Northeast Fisheries Science Center Reference Document 19-08

66th Northeast Regional Stock Assessment Workshop (66th SAW) Assessment Report

by the Northeast Fisheries Science Center

April 2019

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

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

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B. STOCK ASSESSMENT OF STRIPED BASS FOR 2018

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 66th SARC was convened in Woods Hole at the Northeast Fisheries Science Center, November 27-30, 2018 to review benchmark stock assessments of Summer flounder and Striped bass. CIE reviews for SARC66 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-66 Review Panel reports (available at http://www.nefsc.noaa.gov/nefsc/saw/ under the heading "SARC-66 Panelist Reports").

SARC-66 concluded that the **summer flounder** stock is neither overfished nor did it experience overfishing in 2017. The Panel concluded that the SAW WG had reasonably and satisfactorily completed its tasks. Estimates of recreational catch came from newly calibrated MRIP time-series that reflected a revision of both the intercept and effort surveys. The Bigelow indices take account of trawl efficiency estimates at length from 'sweep-study' experiments. No factor was identified as strongly influencing the spatial shift in spawner biomass or the level of recruitment. The assessment shows that current mortality from all sources is greater than recent recruitment inputs to the stock, which has resulted in a declining stock trend.

SARC-66 concluded that the **striped bass** stock is overfished and experienced overfishing in 2017. The SARC Panel accepted the single stock, non-migration SCA model for management, and concluded that all ToRs were met for that model. In addition, the Panel reviewed a new two stock model developed by the SAW WG. This model represents an innovative advance and the SARC panel recommends continued development and refinement for possible use in the future.

Table 1. 66th Stock Assessment Review Committee Panel.

<u>SARC Chairman (NEFMC SSC):</u>

Dr. Robert Latour
Virginia Inst. Of Marine Science
Gloucester Pt., VA 23062
Email: latour@vims.edu

<u>SARC Panelists (CIE):</u>

Dr. John Casey
26 Outney Road, Bungay, Suffolk, NR35 1DZ
UK
E-mail: blindlemoncasey@gmail.com

Dr. Robin Cook
Senior Research Fellow
MASTS Marine Population Modelling Group
University of Strathclyde
Glasgow, UK
Email: melford@clara.co.uk

Dr. Yan Jiao
Professor
Department of Fish and Wildlife Conservation
Virginia Tech
Blacksburg, VA, 24061-0321
Email: yjiao@vt.edu

Table 2. 66th Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC) Benchmark stock assessment for A. Summer flounder and B. Striped bass

November 27-30, 2018

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

AGENDA* (version: Nov. 20, 2018)

TOPIC	PRESENTER(S)	RAPPORTEUR

Tuesday, Nov. 27

10 – 10:45 AM
Welcome/Description of Review Process **James Weinberg**, SAW Chair
Introductions/Agenda **Robert Latour,** SARC Chair
Conduct of Meeting

10:45 – 12:45 PM Assessment Presentation (A. Summer flounder)
Mark Terceiro **Tony Wood**

12:45 – 1:45 PM Lunch

1:45 – 3:45 PM Assesssment Presentation (A. Summer flounder)
Mark Terceiro **Toni Chute**

3:45 – 4 PM Break

4 – 5:45 PM SARC Discussion w/ Presenters (A. Summer flounder)
Robert Latour, SARC Chair **Toni Chute**

5:45 – 6 PM Public Comments

Wednesday, Nov. 28

8:30 – 10:30 AM Assessment Presentation (B. Striped bass)
Katie Drew **Alicia Miller**
Gary Nelson, Mike Celestino

10:30 – 10:45 AM Break

10:45 – 12:30 PM Assessment Presentation (B. Striped bass)
Katie Drew **Alicia Miller**
Gary Nelson, Mike Celestino

12:30 – 1:30 PM Lunch

1:30 – 3:30 PM SARC Discussion w/presenters (B. Striped bass)

Robert Latour, SARC Chair **Brian Linton**

3:30 – 3:45 PM Public Comments

3:45 -4 PM Break

4 – 6 PM Revisit with Presenters (A. Summer flounder)
Robert Latour, SARC Chair **Brian Linton**

7 PM **(**Social Gathering**)**

Thursday, Nov. 29

8:30 – 10:30 Revisit with Presenters (B. Striped bass)
Robert Latour, SARC Chair **Alicia Miller**

10:30 – 10:45 Break

10:45 – 12:15 Review/Edit Assessment Summary Report (A. Summer flounder)
Robert Latour, SARC Chair **Chris Legault**

12:15 – 1:15 PM Lunch

1:15 – 2:45 PM (cont.) Edit Assessment Summary Report (A. Summer flounder)
Robert Latour, SARC Chair **Chris Legault**

2:45 – 3 PM Break

3 – 6 PM Review/edit Assessment Summary Report (B. Striped bass)
Robert Latour, SARC Chair **Chris Legault**

Friday, Nov. 30

9:00 AM – 5:00 PM SARC Report writing

*All times are approximate, and may be changed at the discretion of the SARC chair. The meeting is open to the public; however, during the Report Writing sessions we ask that the public refrain from engaging in discussion with the SARC.

Table 3. 66th SAW/SARC, List of Attendees, Nov. 27-30, 2018

NAME	AFFILIATION	EMAIL
Robert Latour	Viginia Institute of Marine Science	latour@vims.edu
Yan Jiao	Virginia Tech University	yjiao@vt.edu
Robin Cook	University of Strathclyde, Glasgow, UK	melford@clara.co.uk
John Casey	Independent Consultant	blindlemoncasey@gmail.com
Russell Brown	NEFSC	russell.brown@noaa.gov
Jim Weinberg	NEFSC	james.weinberg@noaa.gov
Mark Terceiro	NEFSC	mark.terceiro@noaa.gov
Katie Drew	ASMFC	kdrew@asmfc.org
Gary Nelson	MA DMF	gary.nelson@mass.gov
Michael Celestino	NJ DFW	mike.celestino@dep.nj.gov
Kirby Rootes-Murdy	ASMFC	krootes-murdy@asmfc.org
Max Appelman	ASMFC	mappelman@asmfc.org
Patrick Sullivan	Cornell University	pjs31@cornell.edu
Jason Boucher	DE Fish and Wildlife	jason.boucher@state.de.us
Patrick Paquette	MA Striped Bass Association	BasicPatrick@aol.com
Tiffany Cunningham	MADMF	tiffany.vidal@mass.gov
Jessica Coakley	MAFMC	jcoakley@mafmc.org
Kiley Dancy	MAFMC	kdancy@mafmc.org
Alicia Miller	NEFSC	alicia.miller@noaa.gov
Anne Richards	NEFSC	anne.richards@noaa.gov
Brian Linton	NEFSC	brian.linton@noaa.gov
Charles Adams	NEFSC	charles.adams@noaa.gov
Charles Perretti	NEFSC	charles.perretti@noaa.gov
Chris Legault	NEFSC	chris.legault@noaa.gov
Dvora Hart	NEFSC	deborah.hart@noaa.gov
Gary Shepherd	NEFSC	gary.shepherd@noaa.gov
Greg Ardini	NEFSC	gregory.ardini@noaa.gov
Michele Traver	NEFSC	michele.traver@noaa.gov
Katherine Sosebee	NEFSC	ksosebee@noaa.gov
Paul Nitschke	NEFSC	pnitschke@noaa.gov
Toni Chute	NEFSC	toni.chute@noaa.gov
Tony Wood	NEFSC	anthony.wood@noaa.gov
Jeff Brust	NJ DFW	jeffrey.brust@dep.nj.gov
Nicole Lengyel	RI DMF	nicole.lengyel@dem.ri.gov
Rick Bellavance	RIPCBA	rickbellavance@gmail.com
Steve Cadrin	SMAST	scadrin@umassd.edu
Evans Kwasi Arizi	URI	evansarizi@uri.edu
Miriam Ameworwor	URI/UCC	mameworwor@gmail.com
Najih Lazar	URI-GSO	nlazar@uri.edu

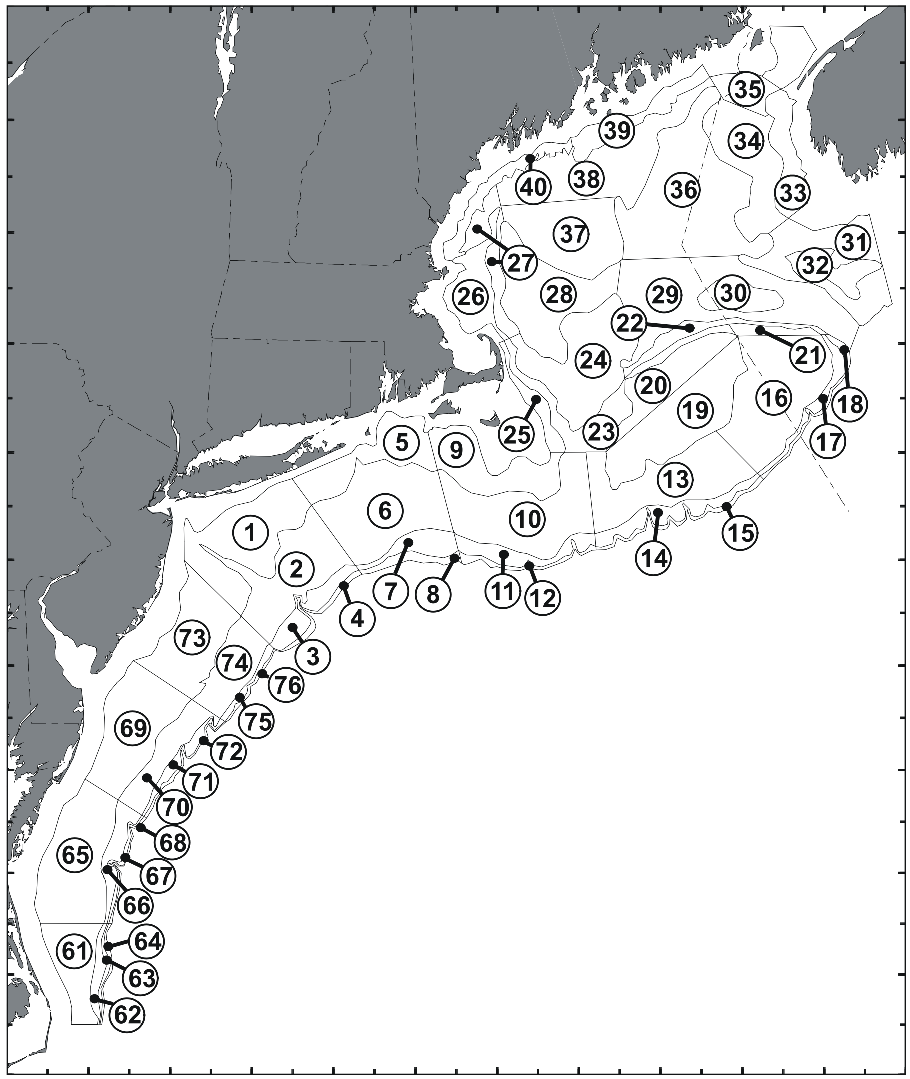

Figure 1. Offshore depth strata that have been sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.

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.

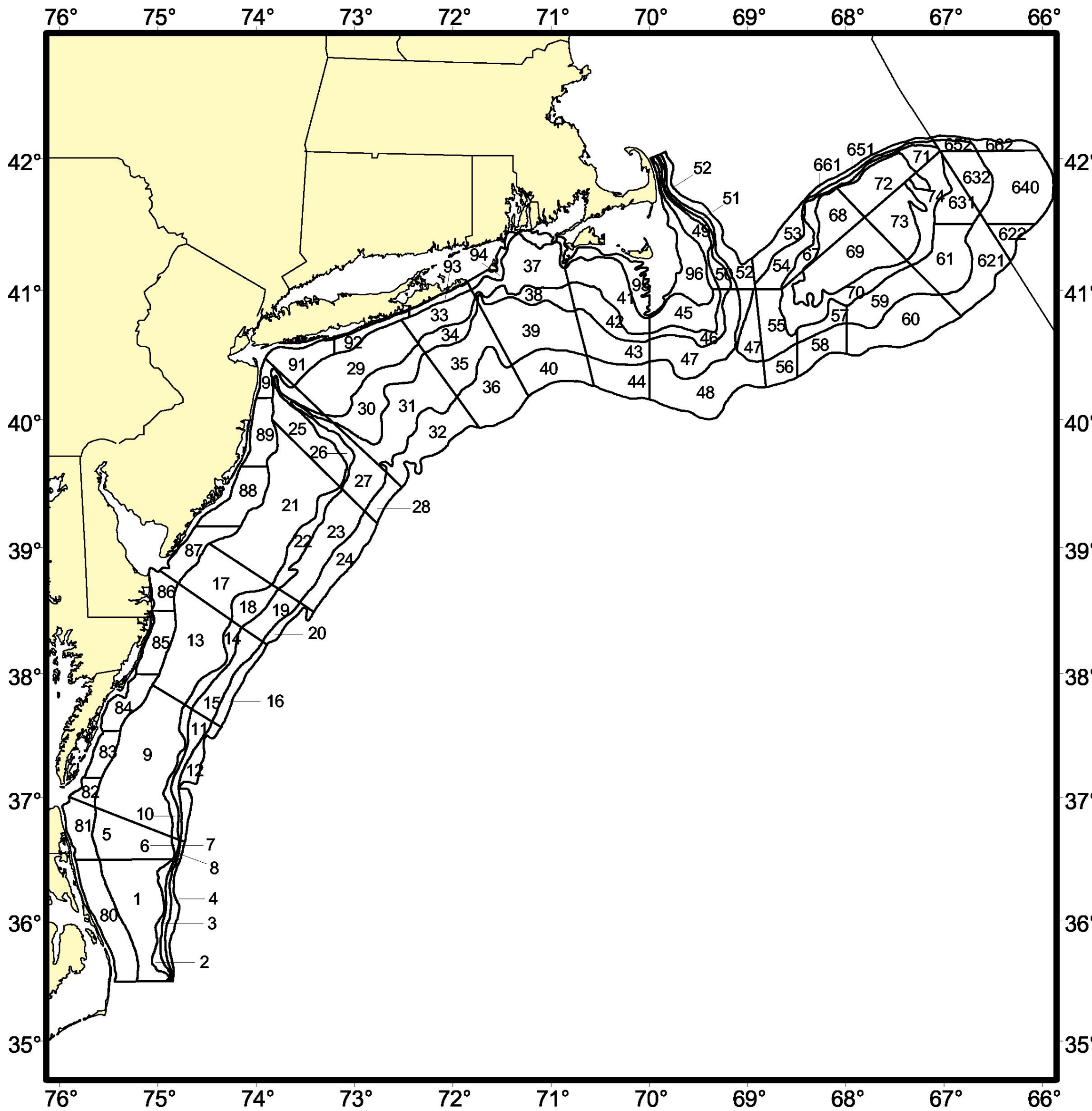

Figure 3. Depth strata sampled during Northeast Fisheries Science Center shellfish surveys.

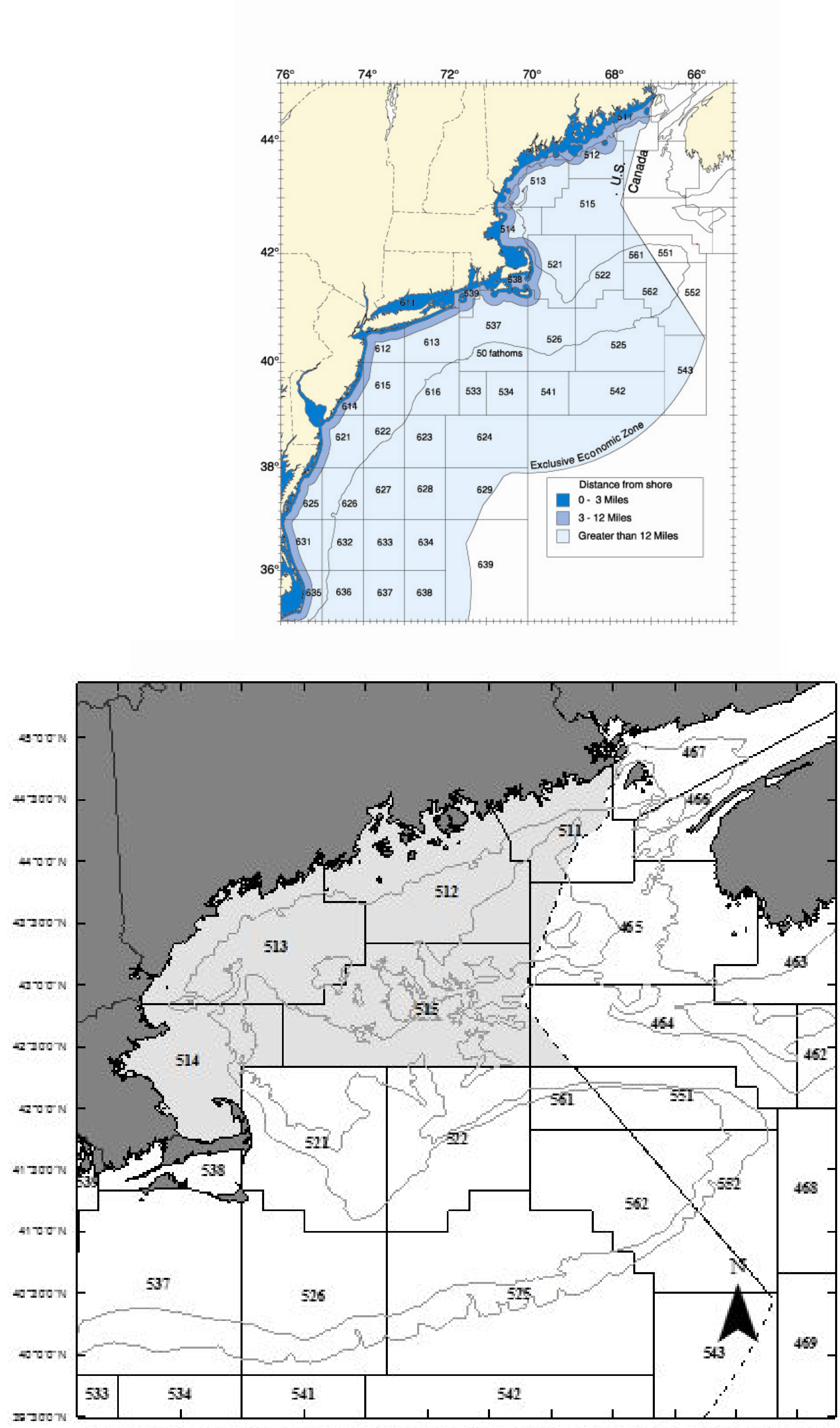

Figure 4. Statistical areas used for reporting commercial catches.

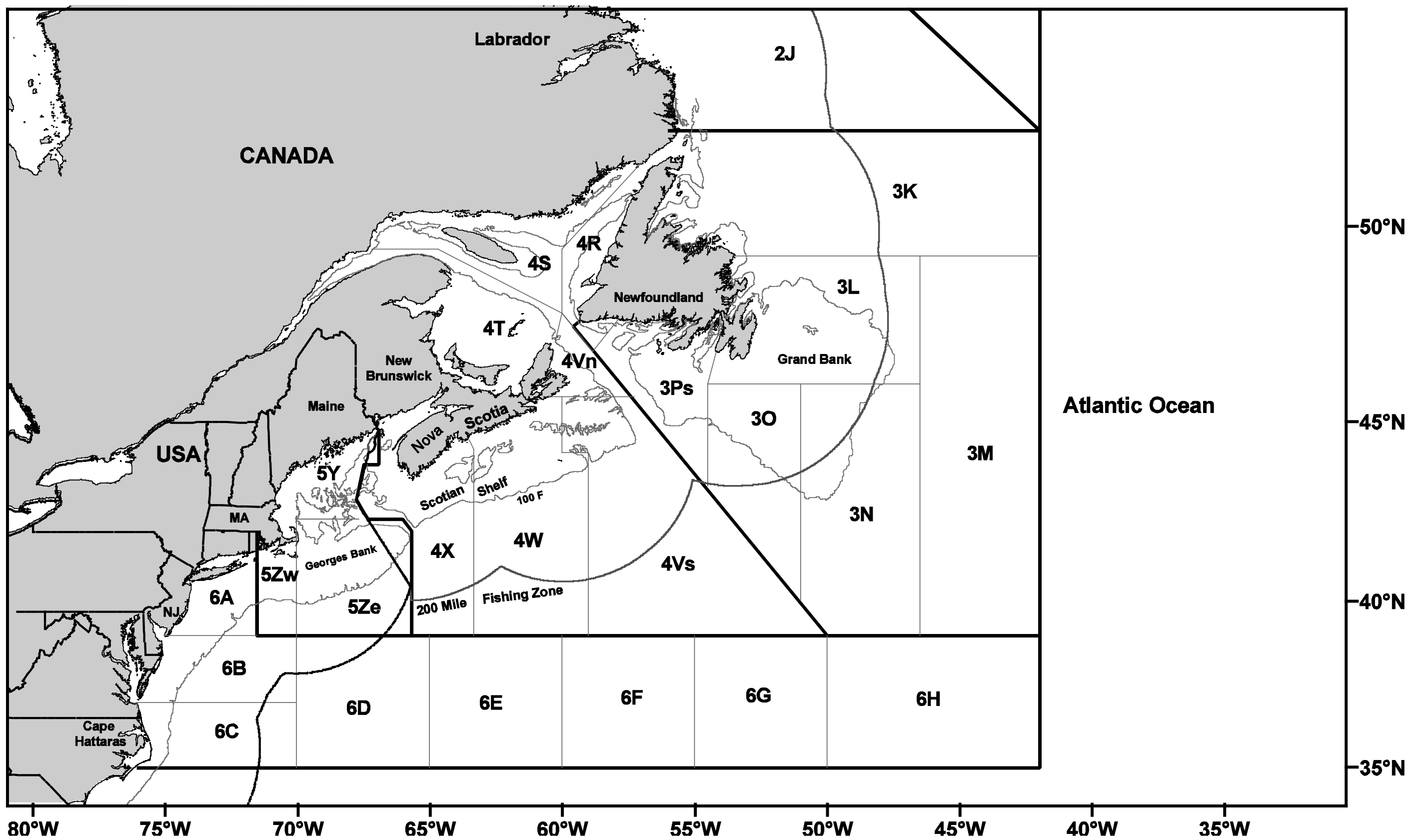

Figure 5. Catch reporting areas of the Northwest Atlantic Fisheries Organization (NAFO) for Subareas 3-6.

A: SUMMER FLOUNDER STOCK ASSESSMENT FOR 2018

Terms of Reference

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. Compare previous recreational data to re-estimated Marine Recreational Information Program (MRIP) data (if available).

2. Present the survey data available, and describe the basis for inclusion or exclusion of those data in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.). 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.

3. Describe life history characteristics and the stock's spatial distribution (for both juveniles and adults), including any changes over time. Describe factors related to productivity of the stock and any ecosystem factors influencing recruitment. If possible, integrate the results into the stock assessment.

4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Include retrospective analyses (both historical and within-model) to allow a comparison with previous assessment results and projections, and to examine model fit. Examine sensitivity of model results to changes in re-estimated recreational data.

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. Make a recommendation[a] about what stock status appears to be, based on the existing model (i.e., model from previous peer reviewed accepted assessment) and with respect to a new modeling approach(-es) developed for this peer review.
   a. Update the existing model with new data and make a stock status recommendation (about overfished and overfishing) with respect to the existing BRP estimates.
   b. Then use the newly proposed modeling approach(-es) and make a stock status recommendation with respect to "new" BRPs and their estimates (from TOR-5).
   c. Include descriptions of stock status based on simple indicators/metrics (e.g., age- and size-structure, temporal trends in population size or recruitment indices, etc).

7. Develop approaches and apply them to conduct stock projections.
   a. Provide numerical annual projections (5 years) and the statistical distribution (i.e., probability density function) of the catch at F_{MSY} or an F_{MSY} proxy (i.e. the overfishing level, OFL) (see Appendix to the SAW TORs). 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. Identify reasonable projection parameters (recruitment, weight-at-age, retrospective adjustments, etc.) to use when setting specifications.
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 and MAFMC SSC reports. Identify new research recommendations.

[a]NOAA Fisheries has final responsibility for making the stock status determination for this stock based on best available scientific information.

EXECUTIVE SUMMARY

TOR1. 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. Compare previous recreational data to re-estimated Marine Recreational Information Program (MRIP) data (if available).

Total U.S. commercial landings of summer flounder from Maine to North Carolina peaked in 1979 at 17,945 mt (39.561 million lb). The reported landings in 2017 of 2,644 mt = 5.829 million lb were about 3% over the final 2017 commercial quota of 2,567 mt = 5.659 million lb. The commercial landings in 2017 were the lowest since 1943. Commercial discards in 2017 were estimated at 906 mt = 1.997 million lb.

Summary landings statistics for the summer flounder recreational fishery (catch type A+B1) were estimated by the National Marine Fisheries Service (NMFS) Marine Recreational Fishery Statistics Survey (MRFSS 1982-2003) and Marine Recreational Information Program (MRIP 2004-2017). Estimated 2017 landings in the recreational fishery (as estimated by the 'Old' MRIP) were 1,447 mt = 3.190 million lb, about 85% of the recreational harvest limit (1,711 mt = 3.772 million lb). The recreational landings in 2017 were the lowest since 1989. Recreational discards were estimated at 442 mt = 0.974 million lb.

In July 2018, the MRIP replaced the existing estimates of recreational catch ('Old' MRIP) with a calibrated 1982-2017 time series that corresponds to new survey methods that were fully implemented in 2018 ('New' MRIP). For comparison with the existing estimates noted above, the 2018 MRIP calibrated estimate of 2017 recreational landings is 4,565 mt = 10.064 million lb, 3.2 times the old estimate. The 2018 MRIP calibrated estimate of 2017 recreational discards is 1,496 mt = 3.298 million lb, 3.4 times the old estimate.

The calibrated recreational catch estimates ('New' MRIP) increased the 1982-2017 total catch by an average of 29% (from 13,308 mt = 29.339 million lb to 17,216 mt = 37.955 million lb), ranging from +11% in 1989 to +43% in 2017. The 2018 SAW-66 stock assessment model includes the 2018 MRIP calibrated estimates of recreational 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 in catch and effort in 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 larger presence of large summer flounder catches on Georges Bank after 2005. Recreational fishing catch distribution (and by inference, effort) from party and charter boats is relatively unchanged throughout the 1990s and 2000s.

TOR2. Present the survey data available, and describe the basis for inclusion or exclusion of those data in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.). 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.

Research survey indices of abundance are available from the NEFSC, MADMF, RIDFW, CTDEEP, NYDEC, NJDFW, DEDFW, MDDNR, VIMS, VIMS ChesMMAP, VIMS NEAMAP, and NCDMF surveys. All available fishery independent research surveys were used in population model calibration. For the NEFSC trawl survey indices, the years sampled by the FSV HB Bigelow (2009-2017) are treated as a separate series from the earlier years (1982-2008) that were sampled by the FSV Albatross IV. The Bigelow indices incorporate trawl efficiency estimates at length from 'sweep-study' experiments and are expressed as absolute abundances.

The SFWG 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 SFWG concluded that the calculation of directed 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, but since the collection of this data is not a focus of their operation 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. For the MRIP recreational data, the calculation of directed effort is even more problematic, as there are a number of different ways to define summer flounder trips. Further, there is variation in the number of rods and reels (gear quantity) and the time of fishing for each trip. The unit of catch is also inconsistently reported in the for-hire recreational VTRs. In total, these elements make the calculation of effort challenging when working with fishery dependent data time series. The SFWG 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 differing in timing and magnitude for each state (e.g., 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 model used for index standardization. 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 modeling difficulties call into question the utility of both the nominal and model-based fishery dependent CPUE as indices of summer flounder abundance. The SFWG felt the standardization procedure was still subject to an unknown, likely negative, bias. In addition, the SFWG 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 SFWG recommended that the fishery dependent standardized indices of abundance not be used in the summer flounder assessment model.

TOR3. Describe life history characteristics and the stock's spatial distribution (for both juveniles and adults), including any changes over time. Describe factors related to productivity of the stock and any ecosystem factors influencing recruitment. If possible, integrate the results into the stock assessment.

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 observed and predicted length and weight 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. These trends in life-history characteristics had an important effect on the values of the biological reference points updated in this assessment.

There are apparent changes in spatial distribution of summer flounder over the last four decades with a general shift northward and eastward. Spatial expansion is more apparent in the years of greater abundance since about 2000, although it has continued even with the most recent declines in biomass. Higher levels of exploitation can lead to reduced heterogeneity in age structure, particularly a reduction in the abundance of older age fish. However, work examining recent shifts in recruits and an examination of other ecosystem factors suggests other mechanisms may also be contributing factors.

The impact of the change in distribution and weight-at-age on summer flounder stock productivity is important but difficult to determine. Although recruitment has been relatively low in recent years, the driver of these low recruitment events has not been identified, as attempts to link specific covariates to changes in the spatial distribution of recruits did not uncover a clear driving variable. Many factors may be impacting the productivity of the stock, and identifying the mechanisms driving these observed changes is challenging and warrants further research. The use of recent weights-at-age and maturity-at-age in the biological reference point estimates (TOR 5) and in catch projections (TOR 7) attempts to capture the effects of these factors on the future productivity of the stock.

TOR4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Include retrospective analyses (both historical and within-model) to allow a comparison with previous assessment results and projections, and to examine model fit. Examine sensitivity of model results to changes in re-estimated recreational data.

Fishing mortality rates and stock sizes were estimated using the ASAP statistical catch at age model. An age-specific instantaneous natural mortality rate providing an average M = 0.25 was assumed for all years. Fishing mortality on the fully selected age 4 fish ranged between 0.744 and 1.622 during 1982-1996 and then decreased to 0.245 in 2007. Since 2007 the fishing mortality rate has increased and was 0.334 in 2017. The 90% confidence interval for F in 2017 was 0.276 to 0.380. Spawning stock biomass (SSB) decreased from 30,451 mt in 1982 to 7,408 mt in 1989 and then increased to 69,153 mt in 2003. SSB has decreased since 2003 and was estimated to be 44,552 in 2017. The 90% confidence interval for SSB in 2017 was 39,195 to 50,935 mt. The 1983 year class is the largest in the assessment time series at 102 million fish, while the 1988 year class is the smallest at only 12 million fish. The average recruitment from 1982 to 2017 is 53 million fish at age 0. Recruitment has been below average since 2011, ranging from 30 to 42 million and averaging 36 million fish. The survival of summer flounder recruits, expressed as the R/SSB ratio, was higher in the 1980s and early 1990s than in the years since 1996.

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 2010. 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. The use of the new calibrated estimates of recreational landings and discards in the current assessment increased the 1982-2017 total catch by an average of almost 30%. While the magnitude of fishing mortality was not strongly affected, the increased catch has resulted in increased estimates of stock size compared to the historical assessments.

TOR5. 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 existing 2013 SAW 57 biological reference points for summer flounder are based on stochastic yield and SSB per recruit and stochastic projection models using values from the 2013 assessment. The fishing mortality reference point is F35% = 0.309 (CV = 15%) as a proxy for FMSY. The biomass reference point proxy is estimated as the projection of Jan 1, 2013 stock sizes at F35% = 0.309 and mean recruitment of 43 million fish per year (1982-2012). The SSBMSY proxy is estimated to be 62,394 mt (137.6 million lb; CV = 13%), and the biomass threshold of one-half SSBMSY is estimated to be 31,197 mt (68.8 million lb; CV = 13%). The MSY proxy is estimated to be 12,945 mt (28.539 million lb; CV = 13%).

The new 2018 SAW-66 biological reference points for summer flounder are similarly based on stochastic yield and SSB per recruit and stochastic projection models. The new fishing mortality reference point is F35% = 0.448 (CV = 15%) as a proxy for FMSY. The biomass reference point proxy is estimated as the projection of Jan 1, 2018 stock sizes at F35% = 0.448 and mean recruitment of 53 million fish per year (1982-2017). The SSBMSY proxy is estimated to be 57,159 mt (126.0 million lb; CV = 15%), and the biomass threshold of one-half SSBMSY is estimated to be 28,580 mt (63.0 million lb; CV = 15%). The MSY proxy is estimated to be 15,973 mt (35.214 million lb; CV = 15%).

The increase in the F reference point (and MSY) but decrease in the biomass reference point is due primarily to the effect of decreased mean weight at age for older ages (mainly ages 6 and 7+, because of increasing numbers of older fish available in fishery and survey samples and increasing number of males [which are smaller and of lower mean weight] present in the catch and survey samples at those ages), and secondarily to a more domed-shaped average fishery selectivity pattern. These combined factors result in 'flatter' (i.e., lower slope through F35%) SSB per recruit at F and percent MSP at F curves in the current assessment when compared to the previous 2013 SAW57 benchmark.

TOR6. Make a recommendation[a] about what stock status appears to be, based on the existing model (i.e., model from previous peer reviewed accepted assessment) and with respect to a new modeling approach(-es) developed for this peer review.

a. Update the existing model with new data and make a stock status recommendation (about overfished and overfishing) with respect to the existing BRP estimates.
b. Then use the newly proposed modeling approach(-es) and make a stock status recommendation with respect to "new" BRPs and their estimates (from TOR-5).
c. Include descriptions of stock status based on simple indicators/metrics (e.g., age- and size-structure, temporal trends in population size or recruitment indices, etc).

a) A model with data through 2017, but with the same configuration and settings as the old (existing) 2013 SAW 57 model, provides estimates appropriate to compare with the old (existing) reference points, which are the fishing mortality threshold FMSY proxy = F35% = 0.309 and biomass target SSBMSY proxy = SSBMSY35% = 62,394 mt, with biomass threshold 1/2SSBMSY35% = 31,197 mt. The existing model indicates that F in 2017 = 0.244 and SSB in 2017 = 34,350 mt, so the stock was not overfished and overfishing was not occurring.

b) The final model adopted by the 2018 SAW-66 SFWG for the evaluation of stock status indicates the summer flounder stock was not overfished and overfishing was not occurring in 2017 relative to the new biological reference points established in this 2018 SAW-66 assessment. The fishing mortality rate was estimated to be 0.334 in 2017, below the new fishing mortality threshold reference point = FMSY = F35% = 0.448. SSB was estimated to be 44,552 mt in 2017, 78% of the new biomass target reference point = SSBMSY = SSB35% = 57,159 mt, and 56% above the new biomass threshold with ½ SSBMSY = ½ SSB35% = 28,580 mt.

c) The age structure of the total catch and NEFSC trawl surveys has expanded since the late 1990s when few fish were caught over age-4 and catch rates were relative low. Most aggregate survey indices showed increasing trends from the late 1990s through the mid-2000s. These metrics indicate that the reduction in fishing mortality that occurred through the F reduction/stock rebuilding plan kept total mortality from all sources (M+F) low enough to allow the abundance as indicated by the surveys to increase and the age-structure to expand. However, since the mid-2000s, most aggregate survey indices of abundance and/or biomass have remained stable or declined. This decline suggests the total mortality is too high to maintain an increasing stock trend. The exact cause of the observed trend is difficult to determine. Although recruitment indices have been below average in the most recent years, the driver of this pattern has not been identified nor is it clear if this pattern will persist in the future. There are also observed declines in the mean weights-at-age for both sexes and the age of maturity for age-1 fish, but no observed changes in the length-weight relationship or fish condition indices (Fulton's K). The observed shift in spatial distribution northward and eastward along shelf has continued since the mid-2000s, during a time of both abundance increase and during the recent declines. Other sources of unaccounted for mortality or changes in fishing pressure or exploitation patterns could be contributing factors. Regardless of cause, declines in survey indices suggest that current mortality from all sources is greater than current recruitment inputs to the stock. If recruitment improves, current catches may allow the stock to increase, but if recruitment remains low or decreases further, then reductions in catch will be necessary.

TOR7. Develop approaches and apply them to conduct stock projections.

a. Provide numerical annual projections (5 years) and the statistical distribution (i.e., probability density function) of the catch at F_{MSY} or an F_{MSY} proxy (i.e. the overfishing level, OFL) (see Appendix to the SAW TORs). 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. Identify reasonable projection parameters (recruitment, weight-at-age, retrospective adjustments, etc.) to use when setting specifications.
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 2019-2023 consistent with the new (updated) 2018 SAW-66 biological reference points. The recommended projections assume that recent (2013-2017) patterns of fishery selectivity, discarding, maturity at age and mean weight at age will continue over the time span of the projections. The projections assume that 100% of the 2018 ABC (5,999 mt = 13.226 million lb) will be caught. The recommended OFL projections use F2019-F2023 = fishing mortality threshold FMSY proxy = F35% = 0.448 and sample from the estimated recruitment for 1982-2017. The recommended OFL catches are 14,208 mt in 2019 (CV = 12%), 14,040 mt in 2020 (CV = 11%), 14,411 mt in 2021 (CV = 11%), 14,912 in 2022 (CV=13%), and 15,335 in 2023 (CV=15%). For the projections at fixed FMSY proxy = F35% = 0.448, there is 0% probability of exceeding the fishing mortality threshold and 0% probability of falling below the biomass threshold during 2019-2023.

b, c) 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.

TOR8. 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 and MAFMC SSC reports. Identify new research recommendations.

Research recommendations have been subset as 8.1) from the previous 2013 SAW 57 benchmark assessment, 8.2) from the 2013-2018 MAFMC SSC reports, and 8.3) new recommendations from the 2018 SAW-66 review.

WORKING GROUP PROCESS

The Stock Assessment Workshop (SAW) Summer Flounder Working Group (SFWG) met during January 30-February 1, May 29-31, and September 17-20, 2018 to develop the benchmark stock assessment of summer flounder (fluke) through 2017. The following scientists and managers constituted the 2018 SFWG:

Jeff Brust	New Jersey Division of Fish and Wildlife (NJDFW)
Jessica Coakley	Mid-Atlantic Fishery Management Council (MAFMC); SFWG Chair
Tiffany Cunningham	Massachusetts Division of Marine Fisheries (MADFW)
Chris Legault	National Marine Fisheries Service (NMFS) Northeast Fisheries Science Center (NEFSC)
Jason McNamee	Rhode Island Division of Fish and Wildlife (RIDFW), Atlantic States Marine Fisheries Commission (ASMFC) Technical Committee Chair
Tim Miller	NMFS NEFSC
Charles Perretti	NMFS NEFSC
Patrick Sullivan	Cornell University
Mark Terceiro	NMFS NEFSC; Assessment Lead

In addition to the SFWG, the following scientists and managers attended these meetings:

Charles Adams	NMFS NEFSC
Ariele Baker	NMFS NEFSC
Jessica Blaylock	NMFS NEFSC
Russ Brown	NMFS NEFSC
Steve Cadrin	University of Massachusetts-Dartmouth-SMAST; SCeMFiS
Matthew Cunningham	NMFS NEFSC
Kiley Dancy	MAFMC
Kevin Friedland	NMFS NEFSC
Emerson Hasbrouck	Cornell University
Andy Jones	NMFS NEFSC
Jeff Kipp	Atlantic States Marine Fisheries Commission (ASMFC)
Joe Langan	University of Rhode Island
Scott Large	NMFS NEFSC
Brian Linton	NMFS NEFSC
Andy Lipsky	NMFS NEFSC
John Maniscalco	New York Department of Environmental Conservation (NYDEC)
Mark Maunder	Inter-American Tropical Tuna Commission (IATTC)
Alicia Miller	NMFS NEFSC
Paul Nitchske	NMFS NEFSC
Mike Palmer	NMFS NEFSC
Eric Powell	University of Southern Mississippi; SCeMFiS

Kirby Rootes-Murdy	ASMFC
Gary Shepherd	NMFS NEFSC
Mike Simpkins	NMFS NEFSC
Laurel Smith	NMFS NEFSC
Jim Weinberg	NMFS NEFSC; SAW Chair
Susan Wigley	NMFS NEFSC
Mike Wilberg	University of Maryland-Chesapeake Biological Lab

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 the 2013 SAW 57 assessment (NEFSC 2013), Kajajian et al. (2013 MS) 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 (n = 138) collected 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 Sr 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.

MANAGEMENT SUMMARY

Summer flounder are jointly managed by the MAFMC and the ASMFC. The MAFMC and ASMFC cooperatively develop fishery regulations, with the National Marine Fisheries Service (NMFS) serving as the federal implementation and enforcement entity within the United States (U.S.) Department of Commerce. Cooperative management was developed because significant catch is taken from both state (0-3 miles offshore) and federal waters (>3-200 miles offshore).

The MAFMC is one of eight regional fishery management councils created when the U.S. Congress passed the Magnuson-Stevens Fishery Conservation and Management Act of 1976 (MSA). The law created a system of regional fisheries management designed to allow for regional, participatory governance. The MAFMC develops fishery management plans and recommends management measures to the Secretary of Commerce through the NMFS for federal fisheries in the Exclusive Economic Zone (EEZ) of the U.S.

The ASMFC is an interstate fisheries commission created by an interstate compact ratified by the 15 U.S. Atlantic coast states and approved by the U.S. Congress in 1942. The ASMFC coordinates the management of 27 species within state waters and is guided by two pieces of legislation: the Atlantic Striped Bass Conservation Act of 1984 and the Atlantic Coastal Fisheries Cooperative Management Act of 1993. As result of these Acts, all Atlantic coast states that are included in an ASMFC fishery management plan must implement required conservation provisions of the plan or the Secretary of Commerce may impose a moratorium for fishing in the noncompliant state's waters.

Cooperative management of the summer flounder fishery began through the implementation of the original joint Summer Flounder Fishery Management Plan (FMP) in 1988, a time that coincided with the lowest levels of stock biomass for summer flounder since the late 1960s. In 1993, Amendment 2 to the FMP enacted the bulk of the fishery management program, including regulations designed to meet fishing mortality rate targets. The FMP measures included an annual fishery landings limit 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 (Maine through North Carolina) based on their share of commercial landings during 1980-1989. In addition, Amendment 2 established: 1) a commercial minimum landed fish size limit of 13 in (33 cm), 2) 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 lb (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, 3) moratoria on commercial summer flounder permits and associated qualifying criteria, 4) reporting requirements for the commercial and for-hire recreational fisheries, 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.

A timeline of major summer flounder management actions is summarized in the table below. Most of the Amendment 2 management measures are still in place at present, with some modifications and additions as described below. Additional management actions and all FMP documents can be viewed at http://www.mafmc.org/fisheries/fmp/sf-s-bsb and http://www.asmfc.org/species/summer-flounder.

Year	Document	Management Action
1988	Original FMP	Established original joint management plan for summer flounder Established a 13-inch (33 cm) total length minimum size requirement (commercial and recreational) Implemented permit requirements for the commercial and recreational fisheries
1990	Amendment 1	Established an overfishing definition for summer flounder
1993	Amendment 2	Established rebuilding schedule Established annual commercial quotas (allocated by state) and recreational harvest limits Established a moratorium permits and qualifying criteria for commercial fishery Established minimum mesh size requirements for trawl vessels (5.5" diamond or 6.0" square in codend) Implemented monthly logbook requirements for commercial and for-hire recreational fisheries; required mandatory weekly dealer reporting (effective Jan. 1, 1994) Established annually adjustable possession limits, size limits, and open seasons for the recreational fishery, including a 14-inch (36 cm) recreational minimum size limit
1993	Amendment 3	Increased the possession threshold triggering mesh requirements to 200 lb (91kg) from November 1-April 30
1995	Amendment 7	Revised the F reduction schedule for summer flounder
1997	Amendment 10	Modified commercial minimum mesh size requirements: 5.5" diamond or 6.0" square required throughout net (previously required only in codend) Continued moratorium on commercial summer flounder permits
1999	Amendment 12	Brought FMP into compliance with revised MSA National Standards, including revising the overfishing definition for summer flounder
1997	1997 fishery specifications	Raised the commercial minimum fish size to 14 inches (36 cm) total length
2001	Framework 2	Established state-specific recreational management option for summer flounder ("conservation equivalency")
2004	Framework 5	Established option for multi-year specification of quota (up to three years at a time)
2007	Framework 7	Built flexibility into process to define and update stock status determination criteria as needed through assessment process
2011	Amendment 15	Established Annual Catch Limits (ACLs) and Accountability Measures (AMs) consistent with the 2007 reauthorization of the Magnuson-Stevens Act

ASSESSMENT HISTORY

Amendment 1 to the FMP in 1990 established the overfishing definition for summer flounder as equal to Fmax, initially estimated as Fmax = 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. 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 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 F = 0.41 for 1996 and F = 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 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 threshold fishing mortality of 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 threshold fishing mortality was revised to be 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 (SFWG 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.

A 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 a Virtual Population Analysis (VPA) model to an Age Structured Assessment Program (ASAP) statistical catch at age model (Legault and Restrepo 1998), with 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 = Fthreshold changed from Fmax to F35%. The assessment concluded that the stock was not overfished and overfishing was not occurring in 2007, relative to the revised biological reference points. The fishing mortality rate was estimated to be 0.288 in 2007, below the threshold fishing mortality reference point FMSY = F35% = 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 SSBMSY = SSB35% = 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 2006 SAW 47 benchmark assessment was subsequently updated in 2009-2012 (Terceiro 2009, 2010, 2011, 2012) with comparable results. The 2011 update indicated that the stock had been rebuilt to the SSB target reference point in 2010.

The most recent peer review of the assessment occurred at the 2013 SAW 57 (NEFSC 2013). The ASAP assessment model and proxy reference points were the same as used in the 2008 SAW 47 and subsequent 2009-2012 updates. The benchmark assessment concluded that the stock was not overfished and overfishing was not occurring in 2012 relative to the updated biological reference points. 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, below the updated threshold fishing mortality reference point FMSY = F35% = 0.309. 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 estimated to be 51,238 mt in 2012, about 82% of the new biomass target reference point SSBMSY = SSB35% = 62,394 mt. While the assessment had historically exhibited a consistent retrospective pattern of underestimation of F and overestimation of SSB, no persistent internal retrospective patterns were evident in the 2013 benchmark. The historical retrospective indicates that general trends of fishing mortality, stock biomass, and recruitment have been consistent since the 1990s assessments. The 2013 SAW 57 benchmark assessment was subsequently updated in 2015 and 2016 (Terceiro 2015, 2016) with comparable results.

The last assessment update in 2016 (Terceiro 2016) indicated that the stock was not overfished but overfishing was occurring in 2015 relative to the biological reference points from the 2013 SAW 57 benchmark assessment. Since 2007 the fishing mortality rate had increased and was 0.390 in 2015, 26% above the 2013 SAW 57 threshold fishing mortality FMSY = F35% =

0.309. Spawning stock biomass (SSB) had decreased since 2010 and was estimated to be 36,240 mt in 2015, 58% of the 2013 SAW 57 target biomass SSBMSY = SSB35% = 62,394 mt, and 16% above the 2013 SAW 57 threshold biomass ½ SSBMSY = ½ SSB35% = 31,197 mt. Recruitment was estimated to have been below average since 2010. By 2016, the consistent pattern in the underestimation of F and the overestimation of SSB noted in earlier assessments had returned. Moderate internal model retrospective patterns in F and SSB were evident in the 2016 assessment model, as the average retrospective errors over the last 7 terminal years were -20% and +11%, about twice as large as the magnitude of the 2013 SAW 57 retrospective errors. The model estimates of 2015 F and SSB adjusted for this internal retrospective error were still within the model estimate 90% confidence intervals, however, and so no adjustment of the terminal year estimates was been made for stock status determination or projections. There continued to be consistent retrospective pattern in recruitment averaging +22%. The historical assessment retrospective likewise indicated the emergence of a gradual upward adjustment of recent F estimates and downward adjustment of recent SSB estimates.

TOR A1. 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. Compare previous recreational data to re-estimated Marine Recreational Information Program (MRIP) data (if available).

COMMERCIAL FISHERY LANDINGS

Total U.S. commercial landings of summer flounder from Maine to North Carolina peaked in 1979 at 17,945 mt (39.561 million lb, Table A1, Figure A1). The reported landings in 2017 of 2,644 mt = 5.829 million lb were about 3% over the final 2017 commercial quota of 2,567 mt = 5.659 million lb. The commercial landings in 2017 were the lowest since 1943.

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 0.2%.

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) 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 1994.

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 A2. 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 40 mt per 100 lengths since 2005, 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 (small, medium, large, jumbo, and unclassified) 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 medium, large, and jumbo 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 A3).

For this benchmark assessment, the 1982-2017 NER commercial landings at age were re-compiled to ensure use of the most recent data and consistent application of standard procedures. The resulting changes in the landings at age in total were relatively minor, ranging from a decrease in total landed numbers of 9% in 1983 and 1990 to an increase of 8% in 1989, with an overall time series increase of 4%. The change over the last 5 years averaged less than -0.1%. The mean size of fish landed in the NER commercial fishery has been increasing since 1994, and has averaged about 1.0 kg (2.2 lb) since 2013, typical of an age 4 summer flounder (Table A4).

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 A5). 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 A6-A7.

COMMERCIAL FISHERY DISCARDS

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 MSA to include standardized bycatch reporting methodology in all FMPs of the New England and Mid-Atlantic Fishery Management Councils. The Standardized Bycatch Reporting Method (SBRM) for the estimation of discards (Wigley *et al.* 2008, 2011) has now been adopted for most NER stock assessments that have been subject to a benchmark review since 2009. In the SBRM, the sampling unit is an individual fishing trip. For summer flounder, trips were partitioned into fleets using four classification variables: calendar quarter, regional area fished, gear type, and mesh size. 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 in the '500' series (which includes Southern New England, Georges Bank, and the Gulf of Maine), and Mid-Atlantic (MA) comprising statistical areas in the '600' series. 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 landed in each trip as reported by Dealer records. Total discards (in weight) by fleet were derived by multiplying the estimated discard rate in that fleet by the corresponding fleet landings from the Dealer reports. Further computational and statistical details are provided in Wigley et al. (2011).

Estimates were developed by calendar quarter, gear (fish trawl, scallop dredge, gillnet, pot, and hand/longline gear), and mesh strata (extra-large =>8 inch; 8 in > large => 5.5 inch; small < 5.5 inch codend). For this assessment, new stratum for hand/longline, pots, and gillnet gear were included (all under 'gillnet' in tables). The new fishery stratum increased the estimates of live discard by 30 mt, or about 2%, over the time series. Overall, live commercial discards averaged 1,396 mt (CV = 35%) over the time series, ranging from 274 mt (CV = 58%) in 1991 to 2,689 mt (CV = 39%) in 1992 (Table A8).

Commercial 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 observed 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 account for much 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 live discards per 100 fish lengths measured. The sampling has been stratified by gear type (fish trawl, scallop dredge, and gillnet/other) 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 A9).

The reasons for discarding in the fish trawl, scallop dredge, and gillnet/pot/handline 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 those tows, and high-grading in 11%. 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 those 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 2006-2017, minimum size regulations were identified as the discard reason in 15-20% of the observed trawl tows, quota or trip limits in 60-70%, and high grading in 5-10%. In the scallop fishery during 2006-2017, quota or trip limits was given as the discard reason for about 40% of the observed tows, with about 50% reported as "unknown." For the entire time series, quota or trip limits was given as the reason for discarding in over 90% of the gillnet/pot/handline hauls. 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 over time, with a higher proportion of older fish being discarded since about 2002 (Table A10).

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 and SAW 57 assessments (NEFSC 2008a, 2013) considered information from 2007 and 2009 Cornell University Cooperative Extension studies (Hasbrouck et al 2011, 2012). These studies conducted scientific trips on summer inshore and winter offshore 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 mean inshore mortality was 78.7%, while the mean offshore mortality was 80.4%; both estimates are 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. The 80% discard mortality rate assumption is reflected in the estimates of commercial fishery discards at age and mean weights at age in Tables A10-A11.

RECREATIONAL FISHERY CATCH

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 2004-2017) are presented in Table A12. Estimated 2017 landings in the recreational fishery were 1,447 mt = 3.190 million lb, about 85% of the recreational harvest limit (1,711 mt = 3.772 million lb). The recreational landings in 2017 were the lowest since 1989.

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 A13). To convert the recreational fishery length frequencies to age, MRFSS sample length frequency data and 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 2001-2017) 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 A14-A15).

Recreational Fishery Discards

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. Biological samples of the MRFSS/MRIP catch type B2 fish were not routinely taken before 2005. 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 CTDEEP 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 CTDEEP 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 CTDEEP 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.

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 1984 MS) 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 in aggregate numbers and weight (Table A16). The average annual CV of the recreational discards is 8% during 1982-2017. Recreational discard sampling intensity, estimates of dead discards at age, and dead discard mean weights at age are presented in Tables A17-A19.

Calibrated ('New') Marine Recreational Information Program (MRIP) Catch

In July 2018, the NOAA NMFS Marine Recreational Information Program (MRIP) released revised catch and effort estimates ('New' MRIP; 1981-2017) as part of its recent transition from the Coastal Household Telephone Survey (CHTS) to the new, mail-based Fishing

Effort Survey (FES). Implemented in 2018, the FES is intended to be a more accurate method of collecting saltwater recreational fishing effort data from shore and private boat anglers on the Atlantic and Gulf coasts. As a result of the improved survey, FES estimates are a few to several times higher than telephone survey estimates and vary by state, type of fishing mode (by boat, shore, or for-hire), and reporting period. However, analyses indicate that the increase in effort estimates is because the FES does a better job of estimating fishing activity, not a sudden rise in fishing.

Calibration is a critical part of the transition to the new survey design. MRIP and academic consultants created a calibration model to re-estimate the fishing effort statistics back to 1981 from the 'Old' CHTS "currency" to the 'New' FES "currency." The model accounts for the change in survey methods and the shift from landline telephone use to cell phone-only households. The model was peer reviewed and accepted by a panel of independent experts. MRIP completed a similar process to adjust historical catch rate estimates produced by the Access Point Angler Intercept Survey, the shoreside survey conducted by the states that collects information on angler catch from Maine to Mississippi. This adjustment accounted for any effects of the 2013 change to an improved sampling design for the intercept survey. The approach was peer reviewed and accepted by a panel of independent experts.

For comparison with the 'Old' estimates noted above, the 2018 MRIP calibrated estimate of summer flounder 2017 recreational landings is 4,565 mt = 10.064 million lb, 3.2 times the old estimate. The 2018 MRIP calibrated estimate of 2017 recreational discards is 1,496 mt = 3.298 million lb, 3.4 times the old estimate noted above. The time series of 'New' MRIP landings estimates in aggregate numbers and weight are presented in Table A20 and a comparison with the 'Old' MRFSS/MRIP estimates is made in Table A21 and Figure A2. The estimated recreational landings in numbers increased an average of 61%, ranging from +23% in 1983 to +208% in 2017. The estimated recreational landings in weight increased an average of 73%, ranging from +30% in 1982 to +215% in 2017. The largest absolute and percentage increases over time occurred for the NJ and NY Private/Rental boat fisheries. As a result of the increased landings, the sampling intensity of the recreational landings decreased to a level that would be considered marginally sufficient, generally between 200 and 300 mt per 100 lengths since 1999 (Table A22). Estimates of the landings and mean weights at age for the 'New' MRIP estimates are presented in Tables A23-A24.

The 'New' MRIP discards estimates in aggregate numbers and weight are presented in Table A25 and a comparison with the 'Old' MRFSS/MRIP estimates is made in Table A26 and Figure A3. The estimated recreational discards in numbers changed by an average of +81%, ranging from -16% in 1982 to +235% in 2017. The estimated recreational discards in weight changed by an average of +74%, ranging from -41% in 1994 to +239% in 2017.

In the recompilation of the discards at age using the 'New' MRIP estimates, the available MRFSS and some newly available (since the previous 2013 SAW 57 benchmark assessment) ALS and VAS data was judged sufficient in quantity and coverage (in time, space, and fish length range) to allow direct characterization the length frequencies of the discards from sample data from 1993-2000. As a result of the increased discards, the sampling intensity of the recreational discards decreased but remained at a level that would be considered excellent, generally between 20 and 30 mt per 100 lengths since 1993 (Table A27). Estimates of the discards and mean weights at age for the 'New' MRIP estimates are presented in Tables A28-A29.

TOTAL FISHERY CATCH COMPOSITION

NER commercial fishery landings and discards at age, North Carolina winter trawl fishery landings and discards at age, and 'Old' MRFSS/MRIP recreational fishery landings and discards at age totals were summed to provide a total fishery catch at age for 1982-2017 (Table A30). 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 A31). Comparable information for the total catch with the 'new' MRIP estimates are provided in Tables A32-A33 and Figures A4-A5. The 2018 SAW-66 stock assessment model includes the 'New' MRIP calibrated estimates of recreational landings and discards (Figure A6).

Using the 'Old' MRIP estimates of recreational catch, commercial landings have accounted for 59% of the total landings and 49% of the total catch since 1993, when the current landings allocation system was implemented. Recreational landings accounted for 41% of the total landings and 34% of the total catch. Commercial discard losses accounted for about 10% of the total catch, and recreational discard losses about 7%. Table A34 provides a tabulation of total catch in weight using the 'Old' MRFSS/MRIP estimates of the recreational fishery catch.

Using the 'New' MRIP estimates of recreational catch, commercial landings have accounted for 43% of the total landings and 36% of the total catch since 1993, when the current landings allocation system was implemented. Recreational landings accounted for 57% of the total landings and 47% of the total catch. Commercial discard losses accounted for about 7% of the total catch, and recreational discard losses about 10%. Table A35 provides a tabulation of total catch in weight using the 'New' MRFSS/MRIP estimates of the recreational fishery catch.

A comparison of total fishery catches in numbers and weight with the 'Old' and 'New recreational catches is made in Table A36. The 'New' recreational catch estimates increased the 1982-2017 total catch in numbers by an average of 24% (4.6 million fish), ranging from +9% in 1989 to +73% in 2017. The 'New' recreational catch estimates increased the 1982-2017 total catch in weight by an average of 29% (3,908 mt = 8.616 million lb), ranging from +12% in 1989 to +77% in 2017.

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 1994-2017. 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 (Miller and Terceiro 2018a MS).

Commercial Fishery

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 A7; brown to purple squares). Large catches of summer flounder continued along the shelf from 2001-2005 with concentrations slightly farther north off DelMarVa (Figure A8). 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 A9-A11).

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 A12-A13). Catch densities from observer trips begin resembling a sub-sample of the commercial VTR catch data after 2000 (Figures A14-A17).

Recreational Fishery

It is important to note that this recreational catch data is based only on party and charter boat trip reports and does not include recreational fishing by individual private boats or anglers or catch from shore. Recreational fishing catch (and by inference, effort) distribution from party and charter boats is relatively unchanged throughout the duration of the VTR database (Figures A18-A22). One exception is a reduced catch south of the Chesapeake Bay 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. Consistent with 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.

TOR A2. Present the survey data available, and describe the basis for inclusion or exclusion of those data in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.). 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.

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 Fisheries Survey Vessel (FSV) *Albatross IV* and FSV *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 1-17 and 61-75 using a flatfish net with a cookie sweep.

In the 2013 SAW 57 assessment (NEFSC 2013), the SFWG undertook a re-consideration of the strata included in indices for all three seasonal surveys, including those in the Great South Channel and Georges Bank. After examination of alternative strata set times series trends and precision, the SFWG decided to retain the winter, spring, and fall survey strata sets used in the assessments since 2002. Those standard strata sets have been retained in the current assessment.

The NEFSC spring and fall survey indices suggest that total stock biomass peaked during 1976-1977 and again during 2003-2007 (Table A37, Figure A23). The FSV *Albatross IV* (ALB) was replaced in spring 2009 by the FSV *Henry B. Bigelow* (BIG) 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 BIG 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 2009-2017 spring and fall BIG survey catch number and weight indices to ALB equivalents.

The aggregate, spring calibration factors from Miller *et al.* (2010) are 3.2255 for numbers (i.e., the BIG 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 are 2.4054 for numbers and 2.1409 for weight (Miller *et al.* 2010; Table A38). The effective total catch number length-based calibration factors vary by year and season, depending on the characteristics of the BIG length frequency distributions. The effective length-based calibration factors for numbers have ranged from 1.825 to 1.994 in the spring (average = 1.887) and from 1.814 to 2.123 in the fall (average = 1.876; Tables A39-A41).

Age composition data from the calibrated NEFSC spring surveys indicate a substantial reduction in the number of ages in the stock between 1976-1990 (Table A42, Figure A24). 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 16 for males and age 14 for females. Mean lengths at age from the NEFSC spring survey are presented in Table A43.

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 indices at-age are presented in Table A44. The NEFSC fall survey catches age-0 summer flounder in abundance, providing an index of summer flounder recruitment (Table A44, Figures A25-A26). NEFSC fall survey indices suggest 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 A45. The standard strata set for summer flounder was not sampled in fall 2017.

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 offshore strata 61-75 (27-110 meters; 15-60 fathoms) off the Delmarva and North Carolina coasts. Other concentrations of fish were found in strata 1-11, 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 13-17). 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 A47-A48). The NEFSC winter survey series ended in 2007.

NEFSC FSV Henry B. Bigelow (BIG) indices as separate time series

In developing assessment model configurations for this assessment, the 2018 SFWG explored using the BIG indices as separate time series (2009-2016/2017), both to more easily incorporate recent research results on the efficiency of the BIG survey gear and to reduce uncertainty due to the BIG-to-ALB calibration. 'Standard' stratified mean numbers and weight per tow indices compile using BIG standard TOGA acceptance criteria are presented in Table A49.

Data from the 2015-2017 'twin trawl sweep study' experimental work was used to estimate mean trawl efficiency at length factors ('sweep q') to compute 'absolute' indices per tow (i.e., what the survey catch per tow would be if trawl efficiency were 100%) for the BIG 2009-2016/2017 survey catch. Application of the experimental efficiencies increases the computed catch per tow of the indices and, for the fall numeric indices, changes the rank order of the annual indices (i.e., 2016 is the highest in the 2019-2017 series; Figures A27-A28). These 'absolute' stratified mean numbers and weight per tow indices compiled using BIG standard TOGA acceptance criteria and efficiency estimates at length are presented in Table A50.

For use in population models, the BIG indices at age were also expressed as Swept Area Numbers (SWAN) indices, wherein the 'Absolute' indices are expanded to the total 'swept area' of the survey (expansion by average wing spread dimension, average tow speed, and annual survey area) to provide absolute estimates of population size (000s of fish at age). 'Standard,' 'Absolute,' and 'SWAN' indices for the NEFSC BIG spring and fall surveys are presented in Tables A51-A52.

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 A53-A54, Figure A29). 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 A55, Figure A30).

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 A56, Figure A31). 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 A57, Figure A31). Recruitment indices are available from both the fall (Figure A30) 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 A58, Figure A31).

Connecticut DEEP

Spring and fall bottom trawl surveys are conducted by the Connecticut Department of Energy and Environmental Protection (CTDEEP). The CTDEEP surveys show a decline in abundance in numbers of summer flounder from 1986 to record lows in 1989. The CTDEEP 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 A59-A60, Figure A32). An index of recruitment is available from the fall series (Figure A33).

New York DEC

The New York Department of Environmental Conservation (NYDEC) 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 A61 Figure A32). An index of recruitment is available (Figure A33).

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 A62, Figure A34). 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 A33).

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 A63-A64, Figure A35). Indices for age-0 to age-4 and older summer flounder have been compiled from the 30 foot head-rope survey (Table A65, Figure A34). 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 A66, Figure A36). This index suggests that weakest year classes in the time series recruited to the stock in 1988, 2005, and 2015, 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 A67, Figure A36).

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 (Table A68, Figures A37-A38).

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; Tables A69-A70, Figures A37-A38).

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 A71, Figure A36). 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.

NEFSC MARMAP and ECOMON

Ichthyoplankton data for summer flounder was collected during the MARMAP (1977-1987) and ECOMON (1999-2015) programs. 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 time series of larval indices from the MARMAP and ECOMON programs are used as indices of summer flounder spawning stock biomass (Table A72, Figure A39).

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, vessel, and regulatory 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 GENMOD was used to model the fishery dependent catch rate data using lognormal (for ln-transformed rates), gamma, Poisson, and negative binomial (for untransformed rates) probability distributions, fitting a generalized linear model to the data by maximum likelihood estimation. There is 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.

Commercial Dealer Landings Reports

Dealer report trawl gear landings rate (LPUE) data for summer flounder were modeled to compile standardized indices of abundance for summer flounder. Descriptive statistics indicated that the Dealer report Trawl gear landings rate distribution is over-dispersed 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 (lb), trips, days fished, and nominal annual LPUE (landings lb per DF), and LPUE scaled to the time series mean are presented in Table A73.

Given that the examination of the total landings lb 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 was used 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 the top of Figure A40, 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 through 2010 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. All models and the nominal index indicate a comparable decrease since 2011. 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 the bottom of Figure A40, 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 A74.

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 lb 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 lb (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)

Commercial 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. Descriptive statistics indicate that the VTR trawl gear catch rate distribution is over-dispersed 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 90% of the reported landings and 70% of the reported discards; the nominal reported discard rate (discards to total catch lb) was 2% for large mesh trips and 5% for small mesh trips. Total catch, trips, days fished, nominal annual total catch lb per day fished (CPUE), and CPUE scaled to the time series mean is presented in Table A75.

Given that the examination of the total catch lb 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 was used 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 the top of Figure A41, with all series scaled to their respective means to facilitate comparison. All model configurations have a moderate smoothing effect on the nominal indices, and indicate a slower decline in stock biomass since 2011 than does the nominal index. The negbin indices and their 95% confidence intervals are compared with the nominal index in the bottom of Figure A41, 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 A76.

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. Descriptive statistics indicate that the VTR P/C boat catch distribution is over-dispersed 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 83% is taken during June, July, and August. The distribution by AREA indicated that about 67% 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 75% 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 A77.

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 1994-2017 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 negbin modeled series indicates no overall trend in stock abundance through 2011, with a strong decreasing trend in stock abundance thereafter. The six-factor ST-SZ-BG negbin indices and their 95% confidence intervals are compared with the nominal index in the top of Figure A42, 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 A78 and the bottom of Figure A42.

Commercial Fishery Observer (OB)

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. Descriptive statistics indicate that the observed trawl gear catch rate distribution is over-dispersed 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 lb 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 67% 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 A79.

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 the top of Figure A43, with all series scaled to their respective means to facilitate comparison.

All modeled series indicate a steeper increase in stock biomass until 2010 than does the nominal series, and a comparable decrease since then. 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 bottom of Figure A43, 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 A80.

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. Descriptive statistics indicate that the observed scallop dredge gear catch distribution is over-dispersed 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 A81.

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 the top of Figure A44, 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, only slightly diverging from the nominal trend. The negbin indices and their 95% confidence intervals are compared with the nominal index in the bottom of Figure A44, 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 A82.

MRFSS/MRIP recreational fishery survey

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. 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. Total catch in numbers, trips, and nominal annual CPUE (total catch per trip) for the intercept catch types combined (total catch) are presented in Table A83.

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 1981-2017 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 resulted 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 very comparable trend compared with the nominal series. The six-factor ST-SZ-BG negbin indices and their 95% confidence intervals are compared with the nominal index in Figure A45, 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 A84.

NEFSC Cooperative Research Commercial Study Fleet

The NEFSC Cooperative Research Program partners with commercial fishing vessels to collect fine-scale, tow-level, self-reported catch data throughout a variety of fisheries on the Northeast Shelf. These data were examined to develop a catch-per-unit (CPUE) index for summer flounder (Gervelis 2018 MS). The index was developed using both time and area information and the annual estimate was a stratified-weighted mean CPUE by commercial statistical areas. No statistical modeling was attempted.

Self-reported tow-level data from Cooperative Research partner vessels (Study Fleet) that captured summer flounder (kept and discards) were included in the summer flounder CPUE index. All tows that caught at least 1 pound of summer flounder were included. The CPUE by time was calculated as the total catch (kept plus discards) of summer flounder in pounds divided by the length of the tow in hours.

$$(Utow\ = \frac{(kept_{tow} + discards_{tow})}{time_{tow}}).$$

In an attempt to quantify "directed" trips, the tow level data were aggregated to the trip level and varying levels of summer flounder catch as a percentage of the total catch were also examined (10%, 25%, 40%, 75%). All tows, by all vessels within in a given commercial statistical area (st) in a given year (yr) were averaged to produce an annual statistical area CPUE.

$$U_{st,yr} = \frac{\sum_{tows} U_{tow,st,yr}}{tows_{st,yr}}$$

The annual CPUE was calculated as the mean statistical area CPUE weighted by the area of the statistical boxes.

$$U_{yr} = \frac{\sum_{st} U_{st,yr} area_{st}}{\sum_{st} area_{st}}$$

All Study Fleet participant trawl vessels that captured at least 1 pound of summer flounder over the time series were included. All statistical areas where at least 1 pound of summer flounder were caught were included and all months were included. Tows with missing values for kept or discard catch were excluded. All tows with latitude/longitude outside the Northeast Shelf or tows longer than 12 hours were also excluded.

An examination of the NEFSC Study Fleet summer flounder trawl vessel effort in time and space was found to be reasonably representative of the overall trawl fishery for summer flounder. The nominal (All trips) CPUE index showed an overall increasing trend with a peak in 2013. The amount of vessels and tows also increased during this time period until reaching its peak in 2014. While number of vessels and tows dropped slightly in 2015 and 2016 respectively, CPUE declined further to nearly half of its peak from 2013. CPUE then increased slightly in 2017. (Table A85 and Figure A46). The CPUE indices generated for the various quantification levels (All, 10%, 25%, 40% and 75%) for 'directed' trips all showed similar trends to one another. Sample year 2013 showed more variability in annual CPUE across the different levels than the other years in the time period.

2018 SAW-66 SFWG Conclusion on Utility as Indices of Abundance

The SFWG evaluated the utility of the nominal and standardized fishery dependent landings- and catch-per unit effort based indices as measures of abundance for the summer flounder stock assessment. The SFWG concluded that the calculation of directed 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 directed effort is even more problematic. In this analysis, all trips which caught summer flounder were used. There are several 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 VTRs, with it being provided incorrectly as 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 SFWG 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 vary 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 model used for index standardization. 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 commercial trawl standardized indices generally indicate trends in abundance comparable to the fishery independent survey indices (higher in the late 1970s, lower in the early 1990s, higher again during the 2000s). The recreational fishery standardized indices, for which inclusion of regulatory measures in the models were successful, indicated weaker trends in abundance than either the commercial indices or most fishery independent survey indices.

The top of Figure A47 compares the time series trends of the fishery dependent nominal indices of abundance and the NEFSC spring survey biomass index, scaled to the terminal year (2017) to facilitate comparison (the Study Fleet All trips index is plotted as a nominal index). The bottom of Figure A47 makes the same comparison including the fishery dependent model indices of abundance (the Study Fleet 40% trips index is plotted as a model index). 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. The SFWG felt the standardization procedure was still subject to an unknown, likely negative, bias. In addition, the SFWG 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 SFWG recommended that the fishery dependent standardized indices of abundance not be used in the summer flounder assessment model.

TOR A3. Describe life history characteristics and the stock's spatial distribution (for both juveniles and adults), including any changes over time. Describe factors related to productivity of the stock and any ecosystem factors influencing recruitment. If possible, integrate the results into the stock assessment.

AGEING RESEARCH

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 ageing 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. Beginning in 2001, both scales and otoliths began to be 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, 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 A48-A49 show the intra-ager age bias and percent agreement for the 2011 NEFSC trawl survey age samples, and Figures A50-A52 show the intra-ager age bias and percent agreement for the 2011 NEFSC commercial fishery age samples. These patterns are typical of those for NEFSC fishery and survey scale samples collected since 2000.

NEFSC commercial fishery and survey samples began to transition from scales only to scales and otoliths (to allow comparison and possible calibration) beginning in 2009. A fourth summer flounder ageing workshop was held at VIMS in 2014, to continue the exchange of age structures and review of ageing protocols for summer flounder. A comparison of scale and otoliths ages from 619 samples collected from 2009 to 2013 indicated was good agreement for all age classes up to 12 years of age (Figure A53). However, there was a minor systematic bias detected with otoliths having slightly higher ages on average. Participants at the 2014 workshop concluded that sectioned otoliths were the desired hard-part to use (Eric Robillard, NEFSC, personal communication 2015).

In 2017, ASMFC sponsored another ageing workshop. For sectioned otoliths the agreement between ageing laboratories was found to be above 80% with low variation and no systematic bias (ASMFC 2017 MS). Both NEFSC survey and commercial samples were completely transitioned to otoliths beginning in 2015 with the 2015 spring trawl survey and quarter 1 commercial samples. Figures A54-A55 show the intra-ager age bias and percent agreement for the 2016 NEFSC trawl survey and commercial fishery quarter 1 age samples, which are typical of the otolith samples collected since 2009.

GROWTH

Trends in NEFSC survey mean length and weight at age

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 for ages 0 through age 10; samples for ages 8 and older are sporadic and variable, although they are more numerous and consistent since 2001.

The winter and spring series indicate no strong 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 A56-A57). 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 mid-1990s (Figure A58).

Individual fish weight collection on NEFSC trawl surveys began in 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 (Figure A59-A61). Trends in the 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 (Figure A62).

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 an overall declining trend since the 1990s for ages 2 and older. Mean lengths of ages 3 and older show decreasing trends for both sexes (Figures A63-A65).

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, 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 1976-2016 (ages for 2017 were not yet available) were used to estimate growth parameters for males, females, and sexes combined for the full time series and for seven multi-year (generally five year) bins. The full time series data provide parameters for males (n = 19,424) of Linf = 63.9 cm, k = 0.18, with maximum length of 67 cm (age 6) and age of 15 (length 56-57 cm); parameters for females (n = 20,689) of Linf = 80.6 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 = 40,942, including small fish of undetermined sex) of Linf = 83.6, k = 0.14, with maximum age of 15 (Table below, Figure A66).

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	40,942	15,14	63.9, 80.6, 83.6	0.18, 0.18, 0.14

The seven multi-year bins were for the years 1976-1981, 1982-1987, 1988-1993, 1994-1999, 2000-2005, 2006-2011, and 2012-2016. 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. 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. 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 (2012-2016) indicating smaller predicted lengths at age than in previous years. The growth curves are more variable for males, and therefore for sexes combined, again with the most recent 2012-2016 curve indicating smaller predicted lengths for older males, and for all ages when sexes are combined (Figures A67-A68).

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 32,507 fish from the NEFSC trawls surveys for 1992-2017 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 1992-2017 time series, for 5 multi-year blocks (1992-1995, 1996-2000, 2001-2005, 2006-2010, and 2011-2017), and by survey seasonal time series (winter 1992-2007, spring 1992-2017, and fall 1992-2016).

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 curves 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 model 'plus group'), a threshold below which over 95% of the fishery catch has occurred (see the 'SVs Age 7 xl' vertical line in Figures A69-A70). 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 A69). In a comparison with survey seasonal curves, the curves are again nearly identical through 62 cm. 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 A70). 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 A71-A73).

SEX RATIO

Sex Ratio in NEFSC Survey Raw Sample Data

The NEFSC winter, spring, and fall 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 (Figure A74).

In the spring survey, the proportion of females showed no trend for age 1 and the time series mean proportion was 0.4; the mean for 2012-2016 was 0.4. For ages 2 and 3, the proportion has decreased from about 0.6-1.0 in the early 1990s to about 0.5 since 2000; the means for 2012-2016 were about 0.4. For ages 4 and 5, the proportion has decreased from a range of 0.8 to 1.0 in the early 1990s to about 0.5 in the mid-2000s; the means for 2012-2016 were 0.4 and 0.5. For ages 6-8 the proportion ranged from 0.5 to 1.0 with no trend for most of the series, but has most recently decreased to near 0.5; the means for 2012-2016 were about 0.7 (Figure A75).

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 the 2010s; the means for 2012-2016 were about 0.3. The proportions at ages 3 and 4 have strongly decreased from about 0.9 through the late 1990s to about 0.5 by the 2010s; the means for 2012-2016 were 0.4 and 0.5. For ages 5-8 and older the proportions have most recently decreased to about 0.7; the means for 2012-2016 were 0.7, 0.8, 0.7, and 0.9 (Figure A76).

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 (1976-2016) series. The spring and fall BIG 2009-2016 indices were calibrated to ALB equivalents using calibration factors at length. The male and female indices generally follow similar trends over time (Figures A77-A78).

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. For ages 7 and older that compose the 'plus group,' the proportion has ranged from 0.8 to 1.0 over the series (Figure A77).

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 0.3-0.5 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. Most recently the proportion of females at ages 5 and older has decreased to less than 0.6 (Figure A79).

In the fall survey, the proportion of females shows no trend for age 0 and the mean proportion was 0.3. For ages 1-3 the proportion has decreased from about 0.5-0.6 in the 1980s to 0.4-0.5 by 2012-2016. The proportions at ages 4 to 7 have strongly decreased from about 0.8 through the late 1990s to about 0.3-0.8 by 2012-2016; proportions at age 8 are highly variable (Figure A80).

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.

The maturity schedule at age for summer flounder used in the 1990 SAW 11 and subsequent stock assessments through 1999 was developed using NEFSC fall survey maturity data for 1982-1989 (G. Shepherd, NEFSC, personal communication, July 1, 1990; NEFSC 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 autumn (November 1), 38% of age 0 fish were mature, 72% of age 1 fish were mature, 90% of age 2 fish were mature, 97% of age 3 fish were mature, 99% of age 4 fish were mature, and 100% of age 5 and older fish (age 5+) were 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 from summer flounder stock assessments beginning 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) re-considered the summer flounder maturity schedule for the assessment, but ultimately retained 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).

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).

In work for the 2013 SAW 57 benchmark assessment (NEFSC 2013), McElroy et al. (2013 MS) produced a working paper 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, which are the ages with the most misclassifications."

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 those fish. 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 (unweighted 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. The McElroy et al. (2013 MS) approach was adopted in compiling the maturities used in the 2013 SAW 57 benchmark assessment (NEFSC 2013).

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) are examined.

For this benchmark assessment of summer flounder, the standard NEFSC fall trawl survey 1982-2016 (35 years) maturity data have been re-examined. The current data set consists of 7,887 males from age 0 to 15 and 6,297 females from age 0 to 14, for a total of 14,184 fish. The 1982-2016 mean percent observed maturities at age (unweighted, simple arithmetic average of annual values at age) are 42% at age 0, 95% at age 1, 99% at age 2, and 100% at ages 3 and older for males; 26% at age 0, 83% at age 1, 96% at age 2, and 100% at ages 3 and older for females; and 36% at age 0, 90% at age 1, 98% at age 2, and 100% at ages 3 and older for sexes combined (Figure A81). The time series value of L50% was estimated to be 26.1 cm for males, 29.8 cm for females, and 27.0 cm for sexes combined (both). The A50% was 0.13 years for males, 0.42 for females, and 0.23 years for sexes combined (i.e., fish about 13-17 months old, based on the actual spawning month and the January 1 ageing convention relative to fall sampling). The current L50% and A50% estimates and estimate maturity at age are comparable to those in previous assessments (Figure A82).

In keeping with the approach from the previous benchmark assessments (NEFSC 2008a, 2013), a sexes combined, three-year moving window ogive was compiled from the NEFSC 1982-2016 fall survey data for use in assessment models. The three-year moving window approach provides well-estimated proportions mature at age that transition smoothly over the course of the time series, while still reflecting any shorter term trends. The sexes combined, three-year moving window estimates are presented in Table A86 and Figure A83. The 1982-2016 mean maturities at age (unweighted, simple arithmetic average of annual values at age) are 29% at age 0, 86% at age 1, 99% at age 2, and 100% at ages 3 and older.; these averages are 1% lower at age 0, 2% lower at age 1, and the same at ages 2 and older, compared to the 2013 SAW 57 values used in the 2013 and subsequent assessments. The most recent 5 year (2012-2016) mean values are 26% at age 0, 75% at age 1, 97% at age 2, and 100% at ages 3 and older.; these averages are the same at age 0, 2% lower at age 1, and the same at ages 2 and older, compared to the 2013 SAW 57 (2008-2012) values used in the 2013 and subsequent assessments.

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 NCDMF age-length data and a mean annual bottom temperature (17.5°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 1996 SAW 20 (NEFSC 1996) 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. A summary of the methods and conclusions from that work is provided here.

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 Stock Synthesis Version 2 (SS2) statistical catch-at-age analysis used in the SAW 47 assessment allowed for log-likelihood profiling of M to determine which M estimate provided 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 2008 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). This M-schedule was retained in the subsequent 2009-2016 benchmark and updated assessments (NEFSC 2013; Terceiro 2012, 2015, 2016) and has been used in this benchmark assessment.

SPATIAL DISTRIBUTION IN THE NEFSC TRAWL SURVEYS

A graphical examination of the Northeast Fisheries Science Center (NEFSC) 1968-2017 trawl survey data was conducted. The trawl survey sample data were examined in aggregate, for ‘juveniles’ (fish < 30 cm) and adults, and by sex. The data were (generally) aggregated into 5 year time intervals, and in some cases by geographical region. A full set of distribution maps is presented in Miller and Terceiro (2018b MS).

Spring Aggregate

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). The earliest years showed the greatest presence of summer flounder in tows from inshore waters from Long Island to Cape Hatteras (Figure A84). 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 (GBK) region or in the Gulf of Maine (GOM). The lowest catch numbers in the time series were seen during the early 1990s just before increasing slowly in the late 1990s (Figure A85). During the rebuilding period of the 2000s, larger catches of summer flounder began appearing in Southern New England (SNE) waters, particularly south of Rhode Island and Massachusetts in offshore strata. More summer flounder were also present along the southern edge of GBK. 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 (Figure A86).

Spatial abundance trends for length data summarized by stratum are similar to the raw survey catch data referenced above, 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 typical 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 (Figure A87-A90).

Fall Aggregate

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. The earliest time block of 1968-1975 shows little or no catch of summer flounder on GBK or in the GOM. The second block of 1976-1980, however, shows more substantial catches over GBK and off SNE (Figure A91). Years of lower abundance (the early 1990s) show summer flounder aggregating more tightly in inshore strata while catches on GBK and of SNE declined (Figure A92). From RI waters to the southwest, most of the catches are confined to the inshore strata and the inner-most band of offshore strata. Abundance over time is similar to the spring with higher catches initially in the time series, dropping in the 1980s and 1990s. By the late 1990s, catches of summer flounder were highest in the southern range, especially surrounding the Chesapeake Bay area. During this rebuilding period, larger catches began occurring more frequently in the Mid-Atlantic Bight (MAB) and approaching SNE. An increased presence in central GBK and in Cape Cod Bay is also noticeable in later years of greater abundance (Figure A93).

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). Nearly all summer flounder caught north of Hudson

Canyon are >30 cm in size. Survey catches during the earliest years of the time series were focused around DelMarVa where the majority of the catch, particularly in inshore strata surrounding Delaware and Chesapeake Bay, were fish <30cm (Figures A94-A95). This divide appears to stretch further south during the rebuilding period during the late 1990s and early 2000s (Figure A96). 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 (Figure A97).

Seasonal distributions by sex

At the broad regional scale of the NEFSC/MADMF spring and fall trawl survey sampling, there do not appear to be major differences in the distribution of summer flounder by sex. The distributions of the sexes seem to be about the same during the historical peak in abundance in the late 1970s (1975-1980), the historical low in abundance in the late 1980s (1986-1990), the most recent peak in abundance in the late 2000s (2006-2010), and in the most recent 5 years from 2011-2015 (Figures A98-A109).

However, finer scale studies suggest that there may be some difference in the timing of migration and distribution by season in inshore waters that are not yet well understood. A recent, small scale study in Rhode Island state waters has suggested that females were more prevalent in shallow waters (≤15m) through all months sampled in a fishery independent survey, with males having greater presence in deeper waters (> 15 m) from May through September (Langan et. al. 2018 MS**).** In addition, recent work examining fishery dependent data, such as Morson et al. (2012**),** identified a significant relationship between the sex ratio of recreational landings and the port at which summer flounder were collected, indicating that summer flounder exhibits some spatial sex segregation while inshore and during different seasons.

Biomass and distributional trends

There is evidence that the spatial distribution of summer flounder has shifted and/or expanded over the last four decades. However, there are conflicting conclusions about the importance of potential drivers of the shift. A Vector Auto-regressive Spatio-Temporal (VAST) model was used to quantitatively investigate whether the distribution of the stock has shifted on the Northeast U.S. Shelf (NES) and the extent to which an observed shift can be explained by changes in abundance, size-structure, environmental variables, and fishing. The generalized linear mixed model (i.e., delta model) estimates the probability of summer flounder encounter and the magnitude of the catch biomass in survey samples as a function of the explanatory variables. Additional details are available in (Perretti 2018 MS).

Data from the NEFSC and NEAMAP spring and fall surveys were used. Model convergence statistics were met for both seasons, and residual plots did not suggest any significant model fit problems, although the model tended to under-predict the highest observations. Sensitivity analyses indicated that observed changes in the in center-of-gravity are unlikely to be due to changes in the spatial distribution of samples as the mean center-of-gravity or the higher observed catch rates in the NEAMAP survey.

A northward and eastward shift was observed in the center-of-gravity, with both recruits (<30 cm total length) and spawners at or near their historical maximum northing in recent years in both seasons (Figures A110-A113). Inclusion of NEAMAP data results in a more northerly center-of-gravity in recent years although this difference was small in the fall model. Similarly, there has been an eastward shift in center-of-gravity in both size-groups and seasons with recent years at or near their historical maximum easterly. The inclusion of the NEAMAP data results in a more eastward shift in recent years. In the counterfactual analysis, the covariates explain relatively little of the variation in the center-of-gravity in either season or size-class.

Biomass trends within geographic subareas were also examined using 3 NES areas (Figure A114). Total biomass and proportion of biomass in each area and season are shown in Figures A115-A118. In both seasons the majority of recruit biomass is found in the southern area and that biomass has trended downward along with the shelf-wide recruit biomass. In recent years the proportion of recruits in the south has declined while the proportion in the middle area has increased. Spawner biomass is more evenly split between the middle and south regions, but similar to recruits, the proportion of spawner biomass in the south has declined as the proportions in the middle and northern areas have increased.

Similar to previous studies, this work indicated that summer flounder are shifting northeast over time, and this shift has continued in recent years. In contrast to previous studies, the distribution shift does not appear to be driven by an increase in the abundance of older, larger fish which tend to inhabit more northeastern waters. This is because the shift northward is evident even in small fish. Indeed, recruits appear to be shifting northward at a faster rate than spawners, suggesting they are not merely tracking the expansion of spawners northward. Instead, they appear to be reacting to some other driver. The northward shift of recruits also suggests that the driver is unlikely to be fishing as recruits are relatively lightly exploited by the fishery. However, neither total biomass nor environmental covariates explain the distribution shift. Instead, most of the distribution shift is attributed to unexplained sources. Additional work is needed to further explore this approach and possible covariates through VAST.

In addition to the VAST work, some preliminary analyses have been done using Conditional Autoregressive (CAR) models and the Integrated Nested Laplace Approximation (R-INLA) approaches to examine the spatial distribution of summer flounder and its relationship to ecological covariates (Deen et al. 2018 MS). Results suggest that the distribution of summer flounder stock is correlated with depth, salinity and regional climate-driven increases in ocean temperature. Additional work is needed to further explore this approach.

Ecosystem Context

Additional contextual ecosystem information was developed for this assessment. Data extractions for spring and fall are confined to the summer flounder stock area based on current survey strata sets. Several aspects of the ecosystem seem to be changing in the most recent years. Fall bottom and surface temperature are increasing and salinity is at or near the historical high levels. These physical series may have shifted around 2012, the warmest year on record for this ecosystem. Spring chlorophyll concentrations, a measure of bottom-up ecosystem production in the summer flounder stock area, are variable, but the fall time series is decreasing, especially so over the period 2013-2017. Spring abundances for key zooplankton prey are variable and may be worth examining alongside recruitment patterns, an issue for future research. Both probability of occurrence and modeled habitat area show similar patterns of increases from the 1990s to the present, which suggests despite reduced abundance in the past five years, the distribution footprint of summer flounder has not contracted. These Ecosystem Context indicators, and methods to develop them, can be found at:

https://www.nefsc.noaa.gov/ExternalDrive/drives/SummerFlounder2018/Sept2018Meeting/friedland_ecosystem_context/ECSA_summer-flounder.html

Conclusions

There are apparent changes in spatial distribution of summer flounder over the last four decades with a general shift northward and eastward. Spatial expansion is more apparent in the years of greater abundance since about 2000, although it has continued even with the most recent declines in biomass. Higher levels of exploitation can lead to reduced heterogeneity in age structure, particularly a reduction in the abundance of older age fish. However, work examining recent shifts in recruits and an examination of other ecosystem factors suggests other mechanisms may also be contributing factors.

The impact of the change in distribution on summer flounder stock productivity is important but difficult to determine. Although recruitment has been relatively low in recent years, the driver of these low recruitment events has not been identified. Attempts to link specific covariates to changes in the spatial distribution of recruits did not uncover a clear driving variable. Many factors may be impacting the productivity of the stock and identifying the mechanisms driving these observed changes warrants further research. The use of recent weight-at-age and maturity-at-age information in the biological reference point estimates (TOR 5) and in catch projections (TOR 7) attempts to integrate the effects of these factors on the future productivity of the stock.

TOR A4. Estimate annual fishing mortality, recruitment and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Include retrospective analyses (both historical and within-model) to allow a comparison with previous assessment results and projections, and to examine model fit. Examine sensitivity of model results to changes in re-estimated recreational data.

2018 MODEL DEVELOPMENT

Background

Fishing mortality rates and stock sizes were estimated using the ASAP statistical catch at age model (Legault and Restrepo 1998, NFT 2012a, b, 2016). 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 (lambdas [L], or 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 modeled assuming a multinomial distribution, while the other model components are assumed to have lognormal error. Specifically, lognormal error distributions were assumed for the total catch in weight, research survey aggregate indices, selectivity parameters, annual fishing mortality parameters, survey catchability parameters, estimated stock numbers at age, and Beverton-Holt stock-recruitment parameters (Beverton and Holt 1957), 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).

The 2013 SAW 57 benchmark assessment model (NEFSC 2013) differed from the previous 2008 SAW 47 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 two, 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 2013 SAW 57 model included two fleets, one for fishery landings and one for fishery discards.

The fishery selectivity models for both landings and discards used an 'estimates-at-age' approach, 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), age 4 (model age 5) in the second landings time block (1995-2007), and also at age 4 (model age 5) in the third landings time block (2008-2012). The reference ages were age 1 in the first discard time blocks and 2 in the second and third discard time blocks. These selectivities were set with L = 1 and Coefficient of Variation (CV) set to 0.50, in effect specifying priors on the initial values that were components of the objective function.

The fishery-independent research survey indices used for model calibration are configured as aggregate indices (in numbers) with associated age compositions modeled as proportions that follow the multinomial distribution. 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 catchabilities (q) and selectivities (S) were set with L = 0 and so were not a component of the objective function. The CV on the different survey qs were initially set at an average value of the empirical sampling CVs, and later sometimes adjusted or 'tuned' in an attempt to improved model diagnostics.

Other 2013 SAW 57 model details included:

1) fishery landings and discard 'fleet' catches L set at 1 and CV = 0.1,

2) landings fleet age composition Effective Sample Size (ESS) = 55 and discards fleet age composition ESS = 30, following initial runs and consideration of suggested Francis (2011) ESS and the median estimated ESS,

4) fishing mortality (F) and stock size (N) in year 1 CVs = 1.0 and Ls = 0, and

5) Stock-Recruitment (S-R) function and population scaler Ls were set to 0, effectively 'turning off' the influence of the S-R function in the model objective function by setting those likelihood components to zero. The recruitment deviations L was also equal to 0, and so also were not part of the objective function, allowing recruitment deviations to be estimated from the fishery and survey data without any prior constraint.

In the 2013 SAW 57 ASAP model age-specific instantaneous natural mortality rates providing an average M = 0.25 were 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. All model inputs were set at consensus values by the 2013 SDWG after multiple sensitivity runs to evaluate a range of inputs (NEFSC 2013).

Existing 2013 SAW 57 Benchmark ASAP Model Updated through 2017: model run F2018

The existing 2013 SAW 57 benchmark ASAP model was updated with data through 2017 in response to TORs 4 and 6a. The 2013 SAW 57 benchmark model settings were generally retained through the 2015 and 2016 assessment updates (Terceiro 2015, 2016), and fishery and survey catches updated through 2017, in updating the existing model, now named 'F2018.' The third fishery selection time block was extended from 2008-2012 to 2008-2017. The fishery landings and discard ESS values of 55 and 30 and the various survey input CVs were retained.

A few minor changes to model settings were made over the course of the transition from the 2013 SAW57 benchmark through the 2015 and 2016 assessment updates to the current model (F2018), based on experience and recommendations from other Northeast assessment during the intervening period. These included: 1) discontinued use of 'likelihood constants,' which to date in Northeast data-rich stock assessments had been found to mainly affect the manner in which recruitment deviations are constrained, 2) a minor change to the initial F, initial N, and recruitment CVs, increasing them from 0.9 to 1.0 for consistency with other initial parameter settings, and 3) recruitment deviations L set to 1 with CV = 1.0, to prevent the estimation of one extremely large cohort while allowing recruitment deviations to be estimated from the fishery and survey data with minimal prior constraint.

Model Fit Diagnostics

Most of the likelihood contribution to the model fit was due to the age compositions, owing to the large number of fishery and survey catch-at-age estimates that are made. The Root Mean Square Error (RMSE) for the aggregate survey indices were all close to or inside the expected 95% confidence for RMSE (NFT 2012b) 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 and age composition fit diagnostics and residuals did not reveal any serious problems, although some trends and isolated large residuals for some surveys were evident. Otherwise, there were no major diagnostic problems with the F2018 model run. The model fit the fishery data well, and most of the observed survey indices were within the 95% confidence interval (<= 2 standardized residuals) of the model estimates.

Some of the 'worst' fitting indices, with more than a single standardized residual >> 2, were:

1) MAS - MA Spring trawl survey
2) RIF - RI Fall trawl survey
3) CTS - CT Spring trawl survey
4) MAYOY - MA seine survey YOY
5) DEESYOY - DE Estuaries survey YOY
6) DEIBYOY - DE Inland Bays survey YOY
7) MDYOY - MD ocean-side estuary survey YOY
8) URIGSO - URI Graduate School of Oceanography Narragansett Bay 2-station survey

A few of the surveys also demonstrated potentially concerning patterning of the residuals, including:

1) DEIBYOY
2) ChesMMAP - VIMS Chesapeake Bay multispecies survey
3) NEAMAP Fall - VIMS 'inshore strata' coastal trawl survey
4) URIGSO

The SFWG concluded that these latter four indices might be candidates for further 'down-weighting' though further inflation of their input CV (which would also likely worsen the size of the largest residuals) or exclusion in subsequent model development. The F2018 model run results are briefly described in the next section and an evaluation of stock status relative to the 2013 SAW 57 biological reference points is presented under TOR 6a.

Retrospective and MCMC Analyses

An 'internal' retrospective analysis for the F2018 run was conducted to examine the stability of the model estimates as data were removed from the end of the time series. Seven retrospective runs ('peels') were made for terminal years back to 2010. 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. Over the terminal 7 years, the F2018 model run annual retrospective change (Mohn's rho; error) in fishing mortality (F) averaged -15% and ranged from -31% in 2012 to <-2% in 2015. The annual retrospective change in SSB averaged +12% and ranged from +7% in 2015 to +25% 2012. The annual retrospective change in recruitment (true age 0, model age 1) averaged +17% and ranged from <-1% in 2016 to +43% in 2012 (Figures A119-A121). The F2018 model run point estimates of instantaneous fishing mortality (F; fully recruited at model age 5, true age 4) and Spawning Stock Biomass (SSB) in 2017 were 0.244 and 34,350 mt. The retrospectively adjusted estimates were 0.287 and 30,670 mt.

A Markov Chain Monte Carlo (MCMC) run of the F2018 model was made to evaluate the precision of the estimates and help judge the magnitude of the retrospective pattern. One million MCMC iterations were made, of which one thousand were saved, that provided median F in 2017 of 0.236, with a 90% confidence interval (CI) from 0.191 to 0.293. The median SSB in 2017 was estimated to be 34,873 mt, with a 90% confidence interval (CI) from 30,533 mt to 39,800 mt. Given recent standard procedures for Northeast stock assessments that use complex age-structured population models (e.g., NEFSC [2013] for summer flounder and NEFSC [2017] for New England groundfish), because the retrospectively adjusted terminal year estimates fall within the 90% CI for both F and SSB, the F2018 model run would be considered to have a minor retrospective pattern, with no adjustment to the terminal year estimates needed to evaluate stock status or conduct projections.

2018 SAW-66 Model Comparison Workshops

Model Comparison Workshop #1

An initial model comparison workshop was held during January 30-February 1, 2018 to examine multiple modeling approaches under consideration for use in the 2018 SAW-66 stock assessment. Overall the first model workshop:

1) Agreed to schedule another model comparison workshop between the end of April and early June
2) Developed strategies for both self-testing and cross-testing the assessment models
3) Identified additional analyses to be completed prior to the next SAW meeting for all assessment models and the VAST model to address TOR 4
4) Agreed to conduct exploratory work to aggregate non-federal survey data
5) Concluded that modeling should start simple, and that complexity (e.g. sex, time varying growth, etc.) should be built into the models given constraints of the data, estimation, and diagnostics results
6) Determined that estimation problems, precision degradation, and diagnostic problems (e.g. residuals and profiles) should be used to guide decisions
7) Will examine modeling approaches to help understand changes in recruitment, distribution, and other regime shifts.

The first model workshop also agreed to the assumptions and settings for the input data and configurations and for potential future work for the population models under consideration, including:

Biological

Retain the Lux and Porter (1966) commercial fishery quarterly length-weight parameters (combined sexes)

Use the 2013 SAW 57 three-year moving window method for calculating maturities, updated with data through 2016 (no fall 2017 maturity data is or will be available)
Retain the 2013 SAW 57 values assumed for natural mortality (M) in model development (i.e., M = 0.3 males, M = 0.2 for females (average = 0.25))

Surveys

Use NEFSC surveys only for across model comparison
Model the NEFSC surveys separately: Albatross (ALB) and Bigelow (BIG, BIGSWAN)
NEFSC BIG surveys incorporating sweep study results
Explore sensitivity to survey data weighting specifications
Explore inclusion of other non-federal surveys where possible

- Agreed to conduct exploratory work to aggregate non-federal survey data (e.g. GLM and/or other approaches will be considered)
- Examine the effect of allowing q's for problematic surveys to vary (e.g. the "problematic" 4)
- Examine the effects of the starting year of data - should the survey year be the first year in the model?

Fleets

Use the four-fleet configuration (i.e., commercial landings, commercial discards, recreational landings, and recreational discards) in model development
Selectivity:

- Explore the fishery selectivity for all fleets including specifications that allow doming, force flat top, and use different not estimated (fixed) ages
- Explore the specification for the fishery selectivity blocks to identify breakpoints over the time series
- Consider changes in size at age
- Consider regulatory changes
- Consider other informative empirical data

Explore sensitivity to fleet data weighting specifications
Examine the effects of the starting year – should the start of the fleet data be the first year in the model?
Determine how to address the proportion of females at age in the fleets

- Obtain data for specific years from Rutgers and NEAMAP
- Examine tagging the data on the end or using approaches to hindcast
- Compare the ratio of the sex at age from these studies with the survey sex at age

Additional Potential Exploratory Work
Examine the autocorrelation in R
Estimate M within the model, or profile over M
R0 profiling
Examine production model diagnostics
BRPs – not internally estimable at this time; will need to examine proxy approaches
Residual analyses

Individual Modeling Work (In Addition to the Above)

ASAP
    Combined sex modeling work (see completed working papers)
    Explore by sex models (see above)
SAL
    Modeling growth (various approaches)
    Incorporate seasonal effects, if enough data to support
    Examine different time blocks for selectivity at length
    Explore how to better model the selectivity by sex
    Incorporate an aging error matrix if possible (not high priority for additional work)
State-space
    Specify the selectivity by sex
    Estimate M within the model
VAST
    Incorporate environmental variables into the model
    Incorporate non-federal survey data, for which spatial effects can be estimated
    Test if observed if changes in distribution seen are due to changes in the sampling locations, by assigning a catch of 1 to each observation and determining if the center of gravity changes
    Examine the differences in spatial effects by sex (for samples that have sex available)
    Compare the VAST output to a design-based estimate

Model Comparison Workshop #2

A second model comparison workshop was held during May 29-31, 2018 to again examine multiple modeling approaches under consideration for use in the 2018 SAW-66 stock assessment. The second workshop made two overall recommendations:

1) The combined sex, Age Structured Assessment Program (ASAP) was identified as the primary assessment model for the following reasons:

The selected model has been used for other stocks in the region and has the necessary components and diagnostics developed for presentation to the stock assessment review committee (SARC), and to provide summer flounder science to support management

There were not strong differences in model outputs (i.e., trends in SSB, F, R) between those models that incorporated additional sex-specific complexity and those that did not; therefore, gains from the additional sex-specific information were not shown, and did not warrant selection of a less developed model that required additional parameters and assumptions

Incorporating the revised Marine Recreational Information Program (MRIP) information will require substantial model diagnostic capability, and ASAP has those diagnostics fully developed

The models not selected as primary required further development and exploratory work to allow the SAW WG to determine that those models are complete and performing at the level of SARC standards

Other proposed model outputs can be treated as secondary, informative models, and will still contribute substantially to the assessment in a supportive manner

2) The workshop agreed that updated information (i.e., 2017-2018 and revised MRIP) should be incorporated into the primary assessment model. Incorporating updated data into supportive models is a lower priority and is secondary to other modeling tasks needed to further develop those secondary models.

The workshop also made recommendations for ongoing work for the primary ASAP model to be included as part of the assessment, to be completed prior to the fall 2018 Data/Model meeting.

ASAP (combined sex)

Update model with most recent fishery dependent and independent information, including any revised MRIP estimates
Explore the sensitivity of the time blocks used for selectivity for all the fleets
Consider commercial discard selectivity as two time-blocks versus the present configuration of three
Examine the sensitivity of the doming in the landings fleets
Explore inclusion of non-federal surveys under various configurations
Include the surveys as individual indices with length compositions
Consider hierarchical analysis to combine indices:
- Combine the young-of-year (YOY) indices only; treat age1+ as individual indices
- Combine by age vector (YOY, age1+) and/or by season
- Use principal components analysis to do a priori bundling of indices (lower priority for work)
- Develop methods for applying length compositions to combined indices

Obtain raw data needed from state agencies to develop empirical estimates of uncertainty
Explore influence of the priors selected

Supportive Assessment Models (ongoing work)

The following describes some specific ongoing work recommended by the SFWG for the supportive and informative models that will be included as part of this assessment, to be completed prior to the fall Data/Model meeting.

Overall

Working paper(s) will be developed by SFWG members that explore how sex-specific models might inform biological reference point development

ASAP (by sex)

Update model to match base case for primary model

SAL (sex-at-length)

Review data inputs to ensure units correctly specified and length frequencies correctly applied
Integrate calculations for spawning stock biomass
Incorporate selectivity time blocks (i.e., starting in 1982, 1995, and 2008)
Develop methods to produce short term forecasts for use in management
Complete a simulation self-test for the model
Update with recent data after additional model development/diagnostics have been completed (lower priority for work)

State-space

Examine scale shift resulting from specification of four fleets versus two
Explore sensitivity of the doming in the landings fleets
Complete additional work to fine tune selectivity
Incorporate selectivity time blocks
Develop methods to produce short term forecasts for use in management
Complete simulation self-test for the model
Update with recent data after additional model development/diagnostics have been completed (lower priority for work)

Stock Synthesis (externally submitted working paper)

M. Maunder - "Stock Synthesis Implementation of a Sex-Structured Virtual Population Analysis Applied to Summer Flounder"
This paper was intended to inform model considerations
Information from the current or an updated version of this working paper will be incorporated in the assessment report and referenced as supportive modeling work

Other Modeling/Analytical Work (ongoing)

The following describes other ongoing work recommended by the workshop, to address aspects of the stock assessment terms of reference.

VAST

Explore the abundance/biomass scaling issue for the spring and fall
Examine if the NEAMAP data (shorter, recent time-series) is causing the observed shift in abundance/biomass distribution in recent years
Consider additional bottom temperature fields and other indicators of secondary productivity
Review whether the day/night sampling is creating issues for the NEAMAP and NEC calibrations
If data are sufficient, examine changes in abundance/biomass distributions by sex
Explore the survey time series by region (e.g., North, South, etc.) to determine if observed northward shift is due to increases in North, decreases in South, or both
If possible, consider whether annual VAST outputs could inform the selectivity block choices in other models

Phenology Work (externally submitted working paper)

J. Langan et al. - "Characterizing Changing Summer Flounder Phenology in Response to climate in a Large Temperate Estuary"
This paper was intended to inform ecosystem considerations
Information from the current or an updated version of this working paper will be incorporated in the assessment report and referenced as supportive work

Habitat Suitability Modeling

Consider this work if submitted as a future working paper

Plan-B

Explore index and catch based approaches to specifying catch limits
If possible, examine whether VAST modeling work could provide inputs to some of these data limited approaches

ASAP Model Building: F2018 model with Four Fleets

As noted above, previous benchmarks have considered ASAP model configurations with more than two fleets, but settled on two - aggregate landings and aggregate discards - as the best compromise between complexity and precision. Over the past few years, however, Northeast U.S. management agencies have implemented regimes that contain Accountability Measures (AMs) by fishery and catch type. Therefore, there has been recent interest in structuring Northeast U.S. assessment models to be better able to monitor the corresponding fishery components, as well as the potential to more accurately model fishery selectivity. To that end, the F2018 model was modified to have 4 input fleets (F2018_4FLEET): commercial landings and discards and recreational landings and discards. This is also reflective of the basis on which the input aggregate catch and catch at age is compiled.

To accommodate the four fleets, the ESS for both landings fleets was initially set at 50 and the discards fleets at 30. Ages with full selection were initially set in line with the two fleet model for three time blocks (1982-1994, 1995-2007, 2008-2017), with S =1 for age true ages 2, 3, and 4 (model ages 3, 4, 5) for the landings fleets and true ages 1, 2, and 2 (model ages 2, 3, 3) for the discards fleets.

The initial run fit the fishery catch data well. The largest fleet catch residuals were for the commercial landings, but the largest standardized residual was less than 1.4. All fleet fits exhibited multi-year runs of residuals, the largest being nine years for both landings fleets in the late 1990s-early 2000s (observed catch smaller than estimated) and 10-11 years in the discard fleets after 2005 (observed catch larger than expected), but the standardized residuals were generally less than 0.5. Therefore, none of the catch residual patterns were of major concern. Fits to the survey aggregate and catch at age indices were very similar to the two fleet model fits.

After an initial F2018_4FLEET run the input ESS was adjusted, based on the time series patterns and medians of the estimated ESS, to 75, 35, 60, and 60. In the initial run the first commercial discards period exhibited an uneven pattern suggesting that S = 1 should be set on true age 2, rather than age 1, so that setting was also changed.

In the second 'adjusted' run, the first commercial landings period continued to exhibit an uneven pattern and large decrease in selection at true ages 5-7+ to less than 0.4, estimates that that cannot be justified from the known characteristics of the fishery. However, the precision of these estimates was acceptable, with CVs from 0.22 to 0.33. The third period commercial landings selection also exhibited at large drop for true ages 6 to 7+ from S = 1.0 to S = 0.60, but with good precision of the true age 7+ estimate of CV = 0.19.

Time series trends in F, SSB, recruitment (model age 1, true age 0), and plus group stock size (model age 8+, true age 7+) for the two fleet (F2018) and four fleet (F2018_4FLEET) models are similar, but differed substantially in absolute magnitude, particularly for the SSB and plus group estimates since about 2000 (Figures A122-A123). Fits to the aggregate survey indices were very similar. Most of the difference was attributable to the differences in estimated fishery selectivity, with the four fleet model estimating more strongly domed selection patterns for the two landings fleets (which generally account for 80-90% of the total catch), which then resulted in larger estimates of stock size for the oldest ages and the SSB. As noted above, low selection at the oldest ages is hard to justify given the known characteristics of the fishery, but the statistical diagnostics of those estimates were acceptable, with CVs generally in the 0.20 to 0.40 range.

A comparison of the two fleet and four fleet model retrospective analyses (table below) indicated that the four fleet model generally had larger retrospective errors (value of Mohn's rho averaged over 7-year peels) for Full F and SSB; while results at-age were variable; the four fleet errors at age were also generally larger (7 of the 8 ages).

Estimate	F2018 (2 fleets)	F2018_4FLEET
Full F	-15%	-19%
SSB	+12%	+15%
Total Stock Size N	+8%	+5%
Age 0 N	+16%	+5%
Age 1 N	+3%	-5%
Age 2 N	-2%	-4%
Age 3 N	+3%	+4%
Age 4 N	+9%	+12%
Age 5 N	+15%	+22%
Age 6 N	+19%	+30%
Age 7+ N	+25%	+35%

ASAP Model Building: F2018 with split NEFSC trawls survey series; ALB and BIG indices

The NEFSC winter (1992-2007), spring (1982-2017) and fall (1982-2016) bottom trawl surveys are among the research survey time series used to calibrate the current F2018 ASAP population model. The surveys were conducted using the FSV *Albatross IV (*ALB*;* with some intermittent substitution of the FSV *Delaware II)* until 2008 and the FSV *Henry B. Bigelow* (BIG) since 2009. A change in nets and towing protocol for the BIG resulted in potential changes in catchability for the spring and fall surveys, and several hundred comparison tows were made during 2008-2009 (both during the regular survey work and on special cruises) to develop calibration coefficients on aggregate number, aggregate weight, and on number at length bases to allow conversion of the BIG survey indices to ALB equivalents (Miller et al. 2010). The current (existing) F2018 (2 fleets) assessment model uses the NEFSC spring and fall ALB equivalent survey catch in relative aggregate numbers and numbers at age index forms.

A model run (F2018_BIGSV) was configured with separate spring and fall ALB (1982-2008) and BIG (2009-2017) time series of relative indices (i.e. stratified mean number per tow at age and in aggregate). All other model input data and settings remained the same as in the F2018 (2 fleets) run. Evaluation of the NEFSC spring and fall catchability coefficient (q) estimates for these relative indices of abundance provides a diagnostic of model uncertainty due to the use of the calibration factors, by comparison of the resulting ratio of BIG to ALB estimated q with the calibration factors.

Industry cooperative ‘twin trawl sweep study’ cruises were conducted during 2015-2017 in an attempt to better understand the behavior and performance of the BIG survey gear for a suite of bottom-tending species, including summer flounder. Preliminary results (T. Miller NEFSC personal communication 2017) from analyses of those data indicate that the average catch efficiency of the BIG gear for summer flounder is about 0.56 (i.e., 56% of the summer flounder encountered by the BIG gear are retained by the net). Averaged over day and night tows, the BIG catch efficiency is about 0.02 at 15 cm, increases to 0.50-0.60 from 32 cm to 60 cm, and increases further to 0.95 at 77 cm.

The ‘sweep study’ work also indicates that herding of fish by the BIG ground cables (wire between the wing end of the net and the trawl doors) and the trawl doors gear is likely to be low, and so the wing spread of the BIG gear (39.4 feet = 12.0 meters) is considered the appropriate dimension to use for swept area calculations. The current standard BIG area swept per tow is 0.00647931 square nautical miles (sqnm). The average values of BIG efficiency at length were first used to convert 'standard' catch per tow (Table A49) to 'absolute' catch per tow (Table A50). Next, the net dimensions and the annual spring and fall total survey coverage area (usually about 27,855 sqnm for the spring and 17,924 sqnm for the fall) were used to compute BIG indices as Swept Area Numbers (SWAN), or absolute estimates of stock numbers at age and in aggregate (Tables A51-A52). These estimates were used in another run, F2018_BIGSWAN, to further evaluate the catchability coefficients estimated for the NEFSC spring and fall surveys and as a diagnostic for the 'scaling' of the model stock size estimates, with the expectation that on the absolute scale, the q estimates are expected be less than or equal to 1.

A comparison of the NEFSC surveys estimated qs and ratios of interest for the F2018, F2018_BIGSV, and F2018_BIGSWAN runs are presented in the table below.

Survey	F2018	F2018_BIGSV	F2018_BIGSWAN
NEC_SPR_ALB	4.519 e-5	4.177 e-5	4.177 e-5
NEC_SPR_BIG	-	10.010 e-5	0.649 e+0
NEC_FAL_ALB	6.052 e-5	5.924 e-5	5.924 e-5
NEC_FAL_BIG	-	11.732 e-5	0.484 e+0
Ratio SPR BIG/ALB qs		2.396	
Ratio FAL BIG/ALB qs		1.980	
Mean BIG/ALB qs		**2.188**	
SPR Calib Factor		1.897	
FAL Calib Factor		1.911	
Mean Calib Factor		**1.904**	

The mean of the F2018_BIGSV run NEFSC spring and fall survey ALB and BIG qs is about 2.2. The mean of the spring and fall length-based calibration factors used to convert the BIG indices into ALB equivalents for the indices used in the current F2018 model is about 1.9. Therefore, the F2018_BIGSV qualitatively returns the same BIG to ALB catch ratio (i.e., numeric calibration factor of about 2) as the calibration experiment factor. Figures A124-A125 compare some results from the F2018 and F2018_BIGSV runs. The F estimates are very similar. The SSB estimates are generally slightly higher for the F2018_BIGSV run since about 2000. Most of the SSB difference is due to higher stock size estimates at the older ages. The estimates at model age 1 (recruitment at true age 0) are very similar, while the largest differences occur for model age 8+ (true age 7+) since 2000.

As noted in TOR 2, application of the experimental 'sweep study' BIG efficiencies at length changes the computed catch per tow of the indices and, for the fall numeric indices, changes the rank order of the annual indices (i.e., 2016 is the highest in the 2019-2017 series; Figures A27-A28), so the BIG indices in the F2018_BIGSWAN run are slightly different than those in the F2018_BIGSV run. Therefore, the F2018_BIGSV and F2018_BIGSWAN configurations do have minor differences in their results.

The NEFSC BIG trawl survey absolute abundance estimates used in the F2018_BIGSWAN run are dependent not only on the results and assumptions from the twin trawl sweep study, but also those assumptions included in the expansion calculations (i.e., trawl wing swept area, no door herding, no escape about the head rope, sufficient sampling to assume the survey index is applicable to the entire survey area, etc.). The resulting q estimates from the BIGSWAN run (mean = (0.649+0.484)/2) = 0.567; see text table above) indicate that for this particular model configuration the NEFSC BIG trawl surveys on average 'count' about 60% of the total stock numbers.

ASAP Model Building: F2018 with Four Fleets and BIGSWAN indices

The next step in ASAP model building was to combine the effects of changing from two fishery catch fleets to four fleets with changing from all NEFSC ALB indices to 'splitting' the ALB and BIG index series. Figures A126-A127 compare the results for the F2018 (two fleets), F2018_4FLEET, and F2018_4FLEET_BIGSWAN model configurations. The plots demonstrate that the larger effect is due to changing from two fleets to four fleets. The 'splitting' of the NEFSC survey series and incorporation of the sweep study BIG efficiency estimates have a moderating effect on the fleet configuration change, with less 'doming' in the older ages for the landed fleets resulting in a smaller increase in SSB (Figure A126) and older age stock sizes (Figure A127). The trends are the same across the three configurations, with the F2018_4FLEET_BIGSWAN model estimates 'intermediate' in scale compared to the F2018 (two fleets) and F2018_4FLEET results, although closer to the F2018 results.

In the F2018_4FLEET_BIGSWAN run, there are no issues of major concern with magnitude or pattern for the model fits to the four fleet aggregate catches. For the commercial landings, there is a single log-scale standardized residual larger than 1.5 (1995) and no unusual patterns. There is some blocking (long run during 2005-2015) of positive residuals for the recreational discards (fleet 4), but the log-scale standardized residuals are all small, generally at less than 0.30. The fits to the fleet age compositions are all generally good, with the largest absolute residuals occurring for the recreational discards, with a few proportional differences of about 0.3 during the late 1990s. The SFWG noted that the ESSs could be adjusted to better approach the median value (in line with most recent standard ASAP procedures for the EFF settings), but that potential adjustment was delayed until the final catches (i.e., calibrated 'New' MRIP recreational catch) were available.

The same surveys that most demonstrated some residual problems (magnitude and patterning) in the current F2018 model (2 fleets, ALB indices) also did so in the F2018_4FLEET_BIGSWAN configuration, namely:

1) DEIBYOY - DE Inland Bays survey YOY
2) ChesMMAP - VIMS Chesapeake Bay multispecies survey
3) NEAMAP Fall - VIMS 'inshore strata' coastal trawl survey
4) URIGSO – URI Graduate School of Oceanography Narragansett Bay 2 station survey

These indices still seem the most likely candidates for further 'down-weighting' though further inflation of their input CV (which would also likely worsen the size of the largest residuals) or exclusion from the model going forward.

A seven-year peel retrospective analysis F2018_4FLEET_BIGSWAN was run to further evaluate model diagnostics. The average retrospective error for F was -15%, the average error for SSB was +13%, the error for Total stock size N was +5%, and the errors for stock size N ranged from -2% for model age 2 (true age 1) to +35 for model age 8+ (true age 7+). These retrospective errors are about the same as for the F2018_4FLEET model configuration (see table below).

Estimate	F2018 (2 fleets)	F2018_4FLEET	F2018_4FLEET_BIGSWAN
Full F	-15%	-19%	-15%
SSB	+12%	+15%	+13%
Total Stock Size N	+8%	+5%	+5%
Age 0 N	+16%	+5%	+9%
Age 1 N	+3%	-5%	-2%
Age 2 N	-2%	-4%	-6%
Age 3 N	+3%	+4%	+2%
Age 4 N	+9%	+12%	+9%
Age 5 N	+15%	+22%	+18%
Age 6 N	+19%	+30%	+26%
Age 7+ N	+25%	+35%	+35%

ASAP Model Building: F2018_4FLEET_BIGSWAN_CALMRIP_V2 - Revision of the catch of the Recreational Landings and Discard Fleets

As a result of the first two Model Comparison workshops' consideration of alternative assessment models, the SFWG concluded that the ASAP F2018_4FLEET_BIGSWAN model was the best candidate to move forward as the primary assessment model. The next step in model development was to replace the existing ('Old') MRIP recreational aggregate catch in weight (mt), catch at age in numbers, and mean weight at age (kg) estimates with the calibrated ('New') MRIP estimates, creating run F2018_4FLEET_BIGSWAN_CALMRIP. All other settings and fishery and survey input data remained the same.

An initial run was made to examine the need to further tune either the fishery or survey ESSs or the input CVs. Upon evaluation of the diagnostics, none of the input CVs were changed. However, the input ESSs were revised ('tuned') to the medians of the estimated ESSs of the initial 'CALMRIP' run to configure run 'CALMRIP_V2' as follows:

Commercial landings (Fleet 1): 83 to 107
Commercial discards (Fleet 2): 54 to 68
Recreational landings (Fleet 3): 66 to 53

Recreational discards (Fleet 4): 56 to 54

For most surveys, the input ESSs did not change or changed by only 1 or 2 digits. The largest survey ESS changes were for the NEFSC winter (56 to 73), the ChesMMAP (90 to 78), and the NEAMAP fall (74 to 85). The changes in the F and SSB estimates due to these changes were minimal, with the two 'CALMRIP' runs providing nearly identical estimates since 2000.

Model Fit Diagnostics

Most of the likelihood contribution to the model fit was due to the age compositions, owing to the large number of fishery and survey catch-at-age estimates that are made. The Root Mean Square Error (RMSE) for the aggregate survey indices were all close to or inside the expected 95% confidence for RMSE (NFT 2012b) 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 and age composition fit diagnostics and residuals did not reveal any serious problems, although some individual residuals at age were large for the commercial and recreational discards fleets.

Some trends and/or isolated large residuals for the usual 'problematic' surveys were evident. As noted for earlier runs in the development sequence, those surveys are the DEIBYOY (DEDFW Inland Bays Young-Of-Year survey; a few large standardized residuals >2.0, and a recent pattern), the ChesMMAP (VIMS Chesapeake Bay multispecies survey; strong pattern), the NEAMAP Fall (VIMS 'inshore strata' coastal trawl survey; strong pattern), and the URIGSO (URI two station trawl survey; strong pattern) surveys. The SFWG decided, however, to retain all available surveys in the model calibration using consensus 'appropriate' input CVs and ESSs. Overall, there were no major diagnostic problems with the 2018_4FLEET_BIGSWAN_CALMRIP_V2 model run. The model fit the fishery data well, and most of the observed survey indices were within the 95% confidence interval (<= 2 standardized residuals) of the model estimates.

Comparison with other configurations

Figures A128-A129 provide a comparison of the trends in F, SSB, recruitment (model age 1, true age 0), and plus group stock size (model age 8+, true age 7+) for the current (existing) two fleet with 'Old' MRIP catch model (F2018), the four fleet with BIGSWAN indices with 'Old' MRIP catch model (F2018_4FLEET_BIGSWAN), and the four fleet with BIGSWAN indices with 'New' MRIP catch model (F2018_4FLEET_BIGSWAN_CALMRIP_V2). Time series trends among these model configurations are similar, but differ substantially in absolute scale. As noted earlier, most of the difference between the '2 fleet' and '4 fleet with BIGSWAN' model is due to the change from two to four fleets. Then, the 24% and 29% average increases in time series catch in numbers and weight due to the 'New' MRIP recreational fishery catch estimates result in an increase of about 40% in stock size (i.e., SSB) in the 'four fleets with BIGSWAN with 'New' MRIP' run. Going forward, the F2018_4FLEET_BIGSWAN_CALMRIP_V2 run was renamed the 'F2018_BASE' run, pending further revision by the SFWG or the SARC-66 Review Panel.

Internal model retrospective analysis

An ‘internal’ retrospective analysis for the renamed F2018_BASE run was conducted to examine the stability of the model estimates as data were removed from the end of the model time series. Seven retrospective runs (‘peels’) were made for terminal years back to 2010. The F2018_BASE retrospective results are compared with earlier runs in the table below. Over the terminal 7 years, the annual retrospective change in fishing mortality (F) averaged -3% and ranged from -19% in 2012 to +13% in 2015. The annual retrospective change in SSB averaged +1% and ranged from -7% in 2014 to +12% 2012. The annual retrospective change in recruitment (true age 0, model age 1) averaged +2% and ranged from -30% in 2011 to +30% in 2012 (table below). For the F2018_BASE run, the revision to use the ‘New’ MRIP recreational fishery catch estimates generally reduced the internal retrospective pattern.

Estimate	F2018 (2 fleets)	F2018_4FLEET_ BIGSWAN	F2018_4FLEET_ BIGSWAN_CALMRIPV2 = F2018_BASE
Full F	-15%	-15%	-3%
SSB	+12%	+13%	+1%
Total Stock Size N	+8%	+5%	-2%
Age 0 N	+16%	+9%	+2%
Age 1 N	+3%	-2%	-9%
Age 2 N	-2%	-6%	-13%
Age 3 N	+3%	+2%	-7%
Age 4 N	+9%	+9%	-1%
Age 5 N	+15%	+18%	+5%
Age 6 N	+19%	+26%	+11%
Age 7+ N	+25%	+35%	+20%

Potential Internal Estimation of Reference Points

The internal estimation of BRPs in the F2018_BASE model configuration using the Beverton-Holt (B-H; 1957) function was attempted. The model run converged successfully and provided estimates of h (steepness) = 1, SSB0 = 145,411 mt, R0 = 50.3 million, SSBMSY = 26,034 mt, FMSY = 1.364, and MSY = 17,062 mt. For most Northeast U.S. finfish assessments, an estimate of FMSY (and associated BRPs) is considered to be infeasible if the value is much larger than Fmax or other FMSY proxies such as F35% or F40% (NEFSC 2002b, NEFSC 2008a). This is generally the case for BRPs estimated using the B-H function if the steepness parameters are estimated to be close to 1 due to the distribution of the SSB and R data pairs, as in the current F2018_BASE model results. Given this precedent, the use of an externally estimated proxy for FMSY such as the currently adopted F35% was developed for the 2018 SAW-66 assessment.

Likelihood Profile over assumptions for Natural Mortality (M) and Unfished Recruitment (R0)

The F2018_BASE model configuration was run over a range of input M (constant over years, constant over ages, except for the F2018_BASE model run where M varies over ages from

0.26 to 0.24 with a mean of 0.25). The value of the objective function (or likelihood) was minimized at M = 0.10 and M = 0.15 (difference of 1 point), indicating that the model 'fit best' under that assumption. The difference in objective function value from M = 0.10 was about 6 points for M = 0.20 and about 21 points for the current average value of M = 0.25 (Figure A130). Because M profiles can vary depending on the input data and model configurations, the SFWG decided to retain the current M values due to biological considerations.

The F2018_BASE model configuration was also run over a range of fixed unexploited recruitment (R0) values and compared with the F2018_BASE model run results. The aggregate catch and index components were minimized at about R0 = 50,000, with the index age compositions minimized at R0 = 40,000 and the catch age compositions minimized at R0 = 65,000. The profile for the individual aggregate and YOY survey indices was 'flatter' than for the major aggregate components, but still with minima in the 40,000 to 65,000 range (Figures A131-A132).

Alternatives for Calibration Index Set

Two alternative calibration index sets were considered in a limited exploration of the effects of the indices included in the model calibration. In the first (DROP_4), the four 'problematic' index series noted earlier were dropped from the model: the DEIBYOY index (multiple large residuals, pattern), the ChesMMAP index (pattern), the NEAMAP Fall index (pattern), and the URIGSO aggregate index (pattern). The second index set (NEC_ONLY) was intended to address the previously voiced concerns by SAW summer flounder Review Panels about the large number of spatially limited (i.e., state and academic agency) surveys included in the model calibration. The second calibration index set therefore included only the NEFSC winter, spring, and fall trawl survey series and the NEFSC MARMAP and ECOMON larval survey series. A comparison between the F2018_BASE, DROP_4, and NEC_ONLY runs shows that the NEC_ONLY run generally estimates lower F and higher SSB (Figure A133), with stock size N differences smallest for model age 1 (true age 0) and largest for model age 8 (true age 7+; Figure A134). Retrospective analyses indicate generally very similar errors for the DROP_4 run compared to the full F2018_BASE model. The NEC_ONLY configuration, however, has a different pattern of retrospective errors, as it 'flips' to a relatively 'strong' pattern with overestimation of F and underestimation of SSB and Total Stock Size N, and a different pattern of errors at age with the smallest errors at the oldest ages (see table below). These results are generally reflective of the recent differing trends in the NEFSC indices (generally stable over the last decade) versus the state and academic indices (generally decreasing over the last decade) and reinforced the SFWG decision to use the F2018_BASE run as the primary assessment model for evaluation of stock status and projections.

Estimate	F2018_BASE	DROP_4	NEC_ONLY
Full F	-3%	-1%	+64%
SSB	+1%	-3%	-39%
Total Stock Size N	-2%	-6%	-41%
Age 0 N	+2%	+2%	-40%
Age 1 N	-9%	-14%	-53%
Age 2 N	-13%	-18%	-48%
Age 3 N	-7%	-9%	-41%
Age 4 N	-1%	-2%	-35%
Age 5 N	+5%	+5%	-31%
Age 6 N	+11%	+11%	-27%
Age 7+ N	+20%	+18%	-18%

Fishery Selection Sensitivity Runs

A first fishery selection sensitivity run of the F2018_BASE model was made that reduced the number of selectivity time blocks for all four fleets from three to two, by combining the last two blocks (1995-2007, 2008-2017) into one (1995-2017). In this SELEX_2BLK run, the changes from three to two selectivity blocks reduced the 'doming' in the landed fleets for ages 5 and older (true ages 4 and older) after 1995, from about 0.70 to 0.8-0.9. However, other associated changes in the pattern back in time resulted in a different trend in average F, so that average F (fully recruited at model age 5 = true age 4) was estimated to be higher during 1995-2006 than in F2018_BASE, and lower since 2007. This F trend translated to higher SSB and stock size at older ages in the SELEX_2BLK run since 2007 (Figures A135-A136). The SFWG decided to keep the three selectivity block model because the changes from block 2 to block 3 make sense given the changes in the management measures over time and the selectivities at age are estimated with good precision (CV < 30%).

A second sensitivity run of the F2018_BASE model was made that forced flat-topped selectivity (S=1) at model ages 5 and older (true ages 4 and older) for the two landings fleets in the most recent (2008-2017) time blocks. The forced flat-topped selection for the landings fleets in this SELEX_FLATLAND run produced an F trend and magnitude comparable to F2018_BASE, slightly lower SSB since 2008, and lower stock sizes at the oldest ages since 2007 (Figures A135-A136). The SFWG decided not to force flat topped selectivity for the landed fleets because the estimated selectivities in the F2018_BASE run are not extreme, make sense given the changes in the fisheries over time, and are estimated with good precision (CV < 0.30).

State/Academic 'Hierarchical Index' Sensitivity Run

As noted in TOR2, the summer flounder assessment includes multiple state and academic fishery independent survey indices of abundance. These indices have relatively restricted temporal and spatial scope compared to the NEFSC indices, but are believed to provide useful information on population trends. A Bayesian hierarchical approach (Conn 2010) was applied to develop aggregate state/academic research survey indices for use in summer flounder population models. This approach is a technique to combine numerous noisy indices of abundance into a single time series. The method works by assuming that each CPUE index is attempting to sample relative abundance but is subject to both sampling and process errors. Each index is represented as a CPUE mean from the fishery independent trawl surveys in the input data set. Different levels of aggregation and combinations of the indices were considered, with the SFWG recommending aggregation of the young-of-the-year (YOY) indices into a single state/academic 'YOY' index and aggregation of the adult indices into a single state/academic 'adult' index.

An 'aggregate Young-of-the-Year' (YOY) index was constructed from the available stand-alone YOY indices: MADMF seine, DEDFW estuarine, DEDFW inland bays, MDDNR, VIMS juvenile, and NCDMF juvenile. An 'aggregate adult' index included the MADMF spring and fall, RIDMF fall and monthly, CT DEEP spring and fall, NY Peconic Bay, NJ Ocean, DE 30 foot, VIMS ChesMMAP, and NEAMAP spring and fall trawl surveys. The MARMAP larval SSB index, ECOMON larval SSB index, and URIGSO trawl surveys index were not included in the aggregate adult indices because they did not include accompanying age compositions. To develop an age composition for the 'aggregate adult' index, the proportions at age of the individual survey age compositions were averaged by using the inverse sigma estimate of each contributing index from the hierarchical approach to compute an overall weighted average proportion at age, which was then applied to the annual aggregate indices to produce 'aggregate adult' indices at age. These aggregated 'hierarchical' indices were used in a HIER_V2 sensitivity run for comparison to the F2018_BASE_V2 run of the assessment model. In the HIER_V2 model, the stand-alone YOY indices were replaced by the 'aggregate YOY' index, and the contributing, full age composition indices were replaced by the 'aggregate adult' indices and accompanying age compositions. The NEFSC ALB winter, spring and fall, NEFSC BIG spring and fall, MARMAP, ECOMON, and URIGSO indices remained as calibration indices in the sensitivity (McNamee 2018 MS).

In this HIER_V2 run, there is significantly more 'doming' in the fishing fleets selectivity patterns for ages 5 and older (true ages 4 and older) after 1995 when compared to the F0218_BASE_V2 run (note that the hierarchical index work was completed after the September 2018 SFWG meeting in which the final model F2018_BASE_V2 was configured and selected as final, was based on that final model, and so is compared to that final model described in the next section). The aggregate (across all fleets) selectivities at ages 5-7+ are 0.88, 0.68, and 0.28 in the HIER_V2 run, and 0.91, 0.88, and 0.65 in the F2018_BASE_V2 run. Combined with apical (model age 5, true age 4) F estimates that are about 20-30% lower than in the F2018_BASE_V2 run, the HIER_V2 model therefore provides higher SSB and stock size estimates (Figures A137-A138). The HIER_V2 run does have larger retrospective errors, however, at +12% for F (overestimation of F) and -13% for SSB (underestimation of SSB), and -8% for recruitment at age 0. In addition, the SFWG noted some concern over the residual patterns for the survey age compositions that may relate to the manner in which the 'aggregate adult' age composition was constructed, an aspect of the hierarchical 'aggregate index' approach that the SFWG felt needed more work.

2018 FINAL MODEL: ASAP F2018_BASE_V2

The SFWG made a few additional decisions and modifications to F2018_BASE in the final meeting held in September 2018, resulting in a final model run renamed F2018_BASE_V2. After further discussion about the suite of survey indices to be included in the model, the SFWG reaffirmed its' decision to include all the available indices, including the 'DROP_4' indices, because a) it was difficult to arrive at a set of 'non-arbitrary' criteria for inclusion/exclusion, b) with the addition of the 'New' MRIP recreational catch data, the size and patterns of some of the residuals for the 'DROP_4' indices improved, while those of some indices not originally considered as candidates for exclusion deteriorated, c) the model results were relatively insensitive to inclusion of the 'DROP_4' indices due to input CV and ESS weight effects, and d) including all the available indices most fully expresses the overall uncertainty of the model and assessment results.

The SFWG noted some minor but persistent patterning/blocking in the commercial and recreational landings age compositions in most of the years of the time series when landings at the youngest ages were very small (i.e., since about 1990). These residual patterns are due to the small magnitude of those estimated landings at model ages 1 and 2 (true ages 0 and 1) and model estimates of stock size at age that are consistently larger than those 'observed' landings. The F2018_BASE_V2 model estimated the landings selectivity for both fisheries at 1-2% since 1995, so these residual patterns are not considered to be problematic. Figures A139-A142 show the estimated selectivity patterns for the four fleets in the F2018_BASE_V2 three selectivity time block model.

Finally, the SFWG made minor changes in the survey selectivity settings (shifting the age of assumed full selection by one age class) for the NEAMAP spring and NEFSC BIGSWAN spring indices. These two changes improved the age composition residual patterns for those indices. Run F2018_BASE_V2 provided estimates that had very minor differences from the previous run, and so the alternative run configuration comparisons and profiles were not repeated. However, the final model diagnostics, final model estimates, internal retrospective, and MCMC analyses were updated.

Model Fit Diagnostics

Most of the likelihood contribution to the model fit was due to the age compositions, owing to the large number of fishery and survey catch-at-age estimates that are made (Figure A143). The Root Mean Square Error (RMSE) for the aggregate survey indices were all close to or inside the expected 95% confidence for RMSE (NFT 2012b) except for the MADMF YOY index, which was still well outside the confidence interval even with the input CV increased to 1.0 (Figure A144). The aggregate landings and discards and age composition fit diagnostics and residuals did not reveal any serious problems, although some individual residuals at age were large for the commercial and recreational discards fleets, and as noted earlier there is some patterning/blocking for the youngest ages in the landings fleets (Figures A145-A152). Figures A149 and A151 show the previously noted minor but persistent patterning in the commercial and recreational landings age compositions in most of the years of the time series when landings at the youngest ages were very small (i.e., since about 1990). These residual patterns are due to the small magnitude of those estimated landings at model ages 1 and 2 (true ages 0 and 1) and model estimates of stock size at age that are consistently larger than those 'observed' landings. The F2018_BASE_V2 model estimated the landings selectivity for both fisheries at 1-2% since 1995, so these residual patterns are not considered to be problematic.

Some trends and/or isolated large residuals for the DROP_4 'problematic' surveys were again evident. As noted for earlier runs in the development sequence, those surveys are the DEIBYOY (DEDFW Inland Bays Young-Of-Year survey; a few large standardized residuals >2.0, and a recent pattern), the ChesMMAP (VIMS Chesapeake Bay multispecies survey; strong pattern), the NEAMAP Fall (VIMS 'inshore strata' coastal trawl survey; strong pattern), and the URIGSO (URI 2 station trawl survey; strong pattern) surveys. As noted earlier, however, during the course of model development other patterns for other indices also emerged, in particular the appearance of more than one or two large annual residuals (e.g., for the MADMF spring, the RIDFW fall, and CTDEEP spring, the MADMF YOY). The SFWG decided, therefore, to retain all available surveys in the model calibration using consensus 'appropriate' input CVs and ESSs.

Overall, there were no major diagnostic problems with the F2018_BASE_V2 model run. The model fit the fishery data well, and most of the observed survey indices were within the 95% confidence interval (<= 2 standardized residuals) of the model estimates (Figures A153-A195).

Internal model retrospective analysis

An 'internal' retrospective analysis for the F2018_BASE_V2 run was conducted to examine the stability of the model estimates as data were removed from the end of the model time series. Seven retrospective runs ('peels') were made for terminal years back to 2010. Over the terminal 7 years, the annual retrospective change in fishing mortality (F) averaged -4% (underestimated by 4%) and ranged from -21% in 2012 to +12% in 2015 (Figure A196). The annual retrospective change in SSB averaged +2% (overestimated by 2%) and ranged from -6% in 2014 to +14% 2012 (Figure A197). The annual retrospective change in recruitment (true age 0, model age 1) averaged +2% (overestimated by 2%) and ranged from -29% in 2011 to +31% in 2012 (Figure A198). For the F2018_BASE_V2 run, the revision to use the calibrated ('New') MRIP estimates of recreational catch generally reduced the internal retrospective pattern compared to models using the 'Old' MRIP estimates.

Model estimates of stock size and fishing mortality

The F2018_BASE_V2 estimates of instantaneous fishing mortality (F; fully recruited at model age 5, true age 4) and Spawning Stock Biomass (SSB) in 2017 were 0.334 and 44,552 mt (Table A87). The retrospectively adjusted estimates were 0.348 and 43,678 mt. An MCMC run was made to evaluate the precision of the estimates and help judge the magnitude of the retrospective pattern. One million MCMC iterations were made, of which one thousand were saved, that provided median F in 2017 of 0.324, with a 90% confidence interval (CI) from 0.276 to 0.380 (Figure A199). The median SSB in 2017 was estimated to be 44,647 mt, with a 90% CI from 39,195 mt to 50,935 mt (Figure A200). Given recent standard procedures for Northeast stock assessments that use complex age-structured population models (e.g., NEFSC [2013] for summer flounder and NEFSC [2017] for New England groundfish), because the retrospectively adjusted terminal year estimates fall within the 90% CI for both F and SSB, the F2018_BASE_V2 model run for summer flounder would be considered to have a minor retrospective pattern, with no adjustment to the terminal year estimates needed to evaluate stock status or conduct projections. Estimates of F at age and stock numbers at age from the F2018_BASE_V2 model run are presented in Tables A88-A89.

Historical Retrospective Analyses

The F, SSB, and recruitment estimates from the 2008 SAW 47 benchmark assessment, the 2009-2012 assessment updates, 2013 SAW 57 benchmark assessment, the 2015-2016 assessment updates, the existing ('Old') model updated through 2017 with 'Old' MRIP (F2018_OLD_MODEL) , and the final F2018_BASE_V2 model with 'New' MRIP for the 2018 SAW-66 assessment are compared in Figures A201-A202. The ASAP model has been used in the assessment during the 2008-2016 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' model age 5 (true age 4; S = 1) in the 2013 and later assessments.

A longer term retrospective look over all assessments dating back to 1990 is provided in Figure A203. It should be noted that the ADAPT Virtual Population Analysis (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 2008-2018 assessments. Despite these changes in model estimation procedures, configurations, and assumptions, these 'historical' retrospectives indicate that general trends of fishing mortality and stock biomass have been consistent since the 1990s assessments. The use of the new calibrated estimates of recreational landings and discards in the current assessment increased the 1982-2017 total catch by an average of almost 30%. While the magnitude of fishing mortality was not strongly affected, the increased catch has resulted in increased estimates of stock size compared to the historical assessments.

Other Supportive Model Comparisons

Several other models were examined and considered as part of the SFWG model building process, through the two Model Comparison workshops and the September 2018 Data/Model meeting. While not the final model choice of the SFWG, these other modeling approaches are briefly presented to support the SFWG final model choice and provide additional sensitivities. Because these other models are under development, they are not a substitute for the final model, nor should they be used as a basis for developing management advice.

Figures A204-A205 compare the model outputs (SSB and Full F) from these 'other' models to the final model run (ASAP_BASE_V2). After exploring these models, the SFWG concluded that gains from the additional sex-specific information were not shown and did not warrant selection of less developed models that required additional parameters and assumptions. As shown in Figures A204-A205, these models show similar trends and capture major year class signals, despite being configured slightly differently. The following models were developed:

A) ASAP_BySex (Terceiro 2017 MS)

Independent sex-specific ASAP models for males and females were developed. The 2008 SARC 47 natural mortality vector at age for the sexes was used in this model. These models have all the same data as the final assessment model, except that the mean weights at age in the fishery landings and discards are derived from the NEFSC spring and fall survey data (to use the available lengths and weights by sex), rather than from fishery data as in the final assessment model. All the 'model settings' (lambdas, CVs, ESSs) were left the same in all runs - no individual run 'tuning' was performed. The diagnostics (residuals, RMSEs, retrospective analyses) looked reasonable. The spawning stock biomass and mean F from the male and female models were summed/averaged for comparison.

B) Stock Synthesis implementation of sex-structured virtual population analysis (Maunder 2018 MSa)

A Stock Synthesis model was developed that mimicked a sex-structured Virtual Population Analysis. The features included flexible initial numbers at age, time varying sex and age-specific selectivity, freely estimated recruitment, and the use of weight-at-age data. The model would need to go through a systematic model building and diagnostic approach before further consideration. It was constructed to be like the current ASAP model; however, there are differences in this implementation from the final ASAP_BASE_V2 model. For example, only the NEFSC surveys were used.

C) Sex-Age-Length (SAL) structured model (Sullivan 2018 MS)

This model was constructed in Template Model Builder (TMB) to address sex specific differences in growth and mortality that can result in differences in size specific selectivity by fishery. Preliminary analyses have been conducted using simulated data. The model is being applied to the actual sex-age-length based data derived from currently available data sources and configured using the NEFSC survey data and four fleet configuration. While outputs are not yet deemed reliable (not shown in Figures A204-A205), this model framework could be a candidate for future assessments.

D) State-space, sex-specific, age-structured assessment model (Miller and Terceiro 2018a, b MS)

The general state-space model was configured in various ways over the series of SFWG meetings. This approach uses the population models described by Miller et al. (2016) and Miller and Hyun (2018) for each sex, but with certain parameters shared by the two sexes. In Miller and Terceiro (2018b MS), revised recreational catch and discard data were used, but unlike the final ASAP_BASE_V2, only the NEFSC surveys were used for relative abundance indices, as was also done for all the non-final models. The differences in numbers at age for males and females were informed by observations of the proportion at age in the NEFSC surveys. The likelihood for these data was a generalization of the zero-or-one inflated beta distribution described by Ospina and Ferrari (2012) to deal with zeros and ones along with the proportions that would otherwise be modeled with a beta distribution.

Miller and Terceiro (2018a, b MS) focused on estimation of three models that assumed different age- and size-based selectivity and differences in selectivity by sex. Size effects on selectivity were modeled using empirical estimates of size at age. Ultimately there was no statistical evidence (as measured by AIC) found for differences in selectivity at age by sex, and size-based selectivity did not outperform age-based selectivity. Figures A204-A205 present the simplest and best model fit (based on AIC) without sex effects on selectivity. However, there were differences in recruitment and the assumed natural mortality differed for each sex. Therefore, per-recruit-based biological reference points that accounted for sex were also explored (Miller 2018 MS).

TOR A5. State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for BMSY, BTHRESHOLD, FMSY 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 = Fmax = 0.263, yield per recruit (Y/R) at Fmax was 0.552 kg/recruit, and Jan 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 lb) at a Total Stock Biomass (TSBmax as a proxy for BMSY) of 106,444 mt (234.669 million lb). The biomass threshold, one-half TSBmax as a proxy for one-half BMSY, was therefore estimated to be 53,222 mt (117.334 million lb). 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 Fthreshold 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 and survey data through 2004 (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 ± one standard error interval of the estimate for Pleuronectid flatfish (0.8 ± 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 FMSY = Fmax = 0.276, MSY = Ymax = 19,072 mt (42.047 million lb), BMSY = TSBmax = 92,645 mt (204.247 million lb), and biomass threshold of 0.5*TSBmax = 46,323 mt (102.125 million lb; 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). 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 lb (as the proxy for MSY); the product of the mean recruitment and SSB/R at Fmax was 89,411 mt = 197.118 million lb (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 of 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 MS).

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, 1975).

The reference points estimated in the 2008 SAW 47 assessment using the parametric approach were suspect because the Beverton-Holt function steepness (h) parameter was always very near 1. 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 viable 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 lb) and SSBMSY (60,074 mt = 132.440 million lb) estimates from long-term stochastic projections. These 2008 SAW47 BRPs based on F35% 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).

Old (Existing) 2013 SAW 57 Reference Points

In developing recommendations for biological reference points, the 2013 SAW 57 SFWG reviewed previous 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 (2013 MS), 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 value 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 a 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 SFWG 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.

The parametric reference points estimated internally in ASAP for the 2013 SAW 57 final model run were suspect because the Beverton-Holt function steepness parameter was very near 1, and the FMSY was estimated to be 3.0, constrained at the estimation boundary. 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 estimate of Fmax using mean M = 0.25 and updated fishery selectivity and mean weights at age was relatively high (0.480) and the Yield per Recruit (YPR) to F relationship did not indicate a well-defined peak.

The 2013 SAW 57 discussed the merits of F30% = 0.378 and F35% = 0.309 as the fishing mortality reference point proxy. F30% provided an increase of about 2% in YPR over F35%, but a corresponding decline in Spawning Stock Biomass per Recruit (SSBR) of 14%. The 2013 SAW 57 SFWG recommended proxies for FMSY and SSBMSY of F35% = 0.309 (CV = 15%) and associated estimates from long-term stochastic projections of MSY = 12,945 mt (28.539 million lb; CV = 13%) and SSBMSY = 62,394 mt (137.555 million lb; CV = 13%). The biomass threshold of one-half SSBMSY was estimated to be 31,197 mt (68.8 million lb; CV = 13%).

New (Updated) 2018 SAW-66 Reference Points

Fishing mortality reference point

The parametric reference points estimated internally in ASAP for the 2018 SAW-66 final ASAP model run F2018_BASE_V2 were suspect because the Beverton-Holt function steepness parameter was very near 1 and the FMSY was estimated to be 1.3. Therefore, as in the previous two benchmark assessments, the non-parametric reference point of F35% and the corresponding biomass and yield reference points were used as a proxies for FMSY, SSBMSY, and MSY. Table A90 provides the input data and assumptions for the SSBR and YPR model used to compute the non-parametric reference points based on the F2018_BASE_V2 model run.

The 2018 SAW-66 SFWG recommended a proxy for the fishing mortality threshold FMSY of F35% = 0.448 (CV = 15%). The SFWG noted that that the estimate of F35% (0.448) is 45% higher than the 2013 SAW 57 value (0.309; Table A91). This is due mostly to reductions in mean weights at the older ages (ages 6-7+) from the 2010-2012 averages used in the 2013 SAW 57 calculations (a 3 year average was the accepted period then) to the 2013-2017 averages used in the current calculations (a 5 year average has become the standard period in most NEFSC groundfish assessments; NEFSC 2017) . For example, the SSB mean weights at ages 6 and 7+ were 2.227 kg and 3.561 kg in the 2013 SAW 57 calculations, but 1.758 kg and 1.964 kg in the current calculations, decreases of 21% and 45% (Figure A206 top panel). The current fishery selectivity proportions are now slightly more 'dome-shaped' for ages 5 and older than the 2013 proportions, while the proportions mature are very similar (Figure A206 middle and bottom panels).

In previous summer flounder benchmark assessments (NEFSC 2008a, 2013) for older aged fish with limited, highly variable, or missing samples, Gompertz functions based on younger ages were used to estimate mean weights for the older ages in the BRP calculations. Specifically, the mean weight at age for the plus group (ages 7+) was estimated by using a weighted average of mean weights for ages 7-15 (observed catch weights for ages 7-10; Gompertz calculated weights for ages 11-15 as estimated from observed ages 0-10) based on the relative proportions at age given a total mortality rate of 0.55 (mean M = 0.25 + F = 0.30; a value then generally consistent with the F35% proxies for FMSY). In the current assessment, there is sufficient, consistent data for ages 5 and older from the NEFSC fisheries sample data since 2010 (e.g., Tables A32-A33, Figures A4-A5) to use the mean weights directly for older ages and to then calculate the plus group mean weight. Although the fishery data are not sampled by sex, the NEFSC survey sample data by sex indicate that the decrease in mean weights at older ages in survey samples is due in part to the increasing contribution that smaller male fish have to the mean weights of those ages since 2010, and in part to the decreases in in mean length exhibited by both sexes (and by extension mean weight; e.g., Figures A63-A64, A74-A75, A78-A79).

Sensitivity calculations of the F35% value were made to judge the relative impact of the changes in fishery mean weights and fishery selectivities at ages 5-7+. The table below shows that most of the difference in the value of F35% is due to the change in mean weights at age. Changing only the fishery selectivity for ages 5-7+ (SELEX column) from the 2018 values to the 2013 values reduces F35% from 0.448 to 0.437, while changing only the age 5-7+ mean weights (fishery and SSB; XW) reduces F35% from 0.448 to 0.334. Changing both sets of age 5-7+ inputs (XW+SELEX) reduces the F35% to 0.322, close to the 2013 SAW 57 estimate of 0.309.

Sensitivity Runs	If age 5-7+ XW and/or Selex like 2013 SAW57			
SAW-66	SELEX	XW	XW+SELEX	SAW57
0.448	0.437	0.334	0.322	0.309

Biomass and Yield reference points

The SFWG developed two sets of biomass (SSBMSY) and yield (MSY) reference points, using long-term (100 year) projections, that correspond to the FMSY proxy = F35% = 0.448. Termed ‘recommended’ and ‘alternative,’ they differ in the magnitude of recruitment assumed for the future. The SFWG discussion justifying the development of the alternative BRPs considered whether the use of recent recruitment (the ‘alternative’) was more ‘dynamic’ and potentially better represented environmental/climatic conditions in the near future than the ‘recommended’, which as in previous assessments used the full time series of recruitment (Maunder 2018 MSb).

The SFWG considered the ‘recommended’ BRPs and associated OFL projections (TOR 7) to be the ‘most realistic,’ and the recommended status evaluation (TOR 6) is therefore based on those BRPs. The recommended BRPs assume that the magnitude of recruitment estimated for the full time series of the assessment (scenario ‘R36’: 1982-2017, with a median of 51 million age 0 fish) will persist into the future. The recommended estimates are MSY = 15,973 mt (35.214 million lb; CV = 15%) and SSBMSY = 57,159 mt (126.014 million lb; CV = 15%; Table A91). The recommended biomass threshold of one-half SSBMSY was estimated to be 28,580 mt (63.0 million lb; CV = 15%).

The SFWG noted that the recommended SSBMSY proxy is 8% lower than the 2013 SAW57 value, even though the adult stock sizes and recruitment estimated by the F2018_BASE_V2 model run used as the basis for stock status have increased due to the inclusion of the calibrated MRIP estimates of recreational catch. Table A91 and Figure A207 show how the changes in mean weights and selectivity have impacted the SSBR, Percent MSP, and YPR 2018 calculations. These combined factors result in ‘flatter’ (i.e., lower slope through F35%) SSBR at F and Percent MSP (and also YPR) at F curves in the 2018 calculations when compared to the previous 2013 SAW57 benchmark. In particular, the SSBR estimate is 25%

lower, so even though the long-term median recruitment is 26% higher, at the higher F rate the resulting projected SSB35% is 8% lower.

An ‘alternative’ set of BRPs and OFL projections was developed under the assumption that recent below-average recruitment estimated for 2011-2017 (scenario R7: median of 36 million age 0 fish) will persist into the future. As noted in TOR3, however, the driver of these low recruitment events has not been identified, and so these BRPs are considered an alternative, but not recommended, illustration of potential stock productivity should below average recruitment persist into the future. The alternative BRP estimates are MSY = 10,920 mt (24.074 million lb; CV = 15%) and SSBMSY = 39,079 mt (86.154 million lb; CV = 15%; Table A91). The alternative biomass threshold of ½ SSBMSY was estimated to be 19,540 mt (43.1 million lb; CV = 15%).

TOR A6. Make a recommendation[a] about what stock status appears to be, based on the existing model (i.e., model from previous peer reviewed accepted assessment) and with respect to a new modeling approach(-es) developed for this peer review.

a. Update the existing model with new data and make a stock status recommendation (about overfished and overfishing) with respect to the existing BRP estimates.
b. Then use the newly proposed modeling approach(-es) and make a stock status recommendation with respect to "new" BRPs and their estimates (from TOR-5).
c. Include descriptions of stock status based on simple indicators/metrics (e.g., age- and size-structure, temporal trends in population size or recruitment indices, etc.).

[a]NOAA Fisheries has final responsibility for making the stock status determination for this stock based on best available scientific information.

2018 STOCK STATUS

a. Old (Existing) Model and Reference Points

Model run F2018 is the 2013 SAW 57 ASAP model (2 fleets, ALB indices) with 'Old' MRIP data through 2017 and provides estimates appropriate to compare with the old (existing) reference points, which are the threshold fishing mortality FMSY proxy = F35% = 0.309, target biomass SSBMSY proxy = SSBMSY35% = 62,394 mt, and threshold biomass ½ SSBMSY proxy = ½ SSBMSY35% = 31,197 mt (TOR 6a). This 'old' model indicates that F in 2017 = 0.244 and SSB in 2017 = 34,350 mt, so the stock was not overfished and overfishing was not occurring.

b. New (Updated) Model and Reference Points

Recommended Reference Points

Model run F2018_BASE_V2 is the final ASAP model adopted by the 2018 SAW-66 SFWG for the evaluation of stock status. The 2018 SAW-66 SFWG recommends that the summer flounder stock was not overfished and overfishing was not occurring in 2017 relative to the recommended biological reference points updated in this benchmark assessment. The fishing mortality rate was estimated to be 0.334 in 2017, 25% below the recommended threshold fishing mortality reference point = FMSY = F35% = 0.448. SSB was estimated to be 44,552 mt = 98.220 million lb in 2017, 78% of the recommended target biomass reference point = SSBMSY = SSB35% = 57,159 mt (126.014 million lb) and 56% above the recommended threshold biomass of ½ SSBMSY = ½ SSBMSY35% = 28,580 mt (63.0 million lb; Table A92, Figure A208).

Fishing mortality on the fully selected age 4 fish ranged between 0.744 and 1.622 during 1982-1996 and then decreased from 0.758 in 1997 to 0.245 in 2007. Since 2007 the fishing mortality rate has increased and was 0.334 in 2017, 75% of the 2018 SAW-66 FMSY proxy = F35% = 0.448 (Figure A209). The 90% confidence interval for F in 2017 was 0.276 to 0.380. Spawning stock biomass (SSB) decreased from 30,451 mt in 1982 to 7,408 mt in 1989 and then increased to 69,153 mt in 2003. SSB has decreased since 2003 and was estimated to be 44,552 in 2017, 78% of the 2018 SAW-66 SSBMSY proxy = SSB35% = 57,159 mt, and 56% above the 2018 SAW-66 ½ SSBMSY proxy = ½ SSB35% = 28,580 mt (Figure A210). The 90% confidence interval for SSB in 2017 was 39,195 to 50,935 mt. The 1982 and 1983 year classes are the largest in the assessment time series, at 82 and 102 million fish, while the 1988 year class is the smallest at only 12 million fish. The average recruitment from 1982 to 2017 is 53 million fish at age 0. Recruitment has been below average since 2010, ranging from 29 to 52 million and averaging 38 million fish (Figures A210-A211). The survival of summer flounder recruits, expressed as the R/SSB ratio, was higher in the 1980s and early 1990s than in the years since 1996 (Figure A212).

Alternative Reference Points

Under the alternative biological reference points that have been developed in this benchmark assessment, the 2018 SAW-66 SFWG notes that the summer flounder stock was not overfished and overfishing was not occurring in 2017. The fishing mortality rate was estimated to be 0.334 in 2017, 25% below the alternative (also new recommended) threshold fishing mortality reference point = FMSY = F35% = 0.448. SSB was estimated to be 44,552 mt = 98.220 million lb in 2017, 14% above the alternative target biomass reference point = SSBMSY = SSB35% = 39,079 mt (86.154 million lb) and 2.28 times the alternative threshold biomass of ½ SSBMSY = ½ SSBMSY35% = 19,540 mt (43.1 million lb; Table A92).

c. Stock status based on simple indicators/metrics

The age structure of the total catch (Figure A4) and NEFSC trawl surveys (Figures A24-A25) has expanded since the late 1990s when few fish were caught over age-4 and catch rates were relatively low. Most aggregate survey indices showed increasing trends from the late 1990s through the mid-2000s (Figures A23, A29, A31, A32, A34, and A37). These metrics indicate that the reduction in fishing mortality that occurred through the F reduction/stock rebuilding plan kept total mortality from all sources (M+F) low enough to allow the abundance as indicated by the surveys to increase and the age-structure to expand.

However, since the mid-2000s, most aggregate survey indices of abundance and/or biomass have remained stable or declined. This decline suggests the total mortality is too high to maintain an increasing stock trend. The exact cause of the observed trend is difficult to determine. Although recruitment indices have been below average in the most recent years (Figures A26, A30, A33, A35, A36, and A38), the driver of this pattern has not been identified nor is it clear if this pattern will persist in the future. There are also observed declines in the mean weights-at-age for both sexes and the age of maturity for age-1 fish, but no observed changes in the length-weight relationship or fish condition indices (Fulton's K). The observed shift in spatial distribution northward and eastward along shelf has continued since the mid-2000s, during a time of both abundance increase and during the recent declines. Other sources of unaccounted for mortality or changes in fishing pressure or exploitation patterns could be contributing factors. Regardless of cause, declines in survey indices suggest that current mortality from all sources is greater than current recruitment inputs to the stock. If recruitment improves, current catches may allow the stock to increase, but if recruitment remains low or decreases further, then reductions in catch will be necessary.

TOR A7. Develop approaches and apply them to conduct stock projections.

a. **Provide numerical annual projections (5 years) and the statistical distribution (i.e., probability density function) of the catch at F_{MSY} or an F_{MSY} proxy (i.e. the overfishing level, OFL) (see Appendix to the SAW TORs). 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. Identify reasonable projection parameters (recruitment, weight-at-age, retrospective adjustments, etc.) to use when setting specifications.**
c. **Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.**

INTRODUCTION

Stochastic projections were made to provide forecasts of stock size and catches in 2019-2023 consistent with the new (updated) 2018 SAW-66 biological reference points. The projections assume that recent (2013-2017) patterns of fishery selectivity, discarding, maturity at age and mean weight at age will continue over the time span of the projections. The projections assume that 100% of the 2018 ABC (5,999 mt = 13.226 million lb) will be caught. The SFWG noted that these projections are essentially 'placeholders' pending the availability of calibrated ('New') MRIP estimates for recreational catch in 2018. The SFWG did not make a quantitative assumption of the magnitude of the 2018 recreational (and therefore total) catch, but noted that it would likely be higher than the 'Old' 2018 estimate, and therefore the current 'placeholder' 2018 ABC likely is an underestimate of the final 2018 catch. The SFWG made two sets of OFL projections, based on the recommended and alternative biological reference points (BRPs) estimated for TOR6, that differ in the magnitude of recruitment assumed for the future. The SFWG considered the 'recommended' BRPs and OFL projections to be the 'most realistic.'

PROJECTIONS USING RECOMMENDED BRPs

The OFL projection uses F2019-F2023 = FMSY proxy = F35% = 0.448 and samples from the estimated recruitment for 1982-2017 (scenario R36: median recruitment = 51 million age 0 fish). The recommended OFL catches are 14,208 mt in 2019 (CV = 12%), 14,040 mt in 2020 (CV = 11%), 14,411 mt in 2021 (CV = 11%), 14,912 in 2022 (CV=13%), and 15,335 in 2023 (CV=15%; Table A93). For projections at the fixed FMSY proxy = F35% = 0.448, there is 0% probability of exceeding the fishing mortality threshold and 0% probability of falling below the biomass threshold during 2019-2023. The projection results presented have a realistic probability of being achieved, and the summer flounder stock has a low vulnerability to becoming overfished, given current status and the management regime in place.

USING ALTERNATIVE BRPs

The OFL projection uses F2019-F2023 = FMSY proxy = F35% = 0.448 and samples from the estimated recruitment for 2011-2017 (median recruitment = 36 million age 0 fish). The alternative OFL catches are 14,175 mt in 2019 (CV = 13%), 13,783 mt in 2020 (CV = 11%), 13,402 mt in 2021 (CV= 10%), 12,790 mt in 2022 (CV = 9%), and 12,082 mt in 2023 (CV = 9%; Table A93). For projections at the fixed FMSY proxy = F35% = 0.448, there is 0% probability of exceeding the fishing mortality threshold and 0% probability of falling below the biomass threshold during 2019-2023. The projection results presented have a realistic probability of being achieved, and the summer flounder stock has a low vulnerability to becoming overfished, given current status and the management regime in place.

TOR A8. 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 and MAFMC SSC reports. Identify new research recommendations.

SFWG responses to each of these recommendations are given in *italics*.

8.1. 2013 SARC 57 RESEARCH RECOMMENDATIONS

1) 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 and telemetry.

Other than estimation of natural mortality within modeling frameworks by some of the supportive models described under TOR4, no additional empirical methods to estimate natural mortality have been conducted. The SFWG recommends this be removed, as this is not considered an urgent research issue.

2) 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).

Some progress has been made (for b) as demonstrated in the development of sex-specific supportive models for this assessment described under TOR4. Gains in the reliability of advice produced from the inclusion of sex specific complexity have not been shown (for a or b), with the sex-specific supportive models providing similar overall results/advice to the primary assessment model presented. Some fine scale and regional analyses have been conducted that examine the distribution and movement by sex (for c), as well as distribution of adults and recruits along the shelf, which has provided some insight into the complexity of patterns in movement for this species (see TOR3). Work will continue in the future by different researchers on these topics for future SAWs.

3) Develop comprehensive study to determine the contribution of summer flounder nursery area to the overall summer flounder population, based off approaches that are similar to those

developed in 2013 SAW 57 WPA12.

WPA12 noted above recommended that work be done to identify contributions to nursery areas utilizing otolith microchemistry. While the work has not yet been published, Joel Fodrie at the University of North Carolina is conducting work using otolith microchemistry, and Jennifer Hoey at Rutgers University, NJ has conducted work using genetic markers. The SFWG recommends this be removed and replaced with the new, more broadly focused SFWG recommendation #1.

4) Develop an 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.

No ongoing, synoptic sampling program has been developed, although comprehensive data collections were conducted in 2010-2012 and 2016 by Jason Morson and Daphne Munroe at Rutgers University, NJ.

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

Significant progress has been made by the SFWG during this assessment under TOR2 to explore these approaches and develop sensitivity analyses to the primary assessment model, although ongoing work to improve treatment of age composition in the aggregated indices and estimation of uncertainty is needed.

6) 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.

These continue to be monitored in at least the NEFSC, NEAMAP, and MADMF trawl surveys as described under TOR2.

7) 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.

Progress has been made. The recent retrospective is negligible in the SAW-66 assessment as shown under TOR4. The inclusion of substantially higher catch in the recreational fleet time series resulting from the revised estimates is a contributing factor for this change. The SFWG recommends this be removed because it is no longer an issue.

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

This recommendation is unclear as written to original intent (even to SFWG members who were *in the room when it was originally written. The SFWG recommends this be removed and replaced with new SFWG recommendation #2.*

8.2 MAFMC SSC 2013-2018 RESEARCH RECOMMENDATIONS

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

The SFWG was unable to recommend an OFL CV modification, and there is not a strong analytical basis for any adjustment to the OFL CV. The calculated assessment OFL CVs for 2019-2023 range from 11%-14% (TOR 7).

The MAFMC SSC (Paul Rago) has work in progress to provide options for alternative quantitative calculations of the OFL CV.

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

See the SFWG response above under section 8.1, recommendation #4.

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

The SFWG has explored this issue and recommends it be removed. In this assessment, changes in the selectivity of the fleets in response to regulation was examined and tested using different time blocks.

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

Sex specific differences were incorporated and tested in the supportive modeling approaches presented under TOR4. Also see the SFWG response above under section 8.1, recommendation #4 and #6.

5) Determine and evaluate the sources of the over-optimistic stock projections.

This recommendation has been explored over the last few years, with results presented to the MAMFC SSC (Paul Rago analyses); however, with newly calibrated recreational catch estimates ('New' MRIP) included in the assessment, a new baseline for projection performance must be established and evaluated in the future.

6) Evaluate the causes of decreased recruitment and changes in recruitment per spawner in recent years.

Some progress has been made by the SFWG in describing potential causes for recent below average recruitment. However, understanding and verifying the mechanisms that may be causing the observed patterns warrants further research. Under TOR3, factors causing the shifts in the distribution of recruits and changes in habitat use/availability by early life stage are identified as *two areas to be considered for further work.*

7) Explore if and how changes in distribution and movement of the summer flounder stock may affect survey indices and fishery performance.

Substantial progress has been made by the SFWG under TORs 1, 2, and 3. This SAW-66 assessment examined information on the changing distribution of the fishery (under TOR1), explored survey catch rates spatially and factors effecting relative efficiency (such as diel sampling) under (TOR2), conducted work to aggregate indices using habitat occupancy information (TOR2), and examined changes in distribution and movement in response to environmental factors under TOR3. This recommendation has been fully explored and the SFWG recommended it be removed.

8.3. NEW 2018 SARC-66 RESEARCH RECOMMENDATIONS

1) Continue to explore changes in the distribution of recruitment. Develop studies, sampling programs, or analyses to better understand how and why these changes are occurring, and the implications to stock productivity.

2) The reference points are internally consistent with the current assessment. It may be useful to carry uncertainty estimates through all the components of the assessment, BRPs, and projections.

3) Explore the potential mechanisms for recent slower growth that is observed in both sexes.

Process recommendation

Provide an opportunity for the NMFS stock assessment scientists and Council SSCs to meet in person to promote common understanding of how the assessment products are used and considered in the process of developing SSC acceptable biological catch (ABC) limit advice for the Councils. The intent of this meeting is to align expectations and find opportunities to improve products and the process for both groups.

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

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	2,569	406	1,588	2,602	8	284	3,886	4,836	17,372	7,880
2005	3	0	1,278	2,925	449	1,799	2,157	5	338	3,897	4,059	16,911	7,671
2006	7	0	924	2,123	317	1,220	2,380	4	248	2,757	3,947	13,925	6,316
2007	4	0	661	1,496	205	940	1,698	3	298	2,043	2,669	10,017	4,544
2008	1	0	647	1,474	221	857	1,538	1	283	1,767	2,424	9,213	4,179
2009	0	0	732	1,794	257	1,140	1,799	3	330	2,178	2,819	11,052	5,013
2010	0	0	852	2,289	308	1,364	2,162	2	260	2,911	3,253	13,401	6,078
2011	0	0	1,132	2,824	403	1,517	2,831	1	259	4,784	2,822	16,572	7,517
2012	0	0	892	2,410	317	1,238	2,269	1	165	4,666	1,091	13,048	5,918
2013	0	0	859	2,193	288	1,034	2,004	1	245	5,371	561	12,557	5,696
2014	0	0	696	2,056	254	833	1,835	2	192	2,221	2,910	10,999	4,989
2015	0	0	748	1,716	287	831	1,688	1	244	2,281	2,912	10,710	4,858
2016	0	0	585	1,305	191	605	1,288	2	159	1,563	2,100	7,799	3,537
2017	0	0	421	897	134	500	962	8	103	1,253	1,550	5,829	2,644

Table A2. Summary of sampling of the commercial fishery for summer flounder, Northeast Region, Maine Virginia (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	11,456	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	2,964	87
1991	4,627	1,089	4,644	100
1992	3,385	899	6,361	188
1993	3,638	844	4,481	123
1994	3,950	956	4,981	126
1995	2,982	682	4,911	165
1996	4,580	1,235	3,948	86
1997	8,855	2,332	3,312	37
1998	10,055	2,641	3,730	37
1999	10,460	3,244	3,548	34
2000	10,952	3,307	3,573	33
2001	10,310	2,838	3,697	36
2002	7,422	1,870	4,724	64
2003	8,687	2,210	4,871	56
2004	13,970	3,560	5,953	43
2005	17,188	4,903	5,985	35
2006	18,118	5,062	4,472	25
2007	19,581	6,247	3,344	17
2008	14,803	4,661	3,073	21
2009	18,560	4,694	3,682	20
2010	15,185	3,510	4,451	29
2011	16,587	3,121	6,248	38
2012	15,709	2,999	5,429	35
2013	17,448	4,053	5,345	31
2014	15,183	3,851	3,703	24
2015	13,971	3,818	3,523	25
2016	11,229	3,072	2,587	26
2017	8,066	2,321	1,941	24

Table A3. Commercial fishery landings at age of summer flounder (000s), Northeast Region, Maine-Virginia (ME-VA).

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	1913	7190	3907	636	218	80	64	37	21	5	7	14076
1983	918	8920	4981	1311	714	351	86	50	12	24	20	17386
1984	1223	11324	5926	1470	890	107	2	7	3	16	0	20969
1985	814	5226	10662	758	301	384	26	15	3	1	0	18192
1986	886	6120	6151	1964	160	88	45	5	1	0	0	15420
1987	210	8407	7492	959	258	23	15	17	4	0	1	17386
1988	1078	9713	8220	1290	202	34	7	4	2	0	0	20550
1989	93	1642	5932	1222	165	20	5	3	3	0	0	9086
1990	0	2325	873	431	69	22	11	3	1	0	0	3735
1991	0	3510	3343	155	56	7	2	1	0	0	0	7074
1992	94	6005	3522	346	21	23	4	1	0	0	0	10016
1993	61	4685	1979	159	33	31	29	3	2	0	0	6982
1994	127	3592	3774	278	69	11	5	1	5	0	0	7862
1995	25	2561	4316	272	44	7	2	1	0	0	0	7228
1996	0	1756	2872	909	171	12	2	0	1	0	0	5723
1997	0	414	2401	1196	250	64	13	5	0	1	0	4344
1998	0	188	1726	2064	395	67	56	5	0	0	0	4501
1999	0	137	1531	1537	579	151	25	8	0	0	0	3968
2000	0	224	1951	1134	397	111	33	10	2	1	1	3864
2001	0	750	1300	868	343	178	75	23	4	2	2	3545
2002	0	441	2722	1321	415	137	69	12	1	1	0	5119
2003	0	437	2092	1380	507	248	113	41	20	2	1	4841
2004	0	305	2633	1684	751	323	132	54	27	7	4	5920
2005	3	560	1434	1755	1082	643	326	159	109	44	27	6142
2006	0	387	2326	1166	553	255	125	45	17	3	1	4878
2007	0	193	758	1507	479	229	116	43	15	6	5	3351
2008	0	137	464	688	946	345	150	71	32	9	5	2847
2009	0	191	780	1059	789	521	166	65	32	11	4	3618

Table A3 continued. Commercial fishery landings at age of summer flounder (000s), Northeast Region, Maine-Virginia (ME-VA).

Year	0	1	2	3	4	5	6	7	8	9	10	Total
2010	0	205	694	1300	1232	537	240	90	48	26	9	4382
2011	0	100	769	1838	1684	863	320	177	80	33	19	5883
2012	0	62	762	1829	1365	657	305	175	93	25	13	5286
2013	0	44	588	1683	1772	677	306	135	48	29	27	5309
2014	0	77	560	878	1112	596	182	84	28	24	27	3568
2015	0	141	754	985	824	530	328	112	54	15	24	3767
2016	0	27	661	802	493	253	209	116	47	20	20	2648
2017	0	38	269	545	439	222	147	99	69	41	17	1885

Table A4. Mean weight (kg) at age of summer flounder landed in the commercial fishery, Northeast Region, Maine-Virginia (ME-VA).

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	0.195	0.385	0.677	1.234	1.723	2.224	2.644	3.417	3.643	3.283	4.501	0.536
1983	0.281	0.373	0.635	1.042	1.347	1.661	2.200	2.924	3.020	3.243	4.310	0.586
1984	0.267	0.390	0.578	1.099	1.480	2.258	3.217	3.733	4.853	4.242	0.000	0.547
1985	0.296	0.412	0.567	1.040	1.831	2.143	2.596	4.572	4.777	5.195	0.000	0.592
1986	0.235	0.453	0.604	1.105	1.864	2.076	2.845	3.150	4.793	0.000	0.000	0.616
1987	0.277	0.445	0.602	1.002	1.947	2.822	3.070	2.570	4.477	0.000	5.307	0.572
1988	0.207	0.476	0.593	1.071	1.815	2.745	4.153	4.174	5.105	0.000	0.000	0.565
1989	0.348	0.522	0.643	0.937	1.764	2.272	2.976	3.352	2.271	0.000	0.000	0.684
1990	0.000	0.557	0.927	1.434	1.877	2.632	3.469	3.911	4.935	0.000	0.000	0.794
1991	0.000	0.511	0.731	1.537	2.417	3.157	3.974	4.607	0.000	0.000	0.000	0.657
1992	0.324	0.498	0.754	1.588	2.487	2.774	3.727	4.845	0.000	0.000	0.000	0.635
1993	0.375	0.507	0.796	1.730	2.156	1.881	2.873	4.079	4.937	0.000	0.000	0.642
1994	0.456	0.545	0.622	1.373	2.275	3.335	3.287	4.123	3.791	0.000	0.000	0.633
1995	0.315	0.514	0.702	1.548	2.486	2.326	4.126	4.427	0.000	0.000	0.000	0.680
1996	0.000	0.484	0.606	1.098	1.835	2.871	3.700	0.000	4.753	0.000	0.000	0.690
1997	0.000	0.555	0.636	0.833	1.461	2.135	2.734	3.267	0.000	4.853	5.076	0.762
1998	0.000	0.525	0.628	0.836	1.363	2.093	2.264	3.524	0.000	0.000	0.000	0.829
1999	0.000	0.500	0.611	0.870	1.389	1.978	2.972	3.749	0.000	0.000	0.000	0.894
2000	0.000	0.559	0.684	0.987	1.534	2.216	2.849	3.128	3.905	3.368	3.814	0.925
2001	0.000	0.574	0.753	1.051	1.797	2.422	2.875	3.620	3.790	3.792	5.345	1.044
2002	0.000	0.563	0.697	1.022	1.649	2.138	2.899	3.817	3.392	2.983	0.000	0.923
2003	0.000	0.619	0.709	1.007	1.451	1.934	2.577	3.267	3.641	3.481	5.195	1.006
2004	0.000	0.536	0.700	0.990	1.428	1.875	2.450	2.895	3.054	3.657	3.209	1.005
2005	0.091	0.537	0.619	0.796	1.057	1.396	1.727	2.067	2.304	2.999	3.083	0.974
2006	0.000	0.558	0.646	0.923	1.319	1.816	2.325	2.773	3.229	3.917	4.172	0.917
2007	0.000	0.558	0.677	0.863	1.220	1.700	2.259	2.453	2.652	3.139	4.038	0.997
2008	0.000	0.566	0.639	0.808	1.106	1.497	1.942	2.269	2.603	2.952	3.421	1.079
2009	0.000	0.521	0.625	0.801	1.051	1.521	1.933	2.528	2.858	3.331	3.474	1.018

Table A4 continued. Mean weight (kg) at age of summer flounder landed in the commercial fishery, Northeast Region, Maine-Virginia (ME-VA).

Year	0	1	2	3	4	5	6	7	8	9	10	Total
2010	0.000	0.425	0.562	0.765	1.024	1.391	2.086	2.469	2.759	3.120	3.750	1.016
2011	0.000	0.475	0.553	0.691	1.017	1.535	1.953	2.461	2.852	3.111	3.745	1.061
2012	0.000	0.538	0.627	0.728	0.977	1.462	1.927	1.996	2.530	2.913	3.577	1.027
2013	0.000	0.511	0.592	0.745	0.940	1.314	1.906	2.140	2.506	2.830	3.320	1.007
2014	0.000	0.527	0.651	0.786	0.983	1.355	1.734	2.114	2.493	2.917	2.727	1.038
2015	0.000	0.535	0.629	0.737	0.908	1.231	1.436	1.668	1.833	2.330	2.329	0.935
2016	0.000	0.661	0.669	0.766	0.997	1.323	1.462	1.677	2.008	2.091	2.487	0.977
2017	0.000	0.604	0.677	0.827	0.997	1.267	1.425	1.703	1.506	1.299	2.141	1.032

Table A5. 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	2,194	11
2005	20,598	620	1,841	9
2006	20,911	682	1,790	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	1,413	6
2011	16,962	417	1,280	8
2012	7,439	541	495	7
2013	6,336	575	255	4
2014	20,801	1,113	1,320	6
2015	28,048	884	1,321	5
2016	24,264	905	953	4
2017	14,258	925	703	5

Table A6. Commercial fishery landings at age of summer flounder (000s), North Carolina commercial trawl fishery.

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

Table A6 continued. Commercial fishery landings at age of summer flounder (000s), North Carolina commercial trawl fishery.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
2010	0	19	222	513	403	178	155	43	12	7	1	1553
2011	0	0	165	306	529	141	94	86	25	10	4	1360
2012	0	2	44	159	124	88	36	18	12	6	3	492
2013	0	6	33	53	55	14	7	2	3	1	0	174
2014	0	12	127	310	367	250	70	26	10	10	9	1191
2015	0	8	137	333	182	256	236	64	40	6	20	1282
2016	0	4	78	208	170	120	107	140	26	10	12	875
2017	0	4	27	132	180	110	50	49	64	20	23	659

Table A7. 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

Table A7 continued. 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
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	0.946
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
2013	0.000	0.658	0.695	0.859	0.998	1.448	1.798	2.400	2.435	2.702	4.274	1.006
2014	0.000	0.580	0.712	0.886	1.045	1.260	1.626	2.376	2.492	2.002	4.527	1.118
2015	0.000	0.561	0.639	0.769	1.007	1.138	1.277	1.293	1.322	1.879	3.976	1.053
2016	0.000	0.537	0.602	0.747	0.955	1.211	1.273	1.296	1.238	2.052	3.452	1.056
2017	0.000	0.456	0.679	0.776	0.903	1.042	1.231	1.347	1.340	1.207	1.361	1.014

Table A8. Dealer reported landings, live discard estimates and coefficient of variation (CV), total commercial catch, and discard as a percentage of total catch for summer flounder. Catches are in metric tons.

Year	Dealer Landings	Trawl Discards	Trawl CV	Scallop Discards	Scallop CV	Gillnet Discards	Gillnet CV	Comm Discards	Comm CV	Comm Catch	Live Discard: Catch (%)
1989	5,817	570	0.66					570	0.66	6,387	8.9%
1990	2,749	1,122	0.68					1,122	0.68	3,871	29.0%
1991	4,355	273	0.58	1	0.00			274	0.58	4,629	5.9%
1992	6,066	2,375	0.42	314	0.16			2,689	0.39	8,755	30.7%
1993	3,995	735	0.68	141	0.74			876	0.69	4,871	18.0%
1994	4,968	1,604	0.23	315	0.45	5	0.41	1,924	0.27	6,892	27.9%
1995	4,911	618	0.41	409	0.32	6	0.77	1,033	0.38	5,944	17.4%
1996	3,718	1,326	0.54	468	0.43	1	0.34	1,795	0.51	5,513	32.6%
1997	3,994	502	0.65	505	0.11	1	0.25	1,008	0.38	5,002	20.2%
1998	5,076	575	0.44	218	0.17	4	0.40	797	0.37	5,873	13.6%
1999	4,820	1,880	0.36	195	0.71	8	0.63	2,083	0.39	6,903	30.2%
2000	5,085	1,218	0.63	804	0.49	3	0.37	2,025	0.57	7,110	28.5%
2001	4,970	257	0.70	249	0.26	8	0.69	514	0.49	5,484	9.4%
2002	6,573	604	0.50	548	0.28	33	0.69	1,185	0.41	7,758	15.3%
2003	6,450	795	0.47	635	0.38	20	0.34	1,450	0.43	7,900	18.4%
2004	7,880	1,249	0.42	759	0.21	28	0.21	2,036	0.34	9,916	20.5%
2005	7,671	1,328	0.26	527	0.22	19	0.17	1,874	0.25	9,545	19.6%
2006	6,316	1,476	0.35	377	0.34	44	0.30	1,897	0.34	8,213	23.1%
2007	4,544	2,023	0.32	614	0.32	23	0.25	2,660	0.32	7,204	36.9%
2008	4,179	888	0.37	539	0.21	26	0.24	1,453	0.31	5,632	25.8%
2009	5,013	1,154	0.30	654	0.18	95	0.33	1,903	0.26	6,916	27.5%
2010	6,078	1,023	0.28	809	0.20	16	0.15	1,848	0.25	7,926	23.3%
2011	7,517	747	0.29	623	0.20	59	0.13	1,429	0.25	8,946	16.0%
2012	5,918	457	0.13	440	0.07	46	0.11	943	0.10	6,861	13.7%
2013	5,696	668	0.13	346	0.08	64	0.24	1,078	0.12	6,774	15.9%
2014	4,989	597	0.09	384	0.08	56	0.15	1,037	0.09	6,026	17.2%
2015	4,858	645	0.09	192	0.12	41	0.17	878	0.10	5,736	15.3%
2016	3,537	564	0.10	360	0.09	41	0.21	965	0.10	4,502	21.4%
2017	2,644	617	0.06	450	0.06	66	0.25	1,133	0.07	3,777	30.0%
mean	5,186	962	0.38	440	0.26	30	0.32	1,396	0.35	6,582	21.2%

Table A9. Summary of Observer discard sampling of the commercial fishery for summer flounder, Northeast Region, Maine-Virginia (ME-VA); catches are in metric tons (mt); sampling intensity is 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
	Gillnet	16		5	31
	All	3,014	354	1,924	64
1995	Trawl	1,822		618	34
	Scallop	731		409	56
	Gillnet	46		6	13
	All	2,599	n/a	1,033	40
1996	Trawl	1,873		1,326	71
	Scallop	854		468	55
	Gillnet	93		1	1
	All	2,820	n/a	1,795	64
1997	Trawl	839		502	60
	Scallop	556		505	91
	Gillnet	79		1	1
	All	1,474	n/a	1,008	68
1998	Trawl	721		575	80
	Scallop	150		218	145
	Gillnet	34		4	12
	All	905	n/a	797	88
1999	Trawl	1,145		1,880	164
	Scallop	216		195	90
	Gillnet	10		8	80
	All	1,371	n/a	2,083	152

Table A9 continued. Summary of Observer discard sampling of the commercial fishery for summer flounder, Northeast Region, Maine-Virginia (ME-VA); catches are in metric tons (mt); sampling intensity is expressed as mt of live discards per 100 lengths.

Year	Gear	Lengths	Ages	Live Discards (mt)	Sampling Intensity (mt/100 lengths)
2000	Trawl	1,470		1,218	83
	Scallop	2,611		804	31
	Gillnet	53		3	6
	All	4,134	n/a	2,025	49
2001	Trawl	1,528		257	17
	Scallop	705		249	35
	Gillnet	28		8	29
	All	2,261	n/a	514	23
2002	Trawl	3,438		604	18
	Scallop	2,952		548	19
	Gillnet	49		33	67
	All	6,439	n/a	1,185	18
2003	Trawl	4,233		795	19
	Scallop	2,594		635	24
	Gillnet	122		20	16
	All	6,949	n/a	1,450	21
2004	Trawl	5,760		1,249	22
	Scallop	8,811		759	9
	Gillnet	269		28	10
	All	14,840	n/a	2,036	14
2005	Trawl	9,562		1,328	14
	Scallop	4,690		527	11
	Gillnet	58		19	33
	All	14,310	n/a	1,874	13
2006	Trawl	8,283		1,476	18
	Scallop	1,911		377	20
	Gillnet	47		44	94
	All	10,241	n/a	1,897	19
2007	Trawl	12,725		2,023	16
	Scallop	4,972		614	12
	Gillnet	99		23	23
	All	17,796	n/a	2,660	15
2008	Trawl	6,815		888	13
	Scallop	8,211		539	7
	Gillnet	194		26	13
	All	15,220	n/a	1,453	10
2009	Trawl	9,441		1,154	12
	Scallop	8,970		654	7
	Gillnet	280		95	34
	All	18,691	n/a	1,903	10

Table A9 continued. Summary of Observer discard sampling of the commercial fishery for summer flounder, Northeast Region, Maine-Virginia (ME-VA); catches are in metric tons (mt); sampling intensity is expressed as mt of live discards per 100 lengths.

Year	Gear	Lengths	Ages	Live Discards (mt)	Sampling Intensity (mt/100 lengths)
2010	Trawl	8,460		1,023	12
	Scallop	7,826		809	10
	Gillnet	277		16	6
	All	16,563	n/a	1,848	11
2011	Trawl	8,710		747	9
	Scallop	6,785		623	9
	Gillnet	457		59	13
	All	15,952	n/a	1,429	9
2012	Trawl	3,725		457	12
	Scallop	5,156		440	9
	Gillnet	277		46	17
	All	9,158	n/a	943	10
2013	Trawl	5,488		668	12
	Scallop	3,416		346	10
	Gillnet	42		64	152
	All	8,946	n/a	1,078	12
2014	Trawl	4,839		597	12
	Scallop	4,495		384	9
	Gillnet	240		56	23
	All	9,574	n/a	1,037	11
2015	Trawl	4,639		645	14
	Scallop	3,440		192	6
	Gillnet	172		41	24
	All	8,251	n/a	878	11
2016	Trawl	4,613		564	12
	Scallop	6,405		360	6
	Gillnet	129		41	32
	All	11,018	n/a	965	9
2017	Trawl	2,721		617	23
	Scallop	3,585		450	13
	Gillnet	208		66	32
	All	6,514	n/a	1,133	17

Table A10. Estimated commercial fishery discards at age of summer flounder (000s).

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	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
1984	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
1986	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
1988	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
1990	1043	3299	131	22	0	0	0	0	0	0	0	4495
1991	339	867	19	0	0	0	0	0	0	0	0	1225
1992	2830	6192	589	21	0	0	0	0	0	0	0	9633
1993	688	1846	456	0	0	0	0	0	0	0	0	2991
1994	791	3921	1160	10	3	1	0	0	0	0	0	5885
1995	1653	554	526	35	5	1	0	0	0	0	0	2774
1996	115	1435	1340	266	90	29	2	2	2	0	0	3281
1997	38	305	743	225	39	12	1	0	0	0	0	1362
1998	84	150	465	232	55	20	12	2	0	0	0	1021
1999	108	1274	1399	463	167	50	4	0	0	0	0	3466
2000	20	249	1192	442	161	38	13	3	1	0	0	2120
2001	39	218	134	98	30	15	4	2	1	1	0	543
2002	103	695	599	126	47	23	21	5	2	0	0	1620
2003	7	607	694	197	76	39	29	12	8	1	1	1672
2004	21	206	791	369	162	82	50	26	18	6	1	1730
2005	16	210	454	294	166	131	85	49	47	28	12	1491
2006	5	111	751	234	182	99	75	36	24	4	3	1524
2007	22	131	259	710	294	158	116	54	29	8	8	1790
2008	18	190	236	194	261	107	63	40	27	10	5	1151
2009	17	188	487	301	197	169	76	46	27	13	5	1526

Table A10 continued. Estimated commercial fishery discards at age of summer flounder (000s).

Year	0	1	2	3	4	5	6	7	8	9	10	Total
2010	11	354	658	455	269	116	64	33	23	12	4	1998
2011	14	130	515	439	198	105	45	29	17	9	7	1509
2012	38	55	205	259	145	60	37	26	16	9	4	855
2013	10	62	145	188	176	73	39	17	10	5	8	735
2014	14	122	224	221	208	103	32	17	7	7	8	963
2015	20	124	207	185	109	76	52	21	14	6	8	821
2016	30	75	250	238	126	65	52	32	18	8	5	898
2017	33	104	195	267	171	94	48	36	26	15	8	996

Table A11. Estimated commercial fishery summer flounder discard mean weight at age (kg).

Year	0	1	2	3	4	5	6	7	8	9	10	Mean
1989	0.099	0.196	0.261	0.709	1.143	0	0	0	0	0	0	0.181
1990	0.179	0.193	0.490	0.539	0	0	0	0	0	0	0	0.200
1991	0.131	0.196	0.207	0	0	0	0	0	0	0	0	0.178
1992	0.175	0.234	0.305	1.299	0	0	0	0	0	0	0	0.224
1993	0.170	0.246	0.283	0	0	0	0	0	0	0	0	0.234
1994	0.138	0.263	0.321	1.442	1.759	3.133	0	0	0	0	0	0.261
1995	0.174	0.324	0.548	1.402	1.932	3.873	0	0	0	0	0	0.295
1996	0.153	0.268	0.373	1.030	1.637	2.776	3.367	5.246	5.691	0	0	0.436
1997	0.189	0.330	0.553	0.886	1.408	2.322	3.075	0	0	0	0	0.590
1998	0.181	0.324	0.472	0.784	1.370	2.680	2.998	3.745	0.000	0	0	0.627
1999	0.176	0.265	0.432	0.762	1.424	1.990	2.897	0	0	0	0	0.480
2000	0.119	0.328	0.554	0.956	1.521	2.096	2.880	3.239	5.207	0	0	0.729
2001	0.134	0.391	0.730	1.053	1.702	2.581	2.981	3.642	3.784	6.231	0	0.757
2002	0.179	0.338	0.522	1.063	1.897	2.533	3.299	3.914	5.525	0	0	0.583
2003	0.185	0.355	0.527	1.006	1.684	2.209	3.000	3.396	4.108	3.693	5.030	0.697
2004	0.180	0.333	0.580	0.990	1.521	2.125	2.763	3.103	4.015	4.206	3.452	0.944
2005	0.200	0.335	0.509	0.778	1.136	1.573	2.000	2.413	2.884	3.702	3.393	1.003
2006	0.160	0.411	0.509	0.980	1.352	1.832	2.549	3.026	4.073	4.205	3.842	0.994
2007	0.154	0.362	0.646	0.890	1.323	1.945	2.491	2.585	3.413	3.508	3.939	1.193
2008	0.148	0.306	0.499	0.768	1.099	1.578	2.174	2.651	3.128	3.387	3.589	1.009
2009	0.168	0.328	0.474	0.752	1.145	1.731	2.306	2.962	3.523	4.057	4.336	0.996

Table A11 continued. Estimated commercial fishery summer flounder discard mean weight at age (kg).

Year	0	1	2	3	4	5	6	7	8	9	10	Mean
2010	0.200	0.284	0.424	0.649	0.986	1.424	2.260	2.751	3.427	3.468	3.820	0.739
2011	0.217	0.302	0.397	0.539	0.946	1.591	2.186	2.830	3.368	3.696	3.947	0.753
2012	0.153	0.298	0.441	0.606	0.962	1.644	1.976	2.398	3.449	3.825	4.691	0.881
2013	0.136	0.307	0.447	0.698	1.077	1.726	2.407	2.669	3.353	3.535	4.175	1.035
2014	0.204	0.279	0.439	0.650	0.943	1.543	2.077	2.874	3.302	3.839	3.719	0.859
2015	0.179	0.302	0.456	0.638	0.911	1.538	1.888	2.180	3.126	3.772	3.659	0.860
2016	0.084	0.296	0.526	0.667	0.980	1.369	1.754	2.017	3.033	3.103	2.819	0.863
2017	0.121	0.373	0.608	0.788	0.960	1.228	1.633	2.080	2.393	2.117	3.551	0.931

Table A12. Estimated landings of summer flounder in numbers (000s) and weight (metric tons; mt) in the recreational fishery as estimated by the Marine Recreational Fisheries Statistics Survey (MRFSS 1982-2003) and Marine Recreational Information Program (MRIP 2004-2017). PSE = Proportional Standard Error. 'Old' MRFSS/MRIP.

Year	Landings (000s)	Landings (000s) PSE	Landings (mt)	Landings (mt) PSE
1982	15,473	26%	8,267	25%
1983	20,996	7%	12,687	7%
1984	17,475	8%	8,512	8%
1985	11,066	12%	5,665	11%
1986	11,621	7%	8,102	9%
1987	7,865	5%	5,519	9%
1988	9,960	4%	6,634	4%
1989	1,717	6%	1,435	6%
1990	3,794	4%	2,329	4%
1991	6,068	4%	3,611	4%
1992	5,002	4%	3,242	4%
1993	6,494	4%	4,006	4%
1994	6,703	4%	4,231	4%
1995	3,326	4%	2,459	5%
1996	6,997	3%	4,454	3%
1997	7,167	4%	5,382	4%
1998	6,979	4%	5,659	5%
1999	4,107	4%	3,795	5%
2000	7,801	3%	7,470	4%
2001	5,294	4%	5,279	4%
2002	3,262	4%	3,632	4%
2003	4,559	4%	5,279	4%
2004	4,316	6%	4,974	6%
2005	4,028	6%	4,929	6%
2006	3,951	7%	4,804	6%
2007	3,109	6%	4,199	7%
2008	2,350	9%	3,689	8%
2009	1,807	7%	2,716	11%
2010	1,502	8%	2,317	13%
2011	1,830	8%	2,645	12%
2012	2,199	8%	2,853	8%
2013	2,534	9%	3,351	9%
2014	2,459	7%	3,356	8%
2015	1,677	7%	2,209	8%
2016	2,028	7%	2,804	7%
2017	1,029	7%	1,447	7%

Table A13. Recreational fishery sampling intensity of summer flounder landings in metric tons (mt) by subregion. Includes both Marine Recreational Fisheries Statistics Survey and Marine Recreational Information Program and State agency lengths. 'Old' MRFSS/MRIP.

Year	Landings (mt)	Number Measured	mt/100 Lengths
1982	8,163	3,703	220
1983	12,527	5,193	241
1984	8,405	2,646	318
1985	5,594	2,286	245
1986	8,000	2,362	339
1987	5,450	2,559	213
1988	6,550	3,918	167
1989	1,417	2,047	69
1990	2,300	4,070	57
1991	3,566	5,657	63
1992	3,201	5,495	58
1993	3,956	5,507	72
1994	4,178	5,922	71
1995	2,428	2,456	99
1996	4,398	5,480	80
1997	5,314	4,800	111
1998	5,588	5,321	105
1999	3,747	2,590	145
2000	7,376	3,321	222
2001	5,213	4,247	123
2002	3,586	3,657	98
2003	5,213	3,656	143
2004	4,974	4,310	115
2005	4,929	2,814	175
2006	4,804	2,691	179
2007	4,199	3,363	125
2008	3,689	1,993	185
2009	2,716	2,331	117
2010	2,317	1,746	133
2011	2,645	2,202	120
2012	2,853	2,001	143
2013	3,351	2,735	123
2014	3,356	2,416	139
2015	2,209	2,701	82
2016	2,804	2,388	117
2017	1,447	1,807	80

Table A14. Estimated recreational landings at age of summer flounder (000s): 'Old' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	2750	8445	3498	561	215	1	3	0	0	0	0	15,473
1983	2302	11612	4978	1340	528	220	0	16	0	0	0	20,996
1984	2282	9198	4831	1012	147	4	1	0	0	0	0	17,475
1985	1002	5002	4382	473	148	59	0	0	0	0	0	11,066
1986	1170	6405	2785	1089	129	15	28	0	0	0	0	11,621
1987	467	4676	2085	449	182	1	5	0	0	0	0	7,865
1988	429	5742	3311	387	88	3	0	0	0	0	0	9,960
1989	74	539	946	135	16	2	5	0	0	0	0	1,717
1990	353	2770	529	118	23	1	0	0	0	0	0	3,794
1991	86	3611	2251	79	40	1	0	0	0	0	0	6,068
1992	82	3183	1620	90	1	26	0	0	0	0	0	5,002
1993	79	3930	2323	159	1	2	0	0	0	0	0	6,494
1994	790	3998	1698	184	28	1	4	0	0	0	0	6,703
1995	231	1510	1426	116	26	16	1	0	0	0	0	3,326
1996	116	2935	3468	354	123	1	0	0	0	0	0	6,997
1997	4	1148	4188	1465	274	88	0	0	0	0	0	7,167
1998	0	768	2915	2714	515	63	4	0	0	0	0	6,979
1999	0	201	1982	1520	325	60	19	0	0	0	0	4,107
2000	0	578	4121	2284	643	170	5	0	0	0	0	7,801
2001	0	838	1975	1781	539	121	36	4	0	0	0	5,294
2002	1	194	1327	1204	421	92	20	1	2	0	0	3,262
2003	0	237	1674	1751	648	171	62	16	0	0	0	4,559
2004	24	213	1554	1720	681	220	120	25	0	0	0	4,557
2005	3	184	1197	1539	755	238	99	60	35	0	0	4,110
2006	4	72	1412	1319	729	317	135	40	24	0	0	4,052
2007	2	70	577	1580	714	286	103	33	28	0	0	3,393
2008	1	25	97	437	854	520	213	77	148	0	0	2,372
2009	1	20	108	467	661	442	130	54	21	5	1	1,910

Table A14 continued. Estimated recreational landings at age of summer flounder (000s): 'Old' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
2010	0	14	49	231	575	376	153	47	23	10	6	1,484
2011	1	8	34	254	686	520	170	71	23	8	7	1,782
2012	1	8	158	578	772	389	179	85	19	9	1	2,199
2013	1	11	93	624	1028	414	145	57	25	9	12	2,419
2014	1	27	257	495	854	572	148	48	17	10	28	2,457
2015	1	12	206	443	401	321	184	56	27	8	18	1,677
2016	1	16	423	575	457	227	174	97	36	7	15	2,028
2017	0	7	96	328	256	159	707	56	32	15	10	1,029

Table A15. Mean weight (kg) at age of summer flounder landings in the recreational fishery: 'Old' MRFSS/MRIP.

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

Table A15 continued. Mean weight (kg) at age of summer flounder landings in the recreational fishery: 'Old' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
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
2013	0.185	0.313	0.753	0.961	1.205	1.620	1.946	1.962	2.272	2.486	2.150	1.274
2014	0.208	0.515	0.794	1.016	1.216	1.524	1.885	2.204	2.637	1.852	2.041	1.277
2015	0.214	0.520	0.885	1.037	1.197	1.434	1.582	1.921	1.658	2.178	1.779	1.241
2016	0.062	0.568	0.947	1.108	1.369	1.583	1.666	1.798	1.683	2.125	2.082	1.283
2017	0.000	0.606	1.003	1.162	1.426	1.564	1.636	1.831	1.730	1.896	1.997	1.376

Table A16. Estimated dead discards of summer flounder in numbers (000s) and weight (metric tons; mt) in the recreational fishery as estimated by the Marine Recreational Fisheries Statistics Survey (MRFSS 1982-2003) and Marine Recreational Information Program (MRIP 2004-2017). PSE = Proportion Standard Error. 'Old' MRFSS/MRIP.

Year	Dead Discards (000s)	Dead Discards (mt)	Dead Discards (000s) PSE
1982	808	296	59%
1983	1,107	376	16%
1984	1,230	415	11%
1985	246	92	15%
1986	1,367	578	8%
1987	1,316	522	6%
1988	720	341	6%
1989	96	45	10%
1990	530	234	5%
1991	1,001	429	5%
1992	691	344	5%
1993	1,774	910	5%
1994	1,233	687	5%
1995	1,357	753	5%
1996	1,299	681	4%
1997	1,389	556	4%
1998	1,696	734	4%
1999	1,783	711	5%
2000	1,864	952	4%
2001	2,405	1274	3%
2002	1,407	777	3%
2003	1,641	882	4%
2004	1,701	1034	5%
2005	2,314	999	6%
2006	1,754	795	6%
2007	2,028	1130	5%
2008	2,262	1251	5%
2009	2,375	1195	6%
2010	2,243	1079	6%
2011	2,038	1093	6%
2012	1,446	815	7%
2013	1,333	758	8%
2014	1,744	932	7%
2015	1,081	563	7%
2016	1,214	671	7%
2017	742	442	7%

Table A17. Recreational fishery sampling intensity for summer flounder discards: 'Old' MRFSS/MRIP.

Year	Dead Discard Mortality (mt)	Number Measured	mt/100 Lengths
1982	296		
1983	376		
1984	415		
1985	92		
1986	578		
1987	522		
1988	341		
1989	45		
1990	234		
1991	429		
1992	344		
1993	910		
1994	687		
1995	753		
1996	681		
1997	556		
1998	734		
1999	711		
2000	952		
2001	1,274	8,239	15
2002	777	7,030	11
2003	882	6,255	14
2004	1,034	4,357	24
2005	999	7,949	13
2006	795	10,276	8
2007	1,130	8,740	13
2008	1,251	9,857	13
2009	1,195	17,741	7
2010	1,079	13,723	8
2011	1,093	11,533	9
2012	815	7,002	12
2013	758	7,224	10
2014	932	6,363	15
2015	563	7,493	8
2016	671	5,301	13
2017	442	5,516	8

Table A18. Estimated recreational fishery discards at age of summer flounder (000s). 'Old' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	172	636	0	0	0	0	0	0	0	0	0	808
1983	175	932	0	0	0	0	0	0	0	0	0	1107
1984	210	1020	0	0	0	0	0	0	0	0	0	1230
1985	40	206	0	0	0	0	0	0	0	0	0	246
1986	150	1217	0	0	0	0	0	0	0	0	0	1367
1987	106	1210	0	0	0	0	0	0	0	0	0	1316
1988	55	665	0	0	0	0	0	0	0	0	0	720
1989	13	83	0	0	0	0	0	0	0	0	0	96
1990	60	470	0	0	0	0	0	0	0	0	0	530
1991	24	977	0	0	0	0	0	0	0	0	0	1001
1992	17	674	0	0	0	0	0	0	0	0	0	691
1993	34	1740	0	0	0	0	0	0	0	0	0	1774
1994	216	1017	0	0	0	0	0	0	0	0	0	1233
1995	189	1168	0	0	0	0	0	0	0	0	0	1357
1996	50	1249	0	0	0	0	0	0	0	0	0	1299
1997	24	820	522	23	0	0	0	0	0	0	0	1389
1998	0	685	875	136	0	0	0	0	0	0	0	1696
1999	84	587	987	125	0	0	0	0	0	0	0	1783
2000	0	587	1097	180	0	0	0	0	0	0	0	1864
2001	0	1261	888	239	17	0	0	0	0	0	0	2405
2002	75	565	569	190	8	0	0	0	0	0	0	1407
2003	49	785	599	194	14	0	0	0	0	0	0	1641
2004	85	508	794	307	7	0	0	0	0	0	0	1701
2005	254	1153	739	160	8	0	0	0	0	0	0	2314
2006	155	552	887	145	13	2	0	0	0	0	0	1754
2007	101	667	674	514	65	7	0	0	0	0	0	2028
2008	140	807	609	398	246	45	10	3	2	2	0	2262
2009	218	897	626	440	162	28	2	1	1	0	0	2375

Table A18 continued. Estimated recreational fishery discards at age of summer flounder (000s). 'Old' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
2010	150	808	594	450	194	35	7	2	1	1	1	2243
2011	97	482	571	595	241	41	5	3	1	1	1	2038
2012	101	165	411	539	197	21	7	3	1	1	0	1446
2013	66	204	348	463	236	13	2	0	1	0	0	1333
2014	121	467	525	326	231	54	13	4	1	1	1	1744
2015	55	286	329	215	109	47	22	12	4	1	1	1081
2016	14	265	423	299	106	51	30	16	7	2	1	1214
2017	6	84	210	212	135	36	23	14	11	8	3	742

Table A19. Mean weight (kg) at age of summer flounder discards in the recreational fishery: ‘Old’ MRFSS/MRIP.

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

Table A19 continued. Mean weight (kg) at age of summer flounder discards in the recreational fishery: 'Old' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
2010	0.167	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
2013	0.175	0.284	0.476	0.660	0.783	0.993	1.243	1.310	1.171	0.000	0.000	0.557
2014	0.191	0.352	0.525	0.619	0.752	1.099	1.383	1.823	3.108	2.635	3.156	0.534
2015	0.177	0.312	0.525	0.627	0.712	0.866	0.980	0.887	0.916	0.913	1.133	0.521
2016	0.090	0.315	0.550	0.615	0.710	0.695	0.852	0.947	2.162	0.830	1.491	0.553
2017	0.096	0.384	0.573	0.660	0.570	0.712	0.741	0.851	0.821	0.691	0.871	0.595

Table A20. Estimated landings of summer flounder in numbers (000s) and weight (metric tons; mt) in the recreational fishery as estimated by the Calibrated Marine Recreational Information Program 1982-2017. PSE = Proportional Standard Error. 'New' MRFSS/MRIP.

Year	Landings (000s)	Landings (000s) PSE	Landings (mt)	Landings (mt) PSE
1982	19,294	10%	10,758	8%
1983	25,780	8%	16,665	9%
1984	23,449	8%	12,803	9%
1985	21,389	11%	11,405	13%
1986	16,384	21%	12,005	18%
1987	11,926	16%	10,638	18%
1988	14,822	8%	9,429	14%
1989	3,103	7%	2,566	8%
1990	6,074	7%	3,517	8%
1991	9,834	8%	5,854	8%
1992	8,787	9%	5,746	8%
1993	9,801	6%	6,228	6%
1994	9,823	6%	6,481	6%
1995	5,473	5%	4,090	5%
1996	10,184	7%	6,813	7%
1997	11,037	6%	8,403	6%
1998	12,371	6%	10,368	6%
1999	8,096	5%	7,573	5%
2000	13,045	6%	12,259	6%
2001	8,029	5%	8,417	6%
2002	6,505	5%	7,388	5%
2003	8,209	5%	9,746	5%
2004	8,158	5%	9,616	6%
2005	7,044	6%	8,412	7%
2006	6,947	8%	8,452	8%
2007	4,850	8%	6,300	9%
2008	3,781	7%	5,597	7%
2009	3,645	10%	5,288	9%
2010	3,512	7%	5,142	8%
2011	4,327	8%	6,116	8%
2012	5,737	8%	7,318	8%
2013	6,601	8%	8,806	8%
2014	5,365	9%	7,364	10%
2015	4,034	8%	5,366	10%
2016	4,302	7%	6,005	8%
2017	3,167	10%	4,565	11%

Table A21. Estimated landings of summer flounder in numbers (000s) and weight (metric tons; mt) in the recreational fishery as estimated by the Calibrated Marine Recreational Information Program ('New' MRIP 1982-2017) and the change in absolute numbers and in percent from 'Old' MRFSS/MRIP estimates.

Year	New MRIP Landings (000s)	New MRIP Landings (mt)	Change from Old Landings (000s)	Change from Old Landings (mt)	Percent Change Landings (000s)	Percent Change Landings (mt)
1982	19,294	10,758	3,821	2,491	25%	30%
1983	25,780	16,665	4,784	3,978	23%	31%
1984	23,449	12,803	5,974	4,291	34%	50%
1985	21,389	11,405	10,323	5,740	93%	101%
1986	16,384	12,005	4,763	3,903	41%	48%
1987	11,926	10,638	4,061	5,119	52%	93%
1988	14,822	9,429	4,862	2,795	49%	42%
1989	3,103	2,566	1,386	1,131	81%	79%
1990	6,074	3,517	2,280	1,188	60%	51%
1991	9,834	5,854	3,766	2,243	62%	62%
1992	8,787	5,746	3,785	2,504	76%	77%
1993	9,801	6,228	3,307	2,222	51%	55%
1994	9,823	6,481	3,120	2,250	47%	53%
1995	5,473	4,090	2,147	1,631	65%	66%
1996	10,184	6,813	3,187	2,359	46%	53%
1997	11,037	8,403	3,870	3,021	54%	56%
1998	12,371	10,368	5,392	4,709	77%	83%
1999	8,096	7,573	3,989	3,778	97%	100%
2000	13,045	12,259	5,244	4,789	67%	64%
2001	8,029	8,417	2,735	3,138	52%	59%
2002	6,505	7,388	3,243	3,756	99%	103%
2003	8,209	9,746	3,650	4,467	80%	85%
2004	8,158	9,616	3,842	4,642	89%	93%
2005	7,044	8,412	3,016	3,483	75%	71%
2006	6,947	8,452	2,996	3,648	76%	76%
2007	4,850	6,300	1,741	2,101	56%	50%
2008	3,781	5,597	1,431	1,908	61%	52%
2009	3,645	5,288	1,838	2,572	102%	95%
2010	3,512	5,142	2,010	2,825	134%	122%
2011	4,327	6,116	2,497	3,471	136%	131%
2012	5,737	7,318	3,538	4,465	161%	157%
2013	6,601	8,806	4,067	5,455	160%	163%
2014	5,365	7,364	2,906	4,008	118%	119%
2015	4,034	5,366	2,357	3,157	141%	143%
2016	4,302	6,005	2,274	3,201	112%	114%
2017	3,167	4,565	2,138	3,118	208%	215%
average	9,302	7,875	3,509	3,321	61%	73%

Table A22. Recreational fishery sampling intensity of summer flounder landings in metric tons (mt) by subregion. Includes both Marine Recreational Fisheries Statistics Survey and Marine Recreational Information Program and State agency lengths. 'New' MRIP.

Year	Landings (mt)	Number Measured	mt/100 Lengths
1982	10,758	3,703	291
1983	16,665	5,193	321
1984	12,803	2,646	484
1985	11,405	2,286	499
1986	12,005	2,362	508
1987	10,638	2,559	416
1988	9,429	3,918	241
1989	2,566	2,047	125
1990	3,517	4,070	86
1991	5,854	5,657	103
1992	5,746	5,495	105
1993	6,228	5,507	113
1994	6,481	5,922	109
1995	4,090	2,456	167
1996	6,813	5,480	124
1997	8,403	4,800	175
1998	10,368	5,321	195
1999	7,573	2,590	292
2000	12,259	3,321	369
2001	8,417	4,247	198
2002	7,388	3,657	202
2003	9,746	3,656	267
2004	9,616	4,310	223
2005	8,412	2,814	299
2006	8,452	2,691	314
2007	6,300	3,363	187
2008	5,597	1,993	281
2009	5,288	2,331	227
2010	5,142	1,746	294
2011	6,116	2,202	278
2012	7,318	2,001	366
2013	8,806	2,735	322
2014	7,364	2,416	305
2015	5,366	2,701	199
2016	6,005	2,388	251
2017	4,565	1,807	253

Table A23. Estimated recreational landings at age of summer flounder (000s): 'New' MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	2684	11358	4424	571	203	27	15	8	4	0	0	19,294
1983	2757	14445	6198	1733	408	137	73	14	5	8	2	25,780
1984	1343	14208	6573	1092	215	9	0	9	0	0	0	23,449
1985	1981	9108	9000	856	263	156	6	0	19	0	0	21,389
1986	1386	8926	4260	1548	140	70	50	0	4	0	0	16,384
1987	500	6147	4023	753	475	12	8	8	0	0	0	11,926
1988	322	7715	5982	709	64	16	7	0	7	0	0	14,822
1989	101	893	1729	325	42	7	2	3	1	0	0	3,103
1990	471	4431	668	442	53	8	1	0	0	0	0	6,074
1991	274	5745	3679	75	56	5	0	0	0	0	0	9,834
1992	214	4679	3674	167	30	22	1	0	0	0	0	8,787
1993	144	5625	3810	190	16	9	3	3	1	0	0	9,801
1994	907	6031	2757	109	19	0	0	0	0	0	0	9,823
1995	69	2836	2426	119	8	0	0	1	0	0	14	5,473
1996	29	3957	5530	527	132	9	0	0	0	0	0	10,184
1997	20	1713	6498	2421	333	33	12	7	0	0	0	11,037
1998	1	925	5651	4850	838	100	6	0	0	0	0	12,371
1999	8	366	3506	3319	772	103	22	0	0	0	0	8,096
2000	6	906	7494	3792	627	188	18	6	8	0	0	13,045
2001	0	935	3382	2949	525	171	38	19	5	3	2	8,029
2002	2	373	2763	2421	738	134	62	7	4	1	0	6,505
2003	0	313	3184	2997	1101	378	154	62	9	10	1	8,209
2004	9	285	3063	3042	1135	342	187	75	15	4	1	8,158
2005	5	187	1124	2405	1695	865	399	199	100	46	19	7,044
2006	10	151	2544	2271	1170	473	241	62	17	7	1	6,947
2007	4	106	803	2359	928	409	162	50	15	9	5	4,850
2008	1	47	178	686	1371	872	365	134	92	23	12	3,781
2009	3	58	232	848	1218	867	260	106	43	9	1	3,645

Table A23 continued. Estimated recreational landings at age of summer flounder (000s): 'New' MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
2010	1	43	140	550	1332	881	359	111	56	24	15	3,512
2011	3	18	98	662	1680	1216	401	167	50	16	16	4,327
2012	4	24	432	1532	1991	1008	450	216	52	24	4	5,737
2013	6	30	267	1708	2797	1120	392	157	69	25	30	6,601
2014	2	88	583	1071	1844	1234	322	102	36	22	61	5,365
2015	1	31	535	1082	954	753	427	129	62	19	41	4,034
2016	4	58	1002	1265	911	437	316	190	75	21	23	4,302
2017	0	36	353	1030	758	453	198	164	96	46	33	3,167

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

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	0.214	0.406	0.629	1.441	1.883	2.564	2.091	3.033	3.100	0.000	0.000	0.483
1983	0.197	0.364	0.610	0.923	1.242	1.440	1.933	2.343	2.944	3.010	4.157	0.470
1984	0.168	0.343	0.588	0.999	1.316	2.319	0.000	3.752	0.000	0.000	0.000	0.443
1985	0.244	0.405	0.614	1.074	1.687	1.786	1.132	0.000	3.680	0.000	0.000	0.534
1986	0.172	0.436	0.690	1.285	1.875	1.953	3.074	0.000	4.163	0.000	0.000	0.588
1987	0.234	0.382	0.688	1.240	1.699	2.737	4.166	2.950	0.000	0.000	0.000	0.592
1988	0.235	0.464	0.667	1.133	1.821	3.071	3.268	0.000	4.780	0.000	0.000	0.585
1989	0.217	0.453	0.756	1.170	1.796	1.674	1.576	2.106	1.893	0.000	0.000	0.713
1990	0.268	0.459	0.862	1.223	1.833	1.676	3.436	0.000	0.000	0.000	0.000	0.558
1991	0.245	0.419	0.723	1.458	1.721	2.907	0.000	0.000	0.000	0.000	0.000	0.544
1992	0.218	0.464	0.718	1.559	2.511	2.875	3.106	0.000	0.000	0.000	0.000	0.598
1993	0.301	0.508	0.720	1.775	2.276	1.701	3.112	4.390	3.609	0.000	0.000	0.618
1994	0.408	0.583	0.688	1.433	1.761	0.000	0.000	0.000	0.000	0.000	0.000	0.608
1995	0.261	0.543	0.829	1.588	3.106	0.000	0.000	4.364	0.000	0.000	1.134	0.695
1996	0.373	0.490	0.631	1.225	1.791	2.545	0.000	0.000	0.000	0.000	0.000	0.623
1997	0.222	0.491	0.668	0.910	1.194	2.192	2.150	2.373	0.000	0.000	0.000	0.716
1998	0.238	0.498	0.654	0.821	1.307	2.224	2.672	0.000	0.000	0.000	0.000	0.766
1999	0.134	0.525	0.692	0.926	1.357	2.001	2.745	0.000	0.000	0.000	0.000	0.865
2000	0.201	0.540	0.753	1.002	1.575	2.254	2.679	3.305	3.874	0.000	0.000	0.877
2001	0.000	0.598	0.846	1.066	1.672	2.456	2.380	3.238	3.447	3.723	4.780	1.003
2002	0.238	0.500	0.891	1.109	1.538	2.215	2.761	3.257	3.268	1.677	0.000	1.072
2003	0.000	0.614	0.895	1.117	1.554	1.964	2.311	2.378	2.893	3.326	4.780	1.146
2004	0.238	0.569	0.839	1.043	1.431	1.944	2.332	2.516	3.374	3.603	4.601	1.090
2005	0.267	0.506	0.797	0.997	1.156	1.544	1.827	2.009	2.104	2.764	3.254	1.166
2006	0.133	0.595	0.854	1.092	1.377	1.766	2.199	2.404	3.255	4.286	2.811	1.145
2007	0.168	0.487	0.817	1.132	1.456	1.786	2.142	2.521	2.264	3.156	3.281	1.240
2008	0.238	0.451	0.708	1.150	1.396	1.682	2.005	2.110	2.602	2.792	2.989	1.500
2009	0.206	0.438	0.797	1.064	1.254	1.647	2.090	2.479	2.586	3.133	3.678	1.377

Table A24 continued. Mean weight (kg) at age of summer flounder landings in the recreational fishery: 'New' MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
2010	0.265	0.453	0.563	0.974	1.235	1.490	1.860	2.169	2.428	2.426	2.777	1.349
2011	0.163	0.434	0.624	0.970	1.179	1.538	1.864	2.011	2.193	2.669	2.123	1.348
2012	0.326	0.461	0.878	0.962	1.179	1.524	1.712	1.820	2.512	2.789	3.538	1.242
2013	0.178	0.311	0.740	0.949	1.199	1.620	1.940	1.946	2.310	2.611	1.952	1.264
2014	0.224	0.503	0.774	1.006	1.209	1.519	1.877	2.186	2.625	1.844	1.993	1.260
2015	0.213	0.527	0.880	1.035	1.191	1.424	1.566	1.892	1.645	2.106	1.738	1.225
2016	0.062	0.587	0.876	1.035	1.288	1.478	1.540	1.561	1.523	1.876	1.919	1.167
2017	0.000	0.588	0.987	1.154	1.430	1.553	1.631	1.810	1.665	1.771	2.009	1.349

Table A25. Estimated dead discards of summer flounder in numbers (000s) and weight (metric tons; mt) in the recreational fishery as estimated by the Calibrated Marine Recreational Information Program (MRIP 2004-2017). PSE = Proportion Standard Error. 'New' MRIP.

Year	Dead Discards (000s)	Dead Discards (mt)	Dead Discards (00s) PSE
1982	677	250	12%
1983	1,057	356	13%
1984	1,637	537	10%
1985	489	184	13%
1986	1,613	646	17%
1987	1,801	668	8%
1988	1,063	483	9%
1989	196	84	9%
1990	940	414	12%
1991	1,500	617	9%
1992	1,232	559	8%
1993	2,638	703	7%
1994	1,628	409	7%
1995	2,236	589	6%
1996	1,956	624	7%
1997	2,083	663	7%
1998	2,671	997	5%
1999	3,478	1078	5%
2000	3,021	1182	6%
2001	3,565	1897	5%
2002	2,798	1564	5%
2003	2,800	1867	5%
2004	2,979	1833	5%
2005	3,894	1711	6%
2006	3,096	1583	7%
2007	3,041	1801	8%
2008	3,570	1970	7%
2009	4,698	2484	6%
2010	5,538	2710	6%
2011	5,172	2711	7%
2012	3,897	2172	7%
2013	3,836	2119	12%
2014	3,921	2092	8%
2015	3,011	1572	8%
2016	2,694	1482	8%
2017	2,487	1496	8%

Table A26. Estimated dead discards of summer flounder in numbers (000s) and weight (metric tons; mt) in the recreational fishery as estimated by the Calibrated Marine Recreational Information Program ('New' MRIP 1982-2017) and the change in absolute numbers and in percent from 'Old' MRFSS/MRIP estimates.

Year	New MRIP Dead Discards (000s)	New MRIP Dead Discards (mt)	Change from Old Dead Discards (000s)	Change from Old Dead Discards (mt)	Percent Change Dead Discards (000s)	Percent Change Dead Discards (mt)
1982	677	250	-131	-46	-16%	-15%
1983	1,057	356	-50	-20	-5%	-5%
1984	1,637	537	407	122	33%	29%
1985	489	184	243	92	99%	100%
1986	1,613	646	246	68	18%	12%
1987	1,801	668	485	146	37%	28%
1988	1,063	483	343	142	48%	42%
1989	196	84	100	39	104%	87%
1990	940	414	410	180	77%	77%
1991	1,500	617	499	188	50%	44%
1992	1,232	559	541	215	78%	62%
1993	2,638	703	864	-207	49%	-23%
1994	1,628	409	395	-278	32%	-41%
1995	2,236	589	879	-164	65%	-22%
1996	1,956	624	657	-57	51%	-8%
1997	2,083	663	694	107	50%	19%
1998	2,671	997	975	263	58%	36%
1999	3,478	1,078	1,695	367	95%	52%
2000	3,021	1,182	1,157	230	62%	24%
2001	3,565	1,897	1,160	623	48%	49%
2002	2,798	1,564	1,391	787	99%	101%
2003	2,800	1,867	1,159	985	71%	112%
2004	2,979	1,833	1,278	799	75%	77%
2005	3,894	1,711	1,580	712	68%	71%
2006	3,096	1,583	1,342	788	76%	99%
2007	3,041	1,801	1,013	671	50%	59%
2008	3,570	1,970	1,308	719	58%	57%
2009	4,698	2,484	2,323	1,289	98%	108%
2010	5,538	2,710	3,295	1,631	147%	151%
2011	5,172	2,711	3,134	1,618	154%	148%
2012	3,897	2,172	2,451	1,357	169%	167%
2013	3,836	2,119	2,503	1,361	188%	180%
2014	3,921	2,092	2,177	1,160	125%	124%
2015	3,011	1,572	1,930	1,009	179%	179%
2016	2,694	1,482	1,480	811	122%	121%
2017	2,487	1,496	1,745	1,054	235%	239%
average	2,581	1,225	1,158	521	81%	74%

Table A27. Recreational fishery sampling intensity for summer flounder discards: 'New' MRIP.

Year	Discard Mortality (mt)	Number Measured	mt/100 Lengths
1982	250		
1983	356		
1984	537		
1985	184		
1986	646		
1987	668		
1988	483		
1989	84		
1990	414		
1991	617		
1992	559		
1993	703	4,889	14
1994	409	4,140	10
1995	589	2,574	23
1996	624	3,022	21
1997	663	2,689	25
1998	997	4,098	24
1999	1,078	4,117	26
2000	1,182	9,957	12
2001	1,897	8,239	23
2002	1,564	7,030	22
2003	1,867	6,255	30
2004	1,833	4,357	42
2005	1,711	7,949	22
2006	1,583	10,276	15
2007	1,801	8,740	21
2008	1,970	9,857	20
2009	2,484	17,741	14
2010	2,710	13,723	20
2011	2,711	11,533	24
2012	2,172	7,002	31
2013	2,119	7,224	29
2014	2,092	6,363	33
2015	1,572	7,493	21
2016	1,482	5,301	28
2017	1,496	5,516	27

Table A28. Estimated recreational fishery discards at age of summer flounder (000s). 'New' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	129	548	0	0	0	0	0	0	0	0	0	677
1983	169	888	0	0	0	0	0	0	0	0	0	1057
1984	141	1496	0	0	0	0	0	0	0	0	0	1637
1985	87	402	0	0	0	0	0	0	0	0	0	489
1986	217	1397	0	0	0	0	0	0	0	0	0	1613
1987	135	1666	0	0	0	0	0	0	0	0	0	1801
1988	43	1020	0	0	0	0	0	0	0	0	0	1063
1989	20	176	0	0	0	0	0	0	0	0	0	196
1990	90	850	0	0	0	0	0	0	0	0	0	940
1991	68	1432	0	0	0	0	0	0	0	0	0	1500
1992	54	1179	0	0	0	0	0	0	0	0	0	1232
1993	830	1560	248	0	0	0	0	0	0	0	0	2638
1994	832	533	263	0	0	0	0	0	0	0	0	1628
1995	779	1328	129	0	0	0	0	0	0	0	0	2236
1996	111	1437	408	0	0	0	0	0	0	0	0	1956
1997	334	1189	539	21	0	0	0	0	0	0	0	2083
1998	14	1401	1160	96	0	0	0	0	0	0	0	2671
1999	464	1687	1202	125	0	0	0	0	0	0	0	3478
2000	147	1560	1276	38	0	0	0	0	0	0	0	3021
2001	0	1639	1597	329	0	0	0	0	0	0	0	3565
2002	134	1113	1207	316	26	1	1	0	0	0	0	2798
2003	0	123	1840	837	0	0	0	0	0	0	0	2800
2004	147	837	1433	521	28	8	4	1	0	0	0	2979
2005	316	1747	1256	472	84	12	1	3	1	1	1	3894
2006	212	989	1436	389	56	10	2	1	1	0	0	3096
2007	115	909	938	943	111	13	8	2	1	1	0	3041
2008	210	1259	967	627	404	74	17	6	4	1	1	3570
2009	443	1536	1331	929	344	90	16	5	2	1	1	4698

Table A28 continued. Estimated recreational fishery discards at age of summer flounder (000s). 'New' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
2010	6	1547	1837	1309	649	156	23	4	4	2	1	5538
2011	1	733	1290	1935	994	196	13	7	2	1	1	5172
2012	276	439	1111	1464	529	52	15	7	2	1	1	3897
2013	179	607	1016	1316	671	37	7	1	2	0	0	3836
2014	284	1062	1173	726	512	118	29	9	2	2	4	3921
2015	149	804	919	594	300	132	61	34	11	4	3	3011
2016	42	613	924	645	232	113	67	36	16	4	2	2694
2017	26	303	686	679	460	125	77	51	39	28	13	2487

Table A29. Mean weight (kg) at age of summer flounder discards in the recreational fishery: 'New' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
1982	0.214	0.406	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.369
1983	0.197	0.364	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.337
1984	0.168	0.343	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.328
1985	0.244	0.405	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.376
1986	0.172	0.436	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.401
1987	0.234	0.382	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.371
1988	0.235	0.464	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.455
1989	0.217	0.453	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.429
1990	0.268	0.459	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.441
1991	0.245	0.419	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.411
1992	0.218	0.464	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.453
1993	0.202	0.287	0.353	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.266
1994	0.205	0.295	0.307	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.251
1995	0.196	0.293	0.363	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.263
1996	0.212	0.311	0.376	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.319
1997	0.206	0.320	0.381	0.415	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.318
1998	0.238	0.332	0.417	0.465	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.373
1999	0.134	0.269	0.419	0.467	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.310
2000	0.200	0.351	0.459	0.515	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.391
2001	0.000	0.447	0.583	0.709	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.532
2002	0.209	0.419	0.666	0.763	0.813	1.773	1.893	0.000	0.000	0.000	0.000	0.559
2003	0.000	0.349	0.670	0.707	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.667
2004	0.227	0.435	0.682	0.764	1.126	2.167	2.268	2.271	0.000	0.000	0.000	0.615
2005	0.223	0.330	0.524	0.650	0.823	1.353	1.896	1.561	1.792	1.920	3.080	0.439
2006	0.135	0.346	0.582	0.767	0.949	1.278	2.390	3.236	3.762	0.000	0.000	0.511
2007	0.173	0.340	0.610	0.794	0.965	1.446	1.720	2.900	3.149	2.597	0.000	0.592
2008	0.184	0.346	0.552	0.736	0.888	1.154	1.621	2.287	2.486	3.316	2.030	0.552
2009	0.165	0.319	0.542	0.751	0.959	1.277	1.929	2.749	2.997	3.048	3.268	0.529

Table A29 continued. Mean weight (kg) at age of summer flounder discards in the recreational fishery: 'New' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
2010	0.031	0.221	0.426	0.645	0.804	1.020	1.357	2.058	3.146	2.783	2.356	0.489
2011	0.100	0.195	0.379	0.560	0.765	0.983	1.561	1.848	1.872	2.572	2.655	0.524
2012	0.204	0.335	0.485	0.620	0.768	1.237	1.635	1.902	3.175	3.155	4.237	0.557
2013	0.179	0.282	0.472	0.655	0.782	1.001	1.231	1.287	1.173	0.000	0.000	0.552
2014	0.188	0.352	0.527	0.622	0.750	1.101	1.381	1.821	3.118	2.612	3.329	0.534
2015	0.180	0.313	0.522	0.624	0.713	0.884	1.028	0.927	0.963	0.970	1.196	0.522
2016	0.084	0.310	0.549	0.616	0.720	0.708	0.882	0.993	2.230	0.817	1.479	0.550
2017	0.096	0.405	0.576	0.660	0.556	0.716	0.754	0.909	0.864	0.692	1.921	0.602

Table A30. Total catch at age of summer flounder (000s), Maine-North Carolina. Includes ‘Old’ MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
1982	5816	19734	8426	1339	485	100	73	41	23	5	7	36047	74
1983	3887	25242	11540	2938	1377	612	89	69	13	24	20	45810	126
1984	4622	27200	14646	3032	1144	129	4	7	3	16	0	50804	26
1985	2052	13408	18573	1569	534	467	31	16	3	1	0	36656	20
1986	2422	16220	10833	3532	318	135	74	6	2	0	0	33542	8
1987	1016	16713	10876	1673	465	25	20	17	4	0	1	30810	22
1988	1562	19037	13756	2148	517	76	8	10	3	0	0	37117	13
1989	1078	3364	8857	2094	371	59	11	5	3	0	0	15842	8
1990	1458	9007	2263	989	209	35	12	4	1	0	0	13978	5
1991	449	9347	7254	755	212	28	4	1	0	0	0	18050	1
1992	3023	16090	6526	1154	153	70	6	1	0	0	0	27024	1
1993	862	12716	5859	570	78	34	29	3	2	0	0	20154	5
1994	1931	12788	7895	975	215	27	12	1	5	0	0	23848	6
1995	2107	5978	7664	1282	406	77	5	1	0	0	0	17519	1
1996	282	7955	9869	2083	516	98	17	3	5	1	0	20829	9
1997	66	2704	8479	3287	581	167	14	5	0	1	0	15303	6
1998	102	2338	6675	5376	993	153	72	7	0	0	0	15717	7
1999	193	2269	6403	4224	1223	349	54	11	0	0	0	14727	11
2000	20	1688	8759	4946	1546	374	69	14	5	1	1	17424	21
2001	39	3146	4705	3542	1263	377	133	34	5	3	2	13251	44
2002	179	1974	5791	3873	1351	322	140	21	5	1	0	13656	27
2003	56	2109	5395	4234	1607	582	254	77	29	3	2	14348	110
2004	130	1256	6380	4943	2050	863	359	127	47	14	5	16172	192
2005	276	2124	4295	4580	2400	1155	554	282	194	73	39	15971	587
2006	164	1140	5812	3522	1924	931	430	147	70	10	5	14155	233
2007	125	1073	2388	4892	1897	815	389	155	83	16	14	11848	268
2008	159	1173	1509	1989	2732	1151	519	222	220	22	10	9705	475
2009	236	1299	2123	2665	2252	1458	473	190	99	30	11	10836	330

Table A30 continued. Total catch at age of summer flounder (000s), Maine-North Carolina. Includes 'Old' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
2010	161	1400	2217	2949	2673	1242	619	215	107	57	21	11660	400
2011	112	720	2054	3432	3338	1670	634	366	146	61	38	12572	611
2012	140	292	1580	3364	2603	1215	564	307	141	50	21	10277	519
2013	77	327	1207	3011	3267	1191	499	211	87	44	47	9970	390
2014	136	705	1693	2230	2772	1575	444	179	63	52	73	9923	367
2015	76	571	1633	2161	1625	1230	822	265	139	36	71	8628	510
2016	45	387	1835	2122	1352	716	572	401	134	47	53	7663	634
2017	39	237	797	1485	1181	621	337	253	202	99	61	5311	616

Table A31. Mean weight (kg) at age of summer flounder catch, Maine-North Carolina. Includes ‘Old’ MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
1982	0.234	0.406	0.642	1.278	1.771	2.188	2.614	3.300	3.548	3.283	4.501	0.500	3.485
1983	0.219	0.383	0.649	0.999	1.280	1.554	2.184	2.220	2.995	3.243	4.310	0.529	2.828
1984	0.246	0.398	0.625	1.048	1.520	2.243	3.501	3.733	4.853	4.242	0.000	0.521	4.189
1985	0.276	0.417	0.599	1.093	1.783	2.198	2.672	4.572	4.777	5.195	0.000	0.577	4.641
1986	0.241	0.459	0.654	1.160	1.792	2.119	3.094	3.164	4.216	0.000	0.000	0.606	3.425
1987	0.264	0.443	0.639	1.106	1.901	2.836	3.513	2.570	4.477	0.000	5.307	0.570	3.064
1988	0.234	0.470	0.621	1.047	1.558	2.190	3.924	3.473	4.559	0.000	0.000	0.570	3.726
1989	0.133	0.416	0.631	0.971	1.457	2.197	2.350	3.010	2.271	0.000	0.000	0.624	2.733
1990	0.214	0.387	0.826	1.175	1.535	2.455	3.338	3.926	4.935	0.000	0.000	0.522	4.128
1991	0.166	0.441	0.694	1.192	1.843	2.485	3.241	4.184	0.000	0.000	0.000	0.588	4.184
1992	0.182	0.398	0.674	1.140	1.382	2.589	3.252	4.704	0.000	0.000	0.000	0.484	4.704
1993	0.194	0.473	0.689	1.503	1.717	1.980	2.877	4.079	4.937	0.000	0.000	0.565	4.422
1994	0.315	0.472	0.593	1.333	2.096	2.845	3.391	4.123	3.791	0.000	0.000	0.554	3.846
1995	0.226	0.514	0.669	1.070	1.662	2.584	3.875	4.427	0.000	0.000	0.000	0.625	4.427
1996	0.265	0.466	0.550	1.032	1.559	2.178	2.585	4.575	4.324	4.510	0.000	0.598	4.429
1997	0.204	0.451	0.633	0.859	1.308	2.275	2.761	3.267	0.000	4.853	0.000	0.694	3.531
1998	0.220	0.520	0.639	0.839	1.312	2.355	2.418	3.596	0.000	0.000	0.000	0.756	3.596
1999	0.155	0.340	0.582	0.880	1.438	1.966	2.797	3.562	0.000	0.000	0.000	0.739	3.562
2000	0.119	0.566	0.786	1.082	1.814	2.741	2.833	3.166	3.962	3.368	3.814	0.992	3.388
2001	0.134	0.533	0.764	0.972	1.477	2.204	2.654	3.555	3.807	4.489	5.345	0.901	3.724
2002	0.191	0.433	0.717	0.961	1.388	2.102	2.768	3.696	4.488	2.983	0.000	0.864	3.812
2003	0.171	0.472	0.740	1.029	1.540	2.094	2.814	3.235	3.794	3.542	5.122	0.986	3.419
2004	0.307	0.486	0.713	0.967	1.361	1.778	2.399	2.975	3.451	3.915	3.236	0.975	3.164
2005	0.206	0.423	0.671	0.919	1.188	1.522	1.932	2.230	2.457	3.279	3.175	0.951	2.497
2006	0.156	0.447	0.662	0.959	1.271	1.667	2.239	2.946	3.440	3.998	3.517	0.951	3.153
2007	0.167	0.392	0.680	0.939	1.284	1.736	2.226	2.542	3.176	3.396	3.697	1.025	2.851
2008	0.180	0.372	0.594	0.872	1.163	1.559	1.924	2.232	2.684	3.304	3.366	1.057	2.516
2009	0.167	0.349	0.581	0.835	1.084	1.503	1.951	2.551	2.767	3.612	4.000	0.961	2.760

Table A31 continued. Mean weight (kg) at age of summer flounder catch, Maine-North Carolina. Includes 'Old' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
2010	0.169	0.316	0.503	0.757	1.049	1.396	1.892	2.330	2.854	3.301	3.395	0.908	2.664
2011	0.182	0.327	0.495	0.678	0.999	1.500	1.874	2.214	2.665	3.010	3.503	0.966	2.481
2012	0.192	0.375	0.595	0.748	1.020	1.470	1.837	1.978	2.585	3.027	3.940	1.000	2.324
2013	0.170	0.327	0.556	0.776	1.020	1.444	1.953	2.138	2.523	2.840	3.175	1.013	2.430
2014	0.192	0.368	0.610	0.813	1.041	1.405	1.781	2.243	2.628	2.640	2.805	1.001	2.477
2015	0.178	0.373	0.619	0.784	0.977	1.270	1.440	1.636	1.754	2.414	2.782	0.953	1.881
2016	0.085	0.348	0.683	0.824	1.093	1.346	1.483	1.571	1.915	2.199	2.603	0.986	1.776
2017	0.117	0.422	0.672	0.866	1.022	1.265	1.423	1.668	1.567	1.443	1.956	1.016	1.628

Table A32. Total catch at age of summer flounder (000s), Maine-North Carolina. Includes 'New' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
1982	5708	22559	9352	1349	473	126	85	49	27	5	7	39738	86
1983	4336	28030	12760	3331	1257	529	162	67	18	32	22	50544	139
1984	3615	32685	16388	3112	1212	134	3	16	3	16	0	57185	35
1985	3079	17710	23191	1952	649	564	37	16	22	1	0	47222	39
1986	2705	18921	12308	3991	329	190	96	6	6	0	0	38552	12
1987	1079	18639	12814	1977	758	36	23	25	4	0	1	35356	30
1988	1443	21365	16427	2470	493	89	15	10	10	0	0	42322	20
1989	1111	3812	9640	2284	397	64	8	8	4	0	0	17328	12
1990	1607	11048	2402	1313	239	42	13	4	1	0	0	16668	5
1991	681	11935	8682	751	228	32	4	1	0	0	0	22315	1
1992	3192	18091	8580	1231	182	66	7	1	0	0	0	31350	1
1993	1723	14231	7594	601	93	41	32	6	3	0	0	24325	9
1994	2664	14337	9217	900	206	26	8	1	5	0	0	27363	6
1995	2535	7464	8793	1285	388	61	4	2	0	0	14	20545	16
1996	256	9165	12339	2256	525	106	17	3	5	1	0	24673	9
1997	392	3638	10806	4241	640	112	26	12	0	1	0	19867	13
1998	117	3211	9696	7472	1316	190	74	7	0	0	0	22084	7
1999	581	3534	8142	6023	1670	392	57	11	0	0	0	20411	11
2000	173	2989	12311	6312	1530	392	82	20	13	1	1	23825	35
2001	39	3621	6821	4800	1232	427	135	49	10	6	4	17146	69
2002	239	2701	7865	5216	1686	365	183	27	7	2	0	18290	36
2003	7	1523	8146	6123	2046	789	346	123	38	13	3	19157	176
2004	177	1657	8528	6479	2525	993	430	178	62	18	6	21051	263
2005	340	2721	4739	5758	3416	1794	855	424	260	120	59	20485	862
2006	227	1656	7493	4718	2408	1095	538	170	64	17	6	18392	258
2007	141	1351	2878	6100	2157	944	456	174	71	26	19	14318	290
2008	229	1647	1948	2467	3407	1532	678	282	166	44	23	12422	516
2009	463	1976	2952	3535	2991	1945	617	246	122	35	12	14894	415

Table A32 continued. Total catch at age of summer flounder (000s), Maine-North Carolina. Includes 'New' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
2010	18	2168	3551	4127	3885	1868	841	281	143	72	30	16983	526
2011	750	1538	3482	4239	4287	2338	867	461	173	69	46	18251	749
2012	318	582	2554	5243	4154	1865	843	442	175	65	25	16267	707
2013	195	749	2049	4948	5471	1921	751	312	132	60	65	16655	570
2014	300	1361	2667	3206	4043	2301	635	238	83	65	109	15008	495
2015	170	1108	2552	3179	2369	1747	1104	360	181	50	96	12915	686
2016	76	777	2915	3158	1932	988	751	514	182	63	62	11417	820
2017	59	485	1530	2654	2008	1004	519	398	294	150	94	9194	937

Table A33. Mean weight (kg) at age of summer flounder catch, Maine-North Carolina. Includes ‘New’ MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
1982	0.229	0.407	0.663	1.327	1.785	2.271	2.509	3.256	3.481	3.283	4.501	0.506	3.425
1983	0.229	0.379	0.637	0.989	1.304	1.590	2.071	2.779	2.981	3.185	4.296	0.520	3.139
1984	0.242	0.382	0.612	1.057	1.453	2.250	3.298	3.744	4.853	4.242	0.000	0.505	4.077
1985	0.266	0.416	0.600	1.083	1.752	2.059	2.424	4.572	3.848	5.195	0.000	0.567	4.178
1986	0.208	0.451	0.645	1.173	1.847	2.010	2.970	3.164	4.181	0.000	0.000	0.598	3.669
1987	0.264	0.427	0.634	1.104	1.789	2.797	3.457	2.693	4.477	0.000	5.307	0.571	3.033
1988	0.214	0.462	0.621	1.061	1.527	2.345	3.625	3.473	4.712	0.000	0.000	0.569	4.089
1989	0.132	0.411	0.636	0.984	1.479	2.104	2.640	2.671	2.177	0.000	0.000	0.627	2.506
1990	0.210	0.400	0.805	1.168	1.588	2.296	3.346	3.926	4.935	0.000	0.000	0.526	4.128
1991	0.188	0.431	0.712	1.207	1.896	2.552	3.241	4.184	0.000	0.000	0.000	0.578	4.184
1992	0.183	0.396	0.685	1.162	1.563	2.389	3.231	4.704	0.000	0.000	0.000	0.495	4.704
1993	0.204	0.449	0.685	1.492	1.805	1.867	2.899	4.235	4.494	0.000	0.000	0.543	4.321
1994	0.266	0.473	0.594	1.323	2.089	2.846	3.137	4.123	3.791	0.000	0.000	0.538	3.846
1995	0.185	0.464	0.685	1.083	1.629	2.493	3.959	4.396	0.000	0.000	1.134	0.592	1.542
1996	0.203	0.422	0.560	1.029	1.668	2.208	2.585	4.575	4.324	4.510	0.000	0.581	4.429
1997	0.205	0.428	0.636	0.871	1.315	2.170	2.479	2.746	0.000	4.853	0.000	0.674	2.908
1998	0.223	0.456	0.629	0.832	1.330	2.235	2.419	3.596	0.000	0.000	0.000	0.733	3.596
1999	0.142	0.309	0.594	0.889	1.379	1.919	2.841	3.562	0.000	0.000	0.000	0.716	3.562
2000	0.191	0.425	0.689	0.964	1.474	2.187	2.759	3.207	3.907	3.368	3.814	0.812	3.485
2001	0.134	0.512	0.754	1.003	1.543	2.337	2.674	3.418	3.627	4.093	5.063	0.894	3.600
2002	0.196	0.436	0.744	0.996	1.415	2.096	2.779	3.600	3.851	2.330	0.000	0.878	3.577
2003	0.185	0.486	0.757	1.006	1.533	2.048	2.591	2.872	3.578	3.373	5.000	1.006	3.093
2004	0.222	0.465	0.731	0.974	1.377	1.810	2.392	2.774	3.432	3.844	3.471	0.972	3.015
2005	0.221	0.387	0.631	0.878	1.115	1.500	1.837	2.104	2.344	3.070	3.199	0.942	2.385
2006	0.135	0.425	0.692	0.979	1.295	1.699	2.215	2.665	3.554	4.117	3.397	0.951	3.000
2007	0.170	0.387	0.692	0.952	1.289	1.735	2.205	2.476	2.875	3.282	3.588	1.016	2.720
2008	0.181	0.365	0.587	0.885	1.185	1.581	1.942	2.210	2.707	3.036	3.113	1.048	2.481
2009	0.165	0.343	0.577	0.843	1.106	1.524	1.976	2.538	2.737	3.534	3.943	0.944	2.721

Table A33 continued. Mean weight (kg) at age of summer flounder catch, Maine-North Carolina. Includes 'New' MRFSS/MRIP.

Year	0	1	2	3	4	5	6	7	8	9	10	Total	7+
2010	0.148	0.258	0.471	0.745	1.054	1.395	1.872	2.292	2.762	3.109	3.263	0.880	2.586
2011	0.005	0.154	0.366	0.811	1.184	1.596	1.881	2.192	2.602	2.962	3.311	0.943	2.427
2012	0.199	0.359	0.593	0.762	1.044	1.484	1.797	1.934	2.576	2.974	3.900	0.984	2.259
2013	0.177	0.302	0.543	0.791	1.058	1.503	1.943	2.071	2.449	2.798	2.802	1.005	2.319
2014	0.189	0.367	0.608	0.823	1.060	1.428	1.796	2.217	2.630	2.495	2.564	0.980	2.399
2015	0.180	0.348	0.630	0.815	1.005	1.288	1.451	1.641	1.701	2.249	2.490	0.936	1.820
2016	0.083	0.343	0.688	0.834	1.096	1.311	1.437	1.503	1.818	2.054	2.456	0.945	1.687
2017	0.110	0.428	0.695	0.905	1.048	1.299	1.404	1.635	1.516	1.398	2.000	1.013	1.597

Table A34. Commercial and recreational fishery landings, estimated commercial and recreational dead discard, and total catch statistics (in metric tons) for summer flounder, Maine to North Carolina. Includes 'Old' MRFSS/MRIP.

Year	Comm Landings	Comm Discard	Comm Catch	Recr Landings	Recr Discard	Recr Catch	Total Landings	Total Discard	Total 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	12,888	25,930	361	26,291
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	8,581	1,417	43	1,460	9,542	499	10,041
1990	4,199	898	5,097	2,300	225	2,525	6,499	1,122	7,621
1991	6,224	219	6,443	3,566	412	3,978	9,790	631	10,421
1992	7,529	2,151	9,680	3,201	332	3,533	10,730	2,483	13,213
1993	5,715	701	6,416	3,956	874	4,830	9,671	1,575	11,246
1994	6,588	1,539	8,127	4,178	660	4,838	10,766	2,199	12,965
1995	6,977	827	7,804	2,428	723	3,152	9,405	1,550	10,955
1996	5,861	1,436	7,297	4,398	656	5,054	10,259	2,092	12,351
1997	3,994	807	4,801	5,314	535	5,849	9,308	1,342	10,650
1998	5,076	638	5,714	5,588	705	6,293	10,664	1,343	12,007
1999	4,820	1,666	6,486	3,747	683	4,430	8,567	2,350	10,917
2000	5,085	1,620	6,705	7,376	915	8,291	12,461	2,535	14,996
2001	4,970	411	5,381	5,213	1,225	6,438	10,183	1,636	11,819
2002	6,573	948	7,521	3,586	746	4,332	10,159	1,694	11,853
2003	6,450	1,160	7,610	5,213	847	6,060	11,663	2,008	13,670
2004	7,880	1,628	9,508	4,974	1,013	5,987	12,854	2,641	15,495
2005	7,671	1,499	9,170	4,929	950	5,879	12,600	2,449	15,049
2006	6,316	1,518	7,834	4,804	768	5,572	11,120	2,286	13,406
2007	4,544	2,128	6,672	4,199	1,002	5,201	8,743	3,130	11,873
2008	4,179	1,162	5,341	3,689	1,154	4,843	7,868	2,316	10,184
2009	5,013	1,522	6,535	2,716	1,140	3,856	7,729	2,662	10,392

Table A34 continued. Commercial and recreational fishery landings, estimated commercial and recreational dead discard, and total catch statistics (in metric tons) for summer flounder, Maine to North Carolina. Includes 'Old' MRFSS/MRIP.

Year	Comm Landings	Comm Discard	Comm Catch	Recr Landings	Recr Discard	Recr Catch	Total Landings	Total Discard	Total Catch
2010	6,078	1,478	7,556	2,317	1,066	3,383	8,395	2,544	10,940
2011	7,517	1,143	8,660	2,645	1,093	3,738	10,162	2,236	12,399
2012	5,918	754	6,672	2,853	815	3,668	8,771	1,569	10,340
2013	5,696	863	6,559	3,351	758	4,109	9,047	1,621	10,668
2014	4,989	830	5,819	3,356	932	4,288	8,345	1,762	10,107
2015	4,858	703	5,561	2,209	563	2,772	7,067	1,266	8,333
2016	3,537	772	4,309	2,804	671	3,475	6,341	1,443	7,784
2017	2,644	906	3,550	1,447	442	1,889	4,091	1,348	5,439

Table A35. Commercial and recreational fishery landings, estimated commercial and recreational dead discard, and total catch statistics (in metric tons) for summer flounder, Maine to North Carolina. Includes 'New' MRFSS/MRIP.

Year	Comm Landings	Comm Discard	Comm Catch	Recr Landings	Recr Discard	Recr Catch	Total Landings	Total Discard	Total Catch
1982	10,400	n/a	10,400	10,758	250	11,008	21,158	250	21,408
1983	13,403	n/a	13,403	16,665	356	17,022	30,068	356	30,425
1984	17,130	n/a	17,130	12,803	537	13,340	29,933	537	30,470
1985	14,675	n/a	14,675	11,405	184	11,589	26,080	184	26,264
1986	12,186	n/a	12,186	12,005	646	12,651	24,191	646	24,837
1987	12,271	n/a	12,271	10,638	668	11,306	22,909	668	23,577
1988	14,686	n/a	14,686	9,429	483	9,912	24,115	483	24,598
1989	8,125	456	8,581	2,566	84	2,650	10,691	540	11,231
1990	4,199	898	5,097	3,517	414	3,931	7,716	1,312	9,028
1991	6,224	219	6,443	5,854	617	6,470	12,078	836	12,914
1992	7,529	2,151	9,680	5,746	559	6,305	13,275	2,710	15,985
1993	5,715	701	6,416	6,228	703	6,931	11,943	1,404	13,347
1994	6,588	1,539	8,127	6,481	409	6,889	13,069	1,947	15,016
1995	6,977	827	7,804	4,090	589	4,679	11,067	1,415	12,482
1996	5,861	1,436	7,297	6,813	624	7,437	12,674	2,060	14,734
1997	3,994	807	4,801	8,403	663	9,066	12,397	1,470	13,867
1998	5,076	638	5,714	10,368	997	11,365	15,444	1,635	17,079
1999	4,820	1,666	6,486	7,573	1,078	8,651	12,393	2,744	15,138
2000	5,085	1,620	6,705	12,259	1,182	13,441	17,344	2,802	20,146
2001	4,970	411	5,381	8,417	1,897	10,314	13,387	2,308	15,695
2002	6,573	948	7,521	7,388	1,564	8,952	13,961	2,512	16,473
2003	6,450	1,160	7,610	9,746	1,867	11,614	16,196	3,028	19,224
2004	7,880	1,628	9,508	9,616	1,833	11,449	17,496	3,461	20,958
2005	7,671	1,499	9,170	8,412	1,711	10,123	16,083	3,210	19,293
2006	6,316	1,518	7,834	8,452	1,583	10,034	14,768	3,100	17,868
2007	4,544	2,128	6,672	6,300	1,801	8,101	10,844	3,929	14,773
2008	4,179	1,162	5,341	5,597	1,970	7,567	9,776	3,132	12,909
2009	5,013	1,522	6,535	5,288	2,484	7,771	10,301	4,006	14,307

Table A35 continued. Commercial and recreational fishery landings, estimated commercial and recreational dead discard, and total catch statistics (in metric tons) for summer flounder, Maine to North Carolina. Includes 'New' MRFSS/MRIP.

Year	Comm Landings	Comm Discard	Comm Catch	Recr Landings	Recr Discard	Recr Catch	Total Landings	Total Discard	Total Catch
2010	6,078	1,478	7,556	5,142	2,710	7,852	11,220	4,188	15,408
2011	7,517	1,143	8,660	6,116	2,711	8,827	13,633	3,854	17,487
2012	5,918	754	6,672	7,318	2,172	9,490	13,236	2,927	16,163
2013	5,696	863	6,559	8,806	2,119	10,925	14,502	2,981	17,483
2014	4,989	830	5,819	7,364	2,092	9,456	12,353	2,922	15,275
2015	4,858	703	5,561	5,366	1,572	6,938	10,224	2,274	12,498
2016	3,537	772	4,309	6,005	1,482	7,487	9,542	2,254	11,796
2017	2,644	906	3,550	4,565	1,496	6,061	7,209	2,402	9,611

Table A36. Total catch of summer flounder in numbers (000s) and weight (metric tons; mt) including recreational catch as estimated by the Calibrated Marine Recreational Information Program ('New' MRIP 1982-2017) and the change in absolute numbers (000s) and weight (metric tons, mt) and in percent from total catch including 'Old' MRFSS/MRIP estimates.

Year	New Total Catch (000s)	New Total Catch (mt)	Change from Old Catch (000s)	Change from Old Catch (mt)	Percent Change Catch (000s)	Percent Change Catch (mt)
1982	39738	21,408	3,690	2,561	10%	14%
1983	50544	30,425	4,734	4,134	10%	16%
1984	57185	30,470	6,381	4,536	13%	17%
1985	47222	26,264	10,566	5,907	29%	29%
1986	38552	24,837	5,009	4,096	15%	20%
1987	35356	23,577	4,546	5,355	15%	29%
1988	42322	24,598	5,205	3,034	14%	14%
1989	17328	11,231	1,486	1,190	9%	12%
1990	16668	9,028	2,690	1,407	19%	18%
1991	22315	12,914	4,265	2,493	24%	24%
1992	31350	15,985	4,326	2,772	16%	21%
1993	24325	13,347	4,171	2,101	21%	19%
1994	27363	15,016	3,515	2,052	15%	16%
1995	20545	12,482	3,026	1,527	17%	14%
1996	24673	14,734	3,844	2,383	18%	19%
1997	19867	13,867	4,564	3,217	30%	30%
1998	22084	17,079	6,367	5,072	41%	42%
1999	20411	15,138	5,684	4,221	39%	39%
2000	23825	20,146	6,401	5,150	37%	34%
2001	17146	15,695	3,895	3,876	29%	33%
2002	18290	16,473	4,634	4,619	34%	39%
2003	19157	19,224	4,809	5,554	34%	41%
2004	21051	20,958	4,879	5,462	30%	35%
2005	20485	19,293	4,514	4,243	28%	28%
2006	18392	17,868	4,237	4,462	30%	33%
2007	14318	14,773	2,470	2,900	21%	24%
2008	12422	12,909	2,717	2,724	28%	27%
2009	14894	14,307	4,058	3,915	37%	38%
2010	16983	15,408	5,323	4,469	46%	41%
2011	18251	17,487	5,679	5,089	45%	41%
2012	16267	16,163	5,989	5,822	58%	56%
2013	16655	17,483	6,685	6,816	67%	64%
2014	15008	15,275	5,085	5,168	51%	51%
2015	12915	12,498	4,287	4,166	50%	50%
2016	11417	11,796	3,754	4,012	49%	52%
2017	9194	9,611	3,883	4,172	73%	77%
average	23,737	17,216	4,649	3,908	24%	29%

Table A37. Northeast Fisheries Science Center (NEFSC) 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 and 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 offshore strata 1-3, 5-7, 9-11, 13-14, 16-17, 61-63, 65-67, 69-71 and 73-75. 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. N/A = not available due to incomplete coverage (spring) or end of survey (winter).

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 A37 continued. Northeast Fisheries Science Center (NEFSC) 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 and 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 offshore strata 1-3, 5-7, 9-11, 13-14, 16-17, 61-63, 65-67, 69-71 and 73-75. 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. N/A = not available due to incomplete coverage (spring) or end of survey (winter).

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 A38. Northeast Fisheries Science Center (NEFSC) spring and fall trawl survey indices from the FSV *HB Bigelow* (BIG) 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 and 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. Indices compiled using SHG acceptance criteria. No survey data available (n/a) for fall 2017.

Year	Spring (n) BIG	Spring (kg) BIG	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	2.050	1.633
2013	5.811	4.528	1.802	1.477
2014	4.258	3.703	1.320	1.208
2015	8.277	4.716	2.566	1.538
2016	3.387	2.888	1.050	0.942
2017	3.453	2.520	1.071	0.822

Year	Fall (n) BIG	Fall (kg) BIG	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
2013	2.919	3.439	1.214	1.606
2014	5.271	4.662	2.191	2.178
2015	3.517	3.485	1.462	1.628
2016	3.966	4.403	1.649	2.057
2017	n/a	n/a	n/a	n/a

Table A39. Northeast Fisheries Science Center (NEFSC) trawl survey spring and fall survey indices from the FSV *HB Bigelow* (BIG) 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 BIG 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 (BIG/ALB ratios) vary by year and season, depending on the characteristics of the BIG length frequency distributions. Indices compiled using SHG acceptance criteria. No survey data available (n/a) for fall 2017.

Year	Spring (n) BIG	BIG 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
2013	5.811	9.6	3.031	1.917
2014	4.258	17.0	2.263	1.882
2015	8.277	22.3	4.222	1.960
2016	3.387	11.9	1.815	1.866
2017	3.453	12.1	1.804	1.914

Year	Fall (n) BIG	BIG 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
2013	4.809	14.3	2.524	1.905
2014	7.116	17.1	3.769	1.888
2015	5.615	18.9	3.012	1.864
2016	4.462	16.4	2.102	2.123
2017	n/a	n/a	n/a	n/a

Table A40. Northeast Fisheries Science Center (NEFSC) trawl survey spring survey indices at age from the FSV *HB Bigelow* (BIG) 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 (BIG/ALB ratios) vary by year and season, depending on the characteristics of the BIG length frequency distributions. Indices compiled using SHG acceptance criteria.

Spring									
2009	0	1	2	3	4	5	6	7+	Total
BIG	0.00	1.76	1.54	1.15	0.61	0.41	0.11	0.11	5.69
ALB	0.00	0.72	0.89	0.63	0.32	0.20	0.05	0.04	2.85
BIG/ALB	0.00	2.44	1.73	1.83	1.91	2.05	2.20	2.75	2.00
2010	0	1	2	3	4	5	6	7+	Total
BIG	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
BIG/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
BIG	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
BIG/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
BIG	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
BIG/ALB	0.00	2.00	1.73	1.72	1.88	1.97	2.00	2.86	1.83
2013	0	1	2	3	4	5	6	7+	Total
BIG	0.00	0.81	0.76	1.44	1.85	0.57	0.23	0.15	5.81
ALB	0.00	0.34	0.43	0.81	0.99	0.29	0.11	0.06	3.03
BIG/ALB	0.00	2.38	1.77	1.78	1.87	1.97	2.09	2.67	1.92
2014	0	1	2	3	4	5	6	7+	Total
BIG	0.00	0.44	0.64	0.94	1.17	0.82	0.14	0.11	4.26
ALB	0.00	0.21	0.37	0.54	0.63	0.41	0.06	0.04	2.26
BIG/ALB	0.00	2.10	1.73	1.74	1.86	2.00	2.33	2.75	1.88
2015	0	1	2	3	4	5	6	7+	Total
BIG	0.00	2.72	1.96	1.50	0.90	0.53	0.33	0.34	8.28
ALB	0.00	1.24	1.08	0.84	0.49	0.27	0.16	0.14	4.22
BIG/ALB	0.00	2.19	1.81	1.79	1.84	1.96	2.06	2.43	1.96
2016	0	1	2	3	4	5	6	7+	Total
BIG	0.00	0.19	0.68	0.92	0.70	0.32	0.22	0.36	3.39
ALB	0.00	0.09	0.39	0.51	0.38	0.17	0.11	0.17	1.82
BIG/ALB	0.00	2.11	1.74	1.80	1.84	1.88	2.00	2.12	1.87

Table A40 continued. Northeast Fisheries Science Center (NEFSC) trawl survey spring survey indices at age from the FSV *HB Bigelow* (BIG) 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 (BIG/ALB ratios) vary by year and season, depending on the characteristics of the BIG length frequency distributions. Indices compiled using SHG acceptance criteria.

Spring

2017	0	1	2	3	4	5	6	7+	Total
BIG	0.00	0.66	0.91	0.84	0.34	0.26	0.14	0.30	3.45
ALB	0.00	0.29	0.51	0.47	0.19	0.13	0.07	0.14	1.80
BIG/ALB	0.00	2.28	1.78	1.79	1.79	2.00	2.00	2.14	1.92

Table A41. Northeast Fisheries Science Center trawl survey fall survey indices at age from the FSV *HB Bigelow* (BIG) 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 (BIG/ALB ratios) vary by year and season, depending on the characteristics of the BIG length frequency distributions. No survey data available (n/a) for fall 2017.

Fall									
2009	0	1	2	3	4	5	6	7+	Total
BIG	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
BIG/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
BIG	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
BIG/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
BIG	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
BIG/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
BIG	0.61	0.43	0.78	1.96	1.15	0.32	0.13	0.19	5.57
ALB	0.17	0.25	0.45	1.08	0.60	0.16	0.06	0.07	2.84
BIG/ALB	3.59	1.72	1.73	1.81	1.92	2.00	2.17	3.00	1.96
2013	0	1	2	3	4	5	6	7+	Total
BIG	0.17	0.45	0.76	1.48	1.28	0.41	0.08	0.18	4.81
ALB	0.08	0.26	0.44	0.81	0.67	0.19	0.03	0.04	2.52
BIG/ALB	2.13	1.73	1.73	1.83	1.91	2.16	2.67	4.50	1.91
2014	0	1	2	3	4	5	6	7+	Total
BIG	0.85	1.67	1.40	1.34	1.25	0.34	0.18	0.09	7.12
ALB	0.35	0.96	0.80	0.72	0.65	0.17	0.08	0.04	3.77
BIG/ALB	2.43	1.74	1.75	1.86	1.92	2.00	2.25	2.25	1.89
2015	0	1	2	3	4	5	6	7+	Total
BIG	0.23	1.32	1.56	1.13	0.60	0.44	0.20	0.14	5.62
ALB	0.10	0.76	0.88	0.61	0.31	0.21	0.09	0.05	3.01
BIG/ALB	2.30	1.74	1.77	1.85	1.94	2.10	2.22	2.80	1.86
2016	0	1	2	3	4	5	6	7+	Total
BIG	0.52	0.73	1.21	1.01	0.40	0.26	0.18	0.15	4.46
ALB	0.07	0.33	0.67	0.54	0.21	0.13	0.08	0.07	2.10
BIG/ALB	7.43	2.21	1.81	1.87	1.90	2.00	2.25	2.14	2.12

Table A42. Northeast Fisheries Science Center (NEFSC) spring trawl survey (offshore strata 1-12, 61-76) stratified mean number of summer flounder per tow at age; calibrated series. 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
2013	0.34	0.43	0.81	0.99	0.29	0.11	0.04	0.02	<0.01	<0.01	3.03	14
2014	0.21	0.37	0.54	0.63	0.41	0.06	0.04				2.26	17
2015	1.24	1.08	0.84	0.49	0.27	0.16	0.08	0.03	0.01	0.02	4.22	22
2016	0.09	0.39	0.51	0.38	0.17	0.11	0.10	0.05	0.01	0.01	1.82	12
2017	0.29	0.51	0.47	0.19	0.13	0.07	0.06	0.04	0.02	0.02	1.80	12

Table A43. Northeast Fisheries Science Center (NEFSC) spring trawl survey (offshore strata 1-12, 61-76) summer flounder mean length (cm) at age; calibrated series.

	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	
2013	27.6	34.8	39.3	43.8	51.5	56.0	56.9	58.8	65.5	70.0	66.7	67.6
2014	28.8	33.9	38.3	44.0	50.6	57.4	60.6	64.0	55.0	69.0	66.7	70.9
2015	27.9	32.3	39.2	43.6	48.7	51.1	49.5	56.7	55.2	58.2	68.6	57.3
2016	29.3	34.1	40.4	42.6	47.5	49.2	50.7	52.3	46.3	53.0		67.0
2017	28.0	35.8	40.7	43.3	49.4	49.8	53.3	51.3	51.1	46.9		53.0

Table A44. Northeast Fisheries Science Center (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; calibrated series. Coefficient of Variation (CV) in percent. No survey data available for fall 2017.

	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
2013	0.08	0.26	0.44	0.81	0.67	0.19	0.03	0.04	2.52	15
2014	0.35	0.96	0.80	0.72	0.65	0.17	0.08	0.04	3.77	18
2015	0.10	0.76	0.88	0.61	0.31	0.21	0.09	0.05	3.01	19
2016	0.07	0.33	0.67	0.54	0.21	0.13	0.08	0.07	2.10	17

Table A45. Northeast Fisheries Science Center (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; calibrated series. No survey data available for fall 2017.

	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
2013	28.1	32.7	36.6	41.3	45.7	54.5	61.5	72.8
2014	27.7	34.2	37.9	41.7	45.9	54.5	57.8	69.9
2015	28.6	33.6	38.6	42.2	47.2	52.8	57.6	59.8
2016	20.3	32.5	40.8	43.4	48.5	47.8	57.6	53.4

Table A46. Northeast Fisheries Science Center (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 A47. Northeast Fisheries Science Center (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 A48. Northeast Fisheries Science Center (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 A49. Northeast Fisheries Science Center (NEFSC) trawl survey spring and fall survey aggregate indices from the FSV *HB Bigelow* (BIG). Spring strata set includes offshore strata 1-12, 61-76. Fall strata set includes offshore strata 1, 5, 9, 61, 65, 69, 73, and inshore strata 1-61. The BIG does not routinely sample the shallowest inshore strata (0-18 m; 0-60 ft; 0-10 fathoms). Indices compiled using TOGA acceptance criteria. No survey data available (n/a) for fall 2017.

Spring Year	Mean number per tow	Mean number CV (%)	Mean weight (kg) per tow	Mean weight CV (%)	Mean weight per fish (kg)	Mean length per fish (cm)
2009	5.655	12.4	3.548	13.6	0.627	37.3
2010	7.153	10.9	4.824	12.2	0.674	38.4
2011	8.174	15.9	4.929	12.4	0.603	37.5
2012	6.693	13.8	5.101	15.3	0.762	40.3
2013	5.811	9.6	4.528	10.0	0.779	40.9
2014	4.267	17.0	3.733	19.8	0.875	42.0
2015	8.239	22.8	4.692	17.0	0.569	35.8
2016	3.387	11.9	2.888	12.9	0.853	41.8
2017	3.453	12.1	2.520	12.3	0.730	39.3

Fall Year	Mean number per tow	Mean number CV (%)	Mean weight (kg) per tow	Mean weight CV (%)	Mean weight per fish (kg)	Mean length per fish (cm)
2009	9.179	19.8	6.713	19.4	0.731	39.2
2010	4.930	16.7	3.402	19.4	0.690	38.6
2011	7.765	22.7	7.895	34.9	1.017	42.5
2012	5.573	23.7	4.933	29.2	0.885	41.0
2013	4.809	14.3	4.745	17.2	0.987	43.1
2014	7.116	17.1	5.495	15.6	0.772	39.5
2015	5.614	18.9	5.012	22.8	0.893	41.1
2016	4.462	16.4	3.837	19.6	0.860	39.5

Table A50. Northeast Fisheries Science Center (NEFSC) trawl survey spring and fall survey aggregate indices from the FSV *HB Bigelow* (BIG). Spring strata set includes offshore strata 1-12, 61-76. Fall strata set includes offshore strata 1, 5, 9, 61, 65, 69, 73, and inshore strata 1-61. The BIG does not routinely sample the shallowest inshore strata (0-18 m; 0-60 ft; 0-10 fathoms). Indices compiled using TOGA acceptance criteria and efficiency estimates at length from 'twin-trawl sweep study' experiments. No survey data available (n/a) for fall 2017.

Spring Year	Mean number per tow	Mean number CV (%)	Mean weight (kg) per tow	Mean weight CV (%)	Mean weight per fish (kg)	Mean length per fish (cm)
2009	14.743	16.5	6.996	13.1	0.475	32.8
2010	14.822	11.1	8.847	11.8	0.597	36.2
2011	15.790	17.4	8.972	12.6	0.568	36.2
2012	11.835	14.0	8.878	15.3	0.750	39.9
2013	12.835	10.5	8.548	10.0	0.666	37.1
2014	7.990	16.5	6.601	19.7	0.826	40.8
2015	20.089	24.2	8.897	17.3	0.443	32.4
2016	6.133	11.8	5.067	12.7	0.826	41.2
2017	7.576	12.8	4.606	12.1	0.608	36.0

Fall Year	Mean number per tow	Mean number CV (%)	Mean weight (kg) per tow	Mean weight CV (%)	Mean weight per fish (kg)	Mean length per fish (cm)
2009	18.169	18.3	11.613	18.9	0.639	37.1
2010	9.055	15.9	5.782	18.7	0.639	37.7
2011	14.058	21.7	12.560	33.7	0.893	41.4
2012	16.271	22.6	8.511	27.1	0.523	32.4
2013	8.812	13.8	7.932	16.6	0.900	42.1
2014	15.340	15.3	9.347	15.1	0.609	36.3
2015	10.525	18.1	8.083	22.1	0.768	39.6
2016	21.370	26.1	6.954	17.3	0.325	26.4

Table A51. Northeast Fisheries Science Center (NEFSC) trawl survey spring survey indices at age from the FSV *HB Bigelow* (BIG). Spring strata set includes offshore strata 1-12, 61-76. ‘Standard’ indices compiled using TOGA acceptance criteria. ‘Absolute’ indices are compiled using efficiency estimates at length from ’sweep-study’ experiments. ‘Swept Area Numbers’ (SWAN) indices are compiled using efficiency estimates at length from ’twin trawl sweep study’ experiments, average wing-spread dimension, average tow speed, and annual survey area to provide estimates of absolute population size.

Standard Indices		**TOGA Indices**									
Year	1	2	3	4	5	6	7	8	9	10+	Total
2009	1.77	1.55	1.13	0.60	0.39	0.11	0.05	0.03	0.02	0.01	5.66
2010	1.94	1.87	1.52	0.94	0.47	0.20	0.10	0.06	0.02	0.03	7.15
2011	1.48	2.44	2.18	1.06	0.63	0.16	0.08	0.06	0.04	0.04	8.17
2012	0.48	1.07	2.61	1.46	0.60	0.24	0.11	0.05	0.02	0.03	6.69
2013	0.81	0.76	1.44	1.85	0.57	0.23	0.08	0.04	0.01	0.02	5.81
2014	0.44	0.64	0.94	1.17	0.82	0.14	0.07	0.02	0.01	0.02	4.27
2015	2.72	1.96	1.49	0.89	0.52	0.33	0.16	0.07	0.04	0.07	8.24
2016	0.19	0.68	0.92	0.70	0.32	0.22	0.20	0.12	0.03	0.02	3.39
2017	0.66	0.91	0.84	0.34	0.26	0.14	0.13	0.08	0.05	0.04	3.45

Absolute Indices		**TOGA Indices**		**Uses 'sweep study' qs at length**							
Year	1	2	3	4	5	6	7	8	9	10+	Total
2009	7.99	2.60	2.02	1.10	0.68	0.18	0.08	0.05	0.03	0.01	14.74
2010	5.77	3.12	2.70	1.73	0.84	0.33	0.16	0.10	0.03	0.04	14.82
2011	4.32	4.06	3.71	1.94	1.14	0.27	0.13	0.10	0.06	0.06	15.79
2012	1.17	1.81	4.37	2.67	1.07	0.41	0.17	0.08	0.03	0.05	11.83
2013	3.92	1.39	2.51	3.37	1.01	0.39	0.13	0.07	0.02	0.03	12.83
2014	1.23	1.14	1.61	2.14	1.46	0.23	0.12	0.03	0.02	0.02	7.99
2015	9.92	3.92	2.59	1.60	0.94	0.57	0.28	0.12	0.05	0.11	20.09
2016	0.46	1.23	1.62	1.25	0.57	0.39	0.35	0.20	0.04	0.03	6.13
2017	2.61	1.65	1.49	0.61	0.46	0.25	0.22	0.14	0.08	0.07	7.58

Table A51 continued. Northeast Fisheries Science Center (NEFSC) trawl survey spring survey indices at age from the FSV *HB Bigelow* (BIG). Spring strata set includes offshore strata 1-12, 61-76. 'Standard' Indices compiled using TOGA acceptance criteria. 'Absolute' indices are compiled using efficiency estimates at length from 'sweep-study' experiments. 'Swept Area Numbers' (SWAN) indices are compiled using efficiency estimates at length from 'sweep-study' experiments, average wing-spread dimension, average tow speed, and annual survey area to provide estimates of absolute population size.

SWAN Indices (000s)

Year	1	2	3	4	5	6	7	8	9	10+	Total
2009	34125	11088	8645	4697	2904	781	331	194	135	46	62946
2010	24785	13415	11620	7430	3614	1421	709	414	140	173	63719
2011	18571	17459	15966	8335	4900	1161	552	413	267	260	67884
2012	5018	7767	18794	11470	4611	1758	749	361	134	215	50877
2013	16852	5991	10772	14503	4322	1664	542	300	91	140	55177
2014	4300	3964	5606	7457	5111	792	402	122	61	82	27897
2015	42627	16832	11147	6880	4030	2440	1203	495	231	481	86366
2016	1960	5309	6953	5357	2445	1684	1491	856	192	118	26364
2017	11205	7078	6407	2625	1962	1082	948	611	346	307	32571

Table A52. Northeast Fisheries Science Center (NEFSC) trawl survey fall survey indices at age from the FSV *HB Bigelow* (BIG). Fall strata set includes offshore strata 1, 5, 9, 61, 65, 69, 73, and inshore strata 1-61. The BIG does not routinely sample the shallowest inshore strata (0-18 m; 0-60 ft; 0-10 fathoms). 'Standard' indices compiled using TOGA acceptance criteria. 'Absolute' indices are compiled using efficiency estimates at length from 'sweep-study' experiments. 'Swept Area Numbers' (SWAN) indices are compiled using efficiency estimates at length from 'sweep-study' experiments, average wing-spread dimension, average tow speed, and annual survey area to provide estimates of absolute population size. No survey data available (n/a) for fall 2017.

Standard Indices		**TOGA Indices**							
Year	0	1	2	3	4	5	6	7+	ALL
2009	0.63	3.46	2.19	1.41	0.85	0.38	0.13	0.14	9.18
2010	0.23	1.68	1.29	0.80	0.47	0.27	0.11	0.10	4.93
2011	0.33	1.77	2.05	1.33	0.74	0.55	0.35	0.65	7.76
2012	0.61	0.43	0.78	1.96	1.15	0.32	0.13	0.21	5.57
2013	0.17	0.45	0.76	1.48	1.28	0.41	0.08	0.18	4.81
2014	0.85	1.67	1.40	1.34	1.24	0.34	0.18	0.09	7.12
2015	0.23	1.32	1.56	1.13	0.60	0.44	0.20	0.13	5.61
2016	0.53	0.73	1.21	1.01	0.40	0.26	0.20	0.12	4.46

Absolute Indices		**TOGA Indices**		**Uses 'sweep study' qs at length**					
Year	0	1	2	3	4	5	6	7+	ALL
2009	3.27	5.91	3.82	2.57	1.52	0.66	0.18	0.25	18.17
2010	0.92	2.91	2.16	1.42	0.85	0.47	0.18	0.15	9.06
2011	1.29	2.94	3.51	2.41	1.37	0.95	0.58	1.00	14.06
2012	7.57	0.73	1.30	3.48	2.11	0.55	0.22	0.31	16.27
2013	0.61	0.85	1.28	2.65	2.35	0.71	0.13	0.25	8.81
2014	4.22	3.01	2.39	2.41	2.27	0.59	0.30	0.14	15.34
2015	1.07	2.35	2.69	2.03	1.09	0.75	0.33	0.21	10.52
2016	11.15	4.55	2.14	1.82	0.71	0.45	0.30	0.25	21.37

Table A52 continued. Northeast Fisheries Science Center (NEFSC) trawl survey fall survey indices at age from the FSV *HB Bigelow* (BIG). Fall strata set includes offshore strata 1, 5, 9, 61, 65, 69, 73, and inshore strata 1-61. The BIG does not routinely sample the shallowest inshore strata (0-18 m; 0-60 ft; 0-10 fathoms). 'Standard' indices compiled using TOGA acceptance criteria. 'Absolute' indices are compiled using efficiency estimates at length from 'sweep-study' experiments. 'Swept Area Numbers' (SWAN) indices are compiled using efficiency estimates at length from 'sweep-study' experiments, average wing-spread dimension, average tow speed, and annual survey area to provide estimates of absolute population size. No survey data available (n/a) for fall 2017.

SWAN Indices (000s)

Year	0	1	2	3	4	5	6	7+	Total
2009	9048	16339	10570	7100	4210	1813	492	690	50262
2010	2490	7888	5845	3860	2304	1279	490	403	24559
2011	3569	8144	9703	6670	3777	2632	1616	2779	38889
2012	20934	2013	3596	9623	5832	1526	617	871	45012
2013	1687	2340	3528	7317	6492	1963	352	696	24376
2014	11685	8333	6623	6671	6273	1641	831	377	42435
2015	2947	6511	7447	5625	3006	2085	904	590	29116
2016	30835	12600	5922	5025	1958	1255	827	694	59116

Table A53. Massachusetts Division of Marine Fisheries (MADMF) spring survey: stratified mean number per tow at age and Coefficient of Variation (CV).

	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
2013		0.174	0.330	0.489	0.416	0.071	0.019	0.023	0.015	1.537	18
2014		0.088	0.261	0.422	0.322	0.095	0.013	0.013	0.013	1.227	20
2015		0.097	0.108	0.329	0.226	0.064	0.021	0.013	0.005	0.863	27
2016		0.076	0.922	1.289	1.547	0.622	0.474	0.065	0.071	5.067	15
2017		0.438	1.194	1.711	0.210	0.079	0.077	0.000	0.000	3.709	13

Table A54. Massachusetts Division of Marine Fisheries (MADMF) fall survey: stratified mean number per tow at age and Coefficient of Variation (CV).

	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			0.013	2.422	15
2013	0.035	0.136	0.255	0.600	0.160					1.186	17
2014	0.168	0.481	1.058	0.696	0.261	0.042	0.023			2.729	21
2015		1.851	2.084	1.491	0.628	0.223	0.013			6.290	14
2016		0.372	0.975	4.290	0.889	0.068	0.012	0.009	0.044	6.658	14
2017	0.266	1.535	1.273	0.643	0.075	0.000	0.000	0.000	0.000	3.792	14

Table A55. Massachusetts Division of Marine Fisheries (MADMF) seine survey: age-0 summer flounder total catch per 100 square meters and Coefficient of Variation (CV).

Year	Total catch	CV (%)
1982	0.00020	71
1983	0.00025	56
1984	0.00011	100
1985	0.00190	38
1986	0.00040	42
1987	0.00035	76
1988	0.00009	100
1989	0.00024	57
1990	0.00137	33
1991	0.00049	47
1992	0	0
1993	0.00017	71
1994	0.00011	100
1995	0.00139	29
1996	0.00055	57
1997	0	0
1998	0.00097	34
1999	0.00083	28
2000	0.00064	34
2001	0.00009	100
2002	0.00630	19
2003	0.00077	32
2004	0.00038	50
2005	0.00008	100
2006	0.00337	25
2007	0.00330	25
2008	0.00833	20
2009	0.00465	25
2010	0.00033	47
2011	0.00014	100
2012	0.00495	24
2013	0.00160	32
2014	0.00120	47
2015	0	0
2016	0.00600	33
2017	0.00473	33

Table A56. Rhode Island Department of Fish and Wildlife (RIDFW) fall trawl survey: stratified mean number per tow at age.

	Age										
Year	0	1	2	3	4	5	6	7	8	9+	Total
1981	0.30	0.97	1.74	0.20	0.01						3.24
1982	0.02	0.21	0.52	0.07	0.01						0.83
1983	0.03	0.14	0.42	0.11	0.01						0.71
1984	0.02	0.74	0.49	0.10							1.35
1985	0.35	0.31	0.28	0.02							0.97
1986	0.35	2.45	0.51	0.13							3.46
1987	0.04	0.94	0.37	0.02	0.04						1.42
1988		0.34	0.24								0.58
1989			0.07								0.07
1990	0.05	0.67	0.12								0.84
1991		0.12	0.08	0.01	0.01						0.22
1992	0.01	0.77	0.41	0.11	0.07						1.38
1993	0.01	0.41	0.22	0.07							0.74
1994	0.04	0.12	0.03								0.19
1995	0.02	0.53	0.20							0.01	0.76
1996	0.10	0.95	1.03	0.01							2.09
1997	0.03	0.56	0.96	0.30	0.02	0.02					1.89
1998		0.09	0.36	0.09							0.54
1999	0.02	1.04	1.91	0.35	0.02	0.01					3.35
2000	0.40	0.50	1.24	0.45	0.14	0.03					2.76
2001		1.05	0.63	0.30	0.09	0.07	0.01				2.15
2002	0.44	2.42	1.38	0.40	0.08	0.02	0.03	0.03			4.79
2003	0.10	2.35	2.08	0.49	0.12	0.04	0.06				5.24
2004	0.03	0.48	1.30	0.78	0.19	0.06	0.01				2.85
2005	0.01	0.84	1.38	0.69	0.15	0.14	0.01	0.04	0.03		3.29
2006	0.10	0.14	1.13	0.44	0.16	0.02	0.01				2.00
2007	0.08	0.43	0.86	1.35	0.34	0.13	0.08	0.02		0.03	3.32
2008	0.12	0.55	1.10	0.62	0.85	0.41	0.16	0.10	0.02		3.93
2009	0.39	1.05	1.59	1.34	0.77	0.24	0.09	0.01			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		0.01	3.09
2013	0.01	0.16	0.26	0.62	0.64	0.11	0.02				1.82
2014	0.12	0.24	0.30	0.49	0.51	0.23	0.04	0.01			1.96
2015	0.12	0.83	0.83	0.82	0.50	0.30	0.14	0.04	0.03	0.02	3.65
2016	0.04	0.19	0.49	0.35	0.16	0.10	0.03	0.04	0.00	0.00	1.39
2017	0.01	0.38	0.66	0.56	0.21	0.18	0.08	0.06	0.00	0.00	2.14

Table A57. Rhode Island Department of Fish and Wildlife (RIDFW) monthly fixed station trawl survey: stratified mean number per tow at age.

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		0.24	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
2013	0.02	0.15	0.22	0.43	0.39	0.08	0.02				1.31
2014	0.04	0.13	0.15	0.21	0.26	0.11	0.02	0.01			0.92
2015	0.04	0.31	0.35	0.34	0.19	0.10	0.05	0.03	0.01		1.43
2016	0.01	0.12	0.29	0.27	0.14	0.06	0.04	0.02	0.01		0.97
2017	0.01	0.16	0.26	0.22	0.11	0.08	0.03	0.03	0.01	0.01	0.92

Table A58. 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	Year	Fox Is	Whale Rk	Average
1959	2.517	3.347	2.932	2000	4.783	8.161	6.472
1960	1.579	1.583	1.581	2001	4.413	5.367	4.890
1961	3.358	1.492	2.425	2002	6.842	8.375	7.608
1962	1.917	1.063	1.490	2003	5.751	7.786	6.769
1963	0.965	0.083	0.524	2004	4.146	4.921	4.533
1964	1.171	0.246	0.708	2005	2.775	3.958	3.367
1965	1.079	0.679	0.879	2006	2.018	2.956	2.487
1966	1.833	0.567	1.200	2007	5.007	4.422	4.715
1967	0.685	0.135	0.410	2008	6.808	5.725	6.267
1968	0.321	0.042	0.181	2009	6.644	10.771	8.708
1969	0.347	0.033	0.190	2010	6.229	9.238	7.710
1970	0.243	0.071	0.157	2011	8.211	17.889	10.793
1971	0.525	0.067	0.296	2012	5.621	6.142	5.756
1972	0.269	0.000	0.135	2013	3.150	4.208	3.679
1973	1.071	0.322	0.697	2014	3.071	4.136	3.603
1974	3.503	0.581	2.042	2015	4.255	4.882	4.569
1975	2.428	1.272	1.850	2016	2.824	4.510	3.667
1976	8.917	2.674	5.795	2017	10.019	5.712	7.865
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				

Table A59. Connecticut Department of Energy and Environmental Protection (CTDEEP) spring trawl survey: summer flounder index of abundance, geometric mean number per tow at age.

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
2013	0.000	0.884	0.668	0.664	0.673	0.205	0.082	0.060	3.236
2014	0.000	0.971	0.706	0.485	0.433	0.298	0.047	0.063	3.002
2015	0.000	0.787	0.349	0.202	0.124	0.091	0.049	0.035	1.637
2016	0.000	0.145	0.415	0.345	0.199	0.095	0.077	0.008	1.357
2017	0.000	0.536	0.411	0.307	0.148	0.111	0.050	0.077	1.652

Table A60. Connecticut Department of Energy and Environmental Protection (CTDEEP) fall trawl survey: summer flounder index of abundance, geometric mean number per tow at age. No survey in 2010; n/a = not available.

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									n/a
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
2013	0.218	0.571	0.608	0.805	0.633	0.189	0.029	0.024	3.066
2014	0.123	0.403	0.395	0.362	0.283	0.082	0.029	0.031	1.709
2015	0.055	0.574	0.672	0.396	0.183	0.082	0.035	0.029	2.026
2016	0.036	0.240	0.622	0.556	0.269	0.122	0.032	0.042	1.920
2017	0.223	0.695	0.186	0.120	0.075	0.032	0.016	0.008	1.354

Table A61. New York Department of Environmental Conservation (NYDEC) Peconic Bay trawl survey: index of summer flounder abundance.

	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
2013	0.04	0.10	0.13	0.18	0.10	0.02	0.00	0.00	0.58	0.04
2014	0.21	0.21	0.17	0.16	0.12	0.03	0.01	0.00	0.90	0.05
2015	0.15	0.22	0.17	0.09	0.04	0.02	0.00	0.00	0.70	0.05
2016	0.07	0.22	0.17	0.12	0.04	0.03	0.01	0.01	0.66	0.05
2017	0.17	0.34	0.24	0.15	0.02	0.03	0.01	0.00	0.96	0.05

Table A62. New Jersey Division of Fish and Wildlife (NJDFW) trawl survey, April - October: index of summer flounder abundance.

	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
2013	0.96	1.33	1.55	1.66	0.91	0.28	0.03	0.02	0.00	0.00	6.74	0.17
2014	1.69	2.13	1.24	0.74	0.57	0.18	0.05	0.04	0.00	0.00	6.65	0.19
2015	0.94	2.87	1.95	0.95	0.38	0.17	0.14	0.04	0.01	0.03	7.48	0.11
2016	0.30	1.60	1.06	0.62	0.16	0.15	0.02	0.05	0.00	0.00	3.96	0.13
2017	0.94	2.11	1.30	0.74	0.22	0.19	0.05	0.07	0.00	0.00	5.62	0.15

Table A63. Delaware Division of Fish and Wildlife (DEDFW) 16 foot trawl survey: index of summer flounder recruitment at age-0 in the Delaware Bay Estuary; geometric mean number per tow.

Year	Number per tow	Year	Number per tow
1980	0.12	2010	0.04
1981	0.06	2011	0.02
1982	0.11	2012	0.02
1983	0.03	2013	0.04
1984	0.08	2014	0.05
1985	0.06	2015	0.03
1986	0.10	2016	0.03
1987	0.14	2017	0.03
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		

Table A64. Delaware Division of Fish and Wildlife (DEDFW) 16 foot trawl survey: index of summer flounder recruitment at age-0 in Delaware Inland Bays; geometric mean number per tow.

Year	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	0.154
2013	0.338
2014	0.376
2015	0.149
2016	0.803
2017	0.283

Table A65. Delaware Division of Fish and Wildlife Delaware Bay (DEDFW) 30 foot trawl survey: index of summer flounder abundance. Due to a 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
2013	0.17	0.14	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.35
2014	0.36	0.53	0.03	0.00	0.02	0.01	0.00	0.00	0.00	0.96
2015	0.30	0.52	0.07	0.01	0.00	0.00	0.00	0.01	0.00	0.91
2016	0.39	0.22	0.02	0.02	0.00	0.00	0.00	0.01	0.00	0.65
2017	0.57	0.51	0.23	0.01	0.00	0.00	0.00	0.00	0.00	1.32

Table A66. Maryland Department of Natural Resources Coastal Bays (MDDNR) trawl survey: index of summer flounder recruitment at age-0. Geometric mean number per tow (re-transformed ln [number per hectare + 1]) and metrics of precision.

Year	Geometric mean number per tow	Coefficient of Variation	Lower 95% Confidence Interval	Upper 95% Confidence Interval
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 A66 continued. Maryland Department of Natural Resources (MDDNR) Coastal Bays trawl survey: index of summer flounder recruitment at age-0. Geometric mean number per tow (re-transformed ln [number per hectare + 1]) and metrics of precision.

Year	Geometric mean number per tow	Coefficient of Variation	Lower 95% Confidence Interval	Upper 95% Confidence Interval
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
2013	9.461	0.12	6.993	12.801
2014	3.864	0.30	2.955	5.026
2015	2.348	0.48	1.888	2.920
2016	3.891	0.30	2.945	5.140
2017	4.241	0.27	3.223	5.580

Table A67. Virginia Institute of Marine Science (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 A67 continued. Virginia Institute of Marine Science (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
1990	2.54	2.06	3.09	0.06	162
1991	2.64	2.14	3.22	0.06	207
1992	0.89	0.68	1.12	0.09	187
1993	0.50	0.36	0.65	0.12	185
1994	2.41	1.91	2.99	0.06	186
1995	0.63	0.52	0.92	0.11	218
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
2013	0.82	0.65	1.02	0.12	225
2014	0.62	0.49	0.77	0.12	225
2015	0.22	0.15	0.31	0.15	225
2016	0.41	0.29	0.55	0.16	225
2017	0.93	0.74	1.15	0.12	225

Table A68. Virginia Institute of Marine Science (VIMS) Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) trawl survey indices for summer flounder. Top: aggregate indices are delta-lognormal model geometric means per tow. Bottom: 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 the top table.

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)
2013	4.1 (39)	1.8 (31)
2014	3.2 (39)	1.6 (28)
2015	5.2 (32)	2.8 (32)
2016	3.0 (32)	1.7 (32)
2017	3.2 (41)	1.7 (35)

Year	0	1	2	3	4+	Total
2002	59.0	19.3	5.6	3.7	4.6	92.1
2003	18.1	12.3	2.6	1.2	1.3	35.5
2004	23.8	6.6	2.6	1.5	1.5	36.0
2005	54.2	28.5	8.3	3.3	2.9	97.2
2006	90.2	22.1	6.8	3.4	3.3	125.7
2007	92.4	12.7	2.2	0.8	1.3	109.5
2008	49.0	8.1	4.2	2.5	2.4	66.2
2009	16.7	6.5	1.9	1.6	1.4	28.1
2010	17.7	7.7	1.8	0.9	1.0	29.2
2011	5.1	7.3	2.9	1.6	1.4	18.3
2012	1.9	0.5	0.5	0.3	0.2	3.4
2013	3.0	0.6	0.1	0.2	0.2	4.1
2014	2.5	1.0	0.2	0.1	0.1	3.9
2015	3.8	1.8	0.6	0.3	0.2	6.7
2016	1.9	1.1	0.4	0.1	0.1	3.6
2017	1.9	1.1	0.4	0.1	0.1	3.6

Table A69. Virginia Institute of Marine Science (VIMS) Northeast Area Monitoring and Assessment Program (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 (%)
Spring 2008	3.05	8.3	1.90	8.0
Spring 2009	2.51	9.0	1.49	9.0
Spring 2010	2.25	10.0	1.27	9.0
Spring 2011	3.17	8.6	1.64	8.3
Spring 2012	1.07	10.3	0.77	10.0
Spring 2013	1.34	8.6	0.81	8.0
Spring 2014	1.54	10.4	0.92	10.8
Spring 2015	1.70	10.9	0.97	10.8
Spring 2016	1.46	9.9	0.84	9.5
Spring 2017	0.50	10.0	0.46	12.0
Fall 2007	4.19	7.1	2.62	7.9
Fall 2008	2.70	9.3	1.69	8.5
Fall 2009	4.99	8.9	2.44	7.6
Fall 2010	3.98	8.1	1.99	8.3
Fall 2011	2.53	8.2	1.50	9.1
Fall 2012	3.29	7.5	1.82	7.8
Fall 2013	1.51	9.6	0.63	9.7
Fall 2014	2.00	10.0	0.86	10.2
Fall 2015	1.53	10.5	0.77	10.3
Fall 2016	1.27	9.4	0.64	10.5
Fall 2017	1.64	9.4	0.65	10.5

Table A70. Virginia Institute of Marine Science (VIMS) Northeast Area Monitoring and Assessment Program (NEAMAP) spring and fall 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 A68.

Spring

Year	1	2	3	4	5	6	7+	Total
2008	0.70	1.15	0.39	0.63	0.24	0.14	0.13	3.38
2009	0.85	0.83	0.49	0.24	0.18	0.11	0.09	2.79
2010	0.78	0.89	0.41	0.20	0.13	0.08	0.08	2.57
2011	0.97	1.43	0.74	0.35	0.15	0.08	0.07	3.79
2012	0.24	0.46	0.29	0.18	0.10	0.06	0.08	1.41
2013	0.31	0.45	0.42	0.31	0.11	0.07	0.07	1.74
2014	0.46	0.66	0.35	0.28	0.13	0.08	0.07	2.03
2015	0.51	0.74	0.45	0.18	0.12	0.07	0.07	2.14
2016	0.58	0.64	0.27	0.21	0.09	0.06	0.06	1.91
2017	0.11	0.20	0.13	0.12	0.08	0.05	0.06	0.75

Fall

Year	0	1	2	3	4	5	6	7+	Total
2007	0.76	1.47	0.62	0.71	0.33	0.16	0.08	0.07	4.20
2008	0.46	1.04	0.85	0.27	0.13	0.08	0.04	0.03	2.90
2009	1.42	1.25	0.98	0.40	0.25	0.13	0.06	0.05	4.54
2010	1.10	1.32	0.79	0.33	0.10	0.09	0.04	0.04	3.81
2011	0.45	0.86	0.65	0.34	0.21	0.08	0.04	0.05	2.68
2012	0.31	0.55	0.83	0.93	0.51	0.13	0.07	0.06	3.39
2013	0.44	0.52	0.33	0.17	0.10	0.02	0.01	0.01	1.60
2014	0.92	0.43	0.33	0.14	0.17	0.03	0.01	0.01	2.04
2015	0.50	0.64	0.33	0.13	0.04	0.04	0.02	0.02	1.72
2016	0.42	0.39	0.33	0.09	0.07	0.04	0.02	0.02	1.38
2017	0.73	0.50	0.24	0.16	0.05	0.03	0.01	0.01	1.73

Table A71. North Carolina Division of Marine Fisheries (NCDMF) Pamlico Sound trawl survey: June index of summer flounder recruitment at age-0.

Year	Mean N 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	n/a
2007	3.62	n/a
2008	14.40	n/a
2009	4.53	n/a
2010	14.28	n/a
2011	6.64	n/a
2012	9.26	n/a
2013	9.80	n/a
2014	6.55	n/a
2015	3.40	n/a
2016	2.76	n/a
2017	5.29	n/a

Table A72. Northeast Fisheries Science Center (NEFSC) Marine Resources Monitoring, Assessment and Prediction program (MARMAP 1978-1986) and Ecosystem Monitoring Program (ECOMON; 1999-2015) larval survey indices of Spawning Stock Biomass (SSB).

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		229.5
2000		509.3
2001		380.8
2002		509.2
2003		544.0
2004		n/a
2005		190.4
2006		476.5
2007		283.1
2008		346.3
2009		479.3
2010		597.4
2011		789.8
2012		495.7
2013		291.4
2014		316.1
2015		683.7

Table A73. Dealer report trawl gear landings (pounds), effort (trips and days fished), days fished per trip (DF/Trip) and nominal landings per day fished (LPUE).

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

Table A73 continued. Dealer report trawl gear landings (pounds), effort (trips and days fished), days fished per trip (DF/Trip) and nominal landings per day fished (LPUE).

Year	Landings	Trips	Days Fished	DF/Trip	Nominal LPUE
2010	7,871,289	13,715	4,804	0.35	1,638
2011	13,858,334	14,491	5,579	0.39	2,484
2012	10,985,335	13,380	5,755	0.43	1,909
2013	10,750,766	13,270	5,133	0.39	2,094
2014	9466706	12,528	5,283	0.42	1,792
2015	9063828	12,262	5,052	0.41	1,794
2016	6598756	12,746	4,290	0.34	1,538
2017	4868853	9,970	3,669	0.37	1,327

Table A74. Year effect parameter estimates (Index; 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	0.561	0.04	0.533	0.590
1965	1.057	0.36	1.016	1.099
1966	0.494	0.04	0.468	0.522
1967	0.451	0.04	0.427	0.477
1968	0.400	0.03	0.376	0.425
1969	0.351	0.03	0.330	0.374
1970	0.359	0.03	0.336	0.383
1971	0.301	0.03	0.283	0.320
1972	0.500	0.07	0.457	0.547
1973	0.594	0.06	0.557	0.634
1974	0.899	0.22	0.859	0.941
1975	0.651	0.05	0.624	0.680
1976	0.884	0.18	0.846	0.923
1977	0.658	0.06	0.629	0.689
1978	0.816	0.10	0.783	0.850
1979	0.813	0.10	0.780	0.848
1980	0.700	0.06	0.669	0.731
1981	0.784	0.09	0.752	0.817
1982	0.859	0.12	0.828	0.892
1983	0.767	0.07	0.740	0.795
1984	0.783	0.07	0.756	0.812
1985	0.827	0.09	0.798	0.856
1986	0.682	0.05	0.658	0.706
1987	0.608	0.04	0.586	0.630
1988	0.628	0.04	0.606	0.651
1989	0.342	0.02	0.328	0.355
1990	0.234	0.01	0.225	0.244
1991	0.303	0.02	0.291	0.315
1992	0.383	0.02	0.369	0.399
1993	0.383	0.02	0.368	0.398
1994	0.505	0.02	0.488	0.522
1995	0.574	0.03	0.556	0.592
1996	0.685	0.04	0.663	0.707
1997	0.599	0.03	0.581	0.618
1998	0.728	0.05	0.706	0.751
1999	0.763	0.06	0.740	0.787
2000	0.889	0.14	0.862	0.918
2001	0.880	0.12	0.853	0.908
2002	1.109	0.15	1.076	1.144
2003	1.158	0.11	1.123	1.194
2004	1.801	0.03	1.745	1.859
2005	1.850	0.03	1.792	1.910
2006	1.521	0.04	1.473	1.571
2007	1.300	0.07	1.257	1.345
2008	1.170	0.11	1.131	1.210

Table A74 continued. Year effect parameter estimates (Index; 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
2009	1.421	0.05	1.375	1.469
2010	1.678	0.03	1.624	1.734
2011	1.746	0.03	1.691	1.804
2012	1.270	0.07	1.229	1.312
2013	1.306	0.06	1.264	1.350
2014	1.127	0.14	1.090	1.165
2015	1.100	0.18	1.064	1.138
2016	0.950	0.33	0.919	0.981
2017	1.000			

Table A75. Vessel Trip report (VTR) trawl gear total catch (landings plus discards in pounds), effort (trips and days fished), and nominal catch per days fished (CPUE).

Year	Total Catch	Trips	Days Fished	Nominal CPUE
1994	5,939,631	9,699	7,965	746
1995	12,409,699	12,852	12,362	1,004
1996	10,641,152	12,262	9,185	1,159
1997	7,162,612	14,276	9,155	782
1998	9,094,256	16,193	10,678	852
1999	9,074,878	17,686	11,776	771
2000	9,660,300	15,854	9,701	996
2001	9,659,316	16,933	9,496	1,017
2002	12,866,048	19,778	10,452	1,231
2003	13,034,298	17,836	8,799	1,481
2004	16,076,388	18,919	9,327	1,724
2005	15,901,575	17,045	9,241	1,721
2006	12,951,765	15,321	8,399	1,542
2007	9,109,678	14,130	6,697	1,360
2008	7,711,220	11,502	5,599	1,377
2009	9,042,244	12,183	5,646	1,602
2010	11,328,834	13,473	5,821	1,946
2011	14,426,363	13,425	6,576	2,194
2012	11,229,349	12,328	6,816	1,648
2013	10,799,446	12,347	6,377	1,694
2014	9,685,345	11,906	6,645	1,457
2015	9,331,482	11,068	6,018	1,551
2016	6,755,752	11,950	5,195	1,300
2017	5,123,217	9,479	4,234	1,210

Table A76. Year effect parameter estimates (Index; 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	0.651	0.036	0.631	0.671
1995	0.699	0.041	0.680	0.720
1996	0.802	0.067	0.779	0.826
1997	0.744	0.049	0.723	0.765
1998	0.990	1.410	0.963	1.018
1999	0.971	0.466	0.945	0.998
2000	1.073	0.199	1.044	1.103
2001	1.146	0.102	1.115	1.177
2002	1.344	0.046	1.309	1.380
2003	1.440	0.038	1.402	1.479
2004	1.625	0.028	1.582	1.668
2005	1.640	0.028	1.597	1.685
2006	1.308	0.053	1.273	1.345
2007	1.243	0.066	1.208	1.278
2008	1.228	0.073	1.192	1.264
2009	1.447	0.040	1.406	1.489
2010	1.633	0.029	1.588	1.680
2011	1.705	0.027	1.658	1.754
2012	1.191	0.084	1.157	1.226
2013	1.129	0.121	1.097	1.162
2014	1.033	0.461	1.003	1.063
2015	1.223	0.074	1.188	1.260
2016	0.980	0.728	0.952	1.009
2017	1.000			

Table A77. Vessel Trip report (VTR) recreational Party/Charter Boat catch (landings plus discards in numbers), effort (trips), and nominal catch per trip (CPUE).

Year	Total Catch	Trips	Nominal CPUE
1994	774,012	6,538	118.39
1995	629,422	6,271	100.37
1996	732,093	6,739	108.64
1997	674,502	7,326	92.07
1998	709,931	8,006	88.67
1999	902,077	7,896	114.24
2000	723,734	8,443	85.72
2001	462,476	7,154	64.65
2002	423,902	6,654	63.71
2003	443,094	6,982	63.46
2004	355,939	6,026	59.07
2005	363,276	5,763	63.04
2006	282,551	5,698	49.59
2007	370,352	6,457	57.36
2008	357,833	5,675	63.05
2009	402,770	6,274	64.20
2010	700,373	7,981	87.76
2011	694,609	8,122	85.52
2012	498,073	7,875	63.25
2013	561,487	7,921	70.89
2014	574,526	7,834	73.34
2015	514,734	8,293	62.07
2016	429,835	7,707	55.77
2017	281,911	6,599	42.72

Table A78. 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	2.46	0.06	2.19	2.76
1995	1.43	0.07	1.25	1.62
1996	1.70	0.06	1.49	1.93
1997	1.54	0.06	1.36	1.75
1998	1.57	0.06	1.38	1.78
1999	1.58	0.06	1.39	1.80
2000	1.41	0.06	1.25	1.60
2001	1.36	0.03	1.27	1.45
2002	1.28	0.03	1.20	1.36
2003	1.32	0.03	1.24	1.40
2004	1.31	0.03	1.23	1.40
2005	1.42	0.03	1.33	1.51
2006	1.62	0.04	1.51	1.75
2007	1.84	0.03	1.74	1.95
2008	1.72	0.04	1.61	1.85
2009	1.96	0.03	1.84	2.09
2010	2.48	0.04	2.31	2.66
2011	2.36	0.03	2.23	2.51
2012	1.44	0.03	1.35	1.52
2013	1.15	0.03	1.07	1.22
2014	1.13	0.04	1.05	1.22
2015	1.17	0.04	1.09	1.26
2016	1.03	0.04	0.95	1.11
2017	1.00			

Table A79. Observed trawl gear trips, hauls, total catch (landings plus discards in pounds), effort (days fished), and nominal catch per days fished (CPUE).

Year	Trips	Hauls	Total Catch (lbs)	Days Fished	Nominal CPUE
1989	57	415	53,290	37	1,457
1990	61	467	48,304	37	1,312
1991	95	724	65,836	67	981
1992	67	614	124,825	64	1,942
1993	43	402	74,745	42	1,776
1994	52	585	177,058	69	2,577
1995	131	1,013	244,586	114	2,144
1996	111	658	103,820	64	1,615
1997	60	349	32,628	38	850
1998	53	333	74,215	37	2,030
1999	59	383	57,164	43	1,345
2000	89	562	144,383	64	2,267
2001	135	566	106,292	53	2,002
2002	166	811	139,652	84	1,660
2003	212	1,328	239,821	151	1,592
2004	582	2,930	611,572	301	2,030
2005	1,026	7,588	939,706	919	1,022
2006	541	4,039	544,045	501	1,087
2007	625	3,742	705,502	438	1,611
2008	558	2,909	488,495	329	1,485
2009	768	4,127	617,686	438	1,412
2010	638	2,836	830,126	299	2,780
2011	571	3,408	781,893	363	2,155
2012	378	1,851	483,179	219	2,209
2013	517	2,191	444,471	225	1,978
2014	731	3,211	577,215	320	1,802
2015	588	2,540	596,209	255	2,335
2016	817	3,030	431,619	286	1,507
2017	1,240	4,912	656,076	287	2,283

Table A80. Year effect parameter estimates (Index; 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	0.543	0.16	0.401	0.735
1990	0.499	0.15	0.372	0.671
1991	0.642	0.12	0.506	0.815
1992	0.704	0.15	0.529	0.937
1993	0.685	0.18	0.485	0.966
1994	1.175	0.16	0.856	1.613
1995	0.641	0.11	0.522	0.788
1996	0.500	0.11	0.401	0.624
1997	0.305	0.15	0.227	0.409
1998	0.714	0.16	0.520	0.980
1999	0.889	0.16	0.654	1.210
2000	1.812	0.13	1.405	2.338
2001	1.227	0.11	0.999	1.507
2002	1.470	0.10	1.218	1.774
2003	1.358	0.09	1.150	1.604
2004	1.750	0.06	1.564	1.958
2005	1.578	0.05	1.433	1.739
2006	1.471	0.06	1.308	1.654
2007	1.873	0.06	1.676	2.092
2008	1.495	0.06	1.331	1.679
2009	1.933	0.05	1.739	2.148
2010	1.799	0.06	1.612	2.008
2011	1.551	0.06	1.384	1.739
2012	1.160	0.07	1.016	1.324
2013	1.257	0.06	1.119	1.412
2014	1.165	0.05	1.050	1.292
2015	1.436	0.06	1.285	1.605
2016	1.062	0.05	0.961	1.173
2017	1.000	0.00	1.000	1.000

Table A81. Observed scallop dredge gear catch (landings plus discards in pounds), effort (days fished), and nominal catch per days fished (CPUE).

Year	Total Catch	Trips	Hauls	Days Fished	Nominal CPUE
1992	1,477	9	178	5	279
1993	2,966	15	671	19	155
1994	5,811	14	651	28	210
1995	10,085	19	1054	45	224
1996	9,609	24	1089	49	197
1997	8,376	24	959	41	204
1998	1,978	22	362	15	129
1999	3,199	10	247	10	312
2000	12,567	77	1076	45	281
2001	12,013	69	1643	68	176
2002	25,739	76	2514	118	217
2003	37,021	79	3248	151	246
2004	76,729	168	5651	255	300
2005	40,010	156	4091	186	215
2006	35,042	124	2748	119	296
2007	51,311	195	3549	142	362
2008	81,232	298	6895	283	287
2009	72,561	291	7916	347	209
2010	64,610	187	6102	275	235
2011	66,294	205	5925	272	244
2012	65,937	251	7951	354	186
2013	41,409	217	4681	208	199
2014	48,798	204	5463	243	201
2015	22,783	183	3424	153	149
2016	43,324	281	5,610	264	164
2017	55,271	268	5,147	247	223

Table A82. 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	Negbin	Negbin L95CI	Negbin U95CI
1992	0.536	0.325	0.884
1993	0.648	0.440	0.954
1994	0.765	0.509	1.148
1995	0.697	0.493	0.987
1996	0.715	0.523	0.977
1997	0.614	0.447	0.844
1998	0.651	0.471	0.900
1999	1.248	0.780	1.996
2000	1.245	1.025	1.511
2001	0.648	0.531	0.791
2002	0.817	0.674	0.991
2003	0.915	0.758	1.105
2004	1.111	0.960	1.287
2005	1.140	0.980	1.326
2006	1.110	0.944	1.305
2007	1.417	1.230	1.631
2008	1.201	1.058	1.362
2009	0.982	0.865	1.114
2010	1.174	1.019	1.352
2011	1.080	0.939	1.243
2012	0.832	0.730	0.948
2013	0.727	0.635	0.832
2014	0.743	0.647	0.853
2015	0.624	0.542	0.719
2016	0.793	0.699	0.898
2017	1.000		

Table A83. MRFSS/MRIP recreational intercept total catch in numbers, angler trips, and nominal catch per trip (CPUE).

Year	Total Catch	Angler Trips	Nominal CPUE
1981	8,595	3,646	2.36
1982	8,915	3,964	2.25
1983	13,711	4,518	3.03
1984	8,418	2,918	2.88
1985	5,326	3,548	1.50
1986	14,690	5,250	2.80
1987	13,775	4,221	3.26
1988	12,969	5,596	2.32
1989	4,619	5,366	0.86
1990	14,655	8,369	1.75
1991	23,930	11,309	2.12
1992	21,098	10,125	2.08
1993	26,326	9,266	2.84
1994	21,776	10,898	2.00
1995	15,408	7,126	2.16
1996	20,989	8,778	2.39
1997	21,228	8,876	2.39
1998	25,970	10,105	2.57
1999	25,408	8,247	3.08
2000	23,861	8,328	2.87
2001	35,705	11,573	3.09
2002	24,141	9,312	2.59
2003	26,969	10,778	2.50
2004	23,020	9,767	2.36
2005	23,188	9,381	2.47
2006	16,423	7,135	2.30
2007	21,723	8,856	2.45
2008	20,132	7,904	2.55
2009	20,946	7,546	2.78
2010	21,816	7,728	2.82
2011	19,232	6,731	2.86
2012	14,284	6,243	2.29
2013	17,641	7,686	2.30
2014	22276	8555	2.60
2015	21150	9098	2.32
2016	18219	8360	2.18
2017	17899	8979	1.99

Table A84. Year effect parameter estimates (Index; 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 recreational intercept six-factor negbin YEAR-WAVE-STATE-BOAT-SIZE-BAG model.

Year	Index	CV	L95CI	U95CI
1981	1.10	0.03	1.03	1.16
1982	1.09	0.03	1.04	1.16
1983	1.75	0.03	1.66	1.84
1984	1.54	0.03	1.45	1.64
1985	0.83	0.03	0.78	0.88
1986	1.31	0.03	1.24	1.37
1987	1.55	0.03	1.47	1.63
1988	1.15	0.03	1.10	1.21
1989	0.43	0.03	0.40	0.45
1990	0.87	0.02	0.83	0.91
1991	1.03	0.02	0.99	1.08
1992	1.05	0.02	1.00	1.09
1993	1.38	0.02	1.32	1.44
1994	0.97	0.02	0.93	1.01
1995	1.08	0.02	1.03	1.13
1996	1.15	0.02	1.10	1.20
1997	1.16	0.02	1.11	1.21
1998	1.28	0.02	1.23	1.34
1999	1.50	0.02	1.43	1.56
2000	1.45	0.02	1.39	1.52
2001	1.42	0.02	1.37	1.48
2002	1.24	0.02	1.18	1.29
2003	1.20	0.02	1.15	1.25
2004	1.16	0.02	1.11	1.21
2005	1.27	0.02	1.22	1.33
2006	1.14	0.02	1.09	1.19
2007	1.20	0.02	1.15	1.25
2008	1.22	0.02	1.16	1.27
2009	1.34	0.02	1.28	1.40
2010	1.38	0.02	1.32	1.44
2011	1.35	0.02	1.29	1.42
2012	1.09	0.02	1.04	1.14
2013	1.16	0.02	1.11	1.21
2014	1.25	0.02	1.20	1.31
2015	1.11	0.02	1.06	1.16
2016	1.07	0.02	1.02	1.12
2017	1.00			

Table A85. NEFSC Study Fleet annual average catch-per-unit effort (CPUE) indices for summer flounder. Percentages represent 'directed' trips where summer flounder comprised equal to or more than the indicated percentage of the total catch.

Year	lbs/hr	lbs/km^2	10% (lbs/hr)	25% (lbs/hr)	40% (lbs/hr)	75% (lbs/hr)
2007	1.3279	95.7478	16.3387	21.2812	N/A	N/A
2008	5.1411	41.3183	32.6249	28.3100	25.2338	25.5097
2009	14.0393	81.9262	58.2136	74.8114	65.9642	65.6433
2010	27.6774	148.3422	37.4087	35.7048	37.9091	36.3724
2011	15.4636	237.0568	46.1111	36.9505	37.5608	59.5981
2012	39.8006	302.0121	92.5633	156.9937	171.6645	162.0571
2013	102.2942	431.0965	102.5425	122.0141	126.7380	167.3110
2014	86.6967	315.8634	119.6207	139.5533	144.9765	163.3192
2015	45.5360	294.9770	88.7930	105.7304	108.5060	131.4495
2016	40.7195	285.0096	92.7333	118.6849	125.2438	162.2700
2017	44.6563	207.0510	76.9731	100.3619	105.6362	117.4558

Table A86. Summer flounder estimated maturity at age using a sexes combined, three-year moving window ogive compiled from the NEFSC 1982-2016 fall survey data with resting females removed.

	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	0.32	0.78	0.96	0.99	1.00	1.00	1.00	1.00
2013	0.33	0.79	0.97	1.00	1.00	1.00	1.00	1.00
2014	0.32	0.80	0.97	1.00	1.00	1.00	1.00	1.00
2015	0.21	0.74	0.97	1.00	1.00	1.00	1.00	1.00
2016	0.11	0.65	0.97	1.00	1.00	1.00	1.00	1.00

Age	0	1	2	3	4	5	6	7+
average	0.29	0.86	0.99	1.00	1.00	1.00	1.00	1.00
std	0.10	0.08	0.01	0.00	0.00	0.00	0.00	0.00
CV	0.33	0.10	0.01	0.00	0.00	0.00	0.00	0.00
5 year mean	0.26	0.75	0.97	1.00	1.00	1.00	1.00	1.00

Table A87. 2018 SAW-66 assessment 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; F2018_BASE_V2 model run.

Year	SSB	R	F
1982	30,451	81,955	0.744
1983	28,896	102,427	1.074
1984	24,266	46,954	1.228
1985	21,797	78,263	1.256
1986	22,185	81,397	1.331
1987	22,913	53,988	1.282
1988	12,572	12,474	1.622
1989	7,408	36,963	1.286
1990	12,121	44,019	0.856
1991	14,072	47,704	1.063
1992	13,077	47,264	1.179
1993	14,543	43,928	1.006
1994	15,916	58,403	0.958
1995	21,103	78,348	1.445
1996	28,923	59,520	1.156
1997	35,649	52,374	0.758
1998	35,365	54,518	0.781
1999	36,344	44,100	0.565
2000	41,262	60,551	0.673
2001	52,588	64,979	0.448
2002	61,339	67,860	0.411
2003	69,153	50,131	0.394
2004	64,394	71,270	0.419
2005	60,941	40,634	0.434
2006	64,754	48,153	0.320
2007	63,850	52,646	0.245
2008	64,312	62,460	0.314
2009	65,969	73,747	0.336
2010	64,519	51,331	0.372
2011	59,019	31,296	0.431
2012	63,401	35,187	0.401
2013	56,052	36,719	0.452
2014	51,785	42,271	0.418
2015	45,930	29,833	0.416
2016	43,000	35,853	0.417
2017	44,552	42,415	0.334

Table A88. 2018 SAW-66 assessment fishing mortality (F) estimates at age; F2018_BASE_V2 model run.

	Age							
	0	1	2	3	4	5	6	7+
1982	0.029	0.417	0.948	0.821	0.744	0.656	0.644	0.820
1983	0.044	0.633	1.396	1.184	1.074	0.951	0.948	1.204
1984	0.045	0.665	1.535	1.356	1.228	1.078	1.046	1.334
1985	0.045	0.663	1.568	1.389	1.256	1.103	1.069	1.364
1986	0.051	0.740	1.678	1.470	1.331	1.171	1.143	1.456
1987	0.048	0.703	1.602	1.416	1.282	1.126	1.092	1.393
1988	0.056	0.832	1.983	1.795	1.622	1.418	1.353	1.730
1989	0.061	0.717	1.631	1.449	1.286	1.119	1.045	1.337
1990	0.062	0.633	1.205	0.974	0.856	0.755	0.733	0.930
1991	0.050	0.656	1.370	1.179	1.063	0.936	0.914	1.163
1992	0.093	0.899	1.694	1.353	1.179	1.037	1.000	1.269
1993	0.061	0.715	1.348	1.125	1.006	0.888	0.869	1.103
1994	0.068	0.705	1.341	1.088	0.958	0.844	0.821	1.041
1995	0.023	0.188	0.917	1.488	1.445	1.262	1.201	1.045
1996	0.022	0.159	0.748	1.197	1.156	0.982	0.944	0.850
1997	0.014	0.104	0.485	0.782	0.758	0.625	0.608	0.554
1998	0.015	0.115	0.509	0.811	0.781	0.641	0.626	0.573
1999	0.015	0.109	0.406	0.605	0.565	0.473	0.462	0.427
2000	0.016	0.117	0.465	0.712	0.673	0.555	0.543	0.503
2001	0.012	0.093	0.328	0.483	0.448	0.376	0.369	0.335
2002	0.009	0.073	0.286	0.436	0.411	0.351	0.340	0.304
2003	0.011	0.080	0.286	0.424	0.394	0.332	0.324	0.295
2004	0.010	0.076	0.294	0.446	0.419	0.356	0.345	0.312
2005	0.011	0.083	0.311	0.465	0.434	0.371	0.360	0.325
2006	0.009	0.065	0.235	0.345	0.320	0.272	0.265	0.242
2007	0.009	0.066	0.201	0.275	0.245	0.209	0.205	0.192
2008	0.008	0.038	0.105	0.200	0.314	0.288	0.281	0.207
2009	0.009	0.043	0.118	0.221	0.336	0.306	0.298	0.221
2010	0.011	0.050	0.136	0.248	0.372	0.336	0.327	0.242
2011	0.011	0.050	0.142	0.277	0.431	0.398	0.390	0.286
2012	0.010	0.042	0.119	0.243	0.401	0.375	0.369	0.268
2013	0.012	0.049	0.136	0.272	0.452	0.420	0.414	0.300
2014	0.011	0.049	0.134	0.258	0.418	0.384	0.377	0.275
2015	0.011	0.046	0.131	0.261	0.416	0.386	0.379	0.277
2016	0.011	0.045	0.127	0.253	0.417	0.388	0.381	0.277
2017	0.009	0.043	0.115	0.213	0.334	0.303	0.295	0.217

Table A89. 2018 SAW-66 assessment January 1 population number (000s) estimates at age; F2018_BASE_V2 model run.

	Age								
	0	1	2	3	4	5	6	7+	Total
1982	81,955	56,043	25,826	3,204	1,102	370	222	252	168,973
1983	102,427	61,401	28,486	7,718	1,098	408	149	178	201,865
1984	46,954	75,541	25,145	5,436	1,840	292	123	87	155,417
1985	78,263	34,603	29,969	4,176	1,091	420	77	52	148,650
1986	81,397	57,712	13,745	4,815	811	242	109	31	158,861
1987	53,988	59,653	21,238	1,979	862	167	58	33	137,978
1988	12,474	39,674	22,770	3,300	374	186	42	22	78,842
1989	36,963	9,098	13,316	2,417	427	58	35	11	62,325
1990	44,019	26,825	3,426	2,009	442	92	15	12	76,839
1991	47,704	31,915	10,988	791	591	146	34	9	92,177
1992	47,264	34,992	12,775	2,154	190	159	45	13	97,591
1993	43,928	33,221	10,976	1,811	434	45	44	16	90,474
1994	58,403	31,857	12,529	2,199	458	123	15	18	105,602
1995	78,348	42,085	12,141	2,528	577	137	41	10	135,867
1996	59,520	59,020	26,897	3,740	445	106	30	12	149,771
1997	52,374	44,901	38,815	9,819	880	109	31	13	146,942
1998	54,518	39,840	31,214	18,434	3,497	321	45	19	147,889
1999	44,100	41,416	27,383	14,465	6,378	1,247	132	27	135,148
2000	60,551	33,485	28,640	14,065	6,151	2,824	605	79	146,399
2001	64,979	45,942	22,959	13,869	5,376	2,444	1,263	311	157,143
2002	67,860	49,508	32,263	12,752	6,661	2,674	1,306	855	173,881
2003	50,131	51,834	35,494	18,696	6,424	3,439	1,466	1,221	168,704
2004	71,270	38,248	36,908	20,554	9,533	3,374	1,922	1,540	183,349
2005	40,634	54,397	27,325	21,199	10,250	4,882	1,841	1,947	162,474
2006	48,153	30,983	38,583	15,435	10,373	5,171	2,624	2,107	153,429
2007	52,646	36,801	22,377	23,528	8,511	5,865	3,069	2,870	155,667
2008	62,460	40,214	26,566	14,106	13,919	5,188	3,708	3,810	169,971
2009	73,747	47,752	29,853	18,451	8,993	7,920	3,029	4,616	194,362
2010	51,331	56,339	35,276	20,465	11,526	5,006	4,541	4,663	189,147
2011	31,296	39,164	41,305	23,746	12,433	6,189	2,786	5,429	162,348
2012	35,187	23,863	28,729	27,637	14,014	6,294	3,239	4,678	143,640
2013	36,719	26,860	17,651	19,665	16,878	7,311	3,370	4,560	133,014
2014	42,271	27,983	19,726	11,882	11,664	8,365	3,739	4,393	130,023
2015	29,833	32,228	20,540	13,304	7,146	5,982	4,436	4,623	118,093
2016	35,853	22,759	23,727	13,886	7,981	3,672	3,169	5,123	116,170
2017	42,415	27,346	16,770	16,119	8,398	4,096	1,941	4,742	121,825

Table A90. Input data and assumptions for the biological reference point estimates from the 2018 Stock Assessment Workshop (SAW) 66 benchmark stock assessment using the F2018_BASE_V2 model run.

2018 SAW-66	**2013-2017**
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	0.03	0.20	0.26	0.10	0.090	0.148	0.201	0.26	0.26	0.33
1	0.11	0.20	0.26	0.10	0.236	0.358	0.431	0.14	0.78	0.07
2	0.32	0.20	0.26	0.10	0.475	0.633	0.693	0.11	0.97	0.01
3	0.62	0.20	0.25	0.10	0.725	0.834	0.895	0.18	1.00	0.01
4	1.00	0.20	0.25	0.10	0.927	1.053	1.137	0.18	1.00	0.01
5	0.92	0.20	0.25	0.10	1.182	1.366	1.413	0.20	1.00	0.01
6	0.91	0.20	0.25	0.10	1.437	1.606	1.758	0.20	1.00	0.01
7+	0.66	0.20	0.24	0.10	1.841	1.964	1.964	0.20	1.00	0.01

Jan 1	Stock	Weights	0.090	0.236	0.475	0.725	0.927	1.182	1.437	1.841
Jul 1	Catch	Weights	0.148	0.358	0.633	0.834	1.053	1.366	1.606	1.964
Nov 1	SSB	Weights	0.201	0.431	0.693	0.895	1.137	1.413	1.758	1.964
2013-2017	Landings	Weights	0.135	0.539	0.742	0.912	1.130	1.409	1.630	1.930
2013-2017	Discards	Weights	0.148	0.329	0.524	0.648	0.778	1.159	1.551	2.292

Table A91. Biological reference point estimates from this 2018 Stock Assessment Workshop (SAW) 66 benchmark stock assessment compared with estimates from the previous 2008 (NEFSC 2008) and 2013 (NEFSC 2013) benchmark assessments. FSMY = Fishing mortality rate at Maximum Sustainable Yield; MSY = Maximum Sustainable Yield; SSBMSY = Spawning Stock Biomass at Maximum Sustainable Yield, Fterm = Fishing mortality rate in the last year of the assessment; Yterm = Yield in the last year of the assessment; SSBterm = Spawning Stock Biomass in the last year of the assessment.

Assessment Model	2008 SAW47 ASAP SCAA	2013 SAW57 ASAP SCAA	2018 SAW-66 ASAP SCAA Recommended	2018 SAW-66 ASAP SCAA Alternative
NON-PARAMETRIC	(deterministic)	(stochastic)	(stochastic)	(stochastic)
Natural mortality (M)	0.25	0.25	0.25	0.25
Median R (000s)	41,553	40,237	50,731	35,853
FMSY Proxy	F35%	F35% (5%ile, 95%ile)	F35% (5%ile, 95%ile)	F35% (5%ile, 95%ile)
FMSY	0.310	0.309 (0.247,0.390)	0.448 (0.338,0.577)	0.448 (0.338,0.577)
Y/R (kg)	0.358	0.303 (0.256, 0.358)	0.301 (0.259, 0.344)	0.301 (0.259, 0.344)
SSB/R (kg)	1.443	1.449 (1.165, 1.856)	1.099 (0.905, 1.342)	1.099 (0.905, 1.342)
MSY (mt)	13,122	12,945 (10,387, 15,997)	15,973 (12,509, 20,298)	10,920 (9,399, 12,695)
SSBMSY(mt)	60,074	62,394 (50,044, 77,273)	57,159 (44,190, 73,088)	39,079 (32,951, 46,154)
PARAMETRIC				
Internal Beverton-Holt	L = 0.05	L = 1; CV = 0.9	L = 1; CV = 1.0	L = 1; CV = 1.0
R0	39,140	40,993	50,455	50,455
SSB0	189,729	140,382	145,924	145,924
Steepness	0.999	0.998	0.995	0.995
FMSY	0.420	3.000	1.334	1.334
MSY	14,686	13,841	17,047	17,047
SSBMSY	43,898	11,423	26,583	26,583

Table A92. Summary of stock status using the biological reference point estimates from this 2018 Stock Assessment Workshop (SAW) 66 benchmark stock assessment compared with estimates from the previous 2008 (NEFSC 2008) and 2013 (NEFSC 2013) benchmark assessments and the 2016 assessment update (Terceiro2016). FSMY = Fishing mortality rate at Maximum Sustainable Yield; MSY = Maximum Sustainable Yield; SSBMSY = Spawning Stock Biomass at Maximum Sustainable Yield, Fterm = Fishing mortality rate in the last year of the assessment; Yterm = Yield in the last year of the assessment; SSBterm = Spawning Stock Biomass in the last year of the assessment.

Assessment Model	2008_SAW47 ASAP SCAA M=0.25 Full F = age 3+	2013_SAW57 ASAP SCAA M=0.25 Full F = age 4	2016 Update ASAP SCAA M=0.25 Full F = age 4	2018 SAW-66 ASAP SCAA Recommended M=0.25 Full F = age 4	2018 SAW-66 ASAP SCAA Alternative M=0.25 Full F = age 4
FMSY or Proxy	F35%	F35%	F35%	F35%	F35%
FMSY	0.310	0.309	0.309	0.448	0.448
MSY (mt)	13,122	12,945	12,945	15,973	10,920
SSBMSY(mt)	60,074	62,394	62,394	57,159	39,079
Fterm	0.288	0.285	0.390	0.334	0.334
Yterm	10,368	10,433	8,285	9,611	9,611
SSBterm	43,363	51,238	36,240	44,552	44,552
Fterm/FMSY	0.93	0.92	1.26	0.75	0.75
Yterm/MSY	0.79	0.81	0.64	0.60	0.88
SSBterm/SSBMSY	0.72	0.82	0.58	0.78	1.14

Table A93. 2018 Summer flounder SAW-66 benchmark assessment OFL Projections for 2019-2023. Projections using the 2018 SAW-66 benchmark assessment model (data through 2017) were made to estimate the OFL catches for 2019-2023. The projections assume that 100% of the 2018 ABC (5,999 mt = 13.226 million lb) will be caught. The OFL projection uses F2019-F2023 = FMSY proxy = F35% = 0.448. The recommended catches (top table) are from projections that sample from the estimated recruitment for 1982-2017 (R36; median = 51 million). The alternative catches (bottom table) are from projections that sample from the estimated recruitment for 2011-2017 (R7: median = 36 million).

R36: The OFL projection uses F2019-F2023 = FMSY proxy = F35% = 0.448 and samples from the estimated recruitment for **1982-2017 (median R = 51 million; SSB35% = 57,159 mt)**.

OFL Total Catch, Landings, Discards, Fishing Mortality (F)
and Spawning Stock Biomass (SSB) in 2018-2023
Catches and SSB in metric tons

Year	Total Catch	Landings	Discards	F	SSB
2018	5,999	4,628	1,371	0.194	49,827
2019	14,208	10,832	3,376	0.448	50,922
2020	14,040	10,567	3,473	0.448	52,323
2021	14,411	10,830	3,581	0.448	53,783
2022	14,912	11,261	3,651	0.448	54,877
2023	15,335	11,605	3,730	0.448	55,724

R7: The OFL projection uses F2019-F2023 = FMSY proxy = F35% = 0.448 and samples from the estimated recruitment for **2011-2017 (median R = 36 million; SSB35% = 39,079 mt)**.

OFL Total Catch, Landings, Discards, Fishing Mortality (F)
and Spawning Stock Biomass (SSB) in 2018-2023
Catches and SSB in metric tons

Year	Total Catch	Landings	Discards	F	SSB
2018	5,999	4,628	1,371	0.194	49,827
2019	14,175	10,828	3,347	0.448	50,213
2020	13,783	10,495	3,288	0.448	48,386
2021	13,402	10,296	3,106	0.448	45,475
2022	12,790	9,857	2,933	0.448	43,154
2023	12,082	9,275	2,807	0.448	41,644

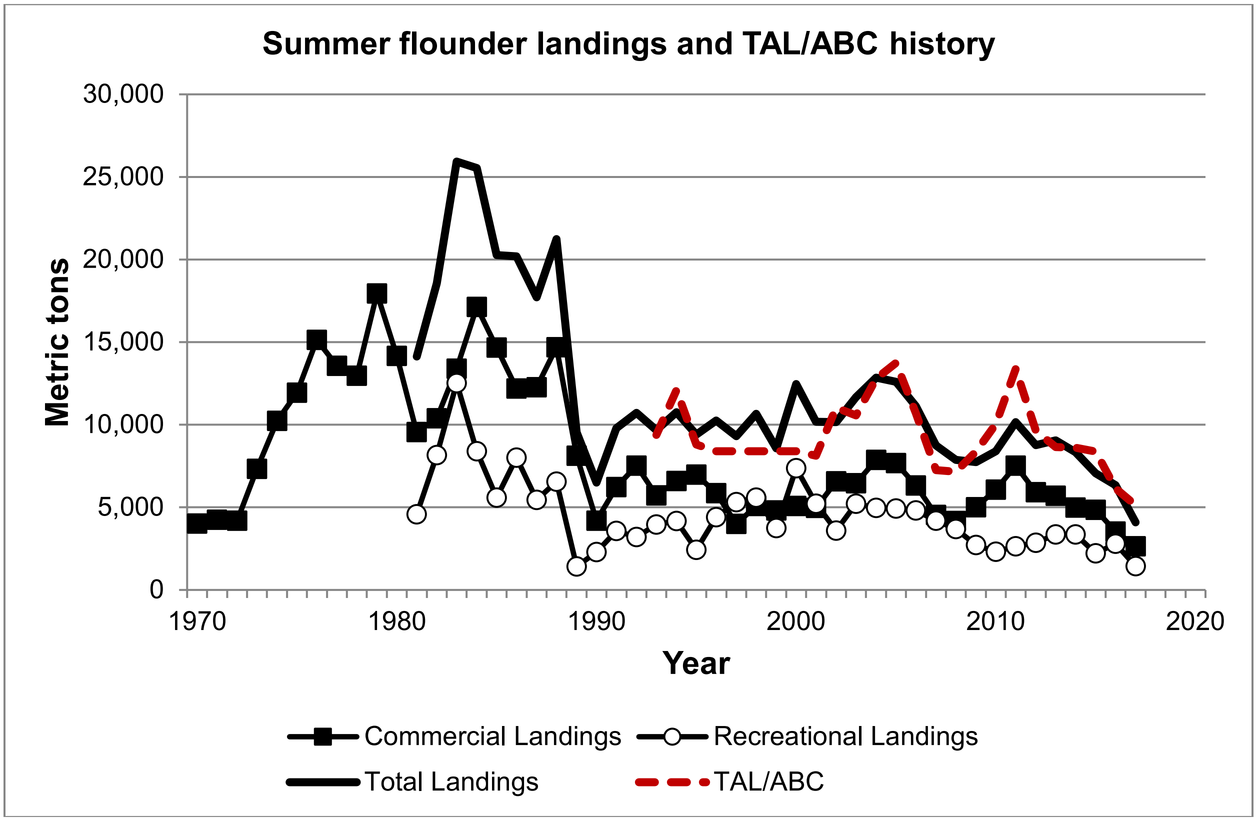


Figure A1. Summer flounder recent commercial (1970-2017), recreational (1981-2017), total fishery (1981-2017) landings history for summer flounder. TAL/ABC is the Total Allowable Landings / Acceptable Biological Catch under the management system established in 1993 that includes the commercial fishery quota and recreational harvest limit.

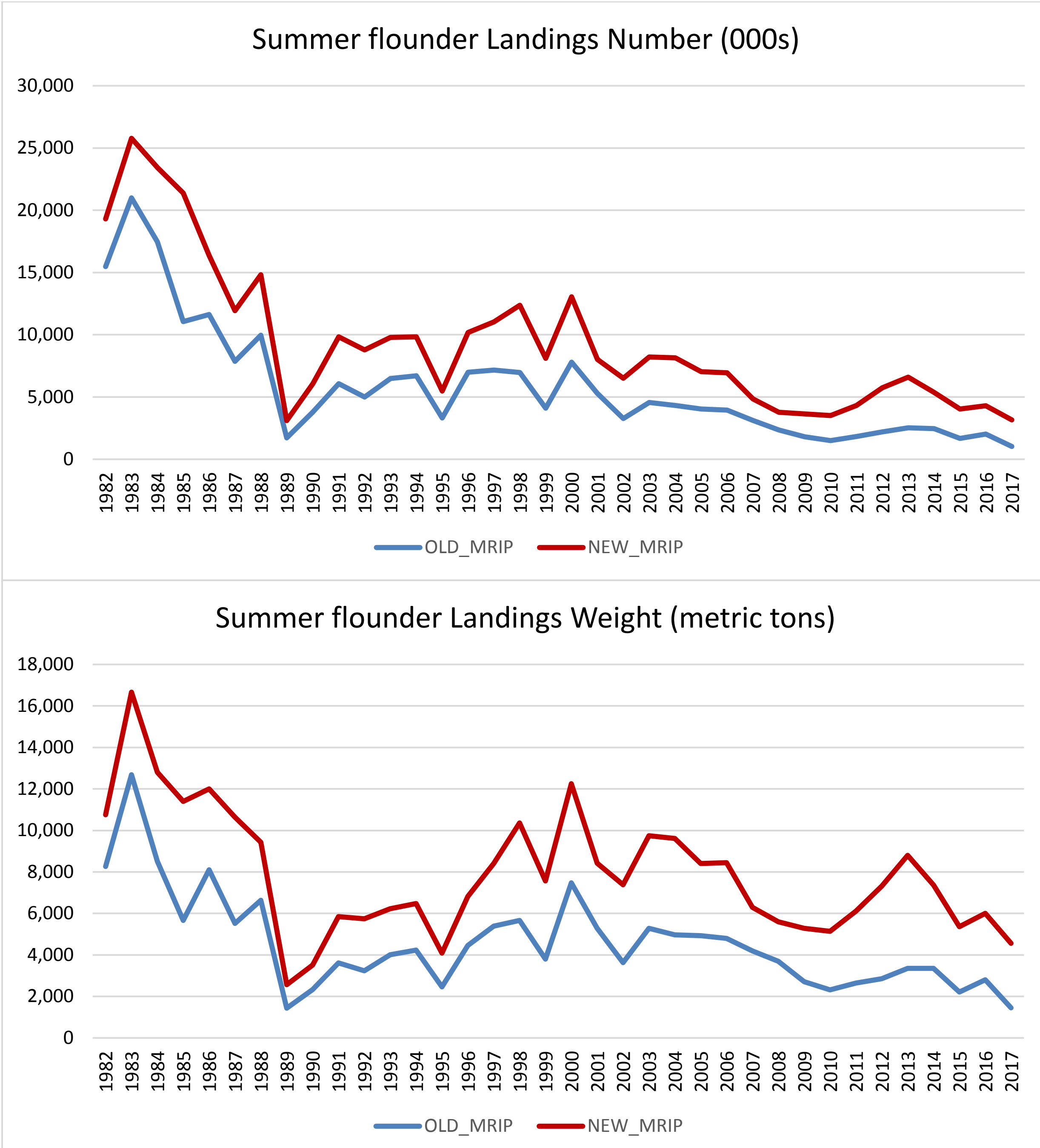


Figure A2. Comparison of summer flounder recreational fishery landings numbers (top; thousands of fish, 000s) and landings weight (metric tons) from the 'Old' and 'New' Marine Recreational Information Program (MRIP) estimates.

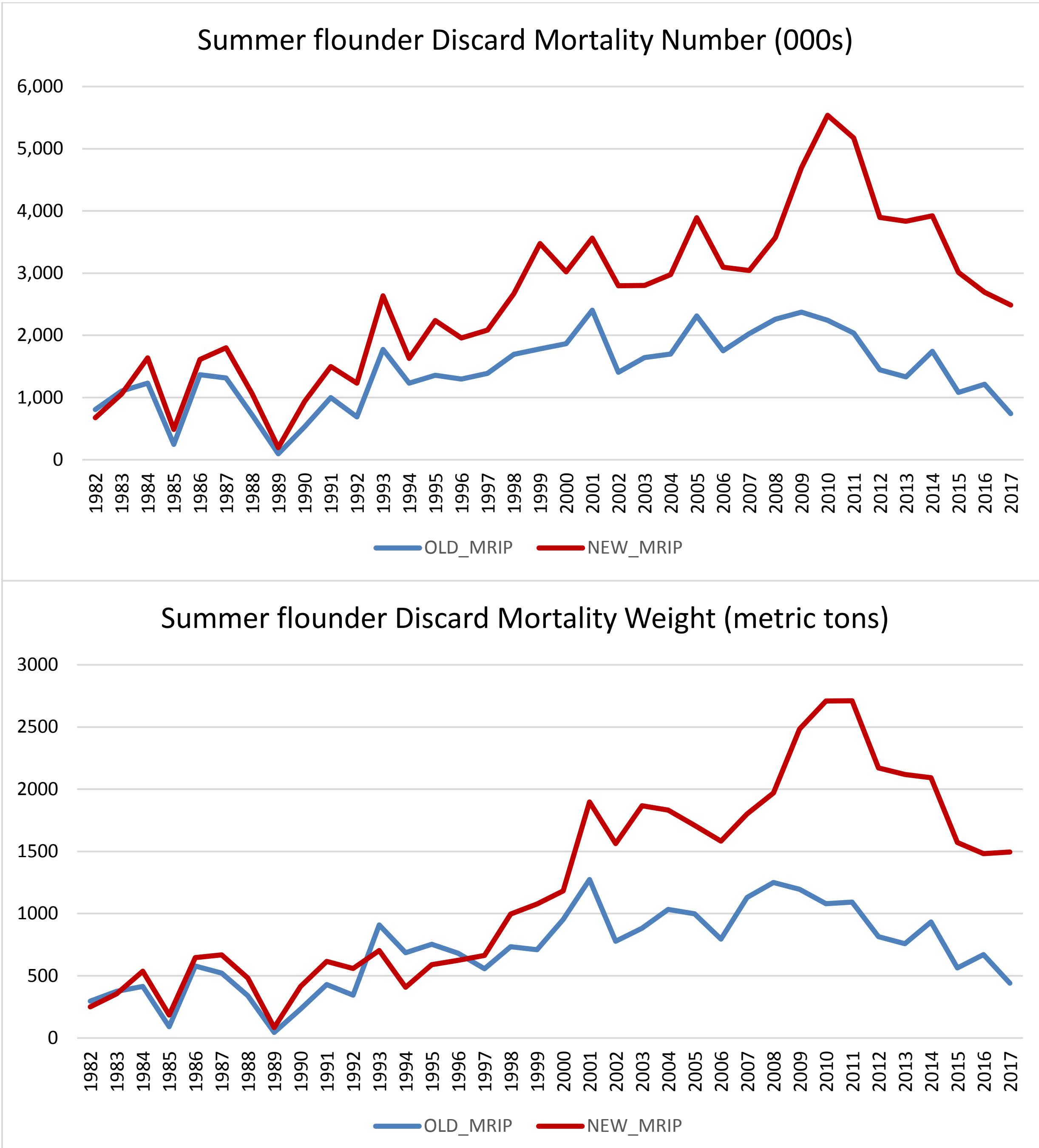


Figure A3. Comparison of summer flounder recreational fishery discards numbers (top; thousands of fish, 000s) and discards weight (metric tons) from the ‘Old’ and ‘New’ Marine Recreational Information Program (MRIP) estimates.

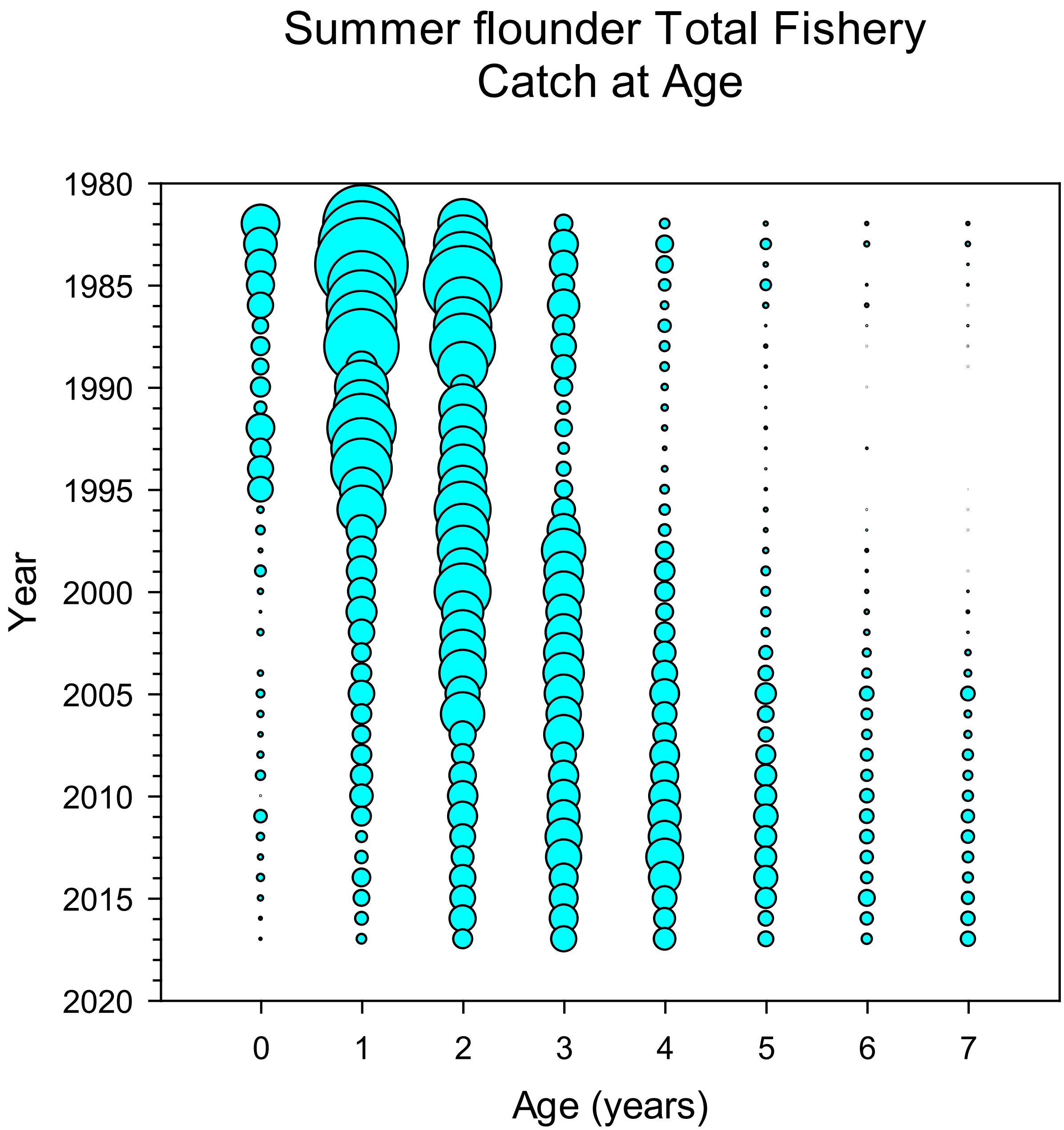


Figure A4. Total fishery catch at age for summer flounder – 'New' Marine Recreational Information Program (MRIP).

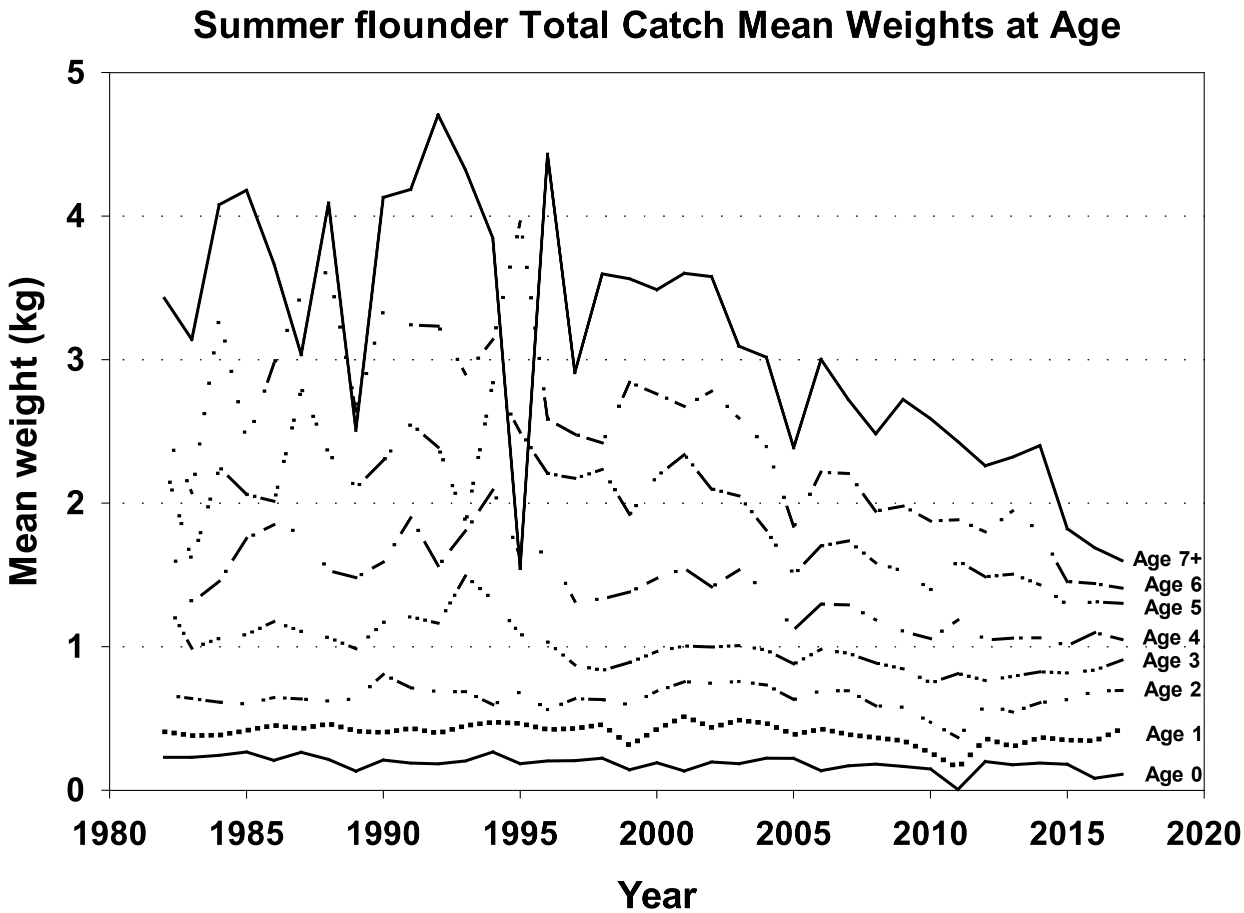


Figure A5. Mean weight at age in the total fishery catch of summer flounder –'New' Marine Recreational Information Program (MRIP).

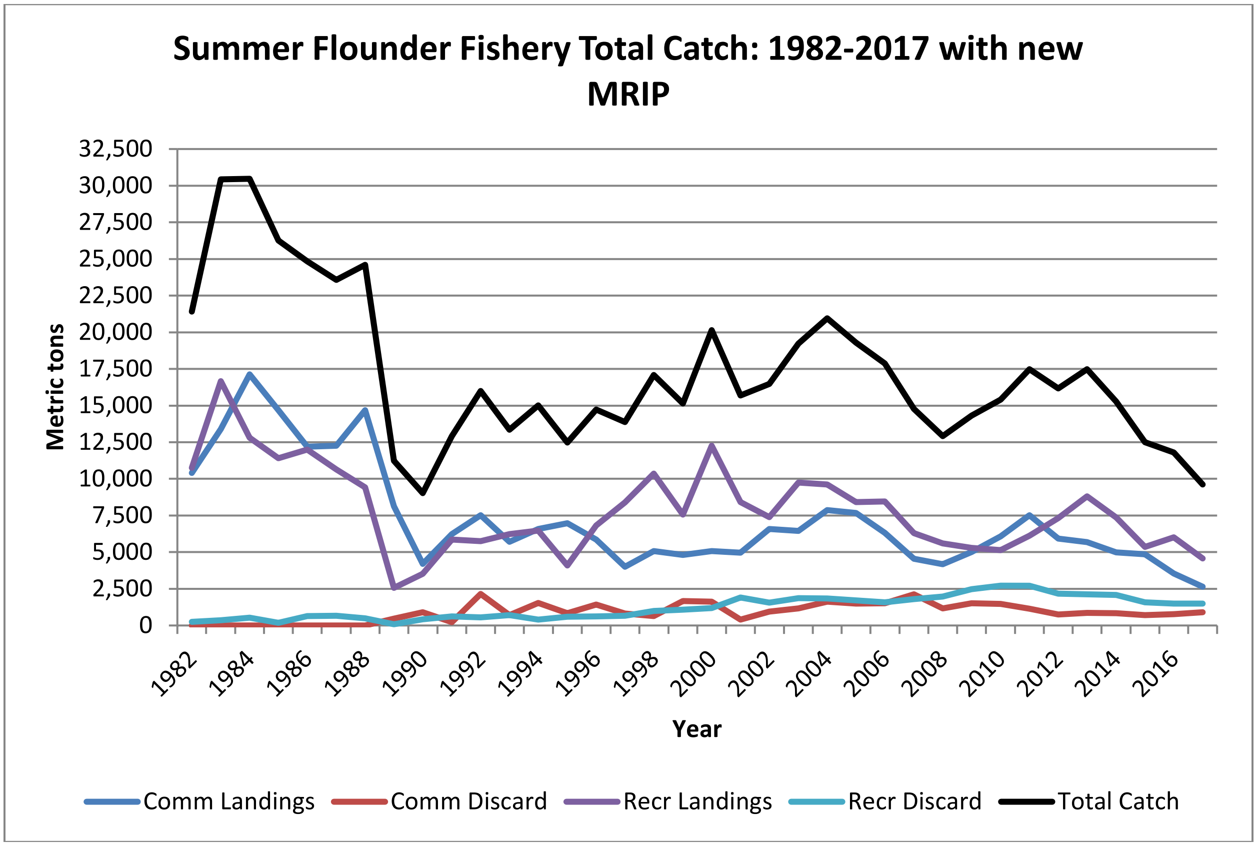


Figure A6. Summer flounder fishery total catch included in the assessment model. Components are commercial landings, commercial discards, recreational landings, and recreational discards from the 'New' Marine Recreational Information Program (MRIP) estimates.

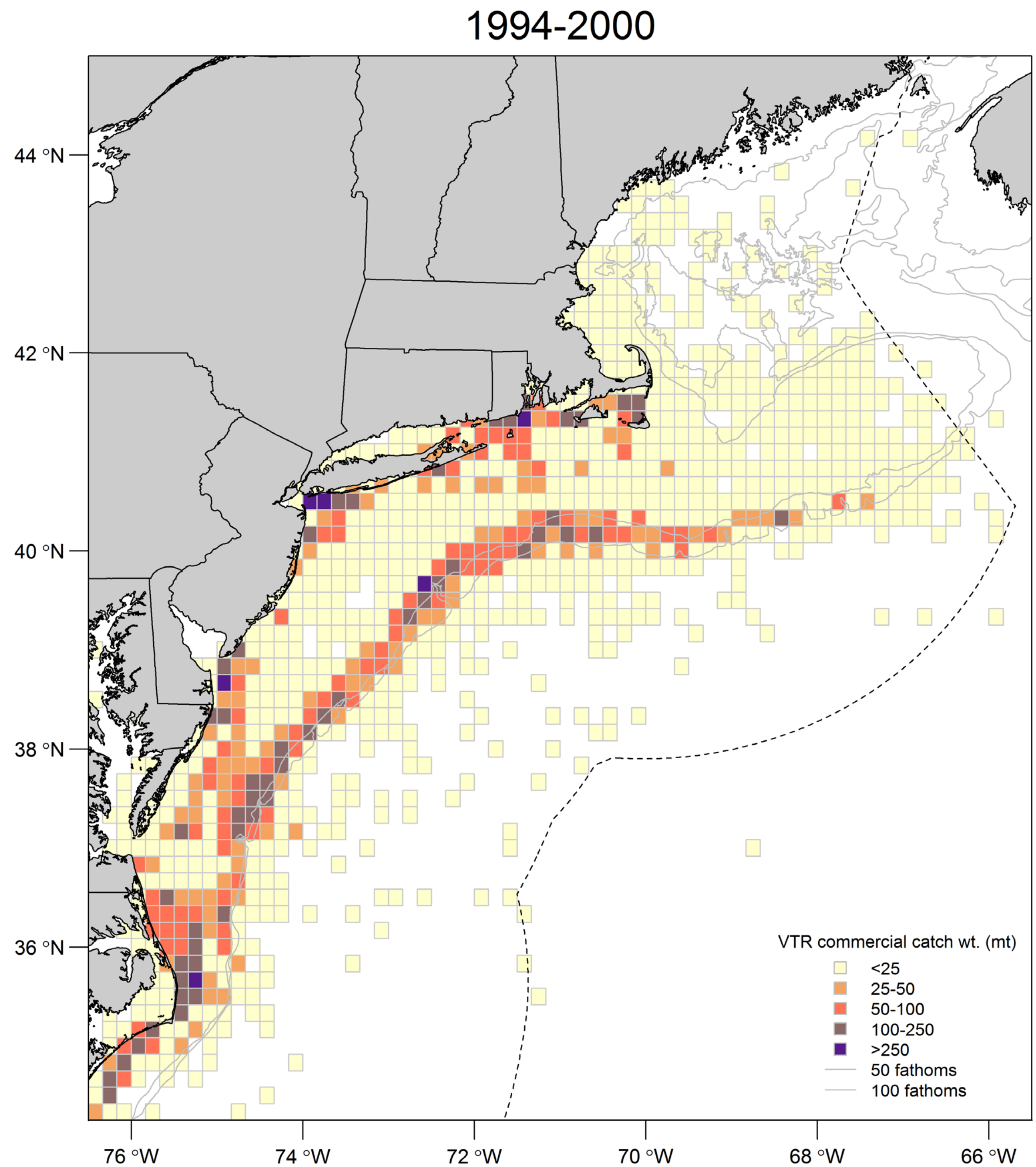


Figure A7. Spatial distribution of commercial Vessel Trip Report (VTR) reported catch weight (landings and discards) binned to ten minute squares from 1994-2000.

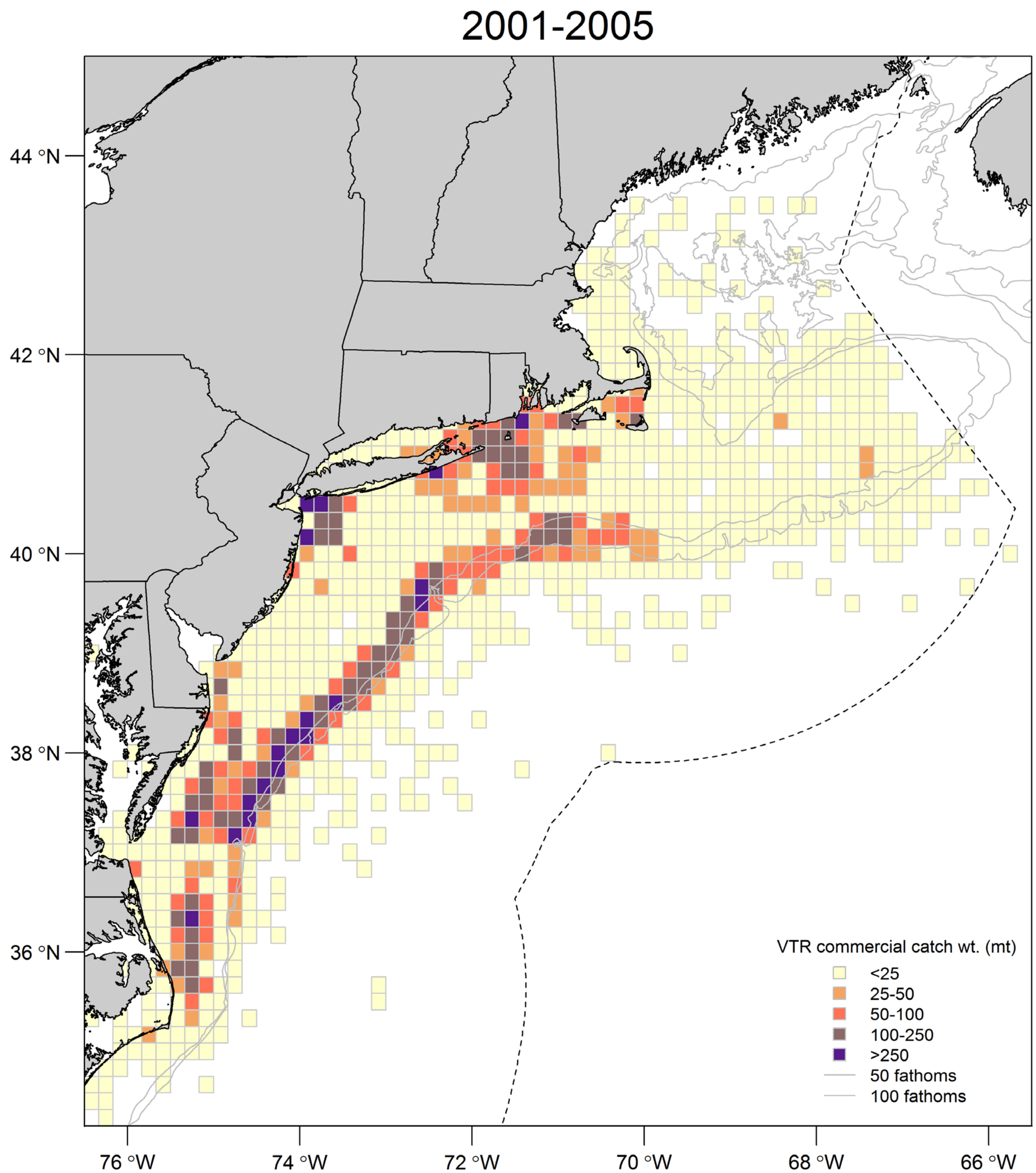


Figure A8. Spatial distribution of commercial Vessel Trip Report (VTR) reported catch weight (landings and discards) binned to ten minute squares from 2001-2005.

2006-2010

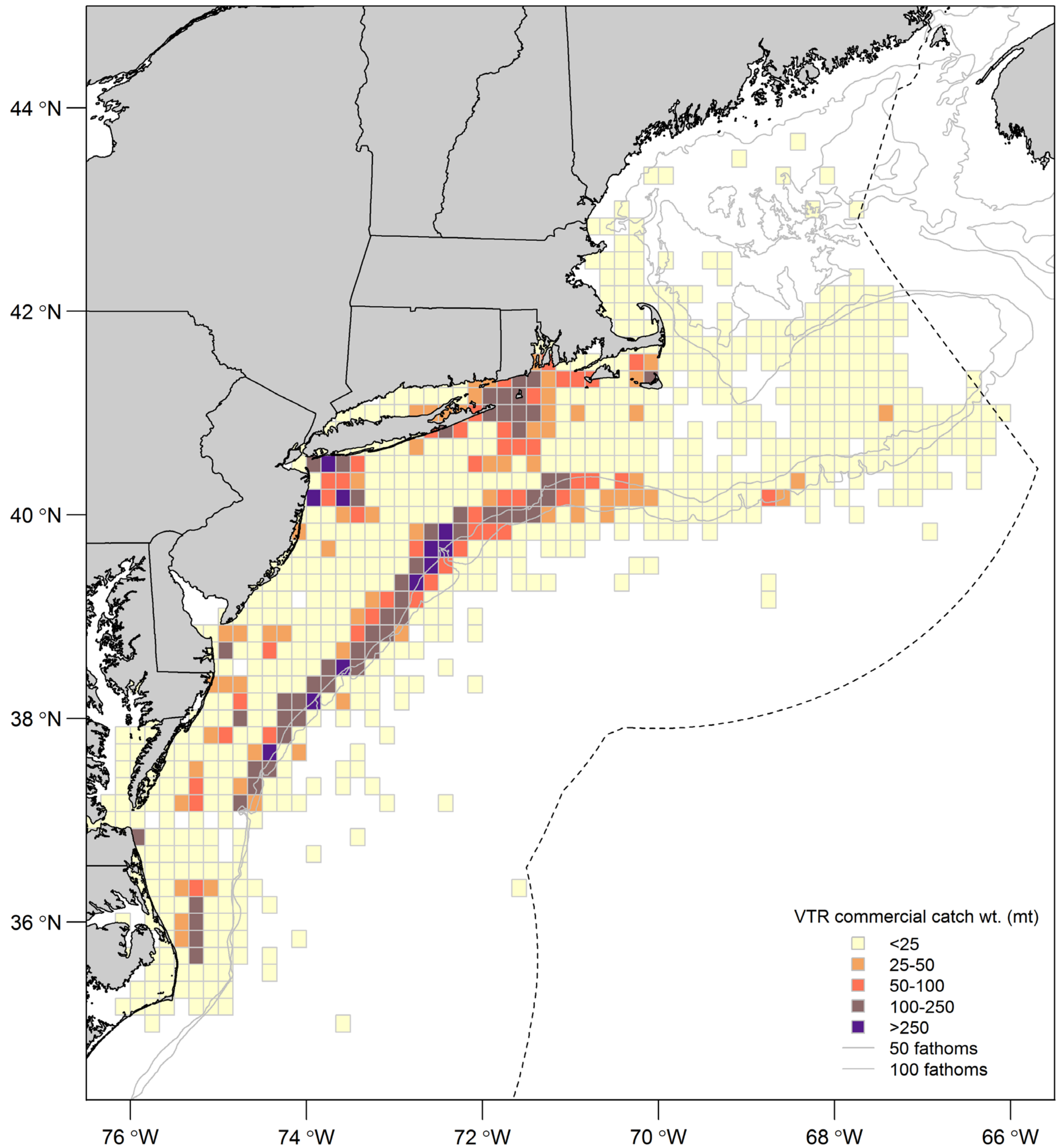


Figure A9. Spatial distribution of commercial Vessel Trip Report (VTR) reported catch weight (landings and discards) binned to ten minute squares from 2006-2010.

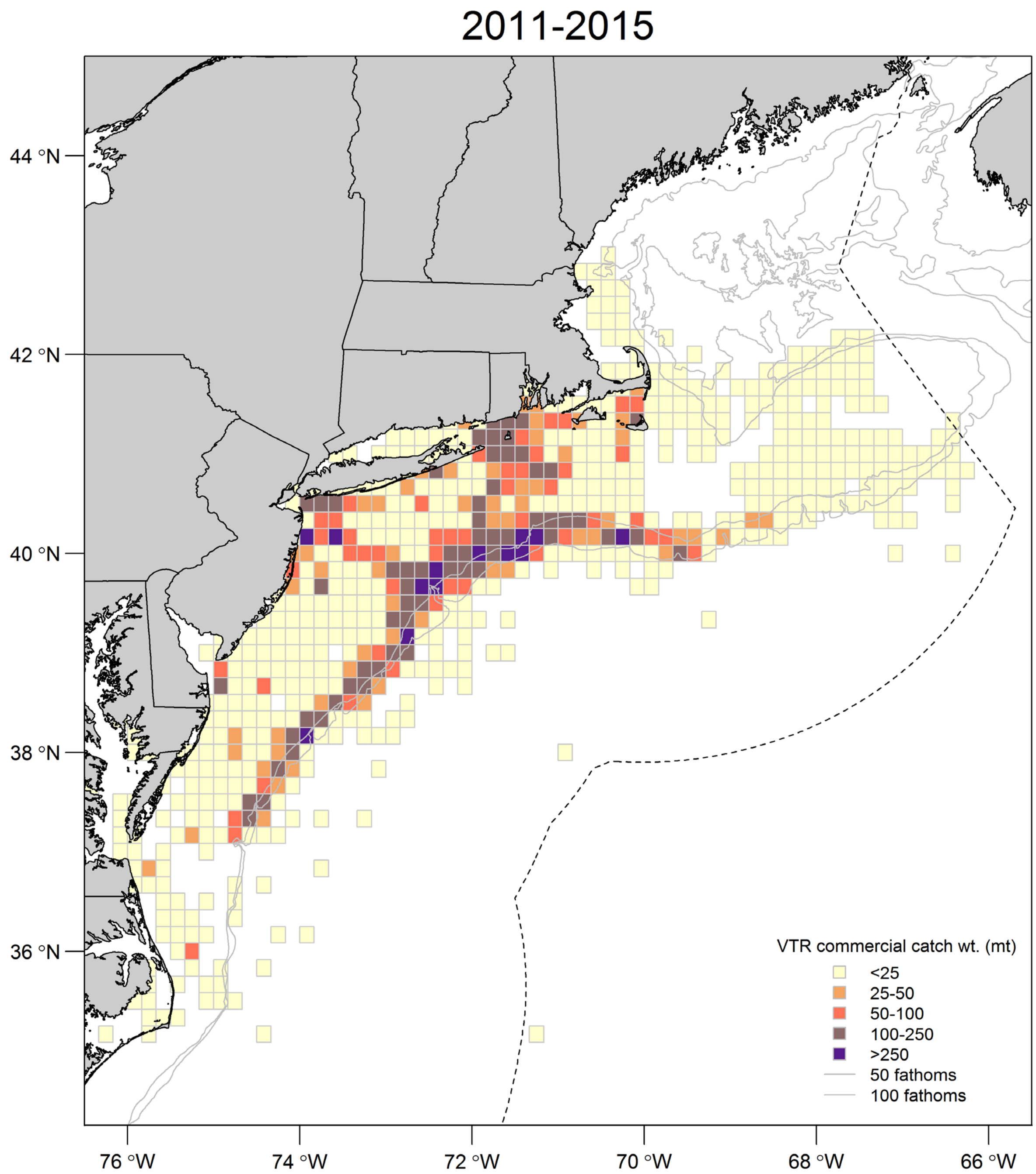


Figure A10. Spatial distribution of commercial Vessel Trip Report (VTR) reported catch weight (landings and discards) binned to ten minute squares from 2011-2015.

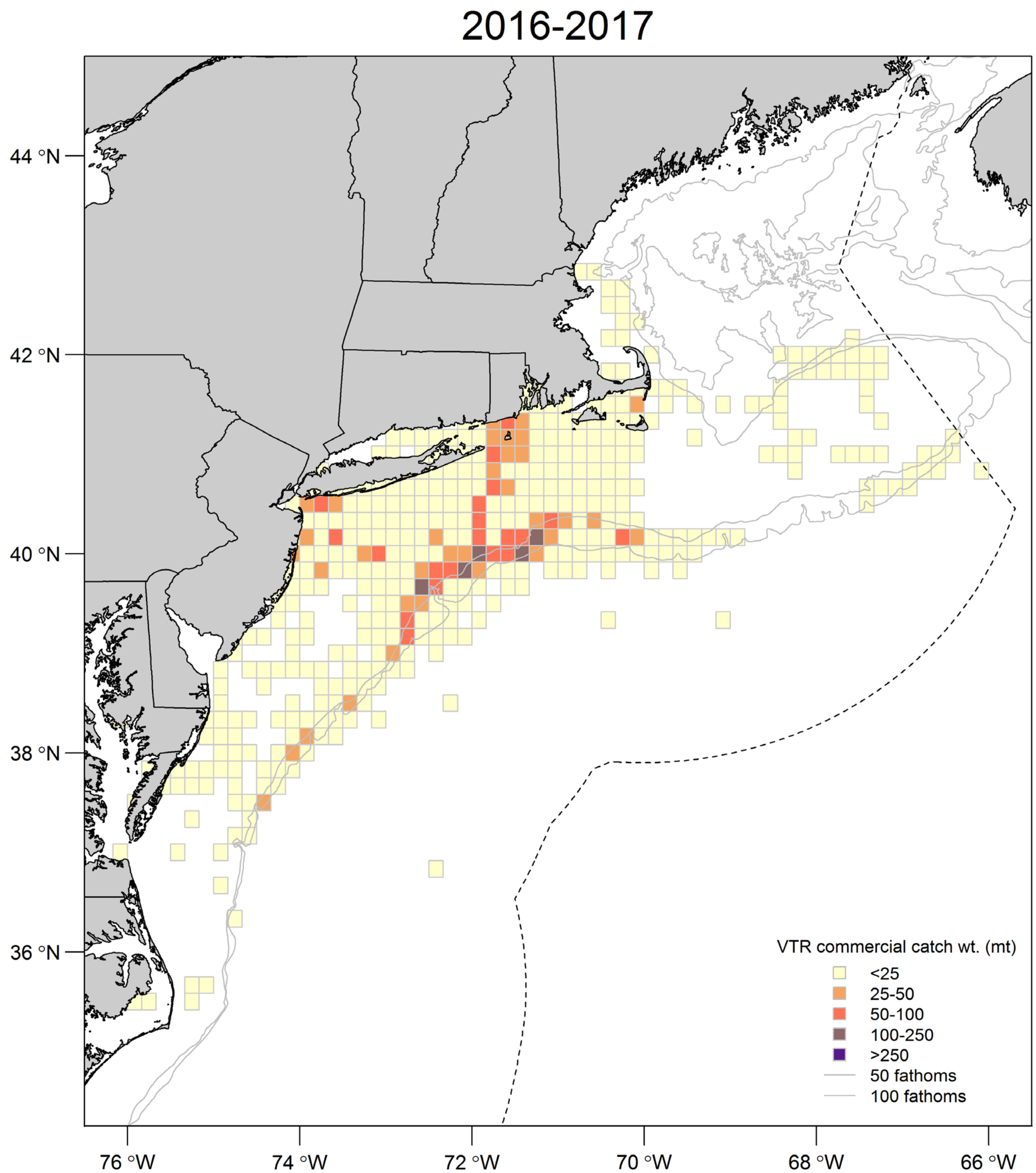


Figure A11. Spatial distribution of commercial Vessel Trip Report (VTR) reported catch weight (landings and discards) binned to ten minute squares from 2016-2017.

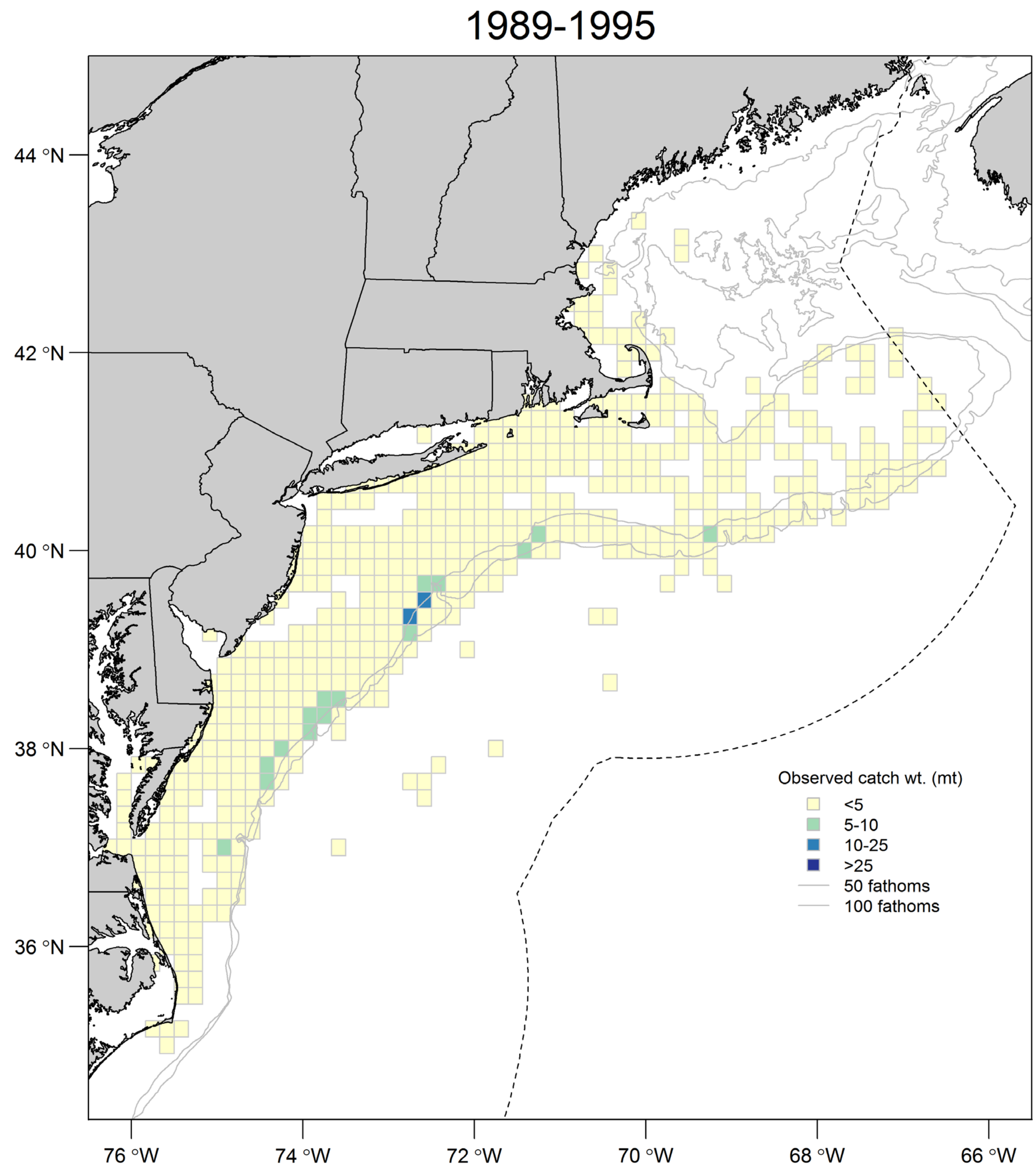


Figure A12. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 1989-1995.

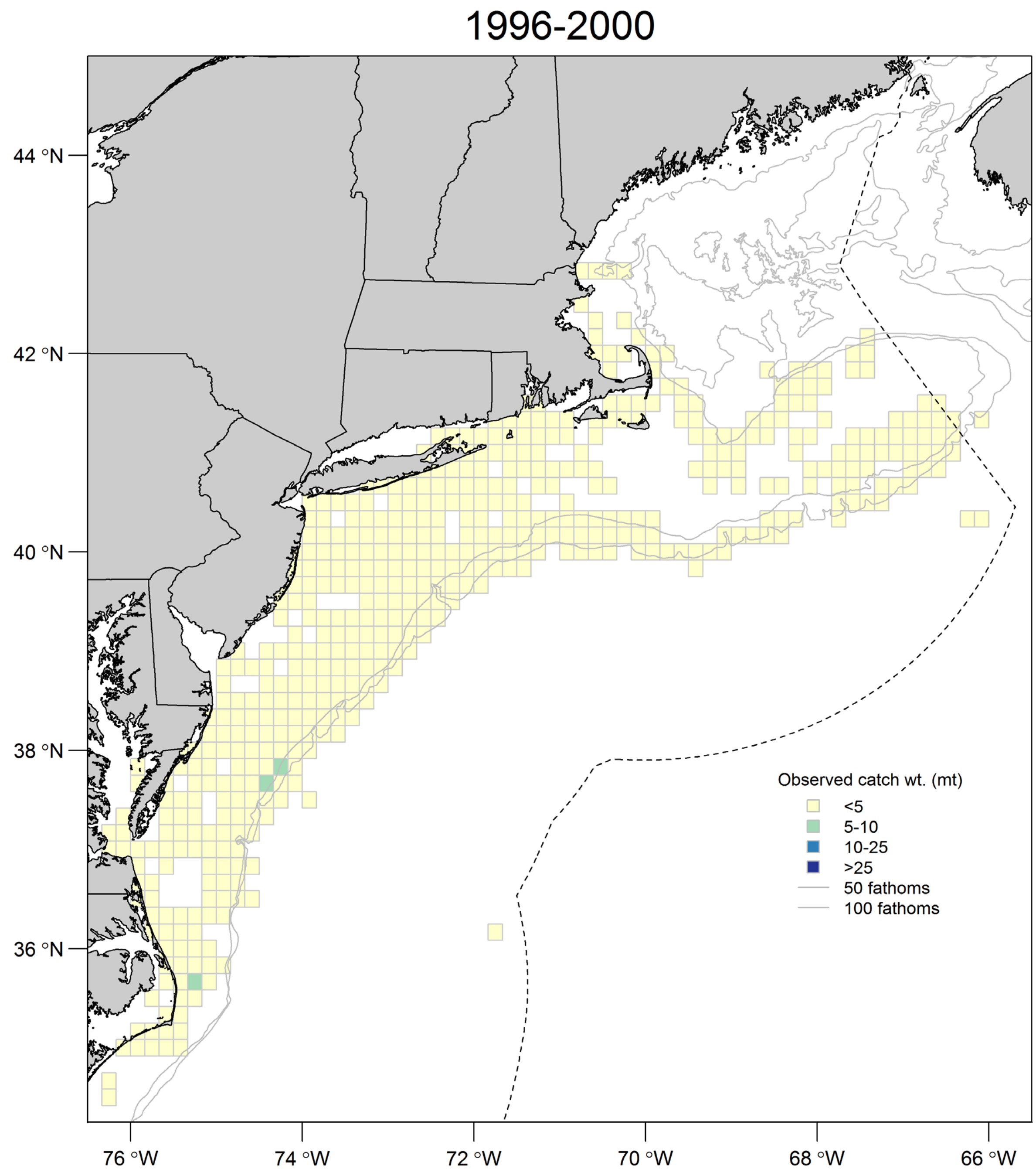


Figure A13. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 1996-2000.

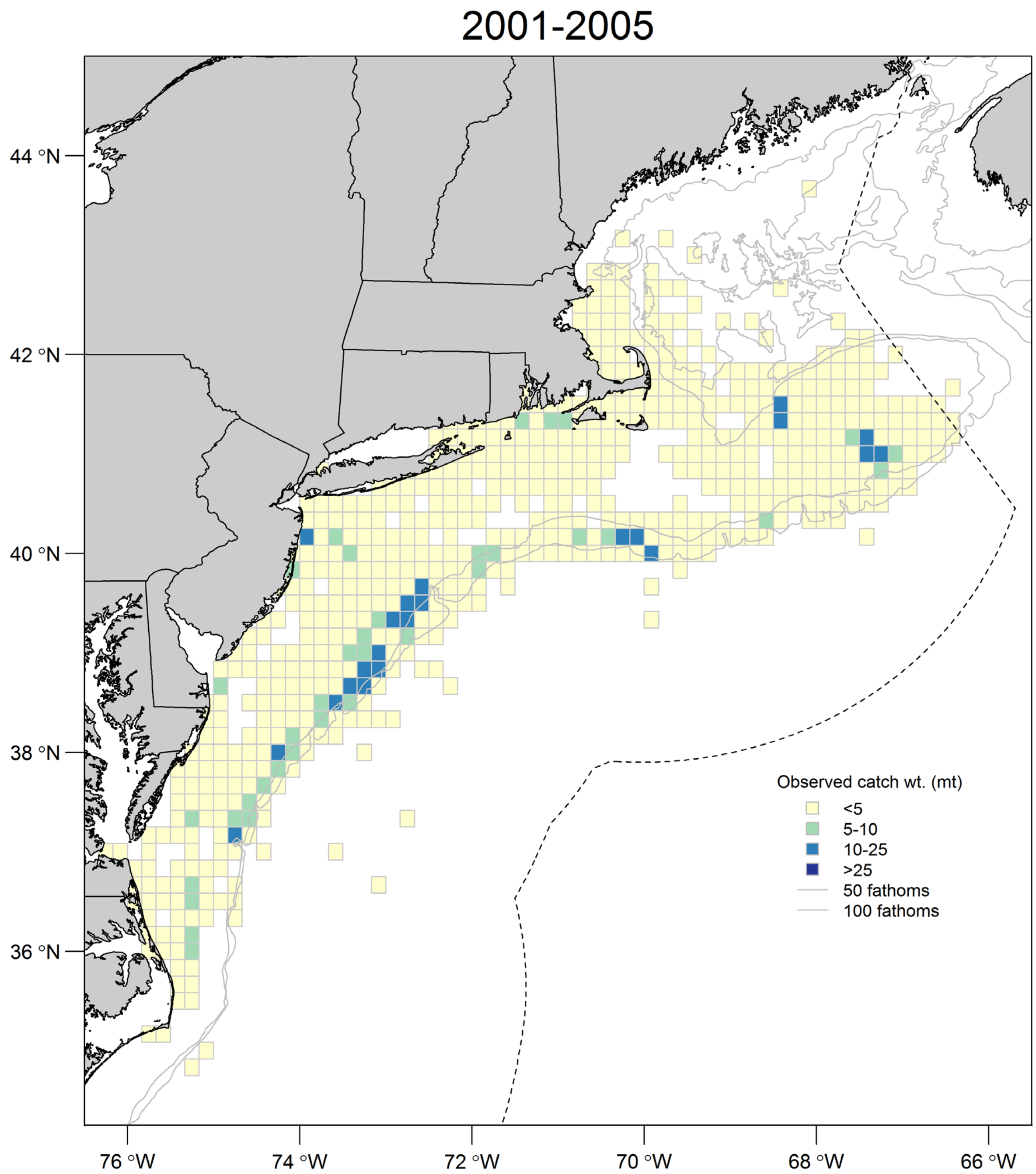


Figure A14. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 2001-2005.

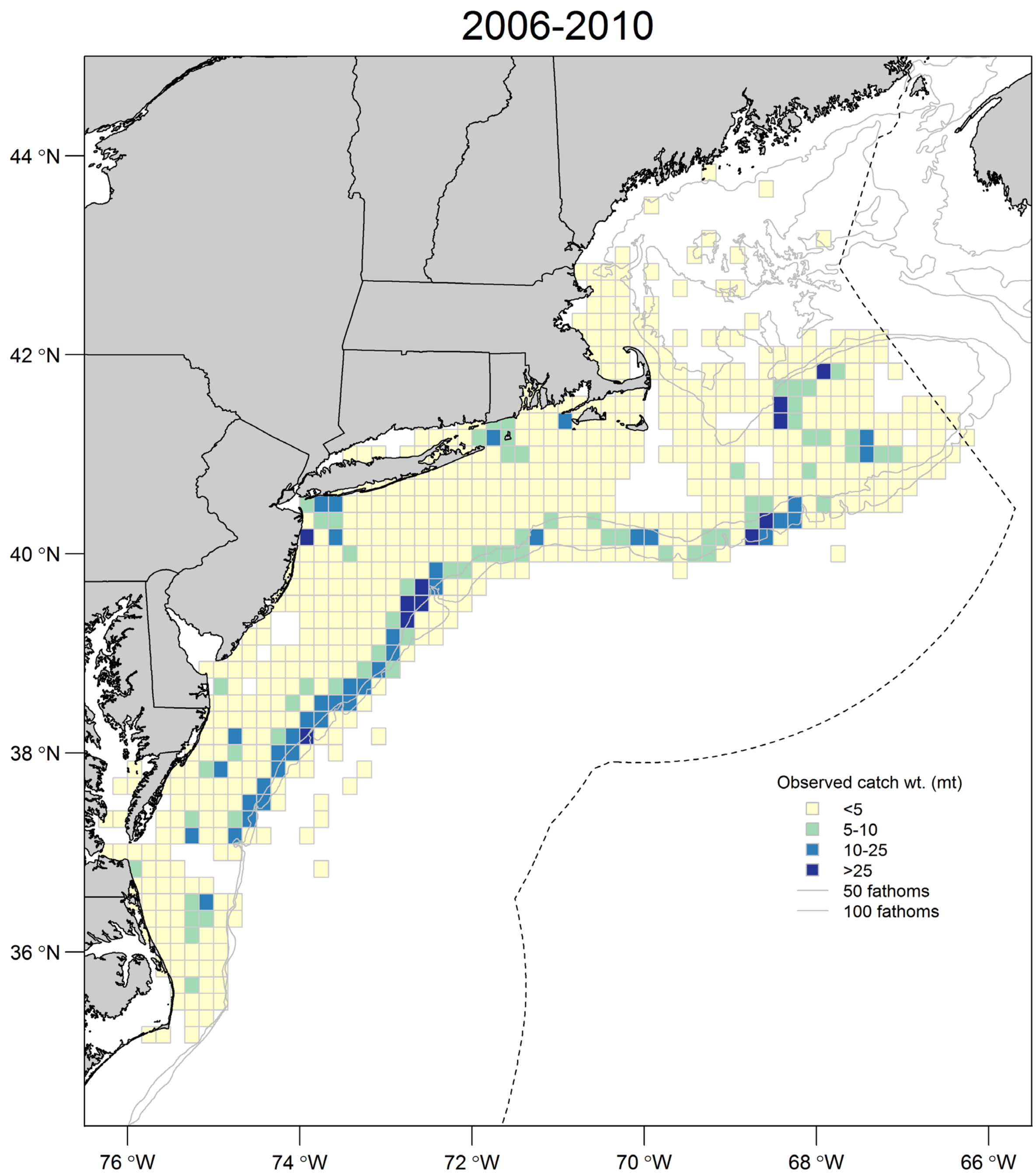


Figure A15. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 2006-2010.

