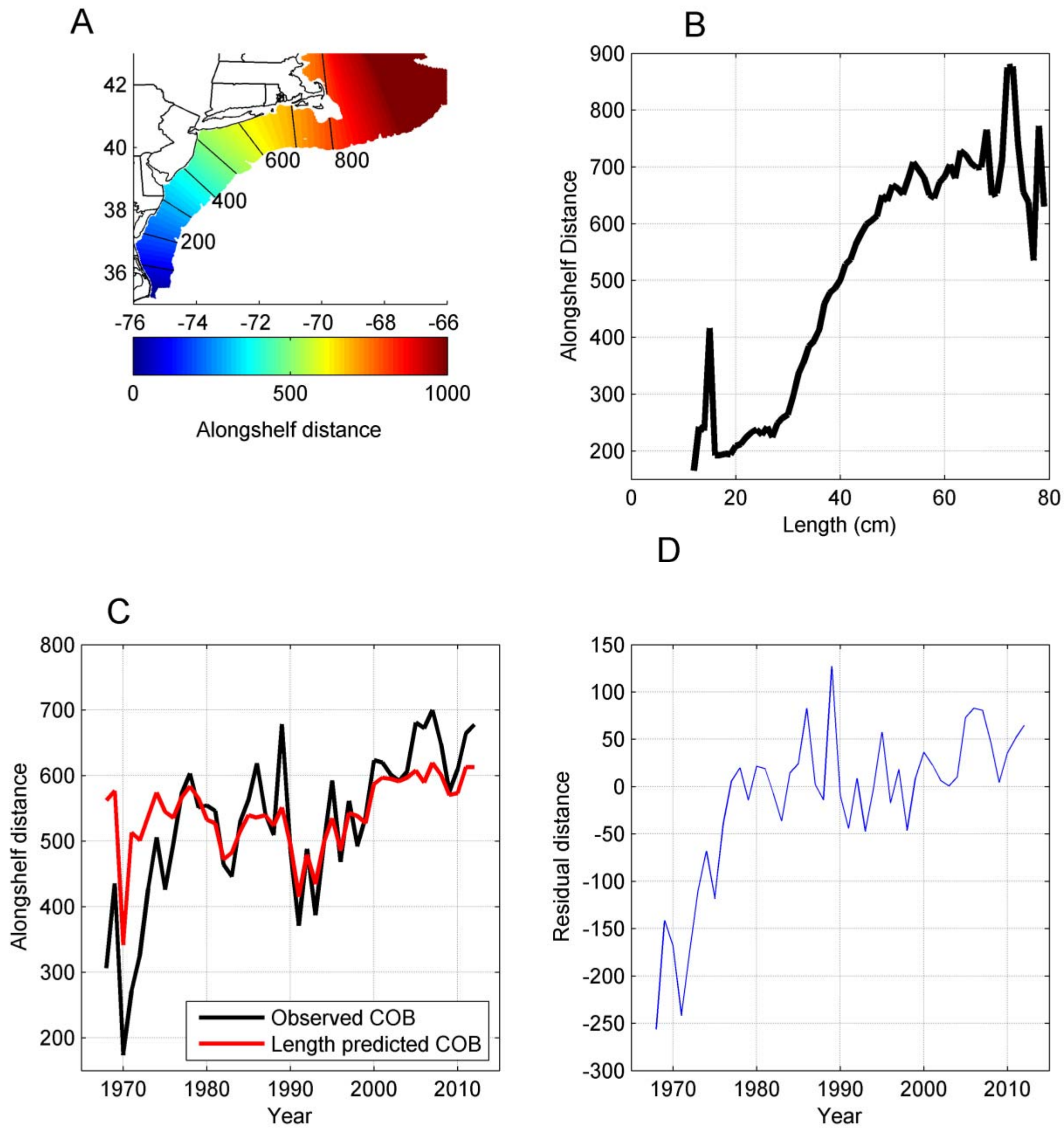


Figure A141. Alongshelf Center of Biomass of Summer Flounder on the fall trawl survey. A) Map of alongshelf positions with distances in kilometers. B) Average alongshelf center of biomass by cm length class for the 1968-2012 spring time series. C) Annual observed center of biomass on the fall trawl survey (black) and center of biomass predicted solely based on the sampled length structure for that survey and the time-series average alongshelf position by length class. D) Residuals of the observed alongshelf distance and predicted alongshelf distance by length class. The residuals correspond to the distribution shift not explained by changes in length structure.

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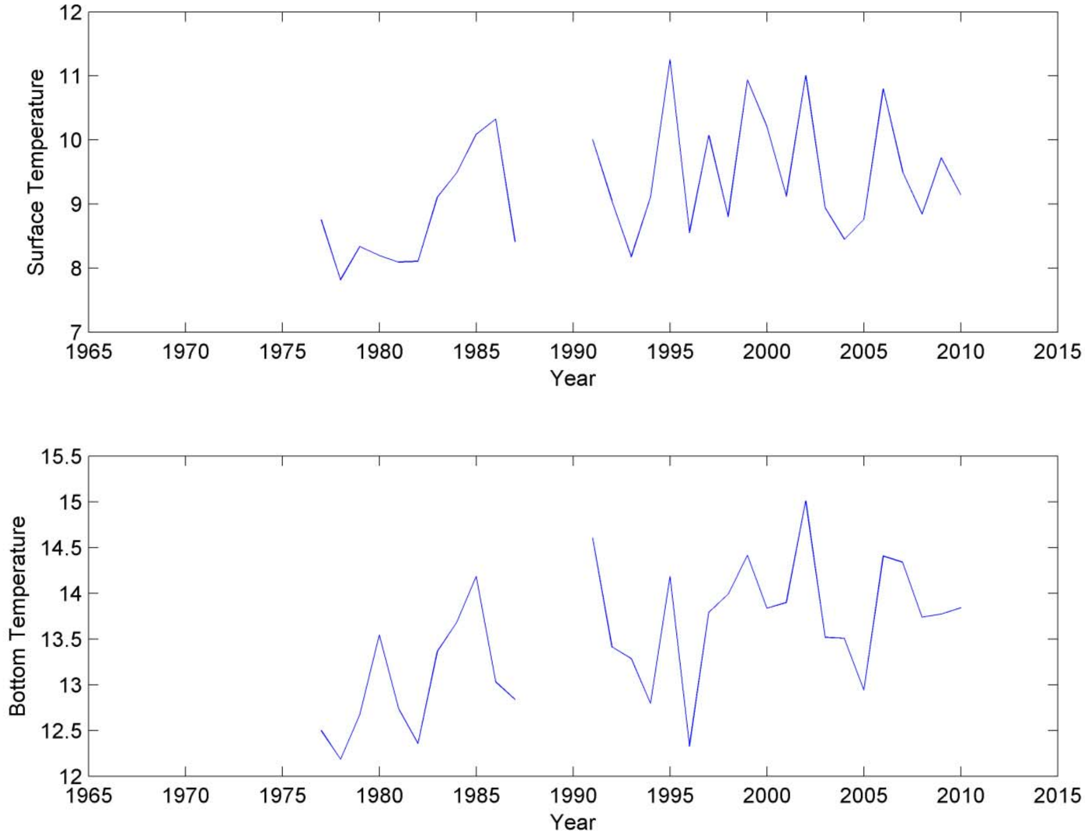


Figure A142. Annual Surface and Bottom temperatures in the Mid-Atlantic Bight

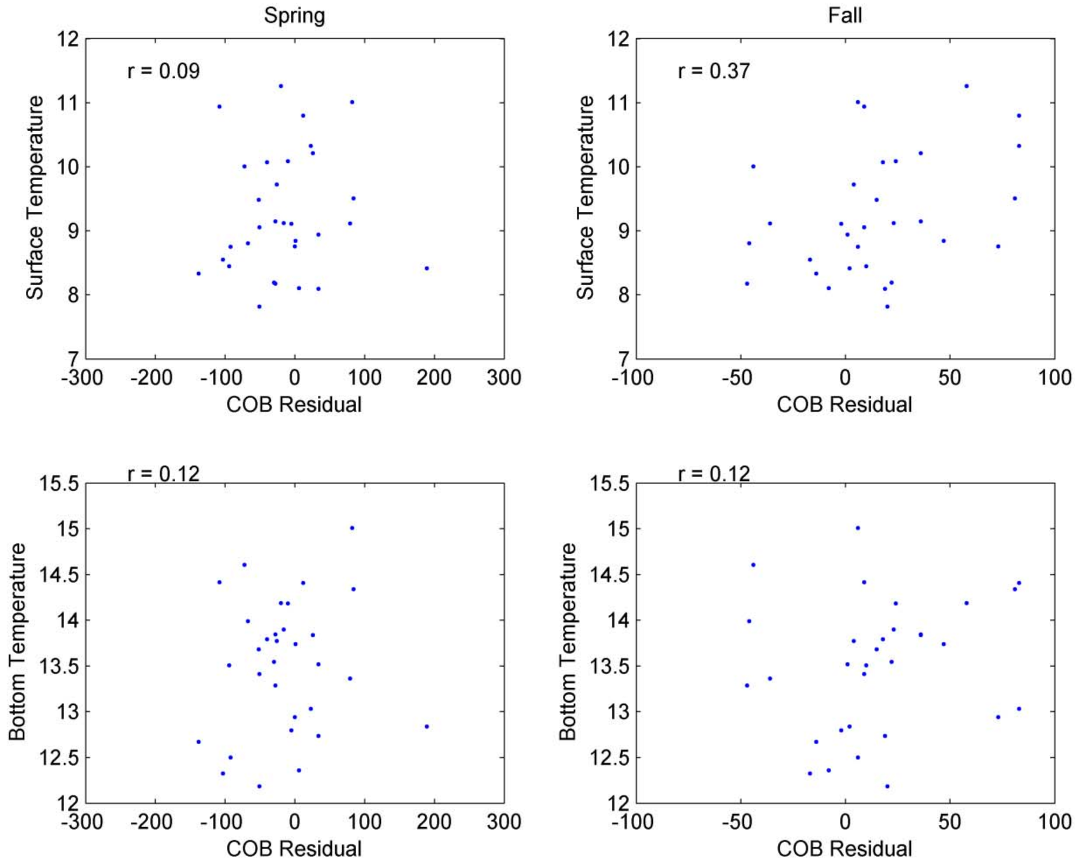


Figure A143. Regressions of the residuals of the Observed COB - Length Predicted COB versus sea surface temperature and bottom temperature for the Spring and Fall survey.

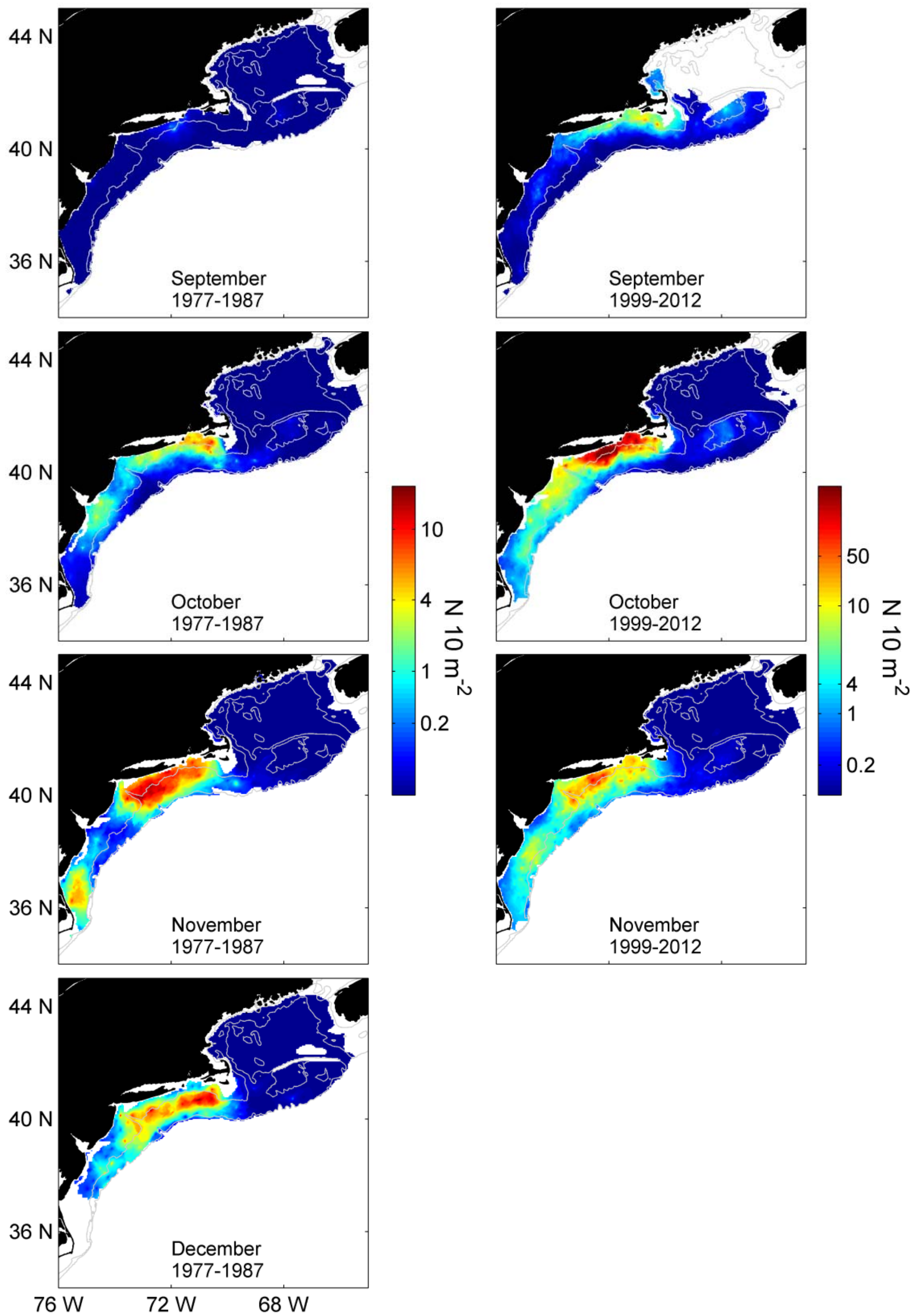


Figure A144. Seasonal summer flounder larval distributions for the MARMAP period (1977-1987) and the ECOMON period (1999-2012).

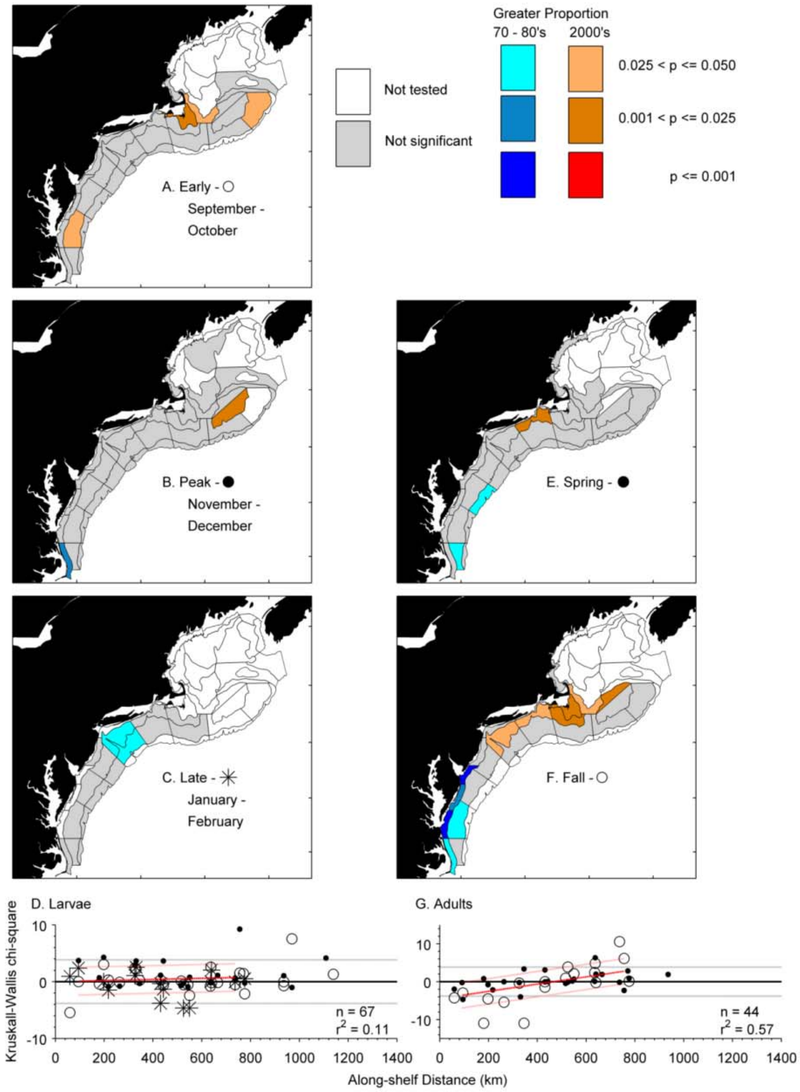


Figure A145. Change in summer flounder larval and mature adult distributions between MARMAP (1977 – 1987) and ECOMON (1999 – 2009) for early (A), peak (B), and late (C) larval seasons and the spring (E) and fall (F) bottom trawl surveys color coded to indicate significant changes in relative proportion for each stratum. Linear regressions were examined for strata (n) from all larval seasons (D) and the two trawl surveys (G) combined. The dashed red line indicates the linear regression and the dotted red lines are the 95 % confidence intervals. The black line indicates the zero line and the black dashed lines indicate significant Kruskal-Wallis H values.

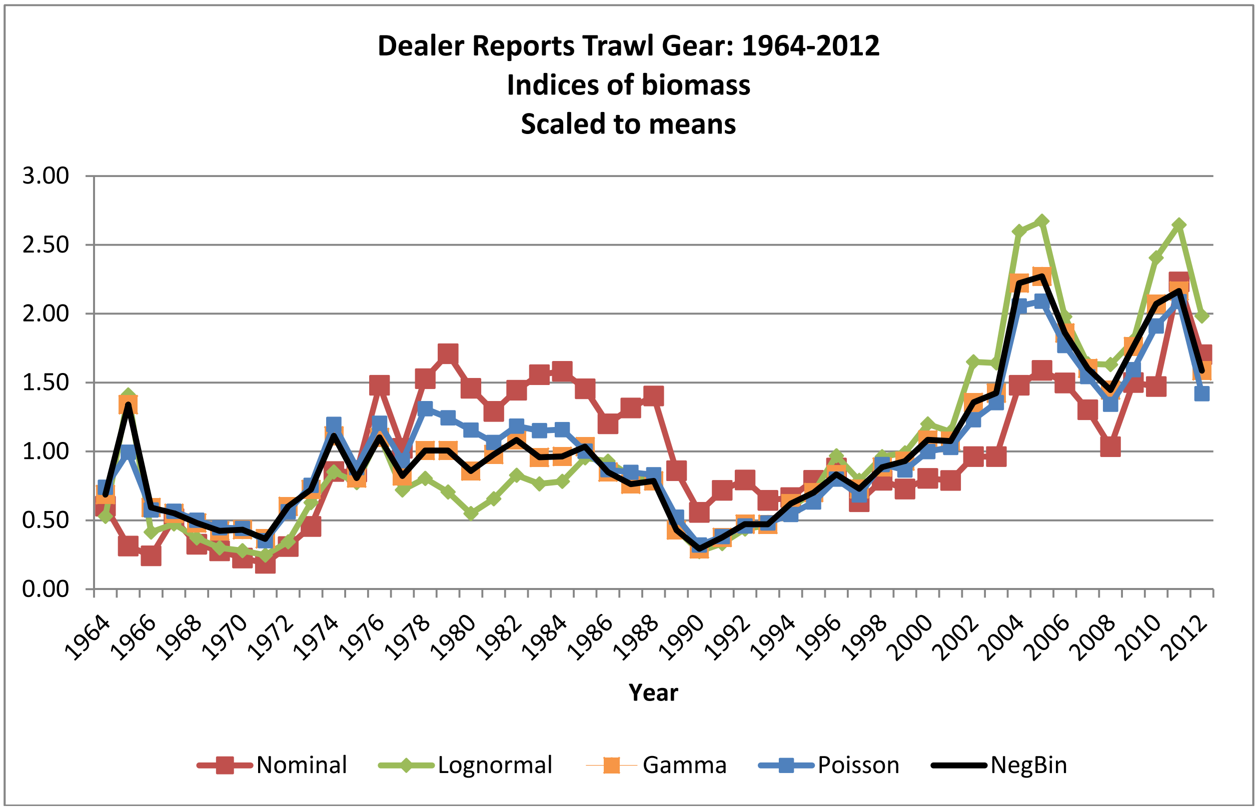


Figure A146. Comparison of the Dealer report trawl gear landings and effort nominal index and model-based standardized indices.

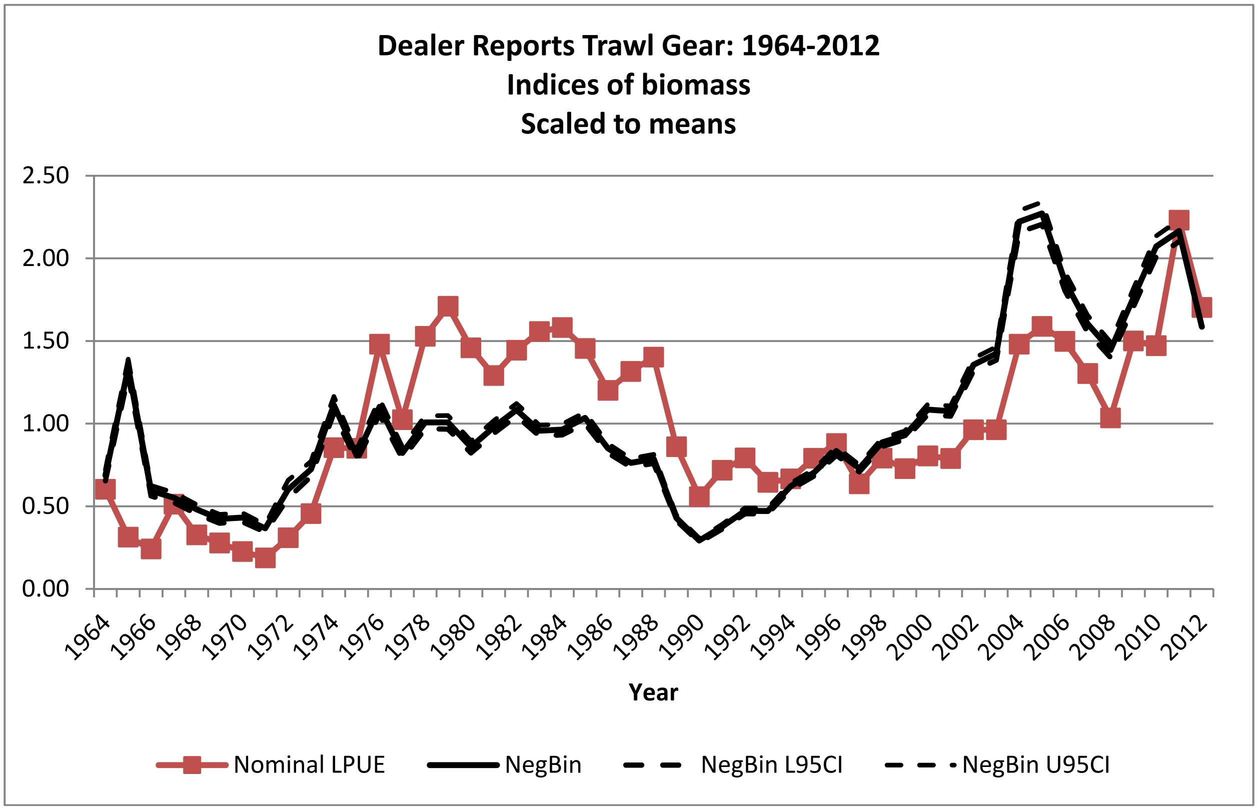


Figure A147. Comparison of the Dealer report trawl gear landings and effort nominal index and negbin model-based standardized index and 95% confidence intervals.

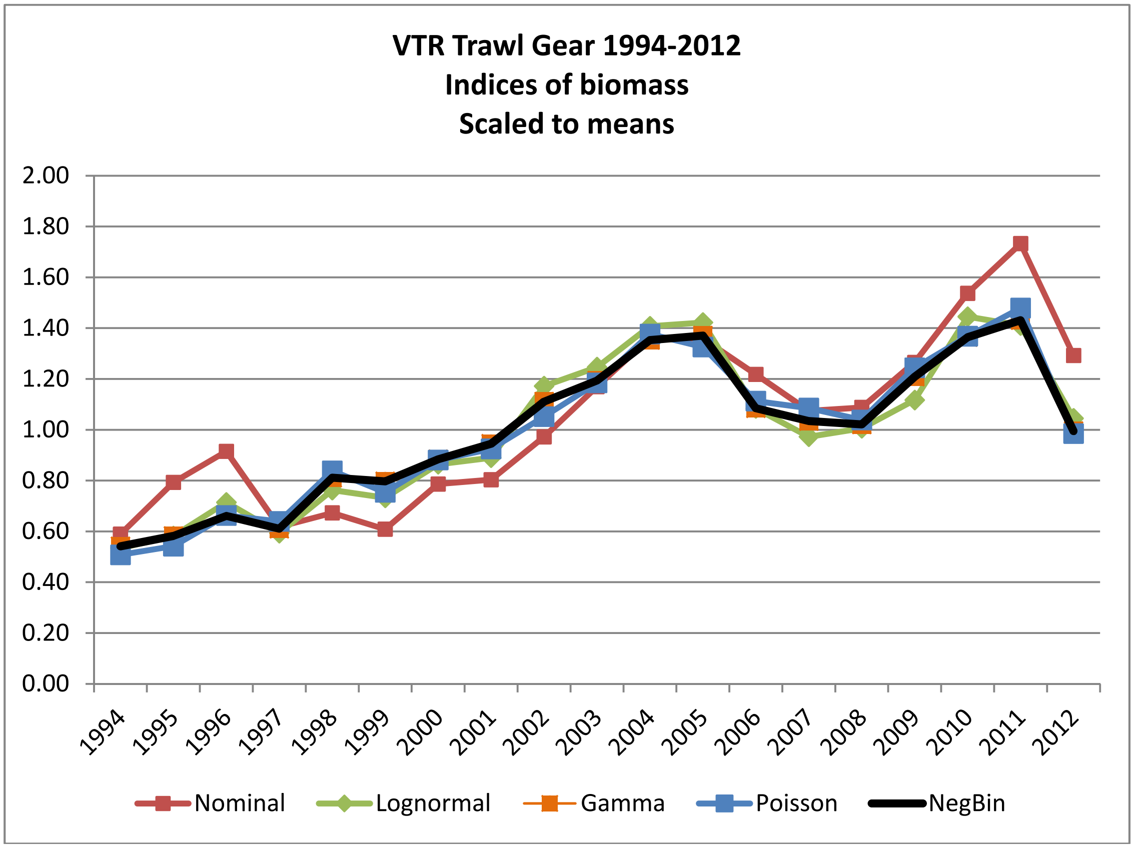


Figure A148. Comparison of the VTR trawl gear catch and effort nominal index and model-based standardized indices.

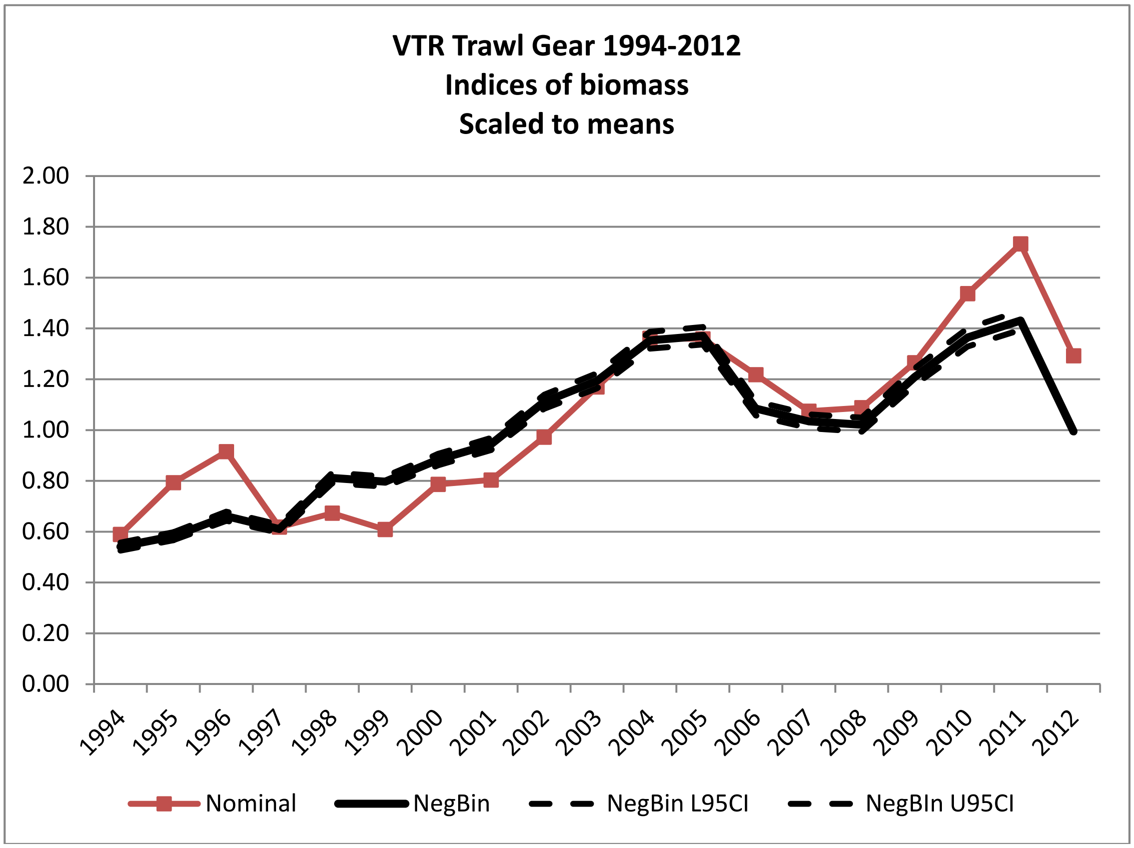


Figure A149. Comparison of the VTR trawl gear landings and effort nominal index and negbin model-based standardized index and 95% confidence intervals.

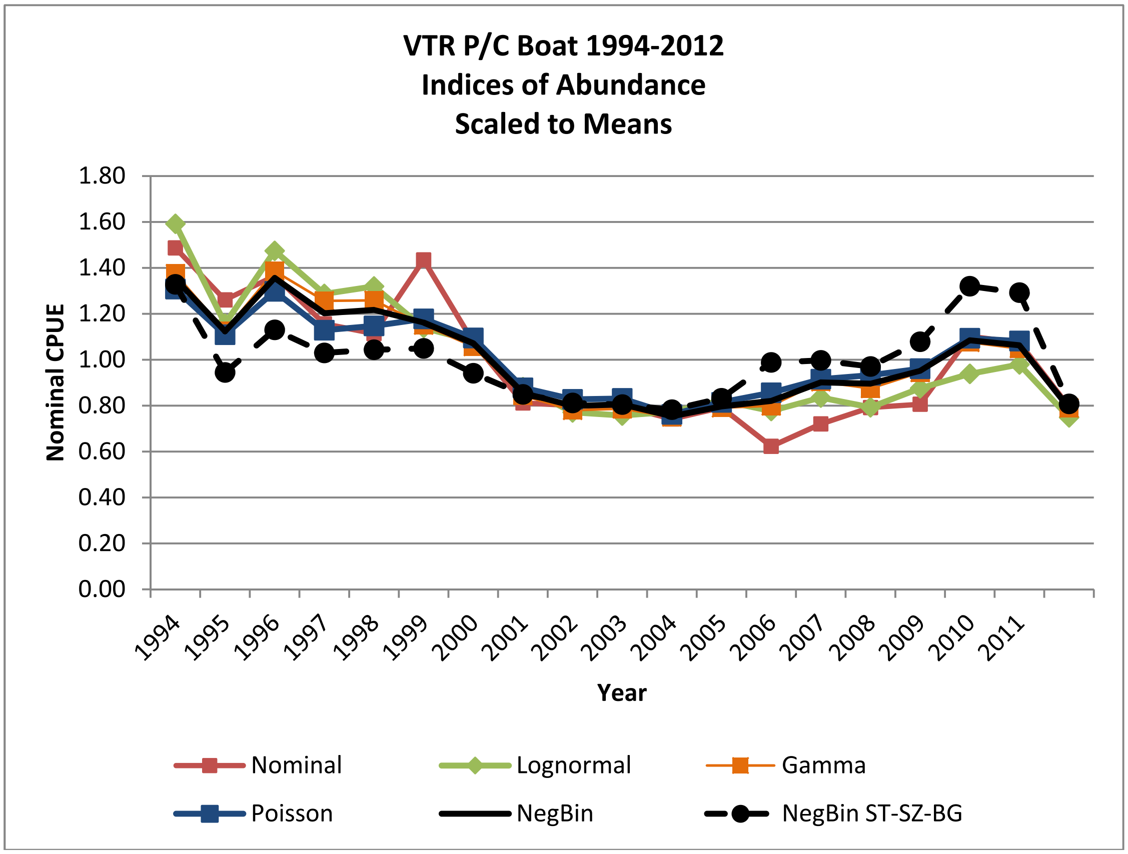


Figure A150. Comparison of the VTR Party/Charter boat nominal index and model-based standardized indices.

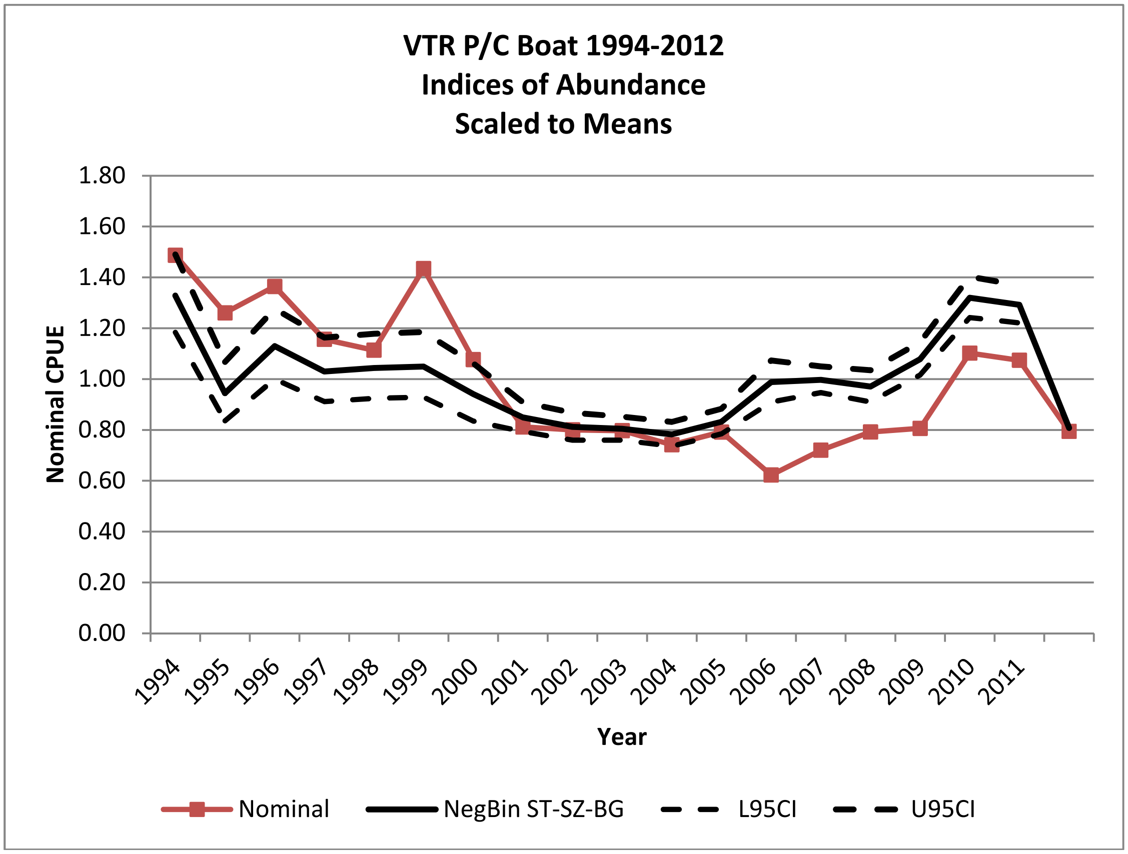


Figure A151. Comparison of the negbin six-factor ST-SZ-BG model-based indices and the nominal index.

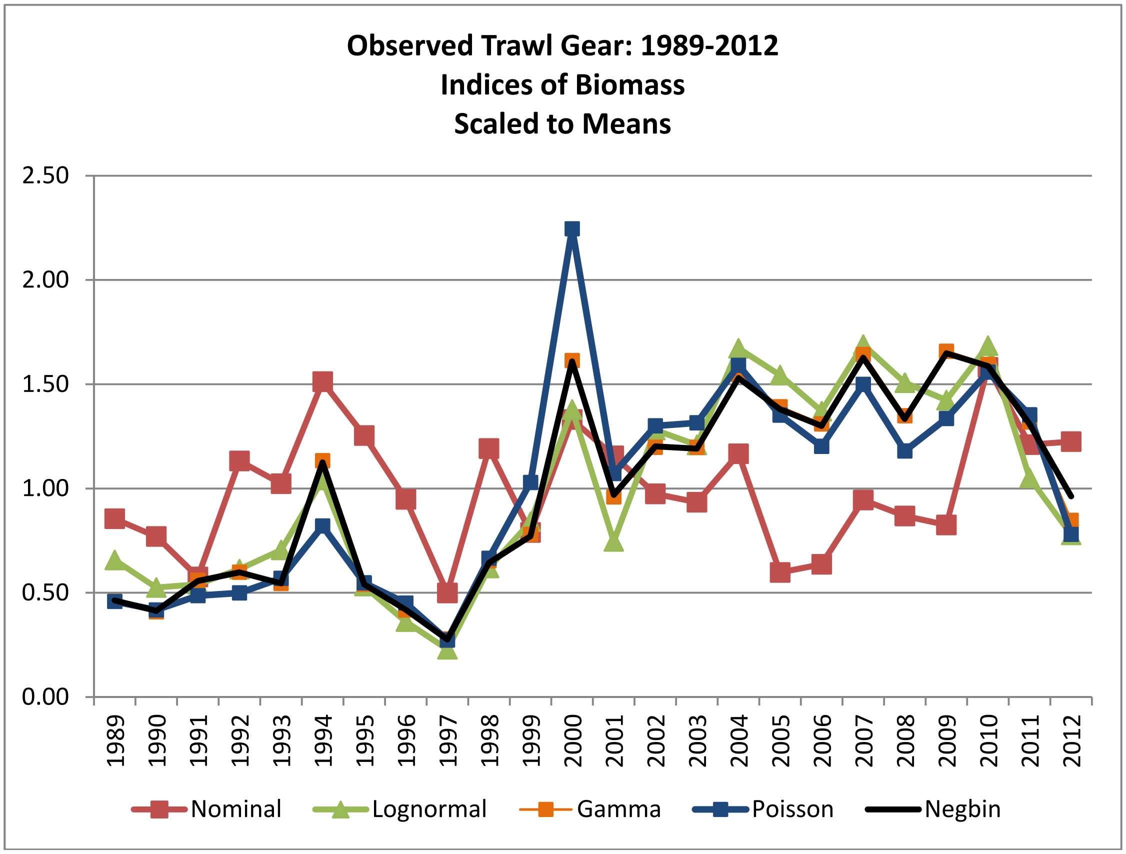


Figure A152. Comparison of the Observed trawl gear nominal index and model-based standardized indices.

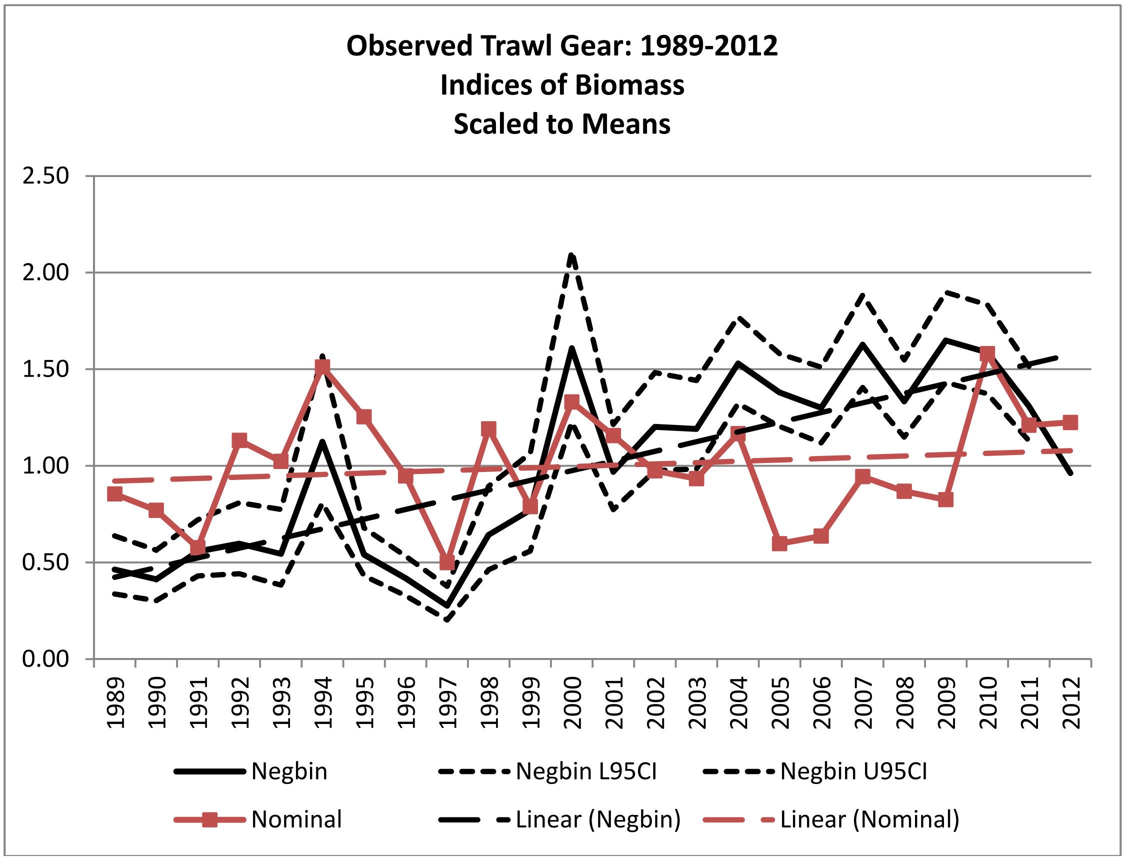


Figure A153. Comparison of the Observed trawl gear negbin model-based index and the nominal index.

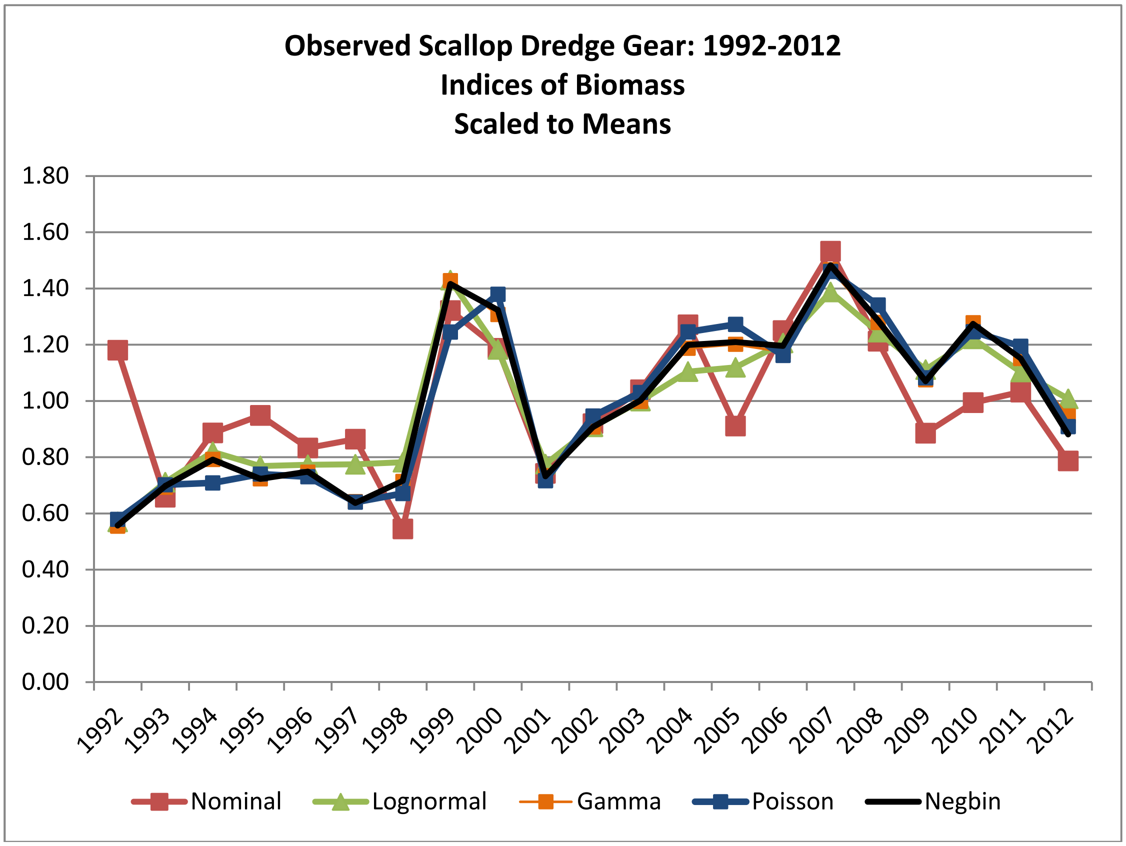


Figure A154. Comparison of the Observed scallop dredge nominal index and model-based standardized indices.

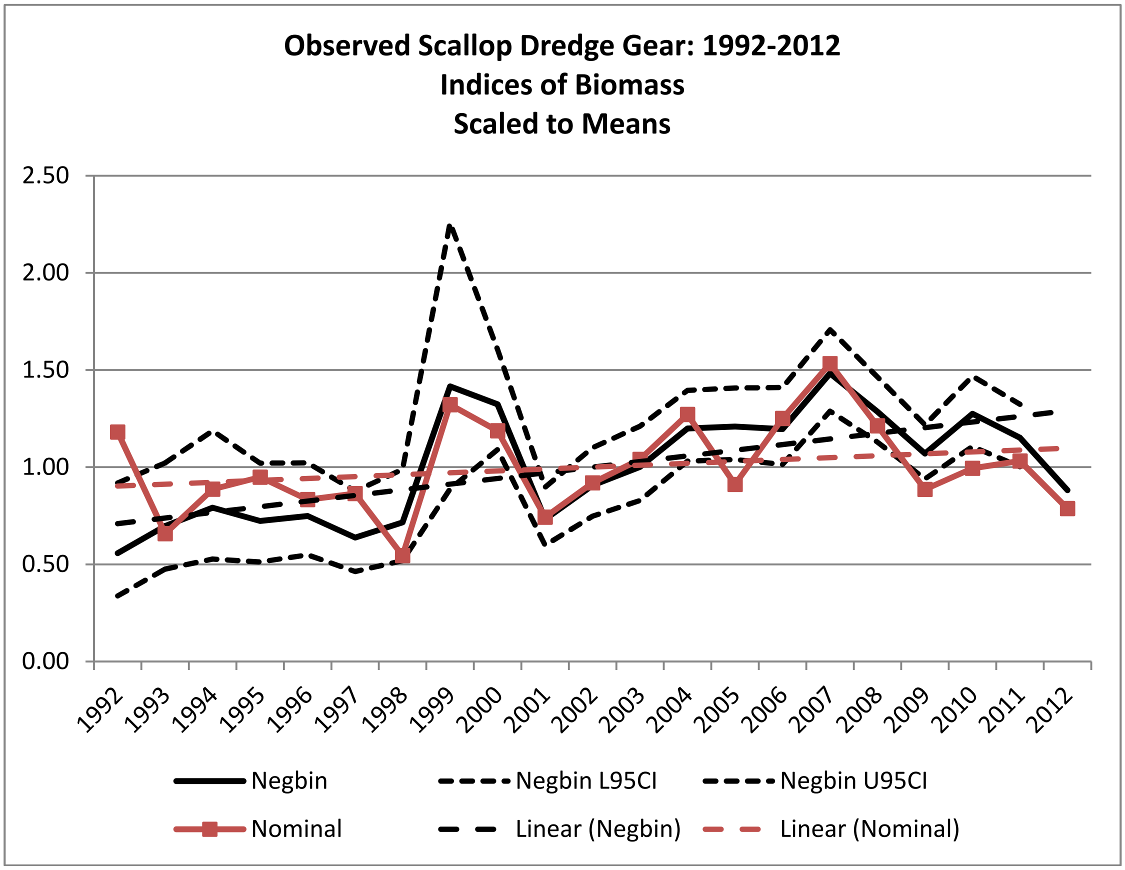


Figure A155. Comparison of the Observed scallop dredge negbin model-based index and the nominal index.

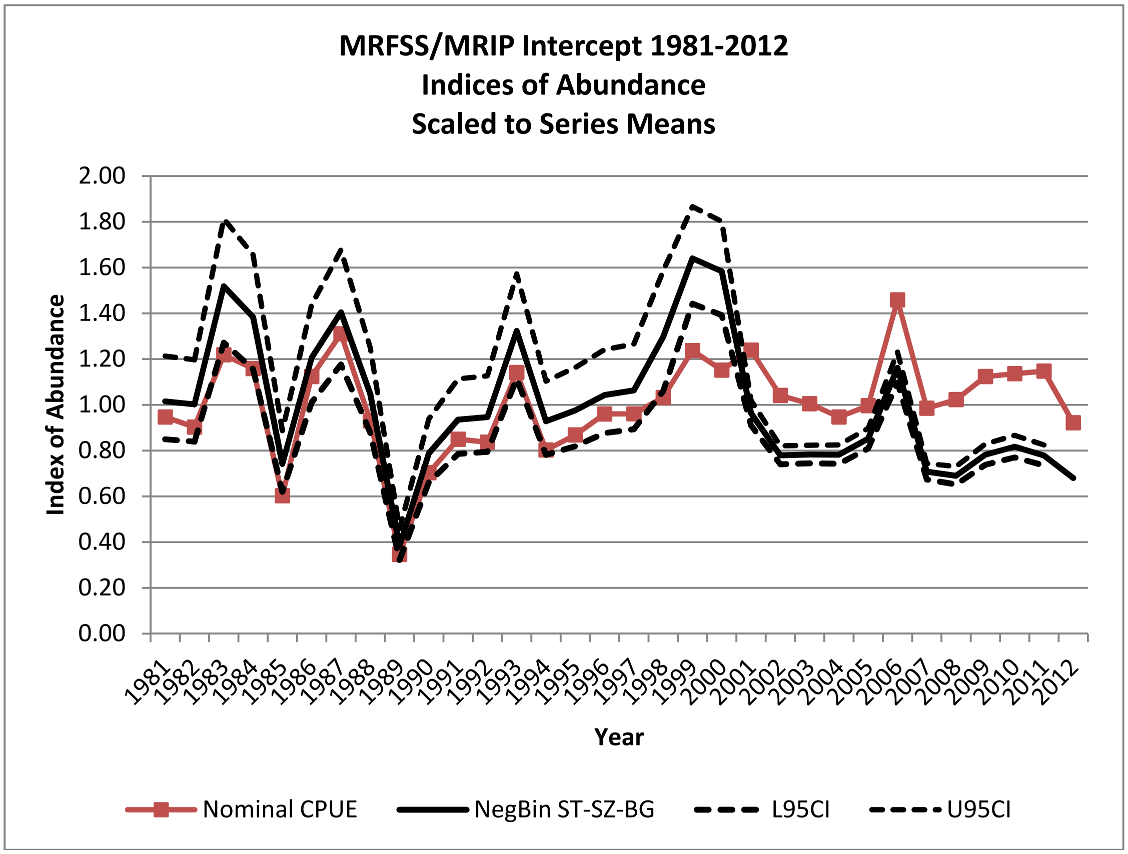


Figure A156. Comparison of the MRFSS/MRIP intercept negbin six-factor ST-SZ-BG model-based indices and the nominal index.

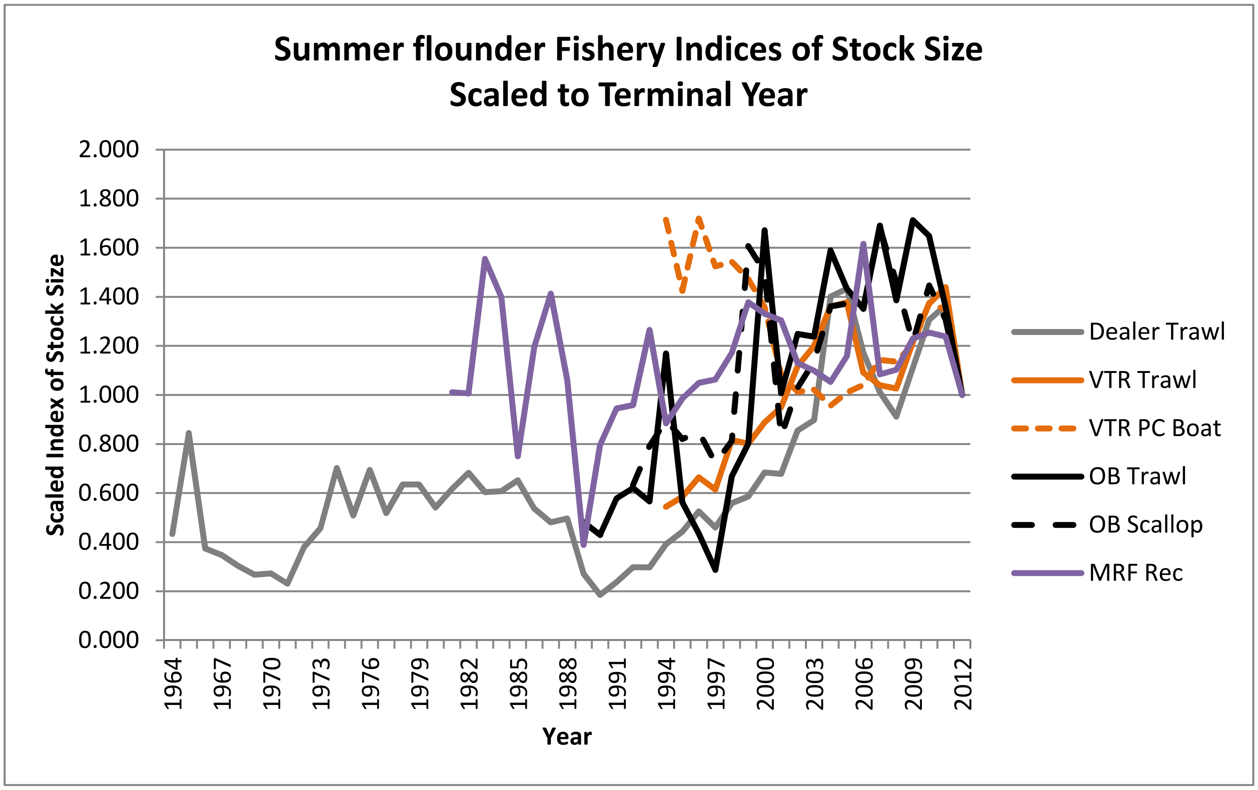


Figure A157. Trends in fishery dependent standardized indices of summer flounder stock size, scaled to the terminal year (2012) to facilitate comparison.

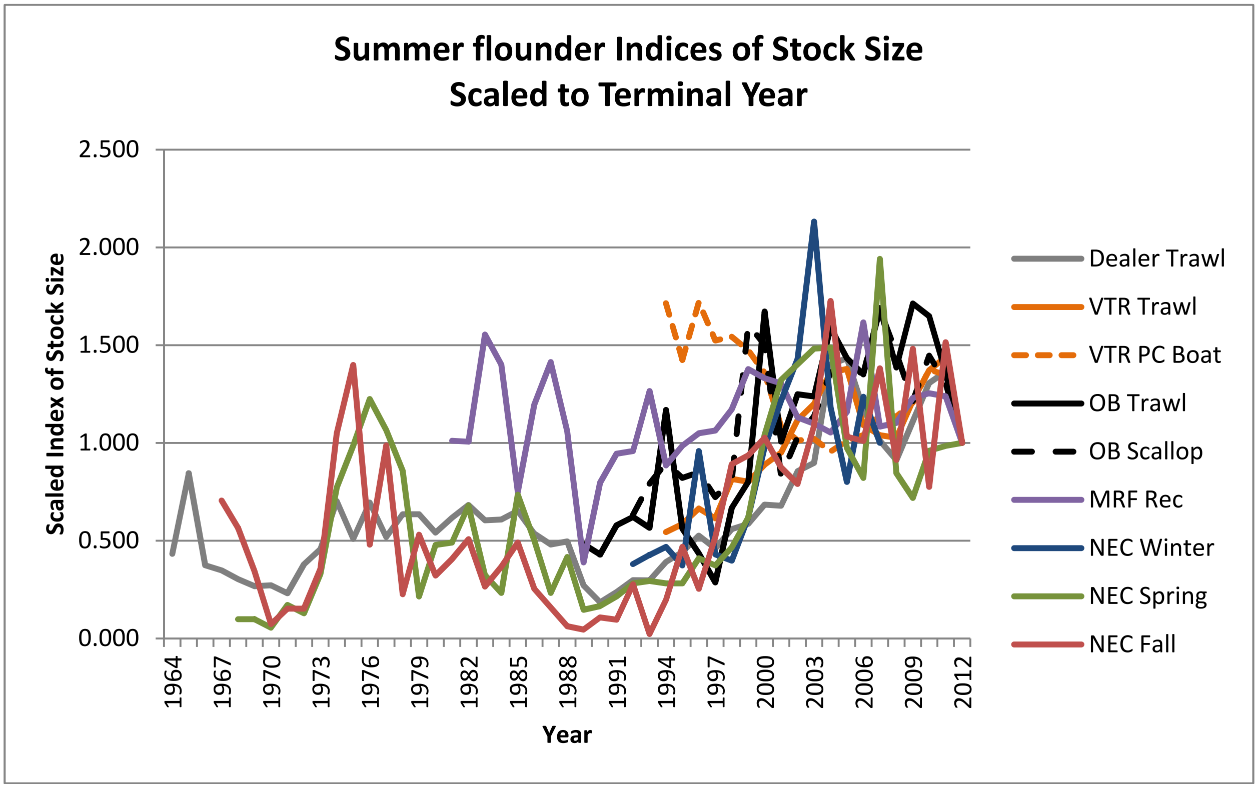


Figure A158. Trends in indices of summer flounder stock size, (including the three NEFSC seasonal trawl surveys, scaled to the terminal year (2012) to facilitate comparison.

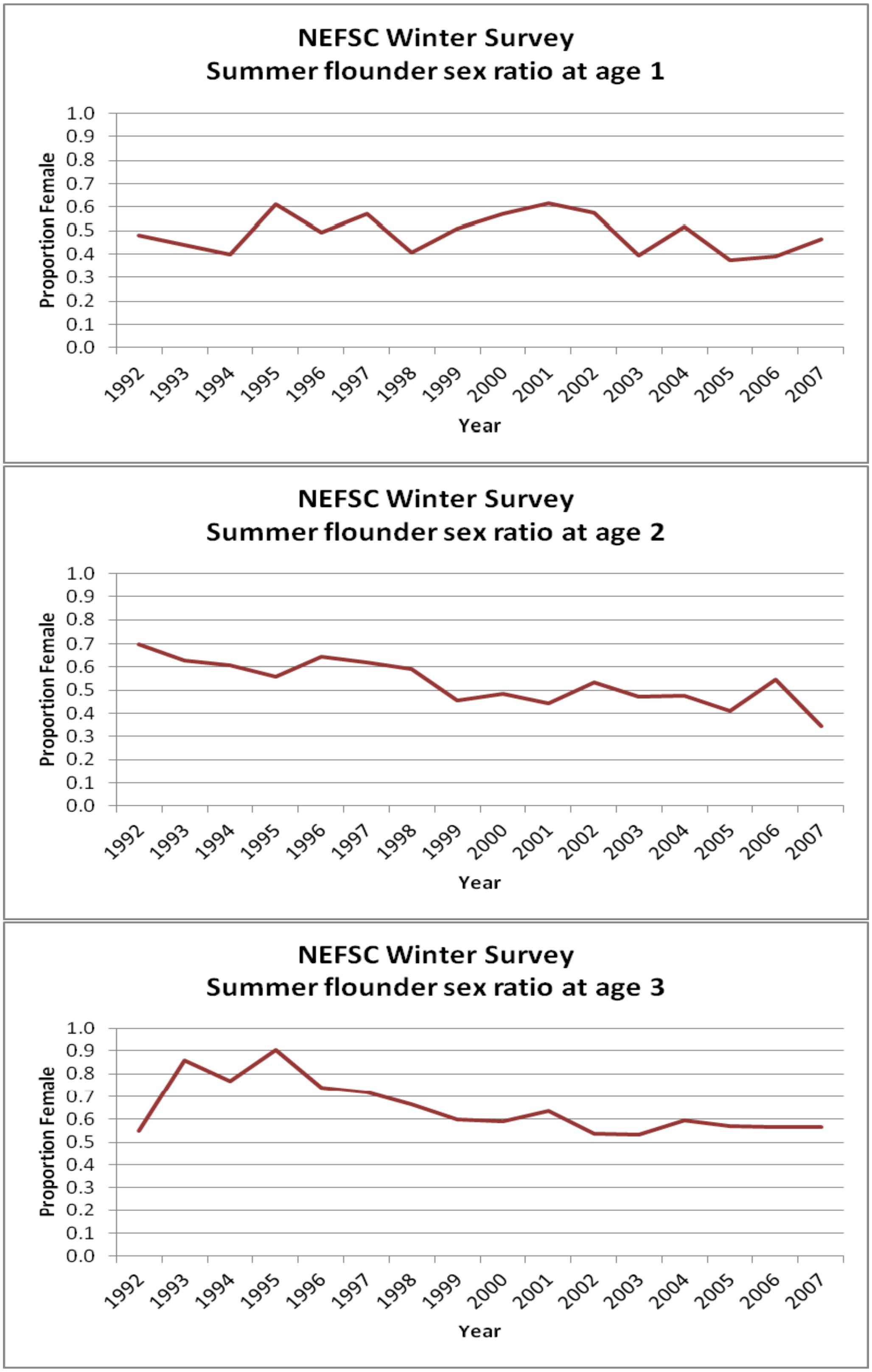


Figure A159. NEFSC winter survey: proportion female at ages 1-3.

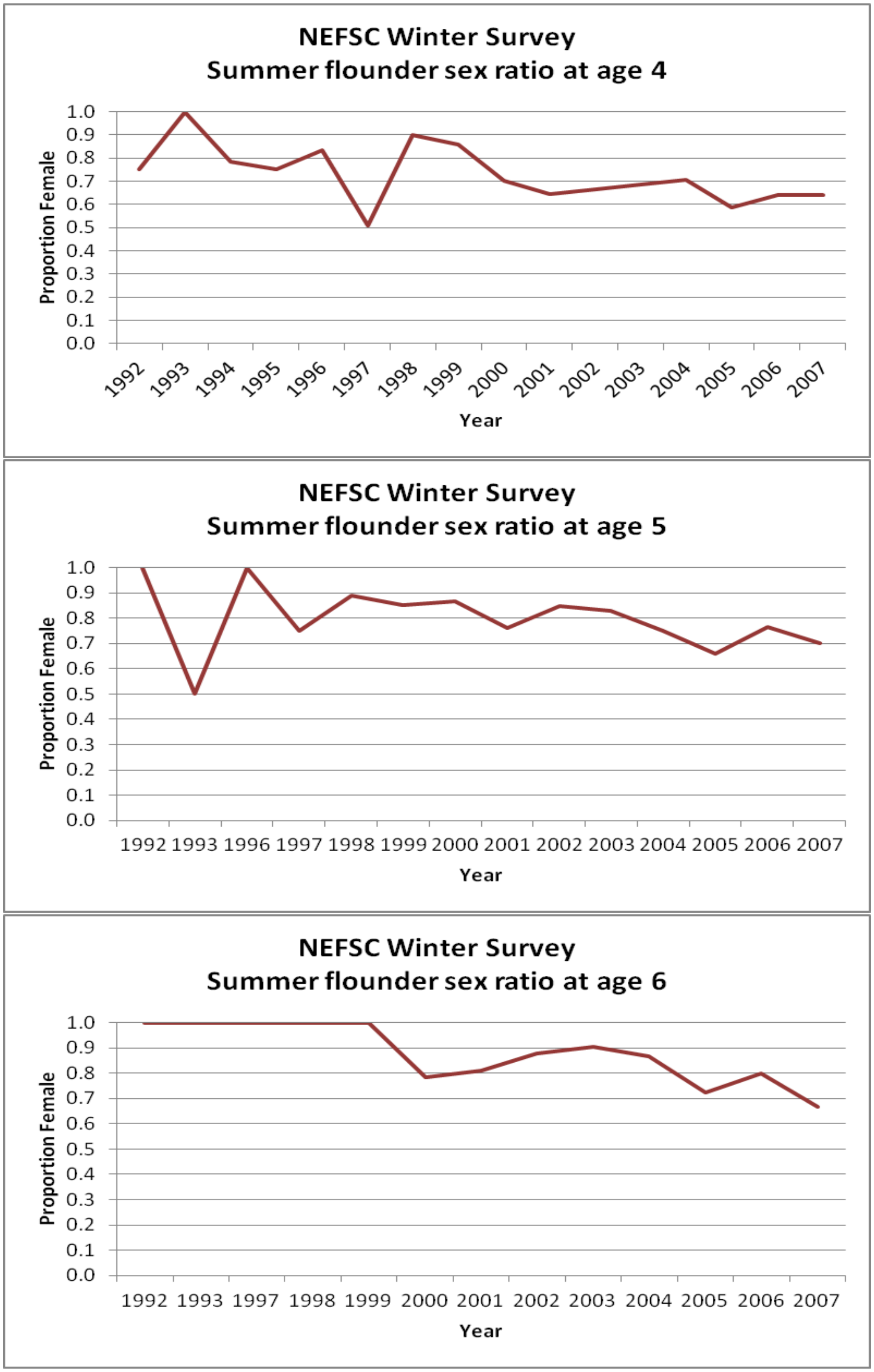


Figure A160. NEFSC winter survey: proportion female at ages 4-6.

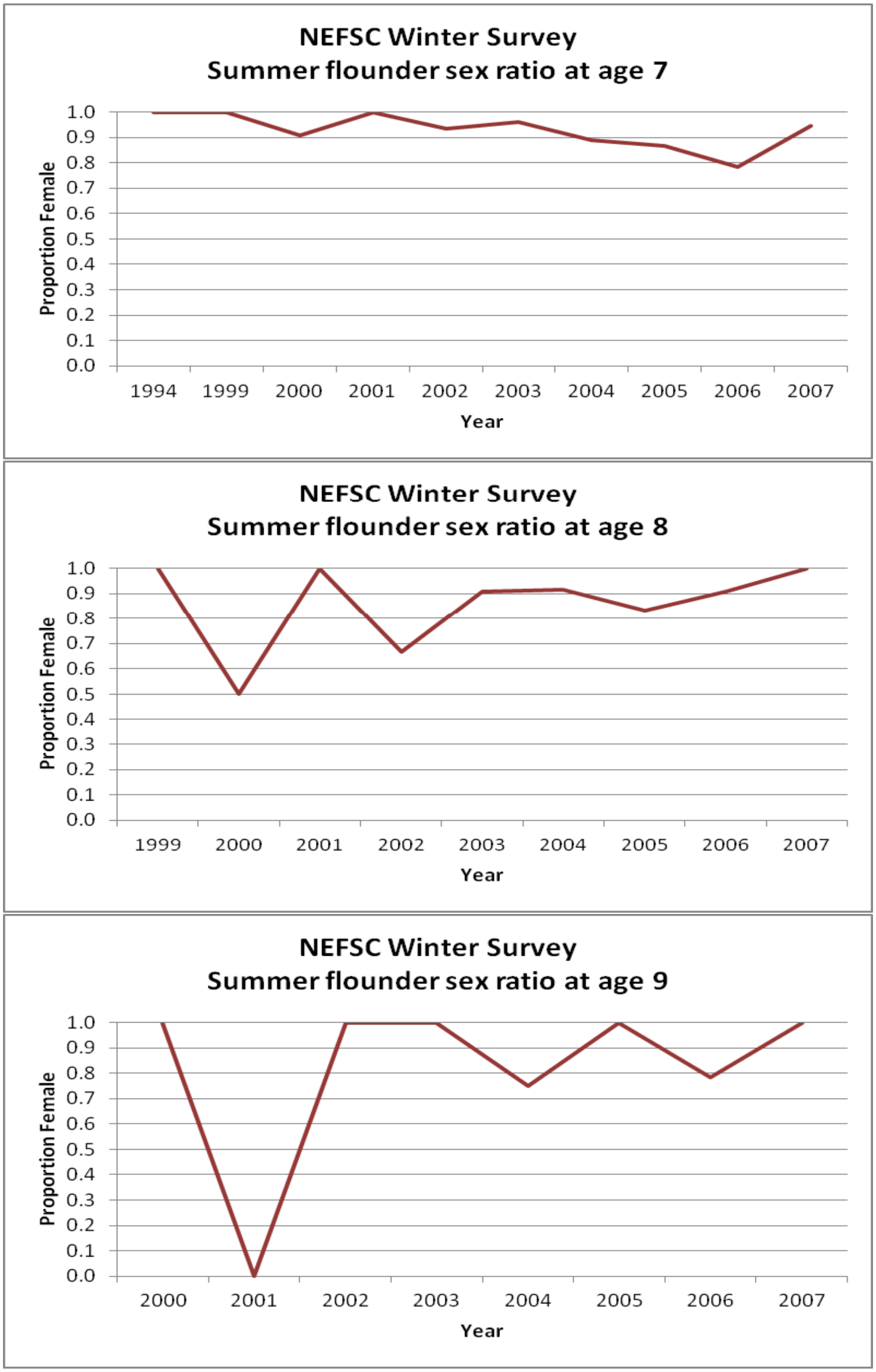


Figure A161. NEFSC winter survey: proportion female at ages 7-9.

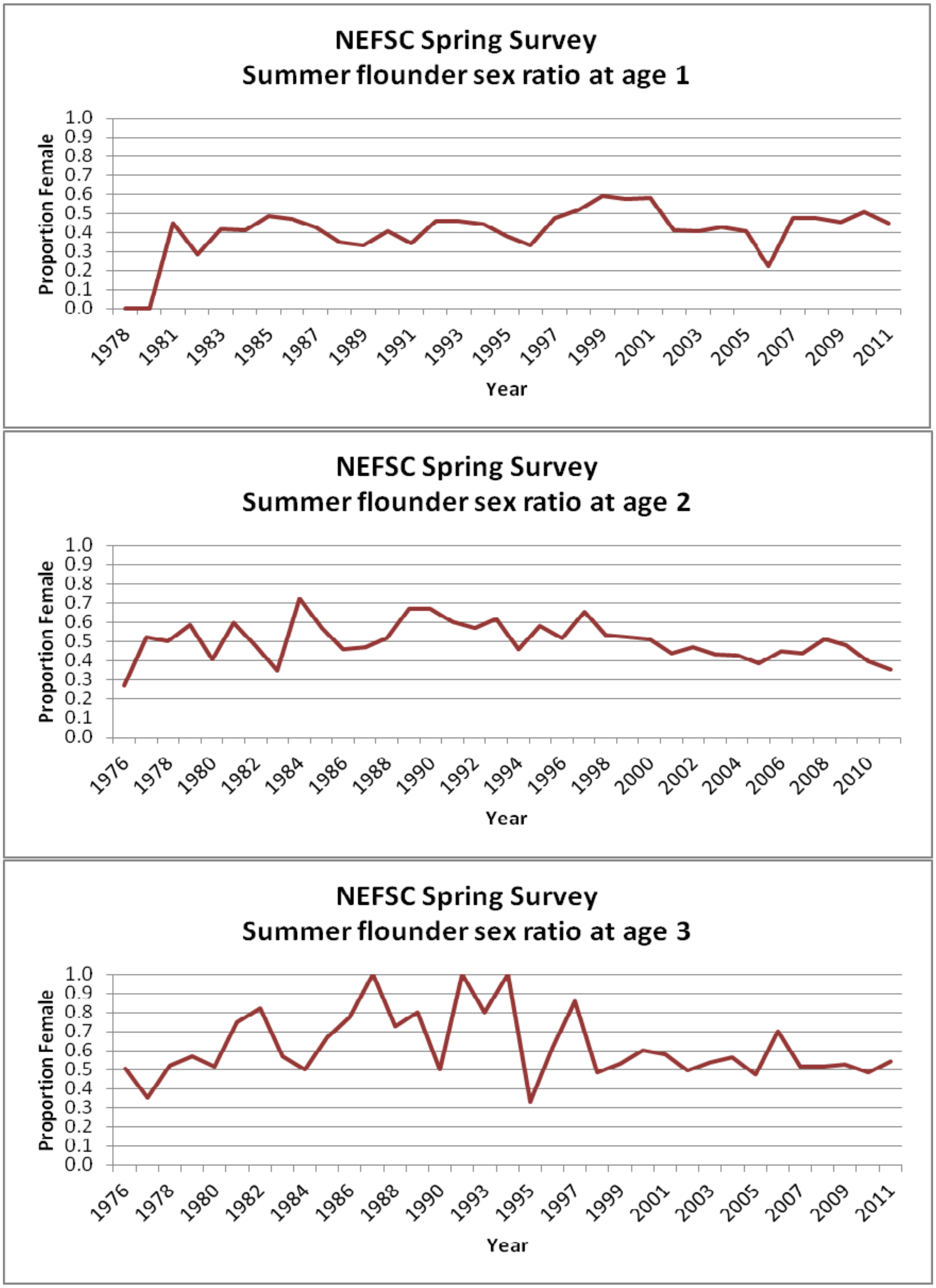


Figure A162: NEFSC spring survey: proportion female at ages 1-3.

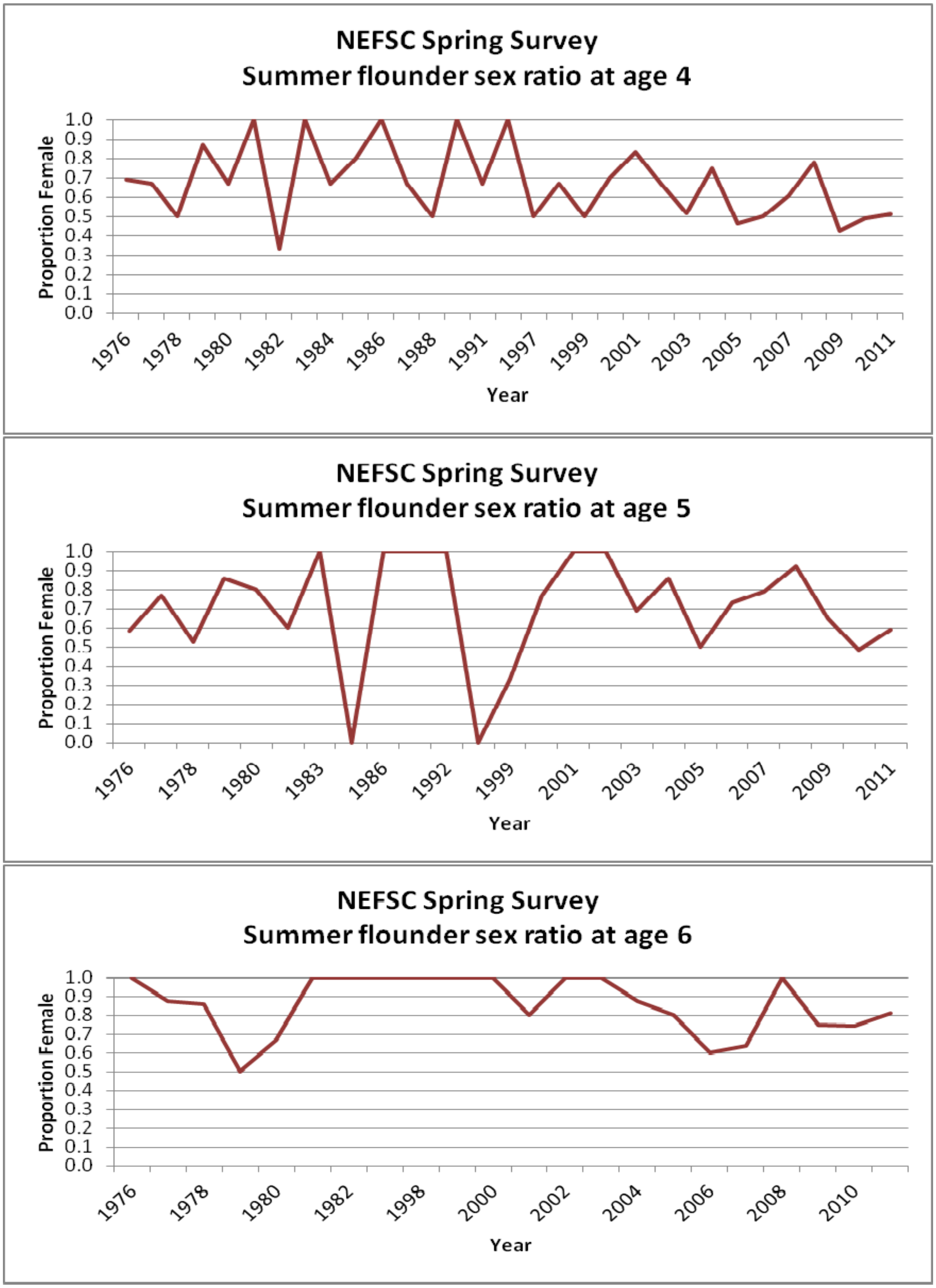


Figure A163: NEFSC spring survey: proportion female at ages 4-6.

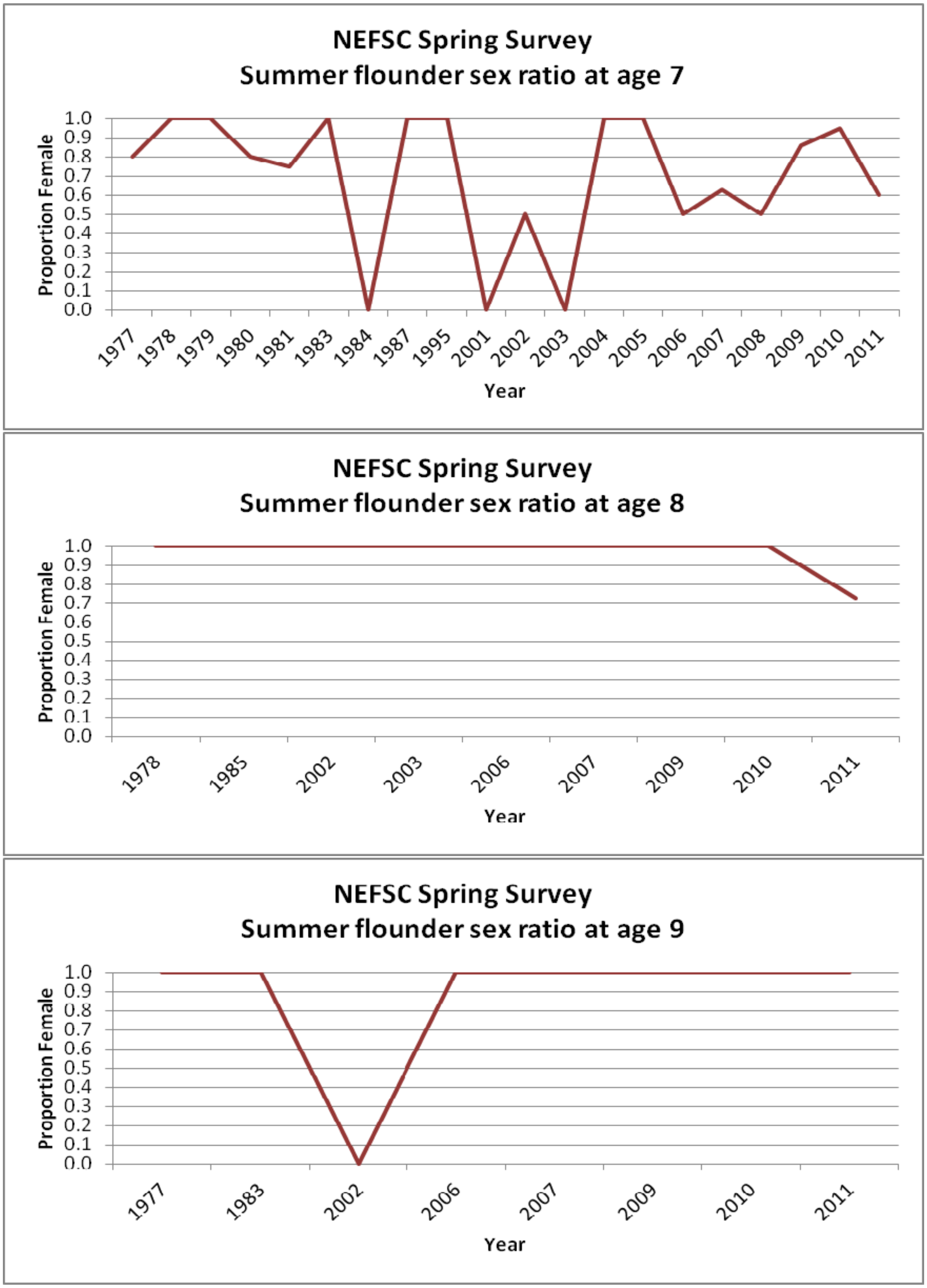


Figure A164: NEFSC spring survey: proportion female at ages 7-9.

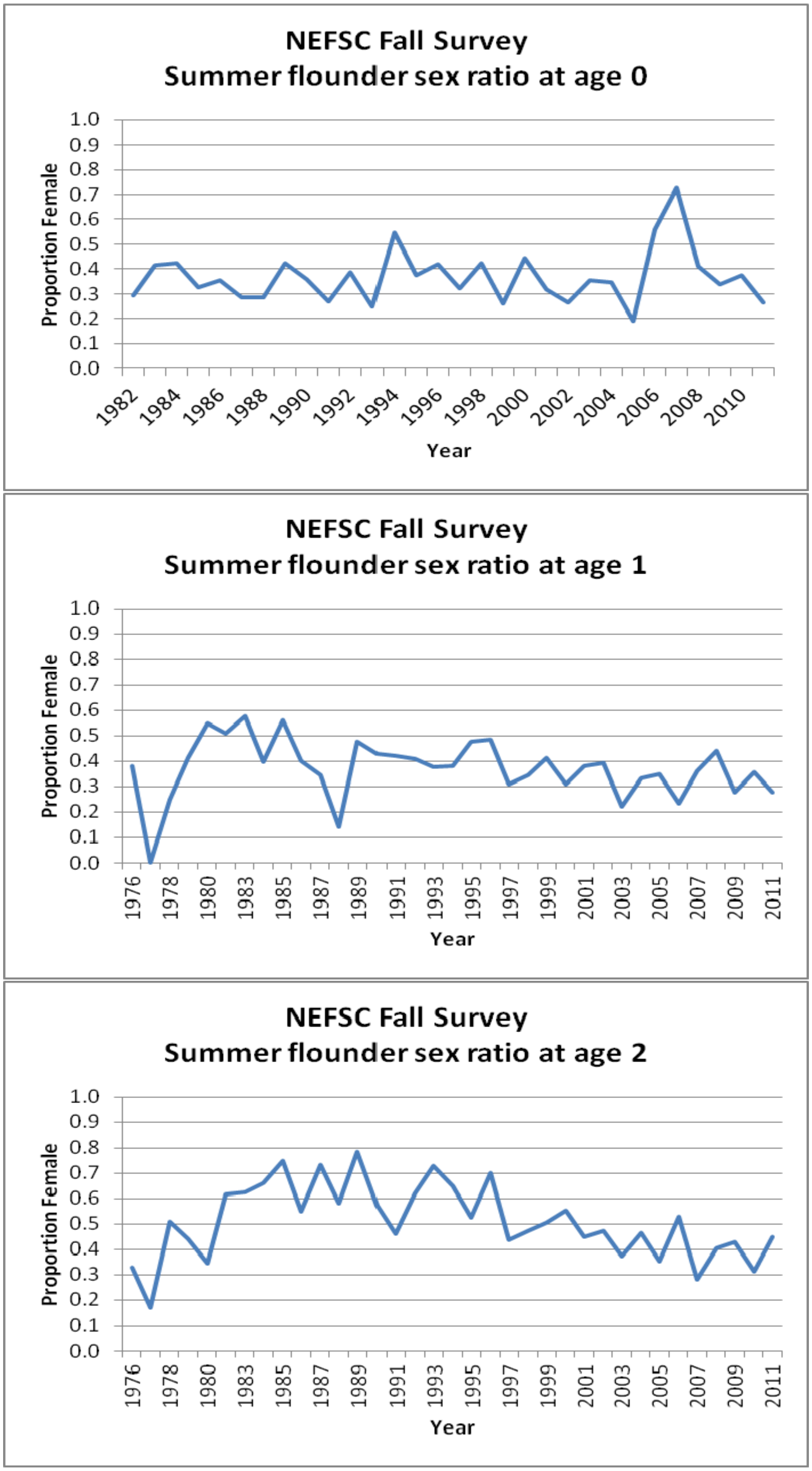


Figure A165: NEFSC fall survey: proportion female at ages 0-2.

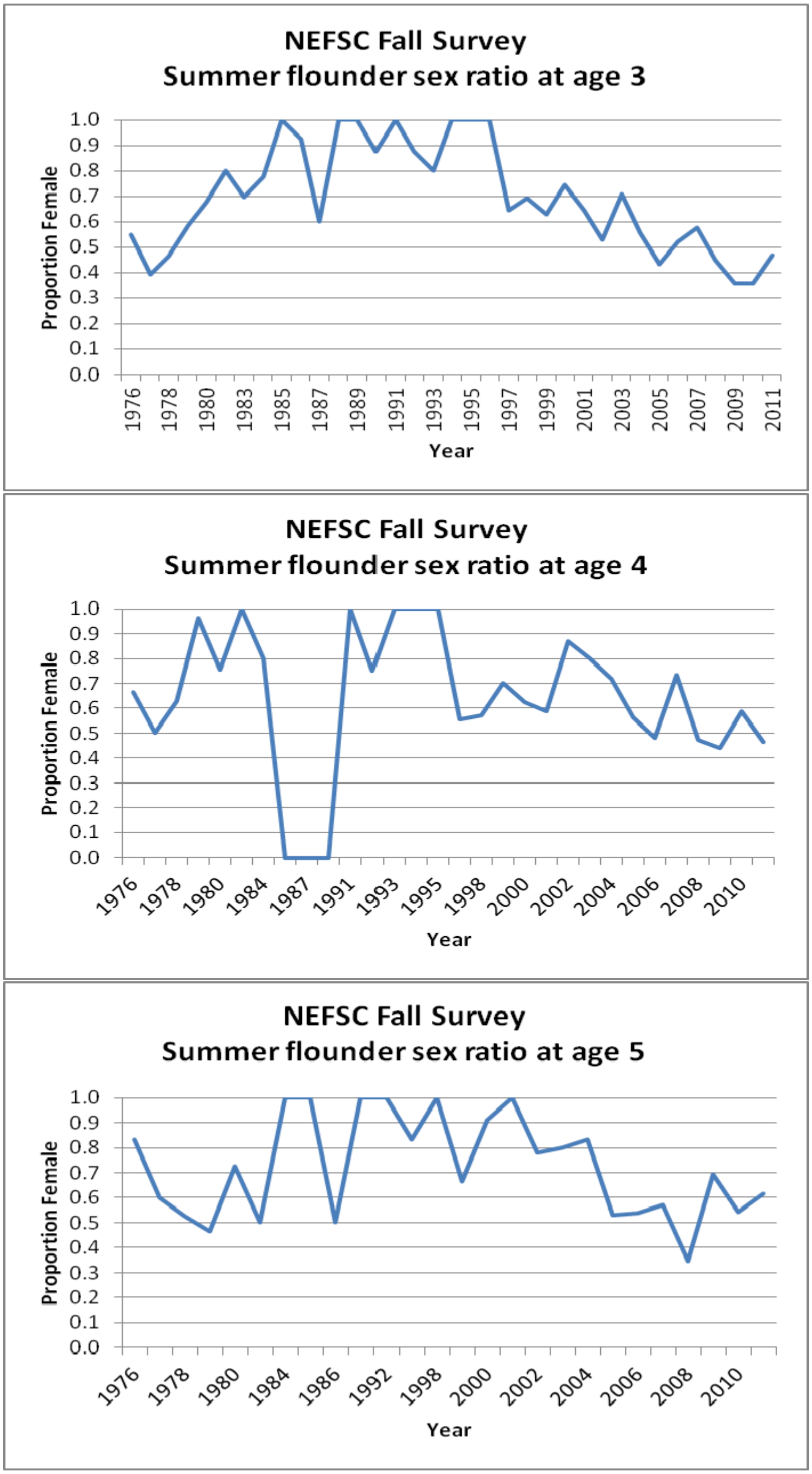


Figure A166: NEFSC fall survey: proportion female at ages 3-5.

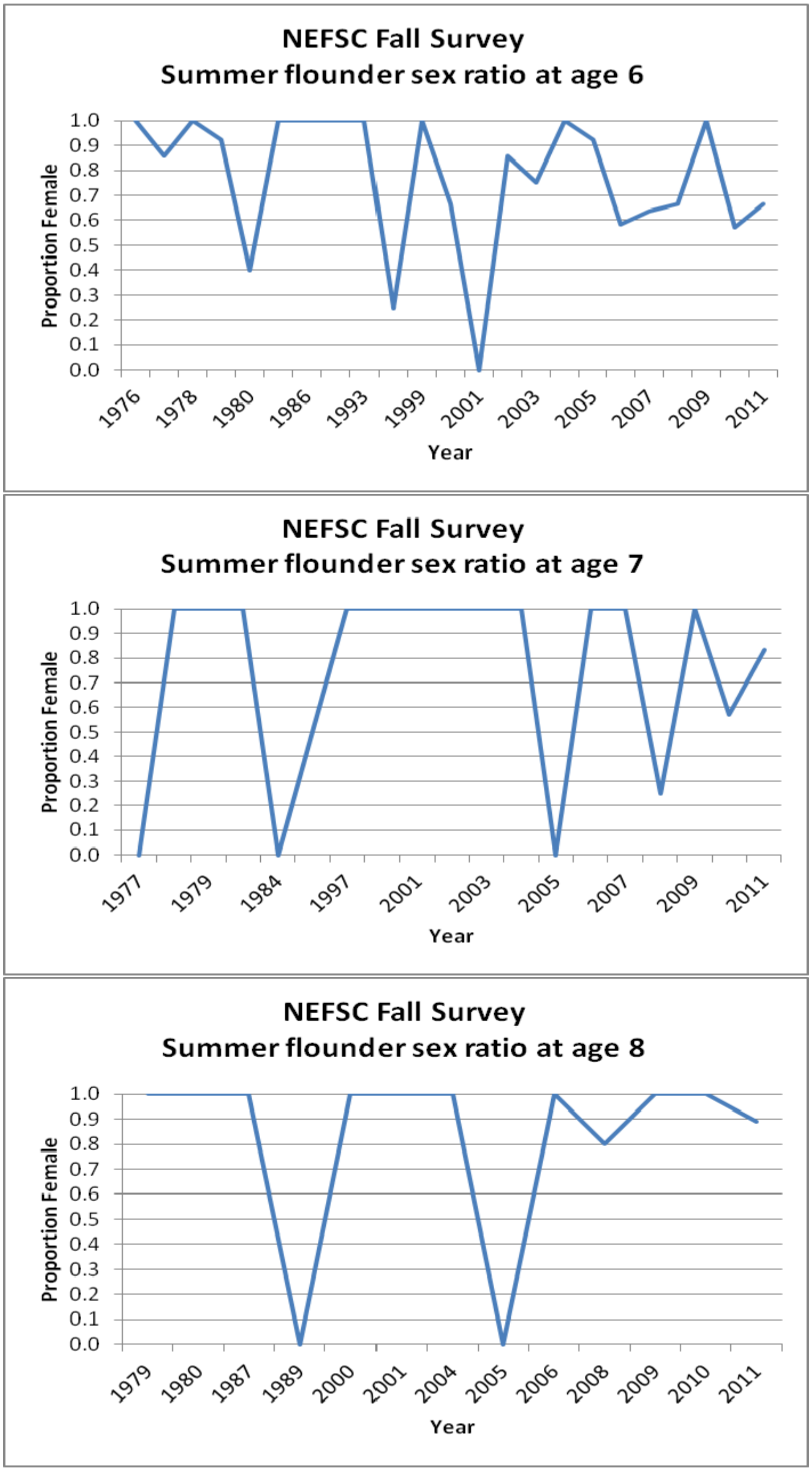
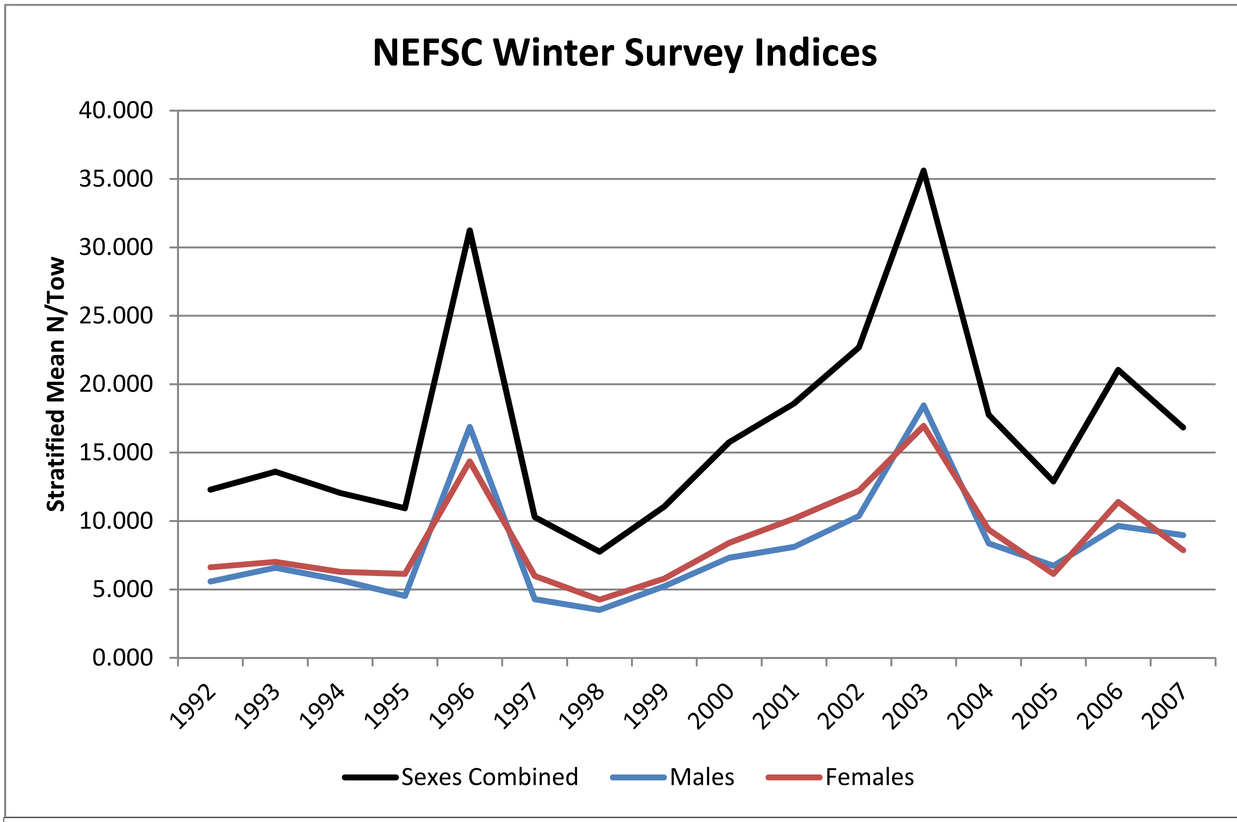


Figure A167: NEFSC fall survey: proportion female at ages 6-8.



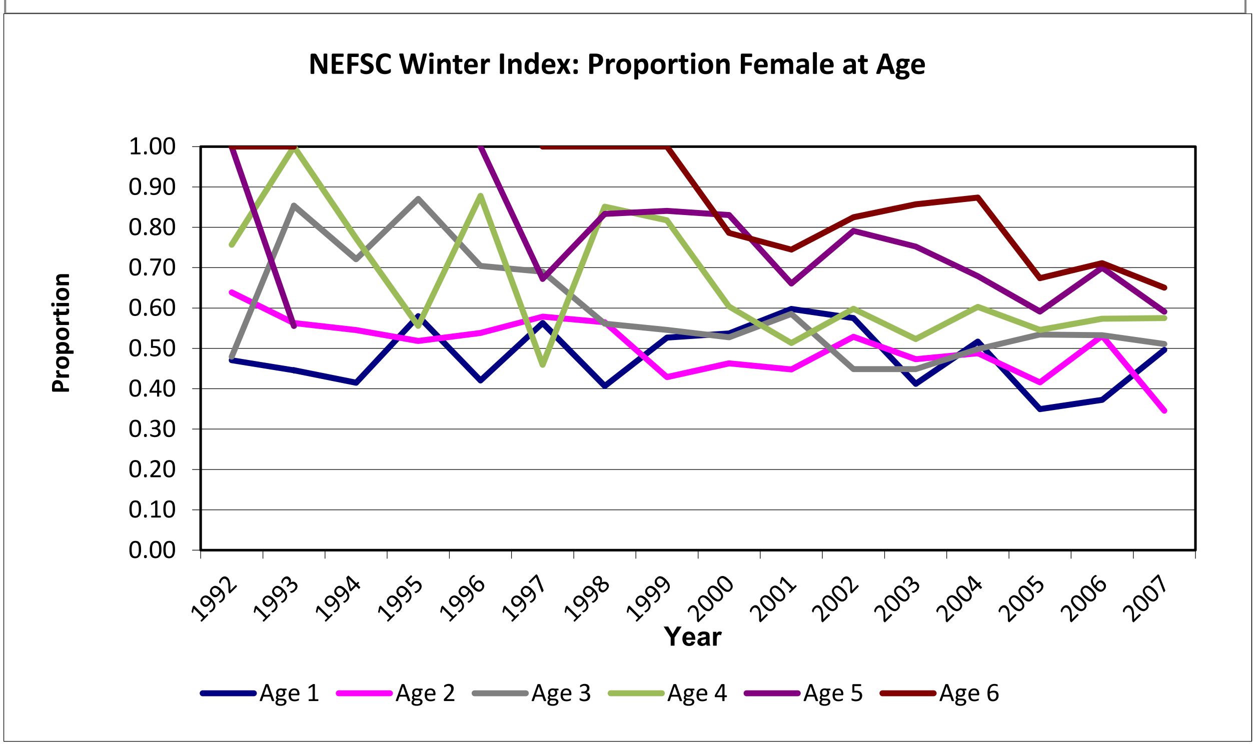
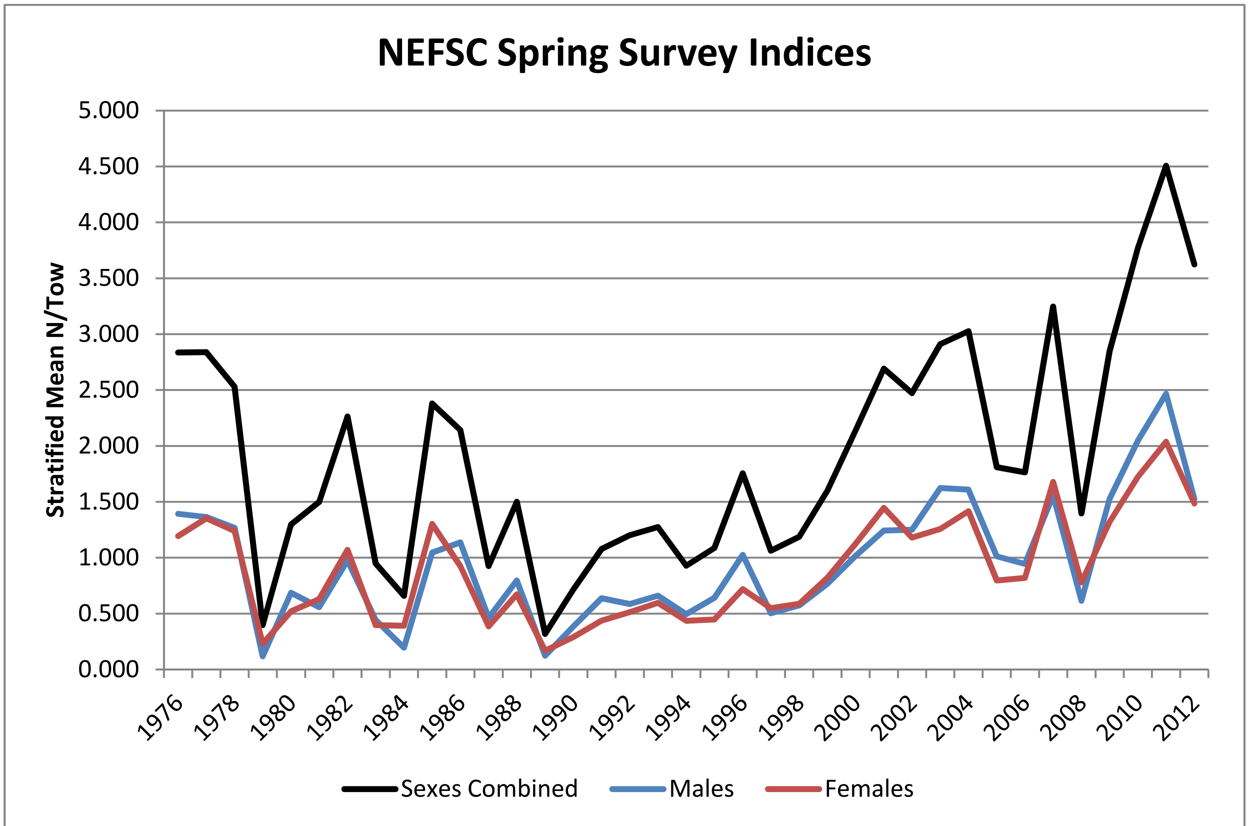


Figure A168. NEFSC winter survey indices of abundance (number per tow) for males, females, and sexes combined (top) and proportion female by age (bottom).



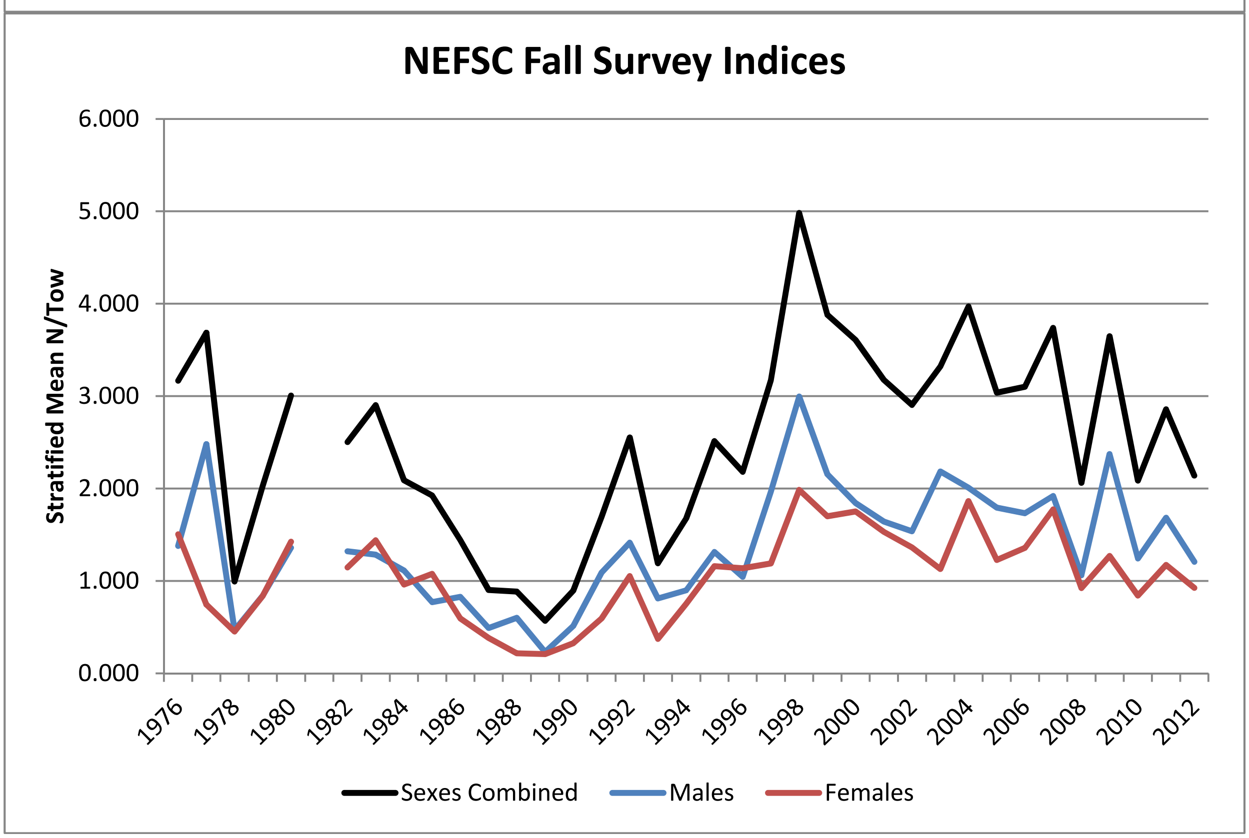
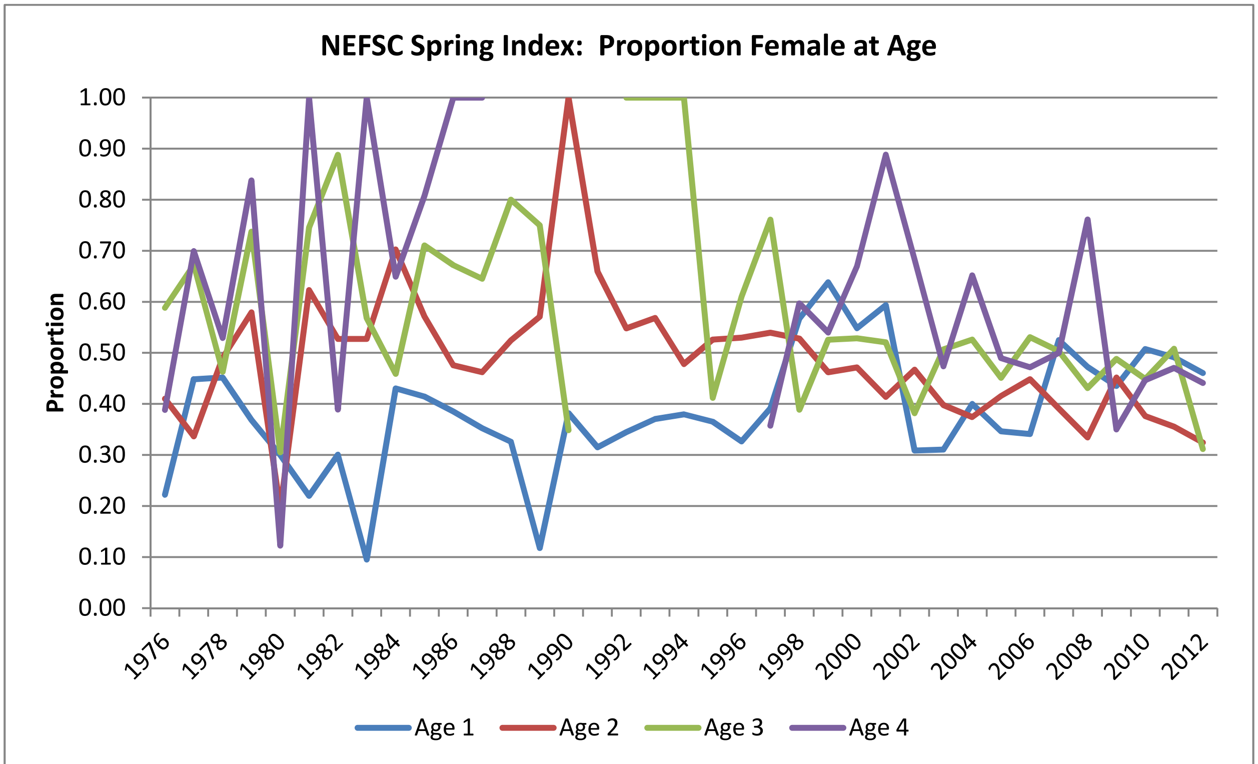


Figure A169. NEFSC spring and fall survey indices of abundance (number per tow) for males, females, and sexes combined.



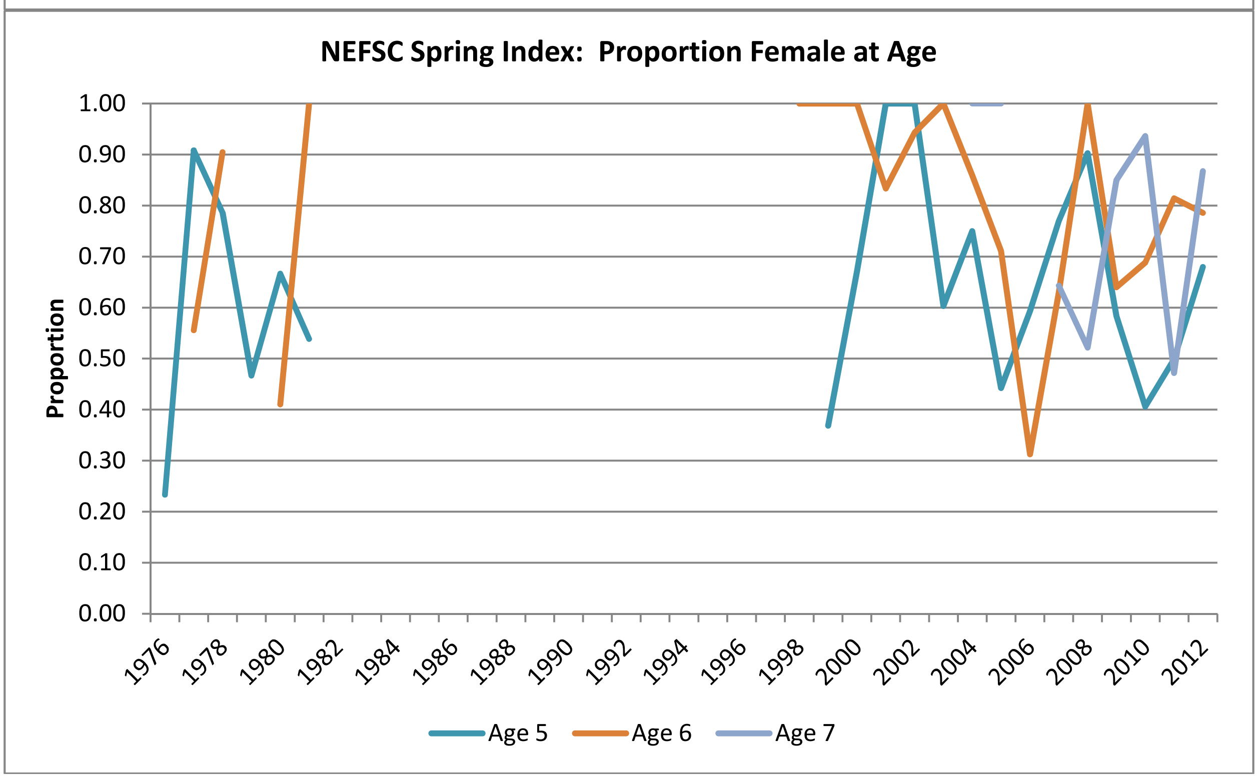
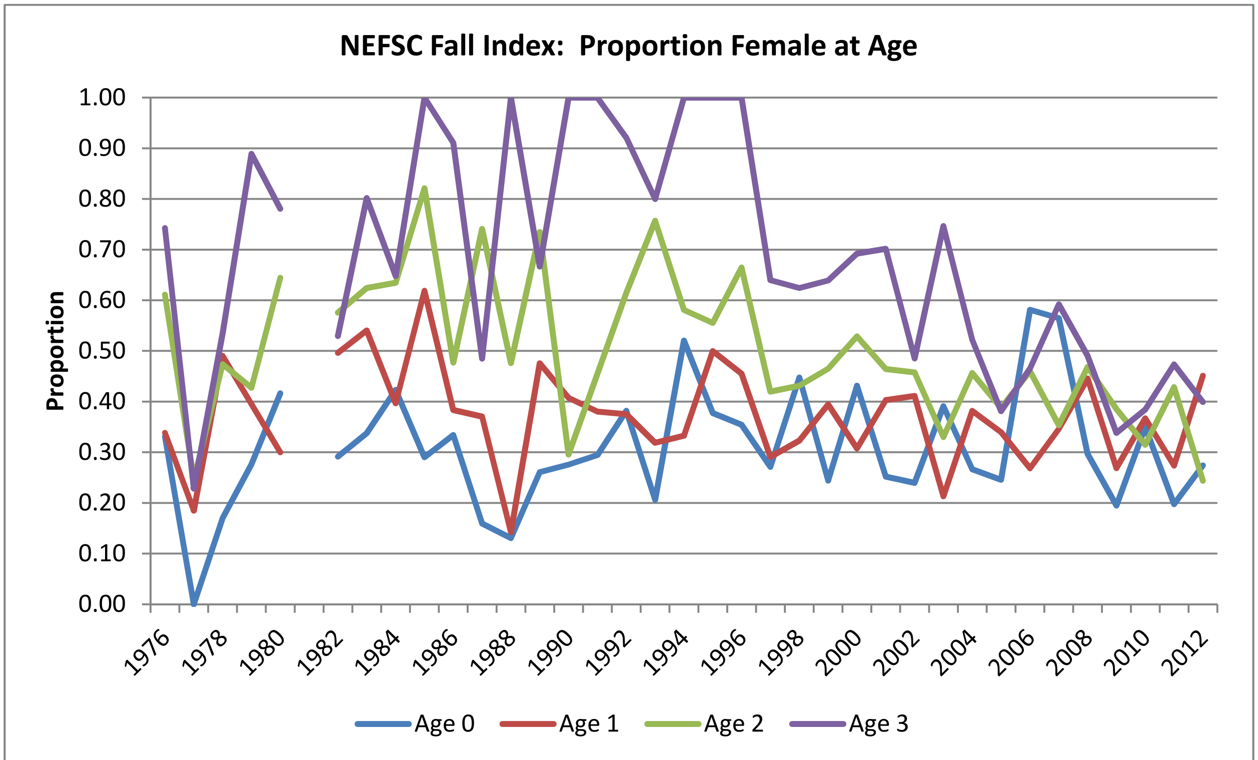


Figure A170. NEFSC spring survey index proportion female by age.



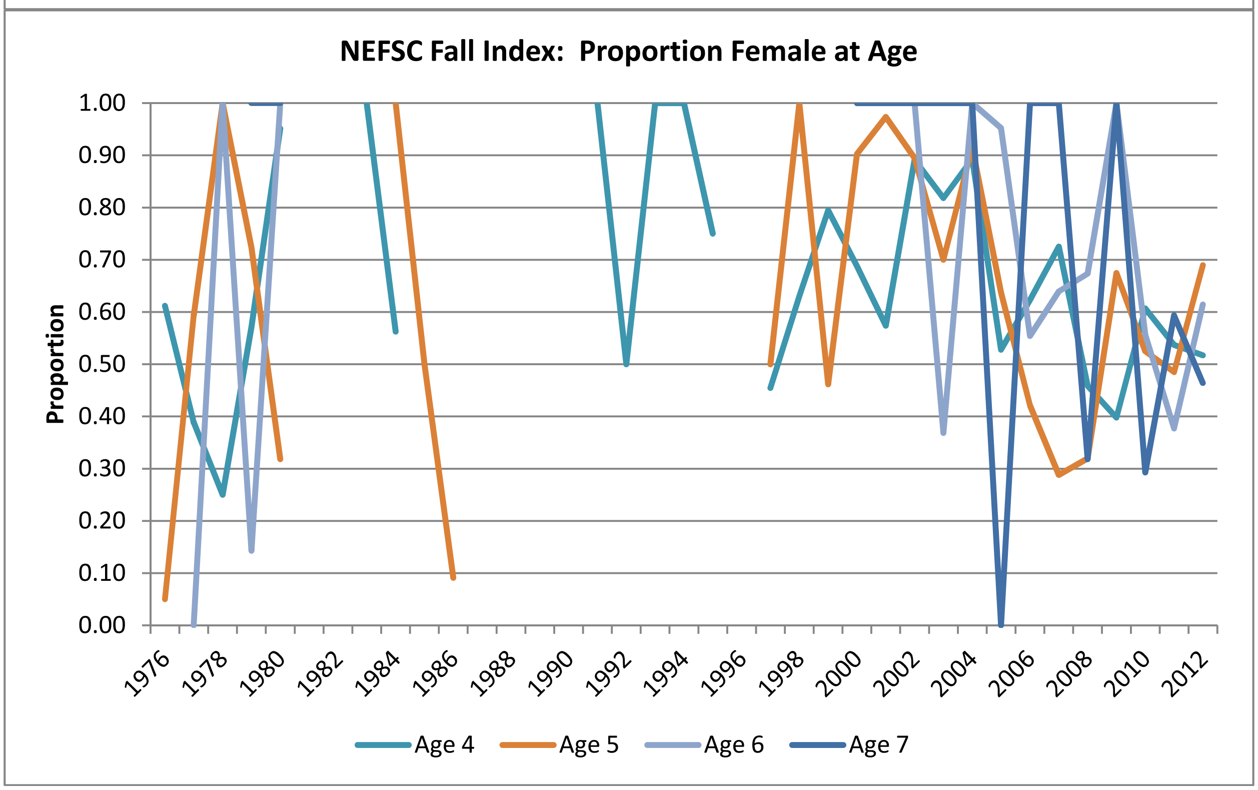


Figure A171. NEFSC fall survey index proportion female by age.

AIC for model fits when stratification by Time, Area, and Sex are applied singly.

Model	AIC
No Stratification	462475
Time Strata	462082
Area Strata	459956
Sex Strata	457161

AIC for multi-strata model fits.

Model	AIC	Delta AIC
No Stratification	462475	9666
Sex Strata	457161	4352
Sex and Time Strata	456443	3634
Sex, Time, and Area Strata	452809	0

Figure A172. Fit diagnostics for a statistical analysis of the variations in length at age by sex, area and time using data collected from NEFSC survey catch of summer flounder (*Paralichthys dentatus*) over the years 1976 through 2010.

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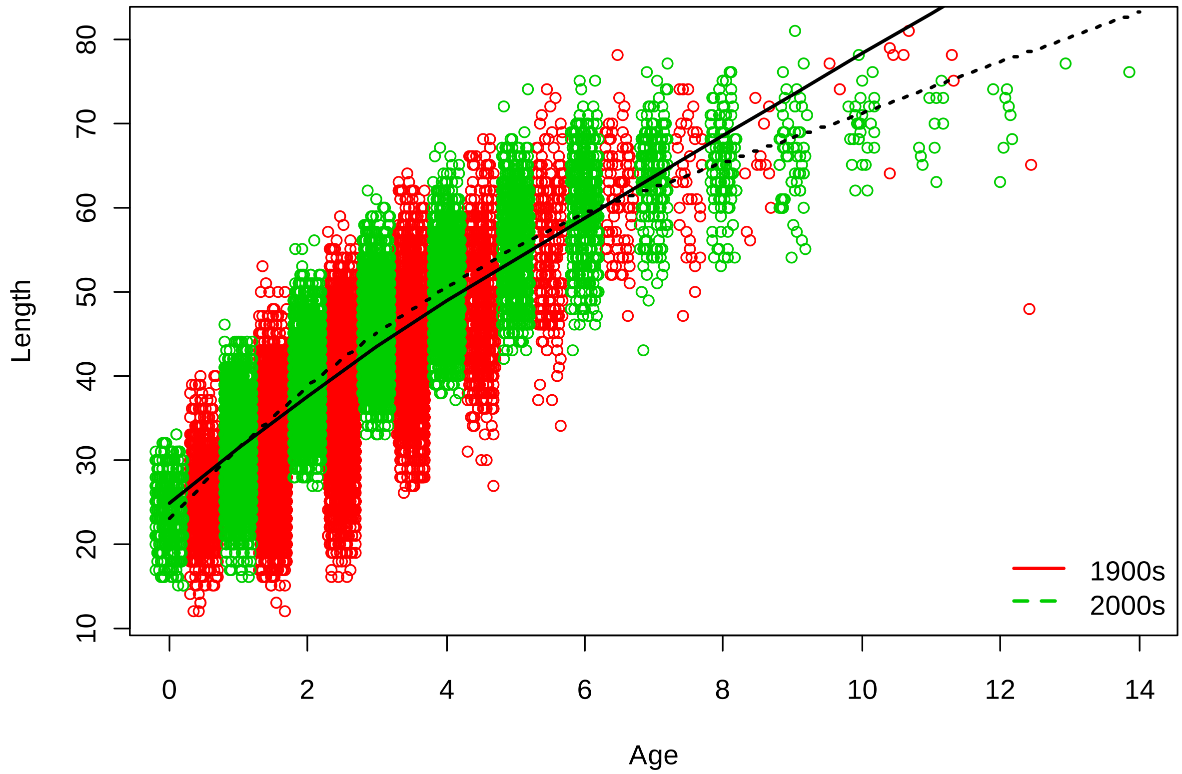


Figure A173. Model fit to time stratification, i.e. 1900s and 2000s data. Early (1900s) estimates: Linf = 142.8, k = 0.06, t0 = -3.3. Late (2000s) estimates: Linf = 85.5, k = 0.14, t0 =-2.2

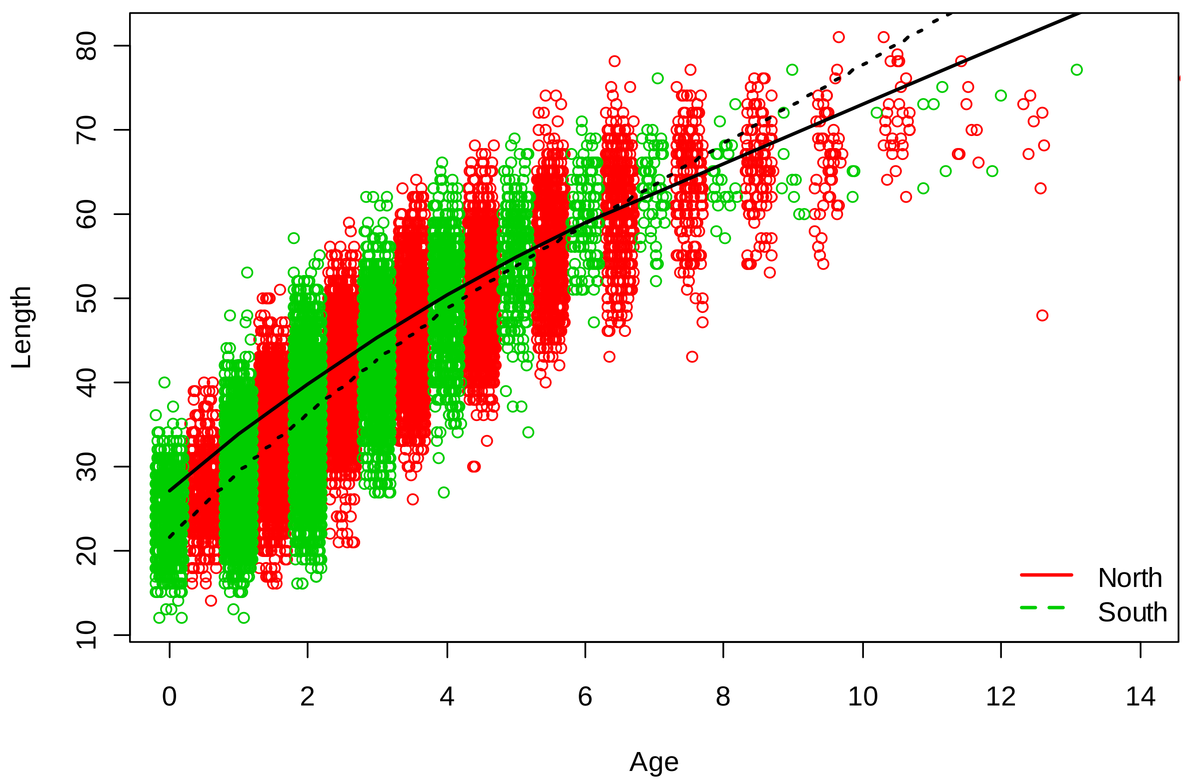


Figure A174. Model fit to area stratification, i.e. north and south data. North estimates: Linf = 101.7, k = 0.09, t0 = -3.3. South estimates: Linf = 120.7, k = 0.08, t0 = -2.5.

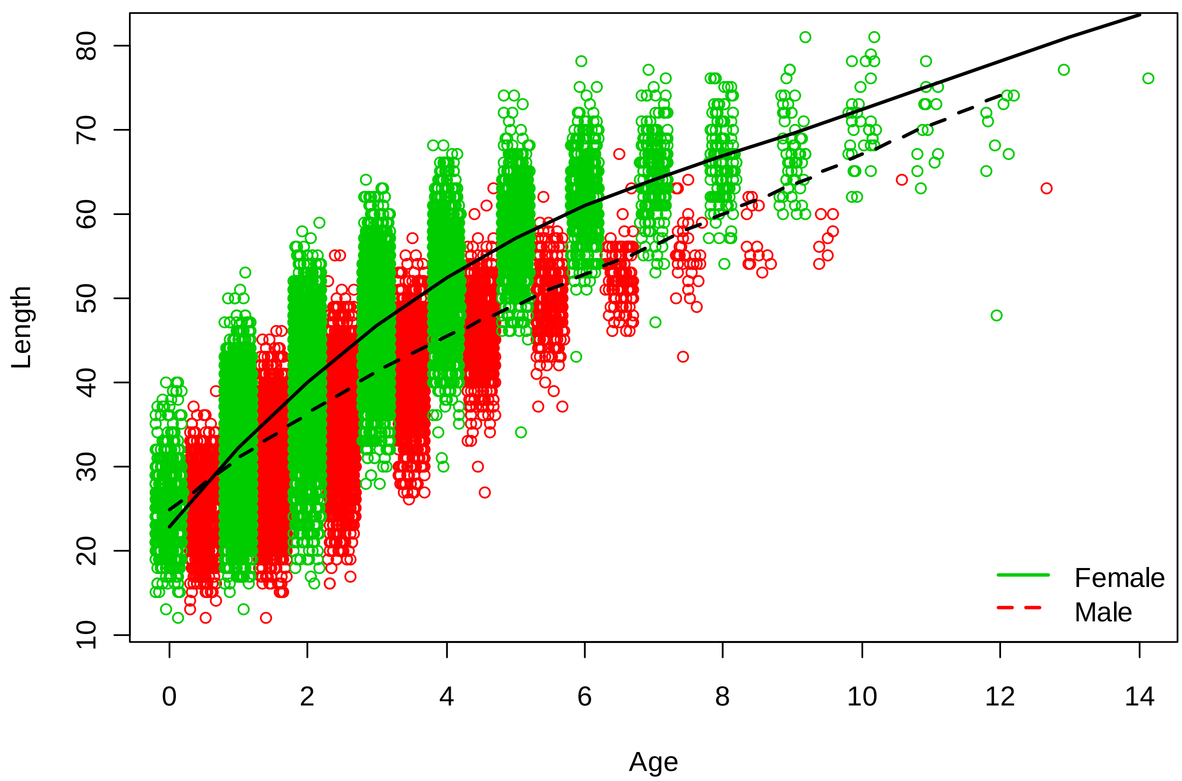
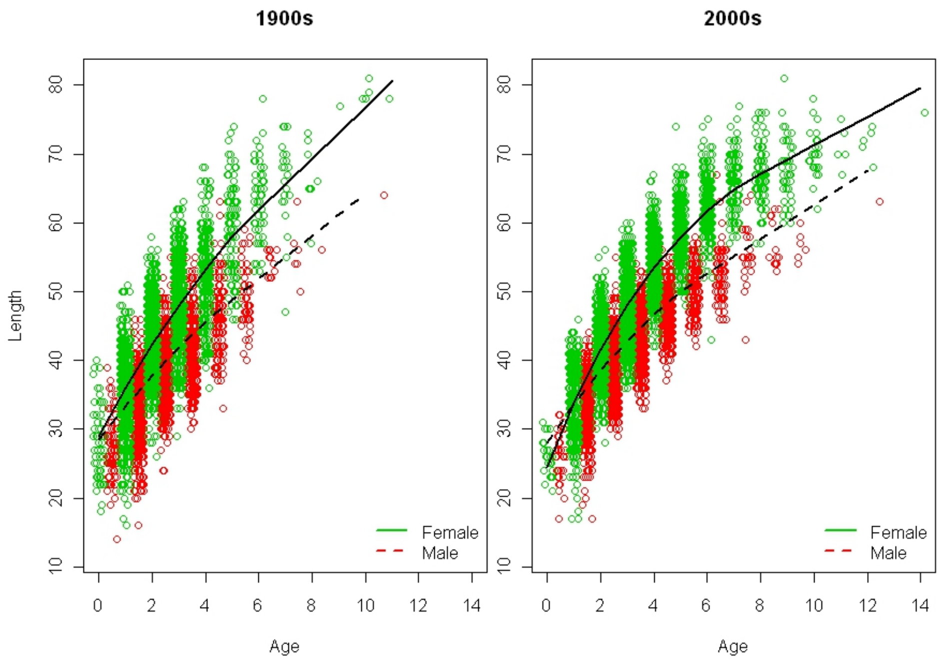
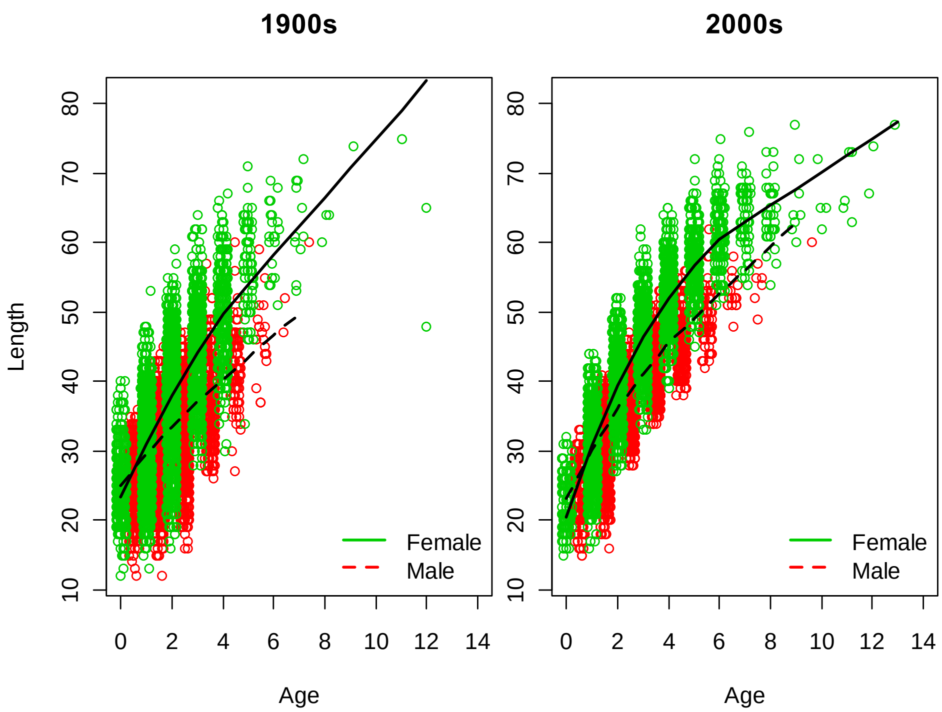


Figure A175. Model fit to sex stratification, i.e. female and male data. Female estimates: Linf = 83.6, k = 0.17, t0 = -1.9. Male estimates: Linf = 86.3, k = 0.10, t0 =-3.3



South



North

Figure A176. Model fit when all strata are included (sex, area, and time period).

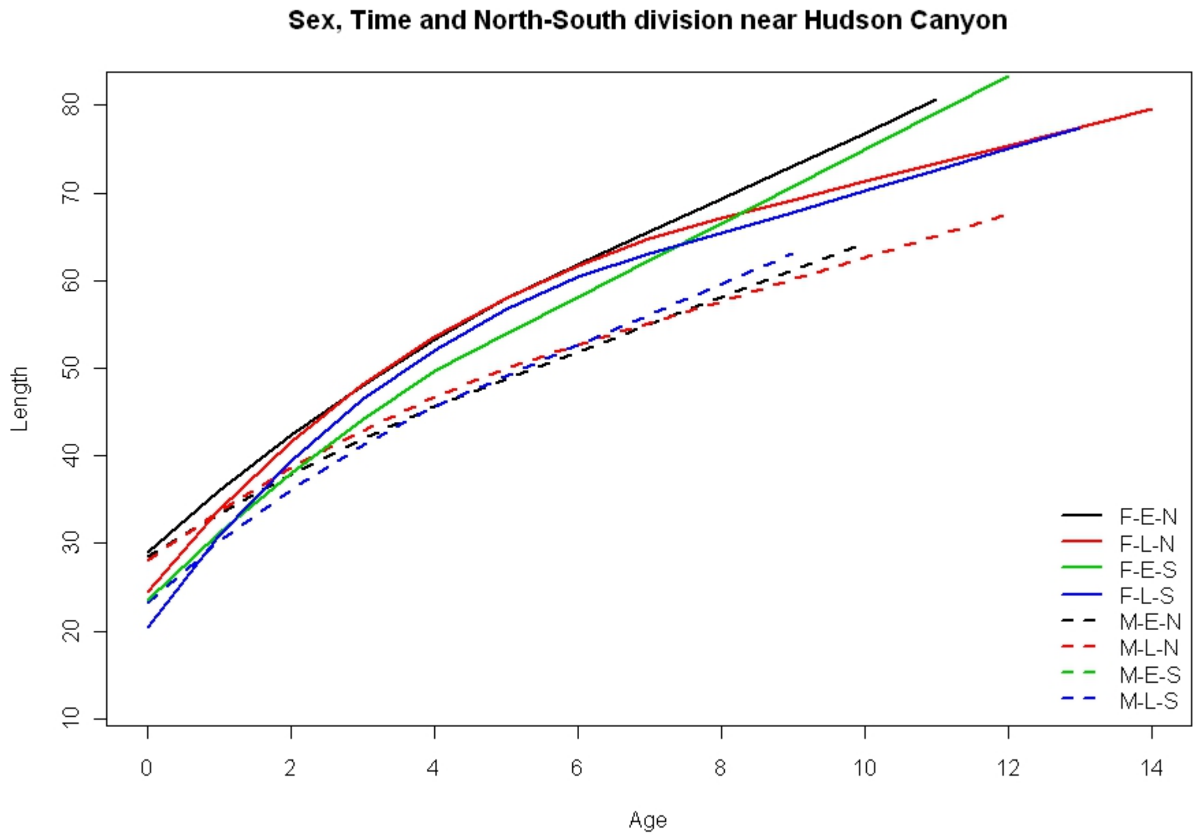


Figure A177. All model fits by strata shown together for comparison.

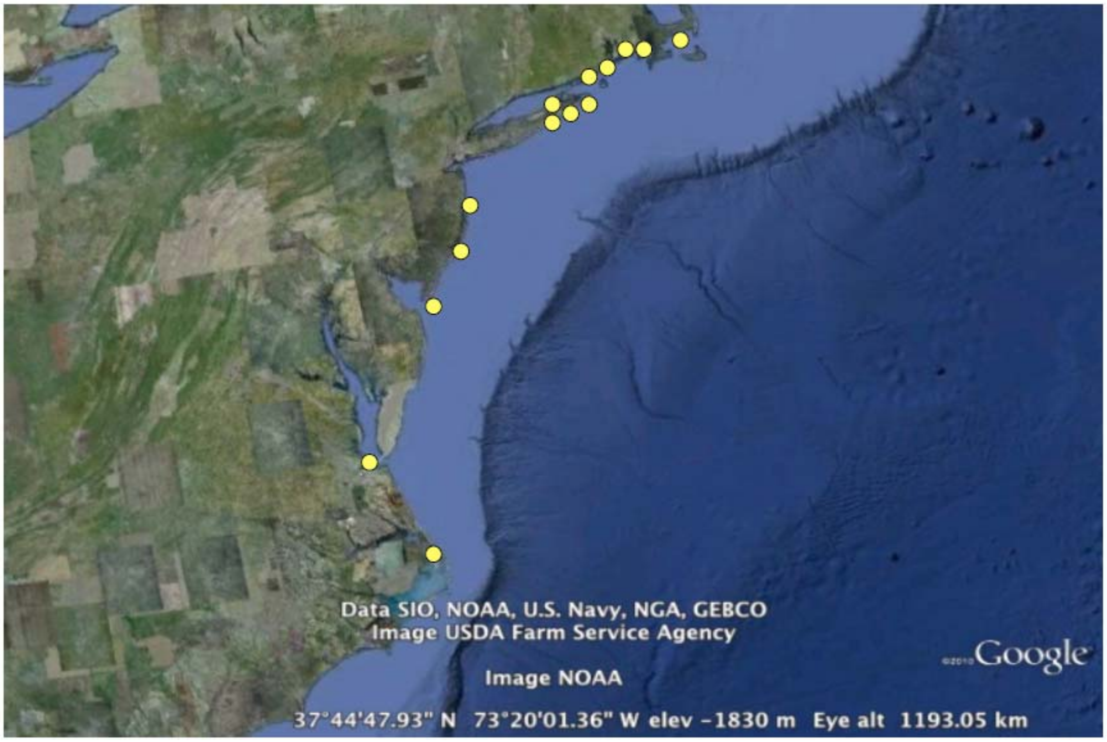


Figure A178. Location of ports (indicated by yellow circles) where summer flounder samples were collected from the commercial fishery. In order from northeast to south, these were: Hyannis, New Bedford, and Westport, MA; Point Judith, RI; Stonington, CT; Montauk, East Hampton, Mattituck, Hampton Bays, and Point Lookout, NY; Point Pleasant, Barnegat Light, and Cape May, NJ; Newport News and Hampton, VA; and Wanchese, NC.

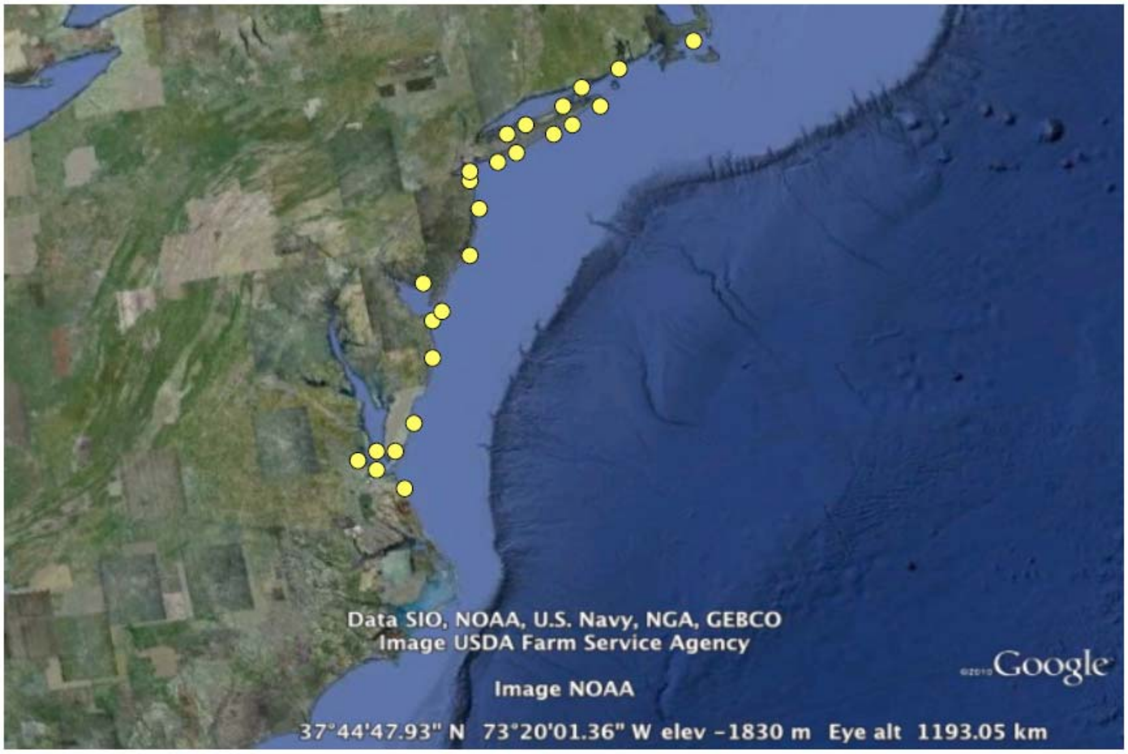


Figure A179. Location of ports (indicated by yellow circles) where summer flounder samples were collected from the recreational fishery. In order from northeast to south, these were: Hyannis and New Bedford, MA; Point Judith, RI; Niantic, CT; Montauk, East Hampton, Greenport, Mattituck, Hampton Bays, Riverhead, Moriches, Port Jefferson, Captree, Huntington, and Freeport, NY; Atlantic Highlands, Point Pleasant, Barnegat Light, Fortescue, and Cape May, NJ; Lewes, DE; Ocean City, MD; Wachapreague, Capeville, James River, Buckroe, Hampton, and Virginia Beach, VA.

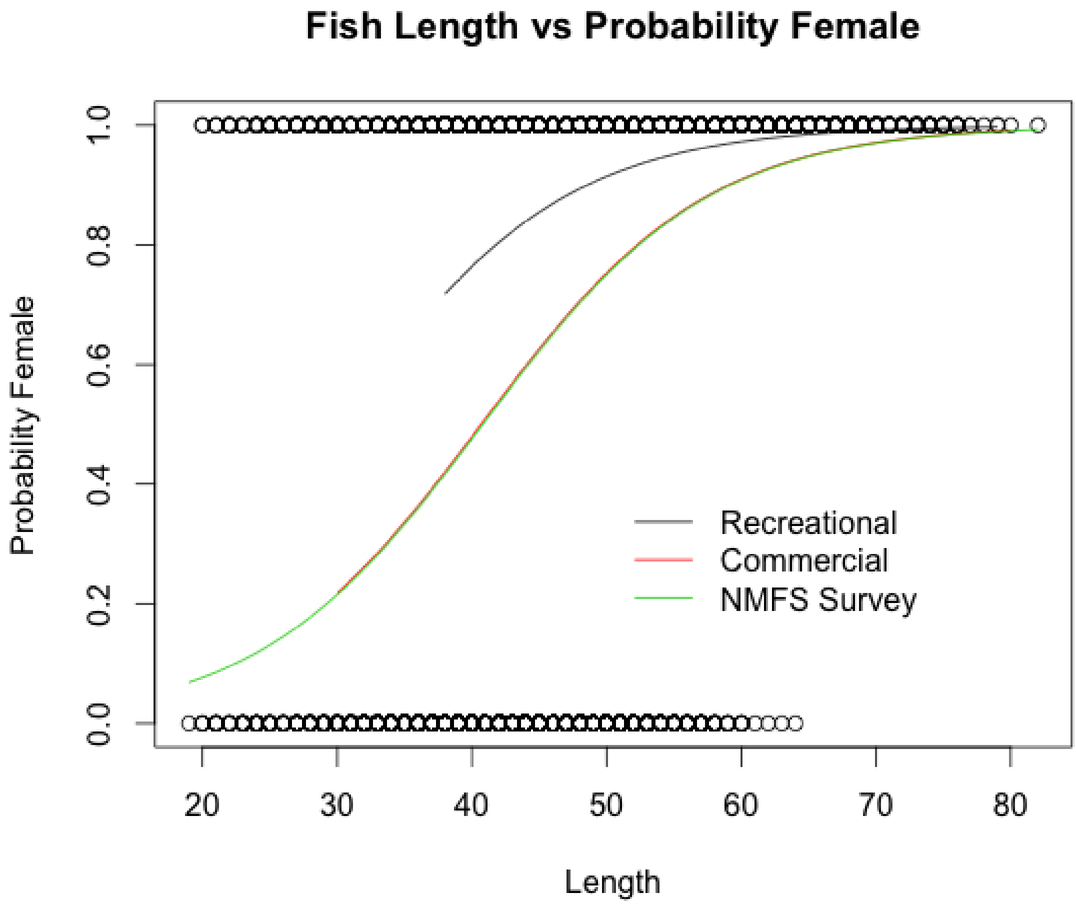


Figure A180. Probability female as a function of fish length in the commercial and recreational fisheries (2010-2011) and the NMFS-NEFSC trawl survey (2009-2011).

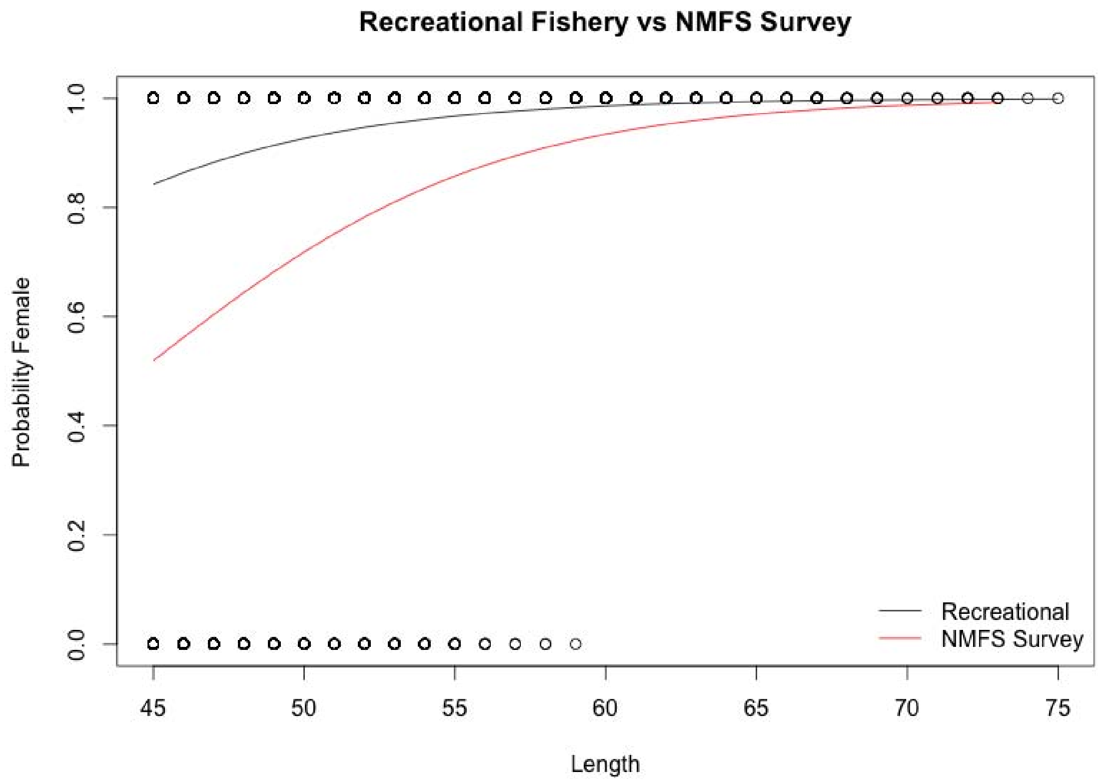


Figure A181. Probability female as a function of fish length in recreational fishery (2010-2011) and the NMFS-NEFSC trawl survey (2009-2011). Data from the NMFS-NEFSC is limited to fish greater than 45 cm total length and data from both the NMFS-NEFSC and the recreational fishery are limited to statistical areas where at least 100 individuals were collected from both the recreational fishery and the NMFS-NEFSC trawl survey.

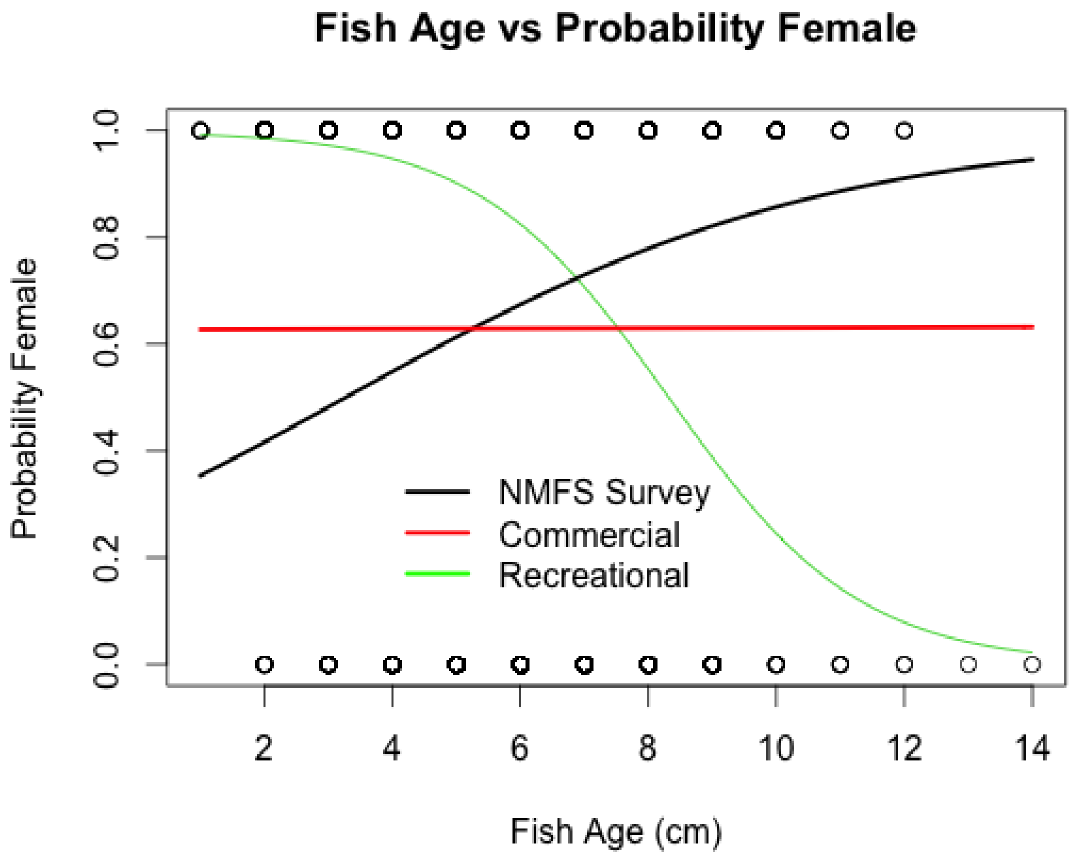


Figure A182. Probability female as a function of fish age in the commercial and recreational fisheries (2010-2011) and the NMFS-NEFSC trawl survey (2009-2011) with separate logistic regression parameters estimated for each line.

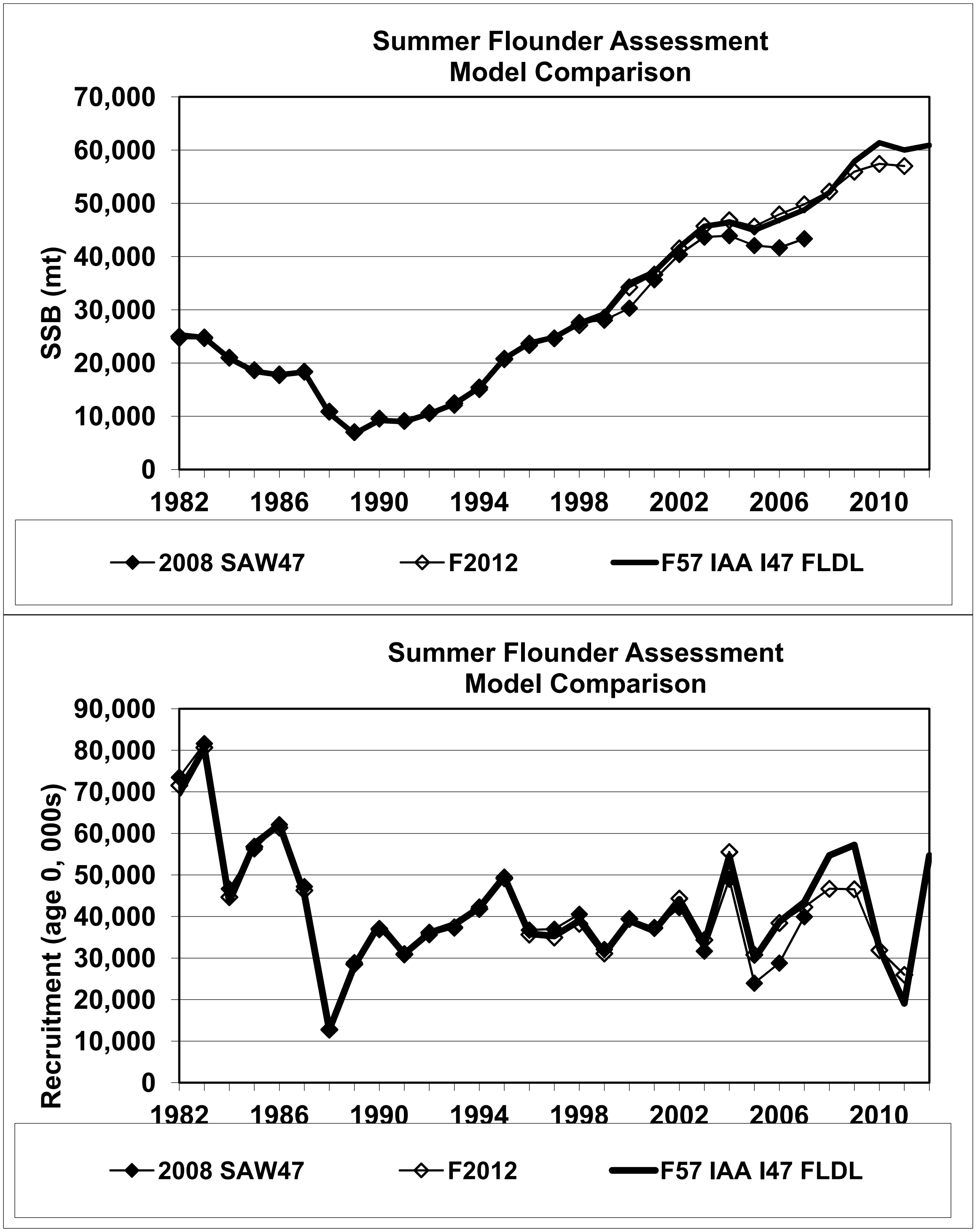


Figure A183. Comparison of SSB and R estimates from the 2008 SAW 47 benchmark and 2012 updated assessments with the comparable model and data from the 2013 SAW 57 assessment (F57-IAA-I47_FLDL; response to TOR 6a).

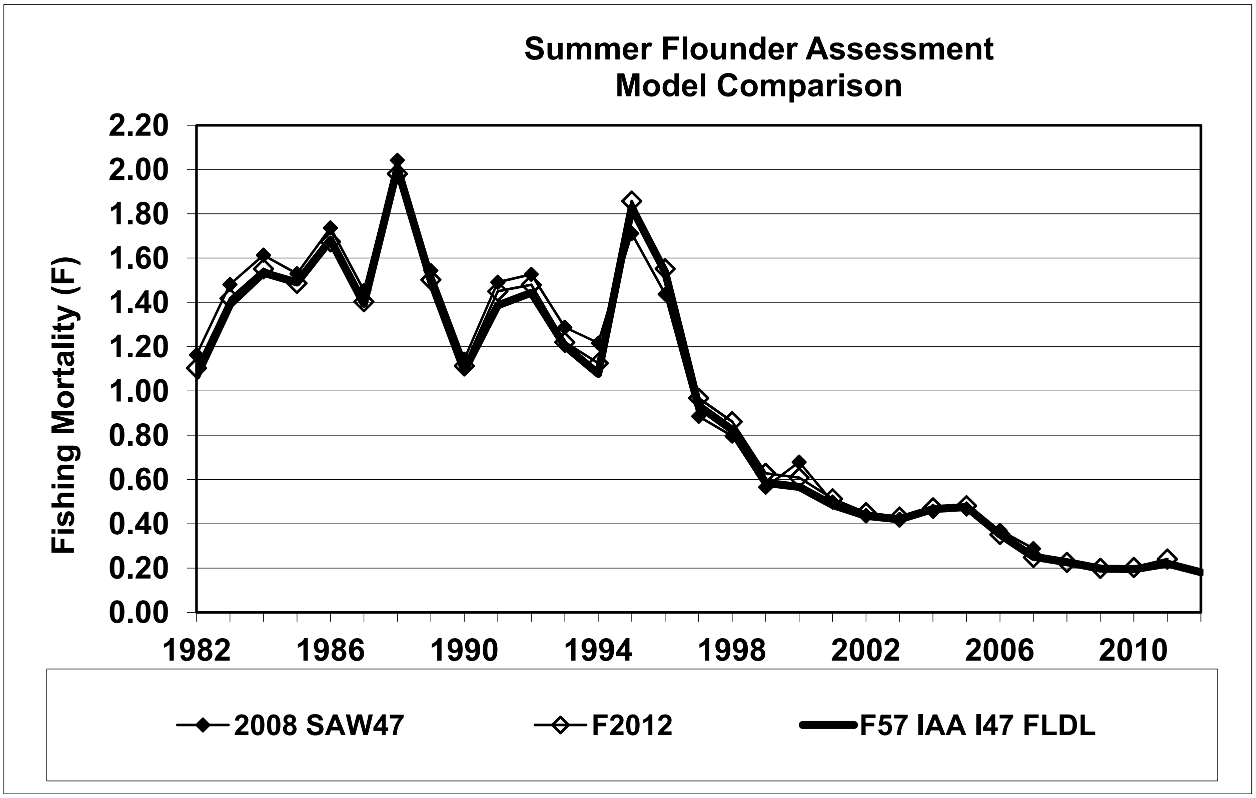
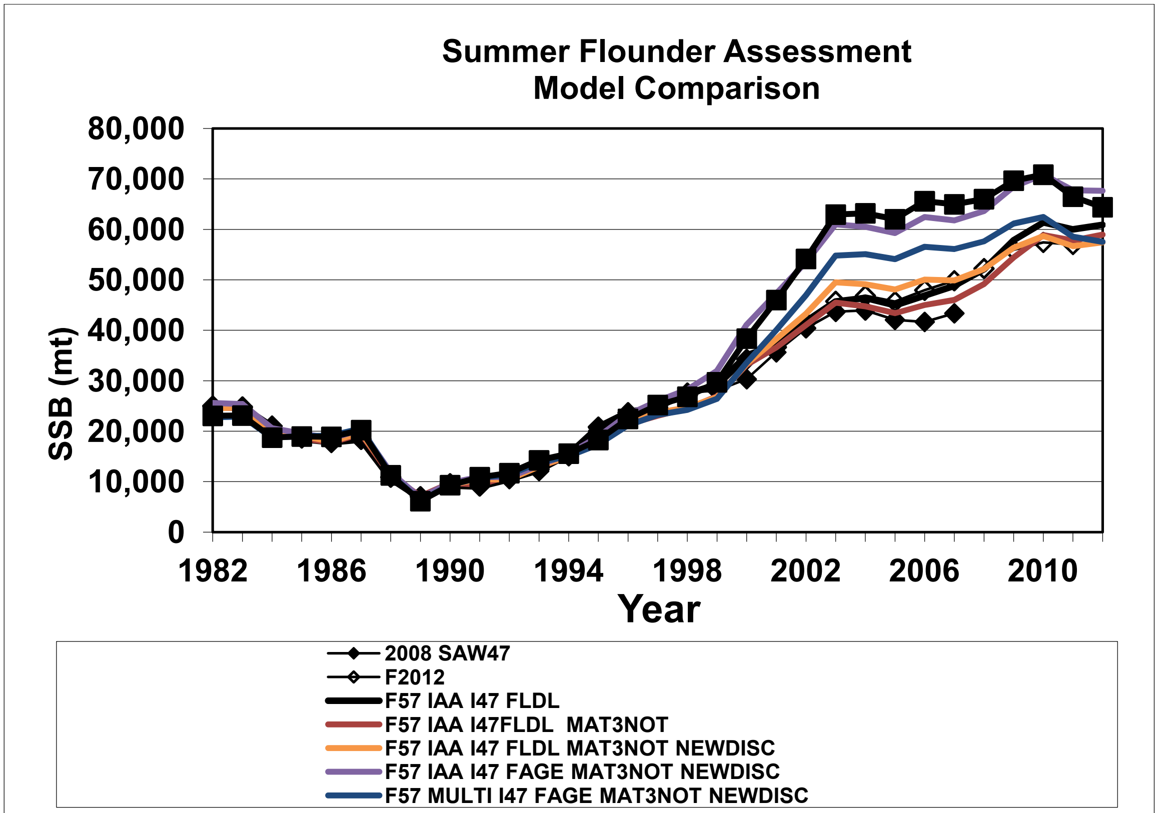


Figure A184. Comparison of fishing mortality estimates from the 2008 SAW 47 benchmark and 2012 updated assessments with the comparable model and data from the 2013 SAW 57 assessment (F57-IAA-I47_FLDL; response to TOR 6a).



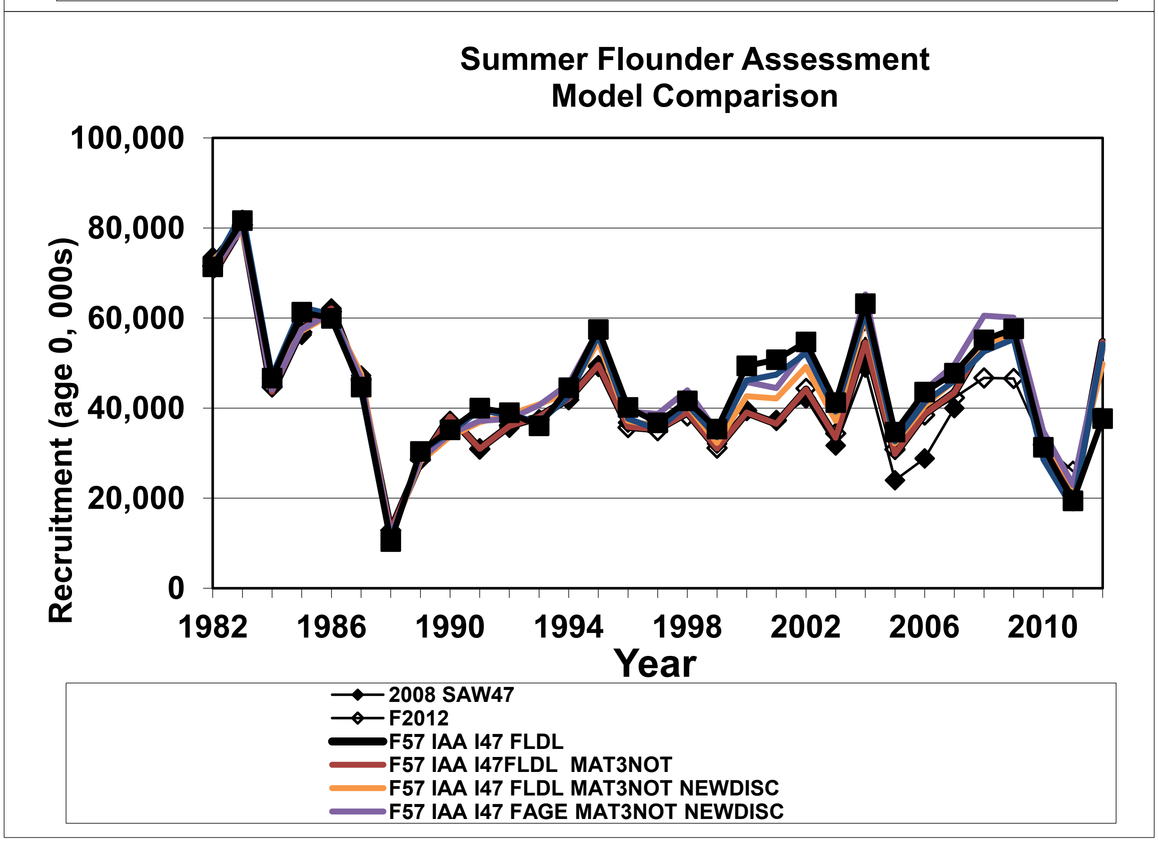


Figure A185. Comparison of SSB and R estimates from 'phase 1' of 2013 SAW 57 model building.

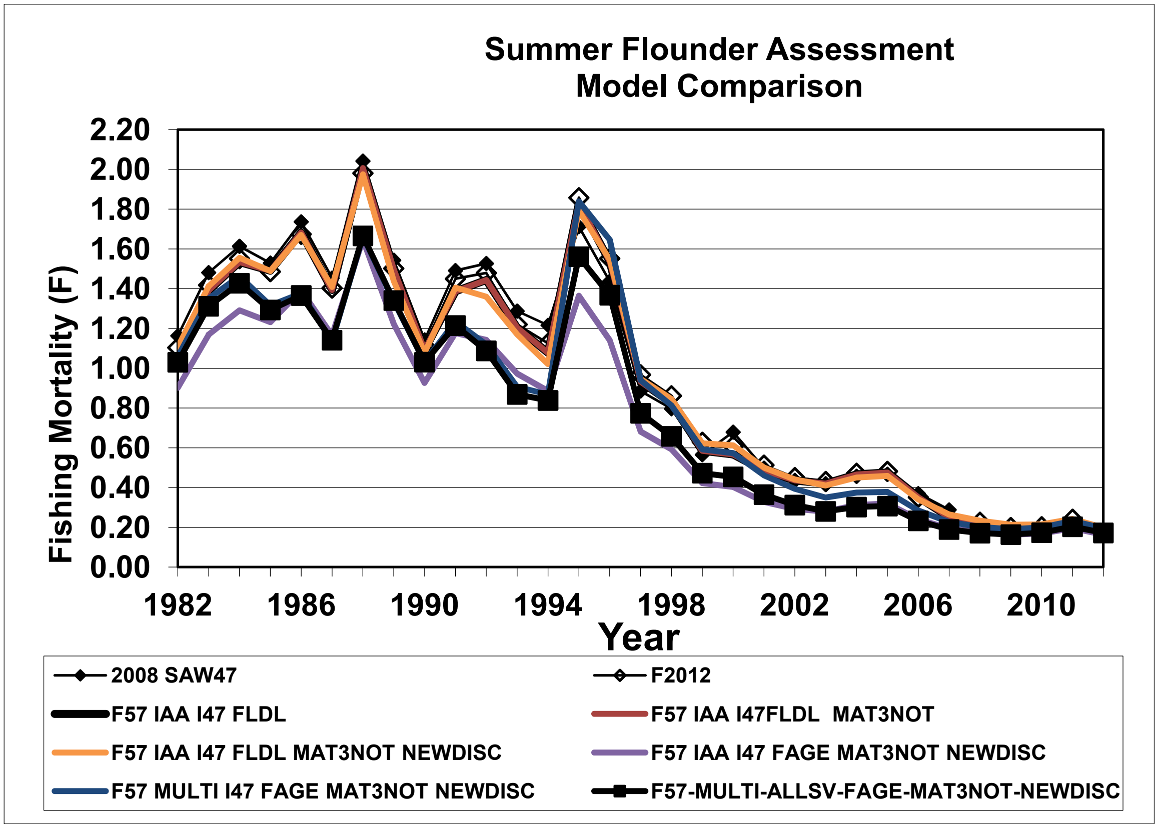
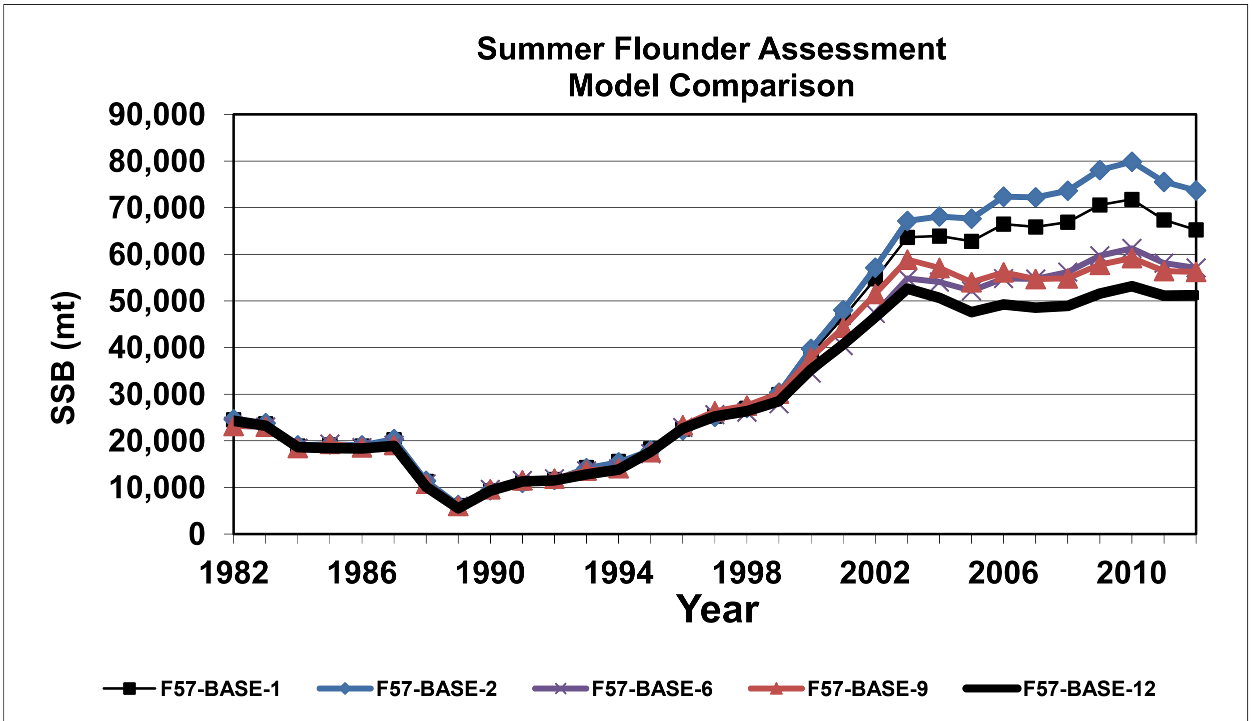


Figure A186. Comparison of of fishing mortality estimates from ‘phase 1’ of 2013 SAW 57 model building.



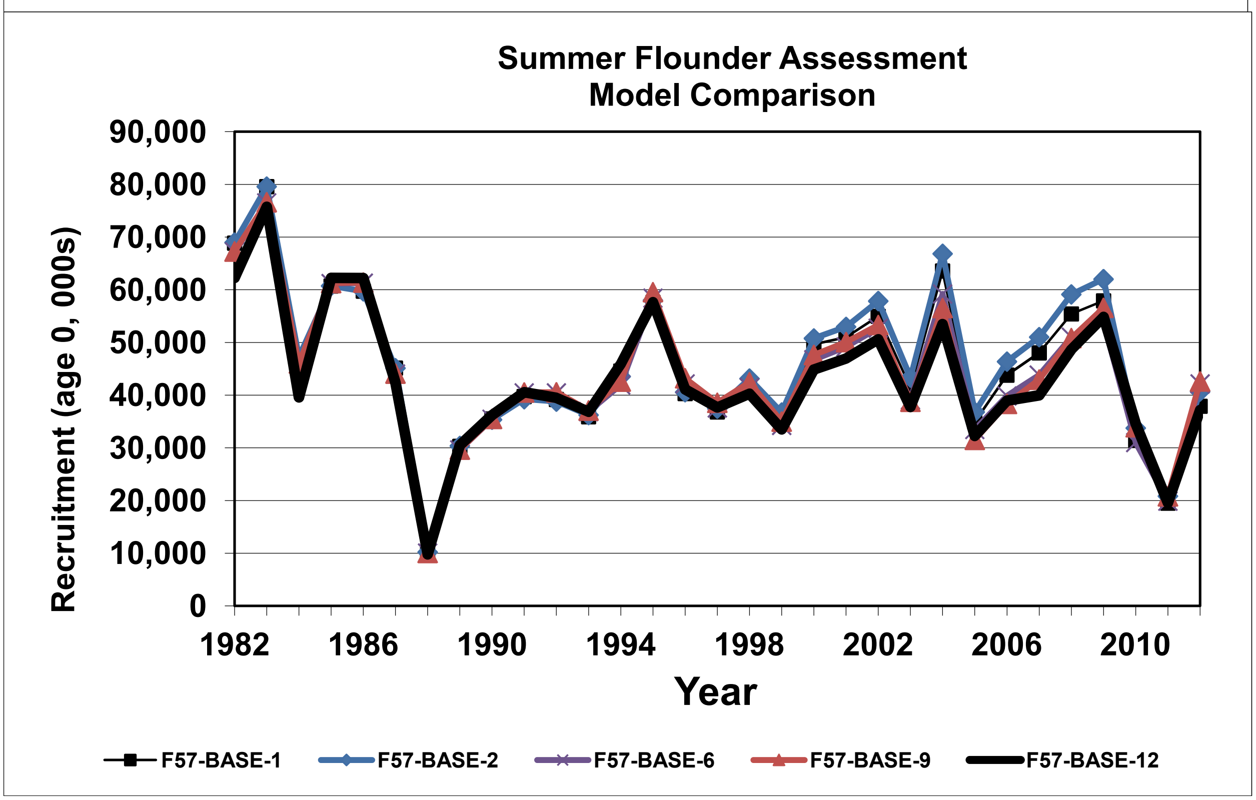


Figure A187. Comparison of SSB and R estimates from 'phase 2' of 2013 SAW 57 model building.

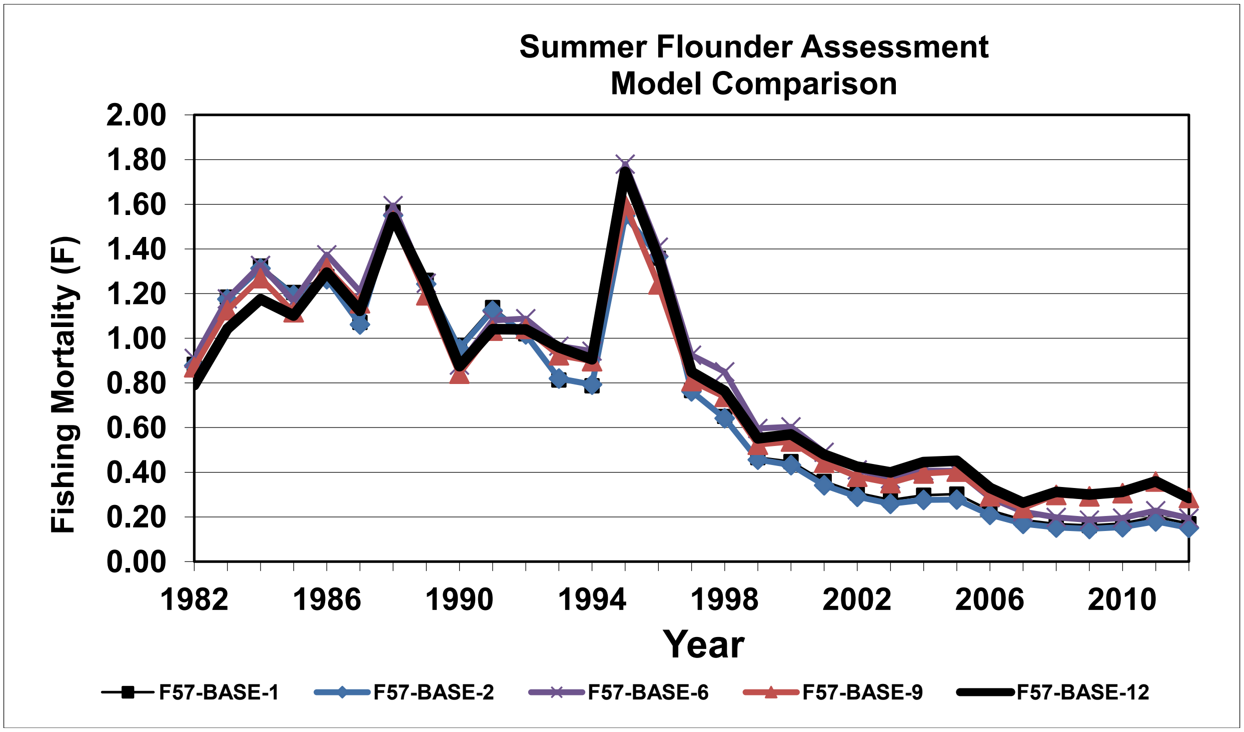


Figure A188. Comparison of of fishing mortality estimates from ‘phase 2’ of 2013 SAW 57 model building.

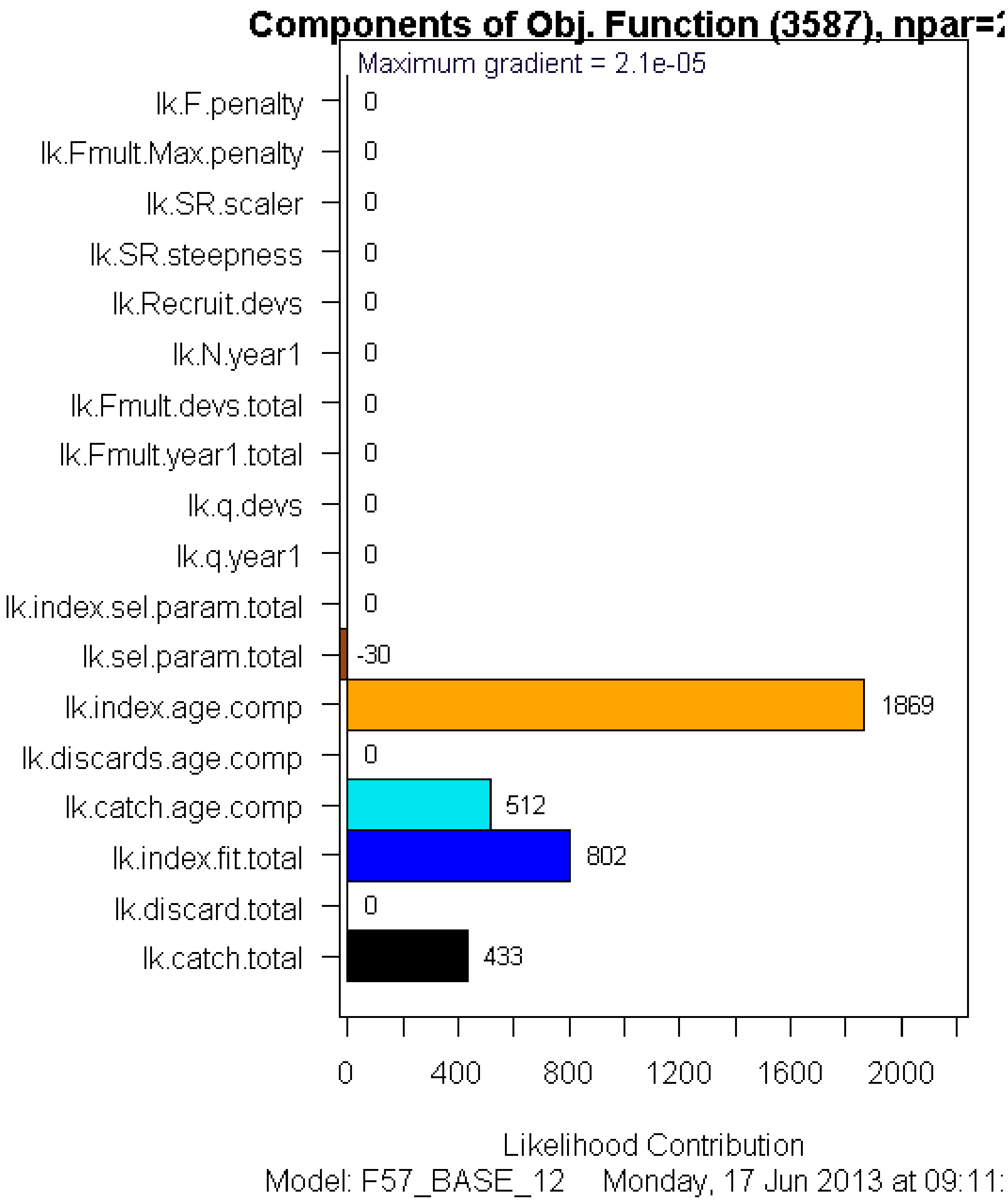


Figure A189. Distribution of objective function components contribution to total likelihood for run F57_BASE_12.

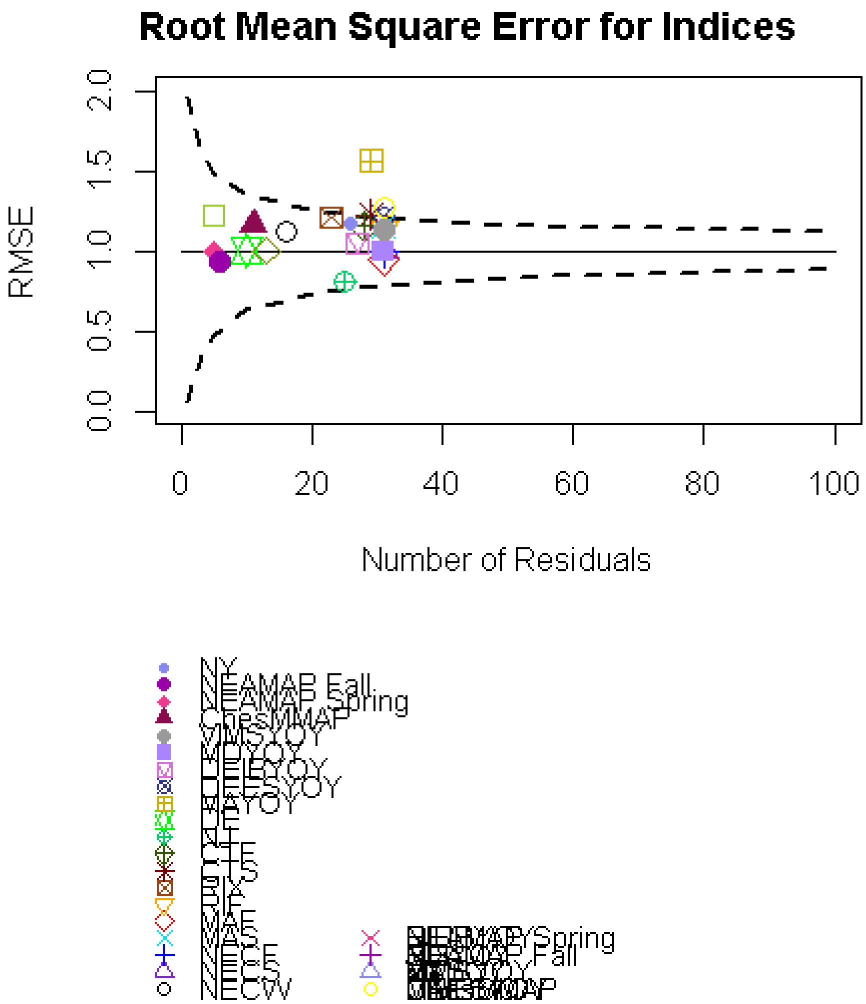


Figure A190. Final Root Mean Square Error (RMSE) values for survey indices in run F57_BASE_12.

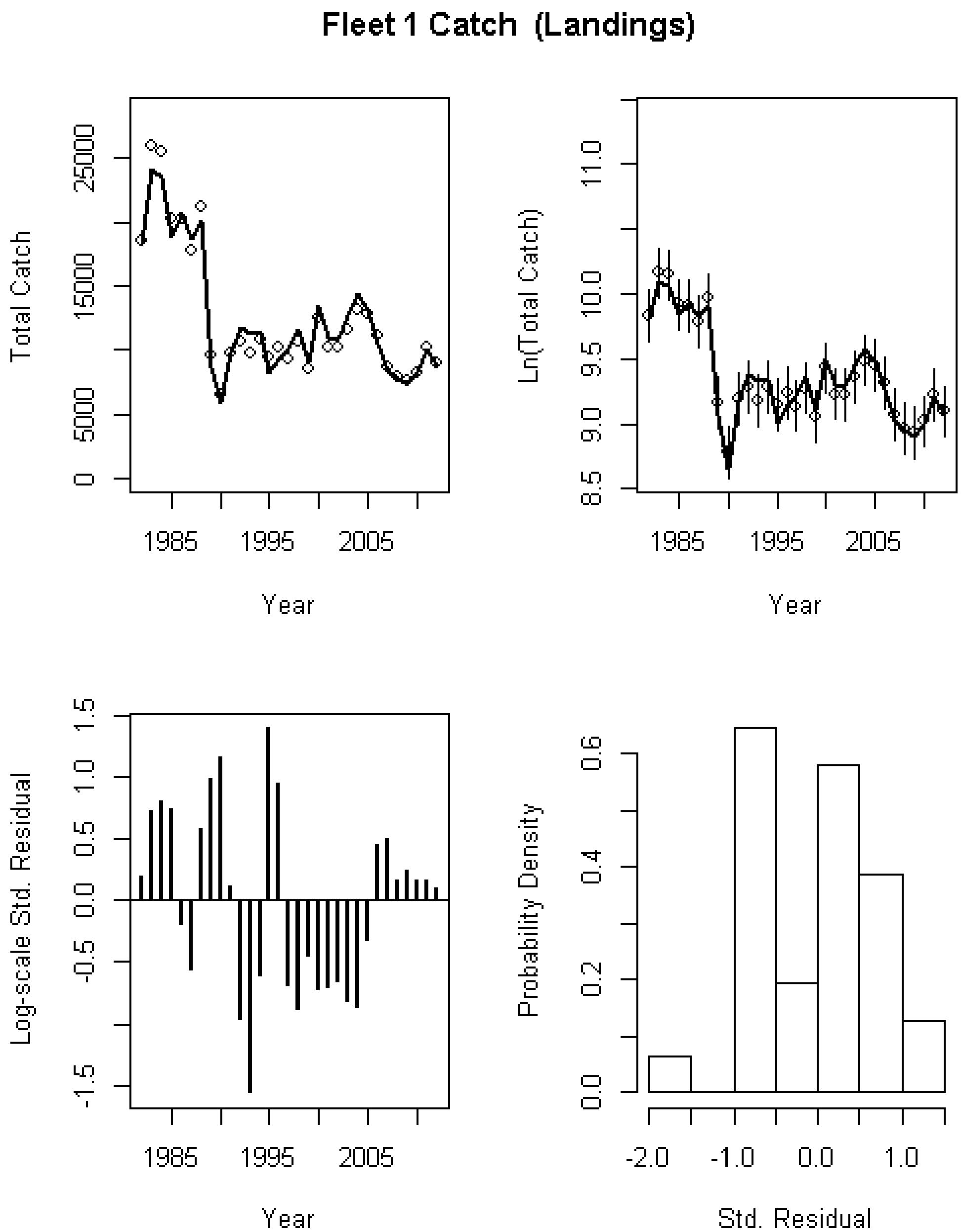


Figure A191. Fit diagnostics for the fishery landings in run F57_BASE_12.

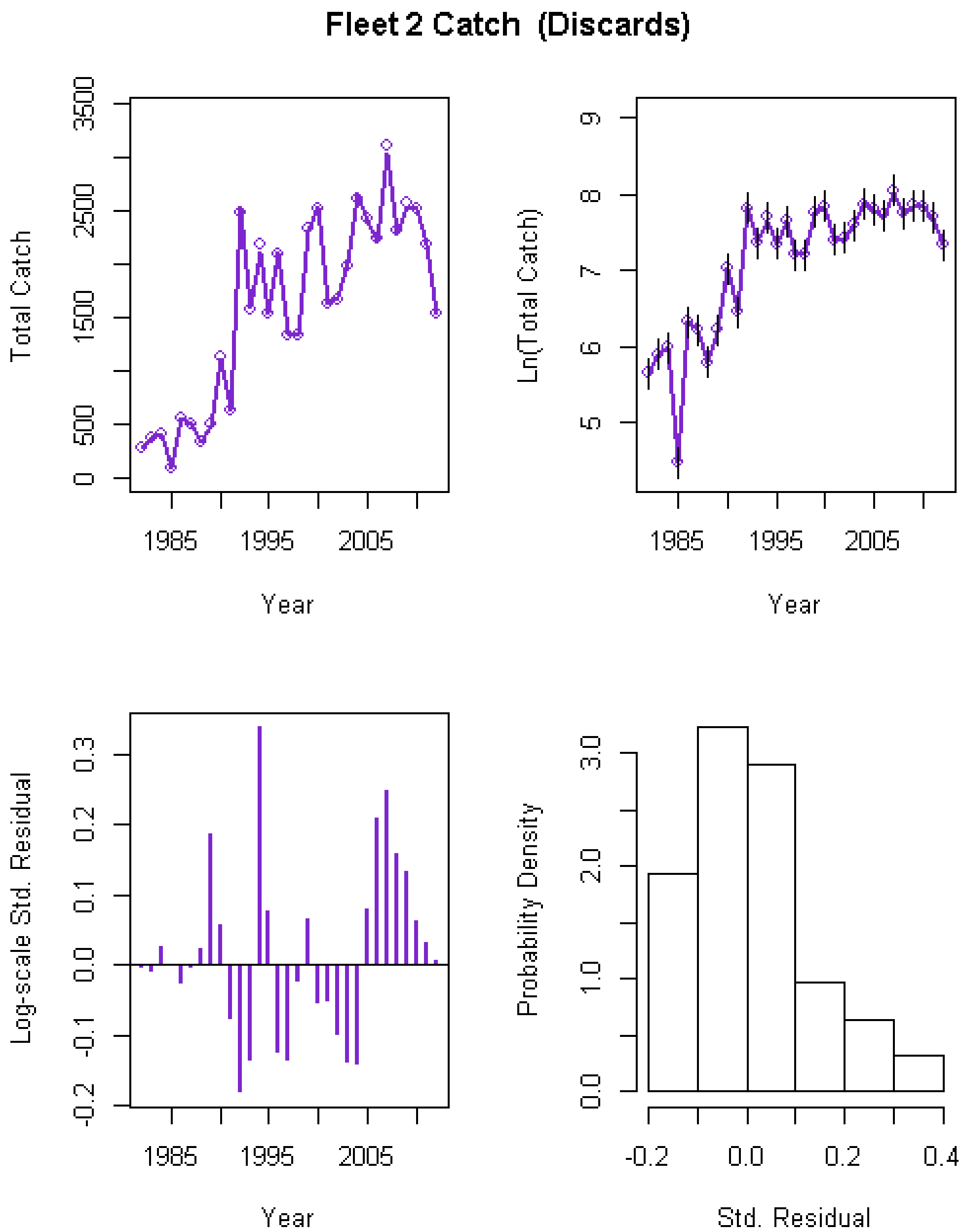


Figure A192. Fit diagnostics for the fishery discards in run F57_BASE_12.

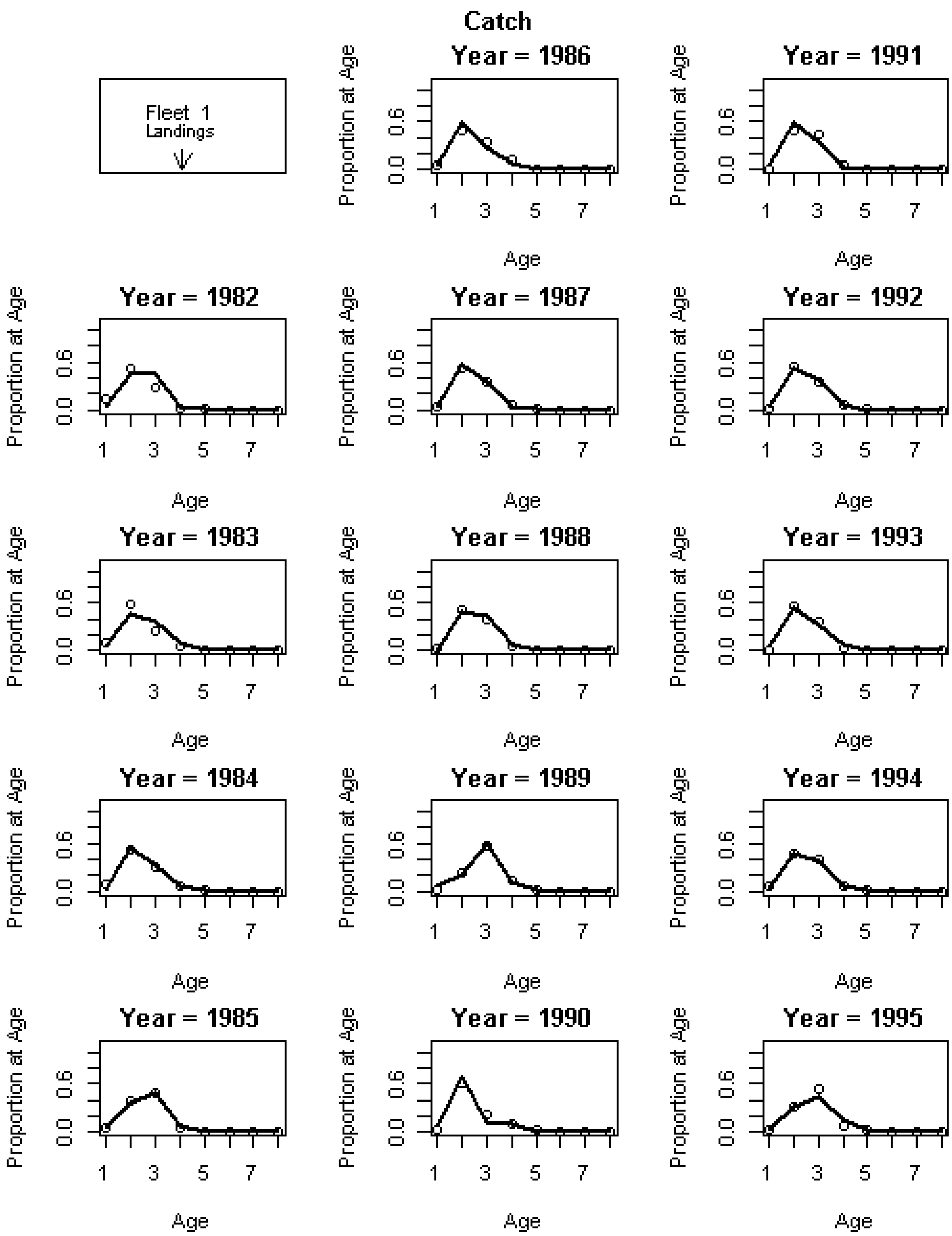


Figure A193. Fits to 1982-1995 landings proportions-at-age in run F57_BASE_12.

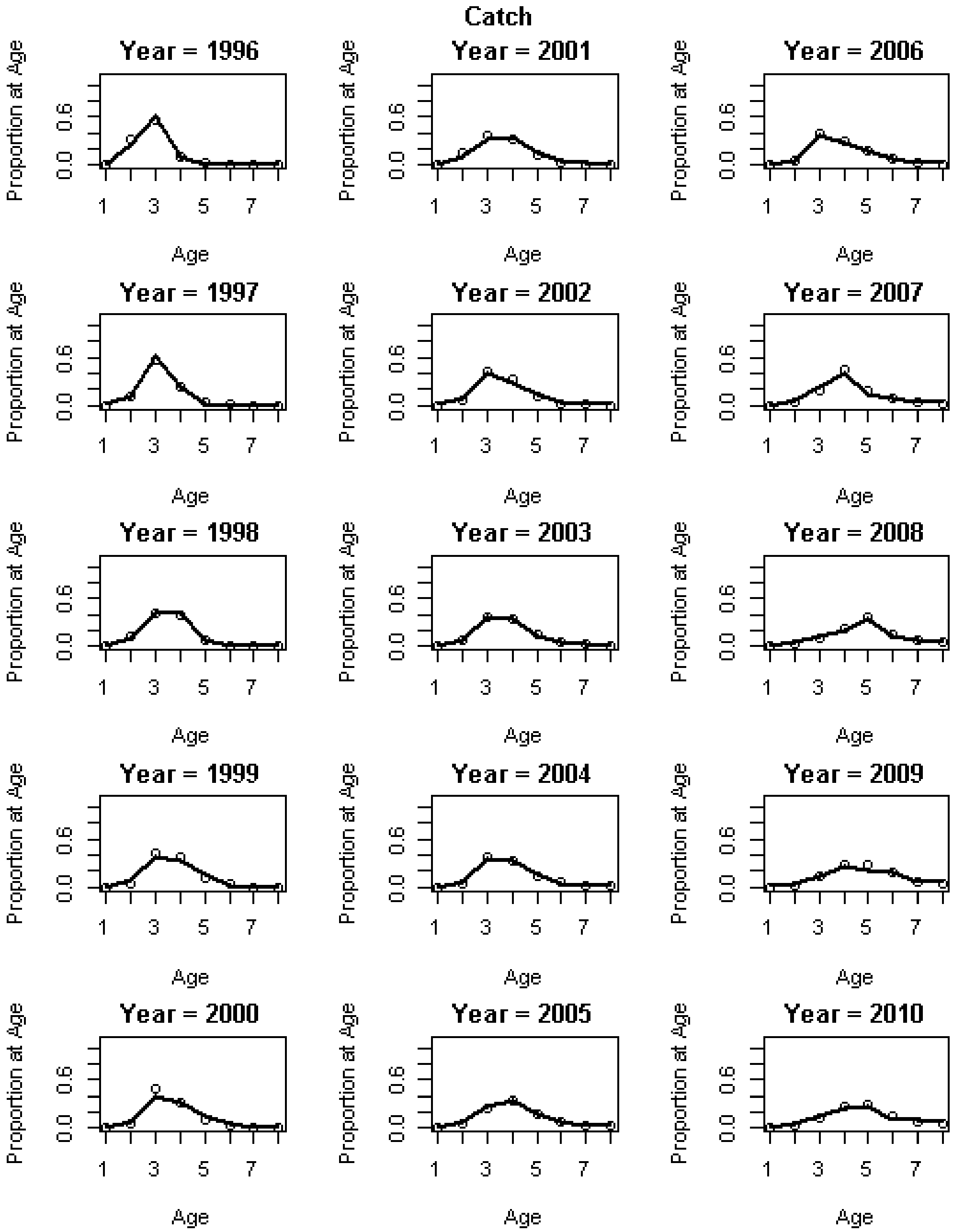


Figure A194. Fits to 1996-2010 landings proportions-at-age in run F57_BASE_12.

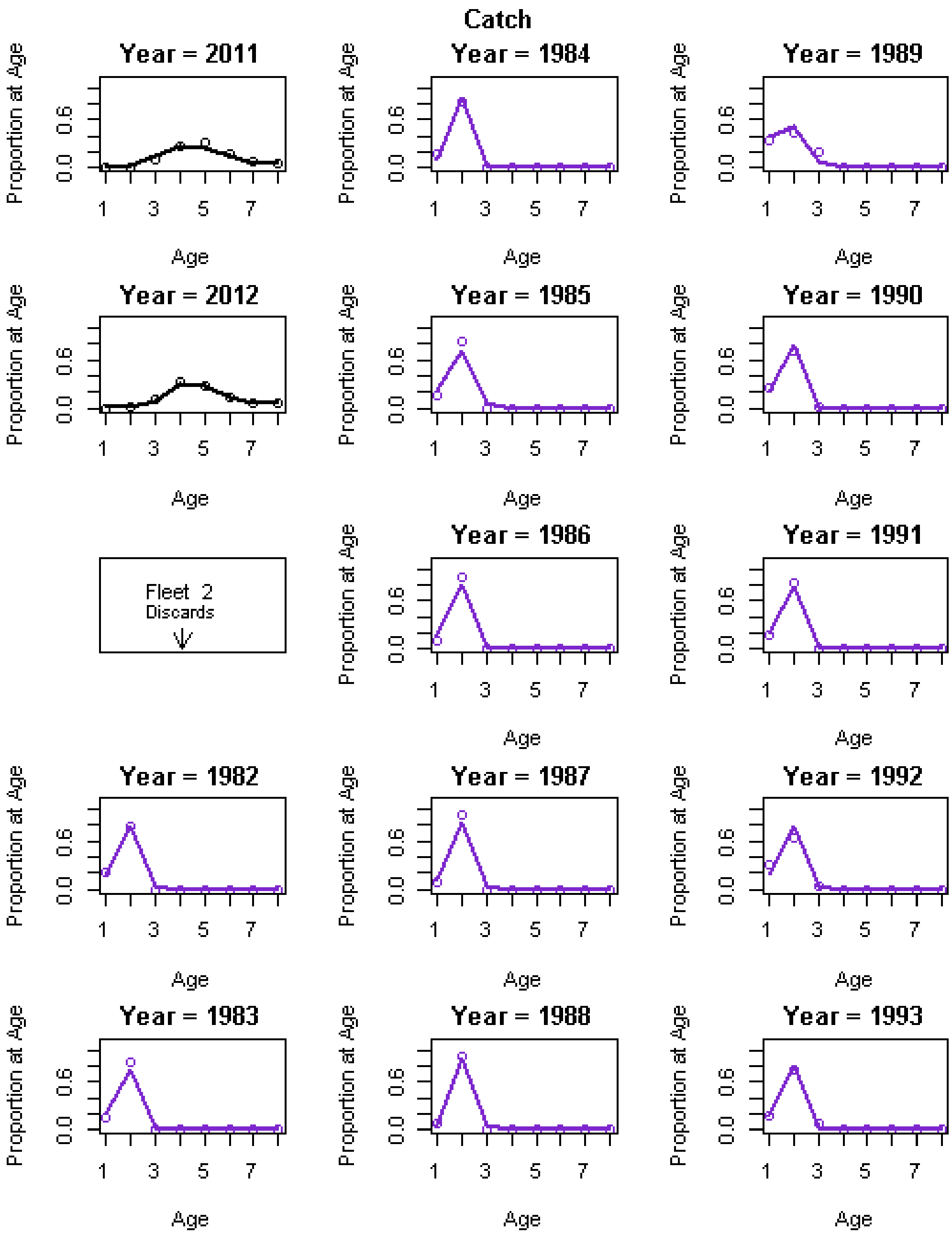


Figure A195. Fits to 2011-2010 landings and 1982-1993 discards proportions-at-age in run F57_BASE_12.

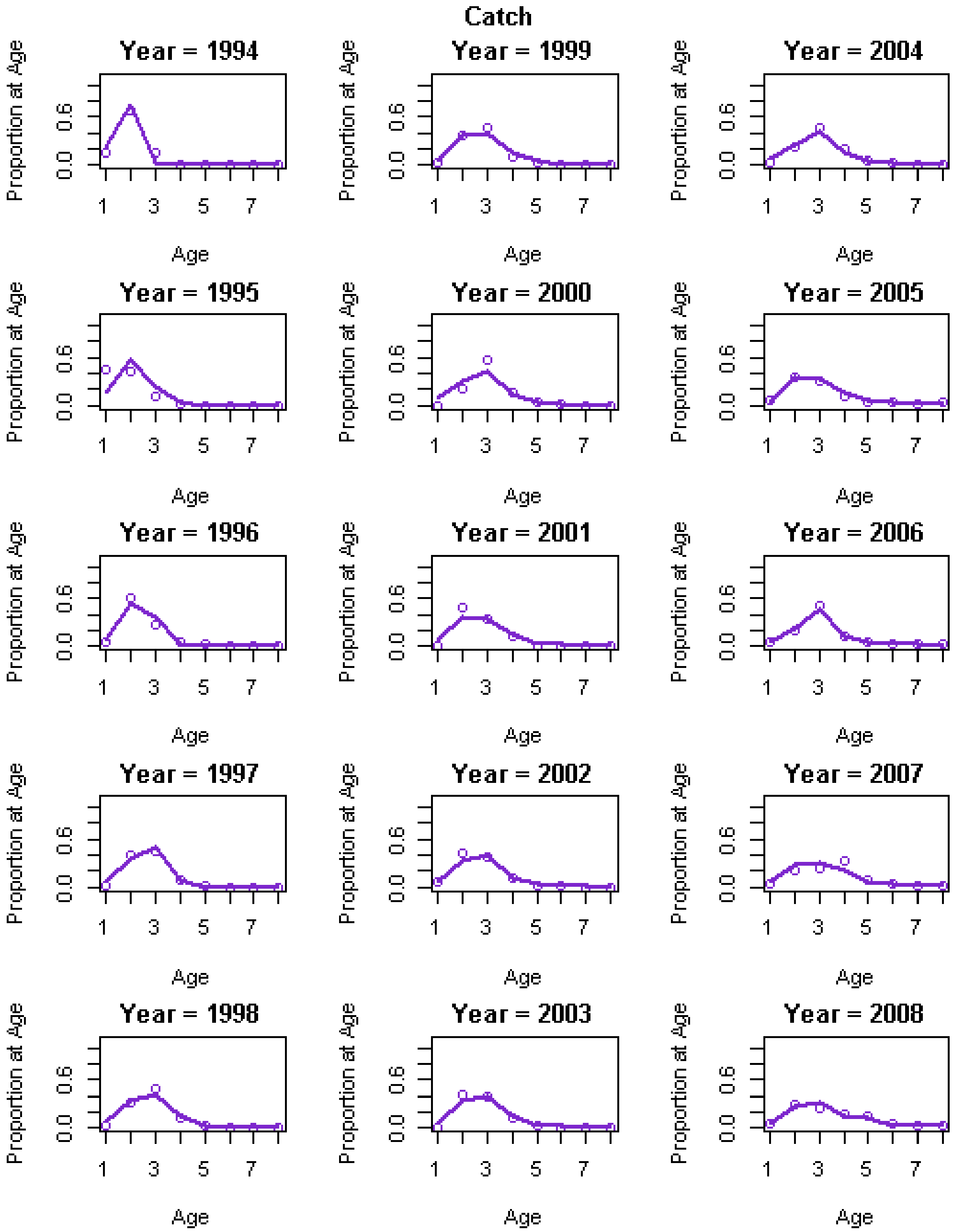


Figure A196. Fits to 1994-2008 discards proportions-at-age in run F57_BASE_12.

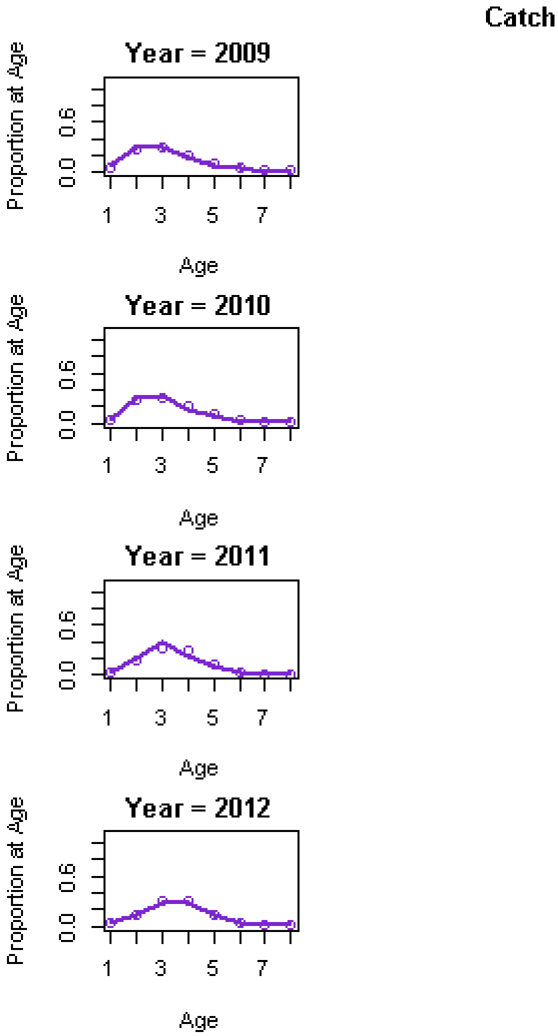


Figure A197. Fits to 2009-2012 discards proportions-at-age in run F57_BASE_12.

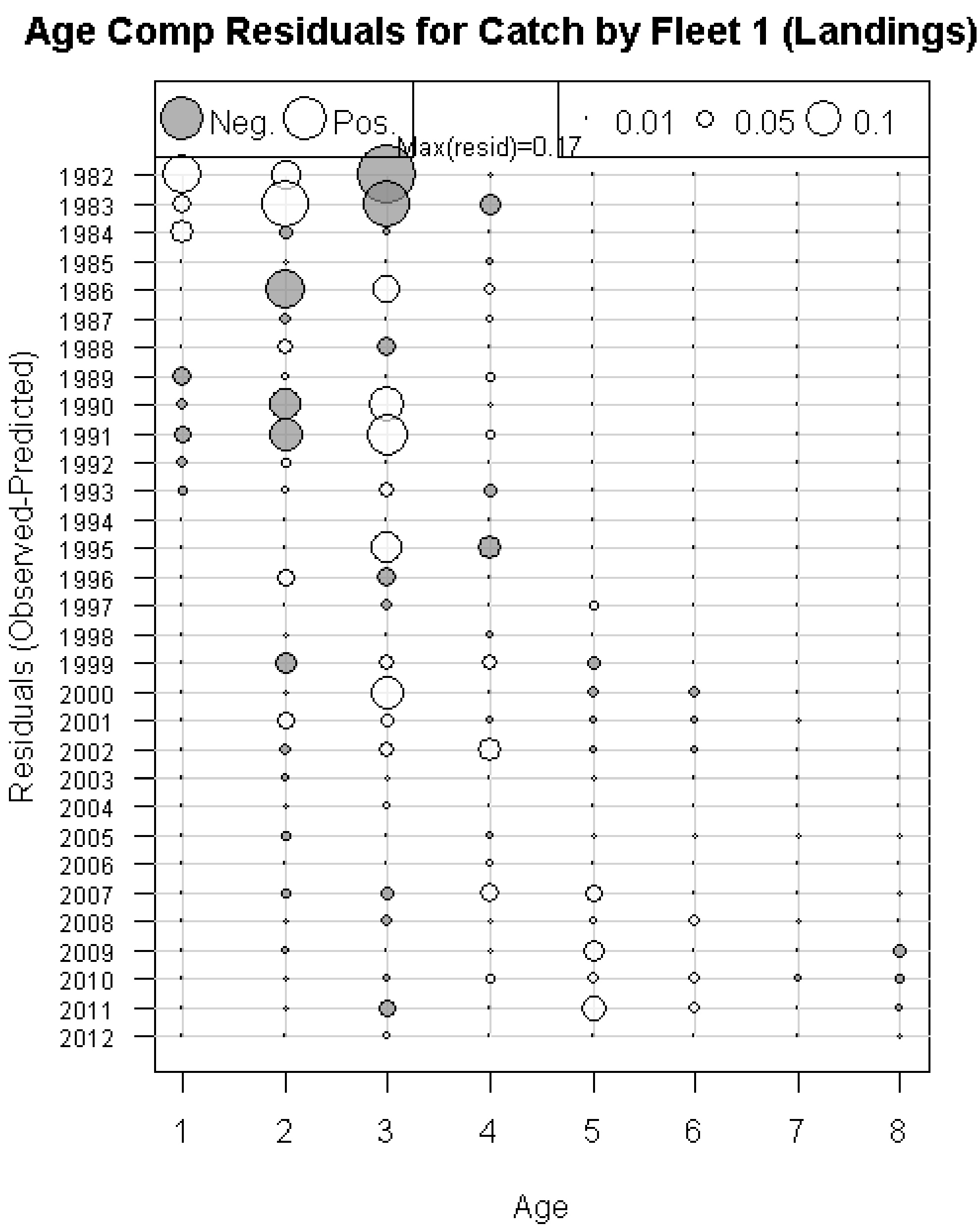


Figure A198. Fishery landings age composition residuals.

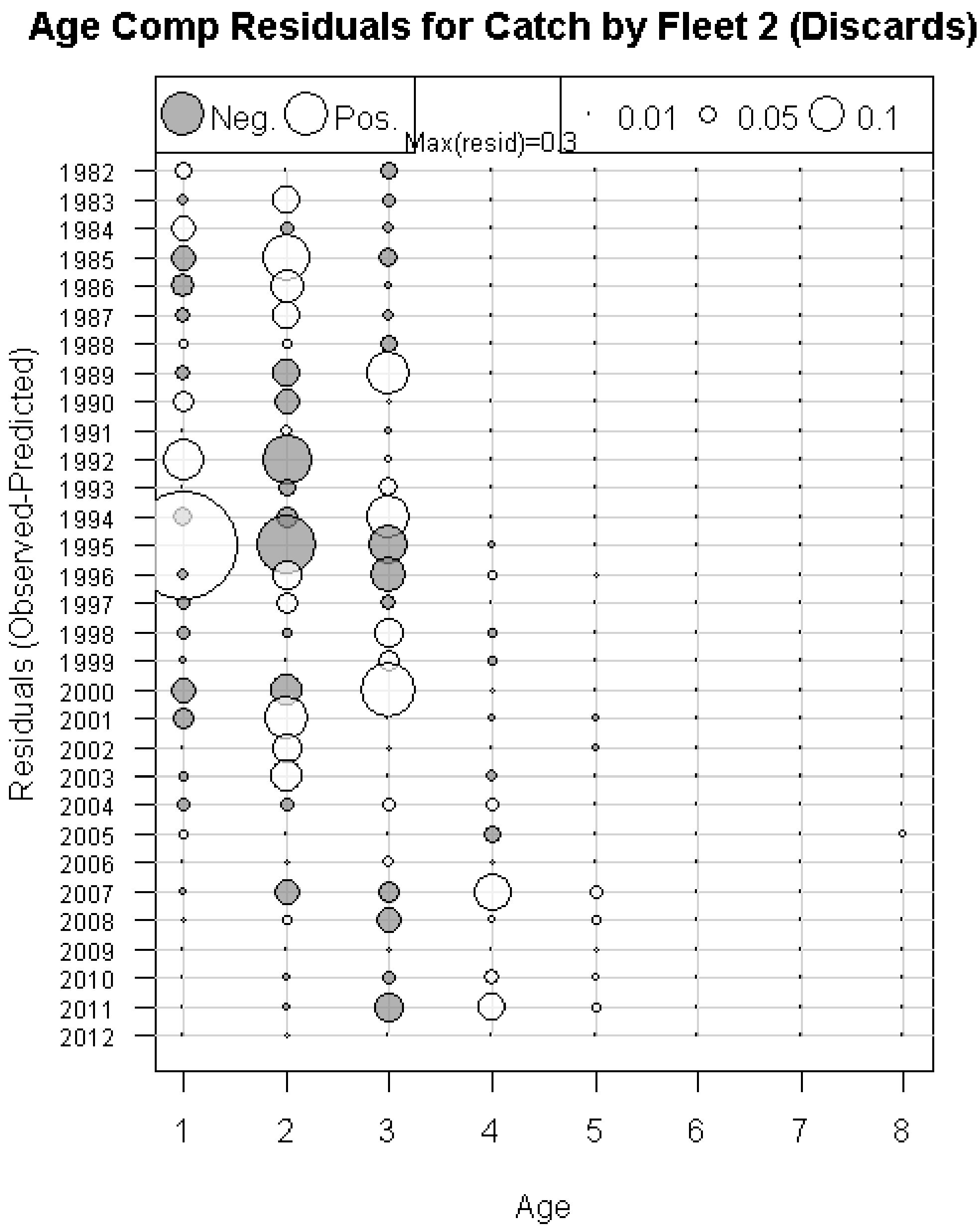


Figure A199. Fishery discards age composition residuals.

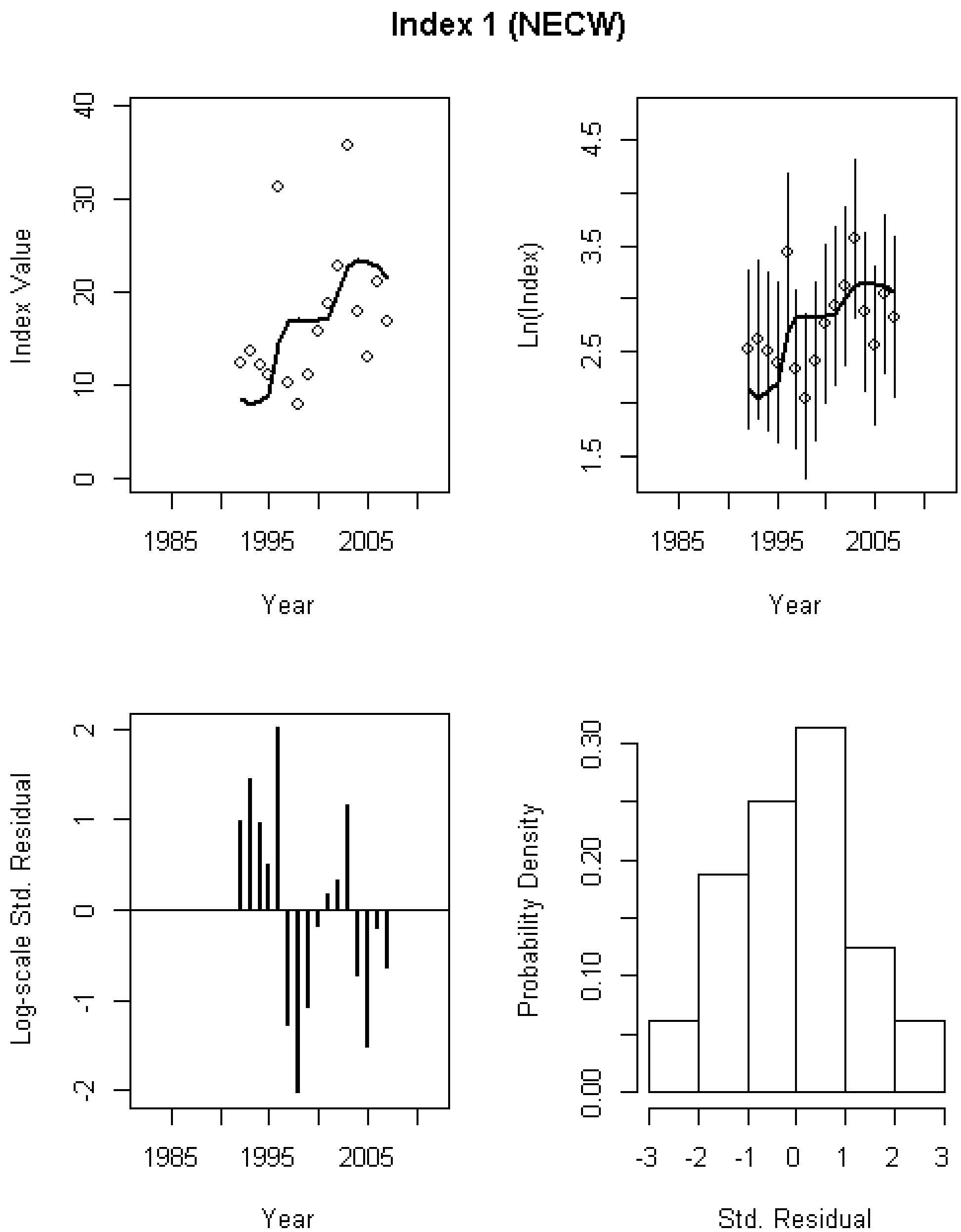


Figure A200. Fit diagnositics for the NEFSC winter trawl survey in run F57_BASE_12.

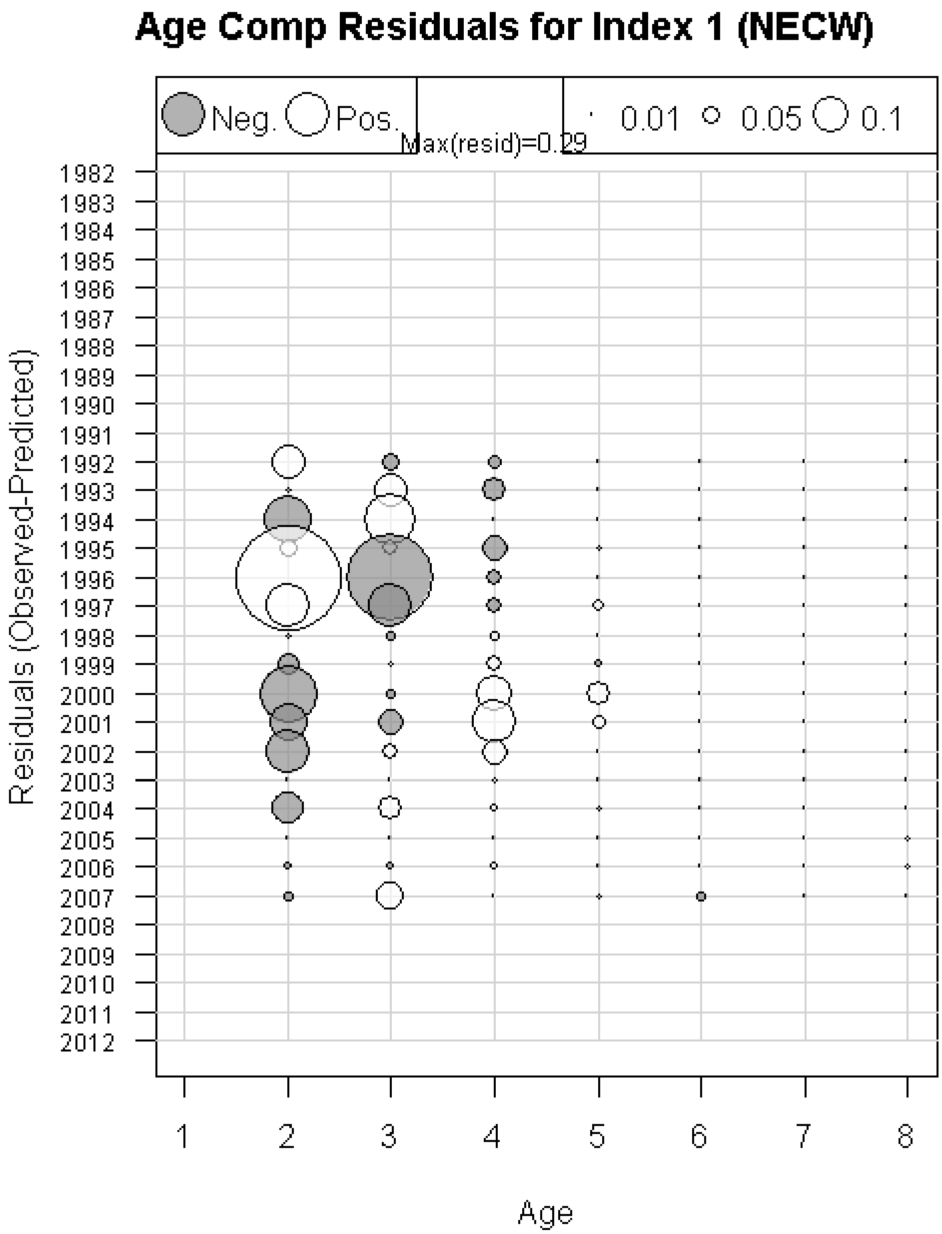


Figure A201. Age composition residuals for the NEFSC winter trawl survey in run F57_BASE_12.

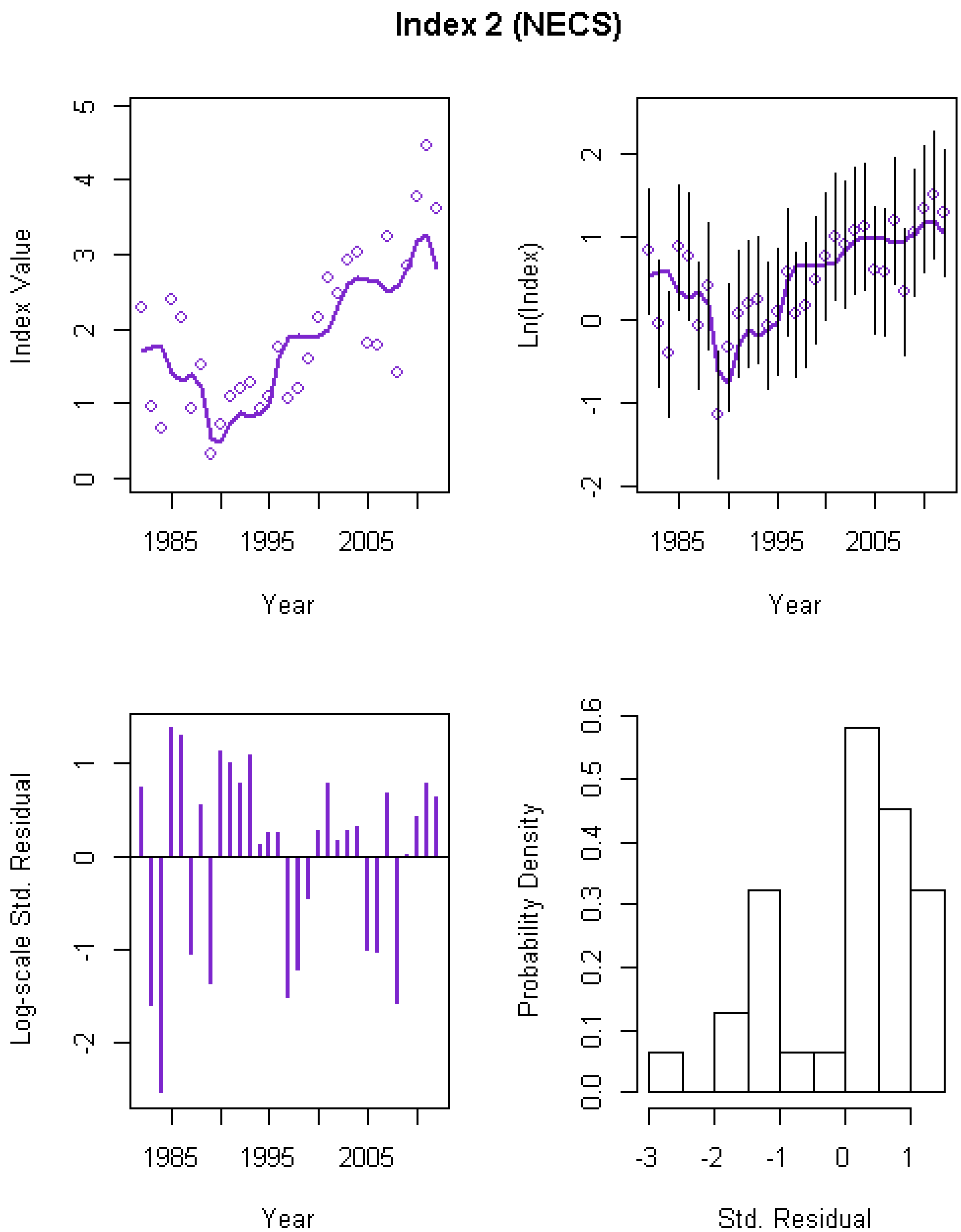


Figure A202. Fit diagnositics for the NEFSC spring trawl survey in run F57_BASE_12.

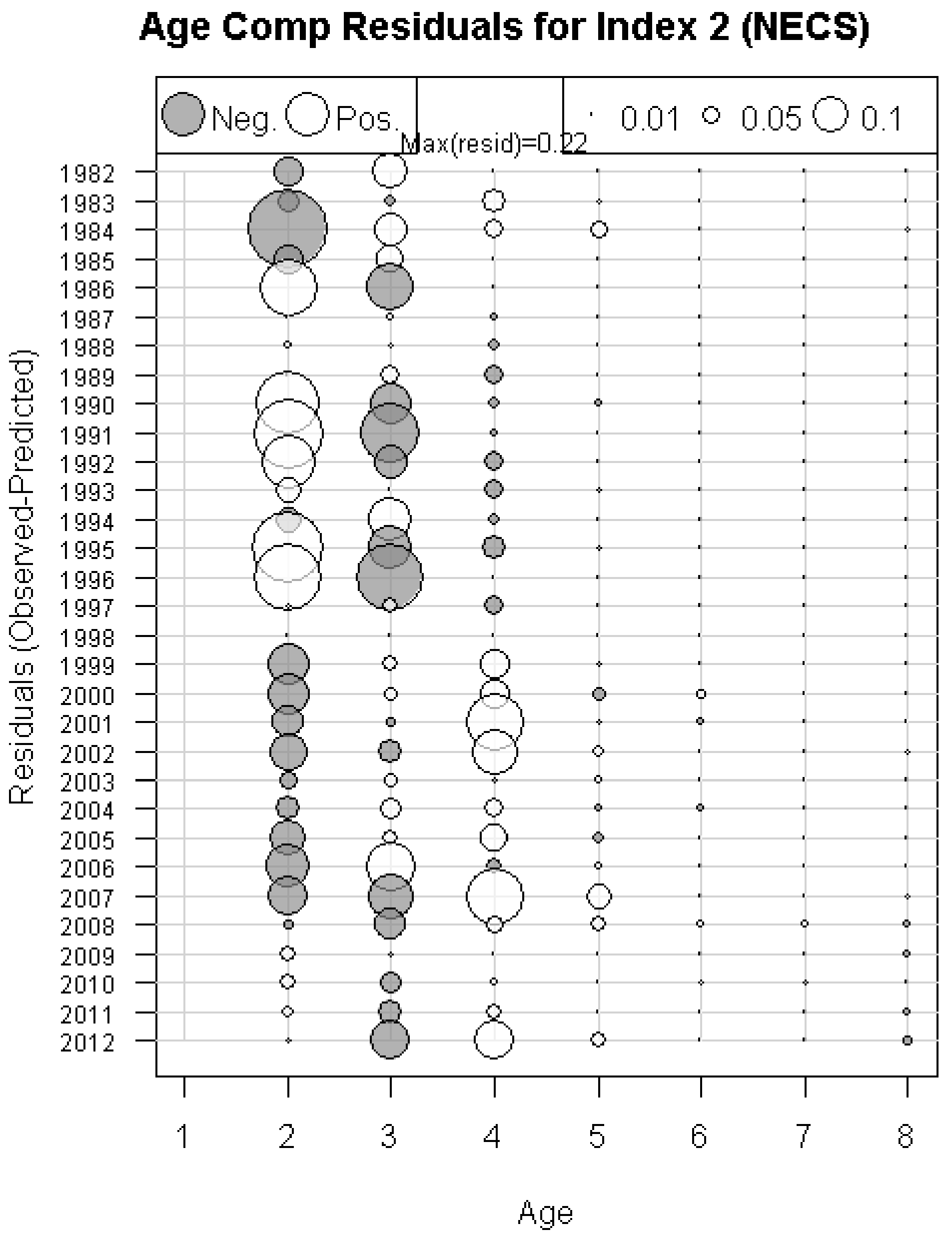


Figure A203. Age composition residuals for the NEFSC spring trawl survey in run F57_BASE_12.