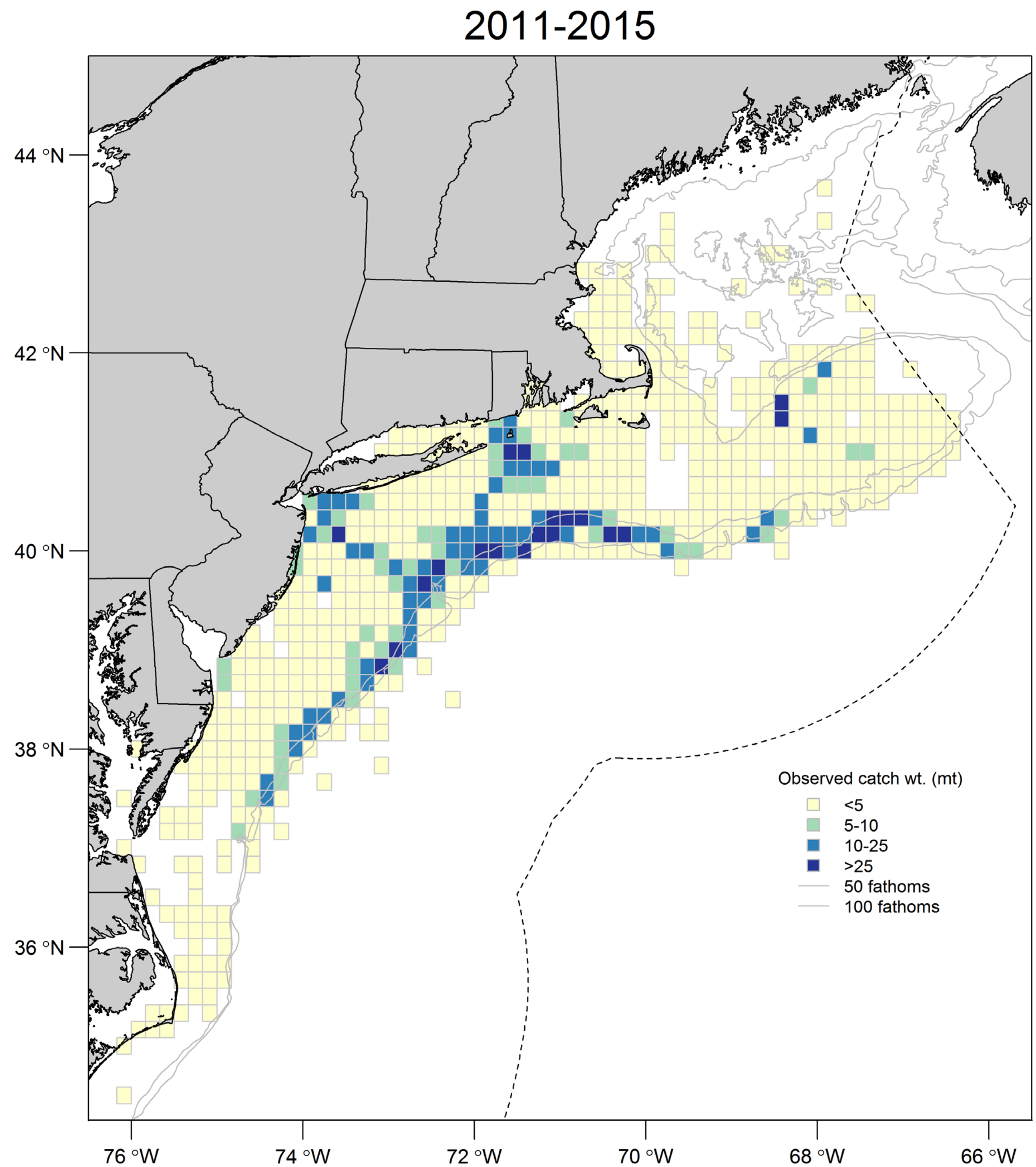


Figure A16. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 2011-2015.

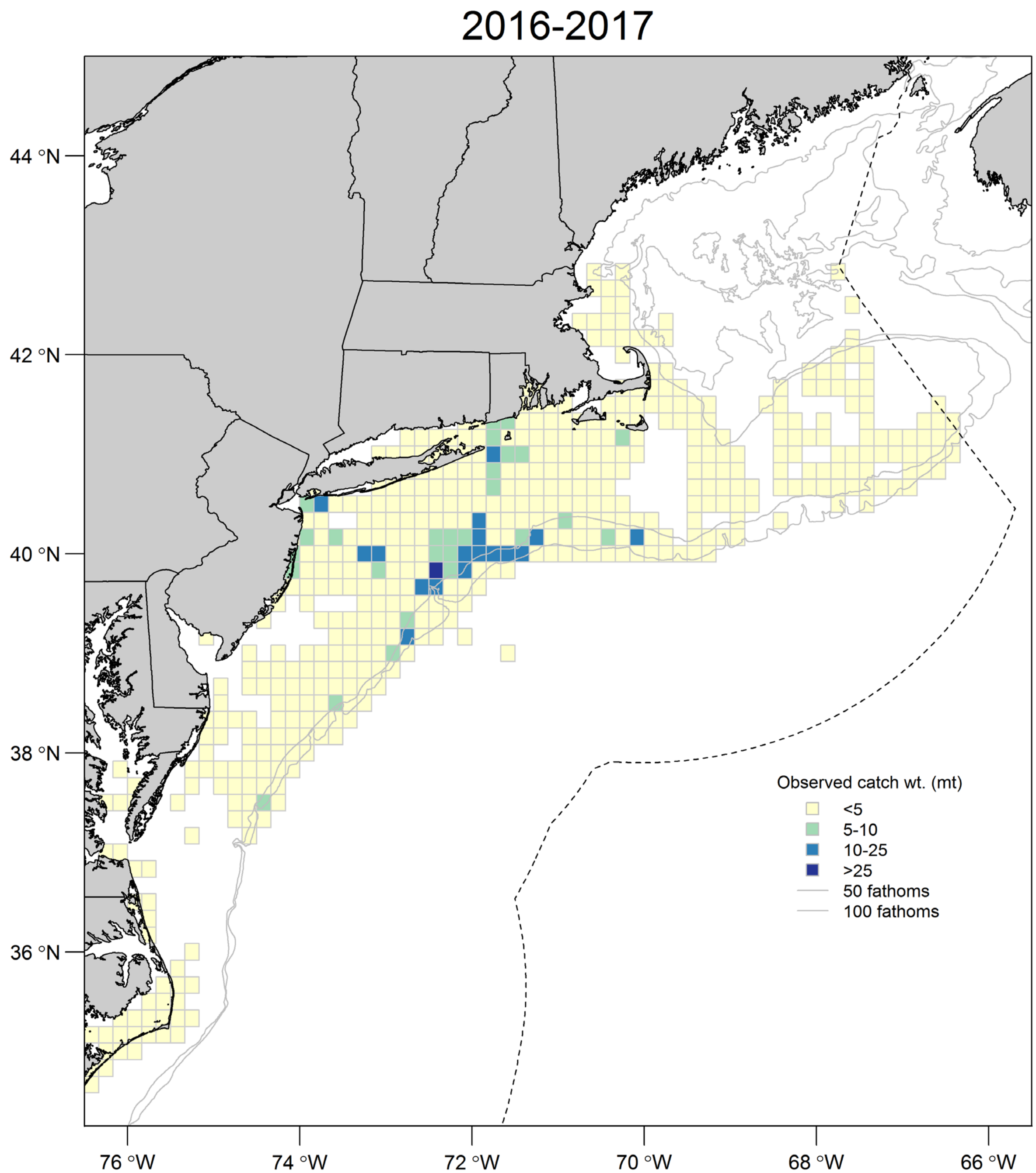


Figure A17. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 2016-2017.

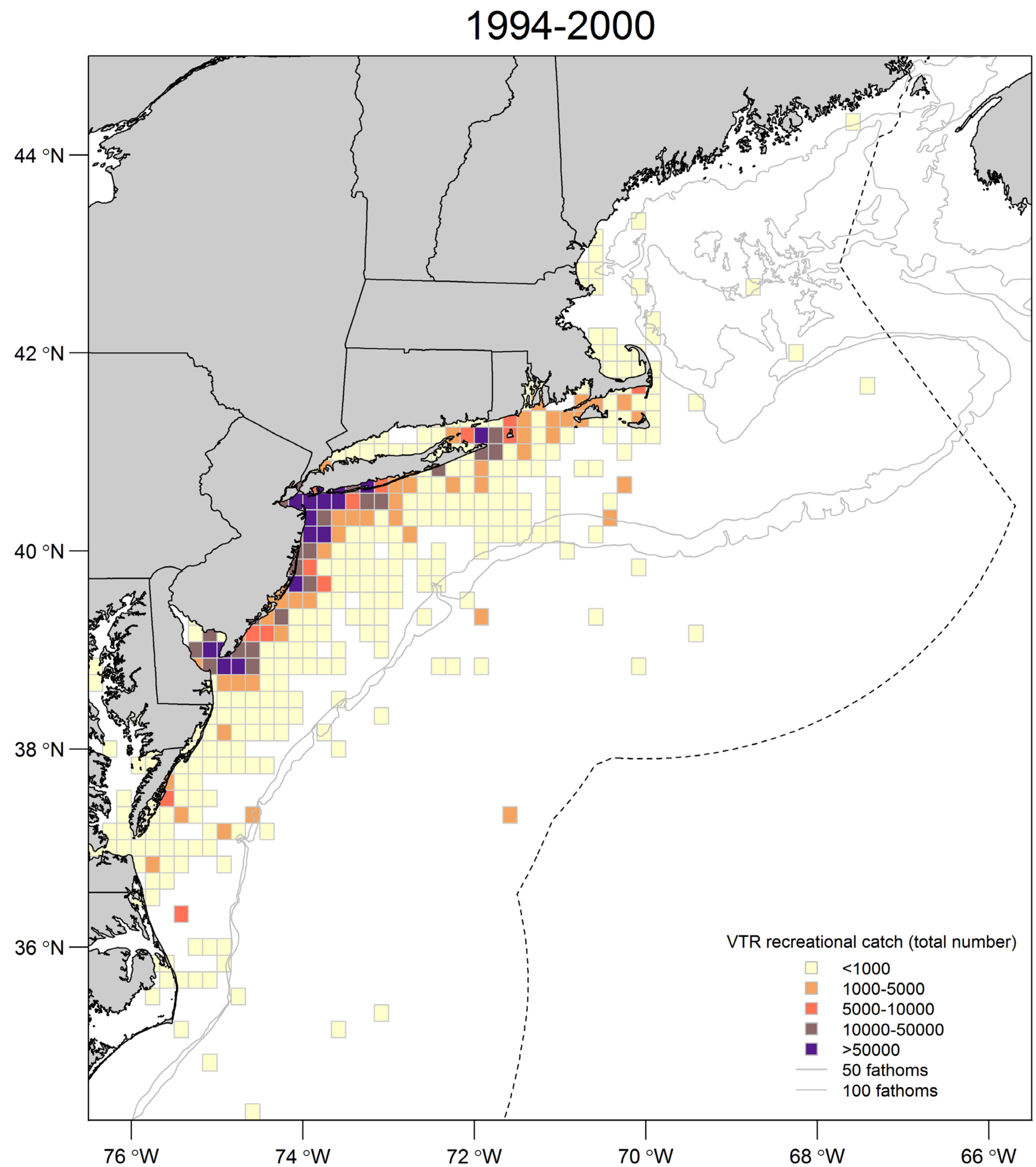


Figure A18. Spatial distribution of recreational (party and charter boat) Vessel Trip Report (VTR) reported catch (total number) binned to ten minute squares from 1994-2000.

2001-2005

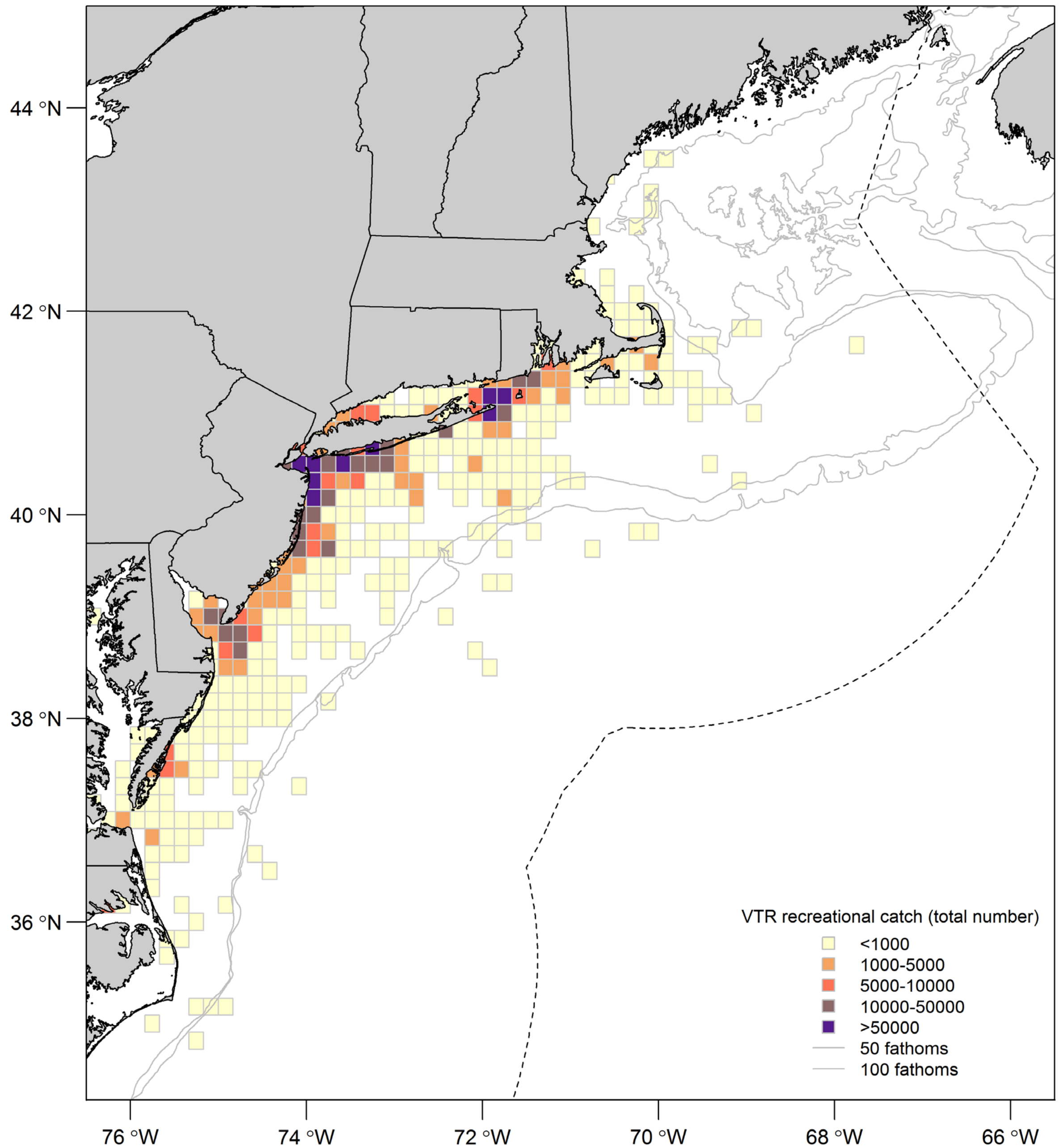


Figure A19. Spatial distribution of recreational (party and charter boat) Vessel Trip Report (VTR) reported catch (total number) binned to ten minute squares from 2001-2005.

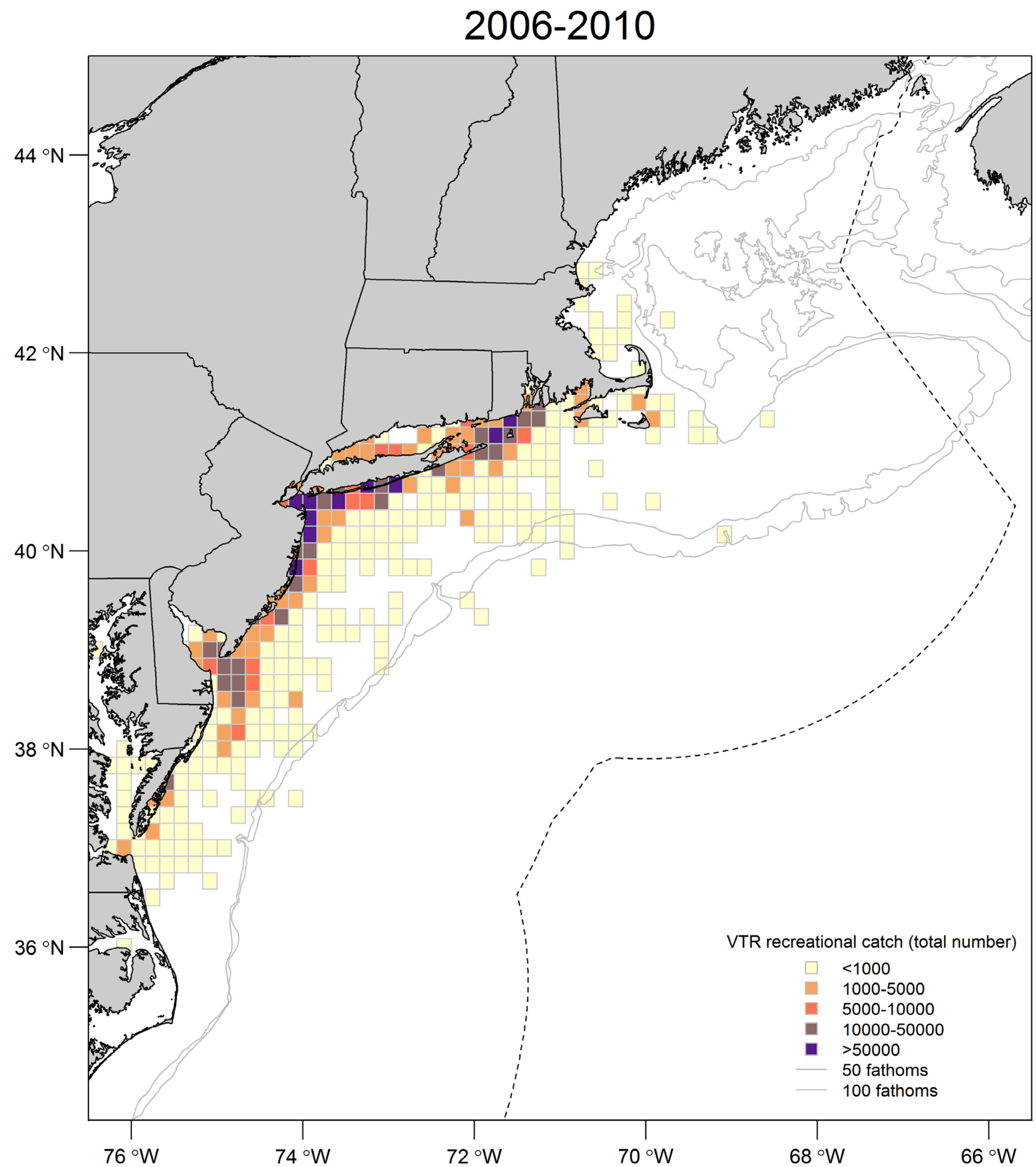


Figure A20. Spatial distribution of recreational (party and charter boat) Vessel Trip Report (VTR) reported catch (total number) binned to ten minute squares from 2006-2010.

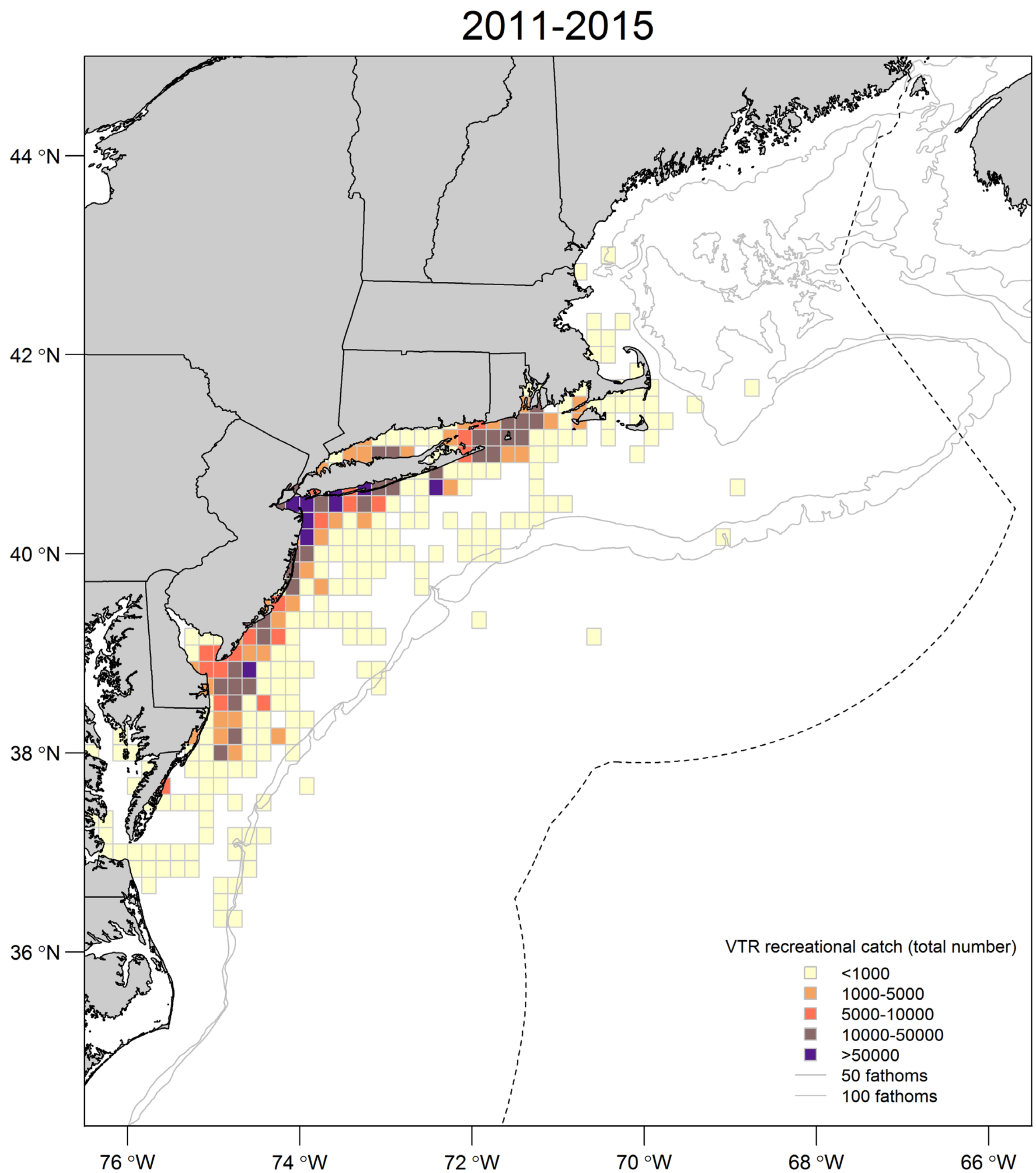


Figure A21. Spatial distribution of recreational (party and charter boat) Vessel Trip Report (VTR) reported catch (total number) binned to ten minute squares from 2011-2015.

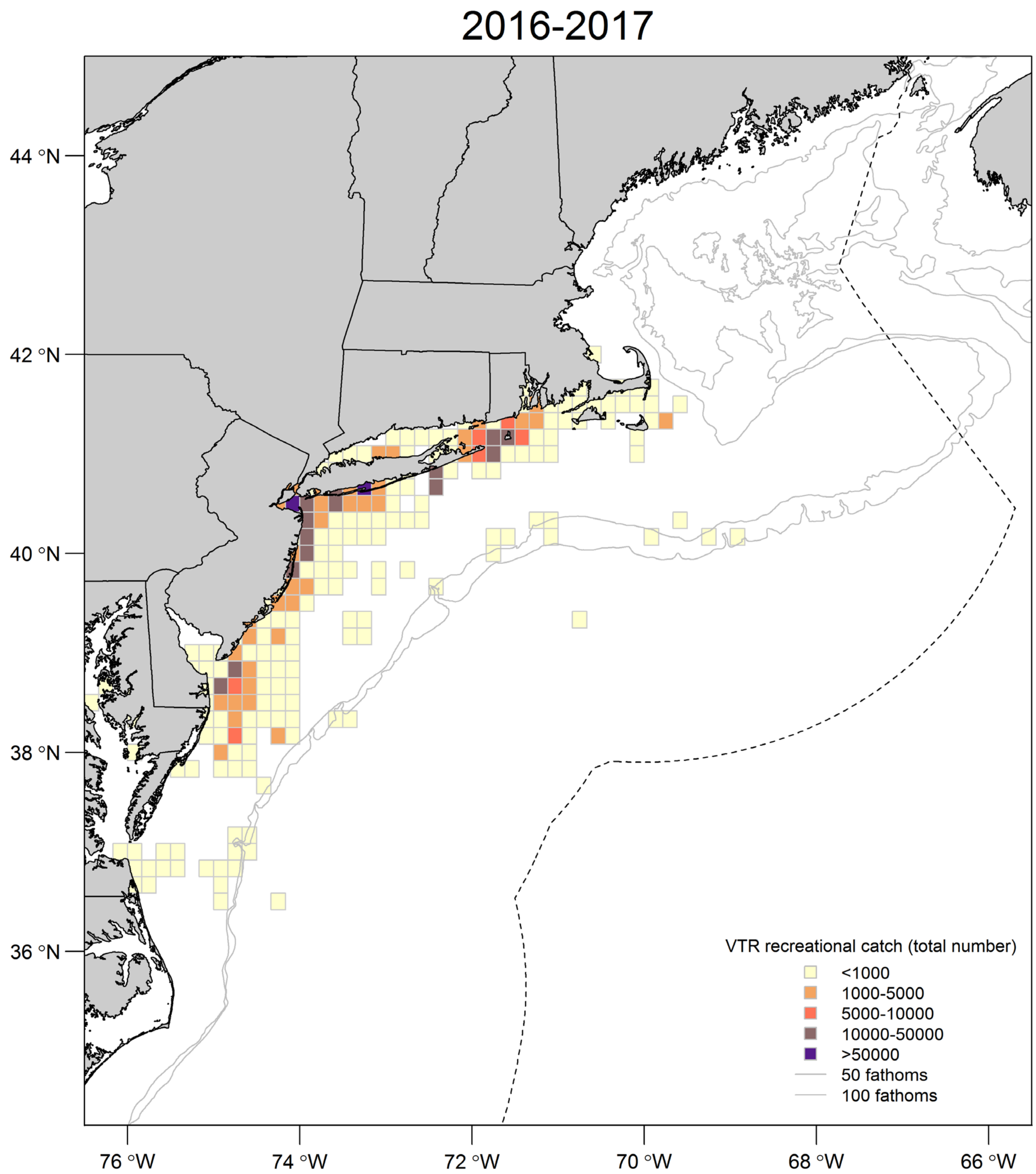


Figure A22. Spatial distribution of recreational (party and charter boat) Vessel Trip Report (VTR) reported catch (total number) binned to ten minute squares from 2016-2017.

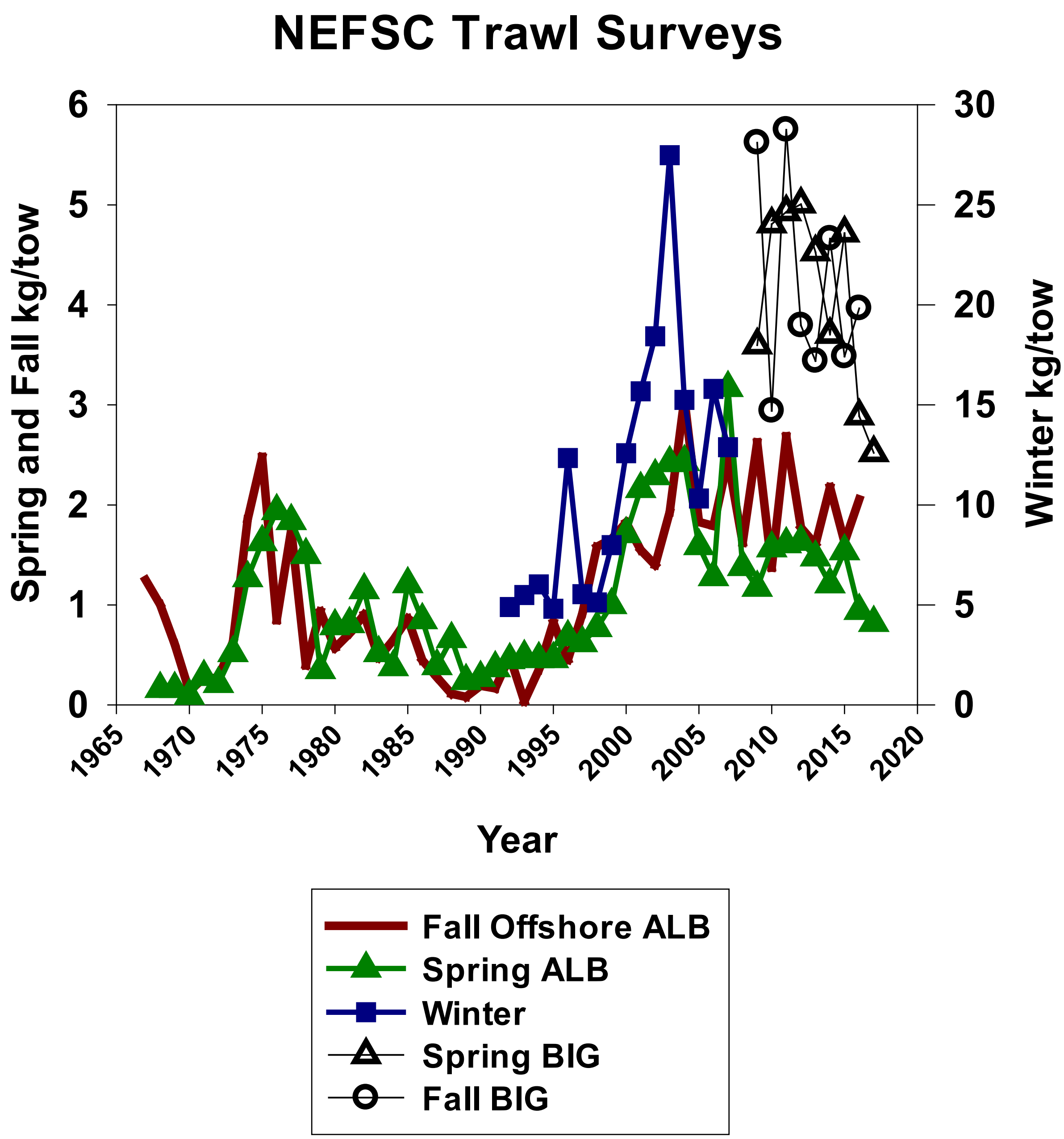


Figure A23. Trends in Northeast Fisheries Science Center (NEFSC) trawl survey biomass indices for summer flounder. Surveys conducted aboard the FSV *Albatross IV* (ALB) and the FSV *Henry B. Bigelow* (BIG).

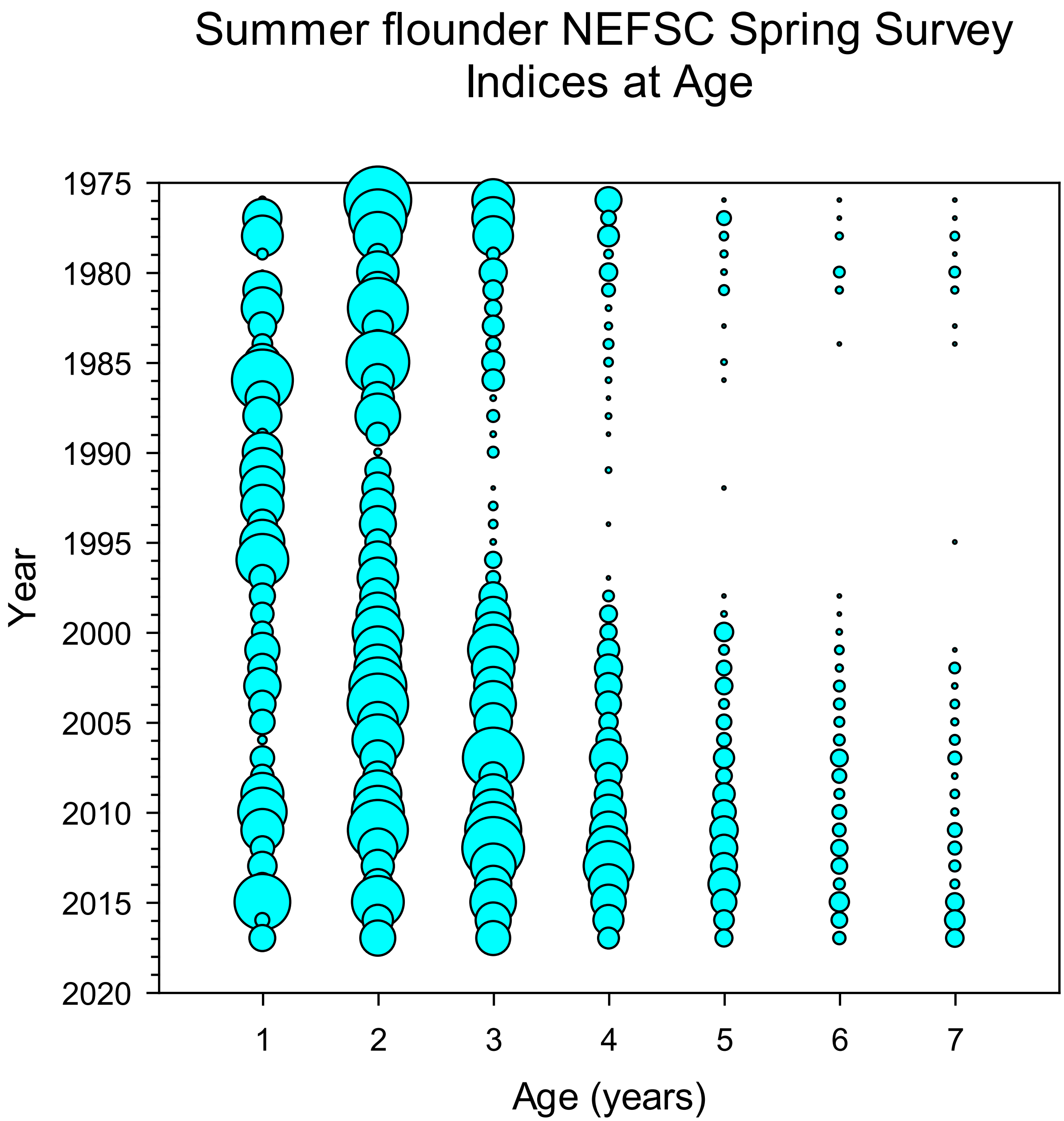


Figure A24. Relative age composition of summer flounder caught in the Northeast Fisheries Science Center (NEFSC) spring trawl survey.

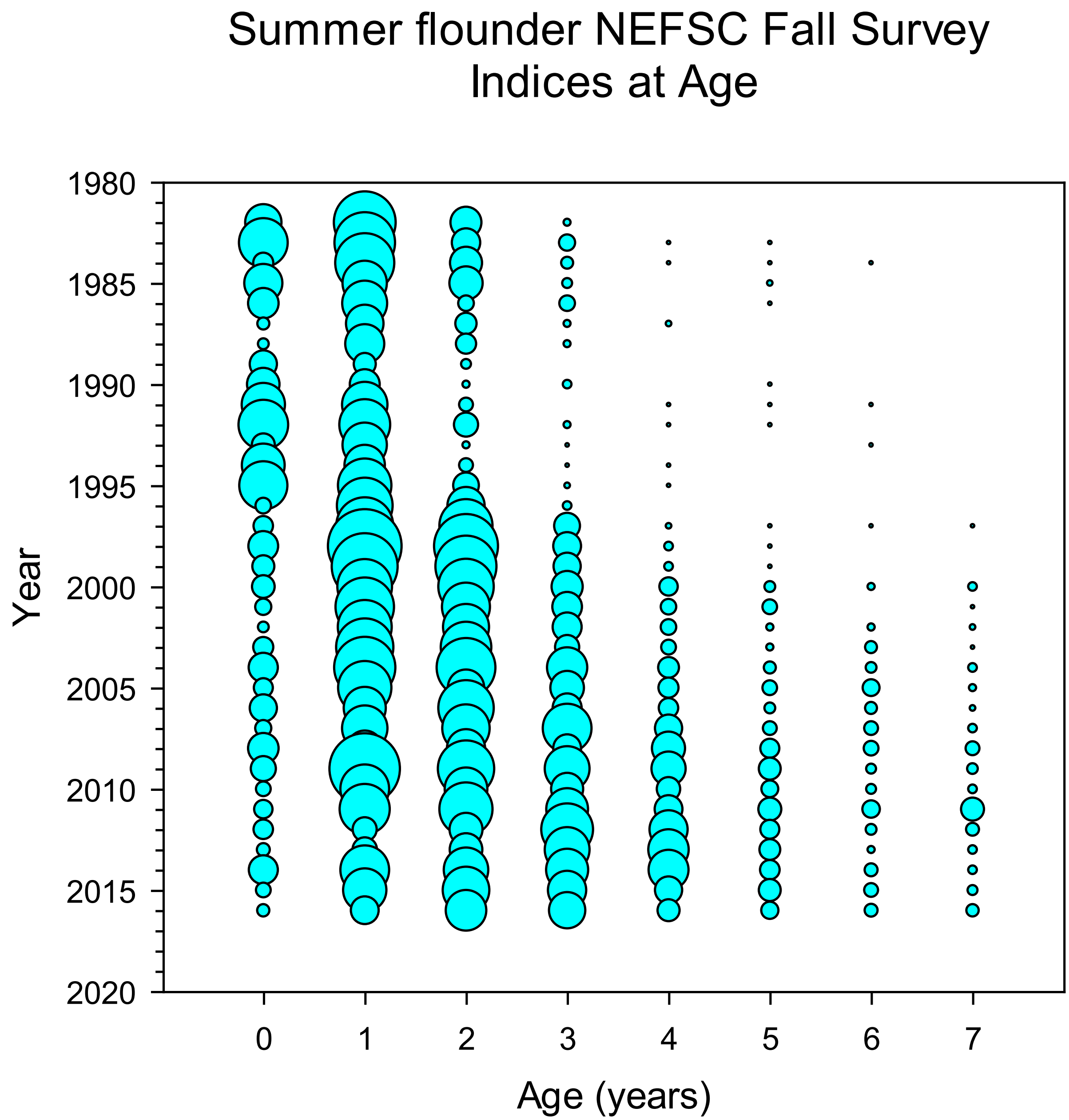


Figure A25. Relative age composition of summer flounder caught in the Northeast Fisheries Science Center (NEFSC) fall trawl survey.

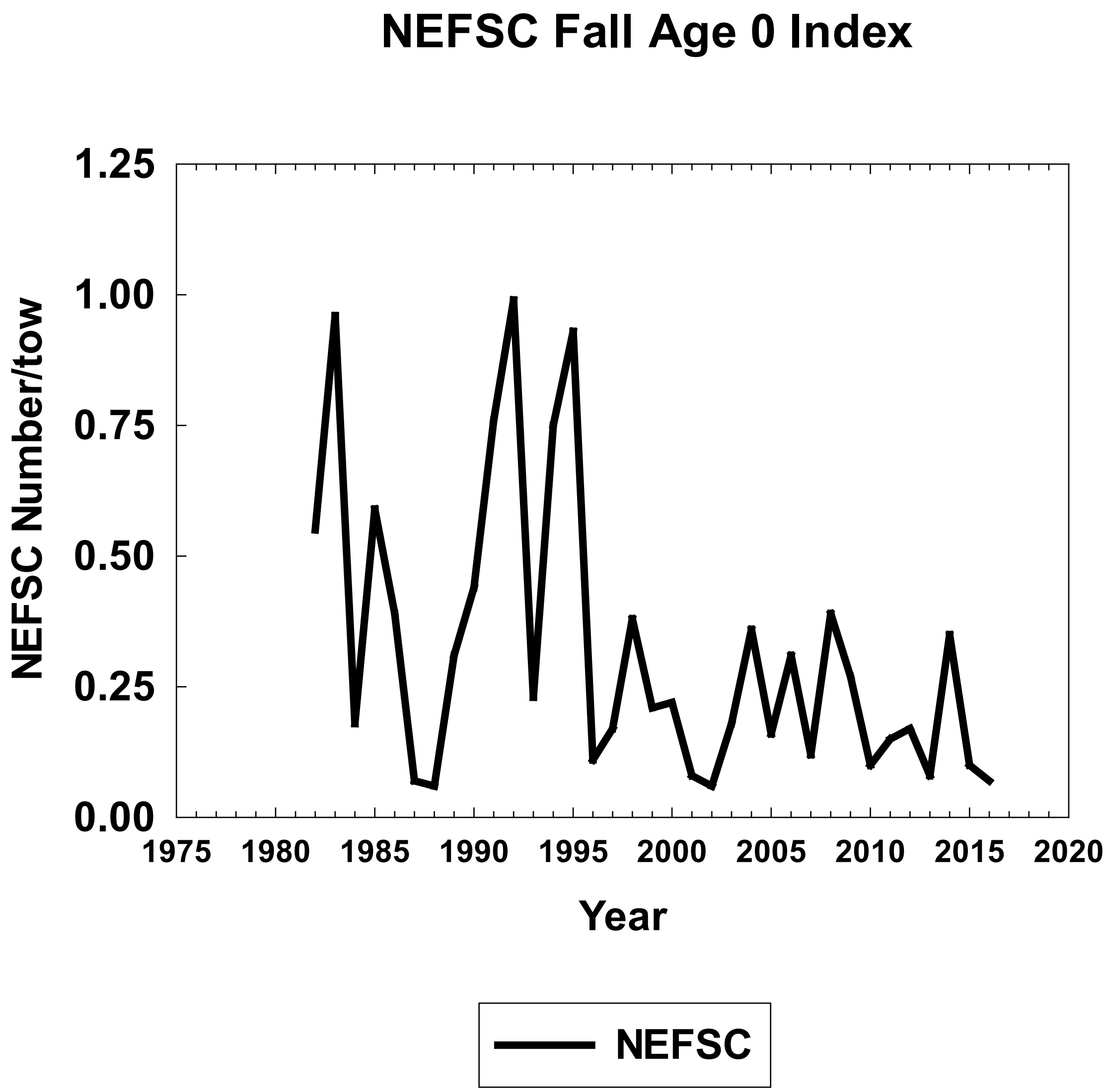


Figure A26. Trend in the Northeast Fisheries Science Center (NEFSC) trawl survey recruitment index for summer flounder young of the year (YOY).

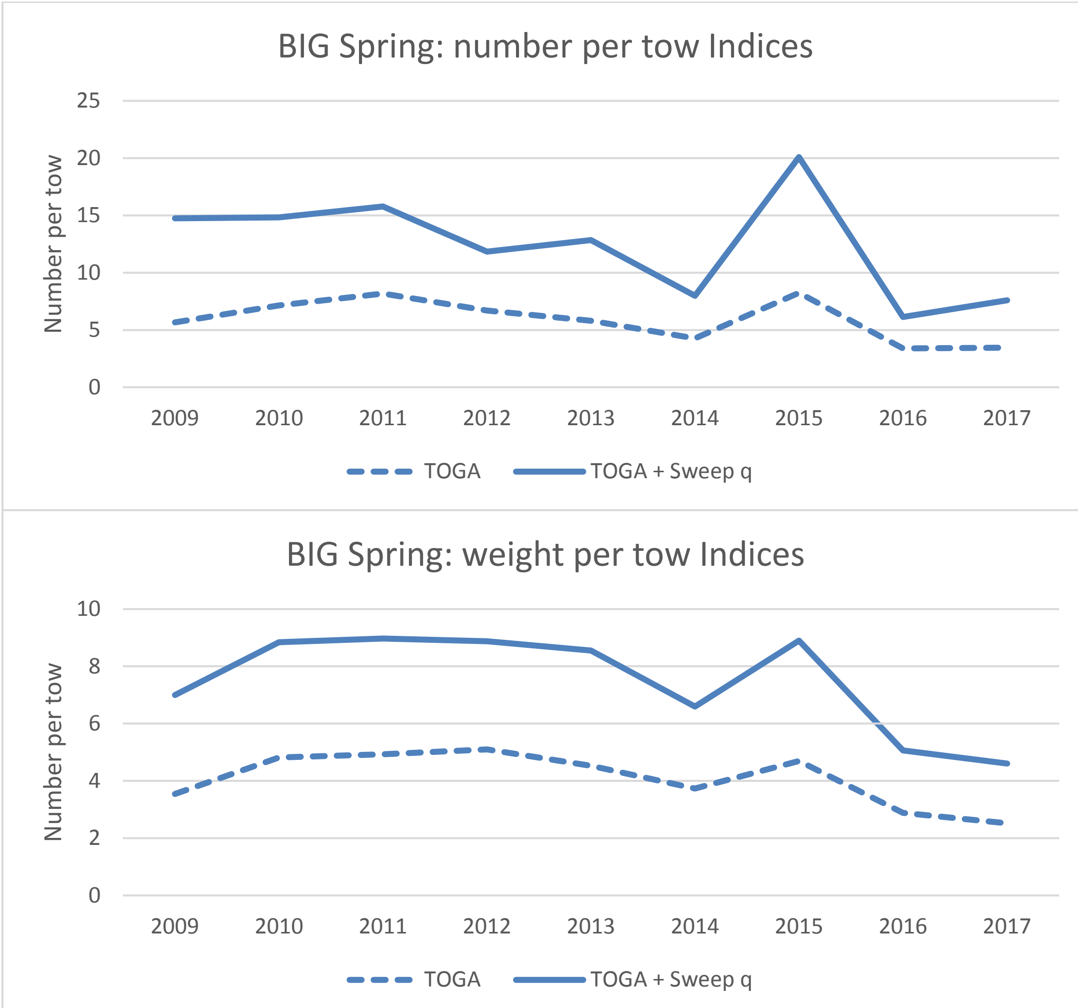


Figure A27. Northeast Fisheries Science Center (NEFSC) spring trawl survey FSV *Henry B. Bigelow* (BIG) indices in number and weight per tow. TOGA are 'standard' indices compiled with TOGA acceptance criteria. TOGA + Sweep q are 'absolute' indices incorporating the 'twin trawl sweep study' mean efficiencies at length (Sweep q).

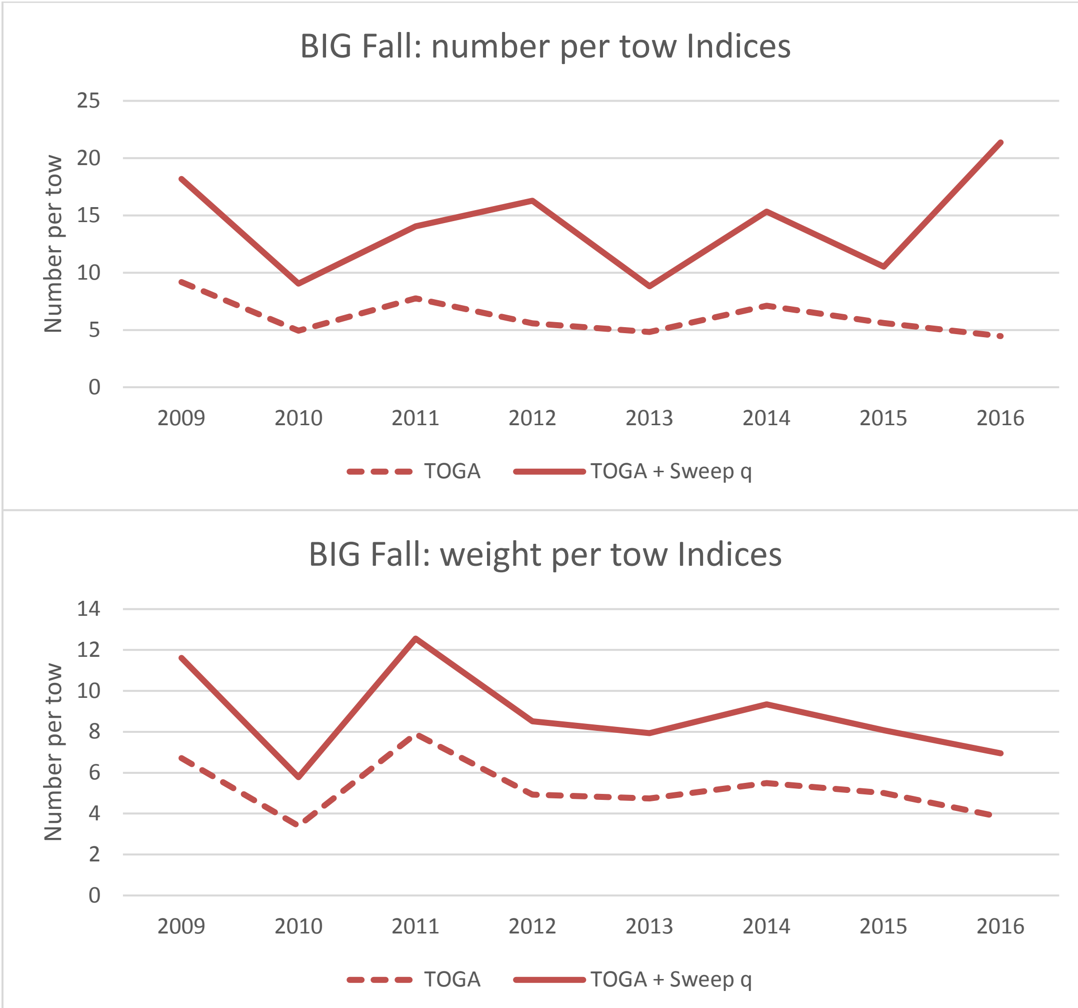


Figure A28. Northeast Fisheries Science Center (NEFSC) fall trawl survey FSV *Henry B Bigelow* (BIG) indices in number and weight per tow. TOGA are 'standard' indices compiled with TOGA acceptance criteria. TOGA + Sweep q are 'absolute' indices incorporating the 'twin trawl sweep study' mean efficiencies at length (Sweep q).

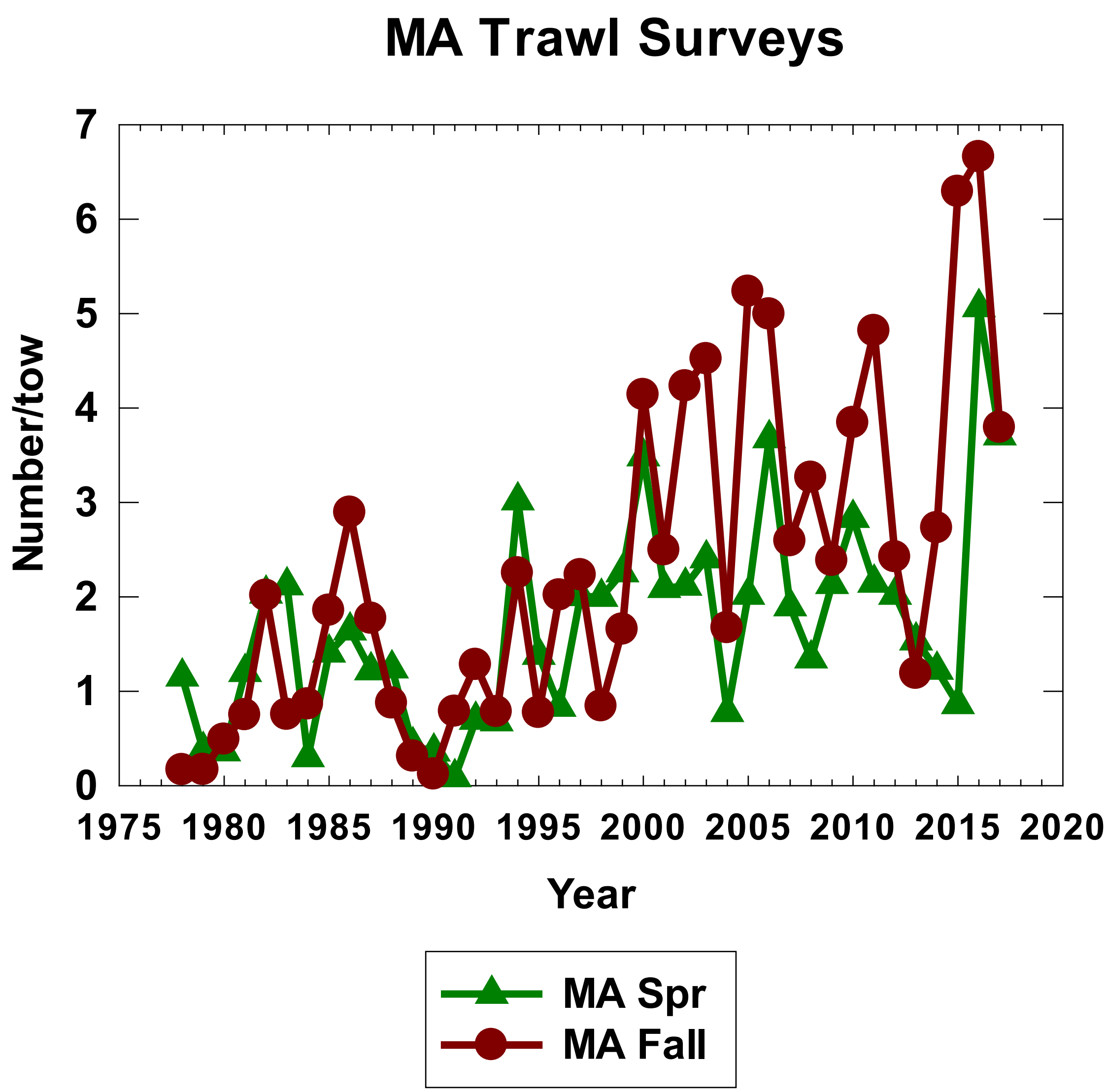


Figure A29. Trends in Massachusetts (MA) trawl survey abundance indices for summer flounder.

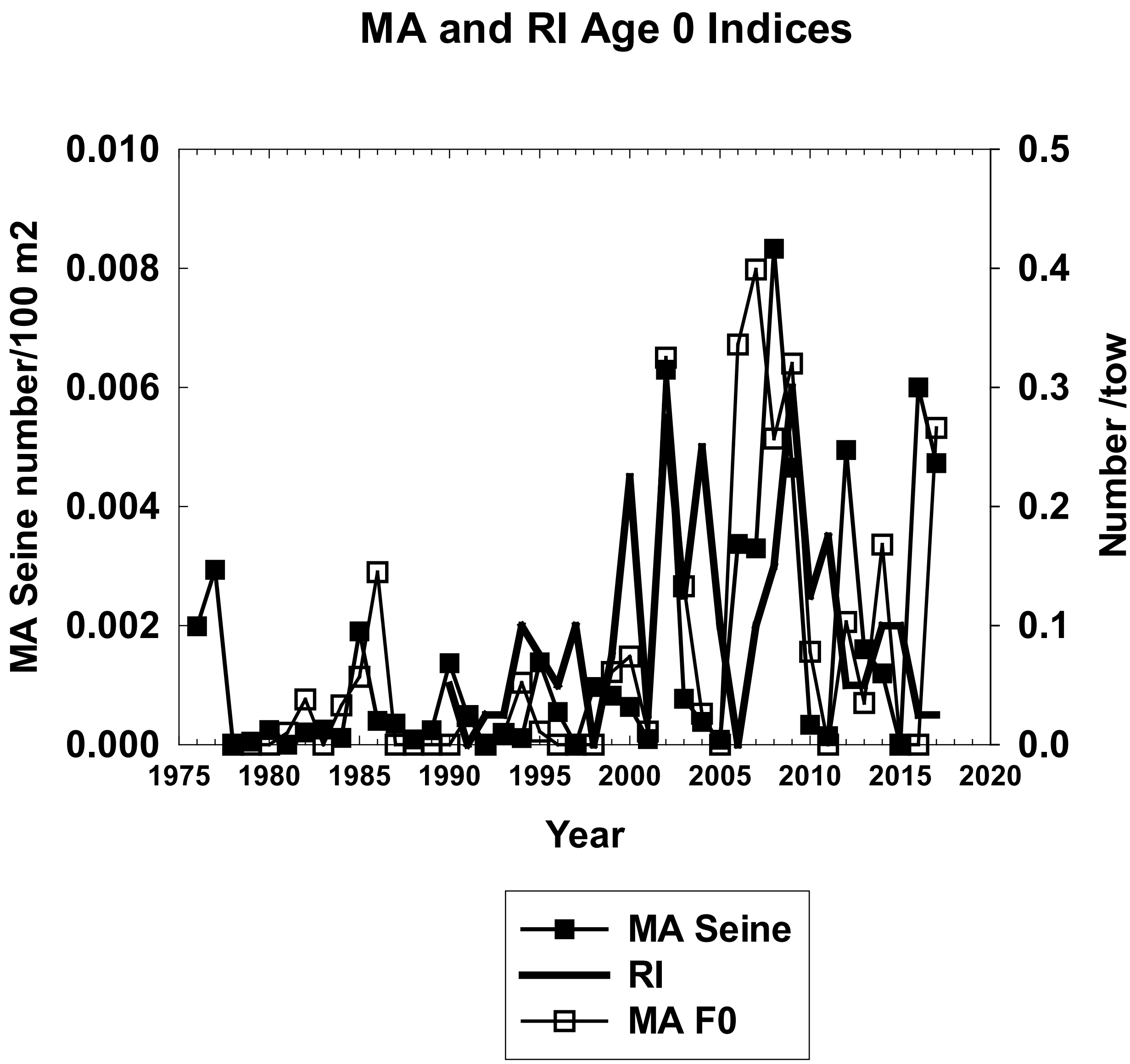


Figure A30. Trends in Massachusetts (MA) and Rhode Island (RI) trawl survey recruitment indices for summer flounder young of the year (YOY).

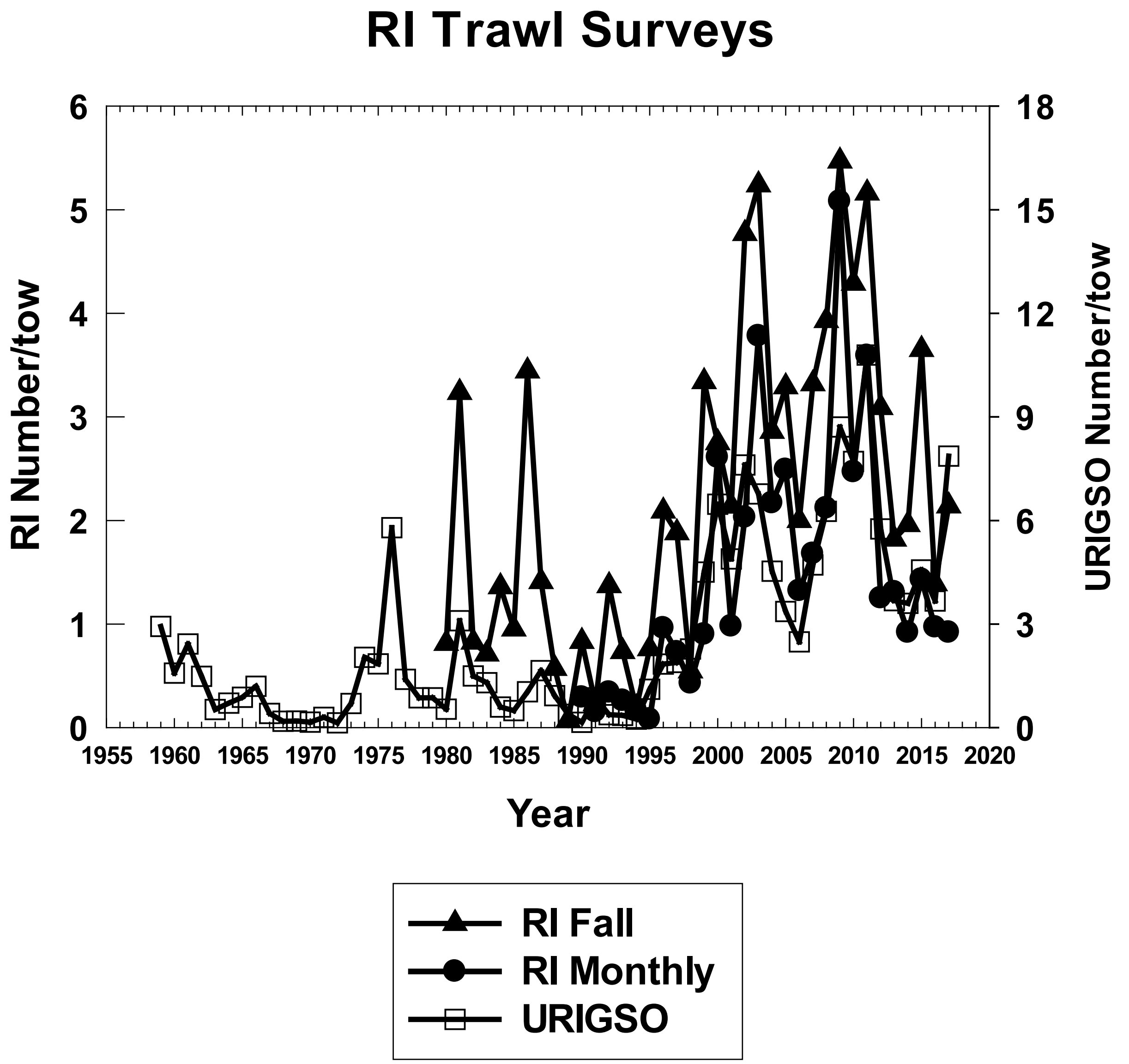


Figure A31. Trends in Rhode Island (RI) fall, monthly, and University of Rhode Island Graduate School of Oceanography (URIGSO) trawl survey abundance indices for summer flounder.

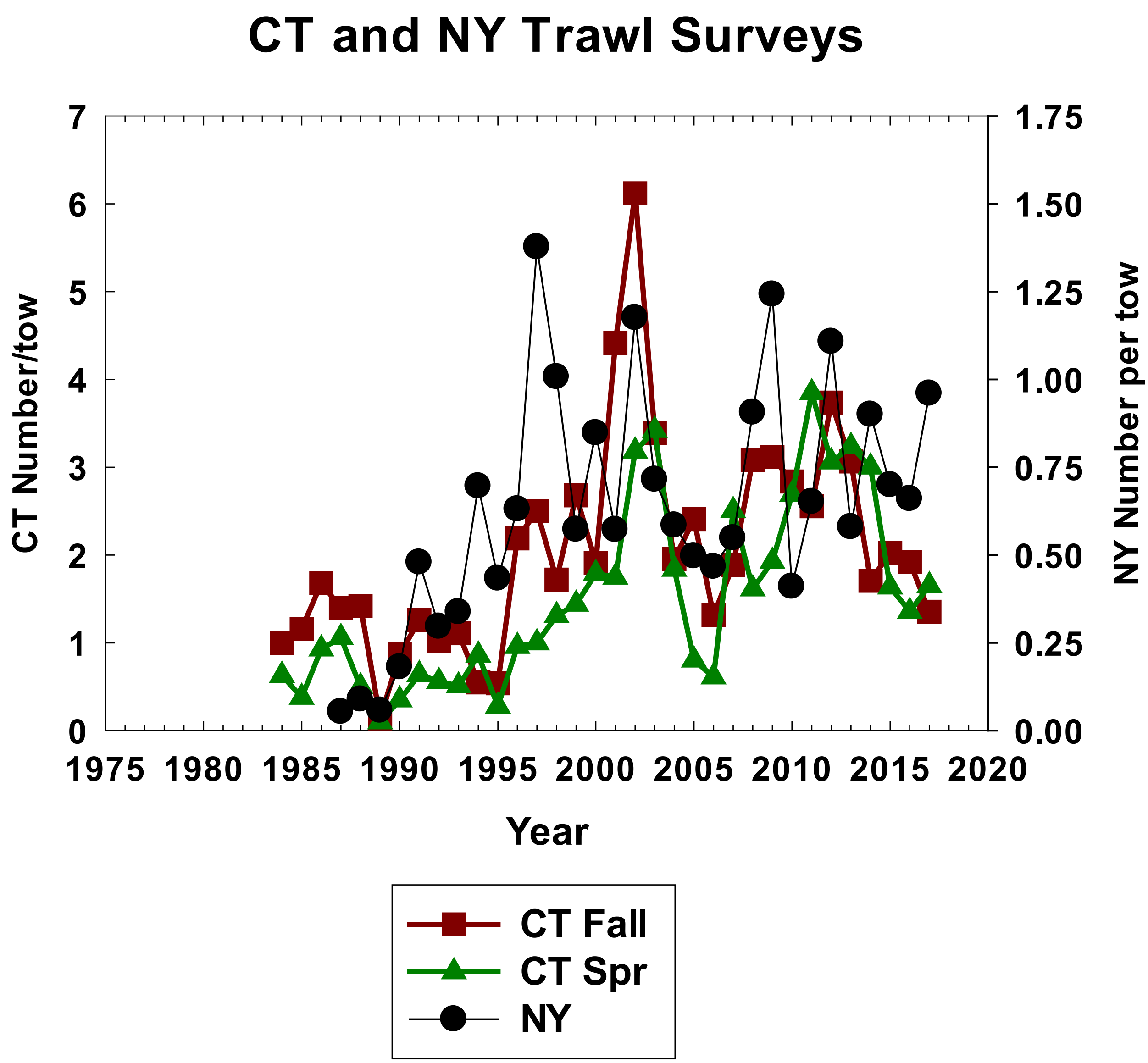


Figure A32. Trends in Connecticut (CT) and New York (NY) trawl survey abundance indices for summer flounder.

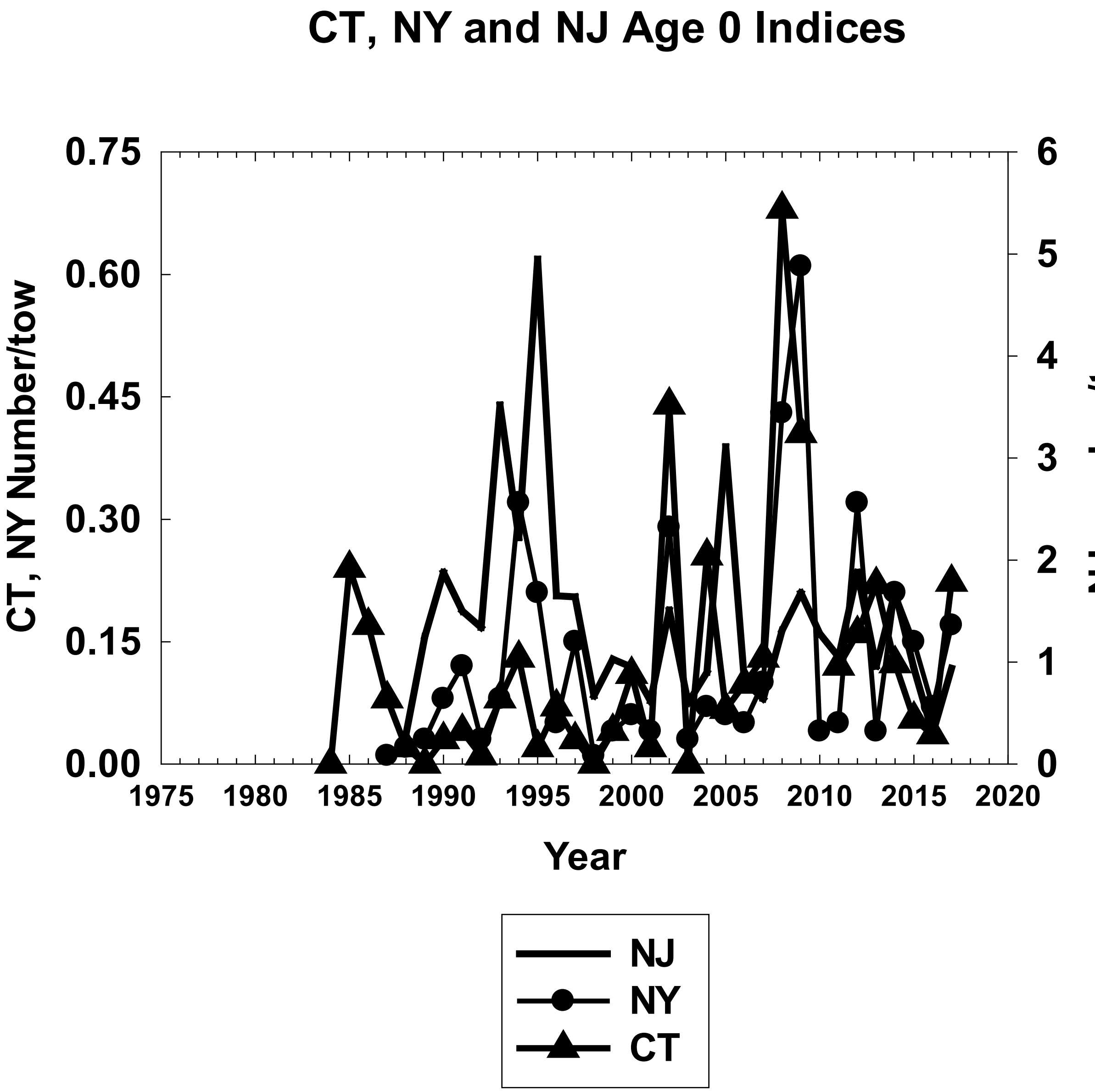


Figure A33. Trends in Connecticut (CT), New York (NY), and New Jersey (NJ) trawl survey recruitment indices for summer flounder young of the year (YOY).

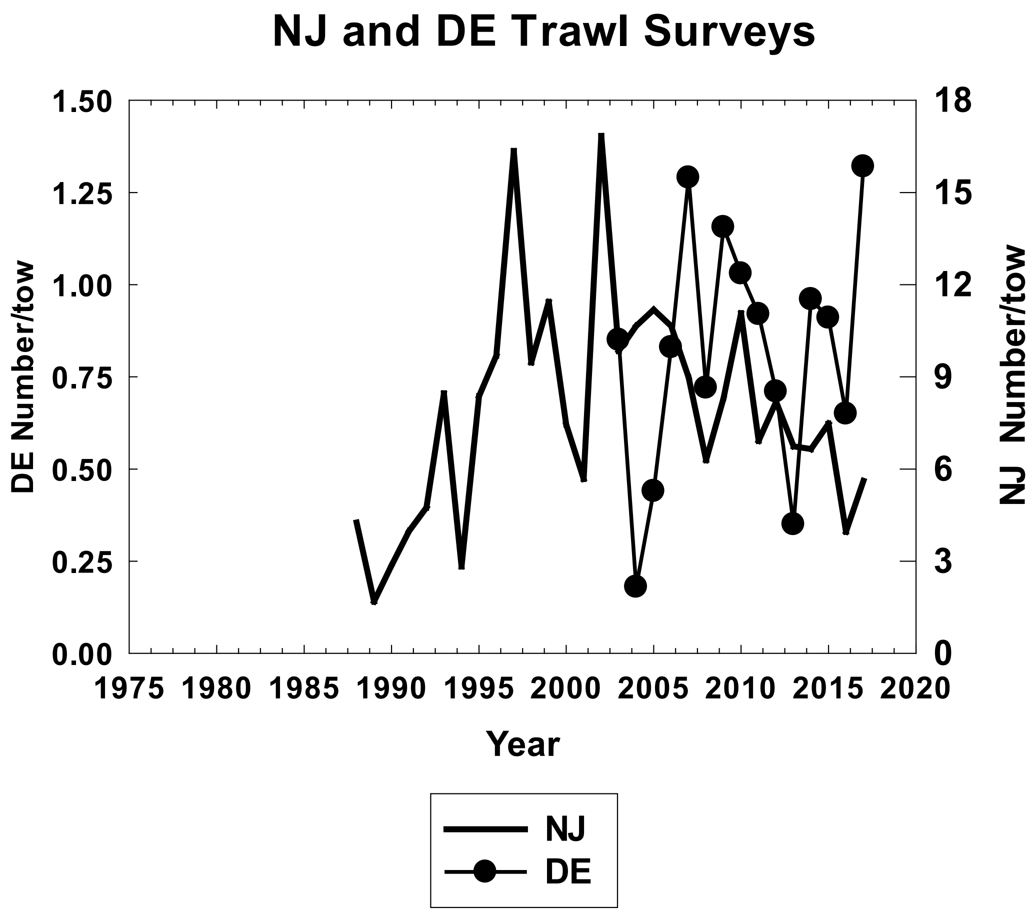


Figure A34. Trends in New Jersey (NJ) and Delaware (DE) trawl survey abundance indices for summer flounder.

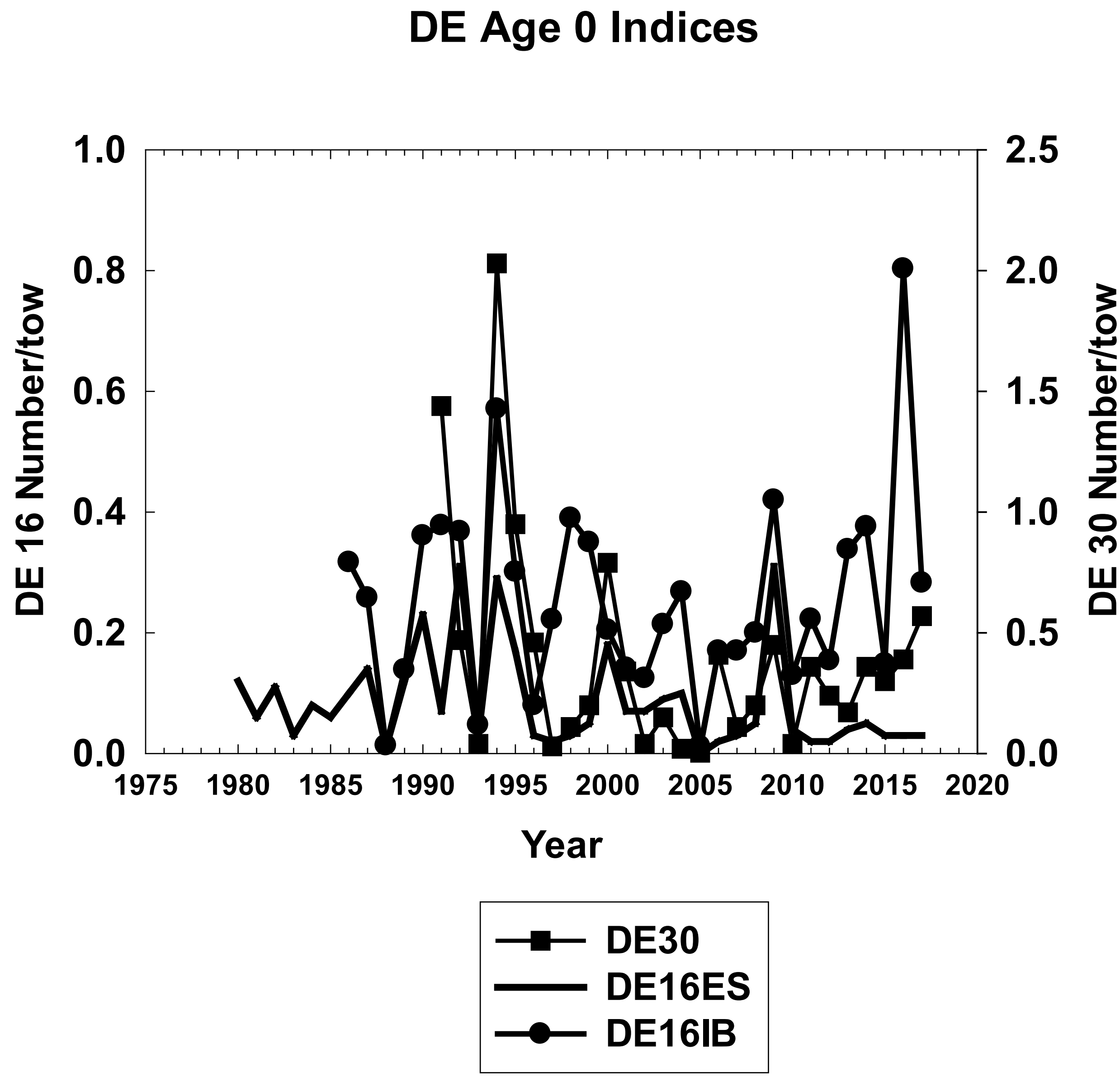


Figure A35. Trends in Delaware (DE) trawl survey recruitment indices for summer flounder young of the year (YOY).

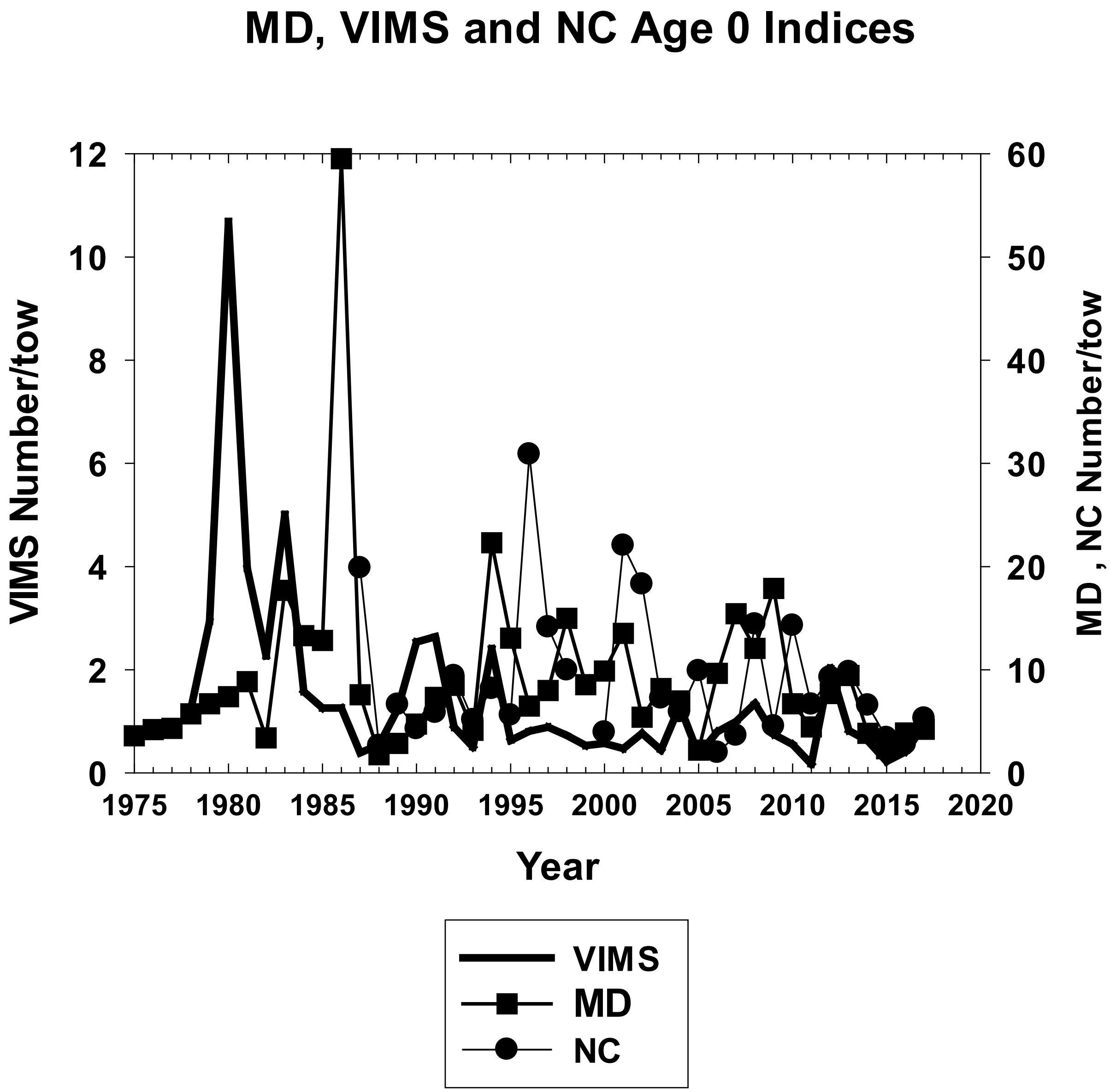


Figure A36. Trends in Maryland (MD), Virginia Institute of Marine Science (VIMS) and North Carolina (NC) trawl survey recruitment indices for summer flounder young of the year (YOY).

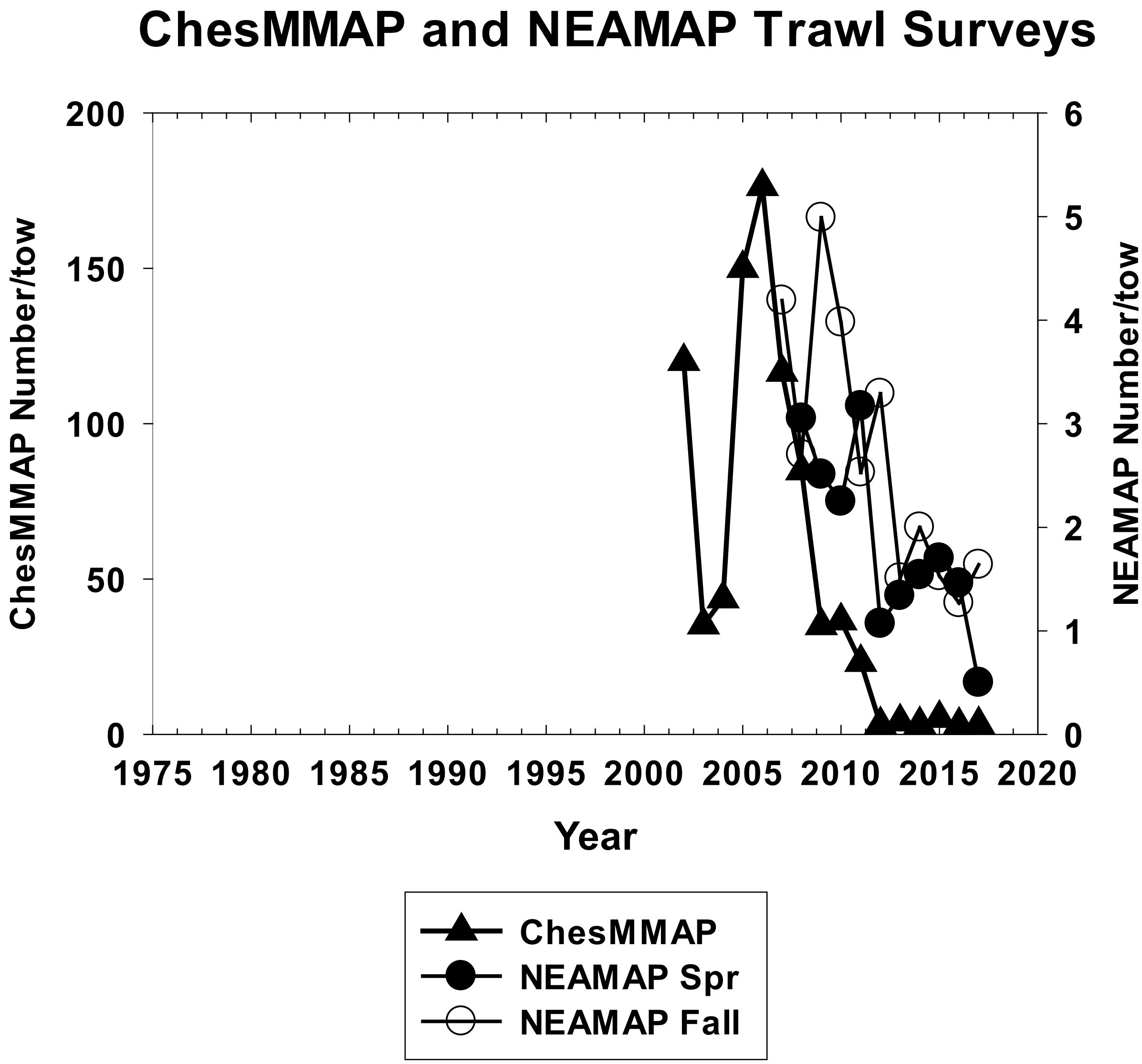


Figure A37. Trends in Northeast Area Monitoring and Assessment Program (NEAMAP) and Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) trawl survey abundance indices for summer flounder.

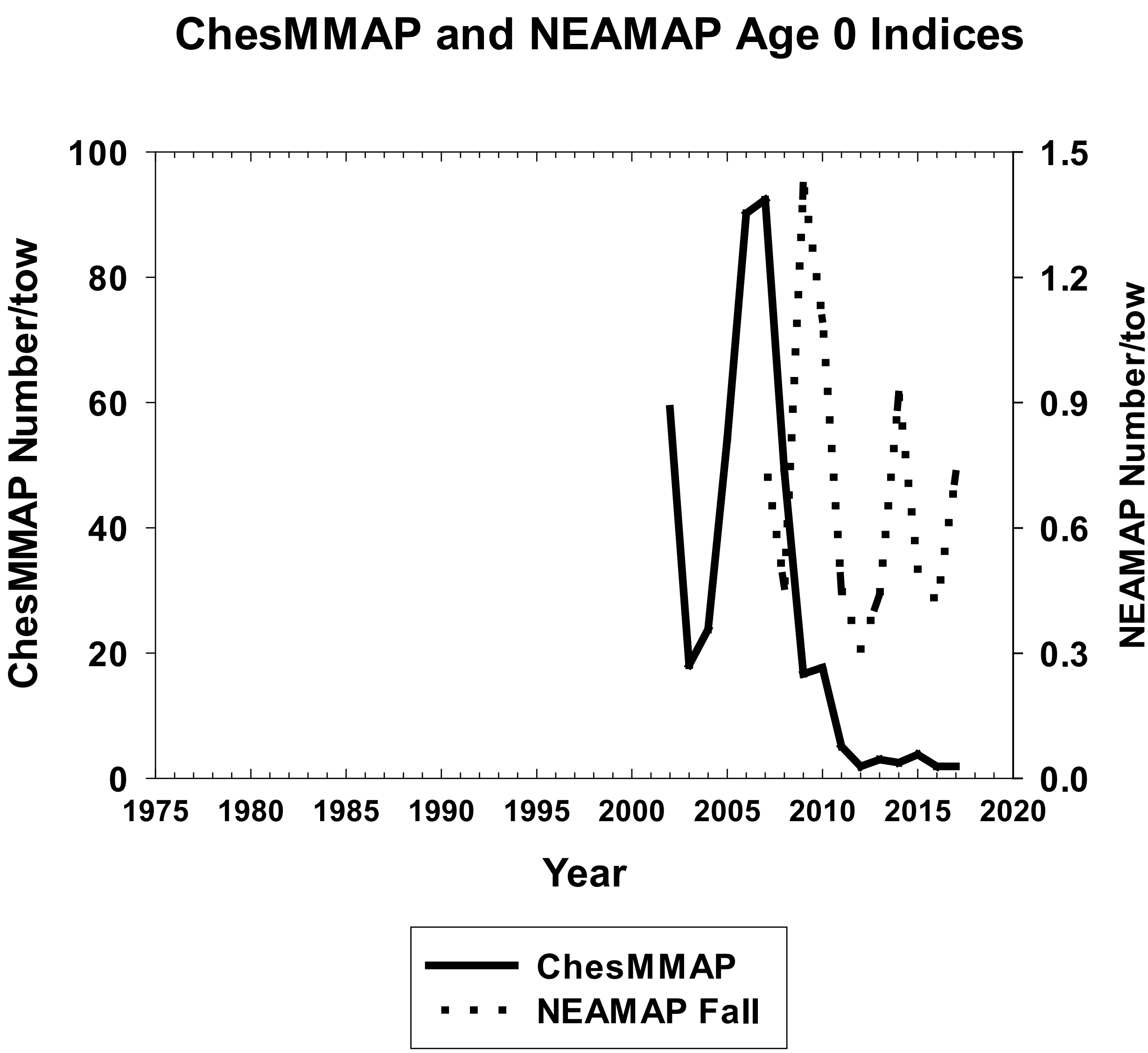


Figure A38. Trends in Northeast Area Monitoring and Assessment Program (NEAMAP) and Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) trawl survey abundance indices and trawl survey recruitment indices for summer flounder young of the year (YOY).

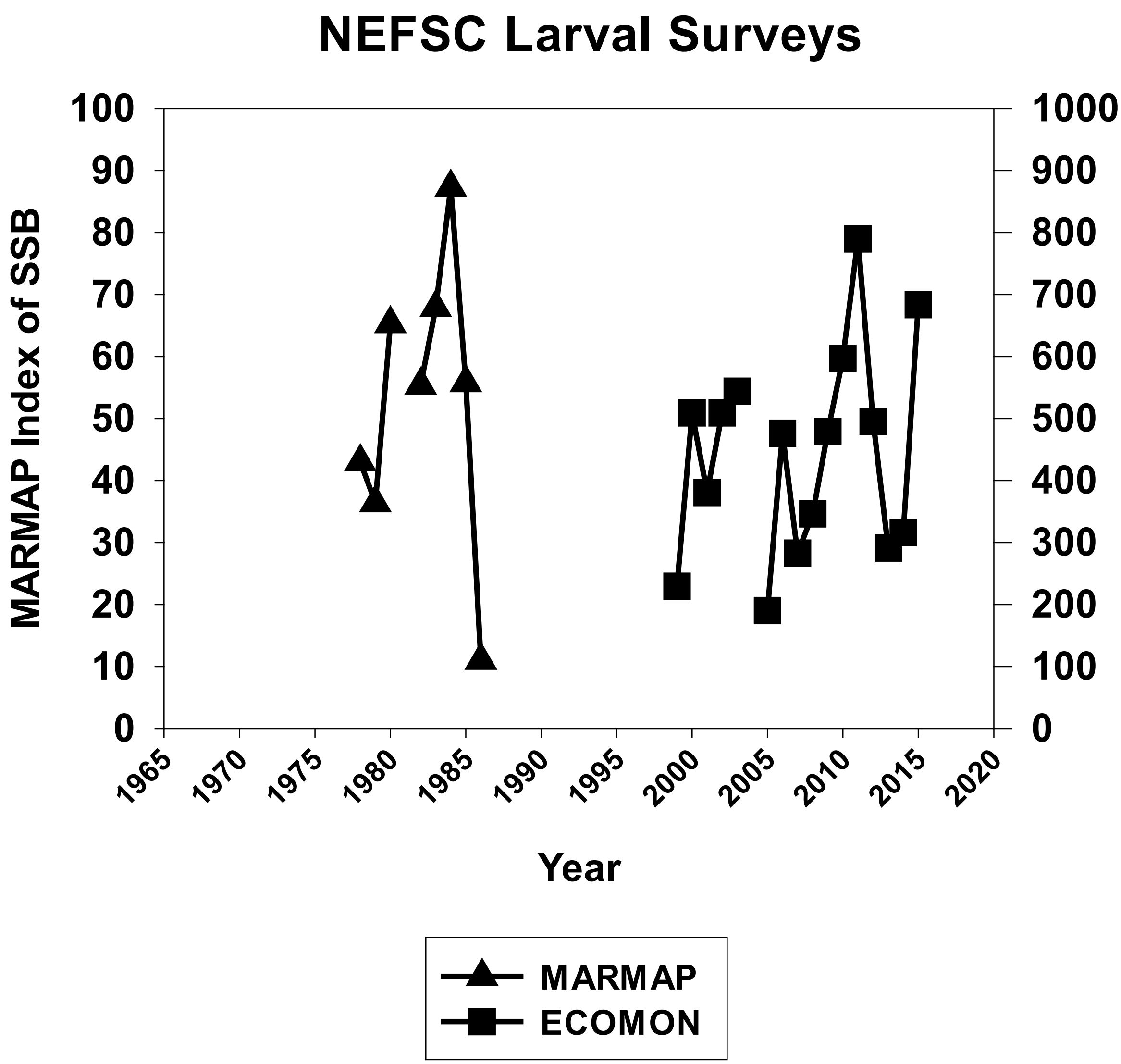
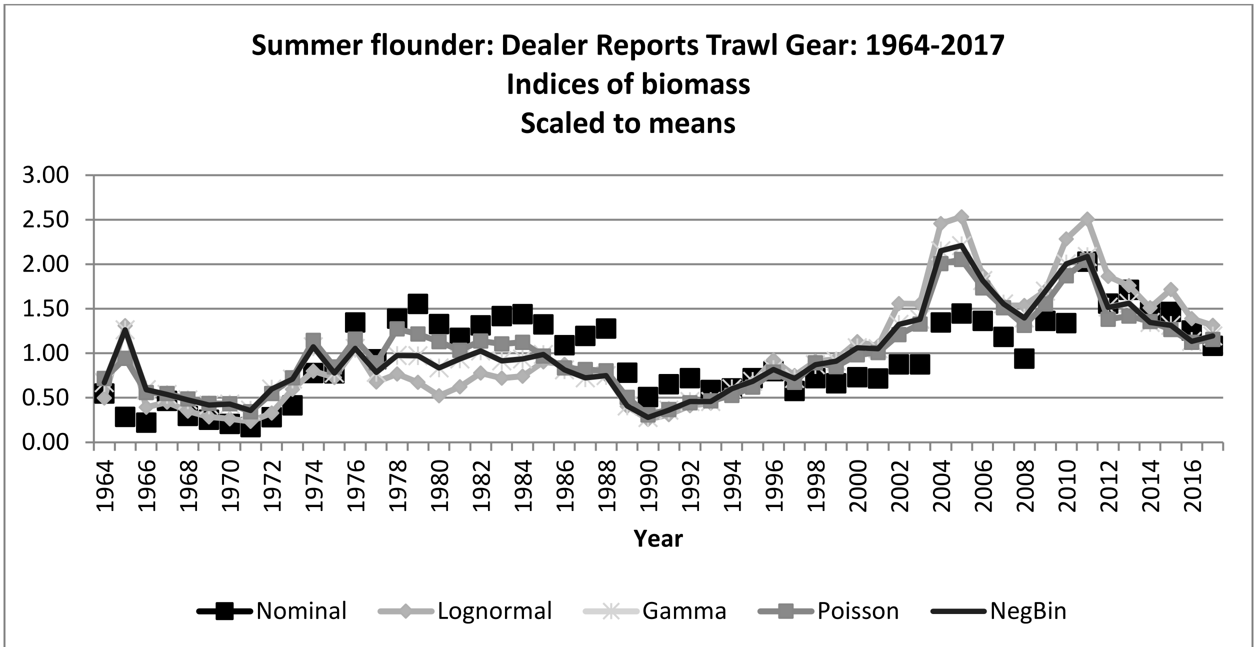


Figure A39. Trends in Northeast Fisheries Science Center (NEFSC) MARMAP and ECOMON larval survey Spawning Stock Biomass (SSB) indices for summer flounder.



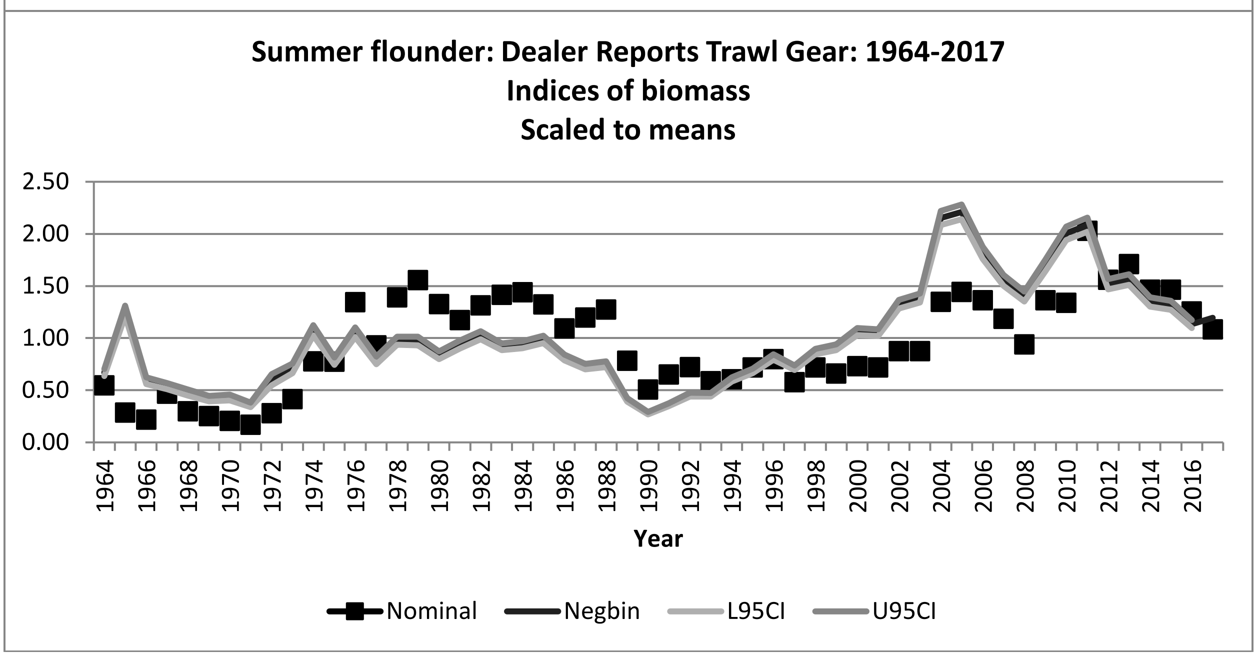
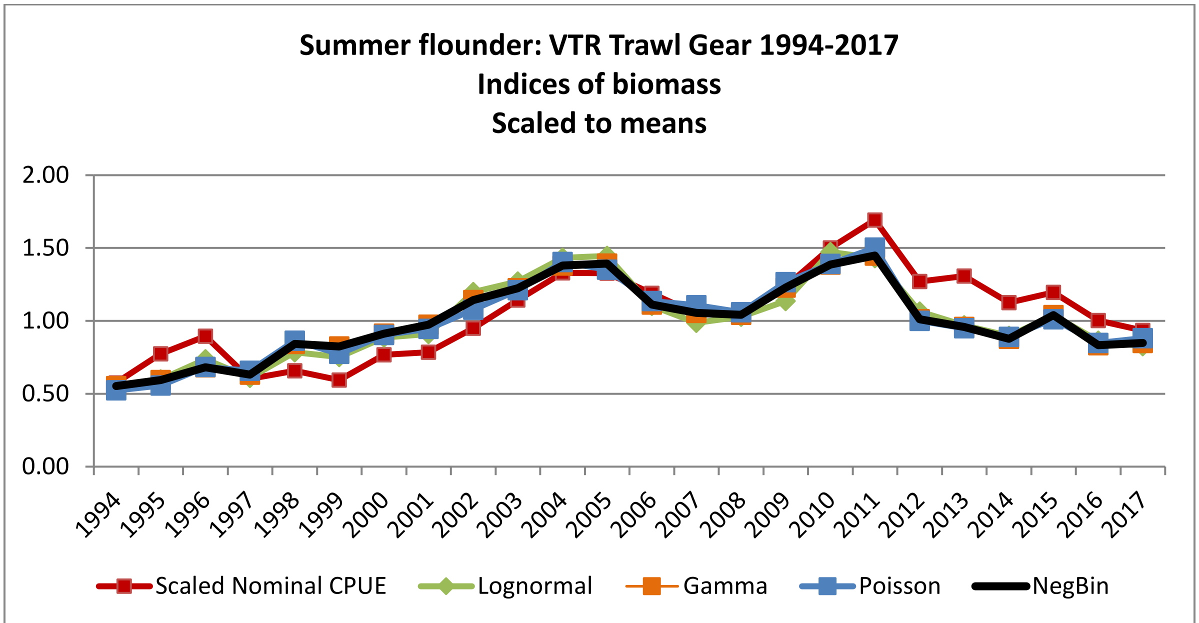


Table A40. Top - comparison of the Dealer report trawl gear landings and effort nominal index and model-based standardized indices. Bottom - comparison of the Dealer report trawl gear landings and effort nominal index and negbin model-based standardized index and 95% confidence intervals.



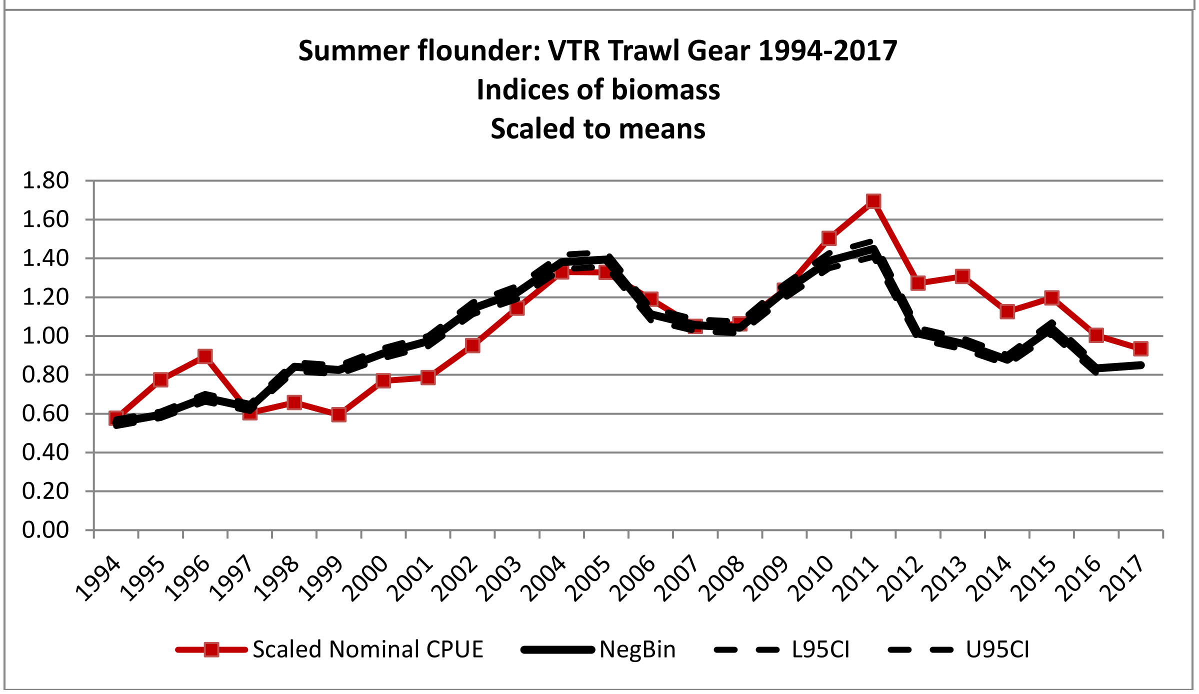


Table A41. Top - comparison of the Vessel Trip Report (VTR) trawl gear landings and effort nominal index and model-based standardized indices. Bottom - comparison of the Vessel Trip Report (VTR) report trawl gear landings and effort nominal index and negbin model-based standardized index and 95% confidence intervals.

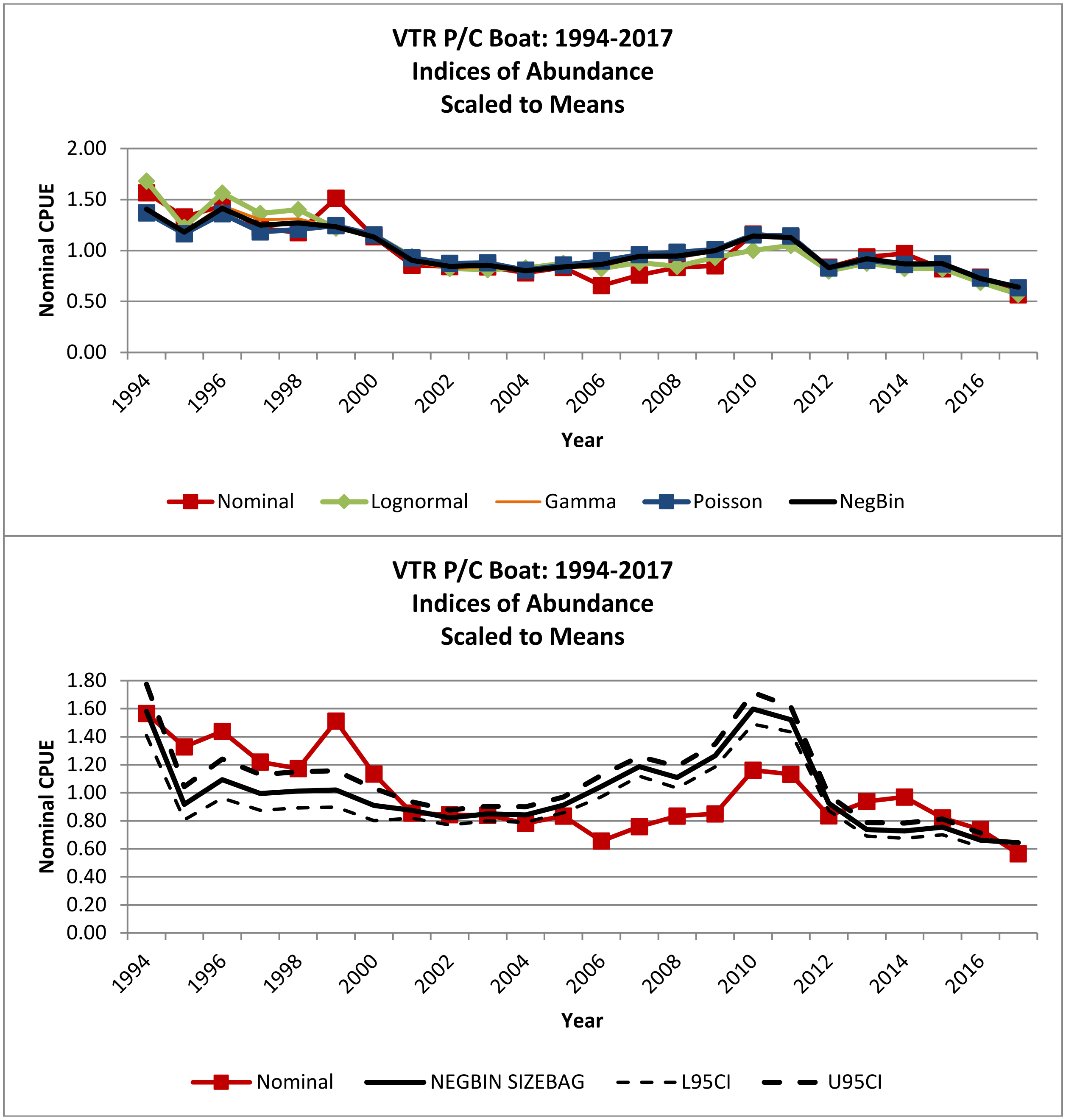


Figure A42. Top - comparison of the Vessel Trip Report (VTR) Party/Charter boat nominal index and model-based standardized indices. Bottom - comparison of the negbin six-factor ST-SZE-BAG model-based indices and the nominal index.

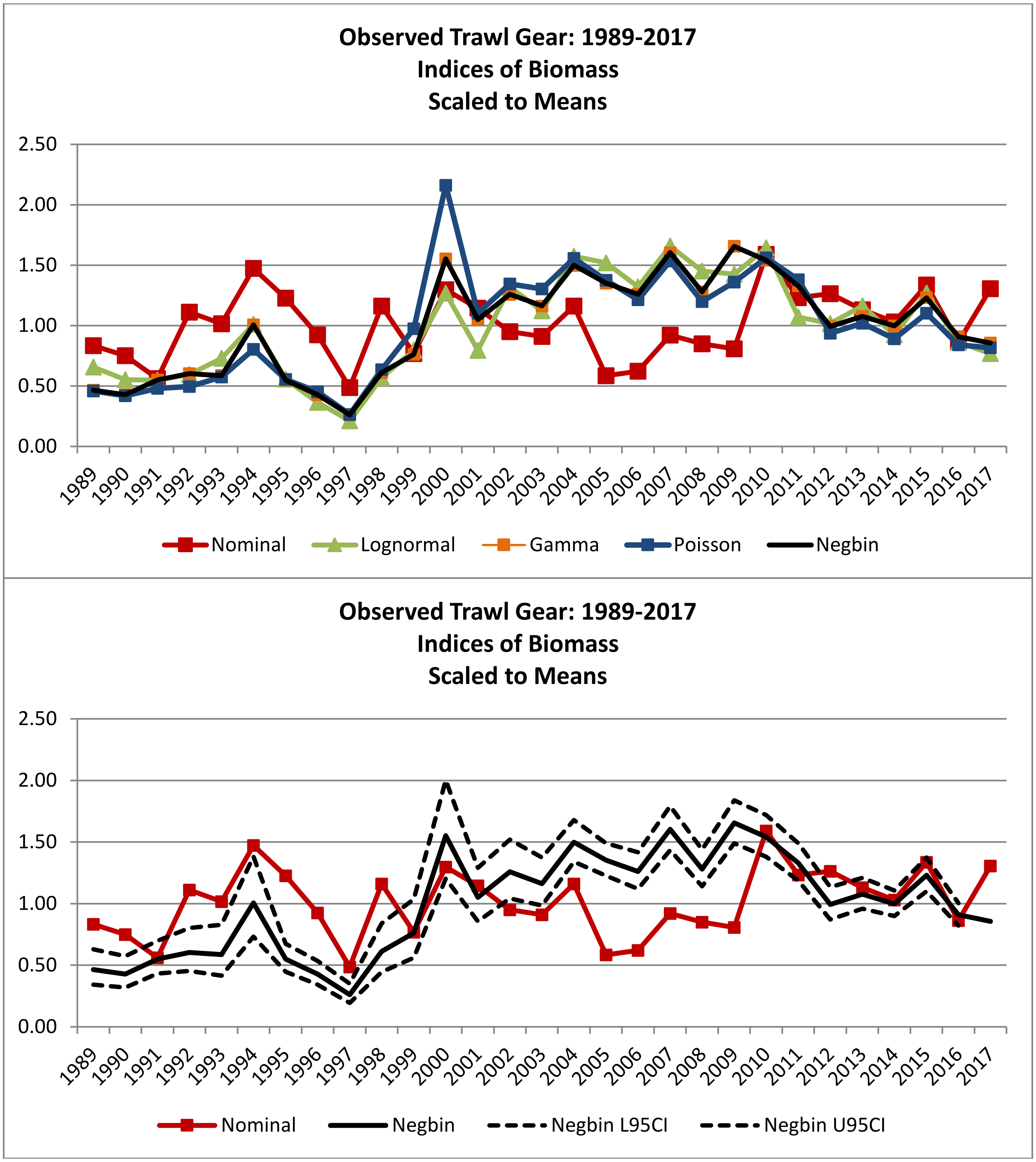


Figure A43. Top - comparison of the Observed trawl gear nominal index and model-based standardized indices. Bottom - comparison of the Observed trawl gear negbin model-based index and the nominal index.

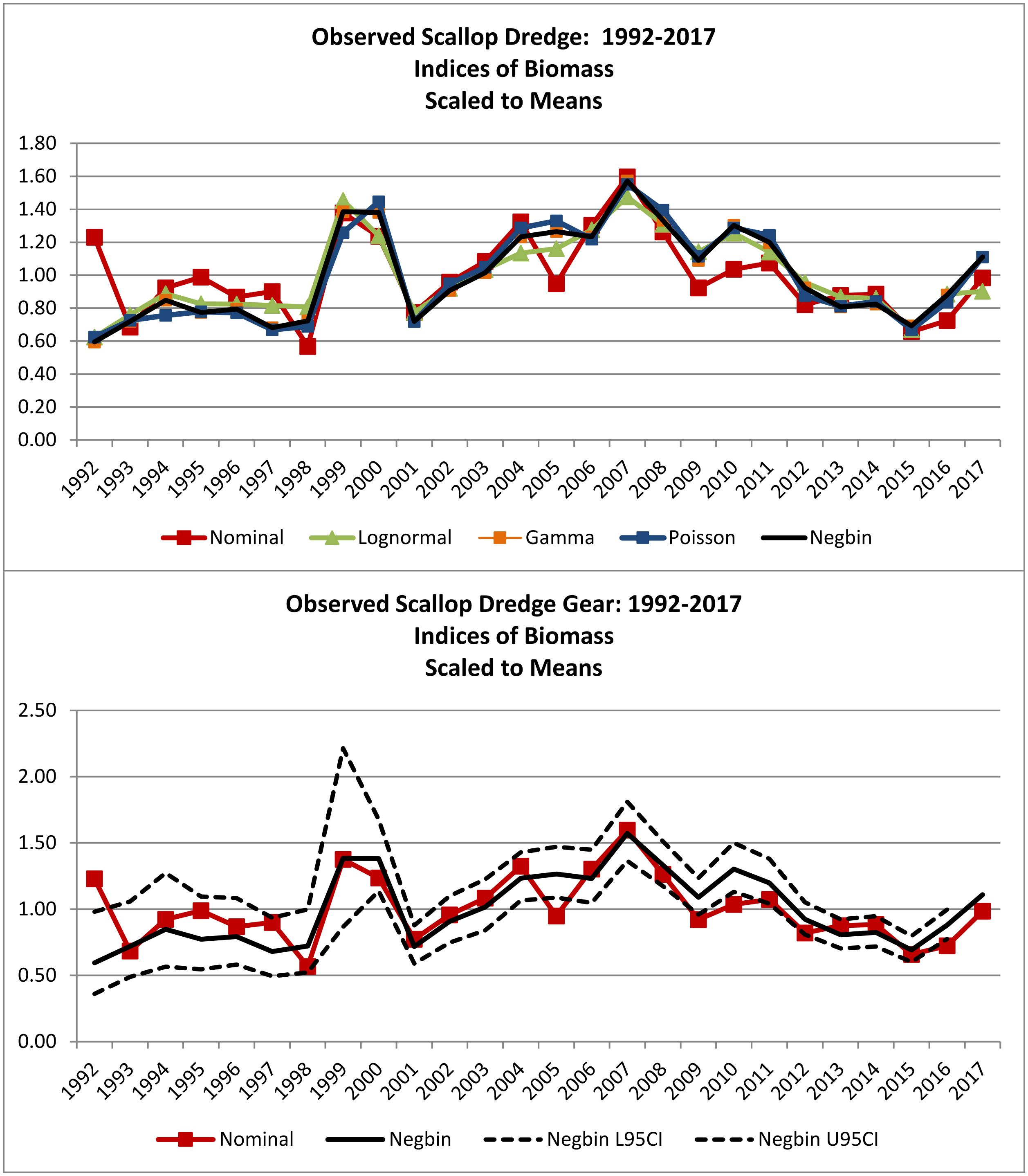


Figure A44. Top - comparison of the Observed scallop dredge gear nominal index and model-based standardized indices. Bottom - comparison of the Observed scallop dredge gear negbin model-based index and the nominal index.

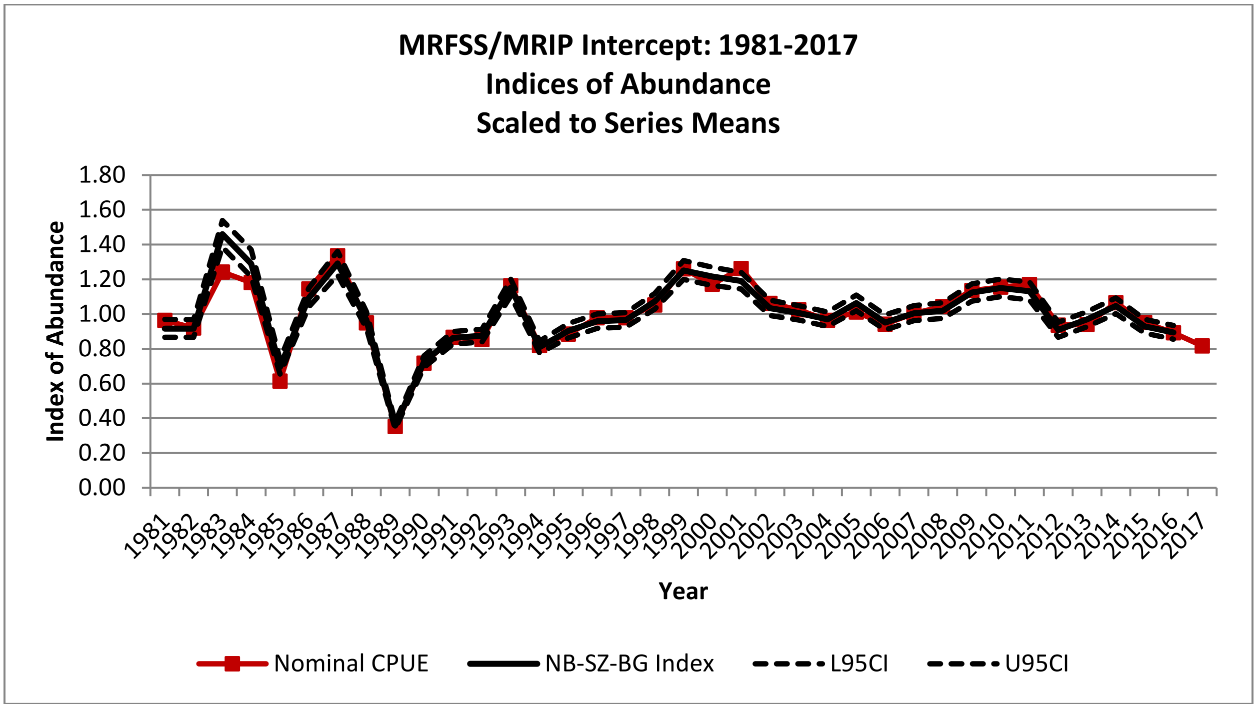


Figure A45. Comparison of the Marine Recreational Fishery Statistics Survey (MRFSS) / Marine Recreational Information Program (MRIP) intercept negbin six-factor ST-SZ-BG model-based indices and the nominal index.

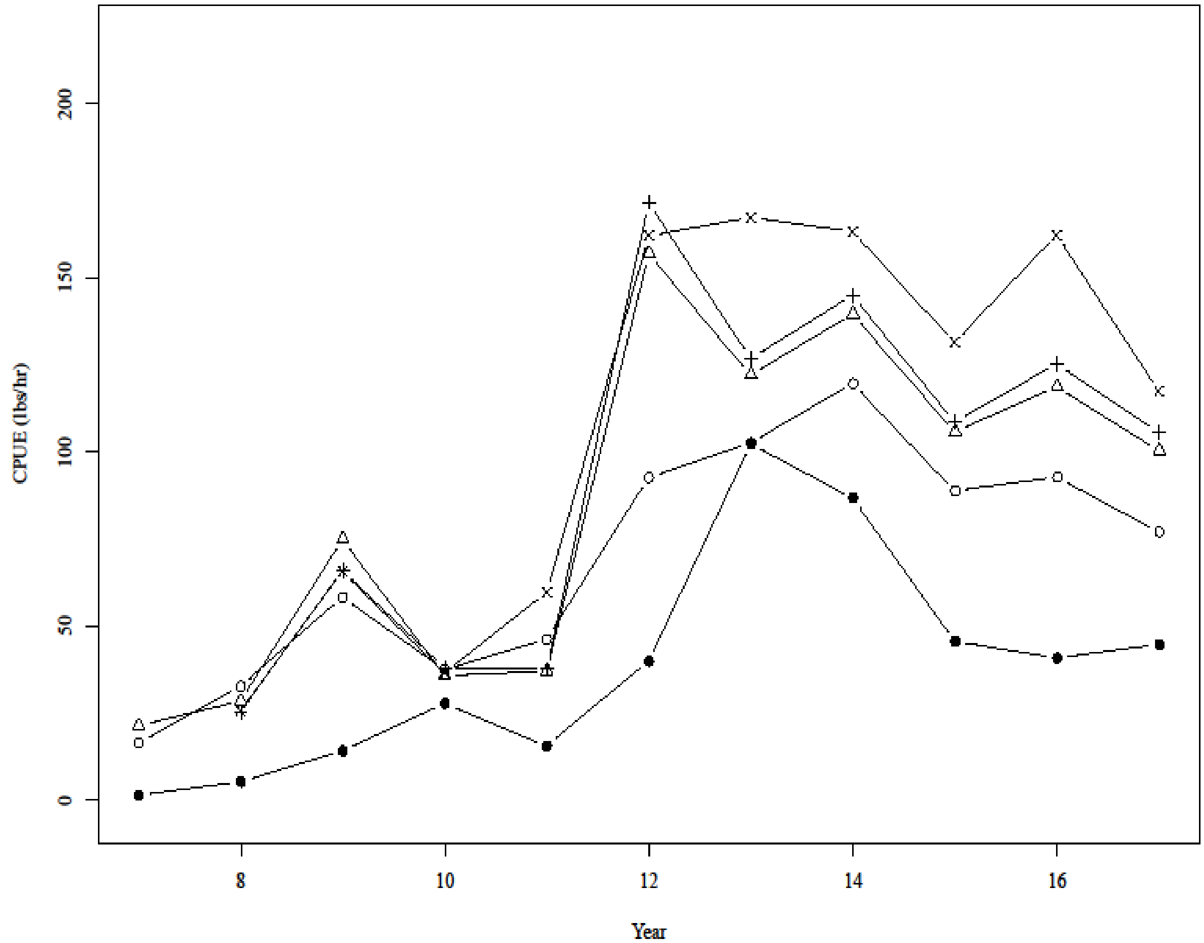
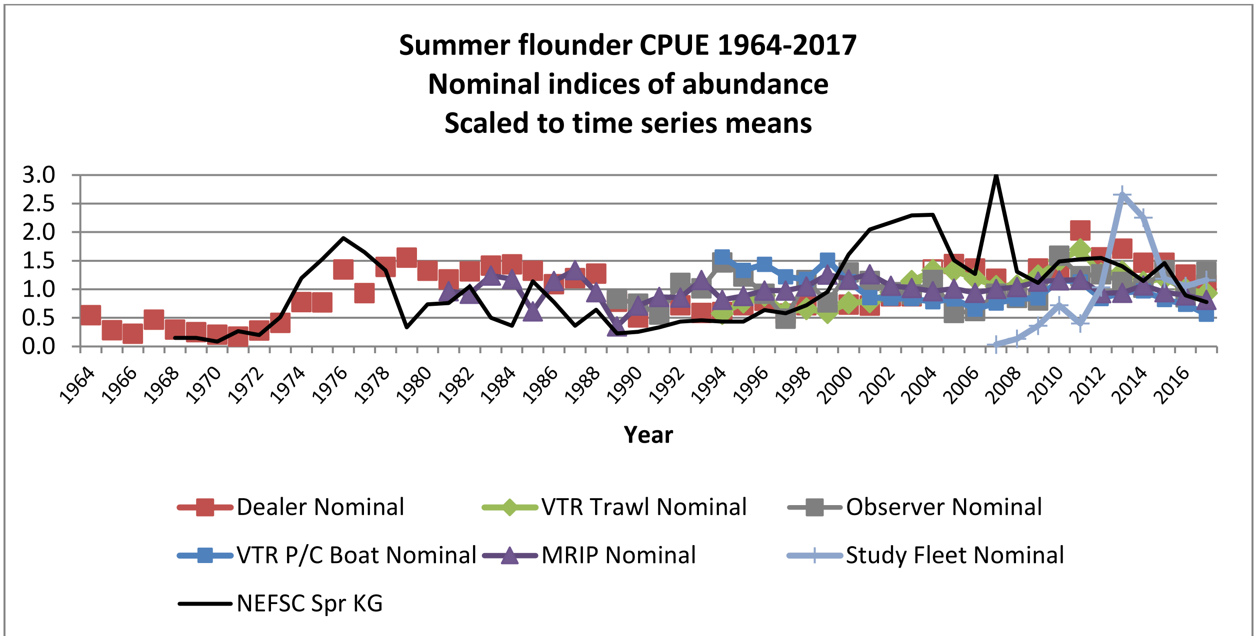


Figure A46. The annul catch-per-unit effort (CPUE) index for summer flounder derived from the NEFSC Cooperative Research Study Fleet Program self-reported data at various quantification levels of 'directed' trips. Values are in pounds per hour (lbs/hr). Filled circles represent All trips, open circles represent where summer flounder comprises at least 10% of the landed catch, open triangles 25%, crosses 40%, and x's 75%. The 40% trips were used as the 'model' indices.



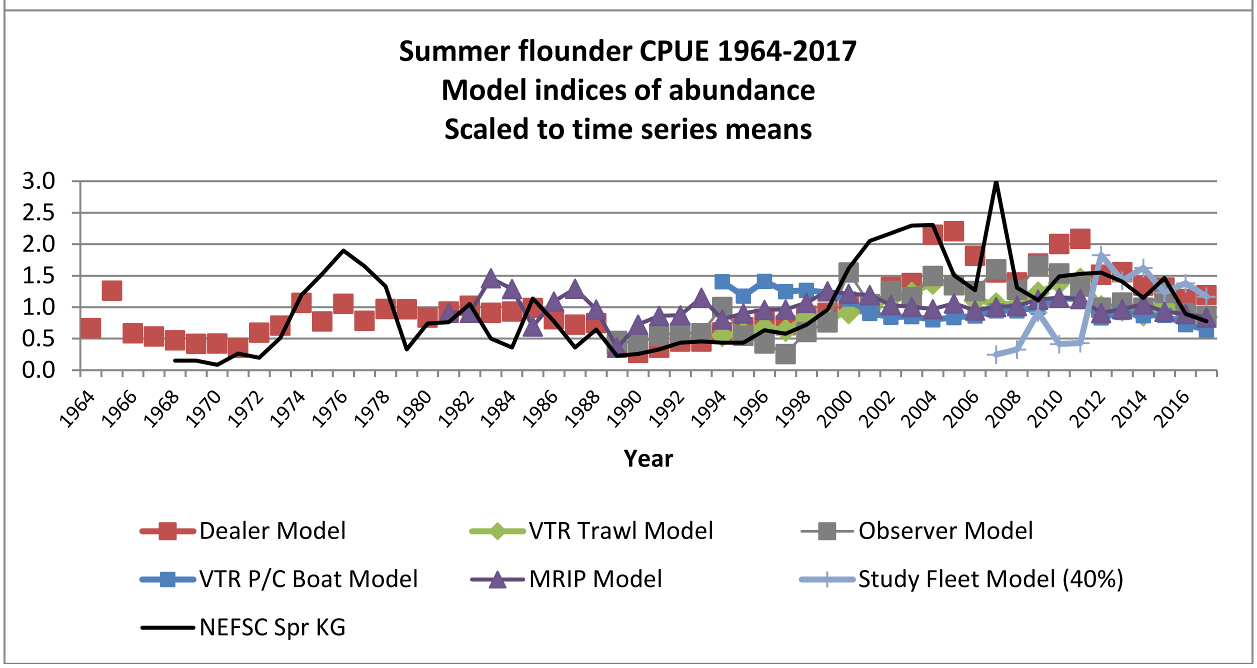


Figure A47. Top - trends in fishery dependent nominal indices of summer flounder stock size. Bottom - trends in fishery dependent model indices of summer flounder stock size Indices are compared with the Northeast Fisheries Science Center (NEFSC) spring survey biomass (KG) index, and all are scaled to the terminal year (2017) to facilitate comparison.

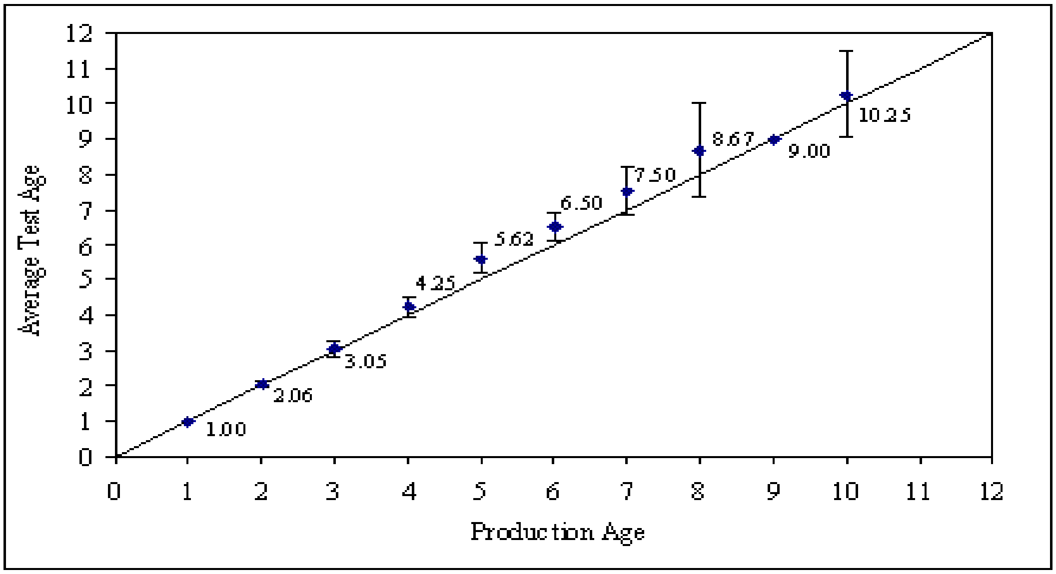


Figure A48. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2011 spring survey ages, 75% agreement.

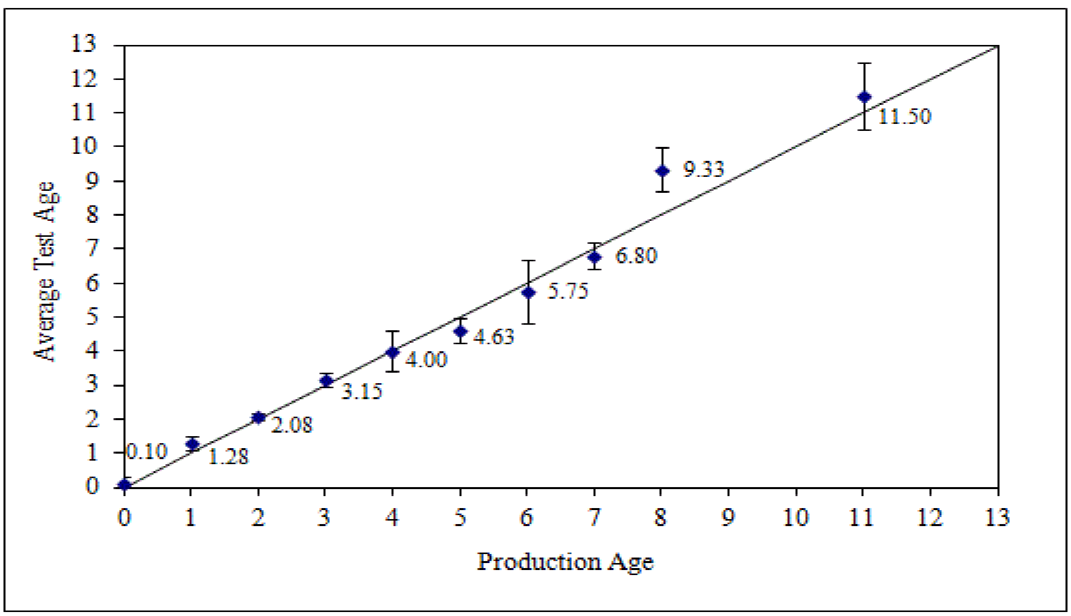


Figure A49. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2011 fall survey ages, 73% agreement.

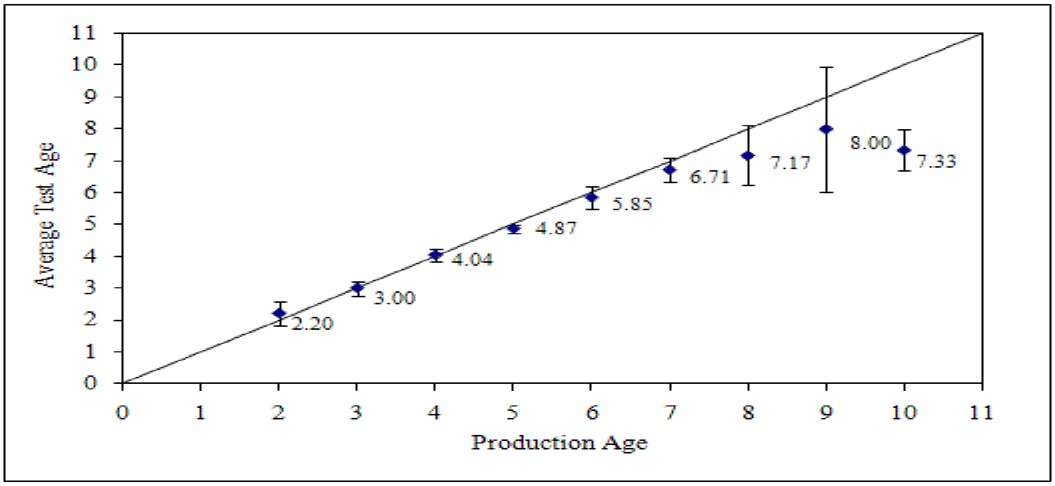


Figure A50. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2011 quarter 1 commercial ages, 69% agreement.

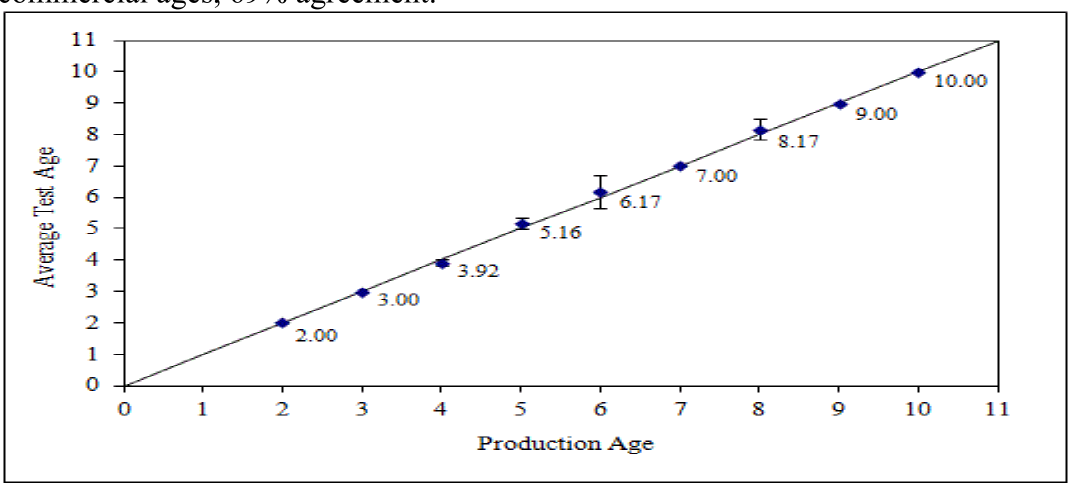


Figure A51. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2011 quarter 2 commercial ages, 92% agreement.

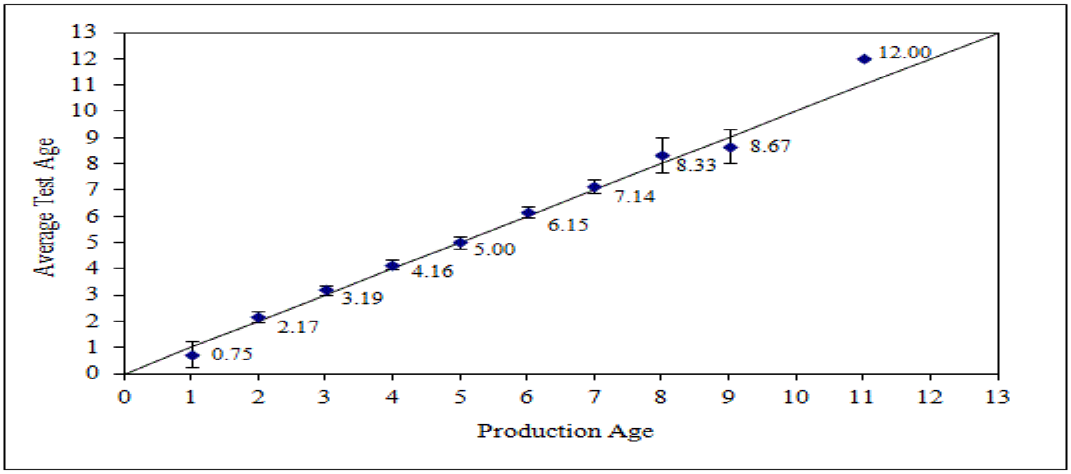


Figure A52. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2011 quarter 3-4 commercial ages, 80% agreement.

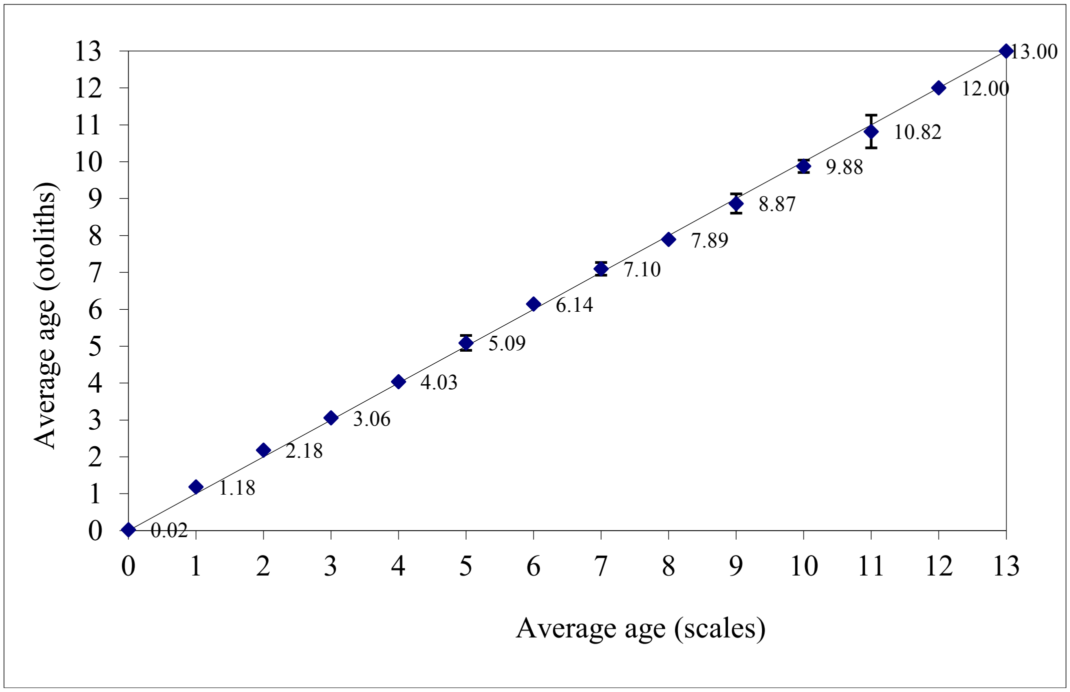


Figure A53. Age bias plot from the Atlantic States Marine Fisheries Commission (ASMFC) 2014 ageing workshop comparing scale and otolith ages for 619 summer flounder collected during 2009-2013. There was 79% agreement with 4.6% coefficient of variation.

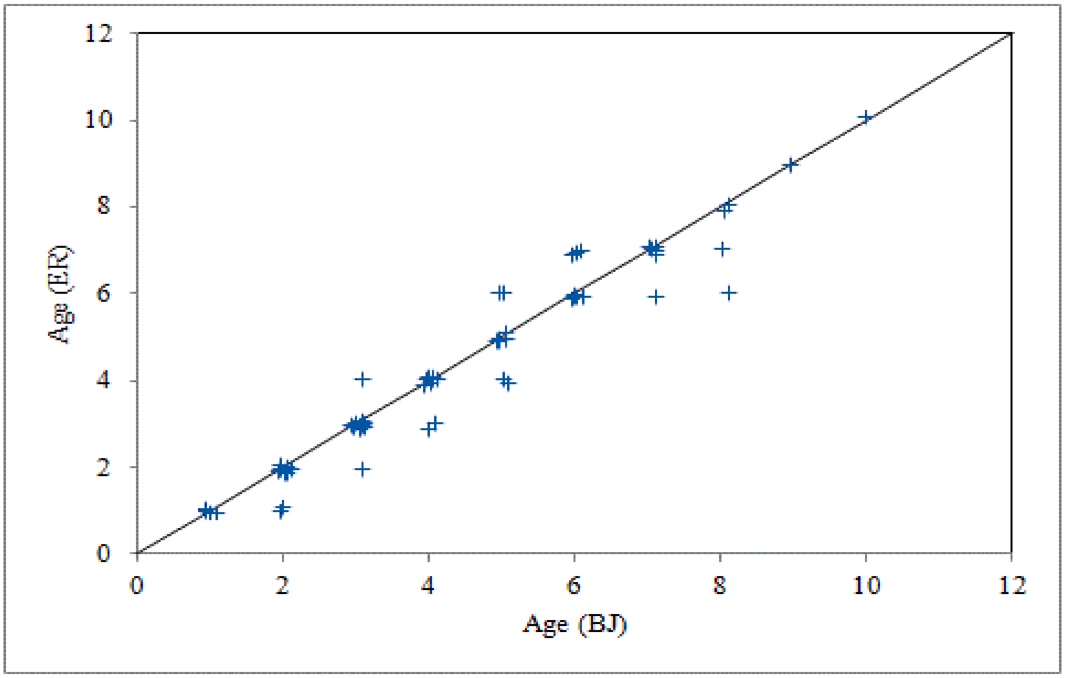


Figure A54. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2016 spring survey ages, 77% agreement.

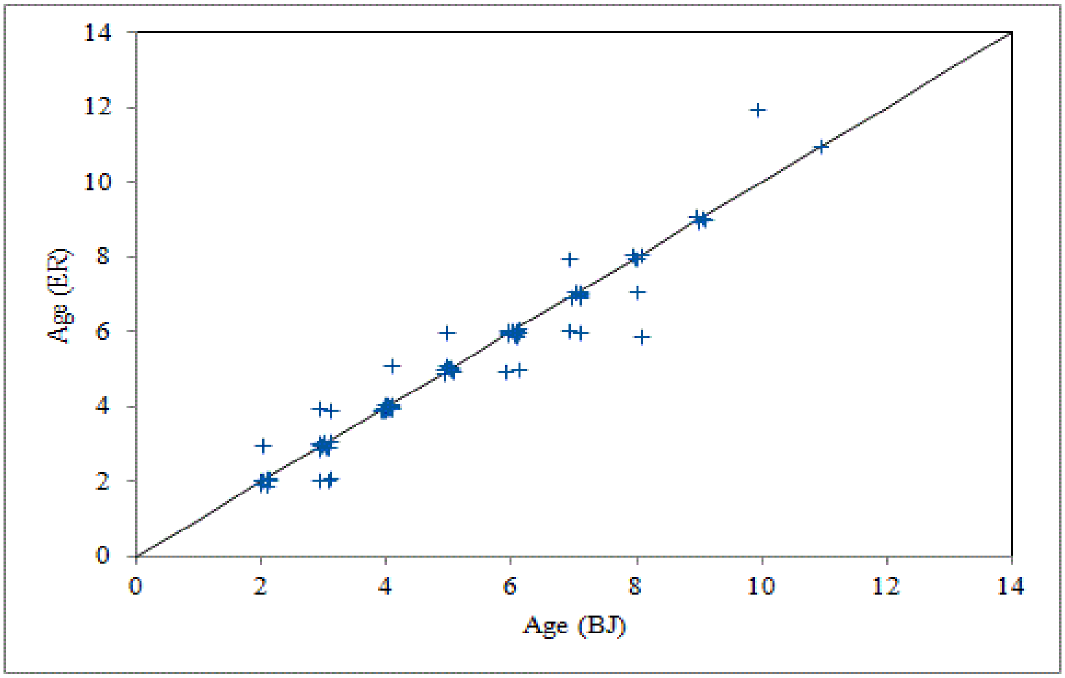


Figure A55. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2016 quarter 1 commercial ages, 83% agreement.

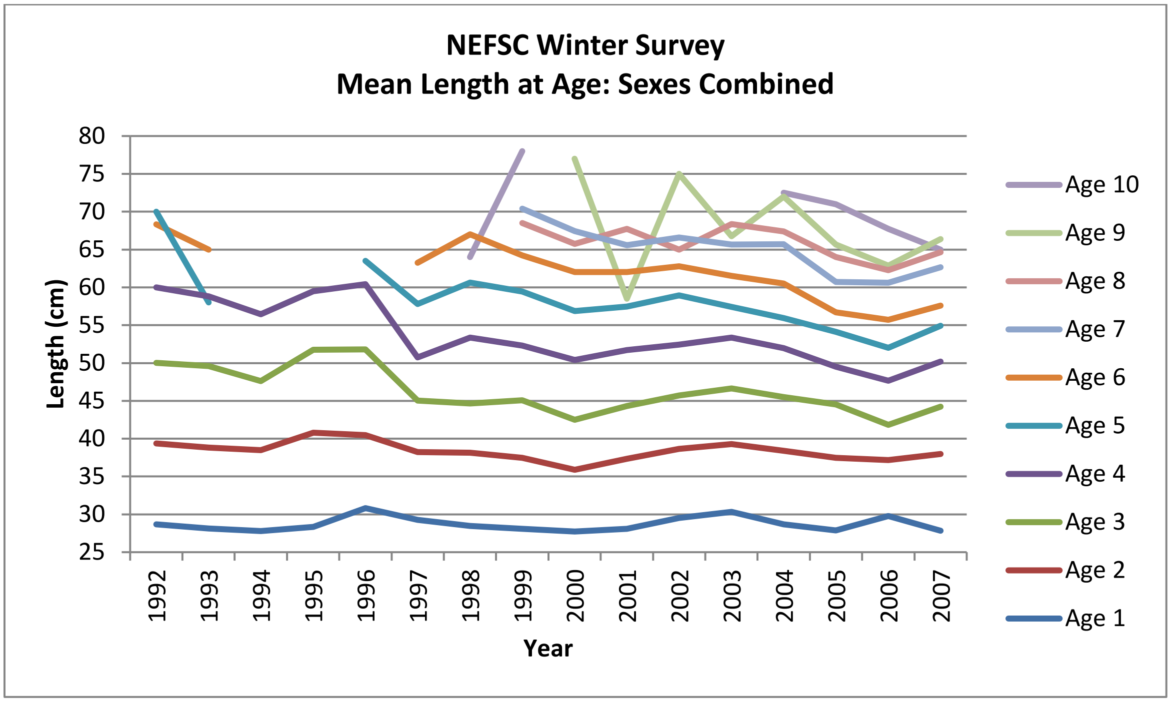


Figure A56. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) winter trawl survey: sexes combined.

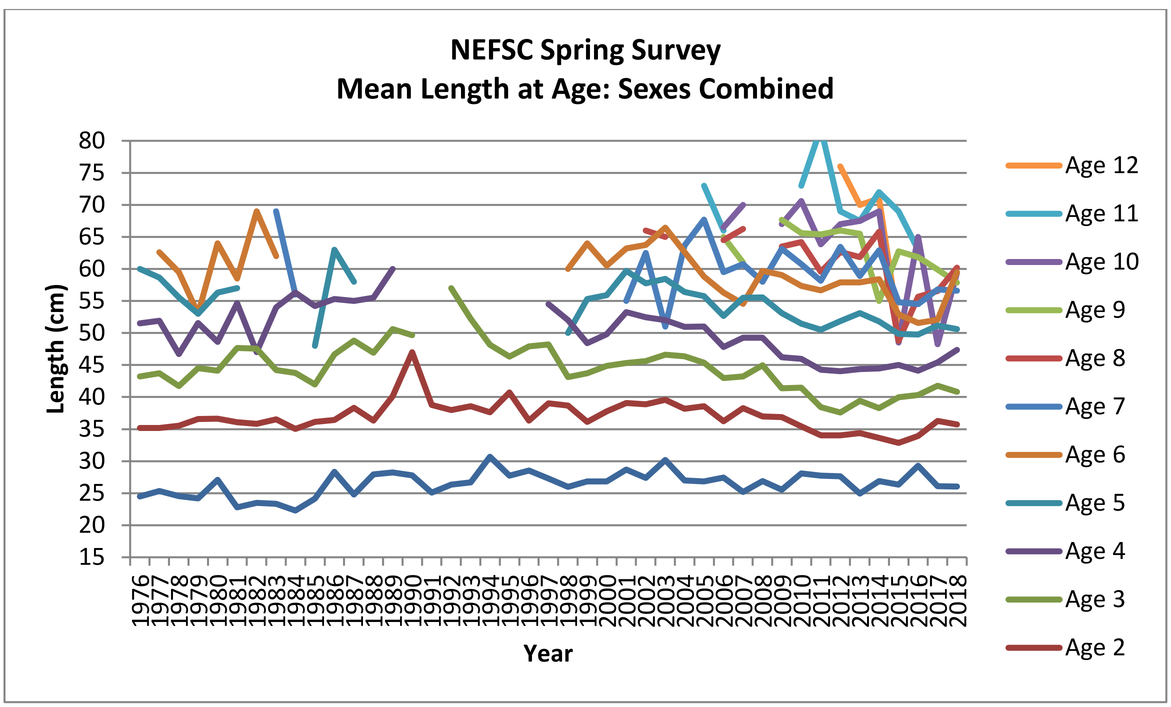


Figure A57. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) spring trawl survey: sexes combined.

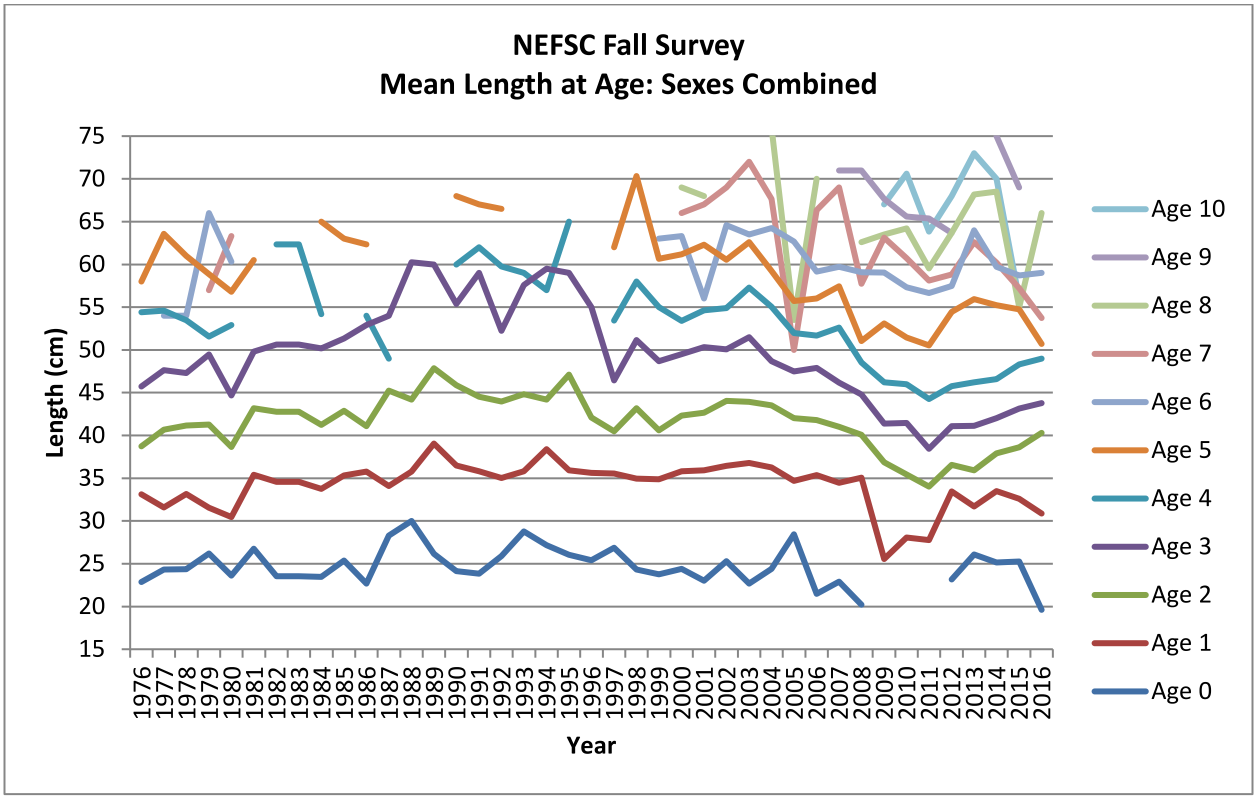


Figure A58. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) fall trawl survey: sexes combined.

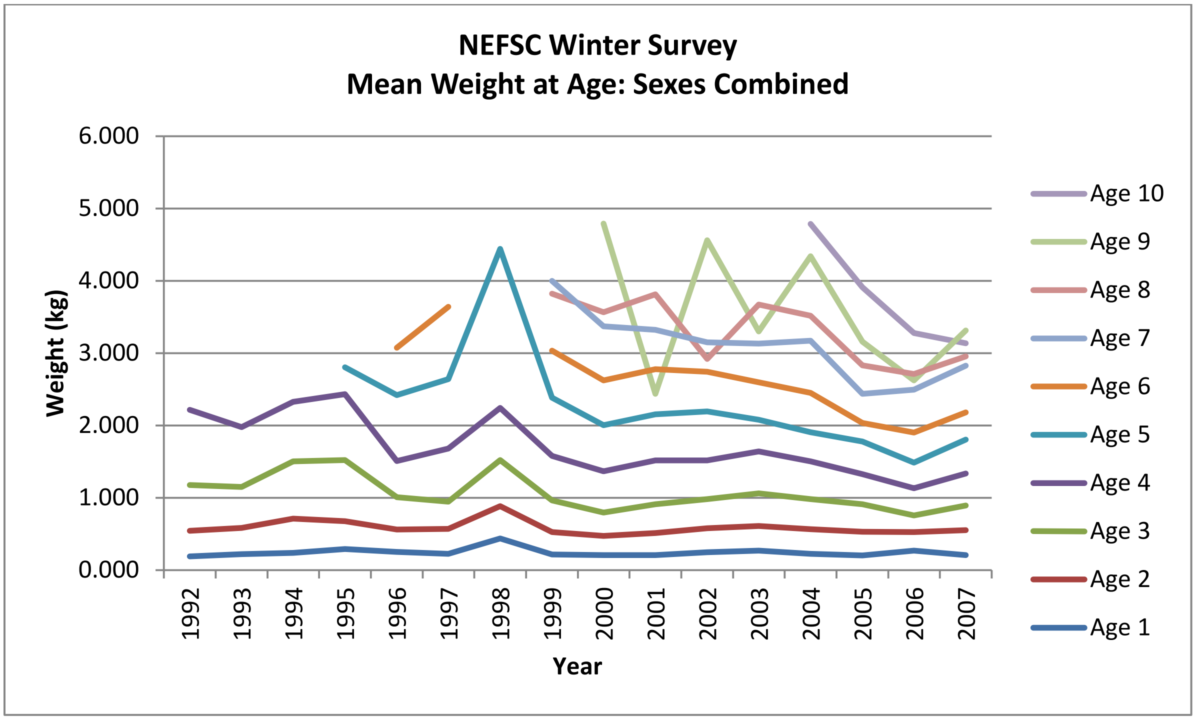


Figure A59. Trend in mean weight at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) winter trawl survey: sexes combined.

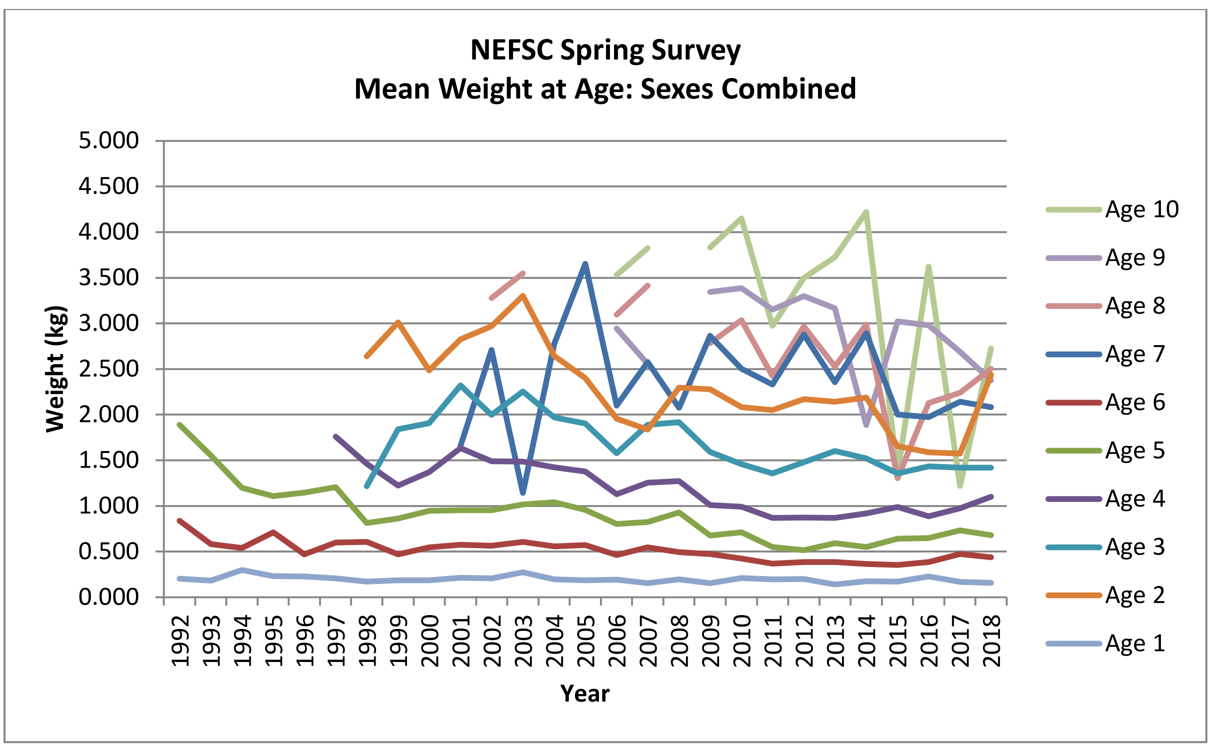


Figure A60. Trend in mean weight at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) spring trawl survey: sexes combined.

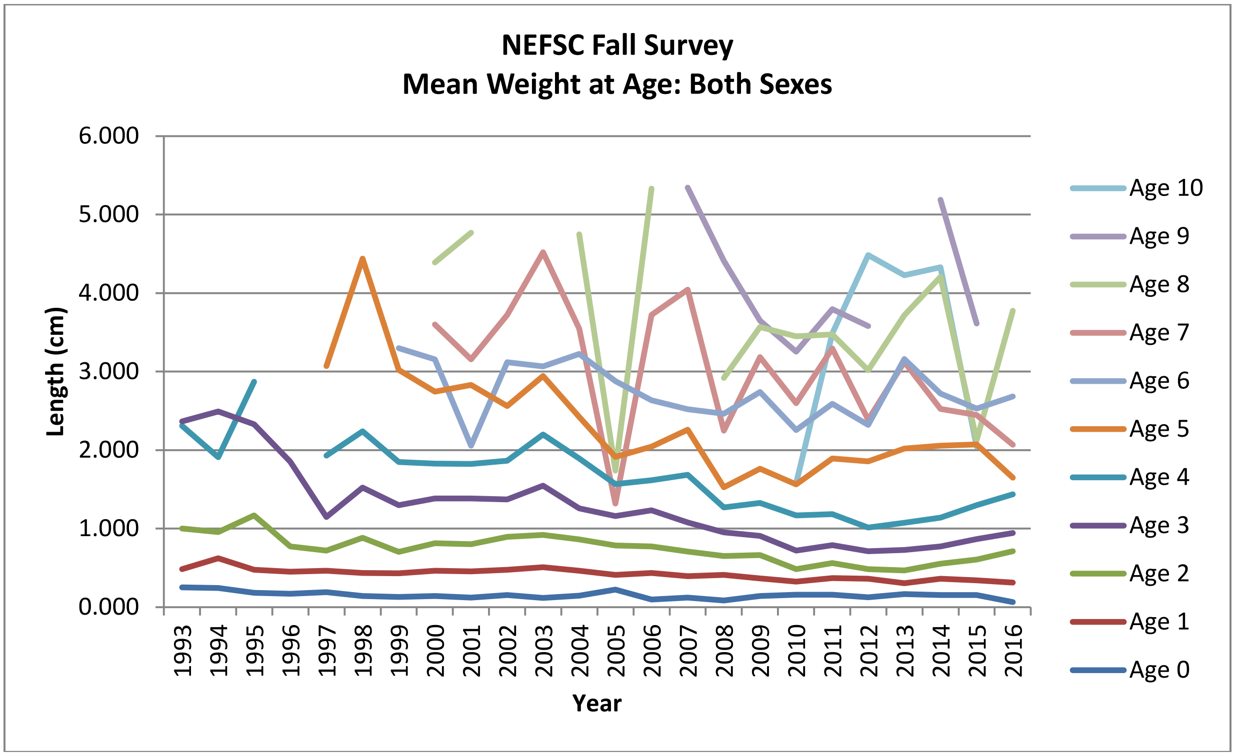


Figure A61. Trend in mean weight at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) fall trawl survey: sexes combined.

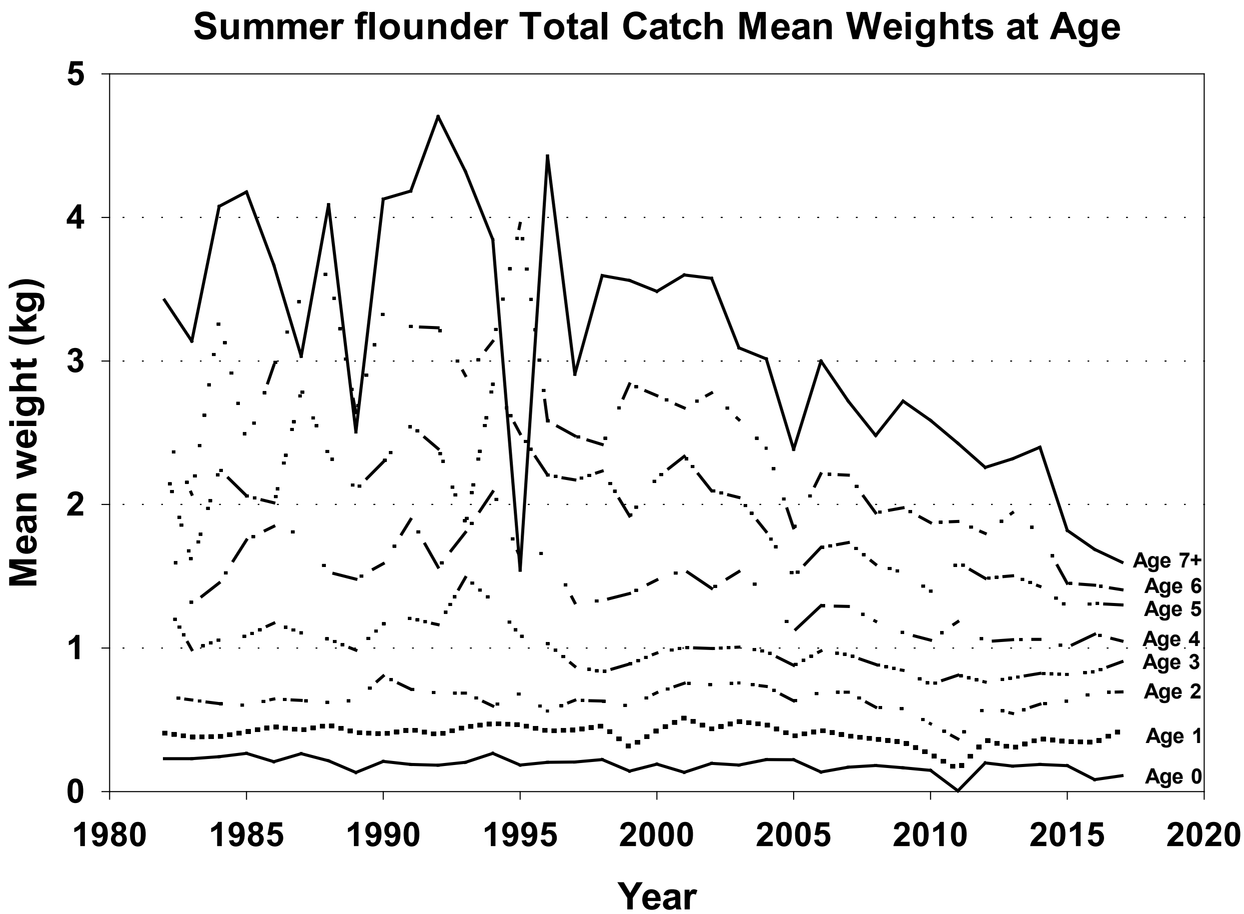
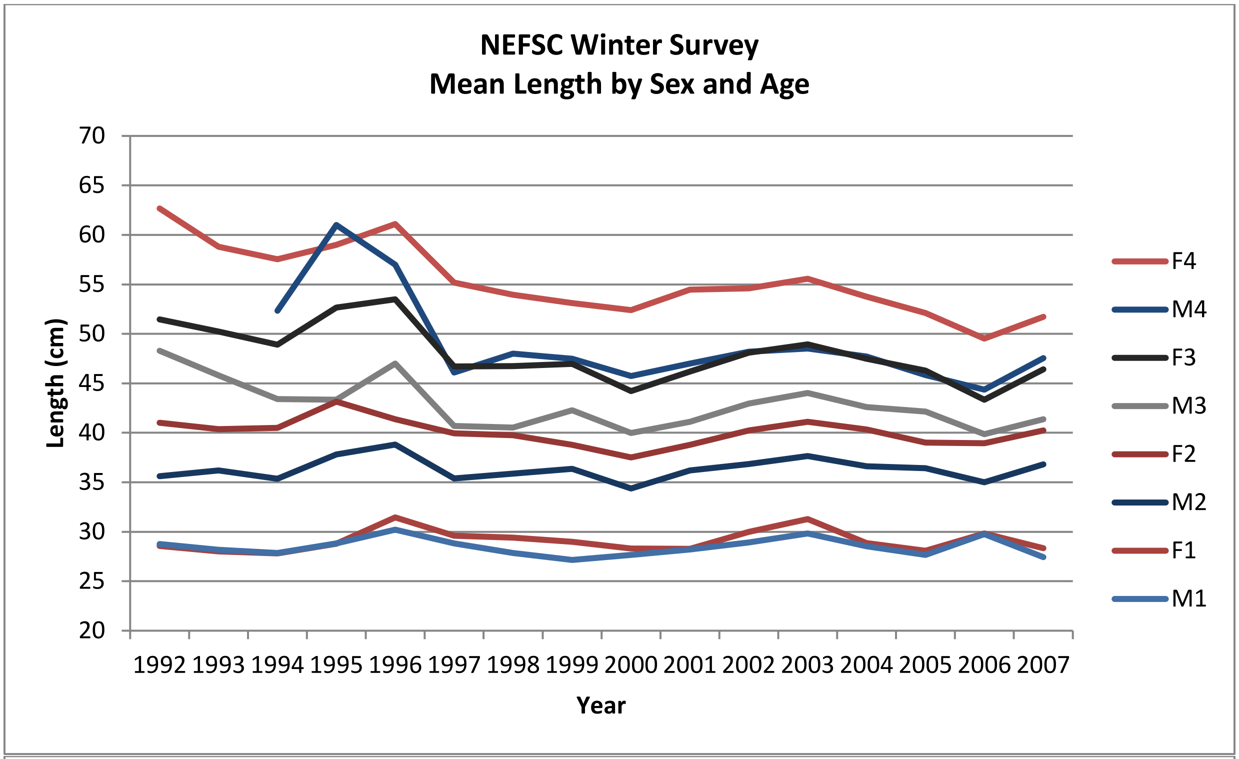


Figure A62. Trend in mean weight at age for the fishery total catch (sampled lengths converted to weights): sexes combined.



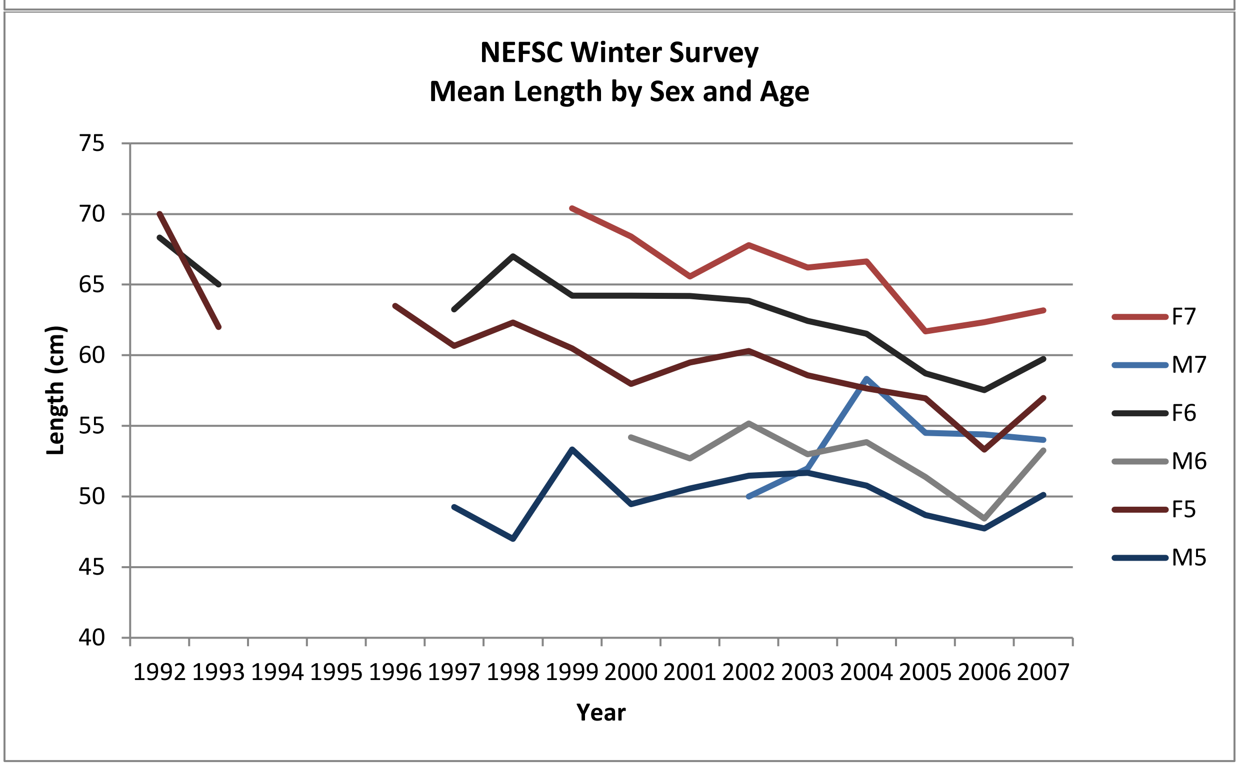
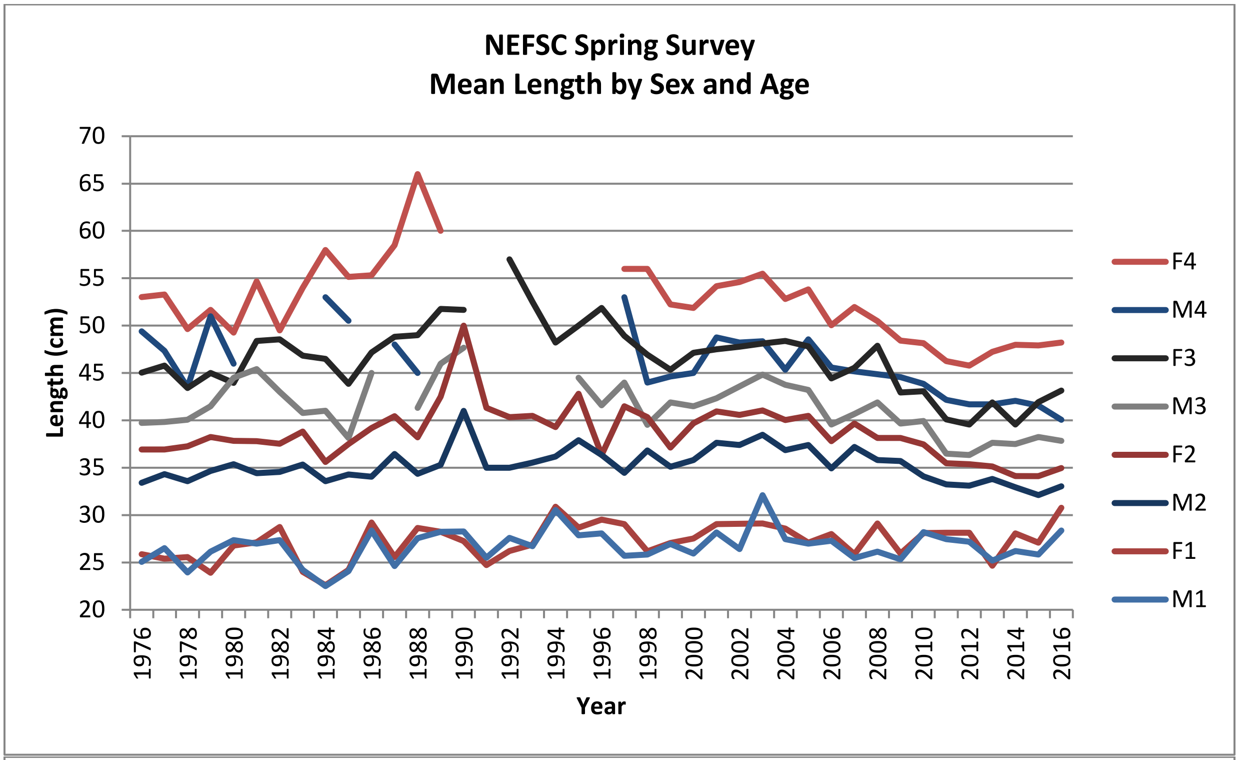


Figure A63. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) winter trawl survey: by sex and age; e.g., M1 = age 1 males, F7 = age 7 females.



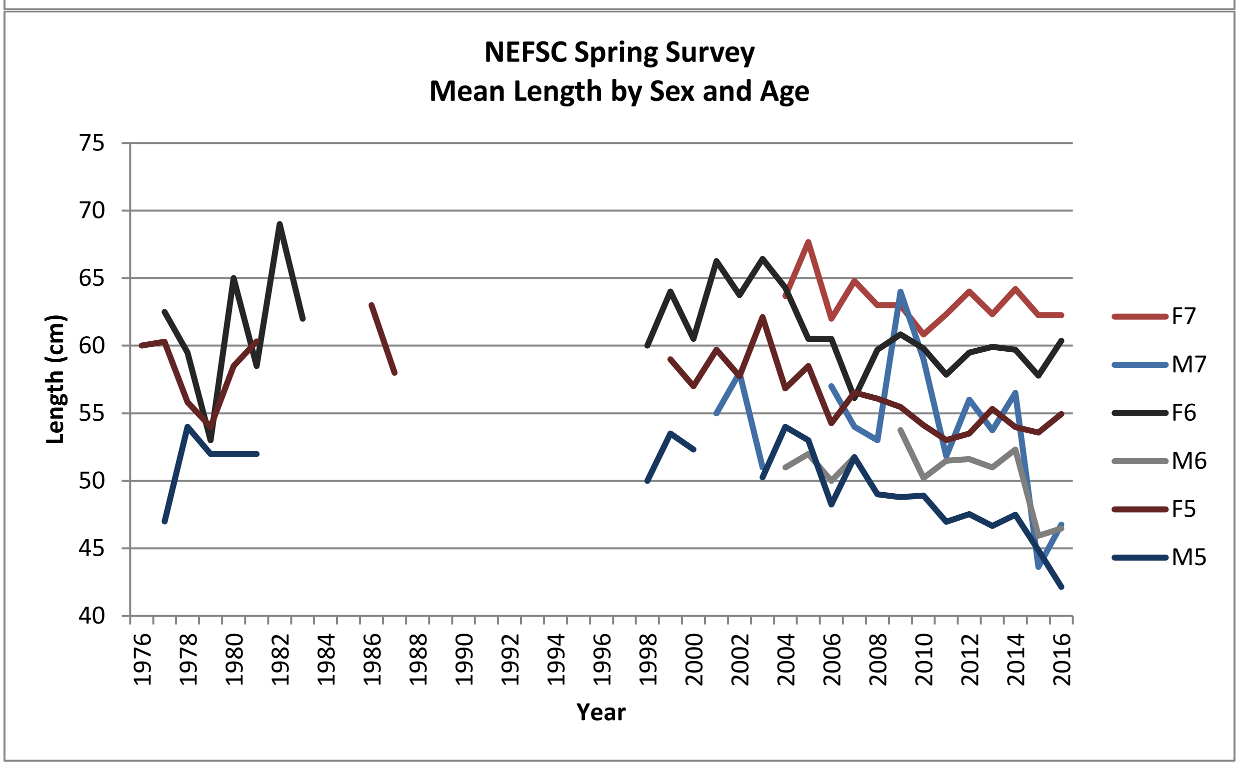
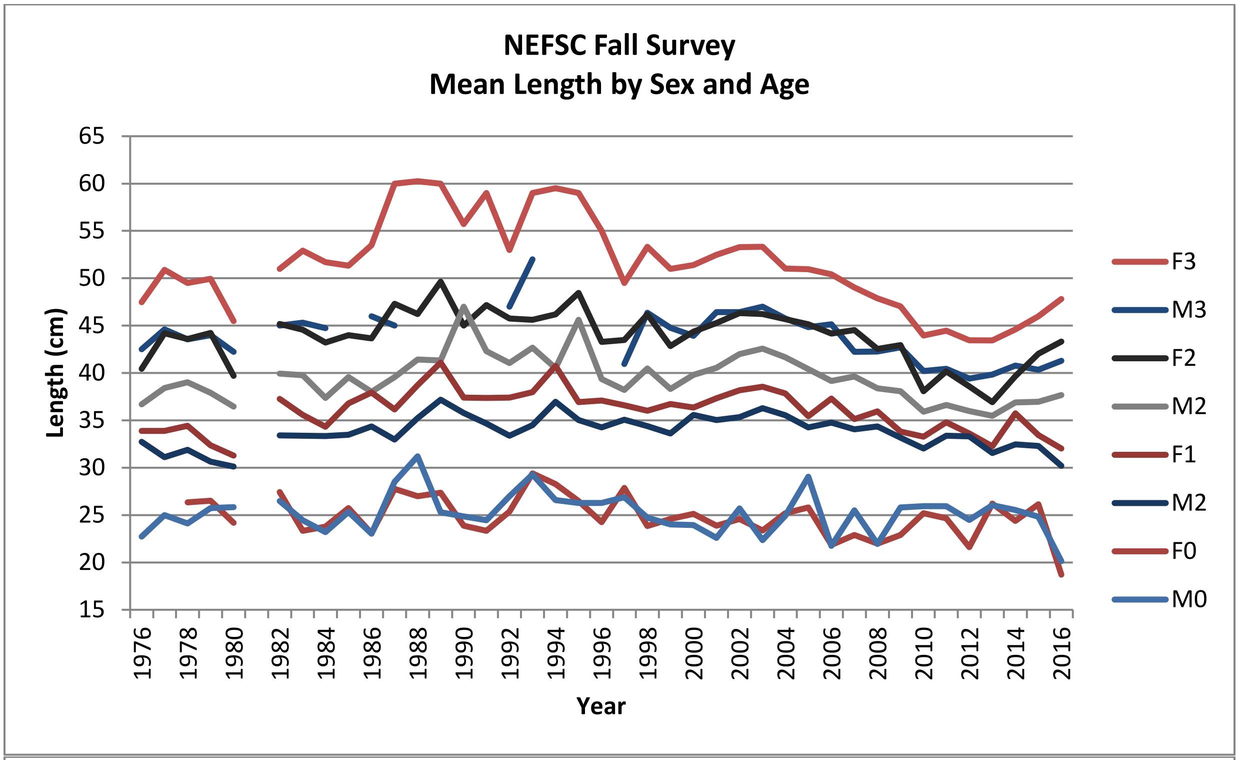


Figure A64. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) spring trawl survey: by sex and age; e.g., M1 = age 1 males, F7 = age 7 females.



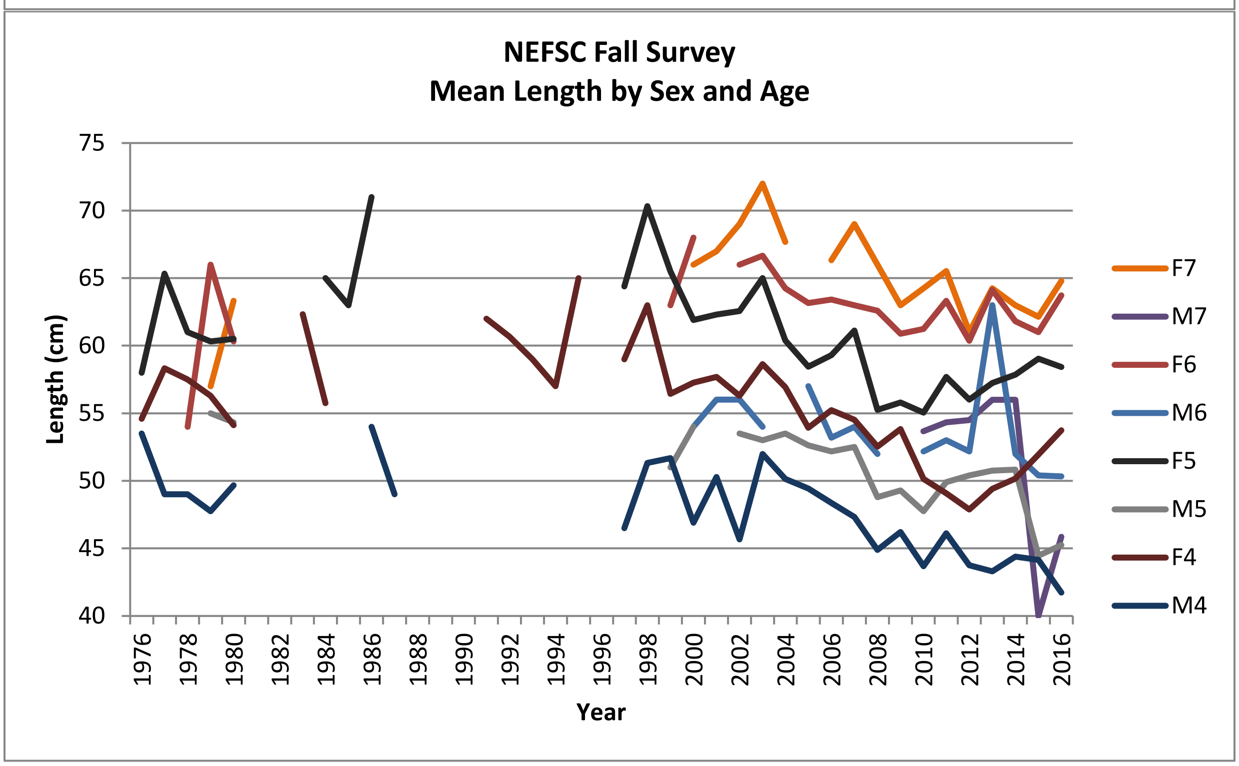


Figure A65. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) fall trawl survey: by sex and age; e.g., M0 = age 0 males, F7 = age 7 females.

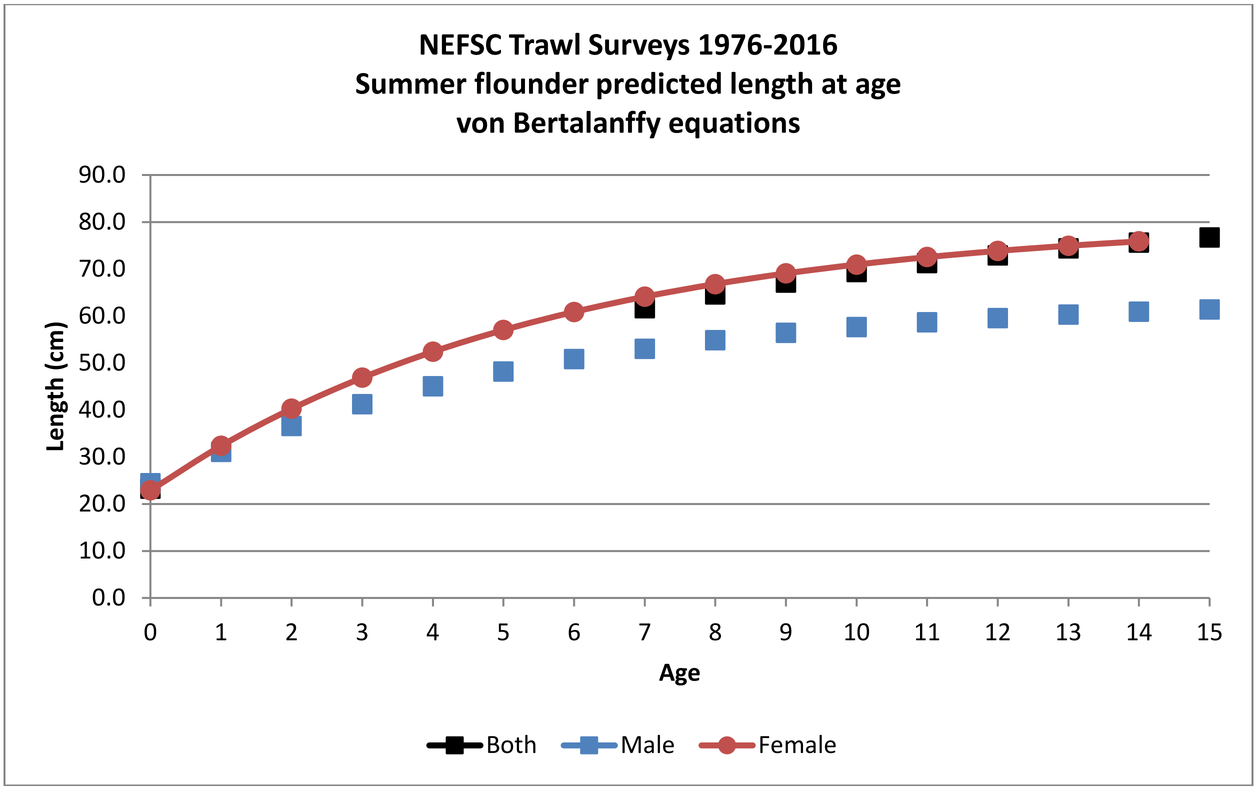
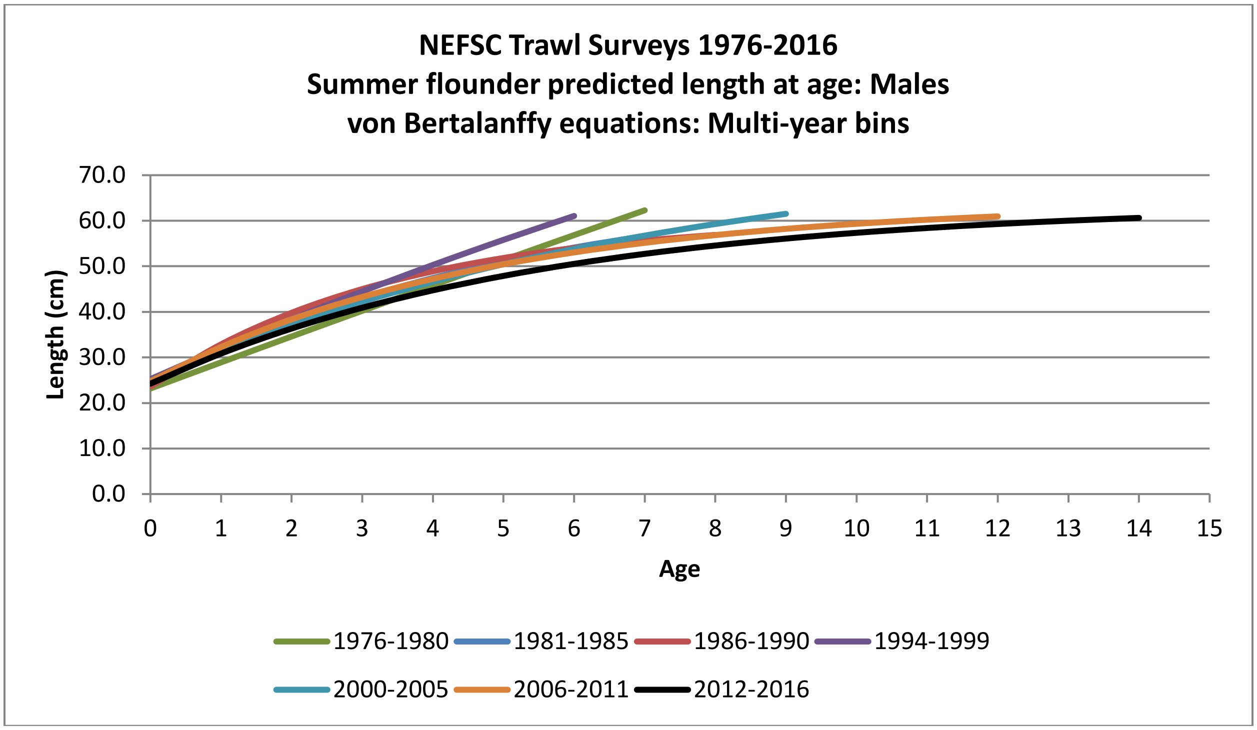


Figure A66. Predicted length at age from von Bertalanffy equations parameters estimated from Northeast Fisheries Science Center (NEFSC) trawl survey data. Maximum observed age for males is age 15; for females is age 14.



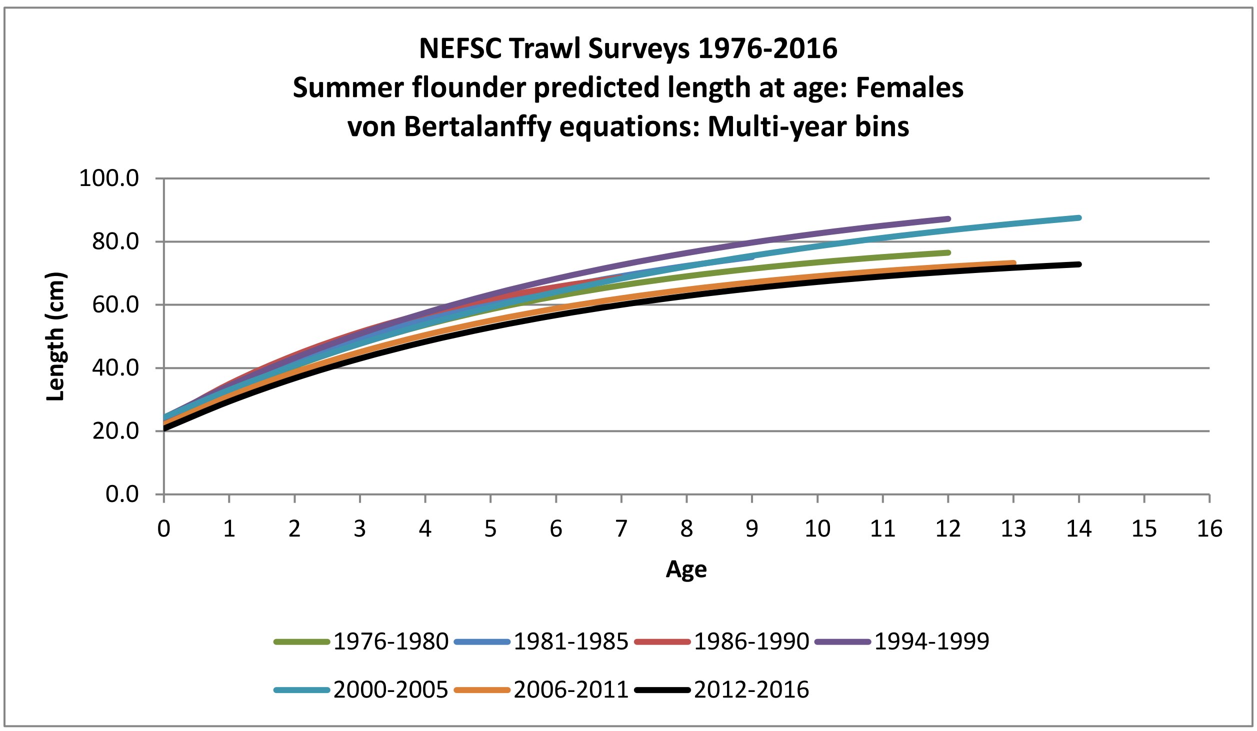


Figure A67. Predicted length at age from von Bertalanffy equations parameters estimated from Northeast Fisheries Science Center (NEFSC) trawl survey data for multi-year bins by sex. Curves plotted through the maximum observed ages for each bin and sex.

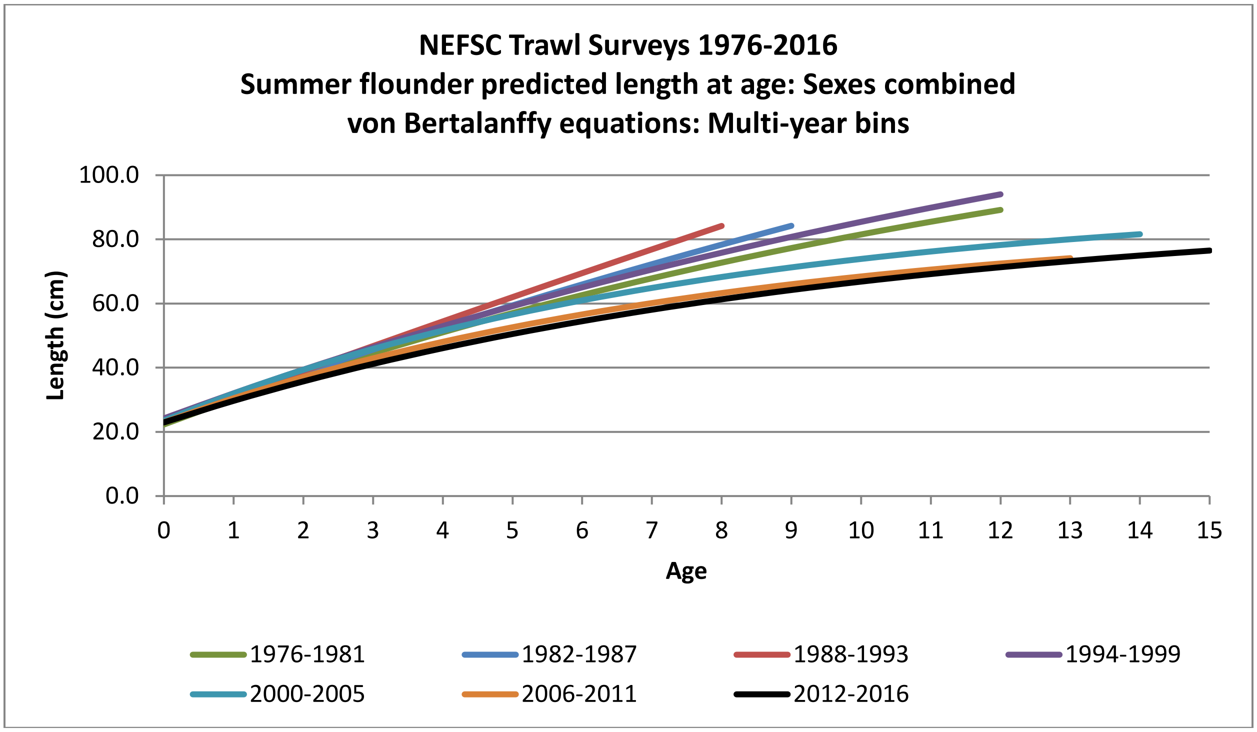


Figure A68. Predicted length at age from von Bertalanffy equations parameters estimated from Northeast Fisheries Science Center (NEFSC) trawl survey data for multi-year bins by sexes combined. Curves plotted through the maximum observed ages for each bin.

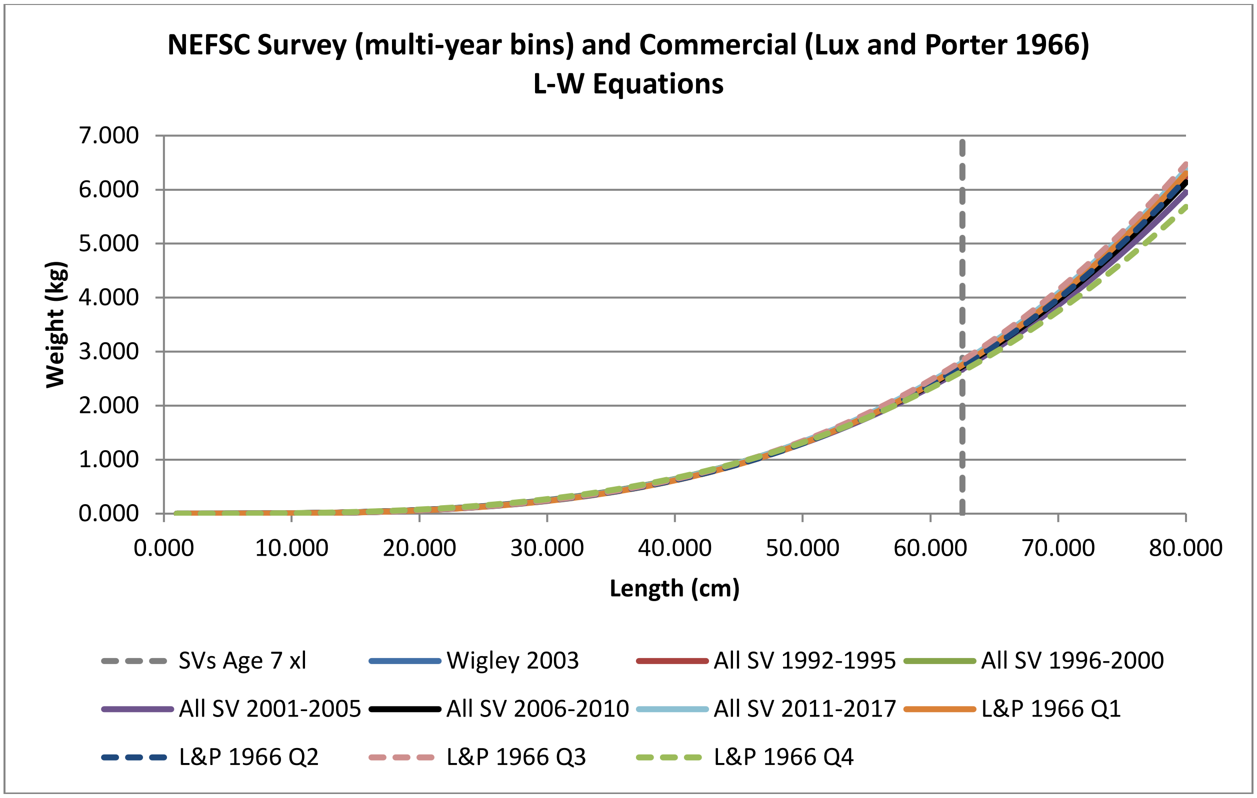


Figure A69. Length-weight relationships from the works of Lux and Porter (1966; L&P), Wigley et al. (2003; Wigley), and the current work (all surveys combined multi-year bins) Vertical gray line is the mean length of age 7 in Northeast Fisheries Science Center (NEFSC) surveys.

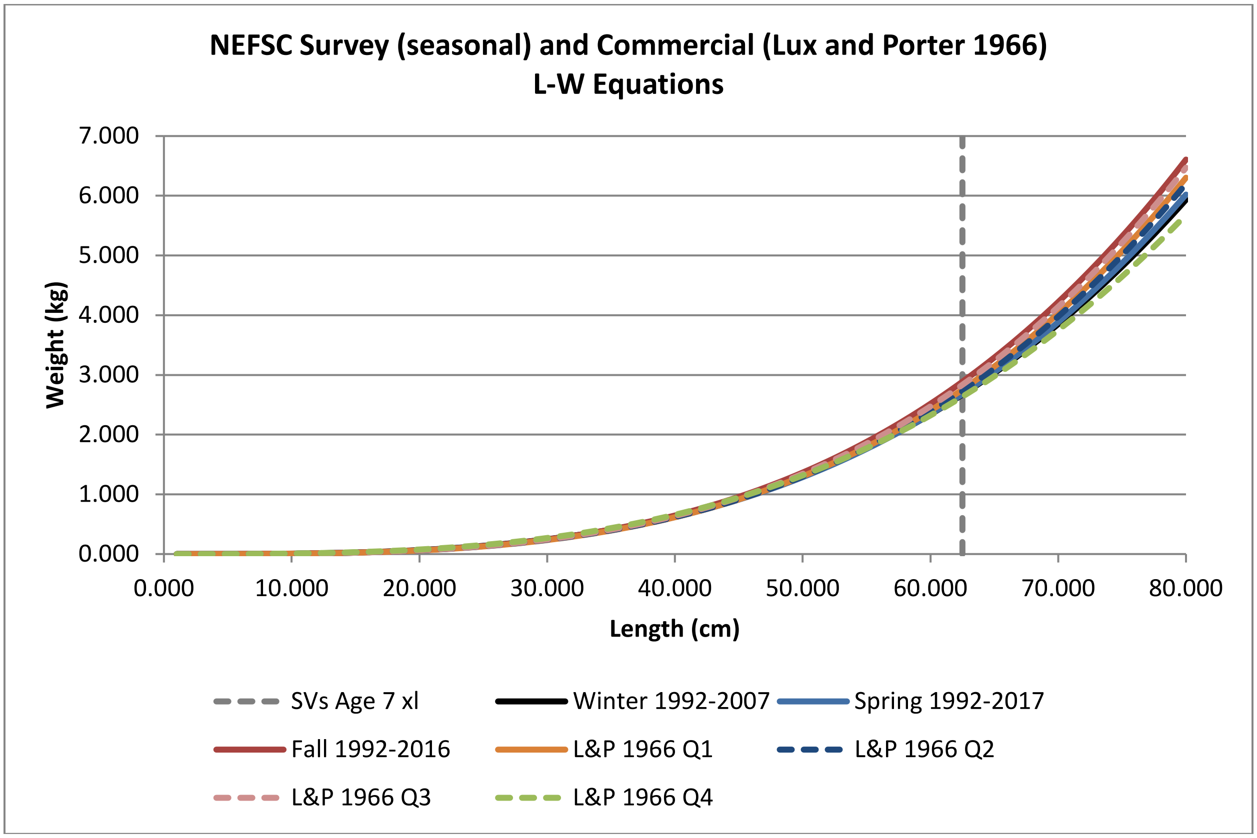


Figure A70. Length-weight relationships from the works of Lux and Porter (1966; L&P) and the current work (seasonal surveys: winter 1992-2007, spring 1992-2017, fall 1992-2016). Vertical gray line is the mean length of age 7 in Northeast Fisheries Science Center (NEFSC) surveys.

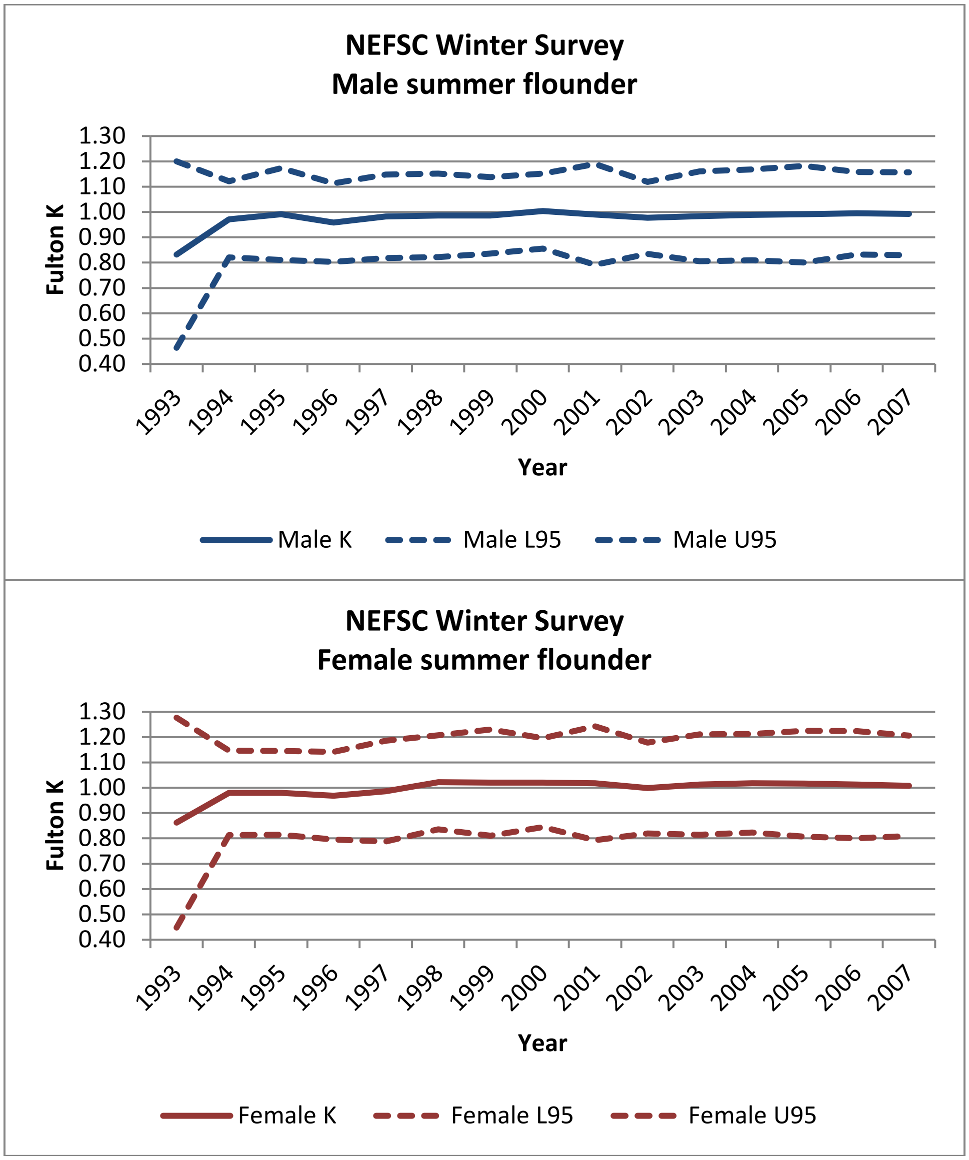


Figure A71. Seasonal condition factor of summer flounder: Northeast Fisheries Science Center (NEFSC) winter survey by sex.

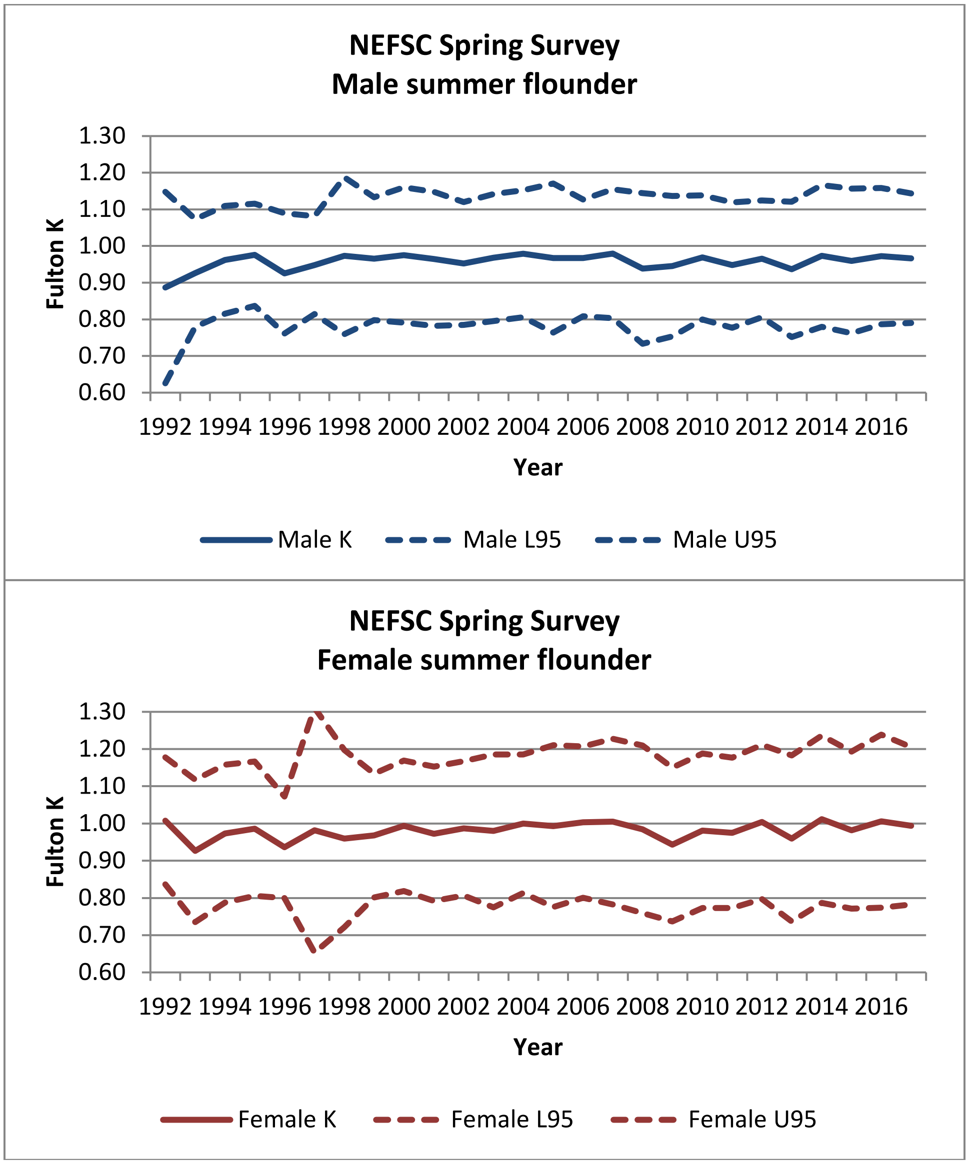


Figure A72. Seasonal condition factor of summer flounder: Northeast Fisheries Science Center (NEFSC) spring survey by sex.

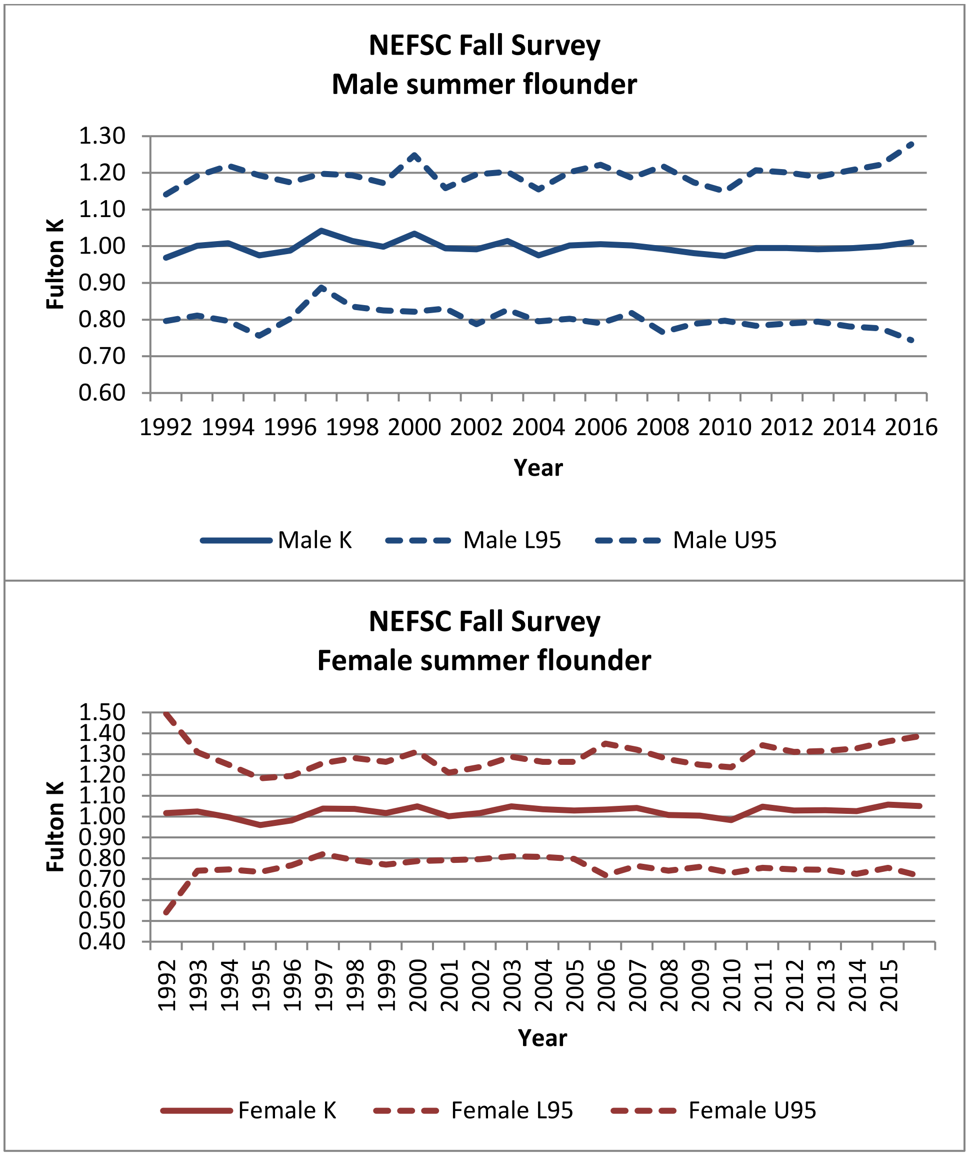


Figure A73. Seasonal condition factor of summer flounder: Northeast Fisheries Science Center (NEFSC) fall survey by sex.

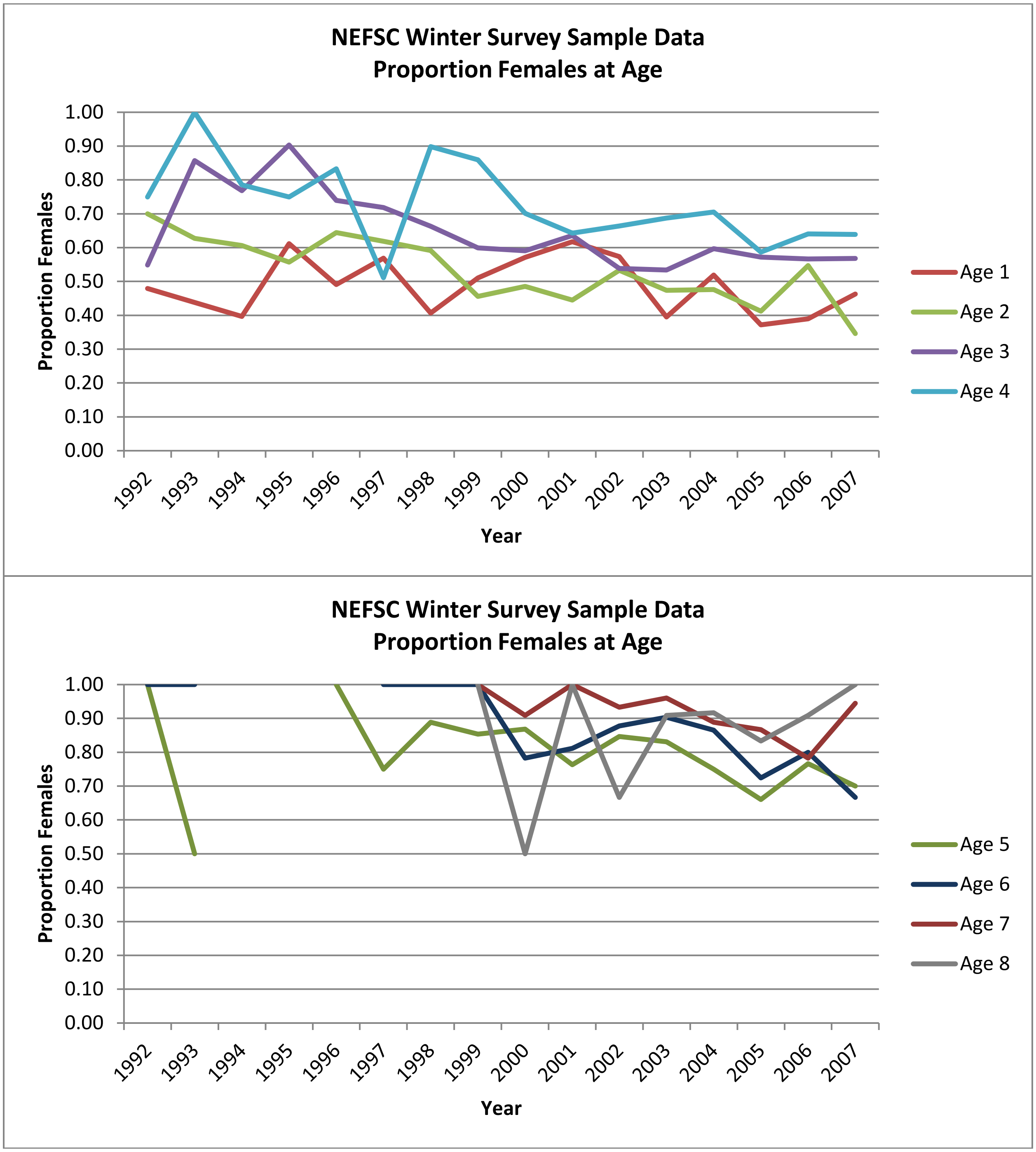


Figure A74. Northeast Fisheries Science Center (NEFSC) winter survey sample data: proportion female at age.

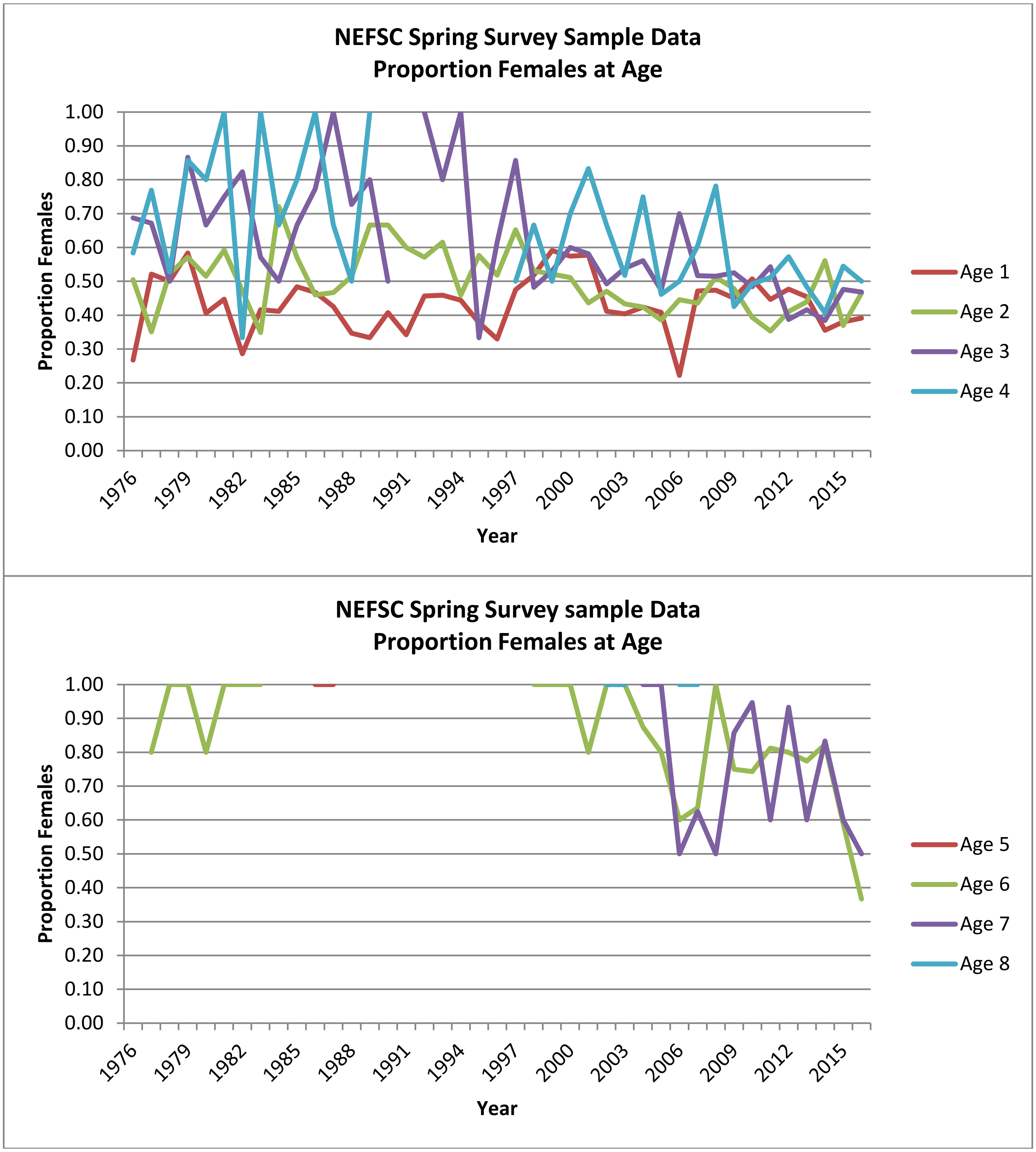
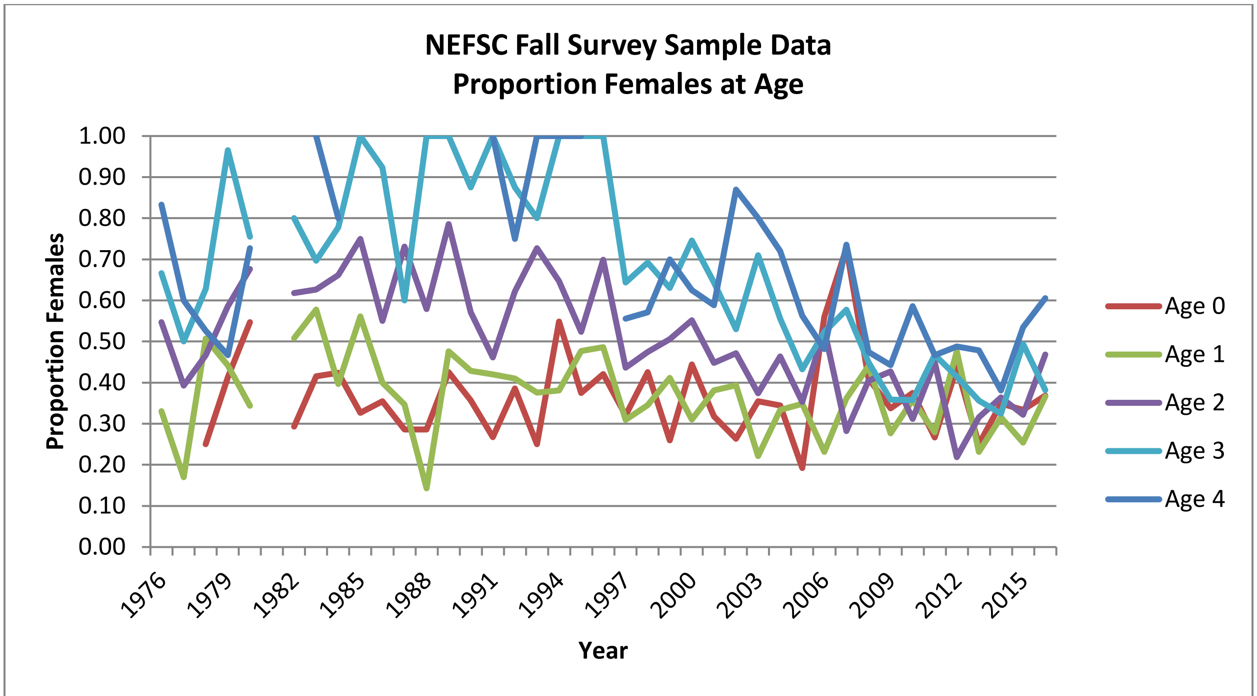


Figure A75: Northeast Fisheries Science Center (NEFSC) spring survey sample data: proportion female at age.



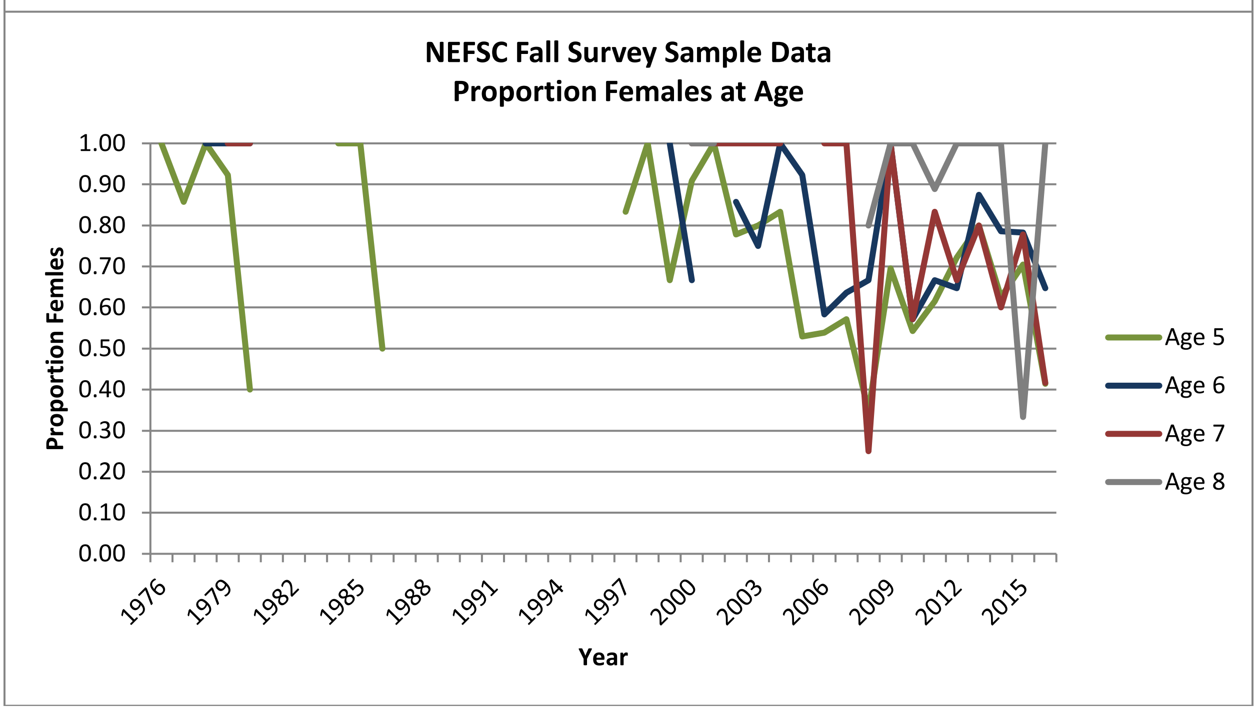
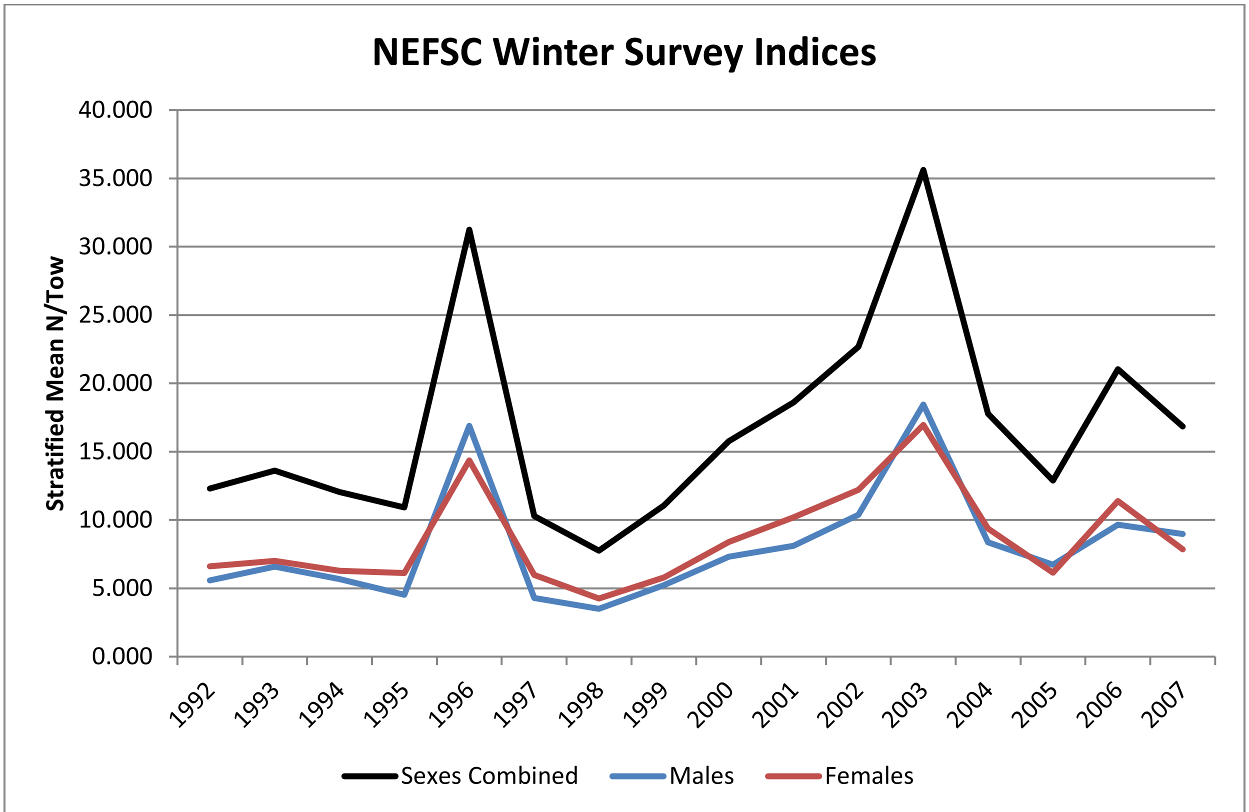


Figure A76: Northeast Fisheries Science Center (NEFSC) fall survey: proportion female at age.



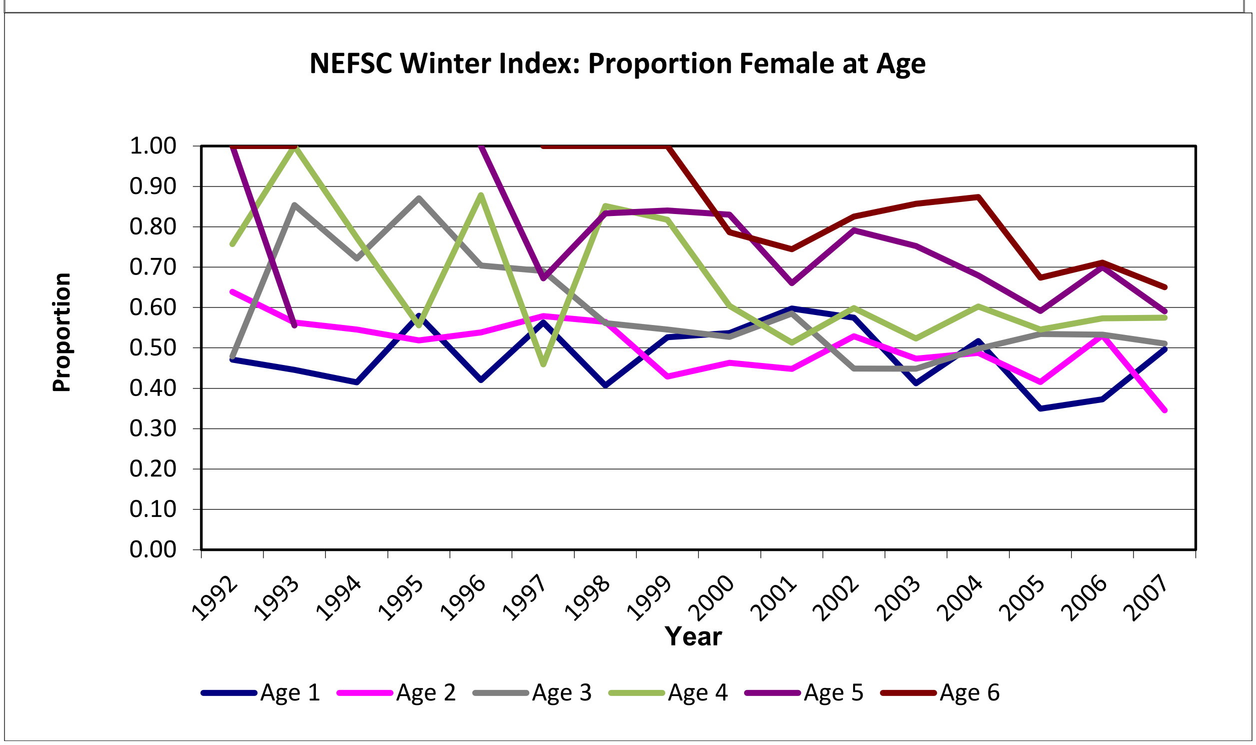
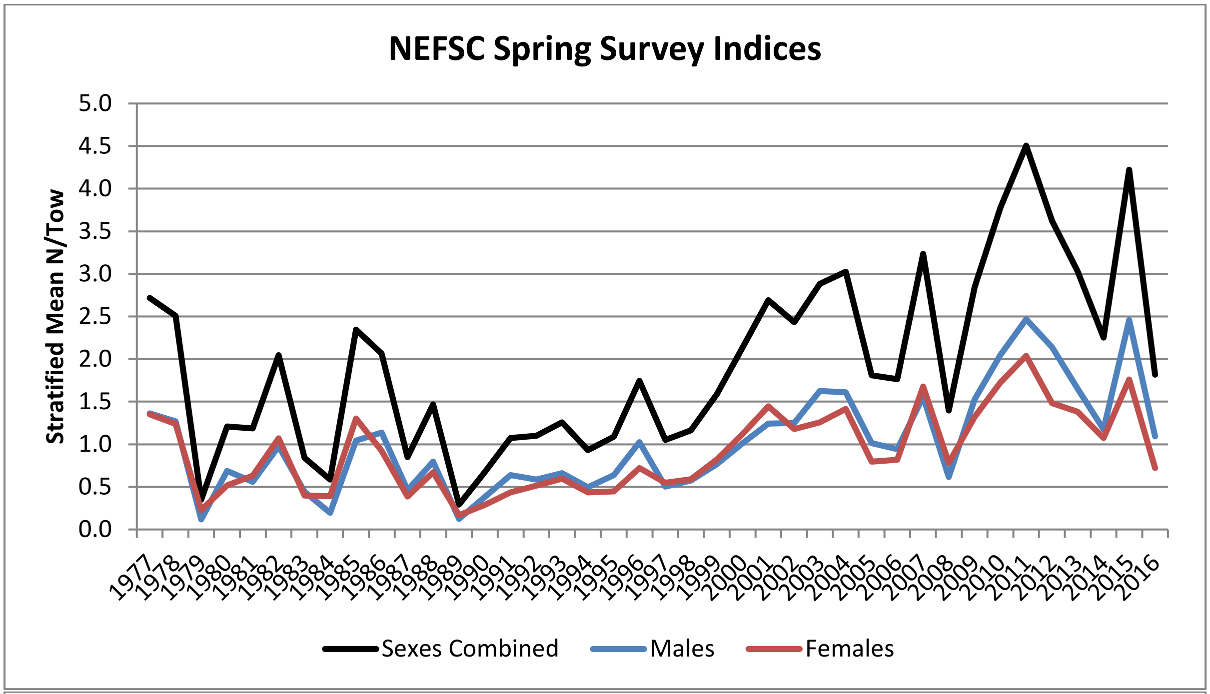


Figure A77. Northeast Fisheries Science Center (NEFSC) winter survey indices of abundance (number per tow) for males, females, and sexes combined (top) and proportion female by age (bottom).



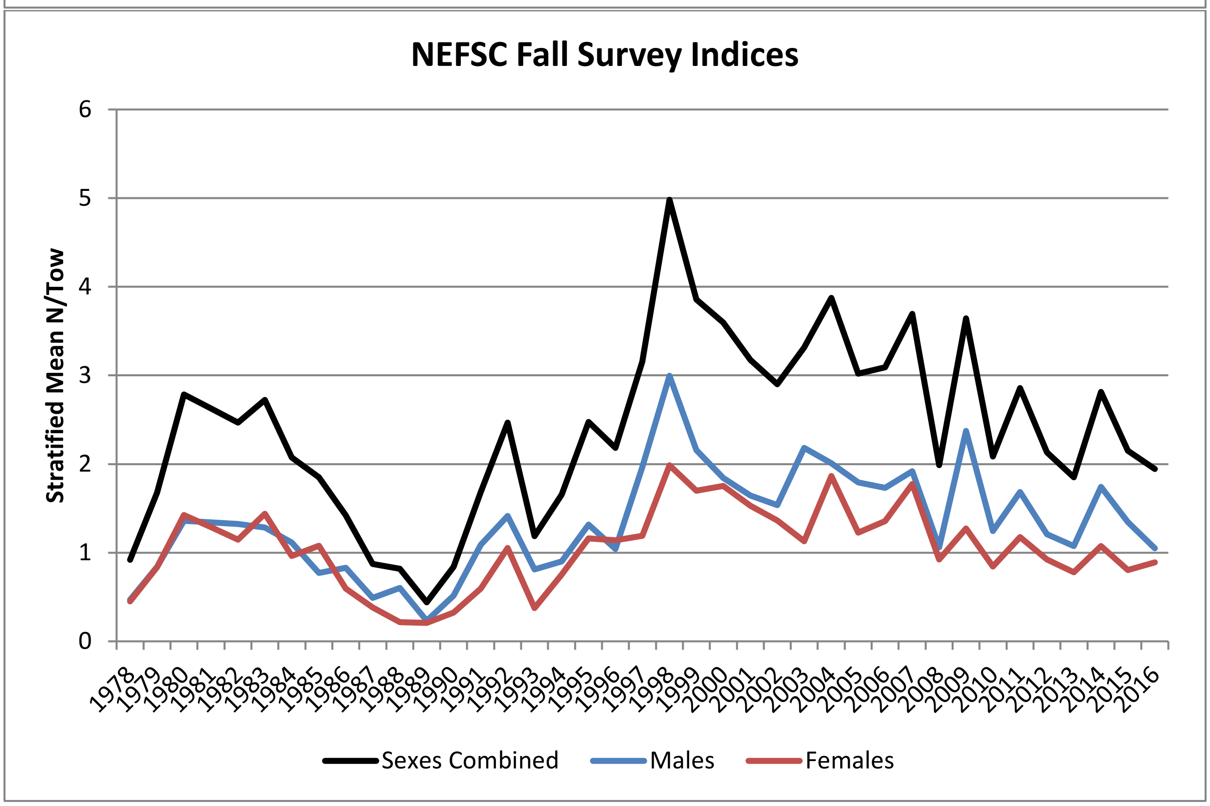


Figure A78. Northeast Fisheries Science Center (NEFSC) spring and fall survey indices of abundance (number per tow) for males, females, and sexes combined.

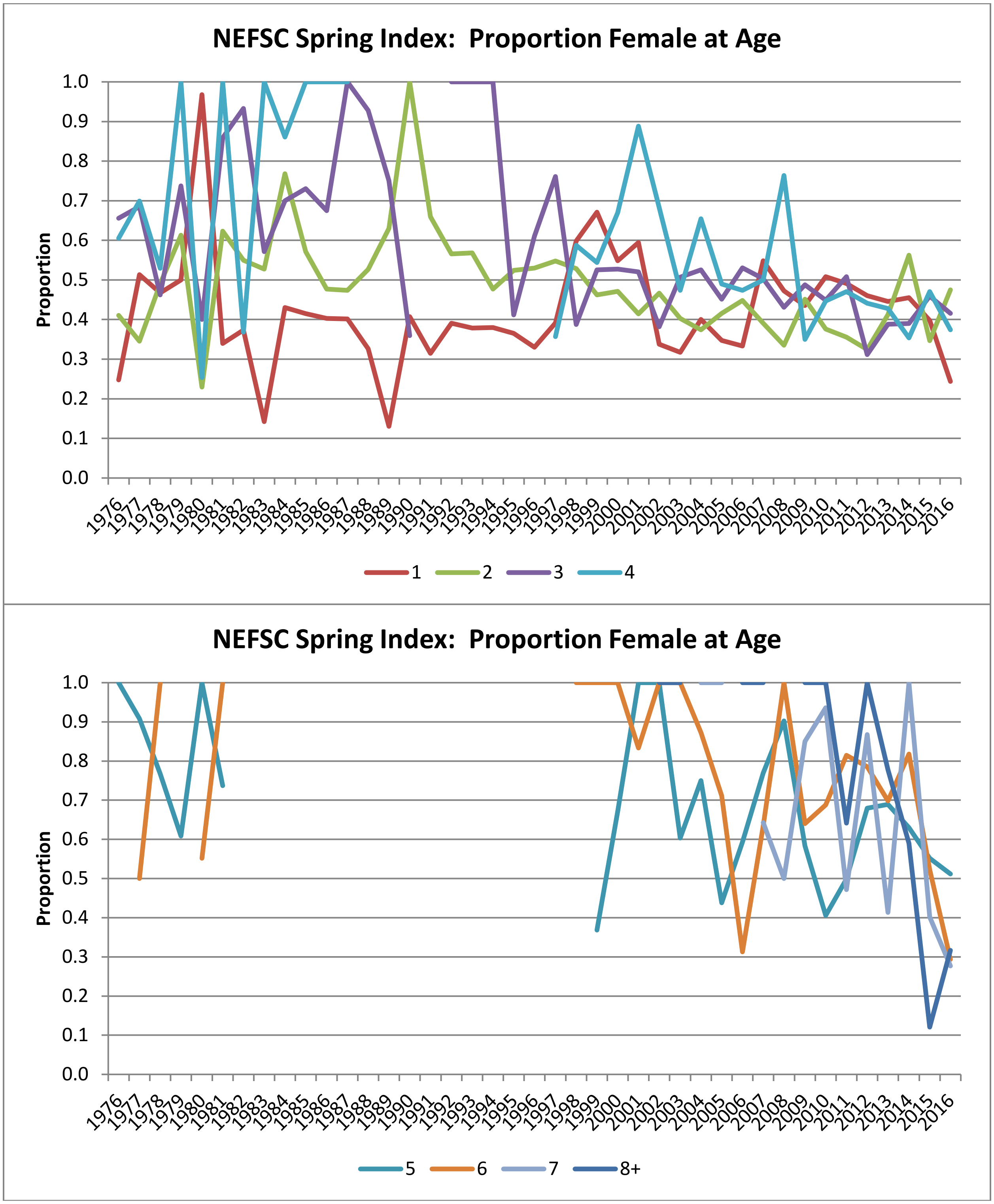


Figure A79. Northeast Fisheries Science Center (NEFSC) spring survey index proportion female by age.

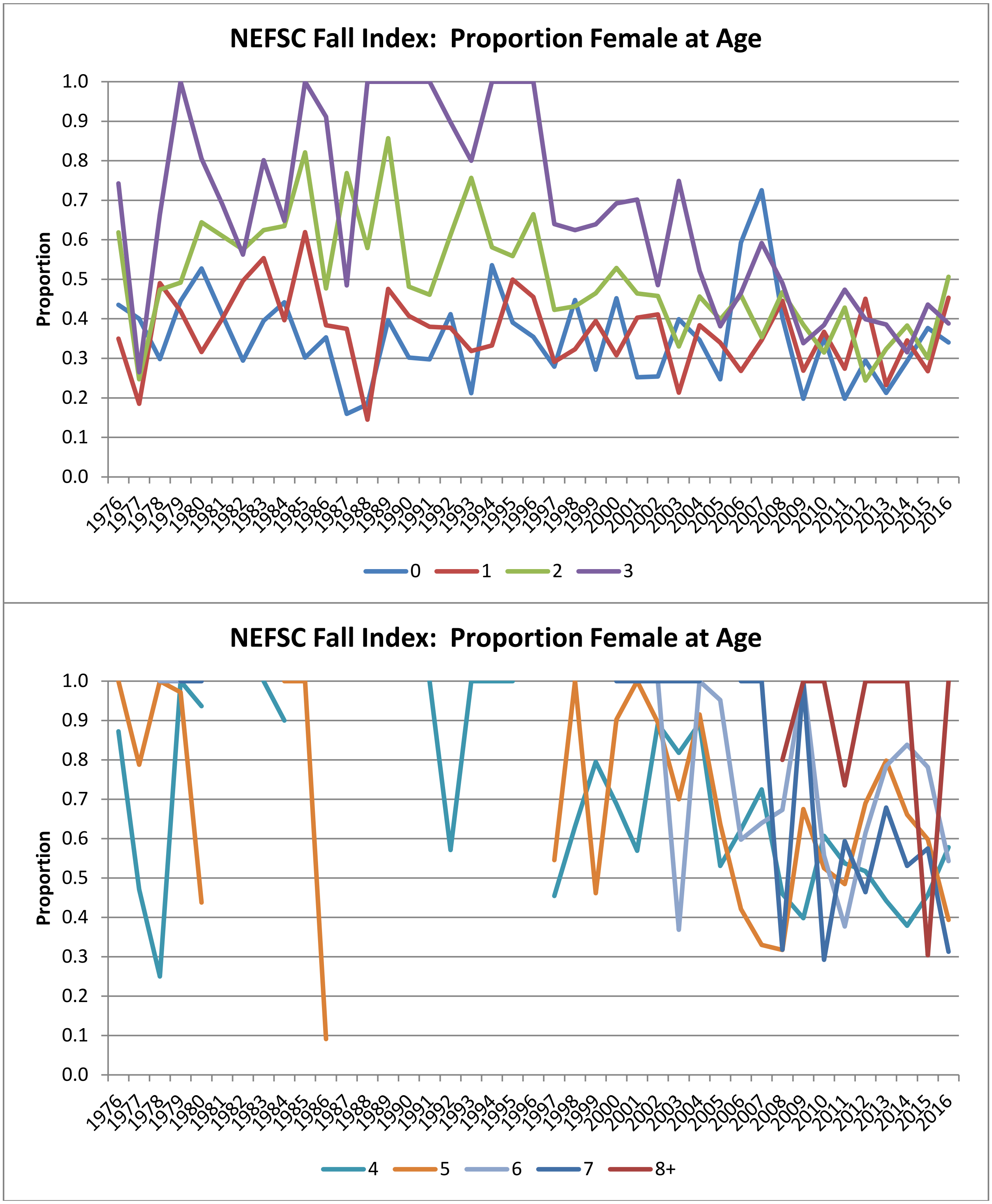


Figure A80. Northeast Fisheries Science Center (NEFSC) fall survey index proportion female by age.

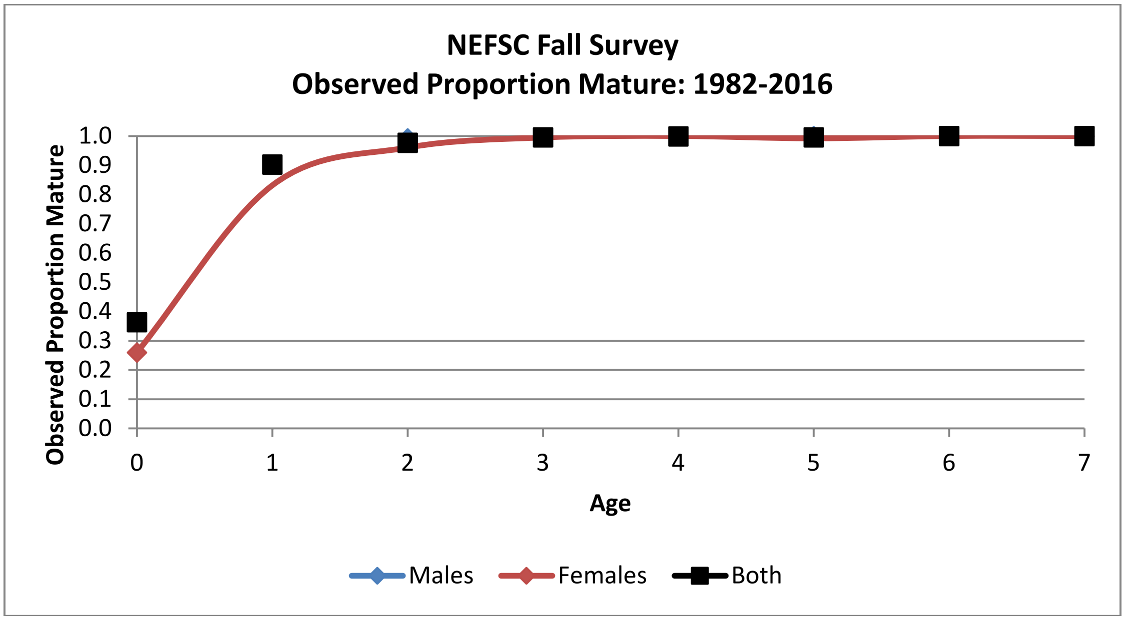


Figure A81. Observed proportion mature at age and sex from the Northeast Fisheries Science Center (NEFSC) Fall survey time series.

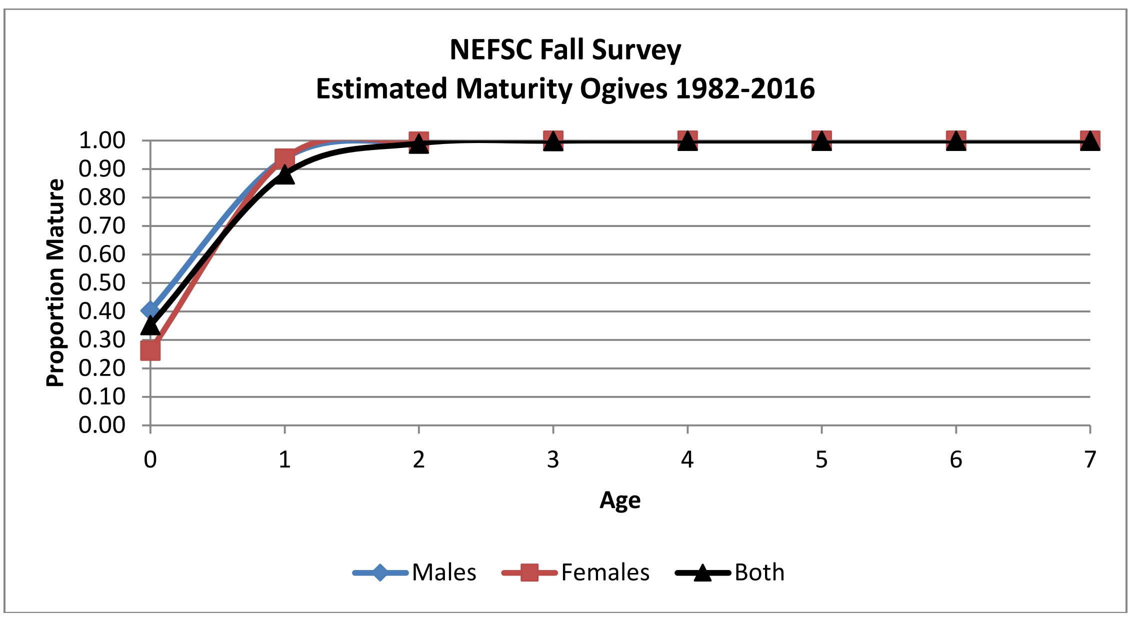


Figure A82. Estimated proportion mature at age and sex from the Northeast Fisheries Science Center (NEFSC) Fall survey time series.

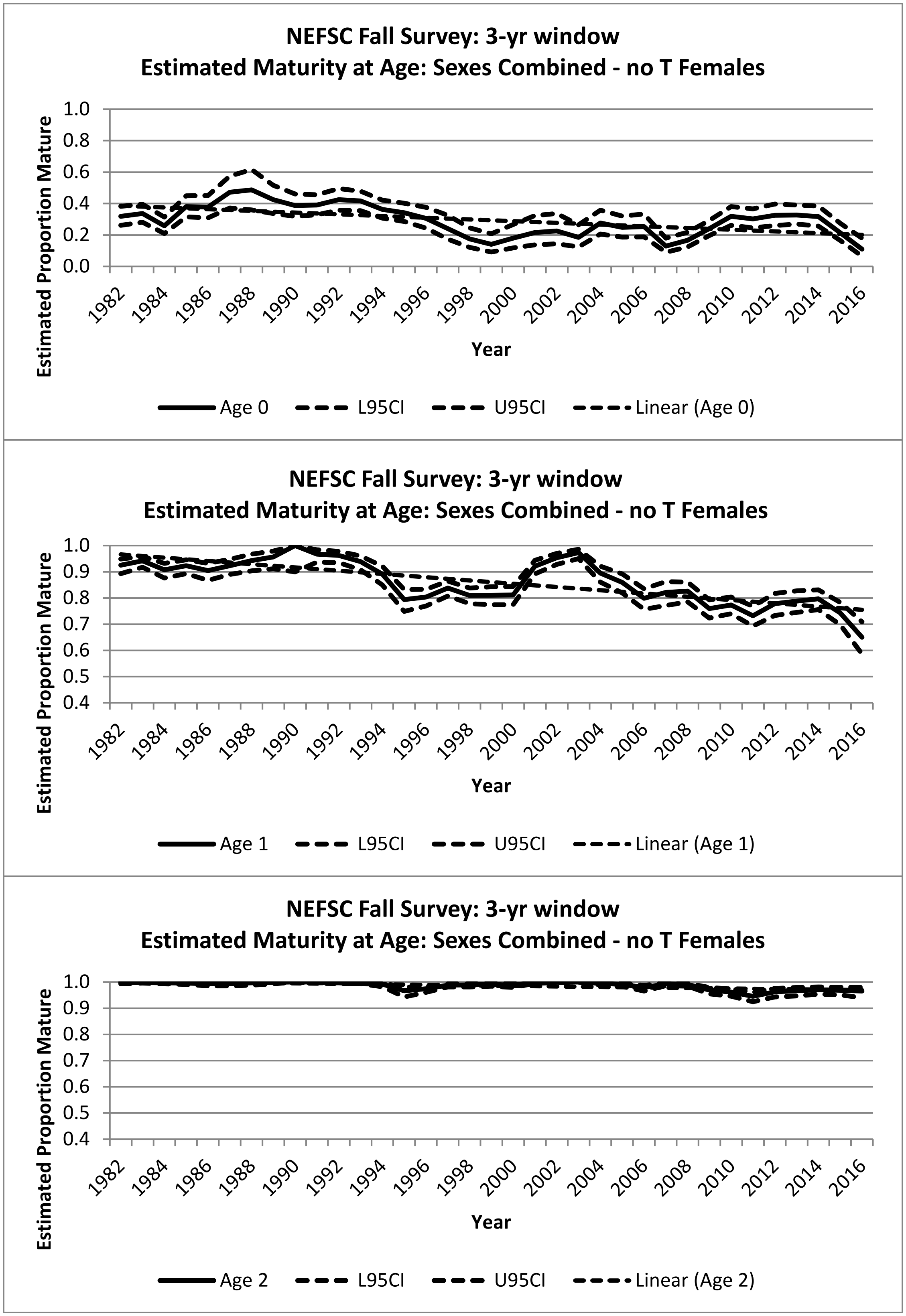


Figure A83. Estimated maturity at ages, 0, 1, and 2, for sexes combined by 3-year moving window, resting (T) females removed. Straight dashed lines are fit linear trends.

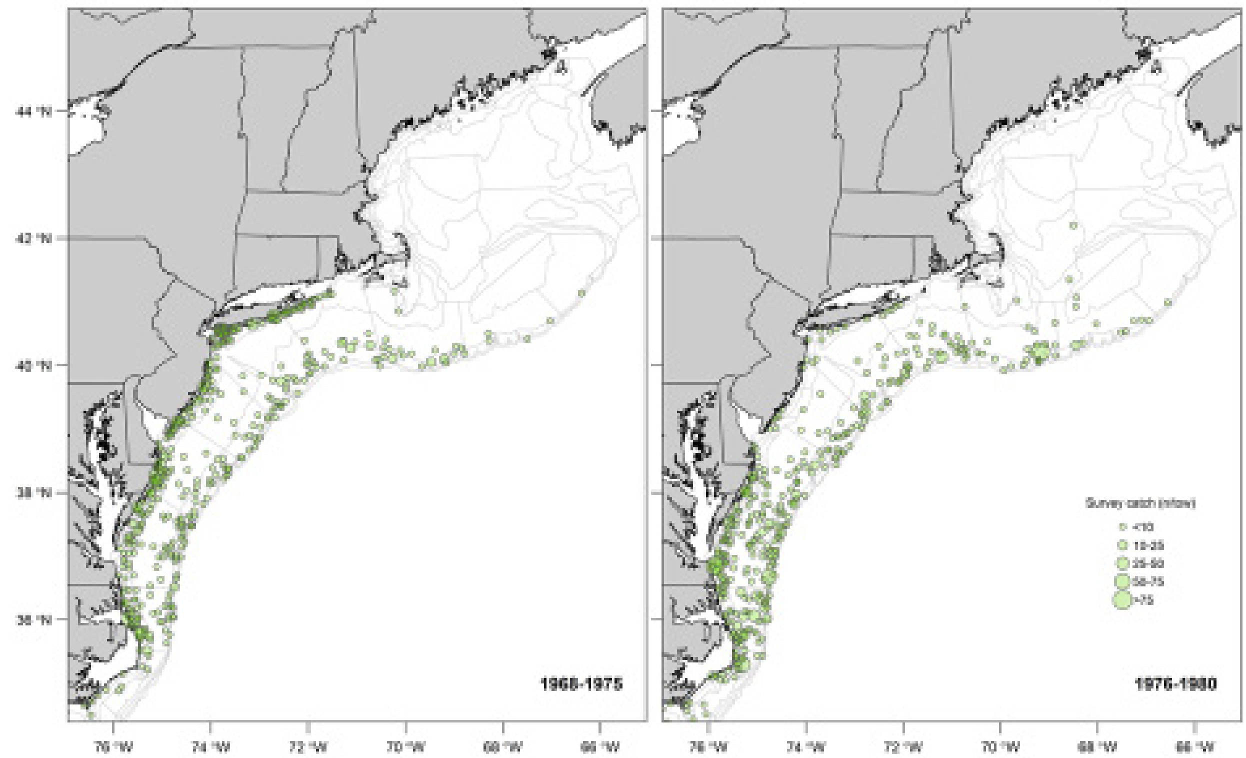


Figure A84. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: spring 1968-1975 and 1976-1980.

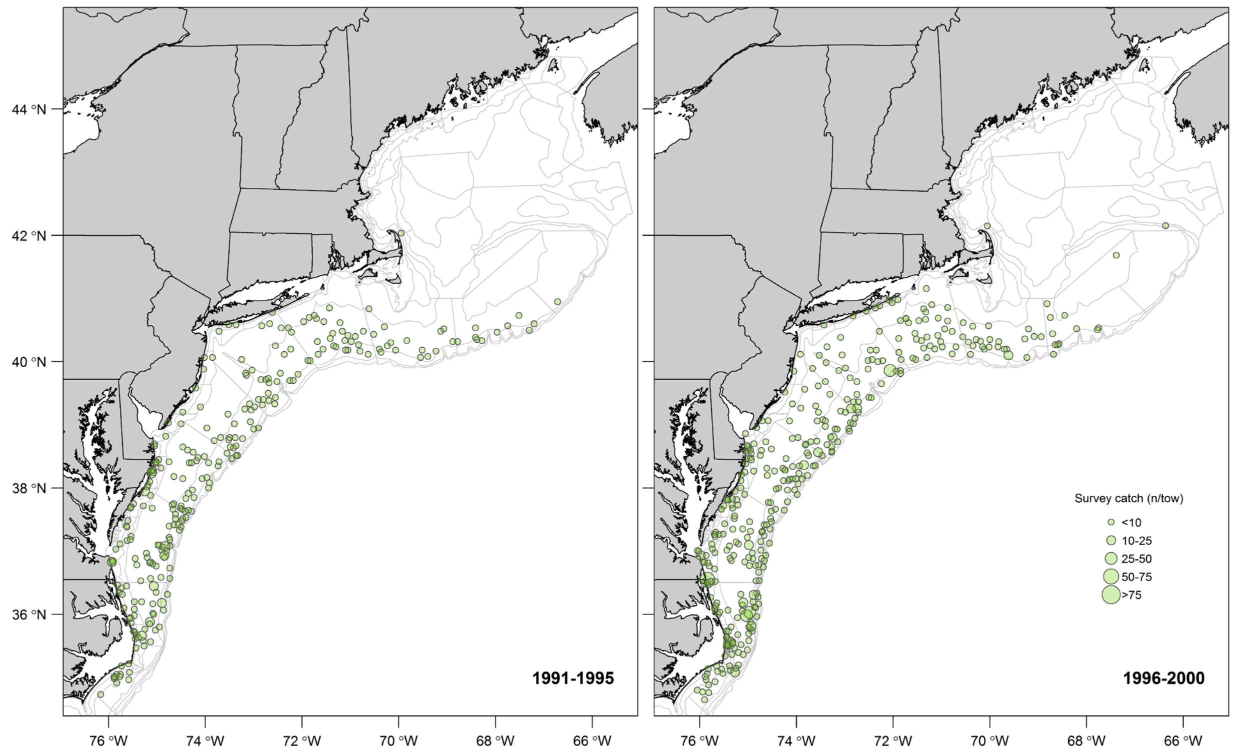


Figure A85. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: spring 1991-1995 and 1996-2000.

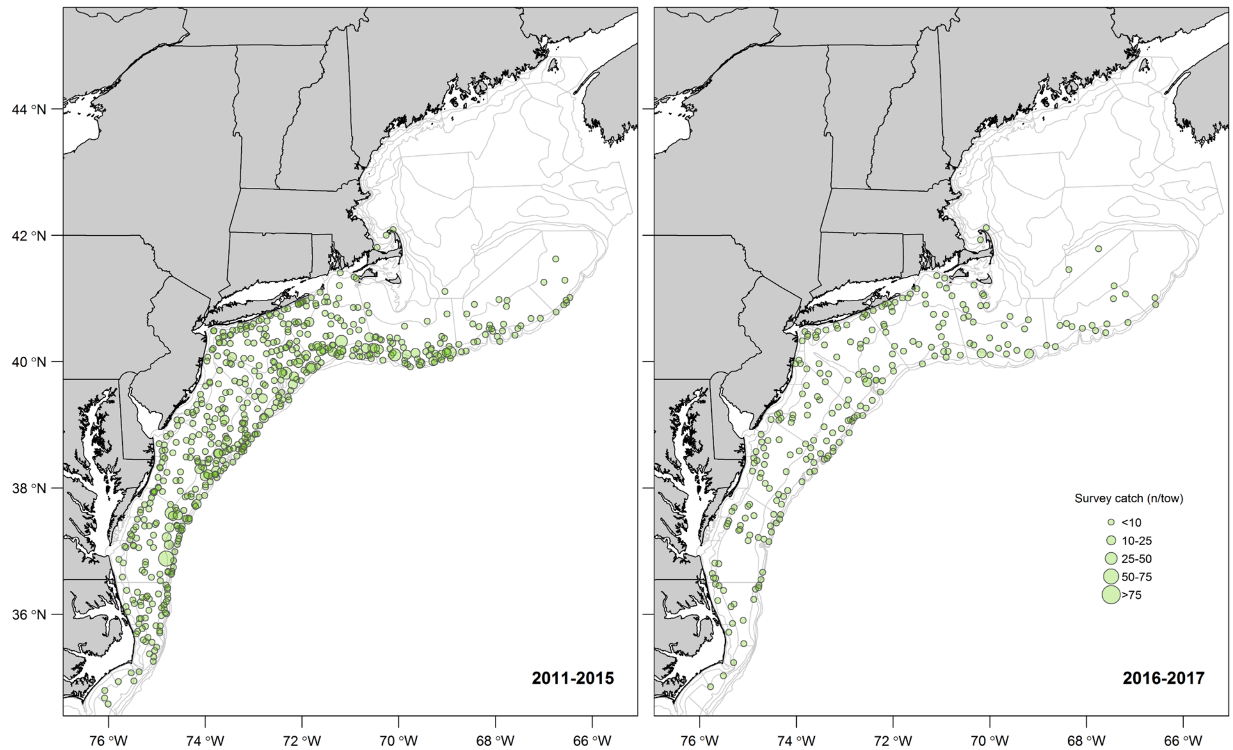


Figure A86. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: spring 2011-2015 and 2016-2017.

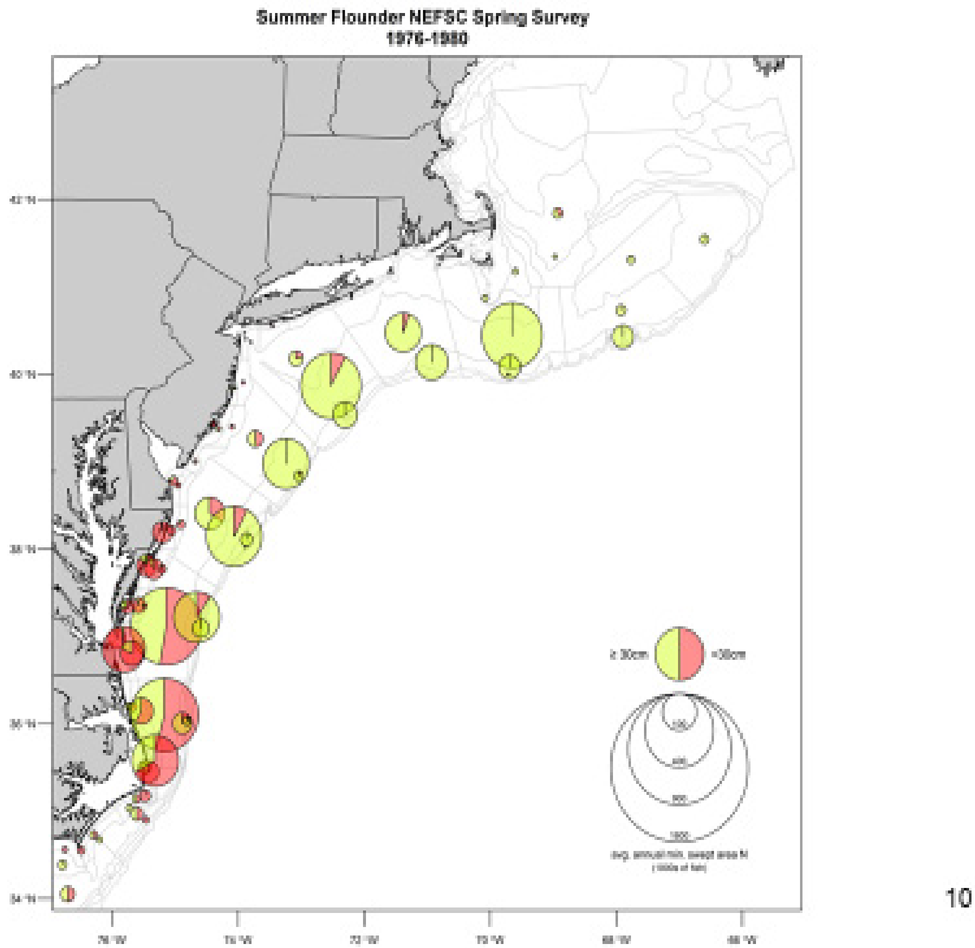


Figure A87. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for spring 1976-1980.

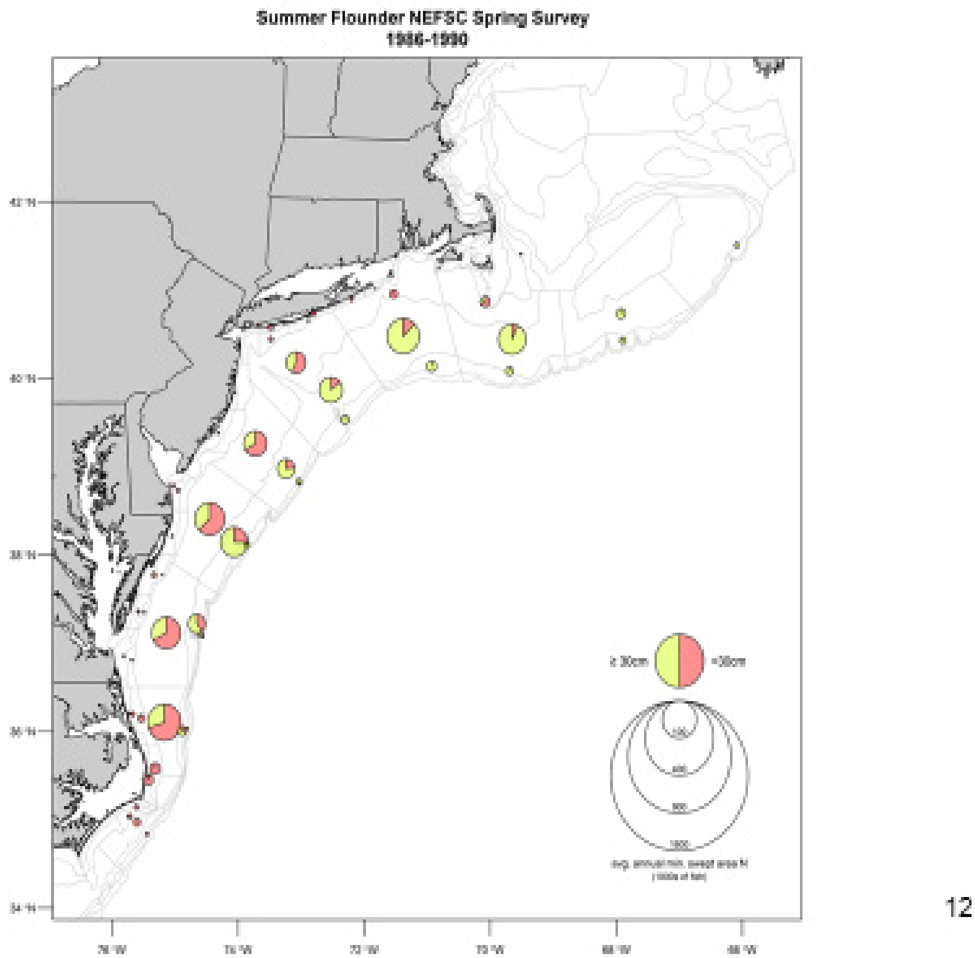


Figure A88. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for spring 1986-1990.

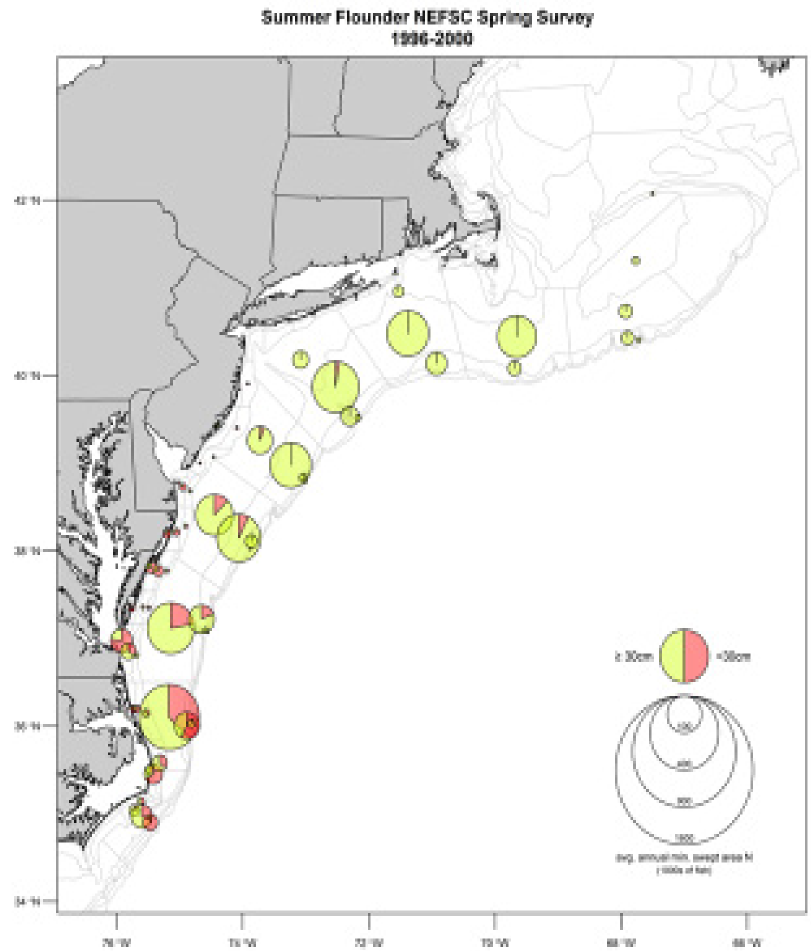


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Figure A89. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for spring 1996-2000.

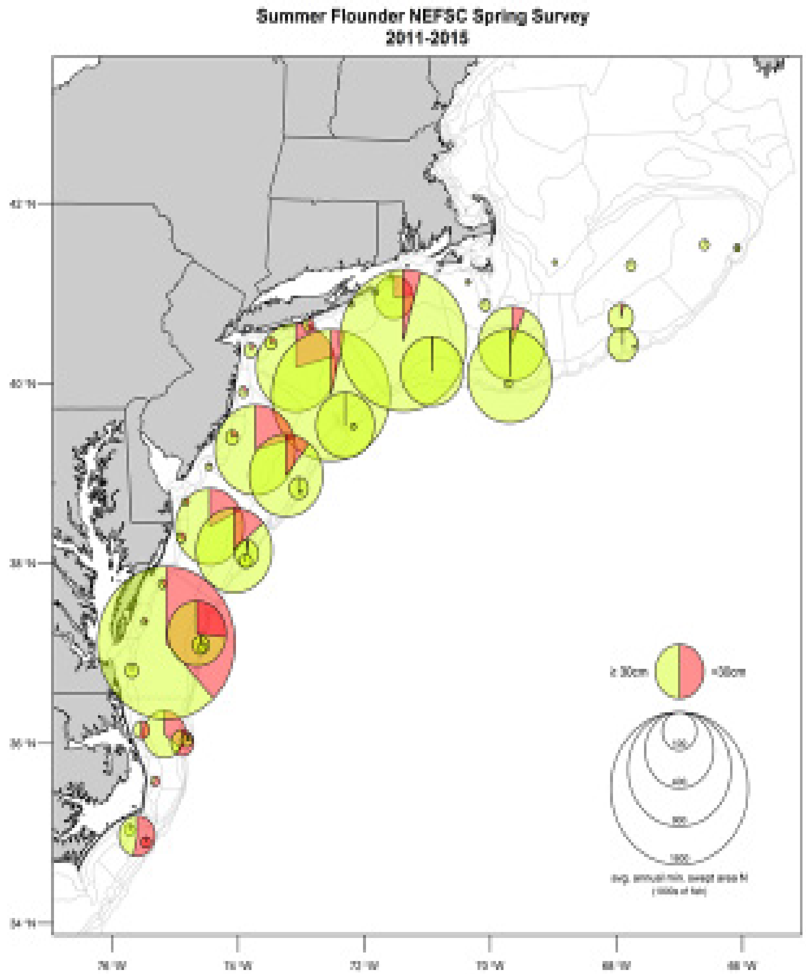

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Figure A90. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for spring 2011-2015.

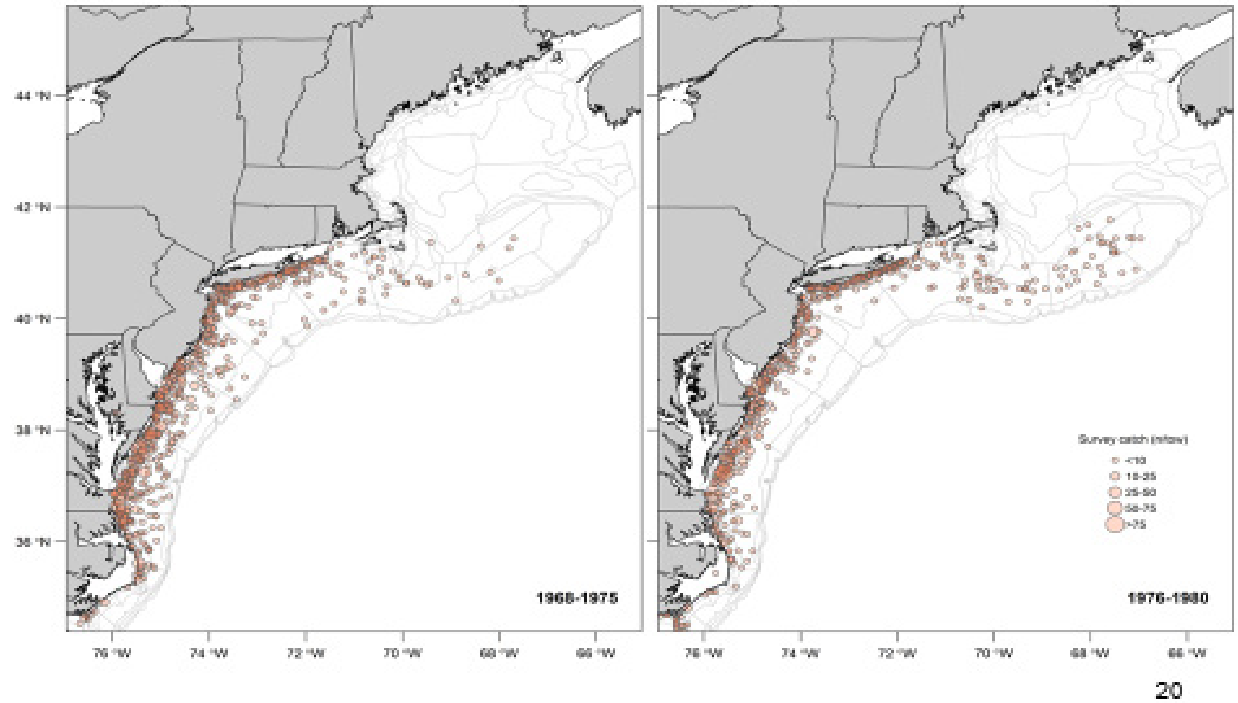

Figure A91. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: fall 1968-1975 and 1976-1980.

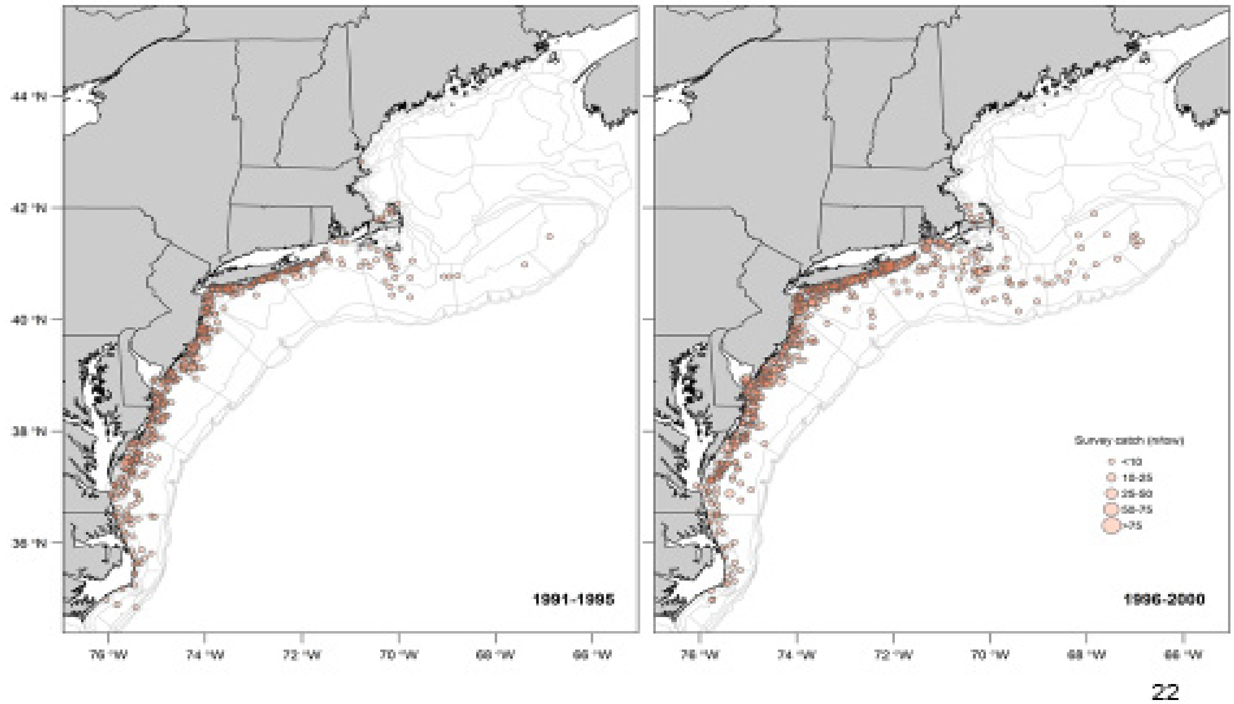

Figure A92. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: fall 1991-1995 and 1996-2000.

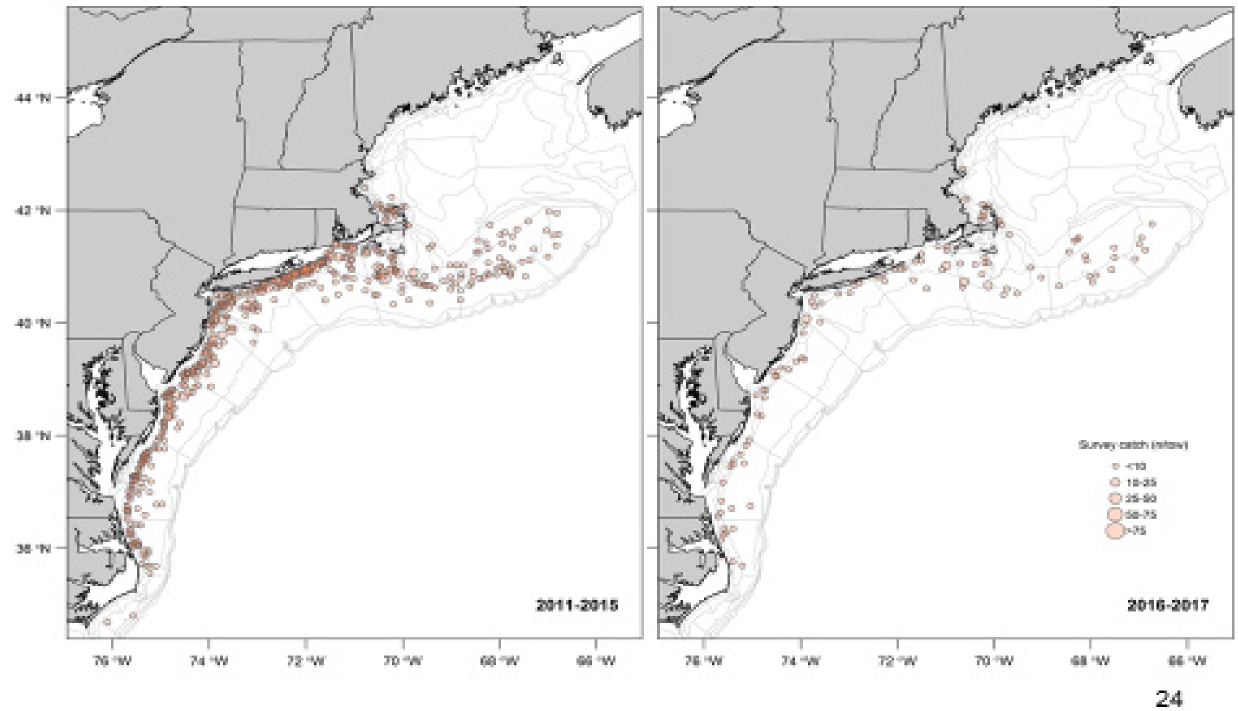

Figure A93. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: fall 2011-2015 and 2016-2017.

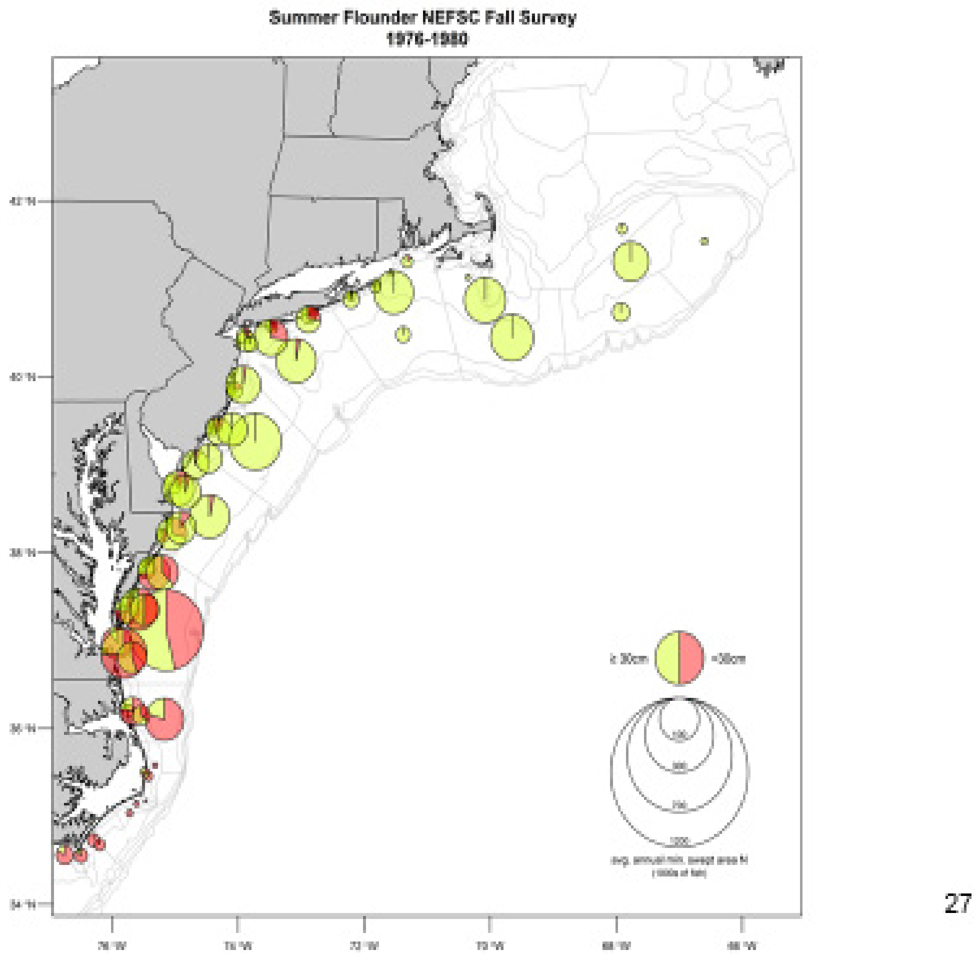

Figure A94. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for fall 1976-1980.

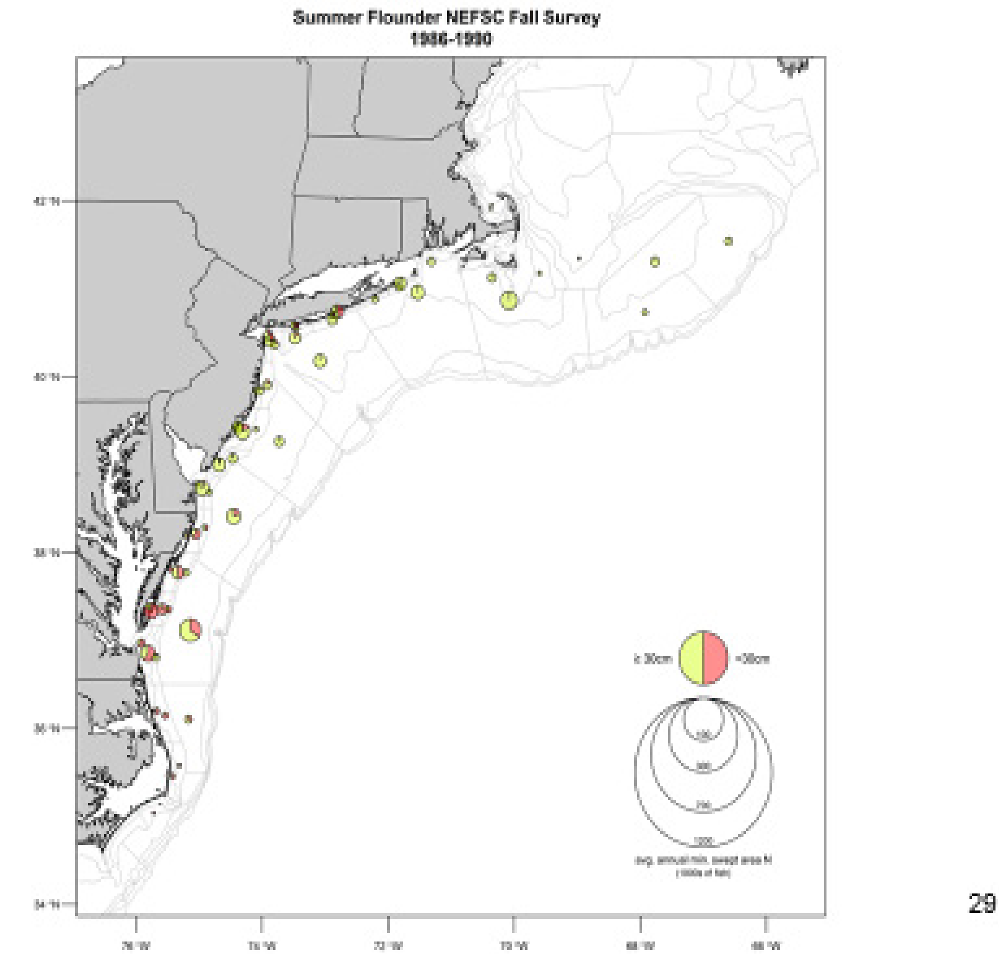

Figure A95. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for fall 1986-1990.

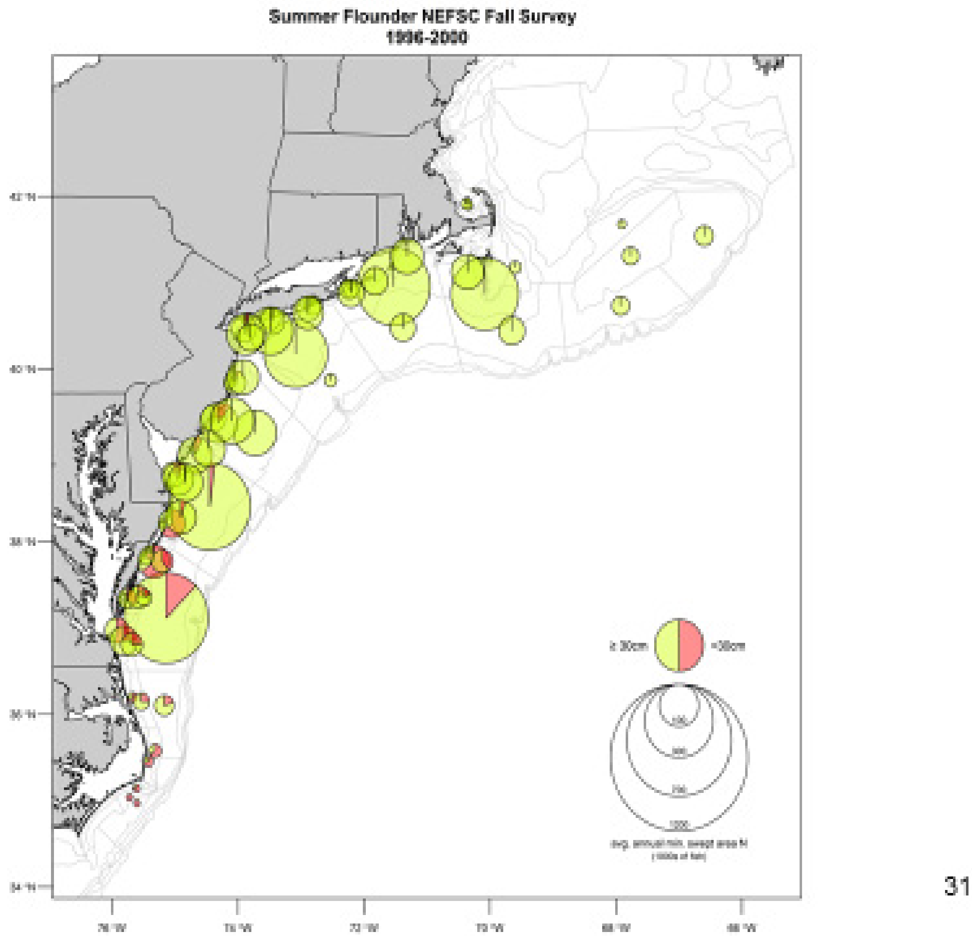

Figure A96. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for fall 1996-2000.

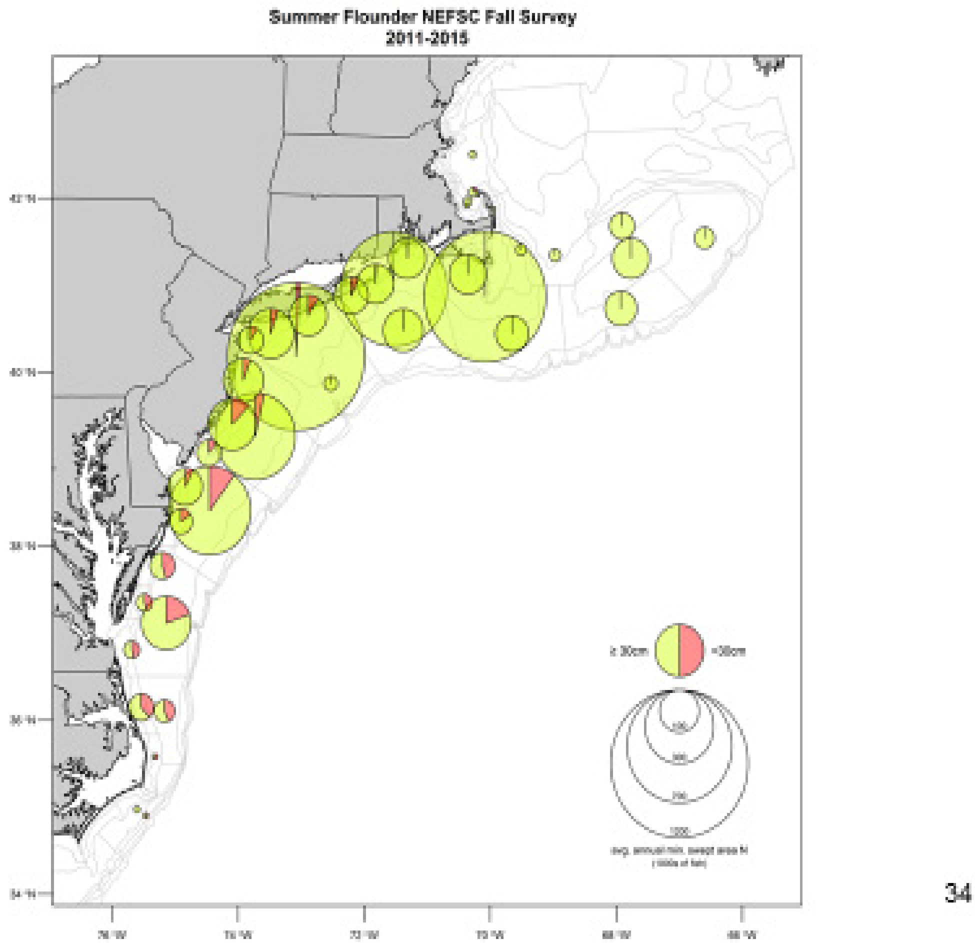

Figure A97. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for fall 2011-2015.

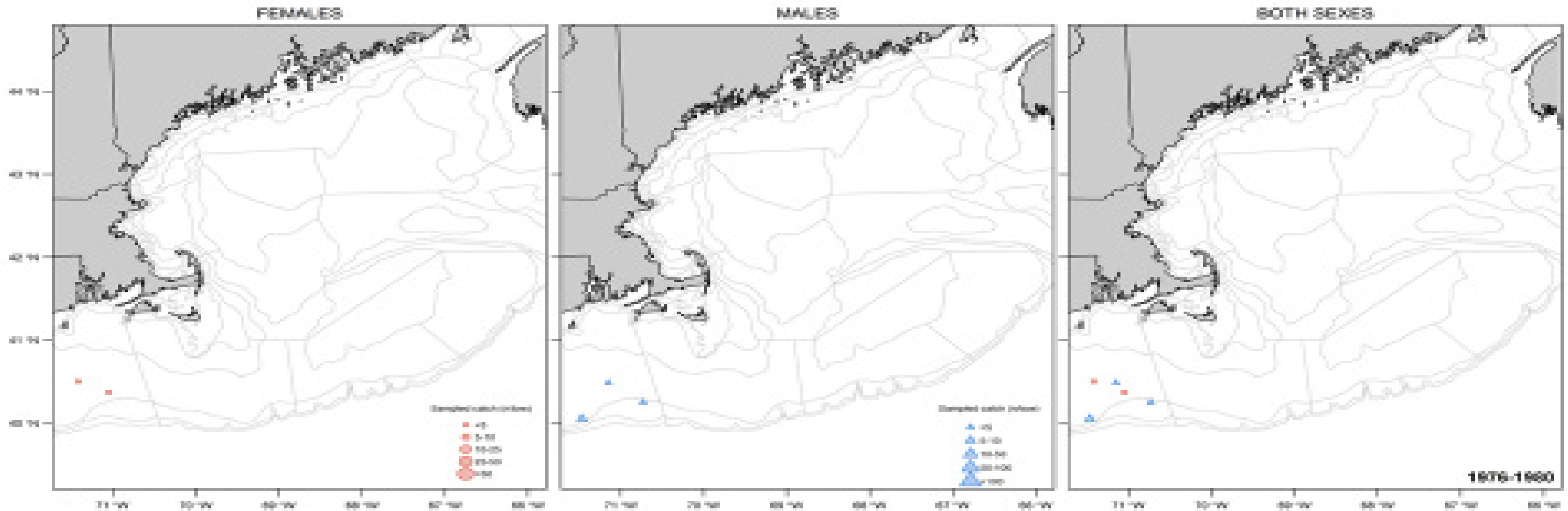

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Figure A98. Northeast Fisheries Science Center (NEFSC) / Massachusetts Division of Marine Fisheries (MADMF) spring survey distribution of summer flounder by sex: Gulf of Maine-Georges Bank 1975-1980.

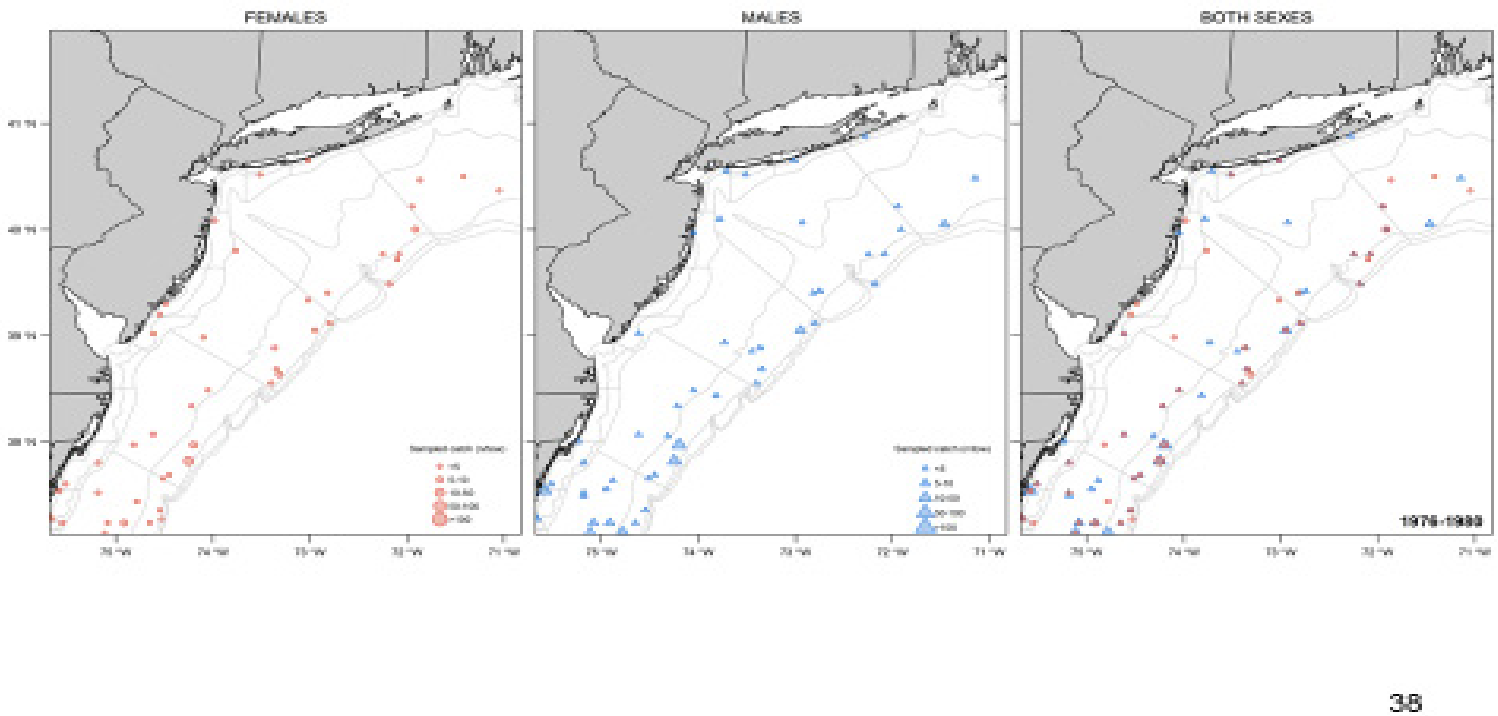

Figure A99. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Southern New England 1975-1980.

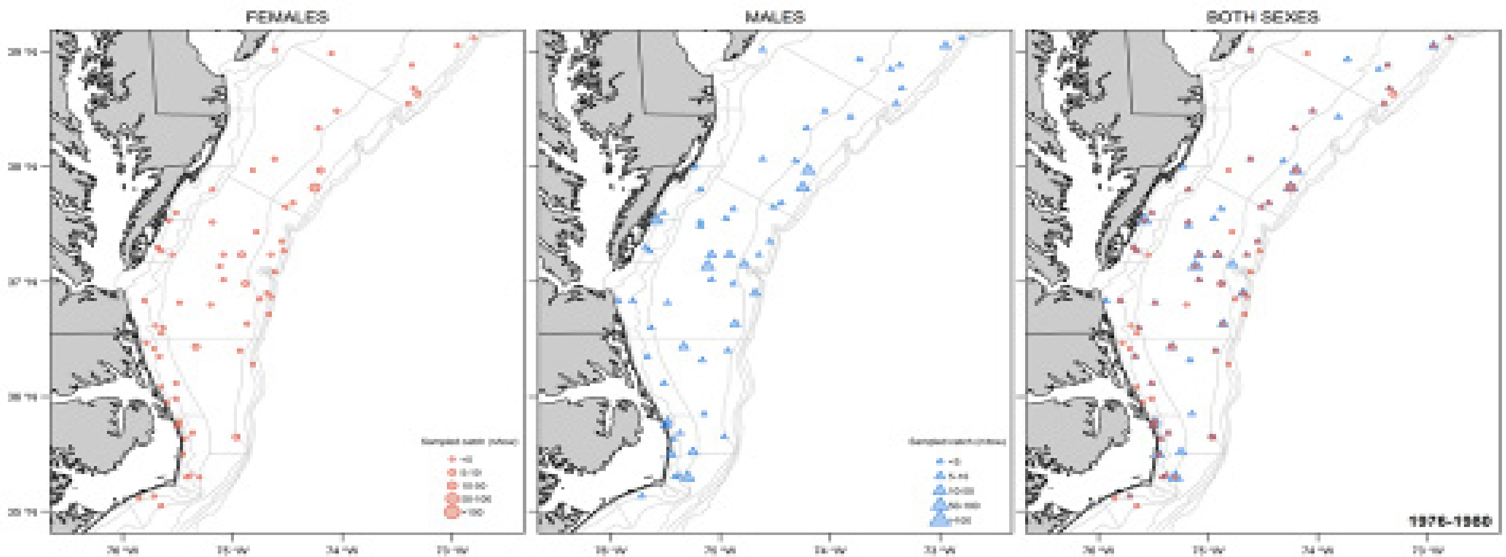

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Figure A100. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Mid-Atlantic Bight 1975-1980.

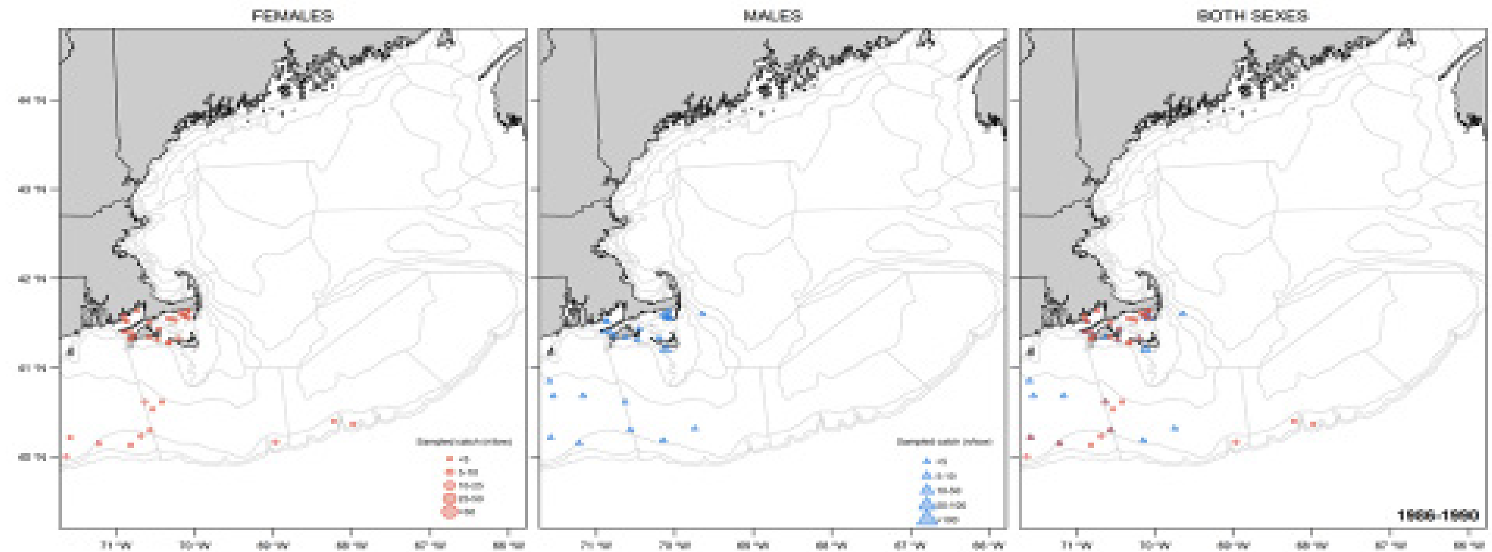

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Figure A101. Northeast Fisheries Science Center (NEFSC) / Massachusetts Division of Marine Fisheries (MADMF) spring survey distribution of summer flounder by sex: Gulf of Maine-Georges Bank 1986-1990.

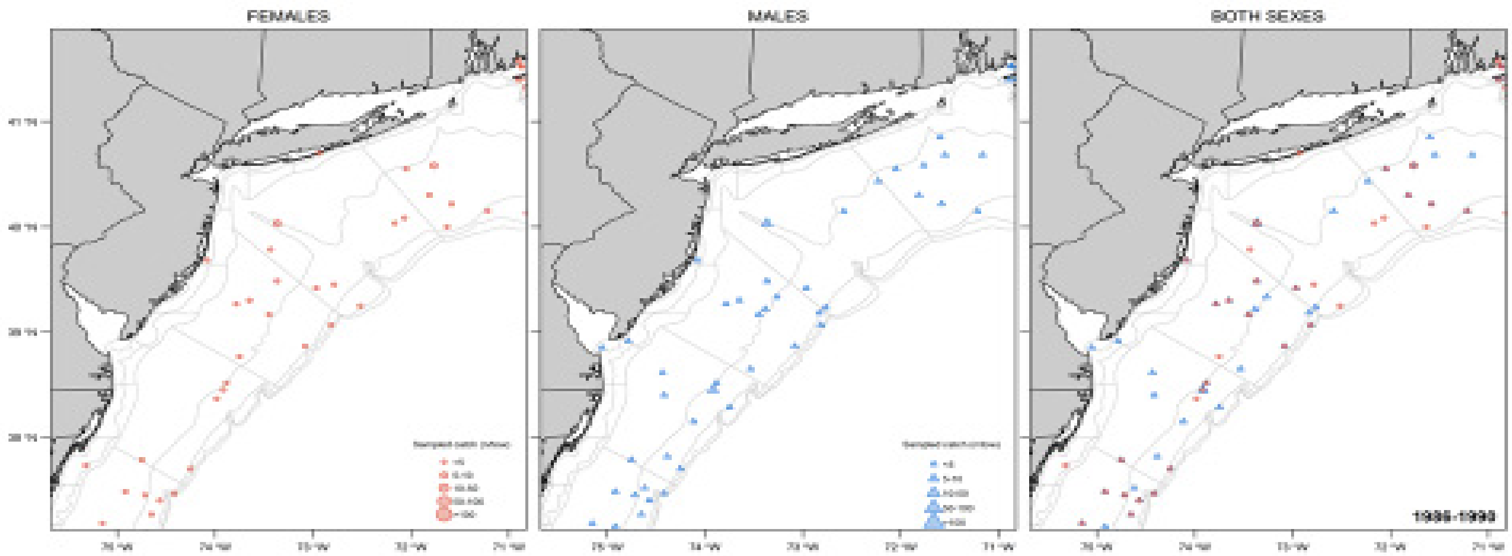

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Figure A102. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Southern New England 1986-1990.

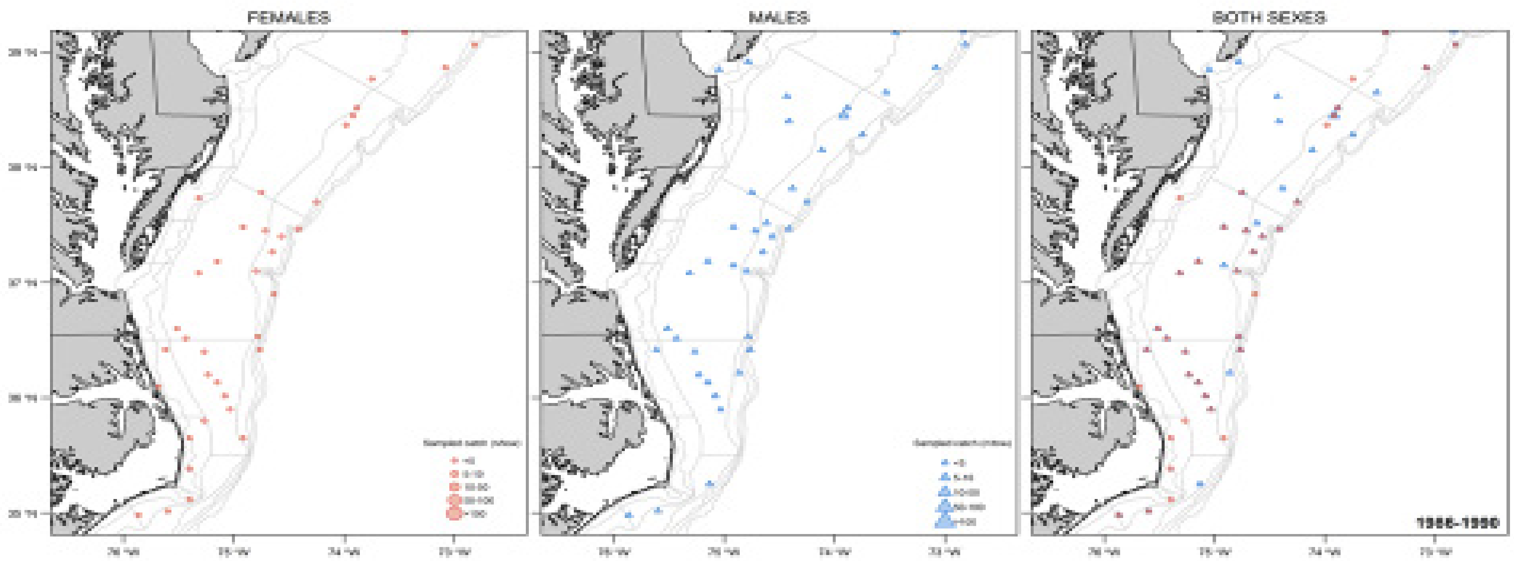

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Figure A103. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Mid-Atlantic Bight 1986-1990.

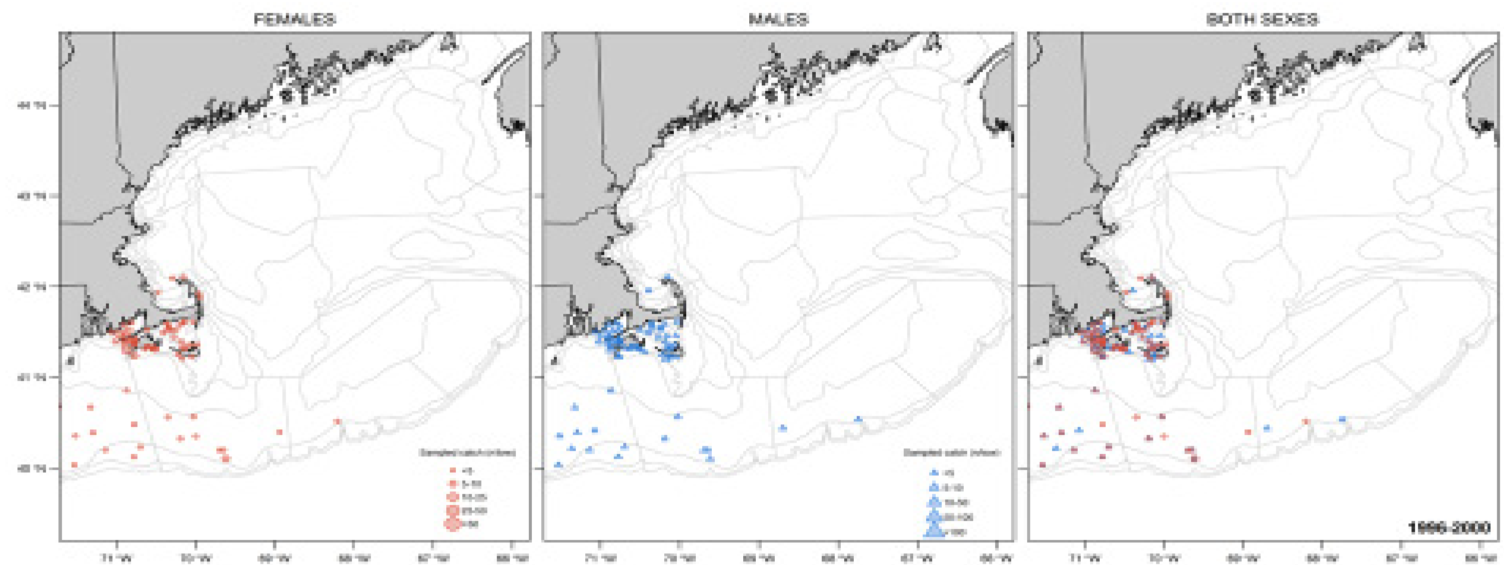

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Figure A104. Northeast Fisheries Science Center (NEFSC) / Massachusetts Division of Marine Fisheries (MADMF) spring survey distribution of summer flounder by sex: Gulf of Maine-Georges Bank 1996-2000.

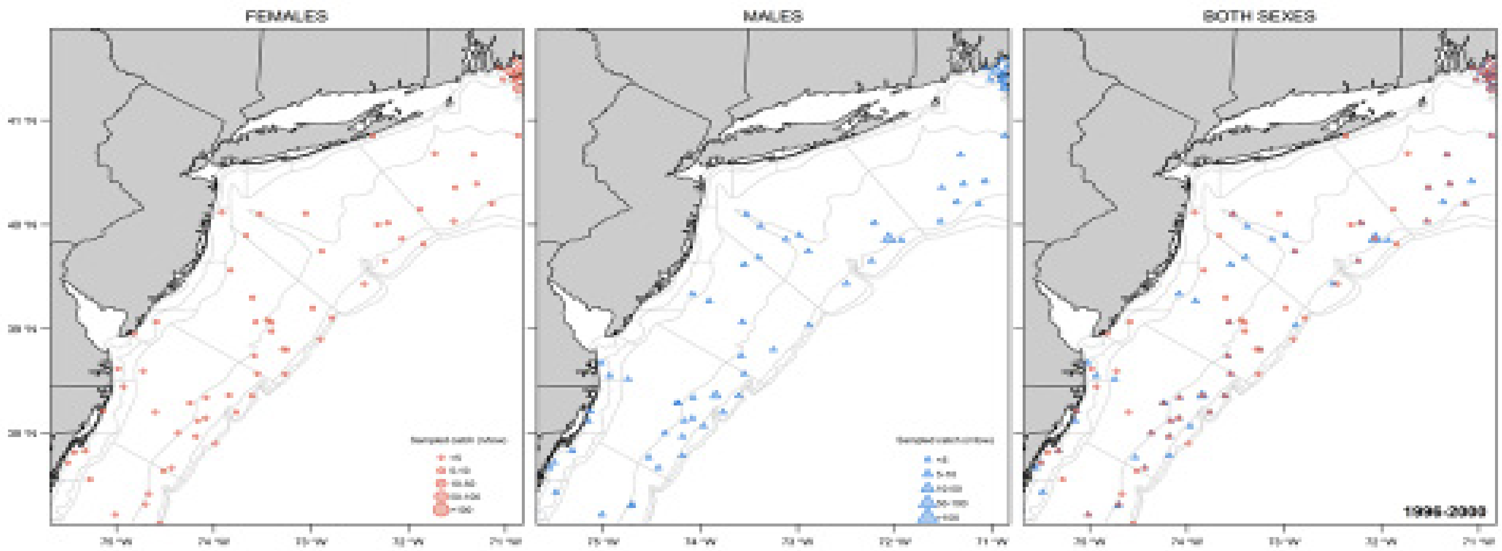

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Figure A105. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Southern New England 1996-2000.

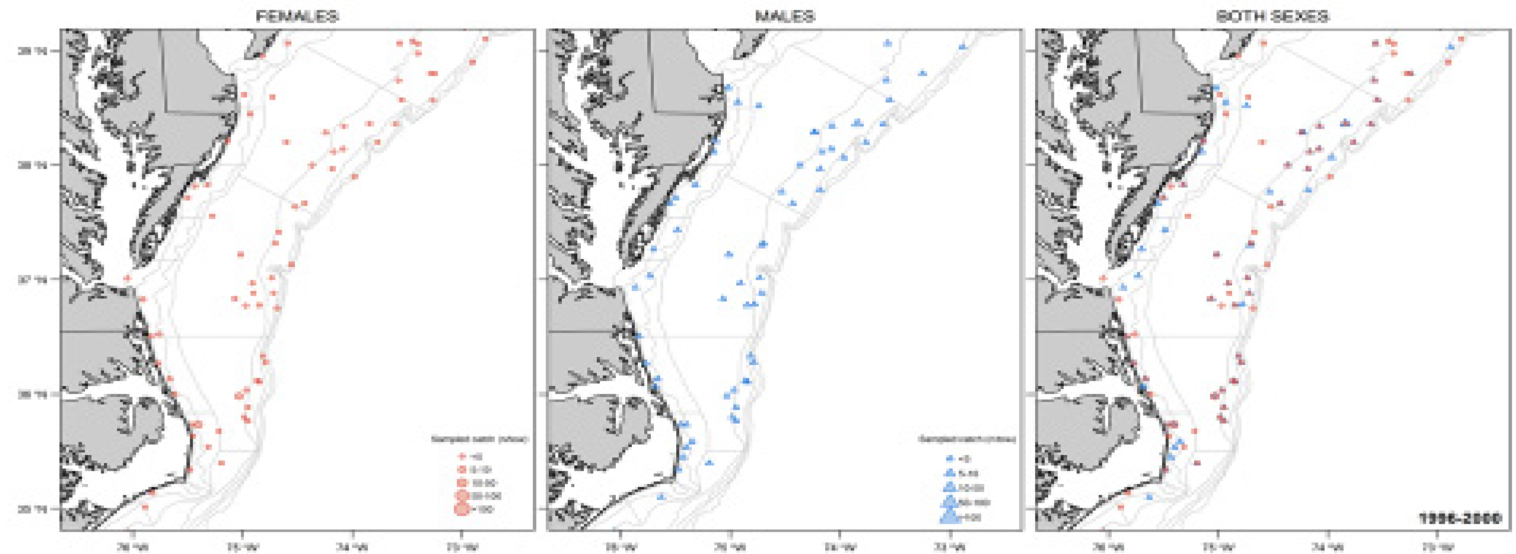

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Figure A106. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Mid-Atlantic Bight 1996-2000.

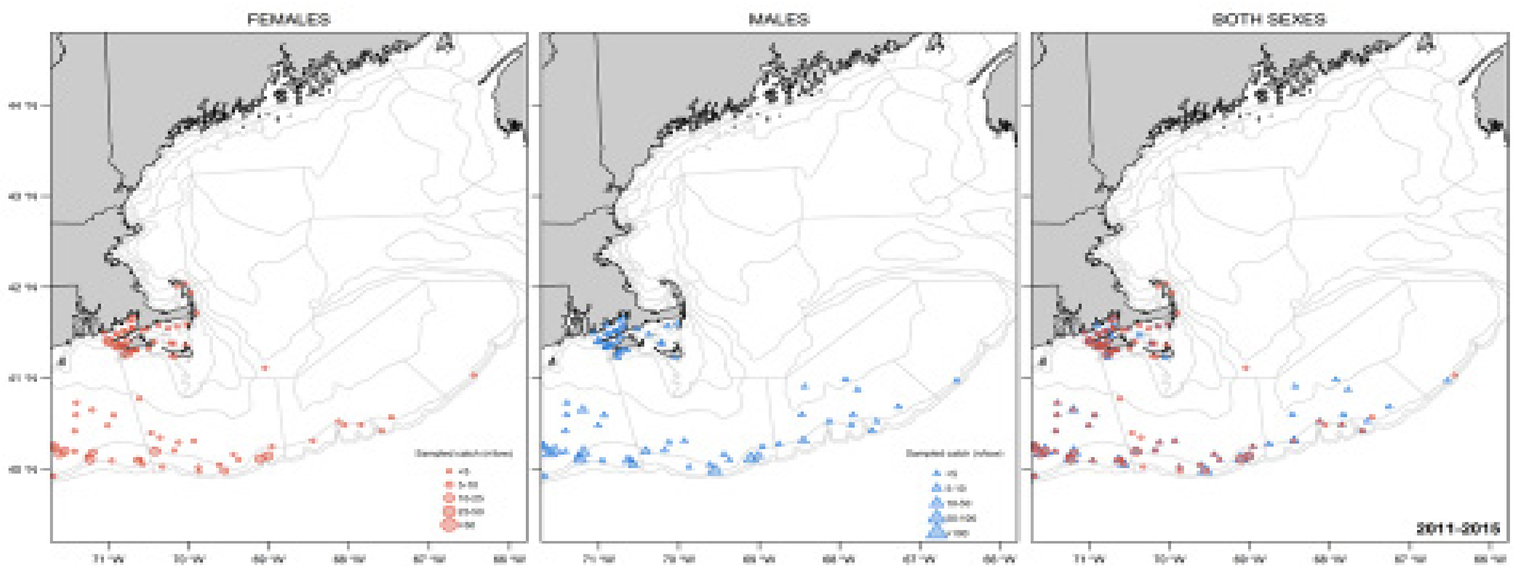

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Figure A107. Northeast Fisheries Science Center (NEFSC) / Massachusetts Division of Marine Fisheries (MADMF) spring survey distribution of summer flounder by sex: Gulf of Maine-Georges Bank 2011-2015.

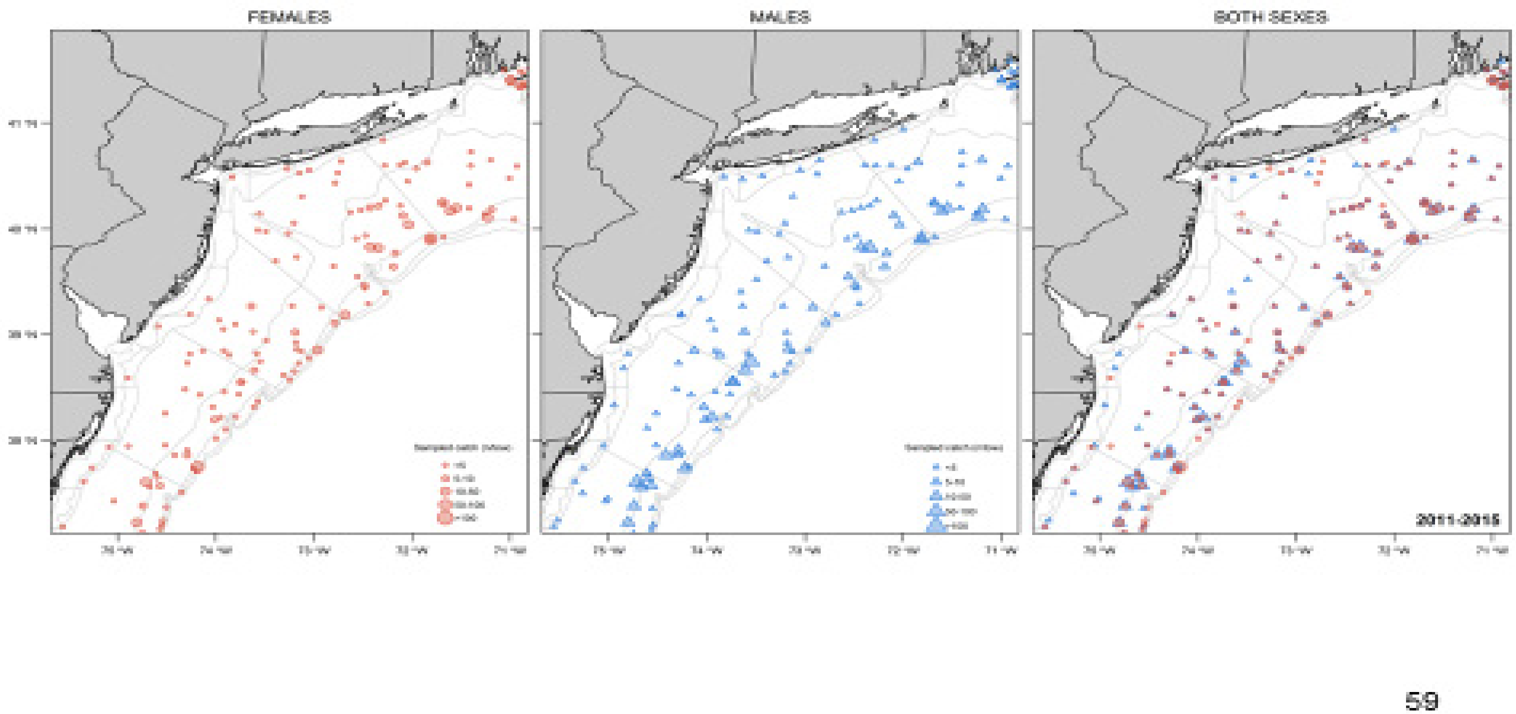

Figure A108. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Southern New England 2011-2015.

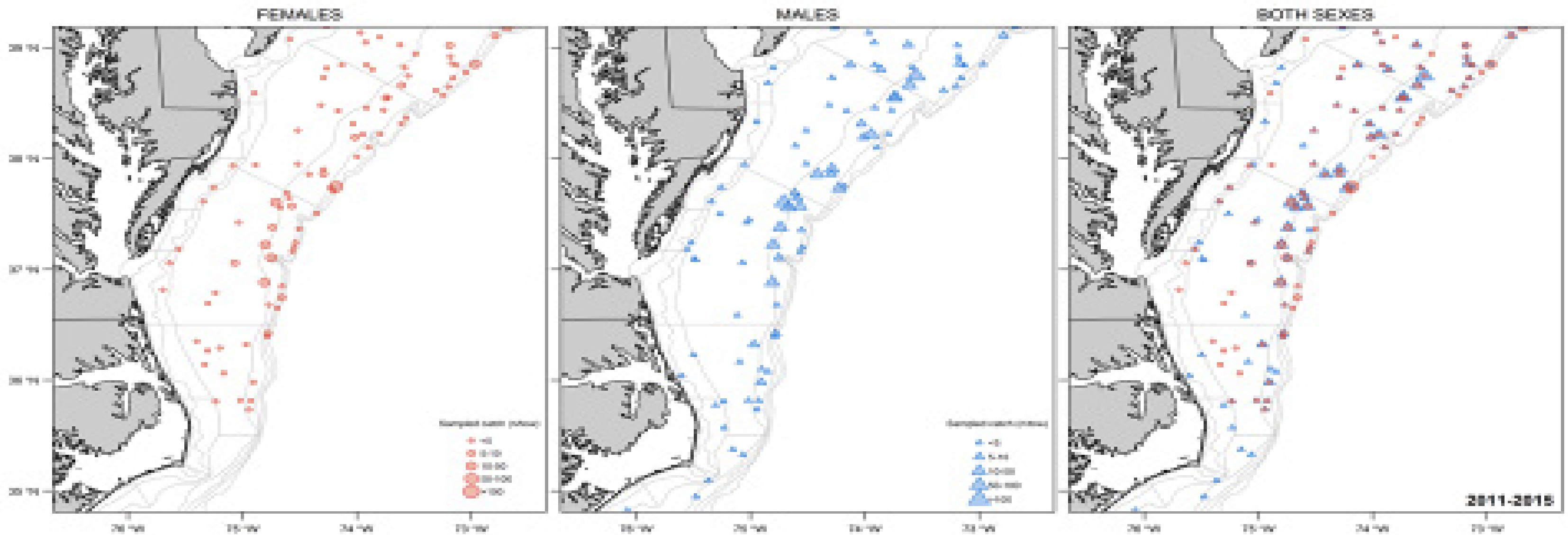

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Figure A109. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Mid-Atlantic Bight 2011-2015.

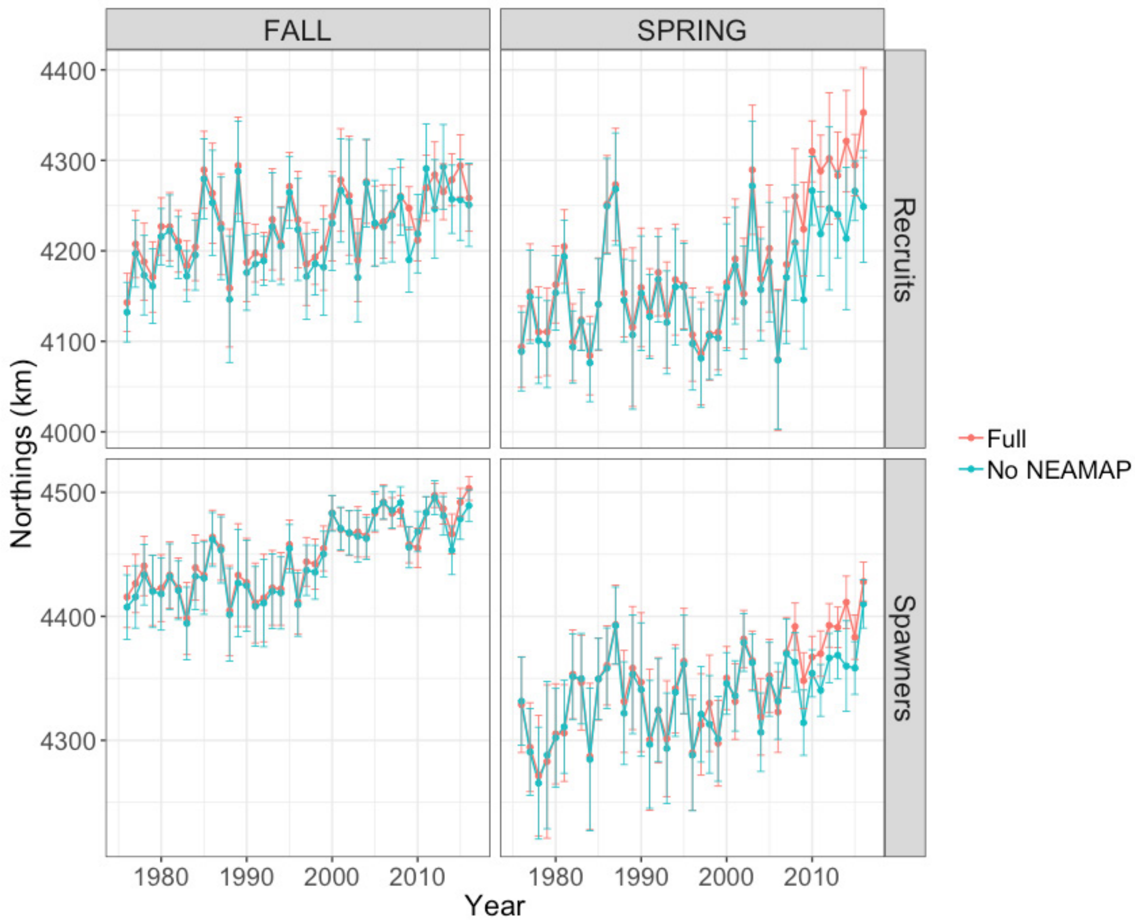


Figure A110. Center-of-gravity of northings for model with and without Northeast Area Monitoring and Assessment Program (NEAMAP) survey data.

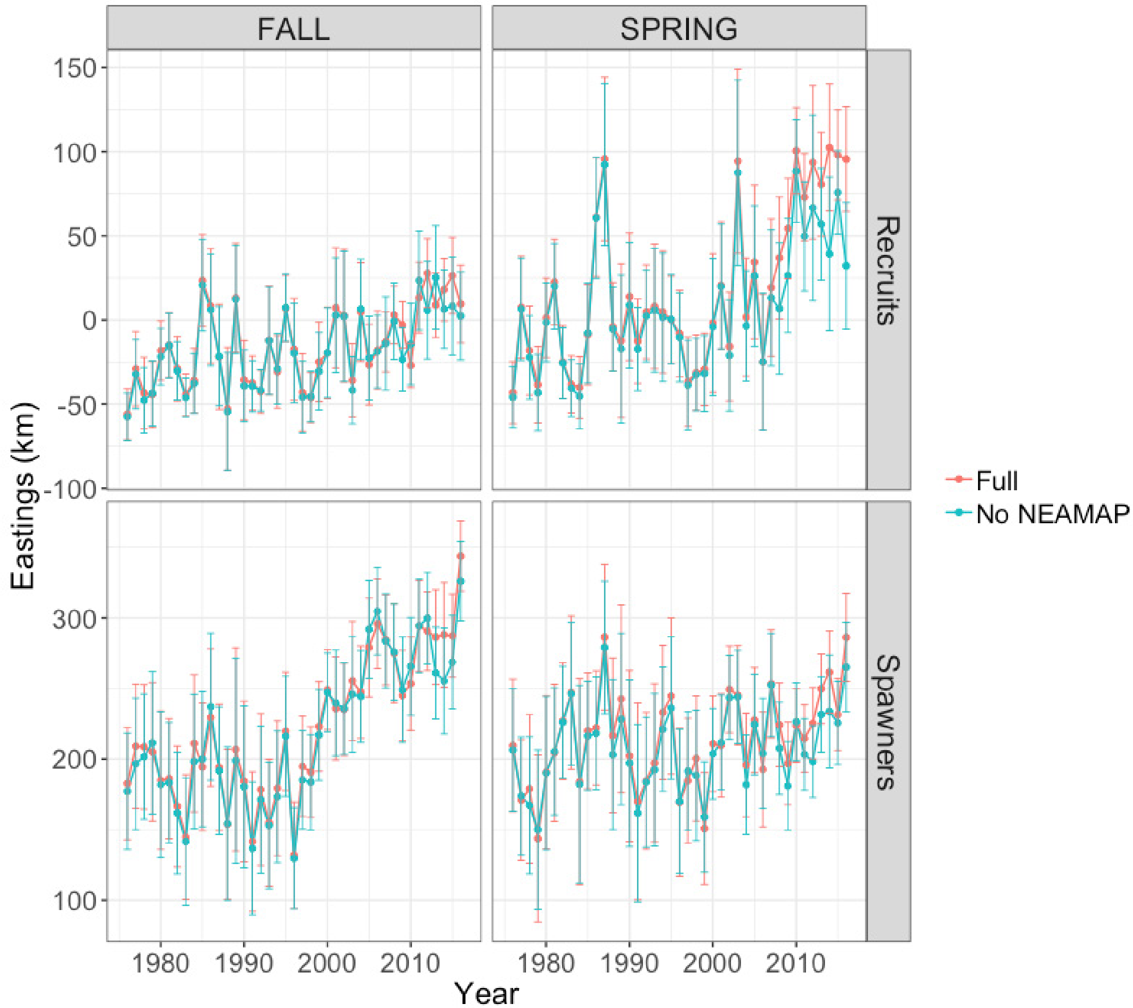


Figure A111. Center-of-gravity of eastings for model with and without Northeast Area Monitoring and Assessment Program (NEAMAP) survey data.

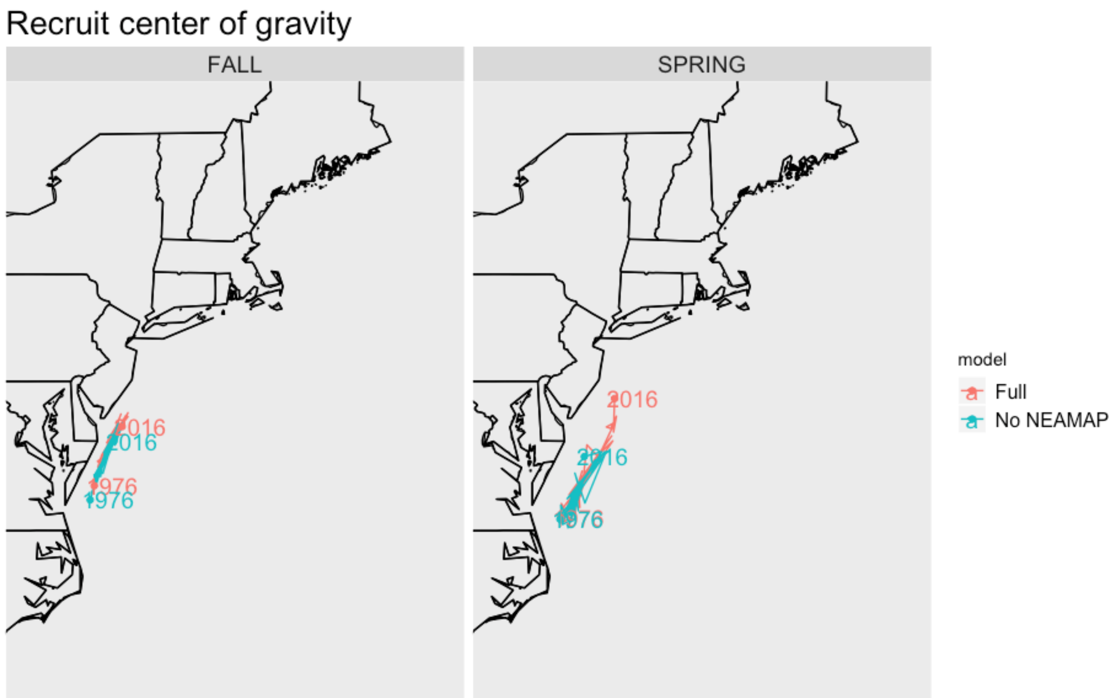


Figure A112. Recruits center of gravity, comparison between Vector Auto-regressive Spatio-Temporal (VAST) model with and without Northeast Area Monitoring and Assessment Program (NEAMAP) survey data.

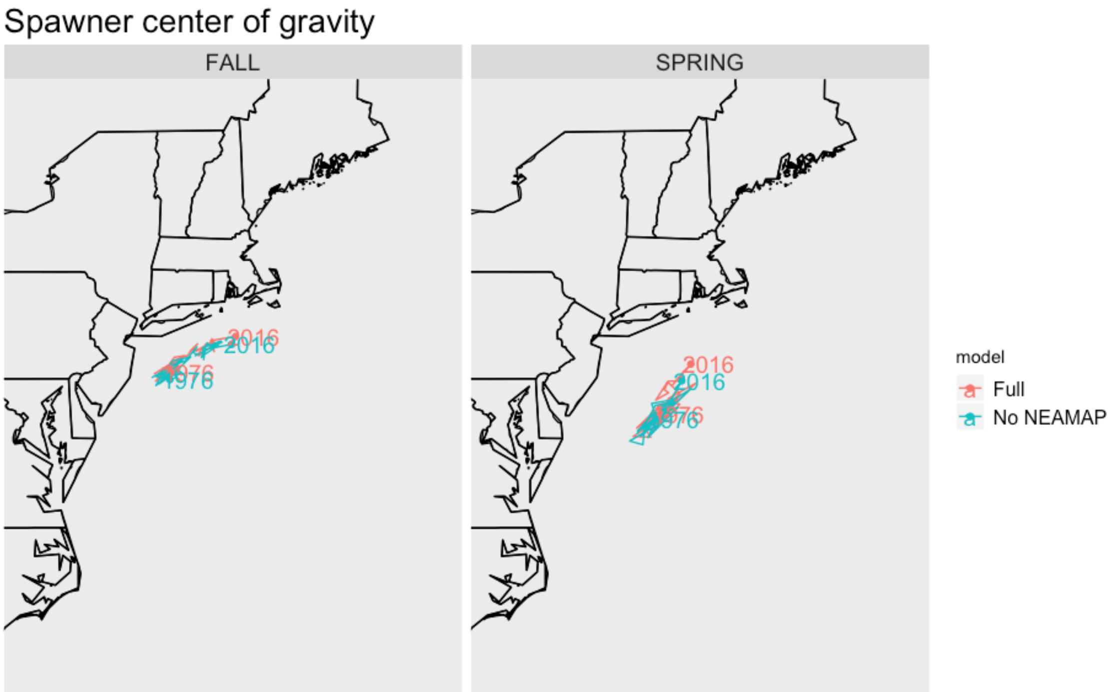


Figure A113. Spawner center of gravity, comparison between Vector Auto-regressive Spatio-Temporal (VAST) model with and without Northeast Area Monitoring and Assessment Program (NEAMAP) survey data.

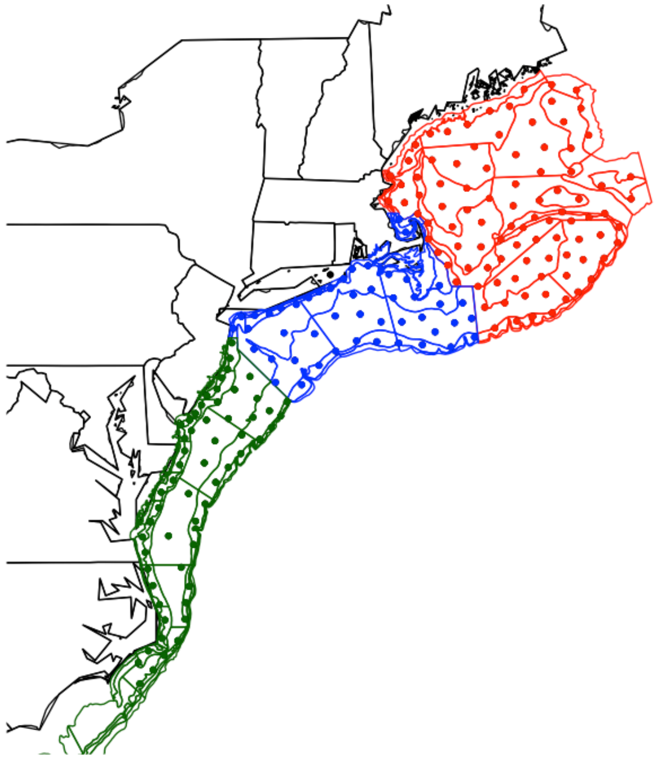


Figure A114. Division of Northeast Fisheries Science Center (NEFSC) survey strata into subareas for analysis of biomass trends in each area. The shelf is divided into north (red), middle (blue) and south (green). Knots associated with each area are shown in the same color.

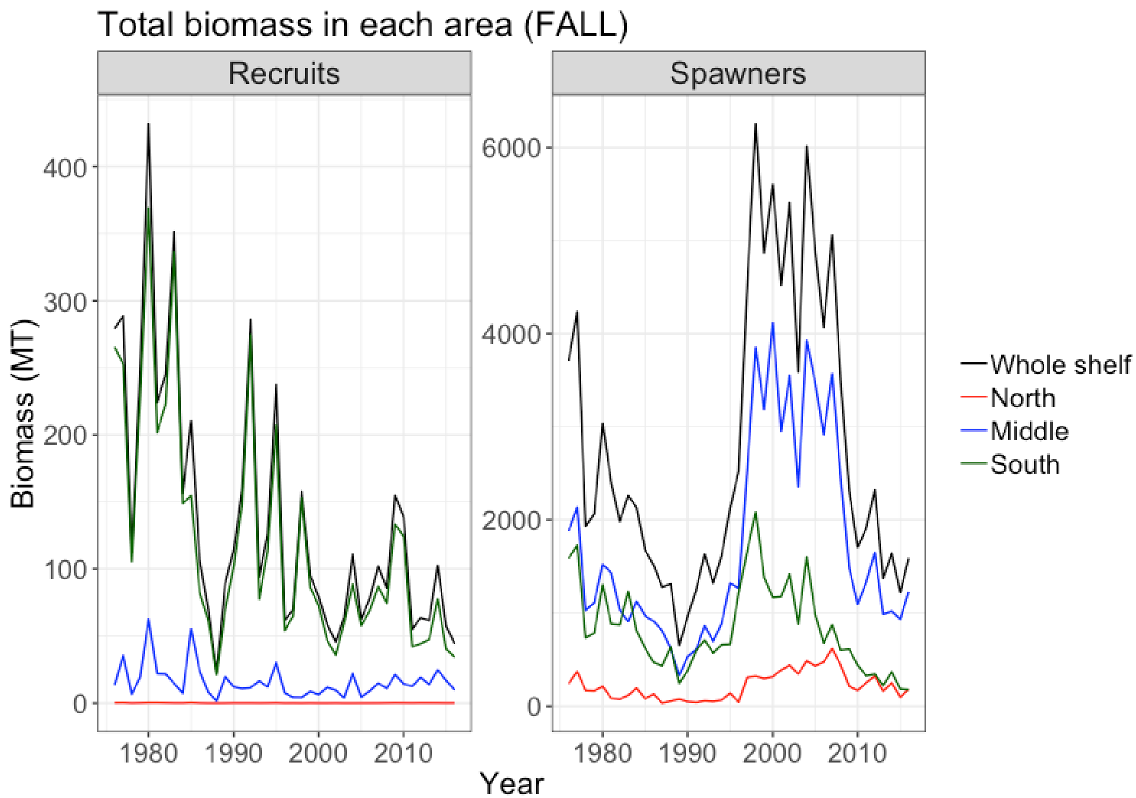


Figure A115. Total biomass in each subarea in the fall.

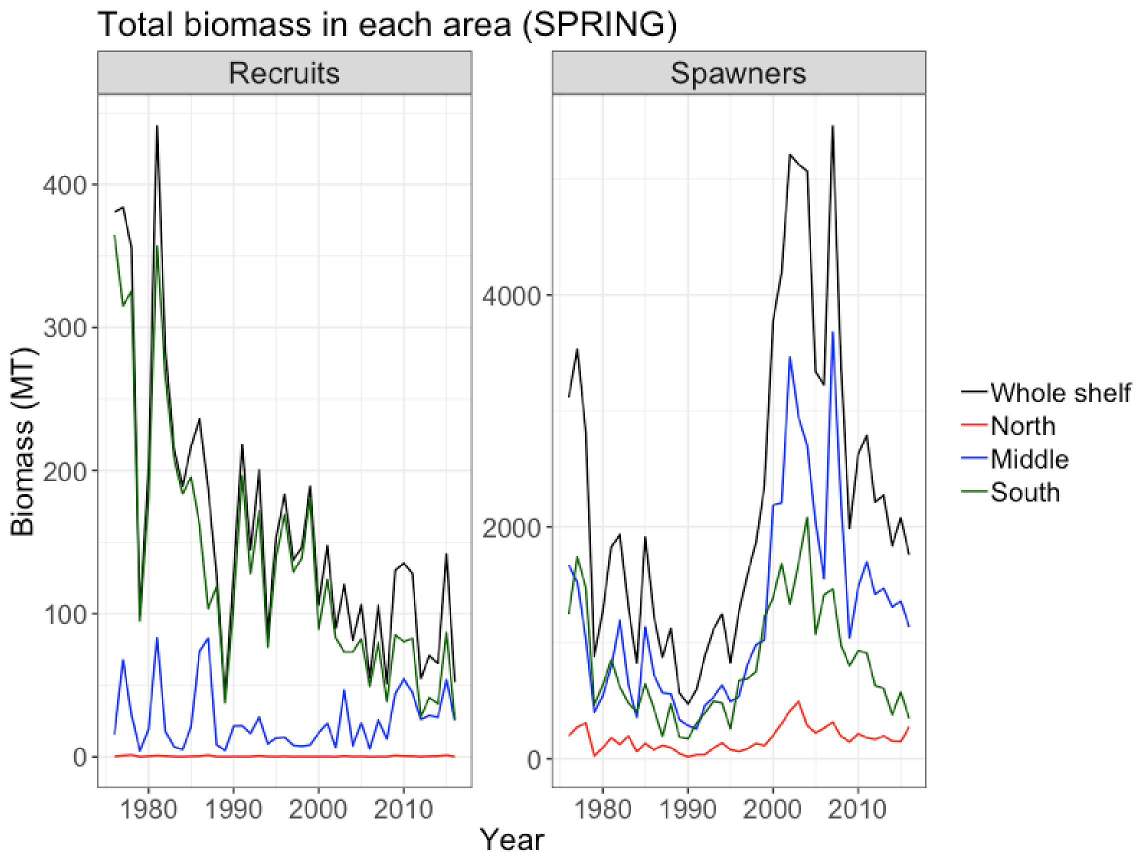


Figure A116. Total biomass in each subarea in the spring.

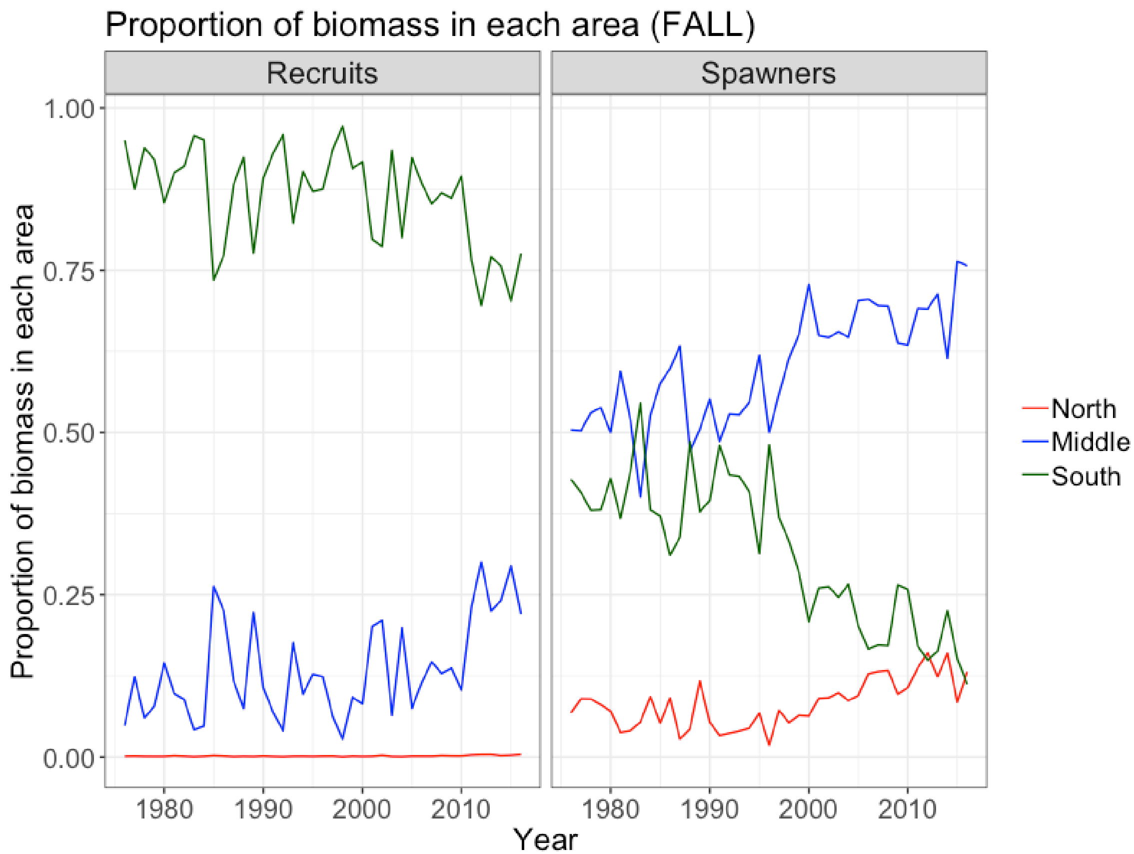


Figure A117. Proportion of biomass in each subarea in the fall.

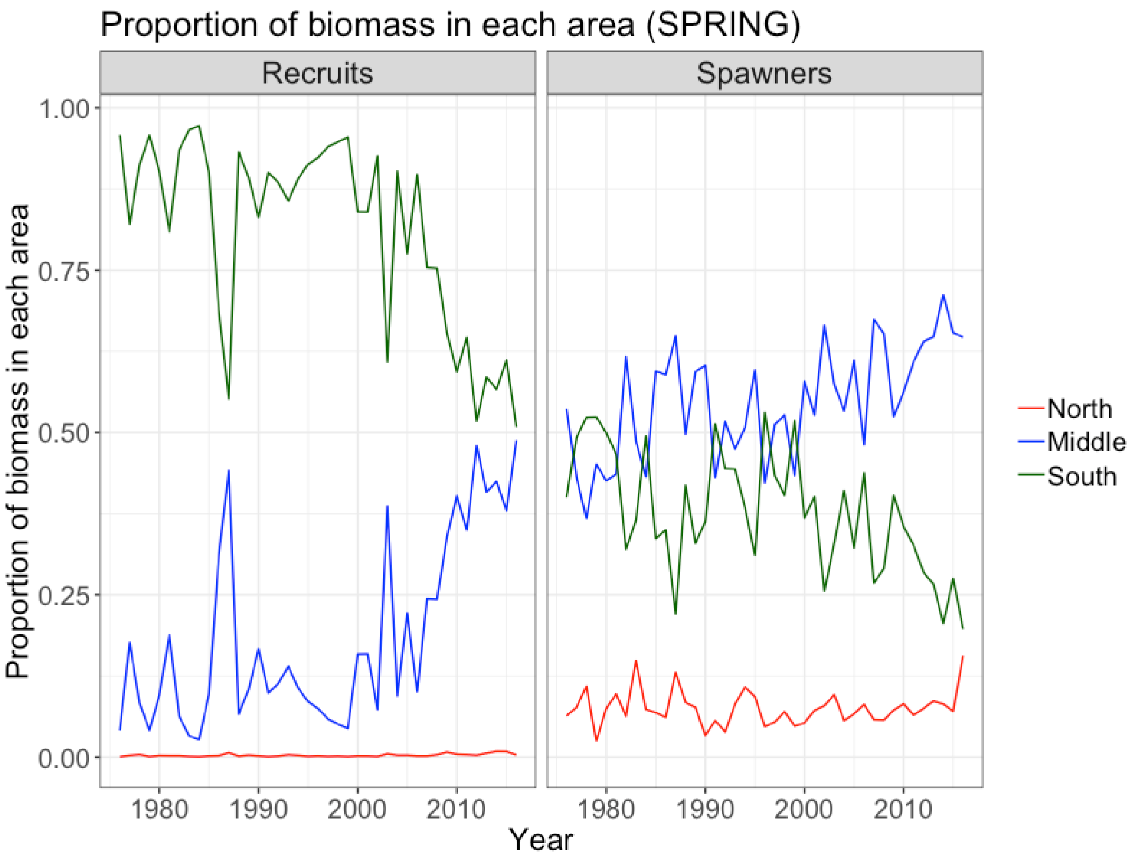


Figure A118. Proportion of biomass in each subarea in the spring.

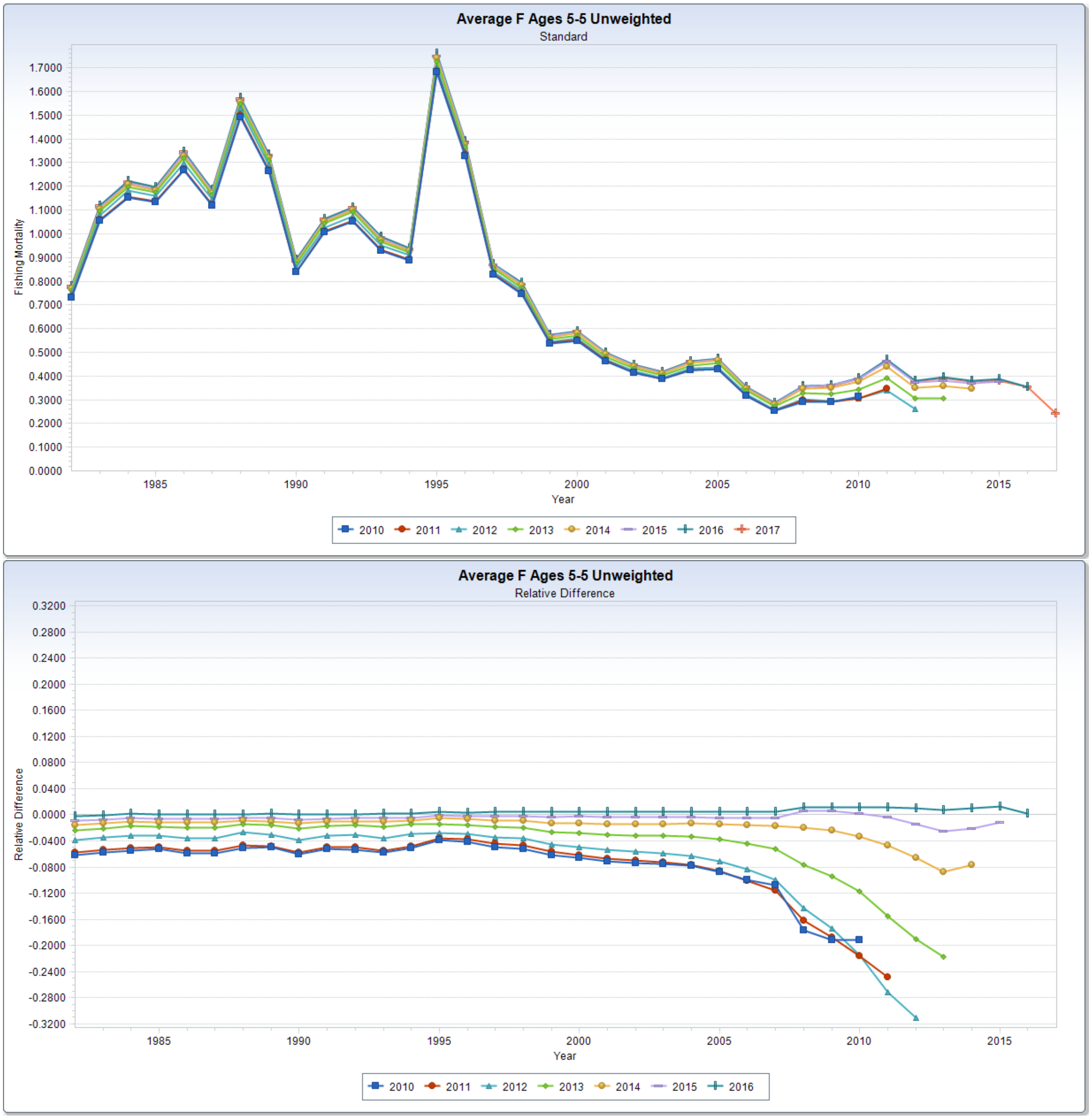


Figure A119. Results of internal model retrospective analysis for the existing (current) ASAP assessment model F2018: fully recruited F (true age 4, model age 5); average retrospective error = -15%.

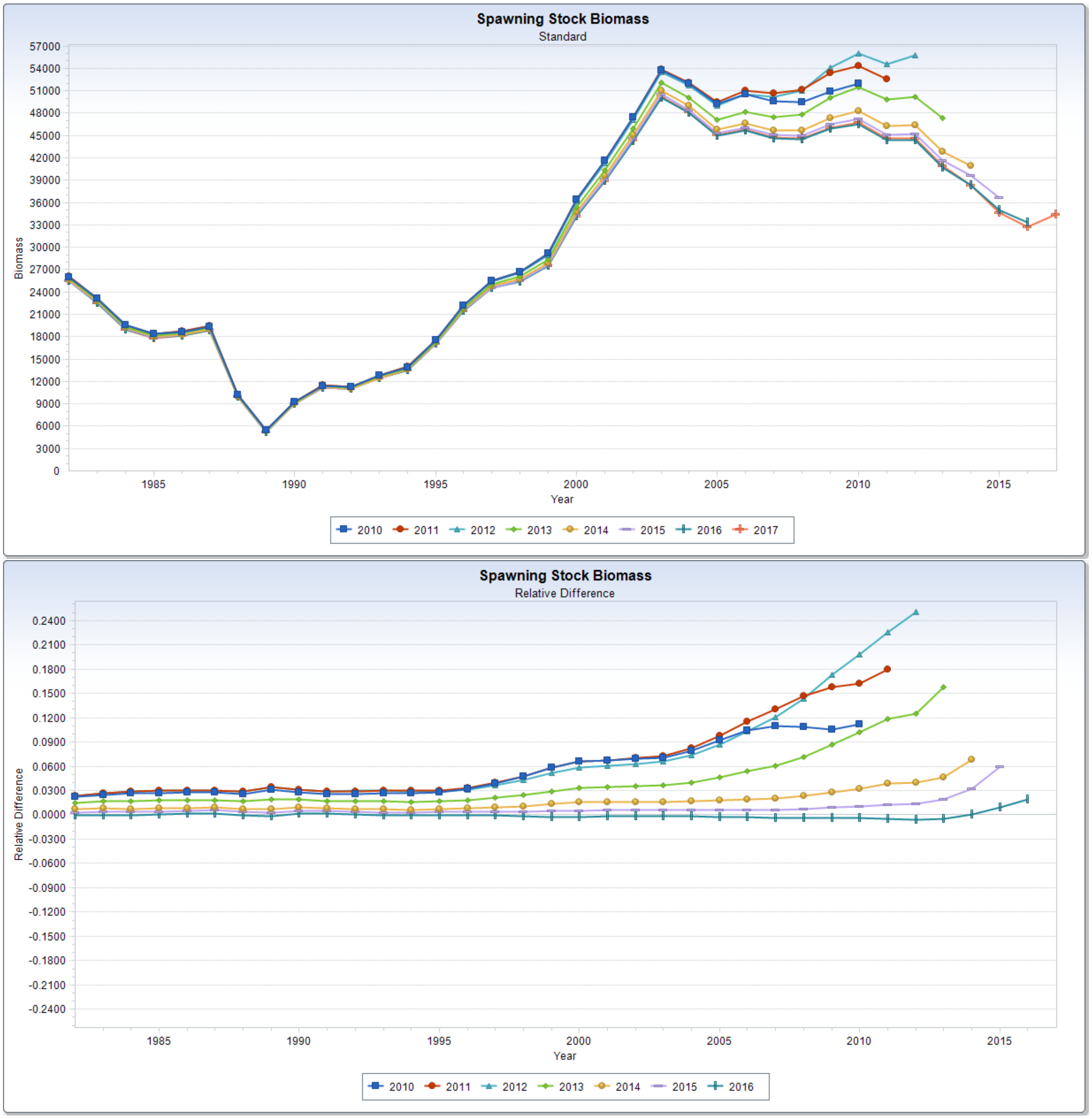


Figure A120. Results of internal model retrospective analysis for the existing (current) ASAP assessment model F2018: Spawning Stock Biomass; average retrospective error = +12%.

Figure A121. Results of internal model retrospective analysis for the existing (current) ASAP assessment model F2018: R (recruitment at true age 0, model age 1); average retrospective error = +22%.

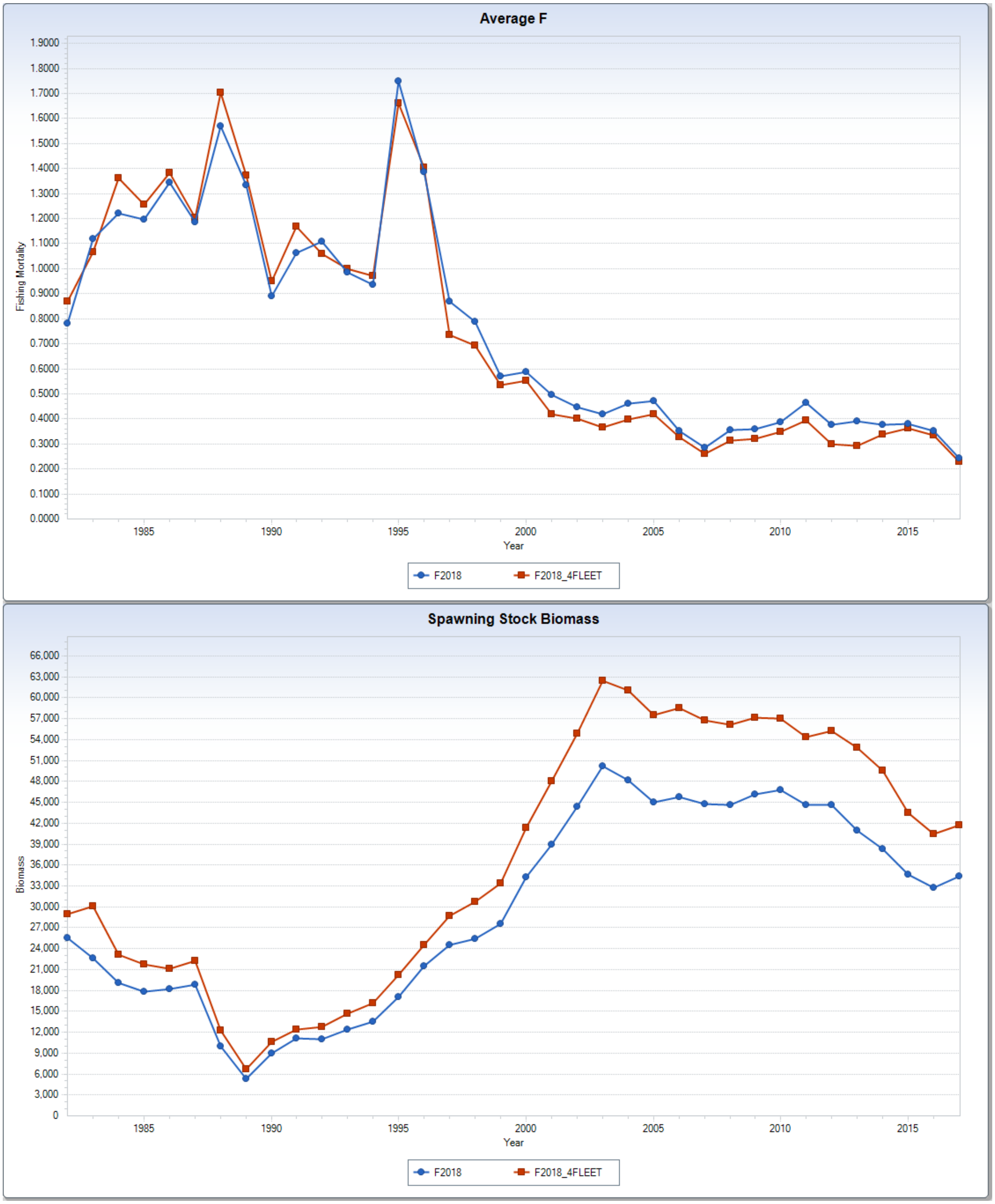


Figure A122. Comparison of the fishing mortality (top panel) and Spawning Stock Biomass (bottom panel) results for the F2018 model (2 fleets) with the F2018_4FLEET configuration of the ASAP model for summer flounder.

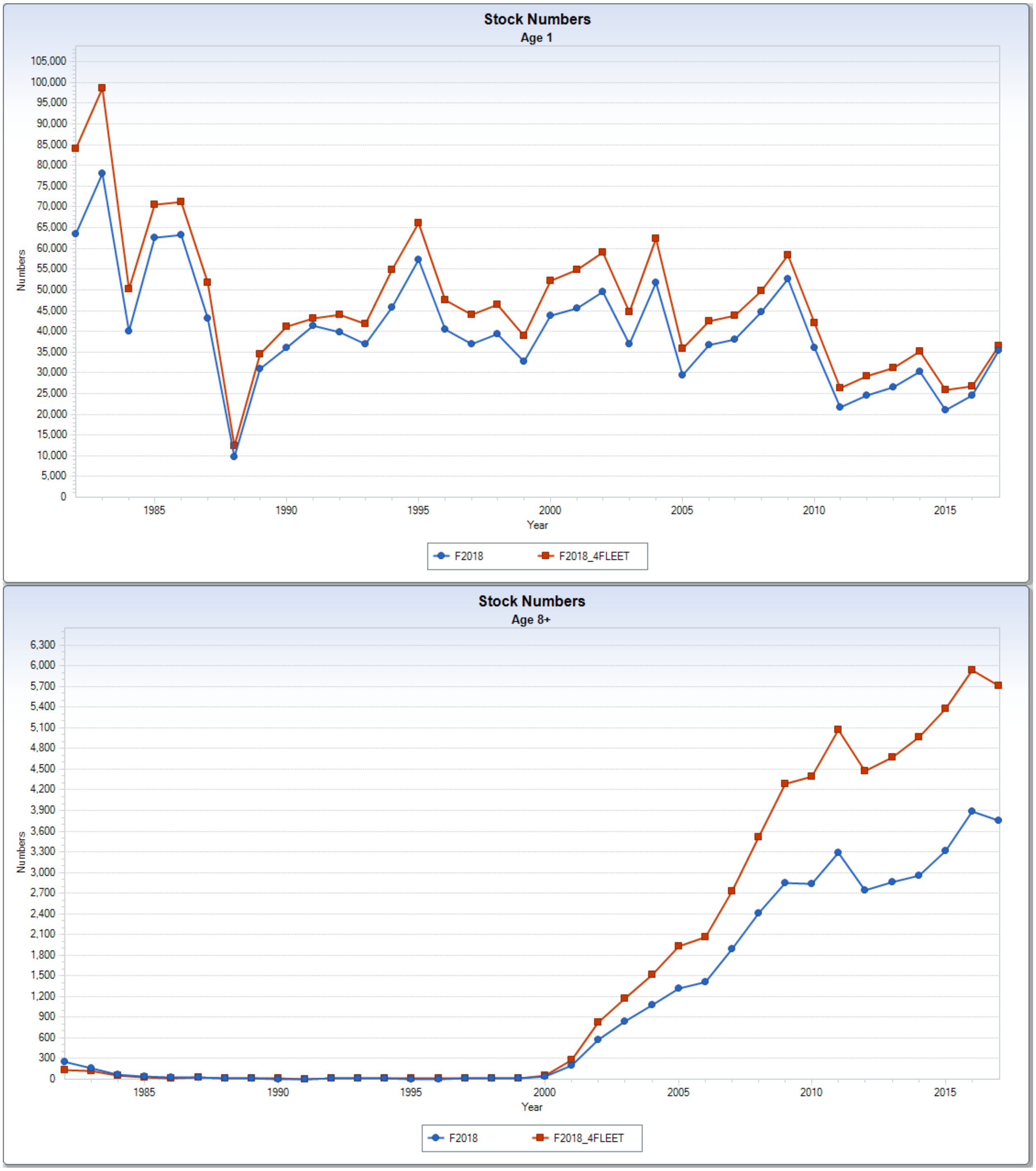


Figure A123. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018 model (2 fleets) with the F2018_4FLEET configuration of the ASAP model for summer flounder.

Figure A124. Comparison of the fishing mortality (top panel) and Spawning Stock Biomass (bottom panel) results for the F2018 model (2 fleets) with the F2018_BIGSV configuration of the ASAP model for summer flounder.

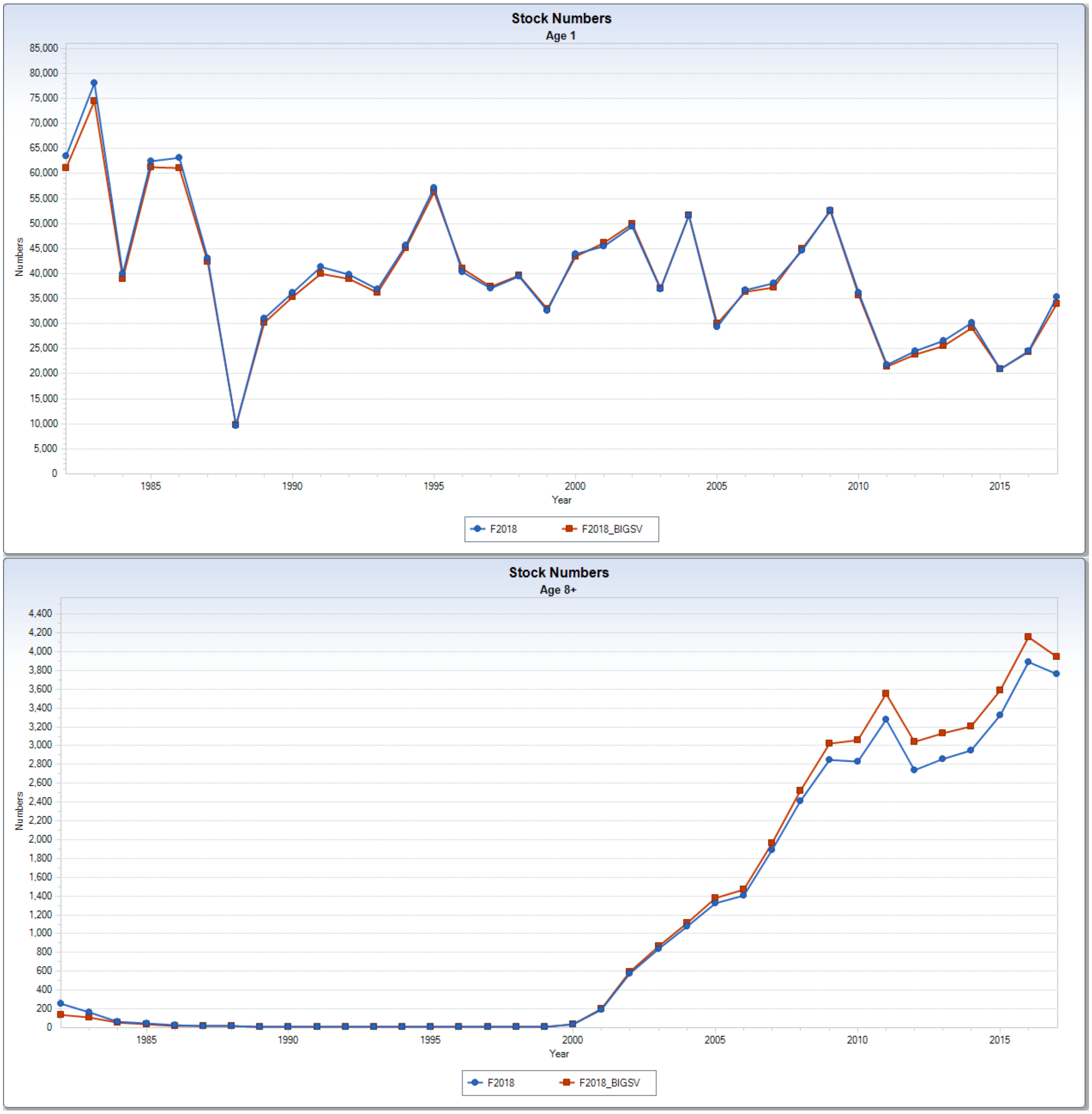
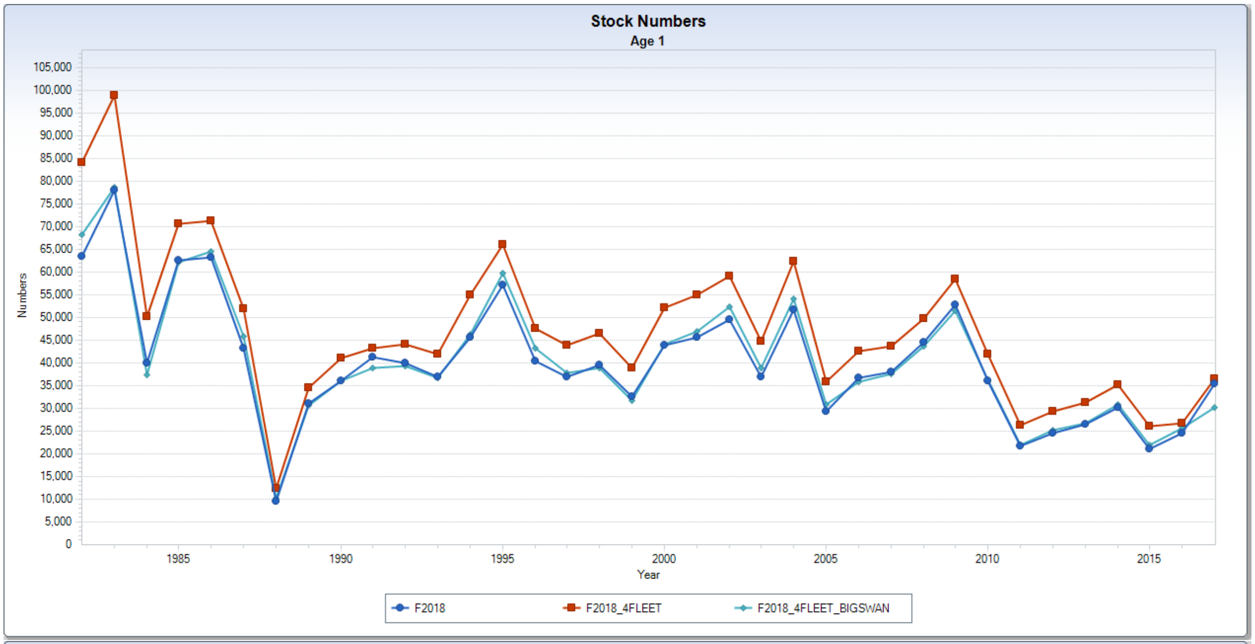


Figure A125. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018 model (2 fleets) with the F2018_BIGSV configuration of the ASAP model for summer flounder.

Figure A126. Comparison of the fishing mortality (top panel) and Spawning Stock Biomass (bottom panel) results for the F2018 model (2 fleets), the F2018_4FLEET, and the F2018_4FLEET_BIGSWAN configurations of the ASAP model for summer flounder.



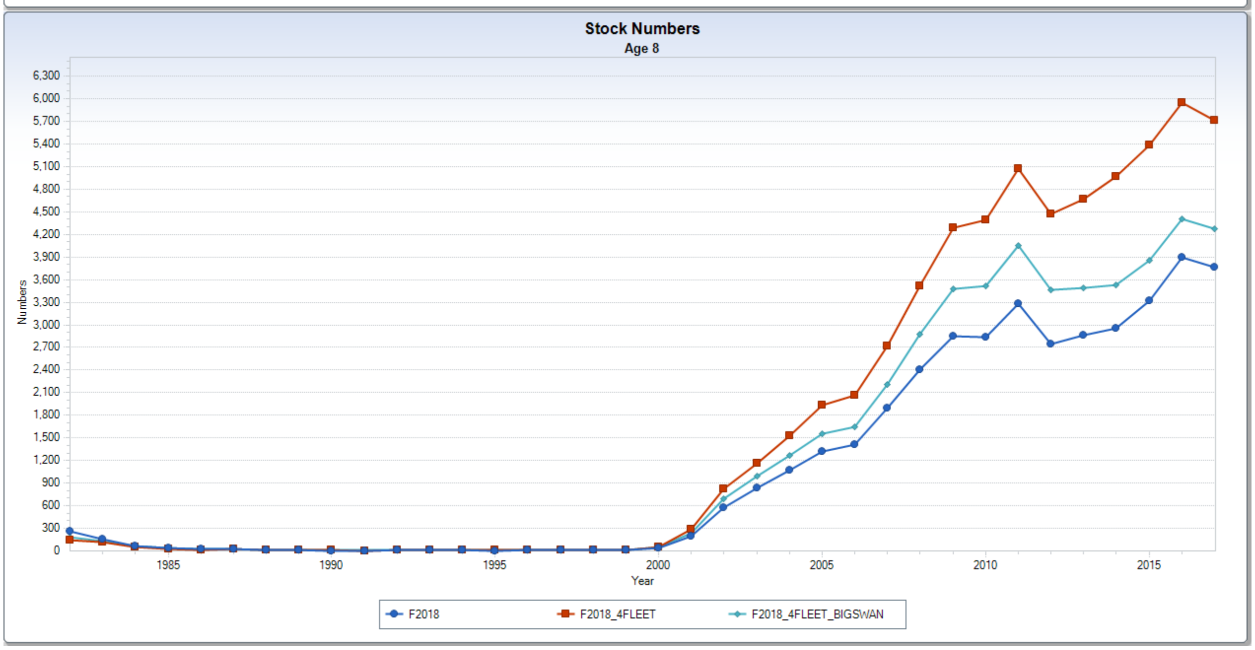


Figure A127. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018 model (2 fleets), F2018_4FLEET, and F2018_4FLEET_BIGSWAN configurations of the ASAP model for summer flounder.

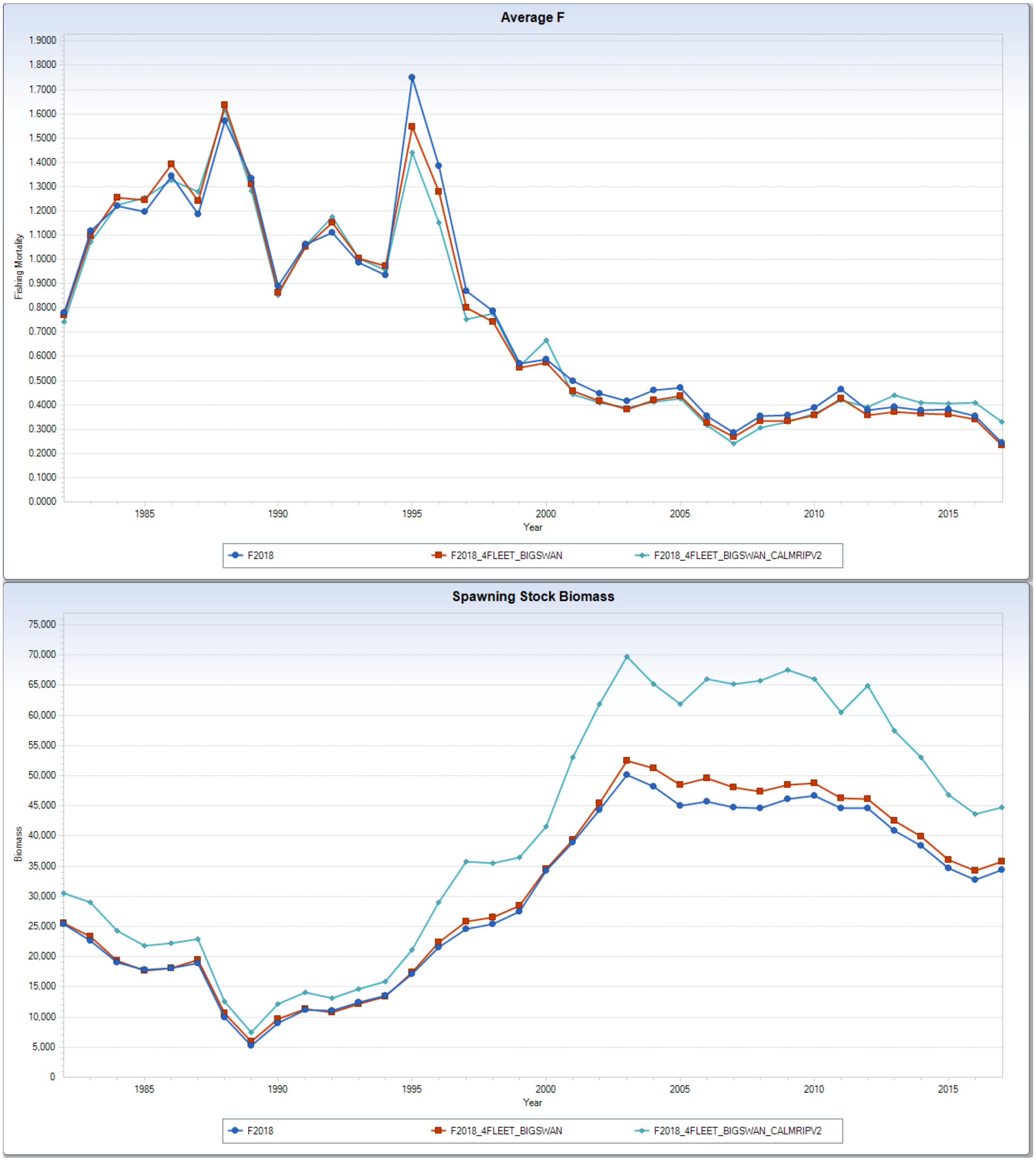


Figure A128. Comparison of the fishing mortality (top panel) and Spawning Stock Biomass (bottom panel) results for the F2018 model (2 fleets, 'Old' MRIP), F2018_4FLEET_BIGSWAN (4 fleets, 'Old' MRIP), and F2018_4FLEET_BIGSWAN_CALMRIP_V2 (4 fleets, 'New' MRIP) configurations of the ASAP model for summer flounder.