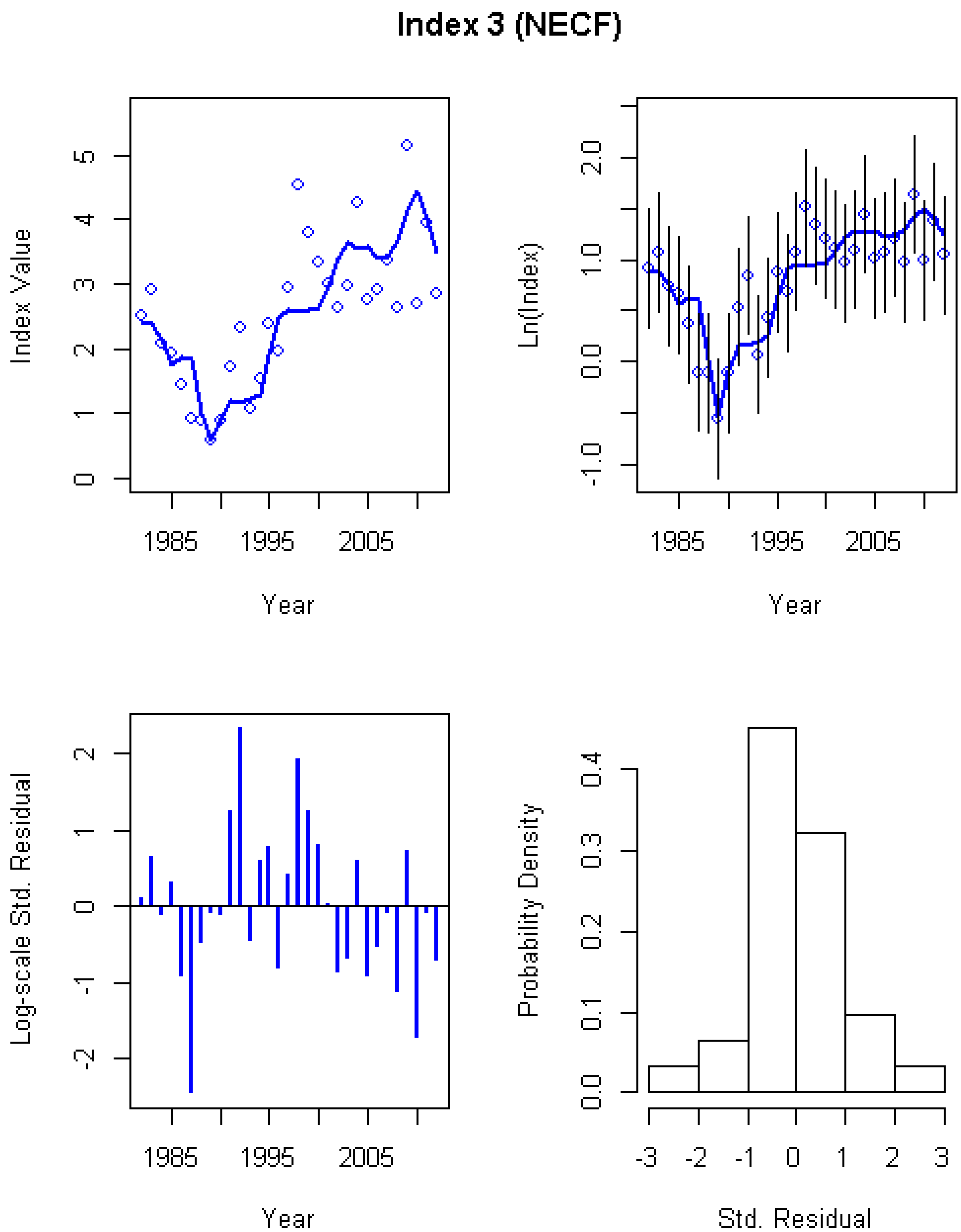


Figure A204. Fit diagnositics for the NEFSC fall trawl survey in run F57_BASE_12.

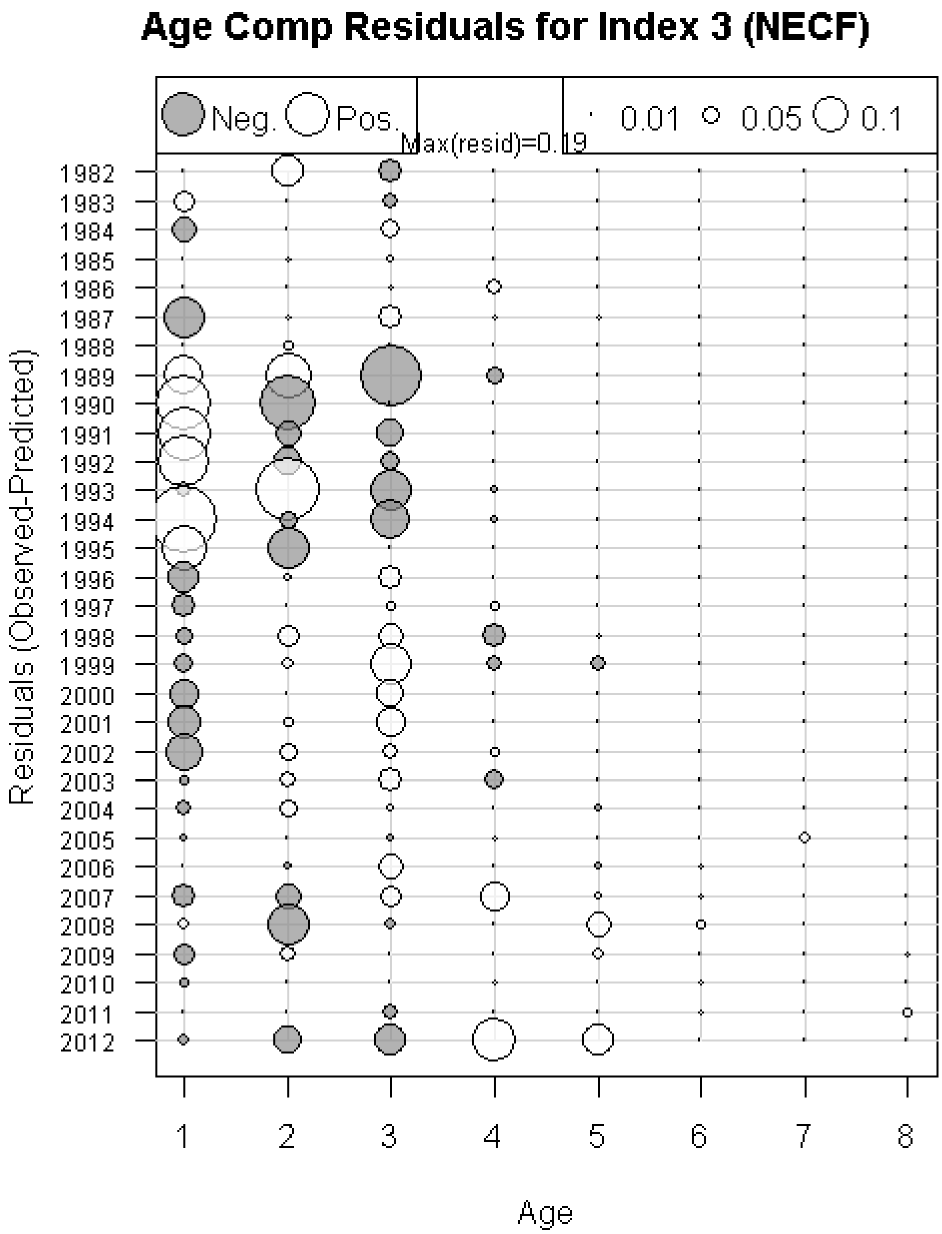


Figure A205. Age composition residuals for the NEFSC fall trawl survey in run F57_BASE_12.

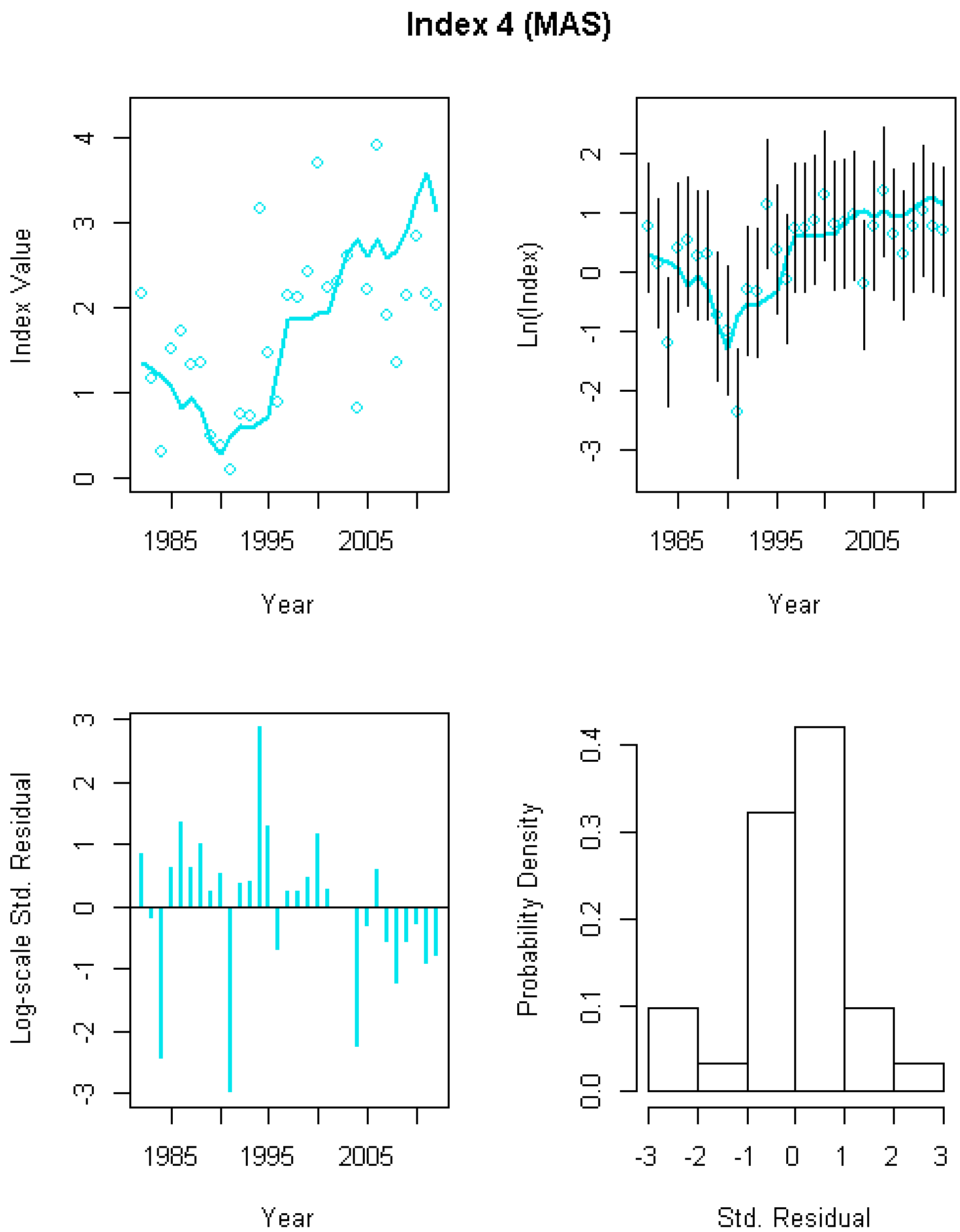


Figure A206. Fit diagnositics for the MADMF spring trawl survey in run F57_BASE_12.

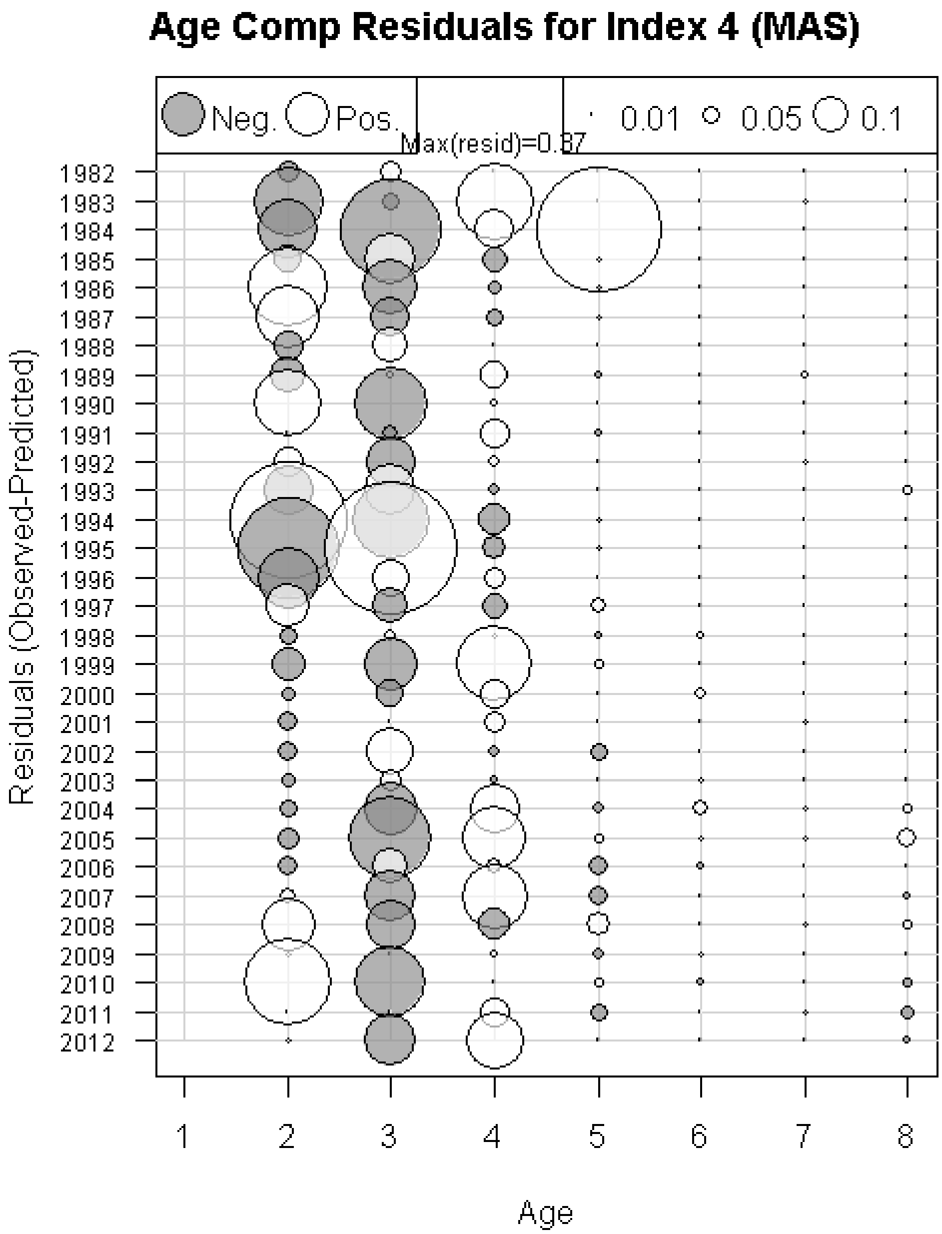


Figure A207. Age composition residuals for the MADMF spring trawl survey in run F57_BASE_12.

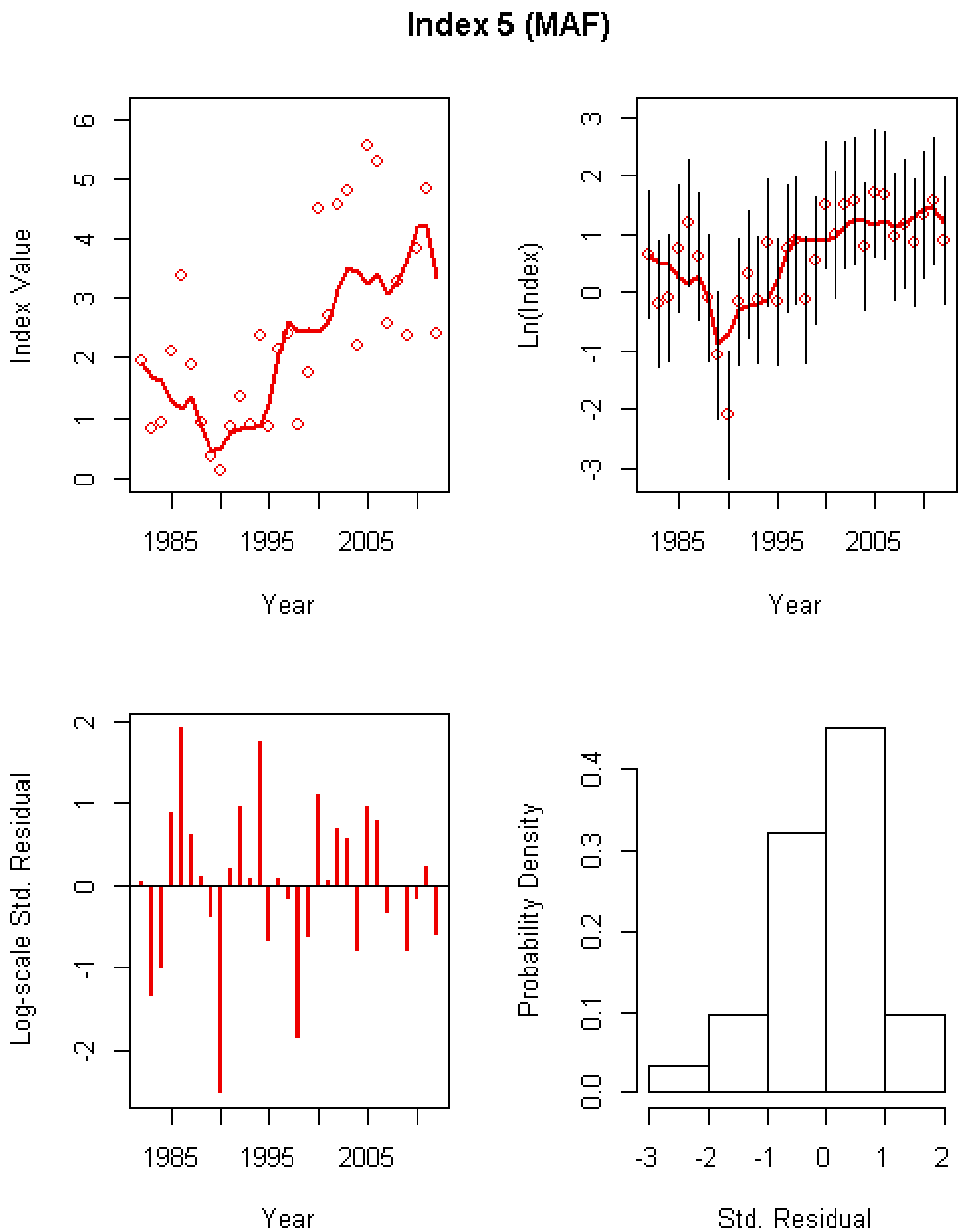


Figure A208. Fit diagnositics for the MADMF fall trawl survey in run F57_BASE_12.

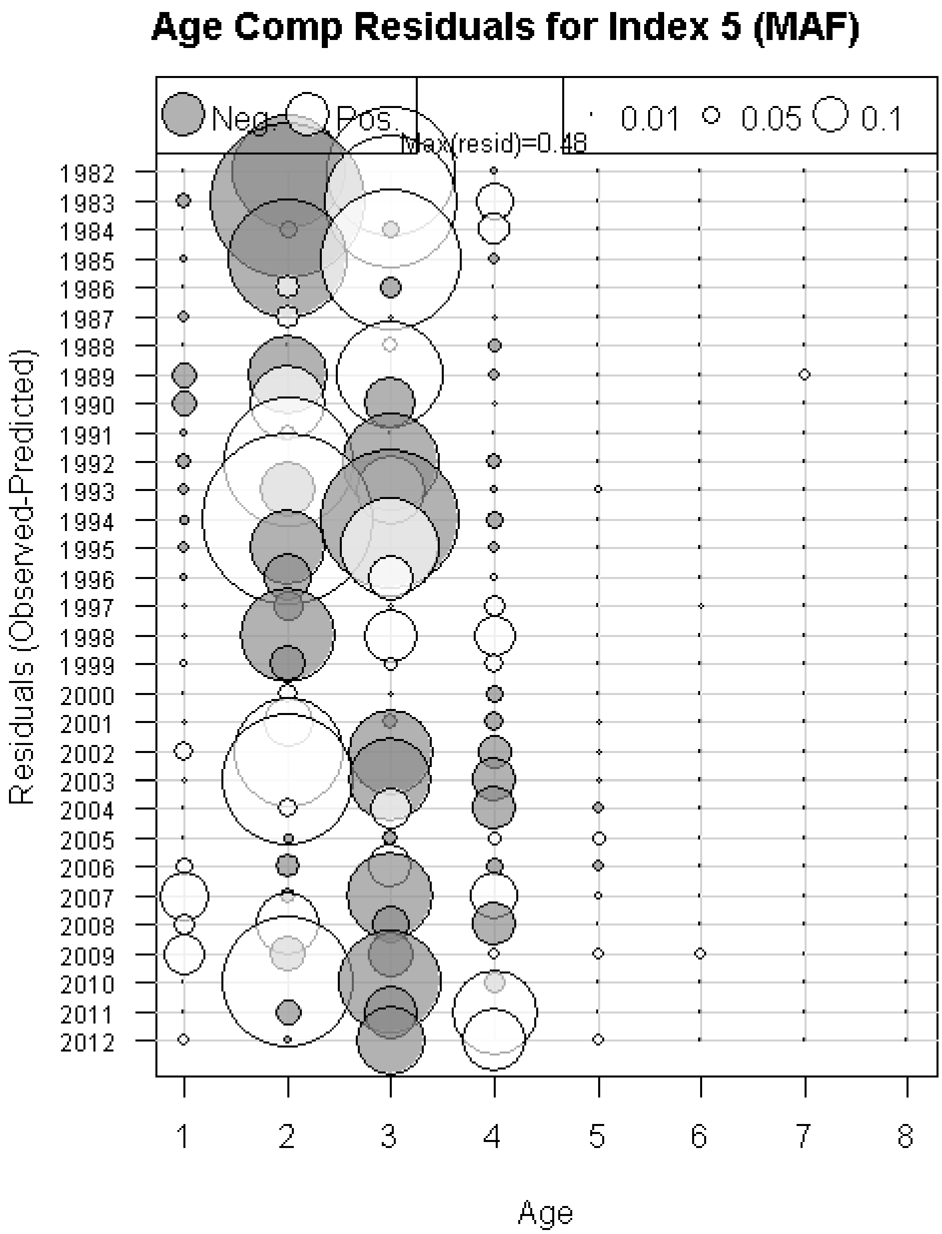


Figure A209. Age composition residuals for the MADMF fall trawl survey in run F57_BASE_12.

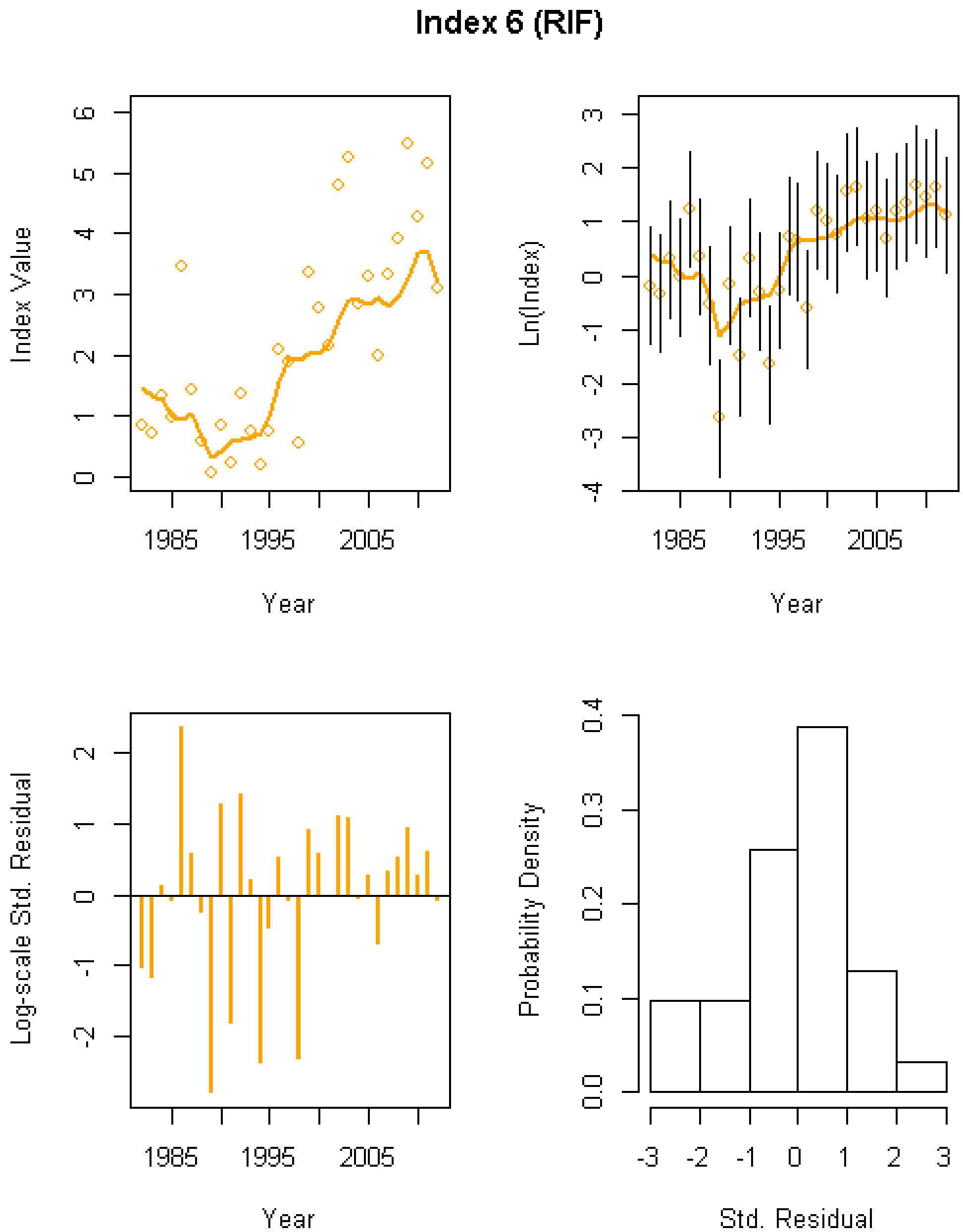


Figure A210. Fit diagnositics for the RIDFW fall trawl survey in run F57_BASE_12.

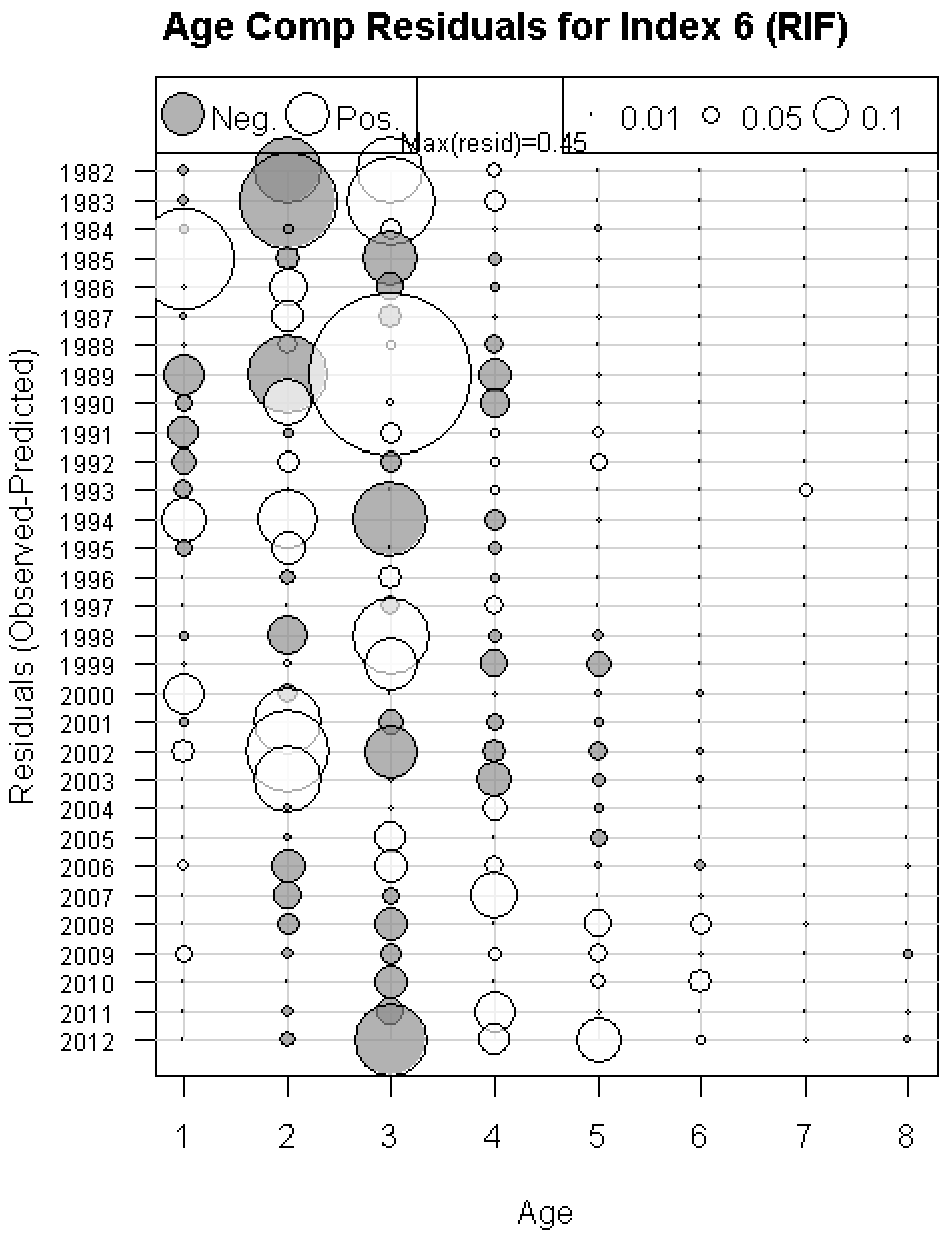


Figure A211. Age composition residuals for the RIDFW fall trawl survey in run F57_BASE_12.

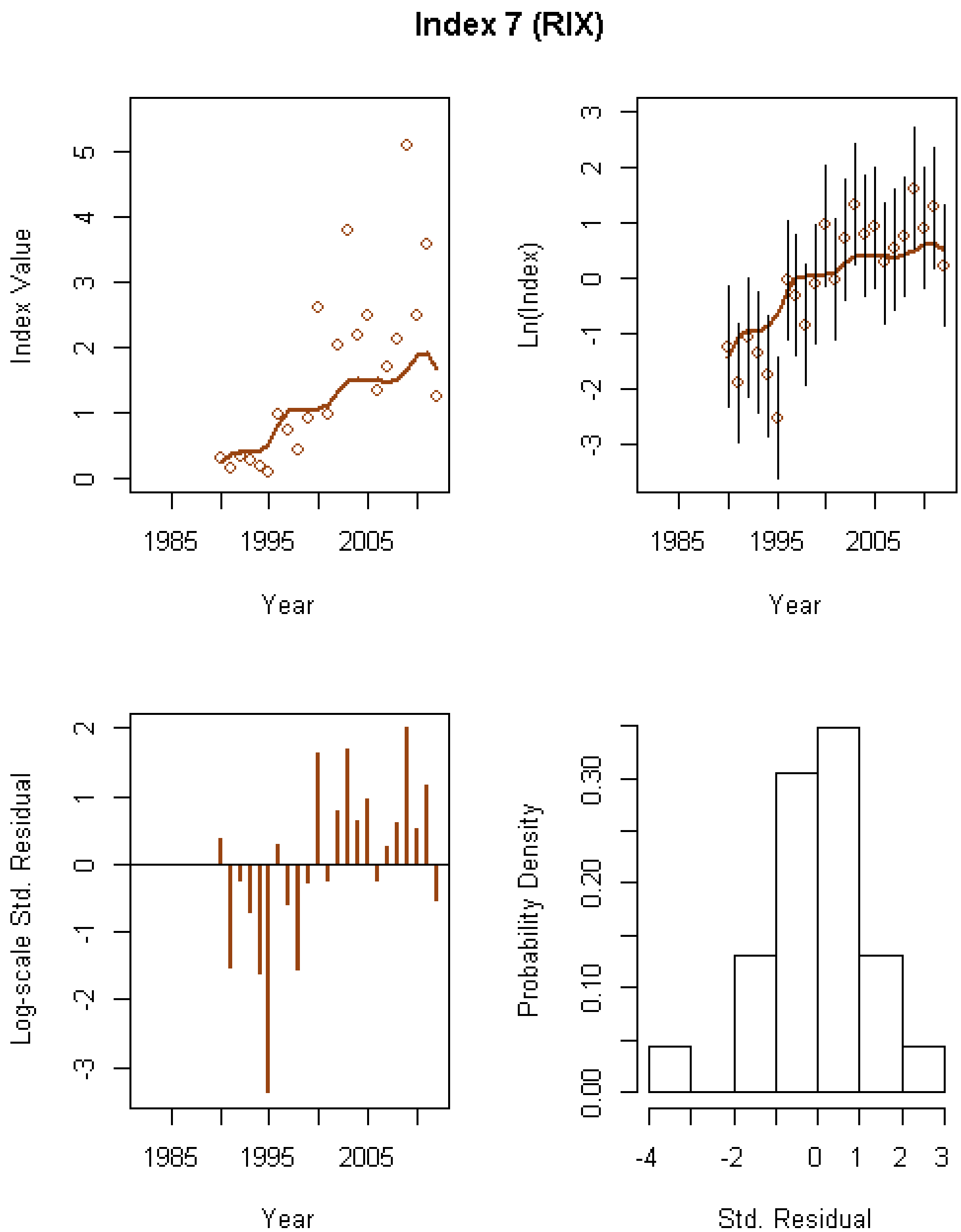


Figure A212. Fit diagnositics for the RIDFW monthly fixed station trawl survey in run F57_BASE_12.

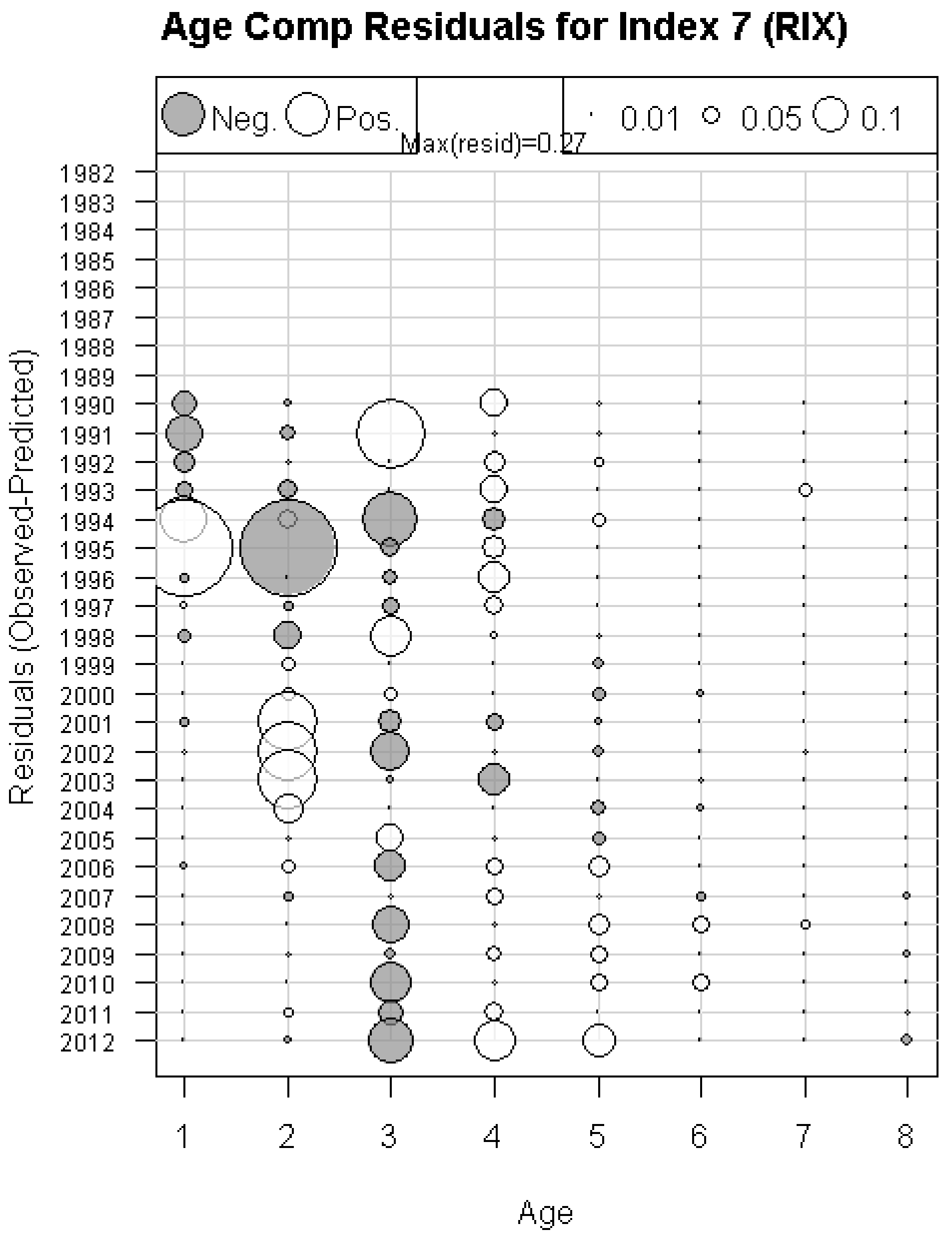


Figure A213. Age composition residuals for the RIDFW monthly fixed station trawl survey in run F57_BASE_12.

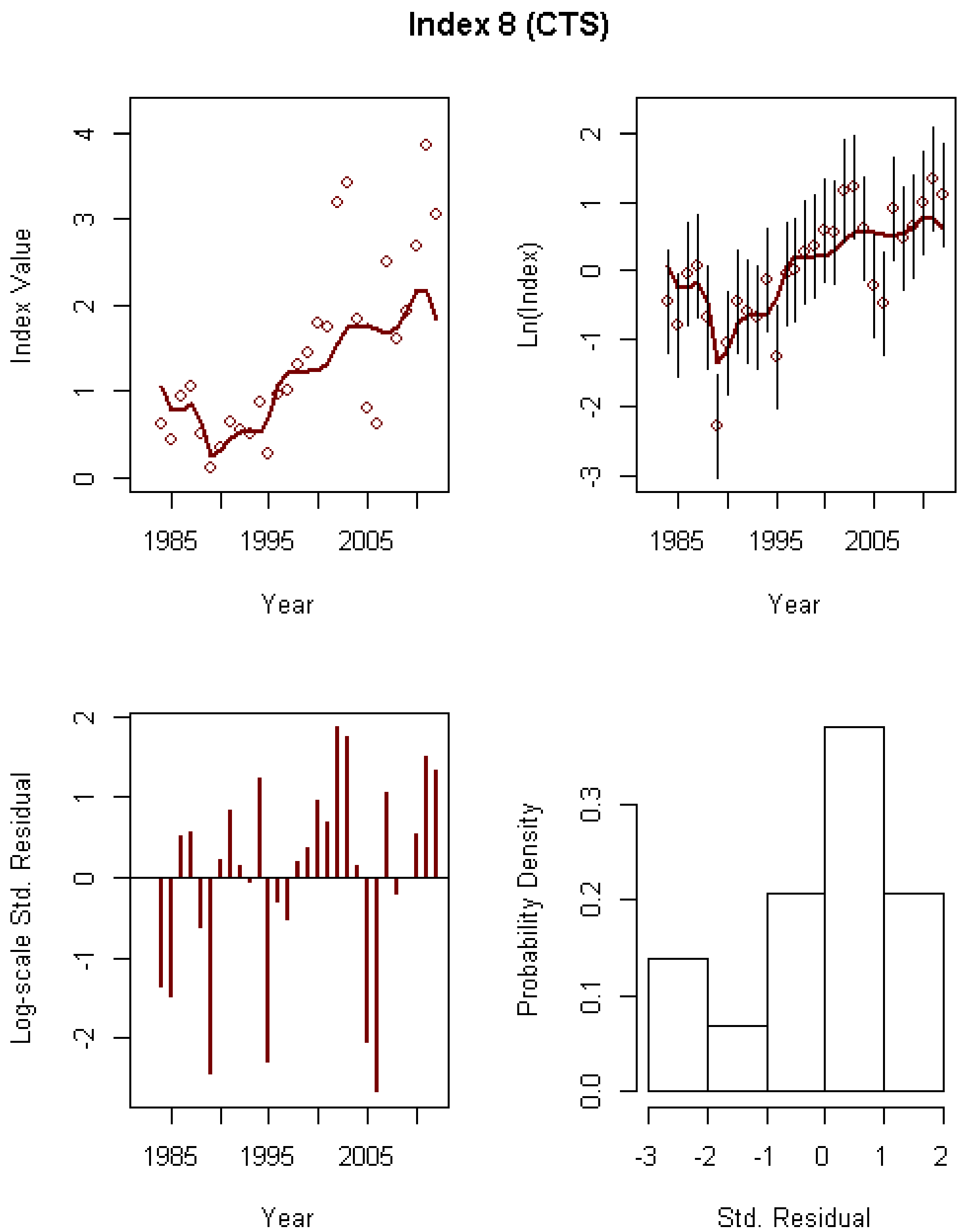


Figure A214. Fit diagnositics for the CTDEP spring trawl survey in run F57_BASE_12.

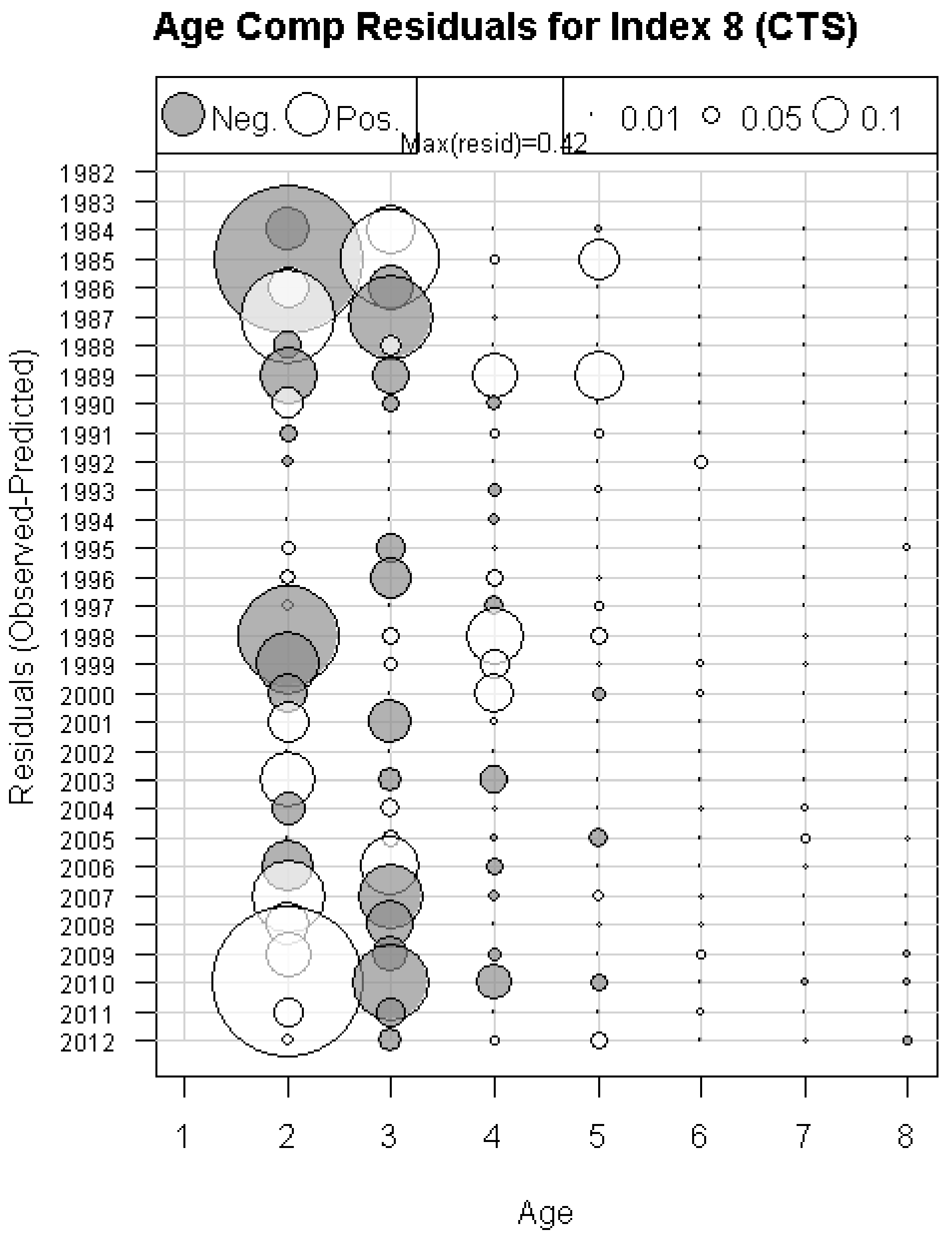


Figure A215. Age composition residuals for the CTDEP spring trawl survey in run F57_BASE_12.

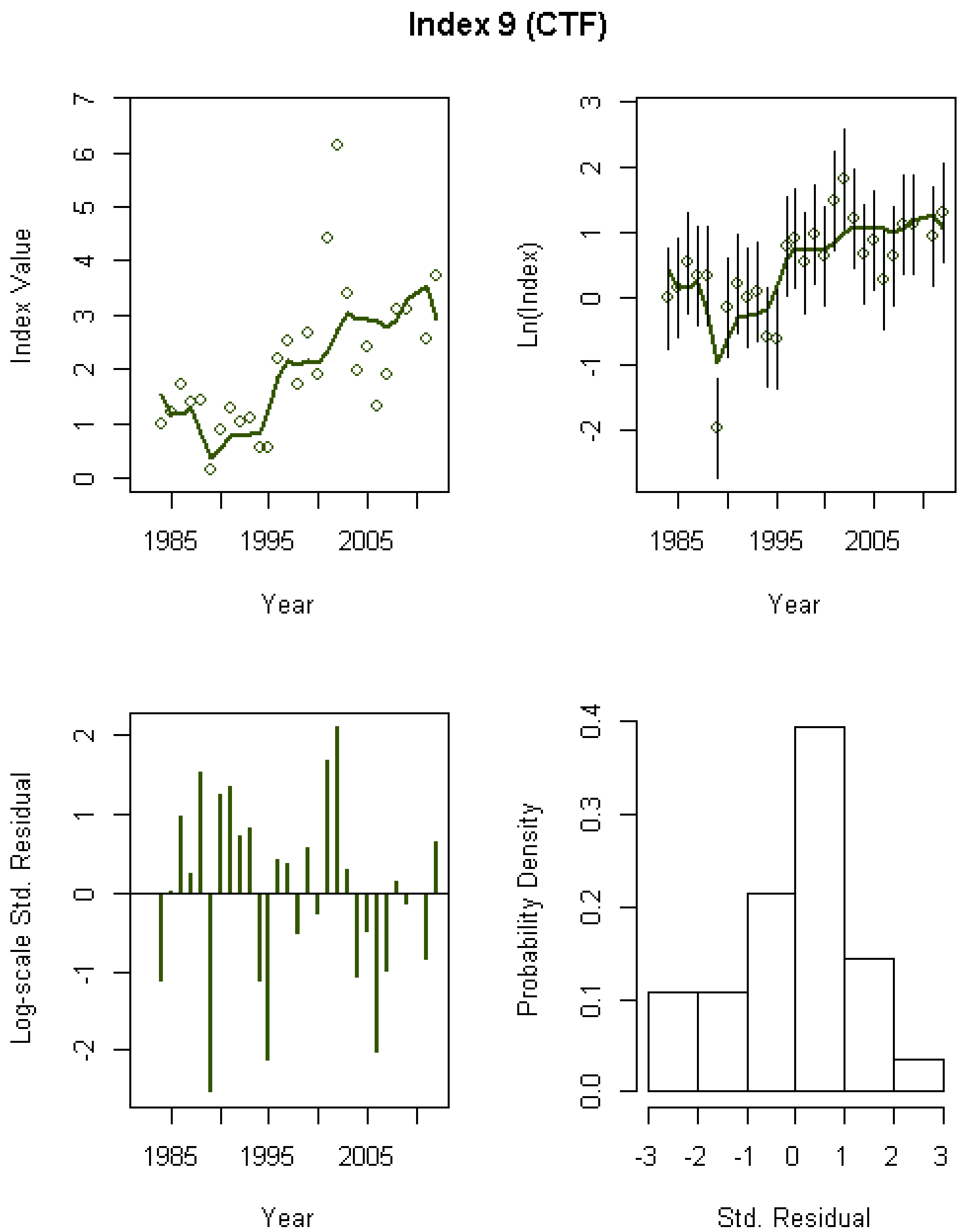


Figure A216. Fit diagnositics for the CTDEP fall trawl survey in run F57_BASE_12.

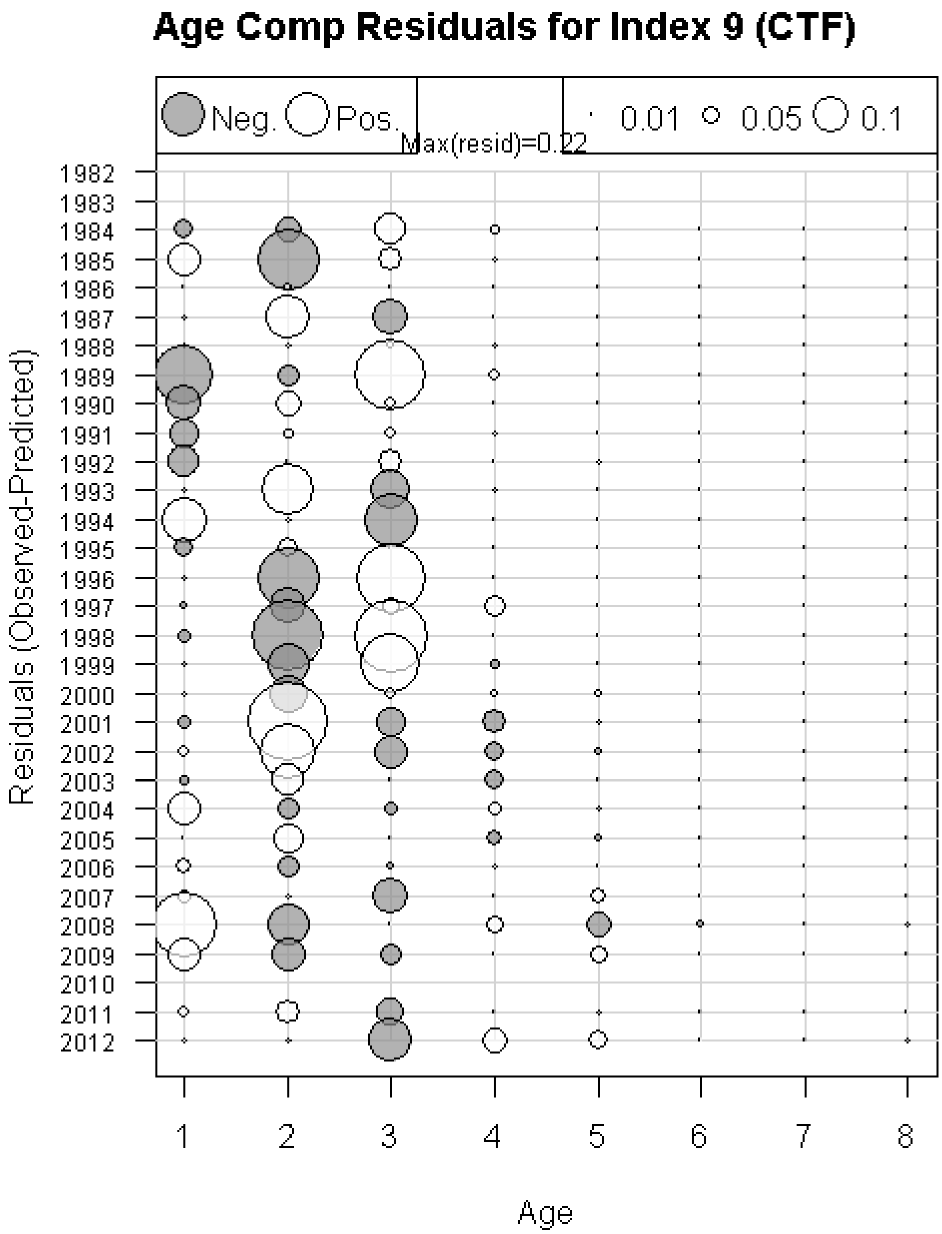


Figure A217. Age composition residuals for the CTDEP fall trawl survey in run F57_BASE_12.

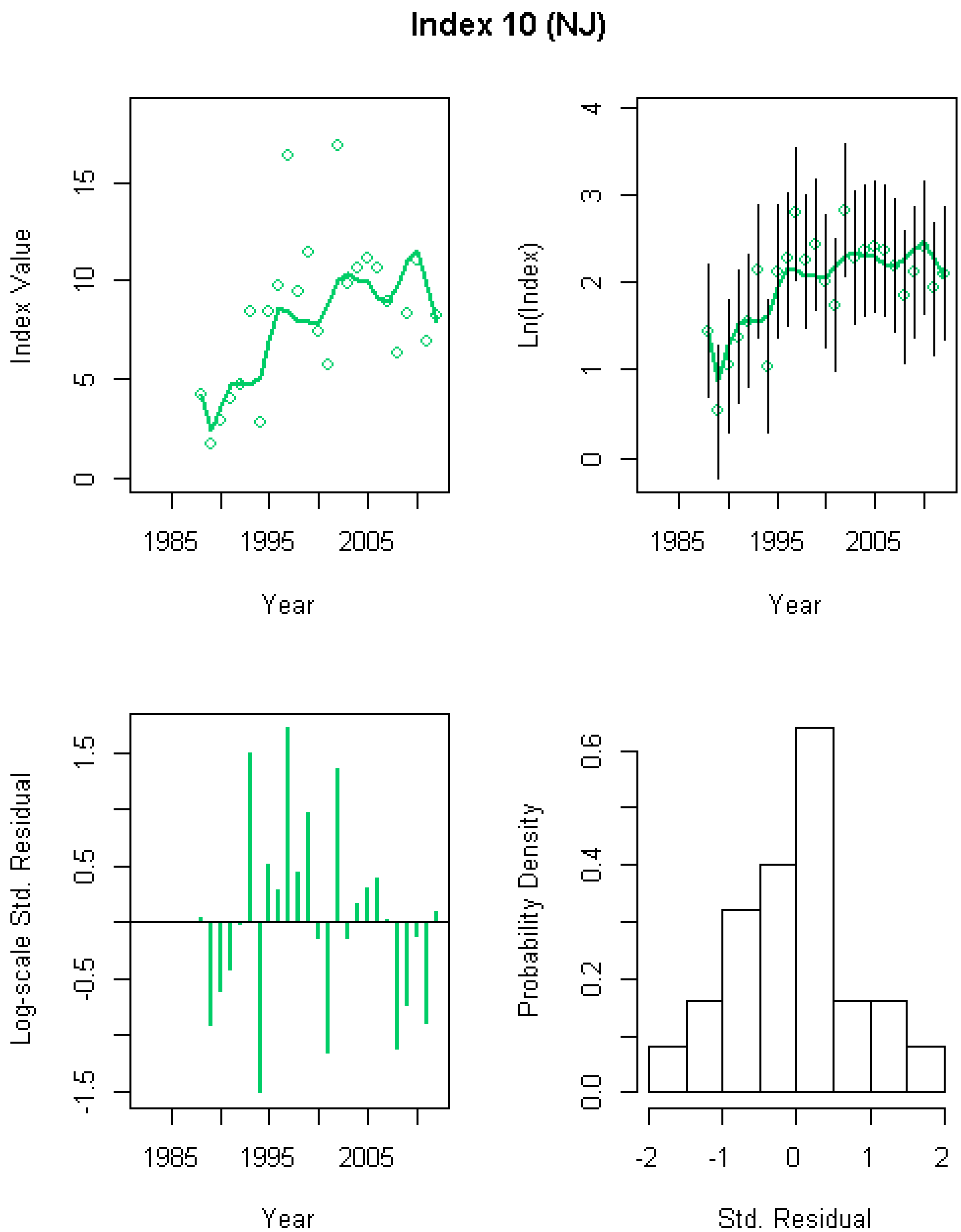


Figure A218. Fit diagnositics for the NJDFW trawl survey in run F57_BASE_12.

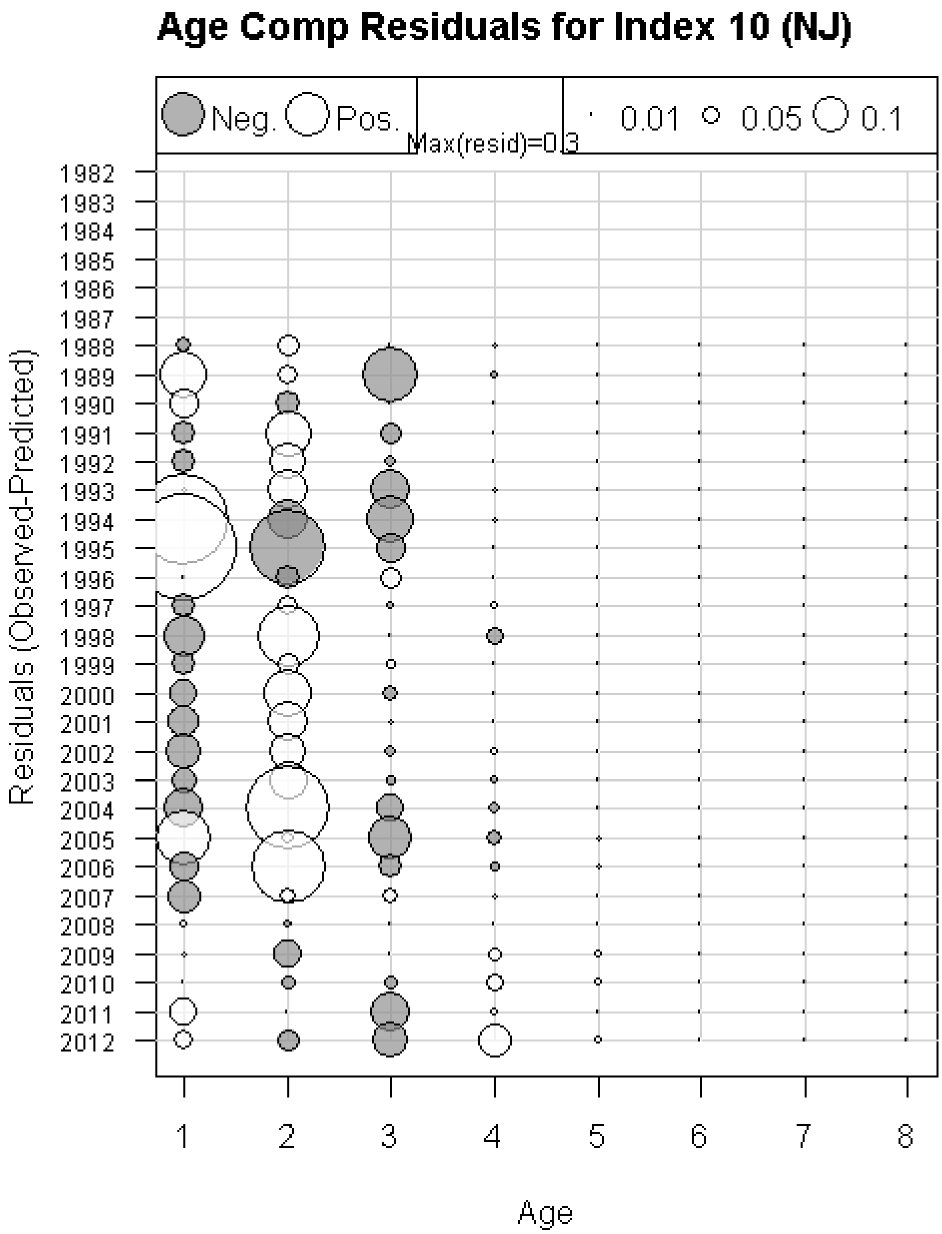


Figure A219. Age composition residuals for the NJDFW trawl survey in run F57_BASE_12.

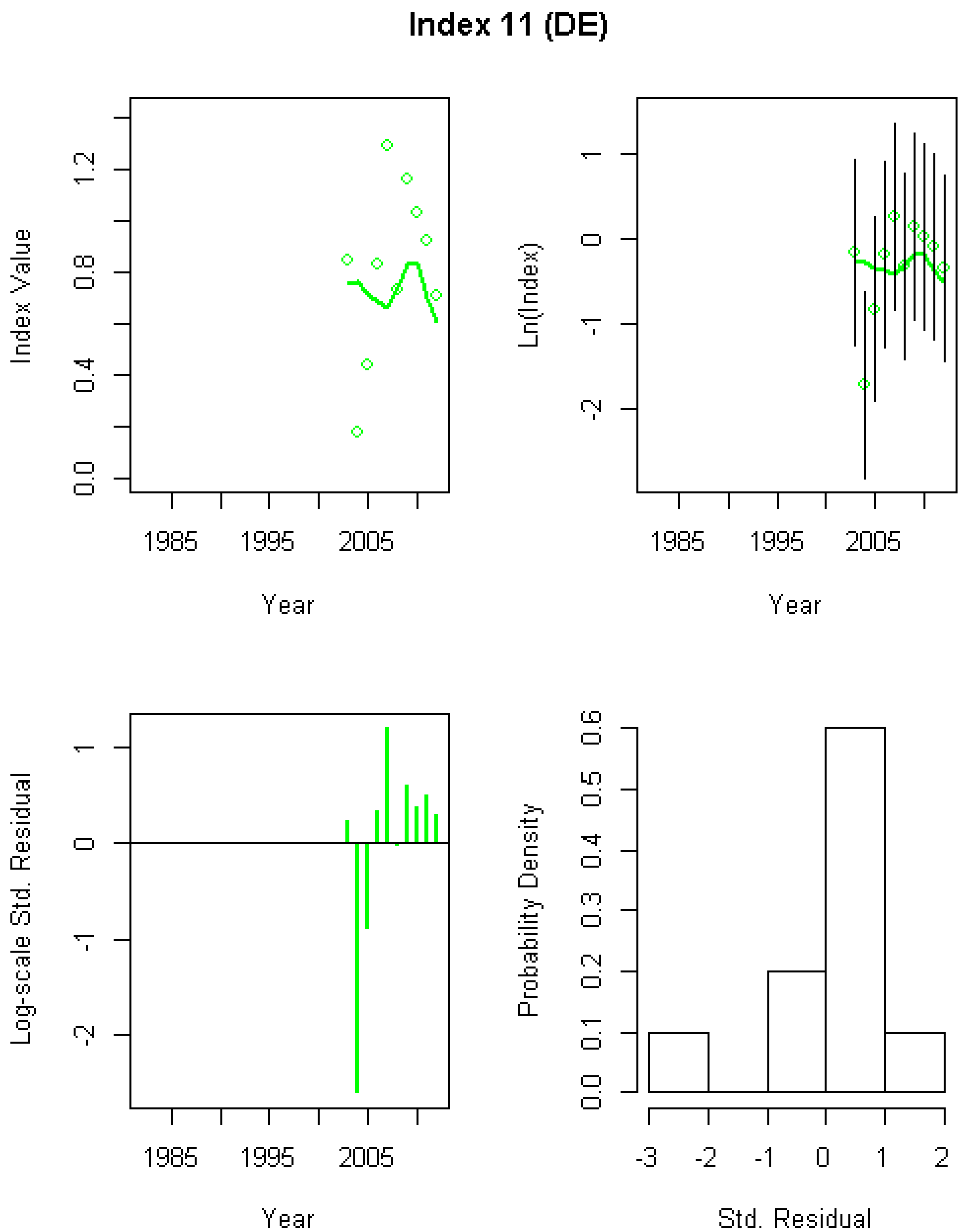


Figure A220. Fit diagnositics for the DEDFW trawl survey in run F57_BASE_12.

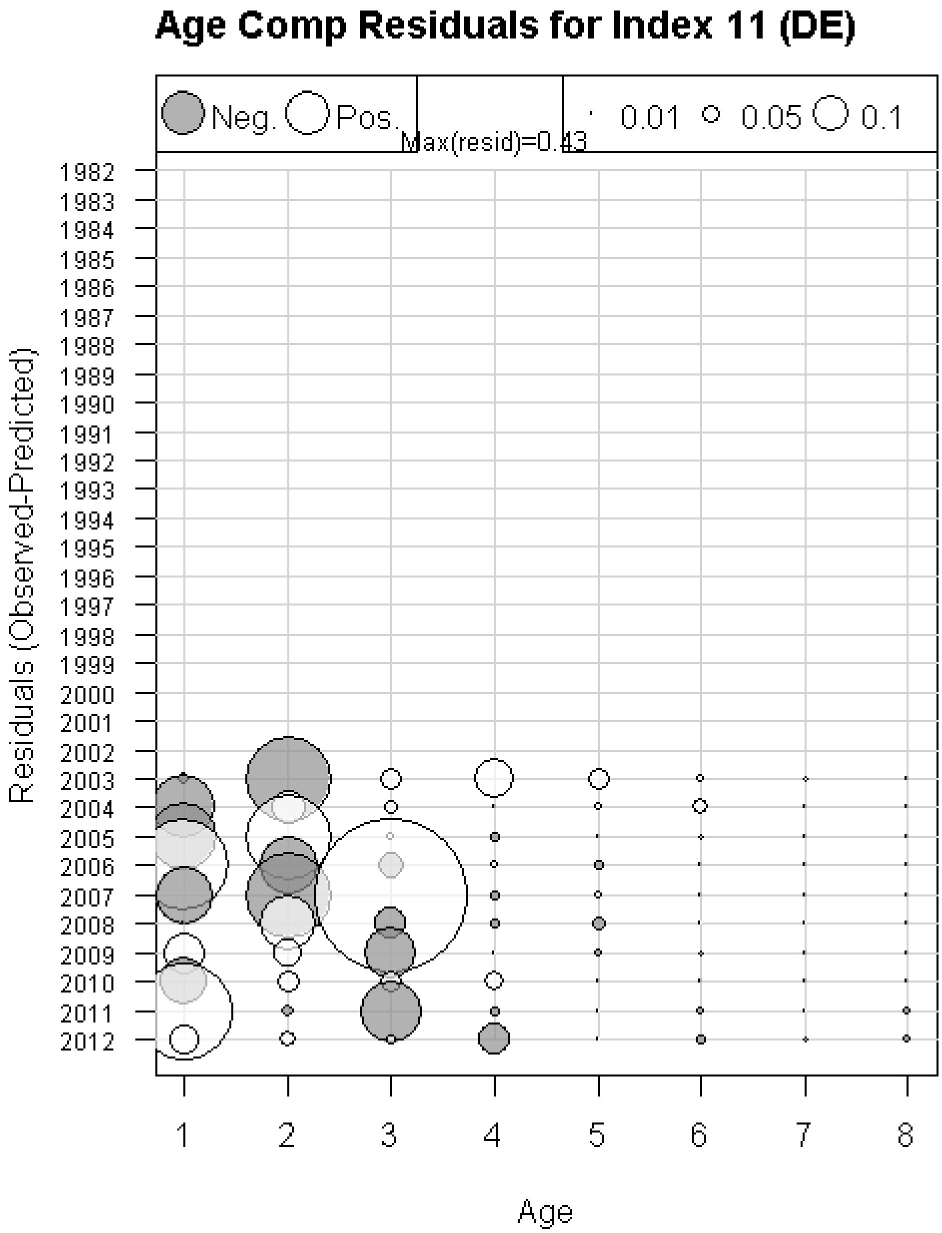


Figure A221. Age composition residuals for the DEDFW trawl survey in run F57_BASE_12.

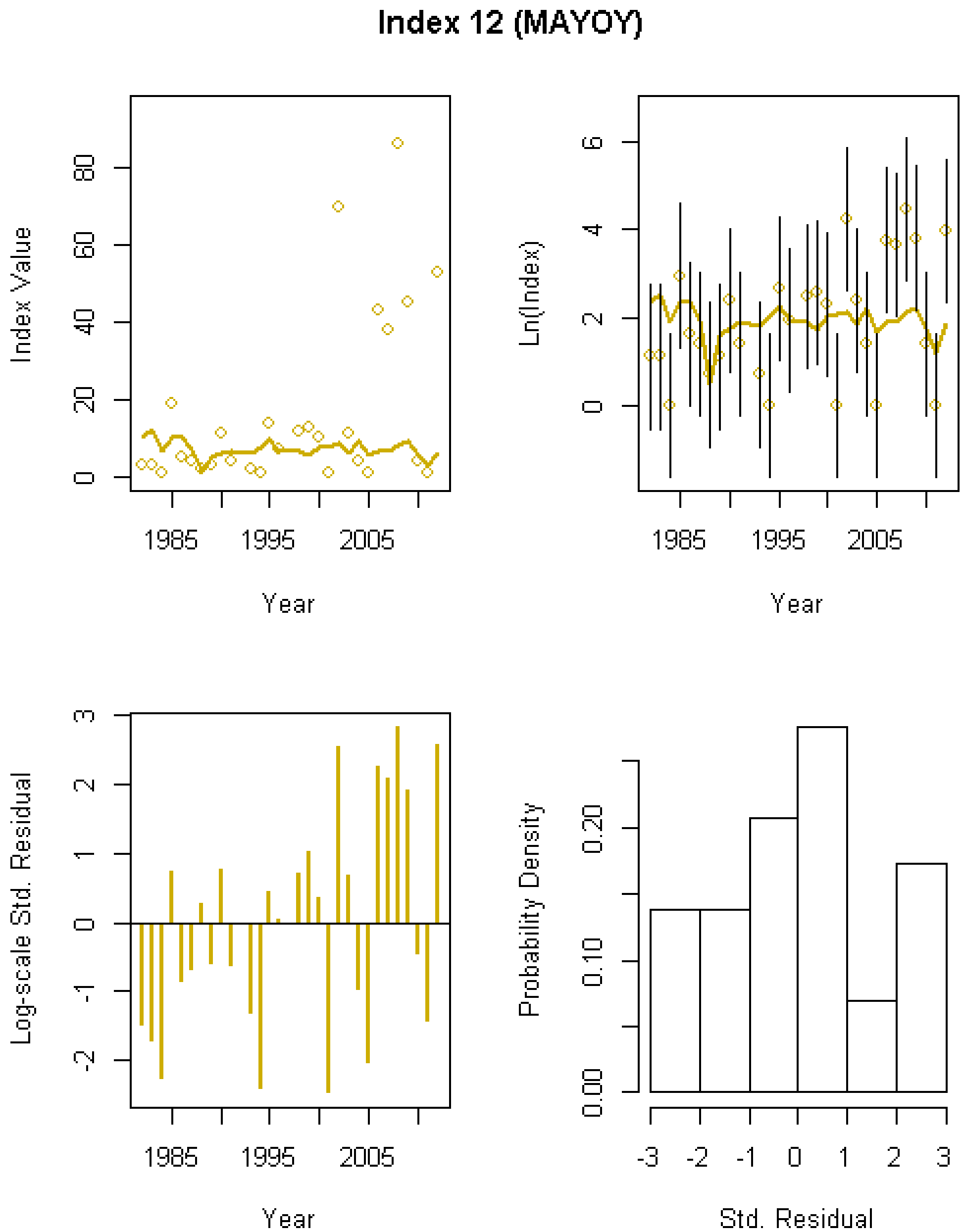


Figure A222. Fit diagnositics for the MADMF YOY seine survey in run F57_BASE_12.

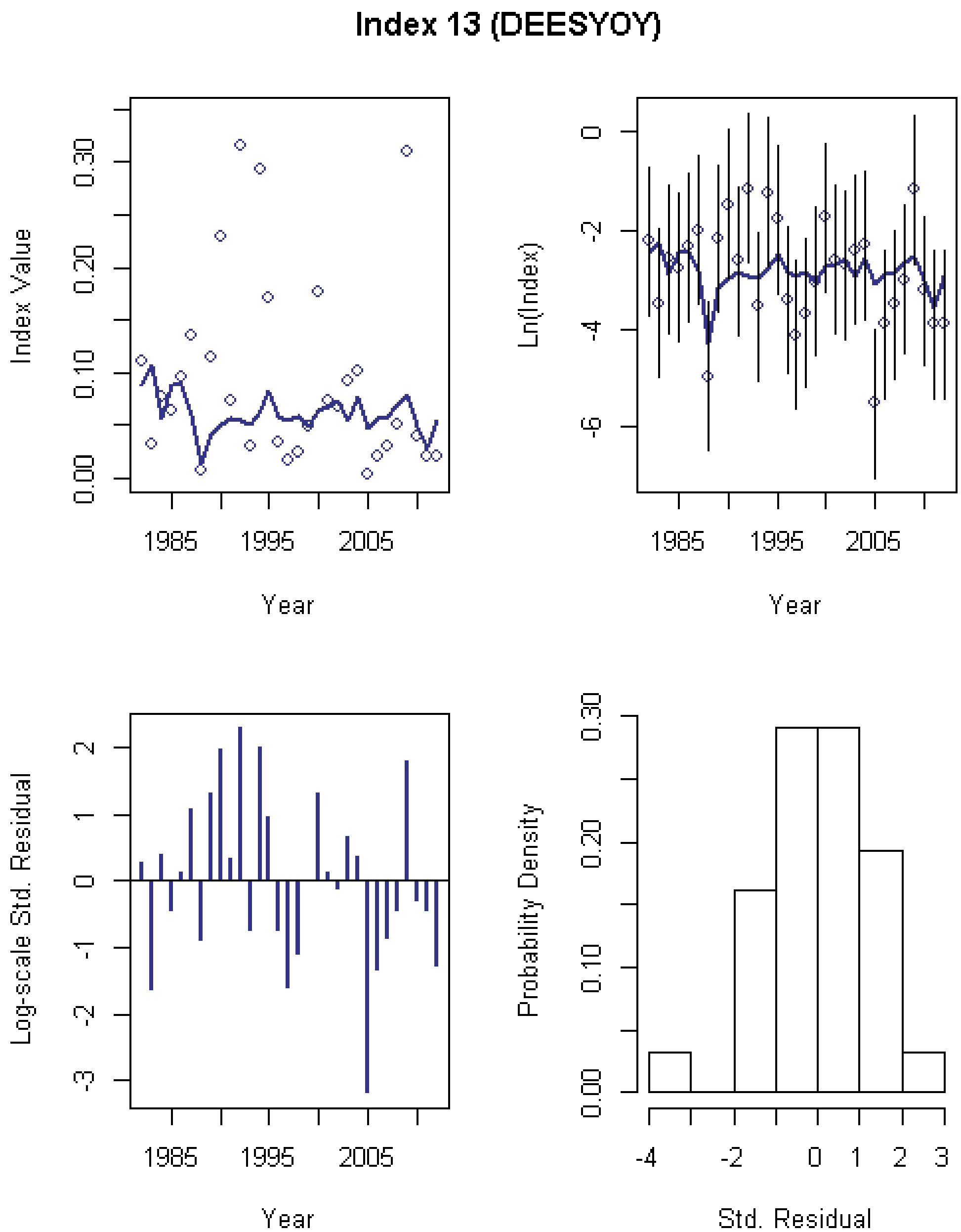


Figure A223. Fit diagnositics for the DEDFW YOY estuary trawl survey in run F57_BASE_12.

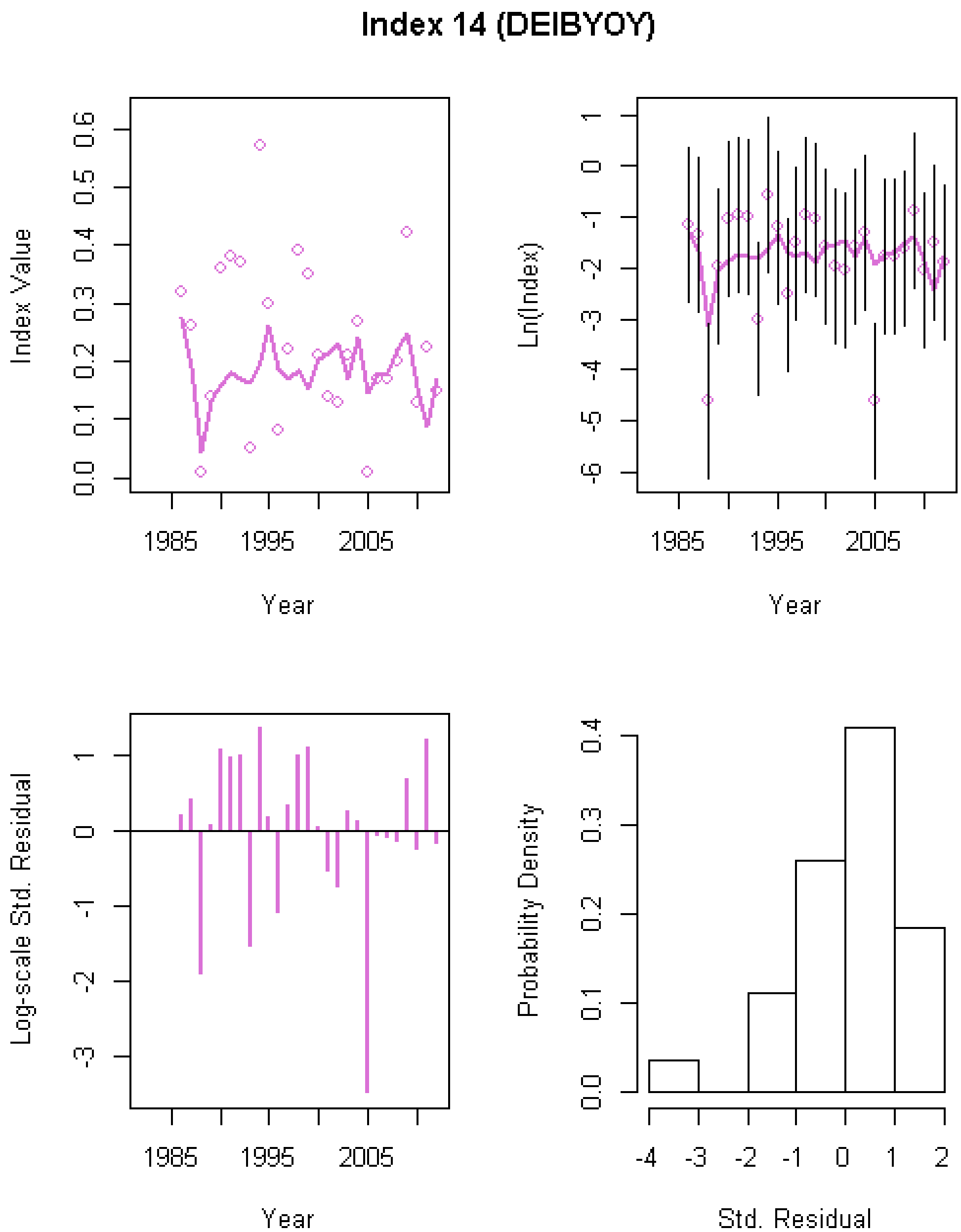


Figure A224. Fit diagnositics for the DEDFW YOY inland bays trawl survey in run F57_BASE_12.

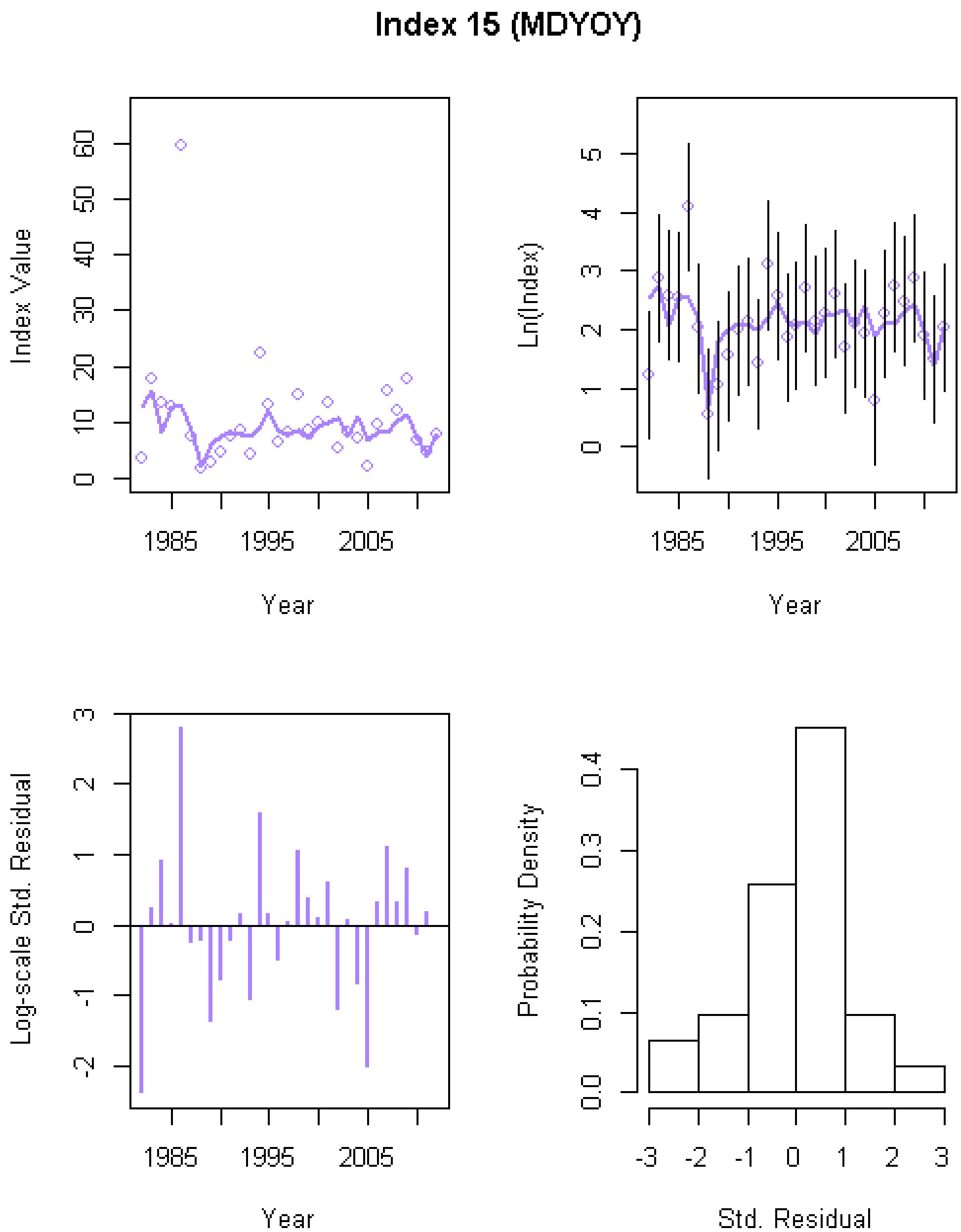


Figure A225. Fit diagnositics for the MDDNR YOY trawl survey in run F57_BASE_12.

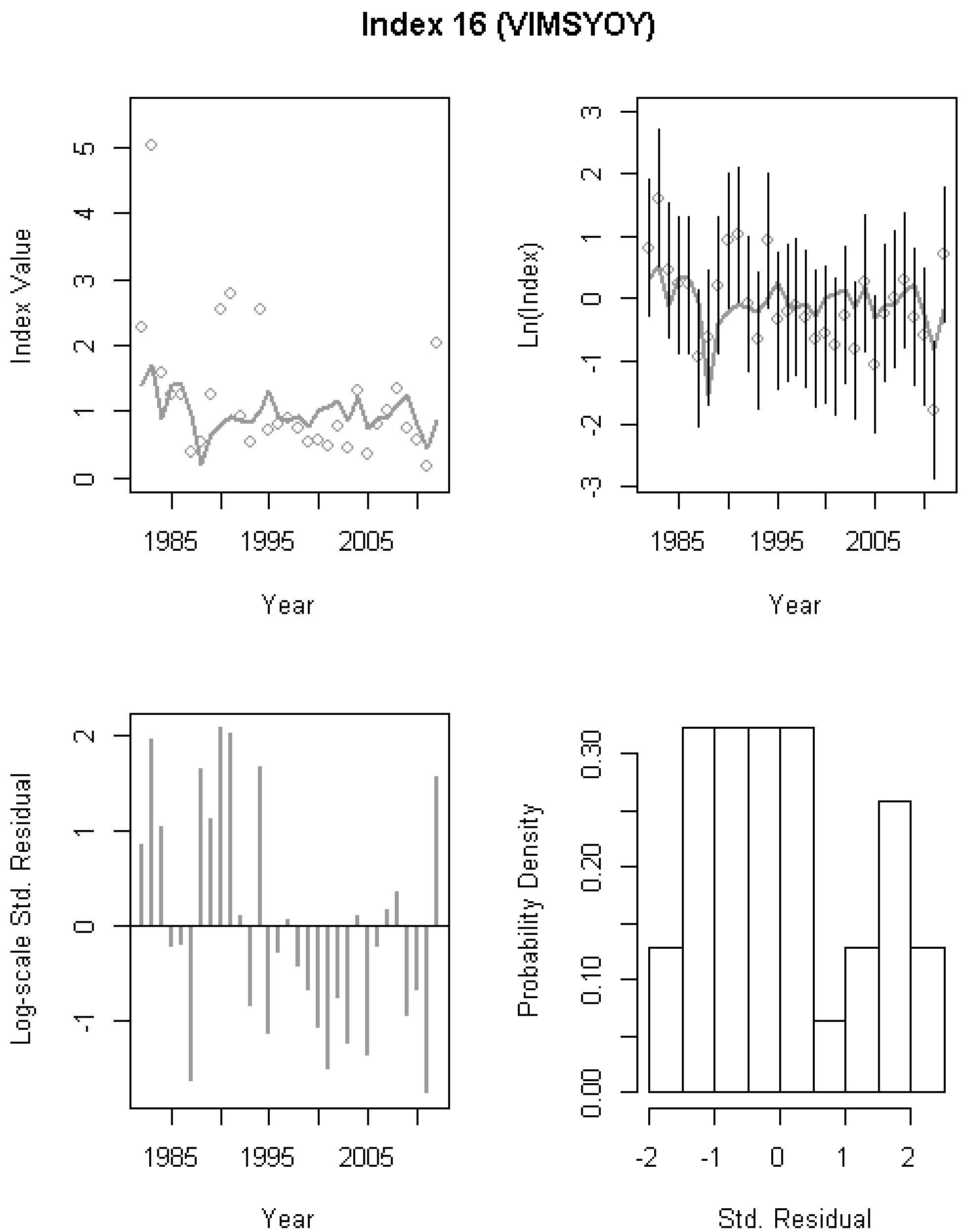


Figure A226. Fit diagnositics for the VIMS YOY trawl survey in run F57_BASE_12.

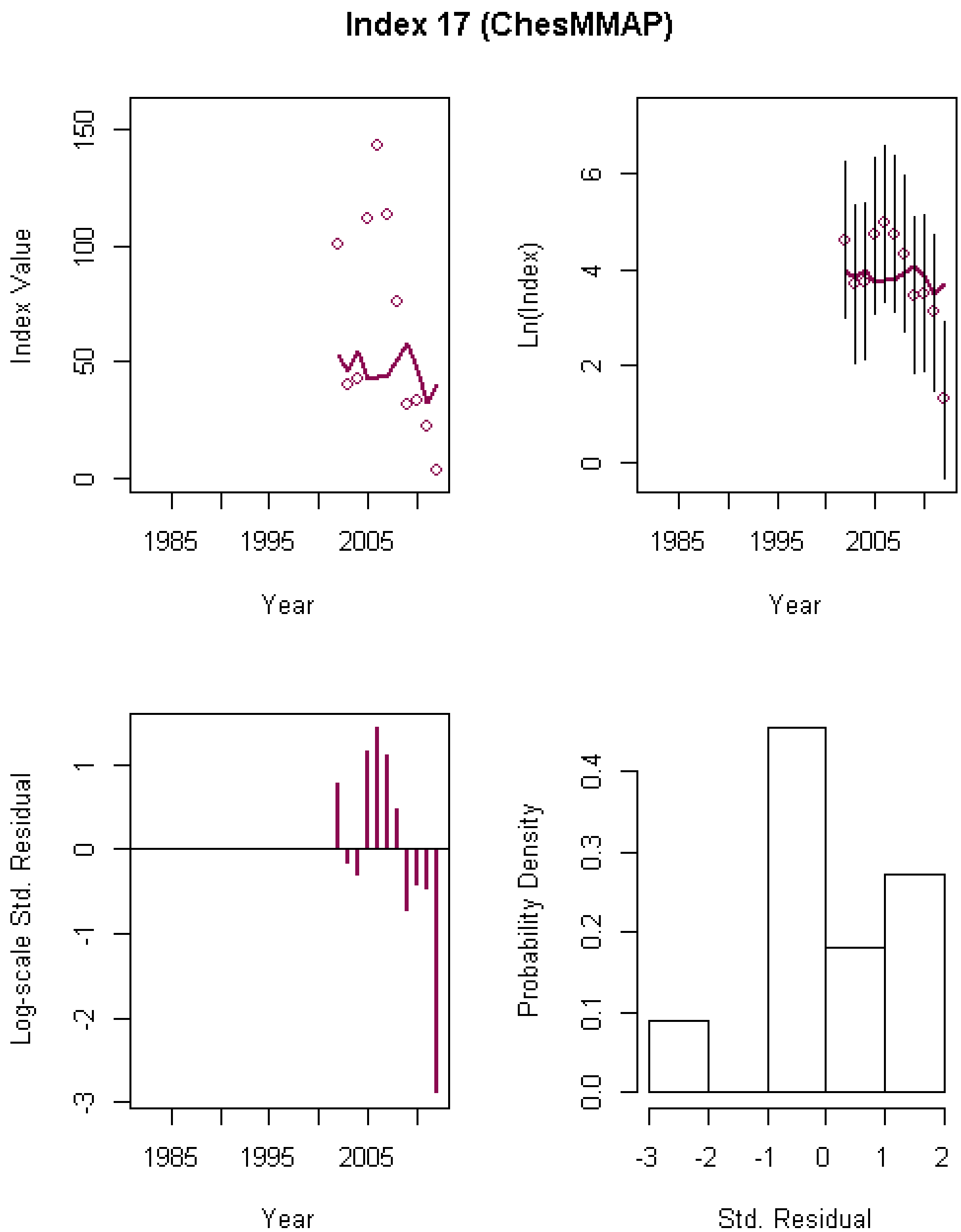


Figure A227. Fit diagnositics for the VIMS ChesMMAP trawl survey in run F57_BASE_12.

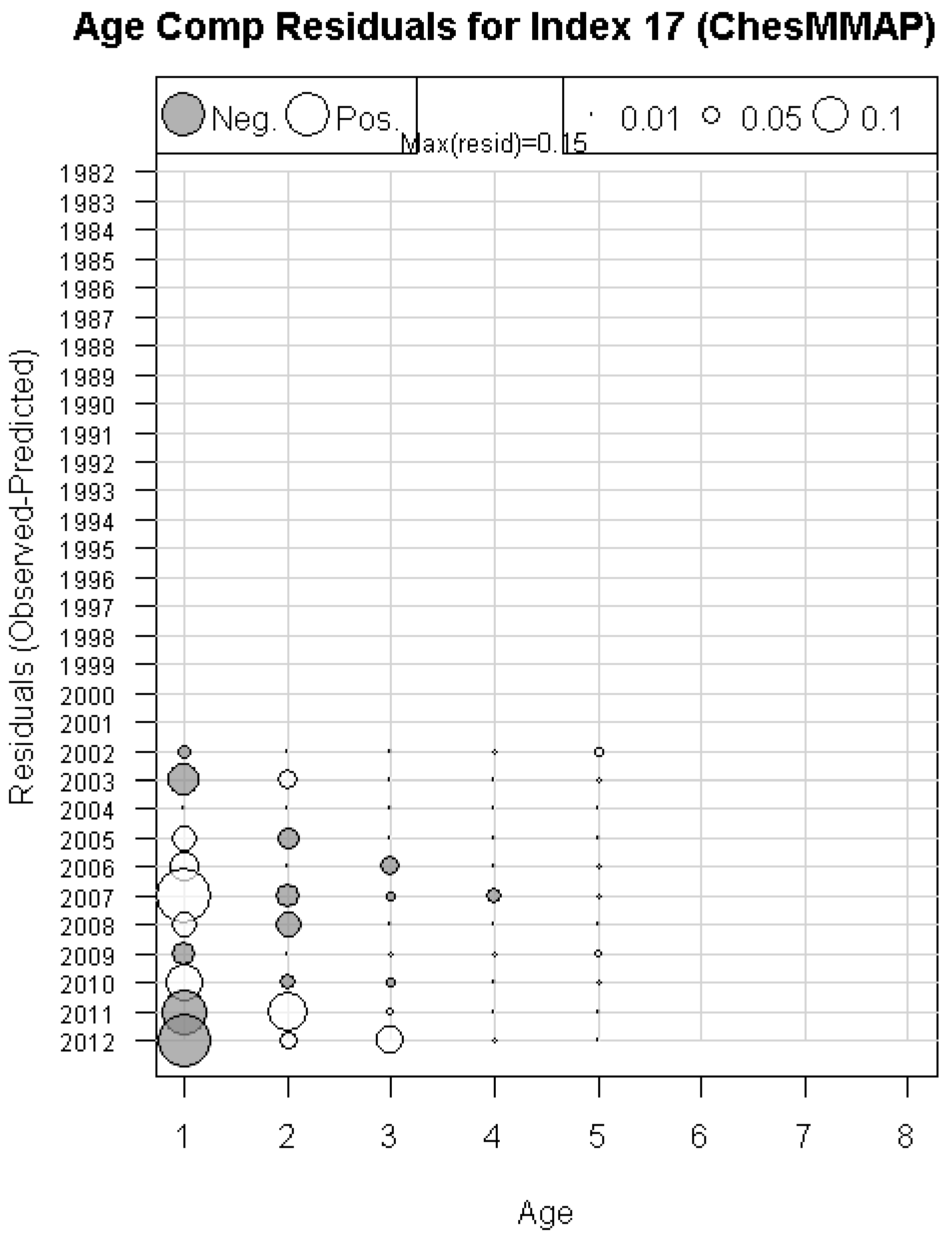


Figure A228. Age composition residuals for the VIMS ChesMMAP trawl survey in run F57_BASE_12.

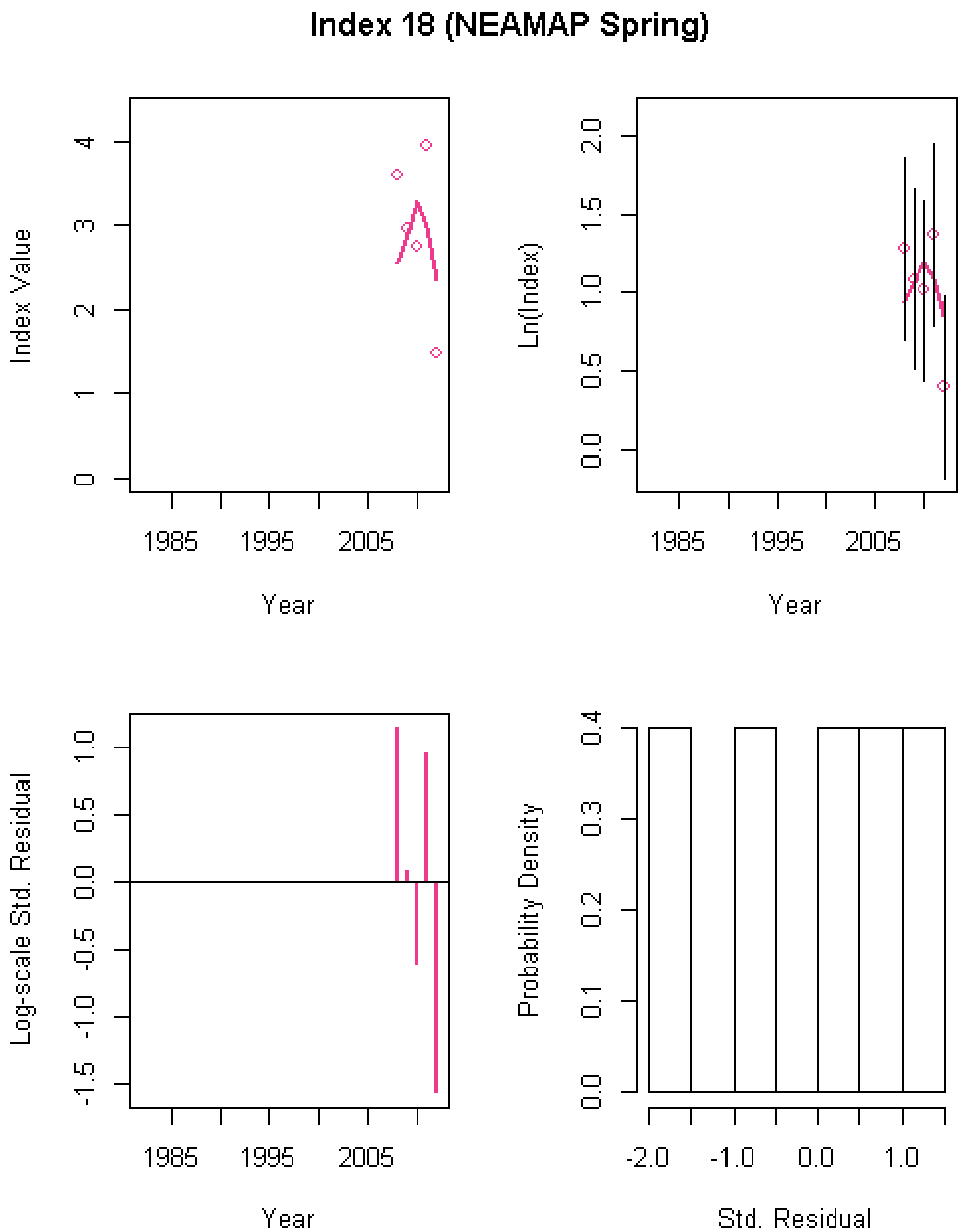


Figure A229. Fit diagnositics for the VIMS NEAMAP spring trawl survey in run F57_BASE_12.

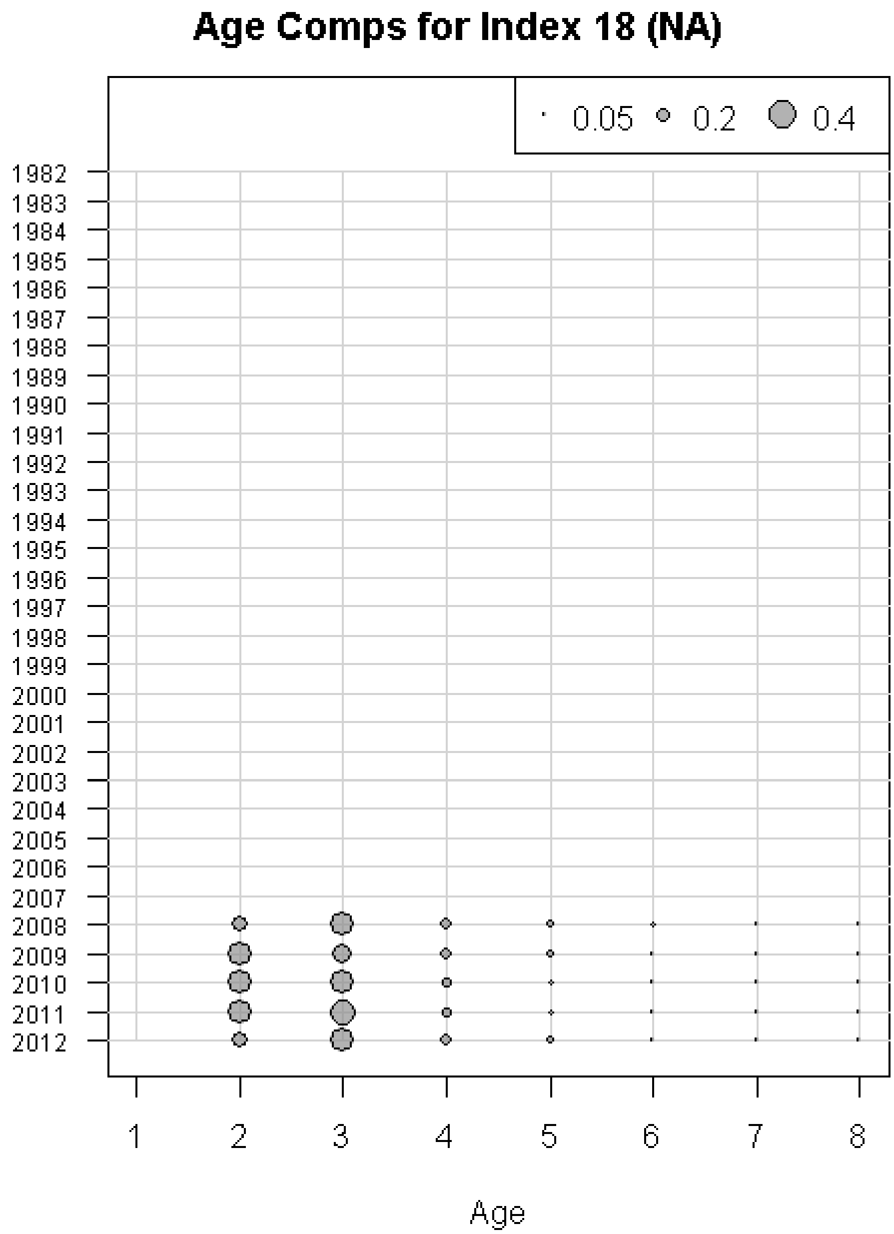


Figure A230. Age composition residuals for the VIMS NEAMAP spring trawl survey in run F57_BASE_12.

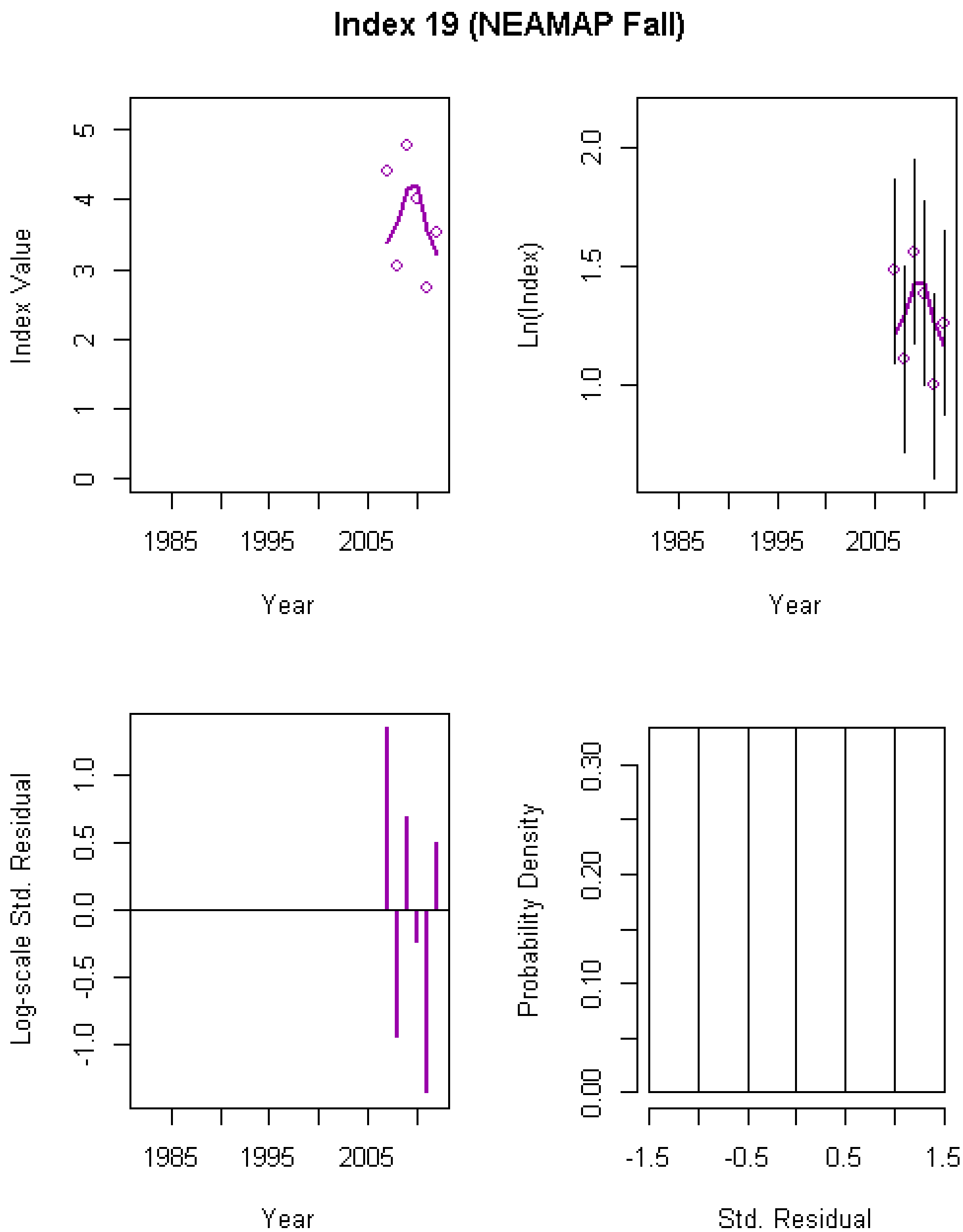


Figure A231. Fit diagnositics for the VIMS NEAMAP fall trawl survey in run F57_BASE_12.

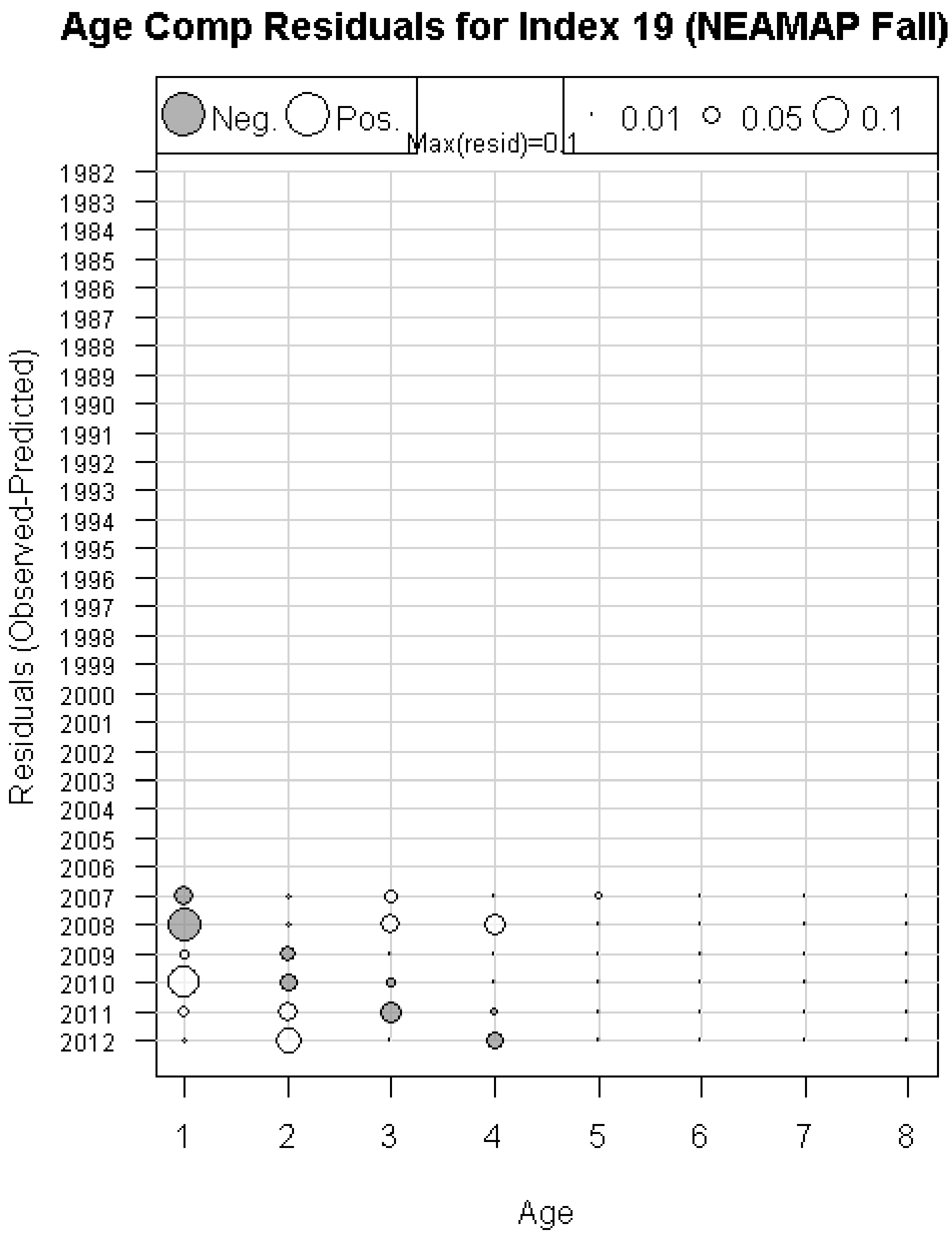


Figure A232. Age composition residuals for the VIMS NEAMAP fall trawl survey in run F57_BASE_12.

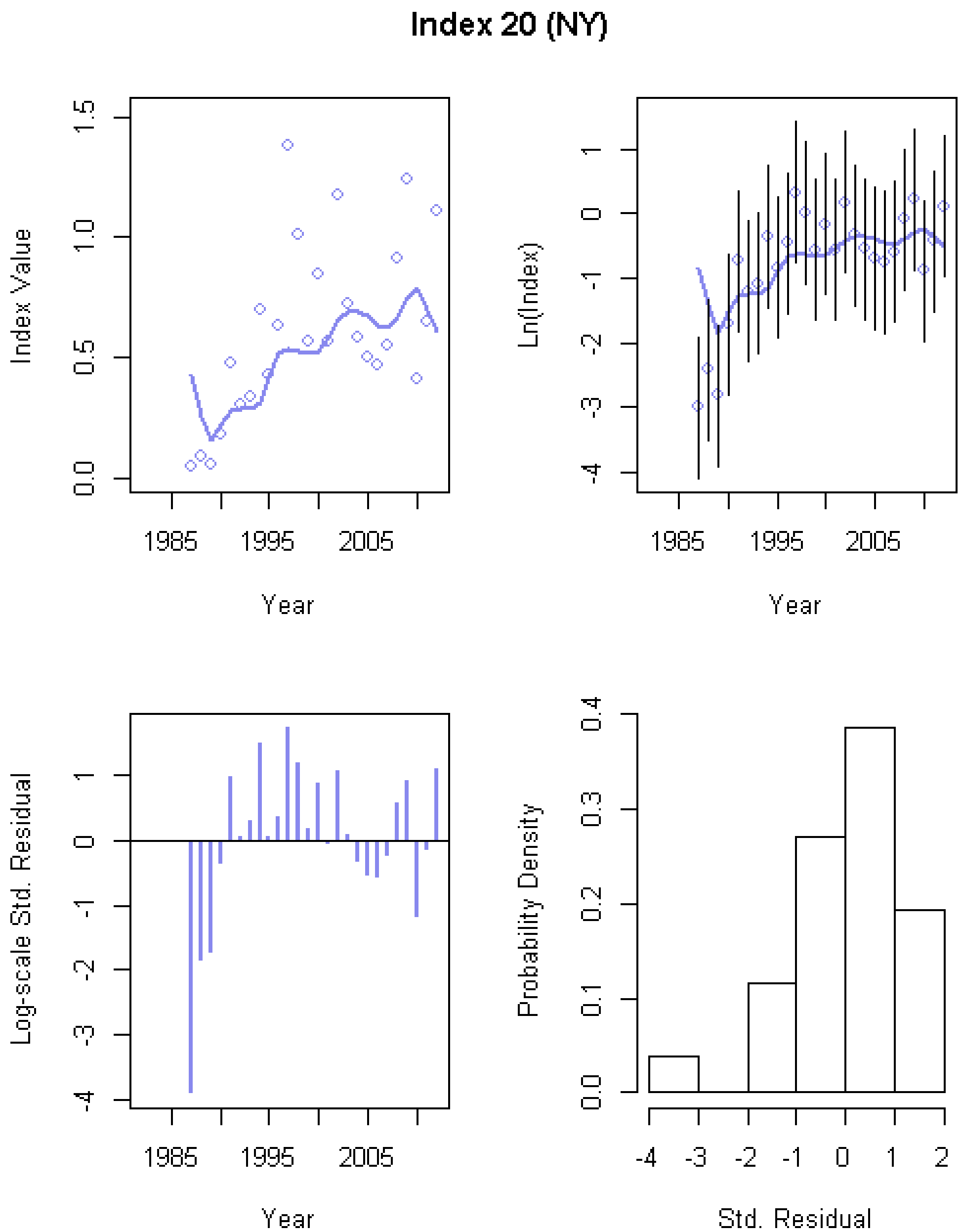


Figure A233. Fit diagnositics for the NYDEC trawl survey in run F57_BASE_12.

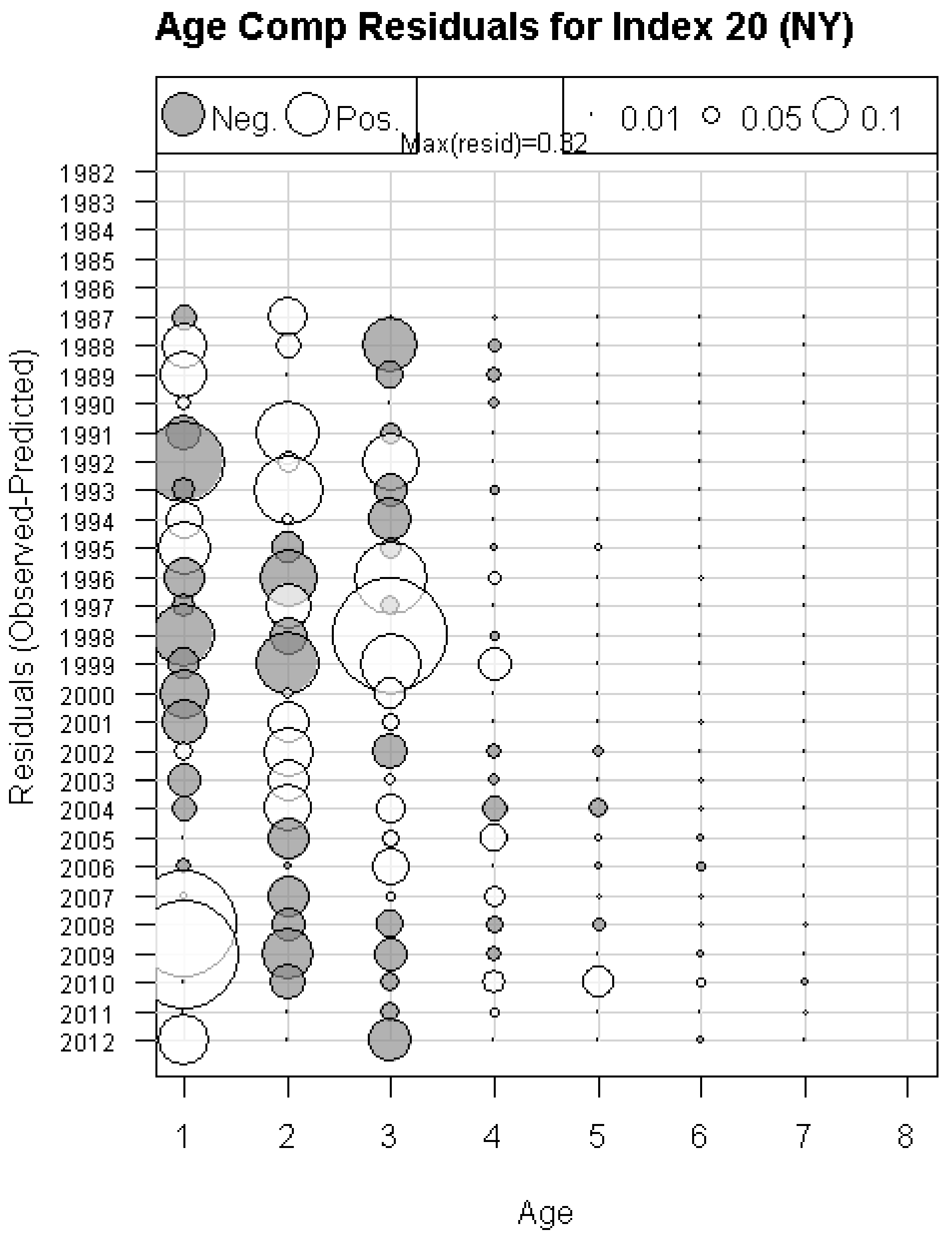


Figure A234. Age composition residuals for the NYDEC trawl survey in run F57_BASE_12.