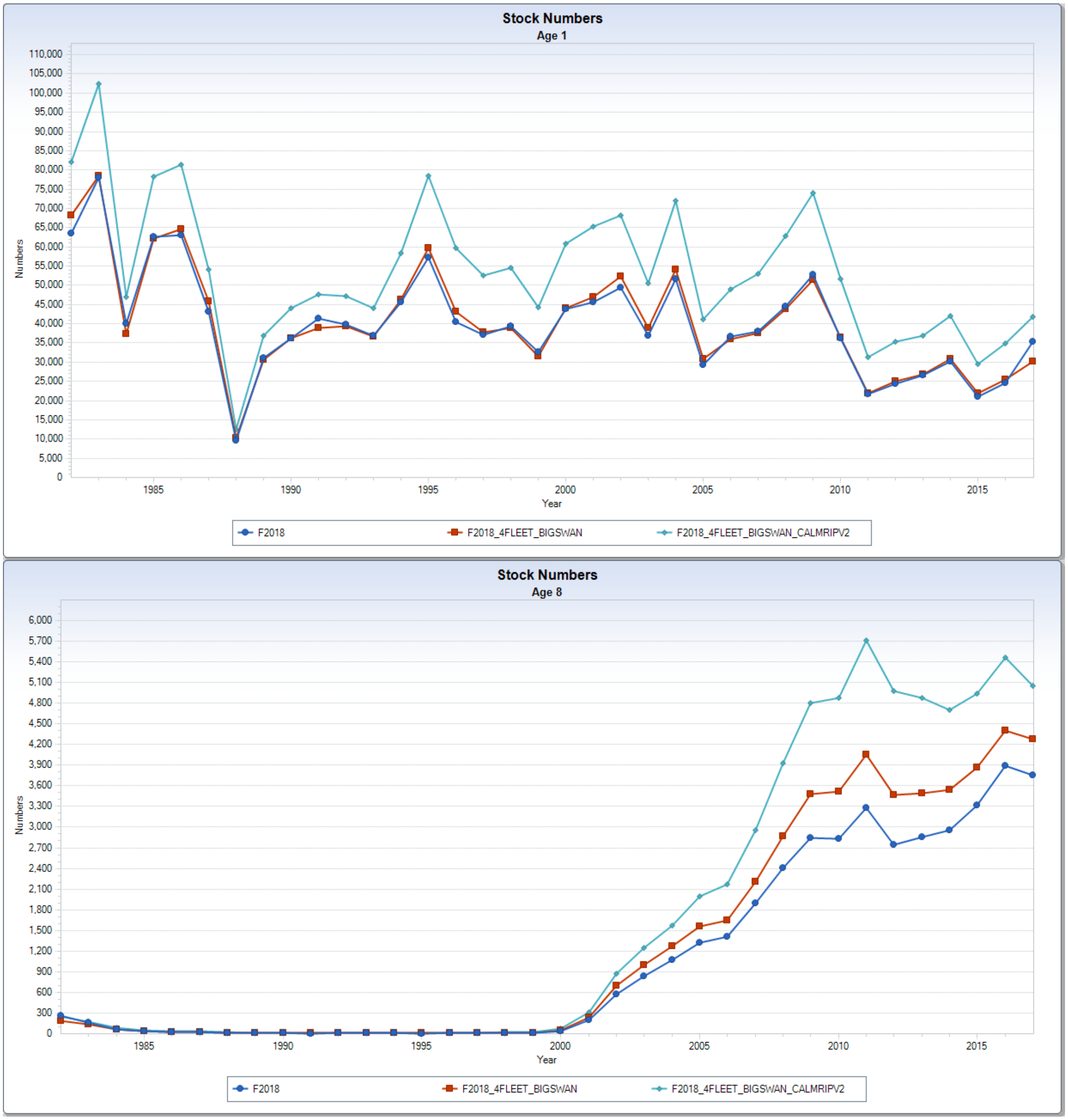


Figure A129. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018 model (2 fleets, 'Old' MRIP), F2018_4FLEET_BIGSWAN (4 fleets, 'Old' MRIP), and F2018_4FLEET_BIGSWAN_CALMRIP_V2 (4 fleets, 'New' MRIP) configurations of the ASAP model for summer flounder.

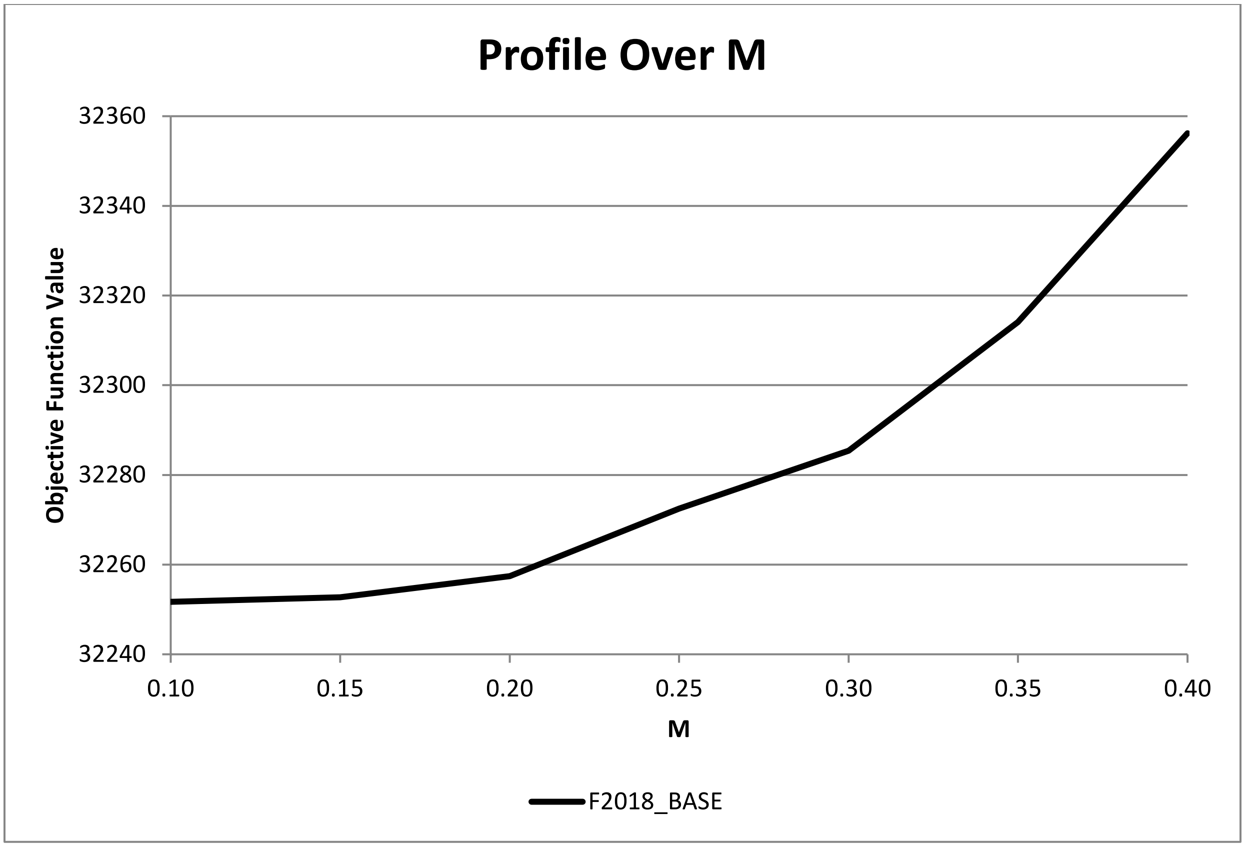


Figure A130. Likelihood profile for the F2018_BASE run over M values from 0.10 to 0.40.

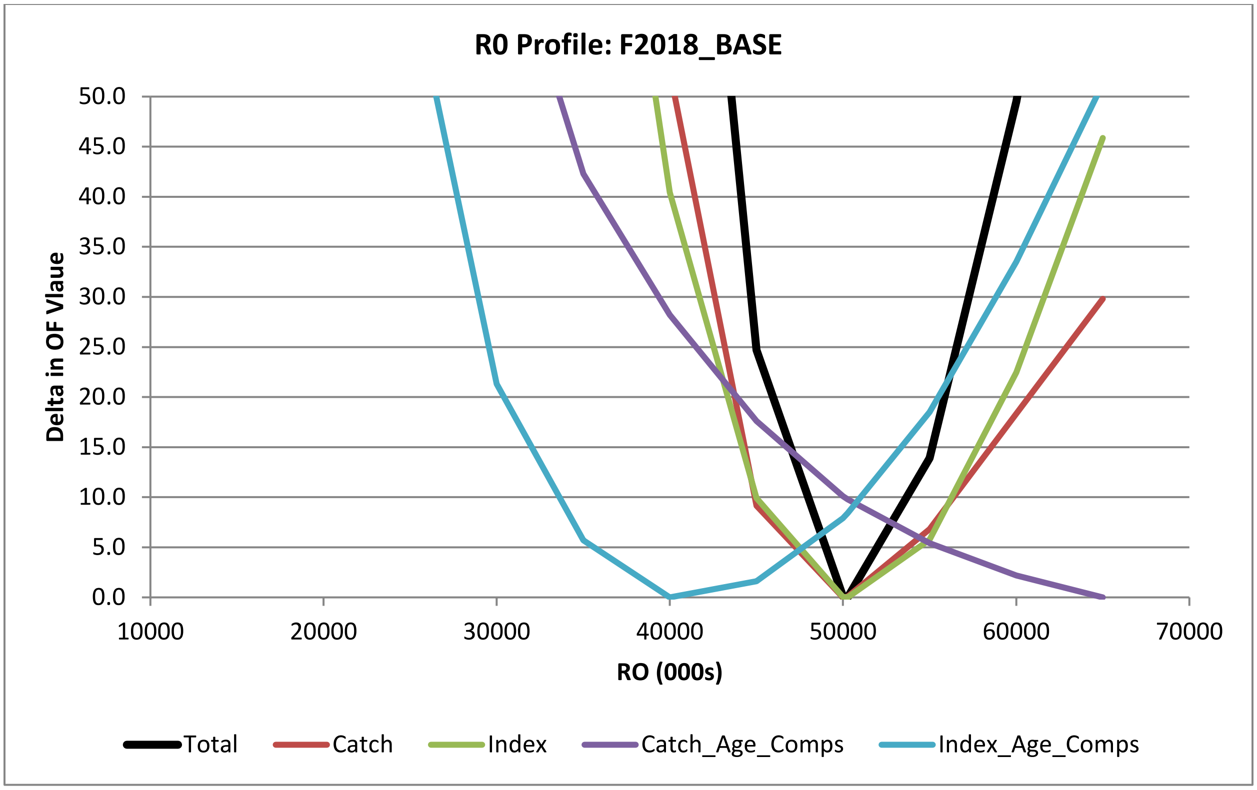


Figure A131. Likelihood profile for the F2018_BASE run over R0 values.

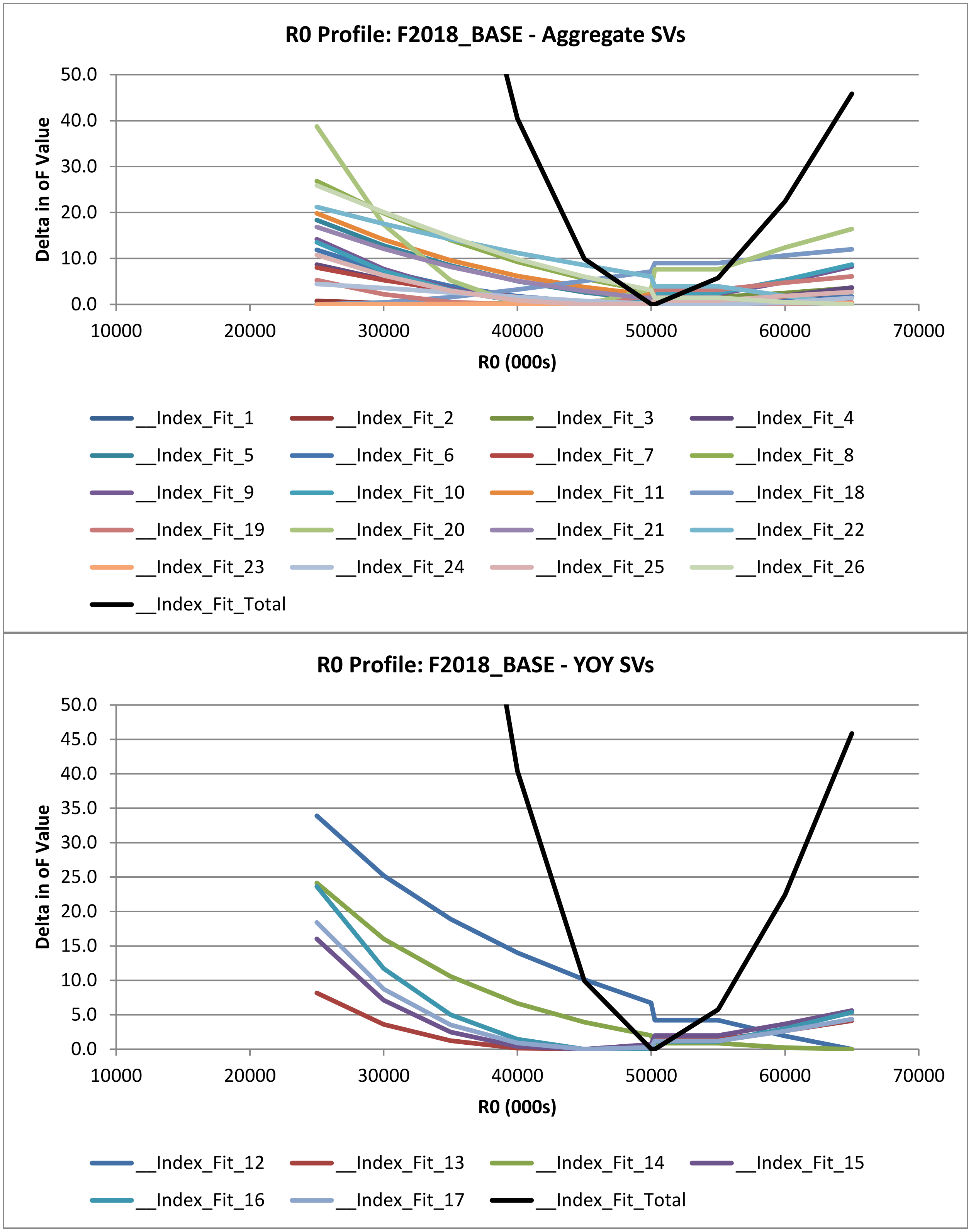


Figure A132 continued. Likelihood profile for the F2018_BASE run over R0 values.

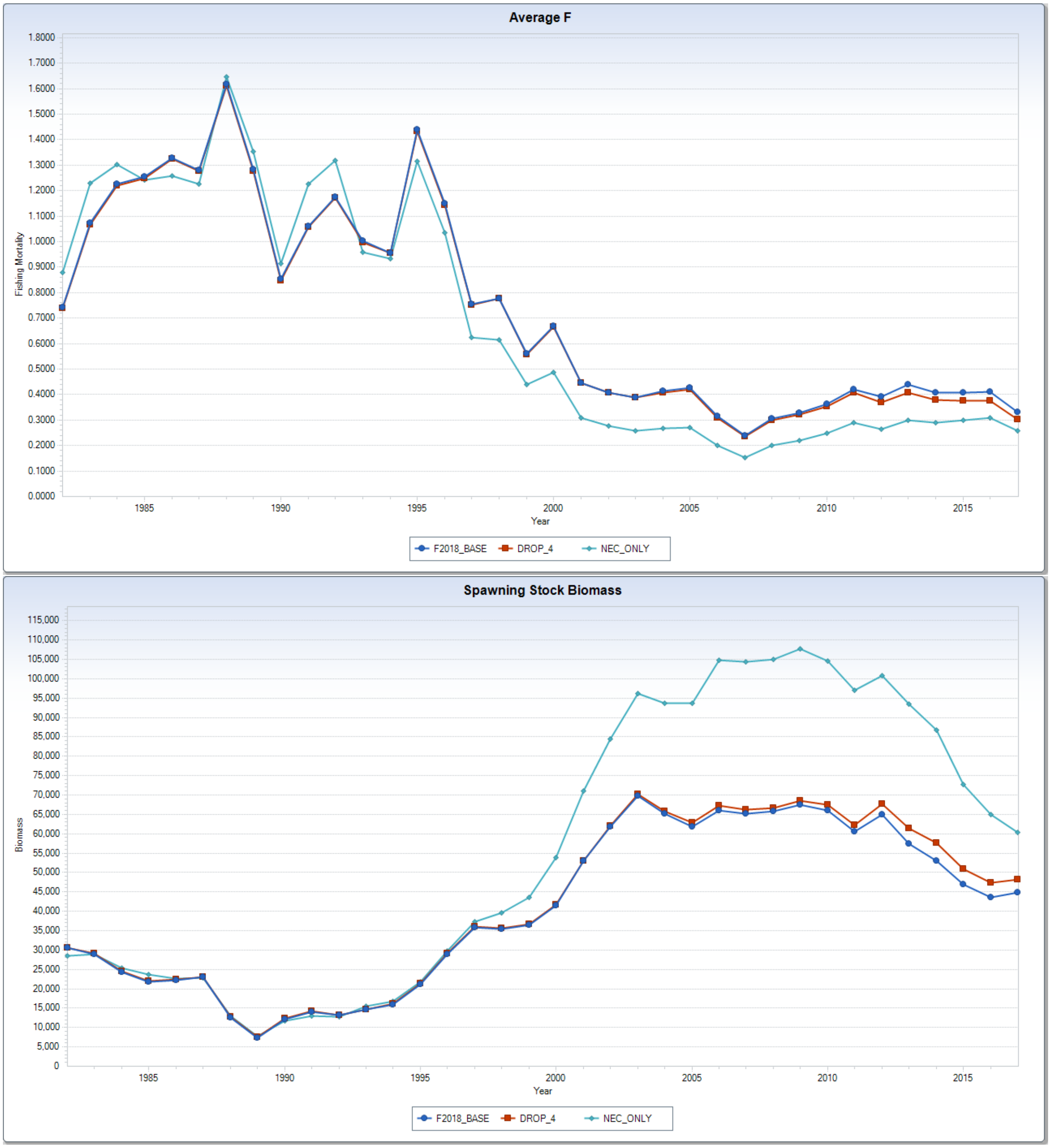


Figure A133. Comparison of the fishing mortality (top panel) and Spawning Stock Biomass (bottom panel) results for the F2018_BASE model with the DROP_4 and NEC_ONLY configurations.

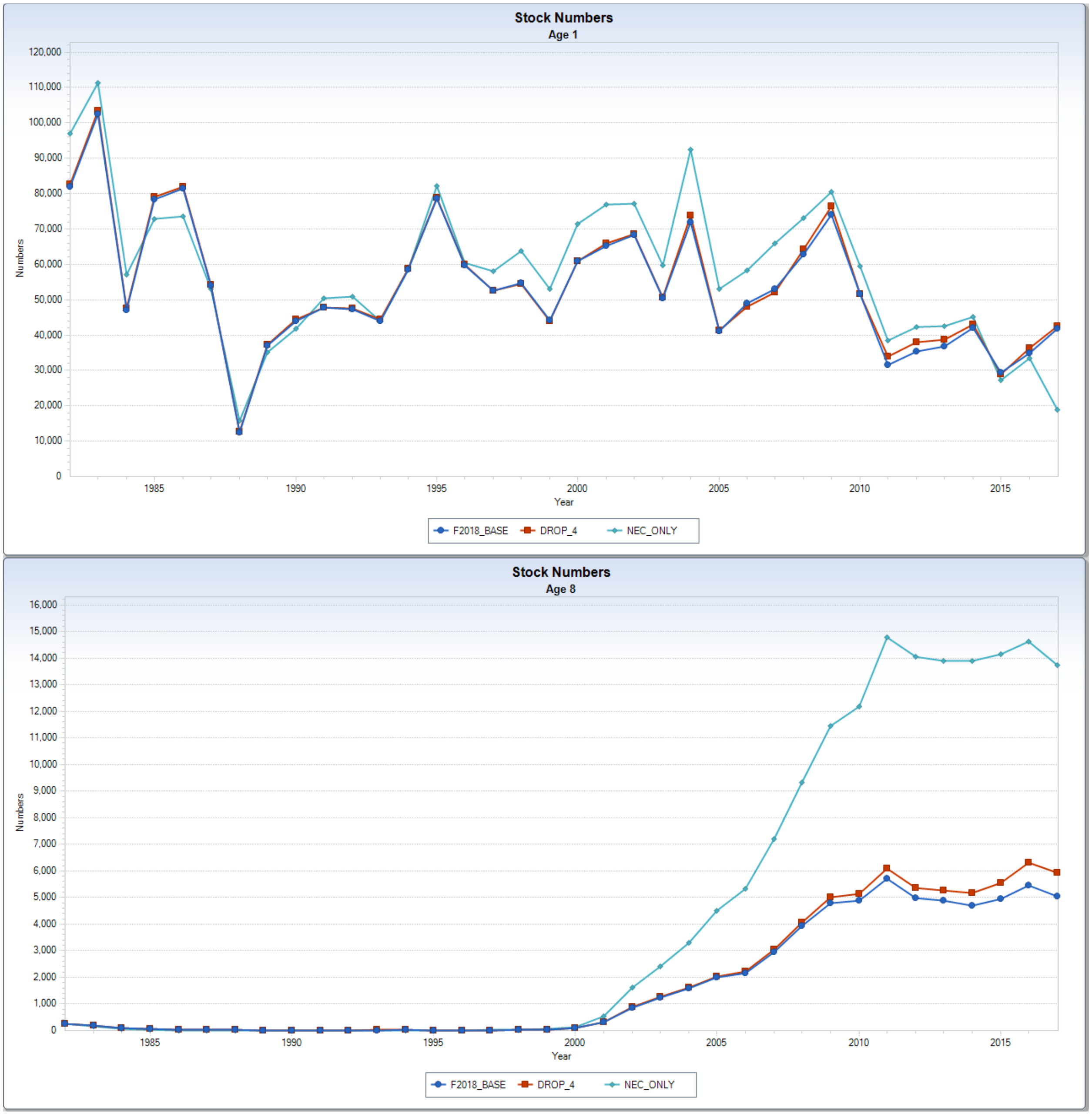


Figure A134. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018_BASE model with the DROP_4 and NEC_ONLY configurations.

Figure A135. Comparison of the fishing mortality (top panel) and Spawning Stock Biomass (bottom panel) results for the F2018_BASE model (three selectivity time blocks) with a two selection block version (1982-1994, 1995-2017; SELEX_2BLK), and a version with fixed flat-topped landings selectivity in the last (2008-2017) block (SELEX_FLATLAND).

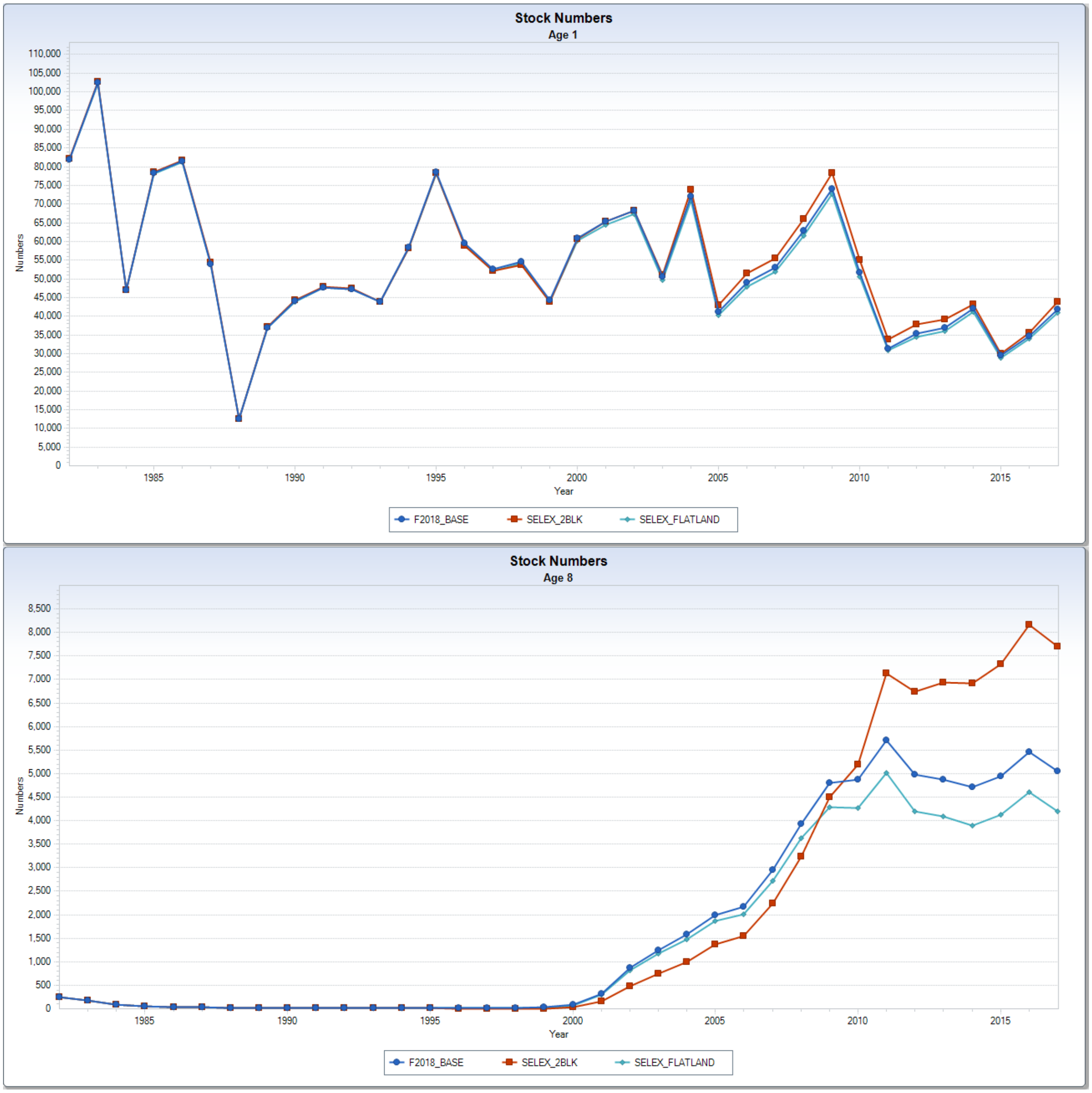


Figure A136. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018_BASE model (three selectivity time blocks) with a two selection block version (1982-1994, 1995-2017; SELEX_2BLK), and a version with fixed flat-topped landings selectivity in the last (2008-2017) block (SELEX_FLATLAND).

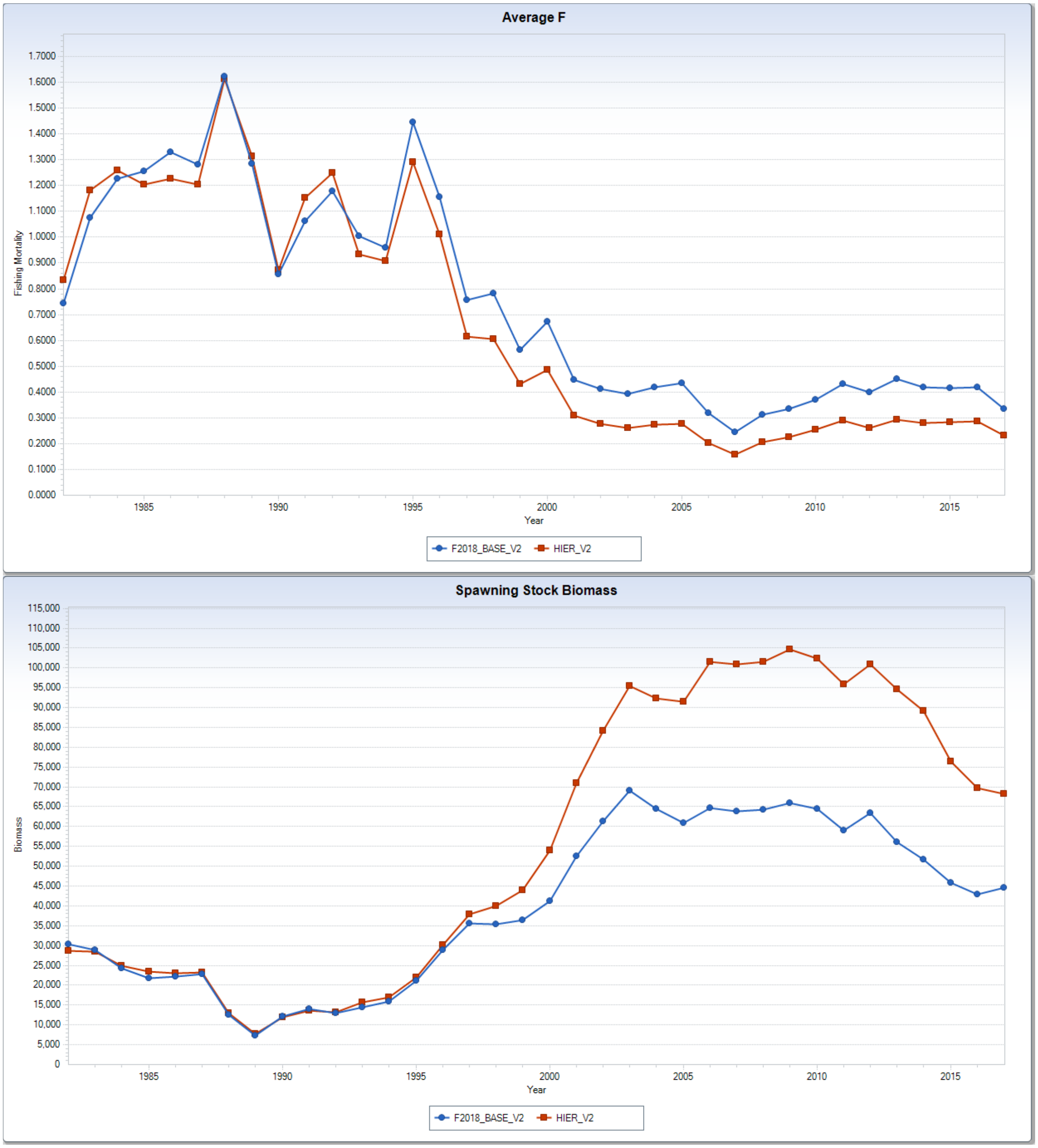


Figure A137. Comparison of the fishing mortality (top panel) and Spawning Stock Biomass (bottom panel) results for the F2018_BASE_V2 model with those for the hierarchical 'aggregate index' model HIER_V2.

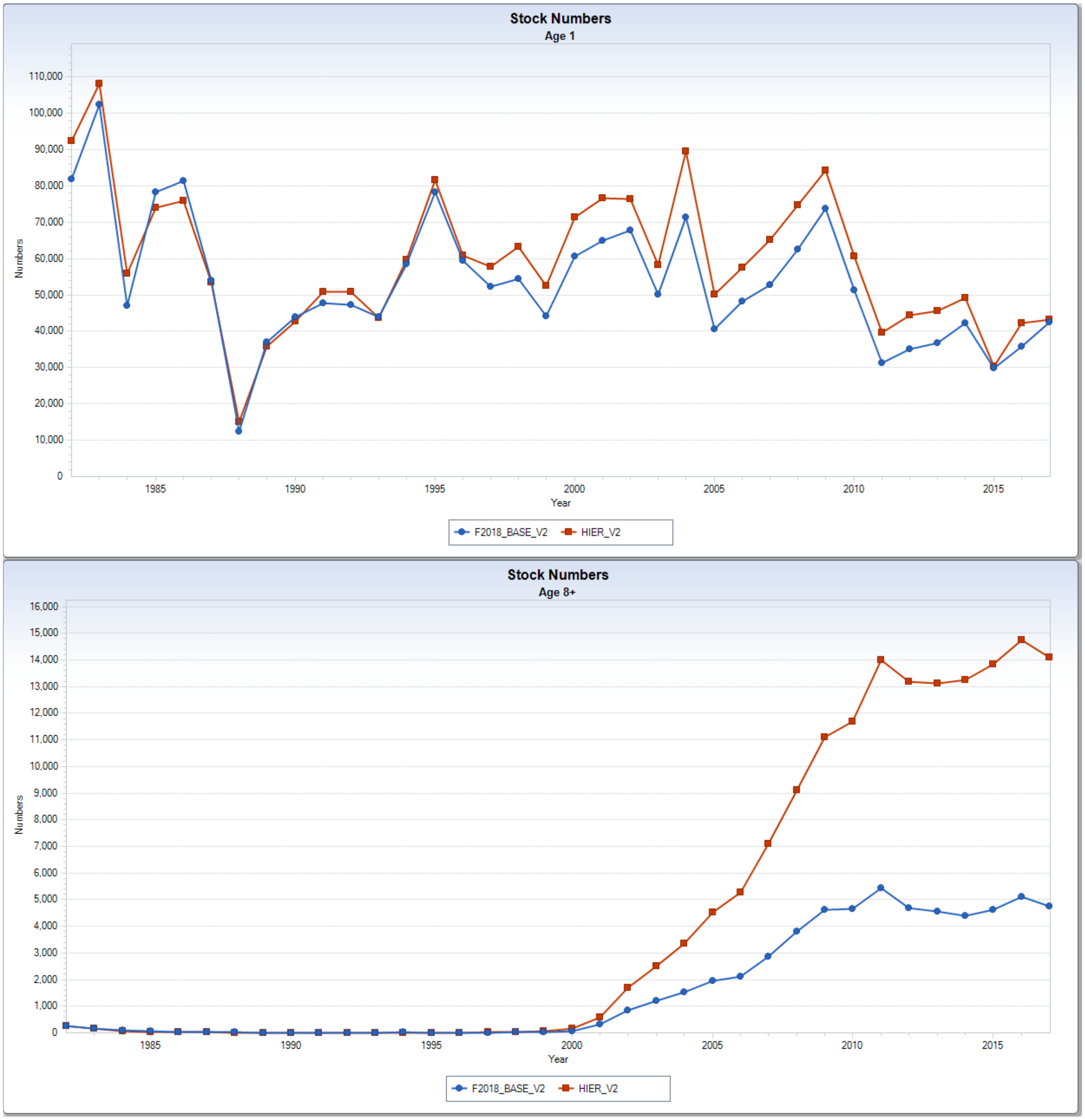


Figure A138. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018_BASE_V2 model with those for the hierarchical 'aggregate index' model HIER_V2.

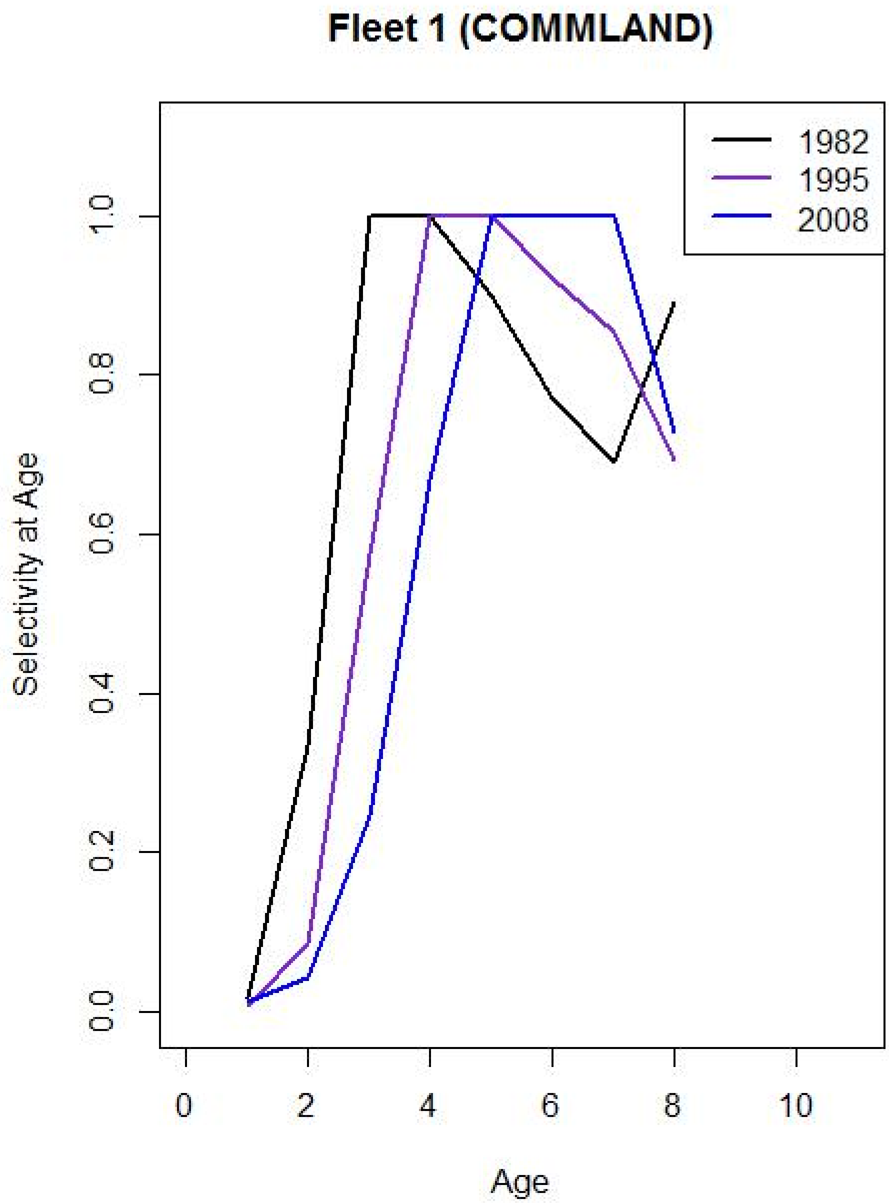


Figure A139. Commercial landings fleet selectivity patterns for the F2018_BASE_V2 model run.

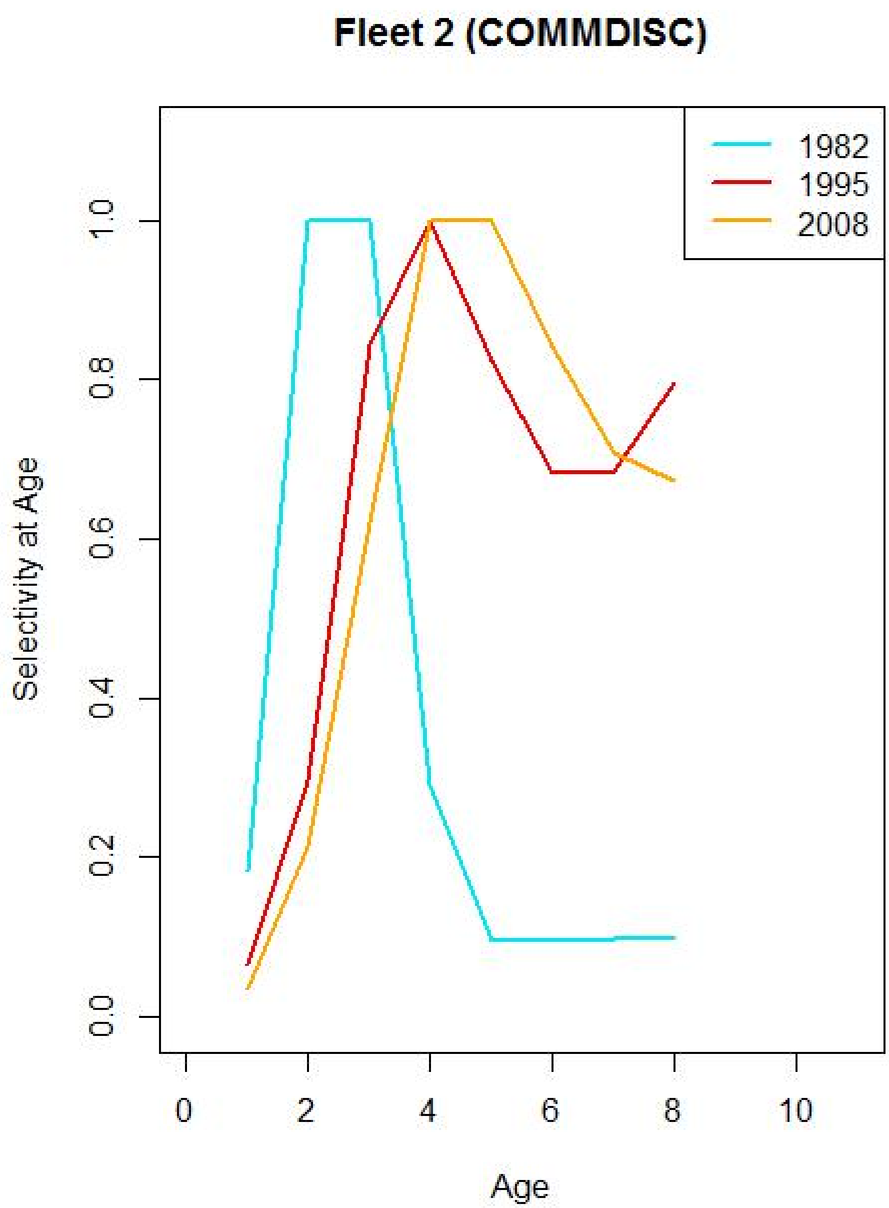


Figure A140. Commercial discards fleet selectivity patterns for the F2018_BASE_V2 model run.

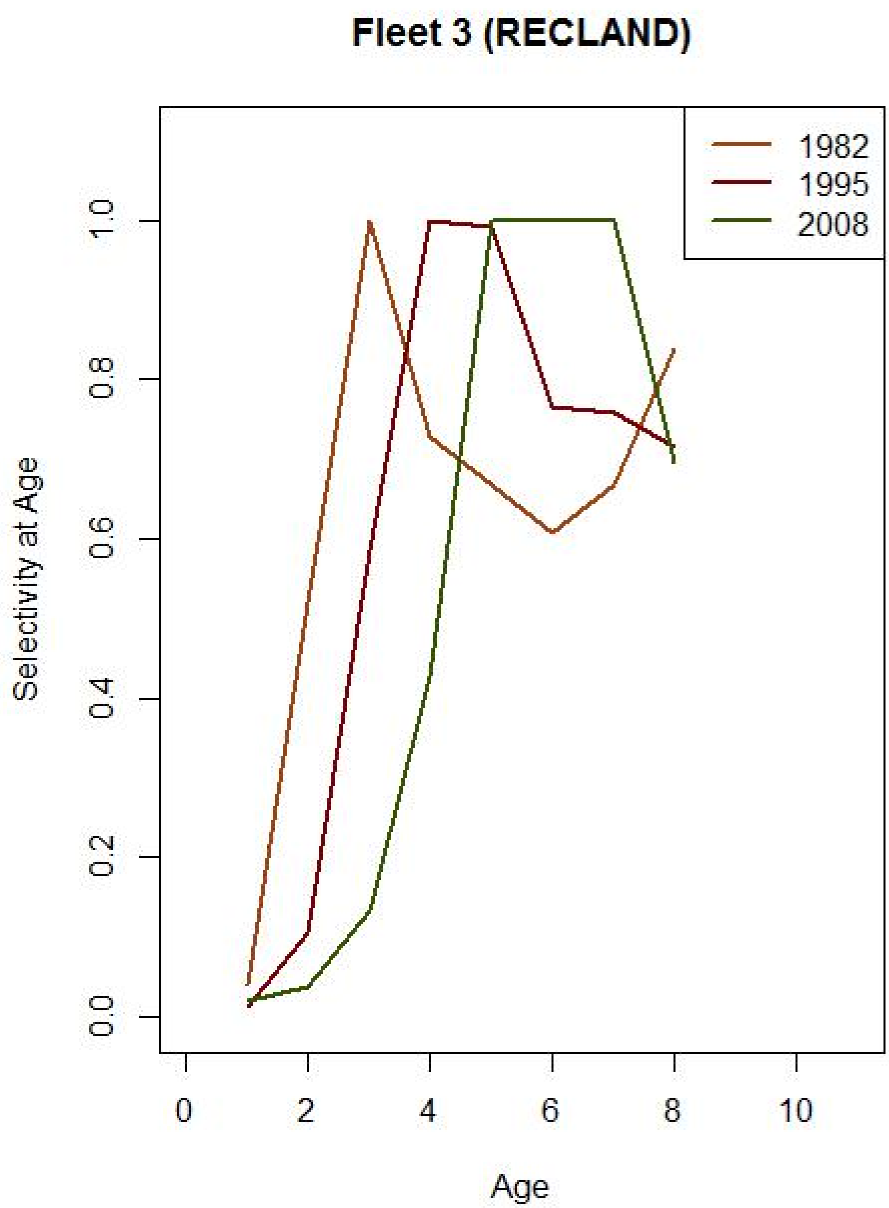


Figure A141. Recreational landings fleet selectivity patterns for the F2018_BASE_V2 model run.

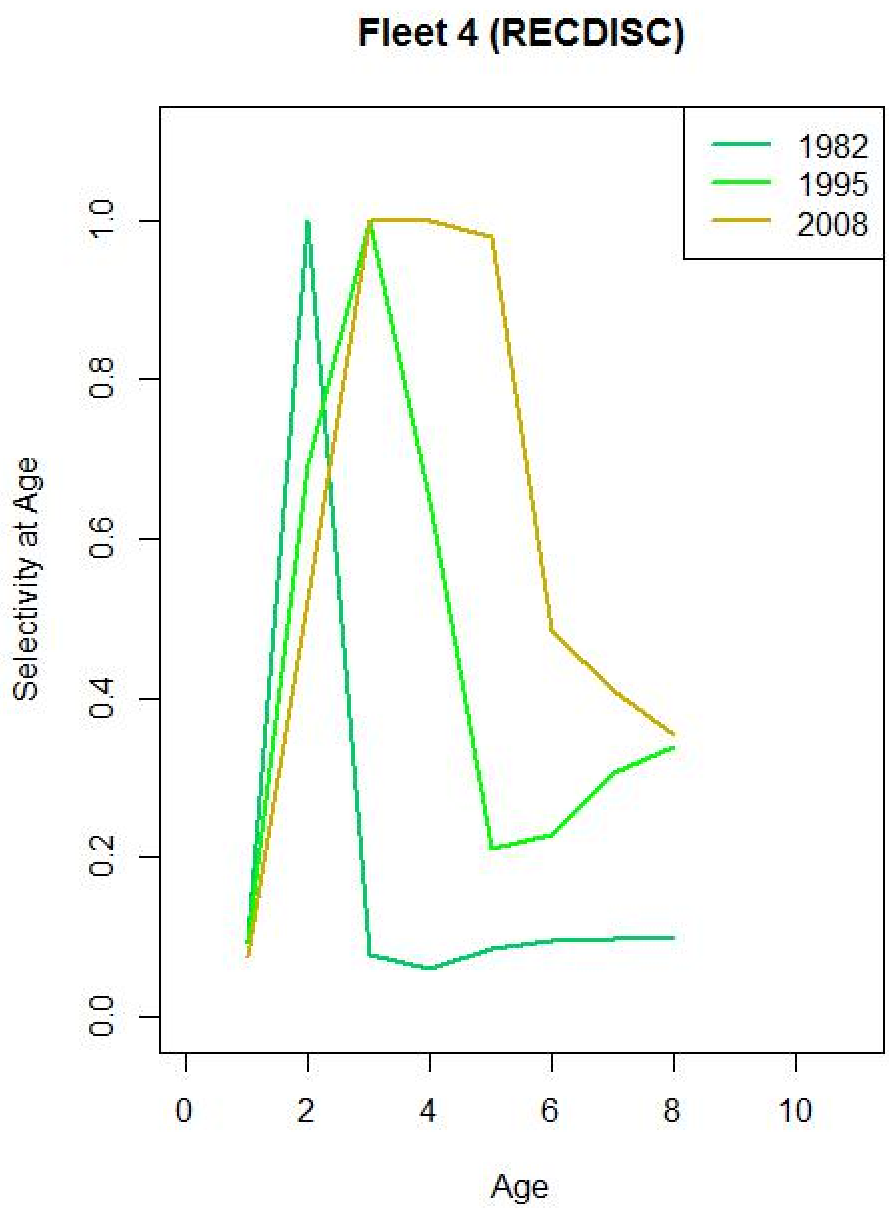


Figure A142. Recreational discards fleet selectivity patterns for the F2018_BASE_V2 model run.

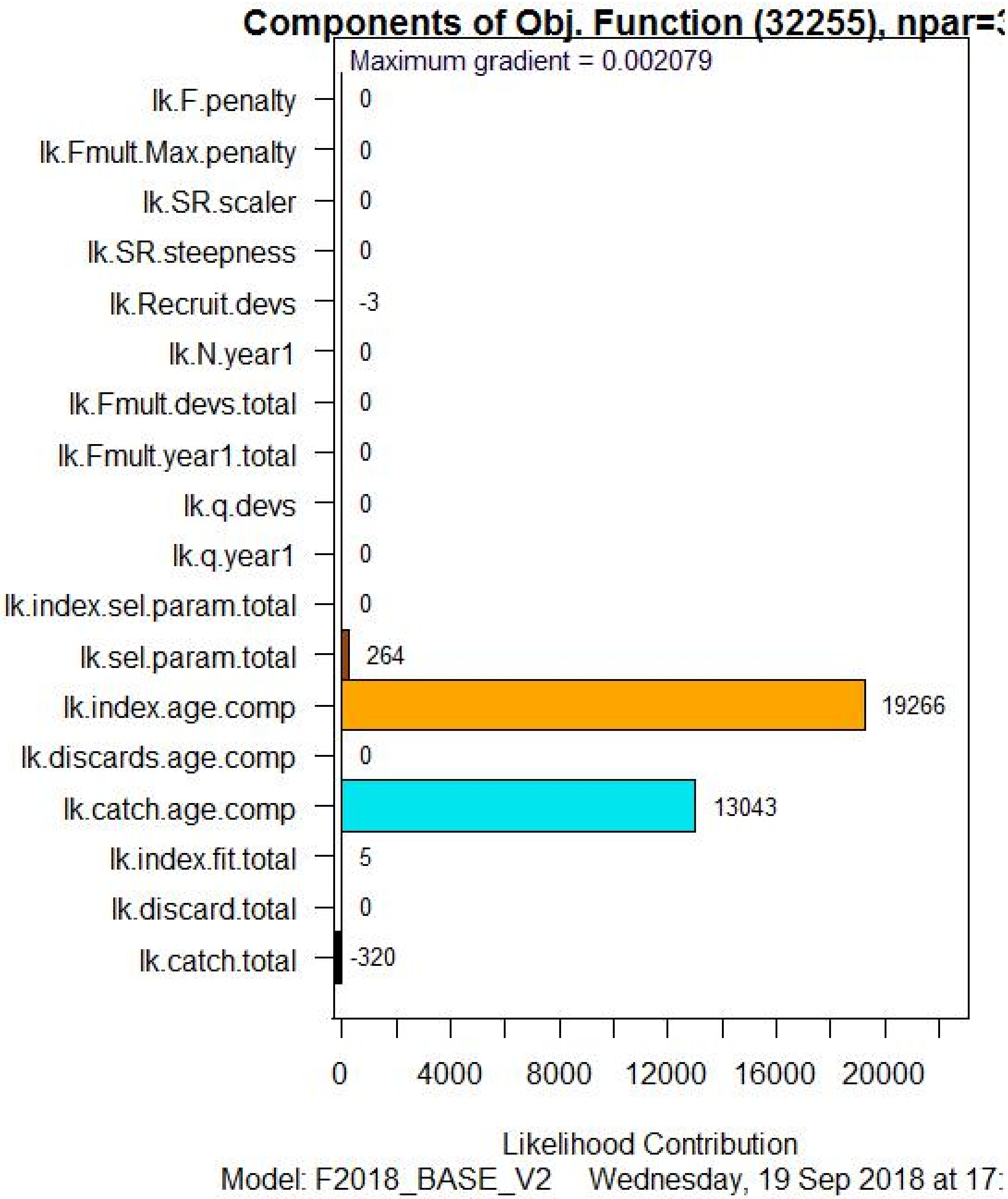


Figure A143. Distribution of the objective function components contribution to total likelihood for the F2018_BASE_V2 model run.

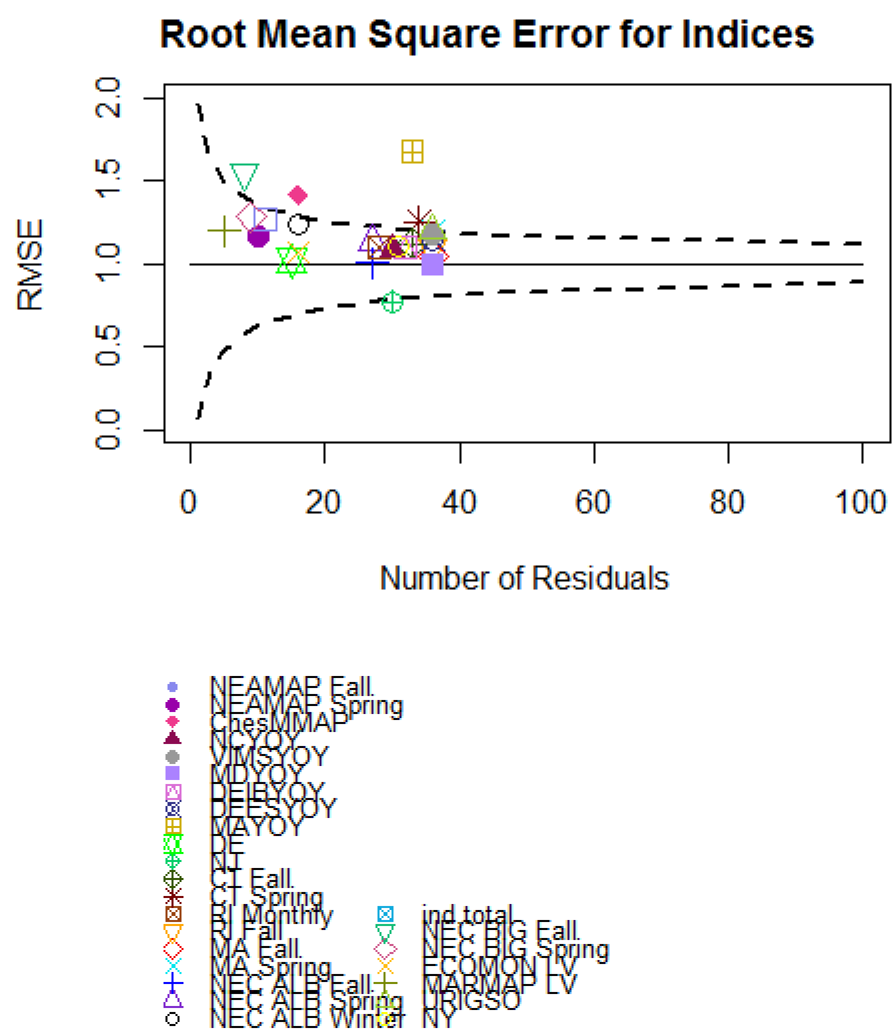


Figure A144. Root Mean Square Error (RMSE) for aggregate survey indices from the F2018_BASE_V2 model run.

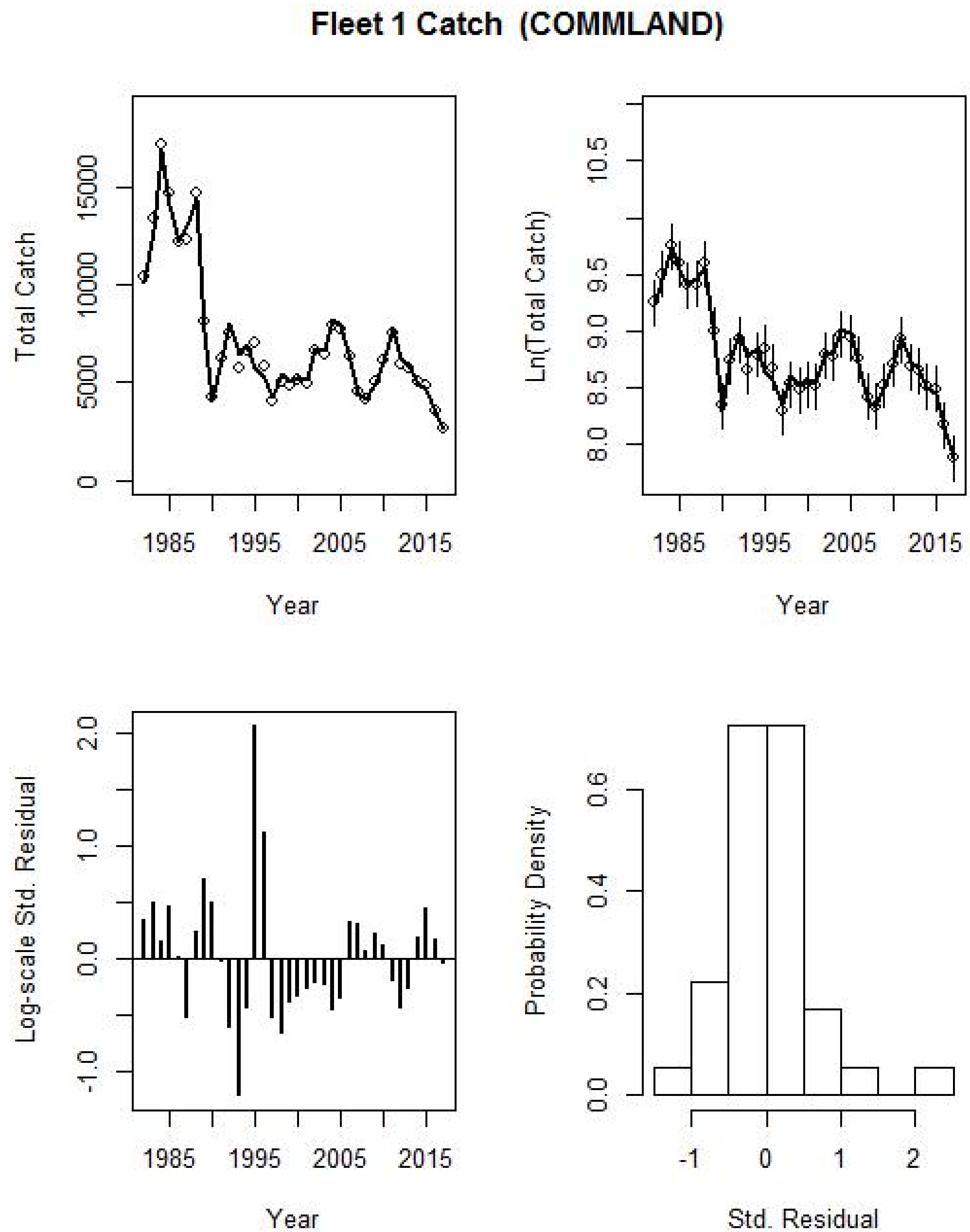


Figure A145. Fit diagnostics for the commercial fishery landings from the F2018_BASE_V2 model run.

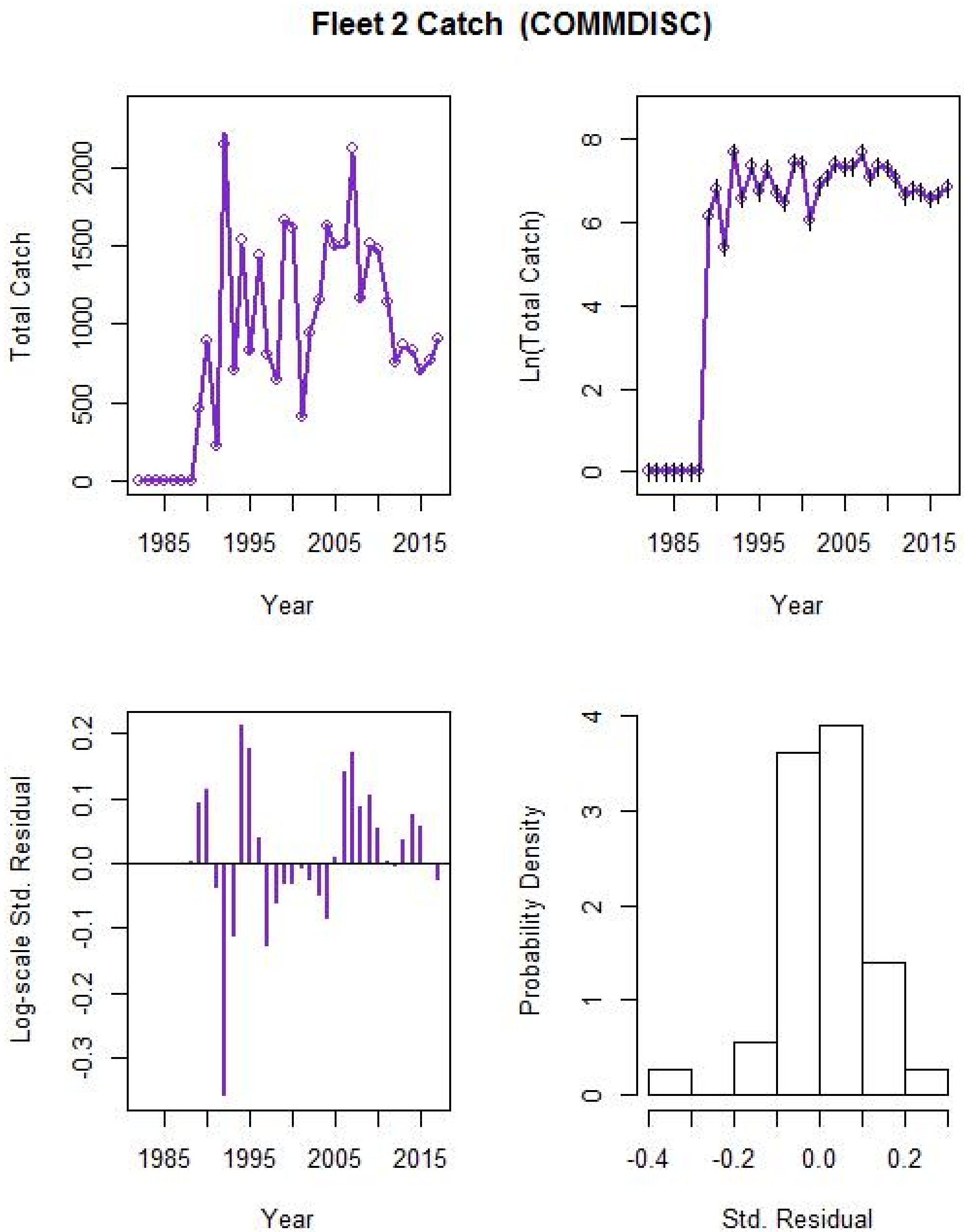


Figure A146. Fit diagnostics for the commercial fishery discards from the F2018_BASE_V2 model run.

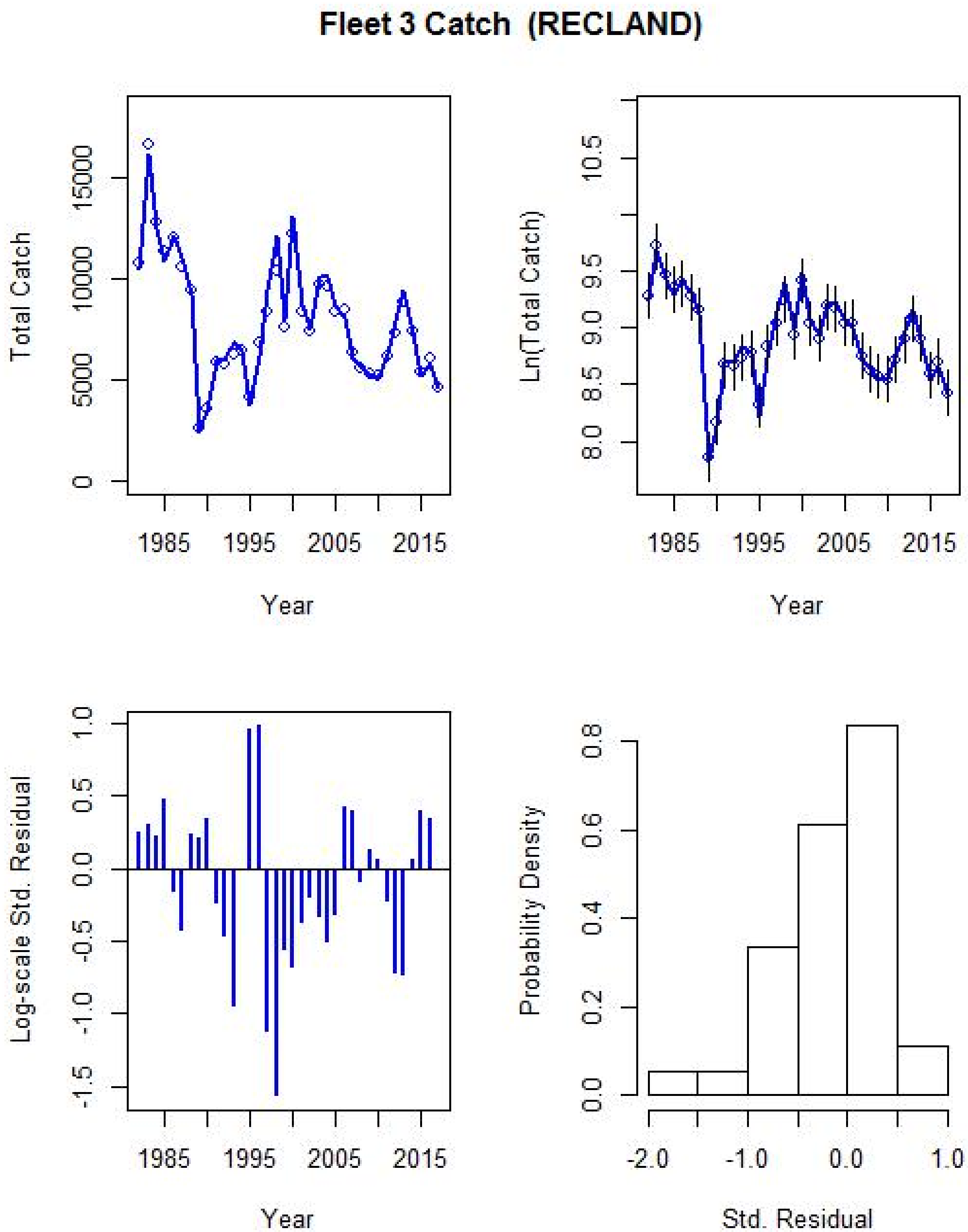


Figure A147. Fit diagnostics for the recreational fishery landings from the F2018_BASE_V2 model run.

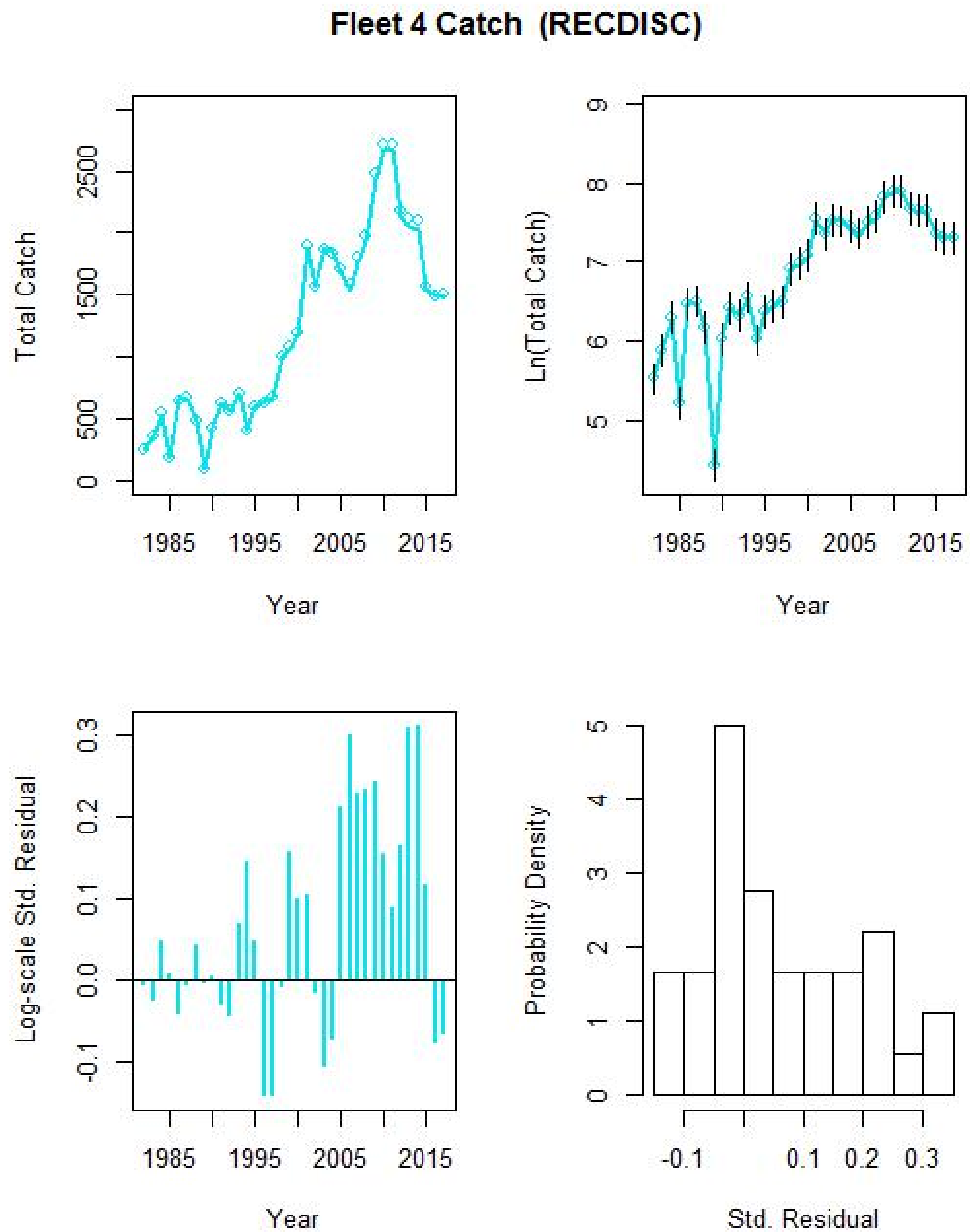


Figure A148. Fit diagnostics for the recreational fishery discards from the F2018_BASE_V2 model run.

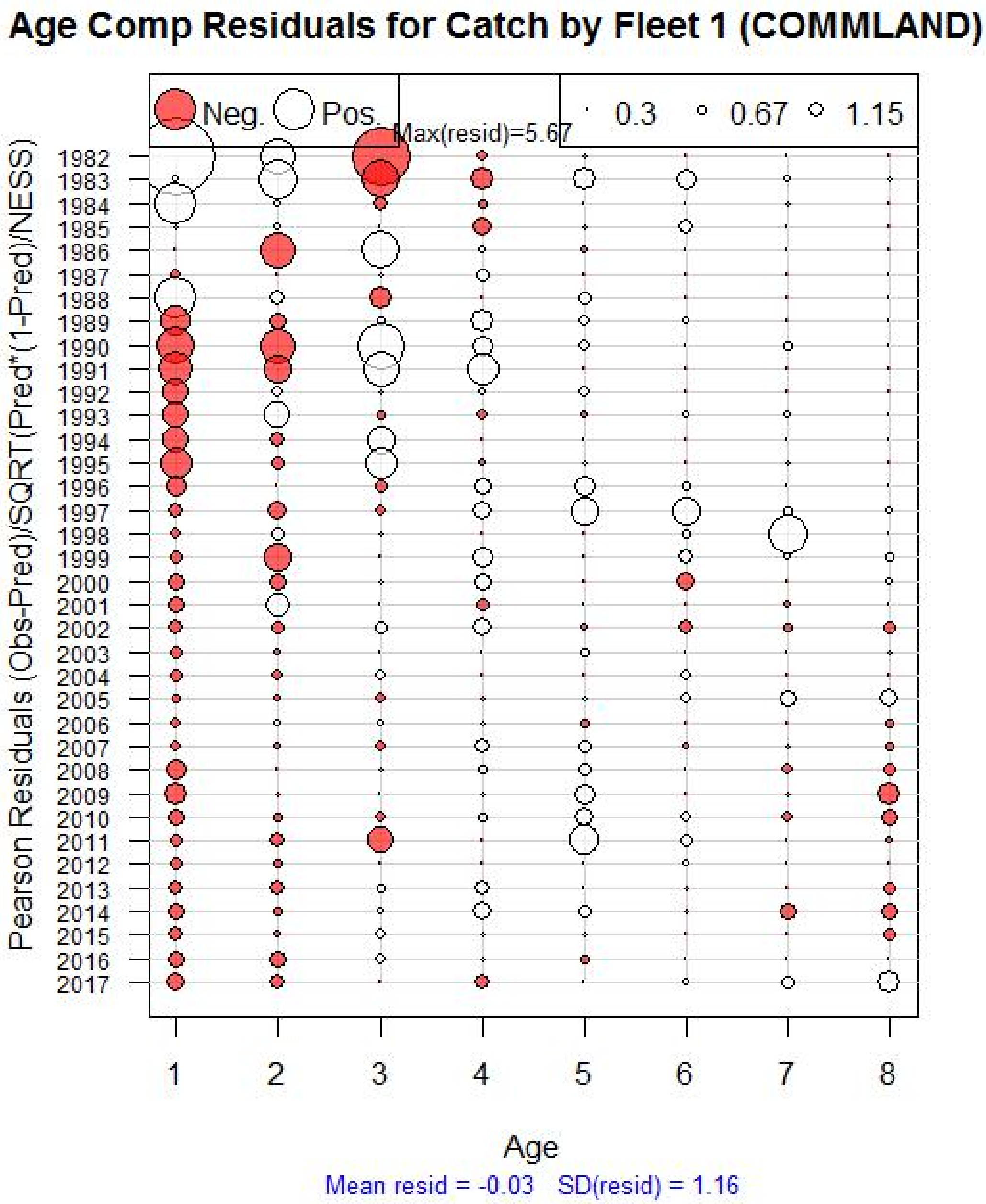


Figure A149. Commercial fishery landings age composition residuals from the F2018_BASE_V2 model run.

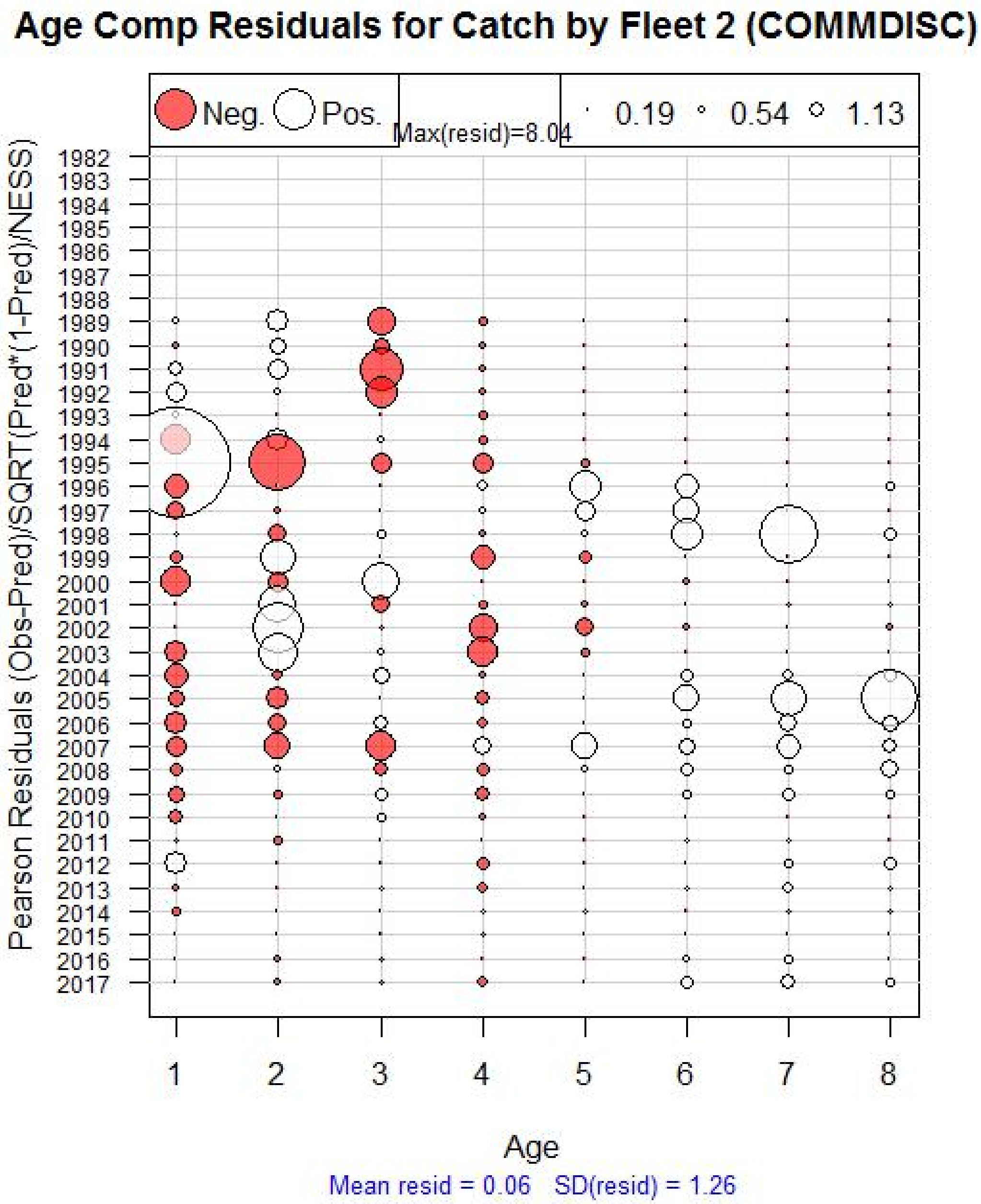


Figure A150. Commercial fishery discards age composition residuals from the F2018_BASE_V2 model run.

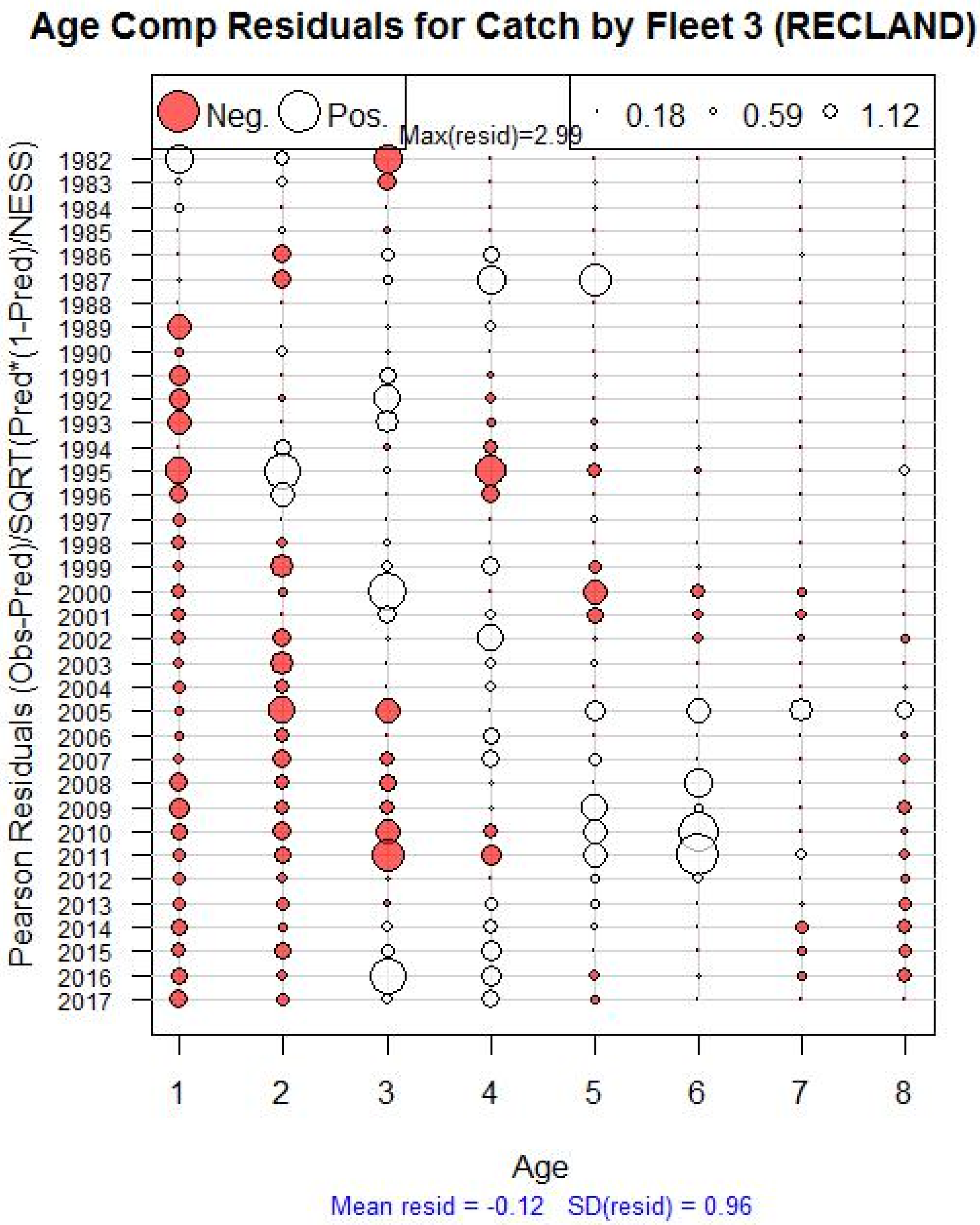


Figure A151. Recreational fishery landings age composition residuals from the F2018_BASE_V2 model run.

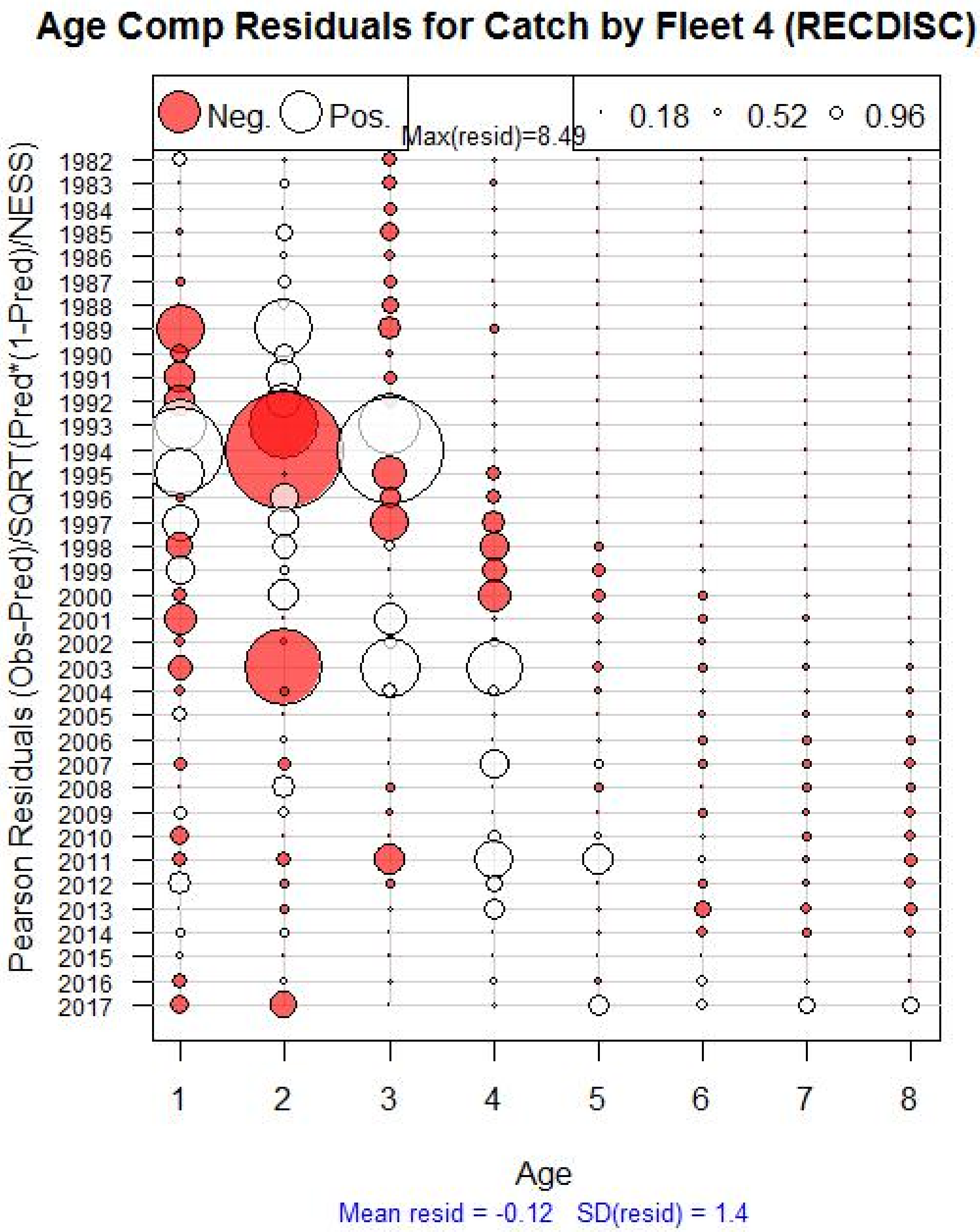


Figure A152. Recreational fishery discards age composition residuals from the F2018_BASE_V2 model run.

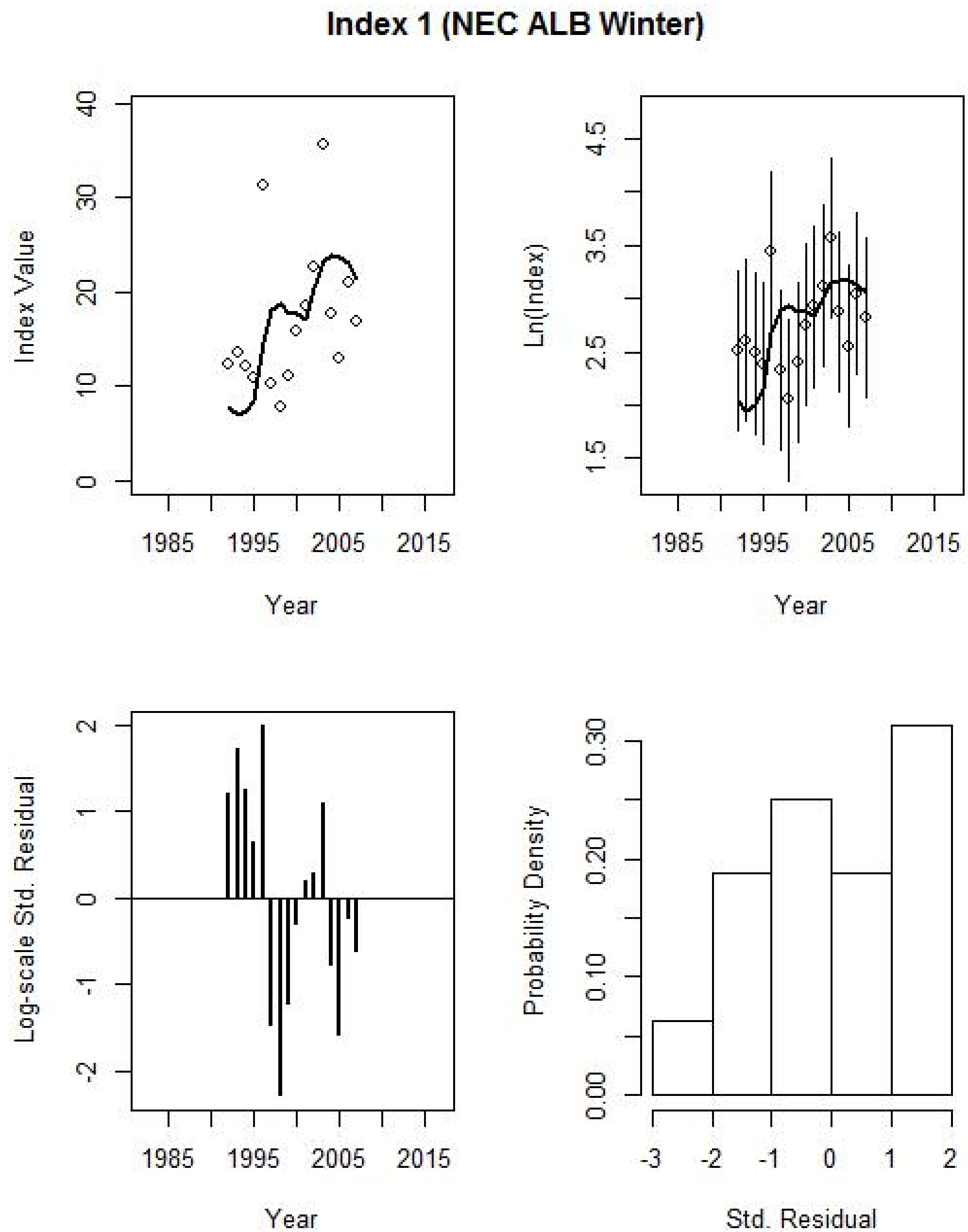


Figure A153. Fit diagnostics for the Northeast Fisheries Science Center (NEC) Albatross (ALB) winter trawl survey from the F2018_BASE_V2 model run.

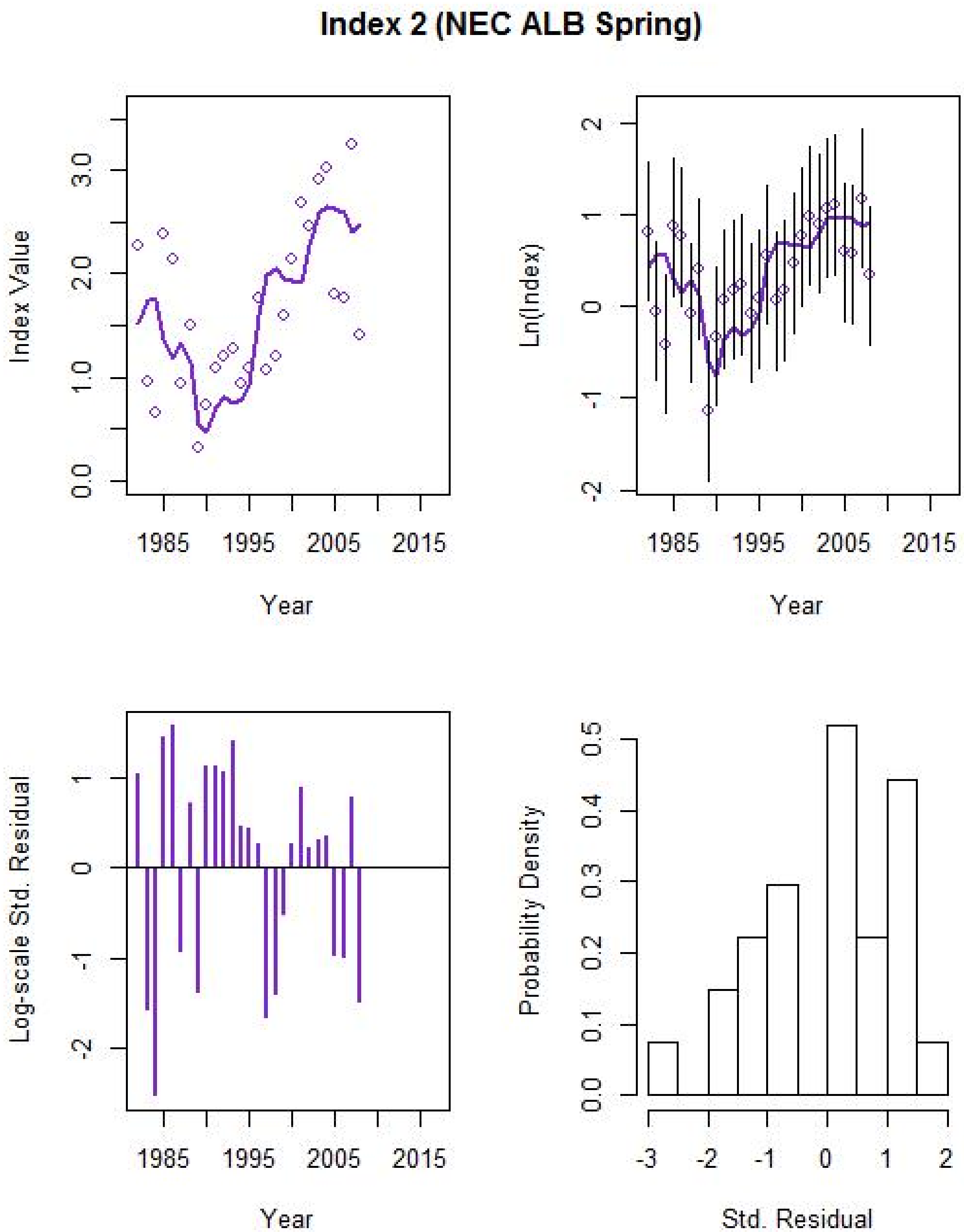


Figure A154. Fit diagnostics for the Northeast Fisheries Science Center (NEC) spring Albatross (ALB) trawl survey from the F2018_BASE_V2 model run.

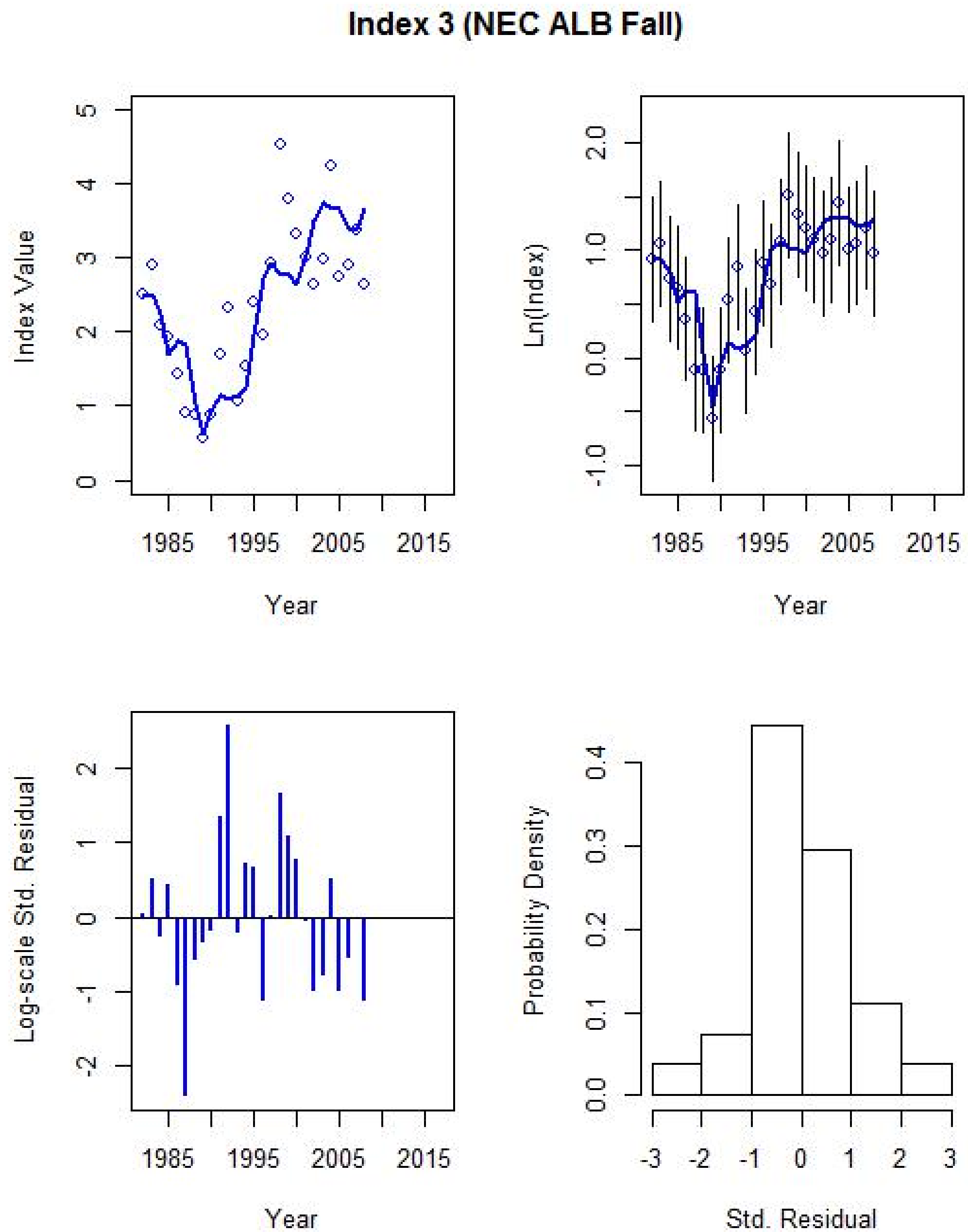


Figure A155. Fit diagnostics for the Northeast Fisheries Science Center (NEC) fall Albatross (ALB) trawl survey from the F2018_BASE_V2 model run.

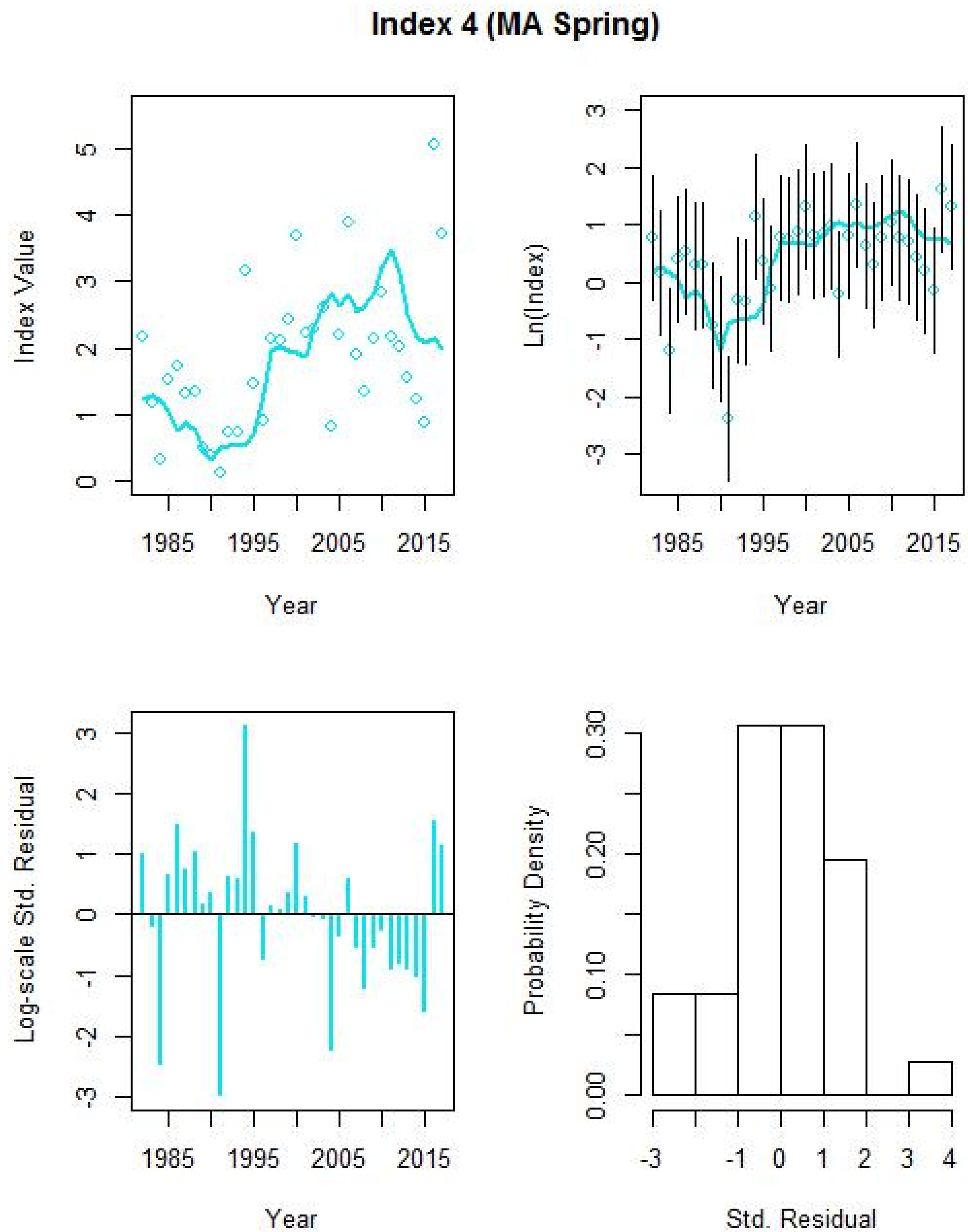


Figure A156. Fit diagnostics for the Massachusetts Division of Marine Fisheries (MA) spring trawl survey from the F2018_BASE_V2 model run.

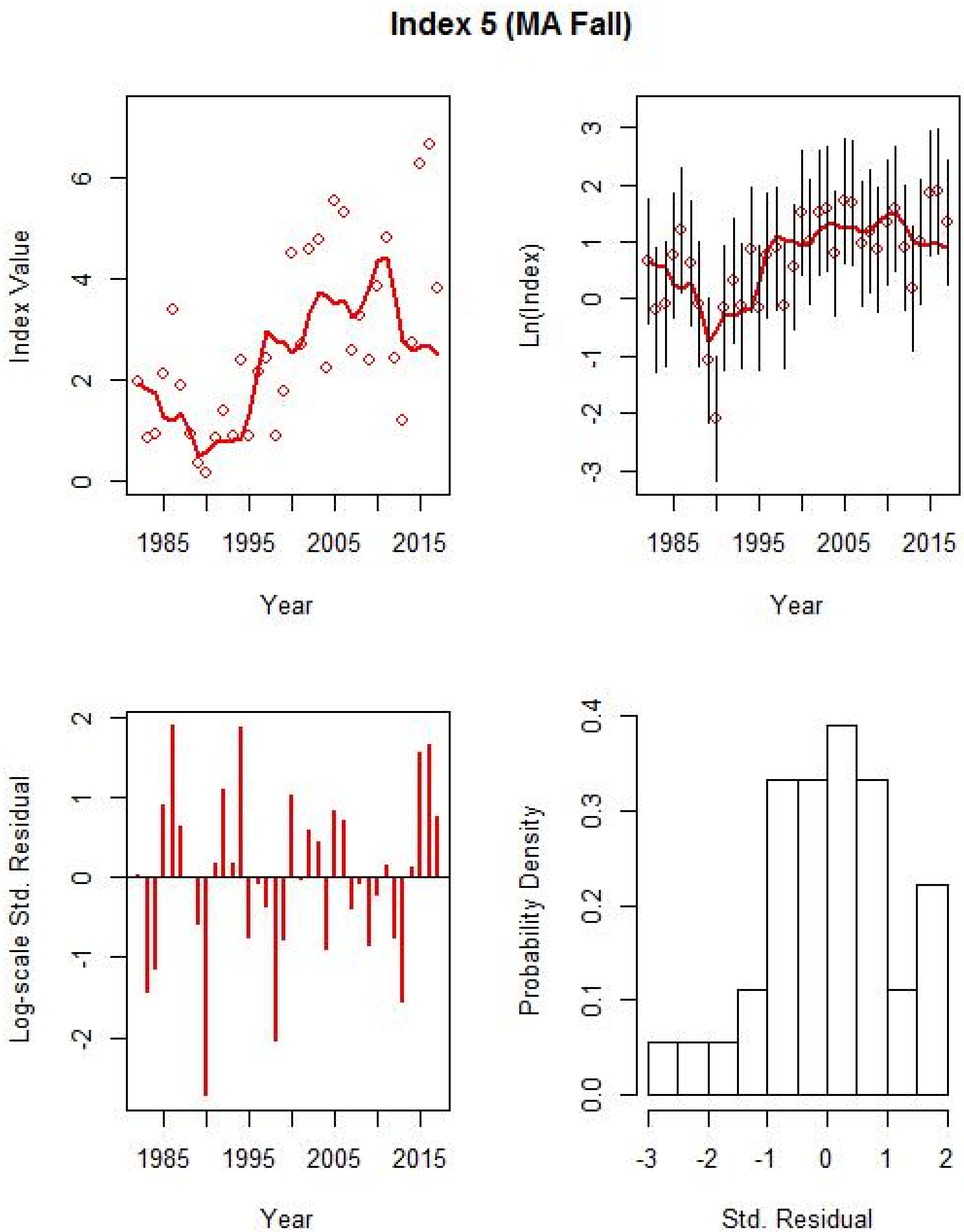


Figure A157. Fit diagnostics for the Massachusetts Division of Marine Fisheries (MA) fall trawl survey from the F2018_BASE_V2 model run.

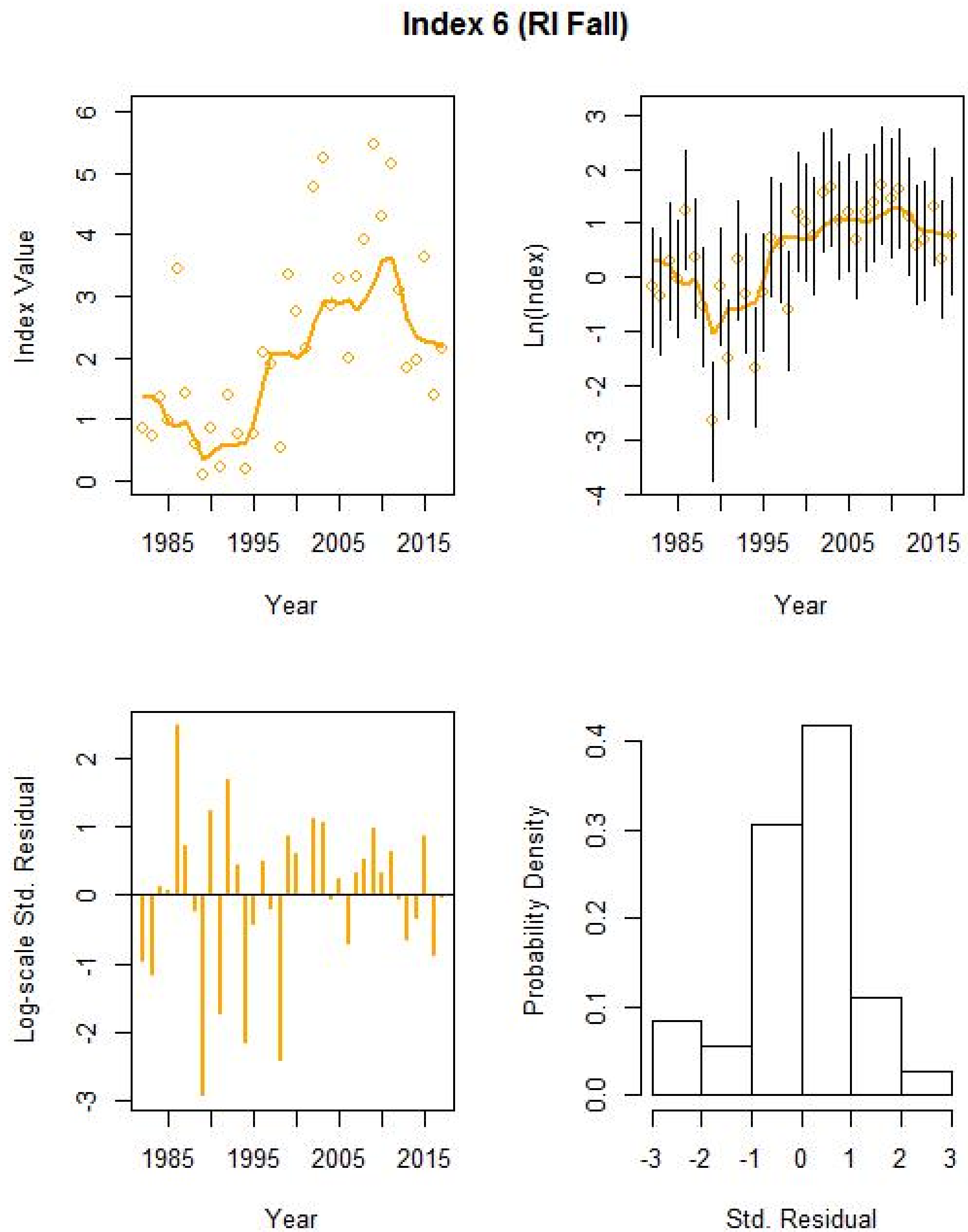


Figure A158. Fit diagnostics for the Rhode Island Department of Fish and Wildlife (RI) fall trawl survey from the F2018_BASE_V2 model run.

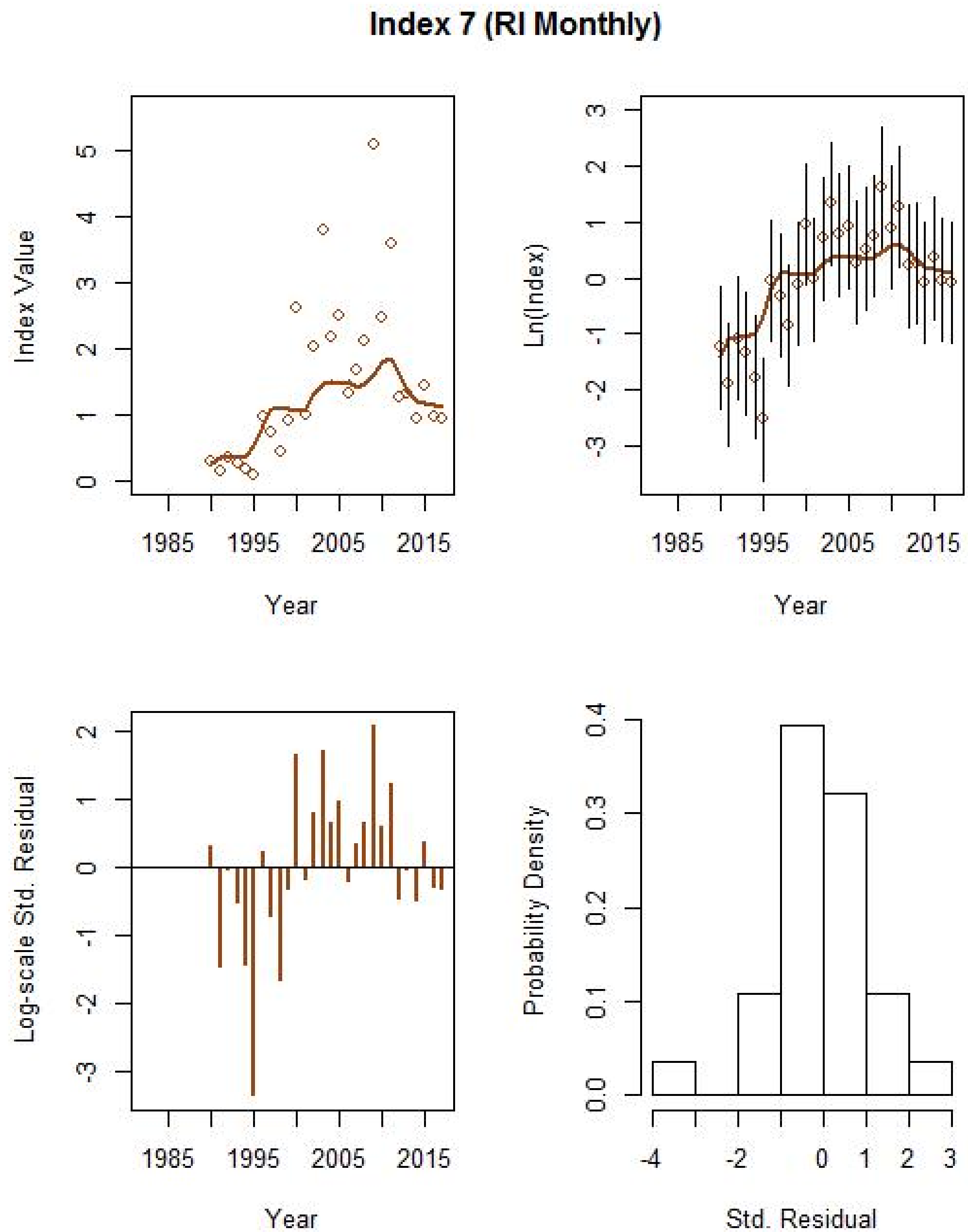


Figure A159. Fit diagnostics for the Rhode Island Department of Fish and Wildlife (RI) monthly trawl survey from the F2018_BASE_V2 model run.

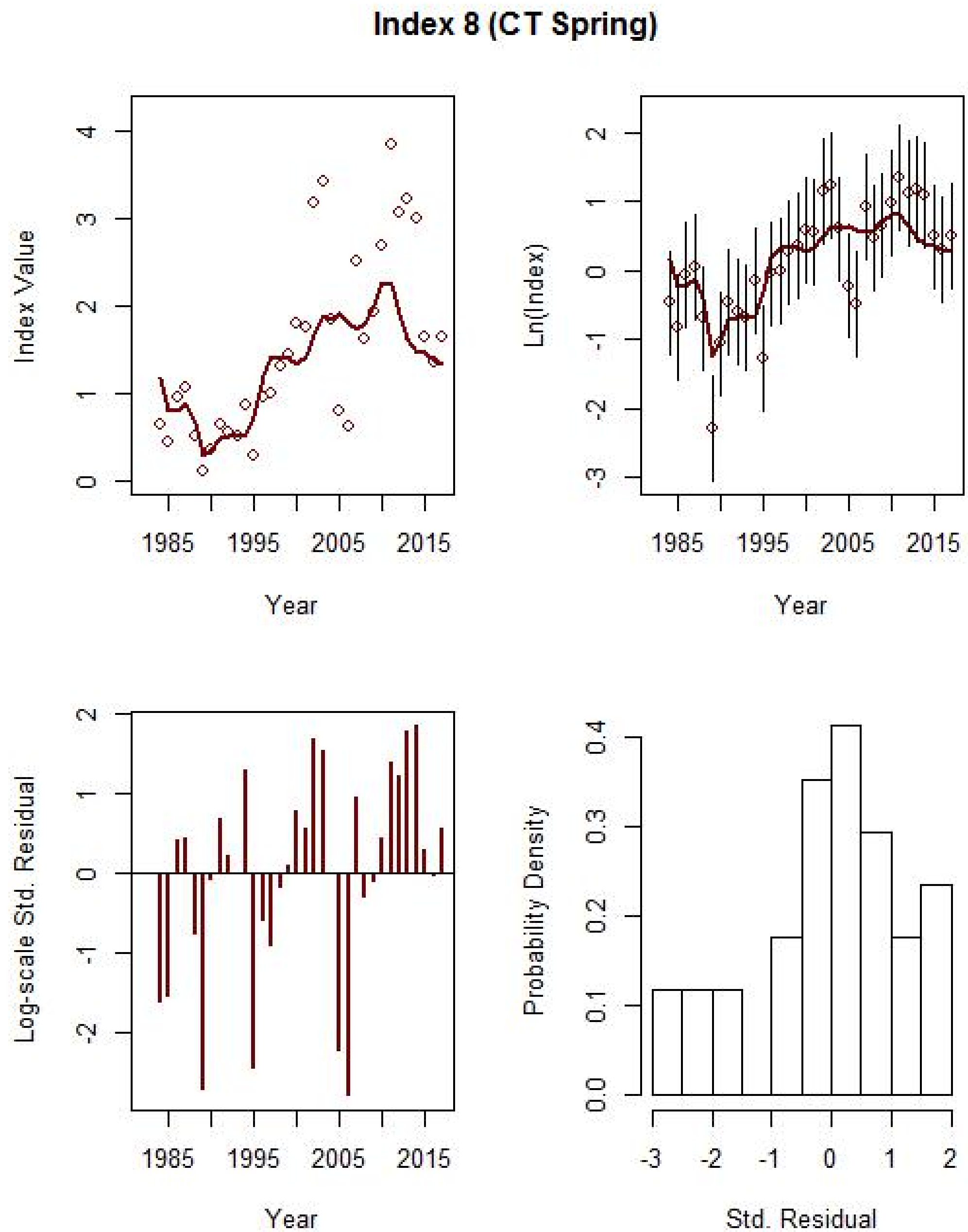


Figure A160. Fit diagnostics for the Connecticut Department of Energy and Environmental Protection (CT) spring trawl survey from the F2018_BASE_V2 model run.

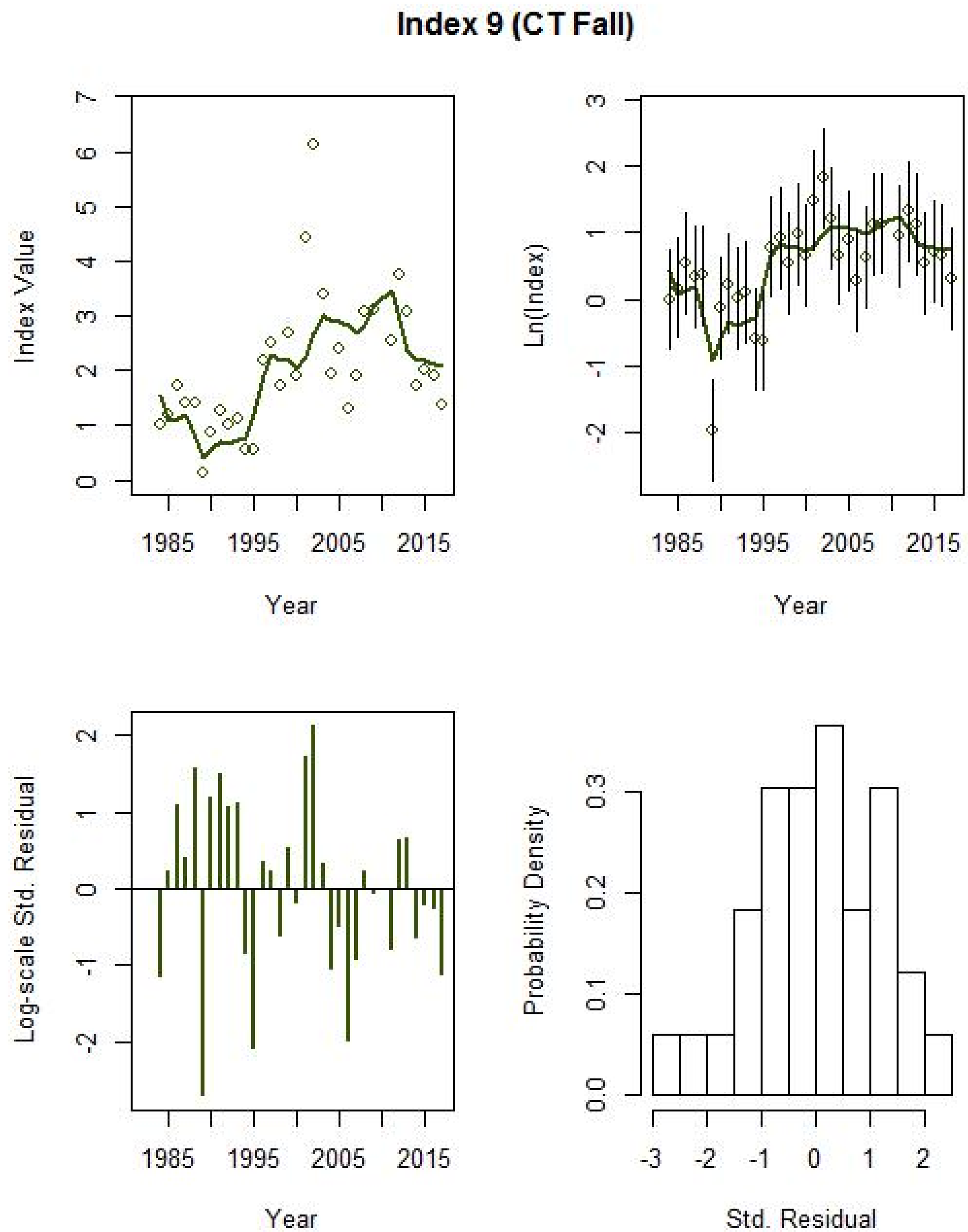


Figure A161. Fit diagnostics for the Connecticut Department of Energy and Environmental Protection (CT) fall trawl survey from the F2018_BASE_V2 model run.

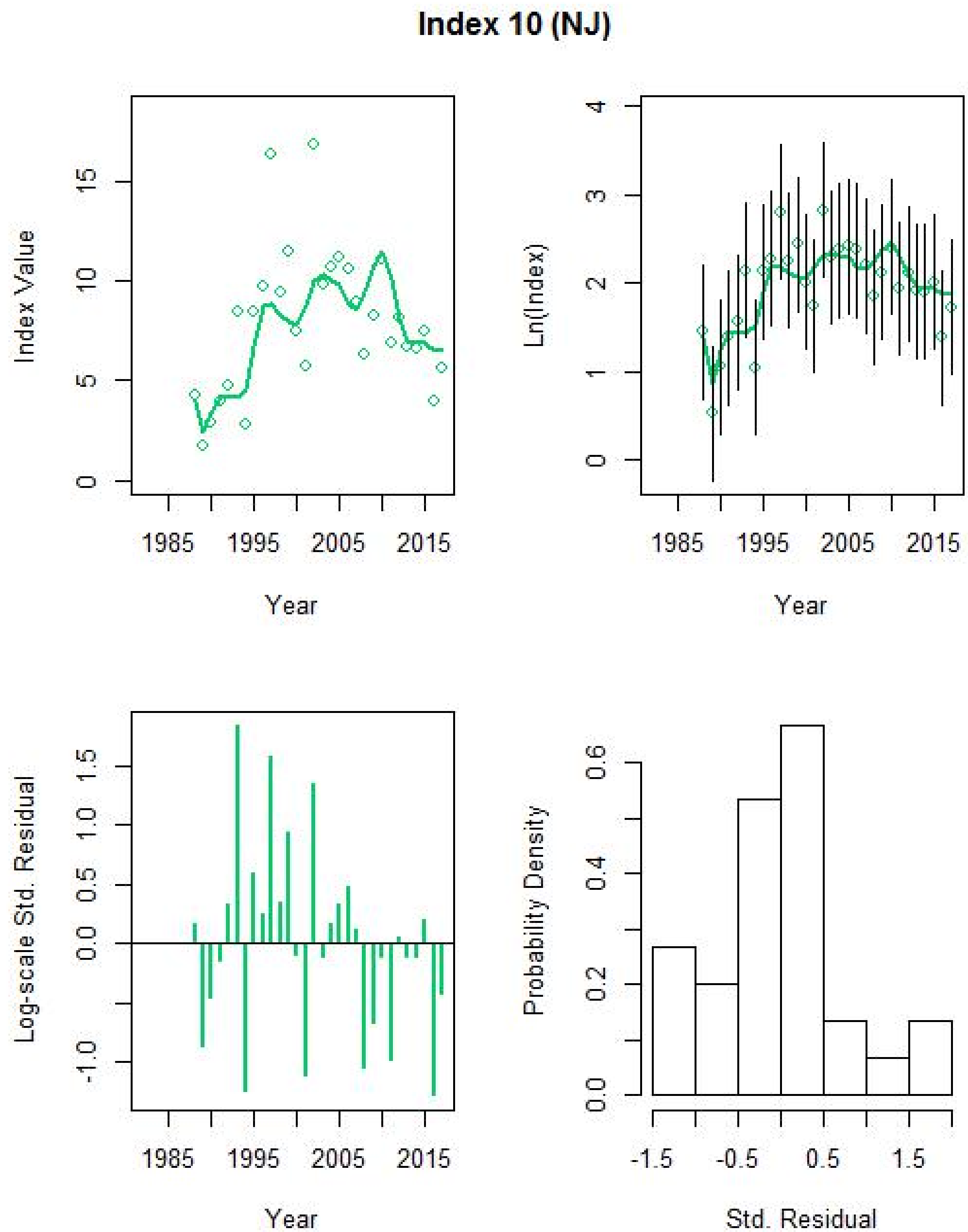


Figure A162. Fit diagnostics for the New Jersey Division of Fish and Wildlife (NJ) trawl survey from the F2018_BASE_V2 model run.

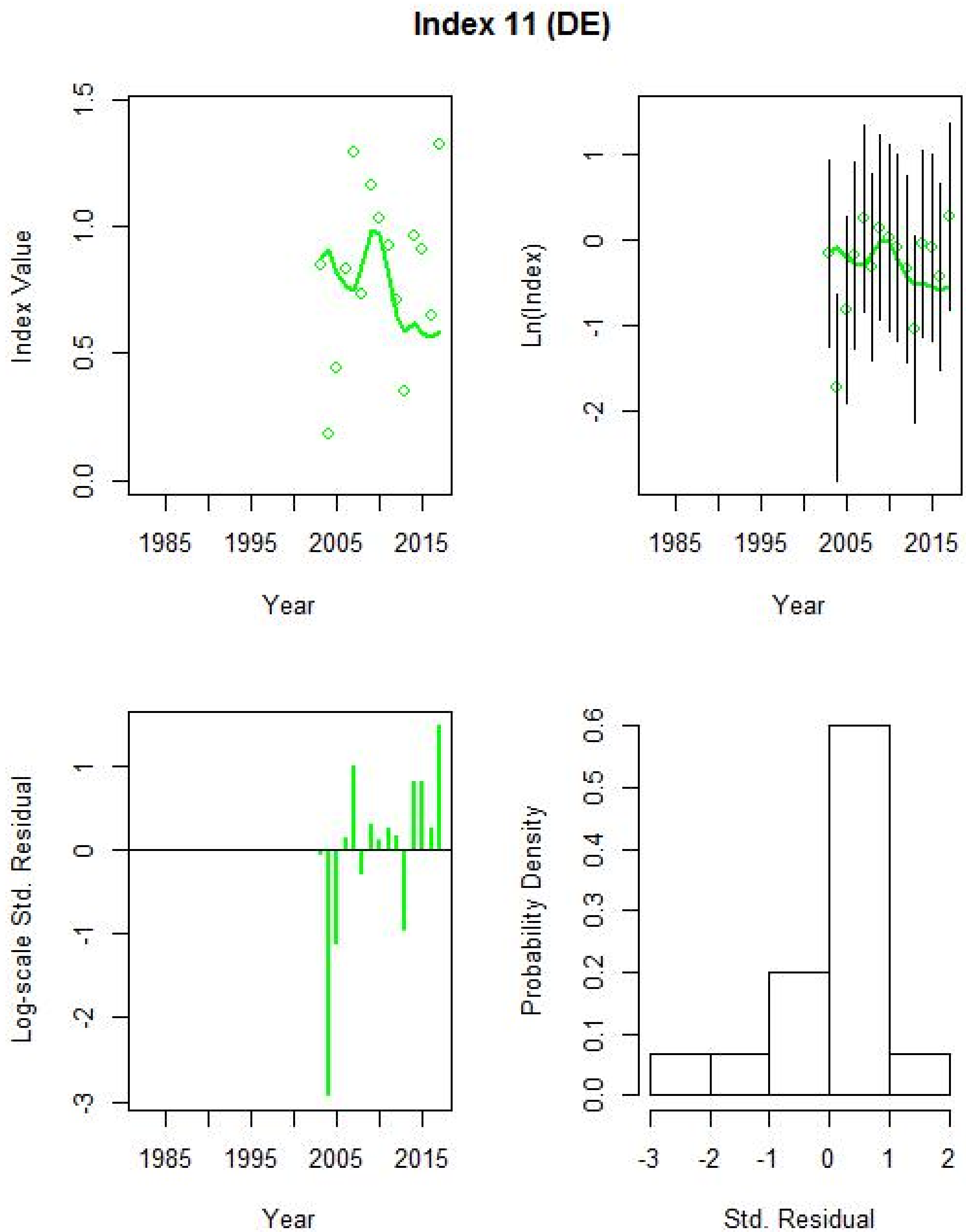


Figure A163. Fit diagnostics for the Delaware Division of Fish and Wildlife (DE) trawl survey from the F2018_BASE_V2 model run.

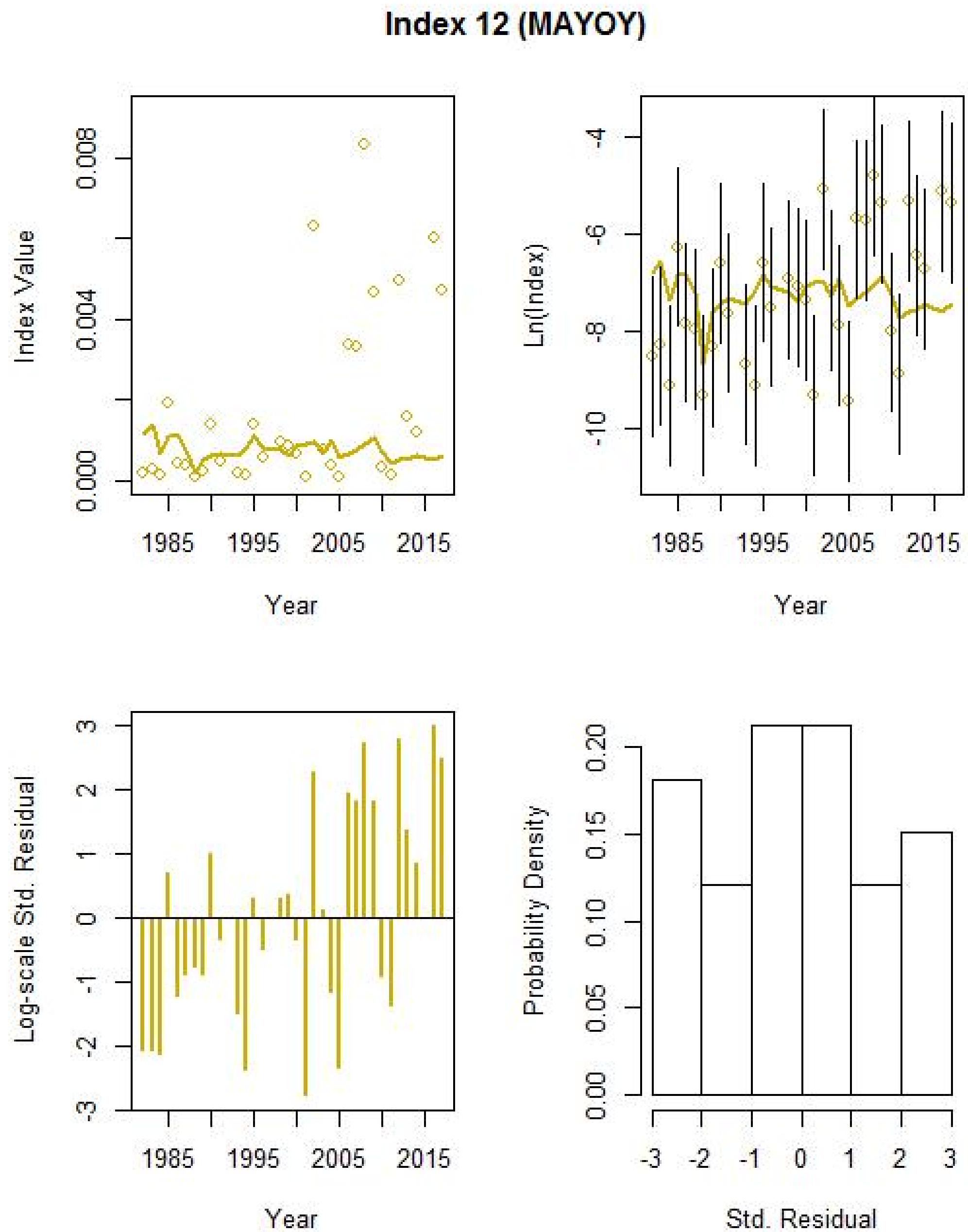


Figure A164. Fit diagnostics for the Massachusetts Division of Marine Fisheries young-of-the-year (MAYOY) seine survey from the F2018_BASE_V2 model run.

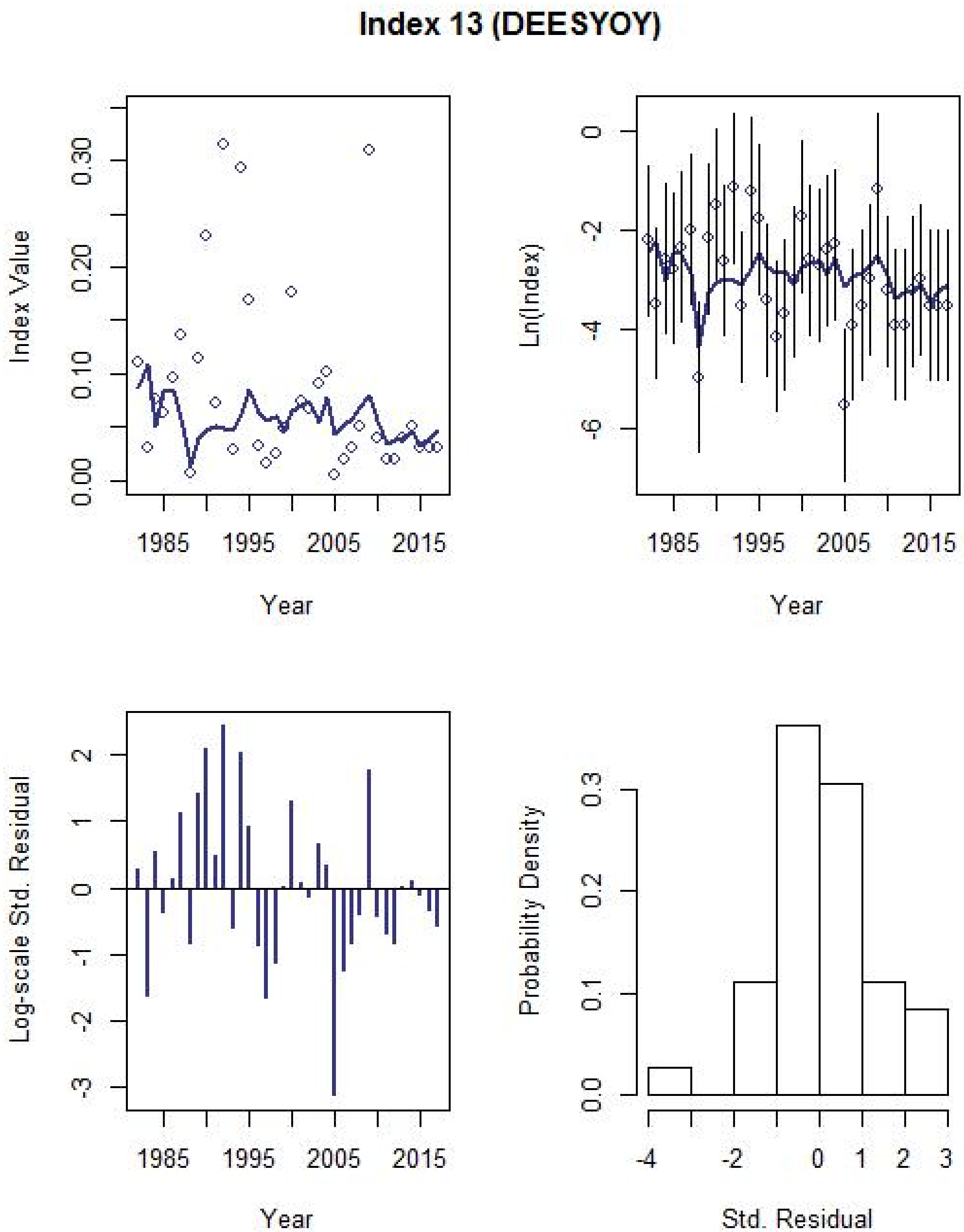


Figure A165. Fit diagnostics for the Delaware Division of Fish and Wildlife Estuaries young-of-the-year (DEESYOY) survey from the F2018_BASE_V2 model run.

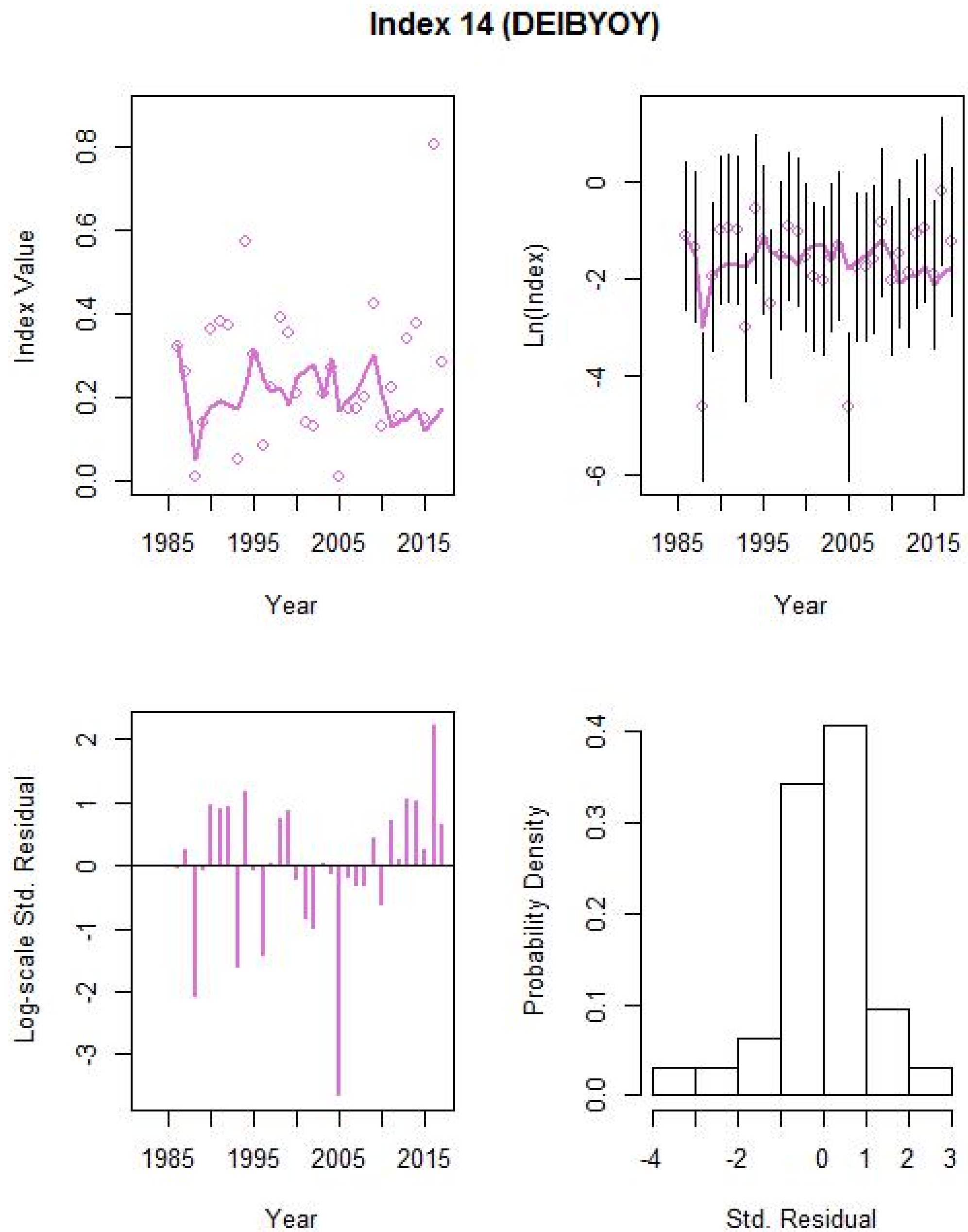


Figure A166. Fit diagnostics for the Delaware Division of Fish and Wildlife Inland Bays young-of-the-year (DEIBYOY) survey from the F2018_BASE_V2 model run.

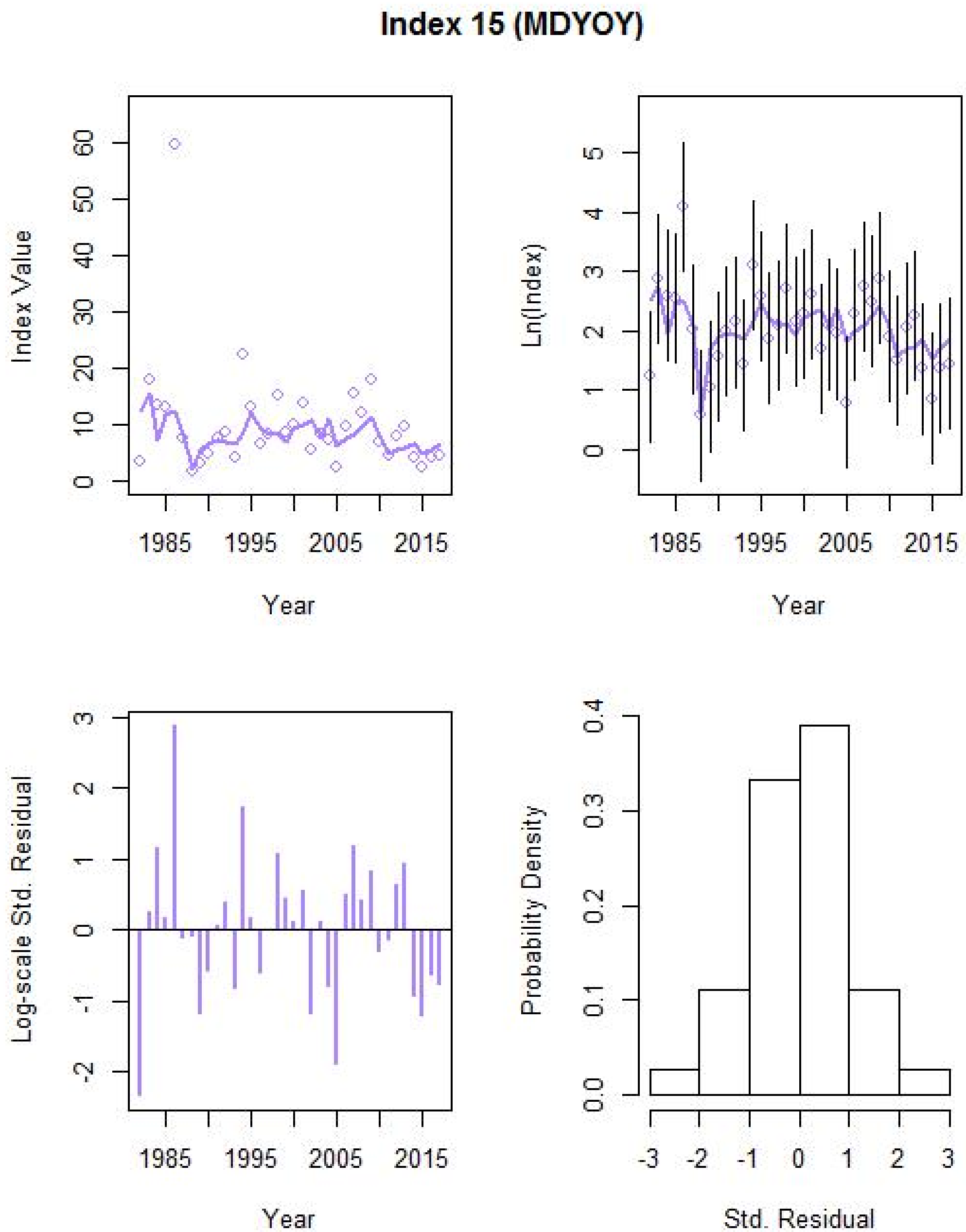


Figure A167. Fit diagnostics for the Maryland Department of Natural Resources young-of-the-year (MDYOY) survey from the F2018_BASE_V2 model run.

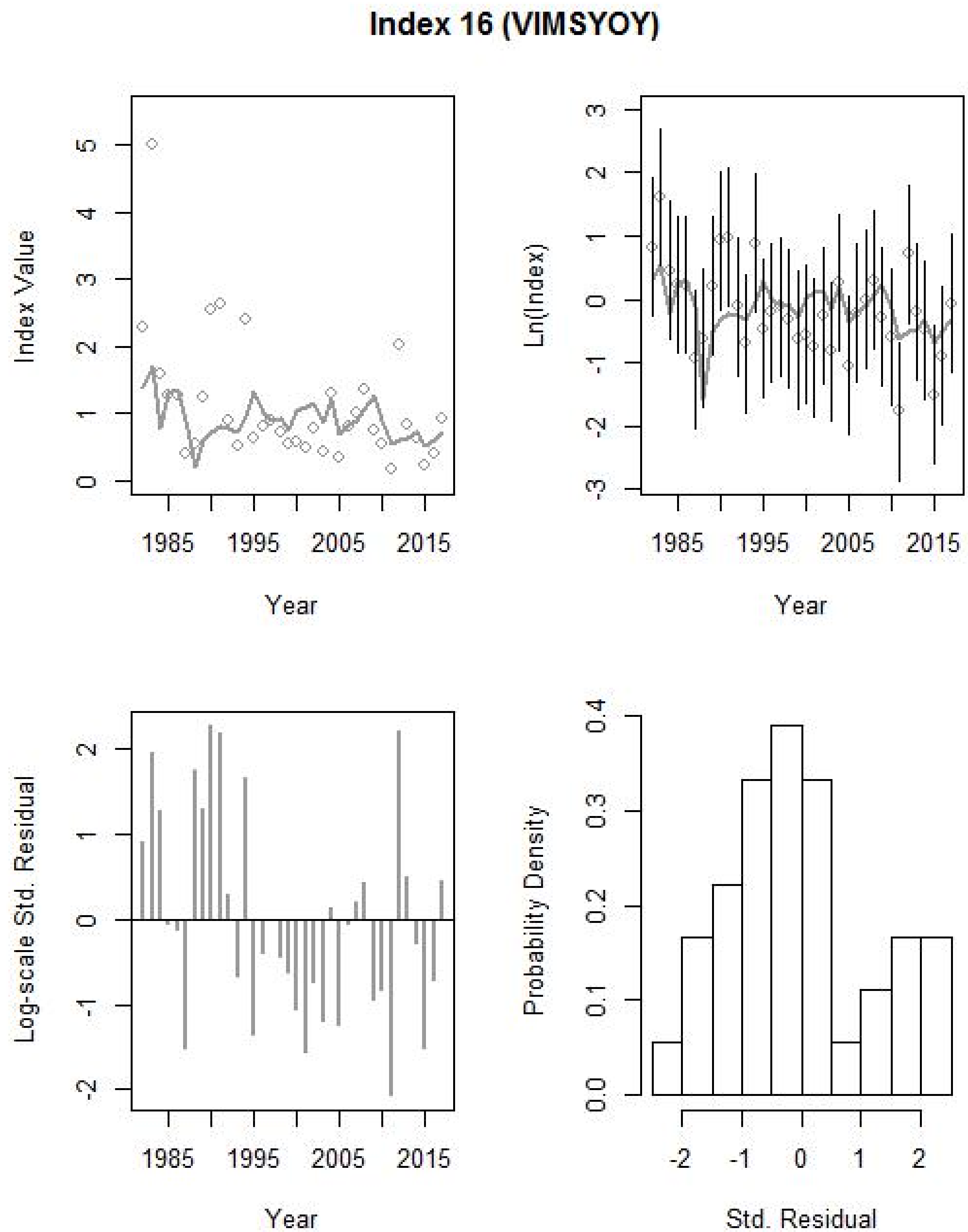


Figure A168. Fit diagnostics for the Virginia Institute of Marine Science young-of-the-year (VIMSYOY) survey from the F2018_BASE_V2 model run.

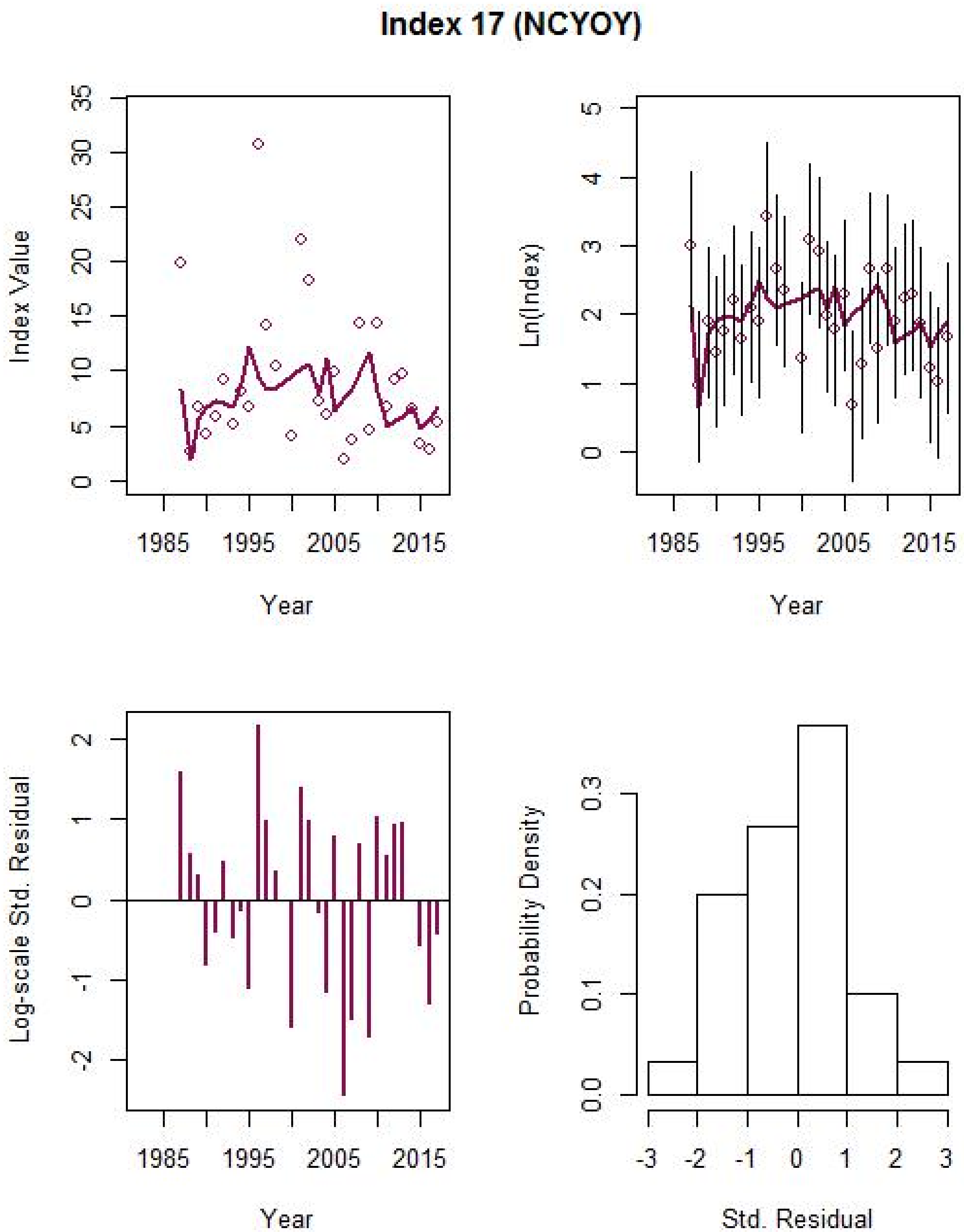


Figure A169. Fit diagnostics for the North Carolina Division of Marine Fisheries young-of-the-year (NCYOY) survey from the F2018_BASE_V2 model run.

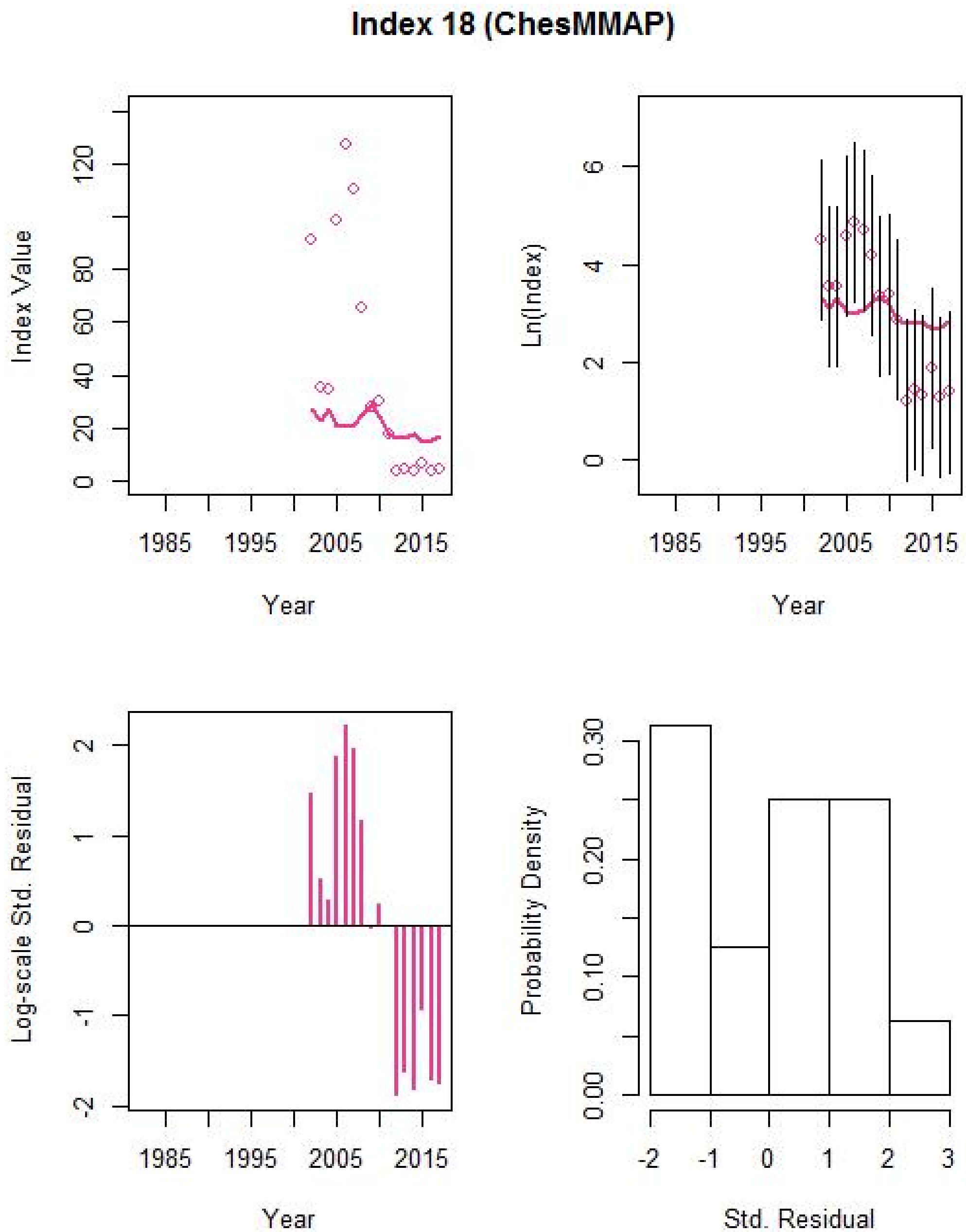


Figure A170. Fit diagnostics for the Virginia Institute of Marine Science Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) trawl survey from the F2018_BASE_V2 model run.

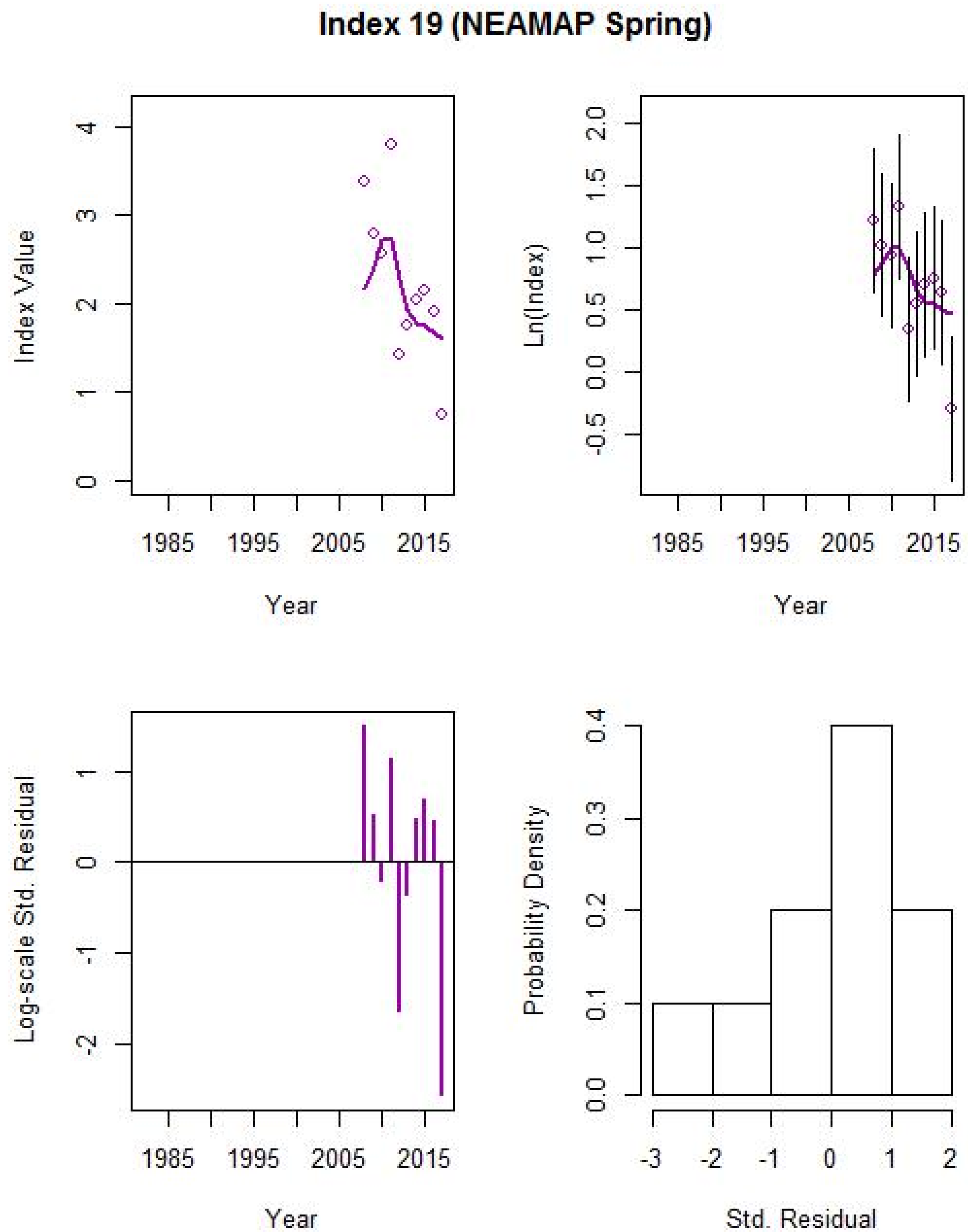


Figure A171. Fit diagnostics for the Virginia Institute of Marine Science Northeast Area Monitoring and Assessment Program (NEAMAP) spring trawl survey from the F2018_BASE_V2 model run.

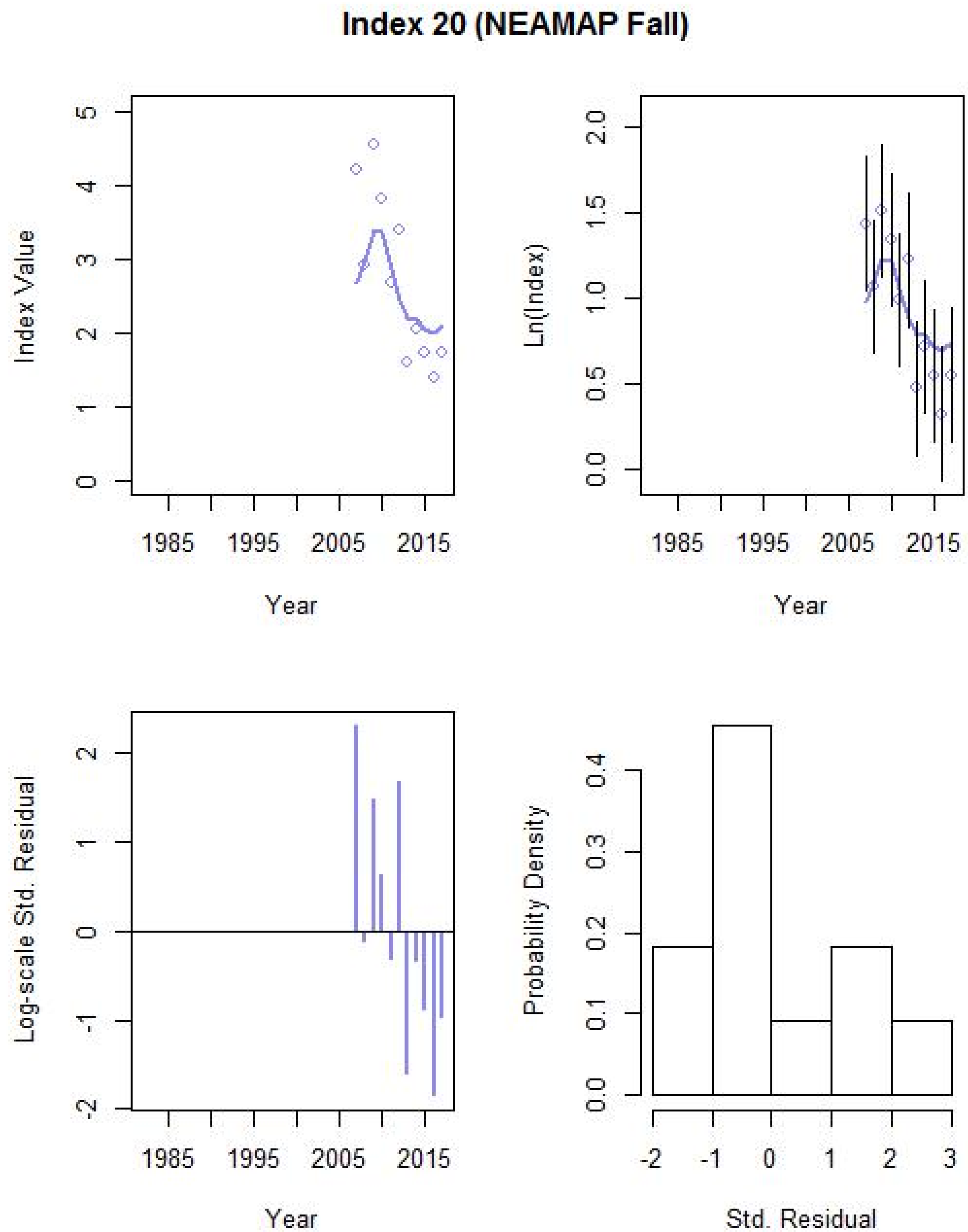


Figure A172. Fit diagnostics for the Virginia Institute of Marine Science Northeast Area Monitoring and Assessment Program (NEAMAP) fall trawl survey from the F2018_BASE_V2 model run.

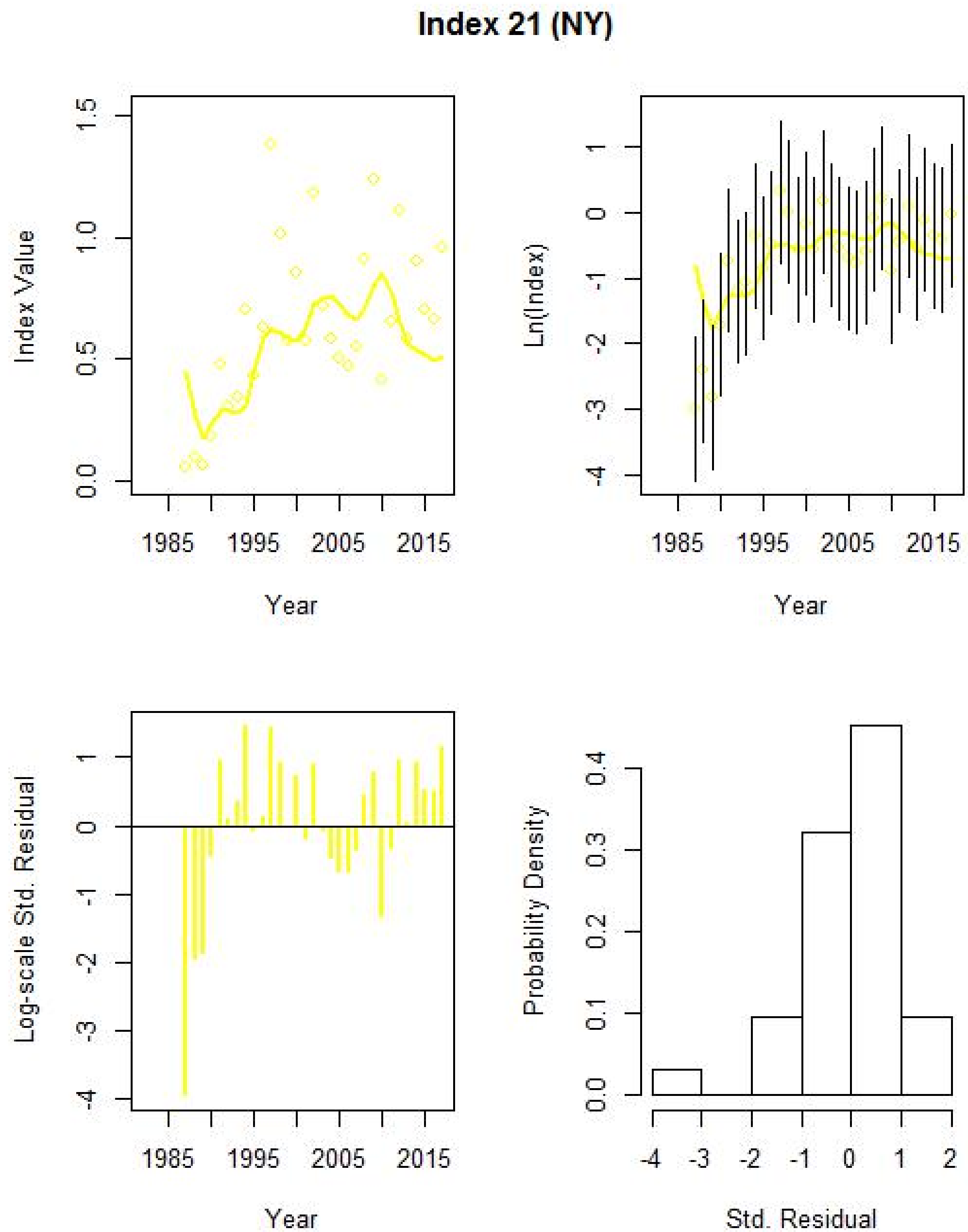


Figure A173. Fit diagnostics for the New York Department of Environmental Conservation (NY) trawl survey from the F2018_BASE_V2 model run.

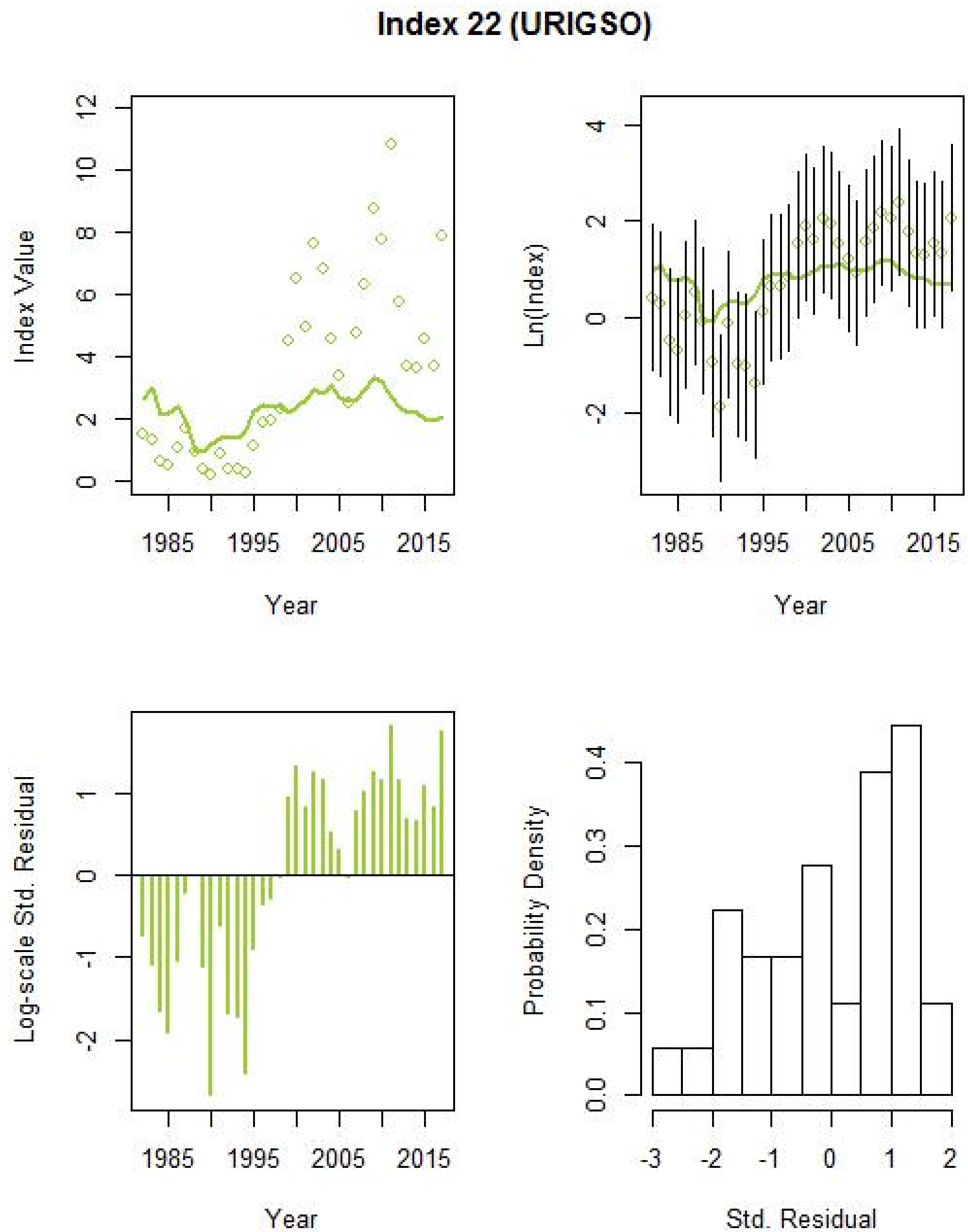


Figure A174. Fit diagnostics for the University of Rhode Island Graduate School of Oceanography (URIGSO) trawl survey from the F2018_BASE_V2 model run.

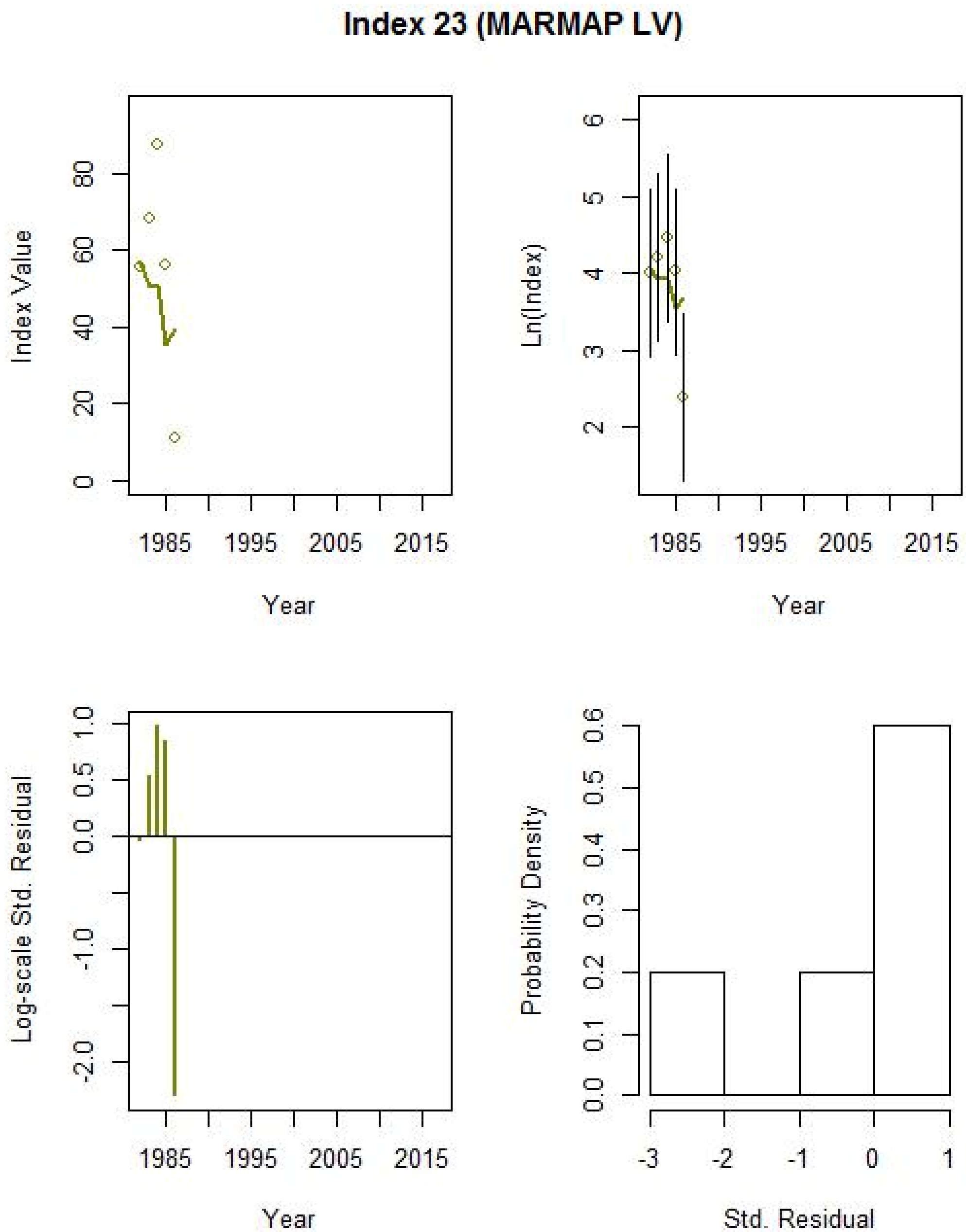


Figure A175. Fit diagnostics for the Northeast Fisheries Science Center MARMAP larval survey from the F2018_BASE_V2 model run.

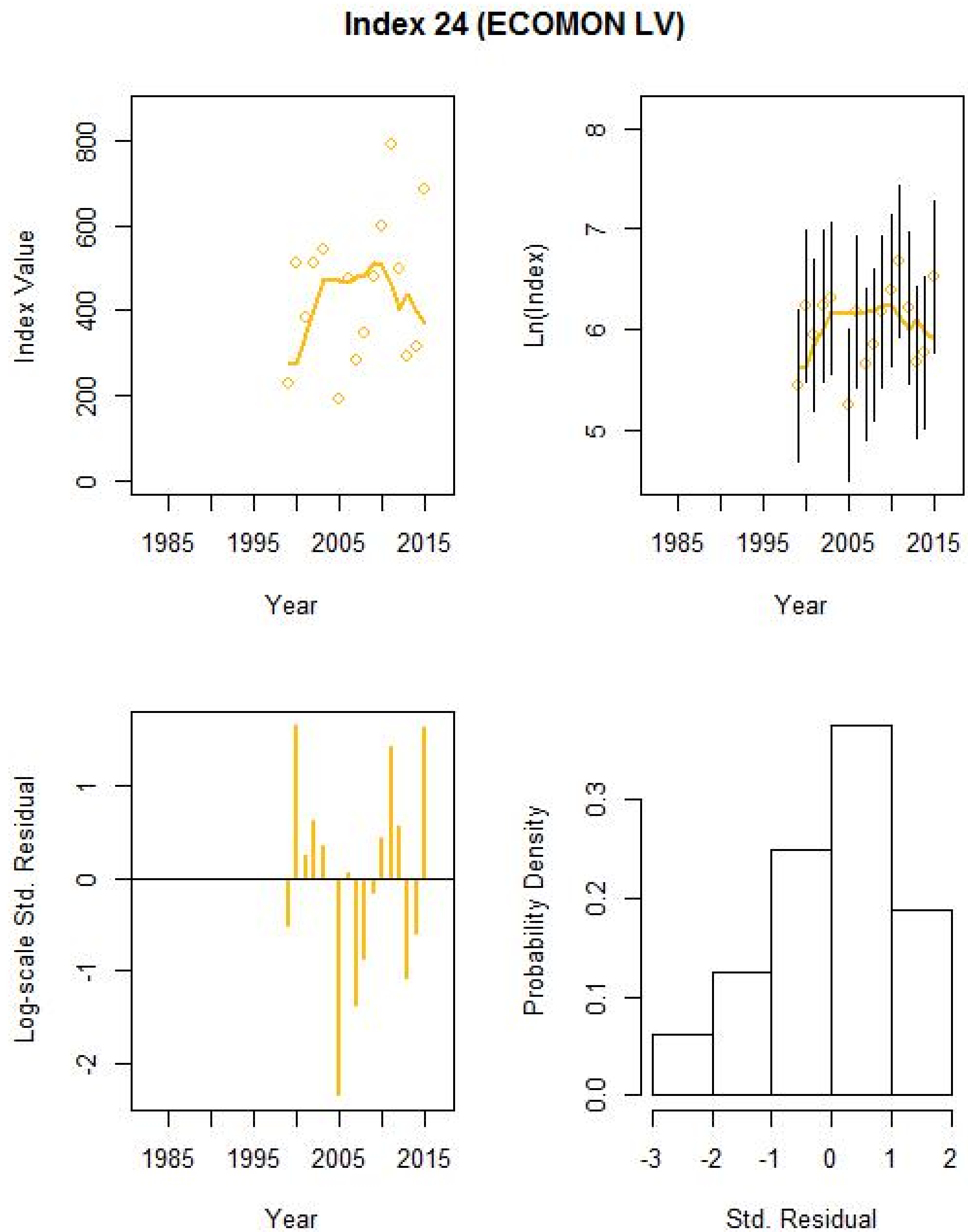


Figure A176. Fit diagnostics for the Northeast Fisheries Science Center ECOMON larval survey from the F2018_BASE_V2 model run.

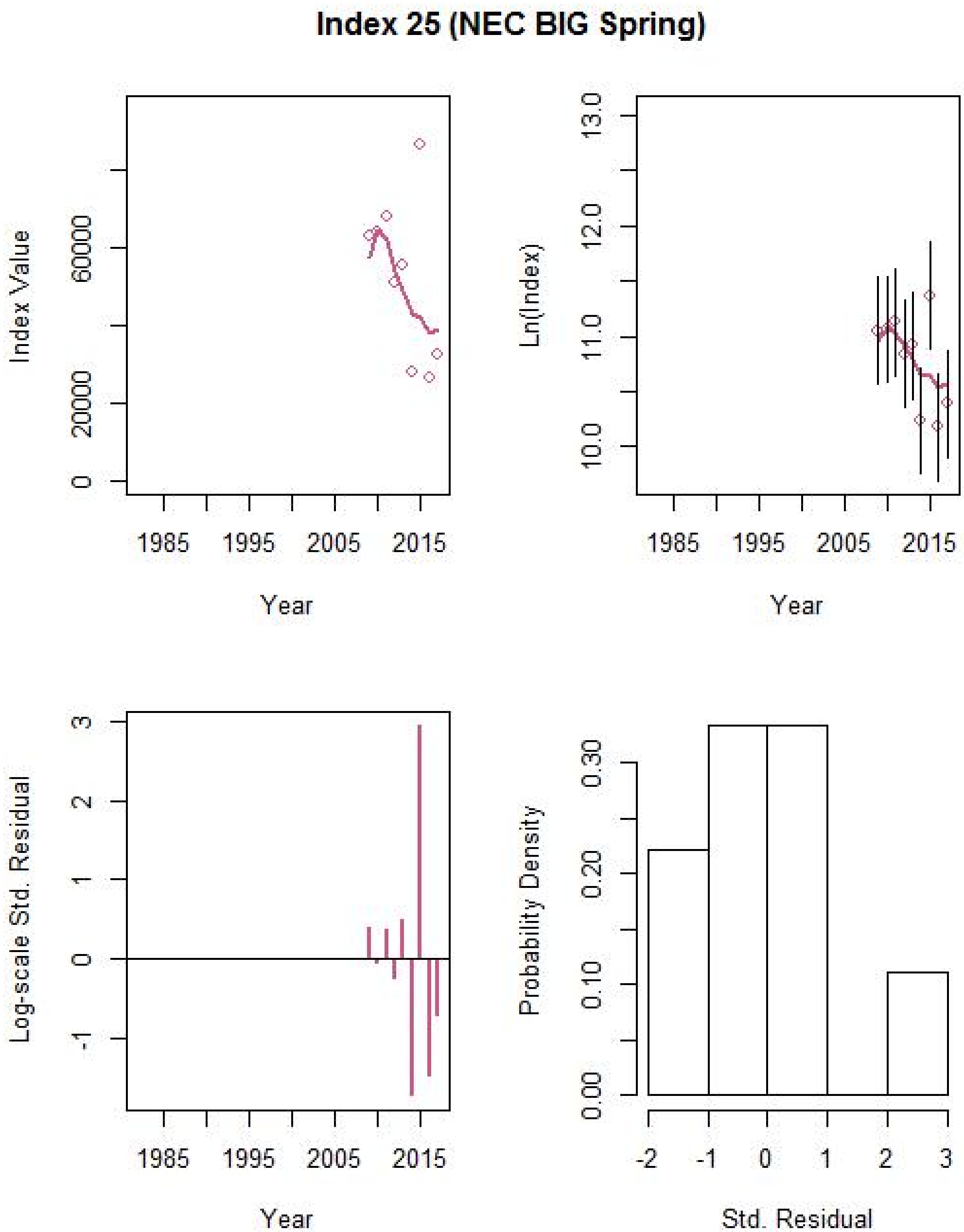


Figure A177. Fit diagnostics for the Northeast Fisheries Science Center (NEC) Bigelow (BIG) spring trawl survey from the F2018_BASE_V2 model run.

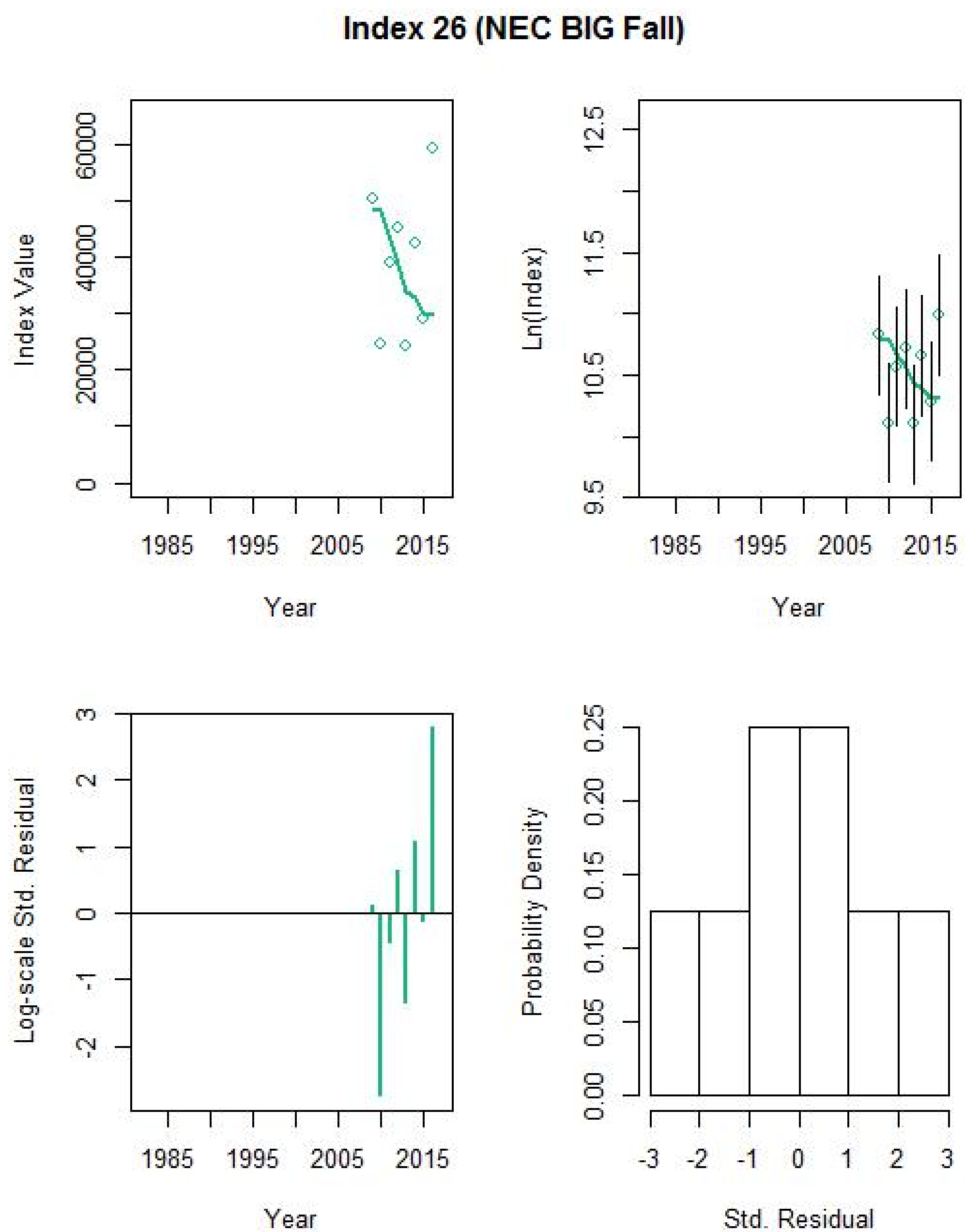


Figure A178. Fit diagnostics for the Northeast Fisheries Science Center (NEC) Bigelow (BIG) fall trawl survey from the F2018_BASE_V2 model run.

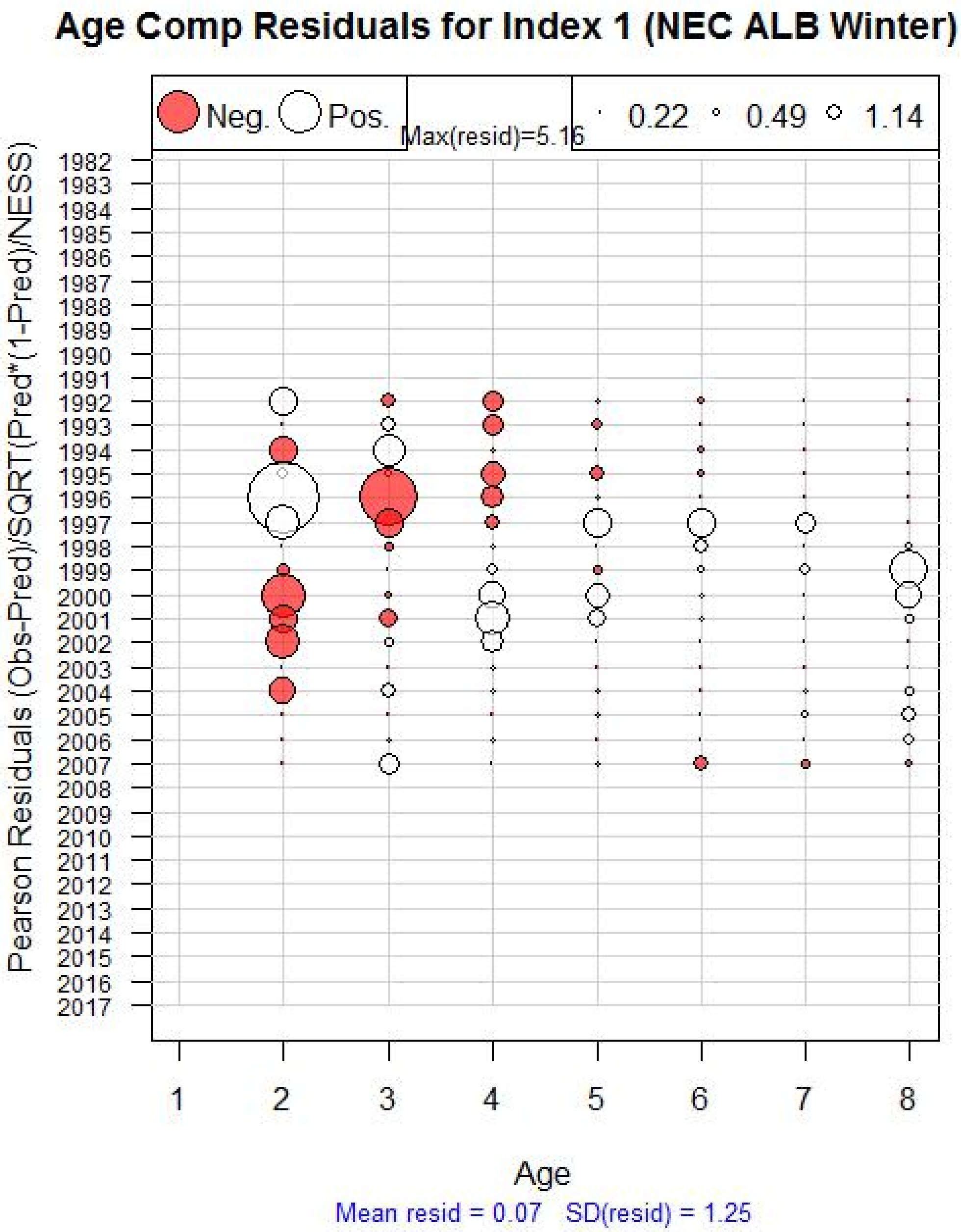


Figure A179. Age composition residuals for the Northeast Fisheries Science Center (NEC) Albatross (ALB) winter trawl survey from the F2018_BASE_V2 model run.

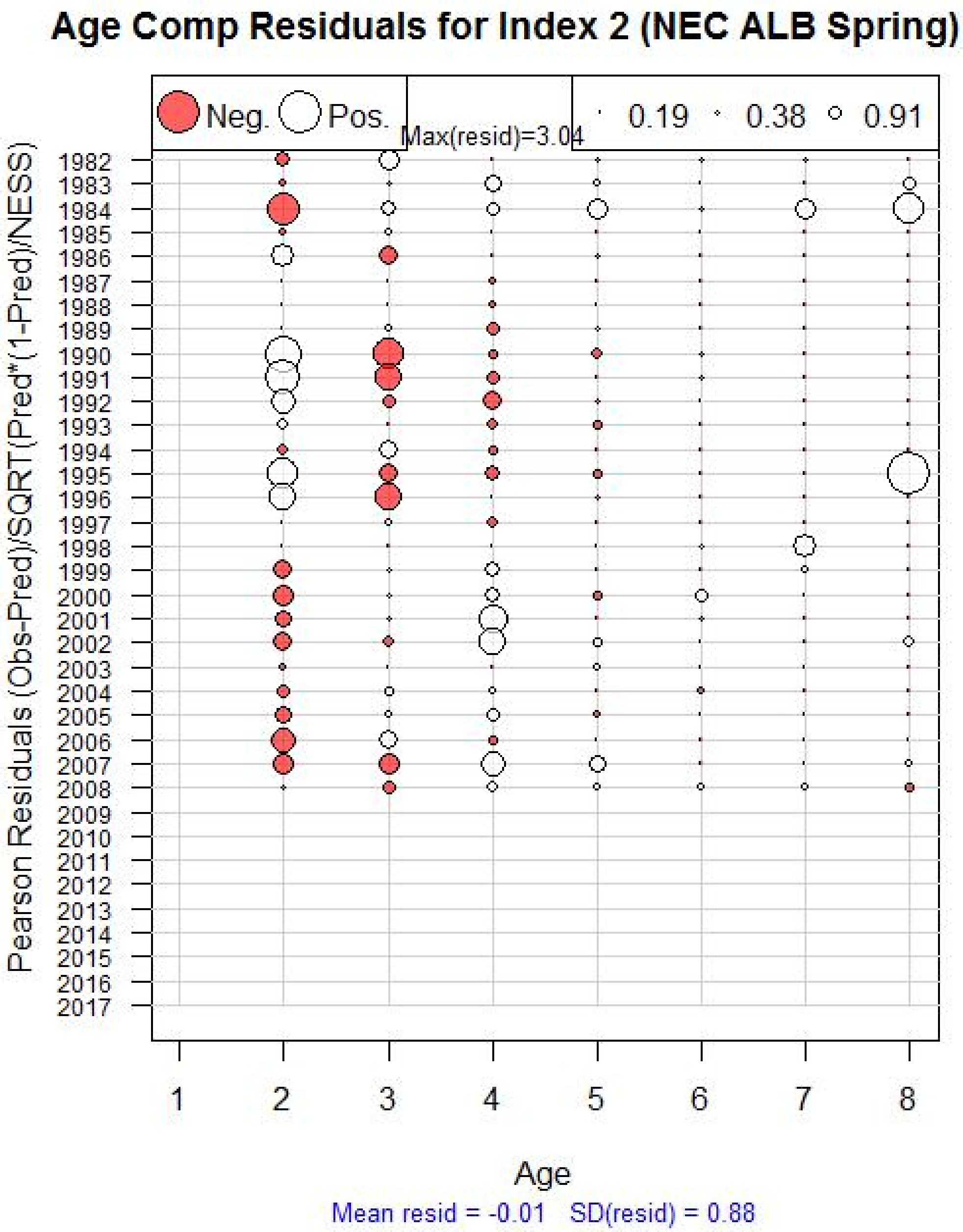


Figure A180. Age composition residuals for the Northeast Fisheries Science Center (NEC) Albatross (ALB) spring trawl survey from the F2018_BASE_V2 model run.

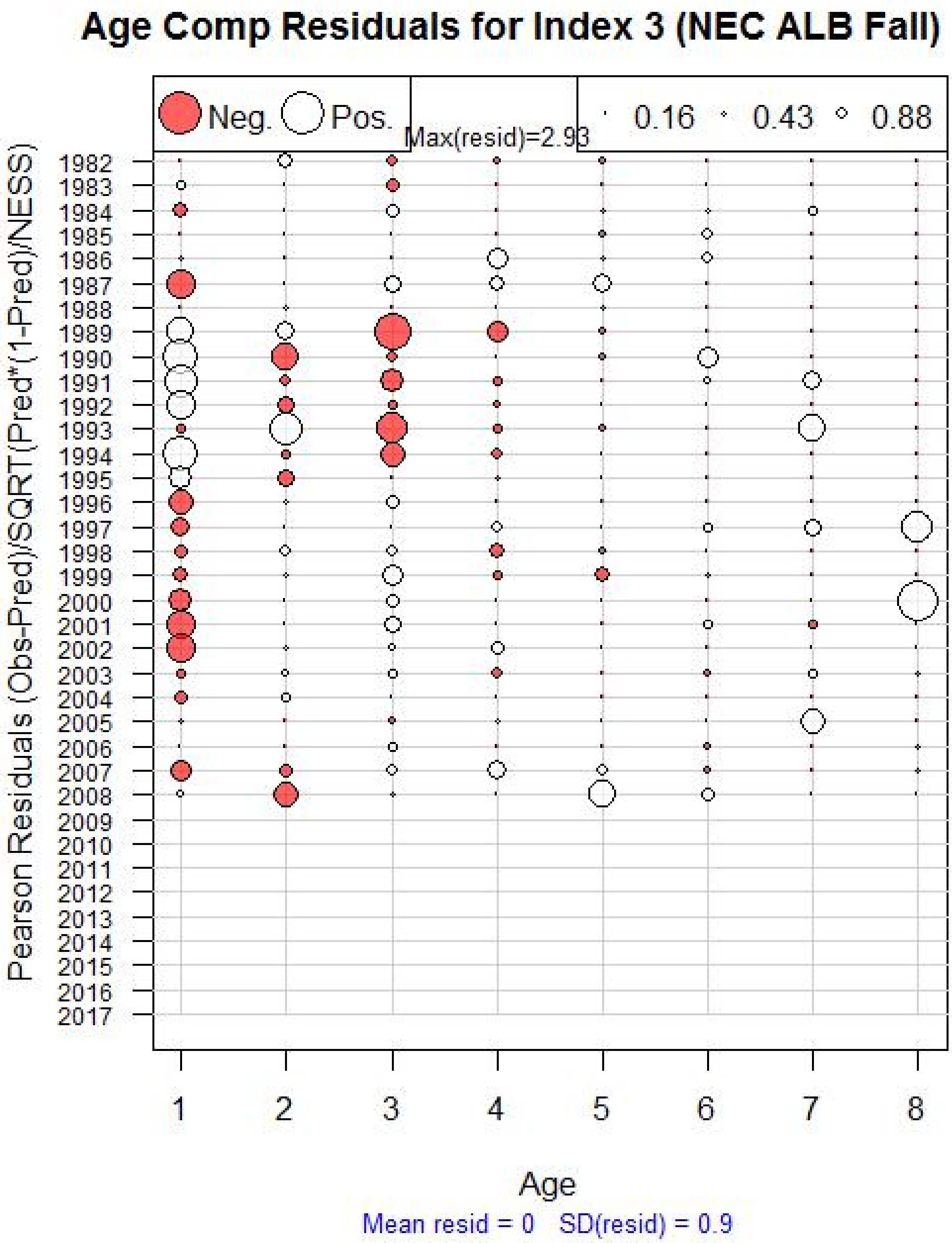


Figure A181. Age composition residuals for the Northeast Fisheries Science Center (NEC) Albatross (ALB) fall trawl survey from the F2018_BASE_V2 model run.

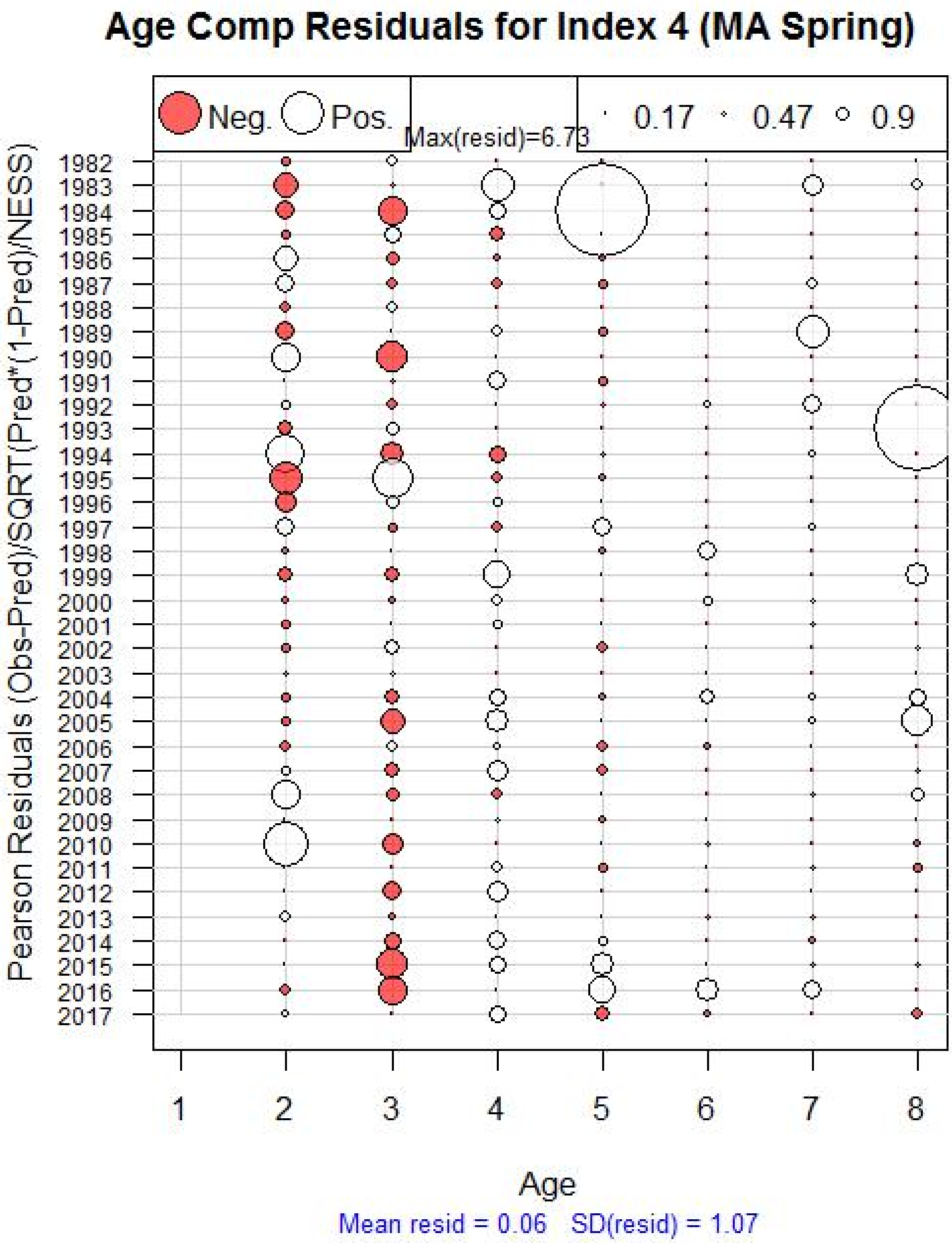


Figure A182. Age composition residuals for the Massachusetts Division of Marine Fisheries (MA) spring trawl survey from the F2018_BASE_V2 model run.

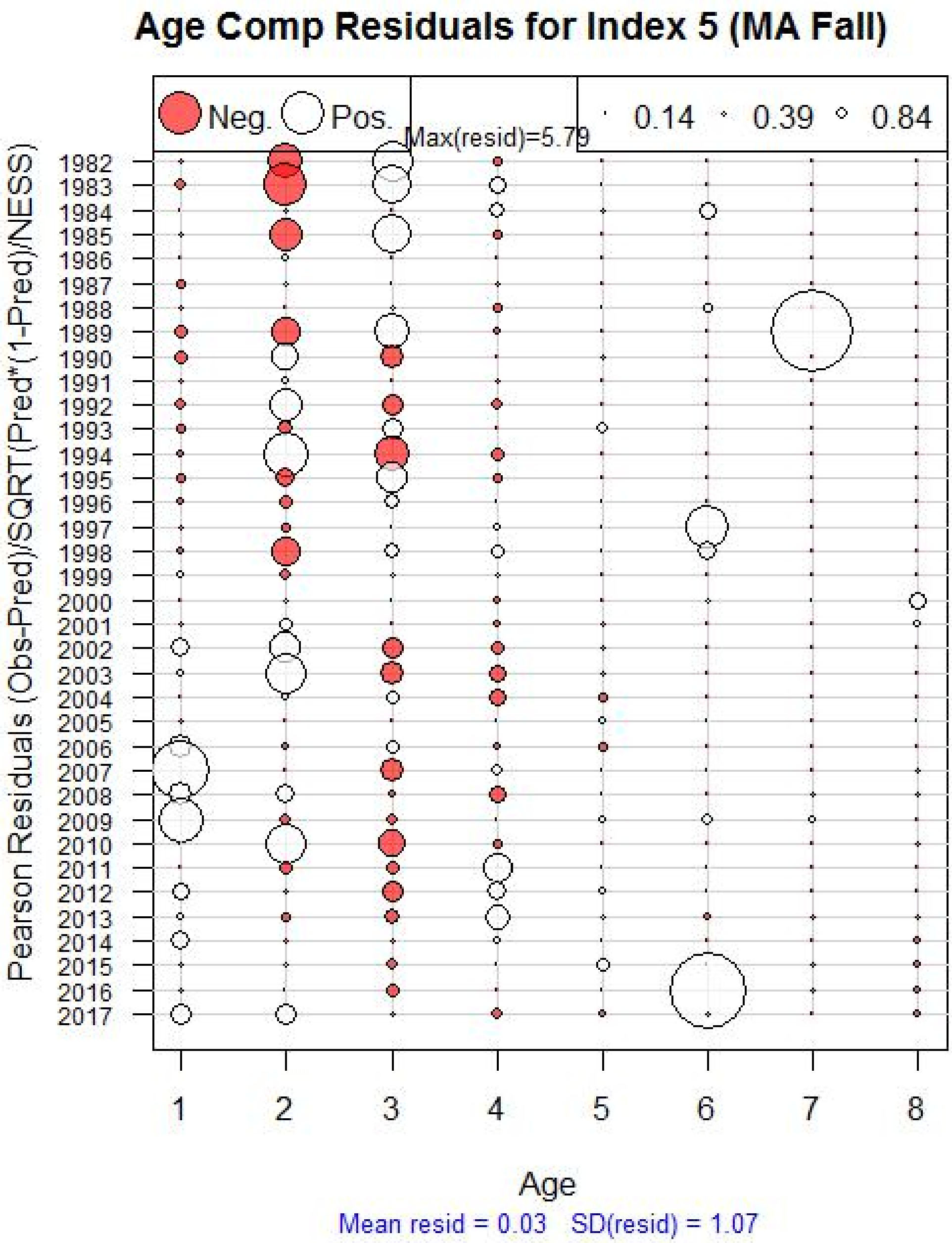


Figure A183. Age composition residuals for the Massachusetts Division of Marine Fisheries (MA) fall trawl survey from the F2018_BASE_V2 model run.

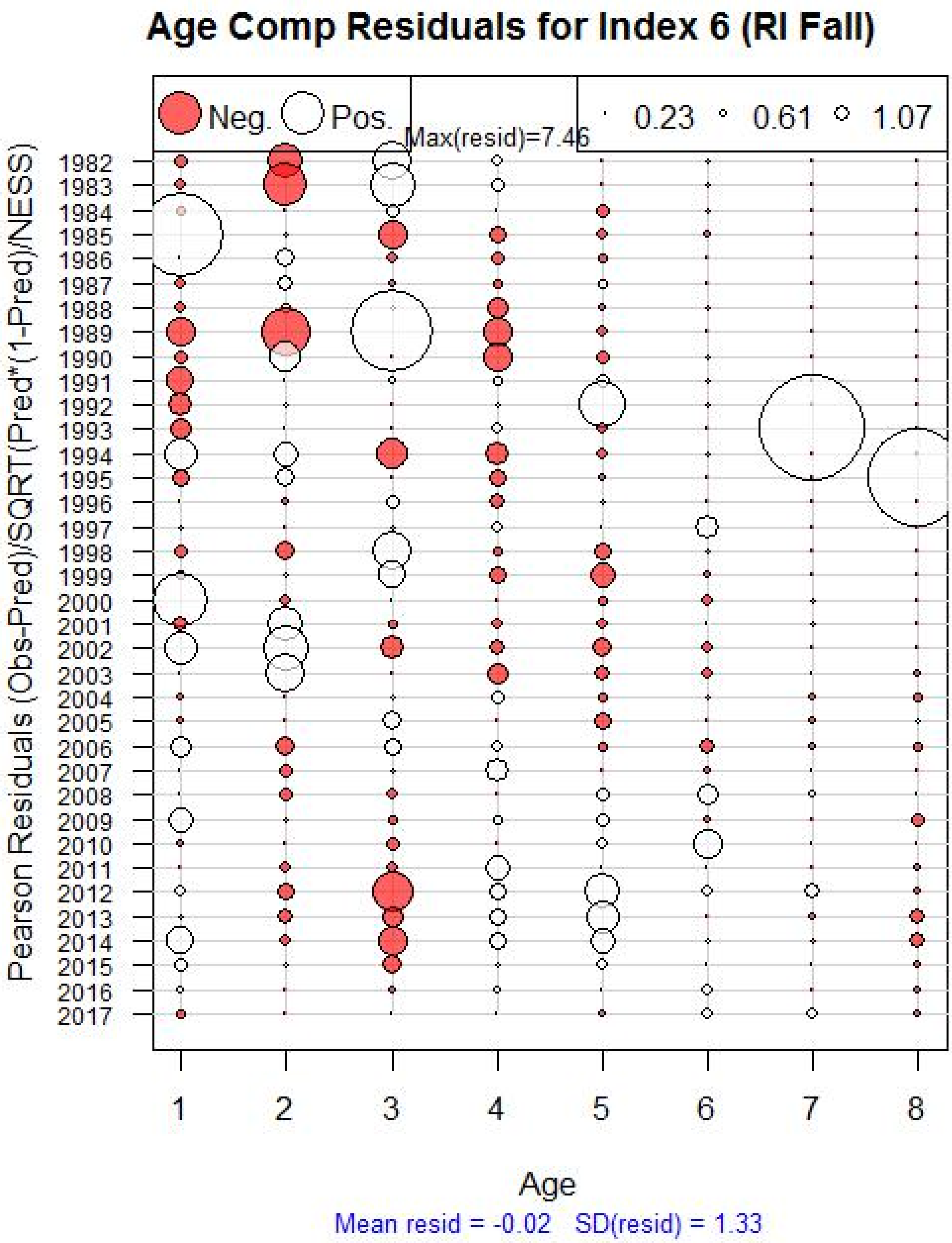


Figure A184. Age composition residuals for the Rhode Island Department of Fish and Wildlife (RI) fall trawl survey from the F2018_BASE_V2 model run.

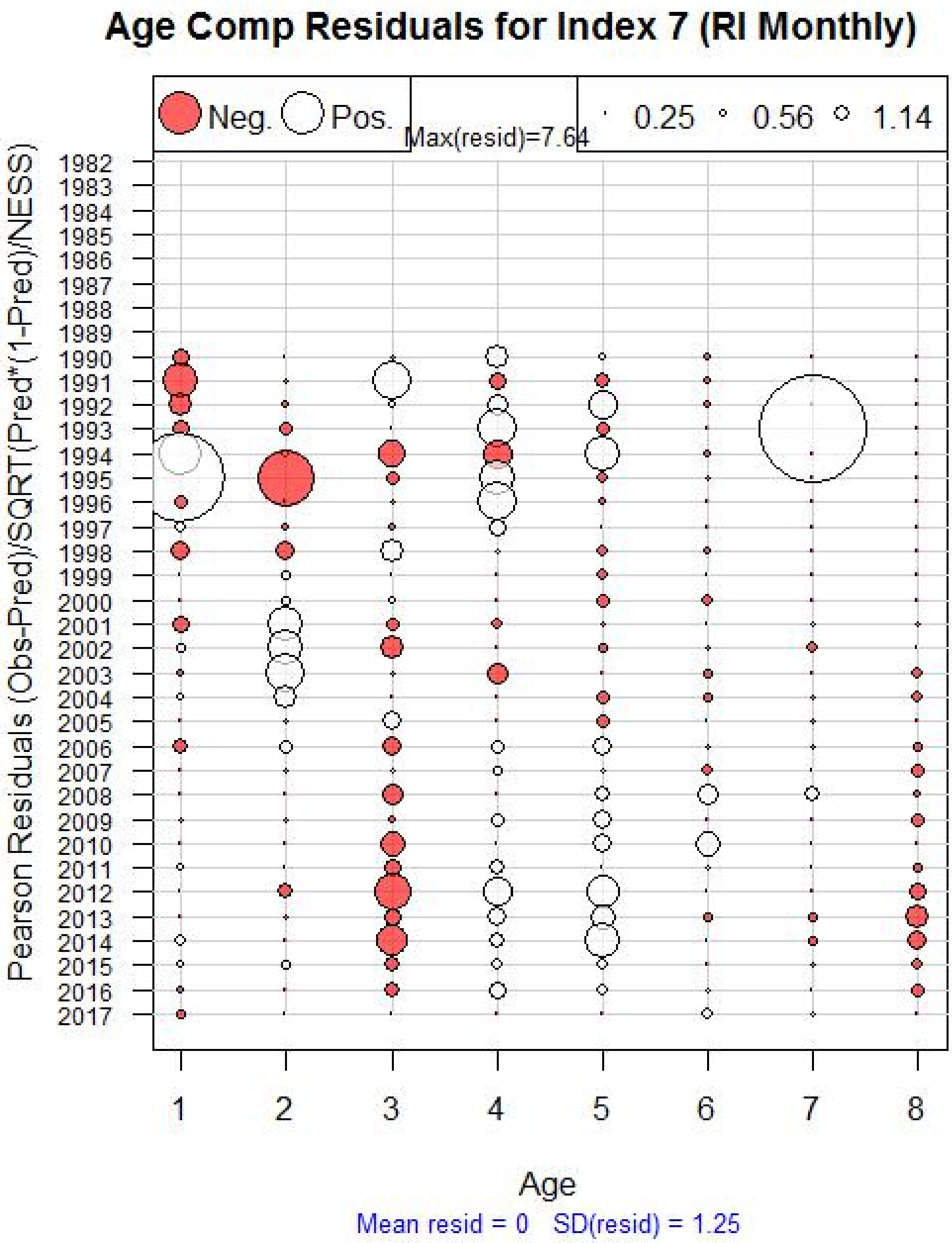


Figure A185. Age composition residuals for the Rhode Island Department of Fish and Wildlife (RI) monthly trawl survey from the F2018_BASE_V2 model run.

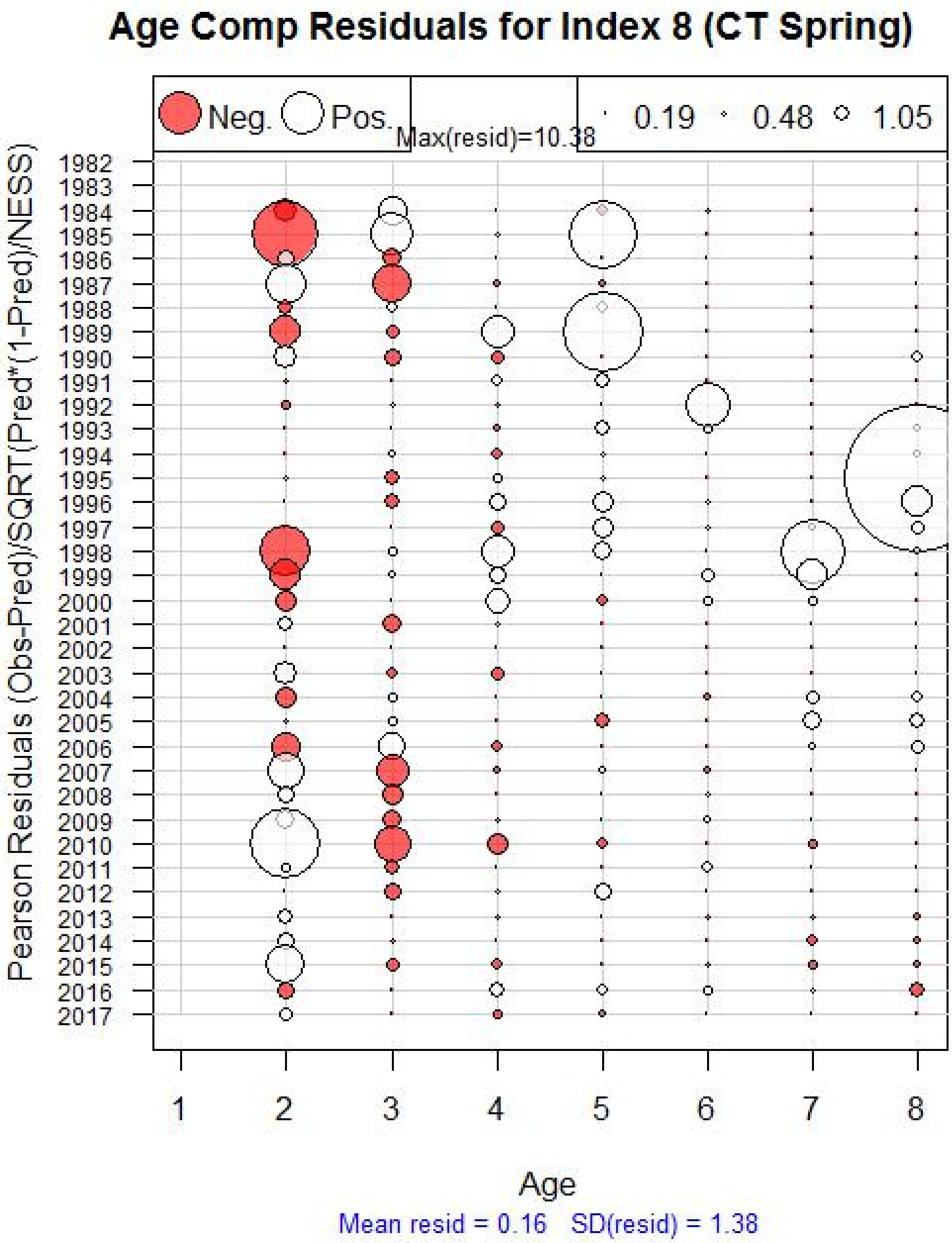


Figure A186. Age composition residuals for the Connecticut Department of Energy and Environmental Protection (CT) spring trawl survey from the F2018_BASE_V2 model run.

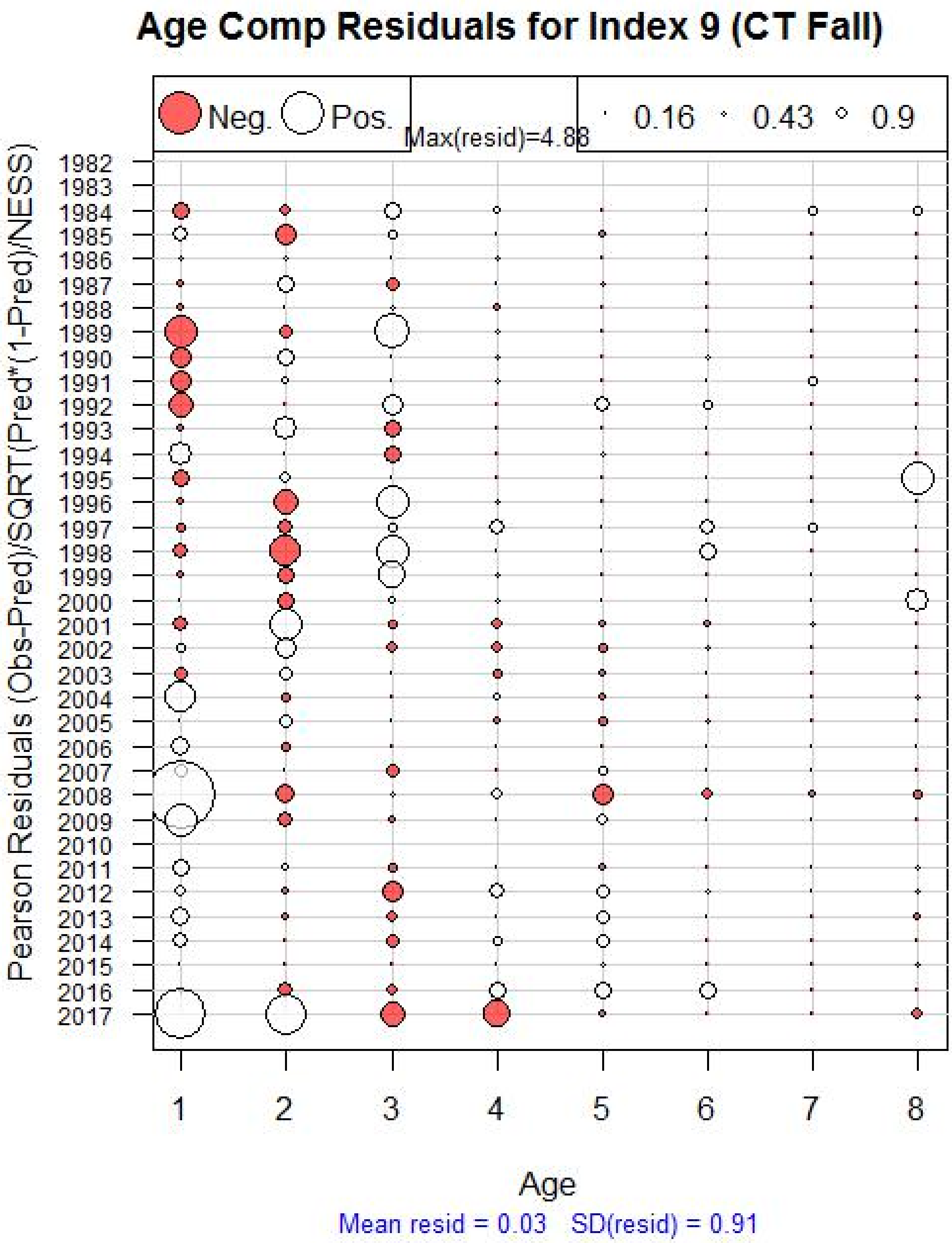


Figure A187. Age composition residuals for the Connecticut Department of Energy and Environmental Protection (CT) fall trawl survey from the F2018_BASE_V2 model run.

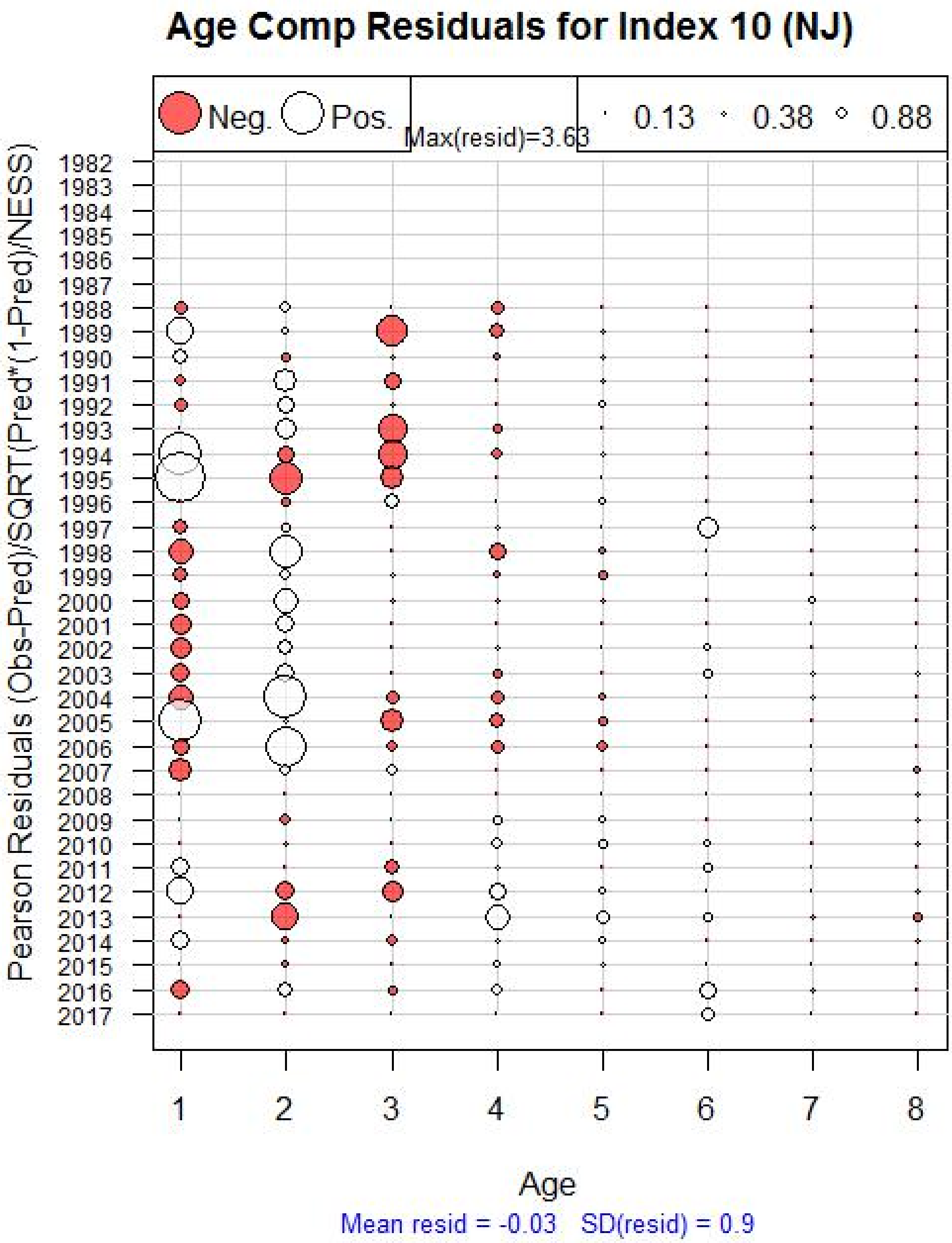


Figure A188. Age composition residuals for the New Jersey Division of Fish and Wildlife (NJ) trawl survey from the F2018_BASE_V2 model run.

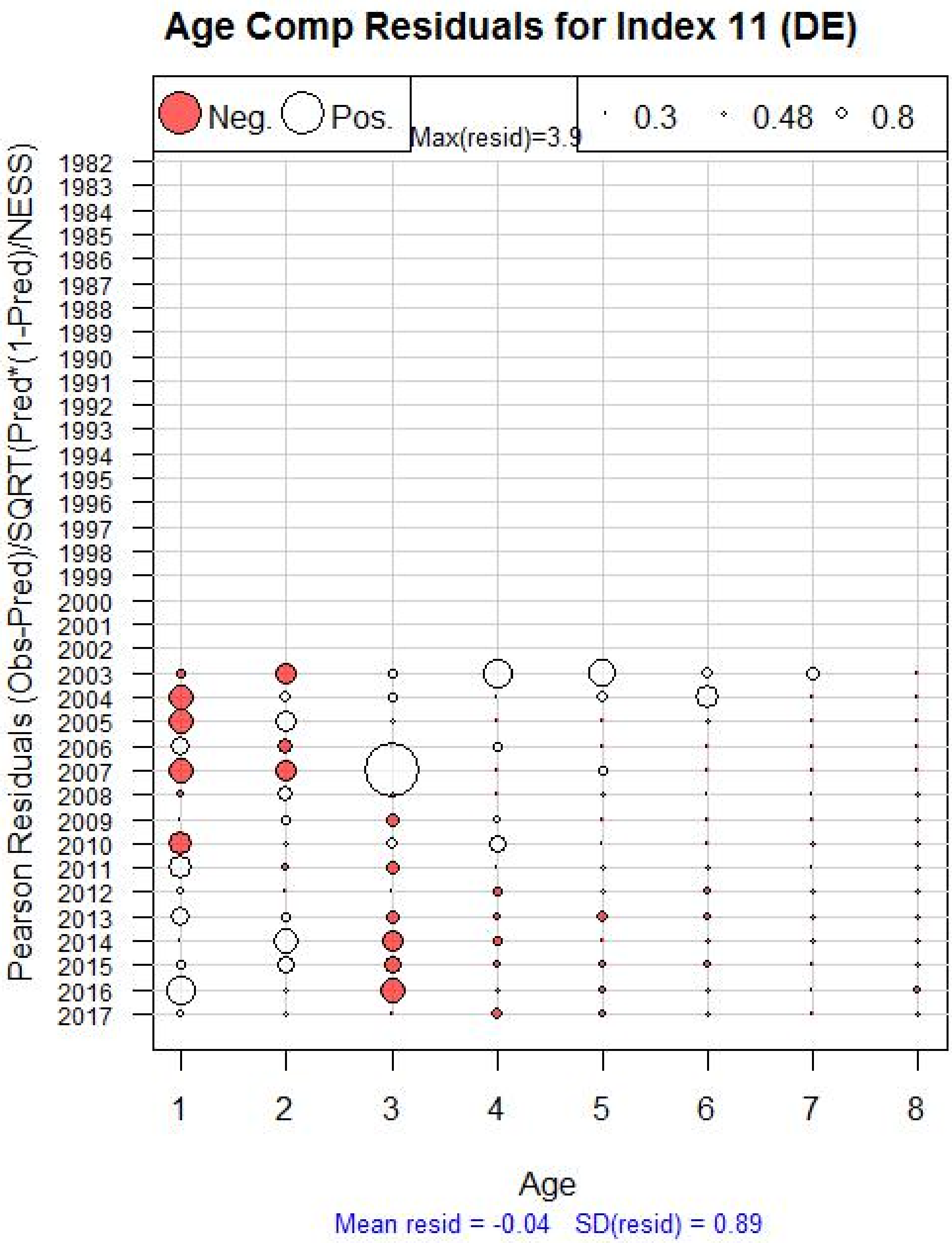


Figure A189. Age composition residuals for the Delaware Division of Fish and Wildlife (DE) trawl survey from the F2018_BASE_V2 model run.

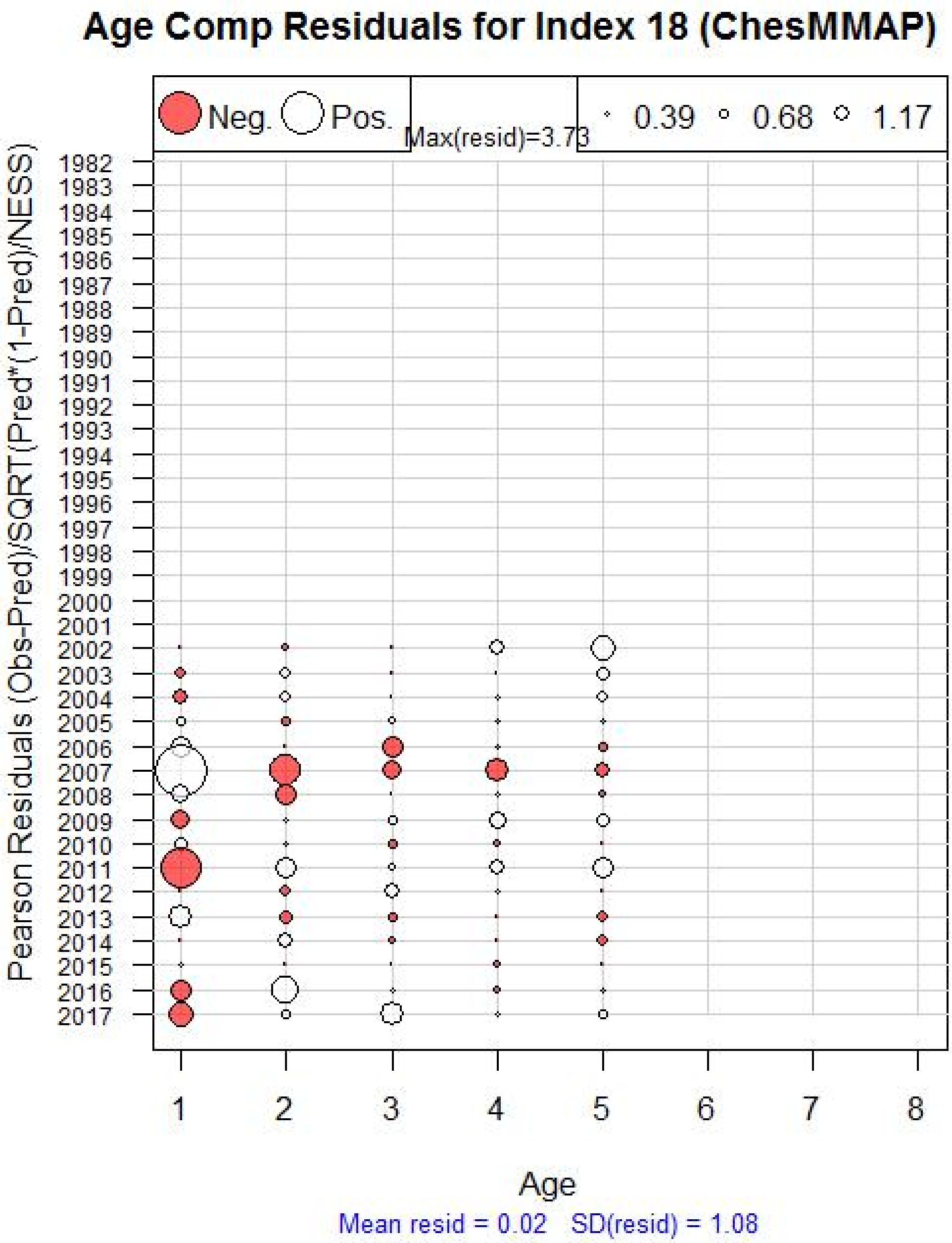


Figure A190. Age composition residuals for the Virginia Institute of Marine Science Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) trawl survey from the F2018_BASE_V2 model run.

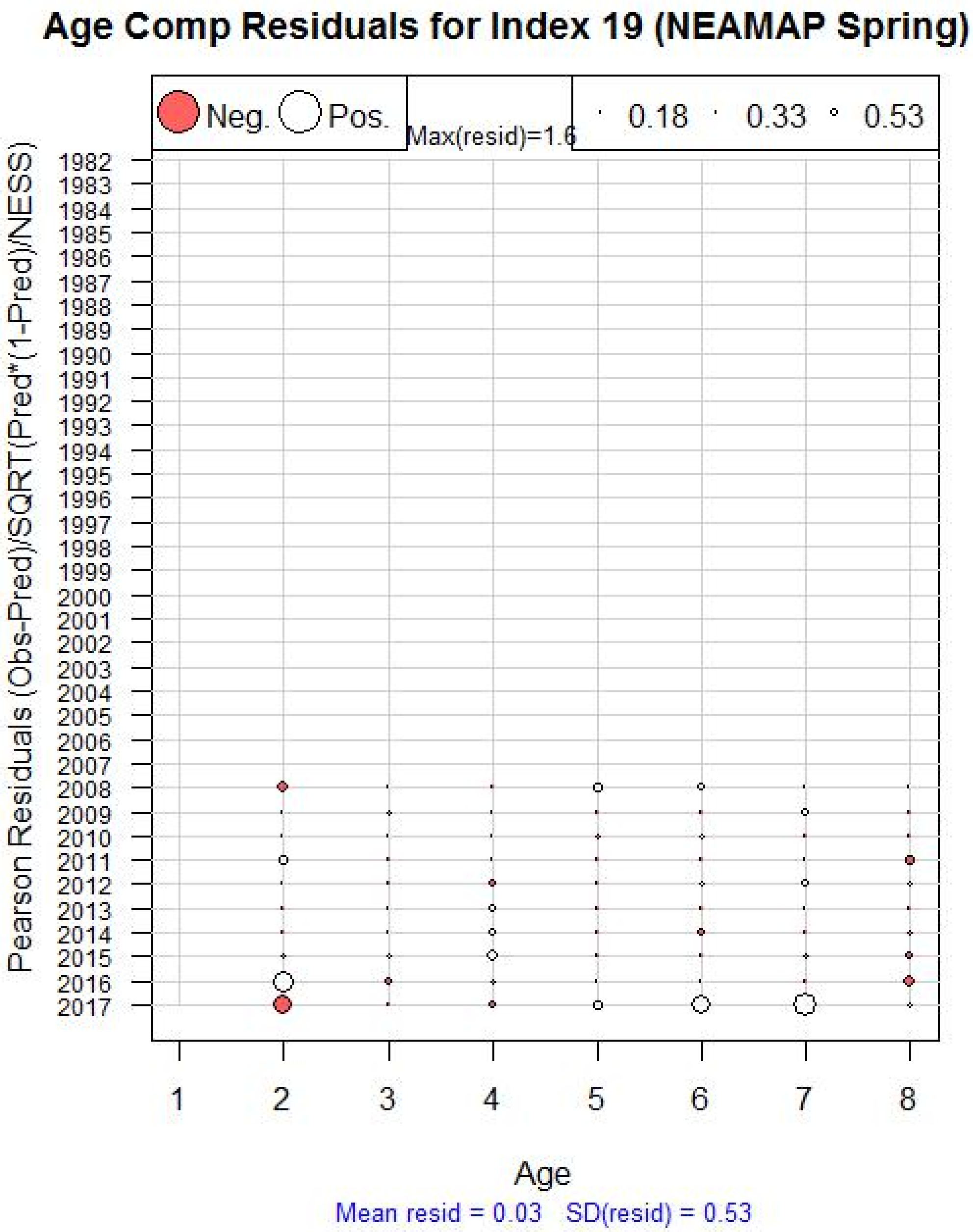


Figure A191. Age composition residuals for the Virginia Institute of Marine Science Northeast Area Monitoring and Assessment Program (NEAMAP) spring trawl survey from the F2018_BASE_V2 model run.

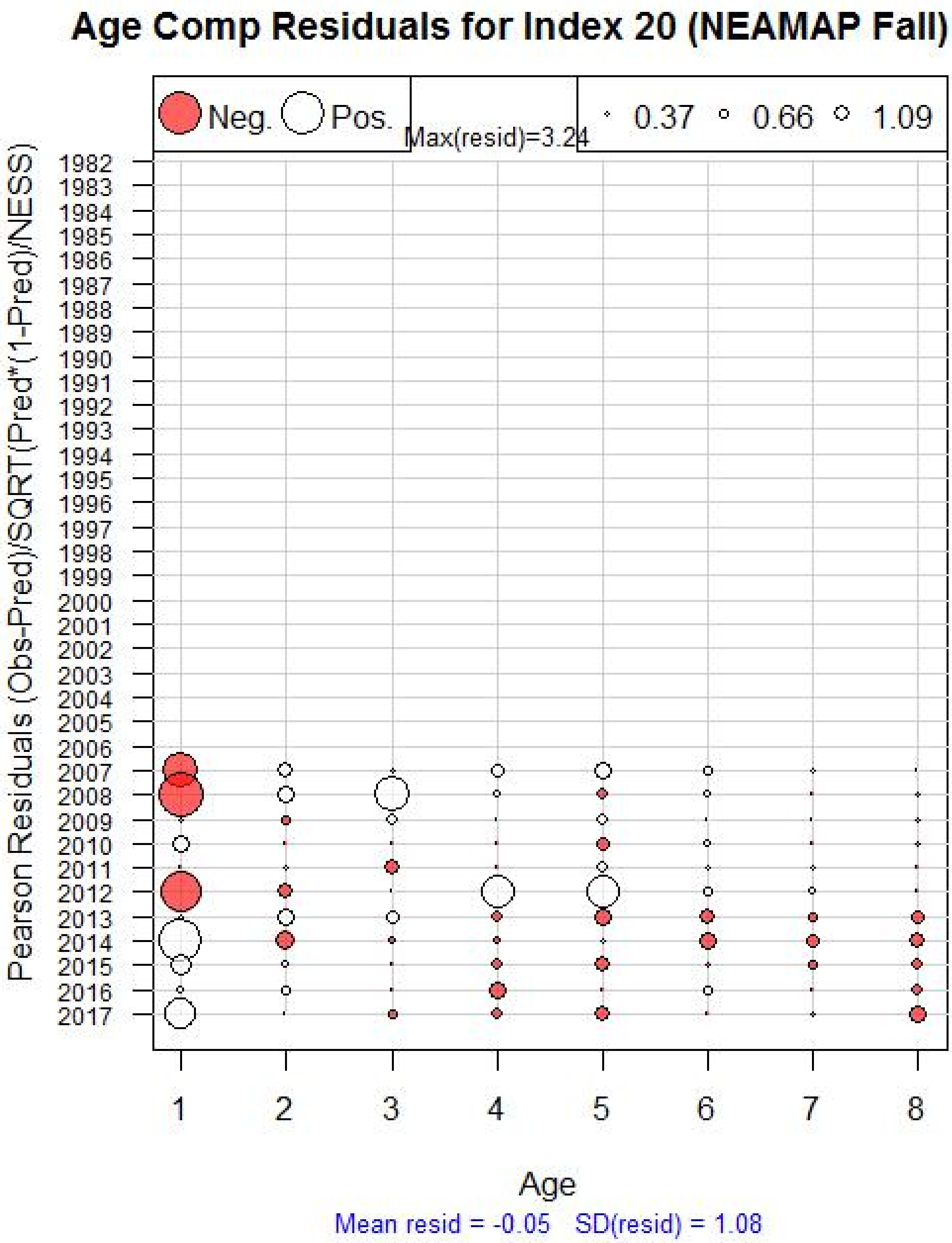


Figure A192. Age composition residuals for the Virginia Institute of Marine Science Northeast Area Monitoring and Assessment Program (NEAMAP) fall trawl survey from the F2018_BASE_V2 model run.

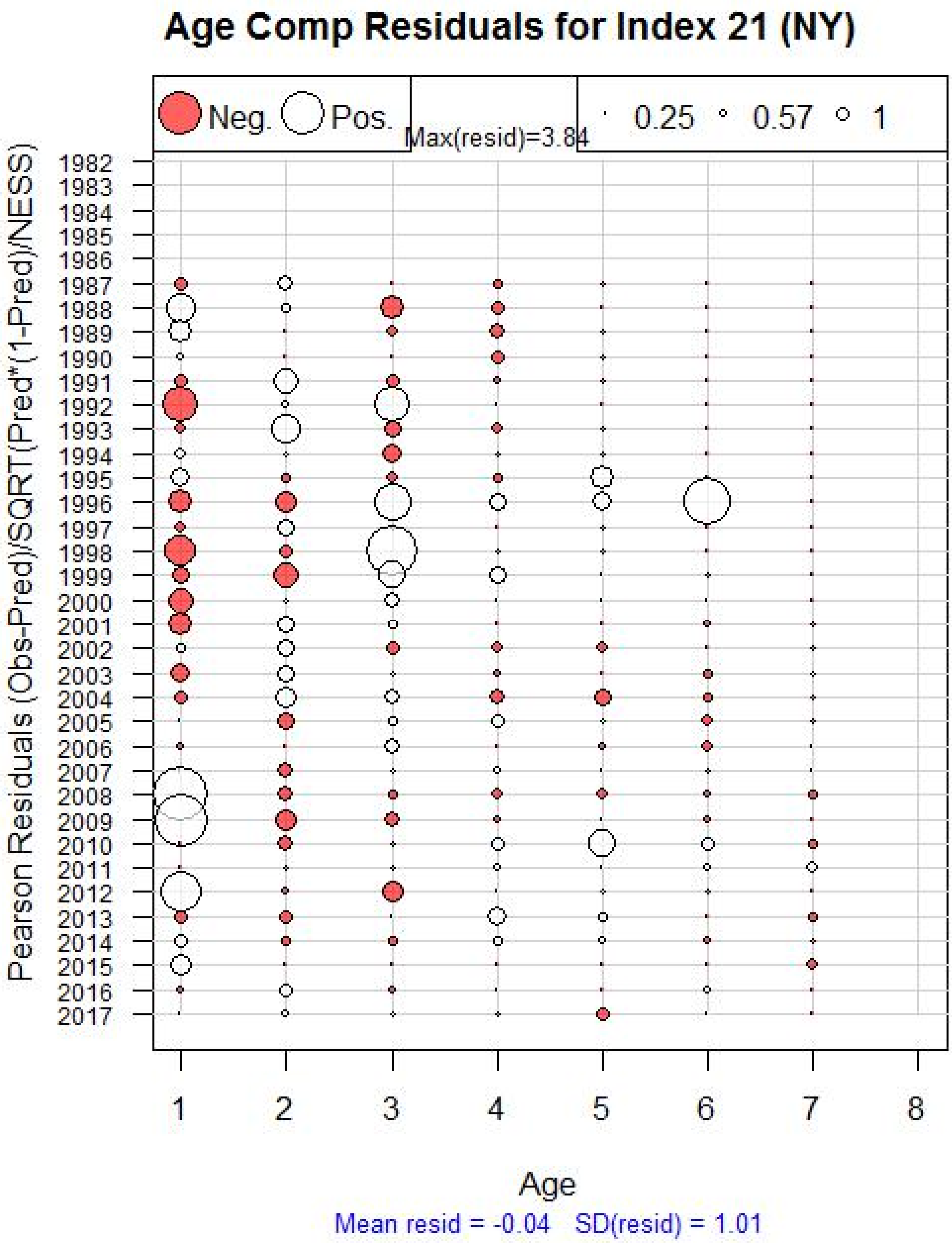


Figure A193. Age composition residuals for the New York Department of Environmental Conservation (NY) trawl survey from the F2018_BASE_V2 model run.

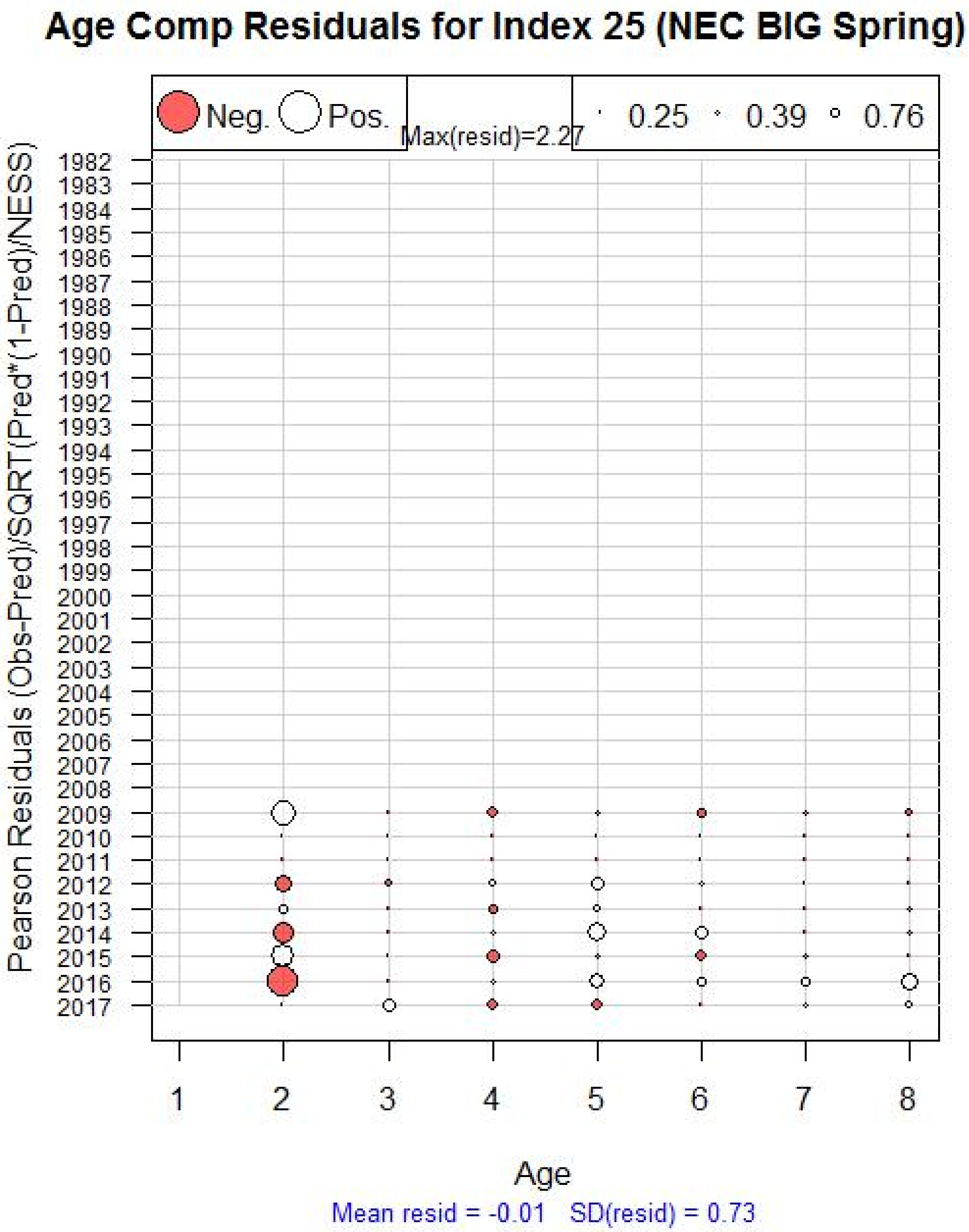


Figure A194. Age composition residuals for the Northeast Fisheries Science Center (NEC) Bigelow (BIG) spring trawl survey from the F2018_BASE_V2 model run.

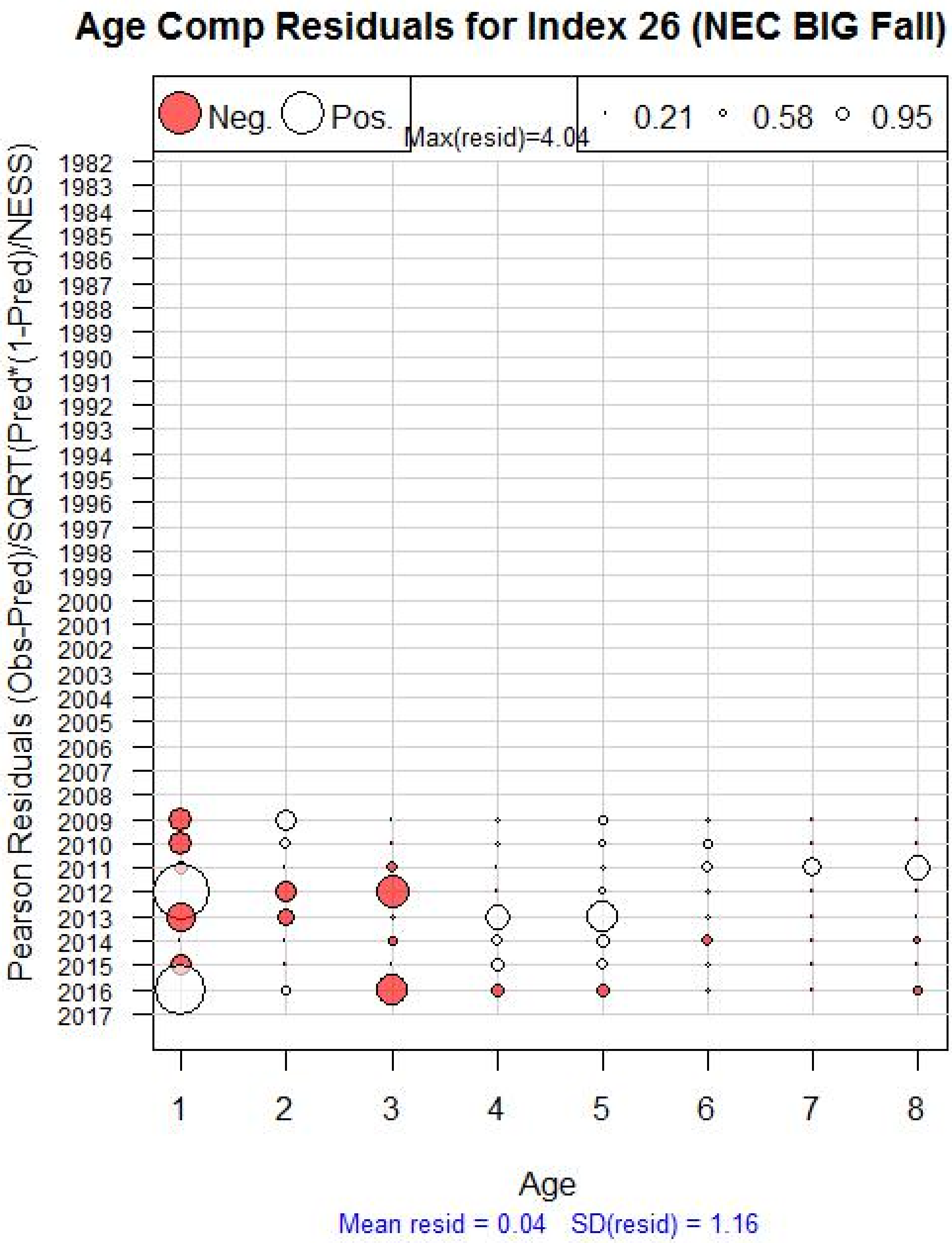
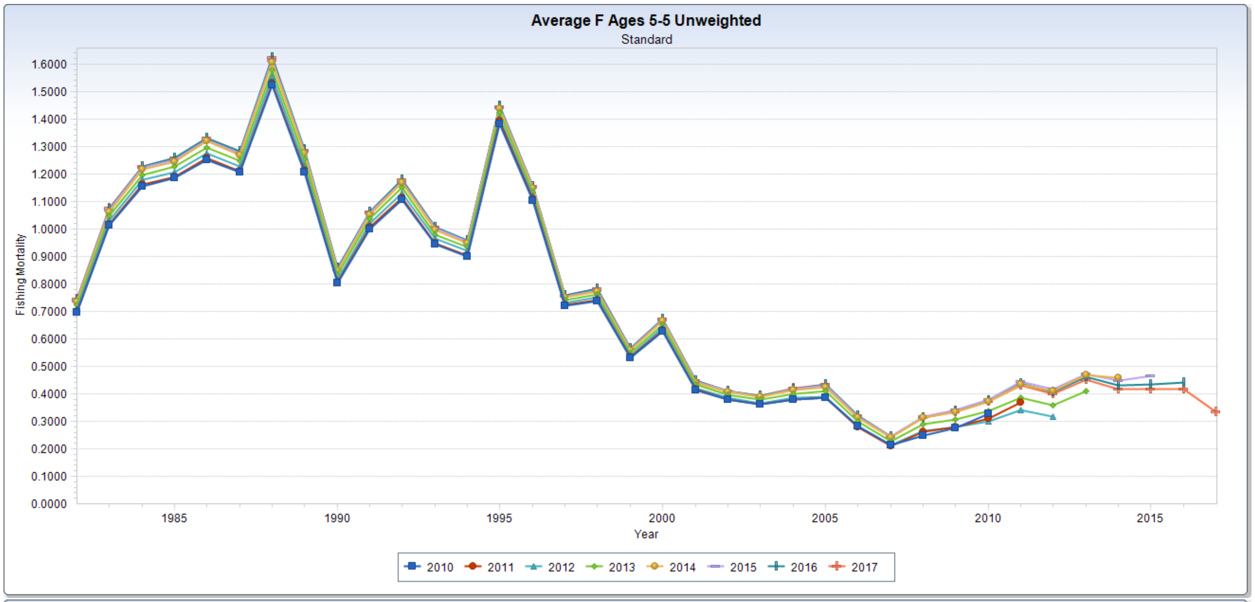


Figure A195. Age composition residuals for the Northeast Fisheries Science Center (NEC) Bigelow (BIG) fall trawl survey from the F2018_BASE_V2 model run.



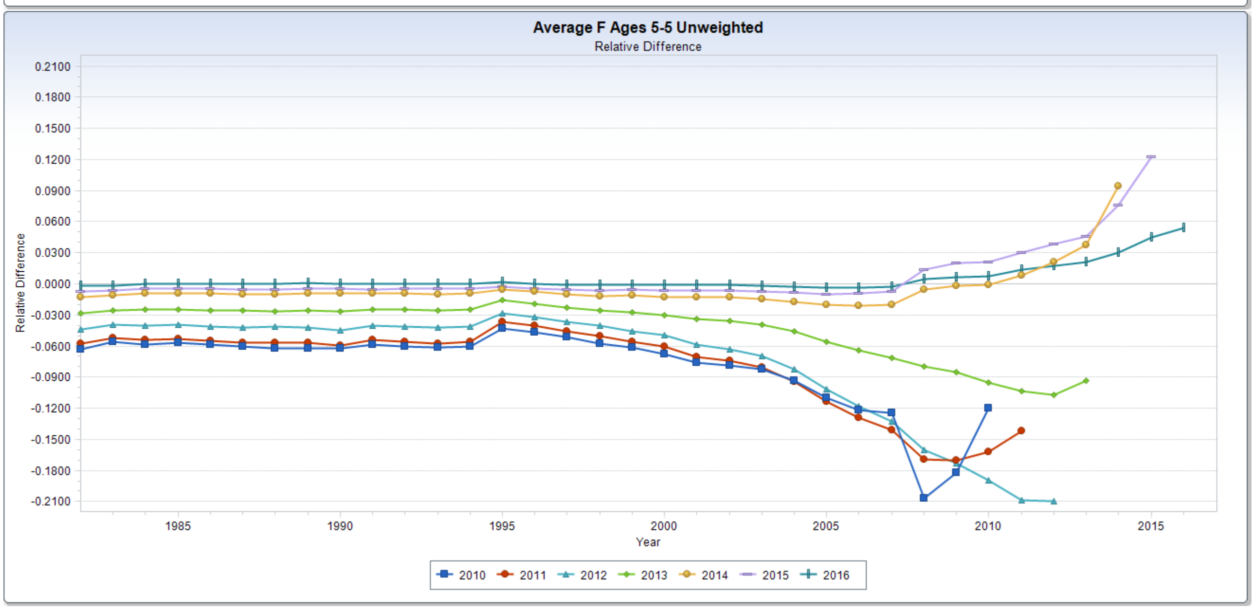


Figure A196. Results of internal model retrospective analysis for the F2018_BASE_V2 model: fully recruited F (true age 4, model age 5); average retrospective error = -4%.

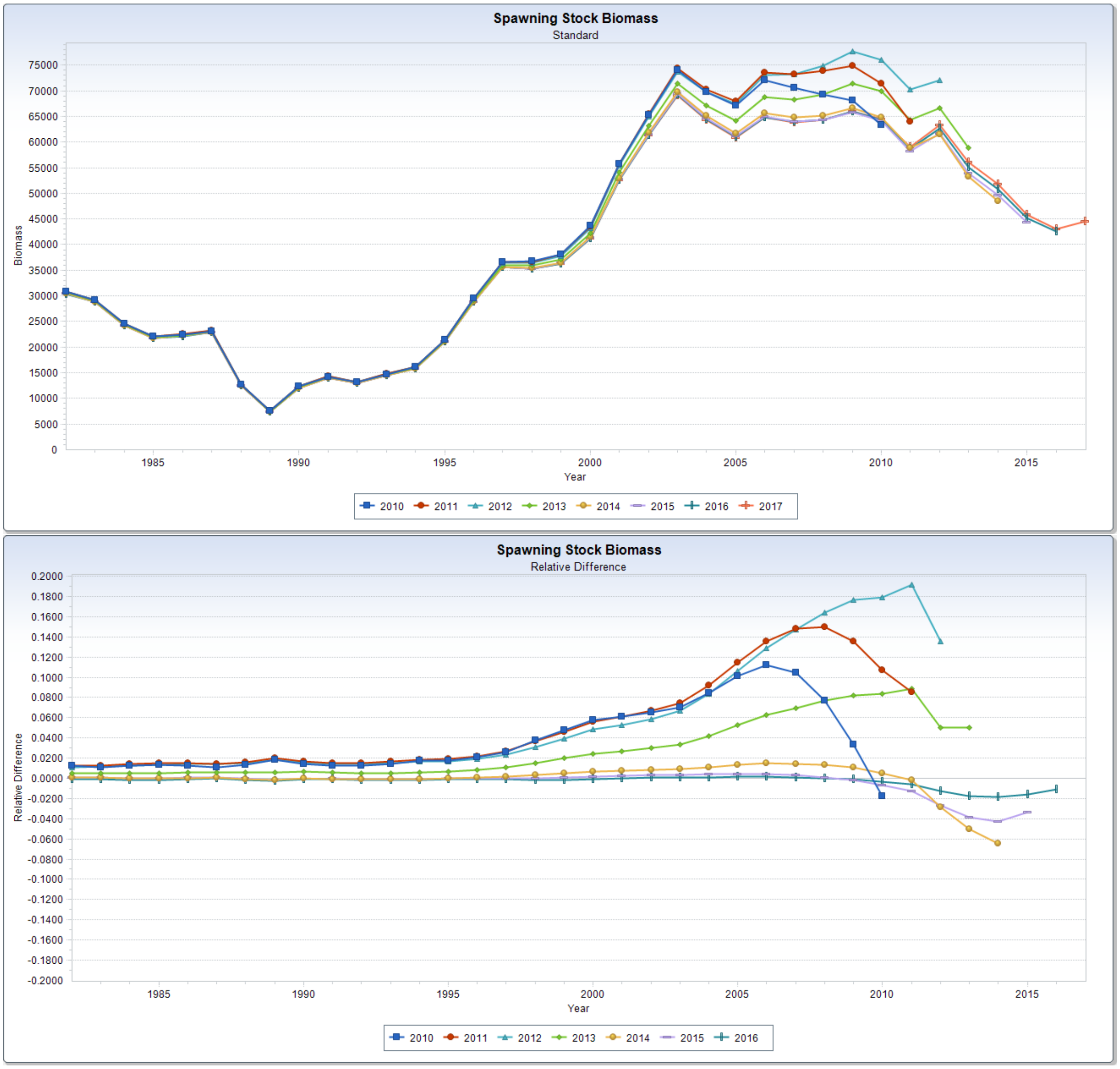


Figure A197. Results of internal model retrospective analysis for the F2018_BASE_V2 model: Spawning Stock Biomass; average retrospective error = +2%.

Figure A198. Results of internal model retrospective analysis for the F2018_BASE_V2 model: R (recruitment at true age 0, model age 1); average retrospective error = +2%.

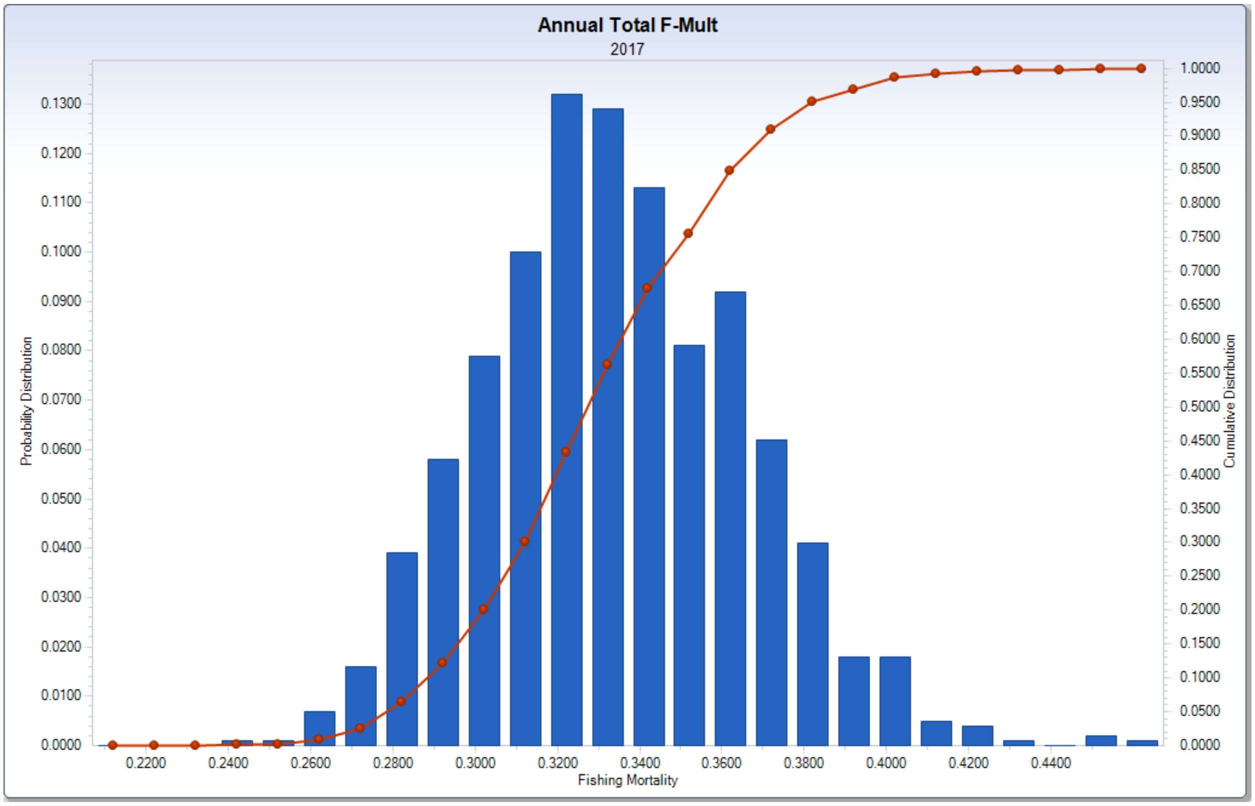


Figure A199. Markov Chain Monte Carlo probability distribution of fishing mortality rate in 2017 (fully recruited F = Fmult for model age 5 = true age 4) from model run F2018_BASE_V2.

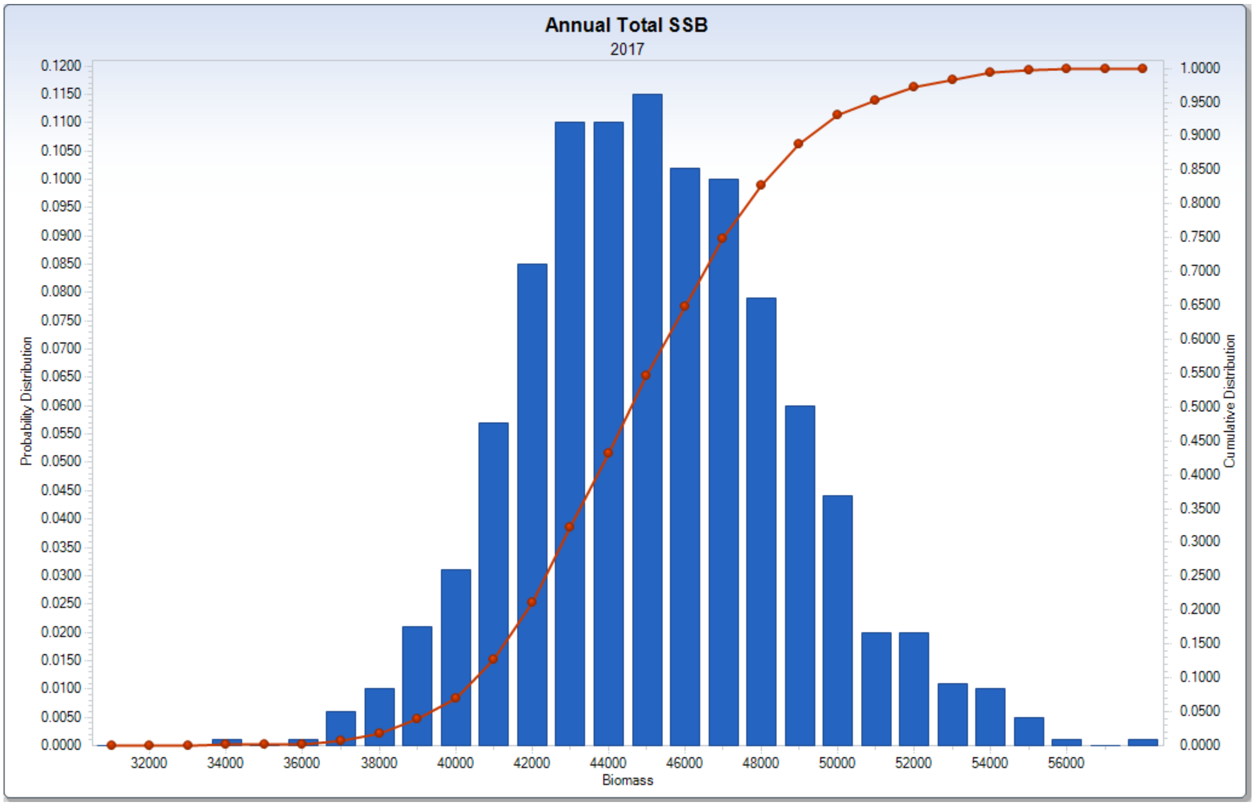


Figure A200. Markov Chain Monte Carlo probability distribution of Spawning Stock Biomass (SSB) in 2017 from model run F2018_BASE_V2.

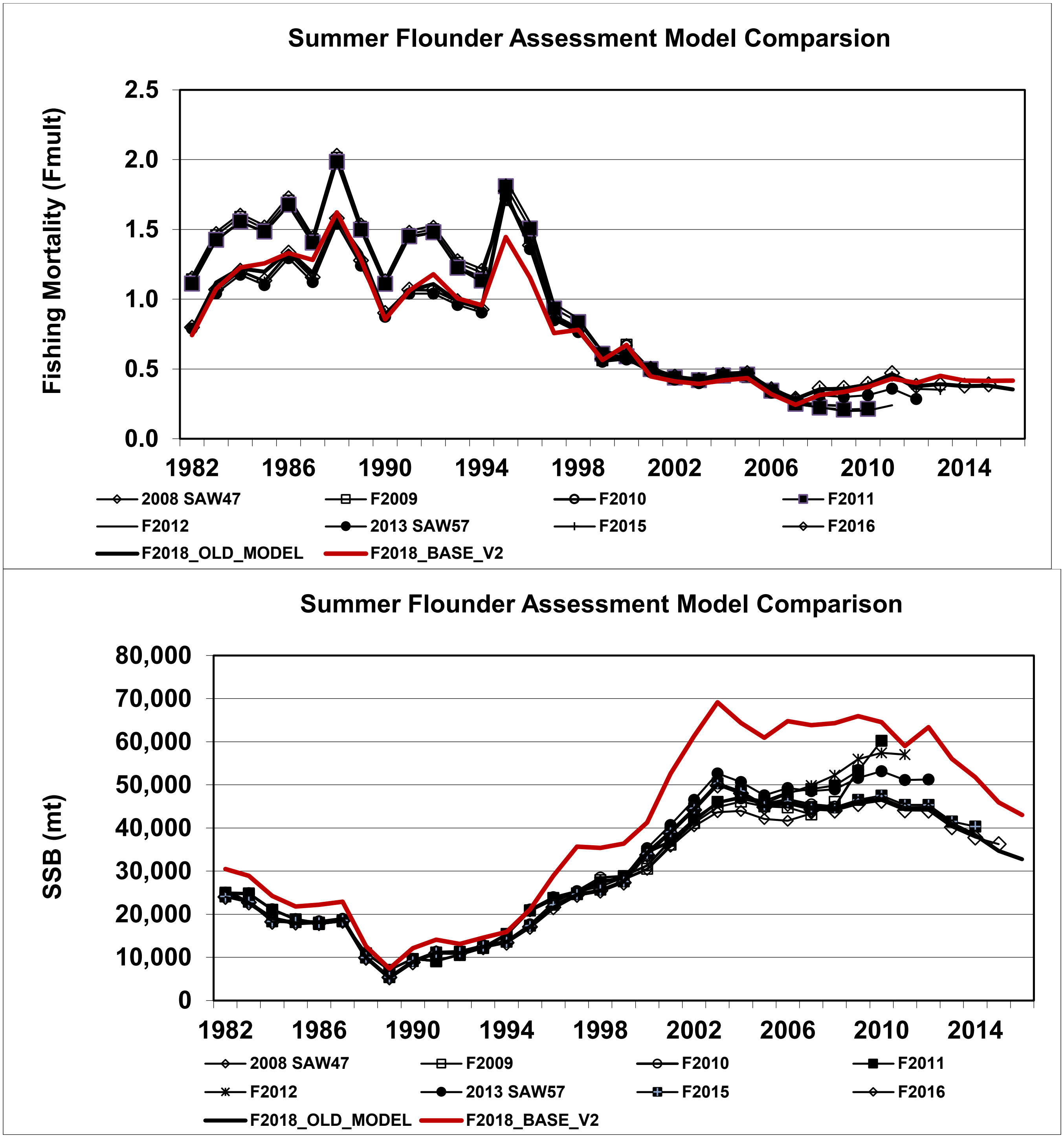


Figure A201. Comparison of the fishing mortality (top panel) and Spawning Stock Biomass (bottom panel) results from the 2008 SAW 47 benchmark assessment, the 2009-2012 assessment updates, 2013 SAW 57 benchmark assessment, the 2015-2016 assessment updates, the existing ('Old') model updated through 2017 with 'Old' MRIP (F2018_OLD_MODEL), and the final F2018_BASE_V2 model with 'New' MRIP (F2018_BASE_NEW) for the 2018 SAW-66 assessment.

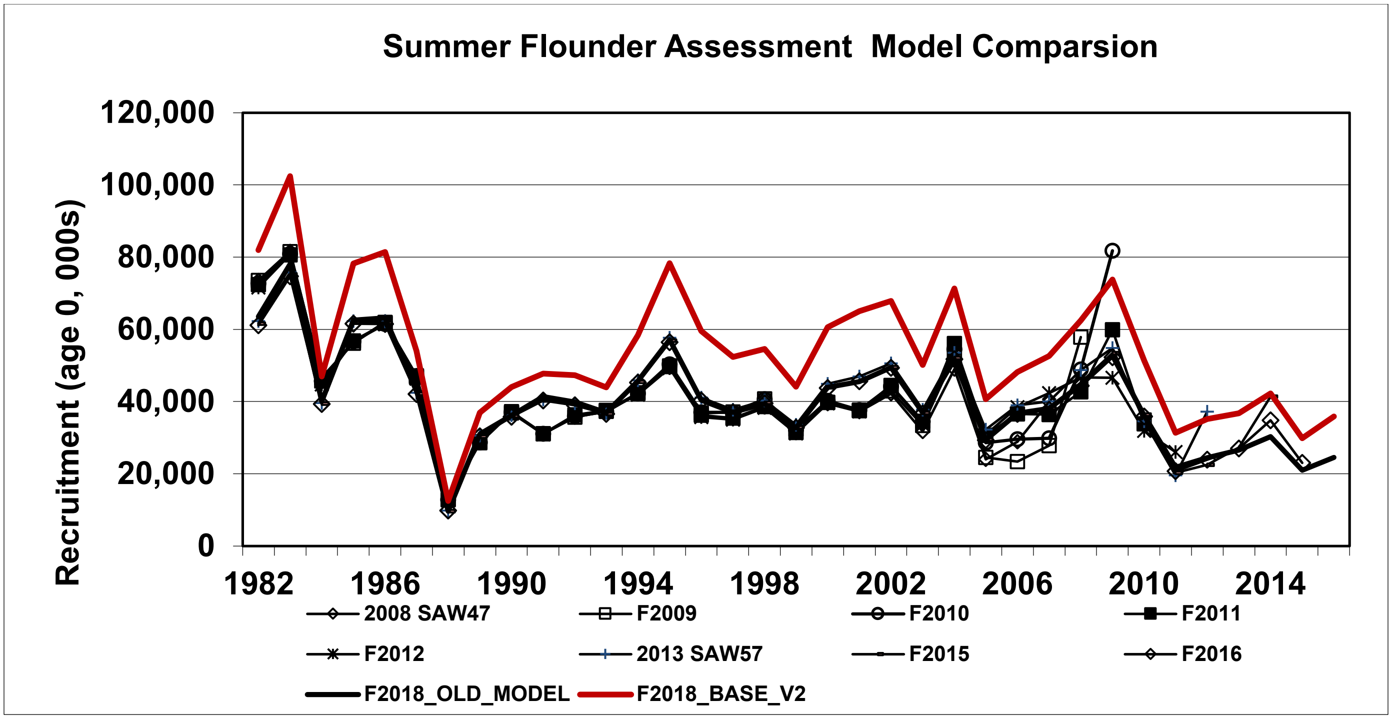


Figure A202. Comparison of the estimated stock numbers for age 0 (model age 1) from the 2008 SAW-47 benchmark assessment, the 2009-2012 assessment updates, 2013 SAW-57 benchmark assessment, the 2015-2016 assessment updates, the existing ('Old') model updated through 2017 with 'Old' MRIP (F2018_OLD_MODEL), and the final F2018_BASE_V2 model with 'New' MRIP (F2018_BASE_NEW) for the 2018 SAW-66 assessment.

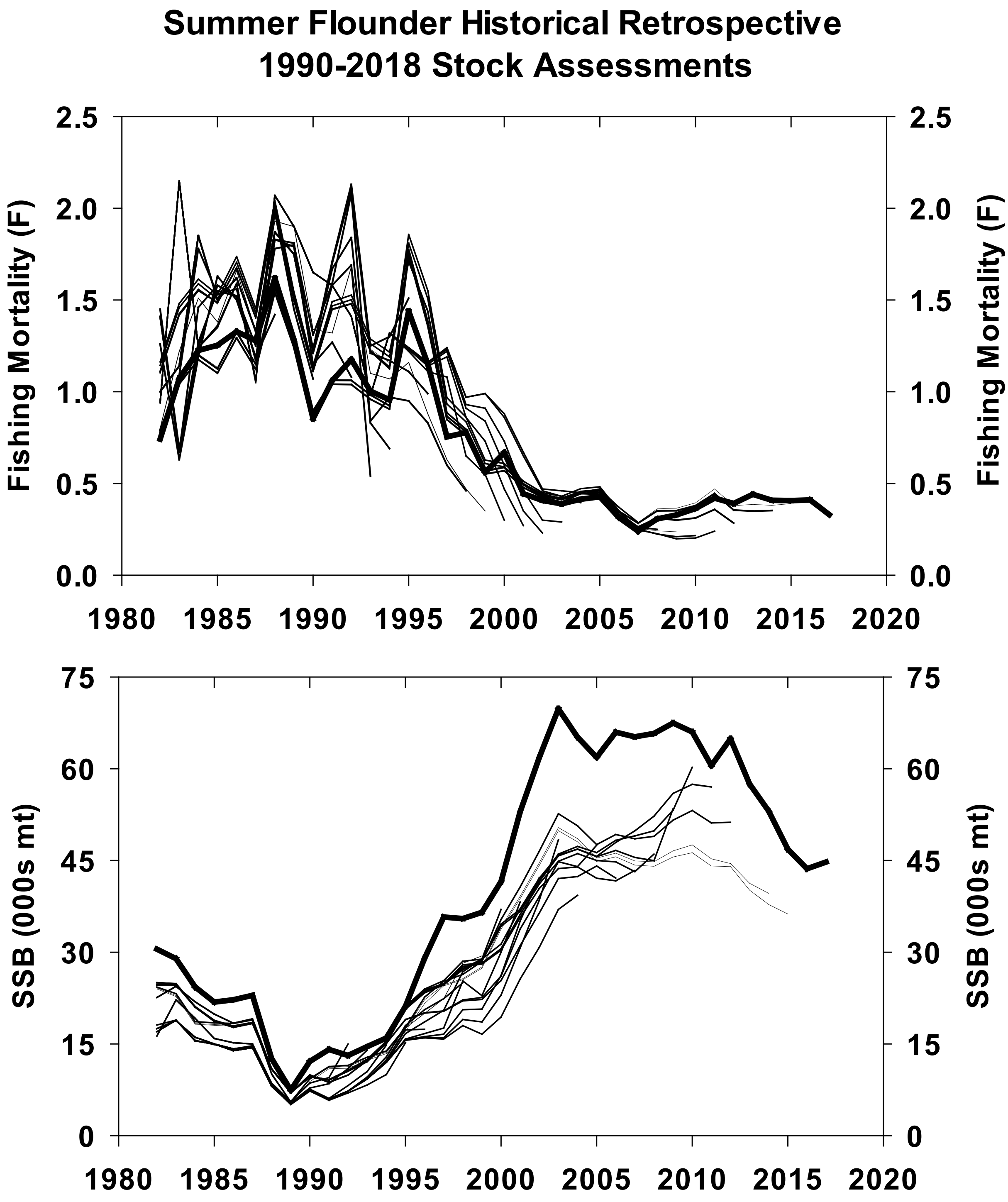


Figure A203. Historical retrospective of the 1990-2018 stock assessments of summer flounder. Note that F for the 1990-2007 assessments is reported for ages 2-7+, F for the 2008-2012 assessments is reported for ages 3-7+, while F for the 2013-2018 assessments is reported for age

4.

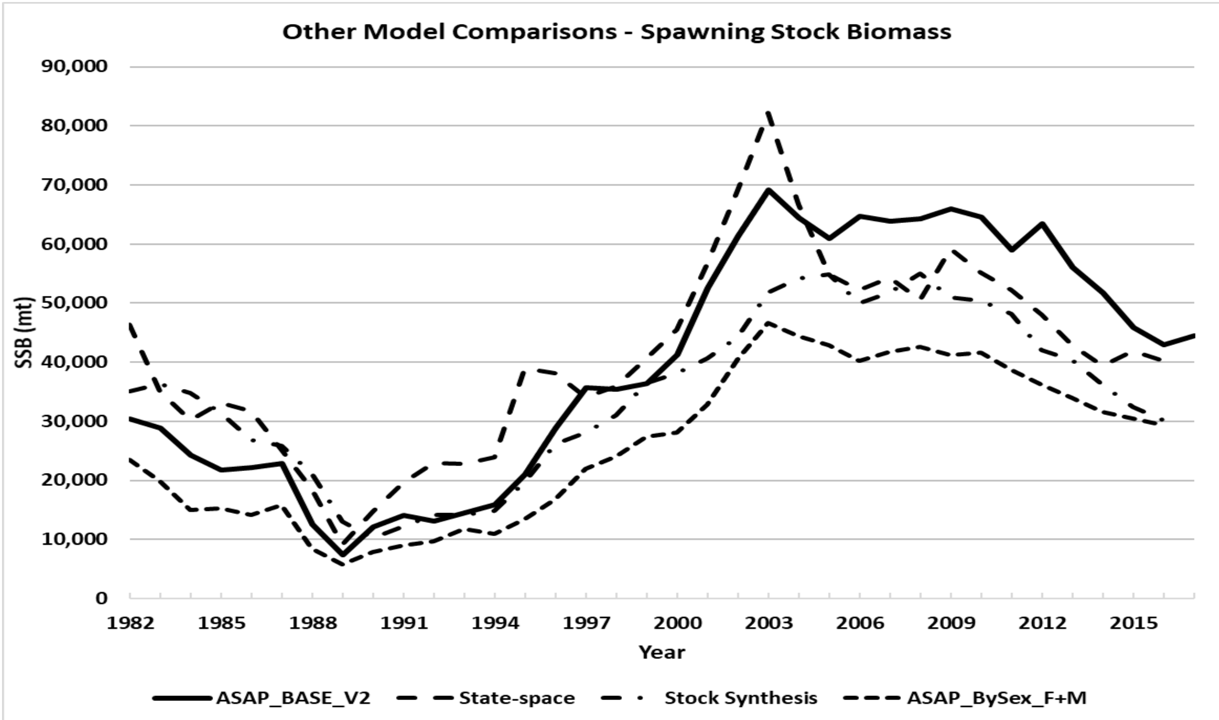


Figure A204. Comparison of spawning stock biomass from other non-preferred models to the ASAP_BASE_V2 final model configuration.

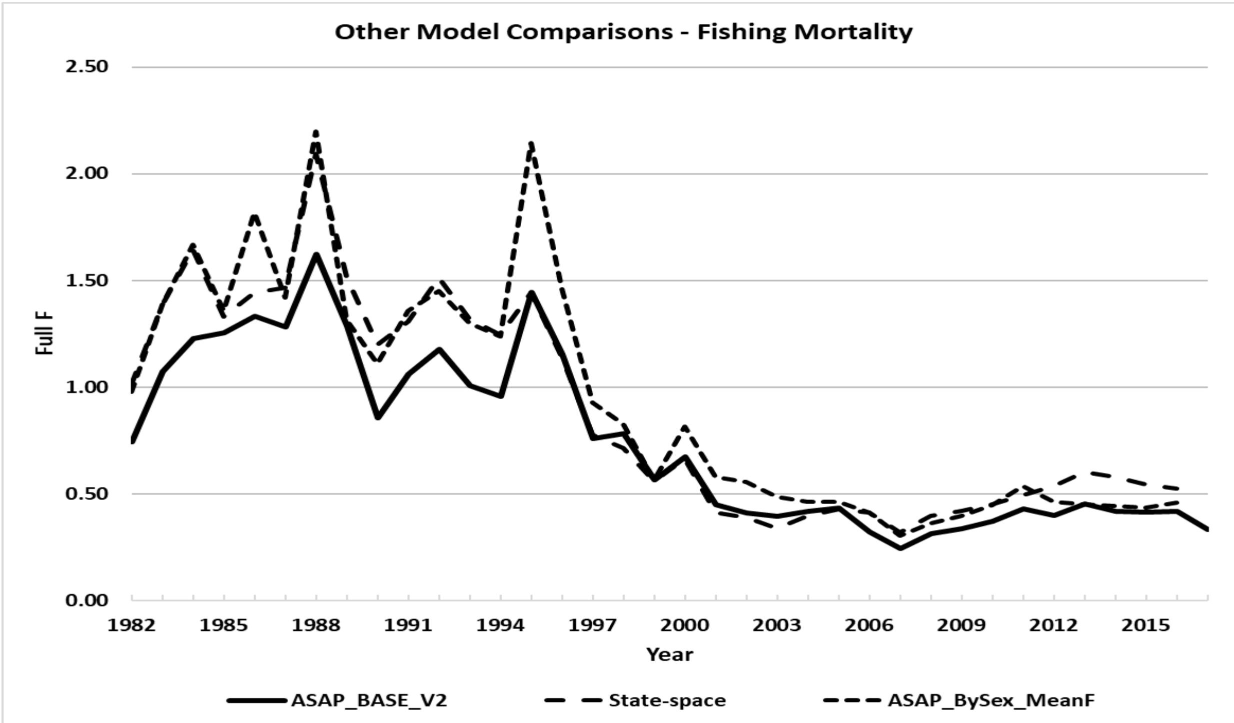


Figure A205. Comparison of fishing mortality from other non-preferred models to the ASAP_BASE_V2 final model configuration. Note: Because of Stock Synthesis use of dome-shaped, time-varying selectivity, it is not shown here.

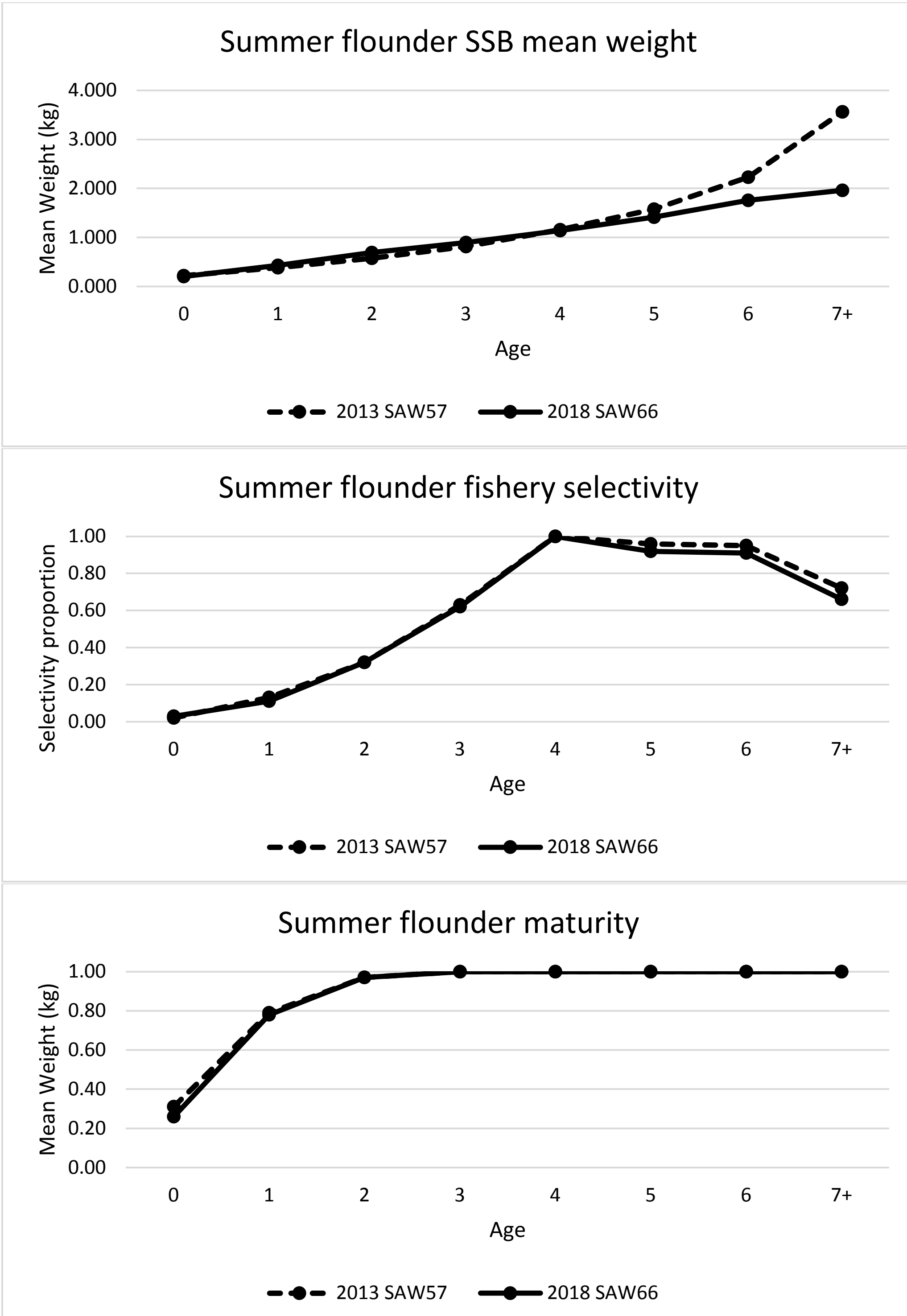


Figure A206. Patterns in Spawning Stock Biomass (SSB) mean weights at age (top), fishery selectivity at age (middle), and maturity at age (bottom) in the 2013 SAW-57 and 2018 SAW-66 summer flounder stock assessments.

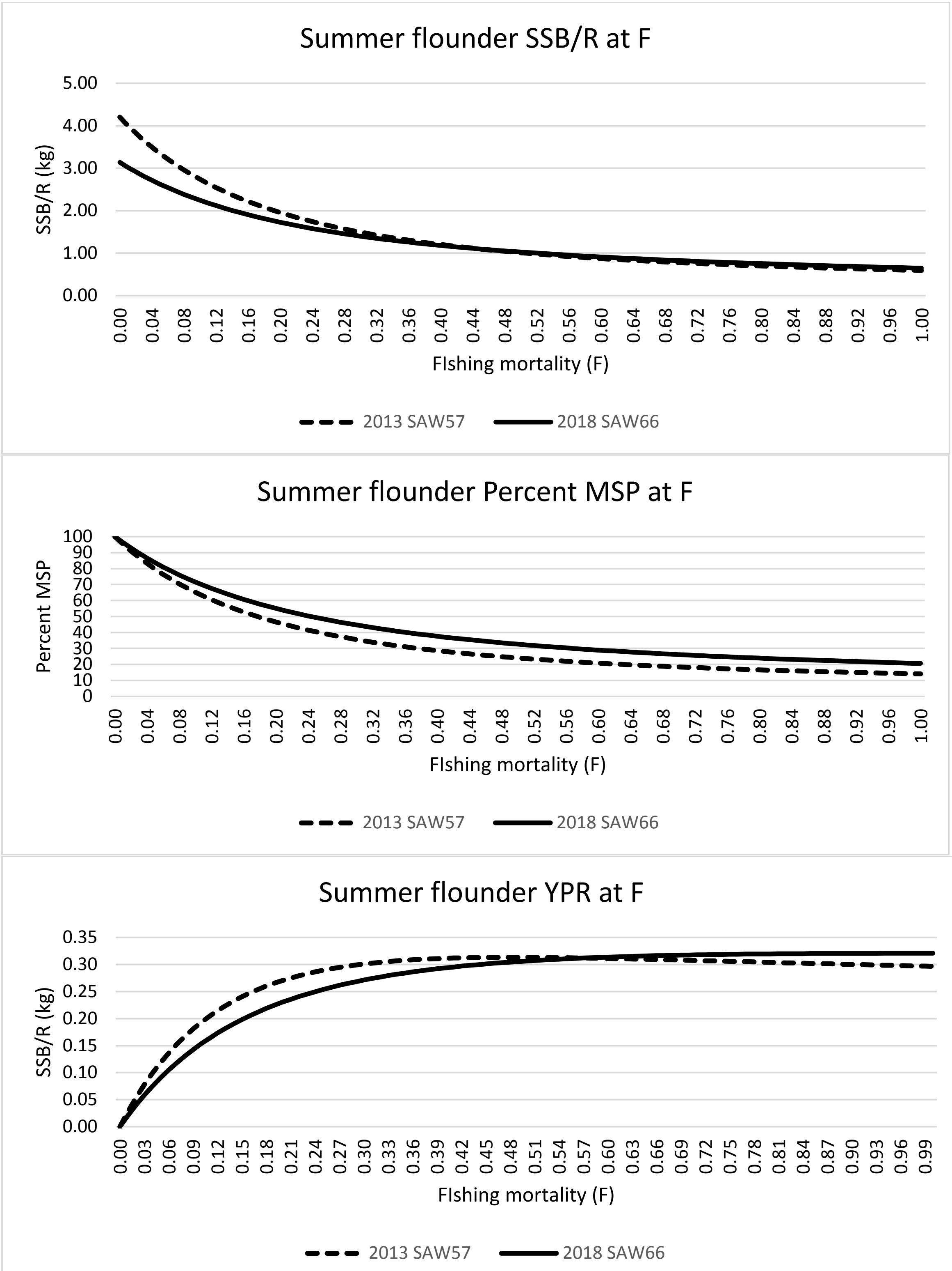


Figure A207. Patterns in Spawning Stock Biomass per Recruit (SSB/R; top), percent Maximum Spawning Potential (Percent MSP; middle), and Yield per Recruit (YPR; bottom) in the 2013 SAW-57 and 2018 SAW-66 summer flounder stock assessments.

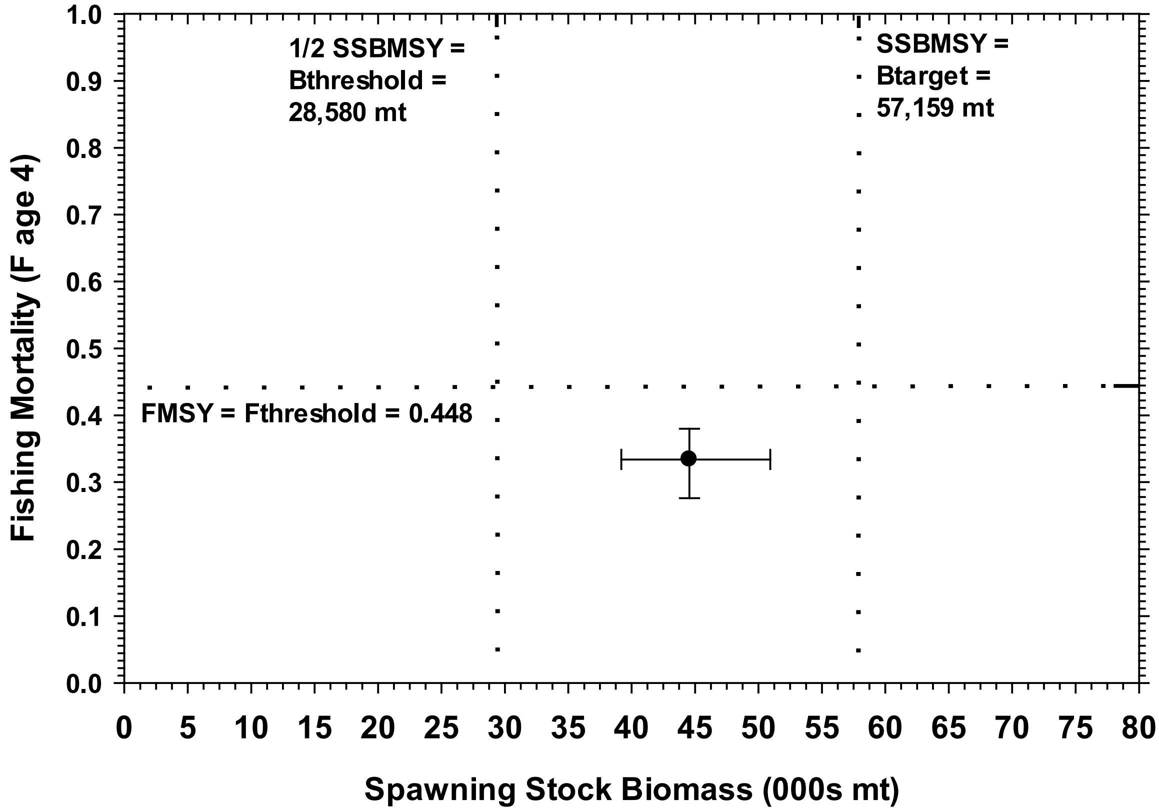


Figure A208. Estimates of summer flounder spawning stock biomass (SSB) and fully-recruited fishing mortality (F, peak at age 4) relative to the 2018 SAW-66 recommended biological reference points. Filled circle with 90% confidence intervals shows the assessment point estimates. The open circle shows the retrospectively adjusted estimates.

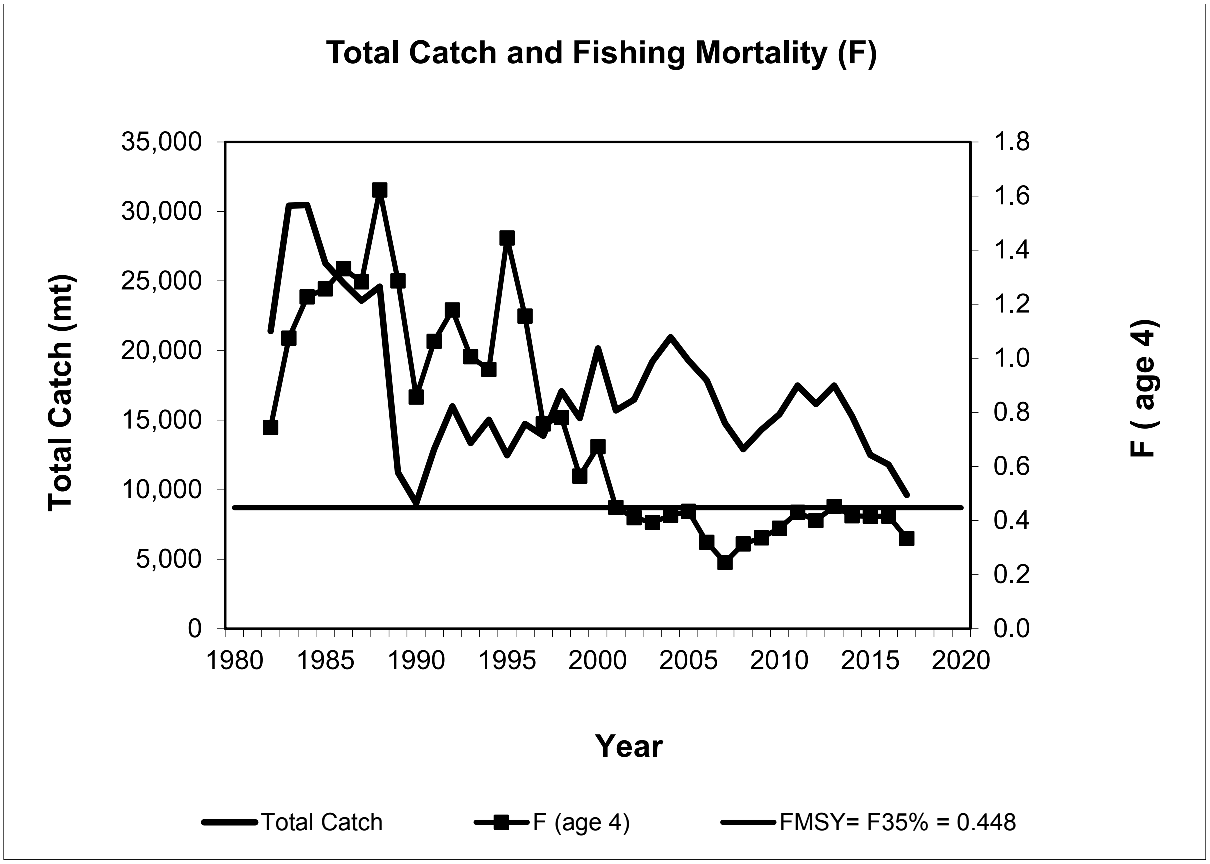


Figure A209. Total fishery catch (metric tons; mt; solid line) and fully-recruited fishing mortality (F, peak at age 4; squares) of summer flounder. The horizontal solid line is the 2018 SAW-66 recommended fishing mortality reference point proxy FMSY = F35% = 0.448.

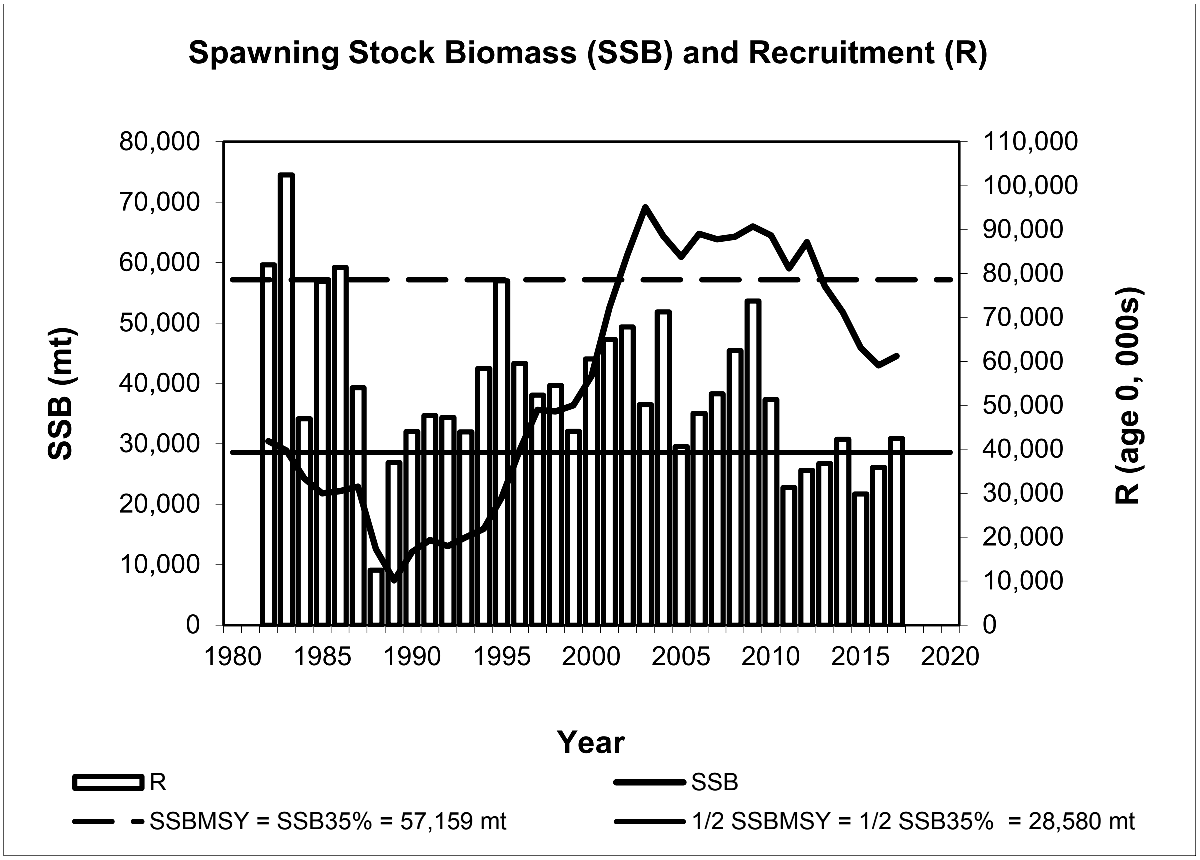


Figure A210. Summer flounder spawning stock biomass (SSB; solid line) and recruitment at age 0 (R; vertical bars) by calendar year. The horizontal dashed line is the 2018 SAW-66 recommended target biomass reference point proxy, SSBMSY = SSBF35% = 57,159 mt. The horizontal solid line is the 2018 SAW-66 recommended threshold biomass reference point proxy ½ SSBMSY = ½ SSBF35% = 28,580 mt.

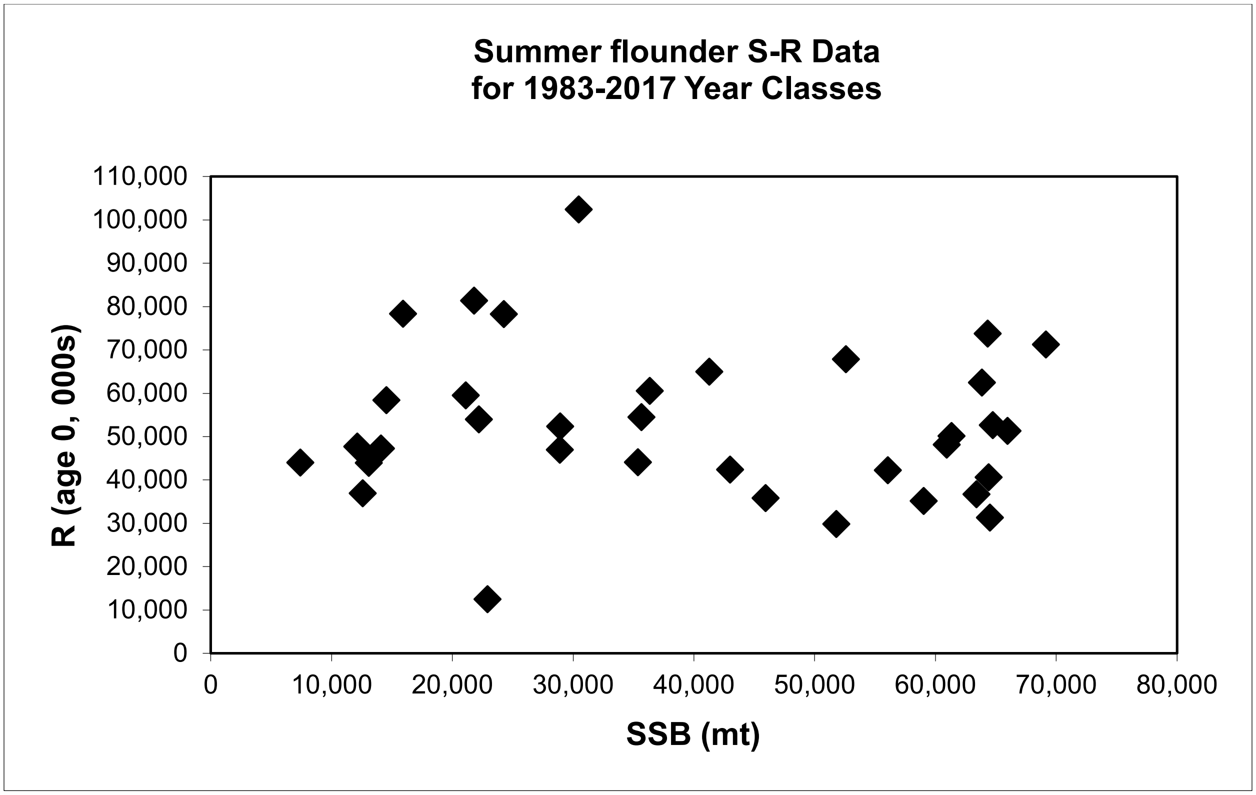


Figure A211. Stock-recruitment (SSB-R) scatter plot for the summer flounder 1983-2017 year classes. The largest recruitment (R) point is the 1983 year class (R = 102 million, SSB = 30,451 mt). The lowest recruitment point is for the 1988 year class (R = 12 million, SSB = 22,913 mt). The 2017 year class is at R = 42 million, SSB = 43,000 mt.

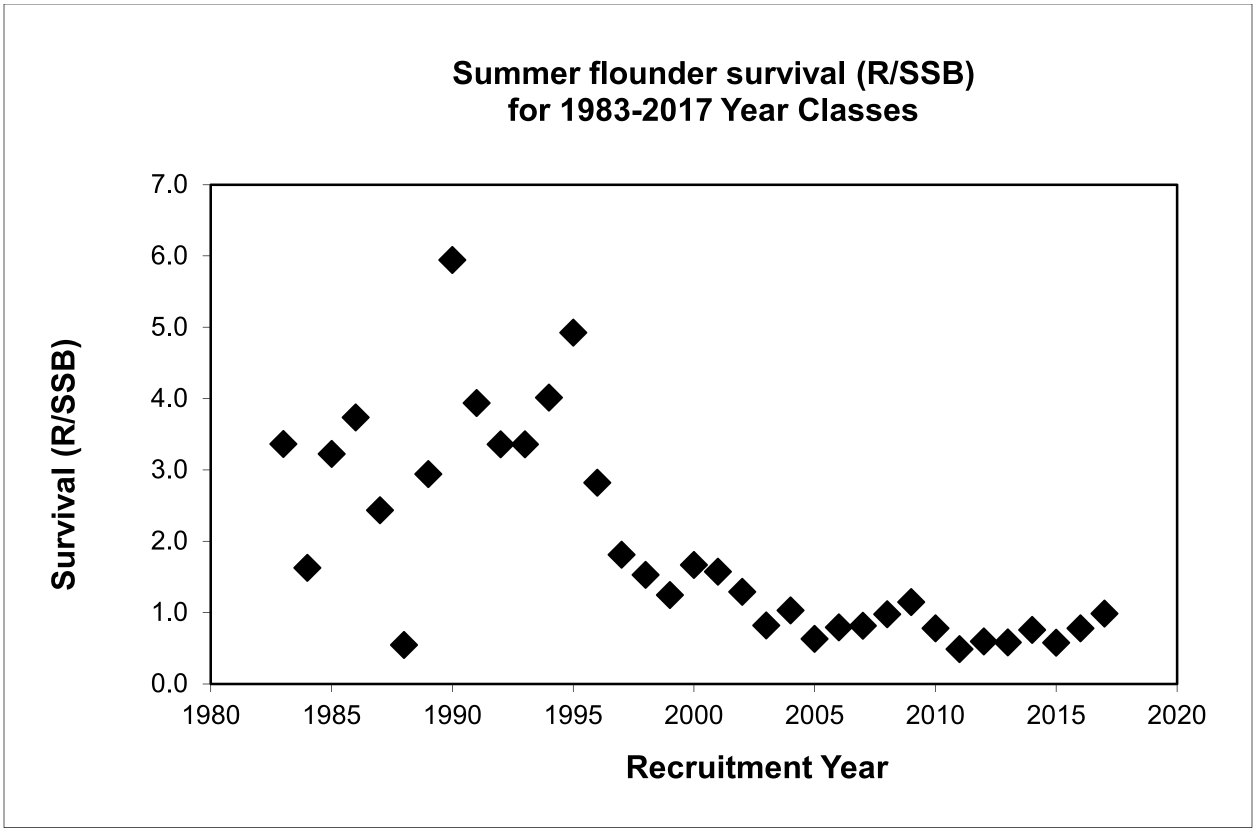
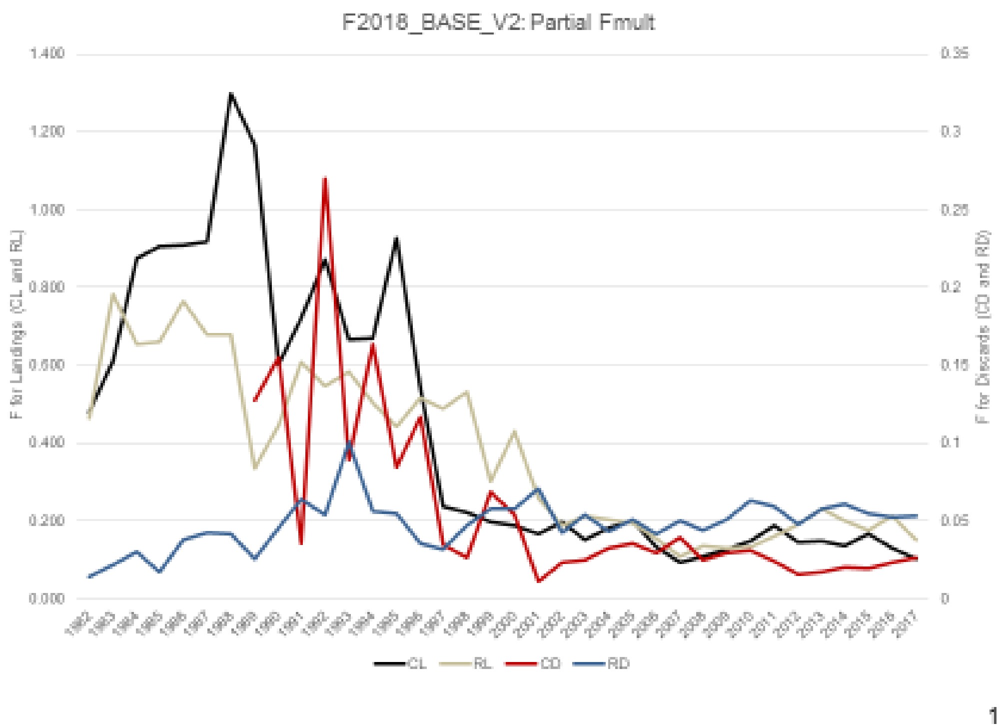
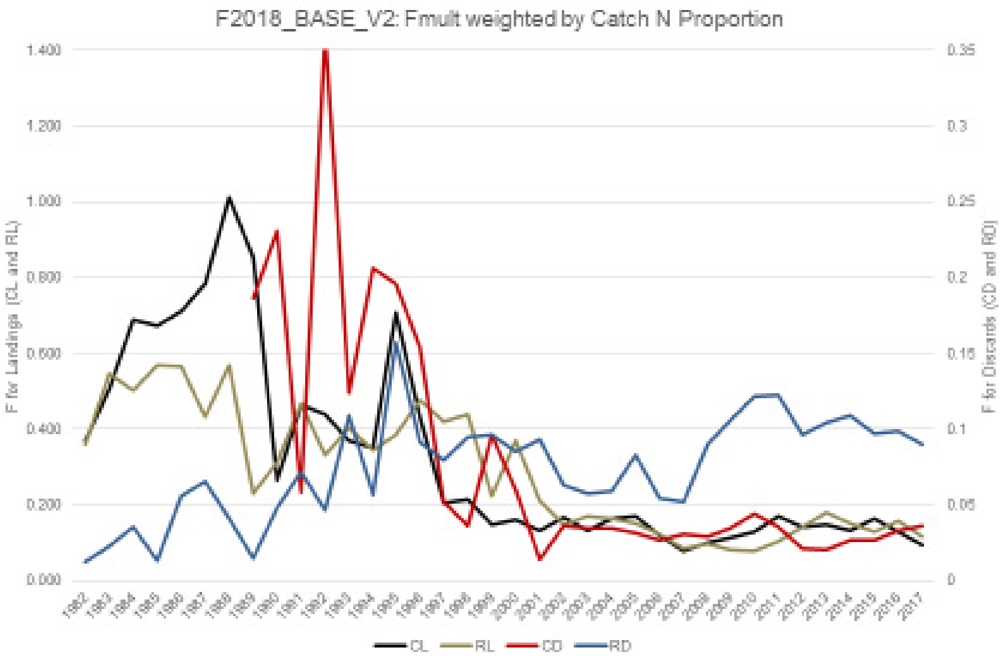


Figure A212. Recruits per Spawning Stock Biomass ratio (R/SSB) plot indicative of the relative survival of the summer flounder 1983-2017 year classes.

A. Summer flounder Appendix 1: In-meeting Analyses for the SARC

1) The SARC was interested in seeing the time series of partial Fs for the four fishery fleets plotted to see if peaks and valleys line up, to explore how much consistency there is in the landings and discards Fs estimated by year. A second presentation was compiled in which the partial Fs are weighted by the fleet total catch numbers. Both of the following plots were prepared and presented to the SARC. The SARC and working group members discussed the reasons why the patterns in landings and discards might not closely match. For the commercial fishery, discards are often regulatory in nature, rather than strictly reflective of the magnitude of directed effort and landings, and both landings and discards integrate the differing selection patterns of multiple gears. For the recreational fishery, the discards are driven strongly by annually varying state-mandated regulations. For both fisheries, discards can be high in years of strong recruitment, and therefore inconsistent with the fishery quotas and realized landings.



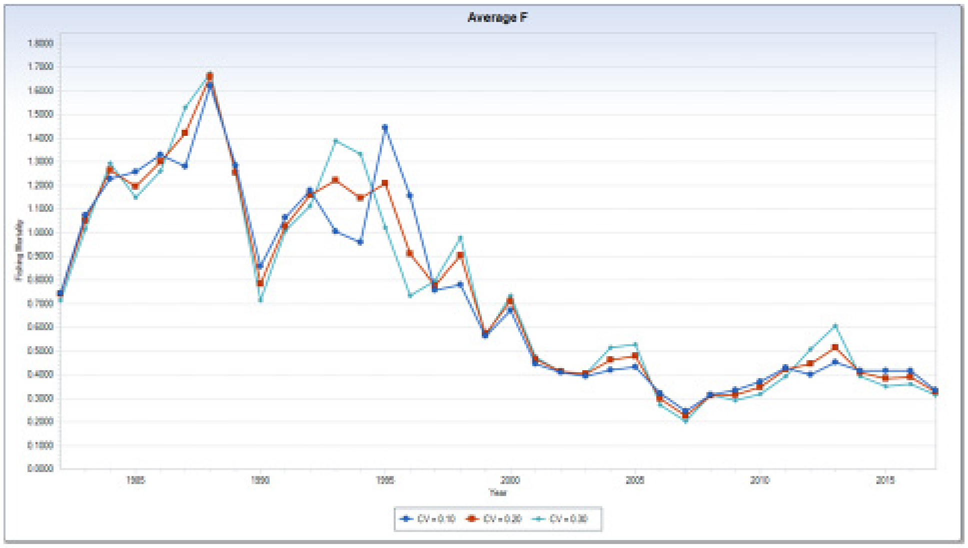

F2018_BASE_V2: Fmult weighted by Catch N Proportion
F for Landings (CL and RL)
F for Discards (CD and RD)
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
CL
RL
CD
RD

2

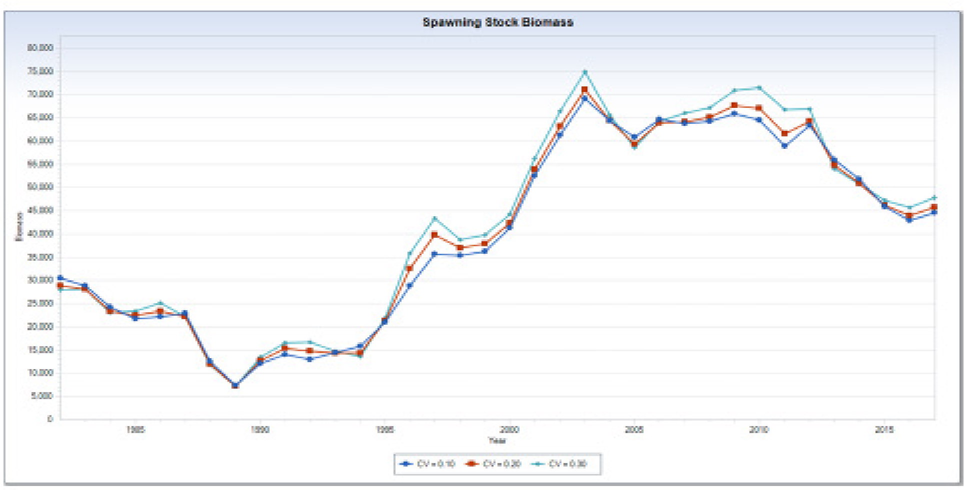
2) The SARC requested some models runs for which the catch CV (0.10 on all 4 fleets) was increased to explore the robustness of the model results when the model fit to the catch is relaxed. Alternatives models with CV = 0.20 and 0.30 were run and the comparative results presented to the SARC (figures below). The SARC concluded that the model was robust to alternative catch weightings, and suggested that this type of sensitivity be performed for future assessments.

F2018_BASE_V2			
Fleets	All CV = 0.1	All CV = 0.2	All CV = 0.3
1988 F	1.62	1.66	1.67
1995 F	1.45	1.21	1.02
2013 F	0.45	0.52	0.61
2017 F	0.33	0.33	0.32
1988 SSB	12572	11974	11877
1995 SSB	21103	21379	21955
2013 SSB	56052	54789	54050
2017 SSB	44552	45726	47796
F rho	-4%	-9%	-13%
SSB rho	+2%	+5%	+7%
Age 0 rho	+2%	+4%	+5%

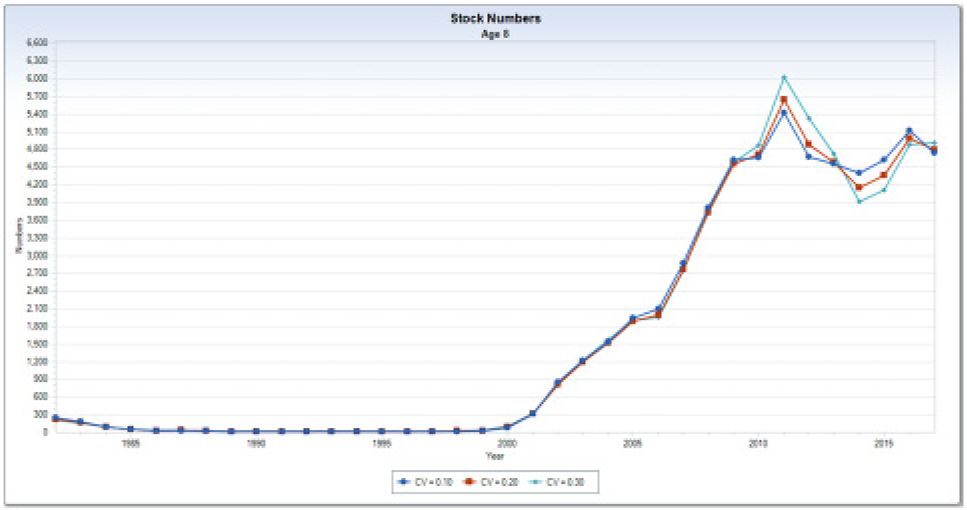
3


Average F
Fishing Mortality
Year
CV = 0.10
CV = 0.20
CV = 0.30

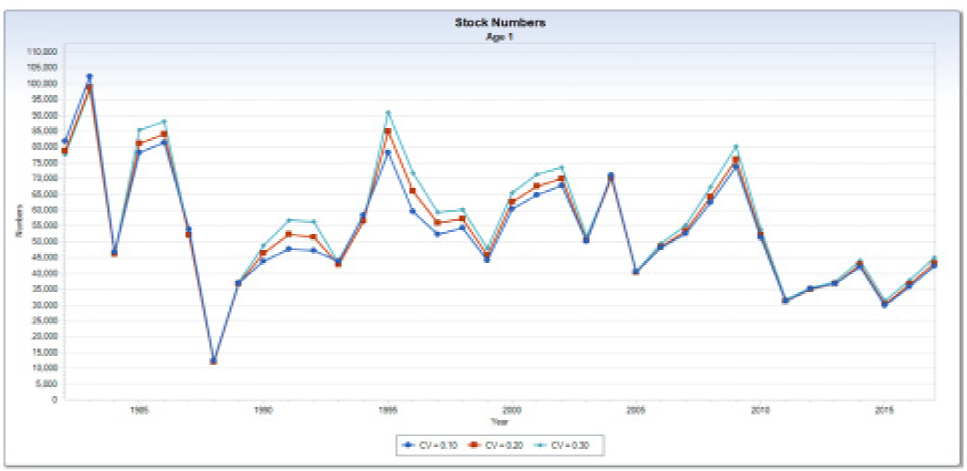
4


Spawning Stock Biomass
Biomass
Year
CV = 0.10
CV = 0.20
CV = 0.30

5


Stock Numbers
Age 8
Numbers
Year
CV = 0.10
CV = 0.20
CV = 0.30

7


Stock Numbers
Age 1
Numbers
Year
CV = 0.10
CV = 0.20
CV = 0.30

6

B: STRIPED BASS STOCK ASSESSMENT FOR 2018

ACKNOWLEDGEMENTS

Special thanks to former Technical Committee member and Stock Assessment Subcommittee Chairman, Edward Hale, for his many contributions to this assessment prior to his departure from Delaware Division of Fish and Wildlife. Also, thanks to Dave Secor for sharing his preliminary data on Atlantic striped bass migration rates.

B1.0 CONTRIBUTORS

Members of the ASMFC Atlantic Striped Bass Technical Committee, Stock Assessment Subcommittee, and Tagging Subcommittee:

Michael Celestino, New Jersey Division of Fish and Wildlife, Stock Assessment Subcommittee Chair
Nicole Lengyel, Rhode Island Division of Marine Fisheries, Technical Committee Chair
Dr. Stuart Welsh, West Virginia University, Tagging Subcommittee Chair
Gail Wippelhauser, Maine Department of Marine Resources
Kevin Sullivan, New Hampshire Department of Fish and Game
Dr. Gary Nelson, Massachusetts Division of Marine Fisheries
Justin Davis, Connecticut Department of Energy and Environmental Protection, Marine Fisheries
Kurt Gottschall, Connecticut Department of Energy and Environmental Protection, Marine Fisheries
Jessica Best, New York Department of Environmental Conservation, Marine Resources
Carol Hoffman, New York Department of Environmental Conservation, Marine Resources
Brendan Harrison, New Jersey Division of Fish and Wildlife
Michael Kaufmann, Pennsylvania Department of Conservation and Natural Resources
Ian Park, Delaware Division of Fish and Wildlife
Dr. Hank Liao, Old Dominion University
Angela Giuliano, Maryland Department of Natural Resources
Dr. Alexei Sharov, Maryland Department of Natural Resources
Beth Versak, Maryland Department of Natural Resources
Ellen Cosby, Potomac River Fisheries Commission
Alex Aspinwall, Virginia Marine Resources Commission
Chris Bonzek, Virginia Institute of Marine Science
Charlton Godwin, North Carolina Department of Natural Resources
Jeremy McCargo, North Carolina Department of Natural Resources
Gary Shepherd, National Marine Fisheries Service, Northeast Fisheries Science Center
Dr. John Sweka, U.S. Fish and Wildlife Service
Steve Minkkinen, U.S. Fish and Wildlife Service
Dr. Wilson Laney, U.S. Fish and Wildlife Service
Josh Newhard, U.S. Fish and Wildlife Service

And

Dr. Katie Drew, ASMFC Stock Assessment Team Leader
Max Appelman, ASMFC Fishery Management Plan Coordinator

B2.0 TERMS OF REFERENCE (TOR)

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.

2. Estimate commercial and recreational landings and discards. Characterize the uncertainty in the data and spatial distribution of the fisheries. Review new MRIP estimates of catch, effort and the calibration method, if available.

3. Use an age-based 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 and sex, where possible, and for total stock complex.

4. Use tagging data to estimate mortality and abundance, and provide suggestions for further development.

5. Update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, SSB_{MSY}, F_{MSY}, MSY) for each stock component where possible and for the total stock complex. Make a stock status determination based on BRPs by stock component, where possible, and for the total stock complex.

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.

7. Review and evaluate the status of the Technical Committee research recommendations listed in the most recent SARC report. Identify 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 – 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.

Age-specific and aggregate indices of relative striped bass abundance are provided by states from fisheries-dependent and fisheries-independent sources. The Atlantic Striped Bass Stock Assessment Subcommittee (SAS) reviewed all indices used in the previous benchmark stock assessment (SAW 57) as well as several new indices. The SAS used a set of evaluation criteria to determine which indices should be considered for inclusion in the assessment. Based on their evaluation, the SAS dropped the Virginia Pound Net and the Northeast Fisheries Science Center Bottom Trawl Survey (NEFSC) as indices for this assessment. The ChesMMAP survey was introduced as a new index to replace the Virginia Pound Net as an adult index for the Chesapeake Bay. The Delaware Bay 30' Trawl survey was also introduced to provide information regarding the striped bass population in Delaware Bay. The following sources were included in the current assessment:

MRIP Total Catch Rate Index
Connecticut Long Island Sound Trawl Survey (CTLISTS)
New York Young-of-the-Year (NYYOY)
New York Western Long Island Beach Seine Survey (NY Age-1)
New York Ocean Haul Seine (NYOHS)
New Jersey Bottom Trawl Survey (NJTRL)
New Jersey Young-of-the-Year Survey (NJYOY)
Delaware Spawning Stock Electrofishing Survey (DESSN)
Delaware 30' Bottom Trawl Survey (DE30)
Maryland Spawning Stock Survey (MDSSN)
Maryland Young-of-the-Year and Yearlings Surveys (MDYOY and MD Age-1)
Virginia Young-of-the-Year Survey (VAYOY)
Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP)

Although not included as an index in the assessment, the Northeast Area Monitoring & Assessment Program (NEAMAP) provided valuable biological data (e.g., age and sex data) for this assessment.

B3.2 Major Findings for TOR 2 - Estimate commercial and recreational landings and discards. Characterize the uncertainty in the data and spatial distribution of the fisheries. Review new MRIP estimates of catch, effort and the calibration method, if available.

Commercial and recreational data from the inland and ocean waters of Maine through Virginia, and the ocean waters of North Carolina were used in this assessment. Striped bass from the inland waters of North Carolina and states further south are believed to be non-migratory, based on tagging data, and are not considered part of the coastal migratory stock. Therefore, data from those regions are not included in this assessment.

Strict commercial 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. Limited data on commercial discarding of striped bass was provided by Maryland and New Jersey and used, in combination with literature values and values from the previous assessment, to determine the discard mortality rates for commercial fishing gears. Recreational catch and harvest estimates for Atlantic striped bass were provided by the Marine Recreational Information Program (MRIP, formerly the Marine Recreational Fisheries Statistics Survey or MRFSS). These data include the newly calibrated MRIP estimates that were released on July 9, 2018. Calibrated annual estimates of recreational harvest (numbers of fish) and total catch (released + harvested fish) are on average 140% and 160% higher than prior MRIP estimates, respectively. Although the magnitude of these estimates has changed, the overall trend throughout time remains similar for both catch and harvest.

Following the striped bass stock reaching an all-time low, 151,000 pounds (68.5 mt or 3,730 fish) were landed in the commercial fishery in 1986. Commercial landings for striped bass increased in the 1990's as the stock recovered and management measures were liberalized. Between 2004 and 2014 landings were relatively stable due to the commercial quota system with average landings of 6.5 million pounds (2,948 mt) per year (943,000 fish per year). In response to the findings of the 2013 benchmark stock assessment, Addendum IV to the striped bass fishery management plan implemented harvest reductions 2015 for both the commercial and recreational sectors. On the commercial side, this was accomplished through a quota reduction. Since implementation of Addendum IV, coastwide commercial landings for Atlantic striped bass have decreased to an average of 4.7 million pounds (2,132 mt or 608,000 fish). Although the age structure of commercial harvest varies from state to state due to size regulations, season of the fisheries, and the size classes of striped bass available to the fisheries, from 2004-2014 ages 3-9 made up 86.5% of the commercial catch in numbers. The implementation of higher size limits in 2015 in several jurisdictions reduced the proportion of age-3 fish in the catch in subsequent years.

Commercial landings have generally exceeded discards since the early 1990's with discards comprising approximately 15% of the total commercial removals from 2015-2017. The Chesapeake Bay fisheries are estimated to have a lower proportion of commercial dead discards than the fisheries in the ocean and other areas; however, the Chesapeake Bay fisheries accounted for 74% of the total commercial removals by number from 2015-2017.

Recreational harvest of striped bass follows a similar trend to the commercial harvest. Since 1984 when landings were at their lowest (264,000 fish), harvest has increased reaching a high of 5.4 million fish in 2010. Between 2004 and 2014, harvest remained at a steady level averaging 4.7 million fish per year. Following the implementation of the size and bag limit changes in the recreational fisheries in Addendum IV, harvest decreased to an average of 3.2 million fish for 2015-2017. The number of recreational dead releases peaked in 2006 at 4.8 million fish and declined through 2011 to 1.5 million fish. Live releases increased after that with an average of 2.9 million dead releases estimated for 2015-2017.

B3.3 Major Findings for TOR 3 – Use an age-based 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 and sex, where possible, and for total stock complex.

For this assessment, the statistical catch-at-age model currently used for management was extensively modified to model two biologically distinct stocks. **However, the SARC-66 Panel concluded that the two stock model was not acceptable to serve as a basis for fishery management advice. The SARC-66 Panel recommended that the single stock statistical catch-at-age (SCA) model, which was accepted at SAW/SARC-57 and updated with new data for this assessment, be used for management. Therefore, final population estimates and stock status determinations were based on the single stock SCA and are presented below.**

The SCA model estimated annual recruitment, annual full F by fleet, and selectivity parameters for indices and fleets in order to calculate abundance and female spawning stock biomass (SSB). Recruitment was estimated as deviations from mean recruitment. Removals were separated into two fleets, a Chesapeake Bay fleet and an ocean fleet. The ocean fleet included removals from ocean waters and other areas such as Delaware Bay and Long Island Sound.

The combined full F was 0.307 in 2017. Fishing mortality for both the Chesapeake Bay fleet and the ocean fleet has been increasing since 1990.

The stock appears to have experienced a period of low recruitment at the beginning of the time series. Mean recruitment through the early 1990s to the present has been higher. The 2015 year class was strong, as was the 2011 year class, but the 2016 year class was below average. Recruitment in 2017 was estimated at 108.8 million age-1 fish, below the time series mean of 140.9 million fish.

Total striped bass abundance (age-1+) increased steadily from 1982 through 1997 when it peaked around 420 million fish. Total abundance fluctuated without trend through 2004 before declining to around 189 million fish in 2009, coinciding with several years of below average recruitment. There were upticks in abundance in 2012 and 2016, due to the strong 2011 and 2015 year classes. Total age-1+ abundance was 249 million fish in 2017. Abundance of age-8+ striped bass (considered the mature component of the population) increased steadily through 2004 to 16.5 million fish. After 2004 age-8+ abundance oscillated and has been in decline since 2011. Age-8+ abundance in 2017 is estimated at 6.7 million fish, a value near the 30th percentile of the time-series.

Female SSB started out at low levels and increased steadily through the late-1980s and 1990s, peaking at 113,602 mt (250 million pounds) in 2003 before beginning to gradually decline; the decline became sharper in 2012. Female SSB was at 68,476 mt (151 million pounds) in 2017, below the SSB threshold of 91,436 mt (202 million pounds).

Total biomass showed a similar pattern to SSB. Total biomass was very low at the beginning of the time series. Total biomass increased through the 1980s and 1990, peaking in 1999 at 334,661 mt (738 million pounds) before declining again. The total biomass of Atlantic coastal migratory stock striped bass was 173,663 mt (383 million pounds) in 2017.

B3.4 Major Findings for TOR 4 – Use tagging data to estimate mortality and abundance, and provide suggestions for further development.

The 2017 estimates of F for fish $\geq$ 28 inches (711 mm) among coastal programs (excluding NYTRL) ranged from 0.07 (NJDB) to 0.12 (NCCOOP) where the unweighted average F was 0.09. The 2017 F estimates for the producer area programs ranged from 0.06 (VARAP) to 0.16 (HUDSON) with a weighted average of 0.09. For fish ≥ 18 inches (457 mm), the 2017 estimates of F among coastal programs (excluding NCCOOP) were similar, ranging from 0.06 (NYTRL) to 0.08 (MADFW) resulting in an unweighted average of 0.07. The average F value varied without trend ranging from 0.07 to 0.13 since 1995. The estimates of F for the producer area programs showed more variation, ranging from 0.06 (VARAP) to 0.12 (HUDSON) for a weighted average of 0.09.

For fish ≥ 28 inches (711 mm), the 2017 coastal program estimates of M (excluding NYTRL) ranged from 0.24 (MADFW) to 0.32 (NCCOOP) with an unweighted average of 0.27. The 2017 range of M values from the producer area programs was 0.27 (HUDSON) to 0.40 (VARAP) with a weighted mean of 0.35. For fish ≥ 18 inches (457 mm), the 2017 estimates of M from the coastal programs (excluding NCCOOP) ranged from 0.24 (MADFW) to 0.42 (NYTRL) with an unweighted average of 0.32. Producer area estimates for 2017 ranged from 0.32 (HUDSON) to 0.60 (VARAP) with a weighted average of 0.49. Overall natural mortality estimates were much higher for the producer area programs which could be driven by the prevalence of *Mycobacteriosis* in the Chesapeake Bay.

For fish ≥ 28 inches (711 mm) stock size estimates for 2017 were 20.9 million, a decrease from the peak value of 39 million that was reached in 2010. The stock size estimates for fish ≥ 18 inches (457 mm) have been decreasing since the peak of 95.4 million in 2006 and was estimated to be 61.4 million in 2016. In 2017 however, estimates showed an increase to 78.1 million.

The primary research need is to improve the estimate of the tag reporting rate. Factors that could be improved upon and may be contributing to the low reporting rate include a decline in tag quality, which has resulted in tags being illegible; angler fatigue as the tagging program has existed since 1987 with no change in reward; and the decrease in tag returns, particularly from the commercial sector.

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

The reference points currently used for management are based on the 1995 estimate of female SSB. The 1995 female SSB is used as the SSB threshold because many stock characteristics (such as an expanded age structure) were reached by this year and the stock was declared recovered. Estimates of female SSB_{1995} from the 2013 benchmark assessment were quite consistent across runs with different recruitment functions. The values currently used in management are $SSB_{Threshold}$ = female SSB_{1995} = 57,626 mt and SSB_{Target} = 125% female SSB_{1995} = 72,032 mt. To estimate the F threshold, population projections were made using a constant F and changing the value until the SSB threshold value was achieved. The projected F to maintain $SSB_{Threshold}$ = $F_{Threshold}$ = 0.22, and the projected F to maintain SSB_{Target} = F_{Target} = 0.18.

For this assessment the reference point definitions remained the same, but values were updated. The SSB threshold was estimated at 91,436 mt (202 million pounds), with an SSB target of 114,295 mt (252 million pounds). The F threshold was estimated at 0.240, and the F target was estimated at 0.197.

Female SSB for Atlantic striped bass in 2017 was 68,476 mt, below the SSB threshold, indicating the stock is overfished. F in 2017 was 0.307, above the F threshold, indicating the stock is experiencing overfishing. Model-based estimates of MSY were not calculated for this assessment.

B3.6 Major Findings for TOR 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.

Six-year projections of female spawning stock biomass (SSB) were made by using the same population dynamics equations used in the assessment model. Four scenarios of constant catch or F were explored.

The model projection began in year 2018. A composite selectivity pattern was calculated as the geometric mean of 2013-2017 of total F-at-age, scaled to the highest F. Residuals from the stock-recruitment fit were randomly re-sampled and added to the deterministic predictions of recruitment from the hockey-stick recruitment function to produce stochastic estimates of age-1 recruitment for each year of the projection. Projections were done using constant 2017 catch, constant 2017 F, F equal to $F_{threshold}$, and F equal the F required to achieve the 1993 estimate of female SSB in the long term.

Under status quo F ($F=F_{2017}$), the population trajectory remained relatively flat from 2018–2023; reducing F to the F threshold resulted in an increasing trend in SSB. However, under all four scenarios, the probability of female SSB being below the SSB threshold in 2023 was very high, equal or close to 100% in all scenarios. In addition, although the probability of F being above the F threshold declined over time in the constant catch scenario, there was still a 60% chance of F being above the F threshold in 2023.

B3.7 Major Findings for TOR 7 - Review and evaluate the status of the Technical Committee research recommendations listed in the most recent SARC report. Identify new research recommendations. Recommend timing and frequency of future assessment updates and benchmark assessments.

The Technical Committee was able to address or make progress on several of the recommendations from the most recent SARC report. These include:

- ✓ Evaluate to what extent rising natural mortality among Chesapeake Bay striped bass affects the existing F and female SSB thresholds, which are based on a fixed M assumption (M = 0.15) (Section B7.1).
- ✓ 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 (Section B9.2)
- ✓ Evaluate the stock status definitions relative to uncertainty in biological reference points (Section B9.2-B9.3).
- ✓ Develop a method to integrate catch-at-age and tagging models to produce a single estimate of F and stock status (Section B7.1).
- ✓ Develop a spatially and temporally explicit catch-at-age model incorporating tag based movement information (Section B7.1).
- ✓ Develop maturity ogives applicable to coastal migratory stocks (Section B5.1.7).

The Technical Committee identified several high priority research recommendations to improve the assessment. These included better characterization of commercial discards, expanded collection of sex ratio data and paired scale-otolith samples, development of an index of relative abundance for the Hudson River stock, better estimates of tag reporting rates, continued collection of mark-recapture data to better understand migration dynamics, and additional work on the impacts of *Mycobacteriosis* on striped bass population dynamics and productivity.

The Technical Committee recommends that the next benchmark stock assessment be conducted in five years in 2024, which will allow progress to be made on issues like state-specific scale-otolith conversion factors and directly incorporating tagging data into the 2SCA model.

B4.0 MANAGEMENT AND ASSESSMENT HISTORY

B4.1 Management History

For centuries, the Atlantic striped bass (*Morone saxatilis*) has supported valuable commercial and recreational fisheries from Maine through North Carolina. Striped bass regulations in the United States date to pre-Colonial times when striped bass were prohibited from being used as fertilizer (circa 1640). In 1981, the Atlantic States Marine Fisheries Commission (ASMFC or Commission) developed a fisheries management plan (FMP) for Atlantic striped bass in response to declining abundance as evidenced by drastic declines in commercial harvest during the 1970's and other indicators of low striped bass abundance and poor recruitment. The FMP recommended increased restrictions on commercial and recreational fisheries, such as minimum size limits and harvest closures on spawning grounds. Two amendments were passed in 1984 recommending additional management measures to reduce fishing mortality. To strengthen the management response and improve compliance and enforcement, the Atlantic Striped Bass Conservation Act (P.L. 98-613) was passed in late 1984. The Striped Bass Act mandated the implementation of striped bass regulations passed by the Commission and gave the Commission authority to recommend to the Secretaries of Commerce and Interior that states be found out of compliance when they failed to implement management measures consistent with the FMP.

The first enforceable plan under the Striped Bass Act, Amendment 3, was approved in 1985, and required size regulations to protect the 1982-year class – 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 1982 cohort to spawn at least once. Smaller size limits were permitted in producer areas than along the coast. Several states, beginning with Maryland in 1985, opted for a more conservative approach and imposed a total moratorium on striped bass commercial landings for several years. Amendment 3 contained a trigger mechanism to relax regulations when the 3-year moving average of the Maryland juvenile abundance index (JAI) exceeded an arithmetic mean of 8.0 – which was attained with the recruitment of the 1989 year class. Also, in 1985, the Commission concluded the Albemarle Sound-Roanoke River (A-R) stock in North Carolina contributed minimally to the coastal migratory population and was therefore allowed to operate under an alternative management program.

Amendment 4, implemented in 1989, aimed to rebuild the resource rather than maximize yield. State fisheries reopened under a target fishing morality (F) of 0.25, which was half the estimated F needed to achieve maximum sustainable yield (MSY). Amendment 4 allowed an increase in the target F once female spawning stock biomass (SSB) was restored to levels estimated during the late 1960s and early 1970s. The dual size limit concept was maintained, recreational trip limits were implemented, and commercial seasons were restricted to reduce harvest to 20% of that in the historic period of 1972-1979. A series of four addenda were implemented from 1990-1994 to maintain protection of the 1982 year class.

In 1990, to provide additional protection to striped bass and ensure the effectiveness of state regulations, NOAA Fisheries passed a final rule (55 Federal Register 40181-02) prohibiting possession, fishing, (i.e., catch and release fishing), harvest and retention of Atlantic striped bass in the Exclusive Economic Zone (EEZ), with the exception of a defined transit zone within Block Island Sound. Atlantic striped bass may be possessed and transported through this defined area, provided that the vessel is not used to fish while in the EEZ and the vessel remains in continuous transit. This federal moratorium remains in effect.

In 1995, Chesapeake Bay, Delaware Bay and Hudson River striped bass stocks were declared recovered by the Commission (the Albemarle Sound/Roanoke River stock was declared recovered in 1997), and Amendment 5 was adopted to increase the target F to 0.33, midway between the existing F_{target} (0.25) and F_{MSY}. F_{target} was allowed to increase again to 0.40 after two years of implementation. Regulations were developed to achieve the target F (which included measures aimed to restore commercial harvest to 70% of the average landings during the 1972-1979 historical period). From 1997-2000, a series of five addenda were implemented to respond to the latest stock status information and adjust the regulatory regime to achieve each change in target F.

Amendment 6 was approved in 2003. It addressed five limitations within the previous management program: potential inability to prevent the exploitation target 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 targets and thresholds for both the fishing mortality rate and female SSB. Additionally, Amendment 6 implemented a list of management triggers based on the female SSB and F targets and threshold, as well as juvenile abundance indices, which, if any or all are triggered in any given year, require the Atlantic Striped Bass Management Board (Board) to alter the management program to ensure achievement of the Amendment 6 objectives.

Under Amendment 6, and prior to Addendum IV (2014), the recreational striped bass fisheries were constrained by minimum size limits meant to achieve target fishing mortalities, rather than annual harvest quotas or caps. Most recreational fisheries were constrained by a two fish bag limit and a 28 inch minimum size limit. Through conservation equivalency, the Albemarle Sound/Roanoke River and Chesapeake Bay were able to employ different bag limits and smaller minimum size limits (18 inches) with the penalty of a target fishing mortality rate of 0.27. 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 were managed to not exceed the 0.27 fishing mortality target. A series of addenda were approved to implement a bycatch data collection program (Addendum I, 2007), to modify the definition of recruitment failure under the FMP (Addendum II, 2010), and to implement a coastwide commercial harvest tagging program to address illegal harvest of striped bass (Addendum III, 2012).

In 2014, Addendum IV was approved. The addendum was initiated in response to the 2013 benchmark assessment which indicated a steady decline in female SSB since the mid-2000s. The addendum established new F reference points (F_{target} = 0.18; $F_{threshold}$ = 0.22) for a coastwide population (which includes the Chesapeake Bay, Hudson River, and Delaware River/Delaware Bay as a metapopulation), and a suite of regulatory measures to reduce F to a level at or below the new target. The Addendum called for a 25% reduction in removals along the coast, and 20.5% reduction in removals in the Chesapeake Bay relative to the base period. To achieve this, coastal commercial quotas were cut by 25% and the Chesapeake Bay commercial quota was set at 3,120,247 pounds (1,415 mt) (a 20.5% reduction from the 2012 harvest level).

For the recreational sector, Atlantic coastal fisheries were required to implement a one fish bag limit and maintain the 28 inch minimum size limit. States could implement alternative regulations through the FMP's conservation equivalency process. The Addendum did not specify a standard measure for Chesapeake Bay fisheries, therefore Chesapeake Bay jurisdictions followed the conservation equivalency process to comply with the requirements of the Addendum. Addendum IV also formally defers management of the Albemarle Sound/Roanoke River stock to the state of North Carolina using Albemarle Sound/Roanoke River stock-specific biological reference points approved by the Board. Striped bass in the ocean waters of North Carolina continue to be managed under Amendment 6 and Addenda I-IV. Refer to Table B4.1 for a summary of commercial and recreational striped bass regulations in 2017, by state.

In February 2017, the Board initiated the development of Draft Addendum V to consider liberalizing coastwide commercial and recreational regulations. The Board's action responded to concerns raised by Chesapeake Bay jurisdictions regarding continued economic hardship endured by its stakeholders since the implementation of Addendum IV and information from the 2016 stock assessment update indicating that the Addendum IV measures successfully reduced F to a level below the target in 2015. The draft addendum proposed alternative measures aimed to increase total removals by 10% relative to 2015 in order to achieve the target F in 2017. However, the Board chose to not advance the draft addendum forward for public comment largely due to harvest estimates having increased in 2016 without changing regulations. Instead, the Board decided to wait until it reviews the results of this benchmark stock assessment before considering making changes to the management program.

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 Albemarle-Roanoke stock is currently managed as a non-coastal migratory stock by the state of North Carolina under the auspices of ASFMC.

The Chesapeake Bay area is defined as the area residing between the baseline from which the territorial sea is measured as it extends from Cape Henry, Virginia, to Cape Charles, Virginia, 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 are 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.

B4.3 Assessment History

B4.3.1 Past Assessments

The first analytical assessment of Atlantic striped bass stocks using virtual population 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 that 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 et al. (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 Chesapeake Bay. Also, estimates of abundance could be made.

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 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 female SSB during 1982-2006 in the 2007 benchmark assessment. This was considered the preferred model over ADAPT.

Also in the 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.

The SCA model was modified for the 57th SAW/SARC based on recommendations by the 2007 SARC and SA committee discussions. The SCA model was 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 were 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 were 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 were 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.

B4.3.2 Current Assessment and Changes from Past Assessments

For this assessment, the SCA model was extensively modified to allow the modeling of two biologically distinct stocks. This new striped bass two-stock statistical catch-at-age (2SCA) model allows the estimation of separate population characteristics for two stocks whose individuals are mixed in a common ("ocean") region where the stock composition of the catch in that region is unknown. The model is based on population dynamics observed for the Chesapeake Bay stock that is comprised of a resident population in the Chesapeake Bay and a migratory population that moves between the Chesapeake Bay and ocean region for spawning. For Stock-1 (the Chesapeake Bay stock), individuals move from the bay to the ocean based on age-specific emigration rates estimated from tag data. Spawning individuals from the ocean return to the bay during a specific period based on maturity schedules. For Stock-2 (the Delaware Bay and Hudson River stocks combined), it is assumed that the ocean region encompasses the spawning grounds and migration is not modeled. The model estimates stock-specific recruitment, stock-, year-, period- and age-specific abundance and fishing mortality, different selectivity functions for the Chesapeake Bay and Ocean catch data and surveys with age composition data, catchability coefficients for surveys and management reference points.

In addition, the inputs for the one-stock SCA model approved for management use at the 57th SAW/SARC were updated to reflect improvements in the 2SCA model data, including the separation of commercial discards into Chesapeake Bay and ocean components so that only two regional fleets were needed.

Both models used new MRIP estimates of recreational catch.

The tagging assessment used only the IRCR model and did not run the MARK model. The year-specific reporting rates were carried forward from the previous assessment and updated for 2012 – 2017. The addition of a new F period was explored given the implementation of Addendum IV and model diagnostics supported its inclusion for most programs.

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 Fisheries

Commission, and North Carolina; Table B4.1). Commercial fishing for striped bass is prohibited in Maine, New Hampshire, Connecticut, New Jersey, Pennsylvania, 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 striped bass migration patterns 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. Since then, the commercial fishery has been managed via size limits and jurisdiction-specific quotas. In 2003, commercial quotas were restored to 100% of the average harvest (in weight) during the period of 1972-1979. In 2014, coastal commercial quotas were reduced by 25% and the Chesapeake Bay-wide quota was reduced by 20.5% relative to 2013 harvest (Addendum IV; 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 and a 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 prior to Addendum IV, recreational fisheries were managed via harvest caps for specific seasonal fisheries. Beginning in 2015, Atlantic coastal fisheries were required to implement a one fish bag limit and maintain the 28 inch minimum size limit. States could implement alternative regulations through the FMPs conservation equivalency process. The Addendum did not specify a standard measure for Chesapeake Bay fisheries, therefore Chesapeake Bay jurisdictions followed the conservation equivalency process to comply with the requirements of the Addendum (i.e., implement measures to achieve a 20.5% reduction relative to 2013-levels; Table B4.1).

TOR B1. 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.

B4.5 Life History and Biology

B4.5.1 Geographic Range

The distribution of Atlantic striped bass along the eastern coast of North America extends from the St. Lawrence River in Canada to the St. Johns River in Florida, but the Atlantic coast migratory stocks range from the Gulf of Maine 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). Striped bass are also naturally found in the Gulf of Mexico from the western coast of Florida to Louisiana (Musick et al. 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 et al 1989). The following life history information applies to the Atlantic coast migratory population.

B4.5.2 Stock Definitions

The anadromous populations of the Atlantic coast are primarily the product of four distinct spawning stocks: an 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 in 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 A-R striped bass (>800 mm TL) are indeed migratory (Callihan et al. 2013). The Striped Bass Technical Committee examined this during the 2017 data workshop for this assessment and concluded that very few fish from the A-R stock, as a fraction of the total coastwide population, contribute to the Atlantic coastal migratory stock. 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 et al. 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 recaptures of mature female striped bass from the Chesapeake Bay stock occur 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. 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 striped bass 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 et al. 1998).

B4.5.3 Movements and Migration

Atlantic striped bass move between a variety of habitats in their life cycle. Generally, spawning and early development occurs at the heads of estuaries and in their tributaries, fish mature in estuaries, and move into the ocean as adults. Movement at all developmental stages is affected by abiotic factors and trophic interactions.

Eggs and Larvae

The movement of planktonic eggs and larvae is largely determined by passive transport. Bilkovic et al. (2002) studied the distribution of striped bass and American shad eggs and larvae in two rivers of a tributary of the Chesapeake Bay, the largest of the four major spawning stocks (Goodyear et al. 1985; Kohlenstein 1980; Fabrizio 1987), and found that predation and competition with American shad were also important factors in the relative spawning and larval locations.

Juveniles

In summer and fall, juvenile striped bass move down river from their parent stream (Richards and Rago 1999; Smith and Wells 1977) to low salinity bays or sounds at about one year old (Shepherd 2007). A number of factors are correlated with the movements of these juveniles, including freshwater and tidal flow (Manderson et al. 2014; Dunning et al. 2009), salinity and pH (Able and Grothues 2007), temperature (Callihan et al. 2015; Hollema et al. 2017), photoperiod (Hollema et al. 2017), prey availability (Ferry and Mather 2012; Hollema et al. 2017), age of fish (Conroy et al. 2015), and abundance (Callihan et al. 2014).The timing of this juvenile migration varies by location. In Virginia, Setzler-Hamilton et al. (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).

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. Otolith microchemistry analysis of striped bass from the Hudson River and from the Roanoke River indicate that individuals in these populations exhibit multiple life history strategies (Morris et al. 2003; Zlokovitz et al. 2003; Secor and Piccoli 2007). Secor (1999), describes the Contingent Hypothesis based on his work with striped bass in the Hudson. Juveniles form distinct migratory groupings, called contingents, which have similar patterns in otolith microchemistry and reflects temporal changes in salinity. Contingents may be the result of divergent early growth rates and dispersal behaviors (Secor and Piccoli 2007), and may promote colonization of new habitats (Morissette et al. 2016). Three contingents, corresponding with freshwater residents, oligohaline migrants, and mesohaline migrants have been identified in the Hudson River (Secor 1999; Gahagan et al. 2015), the St. Lawrence River (Morissette et al. 2016), the Patuxent River (Conroy et al. 2015), and Albemarle Sound, where Patrick (2010) identified them as resident, stager, and sprinter contingents.

Adults
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 (Shepherd 2007; Zurlo 2014), and coastal migrations that are apparently not associated with spawning activity. From Cape Hatteras, North Carolina, to New England, coastal migrations are generally northward in summer and southward in winter. Mather et al. (2009) found that in Massachusetts, some adult striped bass that had traveled long distances remained in small areas for the summer to feed. Results from tagging 6,679 fish from New Brunswick, Canada to the Chesapeake Bay, during 1959 – 1963, suggest that substantial numbers of striped bass leave their birthplaces when they are three or more years old and thereafter migrate in groups along the open coast (Nichols and Miller 1967). These fish are often referred to collectively as the “coastal migratory stock,” suggesting they form one homogeneous group, but this group is probably, in itself, heterogeneous, consisting of many migratory contingents of diverse origin (Clark 1968).

Coastal migrations may be quite extensive. Striped bass tagged in Chesapeake Bay have been recaptured in the Bay of Fundy. They are also quite variable, with the extent of the migration varying between sexes and populations (Hill et al. 1989; Secor and Piccoli 2007). Larger striped bass (>800 mm TL), most of which are females, tend to migrate farther distances (Callihan et al. 2011). Welsh et al. (2007) determined that striped bass tagged off North Carolina and Virginia in the winter migrated northward as far as Maine in the summer, although the largest numbers were recovered from New York to Massachusetts, as well as the waters of Maryland. During the spring months (April, May, and June), the largest numbers of tagged striped bass were caught within the 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 striped 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 et al. 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 et al. 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 et al. 2007).

Striped bass are not usually found more than 6 to 8 km offshore (Bain and Bain 1982), however, Kneebone et al. (2014), using acoustic telemetry, found that adult fish that aggregate on Stellwagen Bank, located in the U.S. Exclusive Economic Zone (EEZ) and beyond the 12-nautical mile territorial sea, move inshore as part of their normal migratory and feeding behavior. Additionally, Fishery-independent data collected by North Carolina DMF, ASMFC and USFWS (i.e., North Carolina Cooperative Winter Tagging Program) suggests striped bass distribution on their overwintering grounds during December through February has changed significantly since the mid-2000s. The migratory portion of the stocks has been well offshore in the EEZ (>3 miles), requiring travel as far as 25 nm offshore of Chesapeake Bay to locate fish to tag (ASMFC 2018).

Finally, strong homing behavior has been observed in some populations (Wingate and Secor 2007), and can make populations susceptible to local effects, such as over fishing and habitat damage. However, Grothues et al. (2009) investigated the dispersal patterns of adult striped bass using telemetry and found that migratory behavior is reactive rather than compulsive. These results are consistent with Patrick (2010), in which he reports finding no genetic basis for migratory behavior using otolith microchemistry, but rather that habitat condition was related to migration of young-of-year.

B4.5.4 Age

Atlantic striped bass have been aged using scales for over 70 years (Merriman 1941). State ageing programs have shown high precision in scale-based ages of striped bass up to age-10. However, it is generally recognized that for older fish, scales may underestimate striped bass ages compared to otolith-based ages and known ages (Secor et al. 1995 and Liao et al. 2013), so ASMFC is working with states to facilitate collection of otoliths for 800 mm striped bass or larger.

Age data are 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 consistently collected age structure. For the benchmark stock assessment, scales remained the primary source for ages although otolith ages from several states across multiple years were used when available to develop age-length-keys (ALKs).

Generally, longevity of striped bass has been estimated as 30 years, although a striped bass was aged to 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. It may also have conferred resiliency against an extended period of recruitment overfishing in the Chesapeake Bay (Secor 2000).

In general, the maximum ages observed have increased since 1995 when the striped bass fisheries reopened. From 1995 to 2016, the maximum observed female age increased from 16 to 31, with the oldest fish caught in Chesapeake Bay, Virginia, in 2014. During the same period, the maximum observed male age increased from 16 to 24 with the oldest fish caught in Chesapeake Bay, Virginia, in 2011. Figure 12 of Appendix B1 presents the maximum observed ages by state, showing that Virginia has the highest mean maximum age of 22.5 whereas New Jersey has the lowest mean maximum age of 12.

B4.5.5 Growth

As a relatively long-lived species, striped bass are capable of attaining moderately large size, reaching as much as 125 pounds (57 kg) (Tresselt 1952). Fish weighing 50-60 pounds (23-27 kg) are not exceptional, and several fish harvested in North Carolina and Massachusetts with recorded weights in excess of 100 pounds (45 kg) were estimated to have been at least 6 feet (1.8 m) long (Smith and Wells 1977).

Growth rates of striped bass are variable, depending on season, age, sex, competition and location. For example, a 35 inch (889 mm) striped bass can be 7 to 15 years of age and a 10-pound (4.5 kg) striped bass can be 6 to 16 years old (ODU CQFE 2006).

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). Annuli form on scales of striped bass caught in Virginia between April and June, or during the spawning season (Grant 1974). From November through March, growth is negligible.

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 greatest growth during the 3rd year, when migratory movements began. The rate dropped sharply at age-4 and remained nearly constant at 6.5-8.0 cm per year until approximately age-8. The growth rate probably decreases even further after the 8th year.

Growth rates and maximum size are significantly different for males and females. Both sexes grow at the same rate until 3 years old; beginning at age-4, females grow faster than males. Females grow to a considerably larger size than males; striped bass over about 30 pounds (14 kg) are almost exclusively female (Bigelow and Schroeder 1953).

Compensatory growth, in which the smaller fish in a year-class grow at an accelerated pace that reduces or eliminates 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).

In preparation for this stock assessment, a review was conducted of age and length data. These data verified that females grow larger than males (Appendix B1, Figure 1). Growth rates were seen to be variable without trend for all states (Appendix B1, Figure 2 – 8). Finally, a comparison of older fish of the same age range showed that the largest fish are observed in Massachusetts and the smallest fish are in Virginia (Appendix B1, Figure 9).

B4.5.6 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 season along the Atlantic coast usually extends from April to June 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 3 pound (1.4 kg) female producing 14,000 eggs and a 50-pound (23 kg) specimen producing nearly 5,000,000.

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 15 mm 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. Environmental 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 and 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 female 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 (NEFSC 2013).

B4.5.7 Female Maturity

The 2013 striped bass benchmark stock assessment (NEFSC 2013) listed development of maturity ogives applicable to coastal migratory stocks as a moderate level research priority. The female striped bass maturity schedule used in the 2013 benchmark stock assessment is based on a 1987 white paper by Jones. In the white paper, data for ages 4-6 were based on relative CPUEs by sex from the 1985-1987 Maryland Spawning Stock Survey (gill net), while data for ages 7-8 appear to be from a Texas Instruments study (Texas Instruments Inc. 1980) done on the Hudson River from 1976-1979 that used a gonadosomatic index to determine maturity.

Both methods use an indirect, rather than histological approach, to estimate female maturity-at-age and the work has not been updated since the stock was rebuilt. The estimated female maturity-at-age was improved by using newer, standardized, and more detailed histological techniques that reflect the dynamics of a restored stock. While the work is summarized here, more information on the analysis can be found in Appendix B2.

The majority of the sampling effort (68%) was on fish between 520-879 mm TL which were estimated to be between 5-8 years old based on Maryland age-length keys. Sampling was focused on this size/age range to adequately characterize the steepest part of the current maturity ogive. However, samples were also collected at smaller and larger sizes where fish were expected to be mostly immature or all mature, respectively. By using only samples from the Chesapeake Bay, the results may be biased towards immature, pre-migratory fish and mature, migratory fish, while lacking immature migratory females that remain on the coast. To minimize this bias, complementary sampling was conducted by coastal states to fill in missing length groups. The New Jersey Bureau of Marine Fisheries, Rhode Island Division of Marine Fisheries, and the Northeast Area Monitoring and Assessment Program (NEAMAP) contributed samples from their routine surveys (Table B5.1). Ovaries were collected from the various surveys in the months of March through July and September through December during pre-spawn, spawning and post-spawn periods (Table B5.2). Total length (mm TL), weight (kg), visual (macroscopic) maturity stage, and external anomalies were recorded from all fish. Scales were collected to assign ages to fish sampled, as scale ages for striped bass are generally accurate through age ten (NEFSC 2013). Otoliths were also collected and could be used for future age validation.

Histological slides were prepared by the Maryland DNR Diagnostics & Histology Laboratory at the Cooperative Oxford Laboratory and followed methods from Boyd (2011). Slides were viewed under 40X or 100X magnification through a dissecting scope, and maturity stages were assigned according to the categories defined in Brown-Peterson et al. (2011). Slides were examined by three biologists to determine the final maturity stage. If there was disagreement between the readers, the slides were viewed and discussed until a final stage was agreed upon. The maturity-at-age data were analyzed using logistic regression by specifying the logit link in a binomial generalized linear model (GLM) in R (R Core Team 2016).

Brown-Peterson et al. (2011) defines immature fish as a gonadotropin independent phase and “fish enter the reproductive cycle when gonadal growth and gamete development first become gonadotropin dependent (i.e., the fish become sexually mature and enter the developing phase).” While a striped bass may enter the developing phase and be physiologically mature, it does not necessarily indicate that the fish will spawn in the upcoming spawning season (Olsen and Rulifson 1992; Berlinsky et al. 1995; Boyd 2011). For this reason, the data were analyzed in two ways: as the percent mature (with developing through regenerating phases designated as mature) and as percent spawning (spawning capable through regressing phases indicating spawning is imminent or completed). When developing fish were considered mature, the age of 50% maturity was 3.6 years old, much lower than the age that the Maryland Spawning Stock Survey observes females on the spawning grounds. Since 1994, no females younger than age four have been caught in the spawning stock survey and only 12 four-year-old fish have been caught in that time. Comparatively, the age of 50% maturity when developing fish were not included as imminently spawning was 5.8 years old and aligned better with observations from the spawning stock survey. For these reasons, the results presented here will only consider fish mature if they are imminently spawning or spawning is completed.

A total of 428 fish were sampled with the majority between the ages of 4 and 6 (Table B5.3). Data were analyzed using two time periods: March-July data (Figure B5.1) and the whole dataset (March-December, Figure B5.2). The GLM estimated maturity-at-age using the whole data set was generally slightly lower when compared to the spring-only dataset (Figure B5.3). Using the observed proportions mature, the maturity-at-age was more similar with the exception of ages 5 and 6 (Figure B5.3).

Studies are often recommended to be done either prior to spawning (Hunter and Macewicz 2003) or prior to and during the spawning season (Murua et al. 2003). This would align best with our March-July data subset or possibly even a smaller subset. However, consideration must also be given to the distribution of fish across the study area, particularly when immature and mature individuals occur in different areas (Berlinsky et al. 1995; Hunter and Macewicz 2003; Murua et al. 2003). It is for this reason that Berlinsky et al. (1995) sampled during the spring and fall feeding migrations even though this required an assumption that maturation rates were not significantly different among stocks. For these reasons and because it includes more coastal fish, this assessment used the maturity-at-age values derived from the full dataset. These values are similar to those reported by Berlinsky et al. (1995) for ages 3-5 and those reported by Jones (1987) for ages 6-9 (Table B5.4).

B4.5.8 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 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 the diets of striped bass in Chesapeake Bay (Griffin and Margraf 2003; Pruell et al. 2003; Walter and Austin 2003; Overton et al. 2009 and 2015). Griffin and Margraf (2003) compared the diets of striped bass collected in the 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) relied more on small pelagic fish prey (such as bay anchovies and age-0 clupeids) in current years than in the 1950s. Pruell et al. (2003) examined δ 13C in striped bass scales collected from Chesapeake Bay between 1982 and 1997 and suggested that enrichment of δ 13C through the years could be 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 to their findings.

After recovery of Atlantic Coast striped bass was declared in 1995 (Richards and Rago 1999), concern emerged about the impact of high striped bass population size on its prey-base, and multiple analyses suggested that the recovered striped bass population had the potential to deplete prey populations along the Atlantic Coast (Griffin and Margraf 2003; Hartman 2003; Uphoff 2003; ASMFC 2004; Savoy and Crecco 2004; Heimbuch 2008; ASMFC Weakfish Technical Committee 2009; Davis et al. 2012; Davis 2016). In recent years, a particular interest was paid to the role of striped bass as the predator of Atlantic menhaden (ASMFC 2008; ASMFC 2014; Buccheister et al. 2017; Uphoff and Sharov 2018). To assess the role of striped bass, ASMFC developed a version of the multispecies VPA with striped bass, bluefish and weakfish as menhaden predators (Garrison et al. 2010). The MSVPA-X predicted that Atlantic Menhaden comprised a moderate proportion of striped bass diet biomass (15-30%) and those consumed consisted largely of age-0 and age-1 Atlantic Menhaden (ASMFC Multispecies Technical Committee 2008; ASMFC Atlantic Menhaden Technical Committee 2010). However, diet studies of large striped bass by Walter and Austin (2003) and Overton et al. (2008) suggested a greater role of Atlantic Menhaden of all ages in striped bass diets. Atlantic Menhaden were often dominant prey in studies of striped bass diets in the Chesapeake Bay and the mid-Atlantic region, and were important prey in New England waters (Walter et al. 2003; Walter and Austin 2003; Ruderhausen et al. 2005; Nelson et al. 2006; Overton et al. 2008; 2009; Overton et al. 2015).

B4.5.9 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. Early assessments assumed an age-constant M of 0.15, consistent with Hoenig's (1983) regression on maximum age. In the 2013 benchmark assessment, age-specific M estimates for ages 1-6 were derived from a curvilinear model fitted to tag-based Z estimates (assuming Z=M) for fish younger than age3 from New York and tag-based M estimates (Jiang et al. 2007) for age three to six striped bass from Maryland calculated for years prior to 1997 (Appendix B3). Natural mortality estimates from NESFC (2013) were used in this assessment.

The epizootic of *Mycobacteriosis* 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 the 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 Chesapeake 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 the Chesapeake Bay.

Prevalence of the disease ranges from ~50%, as determined through standard histological methods (Overton et al. 2003), to 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 either increased mortality in fish which have contracted the disease and do not live to older ages due to limited ability of striped bass to resolve the disease once it is contracted (Matt Smith, *unpublished data*) or cessation of disease and/or healing as fish migrate to ocean waters (Kane et al. 2006). *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 have been made. Gauthier et al. (2008) estimated relative survival of diseased fish was 0.69 (0.55 – 0.84), while Hoenig et al. (2017) reported relative survival of diseased fish ranging from 0.54 to 0.96 depending on the severity of the disease. They also noted that if the mortality associated with the disease is additional to pre-disease estimates of natural mortality, this is equivalent to a change of natural mortality from 0.15 to 0.29 (95% CI 0.20–0.37), or almost a doubling of the natural mortality rate in the population.

In the most recent study, Groner et al. (2018) used a multi-event, multistate mark– recapture model (MMSMR) to quantify *Mycobacteriosis* processes and impacts on the population of striped bass in the Chesapeake Bay. The majority of fish tagged (95%) from the Rappahannock River, Virginia, were between 457 mm and 610 mm, corresponding to ages 3-5. They reported that this disease impacts nearly every adult striped bass. Mortality of diseased fish was high, particularly in severe cases, where it approached 80%. For both healthy and diseased fish, mortality increased with the modeled average summer sea surface temperature (SST); in warmer summers (average SST ≥ 29°C), a cohort is predicted to experience >90% mortality in 1 year. Groner et al. (2018) suggested that these fish are living at their maximum thermal tolerance and that this is driving increased disease and mortality. Accounting for additional mortality due to disease and temperature may result in more conservative population trajectories. Groner et al. (2018) further suggested that disease-associated mortality will likely increase with warming temperatures in the Chesapeake Bay, so these changes will be relevant into the future. Continued monitoring of disease in striped bass is advised to account for the effects of temperature and disease.

B4.5.10 Potential Impacts due to Climate Change

Climate change has the potential to affect striped bass. Striped bass exhibit a number of characteristics identified by NOAA as increasing their vulnerability to climate change effects, including complexity of reproductive strategy, short duration aggregate spawning, sensitivity to temperature, prey-specificity, and specific larval requirements (Morrison et al. 2015). Recent literature, outlined below, provides some information about how climate change, including rising sea temperatures, changes in weather patterns, and more frequent extreme weather events may affect striped bass specifically.

Temperature is correlated with a number of aspects of striped bass biology. Time to hatch and egg and larval mortality (Massoudieh et al. 2011) are affected by temperature and temperatures above 18° C have been found to affect larval growth length and yolk utilization (Peterson et al. 2017). Activity levels (Hollema et al. 2017) and metabolic rate, consumption, and growth (Secor et al. 2000) are also correlated with temperature. Secor et al. (2017) found that seasonal changes in temperature affected growth and mortality in striped bass larvae. Manderson et al. (2014) concluded that changes in seasonal temperature and precipitation could impact the suitability of small estuarine tributaries as juvenile striped bass habitat. Temperature also affects daily, vertical movements (Keyser et al. 2016), and may, for example, affect availability to anglers if fish seek deeper waters as water temperatures rise.

The correlation between temperature and habitat selection/migratory behavior in striped bass is well established (e.g. Able and Grothues 2007; O'Connor et al. 2012). Estuarine residence time of young striped bass is affected by the temperature of freshwater discharge (Manderson et al. 2014). Williams and Waldman (2010) documented striped bass using power plant effluent as a warm-water refuge in the winter. Hollema et al. (2017) found that the presence of striped bass in Plymouth, Kingston, and Duxbury Bay, Massachusetts, was significantly correlated with temperature, and that individuals left the bay when water temperature reached 16.8° C. Brent et al. (1999) observed striped bass seeking cooler waters when temperatures were over 25° C. Temperature (along with photoperiod) has been shown to be a cue to fish to begin their fall migration (Wingate and Secor 2007; Hollema et al. 2017; Manderson et al. 2014).

In addition to rising sea temperatures, climate science predicts an increase in extreme weather events, such as hurricanes, coastal flooding, and marine heat waves (Herring et al. 2015). Bailey and Secor (2016) document novel migration in striped bass in the Hudson River Estuary related to high storm activity. Rates of freshwater flow can have significant impacts on transport and abundance of striped bass larvae within estuaries (Dunning et al. 2009; O'Connor et al 2012). Growth and mortality rates of striped bass larvae are affected by storm events (Secor et al. 2017)

B4.6 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 B4); young of-the-year and age-1 indices had been reviewed and validated previously (ASMFC 1996). The 2004 workshop developed a set of evaluation criteria and tasked states with a review of indices. Both the Technical Committee and the Board approved the criteria and the review. The resulting review led to revisions and elimination of some indices formerly used in the ADAPT VPA. For the 2018 benchmark assessment, based on the review of survey programs and Technical Committee recommendations, some changes were made to the suite of indices.

The Virginia Pound Net Index was dropped, due to concerns about the single, fixed-station design and the uncertainty about the future funding of the survey. The NEFSC Bottom Trawl Survey was also dropped, due to concerns about the low proportion of positive tows and the time-series ending in 2008 with a vessel change and the loss of the inshore strata that comprised the previous index.

The ChesMMAP survey (Section B5.2.2.15) was introduced to replace the information about adult fish in the Chesapeake Bay that the Virginia Pound Net Index provided. The Delaware Bay 30' Trawl survey (Section B5.2.2.9) was introduced to provide additional information about striped bass in the Delaware Bay.

Age-structure information was developed for indices that had previously been treated as age-aggregated indices (the MRFSS/MRIP CPUE and the Connecticut Long Island Sound Trawl Survey), so that the model could fit to both total index values and proportion at age information.

The Striped Bass SAS explored using GLMs to standardize the fishery independent indices for input into the model. However, the SAS ran into several issues with the standardization process, including problems with convergence and model diagnostics for some indices. In addition, not all surveys collected environmental covariates consistently across the entire time series, which would have resulted in the truncation or missing values in the time series. As a result, with a few exceptions noted below, the SAS chose to use the design-based geometric mean index values.

B4.6.1 Fisheries-Dependent Catch Rates

B4.6.1.1 MRIP Total Catch Rate Index

An index of relative abundance for the coastal mixed population of striped bass was developed from MRFSS/MRIP intercept data. The complete MRFSS/MRIP intercept dataset was subset to private/rental boat trips that occurred in ocean waters during Waves 3-5 for states from Maine through Virginia. A guild approach was used to identify striped bass trips. For each state, a subset of commonly caught species was created (i.e., species that were intercepted at least 100 times over the entire time series). For each trip in that state, the presence or absence of each of the commonly caught species was recorded. A Jaccard coefficient was calculated for each species as:

$$S_j = \frac{a}{a+b+c}$$

Where:

- a = number of trips where striped bass and species j were caught together
- b = number of trips where striped bass was caught but not species j
- c = number of trips where species j was caught but not striped bass

The Jaccard coefficient was used to identify species that were commonly caught with striped bass in order to better identify striped bass trips with zero striped bass catch. For each state, a subset of striped bass trips was created from all trips that caught either striped bass or the species with the highest Jaccard coefficient (meaning it was the species caught most often with striped bass). For most states, bluefish or Atlantic mackerel had the highest Jaccard coefficient (Figure B5.4).

The state subsets of striped bass trips were combined into a coastwide set of trips. An index of abundance was calculated using a zero-altered/hurdle model that predicted the number of striped bass per trip as a function of year, wave, state, area fished (state or federal waters), and avidity (number of days fished in the last 12 months). The natural log of hours fished was used as an offset. The model was fit using the *hurdle()* function in the *pscl* package in R. The hurdle model used a binomial model to predict the presence or absence of striped bass on a trip and a negative binomial model was used to predict the number of striped bass caught on positive trips. The statistically important factors for each component of the hurdle model were identified by comparing AIC values across different model formulations; the full model had the lowest AIC for both the binomial and count components. Bootstrapping was used to calculate confidence intervals and CVs for the index.

Age composition for the MRIP index was developed from the total catch-at-age for assessment period-3 for the ocean area. This combined the state-by-state catch-at-age for the harvest with the catch-at-age for the live releases (not scaled by release mortality as was done for the removals at age).

The MRIP index was low in the 1980s, increased through the 1990s to a peak in 1998 before slowly declining through 2010 (Table B5.5; Figure B5.5). The index has been steady since then with an uptick at the end.

B4.6.2 Fisheries-Independent Survey Data

B4.6.2.1 Connecticut Long Island Sound Trawl Survey (CTLISTS)

Connecticut provides an aggregate 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. Striped bass lengths were converted to ages using the same age-length keys used to age CT's recreational catch to develop proportions at age for the index. The Long Island Sound Trawl Survey encompasses an area from New London, Connecticut (longitude 72° 03') to Greenwich, Connecticut (longitude 73° 39'). The sampling area includes Connecticut and New York state waters from 5 to 46 meters in depth and is conducted over mud, sand and transitional (mud/sand) sediment types. Long Island Sound is surveyed in the spring (April-June) and fall (September-October) periods with 40 sites sampled monthly for a total of 200 sites annually.

The sampling gear employed is a 14 m otter trawl with a 51 mm codend. To reduce the bias associated with day-night changes in catchability of some species (Sissenwine and Bowman 1978), sampling is conducted during daylight hours only. 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 km^2 (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 CT LISTS index is computed as the stratified geometric mean number per tow.

The CT LISTS index showed an increasing trend from low levels from the mid-1980s through the late 1990s (Table B5.5, Figure B5.6). It varied without trend through the early 2000s before declining somewhat from about 2007 onwards. The CT LISTS captures primarily age-2-4 fish, but has captured individuals across the full range of ages (Figure B5.6). The age composition of the index showed an expansion in the age structure along with the increasing trend through the late 1990s and then a slight contraction; although striped bass up to age-15+ have been caught in recent years, fewer age-6 – 10 fish were captured recently than in previous years (Figure B5.6)

B4.6.2.2 Northeast Fisheries Science Center Bottom Trawl Survey (NEFSC)

The Northeast Fisheries Science Center provided an aggregate (2-9) index of relative abundance from the spring stratified-random bottom trawl survey in previous assessments. The survey covers waters from the Gulf of Maine to Cape Hatteras, North Carolina. Only data from inshore strata from 1991-2008 were used. The survey was dropped for this assessment due to concerns about the low proportion of positive tows and the time-series ending in 2008 with a vessel change and the loss of the inshore strata that comprised the previous index.

B4.6.2.3 New York Young-of-the-Year (NYYOY)

The juvenile striped bass beach seine survey is New York's most standardized Hudson River striped bass survey and the data is used for the annual striped bass juvenile abundance index. This survey targets young-of-year striped bass in the lower, brackish, tidal portion of the Hudson River Estuary (river miles 22-39) rkm 35-63. The beach seine used in this study is an off-center 200 ft (61 m) seine with one wing measured at 150 ft x 10 ft (45.7 m x 3.05 m), a second smaller wing at 30 ft x 10 ft (9.1 m x 3.05 m) and a bunt measuring 20 ft x 12 ft (6.1 m x 3.7 m). The seine is constructed with 0.25 in (0.64 cm) bar mesh, with floats and a lead line. The floats at each end of the bunt are marked with a different color from the others.

The net is deployed from the rear starboard side of the boat. After nosing into a sample site, the end of the net with the shorter wing is landed and held on the beach, the boat is then rotated to face out from the beach, and the entire net is fed off the rear starboard side in a horseshoe fashion, ending back at the shoreline. With the horseshoe set completed, the river end of the net is dragged the remaining way to shore by hand. The net is then hauled to shore starting at the end with the large wing. Once the buoys marking the bunt are centered, both wings of the net are brought in so that the bunt comes in last. All fish collected are identified to species, counted and returned to the river. A subset of 30 individuals per seine haul of striped bass are measured for total length (mm). Water quality data, including temperature, salinity, pH, dissolved oxygen, conductivity and total dissolved solids is taken at each site, as are prevailing conditions, including wave height, wind velocity, cloud cover, and tide stage. Effort is defined as one haul.

At its Spring 2014 meeting, the Board approved a proposal to revise New York's Hudson River Juvenile Abundance Index. The "old" striped bass index was based on a 6-week, 25-station survey, which was initiated in 1979. Sampling was conducted from August through November. The "new" index is based on three additional weeks of sampling in mid-July, which have been sampled since 1985. The "new" survey runs from mid-July through November. The number of stations has been reduced from 25 to 13, due to staffing constraints, unsafe sites, and redundant habitat sampled, but retains the broad geographical range of the nursery area. Historical replacement sites were chosen when the current sites were not historically sampled. These were selected using proximity to the current site.

The NYYOY index began with two very low points in 1985 and 1986 before jumping to time series high values in 1987 and 1988; it has varied without trend since then (Table B5.6, Figure B5.7).

B4.6.2.4 New York Western Long Island Beach Seine Survey (NY Age-1)

The Western Long Island Survey began in 1984, sampling fixed stations in three bays: Little Neck Bay (LNB, 4 stations), Manhasset Bay (MB, 4 stations), and Jamaica Bay (JAM, 9 stations). Sampling of each bay is conducted using a 61 m by 3 m beach seine net (the same gear as the Hudson River YOY survey). Each bay is sampled twice per month. A single haul is conducted per station at each bay. Sampling occurs during daylight hours. Little Neck and Manhasset Bays are generally sampled on the same day; Jamaica Bay is generally sampled on a different day from LNB/MB, over a period of two days. The yearling (Age -1) index is calculated from samples collected during May through August. Striped bass are counted and measured, and scales are taken to determine ages. The Index is calculated as the geometric mean catch per haul. Other variables measured at each station included surface water salinity, surface water dissolved oxygen, bottom type, cloud cover, wind direction, wind velocity, air temperature, and sampling month. Consistent recording of surface water salinity, surface water dissolved oxygen, and bottom type were not made until 1988.

The NY Age-1 index showed a slight increasing trend through the late 1980s and 1990s followed by a slight declining trend through the 2000s (Table B5.6, Figure B5.7). The index identified strong year classes in 2010 and 2014, consistent with the YOY index (Figure B5.7)

B4.6.2.5 New York Ocean Haul Seine (NYOHS)

New York provides age-specific geometric mean indices of relative abundance for striped bass generated from an ocean haul seine survey that took place from 1987-2006. In 1987, New York DEC started sampling the mixed coastal stocks of striped bass by ocean haul seine. Sampling was 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 was contracted to set and retrieve the gear, and assist department biologists in handling the catch. The survey seine measured approximately 1,800 feet (550 m) long and was composed of two wings attached to a centrally located bunt and cod end. The area swept was approximately ten acres. The seine was 15 feet (4.5 m) 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 was 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 were used to complete the annual survey. These alternate stations occur within the geographic range of the original standard stations. In 1995, funding delays 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 began in late September to early October. In addition, decreased funding led to reductions in annual sampling effort from sixty seine hauls to forty-five seine hauls per season as of 1997. The time series of catch and catch-at-age was standardized by date for the entire time series. An Age-1+ index is calculated as a geometric mean.

The NYOHS index did not show a strong trend across its time series, although it was generally higher from 1996 – 2006 than from 1987 – 1995 (Table B5.5, Figure B5.8). The index age composition showed an expanding age structure from the late 1980s through the mid-1990s (Figure B5.8).

B4.6.2.6 New Jersey Bottom Trawl Survey (NJTRL)

New Jersey provides age-specific (2+) geometric mean indices of relative abundance for striped bass from a stratified-random bottom trawl initiated in 1989. The survey area consists of New Jersey 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 three fathom isobath inshore to approximately the 15 fathom (27 m) 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 New Jersey. Where NMFS strata are extended into New York or Delaware waters, truncated boundaries were drawn which included only waters adjacent to New Jersey, 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 centimeter (cm) total length and only data from April are used for striped bass. Additionally, offshore strata are not included in the index due to low incidence of striped bass.

The NJTRL index was low at the beginning of its time series in 1990, before jumping up in the mid-1990s; it has been mostly high and variable since then (Table B5.5, Figure B5.9). The 2015 value was a time-series low, but the 2017 value was the second highest in the time-series. The age composition showed an expanding age structure through the 1990s and early 2000s followed by a contraction (Figure B5.9).

B4.6.2.7 New Jersey Young-of-the-Year Survey (NJYOY)

A survey of juvenile abundance in the Delaware River has been conducted by the New Jersey Department of Environmental Protection since 1980 using a 30.5 m x 1.8 m beach seine with 5 mm mesh deployed with a vessel. The sample design involved 16 fixed stations sampled twice monthly from mid-July to mid-November, with two hauls per station. The survey design was re-evaluated in 1990 reducing the sampling frame of August through October, no replicate tows per station and incorporating both fixed and random stations. This design was followed until 1998 when the survey was again modified, returning 32 fixed stations sampled twice per month between mid-July and October (mid-June to mid-November 2002-2016) with no replicate tows per station. The NJYOY index is calculated as a geometric mean number per haul of all stations (first haul only where applicable) between August and October, inclusive.

The NJYOY index increased from the 1980s through the mid-1990s and remained at or above average into the early 2000s; the index become more variable after that, with more below-average year classes (Table B5.6, Figure B5.10)

B4.6.2.8 Delaware Spawning Stock Electrofishing Survey (DESSN)

Delaware Division of Fish and Wildlife (DEDFW) provides an Age-1+ geometric mean index of relative abundance from its Spawning Stock Survey (DESSN) conducted from the lower Delaware River at the Delaware Memorial Bridge to the mouth of Big Timber Creek, New Jersey, which encompasses the main spawning grounds in the Delaware River. The spawning grounds are divided into lower and upper zones. The lower zone has twelve sampling stations extending from the Delaware Memorial Bridge to the boundary between the states of Delaware and Pennsylvania. The upper zone has thirteen sampling stations and extends from the Commodore Barry Bridge to Big Timber Creek. The average station length is approximately 1.6 km (ranges is roughly 1.1-2.2 km), however, the segment within each station sampled varies on any particular day depending on the direction of tidal current and fish abundance. Depth at each station ranges from 0.9 to 9.1 m. In addition to the shoreline stations, sampling is also conducted at Cherry Island Flats, a submerged island in the lower zone, as well as along Little Tinicum and Chester Islands in the upper zone.

Stations within the lower and upper zones of the spawning grounds are grouped into two categories based on average catch rates from the previous three years. The annual catch rates have been expressed in numerous ways since the project inception. The survey adopted the use of a geometric mean in 2001 to mitigate for years with substantially less effort (e.g. 2007) or high variation in catch per station. Stations with catch rates below average are categorized as “low” stations, while stations with average or above average catch rates are categorized as “high” stations. On each sampling day, five high stations and three low stations are randomly selected from a given zone. Each of the upper and lower zones are typically sampled weekly throughout the spawning season, which generally extends from mid-April to late May or early June depending on water temperature (14-22°C). In addition to randomized collections, ancillary collections are made at productive stations to increase the number of tagged fish released and the number of samples obtained for age and growth analyses.

Fish are collected using a Smith-Root, Inc. model 18-E boat electrofisher. The standardized sampling time at each station is 720 seconds of pedal time. The boat is operated moving with the tidal current in a serpentine-shaped pattern. Only fish ≥200 mm TL are collected. Fish <200 mm TL, which are typically immature and not yet recruited to the spawning population, generally pass through the mesh of dip nets used aboard the electrofishing boat. Captured fish are held in an onboard, flow-through, 280 liter live-well until the station is completed or until the live-well is full.