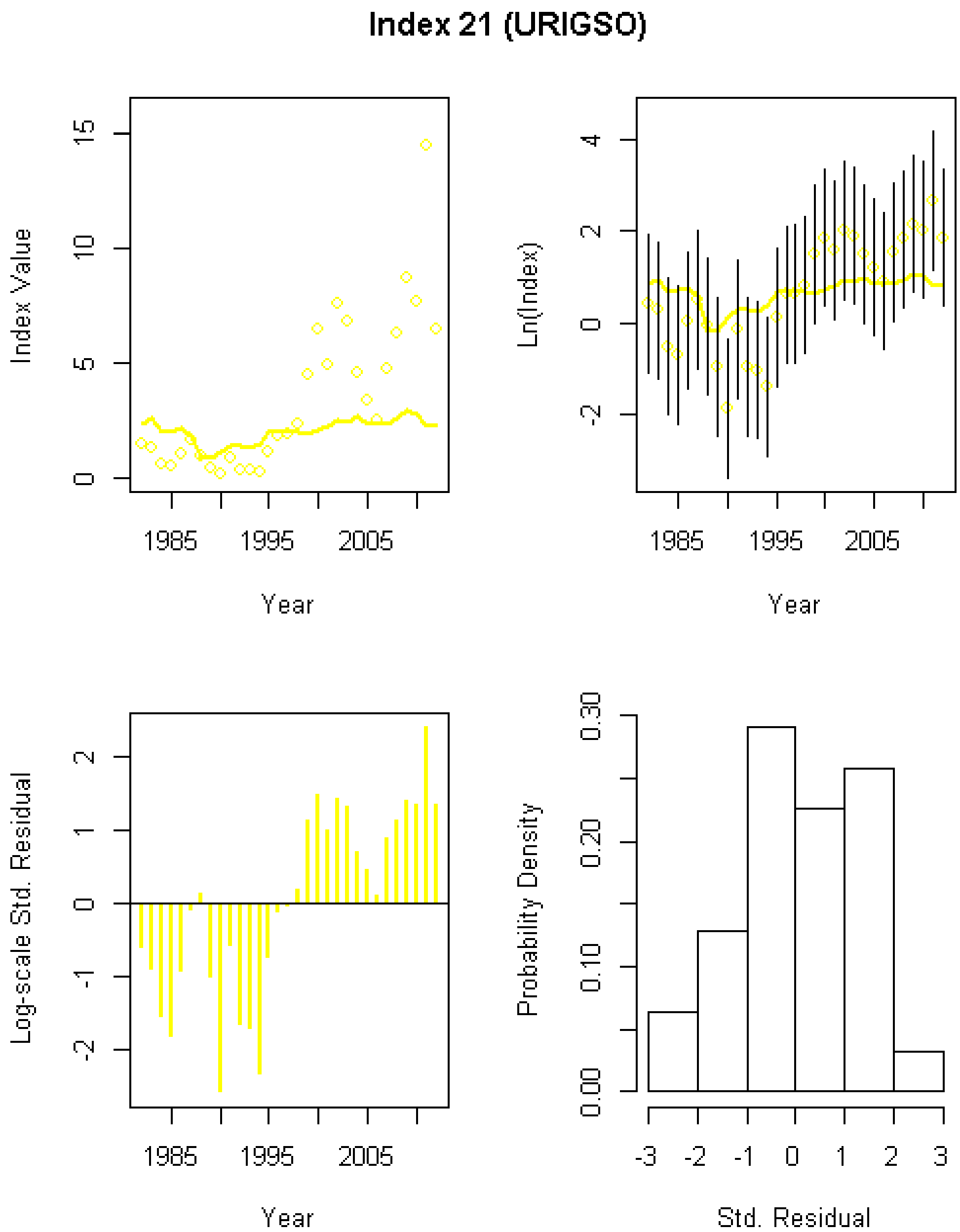


Figure A235. Fit diagnositics for the URIGSO trawl survey in run F57_BASE_12.

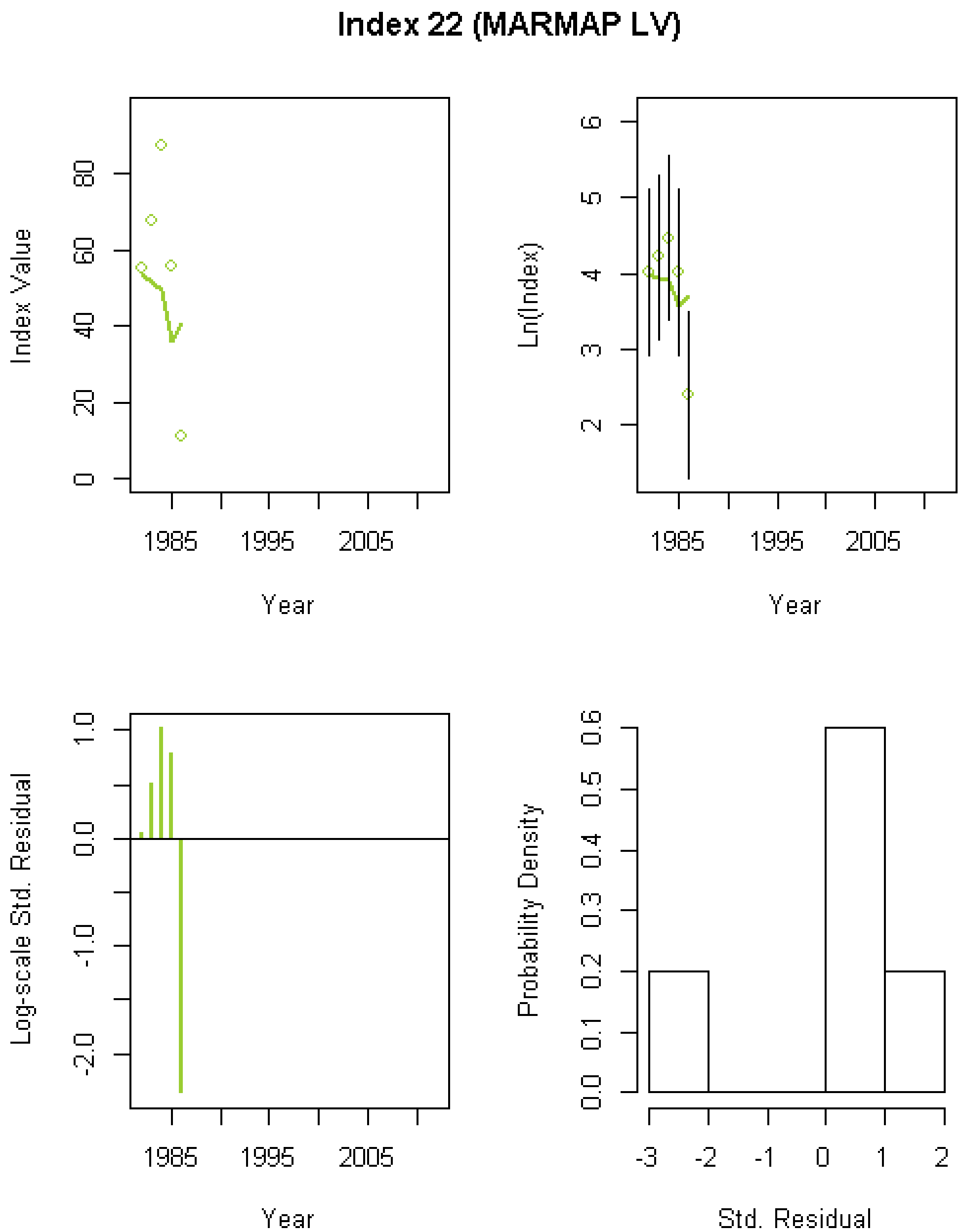


Figure A236. Fit diagnositics for the NEFSC MARMAP larval survey in run F57_BASE_12.

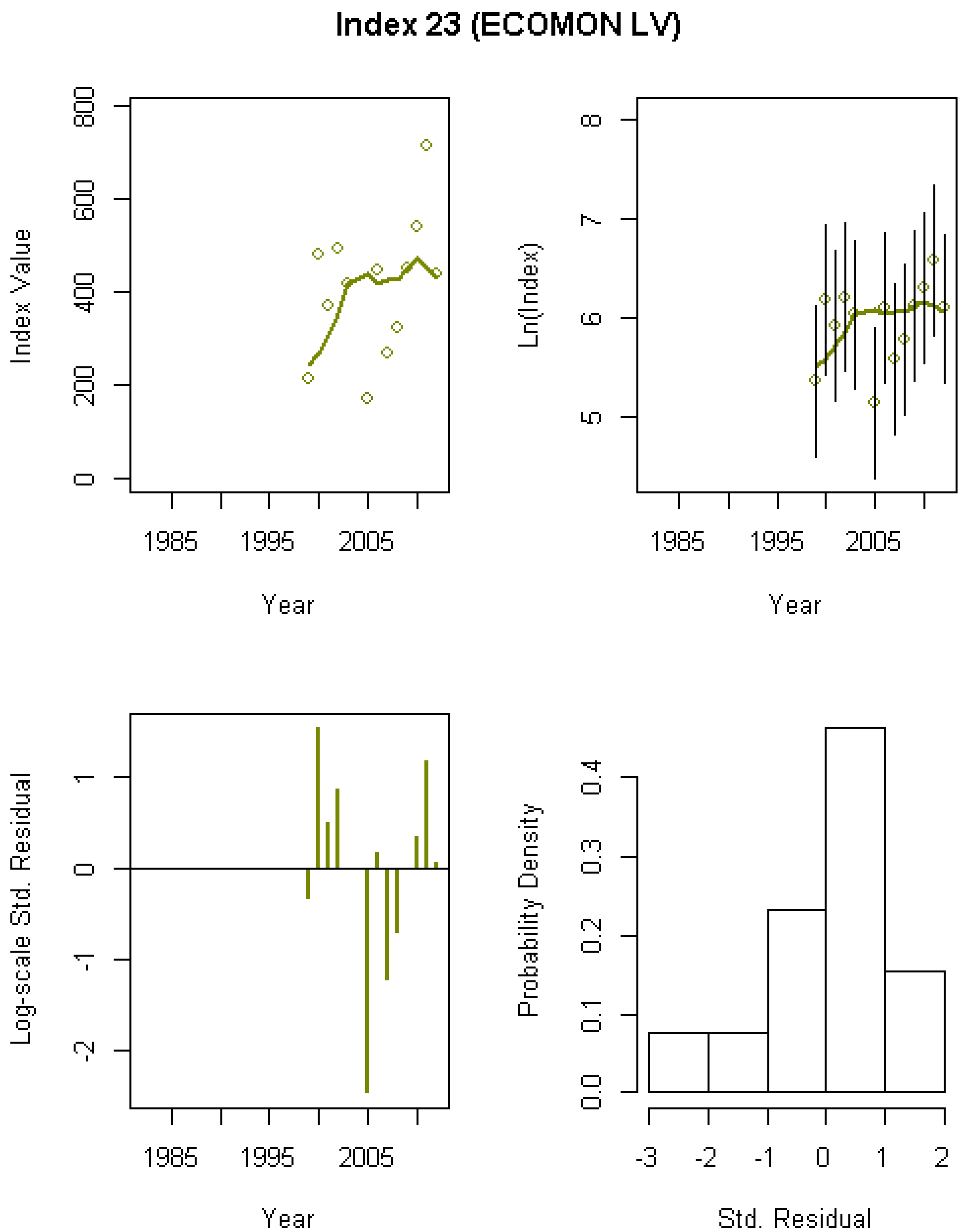


Figure A237. Fit diagnositics for the NEFSC ECOMON larval survey in run F57_BASE_12.

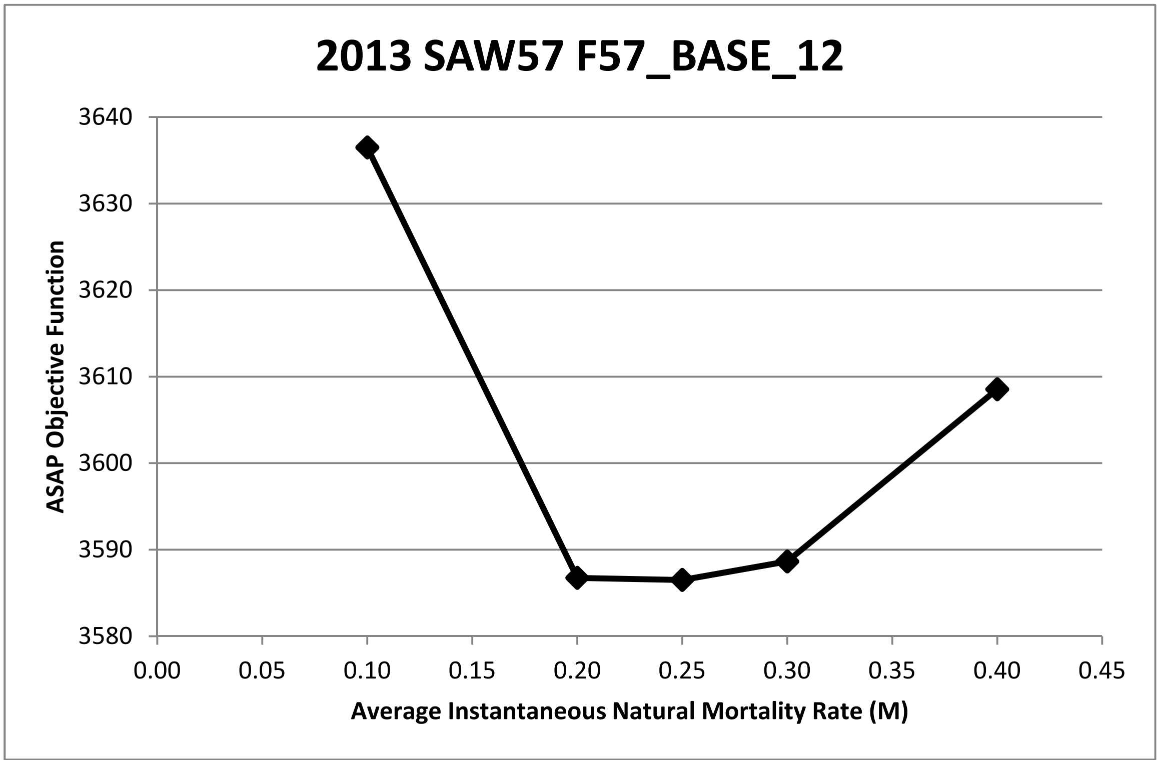


Figure A238. Likelihood profile for run F57_BASE_12 over average M values from 0.10 to 0.40.

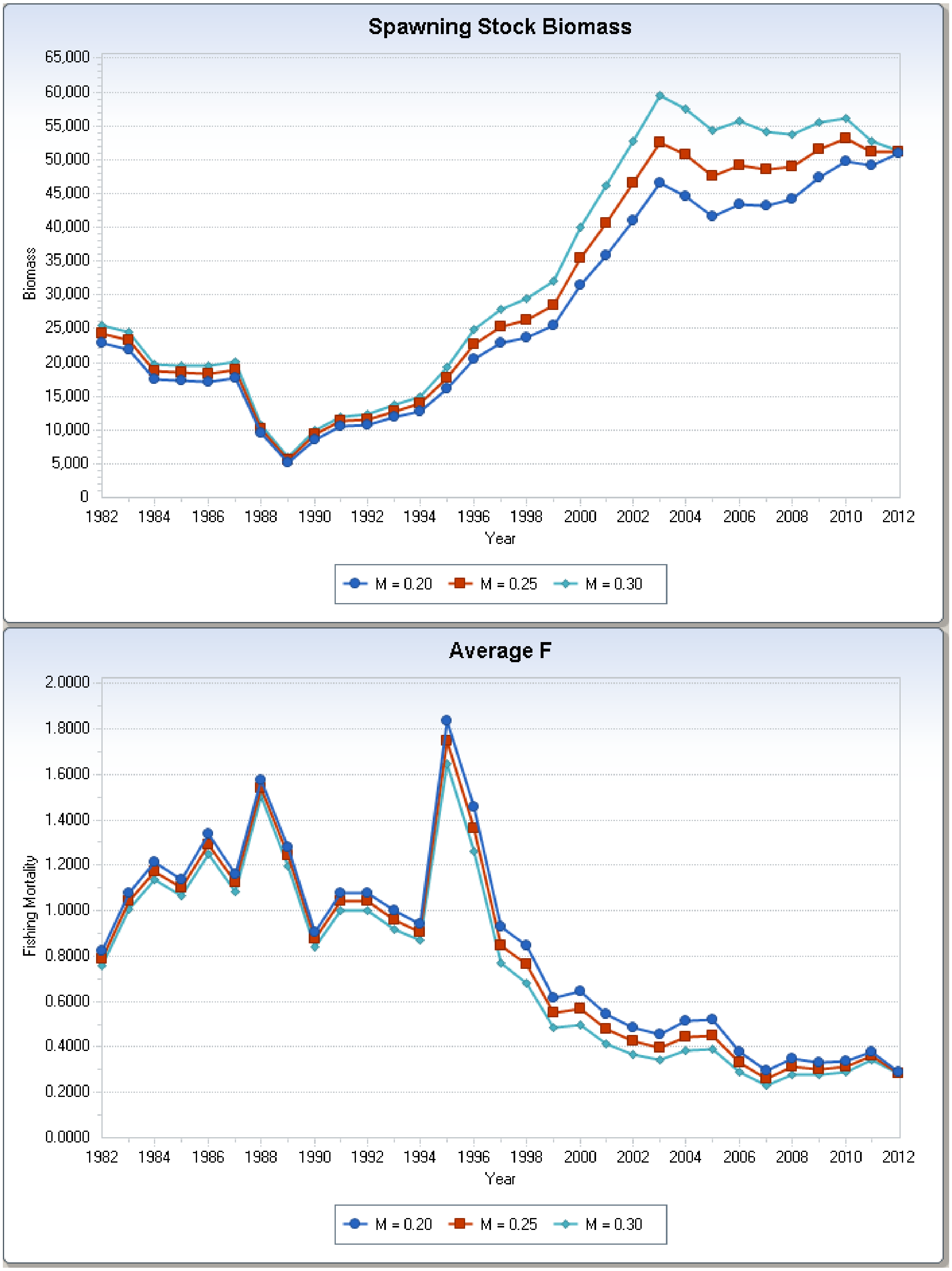


Figure A239. Results for SSB and F for sensitivity runs with average M = 0.2 and 0.3, bracketing run F57_BASE_12 with average M = 0.25.

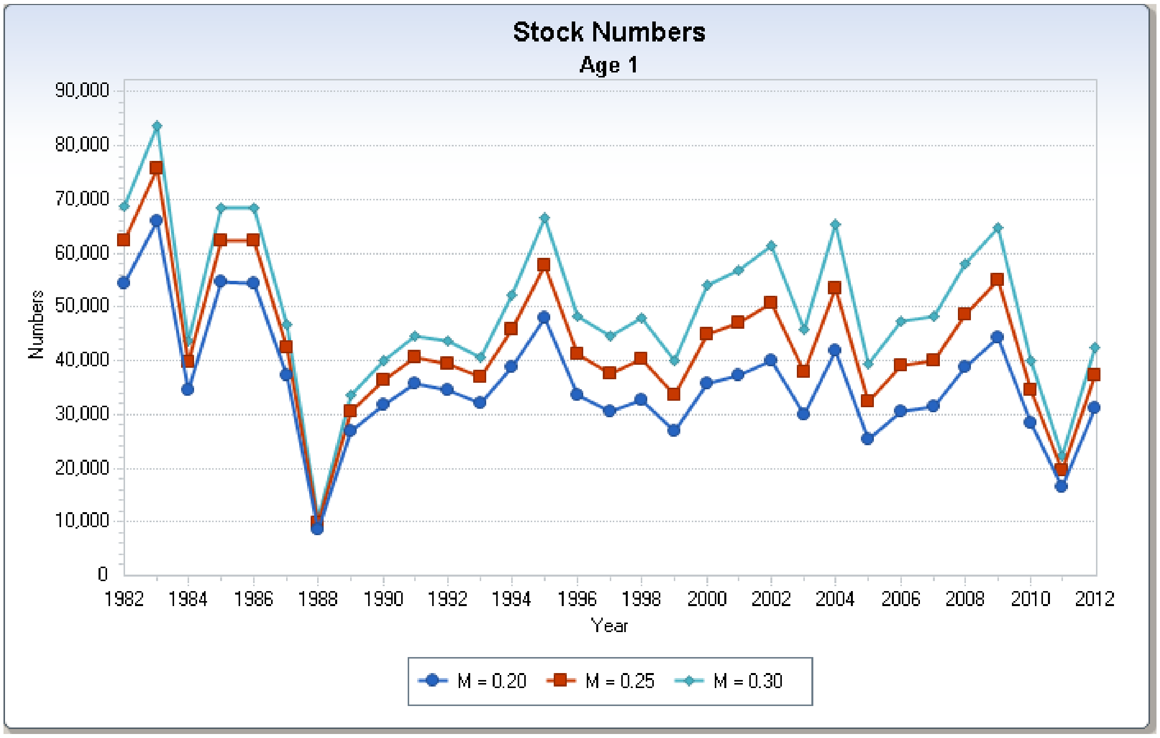


Figure A240. Results for recruitment at age 0 (model age 1) for sensitivity runs with average M = 0.2 and 0.3, bracketing run F57_BASE_12 with average M = 0.25.

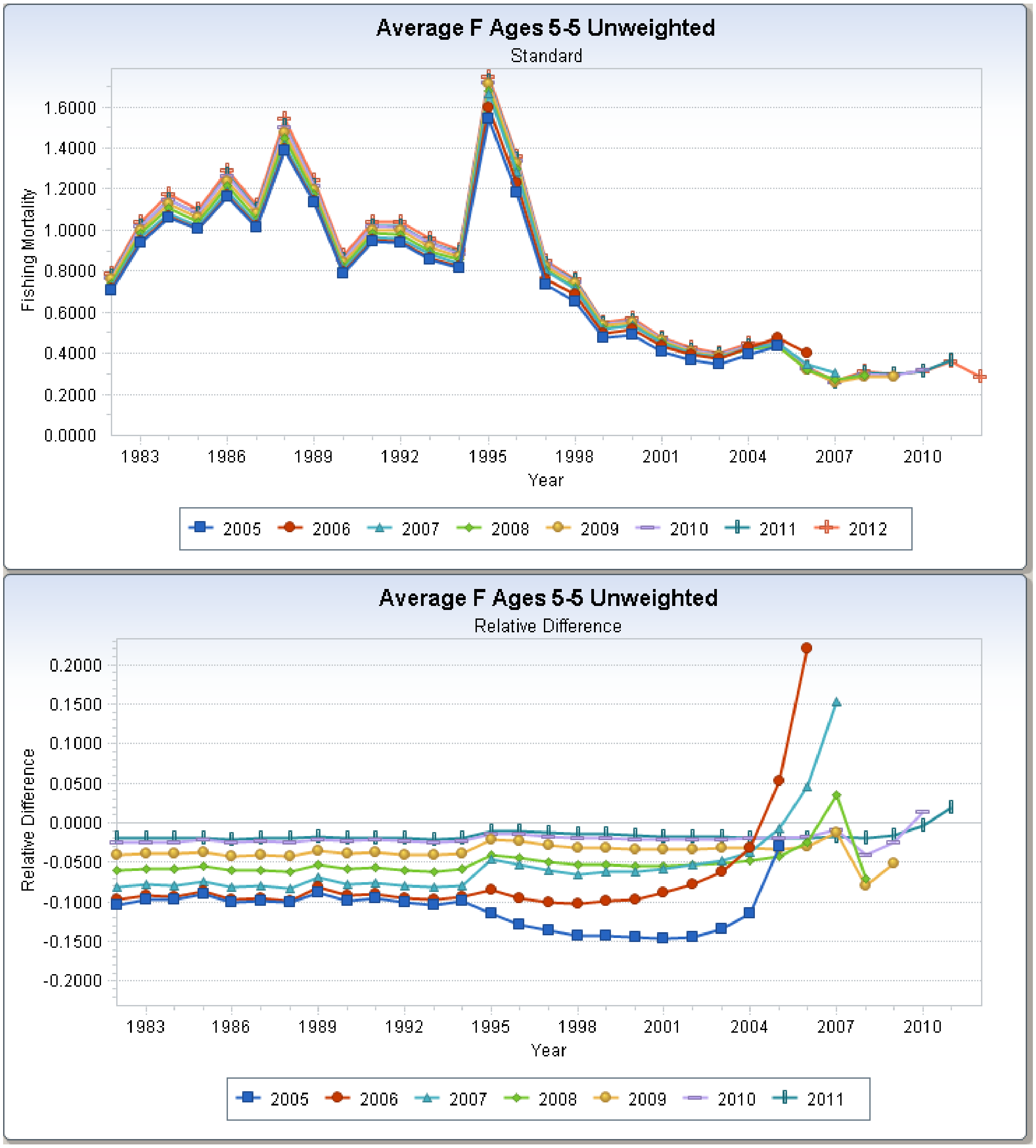


Figure A241. Retrospective analysis of fishing mortality rate (F, age 4). Note that model age 5 is true age 4.

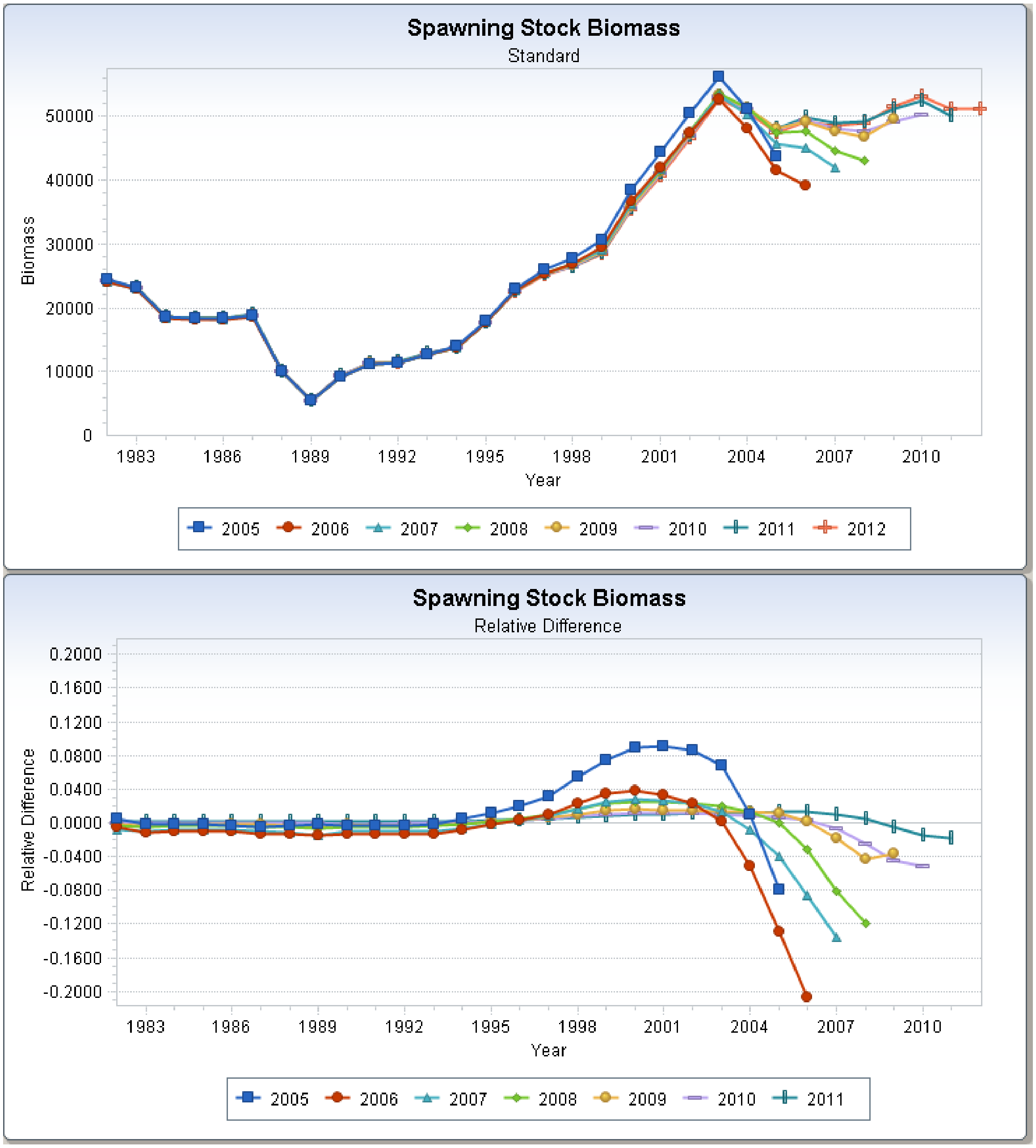


Figure A242. Retrospective analysis of Spawning Stock Biomass (SSB).

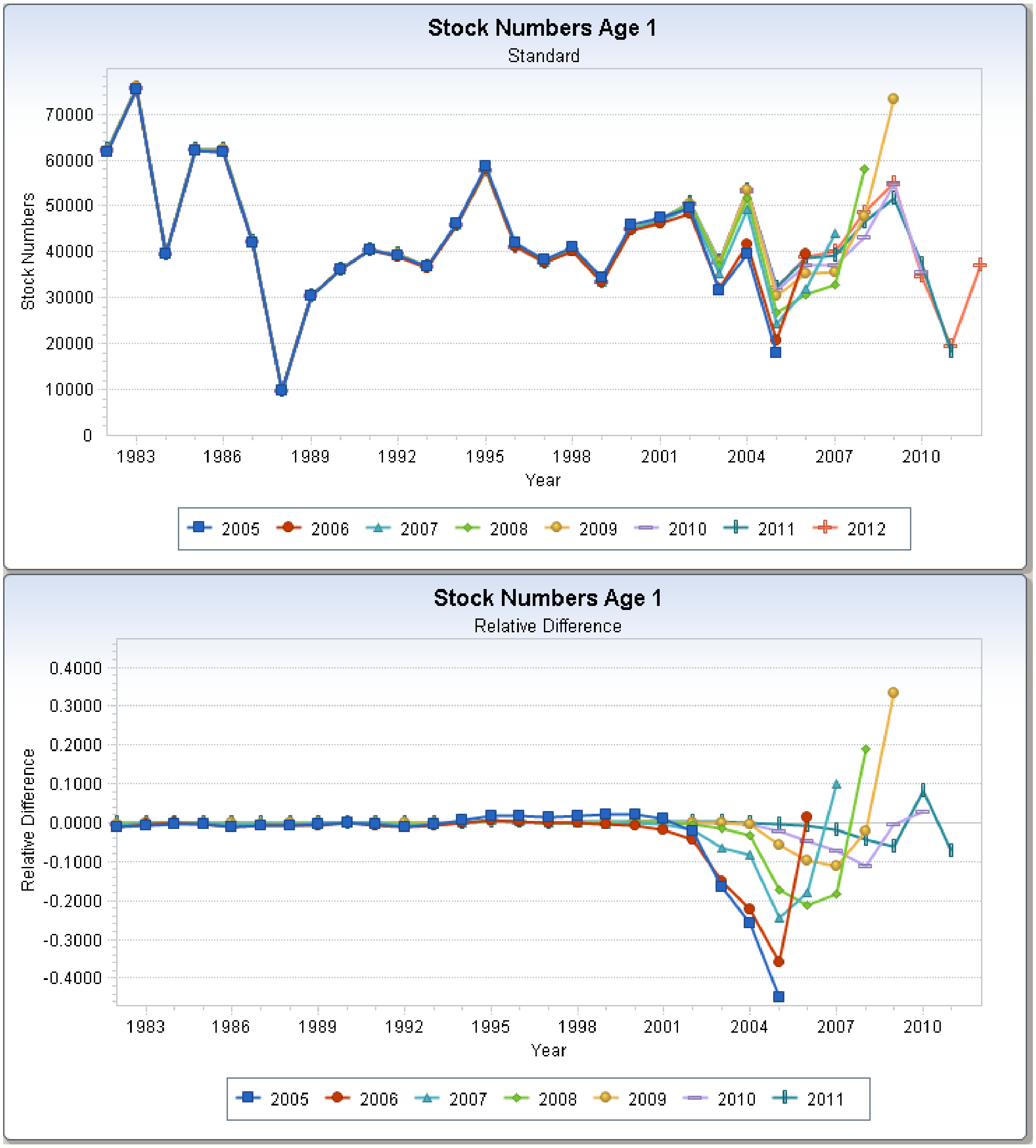


Figure A243. Retrospective analysis of recruitment at age 0. Note that model age 1 is true age 0.

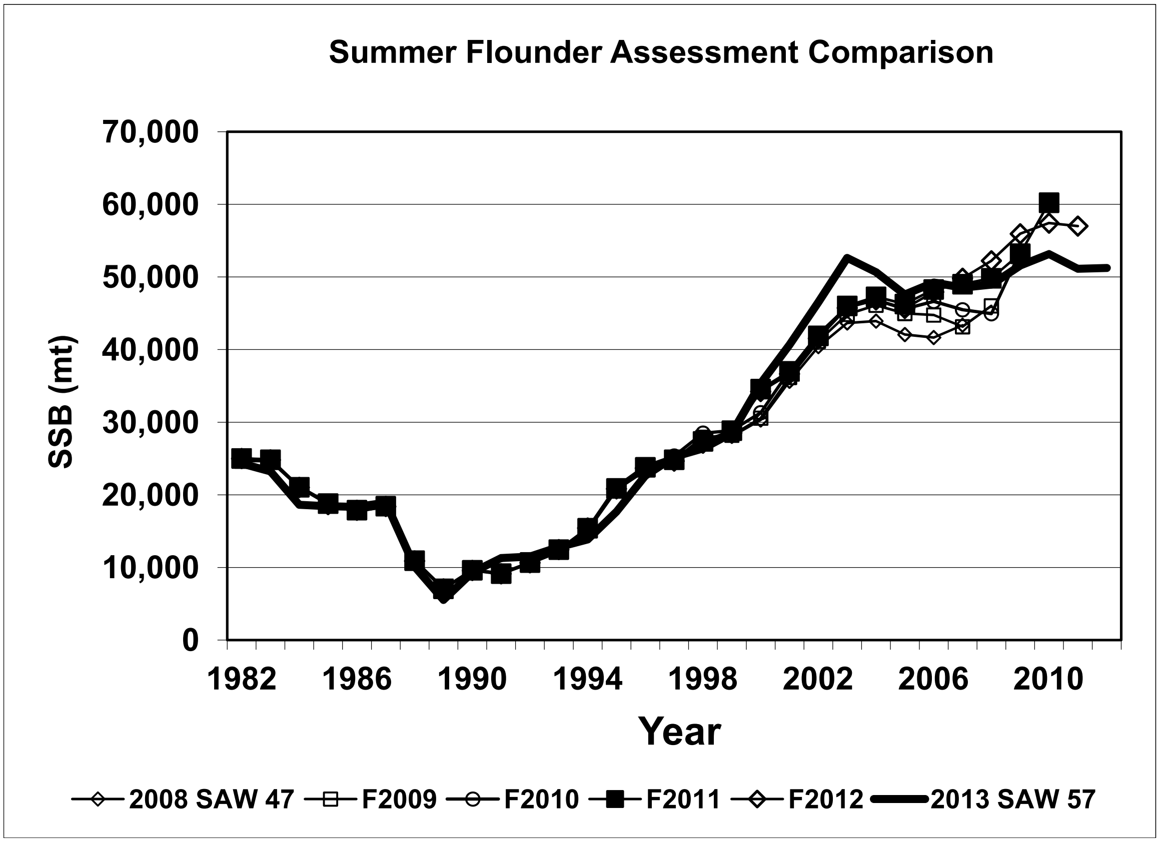


Figure A244. Estimates of Spawning Stock Biomass (SSB) for the 2008-2012 stock assessments compared with the 2013 SAW 57 results.

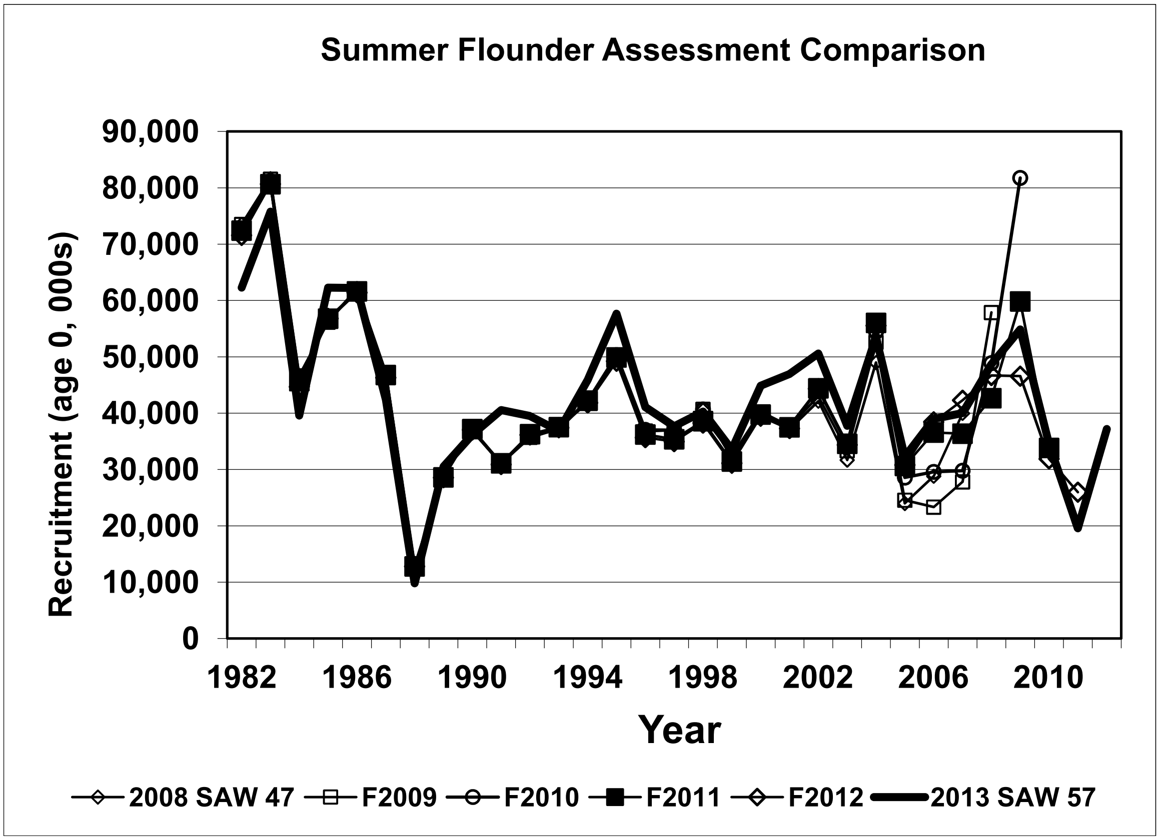


Figure A245. Estimates of recruitment at age 0 for the 2008-2012 stock assessments compared with the 2013 SAW 57 results.

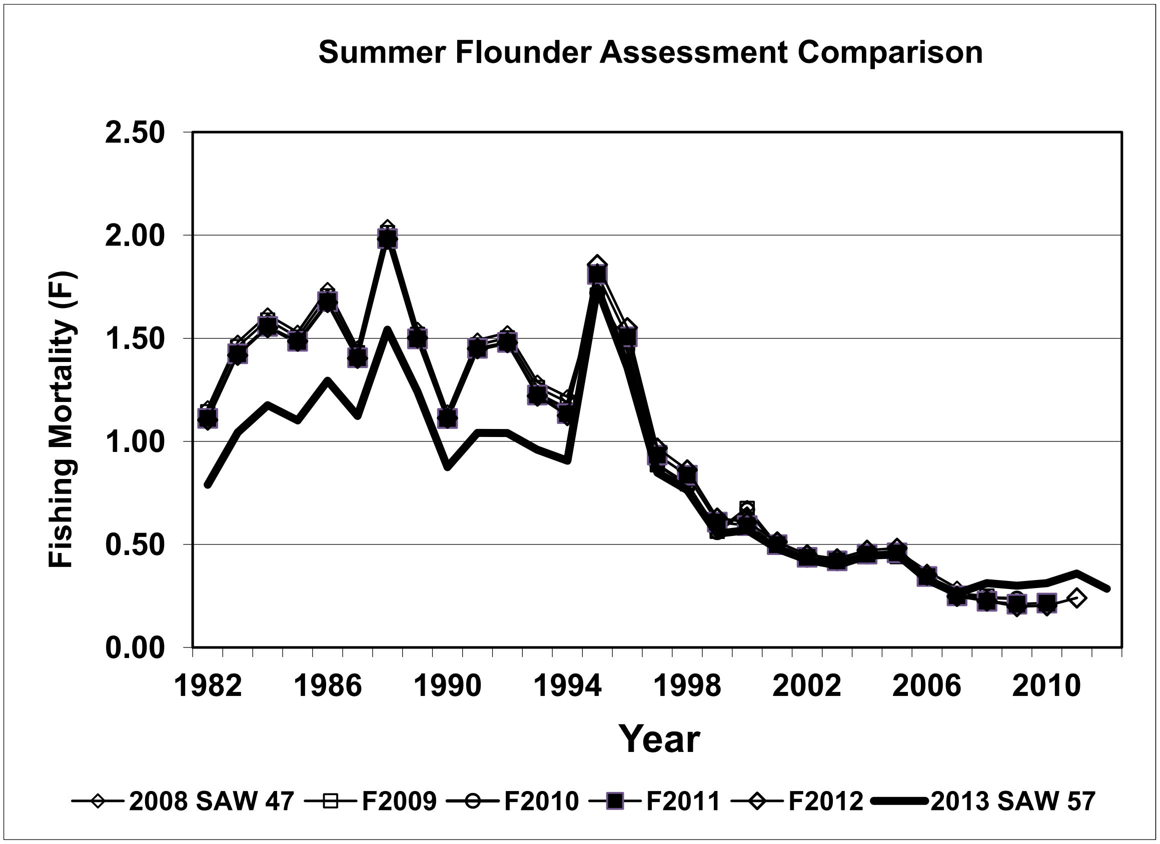


Figure A246. Estimates of fishing mortality (F) for the 2008-2012 stock assessments compared with the 2013 SAW 57 results. Note that for the 2008-2012 assessments F is reported for ages 3-7+, while in the 2013 SAW 57 assessement F is reported for age 4.

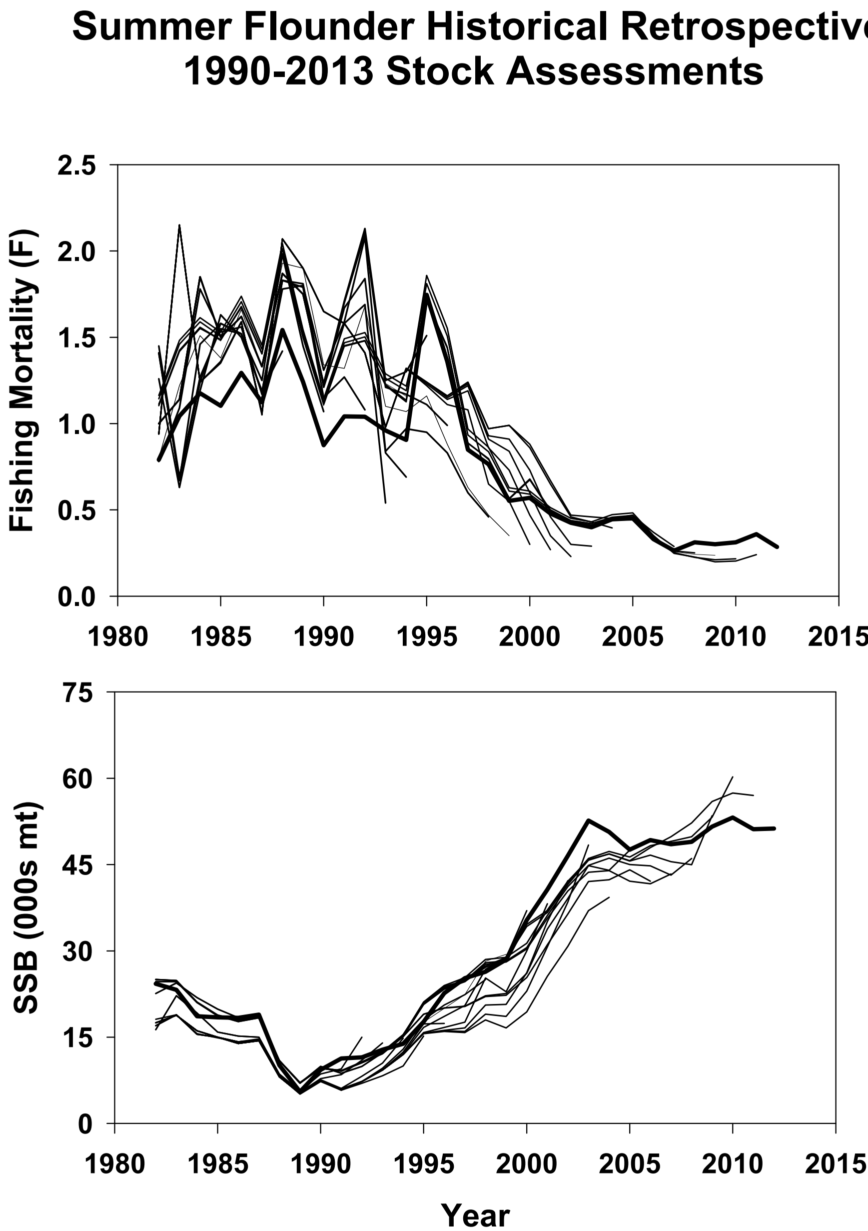


Figure A247. Historical retrospective of the 1990-2013 stock assessments of summer flounder. Note that for the 1990-2007 assessments F is reported for ages 2-7+, for the 2008-2012 assessments F is reported for ages 3-7+, while in the 2013 assessment F is reported for age 4.

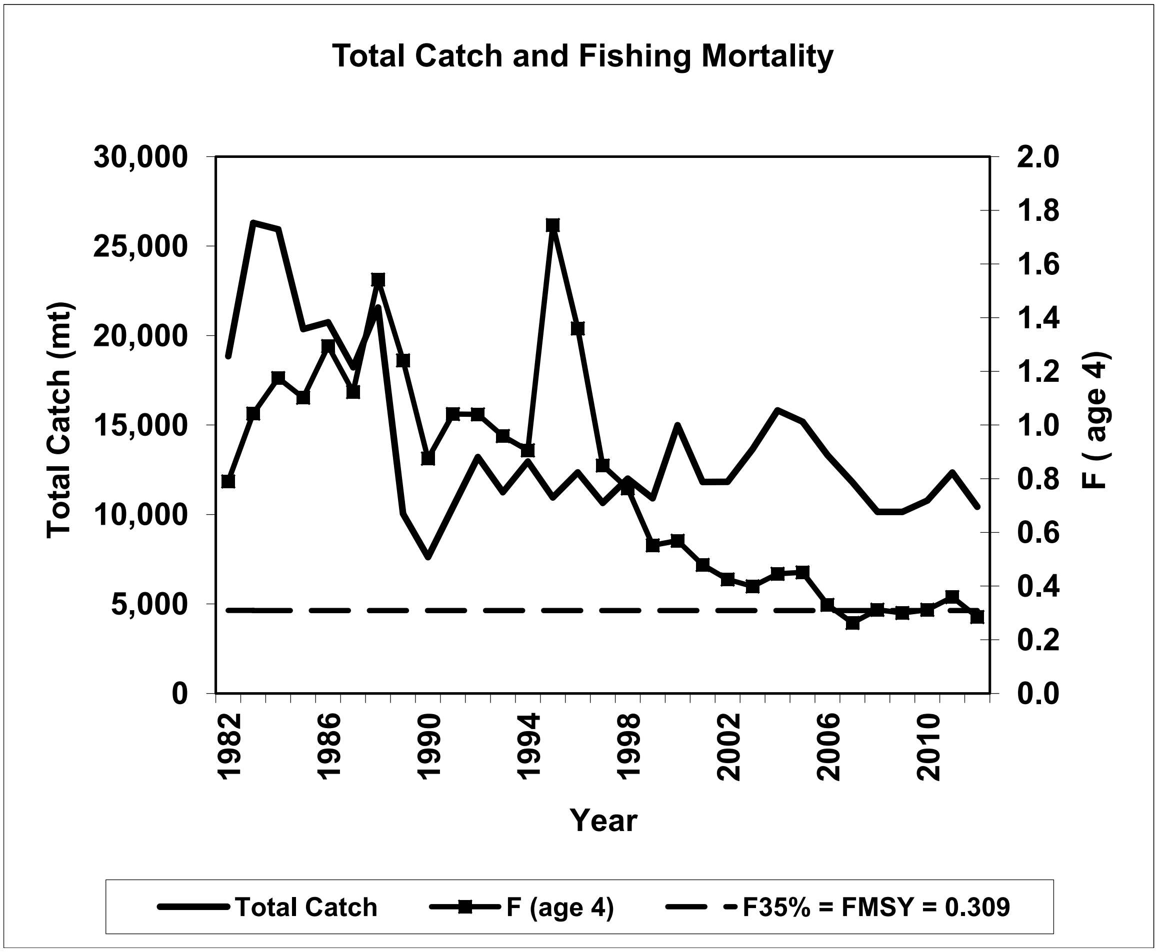


Figure A248. Total fishery catch and fully-recruited Fishing Mortality (F, peak at age 4). The horizontal dashed line is the 2013 SAW 57 fishing mortality reference point proxy.

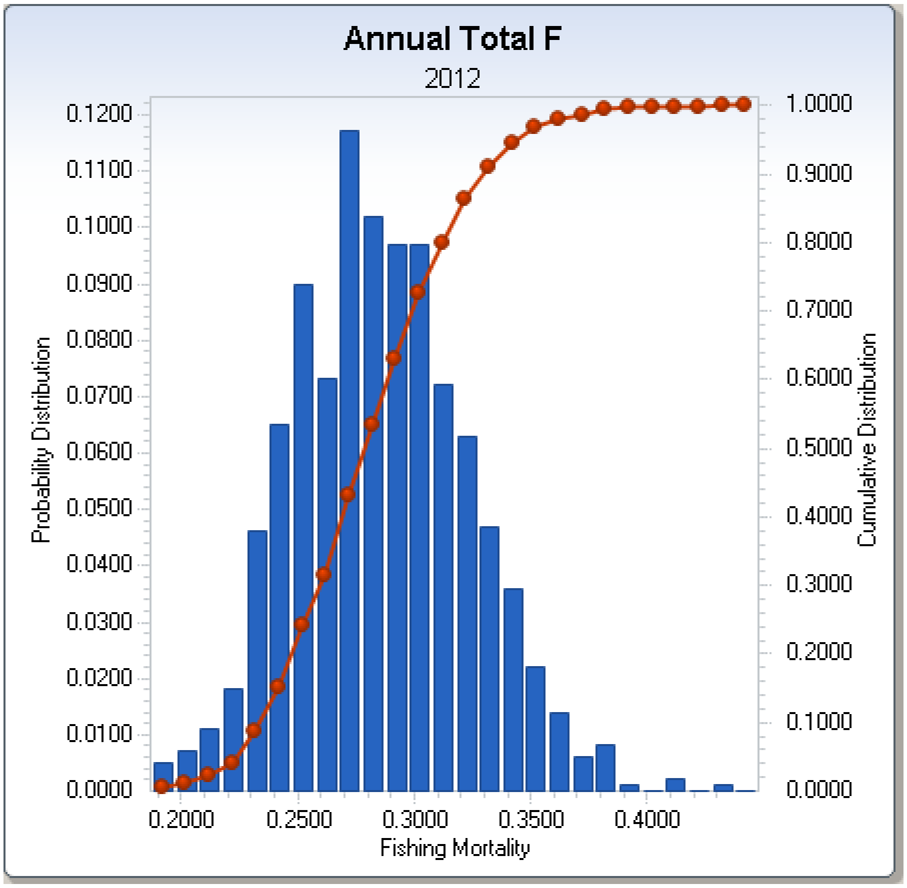


Figure A249. MCMC distribution of fishing mortality rate in 2012 (F, age 4).

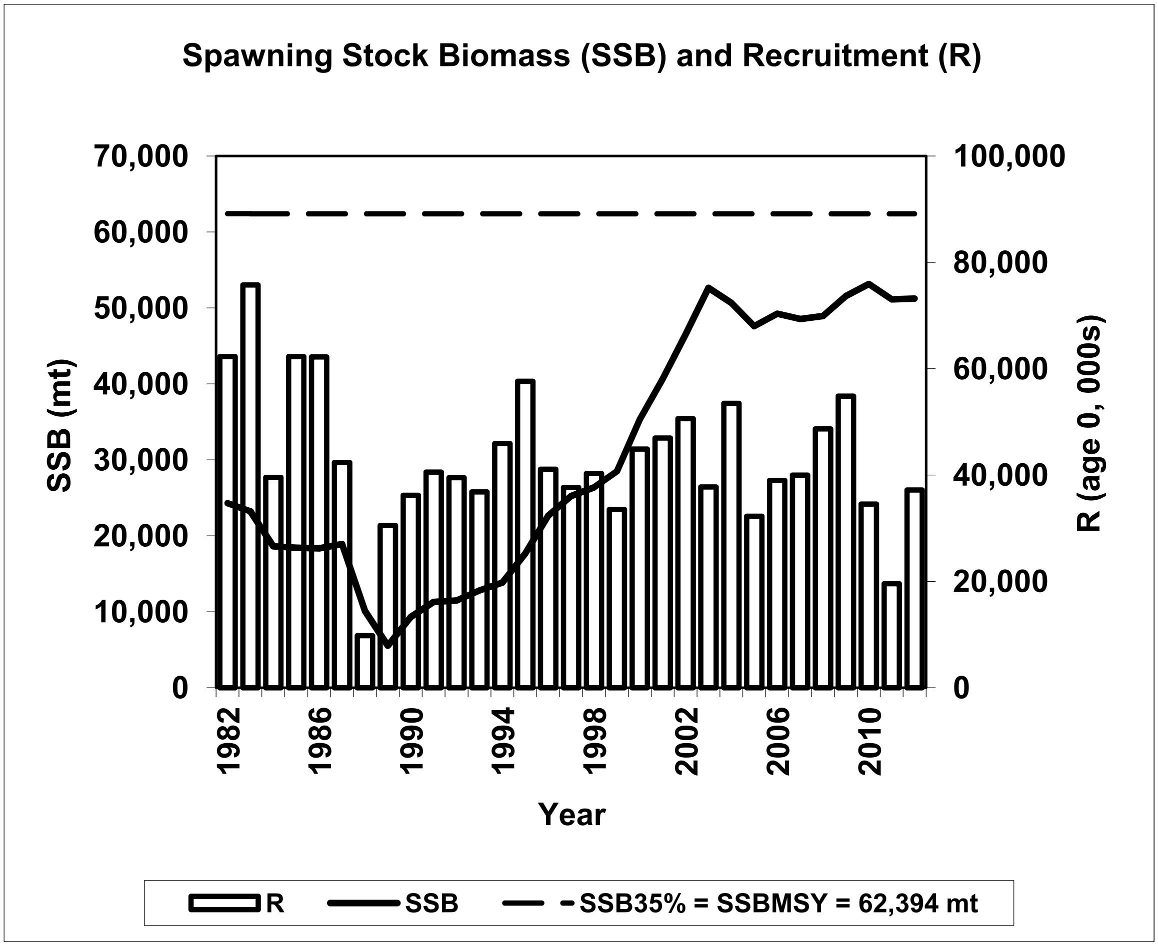


Figure A250. Spawning Stock Biomass (SSB; solid line) and Recruitment at age 0 (R; vertical bars) by calendar year. The horizontal dashed line is the 2013 SAW 57 biomass reference point proxy.

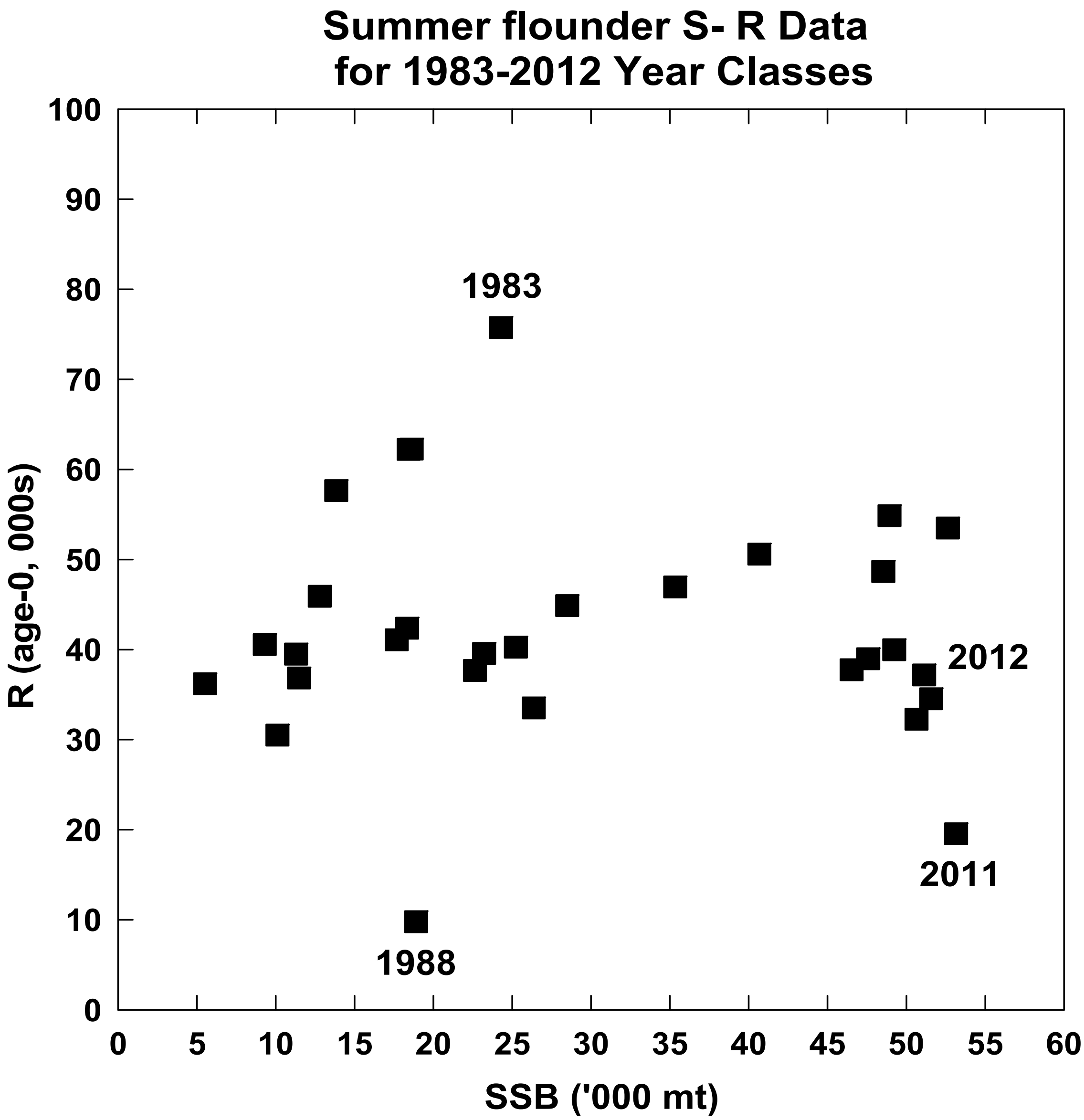


Figure A251. Stock-recruitment scatter plot for the summer flounder 1983-2012 year classes. Highest recruitment point is the 1983 year class (R = 75.5 million, SSB = 24,300 mt); highest SSB point is for the 2011 year class (R = 19.6 million, SSB = 53,156 mt). The 2012 year class is at R = 37.2 million, SSB = 51,129 mt.

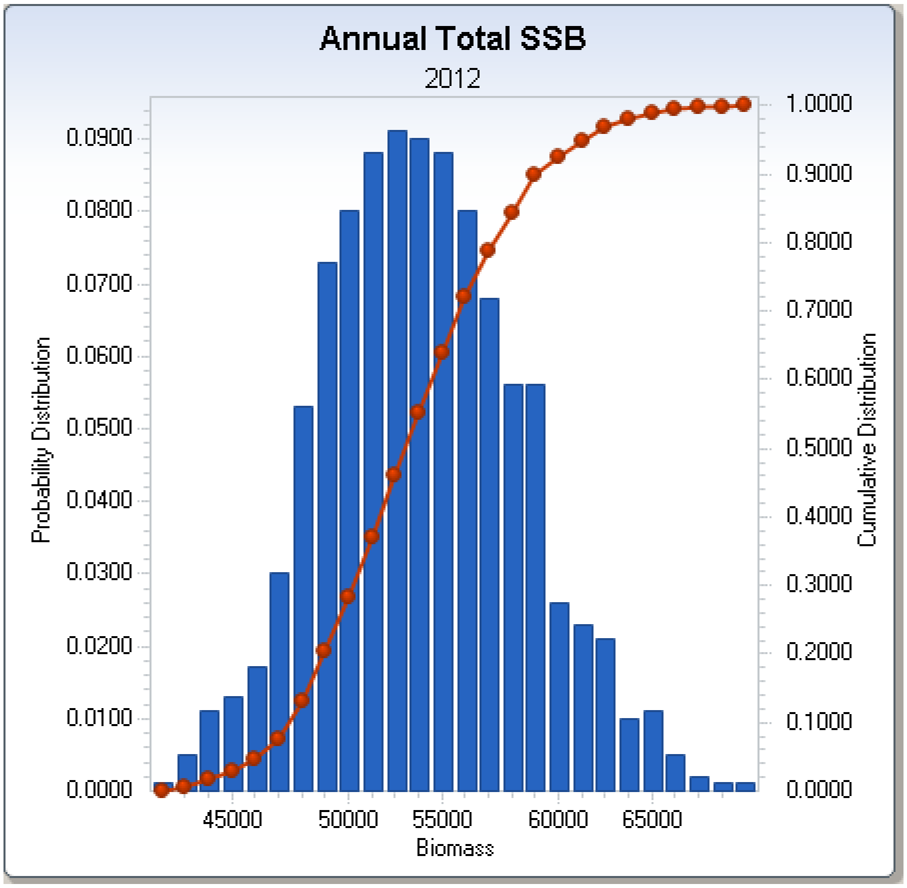


Figure A252. MCMC distribution of Spawning Stock Biomass (SSB) in 2012.

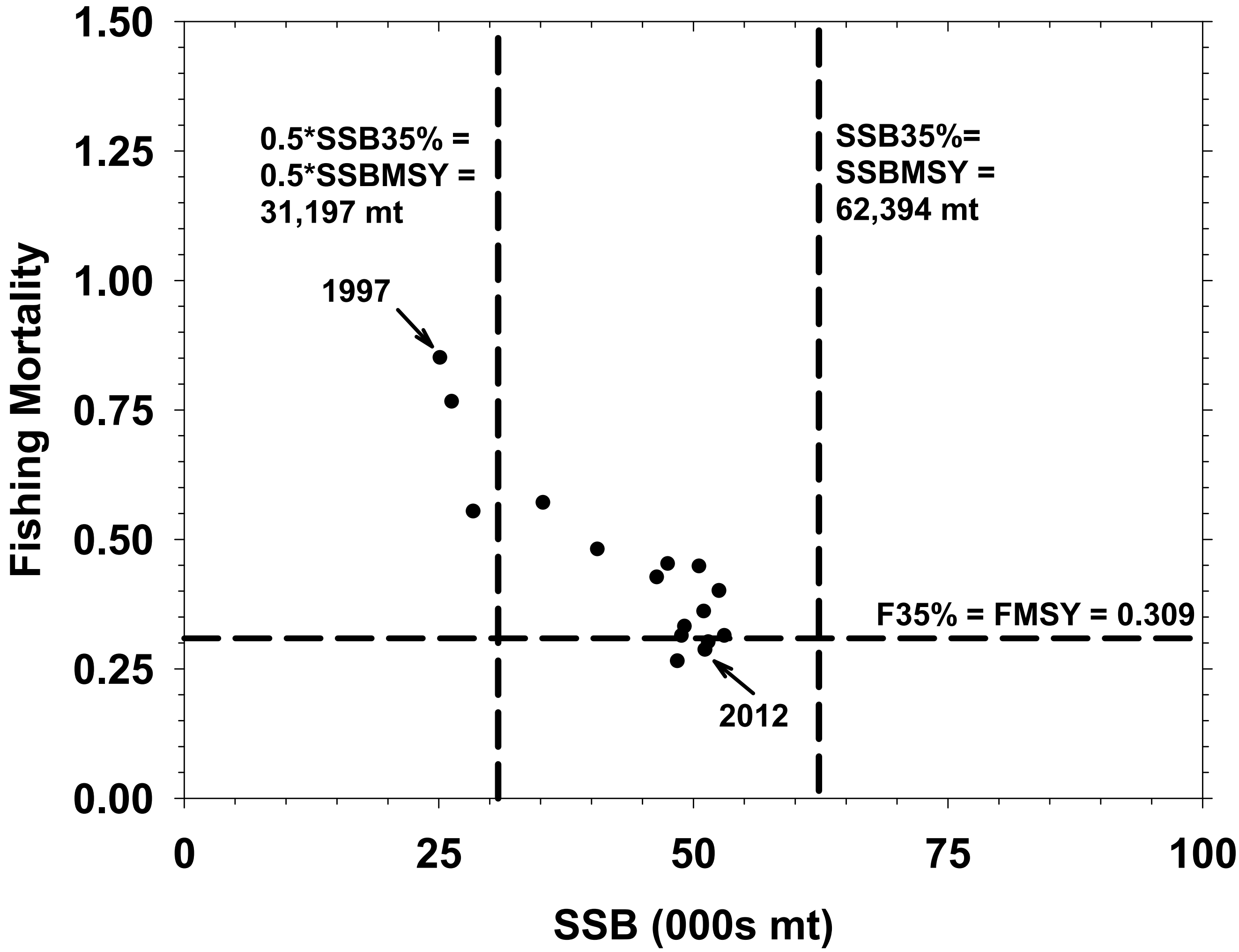


Figure A253. Estimates of summer flounder Spawning Stock Biomass (SSB) and fully-recruited Fishing Mortality (F, peak at age 4) relative to the 2013 SAW 57 biological reference points.

B. STRIPED BASS STOCK ASSESSMENT FOR 2013

B1.0 CONTRIBUTORS

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and

Kate Taylor, ASMFC Coordinator
Dr. Katie Drew, ASMFC Stock Assessment Scientist

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 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.

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.

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

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 α=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^{o} 03') to Greenwich, Connecticut (longitude 73^{o} 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.

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 $\geq$ 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.

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 $\leq$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.

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.

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:

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

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:

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

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:

<u>Beverton-Holt equation:</u>

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

<u>Ricker equation:</u>

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

<u>Shepherd equation:</u>

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

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:

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

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:

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

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

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

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

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

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^u_y is the vector of unadjusted proportions-at-age in year y, A is the ageing error matrix, and P^A_y 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.

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

$$f = -L_l - \sum\nolimits_f L_{f,p} - \sum\nolimits_t L_t^U + P_{rdev} + P_{n1} + P_{fadd}$$

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:

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

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 $\leq$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	$\geq$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 $\geq$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 $\pm$50%. 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).

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

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 ≥ 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);
λ_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:

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

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);
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;
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 ≥ 18 inches TL, corresponding roughly to 3-year-old and older striped bass and for fish ≥ 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 ≥ 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 ≥ 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 ≥ 28 inches and fish ≥ 18 inches. For fish ≥ 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 ≥ 28 inches were 0.30 for the coastal tagging programs and 0.45 for the producer area programs. Values increased for fish ≥ 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 ≥ 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 ≥ 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 ≥ 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.

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).

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 $Pr(SSB \leq SSBref) \leq 0.50$. 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 (≥ 28 inches and 20-26 inches) in Pennsylvania and processed by the Department of Environmental Protection to compare contamination of the two size groups.

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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	Years	n	Sizes (mm)	n_{MS}	n_{MA}	%MS or P/A
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

	Age												
Year	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.

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

	Age												
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

	Age												
Year	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

	Age												
Year	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.

State	Year	Mixed Gear Types: Harvest Pounds	Harvest Number	Effort	Length Samples	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 Harvest Pounds	Hook and Line Harvest Number	Hook and Line BOATDAYS*TOT(Effort	Hook and Line Length Samples	Hook and Line Samples Aged	Poundnet/haul seine Harvest Pounds	Poundnet/haul seine Harvest Number	Poundnet/haul seine FISHDAY*NUMI Effort	Poundnet/haul seine Length Samples	Poundnet/haul seine 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 Harvest Pounds	Gillnet Harvest Number	Gillnet BOATDAYS*TOT(Effort	Gillnet Length Samples	Gillnet Samples Aged	atl trwlgill Harvest Pounds	atl trwlgill Harvest Number	atl trwlgill BOATDAYS*TOT Effort	atl trwlgill Length Samples	atl trwlgill 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.

		Gill Net (Chesapeake Bay Area)					Gill Net (Coastal Area)				
		Harvest			Length	Samples	Harvest			Length	Samples
State	Year	Pounds	Number	Effort	Samples	Aged	Pounds	Number†	Effort	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	

		Hook and Line (Chesapeak Bay Area)					Hook and Line (Coastal Area)				
		Harvest			Length	Samples	Harvest			Length	Samples
State	Year	Pounds	Number†	Effort	Samples	Aged	Pounds	Number	Effort	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.

		Pound Net					Fyke net				
		Harvest			Length	Samples	Harvest			Length	Samples
State	Year	Pounds	Number	Effort	Samples	Aged	Pounds	Number	Effort	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		

		Haul Seine					Other				
		Harvest			Length	Samples	Harvest			Measured	Samples
State	Year	Pounds	Number	Effort	Samples	Aged	Pounds	Number	Effort	Bass	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.

State	Year	Ocean beach haul seine Harvest Pounds	Number	Effort	Length Samples	Samples Aged	Ocean gillnet Harvest Pounds	Number	Effort	Length Samples	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

State	Year	Ocean trawl Harvest Pounds	Number	Effort	Length Samples	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
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
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.

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.

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		Age 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		Age 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 — Age

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 — Age

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.

	Age															
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 Partial Year Estimate	Connecticut River Full Year Estimate	MRFSS/MRIP CT	Corrected State Total	(Percent)[a] Bias
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.

			MRFSS / MRIP				
Year		DE River	NJ	DE	States Combined	Corrected State Total	Percent[a] Bias
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 — Age

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 — Age

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

	Age															
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	$\hat{\bar{n}}$	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 ≥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 ≥ 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 (Chespeake 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	$\hat{P}_{f,y,a}$	$\hat{P}_{f,y,a} = \frac{\hat{C}_{f,y,a}}{\sum_a \hat{C}_{f,y,a}}$
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	$\hat{U}_{t,y,a}$	$\hat{U}_{t,y,a} = \frac{\hat{I}_{t,y,a}}{\sum_a \hat{I}_{t,y,a}}$
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	$\hat{\hat{n}}$	The multiplier from equation 1.8 of Francis (2011) was used to adjust the starting values
Constraints Added To Total Likelihood	$P_{n1}, P_{rdev}, P_{fadd}$	$P_{n1} = \lambda_{n1}(\hat{N}_{y,1} - N^e_{y,1})^2$ - forces $N_{1,1}$ to follow S-R curve $P_{rdev} = \lambda_R \sum_y \log_e(\hat{\sigma}_R) + \frac{\hat{e}^2_y}{2\hat{\sigma}^2_R}$ - for bias correction to constrain deviations $P_{f_{add}} = \begin{cases} \text{phase} < 3, & 10 \cdot \sum_y (F_{f,y} - 0.15)^2 \\ \text{phase} \geq 3, & 0.000001 \cdot \sum_y (F_{f,y} - 0.15)^2 \end{cases}$ - avoid small F values at start

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

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.

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.

				Percentile	
Index	n	Weight	RMSE	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.

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.

	Bay			Coast			Commercial Discards			Total					
Year	Full F	SD	CV	Full F	SD	CV	Full F	SD	CV	Full F	SD	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.

	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.

	2012 Base Model		M=0.15		Lorenzen Ms		Increase M after 1996		ESS 20% Increase		ESS 20% Decrease	
Year	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	0.087	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	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	0	0	1	0	0	0	0	1	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	0	1	1	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	1
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
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
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
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
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
450-499		26	0	82	0	25	16	464	9	4	24	63	0	2171	267	787	0	324	697	46	1	0	0	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
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
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
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
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
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
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
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
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
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
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
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
>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

Table B8.4 cont.

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
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
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
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
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
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
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

Table B8.4 cont.

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	0	2	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.	Marc h	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

	Coast Programs				Producer Area Programs			
Model	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

	Coast Programs				Producer Area Programs			
Model	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

	MADFW			NYOHS/TRL*			NJDB			NCCOOP		
Year	S	F	M	S	F	M	S	F	M	S	F	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

	HUDSON			DE/PA			MDCB			VARAP		
Year	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

	MADFW			NYOHS/TRL*			NJDB			NCCOOP		
Year	S	F	M	S	F	M	S	F	M	S	F	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)	IRC R	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".

<u>Instantaneous Rates Method</u>

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.

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 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.

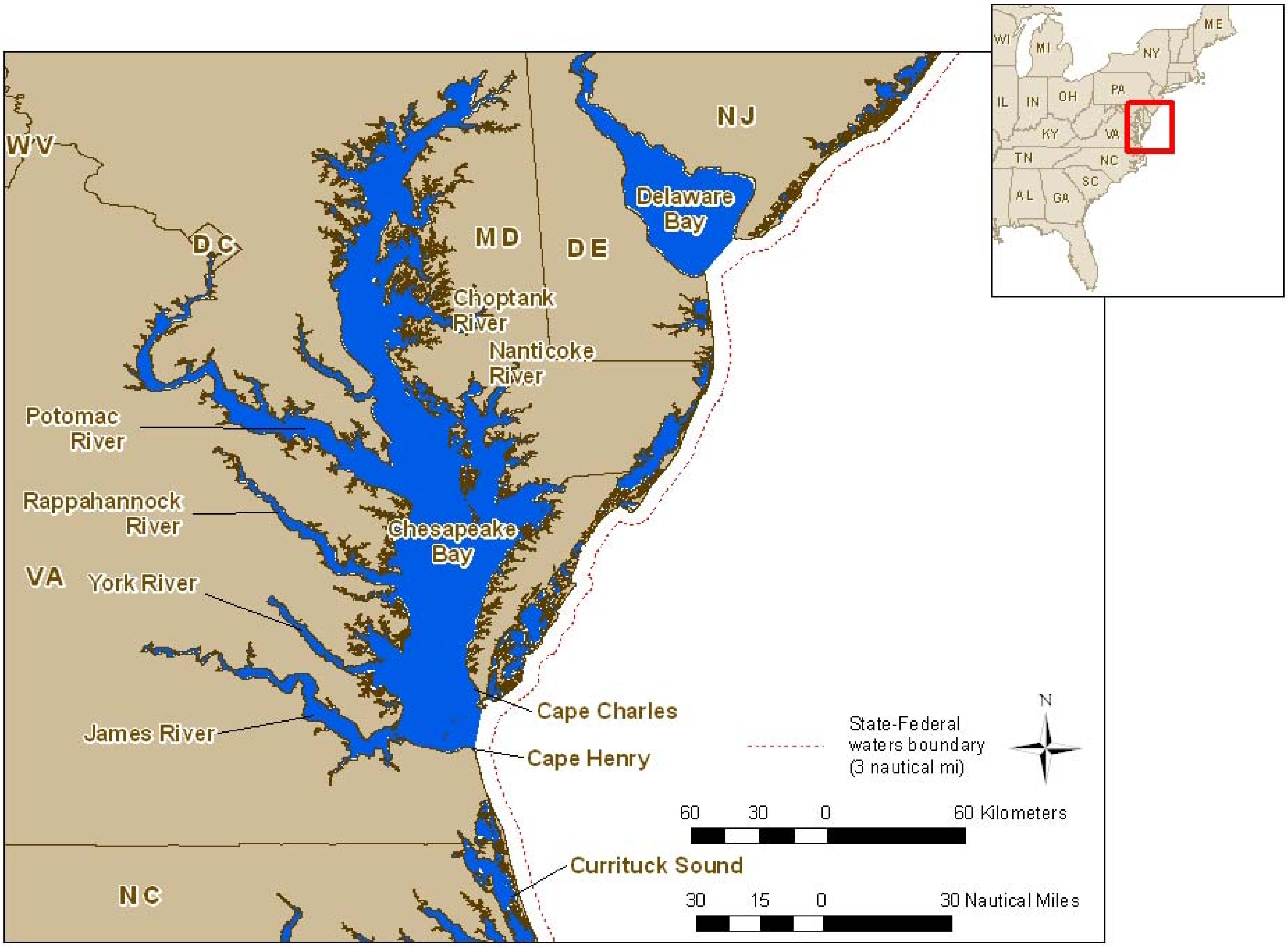


Figure B4.2. Geography of the Chesapeake Bay.

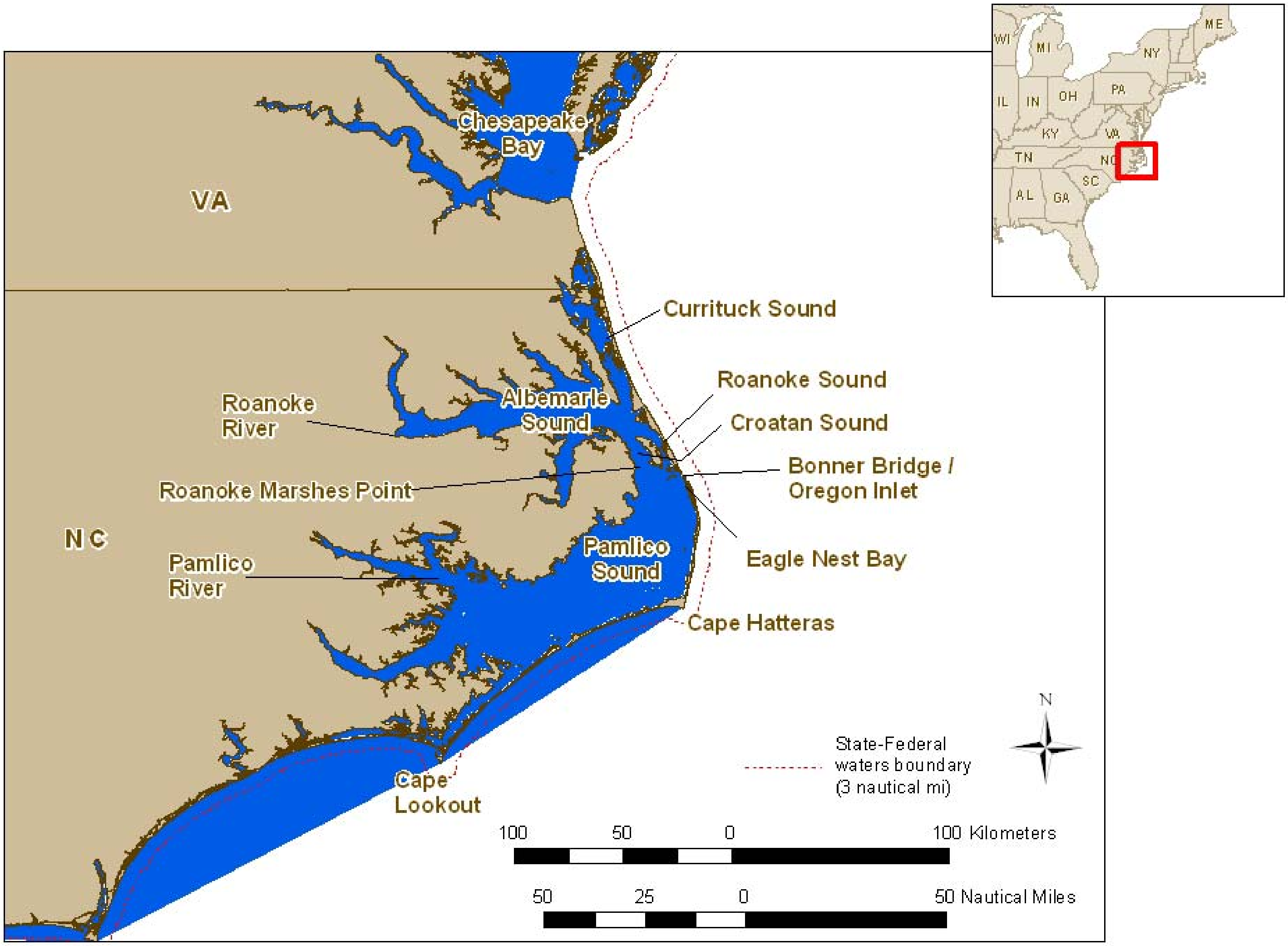


Figure B4.3. Geography of the Albemarle Sound-Roanoke River region.

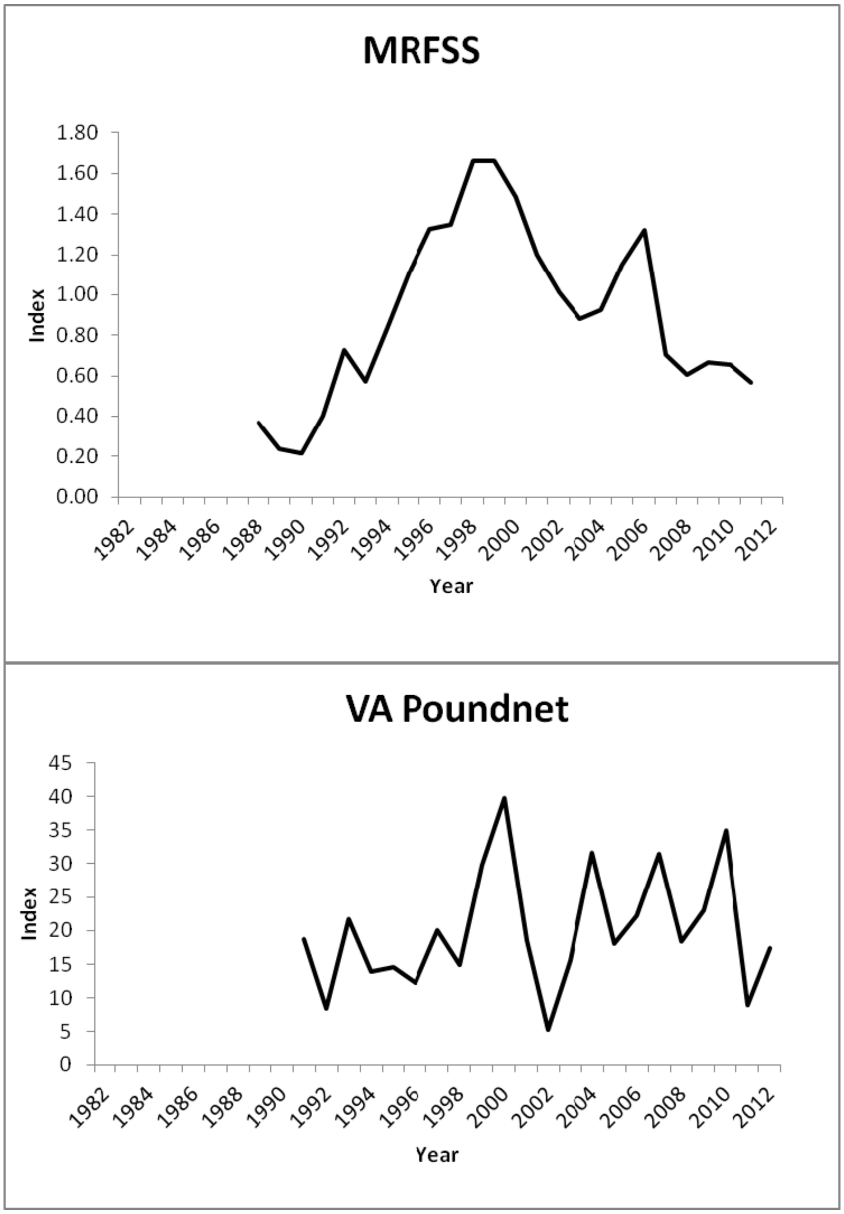


Figure B5.1. Fishery-dependent indices of relative abundance (aggregated), 1982-2012.

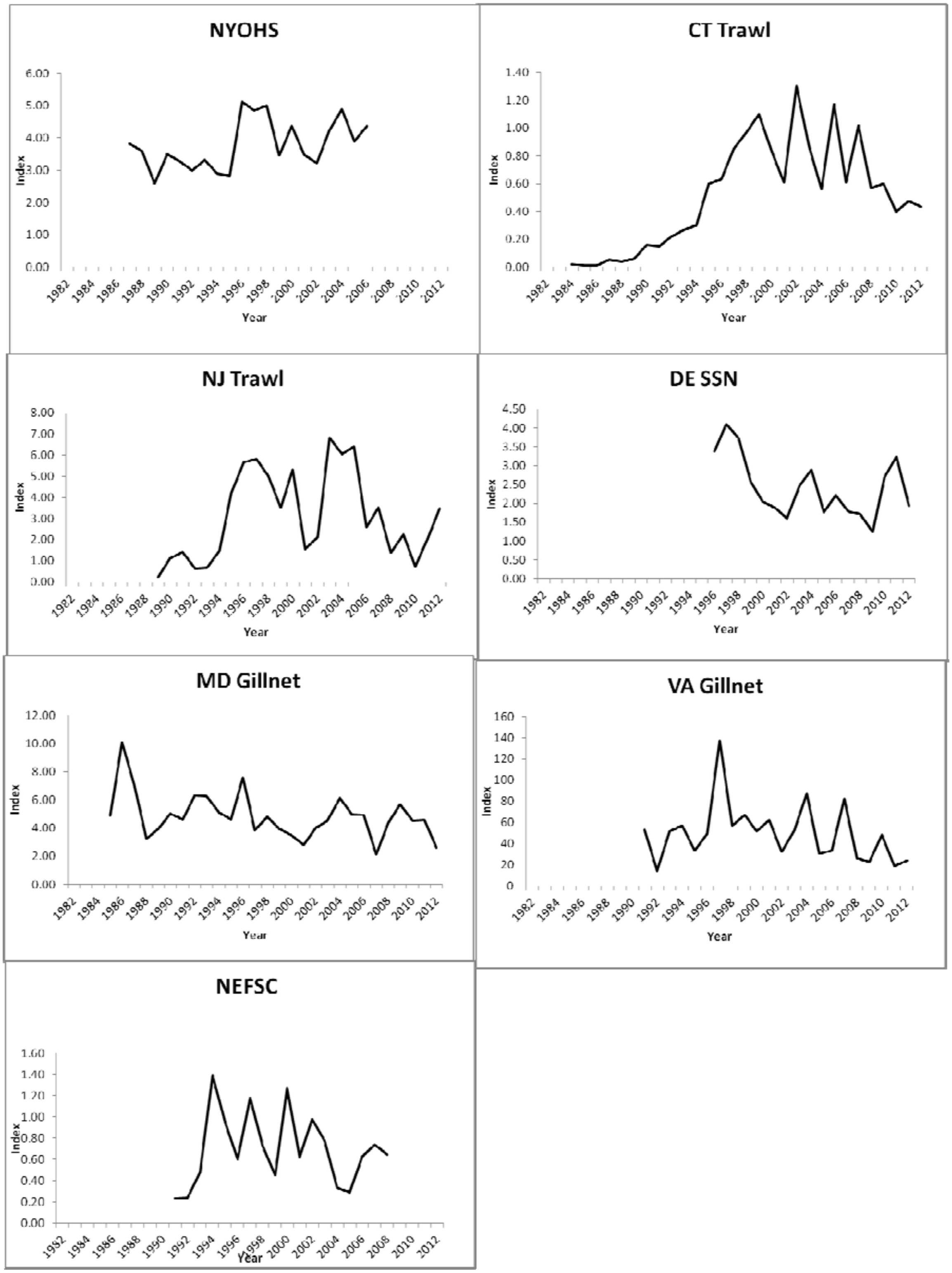


Figure B5.2. Fisheries-independent indices of relative abundance (aggregated), 1982-2012.

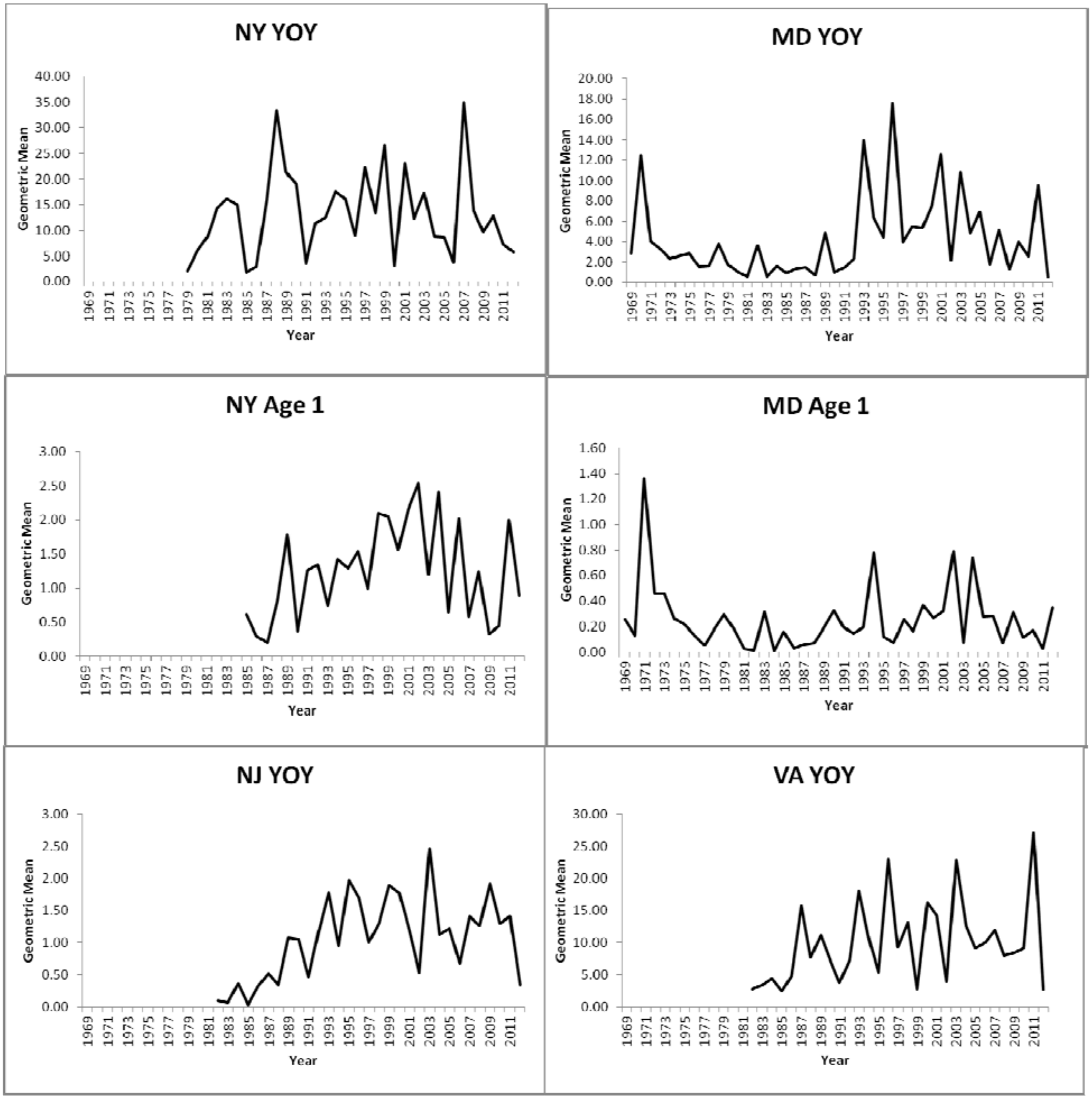


Figure B5.3. Fisheries-independent young-of-the-year and age 1 indices of relative abundance (unlagged), 1982-2012.

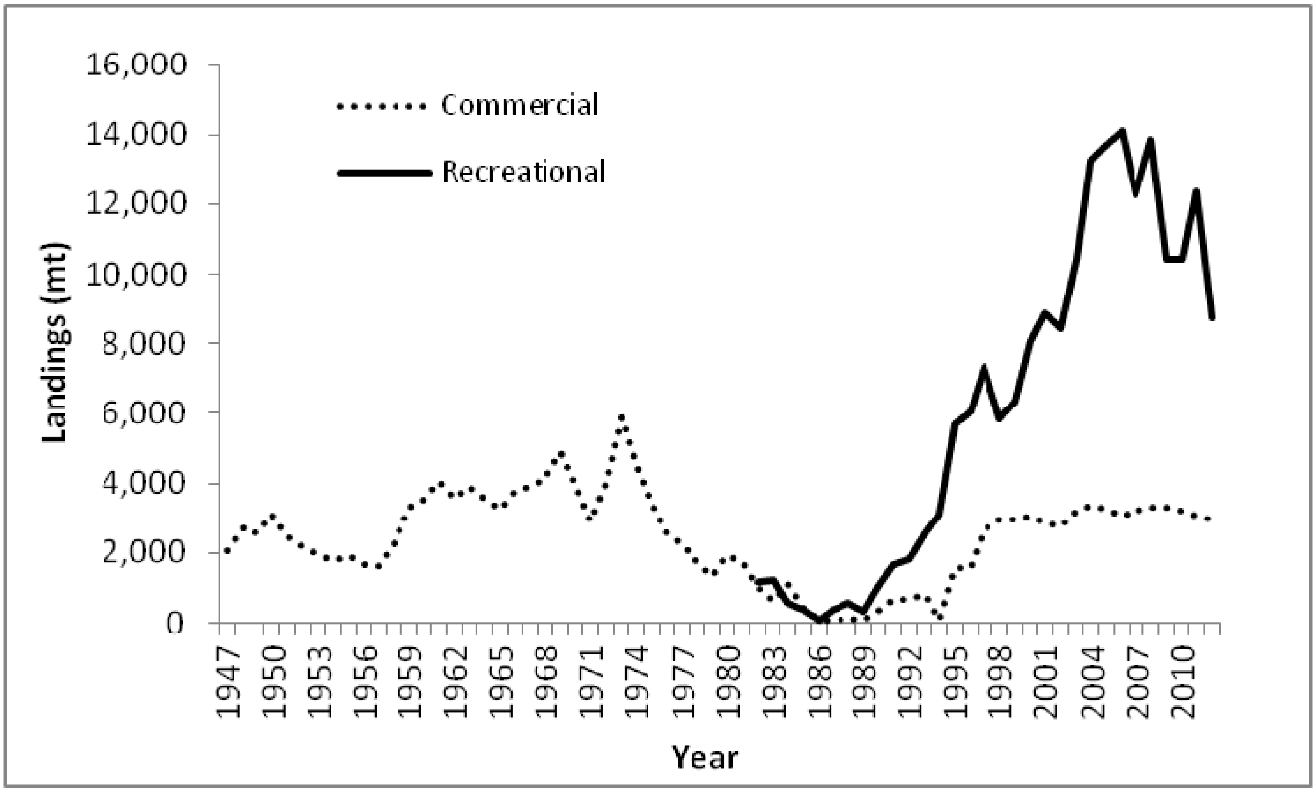


Figure B6.1. Total weight (metric tons) of harvested striped bass by the commercial and recreational fisheries from Maine to North Carolina

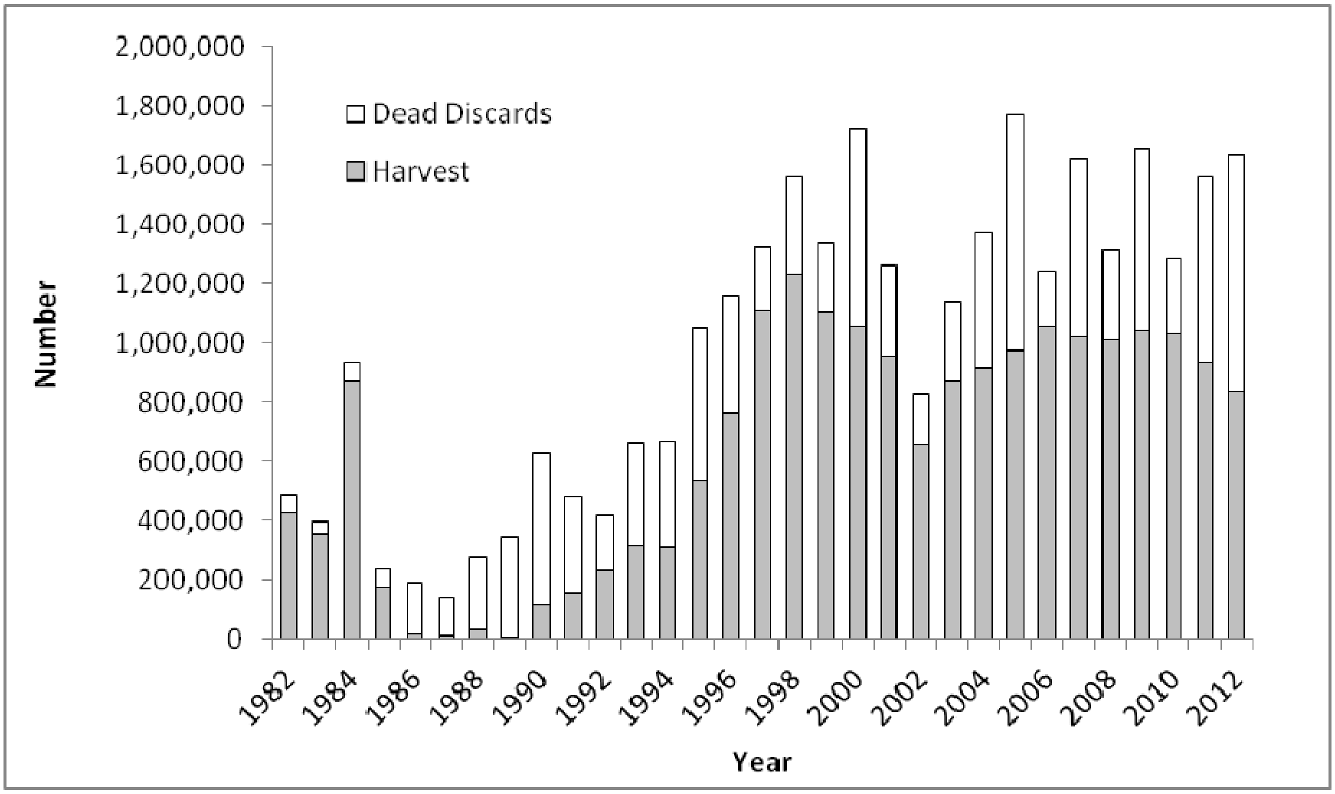


Figure B6.2. Total commercial removals (harvest and dead discards) of Atlantic striped bass, 1982-2012.

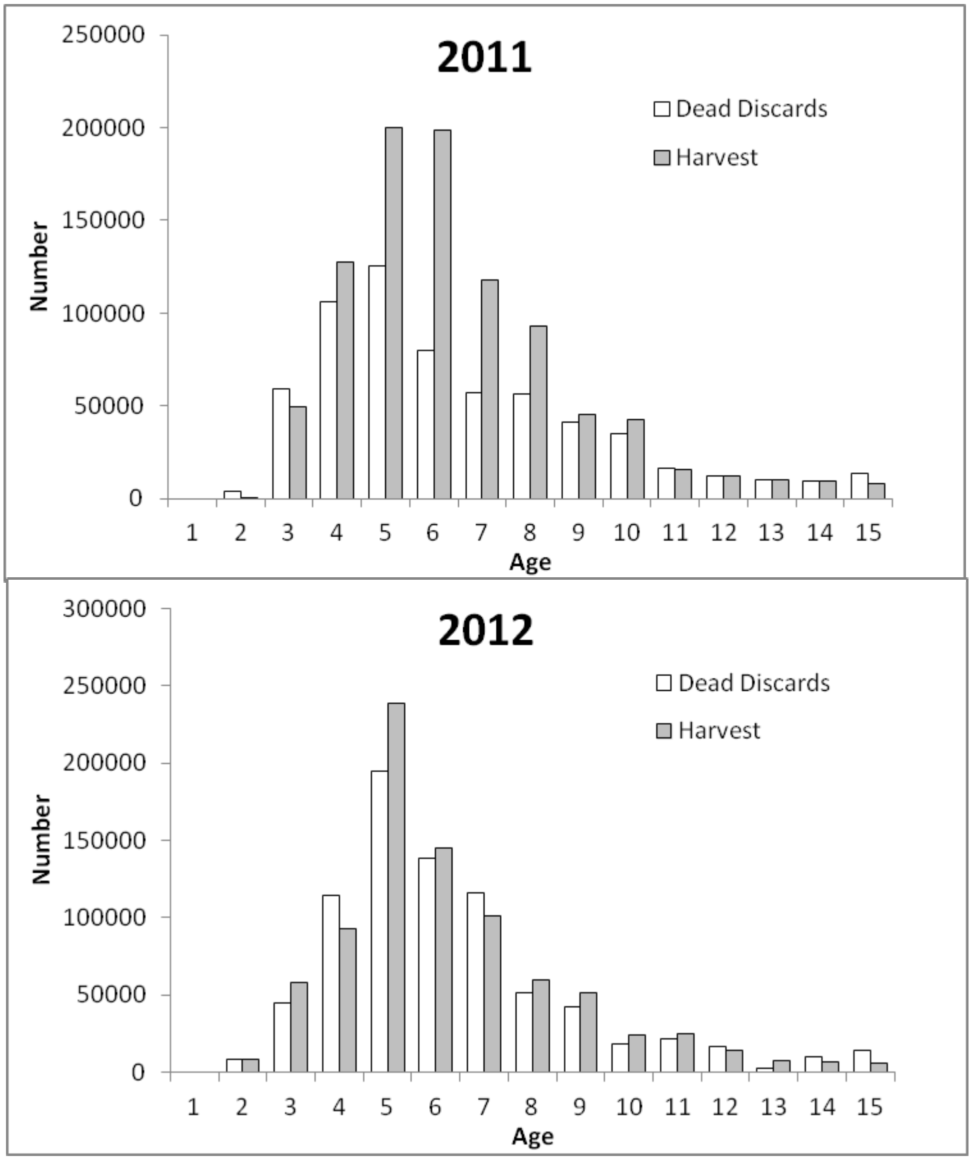


Figure B6.3. Total commercial removals (harvest and dead discards) by age of the Atlantic striped bass, 2011 and 2012

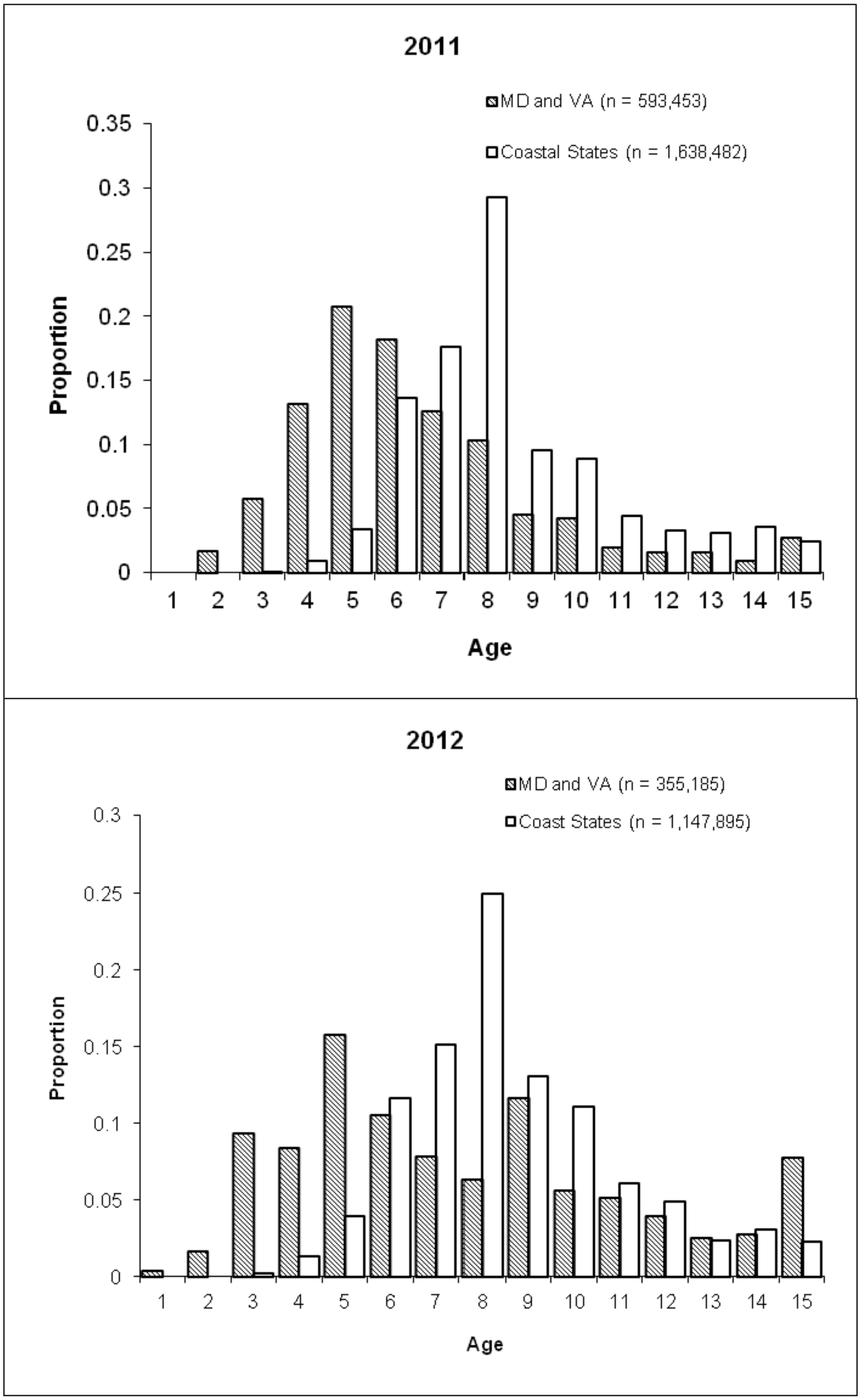


Figure B6.4. Comparison of age compositions from recreational harvest and dead release, 2011 and 2012.

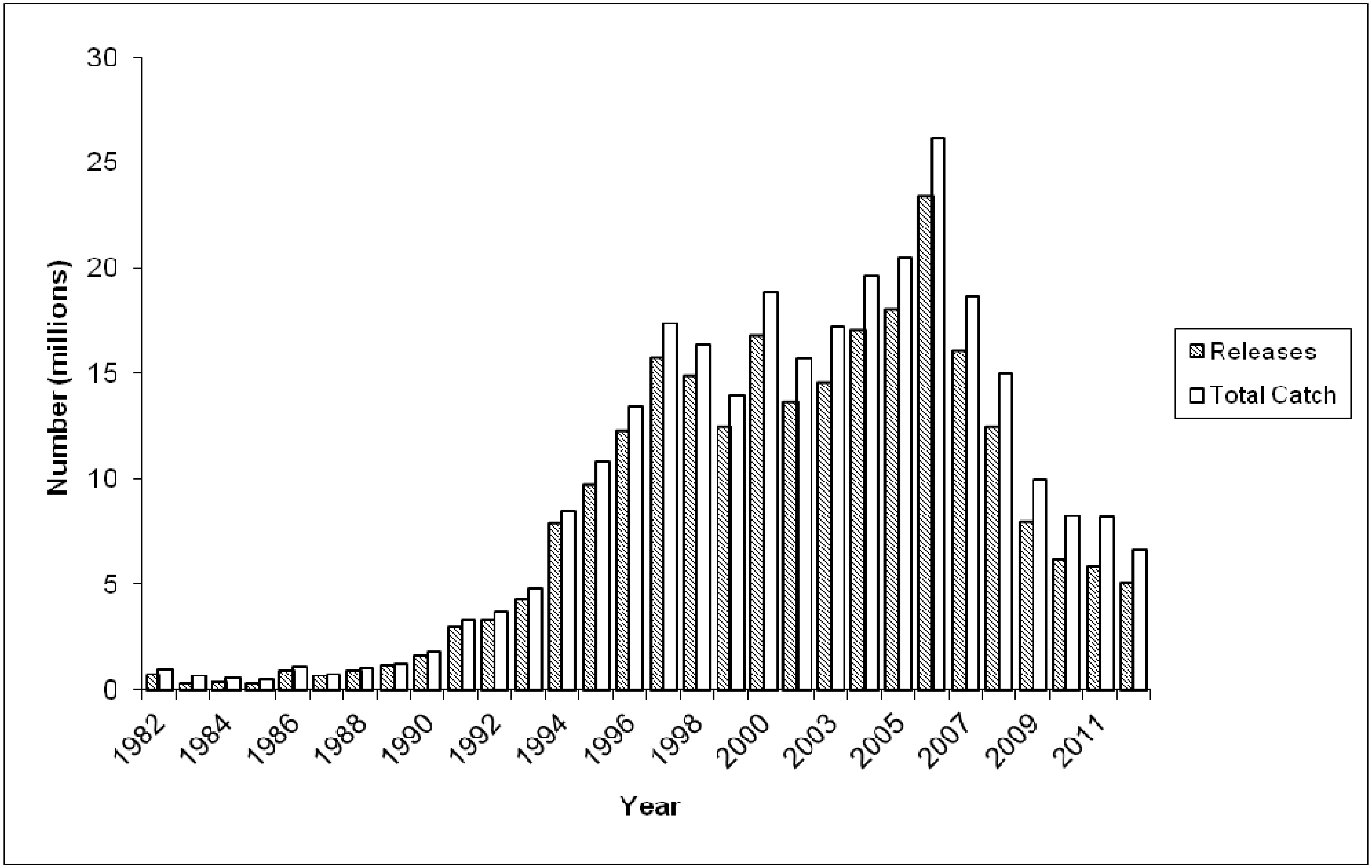


Figure B6.5. Comparison of the numbers of released striped bass to total catch.

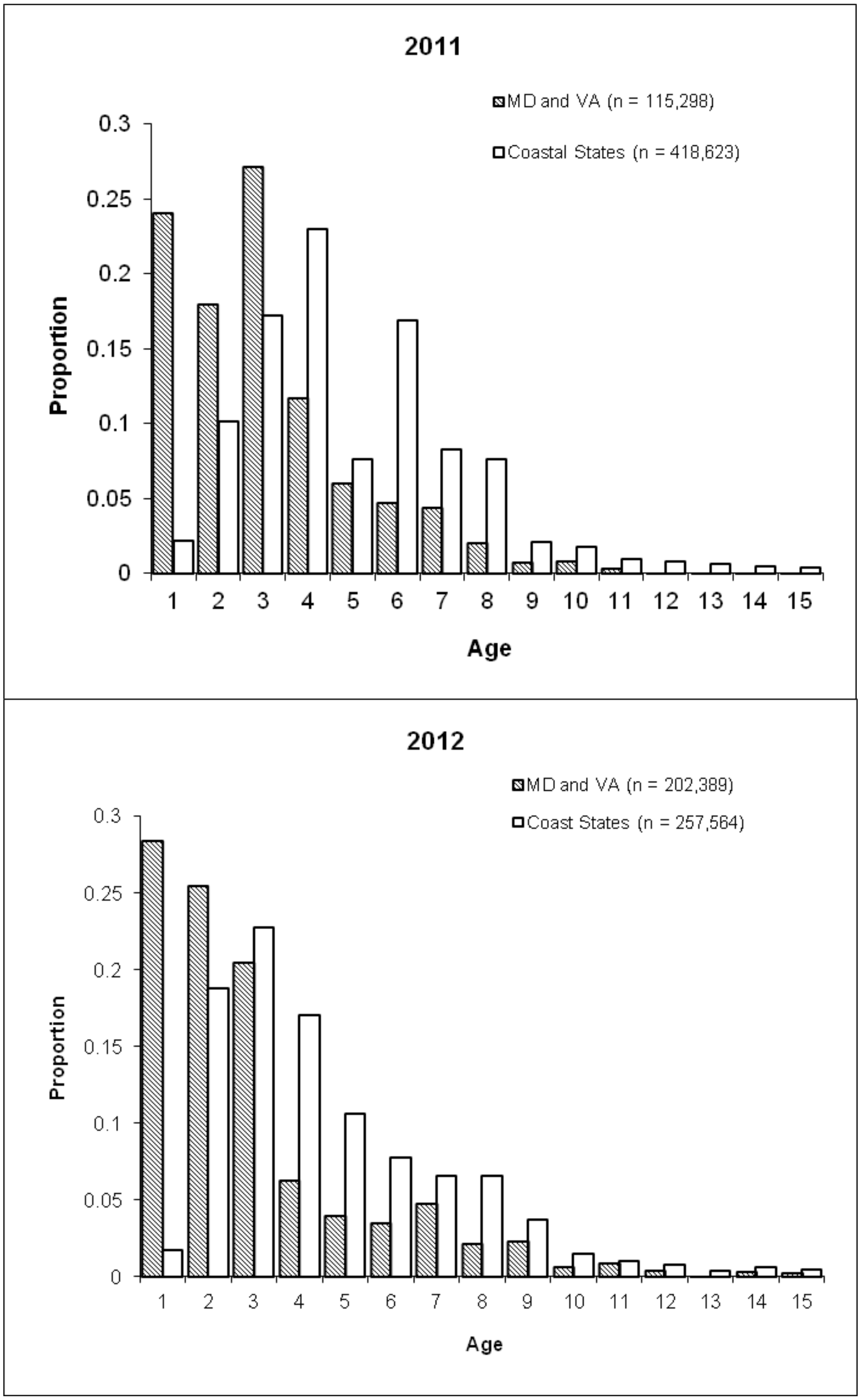
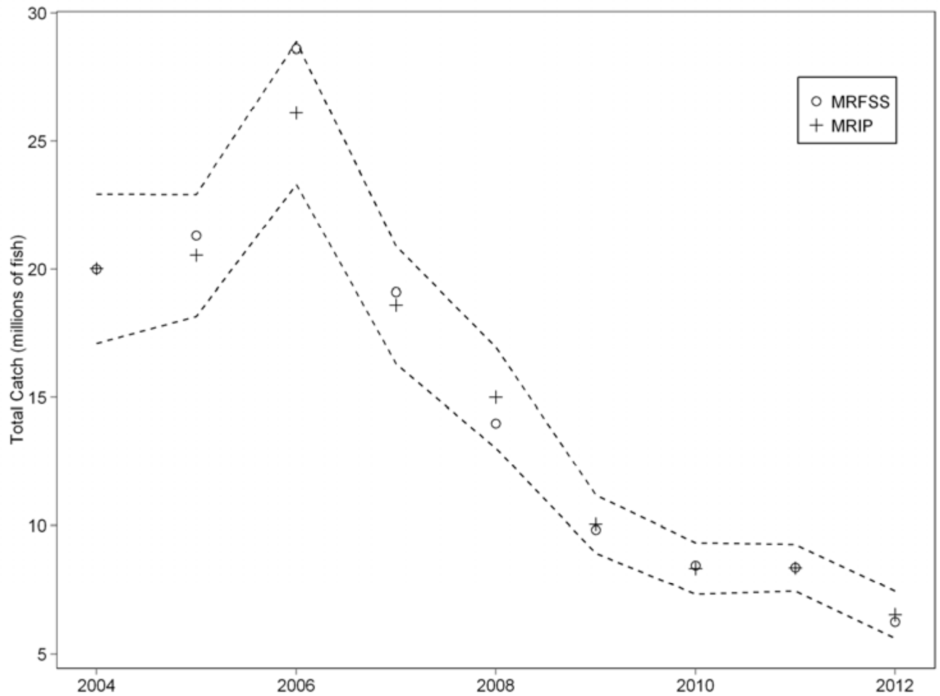


Figure B6.6. Comparison of age compositions of dead recreational discards between coast and Chesapeake Bay in 2011 and 2012.



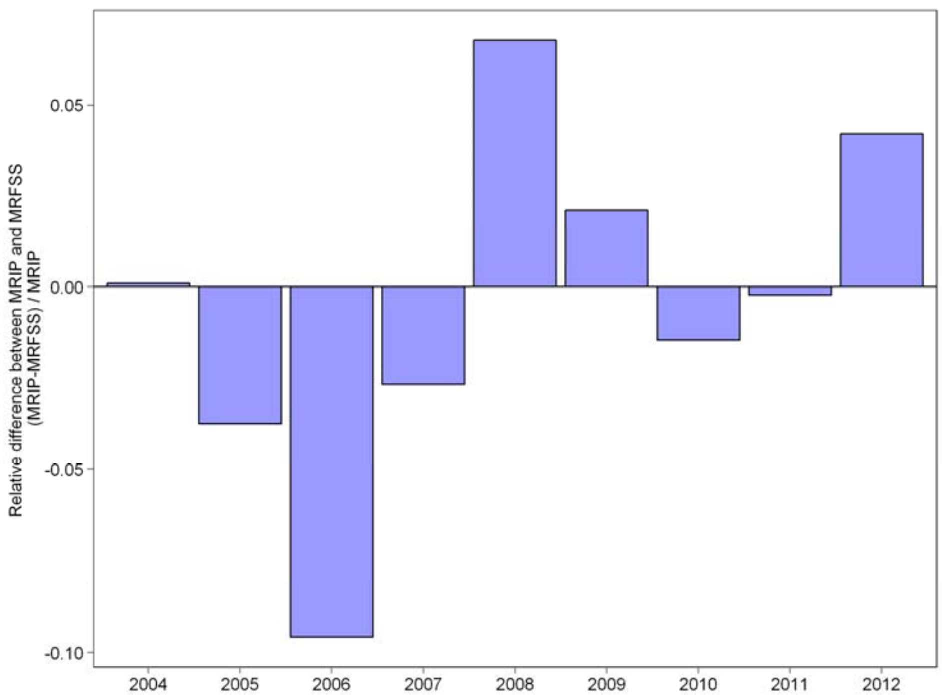


Figure B6.7. MRFSS and MRIP estimates of recreational total catch for the Atlantic coast (top panel) and relative difference between the two estimates (bottom panel). Dashed lines represent 95% confidence intervals for the MRIP estimates.

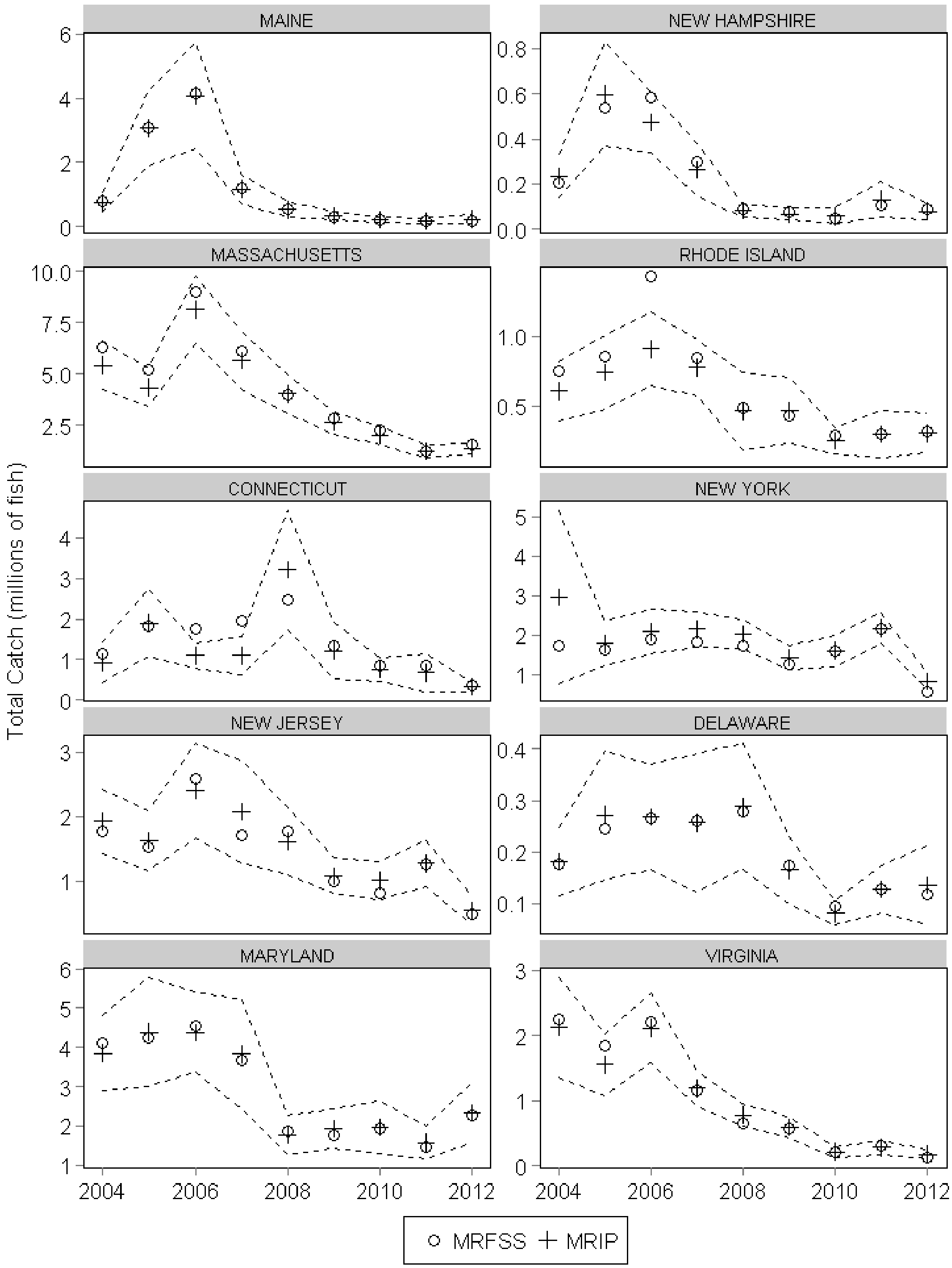


Figure B6.8. MRFSS and MRIP estimates of recreational total catch by state. Dashed lines represent 95% confidence intervals for the MRIP estimates.

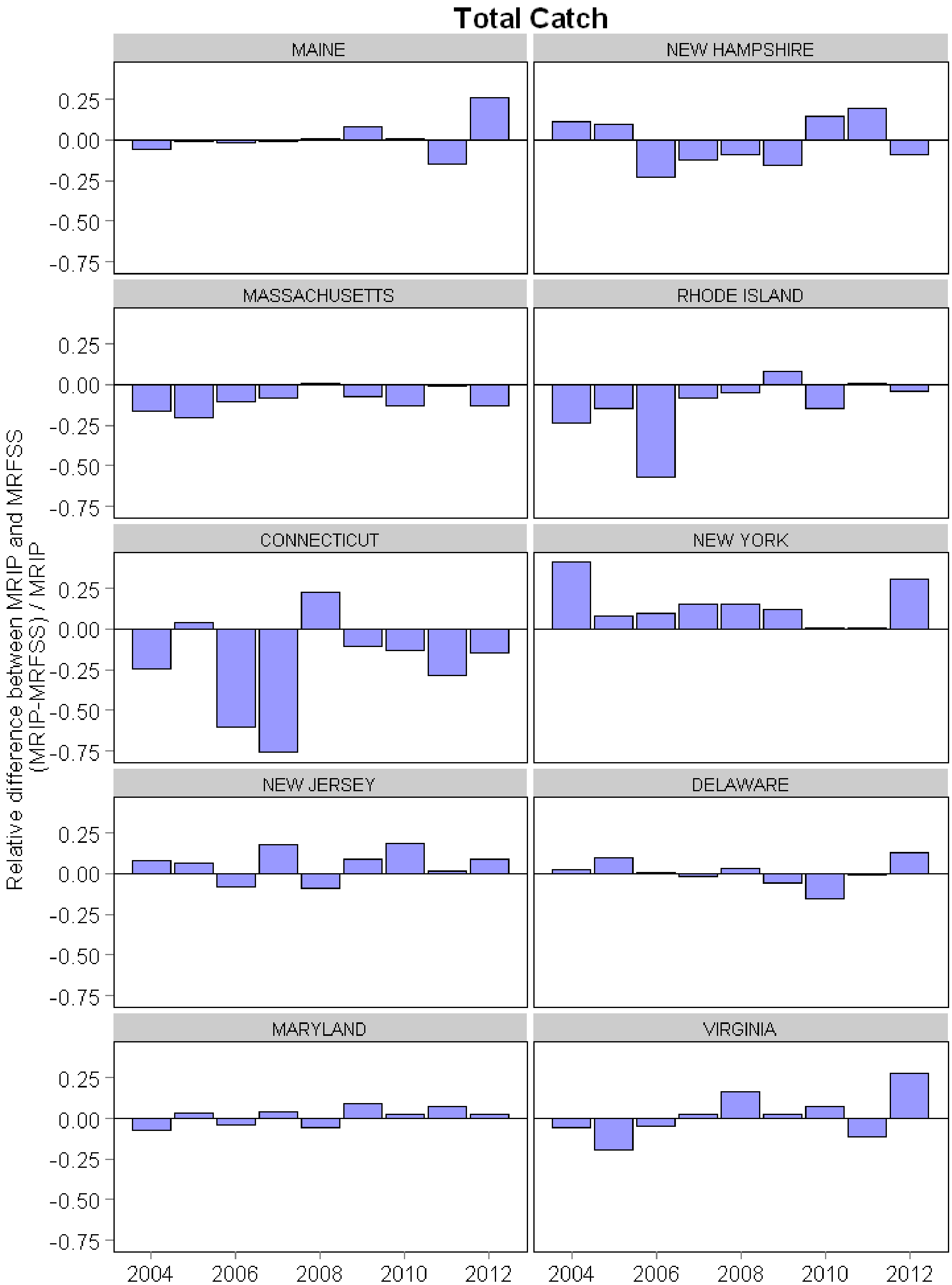


Figure B6.9. Relative differences between MRIP and MRFSS estimates of total recreational catch by state.

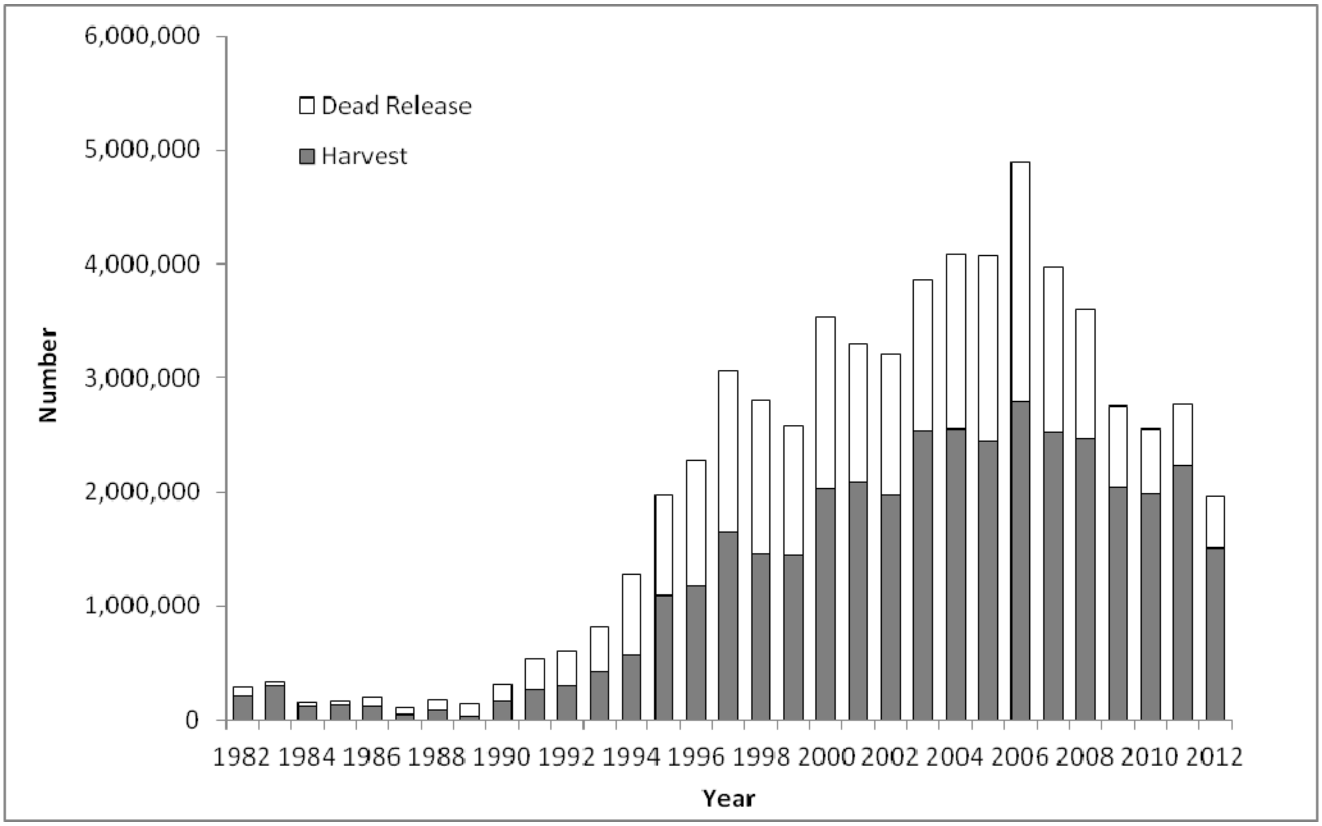


Figure B6.10. Total removals (Dead release and harvest) of striped bass by the recreational fishery, 1982-2012.

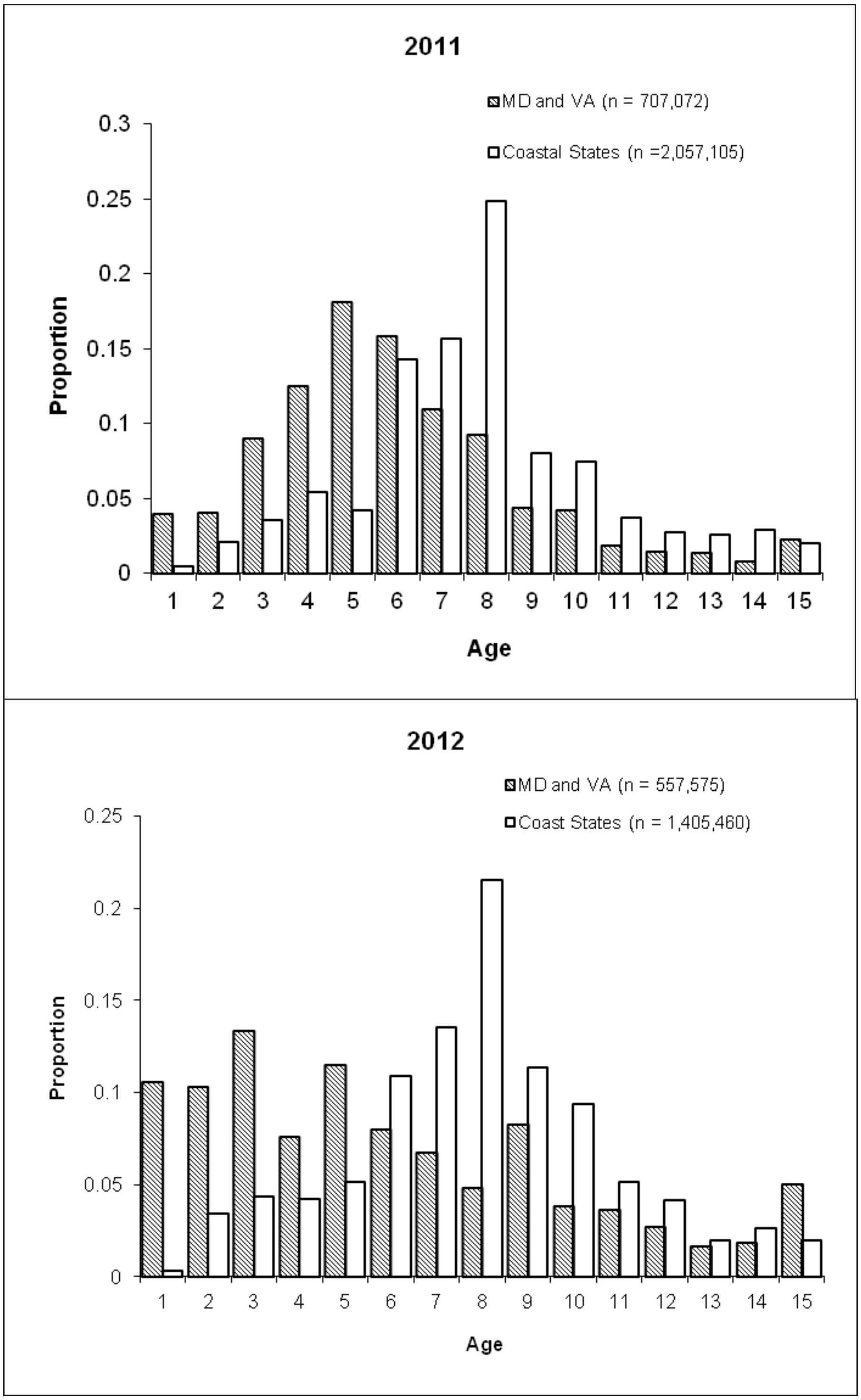


Figure B6.11. Total recreational removals (harvest and dead discards) by age and region, 2011 and 2012.

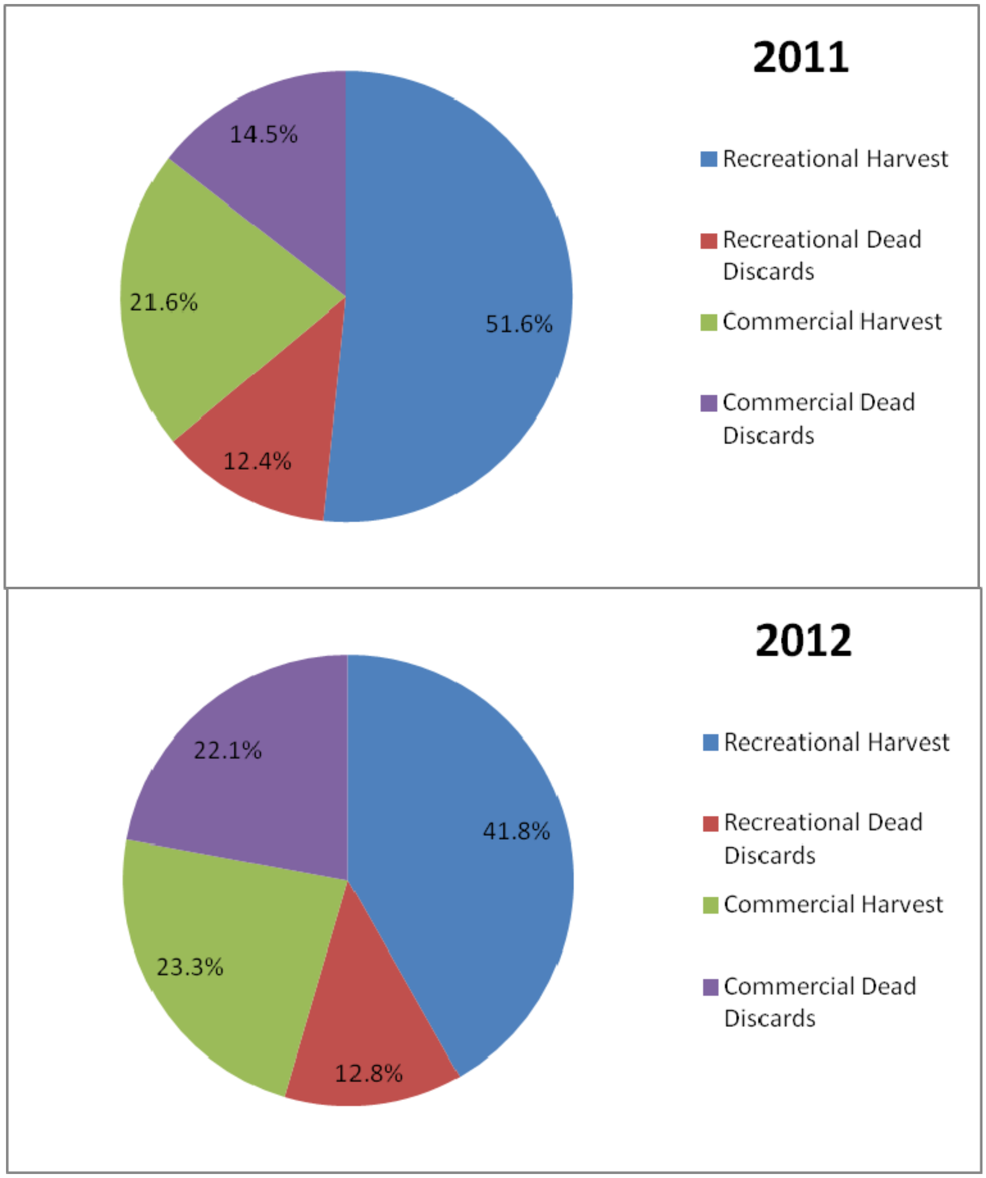


Figure B6.12. Percentage of 2011 and 2012 striped bass mortality by fishery component.

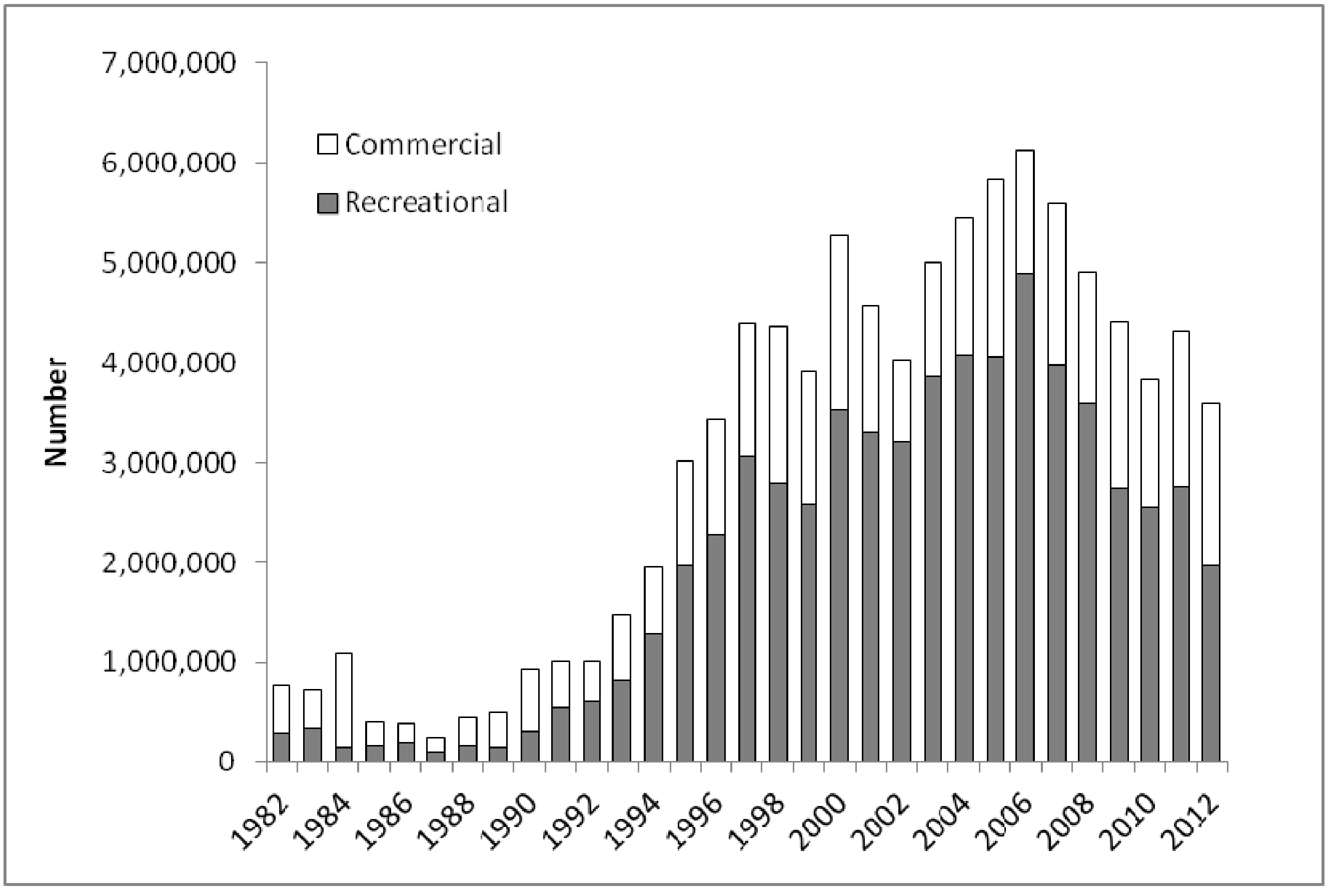


Figure B6.13. Total removals of striped bass partitioned into commercial and recreational contributions, 1982-2012.

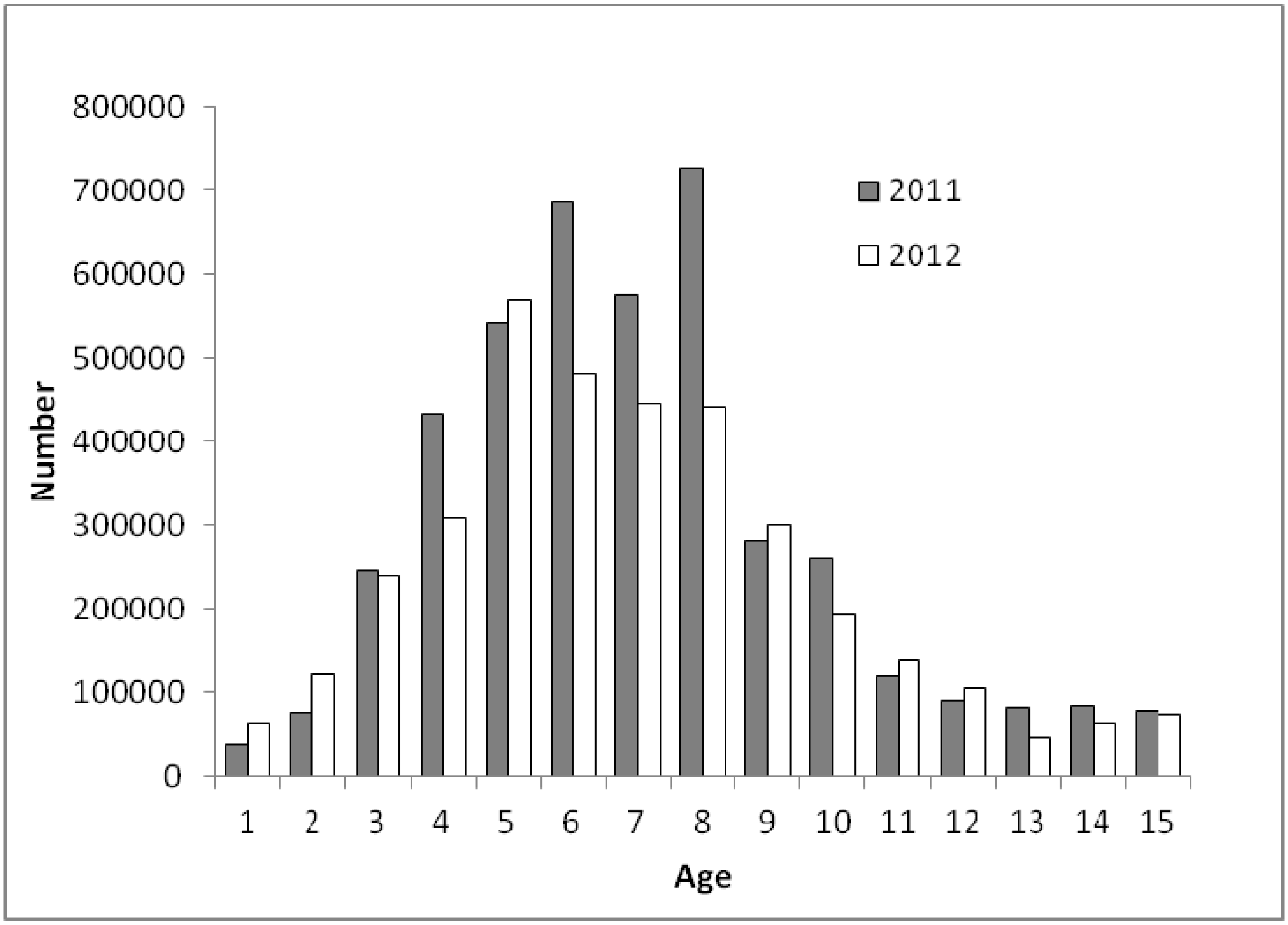


Figure B6.14. Age composition of total removals of striped in 2011 and 2012.

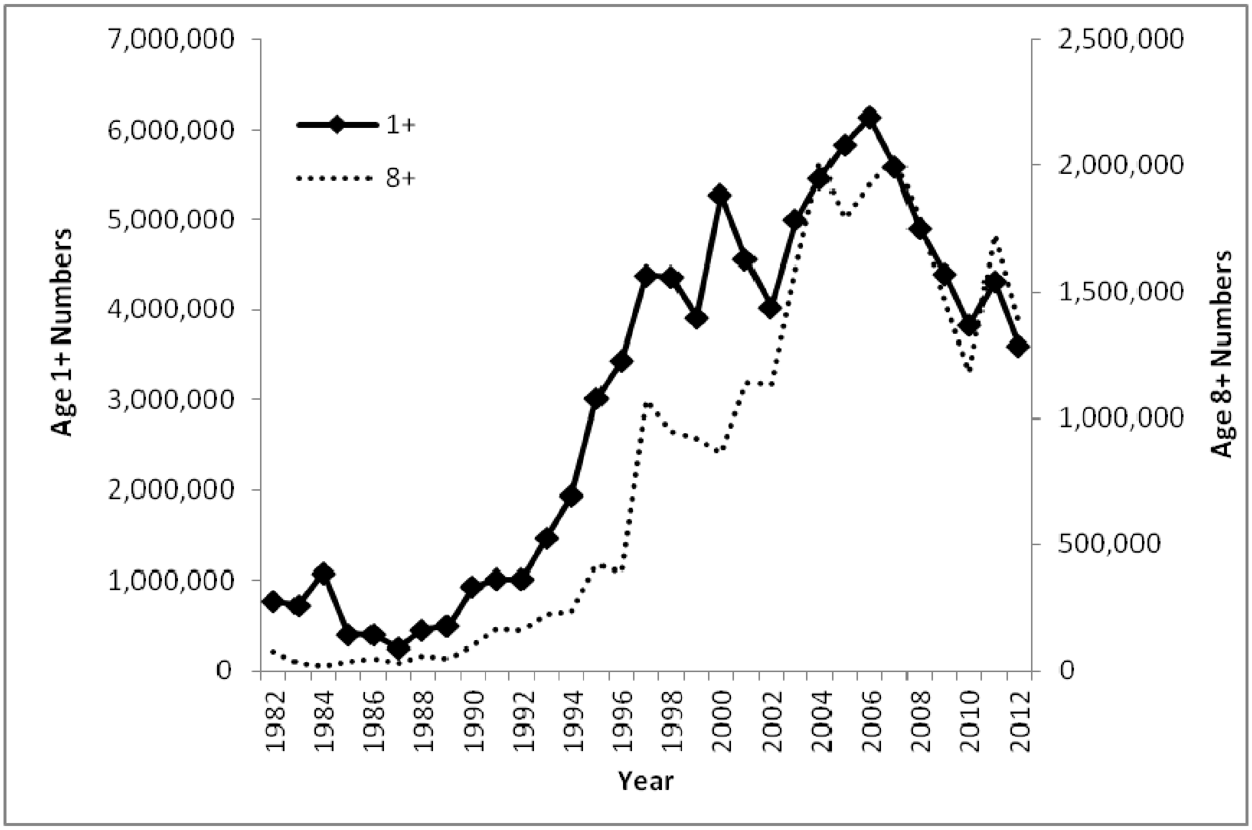


Figure B6.15. Total removals of striped bass by age group, 1982-2012.

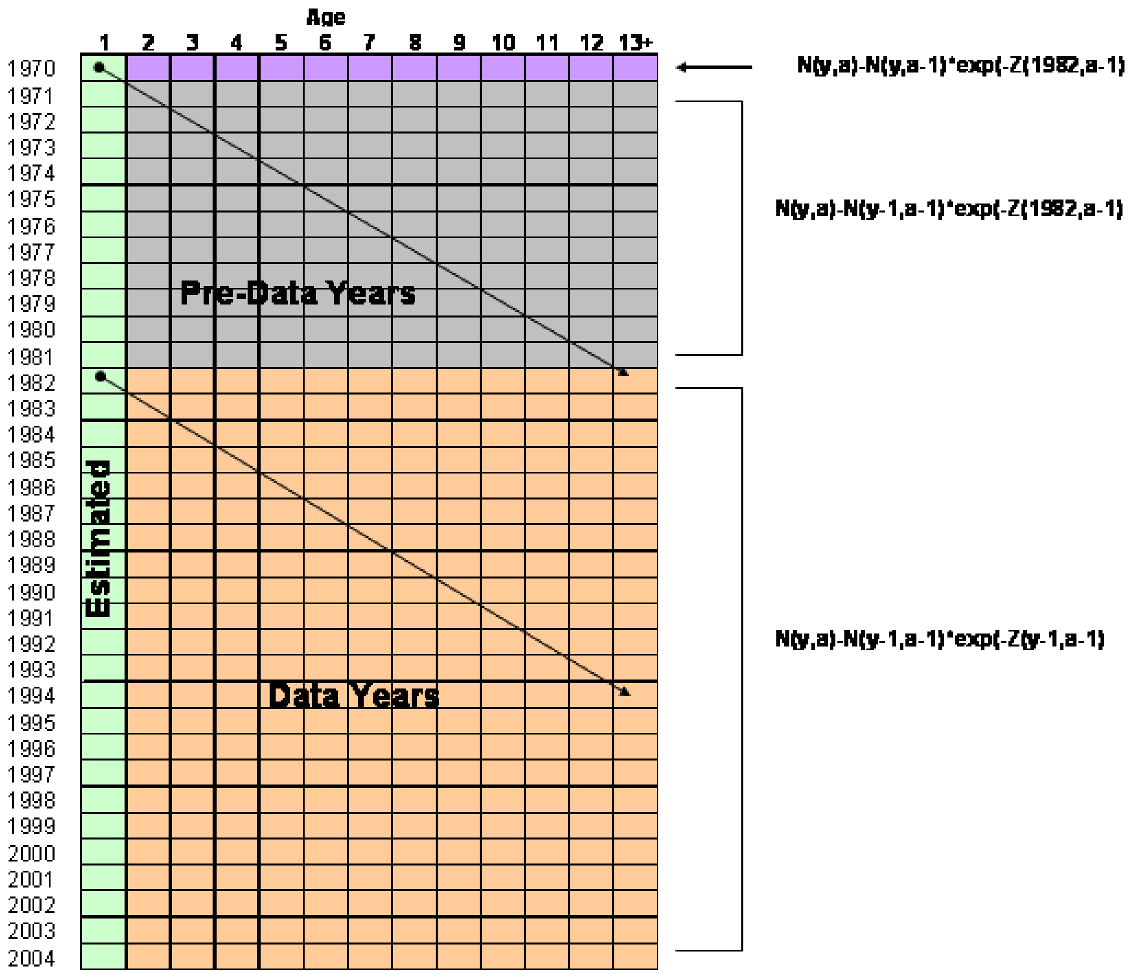
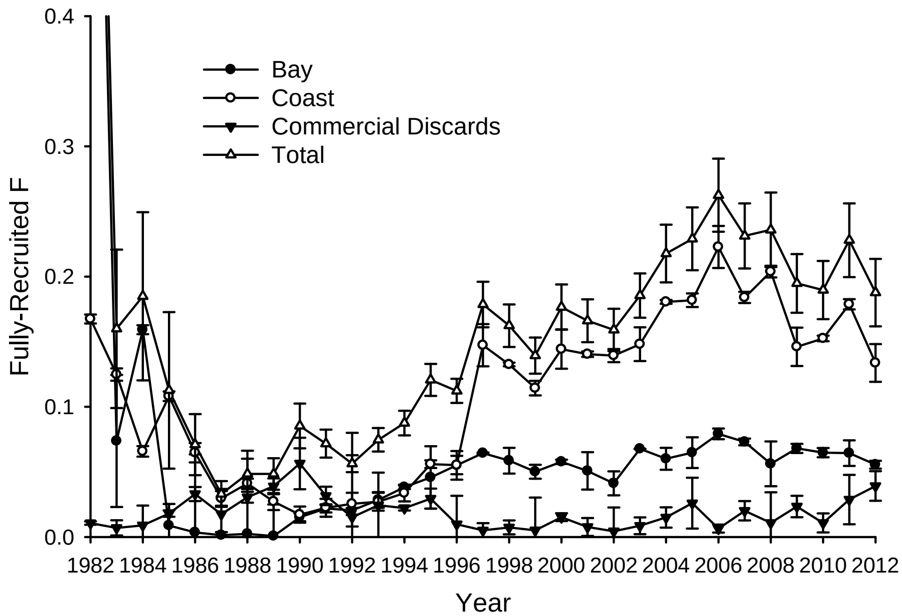


Figure B7.1. Schematic of population abundance-at-age



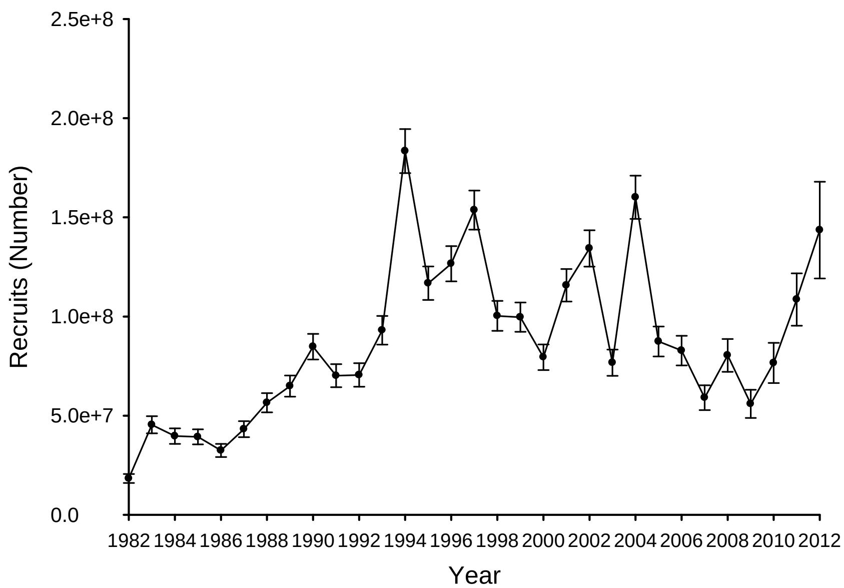


Figure B7.2. Estimates of total and fleet-specific fully-recruited fishing mortality (+1 SD) and recruitment (+1 SD) from the SCA base model run.

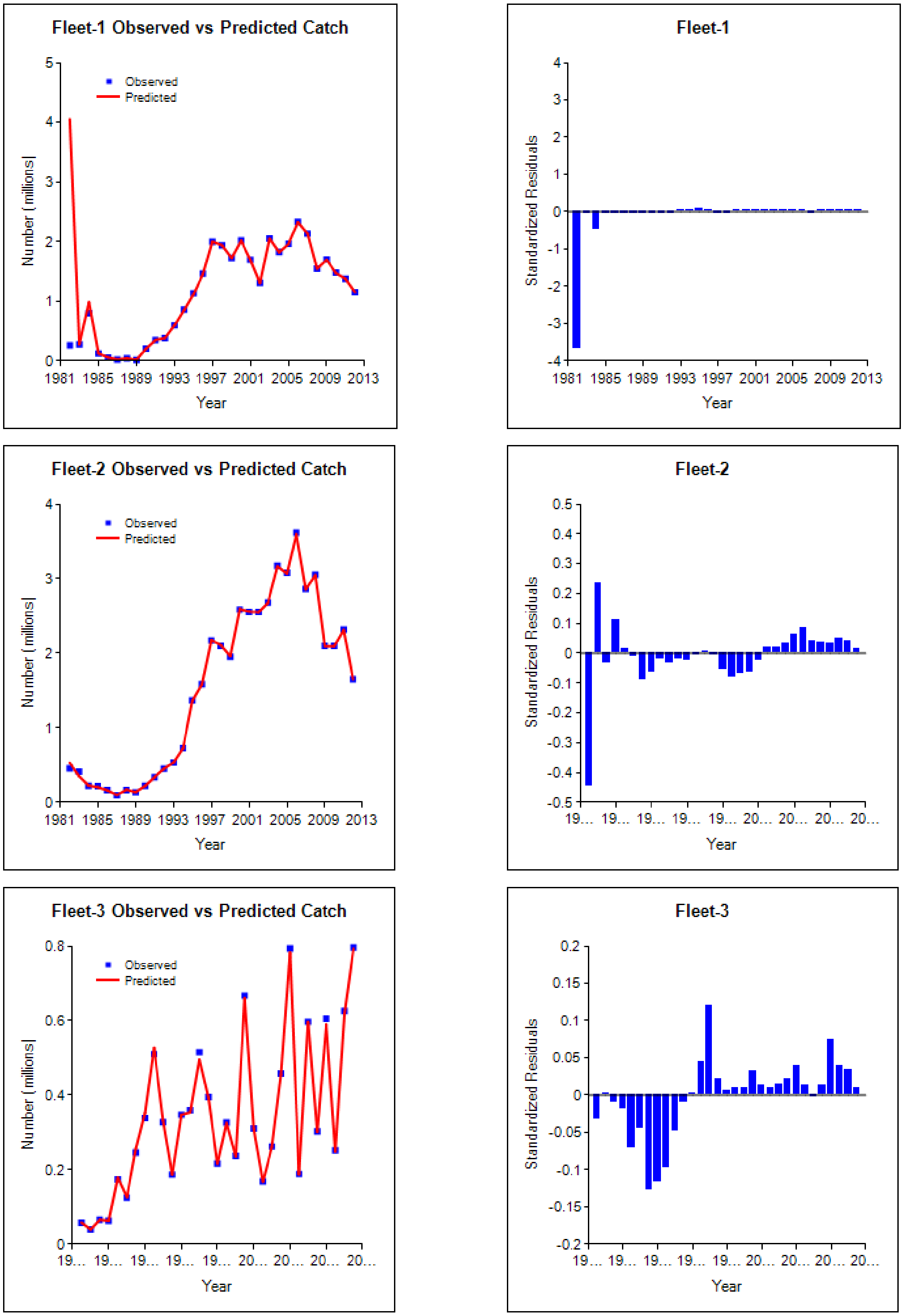


Figure B7.3. Observed and predicted total catch and standardized residuals by fleet.

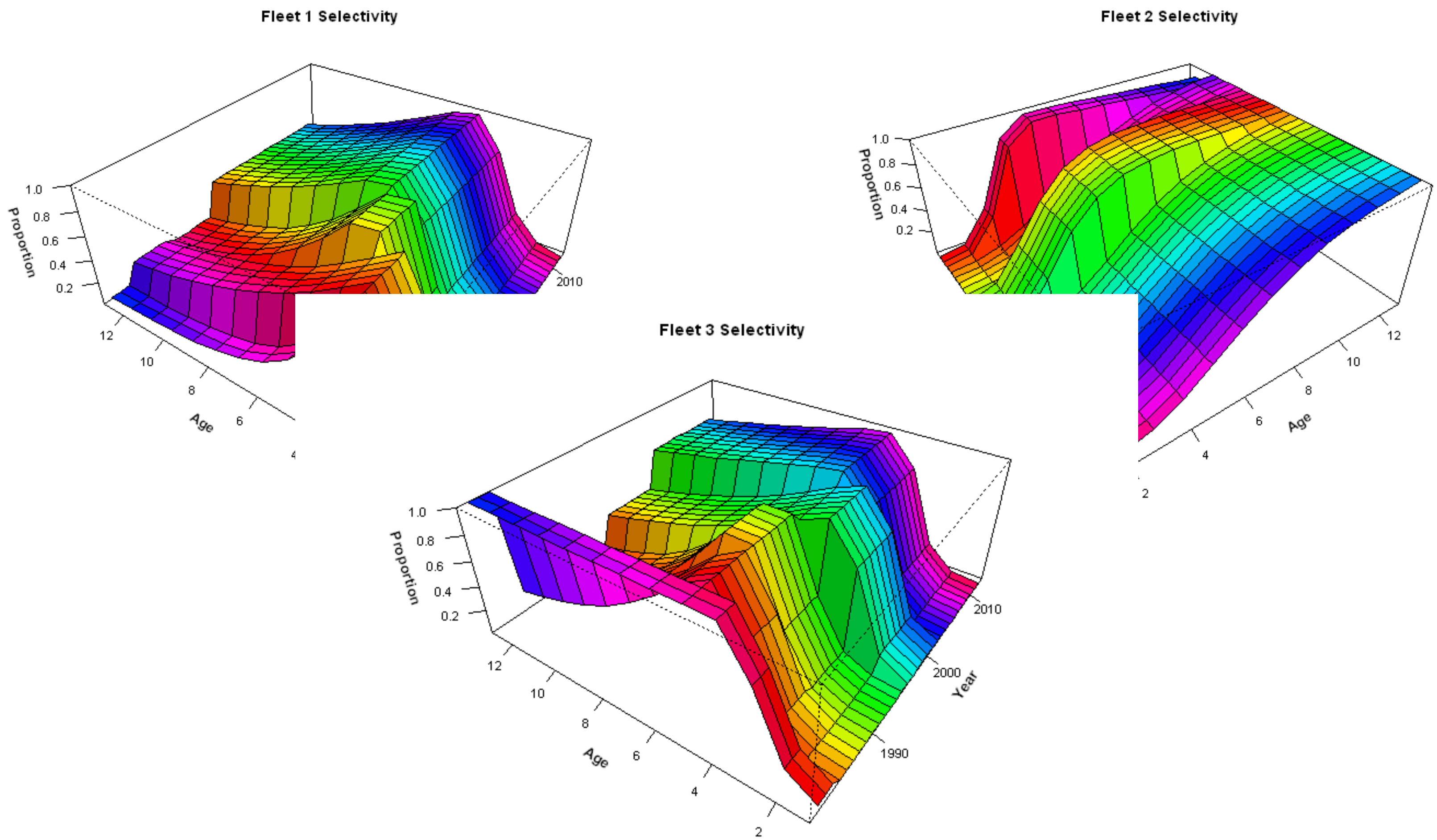


Figure B7.4. Catch selectivity patterns by fleet (Fleet 1 = Bay, Fleet 2 = Coast, Fleet 3 = Commercial Discards).

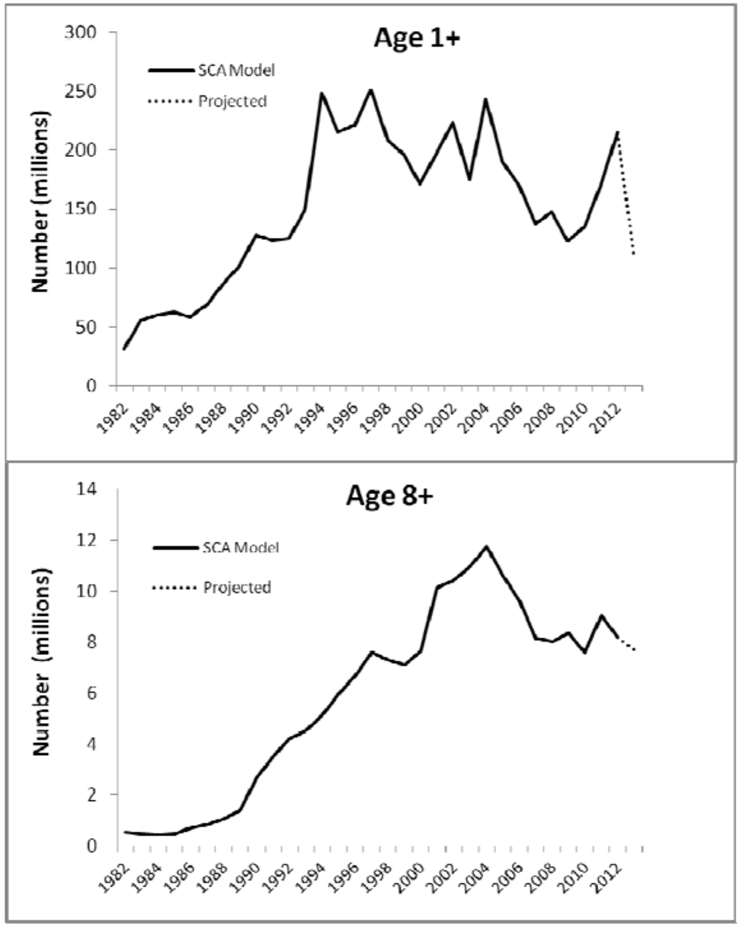


Figure B7.5. Estimates of January-1 total (age 1+) and 8+ abundance for 1982-2013. January-1 abundance for age 1 in 2013 was estimated from the 2012 observed values of the YOY indices and SCA model catchability coefficients, while older ages were projected from January-1 abundances and fishing and natural mortalities-at-age for 2012.

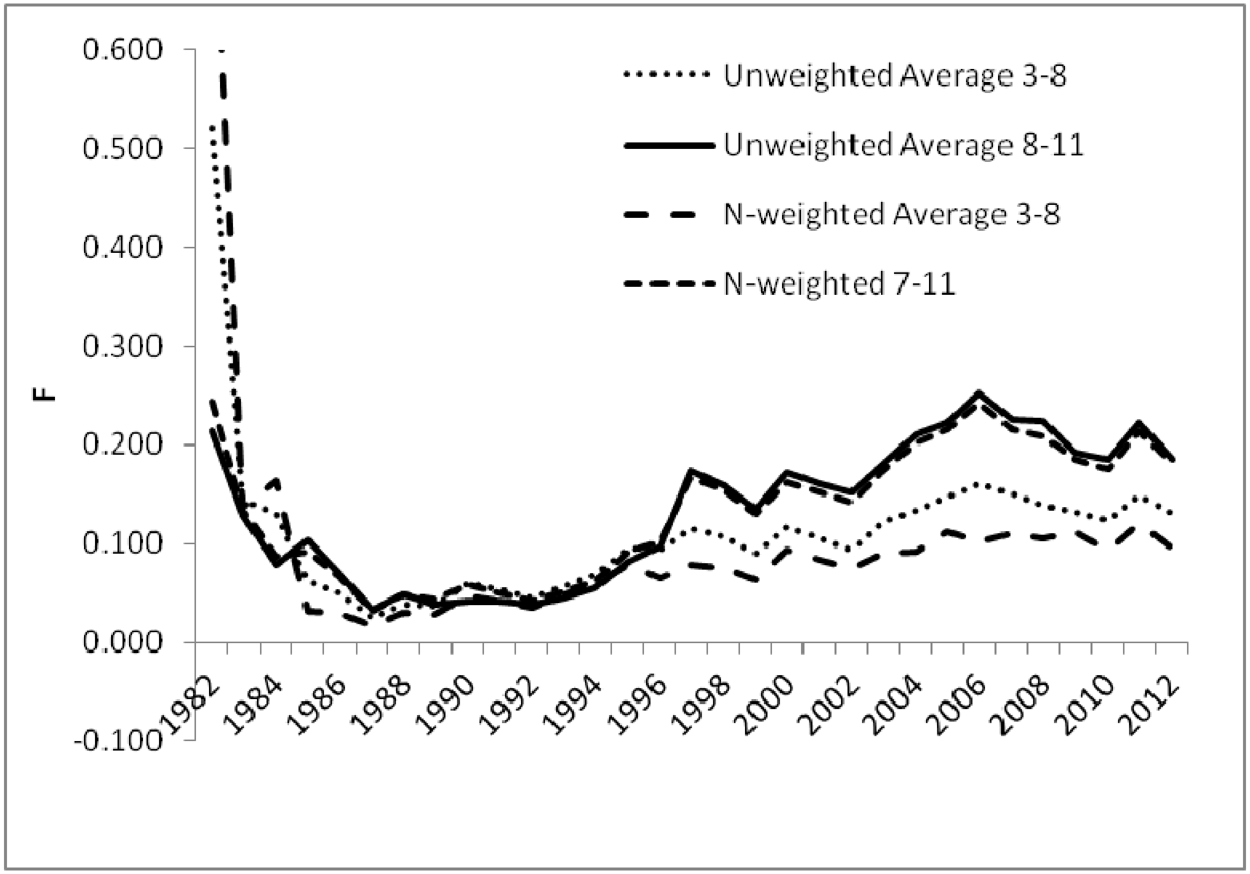


Figure B7.6. Comparison of fishing mortality estimates from the SCA model.

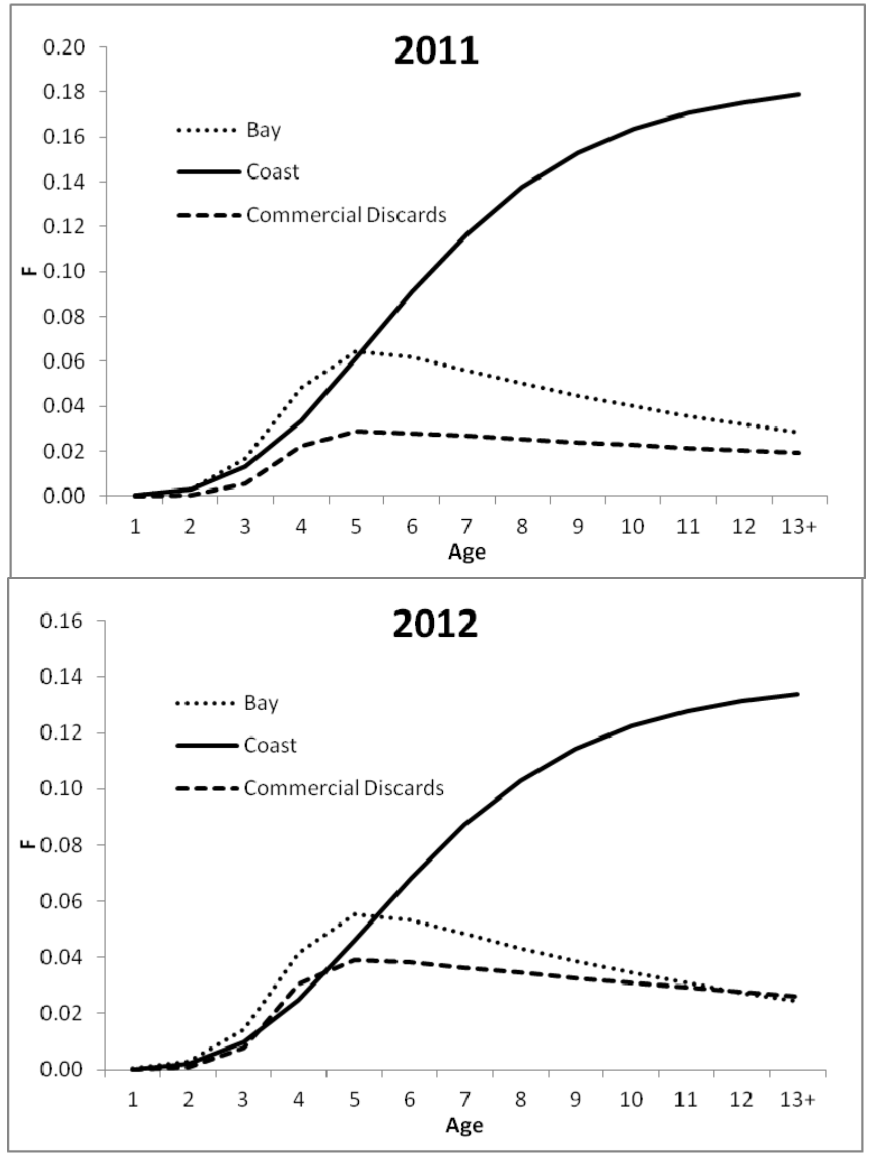


Figure B7.7. Comparison of fishing mortality-at-age in 2011 and 2012 from the SCA model partitioned into fleets

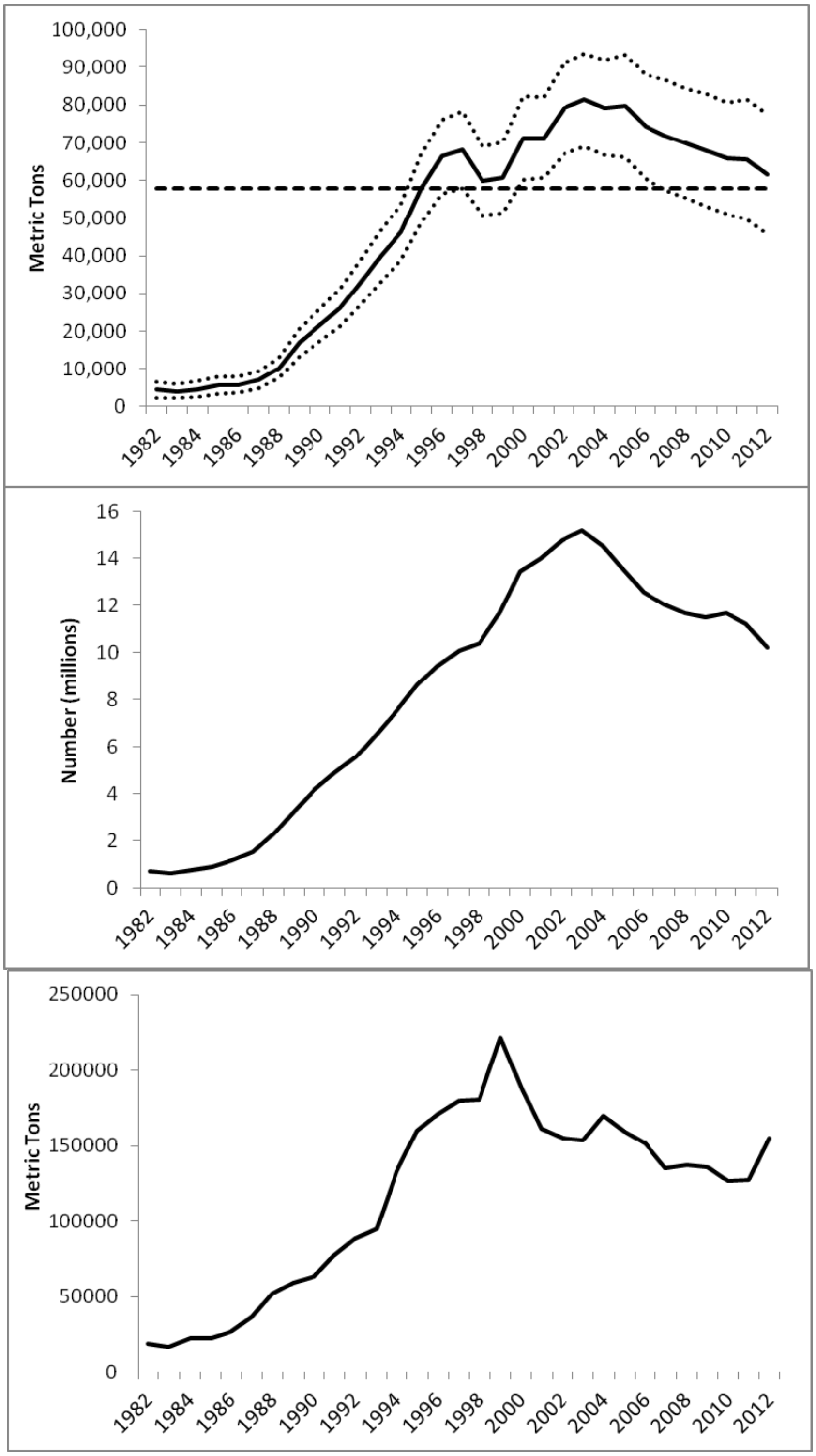


Figure B7.8. Estimates of A) female spawning stock biomass by year (solid line), B) female spawning stock numbers, and C) total January-1 biomass . Dotted lines equal 95% confidence intervals. Dashed line is the female spawning stock reference point (1995 value).

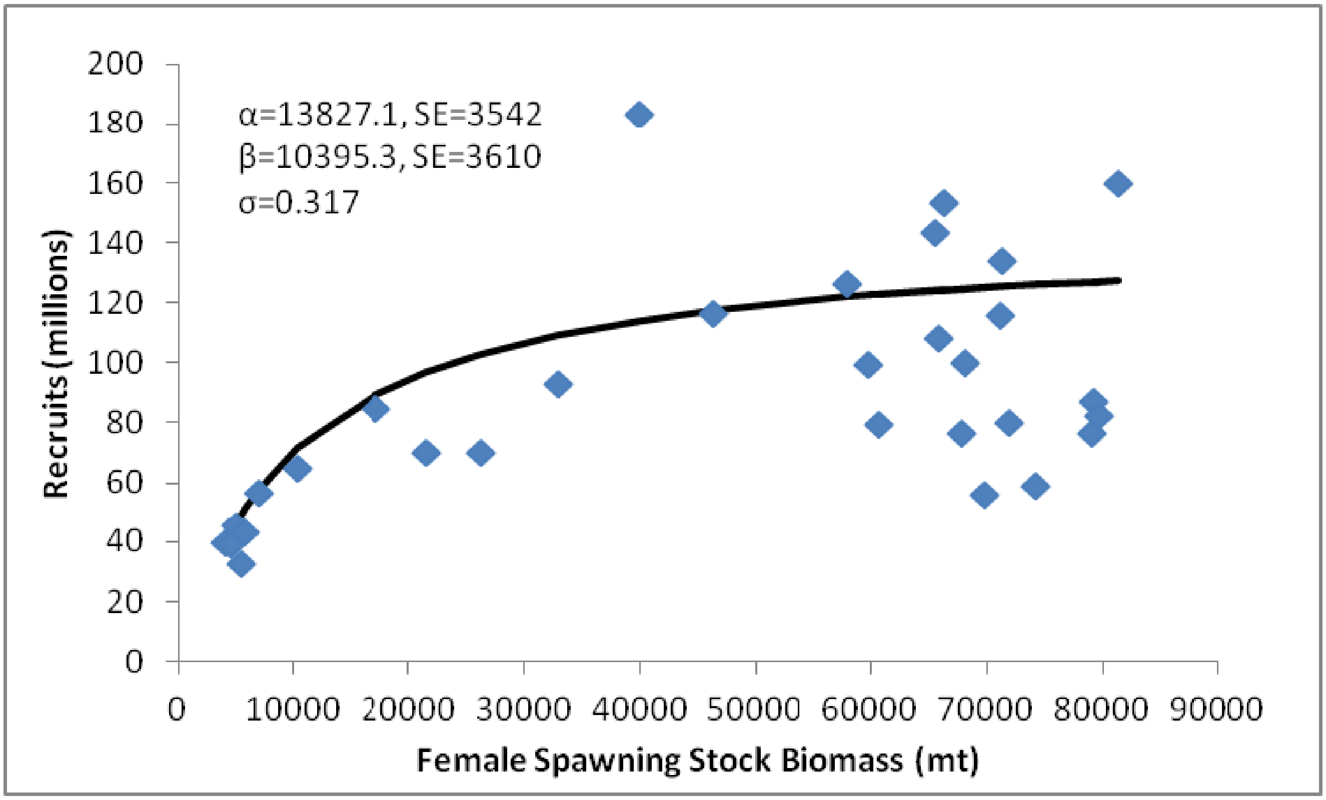


Figure B7.9. Model-estimated stock –recruitment relationship with bias-corrected Beverton-Holt fit (black line).

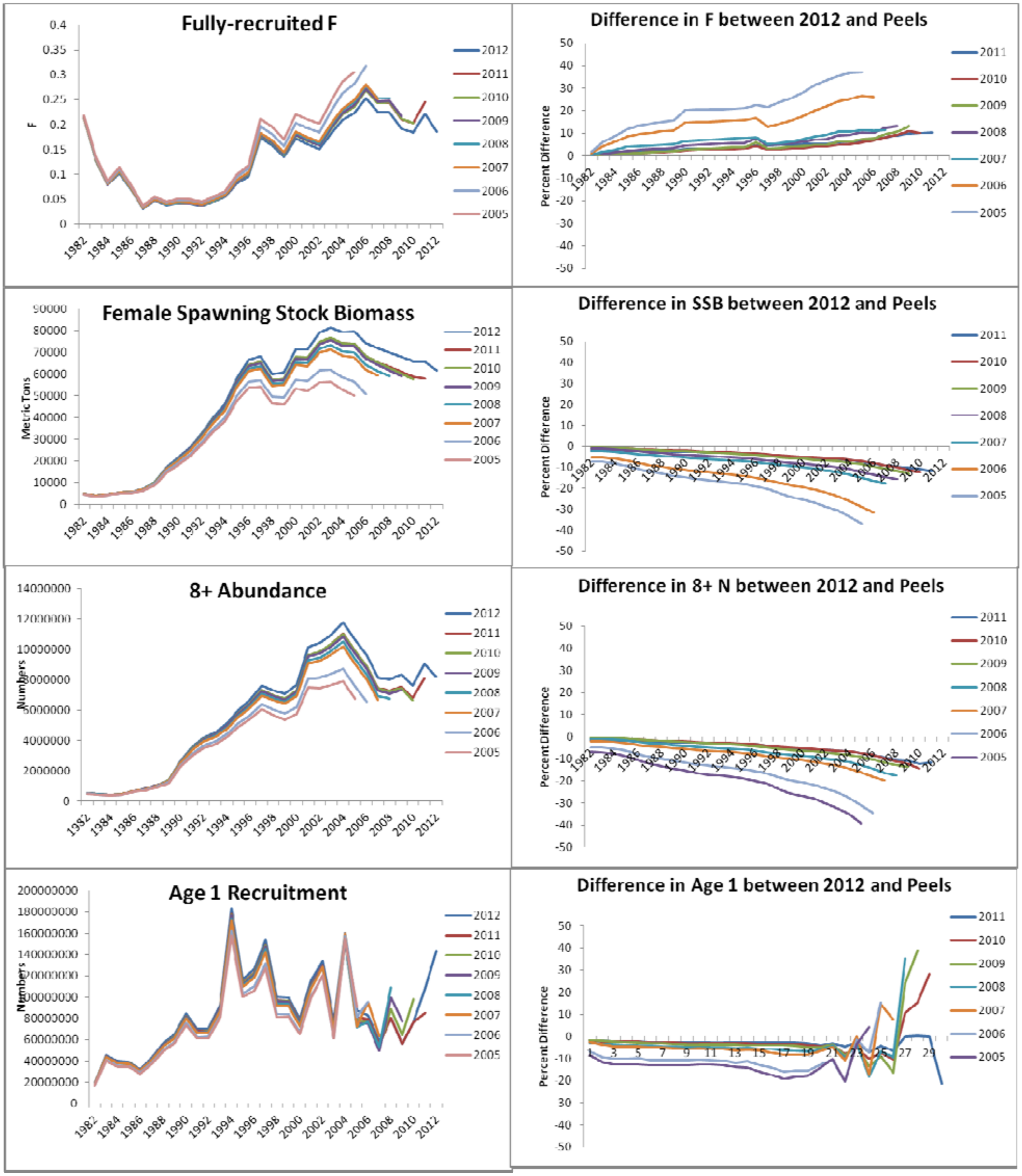


Figure B7.10. Retrospective analysis of fully-recruited F, female spawning stock biomass , 8+ abundance and Age 1 recruits.

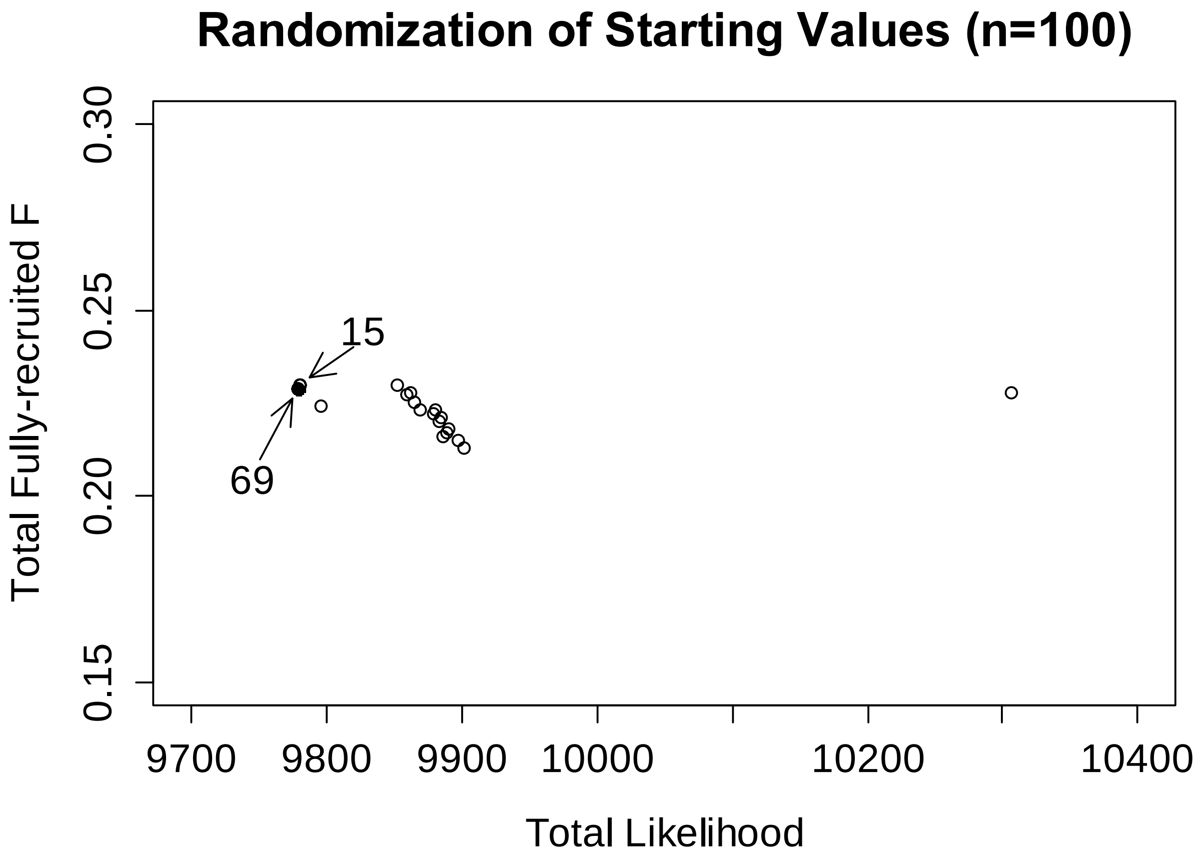


Figure B7.11. Results from 100 SCA model runs in which starting values were randomly permuted by +50%. Solid dot represents the total likelihood and F produced by the base model and the number 69 represents the number of random runs that converged to base run solution. The second point of the most frequent convergence (n=15) is shown.

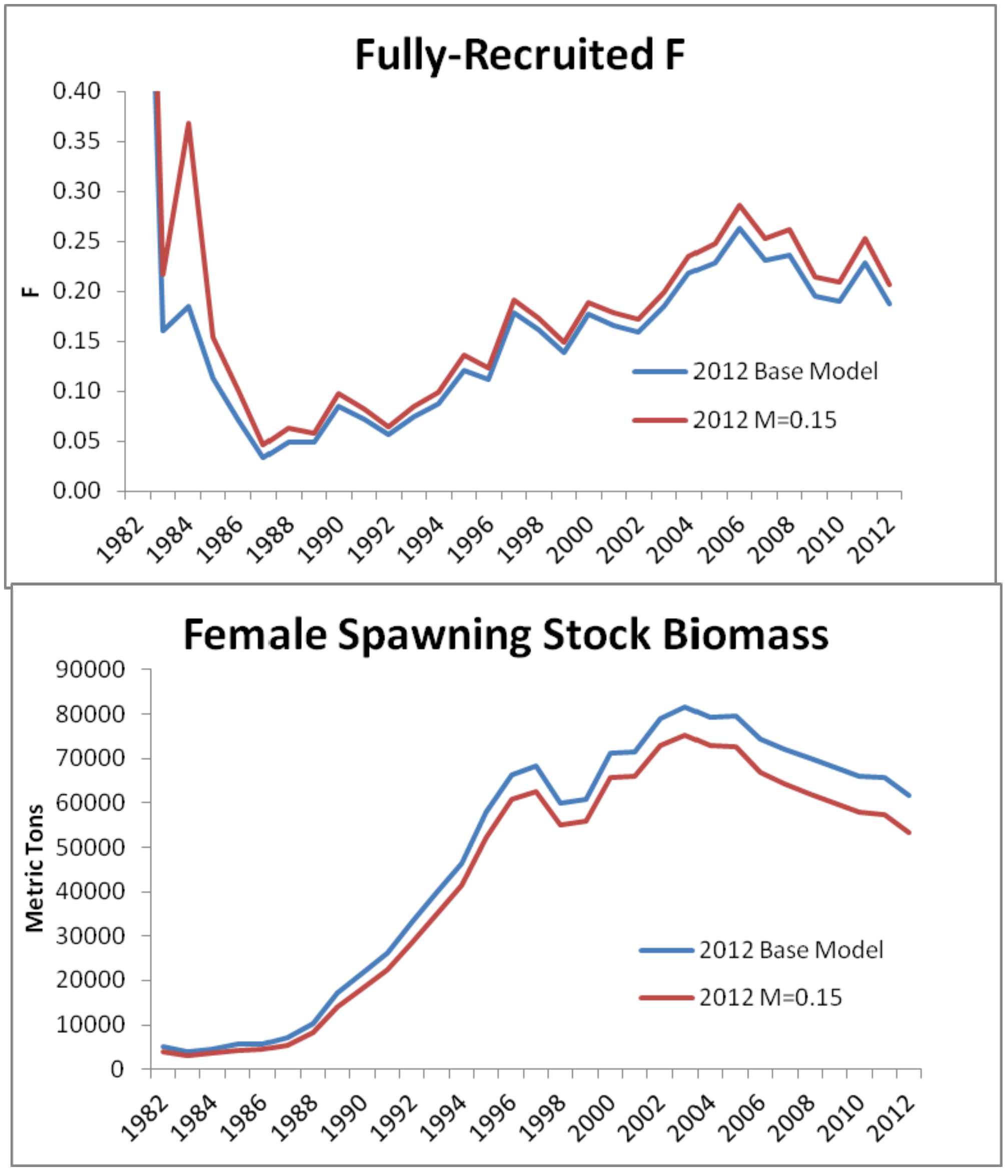
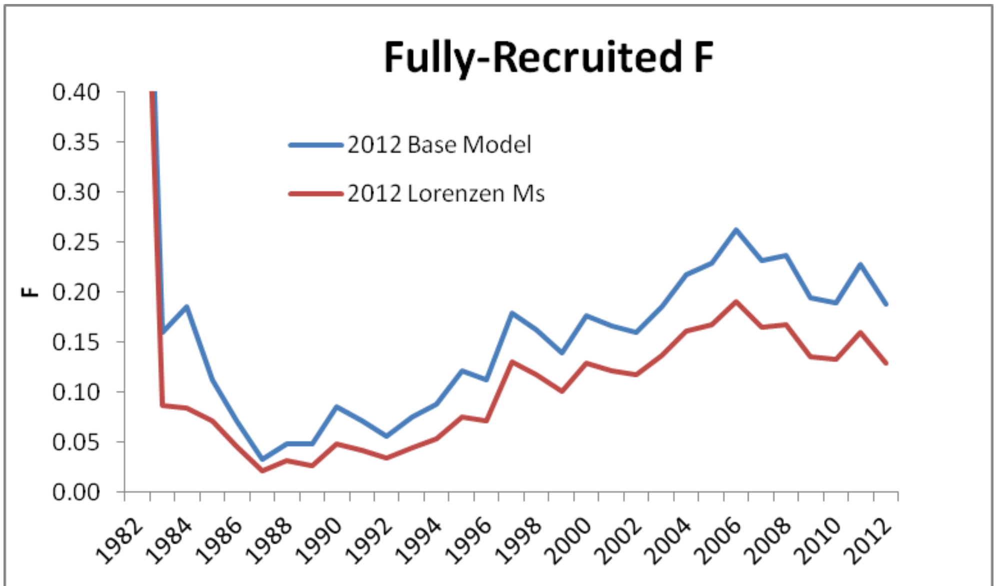


Figure B7.12. Comparison of results from the 2012 base model with age-specific M with results assuming a constant M=0.15.



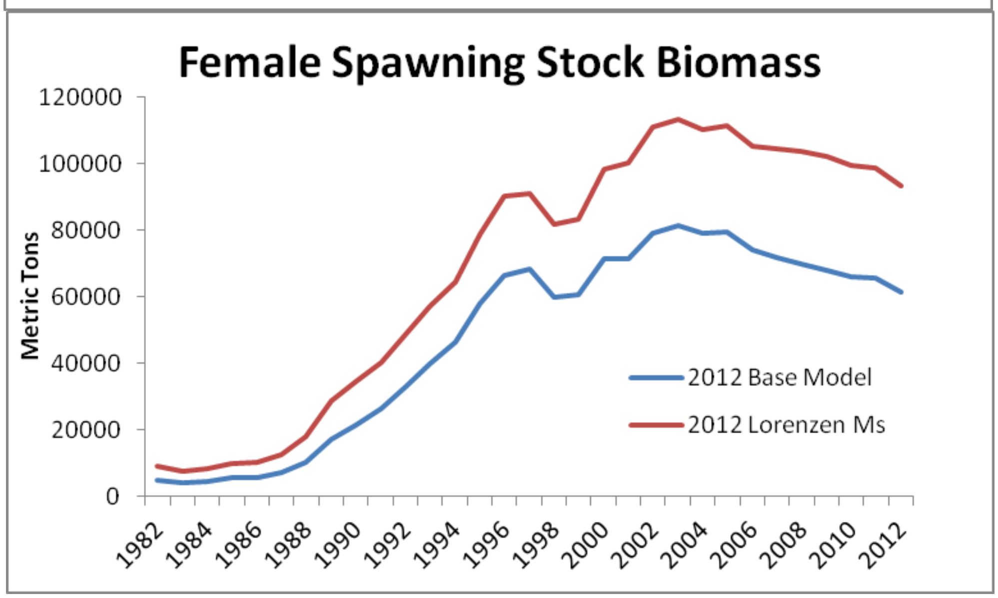
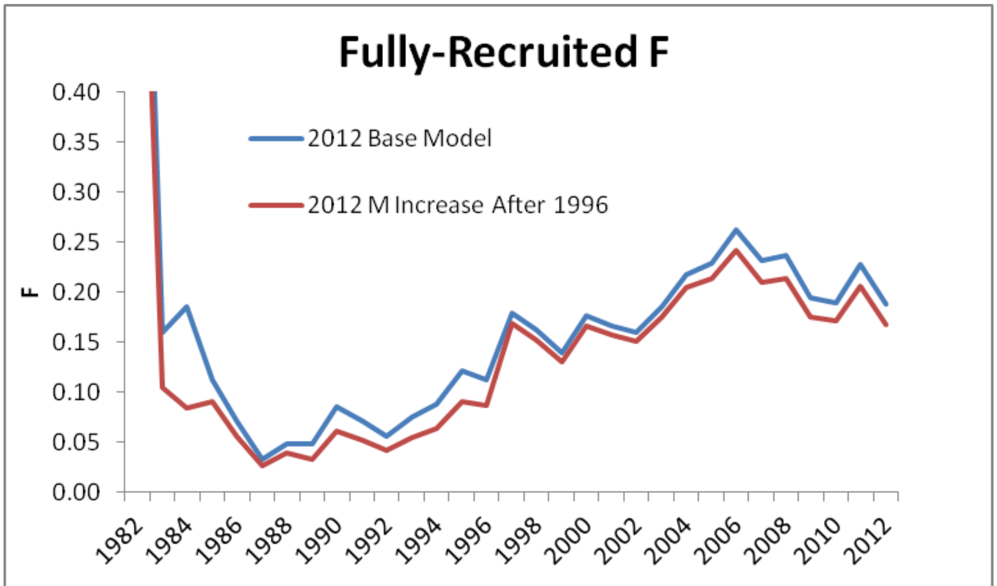


Figure B7.13. Comparison of results from the 2012 base model with age-specific M with results of model using unscaled Lorenzen age-specific M estimates .



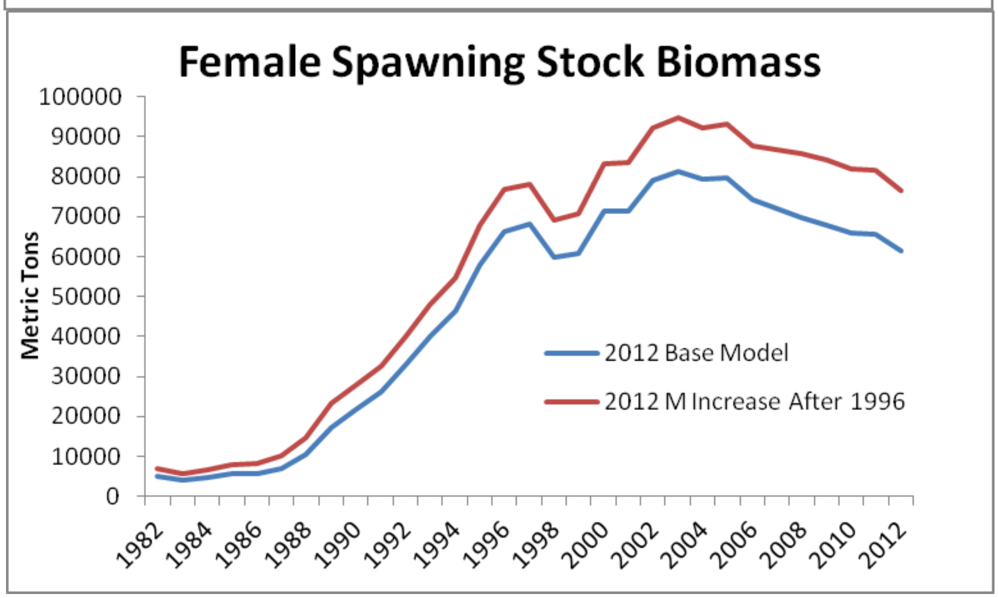
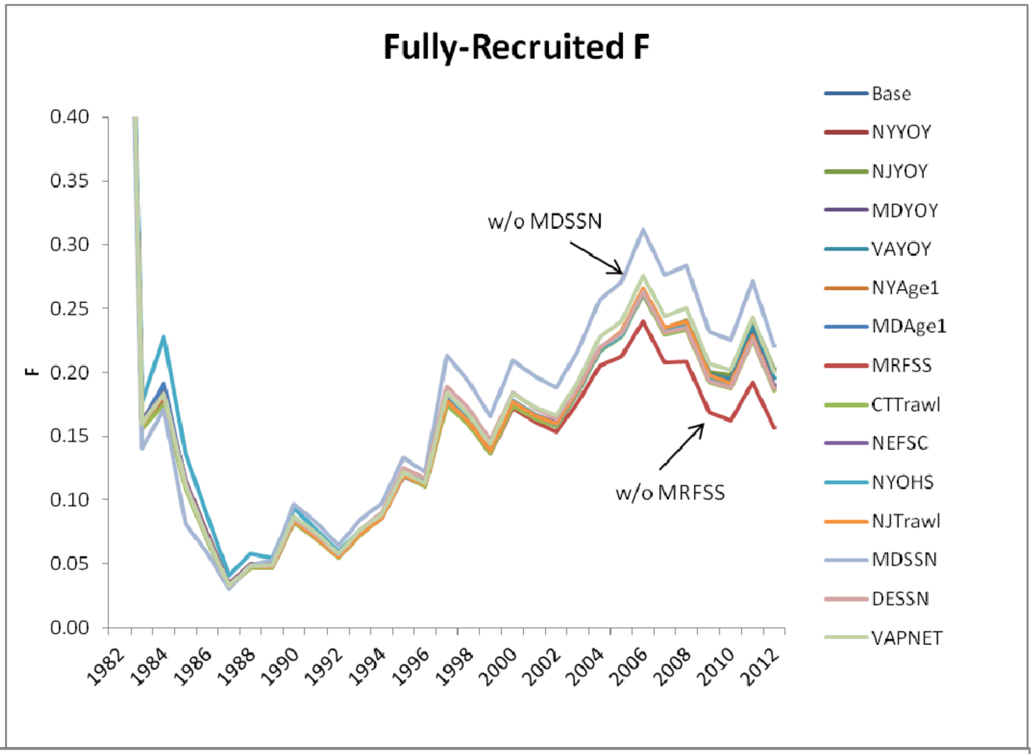


Figure B7.14. Comparison of results from the 2012 base model with age-specific M with results when M is increased on ages 3-8 after 1996.



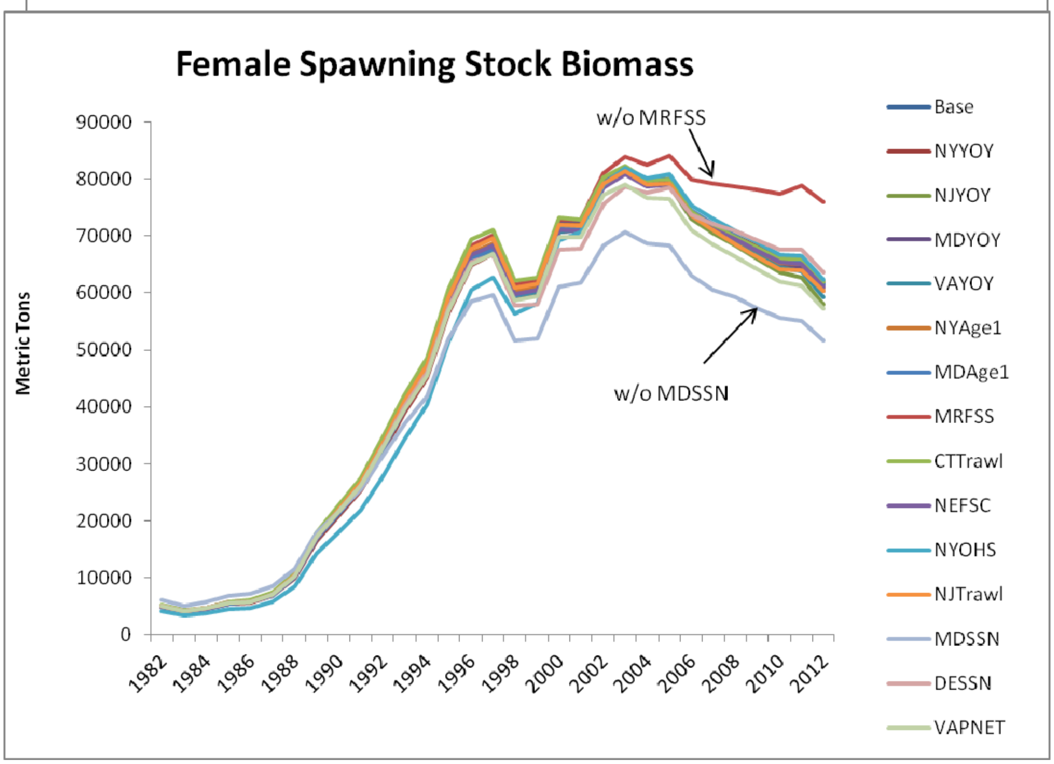
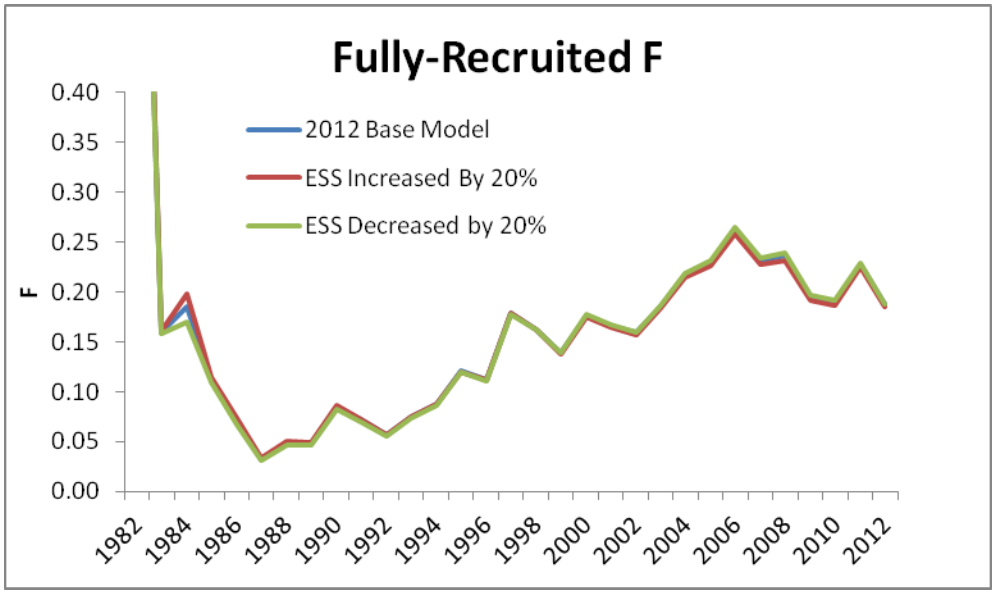


Figure B7.15. Comparison of fully-recruited F estimates when data from each survey were deleted one-at-a-time from the final SCA model configuration.



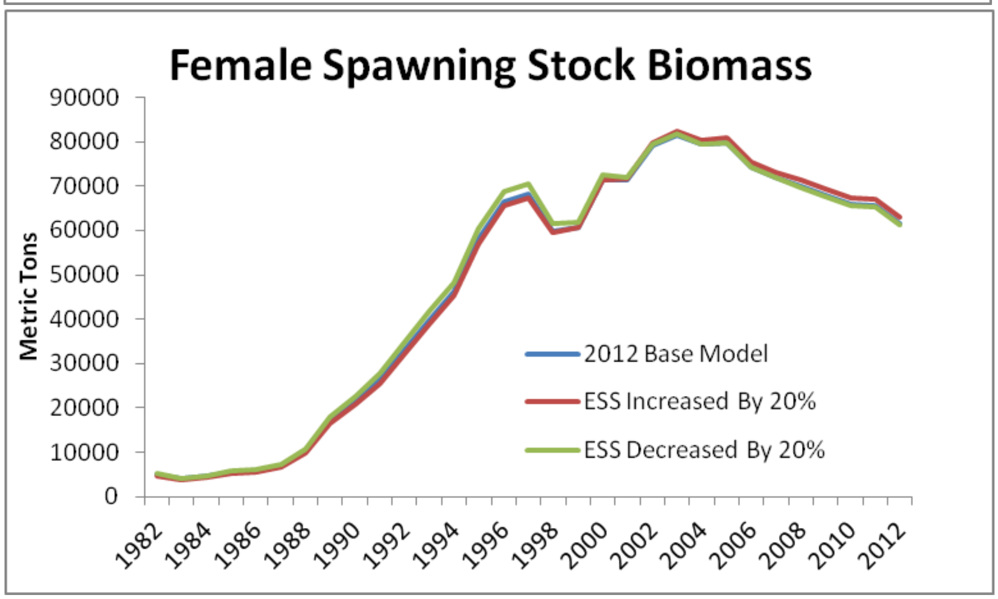
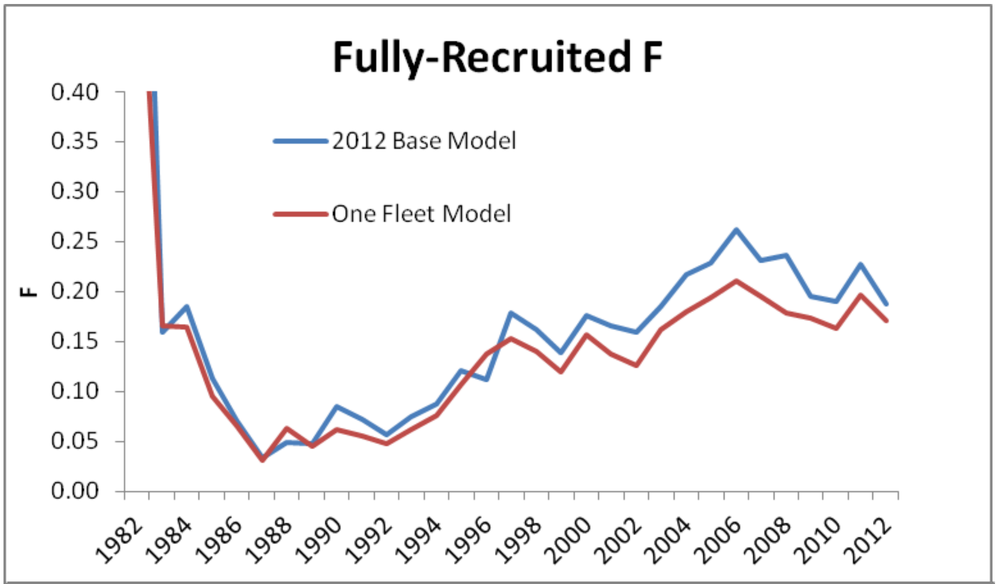


Figure B7.16. Comparison of fully-recruited F and female spawning stock biomass when the average effective sample sizes for the catch and survey multinomial likelihoods were increased and decreased by 20% of the original values.



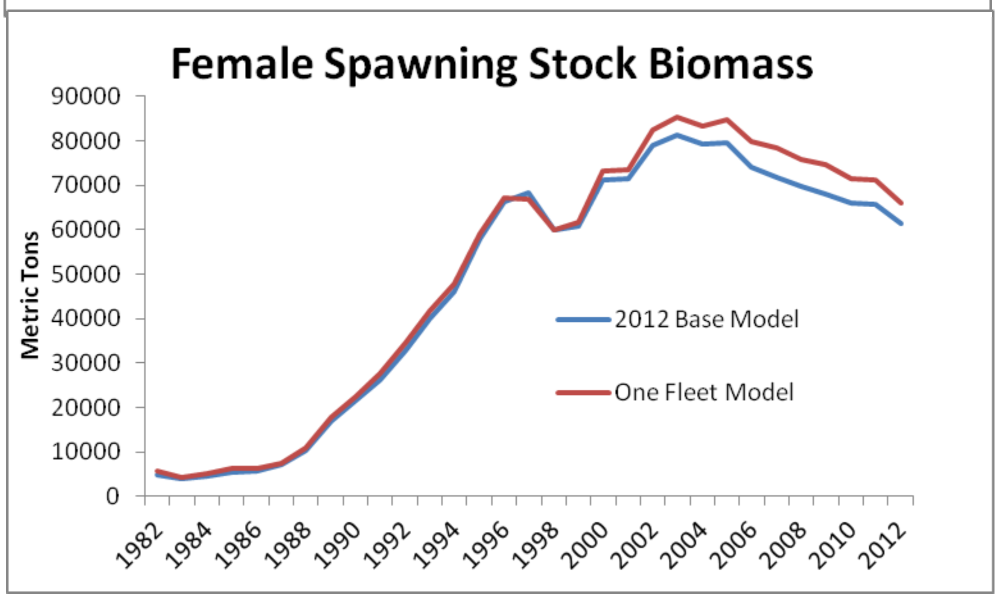


Figure B7.17. Comparison of fully-recruited F and female spawning stock biomass estimates from the 2012 base model and a one fleet model.

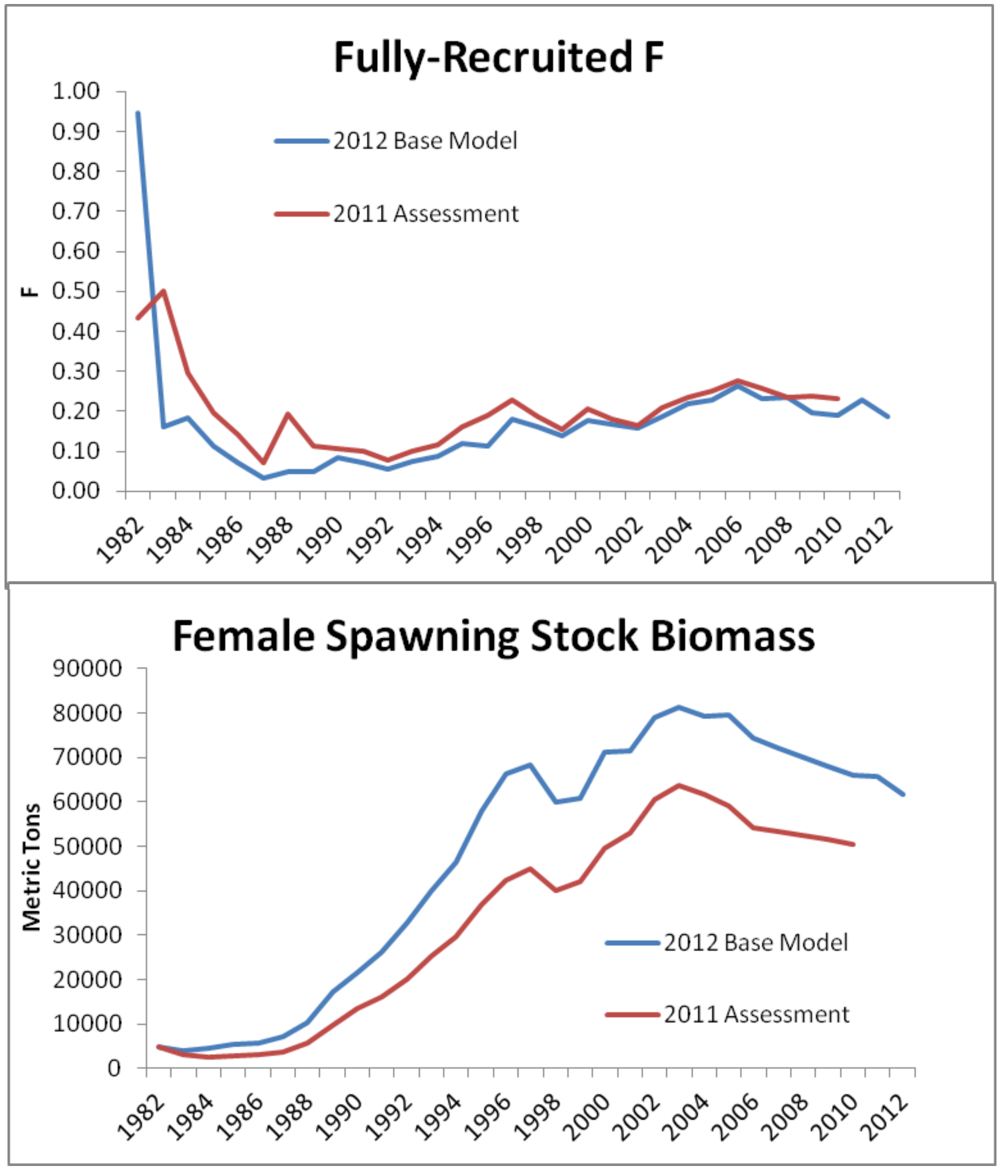


Figure B7.18. Comparison of fully-recruited F and female spawning stock biomass estimates from the 2012 base model and the 2011 assessment.

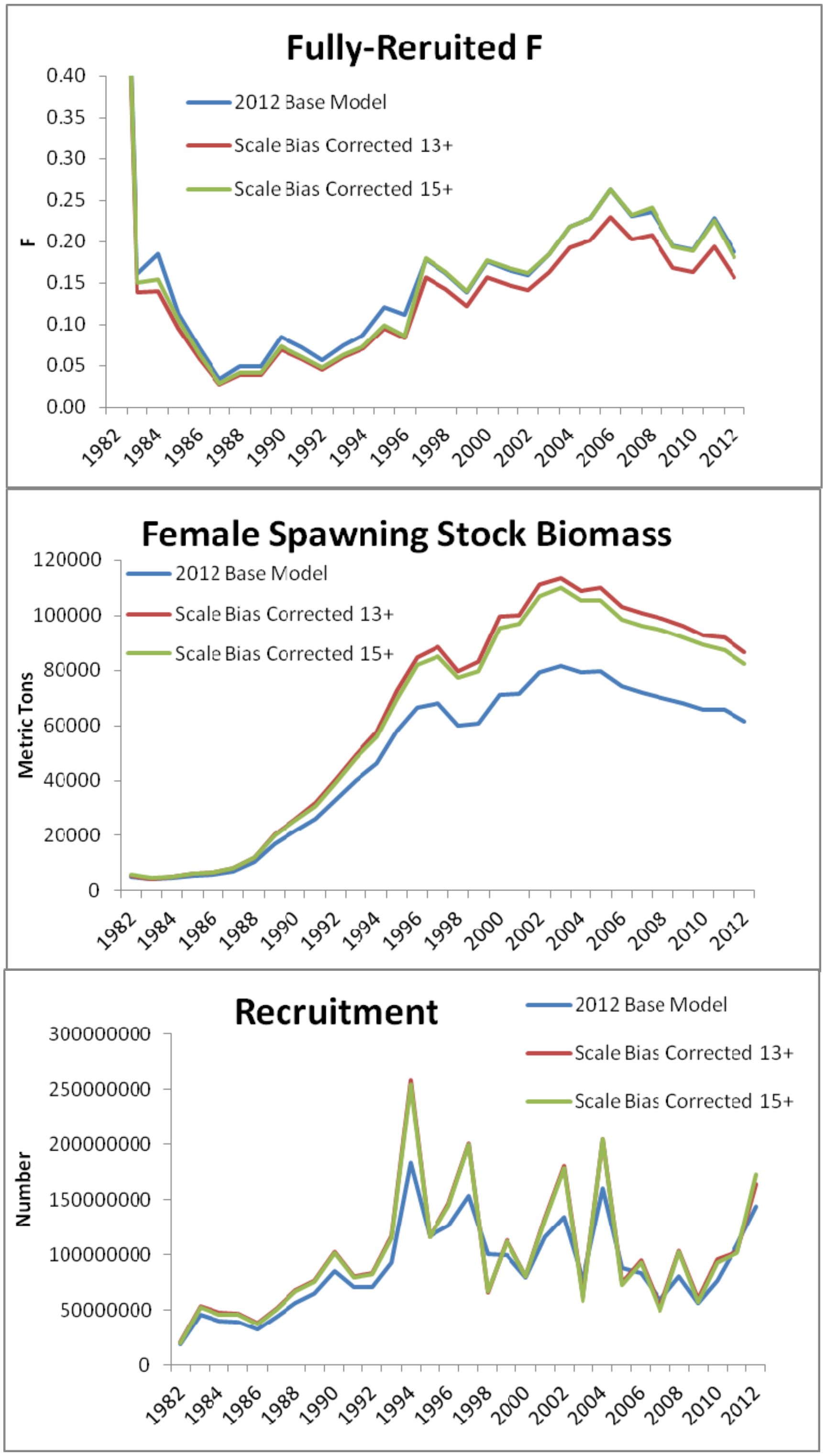


Figure B7.19. Comparison of fully-recruited F, female spawning stock biomass estimates, and recruitment from the 2012 base model and the scale aging bias corrected models with age 13 and 15 plus groups.

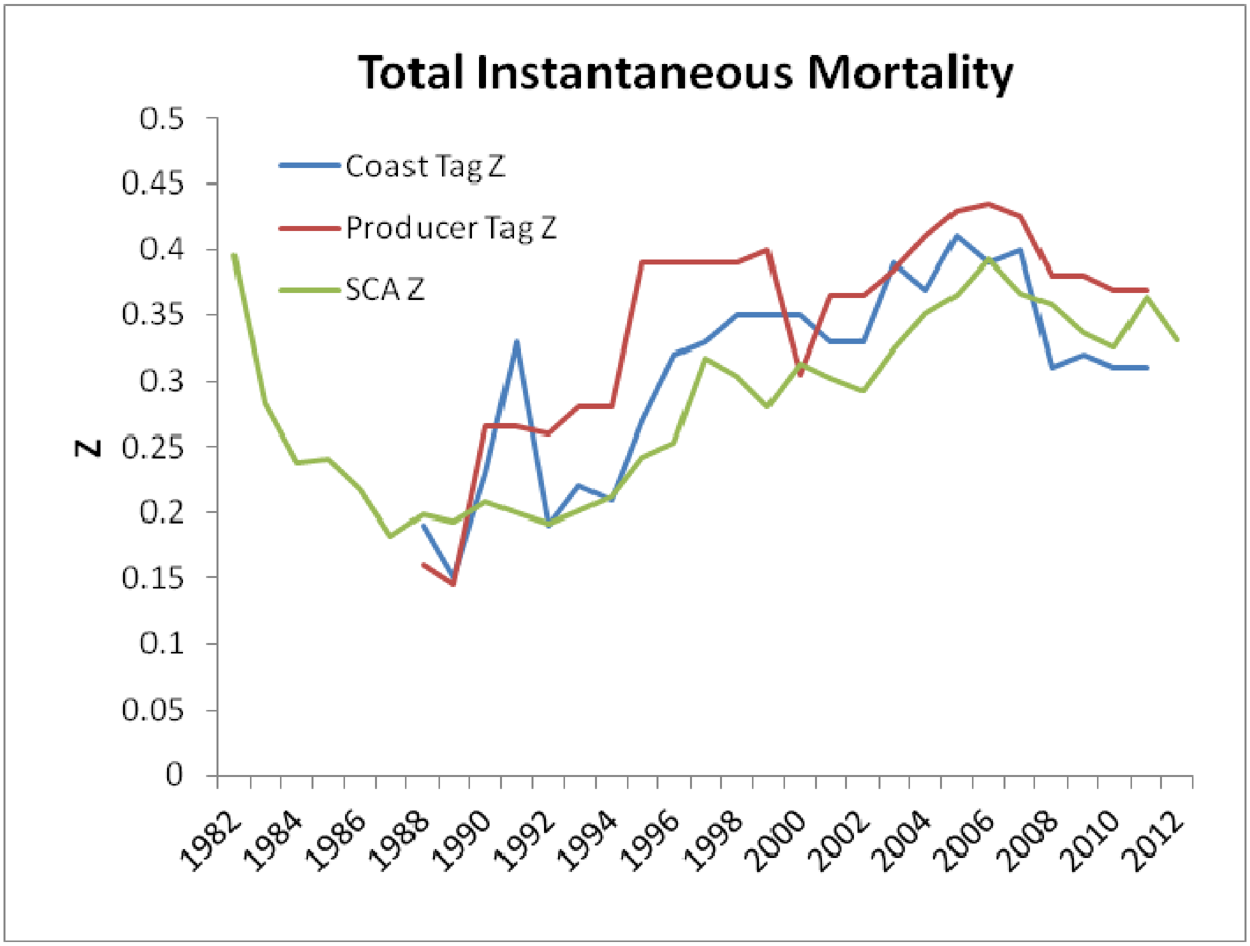


Figure B7.20. Comparison of total instantaneous mortality estimates from the 2012 base SCA and tagging models.

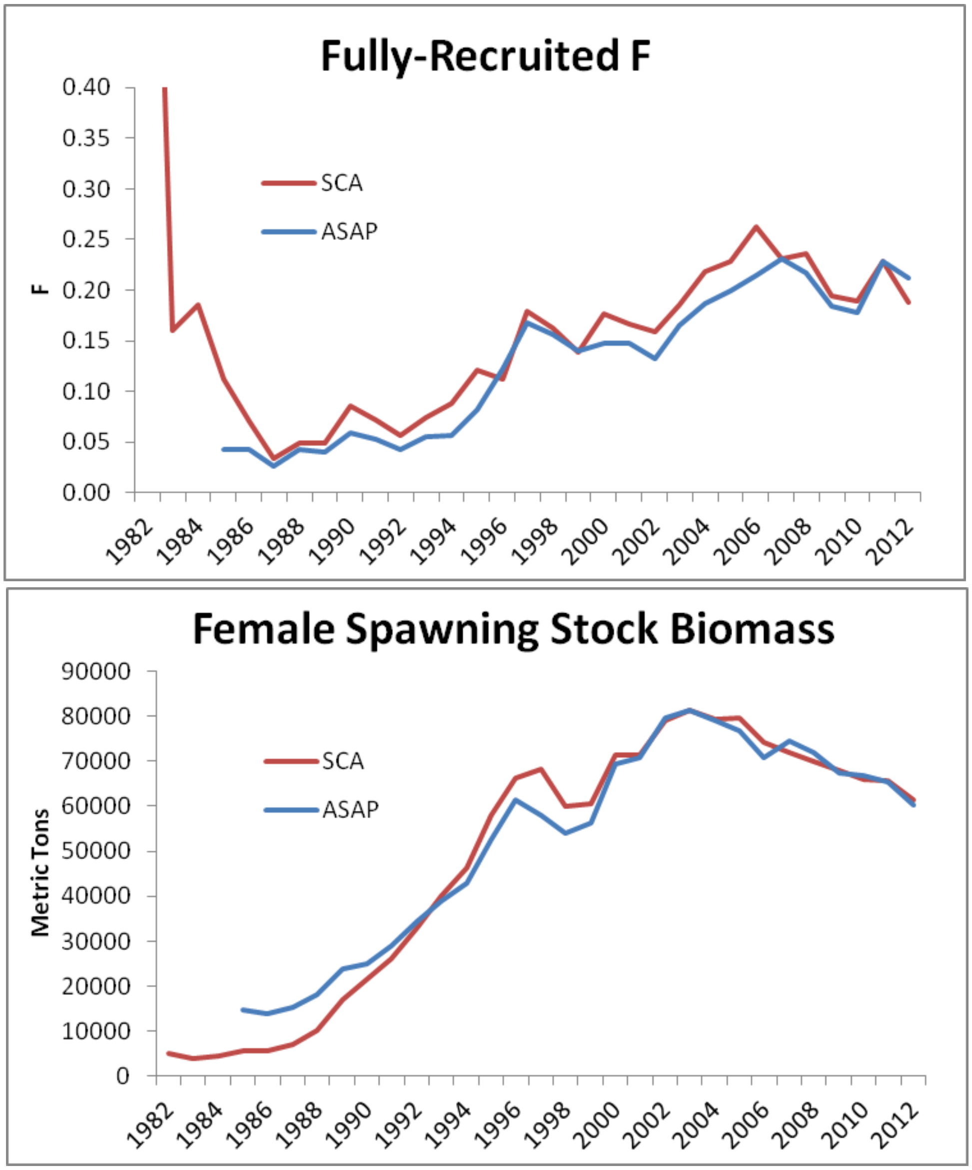
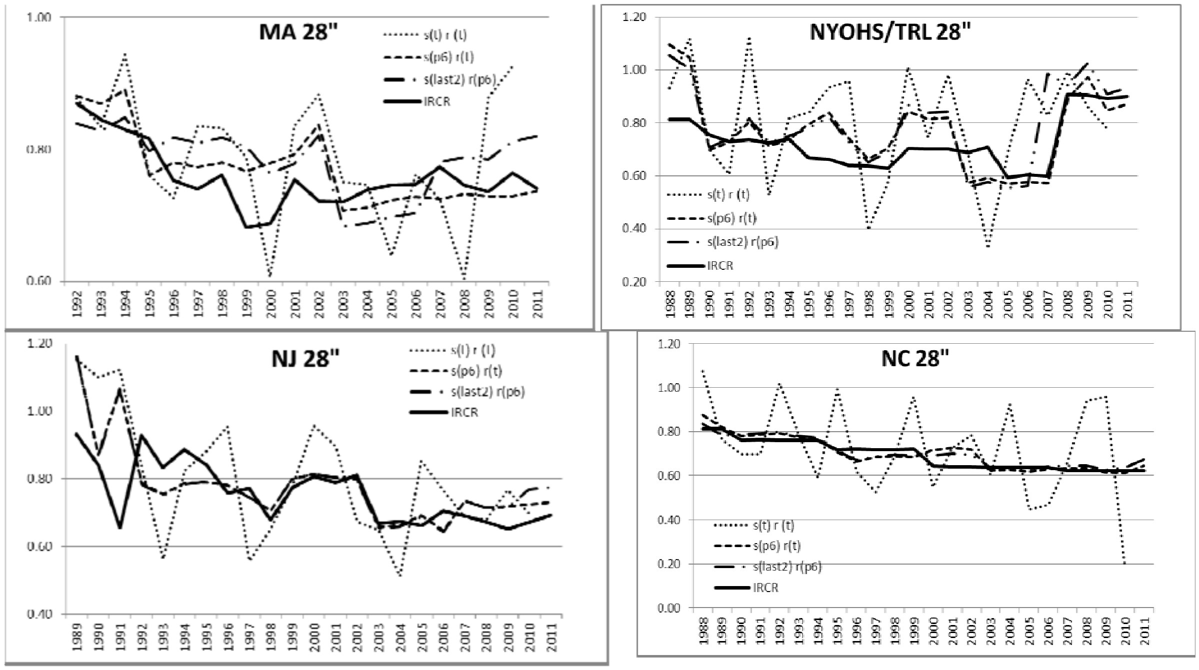


Figure B7.21. Comparison of estimates of fully-recruited F and female spawning stock biomass between the SCA and ASAP models.

Coastal



Producer Areas

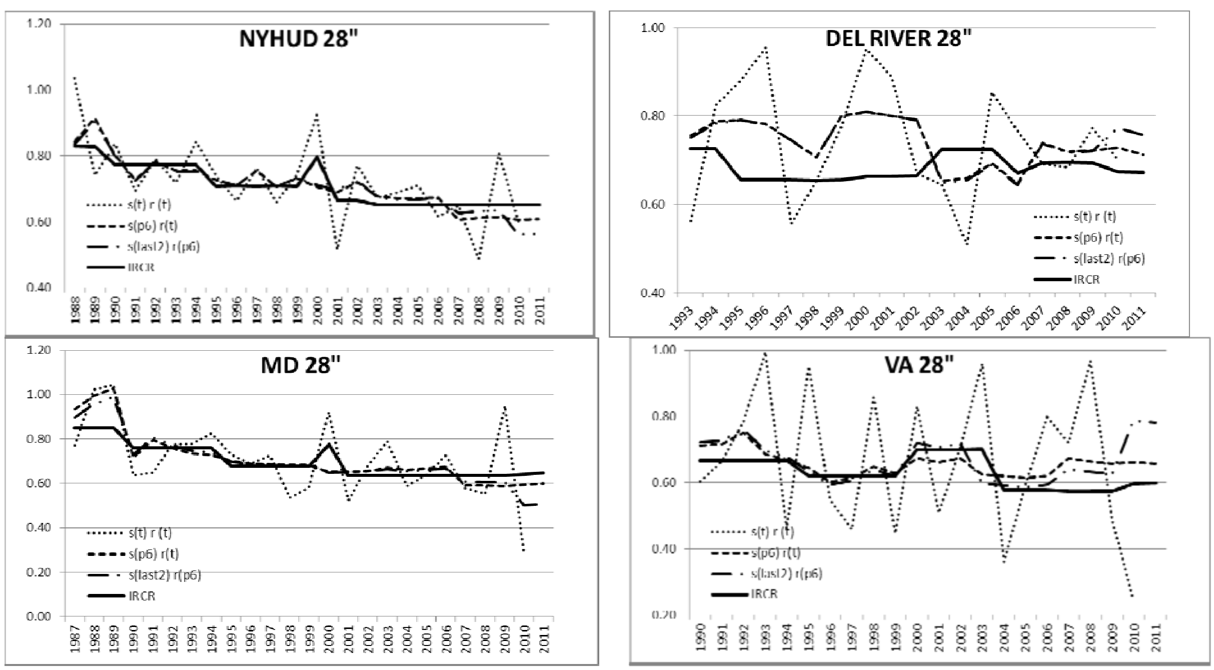
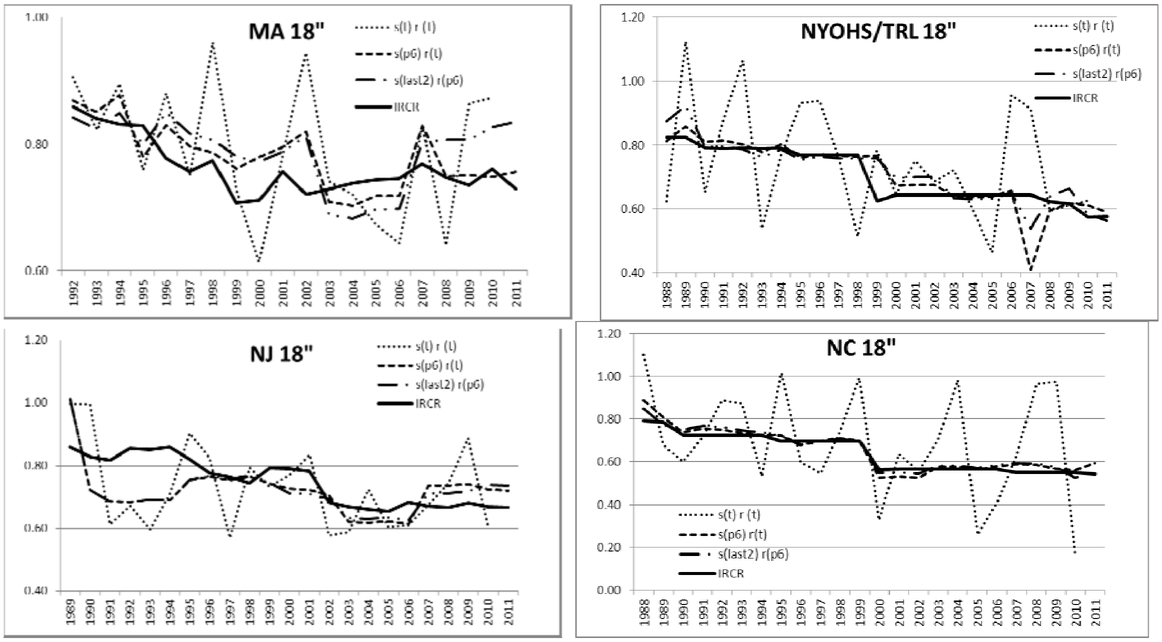


Figure B8.1. Survival estimates from Program MARK and IRCR for fish ≥ 28 inches (note different scales).