All sexually mature fish are measured to the nearest mm total length (TL). Sex is determined by the expression of milt by palpation of the gonadal region of the abdomen, obvious outward appearance, or presence of free flowing eggs. The condition of females is also noted as gravid or spent when apparent. Only sexually mature fish are included in total catch and catch rate calculations. All fish ≥ 400 mm TL and in good physical condition are tagged with a numbered internal anchor tag as part of the coast-wide tagging program coordinated by the U.S. Fish and Wildlife Service. Scale samples are collected from all fish for subsequent age and growth analyses.

Overall, the survey would suggest no trend in the relative abundance of spawning capable striped bass from 1996-2017 (Table B5.5, Figure B5.11). Due to equipment failure and staffing limitations, an index value is not available in 2014. Peaks were observed in 2003 and 2011. However, the two lowest points in the time series were observed in 2015 and 2016. The lower values in the index in recent years were also associated with a lower proportion of older fish in the age composition (Figure B5.11).

B4.6.2.9 Delaware 30' Bottom Trawl Survey (DE30)

The DEDFW has conducted a 30' (9 m) trawl survey within the Delaware Bay since 1966 (1966-1971, 1979-1984, and 1990-present). The Delaware Bay trawl survey occurs one of the producer regions of striped bass hosting a spawning population. The survey has been shown to capture a wide size and age range of striped bass throughout the year historically. The Striped Bass Stock Assessment Subcommittee determined that the Delaware 30-foot trawl survey provides an index of striped bass abundance that correlates to other surveys used in the stock assessment including the DESSN Survey, and the NJTRL survey.

The survey (DE30) collects monthly samples from March through December at nine fixed stations throughout the Delaware portion of the bay. The net used has a 30.5 foot (9.2 m) headrope and 2" (5 cm) stretch mesh codend. Species represented by less than 50 individuals are measured for fork length to the nearest half-centimeter. Species with more than fifty individuals were randomly sub-sampled (50 measurements) for length with the remainder being enumerated. Striped bass from a wide size and age distribution have been historically available to the survey, due to the temporal and spatial coverage of the survey design, including young of year to larger, mature individuals, with fish frequently spanning in size from 10-30" (25-76 cm) TL in any given year, with a range of 1-50" (2.5-127 cm) TL (Figure B5.12).

The data were limited to years 1990 through present to account for discrepancies in early sampling methodology including the number of stations and tow times. Similarly, the data were filtered to include the months of November and December only, as this is the period when the majority of striped bass are caught.

The DE30 survey was chosen for inclusion in the current benchmark stock assessment given the wide range of sizes observed in the survey, the ability to track cohorts through time, and the significant cross-correlations with surveys incorporated in the stock assessment. An Age-1+ index is calculated as the geometric mean. In order to examine the potential progression of cohorts through time in the survey, the total number of fish was expanded to catch at age using the survey specific length frequencies by year, and available age length keys from 2002-2016.

Overall, the index has declined since the 1990s with three large peaks observed in 1995, 1999 and 2002 (Figure B5.13). However, the lowest point in the time series was also observed earlier in the time series in 1991. The index appears to stabilize after 2007 remaining lower than the observed earlier portions of the time series. The survey index generally matches the decline in total catch (commercial harvest, recreational harvest, and dead releases) from Delaware Bay beginning in the early 2000s.

Cohorts can be seen moving through the survey at multiple points in time including, but not limited to Age-1 in 2002, Age-2 and Age-3 in 2005 (Figure B5.13).The survey index was significantly cross-correlated with the DESSN survey and the NJTRL survey at multiple lags in time (Table B5.7, Figure B5.14). The most significant cross-correlation with the DESSN survey occurred at a lag=-4 years, suggesting that recruitment of fish to the DE30 survey is linked to recruitment of fish to the DESSN survey four years later. The most significant cross-correlation of the DE30 survey with the NJTRL survey occurred at a lag=-1 year, suggesting that fish recruited to the DE30 survey are related to fish observed in the NJTRL survey the following year.

B4.6.2.10 Maryland Spawning Stock Survey (MDSSN)

Data consists of records of fish captured during the Maryland DNR striped bass Spawning Stock Survey, 1985-2017. This fishery independent survey's objectives include: estimating relative abundance-at-age for striped bass in Maryland's portion of Chesapeake Bay; characterize the striped bass spawning population and apply USFWS internal anchor tags.

Survey sites are associated by NOAA codes and GPS coordinates, and one randomly selected site is fished per day. The current sites are located in the upper Potomac River and the Upper Chesapeake Bay. The Choptank River was sampled in 1985-1994, and 1996. The Potomac River was not sampled in 1994. The survey is conducted from late March through May, collecting fish with experimental drift gill nets constructed of multifilament nylon webbing. Individual net panels were approximately 150 feet (46 m) long, and ranged from 8.0 to 11.5 feet (2.5-3.5 m) deep depending on mesh size. The Upper Chesapeake Bay and Potomac panels were in 3.0, 3.75, 4.5, 5.25, 6.0, 6.5, 7.0, 8.0, 9.0 and 10.0-inch (8, 10, 11, 13 15, 17, 18, 20, 23, and 25 cm) stretch-mesh, and the Choptank River mesh sizes were similar, but slightly different. 1985-1989 used fewer mesh sizes, but by 1990 the 10 panels were standard. Gill nets were fished 6 days per week, weather permitting. Numbers of days sampled per year varies, as commercial fishermen bid on the job, which has a cap on the total dollar amount.

Data are used to calculate area, age, and sex-specific catch per unit of effort. Sex-specific selectivity coefficients for each mesh and length group were estimated by fitting a skew-normal model to spring data from 1990 to 2000 (Helser et al. 1998). Sex-specific selectivity coefficients were used to correct the mesh-specific length group CPUE estimates. The selectivity-corrected CPUEs were then averaged across meshes and weighted by the capture efficiency of the mesh, resulting in a vector of selectivity-corrected length group CPUEs for each spawning area and sex. A subsample of fish are aged, and sex-specific ALKs are created from these subsample of aged fish and a similar subsample from the Maryland Spring Creel Survey. These sex-specific ALKs were applied to the appropriate vectors of selectivity-corrected length group CPUEs to attain estimates of selectivity-corrected year-class CPUEs. Sex- and area-specific, selectivity-corrected, year-class CPUEs were calculated using the skew-normal selectivity model. These area- and sex-specific estimates of relative abundance were summed to develop estimates of relative abundance for Maryland's Chesapeake Bay. Before pooling over spawning areas, weights corresponding to the fraction of total spawning habitat encompassed by each spawning area were assigned. For years when the Choptank River was sampled, the weights were Upper Chesapeake Bay (0.59), Potomac (0.37) and Choptank (0.04). The Choptank River has not been sampled since 1996, therefore, values for 1997 to the present were weighted using only the Upper Chesapeake Bay (0.615) and the Potomac River (0.385; Hollis 1967).

The MDSSN index was variable but relatively flat since the mid-1980s, while the age composition of the index showed an expanding age structure (Table B5.5, Figure B5.15.)

B4.6.2.11 Maryland Young-of-the-Year and Yearlings Surveys (MDYOY and MD Age1)

Maryland provides an index of relative abundance for young-of-the-year (YOY) and yearling (age-1) striped bass in the Maryland portion of Chesapeake Bay. Begun in 1954, the fixed station survey is conducted in the Upper Chesapeake 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 YOY or age-1 striped bass per haul.

The MD Age-1 index was consistent with the MDYOY index, with a very similar overall pattern and identifying many of the same high and low year classes at a one year lag (Figure B5.16). From the mid-1950s through the early 1970s, the indices were variable but showed frequent strong year classes entering the population; however, from the mid-1970s to the late 1980s, the indices showed time series low values with no strong year classes (Figure B5.16). Very strong year classes appeared in 1993 and 1996, and the indices returned to a pattern similar to the beginning of the time series of variable but high recruitment. Declines were observed from 2004-2010, and in some years, the indices were close to low values not observed since 1990 (Table B5.6, Figure B5.16). However, strong year classes appeared in 2011 and 2015.

B4.6.2.12 Virginia Young-of-the-Year Survey (VAYOY)

Virginia provides an index of relative abundance for young-of-the-year striped 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 striped bass per haul.

The VAYOY was low at the beginning of the time series before showing an increasing trend from the late 1980s through the early 2000s (Table B5.6, Figure B5.17). There was a period of low variability from 2004 – 2010 with no strong or weak year classes, but 2011 was the highest index value in the time series (Figure B5.17).

B4.6.2.13 Composite Young-of-Year Index for the Chesapeake Bay (MDVAYOY)
The MDYOY and VAYOY surveys occur in different areas of the Chesapeake Bay and do not cover the same range of years, but both indices are designed to track recruitment of the Chesapeake Bay stock. The Conn method (Conn 2010) was used to combine both datasets into a single coherent index of recruitment for the Chesapeake Bay stock (MDVAYOY).

The SAS explored using both the geometric mean of each survey and a GLMM-standardized index for each survey as the input to the Conn method. Both sets of input data showed similar trends and identified the same strong and weak year classes, although there were some differences in the relative strength of some year classes (Table B5.6, Figure B5.19). In addition, the MDVAYOY index developed using the GLMM-standardized inputs had a consistently higher CV than the geometric mean version (Figure B5.18). Since the assessment model uses an iterative re-weighting scheme to adjust the CVs of the input data internally (see Section B7.1), this difference was less of a concern to the SAS. The MDVAYOY index developed with the geometric mean indices was used in the base run.

B4.6.2.14 Northeast Area Monitoring & Assessment Program (NEAMAP)
The Northeast Area Monitoring & Assessment Program (NEAMAP) Southern New England and Mid-Atlantic (SNE/MA) Nearshore Trawl Survey was initiated in the fall of 2007 and is designed to sample the late-juvenile and adult stages of fishes during each of two (spring and fall) annual survey cruises sampling in near shore Atlantic waters between Cape Cod, Massachusetts, and Cape Hatteras, North Carolina. The cruises are timed to roughly correspond to those conducted by the Northeast Fisheries Science Center, though they are timed somewhat later than the federal survey during each season.

Due to the particular migration habits of striped bass as they relate to survey timing (during the spring survey most fish are spawning in the estuaries and during the fall survey most fish have not yet begun their southward migration), the NEAMAP SNE/MA survey is not currently considered to be a reliable indicator of stock abundance. However, valuable biological data were extracted from the survey for this assessment (e.g., age and sex data). NEAMAP SNE/MA captured at least one striped bass on approximately 8% of tows (3,636 specimens; 12,243 kg), so it may be worth examining these data for future assessment when the time series is longer.

B4.6.2.15 Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP)
The Chesapeake Bay Multispecies Monitoring & Assessment Program (ChesMMAP) was initiated in 2002 and is designed to sample the late-juvenile and adult stages of fishes over multiple seasonal and geographic gradients. Five bimonthly cruises (i.e., Mar, May, Jul, Sep, and Nov) are conducted annually by the Virginia Institute of Marine Science (VIMS) in the mainstem of Chesapeake Bay.

Fishes and invertebrates are collected using a 13.7 m (headline length), two-bridle, four-seam bottom trawl. During each cruise, 80 sites are sampled at sites selected using a stratified random design, where strata are defined by both latitude and depth. The number of stations sampled in each stratum (i.e., region/depth combination) is proportional to the surface area of that stratum. Sites are selected for a given cruise without replacement.

Each catch is sorted by species and modal size group (e.g., small, medium, and large size) within species. A subsample of five individuals from each species/size group is selected for full processing (see next paragraph). For all remaining specimens, aggregate biomass (kg), individual length measurements, and count are recorded for each species-size group combination.

Data collected from each of the subsampled specimens include individual length, individual whole and eviscerated weights (g), and macroscopic sex and maturity stage (immature, mature-resting, mature-ripe, mature-spent) determination. Stomachs are excised and those containing prey items are preserved for subsequent examination at VIMS. Otoliths or other appropriate ageing structures are removed from each subsampled specimen for age determination at VIMS. For species known to exhibit sexually dimorphic growth such as striped bass, individual length, whole weight, and sex are recorded from an additional 15 specimens per size-class per species per tow.

The ChesMMAP index captures primarily ages 1-3 of striped bass (Figure B5.18). The index declined from 2005 – 2011 during a period of weak recruitment in the Chesapeake Bay, then showed increases as the strong 2011 and 2015 year classes moved through the population (Table B5.5, Figure B5.18).

B4.6.3 Comparison of Fisheries-Dependent and Fisheries-Independent Indices

The time series of each index used in the current assessment are shown in Table B5.5 and Table B5.6.

Indices of Age-1+ abundance were classified by what component of the striped bass population they represented: the coastal mixed population (the MRIP CPUE, and the CTLISTS, NJTRWL, and NYOHS surveys), the Chesapeake Bay stock (MDSSN and ChesMMAP surveys), or the Delaware Bay/Hudson River stock (DESSN and DE30 surveys). The MRIP index and the CT LIST index showed similar trends for the coastal mixed stock; both were low during the 1980s and began increasing during the 1990s, but have since declined (Figure B5.21). The NJTRWL was low at the beginning of its time series in 1990, before jumping up in the mid-1990s; it has been mostly high and variable since then (Figure B5.21). The NYOHS showed no trend from the mid-1980s to the end of its time series in 2007 (Figure B5.21).

The MDSSN survey showed a relatively stable female SSB population since the mid-1980s; the ChesMMAP survey started later, in 2002, and has been more variable as it tracks a smaller, younger component of the population and is more influenced by recruitment (Figure B5.21).

The DE30 survey showed an increase from 1990 to a peak in 1995, and has been variable but generally declining since then, with the current index close to where it was at the beginning of the time series (Figure B5.21). The DESSN index has been more stable, fluctuating around its long-term mean (Figure B5.21).

Recruitment indices (YOY and age-1) in Chesapeake Bay were variable but declines were observed from 2004-2010, and in some years, the indices were close to low values not observed since 1990 (Figure B5.22). However, strong year classes appeared in 2011 and 2015. The MDYOY, VAYOY and MD age-1 indices identified many of the same strong and weak year classes. In Delaware Bay, recruitment increased from the 1980s through the mid-1990s and remained at or above average into the early 2000s; the index became more variable after that, with more below-average year classes (Figure B5.22). Recruitment in the Hudson River showed several strong year classes in the late 1980s after very low values at the beginning of the time series, and has remained variable around the long-term mean since then (Figure B5.22). Strong year-classes were evident in 1993, 1996, 2001, 2003, 2011, and 2015 in Chesapeake Bay; in 1993, 1995, 1999, 2003, 2009, and 2014 in Delaware Bay; and in 1988, 1997, 1999, 2001 and 2007 in Hudson River (Figure B5.22).

B4.7 Sex Proportions-At-Age

Sex and age data were available from the following sources: Massachusetts, Rhode Island, New York, Pennsylvania, Delaware, Maryland, Virginia, the Potomac River Fisheries Commission (PRFC), ChesMMAP, and NEAMAP. The data included both fishery dependent and independent sources, however, data from surveys conducted in known spawning reaches were excluded from the analysis as spawning aggregations are known to have high proportions of males relative to females and the sex ratios would likely be influenced by differences in maturity-at-age. Concerns were also raised regarding the accuracy of Massachusetts's sex determination methods in their commercial fishery monitoring so these data were also excluded from the analysis. Otolith ages were used preferentially in the analysis but scale ages were included if no otoliths were available. Sex ratios-at-age were initially analyzed annually but interannual variation was very large due to limited sample sizes. The analysis instead combined all years of data and the female proportions-at-age were calculated using only known sex fish with associated age data. Analyses were conducted by geographic area (Chesapeake Bay and Delaware Bay/ocean) and season (March-June (waves 2-3) and July-December (waves 4-6)). Following these subsets, the final data used are shown in Table B5.8. While expansion factors were provided for ChesMMAP and NEAMAP, most of the striped bass sampled on those surveys are aged and sexed and the sex ratios-at-age did not differ much between the raw and expanded data. For simplicity and to match the other data sources, the raw data were used. For the observed data, 95% confidence intervals were calculated. While the maximum age observed in the data is 31, sample sizes were low beyond age-15. Therefore, results are shown through age-15, aligning with the plus-group used in the stock assessment models used in this assessment.

The observed sex ratio in Chesapeake Bay in both the spring and fall is approximately 50-50 for ages 1 and 2 (Figure B5.23). As young females migrate to the coast, the observed proportion of females in Chesapeake Bay decreases for ages 3-5. A gradual increase in the proportions of females at age is observed for ages 6+ within Chesapeake Bay using all of the data. However, when samples from November and December were removed, the proportion of females observed remained low for ages 4-12. The increase in female proportions-at-age in the whole dataset is likely due to migratory, ocean run fish that have been observed to return to the lower Chesapeake Bay in the late fall/early winter following schools of bait. Most of the samples from this time frame are from Virginia's commercial fishery, these are likely larger migratory fish influencing the proportion of females-at-age in the fall (waves 4-6).

The ocean fishery consists of predominantly female fish at all ages, showing an increase in the proportion of females for ages 3-5 (Figure B5.24). This corresponds with the decrease in females in Chesapeake Bay at the same ages and is likely caused by females migrating to the coast. The decrease in the proportion of females around age 5 is likely due to some males also migrating to the coast. These observations on migrations by sex and age generally align with those of Kohlenstein (1981) who suggested that large numbers of females migrate to the coast around age-3. Secor and Piccoli (2007), using otolith microchemistry, also noted an increase in coastal migrations of fish with size/age and that both sexes undertook coastal migrations, though males to a lesser extent than females. Similar to Chesapeake Bay, from ages 7+ there is an observed gradual increase in the female proportions-at-age.

A LOESS smoothing function in the stats package in R (R Core Team 2016) was used to reduce the annual variability in observed sex rations of female proportions-at-age. In general, the LOESS smoothed estimates fell within the 95% confidence intervals of the observed data (Figures B5.23 and B5.24). The LOESS smoothed estimates in Table B5.9 were used in the assessment model for waves 2-3 and waves 4-6 for each geographic area (see Section B7.1.1). While the female proportions-at-age for age-15 was used for the plus group in the ocean, an average for ages 15-26 was used for the plus groups in Chesapeake Bay. Sample sizes of available data were much smaller for wave 1 (January-February) and for the model, it was assumed that the female proportions-at-age were the same in wave 1 as in waves 4-6. Exploratory analyses on the wave 1 female proportions-at-age data suggest that this is a reasonable assumption (A. Giuliano, pers. comm.).

While the new LOESS estimates of the female proportions-at-age were used in the new two-stock SCA model for each geographic area and wave period, previously calculated female sex proportions-at-age were used in the single-stock, non-migration SCA model and the ASAP model. These female sex proportions-at-age are used to apportion the numbers-at-age to female numbers-at-age for calculation of female SSB. The sex proportions were derived from available state catch datasets. The proportions used from previous assessments and for the non-migration SCA and ASAP models were:

Age	1	2	3	4	5	6	7	8	9	10	11	12	13+
Proportio n 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

B4.8 Atlantic Coast Striped Bass Tagging Data

Tagging data are compiled from eight tagging programs of the USFWS Atlantic coast-wide striped bass tagging program. Because the Atlantic Coast striped bass is a highly migratory anadromous species, tagging programs are separated as two categories: producer area programs and coastal programs. Most programs tag ≥ 18 inch (457 mm) TL striped bass during routine state monitoring programs.

Producer area tagging programs primarily target spawning grounds during the spring spawning season. Capture methods differ by tagging program, including pound nets, gill nets, seines, and electroshocking. Producer area tagging programs, including the timing of tagging, and the lengths of the current time series, are as follows:
Hudson River (HUDSON) - fish tagged in May, with a time series of 1988–2017;
Delaware and Pennsylvania (DE/PA) - fish tagged in the Delaware River primarily in April and May, with a time series of 1993–2017;
Maryland (MDCB) - fish tagged in the Potomac River and the upper Chesapeake Bay primarily in April and May, with a time series of 1987–2017; and
Virginia (VARAP) - fish tagged in the Rappahannock River during April and May, with a time series of 1990–2017.

Coastal programs tag striped bass from mixed stocks during fall, winter, or early spring. Gears include hook-and-line, seine, gill net, and otter trawl. The coastal tagging programs are as follows:
Massachusetts (MADFW) - fish tagged during fall months, with a time series of 1992–2017;

New York ocean haul seine survey (NYOHS) - fish tagged during fall months, with a time series of 1988–2007. This survey changed to a trawl survey (NYTRL) in 2008 (fish tagged in November), with a time series of 2008–2012. Due to differences in length frequency and gear types, data from the two surveys are analyzed separately.
New Jersey Delaware Bay - fish tagged in March and April, with a time series of 1989–2017; and
North Carolina winter trawl survey (NCCOOP) - fish tagged primarily in January, with a time series of 1988–2017. This survey used a trawl from 1988–2012, a combination of trawl and hook-and-line during 2013, 2014, and 2016, and hook-and-line only during 2015 and 2017. Rulifson et al. (2018) reported that survival and exploitation rates were similar for fish tagged from trawl and hook-and-line surveys, so further analyses of data from this tagging program have continued with a single data series.

The USFWS office in Annapolis, Maryland, maintains the tag release/recovery database and provides rewards to recreational anglers and commercial fishers who report the recaptures of tagged fish. The USFWS office exchanges tag release and recapture data with cooperating tagging agencies. From 1985 through August 2018, there were 542,149 striped bass tagged and released, with 92,344 recaptures reported and recorded in the USFWS database (Josh Newhard, pers. comm.).

Release data, recorded at time of tagging, include the following:
- tag number,
- total length,
- sex (if available),
- release date,
- release location,
- gear, and
- other physical data.

Recapture data obtained directly from anglers are as follows:
- tag number,
- total length,
- disposition,
- recapture date,
- recapture location,
- gear; and
- personal information.

B4.9 Stock Composition Estimates

The SAS examined the USFWS tagging data base (1987-2016) to estimate stock composition of fished striped bass in coastal waters by assigning each tagged fish to a spawning stock based on recapture in putative spawning areas (Chesapeake Bay, Delaware Bay, and the Hudson River) (Kneebone et al. 2014).

The SAS considered fish tagged in coastal waters by three major tagging programs (Massachusetts Division of Fish & Wildlife, North Carolina Cooperative Tagging Program, and New York Department of Environmental Conservation Coastal Program) that were subsequently recaptured in and around spawning areas during the spawning season (Table B5.10 and B5.11). To accomplish this, criteria outlined in Kneebone et al. (2014) was used, with some modifications: (1) limited analyses to released fish where total length was either ≥ 457 mm (18'') or ≥ 711 mm (28'') (Figure B5.25) as these size cutoffs are used by the tagging subcommittee in their analyses (associated with ages 4+ and 7+, respectively, in the two-stock SCA model described in Section B7.1), (2) the fish must have been confirmed to have been alive during at least one spawning period after release, and (3) fish that were recaptured either on the spawning ground during the spawning season, or recaptured anywhere in the 'parent' producer area during the spawning season were assigned to that spawning stock. Preliminary analyses suggested that few fish met the more stringent criterion of recapture on the spawning grounds during the spawning season (e.g., due to regulatory closures), so spatial constraints were relaxed. Even accounting for relaxed spatial constraints, most fish did not meet these criteria, and so the fraction of fish assigned to 'unknown' stocks was large (Table B5.12 and B5.13). Consequently, stock composition accounting for fish from unknown stocks was estimated under the assumption that fish of unknown stock (e.g., fish released and recaptured in the ocean or in a producer area outside of the spawning season) would have distributed themselves identically to the known stock fish (i.e., allocated all 'unknown' stock fish proportional to known stock fish).

All spawning was assumed to occur between March 15th and June 15th in all areas. This window of time is longer than that assumed by Kneebone et al. (2014), but personal observations (A. Giuliano and M. Kauffman, pers. comm.) suggest that this window is reasonable. Fish were removed from the analysis that were at large for fewer than 10 days and only used the first recapture event. Raw tag returns were adjusted following the approach used by Hansen and Jacobson (2003) which used spawning area- and disposition-specific reporting rates and exploitation rates as reported in the 2013 assessment report (NEFSC 2013). Of note, reporting rates and exploitation rates were only available through 2011, so the terminal values were carried forward for the remaining years. Also of note, F in Chesapeake Bay was estimated to be 0 in 1989 by the Striped Bass TSC resulting in infinite adjusted tag returns. To avoid this, F was set at 0.01 in 1989 (a low, nominal value, equivalent to F in 1988), reasoning that the weighting of F in the Chesapeake Bay (NEFSC 2013) and timing of moratoria made this a more likely value than F in 1990 (0.08), or the average of the two. Fish were also assigned to an "unknown" stock wherever a fish was not recaptured in the parent spawning system during the spawning season – as a simplifying assumption, 'unknown' fish tag returns were adjusted using grand averages across dispositions, years, and areas (Figure B5.26).

Finally, the SAS conducted analyses grouping recaptured tags by regulatory period, aligning with the regulatory periods used by the Striped Bass TSC (regulatory periods described in Section B8.4; Figure B5.26). Relative stock composition was then calculated for each stock as the number of individuals assigned to a given spawning stock divided by the total number of individuals for which stock status could be assigned. More detail is available in Celestino and Giuliano (2018).

Stock composition by length group is provided in Table B5.12 and B5.13 and Figure B5.27. It is generally consistent with previous studies (Kneebone et al. 2014; Kohlenstein 1980). For both the 18" (457 mm) and 28" (711 mm) analyses, the contribution of Chesapeake Bay fish tagged in the ocean was low in the 1990s and increased by 2000. The 28" (711 mm) stock composition estimates have a lower Chesapeake Bay stock composition estimate in the 1980s and 1990s than those estimated using 18" (457 mm) fish. This trend reverses starting in 2000 with the Chesapeake Bay stock composition estimated to be higher for 28" (711 mm) fish than when using 18" (457 mm) fish. Fish of unknown stock were principally recaptured in the ocean (65%) or in Chesapeake Bay outside of the spawning season (28%).

As there is some uncertainty about the reporting rate and fishing mortality estimates from the stock assessment, a sensitivity analysis was done to determine the influence these estimates have on the overall stock composition estimates (Figure B5.28). The stock composition estimates were generally insensitive to estimates of reporting rate and fishing mortality between the producer areas, particularly in the 1990s. The differences between the raw recapture data and the reporting rate and fishing mortality adjusted estimates were larger in more recent years compared to the 1990s, particularly for the 28” (711 mm) fish. In all cases, the adjustments for reporting rate and fishing mortality increased the contribution of the Chesapeake Bay stock.

The SAS spent a considerable amount of time discussing the differences in the stock composition estimates across time and between size groups. Due to low numbers of recaptures for 1987-1989 in the producer areas as well as differences in the stock composition estimates in this time period from other studies, the SAS decided to not use the stock composition estimates for these years in the stock assessment model. Additionally, there were concerns based on the emigration rates that not many 18” (457 mm) fish had migrated to the coast from Chesapeake Bay whereas many more fish have migrated to the coast by the time they reach 28” (711 mm). Based on this, the SAS chose to use the 28” (711 mm) results in the base model run as it better aligned with the assumptions of the two-stock SCA model (see Section B7.1), however, the 18” (457 mm results were included as a sensitivity run.

TOR B2. ESTIMATE COMMERCIAL AND RECREATIONAL LANDINGS AND DISCARDS. CHARACTERIZE THE UNCERTAINTY IN THE DATA AND SPATIAL DISTRIBUTION OF THE FISHERIES. REVIEW NEW MRIP ESTIMATES OF CATCH, EFFORT AND CALIBRATION METHOD IF AVAILABLE.

B4.10 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. Commercial harvest in some states is recorded in pounds and is converted to number of fish using conversion methods. Biological data (e.g., length, weight, etc.) and age structures (primarily scales with some supplemental sampling of otoliths) from commercial harvest are collected from a variety of gear types through state-specific port sampling programs. Sample sizes for lengths and age structures are summarized by state for 2000-2017 in Table B6.1. Harvest numbers are apportioned to age classes using length frequencies and age-length keys derived from biological sampling. Appendix B5 details the quota monitoring systems, commercial and recreational sampling programs, and methods used to develop commercial and recreational catch-at-age for each state.

B4.11 Commercial Landings

B4.11.1 Commercial Landings in Weight

Historically, annual commercial harvest of striped bass peaked at approximately 5,888 mt (13 million pounds) in 1973, but due to stock declines and subsequent management actions, landings decreased by 99 percent to 68 mt (151,000 pounds) in 1986 (Table B6.2, Figures B6.1 and B6.2). Commercial landings gradually increased through the early 1990s as the stock recovered and management measures were liberalized. The quota system has kept the commercial landings relatively stable from 2004 – 2014, with average landings of 2,935 mt (6.5 million pounds). The commercial quota was reduced in 2015 in response to the assessment update, and landings average-2,133 mt (4.7 million pounds) from 2015-2017.

B4.11.2 Commercial Landings in Numbers

As with commercial landings in weight, commercial landings in numbers reached a low in 1987 with only 3,730 fish landed, before increasing through the early 1990s (Table B6.3, Figure B6.2). Commercial landings in numbers peaked in 1999 at 1.22 million fish. From 2004 – 2014, commercial landings averaged 943,000 fish per year, although numbers of fish landed was below average in 2012-2014. Total numbers landed continued to decline with the quota reduction implemented in 2015, with an average of 608,000 fish caught from 2015-2017.

From 2004 – 2017, landings from the Chesapeake Bay have made up 57% of total commercial striped bass landings by weight, and 78.5% by number. The difference is due to the higher availability of small fish and the lower size limits in the Chesapeake Bay.

The Chesapeake Bay has seasonal restrictions on commercial harvest to protect the spawning stock; from 2004 – 2014, 29% of commercial landings occurred during January and February (Wave 1, model period-1), 18% occurred from March – June (Waves 2-3, model period-2), and 53% occurred from July – December (Waves 4-6, model period-3). The proportions were not very different in 2015 – 2017, with 23% landed in January and February, 25% landed from March – June, and 51% landed from July – December. If landings were distributed evenly throughout the year, March – June should account for 33% of the total landings.

Commercial landings in the ocean and other areas occur mainly in the second half of the year, with 74% of total landings being taken from July – December for both 2004 – 2014 and 2015 – 2017. The proportion of landings occurring in January and February has declined in recent years; from 2004 – 2014, 7% of landings occurred in those months, while from 2015 – 2017 only 1% of landings occurred then. January and February harvest in the ocean occurs almost exclusively in the ocean waters of Maryland, Virginia, and North Carolina, and North Carolina has reported no commercial landings from their ocean winter fishery since 2013, and Virginia has reported none since 2015. Anecdotal evidence from fishers suggested that the striped bass were no longer available in state waters during January and February in Virginia and North Carolina, and instead were further offshore, where harvest is restricted, and further north than they were historically during that time period.

B4.11.3 Commercial Landings Age Composition

The age structure of commercial harvest varies from state to state due to size regulations, season of the fisheries, and the size classes of striped bass available to the fisheries. From 2004 – 2014, ages 3 – 9 made up 86.5% of the commercial landings in numbers (Figure B6.3). The implementation of higher size limits in 2015 in several jurisdictions reduced the proportion of age-3 fish in the landings (Figure B6.3). Commercial landings from the Chesapeake Bay are dominated by younger fish (ages 4-6), while commercial landings from the ocean and other areas have a broader age structure with most landings coming from ages 6-12 (Figure B6.3).

B4.12 Commercial Discards

B4.12.1 Commercial Discard Mortality Rates

Discard mortality rates for commercial fishing gears were determined through a combination of literature review, review of values used in previous striped bass stock assessments, and new analyses of commercial fishing data from the New Jersey anchor and drift gill net fisheries and the Maryland pound net fishery.

The New Jersey gill net log book data spanned a time period from 2000 through 2015. Records were included in the analysis if they recorded striped bass being caught and the number of live and dead striped bass were specified. Estimated numbers or entries expressing striped bass in terms of weight were omitted. The resulting number of records included 899 anchor gill net sets and 1,880 drift gill net sets. A simple ratio estimator was used to estimate the mortality associated with anchor and drift gill nets, separately. The ratio estimator divided the sum of dead striped bass across all records by the sum of the total number of striped bass (live and dead) caught across all records and the associated variance and standard deviation was calculated.

$$r = \frac{\sum y_i}{\sum x_i}$$

$$\mathrm{var}(r) = \left(\frac{1}{\bar{x}^2}\right) \cdot \sum \frac{(y_i - r \cdot x_i)^2}{n \cdot (n-1)}$$

where r is ratio estimate of mortality, y_i is the number of dead striped bass in gill net i, x_i is the total number of striped bass caught in gill net i, and n is the number of gill nets.

Mortality was higher in New Jersey anchor gill nets than drift gill nets. Mortality in anchor gill nets was 0.46±0.03 (±st. dev.) while mortality in drift gill nets was 0.06±0.003. These estimates were similar to those from Seagraves and Miller (1989) which were used in the previous striped bass stock assessment (0.43 for anchor gill nets and 0.08 for drift gill nets).

The Maryland pound net fishery data spanned 1994 through 2016 and included a total of 754 pound net sets in which striped bass were caught. Of these, 584 (77%) had no mortality of striped bass. Again, a ratio estimator was used to estimate mortality associated with pound nets. Mortality was low with an estimate of 0.01±0.002, which was less than the value used in the previous stock assessment (0.05).

Gear specific values from the literature, previous stock assessments, and the new estimates from the New Jersey gill net and Maryland pound net fisheries are presented in Table B6.4. Gill nets and hook and line gears had several estimates of mortality, but there was little information for other gear types. Given the consistency of these estimates with previous estimates of mortality for these gear, and the lack of new information on other gear types, the estimates of release mortality from the previous assessment (NEFSC 2013) was carried forward for this assessment.

B4.12.2 Commercial Discards Estimation

Prior to 1998, discard estimates for fisheries in Chesapeake Bay and coastal locations were based on the ratio of tags reported from discarded (or released) striped bass in the commercial fishery to tags reported from discarded striped bass in the recreational fishery, scaled by total recreational discards (releases):

1) 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/Marine Recreational Information Program (MRFSS/MRIP),
CT = number of tags returned from discarded fish by commercial fishermen,
RT = number of tags returned from discarded fish by recreational fishermen.

The total commercial discards were then apportioned to gear type by further partitioning of tag data (all dispositions) into gear types, calculating the proportions of tags by gear type and multiplying the proportions by the total discards. The number of dead discards were then calculated using discard mortality estimates for each gear type.

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.

Expanding recreational discards to commercial discards based on reported tag returns assumes equal tag reporting rates in commercial and recreational fisheries but in fact this is not true. To correct for this bias, the TC began calculating (ca. 2004) a correction factor by first calculating the ratios of commercial harvest and recreational harvest (LR) and commercially-harvested tag returns divided by recreationally-harvested tag returns (KT). The correction factor (CF) was then derived by

2) CF=LR/KT

The estimates of total discards are then derived by:

3) CD=RD*(CT/RT)*CF

However, there was considerable year-to-year variation in the estimates of total discards which was unlikely given the relatively consistent commercial and recreational catches among years. In previous years, a three year average of the CFs for the current year and previous two years are used to generate the annual estimates of total commercial discards for each region. Commercial discard estimates were not re-estimated with this new method prior to 2004.

Based on examination of other ways of smoothing variable data (Nelson 2017), commercial total discards are now estimated by applying a generalized additive model (GAM; Wood 2006; Appendix B6) with automatic selection of the degrees of freedom to the time series of number of tags of each fishery and disposition type from 1990 to present (e.g., commercial killed tags, recreational release tags). Predicted tag numbers are then used in Equation 1-3, above, and no smoothing of CF occurs. The GAM model is fitted to tag numbers versus year using the *gam* function in R package *mgcv,* assuming normal errors. Year was modeled as a spline and the maximum number of degrees of freedom was set to 20 (estimated degrees were less than 11 for all models explored).

For years prior to 1990, the smoothed tag data from the GAM and average correction factor for 1990-1991 was used in Equation 3 to calculate total discards in 1982-1989 for each region.
For Delaware Bay, scaling of the time series of total discards was accomplished using discard-to-harvest ratios calculated from landings and discards given in Clark and Kahn (2009) for gillnets in spring of 2002 and 2003. Resulting estimates were 0.40 for 2002 and 0.46 for 2003. Using these ratios and the total landings from the Delaware Bay (24,813 and 31,460 fish in 2002 and 2003), the total number of fish discarded was 9,925 fish in 2002 and 14,471 fish in 2003. The estimated time series of total discards is reduced by the ratio of the estimated total discards from Clark and Kahn in 2002 and 2003 and the estimated total discards from the GAM method for 2002 and 2003. The ratio is:

$$r = \frac{\sum_{2002}^{2003} D_i^{CK}}{\sum_{2002}^{2003} D_i^{tag}}$$

D^{tag} and D^{CK} are the total discard estimates from the smoothed tag data method and using the Clark and Kahn estimates, respectively. The total discard estimates are multiplied by r to scale values.

Total discards are then allocated to fishing gears based on the relative number of tags recovered by commercial gears regardless of disposition. The raw tag data are used for Chesapeake Bay and the Ocean (2016 data for anchor and drift gillnets in Ocean were used for 2017). For Delaware Bay, the raw tag data are used but missing values for 2012, 2014 and 2016 were imputed by using predicted values from a GAM smoothing method of the tag data by gear.

Discards by fishing gear were multiplied by gear-specific release mortalities (anchor gillnet=0.45, drift gillnet=0.06, hook-and-line=0.09, other=0.2, pound net=0.03, seine=0.16 and trawl=0.26; NEFSC 2013) to get 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.

Descriptions of data sources are listed in Table 1 of Appendix B6. Gear specific proportions at age were applied to dead discard estimates by gear and summed across all gears (see next section results).

Tag data used in the estimation came from the USFWS database. Tag returns included in the analyses were selected using multiple criteria to eliminate errors and obtain more consistent time series. Only the first tagging event was used; releases from Canada, data associated with duplicated tag numbers, and records where disposition, gear, date, and state/region were not recorded were dropped.

All commercial harvest data came from state reports and the new MRIP estimates came from the NOAA website. Total discards were estimated for the Chesapeake Bay, Delaware Bay and Ocean regions.

B4.12.3 Commercial Dead Discards and Dead Discards Age Composition by Region

B4.12.3.1 Chesapeake Bay Dead Discards and Dead Discards Age Composition

The number of tags by fishery and disposition, commercial harvest and new estimates of recreational harvest and releases are shown in Table B6.5. There is a general decline in the number of tag returns over time (Figure B6.4). As a proportion of the total number of tag returns, the recreationally killed tag returns have been increasing over time, while the remaining categories have declined (Figure B6.4). To demonstrate the magnitude of change in the estimates of commercial total discards associated with changes in the MRIP harvest and releases, Equation 3 was used to calculate unadjusted (no smoothing of tags or CF) total discards for 1990-2015 using the old MRIP data and for 1990-2017 using the new MRIP data (Table B6.5).

The smoothed estimates of tag numbers are given in Table B6.6 and are compared to the observed values in Figure B6.5.

The estimates of unscaled commercial total discards are listed in Table B6.7 and are shown in Figure B6.6. The number of tags recovered by commercial gear type regardless of disposition by year is shown in Table B6.8. Number of annual returns has been declining and, in recent years, is low (≤32).

Estimates of unscaled commercial total discards apportioned by gear type for 1990-2017 are shown in Table B6.9. Dead discards are listed by gear type for 1990-2017 in Table B6.10. The number of unscaled dead discards-at-age matrix for year 1982-2017 is given in Table B6.11.

The remaining issue is whether the Chesapeake Bay estimates of total discards are realistic or not. If the new estimates are used, the proportion that those numbers represent of the total catch (discards +harvest) range between 63-95% (Figure B6.7). The proportion discarded seems unreasonably high. If the new estimates are scaled using the fraction reduction observed for the Delaware Bay when the new time series is compared to the 2002 and 2003 direct estimates, the range in proportions for Chesapeake Bay drops to 23-75% (Figure B6.7). Another way to look at the data is to calculate the ratio of total discards to harvest and these are shown in Figure B6.8 along with direct estimates from several states and gear types. The ratios using the unscaled new estimates were high compared to other estimates. Using the scaled estimates produces ratios in the range observed in other gears and states (Figure B6.8). Estimates of dead discards-at-age for the scaled total discards estimates are shown in Table B6.12. The SAS adopted the scaled estimates of dead discards for this assessment.

B4.12.3.2 Ocean Region Dead Discards and Dead Discards Age Composition

The number of tags by fishery and disposition, commercial harvest and new estimates of recreational harvest and releases are shown in Table B6.13. There is a general decline in the number of tag returns over time (Figure B6.9). As a proportion of the total number of tag returns, the recreationally killed tag returns have been increasing over time, while the remaining categories have declined (Figure B6.9). To demonstrate the magnitude of change in the estimates of commercial total discards associated with changes in the MRIP harvest and releases, Equation 3 was used to calculate unadjusted (no smoothing of tags or CF) total discards for 1990-2015 using the old MRIP data and for 1990-2017 using the new MRIP data (Table B6.13).

The smoothed estimates of tag numbers are given in Table B6.14 and are compared to the observed values in Figure B6.10.

The estimates of commercial total discards are listed in Table B6.15 and are shown in Figure B6.11. The number of tags recovered by gear type is shown by year in Table B6.16.

Estimates of commercial total discards apportioned by gear type for 1990-2017 are shown in Table B6.17. Dead discards are listed by gear type for 1990-2017 in Table B6.18. The number of dead discards-at-age matrix for year 1982-2017 is given in Table B6.19.

Comparison of the NMFS observer estimates of total discards for gillnets and trawls in the Ocean and the estimates from the tag-based method for the same gear type revealed the tag-based estimates are reasonable, particularly in the later years (Figure B6.12). These results suggested the Ocean estimates of total discards did not need to be adjusted.

B4.12.3.3 Delaware Bay Dead Discards and Dead Discards Age Composition

The number of tags by fishery and disposition, commercial harvest and new estimates of recreational harvest and releases are shown in Table B6.20. There is a general decline in the number of tag returns over time (Figure B6.13). As a proportion of the total number of tag returns, the recreationally killed tag returns have been generally increasing over time, while the remaining categories have declined

(Figure B6.13). To demonstrate the magnitude of change in the estimates of commercial total discards associated with changes in the MRIP harvest and releases, Equation 3 was used to calculate unadjusted (no smoothing of tags or CF) total discards for 1990-2015 using the old MRIP data and for 1990-2017 using the new MRIP data (Table B6.20).

Number of annual returns has been declining and, in recent years, is low (<36). The smoothed estimates of tag numbers are given in Table B6.21 and are compared to the observed values in Figure B6.14.

The unscaled and scaled estimates of commercial total discards are listed in Table B6.22 and the scaled estimates are shown in Figure B6.15. The numbers of tags recovered by commercial gear type regardless of disposition by year are shown in Table B6.23. Estimates of commercial total discards apportioned by gear type for 1990-2017 are shown in Table B6.24. Dead discards are listed by gear type for 1990-2017 (Table B6.25). The complete dead discards-at-age matrix for Delaware Bay for 1982-2017 is given in Table B6.26. The SAS adopted the scaled estimates of dead discards for this assessment.

B4.13 Total Removals by Commercial Fisheries

From 2015 – 2017, total commercial removals (landings and discards) has averaged 713,000 fish, down from a peak of 1.6 million fish in 1998 (Figure B6.16). Landings have generally exceeded discards since the early 1990s; discards made up approximately 15% of total commercial removals coastwide from 2015 – 2017, with a lower proportion of discards estimated for the Chesapeake Bay fisheries than for the fisheries in the ocean and the other areas.

The Chesapeake Bay accounted for 74% of the commercial removals by number from 2015 – 2017; that proportion has varied between 70% and 80% since 2004.

B4.14 Recreational Data Sources

Data on recreational catch and harvest of Atlantic striped bass is provided by the Marine Recreational Information Program (MRIP, formerly the Marine Recreational Fisheries Statistics Survey or MRFSS). MRIP encompasses a suite of regional angler survey programs conducted by federal and state partners, with the goal of providing information on recreational fishing activity within U.S. coastal waters. Broadly, survey programs within MRIP can be thought of as falling into two categories: effort surveys, geared towards assessing the number of fishing trips anglers take along some section of the U.S. coast, and intercept surveys, or surveys designed to assess the outcomes of individual angling trips (e.g. average number and size of fish harvested per trip). Information from these survey types are combined within a mathematical model to produce estimates of seasonal, annual, or regional recreational fishing activity.

During the 40-year history of the program, various modifications have been made to MRFSS/MRIP survey designs and associated mathematical models to improve comprehensiveness, accuracy, and precision of program products. Of particular interest for this stock assessment are recent modifications to relevant effort and intercept surveys.

Prior to 2018, estimates of angler effort (i.e. angler trips) used to calculate annual recreational catch and harvest of Atlantic striped bass were derived from the Coastal Household Telephone Survey (CHTS), a random-digit-dial telephone survey. A 2006 review by the National Research Council (NRC) confirmed general perceptions amongst coastal fishery managers that the CHTS had declined in effectiveness; in particular, the NRC review noted that the CHTS design was inefficient, suffered from coverage bias, and was experiencing declining response rates and associated increased potential for nonresponse bias (NRC 2006). The NRC review prompted a concerted effort to design and test a new effort survey program, which culminated with the adoption of the Fishing Effort Survey (FES) in 2018. The FES is a mail-based survey that offers several improvements over the CHTS – in particular, it leverages the National Saltwater Angler Registry created via the 2006 re-authorization of the federal Magnuson-Stevens Fishery Conservation and Management Act to produce an improved sampling frame that improves response rates and reduces coverage bias. The FES was implemented by federal and state partners using a multi-year transition plan. First, the CHTS and FES were conducted simultaneously for three years (2015-2017). The results of these years of "side-by-side" surveys were used to develop a calibration model, which in effect is able to convert historic CHTS estimates to the new FES "currency." The FES calibration model passed peer review in 2017 and is now available for management use. The CHTS was discontinued after 2017 and the FES survey alone is now used to estimate recreational effort on the U.S. coast.

The 2006 NRC review also noted issues with the Access Point Angler Intercept Survey (APAIS), the on-site intercept survey that collects information from individual anglers on the outcomes of their fishing trips (e.g. numbers and sizes of fish caught and harvested). The NRC review noted several shortcomings of the survey design that could bias results, in particular the probabilities used to select various sites for daily sampling and the temporal coverage of the survey. Subsequently, an improved APAIS sampling design was implemented starting in 2013. As with the transition from CHTS to FES for the effort portion of the study, the transition to a new intercept survey design necessitated a calibration model that could render historic (pre-2013) APAIS estimates comparable to contemporary APAIS estimates. Development of the APAIS calibration model was particularly challenging because, unlike in the CHTS/FES case, there were no years of "side-by-side" old vs. new APAIS survey results available to inform the calibration model. Despite this substantial challenge, an APAIS calibration model passed peer review in 2018 and became available for management use.

As of 2018, the necessary calibration models were available to adjust historic MRIP estimates of Atlantic striped bass recreational catch and harvest such that they become statistically comparable to current estimates produced by FES/revamped APAIS. This effort for Atlantic striped bass was part of a larger effort to create a re-calibrated MRIP time series for a host of important recreational species, a necessary effort given the need to incorporate single, statistically-consistent time series of recreational harvest into stock assessment models. This Atlantic striped bass stock assessment is one of the first stock assessments to incorporate re-calibrated MRIP data that reflects recent changes to effort and intercept survey methodologies.

Anecdotal evidence suggested that North Carolina, Virginia, and possibly other states have had sizeable wave-1 fisheries beginning in 1996; the wave-1 sampling that began in 2004 in North Carolina and the large number of wave-1 tag returns for North Carolina and Virginia supported this contention. However, MRFSS/MRIP did not sample in January and February (wave-1) north of South Carolina prior to 2004, so there were no estimates of wave 1 harvest in the MRFSS/MRIP dataset for 1996 – 2003; after 2003, wave-1 sampling began in North Carolina so there were estimates of harvest and live releases for North Carolina, but not Virginia. Harvest in wave-1 for North Carolina and Virginia in years without MFRSS/MRIP sampling was estimated back to 1996 using observed relationships between landings and tag returns. A linear regression was developed between the number of North Carolina tag returns during wave-1 and the MRIP estimates of recreational harvest for wave 1 from 2005 – 2017 (Figure B6.17). This relationship was used to predict wave-1 harvest from the number of wave-1 tag returns for North Carolina for 1996 – 2003 and for Virginia for 1996 – 2017 (Table B6.27). Live releases for the winter recreational fishery in North Carolina and Virginia were not estimated.

Most states use the length frequency distributions of harvested striped bass measured by MRIP to characterize the size composition of the recreational harvest. The MRIP measurements are converted from fork length (inches) to total length (inches) using conversion equations. Proportions-at-length are calculated and multiplied by the MRIP harvest numbers to obtain total number harvested-at-length. The sample sizes of harvested bass measured by MRIP were inadequate for estimation of length frequencies for some states; therefore, harvest length data collected from other sources (e.g., volunteer angler programs) were used to increase sample sizes (Table B6.28). Appendix B5 details the quota monitoring systems, commercial and recreational sampling programs, and methods used to develop commercial and recreational catch-at-age for each state.

Data on sizes of striped bass released alive come mostly from state-specific sampling or volunteer angling programs (Table B6.28). Proportions-at-length are calculated and multiplied by the MRIP 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.

Many states collect scale samples during state sampling programs designed to collect information on harvest and released striped bass from the recreational fishery. Age-length keys are developed 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, and/or striped bass tagging programs. For those states that do not collect scale samples, age-length keys are borrowed from neighboring states.

The age composition of the estimated wave 1 recreational fishery in North Carolina and Virginia was calculated from length-frequency data collected by MRIP and appropriate state age-length keys. Length-frequencies for the North Carolina winter harvest of 2004 - 2017 came from MRIP wave 1 data. Length-frequencies for the wave 1 harvests of 1996-2003 for North Carolina and 1996 – 2017 for Virginia came from wave 6 of the previous year for each state (e.g., the Virginia wave 6 length frequency of 1995 was used for the Virginia 1996 wave 1 landings). Lengths were converted to age for North Carolina with annual age-length keys from pooled New York and North Carolina data. The Virginia lengths were converted to age with annual Virginia age-length keys

B4.15 Recreational Landings and Releases

B4.15.1 Recreational Total Landings in Weight

Figure B6.1 shows the growth of the Atlantic coast recreational fisheries from 1982 through 2017. Harvest increased from 1,090 mt (2.4 million pounds) in 1984 to 29,510 mt (65 million pounds) in 2013 (Table B6.2). Harvest from 2004 – 2013 was relatively stable, averaging 24,718 mt (55 million pounds). Following the peak in 2013, harvest declined through 2017 to 17,190 mt (38 million pounds) (Figure B6.1).

B4.15.2 Recreational Landings in Numbers

Recreational harvest of striped bass increased from a low of 264,000 fish in 1984 to a high of 5.4 million fish in 2010 (Table B6.3). Harvest was relatively steady from 2004 – 2014, averaging 4.7 million fish per year, but dropped to an average of 3.2 million fish for 2015 – 2017 with the implementation of Addendum IV (Figure B6.18). Harvest was generally highest in Maryland, New Jersey, New York, Virginia, and Massachusetts (Table B6.29). From 2004 – 2013, 32% of landings came from the Chesapeake Bay; after 2013, that percentage increased to 44%, possibly as a result of the strong 2011 year class moving through the population (Figure B6.18). The annual Atlantic coast harvest (in numbers) has been a small fraction of the total catch (harvest and releases, combined) since the 1980s because the live releases (B2s) have accounted for 85 to 90% of the annual catch in most years (see Section B6.6.4); in 2015 – 2017, only 9% of the total catch was landed.

B4.15.3 Recreational Landings Age Composition

The age composition of the recreational harvest is dominated by ages 4 – 10 (Figure B6.19), with the Chesapeake Bay landing more younger fish (ages 3-6) and the ocean and other areas landing more older fish (ages 6-10) (Figure B6.20). Very few age-1-2 fish are landed by the recreational fishery.

B4.15.4 Estimation of Releases

The number of striped bass that are caught and released alive (B2) is estimated by MRIP (Table B6.30). The live releases have accounted for 85 to 90% of the annual catch in most years (Figure B6.21); from 2015 – 2017, 91% of total catch was released alive. While landings of striped bass remained mostly stable from 2004 – 2014, the number of fish released alive peaked in 2006 at 53.5 million fish, and then dropped nearly 70% to 16.5 million fish in 2011. Releases have been increasing since then; live releases in 2015 – 2017 averaged 32.3 million fish per year.

Live releases are generally highest in Massachusetts, Maryland, New York, and New Jersey (Table B6.30). From 2004 – 2014, approximately 27% of live releases occurred in Chesapeake Bay; for 2015 – 2016, that number increased to 43%, then dropped to 24% in 2017, due to a combination of regulation changes and the strong 2011 year class entering the Chesapeake Bay fishery and then moving out to the coast.

B4.15.5 Estimation of Release Mortalities

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 MRIP is taken in ocean or bay waters, the SAS 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 (NEFSC 2013). For this assessment, the SAS 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 release mortalities are presented in Table B6.3. The numbers of fish that died from being released alive increased from 79,660 fish in 1984 to a peak of 4.8 million fish in 2006 before declining through 2011 to 1.5 million fish. Live releases increased after that, with the number of fish that died from being released averaging 2.9 million fish from 2015 – 2017.

B4.15.6 Age Composition of Release Mortalities

The age composition of fish released alive is dominated by ages 2-5 (Figure B6.19). The Chesapeake Bay catches and releases a significantly higher proportion of age-1 fish, and the ocean and other areas catch and release a higher proportion of age 5+ fish, but both regions release predominately age-2-5 fish in similar proportions over the time series (Figure B6.20).

B4.15.7 Comparison of Pre- and Post-Calibration MRIP Estimates

Calibrated estimates of Atlantic striped bass recreational catch and harvest are substantially different from prior MRIP estimates (Figure B6.22). As with other species, the major cause of the difference is the effort calibration; the calibration to account for changes in the APAIS design had a minimal effect compared to the FES calibration (Figure B6.22). Calibrated annual estimate of coastal striped bass harvest (numbers of fish) are on average-140% higher (range approximately 50%-400%) than historic uncalibrated estimates, while live releases averaged 160% higher (range 41% - 295%) (Figure B6.23). On a state by state basis, the pattern is generally similar to the coastwide numbers, with the calibrated numbers becoming increasingly higher than the uncalibrated numbers over time; however, the effect was more extreme in some states than others (Figures B6.24 and B6.25).

The elevation in catch and harvest estimates are not surprising, given analyses conducted during FES/CHTS side-by-side benchmarking that revealed that FES estimates of fishing effort were typically

3-5 times higher than those provided by CHTS. Despite the marked change in magnitude of catch and harvest estimates, the re-calibrated time series describe a similar trend over time in both catch and harvest.

The calibration did not have a significant effect on the length distribution of harvested striped bass. The annual mean length by state showed minor differences for some years and states, but was generally unchanged in recent years (Figure B6.26). The higher variability early in the time series (both from year to year and between calibration methods) is likely due to small sample sizes in those years (Table B6.28).

B4.15.8 Unreported Catch from Inland Waters

The 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 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 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 SAS examined periodic creel surveys conducted by state natural resource agencies and universities in the Connecticut River (Davis 2011), the Hudson River (NAI 2003 and 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 B6.31). Bias to model inputs is even less when considering recreational losses in combination with commercial losses.

B4.16 Total Removals by Recreational Fisheries
Total recreational removals include MRIP estimates of harvest, the MRIP estimates of live releases scaled by the 9% release mortality rate, and the model-based estimates of wave 1 harvest for NC and VA in years when MRIP did not sample during wave 1 (Table B6.27, Section B6.5). Total recreational striped bass removals averaged about half a million fish at the beginning of the time series; removals increased steadily from 260,000 fish in 1987 to a peak of 9.9 million fish in 2006 (Table B6.3, Figure B6.18). Recreational removals have declined since then. Recreational removals averaged 7.4 million fish from 2004 – 2014; with the implementation of Addendum IV, recreational removals have averaged 6.1 million fish from 2015 – 2017. Recreational harvest and releases showed different patterns after 2006, with releases declining faster initially and then increasing, and harvest staying relatively steady through 2013 before beginning to decline. From 2004 – 2014, release mortalities made up 36% of the total recreational removals; from 2015 – 2017, that increased to 48% of total recreational removals, due to a combination of more restrictive regulations and two strong year classes (2011 and 2014) recruiting to the fishery.

From 2004 – 2013, the Chesapeake Bay accounted for approximately 30% of total recreational removals. From 2014 – 2016, that number jumped to 43% as the strong 2011 year class entered the Chesapeake Bay fishery. In 2017, the Chesapeake Bay removals made up 32% of the total recreational removals, as the 2011 year class became more available to the coastal fisheries.

The age composition of the recreational removals consists primarily of ages 2-10. The age composition of 2015 – 2017 tended to be dominated by younger fish, with a lower proportion of age-7+ fish than the 2004 – 2014 age composition, again most likely due to the presence of the 2011 year class.

The majority of recreational removals occurred during July – December (waves 4-6, model period-3) and March - June (waves 2-3, model period-2). Very little of the removals occurred during January and February (wave 1, model period-1). From 2004 – 2014, approximately 4% of ocean removals occurred in wave 1, with 37% occurring in waves 2-3, and 59% occurring in waves 4-6. No wave 1 removals were estimated for the Chesapeake Bay, so waves 2-3 made up 20% of the recreational removals during this time period, and waves 4-6 made up 80% of the removals. From 2015 – 2017, no wave 1 harvest was observed in North Carolina ocean waters, and no tags were returned during this period from Virginia, so no wave 1 harvest was estimated. Anecdotal evidence from anglers suggested this was the result of low availability of striped bass in state waters during January and February for those years. From 2015 – 2017, 38% of recreational removals occurred in waves 2-3 for the ocean, and 31% for the Chesapeake Bay, with the remainder occurring during waves 4-6 for both regions.

B4.17 Total Removals by Commercial and Recreational Fisheries

The recreational fishery has been the dominant source of fishing removals for striped bass for most of the time series (Table B6.3, Figure B6.27). From 2015 – 2017, recreational removals accounted for approximately 90% of the total striped bass removals, with the rest due to commercial landings and discards. Recreational removals have accounted for between 80% and 90% of total removals since 1985. Total removals peaked in 2006 at 11.1 million fish and have been declining since then (Table B6.3, Figure B6.27). From 2004 – 2014, total removals averaged 8.4 million fish; from 2015 – 2017, they averaged 6.8 million fish, due in part to the implementation of harvest reductions through Addendum IV in 2015.

Overall, most of the removals come from July – December (Figure B6.28); from 2015-2017, 66% of Chesapeake Bay removals and 62% of removals from the ocean and other areas occurred from July – December. In recent years, almost no removals have come from the ocean during January and February, and only about 4% of Chesapeake Bay removals occurred during those months.

B4.18 Total Catch Weight at Age

Catch mean weight at age data, which is used to calculate total biomass and female SSB, was calculated for the period 1998-2002 using all available weight data from Massachusetts, New York, Maryland, Virginia, and New Hampshire (1998-2001), and adding data from Rhode Island and Delaware in 2002 (NEFSC 2008b). Mean weights at age for the 2003-2017 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. For ages 1-12, 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. Weights at age for ages 13 through 15+ were predicted from annual age-weight regressions using ages 1-12. Details of developing weights at age for 1982 to 1996 can be found in NEFSC Lab Ref. 98-03. Weights at age for 1982-2017 are presented in Table B6.34.

B4.19 Total Catch Numbers at Age

The catch-at-age from commercial harvest, commercial discards, recreational harvest, and recreational release mortalities were combined to develop total removals-at-age matrices for the Chesapeake Bay (Table B6.32) and for the ocean fisheries (which included Delaware Bay and Long Island Sound) (Table B6.33) broken down by wave period to accommodate the seasonal time-step of the migration model. Total removals are made up predominately by ages 3-10. The age composition of removals in the Chesapeake Bay is dominated by younger fish (ages 2-6), while the age composition of removals from the ocean and other areas has a higher proportion of older fish (ages 4-10) (Figure B6.29).

The age composition of the Chesapeake Bay removals expands during waves 2-3 as mature fish move into the Chesapeake Bay to spawn; the proportion of the catch at older ages is lower during wave 1 and waves 4-6, but is not zero (Figure B6.30). The opposite is true for the ocean, where the proportion of catch at older ages is lower during waves 2-3 as compared to wave 1 and waves 4-6; the difference is not as pronounced for the ocean, since spawning adults from the Delaware Bay and Hudson River stocks are still present in the catch for this region during waves 2-3 (Figure B6.31.)

TOR B3. USE AN AGE-BASED 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 AND SEX, WHERE POSSIBLE, AND FOR TOTAL STOCK COMPLEX.

B4.20 Two-Stock Statistical Catch-At-Age Model (2SCA; Primary Assessment Model)

[SAW-66 Editor's Note: The SARC-66 peer review panel concluded that the two-stock statistical catch-at-age (2SCA) model presented to them was not acceptable to serve as a basis for fishery management advice. These particular sections are included in this report to document the analyses that were done for the peer review, but they are not recommended by SARC-66 as a basis for management. Instead, SARC-66 recommends the single stock, non-migration model described in Section B7.2.1 for management use.]

The striped bass two-stock statistical catch-at-age (2SCA) model was created to allow the estimation of separate population characteristics for two stocks whose individuals are mixed in a common ("ocean") region but the stock catch composition in that region is unknown. The model is based on population dynamics observed for the Chesapeake Bay stock that is comprised of a resident population in the Chesapeake Bay and a migratory population that moves between the Chesapeake Bay and ocean region for spawning. For Stock-1 (the Chesapeake Bay stock), immigration of spawning individuals from the ocean to the Chesapeake Bay occurs during a specific period based on maturity schedules, and mature and immature individuals are allowed to return to the ocean based on emigration rates estimated from tag data. For Stock-2 (the Delaware Bay and Hudson River stocks combined), it is assumed that the ocean region encompass the river habitat and migrations are not explicitly modeled.

The structure was based on limitations of splitting data into periods and the remaining stock components (Figure B7.1). The ability to estimate the number of Chesapeake Bay stock striped bass that occur in the Chesapeake Bay and ocean region is based on catch data split into three periods to reflect changes in age structure due to migration and estimates of ocean-specific stock composition derived from historical tag data.

The model estimates stock-specific (Chesapeake Bay stock and Delaware Bay/Hudson River stock) recruitment, stock-, year-, period- and age-specific abundance and fishing mortality, different selectivity functions for the Chesapeake Bay and Ocean catch data and surveys with age composition data, catchability coefficients for surveys, and management reference points.

B4.20.1 Description of Generalized Model Structure

The structure of the 2SCA model is region-, period- and aged-based and projects the population numbers-at-age forward through time given model estimates of recruitment, age-specific total mortality and migration rates.

B4.20.1.1 Stock-1 (Chesapeake Bay) Sub-model

For Stock-1 (the Chesapeake Bay stock), there are six (2 regions x 3 periods) population numbers-at-age matrices of dimensions Y x A, where Y is the number of years and A is the oldest age group (Figure B7.2). The time horizon for striped bass is 1982-present since complete catch data are only available back to 1982. The initial population abundance-at-age of the Chesapeake Bay stock (*s*=1) in period-1 (*p=1*) of the first year (*y*=1982) for ages 2 through A in the Chesapeake Bay region ($N^{Bay}s,p,y,a$) can be estimated as individual parameters (user controls the number of estimates) or, if not estimated, they are calculated by:

$$N^{Bay}_{1,1,1982,a} = N^{Bay}_{1,1,1982,a-1} e^{-M^{Bay}_{1982,a-1} pm^{Bay}_1}$$

$$N^{Bay}_{1,1,1982,A} = N^{Bay}_{1,1,1982,a-1} e^{-M^{Bay}_{1982,a-1} pm^{Bay}_1} / (1 - e^{-M^{Bay}_{1982,A} pm^{Bay}_1})$$

where $M^{Bay}_{1982,a}$ is the natural mortality rate of age *a* in the first year (1982) and pm_1 is the fraction of natural mortality that occurs during period-1 (Figure B7.2). In the current implementation of this model, ages 2-6 are estimated. The initial population abundance-at-age in the ocean region (N^{ocean}) in period-1 for ages 2 through A in the first year is determined from N^{Bay} using estimates of emigration rates (*E*; see below):

$$N^{Ocean}_{1,1,1982,a} = N^{Bay}_{1,1,1982,a} \cdot E_{1982,a}$$

Recruitment (numbers of age-1 fish) in the Chesapeake Bay stock in year *y* (Figures B7.2) is estimated as a log-normal deviation from average recruitment:

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

where $N_{1,1,y,1}$ is the number of age-1 fish in the Chesapeake Bay stock at the beginning of period-1 in year *y*, $\hat{\bar{N}}1$ is the average recruitment parameter, $e_{1,y}$ 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 $\sigma_{1,R}$ is the standard deviation for the log recruitment residuals which is calculated as:

$$\hat{\sigma}_{1,R} = \sqrt{\frac{\sum_{y}(\hat{e}_{1,y} - \hat{\bar{e}}_1)^2}{n_1 - 1}}$$

where n_1 is the number of estimated recruitment deviations for the Chesapeake Bay stock. The term $-0.5\sigma^2_{1,R}$ is a lognormal bias-correction to ensure that average is equal to the mean recruitment. 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) and is set to 1 in the current implementation. All the Chesapeake Bay stock recruitment occurs in the Chesapeake Bay region.

Movement of Chesapeake Bay stock fish from the ocean to the Chesapeake Bay occurs instantaneously at the beginning of period-2. The abundance of age *a* fish in the Chesapeake Bay at the beginning of period-2 is given by:

$$N^{Bay}_{1,2,y,a} = N^{Bay}_{1,1,y,a} \cdot e^{-s^{Bay}_{y,a}F^{Bay}_{1,y} - M^{Bay}_{y,a}pm^{Bay}_1}$$

Estimation of fishing mortality for each region (Chesapeake Bay and ocean), period, year and age is accomplished by assuming that fishing mortality can be decomposed into yearly and age-specific components (separability):

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

where $F_{p,y}$ is the fully-recruited fishing mortality in period *p* of year *y* and s_{ya} is the selectivity of age *a* in year *y*. The same selectivity is used in each period within year and region. The dimensions of each F-at-age matrix are Y x A. $F_{p,y}$s are modeled as separate parameters.

The number of fish that migrate from the ocean to the Chesapeake Bay (*OI*) is calculated as:

$$OI_{y,a} = N^{Ocean}_{1,1,y,a} \cdot e^{-s^{Ocean}_{y,a}F^{Ocean}_{1,y} - M^{Ocean}_{y,a}pm^{Ocean}_1}\left(f^{Ocean}_{y,a} \cdot m^{female}_a + (1 - f^{ocean}_{y,a}) \cdot m^{male}_a\right)$$

Where $N^{Ocean}_{1,1,y,a}$ is the number of fish of the Chesapeake Bay stock during period-1 in year *y* and of age *a*, $f_{y,a}$ is the proportion of females of age *a* during period-2 in year *y*, and m^{female} and m^{male} are proportion mature-at-age for each sex. It is assumed that all *OI* fish move into the Chesapeake Bay to spawn. Because migrating fish have natural mortality rates different from fish living in the Chesapeake Bay, *OI* fish are tracked in separate matrices. However, both resident fish and OI fish experience the same fishing mortality while in the Chesapeake Bay. The number of fish remaining in the ocean at the beginning of period-2 is:

$$N_{1,2,y,a}^{Ocean} = N_{1,1,y,a}^{Ocean} \cdot e^{-s_{y,a}^{Ocean} F_{1,y}^{Ocean} - M_{y,a}^{Ocean} pm_1^{Oean}} \cdot (1-(f_{female,a}^{Ocean} \cdot m_{female,a}^{Ocean} + (1-f_{female,a}^{Ocean}) \cdot m_{male,a}^{Ocean}))$$

The proportion of females at age *a* in the ocean at the beginning of period-1, -2 and -3 were derived from sampling (Section B5.3) and were assumed constant across years. The values are:

	Age														
Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1	0.513	0.366	0.261	0.191	0.189	0.236	0.303	0.389	0.477	0.560	0.636	0.702	0.755	0.786	0.940
2	0.608	0.484	0.377	0.293	0.237	0.269	0.381	0.502	0.591	0.659	0.708	0.750	0.791	0.820	0.910
3	0.513	0.366	0.261	0.191	0.189	0.236	0.303	0.389	0.477	0.560	0.636	0.702	0.755	0.786	0.940

The proportion mature at age for both sexes were derived from sampling (females; Section B5.1.7) and literature (males; NEFSC 2013) and were assumed constant across years. The values used are:

	Age														
Sex	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
Female	0	0	0	0.09	0.32	0.45	0.84	0.89	1	1	1	1	1	1	1
Male	0	0.5	0.75	1	1	1	1	1	1	1	1	1	1	1	1

The emigration of fish that have spawned and those that were resident in the Chesapeake Bay prior to spawning occurs at the beginning of period-3. Fish remaining in the Chesapeake Bay is calculated as:

$$N_{1,3,y,a}^{Bay} = N_{1,2,y,a}^{Bay} \cdot e^{-s_{y,a}^{Bay} F_{2,y}^{Bay} - M_{y,a}^{Bay} pm_2^{Bay}} \cdot (1 - E_a)$$

where E_a are the probability of age *a* fish migrating to the ocean in year *y*. All remaining OI fish after experiencing fishing mortality in the Chesapeake Bay are assumed to move to the ocean. Therefore the number of fish present in the ocean at the beginning of period-3 is:

$$N_{1,3,y,a}^{Ocean} = N_{1,2,y,a}^{Ocean} \cdot e^{-s_{y,a}^{Ocean} F_{2,y}^{Ocean} - M_{y,a}^{Ocean} pm_2^{Ocean}} + OI_{y,a} e^{-s_{y,a}^{Bay} F_{2,y}^{Bay} - M_{y,a}^{Ocean} pm_2^{Ocean}}$$
$$+ N_{1,2,y,a}^{Bay} \cdot e^{-s_{y,a}^{Bay} F_{2,y}^{Bay} - M_{y,a}^{Bay} pm_2^{Bay}} \cdot E_a$$

The emigration probabilities (E_a) at age were estimated by using tag release-recapture data from Maryland DNR and New York DEC following methods of Dorazio et al. (1994) but estimating migration rates for age rather than length (Appendix B7). Because New York DEC did not age fish after 1995, only data through 1995 were used in the estimation. The estimates of migration rates from Maryland data were used following Dorazio et al. (1994). Emigration rate was assumed constant across years. The estimates of E_a used in the model (Figure B7.3) are:

Age

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
0.01379	0.02302	0.03820	0.06274	0.10138	0.15976	0.24269	0.35069	0.47652	0.60540	0.72112	0.81336	0.88017	0.92520	0.95430

The number of fish at the beginning of period-1 in the following year is calculated as:

$$N_{1,1,y+1,a+1}^{Bay} = N_{1,3,y,a}^{Bay} \cdot e^{-s_{y,a}^{Bay} F_{3,y}^{Bay} - M_{y,a}^{Bay} pm_3^{Bay}}$$
$$N_{1,1,y+1,A}^{Bay} = N_{1,3,y,a}^{Bay} \cdot e^{-s_{y,a}^{Bay} F_{3,y}^{Bay} - M_{y,a}^{Bay} pm_3^{Bay}} + N_{1,3,y,A}^{Bay} \cdot e^{-s_{y,A}^{Bay} F_{3,y}^{Bay} - M_{y,A}^{Bay} pm_3^{Bay}}$$

And

$$N_{1,1,y+1,a+1}^{Ocean} = N_{1,3,y,a}^{Ocean} \cdot e^{-s_{y,a}^{Ocean} F_{3,y}^{Ocean} - M_{y,a}^{Ocean} pm_3^{Ocean}}$$
$$N_{1,1,y+1,A}^{Ocean} = N_{1,3,y,a}^{Ocean} \cdot e^{-s_{y,a}^{Ocean} F_{3,y}^{Ocean} - M_{y,a}^{Ocean} pm_3^{Ocean}} + N_{1,3,y,A}^{Ocean} \cdot e^{-s_{y,A}^{Ocean} F_{3,y}^{Ocean} - M_{y,A}^{Ocean} pm_3^{Ocean}}$$

Natural Mortality

The model dynamics allow different natural mortality rates in each stock, region, year and age. Fish that do not migrate from the Chesapeake Bay region experience additional mortality (+0.12; Smith and Hoenig 2012) above the baseline (see below) when age-3 or older starting in 1997 due to the impact of a *Mycobacterium* outbreak in Chesapeake Bay (Gauthier et al. 2008). Those fish that migrate to the ocean region are assumed to experience baseline natural mortality due to observations that the *Myco* disease does not progress further and in many cases fish may actually heal (Vogelbein et al. 2006). When mature fish return to the Chesapeake Bay region to spawn, the baseline natural mortality is still applied because it is unlikely that fish will be re-infected and experience any ill effects from *Myco* during the short duration spent in the Chesapeake Bay. The baseline and *Myco*-adjusted natural mortality rates are:

	Age														
Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
Bay (1982-1996)	1.13	0.68	0.45	0.33	0.25	0.19	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Bay (1997-2017)	1.13	0.68	0.57	0.45	0.37	0.31	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Ocean	1.13	0.68	0.45	0.33	0.25	0.19	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

The baseline natural mortality rates were derived from a curvilinear model fitted to tag-based Z estimates (assuming Z=M) for fish ≤ age-3 from New York and tag-based M estimates (Jiang et al. 2007) for striped bass from Maryland made for years prior to 1997 (ASMFC 2013).

B4.20.1.2 Stock-2 (the Delaware Bay/Hudson River mixed stock) Sub-model

For Stock-2 (the Delaware Bay/Hudson River stock), there are three population numbers-at-age matrices of the same dimensions (Figure B7.4).The initial population abundance-at-age of the Delaware Bay/Hudson River stock (s=2) in period-1 for ages-2 through -7 in the first year (Figure B7.4) are estimated as individual parameters and the remaining values are calculated as:

$$N_{2,1,1982,a}^{Ocean} = N_{2,1,1982,a-1}^{Ocean} e^{-M_{1982,a-1}^{Ocean} pm_1^{Ocean}}$$

$$N_{2,1,1982,A}^{Ocean} = N_{2,1,1982,a-1}^{Ocean} e^{-M_{1982,a-1}^{Ocean} pm_1^{Ocean}} / (1 - e^{-M_{1982,A}^{Ocean} pm_1^{Ocean}})$$

Estimation of recruitment (numbers of age-1 bass) for the Delaware Bay/Hudson River stock is the same as the Chesapeake Bay stock:

$$N_{2,1,y,1} = \hat{\bar{N}}_2 \cdot \exp^{\hat{e}_{2,y} - 0.5\hat{\sigma}_{2,R}^2}$$

where $N_{2,1,y,1}$ is the number of age-1 fish of the Delaware Bay/Hudson River stock at the beginning of period-1 in year *y*, $\hat{\bar{N}}2$ is the average recruitment parameter, $e_{2,y}$ 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 $\sigma_{2,R}$ is the standard deviation for the log recruitment residuals which are calculated as described for the Chesapeake Bay stock. The same penalty for bias-correction was also applied to the Delaware Bay/Hudson River stock. All recruitment of the Delaware Bay/Hudson River stock is assumed to occur in the ocean.

No movement of fish from the Delaware Bay/Hudson River stock occurs, so the calculation of abundance-at-age is straight-forward. Abundance is calculated as:

Period-2 $$N_{2,2,y,a}^{Ocean} = N_{2,1,y,a}^{Ocean} \cdot e^{-s_{y,a}^{Ocean} F_{1,y}^{Ocean} - M_{y,a}^{Ocean} pm_1^{Ocean}}$$

Period-3 $$N^{Ocean}_{2,3,y,a} = N^{Ocean}_{2,2,y,a} \cdot e^{-s^{Ocean}_{y,a} F^{Ocean}_{2,y} - M^{Ocean}_{y,a} pm^{Ocean}_{2}}$$

Abundance at the beginning of period-1 in the following year is calculated as:

$$N^{Ocean}_{2,1,y+1,a+1} = N^{Ocean}_{2,3,y,a} \cdot e^{-s^{Ocean}_{y,a} F^{Ocean}_{3,y} - M^{Ocean}_{y,a} pm^{Ocean}_{3}}$$

$$N^{Ocean}_{2,1,y+1,A} = N^{Ocean}_{2,3,y,a} \cdot e^{-s^{Ocean}_{y,a} F^{Ocean}_{3,y} - M^{Ocean}_{y,a} pm^{Ocean}_{3}} + N^{Ocean}_{2,3,y,A} \cdot e^{-s^{Ocean}_{y,A} F^{Ocean}_{3,y} - M^{Ocean}_{y,A} pm^{Ocean}_{3}}$$

Natural mortality rates used for the Delaware Bay/Hudson River stock were the baseline values used for the ocean region of the Chesapeake Bay stock. The proportion of females-at-age and female maturity for the Delaware Bay/Hudson River stock used in the calculation of female SSB (see below) are:

	Age														
Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
Female Proportion	0.530	0.560	0.560	0.520	0.570	0.650	0.730	0.810	0.880	0.920	0.950	0.970	0.999	0.999	0.999
Female Maturity	0.000	0.000	0.000	0.090	0.320	0.450	0.840	0.890	1.000	1.000	1.000	1.000	1.000	1.000	1.000

The proportions of females-at-age are different for the Delaware Bay/Hudson River stock because all ages are found in the ocean region, whereas those for the Chesapeake Bay stock represent only the segment of the population that has migrated.

B4.20.1.3 Fishing Mortality Estimation

A fishing mortality penalty for each region is imposed to ensure that extremely small Fs are not produced during the early phases of the estimation process:

$$P_{add} = \begin{cases} \text{phase} < 3, & 10 \cdot \sum_y (F^{Bay}_{p,y} - 0.15)^2 + \\ & 10 \cdot \sum_y (F^{Ocean}_{p,y} - 0.15)^2 \\ \text{phase} \geq 3, & 1e^{-12} \cdot \sum_y (F^{Bay}_{p,y} - 0.15)^2 + \\ & 1e^{-12} \cdot \sum_y (F^{Ocean}_{p,y} - 0.15)^2 \end{cases}$$

B4.20.1.4 Catch Selectivity Estimation

Multiple selectivity functions (logistic, Gompertz and Thompson's (1994) exponential-logistic equations) were included in the model for modeling catch selectivity in each region. The equations are:

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

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

Thompson's (1994) exponential-logistic equation: $\hat{s}_a = \frac{1}{1-\hat{\gamma}} \cdot \left(\frac{1-\hat{\gamma}}{\hat{\gamma}}\right)^{\hat{\gamma}} \frac{\exp^{\hat{\alpha}\hat{\gamma}(\hat{\beta}-a)}}{1+\exp^{\hat{\alpha}(\hat{\beta}-a)}}$

where α, β,and γ 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. In initial analyses, the three-parameter Thompson exponential-logistic equation was applied to all catch data to allow more flexible estimation of the selectivity pattern. If a resulting selectivity pattern was flat-topped, the Thompson function was replaced with the Gompertz or logistic function to save one parameter from being estimated. The final selectivity equations and the number of selectivity blocks used (based on major changes in management regulation for striped bass from previous assessments) were further refined by comparing residuals and AIC values from multiple model runs. The following are time blocks and selectivity functions used for the Chesapeake Bay and ocean regions in the base model run:

Region	Time Block	Function
Bay	1982-1989	Gompertz
	1990-1995	Gompertz
	1996-2017	Gompertz
Ocean	1982-1989	Gompertz
	1990-1996	Gompertz
	1997-2017	Gompertz

An additional time block for 2015-2017 was examined because of major changes to striped regulations in 2015. However, no difference between selectivity curves estimated for 2015-2017 and a 1996-2014 time block was observed, so the two periods were combined into one.

B4.20.1.5 Total Catch and Age Composition of Stocks

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

For the Chesapeake Bay stock, predicted catch-at-age in each period in the Chesapeake Bay region is calculated by:

Period-3 $$\hat{C}^{Bay}_{1,1,y,a} = \frac{\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{1,y}}{\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{1,y} + M^{Bay}_{y,a} \cdot pm^{Bay}_1}(1-e^{-\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{1,y} - M^{Bay}_{y,a} \cdot pm^{Bay}_1}) \cdot \hat{N}^{Bay}_{1,1,y,a}$$

Period-2

$$\hat{C}^{Bay}_{1,2,y,a} = \frac{\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{2,y}}{\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{2,y,a} + M^{Bay}_{y,a} \cdot pm^{Bay}_{2}}(1 - e^{-\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{2,y} - M^{Bay}_{y,a} \cdot pm^{Bay}_{2}}) \cdot \hat{N}^{Bay}_{1,2,y,a} + \frac{\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{2,y,a}}{\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{2,y} + M^{Ocean}_{y,a} \cdot pm^{Ocean}_{2}}(1 - e^{-\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{2,y} - M^{Ocean}_{y,a} \cdot pm^{Ocean}_{2}}) \cdot OI_{y,a}$$

Period-3

$$\hat{C}^{Bay}_{1,3,y,a} = \frac{\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{3,y}}{\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{3,y} + M^{Bay}_{y,a} \cdot pm^{Bay}_{3}}(1 - e^{-\hat{s}^{Bay}_{1,y,a}\hat{F}^{Bay}_{3,y} - M^{Bay}_{y,a} \cdot pm^{Bay}_{3}}) \cdot \hat{N}^{Bay}_{1,3,y,a}$$

Predicted catch-at-age in each period in the ocean region for the Chesapeake Bay stock is calculated by:

Period-3

$$\hat{C}^{Ocean}_{1,1,y,a} = \frac{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{1,y}}{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{1,y} + M^{Ocean}_{y,a} \cdot pm^{Ocean}_{1}}(1 - e^{-\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{1,y} - M^{Ocean}_{y,a} \cdot pm^{Ocean}_{1}}) \cdot \hat{N}^{Ocean}_{1,1,y,a}$$

Period-2

$$\hat{C}^{Ocean}_{1,2,y,a} = \frac{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{2,y}}{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{2,y,a} + M^{Ocean}_{y,a} \cdot pm^{Ocean}_{2}}(1 - e^{-\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{2,y} - M^{Ocean}_{y,a} \cdot pm^{Ocean}_{2}}) \cdot \hat{N}^{Ocean}_{1,2,y,a}$$

Period-3

$$\hat{C}^{Ocean}_{1,3,y,a} = \frac{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{3,y}}{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{1,3,y} + M^{Ocean}_{y,a} \cdot pm^{Ocean}_{3}}(1 - e^{-\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{3,y} - M^{Ocean}_{y,a} \cdot pm^{Ocean}_{3}}) \cdot \hat{N}^{Ocean}_{1,3,y,a}$$

For the Delaware Bay/Hudson River stock, predicted catch-at-age in each period is calculated by:

Period-3

$$\hat{C}^{Ocean}_{2,1,y,a} = \frac{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{1,y}}{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{1,y} + M^{Ocean}_{y,a} \cdot pm^{Ocean}_{1}}(1 - e^{-\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{1,y} - M^{Ocean}_{y,a} \cdot pm^{Ocean}_{1}}) \cdot \hat{N}^{Ocean}_{2,1,y,a}$$

Period-2

$$\hat{C}^{Ocean}_{2,2,y,a} = \frac{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{2,y}}{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{2,y,a} + M^{Ocean}_{y,a} \cdot pm^{Ocean}_{2}}(1 - e^{-\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{2,y} - M^{Ocean}_{y,a} \cdot pm^{Ocean}_{2}}) \cdot \hat{N}^{Ocean}_{2,2,y,a}$$

Period-3

$$\hat{C}^{Ocean}_{2,3,y,a} = \frac{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{3,y}}{\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{1,3,y} + M^{Ocean}_{y,a} \cdot pm^{Ocean}_{3}}(1 - e^{-\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{3,y} - M^{Ocean}_{y,a} \cdot pm^{Ocean}_{3}}) \cdot \hat{N}^{Ocean}_{2,3,y,a}$$

Predicted catch-at-age data for the Chesapeake Bay stock and the Delaware Bay/Hudson River stock are then compared to the observed total catch and age composition through the equations:

Predicted Total Catch $\hat{C}_{s,p,y} = \sum_a \hat{C}_{s,p,y,a}$

Predicted Proportions of Catch-At-Age $\hat{P}_{s,p,y,a} = \frac{\hat{C}_{s,p,y,a}}{\sum_a \hat{C}_{s,p,y,a}}$

where $\hat{C}_{s,p,y}$ is the predicted total catch of stock *s* in period *p* of year *y* and $P_{s,p,y,a}$ is the predicted proportions of age *a* in the catch during year *y* for stock *s* during period *p*.

B4.20.2 Stock-Specific Indices of Relative Abundance

B4.20.2.1 Aggregated Indices of Relative Abundance

Stock-specific single-age or aggregated-age indices of relative abundance are incorporated into the model by linking them to corresponding age abundances, time of year and region.

For the Chesapeake Bay stock in the Chesapeake Bay region,

$$\hat{I}^{Bay}_{t,y,\Sigma a} = \hat{q}^{Bay}_t \cdot \sum_a \hat{N}^{Bay}_{1,p,y,a} \cdot \exp^{-d^{Bay}_{p,t} \cdot \left(\hat{s}^{Bay}_{y,a} \hat{F}^{Bay}_{p,y} + M^{Bay}_{y,a} \cdot pm^{Bay}_p\right)}$$

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* in the Chesapeake Bay region, q_t is the catchability coefficient of index *t*, $N_{p,y,a}$ is the abundance of age *a* in year y at the beginning of period p in the Chesapeake Bay region, and $d_{p,t}$ is the fraction of period *p* that occurs before the survey is conducted. All qs are estimated as free parameters. The equation for the Delaware Bay/Hudson River stock is identical except that the indices are linked to stock-2 abundance (resides in the ocean region). Because age-0 abundance is not modeled, YOY and Age-1 indices are lagged ahead one year and linked to age-1 and age-2 abundances, respectively.

B4.20.2.2 Indices of Relative Abundance with Age Composition Data

Stock-specific indices of relative abundance with age composition data are incorporated into the model by linking them to age abundances, time of year and region. For the Chesapeake Bay stock in the Chesapeake Bay, the general equation is:

$$\hat{I}^{Bay}_{t,y,\Sigma a} = \hat{q}^{Bay}_t \cdot \sum_a \hat{s}^{Bay}_{t,a} \cdot \hat{N}^{Bay}_{1,p,y,a} \cdot \exp^{-d^{Bay}_{p,t} \cdot \left(\hat{s}^{Bay}_{y,a} \hat{F}^{Bay}_{p,y} + M^{Bay}_{y,a} \cdot pm^{Bay}_p\right)}$$

where $s_{t,a}$ is the selectivity coefficient for age *a* in region *R* for survey *t*. For these surveys, multiple selectivity equations are available for modeling: Gompertz, logistic, gamma and Thompson's functions. 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:

$$\hat{I}^{Bay}_{t,y,a} = \hat{q}^{Bay}_{t} \cdot \hat{s}^{Bay}_{t,a} \cdot \hat{N}^{Bay}_{p,y,a} \cdot \exp^{-d^{Bay}_{p,t} \cdot \left(\hat{s}^{Bay}_{y,a}\hat{F}^{Bay}_{p,y} + M^{Bay}_{y,a} \cdot pm^{Bay}_{p}\right)}$$

and predicted age composition (U) is calculated as:

$$\hat{U}^{Bay}_{t,y,a} = \frac{\hat{I}^{Bay}_{t,y,a}}{\sum_{a} \hat{I}^{Bay}_{t,y,a}}$$

The equations for the Delaware Bay/Hudson River stock are identical except there is no region superscript.

B4.20.2.3 Mixed Stock Indices

There are several surveys with age composition data that occur in the ocean and reflect the relative abundance of the Chesapeake Bay stock and the Delaware Bay/Hudson River stock complex in the ocean region. The predicted total index for the mixed stock surveys is calculated as:

$$\hat{I}_{t,y,\Sigma a} = \hat{q}_{t} \cdot \sum_{a} \hat{s}_{t,a} \cdot (\hat{N}^{Ocean}_{1,p,y,a} + \hat{N}_{2,p,y,a}) \cdot \exp^{-d^{Ocean}_{p,t} \cdot \left(\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{p,y} + M^{Ocean}_{y,a} \cdot pm^{Ocean}_{p}\right)}$$

where the numbers-at-age *a* and year *y* for the Chesapeake Bay stock in the ocean and numbers-at-age *a* and year *y* for the Delaware Bay/Hudson River stock are summed. The predicted age composition is computed from the age-specific predicted indices:

$$\hat{I}_{t,y,a} = \hat{q}_{t} \cdot \hat{s}_{t,a} \cdot (\hat{N}^{Ocean}_{1,p,y,a} + \hat{N}_{2,p,y,a}) \cdot \exp^{-d^{Ocean}_{p,t} \cdot \left(\hat{s}^{Ocean}_{y,a}\hat{F}^{Ocean}_{p,y} + M^{Ocean}_{y,a} \cdot pm^{Ocean}_{p}\right)}$$

The predicted age composition (U) is calculated as described above.

B4.20.2.4 Ocean Stock Composition

In order to estimate the Chesapeake Bay stock numbers that occur in the ocean region, the stock composition of catches that occur in the ocean must be known. Unfortunately, there have been no long-term studies to determine the stock composition of fish in the ocean region. Therefore, observed stock composition (proportion of fish from Chesapeake Bay and proportion of fish from the Delaware Bay/Hudson River) was estimated externally by using tag release-recapture data from three state programs conducted in ocean waters (see Section B5.5). The values used in this assessment were derived for fish ≥ 28 inches (711 mm) total length which represent fish of ages 7 to 15+.

The observed stock composition (S) estimates for both stocks were compared to predicted values calculated as:

$$\hat{S}_{1,y} = \frac{\sum_{a=x}^{A} \hat{C}_{1,3,y,a}^{Ocean}}{\sum_{a=x} \hat{C}_{1,3,y,a}^{Ocean} + \hat{C}_{2,3,y,a}}$$

$$\hat{S}_{2,y} = 1 - \hat{S}_{1,y}$$

The stock composition estimates were treated as a multinomial index during estimation (see likelihood below).

B4.20.3 Female Spawning Stock Biomass

Female SSB (mt) in year *y* for each stock is calculated as:

Stock 1 (Chesapeake Bay):

$$SSB_{1,y} = \frac{\sum_{a=1}^{A} (\hat{N}_{1,2,y,a}^{Bay} \cdot f_{1,2,y,a}^{Bay} \cdot m_a^{female} \cdot w_{1,2,y,a}^{Bay}) + (\hat{N}_{1,2,y,a}^{Ocean} \cdot f_{1,2,y,a}^{Ocean} \cdot m_a^{female} w_{1,2,y,a}^{Ocean})}{1000}$$

Stock 2 (Delaware Bay/Hudson River):

$$SSB_{2,y} = \frac{\sum_{a=1}^{A} \hat{N}_{2,2,y,a} \cdot f_{2,2,y,a} \cdot m_a^{female} \cdot w_{1,2,y,a}^{Ocean}}{1000}$$

where *f* is the proportion of females at age, m_a is the proportion mature at age *a* for females, and $w_{y,a}$ are Rivard weights at age *a* (kg). January-1 Rivard weights were calculated and adjusted to match the weights at the time of spawning by averaging the January-1 Rivard weight-at-age and the catch weight-at-age for the current year.

B4.20.4 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 period *p* is calculated as:

$$RSS_{s,p} = \lambda_{s,p} \sum_y \left(\frac{\ln\left(C_{s,p,y} + 1e^{-5}\right) - \ln\left(\hat{C}_{s,p,y} + 1e^{-5}\right)}{\phi_p CV_{s,p,y}} \right)^2$$

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

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

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.

B4.20.5 Likelihood for Age Composition Data

For the catch and survey age compositions, multinomial error distributions are assumed throughout and the generalized negative log-likelihood for a catch age composition in period *p* is calculated as:

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

where $n_{p,y}$ is the effective number of fish aged during period *p* in year y, $P_{p,y,a}$ is the observed proportion-at-age, and λ_p is the relative weight. Similarly, the generalized 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*.

B4.20.6 Likelihood for Stock Composition Data

Stock composition data were treated as a multinomial distribution:

$$-L_S = \sum_y -n_y \cdot \left(S_{1,y} \ln\left(\hat{S}_{1,y} + 1e^{-7}\right) + S_{2,y} \ln\left(\hat{S}_{2,y} + 1e^{-7}\right)\right)$$

B4.20.7 Estimation of Effective Sample Sizes for Age Composition Data

The effective sample sizes (ESS) for the catch and survey age composition data, and stock composition data was estimated by using the equation 1.8 method of Francis (2011). 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.

B4.20.8 Total Log-likelihood of the Model

The total log-likelihood of the model is

$$\ell = -L_l^{Stock1} - L_l^{Stock2} - \sum_p L_p^{Stock1} - \sum_p L_p^{Stock2} - \sum_t L_t^{Stock1,U} - \sum_t L_t^{Stock2,U} - L_S + P_{rdev}^{Stock1} + P_{rdev}^{Stock2} + P_{add}$$

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 estimation proceeds by first calculating $F_{y,a}$ using initial starting values for F_y and s_a (initial parameters estimates are used for the selectivity equations) for stock and period and, with M and initial values of average recruitment by year, the abundance matrices are filled.

B4.20.9 Diagnostics

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

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

For age and stock 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 determined from the Francis (2011) method. The Akaike Information Criterion (AIC) was calculated as:

$$AIC = 2\ell + 2K$$

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

B4.20.10 Data Inputs for 2SCA Model

B4.20.10.1 Plus Group

In previous assessments, 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. In this assessment, an age-15+ plus-group was used because the stock assessment committee believed obtaining better estimates of selectivity for older ages was more important than potential scale-ageing bias.

B4.20.10.2 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 periods (January-February; March-June; July-December) based on seasonal migration patterns and limitations of the MRIP data (estimates are for two-month periods) in an attempt to account for more realistic patterns in catches. As mentioned above, all selectivity time blocks corresponded to Amendment changes. Removals data were split into Chesapeake Bay and Ocean regions (Table B7.1). The Chesapeake Bay fleet includes commercial and recreational harvest and dead discards taken in the Chesapeake Bay by Maryland, Virginia, and the PRFC. The Ocean landings includes commercial and recreational harvest and dead discards taken in the Ocean, Delaware Bay, Long Island Sound, and Hudson River by Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, and North Carolina. 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, period and year are listed in Table B7.1.

Total catch CVs for the Chesapeake Bay and Ocean 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. Only commercial harvest data were generally available during period-1 because the MRIP survey is not conducted in any state except North Carolina during this period. The variance of the combined recreational and dead discards estimates were calculated as:

$$Var(SR) = (PSE_H / 100 * H)^2 + (0.09^2 * (PSE_R / 100 * R)^2$$

where SR is the recreational fish harvest (H) plus dead releases (0.09*releases(R)) and PSE is the proportional standard error for the harvest and releases numbers. It is assumed that the commercial harvest numbers and dead releases are without error, so the CV of the total removals is:

$$CV = \sqrt{\text{var}(SR)}/(H + 0.09R + CH + CD)$$

Because there are no estimates of recreational harvest and releases during period-1, the CVs of total catch were set to 0.2 (based on average found in other periods). If CVs were unrealistic (e.g., <0.01 during early years with small sample sizes) or missing due to no or low number of target species intercepts, the CV was set to 0.2 or was imputed by using CVs from surrounding years.

B4.20.10.3 Young-of-the-Year and Age 1 Indices

The index values for the YOY and age-1 indices are shown in Table B7.2. For the Chesapeake Bay stock, the MDVAYOY (1981-2016) and MD Age-1 indices (1981-2016) 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 Age-1 indices were advanced one year and are linked to age-1 and age-2 abundances, respectively, and are tuned to beginning of period-1 (January 1st) (p=1, d=0; Table B7.4). For the Delaware Bay/Hudson River stock, the NYYOY (1985-2016), NY Age-1 (1984-2016), and NJYOY (1982-2016) indices were also advanced one year and are linked to age-1 and age-2 abundances, respectively, and are also tuned to January 1st (p=1, d=0; Table B7.4). Except for the MDVAYOY index, all YOY and age-1 indices are geometric means and corresponding CVs.

B4.20.10.4 Age-1+ Indices

Stock specific indices of age-1+ relative abundance are shown in Table B7.2; indices of age-1+ relative abundance for the mixed stock in the ocean are shown in Table B7.3. The age compositions for each age-1+ index are shown in Table B7.5. For the Chesapeake Bay stock, total index and age composition data from MDSSN (1985-2017) and the ChesMMAP (2002-2017) surveys are incorporated into the model by linking them to age abundances and the time of year (Table B7.4). Because the MDSSN survey estimates are corrected for mesh-size selectivity, it was determined by trial-and-error that only the selectivity value for ages 2 and 3 had to be estimated; for ages $\geq$ 4, selectivity was set to 1. The selectivity function selected for the ChesMMAP survey was the Gompertz equation. For the Delaware Bay/Hudson River stock, DESSN and DE30 indices were incorporated into the model by linking them to age abundance and time of years. Each survey had a total index and age composition associated with them. The Gompertz equation is used to estimate the selectivity pattern for the DESSN index because theory indicates that vulnerability to electric fields increases with surface area of the fish (Reynolds 1983). For the DE30 survey, the gamma function was selected as the best for describing the selectivity of this survey.

For the mixed stock ocean surveys, the NYOHS (1987-2006), NJTRL (1990-2017), CTLISTS (1986-2017), and the MRIP index (1982-2017) were used in the model (Table B7.3, Table B7.5). For the NYOHS survey, the Gompertz model was used to estimate the selectivity pattern. For the NJTRL and CTLISTS surveys, a gamma function was used to estimate the selectivity pattern. For MRIP, the Thompson exponential-logistic function was used to estimate selectivity.

B4.20.10.5 Weights-At-Age

Weights-at-age used to calculate biomass and female SSB were generated from catch weights-at-age and the Rivard algorithm described in the NEFSC's VPA/ADAPT program. Table B6.34 lists the weight-at-age for catch, January-1 and female SSB. It was assumed that the weights-at-age were the same for both stocks.

B4.20.10.6 Starting Values

Initial starting values for all parameters are given in Table B7.6 and were selected based on trial-and-error.

B4.20.11 Model Specification for 2SCA Model

B4.20.11.1 Phases

Model parameters were solved in two phases. The parameter and phase are shown in Table B7.6.

B4.20.11.2 Data Weighting

Data weighting was accomplished by first running the model with all initial starting values with all lambda weights and CV weight = 1, and the ESS set to 20 for all composition data. The CV weights for the total removal data were then increased to force the model to better fit the observed data. 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.

B4.20.12 Code Checking

The accuracy of the original model code was checked by simulating virtual populations for Stock-1 and Stock-2 in R and catch numbers, catch age composition, one aggregate and age compositions surveys for each stock and one mixed stock index 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. All code is presented in B8.

B4.20.13 Base Model Configuration and Results

The final model configuration CV weights and effective sample sizes used for all sources are shown in Table B7.7. There were 344 parameters estimated in the model.

B4.20.14 Results

Resulting contributions to total likelihood are listed in Table B7.8. The converged total likelihood was 30,826.5 (Table B7.8). Estimates of fully-recruited fishing mortality for each region and period, recruitment, parameters of the selectivity functions for the selectivity periods, catchability coefficients for all surveys, parameters of the survey selectivity functions, and estimates of age abundance in the first year are given in Table B7.9 and are shown graphically in Figures B7.5-7.8.

Graphs depicting the observed and predicted values and residuals for the catch age composition, survey indices, and survey compositions are given in Appendix B9. The model fit the observed total removals in the Chesapeake Bay and ocean in each period and region well (Figure B7.6). For the Chesapeake Bay stock, observed age composition data for period-2 were fitted reasonably well, but older ages were not in periods 1 and 3 (Appendix B9 Figures 1-6). The ocean removals age composition in period-1 was poorly fitted (few removals and samples are made during this period), but those for period-2 and 3 were fitted reasonably well (Appendix B9 Figures 7- 11). The model tended to slightly over-estimate the ocean removals age composition at older ages in the latter years of the time series.

For the Chesapeake Bay stock, the observed MAYOY, VAYOY, MD Age-1, and ChesMMAP survey indices were predicted fairly well but less so for the MDSSN survey (Appendix B9 Figure 12). The NYYOY, NJYOY, NY Age-1 and DESSN indices for the Delaware Bay/Hudson River stock were fitted reasonably well, but less so for the DE30 survey. (Appendix B9 Figure 13 and 14). Based on residuals plots, the NYOHS index for the mixed ocean stocks was fitted poorly. Although a balanced residual pattern was observed for the NJTRL index, trends were not well predicted. The predicted indices for CTLISTS and MRIP surveys showed similar trends as the observed but peaks in the observed data were not matched well (Appendix B9 Figure 15). The estimated selectivity patterns for each age composition survey are shown in Appendix B9 Figure 16. For the Chesapeake Bay stock, the observed trends in age compositions for the MDSSN survey (Appendix B9 Figures 17 and 18) were predicted well by the model, while those for ChesMMAP (Appendix B9 Figures 19 and 20) were predicted less well. For the Delaware Bay/Hudson River stock, the DESSN age composition was predicted fairly well for intermediate ages (less so for older ages) (Appendix B9 Figure 21 and 22), whereas the predicted values for the DE30 survey were only fairly matched (Appendix B9 Figure 23 and 24). For the mixed ocean stock, NYOHS age composition was predicted fairly well (Appendix B9 Figures 25 and 26), NJTRL survey age composition was predicted poorly (Appendix B9 Figures 27 and 28), CTLISTS age composition was predicted fairly well (Appendix B9 Figures 29 and 30) and the MRIP age composition was predicted well (Appendix B9 Figures 31 and 32).

B4.20.14.1 Stock Composition Index

The predicted stock composition for the Chesapeake Bay stock showed an increase in the Chesapeake Bay stock composition of the ocean catches (Figure B7.9). However, the predicted index showed the composition leveling off after 1995 at around 0.65, whereas the observed values for fish > 28 inches (711 mm) leveled off at higher proportions.

B4.20.14.2 Fishing Mortality

Fully-recruited fishing mortality and fishing mortality-at-age by period and region is listed in Table B7.10. Except for period-1, the period fully-recruited F in 2017 was generally higher in ocean than in Chesapeake Bay. F was generally highest during period-3. Fishing mortality in the Chesapeake Bay and in the ocean region peaked at age-15 in most years since 1996-1997.

Annual fully-recruited F cannot be calculated by simply summing the fully-recruited F across periods because the period Fs are not additive. Instead, stock-specific fully-recruited Fs can be estimated by calculating age-specific exploitation rates using the stock total numbers-at-age at the beginning of period-1 and predicted catch numbers-at-age combined across periods and region and then solving for F using the catch equation. Since fish from the Chesapeake Bay stock are present in both the Chesapeake Bay and ocean regions, which have differential natural morality rates, an average M-at-age was used in solving for F. A combined-stock fully-recruited F can be calculated in the same way. The fully-recruited F was considered the largest value in the resulting F vector. Table B7.11 lists the estimates of fully-recruited exploitation rates and resulting F values for the Chesapeake Bay stock, the Delaware Bay/Hudson River stock and combined stocks. Fishing mortality was generally higher for the Delaware Bay/Hudson River stock (Chesapeake Bay stock F_{2017}=0.284; the Delaware Bay/Hudson River stock F_{2017}=0.394) and variation in F of both stocks was similar (Figure B7.10). The resulting fully-recruited Fs for combined stocks showed similar variation as the individual stock values but Fs were slightly higher than the Chesapeake Bay stock Fs (Figure B7.10). The combined fully-recruited F was estimated to be 0.305 in 2017.

B4.20.14.3 Population Abundance (January 1)

The Chesapeake Bay stock population occurs in both the Chesapeake Bay and ocean regions. The movement of numbers between the Chesapeake Bay and ocean regions is shown in the abundance matrices in Table B7.12. Using only period-1 estimates and summing across regions, the striped bass abundance (ages 1+) increased steadily from 1982 through 1997 when it peaked around 483 million fish (Figure B7.11). The Chesapeake Bay stock total abundance fluctuated widely without trend through 2004. A general decline occurred after 2004 to 182 million fish in 2011. Abundance increased in 2012 and again in 2016. Abundance of ages-8+ increased from about 593,000 fish in 1986 to 15 million fish in 2004 (Figure B7.11). Ages-8+ abundance has been declining since 2005 and was estimated to be 5.5 million fish in 2017.

Abundance estimates by period and year for the Delaware Bay/Hudson River stock are listed in Table B7.13. Using only period-1 estimates, the striped bass abundance (ages 1+) for the Delaware Bay/Hudson River stock increased steadily from about 21 million fish in 1982 to its first peak at 158 million fish in 1994 (Figure B7.12). Total abundance of the Delaware Bay/Hudson River stock fluctuated widely without trend through 2004. A general decline in abundance occurred after 2004, and abundance in 2014 was estimated to be only 58 million fish. Age-1+ abundance increased in 2015-2017 to an average-123 million fish (Figure B7.12). Abundance of age-8+ increased from about 1 million fish in 1984 to 5.8 million fish in 2004 (Figure B7.12). Age-8+ abundance has been steadily declining since 2005 and was estimated at 2 million fish in 2017.

B4.20.14.4 Spawning Stock Biomass, Total Biomass and Stock-Recruitment Relationship

For the Chesapeake Bay stock, female SSB grew steadily from 1982 through 2003 when it peaked at about 88 thousand mt (Table B7.14; Figure B7.13). Female SSB has declined since then and was estimated at 50 thousand metric tons (95% CI: 37,813-62,879) in 2017 (Table B7.14; Figure B7.13). For the Delaware Bay/Hudson River stock, female SSB grew steadily from 1986 through 2003 when it peaked at about 42 thousand mt (Table B7.15; Figure B7.13). Female SSB has declined since then and was estimated at 21 thousand metric tons (95% CI: 15,833-26,860) in 2017 (Table B7.15; Figure B7.13). The combined-stock female SSB showed similar trends (Figure B7.13).

Total biomass (January 1) for the Chesapeake Bay stock (Table B7.16) increased from 3,292 metric tons in 1982 to its peak at about 338,000 metric tons in 1999 (Figure B7.14). Total biomass has been declining since then (Figure B7.14). Total biomass (January 1) for the Delaware Bay/Hudson River stock (Table B7.17) increased from 20,000 metric tons in 1986 to its peak at about 128,000 metric tons in 1999 (Figure B7.14). Total biomass has been declining since then (Figure B7.14). The trends in total biomass were similar between stocks.

The stock-recruitment data derived for each stock is shown in Figure B7.15. External fitting of Beverton-Holt curves (assumed the correct functional form for striped bass) to these data were performed to determine equation parameters. The curve fit was good and parameters were reasonably precise for the Chesapeake Bay stock, but the fit for the Delaware Bay/Hudson River stock was not believable because the asymptotic recruitment was not reached until extremely high female SSB levels that have not been observed.

B4.20.14.5 Retrospective Analysis

Retrospective analysis plots and percent difference plots between the 2017 value of period fully-recruited fishing mortality for the Chesapeake Bay and ocean regions and recruit numbers and female SSB for the Chesapeake Bay stock and 2 and 2016-2010 peels are shown in Figures B7.16-18. Fully-recruited F in the Chesapeake Bay for periods 1-3 had low to moderate (in most recent years) retrospective bias and it appears that F is slightly over-estimated in terminal years (Figure B7.16). Fully-recruited F in the ocean for periods 1-3 also had low to moderate (in most recent years) retrospective bias but the pattern in bias was not consistent (Figure B7.17). Retrospective analysis of age-1 recruits showed that the terminal year estimate of age-1 abundance for both stocks were most uncertain (Figure B7.18). For the Chesapeake Bay stock, the terminal year is likely over-estimated (Figure B7.18), while the bias pattern for the Delaware Bay/Hudson River stock is not consistent (there is under- and over-estimation). Retrospective analysis of female SSB for the Chesapeake Bay stock showed that the female SSB can be highly under-estimated in early years (peels 2011, 2013 and 2014) (Figure B7.18). However, trends in bias near the terminal show that female SSB has low bias (<12%) and may be slightly under- or over-estimated. For the Delaware Bay/Hudson River stock, bias in female SSB was low (<15%) but there was no consistent pattern in the direction of bias (Figure B7.18).

B4.20.15 Sensitivity Analysis

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 period-3 in 2017 and corresponding total log-likelihoods assessed convergence stability. The runs demonstrated that the starting values selected produced the smallest total likelihood (15069.2) in 77 out of 100 runs (Figure B7.19).

Natural Mortality

Striped bass residing in the Chesapeake Bay experience higher natural mortality after 1997 due to the advent of *Mycobacteriosis*. To examine the impact of this higher mortality on the results, a sensitivity run was made in which those higher natural mortality rates were substituted for the lower baseline values. (Figure B7.20). Using the lower natural mortality rates prior to 1997 in the Chesapeake Bay resulted in lower fishing mortality in the Chesapeake Bay, higher fishing mortality in the ocean, lower recruitment in the Chesapeake Bay stock and lower female SSB in both stocks (Figure B7.20).

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. Very little change was observed when most indices were removed. The biggest changes resulted the MDSSN and MRIP surveys were removed (Figure B7.21). Without the MRIP index, the fully-recruited F in all periods and regions decreased and female SSB for both stocks increased particularly after 2003 (Figure B7.21). Without the MDSSN index, the magnitude of fully-recruited F increased slightly and the magnitude of the female SSB decreased for both stocks prior to 2012 (Figure B7.21).

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 fully-recruited fishing mortality, recruitment and female SSB was investigated. When the average effective sample sizes were increased or decreased by 50% of the original values, fully-recruited F and recruitment of both stocks changed very little (Figure B7.22). However, increasing ESS by 50% increased the female SSB slightly (more so for the Delaware Bay/Hudson River stock in the early part of the time series), whereas decreasing ESS produced the opposite effect (Figure B7.22).

Effects of Changing the Female and Male Maturity Schedules
Migration of the Chesapeake Bay stock fish back into the Chesapeake Bay region is controlled by the female and male maturity schedules. The impact of the maturity schedules were investigated by sliding the vector of proportions mature-at-age up or down one age. Fishing mortality and recruitment values changed very little except in the ocean during period-2 where decreasing the age increased F slightly and increasing age decreased F slightly (Figure B7.23). As expected, the biggest change happened to female SSB; sliding the vector down one age produced more female SSB, whereas sliding the maturity schedule up one age lowered the female SSB (Figure B7.23).

Effects of Changing Emigration Probabilities
The current vector of emigration probabilities for the Chesapeake Bay was derived using tag data released by Maryland DNR following Dorazio et al. (1994). Maryland tagging occurred through most of the estuary, so the distribution of tagging covered much of the striped bass distribution. The State of Virginia also tags fish in the Rappahannock River near the mouth of Chesapeake Bay, but these data were not used in this assessment because the emigration probabilities would probably not be representative of the whole stock residing in the Chesapeake Bay. However, SAS members were interested in the impacts of using Maryland and Virginia data, so estimates of emigration probabilities by age were made following the Dorazio et al. (1994) methods (Figure B7.3). The combined data estimated that emigration rates for younger ages were lower and rates for older ages were higher than the Maryland-only data. The effects of using the Maryland/Virginia probabilities are shown in Figure B7.24. Relative to the base model, fishing mortality in the Chesapeake Bay region declined while it increased in the ocean, recruitment numbers for both stocks increased slightly, and female SSB estimates for the Chesapeake Bay stock increased, while the Delaware Bay/Hudson River stock female SSB decreased in magnitude (Figure B7.24).

Effects of the Stock Composition Index
The results of the stock assessment are very sensitive to the inclusion of the stock composition index because it is used by the model to scale the recruitment and population estimates. The impact of not using the index is presented in Figure B7.25. Fishing mortality in the bay increased on average by 46%, 47%, and 47% during period-1, -2 and -3 respectively. Fishing mortality in the ocean decreased on average by 11%, 32% and 15% during period-1, -2 and -3, respectively. Chesapeake Bay stock recruitment decreased by 27% on average, and Delaware Bay/Hudson River stock recruitment increased by 72% on average (Figure B7.25). Female spawning stock of the Chesapeake Bay stock decreased on average by 40% and the Delaware Bay/Hudson River stock female spawning stock increased by an average of 101%.

A vector of stock composition estimates for >18" (457 mm) fish was also derived by the committee, but were not used for reasons discussed earlier. However, if this index was used only small changes to fishing mortality and recruitment estimates occurred (Figure B7.25). The biggest influence occurred in the Delaware Bay/Hudson River stock female SSB where biomass increased on average by 32% after 2000.

Effects of Adjusting Commercial Dead Discards
The results of this stock assessment used dead discards for the commercial fishery estimated from tag data and MRIP. The stock assessment subcommittee had decided to rescale the Delaware and Chesapeake Bay estimates of discards by a ratio derived by comparing direct estimates of Delaware Bay discards from 2002 and 2003 to estimates derived by the tag-based method. To explore the impact of not rescaling the discards estimates for these bays, the unadjusted dead discards were included and the model parameters were re-estimated (Figure B7.26). Using the unadjusted dead discards impacted the model results minimally. The fishing mortality for period-1 in the Chesapeake Bay changed the most, but only slight deceases in F were observed during the other periods and within the Chesapeake Bay and ocean regions. Female SSB prior to 1996 increased slightly and it declined slightly after 1999 (Figure B7.26).

B4.20.16 Sources of Uncertainty

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. The assignment of age to scales samples becomes less certain with increasing fish age (≥

age-10). In addition, the same vector of emigration probabilities, female proportions-at-age, and maturity schedules are assumed constant over time which is unlikely.

Estimates of F and female SSB from 2SCA model 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 only slightly biased (<15%).

B4.21 Supporting Models

B4.21.1 Single stock, Non-Migration Statistical Catch-At-Age Model (SCA)

[SAW-66 Editor's Note: The SARC-66 peer review panel SARC-66 recommends the single stock, non-migration model described in this section for management use.]

The 2013 SCA model (NEFSC 2013) was used to estimate fishing mortality, abundance, and female SSB of striped bass during 1982-2017 from total removals-at-age and fisheries-dependent and fisheries-independent survey indices.

A summary of the model structure used in this assessment is listed in Table 1 of Appendix B10.

B4.21.1.1 Data Inputs

Bridge building
The 2013 model (NEFSC 2013) and data configuration were updated with data through 2016 that included uncalibrated recreational MRIP data (ASMFC 2017; Table B7.19). This same model was updated with calibrated MRIP data (Table B7.19). A base model was then constructed with the changes described below and summarized in Table B7.19 to make it comparable to the base case of the preferred 2SCA model.

Plus Group
The 13+ plus-group used in NEFSC (2013) was extended to a 15+ plus-group for catch and indices data. This extension represents a compromise between scale age bias that increases after about age-12, and more complete ocean fishery selection and Chesapeake Bay migration of fish by about age-15.

Catch Data
Total removals 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 two "fleets" in an attempt to account for more realistic patterns in fishing selectivity. For this assessment, the SAS was able to apportion commercial releases into Chesapeake Bay and Coast regions allowing for the elimination of a third commercial dead release "fleet"; this is a change from NEFSC (2013) that included the combined dead commercial

releases as a separate fleet. All selectivity time blocks corresponded to Amendment changes. Removals data were split into *Chesapeake Bay* and *Coast*, each with their respective commercial dead releases.

The Chesapeake Bay fleet includes commercial and recreational harvest and commercial and recreational dead releases taken in the Chesapeake Bay by Maryland, Virginia, and the PRFC. The Coast fleet includes commercial and recreational harvest and commercial and recreational dead releases taken in the coastal regions, Delaware Bay, Long Island Sound, and Hudson River by Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia and North Carolina. The observed total removals and catch age compositions were generated from all state reported landings-at-age, and recreational dead releases-at-age. The total removals and age composition by region were developed by summing the removals-at-age developed for the 2SCA model (Table B7.1) across the three periods in the 2SCA model.

Total catch CVs for the Chesapeake Bay and Coast fleets were assumed equal to the PSEs of MRIP total harvest plus dead releases for the inclusive states (Appendix B10). The CV of the combined harvest and dead releases estimates for each year was calculated as:

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

The commercial landings were assumed errorless. There is error in the commercial dead releases, however it is unaccounted for in the fleet CVs (this is a departure from NEFSC (2013), where commercial dead releases were their own fleet). This represents a source of uncertainty in the assessment; see Data Weighting Section, below.

Young-of-the-Year and Age-1 Indices

Young-of-the-year (YOY) and yearlings (age-1) indices from New York (NYYOY: 1986-2017; NY Age-1: 1985-2017), New Jersey (NJYOY: 1982-2017), Maryland (MDYOY and MD Age-1: 1970-1981), and composite Maryland-Virginia (MDVAYOY: 1982-2017) 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 age-1 indices were advanced one year and are linked to age-1 and age-2 abundances, respectively, and are tuned to January 1st (p=0; Appendix B10). Except for the MDVAYOY index, all YOY and age-1 indices are geometric means and corresponding CVs. More information on these surveys can be found in Section B5.2 and 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: 1988-2016) and Northeast Fisheries Science Center (NEFSC spring bottom trawl survey: 1991-2008) are used in the update of the NEFSC (2013) model by linking them to aggregate age abundances and the time of year (ASMFC 2017). 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 NYOHS survey (1987-2006), NJTRL survey (1990-2017), MDSSN survey (1985-2017), DESSN (1996-2017), DE30 (1999, 2002-2017), CTLISTS (1987-2017), ChesMMAP (2002-2017), and Maine-North Carolina (recreational hook and line: 1982-2017) surveys are incorporated into the updated non-migration SCA model by linking them to age abundances and the time of year (Appendix B10). 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). The Gompertz model is also used to estimate the selectivity pattern on the MRIP survey index. The MDSSN survey estimates are corrected for mesh-size selectivity, only the selectivity value for age-2 had to be estimated (NEFSC 2013); for ages ≥ 3, selectivity was set to 1. For the NYOHS, CTLISTS, DE30, and ChesMMAP surveys the Thompson's exponential-logistic model is used to estimate the selectivity pattern. For the NJTRL survey, a gamma function is used to estimate the selectivity pattern.

Starting Values

Initial starting values for all parameters (Appendix B10) were carried forward from NEFSC (2013), where they were selected based on trial and error. As was the case in NEFSC (2013), the starting effective sample sizes for the age proportions in each fleet were set at 50, based on the coast-wide age samples.

For existing surveys with age composition data, final effective sample sizes from ASMFC (2017) were used as ESS starting values (calculated in NEFSC (2013) using methods in Pennington and Volstad (1994) and Pennington et al. (2002). For new age composition surveys, the average ESS of existing surveys was used (Table B7.19). The sensitivity of results to these starting values was explored (see below).

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 SSB. The sex proportions were derived from available state catch datasets and are unchanged from the previous assessment (NEFSC 2013). The proportions used were truncated to 13+ for the continuity run.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
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	1.00	1.00

Female Maturity

In the past the proportions mature-at-age for females in NEFSC (2013) were derived from literature values and field samples. These values were updated as described in Section B5.1.7 (female maturity).

Female maturity NEFSC (2013):

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

Updated female maturity used for the present assessment:

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
Proportion female	0.00	0.00	0.00	0.09	0.32	0.45	0.84	0.89	1.00	1.00	1.00	1.00	1.00	1.00	1.00

The SAS explored the sensitivity of the results to the change in female maturity.

Natural Mortality
Natural mortality is unchanged from the previous assessment (NEFSC 2013). Age-specific M for ages 1-6 were derived from a curvilinear model fitted to tag-based Z estimates (assuming Z=M) for fish ≤ age-3 from New York and tag-based M estimates (Jiang et al. 2007) for striped bass from Maryland made for years prior to 1997. The age-specific M estimates used in the base model are:

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

B4.21.1.2 Model Specification

Catch Selectivity Functions
In NEFSC (2013), four time blocks were used (Table B7.19). 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 (2015-2017: under Addendum IV) for each fleet was considered by comparing the AICc values of model fits with the additional period (each fleet added sequential) against the model fits without the extra period. The addition of the extra time period did not improve the fit of either fleet. 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. Internal model fits of this relationship were poor and so recruitment is estimated as a log-normal deviation from average recruitment. The SAS explored the sensitivity of the results to this assumption.

Data Weighting
Data weighting was accomplished by first running the model with all initial starting values, lambda weights = 1, and index CV weights = 1, and the ESS as noted in Table B7.19. The lambda weights for the total removal data were increased for the Chesapeake Bay and Coast to force the model to better fit the data. 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.

B4.21.1.3 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 Chesapeake

Bay and Coast fleets. All indices were used. The lambda weights of total catch for the Chesapeake Bay, Coast and Commercial Release fleets were increased by 2 to force the model to better fit the data in the early part of each time series. 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 Appendix B10 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: Chesapeake Bay – 68.4, Coast – 71.1, NYOHS – 21.5, NJTRL – 5.2, MDSSN – 16.8, DESSN – 19.7, MRIP – 35.6, CTLIST – 12.4, DE30 – 7.3, and ChesMMAP – 10.8.

Resulting contributions to total likelihood, 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 Appendix B10 and are shown graphically in Figures B7.27-B7.30. Graphs depicting the observed and predicted values and residuals for the catch age composition, survey indices, and survey compositions are given in Appendix B10. The model fit the observed total catches (Figure B7.28) and catch age compositions (Appendix B10) well with few exceptions (e.g., age compositions of younger ages in fleet 2) and are generally similar to fits seen in NEFSC (2013). Model fits to the YOY indices were all generally reasonable (Appendix B10). The age-1 indices are not fit particularly well. The predicted trends matched the observed trends in age composition survey indices (except MDSSN and NYOHS), and predicted age survey age composition reasonably well (MDSSN) to poorly (NJTRL) (Appendix B10).

Fishing Mortality
Fully-recruited fishing mortality in 2017 for the Chesapeake Bay and Coast fleets was 0.068 and 0.262, respectively (Appendix B10) and always highest in the Coast fleet (Figure B7.27). The maximum total F-at-age in 2017 was 0.307, which occurred on ages 13-14 (Table 7 in Appendix B10). Average fishing mortality (unweighted) on ages 3-8, which are generally targeted in producer areas, was 0.173 (Table B7.20; Figure B7.31). 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 2017 F weighted by N for ages 7-13 (age-7 to compare with tagged fish ≥28" (711 mm)) was 0.267 (Table B7.20; Figure B7.31). An F weighted by N for ages 3-8, comparable to the direct enumeration estimate for Chesapeake Bay, was equal to 0.110 (Table B7.20; Figure B7.31).

Fishing mortality-at-age in 2017 for the two fleets is shown in Figure B7.32. Fishing mortality-at-age peaked at age-6 in the Chesapeake Bay fleet and age-15+ in the Coast fleet. The highest fishing mortality was attributed to the Coast fleet at ages ≥ 5 (Figure B7.32).

Population Abundance (January 1)
Striped bass abundance (1+) increased steadily from 1982 through 1997 when it peaked around 420 million fish (Table B7.21, Figure B7.30). Total abundance fluctuated without trend through 2004. From 2005-2009, age-1+ abundance declined to around 189 million fish. Total abundance increased to 351 million by 2016 before dropping to 249 million fish in 2017 (Figure B7.30). The increase in 2012 was due primarily to the abundant 2011 year class from Chesapeake Bay (Table B7.21). Abundance of age-8+ striped bass increased steadily through 2004 to 16.5 million fish. After 2004 age-8+ abundance oscillated and has been in decline since 2011 (Table B7.21; Figure B7.30). Age-8+ abundance in 2017 is estimated at 6.7 million fish, a value near the 30th percentile of the time-series.

Spawning Stock Biomass, Total Biomass and Stock-Recruitment Relationship
Weights-at-age used to calculate female SSB were generated from catch weights-at-age and the Rivard algorithm described in the NEFSC's VPA/ADAPT program. Female SSB grew steadily from 1986 through 1996 after which female SSB dropped to just below levels observed in 1995. Female SSB grew steadily between 1999 and 2003 when it peaked at 114 thousand metric tons (Table B7.21, Figure B7.33). Female SSB has generally declined since then and was estimated at 68.5 metric tons (95% CI: 53,520-83,431 mt). The female SSB point estimate is approximately 23 thousand metric tons below the threshold level of 91.4 thousand metric tons (SSB_{1995}) and indicates that striped bass are overfished. The spawning stock numbers (Figure B7.33) have declined about the same pace as female SSB.

Total biomass (January 1) increased from 38 thousand metric tons in 1982 to its peak at 335 thousand metric tons in 1999 (Figure B7.33). Total biomass generally declined through 2015, but has since increased slightly in 2017 (Figure B7.33).

The stock-recruitment data derived in the model along with the deterministic externally fit Beverton-Holt curve is shown in Figure B7.34. As was the case with the Delaware Bay/Hudson River stock in the migration model (2SCA), asymptotic recruitment was not reached until high female SSB levels that have not been observed.

B4.21.1.4 Retrospective Analysis
Retrospective analysis plots and percent difference plots between 2017 and peels of the retrospective analysis are shown in Figure B7.35. Very little retrospective trend (+/-2%) was evident in the more recent estimates of fully-recruited total F, female SSB, and age-8+ abundance of SCA (Figure B7.35). Approximately 5 years of additional data are needed before the percent-difference from 2017 estimates increases to +/- 10 to 15%. Percent-difference from the most recent year of data in NEFSC (2013) ranged from 10-30%. The retrospective analysis of age-1 recruits showed that the terminal year estimate of age-1 abundance is most uncertain (Figure B7.35). The retrospective pattern suggests that fishing mortality is likely slightly over-estimated and could decrease with the addition of future years of data. Similar, but larger, retrospective trends have been observed in the previous assessment of striped bass using the ADAPT VPA (ASMFC 2005), the 2007 benchmark, and the 2013 benchmark.

B4.21.1.5 Sensitivity Analysis

Starting Values
To further check the convergence properties of the model, 100 model runs were made, and for each run, starting values were randomly permuted by +50%. A plot of total fully-recruited F in 2017 and corresponding total log-likelihoods assessed convergence stability. The runs demonstrated the stability of the results from the base model (Figure B7.36).

Natural Mortality
To determine if the potential impact of higher M due to the Mycobacterium outbreak in Chesapeake Bay, M for ages 3+ 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+ for years 1997-2017. Increasing M

produced lower estimates of fully-recruited F and higher estimates of female spawning biomass, Age-8+ abundance, and recruitment (Figure B7.37).

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 1982-2017 between base run (all indices) and each one removed one-at-a-time were minor except when the MRIP and MDSSN indices were removed (Figure B7.38). Without the MRIP index, the fully-recruited F decreased and female SSB increased relative to the base run after about 1989 (Figure B7.38); the opposite is true without the MDSSN index (Figure B7.38). Recruitment estimates are unchanged when survey data sources are removed (Figure B7.38).

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 age-8+ abundance, female SSB, recruitment, and fully-recruited fishing mortality was investigated. When the average effective sample sizes were increased or decreased by 20% of the original values, all estimates were virtually unchanged (Figure B7.39). Estimates were also virtually unchanged with a 50% increase in ESS (ESS150). Decreasing ESS by 50% (ESS50) raised age-8+ abundance and female SSB during the 1990s and decreased fully recruited fishing mortality slightly during the 1990s.

Recruitment estimation method
The influence of the method of recruitment estimation on the estimates age-8+ abundance, female SSB, recruitment, and fully-recruited fishing mortality was investigated. When the recruitment estimation method changed (lognormal deviations from mean recruitment (base) versus lognormal deviations from Beverton-Holt stock recruitment relationship) all estimates were virtually unchanged over the time series (Figure B7.40).

Unadjusted commercial dead releases
The influence on making adjustments to commercial dead releases on the estimates age-8+ abundance, female SSB, recruitment, and fully-recruited fishing mortality was investigated. Fully recruited fishing mortality, age-8+ abundance, and recruitment are virtually unchanged, though female SSB is slightly higher after about 2004 (Figure B7.41).

Changes to female maturity
The influence of female maturity schedule on estimates of age-8+ abundance, female SSB, recruitment, and fully-recruited fishing mortality was investigated by shifting the maturity curve left or right by one age, as well as using the curve from NEFSC (2013). Age-8+ abundance, fully recruited fishing mortality and recruitment were virtually unchanged with changes in maturity (Figure B7.42). Female SSB changed as expected with shifts in the maturity curve: higher female SSB when maturity schedule is shifted left as fish are assumed to mature at younger ages, and the opposite when maturity is shifted right. Using female maturity from NEFSC (2013) results in minor changes to female SSB.

B4.21.1.6 Sources of Uncertainty in SCA Model

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. The assignment of age to scales samples becomes less certain with increasing fish age (≥ age-10). Finally, as noted above, there is uncertainty in the estimates of commercial dead releases.

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.

B4.21.2 Age-Structured Assessment Program (ASAP)

A single stock unit model was developed using the statistical catch-at-age approach in the software package Age-Structured Assessment Program (ASAP; version 3.0.16). The basic concept (Legault and Restrepo 1998) is similar to the SCA model, however some of the options available and approaches in fitting the data are different. In the ASAP model, the indices consist of the MDSSN indices at ages 2 to 15+, MRIP CPUE at ages 3 to 15+, NY age-1, MD age-1, ChesMMAP indices at ages 2-15+, CTLISTS indices at ages 3 to 8, NJTRL indices at age-2 to 9, DESSN indices at ages 2-12, DE30 indices at ages 1-8, and a composite swept area estimate of age-0 among all three stocks (adjusted to abundance at Jan 1 in *t*+1). The ChesMMAP index selectivity was fit as a double logistic curve, the DESSN index as a single logistic curve and all others were fit as selectivity at age fixed as flat-top selectivity curves. A CV of 10% was applied to each of two fleets, distinguished as catch within Chesapeake Bay and catch along the coast beginning in 1982. The catch selectivity was separate for Chesapeake Bay and coast, with three Chesapeake Bay time blocks (1982-1989, 1990-1995 and 1996-2017) and three coast time blocks (1982-1984, 1985-1997, and 1998-2017). Chesapeake Bay selectivity block 1 was fit as a double-logistic function. SSB was defined as female SSB. Since ASAP does not accommodate sex ratio as an input, female maturity at age was multiplied by sex ratio at age (the same ratio as SCA) to produce female SSB output. Recruitment was estimated using recruitment deviations with steepness fixed at 1. Retrospective peels were done for 7-years and an MCMC run made using 1000 iterations with a thinning factor of 100. Recruitment in the MCMC was defined by the geometric mean of age-1 for years 1995-2015.

The results of the ASAP model mirrored the updated non-migration SCA results. In general, the ASAP model produced slightly higher F's in the beginning of the time series and comparable values since 2000. The terminal year F in ASAP equaled 0.27 compared to the non-migration SCA model of 0.31 (Figure B7.43). Total abundance was lower in the terminal year due in part to a smaller estimate of recruitment (Figure B7.44and B7.45). Estimates of female SSB were generally lower in ASAP which may be due to the differences in estimation for female only components of SSB (Figure B7.46). There were no issues of retrospective bias in the ASAP runs with Mohn's rho value less than 0.1 for estimates of female SSB (-0.081), F (0.094), abundance (-0.060) and recruitment (-0.10) (Table B7.22). The 90% CI of the median female SSB in 2017 (60,912 metric tons; Figure B7.47) was between 49,517 metric tons and 74,048 metric tons. The 90% CI for Fmult in 2017 (0.27) was between 0.21 and 0.35 (Figure B7.47).

B4.22 Comparison of Model Results

B4.22.1 Comparison of 2017 Continuity Model Results (three-fleet SCA) to 2018 Base SCA Model Results (two-fleet SCA)

As a historical retrospective of model results, the estimates of fully-recruited fishing mortality, female SSB, recruitment, and age-8+ abundance from the 2017 update assessment (continuity run of 2012 base run) are compared to the results of the 2018 base model of the non-migration SCA model in Figure B7.48. We also explored the impact of the calibrated MRIP estimates on model results through a quasi-continuity run where we updated the recreational catch and recreational dead release component of the 2017 update CAA (all other data sources were unchanged). Differences between the 2018 base run and the 2017 continuity run are provided in Figure B7.48.

From 1990 forward, the fully recruited F estimates in the base run are generally higher than the estimates from the 2017 update assessment or when calibrated MRIP estimates were included in the 2017 update. Female SSB is higher in the 2018 base run relative to the 2017 update (due to inclusion of calibrated MRIP estimates); inclusion of the calibrated MRIP estimates into the 2017 update result in higher female SSB estimates than those estimated in the 2018 base run. Commercial dead releases were not updated in the quasi-continuity run and likely account for this increase (see also Figure B7.41). Female SSB since 2000 declined more rapidly in the base run relative to the 2017 update with inclusion of calibrated MRIP estimates (Figure B7.48). Results of age-8+ abundance are similar to those described for female SSB. Estimates of recruitment are higher with the inclusion of calibrated MRIP data (compare Base and newMRIP with update2017 in Figure B7.48).

B4.22.2 Comparison of 2018 2SCA Model Results (Primary Model) to 2017 Continuity Model Results (three-fleet SCA)

As a historical retrospective of model results, the estimates of fully-recruited fishing mortality for both stocks combined and combined female SSB from the 2018 2SCA model 2017 are compared to the results of the 2017 continuity update of the SCA model in Figure B7.49. The fully-recruited F estimates from the 2SCA model were similar in trends but values tended to be higher than the estimates from the 2017 model except during the late 1990s-early 2000s. The female SSB estimates from the 2SCA model were considerably higher than estimates from the 2017 continuity run, and the former showed a steeper decline since 2005 (Figure B7.49). These disparities in results are likely due to the effect of updated

MRIP estimates for striped bass. The 2SCA model includes the updated recreational harvest and dead releases whereas the 2017 SCA continuity run does not.

B4.22.3 Comparison of 2018 2SCA Model Results (Primary Model) to 2018 Base SCA Model Results (two-fleet SCA)

The SCA model was updated with the new MRIP estimate of harvest and releases, and the number of fleets was reduced to two fleets because commercial dead discards were able to be updated prior to 2004 updated and split into Chesapeake Bay, Delaware Bay and Ocean region. The fully-recruited F estimates from the 2SCA model were similar in trends but values were higher prior to 1993 but lower after 1994 (Figure B7.49). The estimates of fully-recruited F in 2017 were nearly identical between the two models. The female SSB estimates from the 2SCA model were considerably higher than estimates from the two-fleet SCA after 1995. The 2SCA model showed a steeper decline beginning in 2005, whereas the two-fleet SCA model estimates did not begin to steeply decline until about 2012 (Figure B7.49).

B4.22.4 Comparison of 2018 2SCA Model Results (Primary Model) to ASAP Model Results

As a confirmatory check of the SCA model output, an ASAP statistical catch-at-age model was applied to the catch-at-age data and relative abundance indices. The ASAP produced fully-recruited fishing mortality estimates that were similar in trend but slightly larger than the 2SCA estimates after 1996 (Figure B7.49). The trends in female spawning biomass were similar the 2SCA results but were lower in magnitude (Figure B7.49).

TOR B4. USE TAGGING DATA TO ESTIMATE MORTALITY AND ABUNDANCE, AND PROVIDE SUGGESTIONS FOR FURTHER DEVELOPMENT.

B4.23 Introduction

This report summarizes results of tagging analyses conducted by the striped bass Tagging Subcommittee (SBTS) of the Technical Committee. Tagging data were obtained from the United States Fish and Wildlife Service's (USFWS) Atlantic coast-wide striped bass tagging program through the 2017 tagging year. Tagging analyses include the calculation of annual exploitation rates as adjusted R/M ratios, descriptive statistics on length frequency distributions of releases (measured as mm total length, TL), and age frequency distributions of recaptures based on an aged subsample at the time of release. Additionally, rates of survival (S), instantaneous fishing mortality (F), and instantaneous natural mortality (M) are estimated using an instantaneous (mortality) rate, catch and release model (IRCR) based on a formulation of Jiang et al. (2007).

B4.24 Description of Atlantic Coast-wide striped bass Tagging Program

Refer to Section B5.4.

B4.25 Annual Exploitation Rates

Annual exploitation rates (μ) were developed for both ≥ 18-inch (457 mm) fish and ≥ 28-inch (711 mm) fish and were estimated as follows:

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

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;

λ_R = reporting rate of released fish and;

M = the number of fish initially tagged and released;

The SBTS defined two categories of tag recoveries for the analysis: a) fish harvested and tag reported and, b) fish caught and released, and tag reported. Only first recapture events were used. The reporting rate estimates for harvested fish and released fish are those used in the IRCR analysis, as described below.

B4.26 Instantaneous Rates Model

Hoenig et al. (1998) first described an instantaneous rates model, where 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. Given that 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 (Massachusetts 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 NEFSC (2013).

Tag recovery matrices of harvested fish and released fish for each program used in the current assessment are presented in Appendix B11. The number of fish recaptured two or more times was examined to ensure that this phenomenon did not cause a bias in model results. Of 92,344 recaptured fish in the database, only 4% (3,695 fish) were recaptured two or more times. Datasets used in the analyses included only first recapture events.

Six biologically reasonable candidate models were formulated based primarily on historical changes in striped bass management (Table B8.1). In the previous assessment, model structure included six regulatory periods, but the current assessment includes a seventh regulatory period from 2015–2017 (Table B8.2). Support for the addition of the seventh regulatory period was based on IRCR results for each tagging program comparing both six and seven regulatory period models. QAICc was used to determine the model with the most support. For most programs, the seven period models received the most weight. Additionally, results did not differ much between the six period (continuity) models and the seven period models (Appendix B11). For each candidate model, the IRCR analysis estimates S, F, F' (mortality on tags recaptured and released), M, and associated standard errors. Model averaged estimates of S, F, F', and M, and associated unconditional standard errors account for model selection uncertainty.

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 (QAICc; Akaike 1973; Anderson et al 1994; 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 2017 (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.

Currently, M is modeled as two time-periods (Tables B8.1 and B8.3), consistent with methods of the previous assessment (NEFSC 2013). This approach to modeling M is biologically-reasonable given 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). The increase in natural mortality has been linked to mycobacterial infections, but other explanations are possible, such as declines in forage fish populations and water quality.

B4.26.1 Assumptions and Structure of the Model

Model assumptions based on an age-dependent IRCR (Jiang 2005) are modified below for the age-independent IRCR model used in the current analysis:
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 ($R'_{i,y}$) 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*.

and

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

and

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

where
$\hat{F}_y$ = 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*;
M = instantaneous rate of natural mortality;
$\hat{\lambda}_h$ = 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*.

The expected number of tag returns from fish tagged and released in year *i* and caught and released 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 caught and released and its tag reported in year *y*.

and

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

and

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

The variable descriptions are the same as above for harvested fish with the exception of $\hat{\lambda}_r$ which is the tag reporting rate given that a tagged fish is caught and released.

B4.26.2 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. 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. Estimated over-dispersion parameters are reasonable within the range of $1 \leq$ c-hat ≤ 4, but higher values provide evidence for a structural lack of fit (Burnham and Anderson 2002).

B4.27 Coastal and Producer Area Programs Tagging Assessment

B4.27.1 Reporting Rate

The reporting rate used throughout these calculations is the proportion of recaptured fish whose tag is reported to the USFWS. Prior to the 2013 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 following methods outlined in NEFSC (2013). The method used to calculate the current fishery sector-specific reporting rates allows for less than 100% of the high reward tags to be reported. This methodology (Appendix B9 of NEFSC 2013) contains additional sources of uncertainty that could influence the harvest and catch and release reporting rates used in the IRCR.

B4.27.2 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 ≥ 18 inches (457 mm; minimum size in Chesapeake Bay for all years of the commercial fishery and prior to 2015 for the recreational fishery) and for fish ≥ 28 inches (711 mm; 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 Maryland (0.67) and Virginia (0.33).

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

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

where:
w_i = (1 / number of coastal programs; will be equal for each program);
$\mathrm{var}(\overline{x}_{state})$ = individual state's variance of mean F.
The additive variance for the weighted producer area mean F was calculated as:

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

where:
w_i = 0.09 for Delaware;
w_i = 0.13 for Hudson;
w_i = 0.78 for Chesapeake Bay; with 0.67 for Maryland and 0.33 for Virginia;
$\mathrm{var}(\overline{x}_{state})$ = 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.

B4.27.3 Methods for Estimation of Stock Size

Stock size was estimated for fish ≥ 18 inches (457 mm) TL, corresponding roughly to 3-year-old and older striped bass and for fish ≥ 28 inches (711 mm) TL, corresponding roughly to 7-year-old and older fish. Estimates were developed using the annual exploitation rate (μ) calculated above, averaged across all of the tagging programs, and a form of Baranov's catch equation:

Average stock size = catch / μ

Since μ was based on an exploitation rate that included discard mortality from released fish, total catch (recreational and commercial harvest and dead discards) was used.

B4.27.4 Coastal and Producer Area Programs Tagging Assessment Results and Discussion

Length frequencies (mm total length at the time of tagging) of fish tagged in 1987 through 2017 were tabulated by program (Table B8.4). The majority (60%) of tagged coastal fish ranged from 450-699 mm, and 34% were ≥ 700 mm. The majority (68%) of producer area tagged fish ranged from 450-699 mm, and 39% were ≥ 700 mm. For coastal programs, a higher percentage of larger fish (≥ 700 mm) have been tagged and released since 2007, a phenomenon influenced primarily by the NCCOOP program. Specifically, the percentage of tagged fish < 700 mm (73%) exceeded that for tagged fish ≥ 700 mm (27%) during 1987-2006, whereas the percentage of tagged fish < 700 (32%) was less than that for those ≥ 700 mm (68%) during 2007-2017. For producer area programs, the percentages of tagged fish for <700 and ≥ 700 mm length categories have remained relatively similar across the time series.

Age distributions of fish released during the entire time series and recaptured in 2017 were tabulated by program (Table B8.5). Ages are based on a subsample of the total number of tagged fish since not all programs age all tagged fish. Ages are read from scales taken at time of tagging. Coastal ages ranged from 3 to 18 and producer area ages ranged from 2 to 19 years.

Geographic distributions of 2017 recaptures from fish tagged and released during the last ten years of the 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 August along the Northeast coast. For the NCCOOP coastal program, a relatively high percentage of recaptures (40%) occurred in Maryland waters during April and May, likely reflecting the mixed stock status of this program. Recaptures from fish tagged and released by coastal programs generally shift south from their areas of release starting in October. Fish tagged by all of the coastal programs predominantly have recaptures in the southern part of the species range 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 more southern reaches in winter.

B4.27.4.1 IRCR Model Selection and Diagnostics

Model selection results differed among some programs, and between analyses of fish ≥ 28 inches (711 mm) and fish ≥ 18 inches (457 mm) (Table B8.9). For fish ≥ 28 inches (711 mm) from coastal programs, model averaged estimates of S and F for NYOHS, NYTRL, and NCCOOP were influenced by relatively high QAICc weights for Model 4 (a model with constant F and constant F' for each regulatory period), whereas estimates for MADFW and NJDB were primarily influenced by Model 3 (a model with separate year estimates of F, and constant F' for each regulatory period). For fish ≥ 28 inches (711 mm) from producer area programs, DE/PA and VARAP had the highest QAICc weights for model 4, but estimates for HUDSON and MDCB were heavily weighted by Models 5 and 6, respectively. The structure of Models 5 and 6 are similar to that of Model 4, but Model 5 has separate estimates of F and F' for the terminal year, and Model 6 has constant estimates of F and F' for the penultimate and terminal years

For fish ≥ 18 inches (457 mm) from coastal programs, highest weights occurred for Model 3 (MADFW), Model 2 (NYOHS and NYTRL), and Model 4 (NJDB and NCCOOP). Model 2 is structured as constant F for each regulatory period, and F' estimated separately each year. For fish ≥ 18 inches (457 mm) from producer area programs, highest weights supported Model 5 (HUDSON), Model 3 (DE/PA and MDCB), and Model 4 (VARAP).

B4.27.4.2 Exploitation Rates

Annual exploitation rates for fish ≥ 28 inches (711 mm) and ≥ 18 inches (457 mm) are presented by program and as an unweighted coast-wide mean (Tables B8.7 and B8.8). For both length groups, the highest exploitation rates are primarily between 1997 and 2000. For fish ≥ 28 inches (711 mm), the unweighted coast-wide mean peaked in 1997 at 0.24, but estimates were ≤ 0.10 for the last three years of the time series (2015–2017), including 0.08 for the terminal year of 2017. For fish ≥ 18 inches (457 mm), the unweighted coast-wide mean peaked in 1997 at 0.13 (considerably lower than that of fish≥ 28 inches (711 mm)), and estimates were ≤ 0.07 for the last three years of the time series (2015–2017), including 0.07 for the terminal year of 2017.

B4.27.4.3 Reporting Rates

Fishery sector-specific tag reporting rates were from previous estimates of 0.11, 0.85 and 0.55 for commercial fishers, recreational fishers and unidentified fishers, respectively (NEFSC 2013). 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 based on methods from NEFSC (2013). 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 (NEFSC 2013).

Following methods of the previous assessment (NEFSC 2013), a single time series of reporting rates was used for the coastal programs. For producer area programs, 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 were similar. 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.

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.

B4.27.4.4 Survival Rates

For striped bass ≥ 28 inches (711 mm), the 2017 IRCR survival rate estimates (and associated unconditional standard errors, SE) of coastal programs ranged from 0.47 (0.25) for NYTRL to 0.73 (0.01) for MADFW (Table B8.10). High SE values for the NYTRL estimates from 2015–2017 likely result from small sample sizes of tagged and recaptured fish of larger sizes during the final years of this program, as this program has not tagged fish since 2011 (making 2012 the terminal year for this program for input to the IRCR model). The unweighted average of survival estimates for 2017 (excluding the NYTRL estimate) was 0.69 (Table B8.11). The unweighted average of survival estimates has varied from 0.63–0.71 since 2000 (excluding 2015–2017 NYTRL estimates). The 2017 survival estimates for the producer areas ranged from 0.64 (MCDB and VARAP) to 0.66 (DE/PA; Table B8.10). The 2017 producer areas weighted average was 0.64, similar to the range of annual survival rates since 2001 (0.62–0.66; Table B8.11).

For striped bass ≥ 18 inches (457 mm), the 2017 IRCR survival rate estimates (and associated unconditional standard errors, SE) of coastal programs ranged from 0.56 (0.05) for NCCOOP to 0.73 (0.01) for MADFW (Table B8.12). An extremely high c-hat value (39.6) was estimated from the IRCR analysis of ≥ 18 inch (457 mm) fish of the NCCOOP program, suggesting a structural lack of fit issue, which renders IRCR results questionable for this program. The unweighted average of survival estimates for 2017 (excluding NCCOOP) was 0.68, and has varied from 0.64–0.72 since 2000 (Table B8.13). The 2017 survival estimates for the producer areas ranged from 0.52 (VARAP) to 0.64 (HUDSON; Table B8.12). The 2017 weighted average of S was 0.56 for producer area programs, similar to the range of annual estimates of S since 2001 (0.53–0.57; Table B8.13).

B4.27.4.5 Fishing Mortality

For fish ≥ 28 inches (711 mm), the 2017 estimates of F among coastal programs (excluding NYTRL) ranged from 0.07 (NJDB) to 0.12 (NCCOOP) where the unweighted average F was 0.09 (Tables B8.14 and B8.15). Reasons for exclusion of the 2015–2017 NYTRL estimates from IRCR analyses were explained in the previous section on survival rates. The average annual estimate of F peaked at 0.24 in 1998, but has only varied between 0.09–0.16 since 2000. The 2017 F estimates for the producer area programs ranged from 0.06 (VARAP) to 0.16 (HUDSON) with a weighted average of 0.09 (Tables B8.14 and B8.15). 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 since 2000.

For fish ≥ 18 inches (457 mm), the 2017 estimates of F among coastal programs (excluding NCCOOP) were similar, ranging from 0.06 (NYTRL) to 0.08 (MADFW) for an unweighted average of 0.07 (Tables B8.16 and B8.17). The average F has varied without trend ranging from 0.07 to 0.13 since 1995. The estimates of F for the producer area programs showed more variation, ranging from 0.06 (VARAP) to 0.12 (HUDSON) for a weighted average of 0.09 (Tables B8.16 and B8.17). Since the reopening of many of the fisheries in 1991, the average F increased with a peak (0.22) in 1998. It has declined since then and varied without trend between 0.09 and 0.15 since 2000.

B4.27.4.6 Natural Mortality

For fish ≥ 28 inches (711 mm), the 2017 coastal program estimates of M (excluding NYTRL) ranged from 0.24 (MADFW) to 0.32 (NCCOOP) with an unweighted average was 0.27 (Tables B8.18 and B8.19). Reasons for exclusion of 2015–2017 IRCR estimates from NYTRL were explained previously under the Survival Rates section. The 2017 range of M values from the producer area programs was 0.27 (HUDSON) to 0.40 (VARAP) with a weighted mean of 0.35 (Tables B8.18 and B8.19). The highest mortality estimates were for Chesapeake Bay programs (VARAP and MDCB) where *Mycobacteriosis* is believed to be most prevalent.

For fish ≥ 18 inches (457 mm), the 2017 estimates of M from the coastal programs (excluding NCCOOP) ranged from 0.24 (MADFW) to 0.42 (NYTRL) with an unweighted average of 0.32 (Tables B8.20 and B8.21). Reasons for exclusion of NCCOOP results were explained previously under the Survival Rates section. Producer area estimates for 2017 ranged from 0.32 (HUDSON) to 0.60 (VARAP) with a weighted average of 0.49 (Tables B8.20 and B8.21). Average natural mortality estimates for fish ≥ 18 inches (457 mm) exceeded those of ≥ 28 inch (711 mm) fish for producer area programs, a finding heavily influenced by high natural mortality estimates from Chesapeake Bay programs.

The values of M in the second natural mortality period for both size groups are much higher than the commonly 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 it is likely M has increased in the stock.

B4.27.4.7 Stock Size

The stock size estimates for fish ≥ 28 inches (711 mm) trended upward from 12.2 million in 1999 to 37.5 million in 2003. Estimates from 2004 to 2009 were without trend, ranging from 31.7 to 37.3 million. A peak of 48.3 million was reached in 2010, where estimates have since trended downward to the 2017 value of 22.4 million (Table B8.22 and Figure B8.1).

The stock size estimates for fish ≥ 18 inches (457 mm) trended upward from 1993 (25.7 million) to a peak in 2006 (142 million). Since 2006, estimates decreased to 60.8 million in 2012 before increasing to 102.6 million in 2015. Compared to 2016, the 2017 estimate increased from 85 million to 93.1 million (Table B8.22 and Figure B8.1).

B4.28 Chesapeake Bay Resident Stock 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). Since Addendum IV to Amendment 6, quotas have been fixed in Chesapeake Bay and this fishing mortality target is no longer being used for management. The striped bass fishery in Chesapeake Bay exploits the pre-migratory/resident striped bass population that consists of smaller fish (TL < 28 inches or 711 mm), 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 (457 and 711 mm) 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 and 28 inches (457 and 711 mm) TL that were recaptured within Chesapeake Bay to estimate fishing mortality on resident fish.

B4.28.1 Reporting Rate

Two high-reward tagging studies have been conducted in the Chesapeake Bay to determine a Chesapeake 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.

B4.28.2 Methods for Estimation of F, M and S

Fishing mortality for resident striped bass in Chesapeake Bay was estimated following the previously described IRCR methods. Model structure for estimating M included two periods, 1987–1996 and 1997–2017. Before analysis, release and recapture data from Maryland and Virginia were combined to produce Chesapeake Bay-wide harvest and release input matrices for the IRCR (Appendix B11) and estimate Chesapeake Bay-wide annual exploitation rates.

B4.28.3 Chesapeake Bay Resident Stock Tagging Assessment Results and Discussion

B4.28.3.1 IRCR Model Selection Diagnostics
The regulatory period model (Model 4) received the highest QAICc weight (0.737) for Chesapeake Bay fish (Table B8.24). The c-hat estimate was 6.396. This is above the value of 4 suggested by Burnham and Anderson (2002) and may suggest structural issues with the model.

B4.28.3.2 Exploitation Rates
Exploitation rate estimates for the Chesapeake Bay resident fish have remained relatively stable throughout the time series (Table B8.23). The 2017 exploitation rate was 0.06 which was an increase from the 2016 estimate. A small peak in exploitation rates can be seen in 2013 and 2014.

B4.28.3.3 Survival Rates
The Chesapeake Bay-wide survival estimate for 2017 was 0.39 (Table B8.25). The estimates show a general decline over the time series, but have been stable since 1997, ranging from 0.39 to 0.40.

B4.28.3.4 Fishing Mortality
Chesapeake Bay-wide estimates of F were all below the previously used target value of 0.27. Fishing mortality increased from near-zero values during the moratorium period, peaked at 0.11 (1995–1999), and has remained at 0.09 – 0.10 from 2000–2017. The 2017 estimate of F for the Chesapeake Bay was 0.09 (Table B8.25).

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 (457-711 mm) males are all resident fish may be incorrect. If the fish are emigrating from the Chesapeake 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. Tag reporting rates may also be too high. The last high reward tagging study was conducted in Chesapeake Bay in 1999. If tag reporting rates have decreased since then and we are using a tag reporting rate that is too high, this would also result in higher estimates of natural mortality and lower estimates of fishing mortality (see sensitivity analyses conducted in NEFSC 2013).

B4.28.3.5 Natural Mortality
The Chesapeake Bay-wide estimate of natural mortality for 2017 was 0.83 (Table B8.25). Estimates of natural mortality for Chesapeake Bay fish increased from 0.25 during the first mortality period (1987-1996) to 0.83 during the second mortality period (1997-2017). 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 of *Mycobacteriosis* in the Chesapeake Bay and the results of the two-period M models by all of the other coastal programs.

B4.29 Sources of Uncertainty in the 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. Sensitivity analyses conducted previously using Maryland data (NEFSC 2013) indicated that overestimating the reporting rate resulted in higher estimates of M and lower estimates of F. The survival estimates, however, were insensitive to misspecifications of the reporting rate. Even a 50% reduction in the reporting rate only resulted in a 6% decrease, on average, in the survival estimate. Whereas a 50% reduction in the reporting rate resulted in a 102% increase in fishing mortality and a 40% decrease in natural mortality.

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 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; 2.6% by Sprankle et al. 1996).

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.

B4.30 Comparison of 2SCA Model Results to Tagging Model Results

The 2SCA model results are provided in Section B7.0 above. The average total mortality of the combined ocean and Chesapeake Bay stocks were calculated using the data in Table B7.11. The average values of total mortality for fish ≥28" for the Coast and Producer areas are plotted with the total mortality estimates for the ocean and the Chesapeake Bay stock from the 2SCA model in Figure B8.2. Increasing trends in total mortality (Z) were similar between the tag-based and 2SCA models, although the coastal tagging programs' Z estimates were slightly lower in magnitude through 2006 (Figure B8.2). After relatively stable Z estimates from 2006-2014, all model Z estimates indicated a decline in total instantaneous mortality in 2015 that has generally increased in recent years (Figure B8.2). 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.

Comparisons were also made between the tag based abundance estimates and the period-3 abundance estimates from the 2SCA model (Figure B8.3). Period-3 was used as most of the catch occurs in this time block, aligning with the tag based model which estimates abundance based on catch. Additionally, the tag based model estimates average stock size which matches best to this mid-year abundance estimate. The tagging model estimates abundance for fish ≥18" and ≥28" which roughly corresponds with ages 3+ and 7+ from the 2SCA model. For ages 3+, the 2SCA estimates higher abundance early in the time series and lower abundance later in the time series when compared to the tagging model estimates. Both estimates, however, show similar trends with an increase in abundance through the late 1980s and early 1990s. Whereas the 2SCA model has peak age 3+ abundance in 1999 before decreasing, the tagging model population abundance peaks in 2010. For ages 7+, the 2SCA and tagging model estimate similar abundance estimates through 1996. The abundance estimates diverge starting in 2000 when the 2SCA model estimates lower numbers of 7+ fish compared to the tag based estimates. Both models show similar trends in age 7+ abundance, including a general decrease since 2010.

B4.31 Suggestions for Further Development of Tag-based Mortality and Abundance Estimates

The primary research need for tagging analysis estimates of S, F, and M involves the issue of reporting rate. While there are uncertainties in the tag reporting rate estimates due to the assumptions used, other factors could also be affecting our tag reporting rate estimates. These include a possible decline in tag quality, which has resulted in tags being illegible; angler fatigue as the tagging program has existed since 1987 with no change in reward; and the decrease in tag returns, particularly from the commercial sector.

TOR B5. 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 BY STOCK COMPONENT WHERE POSSIBLE.

B4.32 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 mortality rates 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 female SSB was developed using a forward projecting model of age-0 recruits as determined by the time series of Maryland juvenile indices (ASMFC 1998). The female SSB index served as the basis for developing a biomass threshold for evaluation of the stock rebuilding status. The female SSB index increased to a level comparable to historic abundance in the 1960s and consequently, in 1995 striped bass was declared recovered. The modeling approach used for the female SSB index also served as the basis for the Crecco model for biological reference points, specifically F_{MSY} (ASMFC 1998). The model applied a combination of minimum sizes (20" (508 mm) in producer areas and 28" (711 mm) on the coast) to define full recruitment to the fisheries. The biological reference point of F_{MSY} = 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 female SSB/R when the jurisdictions requested a reduction in their minimum size limit from 20 inches (508 mm) to 18 inches (457 mm). These values were compared against annual tag based estimates of F for determination of stock status.

In 1997, the 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 (female SSB_{Target}, female $SSB_{Threshold}$, 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. The $SSB_{Threshold}$ (14,000 mt) was chosen to be slightly greater than the female SSB in 1995 when the population was declared recovered. The SSB_{Target} (17,500 mt) was 25% greater than the $SSB_{Threshold}$. 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 $SSB_{threshold}$ equals 36,000 mt with an SSB_{target} 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.

In the 2013 assessment, the SSB_{Target} and $SSB_{Threshold}$ definitions remained the same (1995 female SSB, and 125% of 1995 female SSB, respectively; NEFSC 2013) but were updated with the 2013 SCA model. The $SSB_{threshold}$ equaled 57,626 mt with an SSB_{target} of 72,032 mt. However, F reference points were chosen to link the target and threshold Fs with the target and threshold female SSB values (NEFSC 2013). Using a stochastic projection drawing recruitment from empirical estimates and a distribution of starting population abundance at age, fishing mortality associated with the female SSB target and threshold were determined. Current $F_{target} = 0.18$ and current $F_{threshold} = 0.22$.

B4.33 Updated Biological Reference Points

The Board tasked the SAS with developing a range of F and female SSB reference points as part of the 2018 Benchmark Stock Assessment and to develop threshold reference points (F and biomass) that consider the objectives of the FMP. They also asked the SAS to develop a range of target reference points (F and biomass) that would provide a range of risk that the Board would consider in achieving the objectives of the FMP.

The SAS explored both empirical and SPR-based reference points ($F_{20\%}$, $F_{30\%}$ and $F_{40\%}$ were calculated).

B4.33.1 Two-Stock SCA Model (2SCA)

[SAW-66 Editor's Note: The SARC-66 peer review panel concluded that the two-stock statistical catch-at-age (2SCA) model presented to them was not acceptable to serve as a basis for fishery management advice. These particular sections are included in this report to document the analyses that were done for the peer review, but they are not recommended by SARC-66 as a basis for management. Instead, SARC-66 recommends the reference points (Section B9.2.2) and stock status determinations (Section B9.3.2) based on the single stock, non-migration model for management use.]

The SA committee explored a number of different threshold reference points. These included SPR-based estimates of F20%, F30%, F40% (per Gabriel *et al.* 1989) and the female SSB associated with these quantities, and the F associated with the 1990, 1993 and 1995 female SSB (each representing differences in stock characteristics at the time). In addition, proportional stock density (PSD;

Anderson and Gutreuter 1983) values were calculated (using age instead of length) to determine what fraction of the population represents "quality" fish.

Female Spawning Stock Per Recruit Analysis

Because the dynamics of the Chesapeake Bay stock include migration, the calculation of SPR values was done through a projection model that included the same code as the operational assessment model. The SPR values were calculated using the most recent five-year average (2013 – 2017) for the sum of fully-recruited F across periods in the Chesapeake Bay and F in the ocean regions, the fraction of F that occurs during periods 1, 2 and 3 for the Chesapeake Bay and ocean regions, and weight-at-age for the female SSB; the average of 1990 – 2017 was used for recruitment. In addition, the same natural mortality, emigration probabilities, maturity schedules and catch selectivities for 2017 were used in the projections. Abundance of ages 2-15+ in the Chesapeake Bay and ocean regions for 2018 (derived using the numbers at age from the beginning of period-3 in 2017 and calculating the abundance in 2018 using the period-3 F and fraction of natural mortality) and average recruitment for age-1 are used as starting values and the population is projected 200 years at different levels of the sum of period Fs in the Chesapeake Bay and ocean. The %SPR is calculated by using the female SSB/average recruit of F in the Chesapeake Bay and ocean equal to 0. The sum of period fully-recruited Fs is required because that value is used to assign F to each period in the model. The sum of the period Fs does not represent the actual total F experienced by the stock but they are used as reference points because changes in actual total F would be difficult to translate to changes in F in the Chesapeake Bay and ocean regions for the Chesapeake Bay stock.

For the Delaware Bay/Hudson River stock, the SPR was determined similarly but the equations used are the standard exponential decay abundance and catch equations. Only sum of period Fs from the ocean region are used.

The values of F associated with SPR 20%, 30% and 40% were solved using the Newton method and projection model. For the Chesapeake Bay stock, the average ratio of the sums of period F between Chesapeake Bay and ocean regions over the most recent five years (2013-2017) was applied to F being estimated to maintain the difference between Chesapeake Bay and coast sums of period Fs.

Determination of Associated Quantities from SPR analysis

The female SSB associated with F20%, F30%, and F40% and fishing mortalities associated with the SSB_{1993} and SSB_{1995} estimates were determined through stochastic projections. Using the same dynamics models, starting values of abundance of ages 2-15+ in the Chesapeake Bay and ocean regions for 2018 are derived by re-sampling from a normal distribution parameterized with the abundance estimates and associated standard errors. For the Chesapeake Bay stock, age-1 numbers are stochastically generated by linking the recruitment to previous year's female SSB using the fitted Beverton-Holt curve (Figure B7.15) and re-sampling errors from a normal distribution parameterized at mean of 0 and standard error equal to the residual standard deviation from the model fit before back-transformation of the log-transformed equation. The starting value for age-1 in the first year of the projection was the deterministic recruitment value associated with the SSB_{2017} estimate. The female SSB was calculated in the same way as the stock assessment model.

For the Delaware Bay/Hudson River stock, the abundances of ages 2-15+ were generated in the same way as in the Chesapeake Bay stock model. However, a realistic stock-recruitment curve could not be determined for the Delaware Bay/Hudson River stock data to stochastically generate age-1 numbers. Therefore, two methods were examined. In the first method, the predicted age-1 numbers from original Beverton-Holt fitted equation (Figure B7.15) were used through median female SSB (27,950 mt), but for higher female SSB values, the median recruitment was used (Figure B9.1). This was termed a "hockey-stick" approach and was the SAS's preferred approach. The predicted values from the fitted Beverton-Holt equation were used because it described increasing trend in recruitment at the lower female SSB levels. In the second method, as a sensitivity analysis, the the Delaware Bay/Hudson River stock recruitment values were randomly re-sampled; hence, there was no link to female SSB.

To determine the female SSB associated with F20%, F30%, and F40%, the Chesapeake Bay and ocean sums of F were used to project the population 200 years. The projection was repeated 1,500 times to obtain the resulting distribution of female SSB in year 200.

To determine the sum of period Fs associated with the female SSB levels for years 1993 and 1995, the input F was manually varied to obtain the median female SSB values closest to the threshold values in year 200. Since two sums of F have to be varied in the Chesapeake Bay stock, a single F was applied to average of the last five years' proportion that the sum of F for the Chesapeake Bay (and sum of F for the ocean) represents of the total to derive the allocation to the Chesapeake Bay and ocean.

Proportional Stock Density
For each level of Chesapeake Bay and ocean fishing mortality used to determine SPRs, the PSD for quality fish was calculated. Quality fish was defined as fraction of fish age-10 and greater (age-10 average size = 38 inches or 965 mm) relative to the number of fish age-7 (average size=28 inches or 711 mm considered the stock base).

Reference Points
A contour plot of the percentage of maximum SPR for the Chesapeake Bay stock obtained at different levels of the sum of period Fs in the Chesapeake Bay and the ocean and the Fs associated with the three SPR levels and current Chesapeake Bay and ocean F are displayed on Figure B9.2 and listed in Table B9.1. Full F at SPR20% was estimated to be 0.288 for Chesapeake Bay and 0.342 for the ocean; for SPR30%, it was 0.196 for Chesapeake Bay and 0.233 for the ocean; for SPR40% it was 0.140 for the for Chesapeake Bay and 0.166 for the ocean. Figure B9.3 displays the resulting female SSB estimates (with 95% percentiles) for the projections associated with F20% (female SSB=54,864 mt), F30% (female SSB=84,209 mt), and F40% (111,433 mt). The 2017 estimate of female SSB (50,346 mt) is slightly below the female SSB associated with F20% (54,864 mt; Table B9.1). The F reference values associated with the female SSB estimates in years 1993 and 1995 are given in Table B9.1. Female SSB_{2017} was slightly below the female SSB_{1995} estimate, but above the estimate for 1993.

A contour plot of percent quality for the Chesapeake Bay stock obtained at different levels of the sum of period Fs in the Chesapeake Bay and ocean is shown in Figure B9.2. The percent quality of an unfished stock was estimated to be 62%. At F20%, 30% and 40%, the quality becomes 32.4%, 39.7%, and 45%, respectively. The 2017 estimate of percent quality (46.1%), above the value at F40%.

For the Delaware Bay/Hudson River stock, the percentage of maximum SPR plot and the resulting Fs associated with the three SPR levels are displayed on Figure B9.4 and listed in Table B9.1. Fs at SPR20%, 30% and 40% were estimated at 0.251, 0.168 and 0.118, respectively. The resulting female

SSB estimates for the projection method associated with F20%, F30%, and F40% under the "hockey-stick" stock-recruitment relationship and empirical approach are shown in Figures B9.5-6. At F20%, F30%, and F40%, the "hockey stick" method produced female SSB estimates of 38,493 mt, 57,791 mt, and 77,153 mt, respectively, and the empirical approach produced female SSB estimates of 62,587 mt and 83,906 mt, respectively. The 2017 estimate of female SSB (21,347 mt) was below all female SSB estimates associated with F% regardless of method. The F values associated with the annual female SSB estimates from 1993 and 1995 are given in Table B9.1 for the hockey-stick approach. Female SSB in 2017 was slightly below the female SSB estimate for 1995, but above the estimate for 1993.

Comparison of Empirical and Model-Based Reference Points
The current $SSB_{threshold}$ used in management, female SSB_{1995}, is approximately equal to the equilibrium female SSB associated with F20%SPR for the Chesapeake Bay stock (female SSB_{1995} = 52,893 mt while female $SSB_{20\%SPR}$ = 54,864 mt). The maximum observed female SSB for the Chesapeake Bay stock (88,990 mt in 2003) was just slightly higher than the female SSB associated with F30% SPR (84,209 mt). Even when the stock was below female $SSB_{20\%SPR}$, it was still capable of producing near-average (1989, 1992) and very strong (1993) year classes. The Chesapeake Bay stock also has a relatively high percent stock quality in 2017, despite being below female $SSB_{20\%SPR}$.

For the mixed Delaware Bay/Hudson River stock, female SSB_{1995} was below the female SSB associated with F20%SPR (female SSB_{1995} = 24,683 mt while female $SSB_{20\%SPR}$ = 38,493 mt). The highest female SSB value in the time-series was 42,150 mt, slightly above the female $SSB_{20\%SPR}$ estimate and below the female $SSB_{30\%SPR}$ estimate.

B4.33.2 Non-Migration SCA Model (single stock)

[SAW-66 Editor's Note: The SARC-66 peer review panel recommends the reference points (this section) and stock status determinations (Section 9.3.2) based on the single stock, non-migration model for management use.]

Fishing mortality reference points associated with female SSB in 1995 were generated using projections described in NEFSC (2013), similar to the approach described above for the migration model. Briefly, to start the projections, abundance at age is randomly drawn from a normal distribution parameterized with the 2017 estimates of January 1 abundance-at-age and associated standard errors from the non-migration assessment model. The population is projected forward using the standard exponential decay model with selectivity from 2017 and 2017 adjusted Rivard weights at age for female SSB calculations. For the remaining years, selectivity was calculated as the geometric mean of 2013-2017 of total F at age, scaled to the highest F; spawning stock weights-at-age were calculated as the geometric mean of the 2013-2017 of adjusted Rivard weights-at-age. Age-1 recruitment was stochastically estimated using an approach similar to that described above for the Delaware Bay/Hudson River stock of the migration model ("hockey-stick" approach). That is, predicted age-1 numbers from a Beverton-Holt fitted equation were used through median female SSB (87,835 mt), but for higher female SSB values, the median recruitment (associated with female SSB > median female SSB) was used (Figure B9.7).

Residuals from the stock recruitment fit were randomly re-sampled and added to the deterministic predictions before back-transformation of the log-transformed equation. As a sensitivity run, estimates of recruitment from 1990 and later, when the stock was considered restored but not fully recovered, were randomly re-sampled; hence there was no link to female SSB. The population was projected for 100 years using 2,000 simulations. The input F was manually varied to obtain the median female SSB values closest to the 1995 female SSB value in year 100.

SPR-based reference points for the non-migration SCA, while similar to those developed for the migration model, were associated with unrealistic equilibrium female SSB levels. For example, fishing at F40% resulted in an equilibrium female SSB approximately two times the highest female SSB estimated in the time series. One potential explanation is that the non-migration model is not adequately capturing the sex-specific dynamics of Chesapeake Bay fish; although the Chesapeake Bay fishery has a high selectivity for immature fish, those fish are predominately male, as the immature females migrate to the ocean where they are not as vulnerable to the fishery. Thus, more female SSB is protected than the pooled selectivity and maturity curves would suggest. More reasonable equilibrium female SSB results were associated with lower maximum spawning potential ratios (e.g., F20% = 0.232); the fishery has generally operated at or above these levels since approximately 1995 (Figure B7.27). The SAS was not able to fully explain the dynamics associated with SPR-based reference points and therefore ultimately only considered empirical reference points associated with female SSB levels.

The base model estimate results in an $SSB_{Threshold}$ = female SSB_{1995} = 91,436 mt and an SSB_{Target} = 125% female SSB_{1995} = 114,295 mt; female SSB in 2017 was 68,476 mt. Using the hockey-stick recruitment model, $F_{Threshold}$ = the projected F to maintain $SSB_{Threshold}$ = 0.240, and F_{Target} = the projected F to maintain SSB_{Target} = 0.197; F in 2017 was estimated to be 0.307. Using the empirical recruitment model, $F_{Threshold}$ = the projected F to maintain $SSB_{Threshold}$ = 0.248, and F_{Target} = the projected F to maintain SSB_{Target} = 0.204.

Fleet Fishing mortality reference points

The TORs for this assessment tasked the SAS with developing stock-specific reference points where possible. Stock-specific reference points cannot be developed from the non-migration SCA, but the SAS did develop fleet-specific reference points to provide regional management advice as a proxy. When each fleet fishes at its target F reference point, the maximum total F-at-age on the population is equal to the coastwide F_{target}.

The full F values for the target and threshold were calculated using a composite selectivity that used the geometric mean of the most recent five years of total F-at-age, divided by the maximum F-at-age to scale the curve to one. This essentially weights the selectivity pattern of each fleet (Coast and Chesapeake Bay) by the degree to which they are contributing to total fishing mortality on the population. The Chesapeake Bay fleet is dome-shaped, peaking at age-6, while the coast fleet is flat-topped, peaking at age-15+ (Figure B9.8).

To calculate the Chesapeake Bay-specific F reference point, the ratio of F-at-age-6 from the Chesapeake Bay fleet to total F-at-age-6 was calculated (using the mean of ratio for the last five years). This ratio was multiplied by the selectivity-at-age from the composite fleet at age-6 and the F_{target} and $F_{threshold}$ values to obtain the full F_{target} and threshold values for the Chesapeake Bay (Table B9.3).

For the Coast fleet, a similar approach was used (Table B9.3). Specifically, the ratio of total F-at-age-14 to fleet F-at-age-14 was used, and the reference points were corrected for the not quite full selectivity on age-14 for this fleet (0.99 as opposed to 1), since full selectivity in the ocean fleet occurs at age-15+.

The sum of the individual F targets exceeds the coast wide F_{target} value. However, when the total F-at-age is calculated (by multiplying the individual fleet F reference points by their respective selectivities and summing at age), the maximum F-at-age is equal to the coast wide F_{target} (Table B9.4).

B4.34 Stock Status
B4.34.1 Two-Stock SCA Model (2SCA)

[SAW-66 Editor's Note: The SARC-66 peer review panel concluded that the two-stock statistical catch-at-age (2SCA) model presented to them was not acceptable to serve as a basis for fishery management advice. These particular sections are included in this report to document the analyses that were done for the peer review, but they are not recommended by SARC-66 as a basis for management. Instead, SARC-66 recommends the reference points (Section B9.2.2) and stock status determinations (Section B9.3.2) based on the single stock, non-migration model for management use.]

The current $SSB_{threshold}$ for Atlantic striped bass is the 1995 estimate of female SSB. This definition is the same as the previous assessment, but BRPs were calculated separately for the Chesapeake Bay stock and the Delaware Bay/Hudson River stock. For this reason, it is not appropriate to compare current model estimates to previous model reference points). The $F_{threshold}$ is the F value that allows the population to achieve the long-term average female SSB equal to the $SSB_{threshold}$, assuming that recruitment will vary within the range observed in 1990-2017 period while other population parameters are constant. The sum of period Fs for the Chesapeake Bay and ocean and the female SSB in 2017 for each stock was compared to the reference generated from the SPR and projections methods.

Female SSB_{2017} for the Chesapeake Bay stock was 50,346 mt, less than the $SSB_{threshold}$ of 52,893 mt, indicating the Chesapeake Bay stock is overfished (Figure B9.9). The associated $F_{threshold}$ was 0.297 for the Chesapeake Bay fishery and 0.353 for the ocean fishery; F_{2017} was 0.255 in the Chesapeake Bay and 0.400 in the ocean, indicating the Chesapeake Bay stock is experiencing overfishing in the ocean but not in the Chesapeake Bay (Figure B9.9).

For the mixed Delaware Bay/Hudson River stock, female SSB_{2017} was 21,347 mt, below the $SSB_{threshold}$ of 24,683 mt, indicating the Delaware Bay/Hudson River stock is overfished (Figure B9.10). F_{2017} was 0.400, above the $F_{threshold}$ of 0.340, indicating the Delaware Bay/Hudson River stock is experiencing overfishing (Figure B9.10).

The probability of the 2017 F values exceeding the reference point Fs and the probability of 2017 female SSB falling below the SSB reference points were performed by using function *pgen* in R package *fishmethods*. The comparison between the 2017 values and the SPR SSB reference points were made assuming a log-normal error (since the projection values showed a skewed distribution), while the comparison between the 1995 and 1993 female SSB estimates and the 2017 female SSB estimate were made assuming a normal error given that only estimates of SE were available. Comparison among F reference points and 2017 values were made assuming a normal error for the 2017 F values but no error in F reference points.

Table B9.2 lists the probabilities of the 2017 management value exceeding the F and SSB reference points. For the Chesapeake Bay stock, there was a 15% probability that the F in the Chesapeake Bay exceeded the F threshold, and an 87% chance that the F in the ocean exceeded the F threshold. There was a 63% chance that female SSB was below the SSB threshold. For the DE Bay/Hudson River stock, there was a 93% chance that F in the ocean exceeded the F threshold, and an 83% chance that female SSB was below the SSB threshold.

The non-migration SCA model provided similar status determinations, with the coastal mixed stock complex being overfished relative to the current $SSB_{threshold}$ and experiencing overfishing relative to the current $F_{threshold}$. Fleet-specific F reference points indicated the Chesapeake Bay fleet was equal to its $F_{threshold}$ while the ocean fleet was above its $F_{threshold}$.

B4.34.2 Non-Migration Model

[SAW-66 Editor's Note: The SARC-66 peer review panel recommends the reference points (Section B9.2.2) and stock status determinations (this section) based on the single stock, non-migration model for management use.]

The current $SSB_{threshold}$ for Atlantic striped bass is the 1995 estimate of female SSB. This definition is the same as the previous assessment, but has been updated with data through 2017. The $F_{threshold}$ is the F value that allows the population to achieve the long-term average female SSB equal to the $SSB_{threshold}$. The F and female SSB in 2017 was compared to the reference values generated from the projections methods.

Female SSB_{2017} for the stock was 68,476 mt, which is less than the SSB threshold of 91,436 mt, indicating the stock is overfished (Table B9.5, Figure B9.11). The associated F threshold was 0.240; F_{2017} was 0.307 indicating the stock is experiencing overfishing (Table B9.5, Figure B9.11).

The probability of the 2017 F values exceeding the reference point Fs and the probability of 2017 female SSB being below the SSB reference points were performed by using function *pgen* in R package *fishmethods*. The comparison between the 2017 values and the 1993 and 1995 female SSB estimates were made assuming a normal error given that only estimates of SE were available. Comparison among F reference points and 2017 values were made assuming normal errors (SEs were available for both management values and reference points, so error was assumed for both).

Table B9.6 lists the probabilities of the 2017 management value exceeding the F and SSB reference points. For the coastwide stock, there was a 100% probability that SSB in 2017 was below the threshold. For the coastwide stock there was a 95% probability that F in 2017 exceeded the threshold (Table B9.6).

TOR B6. 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.

[SAW-66 Editor's Note: The SARC-66 peer review panel concluded that the two-stock statistical catch-at-age (2SCA) model presented to them was not acceptable to serve as a basis for fishery management advice. These particular sections are included in this report to document the analyses that were done for the peer review, but they are not recommended by SARC-66 as a basis for management. Instead, SARC-66 recommends the projections based on based on the single stock, non-migration model for management use; these are documented in Appendix B12.]

B4.35 Female Spawning Stock Biomass

Six-year projections of female SSB were made by using the same population dynamics equations used in the assessment model. The model projection began in year 2018 (assuming 2017 fishing mortalities for this year) 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. For each iteration of the simulation, the abundance-at-age in 2018 (calculated in the assessment using the 2017 January-1 abundances—at-age and fishing mortalities) was randomly drawn from a normal distribution parameterized with the 2018 estimates of January-1 abundance–at-age and associated standard errors and female SSB was calculated. For the Chesapeake Bay stock, the abundance of age-1 (recruits) in 2018 was determined from the Beverton-Holt equation by using the 2017 estimate of female SSB. For the remaining years, abundance of age-1 recruits were randomly generated using the estimated stock-recruitment Beverton-Holt relationship and applying log-normal errors.

For the Delaware Bay/Hudson River stock, abundance of age-1 recruits in 2018 was determined from the "hockey-stick" approach by using the 2017 estimate of female SSB or was randomly selected from the 1990-2017 recruit numbers for the empirical approach. For the remaining years, abundance of age-1 recruits were randomly generated using the "hockey-stick" approach applying log-normal errors estimate in the Beverton-Holt equation or was randomly selected from the 1990-2017 recruit numbers for the empirical approach.

Abundance-at-age >1 were calculated using fishing mortality-at-age and natural mortality-at-age used in the assessment. An age-15 plus-group was assumed. Female SSB was calculated by using average adjusted Rivard weight estimates from 2013-2017, sex proportions-at-age, female maturity-at-age, selectivity in 2017 and emigration probabilities. The fully-recruited fishing mortality in the simulation for the Chesapeake Bay stock was apportioned to Chesapeake Bay and ocean using average ratio of Chesapeake Bay and ocean F from 2013-2017 and then apportioned to period by using the average period proportions from 2013-2017.

For each year of the projection, the probability of female SSB going below the female SSB reference point was calculated using female SSB estimates from all iterations of the simulation and function *pgen* in R package *fishmethods* (assuming log-normal errors). Several F scenarios were investigated. For years >2018, simulations were performed using the current fully-recruited Fs for the Chesapeake Bay and ocean regions and F20%, F30% and F40%.

Results of the six-year projections are shown in Figure B10.1 for the Chesapeake Bay stock. When current F is assumed for all six years for the Chesapeake Bay stock, there was little change in mean female SSB over time and there were high probabilities of the female SSB values being below the SPR20%, SPR30%, SPR40%, and female SSB_{1995} reference points (Figure B10.1). At F20% for years 2019-2023, the the Chesapeake Bay stock mean female SSB changed little through time. Female SSB increased and probabilities of being below the SPR20% and female SSB_{1995} reference points declined in only later years of the projection when F30% and F40% were used.

For the Delaware Bay/Hudson River stock, there was very little change in mean female SSB over time at current F (0.4) using the “hockey-stick” or empirical approaches (Figures B10.2-3). The probability of female SSB being below the female SSB reference points was high for all reference points except female SSB_{1993}. As fishing mortality from years 2019-2023 declined with increasing F%SPR, female SSB increased over time and, regardless of method, the probability of being below the SPR20% reference point declined (Figures B10.2-3). However, the probability of the projected female SSB being below SPR30% and SPR40% was always high (Figures B10.2-3)

B4.36 Catch Projections

Total catches (in numbers) achieved in each female SSB projection were saved to examine potential trends in catches over time. For the Chesapeake Bay stock, assuming the 2017 Fs occurred over time, average catches in the Chesapeake Bay and ocean regions increased slightly over time and the final Chesapeake Bay and ocean means were estimated to be 2.7 million and 1.7 million fish, respectively (Figure B10.4). Under F20%, catches in the Chesapeake Bay region increased slightly and remained stable but in the ocean region, catches increased slightly after an initial decline; final average catches in the Chesapeake Bay and ocean were 3.0 million and 1.5 million fish, respectively. Under F30%, there was an initial decline in landings (more so in the ocean region), but catches in the ocean increased slightly over time (Figure B10.4). Estimates of mean catches in 2023 for the Chesapeake Bay and ocean region were 2.2 million and 1.2 million fish, respectively. Under F40%, catches in the Chesapeake Bay region decline initially but remain stable through time, while catches in the ocean region drop initially but increased slightly over time (Figure B10.4). Estimates of mean catch in the final year under F40% were 1.7 million fish in the Chesapeake Bay region and 0.9 million fish in the ocean region.

For the Delaware Bay/Hudson River stock, assuming 2017 over time, catches declined slightly using the "hockey-stick" approach, but increased slightly over time using the empirical method (Figures 10.5-6). Estimates of final mean catch were 2.9 million and 3.4 million fish for the "hockey-stick" and empirical approaches, respectively. Under F20%, catch initially dropped then increased over time, but the projections using the empirical approach showing larger increases (Figure B10.5-6). Final average estimates under F20% were 2.3 million and 2.7 million fish for the "hockey-stick" and empirical approaches, respectively. Similar trends were observed under F30% and F40% (Figure B10.5-6). For the "hockey-stick" and empirical approaches, projected mean catches in 2023 were 1.8 million and 2.0 million fish under F30%, and 1.4 million and 1.5 million fish under F40% (Figure B10.5-6).

TOR B7. REVIEW AND EVALUATE THE STATUS OF THE TECHNICAL COMMITTEE RESEARCH RECOMMENDATIONS LISTED IN THE MOST RECENT SARC REPORT. IDENTIFY NEW RESEARCH RECOMMENDATIONS. RECOMMEND TIMING AND FREQUENCY OF FUTURE ASSESSMENT UPDATES AND BENCHMARK ASSESSMENTS.

B4.37 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.
- Develop studies to provide information on gear specific (including recreational fishery) discard morality rates and to determine the magnitude of bycatch mortality.[1]
- Conduct study to directly estimate commercial discards in the Chesapeake Bay.
- Collect sex ratio information on the catch and improve methods for determining population sex ratio for use in estimates of female SSB and biological reference points.

Moderate

- Improve estimates of striped bass harvest removals in coastal areas during wave 1 and in inland waters of all jurisdictions year round.

B4.38 Fishery-Independent Priorities

High

- Develop and index of relative abundance from the Hudson River Spawning Stock Biomass survey to better characterize the Delaware Bay/Hudson River stock.
- Improve the design of existing spawning stock surveys for Chesapeake Bay and Delaware Bay.

Moderate

- Develop a refined and cost-efficient, fisheries-independent coastal population index for striped bass stocks.
- Collect sex ratio information from fishery-independent sources to better characterize the population sex ratio.

B4.39 Modeling / Quantitative Priorities

High

- Develop better estimates of tag reporting rates; for example, through a coastwide tagging study.
- Investigate changes in tag quality and potential impacts on reporting rate.
- Explore methods for combining tag results from programs releasing fish from different areas on different dates.
- Develop field or modeling studies to aid in estimation of natural mortality and other factors affecting the tag return rate.
- Compare M and F estimates from acoustic tagging programs to conventional tagging programs.

[1] Literature search and some modeling work completed

Moderate

- Examine methods to estimate temporal variation in natural mortality.

Low

- Evaluate truncated matrices to reduce bias in years with no tag returns and covariate based tagging models to account for potential differences from size or sex or other covariates.

B4.40 Life History and Biology

High

- Continue in-depth analysis of migrations, stock compositions, sex ratio, etc. using mark-recapture data.[2]
- Continue evaluation of striped bass dietary needs and relation to health condition.
- 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.

B4.41 Striped Bass Research Priorities Identified as Being Met or Well in Progress

- ✓ Evaluate to what extent rising natural mortality among Chesapeake Bay striped bass affects the existing F and female 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 stock status definitions relative to uncertainty in biological reference points.
- ✓ 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]
- ✓ Develop maturity ogives applicable to coastal migratory stocks.

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

[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 stocks. External analysis of tagging data is used to inform the model but is not explicitly incorporated.

B4.42 Timing of Assessment Updates and Next Benchmark Assessment

The Technical Committee recommends that the next benchmark stock assessment be conducted in five years in 2024, which will allow progress to be made on issues like state-specific scale-otolith conversion factors and directly incorporating tagging data into the 2SCA model.

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B6.0 TABLES

Table B4.1. Summary of Atlantic striped bass commercial and recreational regulations in 2017. Source: 2018 ASMFC State Compliance Reports for Atlantic Striped Bass. Minimum sizes and slot size limits are in total length (TL). *Commercial quota reallocated to recreational bonus fish program.

Commercial Regulations			
STATE	**SIZE LIMITS**	**SEASONAL QUOTA**	**OPEN SEASON**
ME	Commercial fishing prohibited		
NH	Commercial fishing prohibited		
MA	34” minimum size	869,813 lbs. Hook & line only	6.23 until quota reached, Monday and Thursdays only; 15 fish/day with commercial boat permit; 2 fish/day with rod and reel permit (striped bass endorsement required for both permits)
RI	Floating fish trap (FFT): 26” minimum size General category (GC; mostly rod & reel): 34” min.	Total: 181,449 lbs., split 39:61 between the FFT and GC. Gill netting prohibited.	FFT: 4.1 – 12.31, or until quota reached; unlimited possession limit until 70% of quota projected to be harvested, then 500 lbs/day GC: 5.29-8.31, 9.8-12.31, or until quota reached. Closed Fridays and Saturdays during both seasons. 5
CT*	Commercial fishing prohibited; bonus program: 22 – <28” slot size limit, 5.1 – 12.31 (voucher required)		
NY	28-38” minimum size (Hudson River closed to commercial harvest)	795,795 lb. Pound nets, gill nets (6-8”stretched mesh), hook & line.	6.1 – 12.15, or until quota reached. Limited entry permit only.
NJ*	Commercial fishing prohibited; bonus program: 1 fish at 24 – <28” slot size limit, 9.1 – 12.31 (permit required)		
PA	Commercial fishing prohibited		
DE	Gillnet: 28” minimum size, except 20” min in Del. Bay and River during spring season. Hook and Line: 28”	Gillnet: 137,831 lbs. Hook and line: 14,509 lbs.	Gillnet: 2.15-5.31 (2.15-3.30 for Nanticoke River) & 11.15-12.31; drift nets only 2.15-2.28 & 5.1-5.31; no fixed nets in Del. River. No trip limit. Hook and Line: 4.1–12.31, 200 lbs/day trip limit

(Table B4.1 continued – Summary of regulations in 2017)

Commercial Regulations			
STATE	**SIZE LIMITS**	**SEASONAL QUOTA**	**OPEN SEASON**
MD	Ocean: 24” minimum CB and Rivers: 18–36”	Ocean: 90,727 lbs. CB and Rivers: 1,471,888 lbs. (part of Bay- wide quota).	Ocean: 1.1-5.31, 10.1-12.31, Mon- Fri Bay Pound Net: 6.1-12.30, Mon-Sat Bay Haul Seine: 6.1-12.29, Mon-Fri Bay Hook & Line: 6.1-12.28, Mon-Thu Bay Drift Gill Net: 1.2-2.28, 12.1-12.29, Mon-Thu
PRFC	18-36” slot size limit 2.15-3.25 and 18” minimum size all other seasons	583,362 lbs. (part of Bay-wide quota). Allocated by gear and season.	Hook & line: 1.1-3.25, 6.1-12.31 Pound Net & Other: 2.15-3.25, 6.1-12.15 Gill Net: 1.1-3.25, 11.13-12.31 Misc. Gear: 2.15-3.25, 6.1-12.15
DC	Commercial fishing prohibited		
VA	Bay and Rivers: 18” min size, and 18-28” slot size limit 3.26–6.15 Ocean: 28” min	Bay and Rivers: 1,064,997 lbs. (part of Bay- wide quota). Ocean: 136,141 lbs. ITQ- system for both areas.	Bay and Rivers: 1.16-12.31 Ocean: 1.16-12.31
NC	Ocean: 28”	360,360 lbs. (split between gear types). Number of fish allocated to each permit holder. Allocation varies by permit.	Seine fishery was open for 120 days, 150 fish/permit Gill net fisher was open for 45 days, 50 fish/permit Trawl fishery was open for 70 days, 100 fish/permit

(Table B4.1 continued – Summary of regulations in 2017)

Recreational Regulations				
STATE	**SIZE LIMITS**	**BAG LIMIT**	**GEAR RESTRICTIONS**	**OPEN SEASONS**
ME	≥ 28" minimum size	1 fish/day	Hook & line only; circle hooks only when using live bait	All year, except spawning areas are closed 12.1 – 4.30 and catch and release only 5.1 – 6.30
NH	≥ 28" minimum size	1 fish/day	Gaffing and culling prohibited	All year
MA	≥ 28" minimum size	1 fish/day	Hook & line only; no high-	All year
RI	≥ 28" minimum size	1 fish/day	None	All year
CT	≥ 28" minimum size	1 fish/day	Spearing and gaffing prohibited	All year
NY	Ocean and Delaware River: 28" minimum size Hudson River: 18-28" slot limit, or ≥40"	1 fish/day	Angling only. Spearing permitted in ocean waters. Catch and release only during closed season.	Ocean: 4.15 – 12.15 Hudson River: 4.1 – 11.30 Delaware River: All year
NJ	1 fish at 28 to < 43", and 1 fish ≥ 43"			Closed 1.1 – 2.28 in all waters except in the Atlantic Ocean, and 4.1 – 5.31 in the lower Delaware River and tributaries (spawning ground closure)
PA	Upstream from Calhoun St Bridge: 1 fish at ≥ 28" minimum size, year round Downstream from Calhoun St Bridge: 1 fish at ≥ 28" minimum size, 1.1 – 3.31 and 6.1 – 12.31 2 fish at 21-25" slot size limit, 4.1 – 5.31			
DE	28" minimum size, no harvest 38-43" (inclusive)	2 fish/day	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). In Del. River, Bay & tributaries, may only harvest 20-25"slot from 7.1-8.31

(Table B4.1 continued – Summary of regulations in 2017). C&R = catch and release.

Recreational Regulations				
STATE	**SIZE LIMITS**	**BAG LIMIT**	**OTHER**	**OPEN SEASON**
MD	Ocean: 28-38” slot limit or ≥44” CB Spring Trophy: 35” minimum size CB Summer/Fall^: 20” minimum size and only one fish can be >28”	Ocean: 2 fish/day CB Spring Trophy: 1 fish/day CB Summer/Fall^: 2 fish/day	See compliance report for specifics.	Ocean: All year CB: C&R only 1.1-4.14^ CB Spring Trophy: 4.15-5.15 Bay Summer/Fall: 5.16-12.20
PRFC	Spring Trophy: 35” minimum size Summer/Fall: 20” minimum size and only 1 fish can be >28”	Trophy: 1 fish/day Summer/Fall: 2 fish/day	No more than two hooks or sets of hooks for each rod or line	Spring Trophy: 4.15 -5.15 Summer/Fall: 5.16-12.31
DC	20” minimum size and only one fish can be >28”	2 fish/day	Hook & line only	5.16-12.31
VA	Ocean: 28” Ocean Trophy: 36” minimum size CB Trophy: 36” minimum size CB Spring: 20-28” (with 1 fish >36”) CB Fall: 20” minimum size and only one fish can be >28”	Ocean: 1 fish/day Ocean Trophy: 1 fish/day Bay Trophy: 1 fish/day Bay Spring: 2 fish/day Bay Fall: 2 fish/day	Hook & line, rod & reel, hand line only. Gaffing is illegal in Virginia marine waters. No possession in the spawning reaches of the Bay during trophy season	Ocean: 1.1-3.31, 5.16-12.31 Ocean Trophy: 5.1-5.15 Bay Trophy: 5.1-6.15 Bay Spring: 5.16-6.15 Bay Fall: 10.4-12.31
NC	Ocean: 28” min size	Ocean: 1 fish/day	No gaffing allowed.	Ocean: All year

^in Susquehanna Flats and Northeast River: C&R only from 1.1-5.3 and 1 fish/day at 20-26” slot size limit from 5.16-5.31

Table B5.1. Number of fish sampled by state and survey to develop female maturity curve.

State	**Survey**	**Months Sampled**	**N**	**Percent**
Maryland	Spring Creel Survey	April-June	252	58.9%
	Spring Gill Net Survey	April-May	15	3.5%
	Striped Bass Pound Net Sampling	June-July	19	4.4%
	Nanticoke Spring Pound Net and Fyke Net Survey	March	2	0.5%
	Commercial Check Station Sampling	March	3	0.7%
	Fish Health Hook & Line Survey	September-November	5	1.2%
	Patapsco Gill Net Survey	June	3	0.7%
	Shad Gill Net Survey (USFWS)	April-May	8	1.9%
New Jersey	Delaware Bay Gill Net Survey	March-May	15	3.5%
	Ocean Trawl Survey	April-May	9	2.1%
		October	1	0.2%
	Headboat Sampling	December	13	3.0%
	Herring Survey	May	1	0.2%
Rhode Island	Fish Trap Survey	September-October	59	13.8%
NEAMAP	Ocean Trawl Survey	May	16	3.7%
		September-October	7	1.6%
Total			428	

Table B5.2. Number of fish sampled by month to develop female maturity curve.

Month	N	Percent
March	15	3.5%
April	80	18.7%
May	151	35.3%
June	84	19.6%
July	13	3.0%
September	16	3.7%
October	54	12.6%
November	2	0.5%
December	13	3.0%
Total	**428**	

Table B5.3. Number of fish sampled by age develop female maturity curve. Ages were calculated as for the full dataset analysis (e.g., fall developing fish had their ages advanced one year).

Age	N	Percent
2	3	0.7%
3	13	3.0%
4	45	10.5%
5	131	30.6%
6	56	13.1%
7	32	7.5%
8	36	8.4%
9	13	3.0%
10	28	6.5%
11	44	10.3%
12	14	3.3%
13	8	1.9%
14	4	0.9%
16	1	0.2%
Total	**428**	

Table B5.4. Comparison of maturity-at-age estimates from various studies. The maturity-at-age estimates used in the 2013 stock assessment are bolded.

Study	Merriman (1941) a	Texas Instruments (1980) b	Specker et al. (1987) b	**Jones (1987)**	Berlinsky et al. (1995)	Data Subset (this study)	Full Dataset (this study) (Recommended)
Area	New England	Hudson	Coastwide	**MD and Hudson**	Rhode Island	Coastwide	Coastwide
Timing	April-Nov				May-June, Sept-Nov	March-July	March-July, Sept-Dec
Age							
3	0%			**0%**	0%	0%	0%
4	27%	4%	5%	**4%**	12%	7%	9%
5	74%	21%	15%	**13%**	34%	51%	32%
6	93%	60%	45%	**45%**	77%	66%	45%
7	100%	89%	100%	**89%**	100%	90%	84%
8	100%	94%	100%	**94%**	100%	94%	89%
9	100%	100%	100%	**100%**	100%	100%	100%

a: From Berlinksy et al 1995
b: From Jones 1987

Table B5.5. Indices of relative abundance for Age-1+ Atlantic striped bass.

	MRIP CPUE		CT LISTS		NY OHS		NJ OT		DE SSN		DE 30’		MD SSN		ChesMMAP	
Year	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV
1982	0.16	0.67														
1983	0.38	0.93														
1984	0.44	1.50														
1985	0.12	0.72											4.88	0.25		
1986	0.27	0.84											10.07	0.25		
1987	0.46	1.02	0.05	0.32	3.83	0.11							7.15	0.25		
1988	0.47	0.68	0.04	0.44	3.60	0.10							3.27	0.25		
1989	0.44	0.72	0.06	0.30	2.58	0.13							3.96	0.25		
1990	0.64	0.68	0.16	0.27	3.50	0.18	2.20	0.42			2.38	1.32	5.04	0.25		
1991	0.79	0.64	0.15	0.25	3.28	0.19	2.72	0.35			0.32	0.24	4.61	0.25		
1992	1.91	0.57	0.22	0.26	3.00	0.19	1.49	0.37			1.72	0.55	6.29	0.25		
1993	1.78	0.49	0.27	0.18	3.32	0.11	1.60	0.38			2.93	1.17	6.25	0.25		
1994	2.53	0.44	0.30	0.18	2.90	0.15	2.01	0.20			6.36	3.56	5.13	0.25		
1995	3.63	0.49	0.59	0.14	2.84	0.18	13.94	0.11			16.47	5.20	4.62	0.25		
1996	4.08	0.45	0.64	0.14	5.11	0.10	17.10	0.11	1.81	0.30	9.64	2.39	7.59	0.25		
1997	4.59	0.45	0.86	0.12	4.84	0.14	17.08	0.11	2.16	0.32	4.32	1.92	3.83	0.25		
1998	4.77	0.42	0.97	0.13	5.01	0.15	15.78	0.05	2.12	0.38	2.23	0.82	4.79	0.25		
1999	4.58	0.42	1.11	0.11	3.46	0.16	9.57	0.06	1.47	0.26	12.48	4.09	4.02	0.25		
2000	4.22	0.46	0.84	0.12	4.36	0.11	10.87	0.06	1.66	0.32	6.43	2.42	3.54	0.25		
2001	3.44	0.41	0.61	0.15	3.47	0.15	3.91	0.16	1.88	0.39	3.48	1.19	2.87	0.25		
2002	3.17	0.45	1.30	0.10	3.23	0.20	10.13	0.13	1.60	0.35	7.75	2.77	4.10	0.25	31.94	0.24
2003	2.97	0.46	0.87	0.11	4.24	0.19	14.36	0.04	3.21	0.42	2.53	0.99	4.50	0.25	77.74	0.16
2004	2.06	0.40	0.56	0.14	4.88	0.09	10.00	0.07	2.81	0.51	1.08	0.45	6.05	0.25	86.76	0.13
2005	2.60	0.42	1.17	0.12	3.91	0.14	28.06	0.10	1.77	0.31	2.60	1.07	4.96	0.25	146.19	0.16
2006	2.84	0.41	0.61	0.16	4.37	0.14	8.87	0.20	2.22	0.45	4.04	1.68	4.92	0.25	84.48	0.18
2007	1.92	0.40	1.02	0.12			14.14	0.12	1.78	0.72	1.98	0.76	2.14	0.25	71.86	0.18
2008	1.75	0.40	0.57	0.14			3.68	0.17	1.72	0.30	2.39	0.89	4.37	0.25	50.62	0.15
2009	1.61	0.38	0.60	0.18			12.76	0.12	1.25	0.24	1.22	0.42	5.70	0.25	20.89	0.24
2010	1.48	0.37	0.40	0.22			3.54	0.26	2.69	0.63	2.25	1.01	4.53	0.25	20.13	0.28
2011	1.16	0.38	0.48	0.21			7.16	0.09	3.25	0.78	1.15	0.46	4.58	0.25	27.31	0.17
2012	1.22	0.45	0.43	0.17			16.65	0.24	1.94	0.41	1.74	0.44	2.65	0.25	109.14	0.27
2013	2.21	0.36	0.67	0.13			8.84	0.20	2.10	0.42	1.44	0.45	4.42	0.25	74.21	0.20
2014	1.66	0.40	0.41	0.20			8.29	0.35	2.43	0.39	1.92	1.14	5.57	0.25	43.74	0.27
2015	1.62	0.42	0.20	0.24			0.77	0.35	0.86	0.18	2.93	1.45	7.34	0.25	55.26	0.29
2016	1.63	0.37	0.48	0.16			2.01	0.18	0.49	0.13	1.45	1.51	3.96	0.25	139.43	0.21
2017	2.96	0.39	0.34	0.25			18.25	0.12	1.75	0.42	1.66	0.78	5.46	0.25	148.20	0.27

Table B5.6. Unlagged indices of recruitment for Atlantic striped bass.

	NY YOY		NY Age-1		NJ YOY		MD YOY		MD Age-1		VA YOY		MDVA YOY	
Year	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV	Index	CV
1982					0.10	0.05	3.57	0.23	0.02	0.51	2.71	0.46	52.77	0.43
1983					0.07	0.04	0.61	0.65	0.32	0.58	3.40	0.42	84.82	0.32
1984			0.96	0.23	0.37	0.10	1.64	0.43	0.00	0.20	4.47	0.31	64.35	0.38
1985	2.20	0.30	0.61	0.23	0.03	0.03	0.91	0.57	0.16	1.00	2.41	0.41	82.97	0.32
1986	4.65	0.60	0.30	0.09	0.32	0.07	1.34	0.44	0.03	0.25	4.74	0.28	65.11	0.37
1987	28.36	4.80	0.21	0.07	0.53	0.08	1.46	0.41	0.06	0.47	15.74	0.12	88.10	0.31
1988	49.28	5.20	0.81	0.22	0.35	0.05	0.73	0.65	0.07	0.46	7.64	0.24	204.03	0.29
1989	35.37	4.50	1.78	0.42	1.07	0.09	4.87	0.22	0.19	0.29	11.23	0.26	104.21	0.31
1990	35.53	4.70	0.37	0.09	1.05	0.08	1.03	0.49	0.33	0.24	7.34	0.35	110.92	0.27
1991	6.00	0.90	1.26	0.27	0.47	0.04	1.52	0.38	0.20	0.21	3.76	0.40	70.90	0.34
1992	16.93	1.80	1.34	0.29	1.18	0.06	2.34	0.30	0.15	0.22	7.32	0.34	69.92	0.34
1993	21.99	3.10	0.75	0.16	1.78	0.08	13.97	0.06	0.19	0.26	18.12	0.15	83.63	0.30
1994	23.61	2.50	1.43	0.35	0.96	0.06	6.40	0.14	0.78	0.25	10.48	0.26	233.65	0.26
1995	19.03	1.90	1.29	0.29	1.98	0.08	4.41	0.16	0.12	0.18	5.45	0.41	129.02	0.26
1996	12.12	1.40	1.54	0.39	1.70	0.08	17.61	0.05	0.08	0.28	23.00	0.12	107.18	0.31
1997	27.11	3.90	1.00	0.27	1.01	0.06	3.91	0.21	0.26	0.39	9.35	0.26	292.20	0.25
1998	16.10	2.00	2.10	0.58	1.31	0.08	5.50	0.14	0.17	0.23	13.25	0.19	107.68	0.27
1999	30.67	3.40	2.05	0.42	1.90	0.08	5.34	0.12	0.37	0.25	2.80	0.52	149.71	0.24
2000	6.88	1.10	1.56	0.38	1.78	0.08	7.42	0.11	0.26	0.18	16.18	0.18	127.57	0.33
2001	28.90	4.60	2.16	0.45	1.20	0.06	12.57	0.07	0.32	0.20	14.17	0.17	169.70	0.23
2002	14.72	1.50	2.53	0.46	0.53	0.05	2.20	0.34	0.79	0.18	3.98	0.42	221.79	0.28
2003	29.78	4.40	1.19	0.21	2.47	0.09	10.83	0.09	0.07	0.16	22.89	0.12	70.64	0.34
2004	8.73	0.90	2.41	0.45	1.13	0.07	4.85	0.16	0.74	0.33	12.70	0.18	231.43	0.21
2005	11.28	1.80	0.64	0.18	1.22	0.06	6.91	0.12	0.28	0.18	9.09	0.20	149.39	0.24
2006	5.83	0.70	2.02	0.43	0.67	0.05	1.78	0.37	0.28	0.22	10.10	0.27	154.67	0.24
2007	42.65	5.10	0.58	0.14	1.41	0.06	5.12	0.16	0.07	0.21	11.96	0.22	89.06	0.30
2008	19.04	2.10	1.24	0.27	1.26	0.07	1.26	0.45	0.31	0.30	7.97	0.29	135.30	0.25
2009	13.92	1.90	0.33	0.08	1.92	0.08	3.92	0.19	0.12	0.20	8.42	0.30	82.86	0.31
2010	25.62	3.40	0.45	0.11	1.30	0.06	2.54	0.26	0.17	0.27	9.07	0.23	103.97	0.28
2011	12.16	1.90	2.00	0.44	1.41	0.08	9.57	0.09	0.02	0.22	27.09	0.10	111.14	0.27
2012	9.85	1.40	0.90	0.18	0.34	0.04	0.49	0.66	0.35	0.51	2.68	0.58	274.26	0.21
2013	5.07	0.60	0.56	0.11	0.90	0.06	3.42	0.22	0.05	0.17	10.94	0.22	49.85	0.43
2014	24.60	2.60	0.82	0.16	1.65	0.07	4.06	0.19	0.12	0.37	11.30	0.20	116.33	0.26
2015	21.68	2.70	3.16	0.61	0.94	0.06	10.67	0.08	0.23	0.29	12.00	0.22	133.22	0.25
2016	10.93	1.50	2.00	0.39	1.41	0.07	1.25	0.45	0.42	0.13	8.74	0.33	183.47	0.30
2017	17.90	2.20	0.59	0.13	1.20	0.06	5.88	0.14	0.14	0.26	9.17	0.29	74.87	0.33

Table B5.7. Cross-correlation coefficients for Delaware 30’ trawl survey index.

DE 30' Trawl Winter vs. DE SSN																				
-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
-0.088	0.034	0.186	0.179	-0.071	0.228	0.419	-0.056	0.074	0.07	-0.236	-0.128	-0.031	-0.118	-0.025	-0.054	-0.113	-0.029	-0.045	-0.031	-0.063
DE 30' Trawl Winter vs. NJ Trawl																				
-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
0.09	0.252	0.384	0.026	-0.018	0.366	0.433	0.358	0.413	0.633	0.18	0.088	0.117	-0.032	-0.119	-0.184	-0.191	-0.253	-0.228	-0.298	-0.174
NJ YOY vs. DE 30' Trawl Winter																				
-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
-0.046	-0.122	-0.245	0.086	0.035	-0.269	-0.128	0.129	0.099	0.138	0.317	0.347	-0.115	0.028	0.363	0.041	-0.128	-0.133	0.286	0.036	-0.058
MD YOY vs. DE 30' Trawl Winter																				
-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
-0.109	-0.1	-0.183	-0.033	0.24	-0.202	-0.114	0.28	0.255	0.241	0.2	0.519	0.105	-0.046	0.094	0.11	0.127	-0.066	0.076	-0.019	-0.16
MD AGE1 vs DE 30' Trawl Winter																				
-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10
-0.161	-0.083	0.003	-0.155	0.011	0.175	-0.19	-0.147	0.113	0.287	0.127	-0.147	0.191	0.151	0.058	0.297	0.243	0.273	-0.017	0.224	-0.011

Table B5.8. Samples sizes and data sources of sex and age data by geographic area and sample season . Spring = March-June; Fall = July-December; N = number of fish of known sex only.

Area	Season	N	Surveys
Chesapeake Bay	Spring	12,038	VA commercial sampling PRFC commercial sampling MD charter boat sampling ChesMMAP trawl survey
Chesapeake Bay	Fall	7,649	VA commercial sampling PRFC commercial sampling ChesMMAP trawl survey
Ocean	Spring	3,309	VA commercial sampling DE commercial sampling (Bay & inland bays) MA diet study MA otolith collection (carcass program) NEAMAP trawl survey (RI, NY, MD, DE)
Ocean	Fall	2,500	VA commercial sampling DE recreational sampling DE commercial sampling MA diet study MA otolith collection (carcass program) NEAMAP trawl survey (RI, NY, NJ, DE, MD, VA)

Table B5.9. LOESS estimates of sex ratio by geographic region and period (Waves 2-3 = March-June; Waves 4-6 = July-December).

	Chesapeake Bay		**Ocean**	
Age	**Waves 2-3**	**Waves 4-6**	**Waves 2-3**	**Waves 4-6**
1	0.61	0.51	0.61	0.67
2	0.48	0.37	0.71	0.78
3	0.38	0.26	0.77	0.84
4	0.29	0.19	0.78	0.83
5	0.24	0.19	0.72	0.77
6	0.27	0.24	0.64	0.76
7	0.38	0.30	0.64	0.78
8	0.50	0.39	0.68	0.81
9	0.59	0.48	0.75	0.83
10	0.66	0.56	0.82	0.86
11	0.71	0.64	0.85	0.91
12	0.75	0.70	0.84	0.87
13	0.79	0.76	0.83	0.82
14	0.82	0.79	0.83	0.83
15+	0.91	0.94	0.83	0.92

Table B5.10. Number of striped bass ≥18” (457 mm) TL a) released by each agency and b) recaptured between March 15 and June 15 by year and spawning region. Unknown fish were recaptured not in the producer area within the spawning season. Recapture records included both kept and released fish.

a) Number of releases by year and agency

Year	MADFWELE	NCCOOP	NYDECCST	Total
1987	0	0	1,668	1,668
1988	0	1,333	1,677	3,010
1989	23	1,156	846	2,025
1990	0	1,946	1,068	3,014
1991	388	1,779	1,071	3,238
1992	895	1,014	1,328	3,237
1993	675	527	1,731	2,933
1994	375	4,336	1,589	6,300
1995	433	639	689	1,761
1996	204	660	1,539	2,403
1997	317	1,348	1,138	2,803
1998	387	460	1,092	1,939
1999	469	271	1,063	1,803
2000	1,091	4,498	1,239	6,828
2001	456	2,383	1,050	3,889
2002	239	3,802	847	4,888
2003	655	1,906	794	3,355
2004	620	2,463	1,276	4,359
2005	604	3,960	831	5,395
2006	390	4,453	1,042	5,885
2007	530	370	1,411	2,311
2008	456	1,033	358	1,847
2009	501	146	197	844
2010	327	566	473	1,366
2011	504	107	188	799
2012	539	6	100	645
2013	486	2,006	56	2,548
2014	453	920	66	1,439
2015	348	1,375	58	1,781
2016	0	1,348	0	1,348
Total	12,365	46,811	26,485	85,661

b) Recaptures by year and spawning region, kept and released

Year	Ches Bay	Not Ches Bay	Unknown	Total
1987	0	0	0	0
1988	13	7	192	212
1989	10	32	280	322
1990	45	23	383	451
1991	44	38	470	552
1992	44	25	489	558
1993	35	32	516	583
1994	108	39	702	849
1995	91	38	614	743
1996	56	31	592	679
1997	57	25	628	710
1998	37	34	500	571
1999	31	29	394	454
2000	77	16	513	606
2001	66	18	508	592
2002	76	24	627	727
2003	75	23	518	616
2004	79	15	498	592
2005	102	25	437	564
2006	112	33	585	730
2007	58	17	404	479
2008	64	14	403	481
2009	57	15	300	372
2010	27	20	225	272
2011	24	12	222	258
2012	10	9	138	157
2013	35	21	239	295
2014	43	17	187	247
2015	38	15	197	250
2016	43	29	136	208
Total	1,557	676	11,897	14,130

Table B5.11. Number of striped bass ≥28" (711 mm) TL a) released by each agency and b) recaptured between March 15 and June 15 by year and spawning region. Unknown fish were recaptured not in the producer area within the spawning season. Recapture records included both kept and released fish.

a) Number of releases by year and agency						b) Recaptures by year and spawning region, kept and released				
Year	MADFWELE	NCCOOP	NYDECCST	Total		Year	Ches Bay	Not Ches Bay	Unknown	Total
1987	0	0	222	222		1987	0	0	0	0
1988	0	194	351	545		1988	0	2	40	42
1989	3	412	251	666		1989	2	3	75	80
1990	0	323	291	614		1990	3	6	103	112
1991	329	856	296	1,481		1991	10	12	180	202
1992	649	434	247	1,330		1992	10	11	212	233
1993	461	142	272	875		1993	10	11	235	256
1994	217	480	376	1,073		1994	17	11	218	246
1995	263	372	115	750		1995	15	18	271	304
1996	120	557	85	762		1996	14	13	245	272
1997	220	869	86	1,175		1997	26	11	282	319
1998	311	106	88	505		1998	12	17	219	248
1999	345	179	58	582		1999	12	12	171	195
2000	704	165	97	966		2000	9	9	118	136
2001	353	515	182	1,050		2001	19	3	160	182
2002	172	789	149	1,110		2002	9	10	193	212
2003	615	1,578	161	2,354		2003	27	11	231	269
2004	499	783	75	1,357		2004	30	7	244	281
2005	511	557	63	1,131		2005	48	15	159	222
2006	323	2,113	28	2,464		2006	61	17	270	348
2007	480	305	148	933		2007	37	8	207	252
2008	385	923	26	1,334		2008	50	7	248	305
2009	458	121	40	619		2009	41	4	174	219
2010	309	411	150	870		2010	17	12	149	178
2011	468	103	109	680		2011	16	8	149	173
2012	495	5	11	511		2012	6	8	89	103
2013	457	1,929	12	2,398		2013	32	17	198	247
2014	431	918	12	1,361		2014	41	14	176	231
2015	326	1,372	16	1,714		2015	36	14	184	234
2016	0	1,345	0	1,345		2016	42	29	126	197
Total	9,904	18,856	4,017	32,777		Total	652	320	5,326	6,298

Table B5.12. Adjusted number of tag returns for fish ≥18” (457 mm) by stock and regulatory period (left) and associated stock composition (right), (a) with and (b) without fish of unknown stock. (CB = Chesapeake Bay; DR/HR = Delaware and Hudson rivers; UNK = unknown)

a)	adjusted tag returns by regulatory period, including tags from unknown stocks					
	CB	DB/HR	UNK	CB	DB/HR	UNK
1987-1989	5,376	1,526	8,390	0.35	0.10	0.55
1990-1994	5,761	3,170	46,127	0.10	0.06	0.84
1995-1999	3,589	2,217	49,516	0.06	0.04	0.90
2000-2002	3,550	1,046	29,910	0.10	0.03	0.87
2003-2006	5,939	1,489	37,017	0.13	0.03	0.83
2007-2014	6,144	1,970	38,573	0.13	0.04	0.83
2015-2016	1,737	641	6,063	0.21	0.08	0.72
average				0.16	0.05	0.79

b)	adjusted tag returns by regulatory period, excluding tags from unknown stocks			
	CB	DB/HU	CB	DB/HU
1987-1989	5,376	1,526	0.78	0.22
1990-1994	5,761	3,170	0.65	0.35
1995-1999	3,589	2,217	0.62	0.38
2000-2002	3,550	1,046	0.77	0.23
2003-2006	5,939	1,489	0.80	0.20
2007-2014	6,144	1,970	0.76	0.24
2015-2016	1,737	641	0.73	0.27
average			0.73	0.27

Table B5.13. Adjusted number of tag returns for fish ≥28" (711 mm) by stock and regulatory period (left) and associated stock composition (right), (a) with and (b) without fish of unknown stock. (CB = Chesapeake Bay; DB/HR = Delaware Bay and Hudson River; UNK = unknown)

a)	adjusted tag returns by regulatory period, including tags from unknown stocks					
	CB	DB/HU	UNK	CB	DB/HU	UNK
1987-1989	157	108	1,535	0.09	0.06	0.85
1990-1994	954	750	12,933	0.07	0.05	0.88
1995-1999	861	698	16,373	0.05	0.04	0.91
2000-2002	713	310	6,519	0.09	0.04	0.86
2003-2006	2,980	552	12,528	0.19	0.03	0.78
2007-2014	4,821	819	19,287	0.19	0.03	0.77
2015-2016	1,675	412	4,288	0.26	0.06	0.67
average				0.13	0.05	0.82

b)	adjusted tag returns by regulatory period, excluding tags from unknown stocks			
	CB	DB/HU	CB	DB/HU
1987-1989	157	108	0.59	0.41
1990-1994	954	750	0.56	0.44
1995-1999	861	698	0.55	0.45
2000-2002	713	310	0.70	0.30
2003-2006	2,980	552	0.84	0.16
2007-2014	4,821	819	0.85	0.15
2015-2016	1,675	412	0.80	0.20
average			0.70	0.30

Figure B6.1. Number of length and age samples from commercial fisheries by state and gear, 2000-2017.

Year	MA		RI				NY		DE			
	Hook & Line		Trap		Hook & Line		Mixed Gears		Gillnet		Hook & Line	
	Length Samples	Samples Aged	Length Samples	Samples Aged	Length Samples	Samples Aged	Length Samples	Samples Aged	Length Samples	Samples Aged	Length Samples	Samples Aged
2000	481	481	0	0	0	0	814	814	537	356	80	79
2001	540	193	139	135*	0	0	839	839	374	137	56	56
2002	544	197	0	0	197	185*	508	508	336	336	32	32
2003	628	249	314	314*	185	185*	524	524	593	521	35	34
2004	855	249	244	157	319	82	481	481	179	179	32	32
2005	742	251	412	412	492	490	185	185	144	144	6	6
2006	607	306	425	188	424	0	580	580	397	372	2	2
2007	328	328	132	132	350	0	753	734	394	385	21	21
2008	330	330	296	0	366	0	1,154	1,144	227	227	28	28
2009	321	321	371	0	348	0	655	655	221	221	144	10
2010	357	357	589	0	405	0	388	381	286	286	82	79
2011	414	358	265	125	360	48	535	534	148	148	82	82
2012	760	299	163	96	89	48	353		150	146	63	63
2013	426	297	177	89	282	244	276	276	107	107	0	0
2014	804	587	44	45	151	139	420	413	181	181	0	0
2015	691	518	126	126	247	247	516	505	133	133	0	0
2016	700	681	39	38	112	112	404	381	178	170	28	28
2017	492	492	11	11	159	159	316	325	199	198	20	20

Table B6.1 (continued).

Year	MD							
	Gillnet		Hook & Line		Pound net/Haul Seine		Trawl (Ocean)	
	Length Samples	Samples Aged	Length Samples	Samples Aged	Length Samples	Samples Aged	Length Samples	Samples Aged
2000	4,071		1,932	209	633	209	0	0
2001	3,772	184	1,693	226	1,115	226	0	0
2002	4,091	165	1,697	217	1,080	217	0	0
2003	2,810	262	1,777	182	1,290	182	0	0
2004	3,591	193	1,965	256	853	156	0	0
2005	3,381	142	2,158	201	1,159	210	0	0
2006	2,974	183	2,106	196	944	196	560	127
2007	3,063	183	1,680	147	1,187	142	252	202
2008	3,621	211	1,626	148	884	170	244	119
2009	3,734	117	2,260	160	1,087	160	176	133
2010	3,108	119	1,790	157	1,528	158	107	242
2011	3,442	126	1,431	149	1,128	149	208	117
2012	3,800	122	1,988	198	788	198	629	210
2013	3,648	139	1,957	216	514	216	168	147
2014	3,471	149	2,311	216	†	†	160	145
2015	2,907	153	2,202	187	†	†	332	129
2016	3,665	159	2,213	204	†	†	25	149
2017	3,156		1,988		†	†	180	

†: MD pound net samples were combined with hook and line samples after 2013

Table B6.1 (continued).

Year	VA								PRFC	
	Gillnet (CB)		Hook & Line (CB)		Gillnet (Ocean)		Pound/Fyke/Seine		Mixed Gears	
	Length Samples	Samples Aged	Length Samples	Samples Aged	Length Samples	Samples Aged	Length Samples	Samples Aged	Length Samples	Samples Aged
2000	392	835	40	51	1,024	502	506	468	491	491
2001	439	443	154	915	588	1,585	814	2,239	413	413
2002	608	1,544	189	1,015	371	2,180	655	2,036	285	285
2003	1,773	6,358	83	513	207	1,436	465	992	381	381
2004	515	3,224	65	382	72	600	594	2,169	533	533
2005	1,668	7,826	108	199	500	4,022	408	1,097	196	196
2006	1,744	4,066	143	683	867	2,431	345	871	452	452
2007	734	3,311	77	770	293	1,794	455	1,089	423	423
2008	857	4,640	44	345	517	4,729	223	541	329	329
2009	1,444	3,947	229	547	392	3,387	386	772	494	494
2010	1,902	4,021	119	264	445	2,829	394	696	562	562
2011	2,884	3,817	395	874	314	2,957	822	504	179	179
2012	1,302	345	144	71	343	250	405	136	514	514
2013	1,481	422	293	74	311	239	454	132	552	552
2014	3,270	462	255	62	473	293	994	35	395	395
2015	1,121	501	236	21	541	280	1,006	54	375	375
2016	2,541	580	401	211	561	299	1,365	581	350	350
2017	3,333	434	413	47	380	362	1,375	131	380	380

Table B6.1 (continued).

Year	NC					
	Gillnet (Ocean)		Trawl (Ocean)		Haul Seine (Ocean)	
	Length Samples	Samples Aged	Length Samples	Samples Aged	Length Samples	Samples Aged
2000	0	0	270	270	281	281
2001	69	69	103	103	161	161
2002	83	83	160	160	288	288
2003	170	170	239	239	0	0
2004	211	211	285	285	178	178
2005	186	186	33	33	299	299
2006	154	154	115	115	0	0
2007	232	101	461	204	64	64
2008	92	92	142	142	53	53
2009	28	28	151	151	0	0
2010	98	67	359	225	0	0
2011	163	98	226	121	0	0
2012	21	21	0	0	0	0
2013	0	0	0	0	0	0
2014	0	0	0	0	0	0
2015	0	0	0	0	0	0
2016	0	0	0	0	0	0
2017	0	0	0	0	0	0

Table B6.2. Commercial and recreational landings in weight (metric tons and millions of pounds) of striped bass on the Atlantic coast. Estimates of recreational landings are not available prior to 1981.

	Commercial		Recreational	
Year	Metric tons	Millions of lbs	Metric tons	Millions of lbs
1947	2,085	4.6	-	-
1948	2,726	6.0	-	-
1949	2,543	5.6	-	-
1950	3,128	6.9	-	-
1951	2,444	5.4	-	-
1952	2,148	4.7	-	-
1953	1,960	4.3	-	-
1954	1,759	3.9	-	-
1955	1,906	4.2	-	-
1956	1,686	3.7	-	-
1957	1,619	3.6	-	-
1958	2,266	5.0	-	-
1959	3,317	7.3	-	-
1960	3,524	7.8	-	-
1961	4,042	8.9	-	-
1962	3,567	7.9	-	-
1963	3,879	8.6	-	-
1964	3,558	7.8	-	-
1965	3,278	7.2	-	-
1966	3,820	8.4	-	-
1967	3,924	8.7	-	-
1968	4,169	9.2	-	-
1969	4,912	10.8	-	-
1970	3,999	8.8	-	-
1971	2,890	6.4	-	-
1972	4,012	8.8	-	-
1973	5,888	13.0	-	-
1974	4,536	10.0	-	-
1975	3,416	7.5	-	-
1976	2,494	5.5	-	-
1977	2,245	4.9	-	-
1978	1,764	3.9	-	-
1979	1,290	2.8	-	-
1980	1,895	4.2	-	-
1981	1,744	3.8	-	-

	Commercial		Recreational	
Year	Metric tons	Millions of lbs	Metric tons	Millions of lbs
1982	991	2.2	1,844	4.1
1983	639	1.4	2,365	5.2
1984	1,105	2.4	1,090	2.4
1985	431	1.0	4,473	9.9
1986	68	0.2	1,255	2.8
1987	75	0.2	1,131	2.5
1988	130	0.3	1,097	2.4
1989	55	0.1	1,621	3.6
1990	310	0.7	3,723	8.2
1991	352	0.8	4,827	10.6
1992	652	1.4	5,408	11.9
1993	761	1.7	4,610	10.2
1994	781	1.7	6,692	14.8
1995	1,618	3.6	12,280	27.1
1996	2,019	4.5	12,994	28.6
1997	2,417	5.3	13,919	30.7
1998	2,636	5.8	13,475	29.7
1999	2,633	5.8	15,350	33.8
2000	2,735	6.0	15,478	34.1
2001	2,544	5.6	18,124	40.0
2002	2,529	5.6	19,001	41.9
2003	2,709	6.0	24,560	54.1
2004	2,882	6.4	24,594	54.2
2005	2,950	6.5	26,121	57.6
2006	2,731	6.0	22,986	50.7
2007	2,880	6.4	19,433	42.8
2008	2,985	6.6	25,703	56.7
2009	3,256	7.2	24,681	54.4
2010	3,154	7.0	27,909	61.5
2011	3,066	6.8	27,031	59.6
2012	2,973	6.6	24,157	53.3
2013	2,604	5.7	29,510	65.1
2014	2,808	6.2	21,749	47.9
2015	2,151	4.7	18,098	39.9
2016	2,178	4.8	19,817	43.7
2017	2,071	4.6	17,190	37.9

Table B6.3. Commercial and recreational removals of striped bass in numbers of fish.

Year	Commercial Harvest	Commercial Discards	Recreational Harvest*	Recreational Release Mortalities†	Total
1982	359,979	33,214	318,872	193,486	905,551
1983	271,958	47,984	615,844	111,924	1,047,711
1984	467,158	24,850	264,002	79,663	835,673
1985	69,288	29,555	732,002	94,682	925,527
1986	6,352	40,888	268,724	124,475	440,439
1987	3,727	29,785	114,351	145,471	293,334
1988	27,601	54,801	127,827	244,914	455,143
1989	3,908	87,813	161,791	406,866	660,378
1990	93,887	46,630	578,897	442,811	1,162,225
1991	114,170	90,439	798,260	715,552	1,718,422
1992	232,983	197,240	869,781	937,611	2,237,615
1993	314,522	116,921	789,037	812,488	2,032,966
1994	322,574	160,198	1,058,811	1,361,143	2,902,725
1995	537,342	187,185	2,287,578	2,010,689	5,022,794
1996	853,147	261,022	2,544,837	2,609,169	6,268,175
1997	1,076,561	331,383	3,001,559	2,978,716	7,388,220
1998	1,217,047	348,852	3,077,870	3,270,354	7,914,123
1999	1,223,372	332,101	3,330,322	3,161,882	8,047,676
2000	1,216,826	203,084	3,901,584	3,055,801	8,377,295
2001	929,394	174,926	4,212,411	2,454,617	7,771,349
2002	920,628	191,099	4,283,019	2,795,880	8,190,626
2003	862,381	129,813	5,021,287	2,852,116	8,865,597
2004	879,233	160,196	4,809,192	3,677,938	9,526,558
2005	969,808	145,094	4,551,590	3,444,770	9,111,262
2006	1,047,645	158,260	5,054,694	4,813,025	11,073,624
2007	1,014,707	166,397	4,177,242	2,944,764	8,303,111
2008	1,027,387	108,962	4,695,177	2,391,299	8,222,826
2009	1,053,530	128,191	4,901,115	1,943,488	8,026,323
2010	1,031,544	133,064	5,444,331	1,761,624	8,370,563
2011	944,669	87,924	5,048,912	1,482,139	7,563,643
2012	870,365	191,577	4,171,793	1,848,537	7,082,272
2013	784,379	112,097	5,215,393	2,393,952	8,505,821
2014	750,263	121,253	4,033,746	2,172,532	7,077,795
2015	622,079	101,343	3,085,724	2,307,133	6,116,279
2016	609,847	105,119	3,504,611	2,985,523	7,205,099
2017	592,576	108,475	2,934,292	3,423,544	7,058,888

* Includes estimates of Wave 1 harvest for VA and NC from tag releases for years with no MRIP sampling

† 9% release mortality applied to fish released alive

Table B6.4. Estimates of striped bass post release mortality from various commercial fishing gears. Bolded estimates were used to calculate gear specific post release morality for this assessment.

Gear	Estimate	Source	Notes
Anchor Gill Net	0.41	ASMFC 2007	New Jersey
	0.47	ASMFC 2007	Delaware
	0.41	Clark and Kahn 2009	Delaware Bay
	0.43	[1]Seagraves and Miller 1989	
	1.00	Shepherd 2004	
	0.46	This assessment	New Jersey gill net log books
Anchor Gill Net Median	**0.45**		
Drift Gill Net	0.03	ASMFC 2007	New Jersey
	0.07	ASMFC 2007	Delaware
	0.08	[1]Seagraves and Miller 1989	
	0.06	This assessment	New Jersey gill net log books
Drift Gill Net Median	**0.06**		
Gill Net	1.00	ASMFC 2007	Maine
	0.47	ASMFC 2007	New York
Gill Net median	**0.74**		
Hook and line	0.08	ASMFC 2007	Massachusetts
	0.13	ASMFC 2007	New York
	0.08	ASMFC 2007	Delaware
	0.08	ASMFC 2007	PRFC
	0.09	Caruso 2000	
	0.09	**Diodati and Richards 1996**	
	0.08	**[1]**Diodati and Richards 1996	
	0.11	Lukacovic and Uphoff 2007	
	0.02	RMC 1990	
	0.28	Millard et al. 2003	Freshwater
	0.06	Nelson 1998	Freshwater
Hook and line Median[2]	0.08		
Otter Trawl	1.00	Shepherd 2004	
Pound Net	0.05	[1]ASMFC 2007	
	0.01	This assessment	Maryland pound net log books
Pound Net Median	**0.03**		
Seine	0.16	Dunning et al. 1989	Immediate mortality
	0.15	[1]NYDEP	
Seine Median	**0.16**		
Traps	0.05	[1]Consensus opinion	
Trawl	0.35	[1]Crecco 1990	
	0.18	Dunning et al. 1989	Immediate mortality
Trawl Median	**0.26**		

[1]Used in 2007 Atlantic Striped Bass stock assessment
[2]Median from non-freshwater data sources

Table B6.5. Number of tags by disposition and commercial harvest and releases estimates used to calculate commercial discards for the Chesapeake Bay.

					New MRIP							
					Commercial	Recreational	Recreational					Unadjusted
Year	Comm Killed	Comm Released	Rec Killed	Rec Released	Harvest	Harvest	Releases	LR	KT	CT/RT	CF	Total Discards
1990	233	687	339	744	90,632	344,113	1,825,623	0.2634	0.6873	0.9234	0.3832	645,980
1991	173	610	617	1091	116,021	366,590	3,266,536	0.3165	0.2804	0.5591	1.1287	2,061,525
1992	255	215	932	1345	195,576	352,360	3,485,848	0.5550	0.2736	0.1599	2.0286	1,130,395
1993	229	489	992	752	272,421	331,869	2,932,861	0.8209	0.2308	0.6503	3.5559	6,781,600
1994	166	399	1108	867	275,876	560,271	4,673,894	0.4924	0.1498	0.4602	3.2866	7,069,354
1995	208	307	1117	633	377,377	1,027,739	5,754,152	0.3672	0.1862	0.4850	1.9719	5,502,984
1996	458	116	967	576	695,347	1,125,452	6,510,582	0.6178	0.4736	0.2014	1.3045	1,710,372
1997	683	142	817	524	847,968	1,260,838	10,178,428	0.6725	0.8360	0.2710	0.8045	2,219,011
1998	623	112	887	475	976,163	1,268,409	6,918,100	0.7696	0.7024	0.2358	1.0957	1,787,352
1999	667	88	600	295	989,689	1,365,709	8,759,677	0.7247	1.1117	0.2983	0.6519	1,703,392
2000	362	358	618	456	981,140	1,604,220	8,734,046	0.6116	0.5858	0.7851	1.0441	7,159,469
2001	292	138	591	301	705,691	1,294,357	6,145,194	0.5452	0.4941	0.4585	1.1035	3,108,948
2002	150	35	594	306	722,945	1,249,026	7,371,155	0.5788	0.2525	0.1144	2.2921	1,932,462
2003	343	89	509	269	658,248	1,657,555	10,970,911	0.3971	0.6739	0.3309	0.5893	2,139,074
2004	240	98	491	219	677,662	1,474,910	12,856,740	0.4595	0.4888	0.4475	0.9400	5,407,922
2005	78	96	382	161	752,006	1,298,593	9,580,429	0.5791	0.2042	0.5963	2.8361	16,201,195
2006	96	11	304	197	834,425	2,094,924	12,231,818	0.3983	0.3158	0.0558	1.2613	861,467
2007	53	8	212	106	800,333	1,617,626	7,578,540	0.4948	0.2500	0.0755	1.9790	1,131,937
2008	48	4	200	69	786,117	1,355,810	4,690,676	0.5798	0.2400	0.0580	2.4159	656,936
2009	41	9	222	54	825,281	1,802,545	4,838,475	0.4578	0.1847	0.1667	2.4790	1,999,134
2010	19	3	129	48	819,631	1,482,554	5,957,492	0.5529	0.1473	0.0625	3.7536	1,397,614
2011	18	10	141	44	722,489	1,389,294	3,823,146	0.5200	0.1277	0.2273	4.0736	3,539,580
2012	20	5	116	33	659,963	974,842	9,289,954	0.6770	0.1724	0.1515	3.9266	5,526,919
2013	13	3	170	43	579,235	1,434,543	7,130,621	0.4038	0.0765	0.0698	5.2802	2,626,801
2014	21	5	160	34	609,986	1,758,225	9,030,576	0.3469	0.1313	0.1471	2.6433	3,510,370
2015	31	2	105	57	497,809	1,315,657	10,215,851	0.3784	0.2952	0.0351	1.2816	459,386
2016	18	4	123	67	481,420	1,683,228	15,332,989	0.2860	0.1463	0.0597	1.9544	1,789,064
2017	26	6	144	73	459,094	1,201,949	9,044,625	0.3820	0.1806	0.0822	2.1155	1,572,620

					Old MRIP							
					Commercial	Recreational	Recreational					Unadjusted
Year	CommK	CommR	RecK	RecR	Harvest	Harvest	Releases	LR	KT	CT/RT	CF	Total Discards
1990	233	687	339	744	98,738	56,753	592,760	1.7398	0.6873	0.9234	2.5313	1,385,485
1991	173	610	617	1091	116,021	120,097	1,233,416	0.9661	0.2804	0.5591	3.4454	2,376,070
1992	255	215	932	1345	195,576	120,472	862,046	1.6234	0.2736	0.1599	5.9334	817,622
1993	229	489	992	752	272,421	174,868	1,640,829	1.5579	0.2308	0.6503	6.7485	7,200,462
1994	166	399	1108	867	275,876	326,284	2,968,711	0.8455	0.1498	0.4602	5.6435	7,710,298
1995	208	307	1117	633	377,377	492,323	2,709,430	0.7665	0.1862	0.4850	4.1164	5,409,131
1996	458	116	967	576	695,347	521,911	3,087,848	1.3323	0.4736	0.2014	2.8130	1,749,272
1997	683	142	817	524	847,968	651,472	4,961,501	1.3016	0.8360	0.2710	1.5570	2,093,415
1998	623	112	887	475	976,163	620,441	3,297,972	1.5733	0.7024	0.2358	2.2400	1,741,923
1999	667	88	600	295	839,325	553,137	3,250,098	1.5174	1.1117	0.2983	1.3650	1,323,366
2000	362	358	618	456	981,140	794,654	4,106,633	1.2347	0.5858	0.7851	2.1078	6,795,745
2001	292	138	591	301	705,691	651,455	3,393,064	1.0833	0.4941	0.4585	2.1925	3,410,669
2002	150	35	594	306	722,945	543,703	3,518,235	1.3297	0.2525	0.1144	5.2655	2,118,898
2003	343	89	509	269	658,248	890,136	5,551,823	0.7395	0.6739	0.3309	1.0974	2,015,720
2004	240	98	491	219	677,662	688,311	5,107,116	0.9845	0.4888	0.4475	2.0142	4,603,160
2005	78	96	382	161	752,007	757,596	5,038,483	0.9926	0.2042	0.5963	4.8613	14,604,876
2006	96	11	304	197	834,425	1,027,248	5,195,617	0.8123	0.3158	0.0558	2.5723	746,239
2007	53	8	212	106	799,631	984,914	3,886,633	0.8119	0.2500	0.0755	3.2475	952,596
2008	48	4	200	69	786,115	597,858	1,826,362	1.3149	0.2400	0.0580	5.4787	580,062
2009	41	9	222	54	825,281	722,161	1,722,000	1.1428	0.1847	0.1667	6.1878	1,775,901
2010	19	3	129	48	819,630	515,632	1,632,669	1.5896	0.1473	0.0625	10.7923	1,101,266
2011	18	10	141	44	722,489	541,797	1,264,123	1.3335	0.1277	0.2273	10.4458	3,001,081
2012	20	5	116	33	659,963	330,380	2,308,120	1.9976	0.1724	0.1515	11.5860	4,051,804
2013	13	3	170	43	579,235	556,875	2,550,154	1.0402	0.0765	0.0698	13.6020	2,420,038
2014	21	5	160	34	609,986	642,521	2,667,105	0.9494	0.1313	0.1471	7.2333	2,837,035
2015	31	2	105	57	497,809	500,465	3,911,768	0.9947	0.2952	0.0351	3.3691	462,429

LR=ratio of commercial landings to recreational harvest; KT=ratio of tags returned from commercially harvested fish to tags returned from recreationally harvested fish; CT = number of tags returned from discarded fish by commercial fishers; RT = number of tags returned from discarded fish by recreational anglers; CF=LR/KT.

Table B6.6. Predicted tag numbers from the GAM fit to Chesapeake Bay tag returns by disposition.

Year	Comm Killed	Comm Released	Rec Killed	Rec Released
1990	215.1	629.2	371.5	936.2
1991	207.8	511.9	591.8	979.3
1992	205.0	419.2	842.6	969.5
1993	206.3	347.6	1029.0	898.5
1994	221.3	288.6	1108.3	794.9
1995	278.8	238.4	1082.4	686.8
1996	400.5	199.3	986.0	591.6
1997	539.5	171.7	876.1	511.9
1998	594.7	152.8	772.1	446.8
1999	537.3	138.9	678.6	398.3
2000	414.9	124.7	619.7	362.4
2001	308.9	106.5	595.4	329.9
2002	254.0	86.2	570.6	296.0
2003	218.9	66.5	525.5	259.4
2004	170.8	48.1	461.3	219.9
2005	120.0	32.1	378.8	180.1
2006	83.5	20.3	296.8	141.2
2007	60.5	13.1	239.1	105.5
2008	44.6	9.0	204.6	77.5
2009	32.3	6.8	177.8	59.0
2010	23.8	5.5	152.3	47.8
2011	19.2	4.8	136.8	41.4
2012	17.3	4.3	136.9	38.6
2013	17.6	3.9	142.7	39.2
2014	19.5	3.8	138.3	43.0
2015	21.8	3.7	128.0	50.3
2016	23.3	3.8	126.3	60.6
2017	24.7	4.1	135.5	73.2

Table B6.7. Estimates of unscaled commercial total discards (numbers of fish) by year for Chesapeake Bay.

Year	Number
1990	558,168
1991	1,538,554
1992	3,438,837
1993	4,646,049
1994	4,184,633
1995	2,847,613
1996	3,336,623
1997	3,729,744
1998	2,364,229
1999	2,795,206
2000	2,744,379
2001	2,085,072
2002	2,790,765
2003	2,681,484
2004	3,486,128
2005	3,116,813
2006	2,493,946
2007	1,838,920
2008	1,452,759
2009	1,402,585
2010	2,433,416
2011	1,628,076
2012	5,479,817
2013	2,346,792
2014	1,935,558
2015	1,683,565
2016	1,510,643
2017	1,052,849

Table B6.8. The number of tags returns from Chesapeake Bay by year and commercial gear.

Year	Anchor	Drift	Hook	Other	Pound	Seine	Total
1990	132	31	13	9	731	3	919
1991	311	55	10	15	390	1	782
1992	231	81	8	20	128	2	470
1993	102	95	11	5	489	16	718
1994	75	53	10	5	404	18	565
1995	68	32	11	4	393	7	515
1996	178	46	14	1	323	5	567
1997	176	74	46	7	464	24	791
1998	94	51	26	4	534	26	735
1999	70	24	40	2	614	5	755
2000	64	33	27	3	593	0	720
2001	76	27	32	1	289	5	430
2002	29	10	11	0	135	0	185
2003	47	12	16	1	356	0	432
2004	40	31	28	1	238	0	338
2005	33	9	5	1	124	2	174
2006	27	8	11	1	60	0	107
2007	26	14	6	2	12	0	60
2008	16	19	10	0	7	0	52
2009	28	2	7	2	11	0	50
2010	9	1	5	1	6	0	22
2011	9	4	6	0	8	0	27
2012	7	3	13	0	2	0	25
2013	4	2	6	2	2	0	16
2014	10	7	4	0	4	1	26
2015	13	7	6	0	4	0	30
2016	9	1	5	2	4	0	21
2017	7	13	3	0	9	0	32

Table B6.9. Unscaled commercial total discards for Chesapeake Bay apportioned by gear

Year	Anchor	Drift	Hook	Other	Pound	Seine	Total
1990	80,172	18,828	7,896	5,466	443,984	1,822	558,168
1991	611,880	108,210	19,675	29,512	767,309	1,967	1,538,554
1992	1,690,152	592,651	58,533	146,333	936,534	14,633	3,438,837
1993	660,024	614,728	71,179	32,354	3,164,231	103,533	4,646,049
1994	555,482	392,541	74,064	37,032	2,992,198	133,316	4,184,633
1995	375,996	176,939	60,823	22,117	2,173,033	38,705	2,847,613
1996	1,047,476	270,696	82,386	5,885	1,900,757	29,423	3,336,623
1997	829,880	348,927	216,900	33,007	2,187,865	113,165	3,729,744
1998	302,364	164,049	83,633	12,867	1,717,684	83,633	2,364,229
1999	259,158	88,854	148,090	7,405	2,273,187	18,511	2,795,206
2000	243,945	125,784	102,914	11,435	2,260,301	0	2,744,379
2001	368,524	130,923	155,168	4,849	1,401,362	24,245	2,085,072
2002	437,471	150,852	165,937	0	2,036,504	0	2,790,765
2003	291,736	74,486	99,314	6,207	2,209,742	0	2,681,484
2004	412,560	319,734	288,792	10,314	2,454,729	0	3,486,128
2005	591,120	161,214	89,564	17,913	2,221,177	35,825	3,116,813
2006	629,314	186,463	256,387	23,308	1,398,475	0	2,493,946
2007	796,865	429,081	183,892	61,297	367,784	0	1,838,920
2008	447,003	530,816	279,377	0	195,564	0	1,452,759
2009	785,448	56,103	196,362	56,103	308,569	0	1,402,585
2010	995,488	110,610	553,049	110,610	663,659	0	2,433,416
2011	542,692	241,196	361,795	0	482,393	0	1,628,076
2012	1,534,349	657,578	2,849,505	0	438,385	0	5,479,817
2013	586,698	293,349	880,047	293,349	293,349	0	2,346,792
2014	744,445	521,112	297,778	0	297,778	74,445	1,935,558
2015	729,545	392,832	336,713	0	224,475	0	1,683,565
2016	647,418	71,935	359,677	143,871	287,741	0	1,510,643
2017	230,311	427,720	98,705	0	296,114	0	1,052,849

Table B6.10. Unscaled commercial dead discards for Chesapeake Bay by year and gear

year	anchor	drift	hook	other	pound	seine	total
1990	36,077	1,130	711	1,093	13,320	292	52,622
1991	275,346	6,493	1,771	5,902	23,019	315	312,846
1992	760,568	35,559	5,268	29,267	28,096	2,341	861,099
1993	297,011	36,884	6,406	6,471	94,927	16,565	458,264
1994	249,967	23,552	6,666	7,406	89,766	21,331	398,688
1995	169,198	10,616	5,474	4,423	65,191	6,193	261,096
1996	471,364	16,242	7,415	1,177	57,023	4,708	557,928
1997	373,446	20,936	19,521	6,601	65,636	18,106	504,246
1998	136,064	9,843	7,527	2,573	51,531	13,381	220,919
1999	116,621	5,331	13,328	1,481	68,196	2,962	207,919
2000	109,775	7,547	9,262	2,287	67,809	0	196,681
2001	165,836	7,855	13,965	970	42,041	3,879	234,546
2002	196,862	9,051	14,934	0	61,095	0	281,943
2003	131,281	4,469	8,938	1,241	66,292	0	212,222
2004	185,652	19,184	25,991	2,063	73,642	0	306,532
2005	266,004	9,673	8,061	3,583	66,635	5,732	359,687
2006	283,191	11,188	23,075	4,662	41,954	0	364,070
2007	358,589	25,745	16,550	12,259	11,034	0	424,177
2008	201,151	31,849	25,144	0	5,867	0	264,011
2009	353,451	3,366	17,673	11,221	9,257	0	394,968
2010	447,970	6,637	49,774	22,122	19,910	0	546,412
2011	244,211	14,472	32,562	0	14,472	0	305,716
2012	690,457	39,455	256,455	0	13,152	0	999,519
2013	264,014	17,601	79,204	58,670	8,800	0	428,289
2014	335,000	31,267	26,800	0	8,933	11,911	413,912
2015	328,295	23,570	30,304	0	6,734	0	388,903
2016	291,338	4,316	32,371	28,774	8,632	0	365,432
2017	103,640	25,663	8,883	0	8,883	0	147,070

Table B6.11. Unscaled commercial dead discards for Chesapeake Bay by year and age.

	Age																
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1982	0	0	12,610	1,139	1,036	2	26	21	15	7	1	1	0	0	0	0	14,856
1983	0	0	40,700	2,927	3	0	0	0	0	0	0	0	0	0	0	0	43,630
1984	0	0	17,551	2,001	0	0	0	0	0	0	0	0	0	0	0	0	19,552
1985	0	0	3,790	19,163	199	14	0	0	0	0	0	0	0	0	0	0	23,166
1986	0	0	3,000	5,645	20,222	3,917	1	0	0	0	0	0	0	0	0	0	32,784
1987	0	8	899	794	6,633	6,669	1,925	11	0	0	0	0	0	0	0	0	16,940
1988	0	18	2,666	10,190	10,620	7,239	5,340	51	0	0	0	0	0	0	0	0	36,123
1989	0	28	3,594	17,501	16,297	10,668	5,559	1,501	0	0	0	0	0	0	0	0	55,149
1990	0	45	1,483	5,374	13,497	13,468	11,399	6,333	942	61	14	4	2	0	0	0	52,622
1991	0	401	6,324	32,742	107,225	83,963	54,432	23,587	3,535	488	107	32	10	0	0	0	312,846
1992	0	358	7,430	72,356	274,138	231,781	170,083	79,941	22,308	1,871	599	203	30	0	0	0	861,099
1993	0	793	23,122	37,249	64,042	170,092	103,137	38,907	15,202	3,399	1,737	492	72	19	0	0	458,264
1994	0	0	32,911	30,986	79,125	160,940	66,819	14,818	9,372	2,658	713	169	173	5	0	0	398,688
1995	0	196	40,850	73,047	41,771	52,170	38,788	10,577	2,019	882	422	305	65	3	0	0	261,096
1996	0	167	51,603	223,832	116,765	66,483	34,077	22,051	11,311	11,080	11,956	6,483	1,135	983	0	0	557,928
1997	0	150	9,432	125,240	191,334	106,360	42,249	16,423	7,112	2,376	1,616	1,240	412	300	0	0	504,246
1998	0	5	99	17,178	83,377	55,940	27,929	12,010	8,294	5,254	3,005	2,716	1,686	2,363	449	614	220,919
1999	0	576	26,556	69,347	41,901	31,842	14,021	8,497	6,304	3,482	2,459	1,077	1,358	499	0	0	207,919
2000	0	46	28,936	55,784	63,372	26,006	9,976	5,742	3,290	1,601	1,323	324	252	13	6	10	196,681
2001	0	1	1,630	35,784	87,577	68,989	13,119	8,473	6,521	5,272	4,288	1,782	736	262	112	0	234,546
2002	0	2,994	36,102	71,784	35,465	45,932	39,479	21,252	12,044	9,850	3,835	2,505	261	295	65	79	281,943
2003	0	483	4,101	27,034	57,350	53,054	14,267	15,765	10,252	10,379	8,982	5,794	1,979	2,260	379	142	212,222
2004	0	3,574	53,356	75,648	62,421	36,579	23,279	24,945	11,485	7,200	3,555	3,622	447	248	173	0	306,532
2005	0	0	3,336	53,707	123,590	81,476	29,214	20,660	15,389	14,635	6,401	5,308	3,223	1,676	597	478	359,687
2006	0	0	1,692	85,900	101,686	88,931	29,515	12,133	10,712	9,834	12,477	2,975	3,555	2,677	402	1,581	364,070
2007	0	0	3,710	93,510	146,226	58,669	40,896	20,249	13,886	15,256	13,295	9,290	1,311	3,182	2,423	2,273	424,177
2008	0	0	1,207	37,225	82,536	63,622	20,637	15,494	10,165	5,758	9,498	8,100	7,351	1,529	318	571	264,011
2009	0	0	1,153	60,698	125,154	87,176	44,455	13,525	16,622	10,625	9,899	9,924	3,887	8,433	735	2,683	394,968
2010	0	0	3,574	42,643	222,430	156,125	56,980	18,090	11,466	7,443	6,895	4,314	3,414	6,516	3,578	2,944	546,412
2011	0	0	2,039	35,832	62,716	72,967	39,325	21,056	17,401	12,968	10,900	5,984	5,372	5,022	4,847	9,288	305,716
2012	0	0	9,841	122,886	266,171	267,106	123,160	76,665	27,235	27,019	21,019	13,452	8,828	1,866	5,601	28,670	999,519
2013	0	0	4,646	70,827	113,633	93,442	47,382	23,812	13,710	9,937	13,581	5,935	10,009	9,736	1,838	9,803	428,289
2014	0	0	0	19,029	50,742	105,444	78,603	64,406	24,964	20,109	22,920	14,727	2,423	3,068	2,128	5,349	413,912
2015	0	0	0	12,581	136,041	69,056	30,642	21,013	19,510	16,620	18,758	20,040	26,167	6,257	3,038	9,181	388,903
2016	0	0	309	23,179	58,034	113,158	34,625	30,591	18,376	15,832	12,224	19,705	17,187	13,767	4,025	4,419	365,432
2017	0	0	82	9,108	44,728	15,194	32,295	12,289	10,172	4,166	4,287	3,380	4,832	2,910	2,665	964	147,070

Table B6.12. Scaled commercial dead discards for Chesapeake Bay by year and age.

	Age																
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1982	0	0	12,610	1,139	1,036	2	26	21	15	7	1	1	0	0	0	0	14,856
1983	0	0	40,700	2,927	3	0	0	0	0	0	0	0	0	0	0	0	43,630
1984	0	0	17,551	2,001	0	0	0	0	0	0	0	0	0	0	0	0	19,552
1985	0	0	3,790	19,163	199	14	0	0	0	0	0	0	0	0	0	0	23,166
1986	0	0	3,000	5,645	20,222	3,917	1	0	0	0	0	0	0	0	0	0	32,784
1987	0	8	899	794	6,633	6,669	1,925	11	0	0	0	0	0	0	0	0	16,940
1988	0	18	2,666	10,190	10,620	7,239	5,340	51	0	0	0	0	0	0	0	0	36,123
1989	0	28	3,594	17,501	16,297	10,668	5,559	1,501	0	0	0	0	0	0	0	0	55,149
1990	0	7	243	880	2,211	2,206	1,867	1,037	154	10	2	1	0	0	0	0	8,620
1991	0	66	1,036	5,364	17,565	13,755	8,917	3,864	579	80	18	5	2	0	0	0	51,250
1992	0	59	1,217	11,853	44,909	37,970	27,863	13,096	3,654	306	98	33	5	0	0	0	141,064
1993	0	130	3,788	6,102	10,491	27,864	16,896	6,374	2,490	557	285	81	12	3	0	0	75,072
1994	0	0	5,392	5,076	12,962	26,365	10,946	2,427	1,535	435	117	28	28	1	0	0	65,313
1995	0	32	6,692	11,967	6,843	8,546	6,354	1,733	331	145	69	50	11	0	0	0	42,772
1996	0	27	8,454	36,668	19,128	10,891	5,583	3,612	1,853	1,815	1,959	1,062	186	161	0	0	91,399
1997	0	25	1,545	20,517	31,344	17,424	6,921	2,690	1,165	389	265	203	67	49	0	0	82,605
1998	0	1	16	2,814	13,659	9,164	4,575	1,967	1,359	861	492	445	276	387	74	101	36,191
1999	0	94	4,350	11,360	6,864	5,216	2,297	1,392	1,033	570	403	176	222	82	0	0	34,061
2000	0	8	4,740	9,138	10,382	4,260	1,634	941	539	262	217	53	41	2	1	2	32,220
2001	0	0	267	5,862	14,347	11,302	2,149	1,388	1,068	864	702	292	121	43	18	0	38,423
2002	0	491	5,914	11,760	5,810	7,524	6,467	3,481	1,973	1,614	628	410	43	48	11	13	46,188
2003	0	79	672	4,429	9,395	8,691	2,337	2,583	1,680	1,700	1,471	949	324	370	62	23	34,766
2004	0	585	8,741	12,393	10,226	5,992	3,814	4,086	1,881	1,180	582	593	73	41	28	0	50,216
2005	0	0	547	8,798	20,246	13,347	4,786	3,384	2,521	2,397	1,049	870	528	274	98	78	58,924
2006	0	0	277	14,072	16,658	14,569	4,835	1,988	1,755	1,611	2,044	487	582	439	66	259	59,641
2007	0	0	608	15,319	23,955	9,611	6,700	3,317	2,275	2,499	2,178	1,522	215	521	397	372	69,488
2008	0	0	198	6,098	13,521	10,423	3,381	2,538	1,665	943	1,556	1,327	1,204	250	52	94	43,250
2009	0	0	189	9,943	20,503	14,281	7,282	2,216	2,723	1,741	1,622	1,626	637	1,382	120	440	64,703
2010	0	0	585	6,986	36,438	25,576	9,334	2,963	1,878	1,219	1,130	707	559	1,067	586	482	89,513
2011	0	0	334	5,870	10,274	11,953	6,442	3,449	2,851	2,124	1,786	980	880	823	794	1,522	50,082
2012	0	0	1,612	20,131	43,604	43,757	20,176	12,559	4,462	4,426	3,443	2,204	1,446	306	918	4,697	163,740
2013	0	0	761	11,603	18,615	15,308	7,762	3,901	2,246	1,628	2,225	972	1,640	1,595	301	1,606	70,162
2014	0	0	0	3,117	8,313	17,274	12,877	10,551	4,090	3,294	3,755	2,413	397	503	349	876	67,807
2015	0	0	0	2,061	22,286	11,313	5,020	3,442	3,196	2,723	3,073	3,283	4,287	1,025	498	1,504	63,710
2016	0	0	51	3,797	9,507	18,537	5,672	5,011	3,010	2,594	2,003	3,228	2,815	2,255	659	724	59,865
2017	0	0	13	1,492	7,327	2,489	5,291	2,013	1,666	682	702	554	792	477	437	158	24,093

Table B6.13. Number of tags by disposition and commercial harvest and releases estimates used to calculate commercial discards for the ocean.

					New MRIP							
					Commercial	Recreational	Recreational					Unadjusted
Year	Comm Killed	Comm Released	Rec Killed	Rec Released	Harvest	Harvest	Releases	LR	KT	CT/RT	CF	Total Discards
1990	13	63	165	984	25,290	202,532	2,976,214	0.1249	0.0788	0.0640	1.5849	301,994
1991	28	60	255	785	35,705	396,348	4,433,364	0.0901	0.1098	0.0764	0.8204	278,006
1992	39	36	298	773	47,716	477,534	6,587,374	0.0999	0.1309	0.0466	0.7635	234,233
1993	47	46	390	792	36,933	423,208	5,779,901	0.0873	0.1205	0.0581	0.7241	243,096
1994	28	27	322	911	41,277	474,094	10,027,897	0.0871	0.0870	0.0296	1.0013	297,576
1995	54	21	539	744	138,434	1,084,510	16,093,577	0.1276	0.1002	0.0282	1.2741	578,765
1996	37	78	739	963	131,369	1,268,534	21,831,887	0.1036	0.0501	0.0810	2.0684	3,657,573
1997	62	45	767	686	151,464	1,464,866	22,248,787	0.1034	0.0808	0.0656	1.2791	1,866,849
1998	68	22	719	638	179,115	1,561,869	28,456,680	0.1147	0.0946	0.0345	1.2126	1,189,851
1999	61	15	547	510	219,427	1,614,780	25,426,851	0.1359	0.1115	0.0294	1.2185	911,271
2000	44	35	456	559	229,210	1,923,986	24,546,001	0.1191	0.0965	0.0626	1.2346	1,897,492
2001	53	21	627	602	221,692	2,449,329	20,547,075	0.0905	0.0845	0.0349	1.0708	767,481
2002	45	25	595	559	192,602	2,487,808	23,130,298	0.0774	0.0756	0.0447	1.0236	1,058,909
2003	32	11	733	618	180,864	2,861,203	19,953,425	0.0632	0.0437	0.0178	1.4480	514,257
2004	68	24	710	589	204,612	2,839,900	27,117,501	0.0720	0.0958	0.0407	0.7523	831,233
2005	54	17	589	560	190,626	2,923,559	27,663,804	0.0652	0.0917	0.0304	0.7112	597,262
2006	43	14	630	555	185,656	2,535,626	40,181,707	0.0732	0.0683	0.0252	1.0727	1,087,322
2007	29	17	555	415	189,574	2,139,285	23,774,366	0.0886	0.0523	0.0410	1.6959	1,651,639
2008	55	6	541	355	188,848	2,807,578	20,783,249	0.0673	0.1017	0.0169	0.6616	232,408
2009	49	8	468	347	192,419	2,589,584	15,812,661	0.0743	0.1047	0.0231	0.7097	258,722
2010	32	5	510	273	187,187	3,622,452	13,025,310	0.0517	0.0627	0.0183	0.8236	196,467
2011	29	8	421	189	183,977	3,330,997	11,941,641	0.0552	0.0689	0.0423	0.8018	405,289
2012	31	10	302	131	159,143	2,850,682	10,635,561	0.0558	0.1026	0.0763	0.5439	441,544
2013	43	13	348	159	164,309	3,347,768	18,509,785	0.0491	0.1236	0.0818	0.3972	601,125
2014	24	3	270	94	138,948	2,133,709	14,129,123	0.0651	0.0889	0.0319	0.7326	330,352
2015	26	6	231	128	107,977	1,619,083	14,803,506	0.0667	0.1126	0.0469	0.5925	411,155
2016	33	4	270	119	118,136	1,657,194	17,350,595	0.0713	0.1222	0.0336	0.5833	340,162
2017	31	4	278	124	124,032	1,568,681	28,397,719	0.0791	0.1115	0.0323	0.7091	649,537

					Old MRIP							
					Commercial	Recreational	Recreational					Unadjusted
Year	CommK	CommR	RecK	RecR	Harvest	Harvest	Releases	LR	KT	CT/RT	CF	Total Discards
1990	13	63	165	984	24,678	93,709	1,003,326	0.2633	0.0788	0.0640	3.3425	214,710
1991	28	60	255	785	34,946	130,931	1,767,284	0.2669	0.1098	0.0764	2.4307	328,336
1992	39	36	298	773	47,831	167,365	2,396,563	0.2858	0.1309	0.0466	2.1837	243,729
1993	47	46	390	792	36,752	234,778	2,567,873	0.1565	0.1205	0.0581	1.2989	193,728
1994	28	27	322	911	42,226	226,455	4,759,563	0.1865	0.0870	0.0296	2.1444	302,490
1995	54	21	539	744	143,535	524,118	6,838,334	0.2739	0.1002	0.0282	2.7335	527,619
1996	37	78	739	963	131,596	608,424	8,996,683	0.2163	0.0501	0.0810	4.3199	3,147,960
1997	62	45	767	686	152,287	833,089	10,527,112	0.1828	0.0808	0.0656	2.2614	1,561,611
1998	68	22	719	638	178,153	700,506	11,376,812	0.2543	0.0946	0.0345	2.6891	1,054,929
1999	61	15	547	510	216,515	706,473	8,985,309	0.3065	0.1115	0.0294	2.7482	726,281
2000	44	35	456	559	227,388	1,044,268	12,436,023	0.2177	0.0965	0.0626	2.2567	1,757,141
2001	53	21	627	602	216,149	1,193,280	9,800,153	0.1811	0.0845	0.0349	2.1429	732,585
2002	45	25	595	559	191,748	1,140,165	9,964,368	0.1682	0.0756	0.0447	2.2237	990,937
2003	32	11	733	618	185,773	1,408,927	8,758,101	0.1319	0.0437	0.0178	3.0203	470,829
2004	68	24	710	589	207,559	1,584,270	11,561,379	0.1310	0.0958	0.0407	1.3679	644,418
2005	54	17	589	560	195,412	1,534,056	12,600,720	0.1274	0.0917	0.0304	1.3894	531,480
2006	43	14	630	555	190,187	1,541,808	17,644,390	0.1234	0.0683	0.0252	1.8073	804,385
2007	29	17	555	415	192,764	1,346,144	11,677,751	0.1432	0.0523	0.0410	2.7405	1,310,958
2008	55	6	541	355	193,090	1,622,835	10,237,509	0.1190	0.1017	0.0169	1.1704	202,505
2009	49	8	468	347	196,860	1,137,632	5,988,532	0.1730	0.1047	0.0231	1.6527	228,184
2010	32	5	511	273	191,590	1,355,994	4,462,445	0.1413	0.0626	0.0183	2.2562	184,402
2011	29	8	421	189	188,540	1,553,363	4,424,993	0.1214	0.0689	0.0423	1.7620	330,031
2012	31	10	302	131	163,788	1,085,364	2,715,914	0.1509	0.1026	0.0763	1.4701	304,787
2013	43	13	348	159	168,313	1,505,499	5,704,753	0.1118	0.1236	0.0818	0.9048	422,019
2014	24	3	270	95	141,565	1,059,339	4,248,782	0.1336	0.0889	0.0316	1.5034	201,713
2015	26	6	231	128	108,960	665,644	4,337,197	0.1637	0.1126	0.0469	1.4543	295,675

LR=ratio of commercial landings to recreational harvest; KT=ratio of tags returned from commercially harvested fish to tags returned from recreationally harvested fish; CT = number of tags returned from discarded fish by commercial fishers; RT = number of tags returned from discarded fish by recreational anglers; CF=LR/KT.

Table B6.14. Predicted tag numbers from the GAM fit to Ocean tag returns by disposition.

Year	Comm Killed	Comm Released	Rec Killed	Rec Released
1990	21.5	60.0	173.0	904.0
1991	25.5	54.4	238.2	851.4
1992	30.0	49.4	304.5	824.0
1993	34.6	44.8	346.4	821.6
1994	39.2	40.6	399.9	825.3
1995	43.5	36.8	523.6	814.6
1996	47.4	33.4	683.4	776.5
1997	50.4	30.3	751.6	710.3
1998	52.4	27.5	681.0	638.5
1999	53.2	24.9	568.6	589.4
2000	52.9	22.6	523.7	571.0
2001	52.0	20.5	562.9	573.3
2002	50.8	18.6	634.2	583.8
2003	49.4	16.9	686.1	591.4
2004	48.0	15.3	686.0	585.0
2005	46.3	13.9	639.5	558.0
2006	44.5	12.6	599.8	508.9
2007	42.6	11.4	569.6	444.3
2008	40.7	10.4	528.5	377.1
2009	38.7	9.4	500.9	312.1
2010	36.7	8.5	471.0	249.0
2011	34.9	7.7	406.0	194.7
2012	33.4	7.0	346.1	156.7
2013	32.1	6.4	308.6	133.4
2014	30.9	5.8	272.7	120.7
2015	30.0	5.2	251.7	116.5
2016	29.2	4.7	258.5	117.5
2017	28.6	4.3	276.4	119.7

Table B6.15. Estimates of commercial total discards (numbers of fish) by year for Ocean region.

Year	Number
1990	198,674
1991	238,536
1992	400,710
1993	275,054
1994	438,360
1995	1,117,315
1996	1,403,636
1997	1,463,037
1998	1,825,262
1999	1,562,572
2000	1,145,702
2001	719,481
2002	712,351
2003	499,420
2004	730,232
2005	618,845
2006	981,249
2007	724,449
2008	498,916
2009	457,432
2010	295,201
2011	304,033
2012	275,118
2013	416,634
2014	387,344
2015	371,743
2016	441,303
2017	780,489

Table B6.16. The number of tags returns from Ocean by year and commercial gear.

Year	Anchor	Drift	Hook	Other	Pound	Seine	Trawl	Total
1990	22	2	24	1	20	3	4	76
1991	14	1	45	2	14	1	11	88
1992	10	4	38	2	13	6	2	75
1993	11	4	36	5	20	6	11	93
1994	13	0	23	3	4	4	8	55
1995	8	6	41	1	12	4	3	75
1996	12	2	44	2	47	2	6	115
1997	13	7	67	1	2	3	14	107
1998	16	7	50	1	8	1	7	90
1999	20	3	52	1	0	0	0	76
2000	7	5	45	2	6	1	13	79
2001	18	2	42	2	5	0	5	74
2002	18	6	36	4	0	1	5	70
2003	11	1	26	0	3	0	2	43
2004	11	2	62	0	7	0	10	92
2005	7	9	35	1	9	6	4	71
2006	1	6	38	1	7	0	4	57
2007	0	3	26	0	5	0	12	46
2008	4	1	39	0	10	0	7	61
2009	5	1	41	0	4	0	6	57
2010	4	2	24	0	4	0	3	37
2011	2	1	27	1	4	0	2	37
2012	0	2	34	3	2	0	0	41
2013	0	1	50	2	1	0	2	56
2014	1	1	20	2	0	0	3	27
2015	0	2	21	1	5	0	3	32
2016	1	1	33	0	1	0	1	37
2017	0	0	30	1	2	0	2	35

Table B6.17. Commercial total discards for Ocean apportioned to gear.

Year	Anchor	Drift	Hook	Other	Pound	Seine	Trawl	Total
1990	57,511	5,228	62,739	2,614	52,283	7,842	10,457	198,674
1991	37,949	2,711	121,979	5,421	37,949	2,711	29,817	238,536
1992	53,428	21,371	203,026	10,686	69,456	32,057	10,686	400,710
1993	32,533	11,830	106,473	14,788	59,151	17,745	32,533	275,054
1994	103,612	0	183,314	23,911	31,881	31,881	63,761	438,360
1995	119,180	89,385	610,799	14,898	178,770	59,590	44,693	1,117,315
1996	146,466	24,411	537,043	24,411	573,660	24,411	73,233	1,403,636
1997	177,752	95,713	916,107	13,673	27,346	41,020	191,425	1,463,037
1998	324,491	141,965	1,014,034	20,281	162,245	20,281	141,965	1,825,262
1999	411,203	61,680	1,069,128	20,560	0	0	0	1,562,572
2000	101,518	72,513	652,615	29,005	87,015	14,503	188,533	1,145,702
2001	175,009	19,445	408,354	19,445	48,614	0	48,614	719,481
2002	183,176	61,059	366,352	40,706	0	10,176	50,882	712,351
2003	127,759	11,614	301,975	0	34,843	0	23,229	499,420
2004	87,310	15,875	492,113	0	55,561	0	79,373	730,232
2005	61,013	78,445	305,065	8,716	78,445	52,297	34,865	618,845
2006	17,215	103,289	654,166	17,215	120,504	0	68,860	981,249
2007	0	47,247	409,471	0	78,744	0	188,987	724,449
2008	32,716	8,179	318,979	0	81,789	0	57,253	498,916
2009	40,126	8,025	329,030	0	32,100	0	48,151	457,432
2010	31,914	15,957	191,482	0	31,914	0	23,935	295,201
2011	16,434	8,217	221,862	8,217	32,868	0	16,434	304,033
2012	0	13,420	228,147	20,131	13,420	0	0	275,118
2013	0	7,440	371,995	14,880	7,440	0	14,880	416,634
2014	14,346	14,346	286,921	28,692	0	0	43,038	387,344
2015	0	23,234	243,956	11,617	58,085	0	34,851	371,743
2016	11,927	11,927	393,595	0	11,927	0	11,927	441,303
2017	21,094	21,094	632,829	21,094	42,189	0	42,189	780,489

Table B6.18. Commercial dead discards for Ocean by year and gear.

Year	Anchor	Drift	Hook	Other	Pound	Seine	Trawl	Total
1990	25,880	314	5,647	523	1,568	1,255	2,719	37,905
1991	17,077	163	10,978	1,084	1,138	434	7,752	38,627
1992	24,043	1,282	18,272	2,137	2,084	5,129	2,778	55,725
1993	14,640	710	9,583	2,958	1,775	2,839	8,459	40,962
1994	46,626	0	16,498	4,782	956	5,101	16,578	90,541
1995	53,631	5,363	54,972	2,980	5,363	9,534	11,620	143,463
1996	65,910	1,465	48,334	4,882	17,210	3,906	19,041	160,747
1997	79,988	5,743	82,450	2,735	820	6,563	49,771	228,070
1998	146,021	8,518	91,263	4,056	4,867	3,245	36,911	294,881
1999	185,041	3,701	96,222	4,112	0	0	0	289,076
2000	45,683	4,351	58,735	5,801	2,610	2,320	49,019	168,520
2001	78,754	1,167	36,752	3,889	1,458	0	12,640	134,660
2002	82,429	3,664	32,972	8,141	0	1,628	13,229	142,063
2003	57,491	697	27,178	0	1,045	0	6,040	92,451
2004	39,290	952	44,290	0	1,667	0	20,637	106,836
2005	27,456	4,707	27,456	1,743	2,353	8,367	9,065	81,147
2006	7,747	6,197	58,875	3,443	3,615	0	17,903	97,781
2007	0	2,835	36,852	0	2,362	0	49,137	91,186
2008	14,722	491	28,708	0	2,454	0	14,886	61,260
2009	18,057	482	29,613	0	963	0	12,519	61,633
2010	14,361	957	17,233	0	957	0	6,223	39,732
2011	7,395	493	19,968	1,643	986	0	4,273	34,758
2012	0	805	20,533	4,026	403	0	0	25,767
2013	0	446	33,480	2,976	223	0	3,869	40,994
2014	6,456	861	25,823	5,738	0	0	11,190	50,068
2015	0	1,394	21,956	2,323	1,743	0	9,061	36,477
2016	5,367	716	35,424	0	358	0	3,101	44,965
2017	9,492	1,266	56,955	4,219	1,266	0	10,969	84,166

Table B6.19. Commercial dead discards for Ocean by year and age.

	Age															
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1982	0	1	8,749	2,936	3,942	912	290	193	118	110	84	107	181	116	144	413	18,296
1983	0	0	2,322	554	659	368	95	21	17	11	12	16	27	46	31	83	4,260
1984	0	0	2,869	456	706	513	337	95	37	18	10	6	8	18	63	140	5,275
1985	0	0	808	3,534	758	652	250	122	37	12	17	20	16	6	55	88	6,376
1986	0	0	96	1,373	4,388	1,354	305	118	114	47	12	12	31	25	27	200	8,104
1987	0	0	184	961	4,621	5,071	1,513	230	84	44	7	7	7	8	16	49	12,802
1988	0	0	1,846	3,981	4,870	4,141	2,864	304	169	50	19	6	2	15	10	34	18,313
1989	0	0	3,055	8,937	7,857	6,085	3,623	1,815	389	166	118	23	15	21	22	76	32,202
1990	0	0	448	3,957	10,683	9,490	7,148	3,906	1,626	403	174	27	3	8	6	25	37,905
1991	0	17	1,619	4,107	12,411	9,155	5,066	3,562	1,366	973	154	60	24	2	20	91	38,627
1992	0	4	856	6,027	13,076	12,064	8,506	5,586	5,619	2,518	1,025	111	85	20	47	181	55,725
1993	0	0	1,228	2,965	5,375	10,409	7,598	4,057	3,611	3,161	1,698	609	132	25	18	76	40,962
1994	0	0	3,137	5,616	13,265	28,906	15,346	6,357	6,569	5,449	3,364	1,268	605	125	96	438	90,541
1995	0	0	43,778	27,958	14,725	16,968	14,860	6,652	4,552	5,636	4,114	2,140	1,206	525	151	199	143,463
1996	0	0	9,171	50,065	17,660	13,368	14,950	22,064	13,523	9,352	5,246	2,459	2,142	325	129	294	160,747
1997	0	0	3,402	18,809	40,512	25,496	17,953	15,919	31,425	21,836	19,955	15,538	8,777	4,716	2,249	1,484	228,070
1998	0	0	1,944	19,632	64,572	43,312	32,625	24,692	30,332	31,771	19,008	13,966	6,019	3,729	1,441	1,838	294,881
1999	0	0	21,921	79,475	38,508	39,605	37,388	26,431	20,601	11,782	6,746	2,542	2,692	862	137	386	289,076
2000	0	0	2,003	14,349	33,099	23,125	24,038	42,495	15,920	6,124	4,122	2,451	513	116	100	65	168,520
2001	0	0	660	7,119	27,419	31,975	30,146	13,974	14,137	5,482	1,628	1,341	442	259	67	11	134,660
2002	0	0	1,516	2,735	7,757	21,847	21,866	21,152	18,745	15,950	17,885	5,919	2,961	3,525	144	62	142,063
2003	122	591	3,111	3,522	4,270	7,682	9,058	24,232	13,781	9,381	7,146	3,068	2,116	1,362	359	2,650	92,451
2004	0	18	963	4,167	7,148	10,486	16,446	18,469	24,545	13,033	4,555	4,761	1,499	125	608	13	106,836
2005	0	157	3,102	7,070	7,614	12,945	11,744	12,129	8,596	8,406	5,367	2,475	569	616	289	68	81,147
2006	0	0	120	2,510	2,121	15,738	19,266	12,783	14,898	9,743	8,654	6,131	2,588	2,916	202	111	97,781
2007	0	46	1,231	3,763	12,654	17,434	22,792	12,733	8,261	5,205	3,009	1,574	1,661	764	46	12	91,186
2008	0	0	82	828	2,322	13,192	9,942	15,862	7,803	4,145	2,174	1,904	1,461	1,027	363	155	61,260
2009	0	0	108	463	1,654	4,710	21,739	8,736	12,250	4,714	1,927	1,868	1,712	1,129	429	194	61,633
2010	0	0	74	640	981	2,516	7,194	13,896	4,618	4,720	2,325	999	800	510	403	56	39,732
2011	0	0	252	619	1,550	2,456	5,770	7,700	7,344	2,729	2,990	1,205	637	611	433	463	34,758
2012	0	0	194	1,024	1,815	3,721	5,388	5,397	4,066	2,434	555	388	240	209	185	152	25,767
2013	0	0	248	1,353	2,707	4,578	10,076	6,911	6,290	4,799	2,825	391	333	182	101	199	40,994
2014	0	0	28	924	3,049	6,397	8,557	12,253	5,808	4,379	3,665	2,638	783	613	219	755	50,068
2015	0	0	5	175	1,676	5,884	8,326	6,615	4,242	3,258	2,776	1,787	1,028	261	169	274	36,477
2016	0	0	683	707	955	9,553	14,039	6,250	3,305	1,795	1,724	1,667	1,245	1,350	359	1,333	44,965
2017	0	0	972	2,017	2,416	11,936	28,295	16,310	5,711	2,335	3,958	2,052	2,830	1,953	1,412	1,970	84,166

Table B6.20. Number of tags by disposition and commercial harvest and releases estimates used to calculate commercial discards for Delaware Bay.

New MRIP

Year	Comm Killed	Comm Released	Rec Killed	Rec Released	Commercial Harvest	Recreational Harvest	Recreational Releases	LR	KT	CT/RT	CF	Unadjusted Total Discards
1990	1	30	2	46	647	32,252	118,286	0.0201	0.5000	0.6522	0.0401	3,096
1991	3	27	2	42	2,751	35,324	250,683	0.0779	1.5000	0.6429	0.0519	8,367
1992	2	14	2	19	2,496	39,888	344,682	0.0626	1.0000	0.7368	0.0626	15,892
1993	9	21	9	56	3,918	33,958	314,877	0.1154	1.0000	0.3750	0.1154	13,623
1994	3	15	20	59	4,458	24,445	422,025	0.1824	0.1500	0.2542	1.2158	130,451
1995	5	12	35	68	4,962	175,331	493,262	0.0283	0.1429	0.1765	0.1981	17,245
1996	15	15	65	91	19,514	95,448	648,302	0.2044	0.2308	0.1648	0.8859	94,672
1997	14	10	46	52	30,128	62,420	669,636	0.4827	0.3043	0.1923	1.5859	204,226
1998	11	3	65	69	28,497	94,134	962,491	0.3027	0.1692	0.0435	1.7889	74,859
1999	4	9	58	53	31,050	166,252	945,489	0.1868	0.0690	0.1698	2.7081	434,803
2000	4	5	52	37	22,284	280,162	673,300	0.0795	0.0769	0.1351	1.0340	94,083
2001	9	5	71	66	30,980	353,006	581,256	0.0878	0.1268	0.0758	0.6923	30,486
2002	5	1	51	38	24,813	272,696	563,885	0.0910	0.0980	0.0263	0.9281	13,772
2003	6	2	98	71	31,460	266,776	765,845	0.1179	0.0612	0.0282	1.9261	41,553
2004	2	5	60	42	27,939	293,487	891,735	0.0952	0.0333	0.1190	2.8559	303,179
2005	4	1	39	36	26,036	264,262	1,030,990	0.0985	0.1026	0.0278	0.9606	27,510
2006	1	2	34	38	30,052	253,414	1,064,535	0.1186	0.0294	0.0526	4.0320	225,906
2007	2	0	33	29	31,199	189,277	1,366,689	0.1648	0.0606	0.0000	2.7197	0
2008	4	4	17	25	31,738	217,794	1,096,070	0.1457	0.2353	0.1600	0.6193	108,613
2009	1	2	44	48	21,588	308,089	943,174	0.0701	0.0227	0.0417	3.0831	121,163
2010	3	2	44	29	19,736	289,232	590,801	0.0682	0.0682	0.0690	1.0008	40,777
2011	1	3	52	37	20,462	286,070	703,420	0.0715	0.0192	0.0811	3.7195	212,136
2012	0	0	38	31	15,577	220,775	613,785	0.0706	0.0000	0.0000	0.0000	0
2013	1	3	12	34	17,552	375,448	959,064	0.0467	0.0833	0.0882	0.5610	47,473
2014	0	0	16	36	14,747	141,811	979,551	0.1040	0.0000	0.0000	0.0000	0
2015	1	1	11	11	10,930	150,986	615,457	0.0724	0.0909	0.0909	0.7963	44,554
2016	0	0	9	15	8,730	164,190	488,897	0.0532	0.0000	0.0000	0.0000	0
2017	1	0	2	16	9,450	163,663	597,038	0.0577	0.5000	0.0000	0.1155	0

Old MRIP

Year	CommK	CommR	RecK	RecR	Commercial Harvest	Recreational Harvest	Recreational Releases	LR	KT	CT/RT	CF	Unadjusted Total Discards
1990	1	30	2	46	647	12,780	57,507	0.0506	0.5000	0.6522	0.1013	3,799
1991	3	27	2	42	2,751	11,440	60,345	0.2405	1.5000	0.6429	0.1603	6,220
1992	2	14	2	19	2,496	12,342	108,788	0.2022	1.0000	0.7368	0.2022	16,210
1993	9	21	9	56	3,918	19,072	135,865	0.2054	1.0000	0.3750	0.2054	10,465
1994	3	15	20	59	4,458	12,427	202,565	0.3587	0.1500	0.2542	2.3915	123,163
1995	5	12	35	68	4,962	72,742	196,099	0.0682	0.1429	0.1765	0.4775	16,525
1996	15	15	65	91	19,514	44,778	204,137	0.4358	0.2308	0.1648	1.8884	63,543
1997	14	10	46	52	30,128	30,734	229,726	0.9803	0.3043	0.1923	3.2209	142,293
1998	11	3	65	69	28,497	31,242	253,584	0.9122	0.1692	0.0435	5.3900	59,427
1999	4	9	58	53	31,050	60,184	279,314	0.5159	0.0690	0.1698	7.4809	354,823
2000	4	5	52	37	22,284	124,778	266,154	0.1786	0.0769	0.1351	2.3217	83,504
2001	9	5	71	66	30,980	167,671	251,280	0.1848	0.1268	0.0758	1.4576	27,747
2002	5	1	51	38	24,813	124,082	210,452	0.2000	0.0980	0.0263	2.0397	11,296
2003	6	2	98	71	31,460	112,908	301,412	0.2786	0.0612	0.0282	4.5510	38,640
2004	2	5	60	42	27,939	122,550	384,837	0.2280	0.0333	0.1190	6.8394	313,341
2005	4	1	39	36	26,036	114,977	439,695	0.2264	0.1026	0.0278	2.2078	26,966
2006	1	2	34	38	30,052	132,683	503,291	0.2265	0.0294	0.0526	7.7008	203,986
2007	2	0	33	29	31,199	76,868	545,639	0.4059	0.0606	0.0000	6.6969	0
2008	4	4	17	25	31,738	89,617	447,118	0.3542	0.2353	0.1600	1.5052	107,677
2009	1	2	44	48	21,588	79,910	260,282	0.2702	0.0227	0.0417	11.8867	128,913
2010	3	2	44	29	19,736	86,776	162,967	0.2274	0.0682	0.0690	3.3357	37,491
2011	1	3	52	37	20,462	110,729	243,363	0.1848	0.0192	0.0811	9.6092	189,611
2012	0	0	38	31	15,577	65,375	167,858	0.2383	0.0000	0.0000	0.0000	0
2013	1	3	12	34	17,552	112,515	248,118	0.1560	0.0833	0.0882	1.8720	40,983
2014	0	0	16	36	14,747	61,210	349,164	0.2409	0.0000	0.0000	0.0000	0
2015	1	1	11	11	10,930	69,794	175,220	0.1566	0.0909	0.0909	1.7226	27,440

LR=ratio of commercial landings to recreational harvest; KT=ratio of tags returned from commercially harvested fish to tags returned from recreationally harvested fish; CT = number of tags returned from discarded fish by commercial fishers; RT = number of tags returned from discarded fish by recreational anglers; CF=LR/KT.

Table B6.21. Predicted tag numbers from the GAM fit to Delaware Bay tag returns by disposition.

Year	Comm Killed	Comm Released	Rec Killed	Rec Released
1990	1.8	26.7	1.6	38.8
1991	2.6	22.6	2.0	41.7
1992	3.4	19.2	3.4	44.9
1993	4.4	16.3	7.8	48.4
1994	5.5	13.8	18.5	52.0
1995	6.5	11.7	35.4	55.1
1996	7.3	9.9	51.1	57.1
1997	7.7	8.3	58.3	57.9
1998	7.7	7.1	58.7	57.5
1999	7.2	6.0	58.5	56.1
2000	6.6	5.1	59.0	54.2
2001	5.9	4.3	61.4	52.0
2002	5.1	3.7	68.0	49.6
2003	4.4	3.2	70.5	47.0
2004	3.7	2.8	59.3	44.4
2005	3.1	2.4	44.1	41.8
2006	2.6	2.1	33.5	39.5
2007	2.2	1.8	27.8	37.4
2008	1.9	1.6	27.7	35.7
2009	1.6	1.4	34.8	34.1
2010	1.3	1.2	44.7	32.4
2011	1.0	1.0	43.9	30.4
2012	0.8	0.8	31.1	28.2
2013	0.7	0.7	19.9	25.6
2014	0.5	0.5	14.4	22.9
2015	0.5	0.4	11.0	20.1
2016	0.4	0.3	6.5	17.7
2017	0.4	0.2	2.6	15.5

B6.22. Estimates of commercial total discards (numbers of fish) by year for Delaware Bay.

Year	Unscaled Number	Scaled Number
1990	1,462	240
1991	8,257	1,353
1992	9,041	1,481
1993	21,518	3,525
1994	69,179	11,333
1995	16,182	2,651
1996	160,453	26,285
1997	351,539	57,589
1998	273,790	44,852
1999	151,996	24,900
2000	44,722	7,326
2001	44,130	7,229
2002	50,637	8,295
2003	98,289	16,102
2004	84,491	13,841
2005	82,427	13,503
2006	85,276	13,970
2007	137,001	22,443
2008	105,027	17,205
2009	59,587	9,762
2010	51,806	8,487
2011	71,701	11,746
2012	49,544	8,116
2013	36,465	5,974
2014	64,450	10,558
2015	21,713	3,557
2016	6,917	1,133
2017	2,927	480

Table B6.23. The number of tags returns from Delaware Bay by year and commercial gear.

Year	Anchor	Drift	Hook	Other	Pound	Total
1990	30	1	0	0	0	31
1991	27	2	0	1	0	30
1992	10	6	0	0	0	16
1993	14	12	1	2	1	30
1994	15	2	0	0	1	18
1995	13	4	0	0	0	17
1996	21	4	2	1	2	30
1997	18	4	1	1	0	24
1998	12	1	1	0	0	14
1999	10	3	0	0	0	13
2000	6	3	0	0	0	9
2001	7	7	0	0	0	14
2002	4	1	0	1	0	6
2003	2	5	1	0	0	8
2004	3	4	0	0	0	7
2005	4	1	0	0	0	5
2006	0	3	0	0	0	3
2007	1	1	0	0	0	2
2008	4	3	1	0	0	8
2009	1	2	0	0	0	3
2010	5	0	0	0	0	5
2011	2	1	1	0	0	4
2012	0	0	0	0	0	0
2013	1	3	0	0	0	4
2014	0	0	0	0	0	0
2015	1	0	0	1	0	2
2016	0	0	0	0	0	0
2017	1	0	0	0	0	1

Table B6.24. Scaled commercial total discards for Delaware Bay apportioned by gear.

Year	Anchor	Drift	Hook	Other	Pound	Total
1990	232	8	0	0	0	240
1991	1,217	90	0	45	0	1,353
1992	926	555	0	0	0	1,481
1993	1,645	1,410	118	235	118	3,525
1994	9,444	1,259	0	0	630	11,333
1995	2,027	624	0	0	0	2,651
1996	18,400	3,505	1,752	876	1,752	26,285
1997	43,191	9,598	2,400	2,400	0	57,589
1998	38,445	3,204	3,204	0	0	44,852
1999	19,154	5,746	0	0	0	24,900
2000	4,884	2,442	0	0	0	7,326
2001	3,615	3,615	0	0	0	7,229
2002	5,530	1,383	0	1,383	0	8,295
2003	4,025	10,063	2,013	0	0	16,102
2004	5,932	7,909	0	0	0	13,841
2005	10,802	2,701	0	0	0	13,503
2006	0	13,970	0	0	0	13,970
2007	11,222	11,222	0	0	0	22,443
2008	8,603	6,452	2,151	0	0	17,205
2009	3,254	6,508	0	0	0	9,762
2010	8,487	0	0	0	0	8,487
2011	5,873	2,937	2,937	0	0	11,746
2012	4,058	4,058	0	0	0	8,116
2013	1,493	4,480	0	0	0	5,974
2014	7,039	3,519	0	0	0	10,558
2015	1,778	0	0	1,778	0	3,557
2016	567	567	0	0	0	1,133
2017	480	0	0	0	0	480

Table B6.25. Scaled commercial dead discards for Delaware Bay by year and gear.

Year	Anchor	Drift	Hook	Other	Pound	Total
1990	104	0	0	0	0	105
1991	548	5	0	9	0	562
1992	417	33	0	0	0	450
1993	740	85	11	47	4	886
1994	4,250	76	0	0	19	4,344
1995	912	37	0	0	0	950
1996	8,280	210	158	175	53	8,876
1997	19,436	576	216	480	0	20,708
1998	17,300	192	288	0	0	17,781
1999	8,619	345	0	0	0	8,964
2000	2,198	147	0	0	0	2,344
2001	1,627	217	0	0	0	1,843
2002	2,489	83	0	277	0	2,848
2003	1,811	604	181	0	0	2,596
2004	2,669	475	0	0	0	3,144
2005	4,861	162	0	0	0	5,023
2006	0	838	0	0	0	838
2007	5,050	673	0	0	0	5,723
2008	3,871	387	194	0	0	4,452
2009	1,464	390	0	0	0	1,855
2010	3,819	0	0	0	0	3,819
2011	2,643	176	264	0	0	3,083
2012	1,826	243	0	0	0	2,070
2013	672	269	0	0	0	941
2014	3,167	211	0	0	0	3,379
2015	800	0	0	356	0	1,156
2016	255	34	0	0	0	289
2017	216	0	0	0	0	216

Table B6.26. Scaled commercial dead discards for Delaware Bay by year and age.

	Age																
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total
1982	0	0	26	3	15	9	2	4	2	1	0	0	0	0	0	0	61
1983	0	0	45	3	9	25	7	2	2	1	1	0	0	0	0	0	95
1984	0	0	11	0	2	4	4	1	0	0	0	0	0	0	0	0	23
1985	0	0	1	6	1	3	1	1	0	0	0	0	0	0	0	0	13
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	2	11	18	7	3	1	0	0	0	0	0	0	0	43
1988	0	0	0	6	28	119	129	50	20	7	4	0	0	0	0	0	365
1989	0	0	6	4	7	131	170	75	41	17	2	4	4	2	0	0	462
1990	0	0	3	13	17	24	25	14	5	2	0	0	0	0	0	0	105
1991	0	0	14	50	120	155	99	55	36	10	9	14	0	0	0	0	562
1992	0	0	7	76	92	121	86	29	22	7	7	3	0	0	0	0	450
1993	0	0	7	130	196	265	174	40	30	23	14	5	2	1	0	0	886
1994	0	0	420	638	561	1,038	1,003	466	99	56	49	10	5	0	0	0	4,344
1995	0	0	158	136	100	194	225	87	25	8	6	4	5	2	0	0	950
1996	0	0	622	2,466	1,368	1,344	1,498	942	396	130	93	5	11	0	0	0	8,876
1997	0	2	1,009	2,448	7,113	4,145	2,402	1,468	811	389	576	265	39	41	0	0	20,708
1998	0	0	1,071	4,086	3,702	3,369	2,299	1,041	836	642	257	246	82	148	0	0	17,781
1999	0	22	2,471	1,484	1,072	2,171	800	331	287	146	85	50	39	5	0	0	8,964
2000	0	0	420	322	583	458	303	151	43	29	7	6	23	0	0	0	2,344
2001	0	0	41	565	279	247	356	186	75	48	11	23	13	0	0	0	1,843
2002	0	0	192	769	345	568	455	228	113	112	45	22	0	0	0	0	2,848
2003	0	0	12	54	239	1,222	701	232	33	27	35	14	9	19	0	0	2,596
2004	0	0	13	67	308	1,579	896	268	13	0	0	0	0	0	0	0	3,144
2005	0	0	58	837	1,759	1,186	452	313	148	139	45	45	27	9	4	0	5,023
2006	0	0	0	0	0	131	403	119	70	32	29	8	27	19	0	0	838
2007	0	0	0	0	0	298	1,478	2,189	491	492	196	28	370	182	0	0	5,723
2008	0	0	2	8	445	522	2,092	913	251	117	22	56	22	0	0	0	4,452
2009	0	0	0	0	0	59	839	302	277	101	92	42	76	67	0	0	1,855
2010	0	0	0	13	240	1,229	1,803	254	187	40	13	40	0	0	0	0	3,819
2011	0	0	3	8	18	107	313	635	683	728	424	145	19	0	0	0	3,083
2012	0	0	0	0	0	143	371	500	471	314	186	43	29	14	0	0	2,070
2013	0	0	0	0	9	86	276	276	208	66	0	19	0	0	0	0	941
2014	0	0	0	0	37	260	598	538	715	303	204	297	167	167	37	56	3,379
2015	0	0	0	0	0	62	236	407	238	147	13	26	13	11	2	0	1,156
2016	0	0	0	0	0	2	23	30	45	47	64	47	21	8	2	2	289
2017	0	0	0	0	0	28	39	61	31	17	15	17	7	0	2	0	216

Table B6.27. Estimates of wave-1 recreational harvest for Virginia and North Carolina.
* Estimates of wave-1 harvest from 2004 - 2017 for NC come from MRIP; all other estimates were developed from tag returns for this assessment.

Year	VA	NC*
1996	12,395	43,006
1997	110,414	103,022
1998	117,954	35,504
1999	140,574	43,006
2000	72,714	20,500
2001	72,714	43,006
2002	117,954	155,536
2003	72,714	163,038
2004	200,893	206,892
2005	65,174	153,206
2006	170,733	122,791
2007	231,053	68,750
2008	313,992	35,506
2009	200,893	6,548
2010	50,094	34,303
2011	42,555	207,504
2012	125,494	0
2013	57,634	0
2014	0	0
2015	0	0
2016	0	0
2017	0	0

Table B6.28. Sample sizes by year, state, and source to describe the length and age composition of recreational harvest and releases of Atlantic striped bass. Supplemental samples come from programs like volunteer angler logbook, state creel surveys, and the American Littoral Society volunteer angler tagging program.

	ME				NH			MA			
	MRIP		Supplemental		MRIP		Supplemental	MRIP		Supplemental	
Year	Harvest	Released	Harvest	Released	Harvest	Released	Combined	Harvest	Released	Harvest	Released
1982	4	0	0	0	0	0	0	92	0	0	0
1983	14	0	0	0	0	0	0	22	0	0	0
1984	0	0	0	0	0	0	0	4	0	0	0
1985	4	0	0	0	0	0	0	2	0	0	0
1986	0	0	0	0	0	0	0	12	0	0	0
1987	0	0	0	0	2	0	0	20	0	0	0
1988	0	0	0	0	2	0	0	42	0	0	1
1989	4	0	0	0	0	0	0	28	0	0	12
1990	4	0	0	1	0	0	0	36	0	0	276
1991	6	0	0	0	0	0	0	66	0	0	170
1992	10	0	0	0	8	0	0	130	0	0	146
1993	0	0	0	0	8	0	312	168	0	0	155
1994	12	0	0	0	10	0	640	200	0	0	231
1995	14	0	0	0	92	0	2,454	230	0	0	215
1996	10	0	14	3,076	28	0	6,041	216	0	0	288
1997	84	0	287	4,362	66	0	4,614	404	0	0	173
1998	176	0	569	6,099	82	0	7,050	426	0	0	91
1999	114	0	735	6,062	56	0	4,003	202	0	0	73
2000	158	0	961	7,853	32	0	5,354	124	0	0	9
2001	290	0	844	5,013	104	0	4,245	398	0	0	16
2002	226	0	505	4,812	138	0	6,024	524	0	0	90
2003	162	0	601	6,128	192	0	3,531	448	0	377	1,914
2004	61	0	615	7,238	45	3	3,722	120	0	388	2,504
2005	74	0	577	8,555	50	1	3,865	263	1	331	2,005
2006	57	0	384	7,654	25	32	5,412	237	8	148	1,570
2007	85	0	457	5,970	17	1	4,134	104	0	176	1,344
2008	76	0	425	1,665	27	0	1,652	59	3	236	1,313
2009	81	0	265	1,152	37	0	1,626	72	0	375	1,258
2010	37	0	223	1,294	45	0	968	50	1	388	1,229
2011	36	0	151	1,081	76	0	1,299	61	0	696	1,506
2012	11	0	79	916	70	4	1,612	60	1	537	1,248
2013	48	0	233	1,897	80	5	1,368	311	2	364	1,057
2014	76	0	226	1,297	53	0	1,899	233	0	317	1,245
2015	9	0	62	1,491	18	0	1,606	212	0	327	1,245
2016	22	0	44	2,854	19	19	3,780	110	1	279	1,748
2017	38	0	90	2,657	77	1	7,096	215	2	0	484

Table B6.28 (cont.)

	RI				CT				NY			
	MRIP		Supplemental		MRIP		Supplemental		MRIP		Supplemental	
Year	Harvest	Released	Harvest	Released	Harvest	Released	Harvest	Released	Harvest	Released	Harvest	Released
1982	4	0	0	0	36	0	0	1	4	0	0	0
1983	6	0	0	0	6	0	0	0	58	0	0	0
1984	2	0	0	1	8	0	62	390	26	0	0	0
1985	0	0	0	1	2	0	42	719	22	0	440	3
1986	6	0	0	1	4	0	0	376	22	0	549	13
1987	2	0	0	0	2	0	0	431	20	0	1,175	16
1988	12	0	0	8	10	0	0	582	18	0	1,543	49
1989	18	0	0	45	14	0	0	963	30	0	2,317	248
1990	12	0	0	1,149	20	0	0	2,010	50	0	3,690	3,759
1991	74	0	0	1,537	12	0	0	3,151	146	0	2,819	3,635
1992	88	0	0	1,445	40	0	0	3,241	126	0	2,677	4,361
1993	194	0	0	1,248	74	0	11	3,294	246	0	3,889	5,395
1994	80	0	0	1,686	36	0	83	2,981	196	0	3,575	5,170
1995	206	0	0	2,879	56	0	225	6,125	120	0	2,858	4,790
1996	200	0	0	3,584	126	0	560	7,313	224	0	0	6,263
1997	250	0	0	3,480	160	0	524	9,684	164	0	0	6,905
1998	260	0	0	4,980	138	0	442	9,853	164	0	0	6,731
1999	122	0	0	2,671	70	0	379	7,295	220	0	0	6,513
2000	100	0	0	2,825	96	0	276	6,088	104	0	0	5,619
2001	264	0	0	2,350	120	0	257	5,503	144	0	0	6,094
2002	350	0	0	2,261	72	0	278	6,519	162	0	0	6,038
2003	430	0	0	2,473	378	0	337	4,557	348	0	0	6,140
2004	114	0	0	2,588	66	10	217	5,964	205	62	0	5,150
2005	87	0	0	3,350	71	17	283	7,015	364	64	0	5,992
2006	38	1	0	4,334	50	20	167	9,250	278	76	0	5,958
2007	64	2	0	2,194	44	24	197	8,215	462	199	0	4,865
2008	31	0	0	1,440	33	24	146	4,456	513	155	0	3,429
2009	27	0	0	2,017	45	17	157	2,901	511	74	0	2,337
2010	24	3	0	1,329	83	12	134	1,218	676	172	0	2,265
2011	8	0	0	683	59	10	133	1,301	338	64	0	2,092
2012	21	0	0	674	68	10	190	1,669	340	95	0	2,165
2013	65	0	108	2,183	71	14	119	1,294	281	23	0	2,322
2014	40	1	6	556	42	0	95	1,038	97	50	0	1,896
2015	20	0	1	287	43	2	64	756	102	51	0	1,162
2016	17	0	0	745	87	1	64	1,454	151	39	0	2,559
2017	65	3	4	583	74	21	69	1,747	270	156	0	3,323

Table B6.28 (cont.)

	NJ				DE				MD			
	MRIP		Supplemental		MRIP		Supplemental		MRIP		Supplemental	
Year	Harvest	Released	Harvest	Released	Harvest	Released	Harvest	Released	Harvest	Released	Harvest	Released
1982	60	0	0	0	0	0	0	0	2	0	0	0
1983	14	0	0	0	4	0	0	0	146	0	0	0
1984	4	0	0	1	2	0	0	0	20	0	0	0
1985	12	0	0	5	0	0	0	0	4	0	0	0
1986	18	0	0	1	0	0	0	0	20	0	0	0
1987	2	0	0	18	0	0	0	1	0	0	0	0
1988	10	0	0	29	0	0	0	0	2	0	0	0
1989	8	0	0	74	0	0	0	1	0	0	0	0
1990	58	0	0	1,694	22	0	0	237	2	0	0	31
1991	116	0	0	1,807	30	0	0	277	210	0	0	34
1992	78	0	0	1,459	16	0	0	281	246	0	481	54
1993	22	0	0	2,240	44	0	0	268	288	0	667	36
1994	44	0	0	2,680	42	0	0	386	170	0	783	102
1995	154	0	163	2,719	80	0	0	207	454	0	477	766
1996	142	0	0	5,454	212	0	0	180	880	0	1,102	2,895
1997	86	0	0	4,463	244	0	0	407	978	0	455	5,166
1998	112	0	471	5,628	320	0	0	640	1,080	0	112	2,124
1999	168	0	5,939	15,703	214	0	0	308	652	0	129	4,095
2000	158	0	15,051	17,883	252	0	0	334	912	0	1,099	2,959
2001	720	0	25,898	23,332	282	0	0	210	696	0	406	893
2002	464	0	29,615	25,492	362	0	0	119	890	0	731	287
2003	694	0	32,229	30,588	292	0	0	209	1,674	0	1,349	1,386
2004	357	58	20,562	25,635	280	10	0	301	767	253	479	651
2005	352	38	13,696	29,799	194	22	0	187	1,249	336	1,023	864
2006	195	38	20,112	59,816	108	27	0	195	1,211	256	10,340	6,155
2007	133	86	11,762	35,533	79	20	0	109	923	124	9,178	7,702
2008	176	31	6,375	19,787	74	3	0	128	838	2	8,646	4,125
2009	294	40	7,542	13,601	140	14	0	119	972	67	9,187	725
2010	269	22	9,467	7,884	92	0	0	172	1,134	8	8,029	790
2011	213	102	10,417	9,530	82	2	0	67	994	16	8,227	2,583
2012	112	0	1,127	3,181	88	0	63	43	332	22	4,869	1,819
2013	235	105	611	3,116	117	0	0	56	191	1	6,089	1,908
2014	218	79	379	2,549	52	0	0	53	431	0	3,813	1,710
2015	291	94	13,760	21,252	26	0	0	51	394	16	2,041	2,999
2016	189	14	12,990	14,942	11	0	26	3	806	10	2,185	1,492
2017	175	35	0	1,186	31	0	0	8	1,001	32	635	1,454

Table B6.28 (cont.)

	VA				NC-OCEAN			
	MRIP		Supplemental		MRIP		Supplemental	
Year	Harvest	Released	Harvest	Released	Harvest	Released	Harvest	Released
1982	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0
1985	2	0	0	0	0	0	0	0
1986	4	0	0	0	0	0	0	0
1987	4	0	0	0	0	0	0	0
1988	0	0	0	0	2	0	0	0
1989	0	0	0	1	0	0	0	0
1990	124	0	0	24	0	0	0	1
1991	98	0	0	13	2	0	0	488
1992	86	0	0	53	2	0	0	425
1993	428	0	0	61	2	0	0	0
1994	814	0	0	327	38	0	0	10
1995	1,162	0	0	169	138	0	0	7
1996	1,010	0	0	527	270	0	0	11
1997	1,680	0	0	391	458	0	0	11
1998	1,294	0	0	273	544	0	0	5
1999	1,162	0	0	195	364	0	0	6
2000	586	0	0	183	226	0	0	12
2001	1,722	0	0	130	534	0	0	51
2002	1,248	0	0	105	636	0	0	51
2003	956	0	0	64	1,228	0	0	35
2004	631	149	0	35	1,800	0	0	47
2005	480	162	0	36	1,106	0	0	4
2006	642	253	0	136	372	0	0	0
2007	402	84	0	125	375	0	0	4
2008	574	43	0	56	303	0	0	0
2009	461	10	0	173	67	0	0	1
2010	255	1	0	8	95	0	0	8
2011	264	18	0	39	609	0	0	11
2012	148	7	0	81	0	0	0	0
2013	18	3	0	7	0	0	0	0
2014	106	17	0	30	0	0	0	0
2015	85	2	0	75	0	0	0	0
2016	88	2	0	4	0	3	0	0
2017	81	0	0	6	0	2	0	0

Table B6.29. Recreational harvest of striped bass in numbers of fish by state and year.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC (ocean only)	Total
1982	2,074	0	116,679	9,897	107,289	69,071	12,444	0	1,418	0	0	318,872
1983	19,715	1,046	43,403	13,383	34,743	168,372	242,892	3,732	88,559	0	0	615,845
1984	0	0	12,742	4,413	9,075	86,512	53,831	33,525	63,904	0	0	264,002
1985	30,812	0	542,492	12,873	20,384	31,576	80,923	0	10,315	2,627	0	732,002
1986	0	0	48,955	5,754	761	78,338	83,311	0	49,634	1,972	0	268,725
1987	0	1,309	30,782	13,207	998	31,283	15,332	0	2,639	18,802	0	114,352
1988	0	581	28,138	9,233	5,313	29,705	43,567	0	7,145	3,635	510	127,827
1989	5,113	0	43,594	10,087	10,681	62,204	30,113	0	0	0	0	161,792
1990	6,201	486	20,502	6,265	7,569	67,999	123,039	2,723	75,216	342,591	0	652,591
1991	10,488	538	51,070	16,637	7,843	203,104	131,106	9,854	117,890	248,700	1,032	798,262
1992	10,568	4,416	229,178	40,023	11,706	76,700	134,557	7,594	177,912	174,448	2,680	869,782
1993	1,260	5,036	116,384	26,913	35,761	140,472	100,923	19,222	113,610	228,922	531	789,034
1994	6,894	8,915	159,592	13,715	23,295	200,322	67,142	8,373	232,344	332,059	9,830	1,062,481
1995	3,953	7,376	124,301	70,949	75,820	250,266	671,399	25,751	491,182	550,103	16,479	2,287,579
1996	4,108	10,966	156,550	100,605	95,872	511,611	301,235	59,721	564,192	663,246	76,729	2,544,835
1997	43,029	29,883	365,611	124,705	149,048	450,464	171,173	29,050	552,444	909,916	176,237	3,001,560
1998	65,289	14,812	500,885	91,112	114,068	383,847	289,197	51,001	620,500	861,395	85,763	3,077,870
1999	37,524	9,851	327,086	116,607	88,247	450,929	657,133	28,328	532,507	989,468	92,641	3,330,322
2000	77,288	6,047	306,179	156,757	84,019	494,552	939,771	88,295	810,884	893,290	44,500	3,901,583
2001	91,867	23,547	551,039	149,778	78,154	364,153	1,267,491	70,583	577,350	890,529	147,921	4,212,412
2002	135,246	28,089	723,458	181,481	92,467	439,271	957,601	65,712	464,444	978,943	216,309	4,283,022
2003	99,745	41,278	797,161	226,438	181,743	678,437	942,759	75,697	816,849	943,593	217,588	5,021,288
2004	118,305	22,104	666,703	159,551	134,502	458,148	1,042,093	66,567	668,513	1,094,195	378,510	4,809,191

Table B6.29 (continued)

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC (ocean only)	Total
2005	118,323	35,481	536,057	195,579	202,636	854,633	958,051	48,814	819,052	582,494	200,468	4,551,588
2006	140,869	20,865	483,188	129,264	168,265	614,759	972,248	44,454	1,342,325	1,004,276	134,184	5,054,697
2007	95,474	8,146	471,873	135,771	163,871	602,845	722,165	17,171	1,127,310	749,328	83,288	4,177,242
2008	133,379	11,884	514,063	73,408	132,755	1,169,854	791,013	67,707	779,701	984,535	36,876	4,695,175
2009	146,496	17,291	694,992	138,356	100,267	574,187	1,141,495	64,775	1,104,647	912,057	6,548	4,901,111
2010	37,299	21,383	808,175	162,049	170,199	1,449,043	1,091,368	61,374	1,151,822	418,678	72,941	5,444,331
2011	48,517	54,202	873,495	202,238	91,104	1,005,255	1,038,895	43,663	1,112,978	370,959	207,610	5,048,916
2012	31,379	37,303	1,010,564	130,689	137,125	927,502	742,420	51,319	719,623	383,870	0	4,171,794
2013	73,345	63,157	658,713	308,312	269,563	902,451	1,324,244	70,635	1,185,023	359,950	0	5,215,393
2014	86,409	16,522	523,530	171,984	131,829	804,490	501,948	26,171	1,639,631	131,231	0	4,033,745
2015	14,434	10,037	485,316	67,036	140,783	406,786	600,270	41,895	1,111,503	207,666	0	3,085,726
2016	14,180	17,627	230,070	128,354	63,334	697,675	659,574	5,892	1,545,586	138,142	4,177	3,504,611
2017	22,042	37,724	392,347	59,581	94,536	472,322	625,909	27,785	1,091,644	110,402	0	2,934,292

Table B6.30. Recreational live releases of striped bass in numbers of fish by state and year.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC (ocean only)	TOTAL
1982	878	0	21,240	19,733	1,582,883	35,245	235,170	0	254,697	0	0	2,149,846
1983	0	0	36,425	19,483	0	2,919	436,787	0	741,546	6,436	0	1,243,596
1984	3,821	0	209,272	72,850	60,535	96,885	104,110	0	308,879	28,789	0	885,141
1985	184,589	541	54,321	113,835	44,536	196,141	57,459	3,448	388,689	8,465	0	1,052,024
1986	5,304	0	445,610	12,096	14,936	300,813	0	0	590,024	14,275	0	1,383,058
1987	44,790	2,781	233,065	175,420	141,250	542,668	98,455	75,047	249,920	52,943	0	1,616,339
1988	23,238	8,001	440,173	48,534	58,663	220,376	1,284,424	18,144	597,509	22,208	0	2,721,270
1989	46,830	5,582	480,527	137,508	332,551	880,716	1,677,034	13,516	390,794	555,671	0	4,520,729
1990	84,536	18,928	1,251,060	228,155	183,001	761,055	538,129	28,805	1,329,371	497,083	0	4,920,123
1991	255,185	10,480	1,290,442	95,542	583,522	1,408,805	853,856	174,707	2,530,214	746,997	833	7,950,583
1992	118,369	52,946	3,019,869	333,474	369,603	1,636,620	1,275,954	123,497	2,887,007	599,637	928	10,417,904
1993	869,780	34,584	1,942,334	233,449	495,019	1,551,336	716,324	223,141	2,679,070	279,561	3,041	9,027,639
1994	519,236	110,759	4,667,318	436,863	909,634	2,441,685	1,095,898	236,605	4,124,106	572,352	9,360	15,123,816
1995	730,658	449,304	8,427,142	1,312,627	1,172,138	2,196,189	1,864,417	307,705	4,489,612	1,363,030	28,169	22,340,991
1996	3,054,277	433,720	8,215,707	1,116,565	2,646,911	3,392,882	2,767,848	316,632	4,734,249	2,117,661	194,319	28,990,771
1997	2,055,833	483,000	10,675,648	2,106,159	2,030,841	2,206,113	2,684,369	250,618	7,912,299	2,490,298	201,673	33,096,851
1998	1,548,605	524,365	17,386,770	2,259,833	2,045,196	1,870,788	2,780,442	533,373	4,969,391	2,163,289	255,219	36,337,271
1999	1,204,445	320,028	13,434,701	1,461,672	1,305,096	3,683,885	4,206,024	356,988	6,231,220	2,644,849	283,109	35,132,017
2000	1,336,509	411,645	13,743,428	1,658,204	2,053,940	2,913,955	2,446,717	356,349	6,476,653	2,385,261	170,686	33,953,347
2001	1,392,284	299,789	10,222,067	1,136,163	2,521,228	1,852,884	2,533,992	387,588	5,002,275	1,846,231	79,024	27,273,525
2002	2,422,385	594,303	13,532,846	1,666,550	1,413,214	1,444,586	2,152,449	270,781	5,552,322	1,927,684	88,218	31,065,338
2003	1,410,725	560,843	9,787,679	1,356,103	2,104,479	2,644,941	2,246,065	465,896	8,731,485	2,322,166	59,799	31,690,181
2004	1,597,067	592,935	13,338,234	1,898,916	1,413,910	4,567,726	3,685,431	373,239	8,748,126	4,262,565	387,827	40,865,976
2005	4,729,060	1,001,141	9,042,756	2,052,415	4,171,667	3,468,230	3,078,017	560,086	7,492,120	2,468,828	210,903	38,275,223

Table B6.30 (continued).

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC (ocean only)	TOTAL
2006	8,059,186	889,216	19,278,587	2,094,270	2,015,969	4,407,045	3,604,691	685,331	9,023,958	3,374,899	44,907	53,478,059
2007	1,926,571	450,980	10,839,699	1,484,857	1,862,914	3,010,505	4,673,420	597,361	5,660,371	2,184,762	28,155	32,719,595
2008	1,156,915	197,041	7,495,514	777,838	5,062,515	2,782,160	3,668,079	632,685	3,222,361	1,547,375	27,512	26,569,995
2009	674,170	124,428	5,989,390	1,069,924	2,426,767	2,261,982	3,503,107	444,439	4,011,041	1,072,205	16,857	21,594,310
2010	521,578	161,120	5,089,524	619,352	1,416,463	3,035,987	2,436,192	256,325	5,389,724	586,323	61,015	19,573,603
2011	452,780	191,235	4,035,634	621,395	1,570,511	2,691,662	2,447,021	337,788	3,484,488	389,191	246,502	16,468,207
2012	656,576	164,369	3,629,394	1,291,714	892,480	2,427,500	1,822,075	357,725	9,001,233	288,933	7,301	20,539,300
2013	984,636	295,427	4,670,185	2,574,410	2,311,900	3,955,599	4,349,144	272,788	6,676,485	503,041	5,855	26,599,470
2014	1,023,302	315,614	6,425,469	437,611	739,568	2,784,141	2,840,153	529,957	8,303,529	737,784	2,122	24,139,250
2015	823,891	262,425	4,470,735	1,653,332	1,760,810	3,681,877	2,439,859	309,048	8,523,539	1,709,298	0	25,634,814
2016	2,161,647	819,225	6,299,215	1,416,267	1,208,170	3,738,838	1,808,167	217,931	13,780,632	1,637,663	84,726	33,172,481
2017	2,719,207	1,417,708	12,865,678	1,543,148	4,993,204	2,760,840	2,316,365	254,050	7,788,168	1,332,604	48,410	38,039,382

Table B6.31. Estimates of unreported recreational catch from inland waters of the Connecticut River (A), Hudson River (B), and Delaware Bay (C).

A.

Year	Disposition	Connecticut River		MRFSS/MRIP CT	Corrected State Total	(Percent)[a] Bias
		Partial Year Estimate	Full Year Estimate			
1997	Catch	25,941	38,530			
	Harvest	1,965	2,345	149,048	151,393	1.6
	Discards		36,185			
	Discard Loss		3,257	182,776	186,032	1.8
	Total Kill		5,602	331,823	337,425	1.7
1998	Catch	42,095	62,524			
	Harvest	1,225	1,462	114,068	115,530	1.3
	Discards		61,062			
	Discard Loss		5,496	184,068	189,563	3.0
	Total Kill		6,958	298,135	305,093	2.3
2008 - 2009	Catch		39,699			
	Harvest		2,112	233,022	235,134	0.9
	Discards		37,587			
	Discard Loss		3,383	674,035	677,418	0.5
	Total Kill		5,495	907,058	912,552	0.6

[a] Calculated as (unreported inland losses/total unreported and reported losses)*100
Discard loss estimated using 9% release mortality.

Table B6.31 (continued).

B.

Year	Disposition	Hudson River > rkm 74	MRFSS/MRIP NY	Corrected State Total	Percent[a] Bias
2001	Catch	35,018			
	Harvest	6,693	364,152	370,845	1.8
	Discards	28,325			
	Discard Loss	2,549	166,760	169,309	1.5
	Total Kill	9,242	530,912	540,154	1.7
2005	Catch	45,022			
	Harvest	8,827	854,633	863,460	1.0
	Discards	36,195			
	Discard Loss	3,258	312,141	315,398	1.0
	Total Kill	12,085	1,166,774	1,178,859	1.0

C.

Year	Disposition	DE River	MRFSS / MRIP			Corrected State Total	Percent[a] Bias
			NJ	DE	States Combined		
2002	Catch	47,671					
	Kill	582	957,600	65,712	1,023,312	1,023,894	0.1
	Discards	47,089					
	Discard Loss	3,767	193,720	24,370	218,091	221,858	1.7
	Total Kill	4,349	1,151,321	90,082	1,241,403	1,245,752	0.3

[a] Calculated as (unreported inland losses/total unreported and reported losses)*100
Discard loss estimated using 9% release mortality.

Table B6.32. Total striped bass removals at age in numbers of fish from the Chesapeake Bay by year . Total removals include commercial harvest, commercial dead discards, recreational harvest, and recreational release mortalities.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	19	44,400	125,179	49,543	6,686	1,354	232	198	20	74	322	481	15	39	80
1983	255	98,071	94,370	120,103	5,885	6,822	4,992	4,111	400	426	533	1,179	267	444	133
1984	0	74,107	366,352	27,899	7,435	2,061	327	34	0	12	34	16	0	48	0
1985	2,637	10,757	25,844	8,471	450	132	128	23	34	22	6	20	35	20	109
1986	0	23,363	28,178	39,104	8,974	452	241	129	36	0	0	0	20	61	90
1987	2,111	16,325	12,542	5,829	7,251	729	42	23	20	2	2	0	4	22	39
1988	37	21,927	31,331	21,057	24,706	19,453	4,004	487	22	23	0	2	2	11	39
1989	40	30,204	8,362	13,239	8,203	13,992	8,780	2,241	4	2	0	2	2	0	20
1990	868	40,218	52,721	79,170	157,440	247,627	62,936	15,092	2,984	1,977	844	703	508	234	325
1991	3,447	66,159	122,805	101,829	140,848	225,576	92,950	17,720	9,782	4,625	2,028	1,312	899	567	639
1992	2,530	25,909	187,363	219,793	196,071	195,047	120,474	35,193	6,080	3,999	90	50	199	298	436
1993	2,297	43,722	86,204	258,186	254,646	144,299	88,028	49,334	12,626	3,285	1,587	374	320	263	493
1994	1,102	15,320	164,035	346,728	392,870	180,736	117,834	57,345	34,153	11,479	4,449	2,967	242	26	126
1995	32	101,619	324,020	449,636	385,938	312,025	195,032	94,304	62,353	25,217	13,308	7,616	2,368	1,643	4,580
1996	10,532	45,005	720,727	527,498	485,121	335,136	215,684	87,200	41,284	22,452	15,844	3,440	1,602	794	1,116
1997	94,710	244,460	453,271	1,069,711	445,855	367,698	178,125	145,042	83,325	45,813	18,358	10,189	5,202	650	251
1998	8,457	160,198	638,210	848,220	607,780	293,069	132,155	88,600	71,736	50,529	22,618	12,170	6,064	5,820	1,653
1999	5,657	69,497	579,431	750,129	616,467	646,216	219,826	92,858	79,781	47,785	42,036	21,154	14,986	4,111	4,536
2000	60,728	230,891	197,199	822,440	977,845	498,323	347,956	123,466	53,791	55,326	28,909	17,764	9,093	7,075	2,699
2001	80,120	183,957	292,883	423,544	603,150	354,952	241,637	196,246	60,681	52,447	40,163	35,624	14,310	8,517	1,334
2002	32,764	300,878	248,794	399,917	460,460	466,808	326,708	137,940	160,825	51,138	34,435	19,014	14,958	4,678	16,071
2003	79	443,222	496,391	512,771	466,400	364,541	335,399	204,058	185,807	178,348	64,942	38,758	21,822	10,880	10,986
2004	165,908	165,711	784,517	671,371	314,684	285,981	243,344	216,803	154,110	113,638	112,879	48,305	25,736	12,932	12,172
2005	19,466	422,712	230,891	677,372	522,957	207,902	154,185	117,564	198,255	144,007	135,030	78,819	31,483	12,136	20,295

Table B6.32 (continued).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2006	69,310	277,229	812,716	655,788	874,123	470,188	184,393	147,176	140,963	172,800	98,001	67,226	59,102	18,189	40,951
2007	15,534	147,508	191,272	1,082,451	488,189	473,831	188,277	115,567	117,939	101,568	112,992	60,849	27,720	19,919	23,995
2008	71,673	38,119	151,817	412,398	837,252	241,012	247,864	140,136	62,514	98,004	84,846	116,959	42,851	37,013	45,565
2009	9,512	178,104	141,393	694,469	667,021	596,688	126,137	170,692	132,600	62,626	88,490	81,795	98,348	37,434	56,485
2010	19,509	30,084	477,167	449,996	596,449	511,013	453,943	105,233	106,625	54,932	21,821	26,081	26,551	29,237	24,294
2011	53,092	118,536	154,602	716,958	309,362	378,873	301,332	206,542	62,471	83,506	45,460	24,269	22,583	15,404	29,202
2012	248,396	247,847	364,555	285,474	529,166	297,112	219,316	90,482	114,697	44,997	70,929	24,837	24,140	31,127	74,900
2013	2,311	245,136	439,285	633,111	418,875	397,763	160,867	103,305	97,243	130,893	37,539	42,872	9,598	6,667	21,532
2014	18,708	41,765	944,405	667,897	751,576	279,114	182,408	74,111	72,792	63,894	83,157	10,468	17,662	4,591	21,714
2015	220,791	209,169	116,239	875,347	499,886	191,442	144,601	140,994	65,224	109,219	70,544	77,645	16,467	34,686	28,044
2016	210,075	262,907	297,913	404,176	1,380,769	401,046	132,161	67,508	71,891	48,599	91,869	87,801	98,586	13,295	35,000
2017	47,317	185,636	269,659	336,137	528,667	685,419	131,799	79,810	45,042	49,239	33,055	53,570	25,430	18,510	9,860

Table B6.33. Total striped bass removals at age in numbers of fish from the ocean and other areas by year. Total removals include commercial harvest, commercial dead discards, recreational harvest, and recreational release mortalities.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	1,054	66,168	145,091	175,396	65,744	21,374	9,872	7,681	4,877	11,350	18,625	29,046	13,525	21,047	86,060
1983	5,004	33,837	92,902	92,543	159,133	138,200	56,057	37,172	1,897	7,298	48,762	5,848	6,105	4,390	20,574
1984	2,473	18,757	32,938	75,539	73,481	77,590	29,679	13,084	4,427	5,905	2,153	2,668	4,325	8,003	6,334
1985	276	16,794	46,142	64,426	210,097	234,929	216,046	18,748	3,553	3,642	7,857	4,322	4,012	7,510	15,322
1986	280	3,457	40,424	99,937	34,720	69,461	13,546	18,011	5,269	1,348	1,840	1,437	1,664	3,651	11,961
1987	1,540	18,213	34,631	30,567	28,769	14,131	18,462	20,859	16,227	7,813	2,884	5,699	4,069	7,248	20,344
1988	5,521	53,521	42,149	36,274	34,712	45,988	28,534	24,289	24,291	7,713	6,186	2,080	7,300	3,814	9,668
1989	9,083	74,934	99,690	44,528	47,572	34,357	49,674	34,679	37,958	23,877	12,968	3,128	11,005	8,101	28,583
1990	319	34,594	47,797	57,613	58,698	72,739	90,357	103,920	38,346	15,125	8,095	4,800	6,232	9,942	23,696
1991	839	71,513	91,859	110,795	80,577	50,381	77,528	123,902	190,817	50,136	10,516	9,615	2,915	13,284	42,559
1992	6,486	33,992	106,549	127,411	140,675	91,993	89,366	168,048	186,432	178,372	30,210	15,447	6,710	15,504	46,890
1993	347	46,298	82,390	117,984	103,626	100,110	73,765	87,877	138,148	162,229	107,413	25,305	7,098	4,231	30,482
1994	4,966	68,226	138,201	115,399	178,750	162,769	102,705	146,176	226,809	199,007	102,807	88,574	7,525	4,903	30,166
1995	4,694	719,011	306,038	176,618	144,391	313,269	218,367	322,716	338,850	244,546	154,175	58,820	27,925	3,579	10,106
1996	1,463	48,258	570,829	360,554	318,635	370,484	617,809	480,413	339,671	259,741	188,990	120,168	34,091	13,803	29,379
1997	25,929	432,960	475,679	739,712	315,231	340,733	313,431	408,397	384,955	263,904	224,988	113,258	107,271	55,521	23,445
1998	22,974	316,381	521,575	834,812	819,143	555,884	438,366	525,050	352,205	193,181	197,248	75,984	37,497	51,693	24,361
1999	1,982	70,272	683,909	856,414	694,509	765,917	503,883	480,831	289,141	262,465	120,513	70,757	28,315	13,500	10,345
2000	2,731	64,576	502,366	541,864	827,093	684,898	778,945	755,128	335,063	224,305	111,952	56,452	31,528	15,438	10,887
2001	12,886	84,136	203,644	466,378	1,083,082	1,118,948	869,643	585,660	234,611	175,458	193,708	62,433	49,053	24,575	17,114
2002	15,330	325,516	357,065	512,354	494,406	1,031,961	820,864	701,761	613,846	240,425	209,759	92,434	50,918	35,064	13,652
2003	2,597	282,356	450,699	353,717	611,063	597,119	1,035,743	830,482	530,412	354,536	200,275	127,275	74,448	44,251	36,372
2004	1,836	108,355	1,059,726	698,049	513,006	619,491	711,573	924,127	603,348	382,507	286,737	143,763	67,356	47,670	30,922
2005	8,042	663,364	388,084	847,007	887,302	618,755	632,106	505,926	608,666	368,702	287,524	132,152	90,335	51,390	48,833

Table B6.33 (continued).

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
2006	4,248	238,095	1,851,519	493,341	874,629	738,828	439,996	503,545	472,608	571,451	359,928	217,930	105,849	46,059	67,445
2007	4,421	233,599	564,027	834,402	494,794	729,385	478,703	335,161	399,931	418,638	263,206	244,668	70,025	37,447	27,090
2008	14,749	87,354	380,365	457,238	1,030,338	516,571	985,716	622,672	288,696	421,816	256,184	182,364	201,782	57,492	91,468
2009	2,497	152,279	167,730	276,822	405,065	1,252,209	510,006	720,776	387,329	274,331	243,942	178,602	187,784	54,616	70,539
2010	743	51,057	329,163	157,070	333,964	688,774	1,481,556	532,475	630,912	477,853	211,987	197,545	148,562	120,888	75,079
2011	19,083	130,059	227,690	316,897	226,480	695,444	853,319	1,170,147	422,077	367,585	173,700	117,326	118,617	100,166	102,862
2012	1,638	226,478	265,838	157,867	439,150	391,625	600,298	731,628	781,298	217,623	193,811	161,699	86,603	95,518	63,224
2013	1,433	245,541	491,335	416,061	348,165	630,372	654,969	608,936	630,487	1,020,017	246,226	124,365	123,948	80,977	135,991
2014	1,190	30,718	563,451	414,485	344,927	379,265	437,672	315,485	347,094	392,707	245,864	130,323	75,349	67,314	97,694
2015	2,549	45,715	102,714	671,973	537,918	379,063	346,113	270,098	238,673	215,637	178,890	123,635	67,403	48,631	86,969
2016	23,077	525,865	201,226	132,723	810,620	530,906	207,987	191,664	181,117	148,957	175,848	177,555	127,326	61,287	105,345
2017	2,095	664,238	720,747	278,816	471,469	975,076	472,777	261,024	112,078	155,253	114,285	130,235	95,126	51,186	55,331

Table B6.34. Catch weights-at-age (A) and derived Rivard weights for spawning stock biomass (B) and January-1 biomass (C).

A.	Catch Weight-at-Age (kg)														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.13	0.64	1.09	1.54	2.42	3.75	4.83	5.79	6.20	8.68	10.80	11.20	13.36	15.21	17.12
1983	0.20	0.55	0.94	1.37	2.37	3.29	3.77	5.36	6.01	8.10	9.57	10.39	12.35	14.11	15.92
1984	0.24	0.60	1.69	1.62	2.67	3.39	5.07	5.65	6.76	7.76	8.41	12.65	12.94	14.70	16.52
1985	0.06	0.61	1.07	1.66	2.19	3.59	4.91	5.46	6.77	7.45	9.00	10.69	11.97	13.51	15.08
1986	0.14	0.57	1.27	2.40	2.44	3.12	3.95	5.05	5.44	6.09	7.75	9.16	9.78	10.90	12.03
1987	0.20	0.77	1.41	2.11	2.50	2.91	3.61	4.74	5.52	6.49	7.77	9.78	10.38	11.69	13.03
1988	0.31	0.91	1.10	1.98	3.12	4.02	4.38	4.70	5.24	5.62	8.58	10.40	10.55	11.80	13.07
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	11.17	12.31	13.46
1990	0.08	0.89	1.14	2.05	2.35	3.83	4.91	5.96	5.70	5.97	7.44	9.08	9.58	10.54	11.51
1991	0.21	0.92	1.29	2.17	2.62	3.17	4.81	5.64	6.46	6.24	9.46	8.30	10.12	11.17	12.23
1992	0.10	0.69	1.31	1.93	2.81	3.67	4.90	5.79	6.96	8.15	9.77	12.44	13.49	15.33	17.23
1993	0.07	0.76	1.31	1.99	2.77	3.58	4.80	6.11	7.03	8.01	9.53	10.76	12.22	13.70	15.20
1994	0.24	1.05	1.69	2.21	2.85	3.50	4.94	6.20	6.80	7.53	9.73	10.69	11.92	13.29	14.69
1995	0.28	0.70	1.35	2.18	2.77	3.65	5.38	6.16	7.27	8.86	7.57	9.73	10.96	12.08	13.20
1996	0.14	1.05	1.47	2.32	3.23	4.52	6.39	7.11	7.81	9.20	9.31	10.10	11.88	13.03	14.17
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	12.29	13.80	15.35
1998	0.39	0.77	1.20	1.62	2.25	2.95	4.69	5.66	6.82	7.03	7.76	9.87	10.82	12.10	13.41
1999	0.62	0.90	1.11	1.44	1.91	2.51	3.36	5.03	6.56	7.85	8.69	9.76	11.67	13.33	15.04
2000	0.37	0.55	1.10	1.45	1.96	2.79	3.89	5.09	7.11	7.37	9.70	10.70	12.68	14.56	16.51
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	10.42	11.64	12.87
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	11.53	13.05	14.62
2003	0.10	0.60	1.00	1.40	2.20	3.20	4.10	5.20	6.10	7.20	8.50	9.40	10.94	12.33	13.76
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	10.55	11.85	13.18
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	11.30	12.74	14.21
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	11.29	12.81	14.37
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	12.16	13.82	15.54
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	11.77	13.24	14.74
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	11.35	12.76	14.20
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	11.09	12.49	13.91
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	11.34	12.85	14.40
2012	0.08	0.48	1.01	1.67	2.30	3.25	4.44	5.88	6.57	8.31	9.05	10.41	12.12	13.69	15.31
2013	0.19	0.49	0.96	1.39	2.27	3.38	4.14	5.30	6.69	7.55	9.26	10.44	12.12	13.78	15.49
2014	0.49	0.55	0.89	1.27	2.15	3.07	4.28	5.30	6.99	8.43	9.17	11.91	13.50	15.55	17.69
2015	0.15	0.29	0.92	1.59	2.50	3.75	4.56	5.69	6.97	7.69	8.95	10.54	11.96	13.48	15.03
2016	0.17	0.43	0.78	1.25	2.17	3.40	4.75	6.05	7.06	8.92	10.03	11.23	13.42	15.31	17.26
2017	0.21	0.48	1.06	1.59	2.49	3.28	4.46	5.31	6.38	8.57	9.78	10.81	13.06	14.85	16.07

Table B6.34. (continued).

B.	Adjusted Rivard weight-at-age for female SSB (kg)													
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.09	0.58	1.03	1.38	2.24	3.75	4.71	5.74	5.80	8.47	10.91	10.93	13.19	14.73	17.12
1983	0.15	0.38	0.85	1.29	2.13	3.05	3.76	5.22	5.95	7.58	9.34	10.49	12.05	13.92	15.92
1984	0.19	0.46	1.28	1.41	2.26	3.10	4.55	5.11	6.38	7.28	8.33	11.80	12.25	14.08	16.52
1985	0.03	0.48	0.93	1.67	2.03	3.33	4.48	5.36	6.47	7.27	8.67	10.07	12.14	13.36	15.08
1986	0.09	0.32	1.06	1.96	2.22	2.86	3.86	5.01	5.44	6.25	7.67	9.12	10.00	11.16	12.03
1987	0.14	0.50	1.12	1.86	2.47	2.78	3.48	4.53	5.40	6.21	7.31	9.23	10.06	11.18	13.03
1988	0.24	0.62	1.01	1.82	2.83	3.57	3.95	4.40	5.11	5.59	8.00	9.67	10.35	11.43	13.07
1989	0.10	0.65	1.13	1.87	2.74	4.13	5.00	5.70	5.67	7.65	7.96	9.44	10.97	11.85	13.46
1990	0.04	0.58	1.05	1.80	2.32	3.62	4.81	5.81	5.83	5.99	7.73	9.04	9.62	10.70	11.51
1991	0.16	0.50	1.18	1.85	2.46	2.94	4.54	5.45	6.33	6.10	8.43	8.08	9.85	10.75	12.23
1992	0.06	0.51	1.20	1.75	2.63	3.37	4.39	5.53	6.60	7.69	8.73	11.62	11.95	13.82	17.23
1993	0.04	0.46	1.12	1.79	2.53	3.37	4.49	5.78	6.70	7.73	9.16	10.50	12.27	13.65	15.20
1994	0.18	0.53	1.38	1.94	2.61	3.30	4.56	5.82	6.62	7.40	9.27	10.39	11.62	13.02	14.69
1995	0.20	0.54	1.27	2.05	2.62	3.43	4.83	5.83	6.99	8.29	7.56	9.73	10.89	12.04	13.20
1996	0.10	0.75	1.22	2.03	2.93	4.00	5.56	6.63	7.36	8.67	9.20	9.40	11.30	12.48	14.17
1997	0.08	0.43	1.15	2.16	2.68	3.53	4.51	5.37	6.82	8.81	9.75	10.00	11.70	13.30	15.35
1998	0.32	0.49	1.02	1.50	2.30	2.91	4.40	5.35	6.33	6.95	8.09	9.89	10.67	12.15	13.41
1999	0.64	0.73	1.01	1.38	1.83	2.44	3.25	4.94	6.32	7.58	8.24	9.22	11.19	12.65	15.04
2000	0.37	0.57	1.05	1.36	1.81	2.54	3.49	4.59	6.52	7.16	9.20	10.16	11.88	13.77	16.51
2001	0.14	0.38	0.94	1.56	1.99	2.86	3.74	4.71	6.02	7.61	8.31	8.62	10.49	11.89	12.87
2002	0.08	0.26	0.82	1.40	2.06	2.90	3.93	5.10	5.76	7.24	8.75	9.46	10.62	12.34	14.62
2003	0.07	0.40	0.75	1.31	2.00	2.91	3.84	4.93	5.94	6.89	8.25	9.32	10.63	12.13	13.76
2004	0.19	0.24	0.77	1.29	2.12	2.85	3.88	4.88	5.84	6.85	7.92	8.89	10.25	11.62	13.18
2005	0.10	0.41	0.84	1.39	1.98	3.01	3.88	5.22	6.05	6.91	8.14	9.51	10.68	12.15	14.21
2006	0.14	0.29	0.72	1.29	1.87	2.64	3.68	5.03	6.42	7.14	8.21	9.17	10.96	12.42	14.37
2007	0.07	0.36	0.75	1.15	1.88	2.74	3.87	4.90	6.47	7.54	8.85	9.71	11.40	13.14	15.54
2008	0.16	0.31	0.85	1.29	1.89	3.06	4.46	5.18	6.32	7.89	8.83	9.71	11.34	12.96	14.74
2009	0.20	0.47	0.84	1.31	1.78	2.95	4.21	5.56	6.50	7.46	8.67	9.40	10.95	12.51	14.20
2010	0.12	0.55	0.96	1.30	1.83	2.91	4.00	5.02	6.13	7.45	8.64	9.06	10.66	12.19	13.91
2011	0.16	0.39	0.94	1.43	1.83	2.76	3.90	4.90	6.09	7.20	8.06	9.72	10.75	12.39	14.40
2012	0.05	0.39	0.86	1.48	2.08	2.88	4.05	5.37	6.18	7.79	8.65	9.81	11.54	13.06	15.31
2013	0.15	0.31	0.81	1.28	2.10	3.07	3.90	5.07	6.48	7.29	9.01	10.07	11.67	13.34	15.49
2014	0.56	0.42	0.77	1.18	1.93	2.85	4.03	4.98	6.52	7.96	8.74	11.18	12.66	14.61	17.69
2015	0.12	0.33	0.81	1.38	2.11	3.26	4.13	5.30	6.51	7.51	8.82	10.18	11.95	13.48	15.03
2016	0.13	0.33	0.61	1.16	2.01	3.15	4.48	5.64	6.69	8.39	9.39	10.61	12.64	14.39	17.26
2017	0.18	0.37	0.85	1.33	2.10	2.96	4.17	5.16	6.29	8.16	9.56	10.61	12.58	14.48	16.07

C.	Jan-1 Rivard weight-at-age (kg)														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.06	0.53	0.97	1.24	2.08	3.74	4.58	5.68	5.42	8.27	11.01	10.67	13.01	14.26	17.12
1983	0.12	0.27	0.78	1.22	1.91	2.82	3.76	5.09	5.90	7.09	9.11	10.59	11.76	13.73	15.92
1984	0.15	0.35	0.96	1.23	1.91	2.83	4.08	4.62	6.02	6.83	8.25	11.00	11.60	13.48	16.52
1985	0.02	0.38	0.80	1.67	1.88	3.10	4.08	5.26	6.18	7.10	8.36	9.48	12.31	13.22	15.08
1986	0.06	0.18	0.88	1.60	2.01	2.61	3.77	4.98	5.45	6.42	7.60	9.08	10.23	11.42	12.03
1987	0.09	0.33	0.90	1.64	2.45	2.66	3.36	4.33	5.28	5.94	6.88	8.71	9.75	10.69	13.03
1988	0.19	0.43	0.92	1.67	2.57	3.17	3.57	4.12	4.98	5.57	7.46	8.99	10.16	11.07	13.07
1989	0.07	0.51	1.05	1.57	2.46	3.76	4.65	5.22	5.33	6.74	7.09	9.14	10.78	11.40	13.46
1990	0.02	0.38	0.97	1.58	2.29	3.42	4.72	5.66	5.96	6.00	8.04	9.01	9.66	10.85	11.51
1991	0.12	0.27	1.07	1.57	2.32	2.73	4.29	5.26	6.20	5.96	7.52	7.86	9.58	10.34	12.23
1992	0.04	0.38	1.10	1.58	2.47	3.10	3.94	5.28	6.27	7.26	7.81	10.85	10.58	12.45	17.23
1993	0.02	0.28	0.95	1.61	2.31	3.17	4.20	5.47	6.38	7.47	8.81	10.25	12.33	13.60	15.20
1994	0.14	0.27	1.13	1.70	2.38	3.11	4.21	5.46	6.45	7.28	8.83	10.09	11.32	12.74	14.69
1995	0.14	0.41	1.19	1.92	2.47	3.23	4.34	5.52	6.71	7.76	7.55	9.73	10.82	12.00	13.20
1996	0.07	0.54	1.01	1.77	2.65	3.54	4.83	6.18	6.94	8.18	9.08	8.74	10.75	11.95	14.17
1997	0.05	0.29	1.11	1.90	2.55	3.43	4.52	5.69	6.92	8.46	9.56	9.76	11.14	12.81	15.35
1998	0.26	0.32	0.86	1.38	2.35	2.88	4.13	5.05	5.88	6.88	8.44	9.90	10.53	12.20	13.41
1999	0.66	0.59	0.92	1.31	1.76	2.38	3.15	4.86	6.09	7.32	7.82	8.70	10.73	12.01	15.04
2000	0.37	0.58	0.99	1.27	1.68	2.31	3.12	4.14	5.98	6.95	8.73	9.64	11.12	13.03	16.51
2001	0.11	0.37	0.78	1.39	1.79	2.52	3.39	4.42	5.69	7.44	7.98	8.97	10.56	12.15	12.87
2002	0.05	0.22	0.63	1.30	1.95	2.65	3.69	4.75	5.50	6.93	8.41	9.18	9.78	11.66	14.62
2003	0.06	0.27	0.56	1.22	1.82	2.64	3.61	4.67	5.78	6.59	8.02	9.24	10.33	11.92	13.76
2004	0.16	0.18	0.71	1.18	1.84	2.62	3.64	4.60	5.62	6.59	7.67	8.76	9.96	11.39	13.18
2005	0.08	0.34	0.61	1.17	1.76	2.80	3.61	4.83	5.74	6.62	7.78	9.04	10.10	11.59	14.21
2006	0.11	0.22	0.64	1.24	1.79	2.49	3.52	4.73	6.15	6.88	7.87	8.94	10.63	12.03	14.37
2007	0.05	0.29	0.60	1.03	1.68	2.45	3.47	4.52	6.07	7.25	8.34	9.32	10.69	12.50	15.54
2008	0.12	0.21	0.69	1.16	1.67	2.70	3.94	4.87	5.97	7.54	8.49	9.60	10.92	12.69	14.74
2009	0.16	0.36	0.68	1.21	1.66	2.65	3.95	5.38	6.15	7.19	8.53	9.33	10.56	12.26	14.20
2010	0.09	0.43	0.83	1.21	1.68	2.53	3.75	4.84	6.00	7.25	8.33	8.98	10.25	11.90	13.91
2011	0.13	0.29	0.85	1.31	1.68	2.48	3.70	4.68	5.78	6.88	7.92	9.46	10.19	11.94	14.40
2012	0.03	0.31	0.72	1.32	1.89	2.55	3.70	4.91	5.81	7.30	8.26	9.24	11.00	12.46	15.31
2013	0.11	0.20	0.68	1.18	1.95	2.79	3.67	4.85	6.27	7.04	8.77	9.72	11.23	12.92	15.49
2014	0.64	0.32	0.66	1.10	1.73	2.64	3.80	4.68	6.09	7.51	8.32	10.50	11.87	13.73	17.69
2015	0.09	0.38	0.71	1.19	1.78	2.84	3.74	4.93	6.08	7.33	8.69	9.83	11.94	13.49	15.03
2016	0.10	0.25	0.48	1.07	1.86	2.92	4.22	5.25	6.34	7.88	8.78	10.03	11.90	13.53	17.26
2017	0.16	0.28	0.68	1.11	1.77	2.67	3.89	5.02	6.21	7.78	9.34	10.41	12.11	14.12	16.07

Table B7.1. Total removals, proportion at age, and associated coefficients of variations of Atlantic striped bass by region and model period. (Period 1=January-February; Period 2=March-June; Period 3=July-December)

Chesapeake Bay

Total Bay Removals (Period 1)

Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+	CV
1982	78,294	0.0000	0.1621	0.5802	0.2535	0.0025	0.0014	0.0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.200
1983	53,134	0.0000	0.3097	0.5834	0.1025	0.0045	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.200
1984	65,708	0.0000	0.5355	0.4143	0.0441	0.0061	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.200
1985	10	0.0000	0.5355	0.4143	0.0441	0.0061	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.200
1986	10	0.0000	0.5355	0.4143	0.0441	0.0061	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.200
1987	10	0.0000	0.5355	0.4143	0.0441	0.0061	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.200
1988	10	0.0000	0.5355	0.4143	0.0441	0.0061	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.200
1989	10	0.0000	0.5355	0.4143	0.0441	0.0061	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.200
1990	10	0.0000	0.5355	0.4143	0.0441	0.0061	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.200
1991	35,331	0.0005	0.0079	0.0570	0.2124	0.3378	0.1842	0.1468	0.0436	0.0095	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.200
1992	173,383	0.0002	0.0037	0.0879	0.2911	0.2318	0.2285	0.1186	0.0319	0.0055	0.0008	0.0001	0.0000	0.0000	0.0000	0.0000	0.200
1993	159,632	0.0004	0.0111	0.0504	0.3451	0.3506	0.1069	0.0828	0.0322	0.0141	0.0014	0.0013	0.0017	0.0006	0.0003	0.0010	0.200
1994	140,042	0.0000	0.0156	0.0286	0.1541	0.4003	0.2599	0.0998	0.0339	0.0044	0.0028	0.0004	0.0001	0.0000	0.0000	0.0000	0.200
1995	169,003	0.0001	0.0154	0.0393	0.1944	0.3405	0.2887	0.0842	0.0248	0.0065	0.0054	0.0007	0.0000	0.0000	0.0000	0.0000	0.200
1996	251,598	0.0000	0.0105	0.0747	0.1396	0.2778	0.2495	0.1718	0.0456	0.0155	0.0103	0.0030	0.0011	0.0002	0.0002	0.0000	0.200
1997	356,833	0.0000	0.0019	0.0300	0.3826	0.2461	0.2215	0.0736	0.0287	0.0088	0.0046	0.0010	0.0005	0.0003	0.0002	0.0002	0.200
1998	329,607	0.0000	0.0003	0.0389	0.2145	0.5014	0.1390	0.0514	0.0208	0.0176	0.0085	0.0039	0.0022	0.0007	0.0004	0.0005	0.200
1999	156,811	0.0001	0.0170	0.0735	0.1947	0.2764	0.3017	0.0845	0.0235	0.0148	0.0043	0.0037	0.0023	0.0009	0.0008	0.0017	0.200
2000	339,383	0.0000	0.0045	0.0108	0.2063	0.3322	0.2708	0.1313	0.0289	0.0078	0.0055	0.0013	0.0002	0.0004	0.0000	0.0000	0.200
2001	153,487	0.0000	0.0004	0.0178	0.2133	0.3748	0.2463	0.0720	0.0451	0.0136	0.0080	0.0061	0.0015	0.0006	0.0006	0.0000	0.200
2002	242,151	0.0006	0.0078	0.0157	0.1270	0.3032	0.2805	0.1706	0.0362	0.0306	0.0144	0.0059	0.0033	0.0025	0.0004	0.0013	0.200
2003	155,179	0.0001	0.0014	0.0546	0.2092	0.3761	0.1146	0.1024	0.0502	0.0348	0.0371	0.0096	0.0055	0.0021	0.0011	0.0011	0.200
2004	189,334	0.0008	0.0126	0.0734	0.2183	0.2252	0.0759	0.1271	0.1130	0.0599	0.0351	0.0374	0.0107	0.0073	0.0021	0.0010	0.200
2005	274,805	0.0000	0.0007	0.0462	0.3612	0.3692	0.1133	0.0255	0.0236	0.0217	0.0131	0.0125	0.0066	0.0033	0.0012	0.0020	0.200
2006	292,351	0.0000	0.0003	0.0635	0.2197	0.3658	0.2133	0.0432	0.0185	0.0265	0.0256	0.0131	0.0061	0.0025	0.0013	0.0006	0.200
2007	207,048	0.0000	0.0007	0.0212	0.3431	0.1105	0.2522	0.0838	0.0538	0.0506	0.0385	0.0315	0.0070	0.0040	0.0025	0.0005	0.200
2008	226,448	0.0000	0.0002	0.0222	0.1212	0.4275	0.0933	0.0964	0.0490	0.0213	0.0413	0.0405	0.0465	0.0222	0.0091	0.0093	0.200
2009	278,804	0.0000	0.0002	0.0171	0.2759	0.3949	0.1841	0.0219	0.0276	0.0213	0.0173	0.0160	0.0080	0.0114	0.0032	0.0011	0.200
2010	264,690	0.0000	0.0006	0.0699	0.2559	0.2788	0.2205	0.0992	0.0465	0.0148	0.0053	0.0016	0.0027	0.0018	0.0013	0.0011	0.200
2011	213,651	0.0000	0.0010	0.0549	0.1455	0.2598	0.2333	0.1208	0.0872	0.0240	0.0327	0.0126	0.0088	0.0073	0.0053	0.0067	0.200
2012	278,515	0.0000	0.0019	0.0357	0.1333	0.3412	0.1768	0.1111	0.0362	0.0627	0.0261	0.0432	0.0121	0.0077	0.0043	0.0077	0.200
2013	182,910	0.0000	0.0011	0.0406	0.1454	0.3585	0.2438	0.0789	0.0426	0.0291	0.0340	0.0091	0.0072	0.0041	0.0021	0.0035	0.200
2014	173,168	0.0000	0.0000	0.0138	0.0930	0.3291	0.2409	0.1512	0.0816	0.0464	0.0282	0.0093	0.0014	0.0017	0.0008	0.0026	0.200
2015	100,248	0.0000	0.0000	0.0224	0.1724	0.1259	0.2049	0.1839	0.1443	0.0493	0.0557	0.0175	0.0155	0.0038	0.0013	0.0032	0.200
2016	139,514	0.0000	0.0001	0.0327	0.0727	0.2613	0.2163	0.2381	0.0946	0.0354	0.0136	0.0120	0.0108	0.0078	0.0017	0.0030	0.200
2017	127,232	0.0000	0.0000	0.0288	0.1929	0.1057	0.2664	0.1711	0.1272	0.0578	0.0158	0.0114	0.0092	0.0060	0.0059	0.0018	0.200

Table B7.1 Continued (Chesapeake Bay).

Total Bay Removals (Period 2)																
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+	CV
1982	86,437	0.0002	0.3059	0.3597	0.2389	0.0646	0.0143	0.0025	0.0021	0.0002	0.0009	0.0037	0.0056	0.0002	0.0005	0.0009	0.2
1983	88,070	0.0029	0.4959	0.2465	0.1125	0.0473	0.0290	0.0212	0.0234	0.0045	0.0025	0.0001	0.0119	0.0001	0.0021	0.0000	0.2
1984	56,356	0.0000	0.4030	0.4794	0.0790	0.0261	0.0068	0.0045	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0009	0.0000	0.2
1985	30,199	0.0003	0.1652	0.7234	0.0818	0.0118	0.0044	0.0042	0.0008	0.0011	0.0007	0.0002	0.0006	0.0012	0.0006	0.0036	0.2
1986	54,640	0.0000	0.1257	0.2340	0.6141	0.0126	0.0056	0.0028	0.0016	0.0004	0.0000	0.0000	0.0000	0.0004	0.0011	0.0016	0.2
1987	34,942	0.0152	0.3382	0.3136	0.1352	0.1906	0.0033	0.0007	0.0005	0.0006	0.0001	0.0001	0.0000	0.0001	0.0006	0.0011	0.2
1988	15,228	0.0000	0.0659	0.2250	0.2566	0.2016	0.2372	0.0082	0.0004	0.0002	0.0015	0.0000	0.0002	0.0002	0.0008	0.0026	0.2
1989	16,735	0.0000	0.0703	0.2389	0.2079	0.1940	0.1667	0.1190	0.0014	0.0002	0.0001	0.0000	0.0001	0.0001	0.0000	0.0012	0.2
1990	50,835	0.0000	0.0619	0.2068	0.1496	0.1650	0.1509	0.1149	0.1394	0.0036	0.0015	0.0002	0.0002	0.0023	0.0005	0.0032	0.110
1991	89,334	0.0357	0.1133	0.2259	0.1091	0.0979	0.1369	0.1291	0.0905	0.0487	0.0026	0.0017	0.0000	0.0009	0.0022	0.0056	0.110
1992	95,952	0.0004	0.0236	0.3401	0.2020	0.0963	0.1188	0.0916	0.0597	0.0342	0.0226	0.0006	0.0005	0.0021	0.0031	0.0045	0.110
1993	80,246	0.0000	0.0318	0.0942	0.3348	0.1831	0.0902	0.0846	0.0763	0.0479	0.0315	0.0155	0.0010	0.0026	0.0026	0.0040	0.110
1994	120,710	0.0000	0.0205	0.0830	0.1642	0.3318	0.1911	0.0685	0.0679	0.0448	0.0162	0.0086	0.0015	0.0007	0.0002	0.0010	0.110
1995	325,039	0.0000	0.0048	0.0409	0.0874	0.1114	0.2422	0.2463	0.1114	0.0842	0.0365	0.0209	0.0128	0.0001	0.0000	0.0009	0.165
1996	303,468	0.0000	0.0068	0.0769	0.1239	0.1680	0.1691	0.2161	0.1344	0.0580	0.0243	0.0162	0.0048	0.0009	0.0000	0.0005	0.085
1997	433,509	0.0018	0.0399	0.1136	0.2472	0.1237	0.0825	0.0872	0.1273	0.0894	0.0577	0.0160	0.0105	0.0029	0.0004	0.0001	0.054
1998	418,993	0.0041	0.0297	0.1440	0.1918	0.2224	0.1159	0.0668	0.0578	0.0598	0.0476	0.0357	0.0159	0.0062	0.0020	0.0003	0.104
1999	464,322	0.0019	0.0104	0.1107	0.1668	0.1970	0.2382	0.0956	0.0388	0.0503	0.0333	0.0270	0.0169	0.0071	0.0030	0.0030	0.044
2000	597,322	0.0074	0.0091	0.0404	0.1720	0.2465	0.2017	0.1550	0.0680	0.0323	0.0271	0.0169	0.0126	0.0057	0.0024	0.0028	0.099
2001	382,452	0.0015	0.0010	0.0471	0.1229	0.2075	0.1393	0.1418	0.1732	0.0549	0.0373	0.0350	0.0181	0.0160	0.0029	0.0015	0.125
2002	318,952	0.0003	0.0413	0.0646	0.1330	0.2182	0.1633	0.1226	0.0830	0.0830	0.0313	0.0199	0.0115	0.0093	0.0071	0.0116	0.086
2003	713,802	0.0000	0.0175	0.0479	0.0934	0.1183	0.1398	0.1608	0.1118	0.1011	0.1221	0.0384	0.0261	0.0130	0.0055	0.0042	0.086
2004	582,611	0.0289	0.0148	0.1006	0.1097	0.0806	0.0782	0.0767	0.1349	0.1099	0.0966	0.0939	0.0393	0.0203	0.0091	0.0064	0.097
2005	762,307	0.0065	0.0172	0.0309	0.0897	0.1194	0.0700	0.0784	0.0823	0.1595	0.1299	0.1120	0.0682	0.0178	0.0063	0.0120	0.187
2006	674,558	0.0008	0.0067	0.0974	0.0779	0.1671	0.1111	0.0640	0.0736	0.1065	0.1344	0.0698	0.0455	0.0301	0.0091	0.0059	0.122
2007	620,569	0.0012	0.0186	0.0326	0.1974	0.0967	0.1281	0.1077	0.0607	0.0818	0.0858	0.0919	0.0450	0.0189	0.0214	0.0122	0.139
2008	421,009	0.0001	0.0008	0.0216	0.1421	0.2726	0.0827	0.0913	0.0722	0.0576	0.0614	0.0577	0.0855	0.0264	0.0131	0.0148	0.129
2009	548,011	0.0006	0.0284	0.0306	0.1350	0.1295	0.1880	0.0573	0.0918	0.1069	0.0448	0.0690	0.0369	0.0517	0.0117	0.0177	0.146
2010	468,418	0.0000	0.0034	0.1138	0.1227	0.1713	0.1242	0.1622	0.0365	0.0657	0.0628	0.0280	0.0302	0.0320	0.0279	0.0192	0.097
2011	591,641	0.0012	0.0060	0.0467	0.1973	0.1450	0.1160	0.1061	0.1517	0.0485	0.0834	0.0477	0.0203	0.0104	0.0070	0.0126	0.110
2012	487,148	0.0008	0.0134	0.1015	0.0910	0.1466	0.1203	0.1361	0.0978	0.1411	0.0490	0.0554	0.0160	0.0089	0.0118	0.0104	0.116
2013	725,765	0.0000	0.0187	0.0825	0.2204	0.1421	0.1565	0.0596	0.0492	0.0666	0.1109	0.0235	0.0375	0.0092	0.0069	0.0163	0.086
2014	565,949	0.0003	0.0025	0.1046	0.1428	0.1894	0.1024	0.0886	0.0358	0.0578	0.0718	0.1365	0.0162	0.0281	0.0057	0.0173	0.108
2015	614,938	0.0004	0.0029	0.0268	0.2552	0.1121	0.0727	0.0442	0.0444	0.0407	0.0854	0.0800	0.1137	0.0243	0.0554	0.0418	0.127
2016	1,212,630	0.0092	0.0103	0.0551	0.0436	0.4260	0.0949	0.0408	0.0165	0.0257	0.0295	0.0646	0.0692	0.0790	0.0103	0.0254	0.136
2017	851,873	0.0015	0.0210	0.0630	0.1355	0.1481	0.3077	0.0602	0.0391	0.0264	0.0464	0.0340	0.0591	0.0277	0.0203	0.0099	0.134

Table B7.1 Continued (Chesapeake Bay).

Total Bay Removals (Period 3)																	
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+	CV
1982	63,911	0.0000	0.0824	0.7614	0.1416	0.0143	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2
1983	196,785	0.0000	0.1928	0.2117	0.5323	0.0075	0.0217	0.0159	0.0104	0.0000	0.0010	0.0027	0.0007	0.0013	0.0013	0.0007	0.2
1984	356,261	0.0000	0.0455	0.8761	0.0577	0.0156	0.0047	0.0002	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.2
1985	18,487	0.1421	0.3121	0.2162	0.3245	0.0051	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2
1986	46,009	0.0000	0.3585	0.3346	0.1206	0.1800	0.0032	0.0019	0.0009	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2
1987	9,997	0.1581	0.4510	0.1583	0.1104	0.0590	0.0613	0.0016	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2
1988	107,875	0.0003	0.1940	0.2587	0.1590	0.2006	0.1469	0.0360	0.0045	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2
1989	68,357	0.0006	0.4246	0.0638	0.1428	0.0725	0.1639	0.0993	0.0324	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2
1990	612,811	0.0014	0.0605	0.0689	0.1168	0.2432	0.3916	0.0932	0.0131	0.0046	0.0031	0.0014	0.0011	0.0006	0.0003	0.0003	0.065
1991	666,521	0.0004	0.0837	0.1510	0.1269	0.1803	0.3103	0.1144	0.0121	0.0076	0.0066	0.0028	0.0020	0.0012	0.0006	0.0002	0.065
1992	724,195	0.0034	0.0318	0.1926	0.2070	0.2025	0.1989	0.1258	0.0331	0.0026	0.0023	0.0000	0.0000	0.0000	0.0000	0.0000	0.065
1993	705,786	0.0032	0.0558	0.1000	0.2497	0.2607	0.1700	0.0964	0.0540	0.0092	0.0008	0.0002	0.0000	0.0000	0.0000	0.0000	0.065
1994	1,068,659	0.0010	0.0100	0.1404	0.2857	0.2777	0.1135	0.0894	0.0415	0.0263	0.0086	0.0031	0.0026	0.0001	0.0000	0.0000	0.065
1995	1,485,648	0.0000	0.0656	0.2047	0.2614	0.1967	0.1242	0.0678	0.0363	0.0228	0.0084	0.0043	0.0023	0.0016	0.0011	0.0029	0.062
1996	1,958,369	0.0054	0.0206	0.3465	0.2322	0.1860	0.1129	0.0546	0.0178	0.0101	0.0064	0.0052	0.0009	0.0006	0.0004	0.0005	0.063
1997	2,372,318	0.0396	0.0955	0.1658	0.3482	0.1283	0.1066	0.0481	0.0336	0.0175	0.0081	0.0047	0.0023	0.0016	0.0002	0.0001	0.044
1998	2,198,679	0.0031	0.0672	0.2570	0.3171	0.1589	0.0904	0.0397	0.0262	0.0186	0.0126	0.0029	0.0022	0.0015	0.0022	0.0006	0.047
1999	2,573,338	0.0019	0.0241	0.2007	0.2495	0.1872	0.1898	0.0630	0.0277	0.0210	0.0123	0.0112	0.0050	0.0045	0.0010	0.0011	0.043
2000	2,496,799	0.0225	0.0897	0.0678	0.2602	0.2875	0.1145	0.0844	0.0292	0.0127	0.0149	0.0074	0.0041	0.0022	0.0023	0.0004	0.058
2001	2,053,627	0.0387	0.0894	0.1325	0.1674	0.2270	0.1285	0.0859	0.0599	0.0183	0.0180	0.0126	0.0139	0.0039	0.0036	0.0004	0.051
2002	2,114,284	0.0154	0.1352	0.1061	0.1545	0.1501	0.1640	0.1165	0.0486	0.0600	0.0178	0.0126	0.0069	0.0054	0.0011	0.0057	0.058
2003	2,465,425	0.0000	0.1746	0.1840	0.1678	0.1312	0.1002	0.0830	0.0472	0.0439	0.0346	0.0146	0.0078	0.0050	0.0028	0.0032	0.053
2004	2,556,145	0.0583	0.0605	0.2785	0.2215	0.0881	0.0884	0.0683	0.0457	0.0308	0.0198	0.0200	0.0091	0.0049	0.0028	0.0032	0.050
2005	1,935,963	0.0075	0.2115	0.1005	0.2633	0.1707	0.0638	0.0452	0.0250	0.0365	0.0214	0.0239	0.0129	0.0088	0.0036	0.0055	0.056
2006	3,121,246	0.0220	0.0873	0.2334	0.1727	0.2097	0.1066	0.0412	0.0295	0.0197	0.0239	0.0151	0.0111	0.0122	0.0037	0.0118	0.066
2007	2,339,997	0.0063	0.0581	0.0712	0.3799	0.1732	0.1462	0.0445	0.0285	0.0242	0.0172	0.0211	0.0134	0.0065	0.0026	0.0070	0.072
2008	1,980,565	0.0362	0.0190	0.0695	0.1642	0.3159	0.0934	0.0947	0.0498	0.0169	0.0317	0.0259	0.0356	0.0135	0.0149	0.0188	0.063
2009	2,314,978	0.0040	0.0702	0.0518	0.2348	0.2099	0.1911	0.0383	0.0487	0.0294	0.0144	0.0200	0.0256	0.0289	0.0130	0.0201	0.069
2010	2,199,827	0.0089	0.0129	0.1843	0.1476	0.2011	0.1793	0.1599	0.0345	0.0327	0.0110	0.0038	0.0051	0.0050	0.0072	0.0068	0.122
2011	1,716,900	0.0305	0.0668	0.0671	0.3315	0.0979	0.1517	0.1239	0.0572	0.0167	0.0158	0.0085	0.0060	0.0087	0.0059	0.0118	0.077
2012	1,902,311	0.1304	0.1266	0.1604	0.1072	0.1907	0.0995	0.0642	0.0172	0.0150	0.0073	0.0168	0.0072	0.0093	0.0127	0.0356	0.076
2013	1,838,323	0.0013	0.1258	0.2024	0.2429	0.1361	0.1303	0.0561	0.0325	0.0237	0.0241	0.0102	0.0078	0.0012	0.0007	0.0049	0.061
2014	2,495,143	0.0074	0.0162	0.3538	0.2288	0.2354	0.0719	0.0425	0.0159	0.0128	0.0074	0.0017	0.0004	0.0006	0.0005	0.0046	0.102
2015	2,085,113	0.1058	0.0995	0.0468	0.3363	0.2006	0.0605	0.0475	0.0476	0.0169	0.0245	0.0094	0.0029	0.0006	0.0002	0.0010	0.059
2016	2,251,451	0.0884	0.1112	0.1006	0.1515	0.3677	0.1136	0.0220	0.0152	0.0159	0.0049	0.0053	0.0011	0.0008	0.0003	0.0017	0.070
2017	1,520,046	0.0303	0.1104	0.1397	0.1290	0.2560	0.2562	0.0387	0.0199	0.0100	0.0051	0.0017	0.0013	0.0007	0.0003	0.0008	0.081

Table B7.1 continued (ocean and other areas)

Total Ocean Removals (Period 1)

Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+	CV
1982	3,544	0.0000	0.0465	0.0156	0.0210	0.0229	0.0377	0.0462	0.0548	0.0638	0.1810	0.1902	0.1544	0.0367	0.1001	0.0293	0.224
1983	1,454	0.0000	0.0172	0.0040	0.0049	0.0033	0.0009	0.0003	0.0002	0.0290	0.1260	0.2994	0.1935	0.1074	0.1069	0.1068	0.224
1984	560	0.0000	0.0267	0.0042	0.0155	0.0334	0.1801	0.1028	0.0665	0.0663	0.0466	0.0555	0.1770	0.1306	0.0292	0.0656	0.224
1985	10	0.0000	0.0267	0.0042	0.0155	0.0334	0.1801	0.1028	0.0665	0.0663	0.0466	0.0555	0.1770	0.1306	0.0292	0.0656	0.450
1986	10	0.0000	0.0267	0.0042	0.0155	0.0334	0.1801	0.1028	0.0665	0.0663	0.0466	0.0555	0.1770	0.1306	0.0292	0.0656	0.397
1987	10	0.0000	0.0267	0.0042	0.0155	0.0334	0.1801	0.1028	0.0665	0.0663	0.0466	0.0555	0.1770	0.1306	0.0292	0.0656	0.267
1988	10	0.0000	0.0267	0.0042	0.0155	0.0334	0.1801	0.1028	0.0665	0.0663	0.0466	0.0555	0.1770	0.1306	0.0292	0.0656	0.222
1989	10	0.0000	0.0267	0.0042	0.0155	0.0334	0.1801	0.1028	0.0665	0.0663	0.0466	0.0555	0.1770	0.1306	0.0292	0.0656	0.194
1990	2,258	0.0000	0.0076	0.0673	0.1814	0.1649	0.2000	0.2015	0.1167	0.0352	0.0207	0.0040	0.0001	0.0001	0.0001	0.0004	0.200
1991	2,416	0.0001	0.0126	0.0322	0.1036	0.0928	0.0767	0.1883	0.1843	0.1934	0.0758	0.0171	0.0056	0.0047	0.0008	0.0120	0.418
1992	7,360	0.0000	0.0053	0.0381	0.0857	0.0847	0.1061	0.1734	0.2190	0.1623	0.0825	0.0228	0.0117	0.0032	0.0012	0.0041	0.364
1993	7,061	0.0000	0.0151	0.0379	0.0683	0.1308	0.0954	0.0795	0.3214	0.1806	0.0603	0.0076	0.0016	0.0003	0.0002	0.0009	0.212
1994	16,936	0.0000	0.0258	0.0453	0.1002	0.2171	0.1447	0.1311	0.1543	0.0902	0.0488	0.0283	0.0069	0.0034	0.0007	0.0032	0.212
1995	23,255	0.0000	0.1513	0.0967	0.0510	0.0591	0.0726	0.0627	0.1186	0.2285	0.1095	0.0293	0.0146	0.0037	0.0017	0.0007	0.212
1996	55,683	0.0000	0.0004	0.0055	0.0733	0.0366	0.1371	0.2910	0.2598	0.0582	0.0891	0.0303	0.0094	0.0090	0.0002	0.0001	0.212
1997	261,370	0.0000	0.0019	0.0395	0.1005	0.0963	0.1146	0.1784	0.1739	0.1122	0.0739	0.0521	0.0423	0.0103	0.0034	0.0006	0.212
1998	193,508	0.0000	0.0074	0.0965	0.1747	0.0920	0.1439	0.1264	0.1150	0.1065	0.0743	0.0416	0.0060	0.0103	0.0038	0.0015	0.212
1999	256,537	0.0000	0.0210	0.1276	0.1914	0.0886	0.1125	0.1133	0.1242	0.1050	0.0729	0.0278	0.0031	0.0045	0.0057	0.0022	0.212
2000	116,647	0.0000	0.0013	0.0182	0.0851	0.0734	0.2529	0.1956	0.1277	0.0974	0.0551	0.0528	0.0224	0.0037	0.0119	0.0026	0.212
2001	180,078	0.0000	0.0007	0.0076	0.0408	0.0788	0.0862	0.1550	0.1721	0.1390	0.1447	0.1061	0.0223	0.0149	0.0108	0.0211	0.212
2002	332,905	0.0000	0.0009	0.0062	0.0175	0.0601	0.0899	0.0994	0.2116	0.2117	0.1718	0.1020	0.0176	0.0064	0.0027	0.0022	0.212
2003	265,163	0.0003	0.0028	0.0098	0.0321	0.0182	0.0390	0.1318	0.2016	0.2543	0.1472	0.0872	0.0424	0.0093	0.0033	0.0208	0.212
2004	461,332	0.0000	0.0126	0.0056	0.0069	0.0071	0.0118	0.1773	0.1891	0.2254	0.1745	0.1022	0.0518	0.0196	0.0109	0.0051	0.212
2005	254,027	0.0000	0.0009	0.0040	0.0037	0.0085	0.0150	0.0159	0.0705	0.2113	0.2100	0.1731	0.1229	0.0923	0.0363	0.0355	0.205
2006	306,638	0.0000	0.0000	0.0009	0.0038	0.0088	0.0164	0.0468	0.1413	0.2613	0.2103	0.1771	0.0714	0.0357	0.0153	0.0109	0.423
2007	346,001	0.0000	0.0119	0.0263	0.0589	0.0823	0.0872	0.0499	0.0612	0.1521	0.2010	0.1432	0.0723	0.0319	0.0122	0.0097	0.223
2008	386,020	0.0000	0.0000	0.0045	0.0203	0.0239	0.0358	0.0417	0.0375	0.0687	0.1627	0.1846	0.1538	0.0926	0.0357	0.1380	0.181
2009	231,173	0.0000	0.0000	0.0004	0.0034	0.0130	0.0301	0.0795	0.1094	0.0942	0.1628	0.1414	0.1257	0.1046	0.0683	0.0675	0.099
2010	104,570	0.0000	0.0020	0.0072	0.0130	0.0241	0.0322	0.0706	0.1373	0.0974	0.2151	0.1227	0.0826	0.0773	0.0529	0.0658	0.280
2011	285,517	0.0000	0.0000	0.0059	0.0089	0.0234	0.0965	0.1481	0.2387	0.1076	0.1443	0.0501	0.0410	0.0360	0.0302	0.0692	0.173
2012	129,646	0.0000	0.0229	0.1295	0.1811	0.0821	0.0884	0.0762	0.0922	0.0201	0.0333	0.0124	0.0443	0.0719	0.0584	0.0873	0.191
2013	64,042	0.0000	0.0035	0.0120	0.0269	0.0465	0.0281	0.0247	0.0222	0.0525	0.0657	0.2486	0.1290	0.1648	0.0995	0.0760	0.191
2014	624	0.0000	0.0001	0.0044	0.0148	0.0621	0.1378	0.1968	0.2003	0.1098	0.0760	0.1295	0.0149	0.0256	0.0064	0.0215	0.190
2015	2,578	0.0000	0.0000	0.0011	0.0106	0.0376	0.0583	0.0516	0.1530	0.1623	0.1813	0.1337	0.1886	0.0156	0.0034	0.0031	0.190
2016	525	0.0000	0.0039	0.0040	0.0104	0.1140	0.1862	0.0804	0.0952	0.0461	0.0794	0.0790	0.1258	0.1461	0.0021	0.0274	0.190
2017	47	0.0000	0.0045	0.0093	0.0111	0.0549	0.1573	0.0806	0.0375	0.0156	0.1161	0.0594	0.1962	0.0651	0.0408	0.1517	0.190

Table B7.1 continued (ocean and other areas)

Total Ocean Removals (Period 2)																	
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+	CV
1982	402,796	0.0000	0.1176	0.2884	0.3425	0.1186	0.0330	0.0116	0.0021	0.0012	0.0064	0.0110	0.0276	0.0051	0.0156	0.0193	0.164
1983	153,618	0.0000	0.0135	0.2486	0.3375	0.1876	0.0319	0.0079	0.0009	0.0004	0.0378	0.0065	0.0194	0.0120	0.0139	0.0822	0.191
1984	47,525	0.0000	0.0499	0.1072	0.2220	0.2656	0.1167	0.0984	0.0212	0.0147	0.0024	0.0019	0.0138	0.0104	0.0550	0.0208	0.273
1985	98,602	0.0012	0.0859	0.2291	0.1497	0.1721	0.0894	0.1003	0.0607	0.0220	0.0143	0.0148	0.0192	0.0065	0.0132	0.0215	0.345
1986	52,376	0.0000	0.0067	0.0706	0.1932	0.1487	0.1307	0.0694	0.1093	0.0542	0.0157	0.0299	0.0180	0.0058	0.0400	0.1076	0.460
1987	27,453	0.0096	0.0936	0.2316	0.2283	0.1589	0.0801	0.0610	0.0458	0.0365	0.0132	0.0049	0.0093	0.0051	0.0041	0.0181	0.347
1988	51,609	0.0007	0.0916	0.0998	0.1296	0.1432	0.1650	0.1264	0.0909	0.0749	0.0287	0.0101	0.0083	0.0081	0.0111	0.0116	0.210
1989	88,185	0.0322	0.1888	0.1392	0.0776	0.0878	0.0526	0.1360	0.0859	0.0365	0.0057	0.0316	0.0013	0.0665	0.0329	0.0252	0.196
1990	125,624	0.0024	0.0385	0.0763	0.0999	0.1122	0.1488	0.1959	0.1818	0.0565	0.0319	0.0223	0.0152	0.0061	0.0042	0.0080	0.193
1991	180,448	0.0034	0.0796	0.1172	0.1013	0.1055	0.0736	0.1268	0.1644	0.1613	0.0394	0.0111	0.0037	0.0033	0.0011	0.0083	0.181
1992	343,463	0.0014	0.0168	0.0788	0.1078	0.1241	0.0947	0.0962	0.1571	0.1367	0.1233	0.0202	0.0065	0.0010	0.0073	0.0280	0.193
1993	303,391	0.0006	0.0360	0.0925	0.1228	0.0886	0.0889	0.0650	0.1005	0.1185	0.1394	0.0921	0.0309	0.0042	0.0021	0.0178	0.120
1994	442,272	0.0005	0.0223	0.1008	0.0967	0.1419	0.1437	0.0797	0.1003	0.1216	0.1233	0.0376	0.0138	0.0047	0.0020	0.0111	0.098
1995	618,268	0.0026	0.3531	0.1383	0.0672	0.0411	0.0540	0.0450	0.0403	0.0670	0.0860	0.0587	0.0249	0.0171	0.0017	0.0030	0.120
1996	872,055	0.0001	0.0177	0.2367	0.0924	0.0827	0.0987	0.1570	0.1059	0.0800	0.0530	0.0381	0.0188	0.0063	0.0050	0.0075	0.073
1997	1,195,157	0.0148	0.1379	0.1276	0.1949	0.0732	0.0702	0.0633	0.0892	0.0694	0.0543	0.0468	0.0214	0.0202	0.0122	0.0046	0.073
1998	1,531,062	0.0124	0.0934	0.1111	0.1496	0.1748	0.1144	0.0911	0.0877	0.0602	0.0284	0.0394	0.0135	0.0062	0.0148	0.0029	0.091
1999	1,398,371	0.0006	0.0165	0.1491	0.1747	0.1185	0.1411	0.1050	0.1172	0.0765	0.0600	0.0217	0.0119	0.0040	0.0030	0.0003	0.078
2000	1,534,611	0.0013	0.0197	0.1172	0.1186	0.1830	0.1513	0.1500	0.1371	0.0537	0.0337	0.0142	0.0105	0.0044	0.0020	0.0034	0.087
2001	1,547,433	0.0070	0.0353	0.0430	0.0908	0.2159	0.2334	0.1671	0.0851	0.0409	0.0228	0.0327	0.0090	0.0099	0.0045	0.0026	0.062
2002	2,239,772	0.0045	0.0641	0.0833	0.1019	0.0875	0.2088	0.1559	0.1288	0.0867	0.0287	0.0254	0.0119	0.0075	0.0030	0.0018	0.064
2003	2,047,652	0.0009	0.0744	0.0812	0.0574	0.1016	0.1102	0.2153	0.1552	0.0839	0.0522	0.0260	0.0177	0.0107	0.0092	0.0042	0.069
2004	1,975,686	0.0006	0.0146	0.2087	0.0879	0.0694	0.1076	0.1137	0.1575	0.0964	0.0589	0.0416	0.0188	0.0118	0.0072	0.0053	0.190
2005	2,303,488	0.0021	0.0963	0.0510	0.1176	0.1609	0.1251	0.1247	0.0945	0.1027	0.0526	0.0400	0.0096	0.0108	0.0087	0.0034	0.114
2006	2,773,284	0.0011	0.0582	0.2900	0.0555	0.1102	0.0958	0.0572	0.0690	0.0675	0.0864	0.0463	0.0324	0.0075	0.0086	0.0142	0.092
2007	2,287,969	0.0017	0.0541	0.1292	0.1634	0.0982	0.1293	0.1018	0.0639	0.0752	0.0650	0.0386	0.0545	0.0107	0.0092	0.0052	0.086
2008	1,644,954	0.0034	0.0284	0.0985	0.0774	0.2008	0.0898	0.1582	0.1064	0.0534	0.0538	0.0456	0.0376	0.0216	0.0149	0.0103	0.097
2009	1,668,795	0.0003	0.0435	0.0354	0.0586	0.0817	0.2476	0.1161	0.1753	0.0922	0.0476	0.0350	0.0276	0.0267	0.0049	0.0076	0.085
2010	1,682,917	0.0001	0.0144	0.0628	0.0325	0.0707	0.1507	0.2743	0.0873	0.1057	0.0748	0.0360	0.0332	0.0239	0.0210	0.0124	0.109
2011	1,868,859	0.0035	0.0360	0.0524	0.0618	0.0434	0.1375	0.1707	0.2170	0.0813	0.0707	0.0376	0.0206	0.0242	0.0281	0.0153	0.089
2012	1,478,412	0.0005	0.0427	0.0421	0.0342	0.0860	0.0985	0.1739	0.1794	0.1833	0.0529	0.0400	0.0227	0.0174	0.0183	0.0081	0.112
2013	2,277,937	0.0003	0.0585	0.0708	0.0365	0.0371	0.1266	0.1380	0.1274	0.1395	0.1663	0.0516	0.0157	0.0118	0.0076	0.0123	0.111
2014	1,290,527	0.0004	0.0106	0.1609	0.0796	0.0524	0.0986	0.1091	0.0821	0.1087	0.1295	0.0635	0.0451	0.0172	0.0194	0.0230	0.111
2015	1,447,431	0.0001	0.0112	0.0434	0.1897	0.1250	0.1027	0.1347	0.0920	0.0878	0.0722	0.0507	0.0366	0.0167	0.0105	0.0267	0.105
2016	1,383,980	0.0051	0.1558	0.0432	0.0385	0.1478	0.1297	0.0720	0.0714	0.0683	0.0502	0.0621	0.0494	0.0526	0.0315	0.0224	0.137
2017	1,504,735	0.0004	0.1842	0.1196	0.0529	0.1207	0.2281	0.1181	0.0452	0.0202	0.0224	0.0234	0.0246	0.0178	0.0099	0.0124	0.095

Table B7.1 continued (ocean and other areas)

Total Ocean Removals (Period 3)

Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+	CV
1982	270,570	0.0039	0.0689	0.1067	0.1381	0.0661	0.0294	0.0186	0.0245	0.0155	0.0300	0.0499	0.0643	0.0419	0.0532	0.2890	0.218
1983	554,650	0.0090	0.0572	0.0986	0.0734	0.2349	0.2403	0.0989	0.0668	0.0032	0.0024	0.0853	0.0047	0.0074	0.0038	0.0141	0.442
1984	309,271	0.0080	0.0529	0.0900	0.2101	0.1967	0.2326	0.0807	0.0389	0.0119	0.0186	0.0066	0.0062	0.0121	0.0174	0.0172	0.190
1985	755,075	0.0002	0.0110	0.0312	0.0658	0.2558	0.2995	0.2730	0.0169	0.0018	0.0030	0.0085	0.0032	0.0045	0.0082	0.0175	0.556
1986	254,629	0.0011	0.0122	0.1442	0.3527	0.1058	0.2459	0.0389	0.0483	0.0095	0.0021	0.0011	0.0019	0.0053	0.0061	0.0248	0.334
1987	204,003	0.0063	0.0767	0.1386	0.1191	0.1196	0.0585	0.0823	0.0961	0.0746	0.0365	0.0135	0.0267	0.0193	0.0350	0.0973	0.187
1988	280,431	0.0196	0.1740	0.1319	0.1055	0.0974	0.1336	0.0785	0.0699	0.0728	0.0222	0.0202	0.0059	0.0245	0.0116	0.0323	0.233
1989	431,951	0.0145	0.1349	0.2024	0.0872	0.0922	0.0688	0.0872	0.0627	0.0804	0.0541	0.0236	0.0070	0.0119	0.0120	0.0610	0.192
1990	444,390	0.0000	0.0669	0.0856	0.1005	0.0995	0.1206	0.1469	0.1819	0.0701	0.0249	0.0119	0.0065	0.0123	0.0212	0.0511	0.103
1991	744,371	0.0003	0.0767	0.0949	0.1240	0.0824	0.0496	0.0728	0.1260	0.2166	0.0576	0.0114	0.0120	0.0031	0.0176	0.0551	0.111
1992	893,262	0.0067	0.0316	0.0887	0.1005	0.1091	0.0657	0.0616	0.1259	0.1548	0.1516	0.0259	0.0147	0.0071	0.0145	0.0417	0.113
1993	776,850	0.0002	0.0454	0.0696	0.1033	0.0976	0.0933	0.0688	0.0710	0.1299	0.1539	0.1022	0.0205	0.0075	0.0046	0.0323	0.074
1994	1,117,775	0.0042	0.0518	0.0831	0.0635	0.1005	0.0866	0.0584	0.0887	0.1534	0.1285	0.0767	0.0737	0.0048	0.0036	0.0225	0.054
1995	2,401,581	0.0013	0.2070	0.0909	0.0558	0.0490	0.1158	0.0787	0.1229	0.1216	0.0786	0.0488	0.0180	0.0072	0.0010	0.0034	0.110
1996	2,826,551	0.0005	0.0116	0.1288	0.0976	0.0865	0.0979	0.1644	0.1322	0.0943	0.0738	0.0545	0.0365	0.0099	0.0033	0.0081	0.047
1997	2,768,884	0.0030	0.0967	0.1130	0.1736	0.0732	0.0819	0.0690	0.0926	0.0985	0.0649	0.0561	0.0277	0.0291	0.0145	0.0064	0.042
1998	3,241,784	0.0012	0.0530	0.1026	0.1765	0.1646	0.1089	0.0847	0.1137	0.0739	0.0417	0.0397	0.0167	0.0080	0.0087	0.0061	0.049
1999	3,197,844	0.0003	0.0131	0.1384	0.1761	0.1583	0.1688	0.1026	0.0891	0.0485	0.0500	0.0260	0.0167	0.0067	0.0025	0.0029	0.058
2000	3,291,969	0.0002	0.0104	0.0973	0.1063	0.1633	0.1286	0.1598	0.1609	0.0733	0.0505	0.0255	0.0115	0.0074	0.0033	0.0016	0.053
2001	3,453,819	0.0006	0.0085	0.0393	0.0922	0.2127	0.2149	0.1688	0.1225	0.0423	0.0330	0.0359	0.0129	0.0090	0.0046	0.0027	0.051
2002	2,942,679	0.0018	0.0617	0.0572	0.0946	0.0946	0.1816	0.1490	0.1165	0.1186	0.0404	0.0404	0.0204	0.0108	0.0093	0.0030	0.053
2003	3,218,529	0.0002	0.0402	0.0876	0.0707	0.1237	0.1122	0.1740	0.1427	0.0905	0.0648	0.0385	0.0248	0.0156	0.0076	0.0069	0.051
2004	3,761,449	0.0002	0.0196	0.1714	0.1386	0.0991	0.1067	0.1077	0.1398	0.0821	0.0493	0.0419	0.0220	0.0093	0.0076	0.0048	0.070
2005	3,580,673	0.0009	0.1233	0.0753	0.1606	0.1437	0.0913	0.0952	0.0755	0.0889	0.0542	0.0423	0.0220	0.0118	0.0062	0.0089	0.071
2006	3,905,548	0.0003	0.0196	0.2681	0.0866	0.1450	0.1198	0.0683	0.0688	0.0526	0.0684	0.0454	0.0272	0.0190	0.0045	0.0063	0.061
2007	2,501,528	0.0002	0.0423	0.1037	0.1760	0.0966	0.1613	0.0914	0.0670	0.0701	0.0801	0.0501	0.0379	0.0138	0.0048	0.0047	0.069
2008	3,563,831	0.0026	0.0114	0.0608	0.0904	0.1939	0.0996	0.1990	0.1216	0.0489	0.0759	0.0308	0.0172	0.0366	0.0054	0.0060	0.075
2009	2,984,561	0.0007	0.0267	0.0364	0.0597	0.0890	0.2788	0.0998	0.1350	0.0710	0.0527	0.0512	0.0347	0.0399	0.0103	0.0141	0.066
2010	3,650,141	0.0001	0.0073	0.0610	0.0277	0.0582	0.1183	0.2774	0.1017	0.1213	0.0903	0.0379	0.0364	0.0275	0.0219	0.0129	0.074
2011	2,887,078	0.0044	0.0217	0.0444	0.0689	0.0481	0.1423	0.1704	0.2412	0.0829	0.0673	0.0309	0.0232	0.0219	0.0135	0.0189	0.076
2012	2,806,241	0.0003	0.0571	0.0666	0.0299	0.1074	0.0836	0.1188	0.1620	0.1809	0.0481	0.0474	0.0436	0.0184	0.0217	0.0142	0.087
2013	3,416,843	0.0002	0.0328	0.0964	0.0969	0.0763	0.0996	0.0992	0.0929	0.0906	0.1864	0.0330	0.0235	0.0253	0.0168	0.0302	0.075
2014	2,552,384	0.0003	0.0067	0.1394	0.1222	0.1086	0.0987	0.1163	0.0821	0.0810	0.0884	0.0642	0.0283	0.0208	0.0166	0.0266	0.101
2015	1,865,972	0.0013	0.0158	0.0214	0.2130	0.1913	0.1234	0.0809	0.0731	0.0596	0.0593	0.0564	0.0376	0.0232	0.0179	0.0259	0.109
2016	2,216,999	0.0072	0.1399	0.0638	0.0358	0.2733	0.1585	0.0488	0.0419	0.0391	0.0358	0.0406	0.0492	0.0246	0.0080	0.0335	0.097
2017	3,054,955	0.0005	0.1267	0.1770	0.0652	0.0949	0.2068	0.0966	0.0632	0.0267	0.0398	0.0259	0.0305	0.0224	0.0119	0.0120	0.087

Table B7.2. Stock-specific index values and coefficients of variation for the indices of relative abundance used in the model for Stock-1 (A) and Stock-2 (B).

A. Stock-1 (Chesapeake Bay)								
Year	MDVA YOY	CV	MD Age 1	CV	MD SSN	CV	ChesMMA P	CV
1982	52.77	0.430	0.02	0.510				
1983	84.82	0.322	0.02	0.580				
1984	64.35	0.385	0.32	0.200				
1985	82.97	0.321	0.01	1.000	4.88	0.25		
1986	65.11	0.367	0.16	0.250	10.07	0.25		
1987	88.10	0.311	0.03	0.470	7.15	0.25		
1988	204.03	0.294	0.06	0.460	3.27	0.25		
1989	104.21	0.305	0.07	0.290	3.96	0.25		
1990	110.92	0.266	0.19	0.240	5.04	0.25		
1991	70.90	0.339	0.33	0.210	4.61	0.25		
1992	69.92	0.339	0.20	0.220	6.29	0.25		
1993	83.63	0.304	0.15	0.260	6.25	0.25		
1994	233.65	0.263	0.19	0.250	5.13	0.25		
1995	129.02	0.262	0.78	0.180	4.62	0.25		
1996	107.18	0.307	0.12	0.280	7.59	0.25		
1997	292.20	0.253	0.08	0.390	3.83	0.25		
1998	107.68	0.266	0.26	0.230	4.79	0.25		
1999	149.71	0.236	0.17	0.250	4.02	0.25		
2000	127.57	0.327	0.37	0.180	3.54	0.25		
2001	169.70	0.233	0.26	0.200	2.87	0.25		
2002	221.79	0.279	0.32	0.180	4.1	0.25	31.94	0.24
2003	70.64	0.337	0.79	0.160	4.5	0.25	77.74	0.16
2004	231.43	0.213	0.07	0.330	6.05	0.25	86.76	0.13
2005	149.39	0.239	0.74	0.180	4.96	0.25	146.19	0.16
2006	154.67	0.242	0.28	0.220	4.92	0.25	84.48	0.18
2007	89.06	0.301	0.28	0.210	2.14	0.25	71.86	0.18
2008	135.30	0.247	0.07	0.300	4.37	0.25	50.62	0.15
2009	82.86	0.313	0.31	0.200	5.7	0.25	20.89	0.24
2010	103.97	0.278	0.12	0.270	4.53	0.25	20.13	0.28
2011	111.14	0.271	0.17	0.223	4.58	0.25	27.31	0.17
2012	274.26	0.209	0.02	0.510	2.65	0.25	109.14	0.27
2013	49.85	0.434	0.35	0.170	4.42	0.25	74.21	0.2
2014	116.33	0.261	0.05	0.370	5.57	0.25	43.74	0.27
2015	133.22	0.248	0.12	0.285	7.34	0.25	55.26	0.29
2016	183.47	0.302	0.23	0.130	3.96	0.25	139.43	0.21
2017	74.87	0.327	0.42	0.260	5.46	0.25	148.2	0.27

Table B7.2 (continued).

B. Stock-2 (DE Bay/Hudson River)										
Year	NY YOY	CV	NY Age 1	CV	NJ YOY	CV	DE SSN	CV	DE 30	CV
1982										
1983					1.09	0.543				
1984					1.34	0.669				
1985			0.96	0.237	0.52	0.258				
1986	2.20	0.136	0.61	0.377	1.97	0.984				
1987	4.65	0.129	0.30	0.293	0.42	0.209				
1988	28.36	0.169	0.21	0.310	0.31	0.157				
1989	49.28	0.106	0.81	0.277	0.31	0.155				
1990	35.37	0.127	1.78	0.237	0.18	0.088			2.38	1.32
1991	35.53	0.132	0.37	0.250	0.16	0.081			0.32	0.24
1992	6.00	0.150	1.26	0.217	0.18	0.090			1.72	0.55
1993	16.93	0.106	1.34	0.219	0.11	0.053			2.93	1.17
1994	21.99	0.141	0.75	0.217	0.09	0.044			6.36	3.56
1995	23.61	0.106	1.43	0.247	0.13	0.063			16.47	5.20
1996	19.03	0.100	1.29	0.225	0.09	0.043	1.81	0.30	9.64	2.39
1997	12.12	0.116	1.54	0.250	0.09	0.044	2.16	0.32	4.32	1.92
1998	27.11	0.144	1.00	0.274	0.12	0.060	2.12	0.38	2.23	0.82
1999	16.10	0.124	2.10	0.276	0.12	0.058	1.47	0.26	12.48	4.09
2000	30.67	0.111	2.05	0.203	0.08	0.041	1.66	0.32	6.43	2.42
2001	6.88	0.160	1.56	0.242	0.10	0.048	1.88	0.39	3.48	1.19
2002	28.90	0.159	2.16	0.209	0.11	0.053	1.60	0.35	7.75	2.77
2003	14.72	0.102	2.53	0.182	0.19	0.097	3.21	0.42	2.53	0.99
2004	29.78	0.148	1.19	0.176	0.07	0.036	2.81	0.51	1.08	0.45
2005	8.73	0.103	2.41	0.186	0.13	0.064	1.77	0.31	2.60	1.07
2006	11.28	0.160	0.64	0.274	0.10	0.052	2.22	0.45	4.04	1.68
2007	5.83	0.120	2.02	0.215	0.15	0.075	1.78	0.72	1.98	0.76
2008	42.65	0.120	0.58	0.242	0.09	0.044	1.72	0.30	2.39	0.89
2009	19.04	0.110	1.24	0.214	0.11	0.054	1.25	0.24	1.22	0.42
2010	13.92	0.136	0.33	0.237	0.09	0.043	2.69	0.63	2.25	1.01
2011	25.62	0.133	0.45	0.232	0.10	0.048	3.25	0.78	1.15	0.46
2012	12.16	0.156	2.00	0.221	0.11	0.057	1.94	0.41	1.74	0.44
2013	9.85	0.142	0.90	0.195	0.24	0.119	2.10	0.42	1.44	0.45
2014	5.07	0.118	0.56	0.206	0.13	0.067	2.43	0.39	1.92	1.14
2015	24.60	0.106	0.82	0.198	0.08	0.041	0.86	0.18	2.93	1.45
2016	21.68	0.125	3.16	0.194	0.13	0.064	0.49	0.13	1.45	1.51
2017	10.93	0.137	2.00	0.194	0.10	0.050	1.75	0.42	1.66	0.78

Table B7.3. Index values and coefficients of variation for the indices of relative abundance used in the model for the mixed stock ocean population.

Year	NY OHS	CV	NJ OT	CV	CT LISTS	CV	MRIP	CV
1982							0.16	0.67
1983							0.38	0.93
1984							0.44	1.50
1985							0.12	0.72
1986							0.27	0.84
1987	3.83	0.11			0.053	0.32	0.46	1.02
1988	3.6	0.1			0.036	0.44	0.47	0.68
1989	2.58	0.13			0.063	0.30	0.44	0.72
1990	3.5	0.18	2.20	0.419	0.162	0.27	0.64	0.68
1991	3.28	0.19	2.72	0.353	0.146	0.25	0.79	0.64
1992	3	0.19	1.49	0.371	0.22	0.26	1.91	0.57
1993	3.32	0.11	1.60	0.382	0.273	0.18	1.78	0.49
1994	2.9	0.15	2.01	0.197	0.296	0.18	2.53	0.44
1995	2.84	0.18	13.94	0.105	0.594	0.14	3.63	0.49
1996	5.11	0.1	17.10	0.109	0.635	0.14	4.08	0.45
1997	4.84	0.14	17.08	0.106	0.855	0.12	4.59	0.45
1998	5.01	0.15	15.78	0.055	0.972	0.13	4.77	0.42
1999	3.46	0.16	9.57	0.064	1.105	0.11	4.58	0.42
2000	4.36	0.11	10.87	0.061	0.84	0.12	4.22	0.46
2001	3.47	0.15	3.91	0.162	0.607	0.15	3.44	0.41
2002	3.23	0.2	10.13	0.132	1.304	0.10	3.17	0.45
2003	4.24	0.19	14.36	0.036	0.871	0.11	2.97	0.46
2004	4.88	0.09	10.00	0.068	0.556	0.14	2.06	0.40
2005	3.91	0.14	28.06	0.099	1.172	0.12	2.60	0.42
2006	4.37	0.14	8.87	0.195	0.612	0.16	2.84	0.41
2007			14.14	0.121	1.02	0.12	1.92	0.40
2008			3.68	0.165	0.568	0.14	1.75	0.40
2009			12.76	0.125	0.598	0.18	1.61	0.38
2010			3.54	0.263	0.397	0.22	1.48	0.37
2011			7.16	0.088	0.476	0.21	1.16	0.38
2012			16.65	0.239	0.433	0.17	1.22	0.45
2013			8.84	0.202	0.674	0.13	2.21	0.36
2014			8.29	0.351	0.408	0.20	1.66	0.40
2015			0.77	0.351	0.197	0.24	1.62	0.42
2016			2.01	0.181	0.482	0.16	1.63	0.37
2017			18.25	0.124	0.340	0.25	2.96	0.39

Table B7.4. The fraction of total mortality (d) that occurs during period *p* prior to the survey and ages to which survey indices are linked.

Survey	Period	d	Linked Ages
Stock 1			
MDVA YOY	1	0	1
MD Age 1	1	0	2
MD SSN	2	0	2-15+
ChesMMAP	3	0	1-15+
Stock 2			
NY YOY	1	0	1
NY Age 1	1	0	2
NJ YOY	1	0	1
DE SSN	2	0	2-15+
DE 30	3	0.7	1-15+
Mixed Ocean			
NY OHS	3	0.5	2-13
NJ OT	2	0.1	2-15+
CT LISTS	2	0.25	1-15+
MRIP	3	0	1-15+

Table B7.5. Age composition data for the age-specific indices used in the model.

Stock 1

MD SSN

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982															
1983															
1984															
1985	-1	0.287778	0.625909	0.065442	0.009833	0.002702	0.004461	6.38E-05	0.000873	0.000118	8.59E-05	0.000728	0.000528	4.12E-05	0.001438
1986	-1	0.22861	0.259305	0.494191	0.003995	0.005303	0.002014	0.002911	0.00275	0	0	0	2.55E-05	8.71E-06	0.000885
1987	-1	0.198916	0.360882	0.16101	0.246379	0.025061	0.003022	0.003623	0.000334	0	0	0	3.73E-05	0.000384	0.000352
1988	-1	0.124604	0.237121	0.217815	0.1742	0.227794	0.004053	0	0.000122	0.013284	0	0	0	8.57E-05	0.000922
1989	-1	0.083745	0.390805	0.203485	0.114941	0.123191	0.083143	0.000418	0.000167	5.64E-05	0	0	4.86E-05	0	0
1990	-1	0.155024	0.31399	0.239079	0.095904	0.068052	0.063593	0.059202	0.001692	0.000239	0.000186	0.001049	0.001441	0.0002	0.000347
1991	-1	0.159172	0.416128	0.134943	0.102062	0.057954	0.056369	0.041537	0.022908	0.000889	0.003195	0	0.001226	0.00122	0.002395
1992	-1	0.043706	0.35149	0.244069	0.093249	0.111103	0.068249	0.04621	0.021727	0.011205	0.005228	0	0.001499	0.001922	0.000343
1993	-1	0.065484	0.211133	0.299398	0.141098	0.0815	0.083028	0.059351	0.036112	0.011866	0.004967	0.001336	0.002291	0.002255	0.000181
1994	-1	0.052272	0.201645	0.190982	0.229623	0.115854	0.066216	0.083517	0.034226	0.016657	0.005963	0.00245	0.000595	0	0
1995	-1	0.10818	0.25374	0.147982	0.131788	0.111632	0.086612	0.054091	0.042593	0.025052	0.020825	0.00759	0.009915	0	0
1996	-1	0.005219	0.485193	0.134586	0.045753	0.091611	0.084875	0.055672	0.046676	0.02206	0.02003	0.006176	0.002149	0	0
1997	-1	0.095998	0.116811	0.365915	0.121369	0.054597	0.049397	0.057766	0.069281	0.029807	0.025862	0.00853	0.003207	0.00146	0
1998	-1	0.075334	0.298349	0.068357	0.311779	0.067492	0.027617	0.038657	0.036153	0.03137	0.019034	0.020673	0.003617	0.000909	0.000658
1999	-1	0.021351	0.429258	0.196457	0.145851	0.091332	0.02919	0.017474	0.02861	0.012887	0.012064	0.007048	0.002847	0.005352	0.000278
2000	-1	0.040529	0.15786	0.293746	0.135352	0.162961	0.070427	0.038916	0.023296	0.023452	0.019658	0.020872	0.004311	0.007127	0.001492
2001	-1	0.01714	0.136099	0.209925	0.185197	0.080558	0.10135	0.115896	0.040301	0.042297	0.032249	0.021141	0.012191	0.004111	0.001547
2002	-1	0.206519	0.099473	0.096983	0.2093	0.10425	0.085466	0.08066	0.057346	0.020385	0.014192	0.008734	0.012696	0.002906	0.001091
2003	-1	0.034967	0.247514	0.118641	0.078561	0.151897	0.114649	0.061307	0.059356	0.064515	0.032656	0.015938	0.01365	0.005606	0.000743
2004	-1	0.047641	0.319131	0.200163	0.069996	0.057165	0.073321	0.078065	0.0497	0.038238	0.038123	0.011068	0.006967	0.006047	0.004376
2005	-1	0.13311	0.208924	0.148101	0.194784	0.048923	0.052151	0.043816	0.055346	0.041107	0.035221	0.022866	0.005949	0.002044	0.007658
2006	-1	0.015263	0.524255	0.081428	0.096688	0.059413	0.030084	0.025763	0.037434	0.043813	0.026727	0.02234	0.018804	0.005531	0.012458
2007	-1	0.036773	0.10509	0.354955	0.06948	0.071417	0.062923	0.034383	0.04207	0.046757	0.074696	0.03718	0.014231	0.025293	0.024754
2008	-1	0.007457	0.196794	0.247893	0.256926	0.038626	0.052551	0.045106	0.025807	0.027427	0.022994	0.032021	0.030644	0.00748	0.008273
2009	-1	0.070362	0.073779	0.268449	0.090599	0.242478	0.037102	0.039737	0.054784	0.015722	0.027774	0.021244	0.041078	0.008465	0.008427
2010	-1	0.016564	0.330448	0.111209	0.143373	0.111507	0.121263	0.014737	0.030612	0.022497	0.008736	0.01129	0.013076	0.021888	0.042801
2011	-1	0.050136	0.159998	0.269913	0.098969	0.124932	0.082979	0.098026	0.021959	0.019959	0.017142	0.017106	0.008814	0.009362	0.020706
2012	-1	0.057371	0.196488	0.087593	0.089546	0.067423	0.087227	0.085397	0.09458	0.028096	0.062436	0.051209	0.016438	0.025496	0.050699
2013	-1	0.080569	0.130785	0.240418	0.102641	0.116583	0.062439	0.065501	0.047739	0.063404	0.013159	0.026761	0.011364	0.009624	0.029013
2014	-1	0.015294	0.501374	0.094553	0.105235	0.042818	0.059061	0.017576	0.036126	0.027208	0.044914	0.004218	0.01876	0.004105	0.028758
2015	-1	0.025979	0.009989	0.624595	0.063157	0.068696	0.033082	0.028836	0.021464	0.030906	0.026566	0.027916	0.008955	0.013867	0.015993
2016	-1	0.168239	0.135552	0.046928	0.413003	0.060555	0.039455	0.012314	0.015557	0.013546	0.023519	0.019971	0.023501	0.002879	0.024978
2017	-1	0.117019	0.212599	0.061273	0.137128	0.251167	0.040573	0.032527	0.020994	0.02749	0.021427	0.044578	0.013326	0.009019	0.010879

CHESMAP

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1983	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1984	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1985	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1986	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1987	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1988	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1989	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1990	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1991	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1992	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1993	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1994	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1995	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1996	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1997	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1998	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1999	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2000	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2001	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2002	0.349036	0.336188	0.072805	0.059957	0.008565	0.109208	0.027837	0.006424	0.019272	0.002141	0.004283	0.004283	0	0	0
2003	0.008143	0.405537	0.250814	0.118893	0.027687	0.035831	0.063518	0.027687	0.016287	0.039088	0.001629	0	0.004886	0	0
2004	0.316647	0.105937	0.334109	0.112922	0.022119	0.020955	0.023283	0.029104	0.009313	0.008149	0.010477	0.001164	0	0.001164	0.004657
2005	0.034339	0.804176	0.046404	0.068677	0.022738	0.002784	0.006497	0.001856	0.006497	0.003248	0.000928	0.001856	0	0	0
2006	0.054627	0.167224	0.61427	0.013378	0.054627	0.021182	0.014493	0.005574	0.011148	0.021182	0.006689	0.010033	0.004459	0.001115	0
2007	0.003448	0.367241	0.256897	0.289655	0.015517	0.041379	0.012069	0.001724	0	0.003448	0.001724	0.005172	0.001724	0	0
2008	0.091295	0.065817	0.390658	0.123142	0.26327	0.002123	0.019108	0.019108	0.004246	0.004246	0.002123	0	0.004246	0.002123	0.008493
2009	0.016181	0.679612	0.061489	0.106796	0.029126	0.071197	0.003236	0.012945	0.009709	0	0	0.003236	0.006472	0	0
2010	0.056537	0.077739	0.618375	0.028269	0.070671	0.010601	0.102473	0	0.017668	0.007067	0.003534	0	0	0.003534	0.003534
2011	0.242754	0.286232	0.119565	0.192029	0.018116	0.054348	0.028986	0.039855	0.003623	0.003623	0	0	0.003623	0	0.007246
2012	0.693811	0.131379	0.102063	0.016287	0.038002	0.002172	0.008686	0.004343	0.001086	0	0.001086	0	0.001086	0	0
2013	0	0.663295	0.180636	0.059249	0.018786	0.036127	0	0.014451	0.004335	0.018786	0	0.001445	0	0	0.00289
2014	0.078534	0.015707	0.818499	0.04363	0.017452	0.010471	0.006981	0	0.001745	0.00349	0.00349	0	0	0	0
2015	0.354887	0.195489	0.039098	0.353383	0.027068	0.01203	0.004511	0.004511	0.001504	0.003008	0	0.003008	0	0	0.001504
2016	0.471848	0.354481	0.06027	0.001586	0.097542	0.004758	0.002379	0.000793	0.000793	0	0.001586	0.001586	0.001586	0.000793	0
2017	0.0320	0.5908	0.2199	0.0285	0.0000	0.1106	0.0084	0.0063	0.0007	0.0007	0.0000	0.0021	0.0000	0.0000	0.0000

Table B7.5 (continued).

Stock 2

DE SSN

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1983	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1984	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1985	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1986	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1987	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1988	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1989	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1990	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1991	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1992	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1993	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1994	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1995	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1996	-1	0.0060	0.4170	0.1920	0.0610	0.0850	0.0760	0.0640	0.0580	0.0150	0.0090	0.0090	0.0090	-1	-1
1997	-1	0.0930	0.0740	0.3910	0.1370	0.0510	0.0640	0.0730	0.0320	0.0300	0.0230	0.0090	0.0230	-1	-1
1998	-1	0.0400	0.0870	0.0980	0.3470	0.0900	0.0610	0.1050	0.0950	0.0340	0.0250	0.0080	0.0110	-1	-1
1999	-1	0.0000	0.1050	0.1440	0.1770	0.2350	0.0720	0.0540	0.0760	0.0580	0.0510	0.0140	0.0140	-1	-1
2000	-1	0.0360	0.0360	0.2100	0.1710	0.1380	0.2230	0.0660	0.0300	0.0390	0.0320	0.0100	0.0100	-1	-1
2001	-1	0.0060	0.1150	0.1000	0.1850	0.1100	0.1400	0.2000	0.0500	0.0150	0.0400	0.0200	0.0200	-1	-1
2002	-1	0.0340	0.0710	0.1910	0.1780	0.1570	0.1130	0.0890	0.0970	0.0260	0.0160	0.0100	0.0180	-1	-1
2003	-1	0.0200	0.0970	0.0970	0.1340	0.0890	0.1110	0.1250	0.1050	0.1210	0.0340	0.0280	0.0380	-1	-1
2004	-1	0.0070	0.1660	0.2310	0.0980	0.0680	0.0540	0.1120	0.0780	0.0810	0.0440	0.0140	0.0470	-1	-1
2005	-1	0.0960	0.1570	0.1680	0.1980	0.0810	0.0460	0.0300	0.0360	0.0610	0.0360	0.0460	0.0460	-1	-1
2006	-1	0.0595	0.2007	0.0967	0.1413	0.1413	0.0706	0.0520	0.0409	0.0483	0.0483	0.0372	0.0632	-1	-1
2007	-1	0.0061	0.0887	0.3700	0.1804	0.1009	0.0734	0.0306	0.0245	0.0306	0.0275	0.0398	0.0275	-1	-1
2008	-1	0.0299	0.0329	0.1257	0.3024	0.1467	0.1317	0.0449	0.0359	0.0359	0.0269	0.0449	0.0419	-1	-1
2009	-1	0.1296	0.1014	0.0930	0.1803	0.1352	0.0901	0.0789	0.0366	0.0338	0.0169	0.0282	0.0761	-1	-1
2010	-1	0.1469	0.2041	0.1204	0.1143	0.1224	0.0898	0.0469	0.0429	0.0245	0.0224	0.0204	0.0449	-1	-1
2011	-1	0.0220	0.0550	0.1890	0.1720	0.1300	0.0950	0.1140	0.0950	0.0450	0.0300	0.0120	0.0410	-1	-1
2012	-1	0.1538	0.2985	0.2062	0.0308	0.0338	0.0185	0.0677	0.0338	0.0185	0.0154	0.0554	0.0677	-1	-1
2013	-1	0.0382	0.0795	0.0572	0.0684	0.1701	0.1590	0.1335	0.1145	0.0636	0.0334	0.0270	0.0556	-1	-1
2014	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2015	-1	0.0496	0.0780	0.1560	0.2199	0.1064	0.0922	0.0426	0.0213	0.0638	0.0851	0.0355	0.0496	-1	-1
2016	-1	0.0000	0.0051	0.1020	0.3010	0.2602	0.1224	0.0510	0.0357	0.0102	0.0357	0.0102	0.0663	-1	-1
2017	-1	0.109948	0.151832	0.13089	0.115183	0.120419	0.17801	0.062827	0.036649	0.026178	0.041885	0.020942	0	-1	-1

DE 30 Trawl

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1983	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1984	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1985	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1986	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1987	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1988	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1989	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1990	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1991	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1992	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1993	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1994	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1995	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1996	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1997	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1998	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1999	0.101438	0.227636	0.27476	0.242209	0.072652	0.047356	0.01804	0.006554	0.006162	0.003195	0	0	0	0	0
2000	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2001	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2002	0.215007	0.290314	0.176497	0.068182	0.056818	0.125	0.056818	0	0	0	0.011364	0	0	0	0
2003	0.132479	0.295543	0.442712	0.076085	0.009972	0.026591	0.006648	0.009972	0	0	0	0	0	0	0
2004	0.14375	0.20625	0.150699	0.1559	0.035892	0.068396	0.054117	0.079904	0.051454	0.025798	0.019129	0.008712	0	0	0
2005	0.295704	0.331853	0.05206	0.059996	0.128438	0.05677	0.058924	0.007095	0.005091	0.003084	0.000649	0	0.000337	0	0
2006	0.000529	0.075378	0.245824	0.486512	0.091749	0.044362	0.014255	0.01885	0.015012	0.005536	0.001369	0.000624	0	0	0
2007	0.11	0.158056	0.202778	0.245833	0.116352	0.10744	0.016497	0.009604	0.011562	0.011099	0.007444	0	0.003333	0	0
2008	0.02381	0.165344	0.202381	0.276266	0.128177	0.082738	0.039944	0.08134	0	0	0	0	0	0	0
2009	0.174851	0.168899	0.0625	0.010417	0.092566	0.128587	0.126188	0.052119	0.034308	0.107662	0.005445	0	0.005208	0.015625	0.015625
2010	0.168582	0.306513	0.363985	0.015326	0.034483	0.039591	0.011221	0.026546	0.002919	0.024266	0.001642	0	0.001642	0.003284	0
2011	0.651882	0.122312	0.075269	0.075269	0	0	0	0.011649	0.006272	0.024194	0.006272	0.005376	0	0	0.021505
2012	0.386992	0.161789	0.134146	0.04878	0.109756	0.087979	0.020035	0.031359	0.019164	0	0	0	0	0	0
2013	0	0.355848	0.159522	0.053298	0.025523	0.067457	0.070568	0.098199	0.072616	0.046507	0.018981	0.019444	0.012037	0	0
2014	0.574405	0.104167	0.156006	0.064069	0.03273	0.024674	0.009354	0.01369	0.004393	0.002622	0	0.002976	0.000992	0.004464	0.005456
2015	0.356473	0.180113	0.033737	0.087251	0.173699	0.070135	0.042308	0.031895	0	0.009756	0.004878	0.004878	0	0	0.004878
2016	0.763942	0.201967	0	0.000812	0.001623	0.010552	0.003247	0.003247	0.003247	0	0	0	0	0	0.011364
2017	0.230	0.659	0.169	0.016	0.004	0.005	0.016	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table B7.5 (continued).

Mixed stock Ocean

NYOHS

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1983	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1984	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1985	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1986	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1987	-1	0.031815908	0.194997499	0.35927964	0.27883942	0.088344172	0.034917459	0.006703352	0.00170085	0	0.0006003	0	0.002801401	-1	-1
1988	-1	0.226314733	0.269670815	0.19520273	0.166599759	0.085407467	0.021878764	0.014452027	0.003914091	0.002107587	0.000702529	0	0.013749498	-1	-1
1989	-1	0.183612141	0.269458079	0.148051688	0.159871782	0.102674547	0.093759391	0.021736953	0.003005109	0.002003406	0.003005109	0.002003406	0.010818391	-1	-1
1990	-1	0.060787842	0.295640872	0.306238752	0.113877225	0.098480304	0.055688862	0.044391122	0.015796841	0.00579884	0.0009998	0	0.00229954	-1	-1
1991	-1	0.207145002	0.3668568	0.24407085	0.051936355	0.016611628	0.025317722	0.04162914	0.023016111	0.006304413	0.002001401	0.003602522	0.011508056	-1	-1
1992	-1	0.079207921	0.416641664	0.257725773	0.121112111	0.03290329	0.01430143	0.0170017	0.0250025	0.01750175	0.00320032	0.00580058	0.00960096	-1	-1
1993	-1	0.156691729	0.387769424	0.291528822	0.070275689	0.032882206	0.009423559	0.009022556	0.011528822	0.013132832	0.007017544	0.002506266	0.008220551	-1	-1
1994	-1	0.141353383	0.271177945	0.156591479	0.134937343	0.083408521	0.054736842	0.037593985	0.022255639	0.040701754	0.01273183	0.024160401	0.020350877	-1	-1
1995	-1	0.246305419	0.270935961	0.255554439	0.072383633	0.066150598	0.035387554	0.012365537	0.005428772	0.012365537	0.011561275	0.003116518	0.008444757	-1	-1
1996	-1	0.083208321	0.747574757	0.114211421	0.03280328	0.00940094	0.00730073	0.00270027	0.00130013	0.00070007	0	0.00050005	0.00030003	-1	-1
1997	-1	0.206279372	0.242475752	0.450754925	0.066893311	0.01839816	0.00369963	0.00369963	0.00389961	0.00169983	0.00069993	0.00089991	0.00059994	-1	-1
1998	-1	0.18767507	0.297018808	0.171468587	0.285614246	0.036614646	0.009103641	0.005802321	0.00290116	0.00020008	0.0010004	0.0015006	0.00110044	-1	-1
1999	-1	0.069818692	0.628768907	0.172493239	0.059501152	0.043874587	0.005008514	0.003205449	0.004607833	0.00350596	0.003906641	0.000701192	0.004607833	-1	-1
2000	-1	0.127529553	0.193348026	0.434582248	0.15437788	0.036465638	0.036866359	0.004107393	0.003907033	0.001602885	0.001803246	0.001001803	0.004407934	-1	-1
2001	-1	0.052452452	0.455755756	0.147547548	0.213113113	0.073573574	0.027427427	0.019419419	0.003203203	0.003903904	0.001101101	0	0.002502503	-1	-1
2002	-1	0.323373107	0.226712123	0.184798957	0.080717938	0.073698987	0.057354858	0.019853605	0.019853605	0.00130352	0.004812995	0.001804873	0.005715432	-1	-1
2003	-1	0.202442932	0.365138166	0.1252503	0.092310773	0.040648779	0.064677613	0.050660793	0.022727273	0.017721266	0.012615138	0.000901081	0.004905887	-1	-1
2004	-1	0.0501	0.5698	0.2734	0.0628	0.0222	0.0076	0.0061	0.0036	0.0011	0.0014	0.0017	0.0002	-1	-1
2005	-1	0.244375562	0.127987201	0.412558744	0.136986301	0.03359664	0.01379862	0.00349965	0.0089991	0.00649935	0.00349965	0.00369963	0.00449955	-1	-1
2006	-1	0.063906391	0.635963596	0.072807281	0.161016102	0.04240424	0.01440144	0.00570057	0.00250025	0.00030003	0.0010001	0	0	-1	-1
2007	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2008	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2009	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2010	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2011	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2012	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2013	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2014	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2015	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2016	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
2017	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

NJ Trawl

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1983	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1984	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1985	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1986	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1987	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1988	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1989	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1990	-1	0.0769	0.1788	0.2360	0.1014	0.1420	0.1012	0.0754	0.0614	0.0178	0.0075	0.0016	0.0000	0	0
1991	-1	0.1912	0.2824	0.1155	0.0207	0.0197	0.0977	0.0985	0.0644	0.0682	0.0417	0.0000	0.0000	0	0
1992	-1	0.0455	0.6779	0.0484	0.0234	0.0276	0.0639	0.0425	0.0541	0.0167	0.0000	0.0000	0.0000	0	0
1993	-1	0.5333	0.0633	0.1477	0.1048	0.0934	0.0458	0.0035	0.0000	0.0000	0.0083	0.0000	0.0000	0	0
1994	-1	0.2196	0.4400	0.1204	0.0801	0.0458	0.0343	0.0214	0.0272	0.0112	0.0000	0.0000	0.0000	0	0
1995	-1	0.5945	0.2731	0.0349	0.0375	0.0300	0.0154	0.0071	0.0048	0.0011	0.0016	0.0000	0.0000	0	0
1996	-1	0.1112	0.7608	0.0622	0.0260	0.0209	0.0137	0.0046	0.0006	0.0001	0.0000	0.0000	0.0000	0	0
1997	-1	0.3683	0.0885	0.3190	0.1223	0.0476	0.0240	0.0125	0.0080	0.0045	0.0023	0.0010	0.0015	6.24E-05	0.000302
1998	-1	0.5920	0.1024	0.0526	0.1161	0.0599	0.0355	0.0200	0.0129	0.0053	0.0026	0.0002	0.0004	0	0
1999	-1	0.0221	0.3828	0.1815	0.1894	0.1435	0.0457	0.0180	0.0120	0.0051	0.0000	0.0000	0.0000	0	0
2000	-1	0.1981	0.0915	0.1178	0.1707	0.1841	0.1099	0.0483	0.0340	0.0228	0.0122	0.0073	0.0027	0.000315	0.000187
2001	-1	0.1798	0.1680	0.1251	0.2662	0.1613	0.0635	0.0256	0.0084	0.0021	0.0000	0.0000	0.0000	0	0
2002	-1	0.0192	0.0072	0.0539	0.1373	0.2506	0.2202	0.1415	0.0940	0.0301	0.0193	0.0167	0.0084	0.001665	0
2003	-1	0.4955	0.0902	0.0267	0.0737	0.0784	0.1113	0.0587	0.0286	0.0239	0.0058	0.0032	0.0011	0.001129	0.001943
2004	-1	0.1493	0.5719	0.0580	0.0347	0.0548	0.0442	0.0396	0.0230	0.0154	0.0032	0.0023	0.0037	0	0
2005	-1	0.6556	0.1126	0.0585	0.0883	0.0360	0.0254	0.0104	0.0067	0.0029	0.0012	0.0008	0.0002	0.0008	0.0008
2006	-1	0.0814	0.0982	0.0579	0.2676	0.2435	0.1019	0.0689	0.0448	0.0255	0.0052	0.0036	0.0007	0.000727	0
2007	-1	0.2326	0.1724	0.2994	0.0833	0.1196	0.0562	0.0185	0.0099	0.0062	0.0014	0.0001	0.0003	0	0
2008	-1	0.1205	0.0737	0.0902	0.3544	0.0932	0.1213	0.0793	0.0311	0.0156	0.0117	0.0046	0.0022	0.000937	0.001241
2009	-1	0.1000	0.0003	0.0222	0.1499	0.4446	0.0889	0.1016	0.0532	0.0287	0.0082	0.0024	0.0000	0	0
2010	-1	0.0291	0.0104	0.0063	0.0533	0.1934	0.4811	0.0986	0.0752	0.0294	0.0106	0.0073	0.0028	0.002407	0
2011	-1	0.1118	0.0858	0.0757	0.0223	0.1092	0.1635	0.2821	0.0825	0.0594	0.0076	0.0000	0.0000	0	0
2012	-1	0.2201	0.0750	0.0392	0.0757	0.0515	0.1069	0.1750	0.2056	0.0412	0.0099	0.0000	0.0000	0	0
2013	-1	0.6483	0.1400	0.0064	0.0134	0.0433	0.0340	0.0547	0.0388	0.0187	0.0015	0.0006	0.0003	0	0
2014	-1	0.0707	0.8030	0.1263	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0	0
2015	-1	0.3333	0.6667	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0	0
2016	-1	0.5922	0.1442	0.0568	0.0371	0.0337	0.0387	0.0292	0.0200	0.0201	0.0141	0.0075	0.0050	0.001344	0.000223
2017	-1	0.1699	0.5363	0.0465	0.0255	0.0965	0.0627	0.0488	0.0017	0.0017	0.0077	0.0028	0.0000	0	0

Table B7.5 (continued).

Mixed stock Ocean

CT Trawl

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1983	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1984	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1985	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1986	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
1987	0.0577	0.1178	0.1572	0.2614	0.1924	0.1185	0.0585	0.0184	0.0138	0.0022	0.0000	0.0022	0.0000	0.0000	0.0000
1988	0.0420	0.2951	0.2572	0.2149	0.1092	0.0409	0.0121	0.0205	0.0067	0.0013	0.0000	0.0000	0.0000	0.0000	0.0000
1989	0.1298	0.4128	0.1846	0.0000	0.0909	0.0000	0.1364	0.0455	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1990	0.0533	0.6286	0.1611	0.0496	0.0155	0.0367	0.0218	0.0137	0.0099	0.0039	0.0059	0.0000	0.0000	0.0000	0.0000
1991	0.0279	0.3662	0.2157	0.1463	0.0321	0.0194	0.0584	0.0549	0.0499	0.0189	0.0067	0.0013	0.0023	0.0000	0.0000
1992	0.0411	0.1471	0.2764	0.2506	0.1482	0.0239	0.0315	0.0422	0.0270	0.0090	0.0026	0.0005	0.0000	0.0000	0.0000
1993	0.0310	0.0530	0.1573	0.2962	0.1254	0.1206	0.0721	0.1081	0.0119	0.0092	0.0047	0.0103	0.0001	0.0000	0.0000
1994	0.0029	0.1006	0.1804	0.2547	0.2304	0.1184	0.0524	0.0223	0.0170	0.0145	0.0055	0.0010	0.0000	0.0000	0.0000
1995	0.0479	0.7499	0.0755	0.0390	0.0235	0.0338	0.0063	0.0147	0.0009	0.0000	0.0070	0.0014	0.0000	0.0000	0.0000
1996	0.0208	0.0011	0.5691	0.1971	0.0994	0.0279	0.0443	0.0137	0.0139	0.0064	0.0036	0.0027	0.0000	0.0000	0.0000
1997	0.1523	0.3143	0.2360	0.1282	0.0413	0.0535	0.0302	0.0197	0.0158	0.0022	0.0039	0.0019	0.0008	0.0000	0.0000
1998	0.0560	0.4681	0.2639	0.0847	0.1055	0.0153	0.0044	0.0013	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
1999	0.0180	0.2171	0.2669	0.1308	0.1246	0.1681	0.0436	0.0174	0.0053	0.0042	0.0023	0.0016	0.0000	0.0000	0.0000
2000	0.0094	0.3876	0.1974	0.0582	0.1086	0.0777	0.0472	0.0822	0.0177	0.0060	0.0036	0.0020	0.0011	0.0000	0.0013
2001	0.0659	0.2167	0.2568	0.0947	0.1970	0.0977	0.0450	0.0201	0.0039	0.0004	0.0015	0.0001	0.0003	0.0001	0.0000
2002	0.2940	0.2842	0.0815	0.0836	0.0454	0.1053	0.0594	0.0196	0.0198	0.0028	0.0037	0.0000	0.0000	0.0008	0.0000
2003	0.0214	0.4410	0.2255	0.1097	0.0848	0.0442	0.0380	0.0182	0.0085	0.0064	0.0020	0.0002	0.0000	0.0000	0.0000
2004	0.0194	0.2438	0.2513	0.1387	0.0899	0.1009	0.0565	0.0553	0.0214	0.0123	0.0058	0.0047	0.0000	0.0000	0.0000
2005	0.0450	0.5050	0.1030	0.2490	0.0622	0.0154	0.0113	0.0029	0.0036	0.0014	0.0010	0.0001	0.0000	0.0000	0.0000
2006	0.0022	0.0922	0.5205	0.1257	0.1758	0.0481	0.0175	0.0086	0.0033	0.0038	0.0011	0.0006	0.0004	0.0000	0.0000
2007	0.0090	0.0615	0.2351	0.4289	0.1183	0.1043	0.0272	0.0102	0.0038	0.0004	0.0003	0.0011	0.0000	0.0000	0.0000
2008	0.1269	0.0906	0.2189	0.1402	0.2723	0.0391	0.0668	0.0262	0.0095	0.0049	0.0005	0.0005	0.0036	0.0000	0.0000
2009	0.0430	0.3277	0.1213	0.2397	0.1024	0.1444	0.0101	0.0083	0.0011	0.0014	0.0004	0.0002	0.0000	0.0000	0.0000
2010	0.0035	0.0147	0.2207	0.1505	0.2759	0.1284	0.1605	0.0234	0.0141	0.0071	0.0003	0.0008	0.0000	0.0000	0.0000
2011	0.0162	0.0171	0.0551	0.3639	0.0921	0.1895	0.0966	0.1285	0.0167	0.0134	0.0036	0.0022	0.0020	0.0010	0.0020
2012	0.2476	0.2802	0.1091	0.0793	0.1524	0.0328	0.0339	0.0282	0.0244	0.0035	0.0050	0.0017	0.0020	0.0000	0.0000
2013	0.0976	0.2649	0.3015	0.1172	0.0453	0.0928	0.0161	0.0144	0.0248	0.0126	0.0087	0.0009	0.0022	0.0004	0.0004
2014	0.0072	0.0444	0.5509	0.2926	0.0337	0.0030	0.0055	0.0095	0.0170	0.0165	0.0140	0.0035	0.0015	0.0002	0.0005
2015	0.0540	0.0752	0.0823	0.5106	0.1048	0.0289	0.0174	0.0180	0.0257	0.0322	0.0257	0.0193	0.0039	0.0019	0.0000
2016	0.4277	0.3150	0.0599	0.0319	0.1357	0.0111	0.0032	0.0021	0.0030	0.0030	0.0033	0.0032	0.0006	0.0002	0.0002
2017	0.1082	0.5954	0.1251	0.0765	0.0414	0.0384	0.0075	0.0021	0.0021	0.0019	0.0002	0.0013	0.0000	0.0000	0.0000

MRIP

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.026	0.283	0.154	0.141	0.053	0.019	0.010	0.012	0.006	0.014	0.025	0.030	0.022	0.030	0.176
1983	0.061	0.189	0.154	0.098	0.174	0.154	0.061	0.041	0.002	0.001	0.051	0.002	0.003	0.002	0.008
1984	0.041	0.182	0.202	0.201	0.123	0.112	0.038	0.020	0.006	0.009	0.004	0.004	0.006	0.019	0.032
1985	0.002	0.081	0.134	0.086	0.207	0.231	0.209	0.015	0.002	0.003	0.006	0.002	0.003	0.006	0.012
1986	0.001	0.020	0.283	0.360	0.110	0.114	0.017	0.028	0.009	0.001	0.000	0.002	0.005	0.005	0.042
1987	0.012	0.144	0.252	0.193	0.171	0.063	0.047	0.038	0.027	0.011	0.005	0.006	0.004	0.007	0.020
1988	0.032	0.279	0.200	0.152	0.130	0.101	0.041	0.027	0.016	0.006	0.003	0.001	0.004	0.002	0.005
1989	0.022	0.201	0.290	0.114	0.126	0.092	0.072	0.030	0.021	0.013	0.004	0.001	0.002	0.002	0.009
1990	0.000	0.149	0.171	0.128	0.098	0.117	0.140	0.117	0.041	0.015	0.004	0.002	0.003	0.004	0.011
1991	0.001	0.160	0.191	0.202	0.105	0.058	0.076	0.081	0.078	0.023	0.005	0.003	0.001	0.004	0.012
1992	0.013	0.061	0.165	0.171	0.157	0.080	0.073	0.120	0.080	0.052	0.009	0.004	0.002	0.003	0.009
1993	0.000	0.085	0.128	0.179	0.140	0.119	0.079	0.063	0.087	0.067	0.036	0.007	0.002	0.001	0.007
1994	0.008	0.089	0.142	0.097	0.140	0.127	0.075	0.086	0.106	0.070	0.029	0.019	0.002	0.002	0.010
1995	0.003	0.406	0.166	0.088	0.050	0.070	0.039	0.049	0.049	0.038	0.025	0.011	0.004	0.001	0.002
1996	0.001	0.017	0.208	0.163	0.136	0.100	0.147	0.084	0.065	0.035	0.024	0.013	0.003	0.001	0.002
1997	0.005	0.179	0.191	0.282	0.106	0.061	0.040	0.038	0.034	0.022	0.018	0.009	0.008	0.004	0.002
1998	0.001	0.086	0.163	0.256	0.222	0.092	0.062	0.053	0.027	0.015	0.012	0.005	0.002	0.002	0.002
1999	0.001	0.016	0.232	0.295	0.167	0.120	0.051	0.057	0.021	0.022	0.010	0.005	0.002	0.001	0.001
2000	0.000	0.021	0.193	0.169	0.244	0.135	0.101	0.075	0.028	0.017	0.008	0.004	0.003	0.001	0.001
2001	0.001	0.023	0.097	0.148	0.287	0.195	0.122	0.062	0.020	0.014	0.015	0.006	0.005	0.002	0.001
2002	0.005	0.156	0.138	0.161	0.103	0.173	0.098	0.063	0.054	0.013	0.016	0.009	0.005	0.005	0.001
2003	0.000	0.105	0.219	0.137	0.164	0.080	0.115	0.082	0.042	0.026	0.013	0.008	0.005	0.003	0.002
2004	0.000	0.043	0.366	0.224	0.098	0.082	0.057	0.059	0.029	0.014	0.014	0.007	0.002	0.003	0.001
2005	0.002	0.247	0.143	0.250	0.149	0.060	0.043	0.031	0.031	0.018	0.013	0.006	0.003	0.002	0.002
2006	0.001	0.035	0.476	0.138	0.162	0.089	0.027	0.020	0.014	0.016	0.010	0.006	0.004	0.001	0.001
2007	0.000	0.089	0.215	0.334	0.114	0.106	0.040	0.025	0.023	0.023	0.015	0.010	0.004	0.001	0.001
2008	0.006	0.028	0.145	0.203	0.312	0.095	0.090	0.049	0.019	0.022	0.010	0.006	0.010	0.002	0.002
2009	0.002	0.078	0.102	0.149	0.154	0.271	0.059	0.069	0.031	0.025	0.020	0.014	0.016	0.004	0.006
2010	0.000	0.026	0.219	0.091	0.135	0.118	0.189	0.051	0.054	0.041	0.018	0.019	0.015	0.016	0.008
2011	0.015	0.075	0.147	0.188	0.077	0.146	0.106	0.122	0.040	0.031	0.015	0.011	0.011	0.007	0.008
2012	0.001	0.178	0.202	0.068	0.146	0.106	0.067	0.075	0.076	0.020	0.019	0.018	0.008	0.010	0.007
2013	0.001	0.079	0.228	0.213	0.157	0.086	0.054	0.040	0.041	0.064	0.011	0.007	0.008	0.005	0.008
2014	0.001	0.016	0.326	0.243	0.185	0.046	0.043	0.028	0.027	0.028	0.020	0.011	0.007	0.006	0.011
2015	0.002	0.035	0.045	0.359	0.243	0.101	0.046	0.035	0.031	0.030	0.028	0.018	0.009	0.008	0.010
2016	0.014	0.275	0.125	0.060	0.269	0.114	0.025	0.021	0.020	0.015	0.019	0.021	0.009	0.004	0.010
2017	0.001	0.214	0.269	0.104	0.103	0.143	0.055	0.027	0.012	0.017	0.014	0.017	0.013	0.006	0.005

Table B7.6. Starting values for two-stock statistical catch-at-age (2SCA) model parameters.

Stock	Category	ADMB Name	Lower	Upper	Start	Phase
1	Mean recruitment	s1_bay_logavg_R	-25	28	18	1
1	Recruitment devs	s1_bay_log_devR	-15	15		2
1	N Bay in first year	s1_bay_logNyr1	-25	28	18	2
1	F in bay	s1_bay_log_F	-23	1.1	-2.99	1
1	Catch selectivity	s1_bay_select_gompertz_a	-1	150	3.105	1
1	Catch selectivity	s1_bay_select_gompertz_b	0.01	150	0.915	1
1	Catch selectivity	s1_bay_select_logistic_a	-150	150	1.4	1
1	Catch selectivity	s1_bay_select_logistic_b	-150	150	4	1
1	Catch selectivity	s1_bay_select_thompson_a	-20	0	-3.81	1
1	Catch selectivity	s1_bay_select_thompson_b	-25	25	3	1
1	Catch selectivity	s1_bay_select_thompson_c	1E-10	1	0.9	1
1	YOY/Age 1 Catchability Coefficients	s1_bay_logq_agg	-40	0	-17	2
1	AC Surveys Catchability Coefficients	s1_bay_logq_ac	-40	0	-15	2
1	AC Surveys selectivity	s1_bay_ac_gompertz_a	-1	150	3.105	2
1	AC Surveys selectivity	s1_bay_ac_gompertz_b	0.01	150	0.915	2
1	AC Surveys selectivity	s1_bay_ac_logistic_a	-150	150	1.4	2
1	AC Surveys selectivity	s1_bay_ac_logistic_b	-150	150	4	2
1	AC Surveys selectivity	s1_bay_ac_thompson_a	-20	0	-3.81	2
1	AC Surveys selectivity	s1_bay_ac_thompson_b	-25	25	3	2
1	AC Surveys selectivity	s1_bay_ac_thompson_c	1E-10	1	0.9	2
1	AC Surveys selectivity	s1_bay_ac_gamma_a	-150	150	3	2
1	AC Surveys selectivity	s1_bay_ac_gamma_b	-150	150	1	2
2	Mean recruitment	s2_logavg_R	-25	28	17	1
2	Recruitment devs	s2_log_devR	-20	20		2
2	N ocean I first year	s2_logNyr1	-25	28	18	2
2	YOY/Age 1 Catchability Coefficients	s2_logq_agg	-40	0	-9.1	2
2	AC Surveys Catchability Coefficients	s2_logq_ac	-40	0	-9.1	2
2	AC Surveys selectivity	s2_ac_gompertz_a	-1	150	3.105	2
2	AC Surveys selectivity	s2_ac_gompertz_b	0.01	150	0.915	2
2	AC Surveys selectivity	s2_ac_logistic_a	-150	150	1.4	2
2	AC Surveys selectivity	s2_ac_logistic_b	-150	150	4	2
2	AC Surveys selectivity	s2_ac_thompson_a	-20	0	-3.81	2
2	AC Surveys selectivity	s2_ac_thompson_b	-25	25	3	2
2	AC Surveys selectivity	s2_ac_thompson_c	1E-10	1	0.9	2
2	AC Surveys selectivity	s2_ac_gamma_a	-150	150	3	2
2	AC Surveys selectivity	s2_ac_gamma_b	-150	150	1	2
Mixed Ocean	F in Ocean	coast_log_F	-23	1.1	-2.99	1
Mixed Ocean	Catch selectivity	coast_select_gompertz_a	-1	150	3.105	1
Mixed Ocean	Catch selectivity	coast_select_gompertz_b	0.01	150	0.915	1
Mixed Ocean	Catch selectivity	coast_select_logistic_a	-150	150	1.4	1
Mixed Ocean	Catch selectivity	coast_select_logistic_b	-150	150	4	1
Mixed Ocean	Catch selectivity	coast_select_thompson_a	-20	0	-3.81	1
Mixed Ocean	Catch selectivity	coast_select_thompson_b	-25	25	3	1
Mixed Ocean	Catch selectivity	coast_select_thompson_c	1E-10	1	0.9	1
Mixed Ocean	AC Surveys Catchability Coefficients	coast_logq_ac	-40	0	-15	2
Mixed Ocean	AC Surveys selectivity	coast_ac_gompertz_a	-20	150	3.105	2
Mixed Ocean	AC Surveys selectivity	coast_ac_gompertz_b	0.01	150	0.915	2
Mixed Ocean	AC Surveys selectivity	coast_ac_logistic_a	-150	150	1.4	2
Mixed Ocean	AC Surveys selectivity	coast_ac_logistic_b	-150	150	4	2
Mixed Ocean	AC Surveys selectivity	coast_ac_thompson_a	-20	0	-3.81	2
Mixed Ocean	AC Surveys selectivity	coast_ac_thompson_b	-25	25	3	2
Mixed Ocean	AC Surveys selectivity	coast_ac_thompson_c	1E-10	1	0.9	2
Mixed Ocean	AC Surveys selectivity	coast_ac_gamma_a	-150	150	3	2
Mixed Ocean	AC Surveys selectivity	coast_ac_gamma_b	-150	150	1	2

Table B7.7. CV weights, residual mean square error (RMSE), and effective sample sizes for total removals, removals at age, indices, and index age composition data by stock for 2SCA model.

Stock 1

Total Removals			
Period	CV Weights	RMSE	Average ESS
1	1.3	0.083	4
2	1.2	0.081	31
3	0.45	0.075	13

Indices	CV weights	RMSE	Average ESS
MDVAYOY	0.4	0.84	
MD Age 1	1	1.02	
MDSSN	1.5	0.96	34.4
CHESMAP	0.6	1.03	14.2

Stock 2

Indices	CV weights	RMSE	Average ESS
NY YOY	1.7	1.03	
NY Age 1	0.5	0.98	
NJ YOY	2	0.85	
DE SSN	0.35	1	20
DE 30 Trawl	0.7	0.99	7.5

Mixed Stock (Ocean)

Total Removals			
Period	CV Weights	RMSE	Average ESS
1	1	0.1038	5
2	0.5	0.0965	15.9
3	0.3	0.0776	24.6

Indices	CV weights	RMSE	Average ESS
NY OHS*	5	0.49	16.2
NJ Trawl	1.8	1.00	4.6
CT Trawl	0.65	1.00	7.8
MRIP	0.5	0.99	18.8

* purposely down-weighted to ignore total index, but allow use of the age composition data

Table B7.8. Likelihood components with respective contributions from base model run for 2SCA model.

Components	-LogL
Stock 1 Total Removals (All Periods) RSS	11.6437
Ocean Total Removals RSS (All Periods) RSS	17.8379
Stock 1 YOY and Age 1 Indices RSS	584.784
Stock 2 YOY and Age 1 Indices RSS	1117.37
Stock 1 Age-Specific Indices RSS	371.258
Stock 2 Age_Specific Indices RSS	736.139
Mixed Stock Age_Specific Indices RSS	1474.95
Concentrated Likelihood	555.087
Stock 1 Removals Age Composition Likelihood	3618.13
Ocean Removals Age Composition Likelihood	4008.7
Stock 1 Age-Specific Indices Age Composition Likelihood	2618.26
Stock 2 Age -Specific Indices Age Composition Likelihood	1221.44
Mixed Stock Age -Specific Indices Age Composition Likelihood	2730.75
Stock Composition Likelihood	259.813
Composition Data Total Likelihood	14457.1
Total Likelihood	15069.2
Number of Parameters Estimates	344
AIC	30826.5

Table B7.9 2SCA model parameter estimates and associated standard deviations of base model configuration.

Stock 1 Bay

Year	F (Period 1)	SD	CV	F (Period 2)	SD	CV	F (Period 3)	SD	CV
1982	0.1039	0.0761	0.7330	0.1275	0.0837	0.6570	0.1387	0.0494	0.3560
1983	0.0417	0.0337	0.8080	0.0793	0.0580	0.7320	0.2342	0.0759	0.3240
1984	0.0194	0.0159	0.8210	0.0185	0.0139	0.7530	0.1650	0.0553	0.3350
1985	0.0000	0.0000	0.7590	0.0050	0.0036	0.7170	0.0038	0.0011	0.3010
1986	0.0000	0.0000	0.7540	0.0062	0.0044	0.7190	0.0064	0.0019	0.2890
1987	0.0000	0.0000	0.7510	0.0029	0.0020	0.7050	0.0010	0.0003	0.2810
1988	0.0000	0.0000	0.7500	0.0010	0.0007	0.6970	0.0091	0.0025	0.2780
1989	0.0000	0.0000	0.7490	0.0009	0.0006	0.6960	0.0048	0.0013	0.2740
1990	0.0000	0.0000	0.7560	0.0041	0.0017	0.4010	0.0769	0.0128	0.1670
1991	0.0026	0.0020	0.7660	0.0059	0.0024	0.4020	0.0700	0.0116	0.1650
1992	0.0116	0.0092	0.7950	0.0052	0.0021	0.4000	0.0633	0.0103	0.1630
1993	0.0093	0.0073	0.7840	0.0037	0.0015	0.3970	0.0544	0.0084	0.1540
1994	0.0074	0.0057	0.7730	0.0051	0.0020	0.3950	0.0778	0.0113	0.1450
1995	0.0081	0.0063	0.7740	0.0141	0.0089	0.6300	0.1004	0.0144	0.1430
1996	0.0148	0.0115	0.7750	0.0132	0.0041	0.3090	0.1614	0.0204	0.1260
1997	0.0175	0.0134	0.7650	0.0166	0.0034	0.2040	0.1774	0.0200	0.1130
1998	0.0142	0.0105	0.7410	0.0155	0.0058	0.3740	0.1513	0.0170	0.1130
1999	0.0063	0.0046	0.7380	0.0154	0.0026	0.1710	0.1656	0.0179	0.1080
2000	0.0130	0.0094	0.7210	0.0195	0.0069	0.3520	0.1607	0.0188	0.1170
2001	0.0065	0.0048	0.7350	0.0127	0.0055	0.4370	0.1417	0.0155	0.1090
2002	0.0110	0.0080	0.7230	0.0107	0.0033	0.3040	0.1628	0.0183	0.1130
2003	0.0078	0.0056	0.7270	0.0246	0.0074	0.3010	0.2125	0.0232	0.1090
2004	0.0101	0.0073	0.7260	0.0210	0.0071	0.3380	0.2349	0.0256	0.1090
2005	0.0146	0.0105	0.7190	0.0271	0.0169	0.6240	0.1771	0.0201	0.1140
2006	0.0146	0.0106	0.7220	0.0243	0.0101	0.4180	0.2660	0.0326	0.1230
2007	0.0106	0.0078	0.7350	0.0231	0.0110	0.4770	0.1919	0.0247	0.1290
2008	0.0117	0.0086	0.7350	0.0159	0.0071	0.4470	0.1653	0.0199	0.1200
2009	0.0155	0.0114	0.7320	0.0220	0.0111	0.5030	0.2122	0.0263	0.1240
2010	0.0163	0.0117	0.7200	0.0199	0.0067	0.3370	0.2245	0.0391	0.1740
2011	0.0153	0.0111	0.7220	0.0275	0.0104	0.3770	0.2147	0.0288	0.1340
2012	0.0222	0.0160	0.7180	0.0244	0.0096	0.3950	0.2701	0.0367	0.1360
2013	0.0153	0.0111	0.7290	0.0383	0.0115	0.2990	0.2667	0.0343	0.1280
2014	0.0138	0.0104	0.7480	0.0304	0.0114	0.3750	0.3180	0.0533	0.1670
2015	0.0078	0.0059	0.7540	0.0340	0.0150	0.4420	0.2552	0.0355	0.1390
2016	0.0110	0.0082	0.7510	0.0667	0.0308	0.4620	0.2859	0.0427	0.1490
2017	0.0100	0.0075	0.7510	0.0504	0.0239	0.4740	0.1942	0.0319	0.1640

Ocean

Year	F (Period 1)	SD	CV	F (Period 2)	SD	CV	F (Period 3)	SD	CV
1982	0.0008	0.0006	0.6580	0.1077	0.0294	0.2730	0.0841	0.0203	0.2420
1983	0.0003	0.0002	0.6590	0.0402	0.0125	0.3110	0.1511	0.0544	0.3600
1984	0.0001	0.0001	0.6580	0.0124	0.0052	0.4180	0.0907	0.0201	0.2220
1985	0.0000	0.0000	1.2950	0.0240	0.0123	0.5110	0.1768	0.0720	0.4070
1986	0.0000	0.0000	1.1430	0.0125	0.0085	0.6770	0.0636	0.0202	0.3180
1987	0.0000	0.0000	0.7740	0.0058	0.0030	0.5140	0.0424	0.0087	0.2060
1988	0.0000	0.0000	0.6440	0.0098	0.0032	0.3240	0.0483	0.0112	0.2320
1989	0.0000	0.0000	0.5640	0.0147	0.0044	0.3020	0.0599	0.0117	0.1960
1990	0.0004	0.0003	0.5940	0.0335	0.0109	0.3260	0.0876	0.0165	0.1890
1991	0.0004	0.0004	1.2050	0.0421	0.0130	0.3090	0.1190	0.0224	0.1880
1992	0.0009	0.0010	1.0540	0.0689	0.0220	0.3190	0.1198	0.0223	0.1860
1993	0.0007	0.0005	0.6240	0.0559	0.0136	0.2430	0.0866	0.0144	0.1660
1994	0.0015	0.0009	0.6240	0.0697	0.0151	0.2160	0.1042	0.0160	0.1530
1995	0.0017	0.0011	0.6250	0.0844	0.0201	0.2380	0.2023	0.0354	0.1750
1996	0.0038	0.0024	0.6300	0.1072	0.0213	0.1990	0.2102	0.0324	0.1540
1997	0.0134	0.0086	0.6470	0.0931	0.0128	0.1370	0.1436	0.0124	0.0860
1998	0.0088	0.0056	0.6420	0.1078	0.0169	0.1570	0.1549	0.0139	0.0900
1999	0.0114	0.0075	0.6560	0.0915	0.0130	0.1420	0.1419	0.0132	0.0930
2000	0.0045	0.0028	0.6220	0.0969	0.0146	0.1500	0.1372	0.0122	0.0890
2001	0.0067	0.0042	0.6240	0.0966	0.0116	0.1200	0.1383	0.0118	0.0860
2002	0.0125	0.0079	0.6320	0.1438	0.0175	0.1210	0.1164	0.0099	0.0850
2003	0.0095	0.0059	0.6220	0.1383	0.0178	0.1280	0.1278	0.0107	0.0840
2004	0.0194	0.0131	0.6750	0.1631	0.0482	0.2960	0.1555	0.0144	0.0930
2005	0.0097	0.0059	0.6090	0.1660	0.0304	0.1830	0.1538	0.0144	0.0940
2006	0.0148	0.0204	1.3850	0.1992	0.0308	0.1550	0.1760	0.0159	0.0900
2007	0.0141	0.0092	0.6520	0.1686	0.0252	0.1490	0.1155	0.0111	0.0960
2008	0.0158	0.0083	0.5260	0.1217	0.0195	0.1600	0.1662	0.0163	0.0980
2009	0.0097	0.0028	0.2900	0.1280	0.0184	0.1440	0.1437	0.0134	0.0930
2010	0.0044	0.0035	0.7900	0.1384	0.0235	0.1700	0.1843	0.0178	0.0960
2011	0.0128	0.0062	0.4850	0.1765	0.0261	0.1480	0.1596	0.0157	0.0990
2012	0.0064	0.0034	0.5410	0.1512	0.0264	0.1750	0.1654	0.0176	0.1060
2013	0.0034	0.0019	0.5460	0.2551	0.0443	0.1740	0.2308	0.0244	0.1060
2014	0.0000	0.0000	0.5490	0.1636	0.0303	0.1850	0.1867	0.0234	0.1260
2015	0.0002	0.0001	0.5500	0.1811	0.0323	0.1790	0.1425	0.0192	0.1350
2016	0.0000	0.0000	0.5500	0.1662	0.0366	0.2200	0.1699	0.0224	0.1320
2017	0.0000	0.0000	0.5510	0.1661	0.0287	0.1730	0.2337	0.0313	0.1340

Table B7.9 (continued).

Catch Selectivity Parameters

Stock 1 Bay

Time Block	Parameters	Estimate	SD	CV
1982-1989	α	2.466	0.111	0.045
	β	1.292	0.110	0.085
1990-1995	α	3.777	0.229	0.061
	β	0.724	0.078	0.108
1996-2017	α	4.544	0.152	0.033
	β	0.545	0.028	0.052

Ocean

Time Block	Parameters	Estimate	SD	CV
1982-1989	α	3.464	0.262	0.076
	β	0.687	0.085	0.124
1990-1996	α	5.469	0.554	0.101
	β	0.385	0.050	0.129
1997-2017	α	4.467	0.224	0.05
	β	0.489	0.037	0.076

Catchability Coefficents

Survey	Estimate	SD	CV
MDVA YOY	9.6289E-07	6.55E-08	0.068
MD Age 1	5.527E-09	6.6E-10	0.119
MDSSN	1.1124E-07	2.15E-08	0.193
CHESMAP	8.2089E-07	1.03E-07	0.125
NY YOY	3.1424E-07	3.67E-08	0.117
NY Age 1	7.1092E-08	5.15E-09	0.072
NJ YOY	2.2136E-08	1.63E-09	0.074
DE SSN	1.2274E-07	1.48E-08	0.12
DE 30 Trawl	9.217E-08	1.68E-08	0.182
NY OHS	2.254E-07	9.69E-08	0.43
NJ Trawl	4.0752E-07	5.04E-08	0.124
CT Trawl	2.0651E-08	1.71E-09	0.083
MRIP	6.1254E-08	4.16E-09	0.068

Age-Specific Survey Selectivity Parameters

Stock 1 Bay

Survey	Parameters	Estimate	SD	CV
MD SSN	Age 2	0.092	0.01	0.111
	Age 3	0.608	0.044	0.072
CHESMAP	α	1.268	0.111	0.087
	β	2.164	0.697	0.322

Stock 2

Survey	Parameters	Estimate	SD	CV
DE SSN	α	3.693	0.222	0.06
	β	0.708	0.079	0.113
DE Trawl	α	1.081	0.357	0.33
	β	0.215	0.107	0.496

Mixed Stock Ocean

Survey	Parameters	Estimate	SD	CV
NYOHS	α	-4.771	0.160	0.034
	β	2.369	0.047	0.02
	γ	0.932	0.008	0.009
NJ Trawl	α	3.732	0.480	0.129
	β	0.633	0.122	0.193
CT Trawl	α	3.830	0.347	0.091
	β	0.809	0.103	0.128
MRIP	α	-3.385	0.512	0.151
	β	2.391	0.122	0.051
	γ	0.980	0.008	0.008

Age	Stock 1 Bay N	SD	CV
2	1,188,000	260,880	0.220
3	637,850	146,780	0.230
4	179,730	58,361	0.325
5	47,538	25,557	0.538
6	6,457	3,288	0.509

Age	Stock 2 N	SD	CV
2	4,935,500	711,360	0.144
3	2,127,200	335,240	0.158
4	1,645,000	253,300	0.154
5	666,430	140,660	0.211
6	320,090	90,705	0.283
7	252,890	36,739	0.145

Table B7.9 (continued).

	Stock 1			Stock 2		
Year	Recruitment	SD	CV	Recruitment	SD	CV
1982	14,161,000	1,983,200	0.140	10,402,000	1,842,700	0.177
1983	44,721,000	4,707,200	0.105	15,521,000	2,577,600	0.166
1984	36,269,000	4,133,200	0.114	17,977,000	2,513,200	0.140
1985	49,861,000	5,232,600	0.105	15,058,000	2,469,300	0.164
1986	55,819,000	5,886,500	0.105	13,289,000	2,226,600	0.168
1987	63,572,000	6,746,900	0.106	20,311,000	3,042,200	0.150
1988	73,788,000	7,780,800	0.105	29,487,000	3,956,500	0.134
1989	106,110,000	10,248,000	0.097	38,177,000	4,746,400	0.124
1990	139,480,000	12,766,000	0.092	39,908,000	5,230,100	0.131
1991	93,716,000	10,564,000	0.113	39,761,000	5,087,800	0.128
1992	92,593,000	11,287,000	0.122	42,251,000	5,568,900	0.132
1993	120,520,000	13,927,000	0.116	51,097,000	6,162,000	0.121
1994	280,110,000	23,938,000	0.085	123,090,000	10,882,000	0.088
1995	214,990,000	21,901,000	0.102	67,587,000	7,942,800	0.118
1996	251,270,000	24,379,000	0.097	91,451,000	9,263,400	0.101
1997	312,280,000	26,875,000	0.086	92,195,000	9,503,000	0.103
1998	181,850,000	19,078,000	0.105	57,049,000	7,071,000	0.124
1999	149,900,000	16,432,000	0.110	65,037,000	7,317,600	0.113
2000	116,150,000	14,219,000	0.122	58,943,000	6,566,000	0.111
2001	189,030,000	18,138,000	0.096	80,859,000	8,164,400	0.101
2002	214,210,000	19,756,000	0.092	89,076,000	8,546,800	0.096
2003	101,300,000	12,994,000	0.128	52,680,000	5,979,400	0.114
2004	343,710,000	25,984,000	0.076	116,560,000	9,767,700	0.084
2005	159,230,000	16,077,000	0.101	55,011,000	6,400,400	0.116
2006	159,050,000	15,638,000	0.098	49,215,000	5,660,100	0.115
2007	81,587,000	10,544,000	0.129	30,424,000	4,248,000	0.140
2008	147,310,000	14,888,000	0.101	49,343,000	5,393,900	0.109
2009	70,282,000	9,679,500	0.138	30,957,000	4,033,600	0.130
2010	105,280,000	12,912,000	0.123	38,610,000	4,665,000	0.121
2011	98,198,000	13,435,000	0.137	59,425,000	6,459,500	0.109
2012	310,270,000	33,332,000	0.107	53,356,000	6,809,400	0.128
2013	50,745,000	10,157,000	0.200	21,811,000	3,647,300	0.167
2014	80,544,000	13,952,000	0.173	29,982,000	4,647,200	0.155
2015	151,110,000	24,772,000	0.164	86,320,000	11,104,000	0.129
2016	260,990,000	54,000,000	0.207	102,130,000	16,897,000	0.165
2017	81,958,000	26,133,000	0.319	52,409,000	12,230,000	0.233

Table B7.10. Fishing mortality for ages 1-15+ by region, period, and year from 2SCA base model.

Bay Fishing Mortality (Period 1/Wave 1)																
Year	Full F	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	0.104	0.000	0.017	0.063	0.091	0.100	0.103	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104
1983	0.042	0.000	0.007	0.025	0.036	0.040	0.041	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
1984	0.019	0.000	0.003	0.012	0.017	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
1985	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.003	0.000	0.000	0.000	0.001	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1992	0.012	0.000	0.000	0.002	0.005	0.008	0.010	0.011	0.011	0.011	0.011	0.012	0.012	0.012	0.012	0.012
1993	0.009	0.000	0.000	0.002	0.004	0.006	0.008	0.008	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
1994	0.007	0.000	0.000	0.001	0.003	0.005	0.006	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
1995	0.008	0.000	0.000	0.001	0.003	0.005	0.007	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008
1996	0.015	0.000	0.000	0.001	0.004	0.007	0.009	0.011	0.013	0.014	0.014	0.014	0.015	0.015	0.015	0.015
1997	0.017	0.000	0.000	0.002	0.005	0.008	0.011	0.013	0.015	0.016	0.017	0.017	0.017	0.017	0.017	0.017
1998	0.014	0.000	0.000	0.001	0.004	0.007	0.009	0.011	0.012	0.013	0.014	0.014	0.014	0.014	0.014	0.014
1999	0.006	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006
2000	0.013	0.000	0.000	0.001	0.003	0.006	0.008	0.010	0.011	0.012	0.012	0.013	0.013	0.013	0.013	0.013
2001	0.007	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.007	0.007
2002	0.011	0.000	0.000	0.001	0.003	0.005	0.007	0.008	0.009	0.010	0.010	0.011	0.011	0.011	0.011	0.011
2003	0.008	0.000	0.000	0.001	0.002	0.004	0.005	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.008
2004	0.010	0.000	0.000	0.001	0.003	0.005	0.006	0.008	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.010
2005	0.015	0.000	0.000	0.001	0.004	0.007	0.009	0.011	0.013	0.013	0.014	0.014	0.014	0.014	0.015	0.015
2006	0.015	0.000	0.000	0.001	0.004	0.007	0.009	0.011	0.013	0.013	0.014	0.014	0.014	0.015	0.015	0.015
2007	0.011	0.000	0.000	0.001	0.003	0.005	0.007	0.008	0.009	0.010	0.010	0.010	0.010	0.010	0.011	0.011
2008	0.012	0.000	0.000	0.001	0.003	0.005	0.007	0.009	0.010	0.011	0.011	0.011	0.012	0.012	0.012	0.012
2009	0.016	0.000	0.000	0.002	0.004	0.007	0.010	0.012	0.013	0.014	0.015	0.015	0.015	0.015	0.015	0.016
2010	0.016	0.000	0.000	0.002	0.004	0.007	0.010	0.013	0.014	0.015	0.015	0.016	0.016	0.016	0.016	0.016
2011	0.015	0.000	0.000	0.002	0.004	0.007	0.010	0.012	0.013	0.014	0.015	0.015	0.015	0.015	0.015	0.015
2012	0.022	0.000	0.000	0.002	0.006	0.010	0.014	0.017	0.019	0.020	0.021	0.022	0.022	0.022	0.022	0.022
2013	0.015	0.000	0.000	0.002	0.004	0.007	0.010	0.012	0.013	0.014	0.015	0.015	0.015	0.015	0.015	0.015
2014	0.014	0.000	0.000	0.001	0.004	0.006	0.009	0.011	0.012	0.013	0.013	0.013	0.014	0.014	0.014	0.014
2015	0.008	0.000	0.000	0.001	0.002	0.004	0.005	0.006	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.008
2016	0.011	0.000	0.000	0.001	0.003	0.005	0.007	0.008	0.009	0.010	0.010	0.011	0.011	0.011	0.011	0.011
2017	0.010	0.000	0.000	0.001	0.003	0.005	0.006	0.008	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.010

Table B7.10 (continued).

Bay Fishing Mortality (Period 2/Waves 2-3)																
Year	Full F	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	0.127	0.000	0.021	0.077	0.111	0.123	0.126	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127	0.127
1983	0.079	0.000	0.013	0.048	0.069	0.076	0.078	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
1984	0.019	0.000	0.003	0.011	0.016	0.018	0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
1985	0.005	0.000	0.001	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
1986	0.006	0.000	0.001	0.004	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
1987	0.003	0.000	0.000	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
1988	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1989	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1990	0.004	0.000	0.000	0.001	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
1991	0.006	0.000	0.000	0.001	0.003	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
1992	0.005	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
1993	0.004	0.000	0.000	0.001	0.002	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
1994	0.005	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
1995	0.014	0.000	0.000	0.002	0.006	0.009	0.012	0.013	0.013	0.014	0.014	0.014	0.014	0.014	0.014	0.014
1996	0.013	0.000	0.000	0.001	0.003	0.006	0.008	0.010	0.011	0.012	0.013	0.013	0.013	0.013	0.013	0.013
1997	0.017	0.000	0.000	0.002	0.004	0.008	0.011	0.013	0.014	0.015	0.016	0.016	0.016	0.016	0.017	0.017
1998	0.015	0.000	0.000	0.002	0.004	0.007	0.010	0.012	0.013	0.014	0.015	0.015	0.015	0.015	0.015	0.015
1999	0.015	0.000	0.000	0.002	0.004	0.007	0.010	0.012	0.013	0.014	0.015	0.015	0.015	0.015	0.015	0.015
2000	0.020	0.000	0.000	0.002	0.005	0.009	0.012	0.015	0.017	0.018	0.019	0.019	0.019	0.019	0.019	0.020
2001	0.013	0.000	0.000	0.001	0.003	0.006	0.008	0.010	0.011	0.012	0.012	0.012	0.012	0.013	0.013	0.013
2002	0.011	0.000	0.000	0.001	0.003	0.005	0.007	0.008	0.009	0.010	0.010	0.010	0.011	0.011	0.011	0.011
2003	0.025	0.000	0.000	0.002	0.006	0.011	0.016	0.019	0.021	0.023	0.023	0.024	0.024	0.024	0.025	0.025
2004	0.021	0.000	0.000	0.002	0.005	0.010	0.013	0.016	0.018	0.019	0.020	0.020	0.021	0.021	0.021	0.021
2005	0.027	0.000	0.000	0.003	0.007	0.012	0.017	0.021	0.023	0.025	0.026	0.026	0.027	0.027	0.027	0.027
2006	0.024	0.000	0.000	0.002	0.006	0.011	0.016	0.019	0.021	0.022	0.023	0.024	0.024	0.024	0.024	0.024
2007	0.023	0.000	0.000	0.002	0.006	0.011	0.015	0.018	0.020	0.021	0.022	0.023	0.023	0.023	0.023	0.023
2008	0.016	0.000	0.000	0.002	0.004	0.007	0.010	0.012	0.014	0.015	0.015	0.015	0.016	0.016	0.016	0.016
2009	0.022	0.000	0.000	0.002	0.006	0.010	0.014	0.017	0.019	0.020	0.021	0.021	0.022	0.022	0.022	0.022
2010	0.020	0.000	0.000	0.002	0.005	0.009	0.013	0.015	0.017	0.018	0.019	0.019	0.020	0.020	0.020	0.020
2011	0.027	0.000	0.001	0.003	0.007	0.013	0.018	0.021	0.024	0.025	0.026	0.027	0.027	0.027	0.027	0.027
2012	0.024	0.000	0.000	0.002	0.006	0.011	0.016	0.019	0.021	0.022	0.023	0.024	0.024	0.024	0.024	0.024
2013	0.038	0.000	0.001	0.004	0.010	0.018	0.024	0.030	0.033	0.035	0.036	0.037	0.038	0.038	0.038	0.038
2014	0.030	0.000	0.001	0.003	0.008	0.014	0.019	0.023	0.026	0.028	0.029	0.030	0.030	0.030	0.030	0.030
2015	0.034	0.000	0.001	0.003	0.009	0.016	0.022	0.026	0.029	0.031	0.032	0.033	0.033	0.034	0.034	0.034
2016	0.067	0.000	0.001	0.007	0.017	0.031	0.043	0.052	0.058	0.061	0.064	0.065	0.066	0.066	0.067	0.067
2017	0.050	0.000	0.001	0.005	0.013	0.023	0.032	0.039	0.043	0.046	0.048	0.049	0.050	0.050	0.050	0.050

Table B7.10 (continued).

Bay Fishing Mortality (Period 3/Waves 4-6)																
Year	Full F	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	0.139	0.000	0.022	0.084	0.121	0.134	0.137	0.138	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139
1983	0.234	0.000	0.038	0.142	0.204	0.226	0.232	0.234	0.234	0.234	0.234	0.234	0.234	0.234	0.234	0.234
1984	0.165	0.000	0.027	0.100	0.144	0.159	0.163	0.164	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165
1985	0.004	0.000	0.001	0.002	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
1986	0.006	0.000	0.001	0.004	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
1987	0.001	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1988	0.009	0.000	0.001	0.006	0.008	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
1989	0.005	0.000	0.001	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
1990	0.077	0.000	0.002	0.013	0.033	0.051	0.063	0.070	0.073	0.075	0.076	0.077	0.077	0.077	0.077	0.077
1991	0.070	0.000	0.002	0.012	0.030	0.046	0.057	0.064	0.067	0.068	0.069	0.070	0.070	0.070	0.070	0.070
1992	0.063	0.000	0.002	0.011	0.027	0.042	0.052	0.057	0.060	0.062	0.063	0.063	0.063	0.063	0.063	0.063
1993	0.054	0.000	0.001	0.009	0.023	0.036	0.045	0.049	0.052	0.053	0.054	0.054	0.054	0.054	0.054	0.054
1994	0.078	0.000	0.002	0.013	0.033	0.051	0.064	0.071	0.074	0.076	0.077	0.077	0.078	0.078	0.078	0.078
1995	0.100	0.000	0.003	0.017	0.043	0.066	0.082	0.091	0.096	0.098	0.099	0.100	0.100	0.100	0.100	0.100
1996	0.161	0.000	0.003	0.016	0.042	0.074	0.103	0.125	0.139	0.148	0.154	0.157	0.159	0.160	0.161	0.161
1997	0.177	0.000	0.003	0.018	0.046	0.082	0.113	0.137	0.153	0.163	0.169	0.173	0.175	0.176	0.177	0.177
1998	0.151	0.000	0.003	0.015	0.040	0.070	0.097	0.117	0.130	0.139	0.144	0.147	0.149	0.150	0.151	0.151
1999	0.166	0.000	0.003	0.016	0.043	0.076	0.106	0.128	0.143	0.152	0.158	0.161	0.163	0.165	0.165	0.166
2000	0.161	0.000	0.003	0.016	0.042	0.074	0.103	0.124	0.138	0.148	0.153	0.157	0.159	0.160	0.160	0.161
2001	0.142	0.000	0.003	0.014	0.037	0.065	0.090	0.109	0.122	0.130	0.135	0.138	0.140	0.141	0.141	0.142
2002	0.163	0.000	0.003	0.016	0.043	0.075	0.104	0.126	0.140	0.150	0.155	0.159	0.161	0.162	0.162	0.163
2003	0.212	0.000	0.004	0.021	0.056	0.098	0.136	0.164	0.183	0.195	0.203	0.207	0.210	0.211	0.212	0.212
2004	0.235	0.000	0.004	0.023	0.061	0.108	0.150	0.181	0.202	0.216	0.224	0.229	0.232	0.233	0.234	0.235
2005	0.177	0.000	0.003	0.017	0.046	0.081	0.113	0.137	0.153	0.163	0.169	0.172	0.175	0.176	0.177	0.177
2006	0.266	0.000	0.005	0.026	0.070	0.122	0.170	0.205	0.229	0.244	0.254	0.259	0.262	0.264	0.265	0.266
2007	0.192	0.000	0.004	0.019	0.050	0.088	0.122	0.148	0.165	0.176	0.183	0.187	0.189	0.191	0.191	0.192
2008	0.165	0.000	0.003	0.016	0.043	0.076	0.106	0.128	0.142	0.152	0.158	0.161	0.163	0.164	0.165	0.165
2009	0.212	0.000	0.004	0.021	0.055	0.098	0.135	0.164	0.183	0.195	0.202	0.207	0.209	0.211	0.212	0.212
2010	0.224	0.000	0.004	0.022	0.059	0.103	0.143	0.173	0.193	0.206	0.214	0.219	0.221	0.223	0.224	0.224
2011	0.215	0.000	0.004	0.021	0.056	0.099	0.137	0.166	0.185	0.197	0.205	0.209	0.212	0.213	0.214	0.215
2012	0.270	0.000	0.005	0.027	0.071	0.124	0.172	0.208	0.233	0.248	0.258	0.263	0.266	0.268	0.269	0.270
2013	0.267	0.000	0.005	0.026	0.070	0.123	0.170	0.206	0.230	0.245	0.254	0.260	0.263	0.265	0.266	0.267
2014	0.318	0.000	0.006	0.031	0.083	0.146	0.203	0.245	0.274	0.292	0.303	0.310	0.314	0.316	0.317	0.318
2015	0.255	0.000	0.005	0.025	0.067	0.117	0.163	0.197	0.220	0.234	0.243	0.249	0.252	0.253	0.255	0.255
2016	0.286	0.000	0.005	0.028	0.075	0.131	0.182	0.221	0.246	0.263	0.273	0.278	0.282	0.284	0.285	0.286
2017	0.194	0.000	0.004	0.019	0.051	0.089	0.124	0.150	0.167	0.178	0.185	0.189	0.191	0.193	0.194	0.194

Table B7.10 (continued).

Ocean Fishing Mortality (Period 1/Wave 1)																
Year	Full F	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1983	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1984	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1985	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1986	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1987	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1989	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1990	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1993	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1994	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
1995	0.002	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002
1996	0.004	0.000	0.000	0.000	0.001	0.001	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004
1997	0.013	0.000	0.000	0.002	0.004	0.006	0.008	0.010	0.011	0.012	0.013	0.013	0.013	0.013	0.013	0.013
1998	0.009	0.000	0.000	0.001	0.003	0.004	0.006	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009	0.009
1999	0.011	0.000	0.000	0.001	0.003	0.005	0.007	0.009	0.010	0.010	0.011	0.011	0.011	0.011	0.011	0.011
2000	0.004	0.000	0.000	0.001	0.001	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
2001	0.007	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007
2002	0.012	0.000	0.000	0.002	0.004	0.006	0.008	0.009	0.010	0.011	0.012	0.012	0.012	0.012	0.012	0.012
2003	0.010	0.000	0.000	0.001	0.003	0.004	0.006	0.007	0.008	0.009	0.009	0.009	0.009	0.009	0.009	0.010
2004	0.019	0.000	0.001	0.003	0.006	0.009	0.012	0.015	0.016	0.018	0.018	0.019	0.019	0.019	0.019	0.019
2005	0.010	0.000	0.000	0.001	0.003	0.004	0.006	0.007	0.008	0.009	0.009	0.009	0.009	0.010	0.010	0.010
2006	0.015	0.000	0.001	0.002	0.004	0.007	0.009	0.011	0.012	0.013	0.014	0.014	0.014	0.015	0.015	0.015
2007	0.014	0.000	0.001	0.002	0.004	0.007	0.009	0.011	0.012	0.013	0.013	0.014	0.014	0.014	0.014	0.014
2008	0.016	0.000	0.001	0.002	0.005	0.007	0.010	0.012	0.013	0.014	0.015	0.015	0.016	0.016	0.016	0.016
2009	0.010	0.000	0.000	0.001	0.003	0.005	0.006	0.007	0.008	0.009	0.009	0.009	0.010	0.010	0.010	0.010
2010	0.004	0.000	0.000	0.001	0.001	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
2011	0.013	0.000	0.000	0.002	0.004	0.006	0.008	0.010	0.011	0.012	0.012	0.012	0.013	0.013	0.013	0.013
2012	0.006	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006
2013	0.003	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
2014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table B7.10 (continued).

Ocean Fishing Mortality (Period 2/Waves 2-3)																
Year	Full F	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	0.108	0.000	0.007	0.027	0.054	0.076	0.090	0.099	0.103	0.105	0.107	0.107	0.107	0.108	0.108	0.108
1983	0.040	0.000	0.003	0.010	0.020	0.028	0.034	0.037	0.038	0.039	0.040	0.040	0.040	0.040	0.040	0.040
1984	0.012	0.000	0.001	0.003	0.006	0.009	0.010	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
1985	0.024	0.000	0.002	0.006	0.012	0.017	0.020	0.022	0.023	0.024	0.024	0.024	0.024	0.024	0.024	0.024
1986	0.013	0.000	0.001	0.003	0.006	0.009	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.013	0.013	0.013
1987	0.006	0.000	0.000	0.001	0.003	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
1988	0.010	0.000	0.001	0.002	0.005	0.007	0.008	0.009	0.009	0.010	0.010	0.010	0.010	0.010	0.010	0.010
1989	0.015	0.000	0.001	0.004	0.007	0.010	0.012	0.013	0.014	0.014	0.015	0.015	0.015	0.015	0.015	0.015
1990	0.034	0.000	0.001	0.003	0.006	0.010	0.015	0.020	0.024	0.027	0.029	0.031	0.032	0.033	0.033	0.034
1991	0.042	0.000	0.001	0.003	0.007	0.013	0.019	0.025	0.030	0.033	0.036	0.038	0.040	0.041	0.042	0.042
1992	0.069	0.000	0.002	0.005	0.012	0.021	0.031	0.041	0.048	0.055	0.059	0.063	0.065	0.067	0.068	0.069
1993	0.056	0.000	0.001	0.004	0.010	0.017	0.025	0.033	0.039	0.044	0.048	0.051	0.053	0.054	0.055	0.056
1994	0.070	0.000	0.002	0.005	0.012	0.022	0.032	0.041	0.049	0.055	0.060	0.063	0.066	0.068	0.069	0.070
1995	0.084	0.000	0.002	0.007	0.015	0.026	0.038	0.050	0.059	0.067	0.073	0.077	0.080	0.082	0.083	0.084
1996	0.107	0.000	0.002	0.008	0.019	0.033	0.049	0.063	0.075	0.085	0.092	0.098	0.101	0.104	0.106	0.107
1997	0.093	0.000	0.003	0.012	0.027	0.043	0.058	0.070	0.078	0.084	0.088	0.090	0.091	0.092	0.093	0.093
1998	0.108	0.000	0.004	0.014	0.031	0.050	0.068	0.081	0.091	0.097	0.101	0.104	0.106	0.107	0.107	0.108
1999	0.091	0.000	0.003	0.012	0.026	0.043	0.057	0.069	0.077	0.082	0.086	0.088	0.090	0.091	0.091	0.091
2000	0.097	0.000	0.003	0.013	0.028	0.045	0.061	0.073	0.082	0.087	0.091	0.094	0.095	0.096	0.097	0.097
2001	0.097	0.000	0.003	0.013	0.028	0.045	0.061	0.073	0.081	0.087	0.091	0.093	0.095	0.096	0.096	0.097
2002	0.144	0.001	0.005	0.019	0.041	0.067	0.090	0.108	0.121	0.130	0.135	0.139	0.141	0.142	0.143	0.144
2003	0.138	0.001	0.005	0.018	0.040	0.064	0.087	0.104	0.116	0.125	0.130	0.133	0.136	0.137	0.138	0.138
2004	0.163	0.001	0.006	0.021	0.047	0.076	0.102	0.123	0.137	0.147	0.153	0.157	0.160	0.161	0.162	0.163
2005	0.166	0.001	0.006	0.022	0.048	0.077	0.104	0.125	0.140	0.150	0.156	0.160	0.163	0.164	0.165	0.166
2006	0.199	0.001	0.007	0.026	0.057	0.093	0.125	0.150	0.168	0.180	0.187	0.192	0.195	0.197	0.198	0.199
2007	0.169	0.001	0.006	0.022	0.048	0.078	0.106	0.127	0.142	0.152	0.159	0.163	0.165	0.167	0.168	0.169
2008	0.122	0.001	0.004	0.016	0.035	0.057	0.076	0.092	0.102	0.110	0.114	0.117	0.119	0.121	0.121	0.122
2009	0.128	0.001	0.005	0.017	0.037	0.060	0.080	0.096	0.108	0.115	0.120	0.124	0.126	0.127	0.128	0.128
2010	0.138	0.001	0.005	0.018	0.040	0.064	0.087	0.104	0.117	0.125	0.130	0.134	0.136	0.137	0.138	0.138
2011	0.176	0.001	0.006	0.023	0.051	0.082	0.111	0.133	0.149	0.159	0.166	0.170	0.173	0.175	0.176	0.176
2012	0.151	0.001	0.005	0.020	0.043	0.070	0.095	0.114	0.127	0.136	0.142	0.146	0.148	0.150	0.151	0.151
2013	0.255	0.001	0.009	0.033	0.073	0.119	0.160	0.192	0.215	0.230	0.240	0.246	0.250	0.253	0.254	0.255
2014	0.164	0.001	0.006	0.021	0.047	0.076	0.103	0.123	0.138	0.148	0.154	0.158	0.160	0.162	0.163	0.164
2015	0.181	0.001	0.006	0.023	0.052	0.084	0.114	0.136	0.152	0.163	0.170	0.175	0.178	0.179	0.180	0.181
2016	0.166	0.001	0.006	0.022	0.048	0.077	0.104	0.125	0.140	0.150	0.156	0.160	0.163	0.165	0.166	0.166
2017	0.166	0.001	0.006	0.022	0.048	0.077	0.104	0.125	0.140	0.150	0.156	0.160	0.163	0.165	0.166	0.166

Table B7.10 (continued).

		Ocean Fishing Mortality (Period 3/Waves 4-6)														
Year	Full F	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	0.084	0.000	0.005	0.021	0.042	0.059	0.071	0.077	0.081	0.082	0.083	0.084	0.084	0.084	0.084	0.084
1983	0.151	0.001	0.010	0.038	0.076	0.107	0.127	0.138	0.145	0.148	0.149	0.150	0.151	0.151	0.151	0.151
1984	0.091	0.000	0.006	0.023	0.045	0.064	0.076	0.083	0.087	0.089	0.090	0.090	0.090	0.091	0.091	0.091
1985	0.177	0.001	0.012	0.045	0.089	0.125	0.148	0.162	0.169	0.173	0.175	0.176	0.176	0.177	0.177	0.177
1986	0.064	0.000	0.004	0.016	0.032	0.045	0.053	0.058	0.061	0.062	0.063	0.063	0.063	0.064	0.064	0.064
1987	0.042	0.000	0.003	0.011	0.021	0.030	0.036	0.039	0.041	0.041	0.042	0.042	0.042	0.042	0.042	0.042
1988	0.048	0.000	0.003	0.012	0.024	0.034	0.041	0.044	0.046	0.047	0.048	0.048	0.048	0.048	0.048	0.048
1989	0.060	0.000	0.004	0.015	0.030	0.042	0.050	0.055	0.057	0.059	0.059	0.060	0.060	0.060	0.060	0.060
1990	0.088	0.000	0.002	0.007	0.015	0.027	0.040	0.052	0.062	0.069	0.075	0.080	0.083	0.085	0.087	0.088
1991	0.119	0.000	0.003	0.009	0.021	0.037	0.054	0.070	0.084	0.094	0.103	0.108	0.113	0.116	0.118	0.119
1992	0.120	0.000	0.003	0.009	0.021	0.037	0.054	0.071	0.084	0.095	0.103	0.109	0.113	0.116	0.118	0.120
1993	0.087	0.000	0.002	0.007	0.015	0.027	0.039	0.051	0.061	0.069	0.075	0.079	0.082	0.084	0.086	0.087
1994	0.104	0.000	0.002	0.008	0.018	0.032	0.047	0.061	0.073	0.083	0.090	0.095	0.099	0.101	0.103	0.104
1995	0.202	0.001	0.005	0.016	0.036	0.063	0.092	0.119	0.142	0.161	0.174	0.184	0.191	0.196	0.200	0.202
1996	0.210	0.001	0.005	0.016	0.037	0.065	0.095	0.124	0.148	0.167	0.181	0.191	0.199	0.204	0.208	0.210
1997	0.144	0.001	0.005	0.019	0.041	0.067	0.090	0.108	0.121	0.129	0.135	0.139	0.141	0.142	0.143	0.144
1998	0.155	0.001	0.006	0.020	0.044	0.072	0.097	0.117	0.130	0.140	0.146	0.150	0.152	0.153	0.154	0.155
1999	0.142	0.001	0.005	0.018	0.041	0.066	0.089	0.107	0.120	0.128	0.134	0.137	0.139	0.141	0.141	0.142
2000	0.137	0.001	0.005	0.018	0.039	0.064	0.086	0.103	0.116	0.124	0.129	0.132	0.135	0.136	0.137	0.137
2001	0.138	0.001	0.005	0.018	0.040	0.064	0.087	0.104	0.116	0.125	0.130	0.134	0.136	0.137	0.138	0.138
2002	0.116	0.001	0.004	0.015	0.033	0.054	0.073	0.088	0.098	0.105	0.109	0.112	0.114	0.115	0.116	0.116
2003	0.128	0.001	0.005	0.017	0.037	0.059	0.080	0.096	0.108	0.115	0.120	0.123	0.125	0.127	0.127	0.128
2004	0.155	0.001	0.006	0.020	0.045	0.072	0.097	0.117	0.131	0.140	0.146	0.150	0.152	0.154	0.155	0.155
2005	0.154	0.001	0.005	0.020	0.044	0.072	0.096	0.116	0.129	0.139	0.145	0.148	0.151	0.152	0.153	0.154
2006	0.176	0.001	0.006	0.023	0.050	0.082	0.110	0.132	0.148	0.159	0.166	0.170	0.173	0.174	0.175	0.176
2007	0.115	0.001	0.004	0.015	0.033	0.054	0.072	0.087	0.097	0.104	0.109	0.112	0.113	0.114	0.115	0.115
2008	0.166	0.001	0.006	0.022	0.048	0.077	0.104	0.125	0.140	0.150	0.156	0.160	0.163	0.165	0.166	0.166
2009	0.144	0.001	0.005	0.019	0.041	0.067	0.090	0.108	0.121	0.130	0.135	0.139	0.141	0.142	0.143	0.144
2010	0.184	0.001	0.007	0.024	0.053	0.086	0.116	0.139	0.155	0.166	0.173	0.178	0.181	0.183	0.184	0.184
2011	0.160	0.001	0.006	0.021	0.046	0.074	0.100	0.120	0.134	0.144	0.150	0.154	0.157	0.158	0.159	0.160
2012	0.165	0.001	0.006	0.021	0.047	0.077	0.104	0.125	0.139	0.149	0.156	0.160	0.162	0.164	0.165	0.165
2013	0.231	0.001	0.008	0.030	0.066	0.107	0.145	0.174	0.194	0.208	0.217	0.223	0.226	0.229	0.230	0.231
2014	0.187	0.001	0.007	0.024	0.053	0.087	0.117	0.141	0.157	0.168	0.176	0.180	0.183	0.185	0.186	0.187
2015	0.143	0.001	0.005	0.018	0.041	0.066	0.089	0.107	0.120	0.129	0.134	0.138	0.140	0.141	0.142	0.143
2016	0.170	0.001	0.006	0.022	0.049	0.079	0.107	0.128	0.143	0.153	0.160	0.164	0.167	0.168	0.169	0.170
2017	0.234	0.001	0.008	0.030	0.067	0.109	0.147	0.176	0.197	0.211	0.220	0.226	0.229	0.231	0.233	0.234

Table B7.11. Stock-specific and combined stock fully-recruited F for years 1982-2017. Shown are the fully-recruited exploitation rates and natural mortality rates used to solve for F.

			Stock 1				
Year	Stock mu	SD	CV	Stock F	SD	CV	Avg M
1982	0.261	0.080	0.307	0.336	0.103	0.307	0.19
1983	0.235	0.058	0.246	0.297	0.073	0.246	0.19
1984	0.132	0.031	0.231	0.157	0.036	0.231	0.19
1985	0.149	0.054	0.361	0.174	0.063	0.361	0.15
1986	0.061	0.017	0.287	0.067	0.019	0.287	0.15
1987	0.040	0.008	0.194	0.044	0.008	0.194	0.15
1988	0.043	0.010	0.222	0.047	0.011	0.222	0.15
1989	0.053	0.010	0.188	0.058	0.011	0.188	0.15
1990	0.079	0.014	0.174	0.089	0.015	0.174	0.15
1991	0.106	0.018	0.170	0.121	0.020	0.170	0.15
1992	0.106	0.018	0.169	0.121	0.021	0.169	0.15
1993	0.078	0.012	0.154	0.088	0.013	0.154	0.15
1994	0.094	0.013	0.141	0.107	0.015	0.141	0.15
1995	0.176	0.027	0.152	0.210	0.032	0.152	0.15
1996	0.183	0.024	0.132	0.219	0.029	0.132	0.15
1997	0.145	0.013	0.091	0.174	0.016	0.091	0.21
1998	0.148	0.013	0.089	0.179	0.016	0.089	0.21
1999	0.141	0.013	0.092	0.169	0.016	0.092	0.21
2000	0.135	0.012	0.087	0.161	0.014	0.087	0.21
2001	0.132	0.011	0.086	0.157	0.014	0.086	0.21
2002	0.118	0.011	0.096	0.140	0.013	0.096	0.21
2003	0.136	0.012	0.089	0.163	0.015	0.089	0.21
2004	0.162	0.017	0.105	0.197	0.021	0.105	0.21
2005	0.158	0.018	0.116	0.191	0.022	0.116	0.21
2006	0.176	0.022	0.127	0.216	0.028	0.127	0.21
2007	0.129	0.015	0.119	0.154	0.018	0.119	0.21
2008	0.163	0.016	0.096	0.199	0.019	0.096	0.21
2009	0.146	0.014	0.098	0.176	0.017	0.098	0.21
2010	0.170	0.015	0.087	0.208	0.018	0.087	0.21
2011	0.165	0.016	0.097	0.201	0.020	0.097	0.21
2012	0.161	0.016	0.100	0.196	0.020	0.100	0.21
2013	0.216	0.020	0.092	0.272	0.025	0.092	0.21
2014	0.176	0.020	0.113	0.217	0.025	0.113	0.21
2015	0.147	0.016	0.108	0.178	0.019	0.108	0.21
2016	0.192	0.030	0.158	0.239	0.038	0.158	0.21
2017	0.224	0.030	0.133	0.284	0.038	0.133	0.21

Table B7.11 (continued).

			Stock 2				
Year	Stock mu	SD	CV	Stock F	SD	CV	Avg M
1982	0.163	0.032	0.196	0.192	0.038	0.196	0.15
1983	0.158	0.042	0.268	0.186	0.050	0.268	0.15
1984	0.088	0.018	0.202	0.100	0.020	0.202	0.15
1985	0.164	0.054	0.327	0.194	0.063	0.327	0.15
1986	0.066	0.019	0.286	0.074	0.021	0.286	0.15
1987	0.042	0.008	0.196	0.047	0.009	0.196	0.15
1988	0.051	0.010	0.203	0.056	0.011	0.203	0.15
1989	0.065	0.011	0.173	0.073	0.013	0.173	0.15
1990	0.104	0.019	0.185	0.119	0.022	0.185	0.15
1991	0.136	0.024	0.177	0.158	0.028	0.177	0.15
1992	0.158	0.029	0.184	0.187	0.034	0.184	0.15
1993	0.123	0.020	0.166	0.141	0.024	0.166	0.15
1994	0.148	0.022	0.152	0.173	0.026	0.152	0.15
1995	0.229	0.034	0.149	0.282	0.042	0.149	0.15
1996	0.252	0.035	0.137	0.315	0.043	0.137	0.15
1997	0.204	0.018	0.089	0.247	0.022	0.089	0.15
1998	0.219	0.020	0.090	0.268	0.024	0.090	0.15
1999	0.200	0.018	0.090	0.242	0.022	0.090	0.15
2000	0.196	0.017	0.088	0.236	0.021	0.088	0.15
2001	0.198	0.016	0.079	0.239	0.019	0.079	0.15
2002	0.222	0.019	0.084	0.272	0.023	0.084	0.15
2003	0.224	0.019	0.083	0.274	0.023	0.083	0.15
2004	0.267	0.038	0.141	0.337	0.048	0.141	0.15
2005	0.261	0.026	0.100	0.328	0.033	0.100	0.15
2006	0.300	0.030	0.099	0.389	0.038	0.099	0.15
2007	0.241	0.024	0.098	0.299	0.029	0.098	0.15
2008	0.242	0.022	0.090	0.301	0.027	0.090	0.15
2009	0.227	0.019	0.085	0.279	0.024	0.085	0.15
2010	0.257	0.023	0.089	0.323	0.029	0.089	0.15
2011	0.274	0.024	0.088	0.348	0.030	0.088	0.15
2012	0.256	0.025	0.096	0.320	0.031	0.096	0.15
2013	0.360	0.033	0.093	0.486	0.045	0.093	0.15
2014	0.273	0.029	0.106	0.346	0.037	0.106	0.15
2015	0.257	0.029	0.114	0.322	0.037	0.114	0.15
2016	0.264	0.033	0.124	0.333	0.041	0.124	0.15
2017	0.304	0.032	0.105	0.394	0.041	0.105	0.15

Table B7.11 (continued).

Combined Stocks							
Year	Stock mu	SD	CV	Stock F	SD	CV	Avg M
1982	0.165	0.031	0.190	0.195	0.037	0.190	0.15
1983	0.159	0.042	0.266	0.188	0.050	0.266	0.15
1984	0.089	0.018	0.201	0.100	0.020	0.201	0.15
1985	0.164	0.054	0.328	0.193	0.063	0.328	0.15
1986	0.066	0.019	0.285	0.074	0.021	0.285	0.15
1987	0.042	0.008	0.195	0.047	0.009	0.195	0.15
1988	0.051	0.010	0.203	0.056	0.011	0.203	0.15
1989	0.065	0.011	0.172	0.072	0.012	0.172	0.15
1990	0.103	0.019	0.185	0.118	0.022	0.185	0.15
1991	0.135	0.024	0.176	0.157	0.028	0.176	0.15
1992	0.156	0.029	0.182	0.184	0.034	0.182	0.15
1993	0.120	0.020	0.165	0.138	0.023	0.165	0.15
1994	0.142	0.021	0.149	0.165	0.025	0.149	0.15
1995	0.221	0.032	0.147	0.271	0.040	0.147	0.15
1996	0.227	0.029	0.129	0.279	0.036	0.129	0.15
1997	0.165	0.015	0.088	0.201	0.018	0.088	0.21
1998	0.169	0.014	0.085	0.206	0.017	0.085	0.21
1999	0.154	0.014	0.088	0.186	0.016	0.088	0.21
2000	0.146	0.012	0.081	0.177	0.014	0.081	0.21
2001	0.145	0.011	0.075	0.174	0.013	0.075	0.21
2002	0.145	0.012	0.084	0.174	0.015	0.084	0.21
2003	0.157	0.012	0.079	0.191	0.015	0.079	0.21
2004	0.188	0.019	0.101	0.233	0.023	0.101	0.21
2005	0.183	0.017	0.093	0.226	0.021	0.093	0.21
2006	0.205	0.022	0.108	0.257	0.028	0.108	0.21
2007	0.157	0.012	0.077	0.190	0.015	0.077	0.21
2008	0.178	0.016	0.088	0.220	0.019	0.088	0.21
2009	0.167	0.013	0.076	0.204	0.016	0.076	0.21
2010	0.194	0.015	0.078	0.240	0.019	0.078	0.21
2011	0.196	0.016	0.083	0.243	0.020	0.083	0.21
2012	0.188	0.016	0.084	0.232	0.019	0.084	0.21
2013	0.258	0.021	0.083	0.334	0.028	0.083	0.21
2014	0.202	0.020	0.100	0.252	0.025	0.100	0.21
2015	0.175	0.020	0.113	0.215	0.024	0.113	0.21
2016	0.209	0.027	0.130	0.262	0.034	0.130	0.21
2017	0.238	0.028	0.118	0.305	0.036	0.118	0.21

Table B7.12. Estimates of abundance for ages 1-15+ by period and region for Stock 1 (Chesapeake Bay stock).

Stock 1 Bay Population (Period 1)																
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	16,258,843	14,160,900	1,188,030	637,849	179,733	47,538	6,457	5,340	4,596	3,956	3,405	2,931	2,522	2,171	1,869	11,546
1983	50,218,334	44,720,800	4,509,180	554,014	312,667	87,735	23,298	3,111	2,407	1,775	1,231	799	486	280	155	397
1984	53,104,265	36,268,900	14,240,500	2,107,790	274,016	154,606	43,616	11,390	1,423	943	561	293	134	55	20	18
1985	69,653,677	49,861,200	11,551,500	6,821,920	1,143,240	154,725	89,002	24,793	6,065	649	347	155	57	18	5	2
1986	82,527,515	55,819,100	15,884,500	5,709,380	4,161,540	764,478	107,374	61,308	16,020	3,360	290	117	37	9	2	0
1987	96,100,783	63,571,800	17,782,500	7,846,140	3,474,730	2,773,450	528,552	73,681	39,462	8,841	1,495	97	28	6	1	0
1988	112,344,299	73,788,000	20,252,500	8,796,000	4,800,490	2,333,420	1,933,730	365,848	47,841	21,968	3,968	506	23	4	1	0
1989	151,411,387	106,107,000	23,507,000	10,007,900	5,361,590	3,206,450	1,617,300	1,330,330	236,090	26,469	9,799	1,334	120	4	0	0
1990	198,977,506	139,480,000	33,803,300	11,624,300	6,116,570	3,595,010	2,231,850	1,117,500	862,271	131,199	11,859	3,309	318	19	0	0
1991	170,872,701	93,716,300	44,433,200	16,694,700	7,029,600	3,981,250	2,384,530	1,451,220	676,757	446,033	54,611	3,718	733	47	2	0
1992	164,709,480	92,592,900	29,854,700	21,946,100	10,100,300	4,580,520	2,645,180	1,553,740	880,892	350,924	186,123	17,163	825	109	4	0
1993	190,984,593	120,525,000	29,496,800	14,744,900	13,273,600	6,576,750	3,040,010	1,721,240	941,705	456,055	146,199	58,397	3,804	122	10	0
1994	358,906,935	280,109,000	38,395,200	14,573,100	8,937,750	8,690,020	4,401,720	1,998,830	1,055,320	493,482	192,371	46,450	13,108	571	12	1
1995	348,363,641	214,994,000	89,232,200	18,957,800	8,798,760	5,794,590	5,728,800	2,840,540	1,200,370	541,095	203,561	59,754	10,192	1,924	54	1
1996	390,668,911	251,268,000	68,487,600	44,020,600	11,382,200	5,626,180	3,739,050	3,600,260	1,656,460	596,750	216,250	61,238	12,696	1,449	176	3
1997	468,912,773	312,277,000	80,033,300	33,780,100	26,496,600	7,299,090	3,609,050	2,302,300	2,027,660	786,361	225,947	61,316	12,224	1,692	124	9
1998	362,095,846	181,848,000	99,463,300	39,458,700	17,994,100	14,983,100	4,110,650	1,943,300	1,130,540	837,597	258,755	55,635	10,624	1,414	125	6
1999	300,855,212	149,896,000	57,922,200	49,065,900	21,082,600	10,256,900	8,557,660	2,257,030	977,057	479,485	283,470	65,598	9,931	1,266	108	6
2000	242,973,229	116,154,000	47,744,600	28,570,100	26,199,200	11,997,400	5,841,160	4,679,730	1,129,240	412,126	161,328	71,430	11,637	1,176	96	5
2001	292,693,226	189,025,000	36,996,800	23,547,300	15,246,200	14,885,700	6,813,490	3,181,980	2,330,520	473,855	137,900	40,420	12,598	1,370	89	5
2002	329,225,395	214,208,000	60,209,600	18,257,500	12,606,100	8,736,130	8,580,600	3,789,150	1,624,730	1,005,610	163,342	35,633	7,357	1,531	107	4
2003	228,813,331	101,297,000	68,229,300	29,699,800	9,751,440	7,178,970	4,981,500	4,700,650	1,899,880	686,970	339,218	41,269	6,338	874	117	5
2004	440,756,306	343,713,000	32,263,100	33,618,300	15,768,500	5,466,280	3,981,410	2,625,770	2,249,550	762,564	219,224	80,909	6,922	709	63	5
2005	318,689,607	159,226,000	109,470,000	15,890,700	17,812,000	8,790,770	3,002,390	2,070,640	1,236,360	886,698	238,692	51,251	13,295	759	50	3
2006	290,662,661	159,051,000	50,714,700	53,964,600	8,458,620	10,053,100	4,934,220	1,609,170	1,011,110	507,539	289,832	58,368	8,817	1,527	56	2
2007	199,628,123	81,586,700	50,654,600	24,960,800	28,482,100	4,667,760	5,423,600	2,503,120	735,232	385,378	153,278	65,286	9,233	930	103	2
2008	234,788,154	147,313,000	25,985,800	24,967,700	13,277,800	16,047,000	2,611,850	2,894,320	1,215,910	300,064	125,186	37,240	11,158	1,053	68	5
2009	163,518,641	70,282,100	46,921,500	12,816,100	13,324,300	7,544,810	9,114,760	1,423,130	1,441,780	510,382	100,437	31,375	6,570	1,314	80	3
2010	175,453,456	105,279,000	22,384,700	23,117,400	6,801,220	7,459,640	4,175,000	4,789,630	678,518	576,286	162,150	23,846	5,237	732	94	4
2011	167,849,737	98,198,200	33,530,800	11,026,300	12,254,600	3,796,850	4,107,240	2,178,680	2,264,460	268,672	181,264	38,100	3,939	577	52	4
2012	377,060,313	310,266,000	31,275,700	16,517,700	5,846,930	6,846,910	2,093,550	2,147,620	1,032,550	899,091	84,752	42,719	6,312	435	41	2
2013	183,256,220	50,744,800	98,812,400	15,390,000	8,707,740	3,216,590	3,673,860	1,054,080	972,343	389,564	268,596	18,877	6,681	658	29	2
2014	162,810,423	80,543,800	16,160,900	48,619,800	8,110,380	4,785,950	1,723,100	1,845,540	475,926	365,725	115,999	59,622	2,942	694	44	1
2015	219,110,201	151,114,000	25,650,100	7,945,700	25,516,100	4,408,890	2,514,680	842,663	806,663	172,637	104,773	24,737	8,919	293	44	2
2016	344,500,004	260,992,000	48,127,100	12,626,300	4,196,980	14,110,000	2,387,280	1,282,180	387,382	309,569	52,519	23,780	3,944	948	20	2
2017	207,022,227	81,958,200	83,115,800	23,661,700	6,625,600	2,280,780	7,409,560	1,166,550	559,890	140,369	88,585	11,187	3,553	393	60	1

Table B7.12 (continued).

Stock 1 Bay Population (Period 2)																
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	13,598,918	11,728,500	1,045,840	558,470	158,010	43,449	6,225	5,800	5,471	5,314	5,002	4,635	4,217	3,771	3,327	20,888
1983	41,999,881	37,042,200	4,005,340	504,258	291,867	87,037	25,055	4,056	3,790	3,751	3,589	3,410	3,183	2,910	2,611	16,824
1984	45,195,985	30,042,400	12,694,700	1,942,100	261,590	159,105	49,664	16,479	2,637	2,612	2,512	2,427	2,319	2,171	1,987	13,282
1985	59,436,783	41,302,200	10,329,700	6,359,220	1,105,340	162,396	104,524	37,964	12,314	2,089	1,992	1,929	1,869	1,788	1,675	11,783
1986	70,826,740	46,237,500	14,204,500	5,321,300	4,012,820	784,374	121,822	87,945	29,953	9,849	1,549	1,450	1,391	1,343	1,284	9,658
1987	82,883,721	52,659,400	15,901,700	7,313,090	3,351,490	2,842,870	591,053	104,239	72,801	25,688	7,996	1,249	1,166	1,117	1,078	8,783
1988	97,317,865	61,121,900	18,110,500	8,198,440	4,630,730	2,394,050	2,162,810	509,311	87,608	63,590	21,305	6,600	1,029	960	919	8,113
1989	130,956,495	87,893,300	21,020,700	9,328,000	5,172,270	3,291,020	1,811,480	1,853,420	425,695	76,136	52,516	17,515	5,414	843	786	7,400
1990	172,279,832	115,537,000	30,228,000	10,834,600	5,899,950	3,687,610	2,496,400	1,552,880	1,544,930	367,503	62,338	42,721	14,203	4,385	683	6,628
1991	151,449,340	77,629,300	39,730,800	15,553,700	6,775,550	4,088,260	2,683,010	2,051,890	1,246,380	1,293,350	293,376	49,528	33,802	11,203	3,451	5,740
1992	147,306,397	76,698,300	26,688,700	20,414,400	9,698,290	4,678,240	2,961,920	2,195,710	1,628,980	1,026,730	1,009,010	226,766	38,015	25,824	8,532	6,980
1993	170,169,556	99,835,600	26,370,400	13,721,300	12,757,200	6,724,810	3,408,320	2,437,680	1,750,850	1,345,820	802,420	780,542	174,114	29,047	19,670	11,783
1994	311,165,328	232,026,000	34,327,400	13,565,800	8,596,940	8,896,540	4,942,680	2,839,270	1,974,900	1,476,600	1,077,870	638,441	617,934	137,374	22,866	24,713
1995	307,406,529	178,088,000	79,776,900	17,645,300	8,461,120	5,932,130	6,437,620	4,045,610	2,259,550	1,636,880	1,162,530	842,855	496,521	478,705	106,138	36,670
1996	344,495,718	208,134,000	61,227,200	40,970,600	10,940,500	5,749,750	4,184,590	5,079,400	3,063,010	1,754,970	1,190,080	829,727	593,696	346,813	332,581	98,801
1997	410,064,471	258,668,000	71,545,300	30,811,500	24,952,800	7,307,320	3,960,360	3,199,620	3,719,090	2,307,750	1,246,060	833,325	574,704	408,007	237,050	293,585
1998	324,279,695	150,630,000	88,920,100	36,002,700	16,990,200	15,116,900	4,584,170	2,808,200	2,221,870	2,744,070	1,652,270	901,714	606,196	418,532	296,966	385,807
1999	272,707,198	124,165,000	51,789,900	44,803,000	19,944,300	10,412,600	9,634,310	3,312,810	1,973,160	1,649,980	1,959,900	1,186,360	648,820	436,112	300,813	490,133
2000	224,103,058	96,214,000	42,684,500	26,070,700	24,744,600	12,152,300	6,596,100	6,954,790	2,332,840	1,480,110	1,195,450	1,432,480	870,193	476,050	319,729	579,216
2001	264,537,708	156,577,000	33,079,800	21,501,100	14,423,800	15,122,800	7,727,850	4,794,070	4,916,950	1,755,260	1,073,070	873,348	1,049,490	637,507	348,444	657,219
2002	295,847,970	177,436,000	53,830,400	16,663,600	11,911,400	8,852,090	9,686,590	5,660,210	3,415,680	3,720,070	1,276,160	784,900	640,096	768,923	466,622	735,229
2003	214,175,666	83,908,200	61,004,100	27,115,700	9,222,240	7,287,150	5,642,210	7,067,290	4,047,460	2,614,490	2,758,760	955,863	590,189	481,481	577,984	902,549
2004	387,466,328	284,710,000	28,845,300	30,686,200	14,904,500	5,546,810	4,516,420	3,980,980	4,870,780	2,990,700	1,872,240	1,996,500	694,374	428,760	349,454	1,073,310
2005	289,488,427	131,892,000	97,865,300	14,498,400	16,816,600	8,903,580	3,400,760	3,146,450	2,707,690	3,552,890	2,115,070	1,337,560	1,430,960	497,524	306,853	1,016,790
2006	263,872,423	131,747,000	45,338,500	49,235,500	7,984,660	10,169,000	5,563,480	2,414,660	2,169,650	1,986,160	2,507,060	1,500,970	950,390	1,015,760	352,697	936,936
2007	186,803,903	67,581,200	45,288,100	22,782,600	26,916,200	4,733,040	6,144,200	3,789,860	1,602,760	1,541,360	1,368,710	1,743,950	1,046,820	662,305	706,840	895,958
2008	213,915,266	122,024,000	23,232,300	22,786,400	12,544,500	16,265,900	2,957,950	4,384,540	2,649,910	1,204,100	1,123,370	1,008,110	1,289,020	773,726	489,080	1,182,360
2009	154,489,055	58,216,900	41,946,700	11,692,000	12,575,000	7,628,220	10,260,400	2,123,770	3,054,300	1,959,970	854,493	800,912	719,287	918,659	550,654	1,187,790
2010	163,015,540	87,205,900	20,011,100	21,088,400	6,418,720	7,550,820	4,720,300	7,233,100	1,464,040	2,260,110	1,406,340	619,840	583,055	523,534	667,931	1,262,350
2011	155,711,769	81,340,700	29,975,900	10,059,400	11,566,800	3,842,220	4,639,730	3,284,020	4,876,640	1,050,320	1,560,850	977,462	431,400	405,323	363,384	1,337,620
2012	328,138,455	257,002,000	27,956,300	15,059,000	5,509,120	6,908,450	2,356,550	3,229,960	2,229,600	3,543,230	738,864	1,108,050	695,773	306,895	287,973	1,206,690
2013	171,021,812	42,033,500	88,336,500	14,040,600	8,220,590	3,259,830	4,171,880	1,615,640	2,164,070	1,608,850	2,483,750	524,030	788,757	495,106	218,109	1,060,600
2014	150,030,462	66,717,100	14,448,000	44,362,600	7,657,380	4,843,400	1,947,050	2,789,930	1,042,990	1,481,720	1,060,700	1,644,320	346,867	521,014	326,367	841,024
2015	195,013,245	125,173,000	22,933,800	7,254,360	24,135,100	4,483,240	2,869,790	1,302,420	1,821,830	734,693	1,014,880	735,239	1,143,570	241,062	361,549	808,712
2016	299,599,615	216,189,000	43,028,200	11,524,200	3,966,680	14,331,000	2,722,860	1,986,420	883,344	1,334,820	523,501	731,745	532,022	827,220	174,176	844,427
2017	187,951,205	67,888,900	74,311,100	21,598,300	6,263,760	2,318,580	8,470,890	1,819,770	1,288,840	616,549	900,574	356,618	499,508	362,731	563,057	692,028

Table B7.12 (continued).

Stock 1 Bay Population (Period 3)																
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	9,317,059	7,935,100	795,931	425,851	116,761	30,171	3,924	2,979	2,197	1,524	989	602	347	192	103	388
1983	28,839,701	25,063,100	3,075,130	395,438	223,619	61,926	15,793	1,937	1,285	764	399	183	75	28	10	15
1984	32,123,286	20,328,600	9,842,360	1,582,060	210,683	118,211	32,099	7,706	825	441	198	73	22	6	1	1
1985	42,313,899	27,948,100	8,026,300	5,223,630	904,618	122,117	67,672	17,334	3,635	314	126	40	10	2	0	0
1986	50,718,618	31,287,600	11,034,800	4,368,480	3,289,380	602,651	81,542	42,809	9,591	1,622	106	30	6	1	0	0
1987	59,439,654	35,633,300	12,360,000	6,015,540	2,754,510	2,193,400	402,722	51,621	23,704	4,281	546	25	5	1	0	0
1988	69,626,903	41,359,800	14,081,100	6,751,520	3,811,750	1,848,760	1,476,140	256,796	28,792	10,659	1,451	131	4	0	0	0
1989	92,627,643	59,475,500	16,344,100	7,682,180	4,257,670	2,540,710	1,234,710	933,881	142,097	12,844	3,584	345	21	0	0	0
1990	121,369,655	78,181,400	23,503,600	8,921,270	4,852,290	2,843,190	1,699,600	782,220	517,389	63,462	4,324	853	55	2	0	0
1991	108,390,758	52,529,900	30,891,100	12,802,900	5,566,130	3,139,510	1,809,340	1,011,770	404,374	214,824	19,825	954	126	5	0	0
1992	104,848,583	51,899,900	20,751,100	16,806,000	7,969,270	3,592,290	1,993,530	1,075,110	522,198	167,651	67,015	4,367	141	12	0	0
1993	119,360,811	67,556,400	20,504,400	11,298,800	10,489,900	5,170,710	2,298,160	1,195,090	560,257	218,679	52,836	14,914	650	13	1	0
1994	214,430,388	157,006,000	26,690,400	11,168,200	7,064,970	6,834,620	3,329,030	1,388,510	628,174	236,750	69,559	11,870	2,242	63	1	0
1995	215,787,560	120,507,000	62,013,500	14,503,900	6,926,160	4,528,030	4,298,210	1,955,790	707,885	257,127	72,898	15,122	1,726	209	4	0
1996	242,171,165	140,838,000	47,600,600	33,715,200	8,979,480	4,404,680	2,806,400	2,475,470	974,064	282,462	77,083	15,418	2,138	157	12	0
1997	285,605,329	175,032,000	55,618,900	24,350,700	19,654,600	5,366,540	2,541,180	1,483,830	1,117,030	348,579	75,411	14,453	1,927	171	8	0
1998	229,171,558	101,927,000	69,127,400	28,456,600	13,363,100	11,038,500	2,902,520	1,256,730	625,181	372,798	86,724	13,170	1,682	144	8	0
1999	191,381,561	84,018,200	40,262,100	35,413,000	15,689,500	7,584,440	6,073,510	1,468,670	544,048	214,985	95,736	15,651	1,585	130	7	0
2000	155,167,504	65,104,600	33,180,900	20,598,100	19,441,800	8,827,080	4,116,810	3,019,620	622,906	182,942	53,922	16,862	1,838	119	6	0
2001	179,530,912	105,951,000	25,717,900	16,999,300	11,353,400	11,019,700	4,843,240	2,074,480	1,300,440	212,941	46,682	9,666	2,016	141	6	0
2002	200,911,707	120,066,000	41,852,000	13,177,200	9,381,210	6,459,720	6,089,560	2,465,520	904,640	450,856	55,162	8,501	1,174	157	7	0
2003	146,148,635	56,777,500	47,417,200	21,412,900	7,236,600	5,282,290	3,511,280	3,033,490	1,048,150	304,989	113,395	9,744	1,001	89	7	0
2004	261,227,804	192,653,000	22,422,400	24,241,400	11,706,100	4,024,630	2,808,810	1,696,290	1,242,520	338,976	73,379	19,128	1,095	72	4	0
2005	200,975,102	89,245,900	76,065,200	11,446,300	13,186,300	6,440,700	2,103,770	1,326,720	676,654	390,318	79,088	11,991	2,081	76	3	0
2006	182,299,654	89,148,300	35,240,900	38,882,200	6,266,470	7,374,890	3,463,480	1,033,230	554,685	223,980	96,285	13,693	1,384	154	4	0
2007	129,566,286	45,729,600	35,202,500	17,994,000	21,129,800	3,432,560	3,819,840	1,613,780	405,181	170,896	51,177	15,395	1,457	94	7	0
2008	144,921,197	82,569,800	18,060,900	18,009,700	9,865,880	11,833,400	1,846,640	1,874,730	673,586	133,805	42,040	8,833	1,771	107	4	0
2009	105,025,491	39,393,200	32,605,900	9,235,470	9,874,750	5,538,380	6,403,650	914,763	791,903	225,524	33,411	7,371	1,032	133	5	0
2010	108,453,730	59,009,200	15,555,600	16,660,900	5,042,280	5,479,360	2,935,780	3,081,990	373,125	254,970	54,011	5,609	824	74	6	0
2011	103,826,253	55,039,900	23,298,400	7,941,570	9,069,530	2,780,390	2,875,880	1,394,730	1,238,130	118,146	59,996	8,905	616	58	3	0
2012	220,682,266	173,903,000	21,729,900	11,892,200	4,323,000	5,005,250	1,462,390	1,370,860	562,736	394,002	27,952	9,948	983	44	3	0
2013	120,943,852	28,442,100	68,644,800	11,072,700	6,426,450	2,343,870	2,554,870	669,224	526,749	169,626	87,997	4,366	1,033	65	2	0
2014	103,747,338	45,144,600	11,228,900	35,012,700	6,000,080	3,502,300	1,205,370	1,180,110	259,887	160,605	38,340	13,915	459	70	3	0
2015	133,225,895	84,699,200	17,822,900	5,723,370	18,889,200	3,230,080	1,761,920	539,871	441,441	75,986	34,712	5,787	1,396	29	3	0
2016	204,801,618	146,280,000	33,419,000	9,062,680	3,077,930	10,168,000	1,634,760	799,005	205,533	131,835	16,814	5,372	596	92	1	0
2017	133,480,840	45,936,600	57,733,000	17,012,400	4,881,000	1,656,710	5,130,180	736,708	301,517	60,735	28,832	2,570	546	39	4	0

Table B7.12 (continued).

Stock 1 Ocean Population (Period 1)																
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	94,520	0	27,351	24,365	11,276	4,819	1,032	1,296	1,612	1,885	2,061	2,113	2,052	1,911	1,729	11,019
1983	172,924	0	63,035	26,941	27,929	13,614	6,035	1,343	1,732	2,144	2,500	2,731	2,799	2,716	2,530	16,875
1984	388,369	0	199,037	82,577	28,361	29,795	14,596	6,547	1,436	1,753	2,026	2,201	2,246	2,173	2,018	13,603
1985	635,111	0	161,481	264,248	100,281	30,741	32,519	16,161	7,203	1,492	1,696	1,822	1,859	1,816	1,713	12,080
1986	970,836	0	221,923	213,836	318,621	112,310	31,627	33,008	16,129	6,739	1,298	1,370	1,389	1,368	1,315	9,903
1987	1,470,956	0	248,564	296,192	270,067	401,378	140,364	37,963	38,627	17,497	6,703	1,184	1,168	1,140	1,105	9,005
1988	2,151,095	0	283,114	332,271	375,308	342,598	514,262	178,806	46,095	43,232	17,876	6,262	1,032	979	942	8,318
1989	3,034,318	0	328,604	378,335	420,344	473,517	434,717	651,853	219,999	51,594	44,046	16,624	5,431	861	806	7,588
1990	4,208,242	0	472,509	438,756	476,794	526,103	593,935	542,974	792,669	245,689	52,076	40,509	14,250	4,479	700	6,799
1991	5,732,331	0	621,075	632,169	558,246	607,035	671,541	750,437	662,064	881,457	246,411	47,089	33,939	11,443	3,538	5,887
1992	7,049,221	0	417,249	830,240	800,539	699,900	752,938	816,801	877,830	706,272	851,227	215,722	38,195	26,394	8,752	7,163
1993	8,323,849	0	412,244	557,608	1,050,070	1,000,820	863,038	906,827	946,657	928,509	678,309	742,947	174,875	29,682	20,172	12,090
1994	9,865,952	0	536,673	551,431	707,748	1,323,940	1,252,090	1,059,580	1,073,790	1,025,270	915,356	609,313	621,433	140,485	23,468	25,375
1995	12,030,207	0	1,247,180	717,452	698,434	888,234	1,643,960	1,520,660	1,237,380	1,143,070	991,502	806,185	499,796	489,734	108,957	37,663
1996	13,400,637	0	956,894	1,663,150	900,498	857,598	1,061,200	1,889,390	1,656,740	1,214,290	1,010,240	793,073	598,333	355,458	342,093	101,680
1997	14,952,749	0	1,118,290	1,275,930	2,087,500	1,105,190	1,023,480	1,217,670	2,060,130	1,627,130	1,073,190	805,654	585,090	422,254	246,186	305,055
1998	16,742,942	0	1,390,060	1,489,810	1,546,610	2,475,330	1,279,110	1,145,680	1,308,970	2,019,120	1,455,880	878,186	616,572	431,506	307,043	399,065
1999	17,635,031	0	809,434	1,850,780	1,803,000	1,761,110	2,756,980	1,378,440	1,186,750	1,237,150	1,752,030	1,165,260	662,953	450,989	311,850	508,305
2000	18,318,275	0	667,254	1,078,530	2,247,260	2,070,080	1,951,630	2,971,490	1,429,760	1,122,930	1,074,030	1,405,650	884,824	489,119	329,190	596,528
2001	18,672,221	0	517,057	889,107	1,309,340	2,578,300	2,292,360	2,082,790	3,058,210	1,346,090	971,994	861,625	1,070,780	656,639	359,563	678,366
2002	19,068,822	0	841,452	689,029	1,079,720	1,503,040	2,857,100	2,448,110	2,135,320	2,870,520	1,163,590	779,533	657,147	796,671	484,304	763,286
2003	19,572,884	0	953,643	1,121,460	836,639	1,239,810	1,671,570	3,070,830	2,545,540	2,029,410	2,520,990	948,575	604,572	497,480	598,138	934,227
2004	19,074,925	0	450,942	1,270,340	1,359,200	956,382	1,366,780	1,773,010	3,133,860	2,366,900	1,738,260	2,005,740	718,790	447,446	365,235	1,122,040
2005	18,826,558	0	1,529,920	599,855	1,530,520	1,531,620	1,029,810	1,404,350	1,748,260	2,809,620	1,955,570	1,334,290	1,468,190	514,286	317,617	1,052,650
2006	18,061,715	0	708,735	2,035,320	723,176	1,727,550	1,652,670	1,059,470	1,385,020	1,566,310	2,322,400	1,503,850	980,022	1,055,320	366,930	974,942
2007	17,130,785	0	707,891	941,740	2,442,610	809,071	1,843,780	1,678,380	1,032,340	1,221,720	1,271,380	1,748,400	1,079,190	687,709	734,889	931,685
2008	16,680,238	0	363,217	943,067	1,141,270	2,789,570	890,558	1,948,990	1,710,300	957,193	1,045,940	1,012,920	1,331,370	804,821	509,372	1,231,650
2009	16,035,868	0	655,682	483,249	1,138,080	1,291,790	3,021,740	920,622	1,922,860	1,529,700	786,257	798,329	738,137	949,718	569,994	1,229,710
2010	15,405,618	0	312,850	873,103	585,097	1,298,490	1,419,450	3,189,700	931,490	1,767,860	1,290,820	615,149	595,343	538,439	687,777	1,300,050
2011	14,432,282	0	468,552	415,934	1,050,540	657,779	1,392,520	1,451,090	3,118,140	826,750	1,442,580	977,454	444,076	420,338	377,329	1,389,200
2012	13,443,719	0	437,082	623,147	500,804	1,182,600	707,338	1,427,610	1,427,360	2,785,380	680,297	1,101,870	711,764	316,234	297,103	1,245,130
2013	13,412,529	0	1,380,960	581,340	750,980	565,255	1,276,740	728,525	1,407,380	1,276,950	2,294,460	520,769	804,949	508,711	224,360	1,091,150
2014	11,886,742	0	225,793	1,830,060	689,946	818,192	577,828	1,224,560	668,011	1,165,320	975,370	1,628,350	352,816	533,552	334,599	862,345
2015	11,155,363	0	358,459	300,124	2,201,380	775,840	877,460	588,321	1,188,730	585,374	938,786	729,903	1,164,030	246,919	370,719	829,318
2016	11,037,296	0	672,661	477,053	362,139	2,487,200	838,159	904,013	581,423	1,068,240	485,824	727,229	541,684	847,269	178,572	865,830
2017	11,207,188	0	1,161,590	894,031	572,886	404,620	2,629,320	836,208	853,503	495,832	837,371	354,788	508,706	371,533	577,253	709,547

Table B7.12 (continued).

Stock 1 Ocean Population (Period 2)																
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	52,739	0	21,727	19,815	8,051	2,429	419	159	140	0	0	0	0	0	0	0
1983	101,563	0	50,075	21,912	19,946	6,863	2,451	164	151	0	0	0	0	0	0	0
1984	267,420	0	158,119	67,167	20,257	15,023	5,928	802	125	0	0	0	0	0	0	0
1985	446,173	0	128,285	214,942	71,631	15,501	13,208	1,979	626	0	0	0	0	0	0	0
1986	652,756	0	176,302	173,937	227,594	56,632	12,846	4,042	1,403	0	0	0	0	0	0	0
1987	898,718	0	197,466	240,926	192,911	202,394	57,013	4,649	3,359	0	0	0	0	0	0	0
1988	1,170,814	0	224,914	270,273	268,086	172,755	208,882	21,895	4,009	0	0	0	0	0	0	0
1989	1,383,348	0	261,053	307,742	300,255	238,771	176,573	79,820	19,134	0	0	0	0	0	0	0
1990	1,714,644	0	375,371	356,878	340,554	265,253	241,197	66,472	68,919	0	0	0	0	0	0	0
1991	2,134,552	0	493,396	514,199	398,735	306,063	272,721	91,872	57,566	0	0	0	0	0	0	0
1992	2,413,273	0	331,468	675,280	571,740	352,824	305,700	99,964	76,297	0	0	0	0	0	0	0
1993	2,579,270	0	327,493	453,539	749,980	504,546	350,429	110,994	82,289	0	0	0	0	0	0	0
1994	2,778,693	0	426,334	448,489	505,420	667,291	508,233	129,634	93,292	0	0	0	0	0	0	0
1995	3,481,390	0	990,761	583,507	498,746	447,653	667,219	186,018	107,486	0	0	0	0	0	0	0
1996	3,992,171	0	760,120	1,352,440	642,810	431,942	430,302	230,847	143,710	0	0	0	0	0	0	0
1997	4,700,345	0	887,982	1,036,060	1,485,430	553,840	412,250	147,614	177,169	0	0	0	0	0	0	0
1998	5,428,522	0	1,103,960	1,210,450	1,101,980	1,243,080	516,686	139,364	113,002	0	0	0	0	0	0	0
1999	5,694,445	0	642,777	1,503,220	1,283,700	883,335	1,111,840	167,347	102,226	0	0	0	0	0	0	0
2000	5,328,669	0	530,002	876,784	1,603,190	1,041,670	790,497	362,644	123,882	0	0	0	0	0	0	0
2001	4,808,275	0	410,668	722,584	933,487	1,296,070	927,218	253,762	264,486	0	0	0	0	0	0	0
2002	4,381,981	0	668,177	559,559	768,506	753,528	1,151,460	296,977	183,774	0	0	0	0	0	0	0
2003	4,154,735	0	757,345	911,086	595,995	622,414	674,923	373,347	219,625	0	0	0	0	0	0	0
2004	3,862,667	0	357,993	1,030,710	965,509	477,918	548,441	213,958	268,138	0	0	0	0	0	0	0
2005	4,298,702	0	1,214,990	487,318	1,090,250	768,853	415,757	170,718	150,816	0	0	0	0	0	0	0
2006	4,507,024	0	562,743	1,652,380	514,391	865,150	665,093	128,299	118,968	0	0	0	0	0	0	0
2007	4,504,144	0	562,086	764,622	1,737,750	405,304	742,309	203,349	88,724	0	0	0	0	0	0	0
2008	4,002,504	0	288,387	765,526	811,527	1,396,310	358,150	235,828	146,776	0	0	0	0	0	0	0
2009	3,870,153	0	520,713	392,586	810,687	648,451	1,219,930	111,912	165,874	0	0	0	0	0	0	0
2010	3,074,054	0	248,498	709,784	417,411	653,414	574,953	389,283	80,711	0	0	0	0	0	0	0
2011	2,792,517	0	372,061	337,763	747,656	329,709	561,076	175,979	268,273	0	0	0	0	0	0	0
2012	2,388,863	0	347,152	506,456	357,078	594,563	286,161	173,977	123,476	0	0	0	0	0	0	0
2013	3,118,605	0	1,096,940	472,660	535,911	284,580	517,481	88,981	122,052	0	0	0	0	0	0	0
2014	3,016,101	0	179,377	1,488,590	492,830	412,566	234,696	149,946	58,096	0	0	0	0	0	0	0
2015	3,024,249	0	284,769	244,119	1,572,400	391,188	356,369	72,032	103,372	0	0	0	0	0	0	0
2016	2,936,943	0	534,381	388,039	258,677	1,254,150	340,435	110,695	50,566	0	0	0	0	0	0	0
2017	3,507,855	0	922,798	727,215	409,218	204,029	1,067,970	102,395	74,230	0	0	0	0	0	0	0

Table B7.12 (continued)

Stock 1 Ocean Population (Period 3)																
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	250,187	110,947	38,058	35,728	16,747	7,258	1,585	2,016	2,505	2,926	3,199	3,280	3,184	2,966	2,683	17,103
1983	603,334	350,427	117,163	36,901	37,901	18,402	8,173	1,778	2,183	2,532	2,755	2,813	2,723	2,530	2,285	14,768
1984	917,535	284,230	373,452	128,498	37,941	39,286	19,177	8,437	1,755	1,998	2,148	2,193	2,143	2,021	1,854	12,402
1985	1,389,813	390,765	303,906	417,268	144,722	40,605	42,107	20,442	8,602	1,663	1,759	1,786	1,759	1,691	1,585	11,153
1986	1,985,612	437,457	417,861	343,698	488,708	166,363	44,037	44,133	20,044	7,689	1,359	1,341	1,309	1,269	1,214	9,131
1987	2,798,280	498,218	468,112	475,071	412,723	600,436	203,746	51,651	48,527	20,084	7,038	1,160	1,101	1,059	1,023	8,331
1988	3,863,920	578,284	533,214	532,873	572,129	509,683	746,464	247,854	58,242	49,772	18,795	6,142	974	911	873	7,710
1989	5,344,762	831,573	618,835	606,210	639,365	702,077	627,859	902,555	280,436	59,517	46,327	16,302	5,125	801	747	7,033
1990	7,219,914	1,093,110	889,941	703,836	727,068	781,861	858,688	751,406	1,010,460	284,714	54,733	39,619	13,400	4,152	647	6,279
1991	8,797,741	734,462	1,169,620	1,011,770	842,955	885,202	948,061	1,014,910	827,744	1,008,390	257,624	45,883	31,840	10,589	3,264	5,428
1992	10,272,748	725,654	785,555	1,327,230	1,205,550	1,014,890	1,052,940	1,095,010	1,088,820	804,060	887,870	210,230	35,834	24,426	8,074	6,605
1993	11,971,247	944,560	776,264	892,262	1,585,460	1,457,350	1,211,890	1,218,000	1,174,520	1,056,830	707,632	724,804	164,355	27,514	18,640	11,166
1994	15,036,945	2,195,230	1,010,380	881,717	1,067,000	1,923,930	1,753,240	1,418,210	1,325,820	1,160,880	950,602	592,373	582,584	129,950	21,640	23,389
1995	17,422,736	1,684,910	2,347,450	1,145,430	1,048,160	1,280,200	2,277,530	2,011,810	1,509,020	1,278,550	1,017,580	775,432	463,966	448,764	99,542	34,392
1996	19,494,432	1,969,160	1,801,230	2,656,910	1,352,660	1,237,720	1,473,100	2,513,330	2,033,340	1,366,770	1,040,780	763,747	555,290	325,440	312,206	92,749
1997	21,569,043	2,447,260	2,103,860	1,973,280	3,041,950	1,549,600	1,378,550	1,571,940	2,456,060	1,786,230	1,083,480	763,405	535,451	381,532	221,775	274,670
1998	22,550,910	1,425,120	2,614,660	2,303,770	2,171,240	3,357,590	1,670,380	1,437,330	1,519,220	2,171,560	1,453,000	829,819	565,855	391,859	278,147	361,360
1999	23,016,742	1,174,720	1,522,980	2,866,610	2,542,740	2,362,540	3,571,780	1,714,890	1,364,050	1,315,780	1,731,580	1,093,810	605,968	408,388	281,782	459,124
2000	23,198,341	910,279	1,255,280	1,669,170	3,162,700	2,768,890	2,496,110	3,655,020	1,628,600	1,185,700	1,056,680	1,317,630	809,730	443,976	298,261	540,315
2001	23,808,222	1,481,380	972,840	1,376,640	1,844,300	3,452,790	2,935,940	2,554,130	3,476,180	1,420,820	956,991	809,499	983,468	598,653	327,285	617,306
2002	24,219,217	1,678,730	1,582,150	1,063,680	1,511,770	1,999,550	3,632,420	2,994,930	2,412,610	3,017,970	1,140,720	729,123	601,046	723,467	439,134	691,917
2003	23,588,468	793,850	1,792,920	1,730,630	1,170,000	1,643,700	2,112,380	3,719,050	2,841,110	2,102,560	2,438,170	876,514	546,707	446,806	536,435	837,636
2004	24,211,932	2,693,630	847,455	1,955,770	1,888,640	1,254,510	1,702,440	2,118,380	3,452,030	2,425,190	1,664,730	1,838,830	645,663	399,350	325,527	999,787
2005	23,051,665	1,247,820	2,875,250	923,902	2,129,200	2,011,690	1,282,980	1,676,080	1,921,680	2,875,690	1,873,290	1,225,410	1,322,700	460,573	284,090	941,310
2006	22,067,353	1,246,450	1,331,430	3,129,610	1,003,550	2,267,660	2,061,000	1,270,380	1,527,230	1,606,160	2,223,950	1,378,690	880,953	942,980	327,458	869,852
2007	20,488,043	639,382	1,330,430	1,450,820	3,400,660	1,064,870	2,304,190	2,010,950	1,137,120	1,251,180	1,217,120	1,604,340	971,561	615,584	657,038	832,798
2008	20,379,053	1,154,470	682,979	1,456,310	1,597,810	3,699,530	1,123,570	2,348,850	1,896,530	984,561	1,006,150	934,109	1,204,950	724,332	457,912	1,106,990
2009	19,174,626	550,788	1,232,970	746,526	1,595,790	1,719,760	3,838,400	1,118,770	2,150,710	1,583,940	759,066	737,233	668,248	854,767	512,408	1,105,250
2010	18,482,784	825,053	588,222	1,347,450	817,827	1,719,270	1,791,160	3,861,100	1,040,720	1,836,100	1,253,030	571,865	542,839	488,157	622,861	1,177,130
2011	16,987,732	769,557	880,490	640,293	1,459,990	863,338	1,735,130	1,734,940	3,434,170	846,815	1,380,110	895,009	398,630	375,088	336,302	1,237,870
2012	17,526,757	2,431,480	821,589	960,877	699,007	1,562,550	888,695	1,718,160	1,582,120	2,871,140	655,856	1,017,890	644,933	284,891	267,349	1,120,220
2013	15,874,829	397,671	2,592,410	890,307	1,030,920	729,038	1,556,310	856,672	1,525,540	1,294,660	2,180,860	475,225	721,233	453,299	199,696	970,988
2014	14,385,513	631,202	424,477	2,824,440	965,277	1,084,560	727,290	1,474,630	738,362	1,197,460	937,796	1,502,470	319,630	480,745	301,158	776,016
2015	13,983,148	1,184,250	673,653	461,980	3,055,610	1,014,900	1,087,030	697,677	1,298,250	595,491	896,337	669,995	1,050,270	221,660	332,457	743,588
2016	14,715,856	2,045,260	1,263,710	733,435	501,008	3,224,670	1,022,940	1,045,520	616,664	1,052,090	448,717	646,084	473,107	736,268	155,006	751,377
2017	14,147,695	642,276	2,182,820	1,375,780	793,872	526,129	3,223,370	974,552	914,825	494,488	784,672	320,036	451,452	328,146	509,340	625,937

Table B7.13. Estimates of age-specific abundance by period and year for Stock 2 (Delaware Bay/Hudson River stock).

Stock 2 Population (Period 1)																
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	21,911,862	10,402,200	4,935,470	2,127,200	1,644,960	666,431	320,088	252,886	217,661	187,343	161,248	138,787	119,455	102,816	88,495	546,822
1983	25,685,466	15,521,200	3,357,420	2,469,220	1,291,820	1,073,790	452,968	225,154	182,439	155,791	133,541	114,698	98,617	84,834	72,998	450,976
1984	29,143,810	17,977,300	5,009,660	1,679,850	1,499,960	843,742	730,424	318,924	162,599	130,721	111,172	95,096	81,591	70,114	60,299	372,359
1985	27,707,694	15,057,700	5,804,650	2,520,980	1,043,500	1,024,000	610,888	553,866	249,727	126,782	101,702	86,396	73,860	63,353	54,433	335,858
1986	25,544,447	13,289,300	4,859,870	2,902,540	1,527,810	678,400	692,019	426,782	396,609	177,356	89,656	71,763	60,895	52,030	44,615	274,802
1987	32,238,343	20,311,400	4,291,450	2,449,920	1,815,440	1,057,280	500,677	536,832	342,589	317,376	141,695	71,569	57,262	48,579	41,503	254,771
1988	43,714,232	29,487,300	6,559,870	2,167,310	1,543,200	1,274,020	795,848	397,614	442,096	281,575	260,584	116,278	58,716	46,971	39,847	243,003
1989	56,564,692	38,177,100	9,522,960	3,310,810	1,361,790	1,077,650	952,343	626,819	324,504	359,949	228,971	211,768	94,465	47,693	38,151	229,719
1990	63,320,349	39,908,200	12,328,400	4,801,140	2,071,620	943,139	796,221	739,761	503,894	260,070	288,019	183,066	169,242	75,479	38,104	213,994
1991	66,634,454	39,760,900	12,885,700	6,228,490	3,032,810	1,457,780	707,404	623,102	592,729	398,175	203,267	223,262	141,056	129,847	57,736	192,196
1992	71,202,411	42,251,300	12,836,200	6,504,100	3,922,370	2,119,200	1,079,990	543,657	487,657	455,408	301,507	152,241	165,888	104,212	95,548	183,133
1993	82,246,750	51,097,000	13,638,700	6,474,930	4,087,040	2,727,180	1,556,340	819,426	418,463	367,311	337,204	220,394	110,246	119,327	74,611	198,578
1994	158,714,180	123,089,000	16,497,000	6,887,020	4,083,280	2,864,990	2,031,800	1,205,980	648,199	325,645	282,171	256,536	166,486	82,860	89,368	203,844
1995	128,953,979	67,587,300	39,735,300	8,324,260	4,332,410	2,846,190	2,113,350	1,551,610	936,093	493,154	243,866	208,809	188,199	121,384	60,151	211,903
1996	147,772,317	91,451,100	21,808,900	19,998,500	5,191,130	2,960,280	2,027,300	1,533,160	1,126,780	657,752	337,623	163,719	138,198	123,297	78,958	175,620
1997	155,125,760	92,194,500	29,505,500	10,968,100	12,439,900	3,526,630	2,087,320	1,449,050	1,092,130	773,731	438,769	220,364	105,174	87,780	77,695	159,117
1998	123,691,833	57,049,000	29,749,500	14,815,200	6,770,250	8,325,210	2,444,740	1,475,630	1,033,220	761,532	531,490	298,485	148,988	70,834	58,978	158,776
1999	122,508,804	65,037,300	18,407,000	14,926,300	9,119,650	4,503,230	5,714,100	1,705,300	1,035,380	707,604	513,126	354,366	197,685	98,261	46,596	142,906
2000	115,041,951	58,942,900	20,986,800	9,244,150	9,219,820	6,112,320	3,129,360	4,052,860	1,220,730	725,148	488,368	350,793	240,801	133,825	66,363	127,713
2001	134,055,910	80,859,400	19,020,800	10,542,100	5,714,670	6,190,590	4,259,970	2,228,330	2,914,970	859,497	503,319	335,846	239,822	164,020	90,946	131,630
2002	147,646,887	89,076,500	26,092,800	9,553,520	6,514,520	3,833,750	4,308,430	3,027,650	1,599,040	2,047,150	594,941	345,141	228,932	162,869	111,132	150,512
2003	116,004,759	52,680,300	28,740,600	13,091,100	5,879,860	4,331,650	2,629,880	3,003,070	2,122,460	1,094,020	1,377,910	396,229	228,324	150,811	107,011	171,534
2004	170,622,183	116,559,000	16,997,100	14,417,900	8,054,010	3,906,340	2,967,340	1,829,680	2,100,550	1,448,510	734,408	915,132	261,372	149,974	98,799	182,068
2005	124,710,548	55,010,700	37,597,200	8,507,780	8,798,850	5,256,030	2,599,430	1,985,300	1,221,120	1,360,230	919,196	459,962	568,395	161,495	92,365	172,495
2006	106,484,561	49,214,500	17,744,800	18,824,700	5,197,800	5,756,160	3,511,470	1,748,470	1,333,500	796,442	869,834	580,331	288,047	354,147	100,305	164,055
2007	79,749,496	30,424,400	15,871,000	8,865,590	11,410,900	3,341,930	3,738,770	2,273,990	1,122,120	826,533	482,251	518,773	342,801	169,128	207,163	154,147
2008	88,980,706	49,343,100	9,815,360	7,955,380	5,438,380	7,532,000	2,265,370	2,564,530	1,563,720	751,365	543,638	313,540	334,815	220,227	108,343	230,938
2009	71,308,424	30,956,600	15,918,400	4,919,010	4,876,530	3,584,020	5,092,520	1,548,500	1,756,180	1,042,190	491,738	351,616	201,279	213,932	140,306	215,603
2010	72,843,573	38,610,200	9,987,790	7,983,940	3,024,040	3,234,380	2,448,550	3,530,110	1,078,390	1,192,680	695,952	324,803	230,644	131,458	139,345	231,291
2011	92,496,980	59,425,200	12,454,600	5,001,260	4,879,230	1,979,620	2,163,180	1,649,380	2,375,290	704,730	764,295	440,349	203,862	144,034	81,837	230,113
2012	91,929,302	53,355,800	19,167,200	6,231,640	3,047,780	3,174,190	1,310,600	1,437,350	1,091,730	1,523,990	442,802	473,763	270,621	124,613	87,748	189,475
2013	61,108,072	21,811,100	17,211,500	9,599,130	3,810,370	1,997,500	2,126,960	885,111	970,121	715,907	980,210	281,253	298,533	169,678	77,890	172,809
2014	58,780,640	29,981,800	7,030,720	8,568,680	5,744,140	2,381,140	1,238,790	1,294,200	527,108	553,042	396,330	532,432	150,940	159,008	89,953	132,357
2015	113,298,700	86,320,200	9,670,370	3,517,630	5,220,840	3,735,370	1,575,410	822,411	855,741	337,800	347,058	245,353	326,775	92,139	96,738	134,866
2016	146,070,142	102,131,000	27,845,000	4,842,890	2,150,660	3,420,980	2,502,130	1,063,450	554,765	560,803	217,121	220,285	154,492	204,736	57,549	144,281
2017	109,651,782	52,408,700	32,943,500	13,938,500	2,956,170	1,404,250	2,278,370	1,675,950	710,705	359,791	356,455	136,216	137,060	95,627	126,319	124,169

Table B7.13 (continued).

Stock 2 Population (Period 2)																
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	19,270,314	8,616,580	4,406,430	1,973,070	1,556,270	638,852	309,891	246,452	212,115	182,566	157,135	135,246	116,407	100,193	86,237	532,870
1983	22,317,089	12,856,900	2,997,630	2,290,610	1,222,480	1,029,710	438,721	219,525	177,875	151,893	130,199	111,828	96,148	82,711	71,171	439,688
1984	25,227,152	14,891,400	4,472,870	1,558,420	1,419,590	809,233	707,578	311,012	158,565	127,477	108,413	92,736	79,566	68,374	58,802	363,117
1985	24,161,600	12,473,000	5,182,720	2,338,830	987,658	982,210	591,846	540,191	243,561	123,652	99,191	84,262	72,036	61,788	53,089	327,566
1986	22,362,440	11,008,100	4,339,170	2,692,820	1,446,050	650,714	670,449	416,244	386,816	172,977	87,442	69,991	59,391	50,745	43,514	268,017
1987	27,914,282	16,824,800	3,831,660	2,272,900	1,718,280	1,014,140	485,071	523,577	334,131	309,540	138,196	69,802	55,848	47,380	40,478	248,480
1988	37,587,242	24,425,700	5,857,030	2,010,720	1,460,620	1,222,030	771,041	387,797	431,180	274,622	254,150	113,407	57,266	45,812	38,863	237,004
1989	48,551,935	31,623,800	8,502,640	3,071,590	1,288,920	1,033,670	922,658	611,342	316,492	351,062	223,318	206,539	92,133	46,516	37,209	224,047
1990	54,565,423	33,057,700	11,007,400	4,454,090	1,960,620	904,532	771,256	721,317	491,308	253,564	280,806	178,477	164,997	73,586	37,148	208,623
1991	57,670,127	32,935,700	11,505,000	5,778,300	2,870,330	1,398,130	685,241	607,588	577,947	388,232	198,186	217,678	137,526	126,596	56,290	187,383
1992	61,708,770	34,998,500	11,460,600	6,033,730	3,711,870	2,032,140	1,045,890	529,948	475,310	443,841	293,830	148,358	161,652	101,549	93,105	178,447
1993	71,098,429	42,325,800	12,177,200	6,006,750	3,867,820	2,615,280	1,507,320	798,844	407,917	358,031	328,668	214,807	107,448	116,297	72,716	193,531
1994	134,832,485	101,960,000	14,729,000	6,388,680	3,863,760	2,746,820	1,967,150	1,175,180	631,540	317,234	274,854	249,866	162,149	80,699	87,035	198,518
1995	111,968,573	55,985,300	35,476,600	7,721,780	4,099,330	2,728,580	2,045,880	1,511,760	911,874	480,321	237,492	203,333	183,253	118,189	58,566	206,315
1996	127,694,371	75,752,000	19,470,600	18,548,200	4,910,090	2,836,180	1,960,770	1,492,010	1,096,070	639,605	328,224	159,132	134,308	119,816	76,724	170,642
1997	134,196,920	76,364,400	26,331,700	10,158,000	11,729,300	3,361,740	2,005,390	1,399,140	1,053,260	745,592	422,593	212,170	101,243	84,488	74,775	153,129
1998	108,629,879	47,254,400	26,553,700	13,729,000	6,391,830	7,952,820	2,355,500	1,429,690	1,000,270	736,858	514,094	288,653	144,060	68,486	57,019	153,499
1999	107,159,764	53,870,600	16,428,100	13,827,300	8,603,450	4,296,560	5,496,500	1,648,960	1,000,150	683,064	495,111	341,828	190,657	94,757	44,931	137,796
2000	100,917,291	48,824,100	18,735,300	8,571,260	8,715,290	5,850,720	3,023,350	3,939,540	1,186,130	704,404	474,316	340,662	233,830	129,946	64,438	124,005
2001	116,399,190	66,977,500	16,978,800	9,771,970	5,398,530	5,919,530	4,109,950	2,162,410	2,827,060	833,244	487,818	325,449	232,374	158,916	88,113	127,526
2002	127,837,887	73,782,000	23,286,800	8,848,920	6,143,950	3,656,030	4,141,670	2,925,340	1,543,290	1,974,300	573,492	332,596	220,569	156,900	107,051	144,979
2003	102,007,500	43,635,600	25,652,500	12,130,200	5,550,090	4,136,540	2,532,770	2,908,050	2,053,560	1,057,910	1,331,930	382,917	220,621	145,710	103,385	165,717
2004	146,588,911	96,543,000	15,165,500	13,342,500	7,580,750	3,713,220	2,840,070	1,758,620	2,015,470	1,388,230	703,314	875,967	250,111	143,486	94,514	174,159
2005	109,545,919	45,565,900	33,557,300	7,883,160	8,304,970	5,018,910	2,503,190	1,922,250	1,181,310	1,315,130	888,386	444,438	549,130	156,007	89,221	166,617
2006	93,786,853	40,764,000	15,835,300	17,431,100	4,898,890	5,483,440	3,370,670	1,686,450	1,284,510	766,502	836,656	557,992	276,896	340,389	96,399	157,659
2007	70,980,483	25,200,400	14,163,400	8,209,980	10,756,800	3,184,570	3,590,340	2,194,420	1,081,500	795,936	464,144	499,122	329,744	162,664	199,228	148,235
2008	77,844,216	40,870,300	8,758,760	7,365,420	5,124,050	7,171,540	2,173,060	2,471,560	1,504,910	722,418	522,373	301,157	321,513	211,446	104,013	221,696
2009	63,102,094	25,641,700	14,207,900	4,557,860	4,602,780	3,422,290	4,903,890	1,499,290	1,698,900	1,007,610	475,244	339,741	194,453	206,657	135,527	208,252
2010	63,962,045	31,981,900	8,916,260	7,402,820	2,858,580	3,096,000	2,365,650	3,431,490	1,047,850	1,158,600	675,947	315,432	223,975	127,651	135,306	224,584
2011	79,897,134	49,221,800	11,115,100	4,632,170	4,601,180	1,887,520	2,078,950	1,593,190	2,291,730	679,418	736,476	424,186	196,340	138,703	78,802	221,569
2012	79,734,209	44,195,800	17,109,700	5,776,600	2,879,430	3,035,640	1,264,690	1,395,160	1,059,080	1,477,850	429,290	459,235	262,297	120,772	85,041	183,624
2013	54,331,954	18,066,800	15,365,500	8,901,640	3,602,960	1,912,960	2,056,290	861,055	943,469	696,098	952,961	273,412	290,194	164,934	75,710	167,971
2014	51,723,573	24,835,300	6,277,420	7,949,520	5,436,700	2,283,930	1,200,150	1,262,210	514,078	539,369	386,531	519,268	147,208	155,076	87,729	129,084
2015	96,628,504	71,502,900	8,634,210	3,263,400	4,941,220	3,582,660	1,526,150	802,007	834,498	329,411	338,437	239,257	318,656	89,849	94,334	131,515
2016	124,794,075	84,599,600	24,861,600	4,492,950	2,035,560	3,281,330	2,424,090	1,037,170	541,053	546,941	211,754	214,839	150,673	199,675	56,126	140,714
2017	95,740,344	43,412,500	29,413,800	12,931,400	2,797,970	1,346,940	2,207,350	1,634,570	693,157	350,907	347,654	132,852	133,676	93,266	123,199	121,103

Table B7.13 (continued).

Stock 2 Population (Period 3)																
Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	14,695,932	5,909,380	3,488,180	1,652,580	1,320,930	544,708	265,717	212,403	182,005	156,291	134,362	115,577	99,448	85,582	73,656	455,113
1983	16,901,884	8,820,080	2,383,410	1,951,600	1,073,310	920,868	398,134	201,272	162,817	138,915	119,022	102,205	87,865	75,581	65,034	401,770
1984	19,061,738	10,217,000	3,562,810	1,337,130	1,263,820	738,020	657,257	292,494	149,047	119,794	101,865	87,129	74,753	64,236	55,243	341,140
1985	18,482,450	8,557,320	4,125,120	2,000,830	874,185	888,460	544,422	502,652	226,413	114,887	92,136	78,259	66,899	57,380	49,300	304,188
1986	17,284,390	7,552,700	3,456,290	2,310,390	1,287,320	593,414	622,721	391,429	363,568	162,538	82,154	65,753	55,793	47,670	40,877	251,773
1987	21,139,572	11,543,900	3,053,370	1,953,410	1,534,800	929,207	453,074	495,384	316,063	292,765	130,699	66,013	52,815	44,807	38,280	234,985
1988	28,021,497	16,758,700	4,666,150	1,726,350	1,302,070	1,116,570	717,796	365,590	406,326	258,738	239,424	106,831	53,944	43,153	36,607	223,248
1989	36,022,882	21,696,900	6,771,680	2,633,920	1,146,180	941,195	855,410	573,748	296,851	329,172	209,359	193,614	86,364	43,602	34,878	210,010
1990	40,788,001	22,679,300	8,768,210	3,823,770	1,746,030	823,615	712,986	672,715	456,451	234,864	259,505	164,665	152,048	67,755	34,184	191,903
1991	43,467,470	22,594,900	9,162,780	4,957,320	2,552,350	1,269,700	631,023	563,810	533,734	357,175	181,813	199,279	125,715	115,603	51,365	170,903
1992	46,547,778	24,007,500	9,121,860	5,165,750	3,285,060	1,830,180	951,455	484,039	430,728	399,718	263,385	132,534	144,058	90,343	82,732	158,437
1993	53,420,627	29,035,200	9,695,050	5,147,810	3,430,920	2,364,870	1,379,340	735,250	373,052	325,781	297,931	194,180	96,939	104,777	65,450	174,077
1994	97,682,834	69,940,100	11,723,000	5,469,320	3,419,020	2,473,260	1,788,910	1,072,890	571,997	285,524	246,214	223,059	144,398	71,740	77,280	176,122
1995	84,641,430	38,401,300	28,226,900	6,603,090	3,618,070	2,445,680	1,848,130	1,368,270	817,398	427,292	210,065	179,102	160,936	103,578	51,252	180,367
1996	95,575,289	51,955,200	15,483,700	15,833,200	4,316,280	2,524,250	1,753,020	1,332,380	966,887	558,796	284,677	137,289	115,436	102,707	65,647	145,820
1997	100,633,730	52,375,400	20,921,500	8,637,990	10,230,900	2,961,730	1,775,550	1,240,800	926,326	652,089	368,262	184,468	87,898	73,285	64,825	132,707
1998	83,534,616	32,407,900	21,086,900	11,652,600	5,551,950	6,958,910	2,066,470	1,253,990	868,941	635,995	441,870	247,442	123,288	58,550	48,716	131,094
1999	82,009,964	36,948,000	13,053,500	11,760,800	7,507,940	3,788,230	4,871,600	1,464,180	880,851	598,297	432,131	297,675	165,796	82,329	39,017	119,618
2000	77,386,777	33,486,000	14,883,900	7,285,160	7,593,740	5,145,520	2,670,520	3,483,820	1,039,880	613,979	411,874	295,109	202,260	112,297	55,654	107,064
2001	87,621,668	45,936,600	13,488,600	8,306,000	4,704,180	5,206,710	3,630,960	1,912,670	2,479,080	726,464	423,711	282,008	201,057	137,371	76,123	110,134
2002	95,235,861	50,593,100	18,468,800	7,475,500	5,281,830	3,145,890	3,552,270	2,497,160	1,300,600	1,649,550	476,489	275,362	182,207	129,433	88,236	119,434
2003	78,131,488	29,922,100	20,349,100	10,254,900	4,778,890	3,568,550	2,179,900	2,492,780	1,738,720	888,322	1,112,430	318,725	183,244	120,864	85,686	137,277
2004	107,625,244	66,195,000	12,019,500	11,243,600	6,481,220	3,166,620	2,406,700	1,479,640	1,671,230	1,139,930	573,873	711,884	202,750	116,134	76,423	140,740
2005	83,488,865	31,242,000	26,593,300	6,640,510	7,094,460	4,274,280	2,117,340	1,613,750	977,140	1,077,060	722,893	360,170	443,873	125,903	71,934	134,252
2006	71,437,643	27,945,500	12,534,200	14,620,300	4,145,250	4,598,310	2,792,390	1,380,870	1,033,220	609,238	659,874	437,936	216,652	265,823	75,193	122,887
2007	55,175,341	17,278,300	11,223,100	6,913,450	9,181,960	2,708,780	3,031,910	1,838,600	892,600	650,312	376,749	403,460	265,853	130,934	160,206	119,127
2008	59,252,918	28,027,900	6,952,070	6,240,140	4,433,070	6,234,790	1,889,870	2,145,250	1,292,110	615,760	443,150	254,719	271,426	178,297	87,644	186,722
2009	48,817,279	17,584,000	11,274,700	3,858,370	3,974,930	2,966,570	4,248,030	1,295,200	1,450,970	853,991	400,792	285,614	163,150	173,177	113,485	174,300
2010	48,648,111	21,930,800	7,072,870	6,258,250	2,461,300	2,670,750	2,035,930	2,941,250	887,120	972,783	564,496	262,526	186,011	105,873	112,130	186,022
2011	58,912,486	33,747,100	8,805,140	3,896,680	3,918,730	1,599,650	1,746,960	1,326,980	1,878,970	551,188	593,395	340,293	157,081	110,781	62,872	176,666
2012	59,462,316	30,304,500	13,566,100	4,875,350	2,470,160	2,603,100	1,079,710	1,184,350	887,002	1,226,570	354,210	377,508	215,115	98,904	69,580	150,157
2013	41,499,865	12,382,600	12,138,100	7,412,240	3,000,250	1,562,960	1,644,810	675,974	723,999	526,069	713,090	203,309	214,940	121,864	55,855	123,805
2014	39,400,497	17,028,300	4,975,120	6,698,490	4,647,440	1,947,250	1,016,680	1,061,550	426,084	442,686	315,235	421,784	119,271	125,449	70,899	104,259
2015	69,696,396	49,022,300	6,838,700	2,743,600	4,202,790	3,029,760	1,278,750	665,688	681,550	266,133	271,509	191,088	253,791	71,435	74,921	104,381
2016	90,628,912	58,005,200	19,702,100	3,784,620	1,738,770	2,794,260	2,050,200	870,593	447,471	447,859	172,278	174,073	121,770	161,115	45,243	113,360
2017	72,375,220	29,765,500	23,309,600	10,892,800	2,390,040	1,147,020	1,866,910	1,372,070	573,276	287,343	282,848	107,646	108,035	75,257	99,312	97,563

Table B7.14. Estimates of age-specific female spawning stock biomass (mt) by year for Stock 1 (Chesapeake Bay stock).

Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	572.8	0.0	0.0	0.0	4.8	8.1	3.5	9.5	14.5	18.5	28.9	38.3	36.1	39.1	39.6	331.9
1983	451.2	0.0	0.0	0.0	8.9	17.3	13.1	6.0	10.4	15.1	20.8	27.0	28.3	28.6	30.0	245.6
1984	426.6	0.0	0.0	0.0	9.0	35.8	28.7	31.8	7.6	11.8	14.6	17.7	23.6	21.8	23.2	201.0
1985	506.3	0.0	0.0	0.0	42.8	33.0	66.5	74.0	38.1	9.8	11.7	14.8	16.3	17.8	18.5	162.8
1986	816.2	0.0	0.0	0.0	176.6	157.2	61.5	140.5	84.0	38.3	7.8	9.9	11.0	11.0	11.9	106.4
1987	1,667.1	0.0	0.0	0.0	140.3	633.2	281.2	148.6	183.4	98.9	40.1	8.1	9.4	9.2	10.0	104.8
1988	3,646.5	0.0	0.0	0.0	190.0	612.4	1,319.6	813.3	213.8	231.6	96.2	46.9	8.6	8.1	8.7	97.2
1989	8,304.1	0.0	0.0	0.0	218.2	818.1	1,282.1	3,741.2	1,337.9	307.5	324.4	123.8	44.4	7.6	7.7	91.2
1990	12,832.7	0.0	0.0	0.0	239.5	772.5	1,545.2	3,013.0	4,928.5	1,517.8	300.9	293.3	111.7	34.6	6.0	69.9
1991	18,262.1	0.0	0.0	0.0	283.5	922.1	1,375.7	3,823.0	3,779.2	5,839.5	1,445.3	371.1	237.3	90.4	30.7	64.3
1992	26,014.2	0.0	0.0	0.0	383.4	1,130.9	1,752.2	3,981.9	5,038.3	4,849.3	6,273.5	1,759.9	383.9	253.0	97.7	110.2
1993	34,374.7	0.0	0.0	0.0	517.7	1,559.0	2,011.0	4,515.4	5,671.8	6,453.1	5,020.6	6,357.5	1,589.8	292.3	222.3	164.1
1994	43,356.9	0.0	0.0	0.0	377.4	2,123.0	2,857.1	5,346.3	6,447.5	7,012.9	6,462.6	5,261.9	5,580.6	1,308.6	246.5	332.5
1995	52,893.2	0.0	0.0	0.0	392.1	1,425.4	3,879.8	8,097.5	7,413.8	8,218.8	7,819.2	5,669.5	4,200.9	4,274.2	1,058.4	443.6
1996	65,158.5	0.0	0.0	0.0	501.8	1,542.7	2,930.4	11,636.6	11,372.4	9,249.6	8,355.9	6,783.6	4,850.8	3,214.7	3,437.2	1,282.9
1997	65,818.1	0.0	0.0	0.0	1,225.6	1,799.2	2,461.8	5,988.8	11,251.5	11,312.5	8,899.4	7,227.7	4,996.7	3,914.8	2,611.0	4,129.0
1998	63,648.4	0.0	0.0	0.0	590.1	3,290.3	2,428.0	5,277.8	6,865.7	12,685.6	9,394.2	6,512.0	5,215.2	3,662.3	2,988.4	4,738.9
1999	64,798.4	0.0	0.0	0.0	635.5	1,826.2	4,318.8	4,633.4	5,677.8	7,659.1	12,190.9	8,742.2	5,205.0	4,002.8	3,152.0	6,754.6
2000	73,606.6	0.0	0.0	0.0	778.6	2,118.1	3,122.4	10,564.3	6,294.1	7,131.3	7,049.6	11,803.5	7,696.9	4,636.1	3,648.1	8,763.6
2001	74,715.0	0.0	0.0	0.0	521.3	2,889.0	4,130.4	7,855.7	13,691.3	7,826.2	6,743.8	6,506.6	7,881.3	5,484.4	3,432.0	7,753.1
2002	83,640.7	0.0	0.0	0.0	386.8	1,750.0	5,215.3	9,722.2	10,305.3	15,887.2	7,629.2	6,155.9	5,276.0	6,695.0	4,769.2	9,848.6
2003	88,990.5	0.0	0.0	0.0	279.2	1,399.8	3,057.1	11,902.8	11,831.7	11,547.7	15,714.8	7,079.8	4,792.8	4,196.2	5,806.2	11,382.3
2004	88,182.6	0.0	0.0	0.0	445.0	1,130.1	2,416.5	6,819.1	14,185.4	13,038.2	10,629.0	14,205.0	5,381.4	3,603.8	3,362.8	12,966.4
2005	88,608.9	0.0	0.0	0.0	541.4	1,696.6	1,924.7	5,411.8	8,479.7	16,102.0	12,126.0	9,782.6	11,859.1	4,359.0	3,088.4	13,237.7
2006	83,334.1	0.0	0.0	0.0	239.4	1,825.9	2,738.9	3,899.5	6,503.7	9,517.9	14,841.2	11,078.3	7,593.9	9,127.1	3,627.4	12,341.0
2007	81,303.3	0.0	0.0	0.0	720.6	854.6	3,156.0	6,466.4	4,702.5	7,459.3	8,566.0	13,872.3	8,859.3	6,191.5	7,694.7	12,760.2
2008	82,260.3	0.0	0.0	0.0	374.6	2,953.4	1,696.1	8,630.1	8,218.0	5,694.7	7,364.2	8,004.0	10,909.3	7,193.3	5,251.1	15,971.6
2009	77,617.0	0.0	0.0	0.0	380.7	1,302.9	5,635.3	3,912.6	10,078.2	9,495.1	5,280.3	6,237.8	5,891.7	8,247.6	5,703.9	15,450.9
2010	77,141.8	0.0	0.0	0.0	194.3	1,328.9	2,578.7	12,776.1	4,389.7	10,354.8	8,687.3	4,813.7	4,605.5	4,578.1	6,745.5	16,089.2
2011	73,124.8	0.0	0.0	0.0	382.4	676.6	2,399.1	5,637.5	14,259.9	4,773.2	9,319.1	7,077.3	3,653.2	3,573.7	3,728.1	17,644.6
2012	74,447.4	0.0	0.0	0.0	189.6	1,384.9	1,272.5	5,780.6	7,169.3	16,366.1	4,775.0	8,609.2	5,946.6	2,905.1	3,116.4	16,932.0
2013	69,022.6	0.0	0.0	0.0	245.2	662.8	2,424.9	2,807.3	6,617.6	7,829.1	15,059.8	4,246.9	6,925.2	4,738.4	2,410.8	15,054.6
2014	63,770.1	0.0	0.0	0.0	210.0	894.8	1,036.5	4,967.1	3,117.6	7,244.5	7,014.1	12,914.4	3,381.0	5,408.1	3,949.5	13,632.4
2015	55,164.2	0.0	0.0	0.0	771.2	914.9	1,774.0	2,403.1	5,837.1	3,601.3	6,345.4	5,832.8	10,147.0	2,362.4	4,037.9	11,137.1
2016	57,033.9	0.0	0.0	0.0	106.7	2,785.1	1,628.9	3,985.9	3,022.2	6,735.8	3,659.8	6,181.5	4,921.0	8,573.5	2,076.9	13,356.6
2017	50,345.7	0.0	0.0	0.0	193.7	472.1	4,783.9	3,412.6	4,048.3	2,932.0	6,131.8	3,069.3	4,618.4	3,742.0	6,753.8	10,187.7

Table B7.15. Estimates of age-specific female spawning stock biomass (mt) by year for Stock 2 (DE Bay/Hudson River stock).

Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	18,680.3	0.0	0.0	0.0	100.7	261.2	339.5	711.2	877.2	931.7	1,224.6	1,401.1	1,234.1	1,307.9	1,257.5	9,033.8
1983	14,613.7	0.0	0.0	0.0	74.0	399.7	391.0	506.8	669.7	795.9	907.5	992.2	978.4	986.9	980.5	6,931.1
1984	13,193.6	0.0	0.0	0.0	93.9	333.6	641.6	867.8	583.7	715.6	726.1	734.0	910.5	829.4	819.5	5,937.9
1985	12,542.9	0.0	0.0	0.0	77.1	363.9	577.1	1,482.6	941.1	704.1	663.5	694.2	703.5	742.4	702.4	4,891.0
1986	9,880.3	0.0	0.0	0.0	132.7	263.0	560.0	984.4	1,398.4	828.8	503.1	510.2	525.4	502.5	480.6	3,191.2
1987	10,579.6	0.0	0.0	0.0	149.5	457.8	395.1	1,117.5	1,090.9	1,470.5	789.5	484.8	499.9	472.0	448.1	3,204.1
1988	11,787.4	0.0	0.0	0.0	124.3	630.7	805.1	940.3	1,367.7	1,235.0	1,308.2	862.1	537.1	469.6	439.8	3,067.6
1989	14,573.9	0.0	0.0	0.0	112.7	517.4	1,113.7	1,872.5	1,301.6	1,752.5	1,571.9	1,561.9	843.3	505.2	436.3	2,984.7
1990	14,626.7	0.0	0.0	0.0	165.2	382.7	816.9	2,128.5	2,056.6	1,300.5	1,546.8	1,311.0	1,447.6	700.5	393.3	2,377.1
1991	15,627.8	0.0	0.0	0.0	248.2	628.4	589.6	1,692.9	2,269.8	2,163.0	1,112.3	1,743.6	1,077.4	1,234.0	599.1	2,269.6
1992	18,863.8	0.0	0.0	0.0	303.1	976.4	1,032.0	1,428.1	1,894.1	2,579.2	2,078.8	1,231.0	1,821.5	1,201.4	1,273.8	3,044.3
1993	19,637.5	0.0	0.0	0.0	324.5	1,207.2	1,485.7	2,198.7	1,700.3	2,110.0	2,338.4	1,870.2	1,094.7	1,413.1	982.3	2,912.4
1994	21,977.1	0.0	0.0	0.0	350.6	1,305.3	1,899.5	3,284.5	2,647.8	1,848.2	1,871.7	2,200.0	1,633.8	928.2	1,121.5	2,886.1
1995	24,683.4	0.0	0.0	0.0	392.4	1,302.9	2,053.2	4,479.1	3,832.0	2,953.0	1,811.9	1,460.3	1,729.6	1,274.1	698.0	2,696.8
1996	28,654.9	0.0	0.0	0.0	465.6	1,514.5	2,293.6	5,082.4	5,239.7	4,142.7	2,619.3	1,390.1	1,224.3	1,340.9	947.7	2,393.9
1997	27,991.1	0.0	0.0	0.0	1,187.3	1,642.5	2,072.3	3,871.5	4,078.9	4,476.8	3,424.9	1,965.1	982.0	978.7	984.4	2,326.9
1998	27,950.3	0.0	0.0	0.0	447.7	3,337.5	2,008.0	3,859.2	3,856.1	4,106.4	3,288.9	2,218.7	1,381.7	723.5	685.8	2,037.1
1999	28,067.1	0.0	0.0	0.0	554.0	1,436.5	3,926.6	3,288.7	3,563.8	3,800.4	3,452.1	2,676.3	1,704.4	1,050.0	562.7	2,051.7
2000	33,960.1	0.0	0.0	0.0	553.2	1,936.5	2,244.3	8,422.3	3,923.1	4,042.0	3,123.8	2,977.4	2,303.9	1,527.8	878.7	2,027.1
2001	37,193.0	0.0	0.0	0.0	393.7	2,147.6	3,443.0	4,955.8	9,599.0	4,410.9	3,417.2	2,569.4	1,943.4	1,650.4	1,037.3	1,625.4
2002	41,689.0	0.0	0.0	0.0	402.9	1,376.1	3,509.1	7,053.6	5,677.2	10,007.1	3,820.1	2,763.4	2,024.5	1,649.1	1,307.7	2,098.2
2003	42,151.8	0.0	0.0	0.0	339.2	1,510.9	2,153.8	6,855.8	7,293.6	5,528.7	8,440.1	3,002.8	1,994.8	1,533.0	1,241.3	2,258.0
2004	40,668.4	0.0	0.0	0.0	456.6	1,433.9	2,369.4	4,186.1	7,088.7	7,134.1	4,432.3	6,593.4	2,157.9	1,455.9	1,087.0	2,273.2
2005	39,793.7	0.0	0.0	0.0	539.2	1,811.1	2,202.5	4,576.0	4,445.8	7,005.5	5,644.7	3,436.4	5,065.7	1,649.9	1,073.3	2,343.7
2006	36,998.3	0.0	0.0	0.0	296.7	1,874.9	2,605.0	3,803.0	4,657.7	4,328.8	5,494.2	4,354.6	2,462.7	3,692.1	1,184.9	2,243.7
2007	35,345.7	0.0	0.0	0.0	581.4	1,092.3	2,881.9	5,206.8	3,823.1	4,530.2	3,218.8	4,196.5	3,106.0	1,835.6	2,592.1	2,281.0
2008	37,413.8	0.0	0.0	0.0	308.8	2,471.4	1,945.4	6,758.1	5,621.7	4,016.2	3,793.7	2,526.9	3,028.5	2,373.0	1,334.7	3,235.6
2009	36,751.6	0.0	0.0	0.0	281.5	1,113.4	4,238.1	3,870.4	6,808.5	5,764.8	3,259.8	2,798.0	1,772.9	2,239.6	1,677.8	2,926.9
2010	36,944.1	0.0	0.0	0.0	174.4	1,031.0	2,012.4	8,417.9	3,792.0	6,253.1	4,631.1	2,589.8	1,969.2	1,347.5	1,633.2	3,092.7
2011	33,733.8	0.0	0.0	0.0	307.0	630.9	1,679.2	3,805.4	8,095.3	3,638.9	4,878.6	3,247.6	1,850.7	1,476.3	966.2	3,157.8
2012	32,626.3	0.0	0.0	0.0	199.9	1,153.9	1,064.8	3,466.6	4,102.4	8,031.9	3,075.8	3,772.1	2,495.2	1,380.0	1,099.9	2,783.8
2013	29,322.0	0.0	0.0	0.0	216.4	733.6	1,846.4	2,057.6	3,448.7	3,968.0	6,393.1	2,341.0	2,835.6	1,905.4	1,000.2	2,576.0
2014	24,377.1	0.0	0.0	0.0	301.3	803.1	999.4	3,122.8	1,846.6	3,096.0	2,829.4	4,309.0	1,596.9	1,943.1	1,268.8	2,260.7
2015	22,027.2	0.0	0.0	0.0	318.0	1,379.2	1,456.7	2,031.4	3,187.8	1,886.8	2,337.9	2,004.1	3,146.4	1,062.9	1,259.2	1,956.8
2016	22,613.1	0.0	0.0	0.0	110.3	1,201.6	2,232.4	2,847.6	2,198.7	3,219.6	1,633.8	1,915.6	1,550.8	2,498.1	799.9	2,404.8
2017	21,347.1	0.0	0.0	0.0	174.1	515.7	1,912.0	4,176.6	2,579.3	1,943.2	2,610.7	1,206.5	1,375.2	1,161.4	1,766.2	1,926.2

Table B7.16. January-1 total biomass-at-age for Stock 1 (Chesapeake Bay stock).

Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	3,292	895	642	644	237	109	28	30	35	32	45	56	49	53	51	386
1983	8,031	5,164	1,223	451	416	194	83	17	21	23	26	32	35	35	37	275
1984	13,910	5,460	5,002	2,112	373	353	165	73	13	16	18	21	26	26	27	225
1985	14,465	971	4,482	5,678	2,083	349	376	167	70	13	14	17	18	23	23	182
1986	21,585	3,332	2,979	5,213	7,179	1,765	363	355	160	55	10	11	13	14	15	119
1987	35,929	5,961	5,920	7,300	6,130	7,777	1,782	375	338	139	49	9	10	11	12	117
1988	57,383	13,979	8,761	8,401	8,648	6,866	7,761	1,944	387	325	122	50	9	10	10	109
1989	68,731	7,198	12,091	10,944	9,056	9,058	7,714	9,210	2,382	416	363	127	51	9	9	102
1990	77,930	3,290	12,934	11,734	10,427	9,434	9,674	7,831	9,363	2,246	384	352	131	43	8	78
1991	99,955	10,857	12,223	18,566	11,934	10,634	8,341	9,450	7,045	8,237	1,795	382	272	110	37	72
1992	116,192	3,359	11,523	25,004	17,200	13,039	10,537	9,343	9,281	6,624	7,527	1,818	423	280	109	123
1993	124,072	2,178	8,245	14,549	23,127	17,521	12,379	11,030	10,332	8,833	6,156	7,062	1,832	367	274	184
1994	181,712	39,364	10,555	17,141	16,412	23,848	17,604	12,862	11,615	9,790	8,060	5,789	6,405	1,597	299	373
1995	221,722	31,086	37,086	23,425	18,229	16,535	23,779	18,925	13,448	11,307	9,276	6,538	4,962	5,321	1,308	497
1996	248,705	16,716	37,654	46,342	21,737	17,205	16,985	26,512	20,491	12,562	10,031	7,759	5,343	3,838	4,089	1,441
1997	264,842	16,681	23,909	39,021	54,356	21,458	15,884	15,893	23,267	16,695	10,994	8,291	5,832	4,723	3,155	4,682
1998	278,946	46,686	31,909	35,320	27,017	41,074	15,518	12,763	12,325	16,798	11,794	7,877	6,212	4,557	3,746	5,350
1999	337,684	98,672	34,796	47,072	30,084	21,140	26,889	11,446	10,510	10,460	14,894	9,620	5,856	4,854	3,746	7,645
2000	271,279	42,408	28,270	29,500	36,089	23,633	17,989	23,908	10,583	9,180	8,590	12,889	8,644	5,454	4,292	9,850
2001	229,434	21,728	14,066	19,179	22,970	31,262	22,982	17,850	23,813	10,355	8,260	7,202	9,715	6,948	4,369	8,734
2002	214,172	11,496	13,597	12,025	17,798	19,999	30,274	23,017	17,866	21,326	9,201	6,860	6,103	7,804	5,650	11,158
2003	209,154	5,576	18,564	17,161	12,898	15,344	17,572	28,017	20,750	15,705	18,846	7,935	5,647	5,146	7,134	12,858
2004	247,495	53,617	5,943	24,768	20,266	11,846	13,989	16,011	24,785	17,582	12,900	16,014	6,358	4,463	4,159	14,793
2005	222,782	12,107	37,642	10,114	22,703	18,198	11,297	12,529	14,422	21,229	14,516	10,785	13,399	5,202	3,682	14,957
2006	216,143	17,909	11,429	35,638	11,391	21,121	16,422	9,398	11,331	12,748	17,961	12,287	8,844	11,232	4,416	14,015
2007	191,783	3,846	14,780	15,481	31,734	9,222	17,827	14,526	7,989	9,757	10,325	15,129	10,142	7,361	9,184	14,481
2008	203,994	18,004	5,589	17,922	16,717	31,418	9,455	19,070	14,260	7,501	8,835	8,914	12,892	8,796	6,463	18,157
2009	196,521	11,137	17,167	9,054	17,513	14,642	32,203	9,251	18,115	12,552	6,376	7,078	6,947	10,041	6,987	17,458
2010	181,470	9,344	9,683	19,902	8,901	14,671	14,167	29,907	7,787	14,063	10,533	5,321	5,392	5,526	8,189	18,083
2011	167,990	12,677	9,807	9,763	17,452	7,481	13,616	13,432	25,192	6,330	11,165	8,043	4,239	4,288	4,505	19,999
2012	157,560	10,029	9,826	12,422	8,366	15,161	7,141	13,221	12,078	21,390	5,584	9,455	6,634	3,482	3,704	19,067
2013	153,454	5,667	19,837	10,842	11,207	7,363	13,803	6,539	11,544	10,452	18,052	4,734	7,889	5,722	2,899	16,903
2014	193,915	51,301	5,297	33,316	9,717	9,688	6,074	11,677	5,358	9,319	8,196	14,045	3,736	6,341	4,594	15,255
2015	146,861	13,388	9,804	5,866	32,972	9,238	9,632	5,354	9,847	4,607	7,651	6,555	11,531	2,951	5,000	12,464
2016	157,085	26,525	12,394	6,232	4,889	30,829	9,404	9,227	5,089	8,733	4,245	6,596	5,470	10,090	2,417	14,946
2017	152,058	13,099	23,965	16,583	8,013	4,742	26,802	7,798	7,096	3,951	7,201	3,419	5,333	4,505	8,152	11,400

Table B7.17. January-1 total biomass-at-age for Stock 2 (Delaware Bay/Hudson River stock).

Year	Total	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15+
1982	29,466	657	2,606	2,068	2,042	1,383	1,197	1,159	1,237	1,016	1,333	1,528	1,274	1,338	1,262	9,364
1983	24,424	1,792	898	1,915	1,579	2,051	1,278	847	928	919	946	1,045	1,045	998	1,002	7,181
1984	24,654	2,706	1,735	1,620	1,851	1,614	2,070	1,303	750	787	759	785	898	813	813	6,151
1985	23,169	293	2,221	2,020	1,748	1,929	1,891	2,260	1,314	784	722	722	700	780	720	5,065
1986	20,439	793	899	2,555	2,448	1,365	1,809	1,607	1,975	967	576	545	553	532	510	3,305
1987	23,434	1,904	1,409	2,196	2,972	2,590	1,334	1,802	1,482	1,676	842	492	499	474	444	3,318
1988	30,336	5,586	2,799	1,995	2,578	3,269	2,523	1,420	1,821	1,403	1,451	868	528	477	441	3,177
1989	33,749	2,590	4,830	3,488	2,133	2,653	3,580	2,912	1,695	1,918	1,544	1,501	864	514	435	3,091
1990	34,645	941	4,652	4,670	3,276	2,159	2,726	3,489	2,851	1,550	1,730	1,471	1,525	729	413	2,463
1991	41,311	4,606	3,496	6,674	4,770	3,378	1,931	2,674	3,119	2,471	1,212	1,678	1,108	1,244	597	2,351
1992	46,524	1,533	4,886	7,140	6,189	5,233	3,349	2,143	2,574	2,853	2,188	1,189	1,800	1,103	1,190	3,156
1993	47,847	924	3,760	6,156	6,599	6,306	4,936	3,439	2,290	2,343	2,518	1,942	1,130	1,471	1,014	3,019
1994	71,448	17,298	4,472	7,805	6,948	6,823	6,326	5,072	3,536	2,099	2,053	2,265	1,680	938	1,139	2,993
1995	83,485	9,773	16,287	9,911	8,316	7,042	6,816	6,733	5,164	3,311	1,893	1,577	1,831	1,314	722	2,798
1996	91,561	6,084	11,825	20,286	9,187	7,855	7,173	7,404	6,969	4,562	2,761	1,487	1,208	1,326	943	2,489
1997	95,017	4,925	8,693	12,209	23,656	9,004	7,157	6,542	6,216	5,352	3,713	2,107	1,027	978	995	2,442
1998	99,861	14,646	9,412	12,779	9,361	19,586	7,039	6,097	5,220	4,478	3,656	2,518	1,476	746	719	2,128
1999	127,723	42,812	10,905	13,799	11,988	7,921	13,579	5,369	5,029	4,312	3,754	2,770	1,720	1,055	559	2,149
2000	107,453	21,520	12,255	9,198	11,697	10,269	7,224	12,664	5,048	4,337	3,396	3,061	2,322	1,489	865	2,109
2001	92,899	9,295	7,132	8,274	7,929	11,082	10,752	7,555	12,881	4,890	3,746	2,682	2,151	1,732	1,105	1,695
2002	88,273	4,780	5,811	6,063	8,472	7,488	11,404	11,173	7,598	11,263	4,125	2,904	2,102	1,592	1,296	2,200
2003	86,524	2,900	7,712	7,289	7,163	7,895	6,946	10,826	9,907	6,325	9,079	3,176	2,111	1,557	1,276	2,361
2004	99,643	18,183	3,088	10,236	9,530	7,205	7,762	6,660	9,671	8,138	4,840	7,023	2,290	1,493	1,125	2,400
2005	89,852	4,183	12,750	5,218	10,327	9,266	7,283	7,158	5,901	7,812	6,081	3,580	5,141	1,631	1,071	2,451
2006	84,798	5,541	3,944	11,980	6,448	10,320	8,755	6,158	6,306	4,896	5,981	4,564	2,576	3,764	1,207	2,358
2007	73,606	1,434	4,567	5,299	11,709	5,627	9,171	7,900	5,072	5,018	3,495	4,327	3,194	1,808	2,589	2,396
2008	77,960	6,031	2,082	5,502	6,305	12,563	6,115	10,098	7,620	4,482	4,101	2,661	3,215	2,404	1,375	3,405
2009	76,786	4,905	5,744	3,349	5,905	5,939	13,513	6,112	9,455	6,412	3,536	2,999	1,878	2,259	1,720	3,061
2010	71,220	3,427	4,261	6,623	3,644	5,418	6,201	13,231	5,216	7,155	5,045	2,705	2,071	1,347	1,659	3,217
2011	68,333	7,672	3,592	4,267	6,400	3,324	5,355	6,104	11,117	4,073	5,255	3,488	1,929	1,467	977	3,313
2012	60,065	1,725	5,939	4,516	4,017	5,993	3,341	5,315	5,360	8,848	3,232	3,914	2,500	1,370	1,094	2,902
2013	56,999	2,436	3,408	6,516	4,515	3,889	5,930	3,247	4,706	4,490	6,904	2,467	2,902	1,906	1,006	2,677
2014	65,970	19,096	2,273	5,659	6,343	4,116	3,270	4,922	2,469	3,366	2,976	4,430	1,585	1,887	1,235	2,341
2015	52,808	7,647	3,645	2,502	6,211	6,656	4,473	3,077	4,223	2,053	2,545	2,131	3,213	1,100	1,305	2,027
2016	57,567	10,380	7,072	2,303	2,306	6,354	7,295	4,488	2,914	3,554	1,712	1,935	1,549	2,435	779	2,491
2017	61,747	8,376	9,368	9,413	3,291	2,480	6,083	6,526	3,568	2,235	2,772	1,272	1,427	1,158	1,784	1,995

Table B7.18. Sensitivity analysis results for 2018 non-migration SCA assessment model.

	2018 Base model		Continuity		Quasi-continuity		ESS 50% decrease		ESS 50% increase		Increase M after 1996		No adj comm. rel.		Mean R method	
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
1982	0.202	17,465	0.858	5,759	0.858	13,893	0.199	18,621	0.202	16,967	0.143	25,983	0.200	17,784	0.194	18,578
1983	0.153	14,397	0.153	4,719	0.139	11,070	0.151	15,482	0.154	13,940	0.103	22,519	0.150	14,695	0.152	15,333
1984	0.071	14,518	0.162	5,294	0.078	11,947	0.064	15,650	0.075	14,015	0.043	23,636	0.068	14,860	0.070	15,356
1985	0.193	15,204	0.099	6,335	0.208	14,010	0.169	16,462	0.212	14,606	0.116	25,350	0.187	15,601	0.199	15,953
1986	0.054	14,011	0.062	6,568	0.060	13,582	0.048	15,363	0.058	13,293	0.031	24,543	0.052	14,451	0.053	14,491
1987	0.032	17,298	0.030	7,891	0.034	16,646	0.029	18,947	0.034	16,413	0.018	30,569	0.031	17,879	0.031	17,830
1988	0.038	23,022	0.046	11,254	0.041	23,859	0.035	25,188	0.040	21,875	0.021	40,673	0.037	23,840	0.037	23,657
1989	0.049	34,681	0.048	18,190	0.053	38,140	0.046	37,753	0.052	33,042	0.028	61,441	0.048	35,968	0.048	35,582
1990	0.071	40,426	0.086	22,619	0.081	45,851	0.062	43,808	0.077	38,616	0.036	72,351	0.067	42,013	0.068	41,489
1991	0.101	47,252	0.073	27,350	0.089	54,218	0.089	51,029	0.109	45,210	0.048	86,620	0.095	49,248	0.097	48,573
1992	0.121	59,746	0.058	33,971	0.104	65,403	0.107	64,400	0.130	57,188	0.056	113,559	0.119	62,234	0.117	61,513
1993	0.095	66,807	0.077	40,856	0.083	75,033	0.085	71,486	0.102	64,164	0.043	131,842	0.092	69,012	0.092	68,847
1994	0.123	74,994	0.091	46,612	0.105	83,314	0.112	79,668	0.132	72,306	0.054	152,218	0.121	77,085	0.120	77,263
1995	0.223	80,943	0.126	57,954	0.190	100,383	0.201	85,236	0.238	78,393	0.092	171,173	0.216	82,750	0.217	83,302
1996	0.290	90,559	0.115	65,462	0.243	106,224	0.268	94,846	0.306	87,882	0.114	207,437	0.291	92,245	0.282	93,063
1997	0.225	86,031	0.194	66,710	0.172	101,519	0.226	90,057	0.226	83,445	0.105	210,476	0.231	87,127	0.221	88,395
1998	0.233	80,682	0.176	57,693	0.179	92,848	0.236	82,934	0.234	78,952	0.113	188,049	0.236	81,081	0.229	82,589
1999	0.215	80,339	0.151	57,868	0.166	94,995	0.220	81,746	0.216	78,963	0.108	180,244	0.216	80,687	0.212	82,102
2000	0.213	92,760	0.191	67,623	0.172	111,810	0.219	92,964	0.213	91,832	0.111	196,469	0.212	93,423	0.210	94,499
2001	0.211	98,063	0.180	67,540	0.168	115,930	0.216	96,858	0.211	97,829	0.113	194,084	0.210	99,254	0.208	99,436
2002	0.227	110,108	0.171	74,859	0.179	130,481	0.232	107,847	0.226	110,272	0.126	207,537	0.226	111,709	0.224	111,476
2003	0.242	112,431	0.199	77,385	0.195	133,961	0.248	109,526	0.242	112,907	0.136	203,259	0.239	114,325	0.240	113,638
2004	0.269	108,533	0.233	75,514	0.219	130,905	0.276	105,410	0.268	109,154	0.153	190,797	0.266	110,792	0.266	109,558
2005	0.264	107,706	0.244	75,878	0.221	132,254	0.272	104,471	0.263	108,392	0.151	186,797	0.261	110,312	0.261	108,663
2006	0.310	101,725	0.277	70,859	0.251	125,478	0.321	98,435	0.308	102,467	0.177	174,189	0.305	104,487	0.307	102,553
2007	0.229	100,084	0.241	69,165	0.192	124,502	0.238	96,416	0.228	100,965	0.132	172,185	0.227	103,251	0.227	100,823
2008	0.242	106,791	0.242	68,248	0.199	127,239	0.252	102,517	0.240	107,908	0.141	179,891	0.237	110,315	0.240	107,371
2009	0.234	106,473	0.196	67,339	0.197	128,421	0.243	101,650	0.232	107,806	0.139	175,578	0.230	110,365	0.233	106,820
2010	0.272	106,860	0.188	66,748	0.219	125,900	0.283	101,617	0.271	108,330	0.165	172,597	0.269	110,949	0.272	106,953
2011	0.275	100,557	0.224	67,741	0.224	123,409	0.284	95,204	0.274	102,051	0.168	160,514	0.268	104,582	0.276	100,318
2012	0.270	99,821	0.185	68,540	0.218	123,154	0.277	94,526	0.269	101,228	0.166	157,484	0.275	104,190	0.272	99,130
2013	0.363	90,175	0.240	65,497	0.279	113,324	0.371	85,624	0.364	91,265	0.223	140,778	0.358	93,439	0.369	89,022
2014	0.279	80,586	0.214	63,491	0.226	105,849	0.283	76,897	0.281	81,260	0.169	127,969	0.278	83,675	0.285	78,908
2015	0.239	72,721	0.148	59,609	0.184	98,060	0.242	70,177	0.241	72,933	0.147	115,067	0.239	75,424	0.245	70,587
2016	0.272	76,164	0.181	63,642	0.216	101,816	0.274	74,142	0.274	76,045	0.169	118,089	0.272	78,720	0.280	73,381
2017	0.297	70,992	-	-	-	-	0.301	69,605	0.299	70,623	0.187	109,089	0.293	73,061	0.308	67,765

Table B7.19. Comparison of continuity run and updated base run of the non-migration SCA model.

Data Source	Continuity Run	Bridge Run	2018 Base
Recreational data	Uncalibrated MRIP	Calibrated MRIP	Calibrated MRIP
Terminal year	2016	2016	2017
Fleets	3: - Ches. Bay (Rec harvest, dead rel., comm. harvest); starting ESS: 32 - Coast (Rec harvest, dead rel., comm. harvest); starting ESS: 47 - Dead comm. releases (CB and Ocean); starting ESS: 23		2: - Ches. Bay (Rec harvest, dead rel., comm. Harvest, comm dead rel.); starting ESS: 50 - Coast (Rec harvest, dead rel., comm. Harvest, comm dead rel.); starting ESS: 50
Selectivity blocks Selectivities: T = Thompson, G = Gompertz, E = Exponential	-Fleet 1 (CB): 1982-1984 (T), 1985-1989 (T), 1990-1995 (T), 1996-2016 (T) -Fleet 2 (coast): 1982-1984 (T), 1985-1989 (G), 1990-1996 (G), 1997-2016 (G) - Fleet 3 (dead comm rel): 1982-1984 (E), 1985-1989 (T), 1990-1996 (T), 1997-2002 (T), 2003-2016 (T)		-Fleet 1 (CB): 1982-1984 (T), 1985-1989 (T), 1990-1995 (T), 1996-2017 (T) -Fleet 2 (coast): 1982-1984 (G), 1985-1989 (G), 1990-1996 (G), 1997-2017 (G)
Commercial dead discard method	Raw tags		Smoothed and adjusted tags
Age aggregated indices	9: - NY YOY - NJ YOY - MD YOY - VA YOY - NY Age 1 - MD Age 1 - MRIP - CT Trawl - NEFSC Trawl		6: - NY YOY - NJ YOY - MD YOY - Composite YOY - NY Age 1 - MD Age 1

Table B7.19 (continued).

Data Source	Continuity Run Bridge Run	2018 Base
Age composition surveys (with starting ESS)	5: - NY OHS Trawl (19) - NJ Trawl (5) - MD SSN (18) - DE SSN (25) - VA Poundnet (8)	8: - NY OHS Trawl (19.1) - NJ Trawl (4.8) - MD SSN (17.6) - DE SSN (25.2) - MRIP (16.8) - CT Trawl (16.8) - DE 30' Trawl (16.8) - ChesMMAP Trawl (16.8)
Female maturity	NEFSC (2013)	Guiliano (2017)
Female sex ratio	NEFSC (2013)	NEFSC (2013)
Natural mortality	NEFSC (2013)	NEFSC (2013)
Plus group	13+	15+

Table B7.20. Average total fishing mortality from the non-migration SCA model for various age ranges and weighting schemes.

Year	Unweighted Avg. 3-8	Unweighted Avg. 8-11	N-weighted Avg. 3-8	N-weighted Avg. 7-11	Unweighted Avg 7-13	N-weighted Avg 7-13
1982	0.136	0.169	0.103	0.168	0.169	0.168
1983	0.118	0.139	0.100	0.138	0.139	0.139
1984	0.061	0.059	0.063	0.059	0.059	0.059
1985	0.089	0.169	0.043	0.147	0.169	0.151
1986	0.026	0.046	0.015	0.041	0.046	0.041
1987	0.015	0.026	0.009	0.024	0.026	0.024
1988	0.019	0.032	0.013	0.029	0.032	0.029
1989	0.023	0.041	0.016	0.036	0.041	0.036
1990	0.043	0.056	0.031	0.054	0.056	0.055
1991	0.053	0.076	0.036	0.073	0.077	0.073
1992	0.062	0.091	0.041	0.087	0.093	0.088
1993	0.051	0.073	0.037	0.071	0.074	0.071
1994	0.067	0.095	0.050	0.092	0.097	0.093
1995	0.111	0.170	0.078	0.160	0.173	0.165
1996	0.118	0.219	0.065	0.194	0.221	0.201
1997	0.128	0.205	0.084	0.194	0.205	0.196
1998	0.129	0.213	0.083	0.200	0.212	0.203
1999	0.123	0.200	0.080	0.187	0.199	0.189
2000	0.124	0.200	0.096	0.182	0.199	0.184
2001	0.117	0.195	0.094	0.180	0.195	0.182
2002	0.127	0.211	0.102	0.195	0.210	0.196
2003	0.141	0.228	0.103	0.212	0.227	0.214
2004	0.152	0.250	0.100	0.237	0.249	0.239
2005	0.146	0.244	0.103	0.231	0.244	0.234
2006	0.176	0.290	0.106	0.276	0.289	0.280
2007	0.131	0.215	0.092	0.200	0.214	0.203
2008	0.133	0.224	0.103	0.205	0.224	0.209
2009	0.138	0.221	0.119	0.208	0.220	0.211
2010	0.158	0.257	0.126	0.235	0.256	0.238
2011	0.158	0.260	0.135	0.243	0.259	0.245
2012	0.160	0.257	0.121	0.245	0.256	0.247
2013	0.206	0.343	0.132	0.328	0.342	0.333
2014	0.173	0.271	0.101	0.258	0.269	0.261
2015	0.148	0.232	0.113	0.221	0.231	0.225
2016	0.176	0.268	0.140	0.255	0.266	0.258
2017	0.173	0.287	0.110	0.263	0.286	0.267

Table B7.21. Female SSB, recruitment, and abundance estimates from the non-migration SCA model.

Year	Female SSB (mt)	Recruitment (Millions of age-1 fish)	Total Abundance (Millions of fish)	Total Age 8+ Abundance (Millions of fish)
1982	19,112	37.9	56.5	1.8
1983	16,090	75.4	98.4	1.5
1984	16,211	65.6	103.1	1.3
1985	16,866	72.6	114.9	1.5
1986	15,369	69.9	118.0	1.7
1987	18,962	72.1	123.7	2.2
1988	25,288	97.0	152.3	2.6
1989	38,239	108.0	174.2	3.5
1990	44,866	126.3	202.3	5.7
1991	52,912	100.8	188.5	7.0
1992	67,439	108.0	194.1	8.2
1993	75,906	132.4	221.0	8.7
1994	85,180	283.5	382.1	9.3
1995	91,436	182.5	334.9	10.4
1996	101,396	232.2	378.3	10.7
1997	95,812	257.9	419.4	10.7
1998	87,835	144.3	322.2	10.1
1999	86,218	149.7	300.3	9.6
2000	97,695	127.0	267.5	10.0
2001	100,859	195.5	322.6	13.8
2002	112,163	224.7	366.7	14.1
2003	113,602	138.3	295.7	15.4
2004	109,072	312.2	449.0	16.5
2005	107,971	162.3	345.1	14.3
2006	101,869	136.4	293.2	12.9
2007	100,065	92.7	228.9	10.9
2008	106,656	129.2	242.3	11.7
2009	106,094	77.5	189.6	12.9
2010	106,261	104.9	198.0	11.9
2011	99,768	147.9	238.7	14.7
2012	98,798	214.4	316.4	13.2
2013	88,864	65.4	193.7	11.6
2014	78,999	92.6	184.9	8.8
2015	70,858	186.9	272.2	8.2
2016	73,924	239.6	351.3	7.1
2017	68,476	108.8	249.2	6.7

Table B7.22. Mohn's rho values from 7-year retrospective runs for ASAP model.

Estimated Parameter	Mohn's Rho
Average F (age 8-13)	0.094
SSB	-0.081
Jan 1 biomass	-0.049
Exploitable biomass	-0.066
Total stock numbers	-0.060
Stock number age 1	-0.100
Stock number age 2	-0.088
Stock number age 3	-0.069
Stock number age 4	-0.079
Stock number age 5	-0.033
Stock number age 6	-0.053
Stock number age 7	-0.060
Stock number age 8	-0.075
Stock number age 9	-0.078
Stock number age 10	-0.079
Stock number age 11	-0.080
Stock number age 12	-0.079
Stock number age 13	-0.079
Stock number age 14	-0.077
Stock number age 15+	-0.078

Table B8.1. Candidate models used in separate IRCR analyses of recovery matrices of striped bass tagged at ≥ 28 inches (711 mm) and ≥18 inches (457 mm) by coastal and producer area programs, and 18–28 inch (457-711 mm) male striped bass tagged in Chesapeake Bay. Analyses include model structure with seven regulatory periods, with a terminal regulatory period of 2015-2017.

Model	Model structure	Description
1	Fy; F'y; M(2p)	Global model. F and F' estimated each year, 2 M periods
2	F88-89, F90-94, F95-99, F00-02, F03-06, F07-14, F15-17, F'y; M(2p)	Constant F for each regulatory period, F' estimated each year, 2 M periods
3	Fy, F'88-89, F'90-94, F'95-99, F'00-02, F'03-06, F'07-14, F'15-17; M(2p)	F estimated each year, constant F' for each regulatory period, 2 M periods
4	F88-89, F90-94, F95-99, F00-02, F03-06, F07-14, F15-17; F'88-89, F'90-94, F'95-99, F'00-02, F'03-06, F'07-14, F'15-17; M(2p)	Constant F for each regulatory period, constant F' for each regulatory period, 2 M periods
5	F88-89, F90-94, F95-99, F00-02, F03-06, F07-14, F15-16, F17; F'88-89, F'90-94, F'95-99, F'00-02, F'03-06, F'07-14, F'15-16, F'17; M(2p)	Constant F and F' for each regulatory period, but final regulatory period with separate estimates of F and F' for the terminal year, 2 M periods
6	F88-89, F90-94, F95-99, F00-02, F03-06, F07-14, F15, F16-17; F'88-89, F'90-94, F'95-99, F'00-02, F'03-06, F'07-14, F'15, F'16-17; M(2p)	Constant F and F' for each regulatory period, but final regulatory period modeled with separate estimates for F15 and F'15 and constant estimates for F16-17 and F'16-17, 2 M periods

Table B8.2. Explanation of seven regulatory periods used in candidate model sets for IRCR analyses of tag recovery data. Analyses include striped bass tagged at ≥ 28 inches (711 mm) and ≥ 18 inches (457 mm) by coastal and producer area tagging programs, and 18–28 inch (457-711 mm) male striped bass tagged in Chesapeake Bay.

Regulatory period	Explanation
1988-1989	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, minimum size, 1 fish creel limit, variable season lengths in the producer areas (Chesapeake Bay, Hudson River,) and 28" 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.
2007-2014	Change in reporting rate.
2015-2017	Addendum IV to Amendment 6; establish new F reference points.

Table B8.3. Two time periods of natural mortality (M) as estimated in the IRCR analysis of six candidate models for each striped bass tagging program. 28" = 711 mm; 18" = 457 mm.

Tagging programs	Striped bass ≥ 28" M1	Striped bass ≥ 28" M2	Striped bass ≥ 18" M1	Striped bass ≥ 18" M2
Coastal programs				
MADFW	1992-1998	1999-2017	1992-1998	1999-2017
NYOHS/TRL	1988-2004	2005-2017	1988 -1998	1999-2017
NJDB	1989-2002	2003-2017	1989-2001	2002-2017
NCCOOP	1988-1999	2000-2017	1988-1999	2000-2017
Producer programs				
HUDSON	1988-2000	2001-2017	1988-2001	2002-2017
DE/PA	1993-2002	2003-2017	1993-2002	2003-2017
MDCB	1987-2000	2001-2017	1987-1998	1999-2017
VARAP	1990-1997	1998-2017	1990-1997	1998-2017

Table B8.4. Total length frequencies of striped bass tagged in 1987–2017 for coastal and producer area programs.

Coastal 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	2012	2013	2014	2015	2016	2017
<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	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	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	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	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	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	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	0	0	0	0	0	0	0	0	0	0
500-549					2	5	12	1	0	1	3	0	0	2	2	4	0	2	0	0	0	1	0	0	0	1	0	2	0	1	4
550-599					7	28	33	29	17	8	7	2	2	19	4	13	0	1	2	1	0	1	6	0	3	2	0	2	1	5	9
600-649					27	59	60	42	57	21	27	9	16	50	19	10	3	12	12	15	6	10	2	0	10	5	2	3	1	28	21
650-699					18	119	89	68	74	45	37	16	55	89	58	21	26	40	39	35	23	39	27	14	13	21	14	13	16	124	35
700-749					35	102	97	73	93	38	79	11	75	143	99	60	93	65	64	53	59	76	68	42	59	47	58	22	32	174	86
750-799					56	106	80	72	61	26	60	13	51	142	93	51	167	118	80	60	69	78	75	89	96	55	54	43	49	103	92
800-849					83	159	78	52	69	27	32	11	24	74	81	37	154	164	139	83	61	84	85	76	131	123	82	90	55	77	62
850-899					79	151	81	19	32	19	28	13	8	35	45	15	98	92	121	68	72	62	87	44	98	133	84	95	70	63	24
900-949					45	91	85	10	14	5	19	4	10	20	19	13	54	37	65	48	71	48	76	30	45	101	86	84	68	54	18
950-999					25	38	37	7	13	7	12	5	6	14	18	5	24	19	35	19	50	35	48	17	28	36	40	59	42	55	18
1000-1049					7	19	18	4	6	4	6	3	4	8	10	7	15	10	16	4	24	12	14	11	9	13	18	21	13	25	11
1050-1099					2	5	3	0	2	1	6	0	1	1	8	2	15	5	5	2	7	7	10	4	7	4	2	16	1	2	0
>1099					2	13	4	0	2	0	0	0	1	3	1	0	7	4	3	1	6	3	3	0	5	3	3	4	0	0	0

NYOHS (1987–2006), NYTRL (2007–2011)

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	2012	2013	2014	2015	2016	2017
<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						

Table B8.4 (continued).

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	2012	2013	2014	2015	2016	2017
<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	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	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	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	0	0	0	0	0	0
350-399			0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
400-449			0	0	2	2	2	11	3	3	6	0	1	2	15	3	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
450-499			1	0	23	20	45	58	10	23	16	6	16	22	52	17	7	7	9	2	0	2	12	4	1	1	0	0	1	1	0
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	12	1	15	25	14	9
550-599			156	37	82	152	570	545	139	178	79	208	435	698	506	243	357	127	342	190	29	169	376	116	17	41	20	52	93	27	12
600-649			167	40	52	247	501	590	448	382	112	209	682	722	661	523	667	279	335	495	140	357	778	253	53	66	51	41	40	14	6
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	22	81	16	20	14	2
700-749			23	9	9	67	100	281	428	398	33	77	81	181	211	222	296	432	88	153	316	241	224	246	219	14	47	2	7	8	0
750-799			12	3	6	17	14	81	170	213	19	28	29	66	190	85	206	272	59	65	119	146	92	103	225	5	18	1	1	4	0
800-849			7	1	2	12	10	21	37	70	11	21	15	34	117	79	83	164	33	37	35	98	70	38	87	13	8	2	1	5	1
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	7	9	0	0	3	0
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	2	5	1	0	8	1
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	1	0	0	0	11	2
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	0	0	0	0	4	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	0	1	0	0	4	1
>1099			0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1

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	2012	2013	2014	2015	2016	2017
<199		0	0	0	0	0	0	0	0	0	0	0	1	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	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	1	0	0	0	0	0	0	0
300-349		0	0	0	0	0	0	0	0	11	0	0	0	4	0	0	0	0	14	1	0	0	0	0	0	0	0	0	0	0	0
350-399		0	0	10	0	0	0	31	1	18	0	0	0	90	3	3	0	20	28	0	0	0	0	0	0	0	0	0	0	0	0
400-449		3	0	43	0	1	2	211	3	5	3	2	0	1321	42	204	0	180	191	4	0	0	0	0	0	0	0	0	0	0	0
450-499		26	0	85	0	27	16	483	9	4	27	64	0	2274	274	812	0	340	722	48	1	0	0	0	0	0	0	0	0	0	0
500-549		116	11	219	8	70	44	853	26	6	59	82	1	1671	472	967	2	505	917	319	2	1	0	2	0	0	0	0	0	0	1
550-599		301	104	369	45	74	65	1033	48	7	98	98	9	463	367	681	22	408	824	632	4	12	2	16	0	0	0	0	2	1	0
600-649		403	270	529	232	116	113	855	68	20	124	70	28	121	414	356	80	242	604	646	11	18	3	41	0	1	9	0	0	1	0
650-699		251	293	377	494	254	129	595	101	49	140	34	44	95	296	211	151	179	338	544	35	64	15	77	3	0	43	1	0	1	0
700-749		127	239	169	465	153	66	329	115	113	185	29	35	83	199	294	396	195	257	535	49	102	22	106	15	0	127	9	7	1	0
750-799		52	127	86	294	127	39	121	95	162	263	30	64	40	180	230	500	262	182	431	57	134	28	118	27	0	167	25	30	11	6
800-849		20	64	56	161	95	26	53	69	143	226	21	33	26	90	177	361	196	124	492	52	171	25	77	38	1	323	84	86	35	10
850-899		8	25	38	58	67	18	34	63	84	132	16	23	20	53	88	209	103	40	430	65	148	27	68	16	1	453	188	151	114	42
900-949		5	10	15	19	26	8	17	28	42	60	6	22	13	36	30	95	43	14	222	46	175	10	29	6	1	425	253	361	263	83
950-999		1	6	7	2	6	4	8	10	20	23	2	7	6	12	14	53	24	3	93	24	115	6	20	1	1	223	172	402	374	166
1000-1049		4	0	4	1	0	0	4	6	5	12	5	4	3	6	6	28	6	0	46	14	52	3	7	0	0	109	85	207	330	260
1050-1099		4	3	1	0	0	0	1	2	5	2	2	0	1	1	3	6	1	2	7	7	26	3	5	1	0	74	45	73	126	178
>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	1	53	58	56	91	135

Table B8.4 (continued).

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	2012	2013	2014	2015	2016	2017
<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	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	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	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	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	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	0	0	0	0	0	0	0	0	0
450-499		58	18	31	25	37	30	22	20	52	4	23	34	23	36	77	46	87	129	53	72	111	17	50	6	2	30	16	61	81	63
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	17	34	14	75	97	47
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	23	38	7	87	149	59
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	29	61	10	70	172	64
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	31	36	16	34	119	60
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	44	47	32	74	50	55
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	85	91	85	99	54	48
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	158	162	126	177	81	79
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	50	127	180	137	239	175	115
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	105	128	54	135	207	146
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	56	54	38	53	86	73
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	19	19	12	17	21	33
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	6	6	4	5	5	10
>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	3	1	0	4	6	0

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	2012	2013	2014	2015	2016	2017
<199					0	0	0	0	0	0	0	1	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	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	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	0	0	0	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	0	0	0	0	0	0
400-449					2	0	27	50	34	134	137	64	71	76	68	78	81	62	36	139	133	83	40	86	79	126	28	19	92	42	71
450-499					4	0	46	47	43	93	187	114	91	136	127	105	78	51	73	126	115	114	79	82	139	160	96	29	101	87	53
500-549					4	0	63	76	52	47	113	161	80	144	160	122	79	63	62	133	82	79	67	81	169	144	117	14	68	87	50
550-599					6	0	37	62	78	26	82	122	65	129	179	137	95	47	47	80	46	77	41	72	140	106	146	23	53	88	72
600-649					10	14	32	30	81	38	35	76	46	66	130	71	84	39	24	61	24	54	38	43	71	79	97	19	27	52	49
650-699					22	26	36	28	48	15	19	46	35	51	81	35	44	21	18	20	20	37	26	25	44	48	71	17	22	33	35
700-749					5	8	20	24	57	22	13	38	18	29	66	43	47	16	15	20	10	27	24	31	49	34	48	7	17	15	9
750-799					1	3	13	18	49	32	30	33	14	37	42	29	57	22	14	21	18	24	14	32	40	30	34	6	16	13	10
800-849					0	0	10	14	33	29	21	48	24	24	47	25	64	29	17	29	16	11	24	26	21	25	34	6	6	9	5
850-899					0	1	8	6	19	23	31	37	23	20	34	28	57	40	20	36	24	21	16	21	30	27	36	12	14	4	9
900-949					1	2	6	5	7	6	9	33	17	20	17	9	35	26	14	32	31	20	14	18	18	21	38	10	17	13	7
950-999					0	3	4	10	7	2	1	12	12	14	11	11	16	16	13	21	16	24	21	11	16	15	27	6	18	11	15
1000-1049					0	0	3	3	8	3	2	7	2	5	13	5	8	8	11	14	5	11	8	4	11	12	26	2	9	12	11
1050-1099					0	0	0	0	2	1	4	1	3	1	6	3	5	8	2	4	4	4	5	6	6	12	16	1	3	8	6
>1099					0	0	0	2	1	1	1	2	0	2	2	1	4	4	7	9	2	6	6	4	5	16	8	1	11	6	5

Table B8.4 (continued).

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	2012	2013	2014	2015	2016	2017
<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	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	0	0	0	0	0	0
250-299	1	9	0	6	4	2	2	3	5	0	1	0	2	3	1	3	0	0	8	2	3	3	0	6	2	2	2	3	1	3	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	24	15	110	16	58	66
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	43	28	153	163	48	101
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	63	88	112	428	184	154
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	63	130	144	299	399	247
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	72	108	118	155	154	269
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	65	96	87	139	87	153
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	53	91	54	99	65	128
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	30	99	45	69	49	78
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	19	60	37	45	44	54
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	29	27	31	38	31	39
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	54	48	25	24	12	13
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	47	23	37	50	53	20	10	15
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	37	30	55	26	19	22
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	35	34	43	61	43	37
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	28	31	16	35	47	65
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	15	16	16	17	23	48
>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	13	17	16	17	24	24

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	2012	2013	2014	2015	2016	2017
<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	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	0	0	0	0	0
250-299		83	1	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	0	0	0
300-349		119	87	1	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	41	64
350-399		74	110	93	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	86	79
400-449		133	84	390	169	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49	137	90
450-499		277	97	461	356	0	0	0	83	103	277	242	317	350	118	39	107	154	184	211	368	177	131	256	36	124	93	76	128	245	71
500-549		633	142	209	770	0	0	0	60	60	183	303	259	680	212	83	203	212	198	179	379	137	173	444	46	229	152	56	69	273	93
550-599		407	322	167	502	3	1	1	120	44	39	76	105	326	143	52	123	220	137	79	263	97	205	514	59	238	135	24	38	142	88
600-649		174	233	229	311	62	225	35	132	58	7	5	7	34	39	15	20	153	77	15	109	36	103	324	60	188	95	24	9	54	25
650-699		59	122	153	157	23	150	32	80	38	3	1	3	9	14	3	0	46	37	4	2	2	11	29	18	103	38	23	8	13	8
700-749		24	49	85	90	7	79	18	43	26	4	9	13	53	15	9	30	43	20	16	25	5	19	41	22	48	23	12	7	11	4
750-799		25	27	43	33	5	25	15	29	17	15	13	25	71	41	37	78	180	24	19	78	9	29	73	31	42	21	9	3	8	4
800-849		5	20	69	44	6	14	11	36	22	24	18	29	67	59	26	74	198	71	35	101	12	50	66	41	48	18	28	4	3	1
850-899		2	16	71	105	10	22	23	54	6	40	31	26	61	70	26	75	109	79	36	202	13	43	92	31	61	35	41	6	2	1
900-949		4	5	33	89	8	42	20	29	3	45	23	25	38	38	9	55	82	46	41	220	14	47	78	30	58	65	55	15	10	5
950-999		3	0	22	40	5	43	26	19	1	46	31	19	26	22	6	44	41	29	25	154	15	32	62	23	35	38	64	21	29	7
1000-1049		0	0	5	13	0	15	8	11	0	27	14	11	28	14	8	27	22	15	6	44	4	16	42	11	18	15	19	12	26	2
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	13	14	14	4	7	7
>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	17	18	9	3	5	3

Table B8.5. Ages at time of release for tagged striped bass captured in 2017 (except NYOHS/TRL is for 2012, the last year fish were tagged for that program).

Program	Age at release	
	Minimum	Maximum
Coastal		
MADFW	3	15
NYOHS/TRL	3	12
NJDB	4	11
NCCOOP	7	18
Producer Area		
HUDSON	2	18
DE/PA	3	11
MDCB	2	18
VARAP	3	19

Table B8.6. Distribution of tag recaptures by state and month, based on 2017 recaptures from fish tagged and released during 2008-2017 (except NYOHS/NYTRL, which is based on 2012 recaptures from fish tagged and released during 2008-2012). Data are presented separately for each tagging program.

Coastal Programs

MADFW

State	Jan.	Feb.	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME													0
NH													0
MA					3	10	8	11	4				36
RI					2	4				1			7
CT				1	1	1	1						4
NY				5	1		3	1	1		2	1	14
NJ				2							8	1	11
PA													0
DE													0
MD				5	2								7
VA				2	1								3
NC													0
UN					1		1						2
Total	0	0	0	15	11	15	13	12	5	1	10	2	84

NYOHS/NYTRL*

State	Jan.	Feb.	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME													0
NH													0
MA					5	2	2	2	1		2		14
RI						1	1		1				3
CT							1						1
NY					1	4		2	1	4			12
NJ				3							2	1	6
PA													0
DE												1	1
MD				2									2
VA													0
NC													0
Total	0	0	0	5	6	7	4	4	3	4	4	2	39

*NYOHS (1988–2007), NYTRL (2008–2012)

Table B8.6 (continued).

Coastal Programs

NJDB

State	Jan.	Feb.	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME													0
NH													0
MA							3			1			4
RI										1			1
CT													0
NY					2	1							3
NJ					1						1	1	3
PA													0
DE					1								1
MD					1								1
VA	1												1
NC													0
Total	1	0	0	0	5	1	3	0	0	2	1	1	14

NCCOOP

State	Jan.	Feb.	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME						1							1
NH							1	1					2
MA					7	6	15	30	7	2			67
RI					4	4	2	6					16
CT					1	3	2	1	1				8
NY				1	3	9	10	6	2	3	7		41
NJ				2	3	2				1	10	3	21
PA				1									1
DE			1	1									2
MD				20	4					1	1	1	27
VA			2	1									3
NC											1		1
Total	0	0	3	26	22	25	30	44	10	7	19	4	190

Table B8.6 (continued).

Producer Area Programs

HUDSON

State	Jan.	Feb.	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME													0
NH								1					1
MA					2	10	12	24	6	1			55
RI					1	7	3	1	1	1			14
CT						3	3	3	1				10
NY				5	33	14	6	3	4	6	6		77
NJ				5	1	1				1	7	9	24
PA													0
DE													0
MD													0
VA													0
NC													0
Total	0	0	0	10	37	35	24	32	12	9	13	9	181

DE/PA

State	Jan.	Feb.	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME													0
NH													0
MA					2		2	1	2				7
RI													0
CT									1	2			3
NY						2		1			1		4
NJ				1	2	7	1						11
PA					1								1
DE				1	1		1			1	1		5
MD	1				3	9	3	3		1	1	3	24
VA											1		1
NC													0
Total	1	0	0	2	9	18	7	5	3	4	4	3	56

Table B8.6 (continued).

Producer Area Programs

MDCB

State	Jan.	Feb.	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME													0
NH													0
MA					1	1		5	1				8
RI						2		2					4
CT										1			1
NY					1		1						2
NJ						1					4		5
PA													0
DE					1								1
MD		2		3	17	28	23	26	9	9	8	3	128
DC				1		1		1					3
VA			1							1			2
NC													0
Total	0	2	1	4	20	33	24	34	10	11	12	3	154

VARAP

State	Jan.	Feb.	Mar	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME													0
NH													0
MA					2		1	2					5
RI								1					1
CT							1						1
NY													0
NJ					1						1		2
PA													0
DE													0
MD					1		1	2			1		5
VA		1	2	6	3	8		1		5	4	3	33
NC													0
Total	0	1	2	6	7	8	3	6	0	5	6	3	47

Table B8.7. Annual exploitation rates of ≥ 28 inch (711 mm) striped bass calculated with adjusted R/M ratios. The ratio (R/M) is the proportion of recovered tags (R) from fish harvested or killed to the total number of tags released (M). The number of recovered tags from harvested or killed fish is adjusted by reporting rate and by a 9% mortality rate of fish released alive.

	Coastal Programs				Producer Area Programs				
Year	MADFW	NYOHS/ NYTRL*	NJDB	NCCOOP	HUDSON	DE/PA	MDCB	VARAP	Mean
1987									
1988		0.05		0.08	0.10		0.04		0.07
1989		0.05	0.02	0.04	0.07		0.04		0.04
1990		0.07	0.05	0.09	0.11		0.09	0.09	0.08
1991		0.15	0.18	0.07	0.11		0.12	0.12	0.13
1992	0.04	0.13	0.02	0.13	0.13		0.12	0.13	0.10
1993	0.05	0.14	0.09	0.12	0.16	0.14	0.12	0.13	0.12
1994	0.04	0.09	0.05	0.08	0.12	0.09	0.12	0.08	0.08
1995	0.04	0.22	0.11	0.14	0.15	0.14	0.20	0.21	0.15
1996	0.08	0.14	0.20	0.11	0.22	0.30	0.17	0.00	0.15
1997	0.17	0.35	0.25	0.18	0.29	0.29	0.23	0.12	0.24
1998	0.07	0.17	0.35	0.20	0.21	0.29	0.23	0.25	0.22
1999	0.09	0.34	0.08	0.22	0.22	0.16	0.21	0.19	0.19
2000	0.12	0.14	0.13	0.06	0.12	0.29	0.15	0.08	0.14
2001	0.07	0.10	0.14	0.15	0.11	0.25	0.09	0.07	0.12
2002	0.07	0.22	0.10	0.11	0.15	0.18	0.08	0.11	0.13
2003	0.09	0.15	0.13	0.10	0.11	0.13	0.08	0.11	0.11
2004	0.08	0.14	0.14	0.11	0.15	0.17	0.07	0.06	0.11
2005	0.06	0.23	0.14	0.06	0.12	0.13	0.09	0.08	0.11
2006	0.08	0.11	0.12	0.10	0.10	0.17	0.11	0.11	0.11
2007	0.04	0.00	0.11	0.16	0.11	0.12	0.07	0.08	0.09
2008	0.06	0.09	0.12	0.16	0.12	0.09	0.09	0.13	0.11
2009	0.09	0.01	0.19	0.03	0.14	0.18	0.14	0.04	0.10
2010	0.06	0.12	0.11	0.06	0.13	0.18	0.08	0.04	0.10
2011	0.07	0.06	0.10	0.18	0.16	0.09	0.11	0.06	0.10
2012	0.04	0.08	0.11	0.39	0.10	0.17	0.06	0.05	0.13
2013	0.07		0.29	0.11	0.14	0.15	0.10	0.04	0.13
2014	0.09		0.00	0.10	0.09	0.20	0.15	0.04	0.10
2015	0.04		0.00	0.10	0.07	0.08	0.05	0.03	0.05
2016	0.07		0.12	0.10	0.09	0.12	0.13	0.06	0.10
2017	0.08		0.00	0.09	0.15	0.18	0.03	0.06	0.08

*NYOHS (1988–2007), NYTRL (2008–2012)

Table B8.8. Annual exploitation rates of ≥ 18-inch (457 mm) striped bass calculated with adjusted R/M ratios. The ratio (R/M) is the proportion of recovered tags (R) from fish harvested or killed to the total number of tags released (M). The number of recovered tags from harvested or killed fish is adjusted by reporting rate and by a 9% mortality rate of fish released alive.

	Coast Programs				Producer Area Programs				
Year	MADMF	NYOHS/ NYTRL*	NJDB	NCCOOP	HUDSON	DE/PA	MDCB	VARAP	Mean
1987							0.01		
1988		0.02		0.05	0.05		0.02		0.03
1989		0.03	0.04	0.03	0.05		0.01		0.03
1990		0.04	0.07	0.07	0.08		0.07	0.04	0.06
1991		0.07	0.03	0.08	0.08		0.10	0.05	0.07
1992	0.04	0.05	0.04	0.14	0.10		0.13	0.13	0.09
1993	0.04	0.05	0.03	0.11	0.10	0.10	0.11	0.07	0.08
1994	0.04	0.03	0.03	0.08	0.09	0.11	0.12	0.08	0.07
1995	0.03	0.06	0.06	0.14	0.12	0.12	0.19	0.09	0.10
1996	0.06	0.04	0.09	0.11	0.16	0.14	0.17	0.02	0.10
1997	0.12	0.05	0.08	0.16	0.22	0.12	0.21	0.09	0.13
1998	0.08	0.03	0.12	0.14	0.17	0.14	0.22	0.09	0.12
1999	0.06	0.06	0.06	0.21	0.14	0.09	0.17	0.09	0.11
2000	0.08	0.04	0.07	0.08	0.09	0.13	0.15	0.05	0.09
2001	0.05	0.05	0.09	0.11	0.08	0.13	0.11	0.08	0.09
2002	0.07	0.06	0.05	0.11	0.07	0.11	0.10	0.06	0.08
2003	0.07	0.06	0.07	0.10	0.08	0.11	0.10	0.07	0.08
2004	0.07	0.04	0.10	0.10	0.10	0.12	0.08	0.06	0.08
2005	0.05	0.04	0.08	0.05	0.06	0.08	0.09	0.05	0.06
2006	0.07	0.03	0.05	0.09	0.07	0.09	0.11	0.08	0.07
2007	0.04	0.02	0.09	0.13	0.07	0.05	0.07	0.06	0.07
2008	0.06	0.05	0.07	0.15	0.07	0.06	0.09	0.06	0.08
2009	0.07	0.05	0.06	0.04	0.11	0.09	0.14	0.06	0.08
2010	0.06	0.07	0.06	0.06	0.08	0.08	0.11	0.03	0.07
2011	0.07	0.05	0.08	0.17	0.13	0.05	0.11	0.05	0.09
2012	0.04	0.08	0.07	0.33	0.09	0.09	0.10	0.05	0.10
2013	0.07		0.14	0.10	0.12	0.09	0.14	0.06	0.10
2014	0.09		0.02	0.11	0.08	0.16	0.17	0.04	0.10
2015	0.04		0.02	0.10	0.05	0.03	0.11	0.05	0.05
2016	0.08		0.11	0.10	0.05	0.05	0.09	0.03	0.07
2017	0.07		0.00	0.09	0.11	0.09	0.08	0.03	0.07

*NYOHS (1988–2007), NYTRL (2008–2012)

Table B8.9. Akaike weights used to derive model-averaged parameter estimates from IRCR analyses of striped bass tagged at ≥ 28 inches (711 mm) and ≥18 inches (457 mm) by coastal and producer area programs (see Table B8.1 for model descriptions).

	Coastal Programs					Producer Area Programs			
Model	MADFW	NYOHS	NYTRL*	NJDB	NCCOOP	HUDSON	DE/PA	MDCB	VARAP
≥ 28 inches									
1	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000
3	0.999	0.175	0.006	0.988	0.000	0.002	0.005	0.000	0.000
4	0.000	0.640	0.736	0.000	0.590	0.001	0.495	0.204	0.793
5	0.000	0.085	0.142	0.000	0.124	0.944	0.352	0.037	0.102
6	0.001	0.099	0.115	0.000	0.286	0.052	0.148	0.758	0.105
≥ 18 inches									
1	0.000	0.463	0.367	0.027	0.000	0.000	0.000	0.000	0.000
2	0.000	0.536	0.633	0.203	0.000	0.002	0.000	0.000	0.000
3	1.000	0.001	0.000	0.081	0.000	0.002	1.000	1.000	0.007
4	0.000	0.000	0.000	0.452	0.771	0.003	0.000	0.000	0.834
5	0.000	0.000	0.000	0.147	0.114	0.975	0.000	0.000	0.078
6	0.000	0.000	0.000	0.089	0.115	0.018	0.000	0.000	0.081

*NYOHS (1988–2007), NYTRL (2008–2012)

Table B8.10. Model-averaged estimates of survival (S) and unconditional standard error (SE) from IRCR analyses of striped bass (≥ 28 inches; 711 mm) tagged by coastal and producer areas programs.

	Coastal Programs								Producer Area Programs							
	MADFW		NYOHS/ NYTRL*		NJDB		NCCOOP		HUDSON		DE/PA		MDCB		VARAP	
Year	S	SE	S	SE	S	SE	S	SE	S	SE	S	SE	S	SE	S	SE
1987													0.85	0.01		
1988			0.89	0.01			0.83	0.02	0.83	0.02			0.85	0.01		
1989			0.89	0.01	0.92	0.01	0.83	0.02	0.83	0.02			0.85	0.01		
1990			0.79	0.02	0.82	0.07	0.78	0.02	0.77	0.01			0.76	0.01	0.69	0.03
1991			0.78	0.02	0.62	0.10	0.78	0.02	0.77	0.01			0.76	0.01	0.69	0.03
1992	0.88	0.02	0.79	0.01	0.92	0.01	0.78	0.02	0.77	0.01			0.76	0.01	0.69	0.03
1993	0.85	0.02	0.78	0.02	0.83	0.04	0.78	0.02	0.77	0.01	0.76	0.04	0.76	0.01	0.69	0.03
1994	0.84	0.02	0.79	0.01	0.88	0.02	0.78	0.02	0.77	0.01	0.76	0.04	0.76	0.01	0.69	0.03
1995	0.82	0.02	0.70	0.02	0.83	0.02	0.75	0.02	0.71	0.01	0.68	0.02	0.68	0.01	0.65	0.03
1996	0.76	0.02	0.70	0.02	0.75	0.02	0.75	0.02	0.71	0.01	0.68	0.02	0.68	0.01	0.65	0.03
1997	0.75	0.02	0.68	0.02	0.76	0.02	0.75	0.02	0.71	0.01	0.68	0.02	0.68	0.01	0.65	0.03
1998	0.77	0.02	0.68	0.03	0.67	0.03	0.75	0.02	0.71	0.01	0.68	0.02	0.68	0.01	0.55	0.02
1999	0.66	0.02	0.68	0.04	0.76	0.03	0.75	0.02	0.71	0.01	0.68	0.02	0.68	0.01	0.55	0.02
2000	0.66	0.02	0.76	0.03	0.80	0.02	0.64	0.01	0.80	0.01	0.71	0.03	0.78	0.01	0.60	0.02
2001	0.72	0.01	0.76	0.03	0.78	0.02	0.64	0.01	0.66	0.01	0.71	0.03	0.62	0.01	0.60	0.02
2002	0.69	0.02	0.76	0.02	0.81	0.02	0.64	0.01	0.66	0.01	0.60	0.02	0.62	0.01	0.60	0.02
2003	0.69	0.02	0.78	0.03	0.64	0.01	0.63	0.01	0.65	0.01	0.62	0.02	0.62	0.01	0.61	0.02
2004	0.70	0.01	0.79	0.02	0.64	0.01	0.63	0.01	0.65	0.01	0.62	0.02	0.62	0.01	0.61	0.02
2005	0.70	0.01	0.59	0.03	0.63	0.02	0.63	0.01	0.65	0.01	0.62	0.02	0.62	0.01	0.61	0.02
2006	0.71	0.01	0.59	0.03	0.67	0.02	0.63	0.01	0.65	0.01	0.62	0.02	0.62	0.01	0.61	0.02
2007	0.73	0.01	0.58	0.05	0.65	0.02	0.62	0.01	0.65	0.01	0.64	0.02	0.63	0.01	0.63	0.02
2008	0.70	0.01	0.58	0.08	0.63	0.02	0.62	0.01	0.65	0.01	0.64	0.02	0.63	0.01	0.63	0.02
2009	0.69	0.01	0.58	0.08	0.61	0.02	0.62	0.01	0.65	0.01	0.64	0.02	0.63	0.01	0.63	0.02
2010	0.72	0.01	0.58	0.08	0.63	0.02	0.62	0.01	0.65	0.01	0.64	0.02	0.63	0.01	0.63	0.02
2011	0.70	0.01	0.58	0.08	0.64	0.02	0.62	0.01	0.65	0.01	0.64	0.02	0.63	0.01	0.63	0.02
2012	0.73	0.01	0.58	0.08	0.67	0.02	0.62	0.01	0.65	0.01	0.64	0.02	0.63	0.01	0.63	0.02
2013	0.71	0.01	0.58	0.08	0.64	0.03	0.62	0.01	0.65	0.01	0.64	0.02	0.63	0.01	0.63	0.02
2014	0.72	0.01	0.58	0.08	0.65	0.03	0.62	0.01	0.65	0.01	0.64	0.02	0.63	0.01	0.63	0.02
2015	0.75	0.01	0.49	0.20	0.69	0.03	0.64	0.01	0.70	0.01	0.65	0.03	0.66	0.02	0.63	0.02
2016	0.71	0.01	0.45	0.25	0.68	0.03	0.64	0.01	0.69	0.01	0.66	0.02	0.64	0.02	0.63	0.02
2017	0.73	0.01	0.47	0.25	0.72	0.03	0.64	0.01	0.65	0.01	0.66	0.03	0.64	0.02	0.64	0.03

*NYOHS (1988–2007), NYTRL (2008–2012)

Table B8.11. Tag-based estimates of survival (from IRCR analyses) for ≥ 28 inch (711 mm) striped bass, including an unweighted average for coastal programs, a weighted average for producer area programs, and 95% confidence intervals.

	Coastal programs							Producer area programs						
Year	MADMF	NYOHS/ NYTRL*	NJDB	NCCOOP	Unweighted average**	95% LCI	95% UCI	HUDSON	DE/PA	MDCB	VARAP	Weighted average***	95% LCI	95% UCI
1987										0.85		0.85	0.83	0.88
1988		0.89		0.83	0.86	0.81	0.91	0.83		0.85		0.85	0.83	0.87
1989		0.89	0.92	0.83	0.88	0.82	0.94	0.83		0.85		0.85	0.83	0.87
1990		0.79	0.82	0.78	0.80	0.66	0.94	0.77		0.76	0.69	0.74	0.72	0.76
1991		0.78	0.62	0.78	0.73	0.52	0.93	0.77		0.76	0.69	0.74	0.72	0.76
1992	0.88	0.79	0.92	0.78	0.84	0.78	0.90	0.77		0.76	0.69	0.74	0.72	0.76
1993	0.85	0.78	0.83	0.78	0.81	0.71	0.91	0.77	0.76	0.76	0.69	0.74	0.73	0.76
1994	0.84	0.79	0.88	0.78	0.82	0.76	0.88	0.77	0.76	0.76	0.69	0.74	0.73	0.76
1995	0.82	0.70	0.83	0.75	0.77	0.70	0.85	0.71	0.68	0.68	0.65	0.68	0.66	0.70
1996	0.76	0.70	0.75	0.75	0.74	0.66	0.81	0.71	0.68	0.68	0.65	0.68	0.66	0.70
1997	0.75	0.68	0.76	0.75	0.74	0.65	0.82	0.71	0.68	0.68	0.65	0.68	0.66	0.70
1998	0.77	0.68	0.67	0.75	0.72	0.62	0.81	0.71	0.68	0.68	0.55	0.65	0.63	0.67
1999	0.66	0.68	0.76	0.75	0.71	0.61	0.81	0.71	0.68	0.68	0.55	0.65	0.63	0.67
2000	0.66	0.76	0.80	0.64	0.71	0.63	0.80	0.80	0.71	0.78	0.60	0.73	0.71	0.75
2001	0.72	0.76	0.78	0.64	0.73	0.65	0.80	0.66	0.71	0.62	0.60	0.63	0.61	0.65
2002	0.69	0.76	0.81	0.64	0.72	0.65	0.80	0.66	0.60	0.62	0.60	0.62	0.60	0.64
2003	0.69	0.78	0.64	0.63	0.68	0.61	0.76	0.65	0.62	0.62	0.61	0.62	0.60	0.64
2004	0.70	0.79	0.64	0.63	0.69	0.63	0.76	0.65	0.62	0.62	0.61	0.62	0.60	0.64
2005	0.70	0.59	0.63	0.63	0.64	0.57	0.71	0.65	0.62	0.62	0.61	0.62	0.60	0.64
2006	0.71	0.59	0.67	0.63	0.65	0.58	0.73	0.65	0.62	0.62	0.61	0.62	0.60	0.64
2007	0.73	0.58	0.65	0.62	0.65	0.55	0.75	0.65	0.64	0.63	0.63	0.63	0.61	0.65
2008	0.70	0.58	0.63	0.62	0.63	0.47	0.80	0.65	0.64	0.63	0.63	0.63	0.61	0.65
2009	0.69	0.58	0.61	0.62	0.63	0.46	0.79	0.65	0.64	0.63	0.63	0.63	0.61	0.65
2010	0.72	0.58	0.63	0.62	0.64	0.47	0.80	0.65	0.64	0.63	0.63	0.63	0.61	0.65
2011	0.70	0.58	0.64	0.62	0.64	0.47	0.80	0.65	0.64	0.63	0.63	0.63	0.61	0.65
2012	0.73	0.58	0.67	0.62	0.65	0.49	0.82	0.65	0.64	0.63	0.63	0.63	0.61	0.65
2013	0.71	0.58	0.64	0.62	0.64	0.47	0.81	0.65	0.64	0.63	0.63	0.63	0.61	0.65
2014	0.72	0.58	0.65	0.62	0.64	0.47	0.82	0.65	0.64	0.63	0.63	0.63	0.61	0.65
2015	0.75	0.49	0.69	0.64	0.69	0.62	0.76	0.70	0.65	0.66	0.63	0.66	0.63	0.68
2016	0.71	0.45	0.68	0.64	0.68	0.60	0.75	0.69	0.66	0.64	0.63	0.65	0.63	0.67
2017	0.73	0.47	0.72	0.64	0.69	0.62	0.76	0.65	0.66	0.64	0.64	0.64	0.62	0.67

*NYOHS 1988-2007, NYTRL 2008-2017

** Unweighted average of coastal program for 2015-2017 excludes NYTRL owing to issues of small sample size.

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

Table B8.12. Model-averaged estimates of survival (S) and unconditional standard error (SE) from IRCR analyses of striped bass (≥ 18 inches; 457 mm) tagged by coastal and producer areas programs.

	Coastal Programs								Producer Area Programs							
	MADFW		NYOHS/ NYTRL*		NJDB		NCCOOP		HUDSON		DE/PA		MDCB		VARAP	
Year	S	SE	S	SE	S	SE	S	SE	S	SE	S	SE	S	SE	S	SE
1987													0.83	0.01		
1988			0.84	0.01			0.79	0.04	0.82	0.01			0.83	0.01		
1989			0.84	0.01	0.85	0.02	0.79	0.04	0.82	0.01			0.83	0.01		
1990			0.80	0.01	0.84	0.01	0.73	0.03	0.77	0.01			0.77	0.01	0.64	0.02
1991			0.79	0.01	0.84	0.01	0.73	0.03	0.77	0.01			0.74	0.01	0.64	0.02
1992	0.87	0.02	0.80	0.01	0.84	0.01	0.73	0.03	0.77	0.01			0.69	0.01	0.64	0.02
1993	0.85	0.01	0.79	0.01	0.84	0.01	0.73	0.03	0.77	0.01	0.75	0.03	0.71	0.01	0.64	0.02
1994	0.84	0.01	0.81	0.01	0.84	0.01	0.73	0.03	0.77	0.01	0.72	0.03	0.71	0.01	0.64	0.02
1995	0.84	0.01	0.79	0.01	0.77	0.01	0.70	0.04	0.71	0.01	0.74	0.02	0.66	0.01	0.62	0.02
1996	0.79	0.02	0.78	0.01	0.77	0.01	0.70	0.04	0.71	0.01	0.51	0.03	0.68	0.01	0.62	0.02
1997	0.77	0.02	0.78	0.01	0.77	0.01	0.70	0.04	0.71	0.01	0.72	0.02	0.65	0.01	0.62	0.02
1998	0.79	0.02	0.78	0.01	0.77	0.01	0.70	0.04	0.71	0.01	0.70	0.02	0.63	0.02	0.49	0.02
1999	0.68	0.01	0.64	0.01	0.77	0.01	0.70	0.04	0.71	0.01	0.74	0.02	0.47	0.01	0.49	0.02
2000	0.68	0.02	0.66	0.01	0.78	0.01	0.58	0.03	0.79	0.01	0.72	0.02	0.50	0.01	0.50	0.02
2001	0.73	0.01	0.65	0.01	0.78	0.01	0.58	0.03	0.79	0.01	0.73	0.02	0.52	0.01	0.50	0.02
2002	0.69	0.01	0.65	0.02	0.66	0.01	0.58	0.03	0.65	0.01	0.58	0.01	0.54	0.01	0.50	0.02
2003	0.69	0.01	0.64	0.02	0.64	0.01	0.58	0.03	0.65	0.01	0.55	0.02	0.51	0.01	0.50	0.02
2004	0.70	0.01	0.65	0.02	0.64	0.01	0.58	0.03	0.65	0.01	0.56	0.02	0.53	0.01	0.50	0.02
2005	0.70	0.01	0.66	0.01	0.64	0.01	0.58	0.03	0.65	0.01	0.56	0.02	0.54	0.01	0.50	0.02
2006	0.71	0.01	0.66	0.01	0.65	0.01	0.58	0.03	0.65	0.01	0.56	0.02	0.53	0.01	0.50	0.02
2007	0.73	0.01	0.67	0.02	0.64	0.01	0.57	0.04	0.64	0.01	0.59	0.02	0.56	0.01	0.52	0.02
2008	0.71	0.01	0.60	0.03	0.64	0.01	0.57	0.04	0.64	0.01	0.59	0.02	0.55	0.02	0.52	0.02
2009	0.69	0.01	0.60	0.03	0.65	0.01	0.57	0.04	0.64	0.01	0.56	0.02	0.52	0.02	0.52	0.02
2010	0.72	0.01	0.59	0.04	0.64	0.01	0.57	0.04	0.64	0.01	0.57	0.02	0.54	0.02	0.52	0.02
2011	0.69	0.01	0.60	0.03	0.64	0.01	0.57	0.04	0.64	0.01	0.59	0.02	0.53	0.01	0.52	0.02
2012	0.73	0.01	0.59	0.04	0.64	0.01	0.57	0.04	0.64	0.01	0.59	0.02	0.55	0.01	0.52	0.02
2013	0.71	0.01	0.59	0.04	0.64	0.01	0.57	0.04	0.64	0.01	0.58	0.02	0.53	0.01	0.52	0.02
2014	0.71	0.01	0.61	0.03	0.64	0.01	0.57	0.04	0.64	0.01	0.58	0.02	0.51	0.02	0.52	0.02
2015	0.74	0.01	0.60	0.05	0.69	0.02	0.56	0.04	0.67	0.01	0.59	0.02	0.54	0.01	0.52	0.02
2016	0.70	0.01	0.57	0.09	0.69	0.02	0.56	0.04	0.67	0.01	0.60	0.02	0.54	0.01	0.52	0.02
2017	0.73	0.01	0.62	0.05	0.69	0.02	0.56	0.05	0.64	0.01	0.60	0.02	0.55	0.01	0.52	0.02

*NYOHS (1988–2007), NYTRL (2008–2012)

Table B8.13. Tag-based estimates of survival (from IRCR analyses) for ≥ 18 inch (457 mm) striped bass, including an unweighted average for coastal programs, a weighted average for producer area programs, and 95% confidence intervals.

	Coastal programs							Producer area programs						
Year	MADMF	NYOHS/ NYTRL*	NJDB	NCCOOP	Unweighted average**	95% LCI	95% UCI	HUDSON	DE/PA	MDCB	VARAP	Weighted average***	95% LCI	95% UCI
1987										0.83		0.83	0.82	0.84
1988		0.84		0.78	0.84	0.82	0.85	0.82		0.83		0.82	0.81	0.83
1989		0.84	0.85	0.78	0.84	0.81	0.88	0.82		0.83		0.83	0.82	0.84
1990		0.80	0.84	0.73	0.82	0.79	0.85	0.77		0.77	0.64	0.74	0.72	0.75
1991		0.79	0.84	0.73	0.81	0.78	0.85	0.77		0.74	0.64	0.71	0.70	0.73
1992	0.87	0.80	0.84	0.73	0.84	0.79	0.88	0.77		0.69	0.64	0.69	0.67	0.70
1993	0.85	0.79	0.84	0.73	0.83	0.79	0.87	0.77	0.75	0.71	0.64	0.70	0.69	0.72
1994	0.84	0.81	0.84	0.73	0.83	0.79	0.87	0.77	0.72	0.71	0.64	0.70	0.69	0.72
1995	0.84	0.79	0.77	0.70	0.80	0.76	0.84	0.71	0.74	0.66	0.62	0.66	0.65	0.68
1996	0.79	0.78	0.77	0.70	0.78	0.74	0.82	0.71	0.51	0.68	0.62	0.65	0.64	0.67
1997	0.77	0.78	0.77	0.70	0.77	0.73	0.82	0.71	0.72	0.65	0.62	0.66	0.64	0.67
1998	0.79	0.78	0.77	0.70	0.78	0.73	0.83	0.71	0.70	0.63	0.49	0.61	0.59	0.63
1999	0.68	0.64	0.77	0.70	0.70	0.66	0.74	0.71	0.74	0.47	0.49	0.53	0.52	0.55
2000	0.68	0.66	0.78	0.58	0.71	0.66	0.75	0.79	0.72	0.50	0.50	0.56	0.54	0.58
2001	0.73	0.65	0.78	0.58	0.72	0.68	0.76	0.79	0.73	0.52	0.50	0.57	0.55	0.59
2002	0.69	0.65	0.66	0.58	0.67	0.62	0.71	0.65	0.58	0.54	0.50	0.55	0.53	0.56
2003	0.69	0.64	0.64	0.58	0.66	0.61	0.71	0.65	0.55	0.51	0.50	0.53	0.51	0.55
2004	0.70	0.65	0.64	0.58	0.66	0.62	0.71	0.65	0.56	0.53	0.50	0.54	0.53	0.56
2005	0.70	0.66	0.64	0.58	0.67	0.62	0.71	0.65	0.56	0.54	0.50	0.55	0.53	0.56
2006	0.71	0.66	0.65	0.58	0.67	0.63	0.71	0.65	0.56	0.53	0.50	0.54	0.52	0.56
2007	0.73	0.67	0.64	0.57	0.68	0.64	0.72	0.64	0.59	0.56	0.52	0.56	0.54	0.58
2008	0.71	0.60	0.64	0.57	0.65	0.58	0.72	0.64	0.59	0.55	0.52	0.55	0.54	0.57
2009	0.69	0.60	0.65	0.57	0.65	0.57	0.72	0.64	0.56	0.52	0.52	0.54	0.52	0.56
2010	0.72	0.59	0.64	0.57	0.65	0.57	0.73	0.64	0.57	0.54	0.52	0.55	0.53	0.57
2011	0.69	0.60	0.64	0.57	0.64	0.57	0.72	0.64	0.59	0.53	0.52	0.55	0.53	0.57
2012	0.73	0.59	0.64	0.57	0.66	0.57	0.74	0.64	0.59	0.55	0.52	0.56	0.54	0.57
2013	0.71	0.59	0.64	0.57	0.65	0.55	0.74	0.64	0.58	0.53	0.52	0.55	0.53	0.57
2014	0.71	0.61	0.64	0.57	0.66	0.58	0.73	0.64	0.58	0.51	0.52	0.53	0.51	0.55
2015	0.74	0.60	0.69	0.56	0.68	0.57	0.79	0.67	0.59	0.54	0.52	0.55	0.54	0.57
2016	0.70	0.57	0.69	0.56	0.65	0.47	0.83	0.67	0.60	0.54	0.52	0.56	0.54	0.58
2017	0.73	0.62	0.69	0.56	0.68	0.58	0.78	0.64	0.60	0.55	0.52	0.56	0.54	0.58

*NYOHS 1988-2007, NYTRL 2008-2017

** Unweighted average of coastal programs excludes NCCOOP estimates owing to model diagnostic issue of a high c-hat estimate.

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

Table B8.14. Model-averaged estimates of instantaneous fishing mortality (F) and unconditional standard error (SE) from IRCR analyses of striped bass (≥ 28 inches; 711 mm) tagged by coastal and producer areas programs.

	Coastal Programs								Producer Area Programs							
	MADFW		NYOHS/ NYTRL*		NJDB		NCCOOP		HUDSON		DE/PA		MDCB		VARAP	
Year	F	SE	F	SE	F	SE	F	SE	F	SE	F	SE	F	SE	F	SE
1987													0.03	0.01		
1988			0.04	0.01			0.05	0.02	0.09	0.02			0.03	0.01		
1989			0.04	0.01	0.00	0.00	0.05	0.02	0.09	0.02			0.03	0.01		
1990			0.15	0.03	0.11	0.08	0.12	0.01	0.16	0.01			0.13	0.01	0.14	0.02
1991			0.17	0.02	0.39	0.16	0.12	0.01	0.16	0.01			0.13	0.01	0.14	0.02
1992	0.03	0.02	0.16	0.02	0.00	0.00	0.12	0.01	0.16	0.01			0.13	0.01	0.14	0.02
1993	0.06	0.01	0.17	0.02	0.11	0.05	0.12	0.01	0.16	0.01	0.16	0.05	0.13	0.01	0.14	0.02
1994	0.08	0.01	0.16	0.02	0.05	0.02	0.12	0.01	0.16	0.01	0.16	0.05	0.13	0.01	0.14	0.02
1995	0.09	0.02	0.29	0.03	0.11	0.02	0.18	0.02	0.26	0.01	0.27	0.03	0.25	0.01	0.20	0.03
1996	0.17	0.02	0.29	0.03	0.21	0.02	0.18	0.02	0.26	0.01	0.27	0.03	0.25	0.01	0.20	0.03
1997	0.19	0.02	0.31	0.03	0.19	0.03	0.18	0.02	0.26	0.01	0.27	0.03	0.25	0.01	0.20	0.03
1998	0.16	0.02	0.32	0.05	0.33	0.04	0.18	0.02	0.26	0.01	0.27	0.03	0.25	0.01	0.20	0.03
1999	0.18	0.03	0.32	0.06	0.19	0.03	0.18	0.02	0.26	0.01	0.27	0.03	0.25	0.01	0.20	0.03
2000	0.17	0.03	0.20	0.03	0.15	0.03	0.13	0.02	0.14	0.01	0.22	0.02	0.12	0.01	0.11	0.02
2001	0.08	0.02	0.20	0.03	0.17	0.02	0.13	0.02	0.14	0.01	0.22	0.02	0.12	0.01	0.11	0.02
2002	0.13	0.02	0.20	0.03	0.14	0.02	0.13	0.02	0.14	0.01	0.22	0.02	0.12	0.01	0.11	0.02
2003	0.14	0.02	0.18	0.04	0.17	0.02	0.13	0.01	0.16	0.01	0.19	0.02	0.12	0.01	0.10	0.01
2004	0.11	0.02	0.17	0.03	0.17	0.02	0.13	0.01	0.16	0.01	0.19	0.02	0.12	0.01	0.10	0.01
2005	0.11	0.02	0.17	0.03	0.19	0.02	0.13	0.01	0.16	0.01	0.19	0.02	0.12	0.01	0.10	0.01
2006	0.11	0.01	0.16	0.03	0.13	0.02	0.13	0.01	0.16	0.01	0.19	0.02	0.12	0.01	0.10	0.01
2007	0.07	0.01	0.19	0.06	0.16	0.02	0.15	0.01	0.16	0.01	0.16	0.01	0.11	0.01	0.06	0.01
2008	0.12	0.01	0.11	0.03	0.19	0.02	0.15	0.01	0.16	0.01	0.16	0.01	0.11	0.01	0.06	0.01
2009	0.13	0.02	0.11	0.03	0.23	0.03	0.15	0.01	0.16	0.01	0.16	0.02	0.11	0.01	0.06	0.01
2010	0.09	0.01	0.11	0.03	0.20	0.02	0.15	0.01	0.16	0.01	0.16	0.01	0.11	0.01	0.06	0.01
2011	0.12	0.02	0.11	0.03	0.17	0.02	0.15	0.01	0.16	0.01	0.16	0.01	0.11	0.01	0.06	0.01
2012	0.07	0.01	0.11	0.03	0.14	0.02	0.15	0.01	0.16	0.01	0.16	0.01	0.11	0.01	0.06	0.01
2013	0.10	0.01	0.11	0.03	0.17	0.03	0.15	0.01	0.16	0.01	0.16	0.01	0.11	0.01	0.06	0.01
2014	0.09	0.01	0.11	0.03	0.16	0.04	0.15	0.01	0.16	0.01	0.16	0.01	0.11	0.01	0.06	0.01
2015	0.05	0.01	0.28	0.32	0.11	0.04	0.12	0.01	0.09	0.01	0.14	0.03	0.06	0.02	0.06	0.01
2016	0.11	0.01	0.67	3.67	0.12	0.04	0.12	0.01	0.09	0.01	0.13	0.03	0.09	0.01	0.06	0.01
2017	0.08	0.01	0.63	3.67	0.07	0.04	0.12	0.01	0.16	0.02	0.12	0.03	0.09	0.01	0.06	0.02

*NYOHS (1988–2007), NYTRL (2008–2012)

Table B8.15. Tag-based estimates of instantaneous fishing mortality (from IRCR analyses) for ≥ 28-inch (711 mm) striped bass, including an unweighted average for coastal programs, a weighted average for producer area programs, and 95% confidence intervals.

	Coastal programs							Producer area programs						
Year	MADMF	NYOHS/ NYTRL*	NJDB	NCCOOP	Unweighted average**	95% LCI	95% UCI	HUDSON	DE/PA	MDCB	VARAP	Weighted average***	95% LCI	95% UCI
1987										0.03		0.03	0.01	0.05
1988		0.04		0.05	0.05	-0.01	0.10	0.09		0.03		0.04	0.02	0.06
1989		0.04	0.00	0.05	0.03	-0.02	0.08	0.09		0.03		0.04	0.02	0.06
1990		0.15	0.11	0.12	0.13	-0.04	0.30	0.16		0.13	0.14	0.14	0.12	0.16
1991		0.17	0.39	0.12	0.23	-0.10	0.55	0.16		0.13	0.14	0.14	0.12	0.16
1992	0.03	0.16	0.00	0.12	0.08	0.03	0.13	0.16		0.13	0.14	0.14	0.12	0.16
1993	0.06	0.17	0.11	0.12	0.11	0.00	0.23	0.16	0.16	0.13	0.14	0.14	0.12	0.16
1994	0.08	0.16	0.05	0.12	0.10	0.04	0.16	0.16	0.16	0.13	0.14	0.14	0.12	0.16
1995	0.09	0.29	0.11	0.17	0.17	0.08	0.25	0.26	0.27	0.25	0.20	0.24	0.22	0.26
1996	0.17	0.29	0.21	0.17	0.21	0.13	0.30	0.26	0.27	0.25	0.20	0.24	0.22	0.26
1997	0.19	0.31	0.19	0.17	0.22	0.11	0.32	0.26	0.27	0.25	0.20	0.24	0.22	0.26
1998	0.16	0.32	0.33	0.17	0.24	0.11	0.37	0.26	0.27	0.25	0.20	0.24	0.22	0.26
1999	0.18	0.32	0.19	0.17	0.22	0.07	0.36	0.26	0.27	0.25	0.20	0.24	0.22	0.26
2000	0.17	0.20	0.15	0.13	0.16	0.06	0.27	0.14	0.22	0.12	0.11	0.13	0.11	0.15
2001	0.08	0.20	0.17	0.13	0.15	0.06	0.24	0.14	0.22	0.12	0.11	0.13	0.11	0.15
2002	0.13	0.20	0.14	0.13	0.15	0.06	0.24	0.14	0.22	0.12	0.11	0.13	0.11	0.15
2003	0.14	0.18	0.17	0.13	0.16	0.06	0.25	0.16	0.19	0.12	0.10	0.12	0.11	0.14
2004	0.11	0.17	0.17	0.13	0.15	0.08	0.22	0.16	0.19	0.12	0.10	0.12	0.11	0.14
2005	0.11	0.17	0.19	0.13	0.15	0.07	0.23	0.16	0.19	0.12	0.10	0.12	0.11	0.14
2006	0.11	0.16	0.13	0.13	0.13	0.05	0.22	0.16	0.19	0.12	0.10	0.12	0.11	0.14
2007	0.07	0.19	0.16	0.15	0.14	0.02	0.27	0.16	0.16	0.11	0.06	0.11	0.10	0.12
2008	0.12	0.11	0.19	0.15	0.14	0.06	0.23	0.16	0.16	0.11	0.06	0.11	0.10	0.12
2009	0.13	0.11	0.23	0.15	0.15	0.06	0.24	0.16	0.16	0.11	0.06	0.11	0.10	0.12
2010	0.09	0.11	0.20	0.15	0.14	0.05	0.22	0.16	0.16	0.11	0.06	0.11	0.10	0.12
2011	0.12	0.11	0.17	0.15	0.14	0.05	0.22	0.16	0.16	0.11	0.06	0.11	0.10	0.12
2012	0.07	0.11	0.14	0.15	0.12	0.03	0.20	0.16	0.16	0.11	0.06	0.11	0.10	0.12
2013	0.10	0.11	0.17	0.15	0.13	0.04	0.23	0.16	0.16	0.11	0.06	0.11	0.10	0.12
2014	0.09	0.11	0.16	0.15	0.13	0.02	0.23	0.16	0.16	0.11	0.06	0.11	0.10	0.12
2015	0.05	0.28	0.11	0.12	0.09	0.01	0.17	0.09	0.14	0.06	0.06	0.07	0.05	0.09
2016	0.11	0.67	0.12	0.12	0.12	0.03	0.21	0.09	0.13	0.09	0.06	0.08	0.07	0.10
2017	0.08	0.63	0.07	0.12	0.09	0.01	0.17	0.16	0.12	0.09	0.06	0.09	0.07	0.11

*NYOHS 1988-2007, NYTRL 2008-2017

** Unweighted average of coastal program for 2015-2017 excludes NYTRL owing to issues of small sample size.

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

Table B8.16. Model-averaged estimates of instantaneous fishing mortality (F) and unconditional standard error (SE) from IRCR analyses of striped bass (≥ 18 inches; 457 mm) tagged by coastal and producer areas programs.

	Coastal Programs								Producer Area Programs							
	MADFW		NYOHS/ NYTRL*		NJDB		NCCOOP		HUDSON		DE/PA		MDCB		VARAP	
Year	F	SE	F	SE	F	SE	F	SE	F	SE	F	SE	F	SE	F	SE
1987													0.00	0.00		
1988			0.01	0.01			0.02	0.03	0.05	0.01			0.01	0.00		
1989			0.01	0.00	0.02	0.02	0.02	0.03	0.05	0.01			0.00	0.00		
1990			0.06	0.01	0.04	0.01	0.10	0.03	0.11	0.01			0.08	0.01	0.08	0.01
1991			0.07	0.01	0.04	0.01	0.10	0.03	0.11	0.01			0.12	0.01	0.08	0.01
1992	0.03	0.01	0.06	0.01	0.03	0.01	0.10	0.03	0.11	0.01			0.18	0.01	0.08	0.01
1993	0.05	0.01	0.07	0.01	0.03	0.01	0.10	0.03	0.11	0.01	0.11	0.04	0.17	0.01	0.08	0.01
1994	0.07	0.01	0.06	0.01	0.03	0.01	0.10	0.03	0.11	0.01	0.14	0.04	0.16	0.01	0.08	0.01
1995	0.07	0.01	0.09	0.01	0.12	0.01	0.15	0.04	0.20	0.01	0.11	0.02	0.23	0.02	0.11	0.01
1996	0.13	0.01	0.09	0.01	0.12	0.01	0.15	0.04	0.20	0.01	0.48	0.06	0.21	0.02	0.11	0.01
1997	0.15	0.02	0.10	0.01	0.13	0.01	0.15	0.04	0.20	0.01	0.14	0.03	0.25	0.02	0.11	0.01
1998	0.13	0.02	0.09	0.01	0.13	0.01	0.15	0.04	0.20	0.01	0.18	0.03	0.28	0.02	0.11	0.01
1999	0.13	0.02	0.09	0.01	0.12	0.01	0.15	0.04	0.20	0.01	0.12	0.02	0.25	0.03	0.11	0.01
2000	0.13	0.02	0.07	0.01	0.11	0.01	0.11	0.03	0.10	0.01	0.14	0.02	0.20	0.02	0.08	0.01
2001	0.07	0.01	0.07	0.01	0.12	0.01	0.11	0.03	0.10	0.01	0.13	0.02	0.16	0.02	0.08	0.01
2002	0.13	0.02	0.08	0.01	0.11	0.01	0.11	0.03	0.10	0.01	0.10	0.02	0.12	0.02	0.08	0.01
2003	0.12	0.02	0.09	0.02	0.13	0.01	0.11	0.02	0.11	0.00	0.16	0.02	0.17	0.02	0.09	0.01
2004	0.11	0.01	0.09	0.01	0.13	0.01	0.11	0.02	0.11	0.00	0.13	0.02	0.14	0.02	0.09	0.01
2005	0.11	0.01	0.07	0.01	0.13	0.01	0.11	0.02	0.11	0.00	0.13	0.02	0.12	0.02	0.09	0.01
2006	0.10	0.01	0.07	0.01	0.13	0.01	0.11	0.02	0.11	0.00	0.13	0.02	0.14	0.02	0.09	0.01
2007	0.07	0.01	0.06	0.01	0.13	0.01	0.13	0.03	0.12	0.00	0.08	0.02	0.09	0.02	0.06	0.01
2008	0.10	0.01	0.08	0.02	0.13	0.01	0.13	0.03	0.12	0.00	0.09	0.02	0.11	0.02	0.06	0.01
2009	0.12	0.01	0.09	0.01	0.13	0.01	0.13	0.03	0.12	0.00	0.13	0.02	0.16	0.02	0.06	0.01
2010	0.08	0.01	0.10	0.02	0.13	0.01	0.13	0.03	0.12	0.00	0.12	0.02	0.13	0.02	0.06	0.01
2011	0.13	0.02	0.09	0.01	0.13	0.01	0.13	0.03	0.12	0.00	0.08	0.02	0.13	0.02	0.06	0.01
2012	0.07	0.01	0.10	0.02	0.13	0.01	0.13	0.03	0.12	0.00	0.09	0.02	0.10	0.02	0.06	0.01
2013	0.10	0.01	0.11	0.04	0.14	0.01	0.13	0.03	0.12	0.00	0.09	0.02	0.13	0.02	0.06	0.01
2014	0.09	0.01	0.07	0.03	0.13	0.01	0.13	0.03	0.12	0.00	0.10	0.02	0.19	0.03	0.06	0.01
2015	0.05	0.01	0.09	0.05	0.07	0.02	0.14	0.05	0.07	0.01	0.09	0.02	0.13	0.02	0.06	0.01
2016	0.11	0.01	0.15	0.13	0.07	0.02	0.15	0.05	0.08	0.01	0.06	0.02	0.12	0.02	0.06	0.01
2017	0.08	0.01	0.06	0.07	0.07	0.02	0.15	0.06	0.12	0.01	0.07	0.02	0.11	0.01	0.06	0.01

*NYOHS (1988–2007), NYTRL (2008–2012)

Table B8.17. Tag-based estimates of instantaneous fishing mortality (from IRCR analyses) for ≥ 18- inch (457 mm) striped bass, including an unweighted average for coastal programs, a weighted average for producer area programs, and 95% confidence intervals.

	Coastal programs							Producer area programs						
Year	MADMF	NYOHS/ NYTRL*	NJDB	NCCOOP	Unweighted average**	95% LCI	95% UCI	HUDSON	DE/PA	MDCB	VARAP	Weighted average***	95% LCI	95% UCI
1987										0.00		0.00	0.00	0.01
1988		0.01		0.03	0.01	0.00	0.02	0.05		0.01		0.02	0.01	0.02
1989		0.01	0.02	0.03	0.01	-0.02	0.05	0.05		0.00		0.01	0.01	0.01
1990		0.06	0.04	0.10	0.05	0.02	0.07	0.11		0.08	0.08	0.08	0.07	0.09
1991		0.07	0.04	0.10	0.05	0.03	0.08	0.11		0.12	0.08	0.11	0.10	0.12
1992	0.03	0.06	0.03	0.10	0.04	0.01	0.08	0.11		0.18	0.08	0.14	0.13	0.16
1993	0.05	0.07	0.03	0.10	0.05	0.02	0.09	0.11	0.11	0.17	0.08	0.13	0.11	0.15
1994	0.07	0.06	0.03	0.10	0.05	0.02	0.08	0.11	0.14	0.16	0.08	0.13	0.12	0.14
1995	0.07	0.09	0.12	0.14	0.09	0.06	0.12	0.20	0.11	0.23	0.11	0.19	0.17	0.20
1996	0.13	0.09	0.12	0.14	0.11	0.08	0.15	0.20	0.48	0.21	0.11	0.21	0.19	0.23
1997	0.15	0.10	0.13	0.14	0.13	0.08	0.17	0.20	0.14	0.25	0.11	0.20	0.18	0.22
1998	0.13	0.09	0.13	0.14	0.12	0.07	0.16	0.20	0.18	0.28	0.11	0.22	0.19	0.24
1999	0.13	0.09	0.12	0.14	0.12	0.07	0.16	0.20	0.12	0.25	0.11	0.19	0.17	0.22
2000	0.13	0.07	0.11	0.11	0.10	0.06	0.15	0.10	0.14	0.20	0.08	0.15	0.13	0.17
2001	0.07	0.07	0.12	0.11	0.09	0.05	0.12	0.10	0.13	0.16	0.08	0.13	0.11	0.15
2002	0.13	0.08	0.11	0.11	0.11	0.06	0.15	0.10	0.10	0.12	0.08	0.11	0.09	0.12
2003	0.12	0.09	0.13	0.11	0.11	0.06	0.17	0.11	0.16	0.17	0.09	0.14	0.12	0.16
2004	0.11	0.09	0.13	0.11	0.11	0.07	0.15	0.11	0.13	0.14	0.09	0.12	0.10	0.14
2005	0.11	0.07	0.13	0.11	0.11	0.07	0.15	0.11	0.13	0.12	0.09	0.11	0.09	0.13
2006	0.10	0.07	0.13	0.11	0.10	0.06	0.14	0.11	0.13	0.14	0.09	0.12	0.10	0.14
2007	0.07	0.06	0.13	0.13	0.09	0.05	0.13	0.12	0.08	0.09	0.06	0.09	0.07	0.11
2008	0.10	0.08	0.13	0.13	0.10	0.06	0.15	0.12	0.09	0.11	0.06	0.10	0.07	0.12
2009	0.12	0.09	0.13	0.13	0.11	0.07	0.16	0.12	0.13	0.16	0.06	0.12	0.10	0.15
2010	0.08	0.10	0.13	0.13	0.10	0.05	0.16	0.12	0.12	0.13	0.06	0.11	0.09	0.13
2011	0.13	0.09	0.13	0.13	0.12	0.07	0.16	0.12	0.08	0.13	0.06	0.11	0.09	0.13
2012	0.07	0.10	0.13	0.13	0.10	0.04	0.16	0.12	0.09	0.10	0.06	0.09	0.07	0.11
2013	0.10	0.11	0.14	0.13	0.11	0.03	0.20	0.12	0.09	0.13	0.06	0.11	0.09	0.13
2014	0.09	0.07	0.13	0.13	0.10	0.04	0.16	0.12	0.10	0.19	0.06	0.14	0.11	0.16
2015	0.05	0.09	0.07	0.14	0.07	-0.04	0.18	0.07	0.09	0.13	0.06	0.10	0.08	0.12
2016	0.11	0.15	0.07	0.14	0.11	-0.16	0.38	0.08	0.06	0.12	0.06	0.09	0.07	0.11
2017	0.08	0.06	0.07	0.15	0.07	-0.07	0.20	0.12	0.07	0.11	0.06	0.09	0.07	0.11

*NYOHS 1988-2007, NYTRL 2008-2017

** Unweighted average of coastal programs excludes NCCOOP estimates owing to model diagnostic issue of a high c-hat estimate.

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

Table B8.18. Model-averaged estimates of instantaneous natural mortality (M) and unconditional standard error (SE) from IRCR analyses of striped bass (≥ 28 inches; 711 mm) tagged by coastal and producer areas programs.

	Coastal Programs								Producer Area Programs							
	MADFW		NYOHS/ NYTRL*		NJDB		NCCOOP		HUDSON		DE/PA		MDCB		VARAP	
Year	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE
1987													0.13	0.01		
1988			0.06	0.01			0.11	0.02	0.08	0.01			0.13	0.01		
1989			0.06	0.01	0.07	0.01	0.11	0.02	0.08	0.01			0.13	0.01		
1990			0.06	0.01	0.07	0.01	0.11	0.02	0.08	0.01			0.13	0.01	0.22	0.03
1991			0.06	0.01	0.07	0.01	0.11	0.02	0.08	0.01			0.13	0.01	0.22	0.03
1992	0.09	0.01	0.06	0.01	0.07	0.01	0.11	0.02	0.08	0.01			0.13	0.01	0.22	0.03
1993	0.09	0.01	0.06	0.01	0.07	0.01	0.11	0.02	0.08	0.01	0.11	0.02	0.13	0.01	0.22	0.03
1994	0.09	0.01	0.06	0.01	0.07	0.01	0.11	0.02	0.08	0.01	0.11	0.02	0.13	0.01	0.22	0.03
1995	0.09	0.01	0.06	0.01	0.07	0.01	0.11	0.02	0.08	0.01	0.11	0.02	0.13	0.01	0.22	0.03
1996	0.09	0.01	0.06	0.01	0.07	0.01	0.11	0.02	0.08	0.01	0.11	0.02	0.13	0.01	0.22	0.03
1997	0.09	0.01	0.06	0.01	0.07	0.01	0.11	0.02	0.08	0.01	0.11	0.02	0.13	0.01	0.22	0.03
1998	0.09	0.01	0.06	0.01	0.07	0.01	0.11	0.02	0.08	0.01	0.11	0.02	0.13	0.01	0.40	0.03
1999	0.24	0.01	0.06	0.01	0.07	0.01	0.11	0.02	0.08	0.01	0.11	0.02	0.13	0.01	0.40	0.03
2000	0.24	0.01	0.06	0.01	0.07	0.01	0.32	0.01	0.08	0.01	0.11	0.02	0.13	0.01	0.40	0.03
2001	0.24	0.01	0.06	0.01	0.07	0.01	0.32	0.01	0.27	0.01	0.11	0.02	0.36	0.02	0.40	0.03
2002	0.24	0.01	0.06	0.01	0.07	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2003	0.24	0.01	0.06	0.01	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2004	0.24	0.01	0.06	0.01	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2005	0.24	0.01	0.36	0.04	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2006	0.24	0.01	0.36	0.04	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2007	0.24	0.01	0.36	0.04	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2008	0.24	0.01	0.43	0.12	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2009	0.24	0.01	0.43	0.12	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2010	0.24	0.01	0.43	0.12	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2011	0.24	0.01	0.43	0.12	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2012	0.24	0.01	0.43	0.12	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2013	0.24	0.01	0.43	0.12	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2014	0.24	0.01	0.43	0.12	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2015	0.24	0.01	0.43	0.12	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2016	0.24	0.01	0.43	0.12	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03
2017	0.24	0.01	0.43	0.12	0.26	0.01	0.32	0.01	0.27	0.01	0.29	0.02	0.36	0.02	0.40	0.03

*NYOHS (1988–2007), NYTRL (2008–2012)

Table B8.19. Tag-based estimates of instantaneous natural mortality (from IRCR analyses) for ≥ 28-inch (711 mm) striped bass, including an unweighted average for coastal programs, a weighted average for producer area programs, and 95% confidence intervals.

	Coastal programs							Producer area programs						
Year	MADMF	NYOHS/ NYTRL*	NJDB	NCCOOP	Unweighted average**	95% LCI	95% UCI	HUDSON	DE/PA	MDCB	VARAP	Weighted average***	95% LCI	95% UCI
1987										0.13		0.13	0.11	0.14
1988		0.06		0.12	0.09	0.05	0.13	0.08		0.13		0.12	0.10	0.13
1989		0.06	0.07	0.12	0.08	0.04	0.12	0.08		0.13		0.12	0.10	0.13
1990		0.06	0.07	0.12	0.08	0.04	0.12	0.08		0.13	0.22	0.15	0.13	0.17
1991		0.06	0.07	0.12	0.08	0.04	0.12	0.08		0.13	0.22	0.15	0.13	0.17
1992	0.09	0.06	0.07	0.12	0.08	0.04	0.13	0.08		0.13	0.22	0.15	0.13	0.17
1993	0.09	0.06	0.07	0.12	0.08	0.04	0.13	0.08	0.11	0.13	0.22	0.14	0.12	0.16
1994	0.09	0.06	0.07	0.12	0.08	0.04	0.13	0.08	0.11	0.13	0.22	0.14	0.12	0.16
1995	0.09	0.06	0.07	0.12	0.08	0.04	0.13	0.08	0.11	0.13	0.22	0.14	0.12	0.16
1996	0.09	0.06	0.07	0.12	0.08	0.04	0.13	0.08	0.11	0.13	0.22	0.14	0.12	0.16
1997	0.09	0.06	0.07	0.12	0.08	0.04	0.13	0.08	0.11	0.13	0.22	0.14	0.12	0.16
1998	0.09	0.06	0.07	0.12	0.08	0.04	0.13	0.08	0.11	0.13	0.40	0.19	0.17	0.21
1999	0.24	0.06	0.07	0.12	0.12	0.07	0.17	0.08	0.11	0.13	0.40	0.19	0.17	0.21
2000	0.24	0.06	0.07	0.32	0.17	0.13	0.22	0.08	0.11	0.13	0.40	0.19	0.17	0.21
2001	0.24	0.06	0.07	0.32	0.17	0.13	0.22	0.27	0.11	0.36	0.40	0.33	0.31	0.36
2002	0.24	0.06	0.07	0.32	0.17	0.13	0.22	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2003	0.24	0.06	0.26	0.32	0.22	0.17	0.27	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2004	0.24	0.06	0.26	0.32	0.22	0.17	0.27	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2005	0.24	0.36	0.26	0.32	0.29	0.21	0.38	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2006	0.24	0.36	0.26	0.32	0.29	0.21	0.38	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2007	0.24	0.36	0.26	0.32	0.29	0.21	0.38	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2008	0.24	0.43	0.26	0.32	0.31	0.08	0.54	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2009	0.24	0.43	0.26	0.32	0.31	0.08	0.54	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2010	0.24	0.43	0.26	0.32	0.31	0.08	0.54	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2011	0.24	0.43	0.26	0.32	0.31	0.08	0.54	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2012	0.24	0.43	0.26	0.32	0.31	0.08	0.54	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2013	0.24	0.43	0.26	0.32	0.31	0.08	0.54	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2014	0.24	0.43	0.26	0.32	0.31	0.08	0.54	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2015	0.24	0.43	0.26	0.32	0.27	0.23	0.32	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2016	0.24	0.43	0.26	0.32	0.27	0.23	0.32	0.27	0.29	0.36	0.40	0.35	0.32	0.37
2017	0.24	0.43	0.26	0.32	0.27	0.23	0.32	0.27	0.29	0.36	0.40	0.35	0.32	0.37

*NYOHS 1988-2007, NYTRL 2008-2017

** Unweighted average of coastal program for 2015-2017 excludes NYTRL owing to issues of small sample size.

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

Table B8.20. Model-averaged estimates of instantaneous natural mortality (M) and unconditional standard error (SE) from IRCR analyses of striped bass (≥ 18 inches; 457 mm) tagged by coastal and producer areas programs.

	Coastal Programs								Producer Area Programs							
	MADFW		NYOHS/ NYTRL*		NJDB		NCCOOP		HUDSON		DE/PA		MDCB		VARAP	
Year	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE	M	SE
1987													0.17	0.01		
1988			0.15	0.01			0.20	0.04	0.13	0.01			0.17	0.01		
1989			0.15	0.01	0.12	0.01	0.20	0.04	0.13	0.01			0.17	0.01		
1990			0.15	0.01	0.12	0.01	0.20	0.04	0.13	0.01			0.17	0.01	0.36	0.03
1991			0.15	0.01	0.12	0.01	0.20	0.04	0.13	0.01			0.17	0.01	0.36	0.03
1992	0.10	0.01	0.15	0.01	0.12	0.01	0.20	0.04	0.13	0.01			0.17	0.01	0.36	0.03
1993	0.10	0.01	0.15	0.01	0.12	0.01	0.20	0.04	0.13	0.01	0.17	0.02	0.17	0.01	0.36	0.03
1994	0.10	0.01	0.15	0.01	0.12	0.01	0.20	0.04	0.13	0.01	0.17	0.02	0.17	0.01	0.36	0.03
1995	0.10	0.01	0.15	0.01	0.12	0.01	0.20	0.04	0.13	0.01	0.17	0.02	0.17	0.01	0.36	0.03
1996	0.10	0.01	0.15	0.01	0.12	0.01	0.20	0.04	0.13	0.01	0.17	0.02	0.17	0.01	0.36	0.03
1997	0.10	0.01	0.15	0.01	0.12	0.01	0.20	0.04	0.13	0.01	0.17	0.02	0.17	0.01	0.36	0.03
1998	0.10	0.01	0.15	0.01	0.12	0.01	0.20	0.04	0.13	0.01	0.17	0.02	0.17	0.01	0.60	0.03
1999	0.24	0.01	0.34	0.02	0.12	0.01	0.20	0.04	0.13	0.01	0.17	0.02	0.49	0.02	0.60	0.03
2000	0.24	0.01	0.34	0.02	0.12	0.01	0.43	0.05	0.13	0.01	0.17	0.02	0.49	0.02	0.60	0.03
2001	0.24	0.01	0.34	0.02	0.12	0.01	0.43	0.05	0.13	0.01	0.17	0.02	0.49	0.02	0.60	0.03
2002	0.24	0.01	0.34	0.02	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2003	0.24	0.01	0.34	0.02	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2004	0.24	0.01	0.34	0.02	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2005	0.24	0.01	0.34	0.02	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2006	0.24	0.01	0.34	0.02	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2007	0.24	0.01	0.34	0.02	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2008	0.24	0.01	0.42	0.05	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2009	0.24	0.01	0.42	0.05	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2010	0.24	0.01	0.42	0.05	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2011	0.24	0.01	0.42	0.05	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2012	0.24	0.01	0.42	0.05	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2013	0.24	0.01	0.42	0.05	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2014	0.24	0.01	0.42	0.05	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2015	0.24	0.01	0.42	0.05	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2016	0.24	0.01	0.42	0.05	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03
2017	0.24	0.01	0.42	0.05	0.30	0.01	0.43	0.05	0.32	0.01	0.44	0.02	0.49	0.02	0.60	0.03

*NYOHS (1988–2007), NYTRL (2008–2012)

Table B8.21. Tag-based estimates of instantaneous natural mortality (from IRCR analyses) for ≥ 18-inch (457 mm) striped bass, including an unweighted average for coastal programs, a weighted average for producer area programs, and 95% confidence intervals.

	Coastal programs							Producer area programs						
Year	MADMF	NYOHS/ NYTRL*	NJDB	NCCOOP	Unweighted average**	95% LCI	95% UCI	HUDSON	DE/PA	MDCB	VARAP	Weighted average***	95% LCI	95% UCI
1987										0.17		0.17	0.16	0.18
1988		0.15		0.20	0.15	0.13	0.16	0.13		0.17		0.17	0.16	0.18
1989		0.15	0.12	0.20	0.14	0.11	0.16	0.13		0.17		0.17	0.16	0.18
1990		0.15	0.12	0.20	0.14	0.11	0.16	0.13		0.17	0.36	0.22	0.20	0.24
1991		0.15	0.12	0.20	0.14	0.11	0.16	0.13		0.17	0.36	0.22	0.20	0.24
1992	0.10	0.15	0.12	0.20	0.12	0.09	0.16	0.13		0.17	0.36	0.22	0.20	0.24
1993	0.10	0.15	0.12	0.20	0.12	0.09	0.16	0.13	0.17	0.17	0.36	0.22	0.20	0.23
1994	0.10	0.15	0.12	0.20	0.12	0.09	0.16	0.13	0.17	0.17	0.36	0.22	0.20	0.23
1995	0.10	0.15	0.12	0.20	0.12	0.09	0.16	0.13	0.17	0.17	0.36	0.22	0.20	0.23
1996	0.10	0.15	0.12	0.20	0.12	0.09	0.16	0.13	0.17	0.17	0.36	0.22	0.20	0.23
1997	0.10	0.15	0.12	0.20	0.12	0.09	0.16	0.13	0.17	0.17	0.36	0.22	0.20	0.23
1998	0.10	0.15	0.12	0.20	0.12	0.09	0.16	0.13	0.17	0.17	0.60	0.28	0.26	0.29
1999	0.24	0.34	0.12	0.20	0.24	0.19	0.28	0.13	0.17	0.49	0.60	0.44	0.42	0.47
2000	0.24	0.34	0.12	0.43	0.24	0.19	0.28	0.13	0.17	0.49	0.60	0.44	0.42	0.47
2001	0.24	0.34	0.12	0.43	0.24	0.19	0.28	0.13	0.17	0.49	0.60	0.44	0.42	0.47
2002	0.24	0.34	0.30	0.43	0.30	0.25	0.34	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2003	0.24	0.34	0.30	0.43	0.30	0.25	0.34	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2004	0.24	0.34	0.30	0.43	0.30	0.25	0.34	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2005	0.24	0.34	0.30	0.43	0.30	0.25	0.34	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2006	0.24	0.34	0.30	0.43	0.30	0.25	0.34	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2007	0.24	0.34	0.30	0.43	0.30	0.25	0.34	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2008	0.24	0.42	0.30	0.43	0.32	0.23	0.42	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2009	0.24	0.42	0.30	0.43	0.32	0.23	0.42	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2010	0.24	0.42	0.30	0.43	0.32	0.23	0.42	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2011	0.24	0.42	0.30	0.43	0.32	0.23	0.42	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2012	0.24	0.42	0.30	0.43	0.32	0.23	0.42	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2013	0.24	0.42	0.30	0.43	0.32	0.23	0.42	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2014	0.24	0.42	0.30	0.43	0.32	0.23	0.42	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2015	0.24	0.42	0.30	0.43	0.32	0.23	0.42	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2016	0.24	0.42	0.30	0.43	0.32	0.23	0.42	0.32	0.44	0.49	0.60	0.49	0.47	0.51
2017	0.24	0.42	0.30	0.43	0.32	0.23	0.42	0.32	0.44	0.49	0.60	0.49	0.47	0.51

*NYOHS 1988-2007, NYTRL 2008-2017

** Unweighted average of coastal programs excludes NCCOOP estimates owing to model diagnostic issue of a high c-hat estimate.

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

Table B8.22. Coastwide annual exploitation rates and stock size estimates for age-3+ and 7+ from the IRCR model. F is calculated as an unweighted average of producer and coastal programs' means.

	Age 3+			Age 7+		
Year	Exploitation	Kill (includes discards)	Total stock size (thousands)	Exploitation	Kill (includes discards)	Total stock size (thousands)
1988	0.03	374.1	11113	0.07	118.5	1724
1989	0.03	491.0	15453	0.04	221.0	4980
1990	0.06	1159.9	19051	0.08	386.1	4738
1991	0.07	1576.5	22805	0.13	651.8	5134
1992	0.09	2168.7	24226	0.10	903.8	9127
1993	0.08	1940.3	25675	0.12	792.9	6691
1994	0.07	2816.8	38249	0.08	1137.3	13656
1995	0.10	4197.4	41479	0.15	1785.5	11819
1996	0.10	6162.5	62432	0.15	2473.5	16005
1997	0.13	6590.0	50659	0.24	2382.1	10087
1998	0.12	7405.6	59552	0.22	2286.9	10316
1999	0.11	7899.8	71582	0.19	2306.8	12234
2000	0.09	8017.8	92697	0.14	2965.8	21625
2001	0.09	7409.8	86408	0.12	2863.2	23219
2002	0.08	7516.3	94419	0.13	3544.5	27786
2003	0.08	8137.5	98940	0.11	4284.8	37491
2004	0.08	9084.7	108806	0.11	4137.9	36219
2005	0.06	7997.7	127677	0.11	3617.4	31684
2006	0.07	10484.7	142016	0.11	3713.6	32658
2007	0.07	7902.0	120989	0.09	3043.7	34948
2008	0.08	8010.9	105391	0.11	3983.9	37332
2009	0.08	7683.9	97855	0.10	3482.5	33734
2010	0.07	8269.2	124281	0.10	4725.6	48316
2011	0.09	7242.9	80550	0.10	4216.6	40588
2012	0.10	6357.9	60752	0.13	3627.1	28809
2013	0.10	8011.4	77880	0.13	4236.4	32652
2014	0.10	6985.4	73375	0.10	2640.3	27275
2015	0.05	5638.1	102649	0.05	2263.5	43625
2016	0.07	6183.2	85056	0.10	2023.8	20251
2017	0.07	6159.6	93107	0.08	1893.6	22435

Table B8.23. Annual exploitation rates (*u*) of 18–28 inch (457-711 mm) male striped bass from tagging programs of Chesapeake Bay (adjusted for a hooking mortality rate of 0.09 and a 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	0.06
2007	0.05
2008	0.05
2009	0.08
2010	0.04
2011	0.08
2012	0.06
2013	0.10
2014	0.11
2015	0.08
2016	0.04
2017	0.06

Table B8.24. Akaike weights used to derive model-averaged parameter estimates from IRCR analyses of male striped bass tagged at 18–28 inches (457-711 mm) in Chesapeake Bay (see Table B8.1 for model descriptions).

Model	QAICc Wgts
1	0.000
2	0.000
3	0.000
4	**0.737**
5	0.104
6	0.159

Table B8.25. Rate estimates of survival (S), instantaneous fishing mortality (F), and instantaneous natural mortality (M) of 18–28 inch (457-711 mm) male striped bass in Chesapeake Bay. The IRCR models were structured with two periods of M (1987–1996 and 1997–2017) and used a tag-reporting rate of 0.64.

Year	S	SE	F	SE	M	SE
1987	0.77	0.01	0.00	0.00	0.25	0.02
1988	0.77	0.01	0.00	0.00	0.25	0.02
1989	0.77	0.01	0.00	0.00	0.25	0.02
1990	0.71	0.02	0.09	0.01	0.25	0.02
1991	0.71	0.02	0.09	0.01	0.25	0.02
1992	0.71	0.02	0.09	0.01	0.25	0.02
1993	0.71	0.02	0.09	0.01	0.25	0.02
1994	0.71	0.02	0.09	0.01	0.25	0.02
1995	0.69	0.02	0.11	0.01	0.25	0.02
1996	0.69	0.02	0.11	0.01	0.25	0.02
1997	0.39	0.02	0.11	0.01	0.83	0.05
1998	0.39	0.02	0.11	0.01	0.83	0.05
1999	0.39	0.02	0.11	0.01	0.83	0.05
2000	0.39	0.02	0.10	0.02	0.83	0.05
2001	0.39	0.02	0.10	0.02	0.83	0.05
2002	0.39	0.02	0.10	0.02	0.83	0.05
2003	0.39	0.02	0.10	0.02	0.83	0.05
2004	0.39	0.02	0.10	0.02	0.83	0.05
2005	0.39	0.02	0.10	0.02	0.83	0.05
2006	0.39	0.02	0.10	0.02	0.83	0.05
2007	0.40	0.02	0.09	0.01	0.83	0.05
2008	0.40	0.02	0.09	0.01	0.83	0.05
2009	0.40	0.02	0.09	0.01	0.83	0.05
2010	0.40	0.02	0.09	0.01	0.83	0.05
2011	0.40	0.02	0.09	0.01	0.83	0.05
2012	0.40	0.02	0.09	0.01	0.83	0.05
2013	0.40	0.02	0.09	0.01	0.83	0.05
2014	0.40	0.02	0.09	0.01	0.83	0.05
2015	0.39	0.02	0.10	0.03	0.83	0.05
2016	0.39	0.02	0.09	0.02	0.83	0.05
2017	0.39	0.02	0.09	0.02	0.83	0.05

Table B9.1 Reference points derived from SPR analysis and selected annual SSB levels for Stock 1 (top) and Stock 2 (bottom). Numbers in parentheses represent standard error of the parameters.

	Stock 1 (Chesapeake Bay)					
	Model-Based BRPs					
	Bay F_{ref}	Ocean F_{ref}	2017 Bay F	2017 Ocean F	SSB_{ref} [95% CI]	2017 SSB
SPR20%	0.288	0.342	0.255 (0.041)	0.400 (0.042)	54,864 [42,310 - 73,611]	50,346 (6,394)
SPR30%	0.196	0.233	0.255 (0.041)	0.400 (0.042)	84,209 [65,741 - 109,333]	50,346 (6,394)
SPR40%	0.140	0.166	0.255 (0.041)	0.400 (0.042)	111,432 [88,305 - 144,914]	50,346 (6,394)
	Empirical BRPs					
	Bay F_{ref}	Ocean F_{ref}	2017 Bay F	2017 Ocean F	SSB_{ref} [95% CI]	2017 SSB
SSB1993	0.411	0.489	0.255 (0.041)	0.400 (0.042)	34,375 (2,747)	50,346 (6,394)
SSB1995	0.297	0.353	0.255 (0.041)	0.400 (0.042)	52,893 (3,856)	50,346 (6,394)

	Stock 2 (DE Bay/Hudson River)			
	Hockey-stick recruitment			
	Model-Based BRPs			
	Ocean F_{ref}	SSB_{ref} [95% CI]	2017 Ocean F	2017 SSB
SPR20%	0.251	38,493 [28,294 - 52,842]	0.400 (0.042)	21,347 (2,813)
SPR30%	0.168	57,791 [43,816 - 79,288]	0.400 (0.042)	21,347 (2,813)
SPR40%	0.118	77,153 [57,575 - 103,588]	0.400 (0.042)	21,347 (2,813)
	Empirical BRPs			
	Ocean F_{ref}	SSB_{ref}	2017 Ocean F	2017 SSB
SSB1993	0.362	19,638 (2086)	0.400 (0.042)	21,347 (2,813)
SSB1995	0.340	24,683 (2192)	0.400 (0.042)	21,347 (2,813)

Table B9.1 (continued).

	Stock 2 (DE Bay/Hudson River)			
	Empirical recruitment			
	Model-Based BRPs			
	Ocean F_{ref}	SSB_{ref} [95% CI]	2017 Ocean F	2017 SSB
SPR20%	0.251	41,955 [32,078 - 53,108]	0.400 (0.042)	21,347 (2,813)
SPR30%	0.168	62,587 [49,034 - 78,561]	0.400 (0.042)	21,347 (2,813)
SPR40%	0.118	83,905 [66,103 - 101,567]	0.400 (0.042)	21,347 (2,813)
	Empirical BRPs			
	Ocean F_{ref}	SSB_{ref}	2017 Ocean F	2017 SSB
SSB1993	0.460	19,638 (2086)	0.400 (0.042)	21,347 (2,813)
SSB1995	0.387	24,683 (2192)	0.400 (0.042)	21,347 (2,813)

Table B9.2. Probabilities of 2017 management values exceeding corresponding reference points for the Chesapeake Bay stock (top) and the DE Bay/Hudson River stock (bottom).

	Stock 1 (Chesapeake Bay)		
	Model-Based BRPs		
	P(Bay F_{2017}>F_{ref})	P(Ocean F_{2017}>F_{ref})	P(SSB_{2017}<SSB_{ref})
SPR20%	0.21	0.92	0.68
SPR30%	0.92	1.00	0.99
SPR40%	0.99	1.00	0.99
	Empirical BRPs		
	P(Bay F_{2017}>F_{ref})	P(Ocean F_{2017}>F_{ref})	P(SSB_{2017}<SSB_{ref})
SSB1993	0.00	0.01	0.01
SSB1995	0.15	0.87	0.63

	Stock 2 (Delaware Bay/Hudson River)			
	Model-Based BRPs			
	Hockey-Stick Approach		Empirical Approach	
	P(Ocean F_{2017}>F_{ref})	P(SSB_{2017}< SSB_{ref})	P(Ocean F_{2017}>F_{ref})	P(SSB_{2017}<SSB_{ref})
SPR20%	0.99	0.99	0.99	1.00
SPR30%	1.00	1.00	1.00	1.00
SPR40%	1.00	1.00	1.00	1.00
	Empirical BRPs			
	Hockey-Stick Approach		Empirical Approach	
	P(Ocean F_{2017}>F_{ref})	P(SSB_{2017}<SSB_{ref})	P(Ocean F_{2017}>F_{ref})	P(SSB_{2017}<SSB_{ref})
SSB1993	0.82	0.31	0.08	0.31
SSB1995	0.93	0.83	0.62	0.83

Table B9.3. Fleet reference point calculations for non-migration SCA model.

Year	Total F@A6	CB fleet F@A6	annual ratio	Ratio of means	Relative to 1995 SSB F target	Relative to 1995 SSB F threshold	2017 F
2013	0.248	0.079	0.318				
2014	0.209	0.089	0.427				
2015	0.178	0.075	0.419	0.393	0.056	0.068	0.068
2016	0.212	0.100	0.472				
2017	0.209	0.068	0.327				

Year	Total F@A14	Coast fleet F@A14	annual ratio	Ratio of means	F target	F threshold	
2013	0.368	0.314	0.854				
2014	0.282	0.221	0.785				
2015	0.242	0.192	0.790	0.806	0.159	0.194	0.262
2016	0.276	0.208	0.753				
2017	0.307	0.260	0.849				
Coast wide					0.197	0.240	

Table B9.4. Fleet and total F-at-age values (relative to female SSB_{1995}) when fishing at the target for the non-migration SCA model.

	Selectivity			F ref pt at age (Fleet F ref pt * Flt sel)		
Age	Composite	Coast fleet	CB fleet	Coast fleet	CB fleet	Total F
1	0.006	0.003	0.012	0.000	0.001	0.001
2	0.038	0.022	0.070	0.004	0.005	0.009
3	0.163	0.088	0.323	0.017	0.022	0.039
4	0.395	0.213	0.787	0.041	0.053	0.095
5	0.585	0.375	0.996	0.073	0.067	0.140
6	0.718	0.537	1.000	0.104	0.068	0.172
7	0.819	0.675	0.960	0.131	0.065	0.196
8	0.892	0.781	0.915	0.152	0.062	0.214
9	0.942	0.858	0.871	0.167	0.059	0.226
10	0.973	0.910	0.829	0.177	0.056	0.233
11	0.990	0.946	0.790	0.184	0.053	0.237
12	0.998	0.969	0.751	0.188	0.051	0.239
13	1.000	0.984	0.715	0.191	0.048	0.240
14	0.998	0.994	0.681	0.193	0.046	0.239
15	0.994	1.000	0.648	0.194	0.044	0.238
					Max F at age	**0.240**
	Fleet F Thresholds (relative to 1995 SSB)			0.194	0.068	
	Coastwide F threshold					0.240

Table B9.5. Reference points derived from the non-migration model for selected annual SSB levels for Atlantic striped bass under different assumptions about recruitment.

	Hockey-stick recruitment				
	F ref (CV)	SSB ref (SE)		2017 F (SE)	2017 SSB (SE)
SSB 1993	0.278 (0.077)	75,906 (5,025)		0.307 (0.034)	68,476 (7,630)
SSB 1995	0.240 (0.087)	91,436 (5,499)		0.307 (0.034)	68,476 (7,630)

	Empirical recruitment				
	F ref (CV)	SSB ref (SE)		2017 F (SE)	2017 SSB (SE)
SSB 1993	0.287 (0.094)	75,906 (5,025)		0.307 (0.034)	68,476 (7,630)
SSB 1995	0.248 (0.101)	91,436 (5,499)		0.307 (0.034)	68,476 (7,630)

Table B9.6. Probabilities of 2017 F and SSB estimates exceeding their respective reference points for Atlantic striped bass from the non-migration model under different assumptions about recruitment.

	Hockey-stick recruitment		Empirical recruitment	
	$p(F_{2017} > F_{ref})$	$p(SSB_{2017} < SSB_{ref})$	$p(F_{2017} > F_{ref})$	$p(SSB_{2017} < SSB_{ref})$
SSB 1995	0.759	0.839	0.678	0.839
SSB 1993	0.952	0.999	0.925	0.99

B7.0 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.

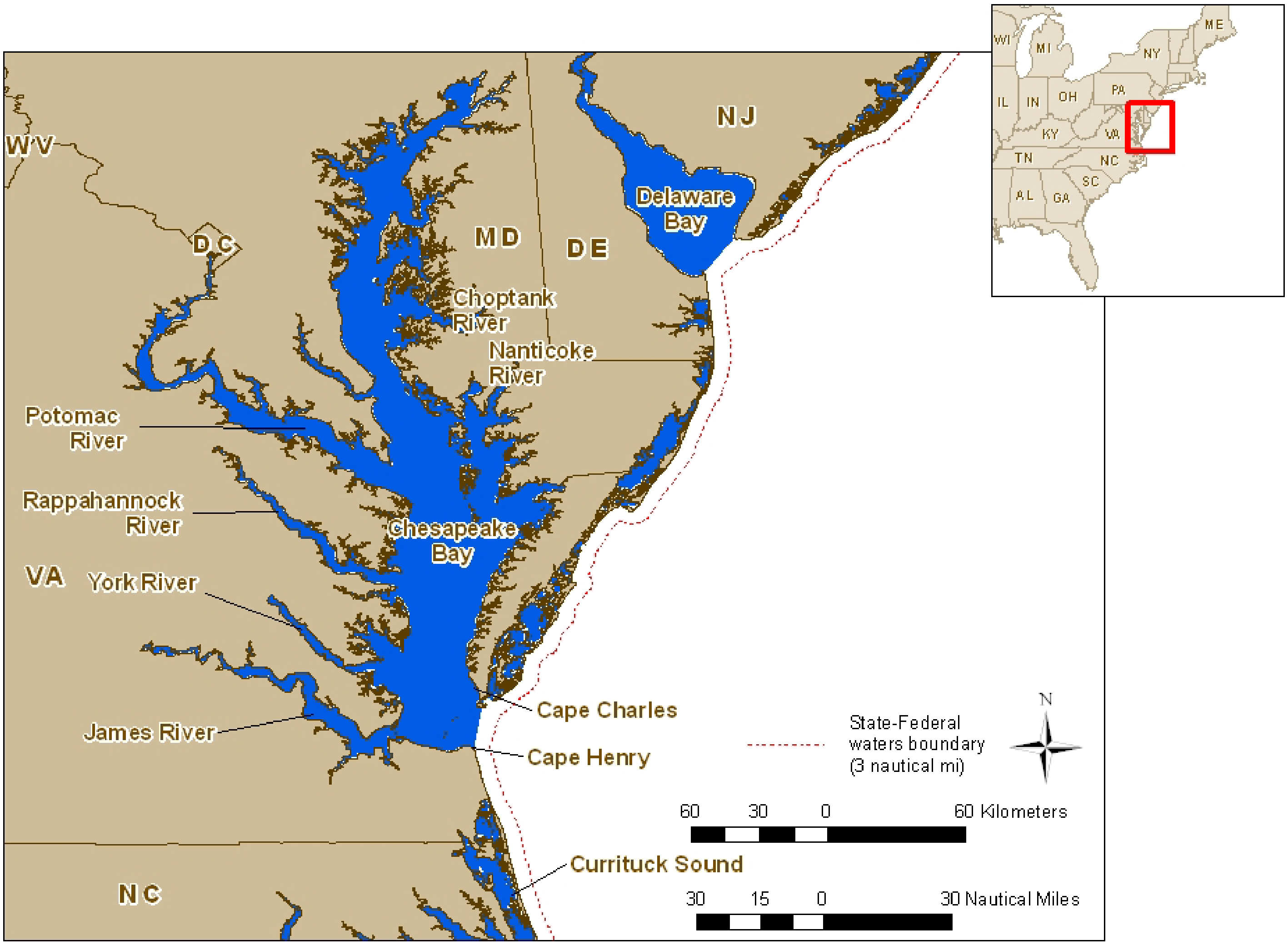


Figure B4.2. Geography of the Chesapeake Bay.

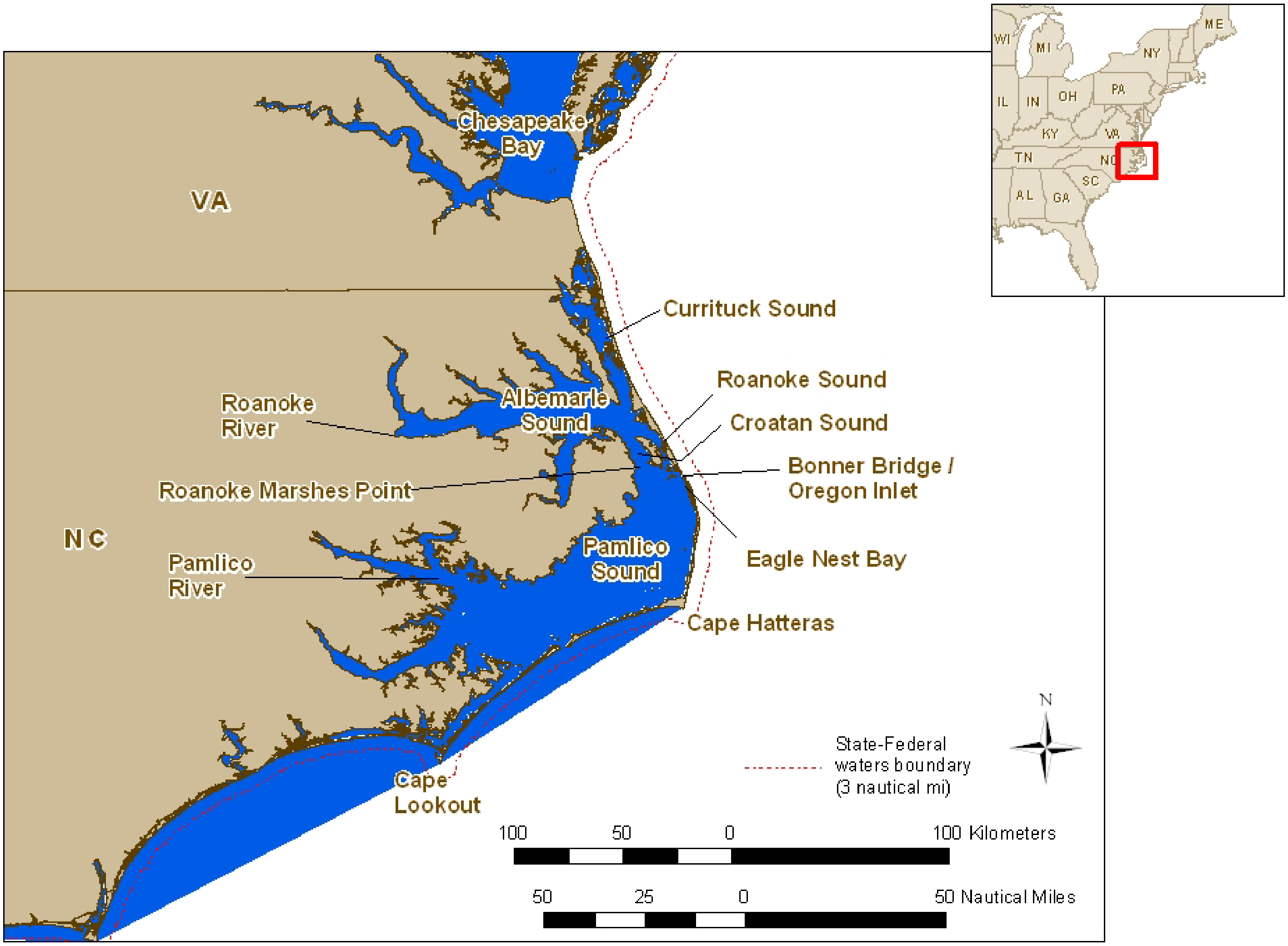


Figure B4.3 Geography of the Albemarle Sound-Roanoke River region.

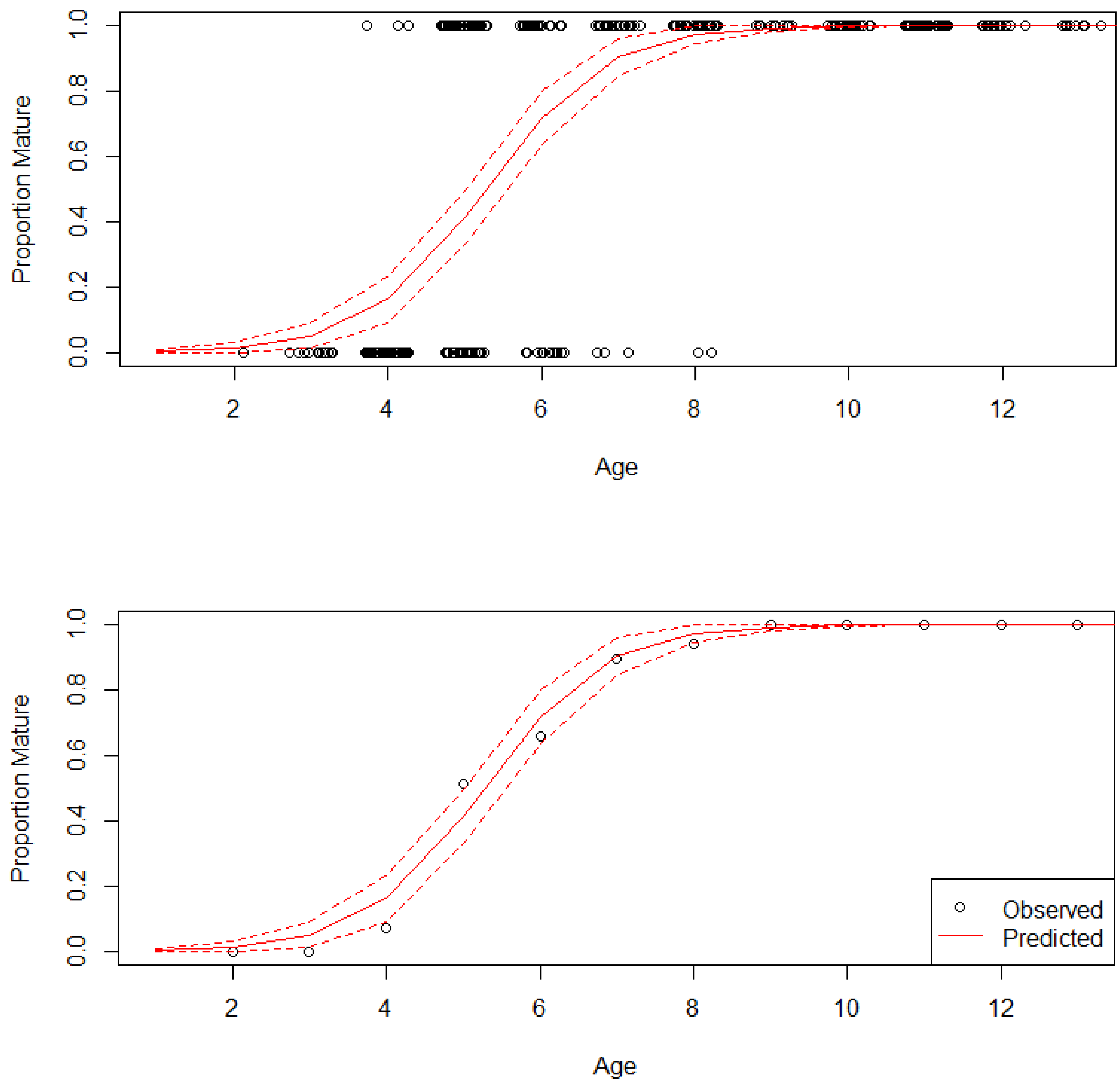


Figure B5.1. Estimated proportions mature, by age, for the March-July dataset. Developing fish are considered not imminently spawning. Top figure shows the sample size and maturity status for each fish sampled, by age, and bottom figure shows the overall observed proportion mature.

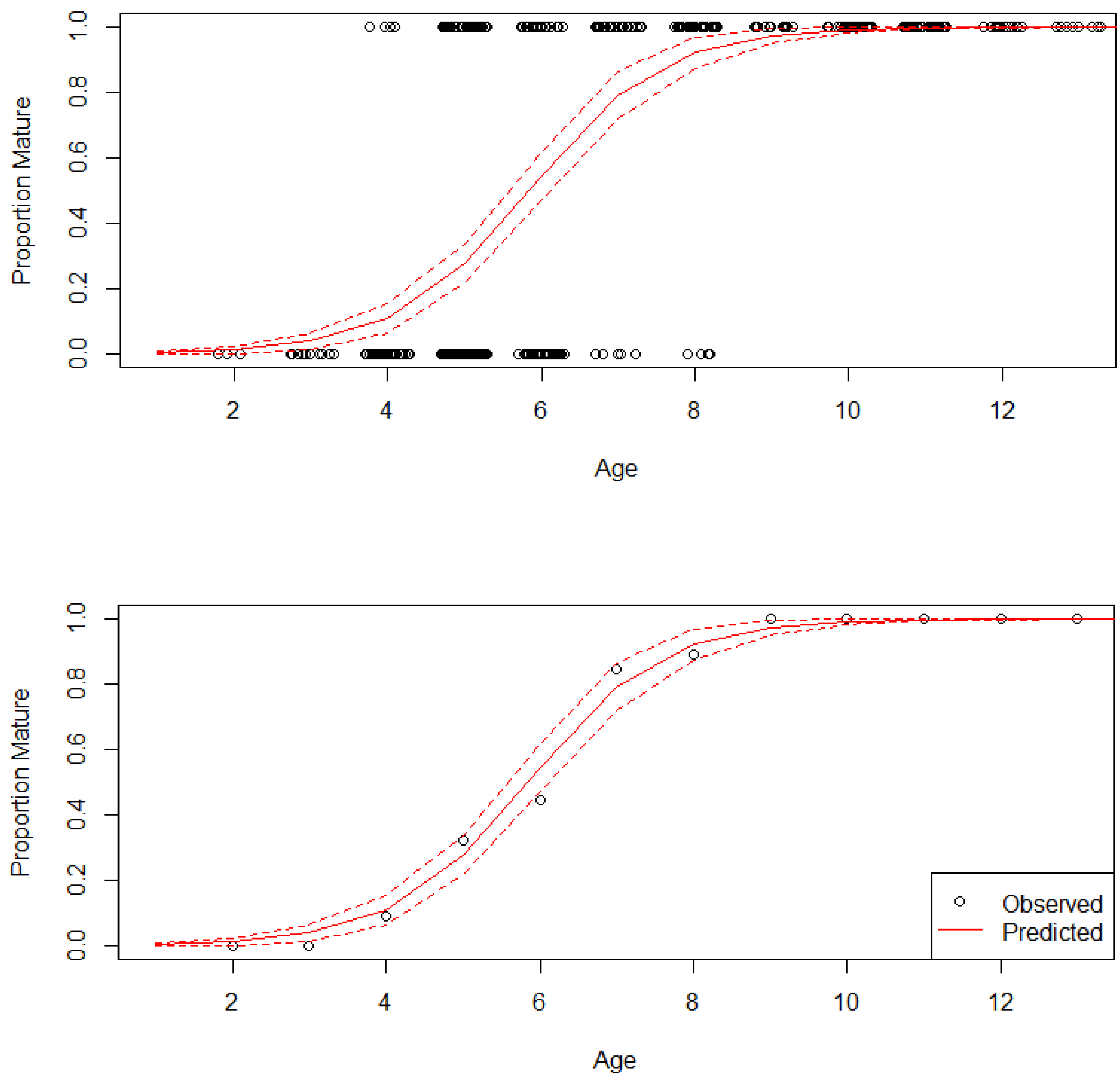


Figure B5.2. Estimated proportions mature, by age, for the full dataset. Developing fish are considered not imminently spawning. Top figure shows the sample size and maturity status for each fish sampled, by age, and bottom figure shows the overall observed proportion mature.

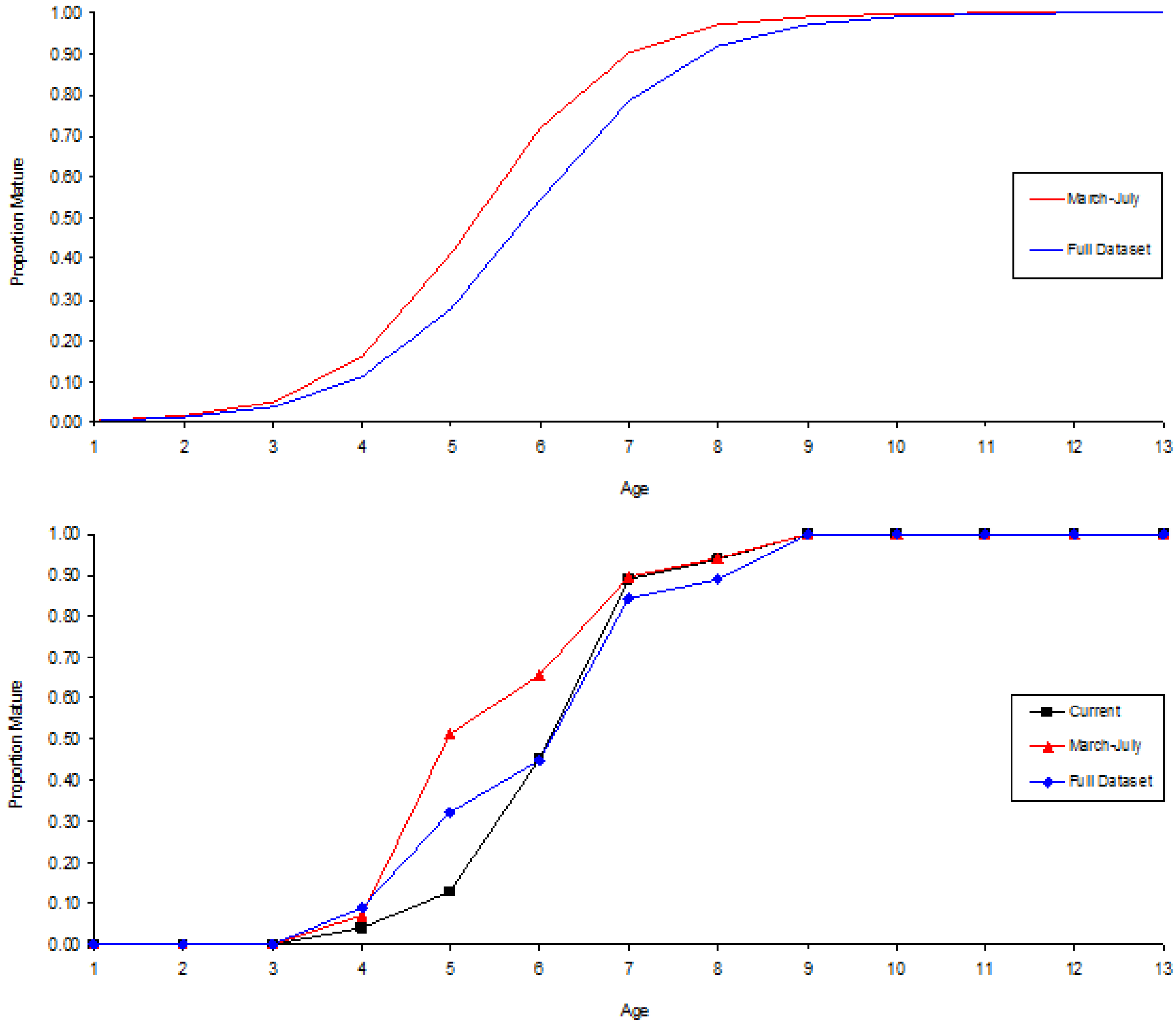


Figure B5.3. Comparison of the maturity-at-age estimates between the different data subsets. Developing fish are classified as not imminently spawning. Top panel compares the logistic regression estimates. Bottom panel shows the observed proportions with the estimates used in the 2013 benchmark assessment (NEFSC 2013).

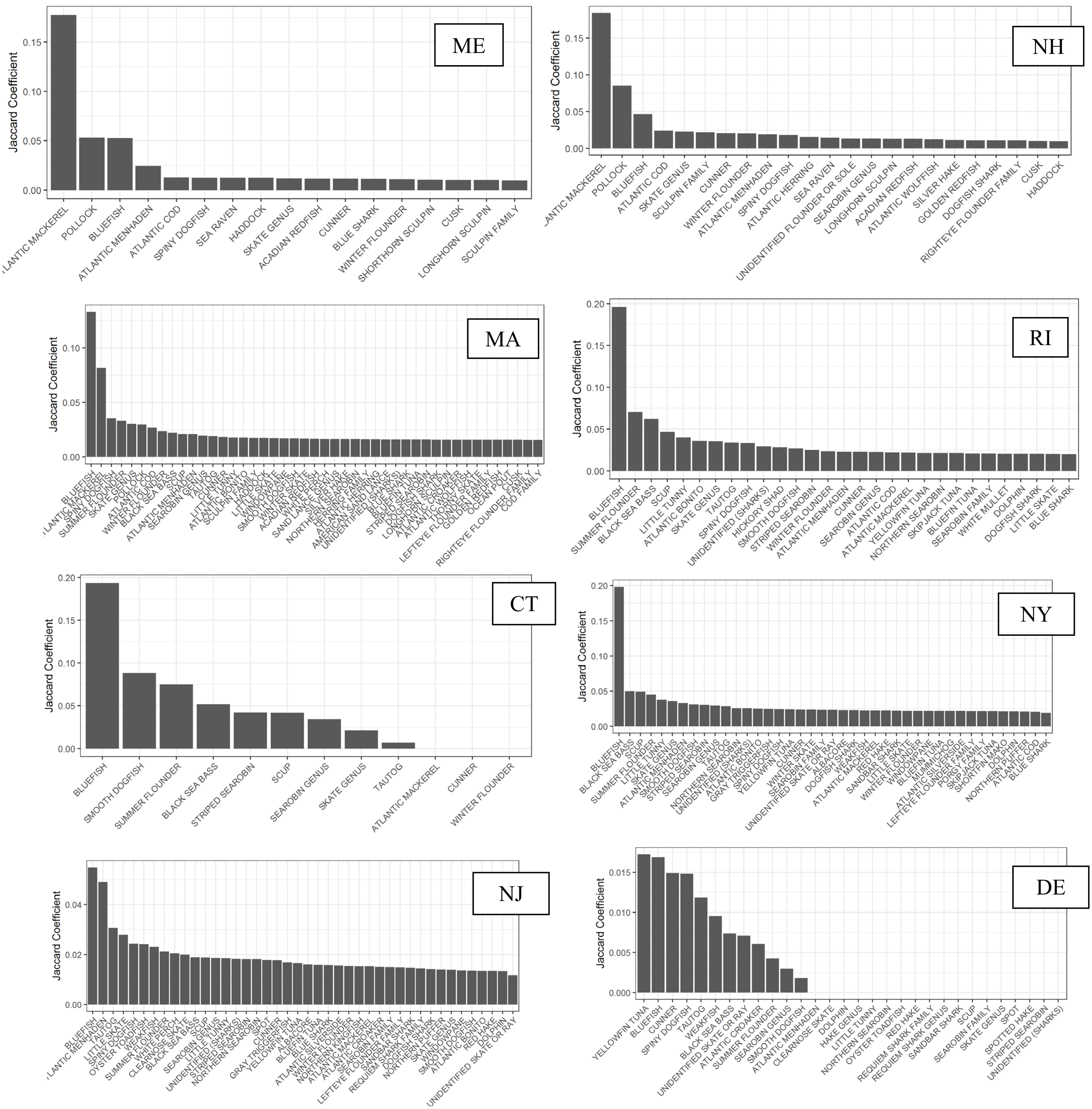


Figure B5.4. Jaccard coefficients for commonly caught recreational species by state. Higher coefficients indicate the species is caught more often with striped bass.

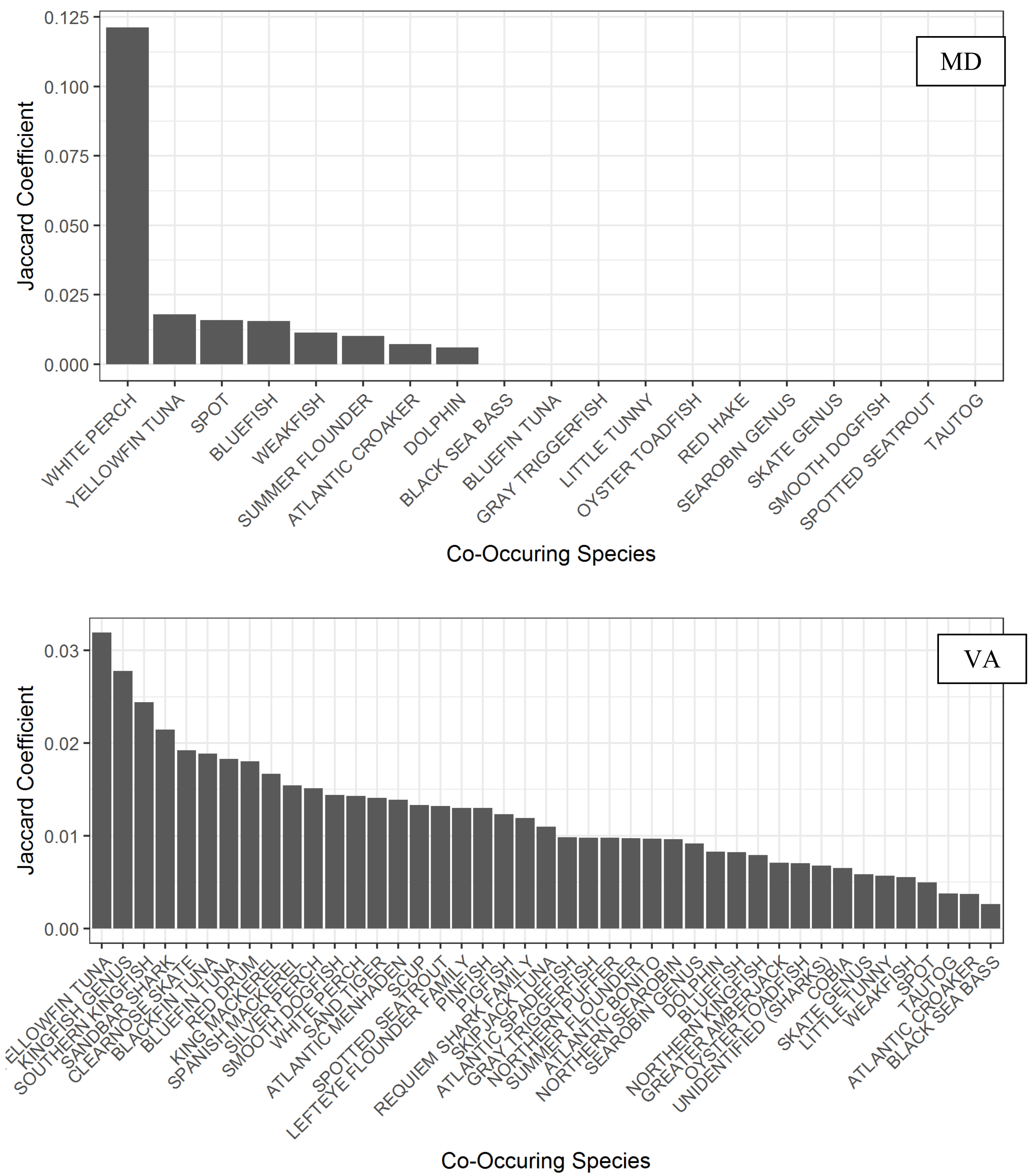


Figure B5.4. (cont.).

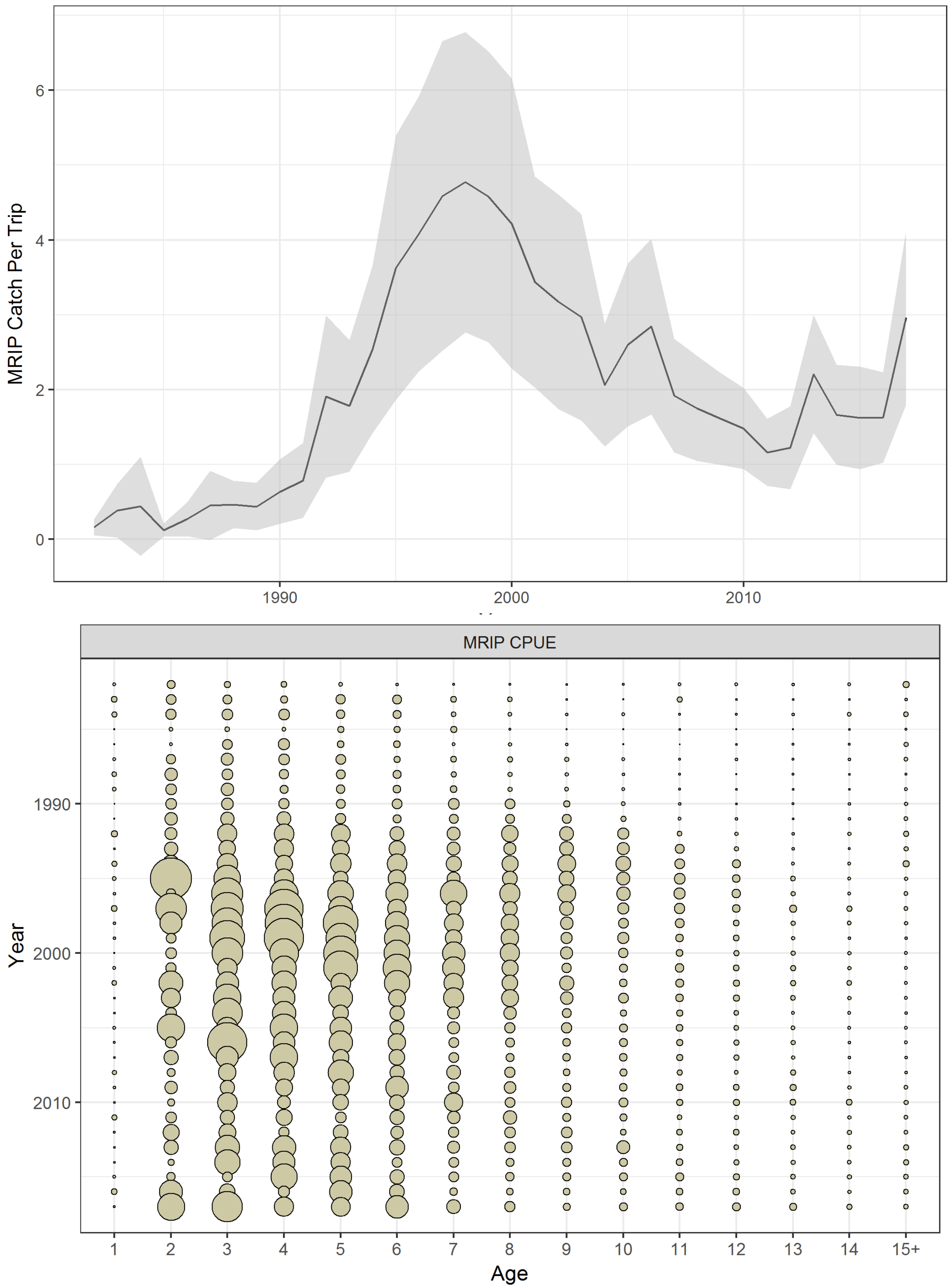


Figure B5.5. MRIP catch per trip (top) and age composition (bottom). Shaded area on top plot indicates 95% confidence intervals.

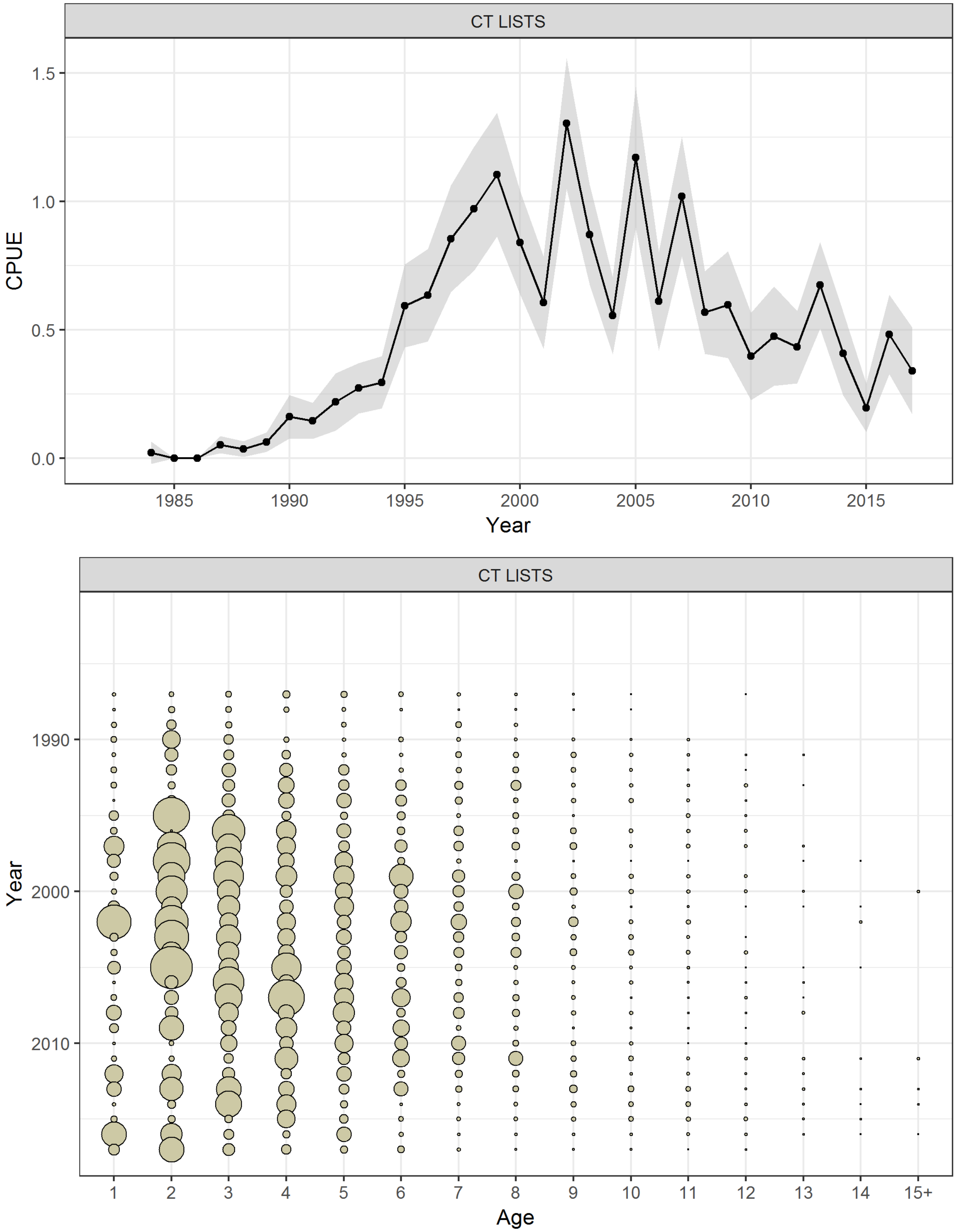


Figure B5.6. Connecticut Long Island Trawl Survey catch-per-tow (top) and age composition (bottom). Shaded area on top plot indicates 95% confidence intervals.

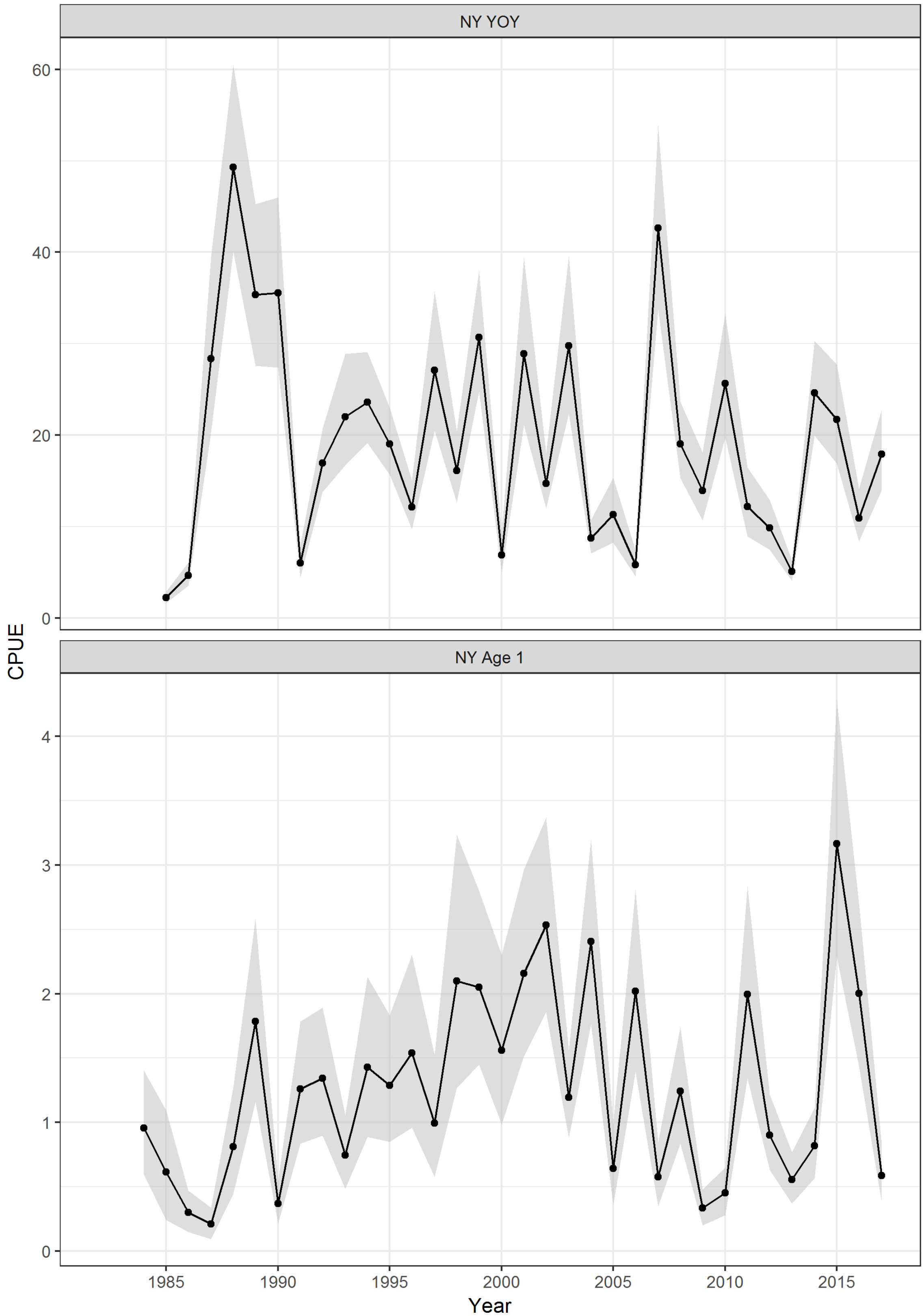


Figure B5.7. New York Hudson River young-of-year index (top) and Wester Long Island Age-1 index (bottom). Shaded area indicates 95% confidence intervals.

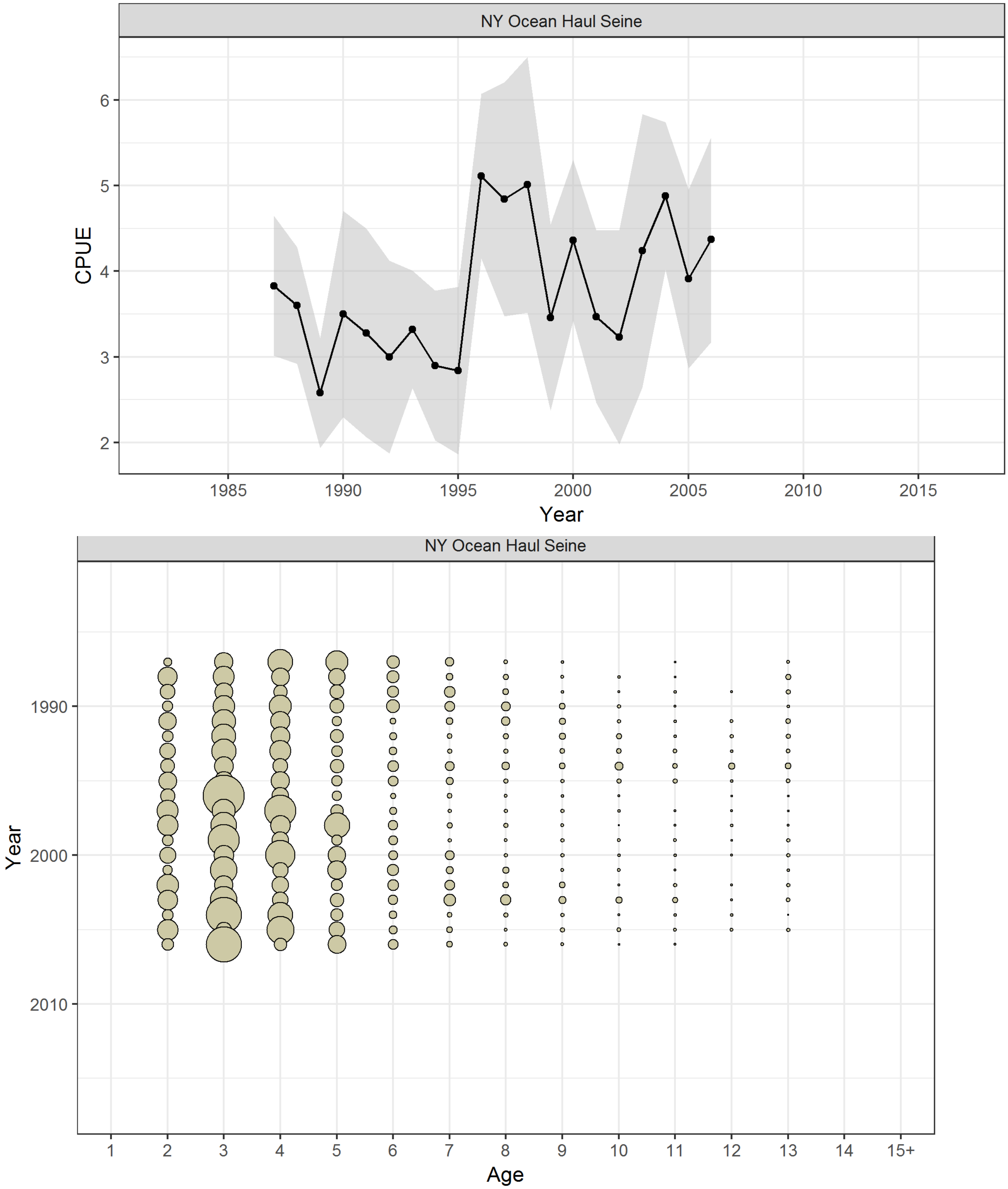


Figure B5.8. NY Ocean Haul Seine catch per haul (top) and age composition (bottom). Shaded area on top plot represents 95% confidence intervals.

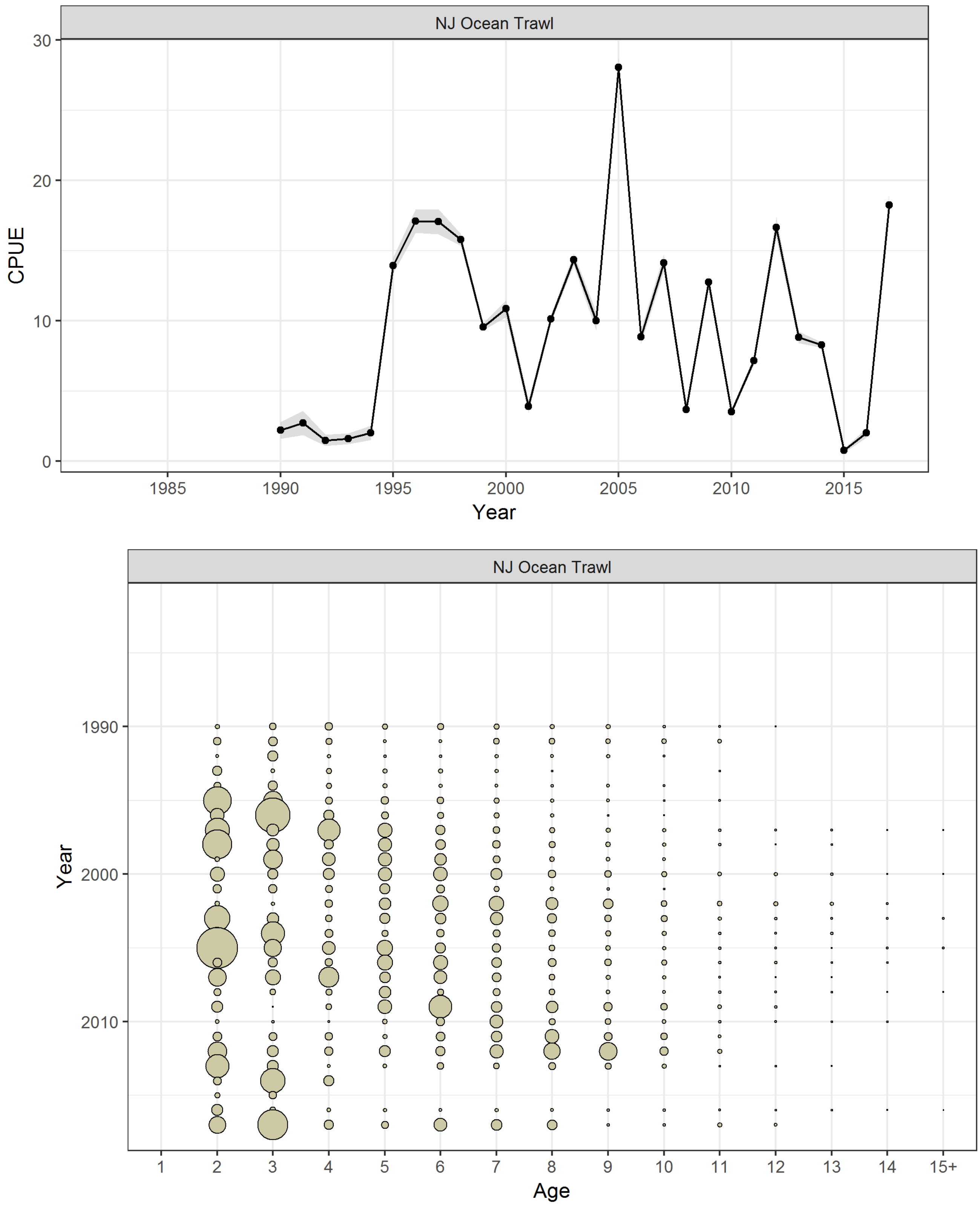


Figure B5.9. New Jersey Ocean Trawl catch per tow (top) and age composition (bottom). Shaded area on top plot indicates 95% confidence intervals.

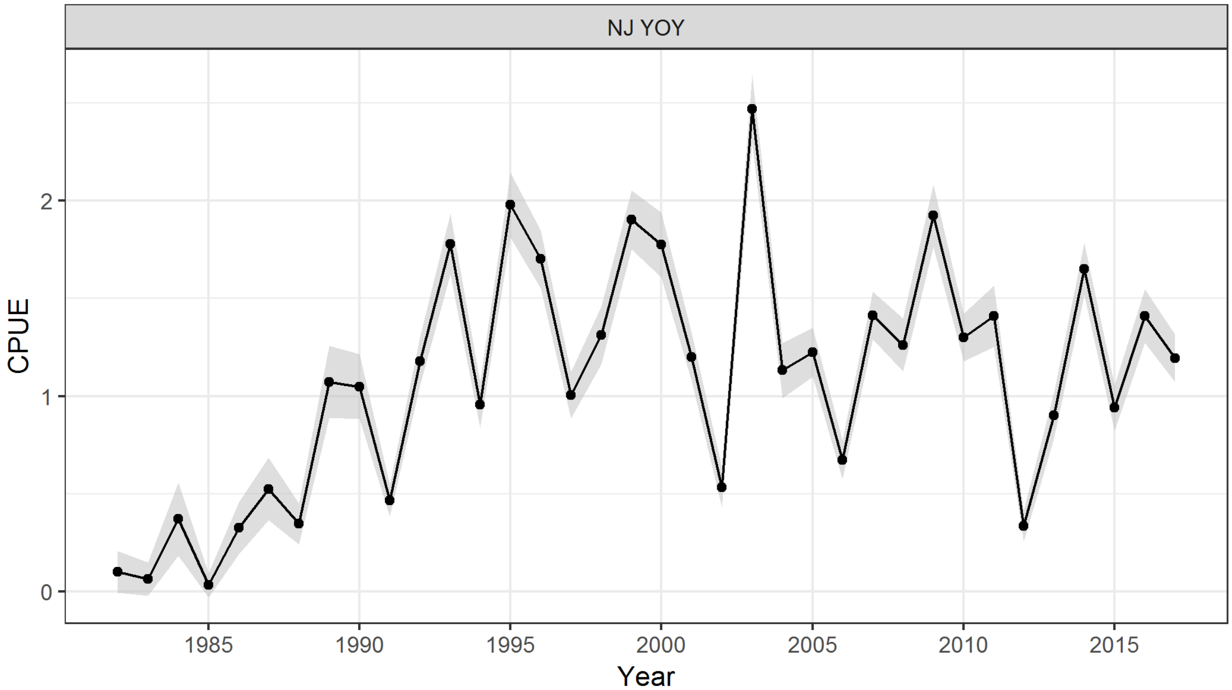


Figure B5.10. New Jersey young-of-year index with 95% confidence intervals.

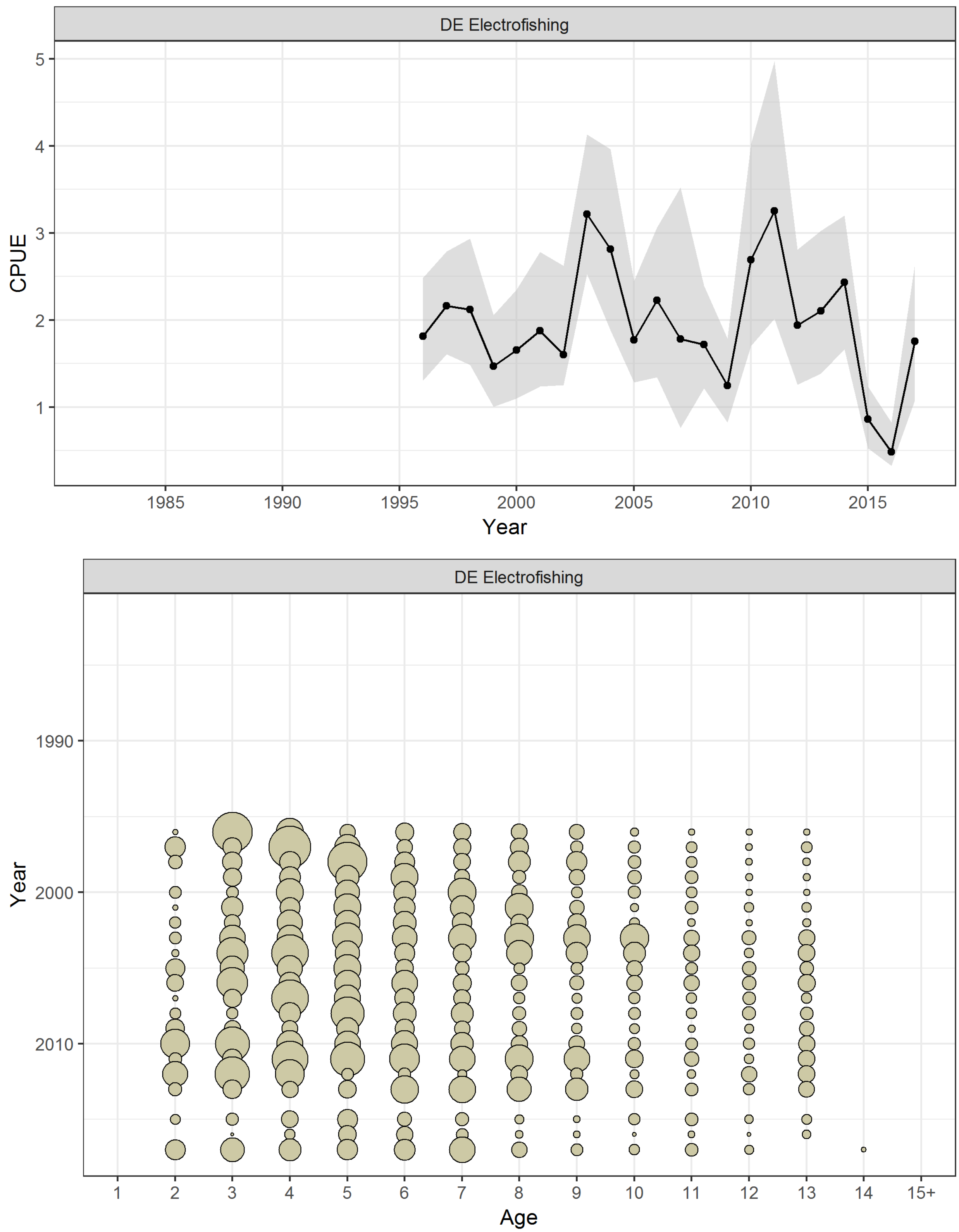


Figure B5.11. Delaware Bay Electrofishing index (top) and age composition (bottom). Shaded area on top plot indicates 95% confidence intervals.

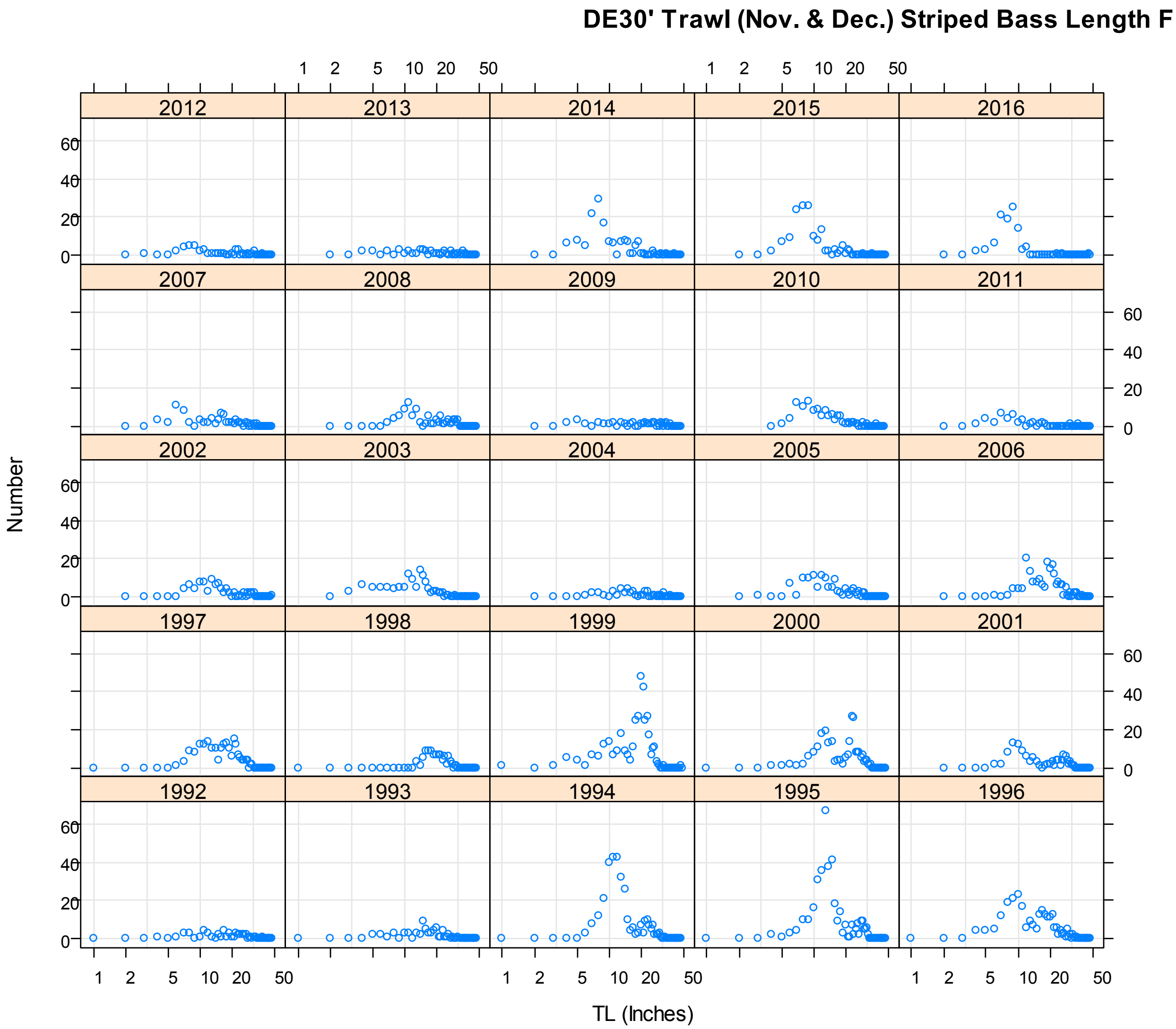


Figure B5.12. Length frequency of striped bass captured by the Delaware Bay 30' Trawl survey by year. (1-inch = 2.5 cm).

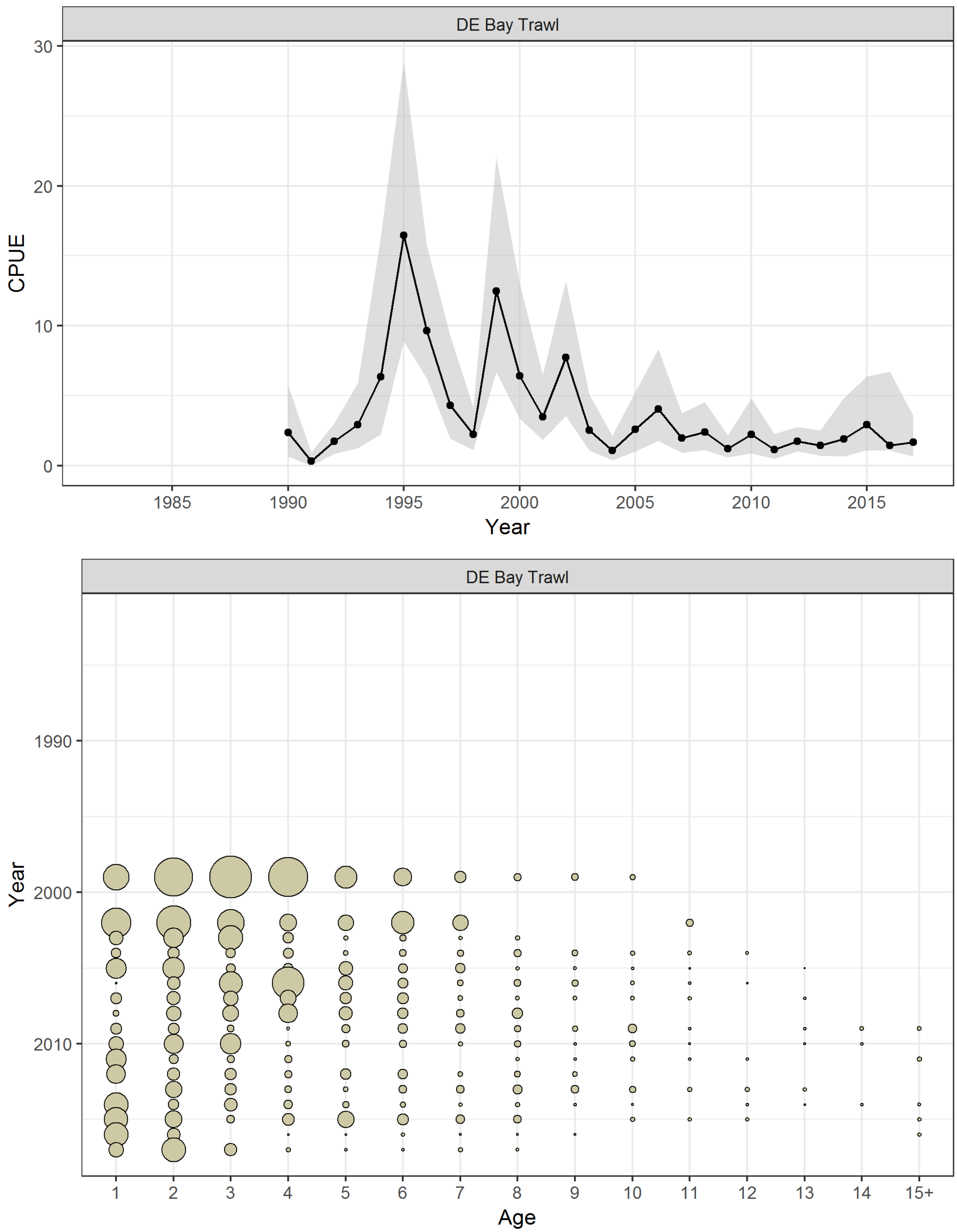


Figure B5.13. Delaware Bay 30’ Trawl index (top) and age composition (bottom). Shaded area on top plot indicates 95% confidence intervals.

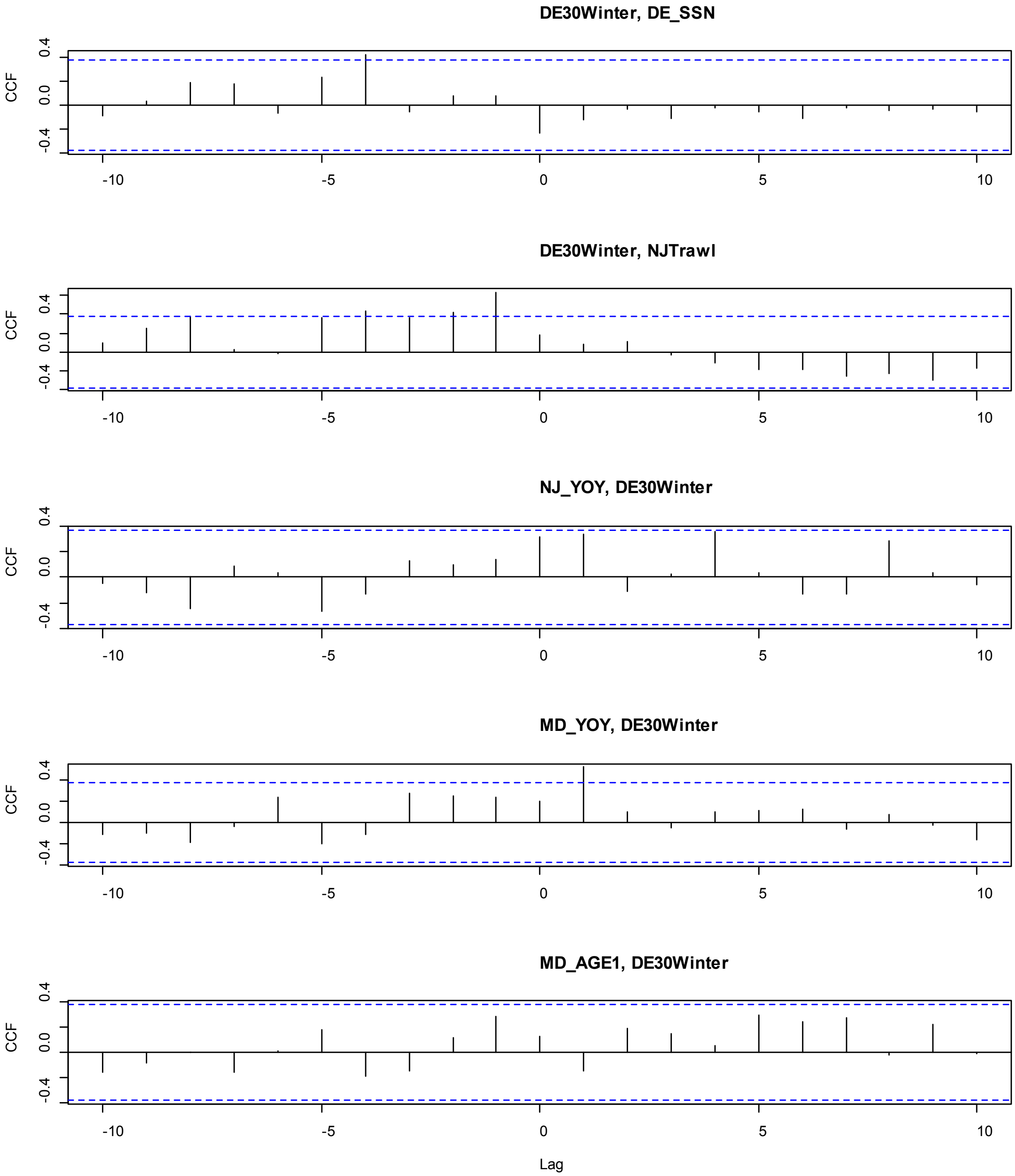


Figure B5.14. Cross-correlations of the Delaware Bay 30' Trawl winter survey and other mid-Atlantic surveys for striped bass (DESSN, NJ Trawl, NJYOY, MDYOY, and MD Age-1) through 2016. Significant correlations at any lag in time are above the blue 95 % significance line. Only negative lags in time are considered biologically relevant. The title denotes if the DE30' winter survey was used as the x or y variable (x, y).

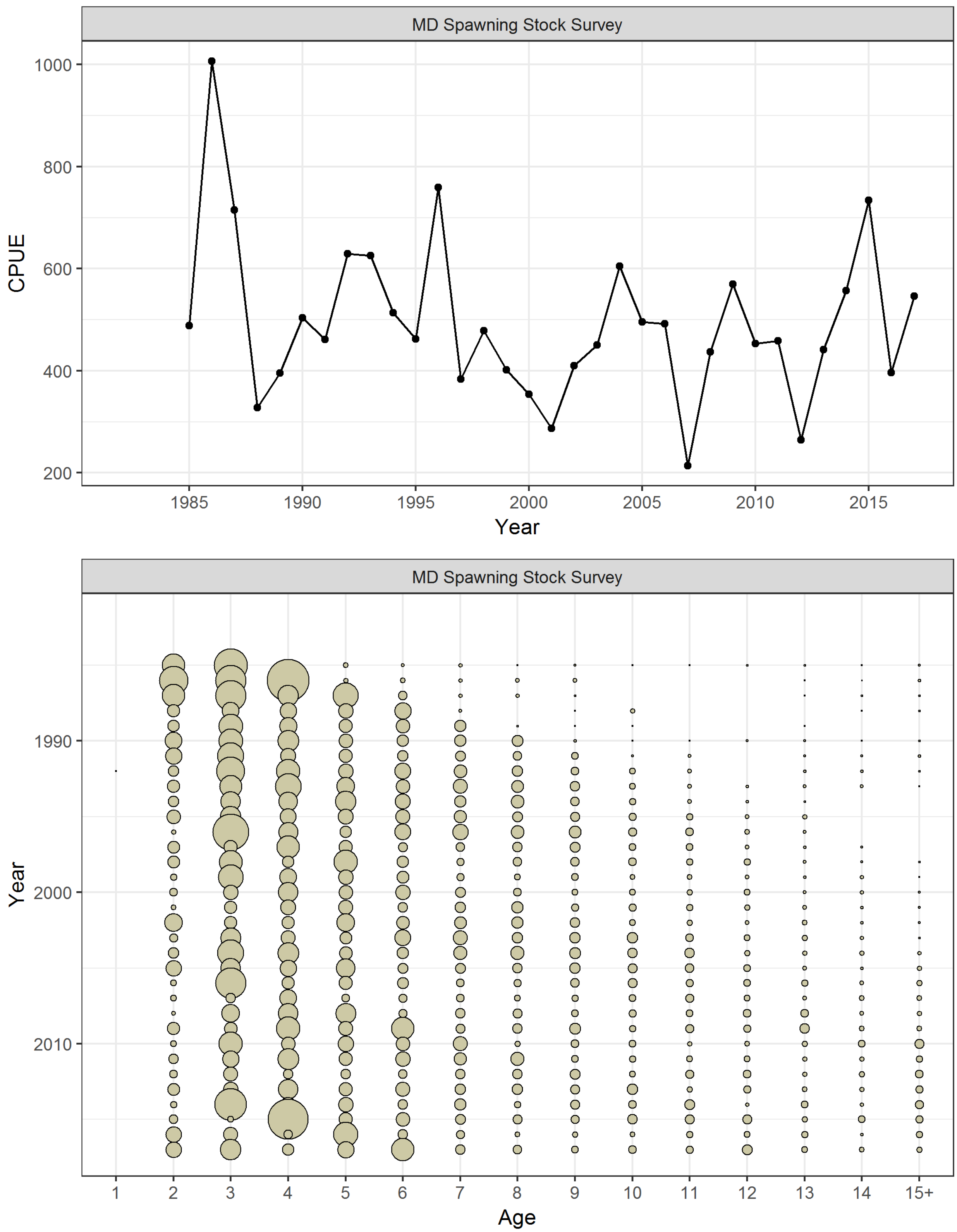


Figure B5.15. Maryland Spawning Stock index (top) and age composition (bottom).

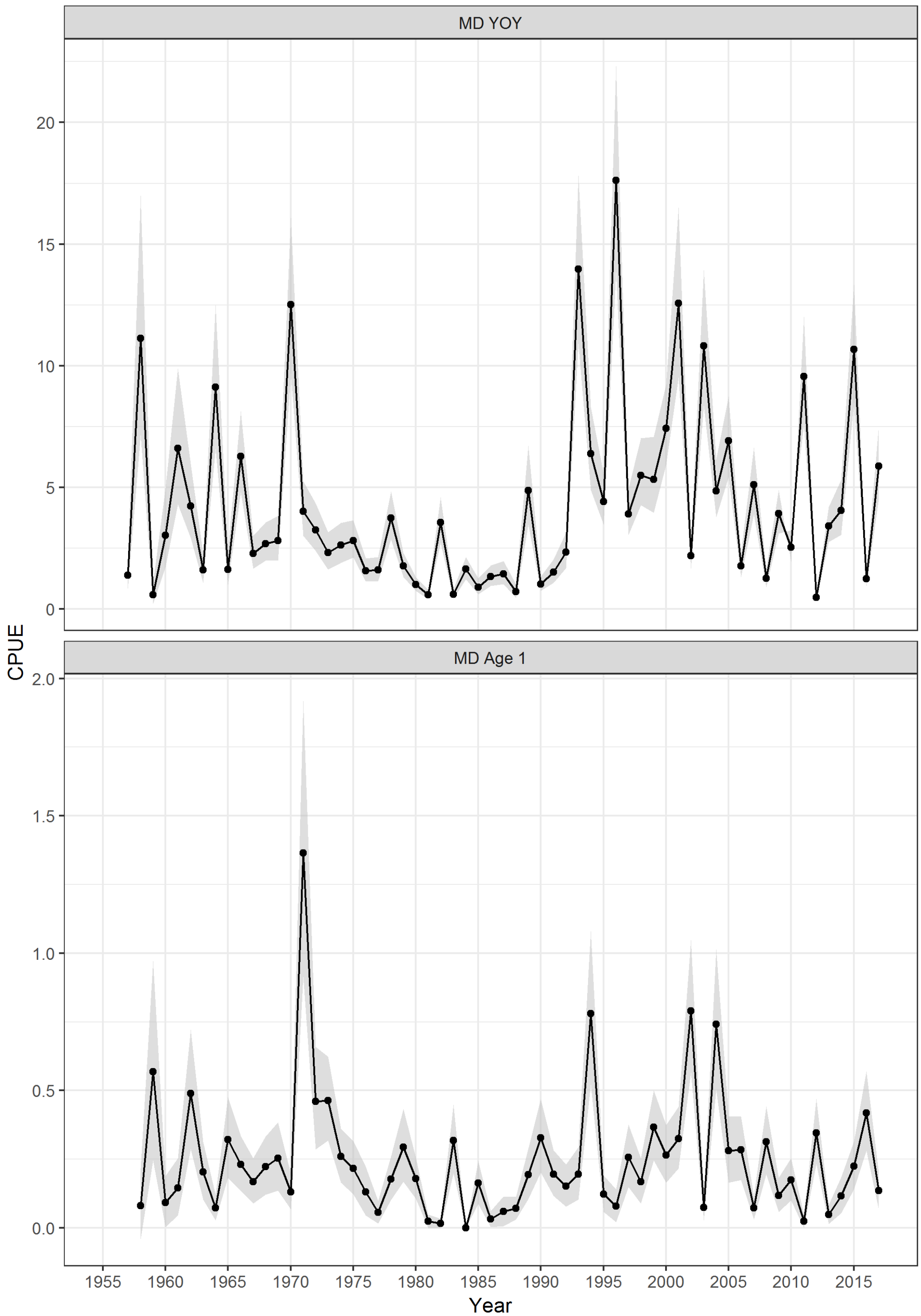


Figure B5.16. Maryland young-of-year (top) and age-1 (bottom) indices for striped bass. Shaded area on plot indicates 95% confidence intervals.

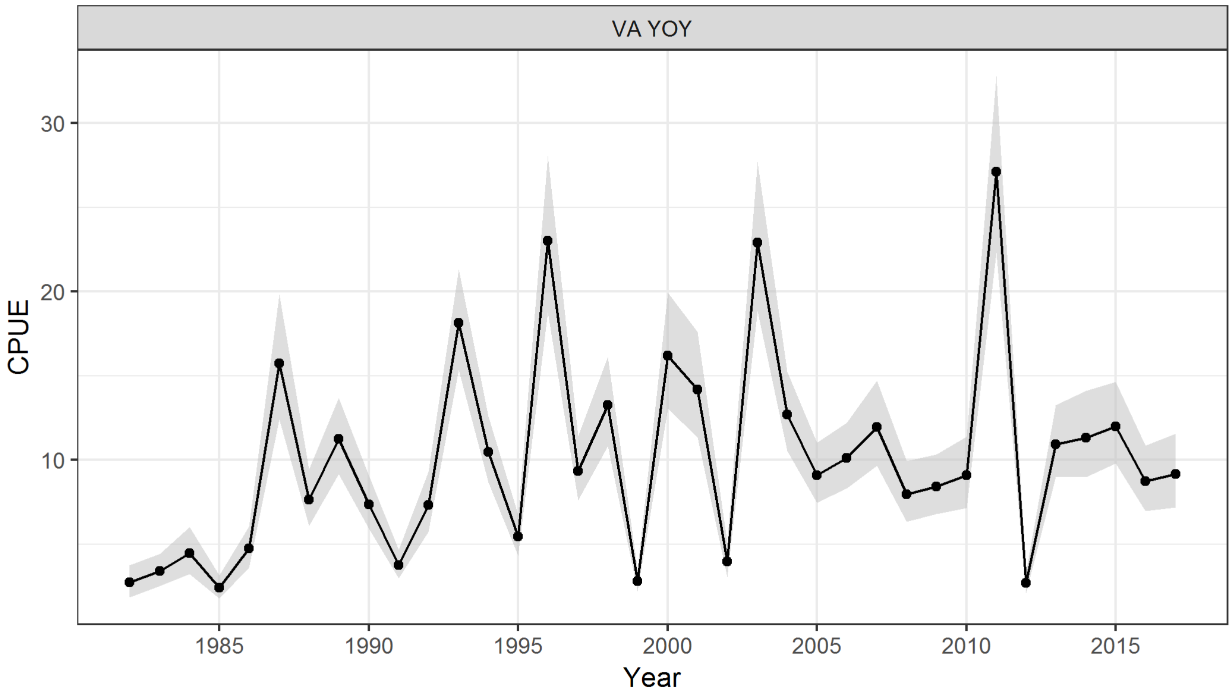


Figure B5.17. Virginia young-of-year index with 95% confidence intervals.

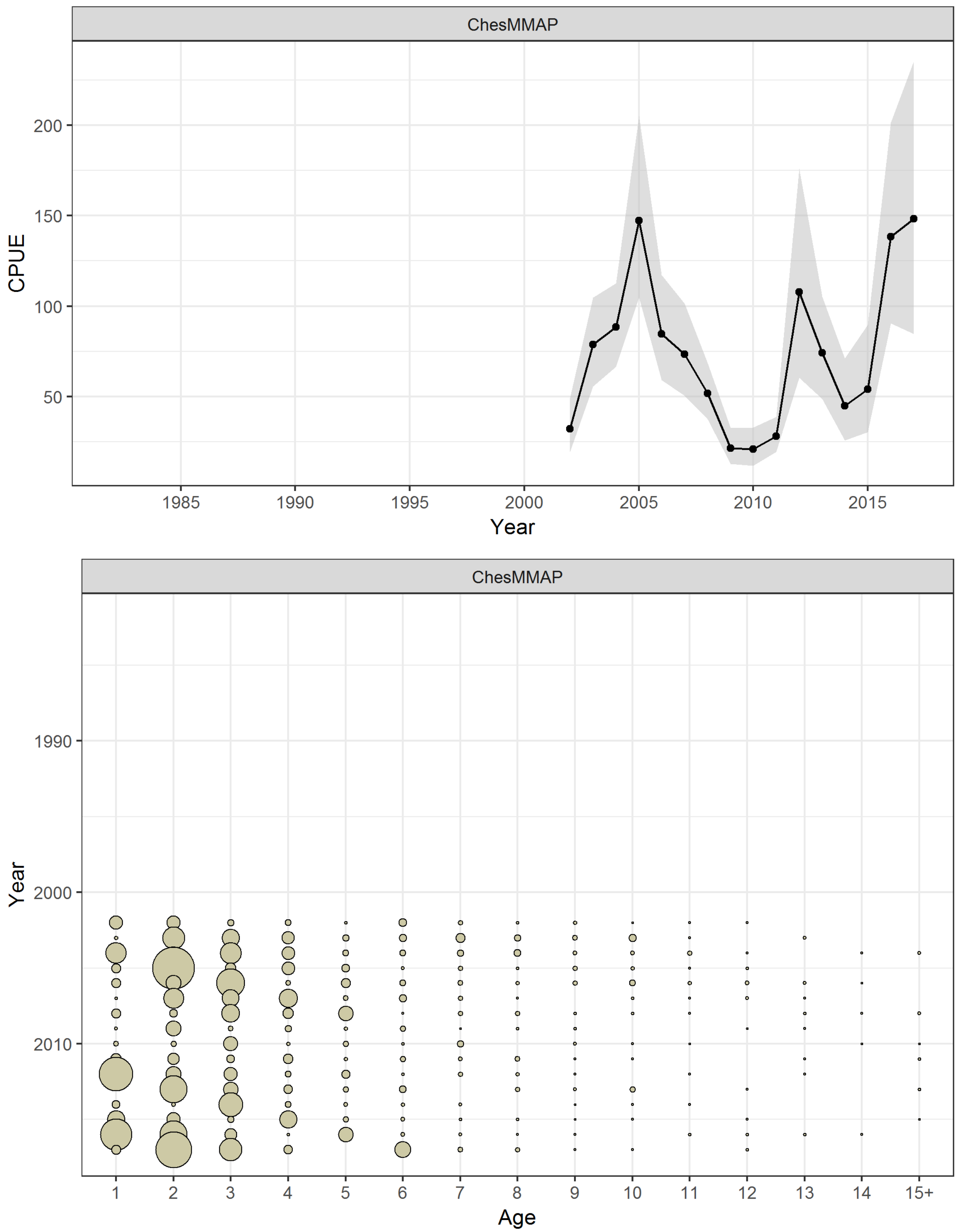
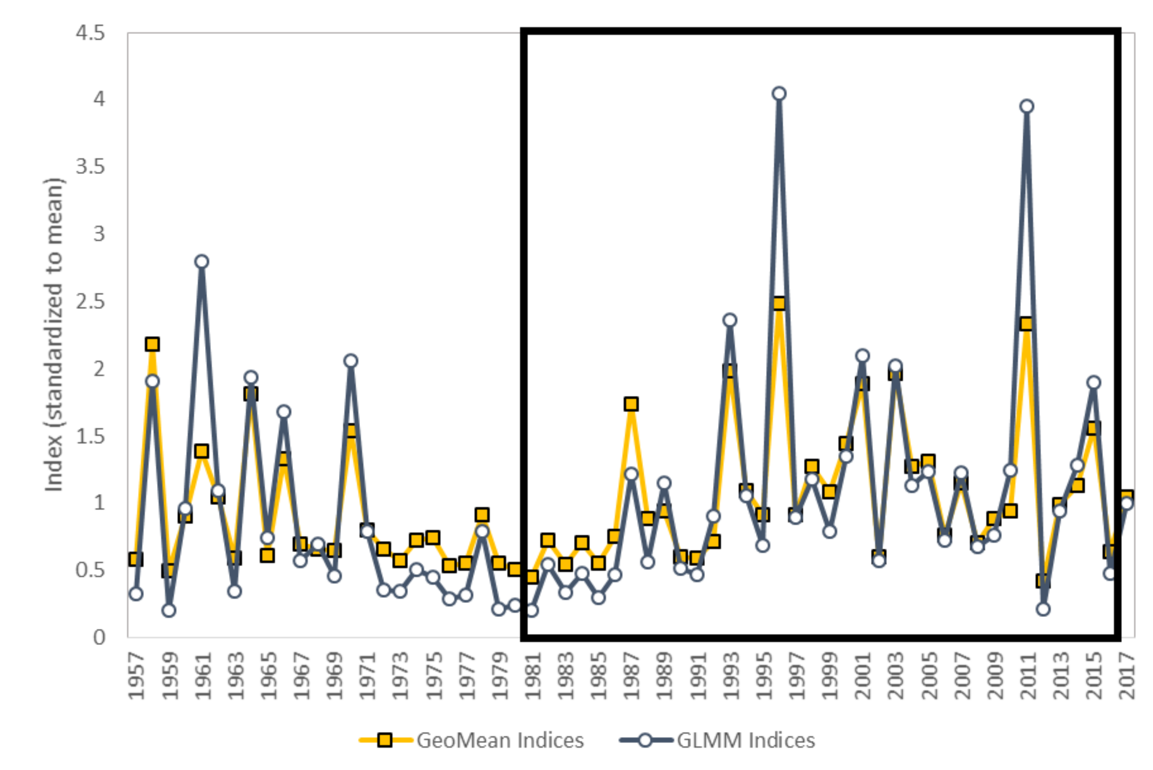


Figure B5.18. ChesMMAP index (top) and age composition (bottom). Shaded area on top plot indicates 95% confidence intervals.



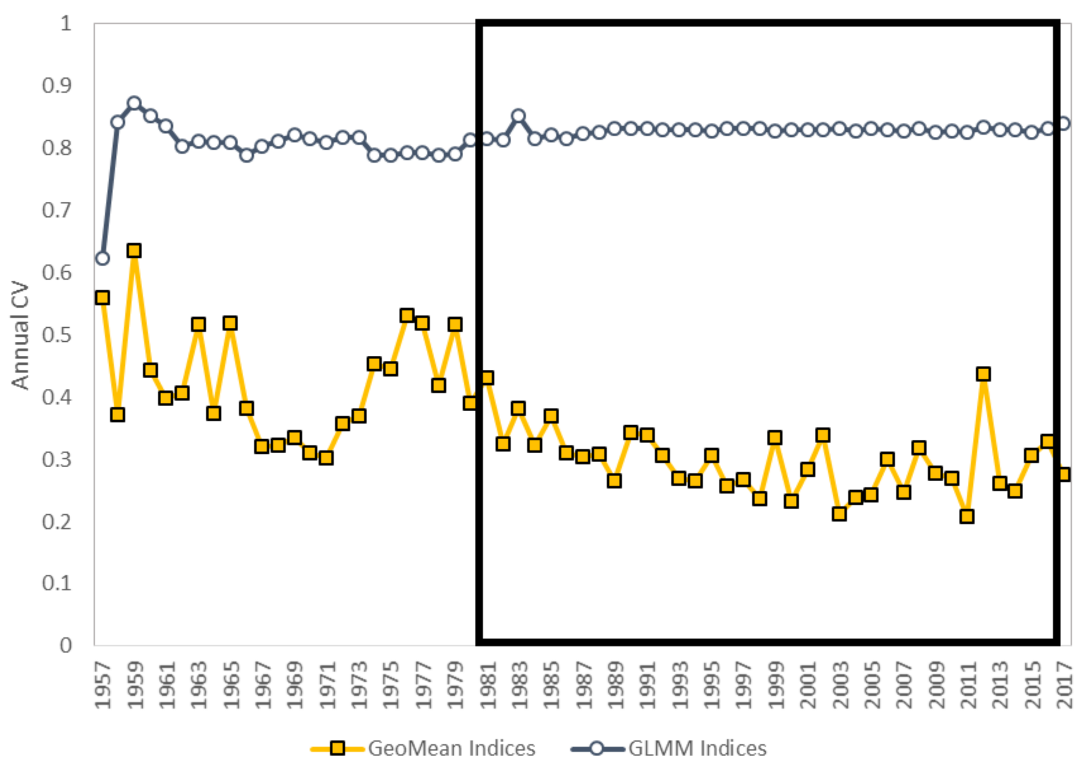


Figure B5.19. Comparison of composite young-of-year index trends (top) and CVs (bottom) for the Chesapeake Bay developed using two different methods to derive the input indices. The solid black box on each plot indicates the years included in the assessment models.