Coastal



Producer

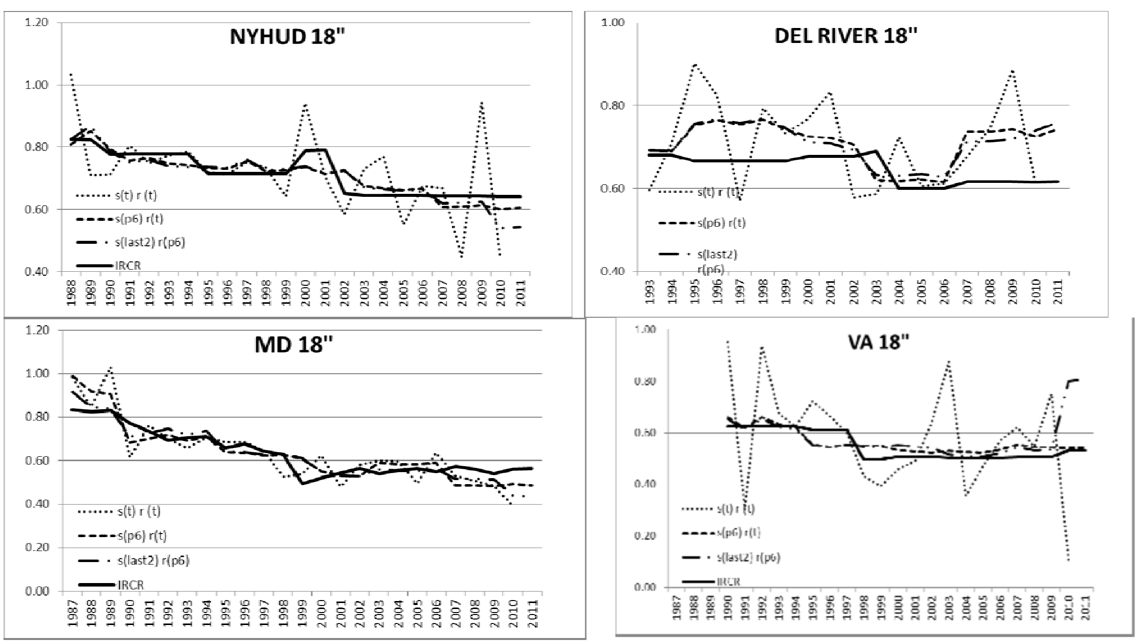


Figure B8.2. Survival estimates from Program MARK and IRCR for fish ≥ 18 inches (note different scales).

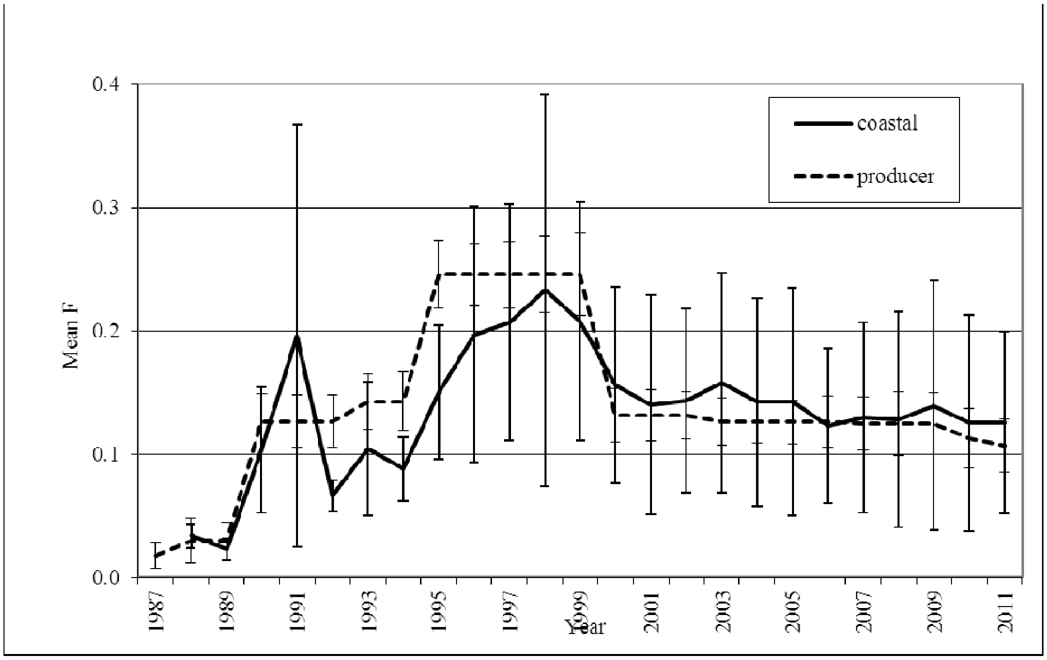


Figure B8.3. Comparison of coastal program (unweighted) and producer area (weighted) mean fishing mortality estimates from IRCR, for fish ≥ 28 inches with 95% confidence intervals.

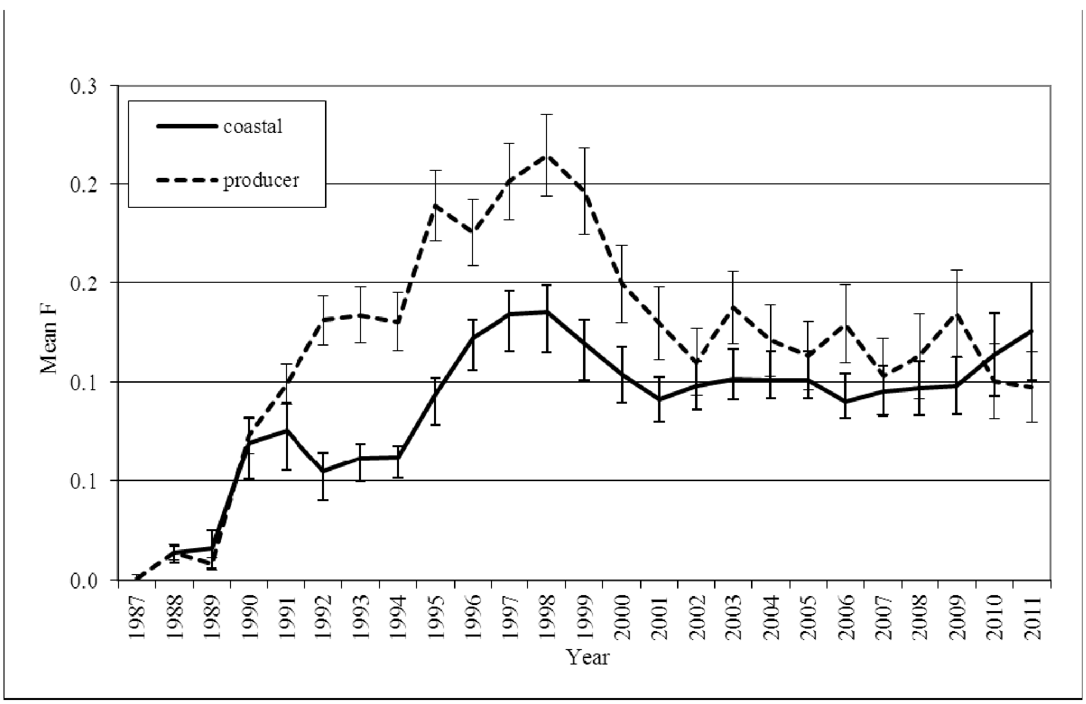


Figure B8.4. Comparison of coastal program (unweighted) and producer area (weighted) mean fishing mortality estimates from IRCR, for fish ≥ 18 inches with 95% confidence intervals.

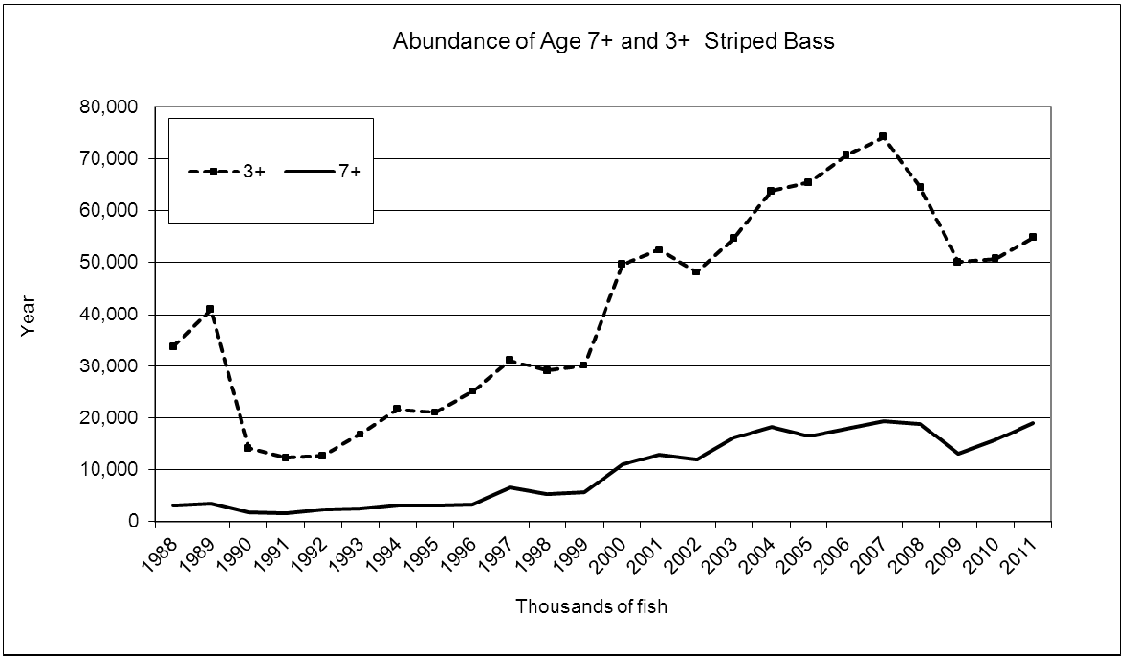


Figure B8.5. Comparison of stock size estimates from IRCR, for fish age seven and older (comparable to fish ≥ 28 inches) and age three and older (comparable to fish ≥ 18 inches). Stock size obtained via "Kill = F * Stock Size".

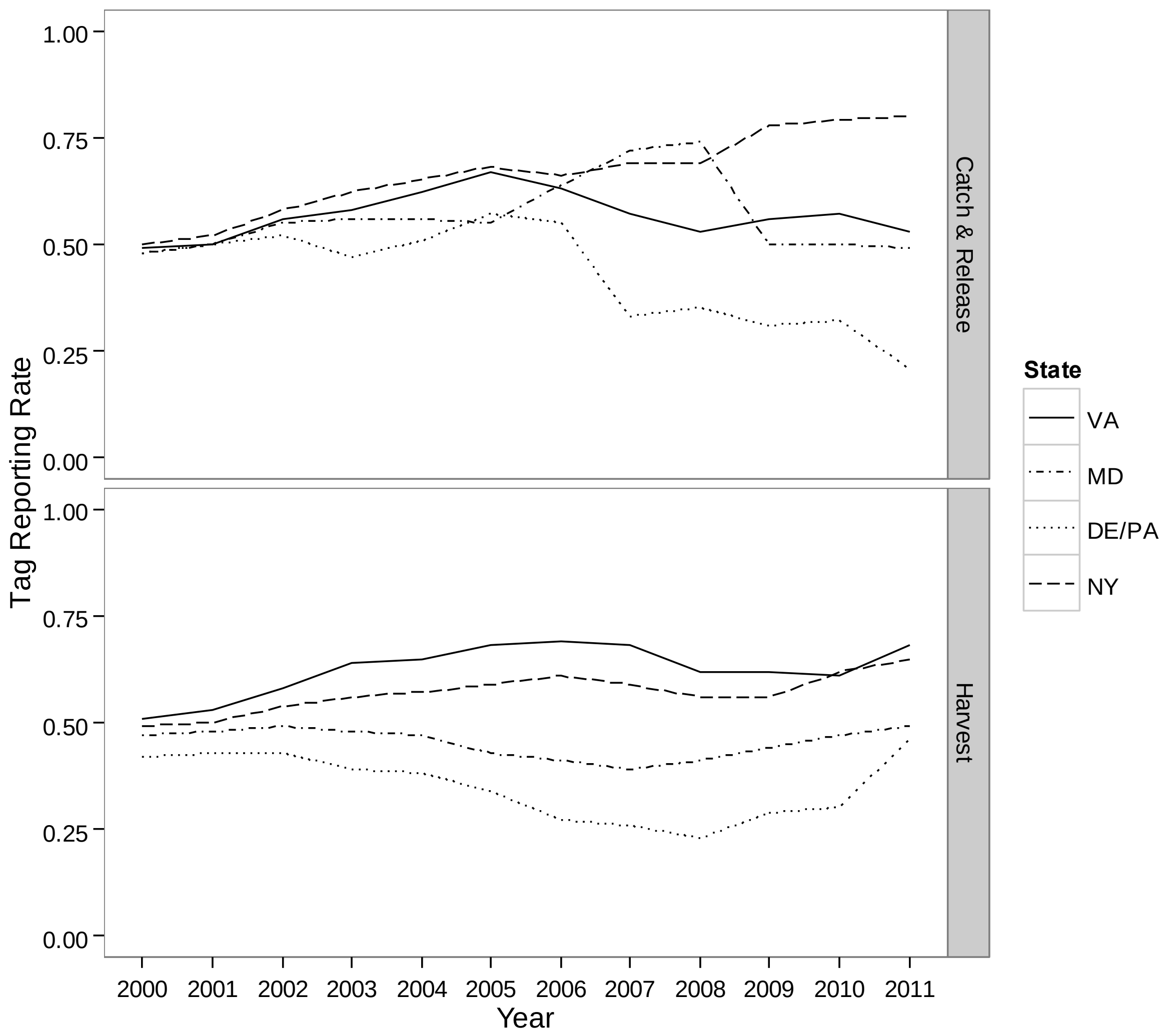


Figure B8.6. Three year moving average estimates of striped bass tag reporting rate for the four producer programs. Results are presented for harvested and catch and release fish. Tag reporting rate for all regions and both recapture dispositions is fixed at 0.43 for all years prior to 2000.

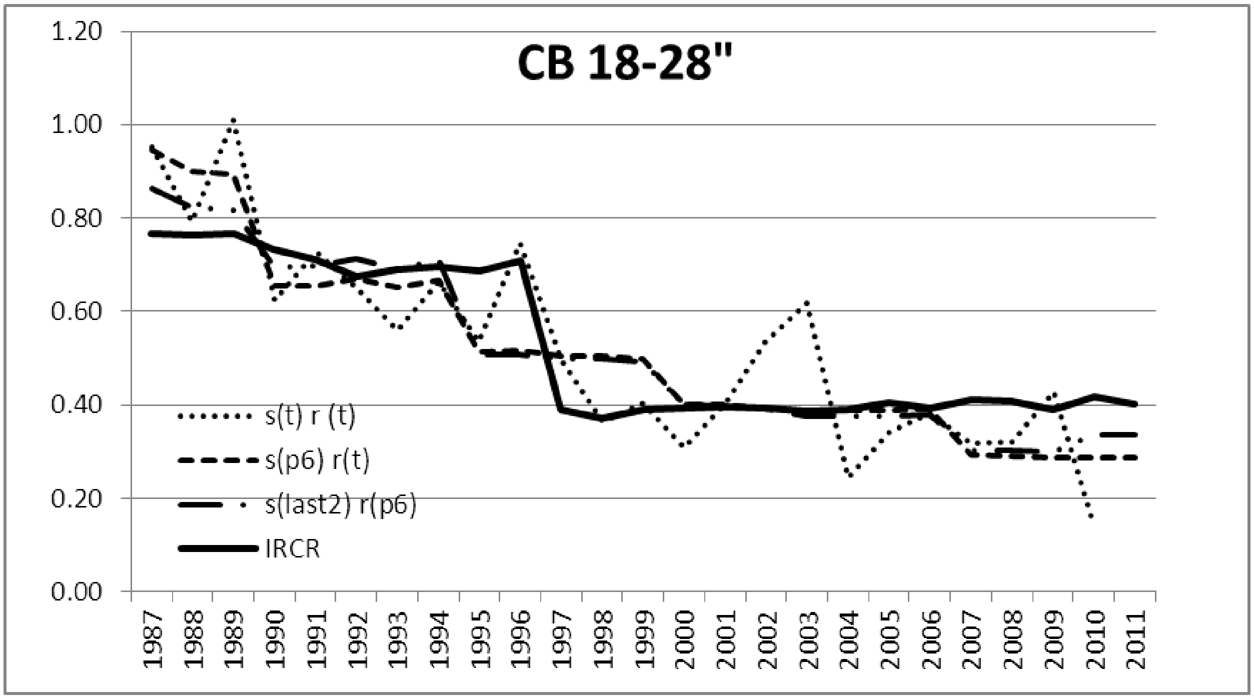
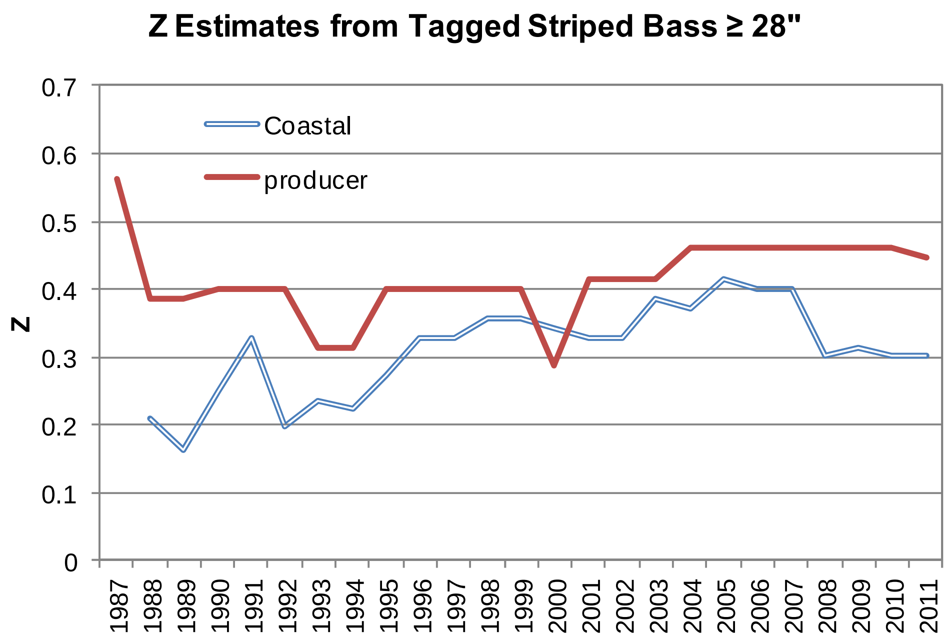


Figure B8.7. Survival estimates from Program MARK and IRCR for Chesapeake Bay male fish 18-28 inches



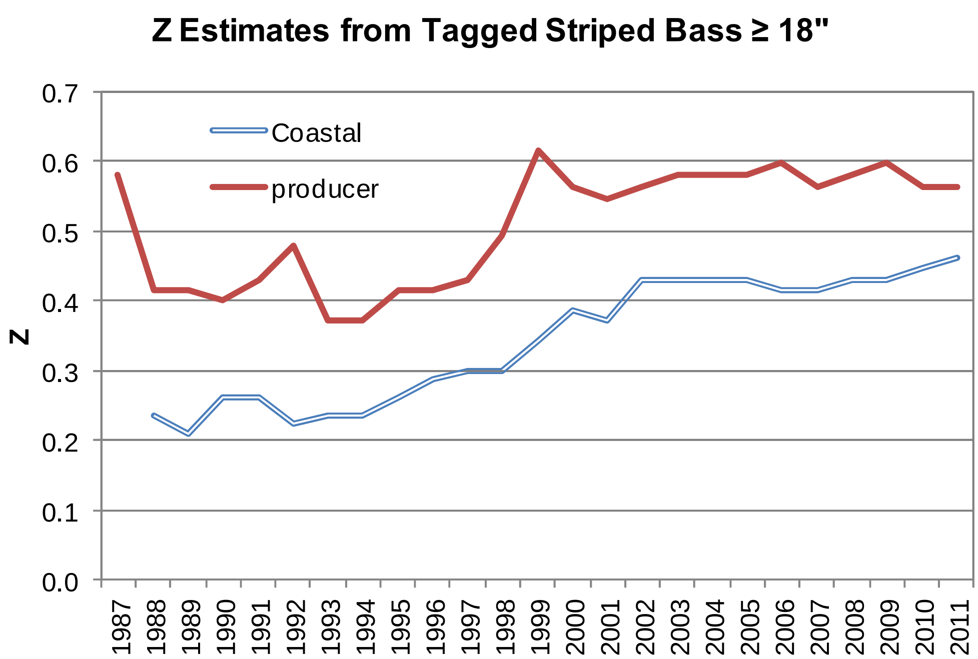


Figure B8.8: Estimates of total mortality (Z) from the IRCR tagging model for coastal and producer areas for fish ≥ 28 inches (top) and ≥ 18 inches (bottom).

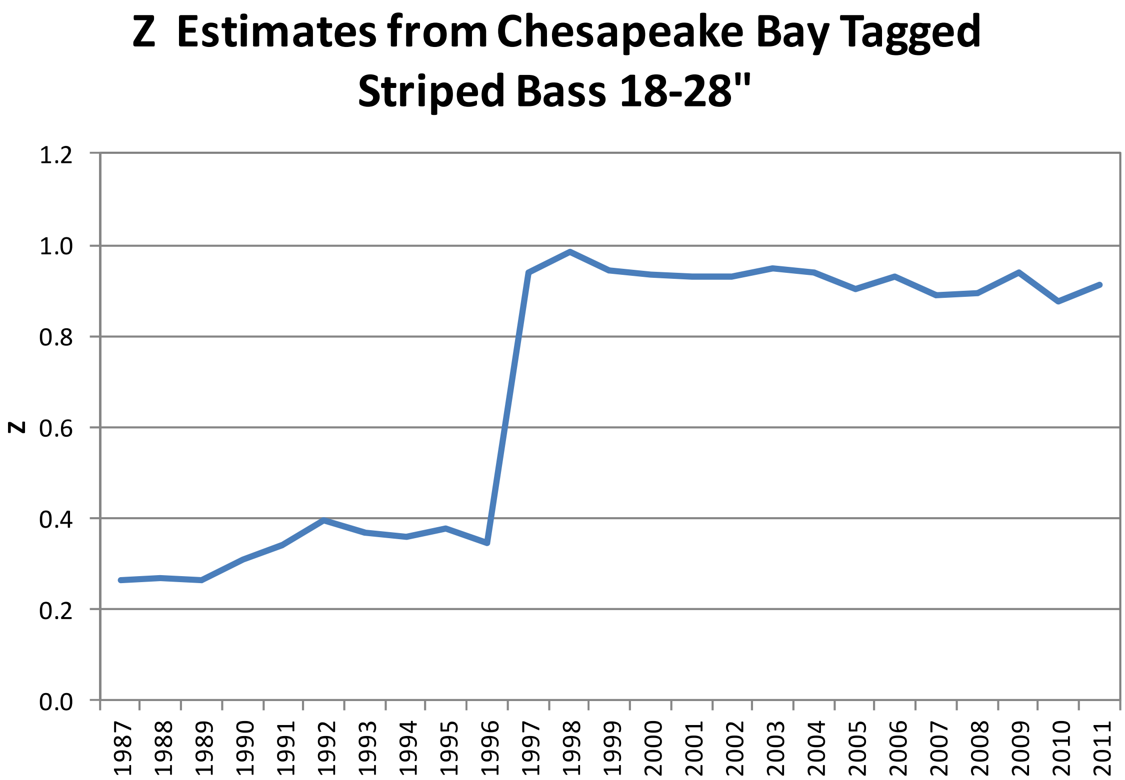


Figure B8.9. Estimates of total mortality (Z) from the IRCR tagging model for Chesapeake Bay fish, 18 – 28 inches.

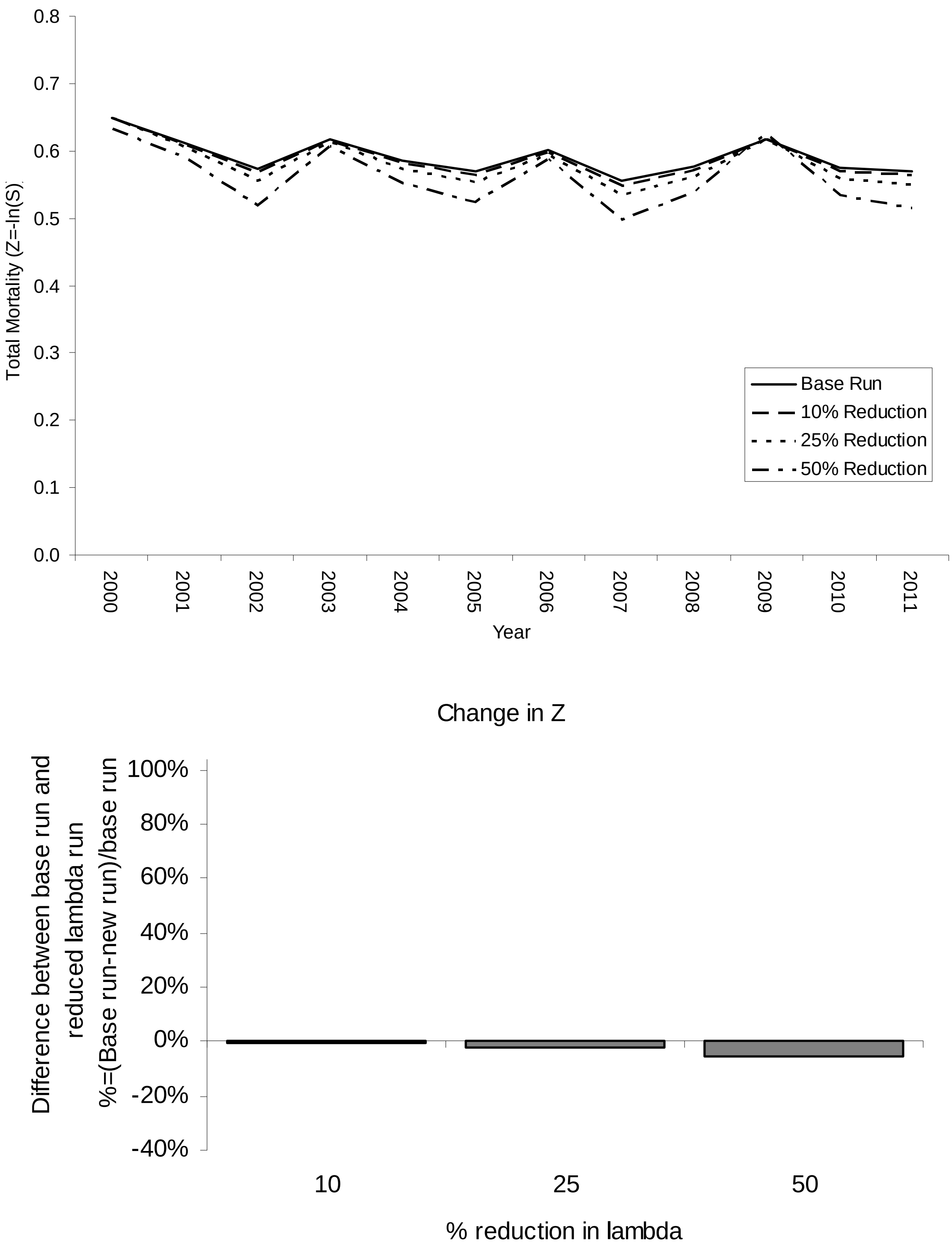


Figure B8.10. Effect of lower reporting rates on estimates of total mortality (Z) from the IRCR tagging model.

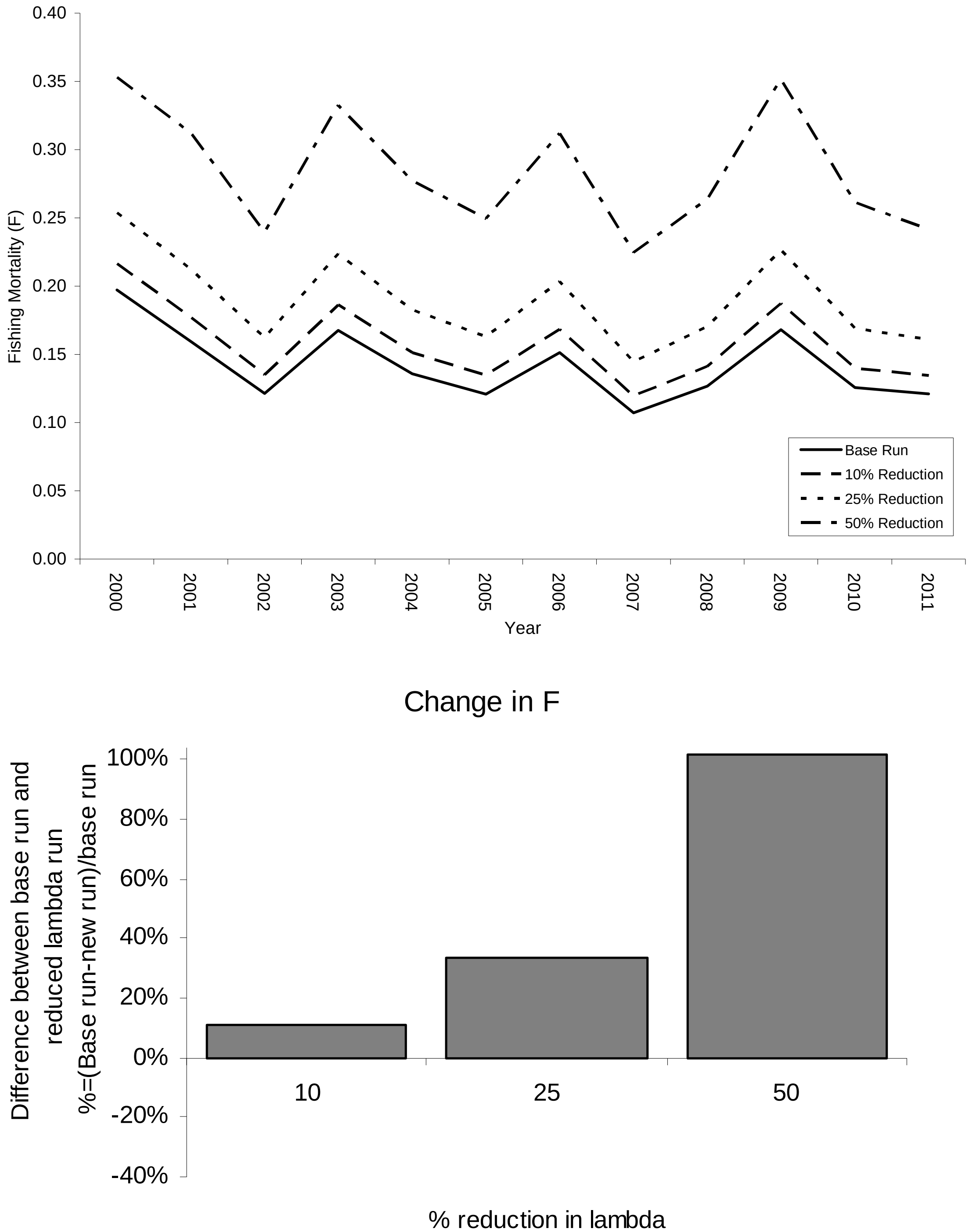


Figure B8.11. Effect of lower reporting rates on estimates of fishing mortality (F) from the IRCR tagging model.

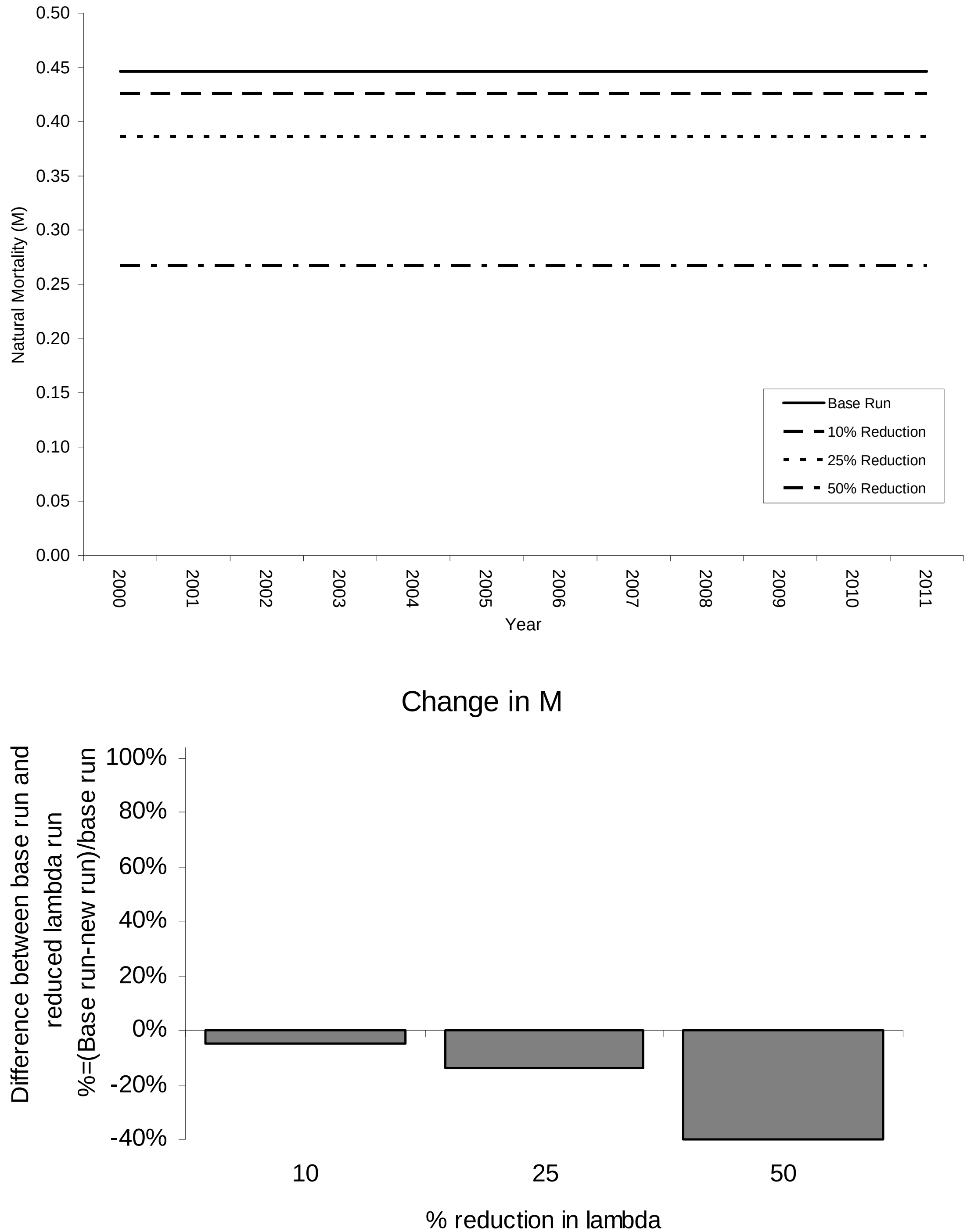


Figure B8.12. Effect of lower reporting rates on estimates of natural mortality (M) from the IRCR tagging model.

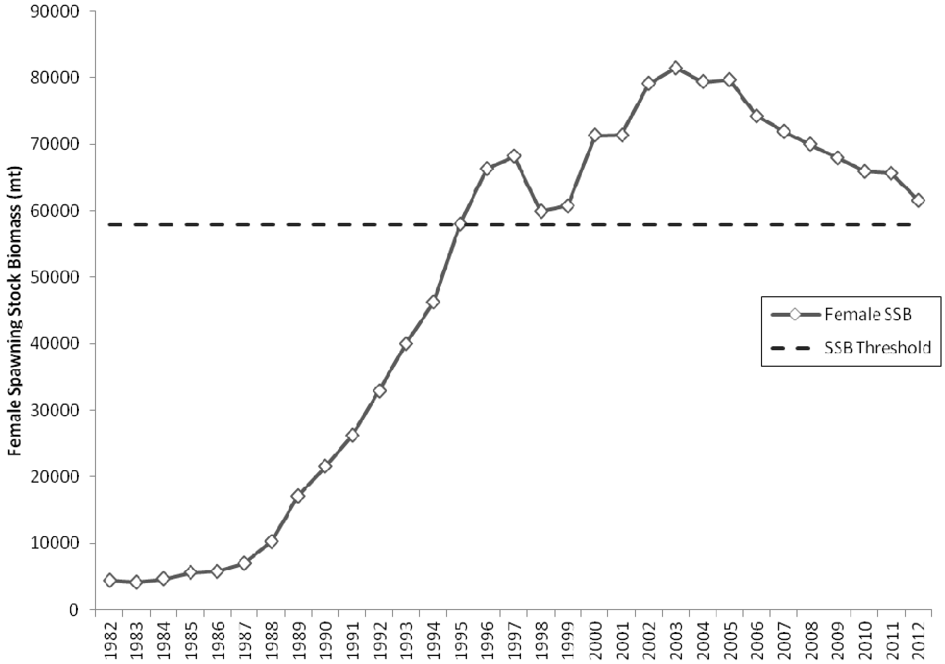


Figure B9.1. Female spawning stock biomass relative to SSB threshold value updated in this assessment.

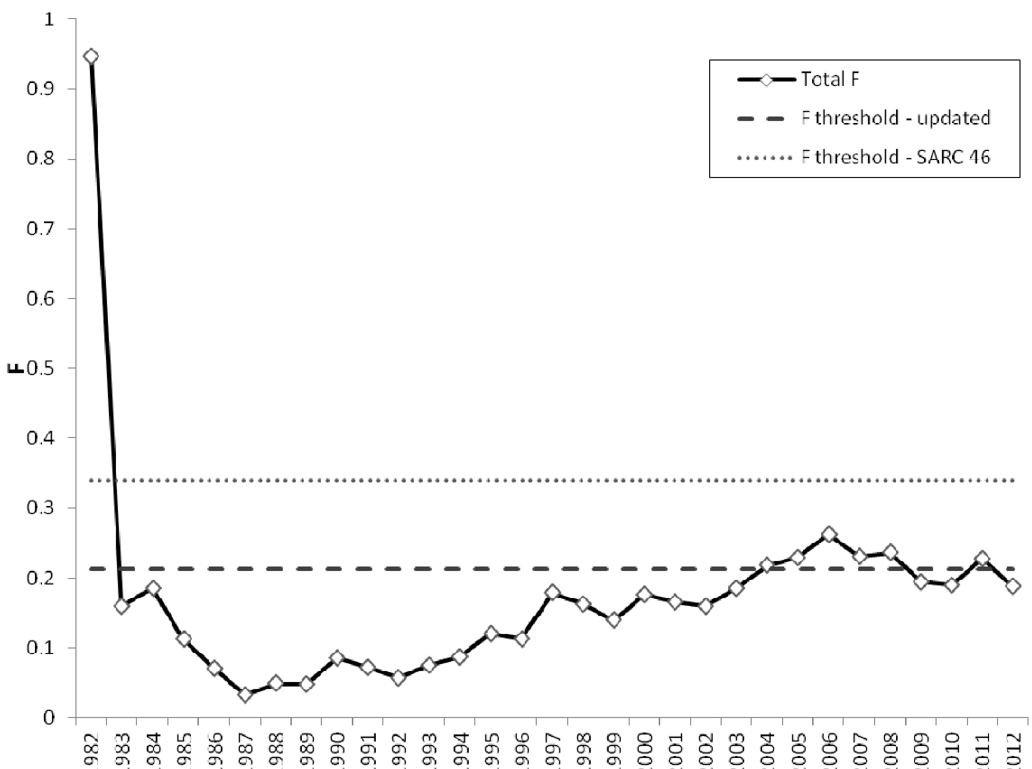


Figure B9.2. Maximum total F at age relative to current (SARC 46) and updated F threshold values.

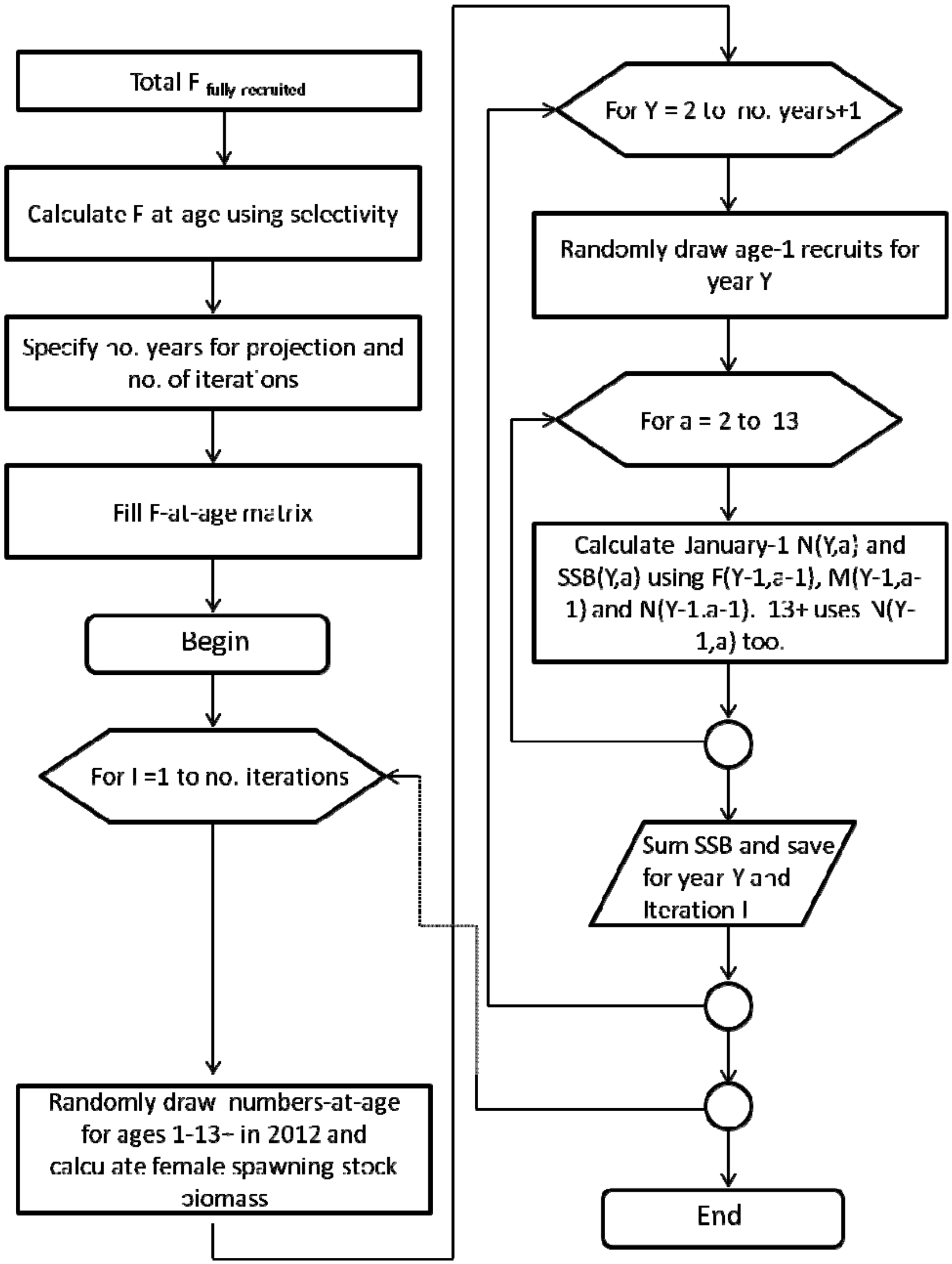


Figure B10.1. Flowchart of female spawning stock biomass projection routine written in R.

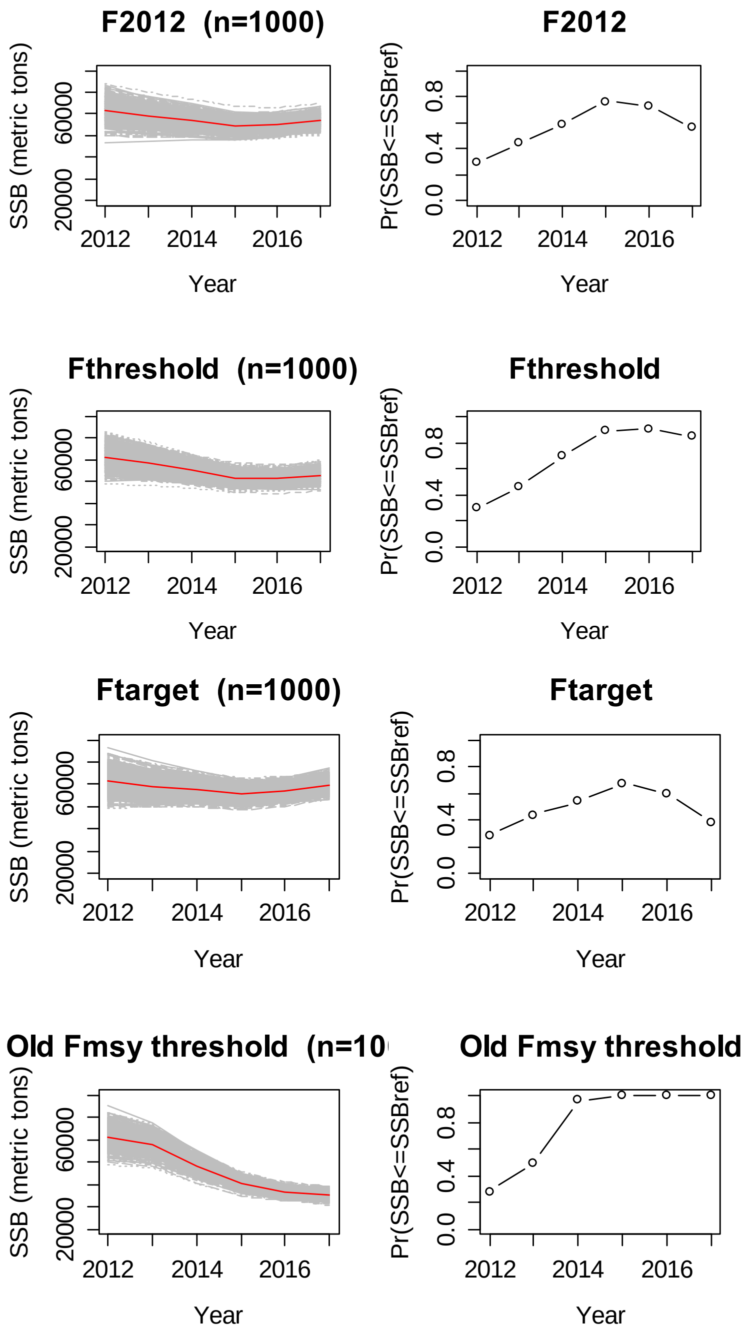


Figure B10.2. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and assuming the Beverton-Holt S-R relationship. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

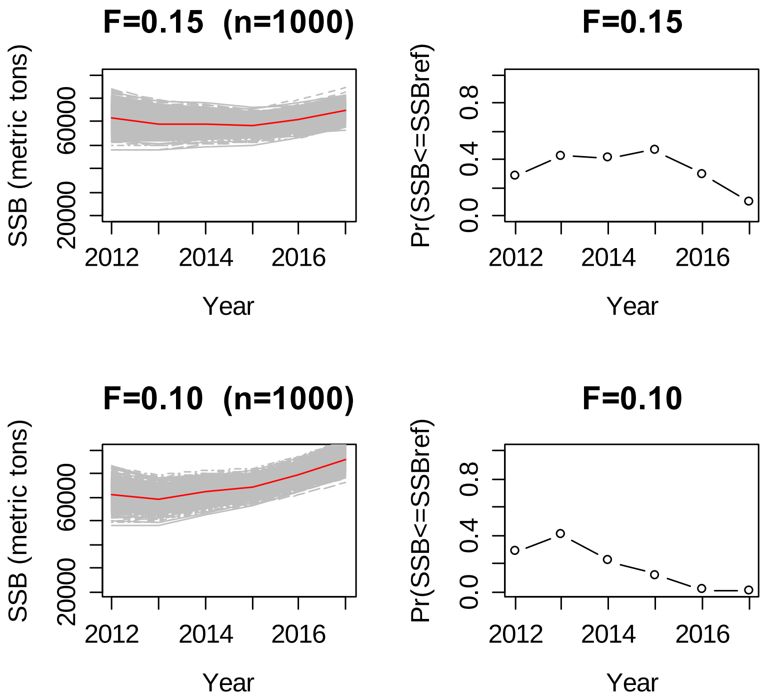


Figure B10.2 cont.

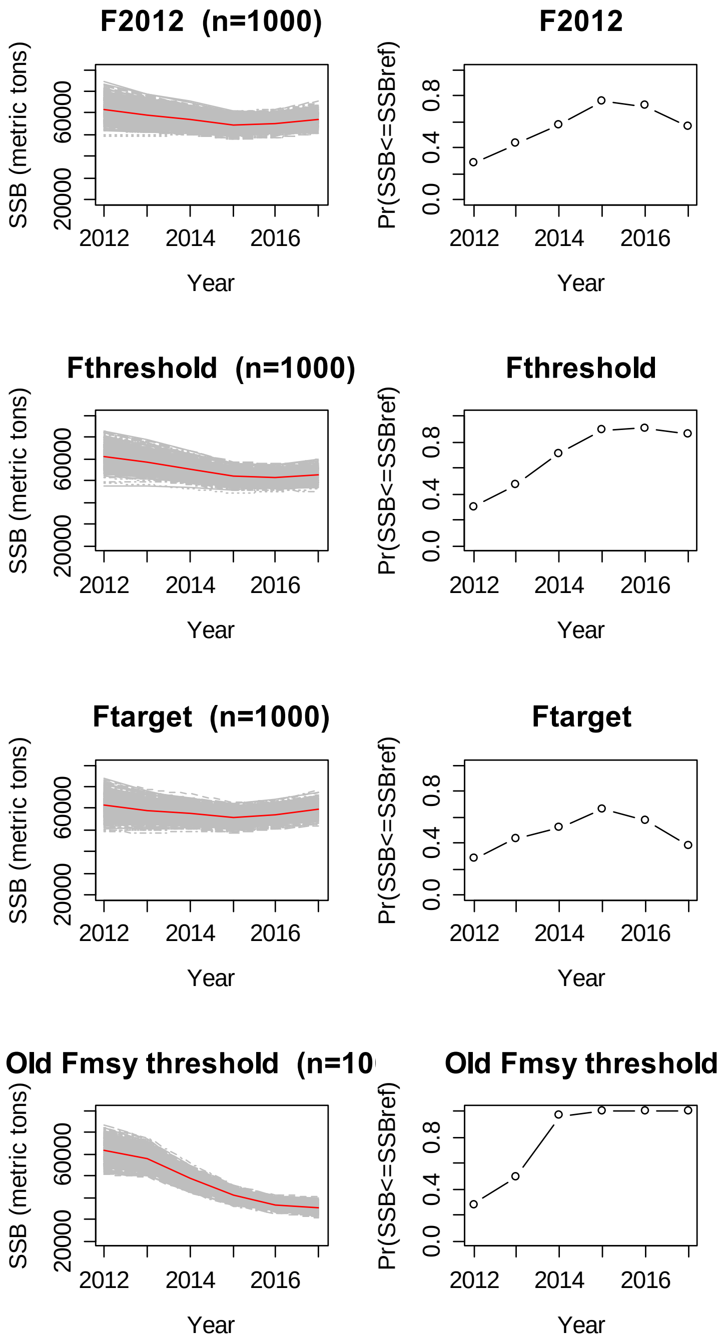
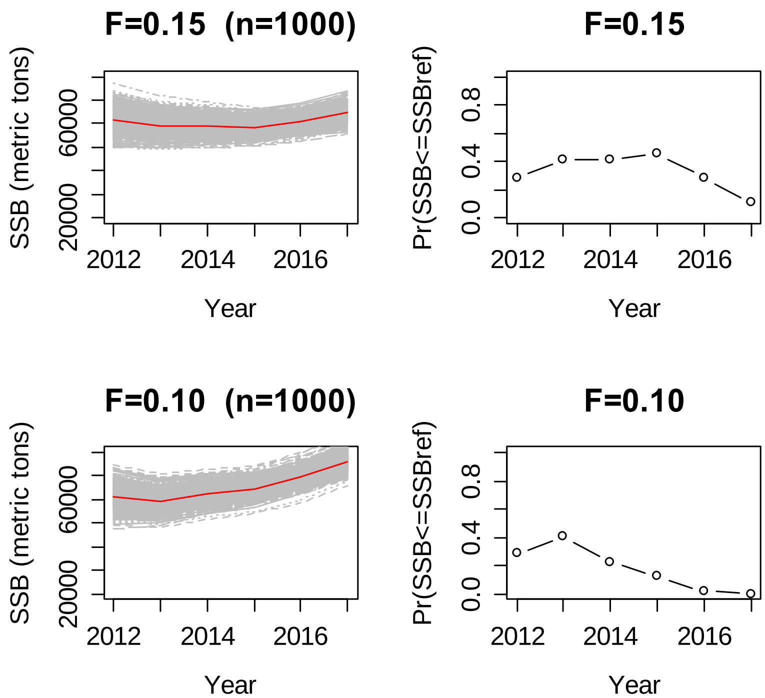


Figure B10.3. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment/SSB ratios from a nonparametric distribution created with the 1990-2012 time series of recruitment and 1989-2011 SSB data. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections



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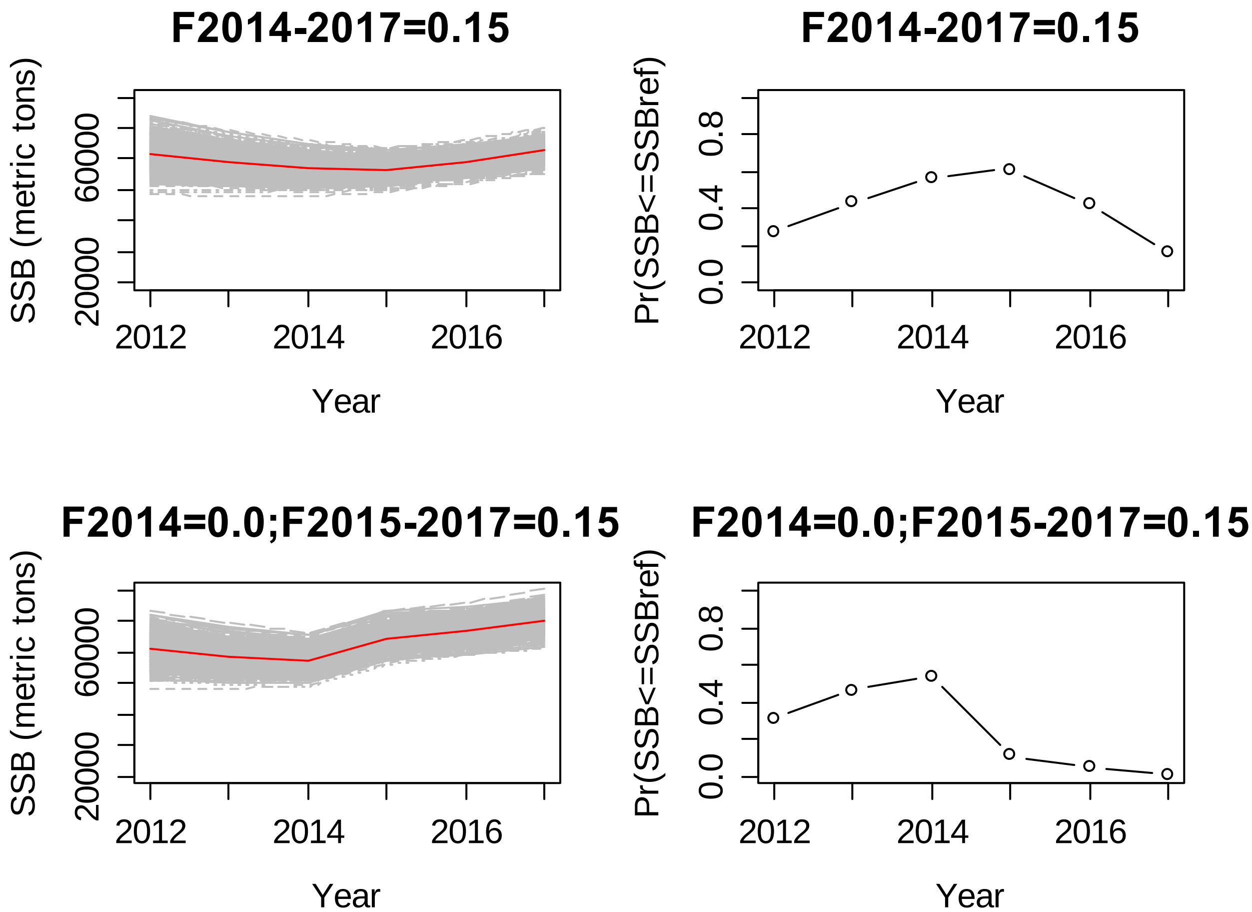


Figure B10.4. Impact of delaying decrease in F until 2014.

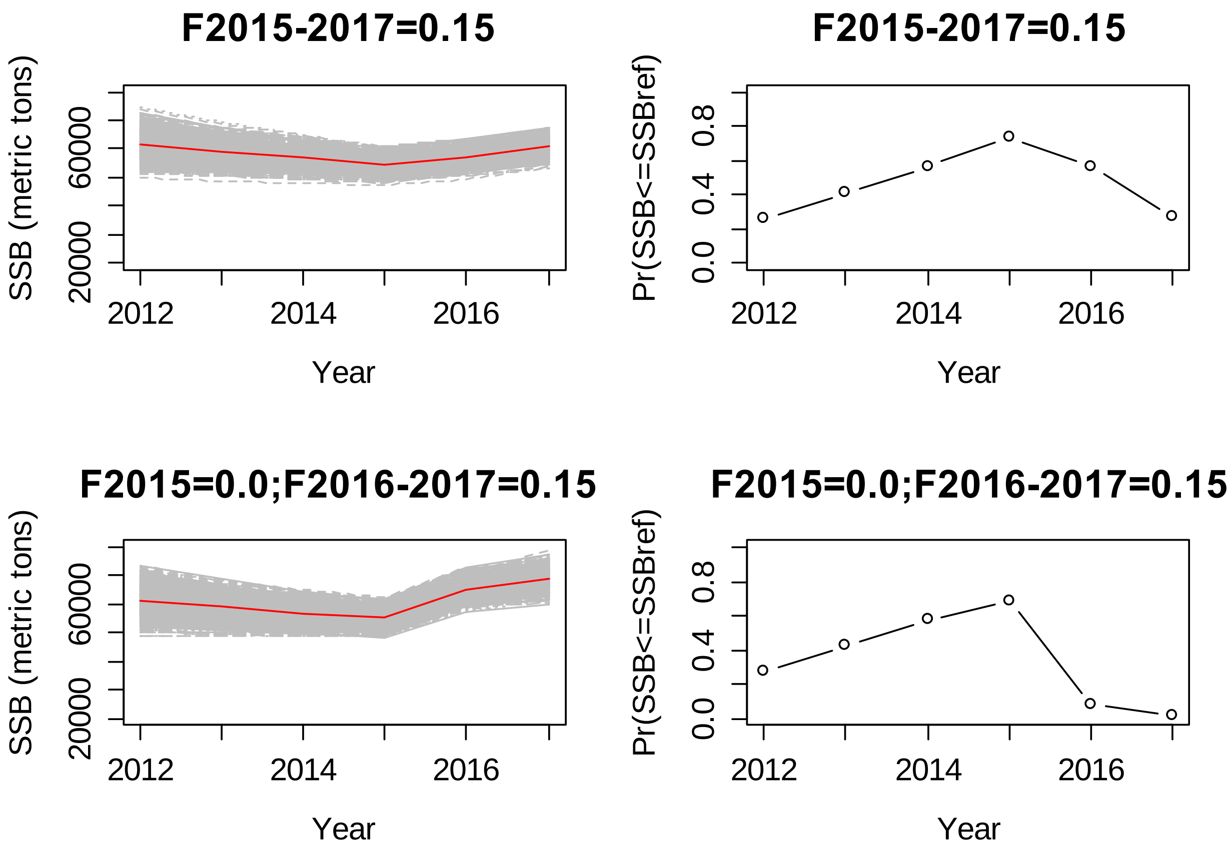


Figure B10.5. Impact of delaying decrease in F until 2015.

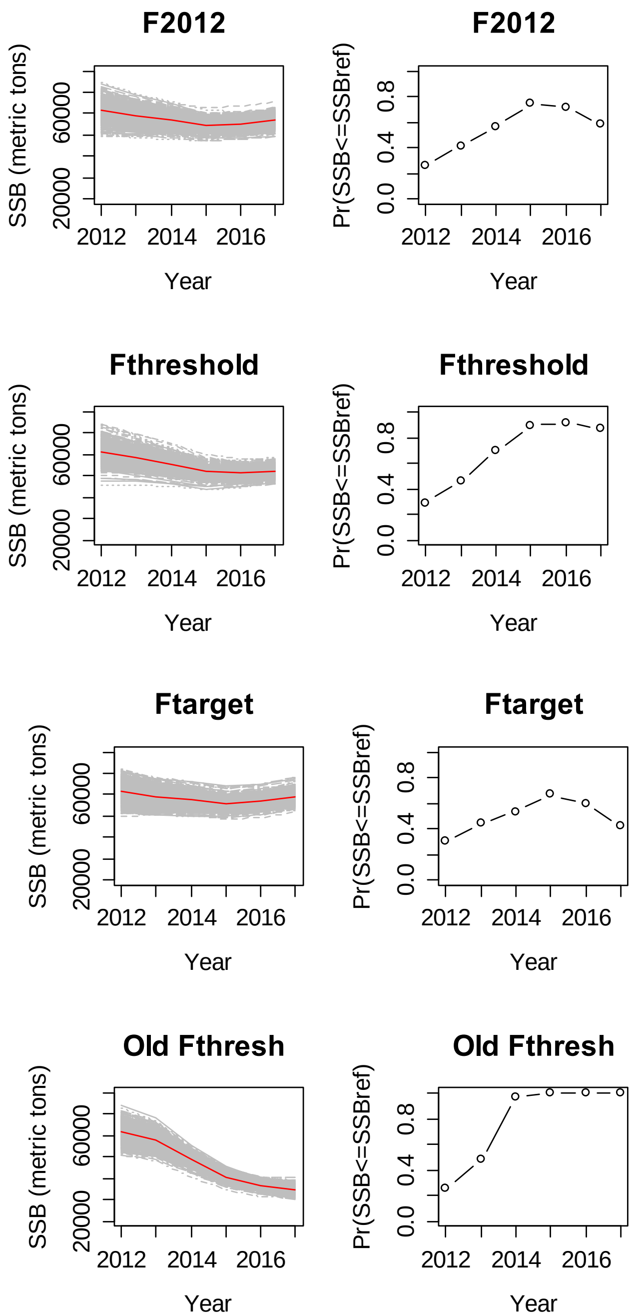


Figure B10.6. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment/SSB ratios from a nonparametric distribution created with the 2002-2012 time series of recruitment and 2001-2011 SSB data. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

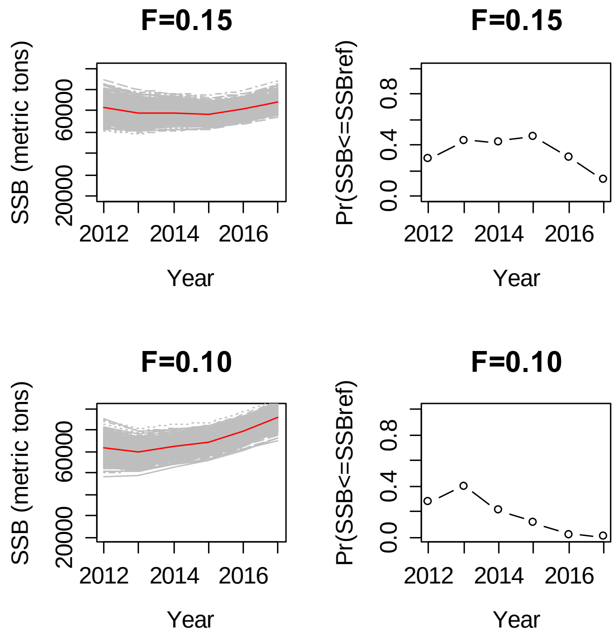


Figure B10.6 cont.

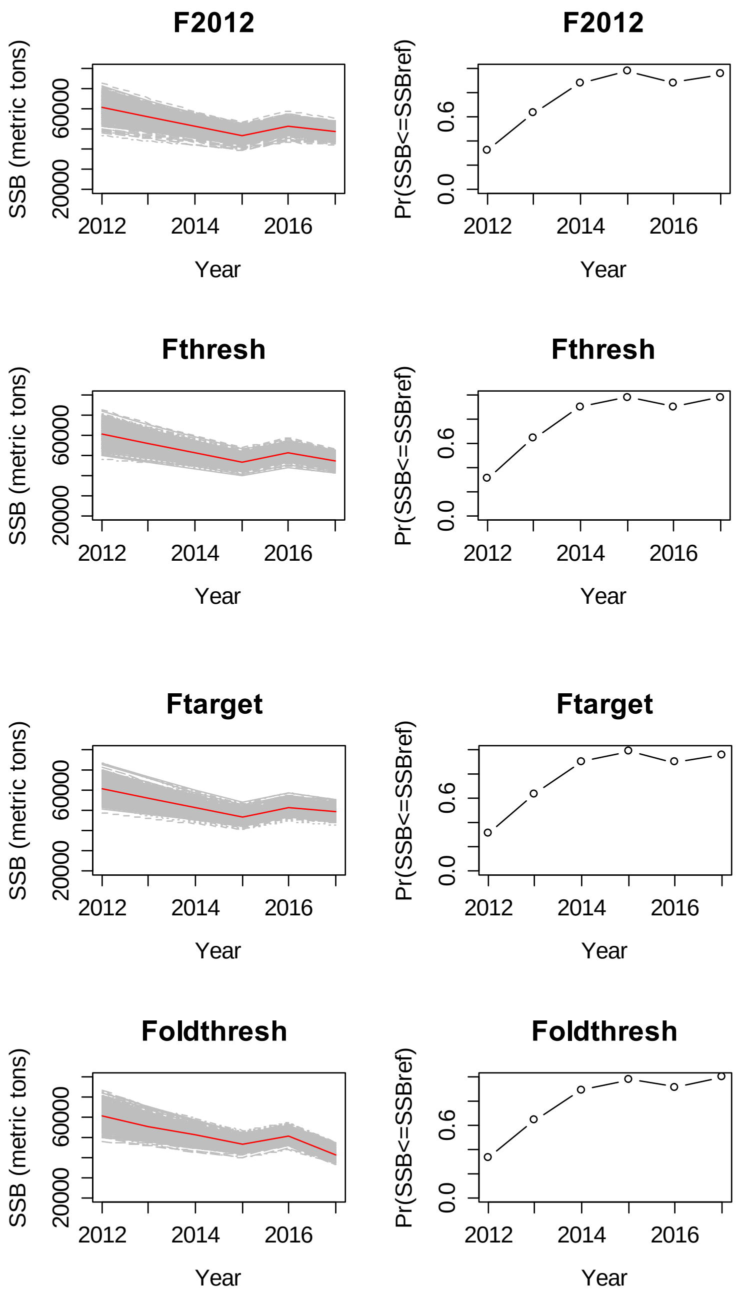


Figure B10.7. Results of the female spawning stock biomass projections using increased natural mortality values on age 3-8 and randomly drawing recruitment/SSB ratios from a nonparametric distribution created with the 1990-2012 time series of recruitment and 1989-2011 SSB data. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

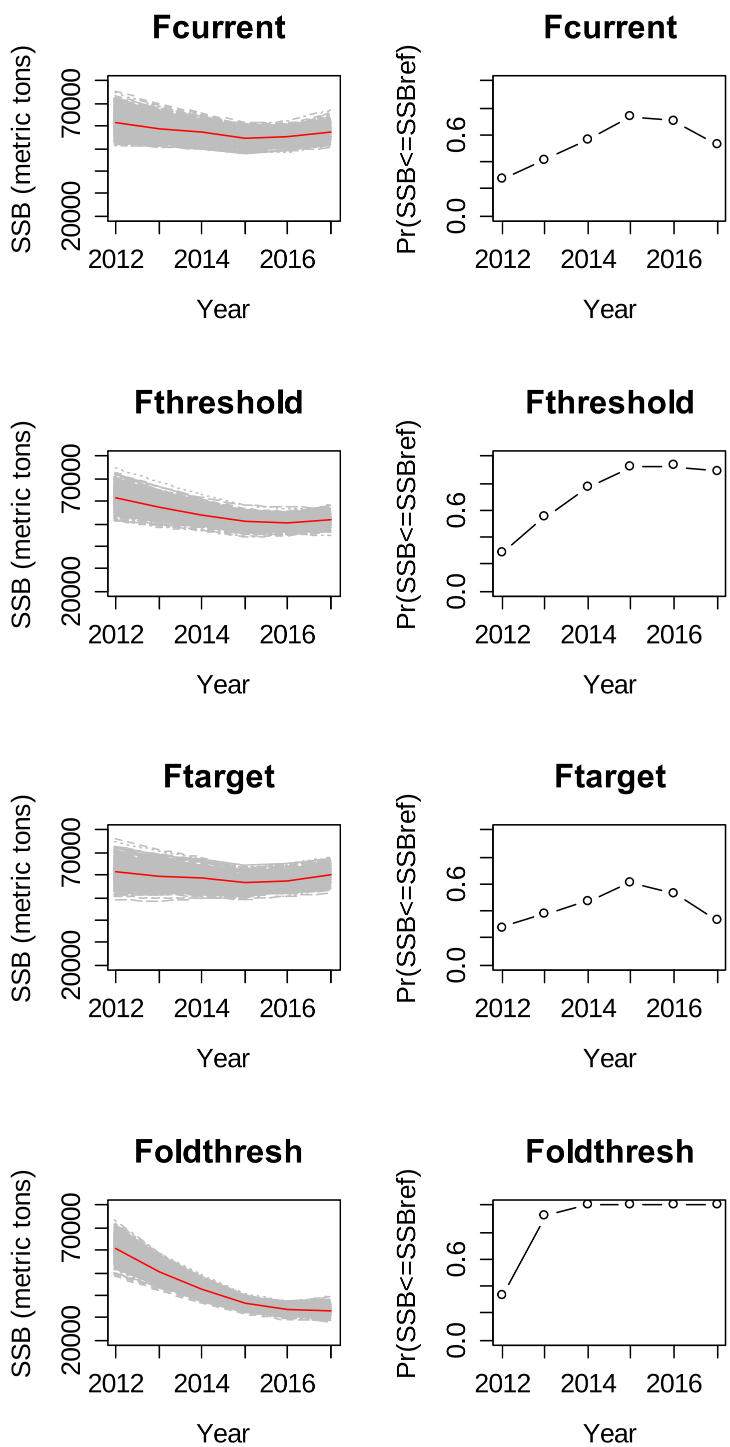
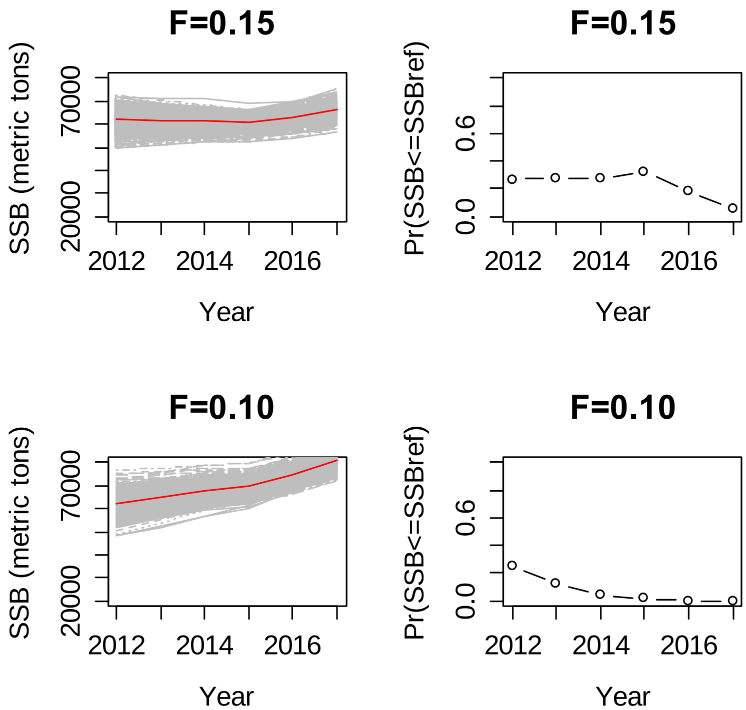


Figure B10.8. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and using the non-bias corrected Beverton-Holt S-R relationship (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.



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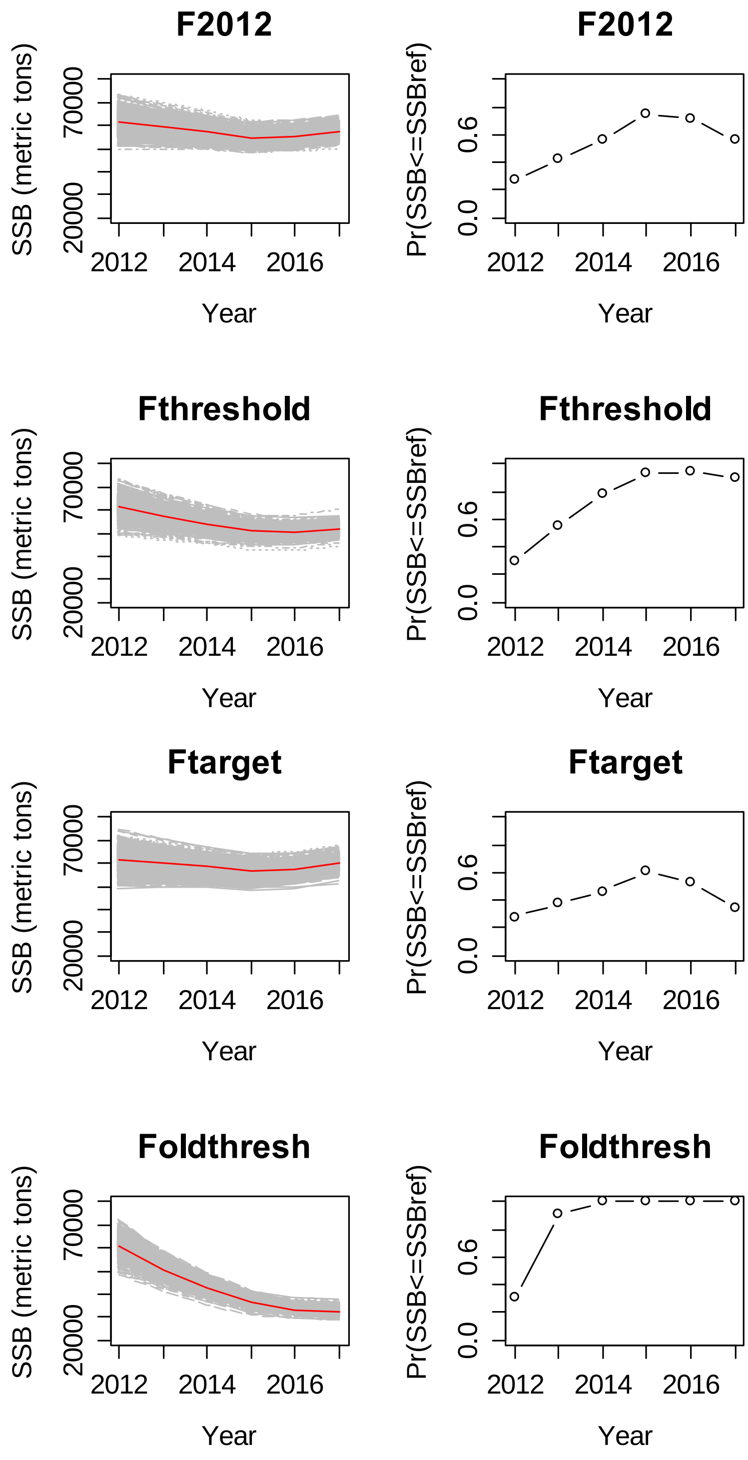


Figure B10.9. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment from the 1990-2012 time series of recruitment (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

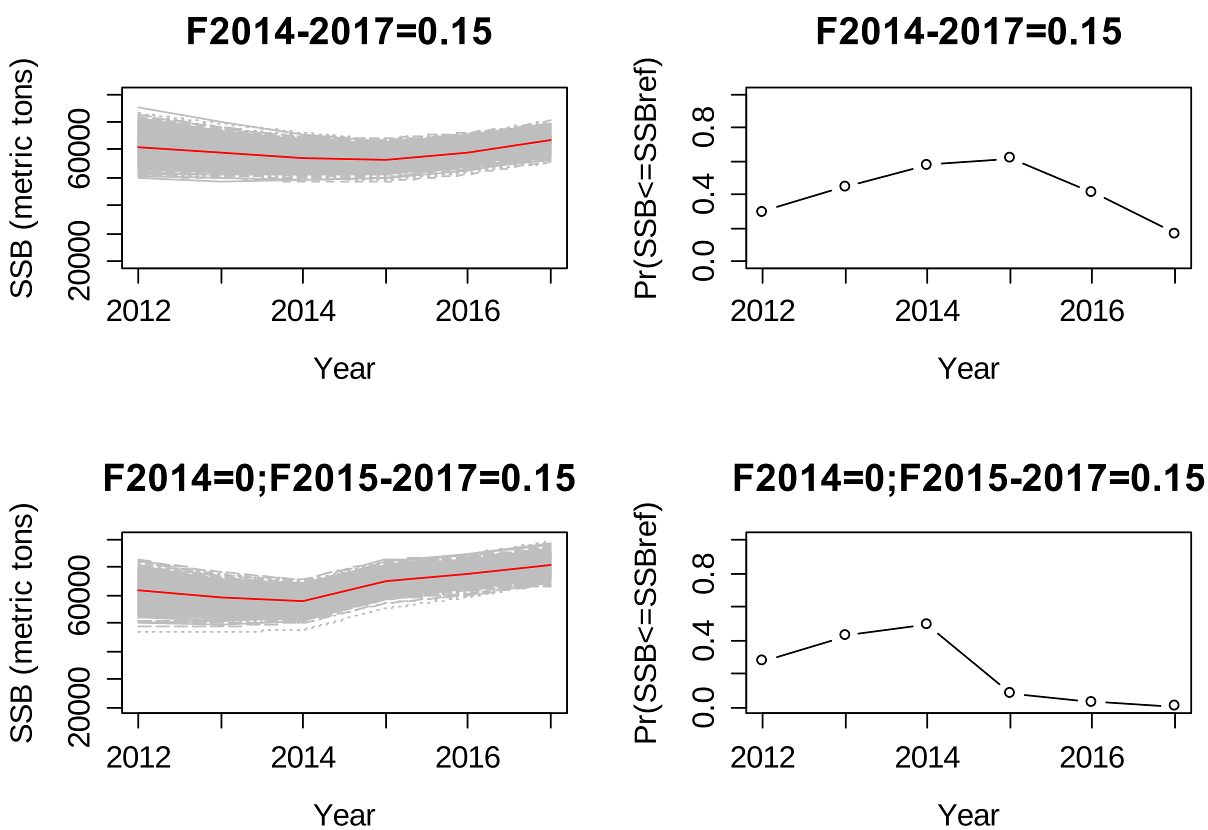


Figure B10.10. Impact of delaying decrease in F until 2014 using empirical recruitment (additional analysis that was completed and peer reviewed during the SARC meeting).

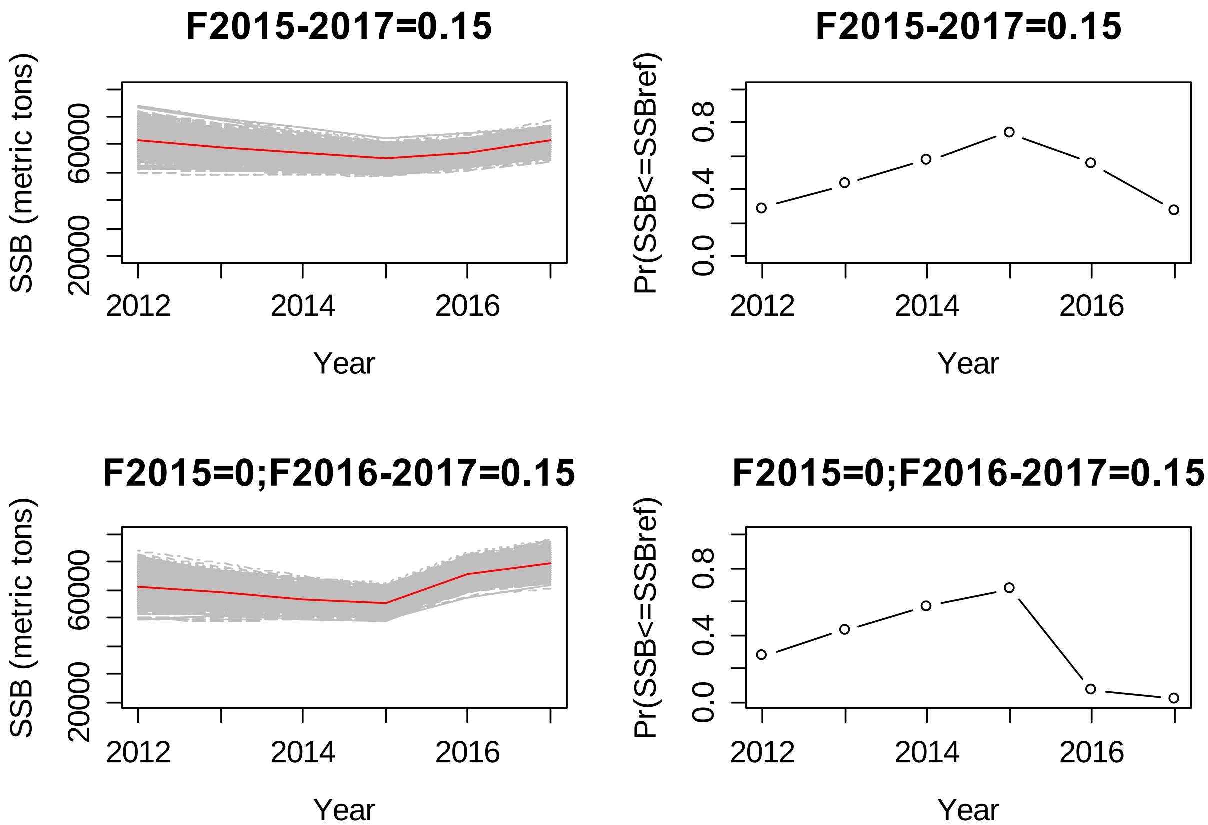


Figure B10.11. Impact of delaying decrease in F until 2015 using empirical recruitment (additional analysis that was completed and peer reviewed during the SARC meeting).

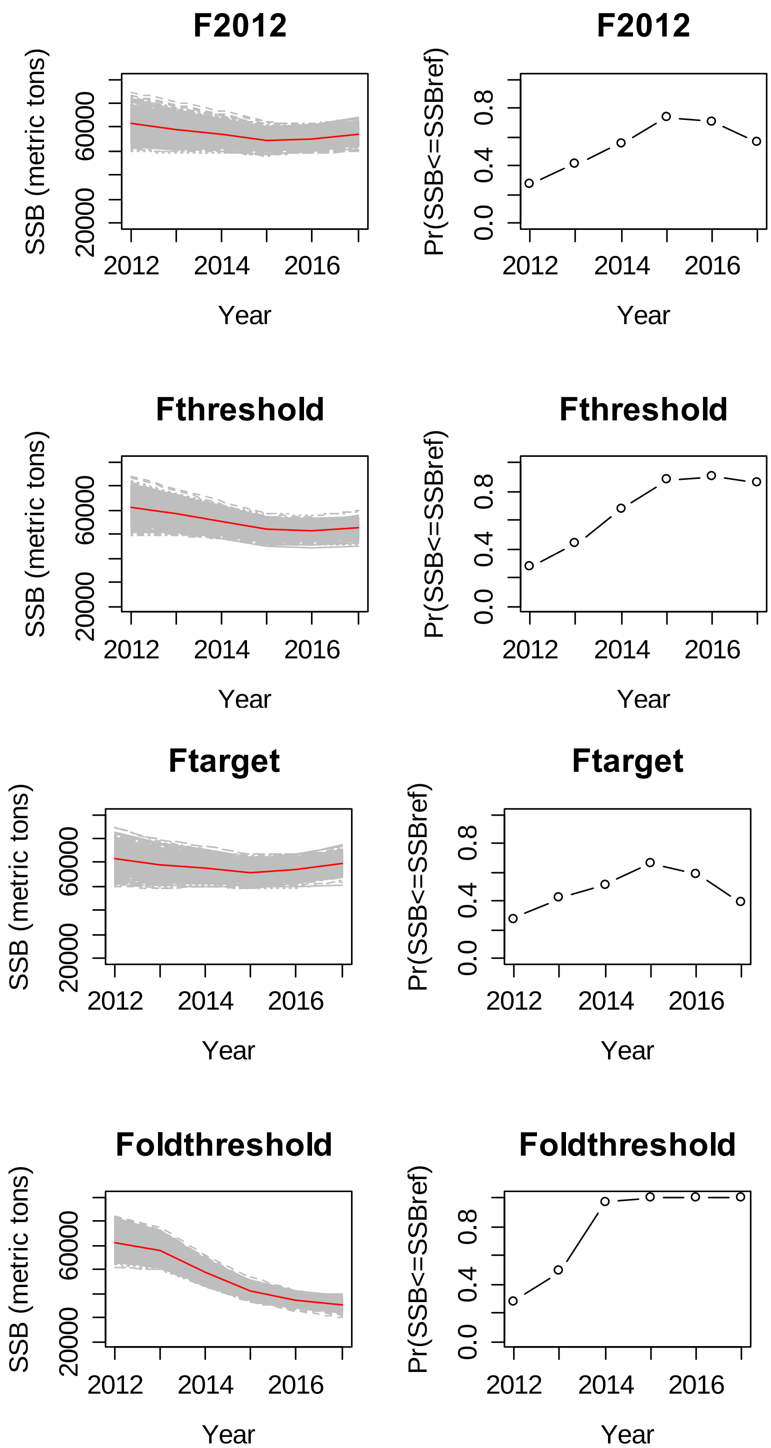


Figure B10.12. Results of the female spawning stock biomass projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment values from the 2002-2012 time series of recruitment (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

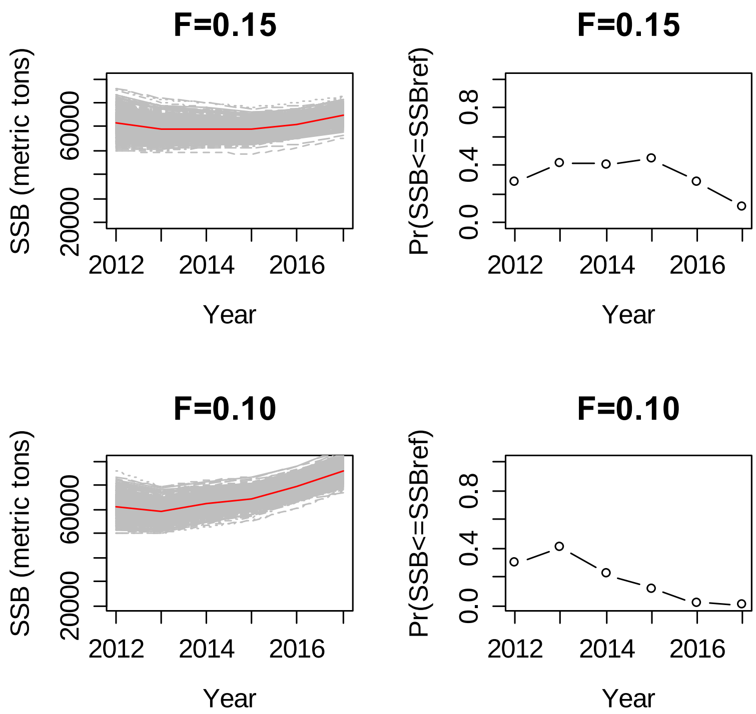


Figure B10.12 cont.

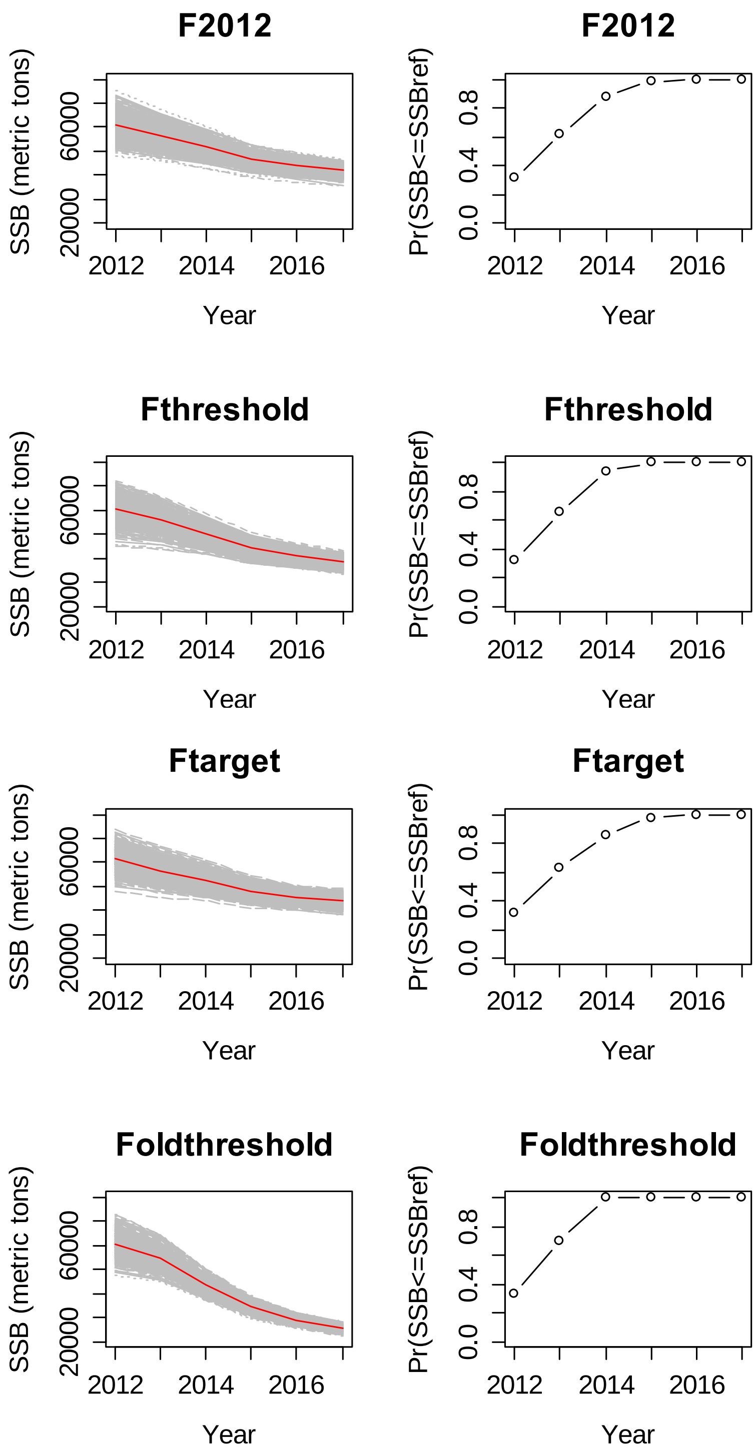
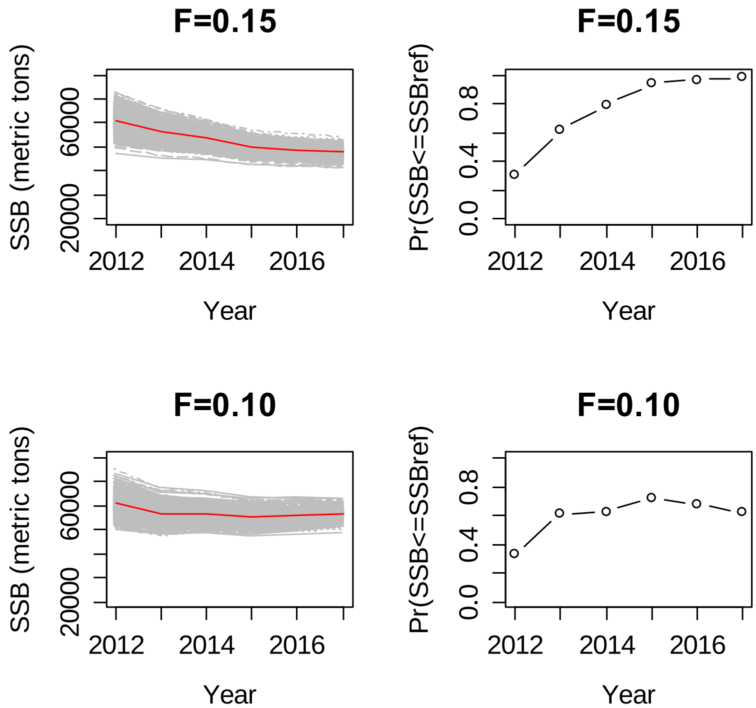


Figure B10.13. Results of the female spawning stock biomass projections using increased natural mortality values on age 3-8 and randomly drawing recruitment values from the 1990-2012 time series (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.



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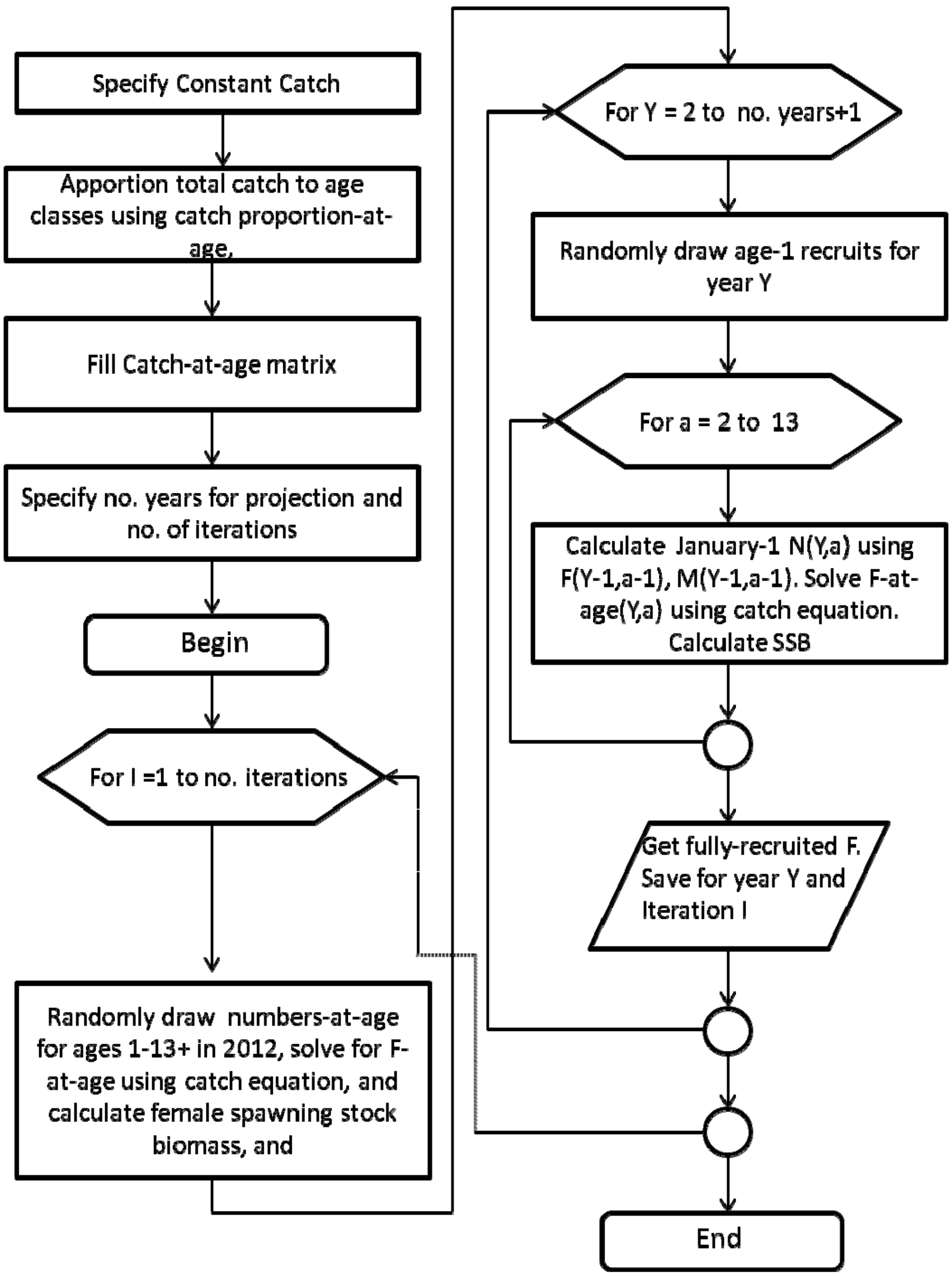


Figure B10.14. Flowchart of the fully-recruited F projection routine written in R.

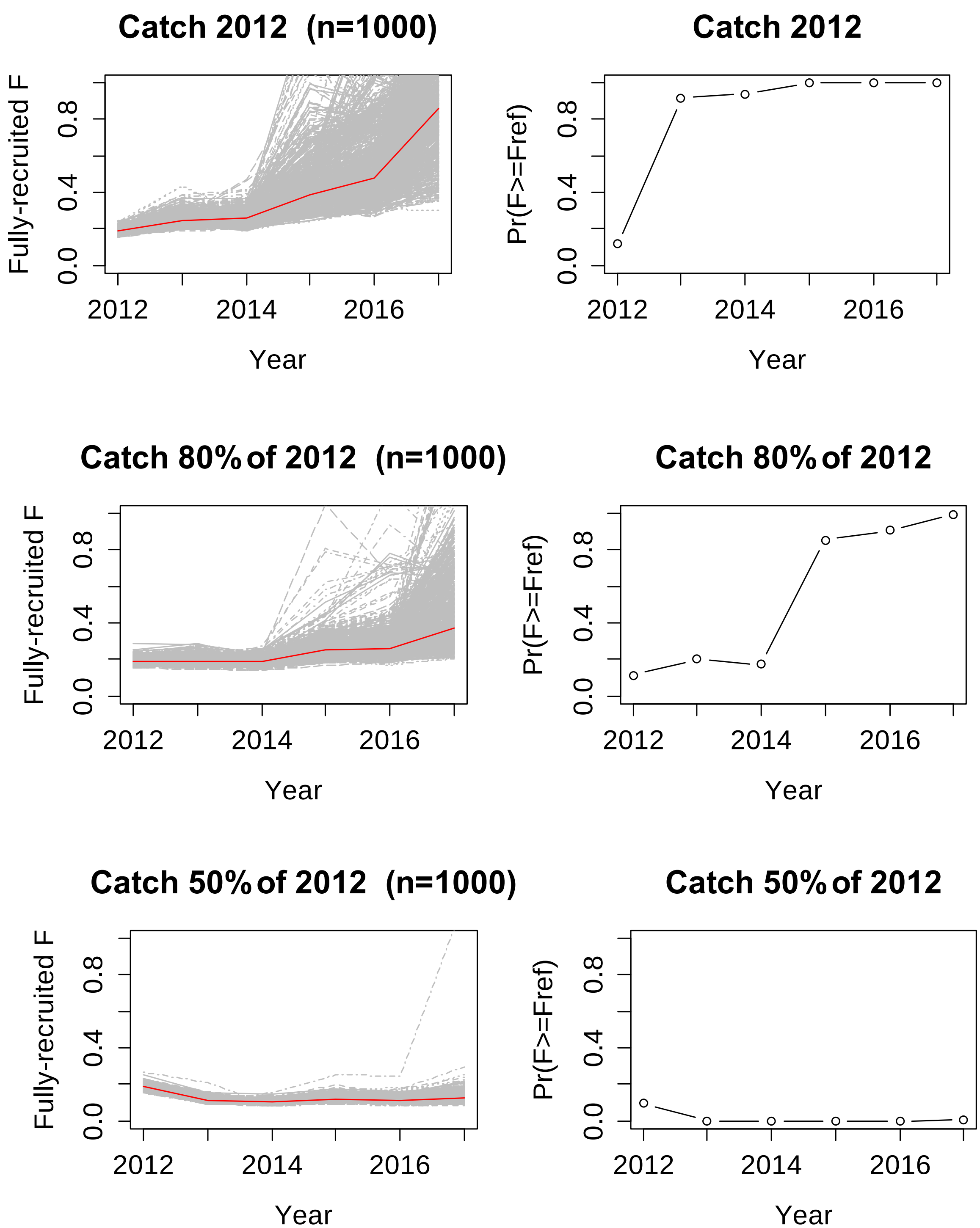


Figure B10.15. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and assuming the Beverton-Holt stock recruitment relationship. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

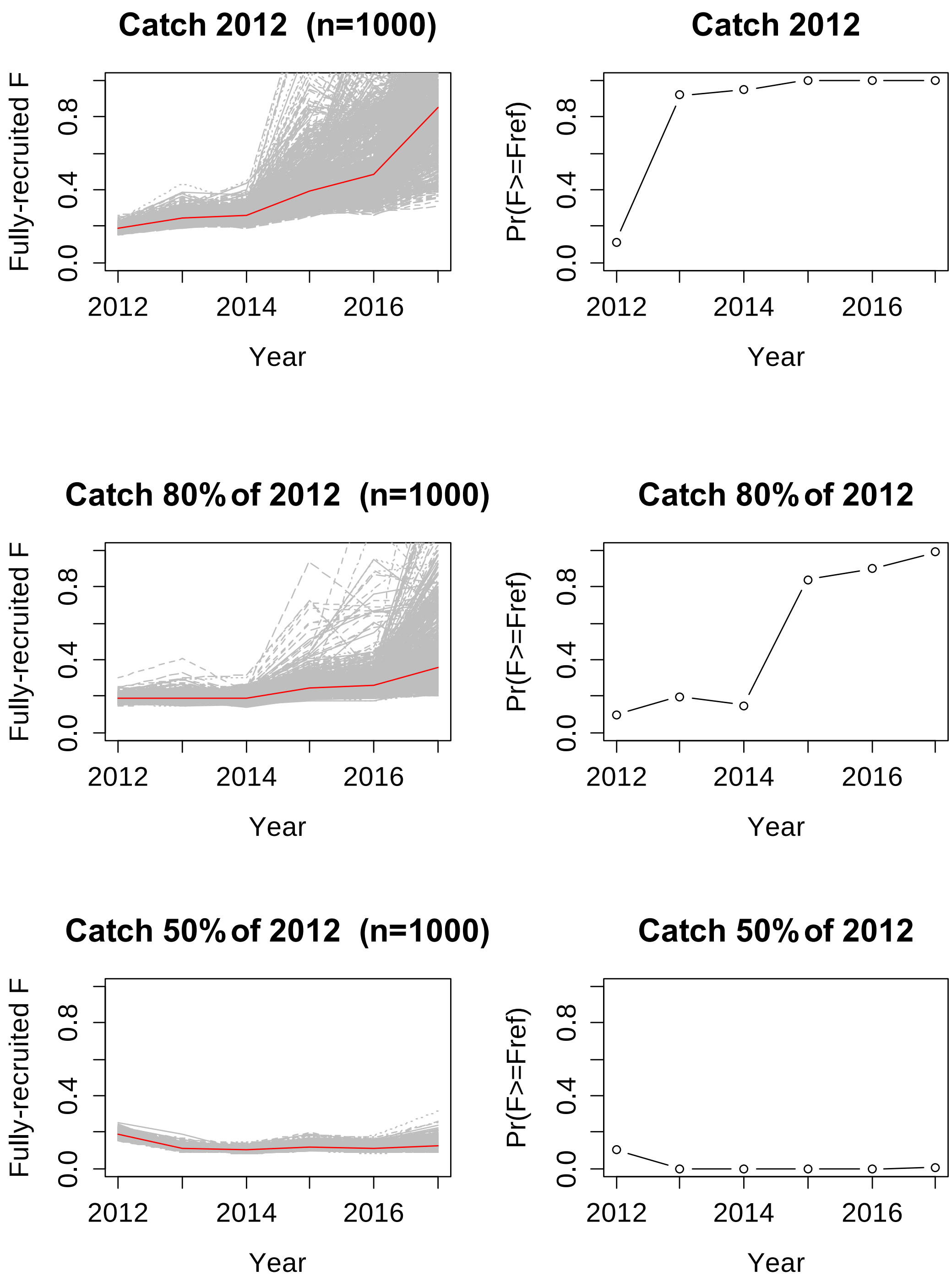


Figure B10.16. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment/SSB ratios from a nonparametric distribution created with the 1990-2012 time series of recruitment and 1989-2011 SSB data. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

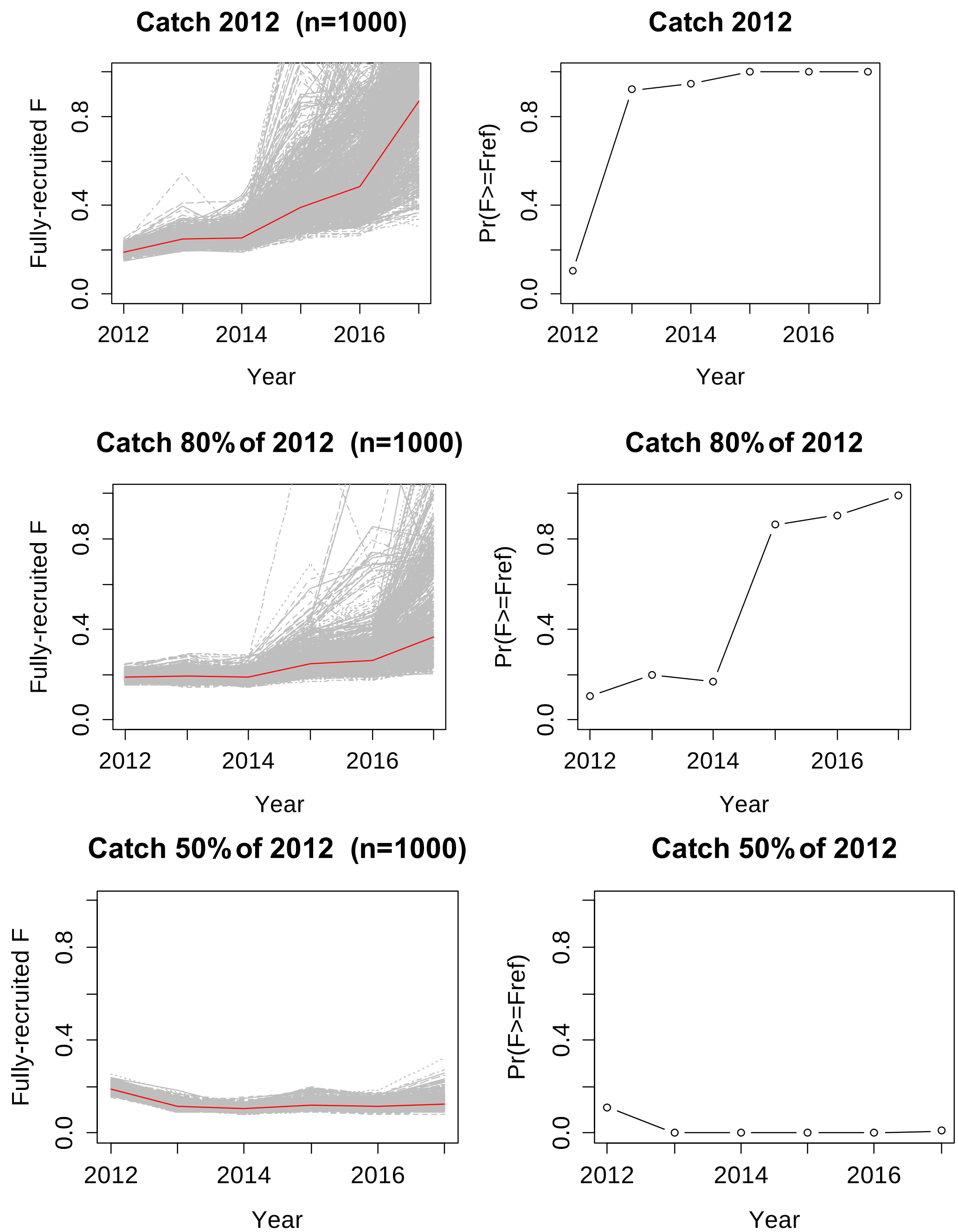


Figure B10.17. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment/SSB ratios from a nonparametric distribution created with the 2002-2012 time series of recruitment and 2001-2011 SSB data. Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

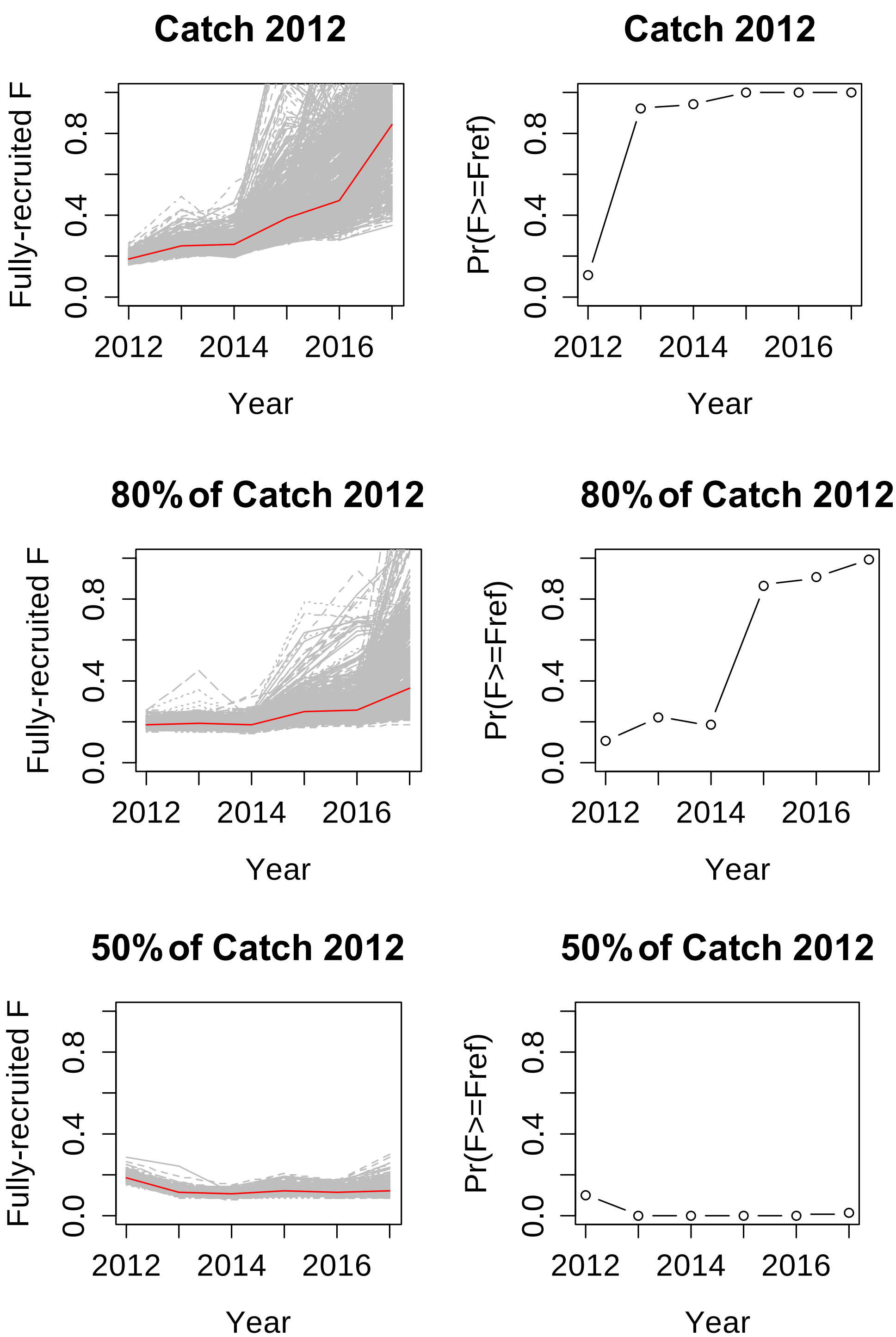


Figure B10.18. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and using the non-bias-corrected Beverton-Holt stock recruitment relationship (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

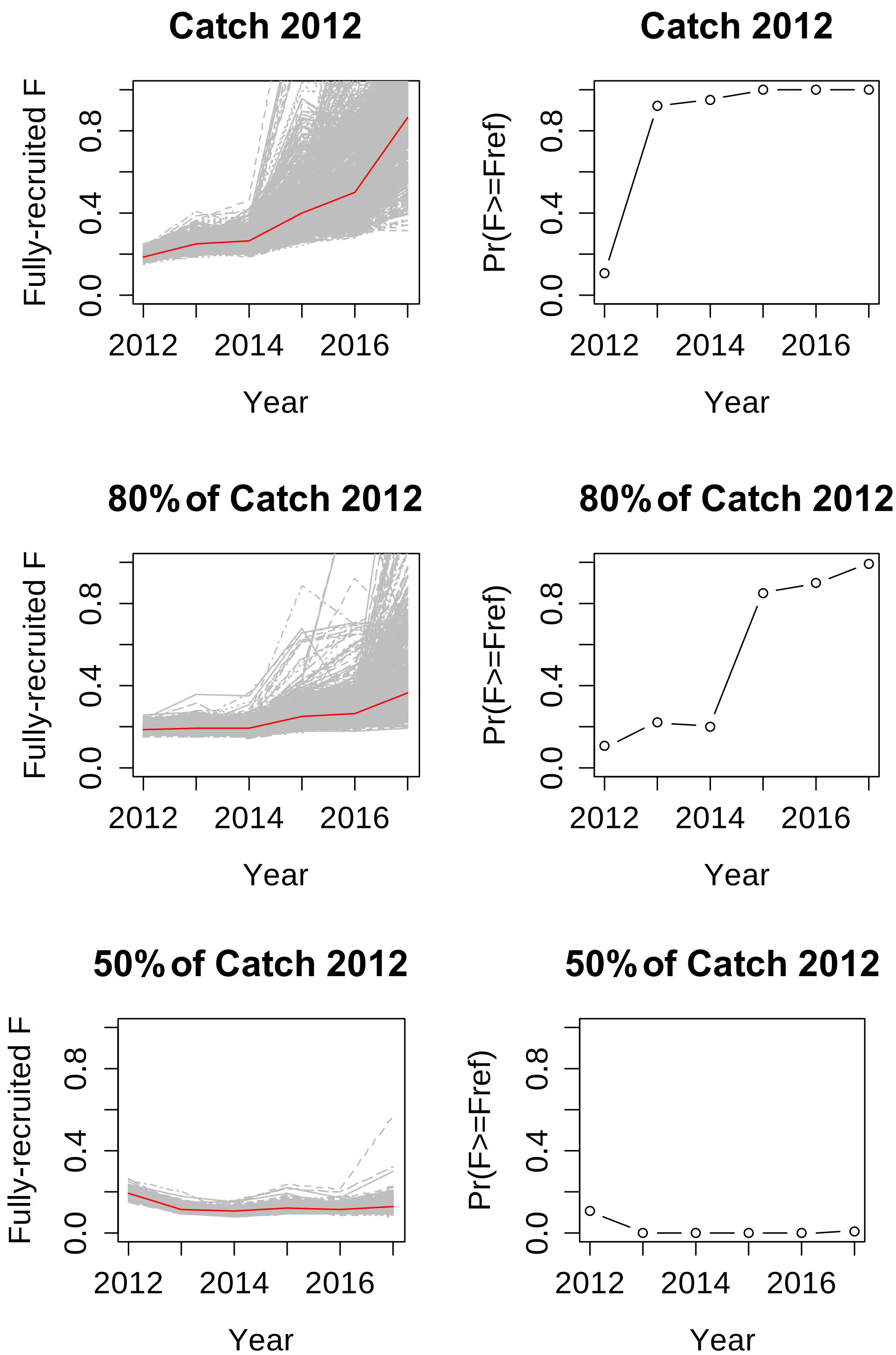


Figure B10.19. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment values from the 1990-2012 time series (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB projections and red line is the median of the 1000 SSB projections.