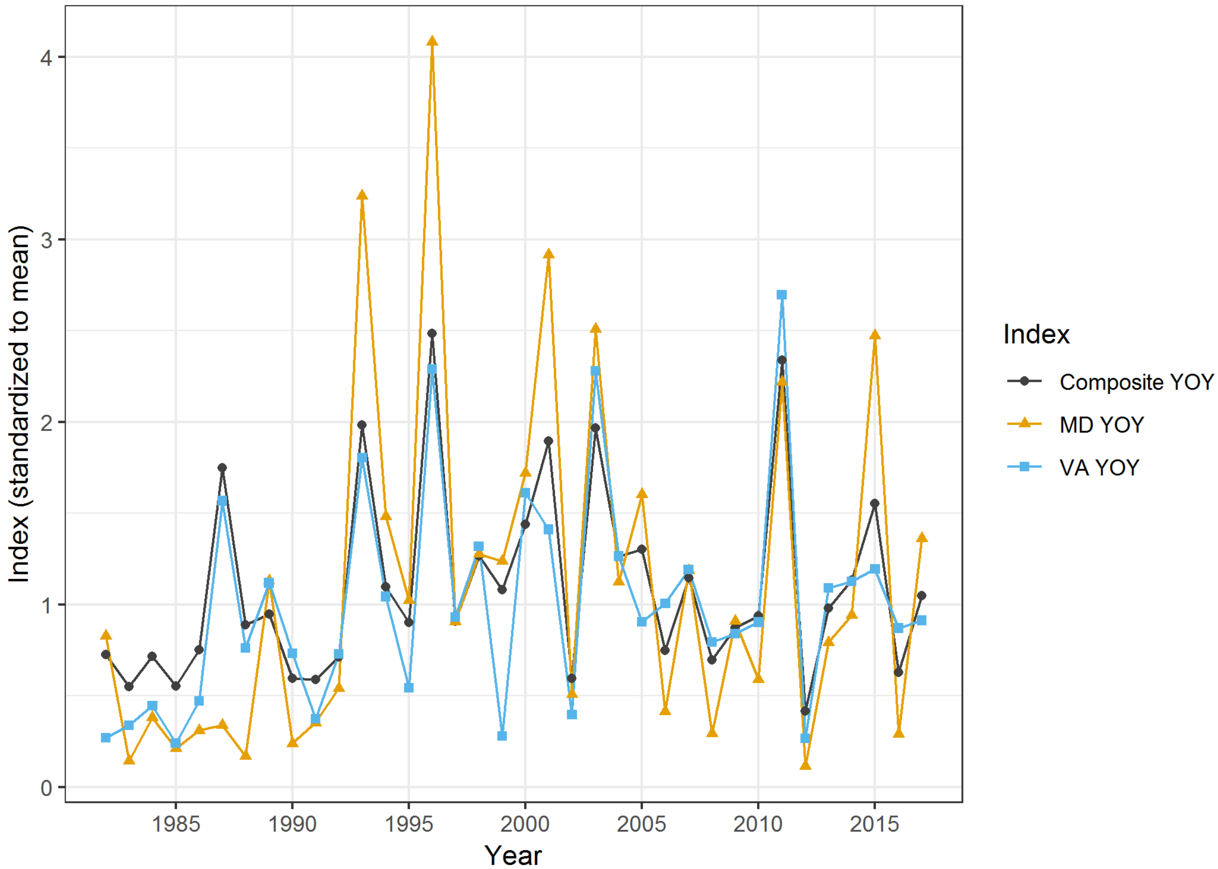


Figure B5.20. Composite Chesapeake Bay young-of-year index plotted with Maryland and Virginia young-of-year indices.

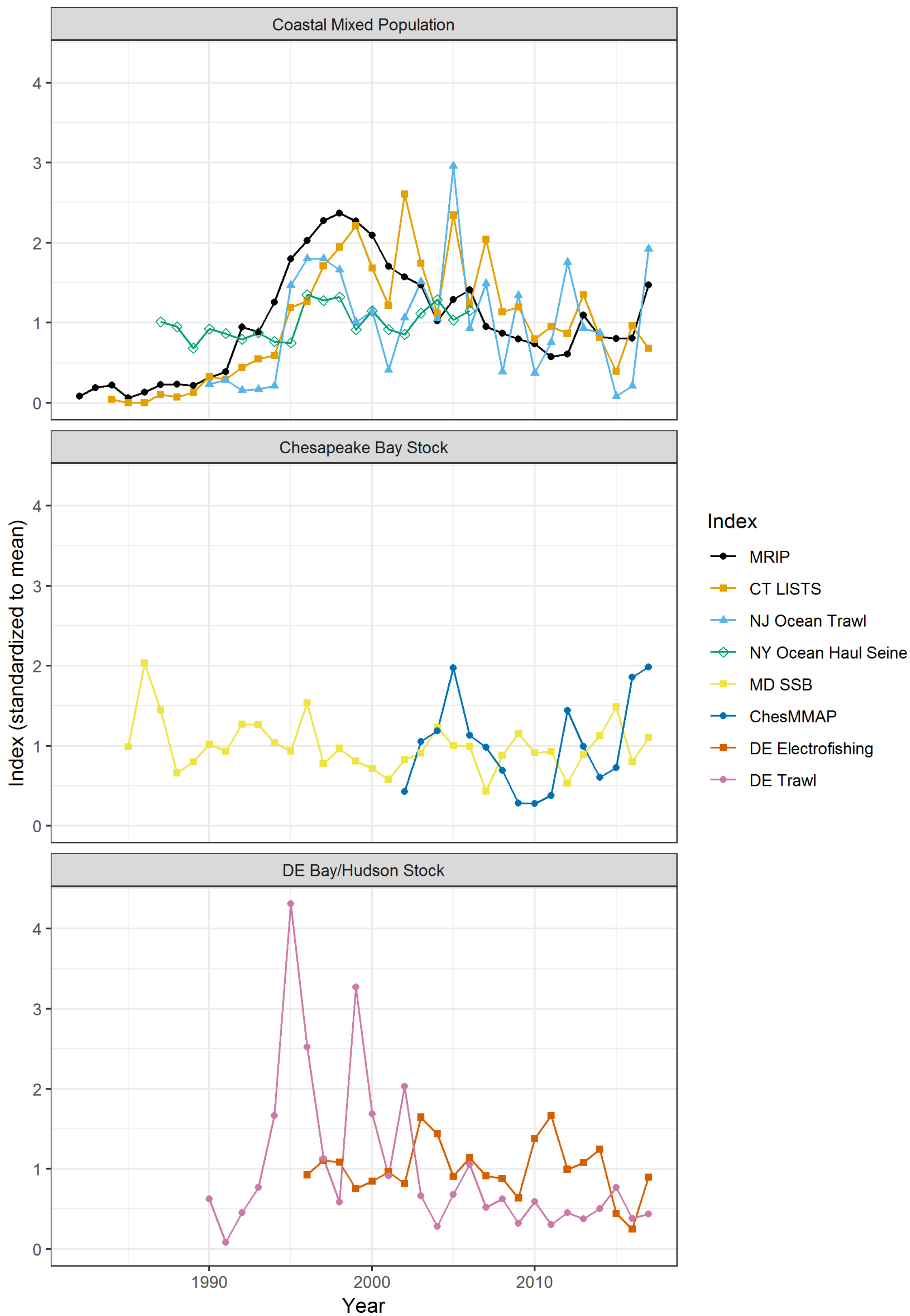


Figure B5.21. Comparison of indices of relative age-1+ abundance for striped bass by stock component.

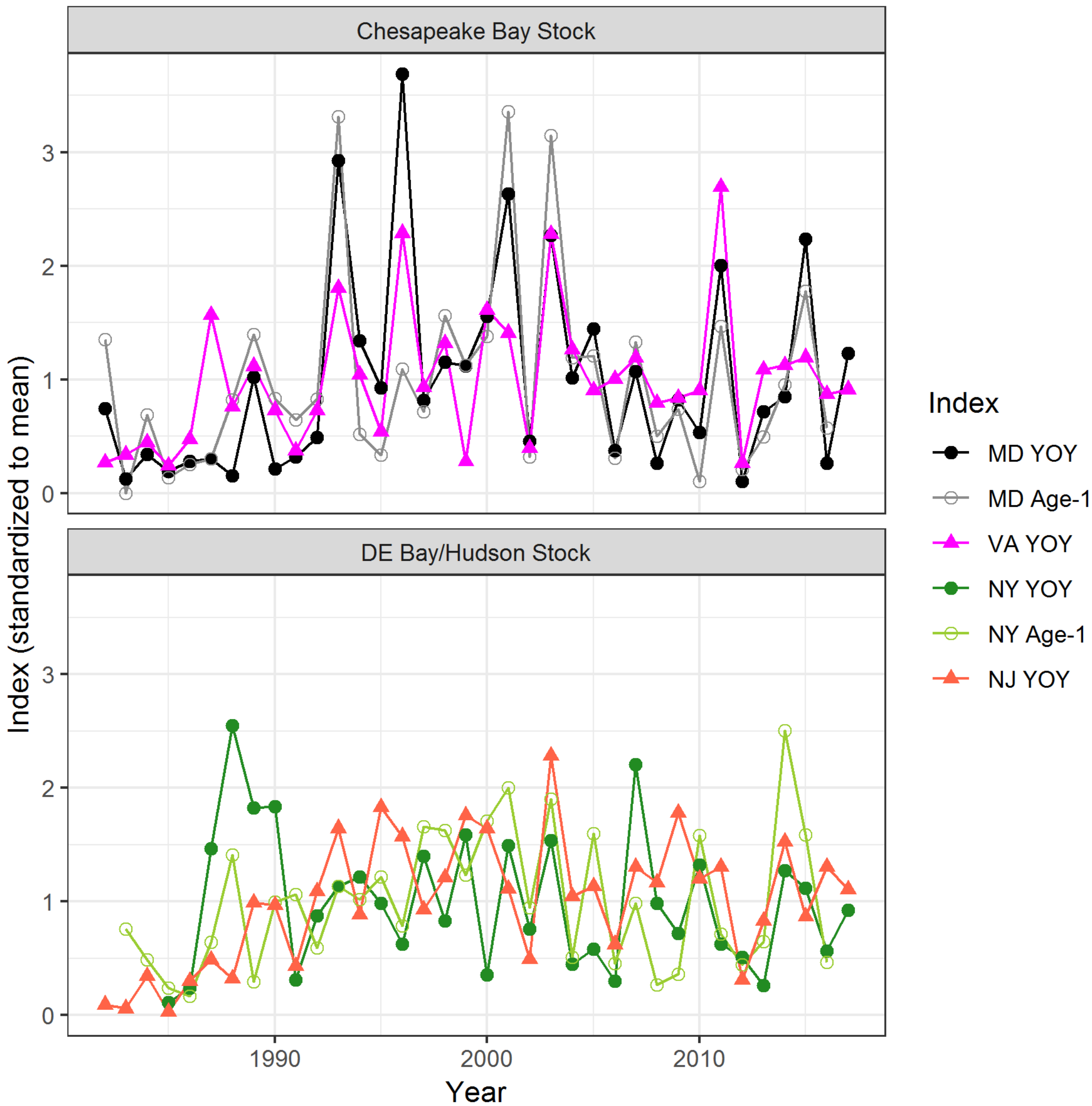


Figure B5.22. Comparison of striped bass recruitment indices by stock. Age-1 indices have been lagged back one year to be more easily compared to the young-of-year indices.

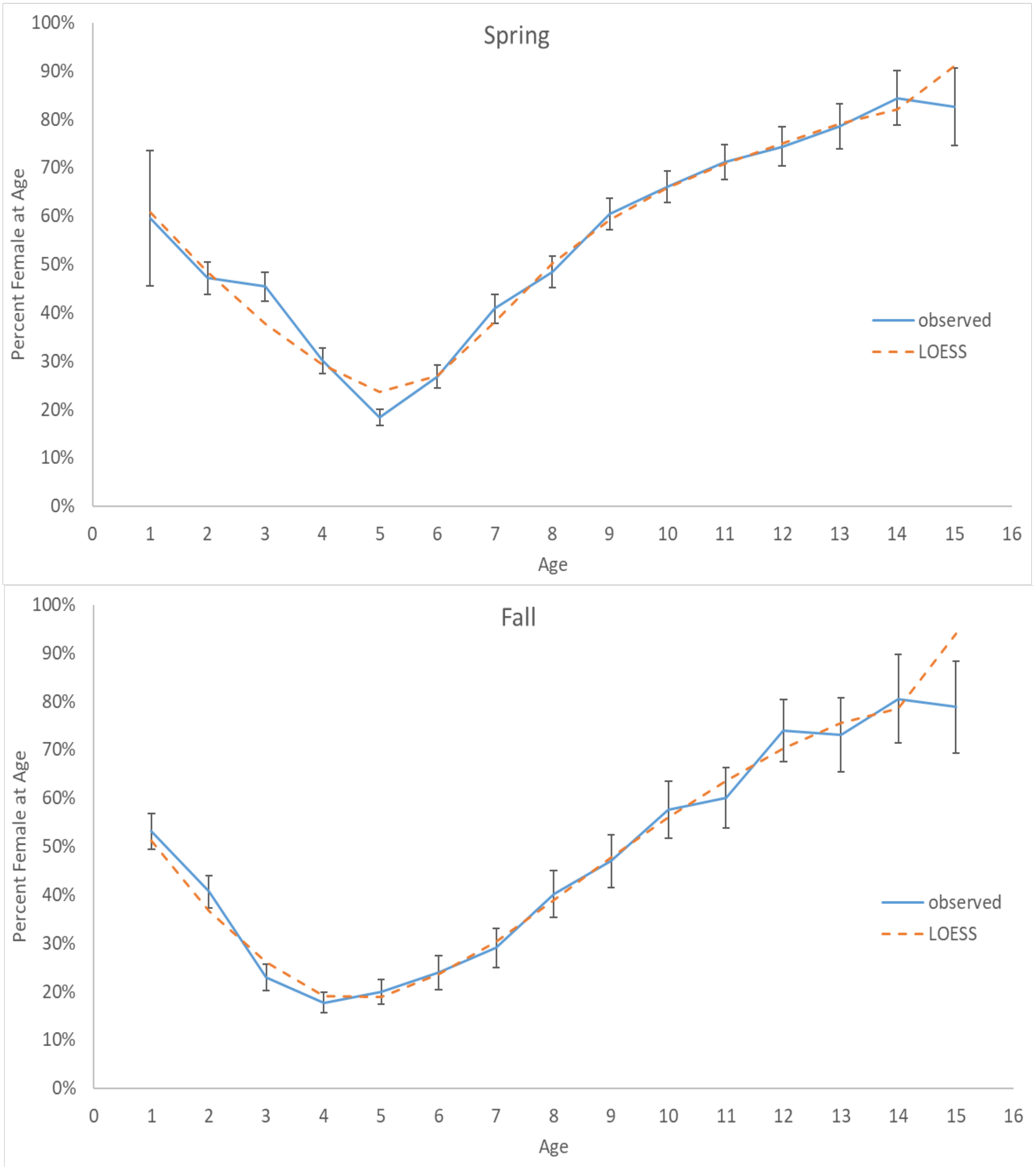


Figure B5.23. Comparison of observed sex ratio-at-age and the LOESS estimate for Chesapeake Bay by season.

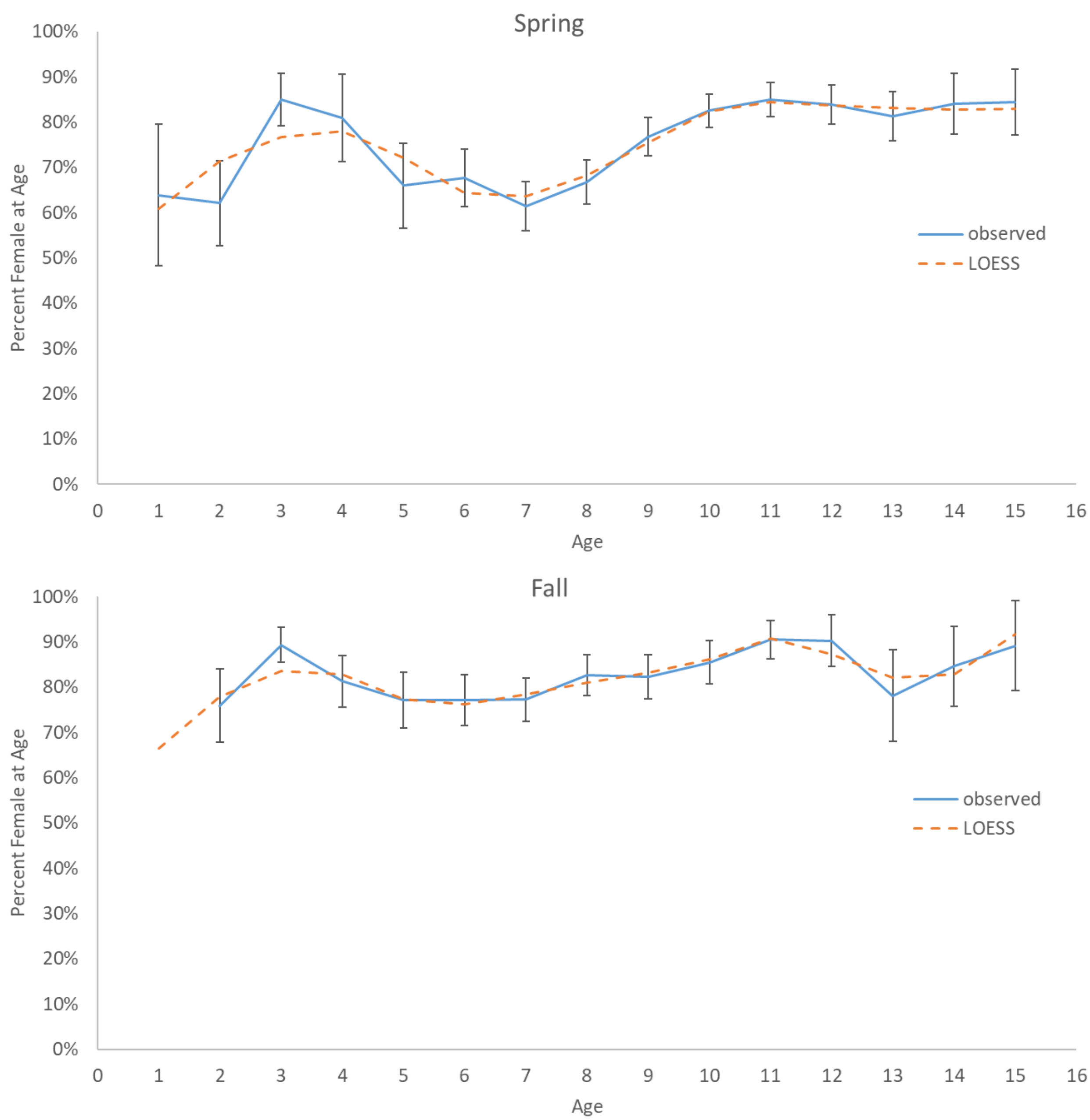


Figure B5.24. Comparison of observed sex ratio-at-age and the LOESS estimate for the ocean stock by season.

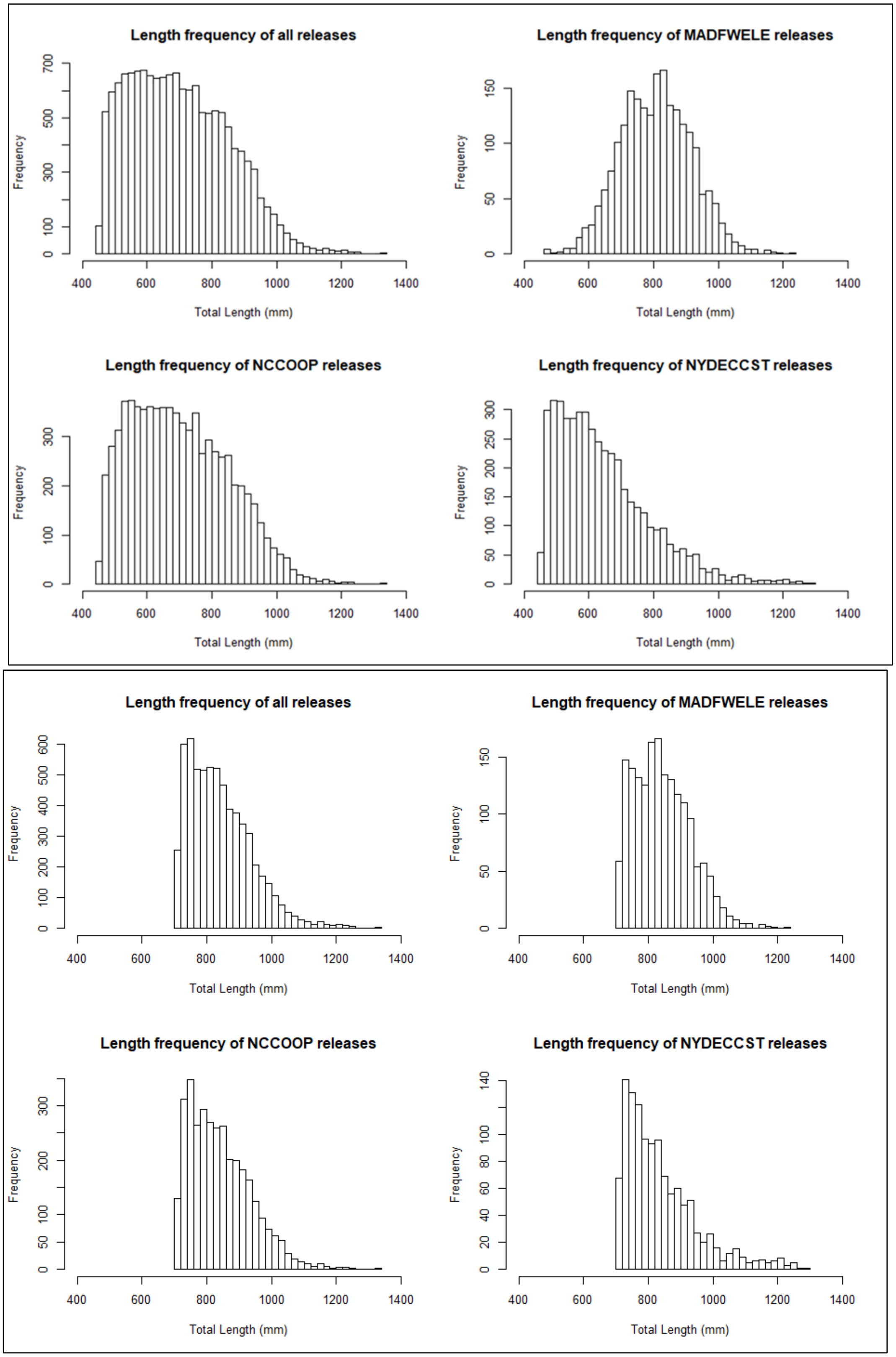


Figure B5.25. Length frequency of all tagged releases and releases by agency that were ≥ 18” (457 mm) TL (top) and ≥ 28” (711 mm) TL (bottom).

Retained record if:

- Event = 1;
- Days at large ≥ 10;
- Release size cut off ≥ 457 mm TL or ≥711 mm TL, depending on scenario.
- Fish must have been confirmed to have been alive during at least one spawning period after release (Kneebone et al. 2014)

Spawning indicated by:

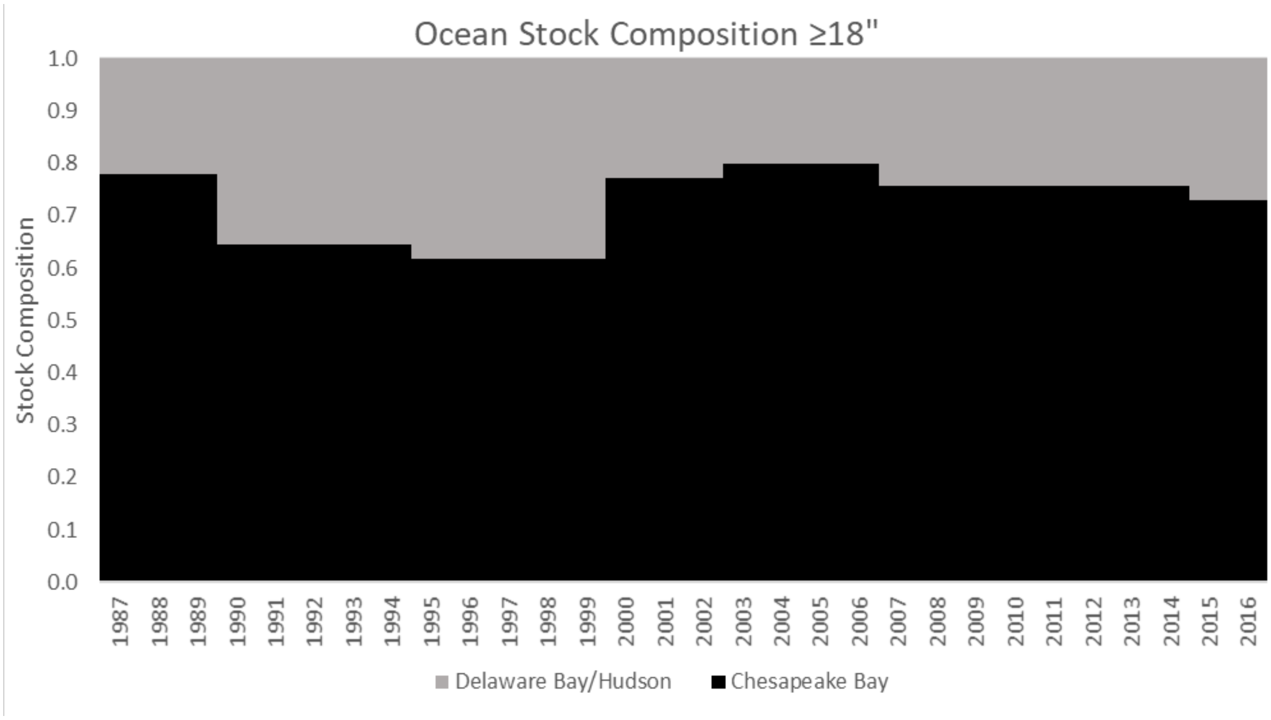
- If recapture = Hudson River NOAA code between March 15th and June 15th.
- If recapture = Delaware River and Tributaries NOAA code between March 15th and June15th.
- If recapture = Chesapeake Bay and Tributaries NOAA code between March 15th and June15th.

Adjusted tag returns by reporting rates (rr) and exploitation rate (Hansen and Jacobsen 2003):

- Fish of known stock [note that F and reporting rates only available through 2011; we carried those terminal values forward]:
  - Assume separate harvest and discard reporting rates:

    raw $tags_{AD}$ ÷ harvest or release rr_{AD} ÷ $[1-\exp(-F_A)]$, where A = parent spawning system and D = fish disposition
- Fish of unknown stock:
  - When applying disposition-specific reporting rates to recaptures:
    - Use mean harvest reporting rate across all years (across all PSSs)
    - Use mean release reporting rate across all years (across all PSSs)
    - Use mean exploitation across all years (across all PSSs)
- Time blocks
  - Regulatory period: 1987-1989, 1990-1994, 1995-1999, 2000-2002, 2003-2006, 2007-2014, and 2015-2016

Figure B5.26. Summary of stock composition estimation methods.



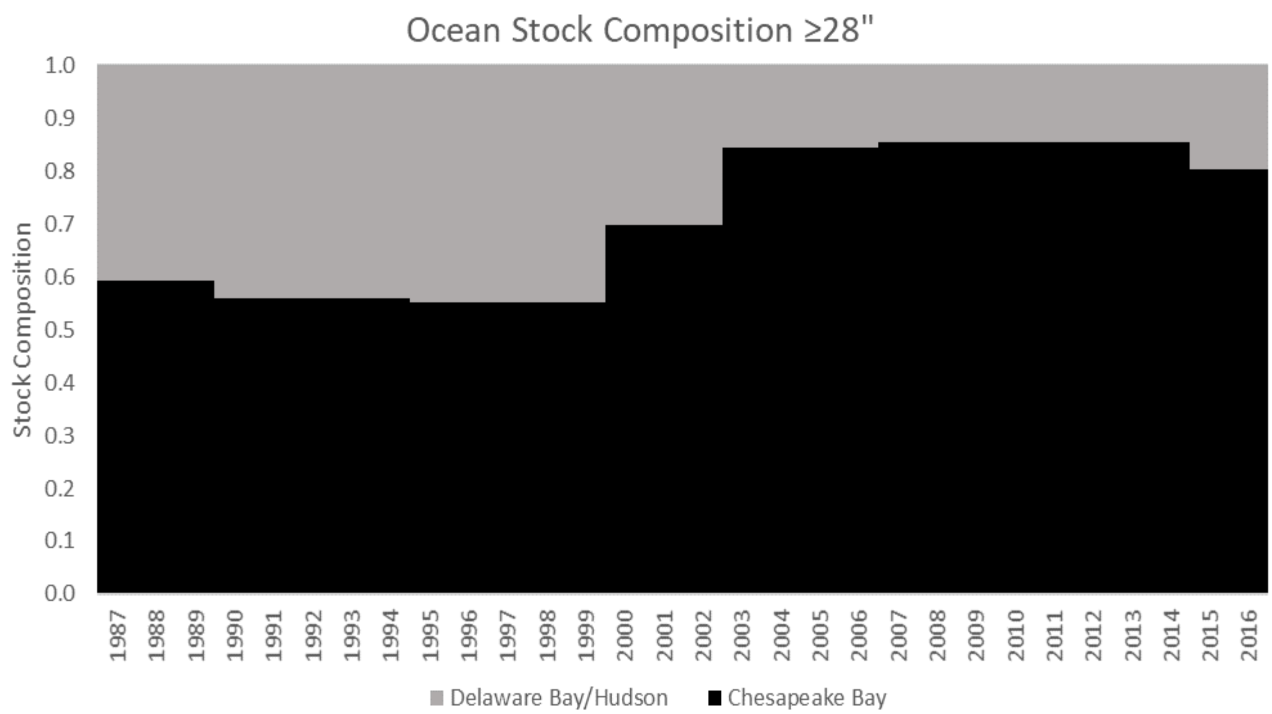


Figure B5.27. Ocean stock composition of fished striped bass ≥ 18” (457 mm, top) and fished striped bass ≥ 28” (711 mm, bottom) based on adjusted recaptures.

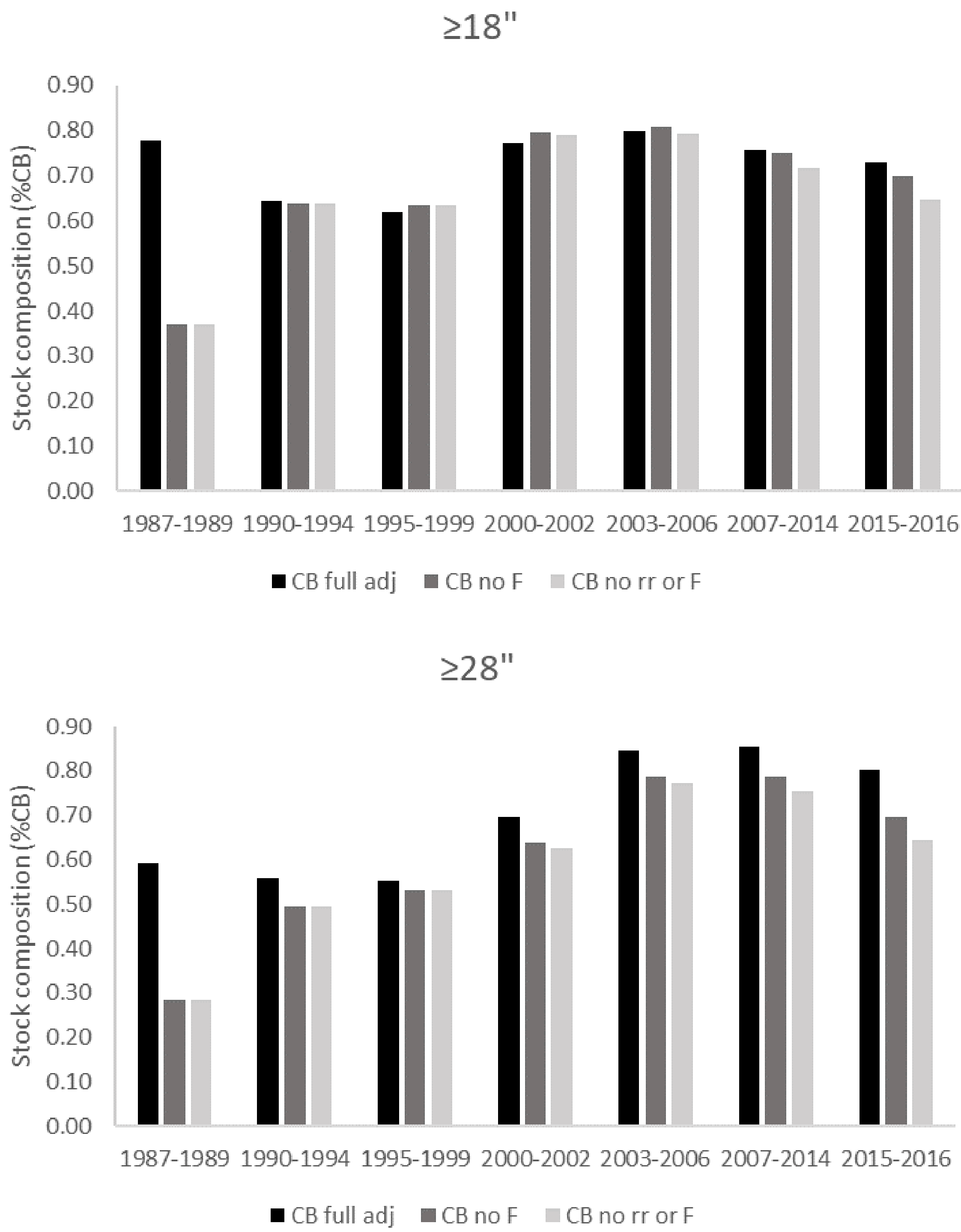


Figure B5.28. Influence of reporting rate and F estimates on stock composition estimates by regulatory time block, for fish ≥18” TL (457 mm, top) and fish ≥28” TL (711 mm, bottom).

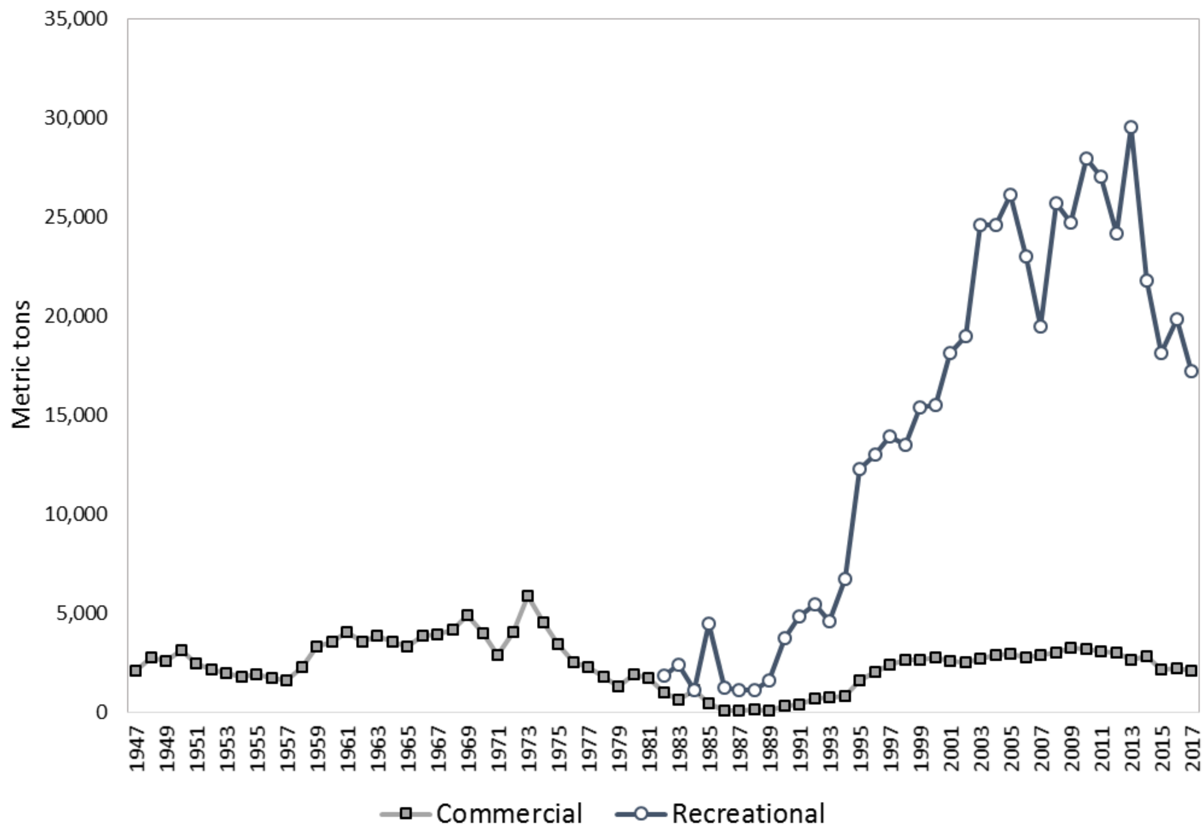


Figure B6.1. Commercial and recreational landings in weight (mt) of striped bass on the Atlantic coast. Estimates of recreational landings are not available prior to 1981.

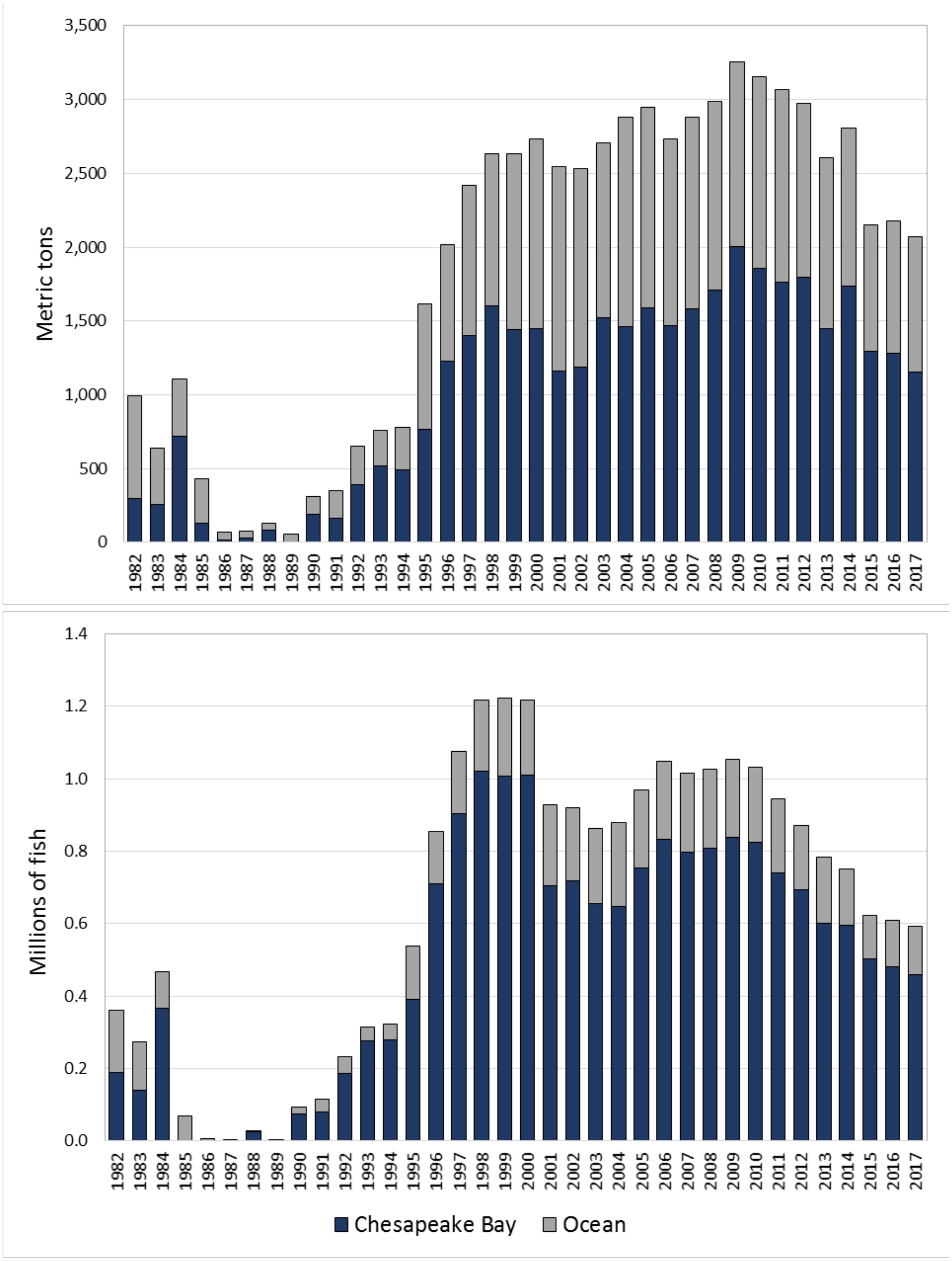
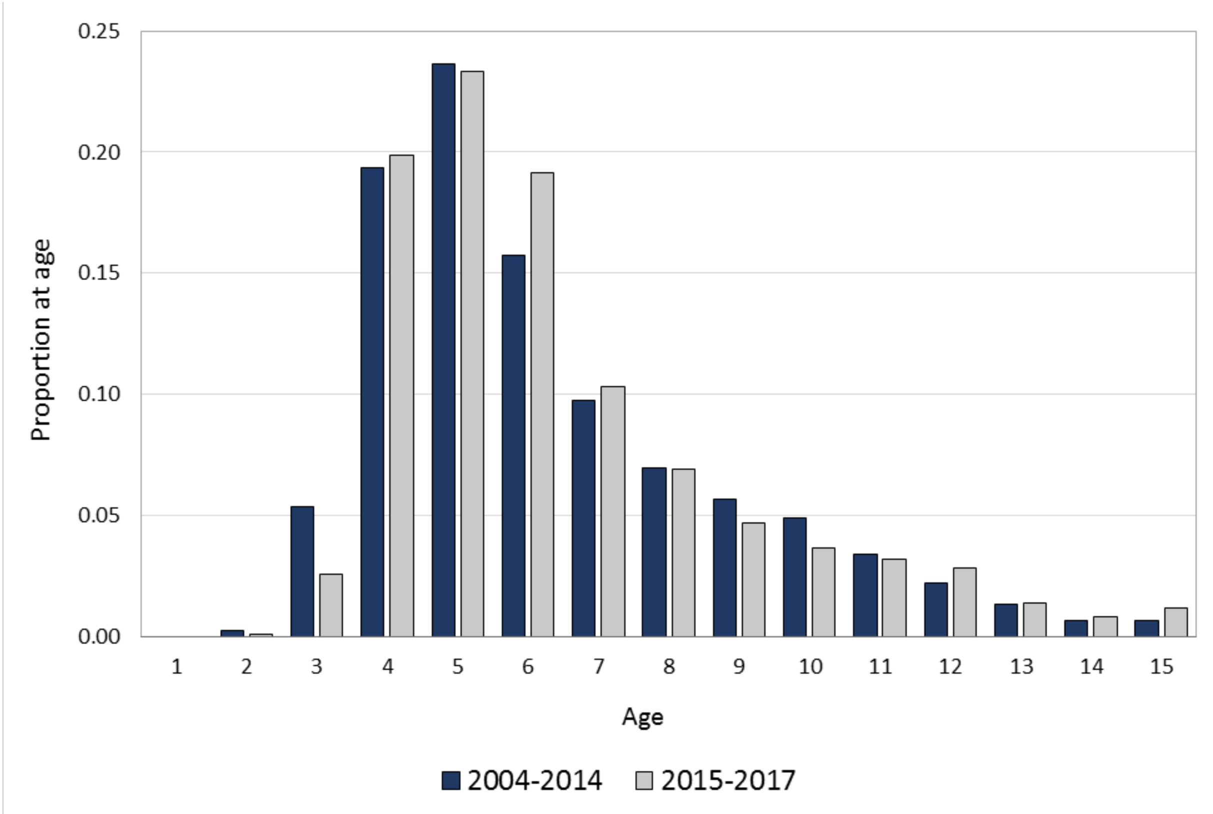


Figure B6.2. Commercial harvest of striped bass by region in weight (top) and numbers of fish (bottom).



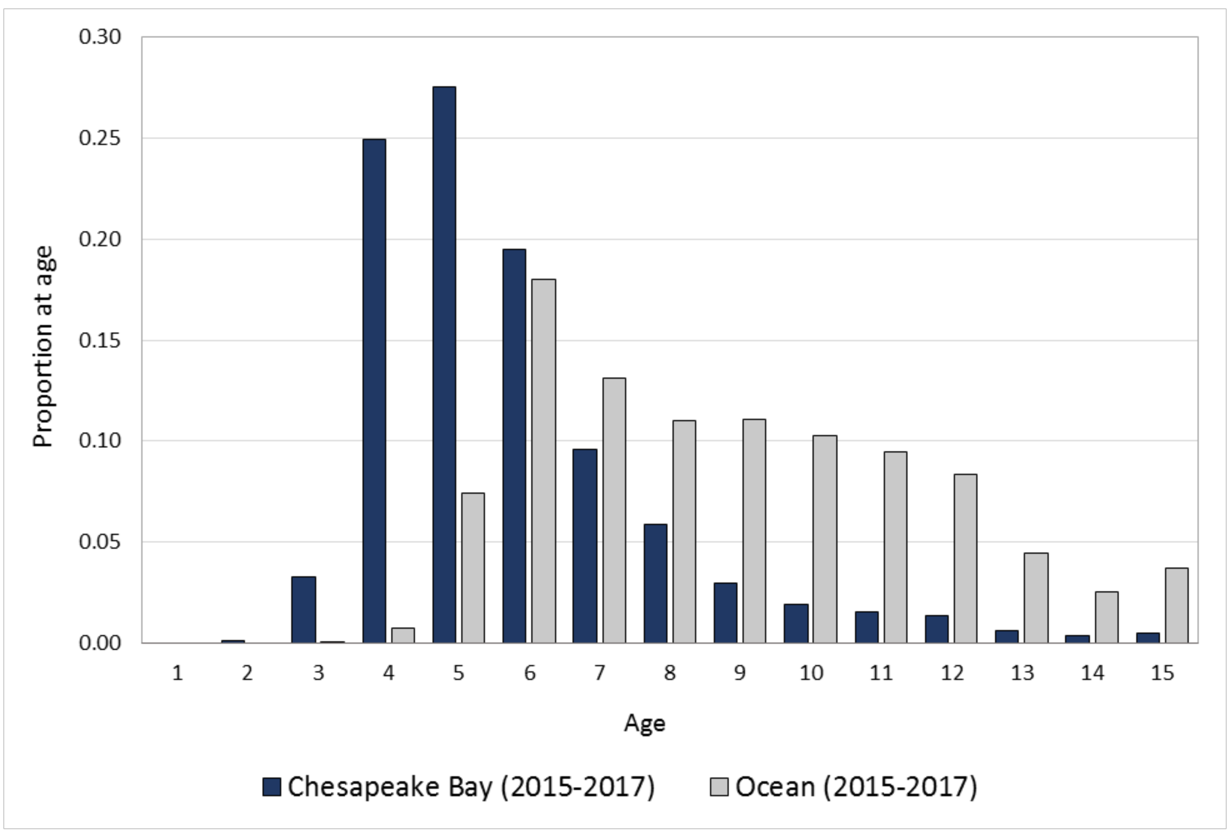


Figure B6.3. Proportion at age in the commercial harvest by management period (top) and region (bottom).

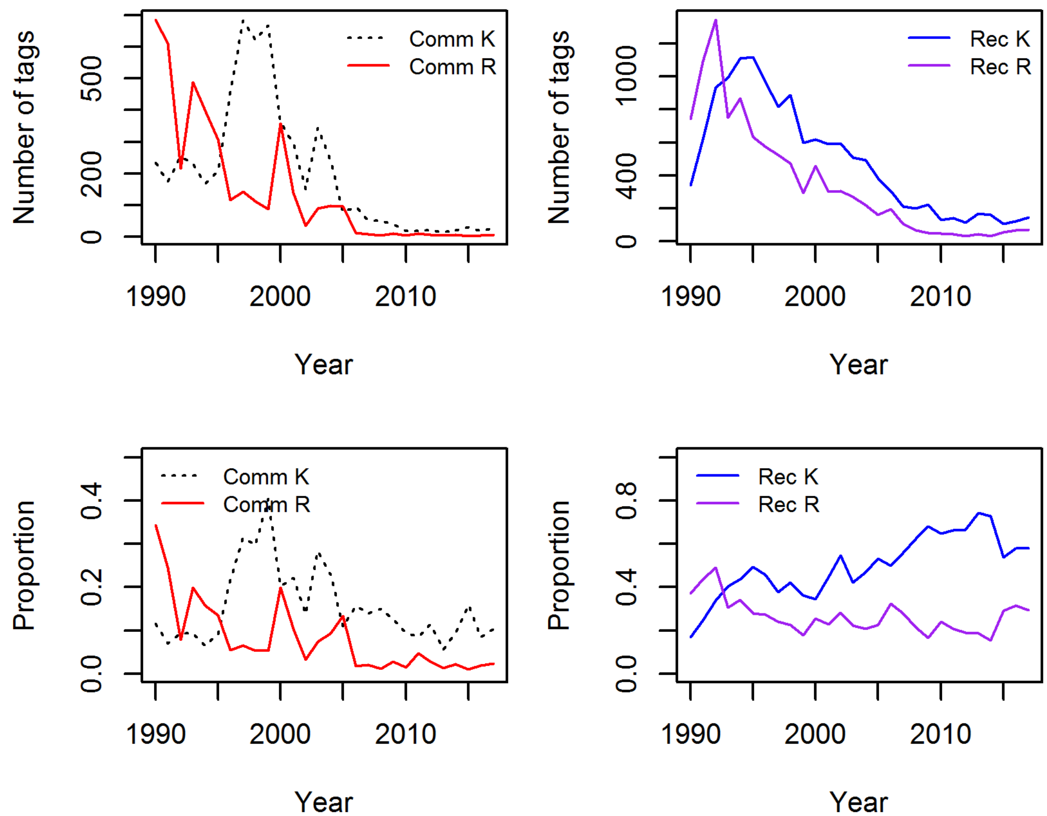


Figure B6.4. Numbers (top row) and proportions (bottom row) of tags returned by disposition and fishery category for Chesapeake Bay. K=killed/harvested, R=released alive.

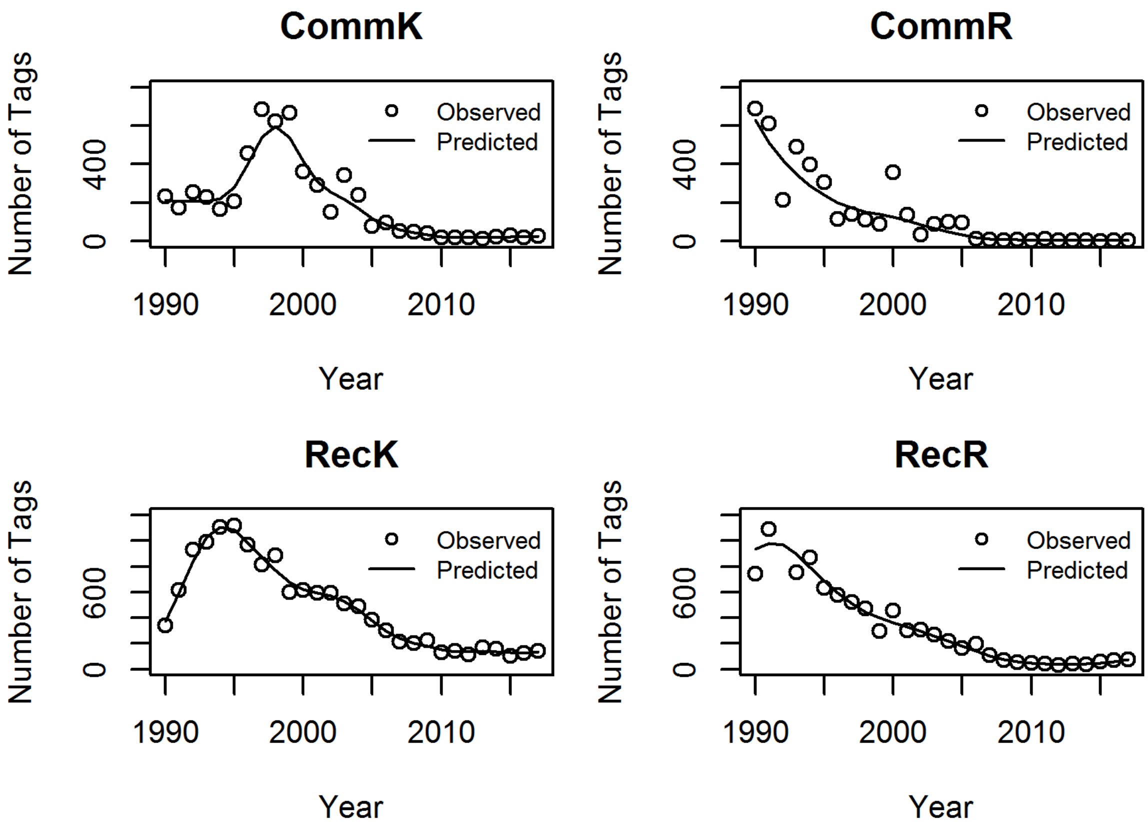


Figure B6.5. Observed and predicted tag numbers from the GAM fits for Chesapeake Bay by fishery and disposition. K=killed/harvested, R=released alive.

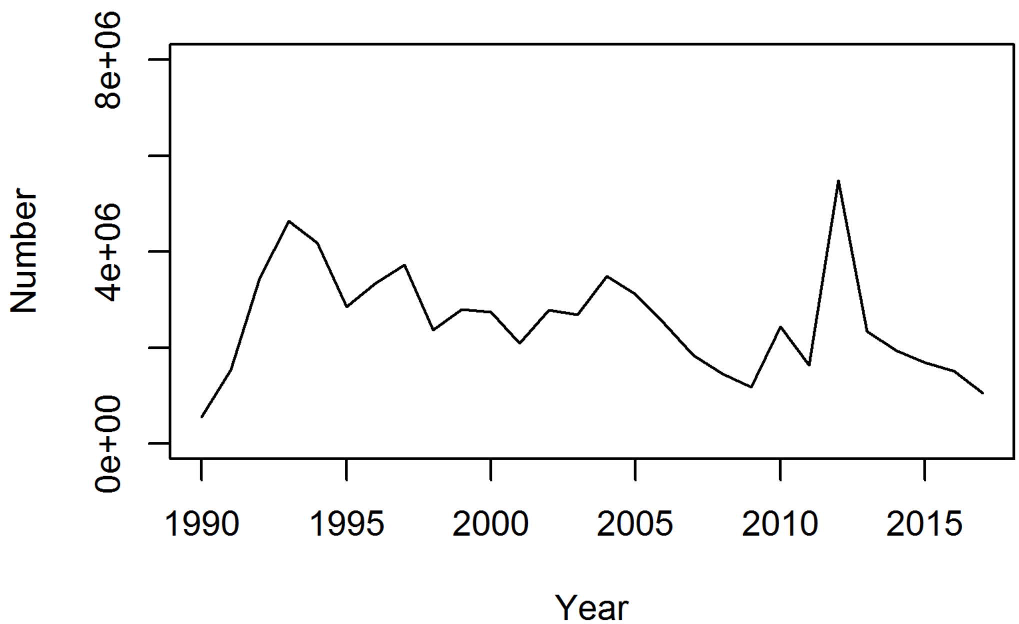


Figure B6.6. Estimates of unscaled commercial total discards for Chesapeake Bay, 1982-2017.

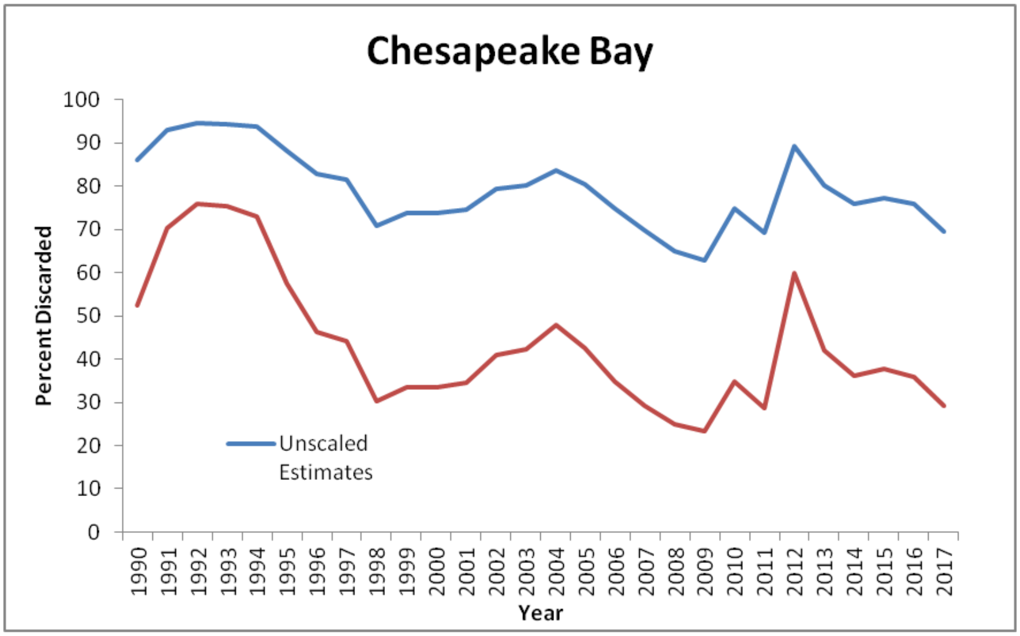


Figure B6.7. Comparison of the percentage of total catch between the unscaled and scaled estimates (red line) of total discards for Chesapeake Bay. Percent discarded = total discards/(harvest + total discards)*100.

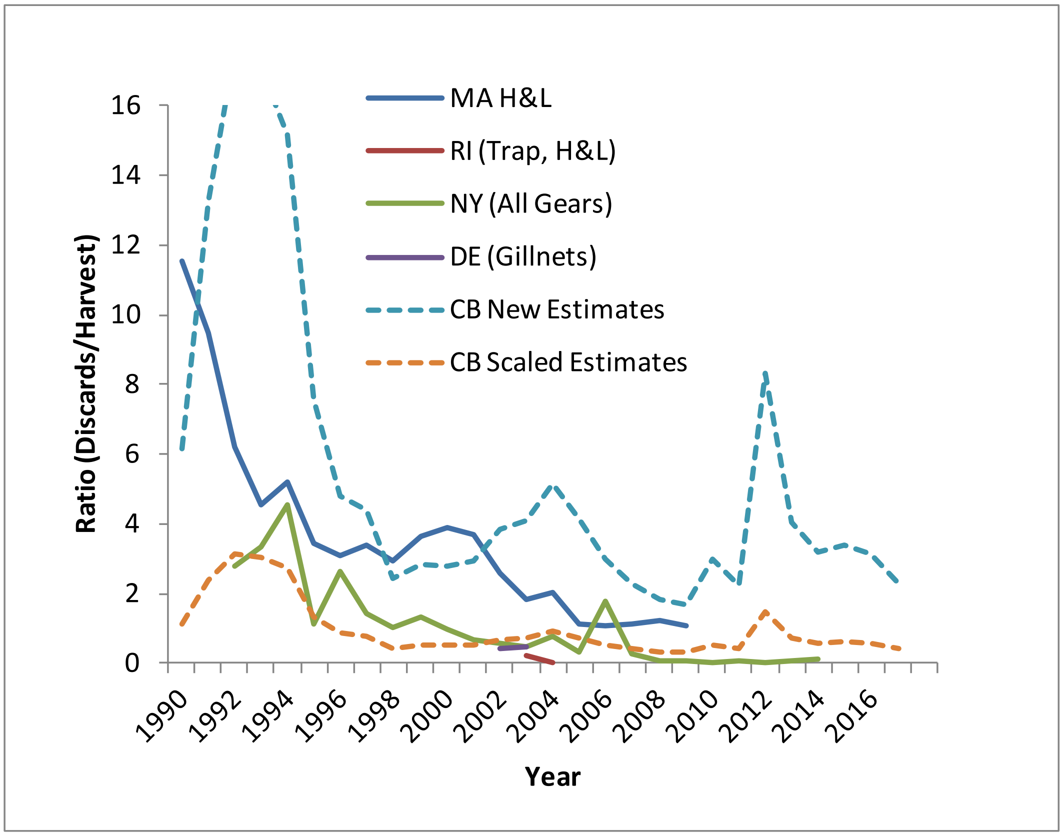


Figure B6.8. Comparison of estimates of total discards-to-harvest ratios for Chesapeake Bay from this assessment (new and scaled) and from Massachusetts, Rhode Island, New York and Delaware fisheries from other studies.

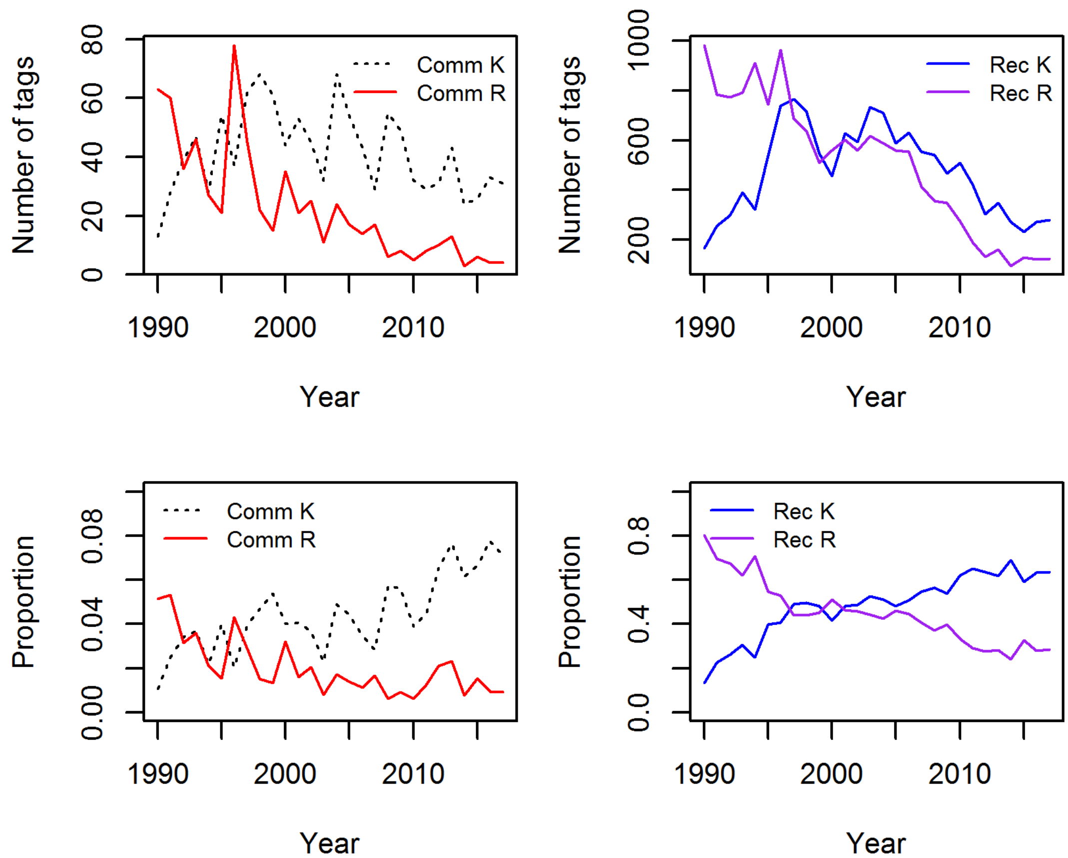


Figure B6.9. Numbers (top row) and proportions (bottom row) of tags returned by disposition and fishery category for the Ocean region. K=killed/harvested, R=released alive.

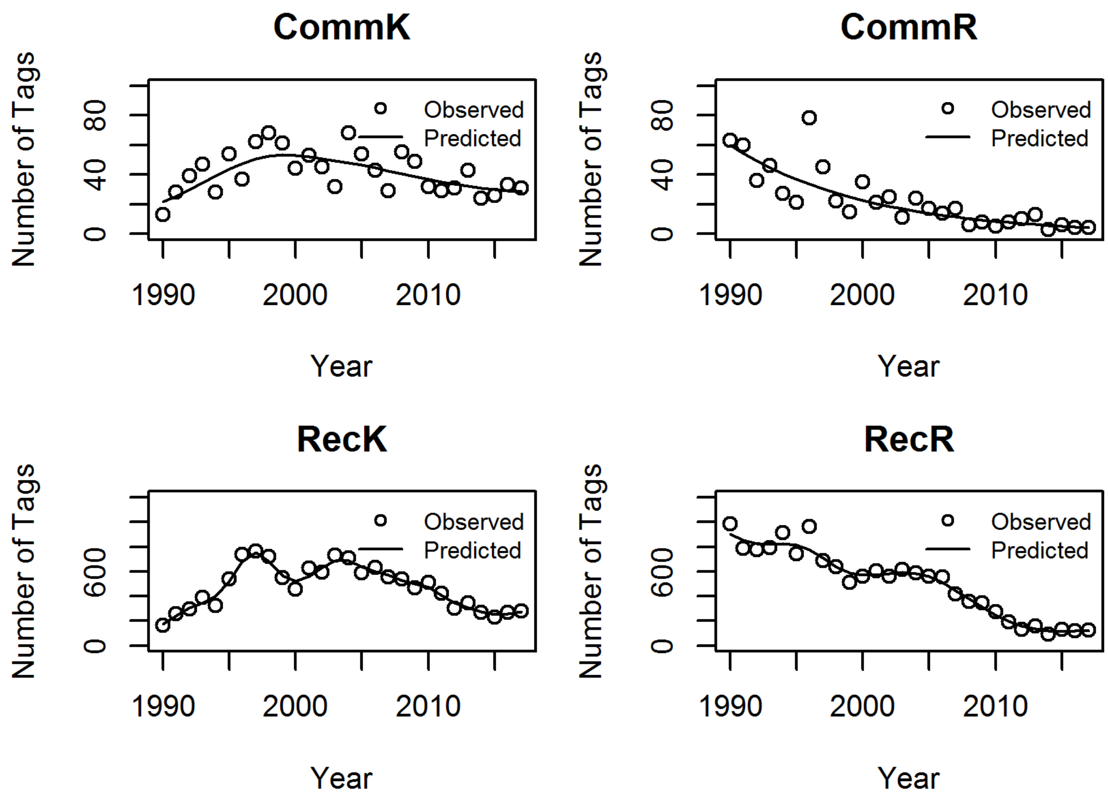


Figure B6.10. Observed and predicted tag numbers from the GAM fits for the Ocean region by fishery and disposition. K=killed/harvested, R=released alive

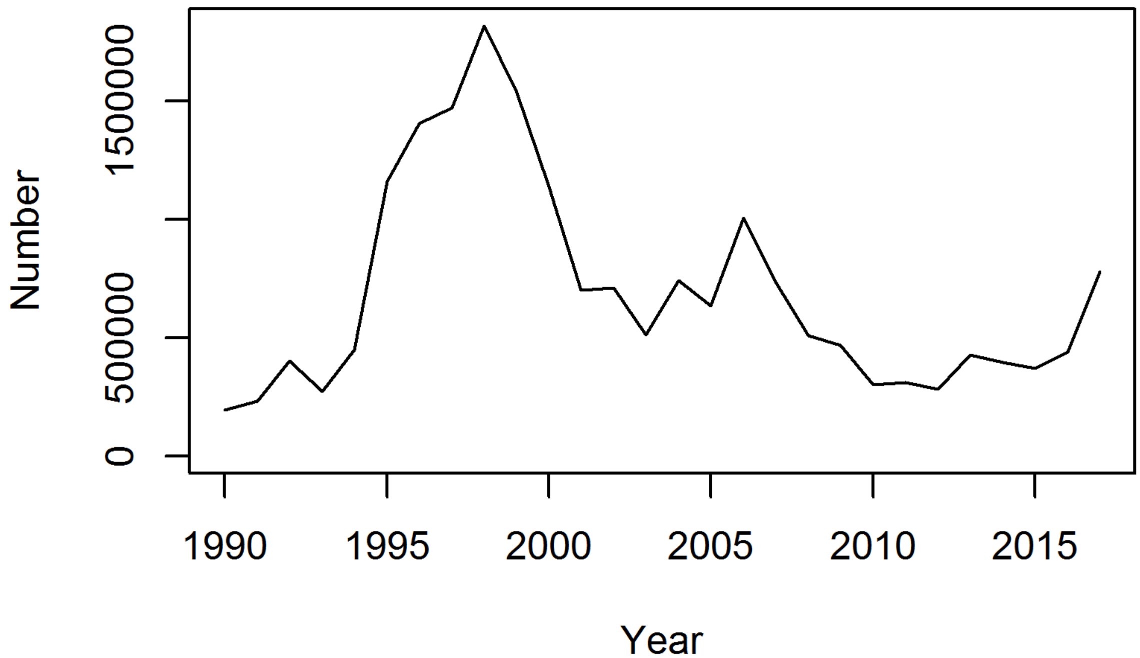


Figure B6.11. Estimates of commercial total discards for the Ocean region, 1990-2017.

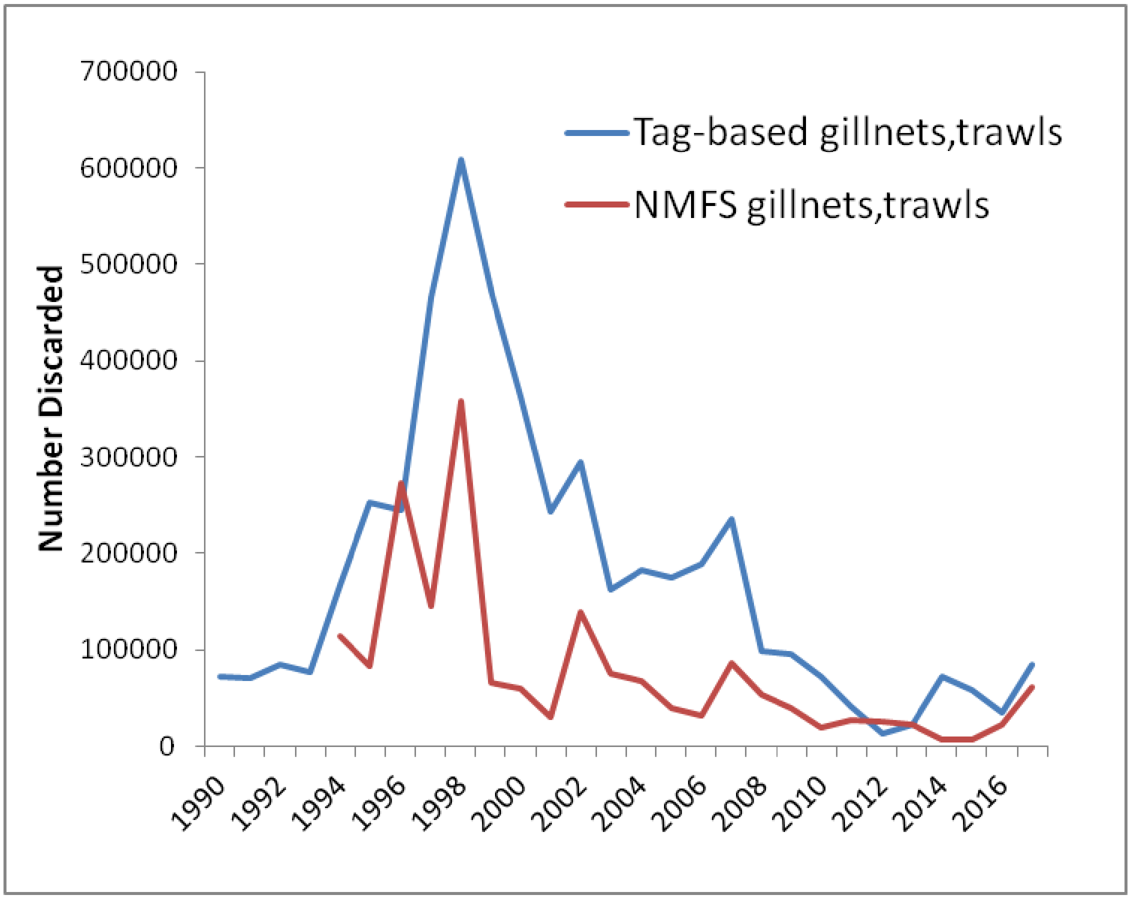


Figure B6.12. Comparison of total number of striped bass discarded in the Ocean region estimated by the tag-based method and NMFS observer program.

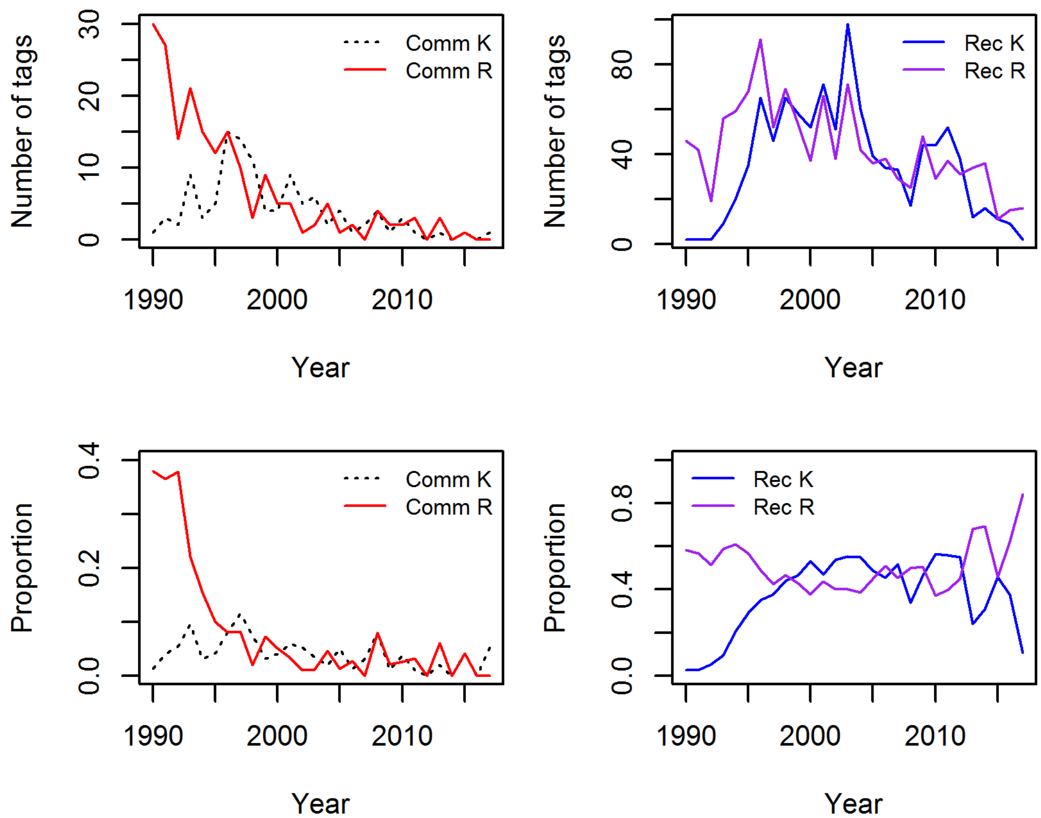


Figure B6.13. Numbers (top row) and proportions (bottom row) of tags returned by disposition and fishery category for Delaware Bay. K=killed/harvested, R=released alive.

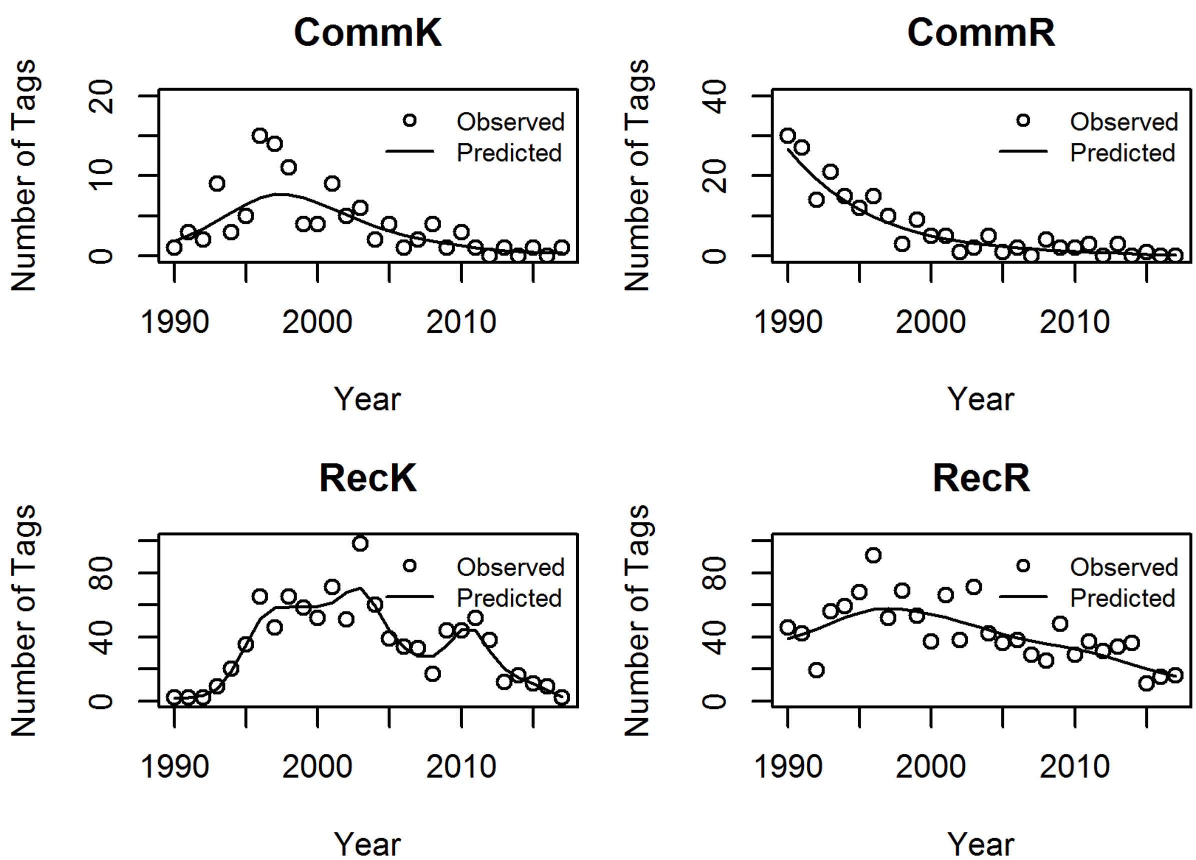


Figure B6.14. Observed and predicted tag numbers from the GAM fits for Delaware Bay by fishery and disposition=killed/harvested, R=released alive.

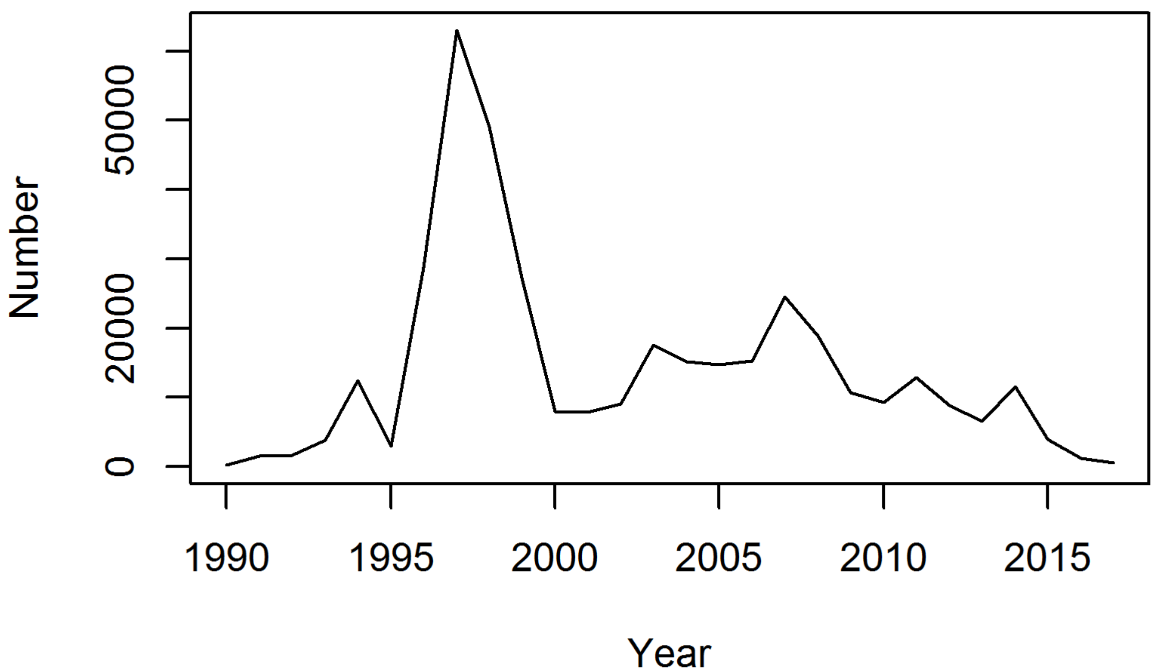


Figure B6.15. Scaled estimates of commercial total discards for Delaware Bay, 1990-2017.

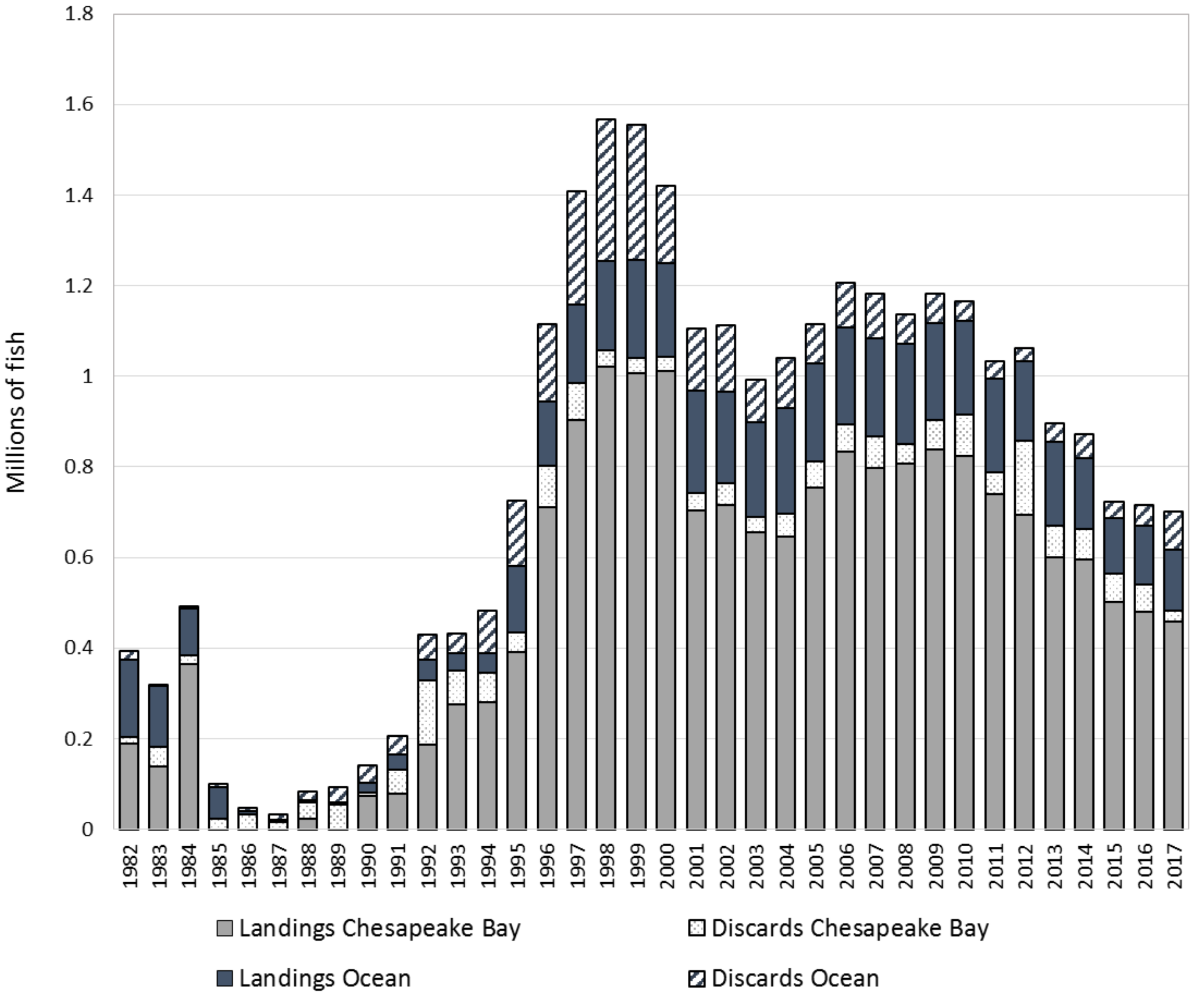


Figure B6.16. Total commercial removals of striped bass by region and disposition.

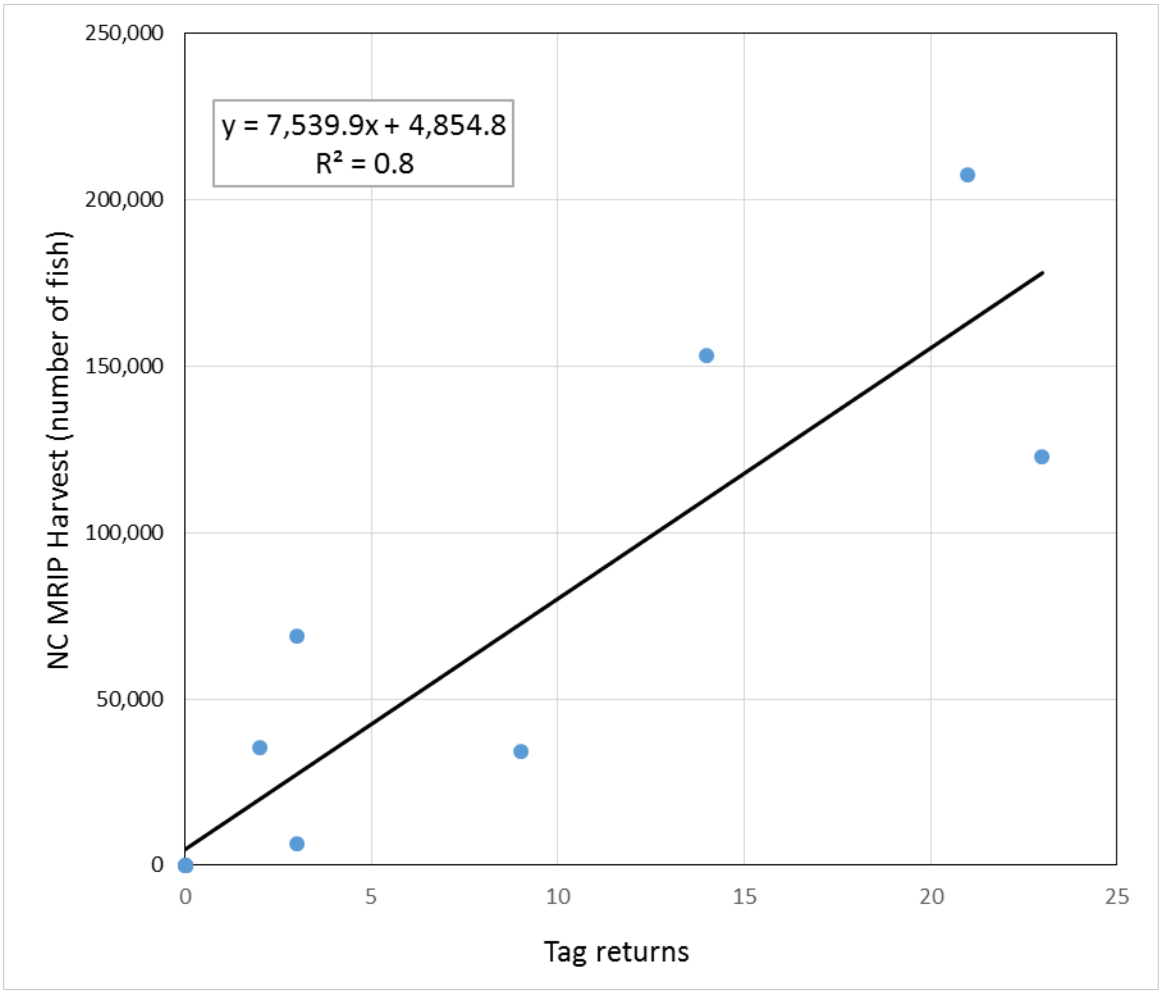


Figure B6.17. Relationship between North Carolina Wave-1 recreational harvest and number of Wave-1 tag returns in a given year, 2005-2017.

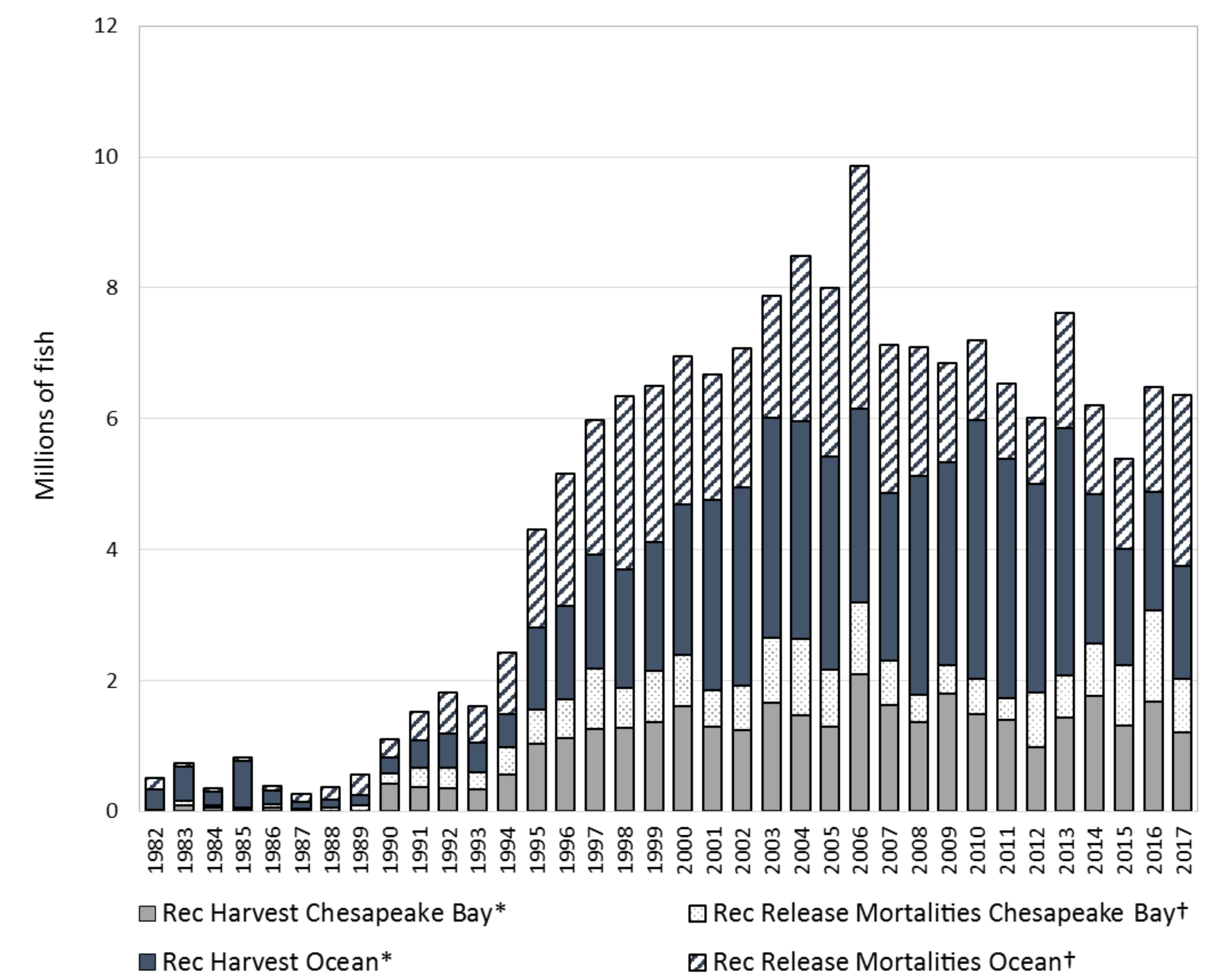
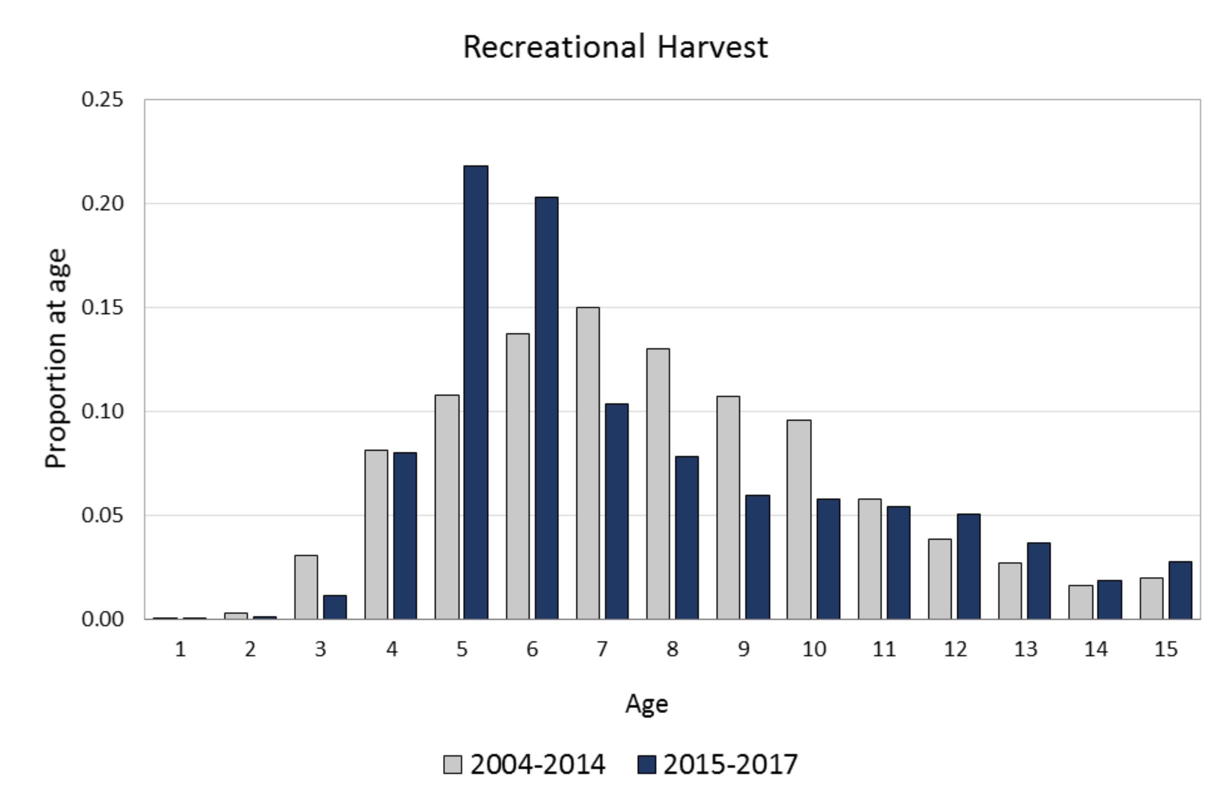


Figure B6.18. Recreational removals of striped bass by year and region. * Harvest includes estimates of Wave-1 harvest for North Carolina and Virginia. † Release mortality of 9% applied to live releases.



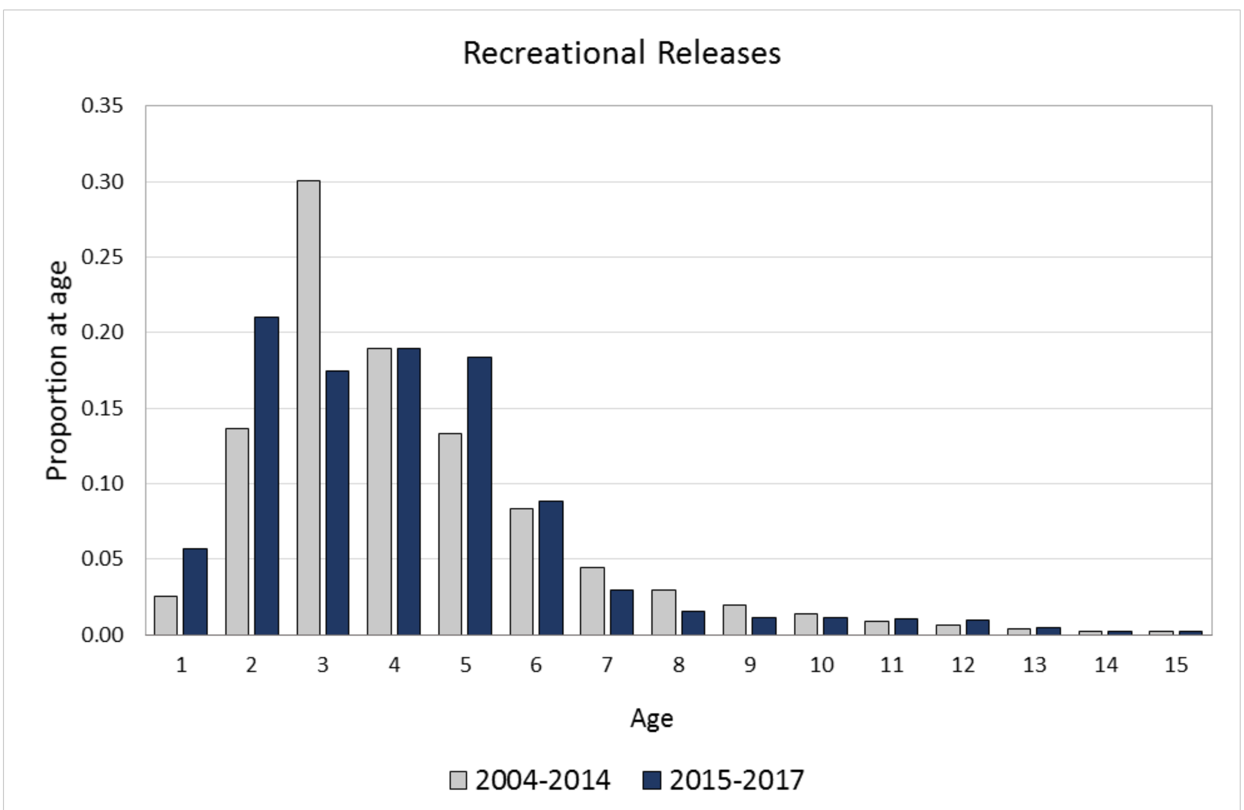
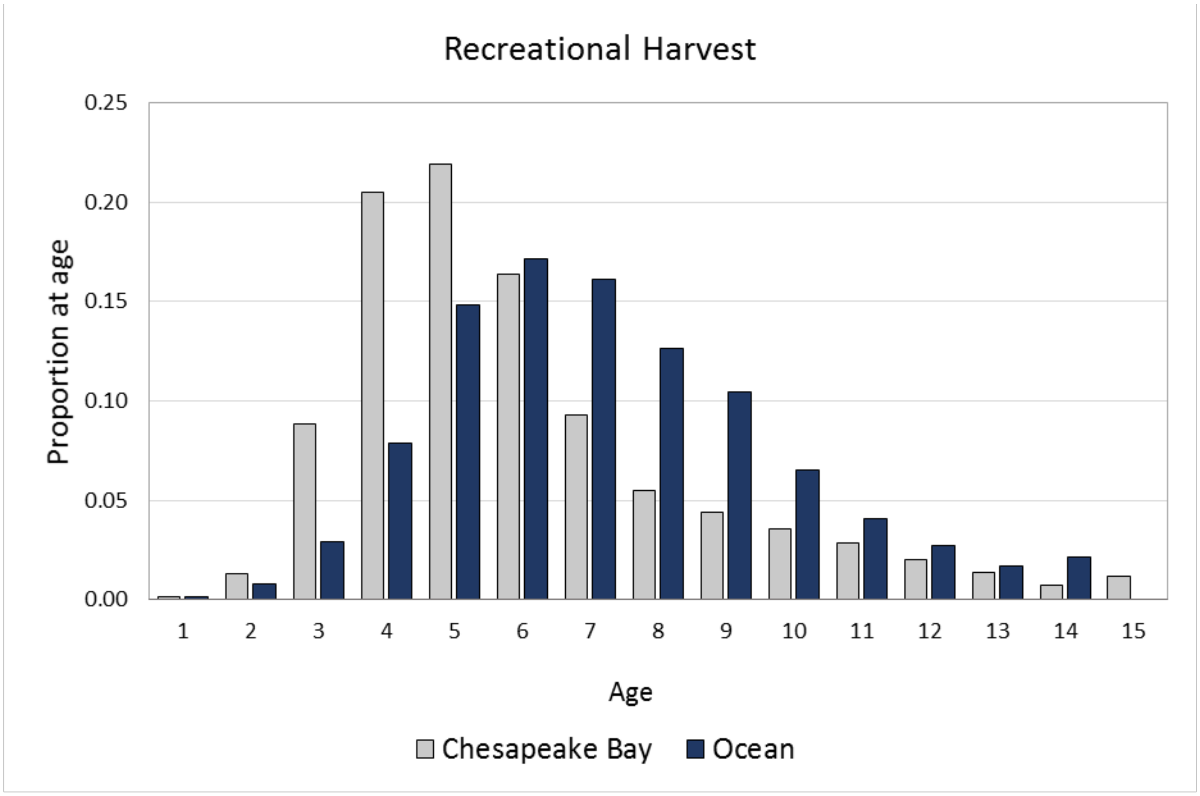


Figure B6.19. Age composition of recreational harvest (top) and recreational releases (bottom) by management period.



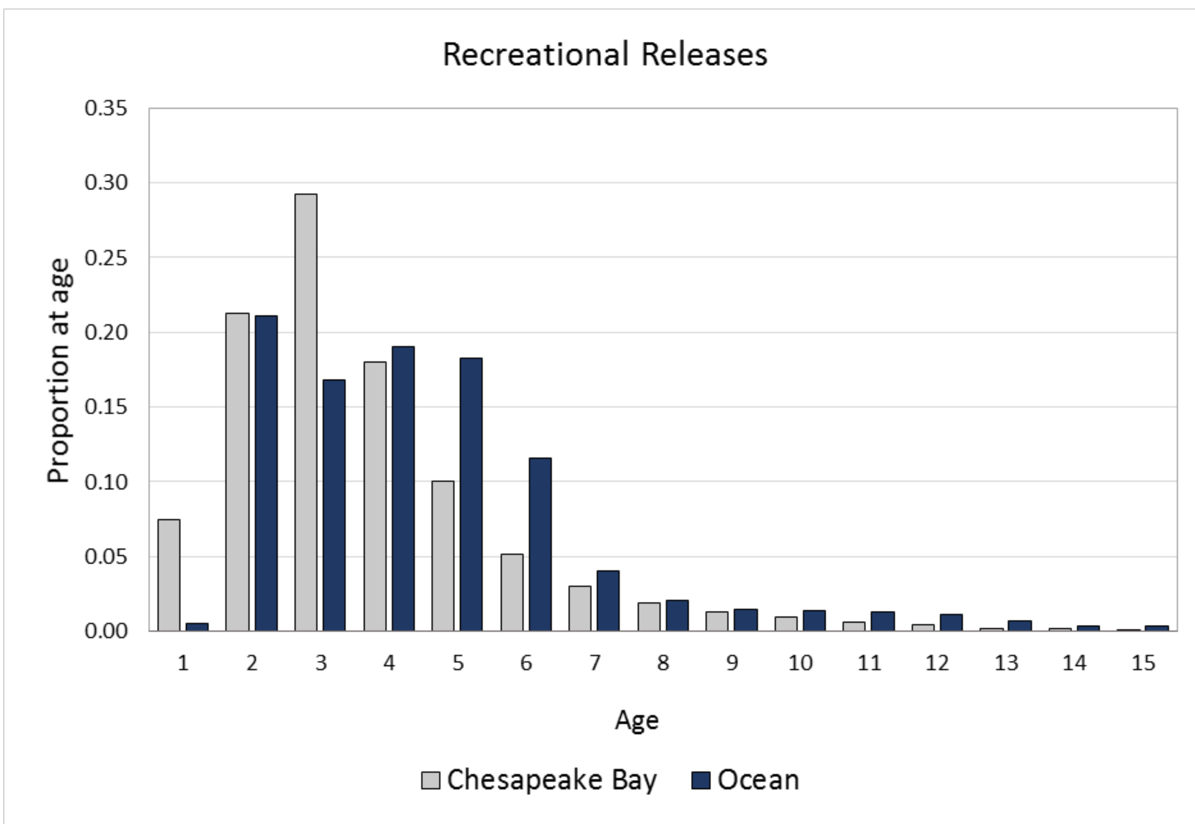


Figure B6.20. Proportion-at-age for recreational harvest (top) and recreational releases (bottom) by region (all years combined).

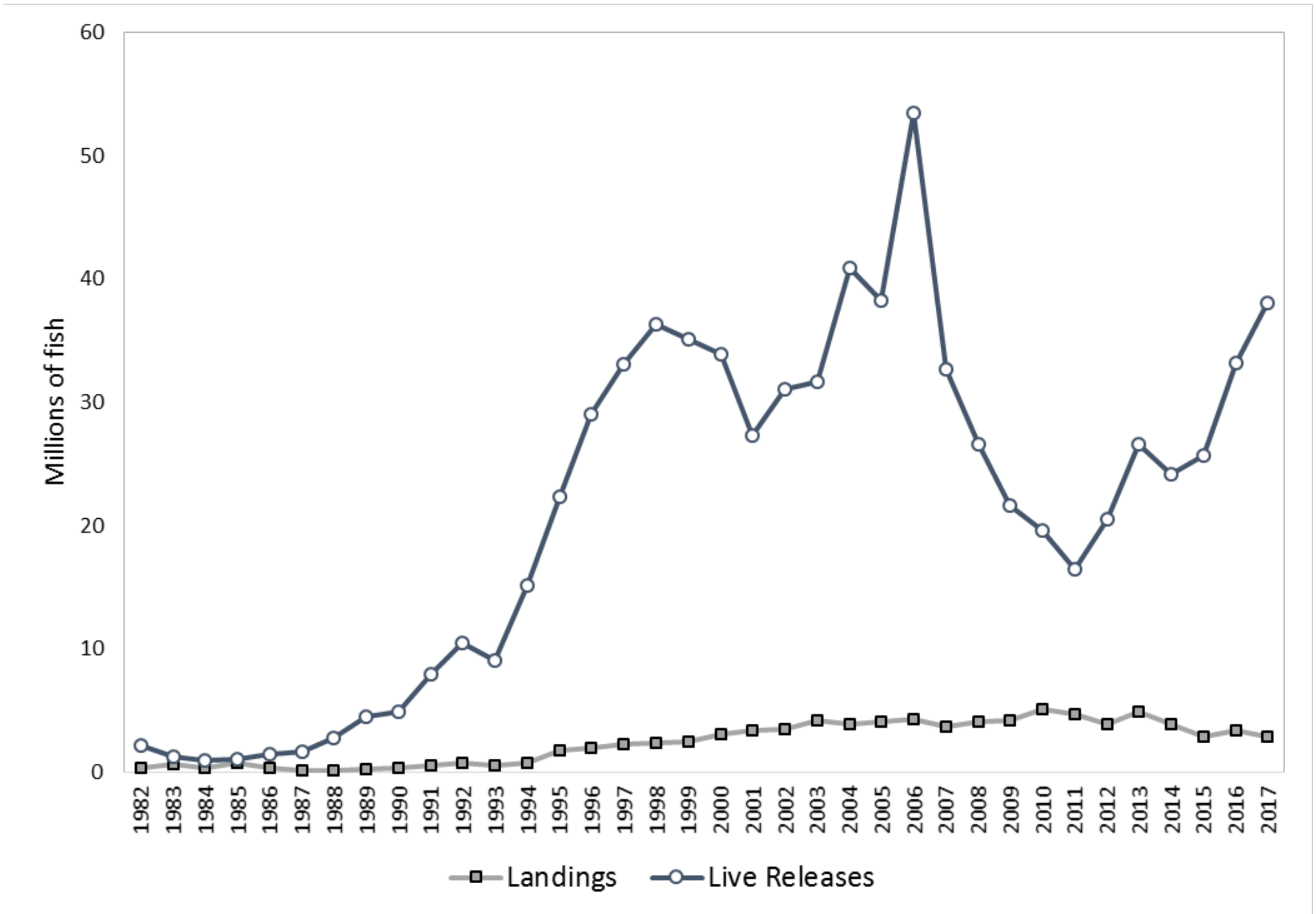


Figure B6.21. Total recreational catch of striped bass on the Atlantic coast by disposition.

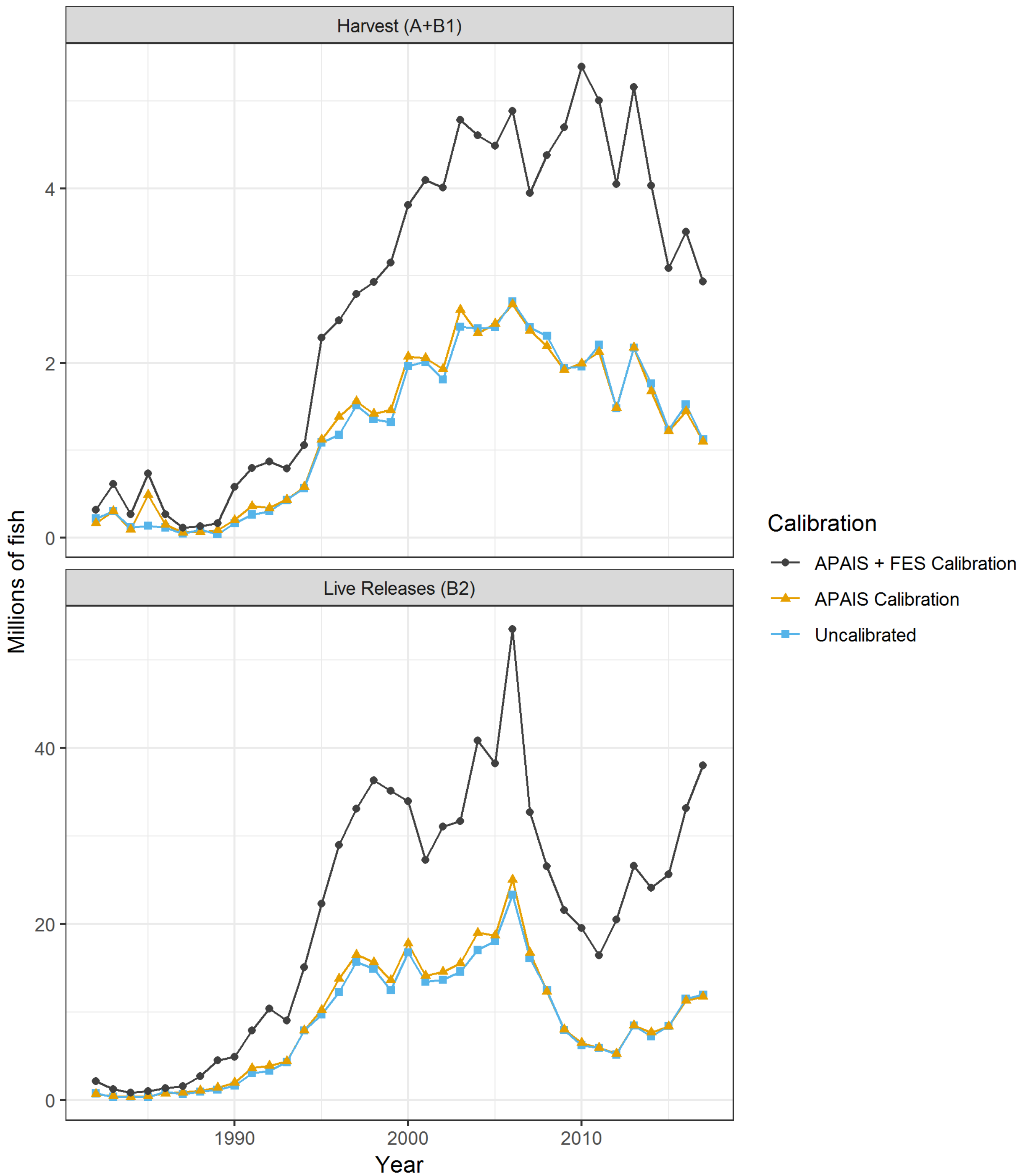


Figure B6.22. Comparison of calibrated and uncalibrated estimates of recreational striped bass harvest (top) and live releases (bottom) used in the assessment.

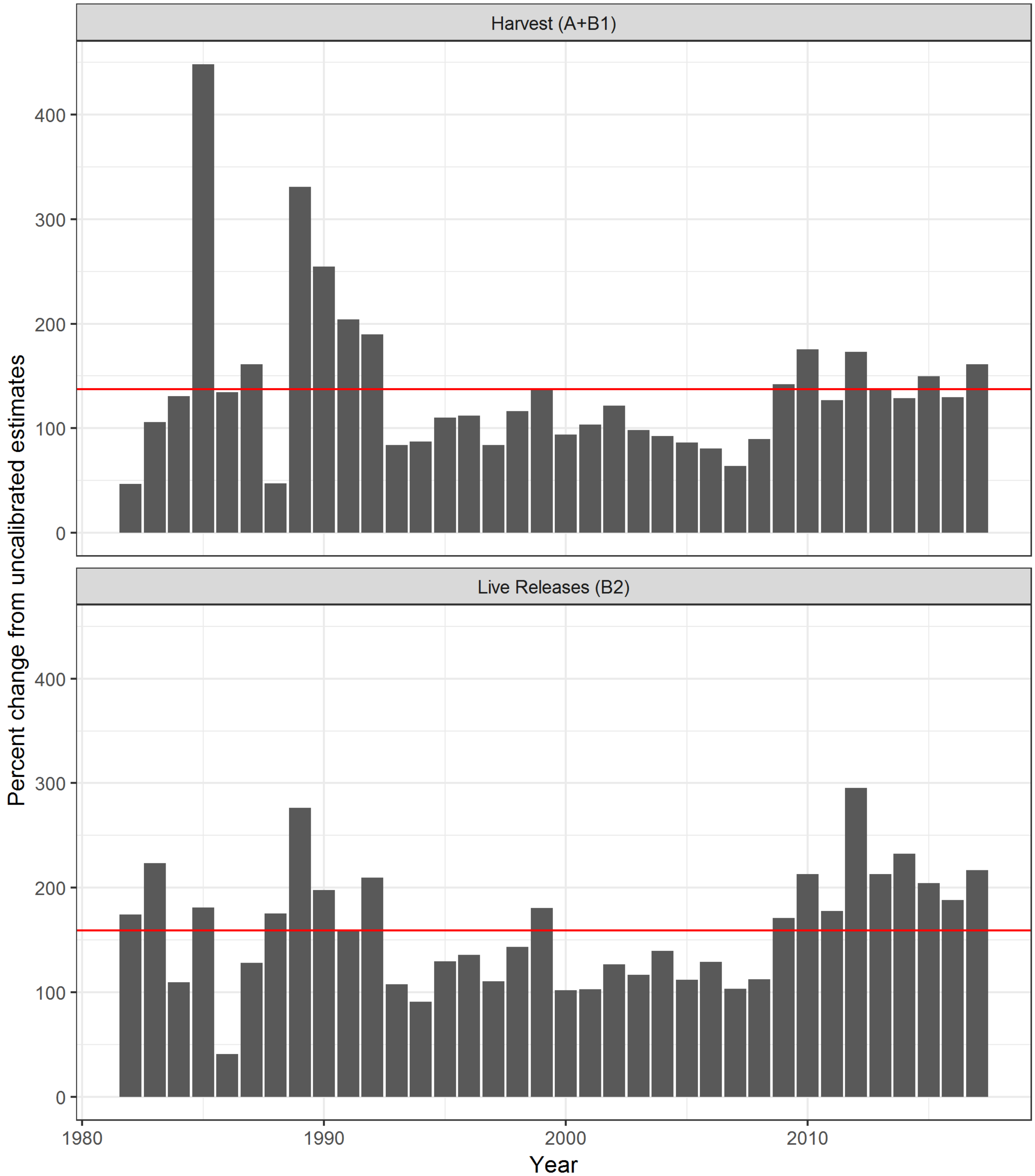


Figure B6.23. Percent difference between calibrated and uncalibrated estimates of recreational striped bass harvest (top) and live releases (bottom) used in the assessment. Red line indicates time series average percent difference.

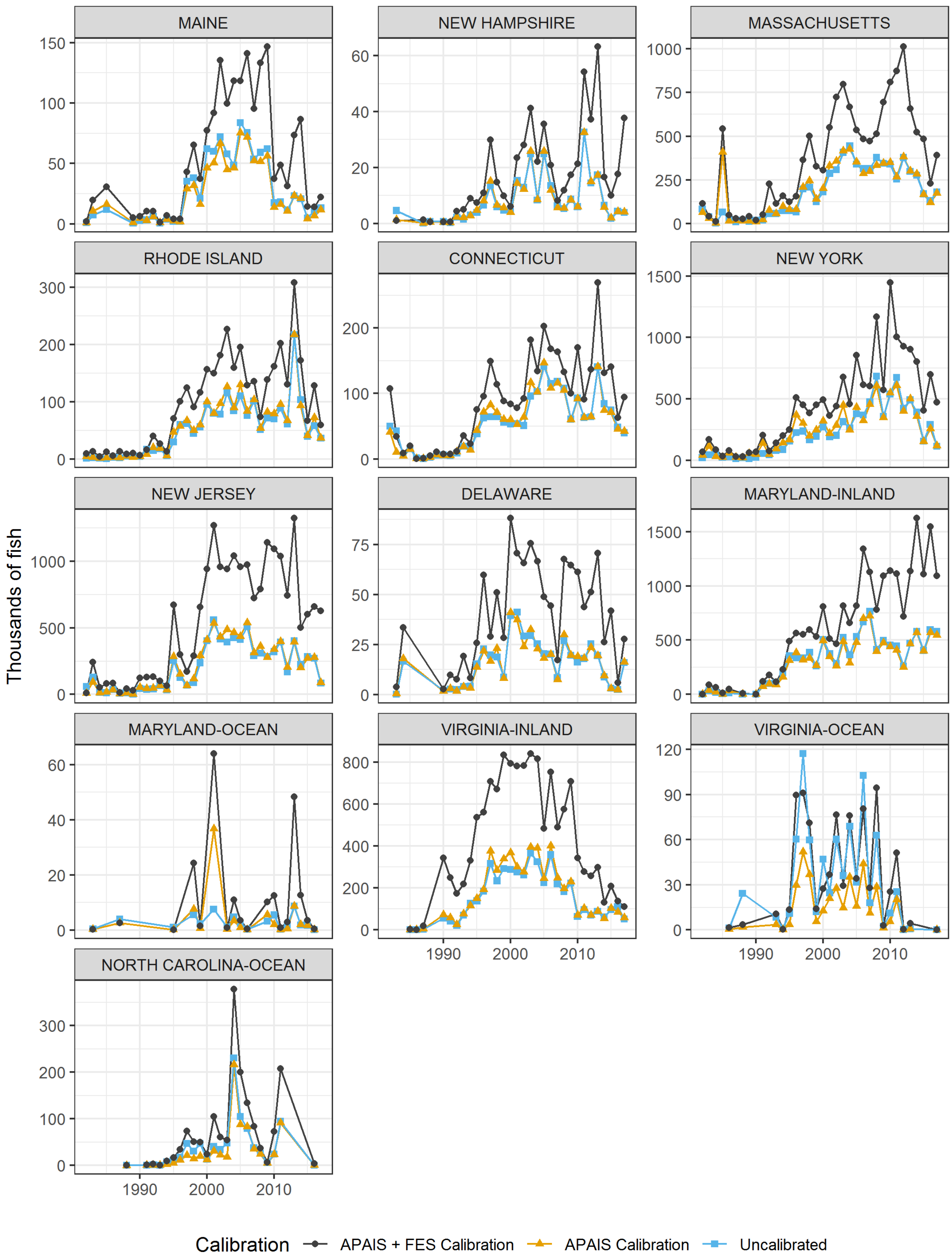


Figure B6.24. Comparison of calibrated and uncalibrated estimates of recreational harvest by state.

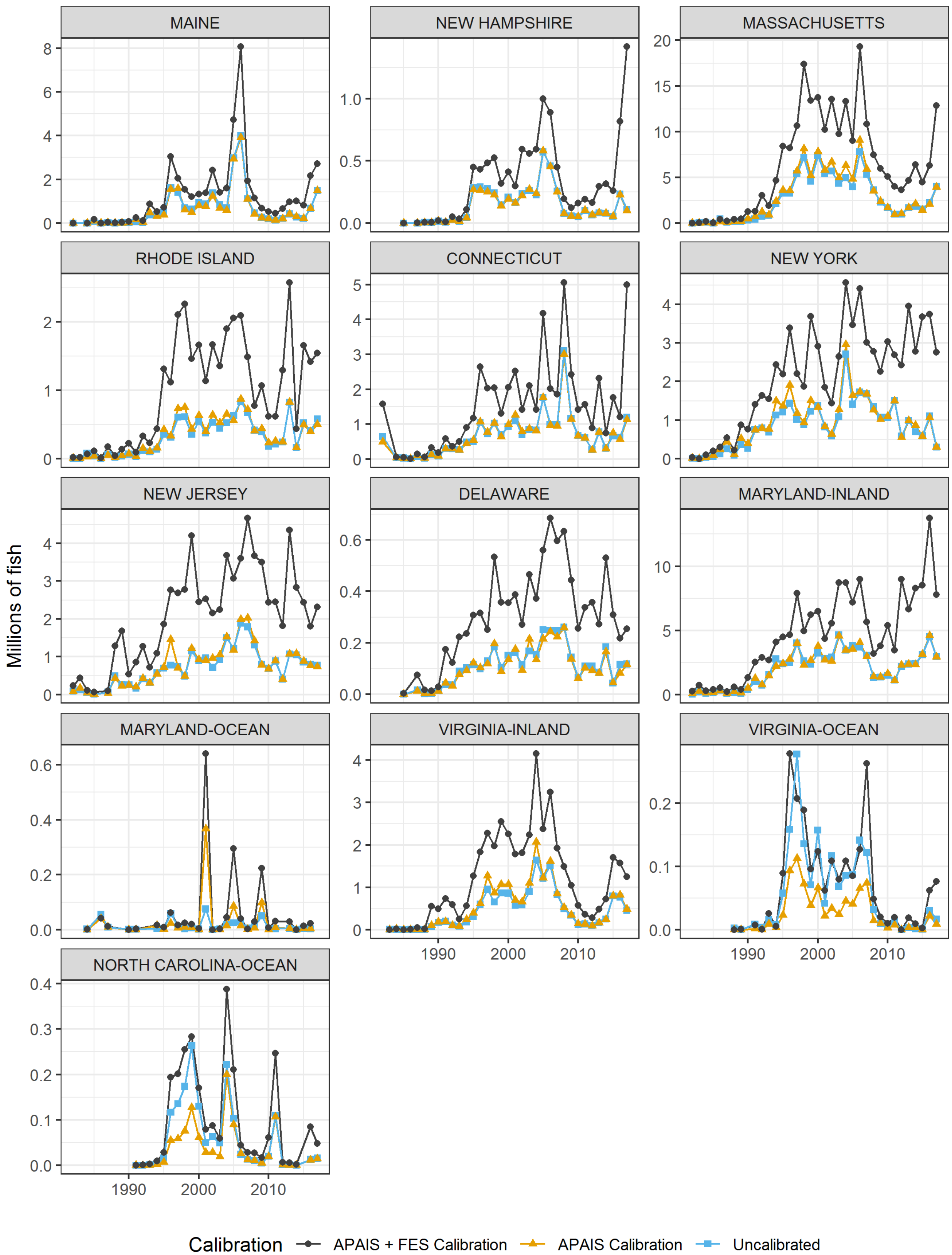


Figure B6.25. Comparison of calibrated and uncalibrated estimates of recreational live releases by state.

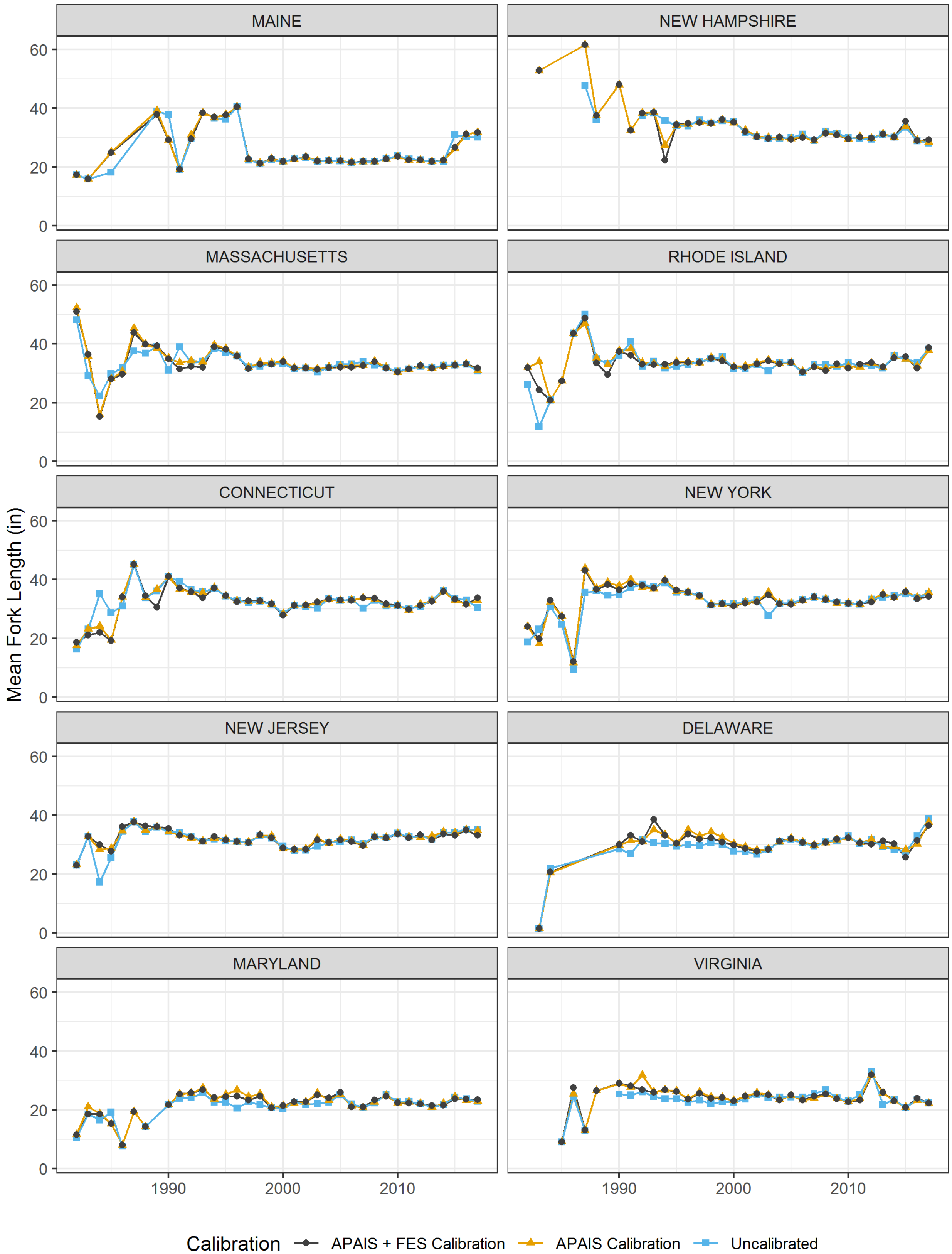


Figure B6.26. Comparison of calibrated and uncalibrated mean lengths of recreationally harvested striped bass by state.

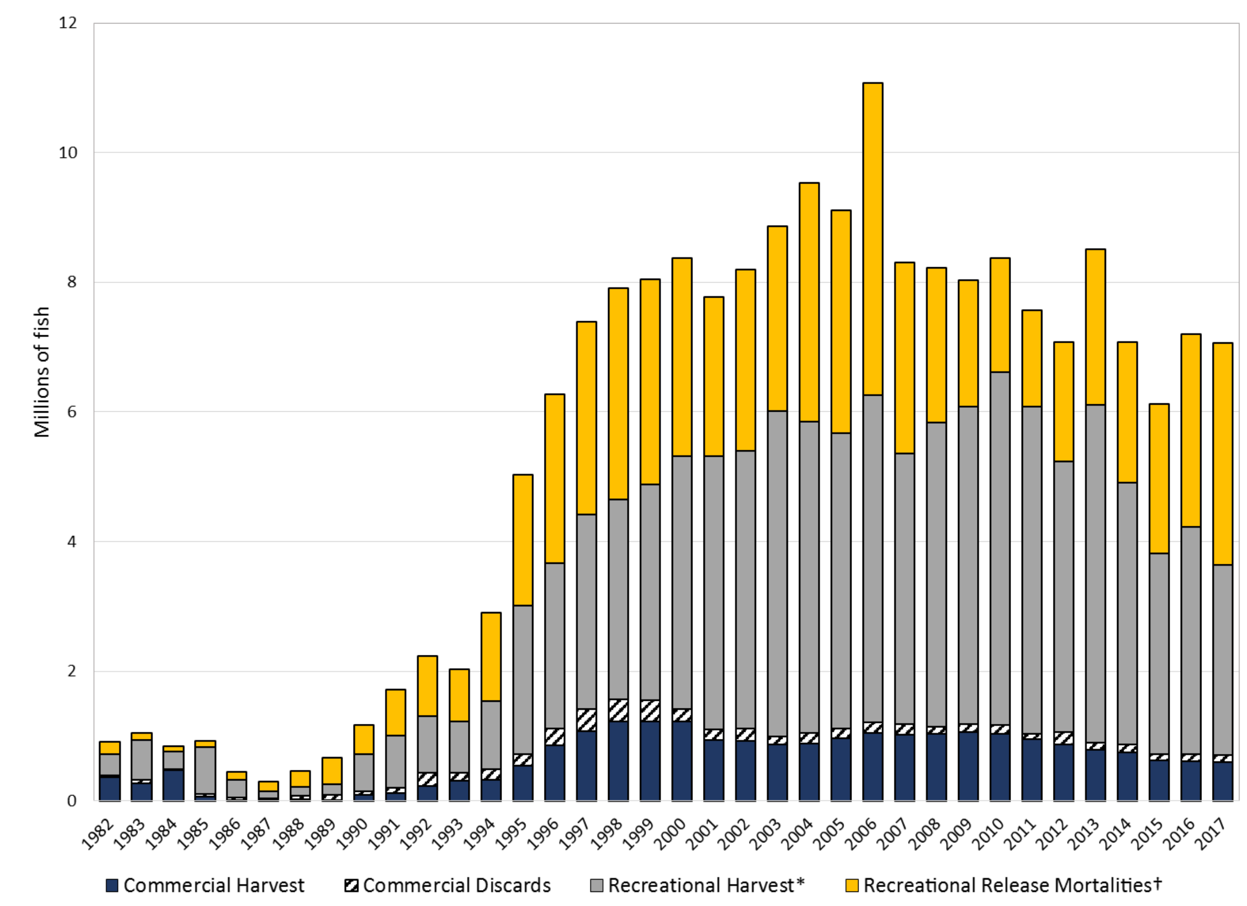


Figure B6.27. Total removals of striped bass on the Atlantic coast by sector.* Recreational harvest includes estimates of Wave-1 harvest for North Carolina and Virginia. † Release mortality of 9% applied to live releases.

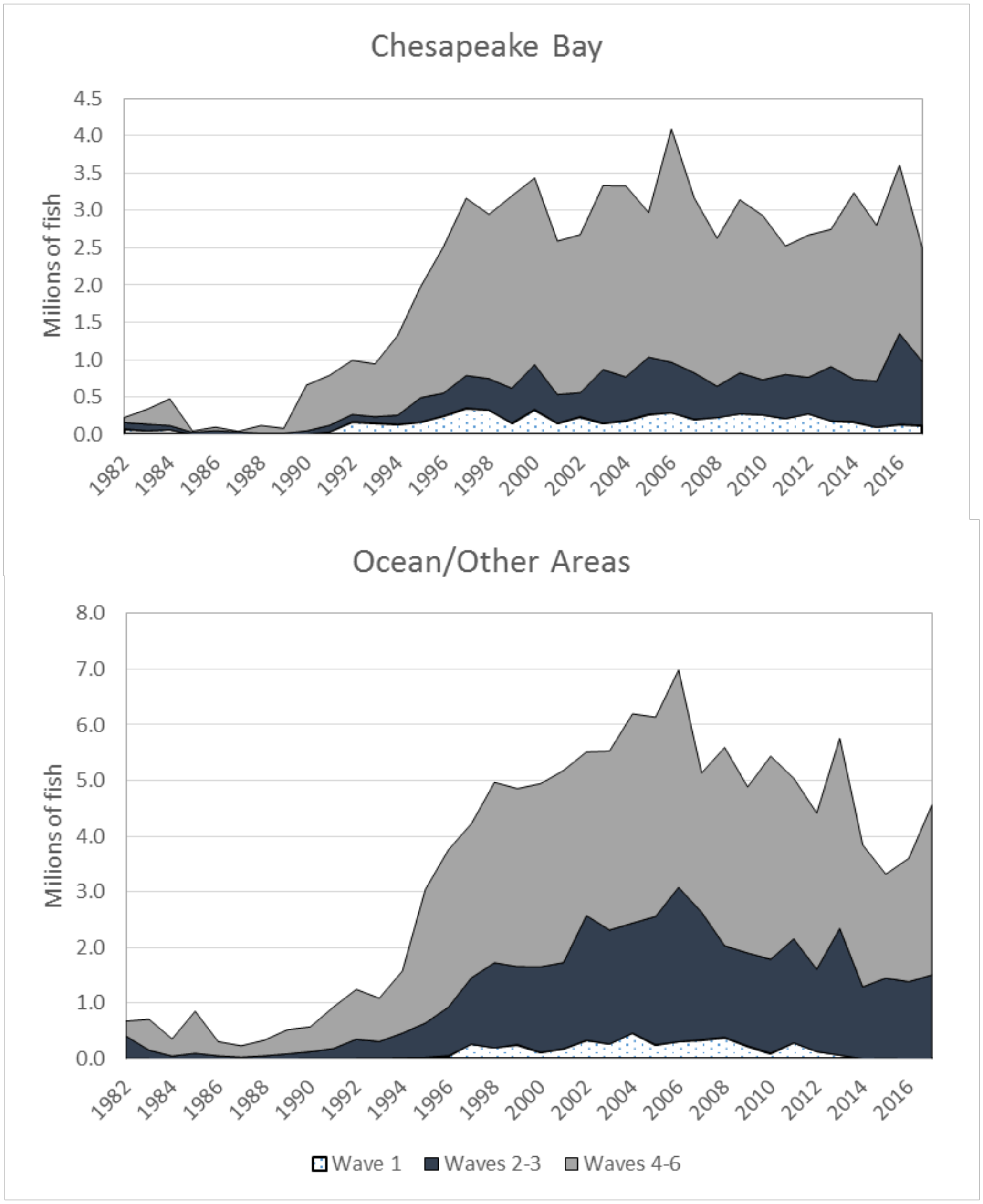


Figure B6.28. Total removals of striped bass by wave period for the Chesapeake Bay (top) and ocean and other areas (bottom).

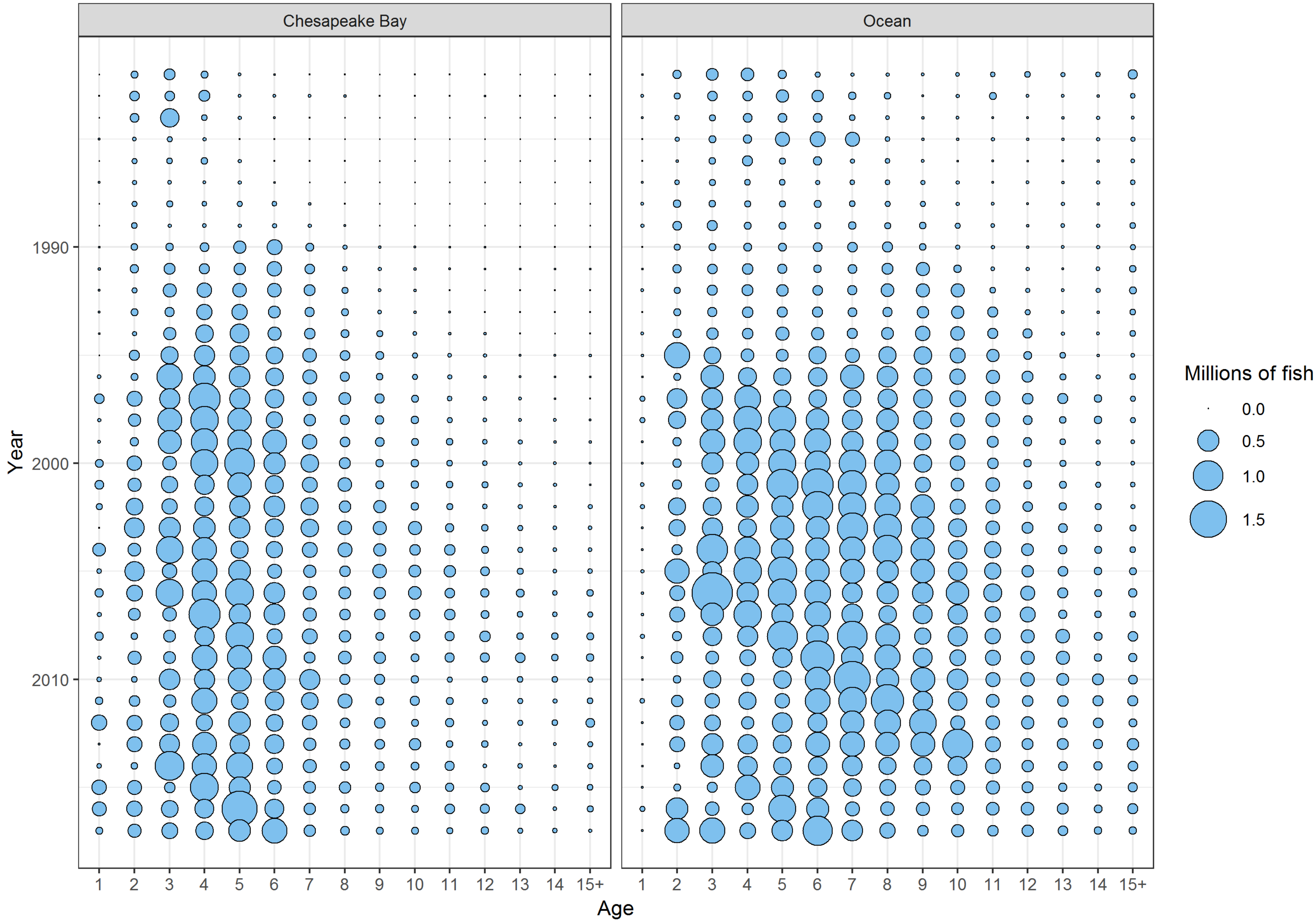


Figure B6.29. Annual total removals at age of striped bass by region.

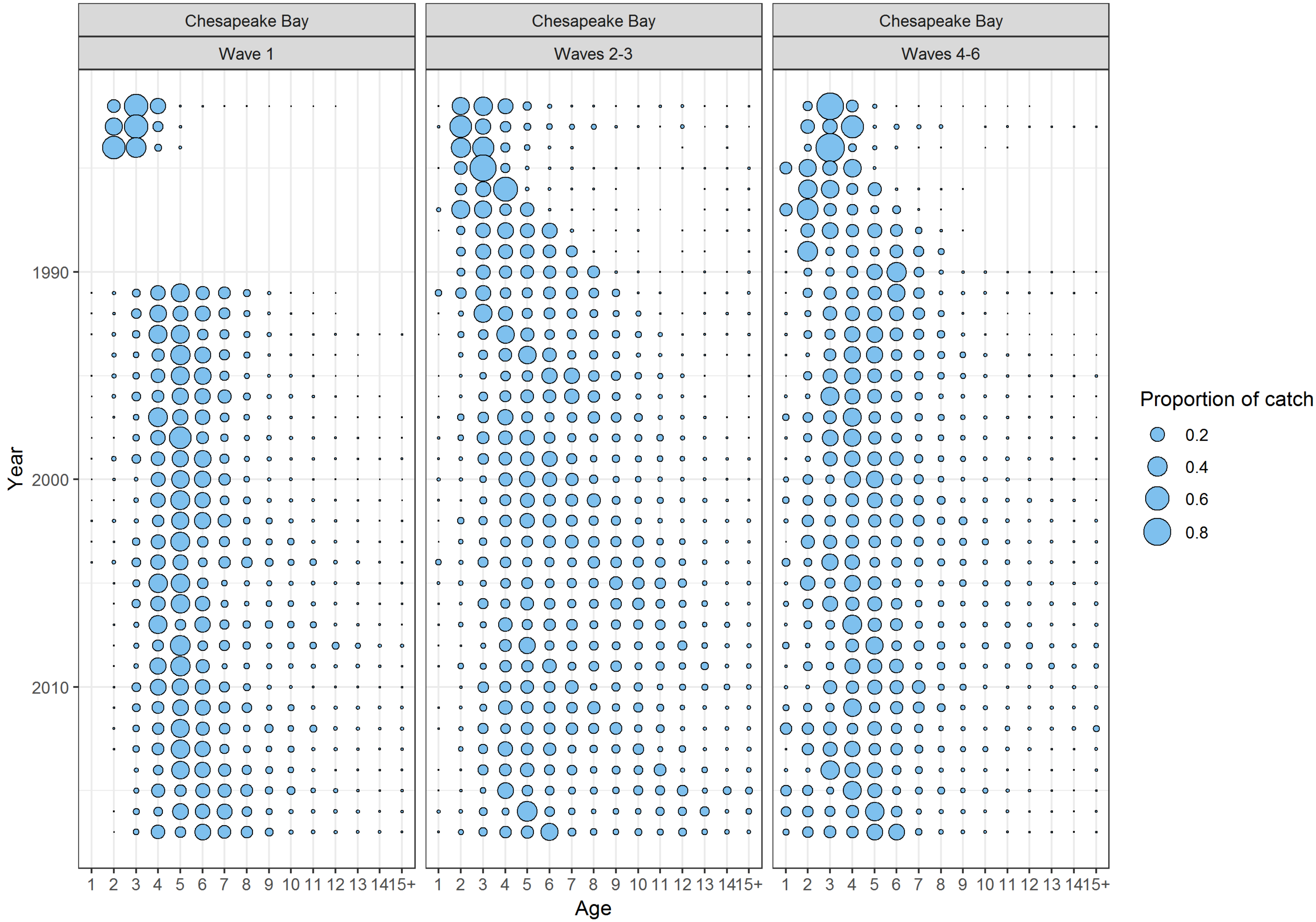


Figure B6.30. Proportion at age in the total removals by year and wave period for the Chesapeake Bay.

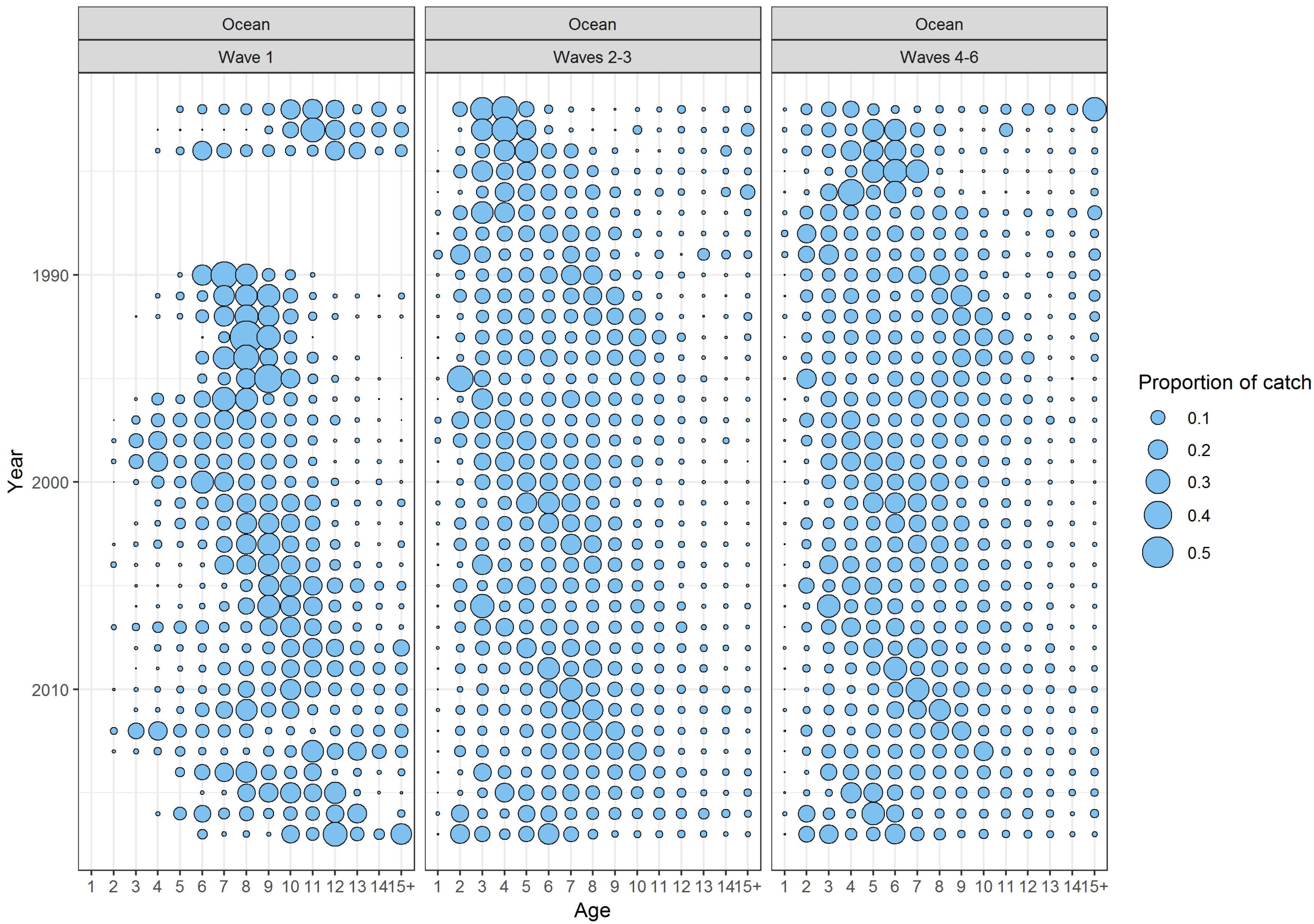


Figure B6.31. Proportion at age in the total removals by year and wave period for the ocean region.

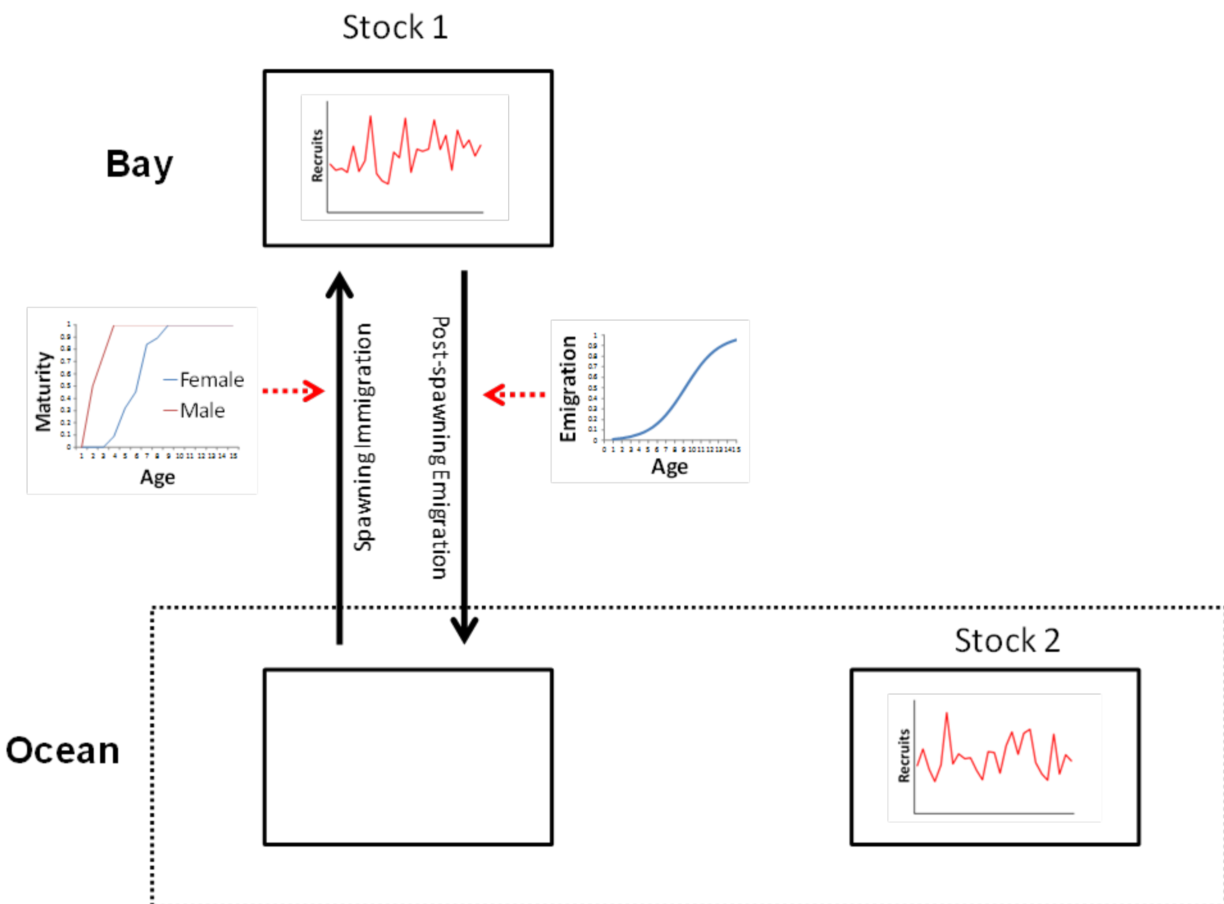


Figure B7.1. Depiction of the general population dynamics of the two-stock model.

Figure B 7.2. Schematic of the abundance calculations for Stock-1 (the Chesapeake Bay stock)..

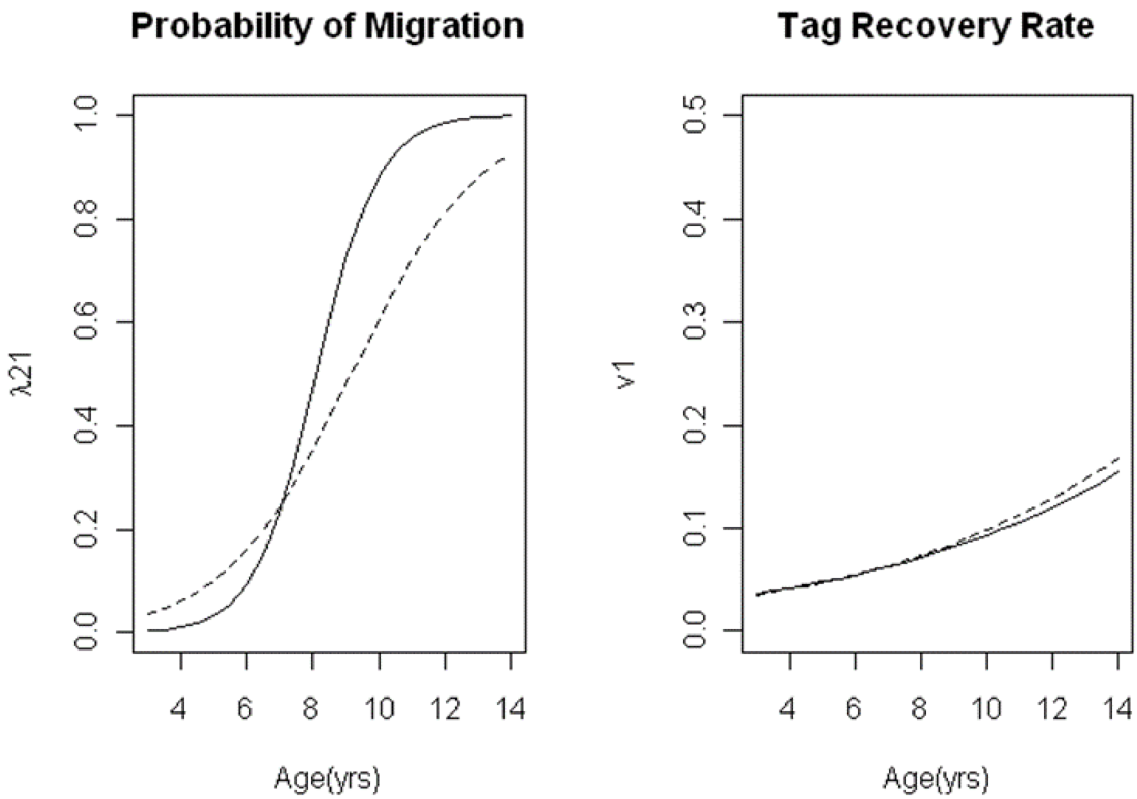


Figure B7.3. Estimates of emigration probabilities (λ21) and tag recovery rate (v1) at-age derived from Dorazio et al. (1994) methodology using 1988-1995 Maryland only data (dashed line) and combined Maryland and Virginia data (solid line).

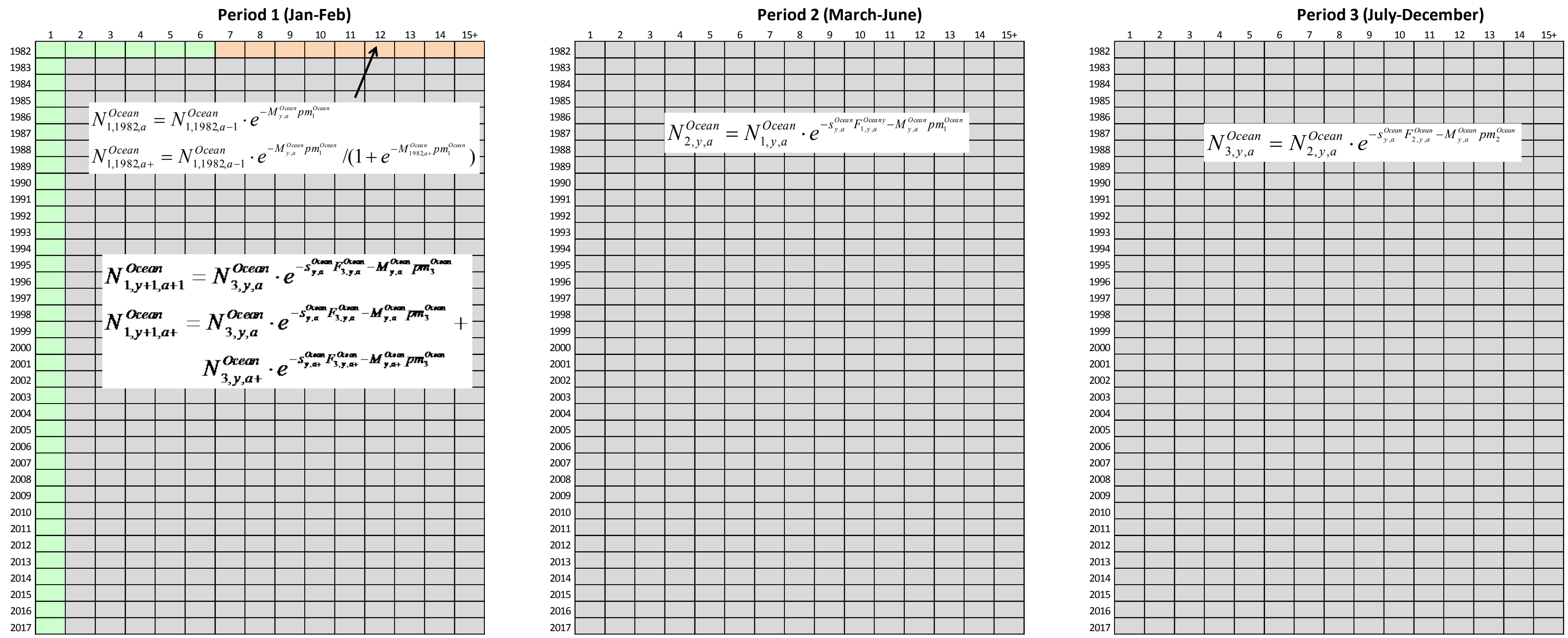


Figure B7.4. Schematic of abundance calculations for Stock-2 (the Delaware Bay/Hudson River).

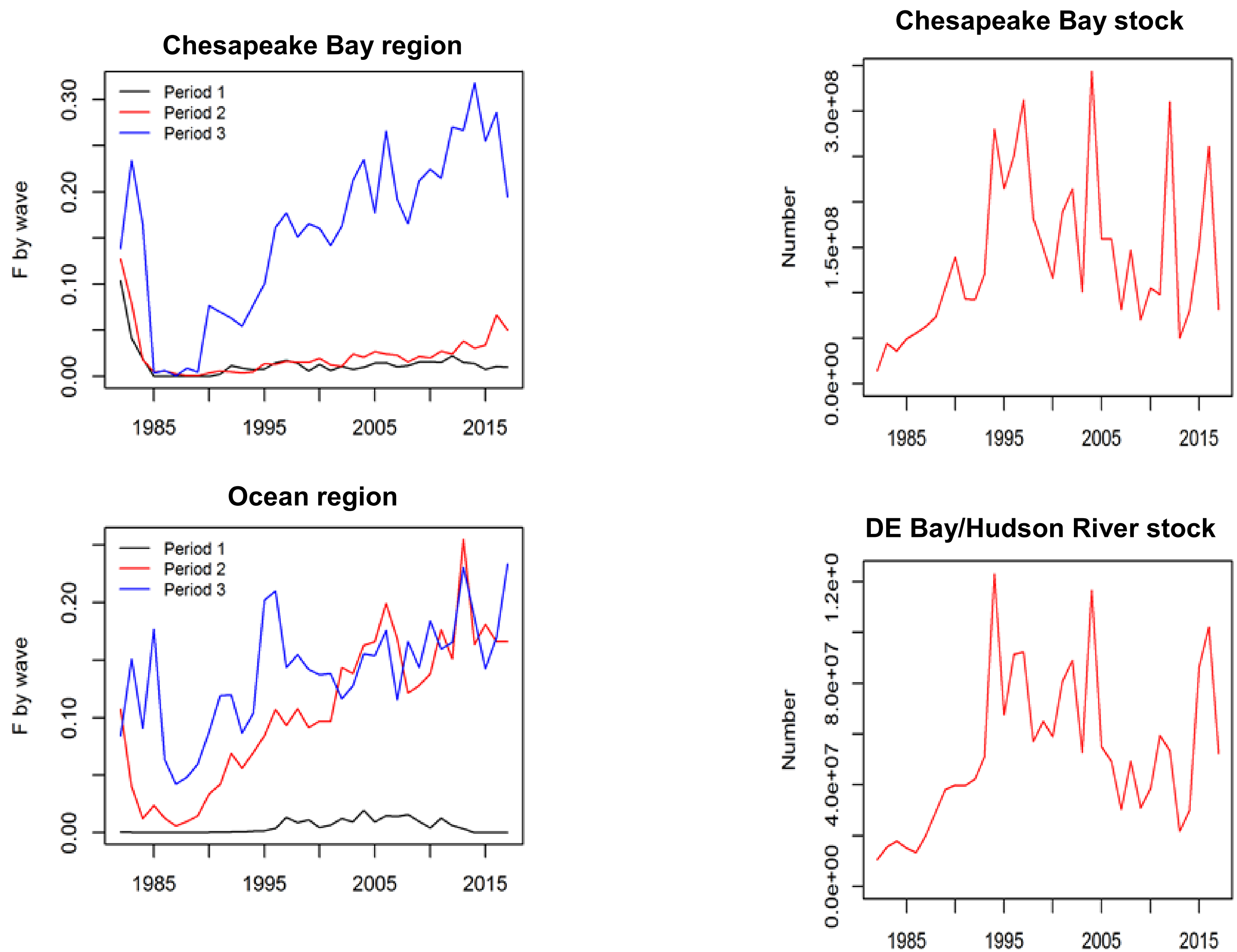


Figure B7.5. Annual estimates of fully-recruited fishing mortality by region and period (left) and annual recruitment (age-1 numbers) (right) by stock.

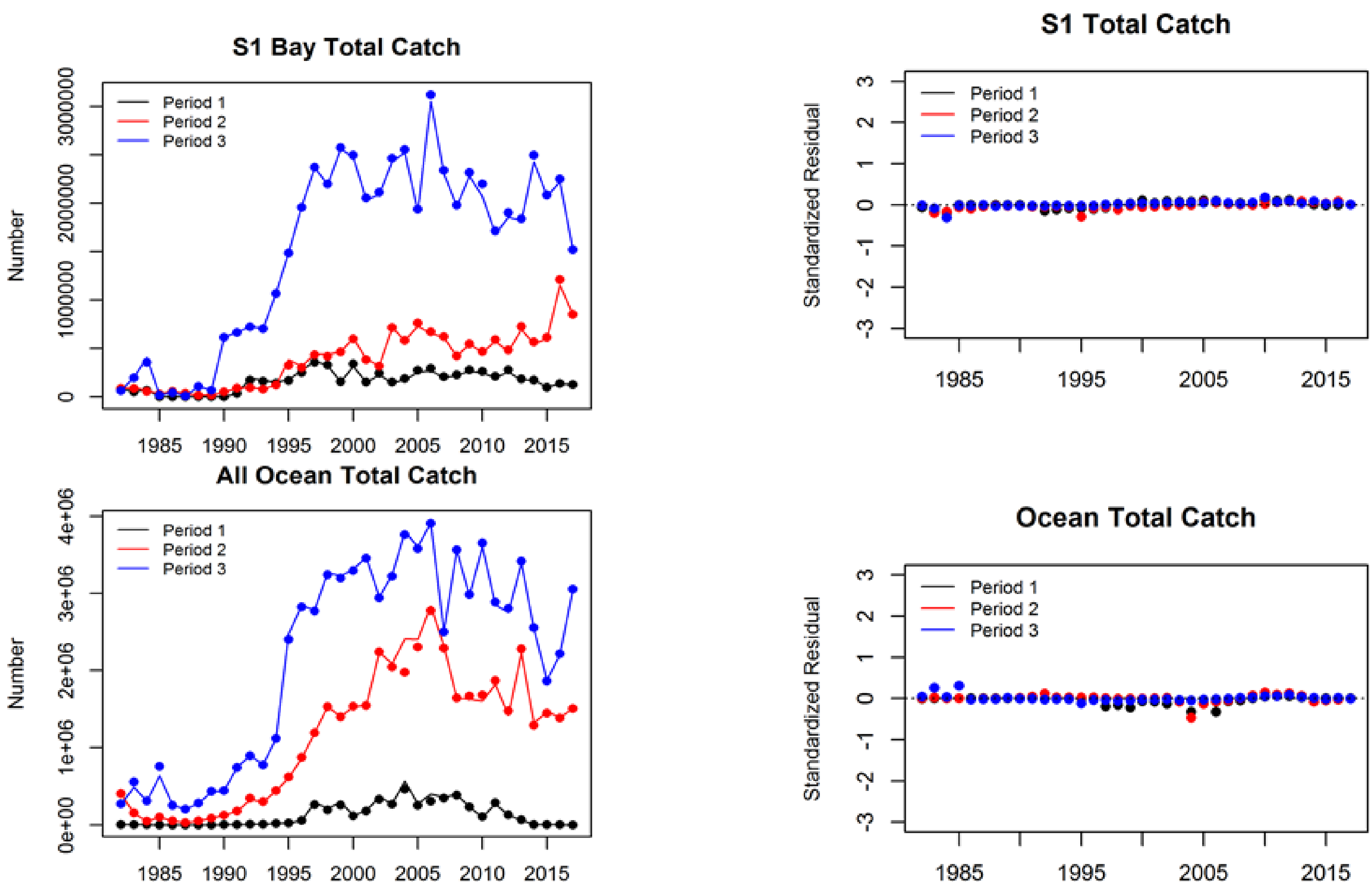
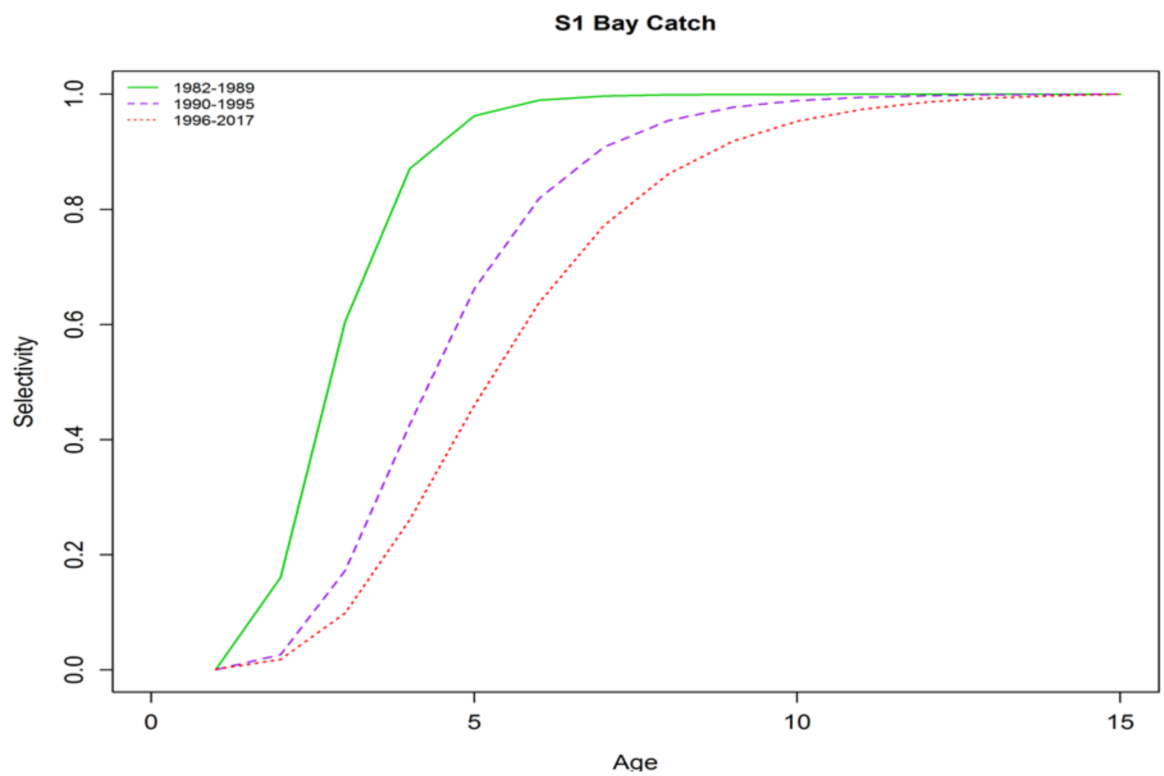


Figure B7.6. Comparison of observed (dot) and predicted (lines) estimates of total catch by region, period and year (left), and standardized residual plots (right).



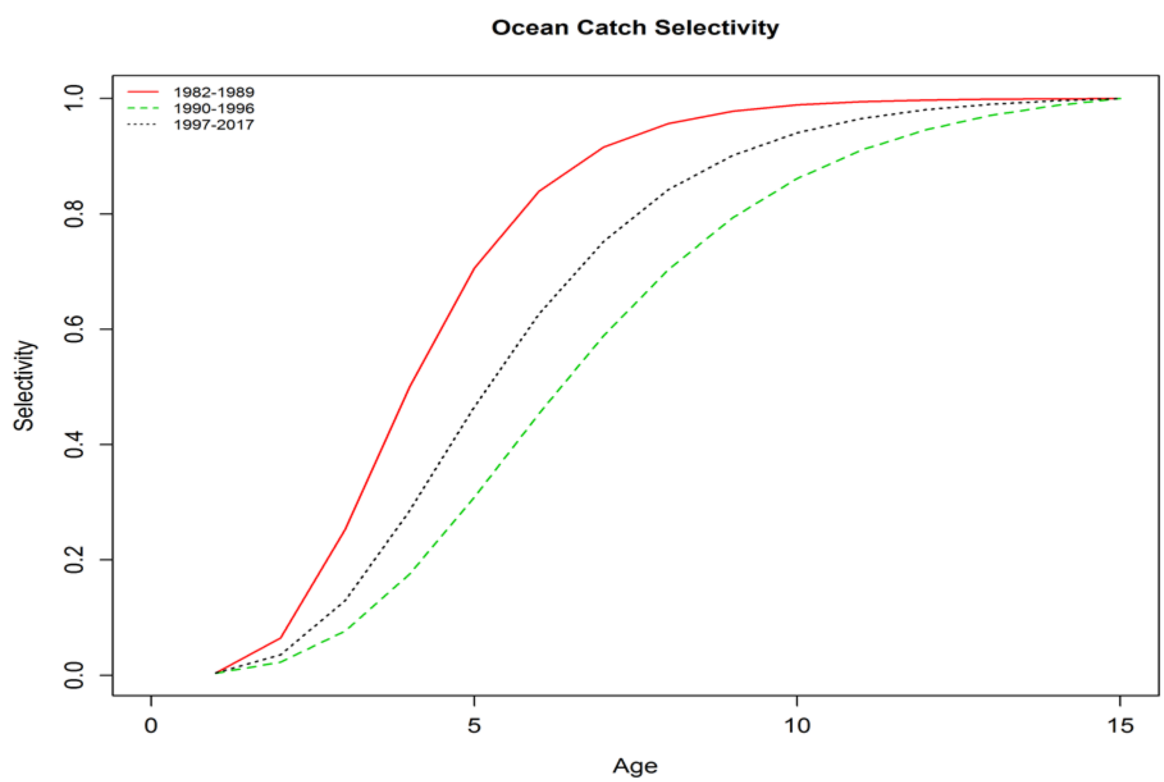


Figure B7.7. Selectivity patterns estimated for the Chesapeake Bay and Ocean fleets by time block and age.

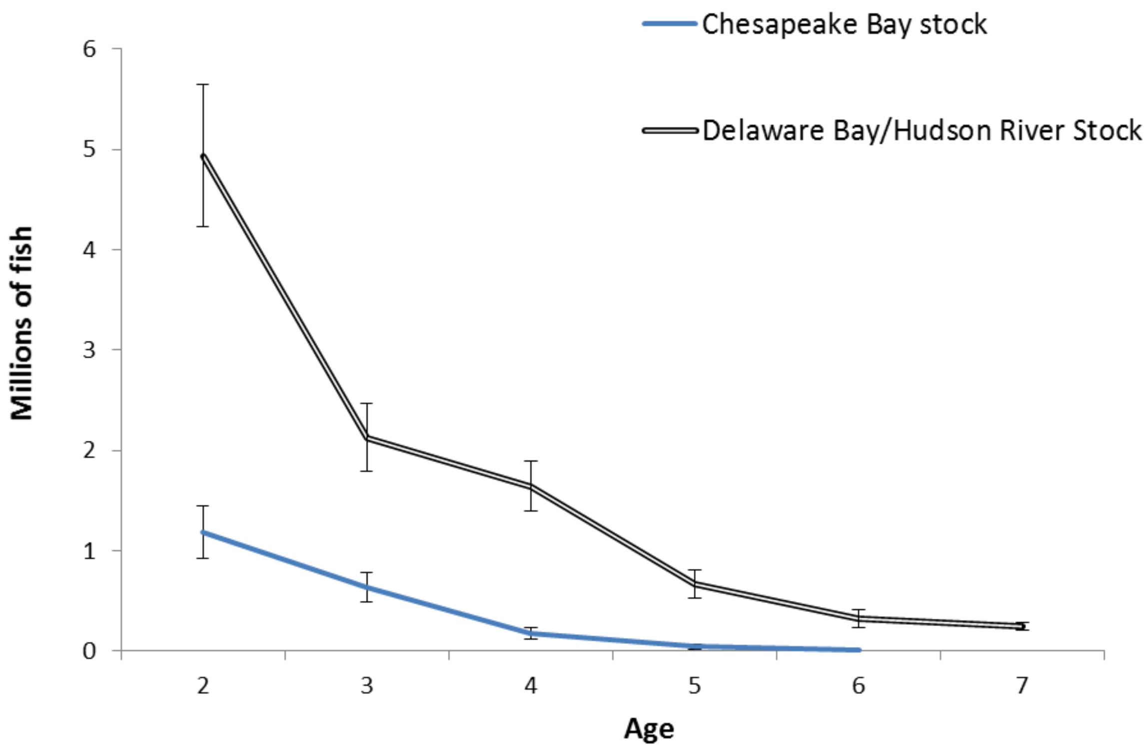


Figure B7.8. Estimates of abundance-at-age in the first year for the Chesapeake Bay stock in the Chesapeake Bay and the Delaware Bay/Hudson River stock in the ocean. Error bars indicate ±1 standard error.

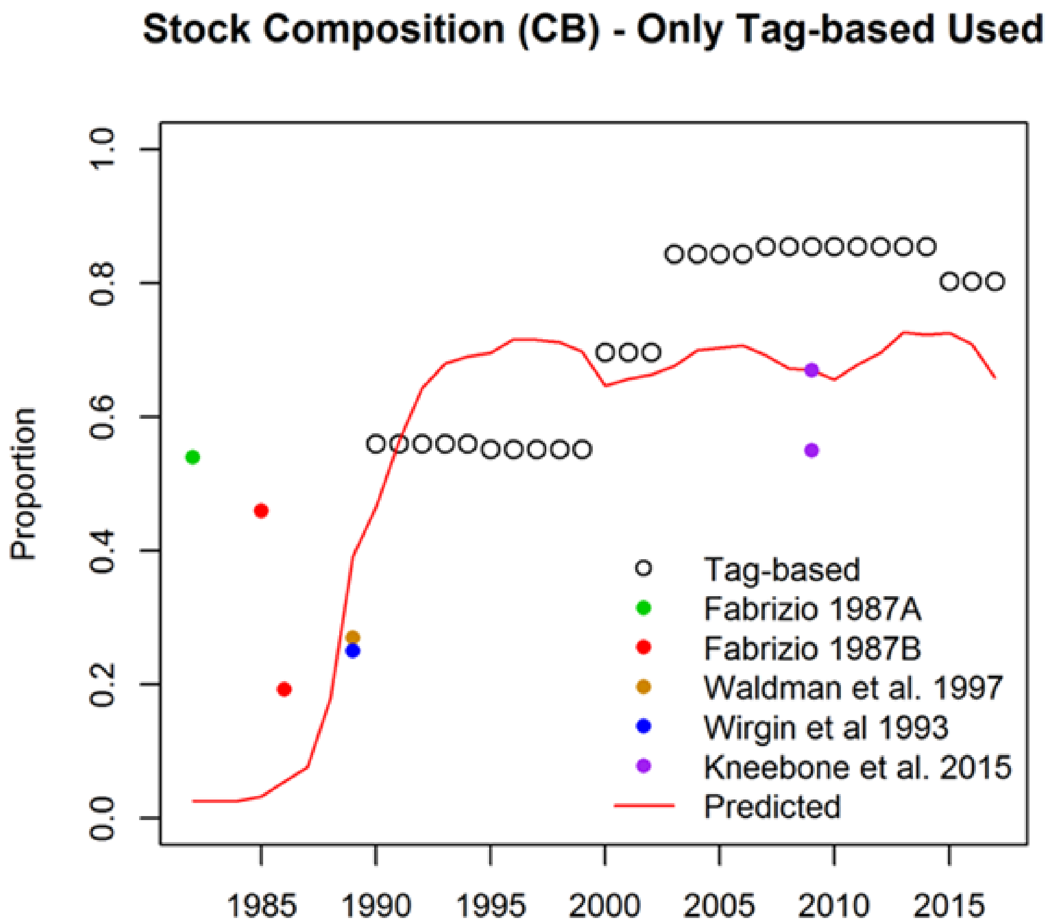


Figure B7.9. Observed versus predicted stock composition for the Chesapeake Bay stock. Literature values not used in the model fitting are indicted by the solid circles for comparison.

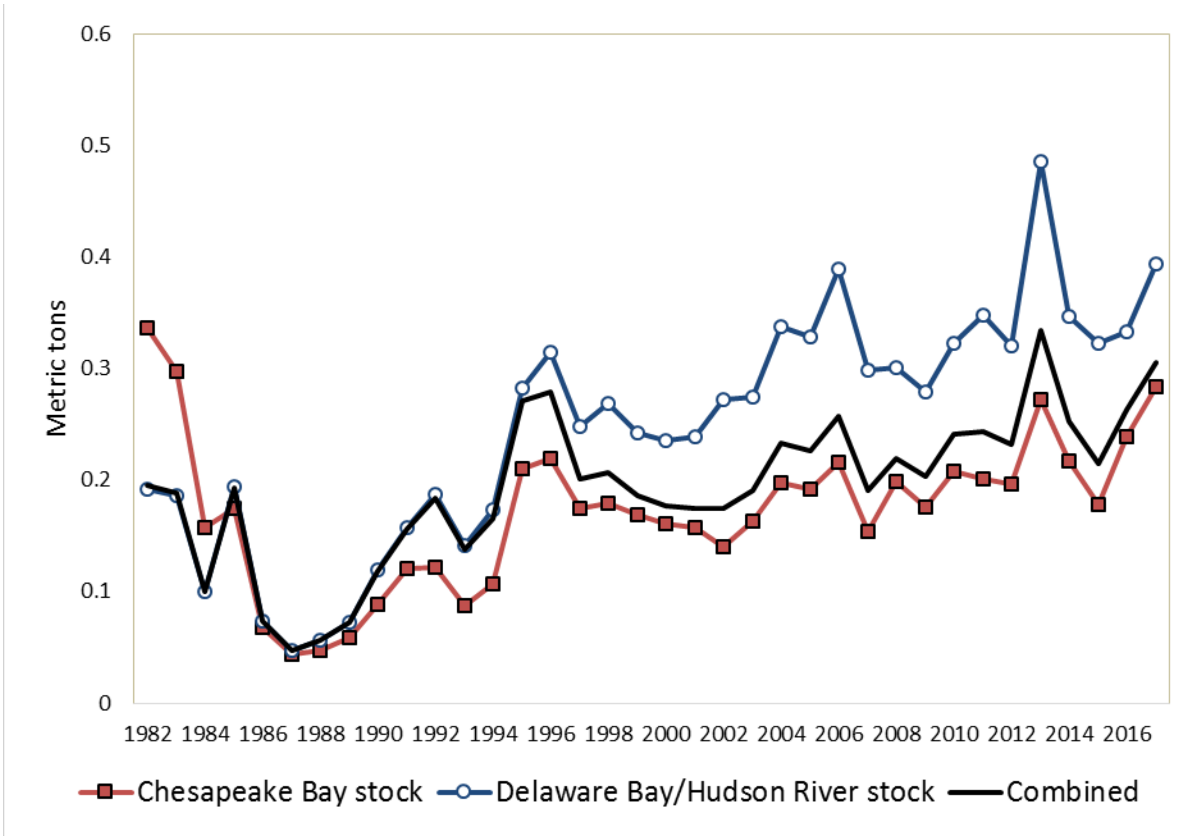


Figure B7.10. Estimates of fully-recruited fishing mortality (F) for the Chesapeake Bay stock and the Delaware Bay/Hudson River stock, and for both stocks combined.

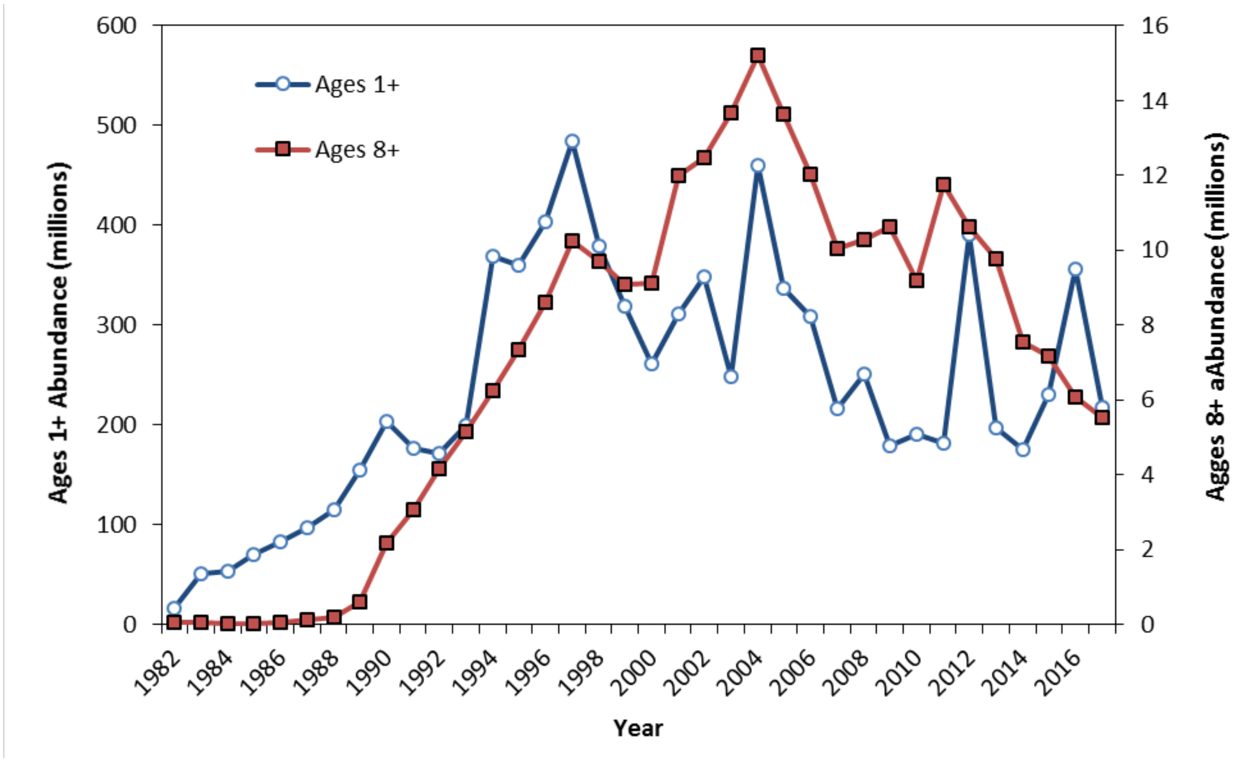


Figure B7.11. Estimates of population abundance of the Chesapeake Bay stock for ages 1+ and ages 8+.

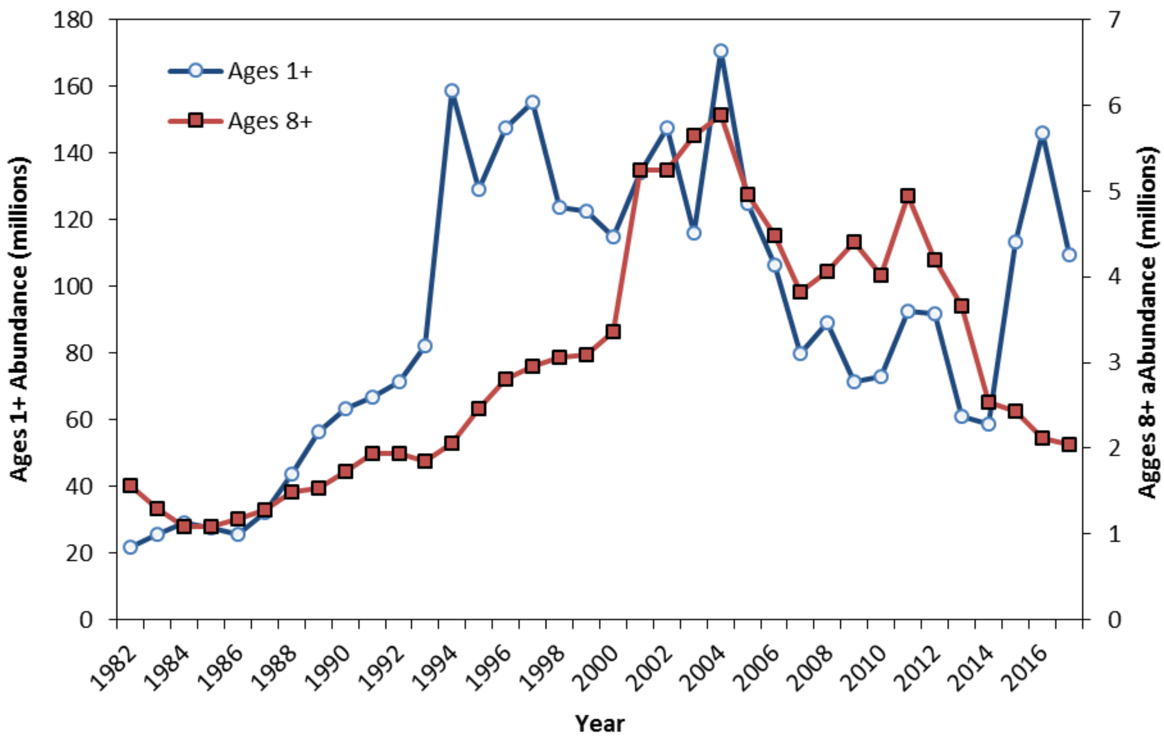


Figure B7.12. Estimates of population abundance of the Delaware River/Hudson Bay stock for ages 1+ and ages 8+.

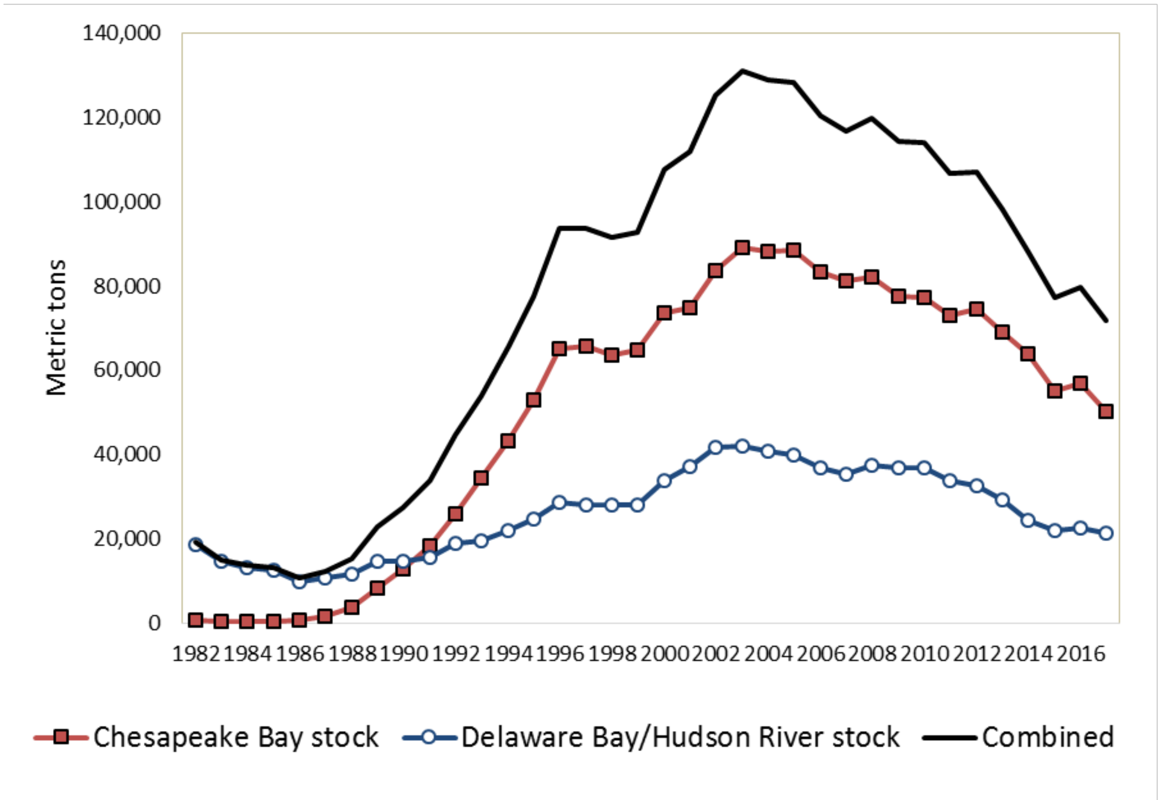


Figure B7.13. Estimates of female spawning stock biomass for Stock-1 (Chesapeake Bay stock) and Stock-2 (Delaware Bay/Hudson River stock) plotted with the combined total female spawning stock biomass.

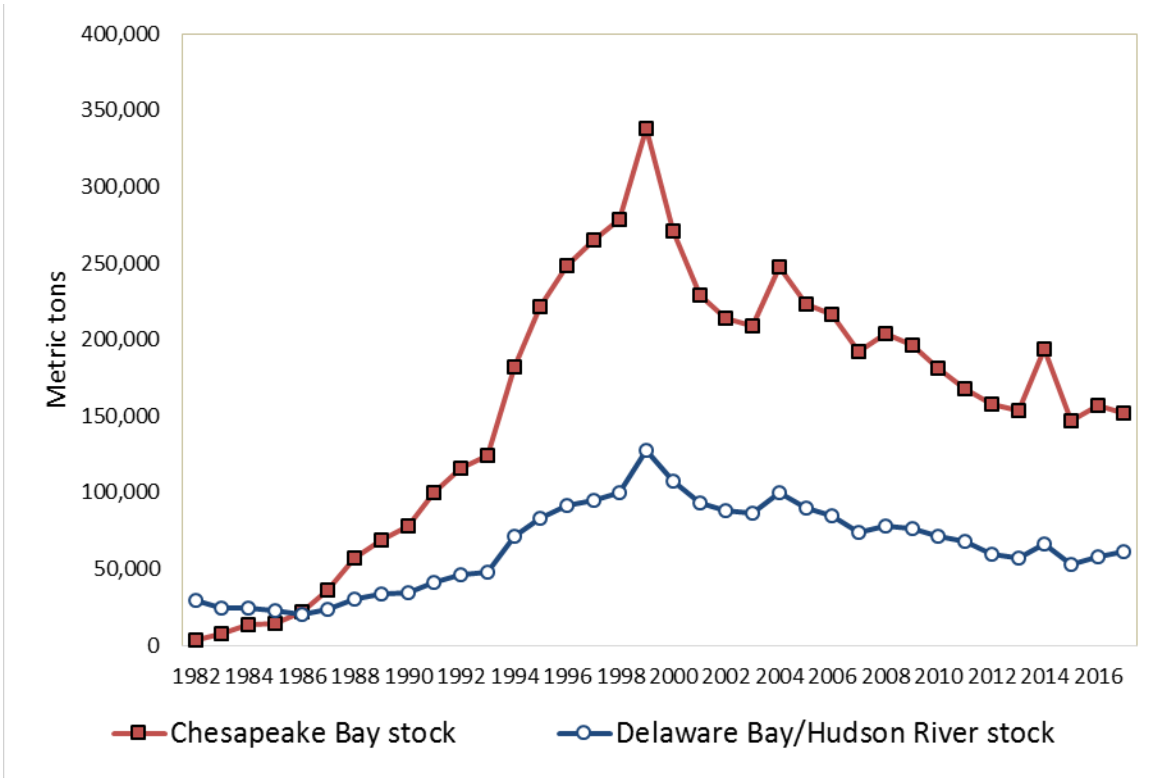
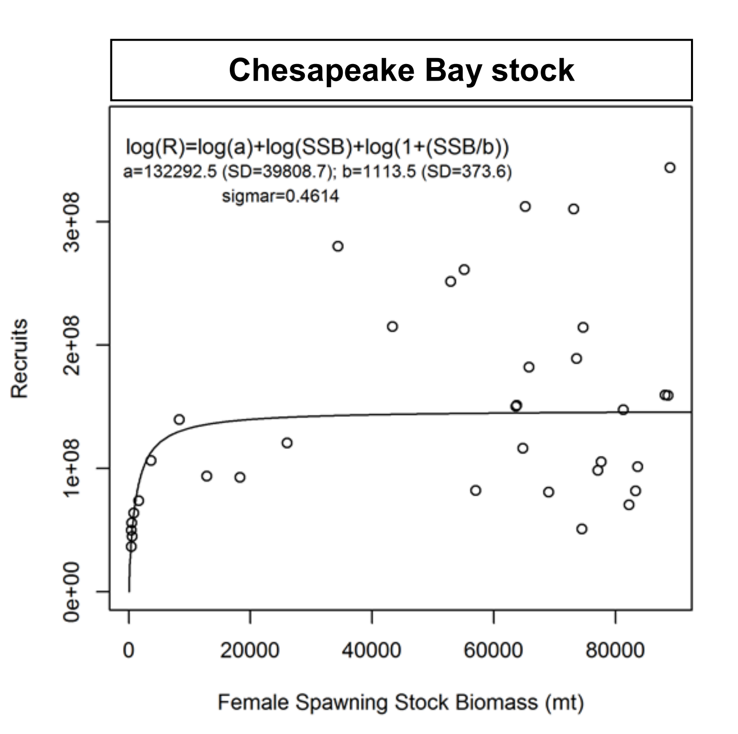


Figure B7.14. Estimates of total January 1 biomass for Stock-1 (Chesapeake Bay stock) and Stock-2 (Delaware Bay/Hudson River stock).



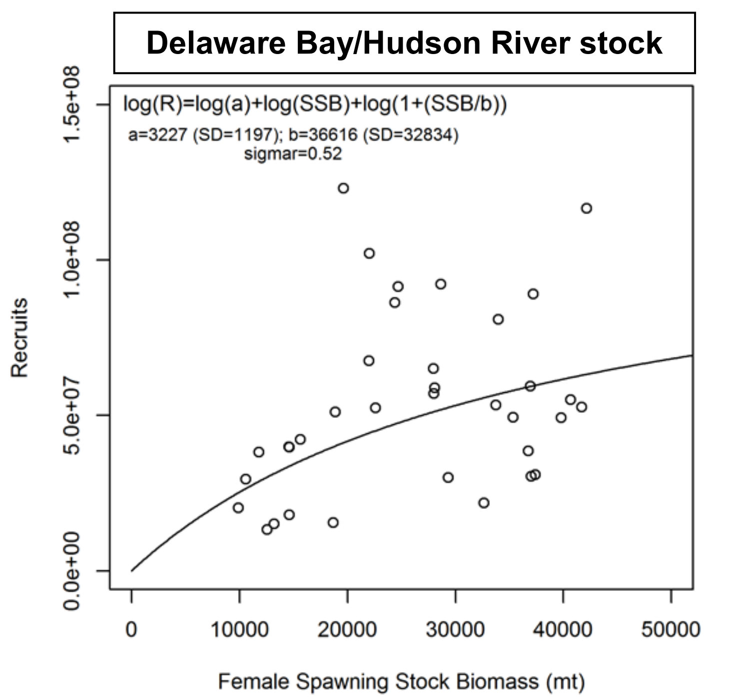


Figure B7.15. Estimates of recruits versus female spawning stock biomass for the Chesapeake Bay stock (top) and the Delaware Bay/Hudson River stock (bottom).

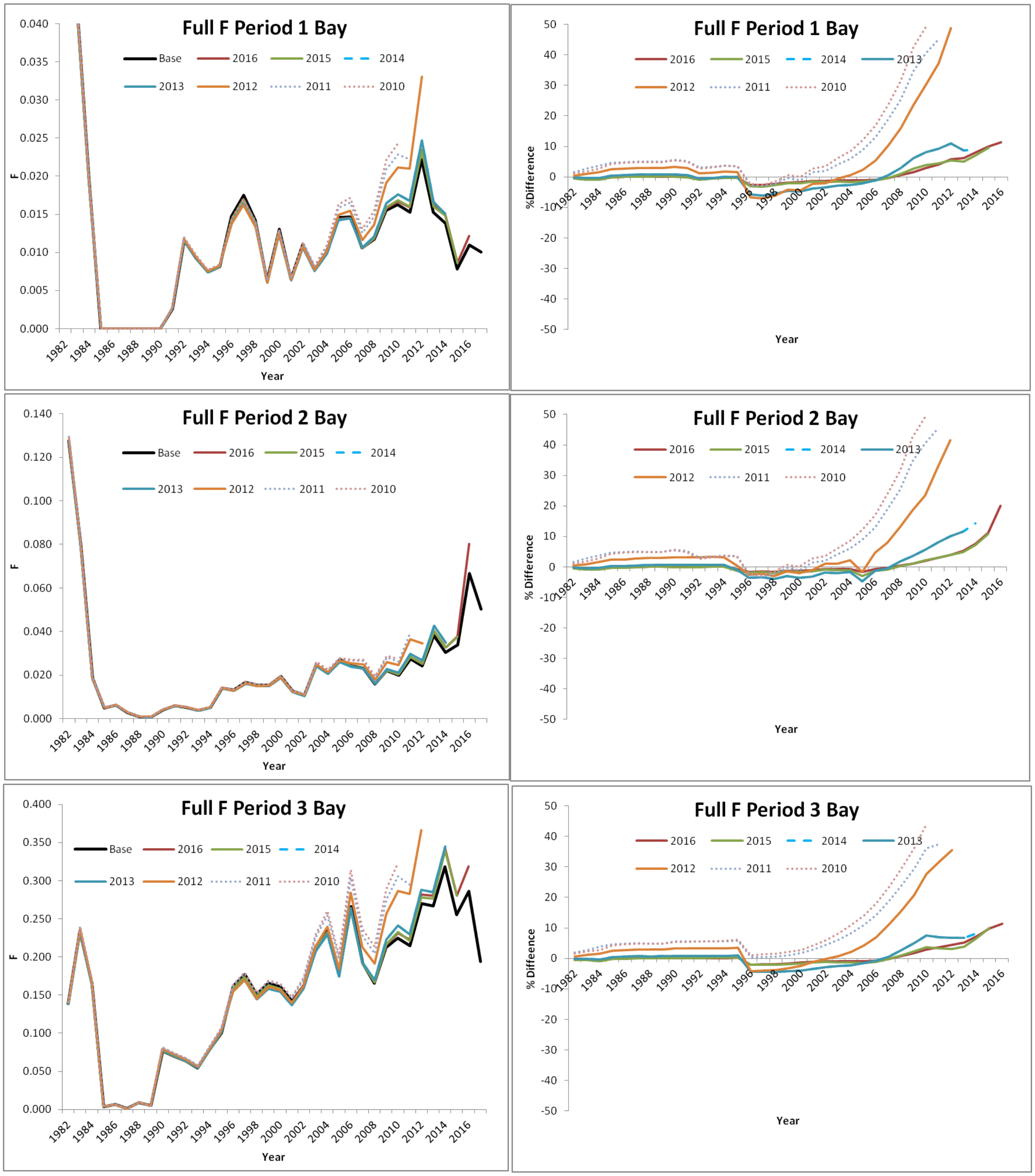


Figure B7.16. Retrospective analyses for fully-recruited fishing mortality (F) in periods 1-3 for the Chesapeake Bay region.

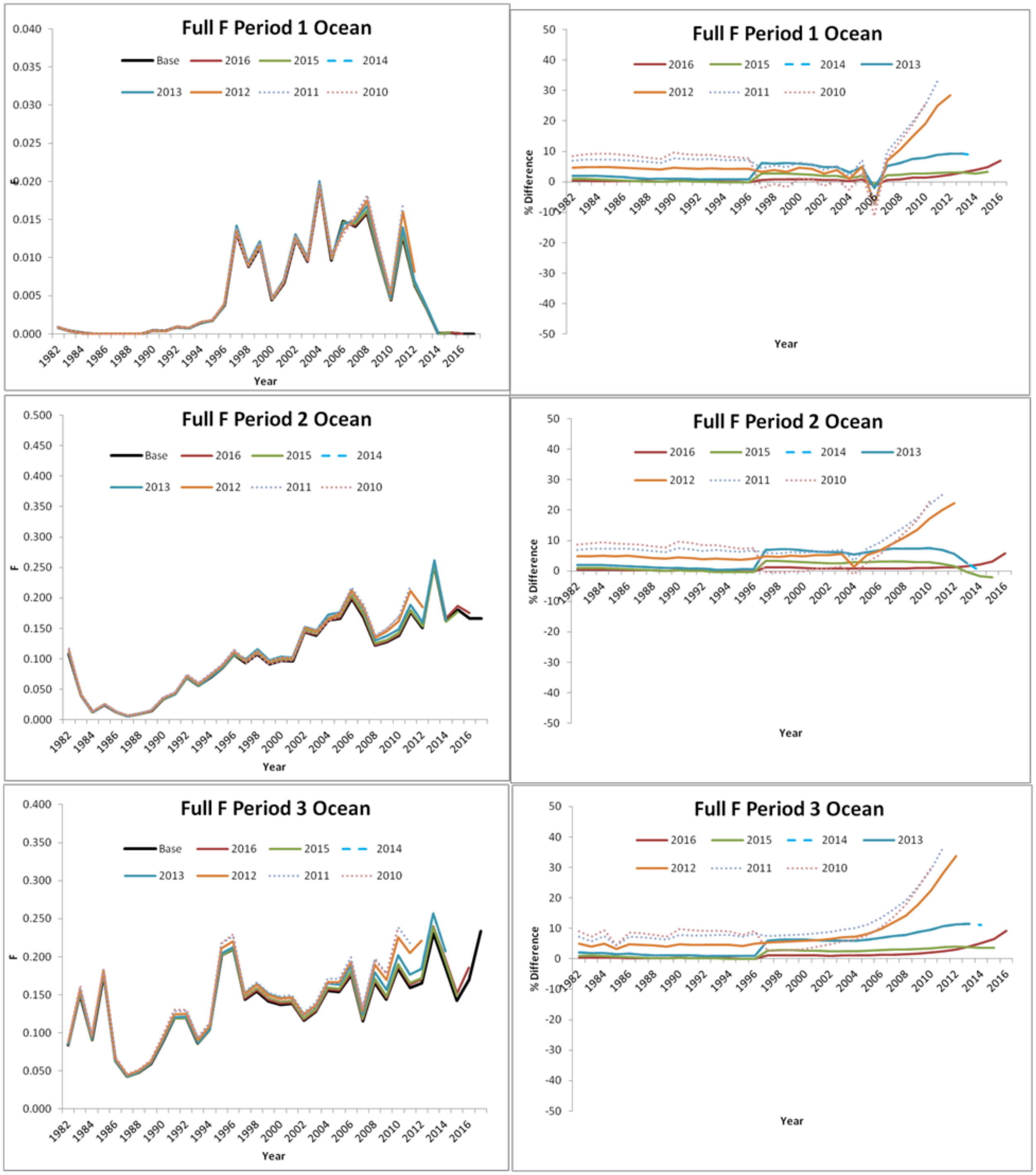


Figure B7.17. Retrospective analyses for fully-recruited fishing mortality (F) in periods 1-3 for the ocean region.

Figure B7.18. Retrospective analyses for Stock-1 (Chesapeake Bay stock) and Stock-2 (Delaware Bay/Hudson River stock) recruitment and female spawning stock biomass.

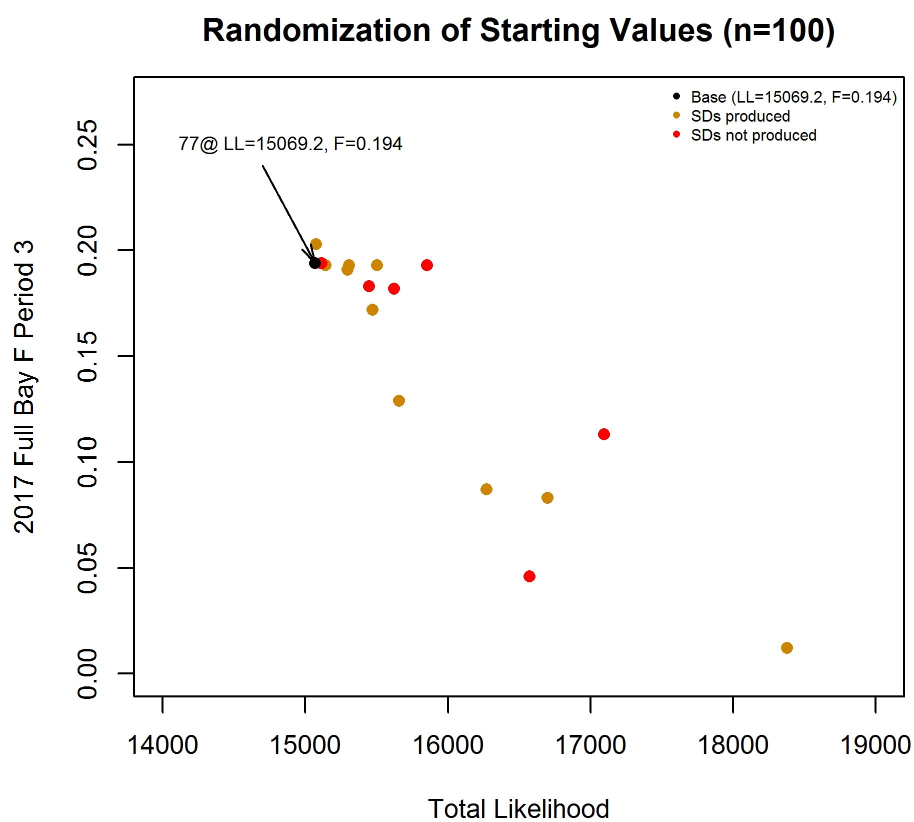


Figure B7.19. Biplot of fully-recruited fishing mortality in the Chesapeake Bay for period-3 versus total likelihood.

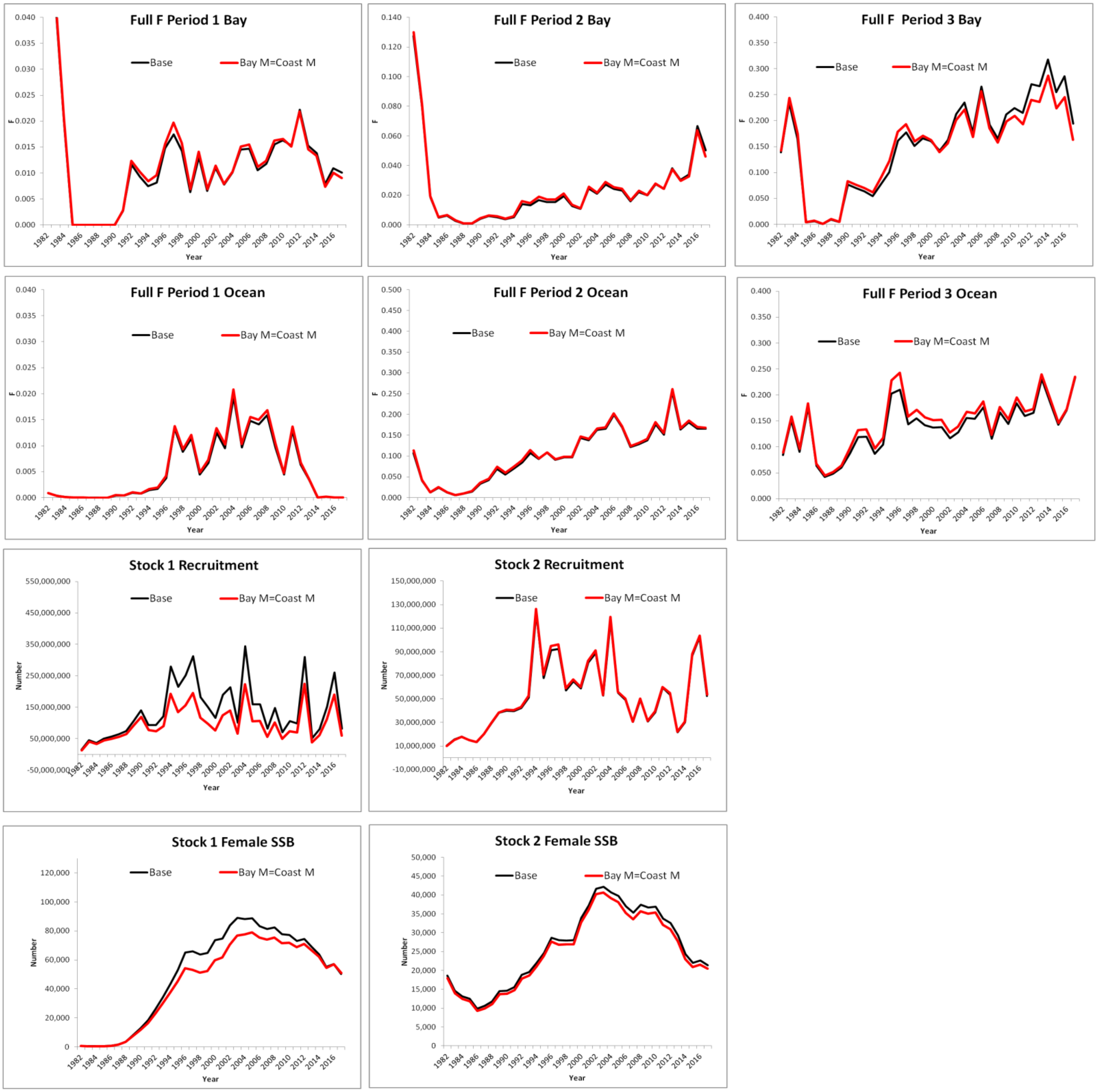


Figure B7.20. Results of sensitivity analysis of natural mortality (M) rates used in the Chesapeake Bay region.

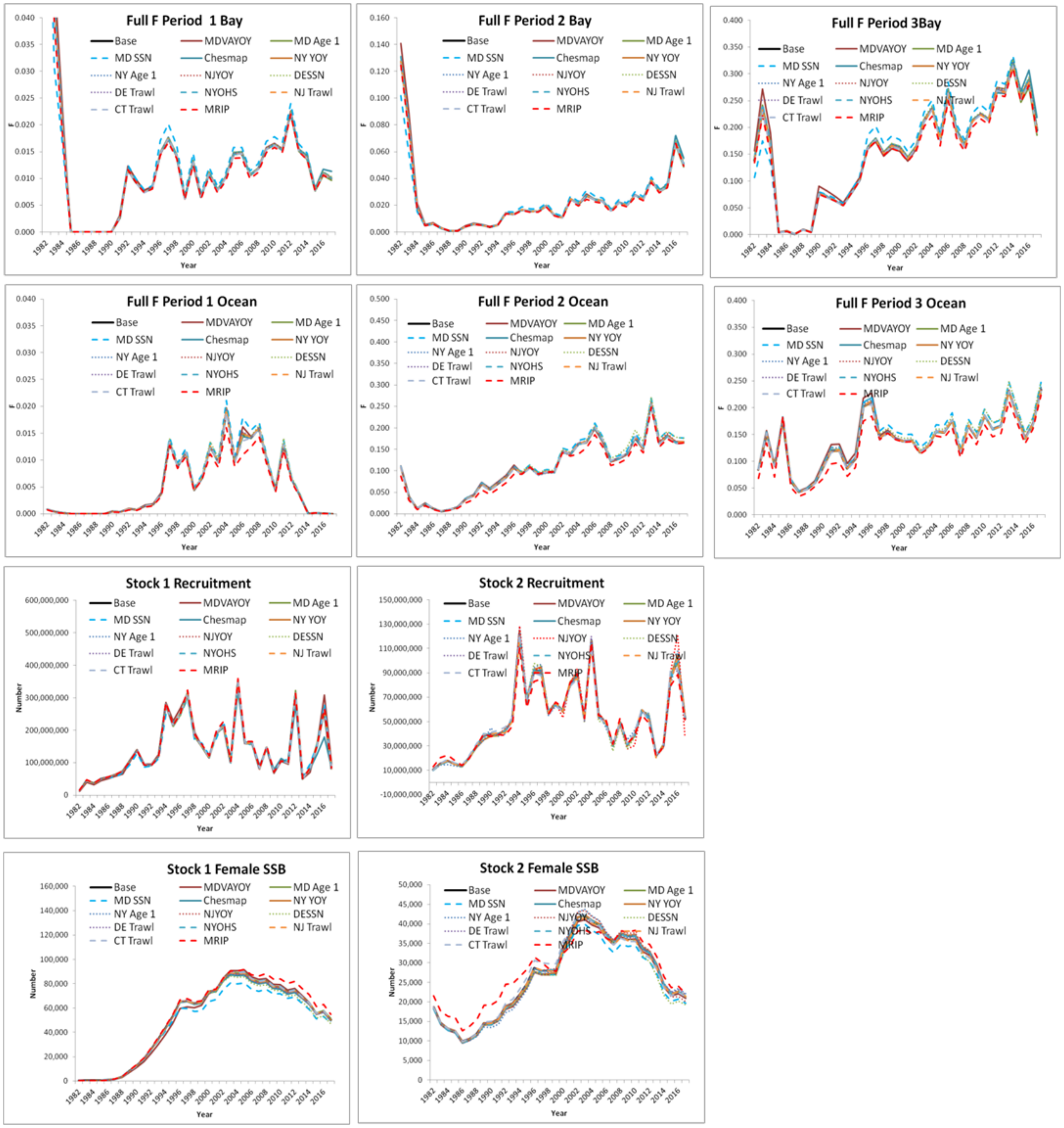


Figure B7.21. Results of sensitivity analysis of deleting one survey-at-a-time.Stock-1 = Chesapeake Bay stock; Stock-2 = Delaware Bay/Hudson River stock

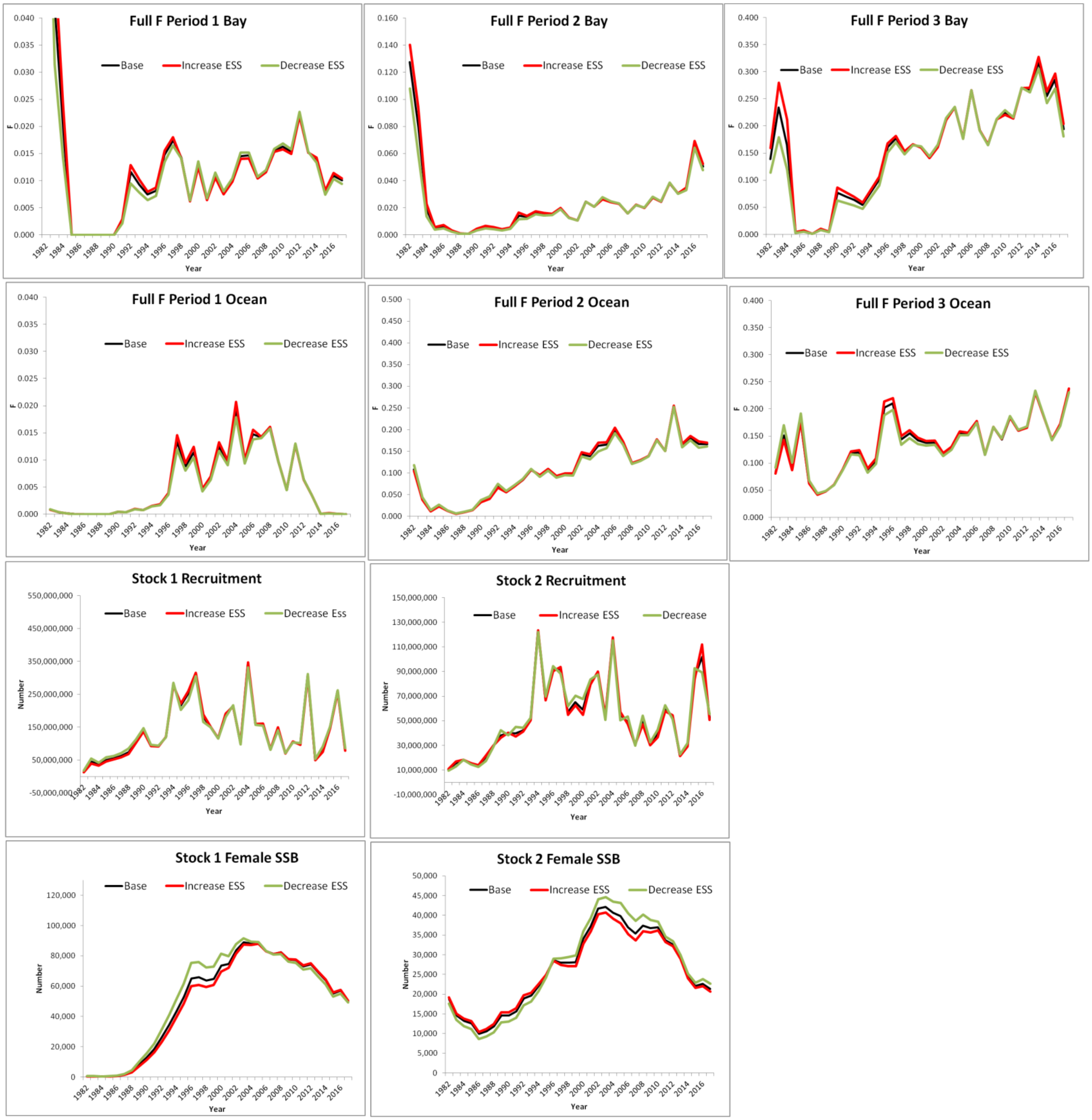


Figure B7.22. Results of sensitivity analysis of increasing or decreasing the effective sample size of composition data. Stock-1 = Chesapeake Bay stock; Stock-2 = Delaware Bay/Hudson River stock

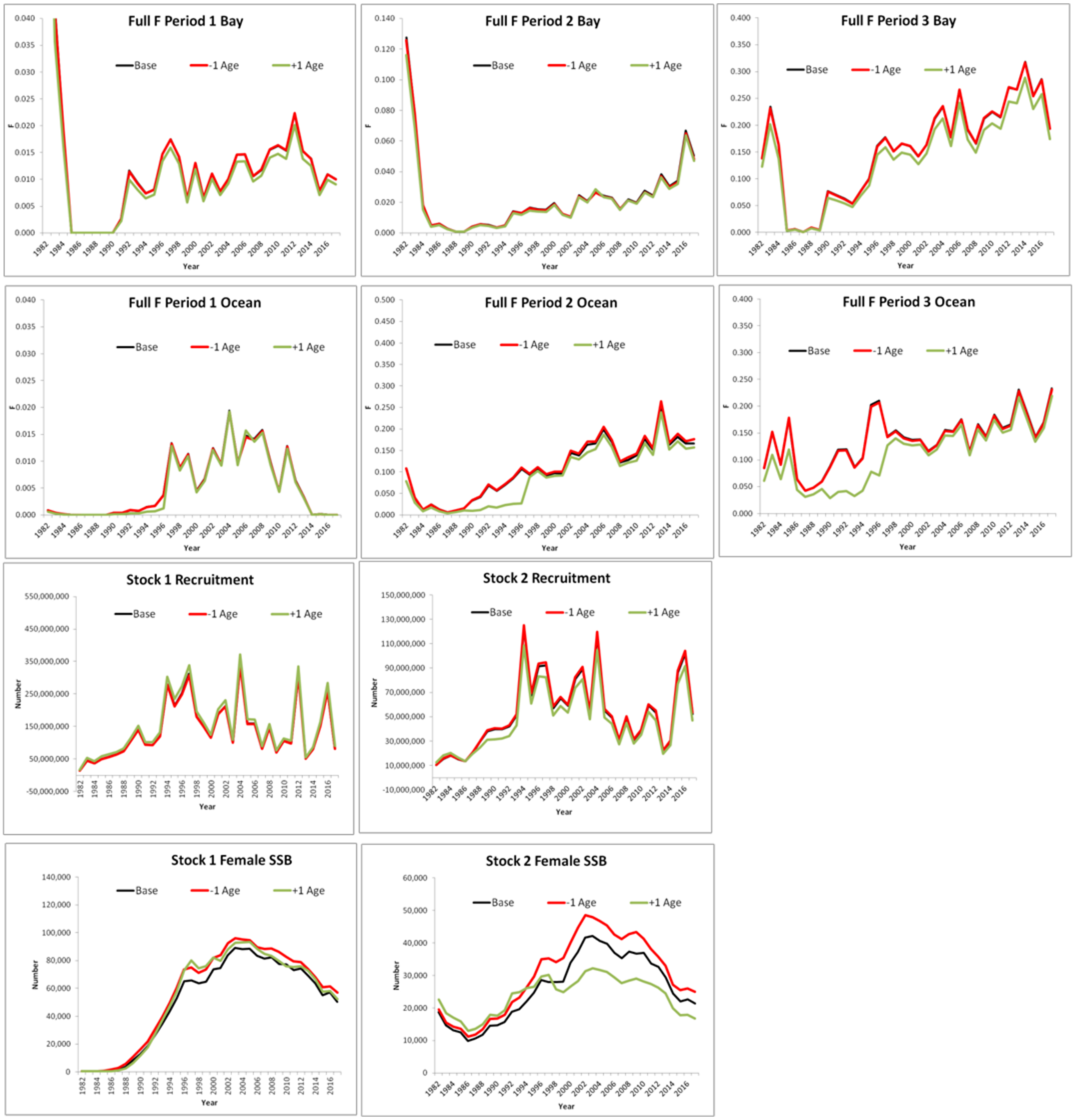


Figure B7.23. Results of sensitivity analysis of female and male maturity schedules. Stock-1 = Chesapeake Bay stock; Stock-2 = Delaware Bay/Hudson River stock

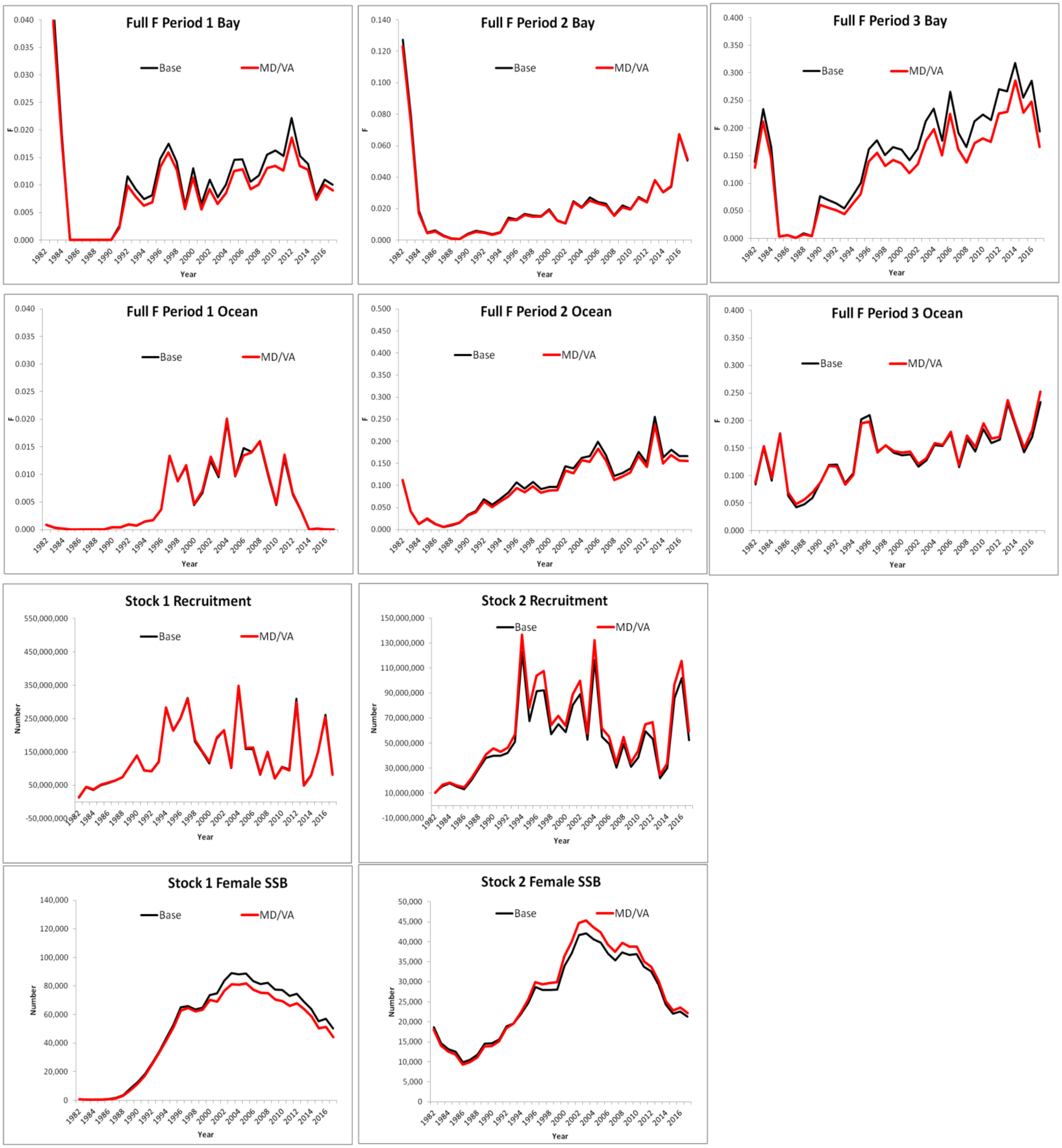


Figure B7.24. Results of sensitivity analysis of emigration probabilities-at-age.Stock-1 = Chesapeake Bay stock; Stock-2 = Delaware Bay/Hudson River stock

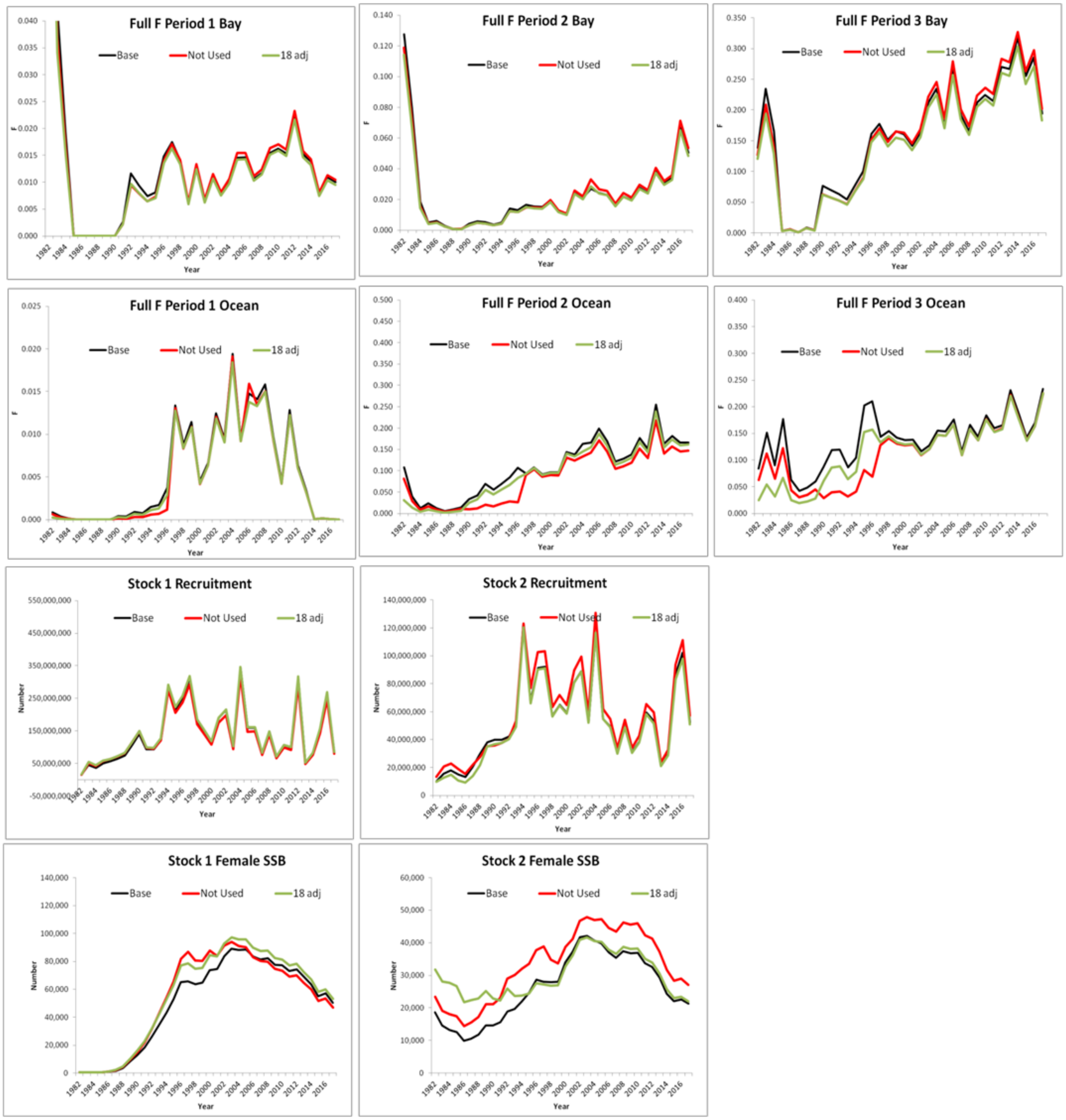


Figure B7.25. Results of sensitivity analysis of the stock composition index.Stock-1 = Chesapeake Bay stock; Stock-2 = Delaware Bay/Hudson River stock

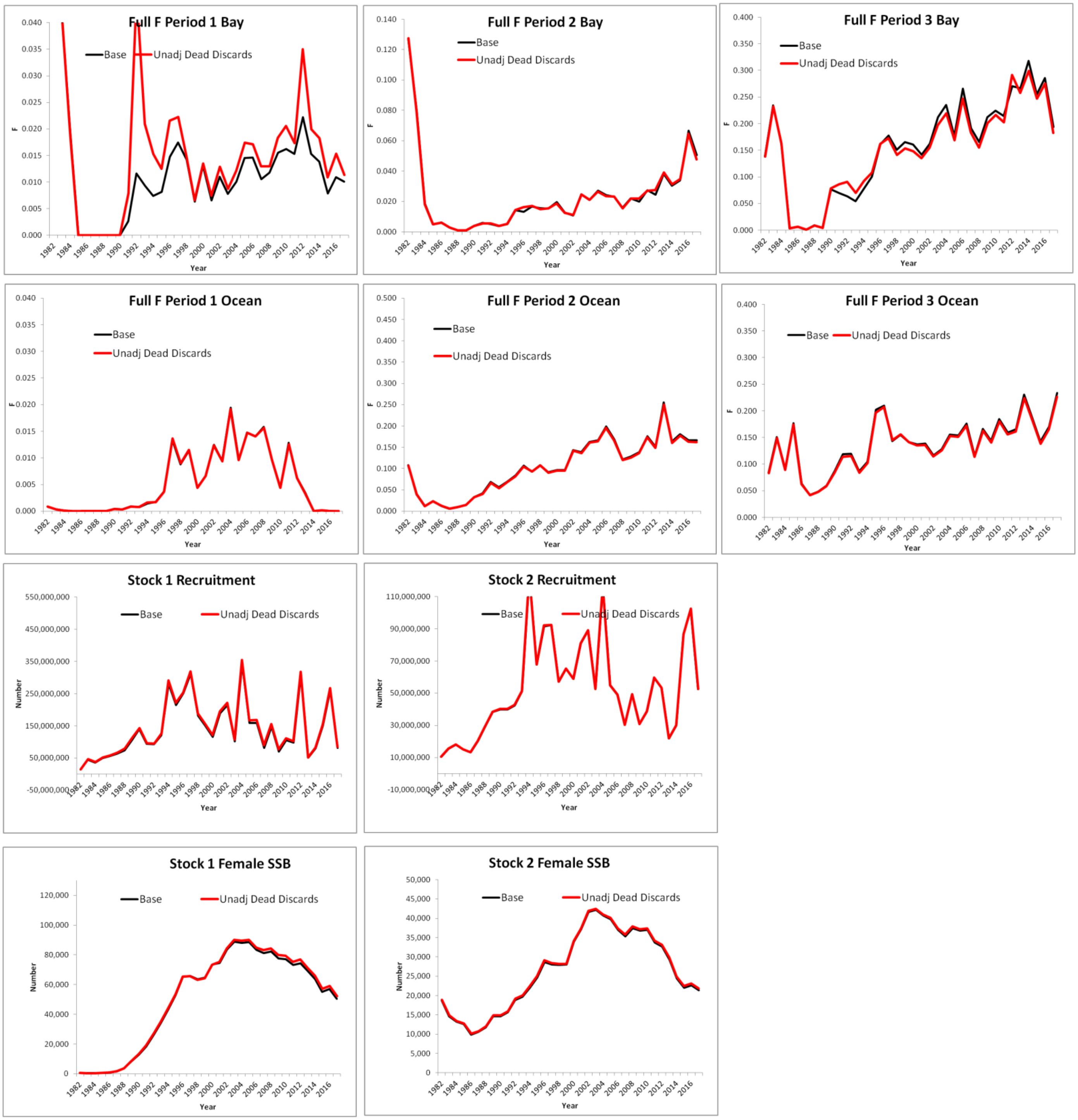


Figure B7.26. Results of sensitivity analysis of the commercial dead discard estimates. Stock-1 = Chesapeake Bay stock; Stock-2 = Delaware Bay/Hudson River stock

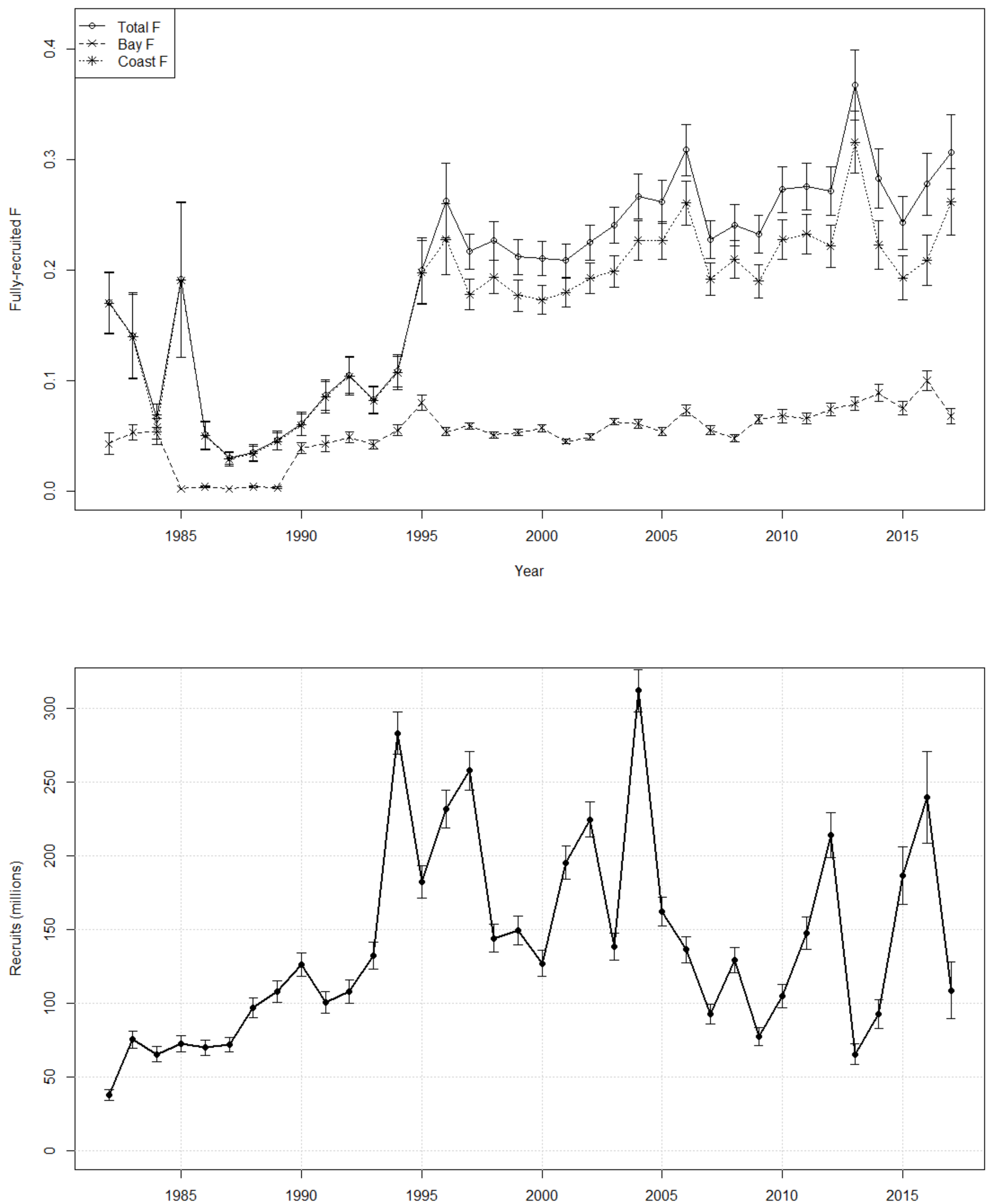


Figure B7.27. Estimates of total and fleet-specific fully-recruited fishing mortality (F) (top) and recruitment (bottom) from the non-migration SCA base model run. Error bars indicate one standard deviation.

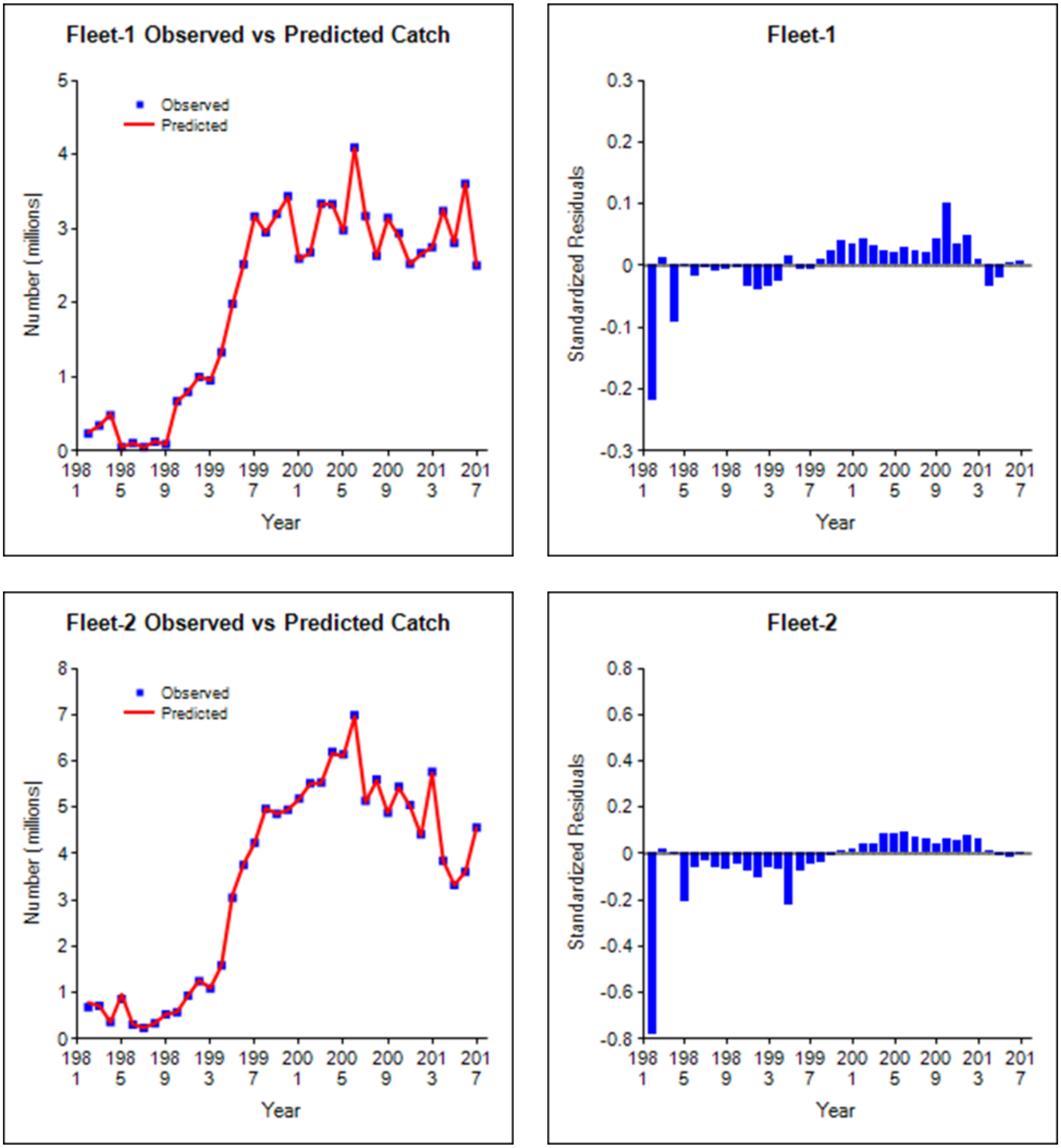
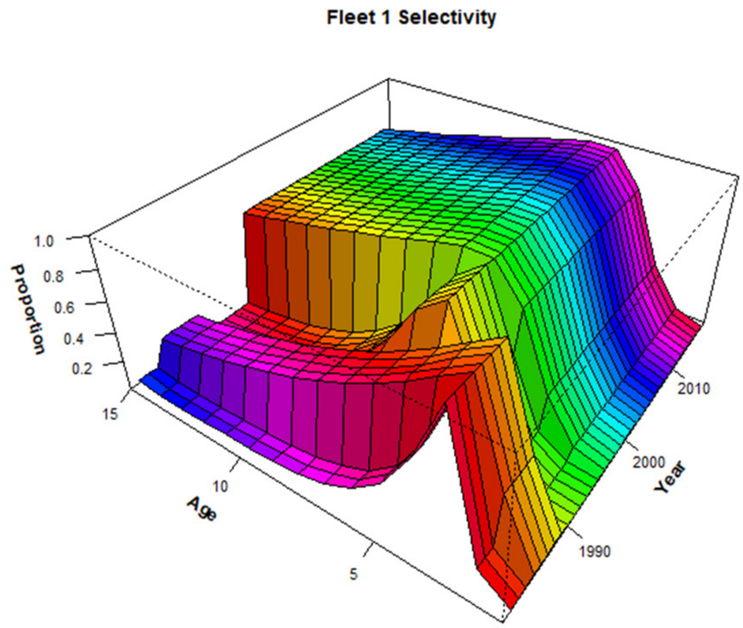


Figure B7.28. Observed and predicted total catch and standardized residuals by fleet for the non-migration SCA (Fleet 1 = Bay, Fleet 2 = Coast).



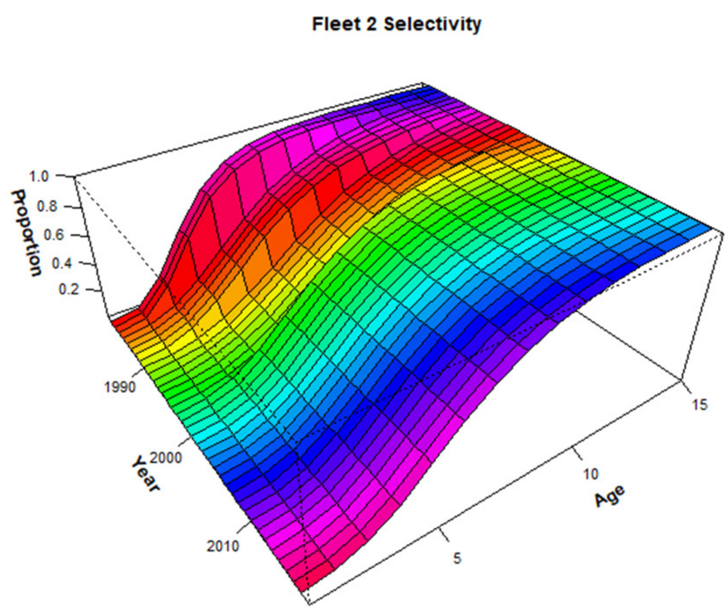


Figure B7.29. Catch selectivity patterns by fleet for the non-migration SCA (Fleet 1 = Bay, Fleet 2 = Coast).

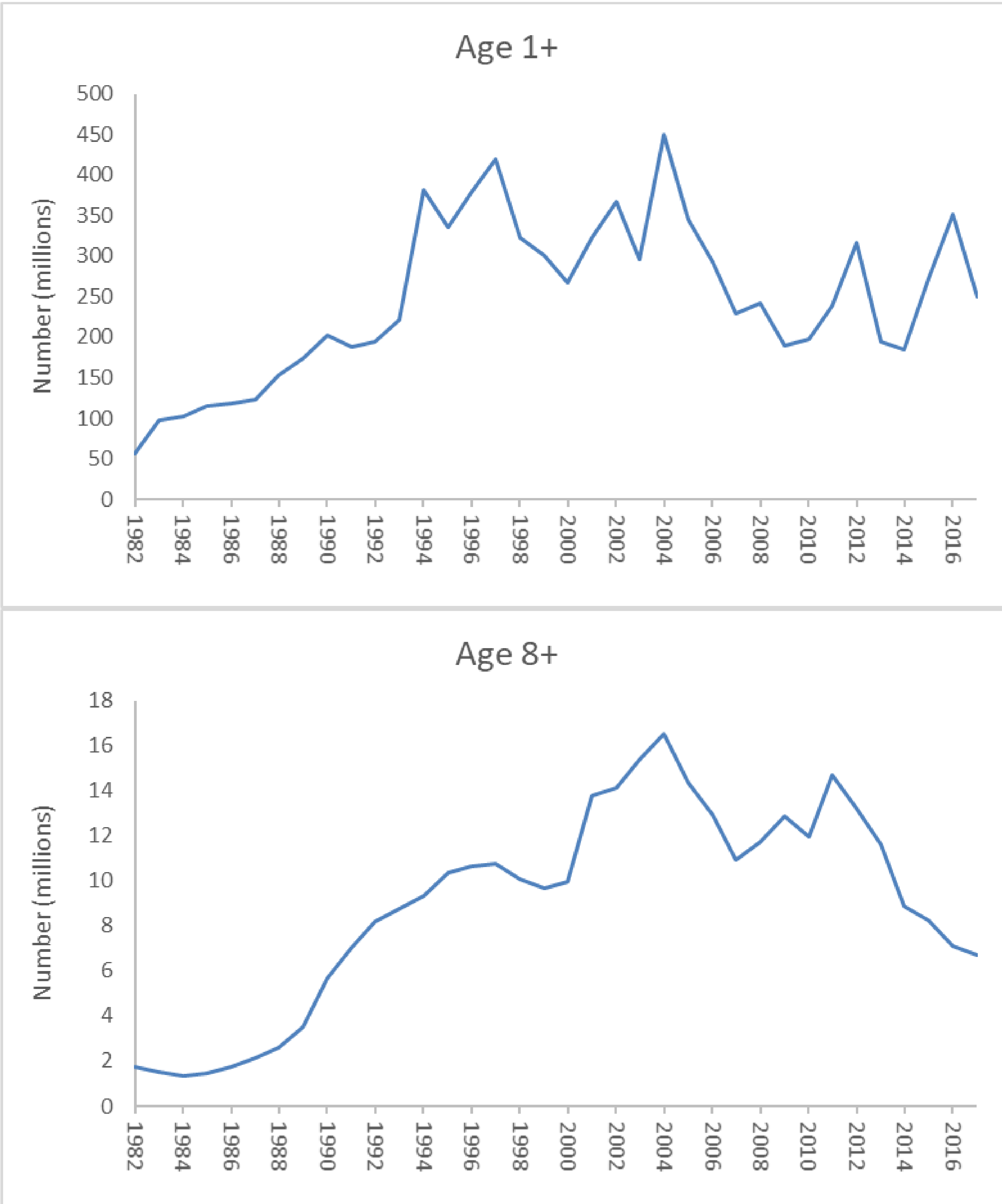


Figure B7.30. Estimates of January-1 total (age 1+) and 8+ abundance for 1982-2017 from the non-migration SCA.

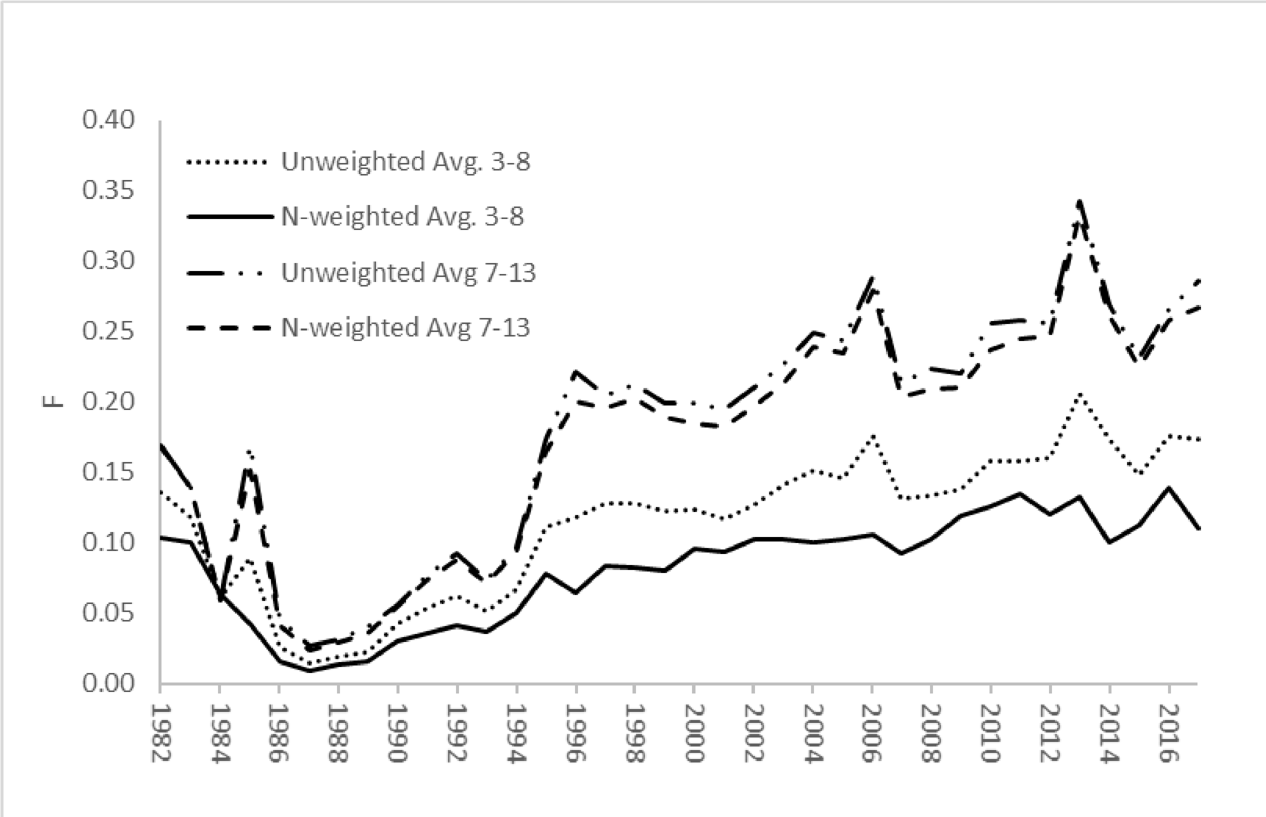


Figure B7.31. Comparison of fishing mortality estimates from the non-migration SCA model.

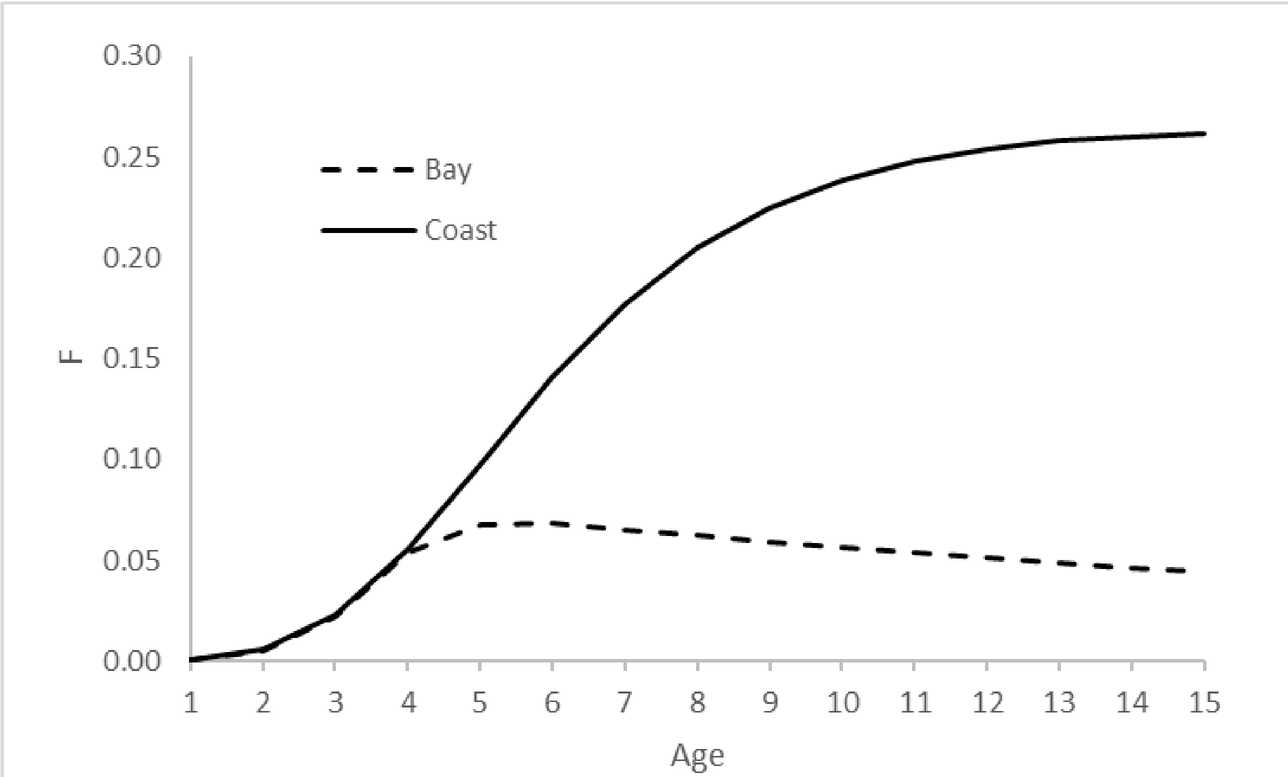


Figure B7.32. Fishing mortality at age in 2017 for the Chesapeake Bay and Coast fleets from the non-migration SCA model.

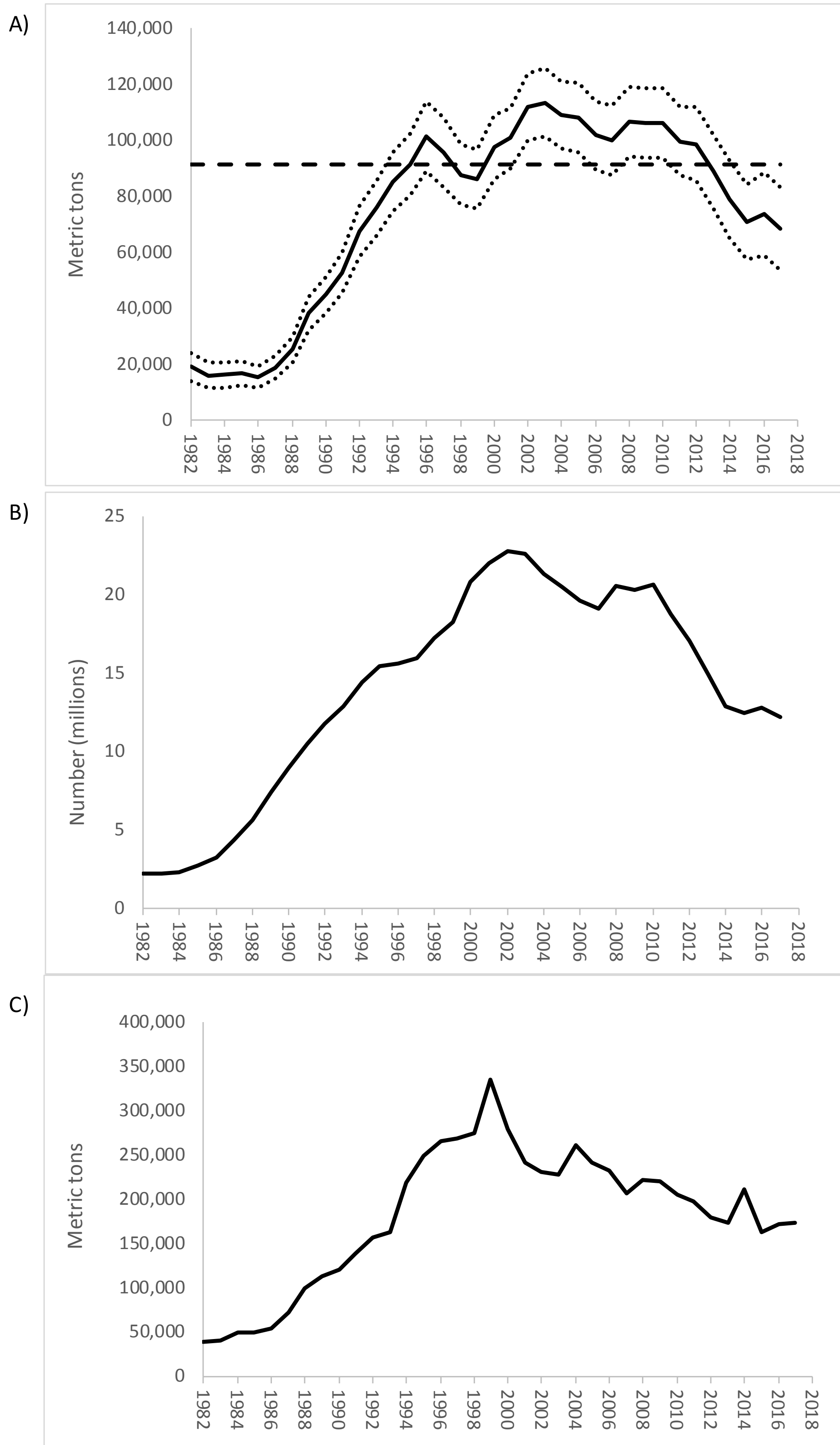


Figure B7.33. Estimates of (A) female spawning stock biomass by year (solid line), (B) female spawning stock numbers, and (C) total January-1 biomass from the non-migration SCA. Dotted lines equal 95% confidence intervals. Dashed horizontal line is the female spawning stock reference point (1995 value).

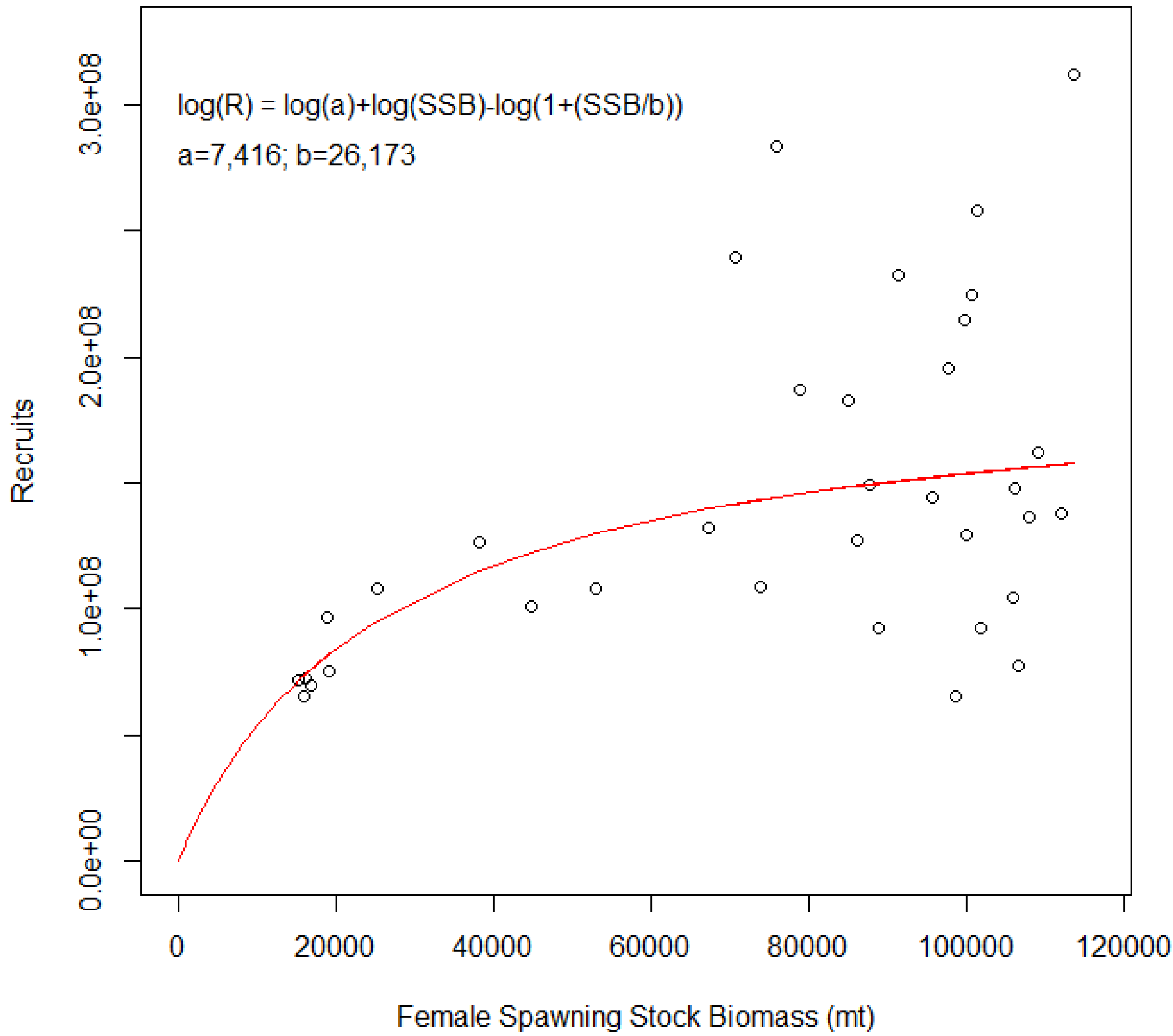


Figure B7.34. Estimates of recruits versus female spawning stock biomass from the non-migration SCA.

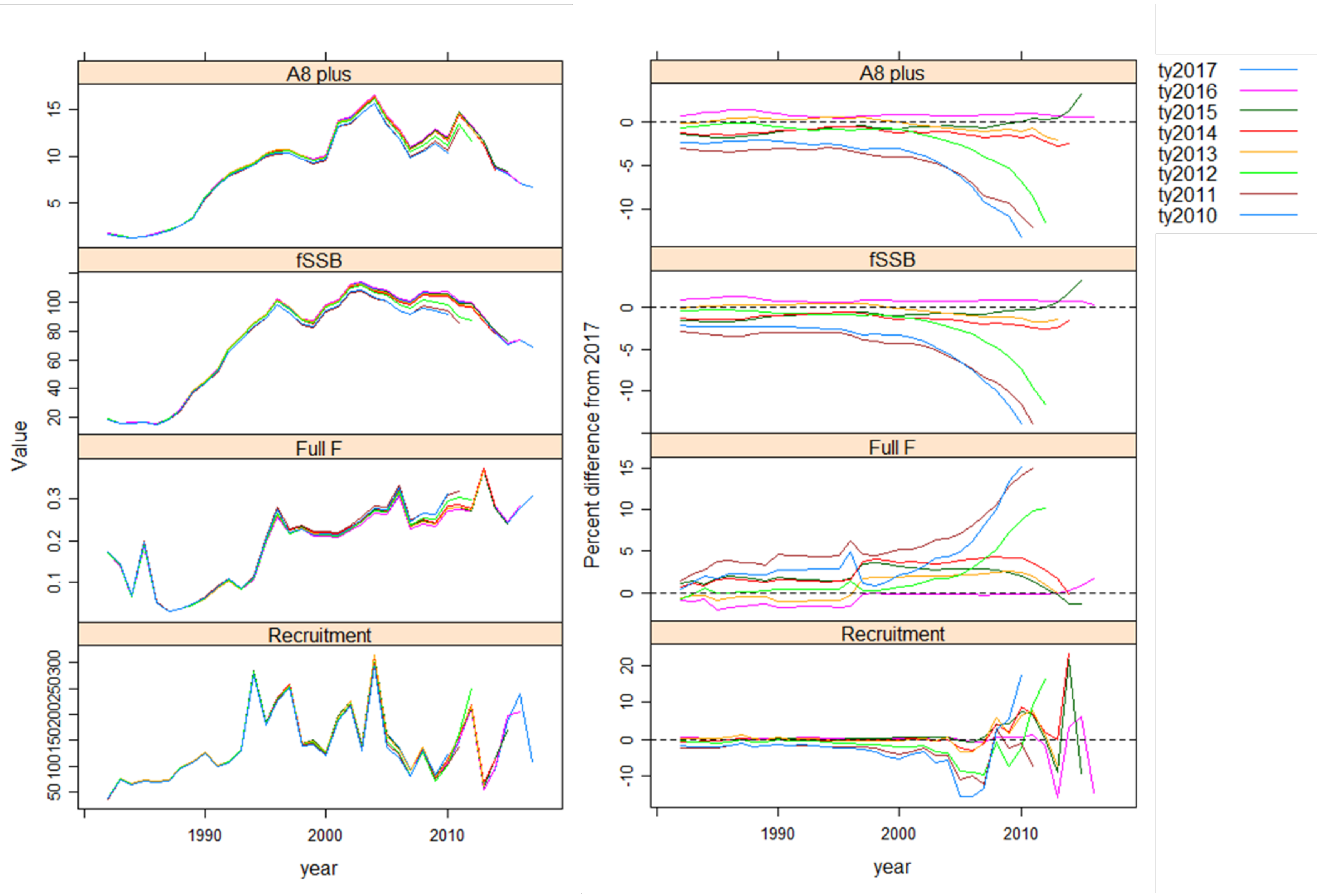


Figure B7.35. Retrospective analysis from the non-migration SCA for fully-recruited F, female spawning stock biomass (fSSB, thousand mt), Age 8+ abundance (million fish), and recruitment (millions of age-1 fish).

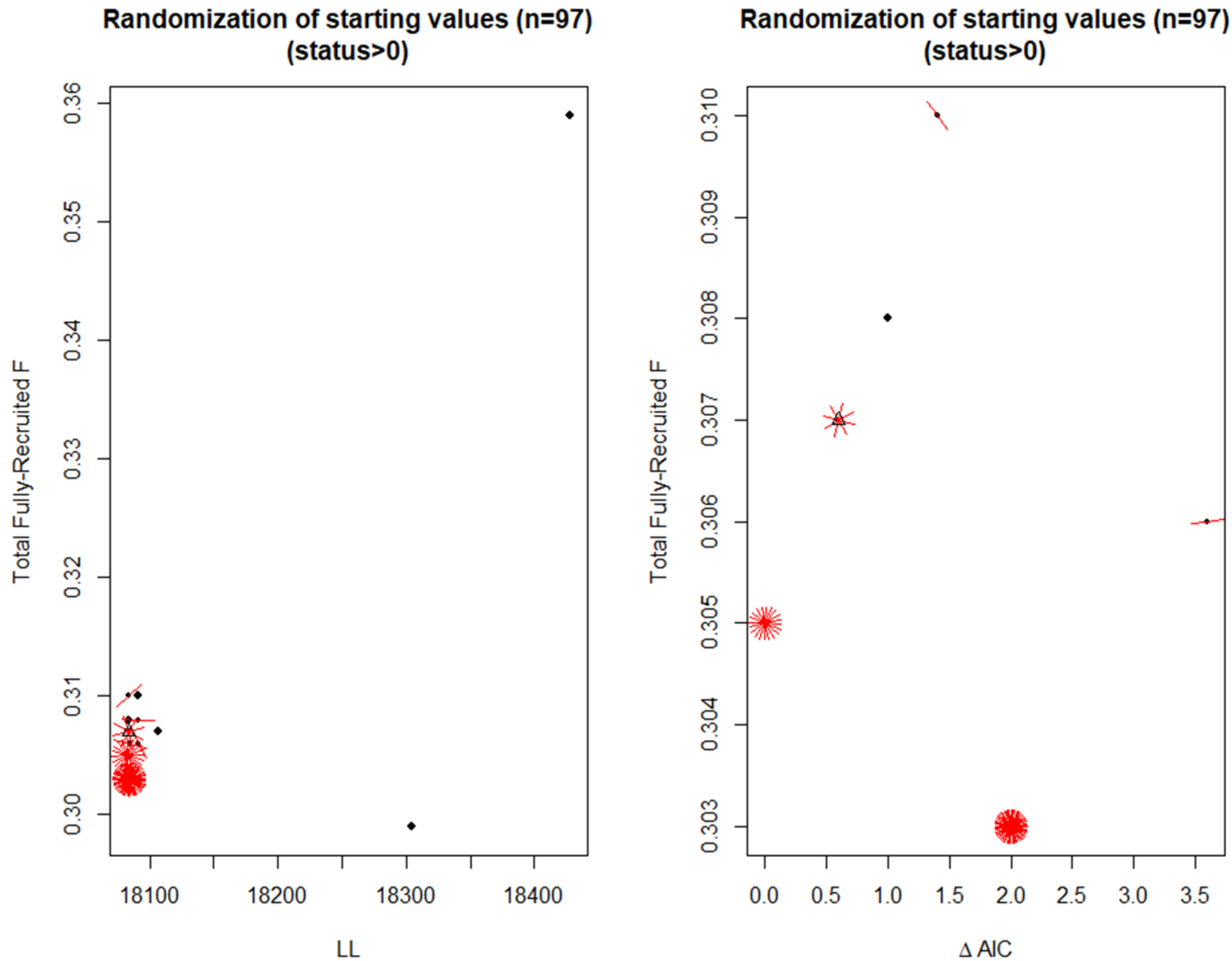


Figure B7.36. Sunflower plot results from 100 runs of the non-migration SCA model in which starting values were randomly permuted by +50%. Overlapping data points are represented by equi-angular red rays. Open triangle represents the total likelihood and F produced by the base model. In three runs the Hessian did not invert (status = 0).

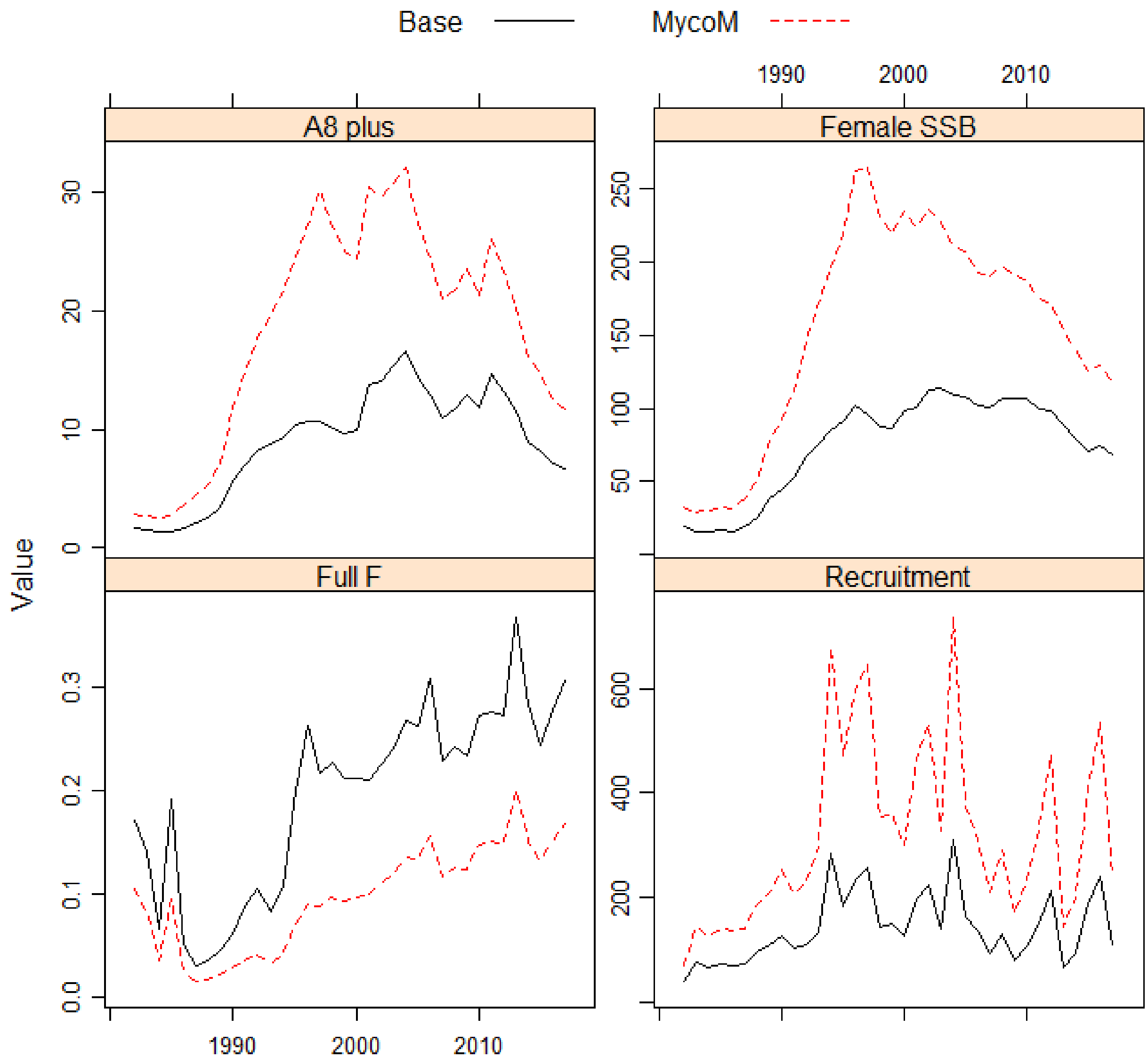


Figure B7.37. Comparison of results from the non-migration SCA model with time-constant age-specific natural mortality (M) with results when M is increased on ages-3+ after 1996.

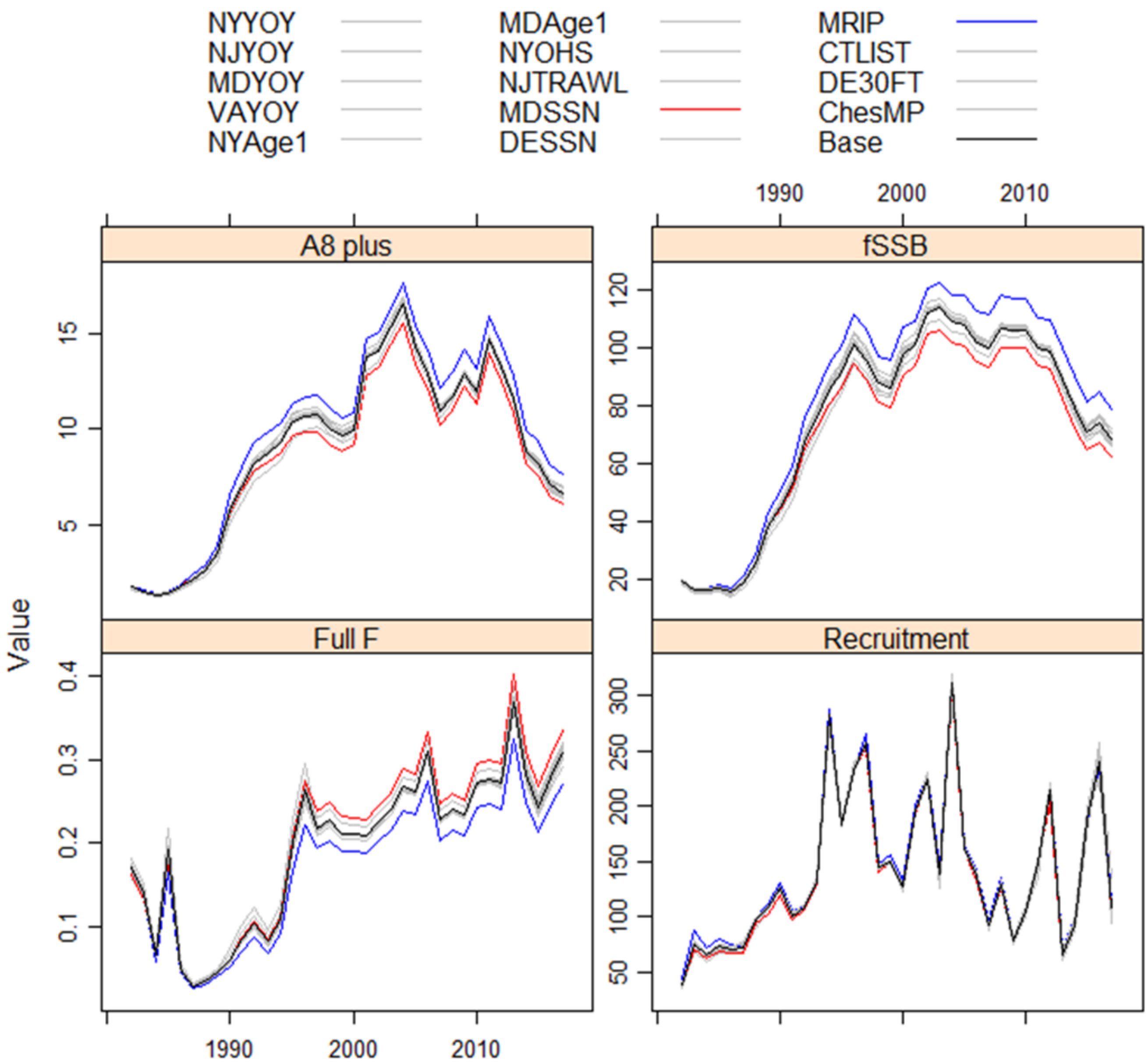


Figure B7.38. Comparison of results of sensitivity runs when data from each survey were deleted one-at-a-time from the final non-migration SCA model configuration. Units are the same as in Figure B7.35. The base run and two most influential surveys are highlighted with alternate colors.

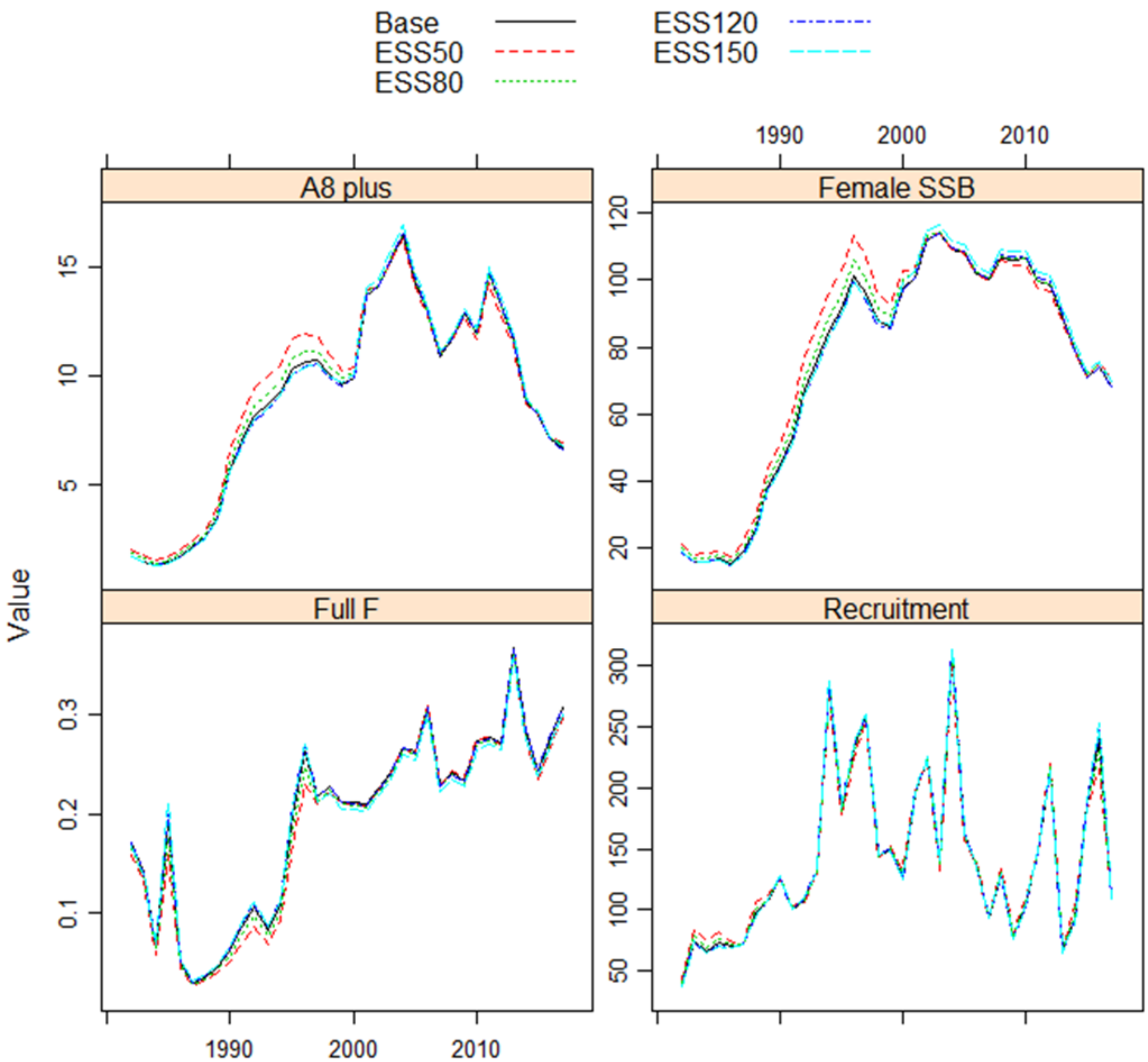


Figure B7.39. Comparison of results of the non-migration SCA model when the average effective sample sizes for the catch and survey multinomial likelihoods were increased (ESS120; ESS150) and decreased (ESS80; ESS50) by 20% and 50% of the original values.

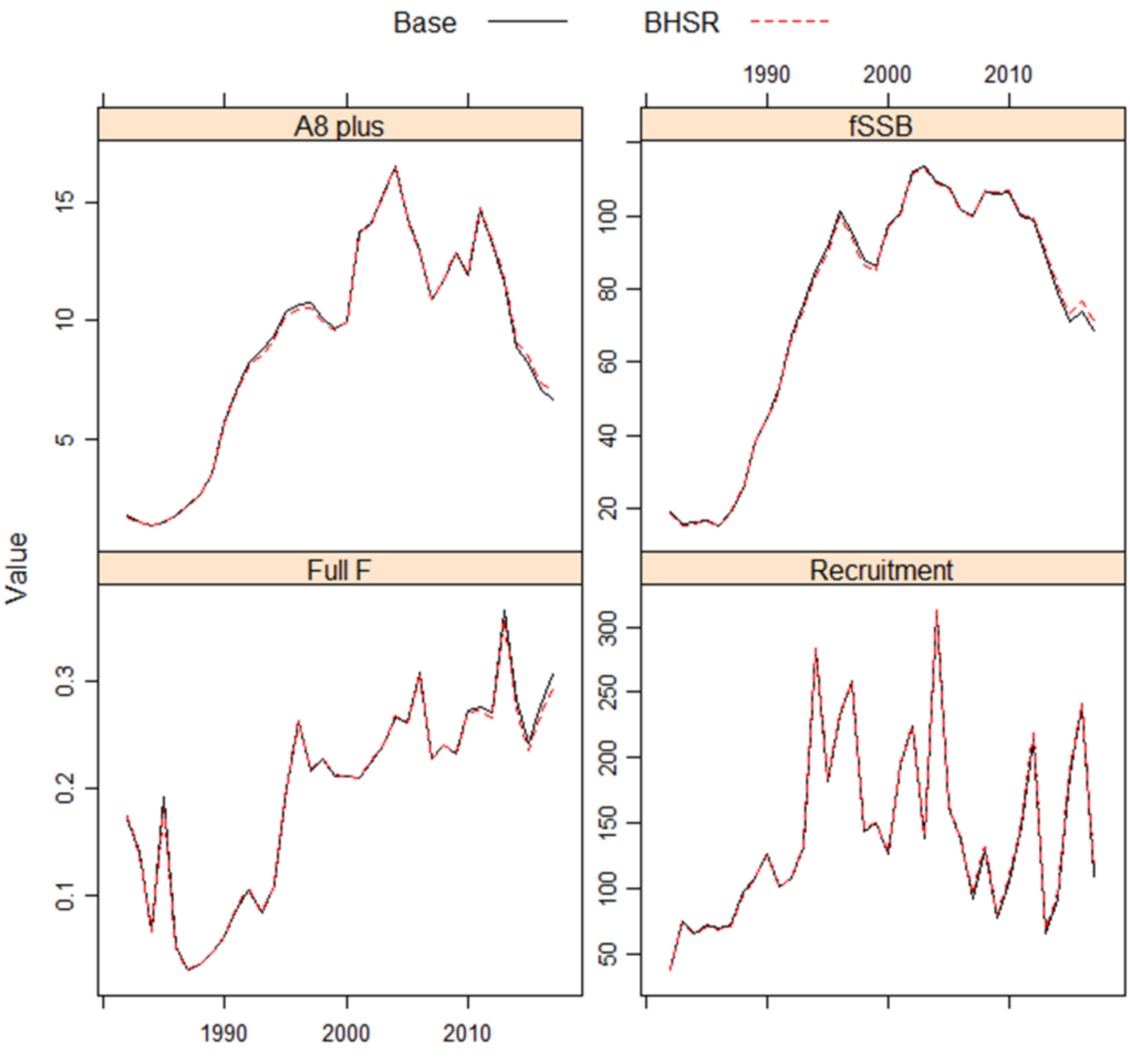


Figure B7.40. Comparison of results from the non-migration SCA model when recruitment is estimated as lognormal deviations from Beverton-Holt stock recruitment relationship (BHSR) or as lognormal deviations from mean recruitment (Base). Units are the same as in Figure B7.35.

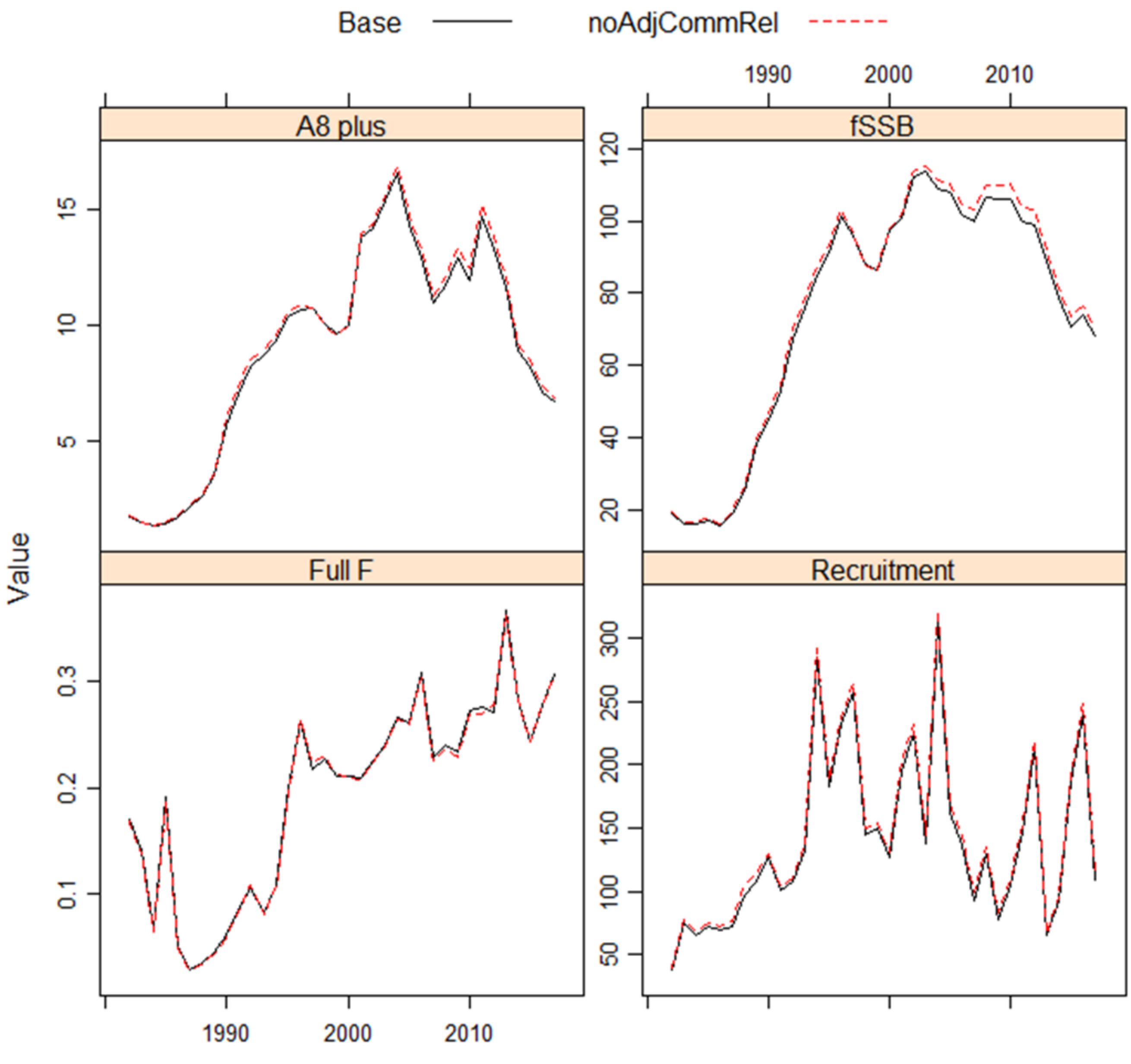


Figure B7.41. Comparison of results from the non-migration SCA model when commercial dead releases are estimated with adjustments (Base) or without (noAdjCommRel). Units are the same as in Figure B7.35.

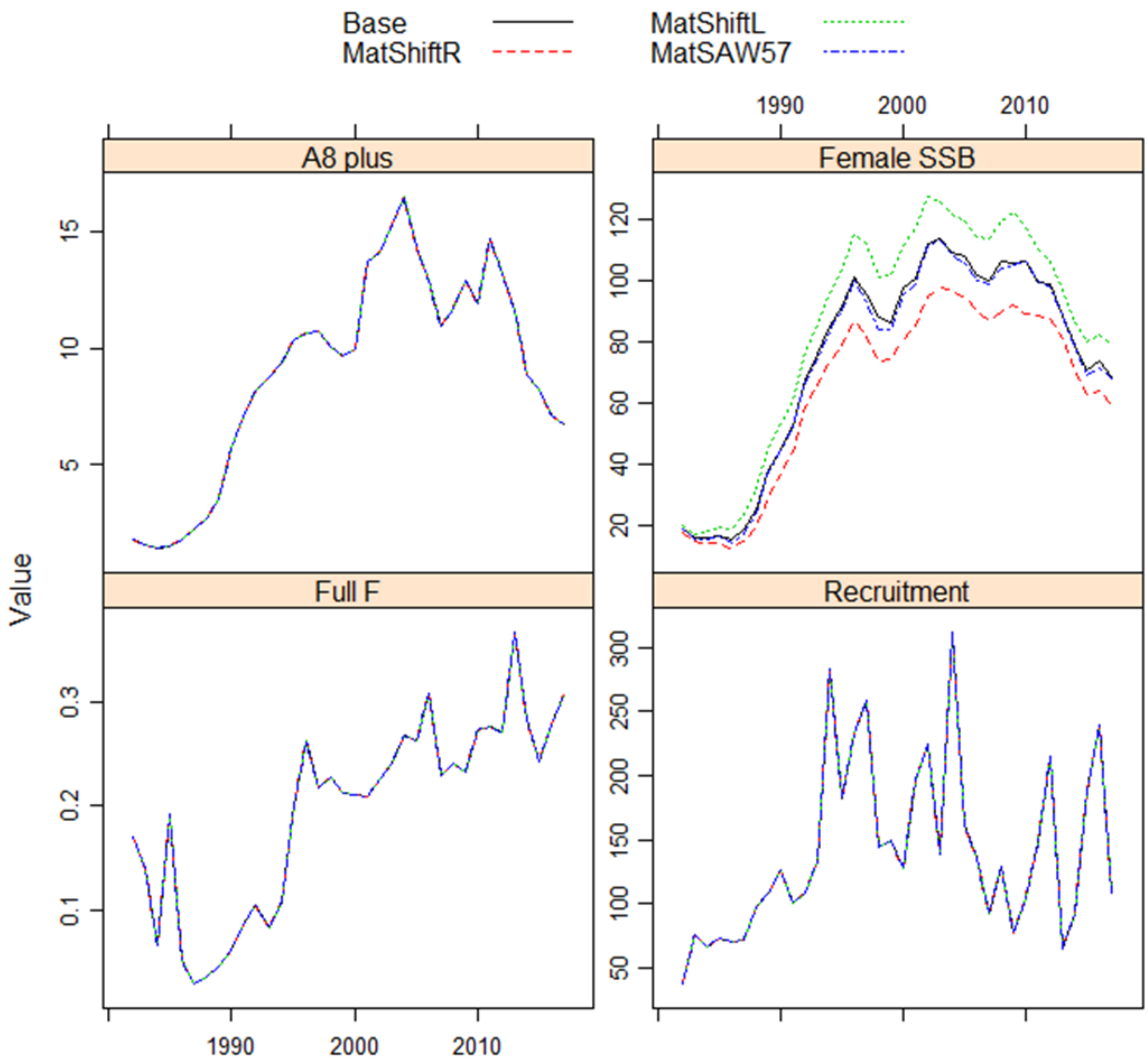


Figure B7.42. Comparison of results from the non-migration SCA model when maturity curve from NEFSC (2013) is used, or 2018 curve is shifted left (MatShiftLeft) or right (MatShiftRight).Units are the same as in Figure B7.35.

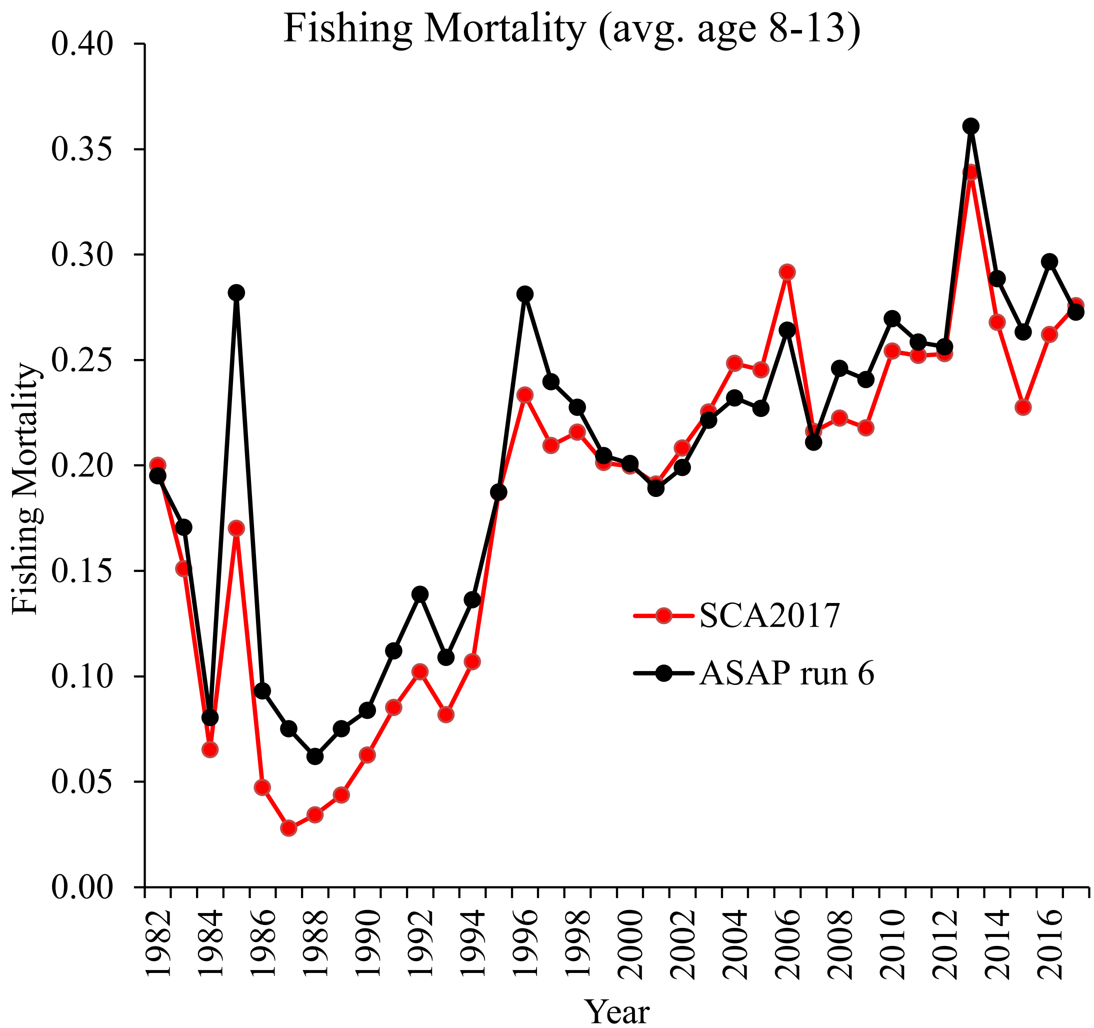


Figure B7.43. Fishing mortality (F) from ASAP compared to the non-migration SCA model, 1982-2017.

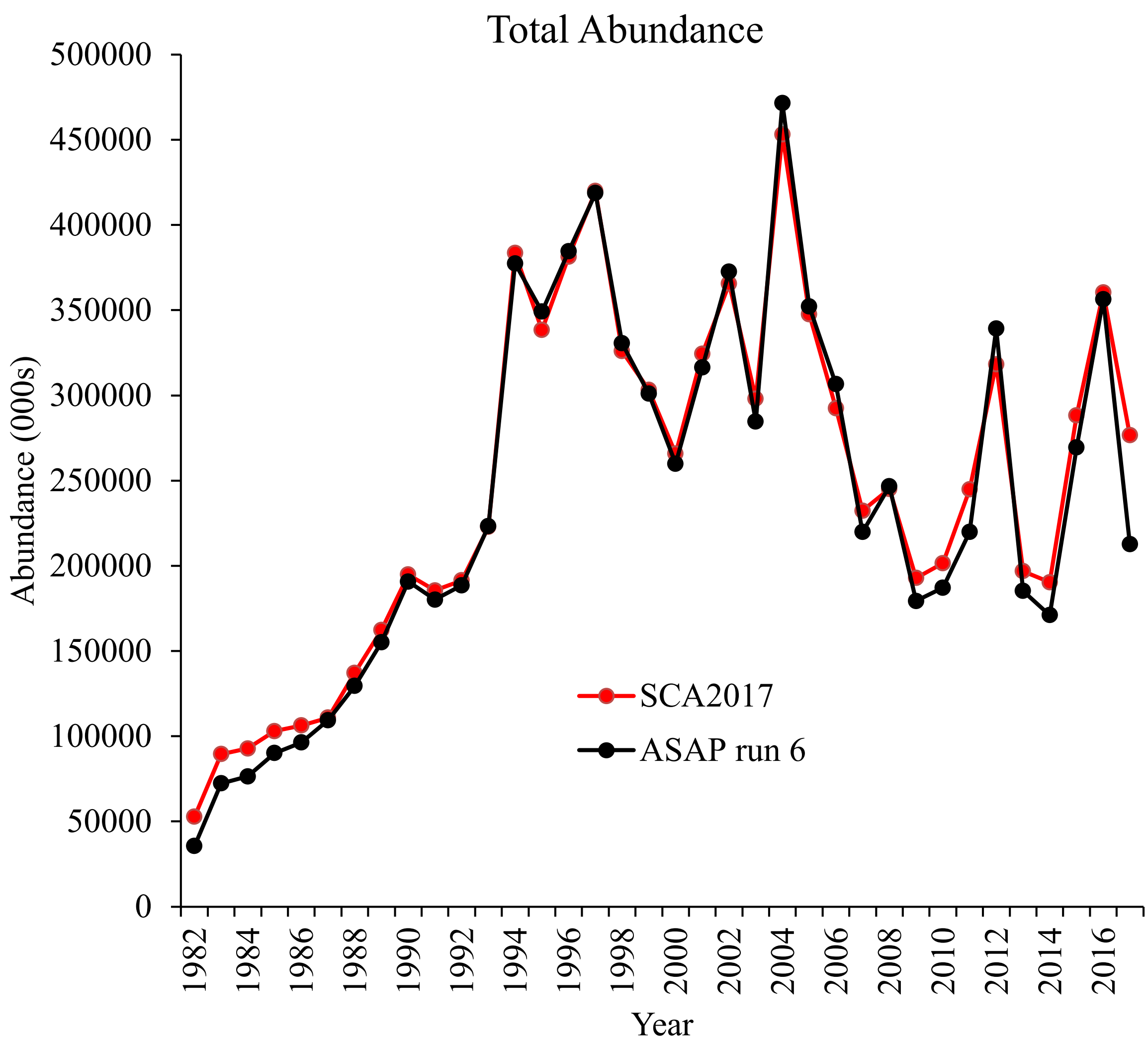


Figure B7.44. Total abundance from ASAP compared to the non-migration SCA model, 1982-2017.

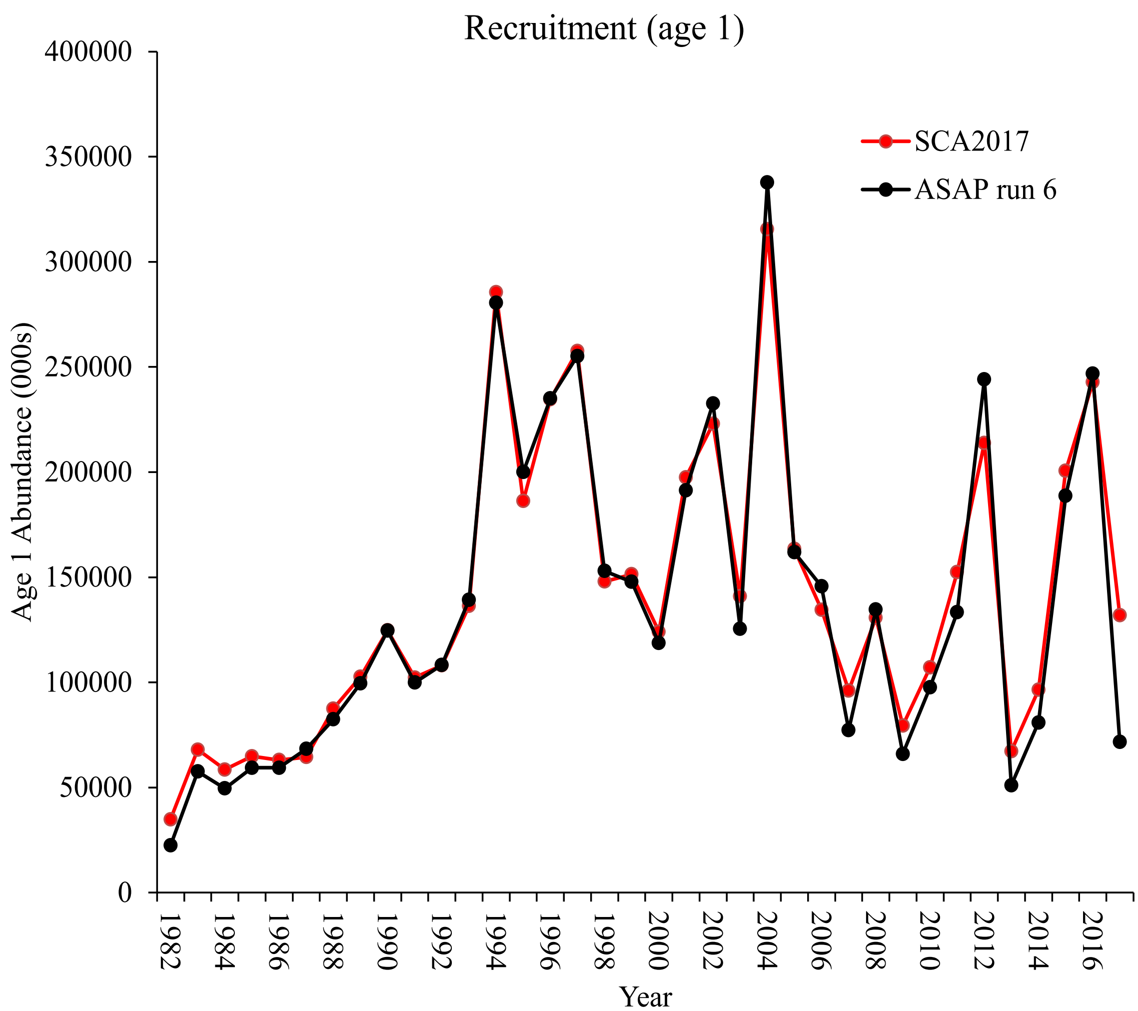


Figure B7.45. Recruitment (Age-1 fish) from ASAP compared to the non-migration SCA model, 1982-2017.

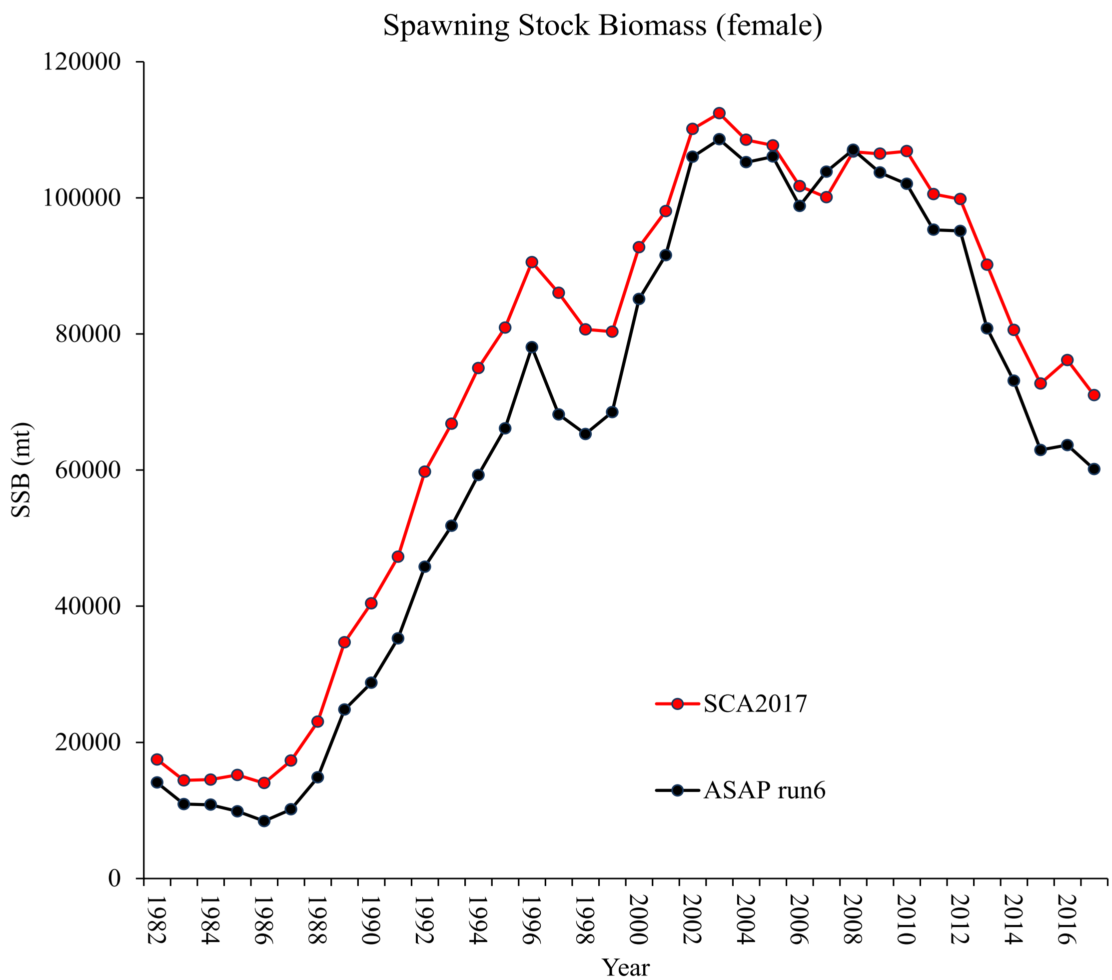


Figure B7.46 Female spawning stock biomass (SSB) from ASAP compared to the non-migration SCA model, 1982-2017.

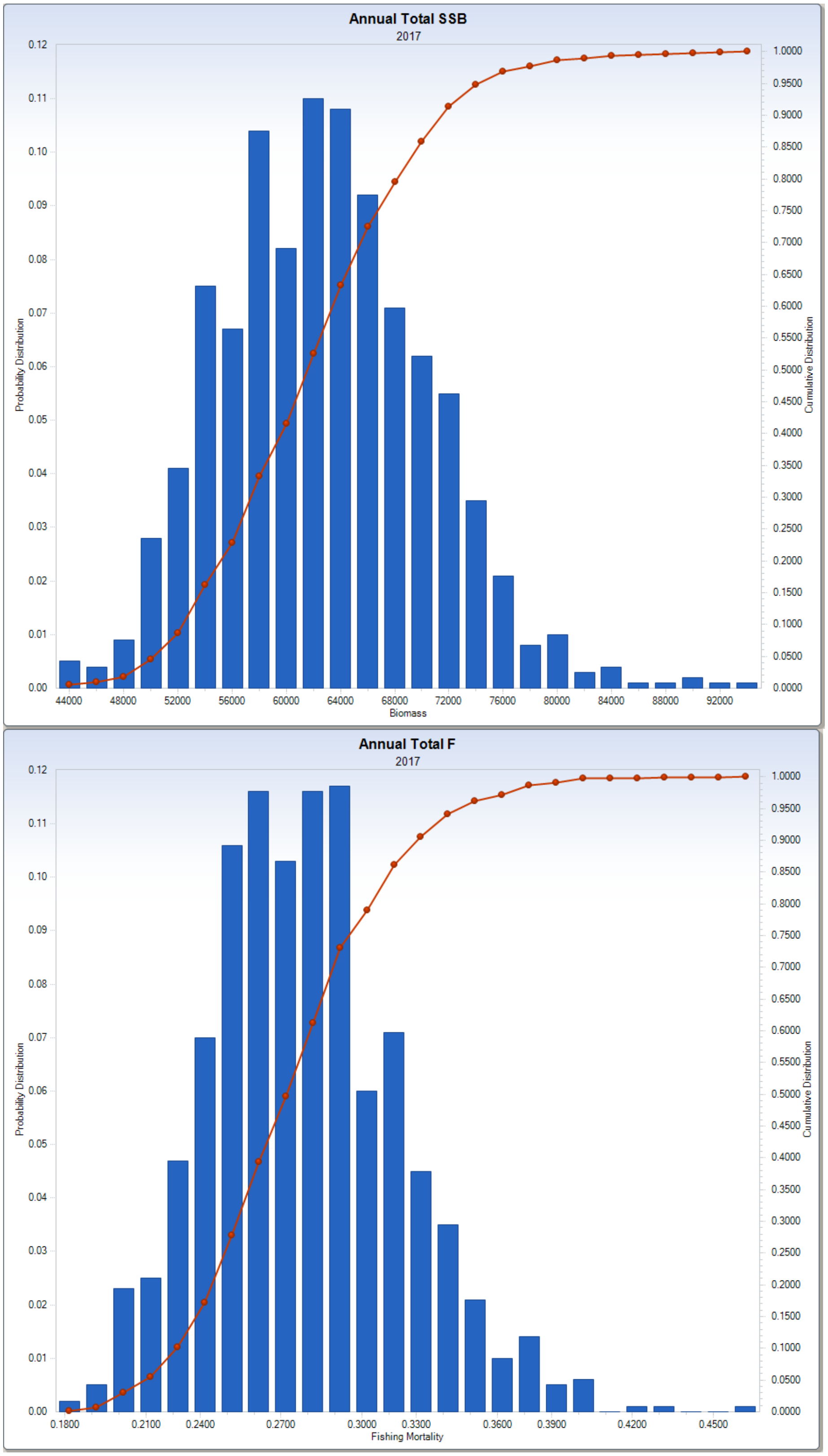


Figure B7.47. Total female spawning stock biomass (SSB; top) and fishing mortality (F; bottom) in 2017 from ASAP with probability distribution bars (primary Y-axis) and cumulative distribution curve (secondary Y-axis).

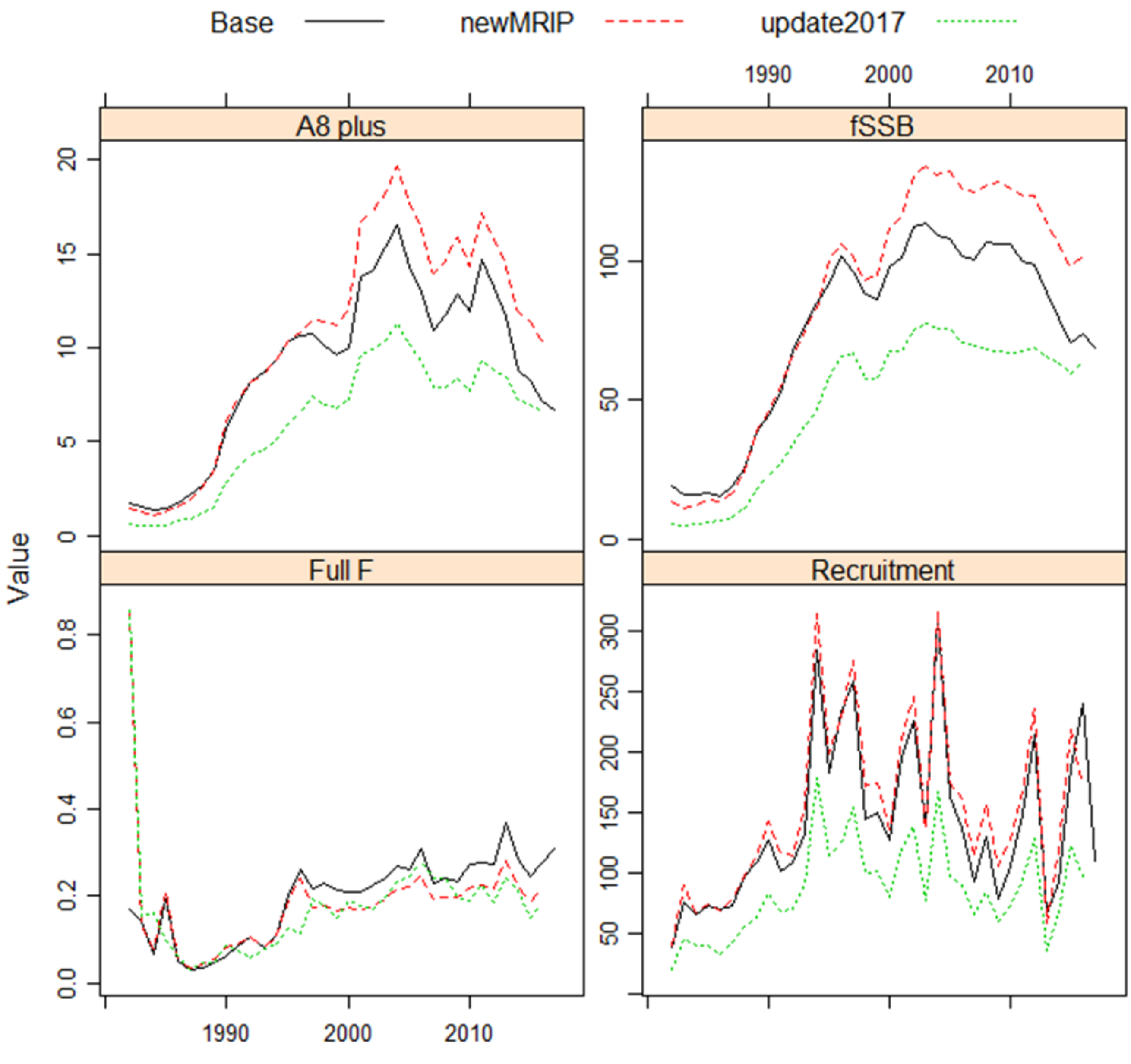
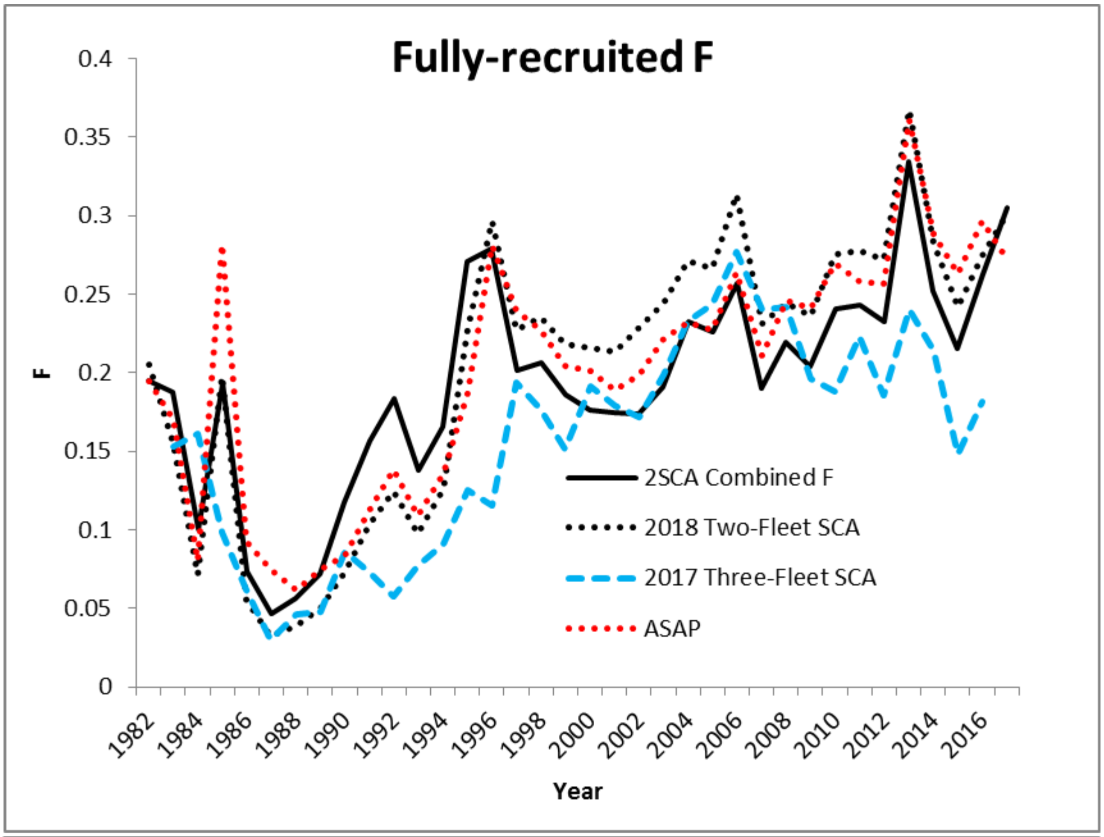


Figure B7.48. Comparison of results from the 2017 update assessment (update2017; continuity run), the 2017 model with the new MRIP data (newMRIP), and the 2018 base run (base) of the non-SCA migration model. Units are the same as in Figure B7.10.



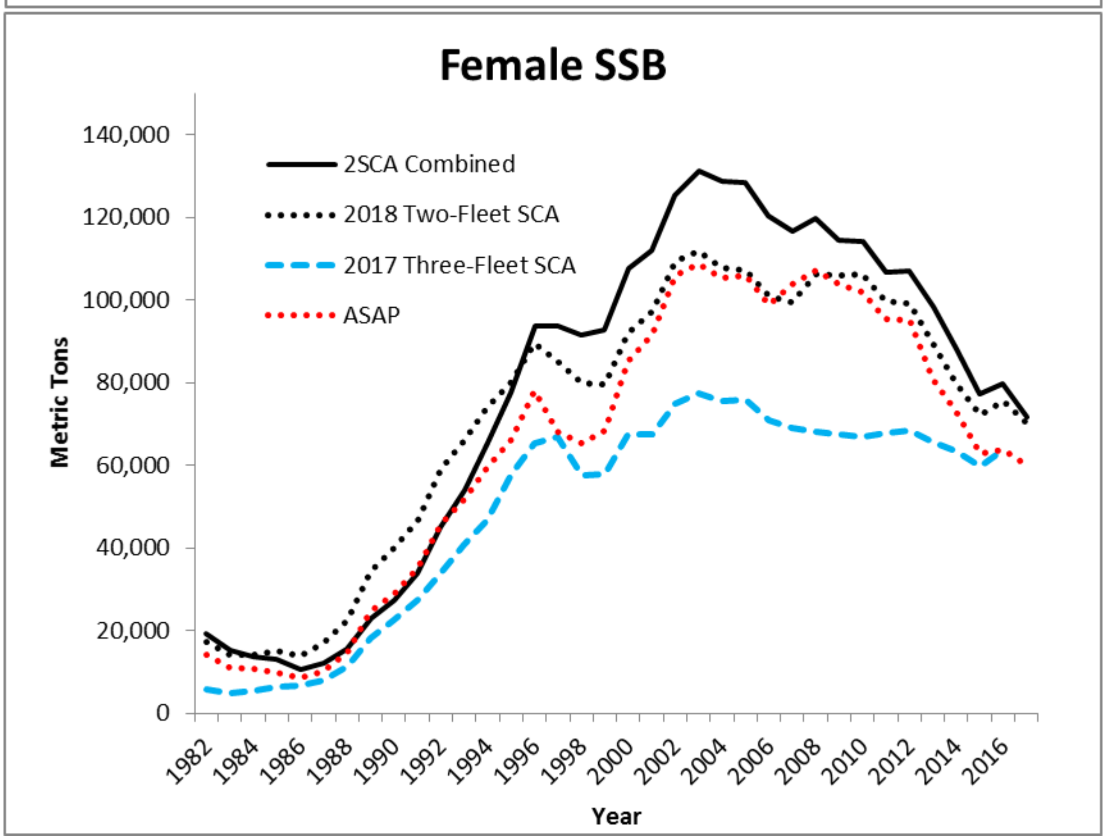


Figure B7.49. Comparison of fishing mortality (F; top) and spawning stock biomass (SSB; bottom) estimates from the preferred 2SCA model, and the continuity run (2017 3-fleet SCA), base non-migration SCA (2018 2-fleet SCA), and ASAP.

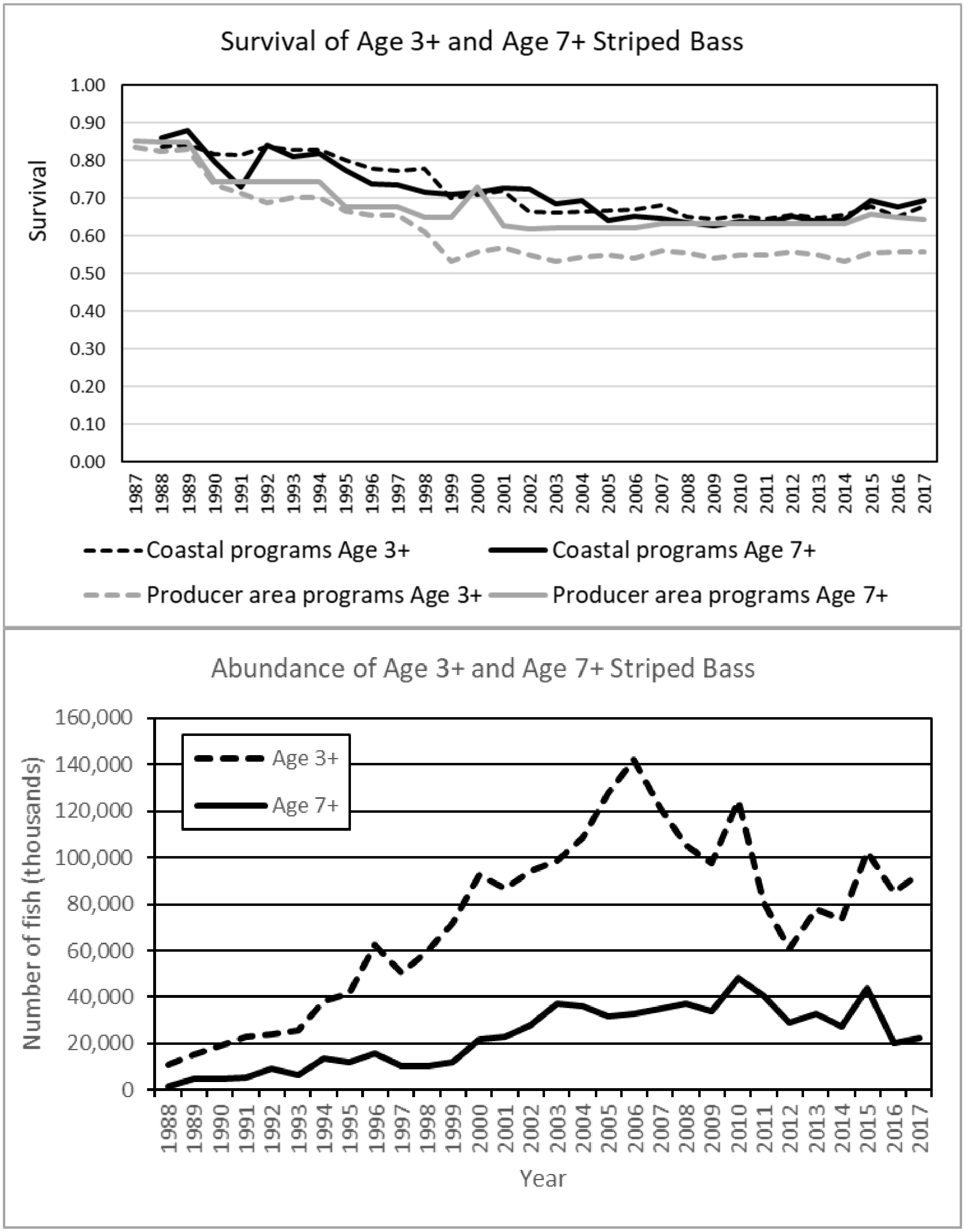


Figure B8.1. Comparison of survival (top) and stock size estimates (bottom) from IRCR tagging model for fish age seven and older (comparable to fish ≥ 28 inches (711 mm)) and age three and older (comparable to fish ≥ 18 inches (457 mm)). Stock size calculated via Kill = μ * Stock Size.

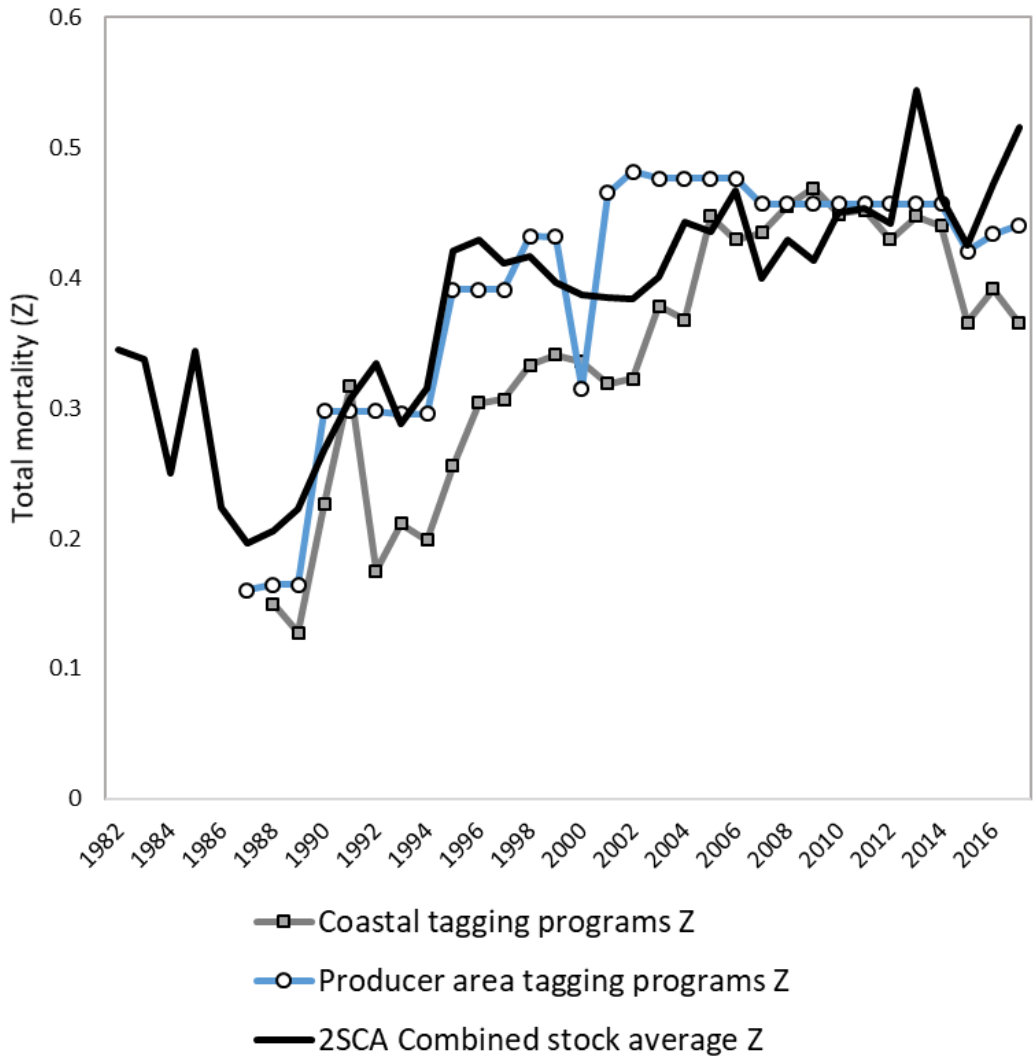


Figure B8.2. Comparison of Z estimates from the tagging models (≥28”; 711 mm) and the 2SCA assessment model.

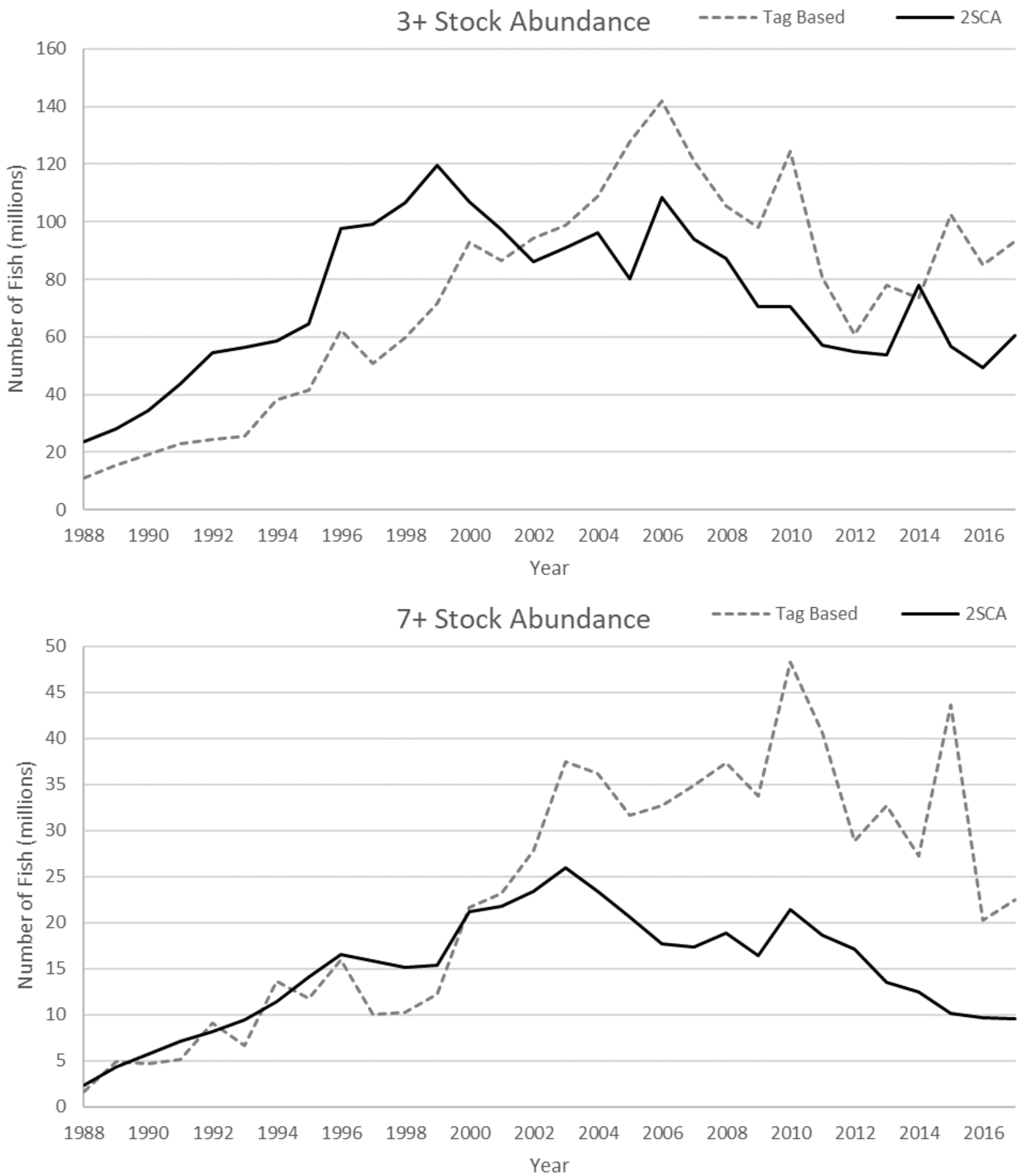


Figure B8.3. Comparison of stock abundance estimates from the tagging analysis and the 2SCA assessment model.

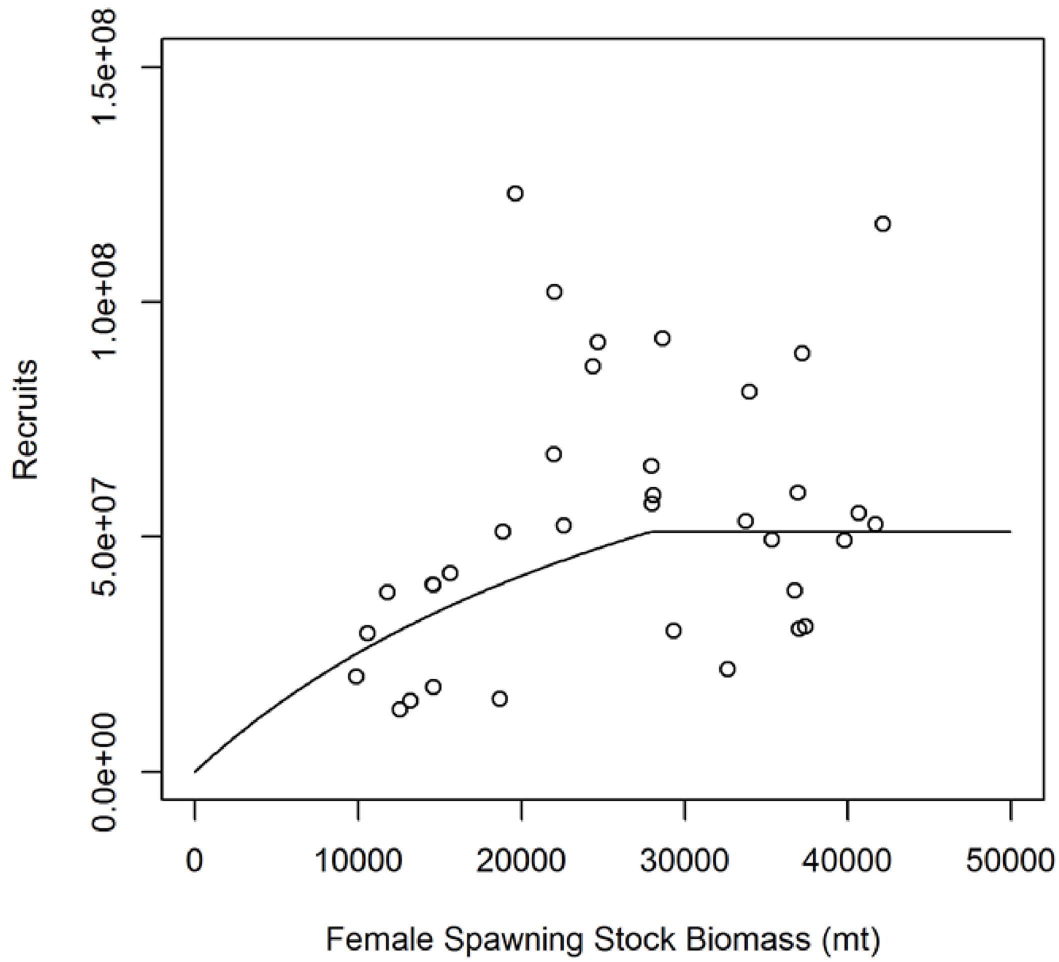
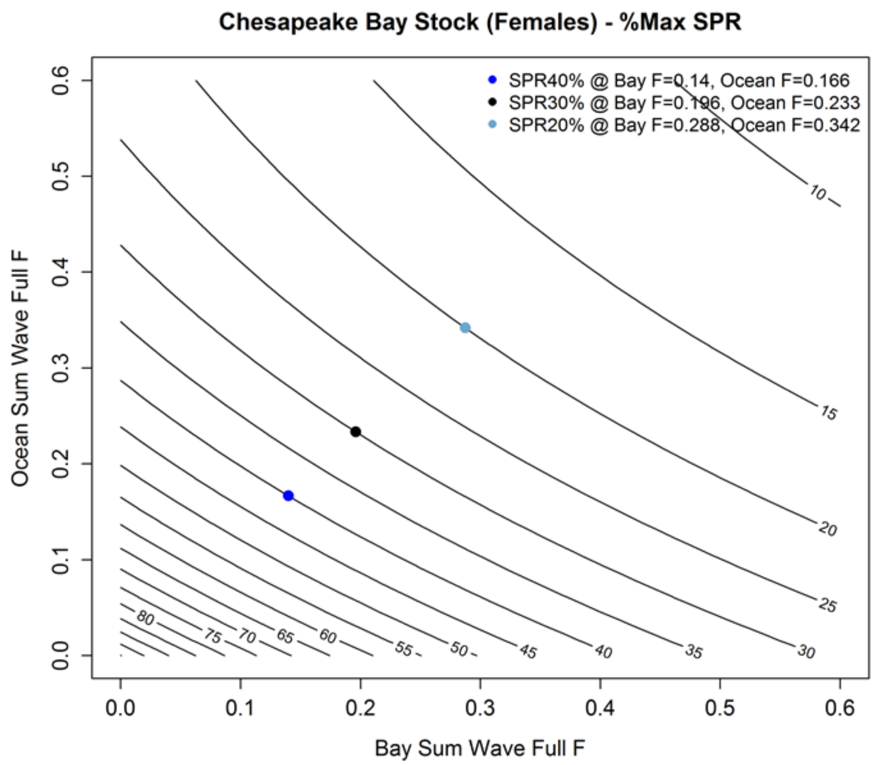


Figure B9.1. The “hockey-stick” female spawning stock biomass-recruitment relationship for the Delaware Bay/Hudson River stock.



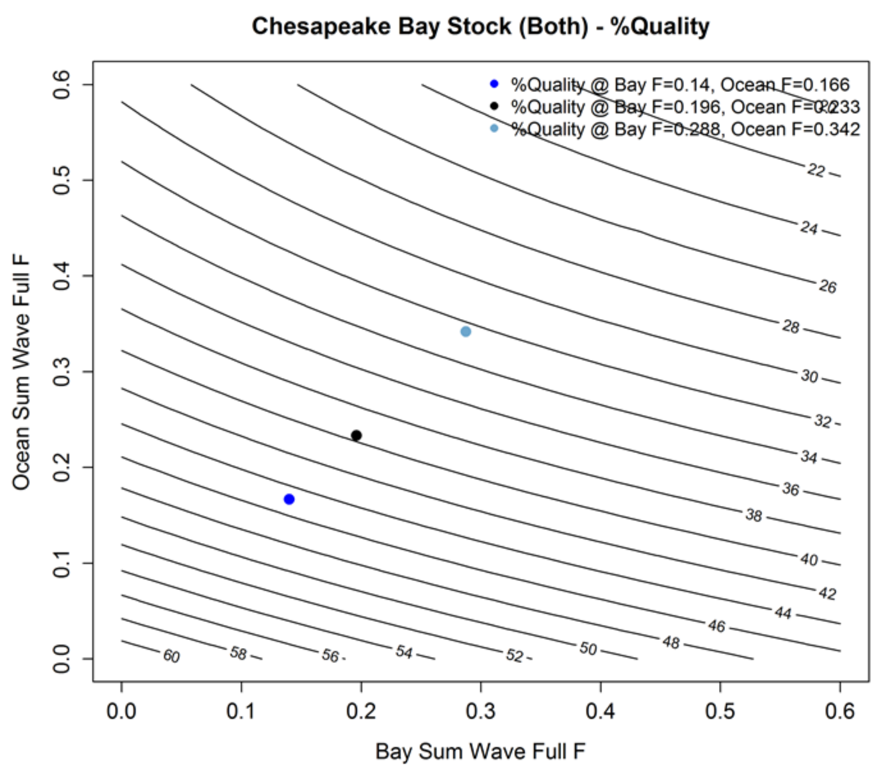


Figure B9.2. The female spawning biomass per recruit analysis (top) and percent quality analysis (bottom) for Stock-1 (Chesapeake Bay) for different levels of sum of period Fs for the Chesapeake Bay and ocean regions.

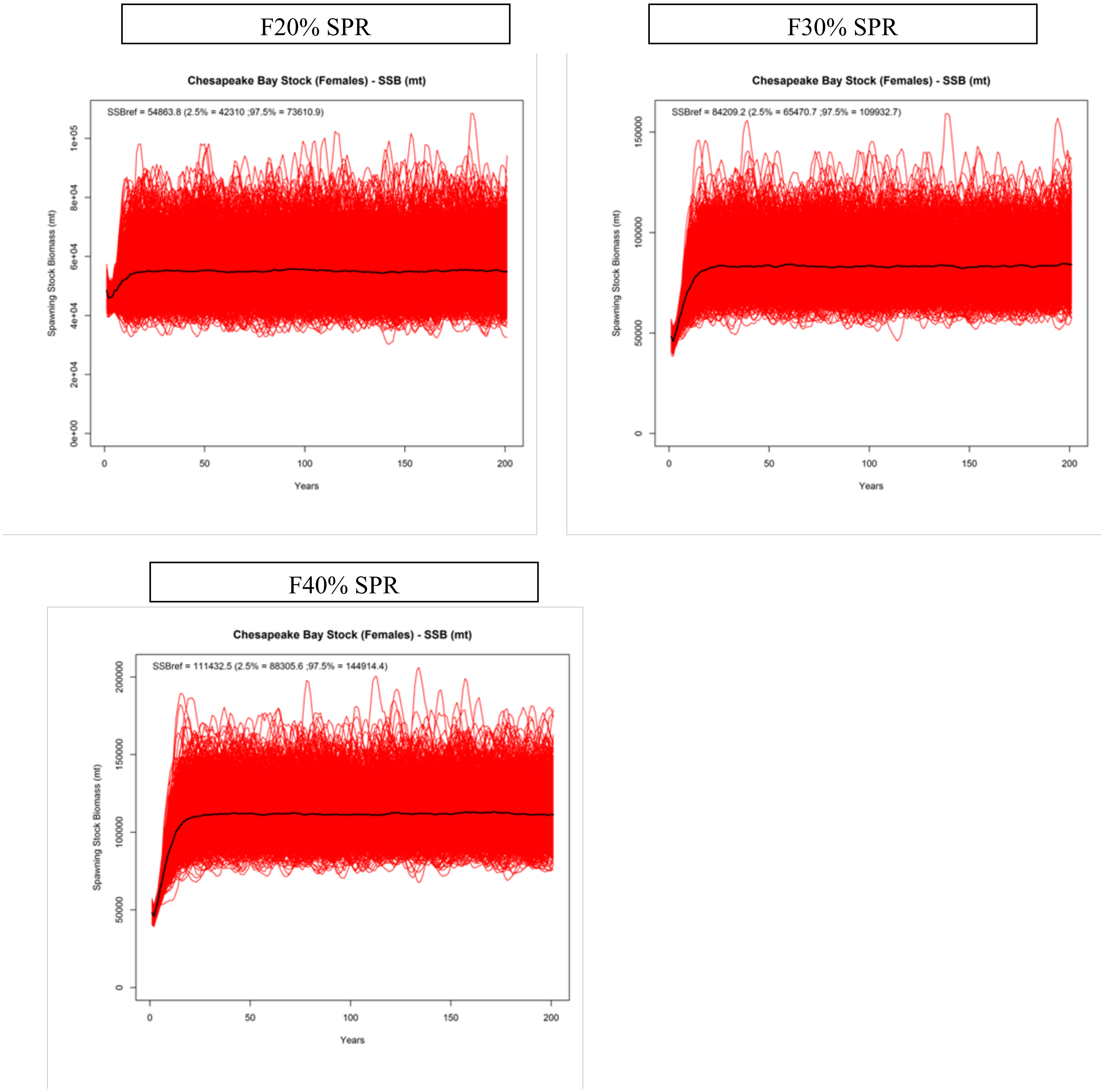


Figure B9.3. Plots of stochastic projection for the Chesapeake Bay stock using F20%, F30% and F40%.

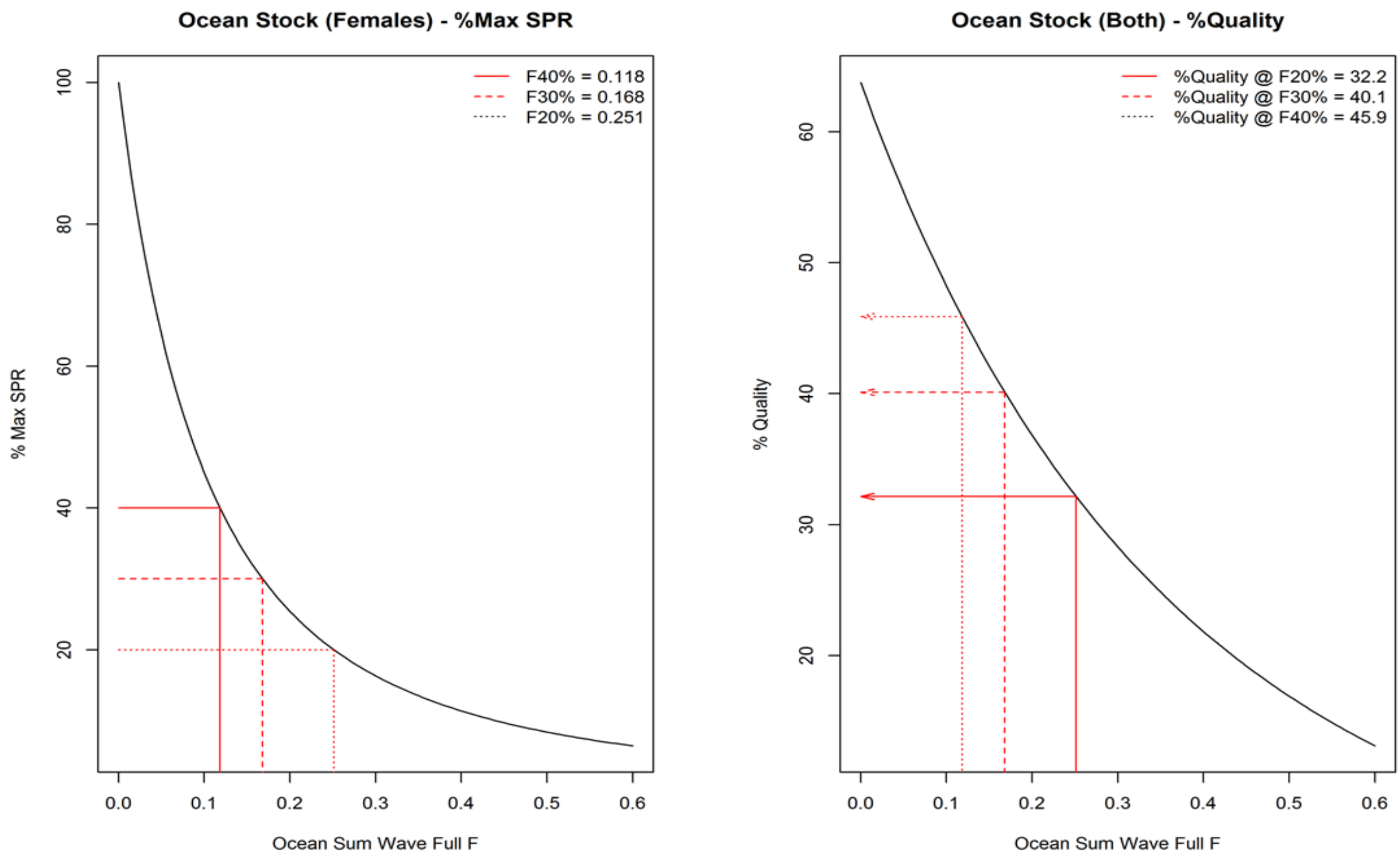


Figure B9.4. The spawning biomass per recruit analysis (left) and percent quality analysis (right) for the Delaware Bay/Hudson River stock in the ocean under different levels of sum of period fishing mortality rates (Fs)

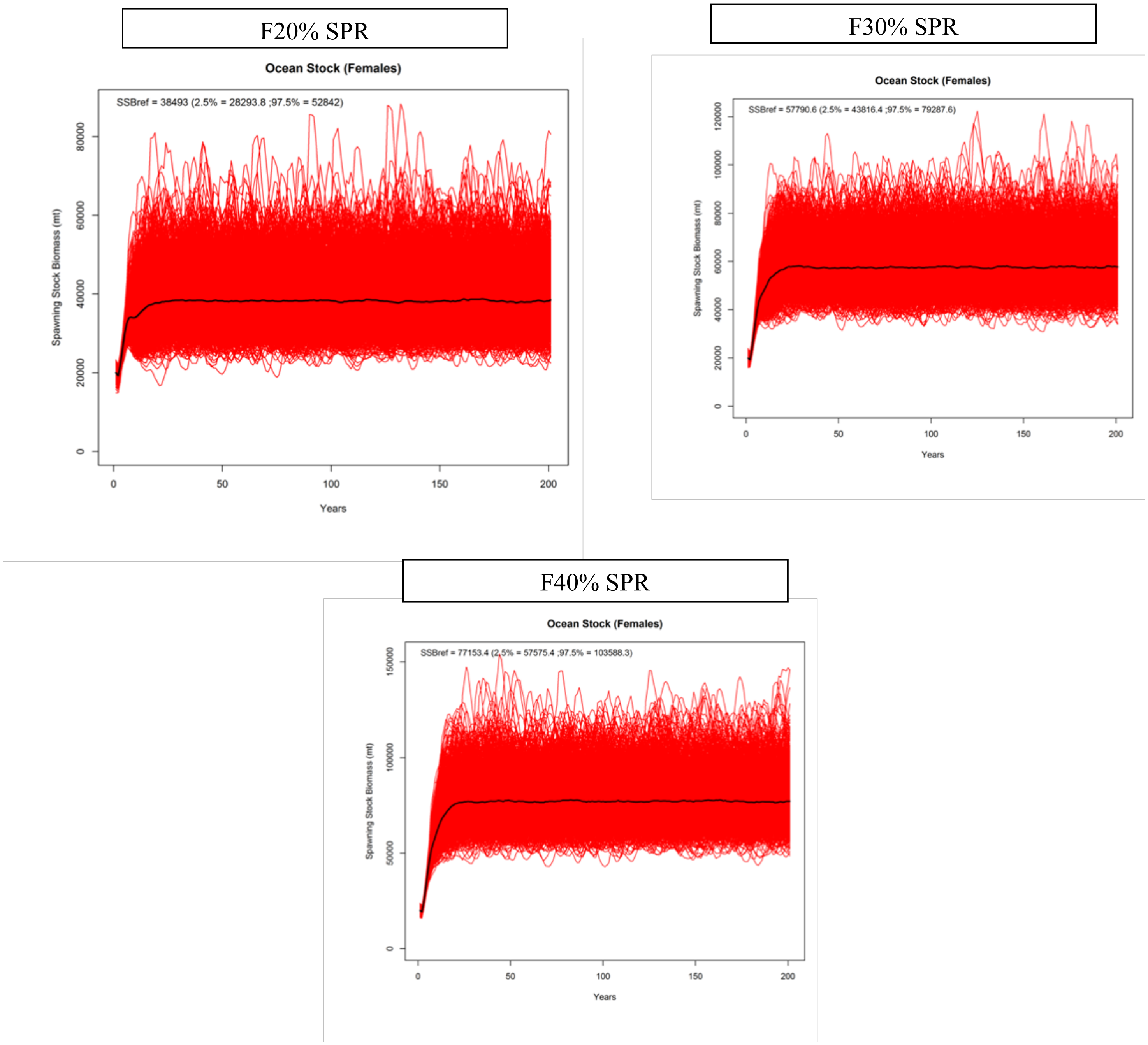


Figure B9.5. Plots of stochastic projection for the Delaware Bay/Hudson River stock using F20%, F30% and F40% under the hockey-stick female spawning stock biomass-recruitment relationship.

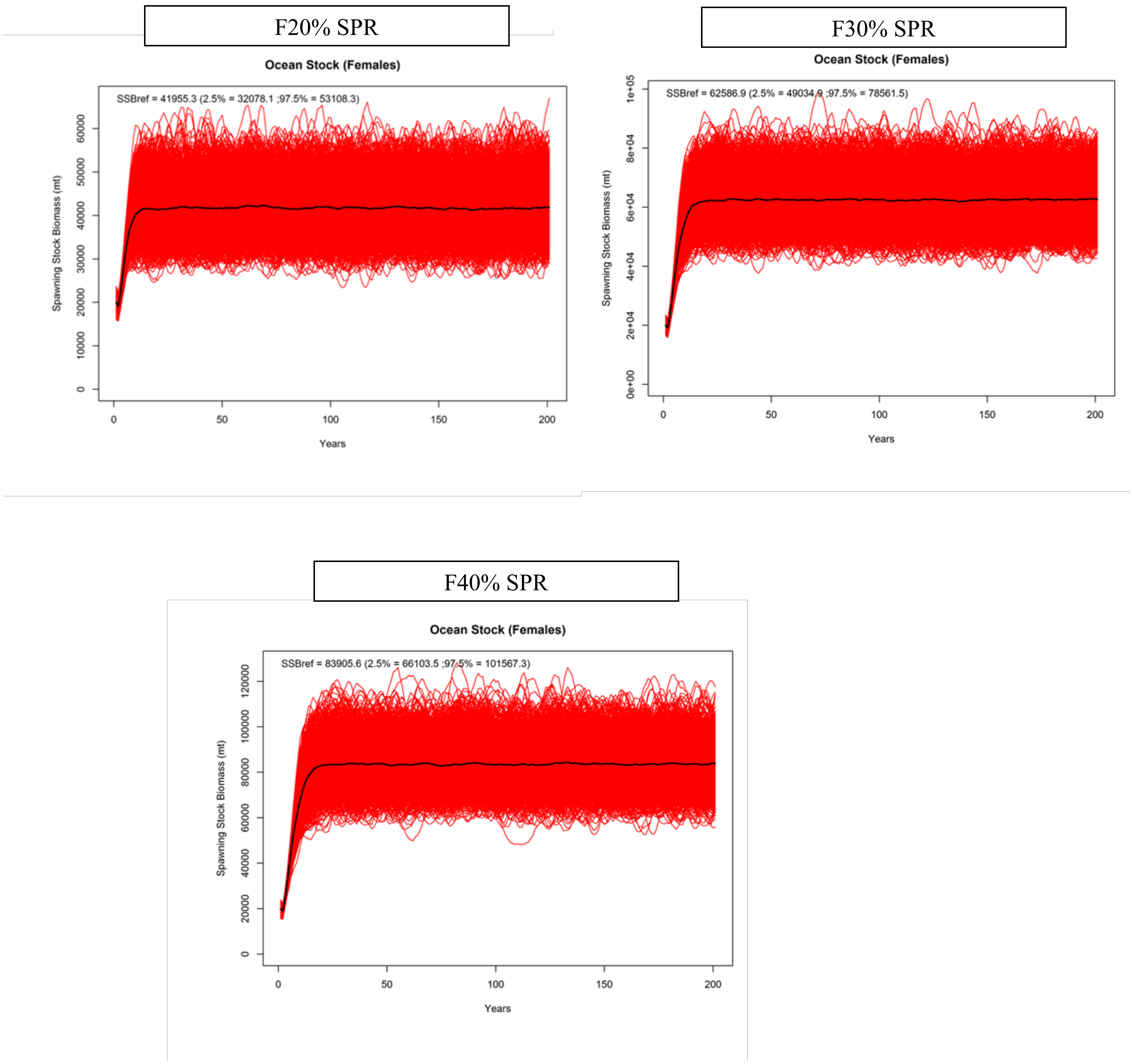


Figure B9.6. Plots of stochastic projection for the Delaware Bay/Hudson River stock using F20%, F30% and F40% under the empirical approach to the female spawning stock biomass-recruitment relationship.

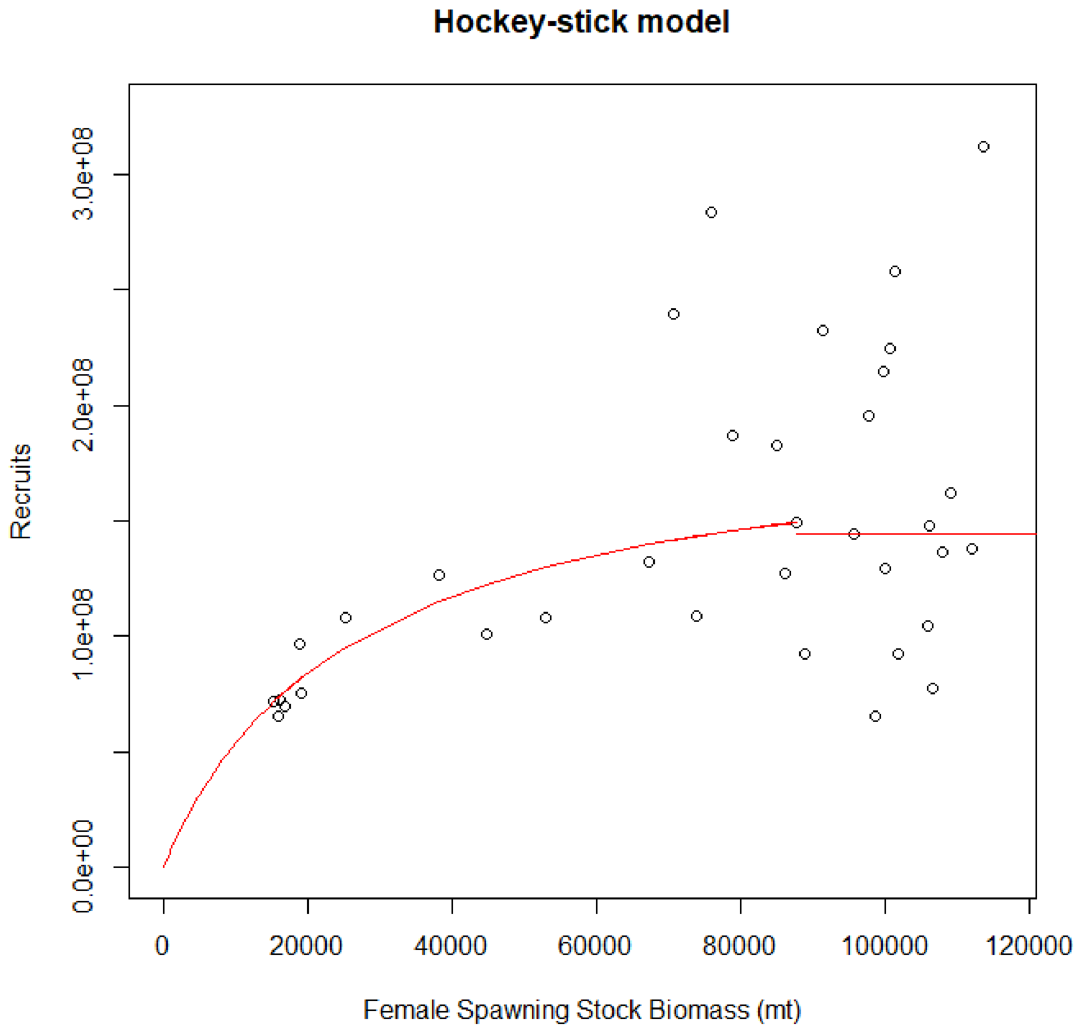


Figure B9.7. Beverton Holt, hockey-stick female spawning stock biomass-recruitment relationship used for non-migration SCA.

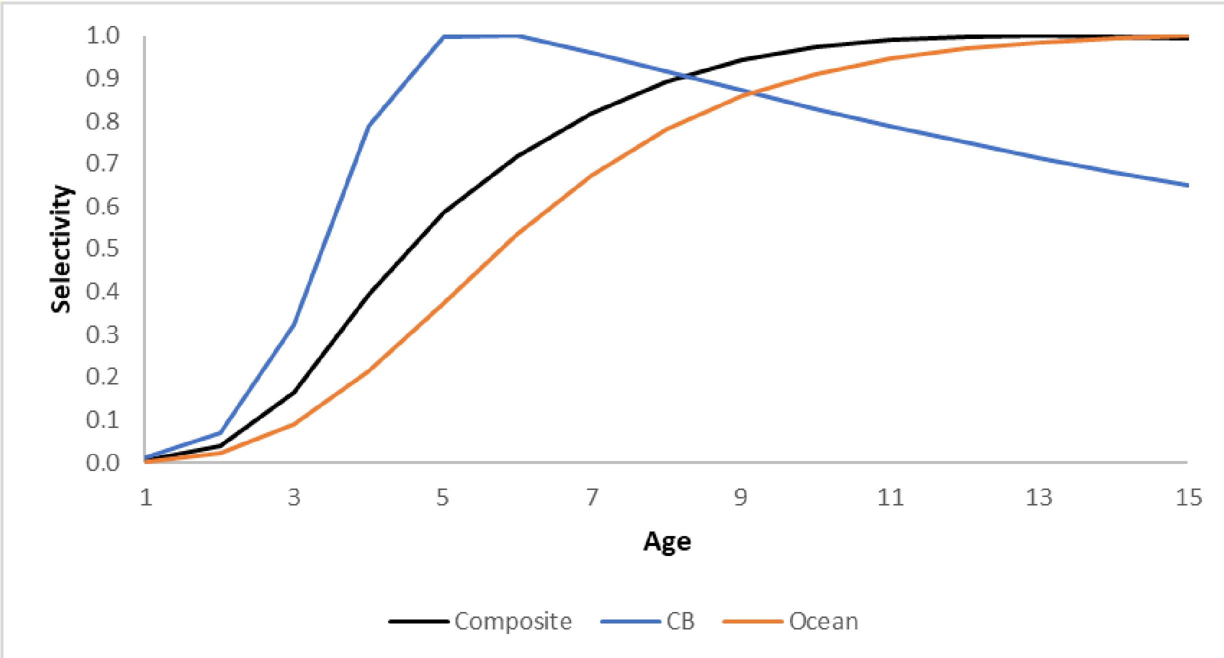


Figure B9.8. Composite selectivity curve used to calculate the fishing mortality rate (F) reference points for the non-migration SCA developed from the selectivities of the two fleets in the model.

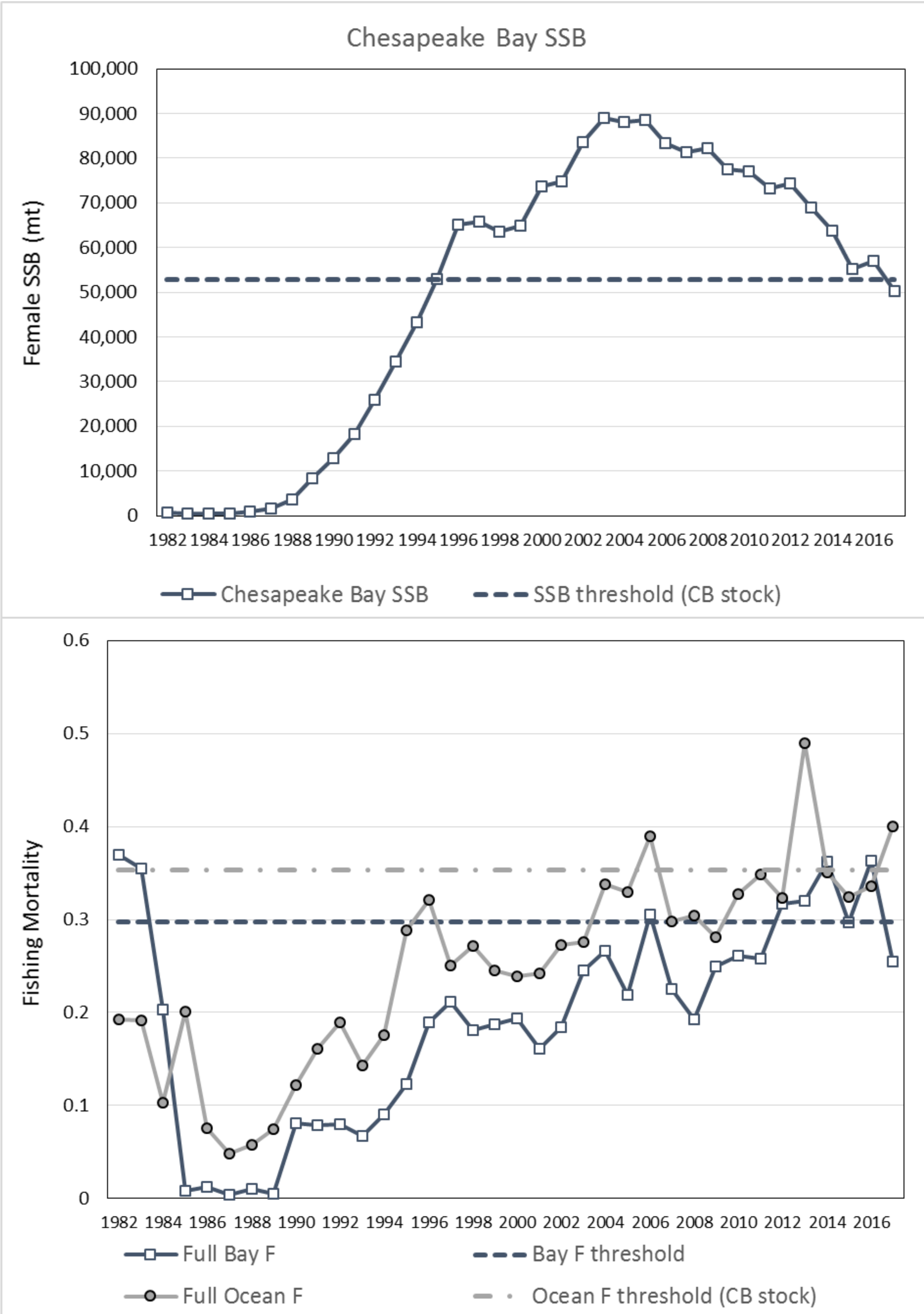


Figure B9.9. Status of the Chesapeake Bay stock relative to current $SSB_{threshold}$ (top) and $F_{threshold}$ (bottom) reference points.

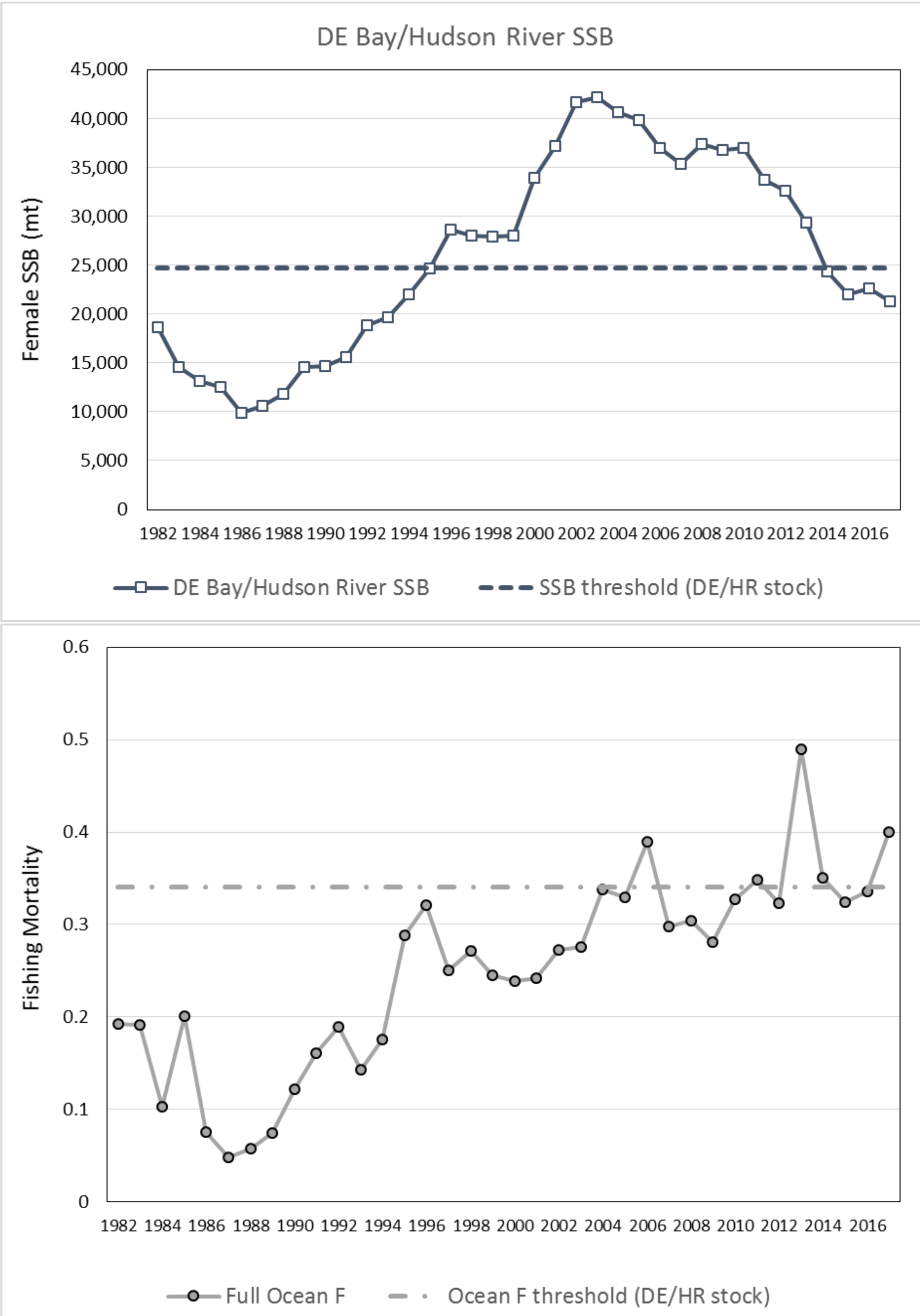


Figure B9.10. Status of the Delaware Bay/Hudson River stock relative to current $SSB_{threshold}$ (top) and $F_{threshold}$ (bottom) reference points.

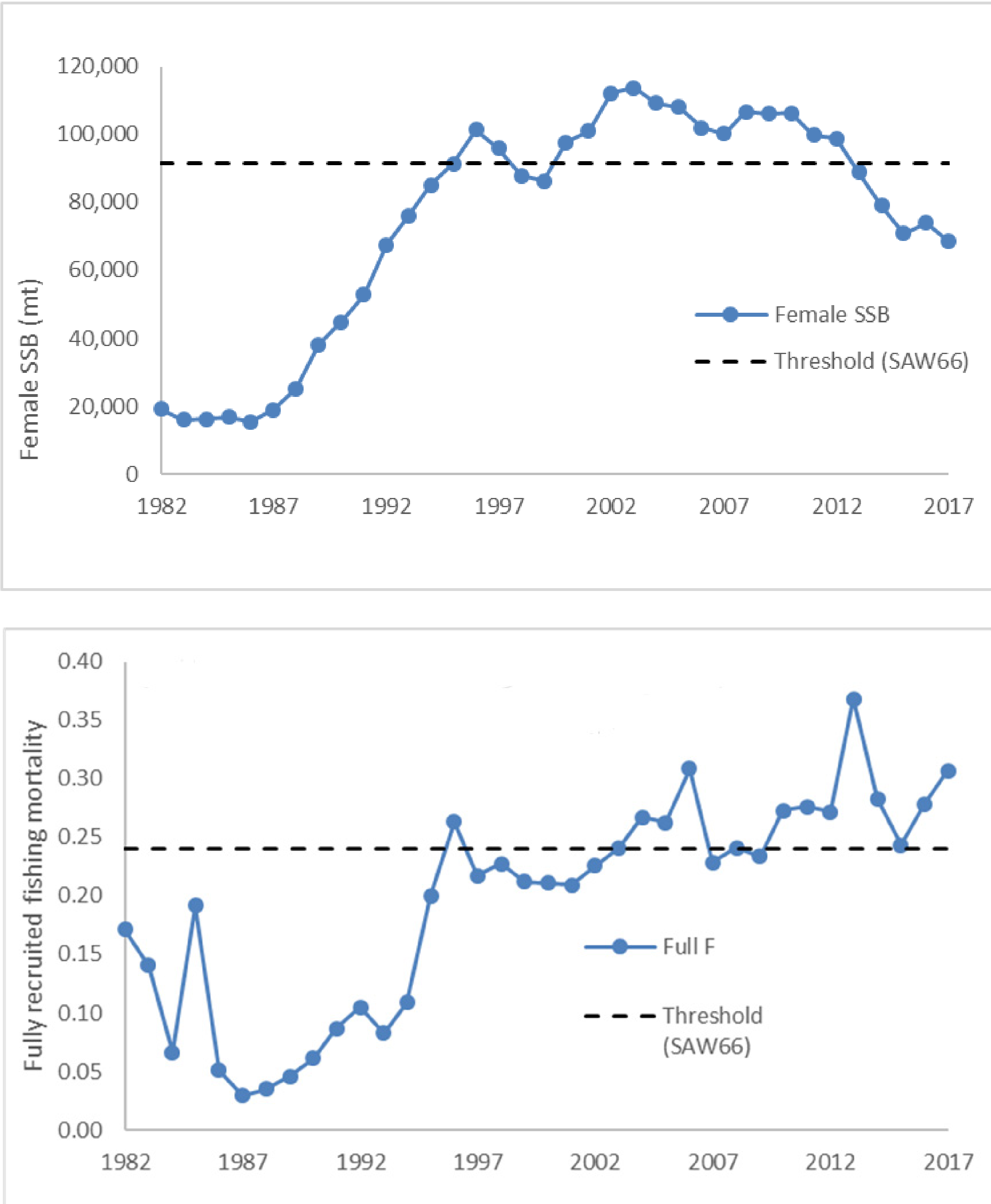
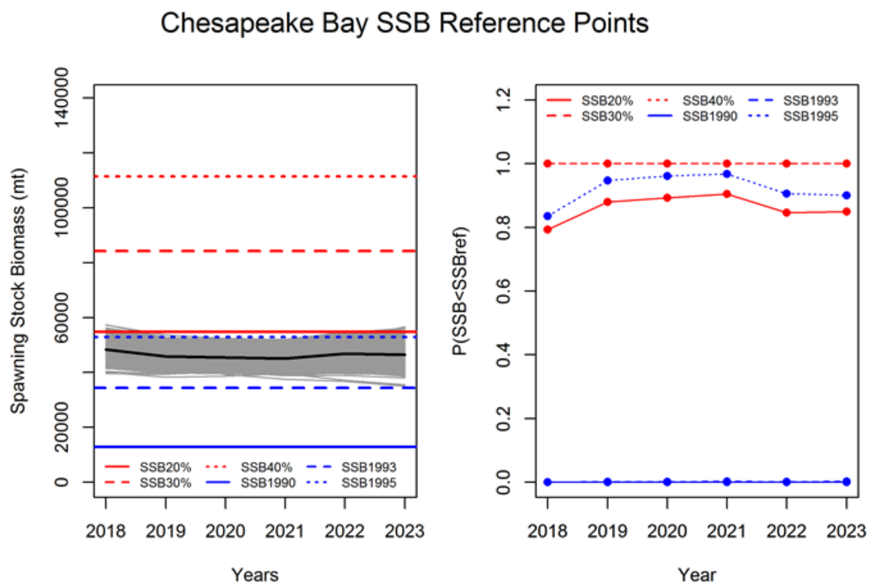


Figure B9.11. Status of Atlantic striped bass from the non-migration model relative to current $SSB_{threshold}$ (top) and $F_{threshold}$ (bottom) reference points.

Fishing at Current Fs (F_{2017} Bay = 0.255; F_{2017} Coast=0.400)



Fishing at F20% (2018=Current Fs; Projection: Bay = 0.288; Ocean=0.342)

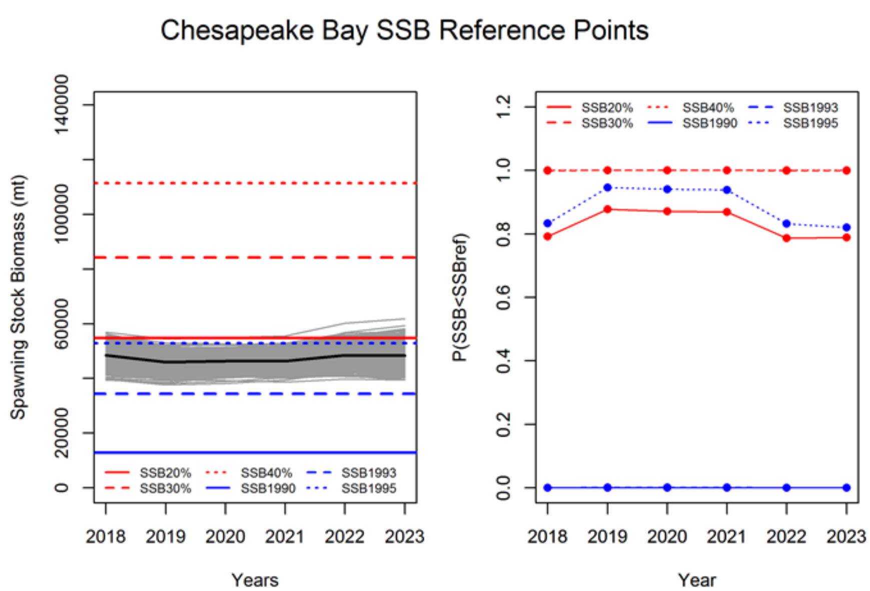
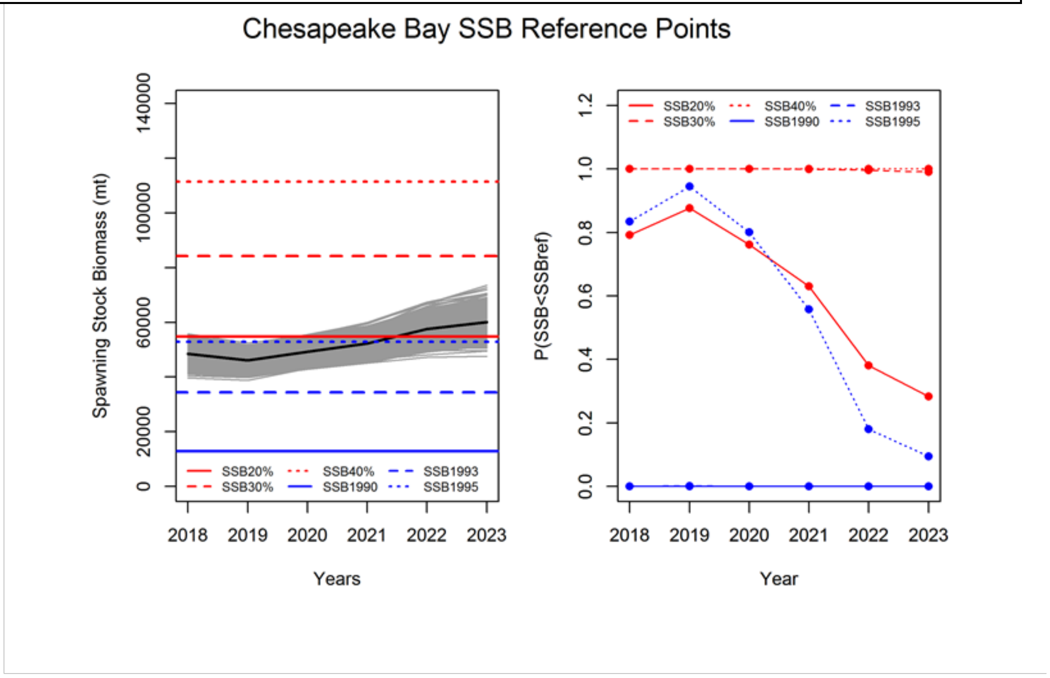


Figure B10.1. Short-term projections of total spawning stock biomass (SSB) and probability of annual total SSB being below the SSB reference points under different fishing scenarios for the Chesapeake Bay stock.

Fishing at F30% (2018=Current Fs; Projection: Bay = 0.196, Ocean=0.233)



Fishing at F40% (2018=Current Fs; Projection: Bay=0.144, Ocean=0.166)

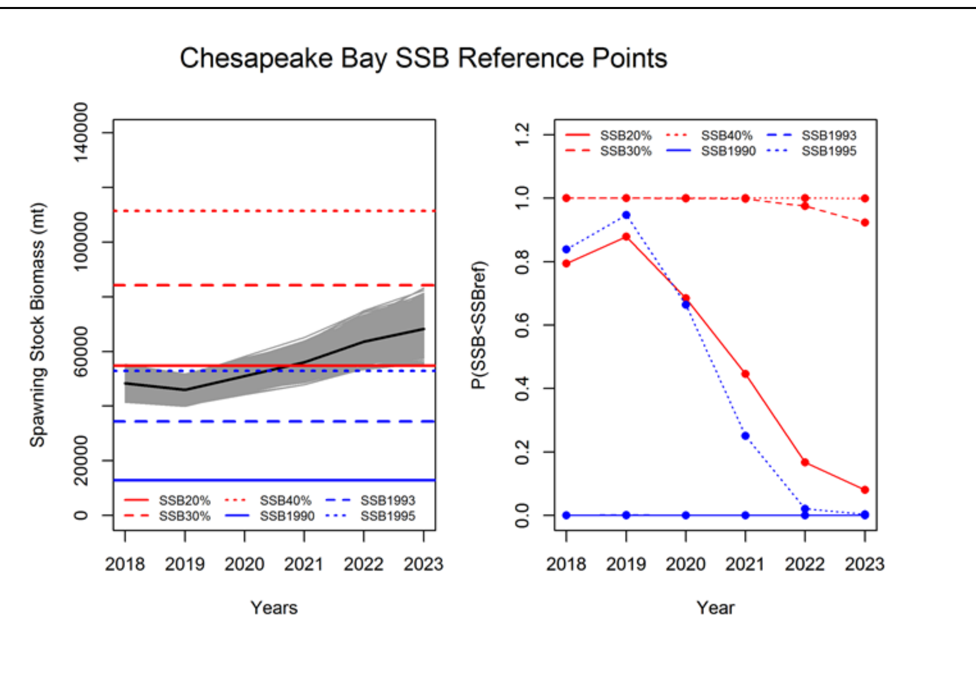
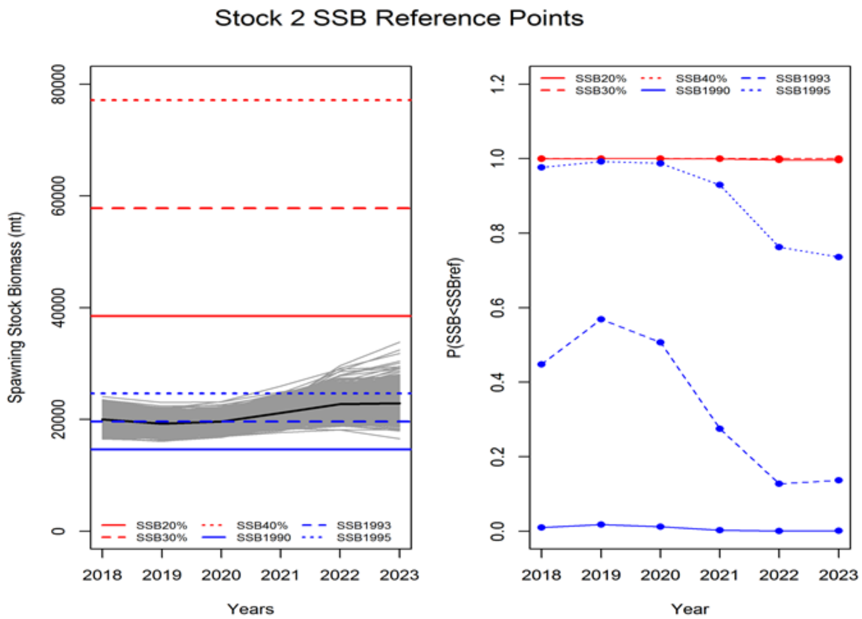


Figure B10.1 (cont.)

Fishing at current F; Ocean=0.400



F20% (2018=Current F; Projection: 0.251)

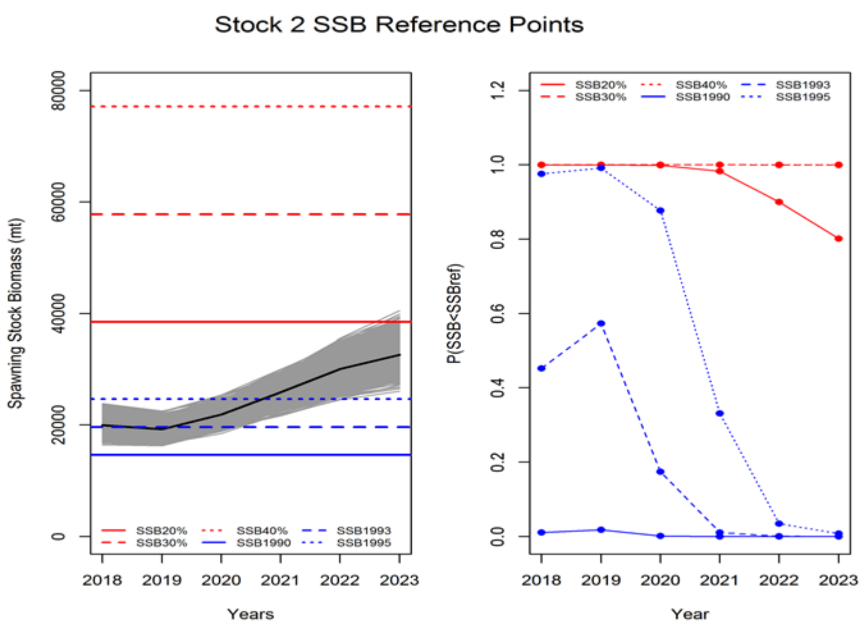
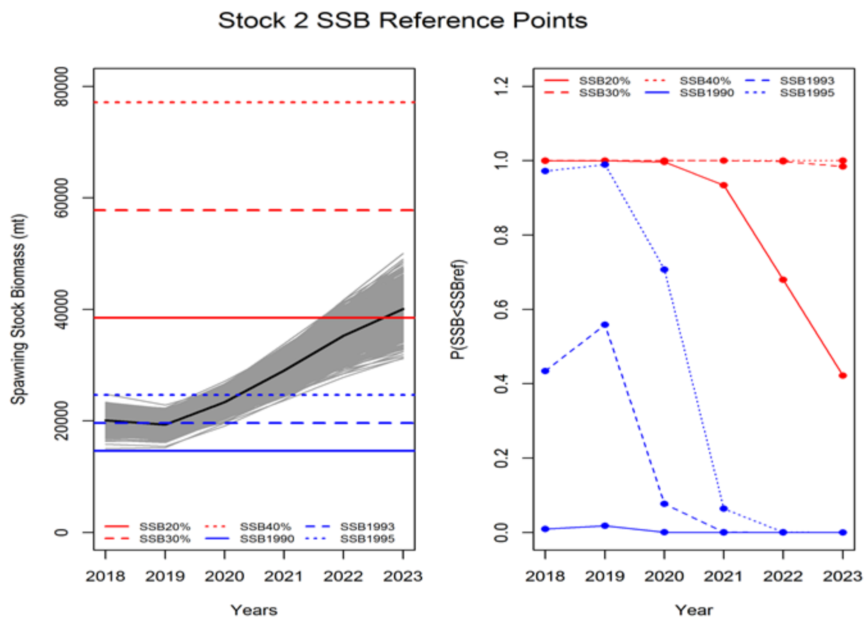


Figure B10.2. Short-term projections of total spawning stock biomass (SSB) and probability of annual total SSB being below SSB reference points under different fishing scenarios for the Delaware Bay/Hudson River stock (Stock 2) using the Hockey-Stick female spawning stock biomass-recruitment method.

F30% (2018=Current F; Projection: 0.168)



F40% (2018=Current F; Projection: 0.118)

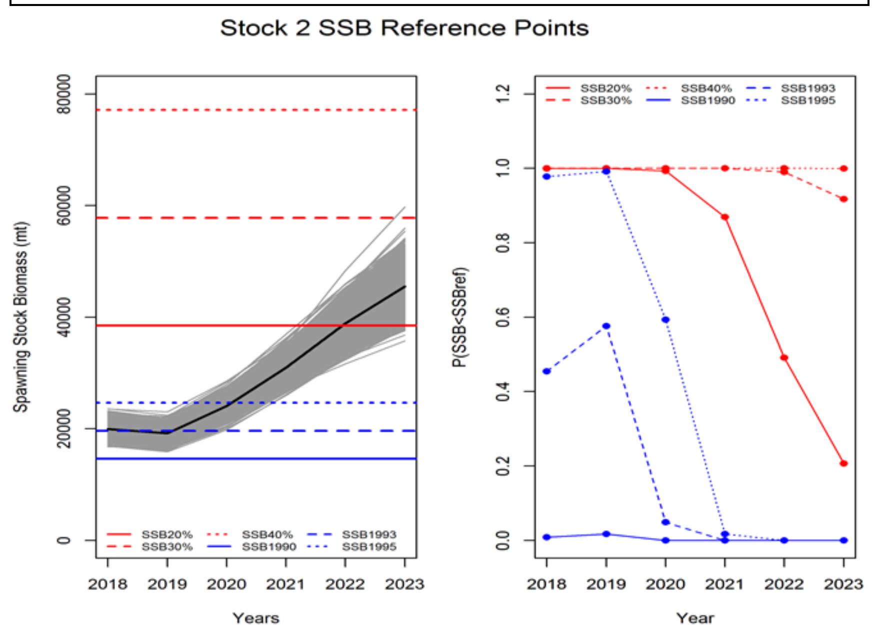


Figure B10.2 (cont.)

Fishing at current F; Ocean=0.400

F20% (2018=Current F; Projection: 0.251)

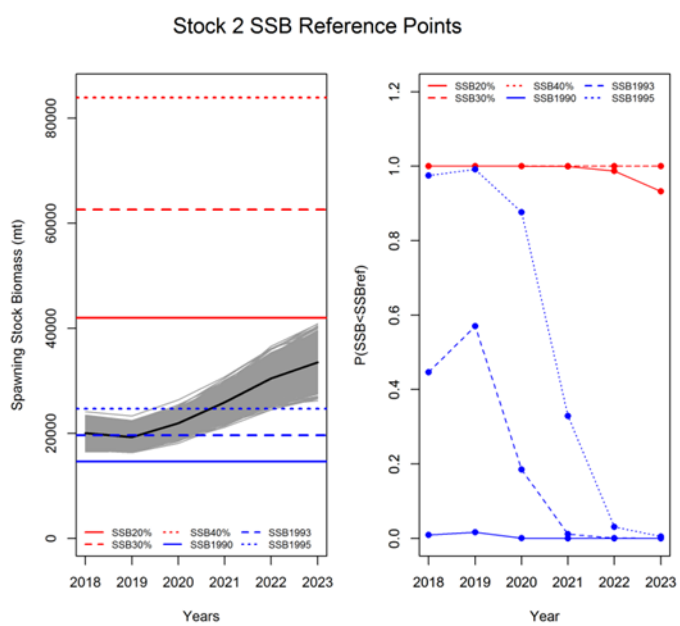
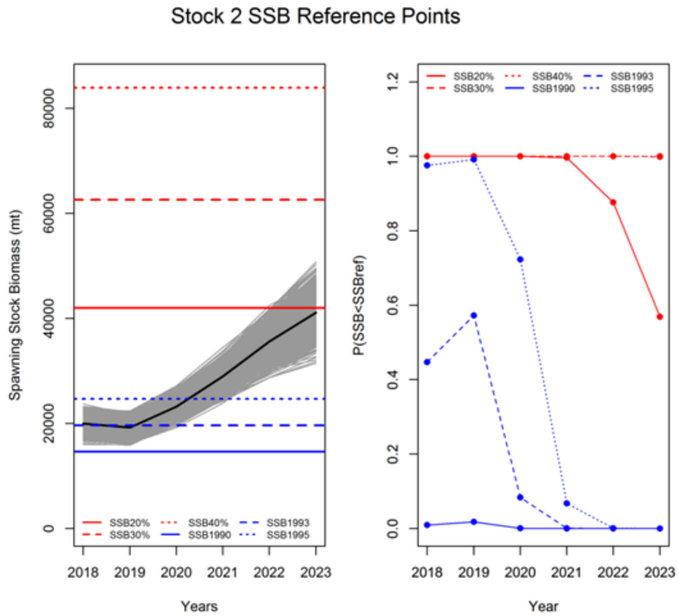


Figure B10.3. Short-term projections of total spawning stock biomass (SSB) and probability of annual total SSB being below SSB reference points under different fishing scenarios for the Delaware Bay/Hudson River stock (Stock 2) using the empirical female spawning stock biomass-recruitment method.

F30% (2018=Current F; Projection: 0.168)



F40% (2018=Current F; Projection: 0.118)

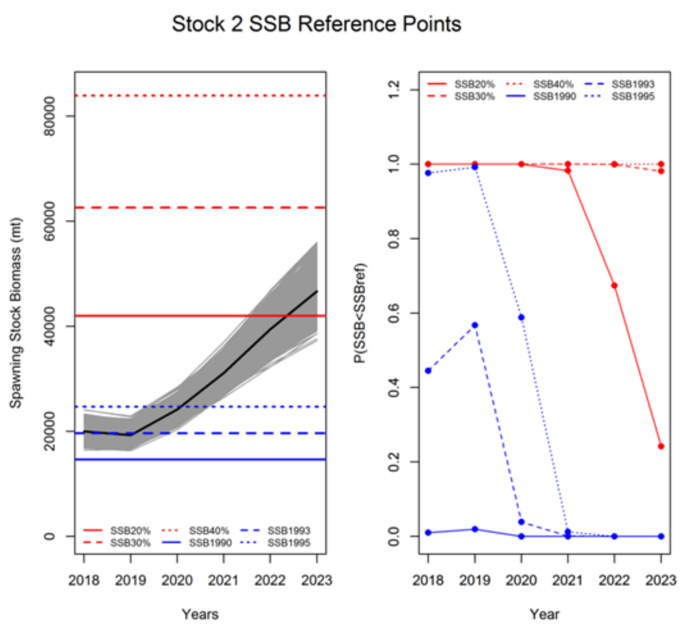


Figure B10.3 (cont.)

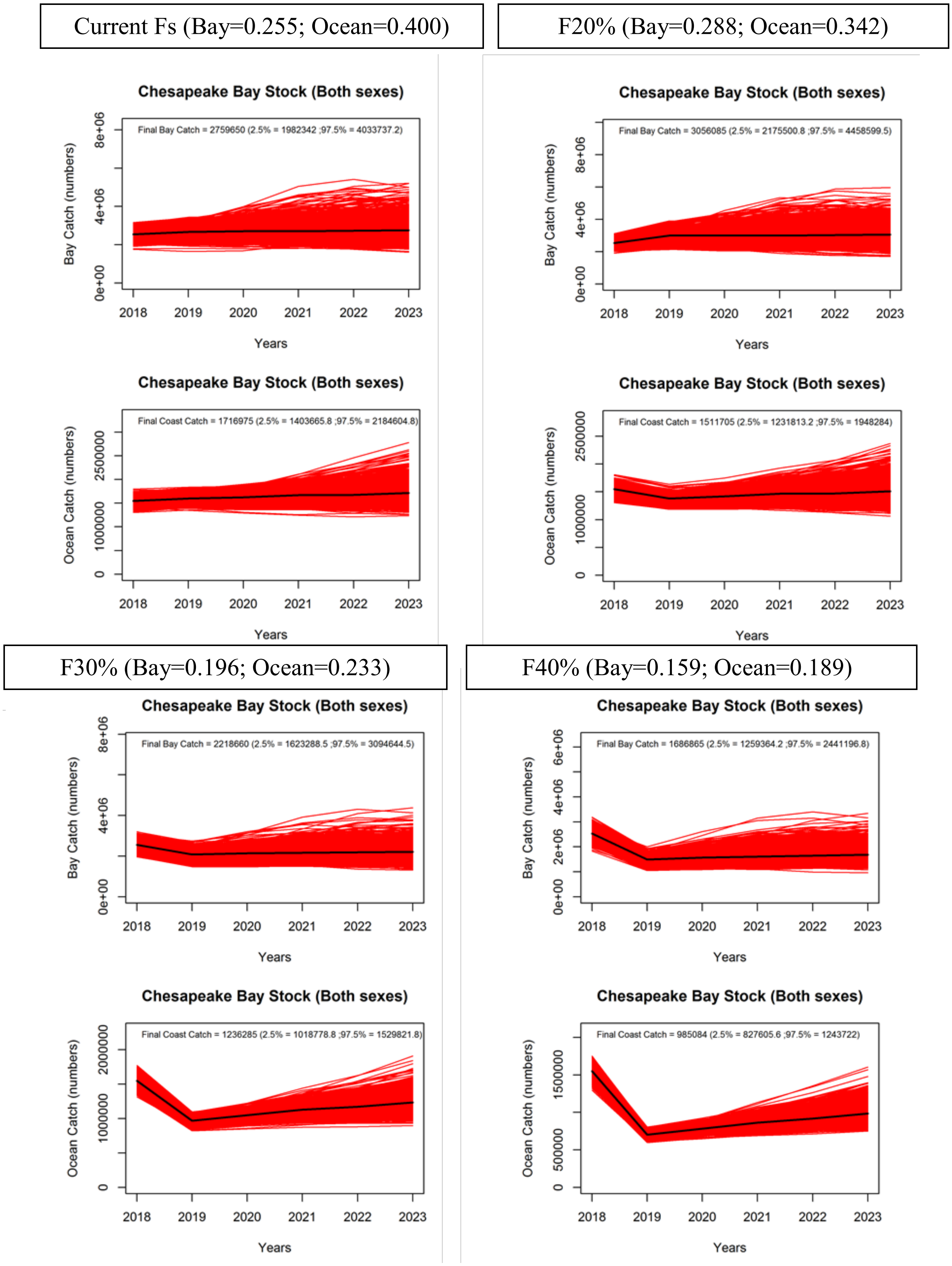


Figure B10.4. Projected total catch from the Chesapeake Bay stock under different fishing mortality scenarios. F_{2018} was assumed equal to F_{2017} in all scenarios.

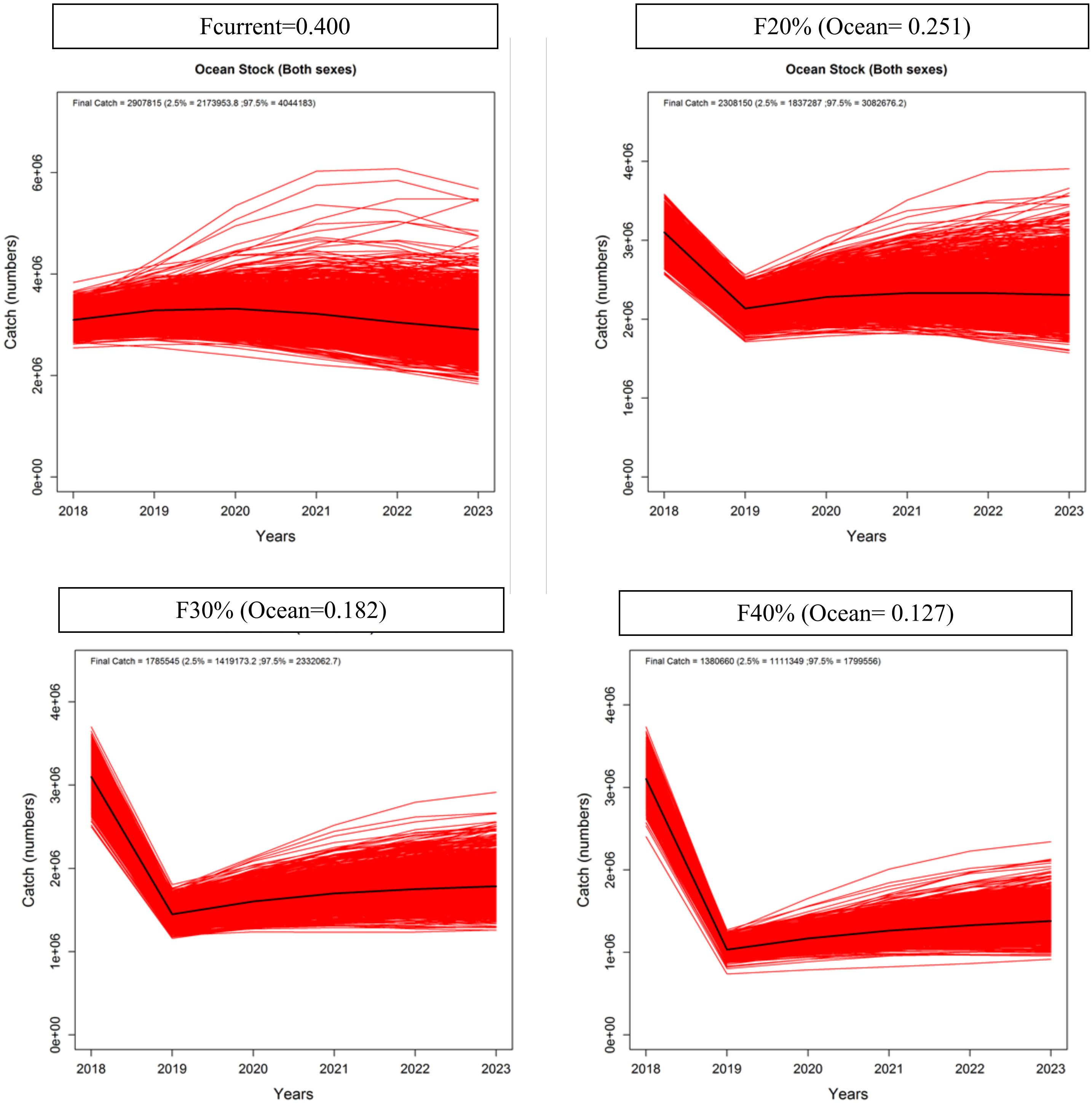


Figure B10.5. Projected total catch from the Delaware Bay/Hudson River stock under different fishing mortality scenarios using the hockey-stick female spawning stock biomass-recruitment approach. F_{2018} was assumed equal to F_{2017} in all scenarios.

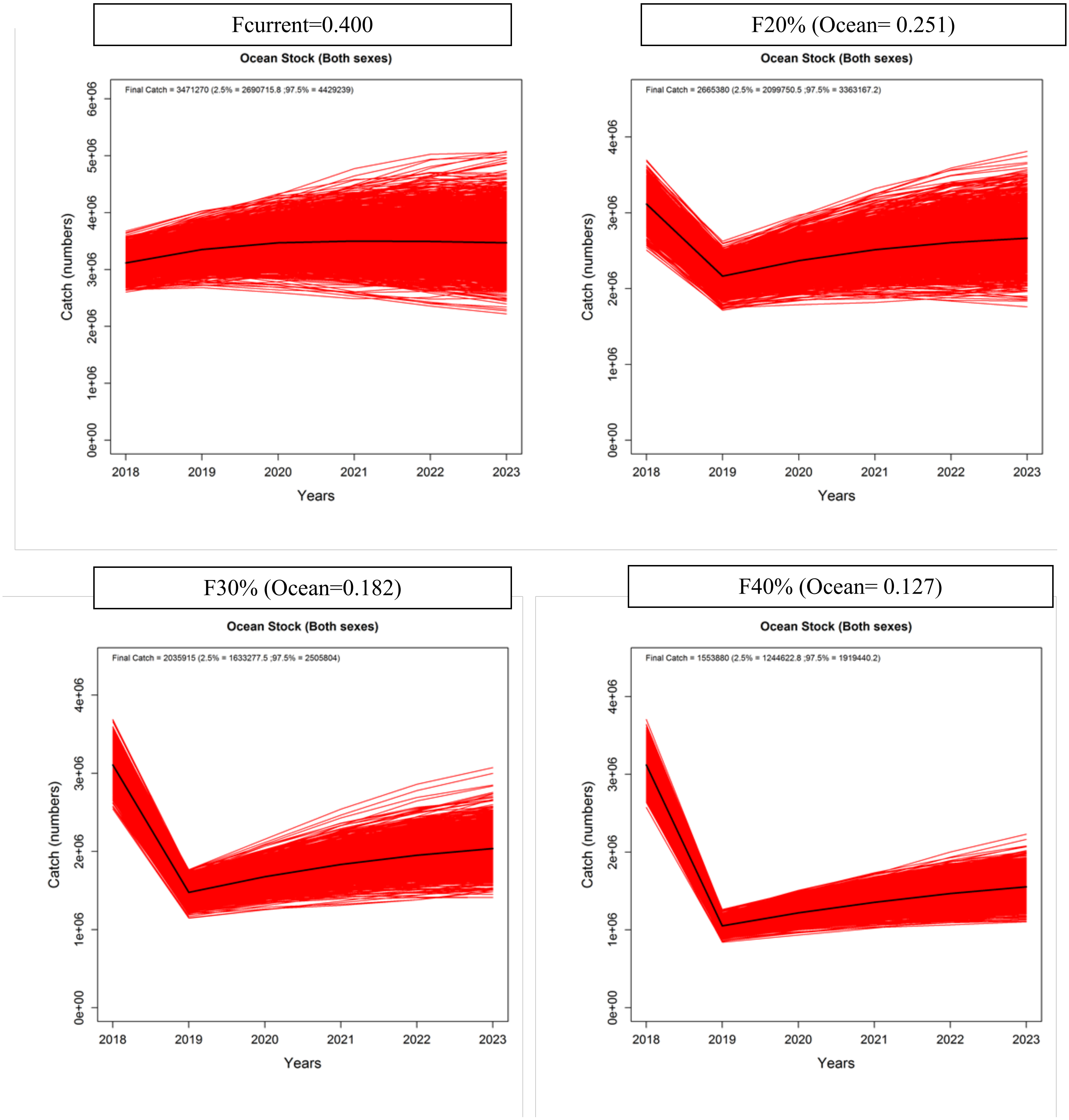


Figure B10.6. Projected total catch from the Delaware Bay/Hudson River stock under different fishing mortality scenarios using the empirical female spawning stock biomass-recruitment approach.

B. Atlantic Striped Bass Stock Assessment Report Appendices

List of Appendices

Appendix B1: Growth, sex ratios, and maximum ages by state and through years

Hongsheng Liao
Old Dominion University
Norfolk, Virginia

July 31, 2018

Introduction

This study attempted to identify temporal and spatial patterns in Striped Bass life history along Atlantic ocean. Three objectives are to examine: 1) growth rates, 2) the maximum ages, and 3) sex ratios. Because of my lacks of knowledges on fisheries activities and managements of each state, I will try to avoid any discussion and speculation on what caused the results observed in this study.

Methods

Data collection

The biological data with ages and total lengths (cm) were collected by eight states, DE, MA, MD, NJ, NY, PA, RI, and VA. However, the time series of the data varied among the states. MA has the longest time series from 1982 to 2016 whereas VA has the shortest one from 1998 to 2016. By finishing this writing, no state has updated its biological data with 2017 ages at ASMFCftp site. Some states provided only scale ages whereas others provided both scale and otolith ages. However, none of the states provided the entire time series of otolith ages. Therefore, this study was using the best age which is defined by the SAS as follows: the otolith age is used as the final age when an otolith age is available and the scale age is used as the final age when an otolith age is not available for a fish. The best age is always referred to as "age" and the total length as "length" hereafter.

Growths

Before examining the growths, I used the boxplot() function in R to remove any outliers by age and sex, assuming that length at age is normally distributed. The data without any outliers were used for further growth analyses. Before examining the temporal and spatial patterns in growth, I used Kimura likelihood ratio test (Kimura 1980) to examine the difference in growth between females and males. More specifically, I used the vblrt() function in R fishmethods package by Gary Nelson to conduct Kimura test. When it was found that the female and male growths were significantly different, all further growth analyses were sex-specific.

I used von Bertalanffy growth model (Quinn and Deriso 1999) to fit the length-age data by state, sex, and year in order to identify any temporal patterns in sex-specific growth within each state. When no temporal pattern was identified, all the years were pooled within each state and the von Bertalanffy growth model was used to fit the year-pooled data within each state to examine spatial variations in growth among the states. I first eyeballed any potential temporal and spatial growth patterns, then used Kimura likelihood ratio test to examine them.

Maximum ages

The maximum age may also provide useful information about the life history of a fish population. For example, Hoenig (1983) presented a method using the maximum age to estimate the total mortality (Z) of a fish population. Although the observed maximum age in the catch of Striped Bass may also be influenced by the fisheries management, it still provides some information on the life history of the Striped Bass stock. I examined the maximum ages using the sex-pooled data by state and through years.

Sex ratios

I examined the sex ratios by state and through years. Such sex ratios indicate only the female to male ratios in the catches by each state and through years, instead of the sex ratio of the stock.

Results

Growths

Kimura test indicates that there is a significant difference in growth between female and male Striped Bass across states and years (Figure 1). Therefore, further growth analyses were sex-specific. In general, I couldn't find any temporal growth pattern within each state (Figure 2, 3, 4, 5, 6, 7, and 8 (Due to the small sample sizes, convergence didn't occur, as a result, no sex- and year-specific growth curves were obtained for RI)). However, in some years, the growth rates were more unique than in other years. For example, MA female growth in 2004 deviated from other years and was much slower (Figure 2 upper panel). The similar situation could be observed in NJ female 1995 (Figure 5 upper panel) and VA female 2004 growth (Figure 8 upper panel). I don't know what caused such suddenly slower growths just in one year for females within a couple of states, but it might be worth to find out the reasons.

There look like suddenly slower growths occurring in some years in some states but the growth curves appeared more like straight lines due to short age ranges (NY female 1986 in Figure 3 uppper panel and NJ female 2000 in Figure 5 upper panel). I have no way to know if those straight lines have reached their growth plateaus or will continue going up. As a result, I don't put them in my discussions. I also ignored one situation where most of years were not converged. For example, in MA (Figure 2 lower panel) and NJ (Figure 5 lower panel) male growths, most years were not converged, therefore, I couldn't compare if MA male 2006 grew slower and NJ male 2016 grew faster than other years.

Since there is no obvious temporal pattern in growth through years within each state except occasional annual growth changes, I pooled years by state to examine spatial patterns in sex-specific growth among states (Figure 9). I found that only two pairs of growths were not significantly different, MD female vs NJ female (Figure 10 upper panel), and NY female vs VA female (Figure 11 upper panel). Because the rest of paired growths were all significantly different, it seems easier to conclude that there are spatial patterns in growth across states. More specifically, MA has the highest growth rates for both females and males whereas VA has the lowest ones (except with NY females). Other states may fall between MA and VA.

Maximum ages

The maximum ages varied through years within each state with some states' more fluctuated than others (Figure 12). In general, all the states' maximum ages were either above or close to their mean maximum age during the past three years except MA and RI. MA maximum ages tended to decrease through years before 2014 whereas RI time series is too short to draw any conclusion. The obvious temporal patterns occurred in NJ and VA, both states' maximum ages had tendency to increase through years. In addition, VA has the highest mean maximum age across years, probably because more otolith ages were used in VA data, and scale-age more likely underestimated ages of older Striped Bass whereas otolith-age provided more accurate age estimates of older Striped Bass (Secor et al. 1995 and Liao et al. 2013).

Sex ratios

The sex ratio in this study is one female versus number of males observed in catch, assuming that the biological data from each state represents the sex ratio in its catch. In general, MA has the lowest sex ratio (0.039) whereas MD has the highest (11.916) (Figure 13). MD and VA sex ratios dropped below their averages since 2001 and 2000, respectively. Some states' sex ratios suddenly increased away above their averages in certain years, most likely due to small sample sizes (such as DE 1991 and NJ 1990). However, NY 2002 sex ratio suddenly increased while its sample size was not small, probably due to a change in fisheries activities, instead of a change of the sex ratio of the stock (I am guessing). Except the sudden changes discussed previously, the sex ratios were relatively consistent through years in DE, MA, NJ, NY, and PA. RI has only three year data with small sample sizes, therefore, no conclusion can be drawn from them.

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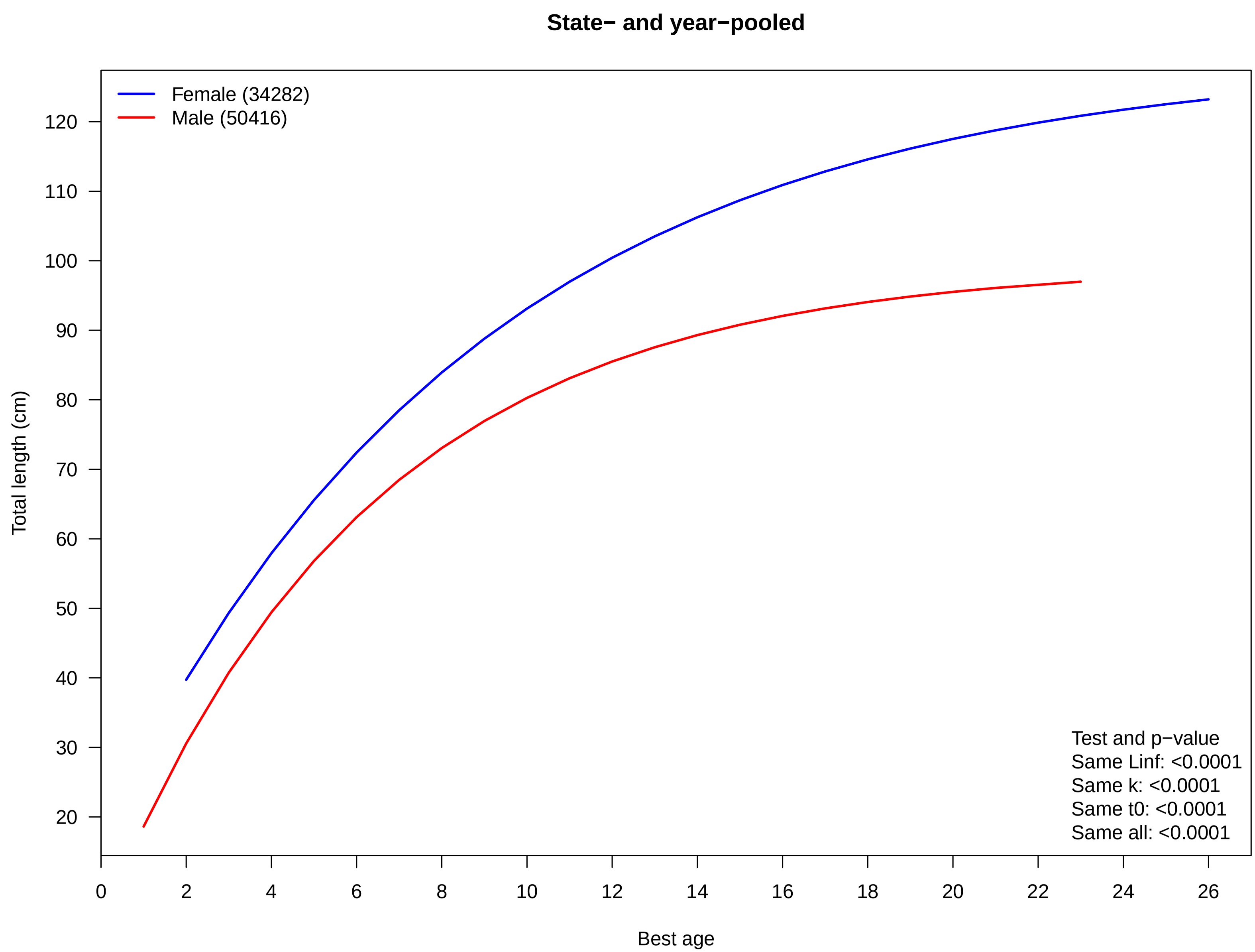

Figure 1: Kimura likelihood ratio test (Legend at bottom-right) indicates that there is a significant difference in growth between female and male Striped Bass while all states and years data are combined. The number in parentheses is the sample size from each sex.

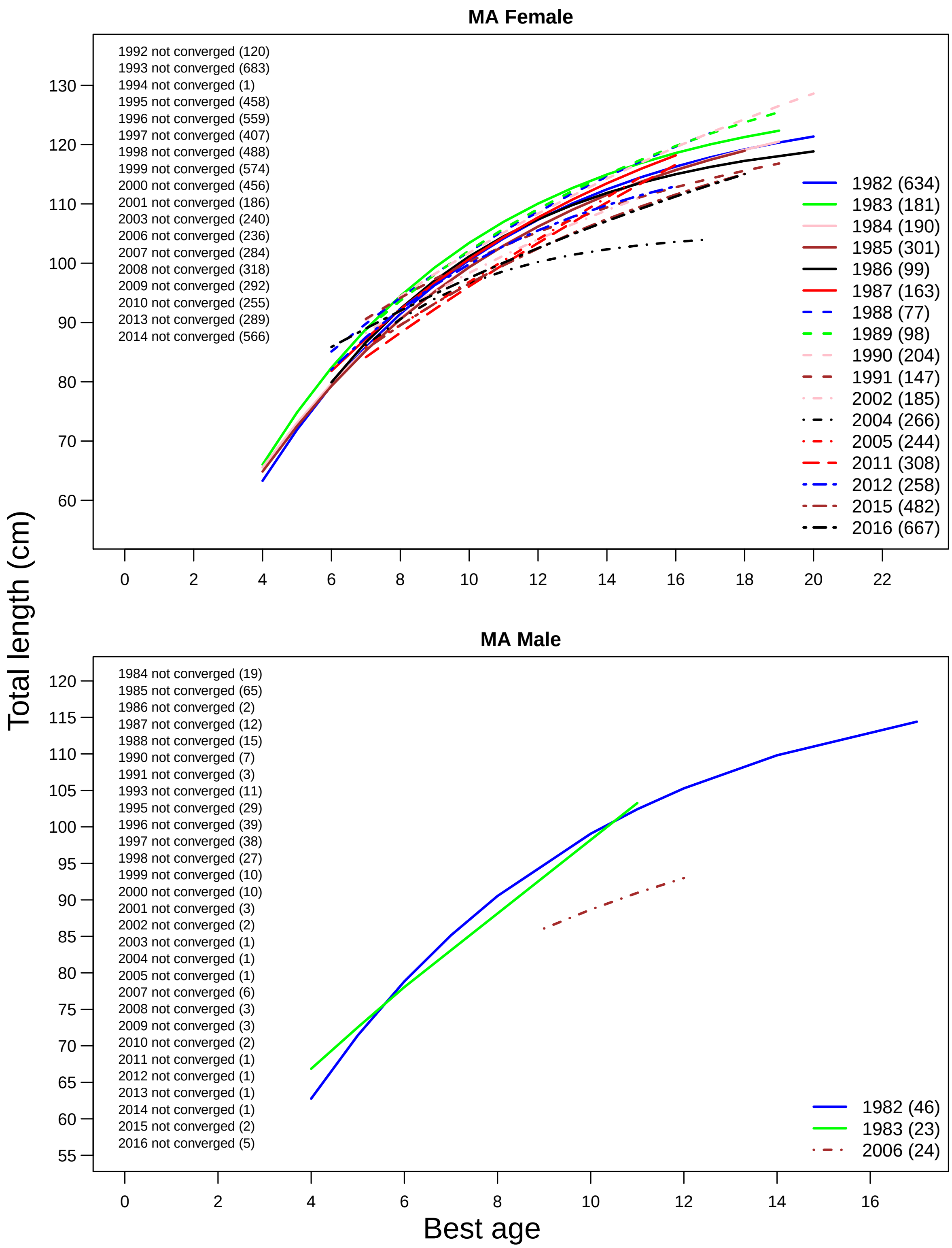

Figure 2: MA growths by sex and year. The number in parentheses is the sample size from each year.

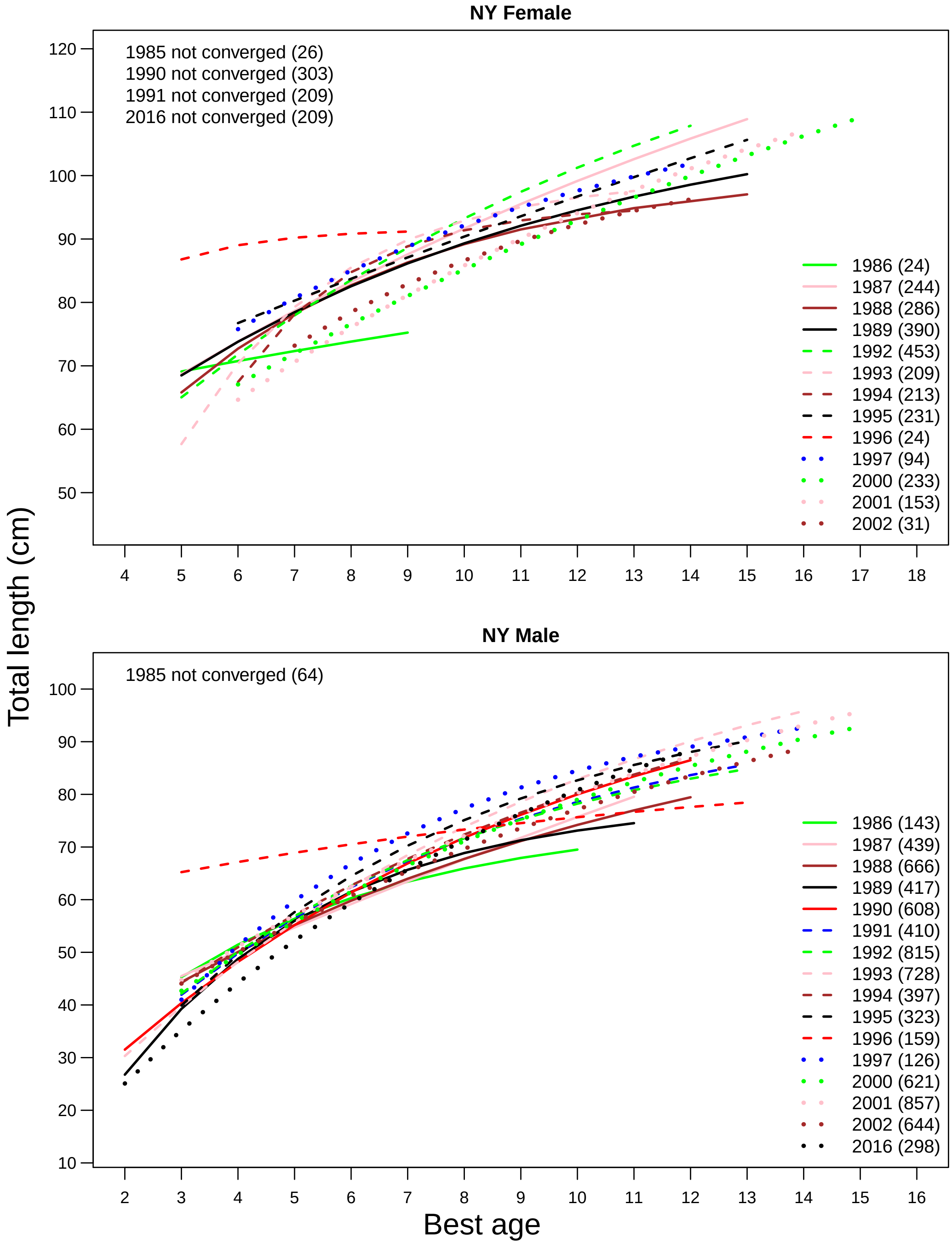

Figure 3: NY growths by sex and year. The number in parentheses is the sample size from each year.

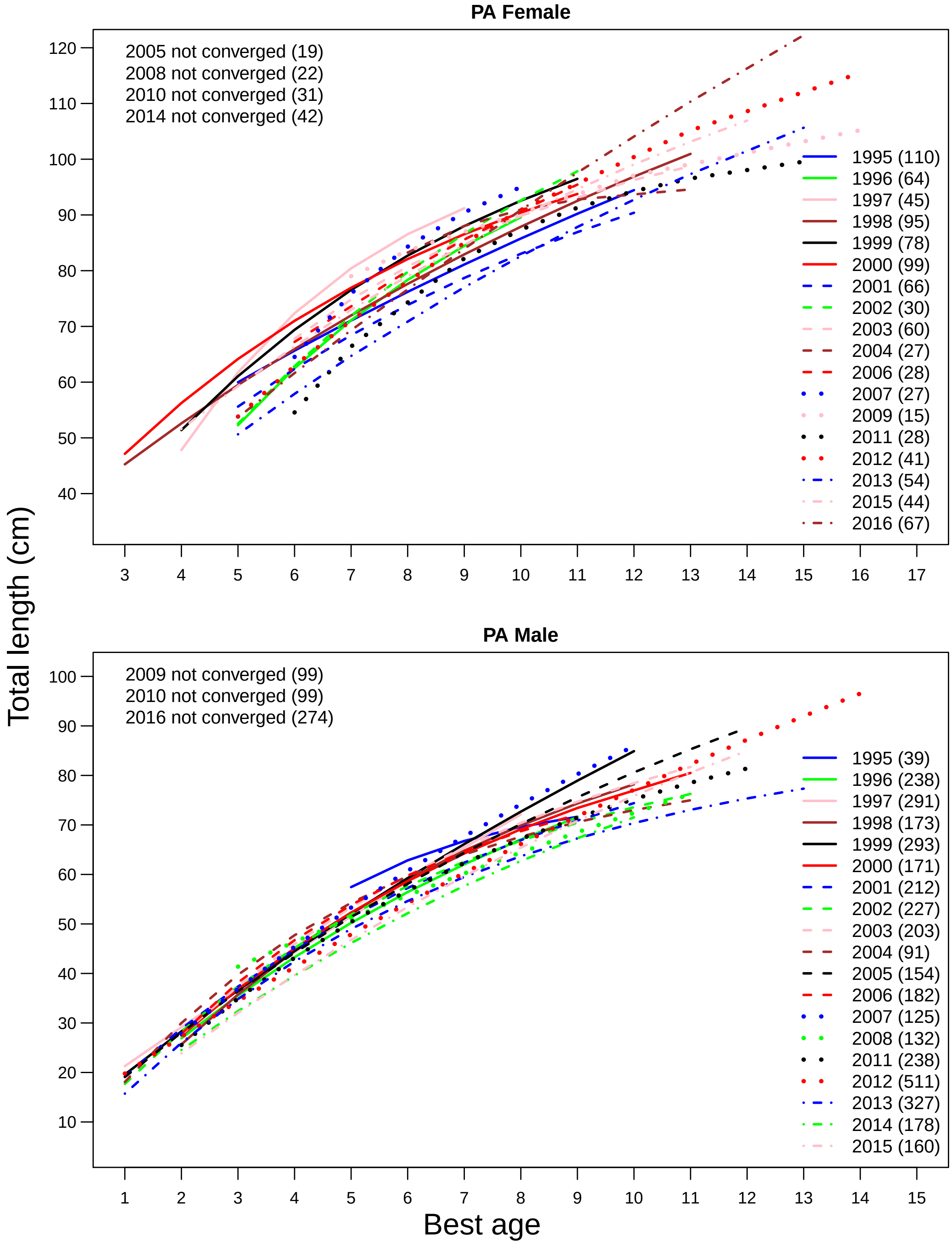

Figure 4: PA growths by sex and year.

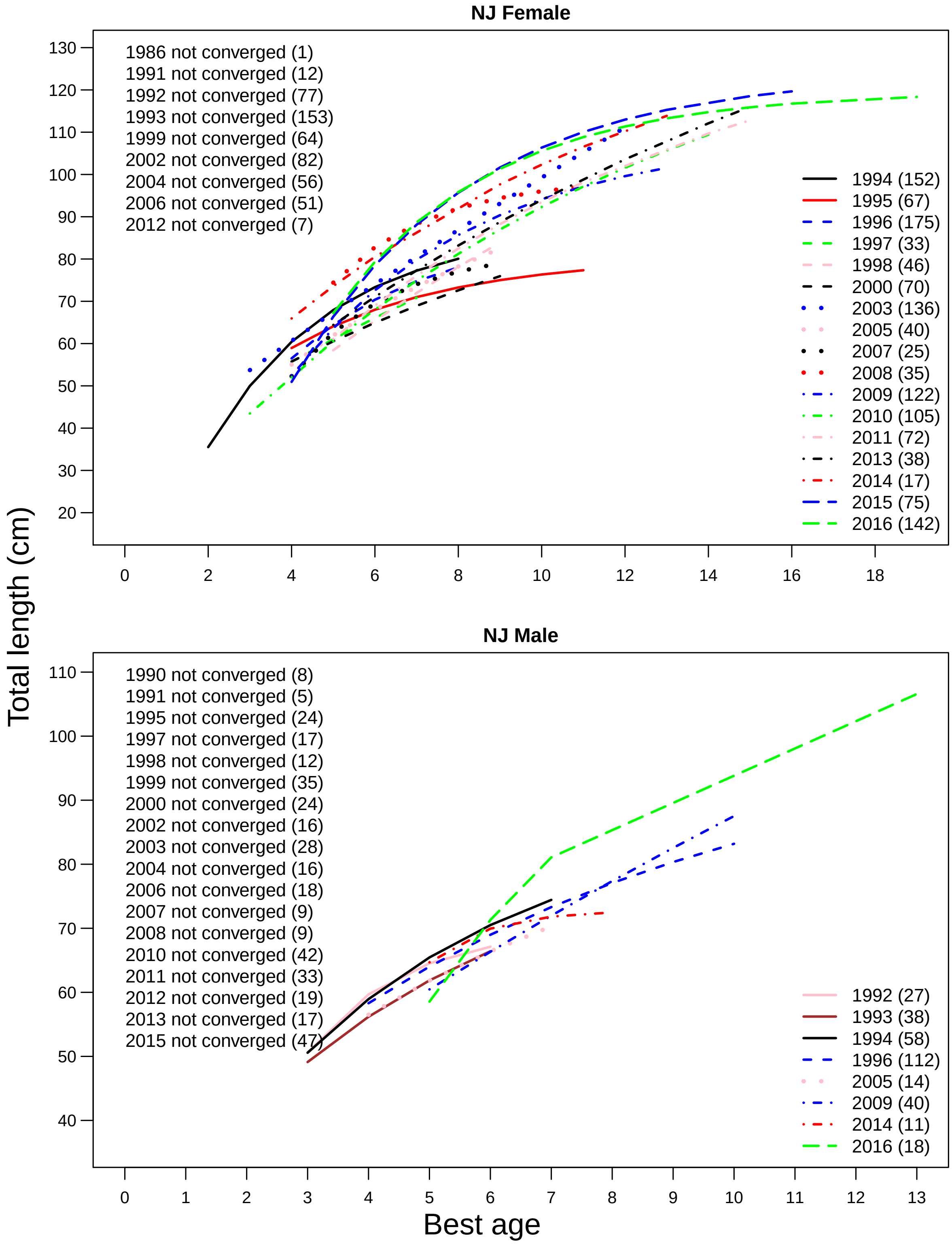

Figure 5: NJ growths by sex and year. The number in parentheses is the sample size from each year.

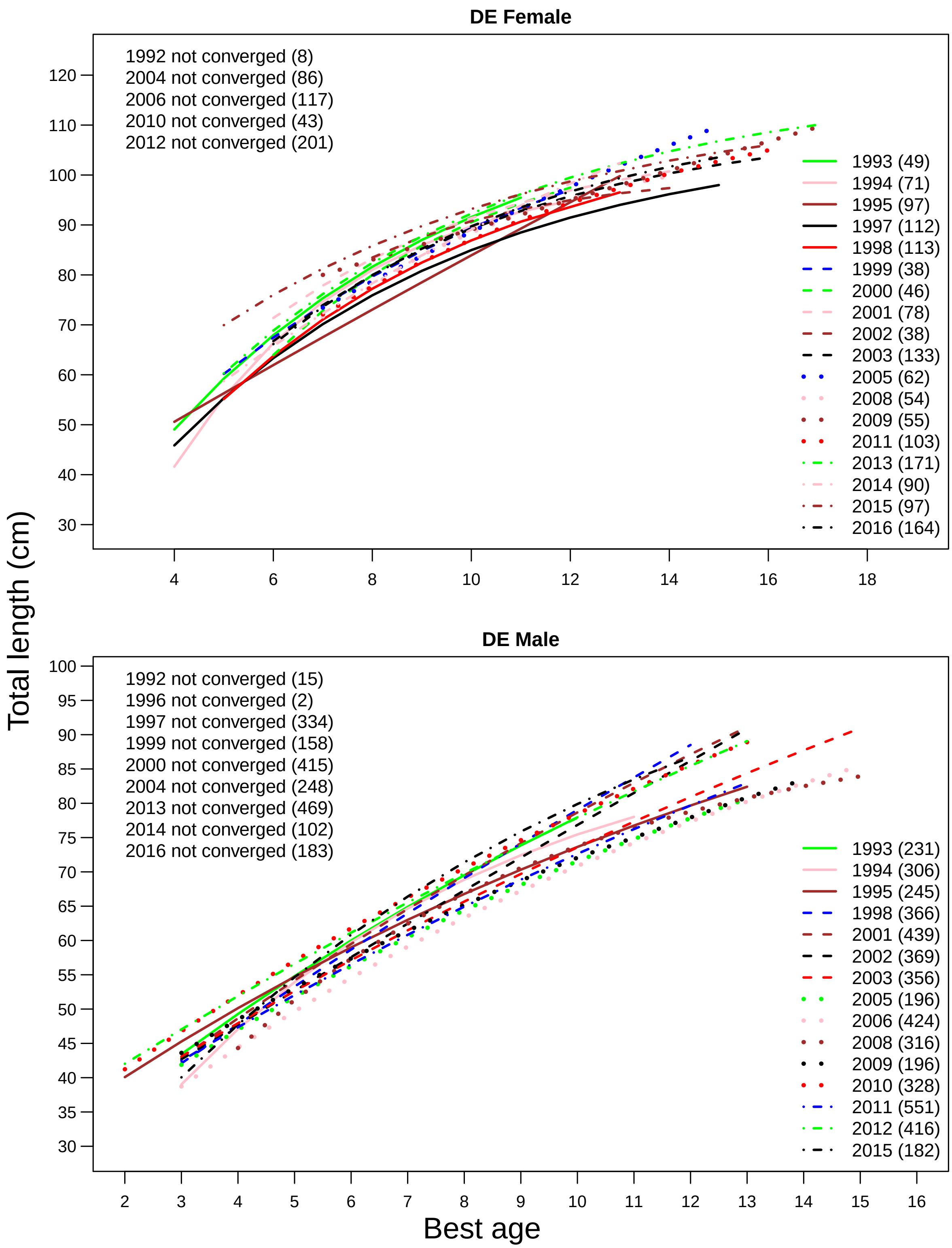

Figure 6: DE growths by sex and year. The number in parentheses is the sample size from each year.

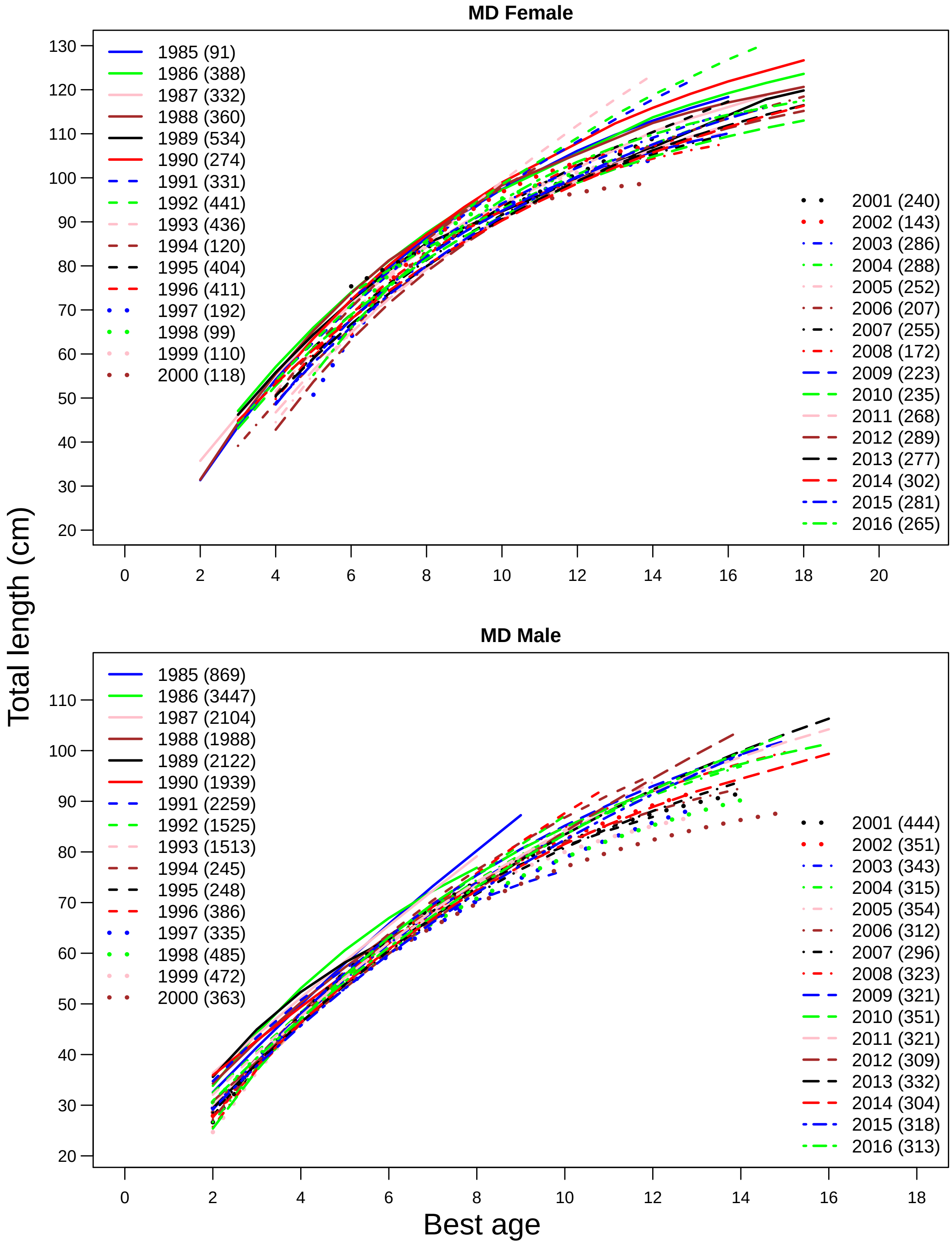

Figure 7: MD growths by sex and year. The number in parentheses is the sample size from each year.

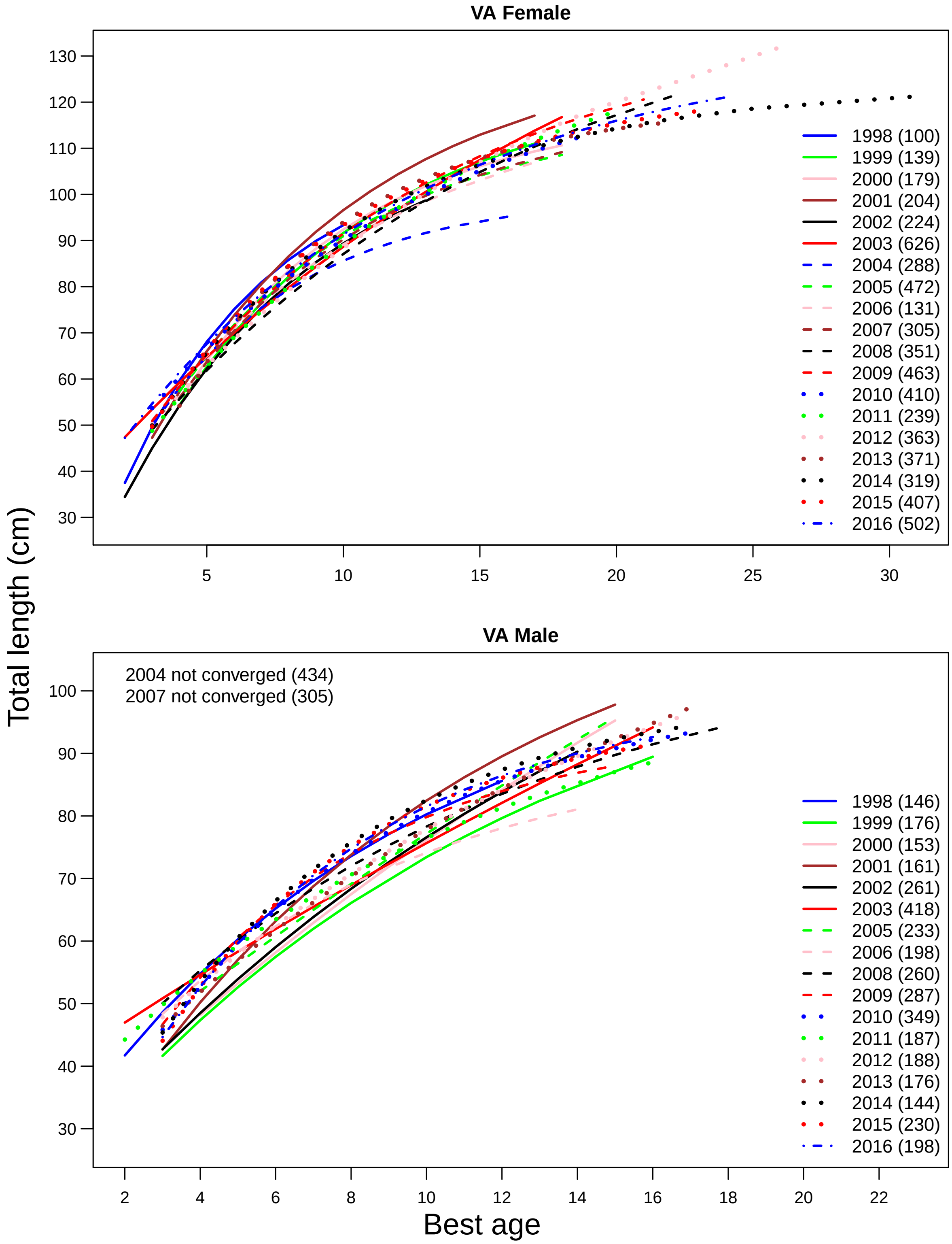

Figure 8: VA growths by sex and year. The number in parentheses is the sample size from each year.

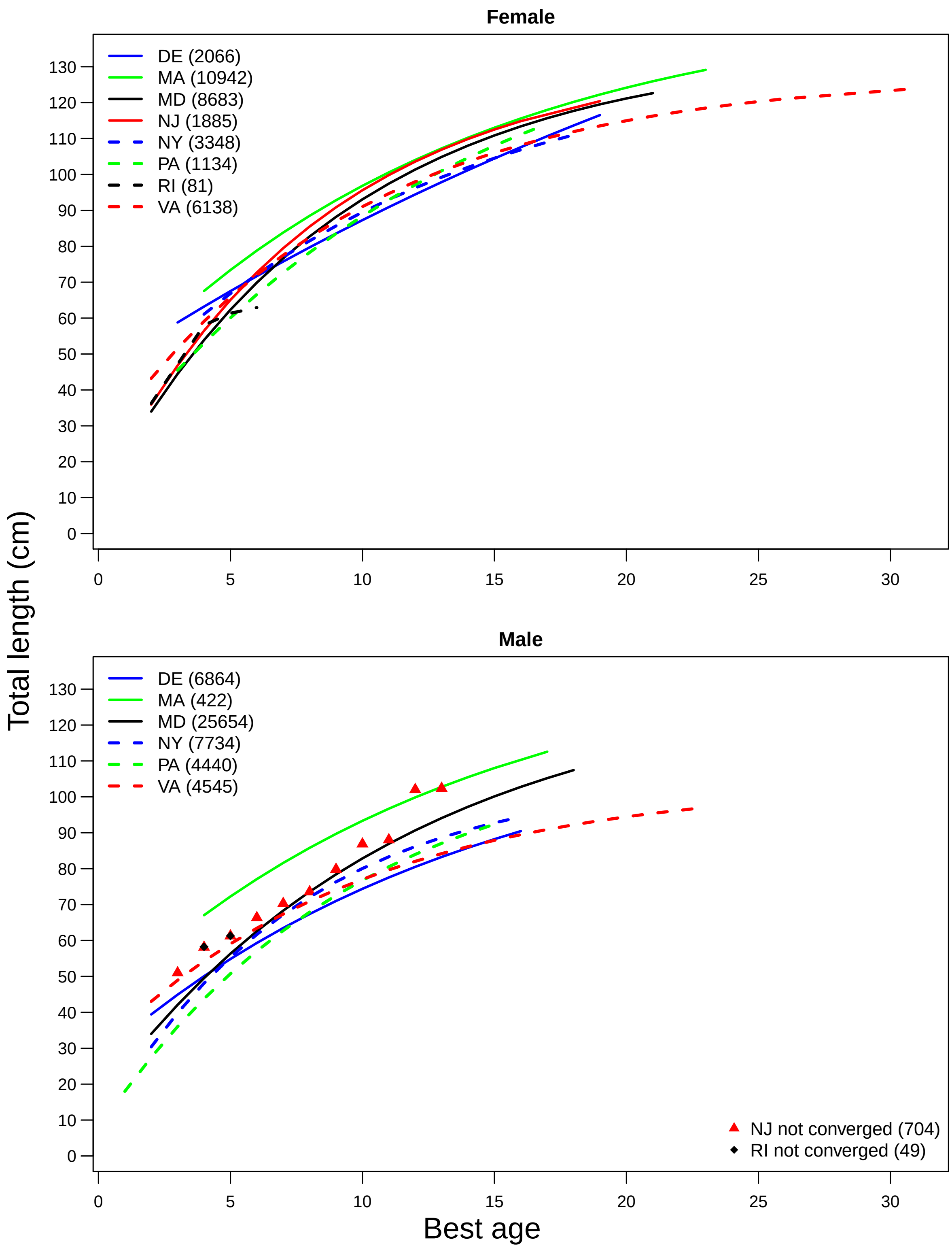

Figure 9: Year-pooled growths by state and sex. The number in parentheses is the sample size from each state with all years pooled.

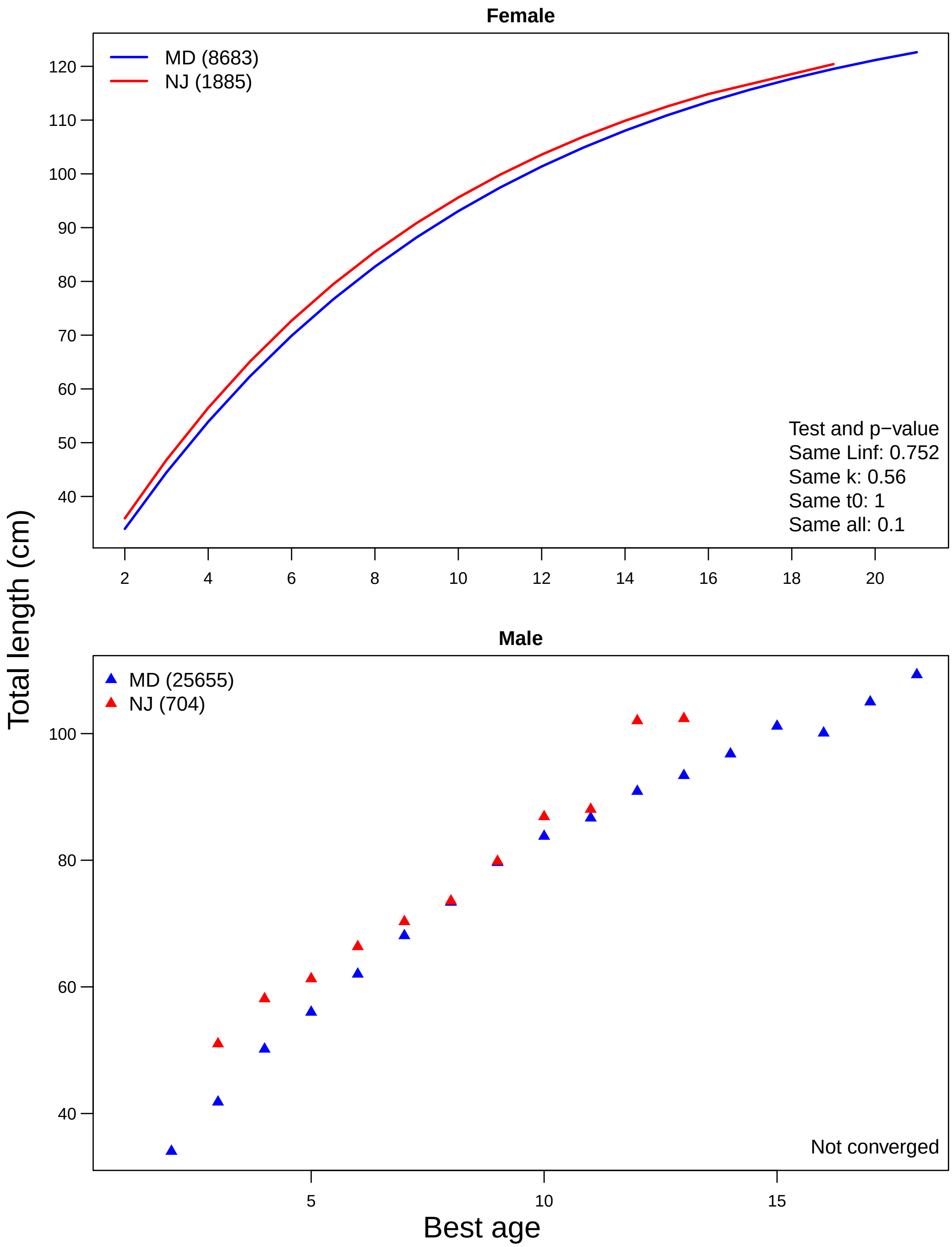

Figure 10: Kimura likelihood ratio test (Legend at bottom-right) indicates that there is no significant difference in the female growth between MD and NJ (Upper panel). The number in parentheses is the sample size from each state.

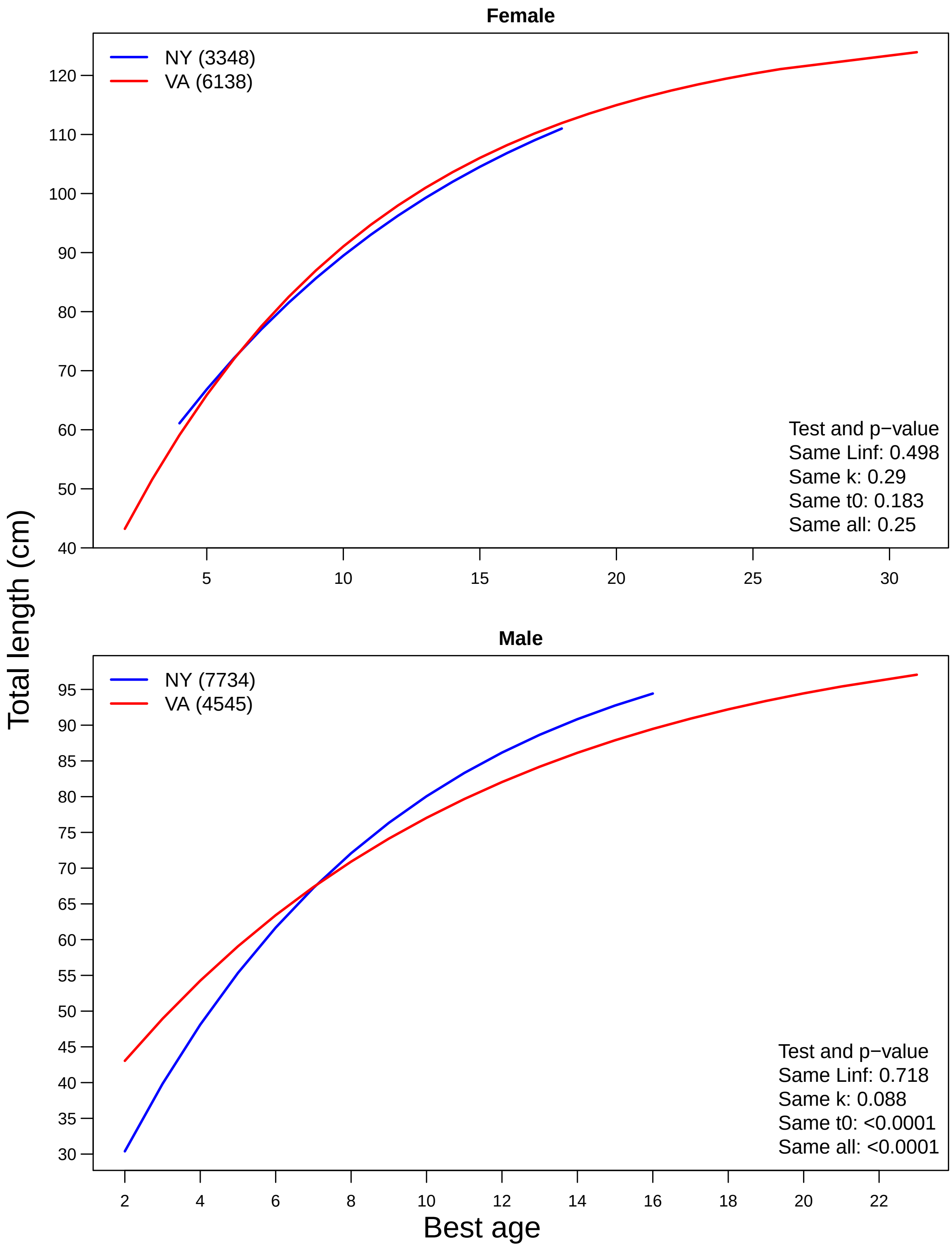

Figure 11: Kimura likelihood ratio test (Legend at bottom-right) indicates that there is no significant difference in the female growth between NY and VA (Upper panel) whereas there is a significant difference in the male growth between two states (Lower panel). The number in parentheses is the sample size from each state.

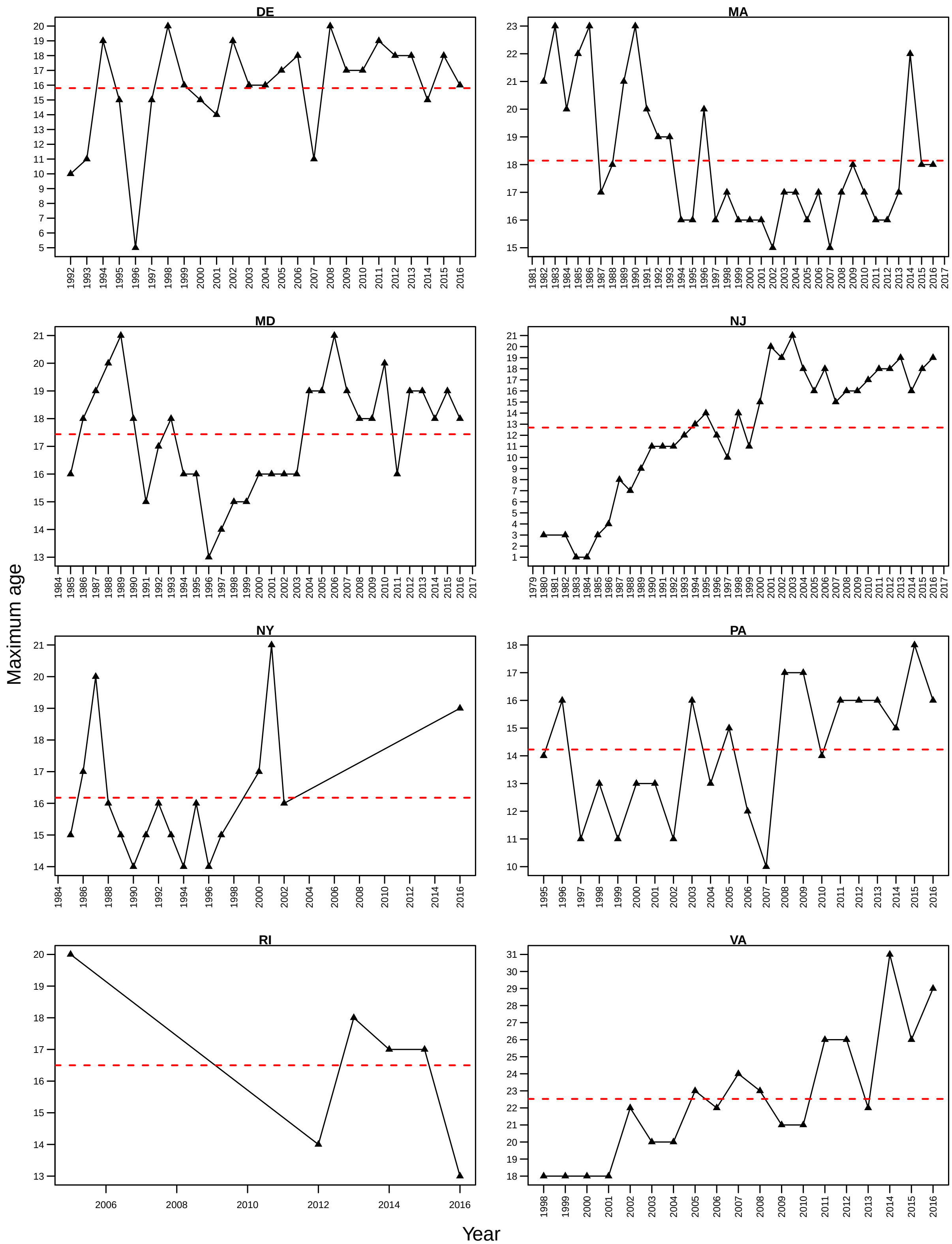

Figure 12: Maximum ages by state and through years. The red dash line is the mean maximum age across years.

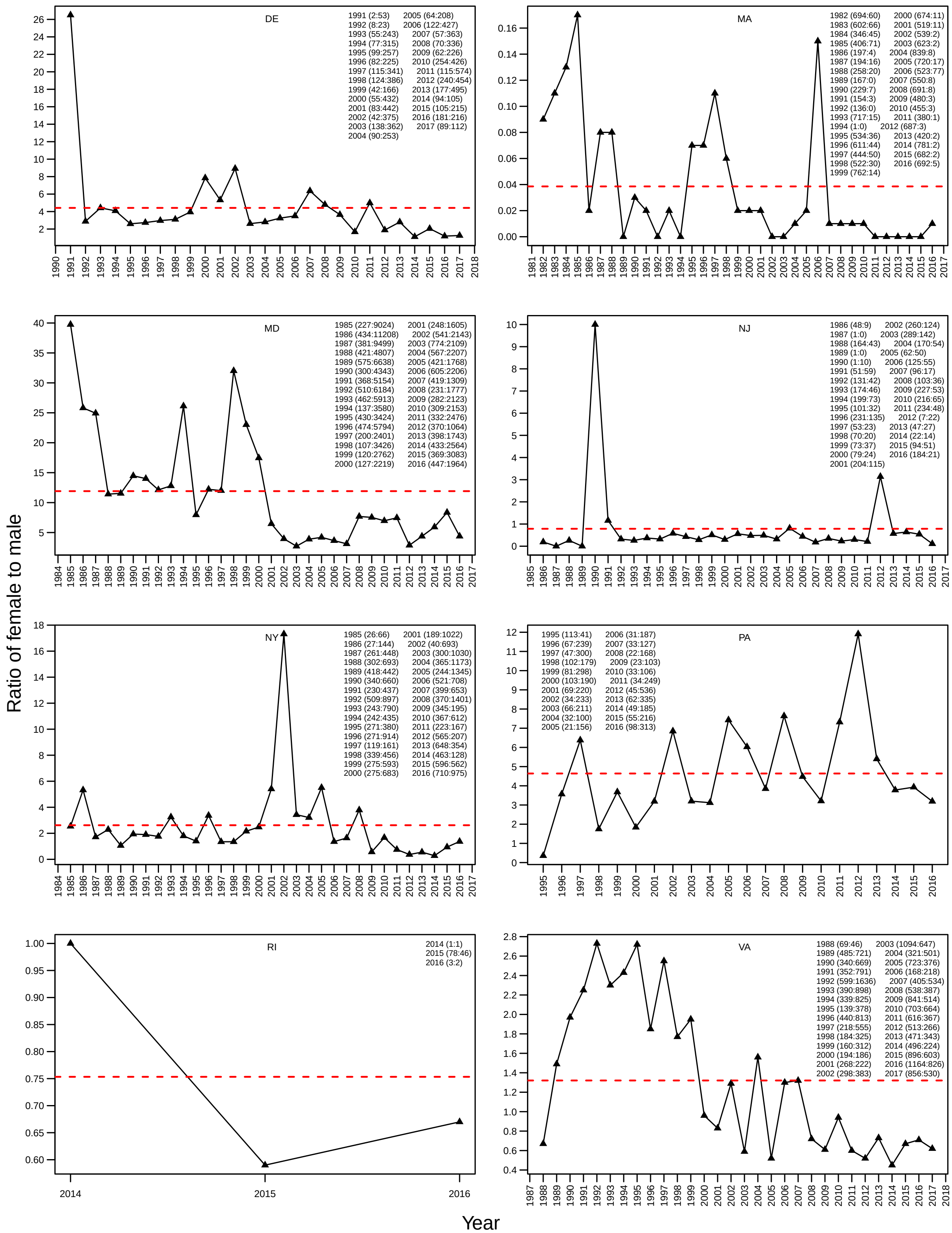

Figure 13: Sex ratios by state and through years. The numbers in parentheses are the sample size of female and male, respectively, from each year. The red dash line is the mean sex ratio across years.

Appendix B2: Update to the Female Striped Bass Maturity Schedule

Angela Giuliano, Simon Brown, and Beth Versak
Maryland Department of Natural Resources

2017

Introduction

The 2013 striped bass benchmark stock assessment (Northeast Fisheries Science Center 2013) lists development of maturity ogives applicable to coastal migratory stocks as a moderate level research priority. The current female striped bass maturity schedule used in the stock assessment is based on a 1987 white paper by Phil Jones (Table 1).

In the white paper, data for ages 4-6 were from the Maryland spawning stock gill net survey from 1985-1987, while data for ages 7-8 appear to be from a Texas Instruments study (Texas Instruments Inc. 1980) done on the Hudson River from 1976-1979. The Maryland study estimated maturity at age by dividing female CPUE from the spawning stock survey by male CPUE while assuming the natural and fishing mortality were the same between the sexes and that all males were mature. The assumption of equivalent mortality between the sexes was valid during the time period of the study due to the moratorium. The Texas Instruments study used a gonadosomatic index (ovary weight divided by fish weight) to separate immature from mature female fish.

Both methods use an indirect, rather than histological approach, to estimate female maturity at age and the work has not been updated since the stock was rebuilt. The estimated female maturity at age is improved by using newer, standardized, and more detailed histological techniques that reflect the dynamics of a restored stock.

This report summarizes the work conducted from 2014-2016 to update the maturity schedule. The secondary goal of calculating fecundity estimates will be completed at a later date.

Methods

Determining Sampling Targets

In an attempt to sample all ages of females in the population, length group targets were established after reviewing past female age frequencies (Table 2) and length frequencies (Figure 1) from the Maryland spring creel survey. Based on sample sizes from five years of creel survey sampling, it was determined that three years of sampling (2014-2016) would be required to achieve adequate sample sizes.

The majority of the sampling effort (68%) was on fish between 520-879 mm TL. Using Maryland's 2012 and 2013 spring age-length keys, these fish should be between 5-8 years old. Sampling was focused on this size/age range to adequately characterize the steepest part of the current maturity ogive (Figure 2). However, samples were also collected at smaller and larger sizes where fish were expected to be mostly immature or all mature, respectively. The proposed target sample sizes, by 20 mm length group, as well as the number sampled, are shown in Table 3 and Figure 3. The length groups in this table and figure are midpoints (i.e. the 610 length group goes from 600-619 mm).

Sample Collection Procedures

The primary source of fish was the Maryland Department of Natural Resources (MDNR) spring creel survey, since all fish encountered were already dead and the harvest over the April through June survey included both resident and migratory fish within the spawning period (Table 4). Additional fish from the

Chesapeake Bay spawning stock were collected from the spawning stock survey and other surveys in Maryland's portion of the Bay.

While the low sample sizes in the 590-830 mm length groups observed in the spring creel survey sampling (Figure 1) could be due to the two different regulatory periods during the spring (trophy season through May 15 and summer/fall season after) and angler behavior, it is also possible that fish in this size range are immature migratory females that have not yet returned to the Chesapeake Bay to spawn. By using only samples from the Chesapeake Bay, the results may be biased towards immature, premigratory fish and mature, migratory fish, while lacking immature migratory females that remain on the coast. To minimize this bias, complementary sampling was conducted by coastal states to fill in missing length groups. The New Jersey Bureau of Marine Fisheries, Rhode Island Division of Fish and Wildlife, and the Northeast Area Monitoring and Assessment Program (NEAMAP) contributed samples from their routine surveys (Table 4). Ovaries were collected from the various surveys in the months of March through July and September through December during pre-spawn, spawning and post-spawn periods (Table 5). Total length (mm TL), weight (kg), visual (macroscopic) maturity stage, and external anomalies were recorded from all fish. Scales were collected to assign ages to fish sampled, as scale ages for striped bass are generally accurate through age ten (ASMFC 2013). Maryland does not have the ability to process and read striped bass otoliths, however, otoliths were collected for future validation.

Histological procedures followed the methods from Boyd (2011). Both ovaries were carefully removed from the body cavity and weighed. One ovary was retained in cold 10% buffered formalin for up to two weeks, depending on ovary size. Formalin was used for preservation on all surveys with the exception of NEAMAP where Normalin was used. Large ovaries were cut in half and remained in formalin for a longer time to ensure complete fixation. After fixation was complete, a 4 mm thick ovary cross-section was placed into one or more labeled, standard histological cassettes and stored in 70% ethanol.

Histological Procedures

The MDNR Diagnostics & Histology Laboratory at the Cooperative Oxford Laboratory prepared MH&E-stained histological slides of ovary tissues.   Detailed laboratory procedures for the processing of ovary slides can be found in Boyd (2011).

Slides were viewed under 40X or 100X magnification through a dissecting scope, and maturity stages were assigned according to the categories defined in Brown-Peterson et al. (2011) (Table 6). Slides were examined by three biologists to determine the final maturity stage. If there was disagreement between the readers, the slides were viewed and discussed until a final stage was agreed upon.

Analytical Procedures

Brown-Peterson et al. (2011) defines immature fish as a gonadotropin independent phase and "fish enter the reproductive cycle when gonadal growth and gamete development first become gonadotropin dependent (i.e., the fish become sexually mature and enter the developing phase)" (Figure 4). While a striped bass may enter the developing phase and be physiologically mature, it does not necessarily indicate that the fish will spawn in the upcoming spawning season (Olsen and Rulifson 1992; Berlinsky et al. 1995; Boyd 2011). For this reason, the data were analyzed in two ways: as the percent mature (with developing through regenerating phases designated as mature) and as percent spawning (spawning capable through regressing phases indicating spawning is imminent or completed).

Ovary slides from fish collected in the fall/winter were essentially all immature or developing fish, with 89% of samples in the developing phase. As stated above, these fish may or may not spawn in the following spawning season. For this reason, the data were also analyzed using a subset of data from the spring and summer, a time period when spawning was occurring or just completed and the full dataset.

For samples collected from March through July, ages were calculated as the sample year minus the assigned year class. Calculation of ages for fish collected in the fall and winter (September through December) were done slightly differently. If a fish was determined to be immature in the fall/winter, it was immature the previous spring and age was calculated as above. Similarly, if a fish was regressing or regenerating in the fall/winter, it was assumed to have spawned the previous spring and age was also calculated as sample year minus year class. Difficulty arose with fish in the developing phase in the fall/winter with no readily apparent indications of previous spawning (e.g. thickened ovarian walls and/or muscle bundles). Therefore, if a fish was in the developing phase, it may or may not have spawned in the previous year. For these fish, we make the assumption that the observed developing phase is in preparation for the upcoming spawning season. For this reason, ages of fish in the developing phase from the fall and winter were advanced one year.

The maturity at age data were analyzed using logistic regression by specifying the logit link in a binomial generalized linear model (GLM) in R (R Core Team 2016).

Results

Over three years, 428 ovary samples were collected and were useable for this study (Figure 3). Of these, 307 were from Maryland's Chesapeake Bay (71.7%) and 121 were from coastal surveys (28.3%, Table 4). Lengths of all females sampled ranged from 350 to 1223 mm TL (mean=697 mm, SE=8.7 mm). Chesapeake Bay fish ranged from 350 to 1223 mm TL (mean=731 mm, SE=10.8 mm) and females sampled on the coast ranged from 350 to 1030 mm TL (mean=610 mm, SE=10.6 mm).

Ages ranged from 2 to 16, with 31% of fish from the above average 2011 year-class. The majority of fish sampled were between ages 4 and 6 (54.2%, Table 7). Sampling targets put the most sampling effort on fish approximately ages 5-8 (68%) in order to characterize the steepest part of the maturity ogive. For our dataset, 59.6% of the samples were from this age range.

Of the 428 fish sampled, 32 were immature (7.5%), 157 were developing (36.7%), 84 were spawning capable (19.6%), 12 were actively spawning (2.8%), 117 were regressing (27.3%), and 26 were regenerating (6.1%).

March-July Dataset

Most studies that examine maturity collect samples during the months of spawning. This data subset used data from March-July as spawning in Chesapeake Bay, where most of these samples were from, is known to occur into early June (Mansueti and Hollis 1963; Hollis 1967). Additionally, through July, fish that had spawned the previous spring were easily identified as being in the regressing and regenerating phases and more samples of small, immature fish were collected from pound nets. Of the 343 fish sampled in this time period, 302 were from Chesapeake Bay and 41 were from coastal states (16 from Delaware Bay, 9 from the New Jersey Ocean Trawl, and 16 from NEAMAP).

When developing fish were identified as mature, the age at 50% maturity was 3.59 years old (Figure 5). When developing fish were identified as not spawning imminently, the age at 50% maturity was 5.27 years old (Figure 6).

Full Dataset

The final dataset analyzed used data from throughout the year (March through December). This dataset included more fish from the coast, specifically samples from Rhode Island, but had the complication of how to define developing fish. Of the 428 fish sampled, 307 were from Chesapeake Bay and 121 were from coastal areas (see Table 4 for more information on sample sizes from specific surveys).

When developing fish were classified as mature, the age at 50% maturity was 3.63 years old (Figure 7). When developing fish were identified as not imminently spawning, the age at 50% maturity was 5.84 years old (Figure 8).

Discussion

The methods recommended in Brown-Peterson et al. (2011) were put forward in an effort to standardize terminology and reproductive phases across a wide variety of fish species. While the inclusion of developing fish as mature makes sense from a physiological standpoint (in the sense that that is the first reproductive phase to be gonadotropin dependent), it does not make sense from a stock assessment perspective for striped bass. Boyd (2011) specifies that for striped bass, fish in the developing phase may not necessarily spawn in the upcoming spawning season and therefore, we believe it makes more sense to treat these fish as not yet part of the spawning stock. Additionally, when developing fish were considered mature, the age of 50% maturity was very low, ranging from 3.6 -3.9 years old depending on the dataset used. This age at 50% maturity is much lower than the age that the Maryland spawning stock survey starts seeing any females on the spawning grounds. Since 1994, no females younger than age four have been caught in the spawning stock survey and only 12 four year olds have been caught in that time. We recommend using a maturity curve where developing fish are considered immature/not imminently spawning.

In general, the logistic regression equations estimate higher maturity-at-age up through age 6 as compared to the maturity schedule currently used in the stock assessment and similar maturity at age for ages 7 and above. The observed proportions mature at age for ages 4-6 are also higher than the values used currently (Table 8). Some of these differences are likely due to methodology. The previous estimates of maturity-at-age were calculated using CPUE data from the Maryland spawning stock survey and a GSI developed from fish on the Hudson River. This study utilizes histology to determine maturity which is known to be more accurate (West 1990). Additionally, those studies were conducted in the mid- to late-1980s and may have been reflective of a depressed stock. However, our observed proportions mature at age for ages 4 and 5 using the full dataset are similar to Berlinsky et al. (1995).

Despite our best efforts to include fish from the coast, it is also possible that some bias was still introduced. First, we continued to observe a bimodal distribution in our length samples (Figure 3). While this could partially be due to poor recruitment in the year classes that would span those sizes, it is also possible that we are still missing some migratory, immature fish. Second, as most of the fish were collected from the Maryland spring creel survey, these fish were subject to the minimum recreational sizes in the Chesapeake Bay (18” minimum in 2014 and 20” minimum in 2015 and 2016). To assess whether the samples were biased by the recreational size limits, comparisons were made to the length frequency sampled from Maryland’s summer/fall pound net and checkstation surveys in 2014-2016. These surveys should provide some estimate of the overall size distribution of age 4 and 5 fish in the Bay as pound nets are not size selective and the pound net survey samples both legal and sublegal fish in proportion to their availability in the net. The size frequencies, though, are sexes-combined as sex cannot be determined at that time of year and it is known that female striped bass tend to be larger at age than male striped bass after age 3 (Mansueti 1961; Mansueti and Hollis 1963; ASMFC 2013). Comparing the size frequency of samples at age from the maturity study to those collected in the pound net survey, it appears that age 4 fish sampled on the coast were larger than those sampled in the Bay (Figure 9). Most of the coastal fish were sampled in the fall from Rhode Island and may be indicative of larger age 4 fish migrating to the coast while smaller age 4 fish remain in the Bay (Dorazio et al. 1994). The Bay samples, however, generally align with the pound net survey samples indicating that the Bay sampling was not biased by the recreational size limits. Sampling of age 5 fish also showed no evidence of bias though differences in the length frequencies sampled were still observed between the Bay and coast with coastal age 5 fish being larger than Chesapeake Bay age 5 fish.

Assuming the Striped Bass Technical Committee and Stock Assessment Subcommittee (SAS) agrees with our suggestion to use a maturity curve where developing fish are considered immature/not imminently spawning, decisions would still need to be made on which dataset and results to use. Studies are often recommended to be done either prior to spawning (Hunter and Macewicz 2003) or prior to and during the spawning season (Murua et al. 2003). This would align best with our March-July data subset or possibly even a smaller subset. However, consideration must also be given to the distribution of fish across the study area, particularly when immature and mature individuals occur in different areas (Berlinsky et al. 1995; Hunter and Macewicz 2003; Murua et al. 2003). It is for this reason that Berlinsky et al. (1995) sampled during the spring and fall feeding migrations even though this required an assumption that maturations rates were not significantly different among stocks.

The March-July dataset includes more immature fish and spans the entire spawning season in Chesapeake Bay which is known to occur into June. However, using this smaller dataset reduces the overall sample size and the number of coastal fish included in the dataset. Use of the full dataset includes all of the fish collected coastwide, including those immature migratory females we may be missing within the Bay; however, some error is likely added by classifying older, developing fish as not imminently spawning. An examination of Figure 8, however, indicates that this is likely not an issue as most of the fish sampled above age 6 were classified as spawning capable or regressing/regenerating. This is likely due to our focus on smaller coastal fish that were between ages 5-8. To aid in deciding which dataset and results to use, a comparison of the logistic regression estimates of maturity-at-age for these two datasets as well as a comparison of the observed proportions mature-at-age in shown in Figure 10. We would recommend using the full dataset.

Acknowledgements

This study was a joint effort that included several state agencies and other programs within MD DNR. First we would like to thank Jacob Boyd of the North Carolina Division of Marine Fisheries for his consultation, advice, and histology slide expertise as we started on this project. We'd also like to thank Heather Corbett and her staff at New Jersey Department of Environmental Protection - Bureau of Marine Fisheries, Nicole Lengyel and her staff at Rhode Island Department of Environmental Management - Division of Fish and Wildlife, and Virginia Institute of Marine Science staff that run the NEAMAP cruises (Jameson Gregg, James Gartland, Rob Latour) for helping us collect additional ovaries from fish along the Atlantic coast. Additional thanks go to the MD Fish and Wildlife Health Program staff, Mark Matsche and Kevin Rosemary, for their demonstrations and knowledge on dissection and histology techniques. Finally we are very grateful for Chris Dungan and his staff (former lab manager Jud Blazek and current manager Laurinda Serafin) in the Diagnostics and Histology Laboratory for processing our many samples and providing guidance and insight throughout the study. We truly appreciate all the cooperation we received along the way.

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Table 1. Current female maturity schedule used for the striped bass stock assessment.

Age	4	5	6	7	8	9
Proportion Mature	0.04	0.13	0.45	0.89	0.94	1.0

Table 2. Number of female striped bass, by age and year, collected during the Maryland spring creel survey, 2009-2013.

Age	2009	2010	2011	2012	2013	Average
3	1	6	1	0	1	2
4	7	6	33	17	17	16
5	7	7	19	25	9	13
6	7	3	3	31	26	14
7	4	17	7	16	3	9
8	18	12	42	13	6	18
9	40	29	14	30	18	26
10	11	27	39	3	28	22
11	10	15	15	8	4	10
12	8	13	6	1	11	8
13	12	12	6	0	3	7
14	6	19	2	0	2	6
15	3	4	6	2	1	3
16	3	3	1	0	0	1
17	1	0	0	1	1	1
18	1	0	0	0	0	0
Totals	139	173	194	147	130	157

Table 3. Targets and sample sizes for maturity schedule survey, along with deficits when targets were not met.

Length Group	Target	2014 Samples	2015 Samples	2016 Samples	Total Samples	Deficit
350		1	2	0	3	
370		1	1	0	2	
390		0	0	0	0	
410		2	6	3	11	
430	10	1	4	1	6	4
450	10	2	0	1	3	7
470	10	7	1	3	11	
490	10	6	1	3	10	
510	10	4	5	3	12	
530	15	2	5	10	17	
550	15	8	10	7	25	
570	15	6	20	4	30	
590	15	4	22	7	33	
610	15	1	19	9	29	
630	15	3	10	4	17	
650	15	6	10	3	19	
670	15	4	4	4	12	3
690	15	2	7	2	11	4
710	15	2	4	3	9	6
730	15	4	4	1	9	6
750	15	0	3	3	6	9
770	15	3	4	2	9	6
790	15	0	5	4	9	6
810	15	4	4	0	8	7
830	15	2	4	3	9	6
850	15	5	6	2	13	2
870	15	5	7	4	16	
890	10	6	5	0	11	
910	10	7	5	0	12	
930	10	7	4	0	11	
950	10	7	4	0	11	
970	10	6	1	5	12	
990	10	5	3	3	11	
1010	3	1	3	1	5	
1030	3	2	0	2	4	
1050	3	0	3	1	4	
1070	3	0	3	0	3	
1090	3	1	1	1	3	
1110		0	1	0	1	
1130		0	0	0	0	
1150		0	0	0	0	
1170		0	0	0	0	
1190		0	0	0	0	
1210		0	0	0	0	
1230		0	1	0	1	
Totals	395	127	202	99	428	66

Table 4. Number of fish sampled by state and survey.

State	Survey	Months Sampled	n	Percent
Maryland				
	Spring Creel Survey	April-June	252	58.9%
	Spring Gill Net Survey	April-May	15	3.5%
	Striped Bass Pound Net Sampling	June-July	19	4.4%
	Nanticoke Spring Pound Net and Fyke Net Survey	March	2	0.5%
	Commercial Check Station Sampling	March	3	0.7%
	Fish Health Hook & Line Survey	September-November	5	1.2%
	Patapsco Gill Net Survey	June	3	0.7%
	Shad Gill Net Survey (USFWS)	April-May	8	1.9%
New Jersey				
	Delaware Bay Gill Net Survey	March-May	15	3.5%
	Ocean Trawl Survey	April-May	9	2.1%
		October	1	0.2%
	Headboat Sampling	December	13	3.0%
	Herring Survey	May	1	0.2%
Rhode Island				
	Fish Trap Survey	September-October	59	13.8%
NEAMAP				
	Ocean Trawl Survey	May	16	3.7%
		September-October	7	1.6%
Total			428	

Table 5. Number of fish sampled by month.

Month	n	Percent
March	15	3.5%
April	80	18.7%
May	151	35.3%
June	84	19.6%
July	13	3.0%
September	16	3.7%
October	54	12.6%
November	2	0.5%
December	13	3.0%
Total	428	

Table 6. Macroscopic and histological description of maturity phases used in the analysis. From Table 2 of Brown-Peterson et al. (2011). Abbreviations used in descriptions: CA = cortical alveolar; GVBD = germinal vesicle breakdown; GVM = germinal vesicle migration; OM = oocyte maturation; PG = primary growth; POF = postovulatory follicle complex; Vtg1 = primary vitellogenic; Vtg2 = secondary vitellogenic; Vtg3 = tertiary vitellogenic.

Phase	Macroscopic and Histological Features
Immature (never spawned)	Small ovaries, often clear, blood vessels indistinct. Only oogonia and PG oocytes present. No atresia or muscle bundles. Thin ovarian wall and little space between oocytes.
Developing (ovaries beginning to develop but not yet ready to spawn)	Enlarging ovaries, blood vessels becoming more distinct. PG, CA, Vtg1, and Vtg2 oocytes present. Not evidence of POFs or Vtg3 oocytes. Some atresia can be present. *Early Developing subphase*: PG and CA oocytes only.
Spawning Capable (fish are developmentally and physiologically able to spawn in this cycle)	Large ovaries, blood vessels prominent. Individual oocytes visible macroscopically. Vtg3 oocytes present or POFs present in batch spawners. Atresia of vitellogenic and/or hydrated oocytes may be present. Early stages of OM can be present. *Actively Spawning subphase*: oocytes undergoing late GVM, GVBD, hydration, or ovulation.
Regressing (cessation of spawning)	Flaccid ovaries, blood vessels prominent. Atresia (any stage) and POFs present. Some CA and/or vitellogenic (Vtg1, Vtg2) oocytes present.
Regenerating (sexually mature, reproductively inactive)	Small ovaries, blood vessels reduced but present. Only oogonia and PG oocytes present. Muscle bundles, enlarged blood vessels, thick ovarian wall and/or gamma/delta atresia or old, degenerating POFs may be present.

Table 7. Number of fish sampled by age. Ages were calculated as for the full dataset analysis (e.g. fall developing fish had their ages advanced one year).

Age	n	Percent
2	3	0.7%
3	13	3.0%
4	45	10.5%
5	131	30.6%
6	56	13.1%
7	32	7.5%
8	36	8.4%
9	13	3.0%
10	28	6.5%
11	44	10.3%
12	14	3.3%
13	8	1.9%
14	4	0.9%
16	1	0.2%
Total	428	

Table 8. Comparison of maturity at age estimates from various studies. The current maturity-at-age estimates used in the stock assessment are bolded.

Study	Merriman (1941) [a]	Texas Instruments (1980) [b]	Specker et al. (1987) [b]	**Jones (1987)**	Berlinsky et al. (1995)	Data Subset (this study)	Full Dataset (this study)
Area	New England	Hudson	Coastwide	**MD and Hudson**	Rhode Island	Coastwide	Coastwide
Timing	April-Nov				May-June, Sept-Nov	March-July	March-July, Sept-Dec
Age							
3	0%			**0%**	0%	0%	0%
4	27%	4%	5%	**4%**	12%	7%	9%
5	74%	21%	15%	**13%**	34%	51%	32%
6	93%	60%	45%	**45%**	77%	66%	45%
7	100%	89%	100%	**89%**	100%	90%	84%
8	100%	94%	100%	**94%**	100%	94%	89%
9	100%	100%	100%	**100%**	100%	100%	100%

a: From Berlinksy et al 1995

b: From Jones 1987

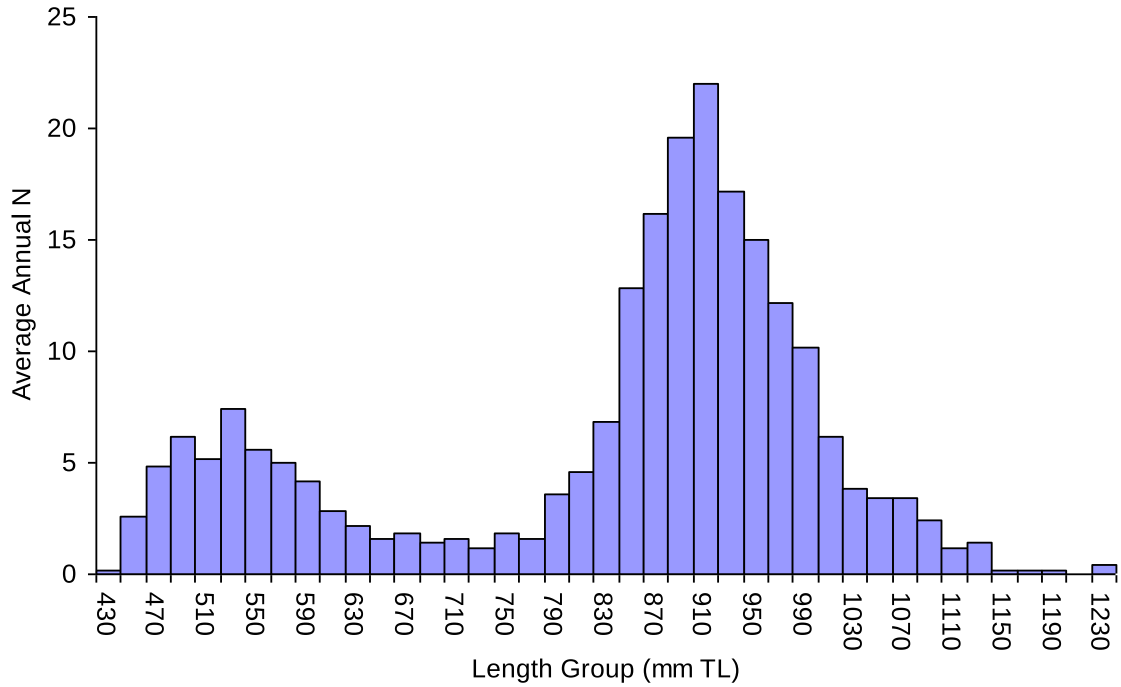


Figure 1. Average annual sample size of female fish by length group from the Maryland spring creel survey, 2009-2013.

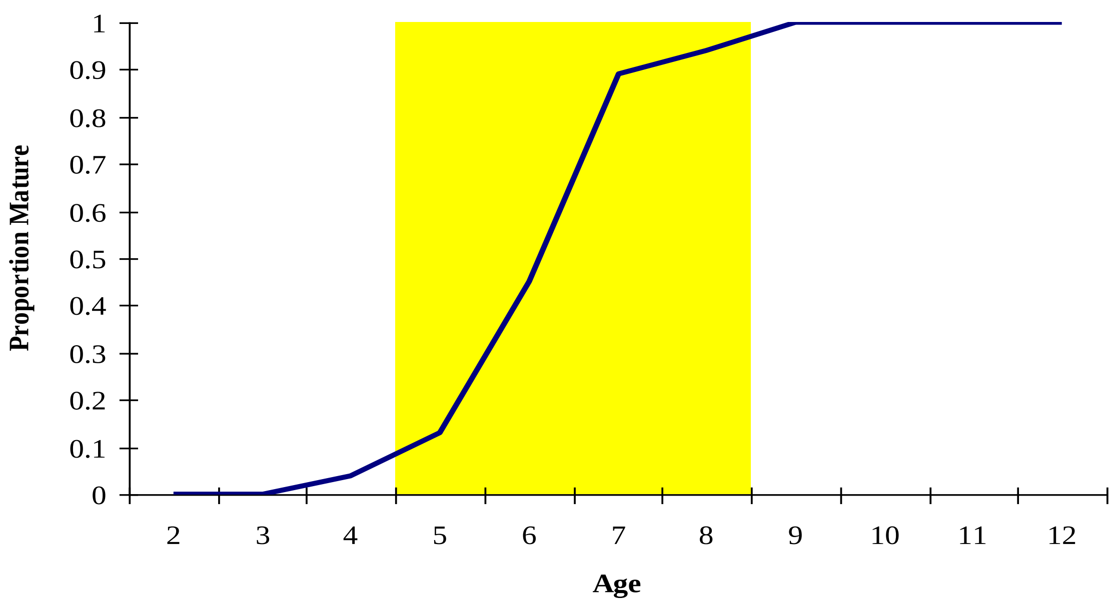


Figure 2. Current maturity ogive for female striped bass. The highlighted area indicates the age range where sampling effort was focused.

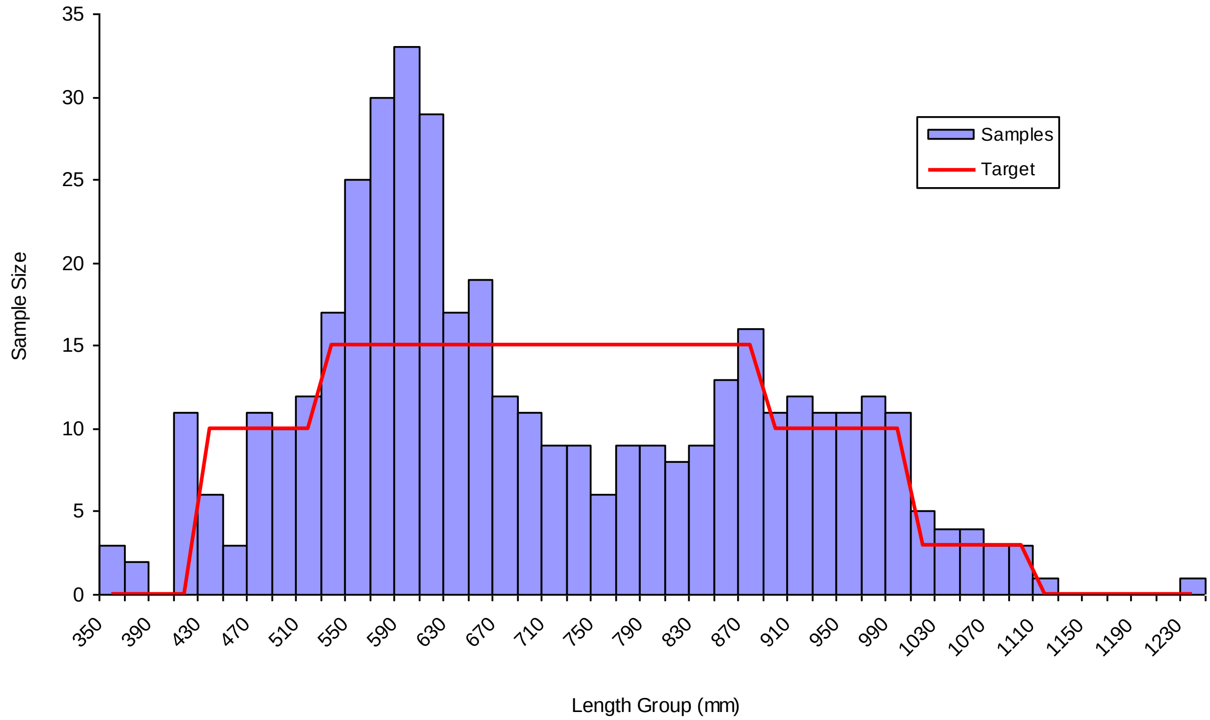


Figure 3. Samples collected vs. targets.

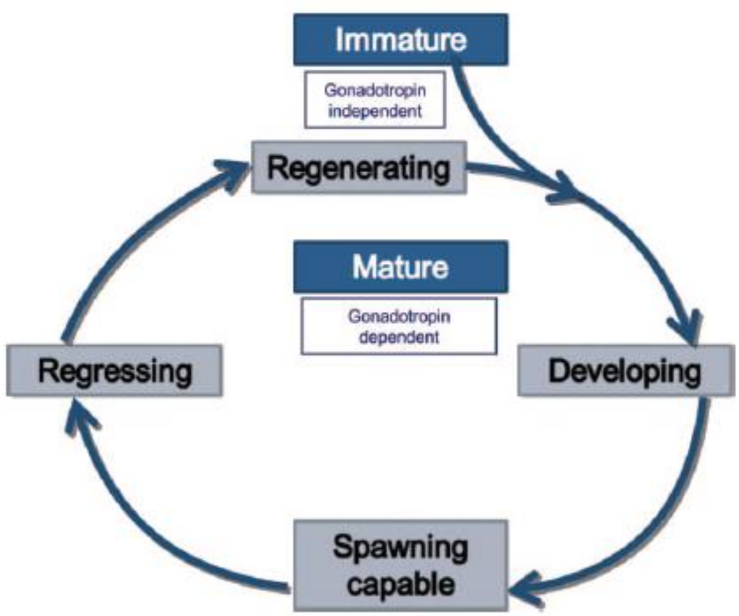
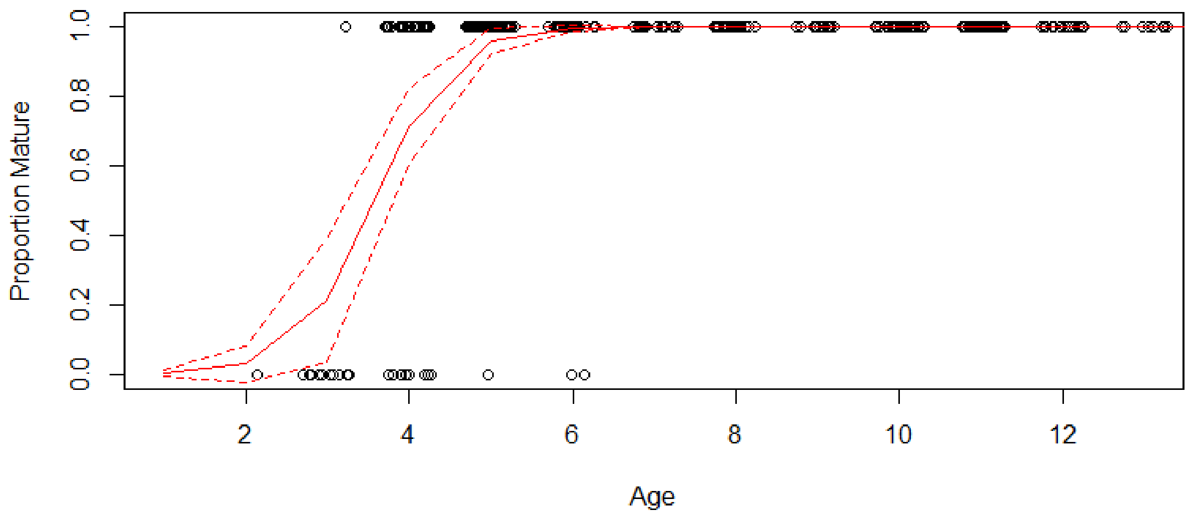


Figure 4. Conceptual model of fish reproductive phase terminology. Figure from Brown-Peterson et al. 2011.



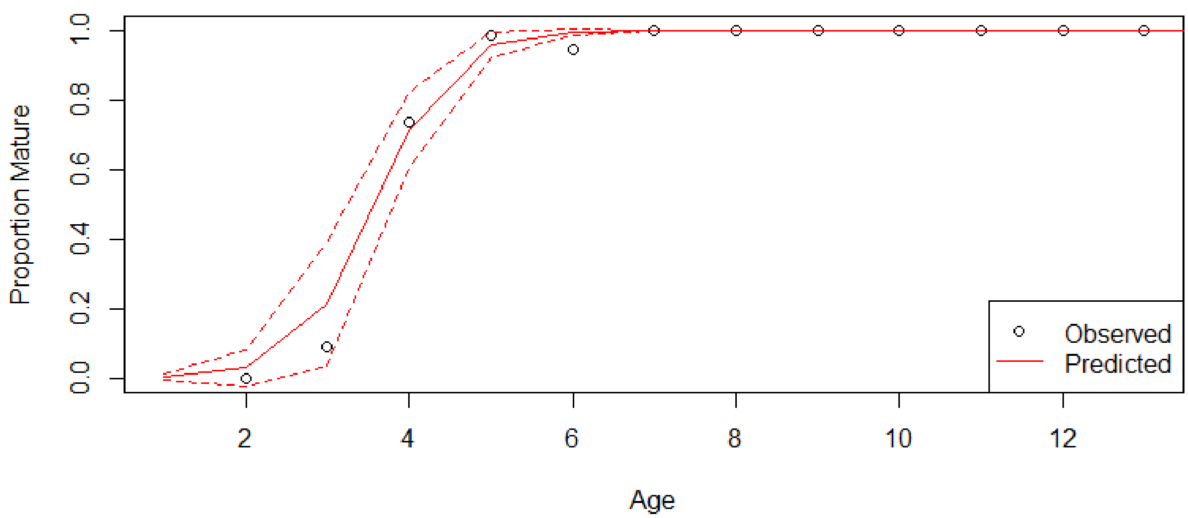


Figure 5. Estimated proportions mature, by age, for the March-July dataset when developing fish are considered mature. Top figure shows the sample size and maturity status for each fish sampled, by age, and bottom figure shows the overall observed proportion mature.

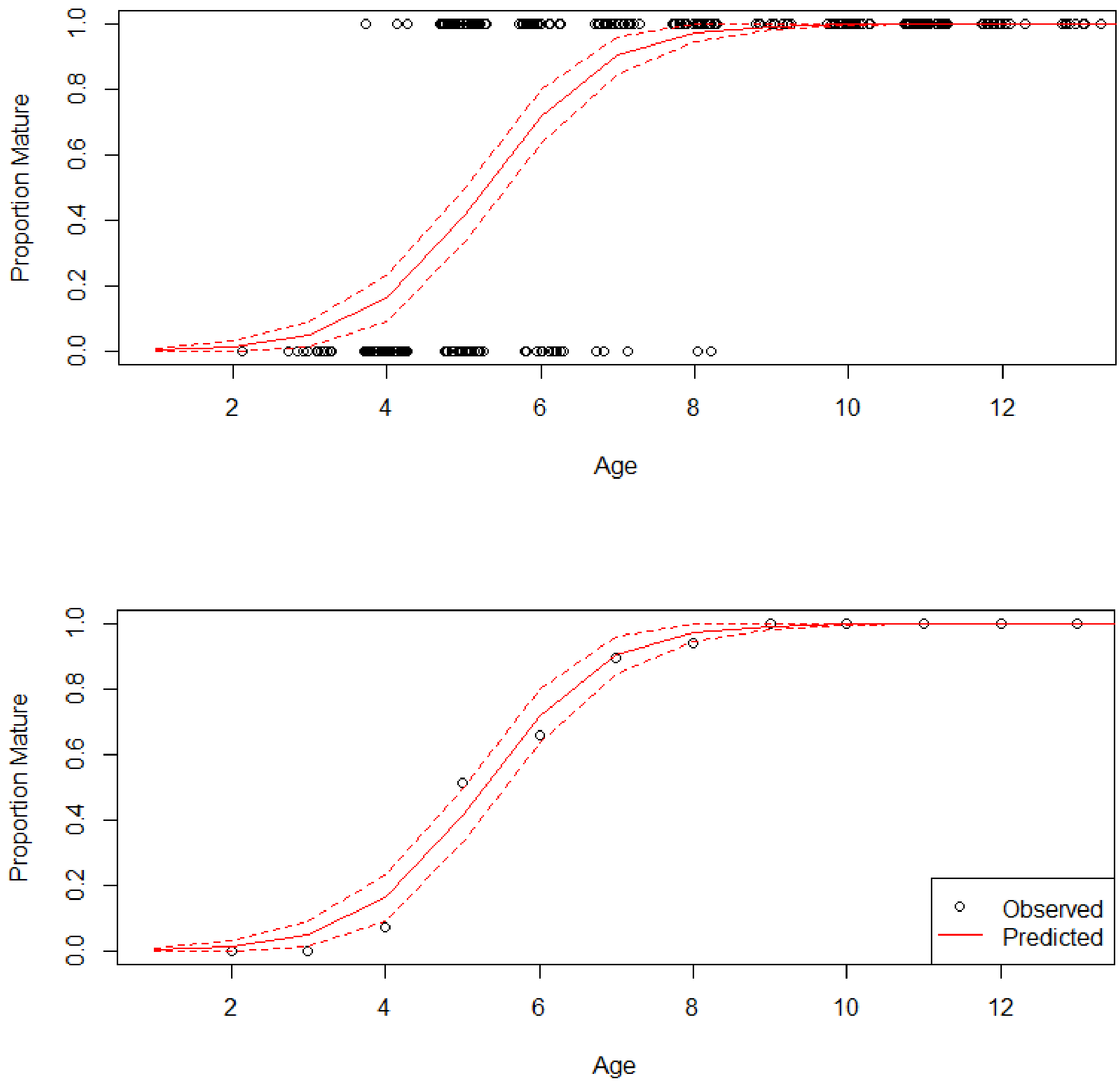


Figure 6. Estimated proportions mature, by age, for the March-July dataset when developing fish are considered not imminently spawning. Top figure shows the sample size and maturity status for each fish sampled, by age, and bottom figure shows the overall observed proportion mature.

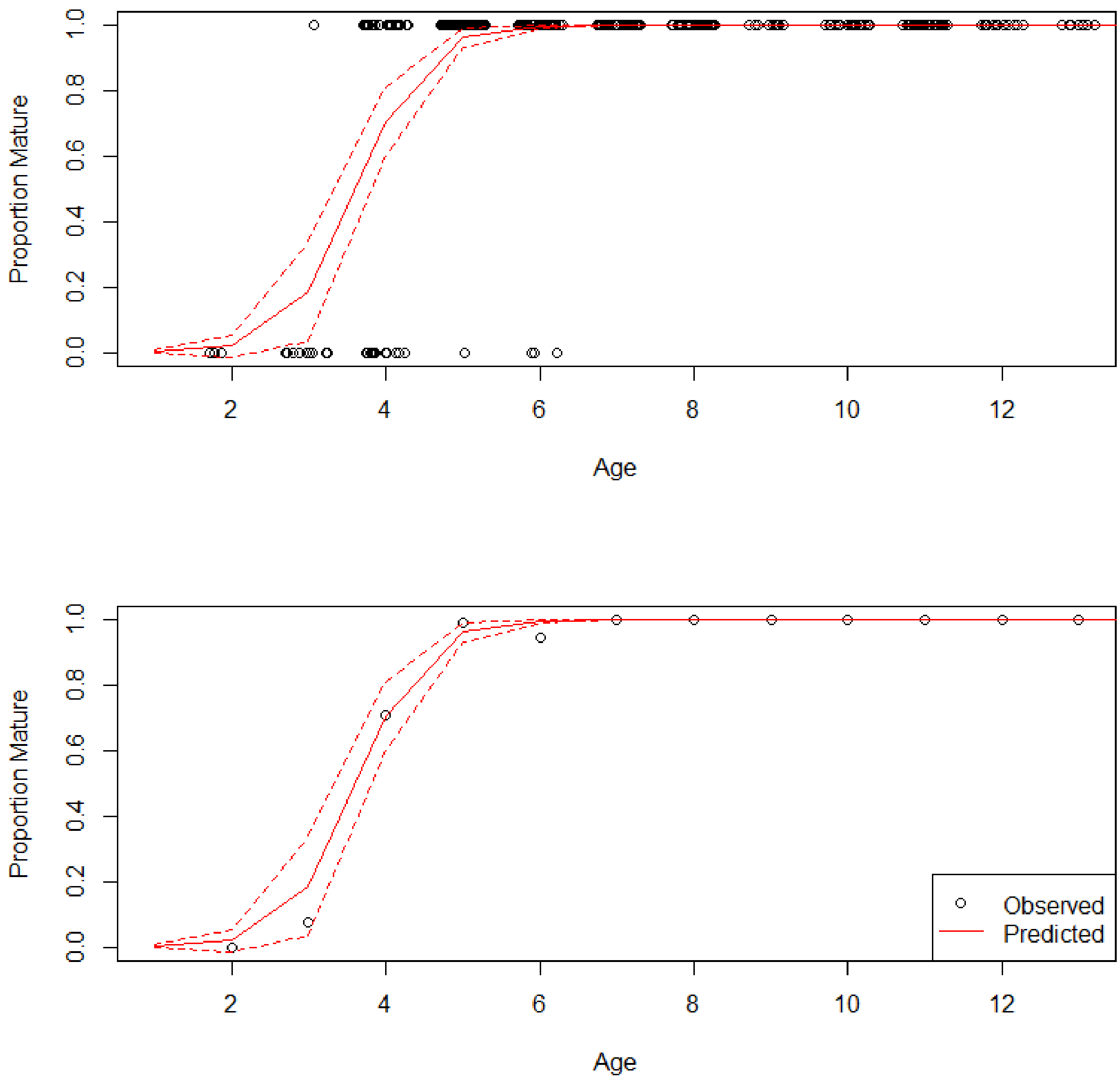


Figure 7. Estimated proportions mature, by age, for the full dataset when developing fish are considered mature. Top figure shows the sample size and maturity status for each fish sampled, by age, and bottom figure shows the overall observed proportion mature.

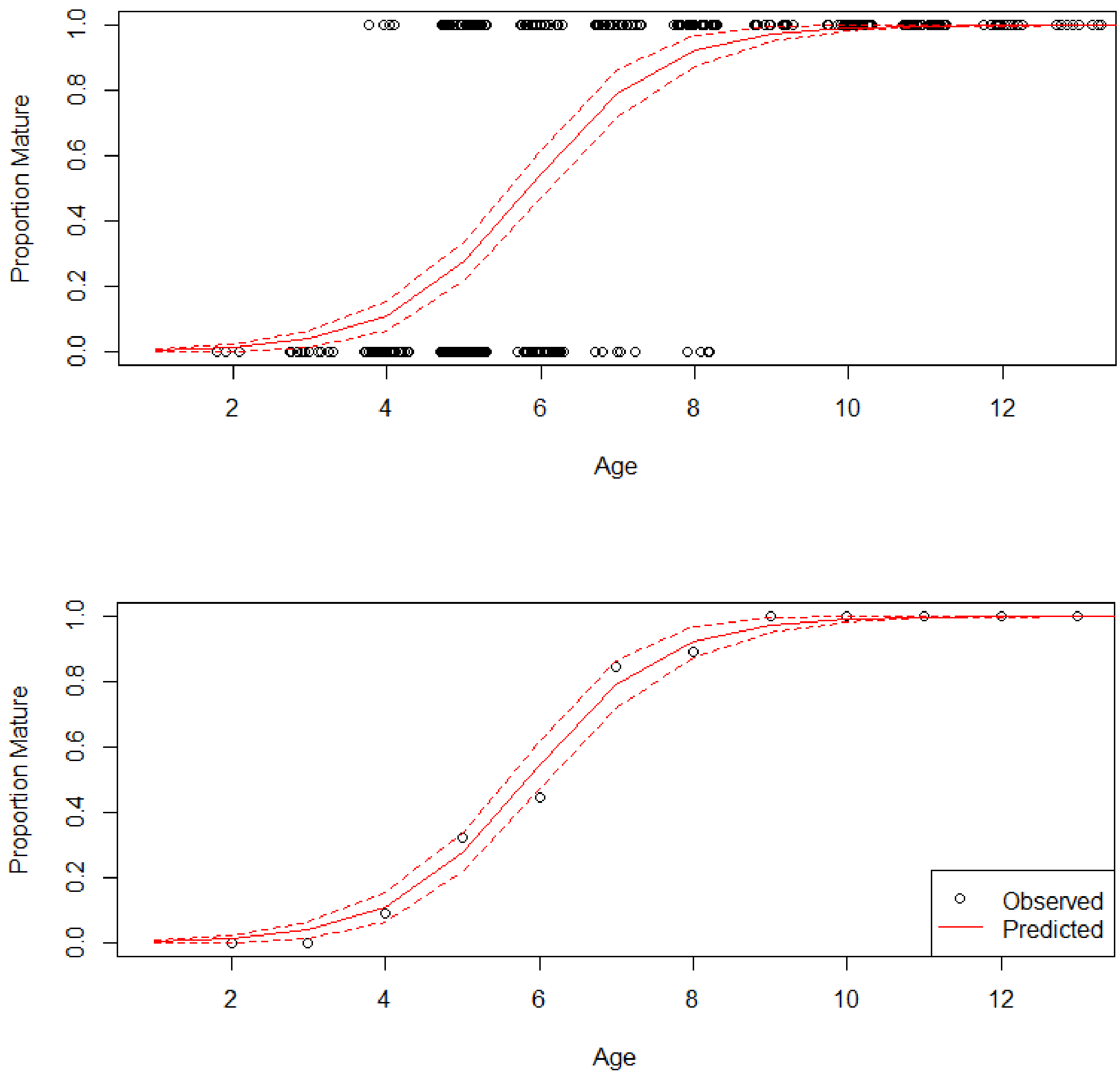


Figure 8. Estimated proportions mature, by age, for the full dataset when developing fish are considered not imminently spawning. Top figure shows the sample size and maturity status for each fish sampled, by age, and bottom figure shows the overall observed proportion mature.

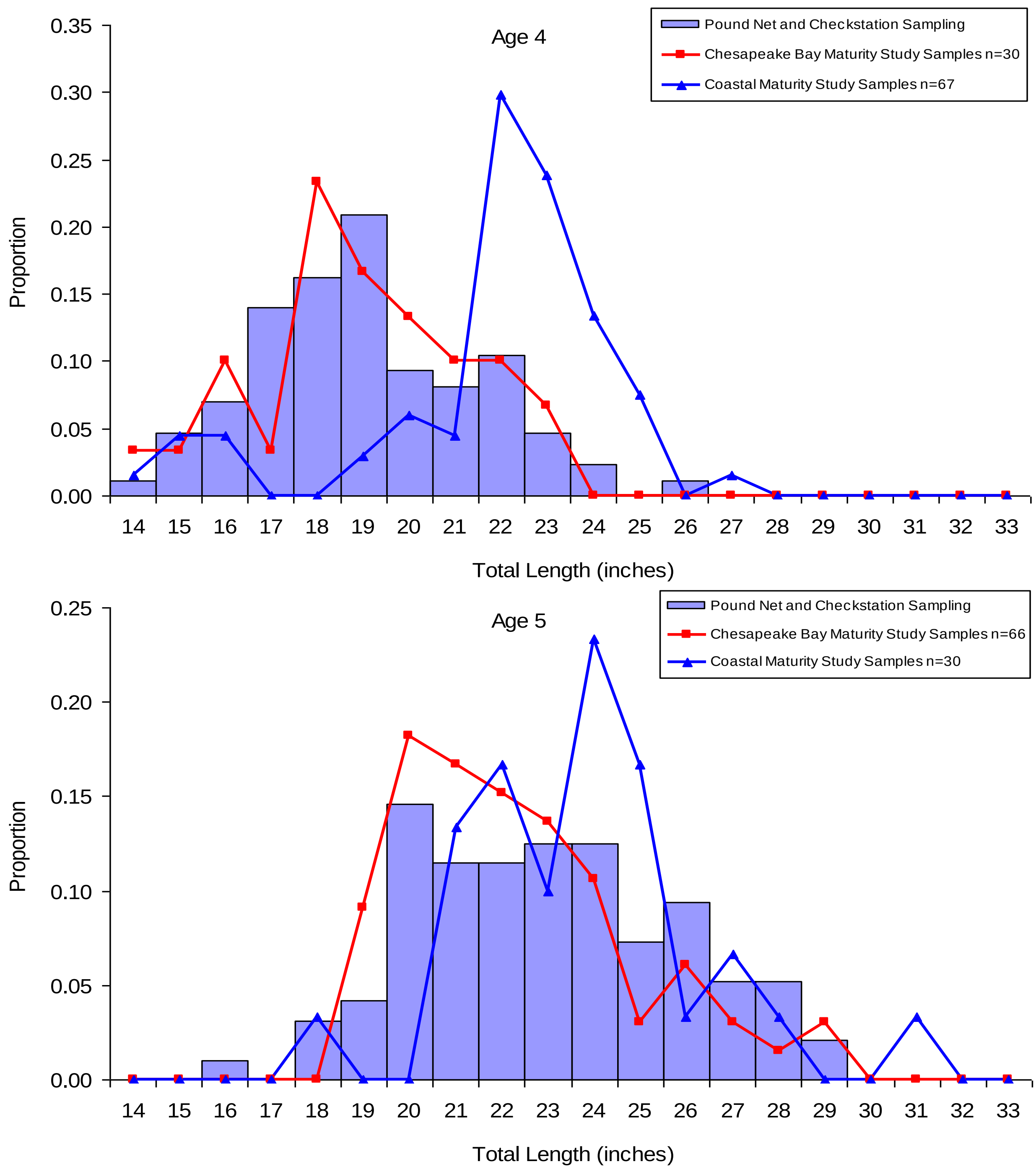


Figure 9. Comparison of the length frequencies, at age, from the summer/fall pound net and checkstation surveys (2014-2016, sexes combined) and fish sampled for the maturity study (2014-2016).

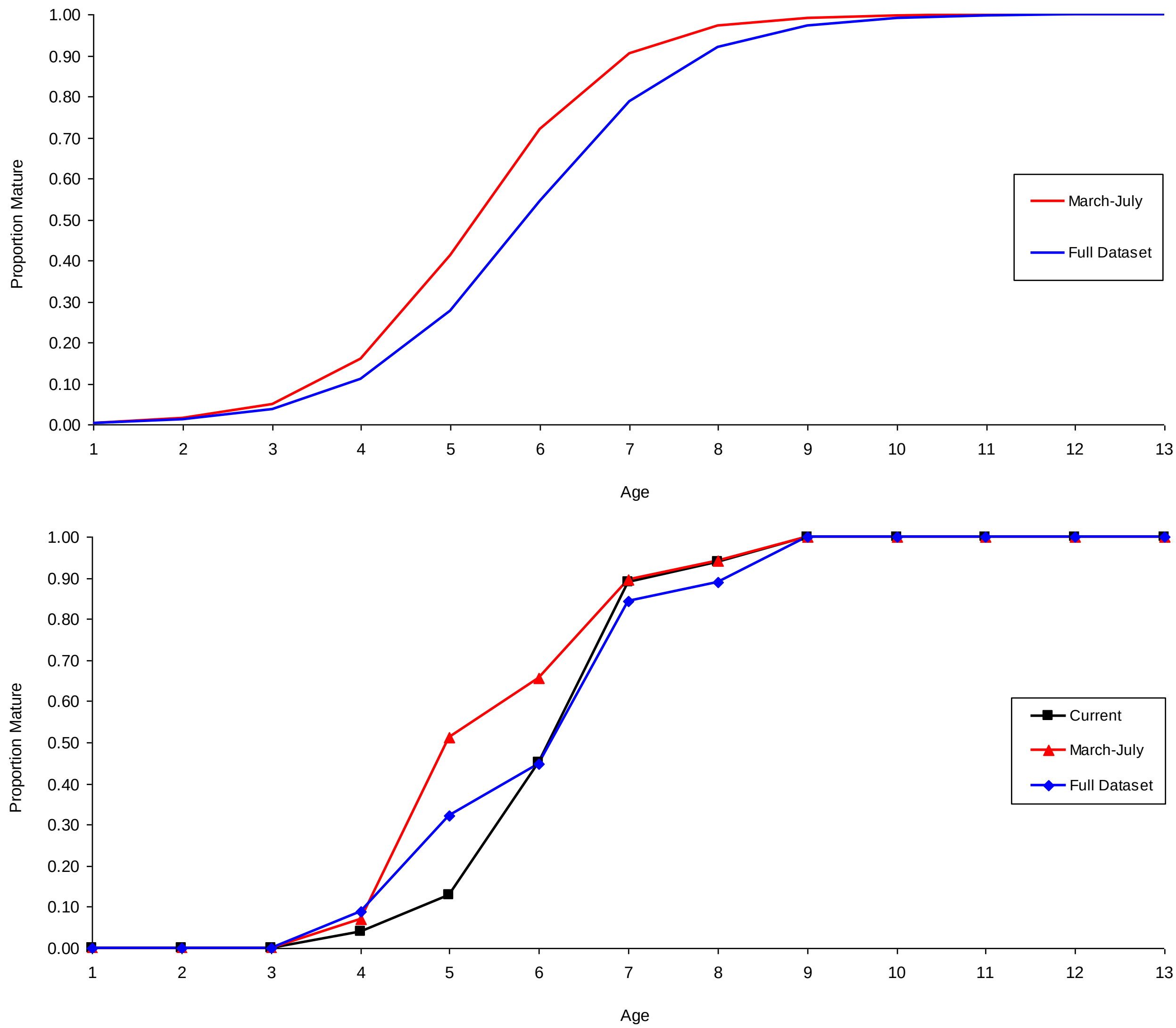


Figure 10. Comparison of the maturity at age estimates between the different data subsets when developing fish are classified as not imminently spawning. Top panel compares the logistic regression estimates. Bottom panel compares the observed proportions.

Appendix B3. Development of Age-specific Natural Mortality Rates for Striped Bass

Gary Nelson
Massachusetts Division of Marine Fisheries

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

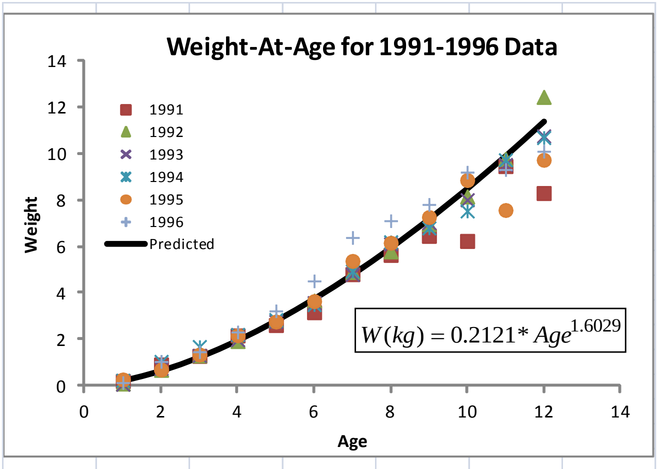


Figure 1. Observed versus predicted weights-at-age.

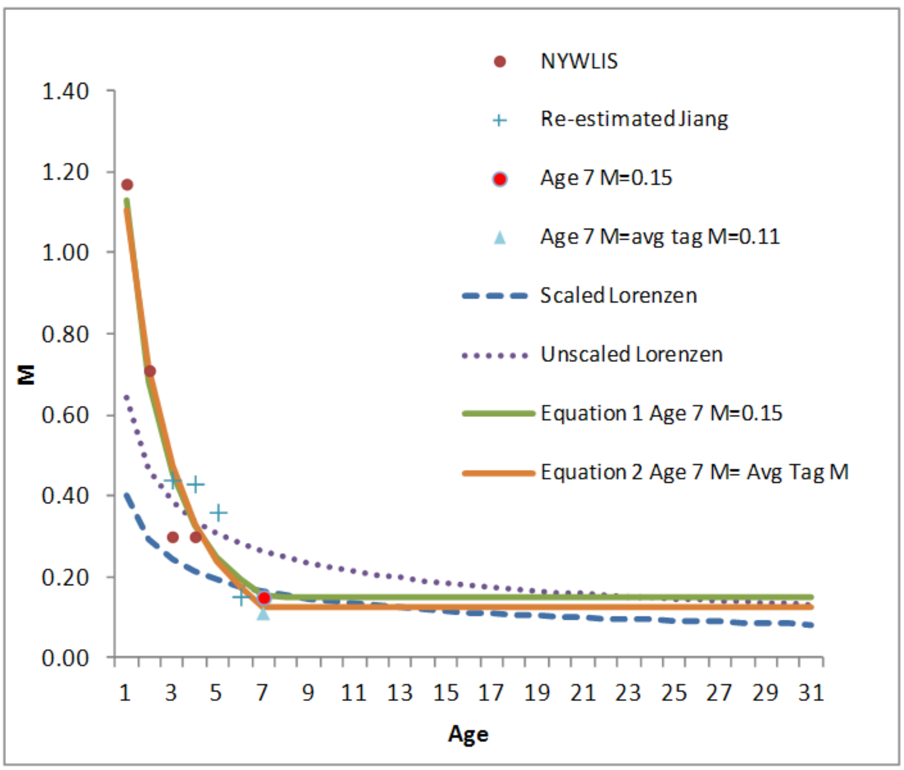


Figure 2. Comparison of estimates of age-specific Ms.

Appendix B4. Report of the Striped Bass VPA Indices Workshop

Baltimore, MD
July 28 & 29, 2004

List of Participants

NAME	AGENCY	ADDRESS
Linda Barker Alexei Sharov	Maryland Department of Natural Resources	Tawes State Office Building 580 Taylor Avenue Annapolis, MD 21401
Tom Baum	New Jersey Department of Environmental Protection – Bureau of Marine Fisheries	P.O. Box 418 Port Republic, NJ 08241
Peter Fricke	National Marine Fisheries Service – NOAA F/SF5	1315 East West Highway #3221 Silver Spring, MD 20910
Megan Gamble Patrick Kilduff	Atlantic States Marine Fisheries Commission	1444 I Street, NW 6th Floor Washington, DC 20005
Bob Harris John Hoenig Phil Sadler	Virginia Institute of Marine Science	P.O. Box 1346 Gloucester Point, VA 23062-1346
Des Kahn Greg Murphy	Delaware Department of Natural Resources & Environmental Control, Fisheries	254 Maine Street P.O. Box 330 Little Creek, DE 19961
Andy Kahnle	New York Department of Environmental Conservation – Bureau of Marine Fisheries	21 South Putts Corner Road New Paltz, NY 12561
Laura Lee	Atlantic States Marine Fisheries Commission/ RI DEM	3 Fort Wetherill Road Jamestown, RI 02835
Gary Nelson	Massachusetts Division of Marine Fisheries	30 Emerson Avenue Gloucester, MA 01930
Gary Shepherd	Northeast Fisheries Science Center	166 Water Street Woods Hole, MA 02543
Clif Tipton	United State Fish & Wildlife Service	177 Admiral Cochrane Annapolis, MD 21401
Vic Vecchio	New York Department of Environmental Conservation – Bureau of Marine Fisheries	205 North Belle Mead Road East Setauket, NY 11733

Workshop Purpose

Impetus: "An objective discrimination of which tuning indices to include or withhold from the model should be integrated in the next assessment." 36^{th} 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.

RPOSE: 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. Atlantic Striped Bass Commercial and Recreational Monitoring and Development of Removals at Age

1. **Commercial Monitoring**

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, they cannot 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 5^{th} 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 5^{th} 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 $\alpha = 0.05$. 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. For the 2018 Benchmark Assessment, the removals-at-age were developed on a seasonal scale to match the time step of the assessment model: January – February (Period 1), March – June (Period 2), and July-December (Period 3). When the biological sampling was adequate, length frequencies were developed by gear and period; for Maryland and Virginia, length frequencies were also developed by area: Chesapeake Bay and ocean.

Massachusetts
The proportion that each age comprises the total samples of harvested fish was estimated from a sub-sample of 250-350 fish which guarantees a precision of ±10% at $\alpha = 0.05$. Weighted proportions at age were generated by weighting the age proportions sampled in each county by county harvest. The number of fish harvested was then multiplied by the proportions-at-age to get numbers harvested-at-age.

Rhode Island
Gear-specific age-length keys were computed based on the length and age samples collected from the commercial dockside sampling program. In years when no RI age data was available, a combined MA and NY age-length key was used. The keys were applied to the commercial length frequencies to estimate the catch-at-age for each gear and period; when there were less than 5 lengths per gear and period, the lengths were pooled first across periods, then across gears. The numbers at age were summed over gear types to provide an estimate of the total commercial catch-at-age for each period.

New York
Sampling is conducted weekly throughout the open season and open geographic area; length frequencies were developed by period, pooled over gears for 1998 forward. Historical catch-at-length data was available by gear and season from 1982-1984.

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 from 1998 – 2017; prior to 1998, commercial samples from Virginia were applied to PRFC landings. All sampled fish are aged. Age frequencies were developed by period, pooled over gears. 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. This was done by period and area (Chesapeake Bay and ocean).

Virginia

Commercial harvest at age was estimated using tag returns (commercial harvest tags) in waves 1, 2-3 and 4-6 (2001-2017). All commercially harvested Striped Bass in Virginia are required to be commercially tagged which are reported to VMRC and audited through buyer reports. Prior to 2001 (1988-2000), total harvest (pounds) and average weight (pounds) by gear category and area was used to estimate harvest (number of fish) by year. Prior to 1988, Virginia did not collect biological data from the commercial sector.

Length frequencies were developed using biological sampling data collected during waves 1, waves 2-3 and waves 4-6 by gear types and area. Gear types were split into three different categories: 1.) Non-selective gear types (Pound net, Haul seine, Fyke net) 2.) Selective gear types (Gill nets) 3.) Other gear types (Hook and line and Trotline). Proportions at length were applied to numbers of fish harvested by gear type, area and wave period. If length frequencies were small (< 5 length observations), that wave period would be expanded out to half a year to receive a better representation of harvest at length that is occurring during that wave period. If length information was still lacking for that gear category, a yearly LF specific to that gear category would be used to fill in missing length information. If length information was simply not available that year for that gear category, a length frequency would be generated from other gear types within that wave period and area.

Harvest at lengths were distributed across ages using ALK's by wave period and area. If age information was missing for a specific length or multiple lengths, an annual ALK would be used to fill in the missing age information.

North Carolina

Total pounds landed is obtained from trip ticket program. Then year classes are apportioned to harvest by period 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.

2. Recreational Fishery Monitoring Programs

Recreational Harvest and Releases

Information on harvest and release numbers, harvest weights, and sizes of harvested bass from 1982-2018 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 the entire catch time series using the new effort and intercept calibration factors methodology occurred in 2018 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 1,200 – 9,200 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 1,000-7,000 fish each year. About 95% of the measured fish are released.

Massachusetts

For released and harvested fish, volunteer recreational anglers are solicited to collect length and scale samples from striped bass that they captured each month (May-October). Each person is asked to collect a minimum of 5 scales from at least 10 fish per month, place the scales in marked coin envelopes, and record the disposition of the each fish (released or harvested), and fishing mode. Over 2,200 samples are received each year from over 100 anglers. Approximately 1,000-1,500 lengths of released striped bass are reported each year.

Rhode Island

The size structure of striped bass released from Rhode Island's recreational fishery is based on the American Littoral Society's (ALS) release data for Rhode Island by year.

Connecticut

Release data come from the Volunteer Angler Survey, as described in the previous Connecticut section. About 2000-3000 length measurements of released fishes are obtained each year.

New York

The ALS release data are used to estimate length distribution. The ALS tags are released all around the marine district of New York all year long. Because fish can be tagged at any size, the Bureau of Marine Resources gets both legal and sub-legal length distributions, both within and outside NY's open recreational season. Thus, the length distribution for harvested fish is from the fish >28 in, and the length distribution for the released fish is from the sub-legal (i.e., <28).

New Jersey

Lengths of released striped bass are collected through a volunteer angler survey (VAS), as described in the previous New Jersey section. It is important to note that, although the VAS is primarily administered through the SBBP, the VAS and the SBBP are independent data sources. Someone does not need to harvest a Bonus fish or have a Bonus Permit in order to participate in, fill out, and submit their logbooks. There is a broad range of participant avidity and apparent skill level – from someone that fishes once or twice a year and does not catch/harvest a single bass to someone that fishes 100 days of the year. The only 'screening/removal' of logbooks for analysis the Bureau of Marine Fisheries conducts is to ensure the logbooks are filled out correctly and contain the proper information. Information on the size composition of harvested and released fish as well as effort (by trip and even hours), CPUE and fishing mode are available by region. (The state is broken down into 26 different regions and each location provided by the fisherman is assigned to one of those areas.) The VAS survey was initiated in 1990 when the NJ Fish and Wildlife initiated the SBBP. VAS provides about 500-1500 length measurements on released fish per year.

In addition to the VAS, length information is also collected through Party/Charter Boat Logbooks, administered through the SBBBP. Each boat that signs up to participate in the SBBP is mailed a logbook as well as the instructions on how to fill it out properly. A Private/Charter boat does not need to use or harvest any SBBP fish to fill out or participate in the logbook survey but they do need to be a participant in the SBBP. Boat owners are asked to fill out a daily trip logbook for each trip they take when targeting striped bass, even if no striped bass are caught; they are not asked to record striped bass information when they are making trips targeting other species. They are asked to record the date, location fished, number of patrons, number of hours fished, lengths of released fish (longest length to the nearest inch), number of released fish, lengths of harvested fish, and number of harvested fish. Logbooks must be completed even if no Bonus Cards are used or all bonus cards have been used for the year. All logbooks are returned by the end of the season. Private/Charter Boat Logbooks were first collected in 1997 and have continued ever since. Much of this data has never been looked at closely or analyzed but all of the information has been entered, checked, and screened for incorrect information.

Delaware

Number at length of recreational discards are acquired annually from the American Littoral Society's tag release database for Delaware River, Delaware Bay, and the near shore waters of the Atlantic Ocean adjacent to Delaware Bay.

Maryland

There are two additional sources for size frequency data: a volunteer angler survey and the DNR creel survey during the spring trophy season. Neither of the additional surveys employs statistical design. The DNR creel survey is described in the previous MD section. Maryland DNR has conducted a volunteer angler survey to obtain information on size structure of kept and released striped bass in the recreational fishery since 2000. The areas and time periods covered are defined by the number of responses received from anglers. Anglers are asked to provide information on the date of fishing, number of hours fished, number of anglers in the party, and method of fishing. Anglers also record the total number of striped bass kept and the total number of striped bass released and measure and record the length for the first twenty striped bass caught. A separate form is filled for each trip even if no fish are caught. If more than one survey participant is fishing on the same boat, only one designated individual is asked to fill out the survey form for the group for that day to avoid duplication. The data are submitted to MD DNR either on paper forms or via internet entry. Participation varies from year to year, which is reflected in the total number of entries. The number of reported trips varies between 200 and 300 and the total number of measured fish varies approximately from 600 to 2000 per year. Volunteer angler survey data are combined with the MRFSS/MRIP information and MD DNR Spring Trophy Survey to characterize size frequency distribution of recreational harvest by wave. Volunteer survey data are the only source for the characterization of the discards. The volunteer survey does not provide age information.

Virginia
Data on releases are derived from the MD DNR Volunteer Logbook Survey described above.

North Carolina
North Carolina does not collect information on size of releases. Usually, release length frequency data that reflect the release sizes in NC are borrowed from other states.

Recreational Age Data

Many states collect scale samples during state sampling programs designed to collect information on harvest and released striped bass from the recreational fishery (described above). For those states that do not collect scale samples, age-length keys are usually borrowed from neighboring states. Detailed descriptions of how age samples are collected are given below.

Massachusetts
For released and harvested fish, volunteer recreational anglers are solicited to collect length and scale samples from striped bass that they capture each month (May-October). Each person is asked to collect a minimum of 5 scales from at least 10 fish per month and record the disposition of the each fish (released or harvested) and fishing mode. Over 2,200 samples are received each year from over 100 anglers. The size frequency of released fishes by mode are used to allocate MRFSS/MRIP release numbers by mode among size classes. A sub-sample of all scale samples collected (about 450-520 fish/yr) are aged and combined with commercial samples (250 fish/yr) and tagging samples (about 150-300 fish/yr) to produce an age-length key used to convert the MRFSS/MRIP size distribution into age classes. Recreational scale samples are selected using a weighted random design based on the total number of striped bass caught in each wave and mode stratum (as determined by MRFSS/MRIP).

New York
An age-length key is created using data from NY's combined projects: the cooperative angler survey, western Long Island beach seine survey, and a fall Ocean Haul Seine/Ocean Trawl survey. The cooperative angler (fishery-dependent) data is from both kept and released fish, but the geographical distribution of the samples are biased towards the Western Long Island Sound. Samples are at the pleasure of the cooperating fishers, collected - nearly all year long. Each year, anglers contribute anywhere from 500 to 5,000 samples, over a fairly wide range of sizes. The Western Long Island beach seine survey is a multi-species, fishery-independent survey conducted at fixed sampling sites in bays around the north and south shores of Long Island. Most of the samples are of small juvenile fish, but some larger adult fish are caught. Each year the beach seine survey contributes approximately 1,000 length/age samples collected over the months of April through November. The fall Ocean Haul seine survey is a fishery-independent survey conducted at fixed survey sites. The geographic distribution of sampling is biased towards the eastern South Shore of Long Island, during the months of September through December. The Ocean Trawl Survey replaced the Ocean Haul Seine Survey in 2007. It covers the geographic area of the entire south shore of Long Island, during the month of November. Each year, about 1,000 samples are collected. The survey samples the adult coastal

migratory mixed striped bass stocks. The age-length key created is applied to both legal and sub-legal fish (assumed harvest and discards), broken down into two six-month seasonal keys.

New Jersey
New Jersey collects age (scale) samples from harvested and released fish through a biological sampling program. In 2010, New Jersey instituted new protocols for targeting fishing tournaments and party/charter boats in the spring and fall in order to streamline the collection process and eliminate duplicate data or data not being used for the coastal assessment. A recent decrease in sample sizes necessitated a change in the methods used to collect samples resulting in the development of a new long-term plan. This information is collected, monitored, entered and analyzed by the NJ Bureau of Marine Fisheries.

Delaware
Recreational age data is compiled from directed fishery sampling in the summer slot season (July 1 – Aug 31) and the fall recreational fishery. Length, sex, scales, and otoliths are acquired from each fish, and when available, weight.

Maryland
Direct age data are available from the creel survey of the trophy fishery only. Both scales and otoliths are collected from the fish examined in creel survey. For periods not covered by the creel survey, an age-length key developed from the samples of commercially harvested fish is applied to recreational length frequency to characterize age structure of the recreational harvest.

Virginia
Most age data are collected from the commercial fishery. The sampling group will sometimes sample from one or more recreational tournaments, but not in every year. In 2004, there were two length and age samples; no sampling of tournaments occurred in 2005.

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. For the 2018 Benchmark Assessment, the removals-at-age were developed on a seasonal scale to match the time step of the assessment model: January – February (Wave 1/Period 1), March – June (Waves 2-3/Period 2), and July-December (Waves 4-6/Period 3). State-specific descriptions of the estimation procedures are below. For the states of North Carolina and Delaware through Maine, these state-specific procedures were applied from the mid-1990s onward, when sample sizes were adequate to describe the length frequencies of the harvest and releases by state and model period (see Table B6.28 in the main assessment report for annual length sample sizes by state). For the first 10-15 years of the time series, lengths were pooled on a regional basis: New Jersey through Maine, Maryland through New Jersey, and North Carolina with Virginia ocean waters and New York. The pooled regional length frequencies were adjusted to account for differences in minimum sizes across states and applied to each state's harvest by period. The pooled length frequencies included both MRFSS/MRIP lengths and supplemental lengths collected from state programs such as volunteer angler logbooks and state creel surveys.

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 used the length frequency information gained from the NJ Striped Bass Volunteer Angler Survey to characterize the length structure of NJ's recreational harvest of striped bass and the MRFSS harvest data by period to expand the length frequency data. A variety of age sources were 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 were 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 was developed from the known harvest of 3 distinct sectors of the fishery. Spring landings numbers, lengths, and weights were acquired from MRIP Wave 2 and 3 reports. Age at length was derived from the DFW's spawning stock survey in April and May. Delaware's summer slot (20" - 26") landings numbers, lengths, and weights were acquired from MRIP Wave 4 reports. Age at length was 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 was 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)
Recreational harvest from PRFC waters was included with the MRIP estimates for Virginia and Maryland.

Maryland
Length frequency of recreational harvest was characterized using MRIP, Volunteer Angler Survey, and creel survey length data. The age-length key derived from the spring spawning survey was applied to length frequency for waves 2 and 3. For waves 4–6, an age length key derived from samples of commercial harvest was used. Length frequency data from the NC winter tagging cruise were used to supplement MRIP and VAS data for ocean harvest. For the earliest years of the time series, commercial and fishery independent length data were used to supplement MRIP length data, when sample sizes were insufficient.

Virginia
Recreational harvest estimates were provided using the new and old MRIP length-frequency (LF) distributions (Waves 2-3, Waves 4-6) from Inland (Chesapeake Bay) and Coastal waters (Ocean). Biological sampling data, collected from Virginia's commercial fishery (by year), were used to estimate the conversion factor from fork length to total length (inch).

Harvest at length (TL) was distributed across ages using proportions of length at age from ALK's (commercial data) derived from biological data collected during that wave-period and by area (Chesapeake Bay and Ocean). If age-specific information was not available, an annual ALK was used to fill in missing age information for those lengths.

If an annual ALK did not account for all lengths in the LF distribution, a multi-year ALK (1988-2016) was used to proportion out the harvest at age for those few lengths with missing age data. Recreational harvest without length information was not included in the exercise.

Virginia's Wave-1 coastal fishery was expanded to CAA by applying the proportions at length from the previous year's Wave-6 coastal fishery to Virginia's wave-1 coastal harvest estimates predicted from the updated Wave-1 coastal tag-return model (2005-2017).

Since 2013, Virginia and North Carolina have not had a wave-1 or wave-6 fishery in coastal waters. Maryland's LF distribution from their wave-6 coastal fishery in the previous year was used to expand CAA for Virginia's coastal wave-1 fishery in the following years (2014-2017).

North Carolina
The NY age-length key is used along with MRIP harvest at length estimates for North Carolina to apportion harvest numbers into age classes by period. When less than 5 lengths were available for a given period, the annual length frequency was used. For years where Wave-1 harvest was estimated from tag returns and not by MRIP sampling, the MRIP harvest-at-length values from Wave 6 of the previous year was used to described the length frequency of the Wave 1 harvest.

Recreational Dead Discards-at-Age

A 9% release mortality rate was applied to the total live release estimate for each state to calculate the dead discards. The number of dead discards-at-age was estimated by applying corresponding total numbers of dead discards-at-length to age-length keys. For the 2018 Benchmark Assessment, the removals-at-age were developed on a seasonal scale to match the time step of the assessment model: January – February (Wave 1/Period 1), March – June (Waves 2-3/Period 2), and July-December (Waves 4-6/Period 3). State-specific descriptions of the estimation procedures are below. As with the recreational harvest, for the states of North Carolina and Delaware through Maine, these state-specific procedures were applied from the mid-1990s onward, when sample sizes were adequate to describe the length frequencies of the harvest and releases by state and model period (see Table B6.28 in the main assessment report for annual length sample sizes by state). For the first 10-15 years of the time series, lengths were pooled on a regional basis: New Jersey through Maine, Maryland through New Jersey, and North Carolina with Virginia ocean waters and New York. The pooled length frequencies were developed from supplemental data collected from state programs such as volunteer angler logbooks and state creel surveys, as well as from the American Littoral Society (ALS) volunteer tagging program. Starting in 2004, MRIP began sampling fish released alive on charter boat trips, and these data were used to supplement the state and ALS release length data.

Maine
DMR used age-length data collected by MA DMF. These data are applied to the Maine Volunteer Angler Survey lengths for each period, which was then applied to the dead discard estimates.

New Hampshire
New Hampshire used age-length data collected by MA DMF. These data are applied to the New Hampshire Volunteer Angler Survey lengths for each period, which were then applied to the dead discard estimates.

Massachusetts
Dead discards-at-age were generated by applying total numbers of discards-at-length by period 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 used age-length keys from Long Island Sound provided by NY DEC applied to the dead discards numbers-at-length by period.

New York
The ALS length frequency by period was applied to MRIP numbers of dead releases by period, and a seasonal or annual age-length key was applied to develop the dead releases at age.

New Jersey
New Jersey used the length frequency information gained from the New Jersey Striped Bass Volunteer Angler Survey to characterize the length structure of NJ's recreational removals of striped bass and the MRIP release data by period to expand the length frequency data. A variety of age sources were 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 were 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 were utilized. The appropriate seasonal age-length key was then expanded to the length frequency information to develop NJ's striped bass dead releases by age and period.

Delaware
Dead discards at age for Delaware were calculated by applying the length frequency of released fish from ALS data to the MRIP estimates of dead releases by period. Seasonal age-length keys developed from fishery independent sampling were applied to the length frequencies to develop the dead discards at age.

Maryland
Length frequency of recreational releases was characterized using MRFSS/MRIP, VAS, and creel survey length data. The age-length key derived from the spring spawning survey was applied to length frequency for waves 2 and 3. For waves 4–6, an age-length key derived from samples of commercial harvest was used. Length frequency data from the NC winter tagging cruise were used to supplement MRIP and VAS data for ocean harvest.

Virginia
Virginia Inland releases (B2) were expanded to CAA using length-frequencies and age-length keys provided from Maryland's volunteer angler survey (1995-2017). Prior to 1995, Virginia inland releases were estimated using length-frequencies and age-length keys from Maryland's commercial fishery (1982-1994).

Virginia's coastal releases were expanded to CAA using the same methods adopted by Maryland.

North Carolina
The NY age-length key is used, along with length frequencies, to apportion release numbers into age classes.

DE-Catch at Age Data Sources for DB CAA written by E. Hale

Based on an investigation of historical data sources, it was determined that the commercial and recreational removals from Delaware and New Jersey could not be split into Delaware Bay and ocean waters as was done for the Chesapeake Bay prior to 2002.

A pair-wise analysis conducted by the States of New Jersey and Delaware was conducted in order to estimate total Delaware Bay catch at age. Recreational landings and length frequency data of directed harvest (A + B1) were collected from the MRIP program, using data downloaded from 2004-2016 and a custom query for landings from 1989-2003 (T. Sminkey, pers. comm.). Total length was converted from fork length provided by MRIP using annual regression coefficients from pooled biological characterization data for both states. Recreational harvest data for total number released alive (B2) were similarly collected by both the MRIP webpage and a custom query for those time periods. Length frequency data from the New Jersey volunteer angler program were used to extrapolate recreational dead discards for the State of Delaware. Commercial harvest by number was not available in the State of Delaware prior to 2002. Based on commercial harvester reports, directed harvest was estimated by area (coastal vs. Delaware Bay) from 2002-2016. Length frequency information collected by DEDFW commercial subsampling was applied to the total commercial harvest to estimate catch at age. Unfortunately, length frequency data for commercial subsampling in 2005, 2008 and 2009 were derived from mean values, as raw data could not be found. Age length keys were developed from all available biological characterization data pooled for both states and applied to both sectors (commercial and recreational). Landings were then summed across fishery sectors and states to estimate total Delaware Bay harvest. Overall, total harvest in Delaware Bay appears to be principally driven by the State of New Jersey. Total number landed in both the recreational and commercial fisheries of Delaware appear more stable. However, recreational landings do decline after 2012 with a slight uptick in 2016.

Appendix B6. Supplemental Commercial Discard Materials

This appendix contains:

1. Summary of the GAM fit to tag numbers
2. Summary of data sources to develop commercial discards-at-age

Appendix Table 1. Summary of the GAM fit to tag numbers for Commercial Discards Estimation.

```
Formula:
log(outsfit$CommK) ~ s(outsfit$year, bs = "tp", k = 20)

Parametric coefficients:
      Estimate Std. Error t value Pr(>|t|)
(Intercept) 4.64341  0.05666  81.95  <2e-16 ***
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
         edf Ref.df   F p-value
s(outsfit$year) 8.597 10.61 44.31 <2e-16 ***
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) = 0.945  Deviance explained = 96.3%
GCV = 0.13676 Scale est. = 0.089885 n = 28
```

```
Formula:
log(outsfit$CommR) ~ s(outsfit$year, bs = "tp", k = 20)

Parametric coefficients:
      Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.6708   0.1147  31.99  <2e-16 ***
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Approximate significance of smooth terms:
         edf Ref.df   F p-value
s(outsfit$year) 4.753 5.926 41.76 <2e-16 ***
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

R-sq.(adj) = 0.901  Deviance explained = 91.9%
GCV = 0.46398 Scale est. = 0.36865  n = 28
```

```
Formula:
log(outsfit$RecK) ~ s(outsfit$year, bs = "tp", k = 20)

Parametric coefficients:
      Estimate Std. Error t value Pr(>|t|)
(Intercept) 5.90480  0.02455  240.5  <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
         edf Ref.df   F p-value
s(outsfit$year) 10.09 12.35 81.07 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) = 0.974  Deviance explained = 98.4%
GCV = 0.02796 Scale est. = 0.016881 n = 28
```

```
Formula:
log(outsfit$RecR) ~ s(outsfit$year, bs = "tp", k = 20)

Parametric coefficients:
      Estimate Std. Error t value Pr(>|t|)
(Intercept) 5.28153  0.03365   157  <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Approximate significance of smooth terms:
         edf Ref.df   F p-value
s(outsfit$year) 6.83  8.48 136.9 <2e-16 ***
---
Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

R-sq.(adj) = 0.977  Deviance explained = 98.3%
GCV = 0.044011 Scale est. = 0.031705 n = 28
```

Appendix Table 2. Sources of age data used to develop commercial discards-at-age.

2017			
Notes	Chesapeal	Anchor Gil	VA commercial spring gillnet 2017 in compliance report
		Drift Gill	MD Comm- Bay GillNet landings spreadsheet 2017
		H&L	from MD com Summ ITQ at age in "MD SB Compliance 2017.xls"
		Pound Net	from VIMS Pound independent data Rapp River in "VIMS_CPUE_Summary_spring 1991_2017 for ASMFC
		Trawl	No trawl fishery in CB (used to use Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)
		Other	Average of Anchor, drift, H&L and Pound standardized to sum to 1
	Delaware I	Anchor	Gary calculated by filling in proportions-at-age for a given length interval with n<10, predicted proportions for multinomial model.
		Drift	Gary calculated by filling in proportions-at-age for a given length interval with n<10, predicted proportions for multinomial model.
		H&L	Gary calculated by filling in proportions-at-age for a given length interval with n<10, predicted proportions for multinomial model.
		Other	Average of Anchor, drift, H&L standardized to sum to 1
		Pound	same as above
	Coast	Anchor	combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring) coastal gill net landings 2017
		Drift	combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring) coastal gill net landings 2017
		H&L	Developed from an average commercial length selectivity curve (2005-2014) applied to rec release lengths
		Pounds	RI float trap landings in the RI CAA spreadsheet (no pound net specifc info in RI) 2016
		Trawl	Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial). Usually NC comm landings - mixed fishery with trawl info (landings wt only comm) are added but value is 0 for 2016
		Other	Average of all gears standardized to 1
2016			
Notes	Chesapeal	Anchor Gil	VA commercial spring gillnet 2016 in compliance report
		Drift Gill	MD Comm- Bay GillNet landings spreadsheet 2016
		H&L	from MD com Summ ITQ at age in "MD SB Compliance 2016.xls"
		Pound Net	from VIMS Pound independent data Rapp River in "VIMS_CPUE_Summary_spring 1991_2016 for ASMFC
		Trawl	No trawl fishery in CB (used to use Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)
		Other	Average of Anchor, drift, H&L and Pound standardized to sum to 1
	Delaware I	Anchor	from DE CAA spreadsheet for comm gill net landings - spring 2016
		Drift	from DE CAA spreadsheet for comm gill net landings - spring 2016
		H&L	from DE CAA spreadsheet for H&L Fall 2016
		Other	Average of Anchor, drift, H&L standardized to sum to 1
		Pound	same as above
	Coast	Anchor	combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring) coastal gill net landings 2016
		Drift	combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring) coastal gill net landings 2016
		H&L	Developed from an average commercial length selectivity curve (2005-2014) applied to rec release lengths
		Pounds	RI float trap landings in the RI CAA spreadsheet (no pound net specifc info in RI) 2016
		Trawl	Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial). Usually NC comm landings - mixed fishery with trawl info (landings wt only comm) are added but value is 0 for 2016
		Other	Average of all other gears standardized to 1
2015			
Notes	Chesapeal	Anchor Gil	VA commercial spring gillnet 2015 in compliance report
		Drift Gill	MD Comm- Bay GillNet landings spreadsheet
		H&L	from MD com Summ ITQ at age in "MD SB Compliance 2015.xls"
		Pound Net	from VIMS Pound independent data Rapp River in 11in "VIMS_CPUE_Summary_spring 1991_2015 for ASMFC
		Trawl	No trawl fishery in CB (used to use Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)
		Other	Average of Anchor, drift, H&L and Pound standardized to sum to 1
	Delaware I	Anchor	from DE CAA spreadsheet for comm gill net landings - spring
		Drift	from DE CAA spreadsheet for comm gill net landings - spring
		H&L	from DE CAA spreadsheet for H&L Fall
		Other	Average of Anchor, drift, H&L standardized to sum to 1
		Pound	Same as above
	Coast	Anchor	combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
		Drift	combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
		H&L	Developed from an average commercial length selectivity curve (2005-2014) applied to rec release lengths
		Pounds	RI float trap landings in the RI CAA spreadsheet (no pound net specifc info in RI)
		Trawl	Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial). Usually NC comm landings - mixed fishery with trawl info (landings wt only comm) are added but value is 0 for 2015
		Other	Average of all other gears standardized to 1
2014			
Notes	Chesapeal	Anchor Gil	VIMS commercial spring gillnet 2014 (VA independent GN sampling stopped)
		Drift Gill	MD Comm- Bay GillNet landings spreadsheet
		H&L	from MD com Summ ITQ at age in "MD SB Compliance 2014.xls"
		Pound Net	from VIMS Pound independent data Rapp River in 11in "VIMS_CPUE_Summary_spring 1991_2014 for ASMFC
		Trawl	Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)
		Other	Average of Anchor, drift, H&L and Pound standardized to sum to 1
	Delaware I	Anchor	from DE CAA spreadsheet for comm gill net landings - spring
		Drift	from DE CAA spreadsheet for comm gill net landings - spring
		H&L	from DE CAA spreadsheet for H&L Fall
	Coast	Anchor	combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
		Drift	combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
		H&L	MA discards at age 2014 in spreadsheet
		Pounds	RI float trap landings in the RI CAA spreadsheet (no pound net specifc info in RI)
		Trawl	Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)
		Other	Average of all other gears
2013			
Notes	Chesapeal	Anchor Gil	VIMS fish independent in Rapp and James"VIMS_SSB_1991_2013
		Drift Gill	MD Discard estimates for 11 in MD Comm- Bay GillNet landings spreadsheet
		H&L	from MD com H&L harvest at age in "MD SB Compliance 2013.xls"
		Pound Net	from VIMS Pound independent data Rapp River in 11in "VIMS_CPUE Summary 1991_2013"
		Trawl	Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)
		Other	Average of Anchor, drift, H&L and Pound standardized to sum to 1
	Delaware I	Anchor	from DE CAA spreadsheet for comm gill net landings - spring
		Drift	from DE CAA spreadsheet for comm gill net landings - spring
		H&L	from DE CAA spreadsheet for H&L Fall
	Coast	Anchor	combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
		Drift	combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
		H&L	MA commercial discards at age 2013 in spreadsheet
		Pounds	RI float trap landings in the RI CAA spreadsheet (no pound net specifc info in RI)
		Trawl	Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)
		Other	Average of all other gears

2012

Notes Chesapeal Anchor Gil VIMS fish independent in Rapp and James in 12 in "VIMS_length_frequency_spring1991_2012forVMRC"
Drift Gill MD Discard estimates for 12 in MD Comm- Bay GillNet landings spreadsheet
H&L from MD com H&L harvest at age in "MD SB Compliance 12xls"
Pound Net from VIMS Pound independent data Rapp River in 12in "VIMS_length_frequency_spring 1991_2012 for VMRC
Trawl Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)
Other Average of Anchor, drift, H&L and Pound standardized to sum to 1
Delaware I Anchor from DE CAA spreadsheet for comm gill net landings - spring
Drift from DE CAA spreadsheet for comm gill net landings - spring
H&L from DE CAA spreadsheet for H&L Fall
Other average(anchor and H&L) standardized to 1
Coast Anchor combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
Drift combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
H&L MA discards at age 2012 in spreadsheet
Pounds RI float trap landings in the RI CAA spreadsheet (no pound net specifc info in RI)
Trawl Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)
Other Average of all other gears

2011

Notes Chesapeal Anchor Gil VIMS fish independent in Rapp and James in 11 in "VIMS_length_frequency_spring1991_2011forVMRC"
Drift Gill MD Discard estimates for 11 in MD Comm- Bay GillNet landings spreadsheet
H&L from MD com H&L harvest at age in "MD SB Compliance 11.xls"
Pound Net from VIMS Pound independent data Rapp River in 11in "VIMS_length_frequency_spring 1991_2011 for VMRC
Trawl Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)
Other Average of Anchor, drift, H&L and Pound standardized to sum to 1
Delaware I Anchor from DE CAA spreadsheet for comm gill net landings - spring
Drift from DE CAA spreadsheet for comm gill net landings - spring
H&L from DE CAA spreadsheet for H&L Fall

Coast Anchor combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
Drift combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
H&L MA discards at age 2011 in spreadsheet
Pounds RI float trap landings in the RI CAA spreadsheet (no pound net specifc info in RI)
Trawl Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)
Other Average of all other gears

2010

Notes Chesapeal Anchor Gil VA fish independent in Rapp and James in 10 in "VIMS_length_frequency_spring1991_2010forVMRC"
Drift Gill MD Discard estimates for 2010 in MD Comm- Bay GillNet landings spreadsheet
H&L from MD com H&L harvest at age in "MD Data 2010.xls"
Pound Net from VA Pound independent data Rapp River in 2010 in "VIMS_length_frequency_spring 1991_2010for VMRC
Other Average of Anchor, drift, H&L and Pound

Delaware I Anchor from DE CAA spreadsheet for comm gill net landings - spring
Drift from DE CAA spreadsheet for comm gill net landings - spring

Coast Anchor combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
Drift combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
H&L MA discards at age 2010 in spreadsheet
Pounds RI float trap landings in the RI CAA spreadsheet (no pound net specifc info in RI)
Trawl Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)

2009

Notes Chesapeal Anchor Gil VIMS fish independent in Rapp and James in 09 in "VIMS_length_frequency_spring1991_2009forVMRC"
Drift Gill MD Discard estimates for 09 in MD Comm- Bay GillNet landings spreadsheet
H&L from MD com H&L harvest at age in "MD Data 2009xls"
Pound Net from VIMS Pound independent data Rapp River in 09in "VIMS_length_frequency_spring 1991_2009 for VMRC
Other Average of Anchor, drift, H&L and Pound

Delaware I Anchor from DE CAA spreadsheet for comm gill net landings - spring
Drift from DE CAA spreadsheet for comm gill net landings - spring

Coast Anchor combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
Drift combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
H&L MA discards at age 2009 in spreadsheet
Pounds RI float trap landings in the RI CAA spreadsheet (no pound net specifc info in RI)
Trawl Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)

2008

VA Anchor Gill Spring, VA Anchor Gill Fall, MD Drift Gill, MD Hook & Line, VA Pound Net Spring, VA Pound Net Fall, and MD Pound Net catch at age are all from summary state spreadsheets.
PRFC catch at age estimated from MD gear specific age structure and PRFC annual report data by gear.
DE Total catch at age from Comm CAA matrix, breakdown to gear: 0.79 anchor, 0.21 drift, from G Shepherd for 2008
Coast trawl from Shepherd bycatch summary "com disc OT len.xls" and alk in 2008 NY alk for CA, WLI, and ocean trawl.
Coast Ancl combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
Coast Drift combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
Coast H&L from MA H&L discard at age in 07 MA CAA worksheet
Coast Pound from RI pound net 07 CAA worksheet

2007

VA Anchor Gill Spring, VA Anchor Gill Fall, MD Drift Gill, MD Hook & Line, VA Pound Net Spring, VA Pound Net Fall, and MD Pound Net catch at age are all from summary state spreadsheets.
PRFC catch at age estimated from MD gear specific age structure and PRFC annual report data by gear for pound and H&L.

DE Total catch at age from Comm CAA matrix, breakdown to gear: 0.79 anchor, 0.21 drift, from G Shepherd for 2008
Coast trawl from Shepherd bycatch summary "com disc OT len.xls" and alk in 207 NY alk for CA, WLI, and ocean trawl.
Coast Ancl combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
Coast Drift combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
Coast H&L from MA H&L discard at age in 07 MA CAA worksheet
Coast Pound from RI pound net 07 CAA worksheet

2006

Bay Anchor Gill from VA fish independent in Rapp and James in 06 in "VIMS_monitor_size_freq.xls"
2006 Bay Drift Gill from MD Discard estimates for 06 in MD Comm- Bay GillNet landings spreadsheet
Bay H&L from MD H&L harvest at age inMD_SB_Compliance2006.xls: Sheet=Comm-HLPN"
Bay Pound from VA Pound independent data Rapp River in 06 in "VIMS_monitor_size_freq.xls"
DE Bay Anchor & Drift Gill from DE CAA spreadsheet for comm gill net landings - combined spring and fall
Coast Anchor Gill fror combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
Coast Drift Gill from combined MD (comm - Atl gillnet trawl) and VA (coastal gill net spring, fall) coastal gill net landings
Coast H&L from MA H&L discard at age in "MA1 Data 2006.xls"
Coast Pound from RI float trap landings in the RI CAA spreadsheet (no pound net specifc info in RI)
Coast Trawl from Combined NY comm landings - mixed fishery with trawl landings (landing # known commercial) and NC comm landings - mixed fishery with trawl info (landings wt only comm)

2005

Notes
Bay Anchor Gill from VA fish independent in Rapp and James in 05 in "VIMS_length_weight_data_2005.xls" DE Bay spring gill provoded by DE in Table 9 of "DE 2006 SB CAA Data.xls"
Bay Drift Gill MD Discard estimates for 05 from kill at age estimates in "MD-SB_Compliance2005: Sheet=comm Bay gill net"
Bay H&L from MD H&L harvest at age inMD_SB_Compliance2005.xls: Sheet=Comm-HLPN"
Bay Pound from VA Pound independent data Rapp River in 05 in "VIMS_length_weight_data.xls"
Coast Anchor gill from Shepherd bycatch length frequency and NY July-December age-length key - see page Coast Gillnet Discards Age Prop"
Coast Drift gillfrom Shepherd bycatch length frequency and NY July-December age-length key - see page Coast Gillnet Discards Age Prop"
Coast H&L from "MA Data 2005, sheet - commercial discard # know.xls"
Coast Pound from RI pound discard at age in "RI SB 2004 - sheet catch-age summary.xls" since there were no estimates for 2005
Coast trawl from Shepherd bycatch length frequency and NY July-December age-length key - see page Coast Trawl Discards Age Prop"

2004

Notes
Bay Anchor Gill from VA fish independent in Rapp and James in 04 in "VIMS_lengthr_weight_data.xls" DE Bay spring gill provoded by DE in Table 9 of "DE 03 Data.xls"
Bay Drift Gill MD Discard estimates for 04 from kill at age estimates in "comm Bay gill net.xls"
Bay H&L from MD H&L harvest at age in "comm_HLPN.xls"
Bay Pound from VA Pound independent data Rapp River in 04 in "VIMS_length_weight_data.xls"
Coast Anchor gill from Shepherd bycatch summary in "sbass-comm discards.xls"
Coast Drift gill from Shepherd bycatch summary in "sbass-comm discards.xls"
Coast H&L from "MA Data 2004, sheet - commercial discard # know.xls"
Coast Pound from RI pound discard at age in "RI SB 2004 - sheet catch-age summary.xls"
Coast trawl from Shepherd "comm discard at age.xls"

2003

Notes
Bay Anchor Gill from VA fish independent in Rapp and James in 03 in "VIMS_monitor_size_freq.xls" DE Bay spring gill provoded by DE in Table 9 of "DE 03 Data.xls"
Bay Drift Gill MD Discard estimates for 03 in "mdgillnet discards at age.xls"
Bay H&L from VA com H&L harvest at age in "VA1 Data 2003.xls"
Bay Pound from VA Pound independent data Rapp River in 03 in "VIMS_monitor_size_freq.xls"
Coast Anchor gill from Shepherd bycatch summary in "sbass-comm discards.xls"
Coast Drift gill from Shepherd bycatch summary in "sbass-comm discards.xls"
Coast H&L from MA H&L discard at age in "Copy of MA1 Data 2003.xls"
Coast Pound from RI pound discard at age in "RI Data Calcs.xls"
Coast trawl from Shepherd bycatch summary in "sbass-comm discards.xls"

1982-2002
Age Frequencies from All Comm Discards.xls (under 2003 striped bass assmnt)
CB
CB Copied matrices; for seines, used Pound matrix
Other - took average across gears Anchor, Drift Pound and HL then standadized to 1
Anchor is VA gillnet
Used Drift for Anchor in 1988-1989
DE
DE anchor - used average Anchor (mostly MD) in spreadsheet from All Comm Discards
1991 Hook used MD hook
2008,2011 Hook from Coast H&L
1991, 1993,1996,1997, 2002 Other - Anchor
1993,1994, 1996 Pound = CB pound

For Coast - for HL 1982-1996 (Rec Release age comp), 1997-2002 Commrel age comps

Pound RI new 2000-2001 CAA
2001 Drift - MD wintr Drift
2001,2002 Trawl NY Commlandings
2000 Trawl - NY and NC combined (2000 Catch - 2001 Assessment)
POUND 1982-1983 ri_cat & ny_cat, 1984 ri_cat; used 1985 for 1986
Seine and Pound net 1987-2000 NY Ocean Haul Seine
Seine = 1982-1984 NY Haul Seine, 1985= Seine 1984, 1986 = Pound Net
1997 trawl AR97commCAA
COAST TRAWL Combined NY 1982-1985 from ny_cat in 1997-2000, checked
COAST TRAWL 1999 from NY1999 1997-2000, checked
COAST RAWL 1997 & 1998 NYCOmmHARV+NC Comm HAR from REVISION_CAA1997to1998 in 1997-2000, checked
COAST TRAWL 1990-1996 sum NY+ NC harvest from CAA_com1999 in 1997-2000,checked
TRAWLS 1986-1989 Used Other

Appendix B7: Tag Recovery Estimates of Migration of Striped Bass from Chesapeake and Delaware Bays

Gary Nelson
Massachusetts Division of Marine Fisheries
March 2010

Introduction

A spatial model for striped bass will require emigration and immigration rates to move numbers of striped bass among defined management areas. The only published estimates of emigration rates are due to Dorazio et al. (1994) who used Chesapeake Bay and Hudson River tag data from 1988-1991 to estimate the probability of Chesapeake Bay fish migrating to north of Cape May ("northern region") by fish body size. The spatial stock assessment will be age-based; thus, estimates of migration probabilities in relationship to age will be required. In this paper, I explore the use of the Dorazio method to develop migration probabilities based on age. In addition, I re-estimate the migration probabilities based on length to determine if migration probabilities might have changed between two periods (1988-1995 and 1996-2004).

Methods

Release and recapture data for the Hudson River, Chesapeake Bay, and Delaware Bay from 1988 to 2004 were extracted from the USFWS Access database using SQL code. With no information about QA/QC selection criteria provided in Dorazio et al. (1994), I used all data extracted except recapture information with event>1 to eliminate duplicates. Tag recapture locations were coded to specify southern (south of Cape May, NJ) and northern (north of Cape May, NJ) recapture regions defined by Dorazio et al. (1994).

I developed the statistical model specified by Dorazio et al. (1994) in AD Model Builder (ADMB) and followed his analytic approach (see the paper for a complete description of the methods). In his approach, the probability of migration (λ_{21}) from a spawning bay to the northern region and the tag recovery rate (v_1) in northern rate are estimated (Hudson River migration to southern region is rare, so the migration probability is set to 0). Tag fates are coded as 1 if recovered in the northern region or 0 if recovered in the southern region or not recovered at all .

To estimate the λ_{21} and v_1 and the effects of *size*, *age* and *year* on the migration and recovery rates, logistic models for binary data are used. *Size* (TL in m) and *age* are considered continuous explanatory variables, while *year* is considered a categorical variable (reference cell coding is used in the design matrix). Because it is unlikely that the spatial model will contain sex-specific components, I did not include sex as an explanatory variable.

For λ_{21}, the model is:

$$\hat{\lambda}_{21} = \frac{1}{1 + \exp^{(\alpha + \sum_{j} \beta_i Year_i + \gamma \cdot size\ (or\ age))}}$$

where α is a constant, β_i is the coefficient for year *i*, and γ is the coefficient for size (or age) (based on reference coding Y*ear* is coded as either 0 (if not year) or 1 (if year) and the first year is used as the reference year).

For v_1,

$$\hat{v}_1 = \frac{1}{1 + \exp^{(\alpha + \sum_j \beta_i Year_i + \gamma \cdot size\ (or\ age))}}$$

The parameters are estimated by using the method of maximum likelihood. The log-likelihood for the model is

$$l = \sum_{i=1}^{N1} y_i \log_e(\hat{v}_1) + (1 - y_i)\log e(1 - \hat{v}_1) + \sum_{i=1}^{N2} y_i \log_e(\hat{\lambda}_{21}\hat{v}_1) + (1 - y_i)\log_e(1 - \hat{\lambda}_{21}\hat{v}_1)$$

where *N1* is fish tagged and released in the Hudson River, y_i is *i*th observation (0 or 1), and *N2* is the fish tagged and released in the spawning bay. The “best” model for the combination of explanatory variables was chosen based on the Akaike’s information criterion, examination of deviance and Pearson residual plots, and the precise (CVs) of parameter estimates. Seven models were included in the analysis:

Model	v_1	Λ_{21}
1	Null	Null
2	TL (or Age)	Null
3	TL (or Age)	TL (or Age)
4	TL (or Age)	TL (or Age), Year
5	TL (or Age), Year	Null
6	TL (or Age), Year	TL (or Age)
7	TL (or Age), Year	TL (or Age), Year

A null model contains only the equation constant (α). I used likelihood ratio tests to determine if model differed from the null or each other.

To test if the ADMB Builder code was correct, I estimated the parameters of the “best” model (model 8) of Dorazio et al. (1994) using data from 1988-1991and compared the results to the published estimates in Table 3 of the paper. The results are shown in Table 1 and show that the ADMB model produced estimates close to the published results (differences are probably due to my inability to extract exactly the same dataset used in the paper).

In Dorazio et al. (1994), recaptures from April-November of the same release year are used to estimate the model parameters. Results from our (MA DMF) temperature and acoustic tagging studies indicate that migration of striped bass in northern Massachusetts to the south waters begins near the end of September. It is possible that fish migrating in October and November may reach the southern region and the recaptures may be interpreted as fish that have never migrated north when combined over all months. To avoid this problem, I used data from April-September only.

Age data for Hudson River released fish were only available from 1988 to 1995. In addition, not all released fish were aged. Therefore, the dataset used when *age* was included as an explanatory variable was different in size and no analyses could be conducted for 1996-2004. For Delaware Bay, analyses include data only from 1992-1995 because age data were not available prior to 1992 and release/recapture information from the New Jersey DEP and DE tagging programs were used.

In the original paper, Dorazio et al. (1994) apparently used only tag release data from the Maryland DNR tagging program. Tagging has been also conducted by the State of Virginia in the Rappahannock River since 1990. I made separate analyses including the Virginia data to see if the additional information could improve estimates.

Results

Chesapeake Bay (Maryland Data Only)

<u>1988-1995</u>

Explanatory variables of total length and year in models 2-7 accounted for significant amounts of variation when compared to model 1 ($p \leq 0.001$). The model with the lowest AIC value for 1988-1995 was model 6 (Table 2). However, examination of the parameter coefficients of variation (CV) showed that the precision of most estimates was very poor (CVs>1); therefore, model 3 (total length incorporated in the tag recovery and migration probability sub-models) was selected as the "best" model (Table 3). The parameter estimates from model 3 are given in Table 2. The predicted migration probabilities from model 3 show that as striped bass size increases, the probability of migration increases (Figure 1A). However, when compared to the original predicted migration probabilities from Dorazio et al. (Figure 1A), the new model predicted lower probability at the same length. Plots of residuals (Figure 2A) show reasonable fit, although the use of total length in meters produces many length bins in which Y=0.

Explanatory variables of age and year in models 2-5 accounted for significant amounts of variation when compared to model 1 ($p \leq 0.001$). Models 6 and 7 were not different from model 1. The model with the lowest AIC value for 1988-1995 was model 3 which includes *age* as an explanatory variable in tag recovery rate and migration probability sub-models (Table 2). Model output showed that the probability of migration and tag recovery rate increased with age (Figure 1B; Table 3). Plots of residuals (Figure 2B) show reasonable fit.

<u>1996-2004</u>

Explanatory variables in models 2-7 accounted for significant amounts of variation when compared to model 1 ($p \leq 0.001$). The model with the lowest AIC value for 1996-2004 was model 3 (Table 2). Parameter estimates from model 3 are given in Table 2. The predicted migration probabilities from model 3 show that as striped bass size increases, the probability of migration increases (Figure 3A). However, when compared to the predicted migration probabilities from 1988-1994, the model predicted lower migration probability and lower tag recovery rate at the same length (Figure 3A). Plots of residuals (Figure 3B) show reasonable fit.

Chesapeake Bay (Maryland and Virginia Data)

1988-1995

Explanatory variables of total length and year in models 2-7 accounted for significant amounts of variation when compared to model 1 ($p \leq 0.001$). The model with the lowest AIC value for 1988-1995 was model 6 (Table 4). However, examination of the parameter coefficients of variation (CV) showed that the precision of most estimates was very poor (CVs>1). Model 7 was the next lowest AIC, but had very low precision estimates too. Therefore, model 3 (total length incorporated in the tag recovery and migration probability sub-models) was selected as the "best" model (Table 4). The parameter estimates from model 3 are given in Table 5. The predicted migration probabilities from model 3 show that as striped bass size increases, the probability of migration increases (Figure 4A) and, incorporating Virginia data, produced similar patterns as the model using only MD data (Figure 4A). Plots of residuals (Figure 4B) show reasonable fit, although the use of total length in meters produces many length bins in which Y=0.

Explanatory variables of age and year in models 2-5 and 7 accounted for significant amounts of variation when compared to model 1 ($p \leq 0.001$). Models 6 was not different from model 1. The model with the lowest AIC value for 1988-1995 was model 3 which includes *age* as an explanatory variable in tag recovery rate and migration probability sub-models (Table 4). Model output showed that the probability of migration and tag recovery rate increases with age (Figure 5A; Table 5). There was considerable difference in migration probabilities between this model and the best model that used only MD data (Figure 5A). Plots of residuals (Figure 5B) show reasonable fit.

1996-2004

Explanatory variables in models 2-7 accounted for significant amounts of variation when compared to model 1 ($p \leq 0.001$). The model with the lowest AIC value for 1996-2004 was model 3 (Table 4). Parameter estimates from model 3 are given in Table 5. The predicted migration probabilities from model 3 show that as striped bass size increases, the probability of migration increases (Figure 6A). However, when compared to the predicted migration probabilities using only MD data, the model predicted higher migration probability and lower tag recovery rate at the same length (Figure 6B). Plots of residuals (Figure 6B) show reasonable fit.

Delaware Bay

<u>1992-1995</u>

Explanatory variables of total length and year in models 2-7 accounted for significant amounts of variation when compared to model 1 ($p \leq 0.001$). The model with the lowest AIC value for 1992-1995 was model 2 where total length was included in the tag recovery sub-model only (Table 6). The parameter estimates from model 2 are given in Table 7. The Model output shows that the probability of migration is constant across size (Figure 7A). Plots of residuals (Figure 7B) show a systematic trend which indicate a general lack of fit. The relatively few years of data is probably responsible for the lack of fit.

Explanatory variables of age and year in models 2-7 accounted for significant amounts of variation when compared to model 1 ($p \leq 0.001$). The model with the lowest AIC value for 1992-1995 was model 3; however, comparison of model 2 and model 3 using a likelihood ratio test indicated not significant differences between the models. Thus, based on the rule of parsimony, model 2 should be selected. Model 2 includes *age* as an explanatory variable in tag recovery rate sub-model only (Table 6). The model output shows that the probabilities of migration is constant across age (Figure 8A). Plots of residuals (Figure 8B) show reasonable fit.

<u>1996-2004</u>

Explanatory variables of total length and year in models 2-7 accounted for significant amounts of variation when compared to model 1 ($p \leq 0.001$). The models with the lowest AIC value for 1988-1995 were models 6 and 7 (Table 6). However, examination of the parameter coefficients of variation (CV) of each showed that the precision of most estimates was very poor (CVs>1); therefore, model 3 (total length incorporated in the tag recovery and migration probability sub-models) was selected as the "best" model (Table 6). The parameter estimates from model 3 are given in Table 7. The model output shows that as striped bass size increases, the probabilities of migration increases (Figure 9A). Plots of residuals (Figure 9B) show reasonable fit.

Discussion

The analyses presented should be considered preliminary. The results suggest estimation of migration probabilities based on age is possible. I need to consult lead state personnel to discuss what data to include in each analysis, and to develop criteria for scrutinizing data. NY may have age data for post-1995 releases, and estimation of migration probabilities post-1995 may be possible. I'll try to get those data. In their paper, Dorazio et al. (2004) wrote that they used total length in centimeters in their modeling, but they actually used total length in meters. It would be wiser to use centimeters because it would allow improved assessment of the residuals by creating length bins that could have positive values associated with each bin. Some of the odd patterns observed in the residual plots are due to zeros in the meter bins. Also, other model fit assessment techniques need to be examined (eg., Hosmer-Lemeshow tests).

Table 1. Parameters of model 8 of Dorazio et al. (1994) re-estimated using the ADMB program. Dorazio parameters are used to predict the probability of not migrating. To get probability of migration, signs are reversed (see Figure 5 of Dorazio et al., 1994).

Parameter	Dorazio	ADMB
Tag recovery rate v_1		
Constant	-4.10	4.06
Effect of total length (m)	1.91	-1.89
Effect of 1989	0.25	-0.27
Effect of 1990	0.57	-0.56
Effect of 1991	0.45	-0.44
Migration rate λ_{21}		
Constant	-15.5	15.2
Effect of total length (m)	19.1	-18.6

Table 2. Comparison of models to examine the effects of striped bass total length (TL; m) or age (years), and year of recovery (Year) on the rates of migration λ_{21} from Chesapeake Bay (MD) to the northern region (Apr-Sept recoveries), and tag recovery v_1 in the northern region for 1998-1995 and 1996-2004. *n* is the number of parameters, *-LL* is the log-likelihood, and *AIC* is the Akaike's Information Criterion.

1988-1995

Model	v_1	Λ_{21}	*n*	*-LL*	*AIC*
1	Null	Null	2	2354.8	4713.5
2	TL	Null	3	2220.5	4447.0
3	TL	TL	4	2152.5	4312.7
4	TL	TL, Year	11	2148.1	4318.2
5	TL, Year	Null	10	2204.5	4428.9
6	TL, Year	TL	11	2141.7	4305.5
7	TL, Year	TL, Year	18	2136.6	4309.2

Model	v_1	Λ_{21}	*n*	*-LL*	*AIC*
1	Null	Null	2	1999.0	4002.0
2	Age	Null	3	1949.2	3904.3
3	Age	Age	4	1932.1	3872.2
4	Age	Age, Year	11	1928.8	3879.7
5	Age, Year	Null	10	1936.5	3893.0
6	Age, Year	Age	11	1990.4	4003.2
7	Age, Year	Age, Year	18	1991.9	4019.8

1996-2004

Model	v_1	Λ_{21}	*n*	*-LL*	*AIC*
1	Null	Null	2	2625.9	5255.9
2	TL	Null	3	2536.7	5079.3
3	TL	TL	4	2466.6	4941.2
4	TL	TL, Year	12	2462.5	4949.0
5	TL, Year	Null	11	2529.0	5080.0
6	TL, Year	TL	12	2460.0	4944.0
7	TL, Year	TL, Year	19	2455.7	4951.3

Table 3. Maximum-likelihood estimates of the parameters from the “best” model for 1988-1995 and 1996-2004 MD data only when total length or age is used as an explanatory variable.

Parameter	Estimate	SE	CV
1988-1995			
Tag recovery rate v_1			
Constant	4.149	0.247	0.059
Effect of TL (m)	-2.104	0.311	0.148
Migration rate λ_{21}			
Constant	13.022	1.660	0.127
Effect of TL (m)	-15.376	2.299	0.149
Tag recovery rate v_1			
Constant	3.784	0.200	0.053
Effect of Age (yrs)	-0.156	0.024	0.152
Migration rate λ_{21}			
Constant	4.792	0.802	0.167
Effect of Age (yrs)	-0.522	0.114	0.219
1996-2004			
Tag recovery rate v_1			
Constant	3.957	0.234	0.059
Effect of TL (m)	-1.738	0.297	0.171
Migration rate λ_{21}			
Constant	8.738	0.777	0.089
Effect of TL (m)	-9.220	1.012	0.110

Table 4. Comparison of models to examine the effects of striped bass total length (m) or age (years), and year of recovery (Year) on the rates of migration λ_{21} from Chesapeake Bay (MD and VA) to the northern region, and tag recovery v_1 in the northern region by period. *n* is the number of parameters, *-LL* is the log-likelihood, and *AIC* is the Akaike's Information Criterion.

1988-1995

Model	v_1	Λ_{21}	*n*	*-LL*	*AIC*
1	Null	Null	2	2677.4	5358.8
2	TL	Null	3	2475.9	4957.9
3	TL	TL	4	2374.3	4756.7
4	TL	TL, Year	11	2370.2	4762.4
5	TL, Year	Null	10	2459.8	4939.5
6	TL, Year	TL	11	2364.4	4750.8
7	TL, Year	TL, Year	18	2358.2	4752.4

Model	v_1	Λ_{21}	*n*	*-LL*	*AIC*
1	Null	Null	2	2632.2	5268.4
2	Age	Null	3	2482.4	4970.9
3	Age	Age	4	2383.2	4774.4
4	Age	Age, Year	11	2384.1	4790.2
5	Age, Year	Null	10	2478.6	4977.3
6	Age, Year	Age	11	2663.9	5349.8
7	Age, Year	Age, Year	18	2404.3	4844.7

1996-2004

Model	v_1	Λ_{21}	*n*	*-LL*	*AIC*
1	Null	Null	2	3297.5	6599.0
2	TL	Null	3	3114.5	6235.1
3	TL	TL	4	3009.9	6027.8
4	TL	TL, Year	12	3004.6	6033.3
5	TL, Year	Null	11	3109.5	6241.1
6	TL, Year	TL	12	3004.6	6032.9
7	TL, Year	TL, Year	20	2995.8	6031.5

Table 5. Maximum-likelihood estimates of the parameters from the "best" model for 1988-1995 and 1996-2004 MD and VA data when total length or age is used as an explanatory variable.

Parameter	Estimate	SE	CV
1988-1995			
Tag recovery rate v_1			
Constant	4.116	0.236	0.057
Effect of TL (m)	-2.059	0.293	0.142
Migration rate λ_{21}			
Constant	13.944	1.403	0.100
Effect of TL (m)	-16.729	1.940	0.116
Tag recovery rate v_1			
Constant	3.718	0.192	0.052
Effect of Age	-0.144	0.022	0.153
Migration rate λ_{21}			
Constant	8.702	0.799	0.092
Effect of Age	-1.071	0.122	0.114
1996-2004			
Tag recovery rate v_1			
Constant	3.799	0.225	0.059
Effect of TL (m)	-1.510	0.284	0.188
Migration rate λ_{21}			
Constant	9.213	0.712	0.077
Effect of TL (m)	-10.387	0.971	0.093

Table 6. Comparison of models to examine the effects of striped bass total length (m) or age (years), and year of recovery (Year) on the rates of migration λ_{21} from Chesapeake Bay (MD and VA) to the northern region, and tag recovery v_1 in the northern region by period. n is the number of parameters, -*LL* is the log-likelihood, and *AIC* is the Akaike's Information Criterion.

1992-1995

Model	v_1	Λ_{21}	n	-*LL*	*AIC*
1	Null	Null	2	2481.4	4966.8
2	TL	Null	3	2463.4	4932.7
3	TL	TL	4	2463.0	4934.0
4	TL	TL, Year	7	2461.6	4937.3
5	TL, Year	Null	6	2460.6	4933.1
6	TL, Year	TL	7	2460.4	4934.7
7	TL, Year	TL, Year	10	2457.6	4935.2

Model	v_1	Λ_{21}	n	-*LL*	*AIC*
1	Null	Null	2	1443.3	2890.6
2	Age	Null	3	1430.4	2866.8
3	Age	Age	4	1428.9	2865.8
4	Age	Age, Year	7	1432.3	2878.7
5	Age, Year	Null	6	1429.6	2871.1
6	Age, Year	Age	7	1428.1	2870.3
7	Age, Year	Age, Year	10	1428.4	2876.8

1996-2004

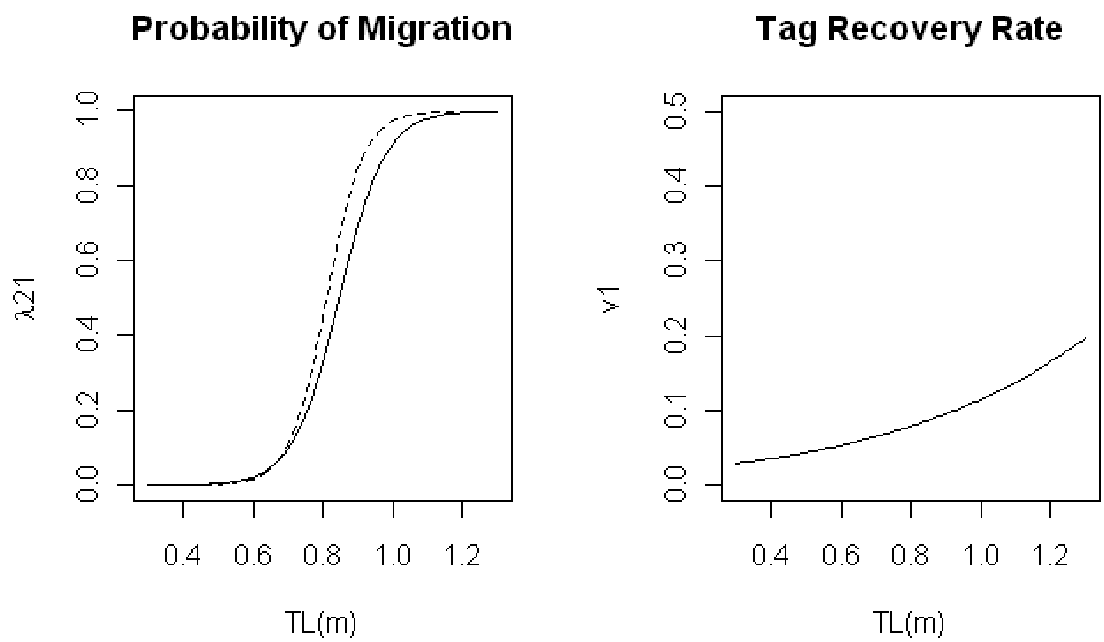
Model	v_1	Λ_{21}	n	-*LL*	*AIC*
1	Null	Null	2	6255.5	12515.0
2	TL	Null	3	6216.8	12439.5
3	TL	TL	4	6193.7	12395.7
4	TL	TL, Year	12	6188.7	12401.5
5	TL, Year	Null	11	6206.9	12435.7
6	TL, Year	TL	12	6183.3	12390.5
7	TL, Year	TL, Year	20	6177.6	12395.3

Table 7. Maximum-likelihood estimates of the parameters from the "best" model for 1992-1995 and 1996-2004 DE data when total length or age is used as an explanatory variable.

Parameter	Estimate	SE	CV
1992-1995			
Tag recovery rate v_1			
Constant	4.131	0.287	0.069
Effect of length (m)	-2.278	0.386	0.169
Migration rate λ_{21}			
Constant	-1.442	0.438	0.304
Tag recovery rate v_1			
Constant	3.242	0.209	0.065
Effect of age	-0.122	0.023	0.196
Migration rate λ_{21}			
Constant	-0.441	0.303	0.686
1996-2004			
Tag recovery rate v_1			
Constant	3.568	0.182	0.051
Effect of length (m)	-1.274	0.260	0.204
Migration rate λ_{21}			
Constant	15.238	3.236	0.212
Effect of length (m)	-31.241	6.733	0.216

Figure 1. A) Predicted migration probabilities (λ_{21}) using 1988-1995 MD data only (solid line) compared to predicted probabilities from Dorazio et al. (1994)(dashed line), and tag recovery rate (v_1) by total length, and B) predicted migration probabilities (λ_{21}) and tag recovery rate (v_1) using 1988-1995 MD data only by age.

A.



B.

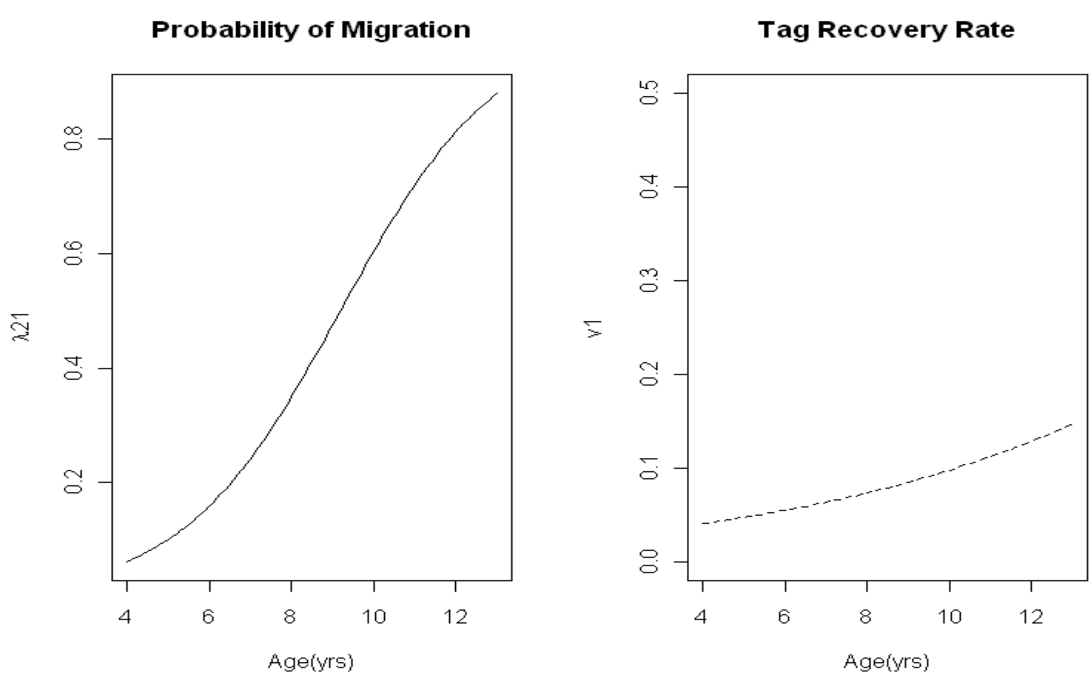
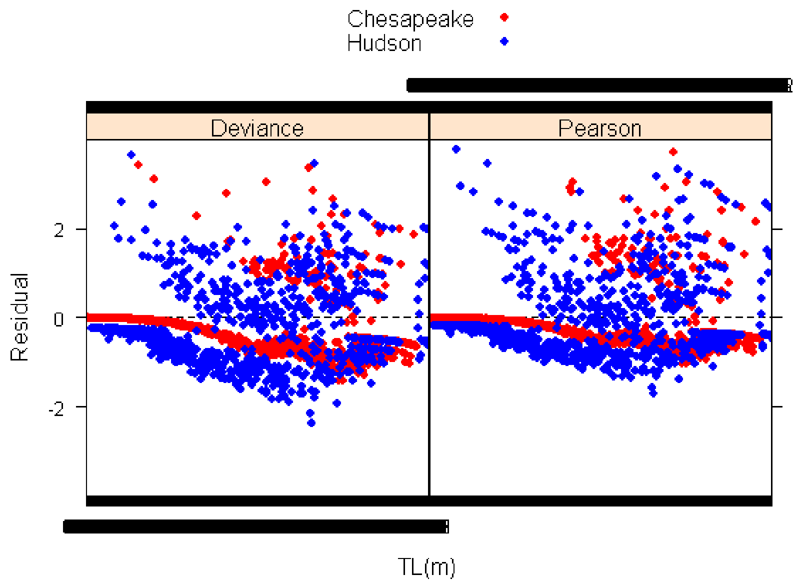


Figure 2. Plots of deviance and Pearson residuals for 1988-1995 MD only data from the "best " models when A) total length or B) age was used as an explanatory variable.

A.



B.

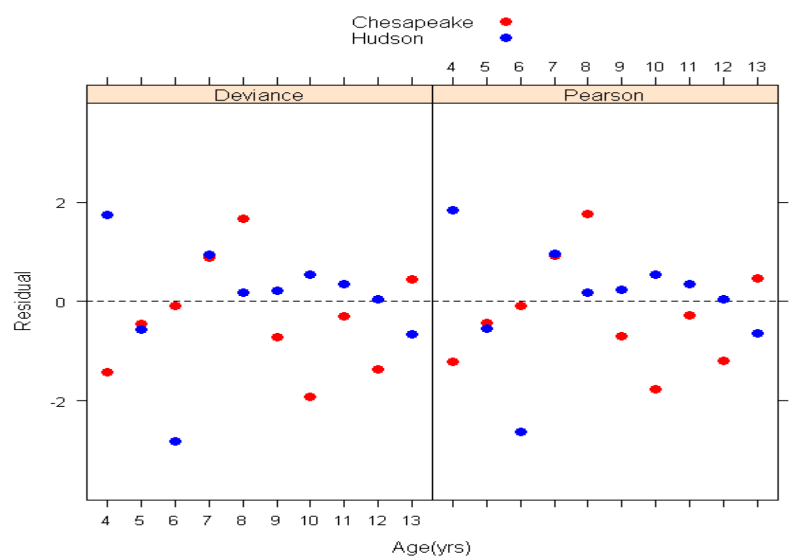
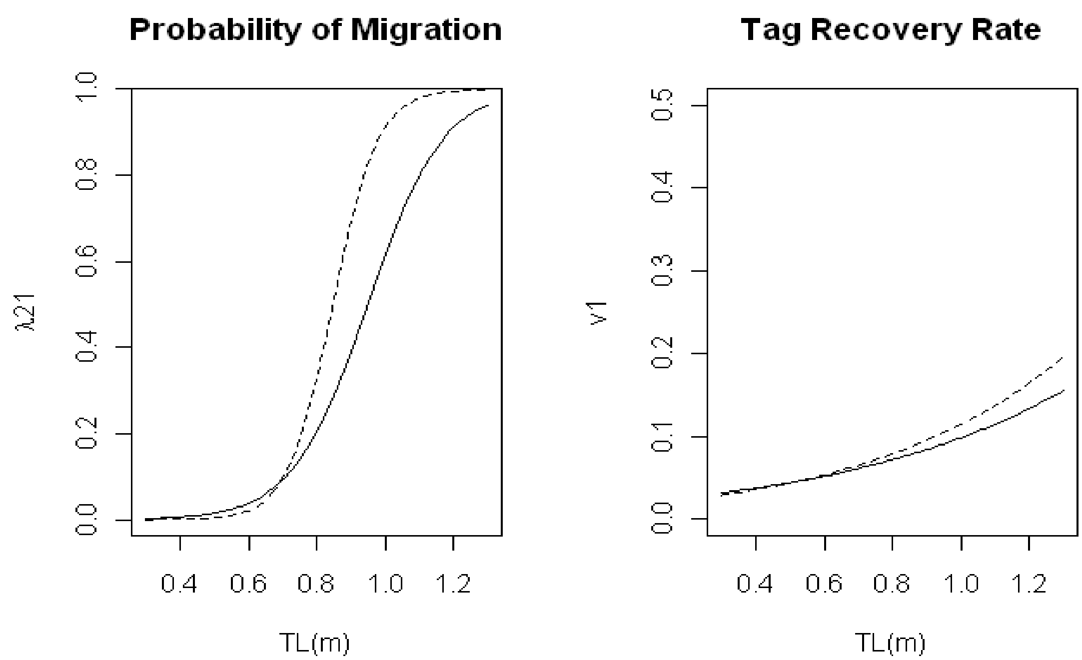


Figure 3. A). Predicted migration probabilities (λ_{21}) and tag recovery rate (v_1) by total length using 1996-2004 MD data only (solid line) compared to predicted probabilities from 1988-1995 (dashed line), and B) plots of deviance and Pearson residuals.

A.



B.

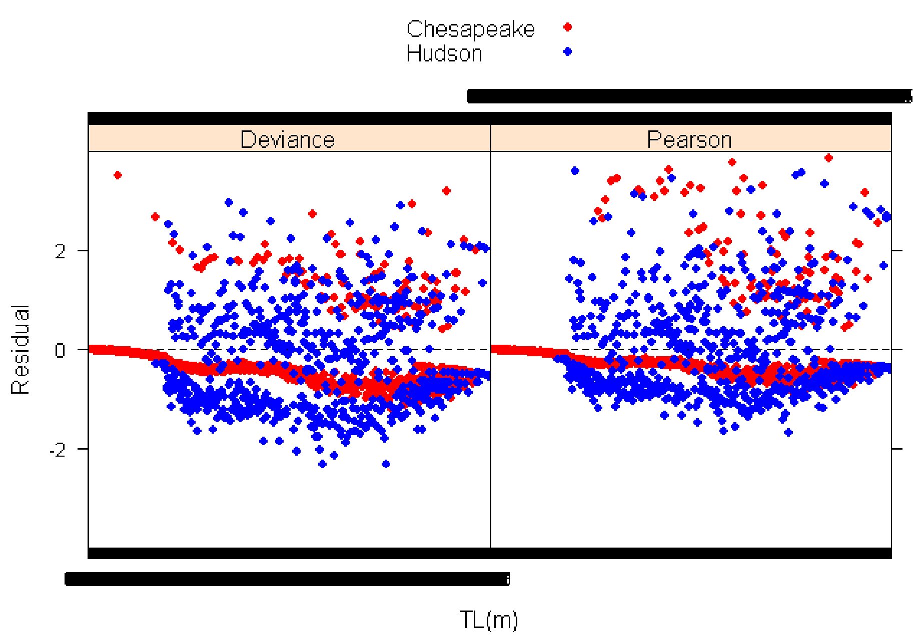
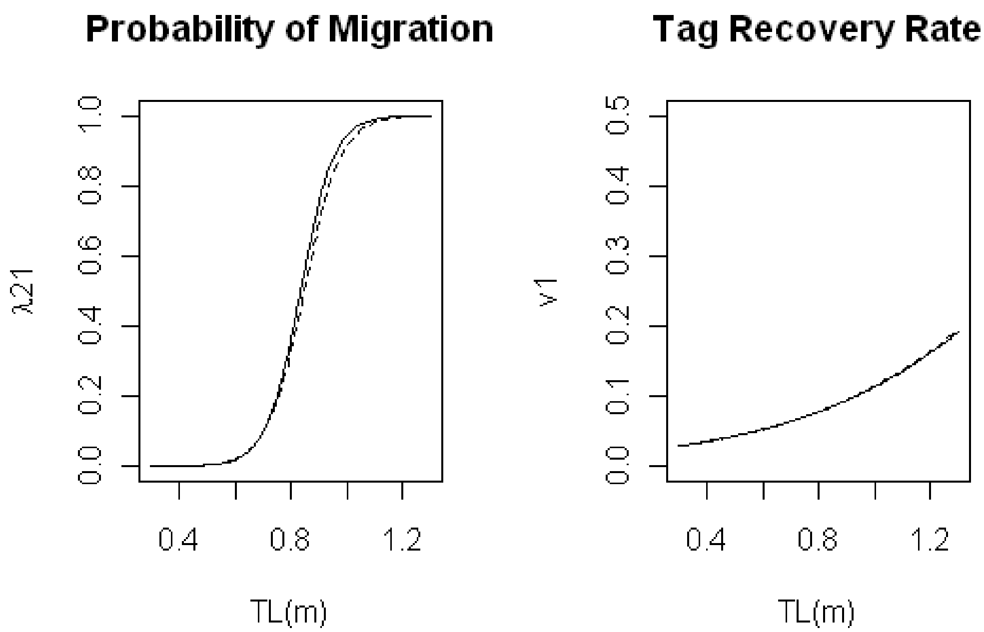


Figure 4. A) Predicted migration probabilities (λ_{21})) and tag recovery rate (v_1) using 1988-1995 MD and VA data (solid line) compared to predicted probabilities using MD data only (dashed line) by total length, and B) plots of deviance and Pearson residuals.

A.



B.

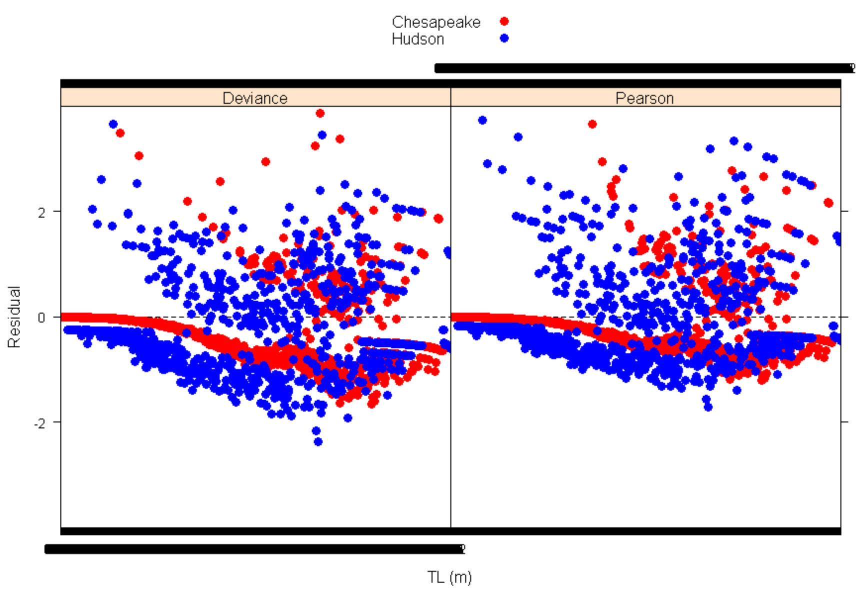
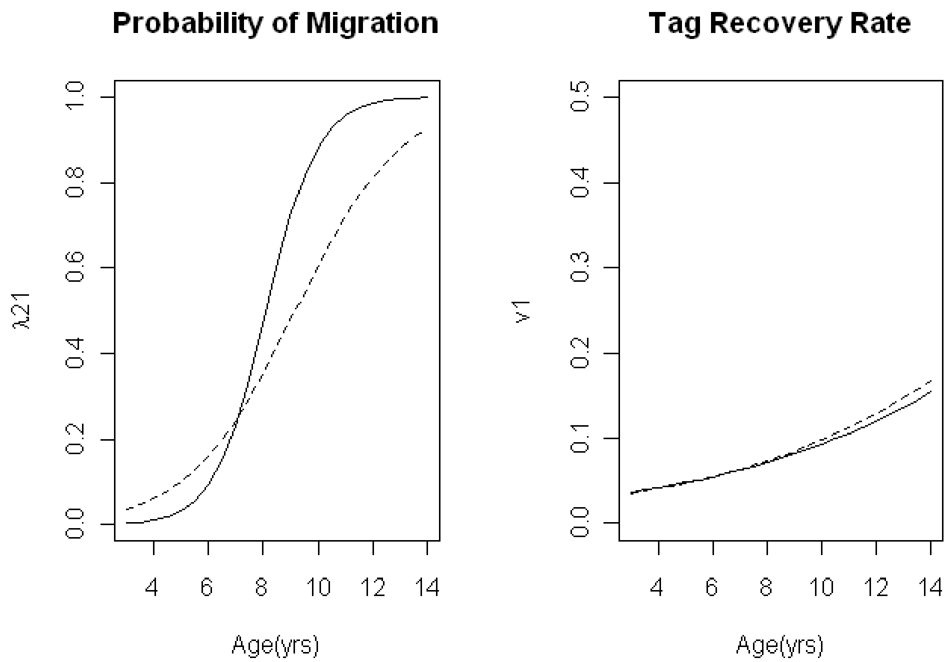


Figure 5. A) Predicted migration probabilities (λ_{21})) and tag recovery rate (v_1) using 1988-1995 MD and VA data (solid line) compared to predicted probabilities using MD data only (dashed line) by age, and B) plots of deviance and Pearson residuals.

A.



B.

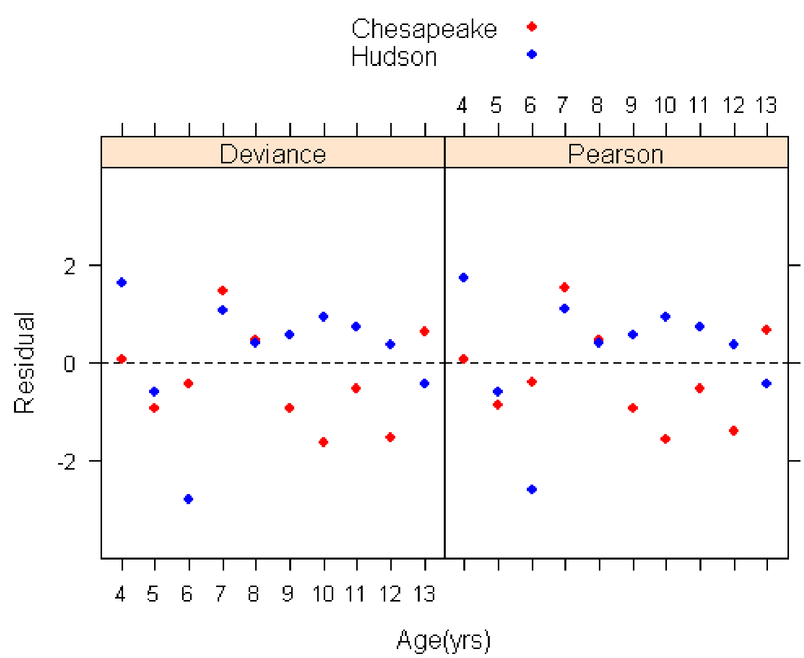
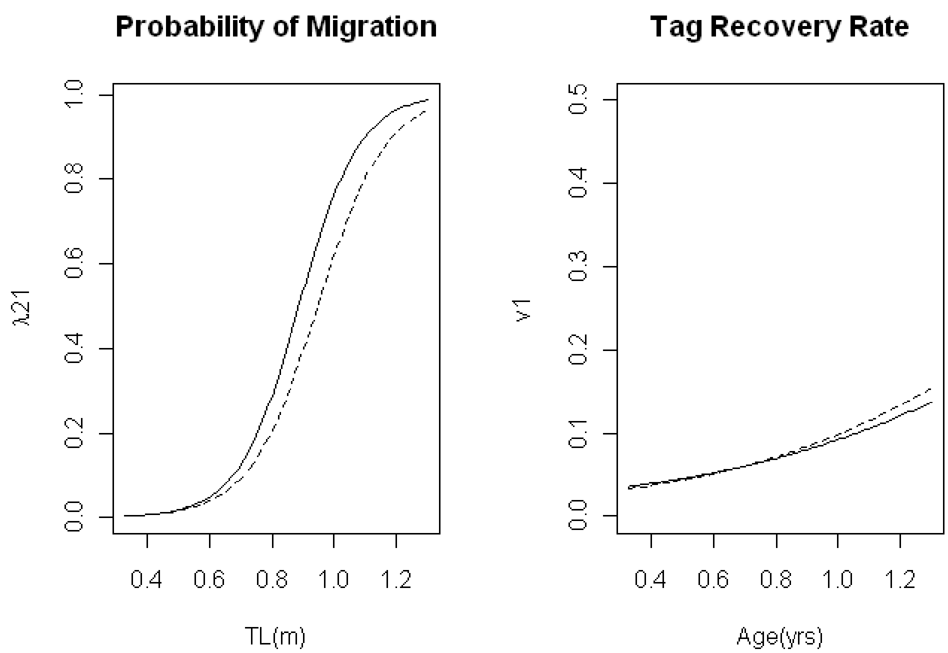


Figure 6. A) Predicted migration probabilities (λ_{21})) and tag recovery rate (v_1) using 1996-2004 MD and VA data (solid line) compared to predicted probabilities using MD data only (dashed line) by total length, and B) plots of deviance and Pearson residuals.

A.



B.

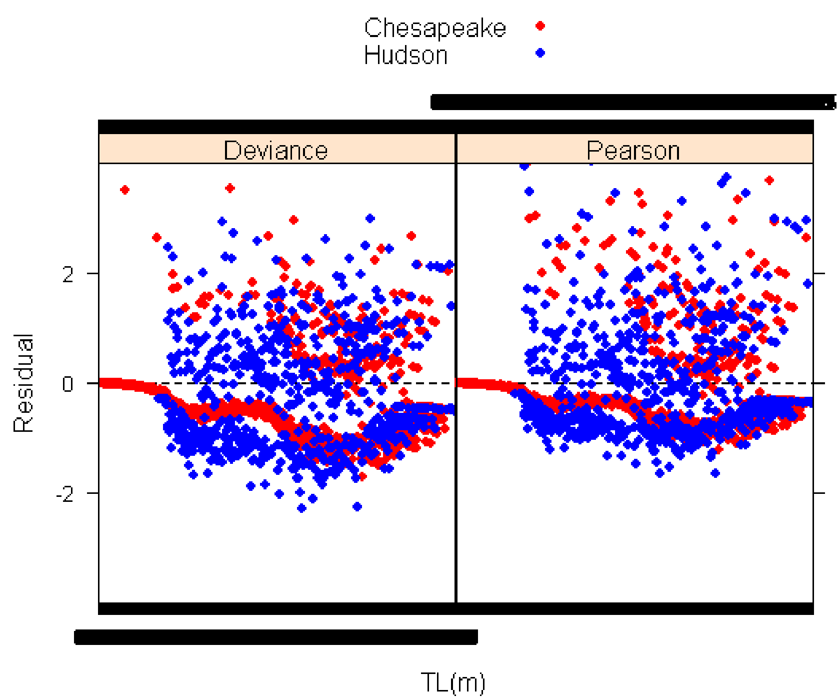
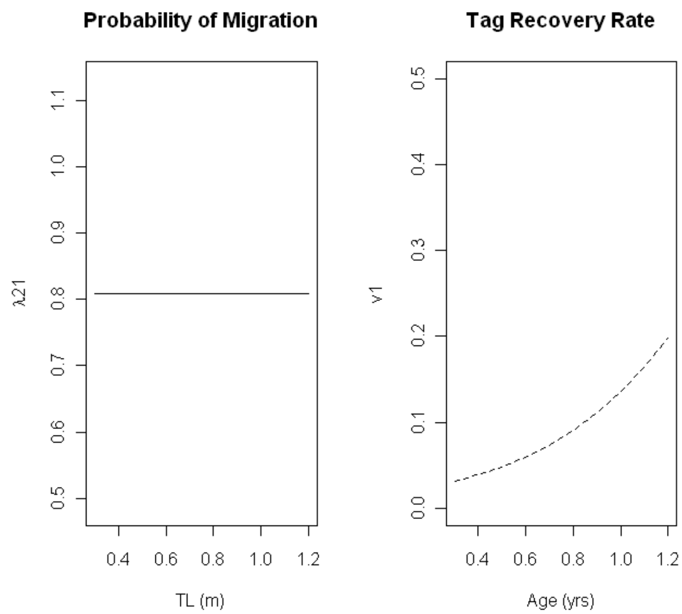


Figure 7. A) Predicted migration probabilities (λ_{21}) and tag recovery rate (v_1) using 1992-1995 DE/NJ data by total length, and B) plots of deviance and Pearson residuals.

A.



B.

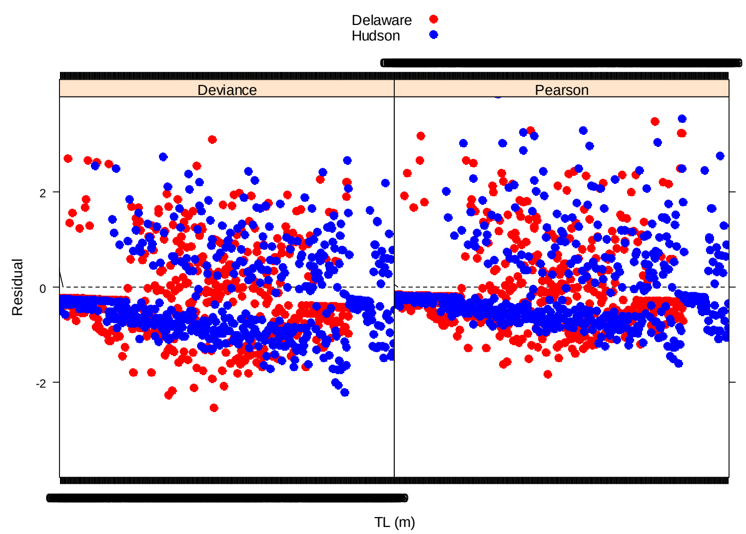
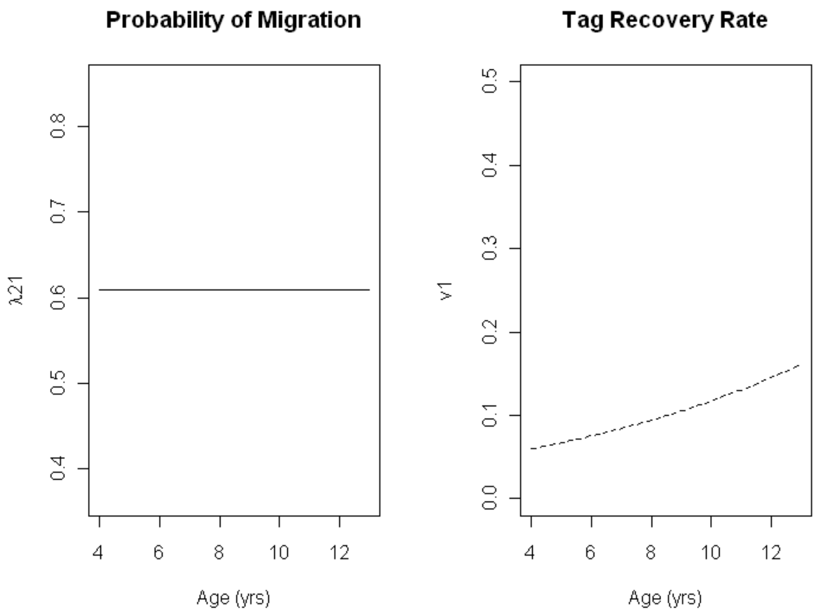


Figure 8. A) Predicted migration probabilities (λ_{21}) and tag recovery rate (v_1) using 1992-1995 DE/NJ data by age, and B) plots of deviance and Pearson residuals.

A.



B.

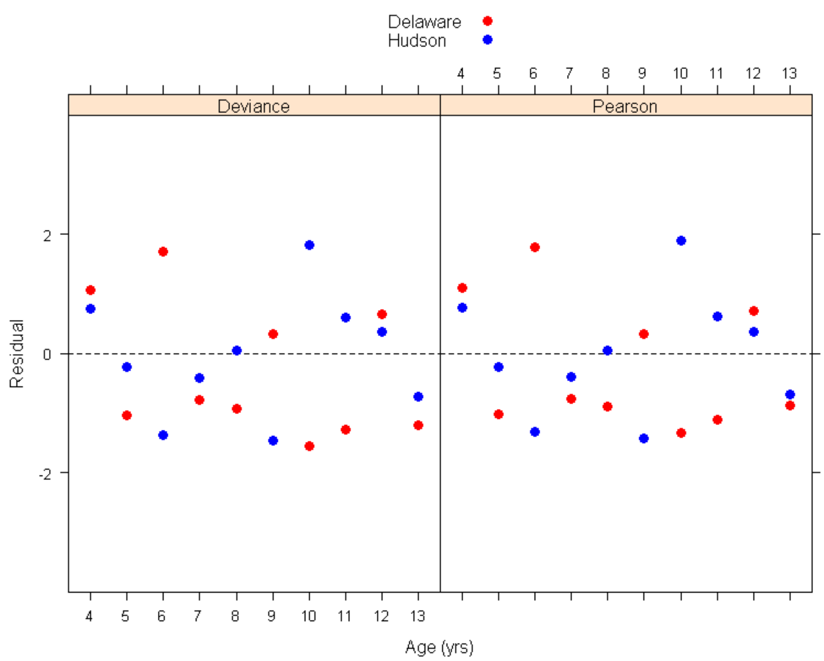
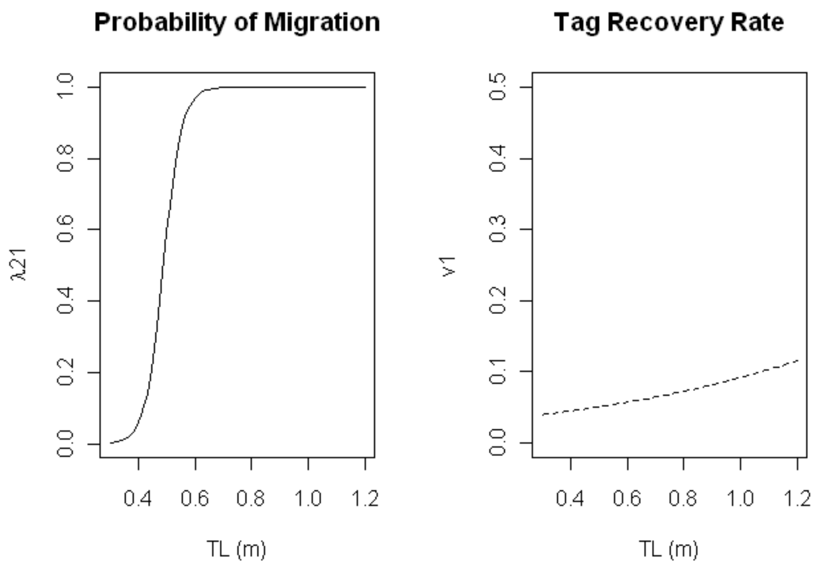
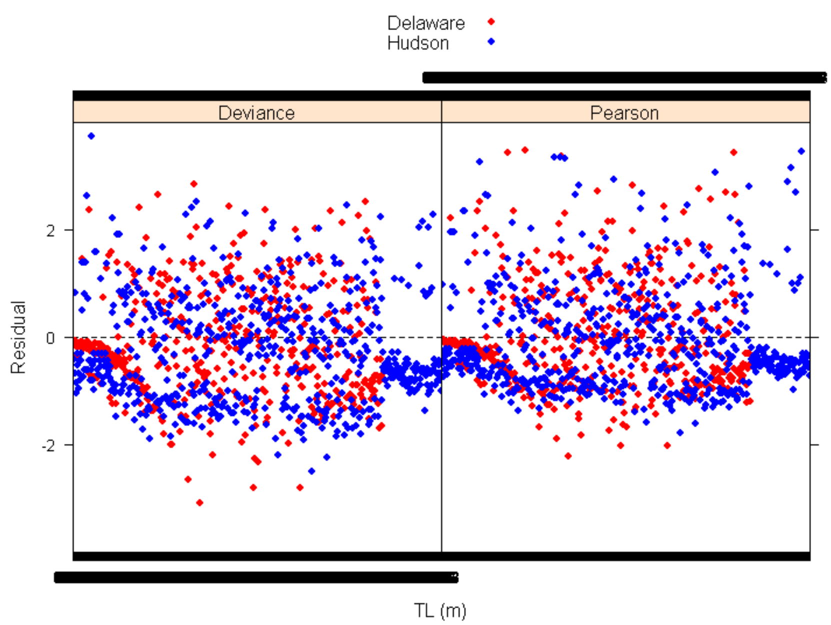


Figure 9. A) Predicted migration probabilities (λ_{21}) and tag recovery rate (v_1) using 1996-2004 DE/NJ data by total length, and B) plots of deviance and Pearson residuals.

A.



B.



Appendix B8. ADMB Code for the Striped Bass Two-Stock Statistical Catch-At-Age (2SCA) Model

```
//-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>
//
//          Striped Bass Two-Stock Statistical Catch-At-Age Model
//          Gary A. Nelson
//          Massachusetts Division of Marine Fisheries
//          Gloucester, MA 01930
//
//          Code for the calculation of effective sample size using the Francis (2011) method
//                         copied from ASAP written by Chris Legault, NMFS.
//-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>-><>
TOP_OF_MAIN_SECTION
 arrmblsize=1000000;
GLOBALS_SECTION
 #include <string.h>
 #include<ctime>
 #include <admodel.h>
 #include <iostream>
  char hh[2];
  using namespace std;
  void find_and_replace(string& source, string const& find, string const& replace)
  {
    for(string::size_type i = 0; (i = source.find(find, i)) != string::npos;)
    {
        source.replace(i, find.length(), replace);
        i += replace.length();
    }
  };
  string dir;
  string dirnew;
DATA_SECTION
 //!!ad_comm::change_datafile_name("mig2stockmodel.dat");
 init_adstring dirfirst;
 init_int substructure;
 init_int ncoastwaves;
 init_int styr;
 init_int endyr;
 init_int nages;
 //Stock 1
 init_matrix s1_bay_total_catch(styr,endyr,1,substructure);
 init_matrix s1_bay_total_catch_CV(styr,endyr,1,substructure);
 init_vector s1_bay_total_catch_lambda_wgts(1,substructure);
 init_matrix s1_bay_catch_paa_ess(styr,endyr,1,substructure);
 init_3darray s1_bay_catch_paa(1,substructure,styr,endyr,1,nages);//Proportions-at-age for Bay Period 1
 init_vector s1_bay_catch_paa_lambda_wgts(1,substructure);
 init_number s1_bay_reg_nperiods;//this has to be the number of rows of reg periods
 init_matrix s1_bay_select_years_type(1,s1_bay_reg_nperiods,1,4);//wave group (1,2,3) styr endyr type
 init_int s1_bay_sel_phase;
 init_int s1_bay_nagg;
 init_vector s1_bay_use_agg(1,s1_bay_nagg);
 init_vector s1_bay_agg_index_lambda_wgts(1,s1_bay_nagg);
 init_vector s1_bay_agg_time(1,s1_bay_nagg);
 init_vector s1_bay_agg_ages(1,s1_bay_nagg);
 init_int s1_bay_agg_phase;
 init_matrix s1_bay_agg_index(styr,endyr,1,s1_bay_nagg);//index
 init_matrix s1_bay_agg_index_CV(styr,endyr,1,s1_bay_nagg);//index
 init_int s1_bay_nac;
 init_vector s1_bay_use_ac(1,s1_bay_nac);
 init_vector s1_bay_ac_index_lambda_wgts(1,s1_bay_nac);
 init_vector s1_bay_ac_time(1,s1_bay_nac);
 init_vector s1_bay_ac_sel_type(1,s1_bay_nac);
 init_int s1_bay_ac_phase;
 init_matrix s1_bay_ac_index(styr,endyr,1,s1_bay_nac);
 init_matrix s1_bay_ac_index_CV(styr,endyr,1,s1_bay_nac);
 init_matrix s1_bay_ac_index_paa_ess(styr,endyr,1,s1_bay_nac);
 init_3darray s1_bay_ac_index_paa(1,s1_bay_nac,styr,endyr,1,nages);
 init_vector s1_bay_ac_index_paa_lambda_wgts(1,s1_bay_nac);
```

```
init_int s1_bay_ac_sel_phase;
init_vector s1_bay_pM(1,substructure);
init_matrix s1_bay_M(styr,endyr,1,nages); //M-at-age for bay
init_matrix s1_female_mat(styr,endyr,1,nages);
init_matrix s1_male_mat(styr,endyr,1,nages);
init_3darray s1_bay_prop_female(1,substructure,styr,endyr,1,nages);
init_matrix s1_bay_weight_at_age(styr,endyr,1,nages);
init_matrix s1_test_emig_probs(styr,endyr,1,nages);
//Everything else
init_int s2_nagg;
init_vector s2_use_agg(1,s2_nagg);
init_vector s2_agg_index_lambda_wgts(1,s2_nagg);
init_vector s2_agg_time(1,s2_nagg);
init_vector s2_agg_ages(1,s2_nagg);
init_int s2_agg_phase;
init_matrix s2_agg_index(styr,endyr,1,s2_nagg);//index
init_matrix s2_agg_index_CV(styr,endyr,1,s2_nagg);//index
init_int s2_nac;
init_vector s2_use_ac(1,s2_nac);
init_vector s2_ac_index_lambda_wgts(1,s2_nac);
init_vector s2_ac_time(1,s2_nac);
init_vector s2_ac_sel_type(1,s2_nac);
init_int s2_ac_phase;
init_matrix s2_ac_index(styr,endyr,1,s2_nac);
init_matrix s2_ac_index_CV(styr,endyr,1,s2_nac);
init_matrix s2_ac_index_paa_ess(styr,endyr,1,s2_nac);
init_3darray s2_ac_index_paa(1,s2_nac,styr,endyr,1,nages);
init_vector s2_ac_index_paa_lambda_wgts(1,s2_nac);
init_int s2_ac_sel_phase;
init_matrix s2_female_mat(styr,endyr,1,nages);
init_matrix s2_male_mat(styr,endyr,1,nages);
 //Observed combined coast
init_matrix coast_total_catch(styr,endyr,1,ncoastwaves);
init_matrix coast_total_catch_CV(styr,endyr,1,ncoastwaves);
init_vector coast_total_catch_lambda_wgts(1,ncoastwaves);
init_matrix coast_catch_paa_ess(styr,endyr,1,ncoastwaves);
init_3darray coast_catch_paa(1,ncoastwaves,styr,endyr,1,nages);//Proportions-at-age for Coast Period 1
init_vector coast_catch_paa_lambda_wgts(1,ncoastwaves);
init_number coast_reg_nperiods;
init_matrix coast_select_years_type(1,coast_reg_nperiods,1,4);//wave group (1,2,3) styr endyr type
init_int coast_sel_phase;
init_int coast_nagg;
init_vector coast_use_agg(1,coast_nagg);
init_vector coast_agg_index_lambda_wgts(1,coast_nagg);
init_vector coast_agg_time(1,coast_nagg);
init_vector coast_agg_ages(1,coast_nagg);
init_int coast_agg_phase;
init_matrix coast_agg_index(styr,endyr,1,coast_nagg);//index
init_matrix coast_agg_index_CV(styr,endyr,1,coast_nagg);//index
init_int coast_nac;
init_vector coast_use_ac(1,coast_nac);
init_vector coast_ac_index_lambda_wgts(1,coast_nac);
init_vector coast_ac_time(1,coast_nac);
init_vector coast_ac_sel_type(1,coast_nac);
init_int coast_ac_phase;
init_matrix coast_ac_index(styr,endyr,1,coast_nac);
init_matrix coast_ac_index_CV(styr,endyr,1,coast_nac);
init_matrix coast_ac_index_paa_ess(styr,endyr,1,coast_nac);
init_3darray coast_ac_index_paa(1,coast_nac,styr,endyr,1,nages);
init_vector coast_ac_index_paa_lambda_wgts(1,coast_nac);
init_int coast_ac_sel_phase;
init_vector coast_pM(1,substructure);
init_matrix coast_pF(styr,endyr,1,substructure);
init_matrix coast_M(styr,endyr,1,nages);
init_3darray coast_prop_female(1,substructure,styr,endyr,1,nages);
init_matrix coast_weight_at_age(styr,endyr,1,nages);
```

```
init_int use_stockcomp;
init_int stock_comp_time;
init_vector stock_comp_ess(styr,endyr);
init_matrix stock_composition(styr,endyr,1,2);
init_number stock_comp_lambda_wgt;
init_int stock_comp_firstage;
init_int stock_comp_lastage;
init_int biascor;
init_number s1_Rdev_lambda;
init_number s2_Rdev_lambda;
init_number n_s1_bay_Nyr1;
init_number n_s1_coast_Nyr1;
init_number n_s2_Nyr1;
init_number s1_bay_logavgR_low;init_number s1_bay_logavgR_up;init_number s1_bay_logavgR_start;init_int s1_bay_R_phase;
init_number s1_bay_Rdevs_low; init_number s1_bay_Rdevs_up;init_int s1_bay_devR_phase;
init_number s1_bay_logNyr1_low;init_number s1_bay_logNyr1_up;init_number s1_bay_logNyr1_start;init_int s1_bay_logNyr1_phase;
init_number s1_coast_logNyr1_low;init_number s1_coast_logNyr1_up;init_number s1_coast_logNyr1_start; init_int s1_coast_logNyr1_phase;
init_number s1_bay_logF_low;init_number s1_bay_logF_up;init_number s1_bay_logF_start; init_int s1_bay_logF_phase;
init_number s1_bay_catch_gompertz_a_low;init_number s1_bay_catch_gompertz_a_up;init_number s1_bay_catch_gompertz_a_start;
init_number s1_bay_catch_gompertz_b_low;init_number s1_bay_catch_gompertz_b_up;init_number s1_bay_catch_gompertz_b_start;
init_number s1_bay_catch_logistic_a_low;init_number s1_bay_catch_logistic_a_up;init_number s1_bay_catch_logistic_a_start;
init_number s1_bay_catch_logistic_b_low;init_number s1_bay_catch_logistic_b_up;init_number s1_bay_catch_logistic_b_start;
init_number s1_bay_catch_thompson_a_low;init_number s1_bay_catch_thompson_a_up;init_number s1_bay_catch_thompson_a_start;
init_number s1_bay_catch_thompson_b_low;init_number s1_bay_catch_thompson_b_up;init_number s1_bay_catch_thompson_b_start;
init_number s1_bay_catch_thompson_c_low;init_number s1_bay_catch_thompson_c_up;init_number s1_bay_catch_thompson_c_start;
init_number s1_bay_log_q_agg_low;init_number s1_bay_log_q_agg_up;init_number s1_bay_log_q_agg_start;
init_number s1_bay_log_q_ac_low;init_number s1_bay_log_q_ac_up;init_number s1_bay_log_q_ac_start;
init_number s1_bay_ac_gompertz_a_low;init_number s1_bay_ac_gompertz_a_up;init_number s1_bay_ac_gompertz_a_start;
init_number s1_bay_ac_gompertz_b_low;init_number s1_bay_ac_gompertz_b_up;init_number s1_bay_ac_gompertz_b_start;
init_number s1_bay_ac_logistic_a_low;init_number s1_bay_ac_logistic_a_up;init_number s1_bay_ac_logistic_a_start;
init_number s1_bay_ac_logistic_b_low;init_number s1_bay_ac_logistic_b_up;init_number s1_bay_ac_logistic_b_start;
init_number s1_bay_ac_thompson_a_low;init_number s1_bay_ac_thompson_a_up;init_number s1_bay_ac_thompson_a_start;
init_number s1_bay_ac_thompson_b_low;init_number s1_bay_ac_thompson_b_up;init_number s1_bay_ac_thompson_b_start;
init_number s1_bay_ac_thompson_c_low;init_number s1_bay_ac_thompson_c_up;init_number s1_bay_ac_thompson_c_start;
init_number s1_bay_ac_gamma_a_low;init_number s1_bay_ac_gamma_a_up;init_number s1_bay_ac_gamma_a_start;
init_number s1_bay_ac_gamma_b_low;init_number s1_bay_ac_gamma_b_up;init_number s1_bay_ac_gamma_b_start;
init_number s2_logavgR_low;init_number s2_logavgR_up;init_number s2_logavgR_start;init_int s2_R_phase;
init_number s2_Rdevs_low; init_number s2_Rdevs_up;init_int s2_devR_phase;
init_number s2_logNyr1_low;init_number s2_logNyr1_up;init_number s2_logNyr1_start;init_int s2_logNyr1_phase;
init_number s2_log_q_agg_low;init_number s2_log_q_agg_up;init_number s2_log_q_agg_start;
init_number s2_log_q_ac_low;init_number s2_log_q_ac_up;init_number s2_log_q_ac_start;
init_number s2_ac_gompertz_a_low;init_number s2_ac_gompertz_a_up;init_number s2_ac_gompertz_a_start;
init_number s2_ac_gompertz_b_low;init_number s2_ac_gompertz_b_up;init_number s2_ac_gompertz_b_start;
init_number s2_ac_logistic_a_low;init_number s2_ac_logistic_a_up;init_number s2_ac_logistic_a_start;
init_number s2_ac_logistic_b_low;init_number s2_ac_logistic_b_up;init_number s2_ac_logistic_b_start;
init_number s2_ac_thompson_a_low;init_number s2_ac_thompson_a_up;init_number s2_ac_thompson_a_start;
init_number s2_ac_thompson_b_low;init_number s2_ac_thompson_b_up;init_number s2_ac_thompson_b_start;
init_number s2_ac_thompson_c_low;init_number s2_ac_thompson_c_up;init_number s2_ac_thompson_c_start;
init_number s2_ac_gamma_a_low;init_number s2_ac_gamma_a_up;init_number s2_ac_gamma_a_start;
init_number s2_ac_gamma_b_low;init_number s2_ac_gamma_b_up;init_number s2_ac_gamma_b_start;
init_number coast_logF_low;init_number coast_logF_up;init_number coast_logF_start; init_int coast_logF_phase;
init_number coast_catch_gompertz_a_low;init_number coast_catch_gompertz_a_up;init_number coast_catch_gompertz_a_start;
init_number coast_catch_gompertz_b_low;init_number coast_catch_gompertz_b_up;init_number coast_catch_gompertz_b_start;
init_number coast_catch_logistic_a_low;init_number coast_catch_logistic_a_up;init_number coast_catch_logistic_a_start;
init_number coast_catch_logistic_b_low;init_number coast_catch_logistic_b_up;init_number coast_catch_logistic_b_start;
init_number coast_catch_thompson_a_low;init_number coast_catch_thompson_a_up;init_number coast_catch_thompson_a_start;
init_number coast_catch_thompson_b_low;init_number coast_catch_thompson_b_up;init_number coast_catch_thompson_b_start;
init_number coast_catch_thompson_c_low;init_number coast_catch_thompson_c_up;init_number coast_catch_thompson_c_start;
init_number coast_plusgroup_low;init_number coast_plusgroup_up;init_number coast_plusgroup_start;
init_number coast_log_q_agg_low;init_number coast_log_q_agg_up;init_number coast_log_q_agg_start;
init_number coast_log_q_ac_low;init_number coast_log_q_ac_up;init_number coast_log_q_ac_start;
init_number coast_ac_gompertz_a_low;init_number coast_ac_gompertz_a_up;init_number coast_ac_gompertz_a_start;
init_number coast_ac_gompertz_b_low;init_number coast_ac_gompertz_b_up;init_number coast_ac_gompertz_b_start;
init_number coast_ac_logistic_a_low;init_number coast_ac_logistic_a_up;init_number coast_ac_logistic_a_start;
init_number coast_ac_logistic_b_low;init_number coast_ac_logistic_b_up;init_number coast_ac_logistic_b_start;
init_number coast_ac_thompson_a_low;init_number coast_ac_thompson_a_up;init_number coast_ac_thompson_a_start;
```

```
init_number coast_ac_thompson_b_low;init_number coast_ac_thompson_b_up;init_number coast_ac_thompson_b_start;
init_number coast_ac_thompson_c_low;init_number coast_ac_thompson_c_up;init_number coast_ac_thompson_c_start;
init_number coast_ac_gamma_a_low;init_number coast_ac_gamma_a_up;init_number coast_ac_gamma_a_start;
init_number coast_ac_gamma_b_low;init_number coast_ac_gamma_b_up;init_number coast_ac_gamma_b_start;
init_int altcoast_Nyr1;
init_int pickRmethod;// 3 choices 0=avg and devs for each; 1=use s1avgr and s1Rfrac for stock 2; 2=use absoulte estimates of recruit
abundance
init_number s1Rfrac;
init_int estmig;
init_matrix absrecruit(styr,endyr,1,2); // Absoulte estimates of recruitment CB, DE& HR combined
init_vector s2_fem_sex(1,nages);
int a;
int y;
int p;
int t;
int cnt;
int cnt1;
int cnt2;
int cnt3;
int cnt4;
int realage;
int regperiod;
int wvgroup;
int wvtime;
int ndiffbaycoast;
int used_cnt;
int n_parms;
//Determine number of two and three parm curves for each period
//stock 1
number s1_bay_sel_ngompertz;
number s1_bay_sel_nlogistic;
number s1_bay_sel_nthompson;
number s1_bay_sel_gompertz_fit;
number s1_bay_sel_logistic_fit;
number s1_bay_sel_thompson_fit;
number s1_bay_ac_sel_ngompertz;
number s1_bay_ac_sel_nlogistic;
number s1_bay_ac_sel_nthompson;
number s1_bay_ac_sel_nuser;
number s1_bay_ac_sel_ngamma;
number s1_bay_ac_sel_gompertz_fit;
number s1_bay_ac_sel_logistic_fit;
number s1_bay_ac_sel_thompson_fit;
number s1_bay_ac_sel_gamma_fit;
number s1_bay_ac_sel_user_fit;
number s1_bay_nagg_used;
number s1_bay_nac_used;
int s1_bay_wv3_count;
 //Stock 2
number s2_nagg_used;
number s2_nac_used;
number s2_ac_sel_ngompertz;
number s2_ac_sel_nlogistic;
number s2_ac_sel_nthompson;
number s2_ac_sel_ngamma;
number s2_ac_sel_gompertz_fit;
number s2_ac_sel_logistic_fit;
number s2_ac_sel_thompson_fit;
number s2_ac_sel_gamma_fit;
//Coast
number coast_sel_ngompertz;
number coast_sel_nlogistic;
number coast_sel_nthompson;
number coast_sel_gompertz_fit;
number coast_sel_logistic_fit;
number coast_sel_thompson_fit;
```

```
number coast_ac_sel_ngompertz;
number coast_ac_sel_nlogistic;
number coast_ac_sel_nthompson;
number coast_ac_sel_ngamma;
number coast_ac_sel_gompertz_fit;
number coast_ac_sel_logistic_fit;
number coast_ac_sel_thompson_fit;
number coast_ac_sel_gamma_fit;
number s1_est_emig_prob_fit;
number coast_nagg_used;
number coast_nac_used;
number coast_cnt_gompertz;
number coast_cnt_logistic;
number coast_cnt_thompson;
number bay_cnt_gompertz;
number bay_cnt_logistic;
number bay_cnt_thompson;
number logs1Rfrac;
int coast_wv3_count;
int df;
int nyr1cnt;
LOCAL_CALCS
 dirnew=dirfirst;
 find_and_replace(dirnew, "*", " ");
 logs1Rfrac=log((1.-s1Rfrac)/s1Rfrac);
 df=0;
 //s1 avg R & Devs
 df+=1+(endyr-styr+1);
 //Number of Yr1 in Bay ages
 df+=n_s1_bay_Nyr1;
 //If estimates how many ages in coast
 if(altcoast_Nyr1>0) df+=n_s1_coast_Nyr1;
 //Fs by wave
 df+=substructure*(endyr-styr+1);
  //S1_bay Catch selectivity
 s1_bay_sel_ngompertz=0;
 s1_bay_sel_nlogistic=0;
 s1_bay_sel_nthompson=0;
 s1_bay_wv3_count=0;
 s1_bay_sel_gompertz_fit=s1_bay_sel_phase;
 s1_bay_sel_logistic_fit=s1_bay_sel_phase;
 s1_bay_sel_thompson_fit=s1_bay_sel_phase;
 for(regperiod=1;regperiod<=s1_bay_reg_nperiods;regperiod++){
  if(s1_bay_select_years_type(regperiod,1)==3) s1_bay_wv3_count+=1;
  if(s1_bay_select_years_type(regperiod,4)==1) s1_bay_sel_ngompertz+=1;
  if(s1_bay_select_years_type(regperiod,4)==2) s1_bay_sel_nlogistic+=1;
  if(s1_bay_select_years_type(regperiod,4)==3) s1_bay_sel_nthompson+=1;
  }
  if(s1_bay_sel_ngompertz==0) s1_bay_sel_gompertz_fit=-1;
  if(s1_bay_sel_nlogistic==0) s1_bay_sel_logistic_fit=-1;
  if(s1_bay_sel_nthompson==0) s1_bay_sel_thompson_fit=-1;
 //Number fo catch selctivty parm
  df+=s1_bay_sel_ngompertz*2;
  df+=s1_bay_sel_nlogistic*2;
  df+=(s1_bay_sel_nthompson*3);
 //s1_agg
  s1_bay_nagg_used=0;
  for(t=1;t<=s1_bay_nagg;t++){
     if(s1_bay_use_agg(t)>0) s1_bay_nagg_used+=1;
  }
  if(s1_bay_nagg_used==0) s1_bay_agg_phase=-1;
  //Add qs for agg
  df+=s1_bay_nagg_used;
  s1_bay_nac_used=0;
  for(t=1;t<=s1_bay_nac;t++){
     if(s1_bay_use_ac(t)>0) s1_bay_nac_used+=1;
```

```
  }
   if(s1_bay_nac_used==0) s1_bay_ac_phase=-1;
   df+=s1_bay_nac_used;
//s1_bay Age Comp survey selcticivities
s1_bay_ac_sel_ngompertz=0;
s1_bay_ac_sel_nlogistic=0;
s1_bay_ac_sel_nthompson=0;
s1_bay_ac_sel_ngamma=0;
s1_bay_ac_sel_nuser=0;
s1_bay_ac_sel_gompertz_fit=s1_bay_ac_sel_phase;
s1_bay_ac_sel_logistic_fit=s1_bay_ac_sel_phase;
s1_bay_ac_sel_thompson_fit=s1_bay_ac_sel_phase;
s1_bay_ac_sel_gamma_fit=s1_bay_ac_sel_phase;
s1_bay_ac_sel_user_fit=s1_bay_ac_sel_phase;
for(t=1;t<=s1_bay_nac;t++){
 if(s1_bay_ac_sel_type(t)==0 && s1_bay_use_ac(t)>0) s1_bay_ac_sel_nuser+=1;
 if(s1_bay_ac_sel_type(t)==1 && s1_bay_use_ac(t)>0) s1_bay_ac_sel_ngompertz+=1;
 if(s1_bay_ac_sel_type(t)==2 && s1_bay_use_ac(t)>0) s1_bay_ac_sel_nlogistic+=1;
 if(s1_bay_ac_sel_type(t)==3 && s1_bay_use_ac(t)>0) s1_bay_ac_sel_nthompson+=1;
 if(s1_bay_ac_sel_type(t)==4 && s1_bay_use_ac(t)>0) s1_bay_ac_sel_ngamma+=1;
}
//acselct parms
 df+=s1_bay_ac_sel_nuser*2;
 df+=s1_bay_ac_sel_ngompertz*2;
 df+=s1_bay_ac_sel_nlogistic*2;
 df+=s1_bay_ac_sel_nthompson*3;
 df+=s1_bay_ac_sel_ngamma*2;

 if(s1_bay_ac_sel_nuser==0) s1_bay_ac_sel_user_fit=-1;
 if(s1_bay_ac_sel_ngompertz==0) s1_bay_ac_sel_gompertz_fit=-1;
 if(s1_bay_ac_sel_nlogistic==0) s1_bay_ac_sel_logistic_fit=-1;
 if(s1_bay_ac_sel_nthompson==0) s1_bay_ac_sel_thompson_fit=-1;
 if(s1_bay_ac_sel_ngamma==0) s1_bay_ac_sel_gamma_fit=-1;
 //Stock 2
  df+=1+(endyr-styr+1);
  df+=n_s2_Nyr1;
 s2_nagg_used=0;
 for(t=1;t<=s2_nagg;t++){
    if(s2_use_agg(t)>0) s2_nagg_used+=1;
 }
   if(s2_nagg_used==0) s2_agg_phase=-1;
 df+=s2_nagg_used;
s2_nac_used=0;
for(t=1;t<=s2_nac;t++){
    if(s2_use_ac(t)>0) s2_nac_used+=1;
 }
 if(s2_nac_used==0) s2_ac_phase=-1;
  df+=s2_nac_used;
s2_ac_sel_ngompertz=0;
s2_ac_sel_nlogistic=0;
s2_ac_sel_nthompson=0;
s2_ac_sel_ngamma=0;
s2_ac_sel_gompertz_fit=s2_ac_sel_phase;
s2_ac_sel_logistic_fit=s2_ac_sel_phase;
s2_ac_sel_thompson_fit=s2_ac_sel_phase;
s2_ac_sel_gamma_fit=s2_ac_sel_phase;
for(t=1;t<=s2_nac;t++){
 if(s2_ac_sel_type(t)==1 && s2_use_ac(t)>0) s2_ac_sel_ngompertz+=1;
 if(s2_ac_sel_type(t)==2 && s2_use_ac(t)>0) s2_ac_sel_nlogistic+=1;
 if(s2_ac_sel_type(t)==3 && s2_use_ac(t)>0) s2_ac_sel_nthompson+=1;
 if(s2_ac_sel_type(t)==4 && s2_use_ac(t)>0) s2_ac_sel_ngamma+=1.;
}
 df+=s2_ac_sel_ngompertz*2;
 df+=s2_ac_sel_nlogistic*2;
 df+=s2_ac_sel_nthompson*3;
 df+=s2_ac_sel_ngamma*2;
```

```
 if(s2_ac_sel_ngompertz==0) s2_ac_sel_gompertz_fit=-1;
 if(s2_ac_sel_nlogistic==0) s2_ac_sel_logistic_fit=-1;
 if(s2_ac_sel_nthompson==0) s2_ac_sel_thompson_fit=-1;
 if(s2_ac_sel_ngamma==0) s2_ac_sel_gamma_fit=-1;
 //Coast
 df+=ncoastwaves*(endyr-styr+1);//F by wave
 coast_sel_ngompertz=0;
 coast_sel_nlogistic=0;
 coast_sel_nthompson=0;
 coast_sel_gompertz_fit=coast_sel_phase;
 coast_sel_logistic_fit=coast_sel_phase;
 coast_sel_thompson_fit=coast_sel_phase;
 coast_wv3_count=0;
 for(regperiod=1;regperiod<=coast_reg_nperiods;regperiod++){
 if(coast_select_years_type(regperiod,1)==3) coast_wv3_count+=1;
  if(coast_select_years_type(regperiod,4)==1) coast_sel_ngompertz+=1.;
  if(coast_select_years_type(regperiod,4)==2) coast_sel_nlogistic+=1.;
  if(coast_select_years_type(regperiod,4)==3) coast_sel_nthompson+=1.;
 }
 //coast catch selectivity
 df+=coast_sel_ngompertz*2;
 df+=coast_sel_nlogistic*2;
 df+=coast_sel_nthompson*3;
 if(coast_sel_ngompertz==0) coast_sel_gompertz_fit=-1;
 if(coast_sel_nlogistic==0) coast_sel_logistic_fit=-1;
 if(coast_sel_nthompson==0) coast_sel_thompson_fit=-1;
  coast_nagg_used=0;
  for(t=1;t<=coast_nagg;t++){
    if(coast_use_agg(t)>0) coast_nagg_used+=1;
  }
  if(coast_nagg_used==0) coast_agg_phase=-1;
 df+=coast_nagg_used;
coast_nac_used=0;
for(t=1;t<=coast_nac;t++){
    if(coast_use_ac(t)>0) coast_nac_used+=1;
 }
if(coast_nac_used==0) coast_ac_phase=-1;
df+=coast_nac_used;
coast_ac_sel_ngompertz=0;
coast_ac_sel_nlogistic=0;
coast_ac_sel_nthompson=0;
coast_ac_sel_ngamma=0;
coast_ac_sel_gompertz_fit=s1_bay_ac_sel_phase;
coast_ac_sel_logistic_fit=s1_bay_ac_sel_phase;
coast_ac_sel_thompson_fit=s1_bay_ac_sel_phase;
coast_ac_sel_gamma_fit=s1_bay_ac_sel_phase;
for(t=1;t<=coast_nac;t++){
 if(coast_ac_sel_type(t)==1 && coast_use_ac(t)>0) coast_ac_sel_ngompertz+=1;
 if(coast_ac_sel_type(t)==2 && coast_use_ac(t)>0) coast_ac_sel_nlogistic+=1;
 if(coast_ac_sel_type(t)==3 && coast_use_ac(t)>0) coast_ac_sel_nthompson+=1;
 if(coast_ac_sel_type(t)==4 && coast_use_ac(t)>0) coast_ac_sel_ngamma+=1;
}
 df+=coast_ac_sel_ngompertz*2;
 df+=coast_ac_sel_nlogistic*2;
 df+=coast_ac_sel_nthompson*3;
 df+=coast_ac_sel_ngamma*2;
 if(coast_ac_sel_ngompertz==0) coast_ac_sel_gompertz_fit=-1;
 if(coast_ac_sel_nlogistic==0) coast_ac_sel_logistic_fit=-1;
 if(coast_ac_sel_nthompson==0) coast_ac_sel_thompson_fit=-1;
 if(coast_ac_sel_ngamma==0) coast_ac_sel_gamma_fit=-1;
if(altcoast_Nyr1<=0){
 s1_coast_logNyr1_phase=-1;
}
if(pickRmethod==1){
 s2_R_phase=-1;
}
```

```
 if(pickRmethod==2){
  s2_devR_phase=-1;
  s2_R_phase=-1;
  s1_bay_R_phase=-1;
  s1_bay_devR_phase=-1;
 }
 if(estmig>0) df+=1;
 n_parms=df;
 //Number of transformed parameters
 //s1_R
 df+=endyr-styr+1;

 //s2 R
 df+=endyr-styr+1;
 //S1_bay Nyr1
 df+=n_s1_bay_Nyr1;
 //if estimating coast NYR1
 // n_s1_coast_Nyr1
 //s2_Nyr1
 df+=n_s2_Nyr1;
 //s1 bay F
 df+=substructure*(endyr-styr+1);
 //coast F
 df+=ncoastwaves*(endyr-styr+1);
 df+=s1_bay_nac_used;
 df+=s2_nac_used;
 df+=coast_nac_used;
 df+=s1_bay_nagg_used;
 df+=s2_nagg_used;
 df+=coast_nagg_used;
 df+=2*(endyr-styr+1);
 nyr1cnt=df+1;//df+1
 df+=9*nages;
 df+=(endyr-styr+1);//s1_mu_full
 df+=(endyr-styr+1);//s2_mu_full
 df+=(endyr-styr+1);//comb_mu_full
END_CALCS
 !!cout<<df<<endl;
 !!cout<<nyr1cnt<<endl;
 matrix sigma(1,df,1,df+1);
 !! set_covariance_matrix(sigma);
PARAMETER_SECTION
 //Stock1
 init_bounded_number s1_bay_log_avgR(s1_bay_logavgR_low,s1_bay_logavgR_up,s1_bay_R_phase);
 init_bounded_dev_vector s1_bay_log_Rdev(styr,endyr,s1_bay_Rdevs_low,s1_bay_Rdevs_up,s1_bay_devR_phase);
 init_bounded_vector s1_bay_log_N1(1,n_s1_bay_Nyr1,s1_bay_logNyr1_low,s1_bay_logNyr1_up,s1_bay_logNyr1_phase);
 init_bounded_vector s1_coast_log_N1(1,n_s1_coast_Nyr1,s1_coast_logNyr1_low,s1_coast_logNyr1_up,s1_coast_logNyr1_phase);
 init_bounded_matrix s1_bay_log_F(styr,endyr,1,substructure,s1_bay_logF_low,s1_bay_logF_up,s1_bay_logF_phase);//Estimate F for each
period
 init_bounded_vector
s1_bay_select_gompertz_a(1,s1_bay_sel_ngompertz,s1_bay_catch_gompertz_a_low,s1_bay_catch_gompertz_a_up,s1_bay_sel_gompertz_fit);
 init_bounded_vector
s1_bay_select_gompertz_b(1,s1_bay_sel_ngompertz,s1_bay_catch_gompertz_b_low,s1_bay_catch_gompertz_b_up,s1_bay_sel_gompertz_fit)
;
 init_bounded_vector
s1_bay_select_logistic_a(1,s1_bay_sel_nlogistic,s1_bay_catch_logistic_a_low,s1_bay_catch_logistic_a_up,s1_bay_sel_logistic_fit);
 init_bounded_vector
s1_bay_select_logistic_b(1,s1_bay_sel_nlogistic,s1_bay_catch_logistic_b_low,s1_bay_catch_logistic_b_up,s1_bay_sel_logistic_fit);
 init_bounded_vector
s1_bay_select_thompson_a(1,s1_bay_sel_nthompson,s1_bay_catch_thompson_a_low,s1_bay_catch_thompson_a_up,s1_bay_sel_thompson_
fit);
 init_bounded_vector
s1_bay_select_thompson_b(1,s1_bay_sel_nthompson,s1_bay_catch_thompson_b_low,s1_bay_catch_thompson_b_up,s1_bay_sel_thompson_
fit);
```

```
 init_bounded_vector
s1_bay_select_thompson_c(1,s1_bay_sel_nthompson,s1_bay_catch_thompson_c_low,s1_bay_catch_thompson_c_up,s1_bay_sel_thompson_f
it);
 init_bounded_vector s1_bay_log_q_agg(1,s1_bay_nagg_used,s1_bay_log_q_agg_low,s1_bay_log_q_agg_up,s1_bay_agg_phase);
 init_bounded_vector s1_bay_log_q_ac(1,s1_bay_nac_used,s1_bay_log_q_ac_low,s1_bay_log_q_ac_up,s1_bay_ac_phase);
 init_bounded_vector
s1_bay_ac_sel_gompertz_a(1,s1_bay_ac_sel_ngompertz,s1_bay_ac_gompertz_a_low,s1_bay_ac_gompertz_a_up,s1_bay_ac_sel_gompertz_fit
);
 init_bounded_vector
s1_bay_ac_sel_gompertz_b(1,s1_bay_ac_sel_ngompertz,s1_bay_ac_gompertz_b_low,s1_bay_ac_gompertz_b_up,s1_bay_ac_sel_gompertz_fit
);
 init_bounded_vector
s1_bay_ac_sel_logistic_a(1,s1_bay_ac_sel_nlogistic,s1_bay_ac_logistic_a_low,s1_bay_ac_logistic_a_up,s1_bay_ac_sel_logistic_fit);
 init_bounded_vector
s1_bay_ac_sel_logistic_b(1,s1_bay_ac_sel_nlogistic,s1_bay_ac_logistic_b_low,s1_bay_ac_logistic_b_up,s1_bay_ac_sel_logistic_fit);
 init_bounded_vector
s1_bay_ac_sel_thompson_a(1,s1_bay_ac_sel_nthompson,s1_bay_ac_thompson_a_low,s1_bay_ac_thompson_a_up,s1_bay_ac_sel_thompson
_fit);
 init_bounded_vector
s1_bay_ac_sel_thompson_b(1,s1_bay_ac_sel_nthompson,s1_bay_ac_thompson_b_low,s1_bay_ac_thompson_b_up,s1_bay_ac_sel_thompson
_fit);
 init_bounded_vector
s1_bay_ac_sel_thompson_c(1,s1_bay_ac_sel_nthompson,s1_bay_ac_thompson_c_low,s1_bay_ac_thompson_c_up,s1_bay_ac_sel_thompson_
fit);
 init_bounded_vector
s1_bay_ac_sel_gamma_a(1,s1_bay_ac_sel_ngamma,s1_bay_ac_gamma_a_low,s1_bay_ac_gamma_a_up,s1_bay_ac_sel_gamma_fit);
 init_bounded_vector
s1_bay_ac_sel_gamma_b(1,s1_bay_ac_sel_ngamma,s1_bay_ac_gamma_b_low,s1_bay_ac_gamma_b_up,s1_bay_ac_sel_gamma_fit);
 init_bounded_number s1_bay_ac_sel_user_a(0,1,s1_bay_ac_sel_user_fit);
 init_bounded_number s1_bay_ac_sel_user_b(0,1,s1_bay_ac_sel_user_fit);
 init_bounded_number s2_log_avgR(s2_logavgR_low,s2_logavgR_up,s2_R_phase);
 init_bounded_dev_vector s2_log_Rdev(styr,endyr,s2_Rdevs_low,s2_Rdevs_up,s2_devR_phase);
 init_bounded_vector s2_log_N1(1,n_s2_Nyr1,s2_logNyr1_low,s2_logNyr1_up,s2_logNyr1_phase);
 init_bounded_vector s2_log_q_agg(1,s2_nagg_used,s2_log_q_agg_low,s2_log_q_agg_up,s2_agg_phase);
 init_bounded_vector s2_log_q_ac(1,s2_nac_used,s2_log_q_ac_low,s2_log_q_ac_up,s2_ac_phase);
 init_bounded_vector s2_ac_sel_gompertz_a(1,s2_ac_sel_ngompertz,s2_ac_gompertz_a_low,s2_ac_gompertz_a_up,s2_ac_sel_gompertz_fit);
 init_bounded_vector s2_ac_sel_gompertz_b(1,s2_ac_sel_ngompertz,s2_ac_gompertz_b_low,s2_ac_gompertz_b_up,s2_ac_sel_gompertz_fit);
 init_bounded_vector s2_ac_sel_logistic_a(1,s2_ac_sel_nlogistic,s2_ac_logistic_a_low,s2_ac_logistic_a_up,s2_ac_sel_logistic_fit);
 init_bounded_vector s2_ac_sel_logistic_b(1,s2_ac_sel_nlogistic,s2_ac_logistic_b_low,s2_ac_logistic_b_up,s2_ac_sel_logistic_fit);
 init_bounded_vector
s2_ac_sel_thompson_a(1,s2_ac_sel_nthompson,s2_ac_thompson_a_low,s2_ac_thompson_a_up,s2_ac_sel_thompson_fit);
 init_bounded_vector
s2_ac_sel_thompson_b(1,s2_ac_sel_nthompson,s2_ac_thompson_b_low,s2_ac_thompson_b_up,s2_ac_sel_thompson_fit);
 init_bounded_vector
s2_ac_sel_thompson_c(1,s2_ac_sel_nthompson,s2_ac_thompson_c_low,s2_ac_thompson_c_up,s2_ac_sel_thompson_fit);
 init_bounded_vector s2_ac_sel_gamma_a(1,s2_ac_sel_ngamma,s2_ac_gamma_a_low,s2_ac_gamma_a_up,s2_ac_sel_gamma_fit);
 init_bounded_vector s2_ac_sel_gamma_b(1,s2_ac_sel_ngamma,s2_ac_gamma_b_low,s2_ac_gamma_b_up,s2_ac_sel_gamma_fit);
 init_bounded_matrix coast_log_F(styr,endyr,1,ncoastwaves,coast_logF_low,coast_logF_up,coast_logF_phase);
 init_bounded_vector
coast_select_gompertz_a(1,coast_sel_ngompertz,coast_catch_gompertz_a_low,coast_catch_gompertz_a_up,coast_sel_gompertz_fit);
 init_bounded_vector
coast_select_gompertz_b(1,coast_sel_ngompertz,coast_catch_gompertz_b_low,coast_catch_gompertz_b_up,coast_sel_gompertz_fit);
 init_bounded_vector
coast_select_logistic_a(1,coast_sel_nlogistic,coast_catch_logistic_a_low,coast_catch_logistic_a_up,coast_sel_logistic_fit);
 init_bounded_vector
coast_select_logistic_b(1,coast_sel_nlogistic,coast_catch_logistic_b_low,coast_catch_logistic_b_up,coast_sel_logistic_fit);
 init_bounded_vector
coast_select_thompson_a(1,coast_sel_nthompson,coast_catch_thompson_a_low,coast_catch_thompson_a_up,coast_sel_thompson_fit);
 init_bounded_vector
coast_select_thompson_b(1,coast_sel_nthompson,coast_catch_thompson_b_low,coast_catch_thompson_b_up,coast_sel_thompson_fit);
 init_bounded_vector
coast_select_thompson_c(1,coast_sel_nthompson,coast_catch_thompson_c_low,coast_catch_thompson_c_up,coast_sel_thompson_fit);
 init_bounded_vector coast_log_q_agg(1,coast_nagg_used,coast_log_q_agg_low,coast_log_q_agg_up,coast_agg_phase);
 init_bounded_vector coast_log_q_ac(1,coast_nac_used,coast_log_q_ac_low,coast_log_q_ac_up,coast_ac_phase);
 init_bounded_vector
coast_ac_sel_gompertz_a(1,coast_ac_sel_ngompertz,coast_ac_gompertz_a_low,coast_ac_gompertz_a_up,coast_ac_sel_gompertz_fit);
```

```
 init_bounded_vector
coast_ac_sel_gompertz_b(1,coast_ac_sel_ngompertz,coast_ac_gompertz_b_low,coast_ac_gompertz_b_up,coast_ac_sel_gompertz_fit);
 init_bounded_vector
coast_ac_sel_logistic_a(1,coast_ac_sel_nlogistic,coast_ac_logistic_a_low,coast_ac_logistic_a_up,coast_ac_sel_logistic_fit);
 init_bounded_vector
coast_ac_sel_logistic_b(1,coast_ac_sel_nlogistic,coast_ac_logistic_b_low,coast_ac_logistic_b_up,coast_ac_sel_logistic_fit);
 init_bounded_vector
coast_ac_sel_thompson_a(1,coast_ac_sel_nthompson,coast_ac_thompson_a_low,coast_ac_thompson_a_up,coast_ac_sel_thompson_fit);
 init_bounded_vector
coast_ac_sel_thompson_b(1,coast_ac_sel_nthompson,coast_ac_thompson_b_low,coast_ac_thompson_b_up,coast_ac_sel_thompson_fit);
 init_bounded_vector
coast_ac_sel_thompson_c(1,coast_ac_sel_nthompson,coast_ac_thompson_c_low,coast_ac_thompson_c_up,coast_ac_sel_thompson_fit);
 init_bounded_vector
coast_ac_sel_gamma_a(1,coast_ac_sel_ngamma,coast_ac_gamma_a_low,coast_ac_gamma_a_up,coast_ac_sel_gamma_fit);
 init_bounded_vector
coast_ac_sel_gamma_b(1,coast_ac_sel_ngamma,coast_ac_gamma_b_low,coast_ac_gamma_b_up,coast_ac_sel_gamma_fit);
 init_bounded_number s1_emig_a(0,1,estmig);
 //Stock 1
 matrix s1_bay_pred_total_catch(styr,endyr,1,substructure);
 3darray s1_bay_pred_catch_caa(1,substructure,styr,endyr,1,nages);
 3darray s1_bay_pred_catch_paa(1,substructure,styr,endyr,1,nages);
 3darray s1_bay_F(1,substructure,styr,endyr,1,nages);
 3darray s1_bay_Z(1,substructure,styr,endyr,1,nages);
 3darray s1_bay_select_at_age(1,substructure,styr,endyr,1,nages);
 matrix s1_bay_pred_agg_index(styr,endyr,1,s1_bay_nagg_used);
 matrix s1_coast_pred_total_catch(styr,endyr,1,substructure);
 3darray s1_coast_pred_catch_caa(1,substructure,styr,endyr,1,nages);
 matrix s1_bay_pred_migrants_catch_caa(styr,endyr,1,nages);
 3darray s1_coast_pred_catch_paa(1,substructure,styr,endyr,1,nages);
 3darray s1_coast_F(1,substructure,styr,endyr,1,nages);
 3darray s1_coast_Z(1,substructure,styr,endyr,1,nages);
 matrix s1_bay_N(styr,endyr,1,nages);
 matrix s1_bay_Nwv23(styr,endyr,1,nages);
 matrix s1_bay_Nwv46(styr,endyr,1,nages);
 matrix s1_bay_emigrants(styr,endyr,1,nages);
 matrix s1_coast_N(styr,endyr,1,nages);
 matrix s1_coast_Nwv23(styr,endyr,1,nages);
 matrix s1_coast_Nwv46(styr,endyr,1,nages);
 matrix s1_coast_immigrants(styr,endyr,1,nages);
 matrix s1_coast_immigrants_female(styr,endyr,1,nages);
 matrix s1_coast_immigrants_male(styr,endyr,1,nages);
 matrix s1_bay_ac_select_at_age(1,s1_bay_nac_used,1,nages);
 3darray s1_bay_pred_ac_index_paa(1,s1_bay_nac_used,styr,endyr,1,nages);
 matrix s1_bay_pred_ac_index(styr,endyr,1,s1_bay_nac_used);
 matrix s1_ssb(styr,endyr,1,nages);
 number s1_bay_max;
 vector s1_bay_total_catch_RSS(1,substructure);
 number s1_bay_total_catch_wgted_RSS;
 vector s1_bay_catch_paa_like(1,substructure);
 number s1_bay_catch_paa_wgted_like;
 vector s1_bay_agg_index_RSS(1,s1_bay_nagg_used);
 number s1_bay_agg_index_wgted_RSS;
 vector s1_bay_ac_index_RSS(1,s1_bay_nac_used);
 number s1_bay_ac_index_wgted_RSS;
 vector s1_bay_ac_index_paa_like(1,s1_bay_nac_used);
 number s1_bay_ac_index_paa_wgted_like;
 matrix s1_emig_probs(styr,endyr,1,nages);
 //stock 3
 matrix s2_N(styr,endyr,1,nages);
 3darray s2_F(1,substructure,styr,endyr,1,nages);
 3darray s2_Z(1,substructure,styr,endyr,1,nages);
 matrix s2_Nwv23(styr,endyr,1,nages);
 matrix s2_Nwv46(styr,endyr,1,nages);
 matrix s2_ssb(styr,endyr,1,nages);
 matrix s2_pred_agg_index(styr,endyr,1,s2_nagg_used);
 vector s2_agg_index_RSS(1,s2_nagg_used);
```

```
number s2_agg_index_wgted_RSS;
vector s2_ac_index_RSS(1,s2_nac_used);
number s2_ac_index_wgted_RSS;
vector s2_ac_index_paa_like(1,s2_nac_used);
number s2_ac_index_paa_wgted_like;
matrix s2_ac_select_at_age(1,s2_nac_used,1,nages);
3darray s2_pred_ac_index_paa(1,s2_nac_used,styr,endyr,1,nages);
matrix s2_pred_ac_index(styr,endyr,1,s2_nac_used);
3darray s2_pred_catch_caa(1,substructure,styr,endyr,1,nages);
matrix s2_pred_total_catch(styr,endyr,1,substructure);
number s2_max;
//Combined coast
number coast_max;
matrix coast_pred_total_catch(styr,endyr,1,ncoastwaves);
3darray coast_pred_catch_caa(1,ncoastwaves,styr,endyr,1,nages);
3darray coast_pred_catch_paa(1,ncoastwaves,styr,endyr,1,nages);
3darray coast_select_at_age(1,ncoastwaves,styr,endyr,1,nages);
3darray coast_F(1,substructure,styr,endyr,1,nages);
3darray coast_Z(1,substructure,styr,endyr,1,nages);
matrix coast_pred_agg_index(styr,endyr,1,coast_nagg_used);
matrix coast_pred_ac_index(styr,endyr,1,coast_nac_used);
3darray coast_pred_ac_index_paa(1,coast_nac_used,styr,endyr,1,nages);
matrix coast_ac_select_at_age(1,coast_nac_used,1,nages);
vector coast_total_catch_RSS(1,ncoastwaves);
number coast_total_catch_wgted_RSS;
vector coast_catch_paa_like(1,ncoastwaves);
number coast_catch_paa_wgted_like;
vector coast_agg_index_RSS(1,coast_nagg_used);
number coast_agg_index_wgted_RSS;
vector coast_ac_index_RSS(1,coast_nac_used);
number coast_ac_index_wgted_RSS;
vector coast_ac_index_paa_like(1,coast_nac_used);
number coast_ac_index_paa_wgted_like;
number stock_comp_like;
number stock_comp_wgted_like;
matrix stock_comp_predicted(styr,endyr,1,3);
//Residuals
matrix s1_bay_total_catch_resid(styr,endyr,1,substructure);
matrix coast_total_catch_resid(styr,endyr,1,ncoastwaves);
matrix s1_bay_total_catch_std_resid(styr,endyr,1,substructure);
matrix coast_total_catch_std_resid(styr,endyr,1,ncoastwaves);
vector s1_bay_total_catch_RMSE(1,substructure);
vector coast_total_catch_RMSE(1,ncoastwaves);
3darray s1_bay_std_resid_catch_paa(1,substructure,styr,endyr,1,nages);
3darray coast_std_resid_catch_paa(1,ncoastwaves,styr,endyr,1,nages);
3darray s1_bay_std_resid_index_paa(1,s1_bay_nac_used,styr,endyr,1,nages);
3darray s2_std_resid_index_paa(1,s2_nac_used,styr,endyr,1,nages);
3darray coast_std_resid_index_paa(1,coast_nac_used,styr,endyr,1,nages);
matrix s1_bay_resid_agg(styr,endyr,1,s1_bay_nagg_used);
matrix s2_resid_agg(styr,endyr,1,s2_nagg_used);
matrix coast_resid_agg(styr,endyr,1,coast_nagg_used);
matrix s1_bay_std_resid_agg(styr,endyr,1,s1_bay_nagg_used);
matrix s2_std_resid_agg(styr,endyr,1,s2_nagg_used);
matrix coast_std_resid_agg(styr,endyr,1,coast_nagg_used);
vector s1_bay_RMSE_agg(1,s1_bay_nagg_used);
vector s2_RMSE_agg(1,s2_nagg_used);
vector coast_RMSE_agg(1,coast_nagg_used);
matrix stock_comp_std_resid(styr,endyr,1,3);
matrix s1_bay_resid_ac(styr,endyr,1,s1_bay_nac_used);
matrix s2_resid_ac(styr,endyr,1,s2_nac_used);
matrix coast_resid_ac(styr,endyr,1,coast_nac_used);
matrix s1_bay_std_resid_ac(styr,endyr,1,s1_bay_nac_used);
matrix s2_std_resid_ac(styr,endyr,1,s2_nac_used);
matrix coast_std_resid_ac(styr,endyr,1,coast_nac_used);
vector s1_bay_RMSE_ac(1,s1_bay_nac_used);
vector s2_RMSE_ac(1,s2_nac_used);
```

```
vector coast_RMSE_ac(1,coast_nac_used);
number SSB;
number sumcatch;
number sumage;
number sumdo;
number adds;
number diff2;
number pgroup;
number wvfraction;
number fpen;
number recpen;
number concll;
number ntotals;
number s1_recvar;
number s2_recvar;
vector s1_Neff_stage2_mult_catch(1,substructure);
vector coast_Neff_stage2_mult_catch(1,ncoastwaves);
number coast_Neff_stage2_mult_stock_comp;
vector s1_Neff_stage2_mult_index(1,s1_bay_nac_used);
vector s2_Neff_stage2_mult_index(1,s2_nac_used);
vector coast_Neff_stage2_mult_index(1,coast_nac_used);
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;
vector logit(1,nages);
matrix s1_outpt_agg(styr,endyr,1,s1_bay_nagg_used);
matrix s2_outpt_agg(styr,endyr,1,s2_nagg_used);
matrix coast_outpt_agg(styr,endyr,1,coast_nagg_used);
matrix s1_outpt_ac(styr,endyr,1,s1_bay_nac_used);
matrix s2_outpt_ac(styr,endyr,1,s2_nac_used);
matrix coast_outpt_ac(styr,endyr,1,coast_nac_used);
3darray s1_outpt_ac_paa(1,s1_bay_nac_used,styr,endyr,1,nages);
3darray s2_outpt_ac_paa(1,s2_nac_used,styr,endyr,1,nages);
3darray coast_outpt_ac_paa(1,coast_nac_used,styr,endyr,1,nages);
matrix tempmat(styr,endyr,1,nages);
matrix s1_bay_ssb_wgts(styr,endyr,1,nages);
matrix coast_ssb_wgts(styr,endyr,1,nages);
matrix W2(styr,endyr,1,nages);
vector sumssb(1,nages);
matrix s1_mu(styr,endyr,1,nages);
matrix s1_avgM(styr,endyr,1,nages);
vector mu_max_age(styr,endyr);
matrix s2_mu(styr,endyr,1,nages);
matrix comb_mu(styr,endyr,1,nages);
number FF;
number ssq;
sdreport_vector s1_bay_R(styr,endyr);
sdreport_vector s2_R(styr,endyr);
sdreport_vector s1_bay_Nyr1(1,n_s1_bay_Nyr1);
//sdreport_vector s1_coast_Nyr1(1,nages);
sdreport_vector s2_Nyr1(1,n_s2_Nyr1);
sdreport_matrix s1_bay_fullF(styr,endyr,1,substructure);
sdreport_matrix coast_fullF(styr,endyr,1,ncoastwaves);
sdreport_vector s1_bay_q_ac(1,s1_bay_nac_used);
sdreport_vector s2_q_ac(1,s2_nac_used);
sdreport_vector coast_q_ac(1,coast_nac_used);
sdreport_vector s1_bay_q_agg(1,s1_bay_nagg_used);
sdreport_vector s2_q_agg(1,s2_nagg_used);
//sdreport_vector coast_q_agg(1,coast_nagg_used);
```

```
 sdreport_vector s1_femSSB(styr,endyr);
 sdreport_vector s2_femSSB(styr,endyr);
 sdreport_vector s1_bay_proj_N(1,nages);
 sdreport_vector s1_bay_proj_N_female(1,nages);
 sdreport_vector s1_bay_proj_N_male(1,nages);
 sdreport_vector s1_coast_proj_N(1,nages);
 sdreport_vector s1_coast_proj_N_female(1,nages);
 sdreport_vector s1_coast_proj_N_male(1,nages);
 sdreport_vector s2_proj_N(1,nages);
 sdreport_vector s2_proj_N_female(1,nages);
 sdreport_vector s2_proj_N_male(1,nages);
 sdreport_vector s1_mu_full(styr,endyr);
 sdreport_vector s2_mu_full(styr,endyr);
 sdreport_vector comb_mu_full(styr,endyr);
 objective_function_value f;
INITIALIZATION_SECTION
  s1_bay_log_F s1_bay_logF_start;
  coast_log_F coast_logF_start;
RUNTIME_SECTION
 maximum_function_evaluations 100000,100000,100000; //number of evaluation in each phase
 convergence_criteria 1e-5,1e-10,1e-15; //convergence criterion for each phase
PRELIMINARY_CALCS_SECTION
 s1_bay_pred_catch_caa.initialize();
 s1_coast_pred_catch_caa.initialize();
 s1_bay_F.initialize();
 s1_bay_Z.initialize();
 s1_coast_F.initialize();
 s1_coast_Z.initialize();
 s1_bay_N.initialize();
 s1_bay_Nwv23.initialize();
 s1_bay_Nwv46.initialize();
 s1_coast_N.initialize();
 s1_coast_Nwv23.initialize();
 s1_coast_Nwv46.initialize();
 s2_N.initialize();
 s2_Nwv23.initialize();
 s2_Nwv46.initialize();
 //SSB Rivard weights
 //Stock 1
  for(a=2;a<=nages-1;a++){
   for(y=styr+1;y<=endyr;y++){
     W2(y,a)=(log(s1_bay_weight_at_age(y,a))+log(s1_bay_weight_at_age(y-1,a-1)))/2;
    }
   }
 for(y=styr;y<=endyr-1;y++){
     W2(y,1)=2*log(s1_bay_weight_at_age(y,1))-W2(y+1,2);
    }
 for(a=1;a<=nages-2;a++){
     W2(styr,a)=2*log(s1_bay_weight_at_age(styr,a))-W2(styr+1,a+1);
   }
 W2(styr,nages-1)=(log(s1_bay_weight_at_age(styr,nages-1))+log(s1_bay_weight_at_age(styr,nages-2)))/2;
 W2(endyr,1)=2*log(s1_bay_weight_at_age(endyr,1))-W2(endyr,2);
 for(y=styr;y<=endyr;y++){
     W2(y,nages)=log(s1_bay_weight_at_age(y,nages));
    }
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
   //rwgts(y,a)=exp(W2(y,a));
     s1_bay_ssb_wgts(y,a)=exp((W2(y,a)+log(s1_bay_weight_at_age(y,a)))/2); // Added 4-3-2013
   }
  }
  //Coast
  for(a=2;a<=nages-1;a++){
   for(y=styr+1;y<=endyr;y++){
     W2(y,a)=(log(coast_weight_at_age(y,a))+log(coast_weight_at_age(y-1,a-1)))/2;
    }
```

```
  }
for(y=styr;y<=endyr-1;y++){
    W2(y,1)=2*log(coast_weight_at_age(y,1))-W2(y+1,2);
   }
for(a=1;a<=nages-2;a++){
    W2(styr,a)=2*log(coast_weight_at_age(styr,a))-W2(styr+1,a+1);
  }
W2(styr,nages-1)=(log(coast_weight_at_age(styr,nages-1))+log(coast_weight_at_age(styr,nages-2)))/2;
W2(endyr,1)=2*log(coast_weight_at_age(endyr,1))-W2(endyr,2);
for(y=styr;y<=endyr;y++){
    W2(y,nages)=log(coast_weight_at_age(y,nages));
   }
for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  //rwgts(y,a)=exp(W2(y,a));
    coast_ssb_wgts(y,a)=exp((W2(y,a)+log(coast_weight_at_age(y,a)))/2); // Added 4-3-2013
  }
 }
s1_bay_log_avgR=s1_bay_logavgR_start;
s1_bay_log_N1=s1_bay_logNyr1_start;
s1_bay_select_gompertz_a=s1_bay_catch_gompertz_a_start;
s1_bay_select_gompertz_b=s1_bay_catch_gompertz_b_start;
s1_bay_select_logistic_a=s1_bay_catch_logistic_a_start;
s1_bay_select_logistic_b=s1_bay_catch_logistic_b_start;
s1_bay_select_thompson_a=s1_bay_catch_thompson_a_start;
s1_bay_select_thompson_b=s1_bay_catch_thompson_b_start;
s1_bay_select_thompson_c=s1_bay_catch_thompson_c_start;
s1_bay_ac_sel_gompertz_a=s1_bay_ac_gompertz_a_start;
s1_bay_ac_sel_gompertz_b=s1_bay_ac_gompertz_b_start;
s1_bay_ac_sel_logistic_a=s1_bay_ac_logistic_a_start;
s1_bay_ac_sel_logistic_b=s1_bay_ac_logistic_b_start;
s1_bay_ac_sel_thompson_a=s1_bay_ac_thompson_a_start;
s1_bay_ac_sel_thompson_b=s1_bay_ac_thompson_b_start;
s1_bay_ac_sel_thompson_c=s1_bay_ac_thompson_c_start;
s1_bay_ac_sel_gamma_a=s1_bay_ac_gamma_a_start;
s1_bay_ac_sel_gamma_b=s1_bay_ac_gamma_b_start;
s1_bay_ac_sel_user_a=0.2;
s1_bay_ac_sel_user_b=0.4;
s1_bay_log_q_agg=s1_bay_log_q_agg_start;
s1_bay_log_q_ac=s1_bay_log_q_ac_start;
//s1_coast_log_N1=s1_coast_logNyr1_start;
s2_log_N1=s2_logNyr1_start;
s2_log_avgR=s2_logavgR_start;
s2_log_q_agg=s2_log_q_agg_start;
s2_log_q_ac=s2_log_q_ac_start;
s2_ac_sel_gompertz_a=s2_ac_gompertz_a_start;
s2_ac_sel_gompertz_b=s2_ac_gompertz_b_start;
s2_ac_sel_logistic_a=s2_ac_logistic_a_start;
s2_ac_sel_logistic_b=s2_ac_logistic_b_start;
s2_ac_sel_thompson_a=s2_ac_thompson_a_start;
s2_ac_sel_thompson_b=s2_ac_thompson_b_start;
s2_ac_sel_thompson_c=s2_ac_thompson_c_start;
s2_ac_sel_gamma_a=s2_ac_gamma_a_start;
s2_ac_sel_gamma_b=s2_ac_gamma_b_start;
coast_select_gompertz_a=coast_catch_gompertz_a_start;
coast_select_gompertz_b=coast_catch_gompertz_b_start;
coast_select_logistic_a=coast_catch_logistic_a_start;
coast_select_logistic_b=coast_catch_logistic_b_start;
coast_select_thompson_a=coast_catch_thompson_a_start;
coast_select_thompson_b=coast_catch_thompson_b_start;
coast_select_thompson_c=coast_catch_thompson_c_start;
//coast_plusgroup=coast_plusgroup_start;
coast_log_q_agg=coast_log_q_agg_start;
coast_log_q_ac=coast_log_q_ac_start;
coast_ac_sel_gompertz_a=coast_ac_gompertz_a_start;
coast_ac_sel_gompertz_b=coast_ac_gompertz_b_start;
```

```
coast_ac_sel_logistic_a=coast_ac_logistic_a_start;
coast_ac_sel_logistic_b=coast_ac_logistic_b_start;
coast_ac_sel_thompson_a=coast_ac_thompson_a_start;
coast_ac_sel_thompson_b=coast_ac_thompson_b_start;
coast_ac_sel_thompson_c=coast_ac_thompson_c_start;
coast_ac_sel_gamma_a=coast_ac_gamma_a_start;
coast_ac_sel_gamma_b=coast_ac_gamma_b_start;
if(estmig>0){
s1_emig_a=0.013;
 }

PROCEDURE_SECTION
 moveprobs();
s1_calc_selectivities();
coast_calc_selectivities();
coast_calc_mortalities();
s1_calc_mortalities();
s2_calc_mortalities();
s1_calc_N_C();
s2_calc_N_C();
s1_bay_predict_indices();
s2_predict_indices();
coast_predict_indices();
s1_likelihood();
s2_likelihood();
coast_likelihood();
fit_stock_composition();
mu_at_age();
evaluate_the_objective_function();

FUNCTION print
cout<<"STOCK 1-----------------"<<endl;
cout<<s1_bay_log_avgR<<endl;;
cout<<s1_bay_log_Rdev<<endl;
cout<<"Rdev bounds"<<endl;
cout<<s1_bay_logavgR_low<<" "<<s1_bay_logavgR_up<<" "<<s1_bay_R_phase<<endl;
cout<<s1_bay_log_N1<<endl;
//cout<<s1_coast_log_N1<<endl;
cout<<s1_bay_log_F<<endl;
//Selectivities
cout<<s1_bay_select_gompertz_a<<endl;
cout<<s1_bay_select_gompertz_b<<endl;
cout<<s1_bay_select_logistic_a<<endl;
cout<<s1_bay_select_logistic_b<<endl;
cout<<s1_bay_select_thompson_a<<endl;
cout<<s1_bay_select_thompson_b<<endl;
cout<< s1_bay_select_thompson_c<<endl;
cout<< s1_bay_log_q_agg<<endl;
cout<< s1_bay_log_q_ac<<endl;
cout<< s1_bay_ac_sel_gompertz_a<<endl;
cout<< s1_bay_ac_sel_gompertz_b<<endl;
cout<< s1_bay_ac_sel_logistic_a<<endl;
cout<< s1_bay_ac_sel_logistic_b<<endl;
cout<< s1_bay_ac_sel_thompson_a<<endl;
cout<< s1_bay_ac_sel_thompson_b<<endl;
cout<< s1_bay_ac_sel_thompson_c<<endl;
cout<< s1_bay_ac_sel_gamma_a<<endl;
cout<< s1_bay_ac_sel_gamma_b<<endl;
 //stock3
cout<<"s2-----------------"<<endl;
cout<< s2_log_avgR<<endl;
cout<< s2_log_Rdev<<endl;
cout<< s2_log_N1<<endl;
cout<< s2_log_q_agg<<endl;
cout<< s2_log_q_ac<<endl;
cout<< s2_ac_sel_gompertz_a<<endl;
```

```
 cout<< s2_ac_sel_gompertz_b<<endl;
 cout<< s2_ac_sel_logistic_a<<endl;
 cout<< s2_ac_sel_logistic_b<<endl;
 cout<< s2_ac_sel_thompson_a<<endl;
 cout<< s2_ac_sel_thompson_b<<endl;
 cout<< s2_ac_sel_thompson_c<<endl;
 cout<< s2_ac_sel_gamma_a<<endl;
 cout<< s2_ac_sel_gamma_b<<endl;
 cout<<"COAST-----------------"<<endl;
 cout<< coast_log_F<<endl;
 cout<< coast_select_gompertz_a<<endl;
 cout<< coast_select_gompertz_b<<endl;
 cout<< coast_select_logistic_a<<endl;
 cout<< coast_select_logistic_b<<endl;
 cout<< coast_select_thompson_a<<endl;
 cout<< coast_select_thompson_b<<endl;
 cout<< coast_select_thompson_c<<endl;
 //cout<< coast_plusgroup<<endl;
 cout<< coast_log_q_agg<<endl;
 cout<< coast_log_q_ac<<endl;
 cout<< coast_ac_sel_gompertz_a<<endl;
 cout<< coast_ac_sel_gompertz_b<<endl;
 cout<< coast_ac_sel_logistic_a<<endl;
 cout<< coast_ac_sel_logistic_b<<endl;
 cout<< coast_ac_sel_thompson_a<<endl;
 cout<< coast_ac_sel_thompson_b<<endl;
 cout<< coast_ac_sel_thompson_c<<endl;
 cout<< coast_ac_sel_gamma_a<<endl;
 cout<< coast_ac_sel_gamma_b<<endl;
  cout<<"Likelihood weights"<<endl;
 cout<<s1_bay_total_catch_wgted_RSS<<endl;
 cout<<s1_bay_agg_index_wgted_RSS<<endl;
 cout<<s1_bay_ac_index_wgted_RSS<<endl;
 cout<<s2_agg_index_wgted_RSS<<endl;
 cout<<coast_catch_paa_wgted_like<<endl;
 cout<<coast_agg_index_wgted_RSS<<endl;
 cout<<coast_ac_index_wgted_RSS<<endl;
 cout<<s1_bay_catch_paa_wgted_like<<endl;
 cout<<s1_bay_ac_index_paa_wgted_like<<endl;
  cout<<coast_total_catch_wgted_RSS<<endl;
 cout<<coast_catch_paa_wgted_like<<endl;
 cout<<coast_ac_index_paa_wgted_like<<endl;
 cout<<stock_comp_wgted_like<<endl;
 cout<<coast_total_catch<<endl;
FUNCTION moveprobs
 if(estmig>0){
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
    if(a<10) s1_emig_probs(y,a)=s1_test_emig_probs(y,a);
     if(a>=10) s1_emig_probs(y,a)=s1_emig_a;
     }
    }
  }
 if(estmig<=0) s1_emig_probs=s1_test_emig_probs;

FUNCTION s1_calc_selectivities

 //---------------------------stock 1 bay-------------------
 bay_cnt_gompertz=0.;
 bay_cnt_logistic=0.;
 bay_cnt_thompson=0.;
  //checked 2/26/2018
   for(regperiod=1;regperiod<=s1_bay_reg_nperiods;regperiod++){
       if(s1_bay_select_years_type(regperiod,4)==1) bay_cnt_gompertz+=1;
       if(s1_bay_select_years_type(regperiod,4)==2) bay_cnt_logistic+=1;
       if(s1_bay_select_years_type(regperiod,4)==3) bay_cnt_thompson+=1;
```

```
      for(y=styr;y<=endyr;y++){
       if(y>=s1_bay_select_years_type(regperiod,2) && y<=s1_bay_select_years_type(regperiod,3)){
         if(s1_bay_select_years_type(regperiod,4)==1){//Gompertz
           s1_bay_max=0;
           for(a=1;a<=nages;a++){
            s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)=mfexp(-1.*mfexp(-
1.*s1_bay_select_gompertz_b(bay_cnt_gompertz)*(a-s1_bay_select_gompertz_a(bay_cnt_gompertz))));
            if(s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)<0.)
s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)=0.;
            if(s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)>1.)
s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)=1.;
            if(s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)>s1_bay_max)
s1_bay_max=s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a);
           }

s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y)=s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y)/s1_bay_ma
x;
         }
      if(s1_bay_select_years_type(regperiod,4)==2){//Logistic
          s1_bay_max=0;
          for(a=1;a<=nages;a++){
            s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)=1./(1.+mfexp(-1.*s1_bay_select_logistic_b(bay_cnt_logistic)*(a-
s1_bay_select_logistic_a(bay_cnt_logistic))));
            if(s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)<0.)
s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)=0.;
            if(s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)>1.)
s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)=1.;
            if(s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)>s1_bay_max)
s1_bay_max=s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a);
           }

s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y)=s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y)/s1_bay_ma
x;
        }
      if(s1_bay_select_years_type(regperiod,4)==3){//Thompson
          s1_bay_max=0;
          for(a=1;a<=nages;a++){
            s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)=(1./(1.-s1_bay_select_thompson_c(bay_cnt_thompson)))*pow((1.-
s1_bay_select_thompson_c(bay_cnt_thompson))/
            s1_bay_select_thompson_c(bay_cnt_thompson),s1_bay_select_thompson_c(bay_cnt_thompson))*
            (mfexp(s1_bay_select_thompson_a(bay_cnt_thompson)*s1_bay_select_thompson_c(bay_cnt_thompson)*
            (s1_bay_select_thompson_b(bay_cnt_thompson)-double(a)))/
            (1.+mfexp(s1_bay_select_thompson_a(bay_cnt_thompson)*(s1_bay_select_thompson_b(bay_cnt_thompson)-double(a)))));
            if(s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)<0.)
s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)=0.;
            if(s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)>1.)
s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)=1.;
            if(s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a)>s1_bay_max)
s1_bay_max=s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y,a);
           }

s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y)=s1_bay_select_at_age(s1_bay_select_years_type(regperiod,1),y)/s1_bay_ma
x;
        }
       }
     }//y
    }//regperiod
   if(s1_bay_wv3_count==0){
   s1_bay_select_at_age(2)=s1_bay_select_at_age(1);
   s1_bay_select_at_age(3)=s1_bay_select_at_age(1);
  }

FUNCTION coast_calc_selectivities
 coast_cnt_gompertz=0.;
 coast_cnt_logistic=0.;
 coast_cnt_thompson=0.;
```

```
 //checked 3/2/2018
  for(regperiod=1;regperiod<=coast_reg_nperiods;regperiod++){
       if(coast_select_years_type(regperiod,4)==1) coast_cnt_gompertz+=1;
       if(coast_select_years_type(regperiod,4)==2) coast_cnt_logistic+=1;
       if(coast_select_years_type(regperiod,4)==3) coast_cnt_thompson+=1;
    for(y=styr;y<=endyr;y++){
       if(y>=coast_select_years_type(regperiod,2) && y<=coast_select_years_type(regperiod,3)){
        if(coast_select_years_type(regperiod,4)==1){//Gompertz
          coast_max=0;
          for(a=1;a<=nages;a++){
           coast_select_at_age(coast_select_years_type(regperiod,1),y,a)=mfexp(-1.*mfexp(-
1.*coast_select_gompertz_b(coast_cnt_gompertz)*(a-coast_select_gompertz_a(coast_cnt_gompertz))));
           if(coast_select_at_age(coast_select_years_type(regperiod,1),y,a)<0)
coast_select_at_age(coast_select_years_type(regperiod,1),y,a)=0.;
           if(coast_select_at_age(coast_select_years_type(regperiod,1),y,a)>1)
coast_select_at_age(coast_select_years_type(regperiod,1),y,a)=1.;
           if(coast_select_at_age(coast_select_years_type(regperiod,1),y,a)>coast_max)
coast_max=coast_select_at_age(coast_select_years_type(regperiod,1),y,a);
          }
         coast_select_at_age(coast_select_years_type(regperiod,1),y)=coast_select_at_age(coast_select_years_type(regperiod,1),y)/coast_max;
        }
       if(coast_select_years_type(regperiod,4)==2){//Logistic
          coast_max=0;
          for(a=1;a<=nages;a++){
           coast_select_at_age(coast_select_years_type(regperiod,1),y,a)=1./(1.+mfexp(-1.*coast_select_logistic_b(coast_cnt_logistic)*(a-
coast_select_logistic_a(coast_cnt_logistic))));
           if(coast_select_at_age(coast_select_years_type(regperiod,1),y,a)<0)
coast_select_at_age(coast_select_years_type(regperiod,1),y,a)=0.;
           if(coast_select_at_age(coast_select_years_type(regperiod,1),y,a)>1)
coast_select_at_age(coast_select_years_type(regperiod,1),y,a)=1.;
           if(coast_select_at_age(coast_select_years_type(regperiod,1),y,a)>coast_max)
coast_max=coast_select_at_age(coast_select_years_type(regperiod,1),y,a);
          }
         coast_select_at_age(coast_select_years_type(regperiod,1),y)=coast_select_at_age(coast_select_years_type(regperiod,1),y)/coast_max;
        }
       if(coast_select_years_type(regperiod,4)==3){//Thompson
          coast_max=0;
          for(a=1;a<=nages;a++){
           coast_select_at_age(coast_select_years_type(regperiod,1),y,a)=(1./(1.-coast_select_thompson_c(coast_cnt_thompson)))*pow((1-
coast_select_thompson_c(coast_cnt_thompson))/coast_select_thompson_c(coast_cnt_thompson),coast_select_thompson_c(coast_cnt_thom
pson))*

(mfexp(coast_select_thompson_a(coast_cnt_thompson)*coast_select_thompson_c(coast_cnt_thompson)*(coast_select_thompson_b(coast_c
nt_thompson)-double(a)))/
           (1+mfexp(coast_select_thompson_a(coast_cnt_thompson)*(coast_select_thompson_b(coast_cnt_thompson)-double(a)))));
           if(coast_select_at_age(coast_select_years_type(regperiod,1),y,a)<0)
coast_select_at_age(coast_select_years_type(regperiod,1),y,a)=0.;
           if(coast_select_at_age(coast_select_years_type(regperiod,1),y,a)>1)
coast_select_at_age(coast_select_years_type(regperiod,1),y,a)=1.;
           if(coast_select_at_age(coast_select_years_type(regperiod,1),y,a)>coast_max)
coast_max=coast_select_at_age(coast_select_years_type(regperiod,1),y,a);
          }
         coast_select_at_age(coast_select_years_type(regperiod,1),y)=coast_select_at_age(coast_select_years_type(regperiod,1),y)/coast_max;
        }
       }
      }//y
     }//regperiod
   if(ncoastwaves==3 & coast_wv3_count==0){
    coast_select_at_age(2)=coast_select_at_age(1);
    coast_select_at_age(3)=coast_select_at_age(1);
  }
FUNCTION coast_calc_mortalities

 //checked 2/26/2018
  if(substructure==ncoastwaves){
    for(wvgroup=1;wvgroup<=substructure;wvgroup++){
```

```
      for(y=styr;y<=endyr;y++){
       coast_fullF(y,wvgroup)=mfexp(coast_log_F(y,wvgroup));
       for(a=1;a<=nages;a++){
       coast_F(wvgroup,y,a)=mfexp(coast_log_F(y,wvgroup))*coast_select_at_age(wvgroup,y,a);
       coast_Z(wvgroup,y,a)=coast_F(wvgroup,y,a)+coast_M(y,a)*coast_pM(wvgroup);
       }
      }
     }
   }
  if(substructure>ncoastwaves){
    ndiffbaycoast=0;
    for(wvgroup=1;wvgroup<=substructure;wvgroup++){
      if(ncoastwaves>ndiffbaycoast) ndiffbaycoast+=1;
       for(y=styr;y<=endyr;y++){
        coast_fullF(y,ndiffbaycoast)=mfexp(coast_log_F(y,ndiffbaycoast))*coast_pF(y,wvgroup);
        for(a=1;a<=nages;a++){
          coast_F(wvgroup,y,a)=mfexp(coast_log_F(y,ndiffbaycoast))*coast_pF(y,wvgroup)*coast_select_at_age(ndiffbaycoast,y,a);
          coast_Z(wvgroup,y,a)=coast_F(wvgroup,y,a)+coast_M(y,a)*coast_pM(wvgroup);
        }
       }
    }
   }

FUNCTION s1_calc_mortalities
  //checked 2/26/2018
  for(wvgroup=1;wvgroup<=substructure;wvgroup++){
    for(y=styr;y<=endyr;y++){
      s1_bay_fullF(y,wvgroup)=mfexp(s1_bay_log_F(y,wvgroup));
      for(a=1;a<=nages;a++){
        s1_bay_F(wvgroup,y,a)=mfexp(s1_bay_log_F(y,wvgroup))*s1_bay_select_at_age(wvgroup,y,a);
        s1_bay_Z(wvgroup,y,a)=s1_bay_F(wvgroup,y,a)+s1_bay_M(y,a)*s1_bay_pM(wvgroup);
      }
    }
  }
  s1_coast_F=coast_F;
  s1_coast_Z=coast_Z;

FUNCTION s1_calc_N_C
   for(y=styr;y<=endyr;y++){
     if(pickRmethod<=1){
      s1_bay_N(y,1)=mfexp(s1_bay_log_avgR+s1_bay_log_Rdev(y));
      s1_bay_R(y)=s1_bay_N(y,1);
     }
    if(pickRmethod==2){
     s1_bay_N(y,1)=absrecruit(y,1);
     s1_bay_R(y)=s1_bay_Z(1,y,1);

    }
   }
  //Abundance in first year
 p=2+n_s1_bay_Nyr1-1;
 for(a=2;a<=p;a++) s1_bay_N(styr,a)=mfexp(s1_bay_log_N1(a-1));
   s1_bay_Nyr1=mfexp(s1_bay_log_N1);
  if(p<nages){
  for(a=p+1;a<=nages;a++){
    if(a<nages) s1_bay_N(styr,a)=s1_bay_N(styr,a-1)*mfexp(-s1_bay_M(styr,a-1));
    if(a==nages) s1_bay_N(styr,a)=(s1_bay_N(styr,a-1)*mfexp(-s1_bay_M(styr,a-1)))/(1-mfexp(-s1_bay_M(styr,a)));
   }
 }
 if(altcoast_Nyr1>0){
  p=2+n_s1_coast_Nyr1-1;
  s1_coast_N(styr,1)=0;
  for(a=2;a<=p;a++) s1_coast_N(styr,a)=mfexp(s1_coast_log_N1(a-1));
  if(p<nages){
   for(a=p+1;a<=nages;a++){
    if(a<nages) s1_coast_N(styr,a)=s1_coast_N(styr,a-1)*mfexp(-coast_M(styr,a-1));
```

```
//Plus group
   if(a==nages) s1_coast_N(styr,a)=(s1_coast_N(styr,a-1)*mfexp(-coast_M(styr,a-1)))/(1-mfexp(-coast_M(styr,a)));
  }
 }
}
if(altcoast_Nyr1<=0){
 for(a=2;a<=nages;a++) s1_coast_N(styr,a)=s1_bay_N(styr,a)*s1_test_emig_probs(styr,a);
 }

 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
     //Checked 1/31/2018
     s1_bay_pred_catch_caa(1,y,a)=s1_bay_F(1,y,a)/s1_bay_Z(1,y,a)*(1.-mfexp(-s1_bay_Z(1,y,a)))*s1_bay_N(y,a);
     //checked
     s1_bay_Nwv23(y,a)=mfexp(-s1_bay_Z(1,y,a))*s1_bay_N(y,a);
     //checked
     s1_bay_pred_catch_caa(2,y,a)=s1_bay_F(2,y,a)/s1_bay_Z(2,y,a)*(1.-mfexp(-s1_bay_Z(2,y,a)))*s1_bay_Nwv23(y,a);
     //checked
     s1_bay_Nwv46(y,a)=mfexp(-s1_bay_Z(2,y,a))*s1_bay_Nwv23(y,a)*(1.-s1_emig_probs(y,a));
     //checked
     s1_bay_emigrants(y,a)=mfexp(-s1_bay_Z(2,y,a))*s1_bay_Nwv23(y,a)*s1_emig_probs(y,a);
     //checked
     s1_bay_pred_catch_caa(3,y,a)=s1_bay_F(3,y,a)/s1_bay_Z(3,y,a)*(1.-mfexp(-s1_bay_Z(3,y,a)))*s1_bay_Nwv46(y,a);
    //Coast catch from wv 1
     //checked
     s1_coast_pred_catch_caa(1,y,a)=s1_coast_F(1,y,a)/(s1_coast_F(1,y,a)+coast_M(y,a)*coast_pM(1))*(1.-mfexp(-s1_coast_F(1,y,a)-
coast_M(y,a)*coast_pM(1)))*s1_coast_N(y,a);
    //Numbers for period 2
    //checked
     s1_coast_Nwv23(y,a)=(s1_coast_N(y,a)*coast_prop_female(1,y,a)*(1.-s1_female_mat(y,a))+s1_coast_N(y,a)*(1.-
coast_prop_female(1,y,a))*(1.-s1_male_mat(y,a)))*
        mfexp(-s1_coast_F(1,y,a)-coast_M(y,a)*coast_pM(1));
     //checked
     s1_coast_immigrants(y,a)=(s1_coast_N(y,a)*s1_female_mat(y,a)*coast_prop_female(1,y,a)+s1_coast_N(y,a)*s1_male_mat(y,a)*
       (1.-coast_prop_female(1,y,a)))*mfexp(-s1_coast_F(1,y,a)-coast_M(y,a)*coast_pM(1));
     s1_coast_immigrants_female(y,a)=(s1_coast_N(y,a)*s1_female_mat(y,a)*coast_prop_female(1,y,a))*mfexp(-s1_coast_F(1,y,a)-
coast_M(y,a)*coast_pM(1));
     s1_coast_immigrants_male(y,a)=(s1_coast_N(y,a)*s1_male_mat(y,a)*(1.-coast_prop_female(1,y,a)))*mfexp(-s1_coast_F(1,y,a)-
coast_M(y,a)*coast_pM(1));
     //Coastal catch for period two to all catches
    //checked
     s1_coast_pred_catch_caa(2,y,a)=s1_coast_F(2,y,a)/(s1_coast_F(2,y,a)+coast_M(y,a)*coast_pM(2))*(1.-mfexp(-s1_coast_F(2,y,a)-
coast_M(y,a)*coast_pM(2)))*s1_coast_Nwv23(y,a);
    //Add imigrants catches to bay catches in period 2
    //checked

s1_bay_pred_catch_caa(2,y,a)=s1_bay_pred_catch_caa(2,y,a)+s1_coast_immigrants(y,a)*s1_bay_F(2,y,a)/(s1_bay_F(2,y,a)+coast_M(y,a)*coast
_pM(2))*(1.-mfexp(-s1_bay_F(2,y,a)-coast_M(y,a)*coast_pM(2)));
     s1_bay_pred_migrants_catch_caa(y,a)=s1_coast_immigrants(y,a)*s1_bay_F(2,y,a)/(s1_bay_F(2,y,a)+coast_M(y,a)*coast_pM(2))*(1.-
mfexp(-s1_bay_F(2,y,a)-coast_M(y,a)*coast_pM(2)));
      // wv 46
     //checked
     s1_coast_Nwv46(y,a)=s1_coast_Nwv23(y,a)*mfexp(-s1_coast_F(2,y,a)-coast_M(y,a)*coast_pM(2));
     s1_coast_Nwv46(y,a)=s1_coast_Nwv46(y,a)+s1_coast_immigrants(y,a)*mfexp(-s1_bay_F(2,y,a)-
coast_M(y,a)*coast_pM(2))+s1_bay_emigrants(y,a);
        //checked
     s1_coast_pred_catch_caa(3,y,a)=s1_coast_F(3,y,a)/(s1_coast_F(3,y,a)+coast_M(y,a)*coast_pM(3))*(1.-mfexp(-s1_coast_F(3,y,a)-
coast_M(y,a)*coast_pM(3)))*s1_coast_Nwv46(y,a);
  }//a
  if(y<endyr){
   for(a=2;a<=nages;a++){
    //Checked
    s1_bay_N(y+1,a)=s1_bay_Nwv46(y,a-1)*mfexp(-s1_bay_Z(3,y,a-1));
    s1_coast_N(y+1,a)=s1_coast_Nwv46(y,a-1)*mfexp(-s1_coast_F(3,y,a-1)-coast_M(y,a-1)*coast_pM(3));
   }
   s1_bay_N(y+1,nages)= s1_bay_N(y+1,nages)+s1_bay_Nwv46(y,nages)*mfexp(-s1_bay_Z(3,y,nages));
```

```
  s1_coast_N(y+1,nages)=s1_coast_N(y+1,nages)+s1_coast_Nwv46(y,nages)*mfexp(-s1_coast_F(3,y,nages)-
coast_M(y,nages)*coast_pM(3));    }
 for(a=1;a<=nages;a++){
  //SSB at beginning of wave2
  s1_ssb(y,a)=(s1_bay_N(y,a)*mfexp(-s1_bay_F(1,y,a)-
s1_bay_M(y,a)*s1_bay_pM(1))*s1_bay_prop_female(1,y,a)*s1_female_mat(y,a)*s1_bay_ssb_wgts(y,a)/1000)+
  (s1_coast_N(y,a)*s1_female_mat(y,a)*coast_prop_female(1,y,a)*mfexp(-s1_coast_F(1,y,a)-
coast_M(y,a)*coast_pM(1))*coast_ssb_wgts(y,a)/1000);
 }
}//y loop
//Predicted total catch by wave group
for(wvgroup=1;wvgroup<=substructure;wvgroup++){
 for(y=styr;y<=endyr;y++){
  s1_bay_pred_total_catch(y,wvgroup)=sum(s1_bay_pred_catch_caa(wvgroup,y));
  s1_coast_pred_total_catch(y,wvgroup)=sum(s1_coast_pred_catch_caa(wvgroup,y));
 }
}
 //Calculate s1_bay_total_catch_paa//checked 2/27/2018
 for(t=1;t<=substructure;t++){




  for(y=styr;y<=endyr;y++){
    s1_bay_max=0.;
     for(a=1;a<=nages;a++) s1_bay_max+=s1_bay_pred_catch_caa(t,y,a);
       s1_bay_pred_catch_paa(t,y)=s1_bay_pred_catch_caa(t,y)/s1_bay_max;
   }
  }
 for(t=1;t<=substructure;t++){
  for(y=styr;y<=endyr;y++){
    s1_bay_max=0.;
     for(a=1;a<=nages;a++) s1_bay_max+=s1_coast_pred_catch_caa(t,y,a);
       s1_coast_pred_catch_paa(t,y)=s1_coast_pred_catch_caa(t,y)/s1_bay_max;
   }
  }
 s1_femSSB=rowsum(s1_ssb);
 for(a=1;a<=nages;a++){
  s1_bay_proj_N(a)=s1_bay_Nwv46(endyr,a)*mfexp(-s1_bay_Z(3,endyr,a));
  s1_bay_proj_N_female(a)=s1_bay_Nwv46(endyr,a)*mfexp(-s1_bay_Z(3,endyr,a))*s1_bay_prop_female(3,endyr,a);
  s1_bay_proj_N_male(a)=s1_bay_Nwv46(endyr,a)*mfexp(-s1_bay_Z(3,endyr,a))*(1.-s1_bay_prop_female(3,endyr,a));
  s1_coast_proj_N(a)=s1_coast_Nwv46(endyr,a)*mfexp(-coast_Z(3,endyr,a));
  s1_coast_proj_N_female(a)=s1_coast_Nwv46(endyr,a)*mfexp(-coast_Z(3,endyr,a))*coast_prop_female(3,endyr,a);
  s1_coast_proj_N_male(a)=s1_coast_Nwv46(endyr,a)*mfexp(-coast_Z(3,endyr,a))*(1.-coast_prop_female(3,endyr,a));
 }
FUNCTION s2_calc_mortalities
 //checked 2/26/2018
   s2_F=coast_F;
   s2_Z=coast_Z;

FUNCTION s2_calc_N_C
  for(y=styr;y<=endyr;y++){
   if(pickRmethod==0){
     s2_N(y,1)=mfexp(s2_log_avgR+s2_log_Rdev(y));
     s2_R(y)=s2_N(y,1);
    }
   if(pickRmethod==1){
     s2_N(y,1)=mfexp(s1_bay_log_avgR+logs1Rfrac+s2_log_Rdev(y));
     s2_R(y)=s2_N(y,1);
   }
   if(pickRmethod==2){
     s2_N(y,1)=absrecruit(y,2);
    s2_R(y)=coast_Z(1,y,1);
   }
  }
   p=2+n_s2_Nyr1-1;
   for(a=2;a<=p;a++) s2_N(styr,a)=mfexp(s2_log_N1(a-1));
   s2_Nyr1=mfexp(s2_log_N1);
   if(p<nages){
    for(a=p+1;a<=nages;a++){
```

```
    if(a<nages) s2_N(styr,a)=s2_N(styr,a-1)*mfexp(-coast_M(styr,a-1));
    if(a==nages) s2_N(styr,a)=(s2_N(styr,a-1)*mfexp(-coast_M(styr,a-1)))/(1.-mfexp(-coast_M(styr,a)));
  }
 }
  for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
     //Checked 1/31/2018
     s2_pred_catch_caa(1,y,a)=s2_F(1,y,a)/s2_Z(1,y,a)*(1.-mfexp(-s2_Z(1,y,a)))*s2_N(y,a);
     s2_Nwv23(y,a)=mfexp(-s2_Z(1,y,a))*s2_N(y,a);
     s2_pred_catch_caa(2,y,a)=s2_F(2,y,a)/s2_Z(2,y,a)*(1.-mfexp(-s2_Z(2,y,a)))*s2_Nwv23(y,a);
     s2_Nwv46(y,a)=mfexp(-s2_Z(2,y,a))*s2_Nwv23(y,a);
     s2_pred_catch_caa(3,y,a)=s2_F(3,y,a)/s2_Z(3,y,a)*(1.-mfexp(-s2_Z(3,y,a)))*s2_Nwv46(y,a);
    }//a
   if(y<endyr){
    for(a=2;a<=nages;a++) s2_N(y+1,a)=s2_Nwv46(y,a-1)*mfexp(-s2_Z(3,y,a-1));
    s2_N(y+1,nages)= s2_N(y+1,nages)+s2_Nwv46(y,nages)*mfexp(-s2_Z(3,y,nages));
   }
   for(a=1;a<=nages;a++){
    s2_ssb(y,a)=s2_Nwv23(y,a)*s2_female_mat(y,a)*s2_fem_sex(a)*coast_ssb_wgts(y,a)/1000;
   }
 }//y loop
 for(a=1;a<=nages;a++){
  s2_proj_N(a)=s2_Nwv46(endyr,a)*mfexp(-s2_Z(3,endyr,a));
  s2_proj_N_female(a)=s2_Nwv46(endyr,a)*mfexp(-s2_Z(3,endyr,a))*s2_fem_sex(a);
  s2_proj_N_male(a)=s2_Nwv46(endyr,a)*mfexp(-s2_Z(3,endyr,a))*(1.-s2_fem_sex(a));
 }
//Predicted total catch by wave group
 for(wvgroup=1;wvgroup<=substructure;wvgroup++){
  for(y=styr;y<=endyr;y++) s2_pred_total_catch(y,wvgroup)=sum(s2_pred_catch_caa(wvgroup,y));
 }
  s2_femSSB=rowsum(s2_ssb);

FUNCTION s1_bay_predict_indices
 //---------------------Aggregate Indices Include YOY
 //checked 2/26/2018
  if(s1_bay_nagg_used>0){
  s1_bay_q_agg=mfexp(s1_bay_log_q_agg);
   cnt=0;
  for(t=1;t<=s1_bay_nagg;t++){
   if(s1_bay_use_agg(t)==1){
     cnt+=1;
     adds=0;
     realage=0;
     diff2=0;
     wvtime=0;
     wvfraction=0;
     for(y=styr;y<=endyr;y++){
       if (s1_bay_agg_index(y,t)>=0.){ //Skip missing values (-1)
                realage=(int)floor(s1_bay_agg_ages(t));
                diff2=int(ceil(s1_bay_agg_ages(t)*100)-(floor(s1_bay_agg_ages(t))*100));
         wvtime=int(floor(s1_bay_agg_time(t)*100)/100);
         wvfraction=s1_bay_agg_time(t)-floor(s1_bay_agg_time(t));
                pgroup=0;
                for (a=realage;a<=diff2;a++){
          if(wvtime==1) pgroup+=s1_bay_N(y,a)*mfexp(-1.*wvfraction*s1_bay_Z(wvtime,y,a));
          if(wvtime==2) pgroup+=s1_bay_Nwv23(y,a)*mfexp(-1.*wvfraction*s1_bay_Z(wvtime,y,a))+
            s1_coast_immigrants(y,a)*mfexp(wvfraction*(-s1_bay_F(wvtime,y,a)-coast_M(y,a)*coast_pM(wvtime)));
          if(wvtime==3) pgroup+=s1_bay_Nwv46(y,a)*mfexp(-1.*wvfraction*s1_bay_Z(wvtime,y,a));
          }
                 s1_bay_pred_agg_index(y,cnt)=mfexp(s1_bay_log_q_agg(cnt))*pgroup;
      }//agg_surv_indices>=0
      if (s1_bay_agg_index(y,t)==-1) s1_bay_pred_agg_index(y,cnt)=-1;
    }//y loop
  }
 }//t loop
}
```

```
 if(s1_bay_nac_used>0){
  s1_bay_q_ac=mfexp(s1_bay_log_q_ac);
  cnt=0;cnt1=0;cnt2=0;cnt3=0;used_cnt=0;
  for(t=1;t<=s1_bay_nac;t++){
   if(s1_bay_use_ac(t)==1){
     used_cnt+=1;
     s1_bay_max=0;
    for(a=1;a<=nages;a++){
     if(s1_bay_ac_sel_type(t)==0){
        if(a==1) s1_bay_ac_select_at_age(used_cnt,a)=0.;
        if(a==2) s1_bay_ac_select_at_age(used_cnt,a)=s1_bay_ac_sel_user_a;
        if(a==3) s1_bay_ac_select_at_age(used_cnt,a)=s1_bay_ac_sel_user_b;
        if(a>3) s1_bay_ac_select_at_age(used_cnt,a)=1.0;
         if(s1_bay_ac_select_at_age(used_cnt,a)>=s1_bay_max) s1_bay_max=s1_bay_ac_select_at_age(used_cnt,a);
     }
     if(s1_bay_ac_sel_type(t)==1){
         if(a==1) cnt+=1;
         s1_bay_ac_select_at_age(used_cnt,a)=mfexp(-1.*mfexp(-1.*s1_bay_ac_sel_gompertz_b(cnt)*(double(a)-
s1_bay_ac_sel_gompertz_a(cnt))));
         if(s1_bay_ac_select_at_age(used_cnt,a)>=s1_bay_max) s1_bay_max=s1_bay_ac_select_at_age(used_cnt,a);
      }
      if(s1_bay_ac_sel_type(t)==2){
         if(a==1) cnt1+=1;
         s1_bay_ac_select_at_age(used_cnt,a)=1./(1.+mfexp(-1.*s1_bay_ac_sel_logistic_b(cnt1)*(double(a)-s1_bay_ac_sel_logistic_a(cnt1))));
         if(s1_bay_ac_select_at_age(used_cnt,a)>=s1_bay_max) s1_bay_max=s1_bay_ac_select_at_age(used_cnt,a);
     }
       if(s1_bay_ac_sel_type(t)==4){
         if(a==1) cnt2+=1;
         s1_bay_ac_select_at_age(used_cnt,a)=pow(double(a),s1_bay_ac_sel_gamma_a(cnt2))*mfexp(-
1.*s1_bay_ac_sel_gamma_b(cnt2)*double(a));
         if(s1_bay_ac_select_at_age(used_cnt,a)>s1_bay_max) s1_bay_max=s1_bay_ac_select_at_age(used_cnt,a);
      }
      if(s1_bay_ac_sel_type(t)==3){
         if(a==1) cnt3+=1;
         s1_bay_ac_select_at_age(used_cnt,a)=(1./(1.-s1_bay_ac_sel_thompson_c(cnt3)))*pow((1-s1_bay_ac_sel_thompson_c(cnt3))/

s1_bay_ac_sel_thompson_c(cnt3),s1_bay_ac_sel_thompson_c(cnt3))*(mfexp(s1_bay_ac_sel_thompson_a(cnt3)*s1_bay_ac_sel_thompson_c(c
nt3)*(s1_bay_ac_sel_thompson_b(cnt3)-double(a)))/
              (1+mfexp(s1_bay_ac_sel_thompson_a(cnt3)*(s1_bay_ac_sel_thompson_b(cnt3)-double(a)))));
         if(s1_bay_ac_select_at_age(used_cnt,a)>=s1_bay_max) s1_bay_max=s1_bay_ac_select_at_age(used_cnt,a);
      }
    }//a
    s1_bay_ac_select_at_age(used_cnt)=s1_bay_ac_select_at_age(used_cnt)/s1_bay_max;
   }
  }//t
 //Checked 2/27/2018
 //Calculate age comp surveys predicted age comps
  cnt=0;
  for(t=1;t<=s1_bay_nac;t++){
    if(s1_bay_use_ac(t)==1){
          cnt+=1;
          wvtime=int(floor(s1_bay_ac_time(t)*100)/100);
          wvfraction=s1_bay_ac_time(t)-floor(s1_bay_ac_time(t));
        for(y=styr;y<=endyr;y++){
          for(a=1;a<=nages;a++){
             s1_bay_pred_ac_index_paa(cnt,y,a)=0;
              if(wvtime==1)
s1_bay_pred_ac_index_paa(cnt,y,a)=s1_bay_ac_select_at_age(cnt,a)*mfexp(s1_bay_log_q_ac(cnt))*s1_bay_N(y,a)*mfexp(-
1.*wvfraction*s1_bay_Z(wvtime,y,a));
              if(wvtime==2) s1_bay_pred_ac_index_paa(cnt,y,a)=s1_bay_ac_select_at_age(cnt,a)*mfexp(s1_bay_log_q_ac(cnt))*
              (s1_bay_Nwv23(y,a)*mfexp(-1.*wvfraction*s1_bay_Z(wvtime,y,a))+
              s1_coast_immigrants(y,a)*mfexp(wvfraction*(-s1_bay_F(wvtime,y,a)-coast_M(y,a)*coast_pM(wvtime))));
              if(wvtime==3)
s1_bay_pred_ac_index_paa(cnt,y,a)=s1_bay_ac_select_at_age(cnt,a)*mfexp(s1_bay_log_q_ac(cnt))*s1_bay_Nwv46(y,a)*mfexp(-
1.*wvfraction*s1_bay_Z(wvtime,y,a));
          }//a loop
```

```
        }//y loop
      }
  }//t loop
 used_cnt=0;
  for(t=1;t<=s1_bay_nac;t++){
    if(s1_bay_use_ac(t)==1){
      //sum for index
      used_cnt+=1;
     for(y=styr;y<=endyr;y++){
       s1_bay_pred_ac_index(y,used_cnt)=0;
        for(a=1;a<=nages;a++){
         if(s1_bay_ac_index_paa(t,y,a)>=0) s1_bay_pred_ac_index(y,used_cnt)+=s1_bay_pred_ac_index_paa(used_cnt,y,a);
        }
      }
      for(y=styr;y<=endyr;y++)
s1_bay_pred_ac_index_paa(used_cnt,y)=s1_bay_pred_ac_index_paa(used_cnt,y)/sum(s1_bay_pred_ac_index_paa(used_cnt,y));
    }
  }//if surveys>0
 }//if s1_bay_nac>0

FUNCTION s2_predict_indices
 if(s2_nagg_used>0){
   s2_q_agg=mfexp(s2_log_q_agg);
   cnt=0;
  for(t=1;t<=s2_nagg;t++){
   if(s2_use_agg(t)==1){
     cnt+=1;
     adds=0;
     realage=0;
     diff2=0;
     wvtime=0;
     wvfraction=0;
     for(y=styr;y<=endyr;y++){
       if(s2_agg_index(y,t)>=0.){ //Skip missing values (-1)
                realage=(int)floor(s2_agg_ages(t));
                diff2=int(ceil(s2_agg_ages(t)*100)-(floor(s2_agg_ages(t))*100));
         wvtime=int(floor(s2_agg_time(t)*100)/100);
         wvfraction=s2_agg_time(t)-floor(s2_agg_time(t));
                pgroup=0;
                for(a=realage;a<=diff2;a++){
          if(wvtime==1) pgroup+=s2_N(y,a)*mfexp(-1.*wvfraction*coast_Z(wvtime,y,a));
          if(wvtime==2) pgroup+=s2_Nwv23(y,a)*mfexp(-1.*wvfraction*coast_Z(wvtime,y,a));
          if(wvtime==3) pgroup+=s2_Nwv46(y,a)*mfexp(-1.*wvfraction*coast_Z(wvtime,y,a));
         }
               s2_pred_agg_index(y,cnt)=mfexp(s2_log_q_agg(cnt))*pgroup;
      }//agg_surv_indices>=0
      if(s2_agg_index(y,t)==-1) s2_pred_agg_index(y,cnt)=-1;
    }//y loop
   }
  }//t loop
 }
 //Calculate age comp surveys predicted age comps
  if(s2_nac_used>0){
   s2_q_ac=mfexp(s2_log_q_ac);
   cnt=0;cnt1=0;cnt2=0;cnt3=0;used_cnt=0;
  for(t=1;t<=s2_nac;t++){
  if(s2_use_ac(t)==1){
   used_cnt+=1;
    s2_max=0;
   for(a=1;a<=nages;a++){
    if(s2_ac_sel_type(t)==1){
        if(a==1) cnt+=1;
        s2_ac_select_at_age(used_cnt,a)=mfexp(-1.*mfexp(-1.*s2_ac_sel_gompertz_b(cnt)*(double(a)-s2_ac_sel_gompertz_a(cnt))));
        if(s2_ac_select_at_age(used_cnt,a)>=s2_max) s2_max=s2_ac_select_at_age(used_cnt,a);
    }
     if(s2_ac_sel_type(t)==2){
```

```
        if(a==1) cnt1+=1;
        s2_ac_select_at_age(used_cnt,a)=1./(1.+mfexp(-1.*s2_ac_sel_logistic_b(cnt1)*(double(a)-s2_ac_sel_logistic_a(cnt1))));
        if(s2_ac_select_at_age(used_cnt,a)>=s2_max) s2_max=s2_ac_select_at_age(used_cnt,a);
     }
     if(s2_ac_sel_type(t)==4){
        if(a==1) cnt2+=1;
        s2_ac_select_at_age(used_cnt,a)=pow(double(a),s2_ac_sel_gamma_a(cnt2))*mfexp(-1.*s2_ac_sel_gamma_b(cnt2)*double(a));
       if(s2_ac_select_at_age(used_cnt,a)>s2_max) s2_max=s2_ac_select_at_age(used_cnt,a);
     }
     if(s2_ac_sel_type(t)==3){
        if(a==1) cnt3+=1;
        s2_ac_select_at_age(used_cnt,a)=(1./(1.-s2_ac_sel_thompson_c(cnt3)))*pow((1-s2_ac_sel_thompson_c(cnt3))/

s2_ac_sel_thompson_c(cnt3),s2_ac_sel_thompson_c(cnt3))*(mfexp(s2_ac_sel_thompson_a(cnt3)*s2_ac_sel_thompson_c(cnt3)*(s2_ac_sel_th
ompson_b(cnt3)-double(a)))/
            (1+mfexp(s2_ac_sel_thompson_a(cnt3)*(s2_ac_sel_thompson_b(cnt3)-double(a)))));
        if(s2_ac_select_at_age(used_cnt,a)>=s2_max) s2_max=s2_ac_select_at_age(used_cnt,a);
     }
   }//a
   s2_ac_select_at_age(used_cnt)=s2_ac_select_at_age(used_cnt)/s2_max;
  }
 }//t

  used_cnt=0;
 for(t=1;t<=s2_nac;t++){
   if(s2_use_ac(t)==1){
        used_cnt+=1;
        wvtime=int(floor(s2_ac_time(t)*100)/100);
        wvfraction=s2_ac_time(t)-floor(s2_ac_time(t));
      for(y=styr;y<=endyr;y++){
        for(a=1;a<=nages;a++){
          s2_pred_ac_index_paa(used_cnt,y,a)=0;
          if(wvtime==1)
s2_pred_ac_index_paa(used_cnt,y,a)=s2_ac_select_at_age(used_cnt,a)*mfexp(s2_log_q_ac(used_cnt))*s2_N(y,a)*mfexp(-
1.*wvfraction*s2_Z(wvtime,y,a));
          if(wvtime==2)
s2_pred_ac_index_paa(used_cnt,y,a)=s2_ac_select_at_age(used_cnt,a)*mfexp(s2_log_q_ac(used_cnt))*s2_Nwv23(y,a)*mfexp(-
1.*wvfraction*s2_Z(wvtime,y,a));
          if(wvtime==3)
s2_pred_ac_index_paa(used_cnt,y,a)=s2_ac_select_at_age(used_cnt,a)*mfexp(s2_log_q_ac(used_cnt))*s2_Nwv46(y,a)*mfexp(-
1.*wvfraction*s2_Z(wvtime,y,a));
        }//a loop
       }//y loop
   }
 }//t loop

 used_cnt=0;
 for(t=1;t<=s2_nac;t++){
   if(s2_use_ac(t)==1){
   //sum for index
    used_cnt+=1;
    for(y=styr;y<=endyr;y++){
      s2_pred_ac_index(y,used_cnt)=0;
       for(a=1;a<=nages;a++){
         if(t==1){
            if(s2_ac_index_paa(t,y,a)>=0) s2_pred_ac_index(y,used_cnt)+=s2_pred_ac_index_paa(used_cnt,y,a);
         }
         if(t==2){ //to calculate
           if(s2_ac_index(y,t)>=0) s2_pred_ac_index(y,used_cnt)+=s2_pred_ac_index_paa(used_cnt,y,a);
         }
       }
     }
     //convert to proportions at age
     for(y=styr;y<=endyr;y++)
s2_pred_ac_index_paa(used_cnt,y)=s2_pred_ac_index_paa(used_cnt,y)/sum(s2_pred_ac_index_paa(used_cnt,y));
   }
```

```
  }//if surveys>0
 }//if s2_nac_used>0

FUNCTION coast_predict_indices
 if(coast_nagg_used>0){
  //coast_q_agg=mfexp(coast_log_q_agg);
 //Checked 3/9/2018
  cnt=0;
  for(t=1;t<=coast_nagg;t++){
   if(coast_use_agg(t)==1){
    cnt+=1;
    adds=0;
    realage=0;
    diff2=0;
    wvtime=0;
    wvfraction=0;
    for(y=styr;y<=endyr;y++){
      if(coast_agg_index(y,t)>=0.){ //Skip missing values (-1)
                realage=(int)floor(coast_agg_ages(t));
                diff2=int(ceil(coast_agg_ages(t)*100)-(floor(coast_agg_ages(t))*100));
         wvtime=int(floor(coast_agg_time(t)*100)/100);
         wvfraction=coast_agg_time(t)-floor(coast_agg_time(t));
                pgroup=0;
                for(a=realage;a<=diff2;a++){
          if(wvtime==1) pgroup+=(s1_coast_N(y,a)+s2_N(y,a))*mfexp(-1.*wvfraction*coast_Z(wvtime,y,a));
          if(wvtime==2) pgroup+=(s1_coast_Nwv23(y,a)+s2_Nwv23(y,a))*mfexp(-1.*wvfraction*coast_Z(wvtime,y,a));
          if(wvtime==3) pgroup+=(s1_coast_Nwv46(y,a)+s2_Nwv46(y,a))*mfexp(-1.*wvfraction*coast_Z(wvtime,y,a));
          }
                 coast_pred_agg_index(y,cnt)=mfexp(coast_log_q_agg(cnt))*pgroup;
       }//agg_surv_indices>=0
       if(coast_agg_index(y,t)==-1) coast_pred_agg_index(y,cnt)=-1;
    }//y loop
   }
  }//t loop
 }
 //Checked 3/9/2018
 if(coast_nac_used>0){
   coast_q_ac=mfexp(coast_log_q_ac);
  cnt=0;cnt1=0;cnt2=0;cnt3=0;used_cnt=0;
  for(t=1;t<=coast_nac;t++){
   if(coast_use_ac(t)==1){
   used_cnt+=1;
    coast_max=0;
   for(a=1;a<=nages;a++){
    if(coast_ac_sel_type(t)==1){
       if(a==1) cnt+=1;
       coast_ac_select_at_age(used_cnt,a)=mfexp(-1.*mfexp(-1.*coast_ac_sel_gompertz_b(cnt)*(double(a)-coast_ac_sel_gompertz_a(cnt))));
       if(coast_ac_select_at_age(used_cnt,a)>=coast_max) coast_max=coast_ac_select_at_age(used_cnt,a);
    }
    if(coast_ac_sel_type(t)==2){
       if(a==1) cnt1+=1;
       coast_ac_select_at_age(used_cnt,a)=1./(1.+mfexp(-1.*coast_ac_sel_logistic_b(cnt1)*(double(a)-coast_ac_sel_logistic_a(cnt1))));
       if(coast_ac_select_at_age(used_cnt,a)>=coast_max) coast_max=coast_ac_select_at_age(used_cnt,a);
    }
     if(coast_ac_sel_type(t)==4){
       if(a==1) cnt2+=1;
       coast_ac_select_at_age(used_cnt,a)=pow(double(a),coast_ac_sel_gamma_a(cnt2))*mfexp(-1.*coast_ac_sel_gamma_b(cnt2)*double(a));
      if(coast_ac_select_at_age(used_cnt,a)>coast_max) coast_max=coast_ac_select_at_age(used_cnt,a);
    }
    if(coast_ac_sel_type(t)==3){
       if(a==1) cnt3+=1;
       coast_ac_select_at_age(used_cnt,a)=(1./(1.-coast_ac_sel_thompson_c(cnt3)))*pow((1-coast_ac_sel_thompson_c(cnt3))/

coast_ac_sel_thompson_c(cnt3),coast_ac_sel_thompson_c(cnt3))*(mfexp(coast_ac_sel_thompson_a(cnt3)*coast_ac_sel_thompson_c(cnt3)*(
coast_ac_sel_thompson_b(cnt3)-double(a)))/
           (1+mfexp(coast_ac_sel_thompson_a(cnt3)*(coast_ac_sel_thompson_b(cnt3)-double(a)))));
```

```
        if(coast_ac_select_at_age(used_cnt,a)>=coast_max) coast_max=coast_ac_select_at_age(used_cnt,a);
      }
    }//a
    coast_ac_select_at_age(used_cnt)=coast_ac_select_at_age(used_cnt)/coast_max;
   }
  }//t
 //Checked 2/27/2018
 //Calculate age comp surveys predicted age comps
  cnt=0;
  for(t=1;t<=coast_nac;t++){
    if(coast_use_ac(t)==1){
      cnt+=1;
      wvtime=int(floor(coast_ac_time(t)*100)/100);
      wvfraction=coast_ac_time(t)-floor(coast_ac_time(t));
     for(y=styr;y<=endyr;y++){
      for(a=1;a<=nages;a++){
        coast_pred_ac_index_paa(cnt,y,a)=0;
        if(wvtime==1)
coast_pred_ac_index_paa(cnt,y,a)=coast_ac_select_at_age(cnt,a)*mfexp(coast_log_q_ac(cnt))*(s1_coast_N(y,a)+s2_N(y,a))*mfexp(-
1.*wvfraction*coast_Z(wvtime,y,a));
        if(wvtime==2)
coast_pred_ac_index_paa(cnt,y,a)=coast_ac_select_at_age(cnt,a)*mfexp(coast_log_q_ac(cnt))*(s1_coast_Nwv23(y,a)+s2_Nwv23(y,a))*mfexp(
-1.*wvfraction*coast_Z(wvtime,y,a));
        if(wvtime==3)
coast_pred_ac_index_paa(cnt,y,a)=coast_ac_select_at_age(cnt,a)*mfexp(coast_log_q_ac(cnt))*(s1_coast_Nwv46(y,a)+s2_Nwv46(y,a))*mfexp(
-1.*wvfraction*coast_Z(wvtime,y,a));
      }//a loop
     }//y loop
    }
  }//t loop
  used_cnt=0;
  for(t=1;t<=coast_nac;t++){
    if(coast_use_ac(t)==1){
    used_cnt+=1;
    //sum for index
     for(y=styr;y<=endyr;y++){
       coast_pred_ac_index(y,used_cnt)=0;
        for(a=1;a<=nages;a++){
          if(coast_ac_index_paa(t,y,a)>=0) coast_pred_ac_index(y,used_cnt)+=coast_pred_ac_index_paa(used_cnt,y,a);
        }
      }
     for(y=styr;y<=endyr;y++)
coast_pred_ac_index_paa(used_cnt,y)=coast_pred_ac_index_paa(used_cnt,y)/sum(coast_pred_ac_index_paa(used_cnt,y));
   }
  }//if surveys>0
 }//if coast_nac>0

FUNCTION s1_likelihood
 cnt=0;
 //CALCULATE s1_bay_total_catch_like(nbaywaves)
  //Checked 3/9/2018
    s1_bay_total_catch_wgted_RSS=0;
    for(t=1;t<=substructure;t++){
     s1_bay_total_catch_RSS(t)=0.;
     for(y=styr;y<=endyr;y++){
      if(s1_bay_total_catch(y,t)>=0.){
       s1_bay_total_catch_RSS(t)+=square(log((s1_bay_total_catch(y,t)+0.00001)/
       (s1_bay_pred_total_catch(y,t)+0.00001))/s1_bay_total_catch_CV(y,t));
        cnt+=1;
      }
     }
   }
  for(t=1;t<=substructure;t++) s1_bay_total_catch_wgted_RSS+=s1_bay_total_catch_RSS(t)*s1_bay_total_catch_lambda_wgts(t);
  //Checked 3/9/2018
  s1_bay_catch_paa_wgted_like=0;
  for(t=1;t<=substructure;t++){
```

```
    s1_bay_catch_paa_like(t)=0.;
   for(y=styr;y<=endyr;y++){
     for(a=1;a<=nages;a++){
       if(s1_bay_catch_paa(t,y,a)>=0.){
         s1_bay_catch_paa_like(t)-=s1_bay_catch_paa_ess(y,t)*s1_bay_catch_paa(t,y,a)*log(s1_bay_pred_catch_paa(t,y,a)+1e-7);
       }
     }
   }
  }
 for(t=1;t<=substructure;t++) s1_bay_catch_paa_wgted_like+=s1_bay_catch_paa_like(t)*s1_bay_catch_paa_lambda_wgts(t);
//Calculate aggregate survey //checked calculations 3/09/2018
  s1_bay_agg_index_wgted_RSS=0;
  used_cnt=0;
  if(s1_bay_nagg_used>0){
   for(t=1;t<=s1_bay_nagg;t++){
      if(s1_bay_use_agg(t)==1){
         used_cnt+=1;
         s1_bay_agg_index_RSS(used_cnt)=0;
        for(y=styr;y<=endyr;y++){
                 if(s1_bay_agg_index(y,t)>=0.){
            s1_bay_agg_index_RSS(used_cnt)+=square(log((s1_bay_agg_index(y,t)+0.00001)/(s1_bay_pred_agg_index(y,used_cnt)+0.00001))/
               s1_bay_agg_index_CV(y,t));
                 }
       }
     }
   }
  used_cnt=0;
  for(t=1;t<=s1_bay_nagg;t++){
    if(s1_bay_use_agg(t)==1){
      used_cnt+=1;
      s1_bay_agg_index_wgted_RSS+=s1_bay_agg_index_RSS(used_cnt)*s1_bay_agg_index_lambda_wgts(t);
    }
  }
}
// CALCULATE SURVEY WITH AGE COMPOSITIONS checked computation 3/09/2018
 s1_bay_ac_index_wgted_RSS=0;
 used_cnt=0;
 if(s1_bay_nac_used>0){
  for(t=1;t<=s1_bay_nac;t++){
    if(s1_bay_use_ac(t)==1){
      used_cnt+=1;
      s1_bay_ac_index_RSS(used_cnt)=0;
      for(y=styr;y<=endyr;y++){
      if(s1_bay_ac_index(y,t)>=0.){
         s1_bay_ac_index_RSS(used_cnt)+=square(log((s1_bay_ac_index(y,t)+0.00001)/(s1_bay_pred_ac_index(y,used_cnt)+0.00001))/
          s1_bay_ac_index_CV(y,t));
             cnt+=1;
     }
    }
   }
  }
 used_cnt=0;
 for(t=1;t<=s1_bay_nac;t++){
   if(s1_bay_use_ac(t)==1){
    used_cnt+=1;
    s1_bay_ac_index_wgted_RSS+=s1_bay_ac_index_RSS(used_cnt)*s1_bay_ac_index_lambda_wgts(t);
  }
 }
 //checked computation 3/9/2018
 s1_bay_ac_index_paa_wgted_like=0;used_cnt=0;
 for(t=1;t<=s1_bay_nac;t++){
    if(s1_bay_use_ac(t)==1){
       used_cnt+=1;
       s1_bay_ac_index_paa_like(used_cnt)=0;
      for(y=styr;y<=endyr;y++){
       for(a=1;a<=nages;a++){
```

```
      if(s1_bay_ac_index_paa(t,y,a)>=0.){
       s1_bay_ac_index_paa_like(used_cnt)-=s1_bay_ac_index_paa_ess(y,t)*s1_bay_ac_index_paa(t,y,a)*
       log(s1_bay_pred_ac_index_paa(used_cnt,y,a)+1e-7);
      }
     }
    }
   }
  }
  used_cnt=0;
  for(t=1;t<=s1_bay_nac;t++){
     if(s1_bay_use_ac(t)==1){
     used_cnt+=1;
     s1_bay_ac_index_paa_wgted_like+=s1_bay_ac_index_paa_like(used_cnt)*s1_bay_ac_index_paa_lambda_wgts(t);
    }
  }
 }// used

FUNCTION s2_likelihood
 //checked 4/27/2018
  s2_agg_index_wgted_RSS=0;used_cnt=0;
  if(s2_nagg_used>0){
   for(t=1;t<=s2_nagg;t++){
    if(s2_use_agg(t)==1){
     used_cnt+=1;
     s2_agg_index_RSS(used_cnt)=0;
     for(y=styr;y<=endyr;y++){
            if(s2_agg_index(y,t)>=0.){
        s2_agg_index_RSS(used_cnt)+=square(log((s2_agg_index(y,t)+0.00001)/(s2_pred_agg_index(y,used_cnt)+0.00001))/
         s2_agg_index_CV(y,t));
         cnt+=1;
            }
     }
    }
   }
 used_cnt=0;
 for(t=1;t<=s2_nagg;t++){
  if(s2_use_agg(t)==1){
   used_cnt+=1;
   s2_agg_index_wgted_RSS+=s2_agg_index_RSS(used_cnt)*s2_agg_index_lambda_wgts(t);
  }
 }
 }//used
 // CALCULATE SURVEY WITH AGE COMPOSITIONS checked computation 4/27/2018
  s2_ac_index_wgted_RSS=0;used_cnt=0;
  if(s2_nac_used>0){
   for(t=1;t<=s2_nac;t++){
    if(s2_use_ac(t)==1){
     used_cnt+=1;
     s2_ac_index_RSS(used_cnt)=0;
     for(y=styr;y<=endyr;y++){
     if(s2_ac_index(y,t)>=0.){
      s2_ac_index_RSS(used_cnt)+=square(log((s2_ac_index(y,t)+0.00001)/(s2_pred_ac_index(y,used_cnt)+0.00001))/
      s2_ac_index_CV(y,t));
      cnt+=1;
     }
    }
   }
  }
  used_cnt=0;
  for(t=1;t<=s2_nac;t++){
   if(s2_use_ac(t)==1){
   used_cnt+=1;
   s2_ac_index_wgted_RSS+=s2_ac_index_RSS(used_cnt)*s2_ac_index_lambda_wgts(t);
   }
  }
  //checked computation 4/27/2018
```

```
 s2_ac_index_paa_wgted_like=0;used_cnt=0;
 for(t=1;t<=s2_nac;t++){
   if(s2_use_ac(t)==1){
    used_cnt+=1;
     s2_ac_index_paa_like(used_cnt)=0;
     for(y=styr;y<=endyr;y++){
        for(a=1;a<=nages;a++){
          if(s2_ac_index_paa(t,y,a)>=0.){
           s2_ac_index_paa_like(used_cnt)-=s2_ac_index_paa_ess(y,t)*s2_ac_index_paa(t,y,a)*
           log(s2_pred_ac_index_paa(used_cnt,y,a)+1e-7);
          }
         }
      }
    }
 }
 used_cnt=0;
 for(t=1;t<=s2_nac;t++){
  if(s2_use_ac(t)==1){
   used_cnt+=1;
  s2_ac_index_paa_wgted_like+=s2_ac_index_paa_like(used_cnt)*s2_ac_index_paa_lambda_wgts(t);
  }
 }
 }//used

FUNCTION coast_likelihood
  coast_total_catch_wgted_RSS=0;
  coast_catch_paa_wgted_like=0;
  //total catch
  if(ncoastwaves==substructure){ //cehcked 3/9/2018
     for(t=1;t<=substructure;t++){
       coast_total_catch_RSS(t)=0.;
       for(y=styr;y<=endyr;y++){
         if(coast_total_catch(y,t)>=0.){
          coast_total_catch_RSS(t)+=square(log((coast_total_catch(y,t)+0.00001)/
           ((s1_coast_pred_total_catch(y,t)+s2_pred_total_catch(y,t))
           +0.00001))/coast_total_catch_CV(y,t));
          coast_pred_total_catch(y,t)=s1_coast_pred_total_catch(y,t)+s2_pred_total_catch(y,t);
           cnt+=1;
      }
     }
   }
   for(t=1;t<=substructure;t++) coast_total_catch_wgted_RSS+=coast_total_catch_RSS(t)*coast_total_catch_lambda_wgts(t);
 //catch proprtions at age
   for(t=1;t<=substructure;t++){
      for(y=styr;y<=endyr;y++){
        for(a=1;a<=nages;a++) coast_pred_catch_caa(t,y,a)=(s1_coast_pred_catch_caa(t,y,a)+
           s2_pred_catch_caa(t,y,a));
      }
    }
    for(t=1;t<=substructure;t++){
      for(y=styr;y<=endyr;y++){
        coast_max=0;
        for(a=1;a<=nages;a++) coast_max+=coast_pred_catch_caa(t,y,a);//using coast_max as sum
        coast_pred_catch_paa(t,y)=coast_pred_catch_caa(t,y)/coast_max;
     }
   }
  //checked 3/9/2018
   for(t=1;t<=substructure;t++){
        coast_catch_paa_like(t)=0.;
        for(y=styr;y<=endyr;y++){
          for(a=1;a<=nages;a++){
            if(coast_catch_paa(t,y,a)>=0.){
             coast_catch_paa_like(t)-=coast_catch_paa_ess(y,t)*coast_catch_paa(t,y,a)*log(coast_pred_catch_paa(t,y,a)+1e-7);
            }
          }
        }
```

```
  }
  for(t=1;t<=substructure;t++) coast_catch_paa_wgted_like+=coast_catch_paa_like(t)*coast_catch_paa_lambda_wgts(t);
}//ncoastwaves==nbaywaves

if(ncoastwaves<substructure){//1 caa
     //Checked 4/27/2018
      for(y=styr;y<=endyr;y++){
        sumcatch=0.;
        for(t=1;t<=substructure;t++) sumcatch+=s1_coast_pred_total_catch(y,t)+s2_pred_total_catch(y,t);
          coast_pred_total_catch(y,ncoastwaves)=sumcatch;
      }
      coast_total_catch_RSS(ncoastwaves)=0.;
      coast_total_catch_wgted_RSS=0.;
      for(y=styr;y<=endyr;y++){
        if(coast_total_catch(y,ncoastwaves)>=0.){
          coast_total_catch_RSS(ncoastwaves)+=square(log((coast_total_catch(y,ncoastwaves)+0.00001)/
          (coast_pred_total_catch(y,ncoastwaves)+0.00001))/coast_total_catch_CV(y,ncoastwaves));
          cnt+=1;
        }
     }
     coast_total_catch_wgted_RSS+=coast_total_catch_RSS(ncoastwaves)*coast_total_catch_lambda_wgts(ncoastwaves);

  //Catch proportions at age
  //checked 4/27/2018
    for(y=styr;y<=endyr;y++){
      for(a=1;a<=nages;a++){
       sumcatch=0;
       for(t=1;t<=substructure;t++) sumcatch+=s1_coast_pred_catch_caa(t,y,a)+s2_pred_catch_caa(t,y,a);
       coast_pred_catch_caa(ncoastwaves,y,a)=sumcatch;
     }
   }

   for(y=styr;y<=endyr;y++){
     coast_max=0;
     for(a=1;a<=nages;a++) coast_max+=coast_pred_catch_caa(ncoastwaves,y,a);
      coast_pred_catch_paa(ncoastwaves,y)=coast_pred_catch_caa(ncoastwaves,y)/coast_max;
   }
   coast_catch_paa_like(ncoastwaves)=0.;
   coast_catch_paa_wgted_like=0.;
   for(y=styr;y<=endyr;y++){
     for(a=1;a<=nages;a++){
      if(coast_catch_paa(ncoastwaves,y,a)>=0.){
       coast_catch_paa_like(ncoastwaves)-=coast_catch_paa_ess(y,ncoastwaves)*coast_catch_paa(ncoastwaves,y,a)*
           log(coast_pred_catch_paa(ncoastwaves,y,a)+1e-7);
      }
     }
   }
  coast_catch_paa_wgted_like+=coast_catch_paa_like(ncoastwaves)*coast_catch_paa_lambda_wgts(ncoastwaves);
}//if ncoastwaves<nbaywaves
//Calculate aggregate survey checked 4/27/2018
  coast_agg_index_wgted_RSS=0;used_cnt=0;
  if(coast_nagg_used>0){
   for(t=1;t<=coast_nagg;t++){
     if(coast_use_agg(t)==1){
      used_cnt+=1;
      coast_agg_index_RSS(used_cnt)=0;
     for(y=styr;y<=endyr;y++){
                 if(coast_agg_index(y,t)>=0.){
          coast_agg_index_RSS(used_cnt)+=square(log((coast_agg_index(y,t)+0.00001)/(coast_pred_agg_index(y,used_cnt)+0.00001))/
             coast_agg_index_CV(y,t));
                   cnt+=1;
                 }
     }
    }
   }
 used_cnt=0;
```

```
 for(t=1;t<=coast_nagg;t++){
  if(coast_use_agg(t)==1){
    used_cnt+=1;
    coast_agg_index_wgted_RSS+=coast_agg_index_RSS(used_cnt)*coast_agg_index_lambda_wgts(t);
  }
 }
}
 // CALCULATE SURVEY WITH AGE COMPOSITIONS checked computation 4/27/2018
 coast_ac_index_wgted_RSS=0;used_cnt=0;
 if(coast_nac_used>0){
  for(t=1;t<=coast_nac;t++){
   if(coast_use_ac(t)==1){
   used_cnt+=1;
   coast_ac_index_RSS(used_cnt)=0;
   for(y=styr;y<=endyr;y++){
     if(coast_ac_index(y,t)>=0.){
      coast_ac_index_RSS(used_cnt)+=square(log((coast_ac_index(y,t)+0.00001)/(coast_pred_ac_index(y,used_cnt)+0.00001))/
      coast_ac_index_CV(y,t));
      cnt+=1;
     }
    }
   }
  }
  used_cnt=0;
  for(t=1;t<=coast_nac;t++){
   if(coast_use_ac(t)==1){
   used_cnt+=1;
     coast_ac_index_wgted_RSS+=coast_ac_index_RSS(used_cnt)*coast_ac_index_lambda_wgts(t);
  }
 }
 //checked computation 4/27/2018
 coast_ac_index_paa_wgted_like=0;used_cnt=0;
 for(t=1;t<=coast_nac;t++){
      if(coast_use_ac(t)==1){
       used_cnt+=1;
       coast_ac_index_paa_like(used_cnt)=0;
       for(y=styr;y<=endyr;y++){
         for(a=1;a<=nages;a++){
          if(coast_ac_index_paa(t,y,a)>=0.){
           coast_ac_index_paa_like(used_cnt)-=coast_ac_index_paa_ess(y,t)*coast_ac_index_paa(t,y,a)*
           log(coast_pred_ac_index_paa(used_cnt,y,a)+1e-7);
          }
        }
       }
      }
  }
 used_cnt=0;
  for(t=1;t<=coast_nac;t++){
   if(coast_use_ac(t)==1){
     used_cnt+=1;
    coast_ac_index_paa_wgted_like+=coast_ac_index_paa_like(used_cnt)*coast_ac_index_paa_lambda_wgts(t);
   }
  }
 }//used

FUNCTION fit_stock_composition
//checked 3/12/2018
 stock_comp_like=0;
 stock_comp_wgted_like=0;
 stock_comp_predicted=-1;
  for(y=styr;y<=endyr;y++){
   if(stock_comp_time==1){
    for(a=stock_comp_firstage;a<=stock_comp_lastage;a++){
     stock_comp_predicted(y,1)+=s1_coast_pred_catch_caa(1,y,a);
     stock_comp_predicted(y,2)+=s2_pred_catch_caa(1,y,a);
    }
```

```
   }
   if(stock_comp_time==2){
    for(a=stock_comp_firstage;a<=stock_comp_lastage;a++){
      stock_comp_predicted(y,1)+=s1_coast_pred_catch_caa(2,y,a);
      stock_comp_predicted(y,2)+=s2_pred_catch_caa(2,y,a);
    }
   }
   if(stock_comp_time==3){
    for(a=stock_comp_firstage;a<=stock_comp_lastage;a++){
     stock_comp_predicted(y,1)+=s1_coast_pred_catch_caa(3,y,a);
     stock_comp_predicted(y,2)+=s2_pred_catch_caa(3,y,a);
    }
   }
  }
  for(y=styr;y<=endyr;y++){
    adds=0;
    adds=stock_comp_predicted(y,1)+stock_comp_predicted(y,2);
    stock_comp_predicted(y,1)=stock_comp_predicted(y,1)/adds;
    stock_comp_predicted(y,2)=stock_comp_predicted(y,2)/adds;
  }
  for(y=styr;y<=endyr;y++){
       for(p=1;p<=2;p++){
         if(stock_composition(y,p)>=0.){
          stock_comp_like-=stock_comp_ess(y)*stock_composition(y,p)*log(stock_comp_predicted(y,p)+1e-7);
         }
       }
   }
  stock_comp_wgted_like=stock_comp_like*stock_comp_lambda_wgt;
FUNCTION mu_at_age
   s1_mu=0;
  for(t=1;t<=substructure;t++){
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){

s1_mu(y,a)=s1_mu(y,a)+s1_coast_pred_catch_paa(t,y,a)*s1_coast_pred_total_catch(y,t)+s1_bay_pred_catch_paa(t,y,a)*s1_bay_pred_total_c
atch(y,t);
    }
   }
  }
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     s1_mu(y,a)=s1_mu(y,a)/(s1_bay_N(y,a)+s1_coast_N(y,a));
    }
    s1_mu_full(y)=max(s1_mu(y));
  }
  //S2
   s2_mu=0;
  for(t=1;t<=substructure;t++){
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     s2_mu(y,a)=s2_mu(y,a)+s2_pred_catch_caa(t,y,a);
    }
   }
  }
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     s2_mu(y,a)=s2_mu(y,a)/s2_N(y,a);
    }
    s2_mu_full(y)=max(s2_mu(y));
  }
  //Combined
   comb_mu=0;
  for(t=1;t<=substructure;t++){
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     comb_mu(y,a)=comb_mu(y,a)+s2_pred_catch_caa(t,y,a)+s1_bay_pred_catch_caa(t,y,a)+s1_coast_pred_catch_caa(t,y,a);
```

```
    }
   }
  }
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     comb_mu(y,a)=comb_mu(y,a)/(s1_bay_N(y,a)+s1_coast_N(y,a)+s2_N(y,a));
    }
    comb_mu_full(y)=max(comb_mu(y));
  }

FUNCTION evaluate_the_objective_function
 f=0.;
 concll=0.5*cnt*log((s1_bay_total_catch_wgted_RSS+s1_bay_agg_index_wgted_RSS+
 s1_bay_ac_index_wgted_RSS+s2_agg_index_wgted_RSS+s2_ac_index_wgted_RSS+coast_total_catch_wgted_RSS+
 coast_agg_index_wgted_RSS+coast_ac_index_wgted_RSS)/cnt);
 f+=concll;
 f+=s1_bay_catch_paa_wgted_like+s1_bay_ac_index_paa_wgted_like+
     s2_ac_index_paa_wgted_like+coast_catch_paa_wgted_like+coast_ac_index_paa_wgted_like;
  if(use_stockcomp>0) f+=stock_comp_wgted_like;
      s1_recvar=0;s2_recvar=0;recpen=0;
 if(biascor==1){
   s1_recvar=norm2(s1_bay_log_Rdev(styr,endyr)-(sum(s1_bay_log_Rdev(styr,endyr))/(endyr-styr+1)))/(endyr-styr+1-1.0);
    s2_recvar=norm2(s2_log_Rdev(styr,endyr)-(sum(s2_log_Rdev(styr,endyr))/(endyr-styr+1)))/(endyr-styr+1-1.0);
   if(current_phase()==2) f+=norm2(s1_bay_log_Rdev)+norm2(s2_log_Rdev);
    if(current_phase()>2){
       for(y=styr;y<=endyr;y++){
         recpen+=s1_Rdev_lambda*(log(sqrt(s1_recvar))+square(s1_bay_log_Rdev(y))/2*s1_recvar);
         recpen+=s2_Rdev_lambda*(log(sqrt(s2_recvar))+square(s2_log_Rdev(y))/2*s2_recvar);
       }
      f+=recpen;
     }
  }
  if(biascor==0){
    f+=s1_Rdev_lambda*norm2(s1_bay_log_Rdev)+s2_Rdev_lambda*norm2(s2_log_Rdev);
  }
 //CALCULATE PENALTY CONSTRAINT FOR F
  fpen=0;
  if(current_phase()<3){
    fpen=10.*norm2(mfexp(coast_log_F)-0.15);
    fpen+=10.*norm2(mfexp(s1_bay_log_F)-0.15);
   }
   else{
    fpen=0.000000000001*norm2(mfexp(coast_log_F)-0.15);
    fpen+=0.000000000001*norm2(mfexp(s1_bay_log_F)-0.15);
   }
  f+=fpen;
REPORT_SECTION
    report<<"s1_bay_total_catch_wgted_RSS: "<<s1_bay_total_catch_wgted_RSS<<endl;
      report<<"coast_total_catch_wgted_RSS: "<<coast_total_catch_wgted_RSS<<endl;
    report<<"s1_bay_agg_index_catch_wgted_RSS: "<<s1_bay_agg_index_wgted_RSS<<endl;
      report<<"s2_agg_index_catch_wgted_RSS: "<<s2_agg_index_wgted_RSS<<endl;
    report<<"coast_agg_index_catch_wgted_RSS: "<<coast_agg_index_wgted_RSS<<endl;
    report<<"s1_bay_ac_index_catch_wgted_RSS: "<<s1_bay_ac_index_wgted_RSS<<endl;
      report<<"s2_ac_index_catch_wgted_RSS: "<<s2_ac_index_wgted_RSS<<endl;
    report<<"coast_ac_index_catch_wgted_RSS: "<<coast_ac_index_wgted_RSS<<endl;
    report<<"Concentrated_Likelihood: "<<0.5*cnt*log((s1_bay_total_catch_wgted_RSS+s1_bay_agg_index_wgted_RSS+
    s1_bay_ac_index_wgted_RSS+s2_agg_index_wgted_RSS+s2_ac_index_wgted_RSS+coast_total_catch_wgted_RSS+
    coast_agg_index_wgted_RSS+coast_ac_index_wgted_RSS)/cnt)<<endl;
   report<<"s1_bay_catch_paa_wgted_like: "<<s1_bay_catch_paa_wgted_like<<endl;
     report<<"coast_catch_paa_wgted_like: "<<coast_catch_paa_wgted_like<<endl;
   report<<"s1_bay_ac_index_paa_wgted_like: "<<s1_bay_ac_index_paa_wgted_like<<endl;
      report<<"s2_ac_index_paa_wgted_like: "<<s2_ac_index_paa_wgted_like<<endl;
   report<<"coast_ac_index_paa_wgted_like: "<<coast_ac_index_paa_wgted_like<<endl;
    if(use_stockcomp>0)report<<"stock_comp_wgted_like: "<<stock_comp_wgted_like<<endl;
    if(use_stockcomp>0) report<<"PAA_Total_Likelihood: "<<s1_bay_catch_paa_wgted_like+s1_bay_ac_index_paa_wgted_like+
     s2_ac_index_paa_wgted_like+coast_catch_paa_wgted_like+
```

```
     coast_ac_index_paa_wgted_like+stock_comp_wgted_like<<endl;
    if(use_stockcomp==0) report<<"PAA_Total_Likelihood: "<<s1_bay_catch_paa_wgted_like+s1_bay_ac_index_paa_wgted_like+
     s2_ac_index_paa_wgted_like+coast_catch_paa_wgted_like+
     coast_ac_index_paa_wgted_like<<endl;
    report<<"Total_Likelihood: "<<f<<endl;
    report<<"Number_parms: "<<n_parms<<endl;
    report<<"AIC: "<<2*f+2*n_parms<<endl;
FINAL_SECTION
   //Below will go in final section
    std::string u;
   u=dirnew + "\\R.out";
  const char* dir = u.c_str();
   ofstream ofs(dir);
   for(y=styr;y<=endyr;y++){
   ofs<<s1_bay_N(y,1)<<" "<<s2_N(y,1)<<endl;
   }
   ofs.close();

  u=dirnew + "\\s1_bay_N_p.out";
  dir = u.c_str();
  ofs.open(dir);
   for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_N(y,a)<<" ";
    if(a==nages) ofs<<s1_bay_N(y,a)<<endl;
  }
 }
 ofs.close();


 u=dirnew + "\\s2_N_p.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
   if(a<nages) ofs<<s2_N(y,a)<<" ";
   if(a==nages) ofs<<s2_N(y,a)<<endl;
 }
 }
 ofs.close();

  u=dirnew + "\\s1_bay_N_p_female.out";
  dir = u.c_str();
  ofs.open(dir);
   for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_N(y,a)*s1_bay_prop_female(1,y,a)<<" ";
    if(a==nages) ofs<<s1_bay_N(y,a)*s1_bay_prop_female(1,y,a)<<endl;
  }
 }
  ofs.close();
  u=dirnew + "\\s1_bay_N_p_male.out";
  dir = u.c_str();
  ofs.open(dir);
   for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_N(y,a)*(1.-s1_bay_prop_female(1,y,a))<<" ";
    if(a==nages) ofs<<s1_bay_N(y,a)*(1.-s1_bay_prop_female(1,y,a))<<endl;
  }
 }
  ofs.close();
  u=dirnew + "\\s1_bay_Nwv23_p.out";
  dir = u.c_str();
  ofs.open(dir);
   for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
```

```
   if(a<nages) ofs<<s1_bay_Nwv23(y,a)+s1_coast_immigrants(y,a)<<" ";
   if(a==nages) ofs<<s1_bay_Nwv23(y,a)+s1_coast_immigrants(y,a)<<endl;
 }
}
ofs.close();
 u=dirnew + "\\s1_bay_migrants_caa.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(a<nages) ofs<<s1_bay_pred_migrants_catch_caa(y,a)<<" ";
   if(a==nages) ofs<<s1_bay_pred_migrants_catch_caa(y,a)<<endl;
 }
}
ofs.close();
 u=dirnew + "\\s1_bay_Nwv23_p_female.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(a<nages) ofs<<s1_bay_Nwv23(y,a)*s1_bay_prop_female(2,y,a)+s1_coast_immigrants_female(y,a)<<" ";
   if(a==nages) ofs<<s1_bay_Nwv23(y,a)*s1_bay_prop_female(2,y,a)+s1_coast_immigrants_female(y,a)<<endl;
 }
}
 ofs.close();
 u=dirnew + "\\s1_bay_Nwv23_p_male.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(a<nages) ofs<<s1_bay_Nwv23(y,a)*(1.-s1_bay_prop_female(2,y,a))+s1_coast_immigrants_male(y,a)<<" ";
   if(a==nages) ofs<<s1_bay_Nwv23(y,a)*(1.-s1_bay_prop_female(2,y,a))+s1_coast_immigrants_male(y,a)<<endl;
 }
}
 ofs.close();

u=dirnew + "\\s2_N_p_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s2_N(y,a)*s2_fem_sex(a)<<" ";
  if(a==nages) ofs<<s2_N(y,a)*s2_fem_sex(a)<<endl;
}
}
ofs.close();

 u=dirnew + "\\s2_N_p_male.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s2_N(y,a)*(1.-s2_fem_sex(a))<<" ";
  if(a==nages) ofs<<s2_N(y,a)*(1.-s2_fem_sex(a))<<endl;
  }
 }
ofs.close();

 u=dirnew + "\\s1_coast_N_p.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s1_coast_N(y,a)<<" ";
  if(a==nages) ofs<<s1_coast_N(y,a)<<endl;
  }
```

```
 }
 ofs.close();

  u=dirnew + "\\s1_coast_N_p_female.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s1_coast_N(y,a)*coast_prop_female(1,y,a)<<" ";
  if(a==nages) ofs<<s1_coast_N(y,a)*coast_prop_female(1,y,a)<<endl;
  }
 }
 ofs.close();

 ofs.close();
 u=dirnew + "\\s1_coast_N_p_male.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s1_coast_N(y,a)*(1.-coast_prop_female(1,y,a))<<" ";
  if(a==nages) ofs<<s1_coast_N(y,a)*(1.-coast_prop_female(1,y,a))<<endl;
  }
 }
 ofs.close();

 u=dirnew + "\\s1_bay_Nwv46_p_female.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(a<nages) ofs<<s1_bay_Nwv46(y,a)*s1_bay_prop_female(3,y,a)<<" ";
   if(a==nages) ofs<<s1_bay_Nwv46(y,a)*s1_bay_prop_female(3,y,a)<<endl;
 }
}
 ofs.close();
 u=dirnew + "\\s1_bay_Nwv46_p_male.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(a<nages) ofs<<s1_bay_Nwv46(y,a)*(1.-s1_bay_prop_female(3,y,a))<<" ";
   if(a==nages) ofs<<s1_bay_Nwv46(y,a)*(1.-s1_bay_prop_female(3,y,a))<<endl;
 }
}
 ofs.close();


 u=dirnew + "\\s2_Nwv23_p.out";
 dir = u.c_str();
 ofs.open(dir);
 for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s2_Nwv23(y,a)<<" ";
  if(a==nages) ofs<<s2_Nwv23(y,a)<<endl;
}
}
 ofs.close();
 u=dirnew + "\\s2_Nwv23_p_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s2_Nwv23(y,a)*s2_fem_sex(a)<<" ";
  if(a==nages) ofs<<s2_Nwv23(y,a)*s2_fem_sex(a)<<endl;
}
```

```
}
ofs.close();

 u=dirnew + "\\s2_Nwv23_p_male.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s2_Nwv23(y,a)*(1.-s2_fem_sex(a))<<" ";
  if(a==nages) ofs<<s2_Nwv23(y,a)*(1.-s2_fem_sex(a))<<endl;
  }
 }
ofs.close();
 u=dirnew + "\\s1_bay_Nwv46_p.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(a<nages) ofs<<s1_bay_Nwv46(y,a)<<" ";
   if(a==nages) ofs<<s1_bay_Nwv46(y,a)<<endl;
 }
}
ofs.close();

u=dirnew + "\\s2_Nwv46_p.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s2_Nwv46(y,a)<<" ";
  if(a==nages) ofs<<s2_Nwv46(y,a)<<endl;
}
}
ofs.close();

u=dirnew + "\\s2_Nwv46_p_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s2_Nwv46(y,a)*s2_fem_sex(a)<<" ";
  if(a==nages) ofs<<s2_Nwv46(y,a)*s2_fem_sex(a)<<endl;
}
}
ofs.close();

 u=dirnew + "\\s2_Nwv46_p_male.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s2_Nwv46(y,a)*(1.-s2_fem_sex(a))<<" ";
  if(a==nages) ofs<<s2_Nwv46(y,a)*(1.-s2_fem_sex(a))<<endl;
  }
 }
ofs.close();

 u=dirnew + "\\s1_coast_Nwv46_p.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s1_coast_Nwv46(y,a)<<" ";
  if(a==nages) ofs<<s1_coast_Nwv46(y,a)<<endl;
  }
 }
```

```
ofs.close();

u=dirnew + "\\s1_coast_Nwv46_p_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
 for(a=1;a<=nages;a++){
 if(a<nages) ofs<<s1_coast_Nwv46(y,a)*coast_prop_female(3,y,a)<<" ";
 if(a==nages) ofs<<s1_coast_Nwv46(y,a)*coast_prop_female(3,y,a)<<endl;
 }
}
ofs.close();

u=dirnew + "\\s1_coast_Nwv46_p_male.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
 for(a=1;a<=nages;a++){
 if(a<nages) ofs<<s1_coast_Nwv46(y,a)*(1.-coast_prop_female(3,y,a))<<" ";
 if(a==nages) ofs<<s1_coast_Nwv46(y,a)*(1.-coast_prop_female(3,y,a))<<endl;
 }
}
ofs.close();

u=dirnew + "\\s1_coast_Nwv23_p.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
 for(a=1;a<=nages;a++){
 if(a<nages) ofs<<s1_coast_Nwv23(y,a)<<" ";
 if(a==nages) ofs<<s1_coast_Nwv23(y,a)<<endl;
 }
}
ofs.close();

u=dirnew + "\\s1_coast_Nwv23_p_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
 for(a=1;a<=nages;a++){
 if(a<nages) ofs<<s1_coast_Nwv23(y,a)*coast_prop_female(2,y,a)<<" ";
 if(a==nages) ofs<<s1_coast_Nwv23(y,a)*coast_prop_female(2,y,a)<<endl;
 }
}
ofs.close();

u=dirnew + "\\s1_coast_Nwv23_p_male.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
 for(a=1;a<=nages;a++){
 if(a<nages) ofs<<s1_coast_Nwv23(y,a)*(1.-coast_prop_female(2,y,a))<<" ";
 if(a==nages) ofs<<s1_coast_Nwv23(y,a)*(1.-coast_prop_female(2,y,a))<<endl;
 }
}
ofs.close();

 u=dirnew + "\\s1_bay_F.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
 for(p=1;p<=substructure;p++){
  if(p<substructure) ofs<<mfexp(s1_bay_log_F(y,p))<<" ";
  if(p==substructure) ofs<<mfexp(s1_bay_log_F(y,p))<<endl;
 }
}
```

```
ofs.close();

 u=dirnew + "\\coast_F.out";
 dir = u.c_str();
 ofs.open(dir);
 for(y=styr;y<=endyr;y++){
  for(p=1;p<=ncoastwaves;p++){
   if(p<ncoastwaves) ofs<<mfexp(coast_log_F(y,p))<<" ";
   if(p==ncoastwaves) ofs<<mfexp(coast_log_F(y,p))<<endl;
 }
}
ofs.close();
  u=dirnew + "\\s1_femSSB.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s1_ssb(y,a)<<" ";
  if(a==nages) ofs<<s1_ssb(y,a)<<endl;
  }
 }
 ofs.close();

  u=dirnew + "\\s2_femSSB.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
  if(a<nages) ofs<<s2_ssb(y,a)<<" ";
  if(a==nages) ofs<<s2_ssb(y,a)<<endl;
  }
 }
 ofs.close();


//Aggregate indices qs
 if(s1_bay_nagg_used>0){
 u=dirnew + "\\s1_bay_agg_qs.out";
 dir = u.c_str();
 ofs.open(dir);
  used_cnt=0;
 for(y=1;y<=s1_bay_nagg;y++){
 if(s1_bay_use_agg(y)<=0) ofs<<"-99999"<<endl;
 if(s1_bay_use_agg(y)==1){
    used_cnt+=1;
   ofs<<mfexp(s1_bay_log_q_agg(used_cnt))<<endl;
  }
 }
 ofs.close();
 }
 if(s2_nagg_used>0){
  u=dirnew + "\\s2_agg_qs.out";
  dir = u.c_str();
  ofs.open(dir);
  used_cnt=0;
  for(y=1;y<=s2_nagg;y++){
   if(s2_use_agg(y)<=0) ofs<<"-99999"<<endl;
   if(s2_use_agg(y)==1){
    used_cnt+=1;
   ofs<<mfexp(s2_log_q_agg(used_cnt))<<endl;
   }
  }
  ofs.close();
 }

 if(coast_nagg_used>0){
```

```
 u=dirnew + "\\coast_agg_qs.out";
 dir = u.c_str();
 ofs.open(dir);
  used_cnt=0;
 for(y=1;y<=coast_nagg;y++){
   if(coast_use_agg(y)<=0) ofs<<"-99999"<<endl;
   if(coast_use_agg(y)==1){
    used_cnt+=1;
   ofs<<mfexp(coast_log_q_agg(y))<<endl;
  }
 }
 ofs.close();
 }
//Age Comp indices qs
if(s1_bay_nac_used>0){
 u=dirnew + "\\s1_bay_ac_qs.out";
 dir = u.c_str();
 ofs.open(dir);
 used_cnt=0;
  for(y=1;y<=s1_bay_nac;y++){
   if(s1_bay_use_ac(y)<=0) ofs<<"-99999"<<endl;
   if(s1_bay_use_ac(y)==1){
    used_cnt+=1;
    ofs<<mfexp(s1_bay_log_q_ac(used_cnt))<<endl;
   }
 }
 ofs.close();
}
if(s2_nac_used>0){
 u=dirnew + "\\s2_ac_qs.out";
 dir = u.c_str();
 ofs.open(dir);
   used_cnt=0;
   for(y=1;y<=s2_nac;y++){
   if(s2_use_ac(y)<=0) ofs<<"-99999"<<endl;
   if(s2_use_ac(y)==1){
     used_cnt+=1;
     ofs<<mfexp(s2_log_q_ac(used_cnt))<<endl;
   }
  }
 ofs.close();
 }
 if(coast_nac_used>0){
  u=dirnew + "\\coast_ac_qs.out";
 dir = u.c_str();
 ofs.open(dir);
 used_cnt=0;
 for(y=1;y<=coast_nac;y++){
   if(coast_use_ac(y)<=0) ofs<<"-99999"<<endl;
   if(coast_use_ac(y)==1){
    used_cnt+=1;
    ofs<<mfexp(coast_log_q_ac(used_cnt))<<endl;
   }
  }
 ofs.close();
 }
 if(s1_bay_nagg_used>0){
 u=dirnew + "\\s1_pred_agg_indices.out";
 dir = u.c_str();
 ofs.open(dir);
 for(y=styr;y<=endyr;y++){
    used_cnt=0;
   for(t=1;t<=s1_bay_nagg;t++){
     if(s1_bay_use_agg(t)==1){
       used_cnt+=1;
      if(t<s1_bay_nagg) ofs<<s1_bay_pred_agg_index(y,used_cnt)<<" ";
```

```
     if(t==s1_bay_nagg) ofs<<s1_bay_pred_agg_index(y,used_cnt)<<endl;
    }
    if(s1_bay_use_agg(t)<=0){
     if(t<s1_bay_nagg) ofs<<"-99999"<<" ";
     if(t==s1_bay_nagg) ofs<<"-99999"<<endl;
    }
  }
 }
 ofs.close();
}
 if(s2_nagg_used>0){
 u=dirnew + "\\s2_pred_agg_indices.out";
 dir = u.c_str();
 ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   used_cnt=0;
  for(t=1;t<=s2_nagg;t++){
    if(s2_use_agg(t)==1){
      used_cnt+=1;
     if(t<s2_nagg) ofs<<s2_pred_agg_index(y,used_cnt)<<" ";
     if(t==s2_nagg) ofs<<s2_pred_agg_index(y,used_cnt)<<endl;
    }
    if(s2_use_agg(t)<=0){
     if(t<s2_nagg) ofs<<"-99999"<<" ";
     if(t==s2_nagg) ofs<<"-99999"<<endl;
    }
  }
 }
 ofs.close();
 }
 if(coast_nagg_used>0){
 u=dirnew + "\\coast_pred_agg_indices.out";
 dir = u.c_str();
 ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   used_cnt=0;
  for(t=1;t<=coast_nagg;t++){
    if(coast_use_agg(t)==1){
      used_cnt+=1;
     if(t<coast_nagg) ofs<<coast_pred_agg_index(y,used_cnt)<<" ";
     if(t==coast_nagg) ofs<<coast_pred_agg_index(y,used_cnt)<<endl;
    }
    if(coast_use_agg(t)<=0){
     if(t<coast_nagg) ofs<<"-99999"<<" ";
     if(t==coast_nagg) ofs<<"-99999"<<endl;
    }
  }
 }
 ofs.close();
 }
 if(s1_bay_nac_used>0){
 u=dirnew + "\\s1_bay_pred_ac_indices.out";
 dir = u.c_str();
 ofs.open(dir);
 for(y=styr;y<=endyr;y++){
    used_cnt=0;
  for(a=1;a<=s1_bay_nac;a++){
    if(s1_bay_use_ac(a)==1){
    used_cnt+=1;
     if(a<s1_bay_nac) ofs<<s1_bay_pred_ac_index(y,used_cnt)<<" ";
     if(a==s1_bay_nac) ofs<<s1_bay_pred_ac_index(y,used_cnt)<<endl;
    }
    if(s1_bay_use_ac(a)<=0){
     if(a<s1_bay_nac) ofs<<"-99999"<<" ";
     if(a==s1_bay_nac) ofs<<"-99999"<<endl;
    }
```

```
   }
  }
  ofs.close();
  }
  if(s2_nac_used>0){
  u=dirnew + "\\s2_pred_ac_indices.out";
  dir = u.c_str();
  ofs.open(dir);
  for(y=styr;y<=endyr;y++){
   used_cnt=0;
    for(a=1;a<=s2_nac;a++){
      if(s2_use_ac(a)==1){
       used_cnt+=1;
       if(a<s2_nac) ofs<<s2_pred_ac_index(y,used_cnt)<<" ";
       if(a==s2_nac) ofs<<s2_pred_ac_index(y,used_cnt)<<endl;
      }
      if(s2_use_ac(a)<=0){
       if(a<s2_nac) ofs<<"-99999"<<" ";
       if(a==s2_nac) ofs<<"-99999"<<endl;
      }
    }
  }
  ofs.close();
  }
  if(coast_nac_used>0){
  u=dirnew + "\\coast_pred_ac_indices.out";
  dir = u.c_str();
  ofs.open(dir);
  for(y=styr;y<=endyr;y++){
   used_cnt=0;
    for(a=1;a<=coast_nac;a++){
      if(coast_use_ac(a)==1){
       used_cnt+=1;
       if(a<coast_nac) ofs<<coast_pred_ac_index(y,used_cnt)<<" ";
       if(a==coast_nac) ofs<<coast_pred_ac_index(y,used_cnt)<<endl;
      }
      if(coast_use_ac(a)<=0){
       if(a<coast_nac) ofs<<"-99999"<<" ";
       if(a==coast_nac) ofs<<"-99999"<<endl;
      }
    }
  }
 ofs.close();
 }

  // Predicted Catches
  u=dirnew + "\\s1_bay_pred_total_catch.out";
  dir = u.c_str();
  ofs.open(dir);
  ofs<<s1_bay_pred_total_catch<<endl;
  ofs.close();


  u=dirnew + "\\s1_coast_pred_total_catch.out";
  dir = u.c_str();
  ofs.open(dir);
  ofs<<s1_coast_pred_total_catch<<endl;
  ofs.close();


  u=dirnew + "\\s2_pred_total_catch.out";
  dir = u.c_str();
  ofs.open(dir);
  ofs<<s2_pred_total_catch<<endl;
  ofs.close();
```

```
u=dirnew + "\\coast_pred_total_catch.out";
dir = u.c_str();
ofs.open(dir);
ofs<<coast_pred_total_catch<<endl;
ofs.close();

u=dirnew + "\\s1_bay_pred_catch_caa1.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_pred_catch_caa(1,y,a)<<" ";
    if(a==nages) ofs<<s1_bay_pred_catch_caa(1,y,a)<<endl;
   }
  }

ofs.close();
u=dirnew + "\\s1_bay_pred_catch_caa1_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_pred_catch_caa(1,y,a)*s1_bay_prop_female(1,y,a)<<" ";
    if(a==nages) ofs<<s1_bay_pred_catch_caa(1,y,a)*s1_bay_prop_female(1,y,a)<<endl;
   }
  }
ofs.close();

 u=dirnew + "\\s1_bay_pred_catch_caa1_male.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_pred_catch_caa(1,y,a)*(1.-s1_bay_prop_female(1,y,a))<<" ";
    if(a==nages) ofs<<s1_bay_pred_catch_caa(1,y,a)*(1.-s1_bay_prop_female(1,y,a))<<endl;
   }
  }
ofs.close();


u=dirnew + "\\s1_bay_pred_catch_caa2.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_pred_catch_caa(2,y,a)<<" ";
    if(a==nages) ofs<<s1_bay_pred_catch_caa(2,y,a)<<endl;
   }
  }
ofs.close();
u=dirnew + "\\s1_bay_pred_catch_caa2_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_pred_catch_caa(2,y,a)*s1_bay_prop_female(2,y,a)<<" ";
    if(a==nages) ofs<<s1_bay_pred_catch_caa(2,y,a)*s1_bay_prop_female(2,y,a)<<endl;
   }
  }
ofs.close();

 u=dirnew + "\\s1_bay_pred_catch_caa2_male.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
```

```
    if(a<nages) ofs<<s1_bay_pred_catch_caa(2,y,a)*(1.-s1_bay_prop_female(2,y,a))<<" ";
    if(a==nages) ofs<<s1_bay_pred_catch_caa(2,y,a)*(1.-s1_bay_prop_female(2,y,a))<<endl;
   }
  }
ofs.close();



u=dirnew + "\\s1_bay_pred_catch_caa3.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_pred_catch_caa(3,y,a)<<" ";
    if(a==nages) ofs<<s1_bay_pred_catch_caa(3,y,a)<<endl;
   }
  }
ofs.close();
u=dirnew + "\\s1_bay_pred_catch_caa3_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_pred_catch_caa(3,y,a)*s1_bay_prop_female(3,y,a)<<" ";
    if(a==nages) ofs<<s1_bay_pred_catch_caa(3,y,a)*s1_bay_prop_female(3,y,a)<<endl;
   }
  }
ofs.close();

 u=dirnew + "\\s1_bay_pred_catch_caa3_male.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_pred_catch_caa(3,y,a)*(1.-s1_bay_prop_female(3,y,a))<<" ";
    if(a==nages) ofs<<s1_bay_pred_catch_caa(3,y,a)*(1.-s1_bay_prop_female(3,y,a))<<endl;
   }
  }
ofs.close();

 u=dirnew + "\\s1_bay_pred_catch_paa.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=substructure;t++){
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_pred_catch_paa(t,y,a)<<" ";
    if(a==nages) ofs<<s1_bay_pred_catch_paa(t,y,a)<<endl;
   }
  }
 }
ofs.close();

 u=dirnew + "\\s1_coast_pred_catch_paa.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=substructure;t++){
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_coast_pred_catch_paa(t,y,a)<<" ";
    if(a==nages) ofs<<s1_coast_pred_catch_paa(t,y,a)<<endl;
   }
  }
  }
ofs.close();
```

```
  u=dirnew + "\\s1_coast_pred_catch_caa1.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s1_coast_pred_catch_caa(1,y,a)<<" ";
     if(a==nages) ofs<<s1_coast_pred_catch_caa(1,y,a)<<endl;
    }
   }

 ofs.close();
 u=dirnew + "\\s1_coast_pred_catch_caa1_female.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s1_coast_pred_catch_caa(1,y,a)*coast_prop_female(1,y,a)<<" ";
     if(a==nages) ofs<<s1_coast_pred_catch_caa(1,y,a)*coast_prop_female(1,y,a)<<endl;
    }
   }
 ofs.close();

  u=dirnew + "\\s1_coast_pred_catch_caa1_male.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s1_coast_pred_catch_caa(1,y,a)*(1.-coast_prop_female(1,y,a))<<" ";
     if(a==nages) ofs<<s1_coast_pred_catch_caa(1,y,a)*(1.-coast_prop_female(1,y,a))<<endl;
    }
   }
 ofs.close();


 u=dirnew + "\\s1_coast_pred_catch_caa2.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s1_coast_pred_catch_caa(2,y,a)<<" ";
     if(a==nages) ofs<<s1_coast_pred_catch_caa(2,y,a)<<endl;
    }
   }
 ofs.close();
 u=dirnew + "\\s1_coast_pred_catch_caa2_female.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s1_coast_pred_catch_caa(2,y,a)*coast_prop_female(2,y,a)<<" ";
     if(a==nages) ofs<<s1_coast_pred_catch_caa(2,y,a)*coast_prop_female(2,y,a)<<endl;
    }
   }
 ofs.close();

  u=dirnew + "\\s1_coast_pred_catch_caa2_male.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s1_coast_pred_catch_caa(2,y,a)*(1.-coast_prop_female(2,y,a))<<" ";
     if(a==nages) ofs<<s1_coast_pred_catch_caa(2,y,a)*(1.-coast_prop_female(2,y,a))<<endl;
    }
   }
 ofs.close();
```

```
u=dirnew + "\\s1_coast_pred_catch_caa3.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_coast_pred_catch_caa(3,y,a)<<" ";
    if(a==nages) ofs<<s1_coast_pred_catch_caa(3,y,a)<<endl;
   }
  }
ofs.close();
u=dirnew + "\\s1_coast_pred_catch_caa3_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_coast_pred_catch_caa(3,y,a)*coast_prop_female(3,y,a)<<" ";
    if(a==nages) ofs<<s1_coast_pred_catch_caa(3,y,a)*coast_prop_female(3,y,a)<<endl;
   }
  }
ofs.close();

 u=dirnew + "\\s1_coast_pred_catch_caa3_male.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_coast_pred_catch_caa(3,y,a)*(1.-coast_prop_female(3,y,a))<<" ";
    if(a==nages) ofs<<s1_coast_pred_catch_caa(3,y,a)*(1.-coast_prop_female(3,y,a))<<endl;
   }
  }
ofs.close();

u=dirnew + "\\s1_bay_Z_at_age.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=substructure;t++){
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_Z(t,y,a)<<" ";
    if(a==nages) ofs<<s1_bay_Z(t,y,a)<<endl;
   }
  }
}
ofs.close();
u=dirnew + "\\s1_bay_F_at_age.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=substructure;t++){
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_bay_F(t,y,a)<<" ";
    if(a==nages) ofs<<s1_bay_F(t,y,a)<<endl;
   }
  }
}
ofs.close();

  u=dirnew + "\\s2_pred_catch_caa1.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s2_pred_catch_caa(1,y,a)<<" ";
    if(a==nages) ofs<<s2_pred_catch_caa(1,y,a)<<endl;
```

```
   }
  }
 ofs.close();
  u=dirnew + "\\s2_pred_catch_caa2.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s2_pred_catch_caa(2,y,a)<<" ";
    if(a==nages) ofs<<s2_pred_catch_caa(2,y,a)<<endl;
   }
  }
 ofs.close();
  u=dirnew + "\\s2_pred_catch_caa3.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s2_pred_catch_caa(3,y,a)<<" ";
    if(a==nages) ofs<<s2_pred_catch_caa(3,y,a)<<endl;
   }
  }
 ofs.close();


 u=dirnew + "\\s2_pred_catch_caa1_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s2_pred_catch_caa(1,y,a)*s2_fem_sex(a)<<" ";
    if(a==nages) ofs<<s2_pred_catch_caa(1,y,a)*s2_fem_sex(a)<<endl;
   }
  }
 ofs.close();
u=dirnew + "\\s2_pred_catch_caa2_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s2_pred_catch_caa(2,y,a)*s2_fem_sex(a)<<" ";
    if(a==nages) ofs<<s2_pred_catch_caa(2,y,a)*s2_fem_sex(a)<<endl;
   }
  }
 ofs.close();
u=dirnew + "\\s2_pred_catch_caa3_female.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s2_pred_catch_caa(3,y,a)*s2_fem_sex(a)<<" ";
    if(a==nages) ofs<<s2_pred_catch_caa(3,y,a)*s2_fem_sex(a)<<endl;
   }
  }
 ofs.close();



 u=dirnew + "\\s2_pred_catch_caa1_male.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s2_pred_catch_caa(1,y,a)*(1.-s2_fem_sex(a))<<" ";
    if(a==nages) ofs<<s2_pred_catch_caa(1,y,a)*(1.-s2_fem_sex(a))<<endl;
   }
```

```
 }

ofs.close();

 u=dirnew + "\\s2_pred_catch_caa2_male.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s2_pred_catch_caa(2,y,a)*(1.-s2_fem_sex(a))<<" ";
    if(a==nages) ofs<<s2_pred_catch_caa(2,y,a)*(1.-s2_fem_sex(a))<<endl;
   }
  }

ofs.close();

 u=dirnew + "\\s2_pred_catch_caa3_male.out";
dir = u.c_str();
ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s2_pred_catch_caa(3,y,a)*(1.-s2_fem_sex(a))<<" ";
    if(a==nages) ofs<<s2_pred_catch_caa(3,y,a)*(1.-s2_fem_sex(a))<<endl;
   }
  }
ofs.close();


u=dirnew + "\\coast_pred_catch_paa.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=ncoastwaves;t++){
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<coast_pred_catch_paa(t,y,a)<<" ";
    if(a==nages) ofs<<coast_pred_catch_paa(t,y,a)<<endl;
   }
  }
}
ofs.close();


u=dirnew + "\\s1_coast_pred_catch_caa.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=substructure;t++){
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_coast_pred_catch_caa(t,y,a)<<" ";
    if(a==nages) ofs<<s1_coast_pred_catch_caa(t,y,a)<<endl;
   }
  }
}
ofs.close();

u=dirnew + "\\s1_coast_pred_catch_caa_female.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=substructure;t++){
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<s1_coast_pred_catch_caa(t,y,a)*coast_prop_female(t,y,a)<<" ";
    if(a==nages) ofs<<s1_coast_pred_catch_caa(t,y,a)*coast_prop_female(t,y,a)<<endl;
   }
  }
}
```

```
 ofs.close();

 u=dirnew + "\\s1_coast_pred_catch_caa_male.out";
 dir = u.c_str();
 ofs.open(dir);
 for(t=1;t<=substructure;t++){
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s1_coast_pred_catch_caa(t,y,a)*(1.-coast_prop_female(t,y,a))<<" ";
     if(a==nages) ofs<<s1_coast_pred_catch_caa(t,y,a)*(1.-coast_prop_female(t,y,a))<<endl;
    }
   }
 }
 ofs.close();


 u=dirnew + "\\s2_pred_catch_caa.out";
 dir = u.c_str();
 ofs.open(dir);
for(t=1;t<=substructure;t++){
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s2_pred_catch_caa(t,y,a)<<" ";
     if(a==nages) ofs<<s2_pred_catch_caa(t,y,a)<<endl;
    }
   }
 }
 ofs.close();

 u=dirnew + "\\s2_pred_catch_caa_female.out";
 dir = u.c_str();
 ofs.open(dir);
 for(t=1;t<=substructure;t++){
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s2_pred_catch_caa(t,y,a)*s2_fem_sex(a)<<" ";
     if(a==nages) ofs<<s2_pred_catch_caa(t,y,a)*s2_fem_sex(a)<<endl;
    }
   }
 }
 ofs.close();
 u=dirnew + "\\s2_pred_catch_caa_male.out";
 dir = u.c_str();
 ofs.open(dir);
 for(t=1;t<=substructure;t++){
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s2_pred_catch_caa(t,y,a)*(1.-s2_fem_sex(a))<<" ";
     if(a==nages) ofs<<s2_pred_catch_caa(t,y,a)*(1.-s2_fem_sex(a))<<endl;
    }
   }
 }
ofs.close();
if(s1_bay_nac_used>0){
 u=dirnew + "\\s1_bay_pred_ac_index_paa.out";
 dir = u.c_str();
 ofs.open(dir);
 used_cnt=0;
 for(t=1;t<=s1_bay_nac;t++){
    if(s1_bay_use_ac(t)==1) used_cnt+=1;
       for(y=styr;y<=endyr;y++){
        for(a=1;a<=nages;a++){
         if(s1_bay_use_ac(t)==1){
           if(a<nages) ofs<<s1_bay_pred_ac_index_paa(used_cnt,y,a)<<" ";
           if(a==nages) ofs<<s1_bay_pred_ac_index_paa(used_cnt,y,a)<<endl;
         }
```

```
      if(s1_bay_use_ac(t)<=0){
        if(a<nages) ofs<<"-99999"<<" ";
        if(a==nages) ofs<<"-99999"<<endl;
      }
     }
    }
}
ofs.close();
}
if(s2_nac_used>0){
u=dirnew + "\\s2_pred_ac_index_paa.out";
dir = u.c_str();
ofs.open(dir);
  used_cnt=0;
  for(t=1;t<=s2_nac;t++){
   if(s2_use_ac(t)==1) used_cnt+=1;
     for(y=styr;y<=endyr;y++){
      for(a=1;a<=nages;a++){
       if(s2_use_ac(t)==1){
         if(a<nages) ofs<<s2_pred_ac_index_paa(used_cnt,y,a)<<" ";
         if(a==nages) ofs<<s2_pred_ac_index_paa(used_cnt,y,a)<<endl;
       }
      if(s2_use_ac(t)<=0){
        if(a<nages) ofs<<"-99999"<<" ";
        if(a==nages) ofs<<"-99999"<<endl;
      }
     }
    }
}
ofs.close();
}
if(coast_nac_used>0){
u=dirnew + "\\coast_pred_ac_index_paa.out";
dir = u.c_str();
ofs.open(dir);
 used_cnt=0;
for(t=1;t<=coast_nac;t++){
   if(coast_use_ac(t)==1) used_cnt+=1;
     for(y=styr;y<=endyr;y++){
      for(a=1;a<=nages;a++){
       if(coast_use_ac(t)==1){
         if(a<nages) ofs<<coast_pred_ac_index_paa(used_cnt,y,a)<<" ";
         if(a==nages) ofs<<coast_pred_ac_index_paa(used_cnt,y,a)<<endl;
       }
      if(coast_use_ac(t)<=0){
        if(a<nages) ofs<<"-99999"<<" ";
        if(a==nages) ofs<<"-99999"<<endl;
      }
     }
    }
} ofs.close();
}

u=dirnew + "\\s1_bay_select_at_age.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=substructure;t++){
 for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(a<nages) ofs<<s1_bay_select_at_age(t,y,a)<<" ";
   if(a==nages) ofs<<s1_bay_select_at_age(t,y,a)<<endl;
   }
  }
 }
ofs.close();
```

```
u=dirnew + "\\coast_select_at_age.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=ncoastwaves;t++){
 for(y=styr;y<=endyr;y++){
   for(a=1;a<=nages;a++){
    if(a<nages) ofs<<coast_select_at_age(t,y,a)<<" ";
    if(a==nages) ofs<<coast_select_at_age(t,y,a)<<endl;
   }
  }
}
ofs.close();

if(s1_bay_nac_used>0){
 u=dirnew + "\\s1_bay_ac_select_at_age.out";
dir = u.c_str();
ofs.open(dir);
   used_cnt=0;
 for(t=1;t<=s1_bay_nac;t++){
   if(s1_bay_use_ac(t)==1) used_cnt+=1;
   for(a=1;a<=nages;a++){
    if(s1_bay_use_ac(t)==1){
      if(a<nages) ofs<<s1_bay_ac_select_at_age(used_cnt,a)<<" ";
      if(a==nages) ofs<<s1_bay_ac_select_at_age(used_cnt,a)<<endl;
    }
    if(s1_bay_use_ac(t)<=0){
      if(a<nages) ofs<<"-99999"<<" ";
      if(a==nages) ofs<<"-99999"<<endl;
    }
  }
 }
 ofs.close();
 }
if(s2_nac_used>0){
 u=dirnew + "\\s2_ac_select_at_age.out";
dir = u.c_str();
ofs.open(dir);
  used_cnt=0;
 for(t=1;t<=s2_nac;t++){
  if(s2_use_ac(t)==1) used_cnt+=1;
   for(a=1;a<=nages;a++){
    if(s2_use_ac(t)==1){
      if(a<nages) ofs<<s2_ac_select_at_age(used_cnt,a)<<" ";
      if(a==nages) ofs<<s2_ac_select_at_age(used_cnt,a)<<endl;
    }
    if(s2_use_ac(t)<=0){
      if(a<nages) ofs<<"-99999"<<" ";
      if(a==nages) ofs<<"-99999"<<endl;
    }
  }
 }
ofs.close();
}
if(coast_nac_used>0){
u=dirnew + "\\coast_ac_select_at_age.out";
dir = u.c_str();
ofs.open(dir);
  used_cnt=0;
 for(t=1;t<=coast_nac;t++){
  if(coast_use_ac(t)==1) used_cnt+=1;
   for(a=1;a<=nages;a++){
    if(coast_use_ac(t)==1){
      if(a<nages) ofs<<coast_ac_select_at_age(used_cnt,a)<<" ";
      if(a==nages) ofs<<coast_ac_select_at_age(used_cnt,a)<<endl;
    }
    if(coast_use_ac(t)<=0){
```

```
      if(a<nages) ofs<<"-99999"<<" ";
      if(a==nages) ofs<<"-99999"<<endl;
     }
    }
   }
  ofs.close();
  }
  u=dirnew + "\\stock_composition_predicted.out";
  dir = u.c_str();
  ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    ofs<<stock_comp_predicted(y)<<endl;
   }
  ofs.close();

//############### Residuals ####################
  //*********************************************************************************************
  // Compute Standardized Residuals for Total Catch
 //*********************************************************************************************
  //-----------------------------Stock 1-------------------------------

   for(t=1;t<=substructure;t++){
    sumdo=0;
   for(y=styr;y<=endyr;y++){
       if(s1_bay_total_catch(y,t)<0.) s1_bay_total_catch_resid(y,t)=0;
       if(s1_bay_total_catch(y,t)>=0.){
         s1_bay_total_catch_resid(y,t)=log(s1_bay_total_catch(y,t)+1e-5)-log(s1_bay_pred_total_catch(y,t)+1e-5);
         sumdo+=1;
        }
     }
 //Calculate standardized residuals
  for(y=styr;y<=endyr;y++){
       if(s1_bay_total_catch(y,t)>=0.){
         s1_bay_total_catch_std_resid(y,t)=s1_bay_total_catch_resid(y,t)/sqrt(log(square(s1_bay_total_catch_CV(y,t)+1)));
         }
        if(s1_bay_total_catch(y,t)<0.) s1_bay_total_catch_std_resid(y,t)=-99999.0;
   }
 // Calculate RMSE
   adds=0;
   for(y=styr;y<=endyr;y++){
     if(s1_bay_total_catch(y,t)>=0.) adds+=square(s1_bay_total_catch_std_resid(y,t));
     }
    s1_bay_total_catch_RMSE(t)=sqrt(adds/sumdo);
   }//t

    u=dirnew +"\\S1_total_catch_RMSE.out";
    dir = u.c_str();
    ofs.open(dir);
     for(t=1;t<=substructure;t++) ofs<<s1_bay_total_catch_RMSE(t)<<endl;
     ofs.close();

    u=dirnew +"\\S1_total_catch_std_resid.out";
    dir = u.c_str();
    ofs.open(dir);
     for(y=styr;y<=endyr;y++){
       for(t=1;t<=substructure;t++){
        if(t<substructure) ofs<<s1_bay_total_catch_std_resid(y,t)<<" ";
        if(t==substructure) ofs<<s1_bay_total_catch_std_resid(y,t)<<endl;
       }
     }
      ofs.close();

       //-----------------------------Coast-------------------------------
    for(t=1;t<=ncoastwaves;t++){
     sumdo=0;
     for(y=styr;y<=endyr;y++){
```

```
        if(coast_total_catch(y,t)<0.) coast_total_catch_resid(y,t)=0;
        if(coast_total_catch(y,t)>=0.){
          coast_total_catch_resid(y,t)=log(coast_total_catch(y,t)+1e-5)-log(coast_pred_total_catch(y,t)+1e-5);
          sumdo+=1;
         }
    }
  //Calculate standardized residuals
  for(y=styr;y<=endyr;y++){
        if(coast_total_catch(y,t)>=0.){
          coast_total_catch_std_resid(y,t)=coast_total_catch_resid(y,t)/sqrt(log(square(coast_total_catch_CV(y,t)+1)));
         }
         if(coast_total_catch(y,t)<0.) coast_total_catch_std_resid(y,t)=-99999.0;
  }
 // Calculate RMSE
  adds=0;
  for(y=styr;y<=endyr;y++){
    if(coast_total_catch(y,t)>=0.) adds+=square(coast_total_catch_std_resid(y,t));
    }
   coast_total_catch_RMSE(t)=sqrt(adds/sumdo);
 }//t

   u=dirnew +"\\Coast_total_catch_RMSE.out";
   dir = u.c_str();
   ofs.open(dir);
    for(t=1;t<=ncoastwaves;t++) ofs<<coast_total_catch_RMSE(t)<<endl;
    ofs.close();

   u=dirnew +"\\Coast_total_catch_std_resid.out";
   dir = u.c_str();
   ofs.open(dir);
    for(y=styr;y<=endyr;y++){
      for(t=1;t<=ncoastwaves;t++){
       if(t<ncoastwaves) ofs<<coast_total_catch_std_resid(y,t)<<" ";
       if(t==ncoastwaves) ofs<<coast_total_catch_std_resid(y,t)<<endl;
      }
    }
     ofs.close();

 //############### Residuals #####################
 //**************************************************************************************************
 // Compute Standardized Residuals for Aggregate indices
//**************************************************************************************************
 //----------------------------Stock 1-------------------------------
  if(s1_bay_nagg_used>0){
   used_cnt=0;
   for(t=1;t<=s1_bay_nagg;t++){
    if(s1_bay_use_agg(t)==1){
      used_cnt+=1;
      sumdo=0;
      for(y=styr;y<=endyr;y++){
        if(s1_bay_agg_index(y,t)<0.) s1_bay_resid_agg(y,used_cnt)=0;
        if(s1_bay_agg_index(y,t)>=0.){
          s1_bay_resid_agg(y,used_cnt)=log(s1_bay_agg_index(y,t)+1e-5)-log(s1_bay_pred_agg_index(y,used_cnt)+1e-5);
          sumdo+=1;
         }
    }
 //Calculate standardized residuals
     for(y=styr;y<=endyr;y++){
        if(s1_bay_agg_index(y,t)>=0.){
          s1_bay_std_resid_agg(y,used_cnt)=s1_bay_resid_agg(y,used_cnt)/sqrt(log(square(s1_bay_agg_index_CV(y,t)+1)));
         }
         if(s1_bay_agg_index(y,t)<0.) s1_bay_std_resid_agg(y,used_cnt)=-99999.0;
  }
// Calculate RMSE
   adds=0;
   for(y=styr;y<=endyr;y++){
```

```
    if(s1_bay_agg_index(y,t)>=0.) adds+=square(s1_bay_std_resid_agg(y,used_cnt));
    }
  s1_bay_RMSE_agg(used_cnt)=sqrt(adds/sumdo);
 }
}

  u=dirnew +"\\S1_RMSE_agg.out";
   dir = u.c_str();
   ofs.open(dir);
    used_cnt=0;
    for(t=1;t<=s1_bay_nagg;t++){
     if(s1_bay_use_agg(t)==1){
       used_cnt+=1;
       ofs<<s1_bay_RMSE_agg(used_cnt)<<endl;
     }
     if(s1_bay_use_agg(t)<=0) ofs<<"-99999"<<endl;
    }
    ofs.close();

   u=dirnew +"\\S1_std_resid_agg.out";
   dir = u.c_str();
   ofs.open(dir);
    for(y=styr;y<=endyr;y++){
     used_cnt=0;
      for(t=1;t<=s1_bay_nagg;t++){
        if(s1_bay_use_agg(t)==1){
         used_cnt+=1;
         if(t<s1_bay_nagg) ofs<<s1_bay_std_resid_agg(y,used_cnt)<<" ";
         if(t==s1_bay_nagg) ofs<<s1_bay_std_resid_agg(y,used_cnt)<<endl;
        }
        if(s1_bay_use_agg(t)<=0){
         if(t<s1_bay_nagg) ofs<<"-99999"<<" ";
         if(t==s1_bay_nagg) ofs<<"-99999"<<endl;
        }
     }
   }
     ofs.close();
}//indices used


 //----------------------------  Stock 2 -------------------------------
 if(s2_nagg_used>0){
  used_cnt=0;
   for(t=1;t<=s2_nagg;t++){
     if(s2_use_agg(t)==1){
     used_cnt+=1;
     sumdo=0;
     for(y=styr;y<=endyr;y++){
        if(s2_agg_index(y,t)<0.) s2_resid_agg(y,used_cnt)=0;
        if(s2_agg_index(y,t)>=0.){
           s2_resid_agg(y,used_cnt)=log(s2_agg_index(y,t)+1e-5)-log(s2_pred_agg_index(y,used_cnt)+1e-5);
           sumdo+=1;
         }
    }
   //Calculate standardized residuals
   for(y=styr;y<=endyr;y++){
        if(s2_agg_index(y,t)>=0.){
           s2_std_resid_agg(y,used_cnt)=s2_resid_agg(y,used_cnt)/sqrt(log(square(s2_agg_index_CV(y,t)+1)));
          }
         if(s2_agg_index(y,t)<0.) s2_std_resid_agg(y,used_cnt)=-99999.0;
  }
  // Calculate RMSE
  adds=0;
  for(y=styr;y<=endyr;y++){
    if(s2_agg_index(y,t)>=0.) adds+=square(s2_std_resid_agg(y,used_cnt));
    }
```

```
  s2_RMSE_agg(used_cnt)=sqrt(adds/sumdo);
  }
 }
  u=dirnew +"\\S2_RMSE_agg.out";
   dir = u.c_str();
   ofs.open(dir);
    used_cnt=0;
    for(t=1;t<=s2_nagg;t++){
     if(s2_use_agg(t)==1){
       used_cnt+=1;
       ofs<<s2_RMSE_agg(used_cnt)<<endl;
     }
     if(s2_use_agg(t)<=0) ofs<<"-99999"<<endl;
    }
    ofs.close();

   u=dirnew +"\\S2_std_resid_agg.out";
   dir = u.c_str();
   ofs.open(dir);
    for(y=styr;y<=endyr;y++){
      used_cnt=0;
      for(t=1;t<=s2_nagg;t++){
        if(s2_use_agg(t)==1){
         used_cnt+=1;
         if(t<s2_nagg) ofs<<s2_std_resid_agg(y,used_cnt)<<" ";
         if(t==s2_nagg) ofs<<s2_std_resid_agg(y,used_cnt)<<endl;
        }
        if(s2_use_agg(t)<=0){
         if(t<s2_nagg) ofs<<"-99999"<<" ";
         if(t==s2_nagg) ofs<<"-99999"<<endl;
        }
    }
   }
     ofs.close();
}//any indices used

 //----------------------------  Coast -------------------------------
  if(coast_nagg_used>0){
   used_cnt=0;
   for(t=1;t<=coast_nagg;t++){
    if(coast_use_agg(t)==1){
    used_cnt+=1;
    sumdo=0;
  for(y=styr;y<=endyr;y++){
        if(coast_agg_index(y,t)<0.) coast_resid_agg(y,used_cnt)=0;
        if(coast_agg_index(y,t)>=0.){
          coast_resid_agg(y,used_cnt)=log(coast_agg_index(y,t)+1e-5)-log(coast_pred_agg_index(y,used_cnt)+1e-5);
          sumdo+=1;
         }
    }
  //Calculate standardized residuals
    for(y=styr;y<=endyr;y++){
        if(coast_agg_index(y,t)>=0.){
          coast_std_resid_agg(y,used_cnt)=coast_resid_agg(y,used_cnt)/sqrt(log(square(coast_agg_index_CV(y,t)+1)));
         }
         if(coast_agg_index(y,t)<0.) coast_std_resid_agg(y,used_cnt)=-99999.0;
     }
  // Calculate RMSE
    adds=0;
    for(y=styr;y<=endyr;y++){
     if(coast_agg_index(y,t)>=0.) adds+=square(coast_std_resid_agg(y,used_cnt));
    }
    coast_RMSE_agg(used_cnt)=sqrt(adds/sumdo);
   }
  }
  u=dirnew +"\\Coast_RMSE_agg.out";
```

```
   dir = u.c_str();
   ofs.open(dir);
    used_cnt=0;
    for(t=1;t<=coast_nagg;t++){
     if(coast_use_agg(t)==1){
       used_cnt+=1;
       ofs<<coast_RMSE_agg(used_cnt)<<endl;
     }
     if(coast_use_agg(t)<=0) ofs<<"-99999"<<endl;
    }
    ofs.close();

   u=dirnew +"\\Coast_std_resid_agg.out";
   dir = u.c_str();
   ofs.open(dir);

    for(y=styr;y<=endyr;y++){
        used_cnt=0;
      for(t=1;t<=coast_nagg;t++){
        if(coast_use_agg(t)==1){
         used_cnt+=1;
         if(t<coast_nagg) ofs<<coast_std_resid_agg(y,used_cnt)<<" ";
         if(t==coast_nagg) ofs<<coast_std_resid_agg(y,used_cnt)<<endl;
        }
        if(coast_use_agg(t)<=0){
         if(t<coast_nagg) ofs<<"-99999"<<" ";
         if(t==coast_nagg) ofs<<"-99999"<<endl;
        }

    }
   }
     ofs.close();
 }//any indices used

  //**************************************************************************************************
 // Compute Standardized Residuals for AC Surveys indices
 //**************************************************************************************************
 //------------------------ Stock 1----------------------------------
 if(s1_bay_nac_used>0){
  used_cnt=0;
  for(t=1;t<=s1_bay_nac;t++){
   if(s1_bay_use_ac(t)==1){
   sumdo=0;used_cnt+=1;
   for(y=styr;y<=endyr;y++){
        if(s1_bay_ac_index(y,t)<0.) s1_bay_resid_ac(y,used_cnt)=0;
        if(s1_bay_ac_index(y,t)>=0.){
          s1_bay_resid_ac(y,used_cnt)=log(s1_bay_ac_index(y,t)+1e-5)-log(s1_bay_pred_ac_index(y,used_cnt)+1e-5);
          sumdo+=1;
         }
    }
//Calculate standardized residuals
   for(y=styr;y<=endyr;y++){
        if(s1_bay_ac_index(y,t)>=0.){
          s1_bay_std_resid_ac(y,used_cnt)=s1_bay_resid_ac(y,used_cnt)/sqrt(log(square(s1_bay_ac_index_CV(y,t)+1)));
         }
         if(s1_bay_ac_index(y,t)<0.) s1_bay_std_resid_ac(y,used_cnt)=-99999.0;
   }
// Calculate RMSE
   adds=0;
  for(y=styr;y<=endyr;y++){
    if(s1_bay_ac_index(y,used_cnt)>=0.) adds+=square(s1_bay_std_resid_ac(y,used_cnt));
    }
  s1_bay_RMSE_ac(used_cnt)=sqrt(adds/sumdo);
 }
}
```

```
  u=dirnew +"\\S1_RMSE_ac.out";
   dir = u.c_str();
   ofs.open(dir);
    used_cnt=0;
    for(t=1;t<=s1_bay_nac;t++){
     if(s1_bay_use_ac(t)==1){
       used_cnt+=1;
       ofs<<s1_bay_RMSE_ac(used_cnt)<<endl;
     }
     if(s1_bay_use_ac(t)<=0) ofs<<"-99999"<<endl;
    }
    ofs.close();

    u=dirnew +"\\S1_std_resid_ac.out";
    dir = u.c_str();
    ofs.open(dir);
    for(y=styr;y<=endyr;y++){
        used_cnt=0;
      for(t=1;t<=s1_bay_nac;t++){
        if(s1_bay_use_ac(t)==1){
          used_cnt+=1;
          if(t<s1_bay_nac) ofs<<s1_bay_std_resid_ac(y,used_cnt)<<" ";
          if(t==s1_bay_nac) ofs<<s1_bay_std_resid_ac(y,used_cnt)<<endl;
       }
        if(s1_bay_use_ac(t)<=0){
          if(t<s1_bay_nac) ofs<<"-99999"<<" ";
          if(t==s1_bay_nac) ofs<<"-99999"<<endl;
       }
    }
   }
     ofs.close();
  }//any indicies used



 //------------------------ Stock 2-----------------------------------
if(s2_nac_used>0){
 used_cnt=0;
 for(t=1;t<=s2_nac;t++){
  if(s2_use_ac(t)==1){
   used_cnt+=1;
  sumdo=0;
  for(y=styr;y<=endyr;y++){
        if(s2_ac_index(y,t)<0.) s2_resid_ac(y,used_cnt)=0;
        if(s2_ac_index(y,t)>=0.){
           s2_resid_ac(y,used_cnt)=log(s2_ac_index(y,t)+1e-5)-log(s2_pred_ac_index(y,used_cnt)+1e-5);
           sumdo+=1;
         }
    }
//Calculate standardized residuals
   for(y=styr;y<=endyr;y++){
       if(s2_ac_index(y,t)>=0.){
           s2_std_resid_ac(y,used_cnt)=s2_resid_ac(y,used_cnt)/sqrt(log(square(s2_ac_index_CV(y,t)+1)));
          }
         if(s2_ac_index(y,t)<0.) s2_std_resid_ac(y,used_cnt)=-99999.0;
   }
// Calculate RMSE
   adds=0;
  for(y=styr;y<=endyr;y++){
   if(s2_ac_index(y,t)>=0.) adds+=square(s2_std_resid_ac(y,used_cnt));
    }
  s2_RMSE_ac(used_cnt)=sqrt(adds/sumdo);
  }
 }
    u=dirnew +"\\S2_RMSE_ac.out";
   dir = u.c_str();
```

```
   ofs.open(dir);
    used_cnt=0;
    for(t=1;t<=s2_nac;t++){
     if(s2_use_ac(t)==1){
      used_cnt+=1;
      ofs<<s2_RMSE_ac(used_cnt)<<endl;
     }
     if(s2_use_ac(t)<=0) ofs<<"-99999"<<endl;
    }
    ofs.close();

    u=dirnew +"\\S2_std_resid_ac.out";
    dir = u.c_str();
    ofs.open(dir);
    for(y=styr;y<=endyr;y++){
        used_cnt=0;
      for(t=1;t<=s2_nac;t++){
        if(s2_use_ac(t)==1){
          used_cnt+=1;
          if(t<s2_nac) ofs<<s2_std_resid_ac(y,used_cnt)<<" ";
          if(t==s2_nac) ofs<<s2_std_resid_ac(y,used_cnt)<<endl;
       }
        if(s2_use_ac(t)<=0){
          if(t<s2_nac) ofs<<"-99999"<<" ";
          if(t==s2_nac) ofs<<"-99999"<<endl;
       }
     }
   }
     ofs.close();
 }//any indicies used

 //------------------------ Coast-----------------------------------
 if(coast_nac_used>0){
 used_cnt=0;
  for(t=1;t<=coast_nac;t++){
   if(coast_use_ac(t)==1){
   used_cnt+=1;
   sumdo=0;
   for(y=styr;y<=endyr;y++){
         if(coast_ac_index(y,t)<0.) coast_resid_ac(y,used_cnt)=0;
         if(coast_ac_index(y,t)>=0.){
            coast_resid_ac(y,used_cnt)=log(coast_ac_index(y,t)+1e-5)-log(coast_pred_ac_index(y,used_cnt)+1e-5);
            sumdo+=1;
          }
     }
 //Calculate standardized residuals
    for(y=styr;y<=endyr;y++){
         if(coast_ac_index(y,t)>=0.){
            coast_std_resid_ac(y,used_cnt)=coast_resid_ac(y,used_cnt)/sqrt(log(square(coast_ac_index_CV(y,t)+1)));
           }
          if(coast_ac_index(y,t)<0.) coast_std_resid_ac(y,used_cnt)=-99999.0;
    }
// Calculate RMSE
    adds=0;
   for(y=styr;y<=endyr;y++){
     if(coast_ac_index(y,t)>=0.) adds+=square(coast_std_resid_ac(y,used_cnt));
     }
   coast_RMSE_ac(used_cnt)=sqrt(adds/sumdo);
  }
 }

     u=dirnew +"\\Coast_RMSE_ac.out";
    dir = u.c_str();
    ofs.open(dir);
     used_cnt=0;
     for(t=1;t<=coast_nac;t++){
```

```
     if(coast_use_ac(t)==1){
      used_cnt+=1;
      ofs<<coast_RMSE_ac(used_cnt)<<endl;
     }
     if(coast_use_ac(t)<=0) ofs<<"-99999"<<endl;
    }
    ofs.close();

    u=dirnew +"\\Coast_std_resid_ac.out";
    dir = u.c_str();
    ofs.open(dir);
    for(y=styr;y<=endyr;y++){
       used_cnt=0;
      for(t=1;t<=coast_nac;t++){
       if(coast_use_ac(t)==1){
         used_cnt+=1;
         if(t<coast_nac) ofs<<coast_std_resid_ac(y,used_cnt)<<" ";
         if(t==coast_nac) ofs<<coast_std_resid_ac(y,used_cnt)<<endl;
       }
       if(coast_use_ac(t)<=0){
         if(t<coast_nac) ofs<<"-99999"<<" ";
         if(t==coast_nac) ofs<<"-99999"<<endl;
       }
     }
    }
     ofs.close();
 }//any indices used

 //**************************************************************************************************
 //   Standardized Residuals for Catch Age Comp
 //**************************************************************************************************
 //Stock 1

  for(t=1;t<=substructure;t++){
    sprintf(hh,"%i",t);
     u=dirnew +"\\S1_Wave_" + hh + "_std_resid_catch_paa.out";
    dir = u.c_str();
    ofs.open(dir);
    for(y=styr;y<=endyr;y++){
     for(a=1;a<=nages;a++){
      if(s1_bay_catch_paa(t,y,a)>=0.){
         s1_bay_std_resid_catch_paa(t,y,a)=((s1_bay_catch_paa(t,y,a)+1e-5)-(s1_bay_pred_catch_paa(t,y,a)+1e-
5))/sqrt(((s1_bay_pred_catch_paa(t,y,a)+1e-5)*(1-(s1_bay_pred_catch_paa(t,y,a)+1e-5)))/s1_bay_catch_paa_ess(y,t));
       }
      if(s1_bay_catch_paa(t,y,a)<0.) s1_bay_std_resid_catch_paa(t,y,a)=-99999.;
      if(a<nages) ofs<<s1_bay_std_resid_catch_paa(t,y,a)<<" ";
      if(a==nages) ofs<<s1_bay_std_resid_catch_paa(t,y,a)<<endl;
     }
    }
   ofs.close();
  }

   //Coast
  for(t=1;t<=ncoastwaves;t++){
    sprintf(hh,"%i",t);
    u=dirnew +"\\Coast_Wave_" + hh + "_std_resid_catch_paa.out";
    dir = u.c_str();
    ofs.open(dir);
    for(y=styr;y<=endyr;y++){
     for(a=1;a<=nages;a++){
      if(coast_catch_paa(t,y,a)>=0.){
         coast_std_resid_catch_paa(t,y,a)=((coast_catch_paa(t,y,a)+1e-5)-(coast_pred_catch_paa(t,y,a)+1e-
5))/sqrt(((coast_pred_catch_paa(t,y,a)+1e-5)*(1-(coast_pred_catch_paa(t,y,a)+1e-5)))/coast_catch_paa_ess(y,t));
       }
      if(coast_catch_paa(t,y,a)<0.) coast_std_resid_catch_paa(t,y,a)=-99999.;
      if(a<nages) ofs<<coast_std_resid_catch_paa(t,y,a)<<" ";
```

```
      if(a==nages) ofs<<coast_std_resid_catch_paa(t,y,a)<<endl;
     }
    }
    ofs.close();
   }

 //################## Standardized Residuals for Age COmp Surveys Age Comps
  //Stock 1
  if(s1_bay_nac_used>0){
   used_cnt=0;
   for(t=1;t<=s1_bay_nac;t++){
      sprintf(hh,"%i",t);
      u=dirnew +"\\S1_AC" + hh + "_std_resid_AC.out";
      dir = u.c_str();
      ofs.open(dir);
      if(s1_bay_use_ac(t)==1) used_cnt+=1;
      for(y=styr;y<=endyr;y++){
       for(a=1;a<=nages;a++){
       if(s1_bay_use_ac(t)==1){
           if(s1_bay_ac_index_paa(t,y,a)>=0.){
             s1_bay_std_resid_index_paa(used_cnt,y,a)=((s1_bay_ac_index_paa(t,y,a)+1e-5)-(s1_bay_pred_ac_index_paa(used_cnt,y,a)+1e-
5))/sqrt(((s1_bay_pred_ac_index_paa(used_cnt,y,a)+1e-5)*(1-(s1_bay_pred_ac_index_paa(used_cnt,y,a)+1e-
5)))/s1_bay_ac_index_paa_ess(y,t));
           }
           if(s1_bay_ac_index_paa(t,y,a)<0.) s1_bay_std_resid_index_paa(used_cnt,y,a)=-99999.;
           if(a<nages) ofs<<s1_bay_std_resid_index_paa(used_cnt,y,a)<<" ";
          if(a==nages) ofs<<s1_bay_std_resid_index_paa(used_cnt,y,a)<<endl;
       }
       if(s1_bay_use_ac(t)<=0){
         if(a<nages) ofs<<"-99999"<<" ";
         if(a==nages) ofs<<"-99999"<<endl;
       }
      }
    }
   ofs.close();
  }
 }


  //Stock 2
 if(s2_nac_used>0){
  used_cnt=0;
   for(t=1;t<=s2_nac;t++){
      sprintf(hh,"%i",t);
      u=dirnew +"\\S2_AC" + hh + "_std_resid_AC.out";
      dir = u.c_str();
      ofs.open(dir);
      if(s2_use_ac(t)==1) used_cnt+=1;
      for(y=styr;y<=endyr;y++){
       for(a=1;a<=nages;a++){
       if(s2_use_ac(t)==1){
           if(s2_ac_index_paa(t,y,a)>=0.){
             s2_std_resid_index_paa(used_cnt,y,a)=((s2_ac_index_paa(t,y,a)+1e-5)-(s2_pred_ac_index_paa(used_cnt,y,a)+1e-
5))/sqrt(((s2_pred_ac_index_paa(used_cnt,y,a)+1e-5)*(1-(s2_pred_ac_index_paa(used_cnt,y,a)+1e-5)))/s2_ac_index_paa_ess(y,t));
           }
           if(s2_ac_index_paa(t,y,a)<0.) s2_std_resid_index_paa(used_cnt,y,a)=-99999.;
           if(a<nages) ofs<<s2_std_resid_index_paa(used_cnt,y,a)<<" ";
          if(a==nages) ofs<<s2_std_resid_index_paa(used_cnt,y,a)<<endl;
       }
       if(s2_use_ac(t)<=0){
         if(a<nages) ofs<<"-99999"<<" ";
         if(a==nages) ofs<<"-99999"<<endl;
       }
      }
    }
   ofs.close();
```

```
 }
}


//Coast
if(coast_nac_used>0){
 used_cnt=0;
  for(t=1;t<=coast_nac;t++){
    sprintf(hh,"%i",t);
    u=dirnew +"\\Coast_AC" + hh + "_std_resid_AC.out";
    dir = u.c_str();
    ofs.open(dir);
    if(coast_use_ac(t)==1) used_cnt+=1;
    for(y=styr;y<=endyr;y++){
     for(a=1;a<=nages;a++){
     if(coast_use_ac(t)==1){
         if(coast_ac_index_paa(t,y,a)>=0.){
           coast_std_resid_index_paa(used_cnt,y,a)=((coast_ac_index_paa(t,y,a)+1e-5)-(coast_pred_ac_index_paa(used_cnt,y,a)+1e-
5))/sqrt(((coast_pred_ac_index_paa(used_cnt,y,a)+1e-5)*(1-(coast_pred_ac_index_paa(used_cnt,y,a)+1e-5)))/coast_ac_index_paa_ess(y,t));
         }
         if(coast_ac_index_paa(t,y,a)<0.) coast_std_resid_index_paa(used_cnt,y,a)=-99999.;
         if(a<nages) ofs<<coast_std_resid_index_paa(used_cnt,y,a)<<" ";
        if(a==nages) ofs<<coast_std_resid_index_paa(used_cnt,y,a)<<endl;
     }
     if(coast_use_ac(t)<=0){
       if(a<nages) ofs<<"-99999"<<" ";
       if(a==nages) ofs<<"-99999"<<endl;
     }
    }
   }
  ofs.close();
 }
}
 //Stock Composition

    u=dirnew +"\\stock_comp_std_resid.out";
    dir = u.c_str();
    ofs.open(dir);
    for(y=styr;y<=endyr;y++){
     for(p=1;p<=2;p++){
       if(stock_composition(y,p)>0.){
         stock_comp_std_resid(y,p)=((stock_composition(y,p)+1e-5)-(stock_comp_predicted(y,p)+1e-5))/sqrt(((stock_comp_predicted(y,p)+1e-
5)*(1-(stock_comp_predicted(y,p)+1e-5)))/stock_comp_ess(y));
       }
      if(stock_composition(y,p)<0.) stock_comp_std_resid(y,p)=-99999.;
      if(p<2) ofs<<stock_comp_std_resid(y,p)<<" ";
      if(p==2) ofs<<stock_comp_std_resid(y,p)<<endl;
     }
   }
  ofs.close();


 //**************************************************************************************************
 // 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
// Stock 1 Catch
  s1_Neff_stage2_mult_catch=1;
  for (t=1;t<=substructure;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(s1_bay_catch_paa(t,y,a)>=0.){
       mean_age_obs(y)+=s1_bay_catch_paa(t,y,a)*a;
       mean_age_pred(y)+=s1_bay_pred_catch_paa(t,y,a)*a;
       mean_age_pred2(y)+=s1_bay_pred_catch_paa(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 (s1_bay_total_catch(y,t)>=0.){
        mean_age_x=mean_age_resid(y)*sqrt(s1_bay_catch_paa_ess(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)) s1_Neff_stage2_mult_catch(t)=1.0/(mean_age_m2/(mean_age_n-1.0));
}

//Coast
 coast_Neff_stage2_mult_catch=1.;
 for (t=1;t<=ncoastwaves;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(coast_catch_paa(t,y,a)>=0.){
       mean_age_obs(y)+=coast_catch_paa(t,y,a)*a;
       mean_age_pred(y)+=coast_pred_catch_paa(t,y,a)*a;
       mean_age_pred2(y)+=coast_pred_catch_paa(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 (coast_total_catch(y,t)>=0.){
        mean_age_x=mean_age_resid(y)*sqrt(coast_catch_paa_ess(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)) coast_Neff_stage2_mult_catch(t)=1.0/(mean_age_m2/(mean_age_n-1.0));
}

//Stock 1 Indices
if(s1_bay_nac_used>0){
  s1_Neff_stage2_mult_index=1;
  used_cnt=0;
 for (t=1;t<=s1_bay_nac;t++){
   if(s1_bay_use_ac(t)>=1) used_cnt+=1;
   if (s1_bay_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=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(s1_bay_ac_index_paa(t,y,a)>=0.){
    mean_age_obs(y)+=s1_bay_ac_index_paa(t,y,a)*a;
    mean_age_pred(y)+=s1_bay_pred_ac_index_paa(used_cnt,y,a)*a;
    mean_age_pred2(y)+=s1_bay_pred_ac_index_paa(used_cnt,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 (s1_bay_ac_index(y,t)>=0.){
      mean_age_x=mean_age_resid(y)*sqrt(s1_bay_ac_index_paa_ess(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)) s1_Neff_stage2_mult_index(used_cnt)=1.0/(mean_age_m2/(mean_age_n-1.0));
}
}
}//used
 //Stock 2 Indices

if(s2_nac_used>0){
 s2_Neff_stage2_mult_index=1;
 used_cnt=0;
 for (t=1;t<=s2_nac;t++){
  if(s2_use_ac(t)==1) used_cnt+=1;
  if (s2_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=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(s2_ac_index_paa(t,y,a)>=0.){
    mean_age_obs(y)+=s2_ac_index_paa(t,y,a)*a;
    mean_age_pred(y)+=s2_pred_ac_index_paa(used_cnt,y,a)*a;
    mean_age_pred2(y)+=s2_pred_ac_index_paa(used_cnt,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(s2_ac_index(y,t)>=0.){
     if(s2_ac_index_paa_ess(y,t)>=0.){//de trawl recode
      mean_age_x=mean_age_resid(y)*sqrt(s2_ac_index_paa_ess(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)) s2_Neff_stage2_mult_index(used_cnt)=1.0/(mean_age_m2/(mean_age_n-1.0));
 }
}
}//used

 //Coast Indices
if(coast_nac_used>0){
 used_cnt=0;
 coast_Neff_stage2_mult_index=1;
 for (t=1;t<=coast_nac;t++){
  if (coast_use_ac(t)>=1) used_cnt+=1;
  if (coast_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=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
      if(coast_ac_index_paa(t,y,a)>=0.){
        mean_age_obs(y)+=coast_ac_index_paa(t,y,a)*a;
        mean_age_pred(y)+=coast_pred_ac_index_paa(used_cnt,y,a)*a;
        mean_age_pred2(y)+=coast_pred_ac_index_paa(used_cnt,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 (coast_ac_index(y,t)>=0.){
         mean_age_x=mean_age_resid(y)*sqrt(coast_ac_index_paa_ess(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)) coast_Neff_stage2_mult_index(used_cnt)=1.0/(mean_age_m2/(mean_age_n-1.0));
 }
}
}
 //Stock Compostion
if(use_stockcomp>0){
  coast_Neff_stage2_mult_stock_comp=0;
     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(p=1;p<=2;p++){
      if(stock_composition(y,1)>0.){
        mean_age_obs(y)+=stock_composition(y,p)*p;
        mean_age_pred(y)+=stock_comp_predicted(y,p)*p;
        mean_age_pred2(y)+=stock_comp_predicted(y,p)*p*p;
      }
    }
  }
  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 (stock_composition(y,1)>0.){
        mean_age_x=mean_age_resid(y)*sqrt(stock_comp_ess(y))/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)) coast_Neff_stage2_mult_stock_comp=1.0/(mean_age_m2/(mean_age_n-1.0));
}

u=dirnew +"\\S1_Francis_Catch.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=substructure;t++) ofs<<s1_Neff_stage2_mult_catch(t)<<endl;
ofs.close();
u=dirnew +"\\Coast_Francis_Catch.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=ncoastwaves;t++) ofs<<coast_Neff_stage2_mult_catch(t)<<endl;
ofs.close();

if(s1_bay_nac_used>0){
 u=dirnew +"\\S1_Francis_AC.out";
 dir = u.c_str();
 ofs.open(dir);
 used_cnt=0;
 for(t=1;t<=s1_bay_nac;t++){
  if(s1_bay_use_ac(t)==1){
   used_cnt+=1;
   ofs<<s1_Neff_stage2_mult_index(used_cnt)<<endl;
  }
  if(s1_bay_use_ac(t)<=0) ofs<<"-99999"<<endl;
 }
ofs.close();
}
if(s2_nac_used>0){
u=dirnew +"\\s2_Francis_AC.out";
dir = u.c_str();
ofs.open(dir);
used_cnt=0;
for(t=1;t<=s2_nac;t++){
 if(s2_use_ac(t)==1){
 used_cnt+=1;
 ofs<<s2_Neff_stage2_mult_index(used_cnt)<<endl;
 }
if(s2_use_ac(t)<=0) ofs<<"-99999"<<endl;
}
ofs.close();
}
if(coast_nac_used>0){
u=dirnew +"\\Coast_Francis_AC.out";
dir = u.c_str();
ofs.open(dir);
used_cnt=0;
for(t=1;t<=coast_nac;t++){
 if(coast_use_ac(t)==1){
   used_cnt+=1;
   ofs<<coast_Neff_stage2_mult_index(used_cnt)<<endl;
 }
 if(coast_use_ac(t)<=0) ofs<<"-99999"<<endl;
}
 ofs.close();
}

u=dirnew +"\\Stock_Comp_Francis.out";
```

```
 dir = u.c_str();
 ofs.open(dir);
 ofs<<coast_Neff_stage2_mult_stock_comp<<endl;
 ofs.close();

 ofs.close();

 u=dirnew + "\\s1_emig_probs.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s1_emig_probs(y,a)<<" ";
     if(a==nages) ofs<<s1_emig_probs(y,a)<<endl;
    }
   }
 ofs.close();

 u=dirnew + "\\s1_ssb_wgts.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s1_bay_ssb_wgts(y,a)<<" ";
     if(a==nages) ofs<<s1_bay_ssb_wgts(y,a)<<endl;
    }
   }
 ofs.close();

 u=dirnew + "\\coast_ssb_wgts.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<coast_ssb_wgts(y,a)<<" ";
     if(a==nages) ofs<<coast_ssb_wgts(y,a)<<endl;
    }
   }
 ofs.close();


//################# Ouput observed data #######################
  u=dirnew +"\\s1_bay_total_catch.out";
  dir = u.c_str();
  ofs.open(dir);
  ofs<<s1_bay_total_catch<<endl;
  ofs.close();

  u=dirnew +"\\s1_bay_catch_paa.out";
  dir = u.c_str();
  ofs.open(dir);
  for(t=1;t<=substructure;t++){
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<s1_bay_catch_paa(t,y,a)<<" ";
     if(a==nages) ofs<<s1_bay_catch_paa(t,y,a)<<endl;
    }
   }
 }
 ofs.close();

  u=dirnew +"\\s1_bay_agg_index.out";
  dir = u.c_str();
  ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(t=1;t<=s1_bay_nagg;t++){
```

```
      if(t<s1_bay_nagg) ofs<<s1_bay_agg_index(y,t)<<" ";
      if(t==s1_bay_nagg) ofs<<s1_bay_agg_index(y,t)<<endl;
    }
   }
 ofs.close();

 u=dirnew +"\\s1_bay_ac_index.out";
 dir = u.c_str();
 ofs.open(dir);
 for(y=styr;y<=endyr;y++){
   for(t=1;t<=s1_bay_nac;t++){
      if(t<s1_bay_nac) ofs<<s1_bay_ac_index(y,t)<<" ";
      if(t==s1_bay_nac) ofs<<s1_bay_ac_index(y,t)<<endl;
    }
   }
 ofs.close();


  u=dirnew +"\\s1_bay_ac_index_paa.out";
 dir = u.c_str();
 ofs.open(dir);
  for(t=1;t<=s1_bay_nac;t++){
    for(y=styr;y<=endyr;y++){
     for(a=1;a<=nages;a++){
       if(a<nages) ofs<<s1_bay_ac_index_paa(t,y,a)<<" ";
      if(a==nages) ofs<<s1_bay_ac_index_paa(t,y,a)<<endl;
   }
  }
 }
ofs.close();

 u=dirnew +"\\s2_agg_index.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(t=1;t<=s2_nagg;t++){
      if(t<s2_nagg) ofs<<s2_agg_index(y,t)<<" ";
      if(t==s2_nagg) ofs<<s2_agg_index(y,t)<<endl;
    }
   }
 ofs.close();

 u=dirnew +"\\s2_ac_index.out";
 dir = u.c_str();
 ofs.open(dir);
    for(y=styr;y<=endyr;y++){
     for(t=1;t<=s2_nac;t++){
      if(t<s2_nac) ofs<<s2_ac_index(y,t)<<" ";
      if(t==s2_nac) ofs<<s2_ac_index(y,t)<<endl;
     }
   }
ofs.close();

 u=dirnew +"\\s2_ac_index_paa.out";
 dir = u.c_str();
 ofs.open(dir);
  for(t=1;t<=s2_nac;t++){
    for(y=styr;y<=endyr;y++){
     for(a=1;a<=nages;a++){
       if(a<nages) ofs<<s2_ac_index_paa(t,y,a)<<" ";
      if(a==nages) ofs<<s2_ac_index_paa(t,y,a)<<endl;
     }
   }
 }
ofs.close();
//COAST
```

```
 u=dirnew +"\\coast_total_catch.out";
 dir = u.c_str();
 ofs.open(dir);
 ofs<<coast_total_catch<<endl;
 ofs.close();

 u=dirnew +"\\coast_catch_paa.out";
 dir = u.c_str();
 ofs.open(dir);
 for(t=1;t<=ncoastwaves;t++){
 for(y=styr;y<=endyr;y++){
  for(a=1;a<=nages;a++){
   if(a<nages) ofs<<coast_catch_paa(t,y,a)<<" ";
   if(a==nages) ofs<<coast_catch_paa(t,y,a)<<endl;
  }
 }
}
ofs.close();

 u=dirnew +"\\coast_agg_index.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(t=1;t<=coast_nagg;t++){
      if(t<coast_nagg) ofs<<coast_agg_index(y,t)<<" ";
      if(t==coast_nagg) ofs<<coast_agg_index(y,t)<<endl;
    }
   }
 ofs.close();

 u=dirnew +"\\coast_ac_index.out";
 dir = u.c_str();
 ofs.open(dir);
  for(y=styr;y<=endyr;y++){
    for(t=1;t<=coast_nac;t++){
      if(t<coast_nac) ofs<<coast_ac_index(y,t)<<" ";
      if(t==coast_nac) ofs<<coast_ac_index(y,t)<<endl;
    }
   }
 ofs.close();


  u=dirnew +"\\coast_ac_index_paa.out";
 dir = u.c_str();
 ofs.open(dir);
  for(t=1;t<=coast_nac;t++){
    for(y=styr;y<=endyr;y++){
     for(a=1;a<=nages;a++){
       if(a<nages) ofs<<coast_ac_index_paa(t,y,a)<<" ";
      if(a==nages) ofs<<coast_ac_index_paa(t,y,a)<<endl;
    }
  }
 }
ofs.close();


 u=dirnew +"\\stock_composition.out";
 dir = u.c_str();
 ofs.open(dir);
 ofs<<stock_composition<<endl;
 ofs.close();

 u=dirnew +"\\SSB.out";
 dir = u.c_str();
 ofs.open(dir);
 for(y=styr;y<=endyr;y++){
```

```
 ofs<<s1_femSSB(y)<<" "<<s2_femSSB(y)<<endl;
 }
 ofs.close();

//-------------------------------For reference points-----------------------
 u=dirnew +"\\s1_bay_N_refpt.out";
 dir = u.c_str();
 ofs.open(dir);
 p=nyr1cnt;
 for(a=1;a<=nages;a++){
  ofs<<s1_bay_Nwv46(endyr,a)*mfexp(-s1_bay_Z(3,endyr,a))<<" "<<sigma(p,1)<<endl;
  p+=1;
 }
 ofs.close();

 u=dirnew +"\\s1_bay_N_female_refpt.out";
 dir = u.c_str();
 ofs.open(dir);
 for(a=1;a<=nages;a++){
  ofs<<s1_bay_Nwv46(endyr,a)*mfexp(-s1_bay_Z(3,endyr,a))*s1_bay_prop_female(3,endyr,a)<<" "<<sigma(p,1)<<endl;
  p+=1;
 }
 ofs.close();

 u=dirnew +"\\s1_bay_N_male_refpt.out";
 dir = u.c_str();
 ofs.open(dir);
 for(a=1;a<=nages;a++){
  ofs<<s1_bay_Nwv46(endyr,a)*mfexp(-s1_bay_Z(3,endyr,a))*(1.-s1_bay_prop_female(3,endyr,a))<<" "<<sigma(p,1)<<endl;
  p+=1;
 }
 ofs.close();

 u=dirnew +"\\s1_coast_N_refpt.out";
 dir = u.c_str();
 ofs.open(dir);
 for(a=1;a<=nages;a++){
  ofs<<s1_coast_Nwv46(endyr,a)*mfexp(-coast_Z(3,endyr,a))<<" "<<sigma(p,1)<<endl;
  p+=1;
 }
 ofs.close();

 u=dirnew +"\\s1_coast_N_female_refpt.out";
 dir = u.c_str();
 ofs.open(dir);
 for(a=1;a<=nages;a++){
  ofs<<s1_coast_Nwv46(endyr,a)*mfexp(-coast_Z(3,endyr,a))*coast_prop_female(3,endyr,a)<<" "<<sigma(p,1)<<endl;
  p+=1;
 }
 ofs.close();

 u=dirnew +"\\s1_coast_N_male_refpt.out";
 dir = u.c_str();
 ofs.open(dir);
 for(a=1;a<=nages;a++){
  ofs<<s1_coast_Nwv46(endyr,a)*mfexp(-coast_Z(3,endyr,a))*(1.-coast_prop_female(3,endyr,a))<<" "<<sigma(p,1)<<endl;
  p+=1;
  }
 ofs.close();


 u=dirnew +"\\s2_N_refpt.out";
 dir = u.c_str();
 ofs.open(dir);
 for(a=1;a<=nages;a++){
 ofs<<s2_Nwv46(endyr,a)*mfexp(-s2_Z(3,endyr,a))<<" "<<sigma(p,1)<<endl;
```