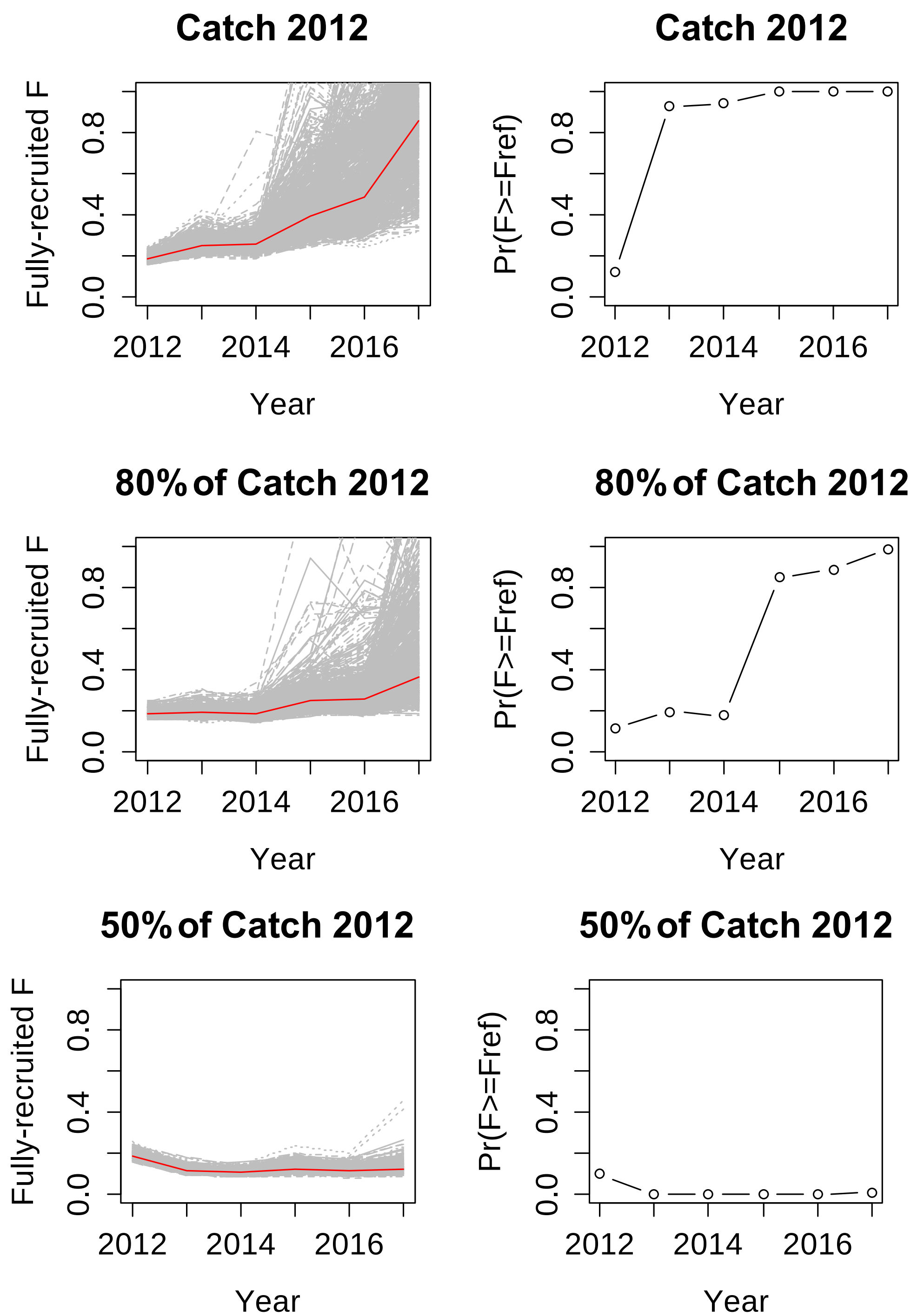


Figure B10.20. Results of the constant catch projections using parameter estimates from the 2012 base SCA model and randomly drawing recruitment from the 2002-2012 time series of recruitment (additional analysis that was completed and peer reviewed during the SARC meeting). Gray lines are the 1000 SSB 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 (≥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 α= 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

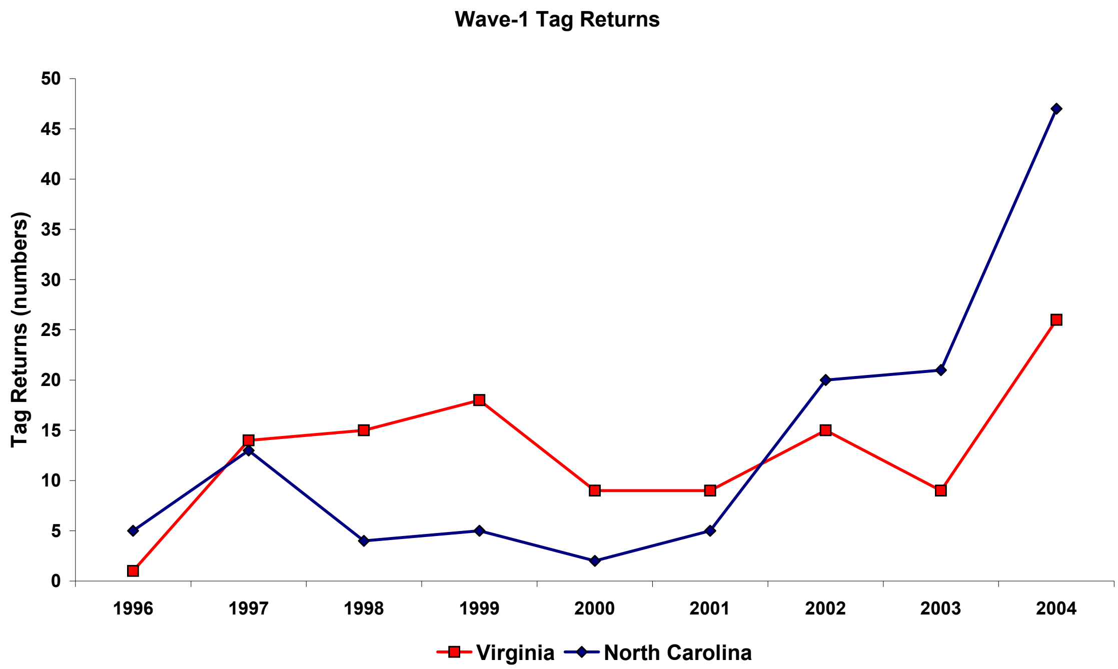


Figure 1. Wave-1 tag returns for Virginia and North Carolina.

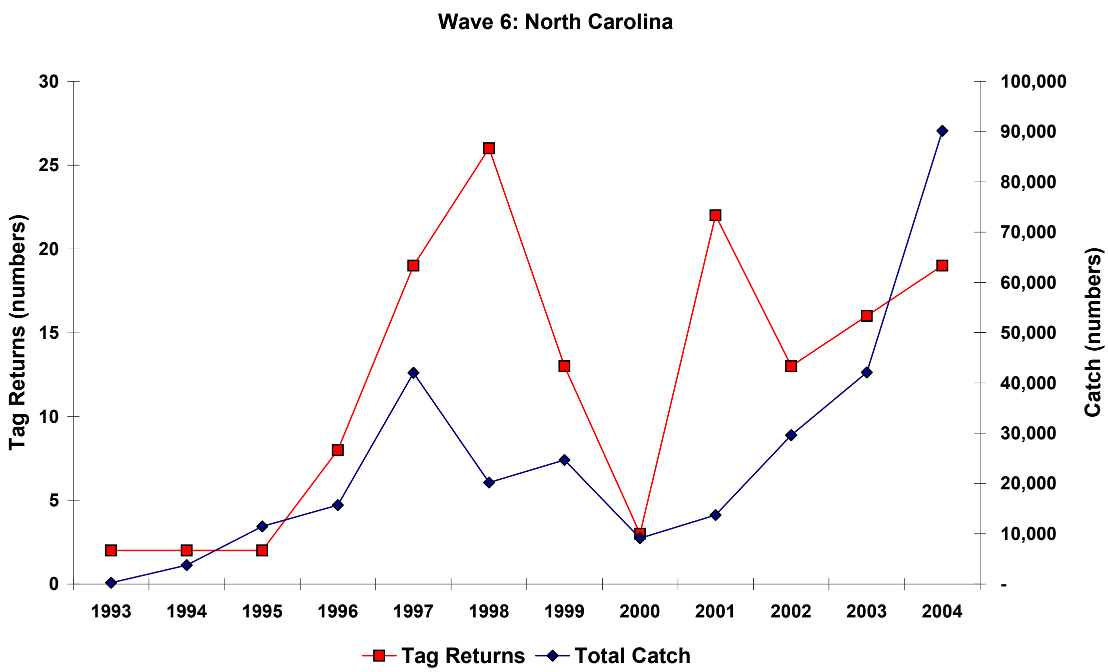


Figure 2. Wave-6 tag returns versus total harvest for North Carolina.

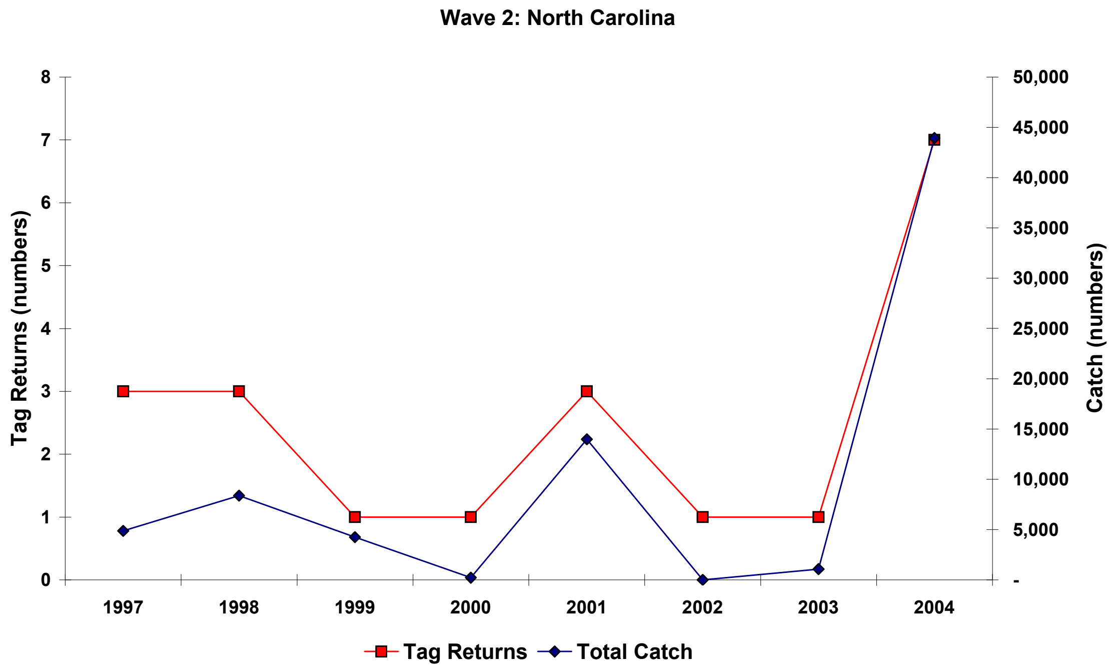


Figure 3. Wave-2 tag returns versus total harvest for North Carolina.

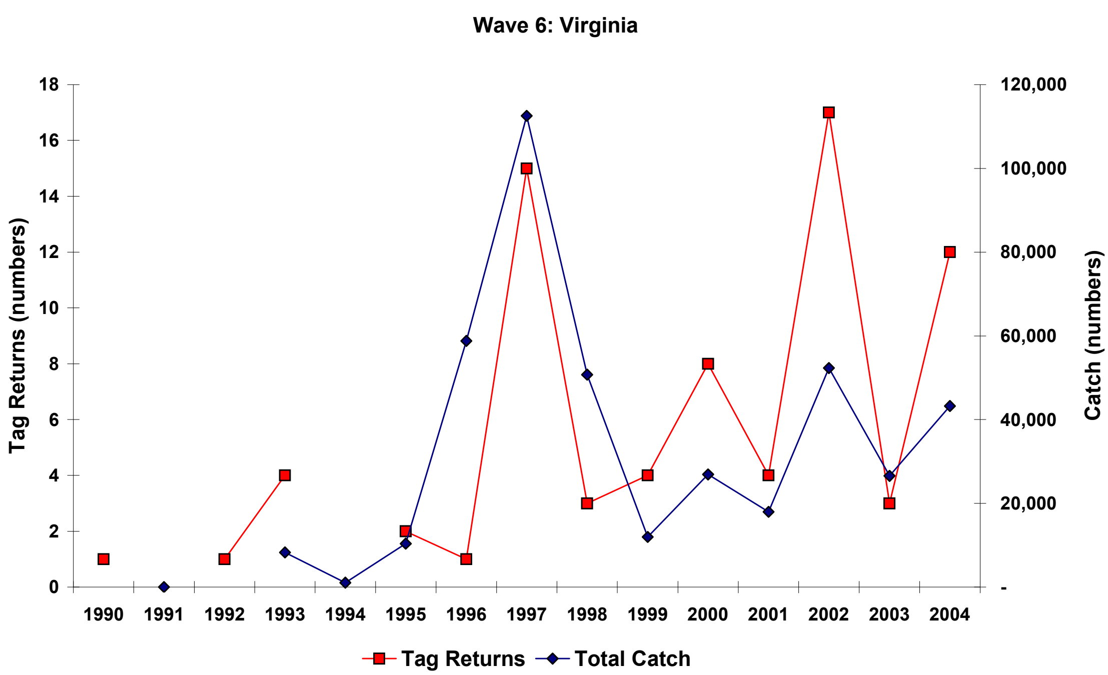


Figure 4. Wave-6 tag returns versus total harvest for Virginia.

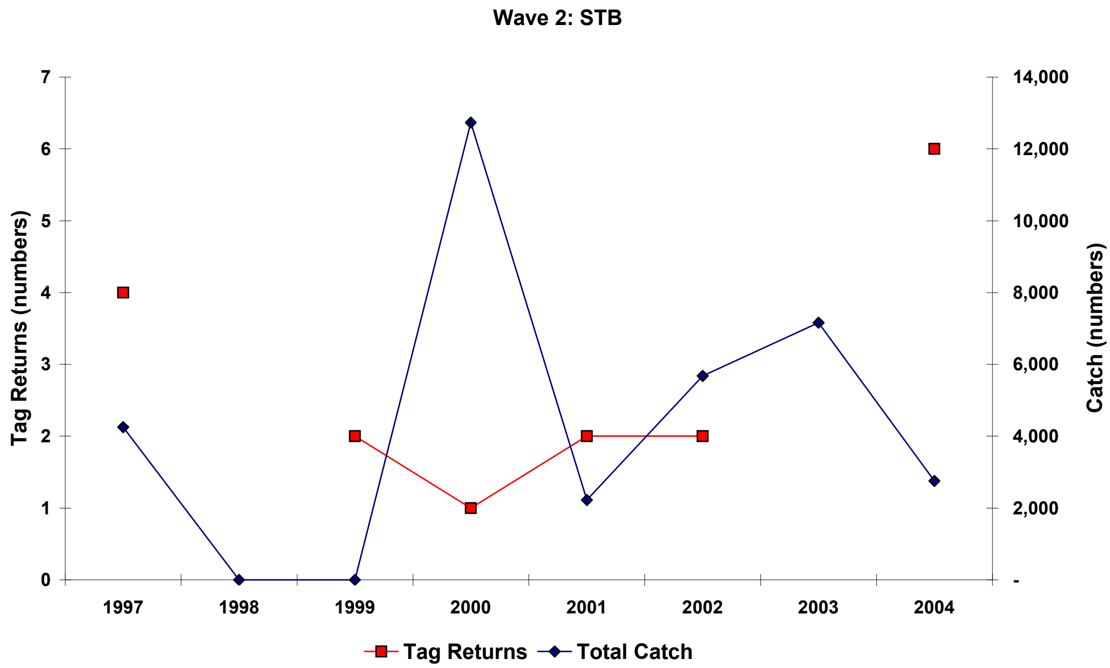


Figure 5. Wave-2 tag returns versus total harvest for Virginia.

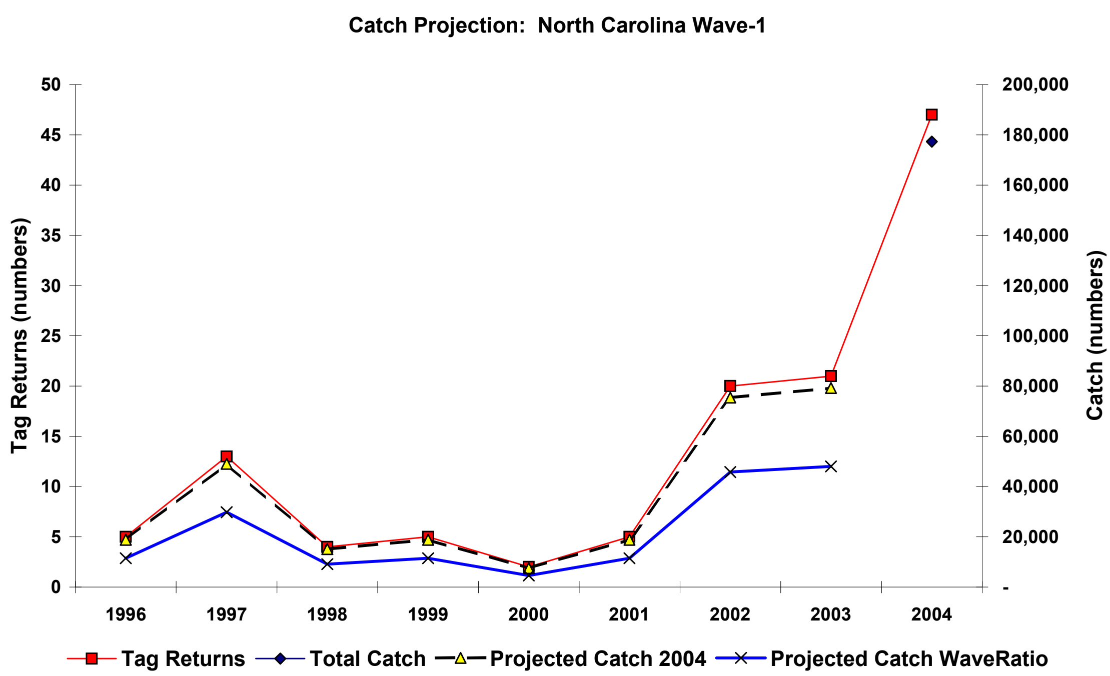


Figure 6. Comparison of harvest projections for North Carolina wave-1.

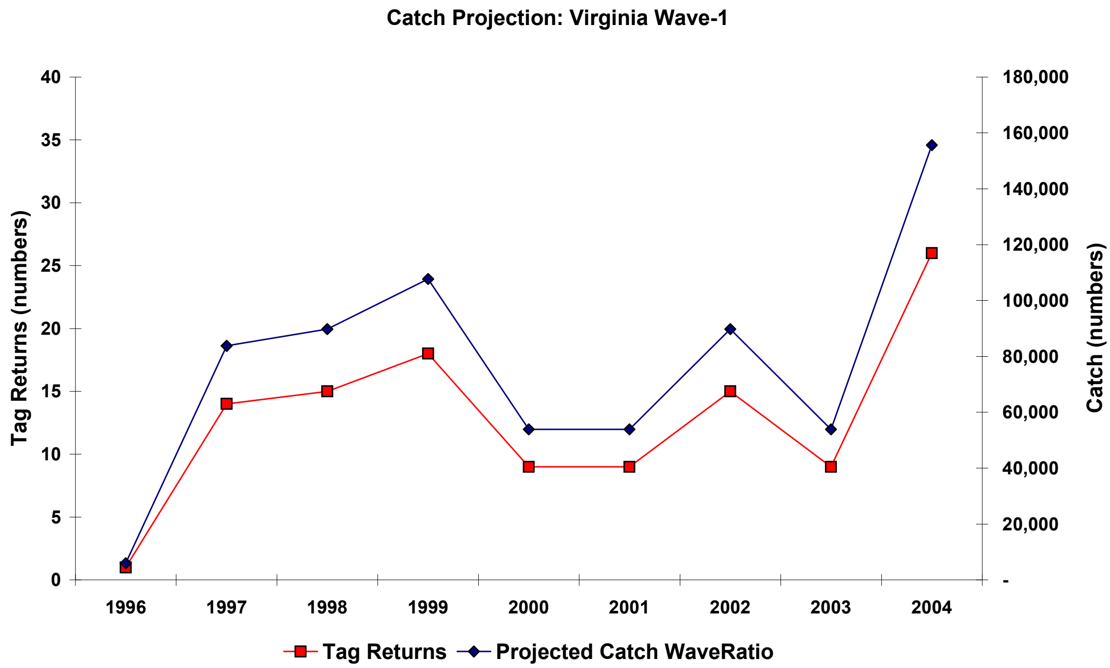


Figure 7. Harvest projection for Virginia wave-1.

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

<u>TASK 4 (Comments from Laura Lee)</u>

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		
Wave : 6		
Species : STRIPED BASS		
Geographic Area: VIRGINIA		
Fishing Mode : ALL MODES COMBINED		
Fishing Area : ALL OCEAN COMBINED		
Type of Catch : HARVEST (TYPE A + B1)		
Information:		
NUMBERS OF FISH		
Year	HARVEST	NumPSE
2004	44,948	19
2005	53,922	23
2006	114,336	15
2007	18,139	20
2008	39,752	18

Year : From: 2004 To: 2008		
Wave : 6		
Species : STRIPED BASS		
Geographic Area: NORTH CAROLINA		
Fishing Mode : ALL MODES COMBINED		
Fishing Area : ALL OCEAN COMBINED		
Type of Catch : HARVEST (TYPE A + B1)		
Information:		
NUMBERS OF FISH		
Year	HARVEST	NumPSE
2004	92,276	18
2005	31,139	28
2006	4,869	30
2007	4,878	25
2008	2265	36

Year : From: 2005 To: 2008		
Wave : 1		
Species : STRIPED BASS		
Geographic Area: NORTH CAROLINA		
Fishing Mode : ALL MODES COMBINED		
Fishing Area : ALL OCEAN COMBINED		
Type of Catch : HARVEST (TYPE A + B1)		
Information:		
NUMBERS OF FISH		
Year	HARVEST	NumPSE
2005	71,982	26
2006	85,884	23
2007	36,382	27
2008	41,741	26

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:

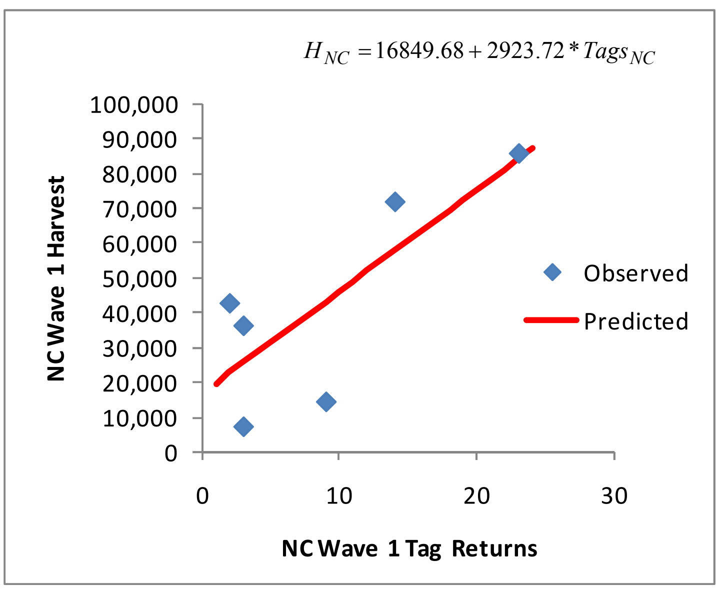
Region = "COAST", disposition="K"
recapturertype="H" or "S",
event=1
capmonth =1 or 2
capyear=2009 or 2010
State = "NC" (or "VA")

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.



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.

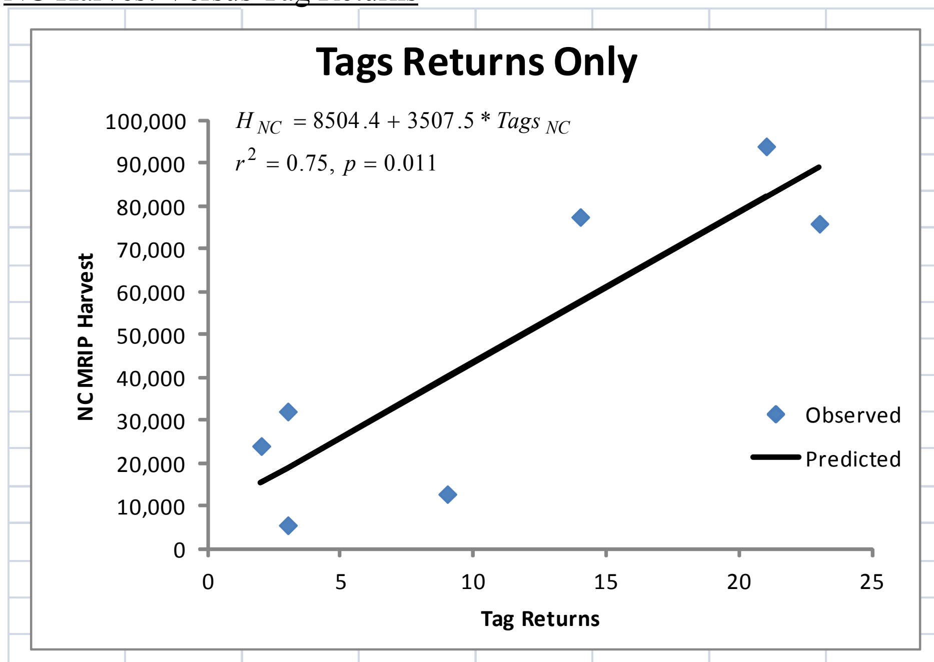
New VA Wave 1 Estimates for 2005-2011 MRIP Updated

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

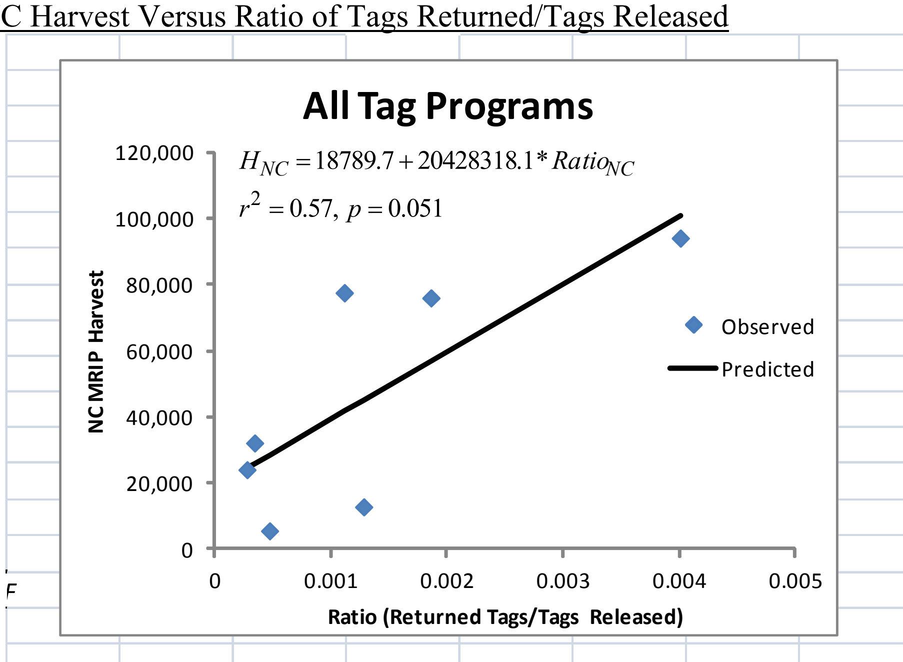
Additional analyses were conducted to determine if a better covariate might be the ratio of tags returned to the total number of fish released with tags by all tagging programs since tag returns are likely to be dependent on the total number released.

NC Harvest Versus Tag Returns



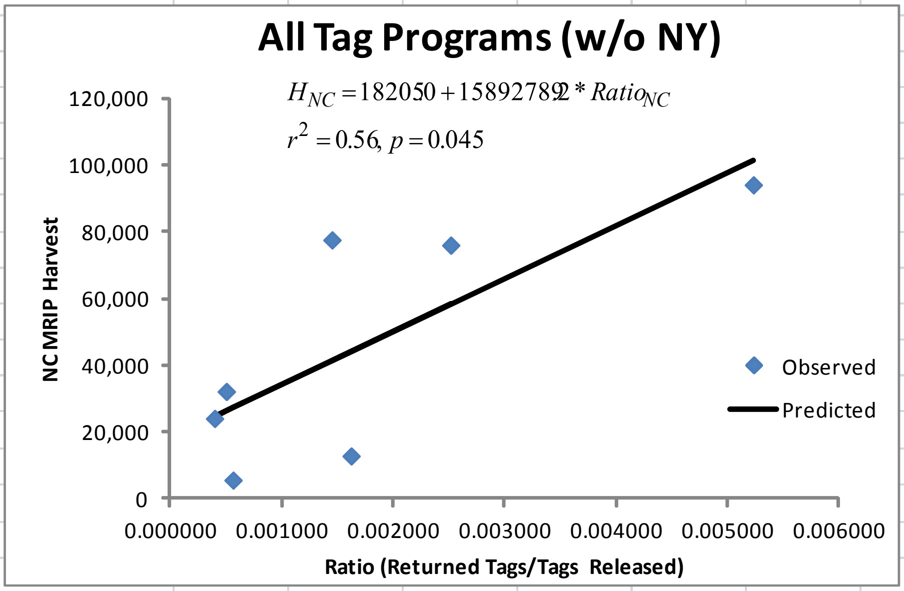
There was a strong linear relationship between MRIP harvest and tag returns for NC. The r^2 for the regression was fairly high (0.75).

NC Harvest Versus Ratio of Tags Returned/Tags Released



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 .



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.

<u>Recreational Age Data</u>

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.

<u>Recreational Dead Discards-at-Age</u>
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 (≥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 recommend ations 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

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Lorenzen (1996)

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.

Empirical Estimates

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.

Results

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.

		Age	
Year	1	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

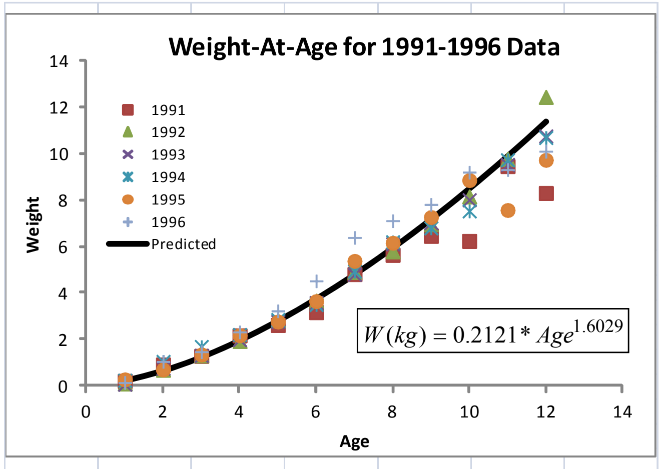


Figure 1. Observed versus predicted weights-at-age.

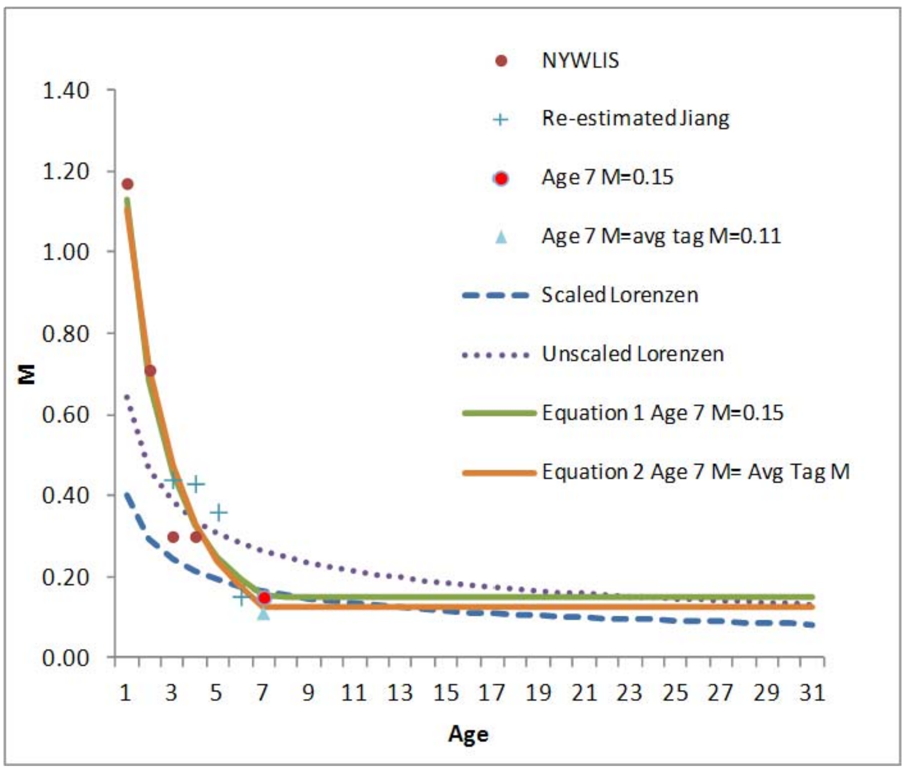


Figure 2. Comparison of estimates of age-specific Ms.

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(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){
```

```
      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

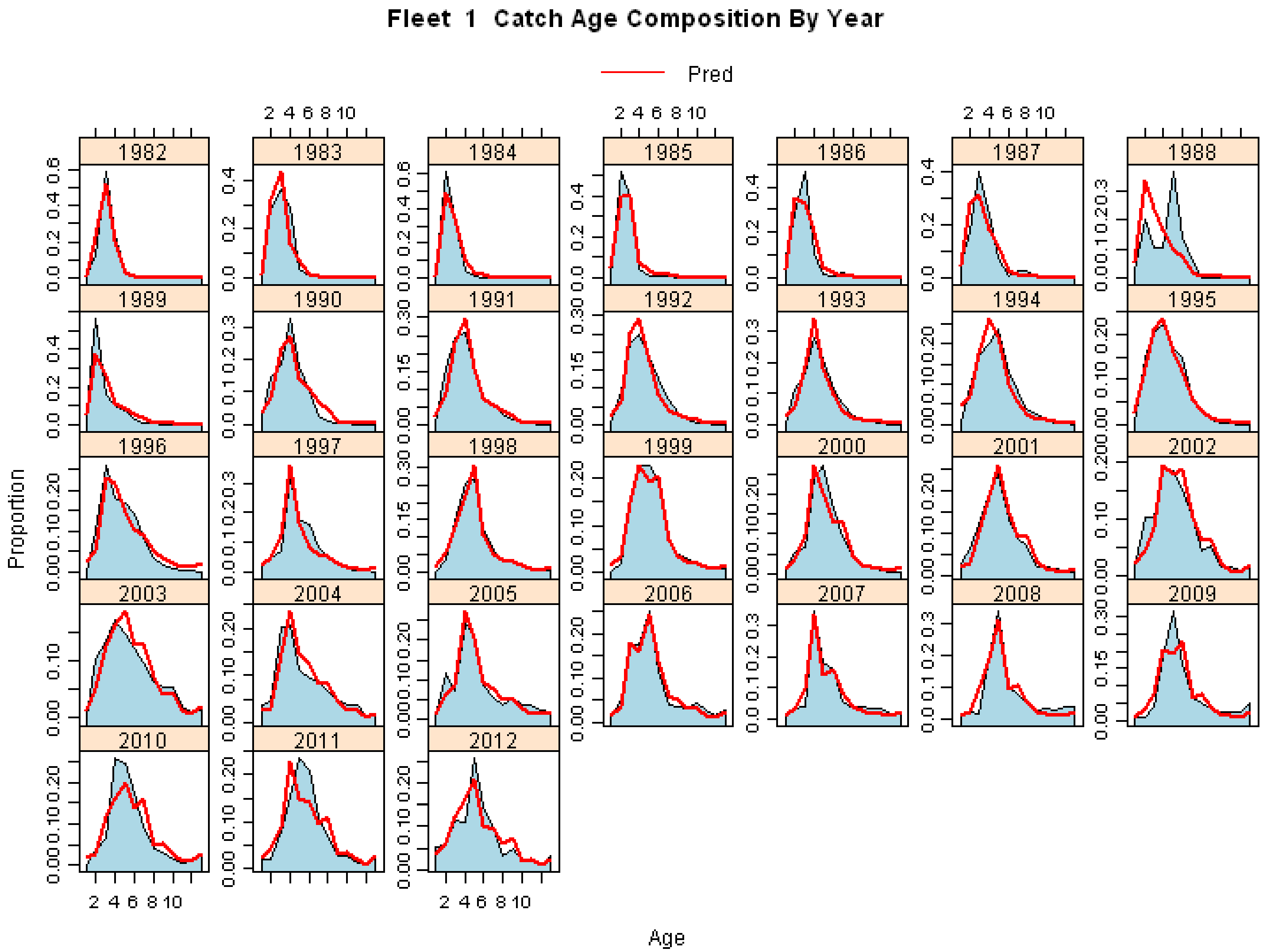


Figure 1. Plots of observed and predicted catch proportions-at-age by year for each fleet.

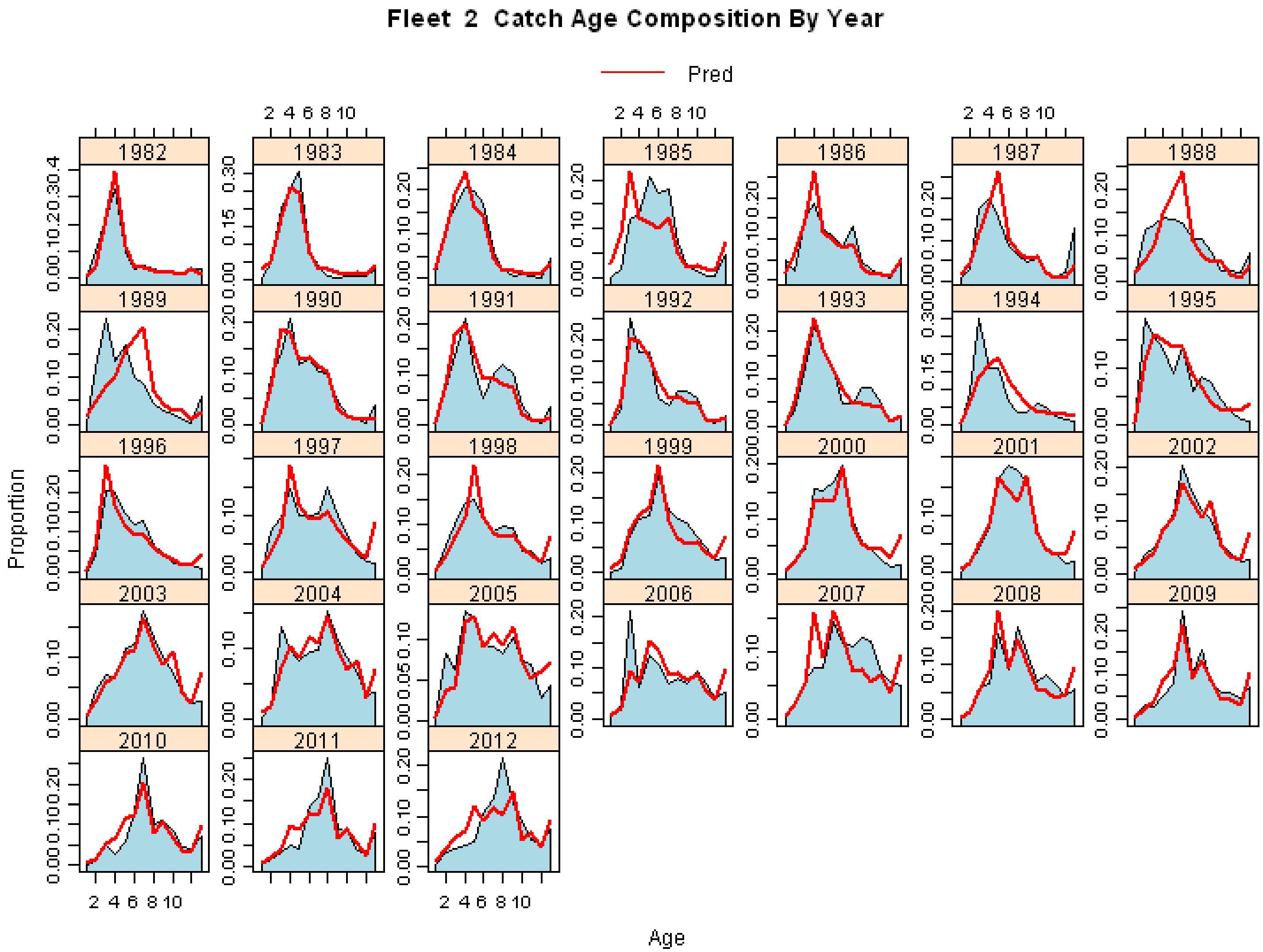


Figure 1 cont.

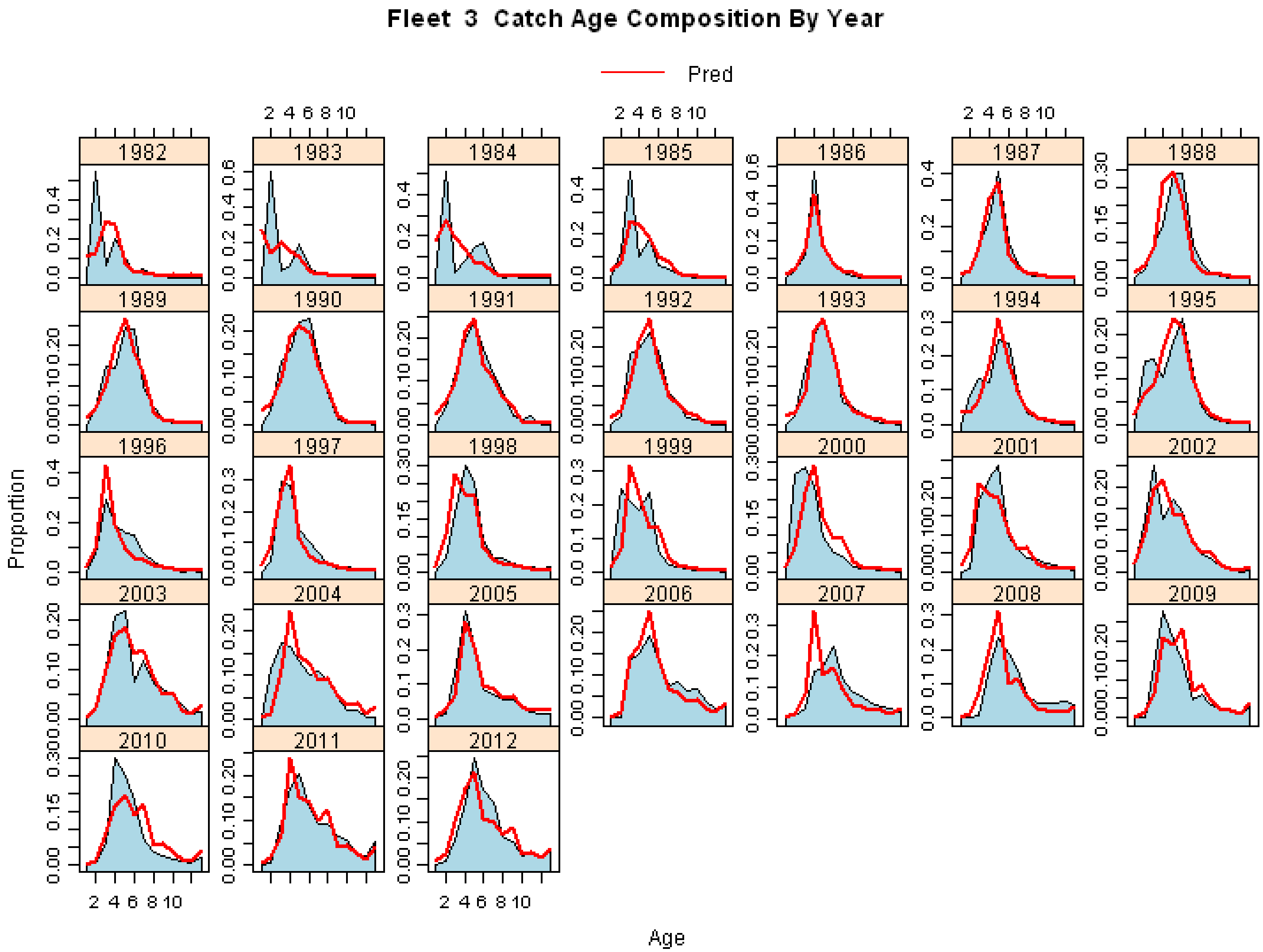


Figure 1 cont.

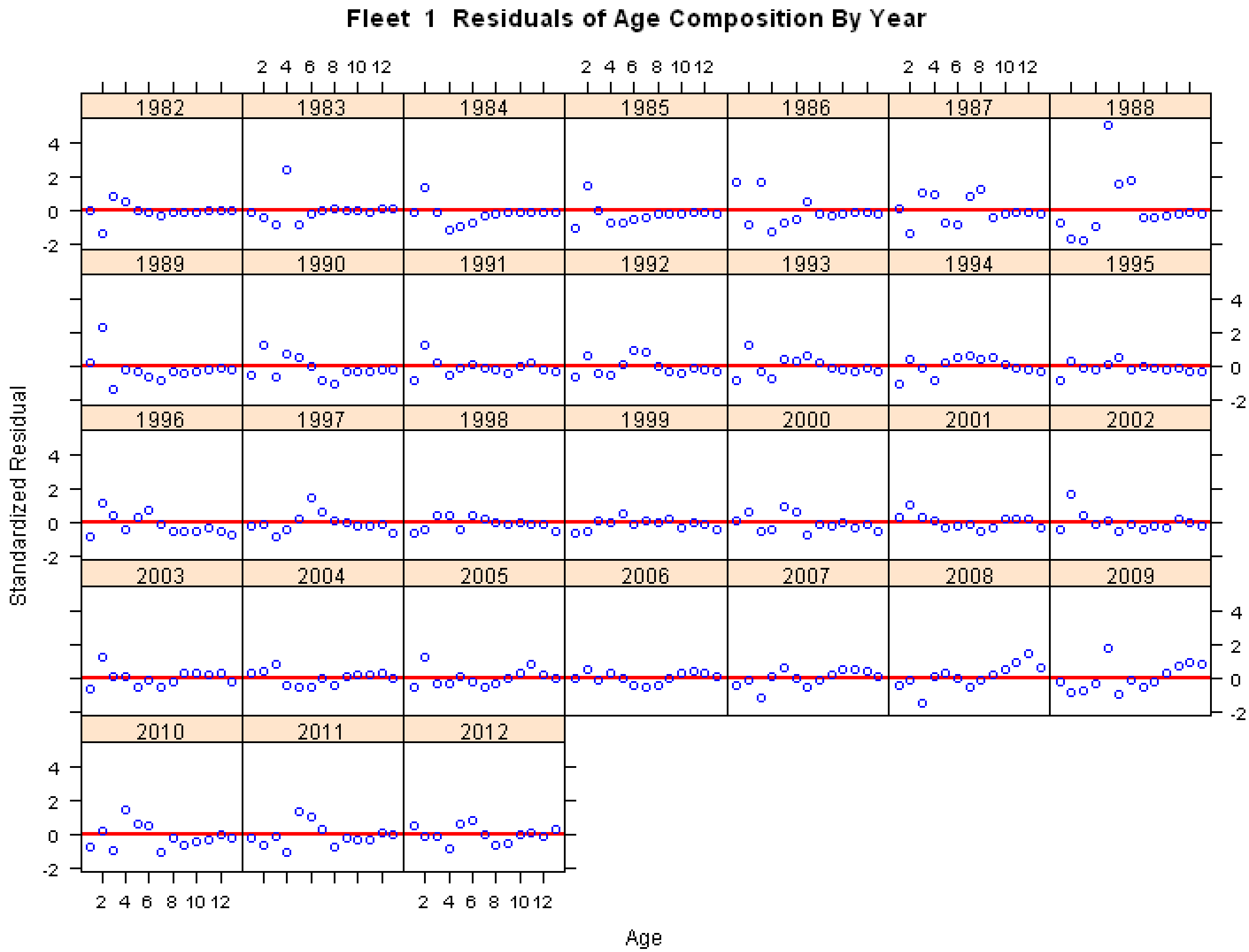


Figure 2. Standardized residuals of catch proportions-at-age by year for each fleet.

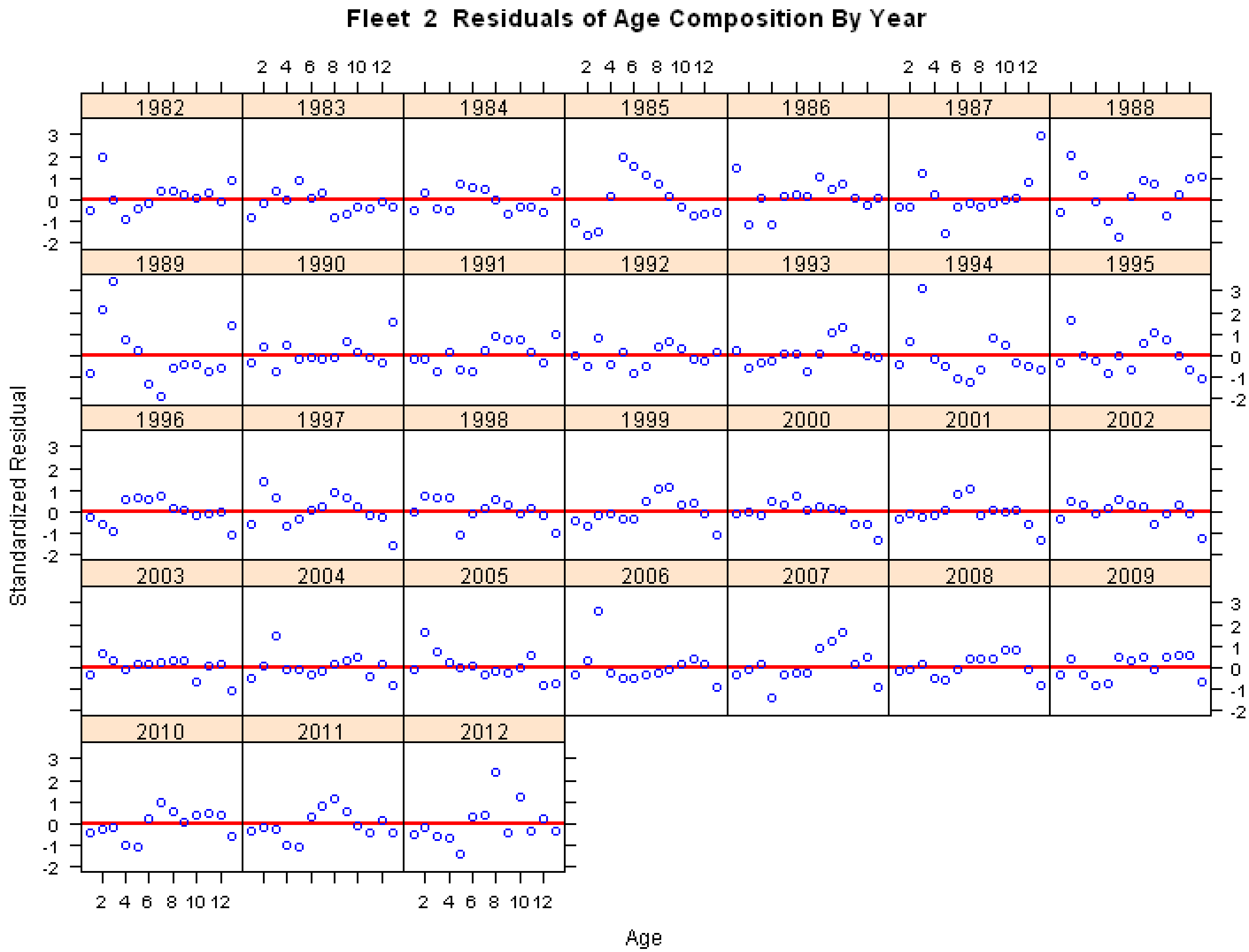


Figure 2 cont.

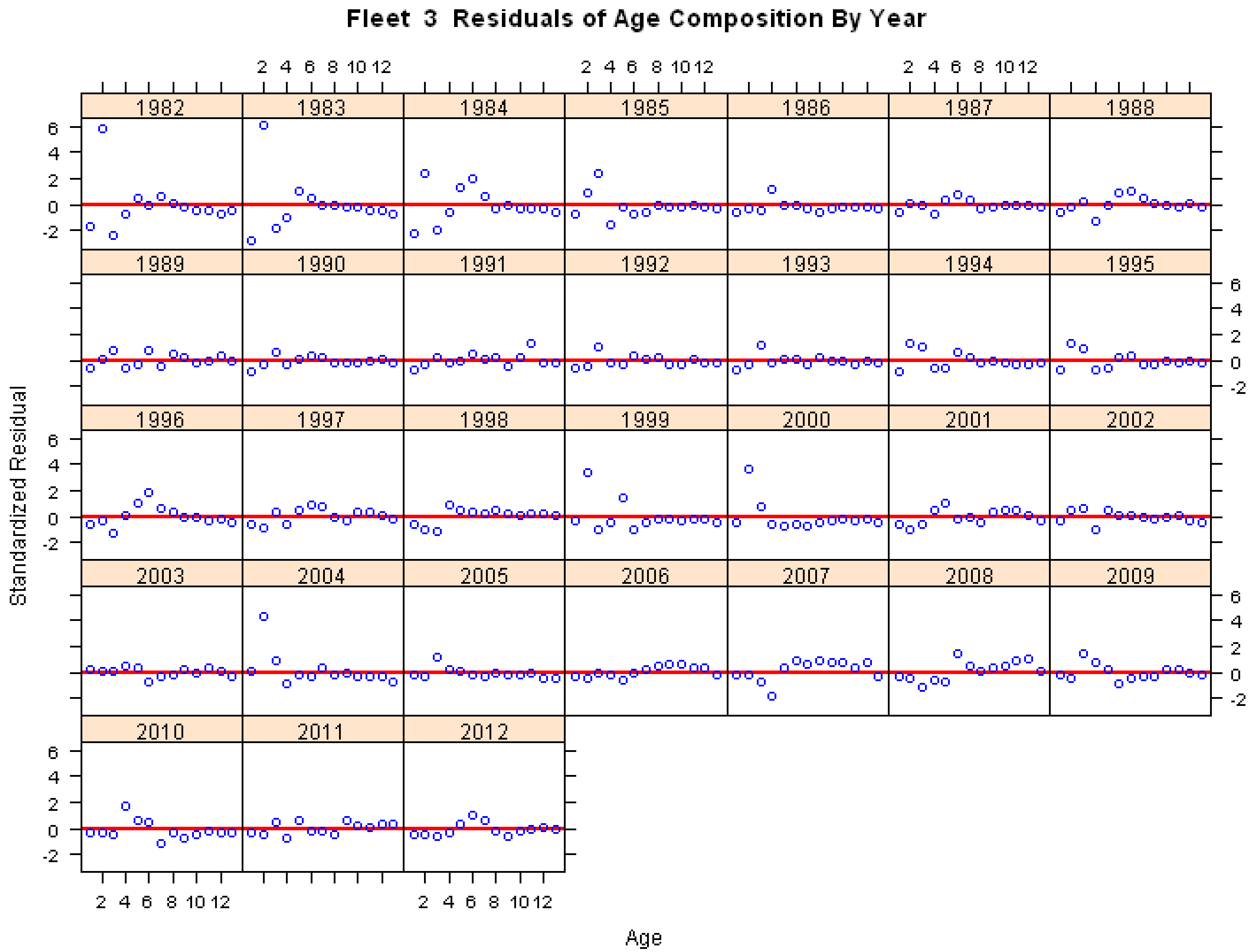


Figure 2 cont.

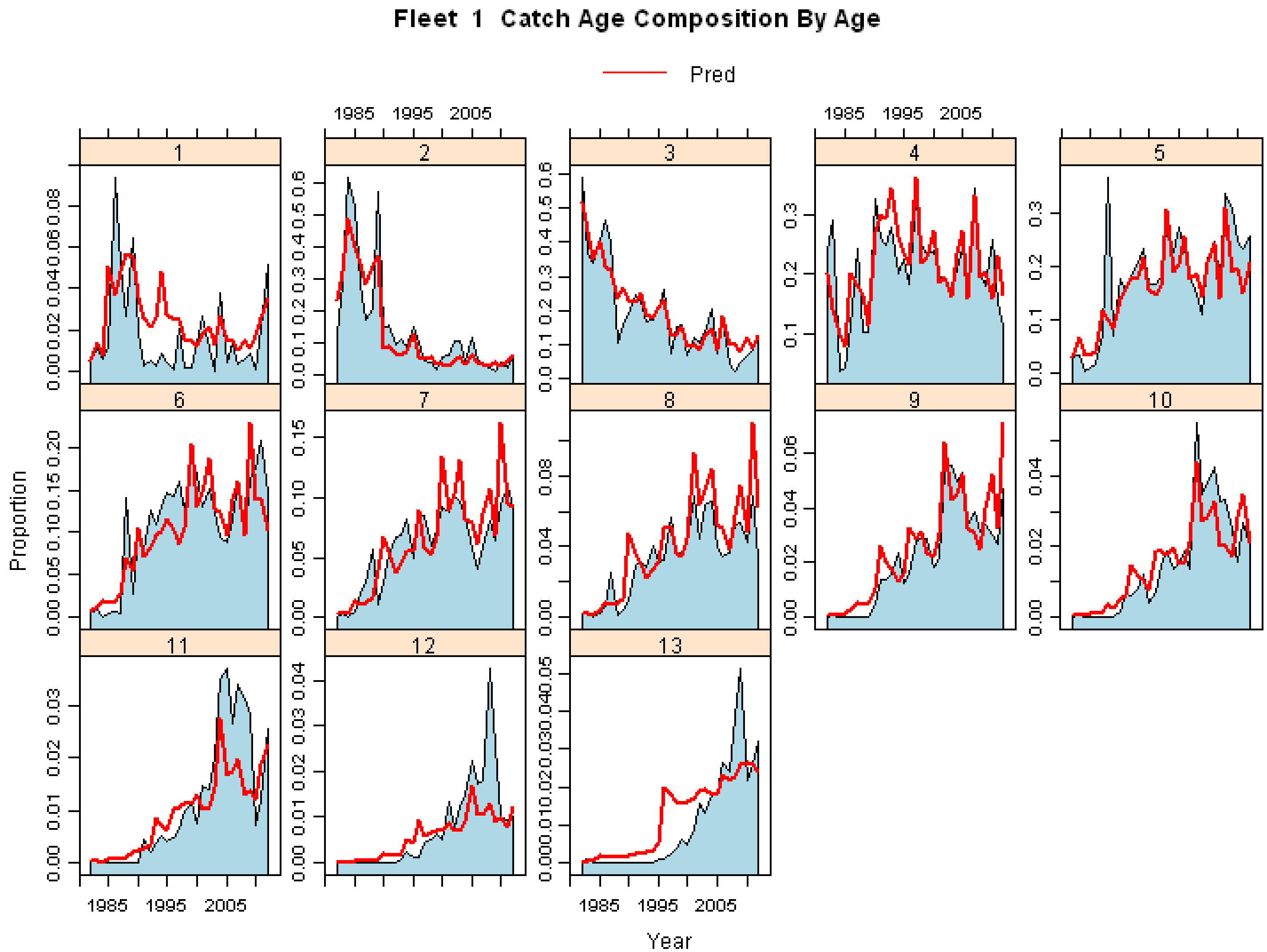


Figure 3 .Observed and predicted catch proportions-at-age by age for each fleet.

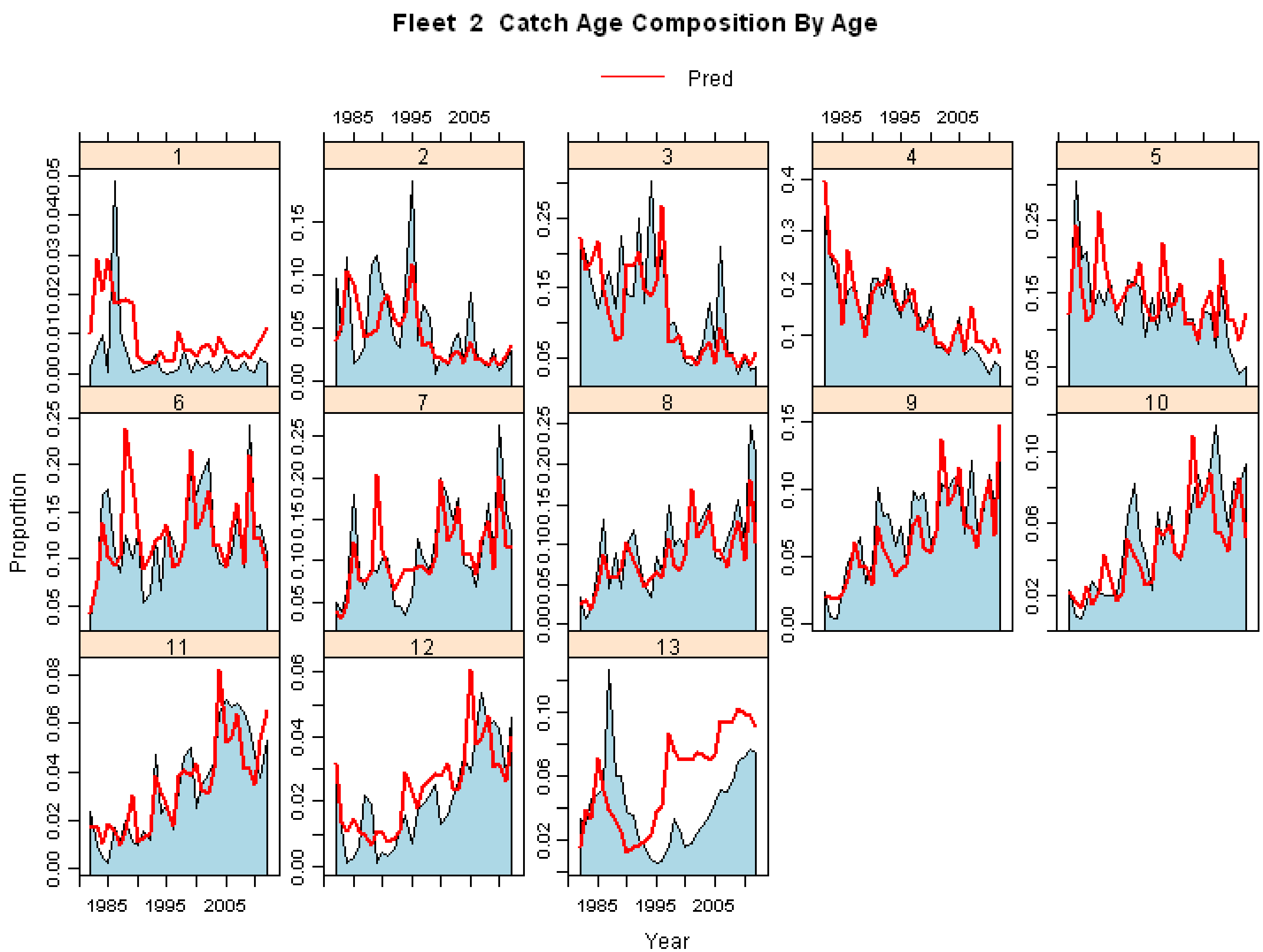


Figure 3 cont.

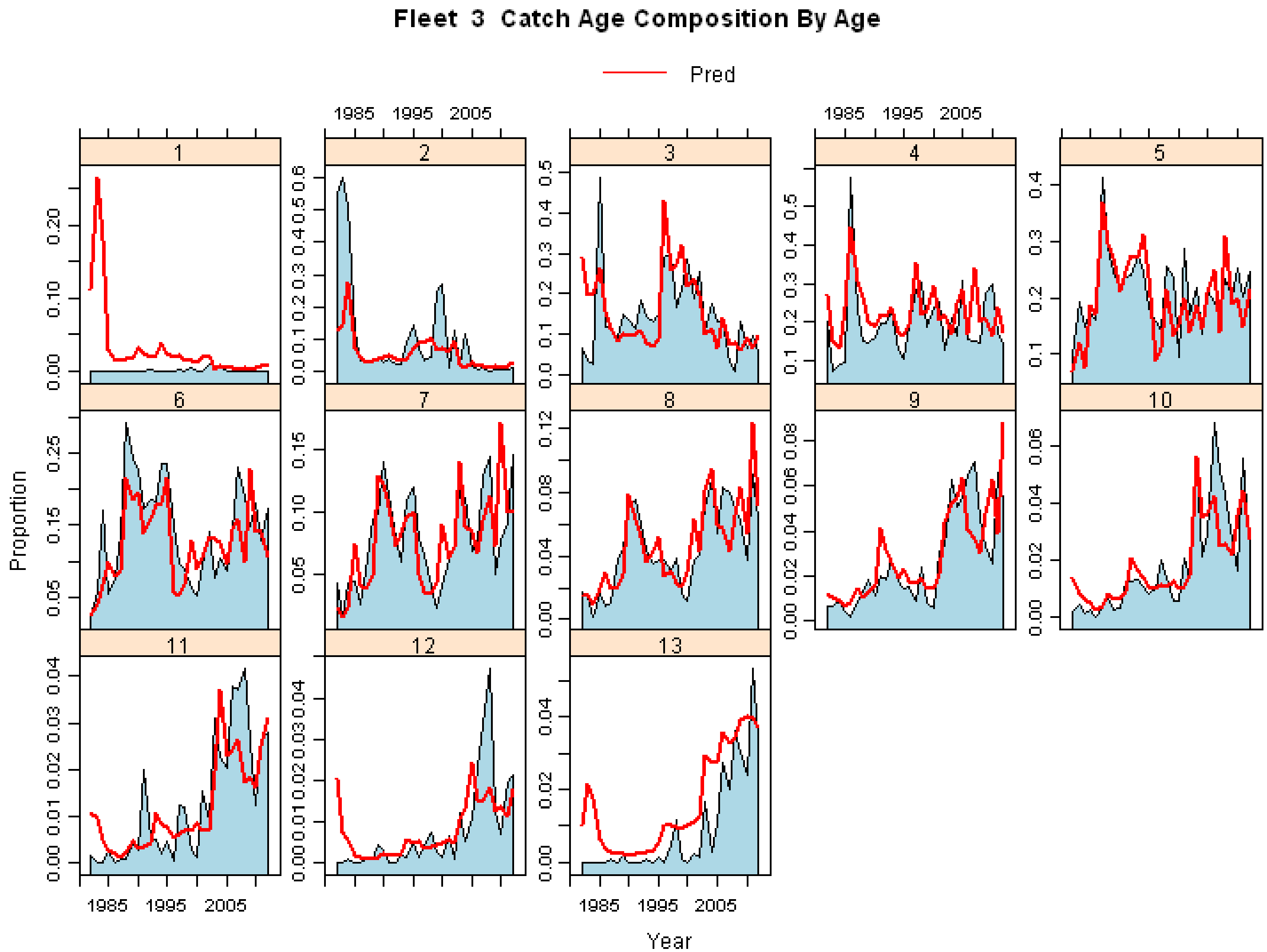


Figure 3 cont.

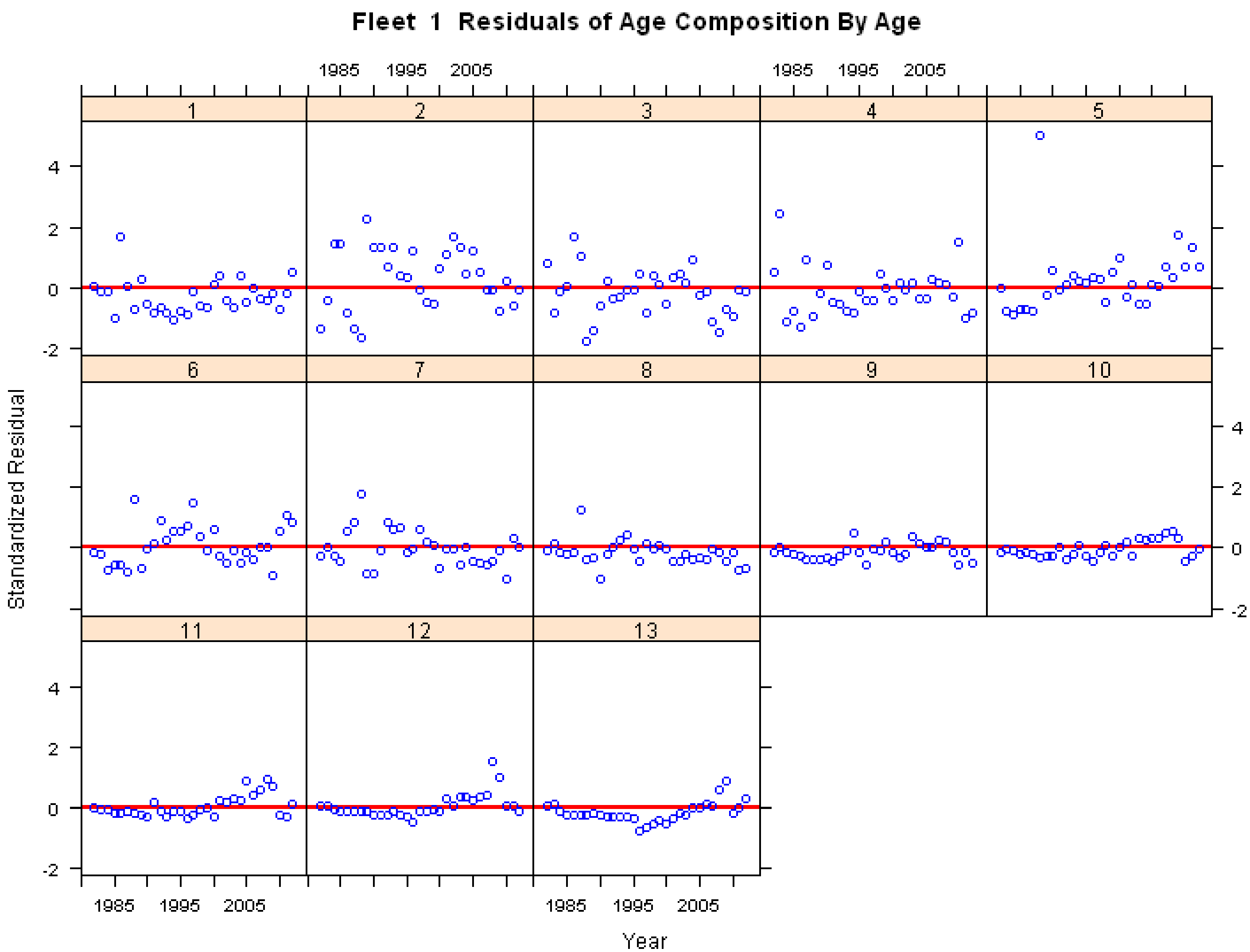
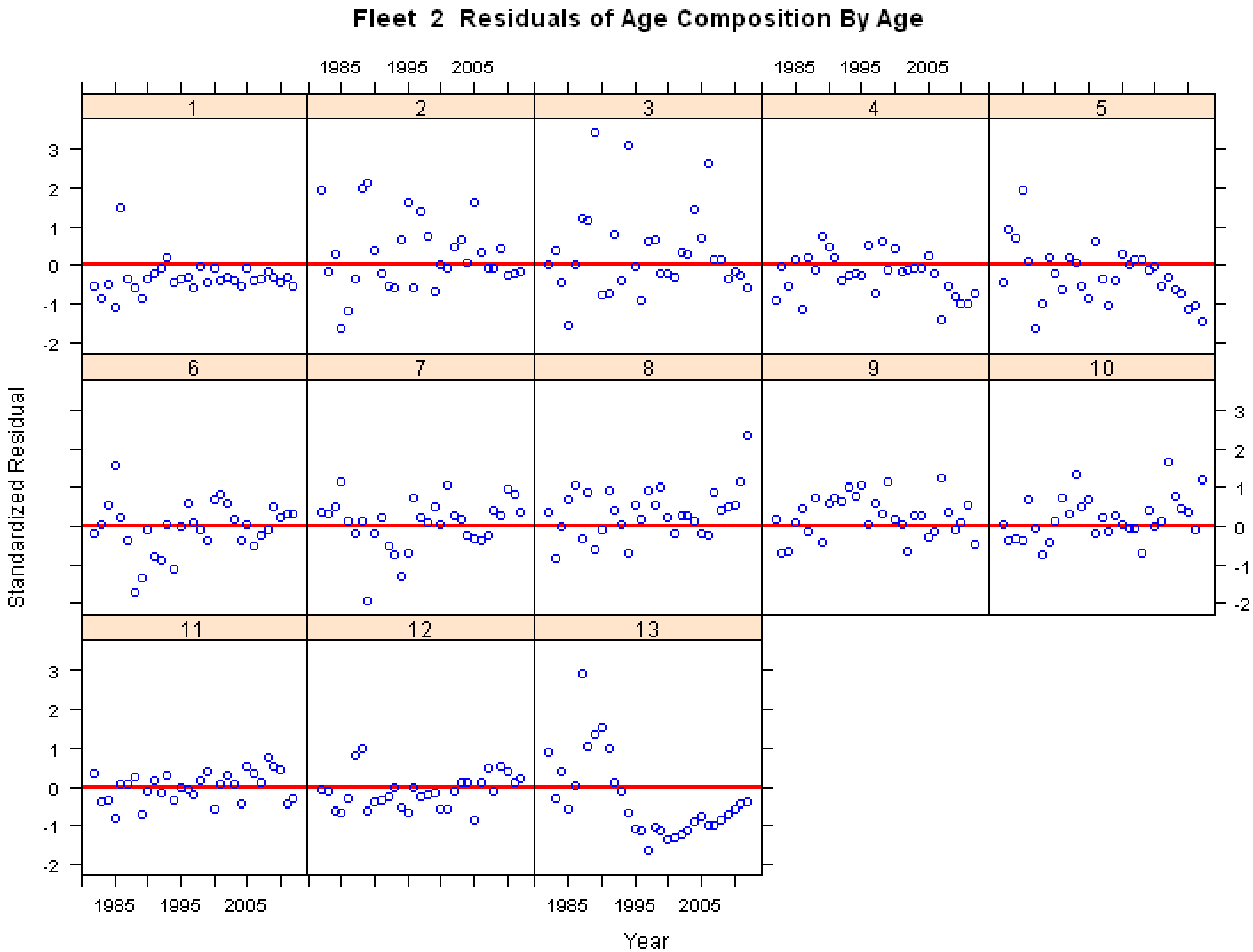


Figure 4. Standardized residuals of catch proportions-at-age by age.



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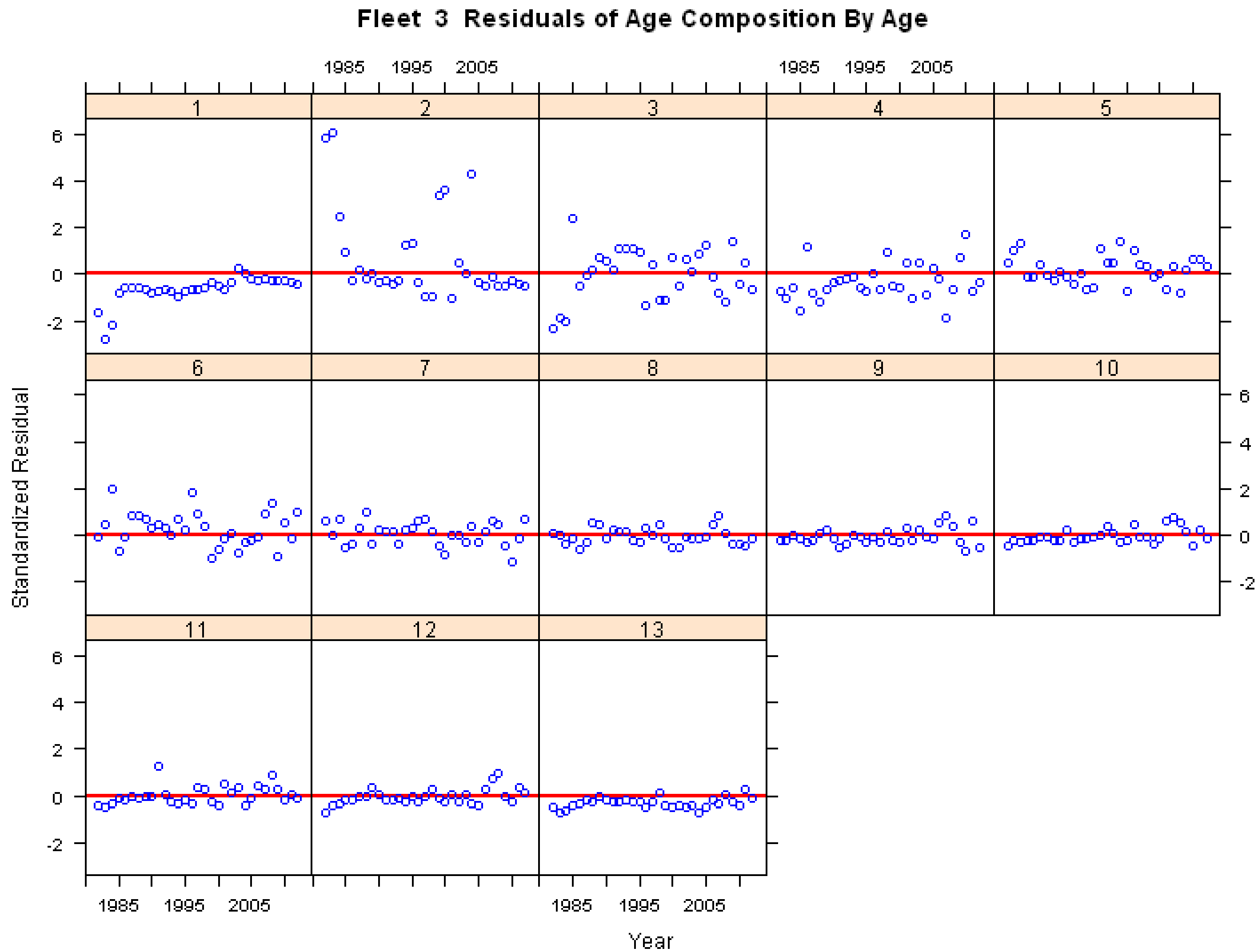


Figure 4 cont.

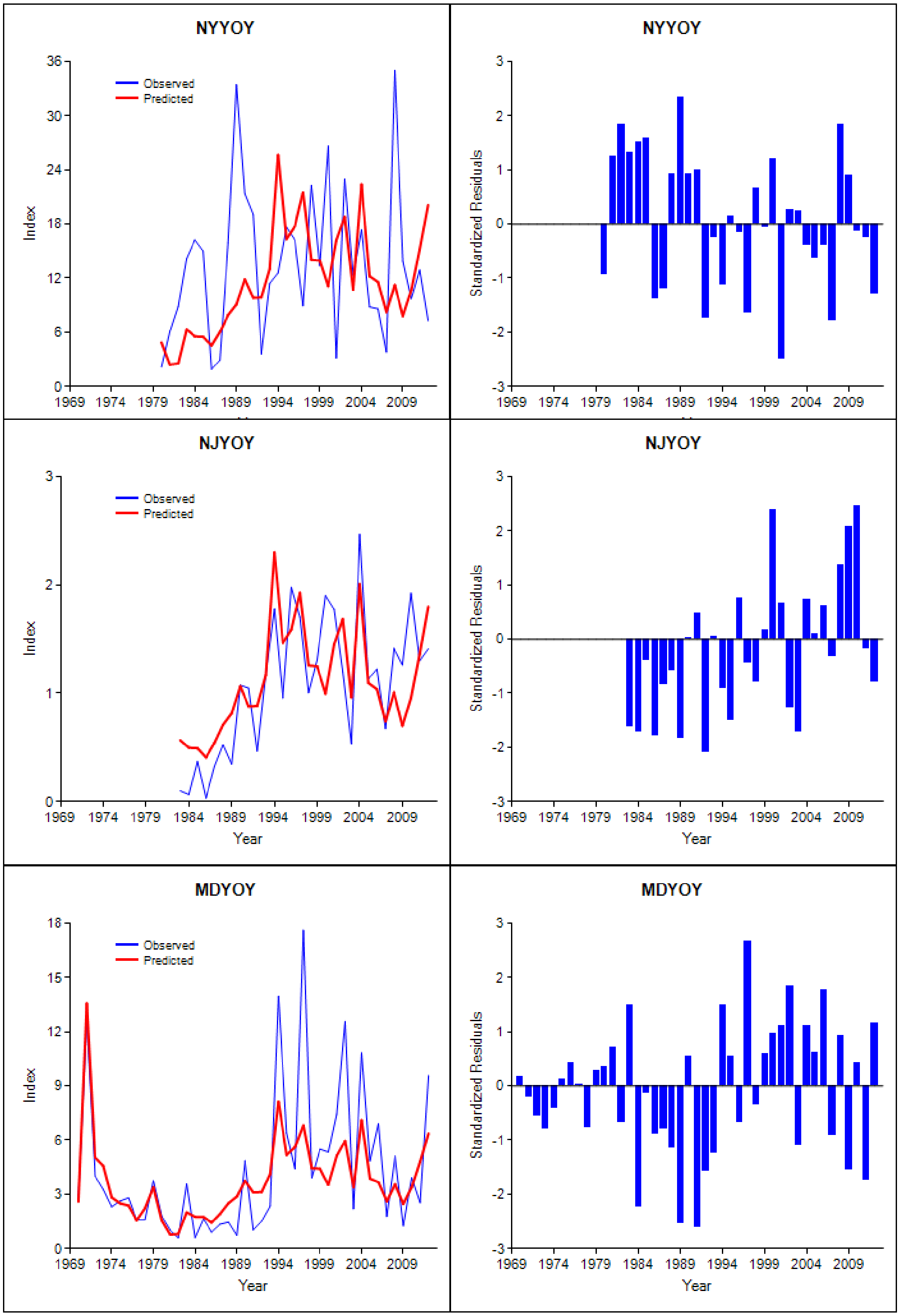


Figure 5. Observed and predicted values and standardized residuals for young-of-the-year and yearling surveys tuned to Age 1 and 2, respectively.

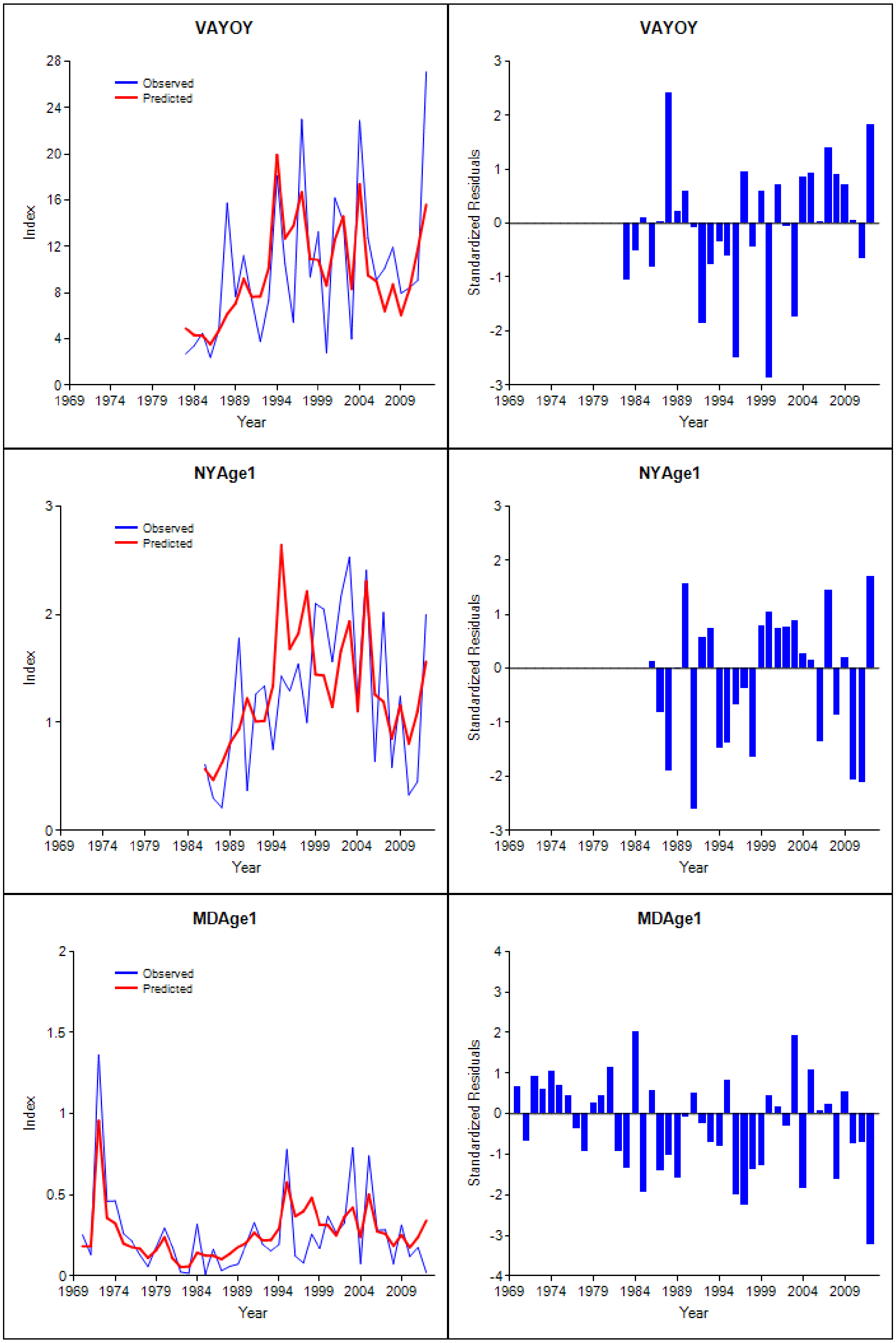


Figure 5 cont.

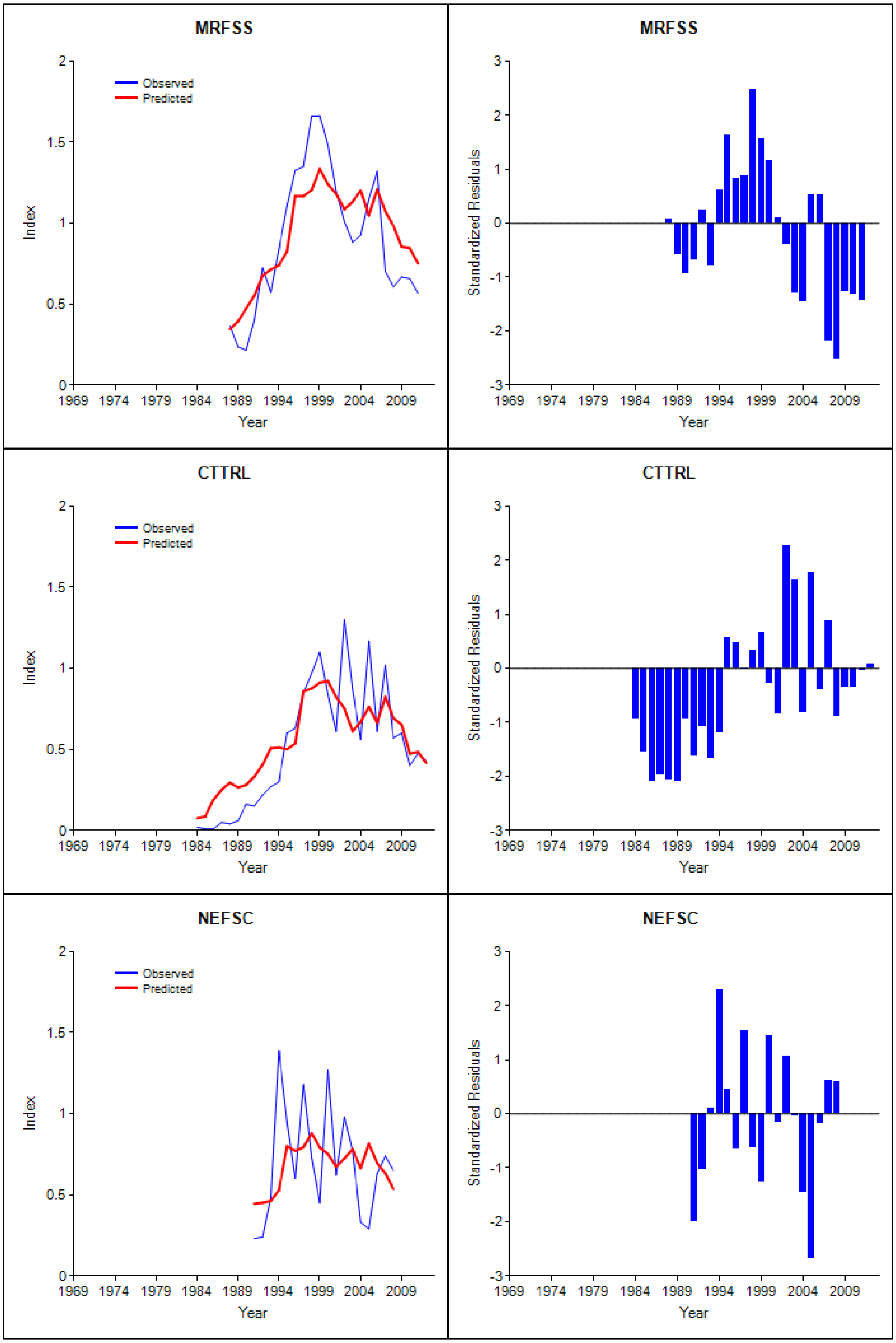


Figure 6. Observed and predicted values and standardized residuals for age-aggregated surveys.

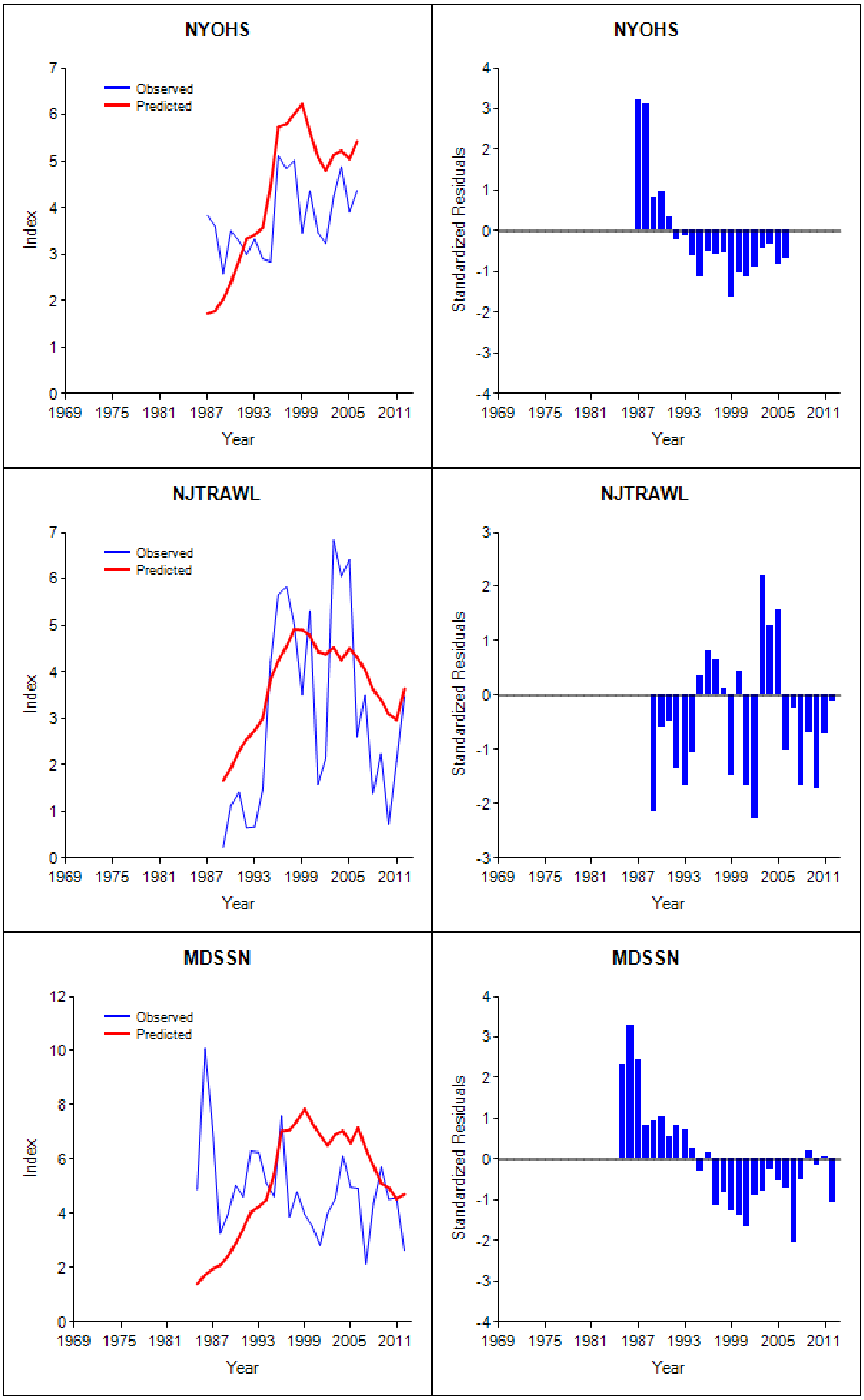


Figure 7. Observed and predicted values of the total index and standardized residuals for surveys with age composition data.

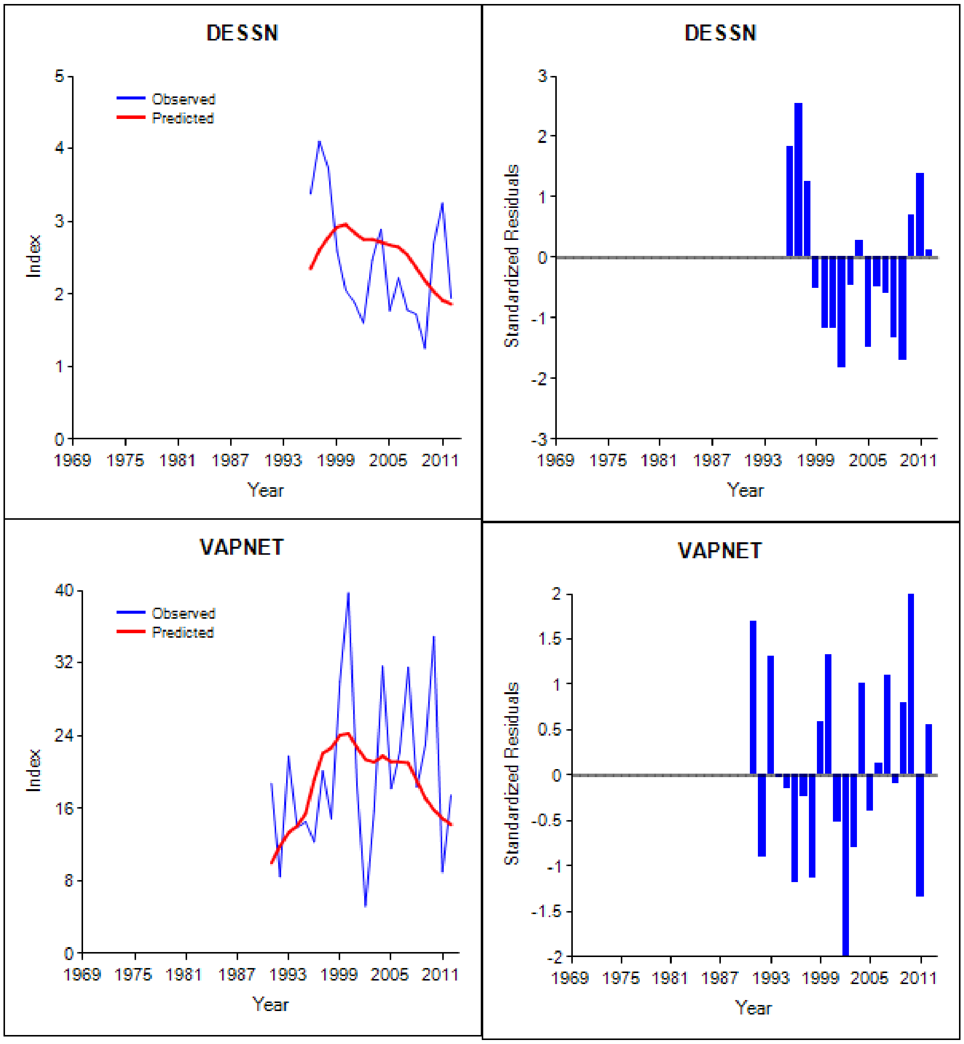


Figure 7 cont.

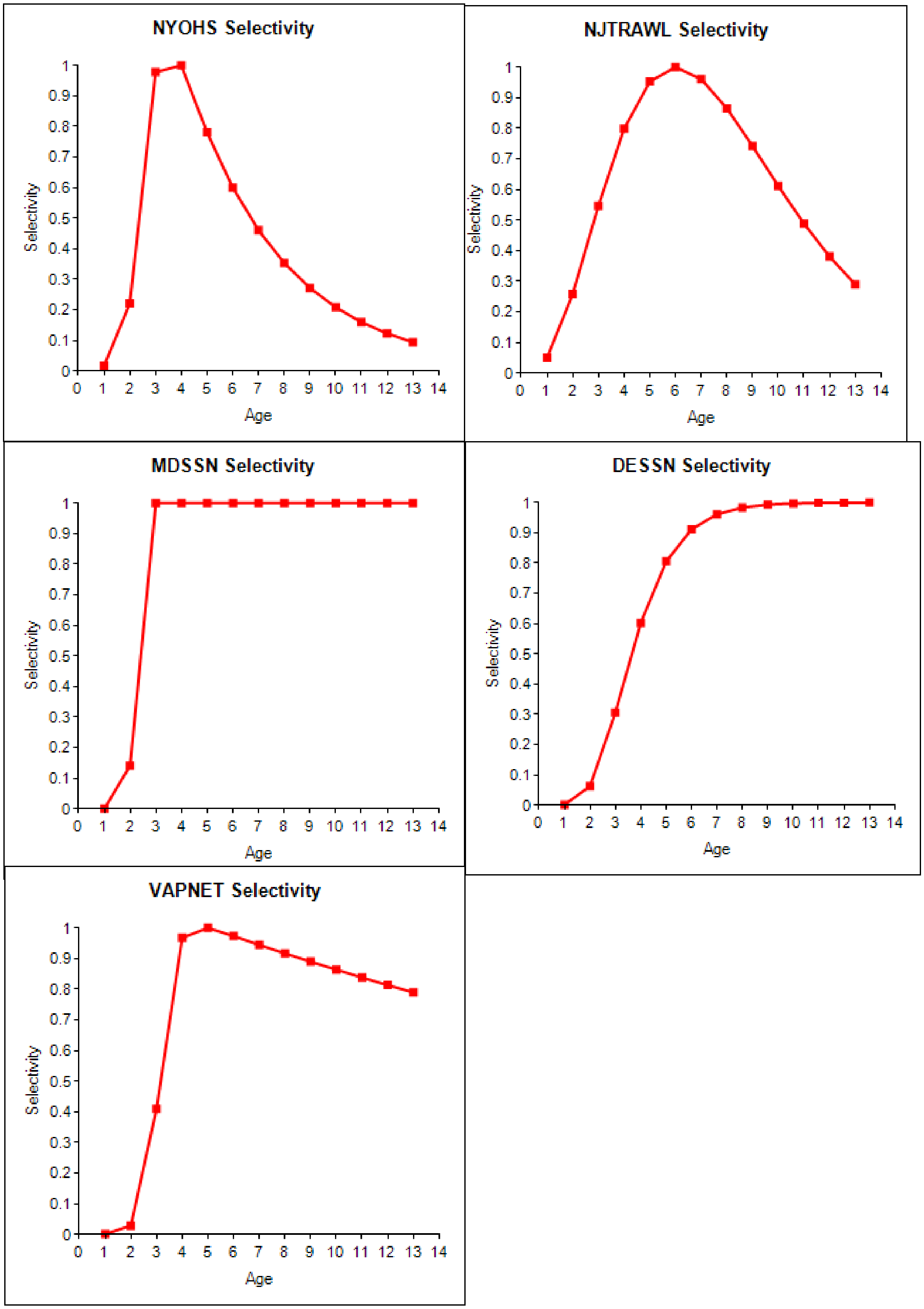


Figure 8. Selectivity patterns estimated for the NYOHS, NJ Trawl, MD SSN, DE SSN surveys and VAPNET.

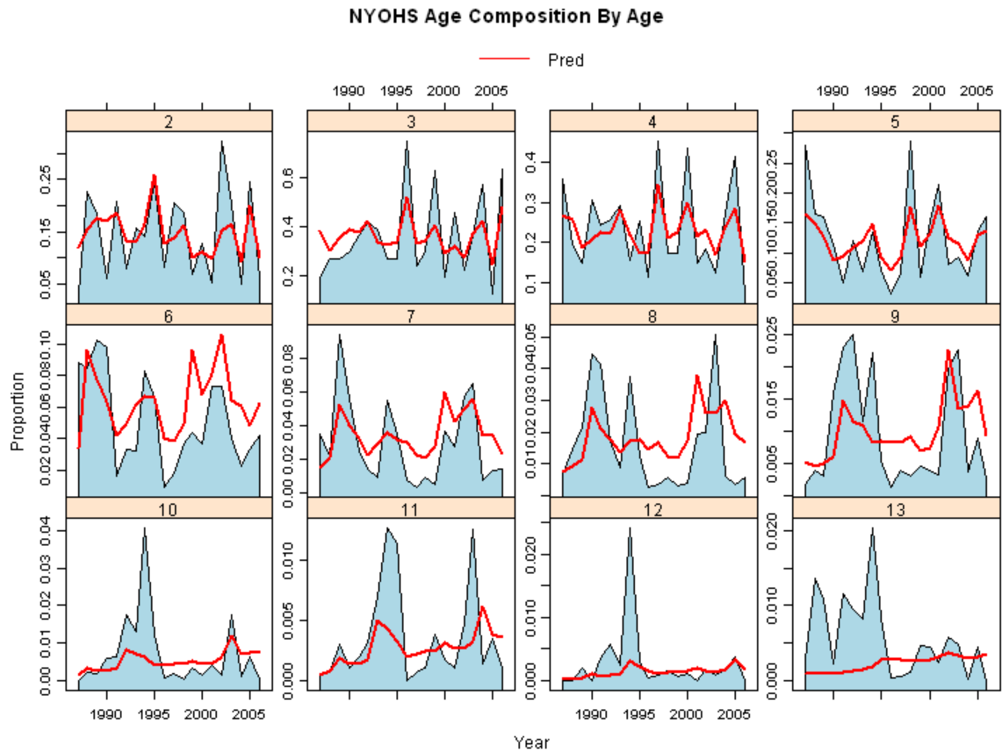
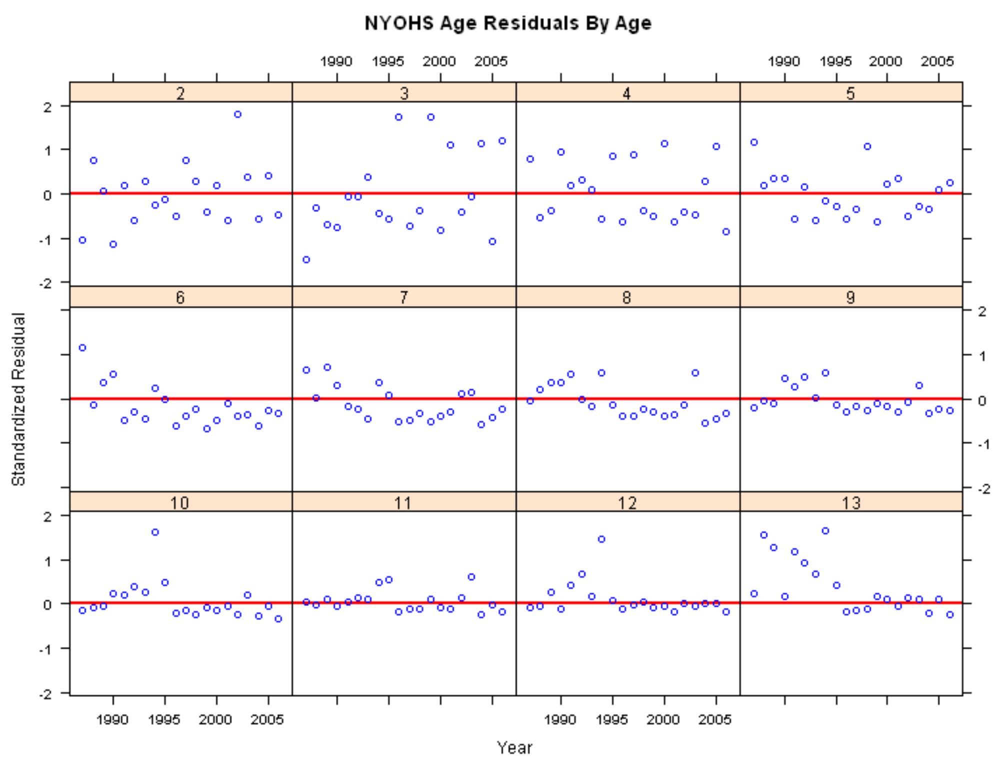


Figure 9. Observed and predicted proportions-at-age and standardized residual for each year by age for the NYOHS survey.



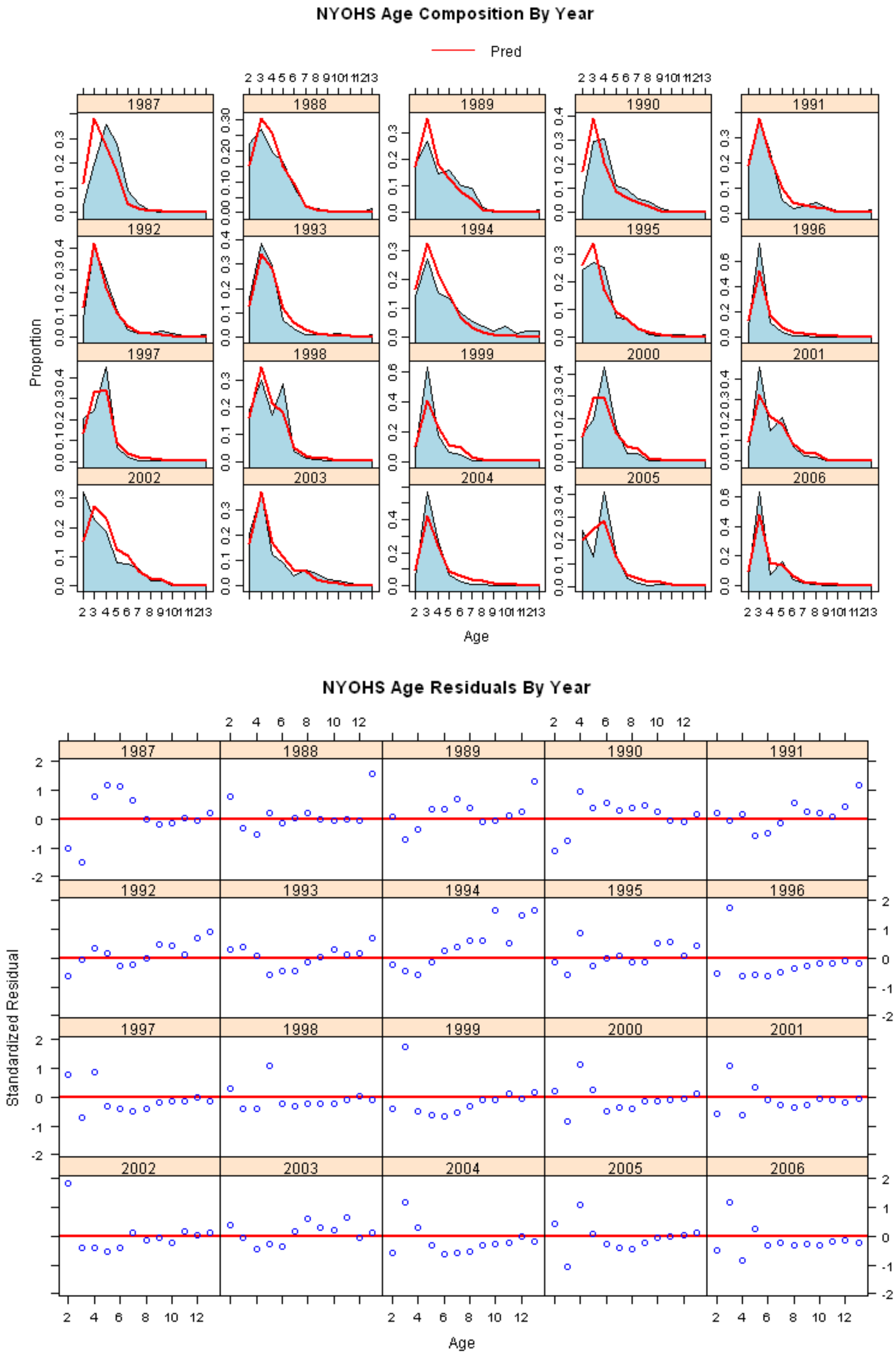
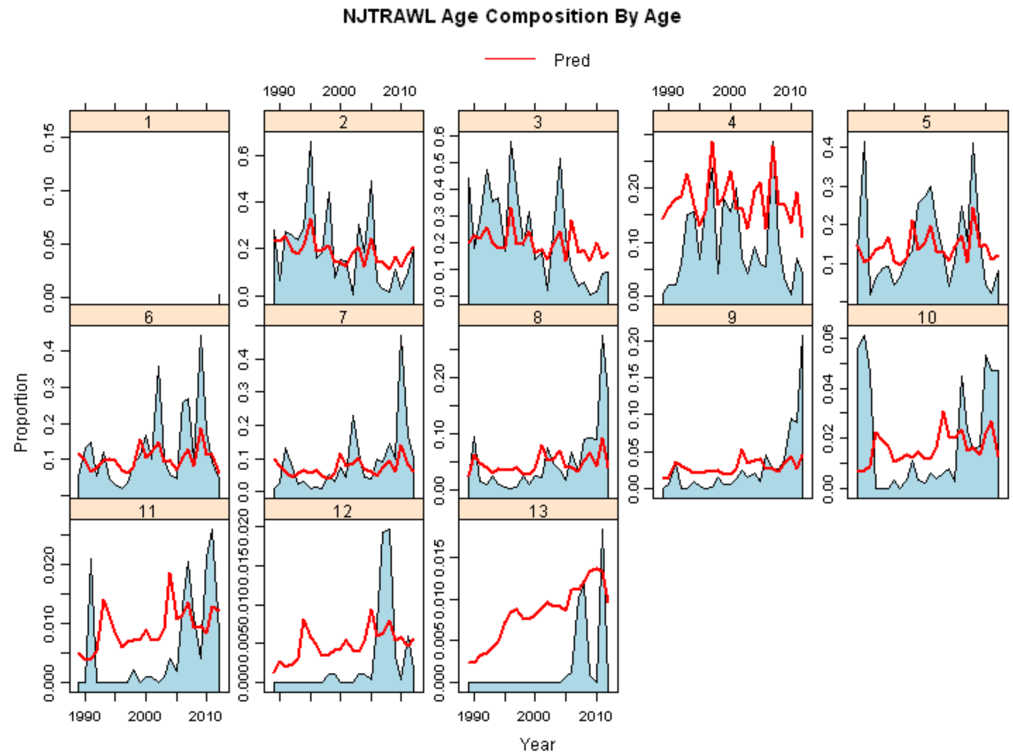


Figure 10. Observed and predicted proportions-at-age and standardized residuals for each age by year for the NYOHS survey.



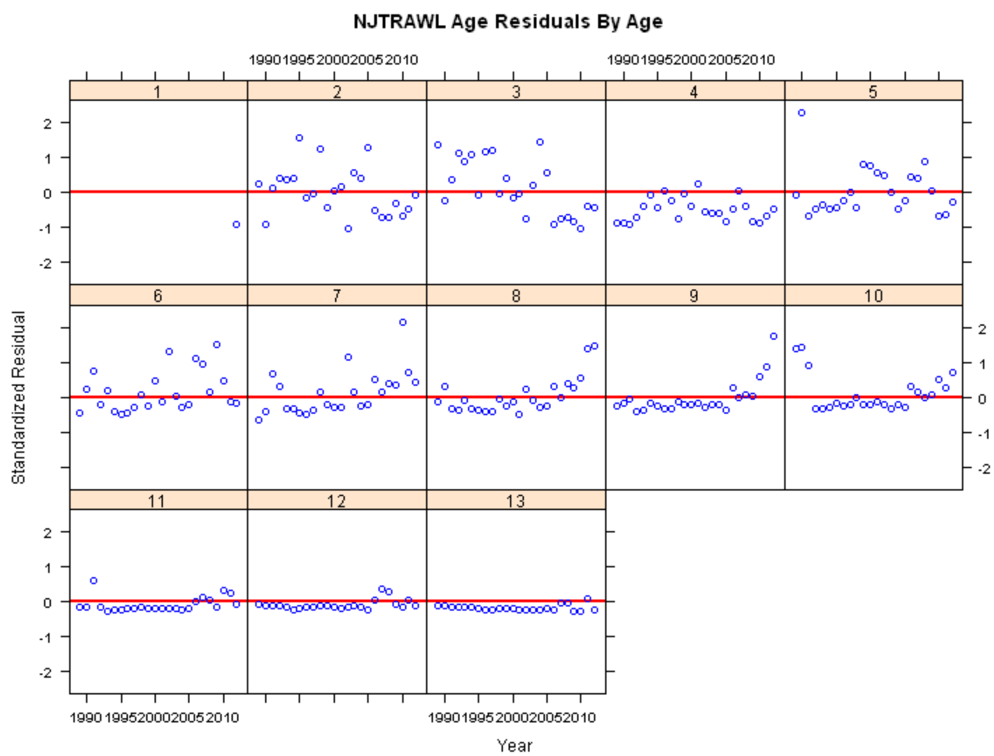
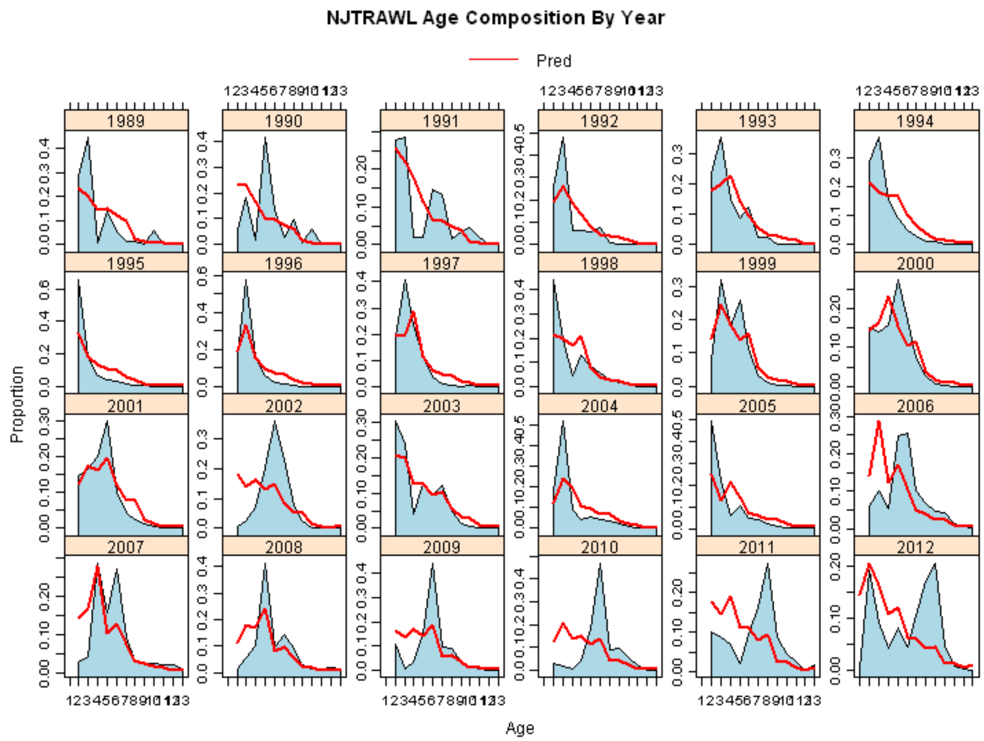


Figure 11. Observed and predicted proportions-at-age and residuals for each year by age for the NJ Trawl survey.



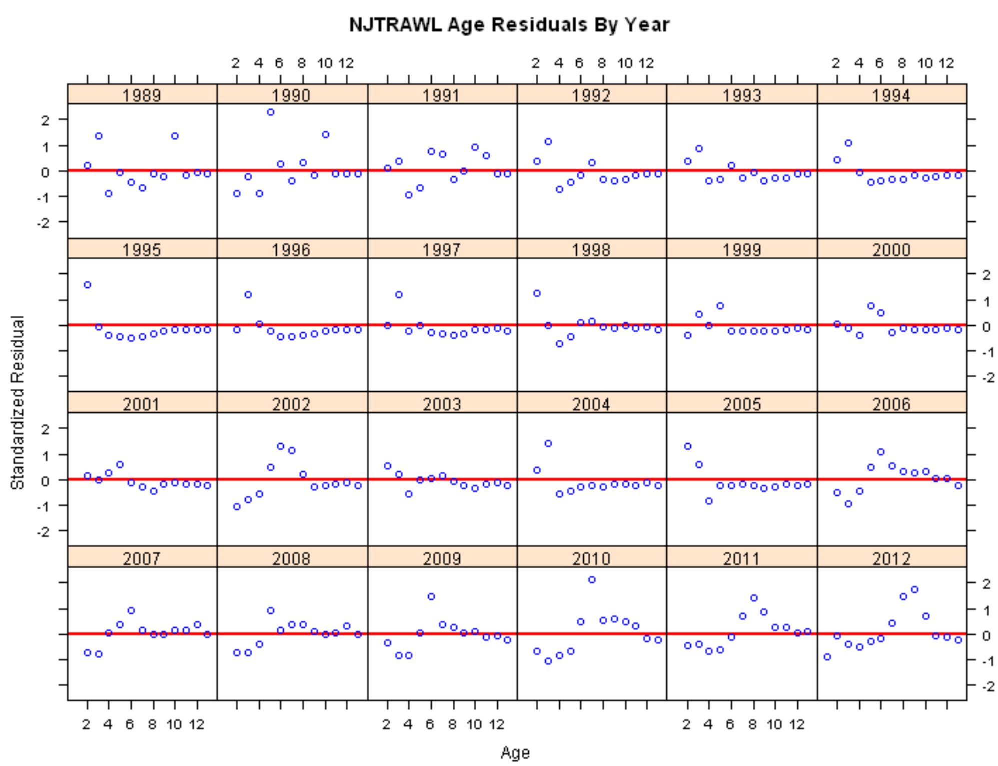


Figure 12. Observed and predicted proportions-at-age and standardized residuals for each age by year for the NJ Trawl survey.

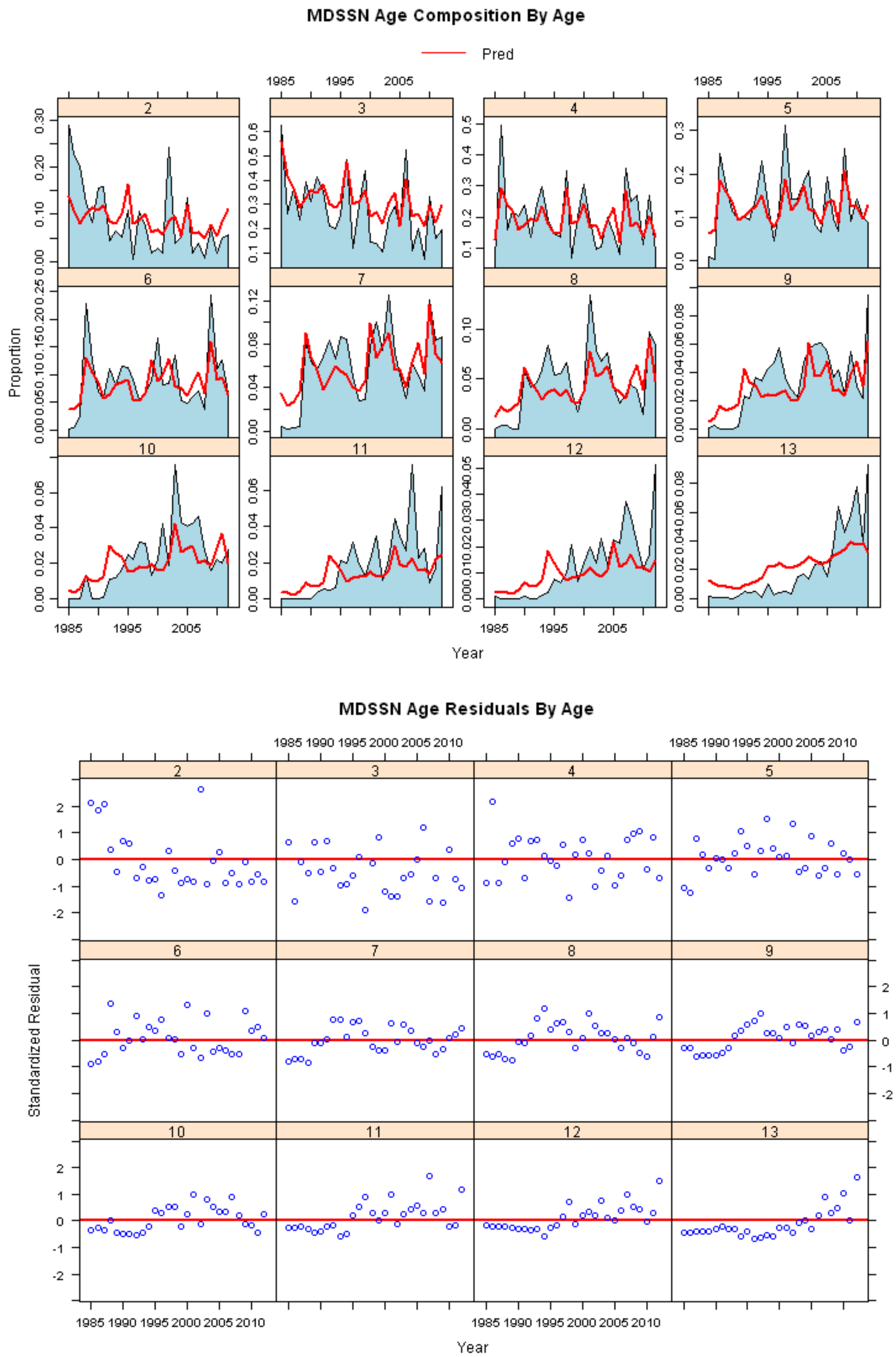
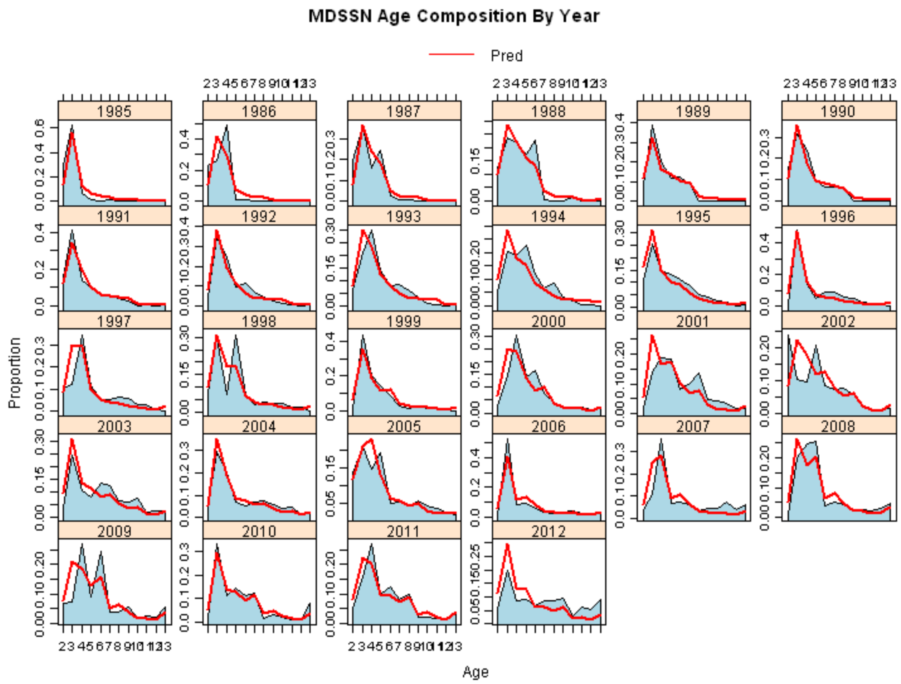


Figure 13. Observed and predicted proportions-at-age and standardized residuals for each year by age for the MD SSN gillnet survey.



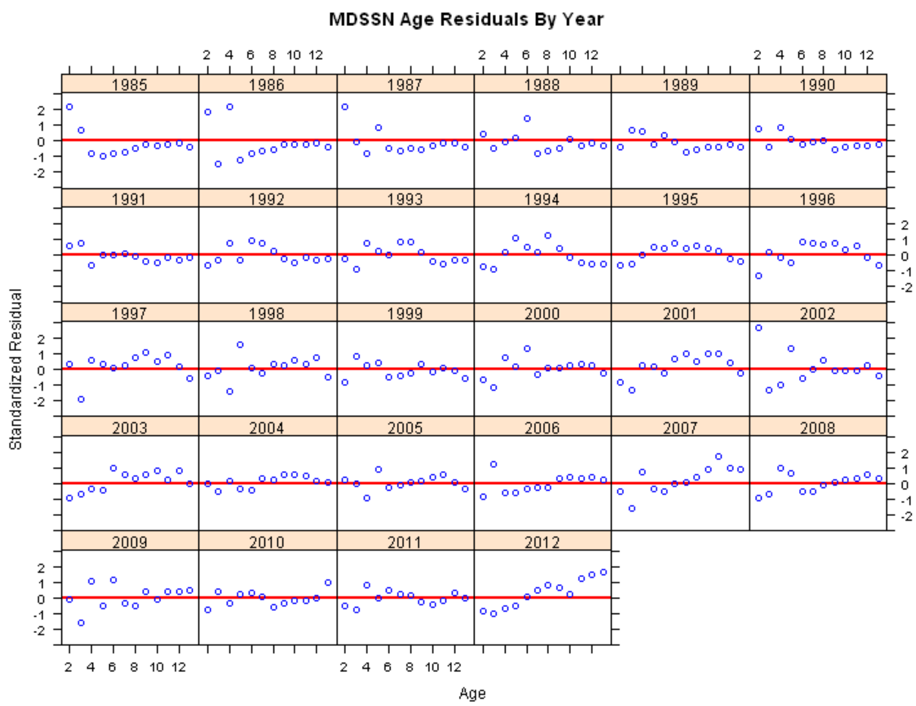
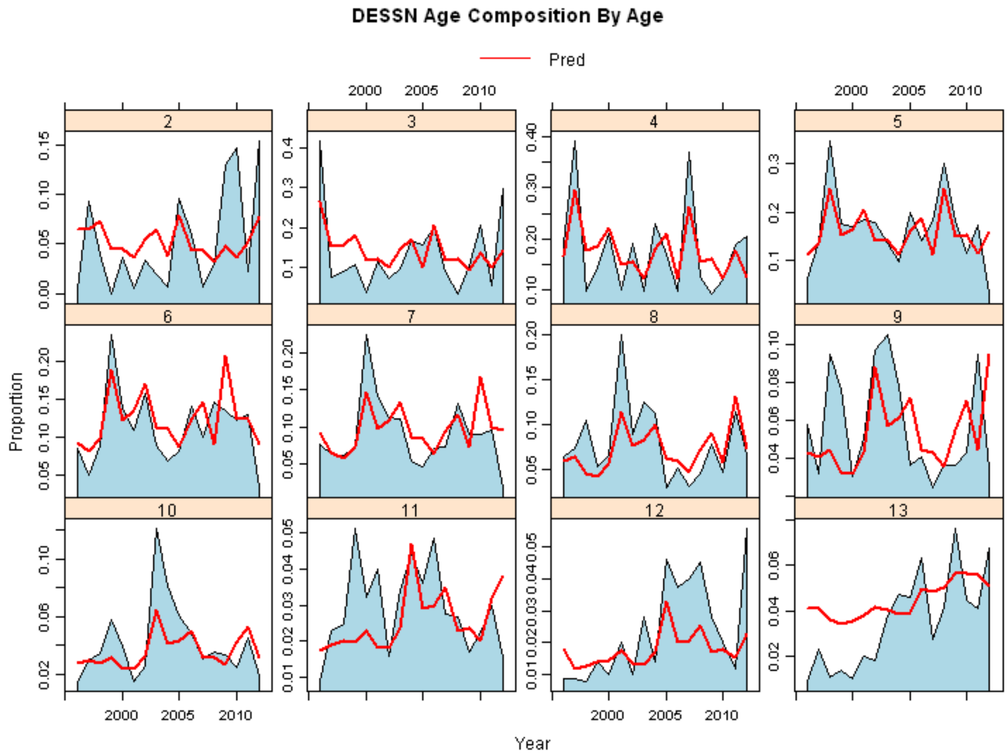


Figure 14. Observed and predicted proportions-at-age for each age by year for the MD SSN gillnet survey.



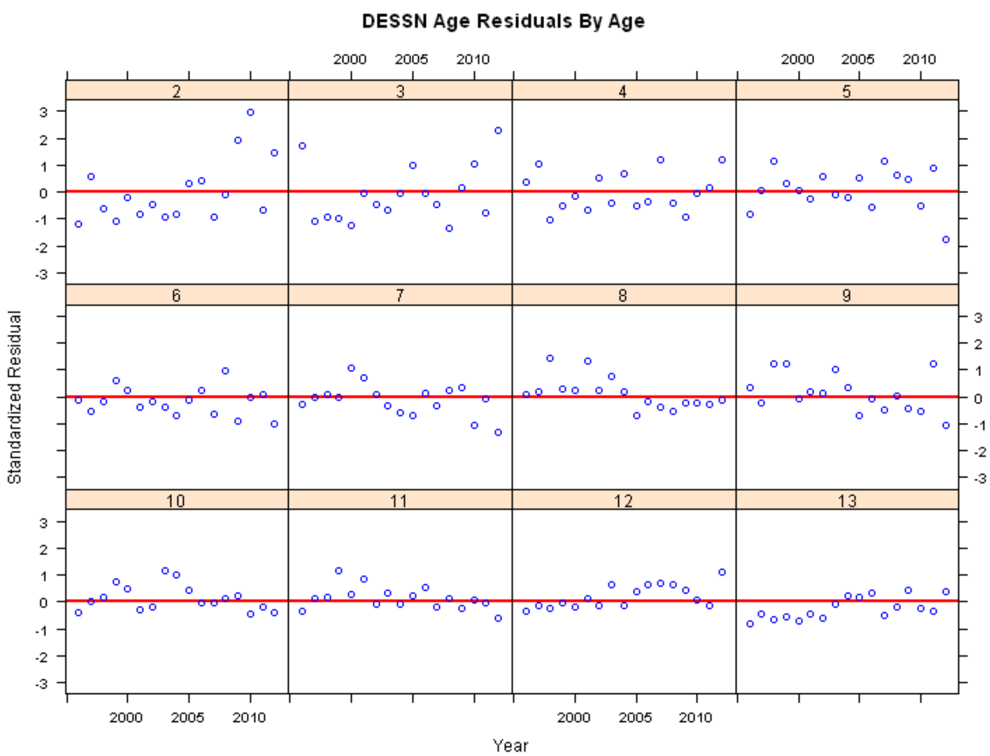


Figure 15. Observed and predicted proportions-at-age and standardized residuals for each year by age for the DE SSN electrofishing survey.

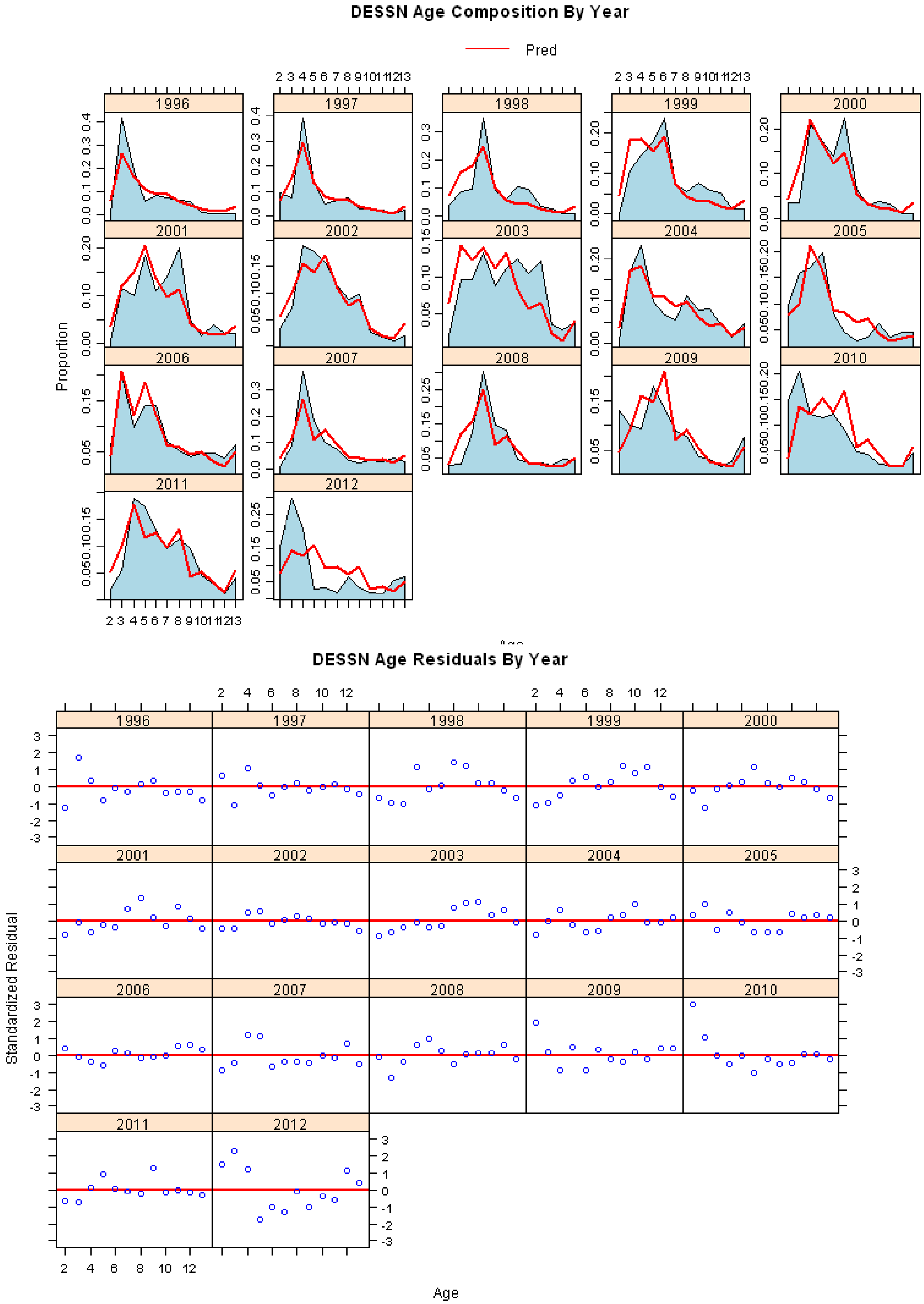
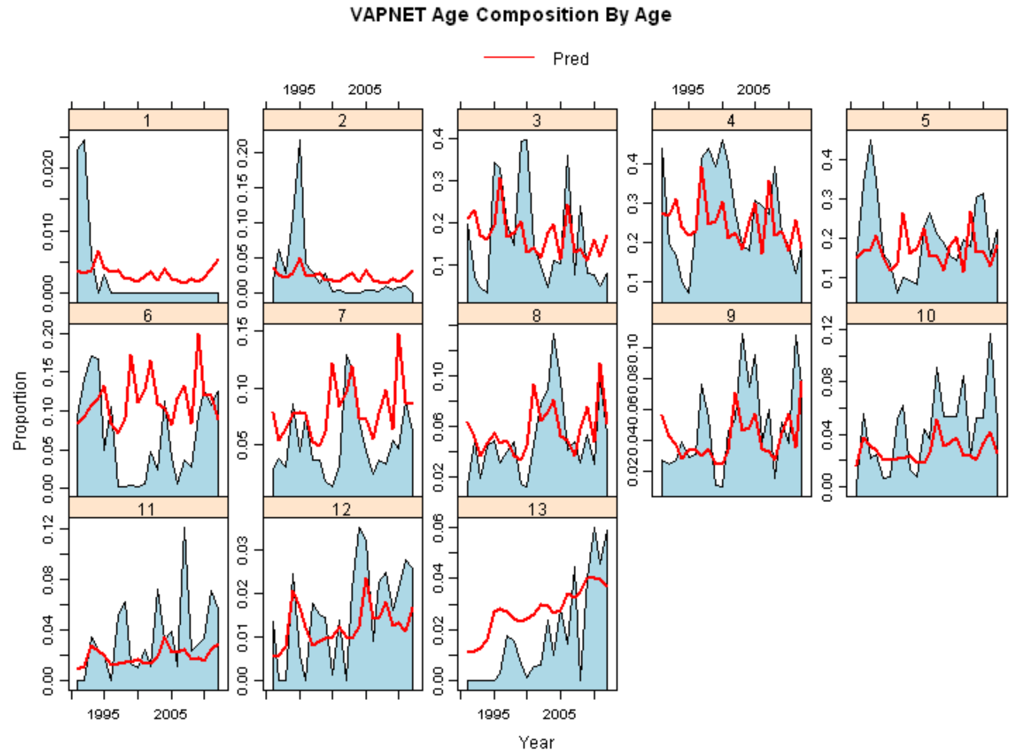


Figure 16. Observed and predicted proportions-at-age and standardized residuals for each age by year for the DE SSN electrofishing survey.



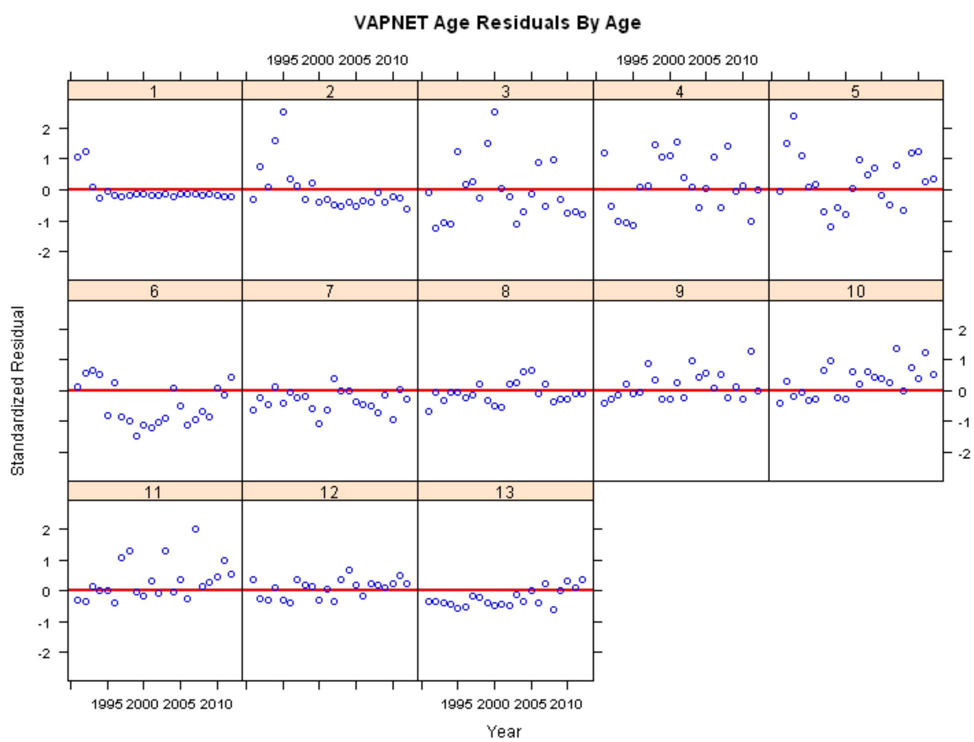
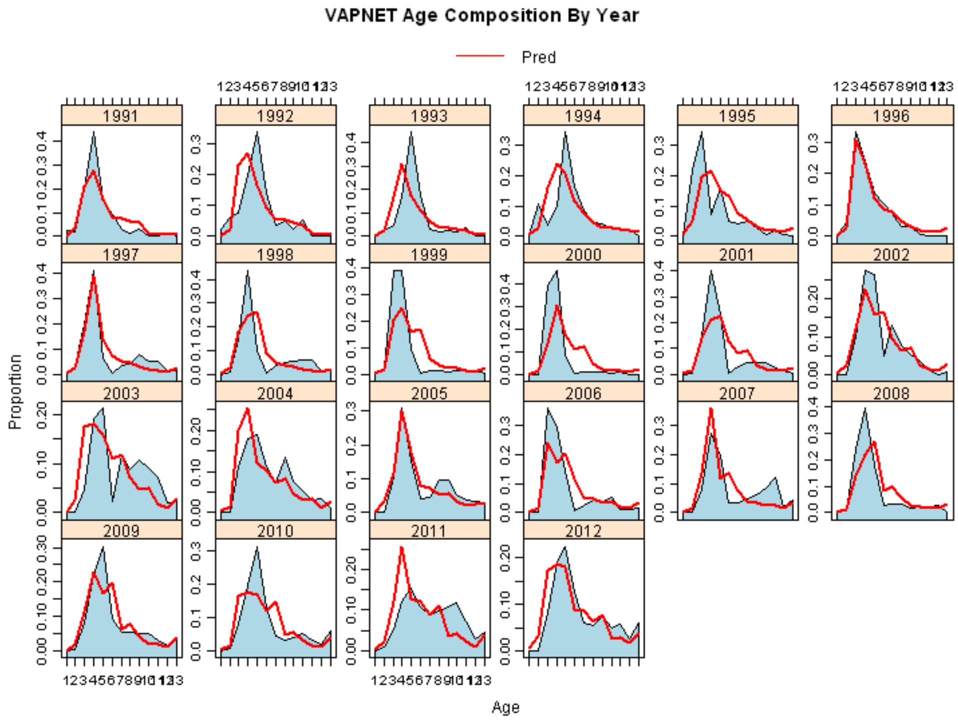


Figure 17. Observed and predicted proportions-at-age and standardized residuals for each year by age for the VAPNET survey.



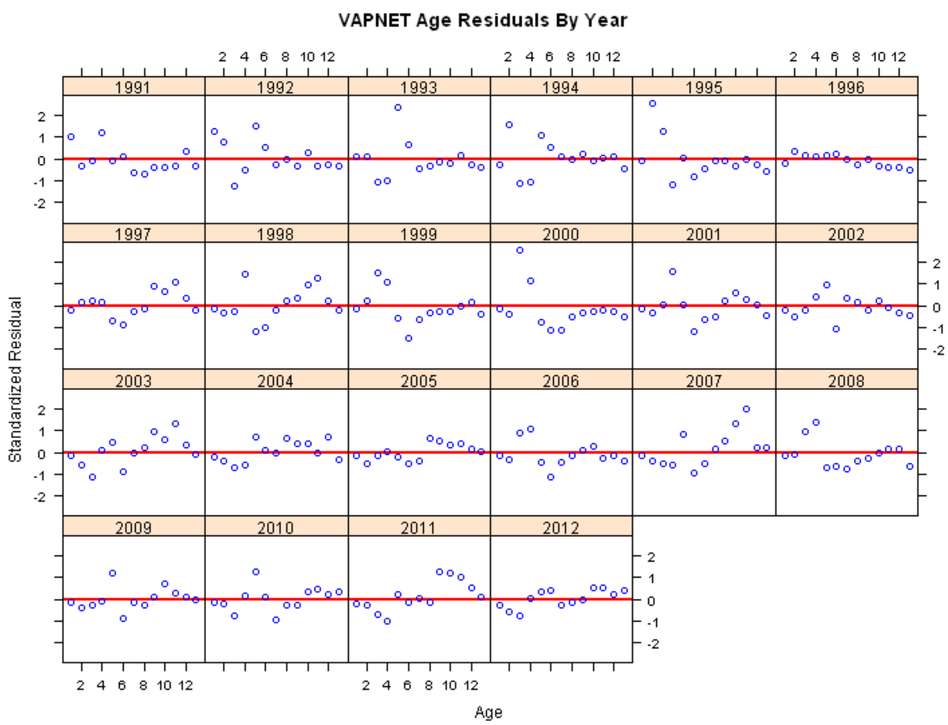


Figure 18. Observed and predicted proportions-at-age and standardized residuals for each age by year for the VAPNET survey.

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.

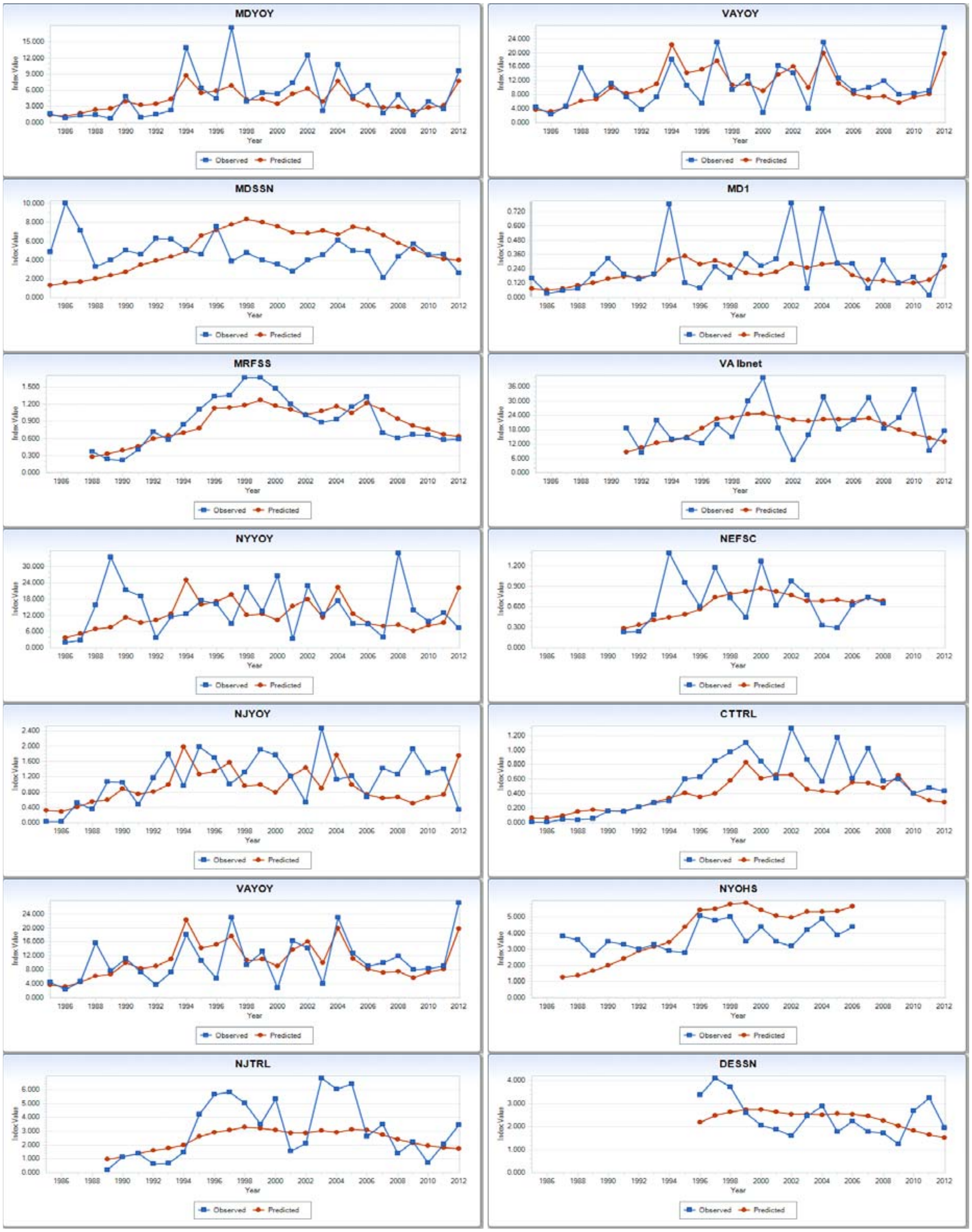


Figure B8.1. Predicted indices vs. observed indices from ASAP striped bass model.

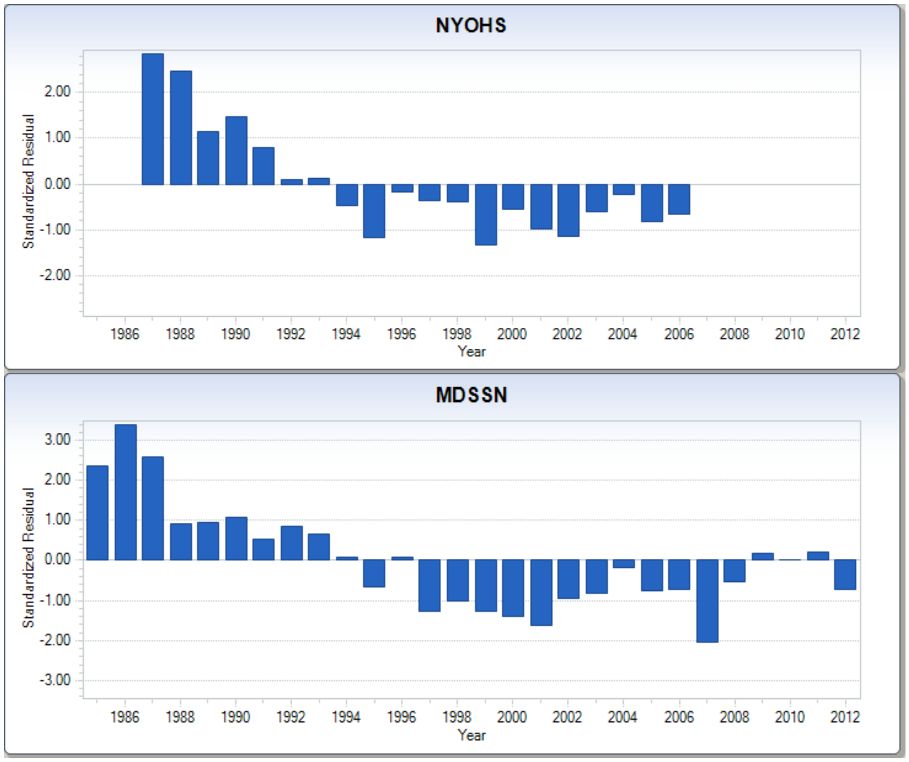


Figure B8.2. Residual patterns from MD spawning stock index and NY ocean haul seine index showing time trended residual patterns.

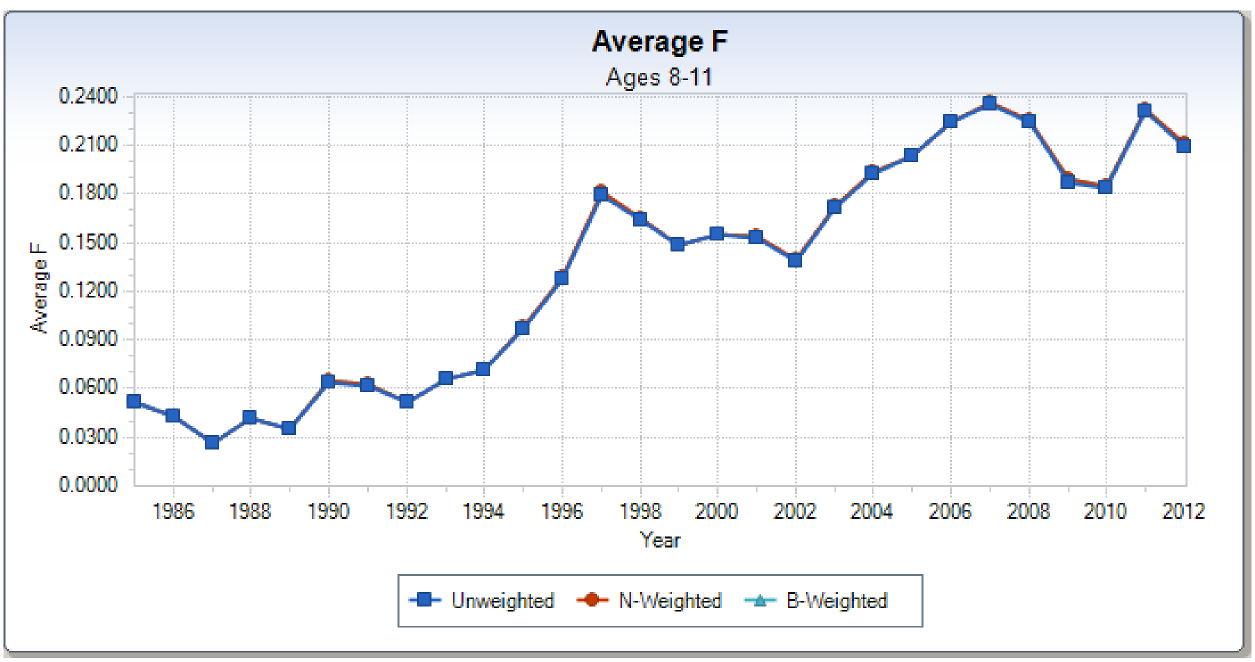


Figure B8.3. Time series of striped bass annual fishing mortality (age 8-11) from ASAP model results.

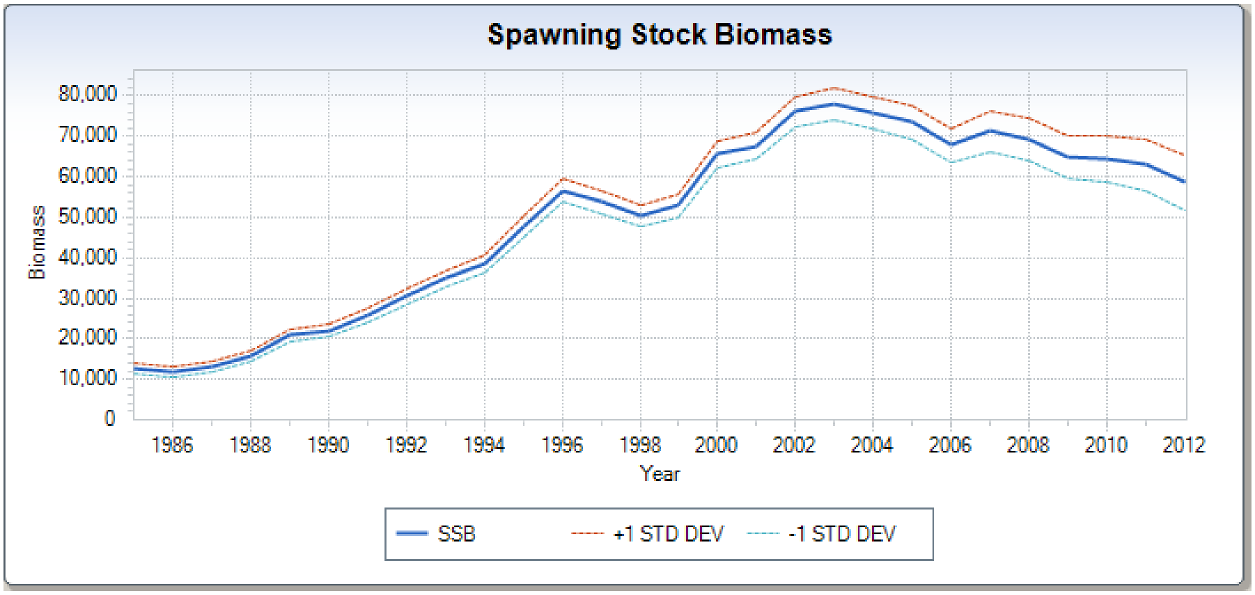


Figure B8.4. Time series of striped bass annual female spawning stock biomass from ASAP model results.

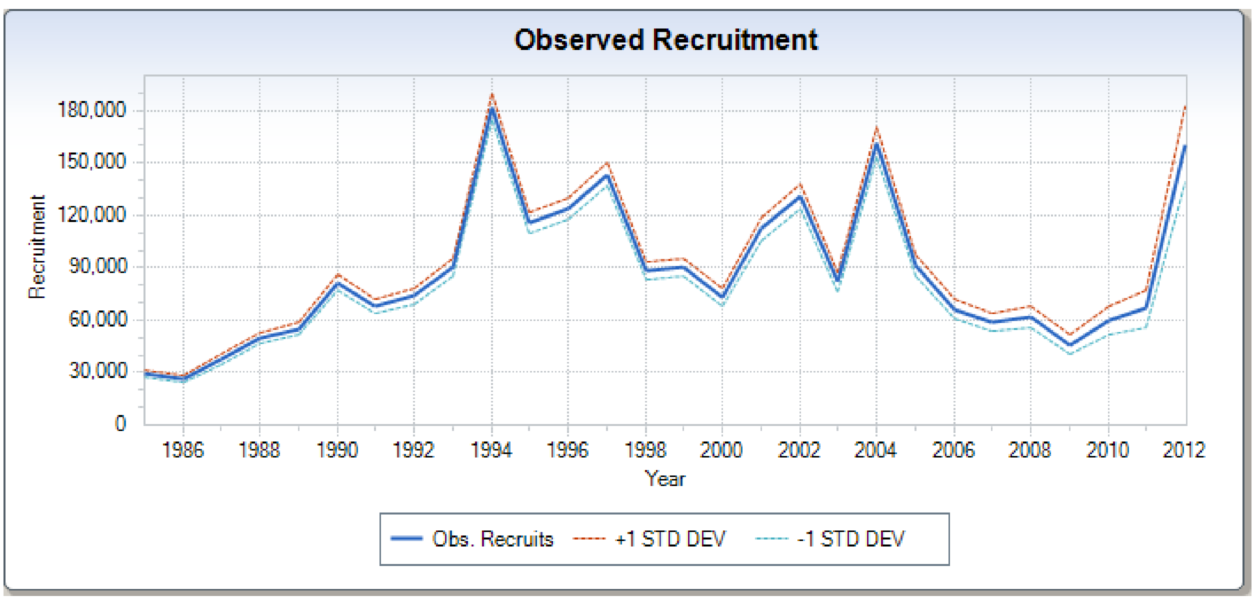


Figure B8.5. Observed striped bass age 1 recruitment estimates from ASAP model.

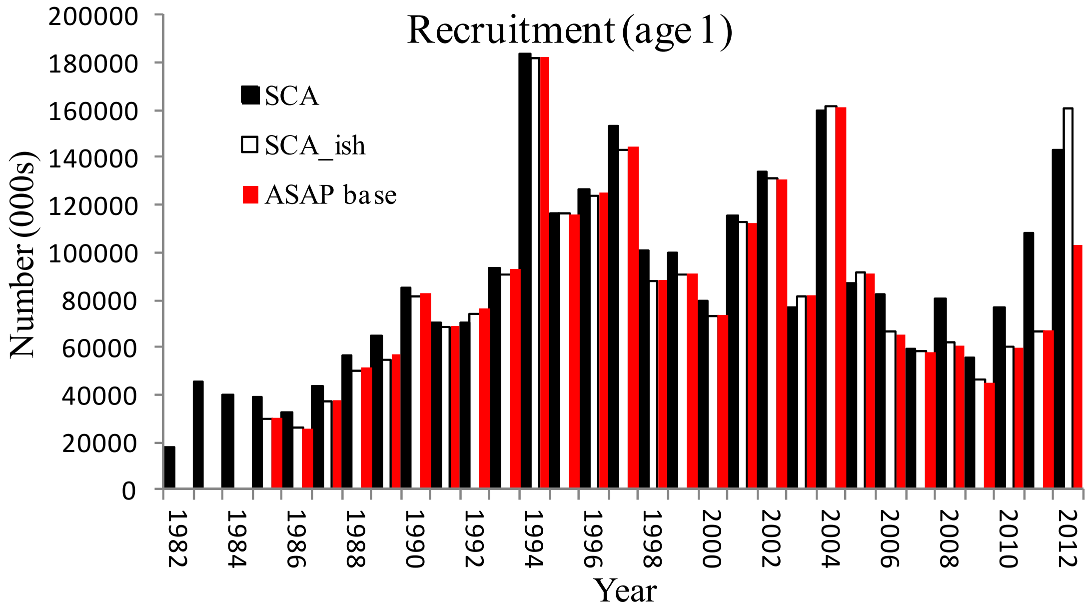


Figure B8.6. Comparison of age 1 recruitment estimates of striped bass from SCA, ASAP run as SCA (SCA_ish) and an alternative model without reduce CV on Chesapeake Bay 2011 yoy index (ASAP base).

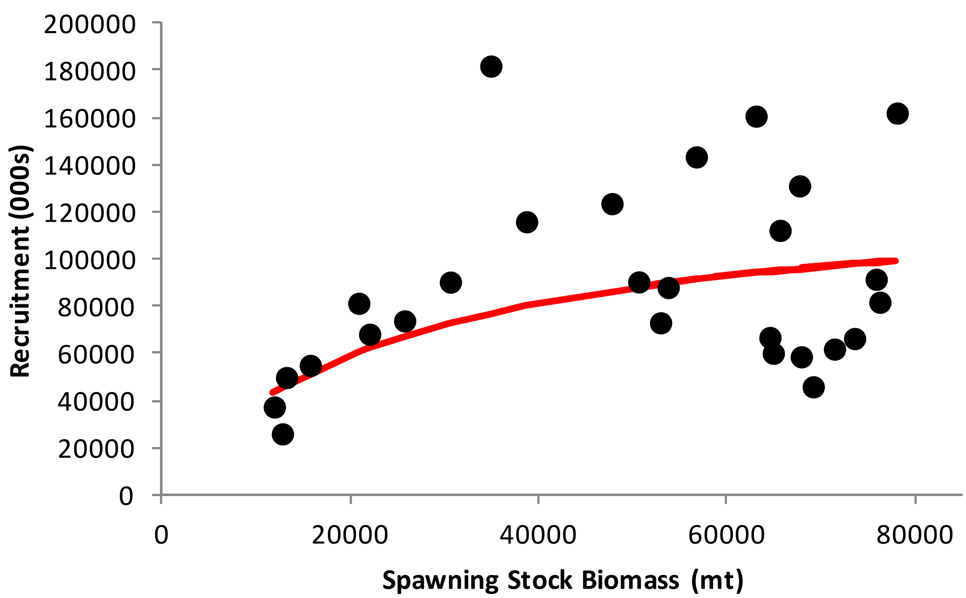


Figure B8.7. Beverton-Holt stock recruitment plot of striped bass generated from ASAP model results.

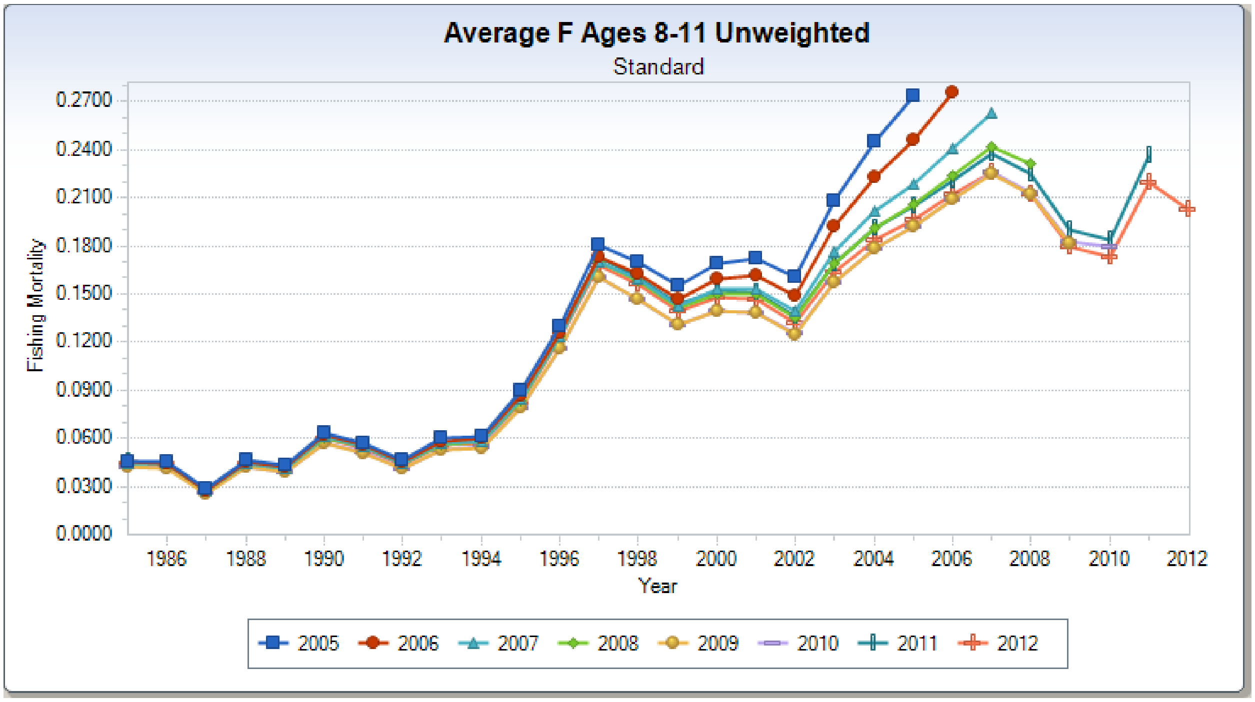


Figure B8.8. Retrospective pattern in striped bass fishing mortality from ASAP model results.

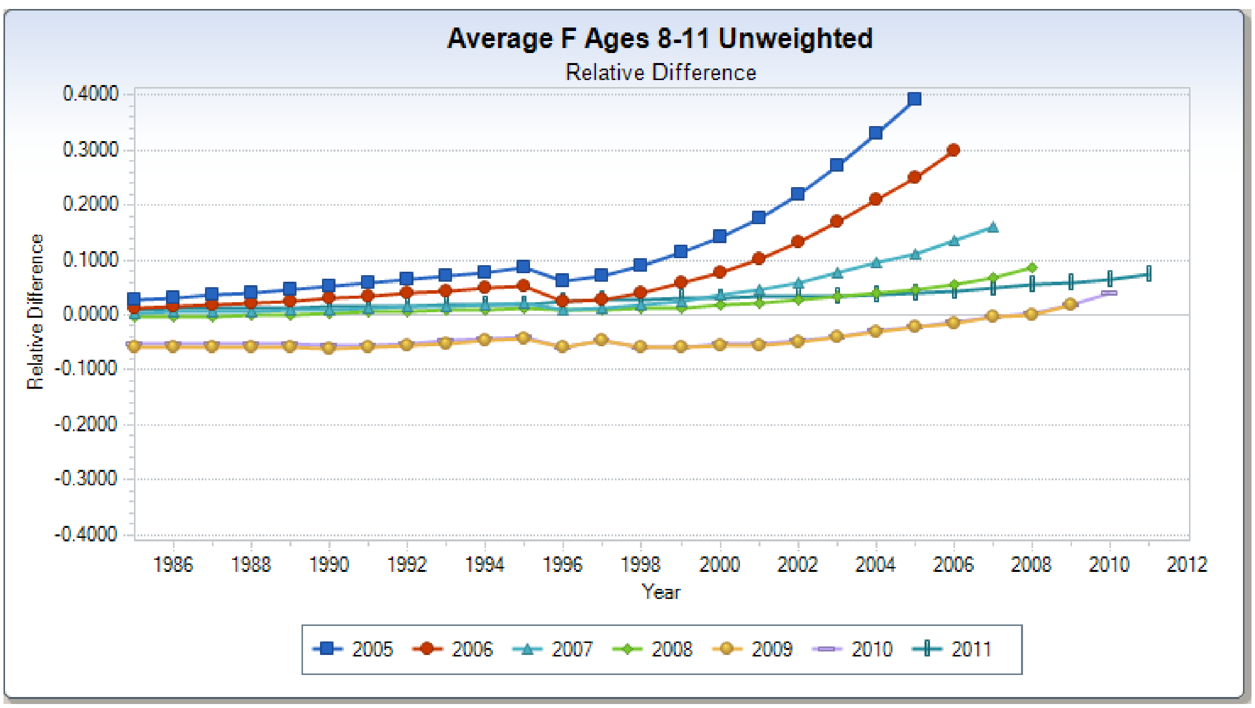


Figure B8.9. Retrospective relative differences in striped bass fishing mortality from ASAP model results.

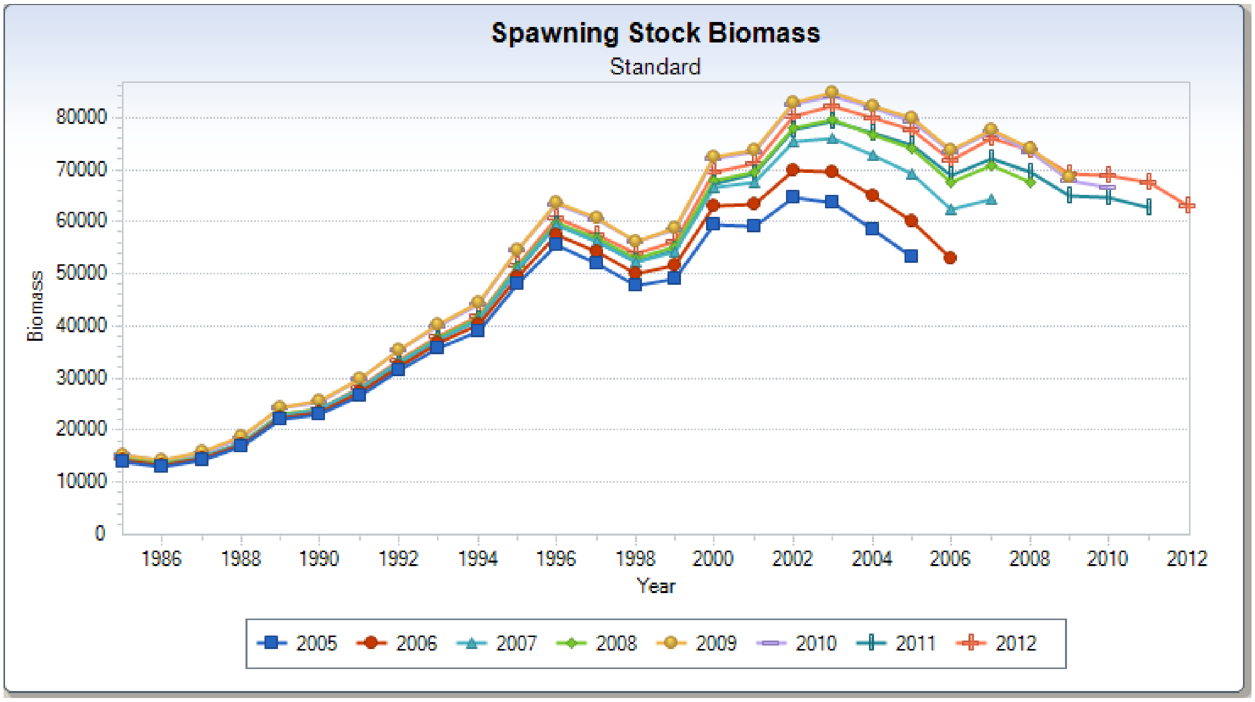


Figure B8.10. Retrospective pattern in striped bass female spawning stock biomass from ASAP model results.

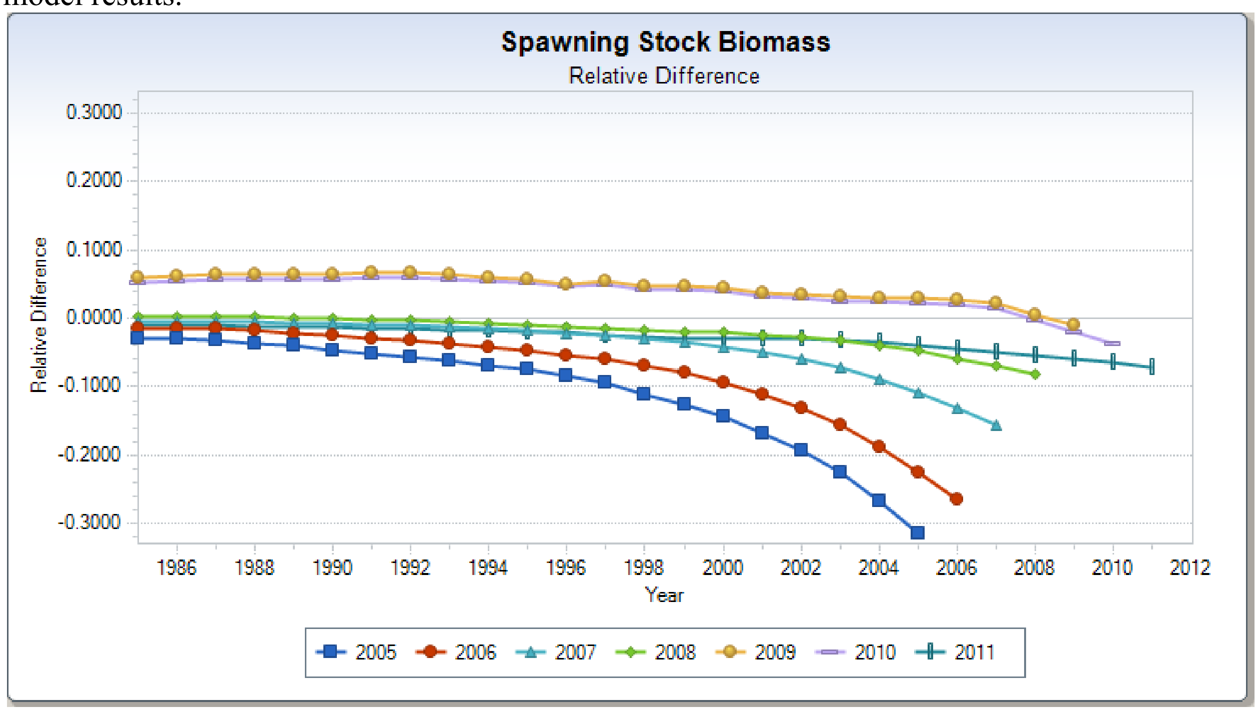


Figure B8.11. Retrospective relative difference pattern in striped bass female spawning stock biomass from ASAP model results.

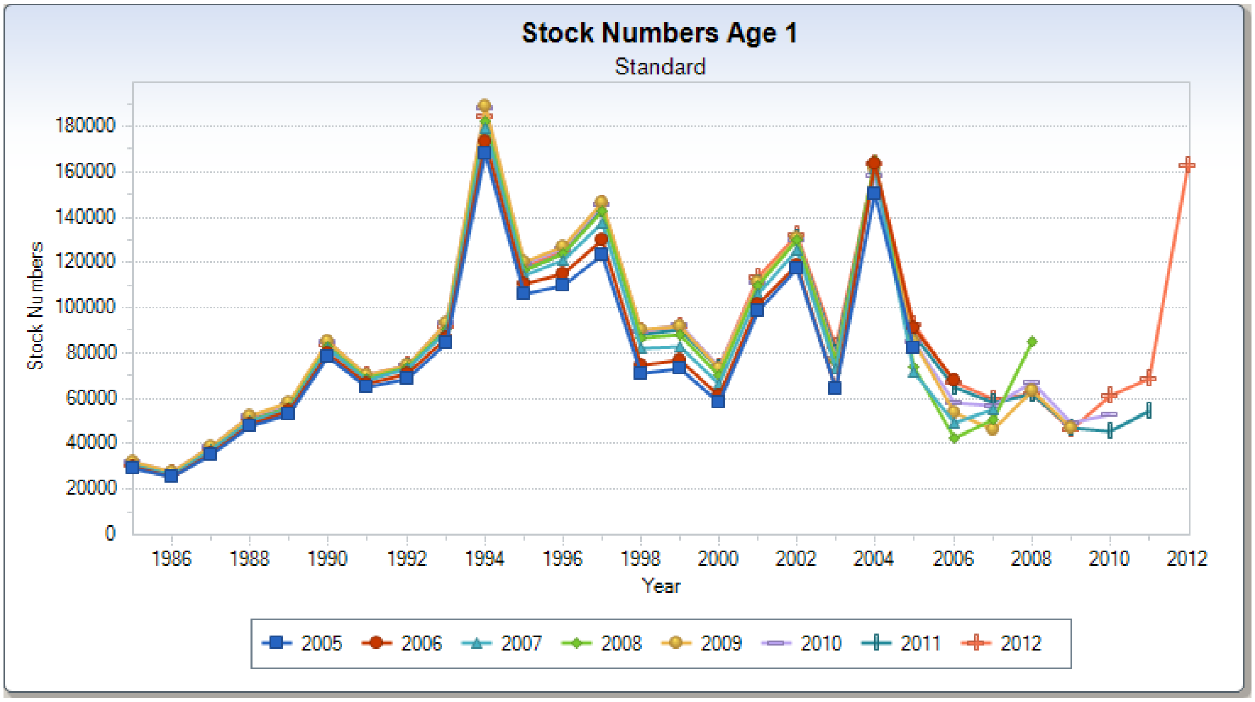


Figure B8.12. Retrospective pattern in striped bass age 1 recruitment from ASAP model results.

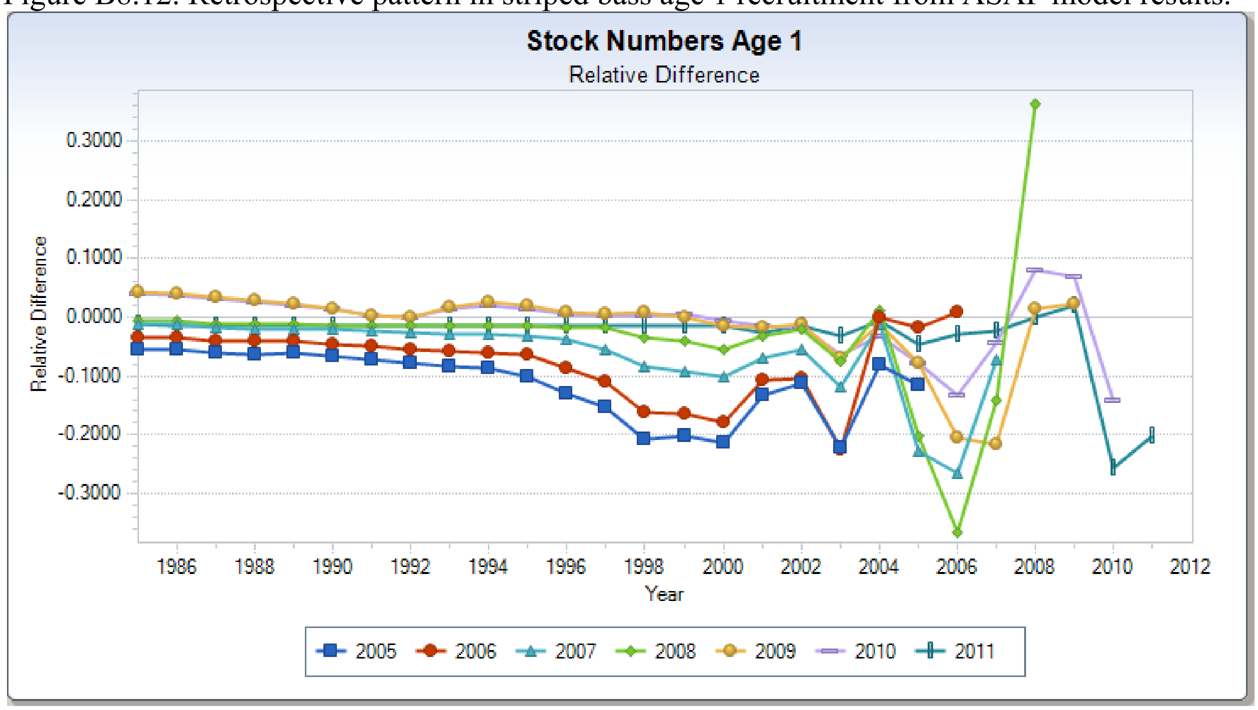


Figure B8.13. Retrospective relative difference pattern in striped bass age 1 recruitment from ASAP model results.

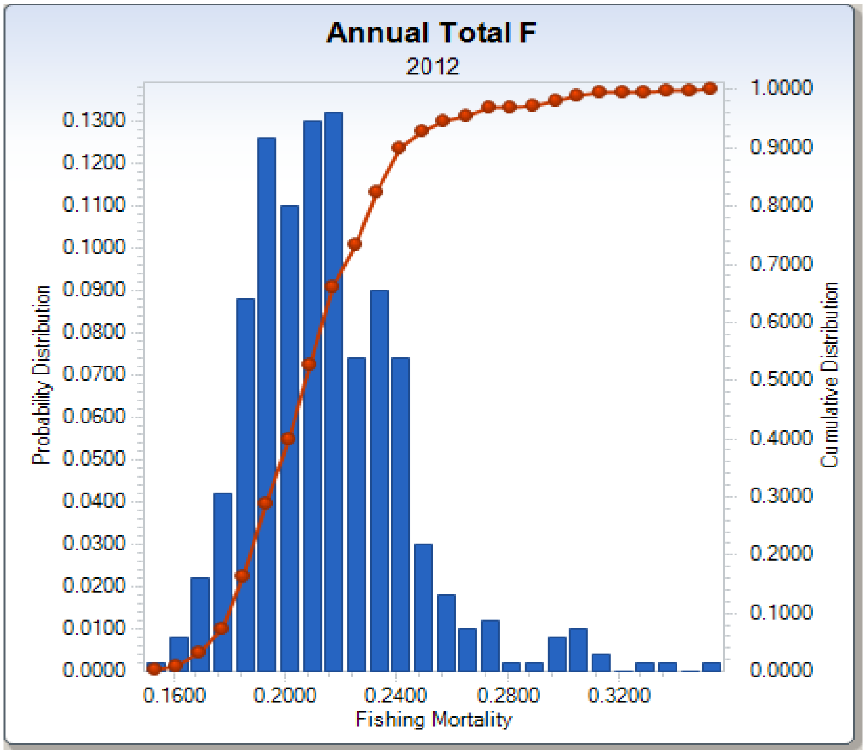


Figure B8.14. MCMC results of total 2012 striped bass fishing mortality from ASAP model results.

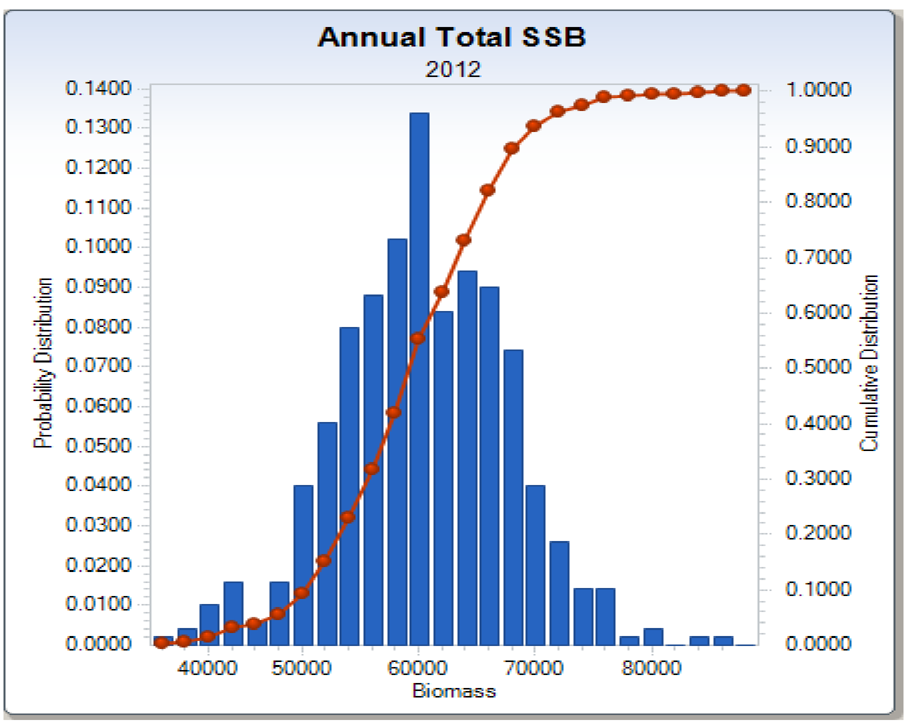


Figure B8.15. MCMC results of total 2012 striped bass female spawning biomass from ASAP model results.

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

$$\lambda_{hat} = (R_{std} / N_{std}) / (R_{high} / N_{high}) , \quad (1)$$

where λ_{hat} is the estimated tag reporting rate for standard tags, Rstd 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

$$\lambda_{rechat} = (R_{std} / N_{std}) / ((R_{high} / N_{high}) / X), \quad (2)$$

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.

$$\lambda_{comhat} = \lambda_{rechat} * (C_{std} / R_{std}) * Y, \quad (3)$$

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

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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 1/100th 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

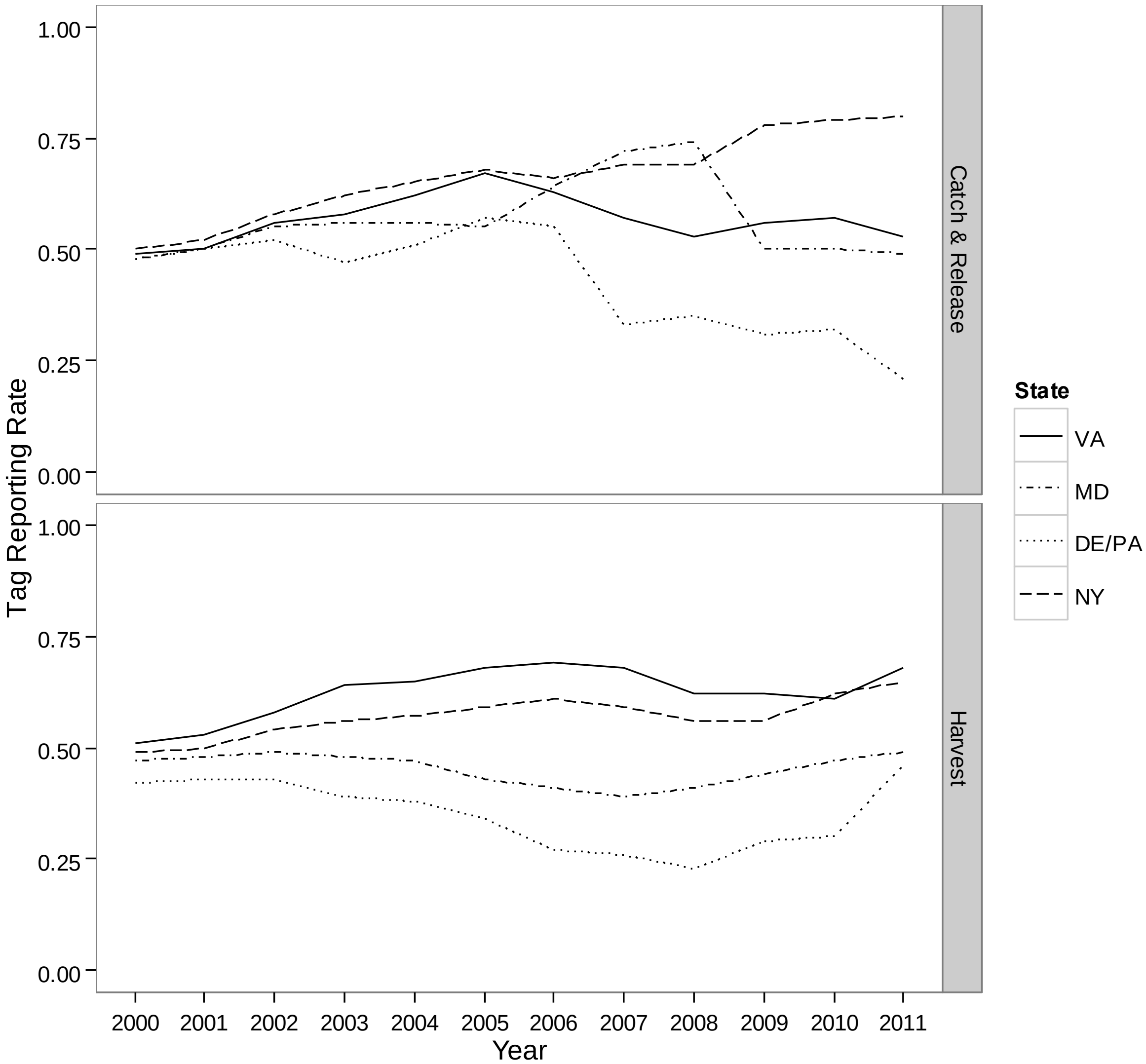


Figure 1. Three year moving average estimates of striped bass tag reporting rate for the four producer programs. Results are presented for harvested and catch and release fish. Tag reporting rate for all regions and both recapture dispositions is fixed at 0.43 for all years prior to 2000.

B9.2 Input Matrices for Tagging Model

Coastal Programs

MADFW - ≥ 28”

Release		Harvested recaptures																			
Number	Year	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		Released (Event 1 only)																			
Number	Year	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”

Release		Harvested recaptures																							
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

Release		Released (Event 1 only)																							
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	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”

Release		Harvested recaptures																						
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

Release		Released (Event 1 only)																						
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”

Release		Harvested recaptures																							
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			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

Release		Released (Event 1 only)																							
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	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		Harvested recaptures																							
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
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		
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		Released (Event 1 only)																							
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
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		Harvested recaptures																		
Number	Year	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		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
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”

Release		Harvested recaptures																								
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

Release		Released (Event 1 only)																								
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”

Release		Harvested recaptures																					
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

Release		Released (Event 1 only)																					
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 - ≥ 18”

Release		Harvested recaptures																			
Number	Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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		Released (Event 1 only)																			
Number	Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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"

Release		Harvested recaptures																							
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	
1,203	2001														20	22	22	11	6	8	4	1	3	1	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

Release		Released (Event 1 only)																							
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”

Release		Harvested recaptures																						
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

Release		Released (Event 1 only)																						
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”

Release		Harvested recaptures																							
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		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

Release		Released (Event 1 only)																							
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		Harvested recaptures																							
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
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		Released (Event 1 only)																							
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
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		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”

Release		Harvested recaptures																								
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

Release		Released (Event 1 only)																								
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"

Release		Harvested recaptures																					
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

Release		Released (Event 1 only)																					
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											
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			1	1								
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

Release		Harvested recaptures																								
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

Release		Released (Event 1 only)																								
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.

Literature Cited

ASMFC. 2003. Proceedings of the Striped Bass Ageing Workshop. Gloucester, MA. 8 pp.

Merriman D. 1941. Studies on the striped bass *Roccus saxatilis* of the Atlantic coast. USFWS Fish Bull 50(35):1-77.

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.

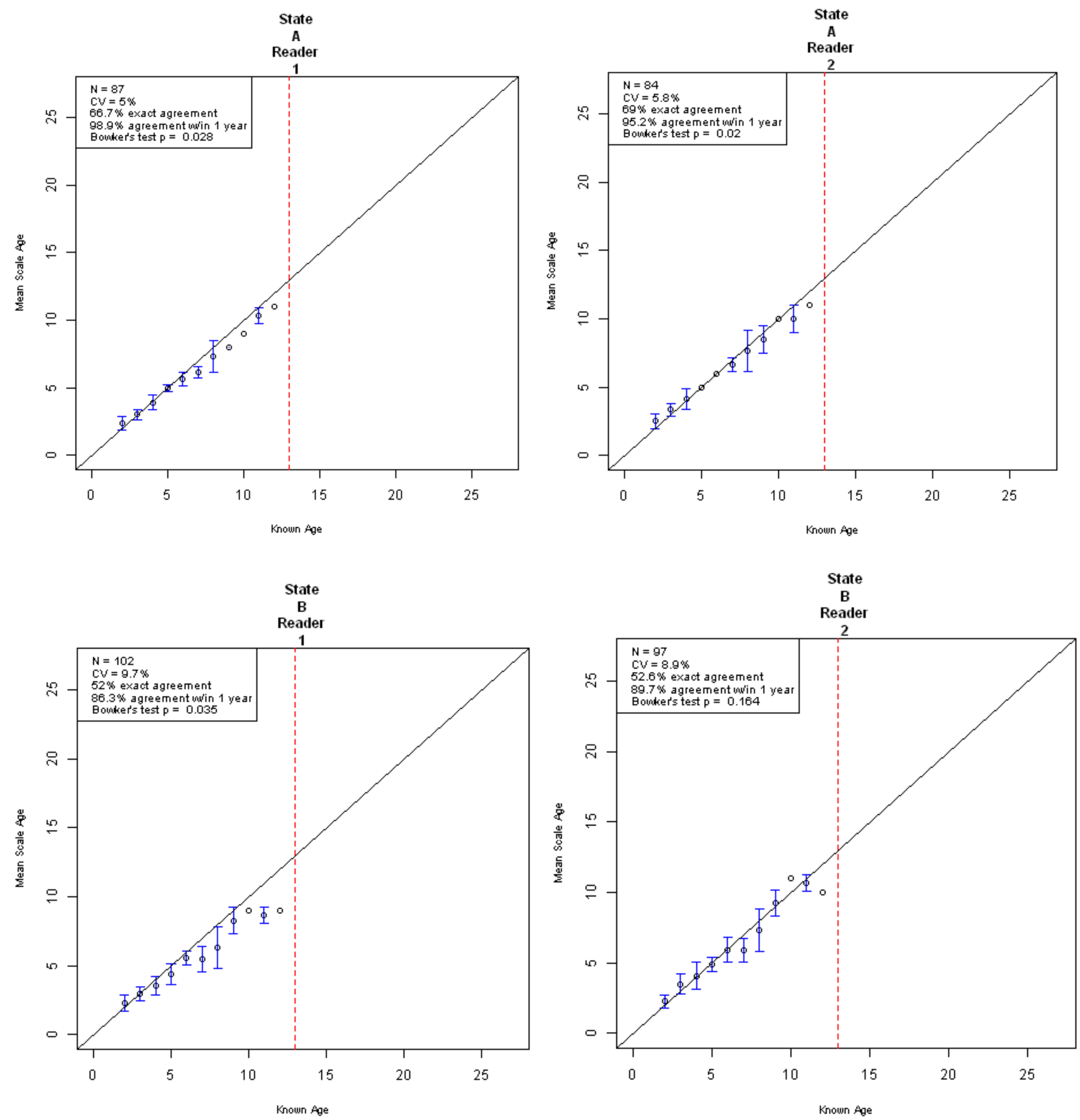


Figure 1: State scale age readings compared to the known age of CWT striped bass. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).

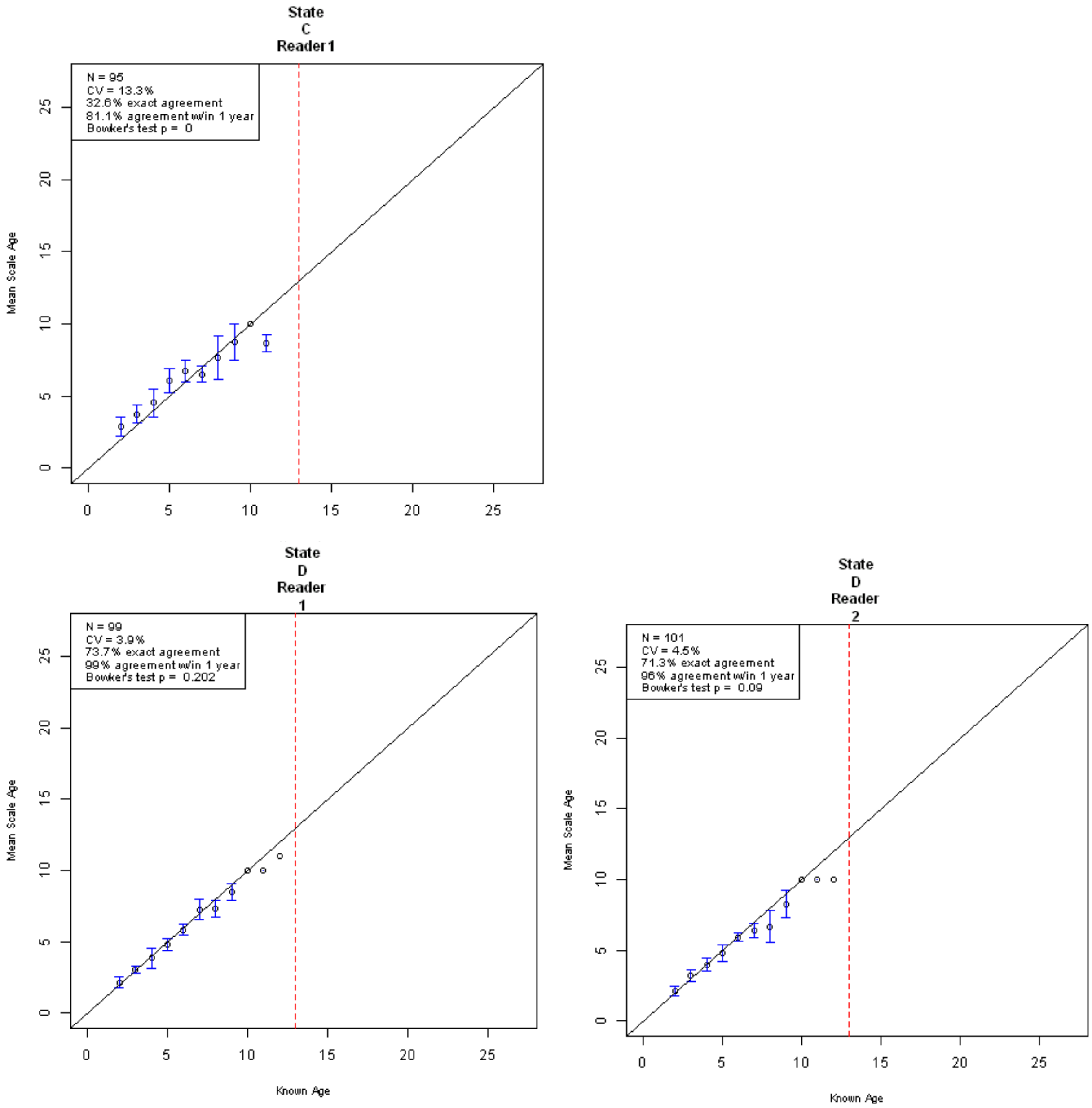


Figure 1 (cont.): State scale age readings compared to the known age of CWT striped bass. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).

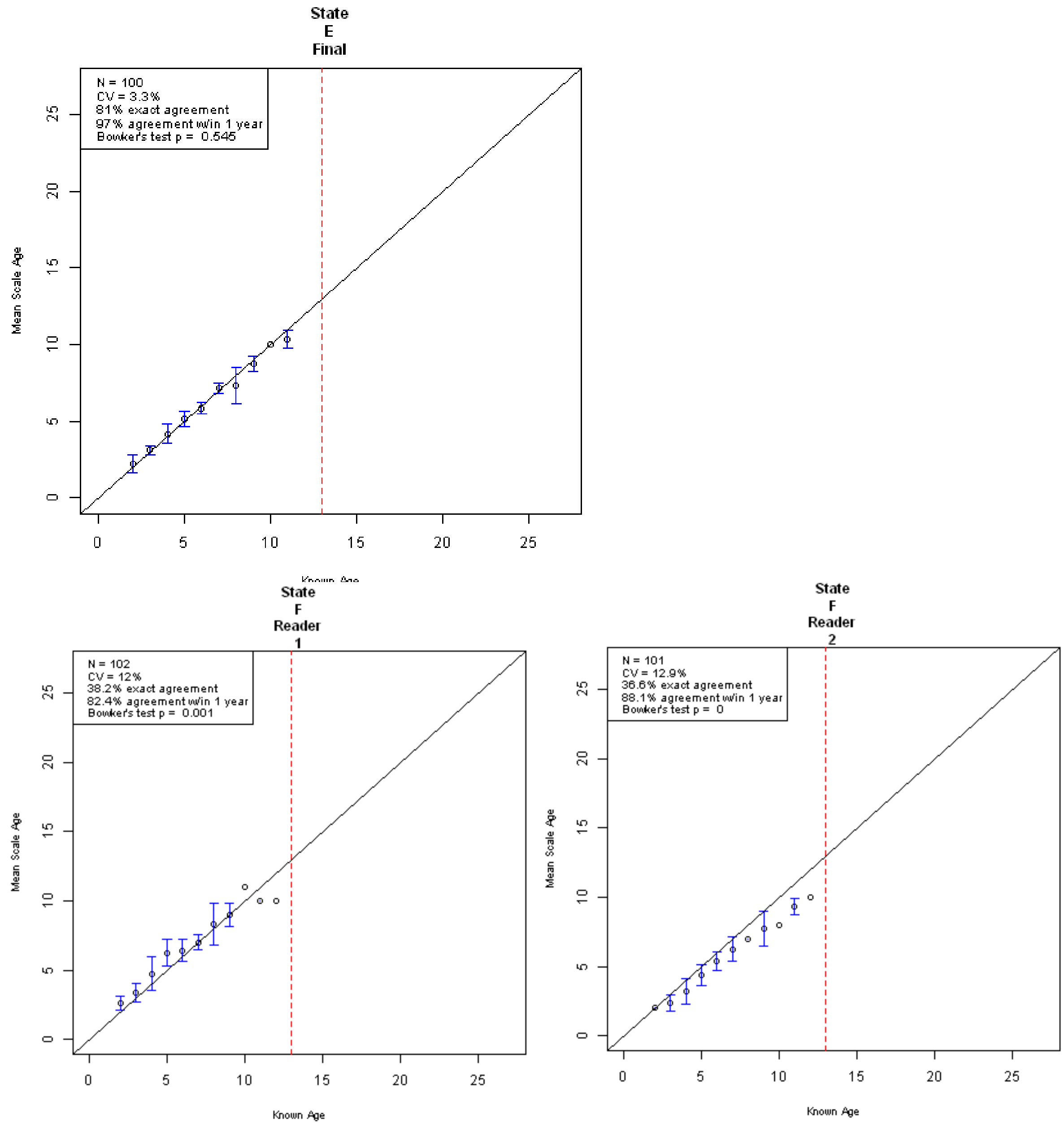


Figure 1 (cont.): State scale age readings compared to the known age of CWT striped bass. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).

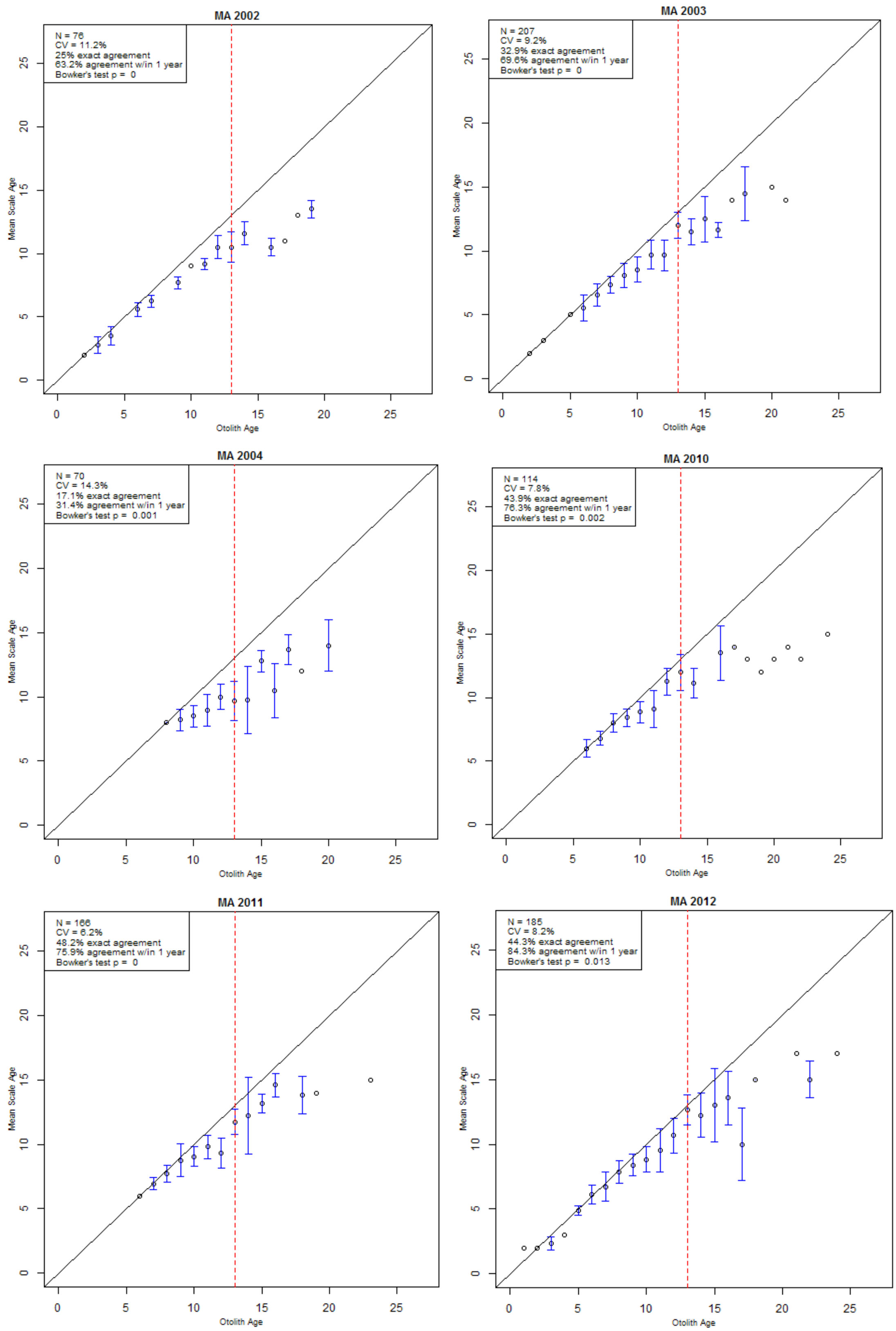


Figure 2: Massachusetts scale-otolith comparisons by year. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).

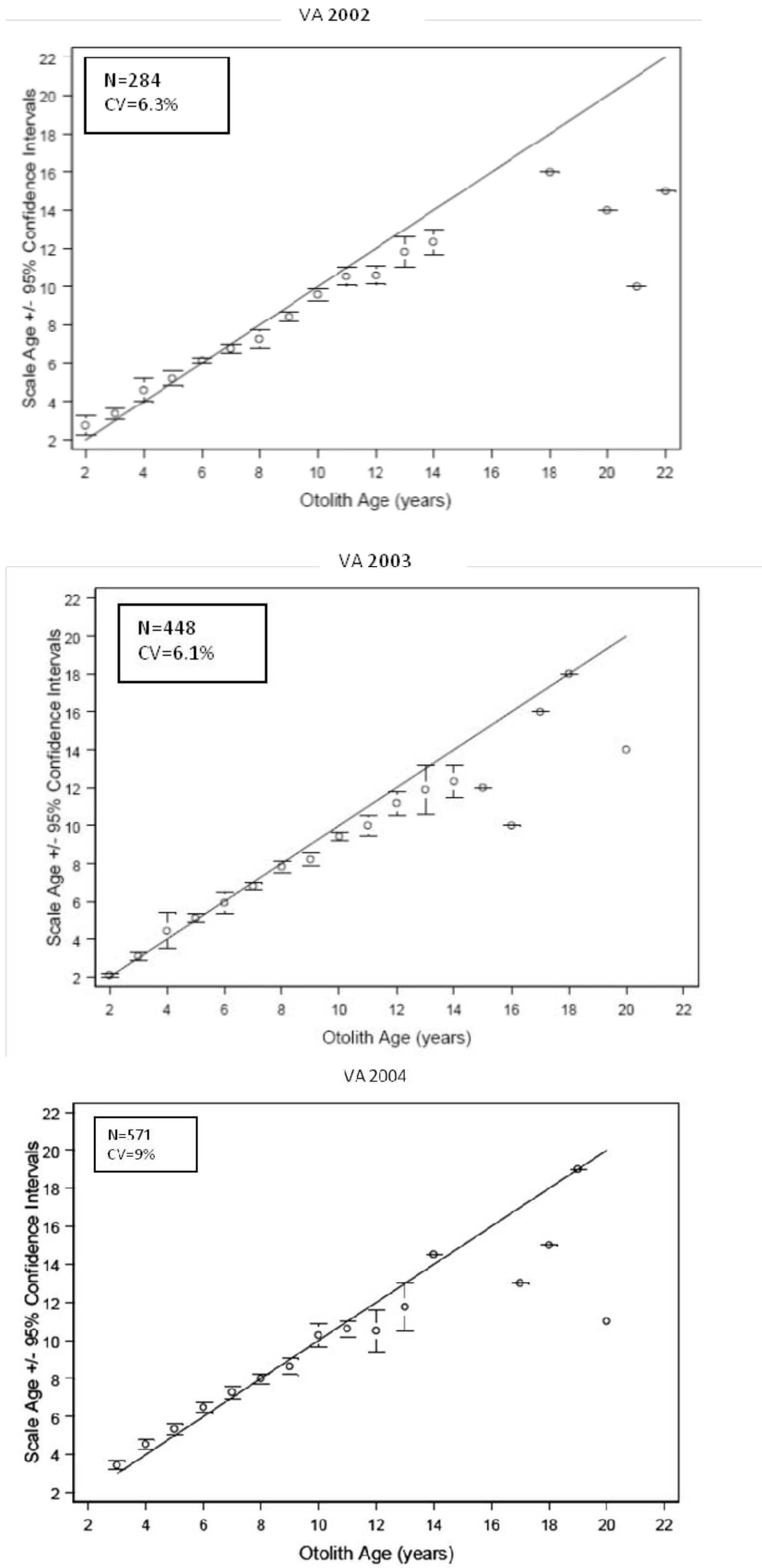


Figure 3: Virginia scale-otolith comparisons by year. Error bars indicate 95% confidence intervals. From VMRC Summary Report on Finfish Ageing 2002, 2003, 2004.

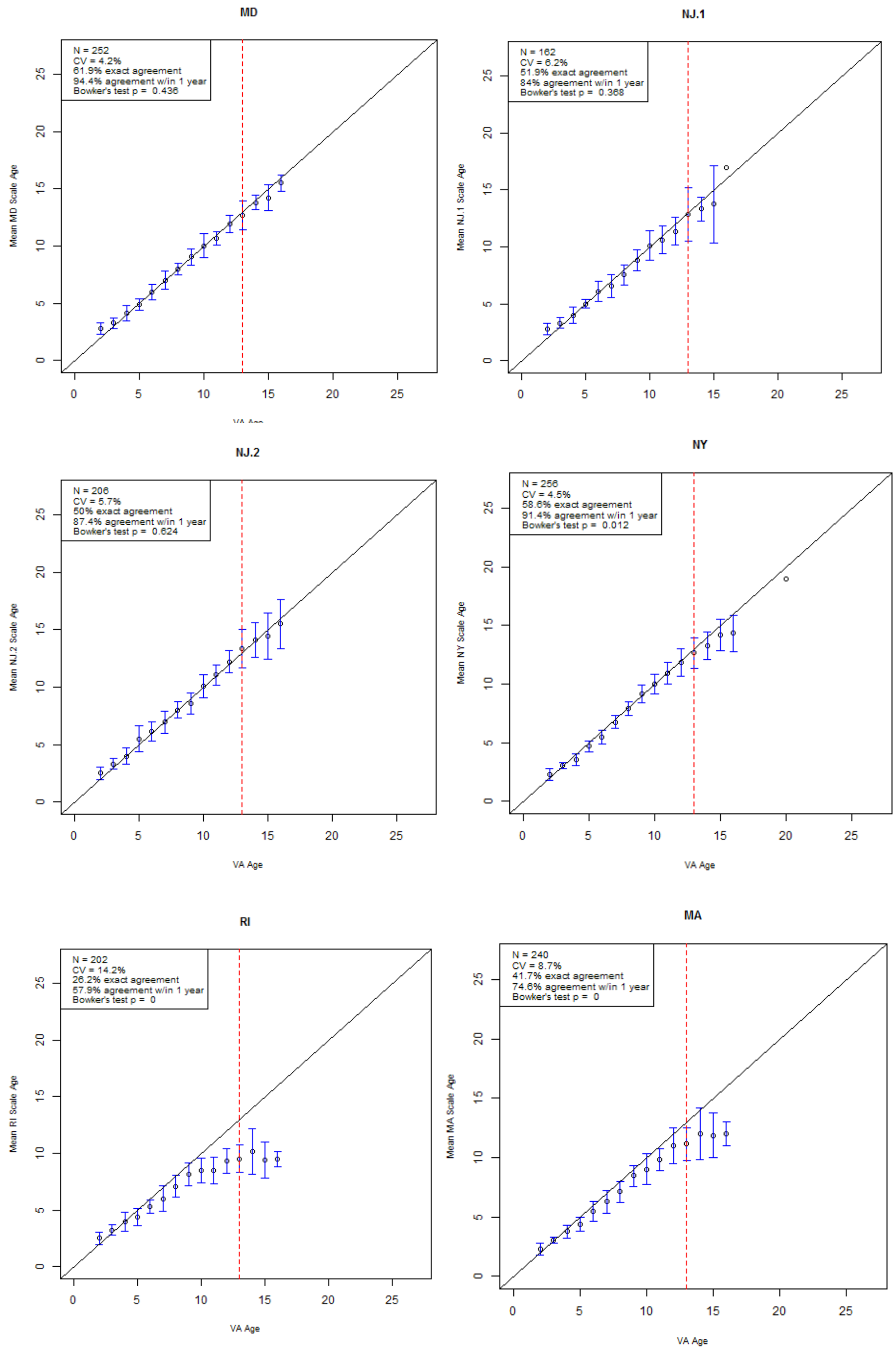


Figure 4: State scale age readings of striped bass compared to the scale ages assigned by Virginia. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).

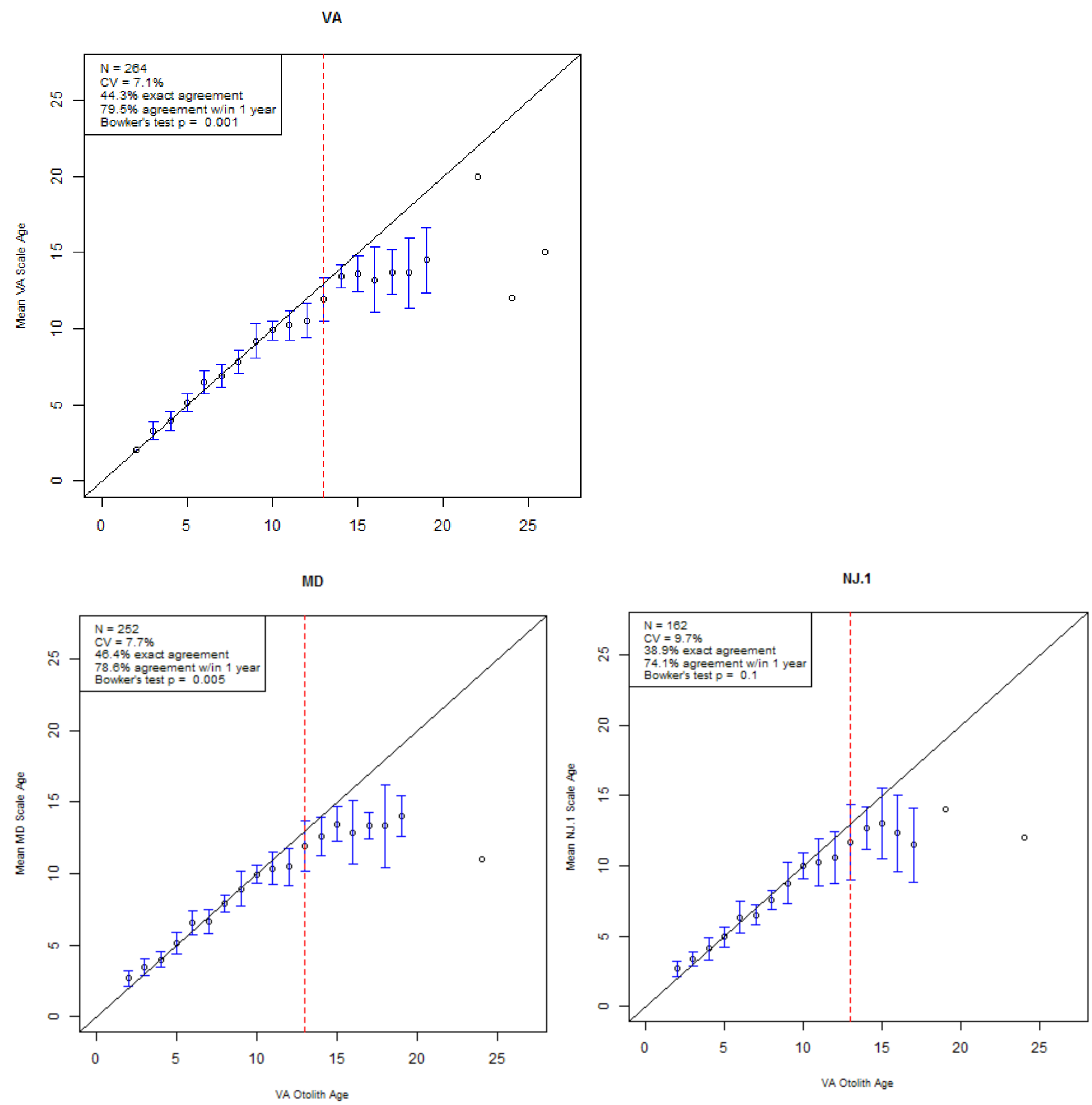


Figure 5: State scale age readings of striped bass compared to the otolith ages assigned by Virginia. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).

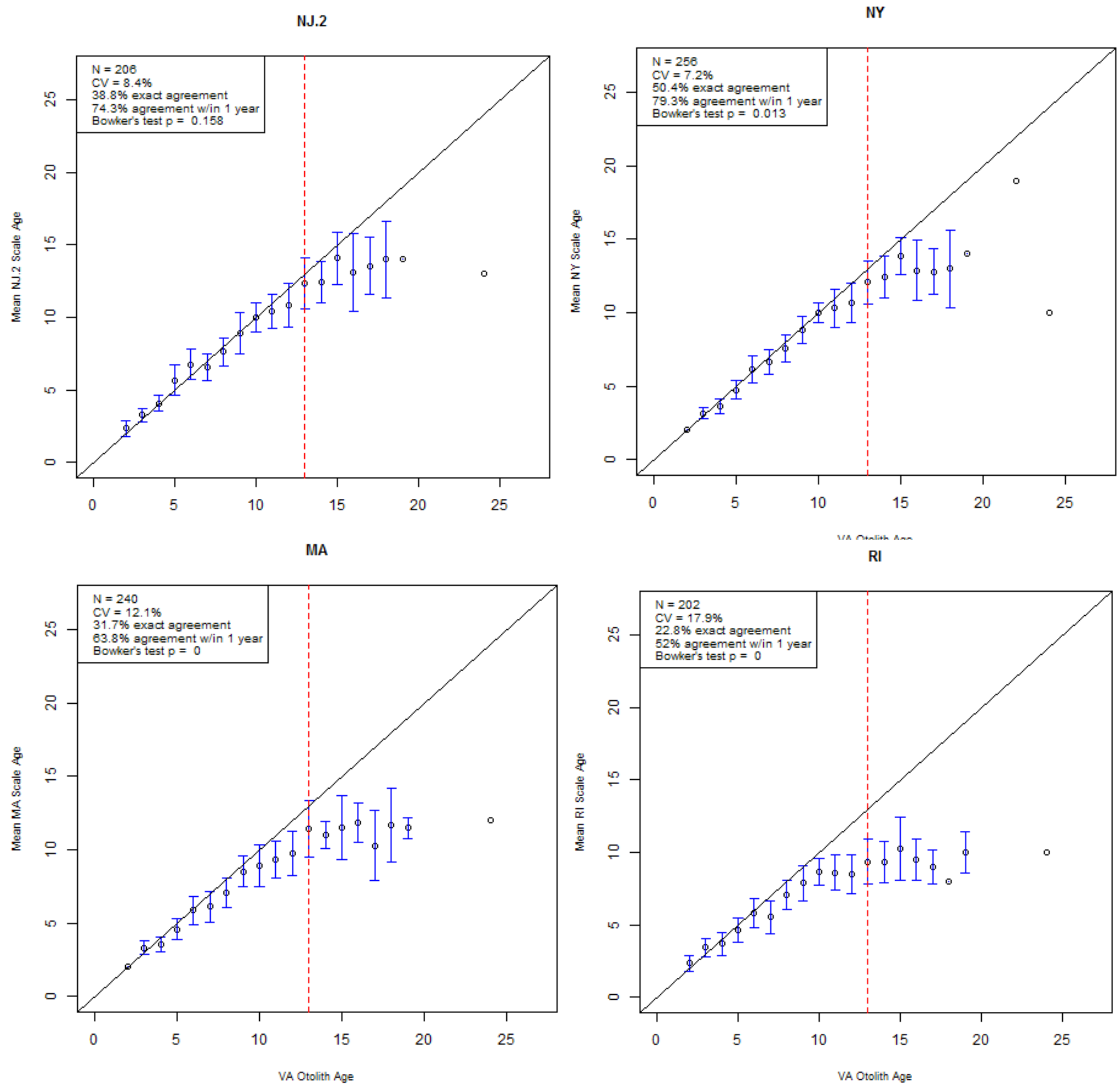
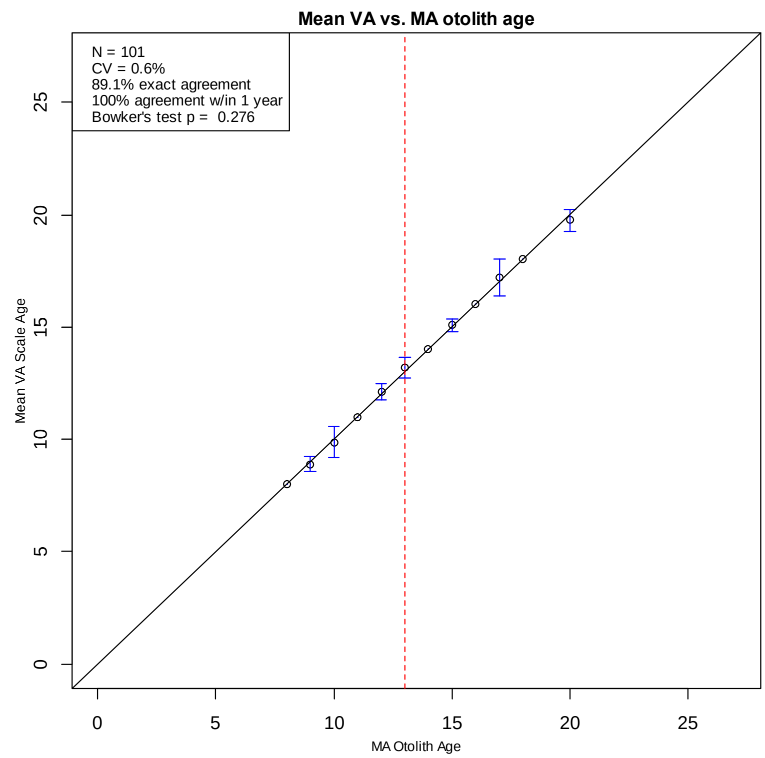


Figure 5 (cont.): State scale age readings of striped bass compared to the otolith ages assigned by Virginia. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+).



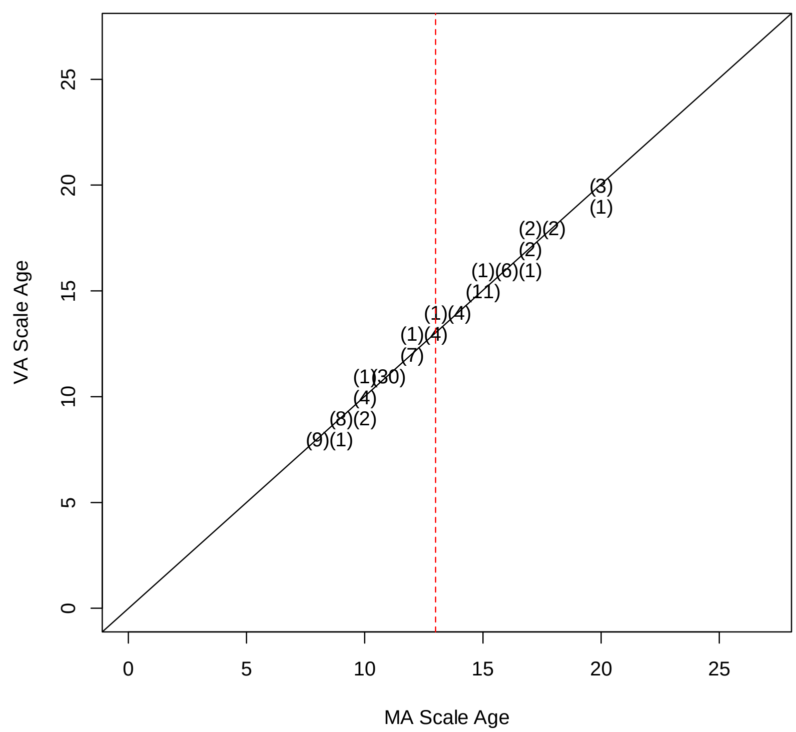


Figure 6: Comparisons of VA and MA otolith ages. Error bars indicate ±1 standard deviation. Dashed red line indicates the age of the plus group in the model (age 13+). Numbers in parentheses indicate sample size.

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.

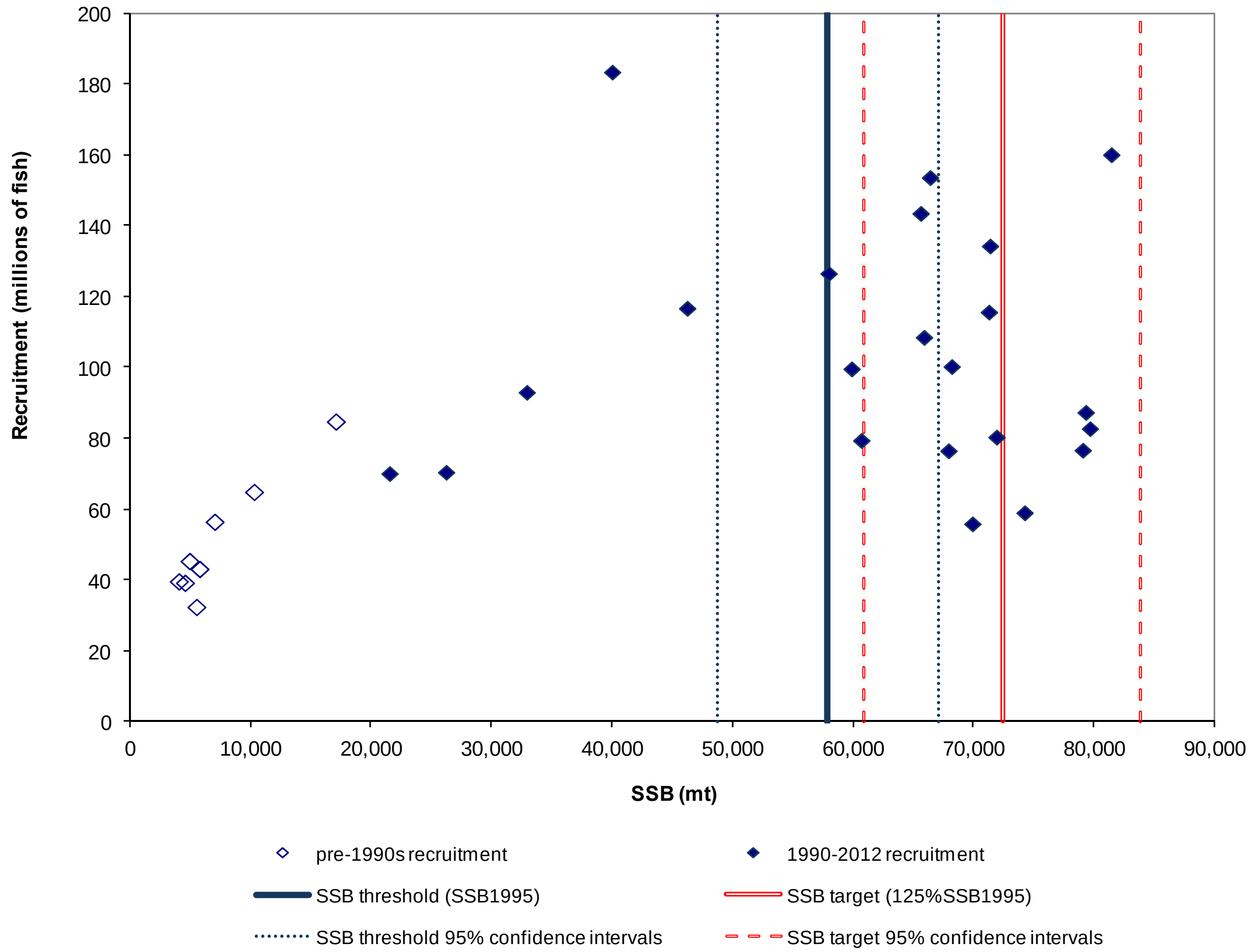
Table B11.1. Comparison of model-based and projection-based BRPs for striped bass.

	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.



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