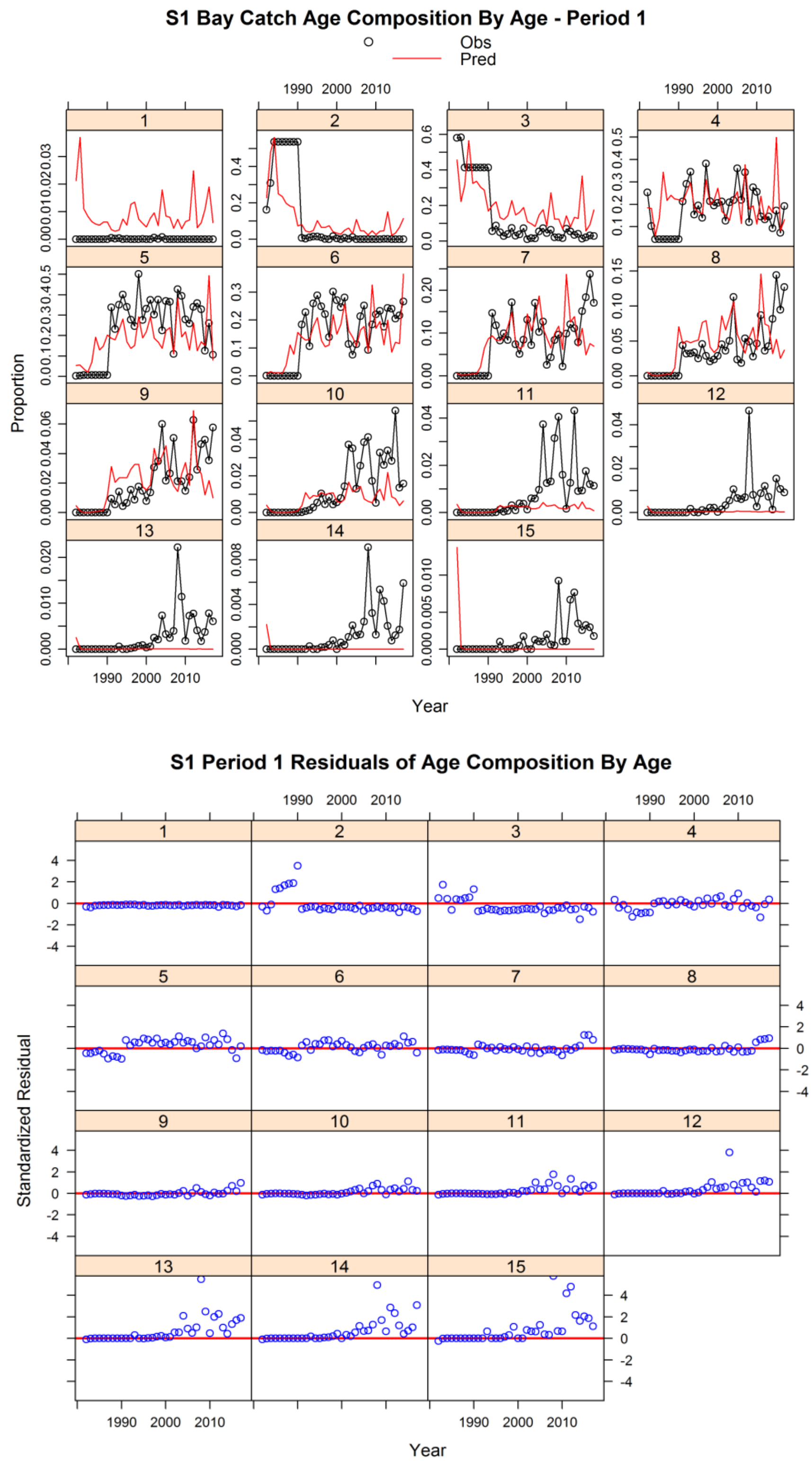
```
p+=1;
 }
ofs.close();

u=dirnew +"\\s2_N_female_refpt.out";
dir = u.c_str();
ofs.open(dir);
for(a=1;a<=nages;a++){
 ofs<<s2_Nwv46(endyr,a)*mfexp(-s2_Z(3,endyr,a))*s2_fem_sex(a)<<" "<<sigma(p,1)<<endl;
 p+=1;
  }
ofs.close();

u=dirnew +"\\s2_N_male_refpt.out";
dir = u.c_str();
ofs.open(dir);
for(a=1;a<=nages;a++){
  ofs<<s2_Nwv46(endyr,a)*mfexp(-s2_Z(3,endyr,a))*(1.-s2_fem_sex(a))<<" "<<sigma(p,1)<<endl;
 p+=1;
  }
ofs.close();
u=dirnew +"\\s1_bay_select_at_age_refpt.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=substructure;t++){
  ofs<<s1_bay_select_at_age(t,endyr)<<endl;
}
ofs.close();
u=dirnew +"\\coast_select_at_age_refpt.out";
dir = u.c_str();
ofs.open(dir);
for(t=1;t<=ncoastwaves;t++){
  ofs<<coast_select_at_age(t,endyr)<<endl;
}
ofs.close();

u=dirnew +"\\s1_R_refpt.out";
dir = u.c_str();
ofs.open(dir);
  for(y=styr;y<=endyr;y++){
     if(y<endyr) ofs<<s1_bay_N(y,1)<<" ";
     if(y==endyr) ofs<<s1_bay_N(y,1)<<endl;
    }
ofs.close();

u=dirnew +"\\s2_R_refpt.out";
dir = u.c_str();
ofs.open(dir);
  for(y=styr;y<=endyr;y++){
     if(y<endyr) ofs<<s2_N(y,1)<<" ";
     if(y==endyr) ofs<<s2_N(y,1)<<endl;
    }
ofs.close();
 u=dirnew +"\\s1_femssb_refpt.out";
dir = u.c_str();
ofs.open(dir);
  ofs<<sum(s1_ssb(endyr))<<endl;
ofs.close();

u=dirnew +"\\s2_femssb_refpt.out";
dir = u.c_str();
ofs.open(dir);
   ofs<<sum(s2_ssb(endyr))<<endl;
ofs.close();

u=dirnew +"\\s1_F_refpt.out";
```

```
  dir = u.c_str();
  ofs.open(dir);
    ofs<<sum(s1_bay_fullF(endyr))<<" "<<sum(coast_fullF(endyr))<<endl;
  ofs.close();

  u=dirnew +"\\s2_F_refpt.out";
  dir = u.c_str();
  ofs.open(dir);
    ofs<<sum(coast_fullF(endyr))<<endl;
  ofs.close();

  u=dirnew +"\\s1_mu_at_age.out";
  dir = u.c_str();
  ofs.open(dir);
  ofs<<s1_mu<<endl;
  ofs.close();

    //Average M at age
   for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     s1_avgM(y,a)=(s1_bay_M(y,a)+coast_M(y,a))/2;
    }
   }
 //checked 8/21/2018
  u=dirnew +"\\s1_stock_mu_F.out";
  dir = u.c_str();
  ofs.open(dir);
   for(y=styr;y<=endyr;y++){
    pgroup=0;
     for(a=1;a<=nages;a++){
       pgroup=s1_mu(y,a);
       if(pgroup==max(s1_mu(y))) cnt1=a;
     }
     FF=max(s1_mu(y));
     diff2=FF/2;
     cnt=0;
     sumdo=0.00001;
   while(cnt==0){
    ssq=max(s1_mu(y))-(FF/(FF+s1_avgM(y,cnt1))*(1-mfexp(-FF-s1_avgM(y,cnt1))));
   if(fabs(ssq)<=sumdo) cnt=1;
    if(cnt==0){
      if(ssq>0) FF=FF+diff2;
              if(ssq<0) FF=FF-diff2;
                diff2=diff2/2;
     }
   }
   ofs<<max(s1_mu(y))<<" "<<sigma(p,1)<<" "<<sigma(p,1)/max(s1_mu(y))<<" "<<FF<<"
"<<sqrt(square(sigma(p,1))*square(FF/max(s1_mu(y))))<<" "<<sqrt(square(sigma(p,1))*square(FF/max(s1_mu(y))))/FF<<"
"<<s1_avgM(y,cnt1)<<endl;
   p+=1;
   }
   ofs.close();

 //Stock 2
  u=dirnew +"\\s2_mu_at_age.out";
  dir = u.c_str();
  ofs.open(dir);
  ofs<<s2_mu<<endl;
  ofs.close();

   //checked 8/21/2018
  u=dirnew +"\\s2_stock_mu_F.out";
  dir = u.c_str();
  ofs.open(dir);
   for(y=styr;y<=endyr;y++){
    pgroup=0;
```

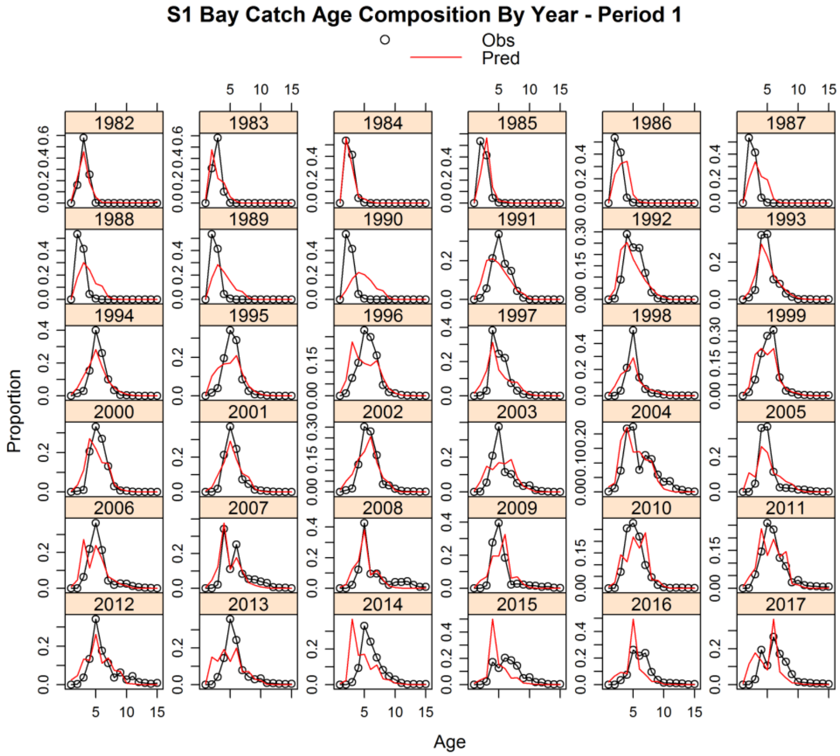
```
      for(a=1;a<=nages;a++){
        pgroup=s2_mu(y,a);
        if(pgroup==max(s2_mu(y))) cnt1=a;
      }
      FF=max(s2_mu(y));
      diff2=FF/2;
      cnt=0;
      sumdo=0.00001;
     while(cnt==0){
      ssq=max(s2_mu(y))-(FF/(FF+coast_M(y,cnt1))*(1-mfexp(-FF-coast_M(y,cnt1))));
     if(fabs(ssq)<=sumdo) cnt=1;
      if(cnt==0){
        if(ssq>0) FF=FF+diff2;
              if(ssq<0) FF=FF-diff2;
               diff2=diff2/2;
      }
    }
    ofs<<max(s2_mu(y))<<" "<<sigma(p,1)<<" "<<sigma(p,1)/max(s2_mu(y))<<" "<<FF<<"
"<<sqrt(square(sigma(p,1))*square(FF/max(s2_mu(y))))<<" "<<sqrt(square(sigma(p,1))*square(FF/max(s2_mu(y))))/FF<<"
"<<coast_M(y,cnt1)<<endl;
    p+=1;
    }
    ofs.close();
  //Combined Stocks
   u=dirnew +"\\comb_mu_at_age.out";
   dir = u.c_str();
   ofs.open(dir);
   ofs<<comb_mu<<endl;
   ofs.close();

    //checked 8/21/2018
   u=dirnew +"\\comb_stock_mu_F.out";
   dir = u.c_str();
   ofs.open(dir);
    for(y=styr;y<=endyr;y++){
      pgroup=0;
      for(a=1;a<=nages;a++){
        pgroup=comb_mu(y,a);
        if(pgroup==max(comb_mu(y))) cnt1=a;
      }
      FF=max(comb_mu(y));
      diff2=FF/2;
      cnt=0;
      sumdo=0.00001;
     while(cnt==0){
      ssq=max(comb_mu(y))-(FF/(FF+s1_avgM(y,cnt1))*(1-mfexp(-FF-s1_avgM(y,cnt1))));
     if(fabs(ssq)<=sumdo) cnt=1;
      if(cnt==0){
        if(ssq>0) FF=FF+diff2;
              if(ssq<0) FF=FF-diff2;
               diff2=diff2/2;
      }
    }
    ofs<<max(comb_mu(y))<<" "<<sigma(p,1)<<" "<<sigma(p,1)/max(comb_mu(y))<<" "<<FF<<"
"<<sqrt(square(sigma(p,1))*square(FF/max(comb_mu(y))))<<" "<<sqrt(square(sigma(p,1))*square(FF/max(comb_mu(y))))/FF<<"
"<<s1_avgM(y,cnt1)<<endl;
    p+=1;
    }
    ofs.close();

    u=dirnew +"\\number_of_output_parameters.out";
    dir = u.c_str();
    ofs.open(dir);
    ofs<<df<<endl;
    ofs.close();
```

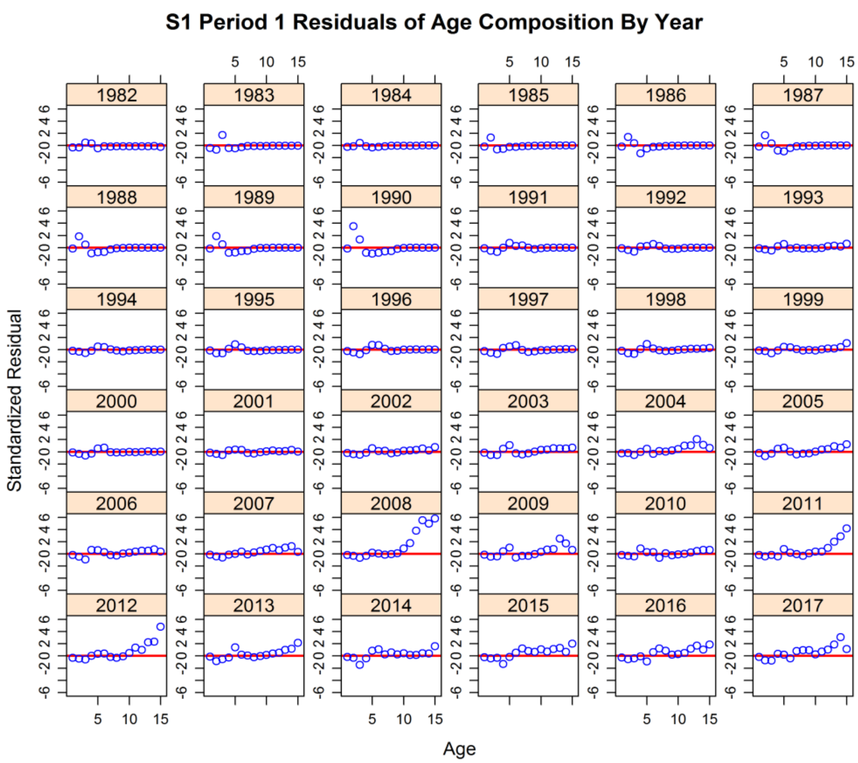
```
  u=dirnew +"\\run.out";
  dir = u.c_str();
  ofs.open(dir);
  for(y=styr;y<=endyr;y++){
  ofs<<max(s1_bay_F(1,y))<<" "<<max(s1_bay_F(2,y))<<" "<<max(s1_bay_F(3,y))<<" "<<max(coast_F(1,y))<<" "<<max(coast_F(2,y))<<"
"<<max(coast_F(3,y))<<" "<<s1_bay_R(y)<<" "<<s2_R(y)<<" "<<s1_femSSB(y)<<" "<<s2_femSSB(y)<<endl;
  }
  ofs.close();

  u=dirnew +"\\s1_sr.out";
  dir = u.c_str();
  ofs.open(dir);
  for(y=styr;y<=endyr-1;y++){
    ofs<<sum(s1_ssb(y))<<" "<<s1_bay_R(y+1)<<endl;
  }
  ofs.close();

  u=dirnew +"\\s2_sr.out";
  dir = u.c_str();
  ofs.open(dir);
  for(y=styr;y<=endyr-1;y++){
    ofs<<sum(s2_ssb(y))<<" "<<s2_R(y+1)<<endl;
  }
  ofs.close();
  u=dirnew + "\\coast_F_at_age.out";
 dir = u.c_str();
 ofs.open(dir);
 for(t=1;t<=substructure;t++){
  for(y=styr;y<=endyr;y++){
    for(a=1;a<=nages;a++){
     if(a<nages) ofs<<coast_F(t,y,a)<<" ";
     if(a==nages) ofs<<coast_F(t,y,a)<<endl;
    }
   }
 }
 ofs.close();
```

Appendix B9: Diagnostic Plots from the 2SCA Model for Atlantic Striped Bass

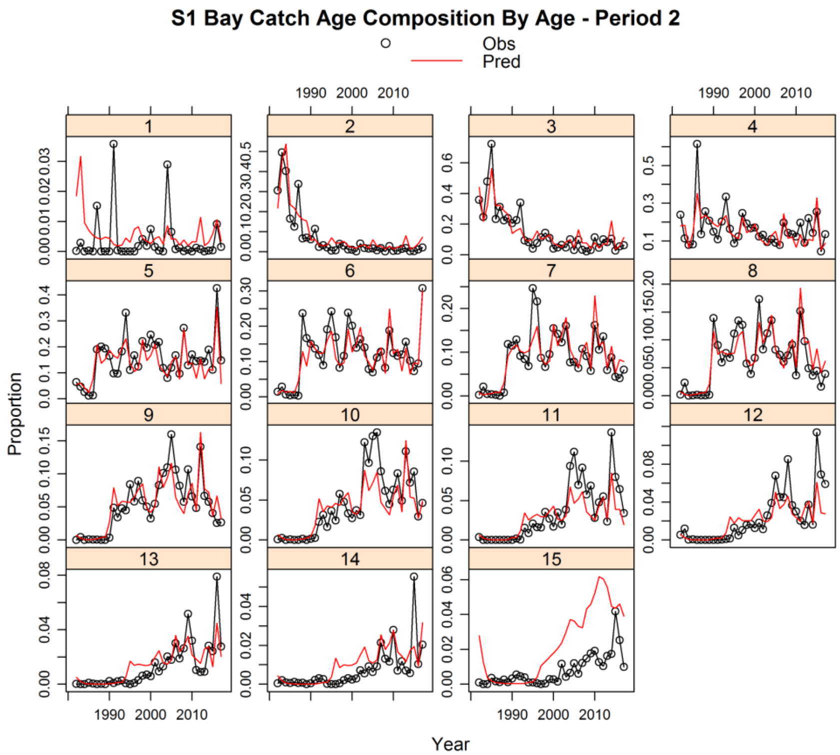


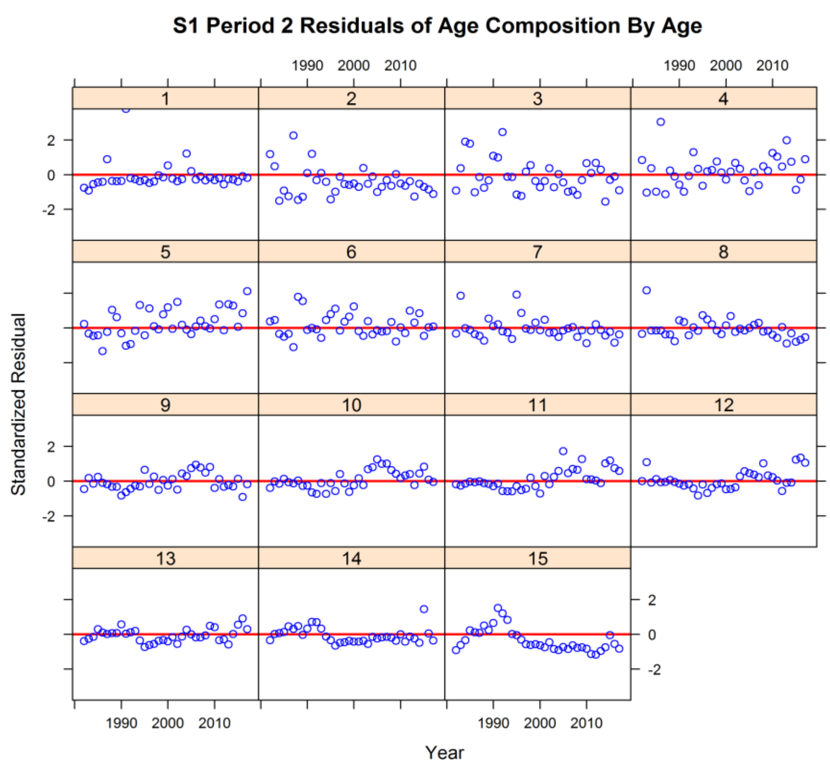
Appendix Figure 1. Observed and predicted estimate of total removal age composition by age and standardized residuals for Stock 1 Bay during period 1.



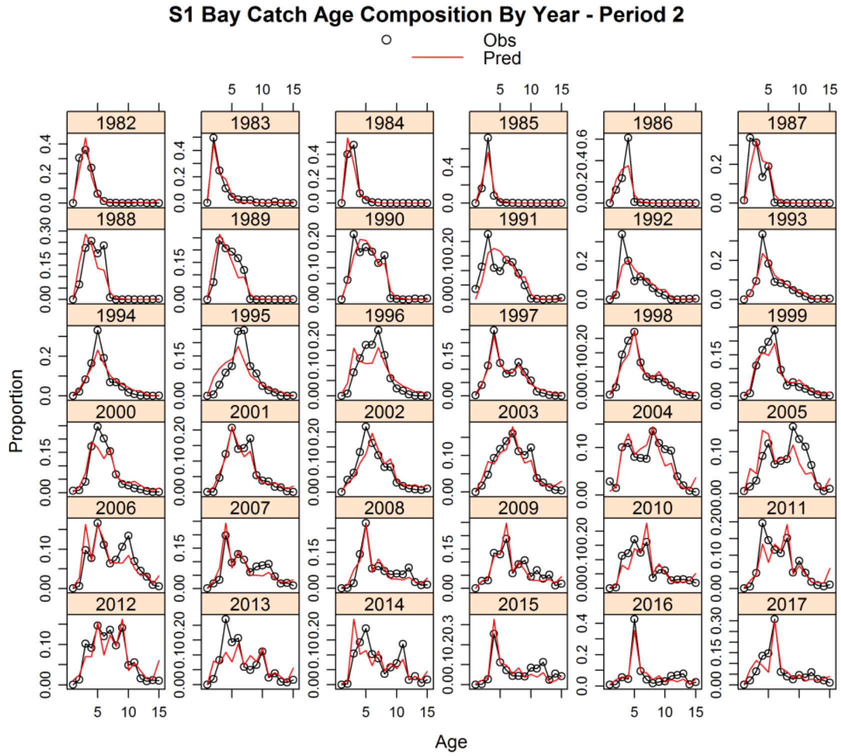


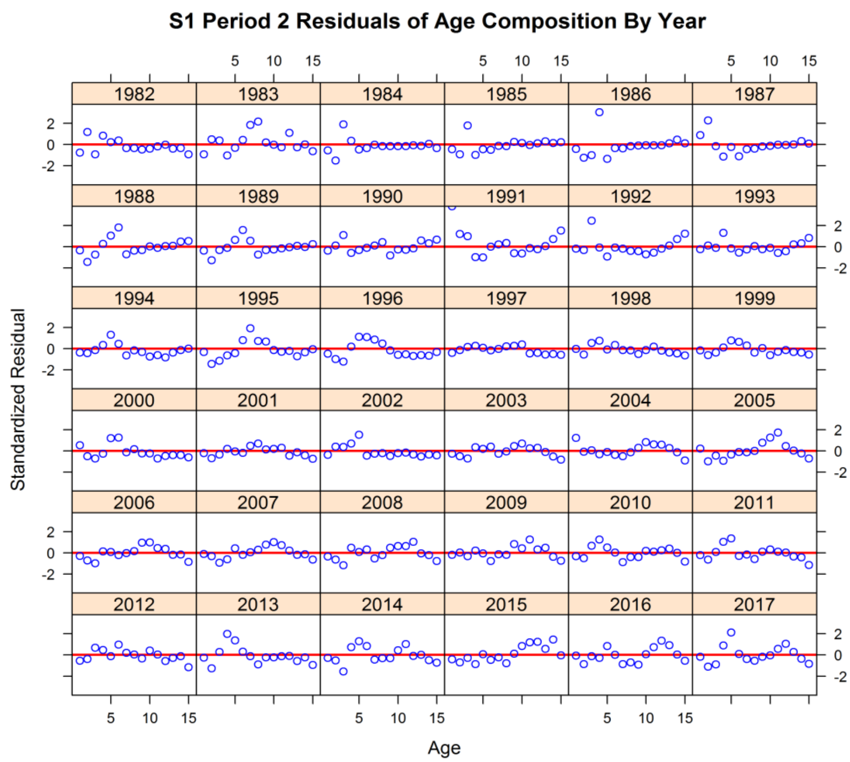
Appendix Figure 2. Observed and predicted estimate of total removal age composition by year and standardized residuals for Stock 1 Bay during period 1.



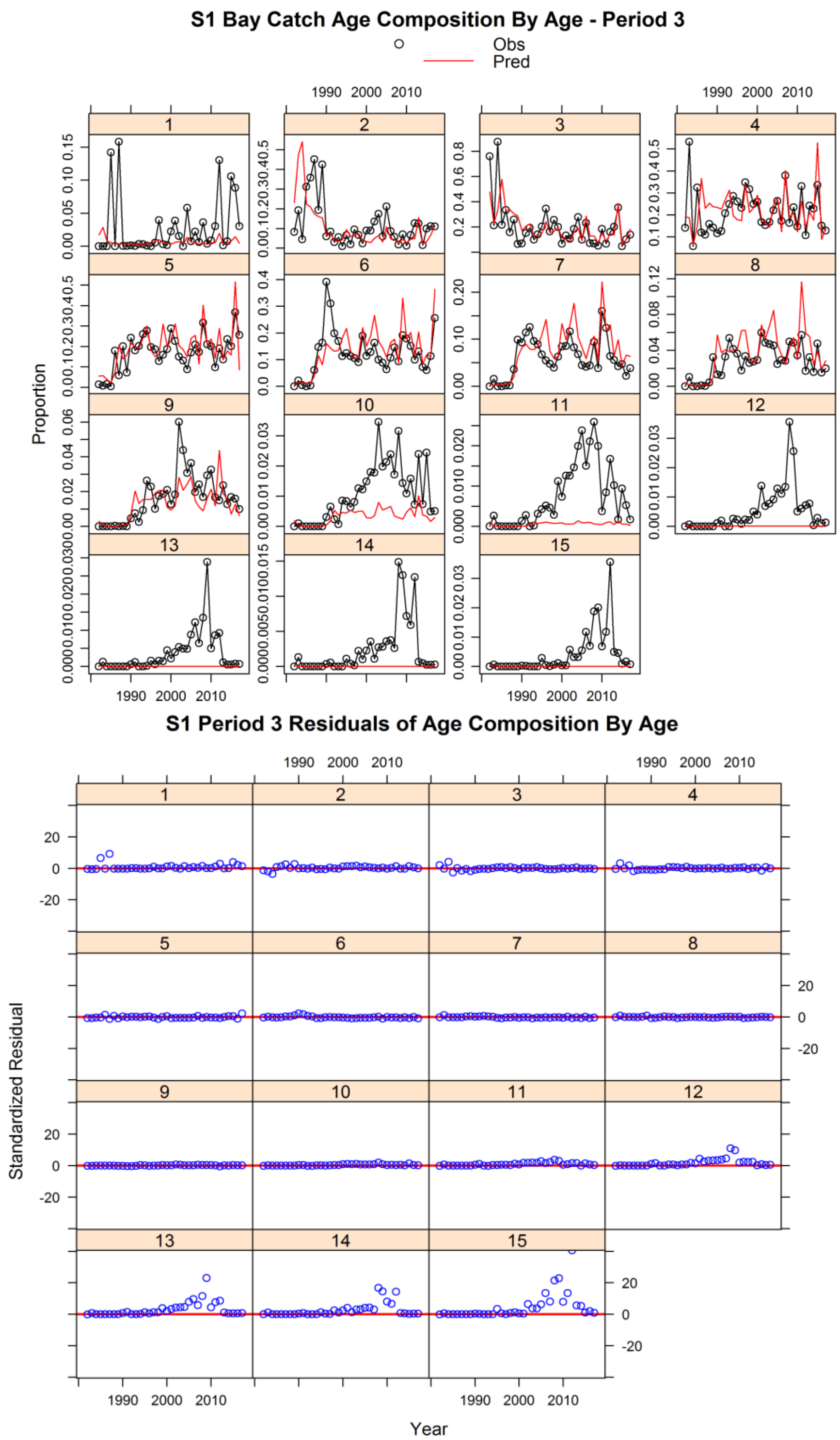


Appendix Figure 3. Observed and predicted estimate of total removal age composition by age and standardized residuals for Stock 1 Bay during period 2.

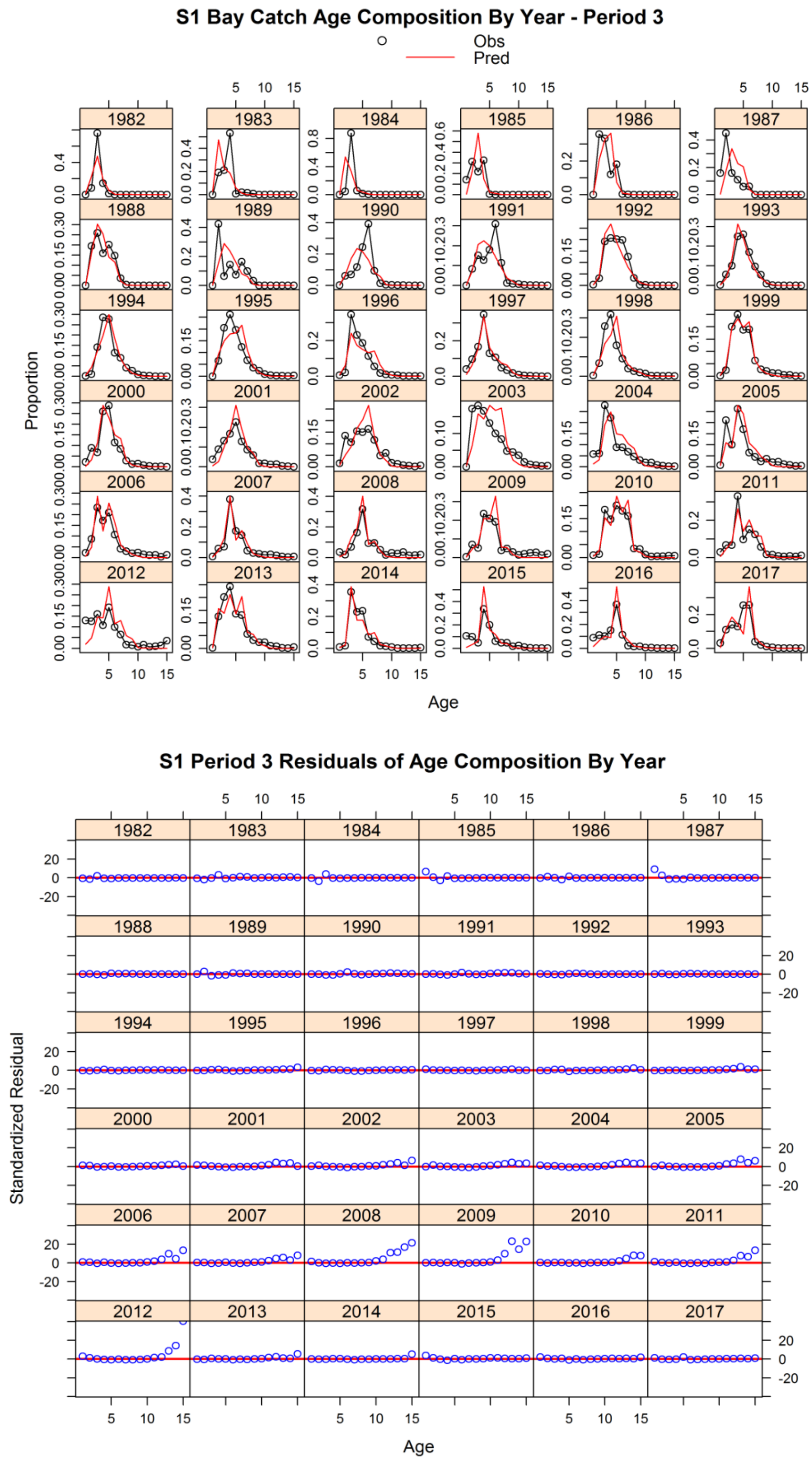




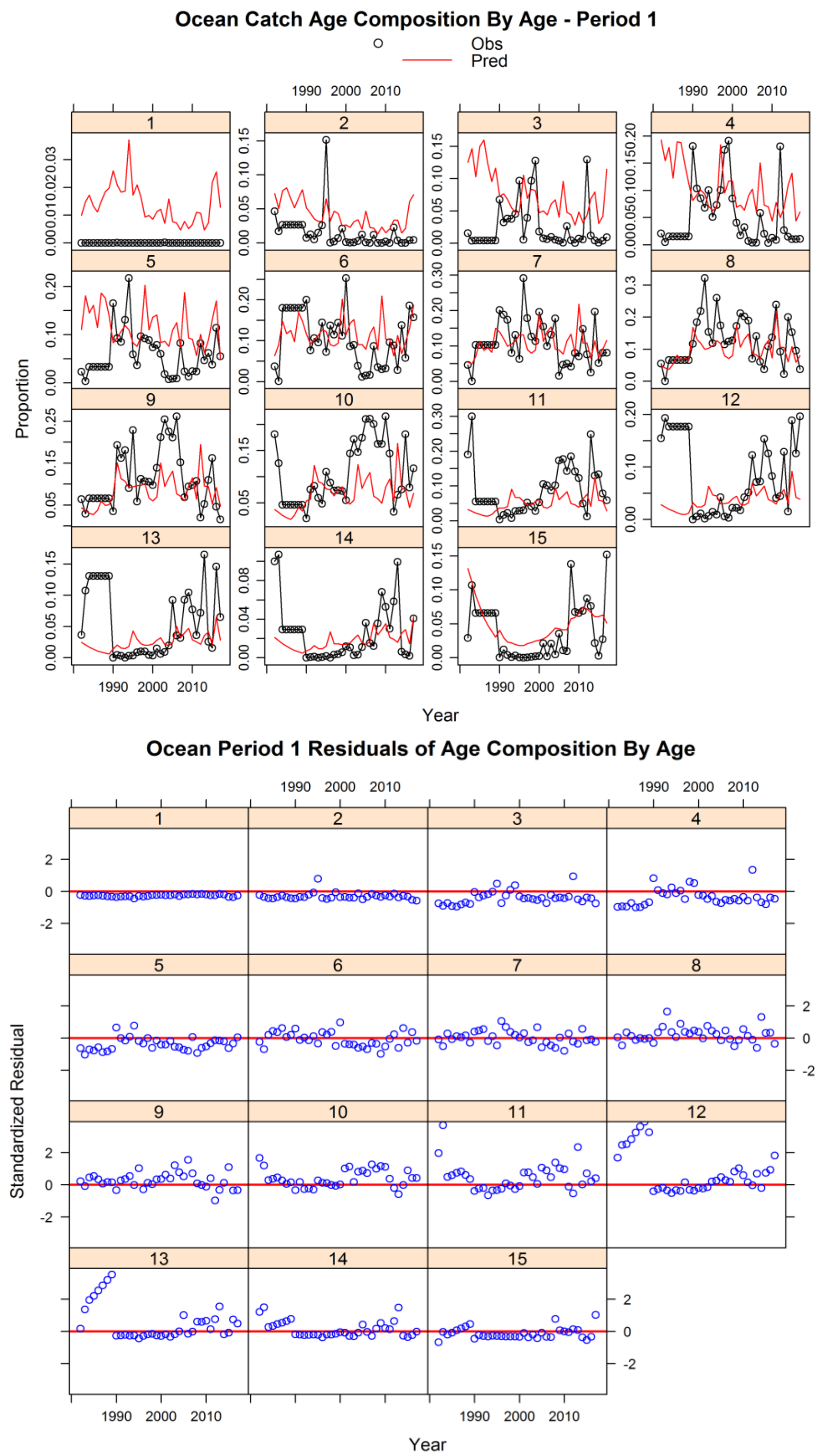
Appendix Figure 4. Observed and predicted estimate of total removal age composition by year and standardized residuals for Stock 1 Bay during period 2.



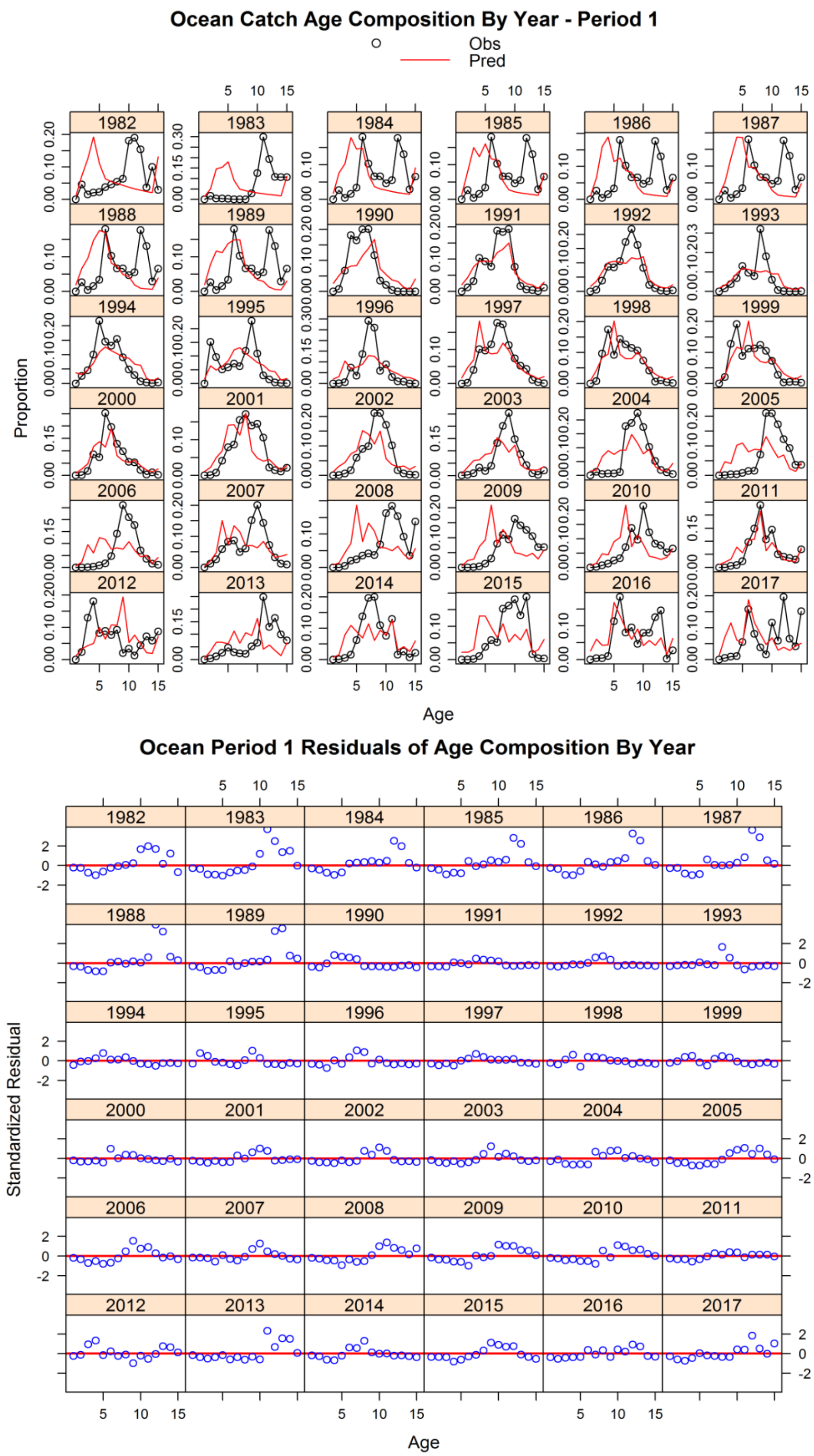
Appendix Figure 5. Observed and predicted estimate of total removal age composition by age and standardized residuals for Stock 1 Bay during period 3.



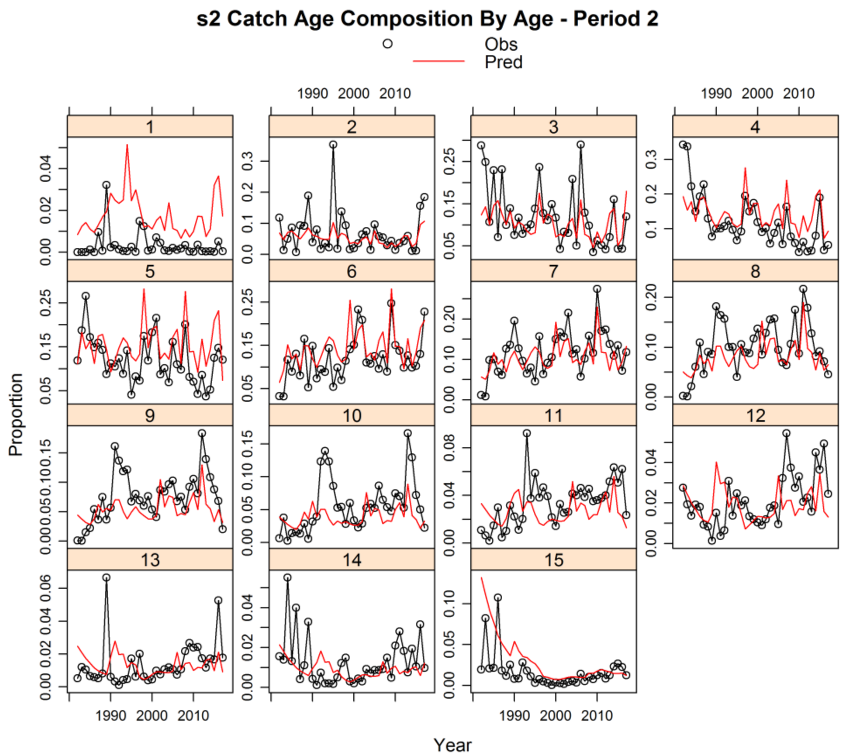
Appendix Figure 6. Observed and predicted estimate of total removal age composition by year and standardized residuals for Stock 1 Bay during period 3.

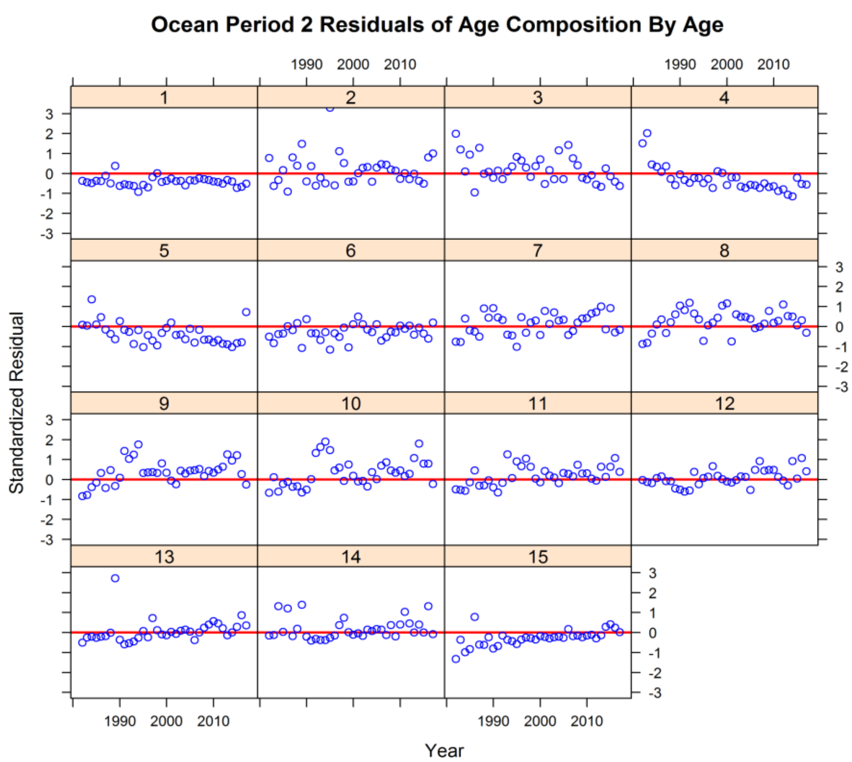


Appendix Figure 7. Observed and predicted estimate of total removal age composition by age and standardized residuals for Ocean during period 1.

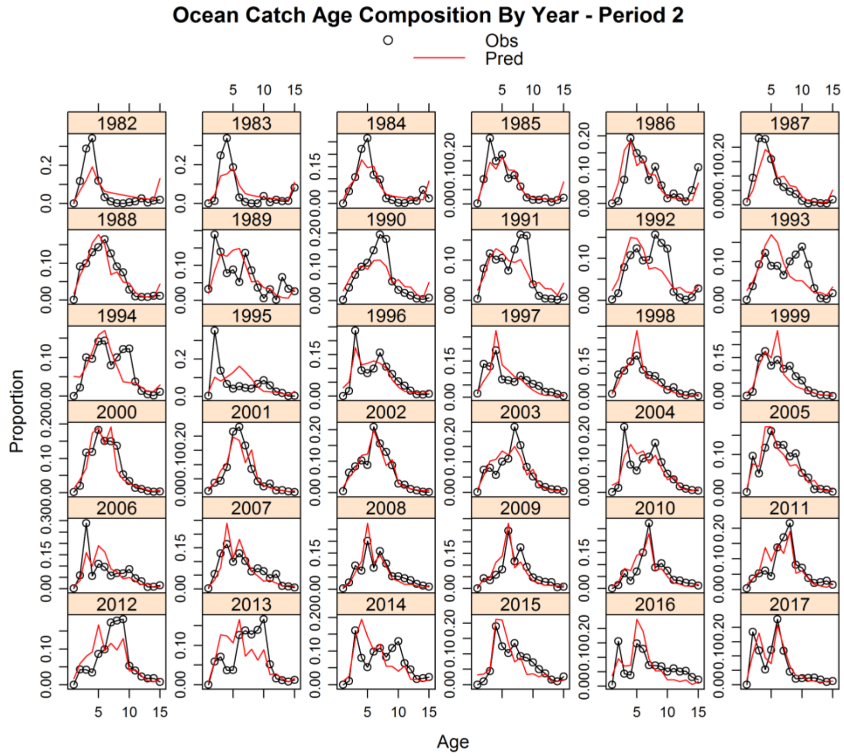


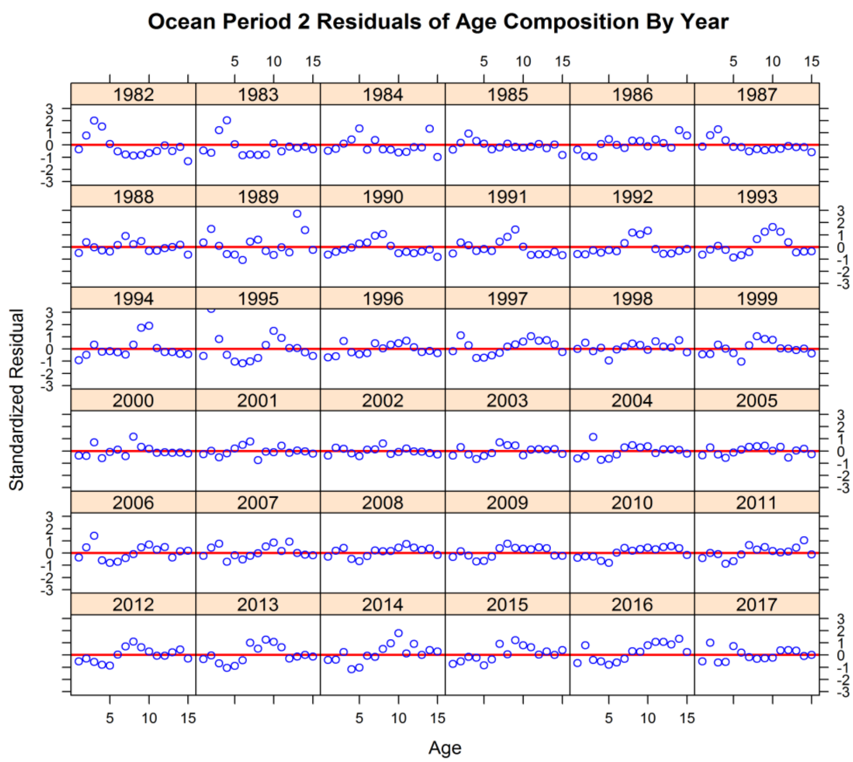
Appendix Figure 8. Observed and predicted estimate of total removal age composition by year and standardized residuals for Ocean during period 1.



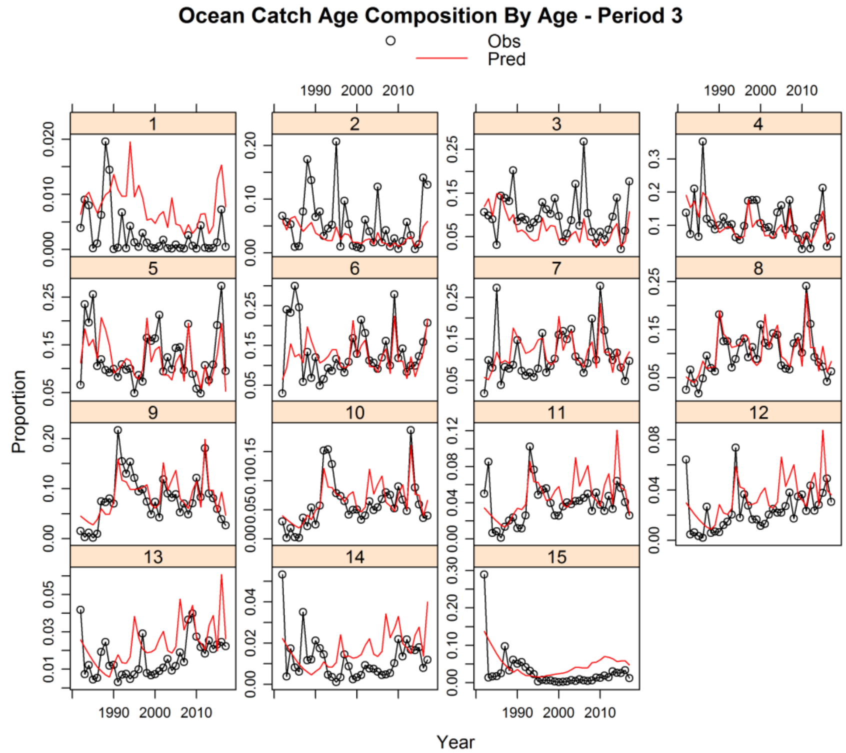


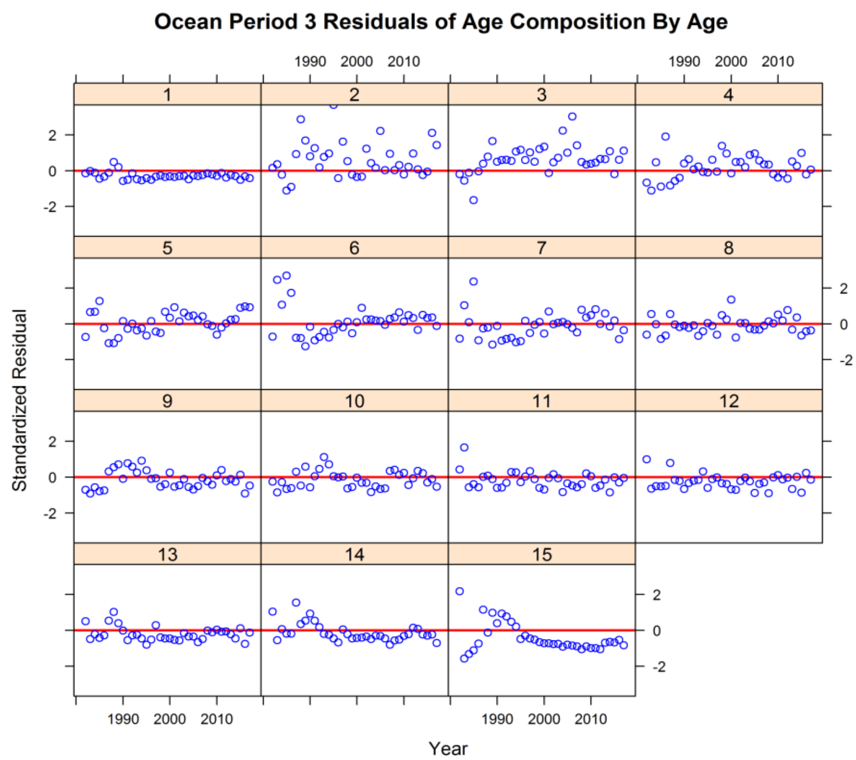
Appendix Figure 9. Observed and predicted estimate of total removal age composition by age and standardized residuals for Ocean during period 2.



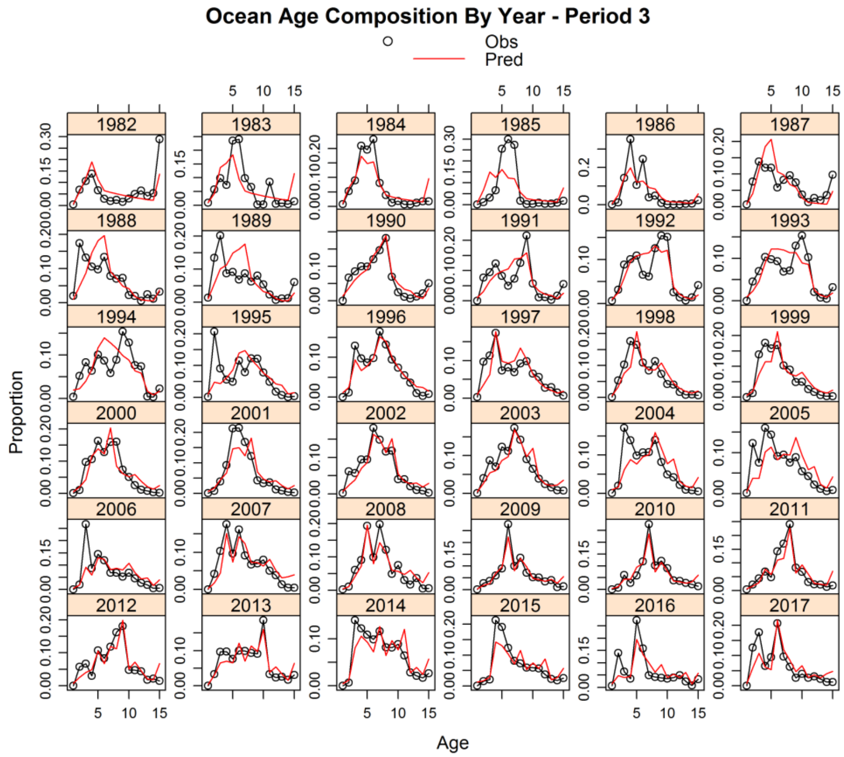


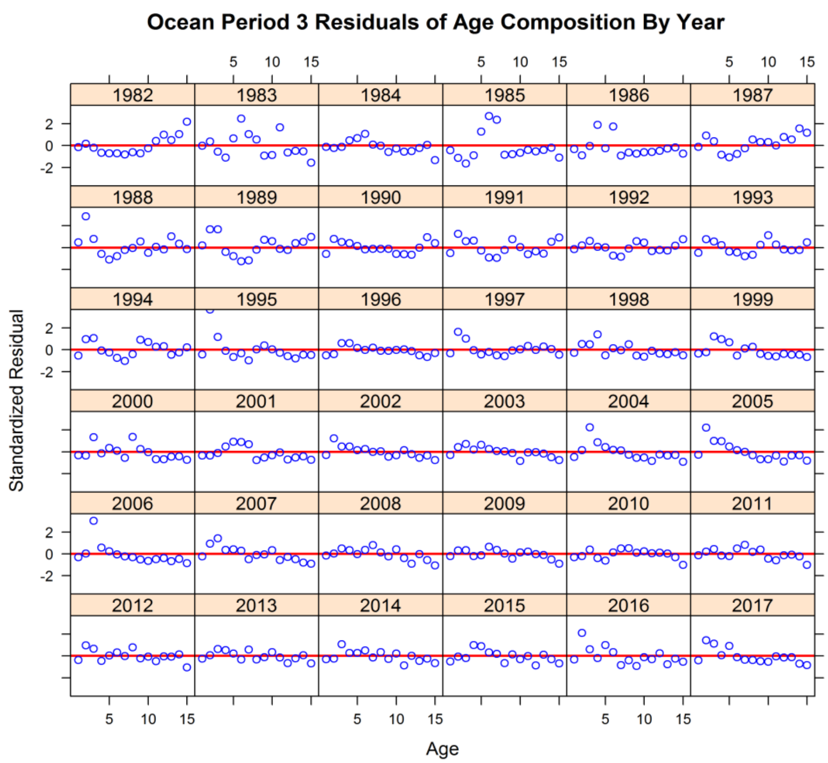
Appendix Figure 10. Observed and predicted estimate of total removal age composition by year and standardized residuals for Ocean during period 2.



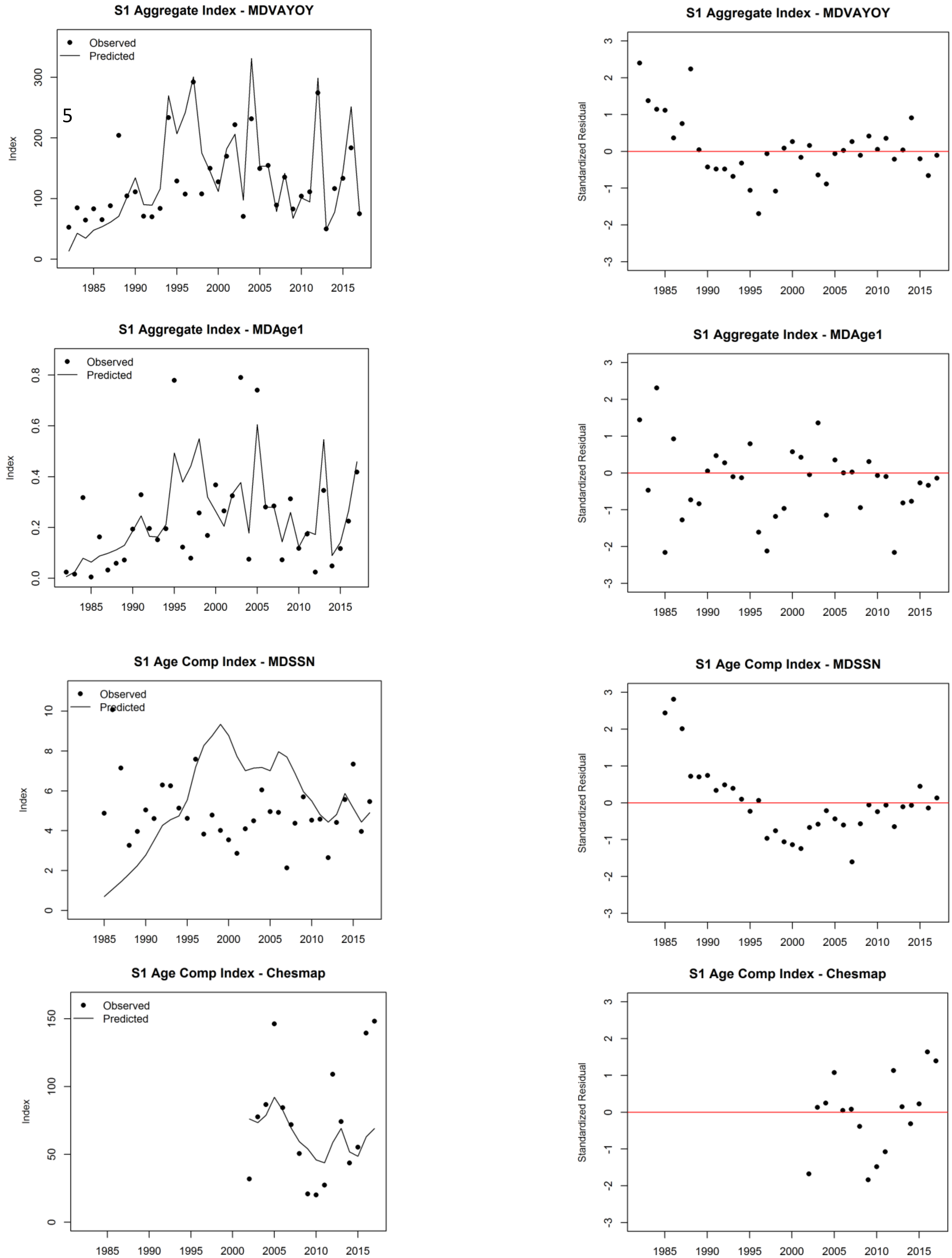


Appendix Figure 8. Observed and predicted estimate of total removal age composition by age and standardized residuals for Ocean during period 3.

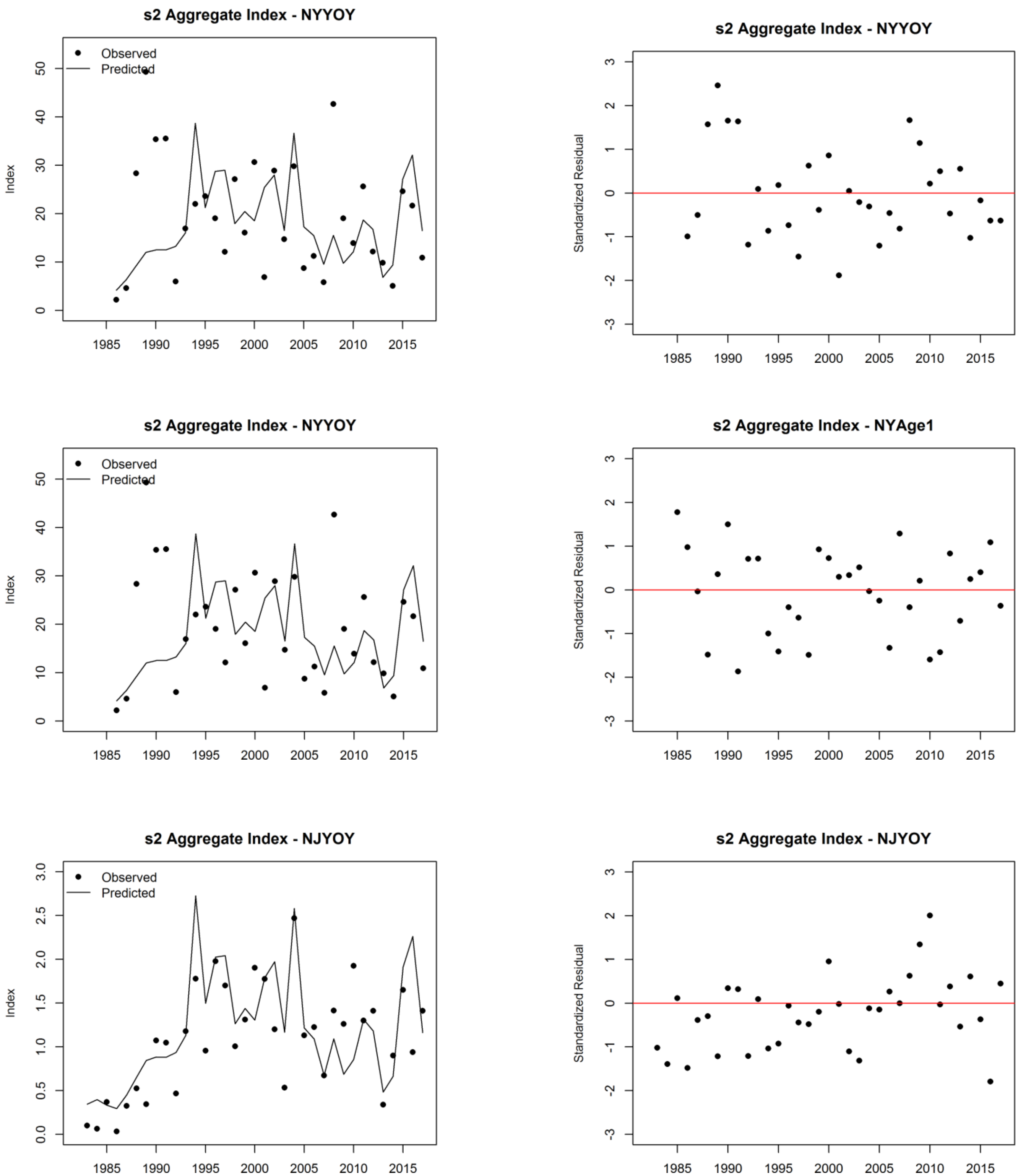




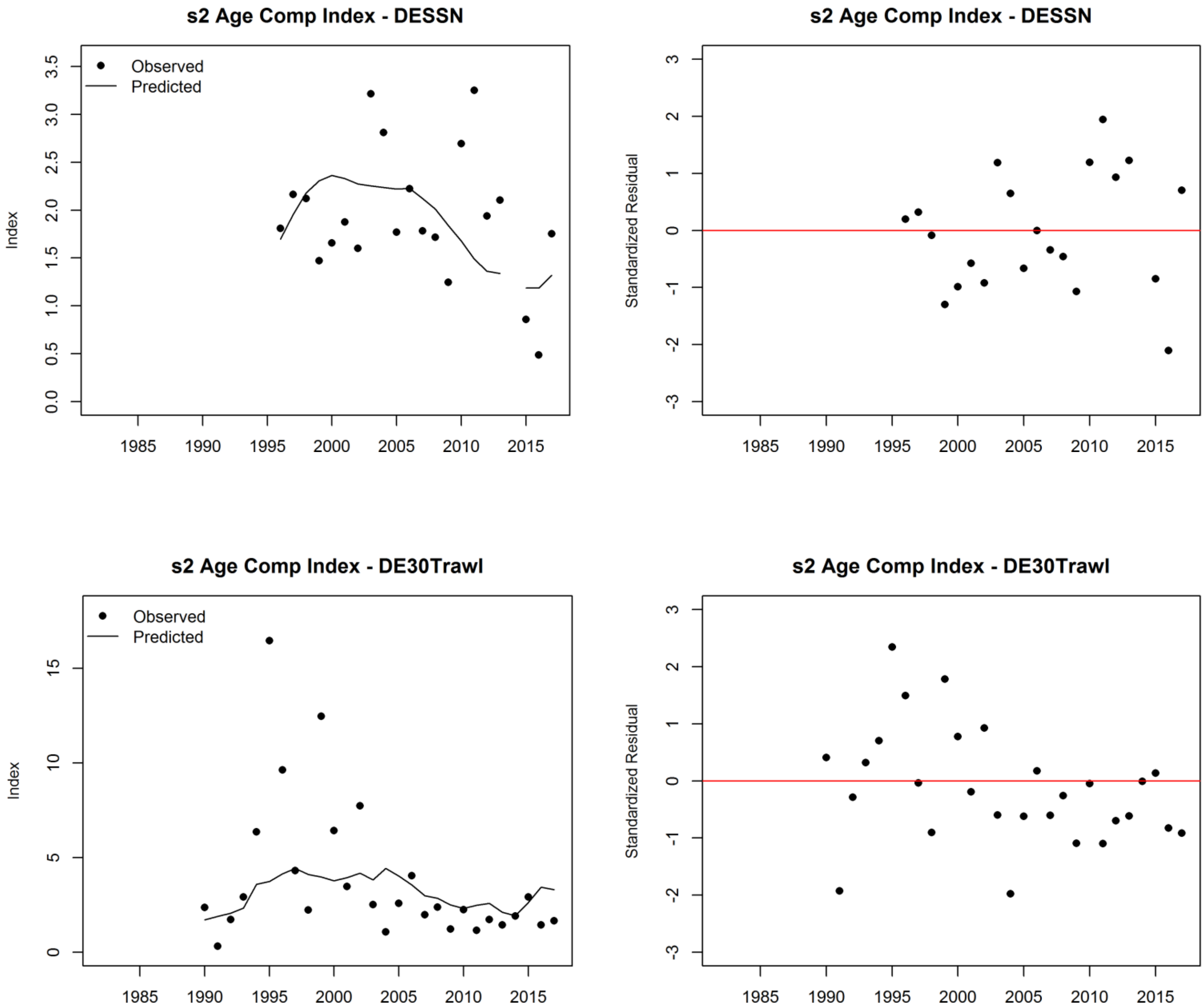
Appendix Figure 11. Observed and predicted estimate of total removal age composition by year and standardized residuals for Ocean during period 3.



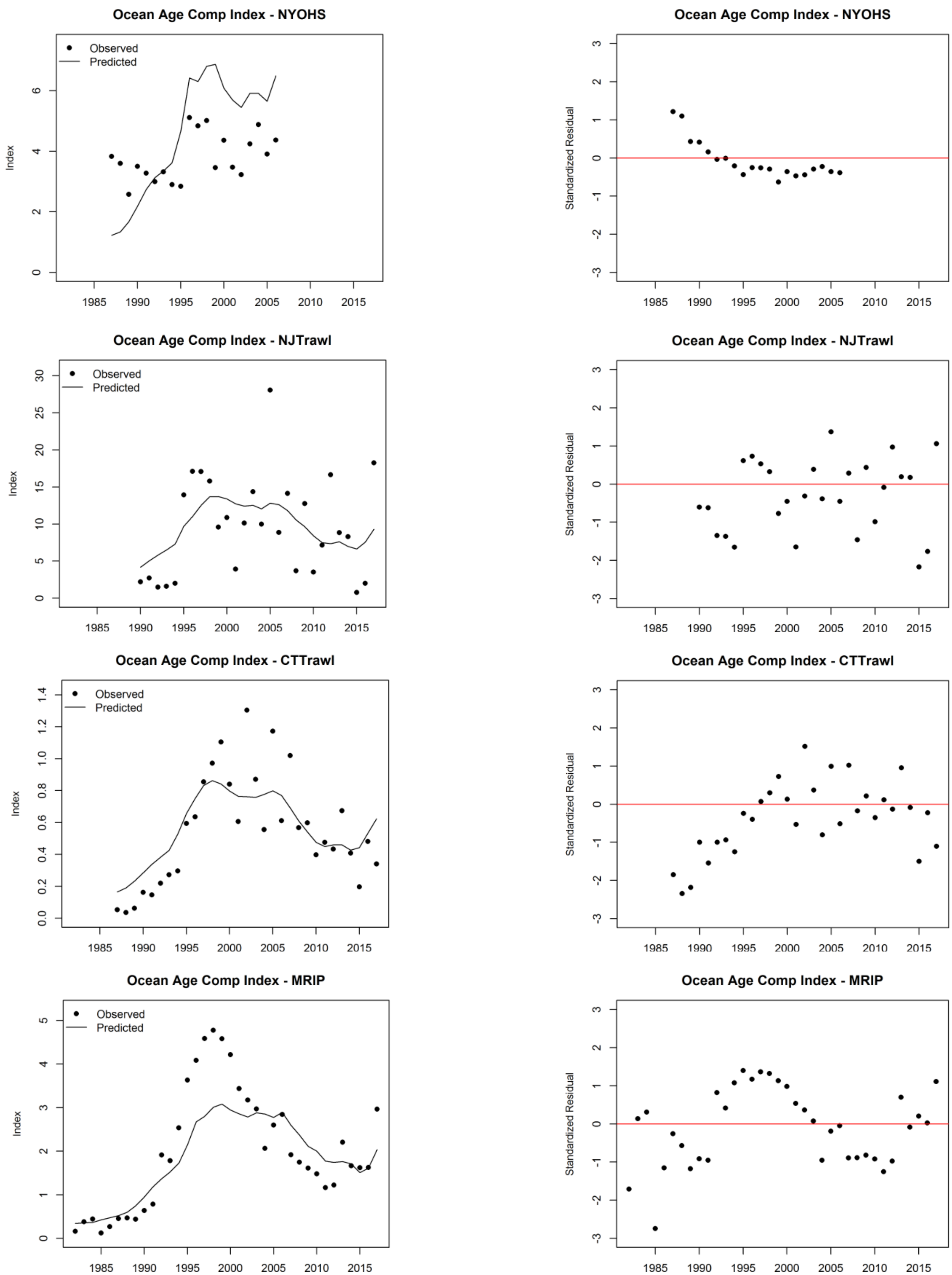
Appendix Figure 12. Observed and predicted indices for Stock 1 in the bay and standardized residual plots.



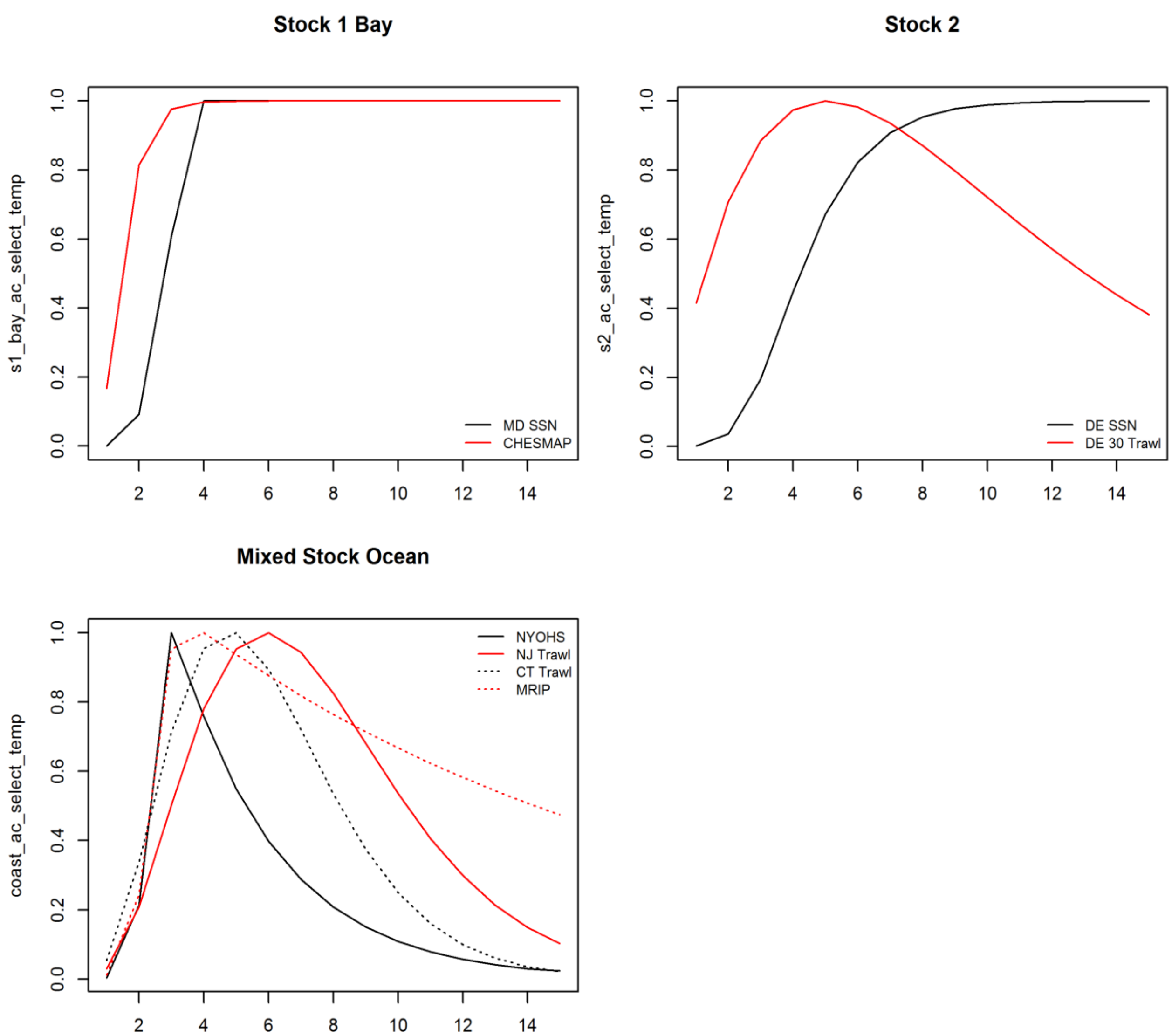
Appendix Figure 13. Observed and predicted YOY and age 1 indices for Stock 2 and standardized residual plots.



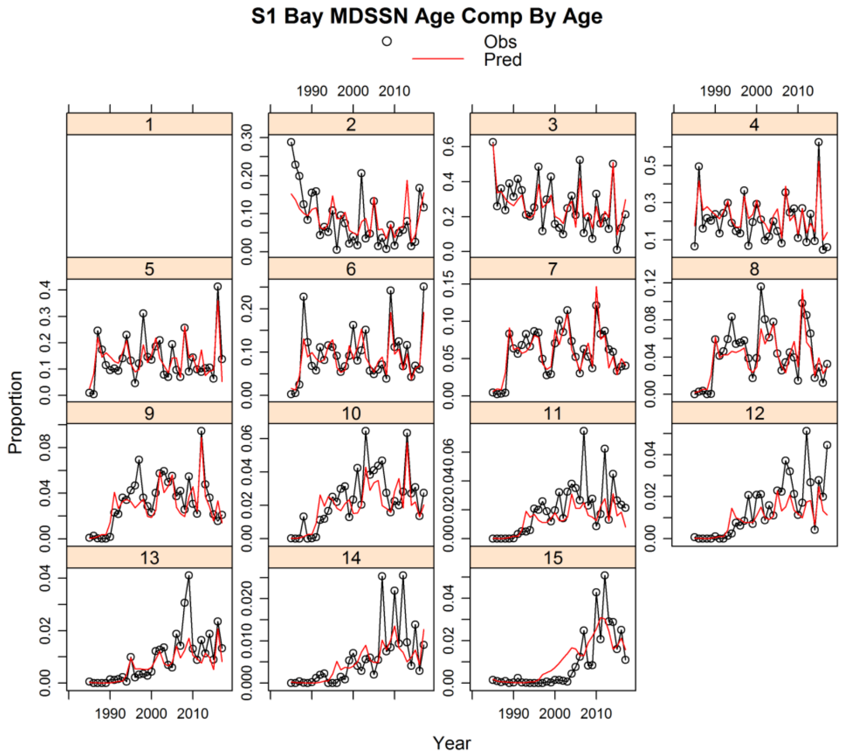
Appendix Figure 14. Observed and predicted age composition survey indices for Stock 2 and standardized residual plots.

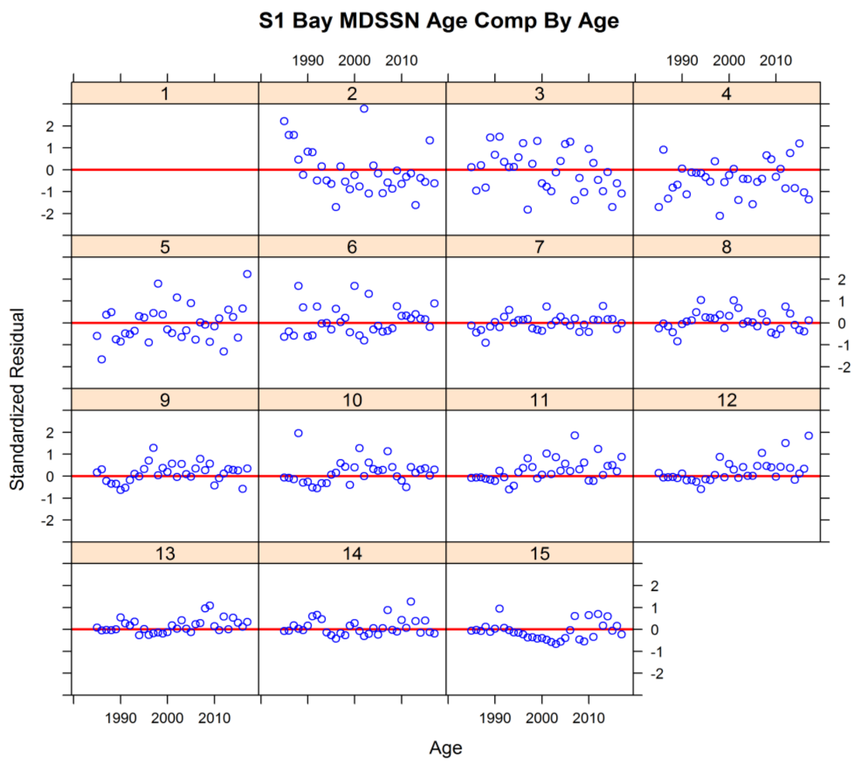


Appendix Figure 15. Observed and predicted age composition survey indices for Mixed Stock and standardized residual plots.

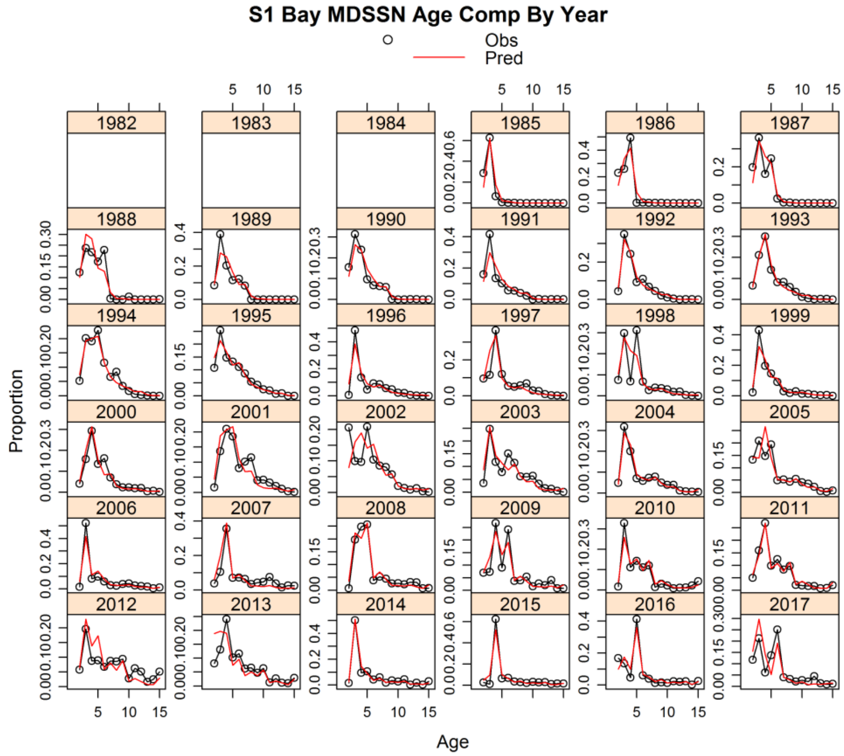


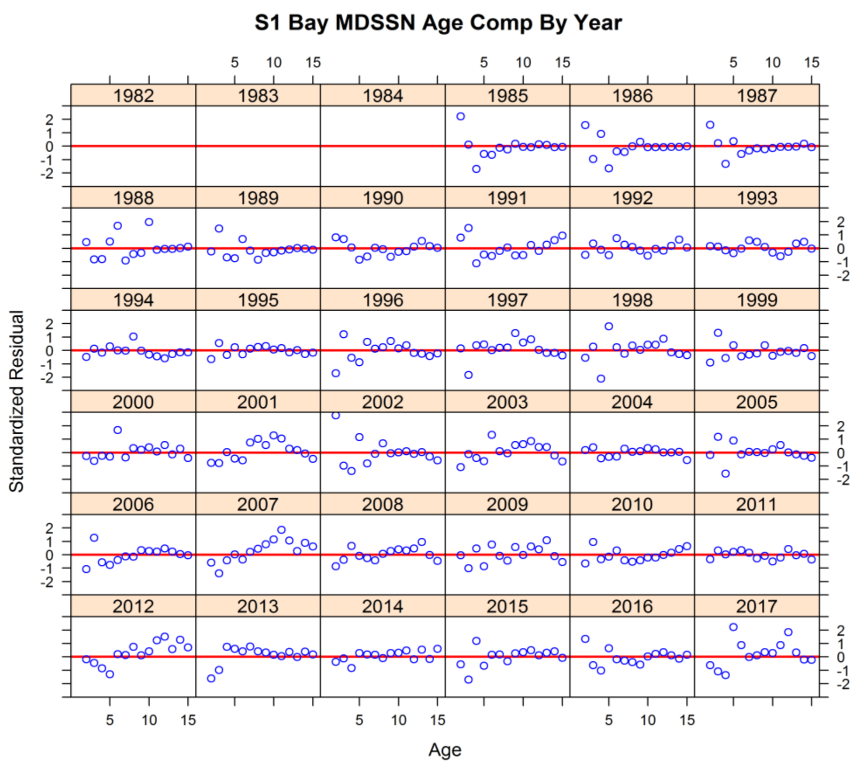
Appendix Figure 16. Selectivity pattern estimated for each age composition survey.



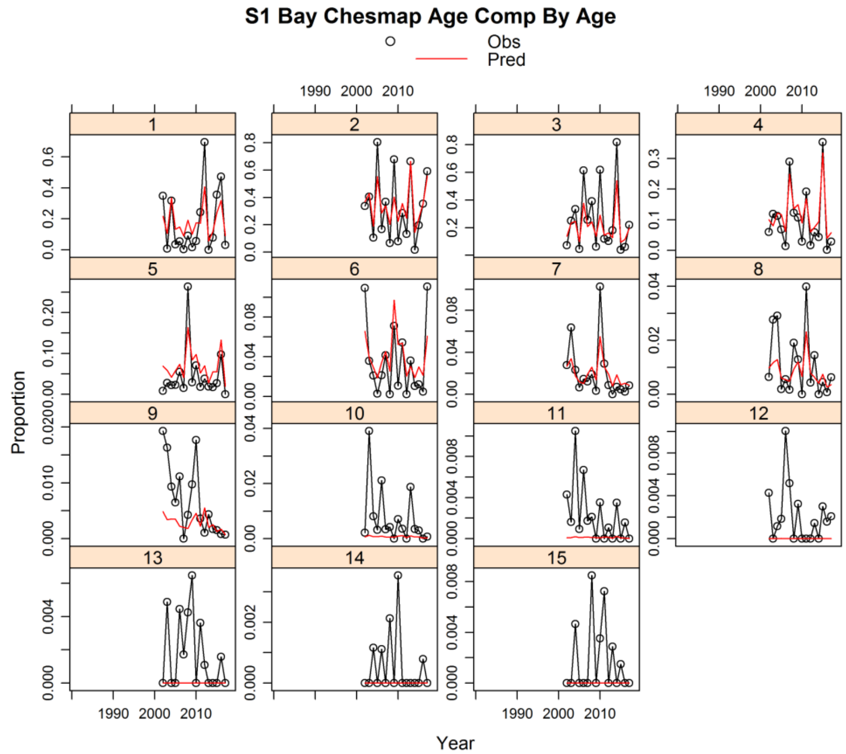


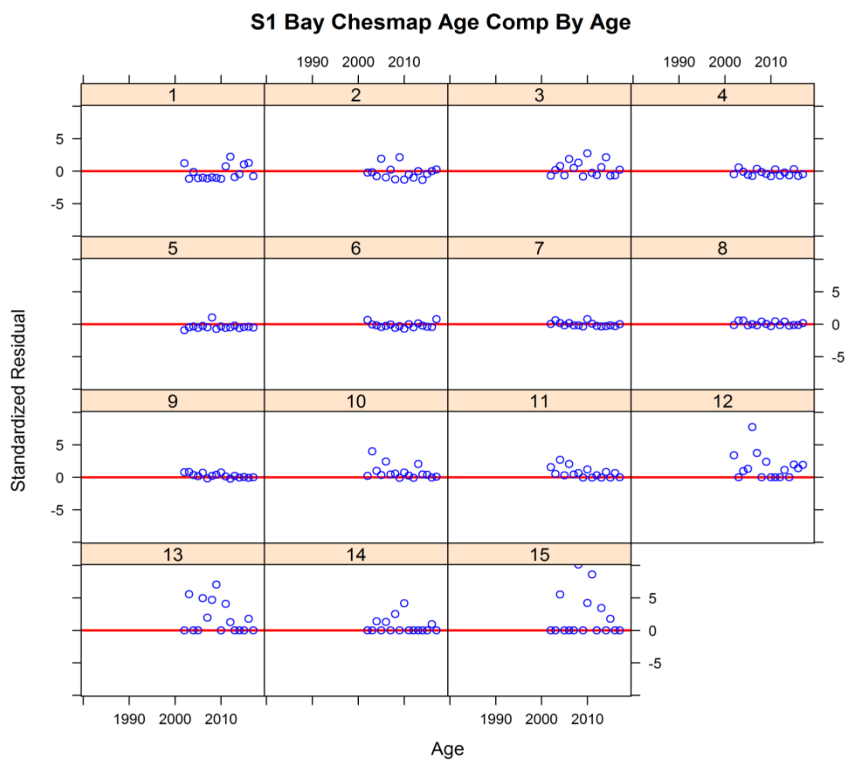
Appendix Figure 17. Observed and predicted age composition for the MDSSN surveys in stock 1 bay by age and standardized residual plots .



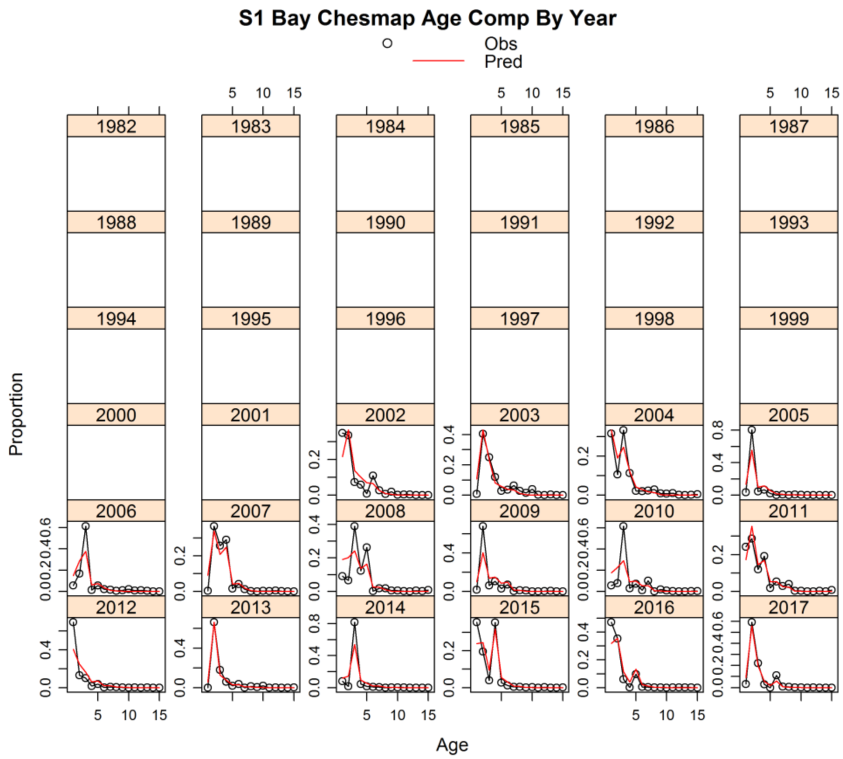


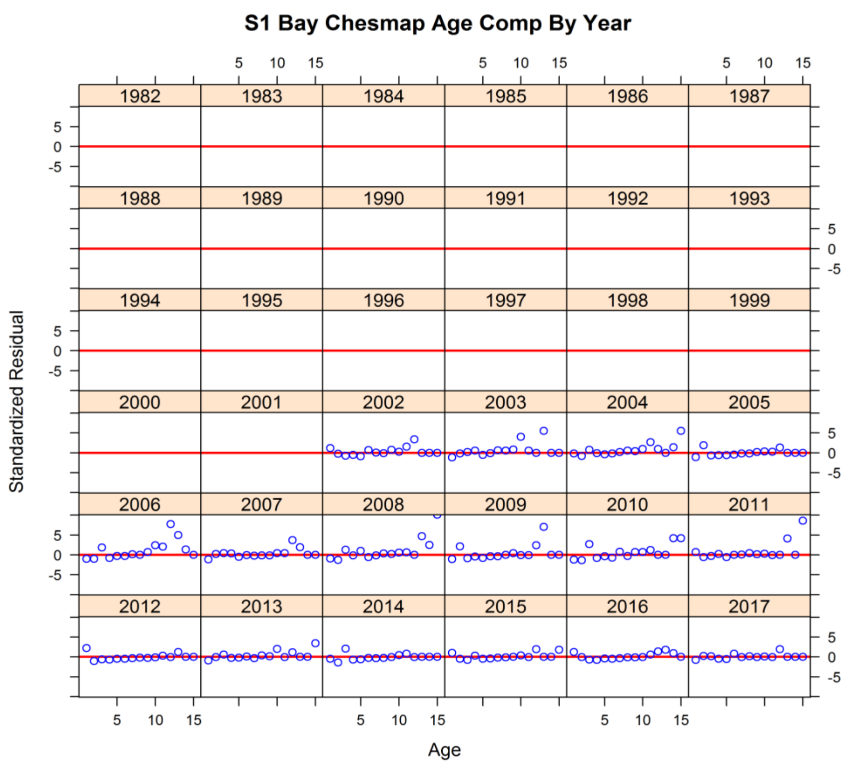
Appendix Figure 18. Observed and predicted age composition for the MDSSN surveys in stock 1 bay by year and standardized residual plots .



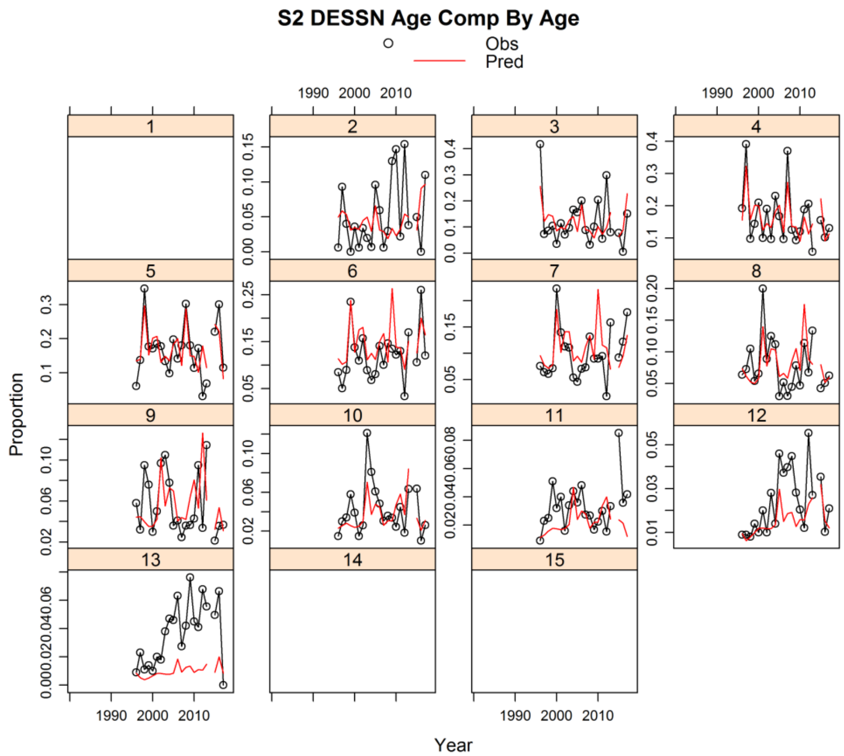


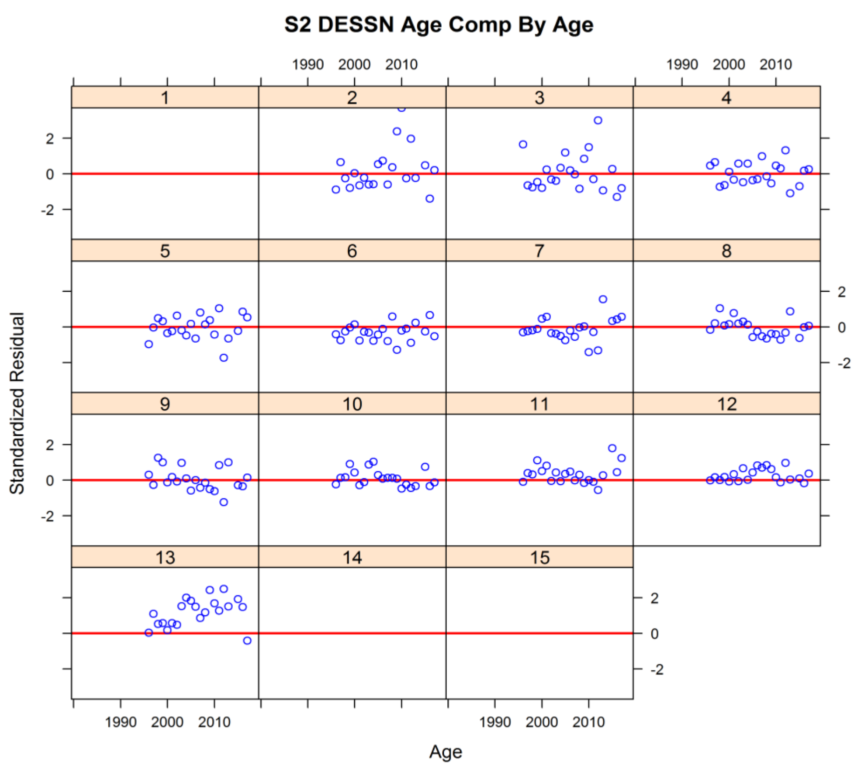
Appendix Figure 19. Observed and predicted age composition for the CHESMAP survey in stock 1 bay by age and standardized residual plots .



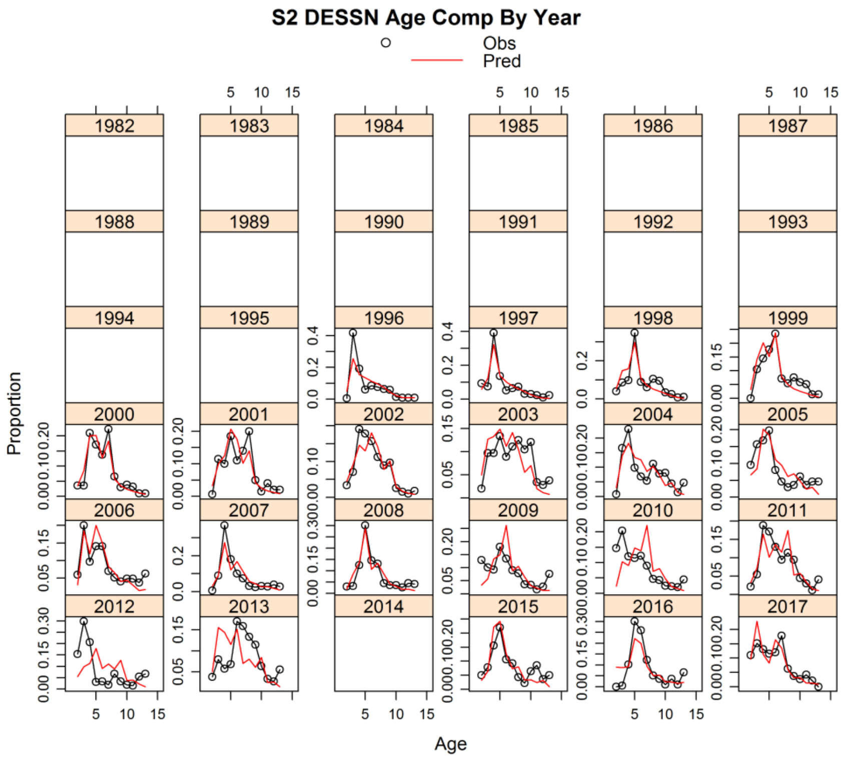


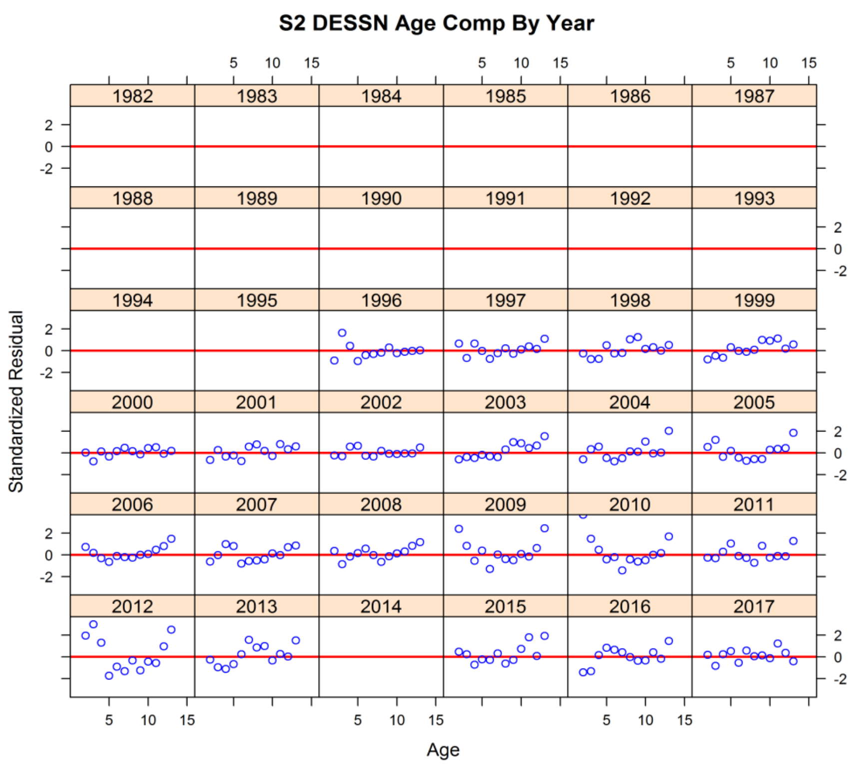
Appendix Figure 20. Observed and predicted age composition for the CHESMAP survey in stock 1 bay by year and standardized residual plots .



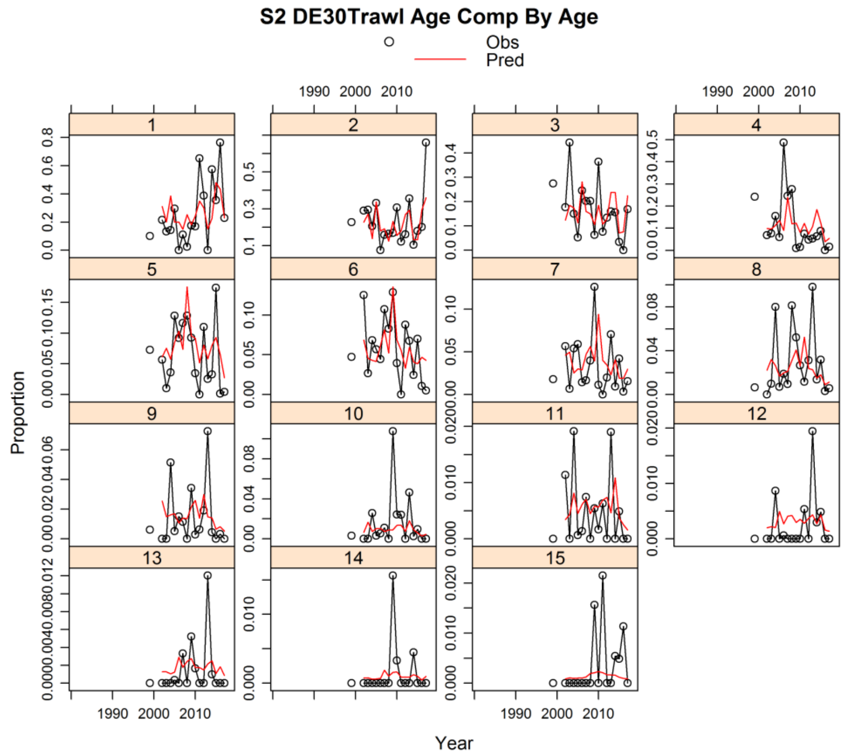


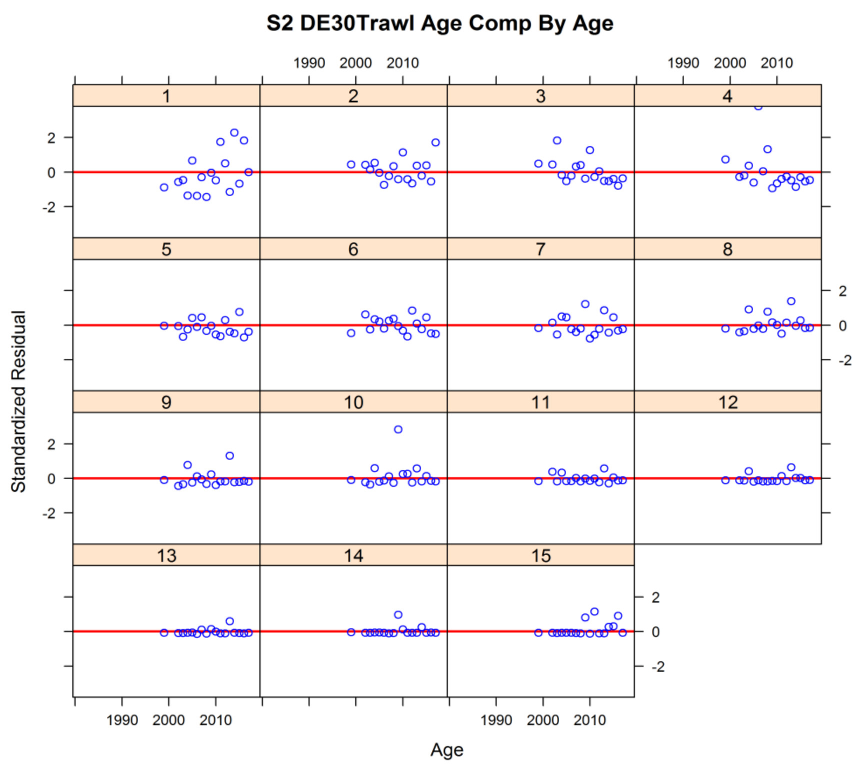
Appendix Figure 21. Observed and predicted age composition for the DESSN survey in stock 2 by age and standardized residual plots.



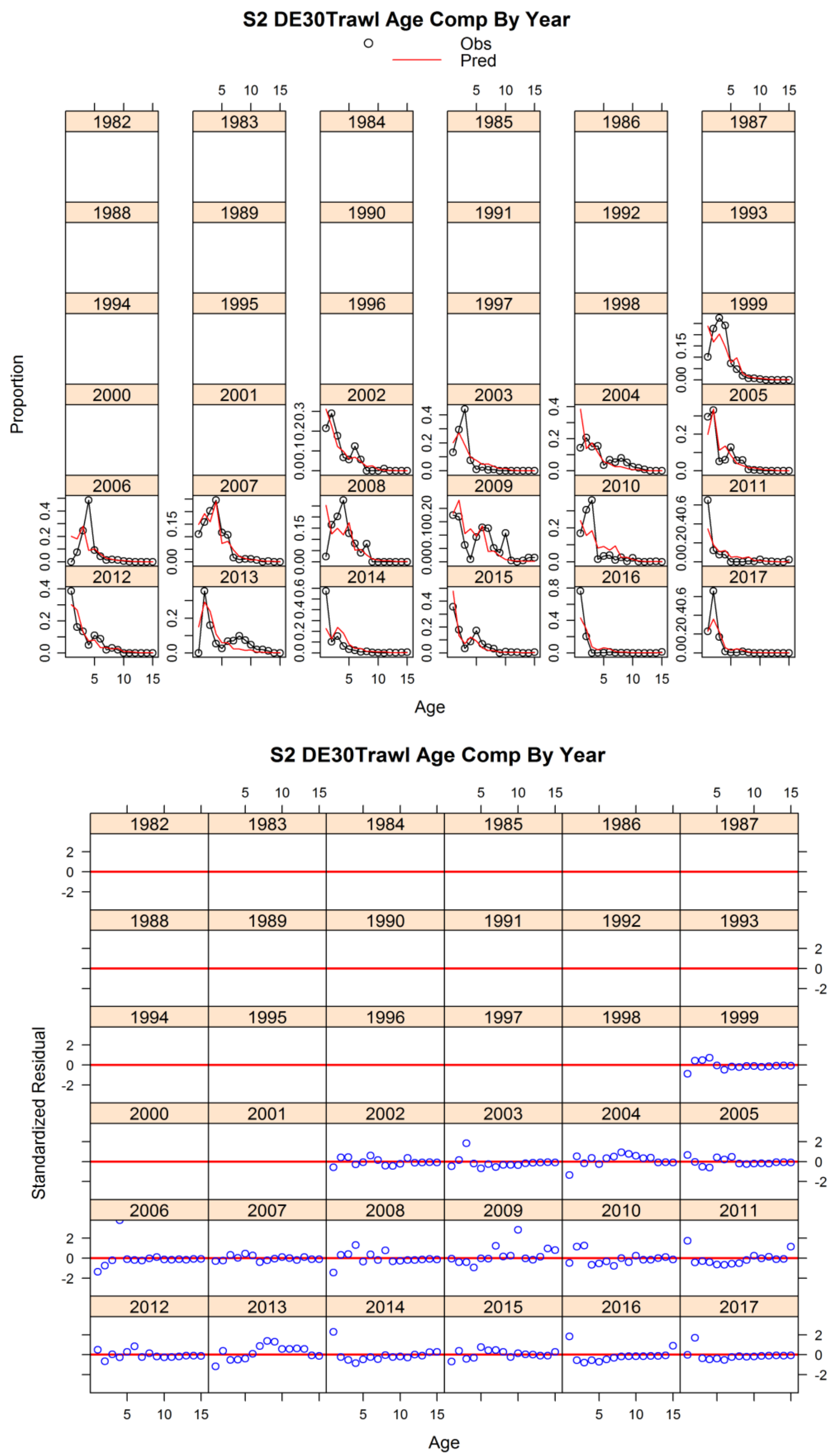


Appendix Figure 22. Observed and predicted age composition for the DESSN survey in stock 2 by year and standardized residual plots.

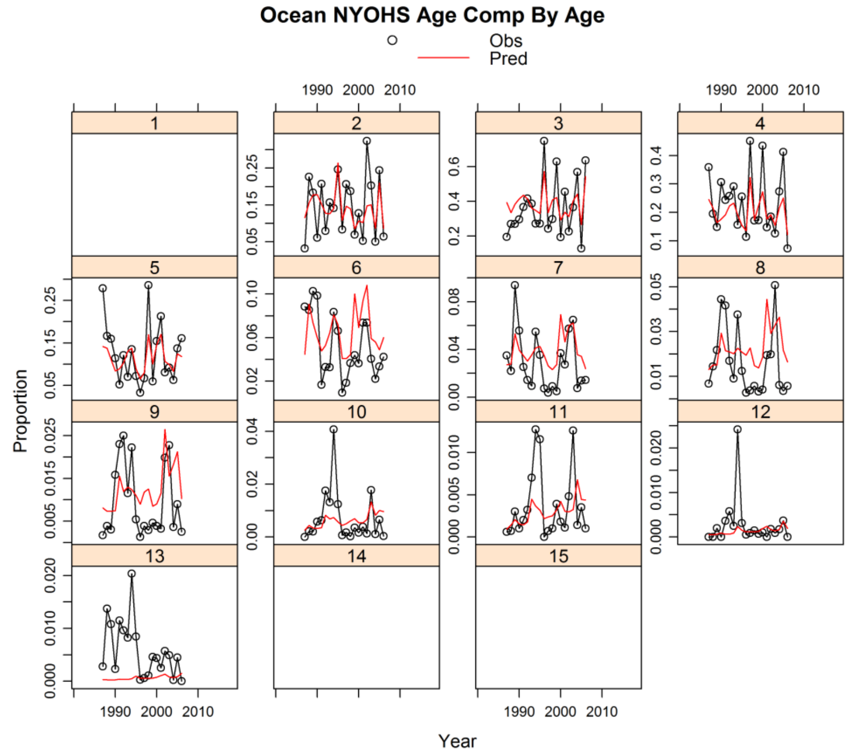


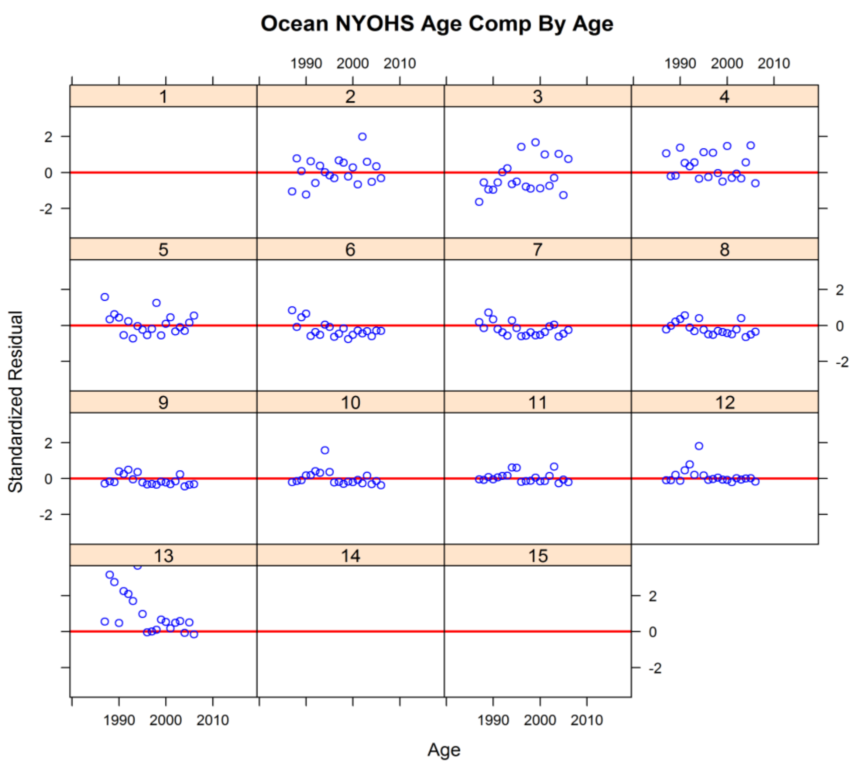


Appendix Figure 23. Observed and predicted age composition for the DE 30' Trawl survey in stock 2 by age and standardized residual plots.

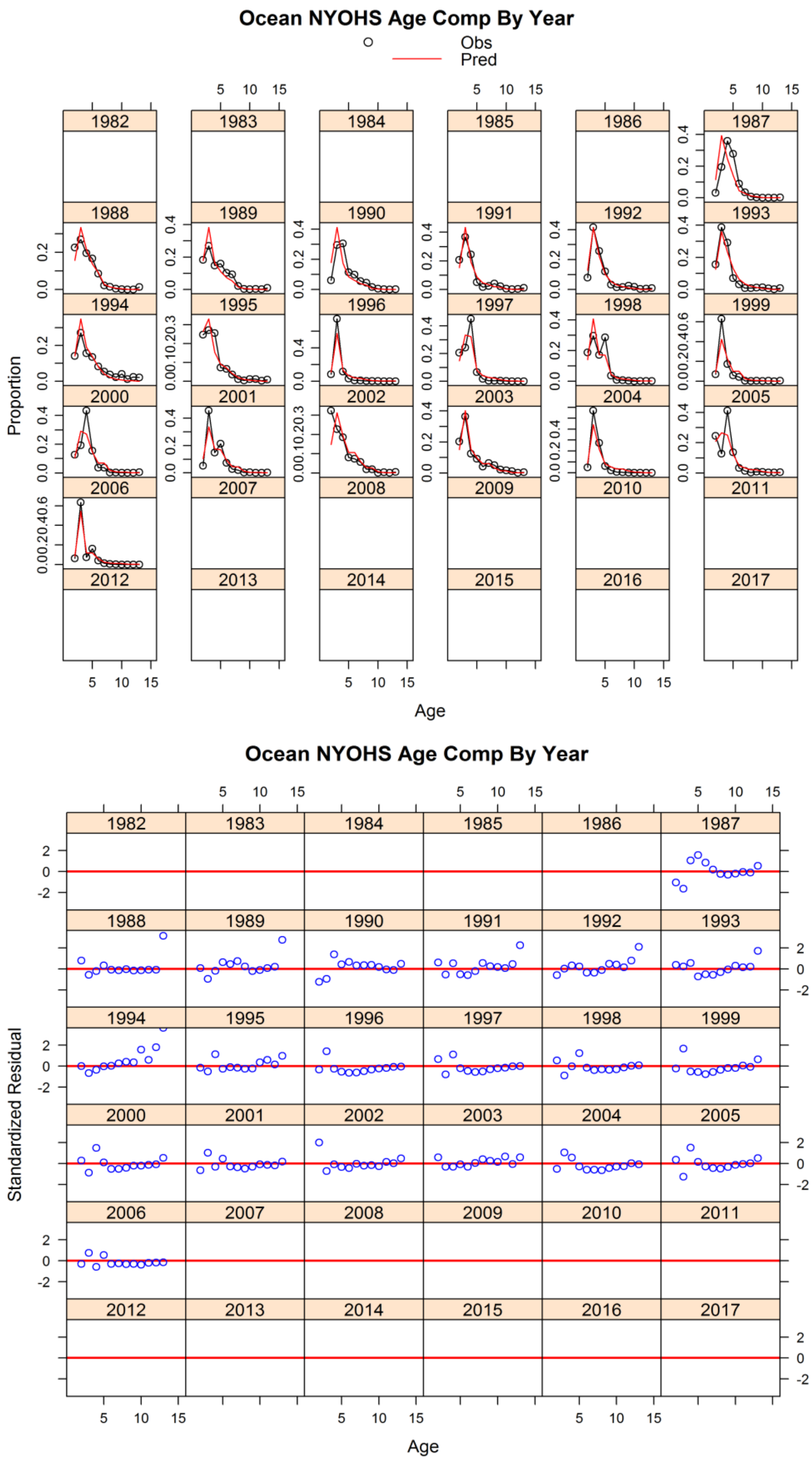


Appendix Figure 24. Observed and predicted age composition for the DE 30' Trawl survey in stock 2 by year and standardized residual plots.

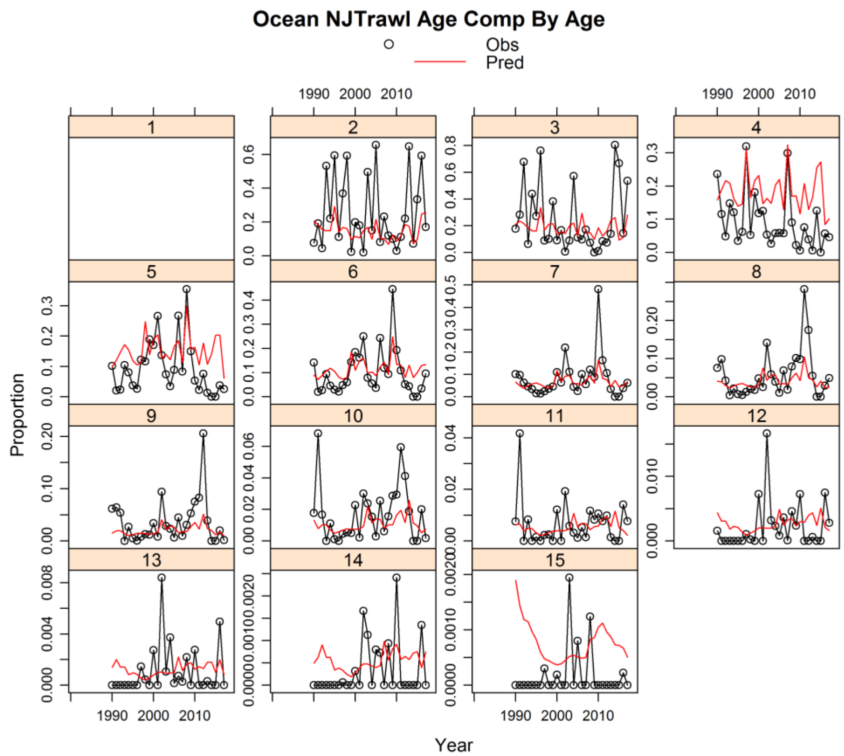


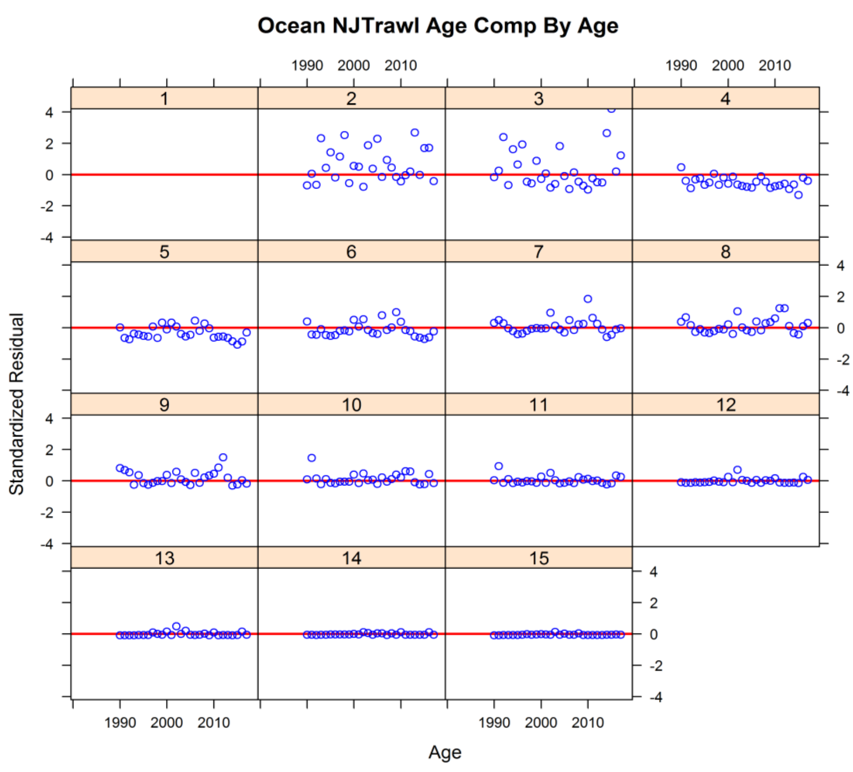


Appendix Figure 25. Observed and predicted age composition for the NY OHS survey in mixed ocean stock by age and standardized residual plots.

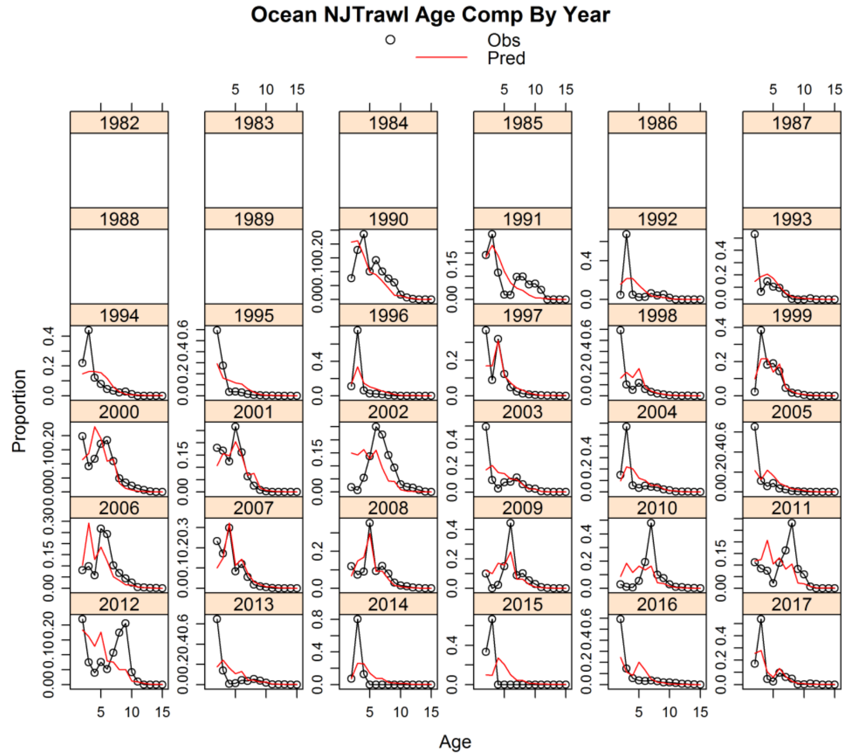


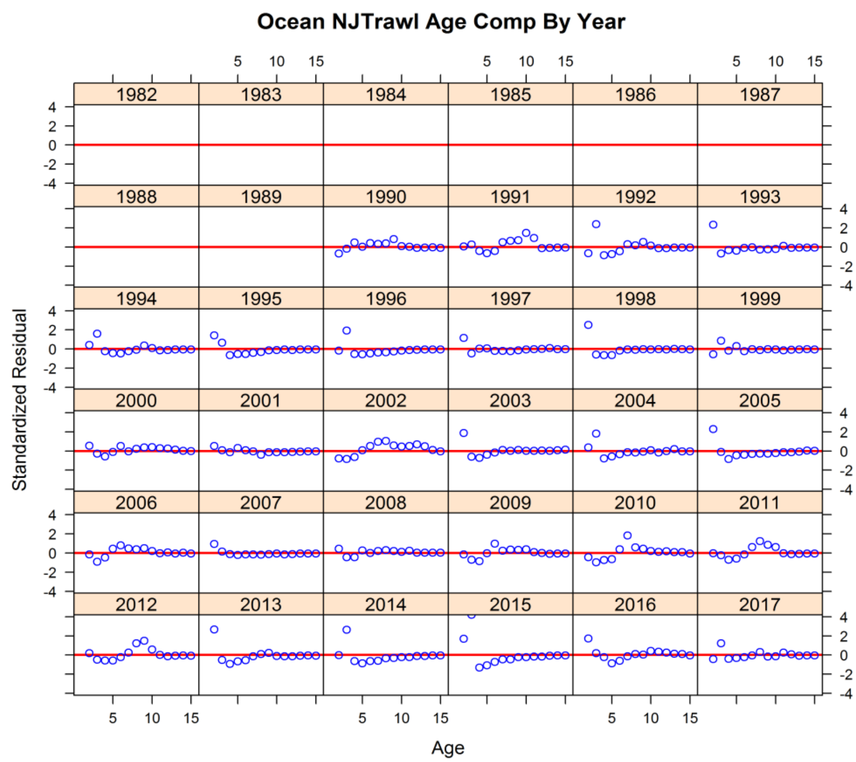
Appendix Figure 26. Observed and predicted age composition for the NY OHS survey in mixed ocean stock by year and standardized residual plots.



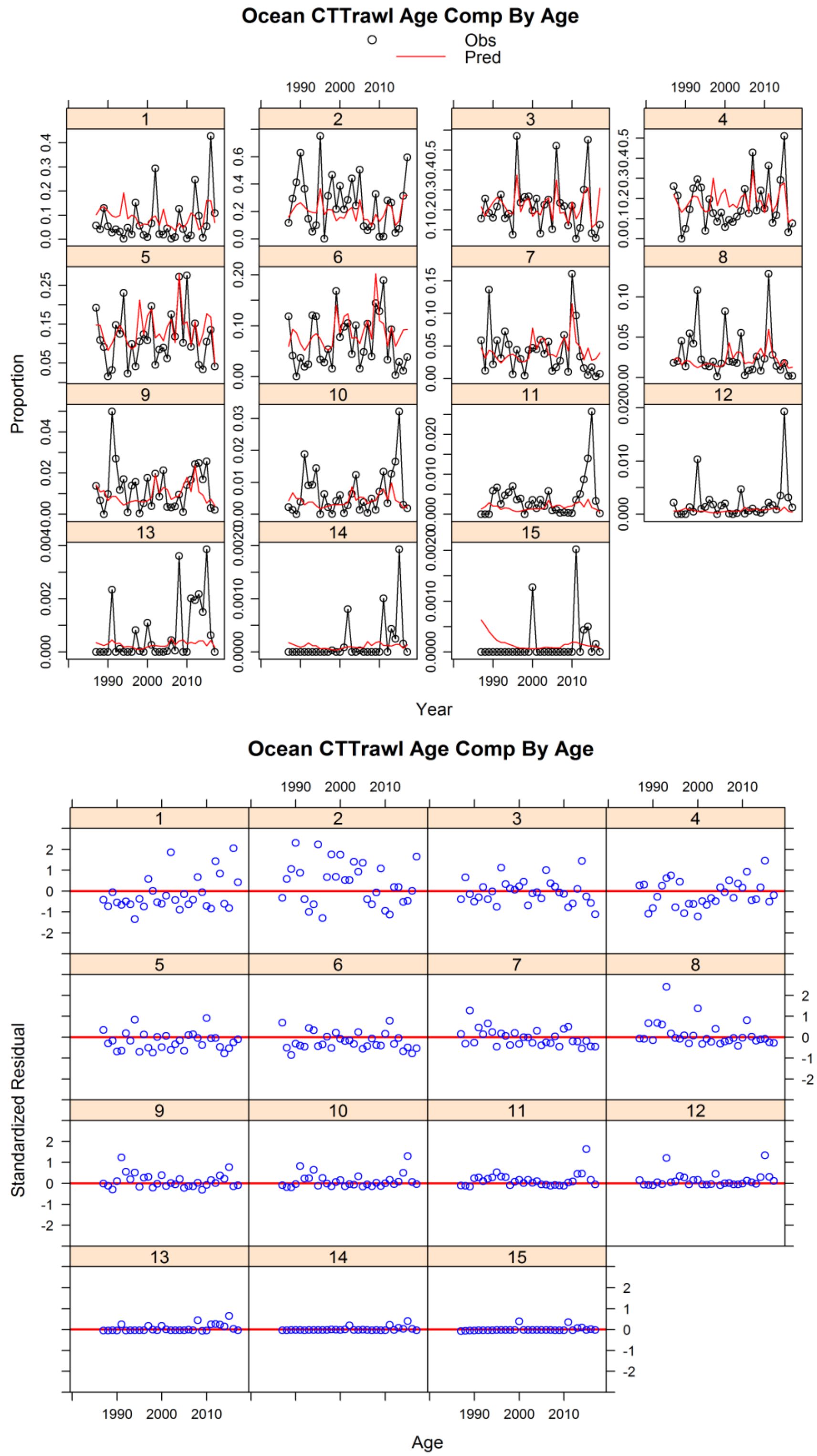


Appendix Figure 27. Observed and predicted age composition for the NJ Trawl survey in mixed ocean stock by age and standardized residual plots.

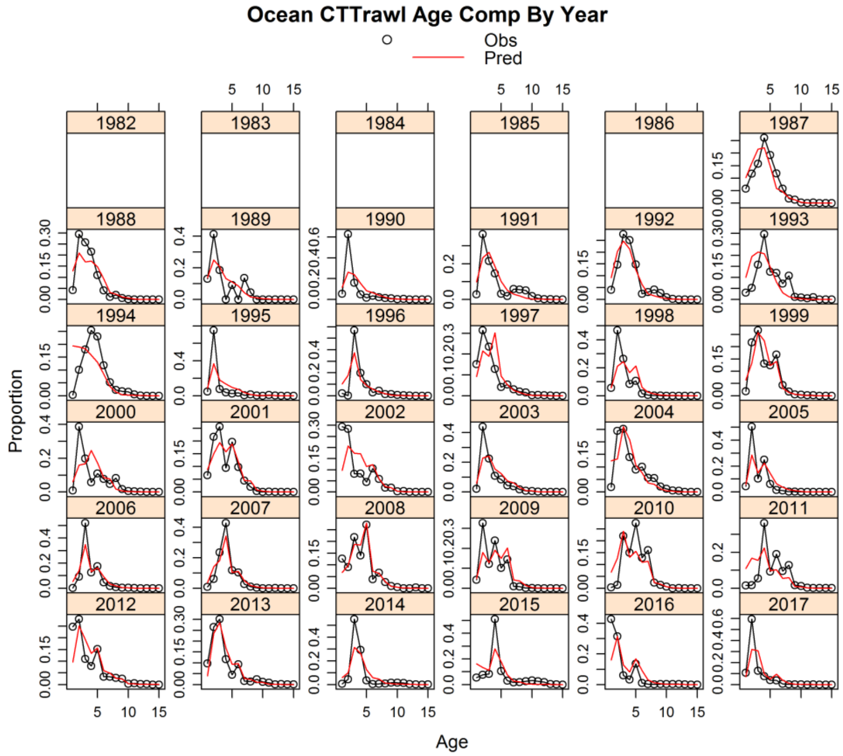


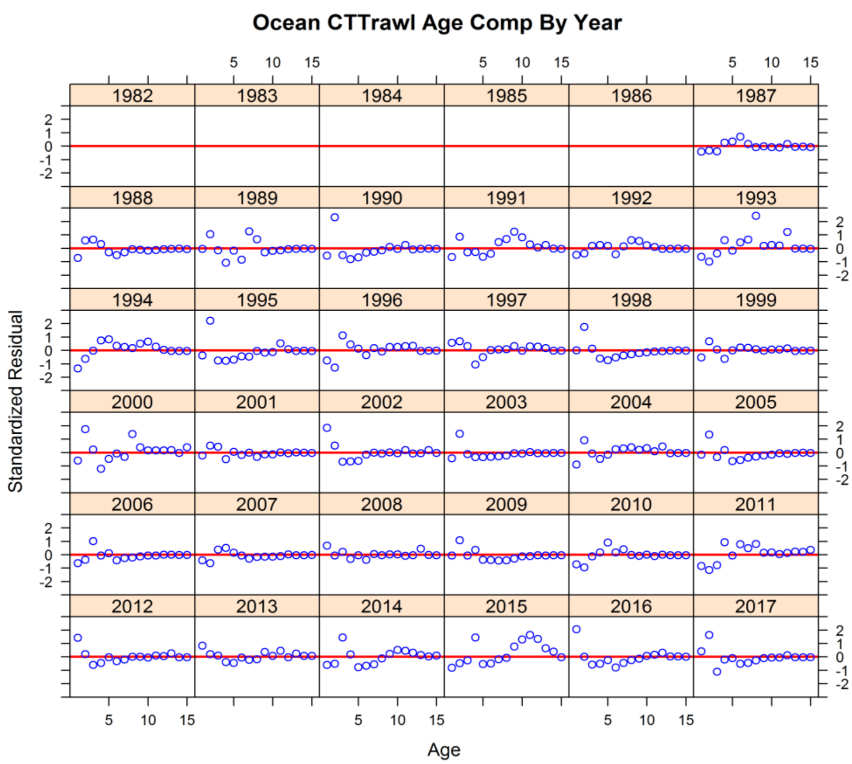


Appendix Figure 28. Observed and predicted age composition for the NJ Trawl survey in mixed ocean stock by year and standardized residual plots.

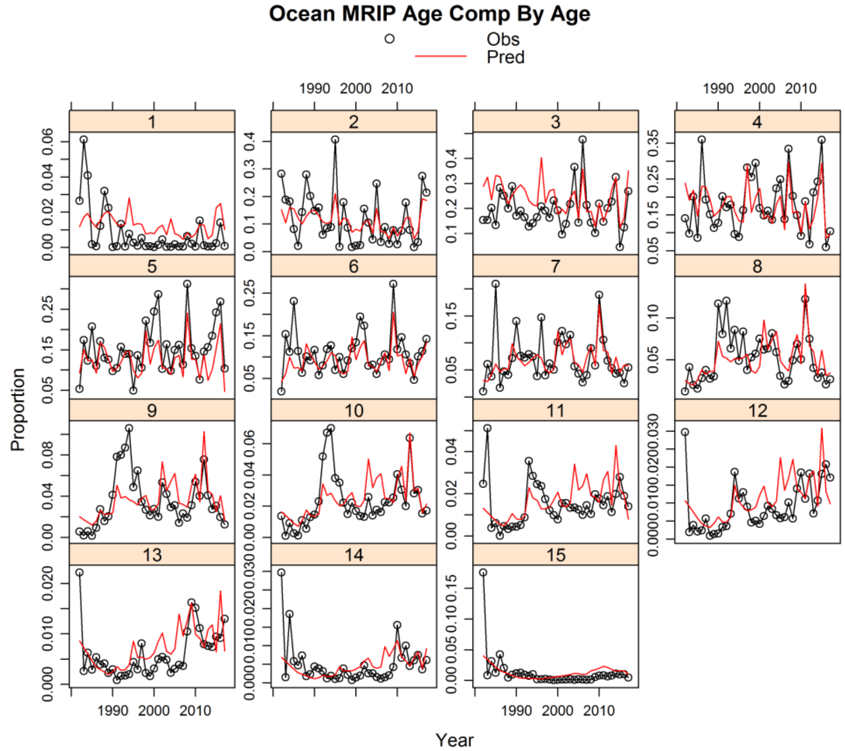


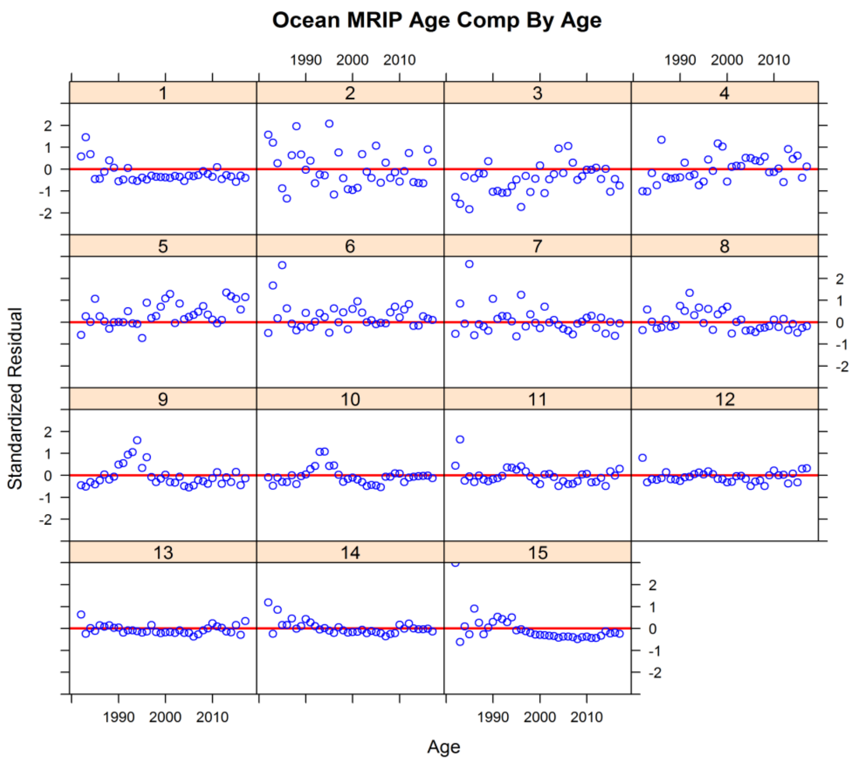
Appendix Figure 29. Observed and predicted age composition for the CT Trawl survey in mixed ocean stock by age and standardized residual plots.



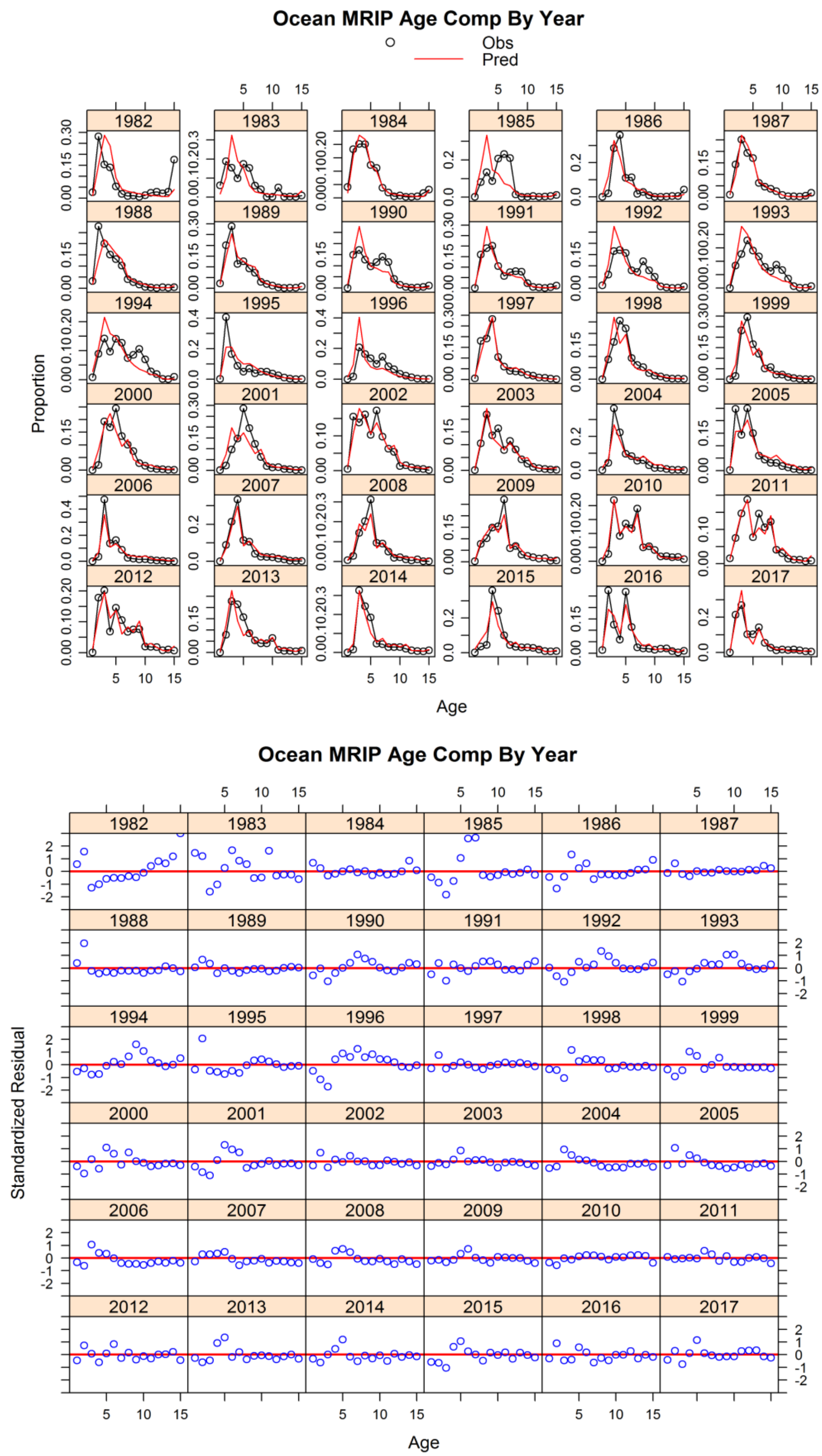


Appendix Figure 30. Observed and predicted age composition for the CT Trawl survey in mixed ocean stock by year and standardized residual plots.





Appendix Figure 31. Observed and predicted age composition for the MRIP survey in mixed ocean stock by age and standardized residual plots.



Appendix Figure 32. Observed and predicted age composition for the MRIP survey in mixed ocean stock by year and standardized residual plots.

Appendix B10. Model Structure, Parameterization, Diagnostic Plots, and Output for the Non-Migration SCA Model for Atlantic Striped Bass

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

General Definitions	Symbol	Description/Definition
Year Index	y	y = {1982,..,2017} for catch. y = {1970,..,2017} for indices.
Age Index	a	a = {1,..,15+}
Fleet Index	f	f = {1: Chesapeake Bay, 2: Coast }
Indices Index:	t	t = {1,..,14}
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 releases estimates with associated proportional standard errors (commercial harvest from census – no error)
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 Indices with Age Composition: 8 (1 fishery-dependent; 7 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)
Effective Sample Size	$\hat{\hat{n}}$	<u>Starting Values</u> Fleets: Bay – 50, Ocean – 50 Indices: NYOHS – 19.1, NJ Trawl – 4.8, MDSSN – 17.6, DESSN – 25.2, MRIP – 16.8, CTLIST – 16.8, DE30FT – 16.8, ChesMP – 16.8. The multiplier from equation 1.8 method of Francis (2011) is used to adjust the starting values.

Table 1 cont.

Population Model	Symbol	Equation
Age-1 numbers	$\hat{N}_{y,1}$	$N_{1,1,y,1} = \hat{\bar{N}}_1 \cdot \exp^{\hat{e}_{1,y} - 0.5\hat{\sigma}^2_{1,R}}$ $\hat{\sigma}_R = \sqrt{\frac{\sum_y (\hat{e}_y - \hat{\bar{e}})^2}{n-1}}$ 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): $\hat{N}_{y,a} = \hat{N}_{y,a-1} \exp^{-\hat{F}_{1982a-1} - M_{1982a-1}}$ Rest of years (ages 2-14): $\hat{N}_{y,a} = \hat{N}_{y-1,a-1} \exp^{-\hat{F}_{y-1,a-1} - M_{y-1,a-1}}$
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, 1996-2017 $\hat{s}_a = \frac{1}{1-\hat{\gamma}} \cdot \left(\frac{1-\hat{\gamma}}{\hat{\gamma}}\right)^{\hat{\gamma}} \frac{\exp^{\hat{\alpha}\hat{\gamma}(\hat{\beta}-a)}}{1+\exp^{\hat{\alpha}(\hat{\beta}-a)}}$ Fleet 2 (Coast): 1982-1984, 1985-1989, 1990-1996, 1997-2017 $\hat{s}_a = \exp^{(-\exp^{-\hat{\beta}(a-\hat{\alpha})})}$
Predicted Catch-At-Age	$\hat{C}_{f,y,a}$	$\hat{C}_{f,y,a} = \frac{\hat{F}_{f,y,a}}{\hat{F}_{f,y,a} + M_{y,a}} \cdot (1-\exp^{-\hat{F}_{y,a} - M_{y,a}}) \cdot \hat{N}_{y,a}$

Table 1 cont.

Population Model	Symbol	Equation
Predicted Total Catch	$\hat{C}_{f,y}$	$\hat{C}_{f,y} = \sum_a \hat{C}_{f,y,a}$
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	$\hat{I}_{t,y,\sum a}$	$\hat{I}_{t,y,\Sigma a} = \hat{q}_t \cdot \sum_a \hat{N}_{y,a} \cdot \exp^{-p_t \cdot Z_{y,a}}$ where q_t is the estimated catchability coefficient of index t and p_t is the fraction of the year when the survey takes place.
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	$SSB_y = \sum_{a=1}^{A} N_{y,a} \cdot sr_a \cdot m_a \cdot w_{y,a} / 1000$

Table 1 cont.

Likelihood	Symbol	Equation
Concentrated Lognormal Likelihood for Fleet Catch (F) and Indices of Relative Abundance (T)	$-L_F$; $-L_T$	$-L_F = 0.5 * \sum_f n_f * \ln\left(\frac{\sum_f RSS_f}{\sum_f n_f}\right)$; $-L_T = 0.5 * \sum_t n_t * \ln\left(\frac{\sum_t RSS_t}{\sum_t n_t}\right)$ where $RSS_f = \lambda_f \sum_y \left(\frac{\ln(C_{f,y} + 1e^{-5}) - \ln(\hat{C}_{f,y} + 1e^{-5})}{\delta_f \cdot CV_{f,y}}\right)^2$ $RSS_t = \lambda_t \sum_y \left(\frac{\ln(I_{t,y} + 1e^{-5}) - \ln(\hat{I}_{t,y} + 1e^{-5})}{\delta_t \cdot CV_{t,y}}\right)^2$ $CV_{f,y}$ and $CV_{t,y}$ are the annual coefficient of variation for the observed total catch (f) and index (t) in year y, δ_f and δ_t is the CV weights for total catch f and index t , and λ_t and λ_f are relative weights.
Multinomial fleet catch (FC) and index (TC) age compositions	$-L_{FC}$; $-L_{TC}$	$-L_{FC} = \lambda_f \sum_y -n_{f,y} \sum_a P_{f,y,a} \cdot \ln(\hat{P}_{f,y,a} + 1e^{-7})$ $-L_{TC} = \lambda_t \sum_y -n_{t,y} \sum_a U_{t,y,a} \cdot \ln(\hat{U}_{t,y,a} + 1e^{-7})$ where λ_f and λ_t are a user-defined weighting factors and n_y are the effective sample sizes.
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

Table 1 cont.

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 2. Total removals and associated coefficients of variation and age proportions of total removals of striped bass split into Chesapeake Bay and Coast, 1982-2017.

	Chesapeake Bay		Age Proportions														
Year	Total	CV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	228,642	0.360	0.00009	0.19419	0.54749	0.21668	0.02924	0.00592	0.00101	0.00087	0.00009	0.00033	0.00141	0.00211	0.00006	0.00017	0.00035
1983	337,990	0.121	0.00075	0.29016	0.27921	0.35534	0.01741	0.02018	0.01477	0.01216	0.00118	0.00126	0.00158	0.00349	0.00079	0.00131	0.00039
1984	478,326	0.345	0.00000	0.15493	0.76590	0.05833	0.01554	0.00431	0.00068	0.00007	0.00000	0.00003	0.00007	0.00003	0.00000	0.00010	0.00000
1985	48,686	0.254	0.05417	0.22096	0.53083	0.17399	0.00925	0.00271	0.00262	0.00048	0.00069	0.00045	0.00012	0.00040	0.00072	0.00040	0.00223
1986	100,649	0.558	0.00000	0.23213	0.27997	0.38852	0.08916	0.00449	0.00240	0.00128	0.00036	0.00000	0.00000	0.00000	0.00020	0.00060	0.00089
1987	44,939	0.444	0.04697	0.36326	0.27908	0.12971	0.16136	0.01621	0.00094	0.00051	0.00044	0.00004	0.00004	0.00000	0.00008	0.00049	0.00086
1988	123,103	0.348	0.00030	0.17812	0.25451	0.17105	0.20069	0.15802	0.03253	0.00396	0.00018	0.00018	0.00000	0.00002	0.00002	0.00009	0.00032
1989	85,092	0.358	0.00047	0.35495	0.09827	0.15559	0.09640	0.16443	0.10319	0.02633	0.00005	0.00002	0.00000	0.00002	0.00002	0.00000	0.00024
1990	663,647	0.203	0.00131	0.06060	0.07944	0.11930	0.23723	0.37313	0.09483	0.02274	0.00450	0.00298	0.00127	0.00106	0.00077	0.00035	0.00049
1991	791,186	0.250	0.00436	0.08362	0.15522	0.12870	0.17802	0.28511	0.11748	0.02240	0.01236	0.00585	0.00256	0.00166	0.00114	0.00072	0.00081
1992	993,530	0.135	0.00255	0.02608	0.18858	0.22122	0.19735	0.19632	0.12126	0.03542	0.00612	0.00403	0.00009	0.00005	0.00020	0.00030	0.00044
1993	945,663	0.117	0.00243	0.04623	0.09116	0.27302	0.26928	0.15259	0.09309	0.05217	0.01335	0.00347	0.00168	0.00040	0.00034	0.00028	0.00052
1994	1,329,411	0.100	0.00083	0.01152	0.12339	0.26081	0.29552	0.13595	0.08864	0.04314	0.02569	0.00864	0.00335	0.00223	0.00018	0.00002	0.00010
1995	1,979,690	0.084	0.00002	0.05133	0.16367	0.22712	0.19495	0.15761	0.09852	0.04764	0.03150	0.01274	0.00672	0.00385	0.00120	0.00083	0.00231
1996	2,513,435	0.082	0.00419	0.01791	0.28675	0.20987	0.19301	0.13334	0.08581	0.03469	0.01643	0.00893	0.00630	0.00137	0.00064	0.00032	0.00044
1997	3,161,870	0.064	0.02970	0.07732	0.14336	0.33832	0.14101	0.11629	0.05634	0.04587	0.02635	0.01449	0.00581	0.00322	0.00165	0.00021	0.00008
1998	2,947,279	0.066	0.00287	0.05435	0.21654	0.28780	0.20622	0.09944	0.04484	0.03006	0.02434	0.01714	0.00767	0.00413	0.00206	0.00197	0.00056
1999	3,193,323	0.063	0.00141	0.02176	0.18145	0.23491	0.19305	0.20236	0.06884	0.02908	0.02498	0.01496	0.01316	0.00662	0.00469	0.00129	0.00142
2000	3,433,504	0.078	0.01769	0.06725	0.05743	0.23953	0.28480	0.14514	0.10134	0.03596	0.01567	0.01611	0.00842	0.00517	0.00265	0.00206	0.00079
2001	2,589,566	0.068	0.03094	0.07104	0.11310	0.16356	0.23292	0.13707	0.09331	0.07578	0.02343	0.02025	0.01551	0.01376	0.00553	0.00329	0.00052
2002	2,675,387	0.075	0.01225	0.11246	0.09299	0.14948	0.17211	0.17448	0.12212	0.05156	0.06011	0.01911	0.01287	0.00711	0.00559	0.00175	0.00601
2003	3,334,406	0.064	0.00002	0.13292	0.14887	0.15378	0.13988	0.10933	0.10059	0.06120	0.05572	0.05349	0.01948	0.01162	0.00654	0.00326	0.00329
2004	3,328,090	0.074	0.04985	0.04979	0.23573	0.20173	0.09455	0.08593	0.07312	0.06514	0.04631	0.03415	0.03392	0.01451	0.00773	0.00389	0.00366
2005	2,973,074	0.102	0.00655	0.14218	0.07766	0.22784	0.17590	0.06993	0.05186	0.03954	0.06668	0.04844	0.04542	0.02651	0.01059	0.00408	0.00683
2006	4,088,156	0.081	0.01695	0.06781	0.19880	0.16041	0.21382	0.11501	0.04510	0.03600	0.03448	0.04227	0.02397	0.01644	0.01446	0.00445	0.01002
2007	3,167,613	0.094	0.00490	0.04657	0.06038	0.34172	0.15412	0.14959	0.05944	0.03648	0.03723	0.03206	0.03567	0.01921	0.00875	0.00629	0.00758
2008	2,628,022	0.082	0.02727	0.01450	0.05777	0.15692	0.31859	0.09171	0.09432	0.05332	0.02379	0.03729	0.03229	0.04450	0.01631	0.01408	0.01734
2009	3,141,793	0.082	0.00303	0.05669	0.04500	0.22104	0.21231	0.18992	0.04015	0.05433	0.04221	0.01993	0.02817	0.02603	0.03130	0.01191	0.01798
2010	2,932,935	0.150	0.00665	0.01026	0.16269	0.15343	0.20336	0.17423	0.15477	0.03588	0.03635	0.01873	0.00744	0.00889	0.00905	0.00997	0.00828
2011	2,522,192	0.089	0.02105	0.04700	0.06130	0.28426	0.12266	0.15022	0.11947	0.08189	0.02477	0.03311	0.01802	0.00962	0.00895	0.00611	0.01158
2012	2,667,975	0.1184	0.09310	0.09290	0.13664	0.10700	0.19834	0.11136	0.08220	0.03391	0.04299	0.01687	0.02659	0.00931	0.00905	0.01167	0.02807
2013	2,746,998	0.0709	0.00084	0.08924	0.15991	0.23047	0.15248	0.14480	0.05856	0.03761	0.03540	0.04765	0.01367	0.01561	0.00349	0.00243	0.00784
2014	3,234,259	0.1107	0.00578	0.01291	0.29200	0.20651	0.23238	0.08630	0.05640	0.02291	0.02251	0.01976	0.02571	0.00324	0.00546	0.00142	0.00671
2015	2,800,299	0.0846	0.07885	0.07470	0.04151	0.31259	0.17851	0.06836	0.05164	0.05035	0.02329	0.03900	0.02519	0.02773	0.00588	0.01239	0.01001
2016	3,603,596	0.0988	0.05830	0.07296	0.08267	0.11216	0.38316	0.11129	0.03667	0.01873	0.01995	0.01349	0.02549	0.02436	0.02736	0.00369	0.00971
2017	2,499,152	0.0983	0.01893	0.07428	0.10790	0.13450	0.21154	0.27426	0.05274	0.03193	0.01802	0.01970	0.01323	0.02144	0.01018	0.00741	0.00395

Table 2 cont.

	Coast		Age Proportions														
Year	Total	CV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	676,910	0.182	0.00156	0.09775	0.21434	0.25911	0.09712	0.03158	0.01458	0.01135	0.00720	0.01677	0.02752	0.04291	0.01998	0.03109	0.12714
1983	709,721	0.431	0.00705	0.04768	0.13090	0.13039	0.22422	0.19472	0.07898	0.05238	0.00267	0.01028	0.06871	0.00824	0.00860	0.00619	0.02899
1984	357,356	0.242	0.00692	0.05249	0.09217	0.21138	0.20562	0.21712	0.08305	0.03661	0.01239	0.01652	0.00602	0.00747	0.01210	0.02239	0.01773
1985	853,676	0.541	0.00032	0.01967	0.05405	0.07547	0.24611	0.27520	0.25308	0.02196	0.00416	0.00427	0.00920	0.00506	0.00470	0.00880	0.01795
1986	307,006	0.302	0.00091	0.01126	0.13167	0.32552	0.11309	0.22625	0.04412	0.05867	0.01716	0.00439	0.00599	0.00468	0.00542	0.01189	0.03896
1987	231,440	0.183	0.00659	0.07870	0.14963	0.13207	0.12430	0.06106	0.07977	0.09012	0.07011	0.03376	0.01246	0.02462	0.01758	0.03131	0.08790
1988	332,024	0.215	0.01658	0.16119	0.12694	0.10925	0.10455	0.13851	0.08594	0.07315	0.07316	0.02323	0.01863	0.00627	0.02199	0.01149	0.02912
1989	520,134	0.176	0.01746	0.14407	0.19166	0.08561	0.09146	0.06606	0.09550	0.06667	0.07298	0.04591	0.02493	0.00601	0.02116	0.01557	0.05495
1990	572,259	0.101	0.00053	0.06045	0.08352	0.10068	0.10257	0.12711	0.15790	0.18160	0.06701	0.02643	0.01415	0.00839	0.01089	0.01737	0.04141
1991	927,235	0.104	0.00090	0.07712	0.09907	0.11949	0.08690	0.05434	0.08361	0.13363	0.20579	0.05407	0.01134	0.01037	0.00314	0.01433	0.04590
1992	1,244,083	0.106	0.00521	0.02732	0.08564	0.10241	0.11308	0.07394	0.07183	0.13508	0.14985	0.14338	0.02428	0.01242	0.00539	0.01246	0.03769
1993	1,087,299	0.068	0.00032	0.04258	0.07577	0.10851	0.09531	0.09207	0.06784	0.08082	0.12706	0.14920	0.09879	0.02327	0.00653	0.00389	0.02803
1994	1,576,982	0.052	0.00315	0.04326	0.08764	0.07318	0.11335	0.10322	0.06513	0.09269	0.14382	0.12620	0.06519	0.05617	0.00477	0.00311	0.01913
1995	3,043,104	0.100	0.00154	0.23628	0.10057	0.05804	0.04745	0.10294	0.07176	0.10605	0.11135	0.08036	0.05066	0.01933	0.00918	0.00118	0.00332
1996	3,754,288	0.044	0.00039	0.01285	0.15205	0.09604	0.08487	0.09868	0.16456	0.12796	0.09048	0.06919	0.05034	0.03201	0.00908	0.00368	0.00783
1997	4,225,412	0.042	0.00614	0.10247	0.11258	0.17506	0.07460	0.08064	0.07418	0.09665	0.09110	0.06246	0.05325	0.02680	0.02539	0.01314	0.00555
1998	4,962,590	0.050	0.00387	0.06375	0.10510	0.16822	0.16506	0.11201	0.08833	0.10580	0.07097	0.03893	0.03975	0.01531	0.00756	0.01042	0.00491
1999	4,852,752	0.053	0.00041	0.01448	0.14093	0.17648	0.14312	0.15783	0.10383	0.09908	0.05958	0.05409	0.02483	0.01458	0.00583	0.00278	0.00213
2000	4,942,552	0.049	0.00042	0.01307	0.10164	0.10963	0.16734	0.13857	0.15760	0.15278	0.06779	0.04538	0.02265	0.01142	0.00638	0.00312	0.00220
2001	5,181,056	0.042	0.00243	0.01624	0.03931	0.09002	0.20905	0.21597	0.16785	0.11304	0.04528	0.03387	0.03739	0.01205	0.00947	0.00474	0.00330
2002	5,515,347	0.044	0.00278	0.05902	0.06474	0.09290	0.08964	0.18711	0.14883	0.12724	0.11130	0.04359	0.03803	0.01676	0.00923	0.00636	0.00248
2003	5,531,222	0.044	0.00045	0.05105	0.08148	0.06395	0.11048	0.10795	0.18725	0.15014	0.09589	0.06410	0.03621	0.02301	0.01346	0.00800	0.00658
2004	6,198,467	0.082	0.00030	0.01748	0.17097	0.11262	0.08276	0.09994	0.11480	0.14909	0.09734	0.06171	0.04626	0.02319	0.01087	0.00769	0.00499
2005	6,138,085	0.064	0.00129	0.10807	0.06323	0.13799	0.14456	0.10081	0.10298	0.08242	0.09916	0.06007	0.04684	0.02153	0.01472	0.00837	0.00796
2006	6,985,468	0.054	0.00061	0.03408	0.26505	0.07062	0.12521	0.10577	0.06299	0.07208	0.06766	0.08181	0.05153	0.03120	0.01515	0.00659	0.00965
2007	5,135,385	0.058	0.00084	0.04549	0.10983	0.16248	0.09635	0.14203	0.09322	0.06526	0.07788	0.08152	0.05125	0.04764	0.01364	0.00729	0.00528
2008	5,594,805	0.063	0.00264	0.01561	0.06799	0.08173	0.18416	0.09233	0.17618	0.11129	0.05160	0.07539	0.04579	0.03260	0.03607	0.01028	0.01635
2009	4,884,529	0.055	0.00051	0.03118	0.03434	0.05667	0.08293	0.25636	0.10441	0.14756	0.07930	0.05616	0.04994	0.03656	0.03844	0.01118	0.01444
2010	5,437,592	0.064	0.00013	0.00939	0.06053	0.02889	0.06142	0.12667	0.27247	0.09792	0.11603	0.08788	0.03899	0.03633	0.02732	0.02223	0.01381
2011	5,041,449	0.059	0.00378	0.02580	0.04516	0.06286	0.04492	0.13795	0.16926	0.23211	0.08372	0.07291	0.03445	0.02327	0.02353	0.01987	0.02040
2012	4,414,299	0.0725	0.00037	0.05131	0.06022	0.03576	0.09948	0.08872	0.13599	0.16574	0.17699	0.04930	0.04391	0.03663	0.01962	0.02164	0.01432
2013	5,758,822	0.0643	0.00025	0.04264	0.08532	0.07225	0.06046	0.10946	0.11373	0.10574	0.10948	0.17712	0.04276	0.02160	0.02152	0.01406	0.02361
2014	3,843,397	0.0799	0.00027	0.00799	0.14660	0.10784	0.08975	0.09868	0.11388	0.08209	0.09031	0.10218	0.06397	0.03391	0.01960	0.01751	0.02542
2015	3,315,571	0.0777	0.00064	0.01379	0.03098	0.20267	0.16224	0.11433	0.10439	0.08146	0.07199	0.06504	0.05395	0.03729	0.02033	0.01467	0.02623
2016	3,601,311	0.0841	0.00635	0.14602	0.05588	0.03685	0.22509	0.14742	0.05775	0.05322	0.05029	0.04136	0.04883	0.04930	0.03536	0.01702	0.02925
2017	4,559,686	0.0693	0.00045	0.14568	0.15807	0.06115	0.10340	0.21385	0.10369	0.05725	0.02458	0.03405	0.02506	0.02856	0.02086	0.01123	0.01213

Table 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 (Jan 1st)
NJ YOY	0	1 (Jan 1st)
MD YOY	0	1 (Jan 1st)
Composite YOY	0	1 (Jan 1st)
MD Age 1	0	2 (Jan 1st)
VA Age 1	0	2 (Jan 1st)
Indices with age composition		
NY OHS	0.75	2-13+
NJ Trawl	0.25	2-15+
MD SSN	0.25	2-15+
DE SSN	0.25	2-13+
MRIP	0.50	1-15+
CT Trawl	0.33	1-15+
DE 30' Trawl	0.90	1-15+
ChesMMAP	0.50	1-15+

Table 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	-15	15
Fishing Mortality (log)		log_F	2	-1.6	-20	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	-25	25
Catch Selectivity	Thompson	flthom_c	4	0.9	1.00E-28	0.9999
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	-150	150
AC Selectivity	Gamma	acgam_b	5	1	-150	150
AC Selectivity	Thompson	acthom_a	5	-3.81	-20	0
AC Selectivity	Thompson	acthom_b	5	2.32	-25	25
AC Selectivity	Thompson	acthom_c	5	0.9	1.00E-28	0.9999
AC Selectivity	User-Defined	userparms	5.00	0.60	0.00	1.00

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

Index	n	Weight	RMSE	Percentile 2.50%	Percentile 97.50%
NYYOY	32	3.03	1.00	0.757	1.248
NJYOY	35	1.75	0.99	0.768	1.239
MDYOY	12	2.10	1.04	0.592	1.379
Comp. YOY	36	0.98	1.01	0.771	1.236
NYAge1	33	3.13	1.02	0.761	1.245
MDAge1	48	3.32	1.04	0.804	1.207
NYOHS	20	2.38	1.03	0.687	1.304
NJTRAWL	28	24.00	1.01	0.738	1.263
MDSSN	33	2.40	1.03	0.761	1.245
DESSN	21	0.95	1.01	0.695	1.298
MRIP	36	0.97	0.98	0.771	1.236
CTLIST	31	1.60	0.99	0.752	1.252
DE30FT	17	0.91	0.99	0.659	1.326
ChesMP	16	2.85	1.00	0.648	1.335

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

Likelihood Components	Weight	RSS
Fleet 1 Total Catch	2	0.17
Fleet 2 Total Catch	2	1.60
Aggregate Abundance Indices		
Survey 1	1	24.94
Survey 2	1	26.40
Survey 3	1	11.10
Survey 4	1	35.38
Survey 5	1	26.95
Survey 6	1	23.51
Age Comp Abundance Indices		
Survey 1	1	20.49
Survey 2	1	20.57
Survey 3	1	29.65
Survey 4	1	19.78
Survey 5	1	30.28
Survey 6	1	23.62
Survey 7	1	14.11
Survey 8	1	13.42
Total RSS		321.98
No. of Obs		470
Conc. Likel.		-88.89
Age Composition Data		Likelihood
Fleet 1 Age Comp	1	4,907.58
Fleet 2 Age Comp	1	6,163.06
Survey 1	1	715.00
Survey 2	1	276.91
Survey 3	1	1,135.95
Survey 4	1	949.68
Survey 5	1	2,762.74
Survey 6	1	723.24
Survey 7	1	241.12
Survey 8	1	321.19
Recr Devs	1	42.97
Total Likelihood		18,083.4
AIC		36,514.7

Table 6.1. Final average effective sample sizes for fleets and age composition data.

Age Composition

Fleet/Index	n_{eff}
Bay Fleet	68.4
Ocean Fleet	71.1
NYOHS	21.5
NJTRAWL	5.2
MDSSN	16.8
DESSN	19.7
MRIP	35.6
CTLIST	12.4
DE30FT	7.3
ChesMP	10.8

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

	Bay			Coast			Total					
Year	Full F	SD	CV	Full F	SD	CV	Full F	SD	CV	Recruitment	SD	CV
1982	0.043	0.010	0.24	0.170	0.028	0.16	0.171	0.028	0.16	37,879,000	3,486,900	0.09
1983	0.053	0.007	0.13	0.140	0.038	0.28	0.141	0.038	0.27	75,360,000	5,813,600	0.08
1984	0.054	0.012	0.23	0.058	0.011	0.19	0.066	0.013	0.19	65,572,000	5,086,500	0.08
1985	0.002	0.000	0.17	0.191	0.070	0.37	0.192	0.070	0.37	72,586,000	5,287,900	0.07
1986	0.004	0.001	0.34	0.050	0.013	0.26	0.051	0.013	0.25	69,913,000	4,976,300	0.07
1987	0.002	0.000	0.27	0.029	0.006	0.20	0.030	0.006	0.20	72,076,000	4,965,900	0.07
1988	0.004	0.001	0.22	0.034	0.007	0.21	0.035	0.007	0.20	96,975,000	6,565,300	0.07
1989	0.003	0.001	0.22	0.045	0.008	0.18	0.046	0.008	0.18	107,990,000	7,259,900	0.07
1990	0.039	0.005	0.14	0.060	0.010	0.17	0.061	0.010	0.17	126,280,000	7,943,500	0.06
1991	0.043	0.007	0.16	0.085	0.014	0.16	0.087	0.014	0.16	100,830,000	7,351,600	0.07
1992	0.049	0.005	0.11	0.104	0.017	0.16	0.105	0.017	0.16	107,980,000	7,906,800	0.07
1993	0.042	0.004	0.10	0.082	0.012	0.15	0.083	0.012	0.15	132,390,000	8,927,000	0.07
1994	0.055	0.005	0.09	0.107	0.015	0.14	0.109	0.015	0.14	283,460,000	14,113,000	0.05
1995	0.080	0.007	0.08	0.198	0.029	0.15	0.200	0.030	0.15	182,470,000	11,035,000	0.06
1996	0.054	0.004	0.07	0.228	0.032	0.14	0.263	0.034	0.13	232,190,000	12,798,000	0.06
1997	0.059	0.003	0.06	0.178	0.014	0.08	0.217	0.016	0.07	257,890,000	13,378,000	0.05
1998	0.051	0.003	0.06	0.194	0.015	0.08	0.227	0.018	0.08	144,270,000	9,598,300	0.07
1999	0.053	0.003	0.06	0.177	0.014	0.08	0.212	0.016	0.07	149,660,000	9,653,400	0.07
2000	0.057	0.003	0.06	0.173	0.013	0.08	0.211	0.015	0.07	127,030,000	8,900,000	0.07
2001	0.045	0.002	0.05	0.180	0.013	0.07	0.209	0.015	0.07	195,510,000	11,133,000	0.06
2002	0.049	0.003	0.06	0.193	0.014	0.07	0.225	0.016	0.07	224,710,000	12,010,000	0.05
2003	0.063	0.003	0.06	0.199	0.014	0.07	0.241	0.016	0.07	138,320,000	9,204,800	0.07
2004	0.061	0.004	0.06	0.227	0.018	0.08	0.267	0.020	0.08	312,200,000	14,213,000	0.05
2005	0.054	0.004	0.07	0.227	0.017	0.08	0.262	0.020	0.07	162,320,000	9,753,700	0.06
2006	0.073	0.005	0.06	0.261	0.020	0.08	0.309	0.023	0.08	136,410,000	8,822,400	0.07
2007	0.055	0.004	0.07	0.192	0.015	0.08	0.228	0.017	0.07	92,700,000	6,966,700	0.08
2008	0.048	0.003	0.06	0.210	0.017	0.08	0.241	0.019	0.08	129,210,000	8,552,900	0.07
2009	0.065	0.004	0.06	0.190	0.015	0.08	0.233	0.017	0.07	77,468,000	6,110,700	0.08
2010	0.068	0.006	0.10	0.228	0.018	0.08	0.273	0.020	0.08	104,880,000	7,923,000	0.08
2011	0.066	0.005	0.07	0.233	0.018	0.08	0.276	0.021	0.08	147,890,000	10,927,000	0.07
2012	0.074	0.006	0.09	0.222	0.019	0.09	0.272	0.022	0.08	214,390,000	15,307,000	0.07
2013	0.079	0.006	0.07	0.316	0.028	0.09	0.368	0.032	0.09	65,411,000	7,069,100	0.11
2014	0.089	0.008	0.09	0.223	0.022	0.10	0.283	0.027	0.10	92,612,000	9,659,500	0.10
2015	0.075	0.006	0.09	0.193	0.020	0.10	0.243	0.024	0.10	186,910,000	19,611,000	0.11
2016	0.100	0.009	0.09	0.209	0.023	0.11	0.278	0.028	0.10	239,580,000	31,100,000	0.13
2017	0.068	0.007	0.10	0.262	0.030	0.11	0.307	0.034	0.11	108,810,000	19,312,000	0.18

Table 7 cont.

Catch Selectivtiy Parameters							
Bay				Ocean			
	Estimate	SD	CV		Estimate	SD	CV
1982-1984				1982-1984			
α	-5.114	0.200	0.039	α	3.543	0.202	0.057
β	2.504	0.050	0.020	β	0.798	0.084	0.105
ϒ	0.882	0.018	0.021				
1985-1989				1985-1989			
α	-4.103	0.436	0.106	α	4.876	0.404	0.083
β	2.150	0.072	0.033	β	0.454	0.049	0.108
ϒ	0.965	0.012	0.012				
1990-1995				1990-1995			
α	-2.068	0.108	0.052	α	6.110	0.509	0.083
β	4.451	0.198	0.045	β	0.348	0.035	0.101
ϒ	0.816	0.035	0.043				
1996-2017				1997-2017			
α	-1.840	0.078	0.042	α	4.985	0.185	0.037
β	3.525	0.096	0.027	β	0.449	0.024	0.053
ϒ	0.973	0.010	0.010				

Survey Selectivity Parameters			
NYOHS	Estimate	SD	CV
α	-6.236	0.133	0.021
β	2.260	0.029	0.013
ϒ	0.966	0.005	0.005
NJ Trawl			
α	1.551	0.583	0.376
β	0.251	0.123	0.490
MDSSN			
s_2	0.137	0.021	0.152
DE SSN			
α	3.962	0.308	0.078
β	0.579	0.089	0.154
MRIP			
α	2.610	0.073	0.028
β	1.053	0.061	0.058
CT Trawl			
α	-2.849	0.308	0.108
β	2.116	0.122	0.058
ϒ	0.964	0.014	0.014
DE Trawl			
α	-1.285	0.773	0.602
β	1.563	0.775	0.496
ϒ	0.948	0.082	0.086
ChesMMAP			
α	-4.211	0.903	0.214
β	2.344	0.133	0.057
ϒ	0.947	0.019	0.020

Catchability Coefficients			
Survey	Estimate	SD	CV
NYYOY	1.17E-07	1.14E-01	0.01
NJYOY	7.90E-09	7.24E-02	0.00
MDYOY	1.36E-07	1.67E-01	0.01
Comp. YOY	9.15E-07	4.51E-02	0.00
NYAge1	1.50E-08	8.10E-02	0.00
MDAge1	9.33E-09	1.87E-01	0.01
NYOHS	1.12E-07	8.74E-02	0.01
NJTRAWL	1.40E-07	1.28E-01	0.01
MDSSN	7.80E-08	9.21E-02	0.01
DESSN	5.32E-08	1.31E-01	0.01
MRIP	4.12E-08	7.92E-02	0.01
CTLIST	7.52E-09	9.36E-02	0.01
DE30FT	2.76E-08	1.92E-01	0.01
ChesMMAP	1.25E-06	1.37E-01	0.01

Table 8. Average total fishing mortality for various age ranges and weighting schemes.

Year	Unweighted Avg. 3-8	Unweighted Avg. 8-11	N-weighted Avg. 3-8	N-weighted Avg. 7-11	Unweighted Avg 7-13	N-weighted Avg 7-13
1982	0.136	0.169	0.103	0.168	0.169	0.168
1983	0.118	0.139	0.100	0.138	0.139	0.139
1984	0.061	0.059	0.063	0.059	0.059	0.059
1985	0.089	0.169	0.043	0.147	0.169	0.151
1986	0.026	0.046	0.015	0.041	0.046	0.041
1987	0.015	0.026	0.009	0.024	0.026	0.024
1988	0.019	0.032	0.013	0.029	0.032	0.029
1989	0.023	0.041	0.016	0.036	0.041	0.036
1990	0.043	0.056	0.031	0.054	0.056	0.055
1991	0.053	0.076	0.036	0.073	0.077	0.073
1992	0.062	0.091	0.041	0.087	0.093	0.088
1993	0.051	0.073	0.037	0.071	0.074	0.071
1994	0.067	0.095	0.050	0.092	0.097	0.093
1995	0.111	0.170	0.078	0.160	0.173	0.165
1996	0.118	0.219	0.065	0.194	0.221	0.201
1997	0.128	0.205	0.084	0.194	0.205	0.196
1998	0.129	0.213	0.083	0.200	0.212	0.203
1999	0.123	0.200	0.080	0.187	0.199	0.189
2000	0.124	0.200	0.096	0.182	0.199	0.184
2001	0.117	0.195	0.094	0.180	0.195	0.182
2002	0.127	0.211	0.102	0.195	0.210	0.196
2003	0.141	0.228	0.103	0.212	0.227	0.214
2004	0.152	0.250	0.100	0.237	0.249	0.239
2005	0.146	0.244	0.103	0.231	0.244	0.234
2006	0.176	0.290	0.106	0.276	0.289	0.280
2007	0.131	0.215	0.092	0.200	0.214	0.203
2008	0.133	0.224	0.103	0.205	0.224	0.209
2009	0.138	0.221	0.119	0.208	0.220	0.211
2010	0.158	0.257	0.126	0.235	0.256	0.238
2011	0.158	0.260	0.135	0.243	0.259	0.245
2012	0.160	0.257	0.121	0.245	0.256	0.247
2013	0.206	0.343	0.132	0.328	0.342	0.333
2014	0.173	0.271	0.101	0.258	0.269	0.261
2015	0.148	0.232	0.113	0.221	0.231	0.225
2016	0.176	0.268	0.140	0.255	0.266	0.258
2017	0.173	0.287	0.110	0.263	0.286	0.267

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

Total Fishing Mortality

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.000	0.012	0.079	0.110	0.138	0.155	0.164	0.168	0.169	0.170	0.170	0.170	0.170	0.170	0.171
1983	0.000	0.012	0.083	0.101	0.119	0.131	0.136	0.138	0.139	0.140	0.140	0.140	0.140	0.140	0.141
1984	0.000	0.009	0.066	0.061	0.060	0.060	0.060	0.060	0.059	0.059	0.059	0.059	0.058	0.058	0.059
1985	0.001	0.006	0.021	0.046	0.077	0.107	0.133	0.153	0.167	0.176	0.182	0.186	0.189	0.191	0.192
1986	0.000	0.003	0.009	0.015	0.023	0.030	0.037	0.042	0.045	0.047	0.049	0.050	0.050	0.050	0.051
1987	0.000	0.001	0.004	0.008	0.013	0.017	0.021	0.024	0.026	0.027	0.028	0.029	0.029	0.029	0.030
1988	0.000	0.003	0.007	0.012	0.017	0.022	0.026	0.029	0.032	0.033	0.034	0.035	0.035	0.035	0.035
1989	0.000	0.002	0.007	0.013	0.020	0.027	0.033	0.037	0.040	0.042	0.044	0.045	0.045	0.045	0.046
1990	0.000	0.002	0.009	0.029	0.054	0.056	0.054	0.054	0.055	0.056	0.057	0.059	0.060	0.060	0.061
1991	0.000	0.002	0.010	0.035	0.064	0.069	0.070	0.072	0.075	0.078	0.080	0.083	0.084	0.086	0.087
1992	0.001	0.003	0.012	0.040	0.073	0.080	0.082	0.085	0.089	0.093	0.097	0.100	0.102	0.104	0.105
1993	0.000	0.002	0.010	0.033	0.061	0.066	0.067	0.068	0.071	0.074	0.077	0.079	0.081	0.082	0.083
1994	0.001	0.003	0.013	0.044	0.081	0.087	0.088	0.090	0.094	0.097	0.101	0.103	0.106	0.107	0.109
1995	0.001	0.005	0.022	0.070	0.128	0.143	0.148	0.157	0.166	0.175	0.183	0.189	0.194	0.197	0.200
1996	0.001	0.007	0.030	0.072	0.108	0.138	0.166	0.191	0.212	0.229	0.241	0.250	0.256	0.260	0.263
1997	0.001	0.008	0.035	0.084	0.125	0.154	0.176	0.193	0.204	0.211	0.215	0.217	0.217	0.217	0.216
1998	0.001	0.008	0.034	0.082	0.123	0.155	0.180	0.198	0.211	0.219	0.224	0.226	0.227	0.227	0.227
1999	0.001	0.008	0.033	0.079	0.119	0.148	0.170	0.187	0.198	0.205	0.209	0.211	0.212	0.212	0.211
2000	0.001	0.008	0.034	0.081	0.121	0.150	0.171	0.187	0.198	0.205	0.209	0.210	0.211	0.211	0.210
2001	0.001	0.007	0.030	0.074	0.112	0.142	0.165	0.182	0.193	0.201	0.206	0.208	0.209	0.209	0.209
2002	0.001	0.008	0.033	0.080	0.121	0.153	0.178	0.196	0.208	0.217	0.221	0.224	0.225	0.225	0.225
2003	0.001	0.009	0.038	0.092	0.138	0.170	0.195	0.213	0.226	0.233	0.238	0.240	0.241	0.241	0.240
2004	0.001	0.009	0.040	0.097	0.146	0.183	0.212	0.233	0.248	0.257	0.263	0.266	0.267	0.267	0.267
2005	0.001	0.009	0.037	0.091	0.139	0.176	0.205	0.227	0.242	0.251	0.257	0.261	0.262	0.262	0.262
2006	0.002	0.011	0.047	0.113	0.170	0.213	0.246	0.270	0.287	0.298	0.304	0.307	0.309	0.309	0.308
2007	0.001	0.008	0.035	0.084	0.127	0.158	0.183	0.201	0.213	0.221	0.225	0.228	0.228	0.228	0.228
2008	0.001	0.008	0.034	0.083	0.127	0.161	0.188	0.208	0.222	0.231	0.236	0.239	0.241	0.241	0.241
2009	0.001	0.009	0.038	0.091	0.136	0.167	0.190	0.208	0.220	0.227	0.231	0.233	0.233	0.233	0.232
2010	0.001	0.010	0.042	0.102	0.153	0.190	0.219	0.240	0.254	0.264	0.269	0.272	0.273	0.272	0.272
2011	0.001	0.010	0.042	0.101	0.153	0.191	0.220	0.242	0.257	0.267	0.272	0.275	0.276	0.276	0.276
2012	0.001	0.010	0.044	0.106	0.157	0.193	0.221	0.241	0.255	0.264	0.269	0.271	0.272	0.271	0.270
2013	0.002	0.013	0.053	0.129	0.197	0.248	0.289	0.319	0.340	0.353	0.361	0.365	0.367	0.368	0.367
2014	0.002	0.011	0.048	0.118	0.172	0.209	0.236	0.256	0.269	0.277	0.281	0.283	0.283	0.282	0.280
2015	0.001	0.010	0.041	0.100	0.147	0.178	0.202	0.219	0.231	0.238	0.241	0.243	0.243	0.242	0.241
2016	0.002	0.012	0.051	0.123	0.178	0.212	0.237	0.255	0.266	0.273	0.277	0.278	0.277	0.276	0.274
2017	0.002	0.011	0.045	0.110	0.166	0.209	0.242	0.267	0.284	0.295	0.302	0.305	0.307	0.307	0.306

Table 9 cont.

Chesapeake Bay

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.000	0.006	0.043	0.025	0.014	0.007	0.004	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.001
1983	0.000	0.007	0.053	0.031	0.017	0.009	0.005	0.003	0.002	0.001	0.000	0.000	0.000	0.000	0.001
1984	0.000	0.008	0.054	0.032	0.017	0.009	0.005	0.003	0.002	0.001	0.000	0.000	0.000	0.000	0.001
1985	0.000	0.001	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
1986	0.000	0.002	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
1987	0.000	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
1988	0.000	0.002	0.004	0.004	0.003	0.003	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001
1989	0.000	0.001	0.003	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000
1990	0.000	0.001	0.005	0.021	0.039	0.034	0.024	0.017	0.011	0.008	0.005	0.004	0.002	0.002	0.001
1991	0.000	0.001	0.006	0.024	0.043	0.038	0.027	0.018	0.012	0.009	0.006	0.004	0.003	0.002	0.001
1992	0.000	0.001	0.007	0.027	0.049	0.042	0.030	0.020	0.014	0.010	0.007	0.004	0.003	0.002	0.001
1993	0.000	0.001	0.006	0.023	0.042	0.036	0.026	0.018	0.012	0.008	0.006	0.004	0.003	0.002	0.001
1994	0.000	0.001	0.007	0.030	0.055	0.048	0.034	0.023	0.016	0.011	0.007	0.005	0.003	0.002	0.002
1995	0.000	0.002	0.011	0.044	0.080	0.070	0.049	0.034	0.023	0.016	0.011	0.007	0.005	0.003	0.002
1996	0.001	0.004	0.017	0.042	0.053	0.054	0.052	0.049	0.047	0.045	0.042	0.040	0.038	0.037	0.035
1997	0.001	0.004	0.019	0.046	0.058	0.059	0.056	0.054	0.051	0.049	0.046	0.044	0.042	0.040	0.038
1998	0.001	0.004	0.017	0.040	0.051	0.051	0.049	0.047	0.045	0.042	0.040	0.038	0.037	0.035	0.033
1999	0.001	0.004	0.017	0.041	0.052	0.053	0.051	0.048	0.046	0.044	0.042	0.040	0.038	0.036	0.034
2000	0.001	0.004	0.018	0.045	0.056	0.057	0.054	0.052	0.049	0.047	0.045	0.043	0.040	0.039	0.037
2001	0.001	0.003	0.015	0.036	0.045	0.045	0.043	0.041	0.039	0.037	0.036	0.034	0.032	0.031	0.029
2002	0.001	0.003	0.016	0.039	0.049	0.049	0.047	0.045	0.043	0.041	0.039	0.037	0.035	0.034	0.032
2003	0.001	0.004	0.020	0.050	0.063	0.063	0.061	0.058	0.055	0.053	0.050	0.048	0.045	0.043	0.041
2004	0.001	0.004	0.020	0.048	0.061	0.061	0.059	0.056	0.053	0.051	0.048	0.046	0.044	0.042	0.040
2005	0.001	0.004	0.017	0.042	0.054	0.054	0.052	0.049	0.047	0.045	0.042	0.040	0.038	0.037	0.035
2006	0.001	0.005	0.024	0.057	0.073	0.073	0.070	0.067	0.063	0.060	0.058	0.055	0.052	0.050	0.047
2007	0.001	0.004	0.018	0.044	0.055	0.055	0.053	0.051	0.048	0.046	0.044	0.042	0.040	0.038	0.036
2008	0.001	0.003	0.016	0.038	0.048	0.048	0.047	0.044	0.042	0.040	0.038	0.036	0.035	0.033	0.031
2009	0.001	0.005	0.021	0.051	0.064	0.065	0.062	0.059	0.056	0.054	0.051	0.049	0.046	0.044	0.042
2010	0.001	0.005	0.022	0.053	0.067	0.068	0.065	0.062	0.059	0.056	0.053	0.051	0.048	0.046	0.044
2011	0.001	0.005	0.021	0.052	0.065	0.066	0.063	0.060	0.057	0.054	0.052	0.049	0.047	0.045	0.043
2012	0.001	0.005	0.024	0.058	0.074	0.074	0.071	0.068	0.065	0.062	0.059	0.056	0.053	0.051	0.048
2013	0.001	0.006	0.026	0.062	0.079	0.079	0.076	0.072	0.069	0.065	0.062	0.059	0.056	0.054	0.051
2014	0.001	0.006	0.029	0.070	0.089	0.089	0.086	0.082	0.078	0.074	0.070	0.067	0.064	0.061	0.058
2015	0.001	0.005	0.024	0.059	0.074	0.075	0.072	0.068	0.065	0.062	0.059	0.056	0.053	0.051	0.048
2016	0.001	0.007	0.032	0.079	0.100	0.100	0.096	0.092	0.087	0.083	0.079	0.075	0.072	0.068	0.065
2017	0.001	0.005	0.022	0.054	0.068	0.068	0.065	0.062	0.059	0.057	0.054	0.051	0.049	0.046	0.044

Table 9 cont.

Coast

	Age														
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
1982	0.000	0.006	0.036	0.085	0.125	0.148	0.160	0.165	0.168	0.169	0.170	0.170	0.170	0.170	0.170
1983	0.000	0.005	0.030	0.070	0.102	0.121	0.131	0.136	0.138	0.139	0.139	0.139	0.140	0.140	0.140
1984	0.000	0.002	0.012	0.029	0.043	0.051	0.055	0.057	0.058	0.058	0.058	0.058	0.058	0.058	0.058
1985	0.001	0.005	0.019	0.044	0.075	0.106	0.132	0.152	0.166	0.175	0.182	0.186	0.188	0.190	0.191
1986	0.000	0.001	0.005	0.011	0.020	0.028	0.034	0.040	0.043	0.046	0.047	0.048	0.049	0.050	0.050
1987	0.000	0.001	0.003	0.007	0.012	0.016	0.020	0.023	0.025	0.027	0.028	0.028	0.029	0.029	0.029
1988	0.000	0.001	0.003	0.008	0.014	0.019	0.024	0.027	0.030	0.032	0.033	0.033	0.034	0.034	0.034
1989	0.000	0.001	0.004	0.010	0.018	0.025	0.031	0.036	0.039	0.041	0.043	0.044	0.045	0.045	0.045
1990	0.000	0.001	0.003	0.008	0.014	0.022	0.030	0.037	0.043	0.048	0.052	0.055	0.057	0.059	0.060
1991	0.000	0.001	0.005	0.011	0.021	0.032	0.043	0.053	0.062	0.069	0.075	0.079	0.082	0.084	0.085
1992	0.000	0.002	0.006	0.013	0.025	0.038	0.052	0.065	0.075	0.084	0.090	0.095	0.099	0.102	0.104
1993	0.000	0.001	0.004	0.011	0.020	0.030	0.041	0.051	0.059	0.066	0.071	0.075	0.078	0.080	0.082
1994	0.000	0.002	0.006	0.014	0.026	0.040	0.054	0.067	0.078	0.086	0.093	0.098	0.102	0.105	0.107
1995	0.001	0.003	0.011	0.026	0.047	0.073	0.099	0.123	0.143	0.160	0.172	0.182	0.189	0.194	0.198
1996	0.001	0.004	0.012	0.030	0.055	0.084	0.115	0.142	0.166	0.184	0.199	0.210	0.218	0.224	0.228
1997	0.000	0.004	0.016	0.038	0.067	0.096	0.120	0.139	0.153	0.162	0.168	0.172	0.175	0.177	0.178
1998	0.000	0.004	0.017	0.041	0.073	0.104	0.131	0.151	0.166	0.176	0.183	0.188	0.191	0.192	0.194
1999	0.000	0.004	0.016	0.038	0.066	0.095	0.120	0.138	0.152	0.161	0.168	0.172	0.174	0.176	0.177
2000	0.000	0.004	0.015	0.037	0.065	0.093	0.117	0.135	0.149	0.158	0.164	0.168	0.171	0.172	0.173
2001	0.000	0.004	0.016	0.038	0.067	0.096	0.121	0.140	0.154	0.164	0.170	0.174	0.177	0.179	0.180
2002	0.000	0.004	0.017	0.041	0.072	0.104	0.130	0.151	0.166	0.176	0.183	0.187	0.190	0.192	0.193
2003	0.001	0.004	0.018	0.042	0.074	0.107	0.134	0.155	0.170	0.181	0.188	0.192	0.195	0.197	0.199
2004	0.001	0.005	0.020	0.048	0.085	0.122	0.153	0.177	0.194	0.206	0.214	0.220	0.223	0.225	0.227
2005	0.001	0.005	0.020	0.048	0.085	0.122	0.153	0.177	0.195	0.207	0.215	0.220	0.224	0.226	0.227
2006	0.001	0.006	0.023	0.056	0.098	0.140	0.176	0.204	0.224	0.237	0.246	0.253	0.256	0.259	0.261
2007	0.000	0.004	0.017	0.041	0.072	0.103	0.130	0.150	0.165	0.175	0.182	0.186	0.189	0.191	0.192
2008	0.001	0.005	0.018	0.045	0.078	0.112	0.141	0.164	0.180	0.191	0.198	0.203	0.206	0.208	0.210
2009	0.000	0.004	0.017	0.041	0.071	0.102	0.128	0.149	0.163	0.173	0.180	0.184	0.187	0.189	0.190
2010	0.001	0.005	0.020	0.049	0.085	0.122	0.154	0.178	0.195	0.207	0.215	0.221	0.224	0.226	0.228
2011	0.001	0.005	0.021	0.050	0.087	0.125	0.157	0.182	0.200	0.212	0.220	0.226	0.229	0.232	0.233
2012	0.001	0.005	0.020	0.047	0.083	0.119	0.150	0.174	0.191	0.202	0.210	0.215	0.219	0.221	0.222
2013	0.001	0.007	0.028	0.067	0.118	0.170	0.213	0.247	0.271	0.288	0.299	0.306	0.311	0.314	0.316
2014	0.001	0.005	0.020	0.047	0.083	0.119	0.150	0.174	0.191	0.203	0.211	0.216	0.219	0.221	0.223
2015	0.000	0.004	0.017	0.041	0.072	0.103	0.130	0.151	0.165	0.176	0.182	0.187	0.190	0.192	0.193
2016	0.001	0.005	0.018	0.045	0.078	0.112	0.141	0.163	0.179	0.190	0.198	0.202	0.206	0.208	0.209
2017	0.001	0.006	0.023	0.056	0.098	0.141	0.177	0.205	0.225	0.239	0.248	0.254	0.258	0.260	0.262

Table 10. Estimates of January 1 population abundance by age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	8+
1982	37,879,200	8,310,650	4,230,280	2,646,920	933,938	392,682	319,102	197,426	171,890	276,834	193,339	303,476	167,049	121,274	320,574	56,464,634	1,751,862
1983	75,360,100	12,234,300	4,162,130	2,492,180	1,704,500	633,455	278,010	233,147	143,697	124,910	201,043	140,374	220,321	121,274	320,574	98,370,015	1,505,340
1984	65,571,900	24,340,000	6,124,170	2,442,040	1,619,410	1,178,240	459,696	208,830	174,723	107,594	93,500	150,479	105,069	164,913	330,482	103,071,046	1,335,590
1985	72,586,400	21,179,400	12,215,600	3,654,990	1,652,210	1,187,850	917,533	372,663	169,359	141,752	87,315	75,892	122,156	85,300	401,920	114,850,340	1,456,357
1986	69,912,900	23,433,600	10,668,300	7,628,970	2,510,560	1,191,650	882,222	691,235	275,323	123,400	102,315	62,631	54,217	87,040	346,286	117,970,649	1,742,447
1987	72,076,500	22,579,700	11,837,100	6,742,550	5,403,280	1,911,380	956,010	731,944	570,728	226,556	101,314	83,880	51,299	44,383	354,568	123,671,193	2,164,673
1988	96,974,800	23,280,600	11,423,100	7,514,200	4,808,210	4,154,810	1,553,510	805,631	615,028	478,587	189,720	84,765	70,139	42,881	333,372	152,329,353	2,620,123
1989	107,989,000	31,321,200	11,763,900	7,229,740	5,340,300	3,682,660	3,361,650	1,302,620	673,344	512,885	398,512	157,828	70,476	58,297	312,646	174,175,058	3,486,608
1990	126,282,000	34,878,300	15,833,200	7,449,520	5,132,850	4,078,000	2,965,110	2,800,510	1,080,350	556,699	423,141	328,329	129,919	57,982	305,035	202,300,945	5,681,965
1991	100,831,000	40,778,800	17,635,100	10,009,800	5,201,120	3,788,440	3,187,840	2,417,490	2,284,060	880,335	453,022	343,869	266,500	105,350	293,997	188,476,723	7,044,623
1992	107,985,000	32,557,000	20,607,900	11,127,300	6,950,100	3,799,970	2,923,320	2,559,510	1,937,140	1,824,770	701,144	359,821	272,508	210,821	315,254	194,131,558	8,180,968
1993	132,385,000	34,864,400	16,446,000	12,981,100	7,685,920	5,029,430	2,899,470	2,318,440	2,023,490	1,525,120	1,430,770	547,794	280,308	211,810	407,887	221,036,939	8,745,619
1994	283,461,000	42,746,500	17,620,800	10,381,400	9,025,440	5,629,360	3,891,710	2,334,720	1,863,450	1,621,840	1,218,840	1,140,470	435,713	222,582	491,137	382,084,962	9,328,752
1995	182,467,000	91,515,500	21,588,300	11,087,900	7,142,310	6,483,970	4,265,980	3,068,980	1,836,820	1,460,730	1,266,510	948,577	885,106	337,411	551,296	334,906,390	10,355,430
1996	232,186,000	58,887,500	46,121,200	13,471,700	7,435,800	4,895,610	4,648,810	3,165,180	2,257,930	1,338,540	1,054,990	907,797	675,803	627,645	626,976	378,301,481	10,654,861
1997	257,890,000	74,906,300	29,613,000	28,544,400	9,012,800	5,196,820	3,526,040	3,388,540	2,249,750	1,571,480	916,318	713,308	608,346	450,103	831,194	419,418,399	10,729,039
1998	144,271,000	83,209,600	37,644,500	18,239,200	18,866,000	6,194,100	3,683,670	2,544,030	2,405,310	1,579,420	1,095,650	636,355	494,428	421,434	888,339	322,173,036	10,064,966
1999	149,660,000	46,552,300	41,824,900	23,210,000	12,085,700	12,986,400	4,386,540	2,648,770	1,796,140	1,677,000	1,092,350	754,146	436,893	339,088	898,430	300,348,657	9,642,817
2000	127,026,000	48,292,400	23,405,300	25,812,500	15,415,500	8,358,220	9,264,470	3,184,870	1,891,720	1,268,440	1,175,900	762,779	525,501	304,199	862,112	267,549,911	9,975,521
2001	195,511,000	40,987,000	24,275,600	14,431,400	17,105,300	10,634,800	5,951,700	6,718,640	2,273,260	1,335,780	889,638	821,557	531,927	366,251	813,534	322,647,387	13,750,587
2002	224,713,000	63,092,900	20,617,000	15,015,000	9,636,690	11,907,400	7,633,870	4,345,200	4,822,030	1,612,460	940,344	623,441	574,317	371,447	823,881	366,728,980	14,113,120
2003	138,321,000	72,510,400	31,718,100	12,720,300	9,965,940	6,647,900	8,451,910	5,501,860	3,074,810	3,369,500	1,117,650	648,634	428,917	394,672	821,502	295,693,095	15,357,545
2004	312,204,000	44,625,100	36,411,700	19,470,300	8,339,100	6,764,340	4,638,290	5,986,390	3,826,350	2,112,070	2,296,510	758,342	439,141	290,183	823,463	448,985,279	16,532,449
2005	162,318,000	100,718,000	22,398,100	22,310,600	12,708,100	5,612,090	4,658,210	3,229,690	4,080,310	2,570,110	1,405,430	1,519,700	500,361	289,400	734,153	345,052,254	14,329,154
2006	136,410,000	52,369,300	50,578,800	13,757,300	14,648,000	8,615,970	3,893,330	3,266,390	2,215,990	2,757,910	1,720,380	935,257	1,008,040	331,404	677,846	293,185,917	12,913,217
2007	92,700,400	43,996,400	26,244,200	30,784,600	8,834,550	9,623,040	5,759,930	2,620,620	2,145,520	1,431,410	1,762,550	1,092,580	592,019	637,262	638,322	228,863,403	10,920,283
2008	129,214,000	29,910,400	22,108,900	16,161,600	20,338,900	6,059,840	6,792,620	4,129,890	1,845,610	1,492,620	988,091	1,211,140	749,006	405,487	873,970	242,282,074	11,695,814
2009	77,468,200	41,693,400	15,031,900	13,624,300	10,695,800	13,955,000	4,266,640	4,844,880	2,887,030	1,272,380	1,019,800	671,421	820,501	506,706	865,393	189,623,351	12,888,111
2010	104,883,000	24,992,900	20,938,600	9,230,320	8,938,500	7,273,090	9,767,710	3,035,400	3,387,610	1,995,170	872,923	696,763	457,841	559,201	936,033	197,965,061	11,940,941
2011	147,889,000	33,833,100	12,538,500	12,802,300	5,993,210	5,975,290	4,974,170	6,755,470	2,055,330	2,260,940	1,319,470	574,226	457,103	300,064	980,552	238,708,725	14,703,155
2012	214,390,000	47,706,300	16,974,000	7,667,930	8,316,890	4,006,780	4,083,410	3,434,640	4,563,800	1,367,920	1,490,490	864,980	375,336	298,436	836,522	316,377,434	13,232,124
2013	65,410,700	69,153,100	23,925,500	10,361,700	4,959,370	5,535,610	2,730,780	2,817,230	2,322,030	3,043,340	904,390	980,635	567,768	246,203	745,338	193,703,694	11,626,934
2014	92,611,600	21,092,500	34,598,100	14,462,800	6,544,530	3,171,970	3,570,620	1,760,420	1,762,370	1,422,830	1,840,120	542,474	585,663	338,436	591,091	184,895,524	8,843,404
2015	186,912,000	29,867,000	10,567,000	21,017,200	9,243,360	4,290,580	2,129,060	2,427,370	1,173,450	1,159,440	928,617	1,195,820	351,905	379,869	604,032	272,246,703	8,220,503
2016	239,584,000	60,294,000	14,988,000	6,466,180	13,673,000	6,217,020	2,969,060	1,497,500	1,678,290	802,078	786,959	627,887	807,234	237,502	665,004	351,293,714	7,102,454
2017	108,810,000	77,257,600	30,192,300	9,083,670	4,109,320	8,912,970	4,158,250	2,016,020	998,963	1,106,670	525,307	513,671	409,412	526,600	590,437	249,211,190	6,687,080

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

	Age																
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Total	SE
1982	0	0	0	152	347	398	862	764	821	2,019	1,874	3,010	2,060	1,671	5,135	19,112	2,567
1983	0	0	0	134	602	523	603	824	707	817	1,674	1,341	2,492	1,584	4,789	16,090	2,266
1984	0	0	0	144	611	997	1,213	727	928	682	700	1,629	1,218	2,196	5,165	16,211	2,260
1985	0	0	0	255	559	1,076	2,365	1,350	903	887	672	692	1,385	1,065	5,659	16,866	2,185
1986	0	0	0	627	932	932	1,978	2,368	1,250	672	706	525	513	920	3,945	15,369	1,872
1987	0	0	0	526	2,243	1,460	1,938	2,269	2,574	1,228	668	712	490	471	4,384	18,962	2,065
1988	0	0	0	573	2,281	4,066	3,576	2,425	2,624	2,337	1,368	754	689	465	4,132	25,288	2,338
1989	0	0	0	566	2,457	4,164	9,767	5,079	3,186	3,421	2,856	1,369	733	654	3,987	38,239	3,057
1990	0	0	0	561	1,989	4,034	8,282	11,097	5,244	2,902	2,941	2,725	1,182	587	3,321	44,866	3,243
1991	0	0	0	773	2,139	3,040	8,394	8,972	12,021	4,666	3,426	2,543	2,477	1,069	3,392	52,912	3,639
1992	0	0	0	812	3,052	3,493	7,436	9,625	10,618	12,172	5,483	3,820	3,067	2,744	5,116	67,439	4,635
1993	0	0	0	973	3,247	4,625	7,544	9,134	11,269	10,251	11,764	5,270	3,248	2,729	5,852	75,906	5,025
1994	0	0	0	841	3,917	5,061	10,262	9,232	10,236	10,409	10,111	10,824	4,767	2,727	6,792	85,180	5,351
1995	0	0	0	945	3,101	6,025	11,852	12,083	10,570	10,422	8,500	8,361	8,999	3,791	6,789	91,436	5,499
1996	0	0	0	1,137	3,617	5,305	14,823	14,127	13,626	9,936	8,562	7,681	7,085	7,262	8,236	101,396	6,260
1997	0	0	0	2,570	4,004	4,967	9,123	12,250	12,597	11,868	7,906	6,443	6,629	5,572	11,883	95,812	6,372
1998	0	0	0	1,136	7,201	4,883	9,295	9,151	12,491	9,408	7,838	5,679	4,909	4,763	11,083	87,835	5,494
1999	0	0	0	1,330	3,677	8,586	8,186	8,816	9,324	10,902	7,971	6,282	4,556	3,998	12,591	86,218	5,452
2000	0	0	0	1,457	4,642	5,741	18,530	9,839	10,128	7,789	9,579	7,004	5,816	3,905	13,265	97,695	5,878
2001	0	0	0	937	5,651	8,250	12,769	21,320	11,233	8,728	6,548	6,405	5,200	4,059	9,758	100,859	5,532
2002	0	0	0	876	3,300	9,332	17,210	14,917	22,781	10,003	7,273	5,325	5,674	4,264	11,209	112,163	6,106
2003	0	0	0	691	3,306	5,220	18,597	18,205	14,952	19,852	8,145	5,449	4,236	4,446	10,503	113,602	6,194
2004	0	0	0	1,042	2,922	5,204	10,287	19,576	18,256	12,346	16,024	6,063	4,171	3,123	10,057	109,072	6,140
2005	0	0	0	1,287	4,164	4,557	10,339	11,309	20,192	15,156	10,079	12,999	4,956	3,261	9,672	107,971	6,348
2006	0	0	0	739	4,534	6,122	8,153	10,972	11,573	16,731	12,395	7,677	10,188	3,797	8,989	101,869	6,241
2007	0	0	0	1,480	2,755	7,141	12,771	8,641	11,377	9,241	13,789	9,574	6,279	7,789	9,228	100,065	6,373
2008	0	0	0	866	6,373	5,014	17,347	14,380	9,551	10,081	7,706	10,600	7,887	4,883	11,968	106,656	6,430
2009	0	0	0	740	3,161	11,140	10,285	18,099	15,378	8,120	7,811	5,692	8,351	5,891	11,427	106,094	6,306
2010	0	0	0	500	2,699	5,702	22,311	10,206	16,963	12,671	6,640	5,674	4,520	6,316	12,059	106,261	6,295
2011	0	0	0	758	1,817	4,447	11,061	22,167	10,211	13,879	9,356	5,011	4,548	3,441	13,073	99,768	6,322
2012	0	0	0	472	2,866	3,108	9,445	12,360	23,011	9,085	11,343	7,622	4,014	3,610	11,864	98,798	6,768
2013	0	0	0	551	1,717	4,554	6,033	9,493	12,176	18,757	7,108	8,792	6,077	3,014	10,592	88,864	6,782
2014	0	0	0	710	2,083	2,430	8,211	5,866	9,372	9,642	14,130	5,445	6,859	4,575	9,676	78,999	7,098
2015	0	0	0	1,201	3,229	3,778	5,030	8,634	6,251	7,444	7,226	10,968	3,905	4,758	8,434	70,858	6,786
2016	0	0	0	310	4,529	5,264	7,576	5,646	9,155	5,731	6,496	5,982	9,440	3,165	10,629	73,924	7,574
2017	0	0	0	502	1,423	7,094	9,871	6,955	5,120	7,681	4,404	4,880	4,752	7,037	8,758	68,476	7,630

Table 12. Sensitivity analysis results for 2018 assessment model.

	2018 Base model		Continuity		Quasi-continuity		ESS 50% decrease		ESS 50% increase		Increase M after 1996		No adj comm. rel.		BHSR method	
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
1982	0.171	19,112	0.858	5,759	0.858	13,893	0.159	21,428	0.168	19,037	0.105	32,443	0.169	19,462	0.175	18,459
1983	0.141	16,090	0.153	4,719	0.139	11,070	0.131	18,303	0.139	15,944	0.082	28,825	0.138	16,417	0.139	15,547
1984	0.066	16,211	0.162	5,294	0.078	11,947	0.058	18,506	0.068	15,981	0.035	30,379	0.064	16,579	0.066	15,766
1985	0.192	16,866	0.099	6,335	0.208	14,010	0.158	19,272	0.211	16,482	0.094	32,380	0.187	17,282	0.181	16,507
1986	0.051	15,369	0.062	6,568	0.060	13,582	0.043	17,753	0.053	14,810	0.024	31,344	0.049	15,820	0.050	15,235
1987	0.030	18,962	0.030	7,891	0.034	16,646	0.026	21,807	0.031	18,301	0.014	38,948	0.029	19,557	0.030	18,812
1988	0.035	25,288	0.046	11,254	0.041	23,859	0.031	29,025	0.037	24,511	0.017	51,742	0.034	26,130	0.035	25,079
1989	0.046	38,239	0.048	18,190	0.053	38,140	0.040	43,697	0.048	37,217	0.022	78,184	0.044	39,571	0.046	37,870
1990	0.061	44,866	0.086	22,619	0.081	45,851	0.051	51,166	0.064	43,761	0.029	92,358	0.058	46,519	0.062	44,328
1991	0.087	52,912	0.073	27,350	0.089	54,218	0.071	60,333	0.091	51,615	0.035	111,219	0.082	54,993	0.088	52,154
1992	0.105	67,439	0.058	33,971	0.104	65,403	0.086	77,031	0.110	65,730	0.041	146,627	0.109	70,018	0.106	66,377
1993	0.083	75,906	0.077	40,856	0.083	75,033	0.069	86,357	0.087	74,102	0.032	170,654	0.080	78,185	0.084	74,585
1994	0.109	85,180	0.091	46,612	0.105	83,314	0.091	96,339	0.113	83,293	0.041	196,112	0.107	87,323	0.110	83,639
1995	0.200	91,436	0.126	57,954	0.190	100,383	0.168	102,449	0.209	89,683	0.070	218,365	0.194	93,260	0.201	89,794
1996	0.263	101,396	0.115	65,462	0.243	106,224	0.229	113,000	0.270	99,754	0.089	261,793	0.266	103,080	0.264	99,723
1997	0.217	95,812	0.194	66,710	0.172	101,519	0.210	106,894	0.211	94,497	0.087	264,650	0.224	96,834	0.218	94,338
1998	0.227	87,835	0.176	57,693	0.179	92,848	0.222	95,664	0.220	87,599	0.095	231,438	0.231	88,090	0.228	86,717
1999	0.212	86,218	0.151	57,868	0.166	94,995	0.209	92,645	0.205	86,615	0.093	219,525	0.213	86,387	0.213	85,263
2000	0.211	97,695	0.191	67,623	0.172	111,810	0.210	102,683	0.204	98,917	0.096	234,204	0.210	98,150	0.212	96,821
2001	0.209	100,859	0.180	67,540	0.168	115,930	0.208	103,226	0.203	102,697	0.099	223,565	0.208	101,854	0.210	100,251
2002	0.225	112,163	0.171	74,859	0.179	130,481	0.224	113,391	0.219	114,521	0.110	235,898	0.225	113,559	0.226	111,598
2003	0.241	113,602	0.199	77,385	0.195	133,961	0.239	113,897	0.234	116,108	0.120	228,035	0.238	115,303	0.241	113,149
2004	0.267	109,072	0.233	75,514	0.219	130,905	0.266	108,940	0.260	111,494	0.135	212,353	0.265	111,151	0.268	108,745
2005	0.262	107,971	0.244	75,878	0.221	132,254	0.262	107,857	0.255	110,380	0.133	207,243	0.260	110,403	0.263	107,711
2006	0.309	101,869	0.277	70,859	0.251	125,478	0.309	101,770	0.299	104,170	0.156	193,003	0.304	104,471	0.308	101,709
2007	0.228	100,065	0.241	69,165	0.192	124,502	0.230	99,692	0.221	102,484	0.116	190,487	0.227	103,078	0.228	100,002
2008	0.241	106,656	0.242	68,248	0.199	127,239	0.243	105,766	0.234	109,099	0.125	197,369	0.237	110,041	0.240	106,716
2009	0.233	106,094	0.196	67,339	0.197	128,421	0.235	104,490	0.227	108,593	0.124	191,581	0.230	109,854	0.232	106,342
2010	0.273	106,261	0.188	66,748	0.219	125,900	0.274	104,107	0.265	108,761	0.147	187,545	0.270	110,225	0.270	106,732
2011	0.276	99,768	0.224	67,741	0.224	123,409	0.277	97,425	0.269	102,226	0.150	174,521	0.270	103,658	0.273	100,526
2012	0.272	98,798	0.185	68,540	0.218	123,154	0.270	96,648	0.265	101,213	0.149	171,381	0.278	103,008	0.267	99,968
2013	0.368	88,864	0.240	65,497	0.279	113,324	0.362	87,355	0.358	91,089	0.199	153,530	0.363	91,954	0.360	90,422
2014	0.283	78,999	0.214	63,491	0.226	105,849	0.276	78,459	0.276	81,121	0.151	140,560	0.282	81,890	0.275	81,031
2015	0.243	70,858	0.148	59,609	0.184	98,060	0.235	71,232	0.237	72,602	0.131	125,916	0.243	73,367	0.236	73,220
2016	0.278	73,924	0.181	63,642	0.216	101,816	0.267	75,217	0.272	75,614	0.151	129,207	0.278	76,284	0.268	76,868
2017	0.307	68,476	-	-	-	-	0.296	70,458	0.299	69,904	0.167	119,119	0.303	70,371	0.295	71,750

Figure 1 Schematic abundance calculations.

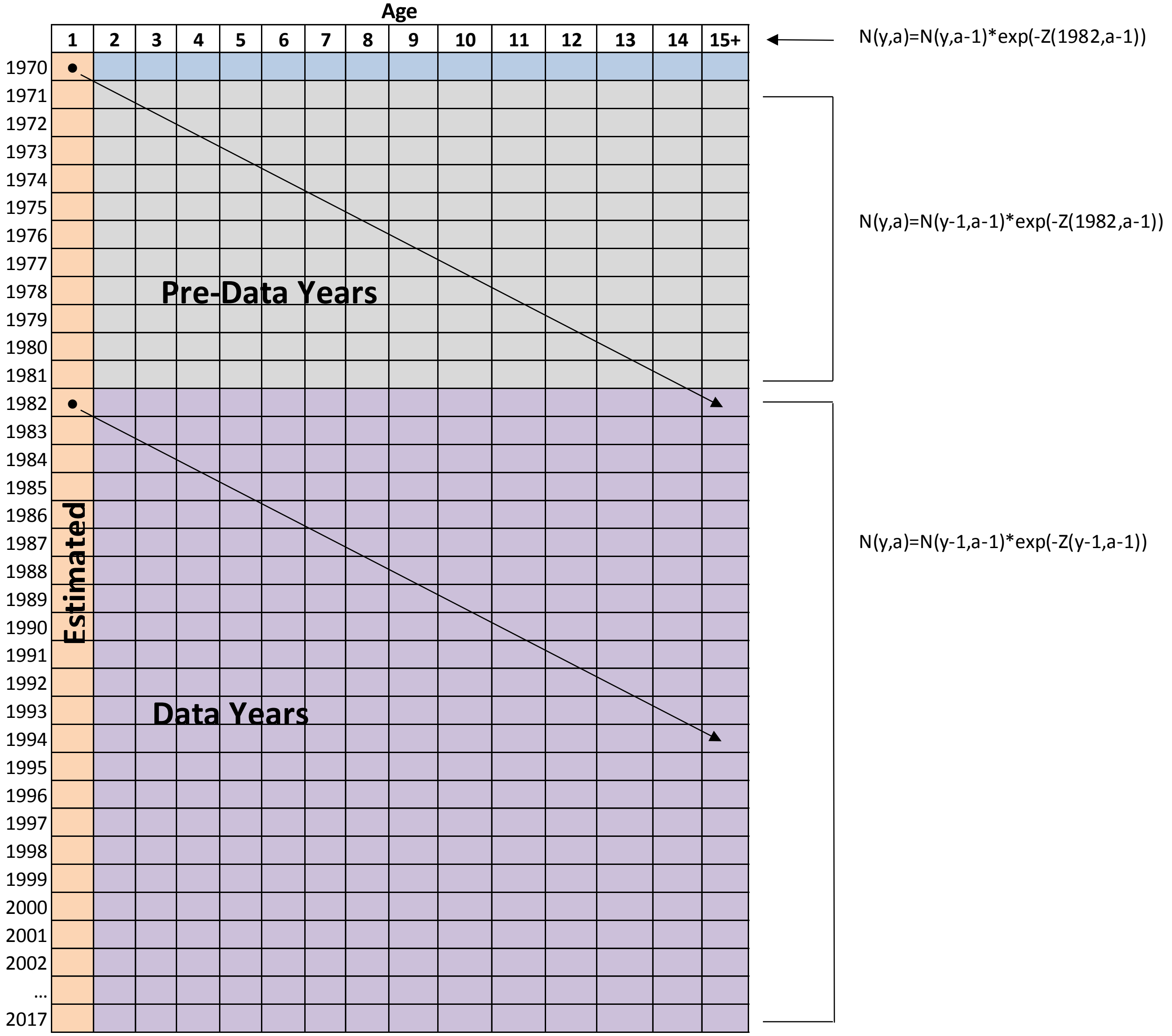


Figure 2. Selectivity pattern estimated for each age composition survey.

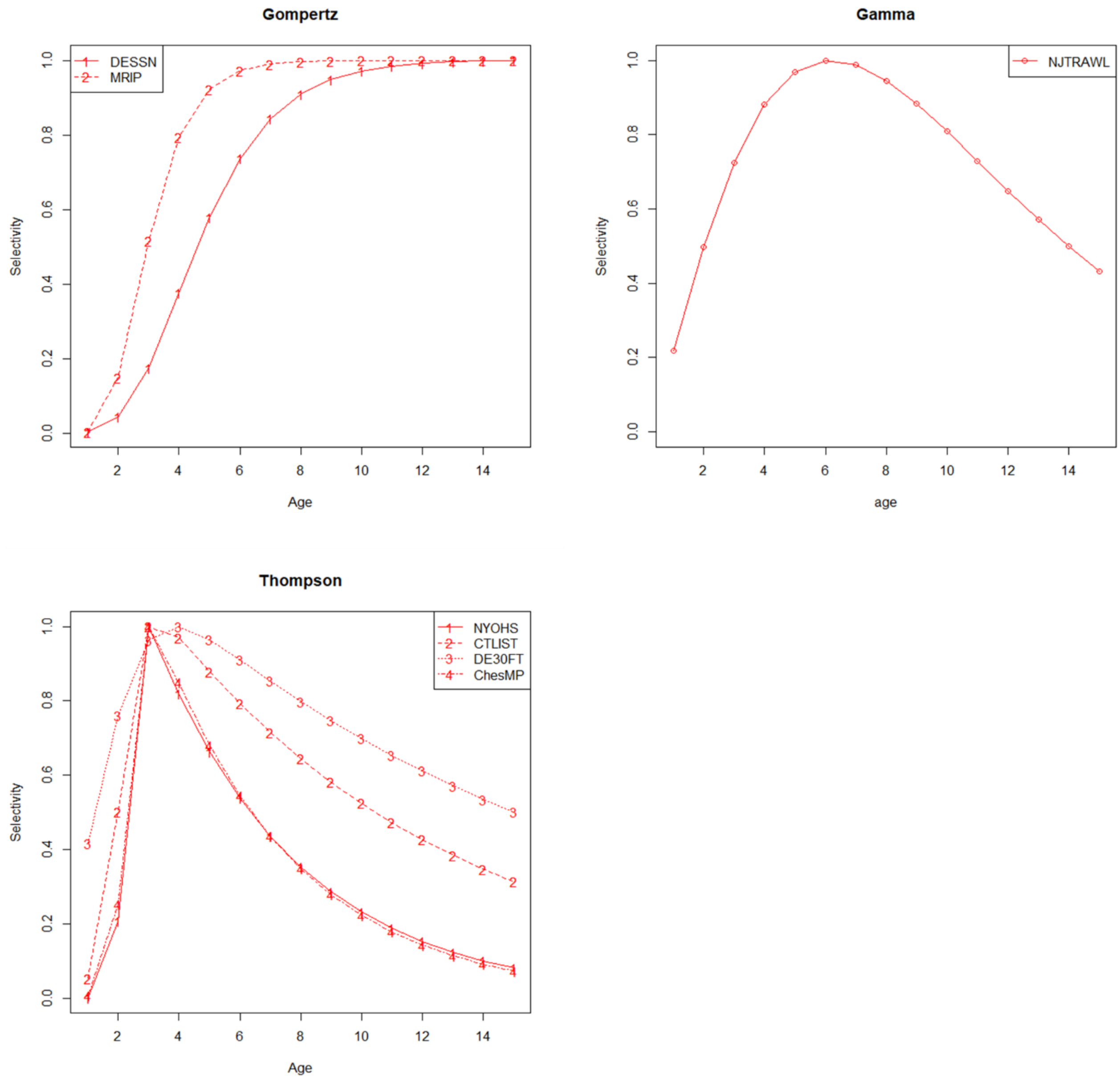
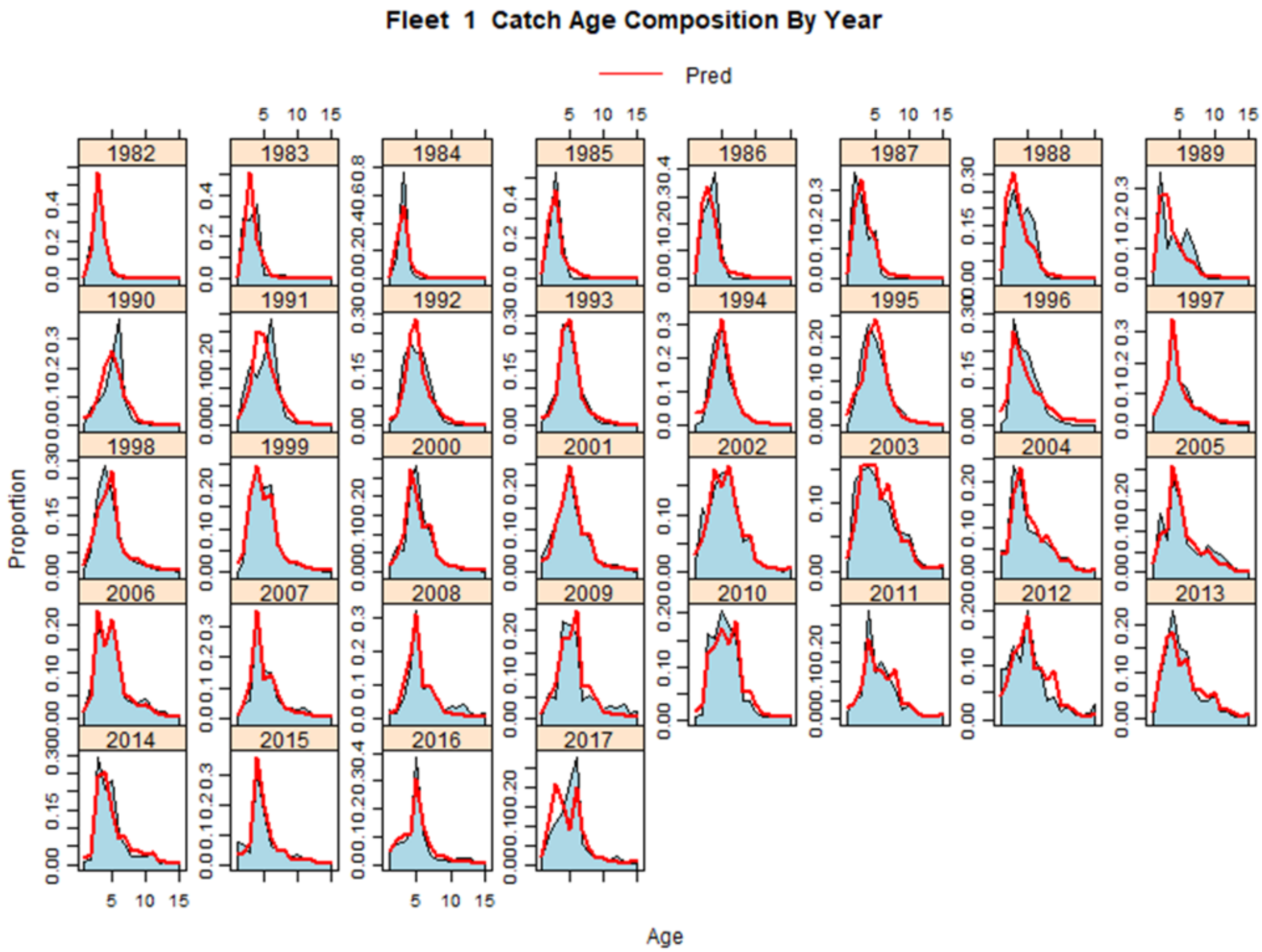


Figure 3. Plots of observed and predicted catch proportions-at-age by year for each fleet.



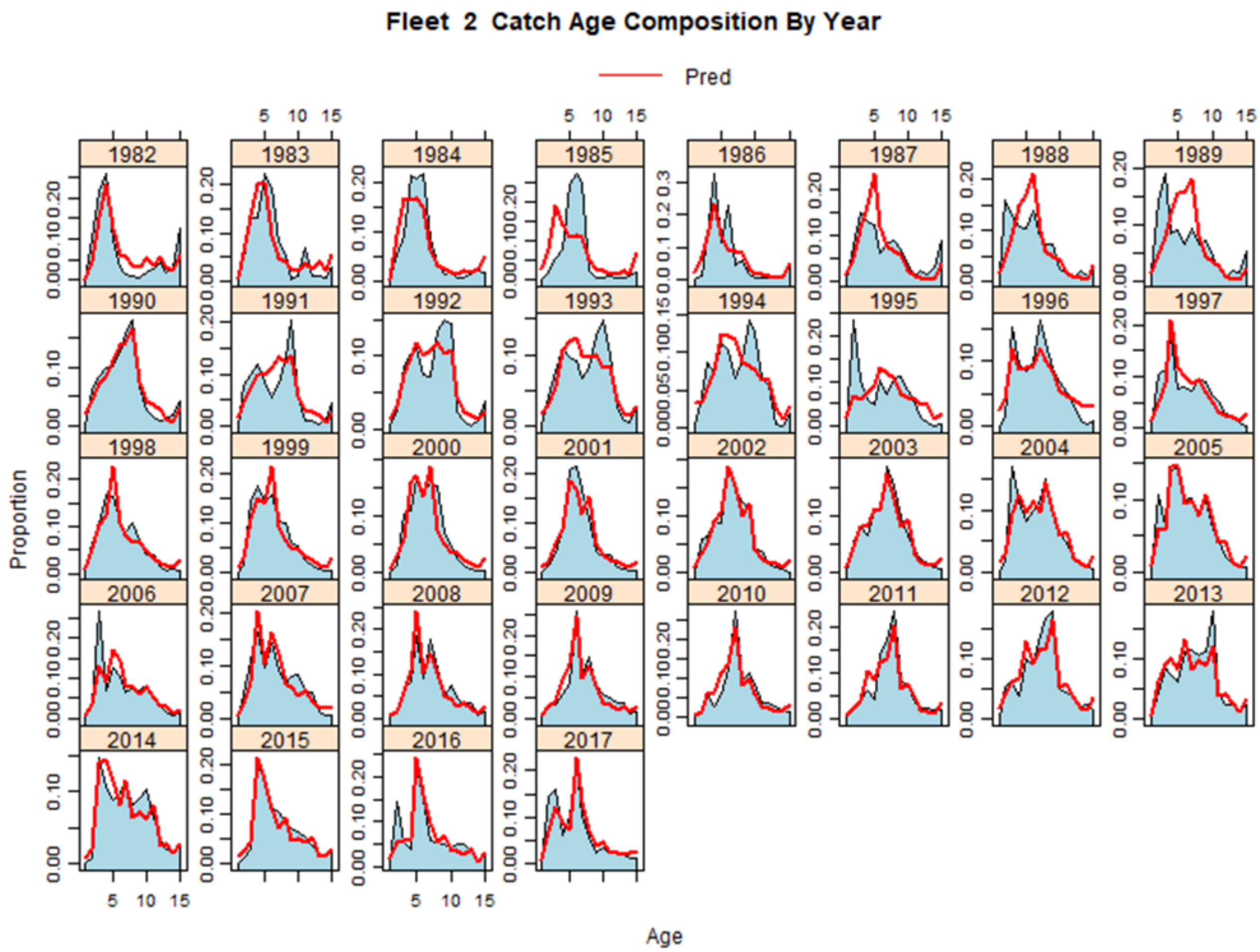
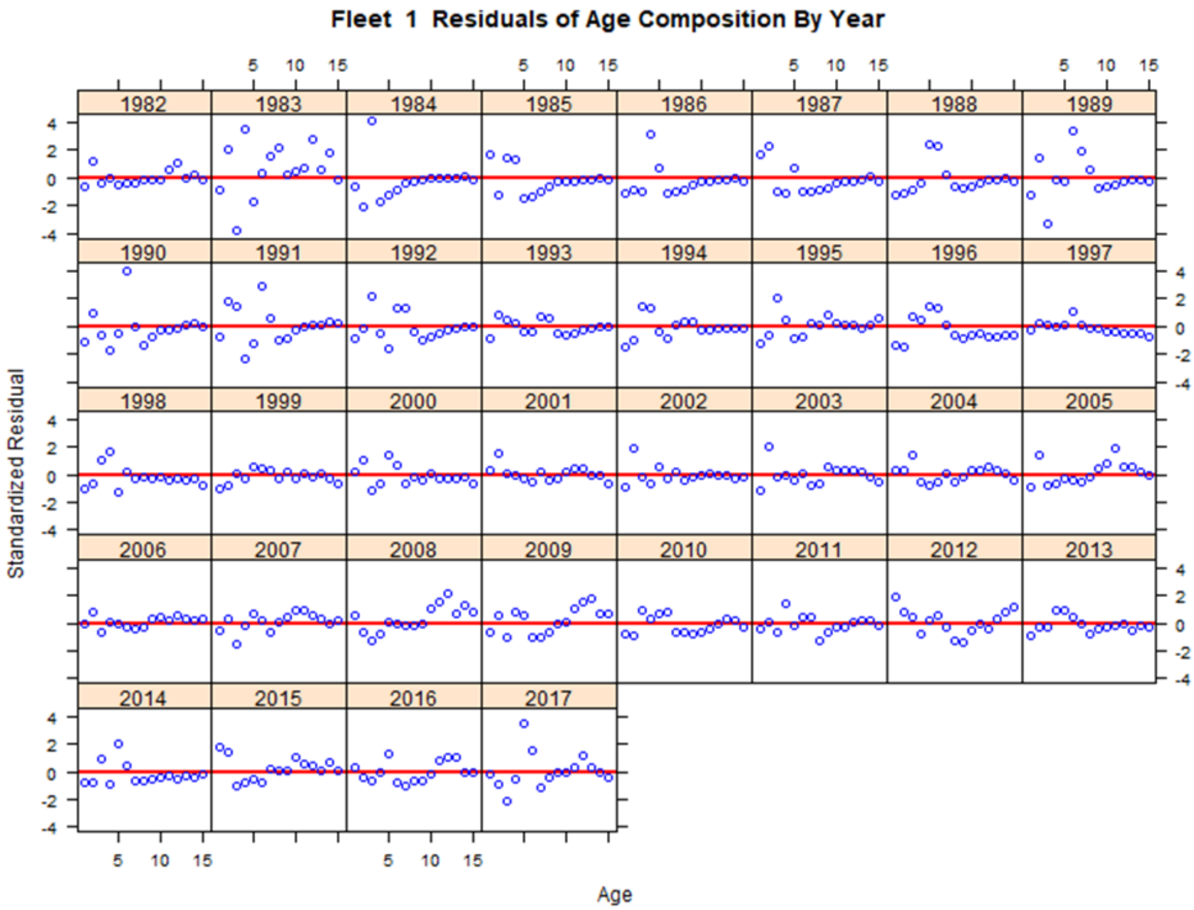

Fleet 2 Catch Age Composition By Year
Pred
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Proportion
Age

Figure 4. Standardized residuals of catch proportions-at-age by year for each fleet.



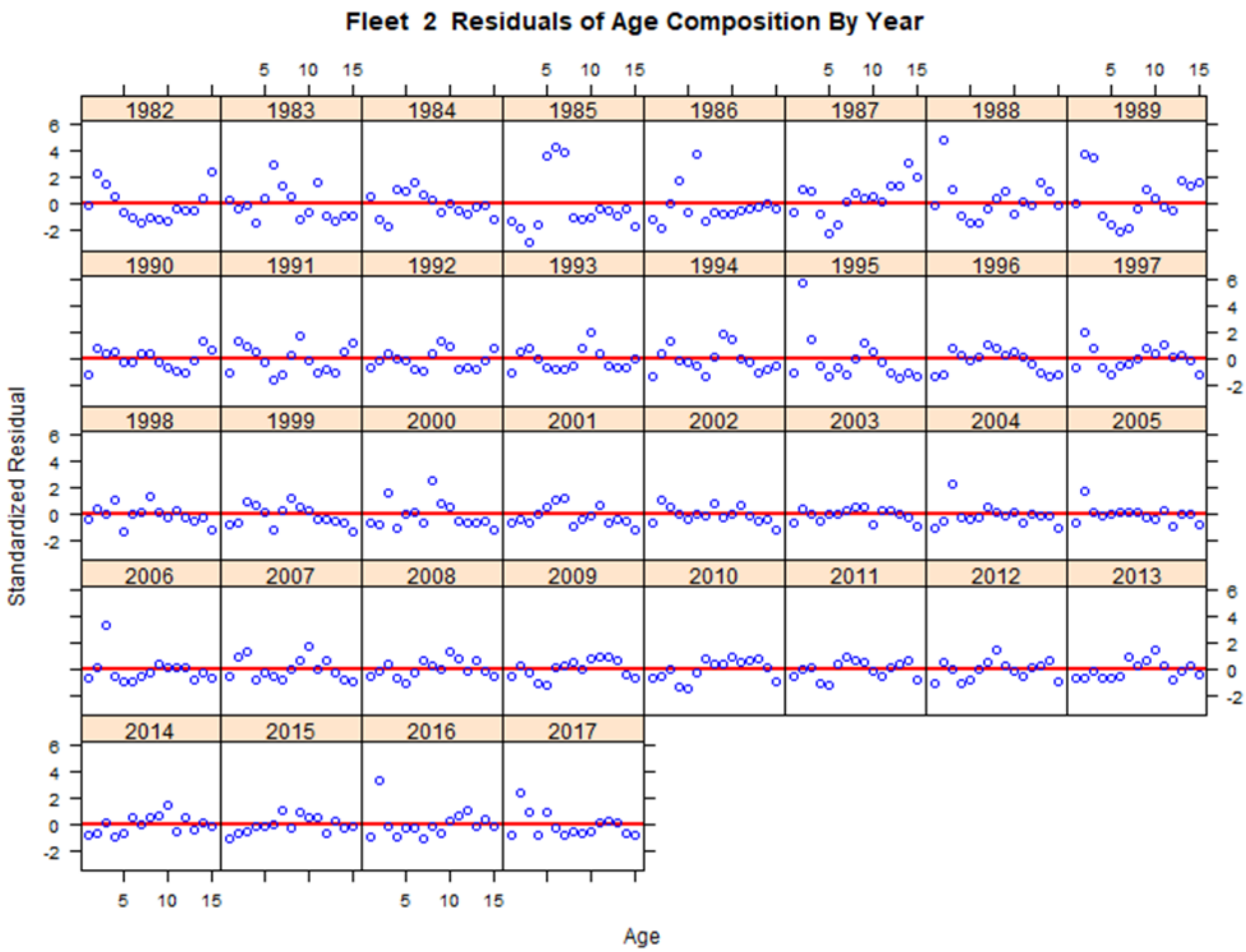
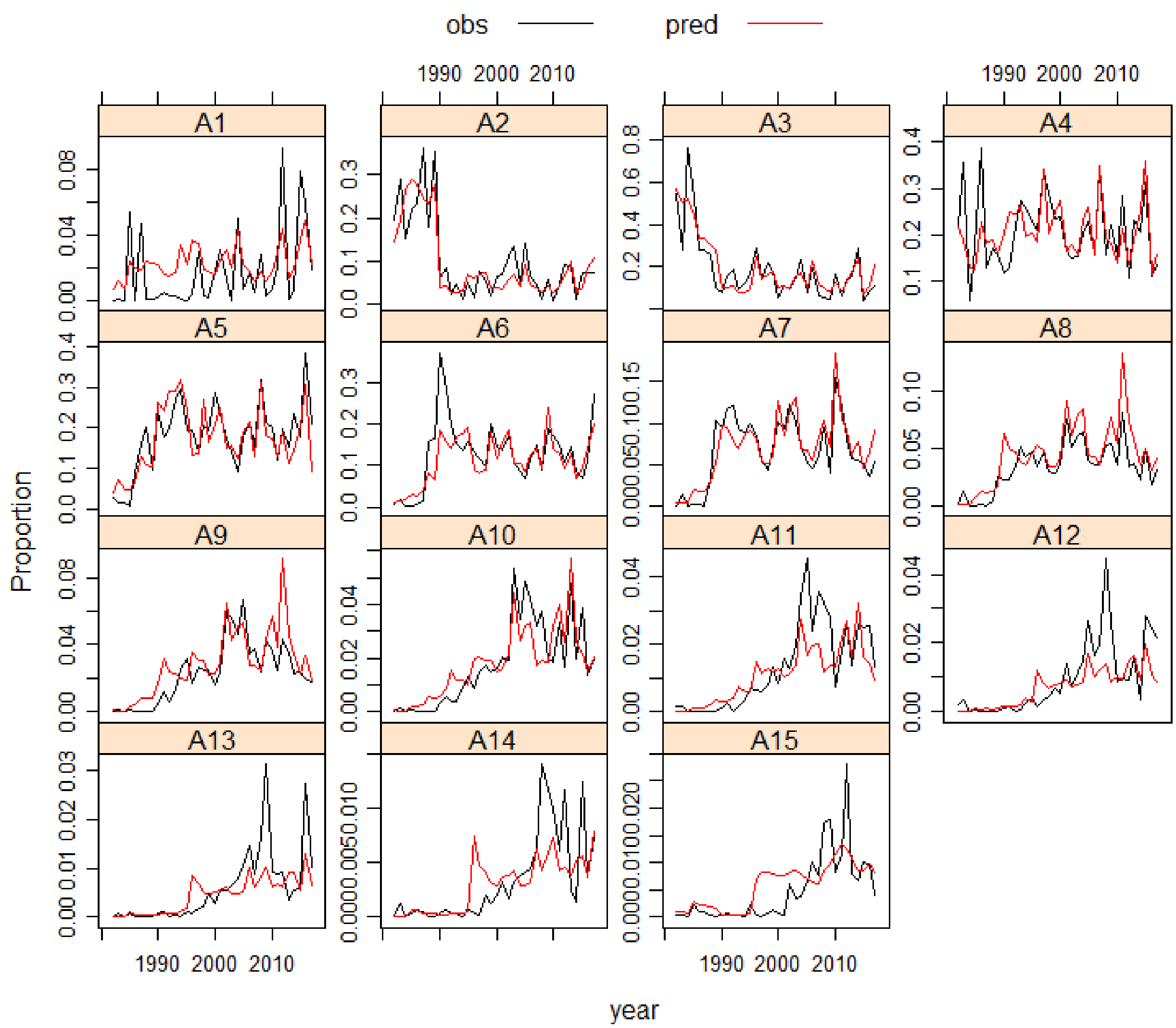
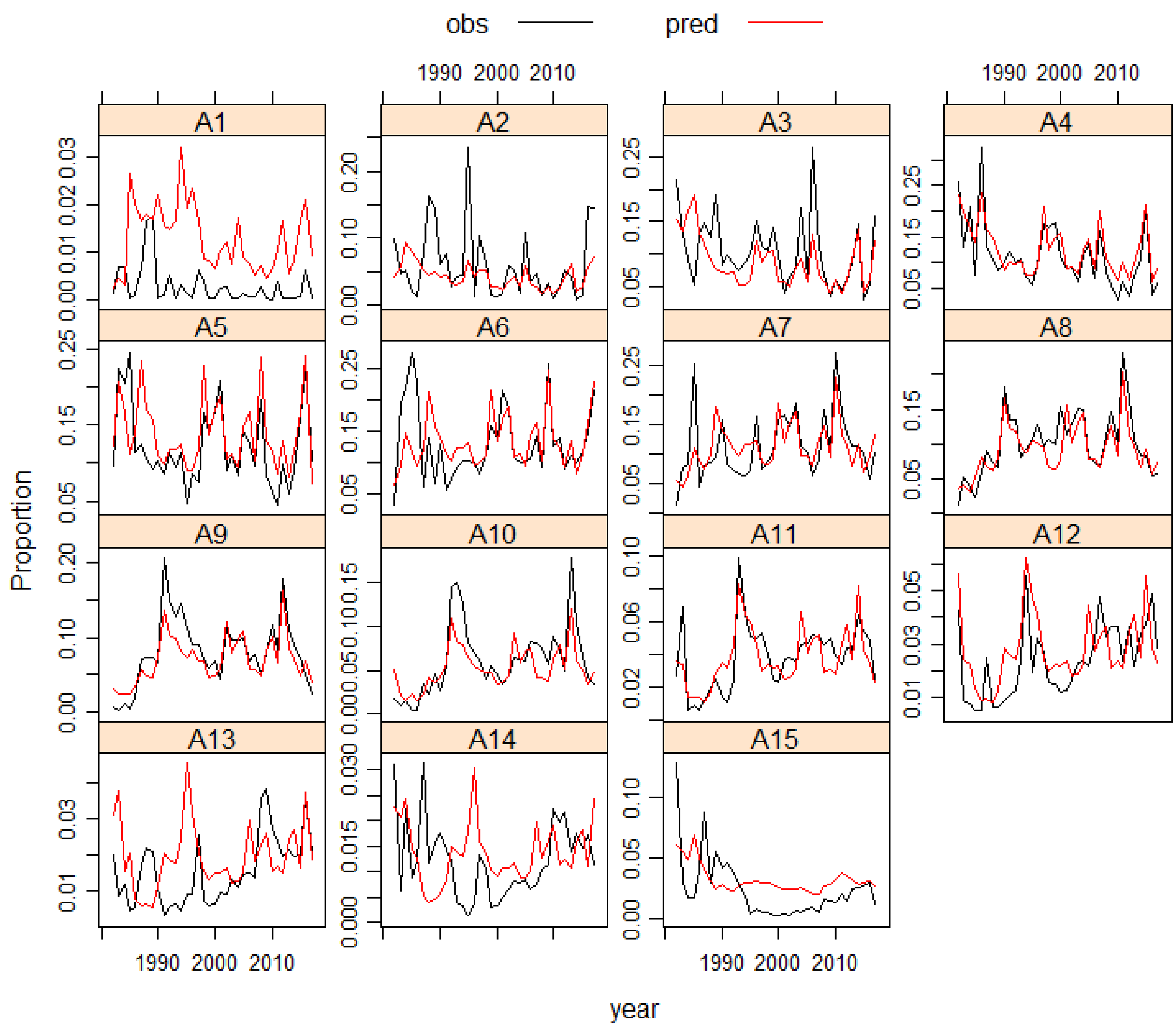

Fleet 2 Residuals of Age Composition By Year
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Standardized Residual
Age

Figure 5. Observed and predicted catch proportions-at-age by age for each fleet.

Fleet 1:

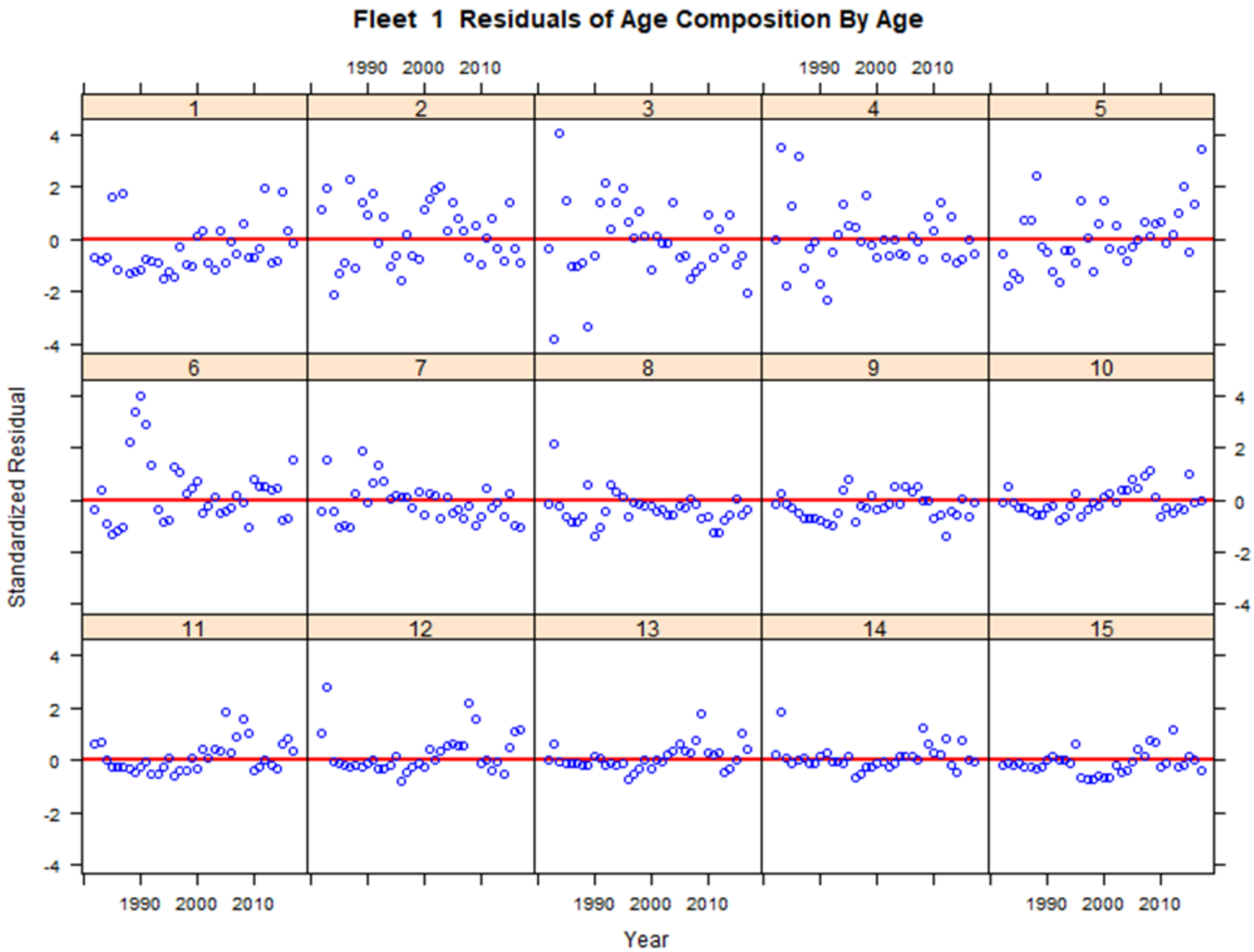


Fleet 2:



obs
pred
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
A15
Proportion
year
1990 2000 2010

Figure 6. Standardized residuals of catch proportions-at-age by age.



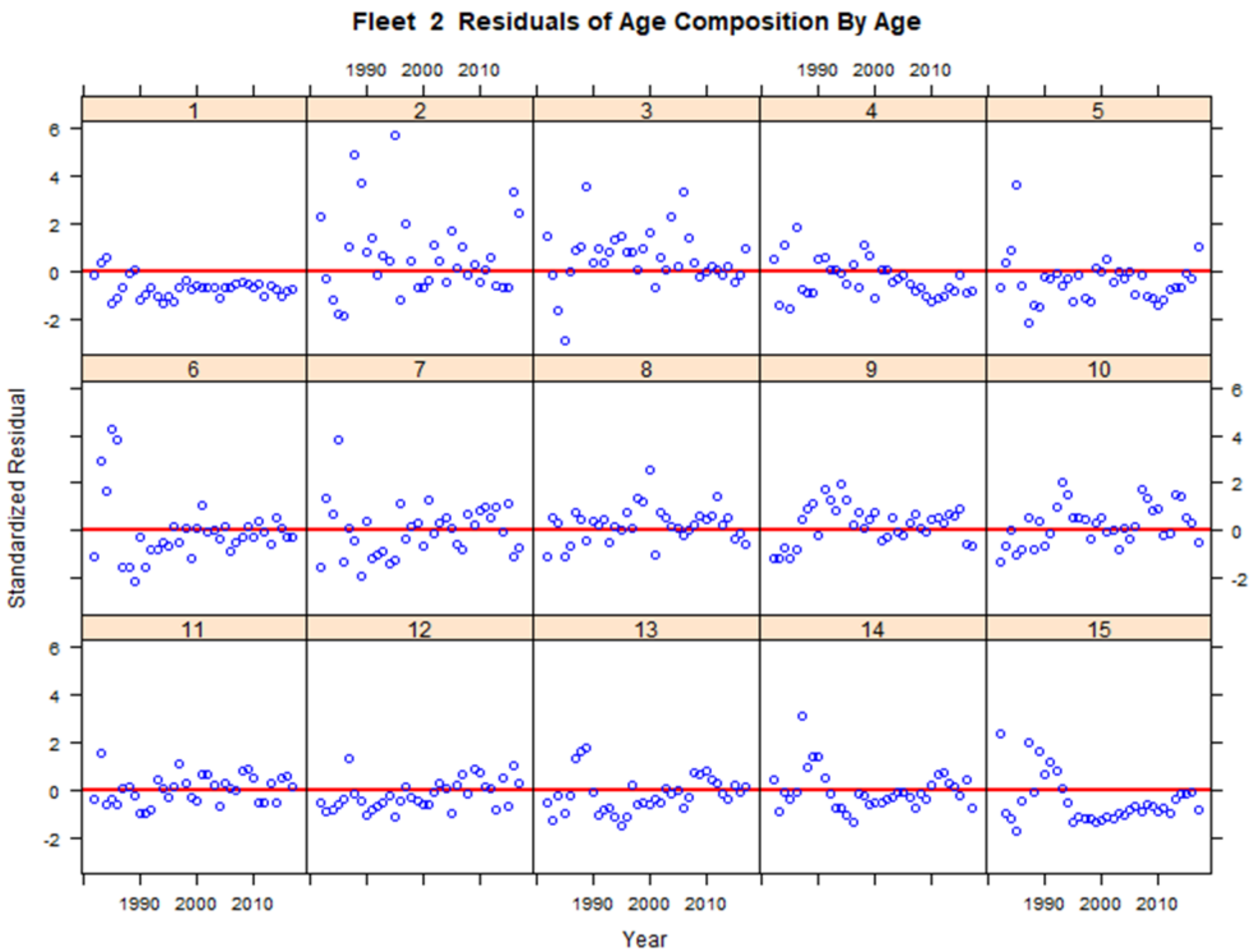
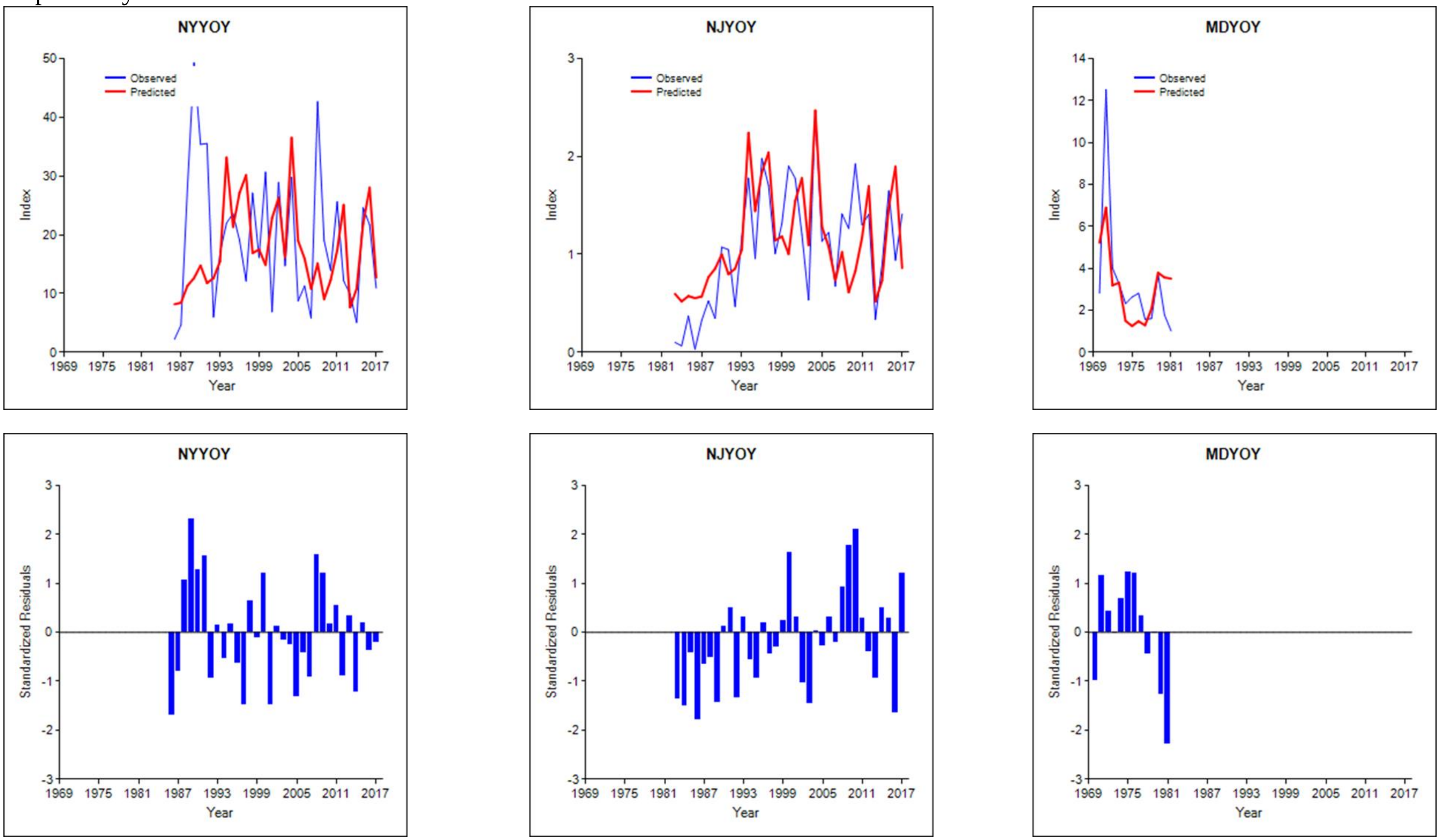

Fleet 2 Residuals of Age Composition By Age
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Standardized Residual
Year
1990
2000
2010
6
4
2
0
-2

Figure 7. Observed and predicted values and standardized residuals for young-of-the-year and yearling surveys tuned to Age 1 and 2, respectively.



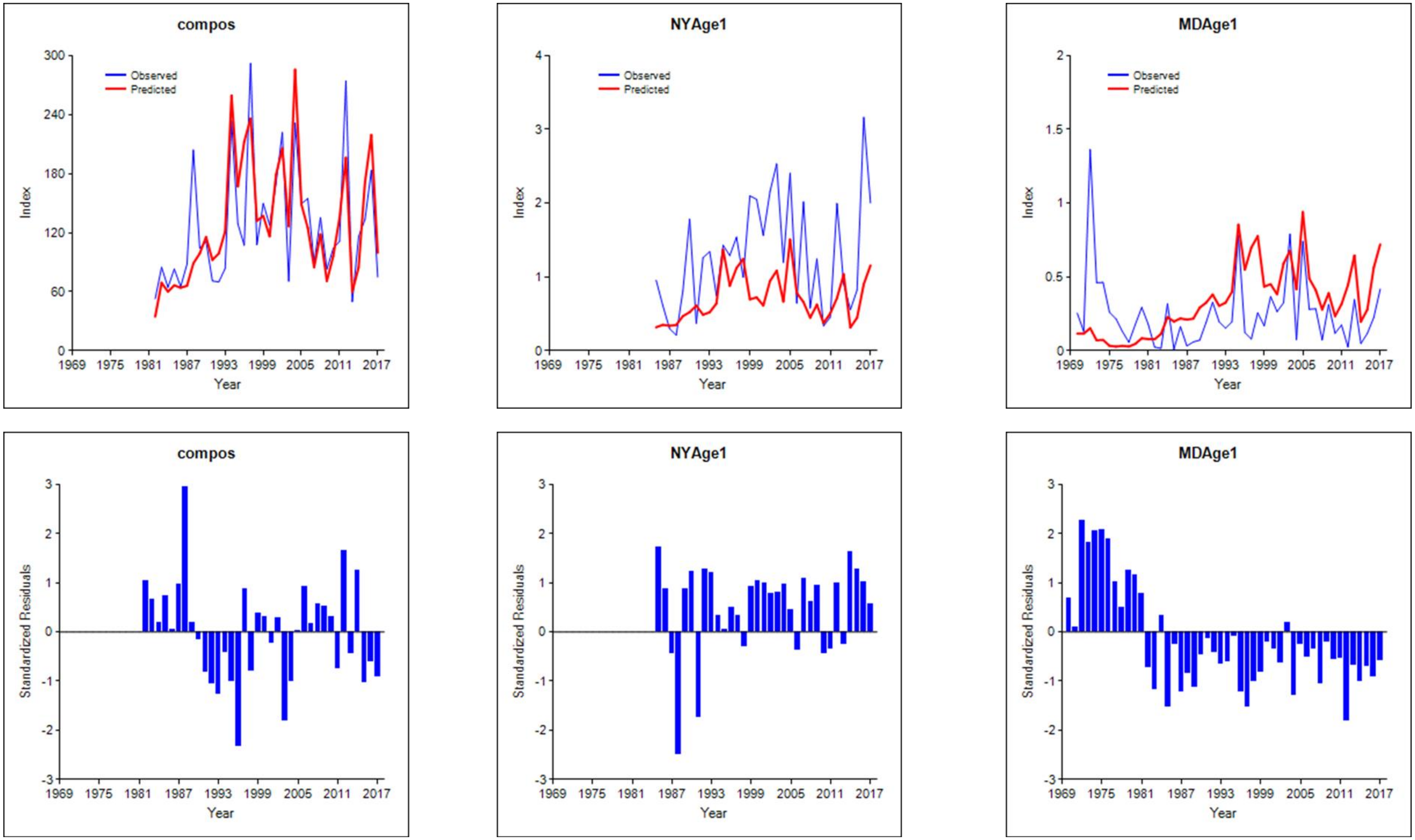

compos
NYAge1
MDAge1
Observed
Predicted
Index
Year
Standardized Residuals

Figure 8. Observed and predicted values of the total index and standardized residuals for surveys with age composition data; observed and predicted proportions-at-age and standardized residual for each year by age, and age by year, for the NYOHS survey.

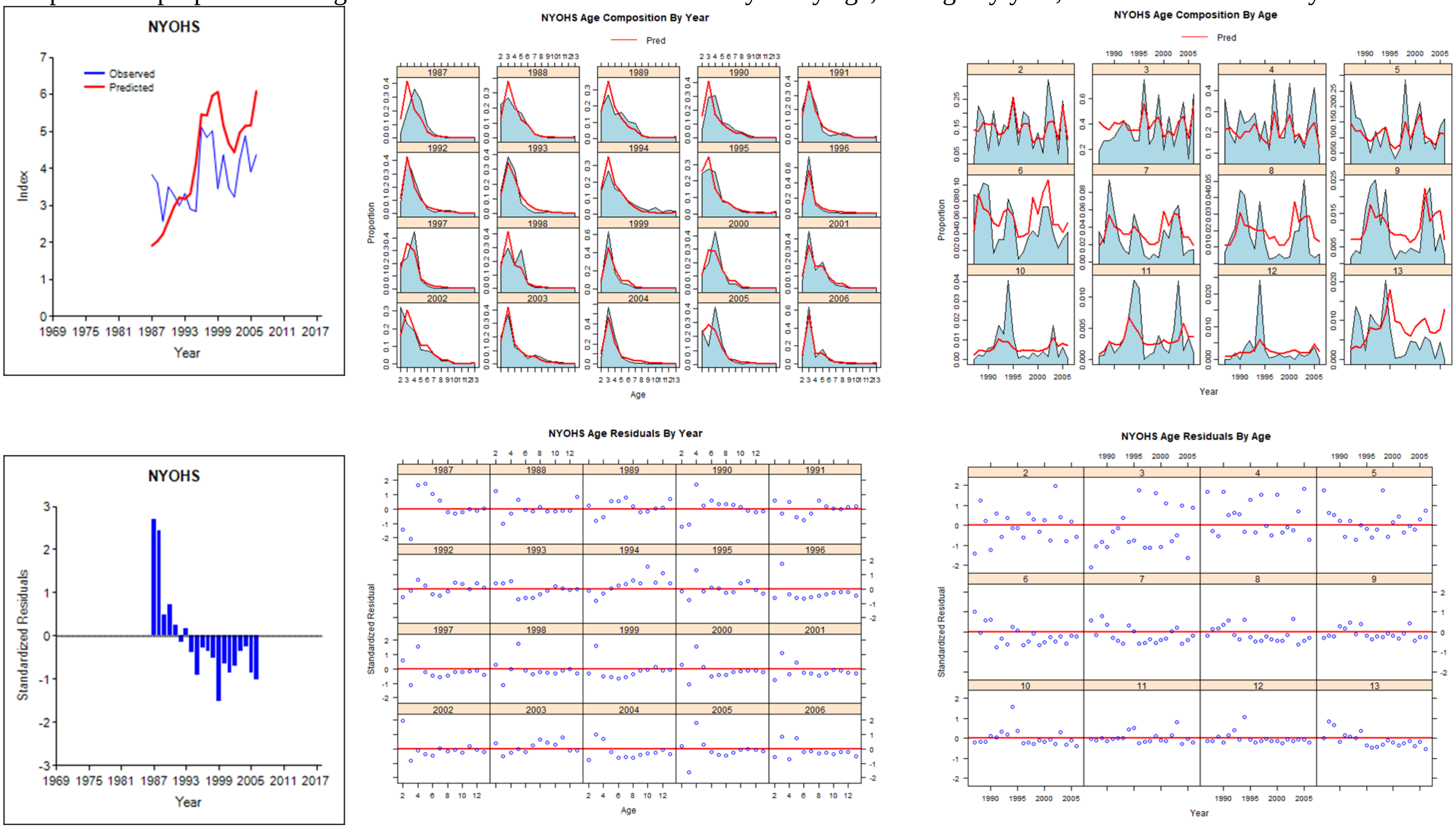


Figure 9. Observed and predicted values of the total index and standardized residuals for surveys with age composition data; observed and predicted proportions-at-age and standardized residual for each year by age, and age by year, for the NJTRAWL survey.

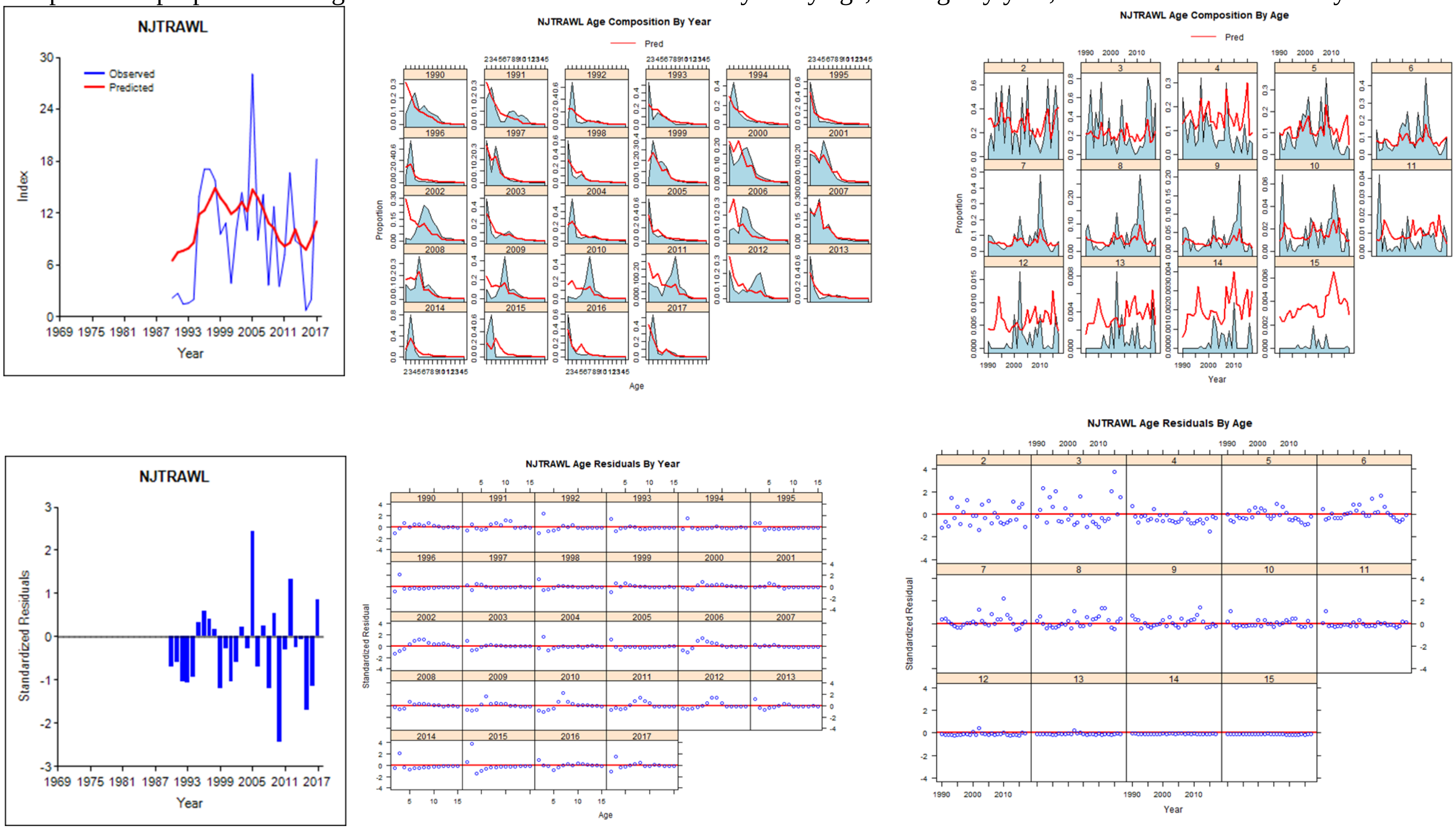


Figure 10. Observed and predicted values of the total index and standardized residuals for surveys with age composition data; observed and predicted proportions-at-age and standardized residual for each year by age, and age by year, for the MDSSN survey.

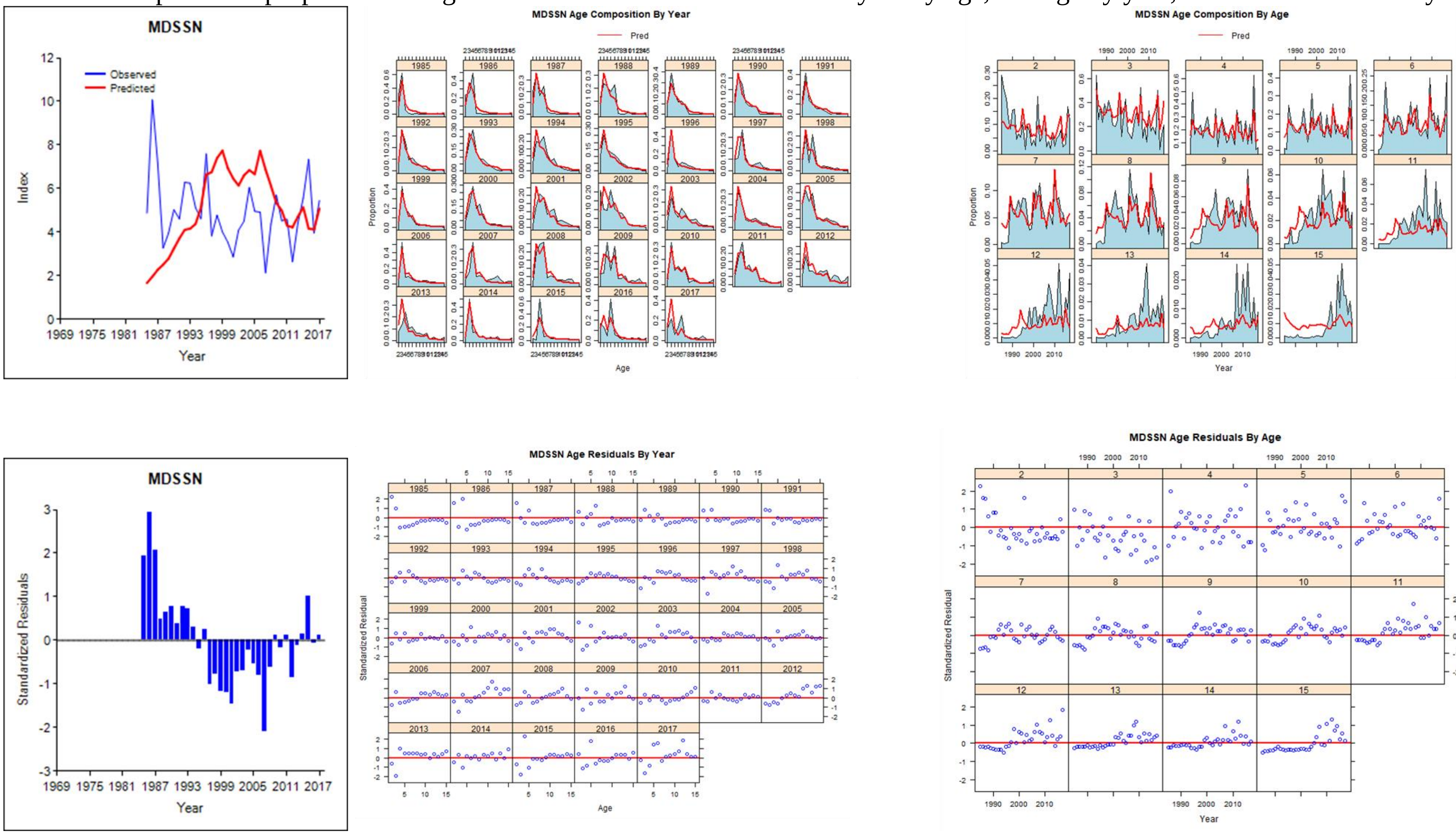


Figure 11. Observed and predicted values of the total index and standardized residuals for surveys with age composition data; observed and predicted proportions-at-age and standardized residual for each year by age, and age by year, for the DESSN survey.

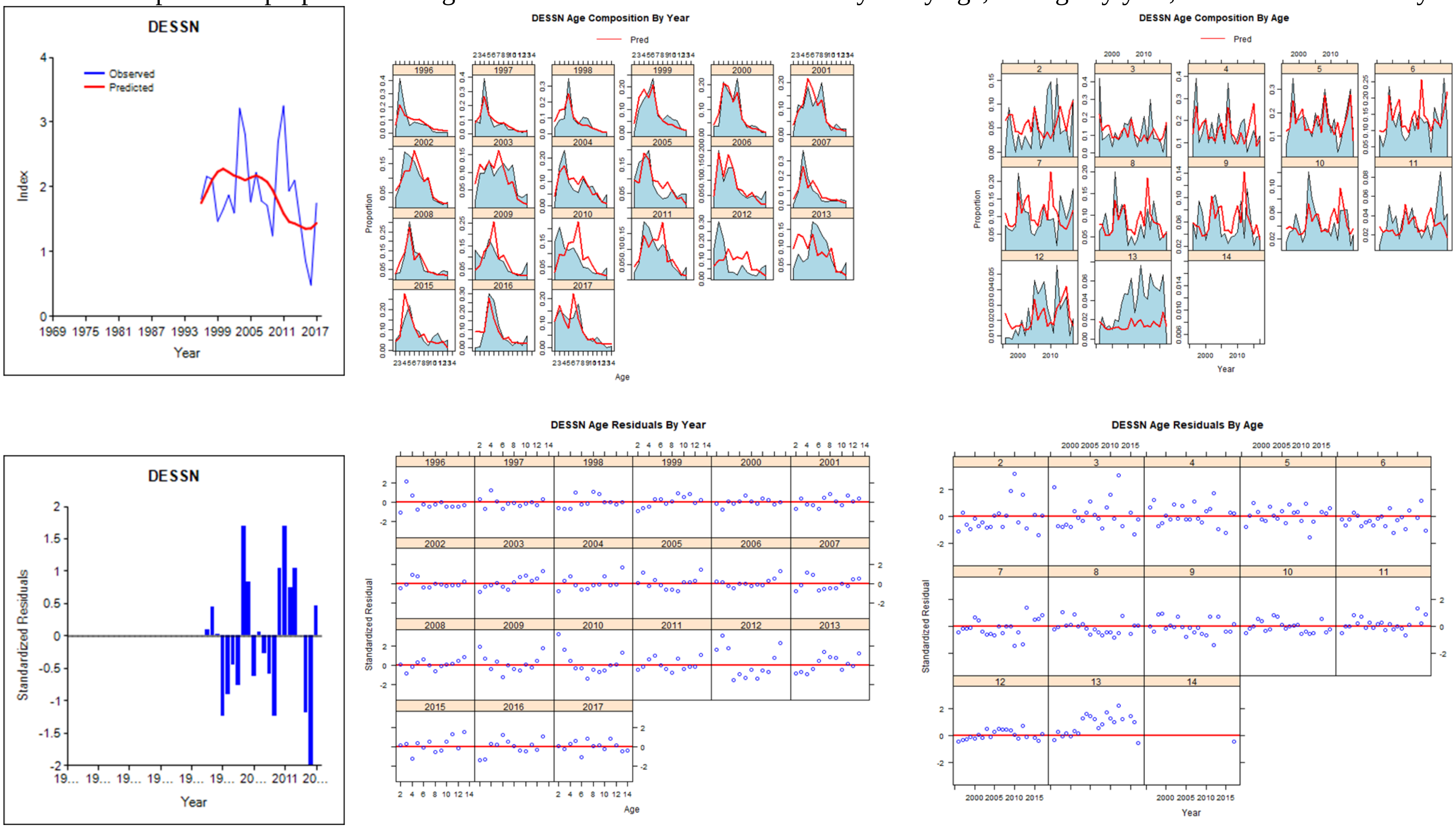


Figure 12. Observed and predicted values of the total index and standardized residuals for surveys with age composition data; observed and predicted proportions-at-age and standardized residual for each year by age, and age by year, for the MRIP survey.

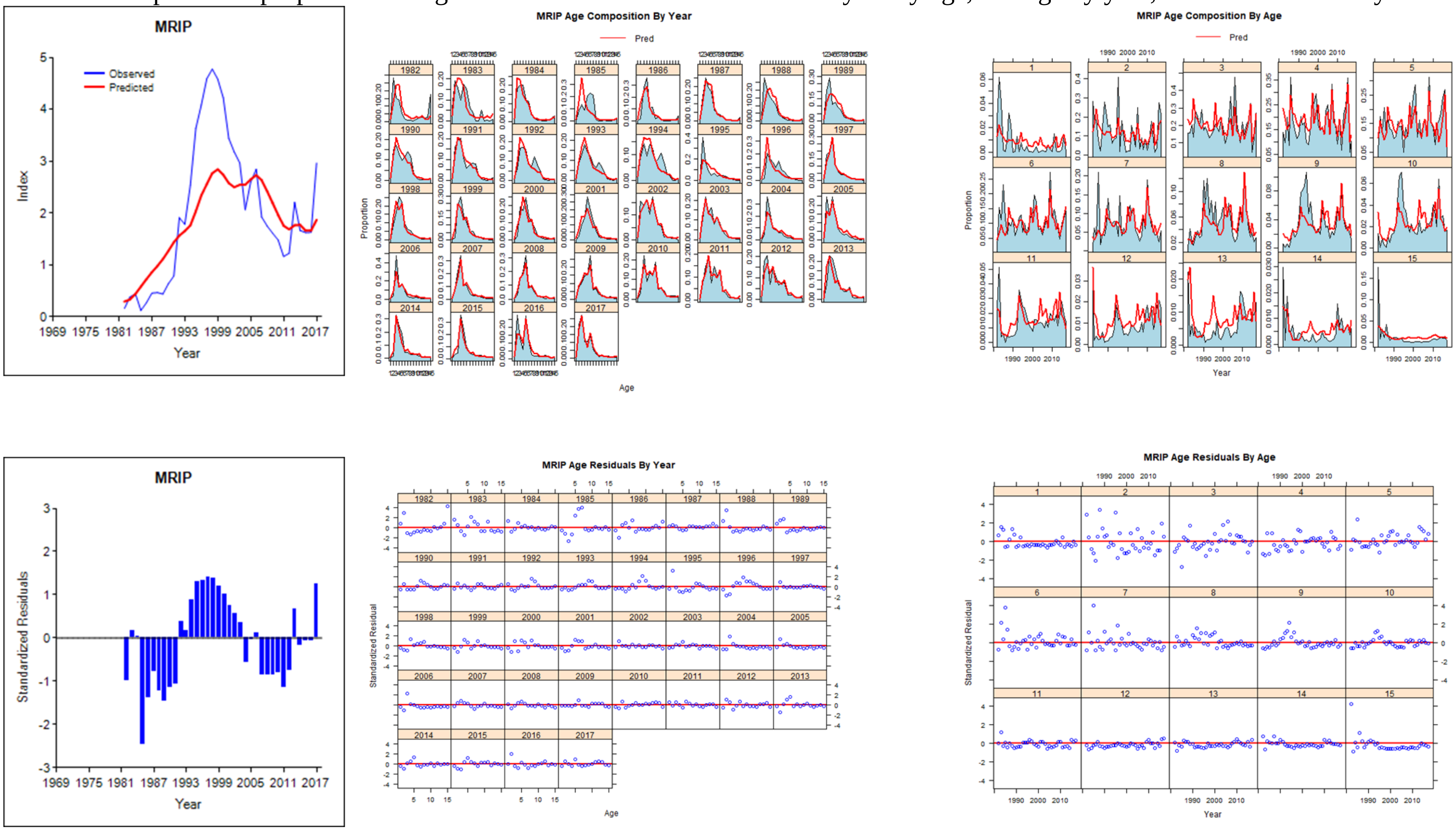


Figure 13. Observed and predicted values of the total index and standardized residuals for surveys with age composition data; observed and predicted proportions-at-age and standardized residual for each year by age, and age by year, for the CTLIST survey.

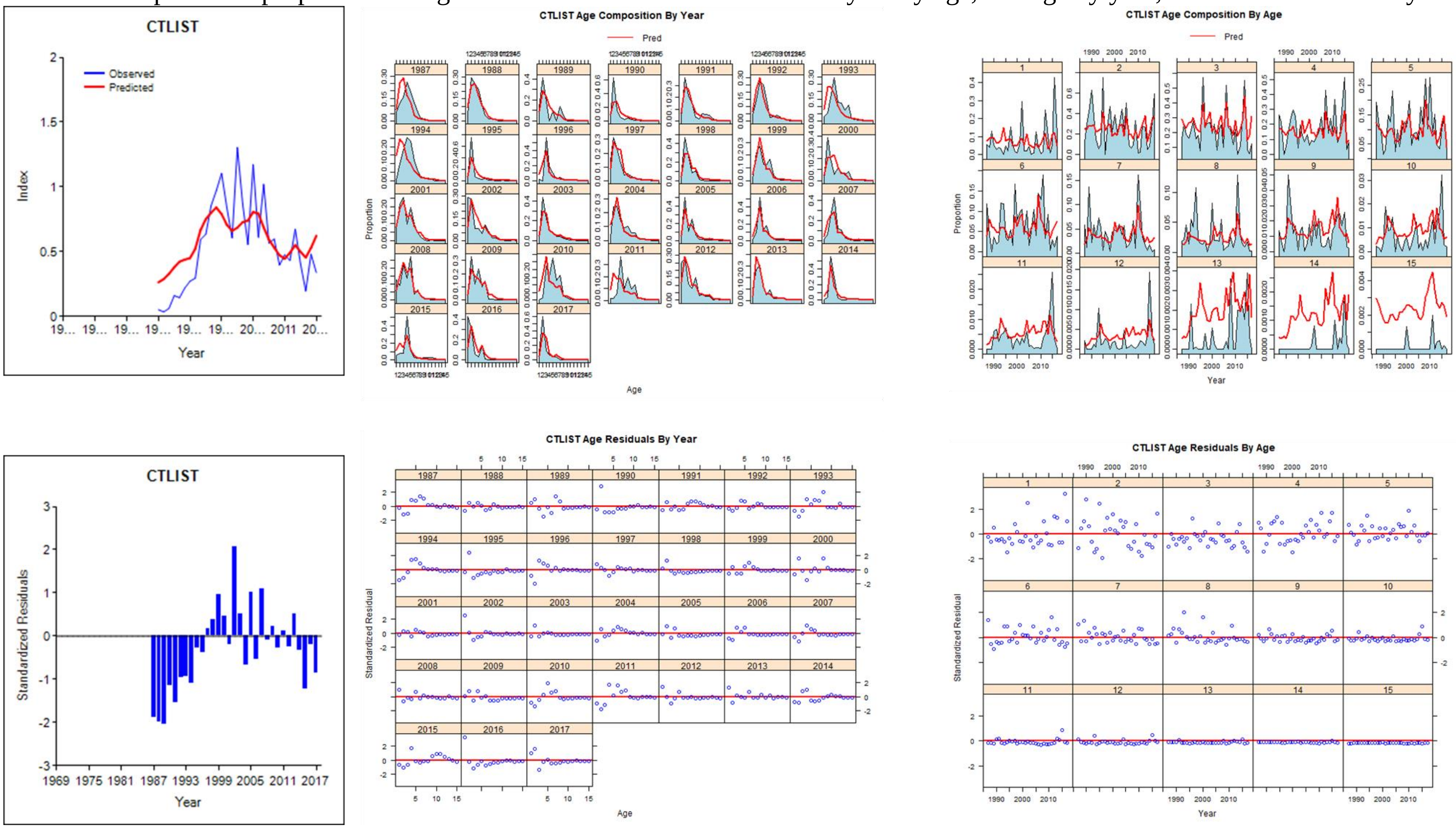


Figure 14. Observed and predicted values of the total index and standardized residuals for surveys with age composition data; observed and predicted proportions-at-age and standardized residual for each year by age, and age by year, for the DE30 survey.

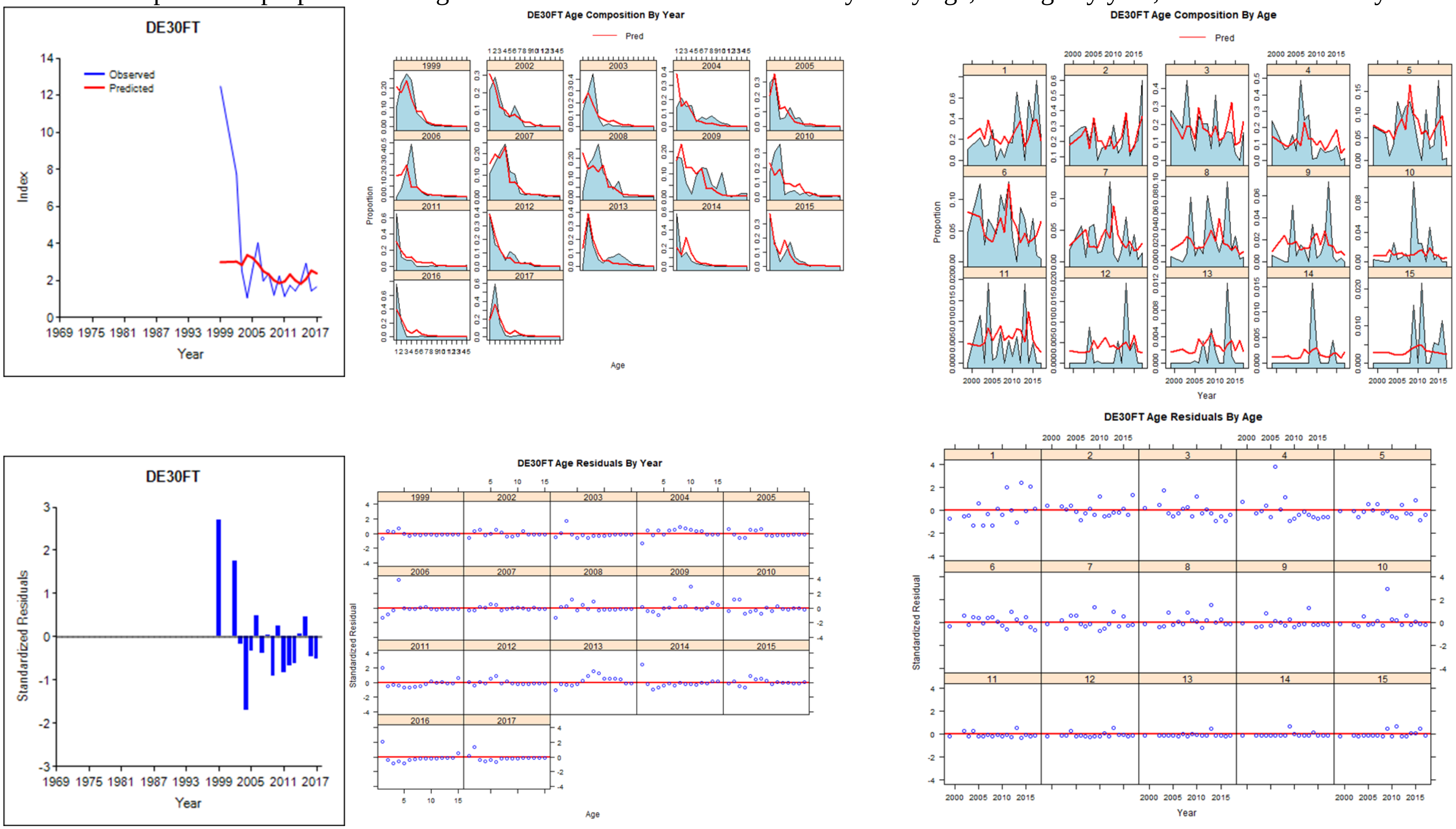
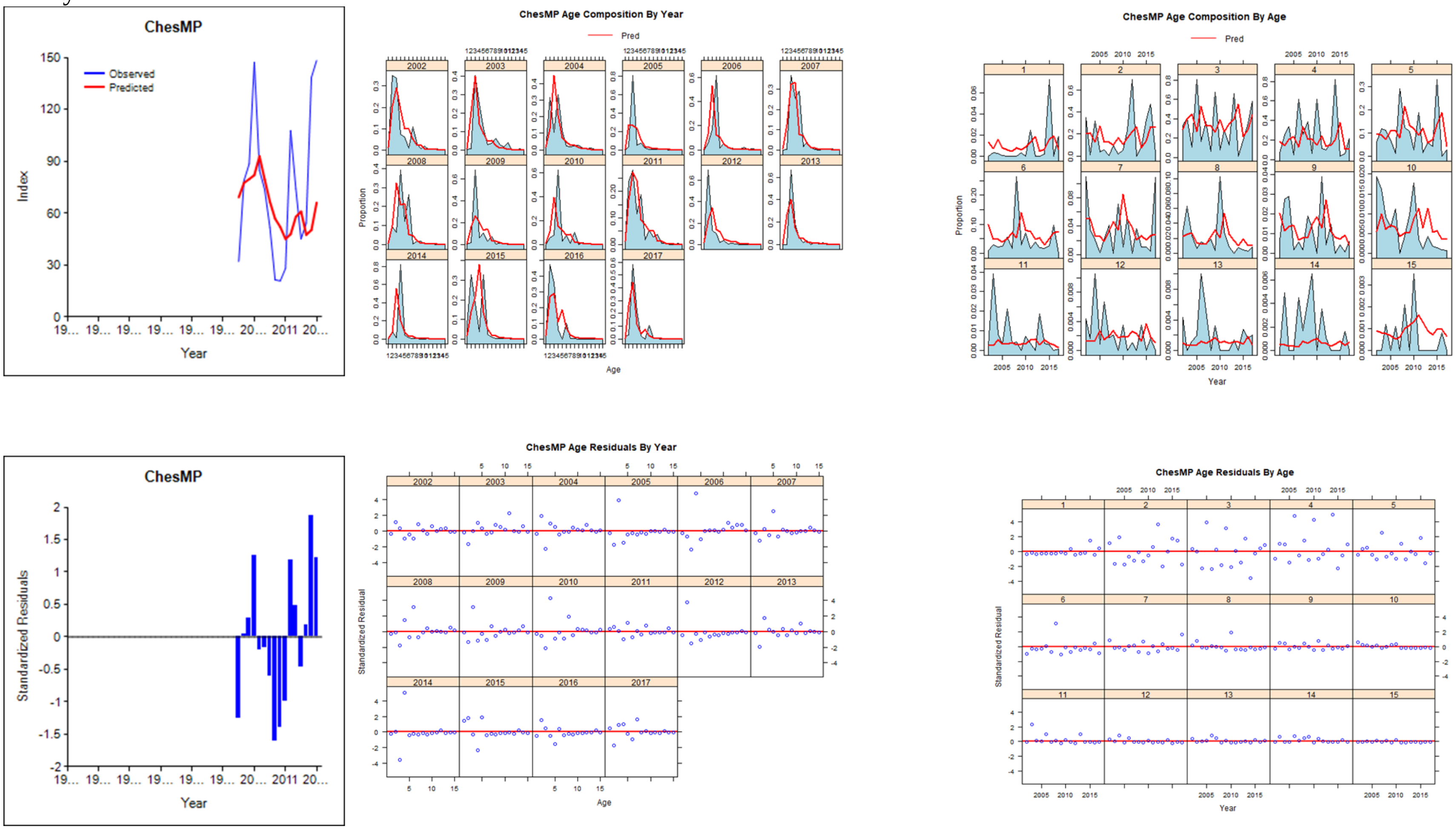


Figure 15. Observed and predicted values of the total index and standardized residuals for surveys with age composition data; observed and predicted proportions-at-age and standardized residual for each year by age, and age by year, for the ChesMMAP survey.



APPENDIX B11. Supplemental Tagging Model Materials

This appendix contains:

1. An analysis of the effect of new MRIP estimates on the tag reporting rate
2. Input matrices for each tagging program by size class
3. Plots of survival estimates by program and size class with and without an additional regulatory period

Effect of New MRIP Estimates on the Tag Reporting Rate

Angela Giuliano
October 1, 2018

Appendix B9 of the 2013 benchmark stock assessment (NEFSC 2013) documents the estimation of the current tag reporting rate used by the Striped Bass Tagging Subcommittee (TSC) in their tagging model analyses. These reporting rates are based on a high reward tagging study conducted in 2007 and 2008. Based on initial analysis in 2009, it appeared that the assumption that 100% of the high reward tags (HRTs) encountered were reported was violated. To overcome this, the TSC used the multicomponent fishery model to estimate the tag reporting rate (proposed by Paulik (1961), Kimura (1976), and Hearn et al. (1999) and described by Pollock et al. (2002)). This method allowed for the assumption that 100% of the HRTs encountered by the recreational sector were reported and was generalizable to allow for less than 100% of the HRTs from the recreational sector to be returned. In addition to knowing how many standard and HRTs were recaptured by sector, this method also used the ratio of recreational and commercial landings as a weighting factor. With the new estimates of recreational harvest by MRIP (Table 1), the analysis for estimating the tag reporting rate was repeated, assuming that the commercial landings numbers did not change.

The first step of the analysis was to calculate the estimated recreational tag reporting rate (λ_{rechat}, Eq. 2 in Appendix B9). As this value was calculated using the numbers of recreationally caught standard tags and HRTs, this value did not change from the previous analysis, assuming as before that 90% of the HRTs were returned by the recreational sector (Table 2). Y is defined as the ratio of the proportion of total landings due to the recreational sector to the proportion of total landings due to the commercial sector. As the proportion of total landings due to the recreational fishery has increased with the new MRIP estimates and the proportion of landings due to the commercial fishery has decreased, Y has increased (Table 2). Using λ_{rechat}, Y, and the ratio of commercial to recreational standard tag returns (Eq. 3 in Appendix B9), the commercial tag reporting rate (λ_{comhat}) is estimated. The commercial tag reporting rate, estimated using the new MRIP estimates, increased compared to the commercial tag reporting rate estimated previously (Table 2). The unknown tag reporting rate ($\lambda_{unknown}$) is calculated as the overall standard tag reporting rate, based on the actual and expected numbers of recreational and commercial tag returns. With the increase in the commercial tag reporting rate, the overall standard tag reporting rate also increased when compared to the previous estimate (Table 2).

As tag reporting rates were found to differ not only by sector but by region as well, separate tag reporting rate estimates were calculated for coastal states and producer areas (Appendix B9 in NEFSC 2013). Using the new recreational and commercial tag reporting rates estimated above, the single coastal reporting rate was recalculated (Table 3). With the higher commercial tag reporting rate, the overall estimated harvest and catch and release tag reporting rates also increased.

Similar results were observed with the producer area tag reporting rates, using the Maryland/Virginia/Delaware combined tag reporting rate as an example (Figure 1). With the increased commercial tag reporting rate, the overall harvest and catch and release tag reporting rates increased when estimated using the new MRIP harvest estimates.

The TSC discussed these results as their September 2018 meeting. The committee consensus was that it is unlikely that the tag reporting rates have increased through time as using the new MRIP based estimates would suggest given the length of the tagging time series, the possibility of angler fatigue, and concerns with the tag quality in recent years. Base tagging model runs used in the assessment used the previously calculated tag reporting rates (NEFSC 2013), not the ones estimated using the new MRIP estimates.

Literature Cited

Hearn, W.S., T. Polecheck, K.H. Pollock and W. Whitelaw. 1999. Estimation of tag reporting rates in age-structured multi-component fisheries where one component has observers. Canadian Journal of Fisheries and Aquatic Sciences 56:1255-1265.

Kimura, D.K. 1976. Estimating the total number of marked fish present in a catch. Transactions of the American Fisheries Society. 105:664-668.

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Paulik, G.J. 1961. Detection of incomplete reporting of tags. Journal of the Fisheries Research Board of Canada 18:817-832.

Pollock, K.H., J.M. Hoenig, W.S. Hearn and B. Calingaert. 2002. Tag reporting rate estimation: II. Use of high-reward tagging and observers in multicomponent fisheries. N. Am. J. Fish. Manage. 22:727-736.

Table 1. Commercial and recreational landings for 2007 and 2008 used in the tag reporting rate analysis. VA recreational landings include wave 1 estimates. Commercial landings, in numbers of fish, remained constant but MRIP landings changed.

	Commercial Landings				Old MRIP Landings				New MRIP Landings			
Year	DE	MD	NY	VA	DE	MD	NY	VA	DE	MD	NY	VA
2007	30,717	598,495	78,287	140,602	10,096	679,024	370,722	366,964	17,171	1,127,310	602,845	749,328
2008	31,866	594,655	73,263	134,603	16,994	442,280	448,271	396,650	67,708	779,700	1,169,855	984,535

Table 2. Comparison of old and new estimates of the sector specific tag reporting rates and ratio of recreational landings to commercial landings (Y).

Variable	Old Estimate	New Estimate
λ_{rechat}	0.85	0.85
Y	1.62	3.27
λ_{comhat}	0.11	0.26
$\lambda_{unknown}$	0.55	0.71

Table 3. Comparison of coastal program tag reporting rates estimated using old and new MRIP estimates.

Reporting rates used in original 2012 calcs					
comm	**0.11**				
rec	0.85				
Harvest Reporting Rate			Catch and Release Reporting Rate		
comm std recaps	65		comm std recaps	5	
rec std recaps	522		rec std recaps	175	
obs recaps	587		obs recaps	180	
Adj Comm	590		Adj Comm	45	
Adj Rec	614		Adj Rec	206	
Adj Recaps	1204		Adj Recaps	251	
Reporting Rate (λ)	**0.51**		**Reporting Rate (λ)**	**0.72**	

Updated reporting rates with MRIP updates					
comm	**0.26**				
rec	0.85				
Harvest Reporting Rate			Catch and Release Reporting Rate		
comm std recaps	65		comm std recaps	5	
rec std recaps	522		rec std recaps	175	
obs recaps	587		obs recaps	180	
Adj Comm	250.0		Adj Comm	19.2	
Adj Rec	614.1		Adj Rec	205.9	
Adj Recaps	864.1		Adj Recaps	225.1	
Reporting Rate (λ)	**0.68**		**Reporting Rate (λ)**	**0.80**	

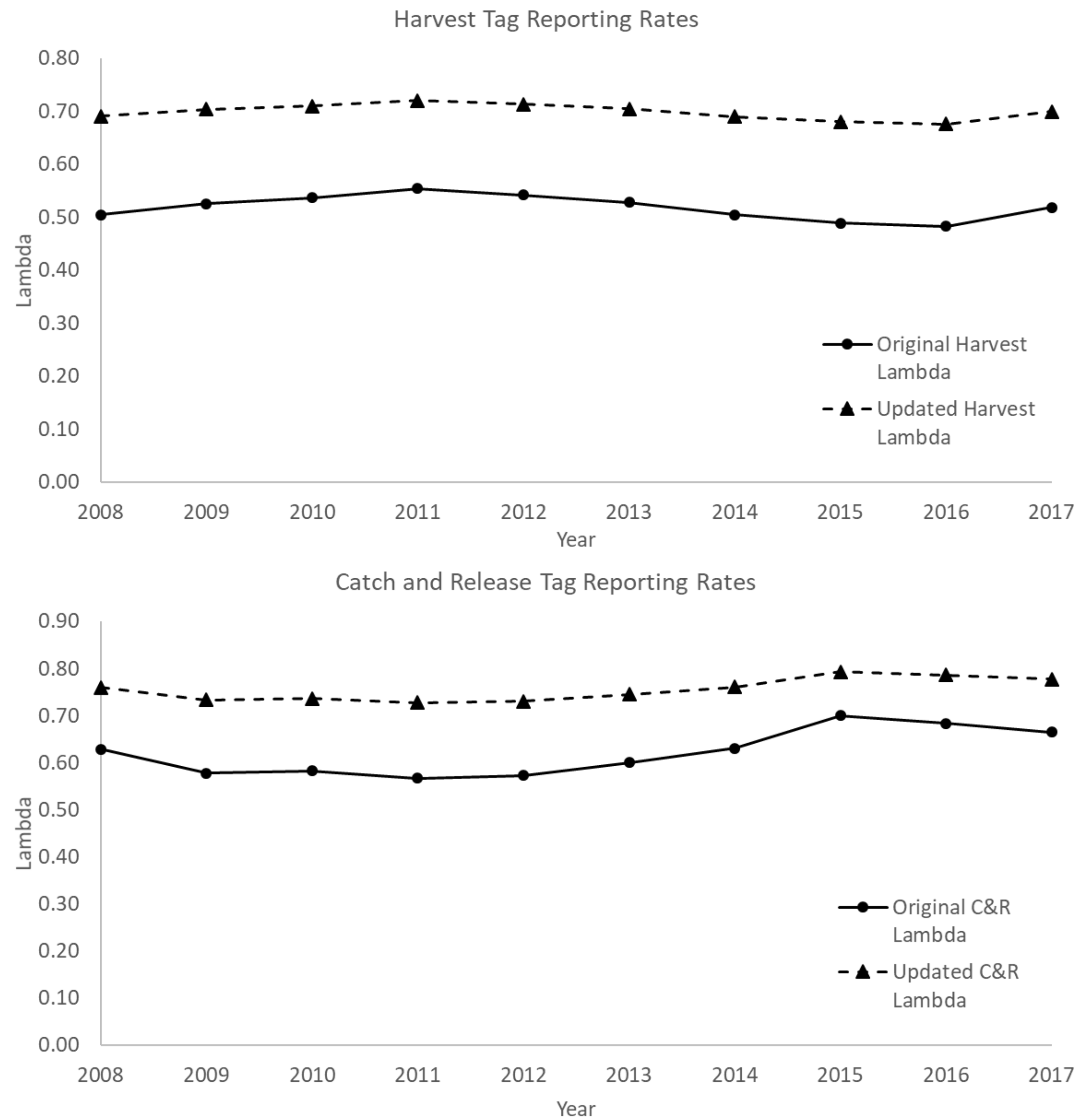


Figure 1. Maryland/Virginia/Delaware combined harvest (top) and catch and release (bottom) tag reporting rates using the old/original MRIP estimates and the updated/new MRIP estimates.

Input matrices of harvested and released recaptures for IRCR analyses of ≥ 28 and ≥ 18 inch striped bass tagged by each program.

Coastal Programs

MADFW ≥ 28”

Tagged		Harvested recaptures																									
Number	Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
329	1992	4	8	9	10	8	4	1	2	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
645	1993		12	20	13	21	20	12	9	3	1	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
460	1994			6	14	26	17	13	7	2	2	2	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0
219	1995				3	9	8	4	2	2	1	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0
271	1996					8	8	13	6	8	1	2	2	0	2	0	0	0	0	0	0	0	1	0	0	0	0
118	1997						8	4	2	3	1	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
220	1998							6	14	5	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	1999								2	3	1	2	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
163	2000									9	3	5	3	3	2	1	1	0	1	0	0	1	0	0	0	0	0
413	2001										12	18	10	9	9	3	0	2	2	1	0	0	1	0	0	0	0
351	2002											10	12	11	6	5	3	2	1	0	0	1	0	0	0	0	0
172	2003												8	3	5	4	0	0	5	0	0	0	2	0	0	0	0
615	2004													24	18	9	9	7	5	0	4	1	0	1	0	1	0
501	2005														17	20	9	13	3	2	4	1	0	0	0	0	0
515	2006															19	9	13	11	11	1	1	3	2	0	2	0
322	2007																7	15	10	1	4	1	1	0	1	1	0
480	2008																	15	19	13	7	5	3	3	1	0	0
385	2009																		17	10	20	0	10	1	0	2	2
458	2010																			13	17	16	6	2	0	4	1
308	2011																				10	6	8	4	2	2	0
468	2012																					9	11	8	3	3	2
553	2013																						20	17	7	9	3
458	2014																							21	11	11	7
432	2015																								8	18	8
326	2016																									12	9
510	2017																										21

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
329	1992	12	14	5	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
645	1993		15	16	12	5	1	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
460	1994			13	6	5	4	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
219	1995				11	4	1	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
271	1996					12	5	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
118	1997						7	4	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	1998							8	6	3	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
59	1999								2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
163	2000									1	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
413	2001										6	5	6	2	1	1	0	3	0	0	0	0	0	0	0	0	0
351	2002											14	2	3	3	3	1	0	0	0	0	0	0	0	0	0	0
172	2003												1	1	1	2	0	0	0	0	0	0	0	0	0	0	0
615	2004													6	7	4	3	1	1	0	1	0	0	0	0	0	0
501	2005														8	5	2	1	0	0	0	0	0	1	0	0	0
515	2006															11	4	1	3	0	0	0	0	0	0	0	0
322	2007																3	4	0	1	0	0	0	0	0	0	0
480	2008																	6	5	3	1	1	0	0	0	0	0
385	2009																		4	3	7	1	1	1	0	0	0
458	2010																			7	3	1	2	2	2	1	1
308	2011																				6	4	3	2	1	0	0
468	2012																					7	6	2	3	0	0
553	2013																						11	2	3	2	2
458	2014																							3	6	2	3
432	2015																								7	6	2
326	2016																									6	3
510	2017																										9

NYOHS/NYTRL* $\geq$ 28”

Tagged		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	2012	2013	2014	2015	2016	2017
213	1988	3	3	5	8	2	4	2	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
342	1989		4	11	10	9	10	5	4	1	3	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
245	1990			6	8	6	3	3	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
280	1991				16	13	6	4	5	2	4	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
286	1992					13	13	7	14	4	3	5	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
235	1993						13	8	12	5	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
251	1994							8	11	18	16	8	4	2	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
353	1995								31	26	18	15	6	5	1	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0
110	1996									6	5	7	6	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
68	1997										10	4	4	0	1	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0
82	1998											6	4	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
83	1999												12	4	3	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
55	2000													3	5	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
93	2001														4	5	7	3	1	0	0	0	0	0	0	0	0	0	0	0	0
175	2002															17	8	4	0	3	0	4	3	0	1	0	0	0	0	0	0
146	2003																10	4	6	1	0	1	2	0	1	0	0	0	0	0	0
153	2004																	10	2	2	1	2	1	0	1	0	0	0	0	0	0
64	2005																		7	3	1	4	1	0	0	0	0	0	1	0	0
57	2006																			3	6	5	0	0	1	0	0	0	0	0	0
25	2007																				0	0	0	1	0	1	0	1	0	0	0
144	2008																					4	9	7	2	2	1	0	0	0	0
26	2009																						0	1	1	0	0	0	0	0	0
38	2010																							3	1	0	0	0	0	0	0
142	2011																								6	4	2	0	0	3	0
102	2012																									6	1	1	3	0	0

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
213	1988	22	13	9	2	2	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
342	1989		31	17	15	5	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
245	1990			16	9	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
280	1991				18	11	6	2	1	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
286	1992					27	11	8	4	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
235	1993						15	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
251	1994							17	6	3	5	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
353	1995								24	11	6	1	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
110	1996									9	0	6	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
68	1997										3	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
82	1998											0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
83	1999												2	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	2000													4	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
93	2001														4	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
175	2002															13	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
146	2003																4	1	0	0	0	0	1	0	0	0	0	0	0	0	0
153	2004																	8	2	1	0	0	0	0	0	0	0	0	0	0	0
64	2005																		2	0	0	0	0	0	0	0	0	0	0	0	0
57	2006																			2	0	0	0	0	0	0	0	0	0	0	0
25	2007																				0	0	0	0	0	0	0	0	0	0	0
144	2008																					5	3	3	0	0	1	0	0	0	0
26	2009																						2	0	0	0	0	0	0	0	0
38	2010																							0	1	0	0	0	0	0	0
142	2011																								2	1	0	0	0	0	0
102	2012																									1	0	0	0	0	0

*NYOHS (1988–2007), NYTRL (2008–2012)

NJDB ≥ 28”

Tagged		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	2012	2013	2014	2015	2016	2017
35	1989	0	2	4	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1990		0	1	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	0
15	1991			1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	1992				0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	1993					3	1	2	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
308	1994						5	9	10	11	9	4	3	2	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0
552	1995							22	30	18	16	10	5	3	3	4	2	1	2	1	1	0	0	0	0	0	1	0	0	0
589	1996								47	18	30	12	6	5	3	3	6	2	0	1	0	0	2	0	0	1	0	0	0	0
68	1997									7	2	1	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126	1998										19	5	5	2	0	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0
101	1999											3	3	5	1	0	1	3	1	0	0	0	0	0	0	0	0	0	0	0
233	2000												13	15	8	9	6	4	0	1	1	0	1	1	0	0	0	0	0	0
522	2001													33	26	21	14	6	5	1	4	0	1	0	0	0	0	0	0	0
359	2002														16	12	11	9	2	3	2	0	3	0	1	0	0	0	0	0
564	2003															34	13	19	5	7	4	4	1	1	1	0	0	0	0	0
847	2004																52	30	17	17	15	11	4	3	0	2	0	0	1	0
180	2005																	12	5	7	3	4	5	0	0	0	0	0	0	0
225	2006																		13	7	9	6	2	1	0	0	0	0	0	0
434	2007																			23	22	12	11	6	2	0	1	0	0	0
518	2008																				30	27	18	12	8	1	2	2	0	0
337	2009																					33	10	10	6	2	2	1	0	0
339	2010																						18	13	4	6	1	3	2	0
525	2011																							28	13	13	8	0	4	2
39	2012																								2	0	1	1	0	0
75	2013																									11	5	3	0	0
6	2014																										0	0	0	0
8	2015																											0	0	0
51	2016																												3	2
6	2017																													0

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
35	1989	4	1	3	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1990		2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	1991			2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
76	1992				7	5	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
91	1993					5	3	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
308	1994						21	16	6	5	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
552	1995							33	21	14	11	4	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
589	1996								35	17	15	1	3	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
68	1997									5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
126	1998										2	5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101	1999											6	3	1	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
233	2000												9	3	4	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0
522	2001													19	12	3	2	2	0	1	0	0	0	0	0	0	0	0	0	0
359	2002														11	11	3	2	0	0	0	0	0	0	0	0	0	0	0	0
564	2003															24	15	8	4	1	1	1	0	0	0	0	0	0	0	0
847	2004																42	18	4	2	0	0	0	0	2	0	0	0	0	0
180	2005																	11	5	4	0	0	1	1	0	0	0	0	0	0
225	2006																		12	3	2	0	0	1	0	0	0	0	0	0
434	2007																			15	5	5	1	3	0	0	0	0	0	0
518	2008																				17	6	7	2	1	0	0	0	0	0
337	2009																					8	6	3	1	1	0	1	0	0
339	2010																						8	8	1	0	0	0	0	0
525	2011																							16	17	6	1	0	2	0
39	2012																								2	0	0	0	0	0
75	2013																									2	0	1	0	0
6	2014																										0	0	0	0
8	2015																											0	0	0
51	2016																												2	0
6	2017																													0

NCCOOP ≥ 28”

Tagged		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	2012	2013	2014	2015	2016	2017
188	1988	5	3	4	0	6	3	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
409	1989		6	7	7	11	4	2	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
321	1990			11	6	11	5	1	2	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
856	1991				23	19	23	20	16	5	11	7	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89	1992					22	11	7	10	7	6	7	5	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
141	1993						6	3	5	3	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
480	1994							14	16	7	6	5	6	1	3	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
372	1995								21	13	16	11	5	2	2	5	1	1	2	0	0	1	0	0	0	0	0	0	0	0	0
557	1996									26	17	12	3	3	3	4	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0
868	1997										67	31	16	9	11	0	3	3	1	0	1	0	1	0	0	0	0	0	0	0	0
106	1998											9	7	0	2	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
179	1999												17	5	5	2	0	2	2	1	1	0	2	0	0	0	0	0	0	0	0
163	2000													4	6	1	2	3	2	1	0	0	0	0	0	0	0	0	0	0	0
515	2001														33	18	11	3	9	6	1	0	0	0	0	1	0	0	0	0	0
789	2002															39	31	20	13	7	3	1	0	0	1	0	0	0	0	0	0
1575	2003																75	53	29	15	12	7	6	4	3	1	0	0	0	0	0
784	2004																	40	18	15	11	5	3	2	4	0	0	1	0	0	0
557	2005																		17	16	10	5	4	1	1	0	0	1	0	0	0
2113	2006																			107	80	46	25	22	11	7	9	2	0	2	4
305	2007																				24	20	9	3	6	4	1	0	0	0	0
923	2008																					73	39	27	15	7	2	4	3	2	0
121	2009																						2	3	1	1	0	0	0	0	0
410	2010																							12	9	5	3	2	0	0	0
103	2011																								9	3	3	1	0	1	0
5	2012																									1	0	0	0	0	0
1929	2013																										103	64	29	27	16
918	2014																											48	22	19	9
1372	2015																												66	39	28
1345	2016																													67	52
880	2017																														40

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
188	1988	14	8	5	3	4	1	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
409	1989		18	13	11	3	3	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
321	1990			14	13	5	3	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
856	1991				51	20	25	14	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
89	1992					24	18	7	4	1	2	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
141	1993						11	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
480	1994							27	9	2	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
372	1995								22	3	1	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
557	1996									9	3	3	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
868	1997										21	13	9	5	2	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0
106	1998											3	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
179	1999												3	3	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
163	2000													5	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
515	2001														14	5	4	2	2	3	0	2	0	0	0	0	0	0	0	0	0
789	2002															13	12	2	5	3	1	1	0	0	0	0	0	0	0	0	0
1575	2003																32	12	9	9	3	0	0	1	1	0	0	0	0	0	0
784	2004																	18	8	11	6	1	1	1	0	0	0	0	0	0	0
557	2005																		8	5	1	2	1	0	0	0	0	0	0	0	0
2113	2006																			46	25	11	6	7	1	2	0	0	0	0	0
305	2007																				7	2	2	0	0	0	0	0	0	0	0
923	2008																					26	14	5	5	1	2	2	0	0	0
121	2009																						2	1	0	0	0	1	0	0	0
410	2010																							4	0	1	0	1	0	0	0
103	2011																								5	0	0	0	1	0	0
5	2012																									0	0	0	0	0	0
1929	2013																										41	13	13	5	5
918	2014																											16	10	1	2
1372	2015																												34	14	7
1345	2016																													27	14
880	2017																														14

HUDSON ≥ 28”

Tagged		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	2012	2013	2014	2015	2016	2017
277	1988	11	9	7	9	6	3	2	1	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
387	1989		9	13	9	4	5	7	4	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
445	1990			17	14	11	9	4	4	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
364	1991				15	14	8	6	9	5	2	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
699	1992					35	27	16	11	11	10	7	3	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
536	1993						33	16	10	16	10	5	5	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
381	1994							17	24	21	8	6	4	4	4	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
461	1995								27	23	20	18	10	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
681	1996									63	43	27	12	2	7	2	3	3	1	1	0	0	0	0	0	0	0	0	0	0	0
184	1997										22	7	8	5	3	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
530	1998											47	29	13	7	13	5	0	1	2	0	1	0	0	0	0	0	0	0	0	0
503	1999												45	13	21	9	12	4	2	3	1	3	1	0	1	0	0	0	0	0	0
485	2000													27	18	13	8	8	6	3	3	0	0	1	0	0	0	0	0	0	0
576	2001														32	23	12	6	5	8	1	3	0	0	0	0	0	0	0	0	0
196	2002															16	8	7	2	5	3	1	2	0	0	0	0	0	0	0	0
677	2003																39	35	25	10	11	3	1	0	4	0	0	0	0	0	0
649	2004																	55	25	24	14	5	2	4	1	0	0	1	0	1	0
574	2005																		40	29	16	8	4	7	0	3	1	0	1	0	0
707	2006																			44	30	29	9	8	9	3	2	2	0	0	0
399	2007																				26	20	10	5	6	4	1	2	0	2	0
540	2008																					33	26	19	8	1	0	0	0	0	0
396	2009																						31	25	13	4	4	2	1	0	0
458	2010																							37	19	8	2	4	1	0	1
243	2011																								23	12	8	4	1	1	1
597	2012																									30	25	13	8	3	4
676	2013																										44	20	9	9	7
484	2014																											20	10	9	8
789	2015																												27	20	17
665	2016																													30	28
548	2017																														37

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
277	1988	14	21	11	2	4	2	2	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
387	1989		33	16	7	5	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
445	1990			45	16	16	4	4	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
364	1991				23	17	5	4	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
699	1992					54	30	18	10	2	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
536	1993						42	20	13	4	5	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
381	1994							26	8	5	2	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
461	1995								23	11	10	3	1	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
681	1996									26	24	6	6	1	2	2	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0
184	1997										7	4	4	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
530	1998											19	16	4	2	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
503	1999												20	9	6	3	2	3	1	1	0	0	0	0	0	0	0	0	0	0	0
485	2000													18	6	9	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0
576	2001														16	16	2	1	1	2	1	0	1	0	0	0	0	0	0	0	0
196	2002															4	3	2	2	2	1	1	1	1	0	0	0	0	0	0	0
677	2003																25	9	10	7	2	0	1	0	0	0	0	0	1	0	0
649	2004																	19	9	10	4	2	0	1	2	1	0	0	0	0	0
574	2005																		19	15	5	6	0	0	0	0	0	0	0	0	0
707	2006																			17	10	7	4	0	1	2	1	0	0	0	0
399	2007																				9	7	5	2	2	1	0	0	0	0	0
540	2008																					16	8	3	2	2	1	1	1	0	0
396	2009																						13	11	4	2	3	1	0	1	0
458	2010																							11	10	5	4	1	1	1	1
243	2011																								5	7	3	1	1	0	1
597	2012																									12	13	8	2	6	3
676	2013																										22	20	13	5	1
484	2014																											11	20	14	5
789	2015																												12	19	9
665	2016																													13	9
548	2017																														16

DE/PA ≥ 28”

Tagged		Harvested recaptures																								
Number	Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
52	1993	3	5	1	4	3	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
81	1994		3	6	4	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
173	1995			10	7	2	6	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	1996				14	3	4	2	2	2	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0
107	1997					13	6	4	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
205	1998						25	7	5	2	4	3	1	1	1	0	2	0	0	0	0	0	0	0	0	0
107	1999							7	10	2	1	3	3	1	0	0	1	0	0	0	0	0	0	0	0	0
148	2000								20	10	2	3	0	3	0	1	0	0	0	0	0	0	0	0	0	0
220	2001									27	10	9	5	4	4	0	2	3	1	1	0	0	0	0	0	0
139	2002										13	5	2	3	1	2	0	1	0	0	0	0	0	0	0	0
286	2003											19	14	8	6	2	0	3	2	2	0	0	0	0	0	0
168	2004												15	8	5	3	0	1	2	0	0	0	0	0	0	0
110	2005													7	6	1	1	2	0	1	1	0	0	0	0	0
180	2006														16	7	3	2	2	2	0	0	0	0	0	0
125	2007															8	4	1	1	0	0	0	0	1	0	0
140	2008																6	5	2	3	0	0	0	0	0	0
127	2009																	12	6	4	1	2	0	0	0	0
147	2010																		14	3	0	2	0	1	2	1
185	2011																			9	8	3	1	3	1	0
184	2012																				17	1	1	1	1	0
256	2013																					20	10	8	1	0
49	2014																						5	2	3	0
107	2015																							4	1	0
88	2016																								5	4
76	2017																									7

Tagged		Released recaptures (event 1 only)																								
Number	Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
52	1993	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
81	1994		3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
173	1995			7	5	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	1996				4	3	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107	1997					2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
205	1998						6	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
107	1999							2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
148	2000								4	2	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
220	2001									2	5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
139	2002										0	7	0	2	0	0	0	0	0	0	0	0	0	0	0	0
286	2003											12	8	3	0	1	0	0	1	0	0	0	0	0	0	0
168	2004												3	1	2	1	0	1	0	0	0	0	0	0	0	0
110	2005													4	3	1	0	0	0	0	0	0	0	0	0	0
180	2006														4	1	1	0	0	0	0	0	0	0	0	0
125	2007															3	0	0	0	1	0	0	0	0	0	0
140	2008																2	2	1	0	1	0	0	0	0	0
127	2009																	3	0	0	0	0	0	0	0	0
147	2010																		6	4	1	1	0	0	0	1
185	2011																			5	2	0	1	2	0	0
184	2012																				1	1	0	0	1	0
256	2013																					7	5	0	0	2
49	2014																						0	0	0	0
107	2015																							2	2	0
88	2016																								0	3
76	2017																									1

MDCB ≥ 28”

Tagged		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	2012	2013	2014	2015	2016	2017
29	1987	0	0	0	0	0	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
129	1988		2	1	3	7	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	1989			3	7	3	3	2	1	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
305	1990				10	8	5	3	1	3	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
395	1991					19	10	13	3	7	3	4	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
436	1992						21	15	11	14	4	8	6	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
627	1993							31	25	30	13	14	7	8	1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
548	1994								25	27	20	16	10	8	4	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
529	1995									45	24	19	12	4	5	2	2	3	0	0	2	0	1	0	0	0	0	0	0	0	0	0
862	1996										62	35	39	15	6	7	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
335	1997											33	19	15	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
242	1998												23	13	2	3	2	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
177	1999													16	5	6	2	1	2	1	0	1	1	0	0	0	0	0	0	0	0	0
248	2000														18	12	0	4	4	1	0	2	1	0	2	0	0	0	0	0	0	0
469	2001															21	10	10	5	2	3	0	1	0	1	0	0	0	0	0	0	0
324	2002																13	18	5	6	0	3	0	1	0	0	0	0	0	0	0	0
324	2003																	14	9	8	6	2	3	0	0	0	0	0	0	1	0	0
367	2004																		13	7	9	2	3	1	1	2	1	0	0	0	0	0
334	2005																			16	11	6	4	2	1	1	0	0	2	0	1	0
270	2006																				14	4	4	4	3	0	2	0	0	0	0	0
190	2007																					6	4	3	2	1	1	1	0	0	0	0
155	2008																						6	3	3	3	1	0	0	0	0	0
255	2009																							18	7	1	2	0	1	1	0	0
198	2010																								8	0	3	1	1	0	0	0
285	2011																									17	6	4	2	0	0	2
262	2012																										8	4	3	0	1	1
298	2013																											16	7	3	3	3
279	2014																												21	3	2	4
274	2015																													7	5	6
240	2016																														15	4
302	2017																															5

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
29	1987	0	0	2	0	1	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	0
129	1988		4	7	4	7	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
220	1989			6	10	14	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
305	1990				13	8	7	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
395	1991					26	13	7	2	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
436	1992						23	15	8	2	3	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
627	1993							29	18	11	2	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
548	1994								27	15	4	0	5	2	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
529	1995									18	7	6	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
862	1996										37	19	7	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
335	1997											8	7	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
242	1998												7	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
177	1999													3	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
248	2000														3	4	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
469	2001															10	9	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
324	2002																5	2	1	1	2	0	0	0	0	0	0	0	0	0	0	0
324	2003																	8	2	1	2	2	0	0	0	0	0	0	0	0	0	0
367	2004																		4	2	2	1	1	0	1	1	0	0	0	0	0	0
334	2005																			5	4	1	0	1	0	0	0	0	0	0	0	0
270	2006																				3	2	2	0	0	1	0	0	0	0	0	0
190	2007																					2	1	0	0	0	0	0	0	0	0	0
155	2008																						1	0	1	0	1	0	0	0	0	0
255	2009																							3	4	1	0	0	0	0	0	0
198	2010																								3	3	0	1	0	0	0	0
285	2011																									3	0	0	0	0	0	0
262	2012																										1	4	0	0	0	0
298	2013																											3	2	1	0	0
279	2014																												1	4	1	0
274	2015																													4	1	0
240	2016																														1	0
302	2017																															4

VARAP ≥ 28”

Tagged		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	2012	2013	2014	2015	2016	2017
303	1990	10	2	6	1	3	5	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
390	1991		19	10	12	9	2	1	2	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	1992			2	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
213	1993				11	11	5	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123	1994					4	4	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
211	1995						18	6	5	2	1	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	1996							0	3	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
212	1997								11	12	6	2	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
157	1998									16	9	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
162	1999										13	2	1	2	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
365	2000											13	11	6	5	3	4	0	1	0	0	0	0	0	0	0	0	0	0
269	2001												9	8	2	6	1	0	0	0	0	0	0	0	0	0	0	0	0
122	2002													7	3	5	1	0	1	1	0	0	0	0	0	0	0	0	0
400	2003														23	13	3	1	2	2	1	2	0	0	0	0	1	0	0
688	2004															21	8	8	3	3	1	1	0	0	0	0	0	0	0
284	2005																12	7	5	1	3	0	0	0	0	0	0	0	0
175	2006																	10	2	4	2	1	4	0	0	0	0	0	0
840	2007																		33	22	11	2	4	0	1	1	1	0	0
75	2008																			5	1	0	0	0	0	1	0	0	0
242	2009																				5	3	0	1	0	1	0	0	0
483	2010																					11	5	4	2	0	1	0	1
191	2011																						6	2	0	0	1	0	0
325	2012																							9	4	1	1	0	0
244	2013																								5	3	3	0	0
247	2014																									5	2	3	0
75	2015																										1	0	0
99	2016																											3	1
33	2017																												1

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
303	1990	16	6	9	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
390	1991		20	11	6	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	1992			2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
213	1993				10	7	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123	1994					4	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
211	1995						7	2	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
67	1996							1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
212	1997								2	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
157	1998									6	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
162	1999										2	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
365	2000											9	7	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
269	2001												7	4	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0
122	2002													2	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0
400	2003														8	5	6	0	0	0	0	0	0	0	0	0	0	0	0
688	2004															15	2	6	1	0	1	0	0	0	0	0	0	0	0
284	2005																4	4	1	0	0	1	0	0	0	0	0	0	0
175	2006																	2	1	0	2	0	0	0	0	0	0	0	0
840	2007																		12	7	1	1	0	1	0	0	0	0	0
75	2008																			0	0	0	0	0	0	0	0	0	0
242	2009																				1	1	0	0	0	0	0	0	0
483	2010																					5	1	0	0	0	0	0	0
191	2011																						1	0	0	0	0	1	0
325	2012																							2	0	0	0	0	0
244	2013																								1	0	0	0	0
247	2014																									3	2	0	2
75	2015																										1	0	0
99	2016																											0	0
33	2017																												0

MADFW ≥ 18”

Tagged		Harvested recaptures																									
Number	Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
387	1992	5	10	9	10	10	4	2	2	4	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
890	1993		14	22	13	26	22	14	11	4	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
675	1994			9	15	27	23	16	8	3	2	3	2	0	2	0	0	1	0	0	0	0	0	0	0	0	0
377	1995				4	10	14	7	4	3	2	0	4	1	0	0	0	1	0	0	0	0	0	0	0	0	0
440	1996					9	10	14	7	13	2	4	4	1	2	0	0	0	0	0	0	0	1	0	0	0	0
202	1997						9	4	3	3	1	1	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0
317	1998							10	14	5	5	4	5	2	0	1	0	0	0	0	0	0	0	0	0	0	0
87	1999								2	3	2	2	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0
253	2000									9	5	8	3	3	2	1	2	0	1	0	1	1	0	0	0	0	0
599	2001										12	24	13	11	14	5	0	2	2	2	0	0	1	0	0	0	0
455	2002											15	13	12	8	5	5	2	2	1	0	1	0	0	0	0	0
238	2003												8	3	5	7	1	0	5	0	0	0	2	0	0	0	0
655	2004													24	18	9	9	7	5	0	4	1	0	1	0	1	0
568	2005														18	20	10	15	3	2	5	1	0	0	0	0	1
581	2006															19	9	13	12	11	2	2	3	2	0	2	0
389	2007																7	15	14	3	4	2	1	0	1	1	0
530	2008																	15	19	13	9	5	3	4	1	0	0
456	2009																		17	11	24	1	10	2	0	2	2
501	2010																			13	18	16	8	2	0	4	1
326	2011																				11	6	8	4	2	3	0
504	2012																					9	12	8	3	4	2
596	2013																						21	18	8	9	3
487	2014																							22	11	11	7
454	2015																								8	19	9
348	2016																									13	9
710	2017																										23

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
387	1992	15	15	5	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
890	1993		21	24	18	9	2	4	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
675	1994			24	10	15	4	5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
377	1995				17	13	2	1	2	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
440	1996					24	12	9	5	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
202	1997						13	6	2	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
317	1998							11	8	4	2	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
87	1999								2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
253	2000									2	3	4	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
599	2001										10	6	8	3	1	2	0	3	0	0	0	0	0	0	0	0	0
455	2002											15	3	4	5	4	2	0	0	0	0	0	0	0	0	0	0
238	2003												3	2	1	2	0	0	1	0	0	0	0	0	0	0	0
655	2004													6	8	4	3	1	1	0	1	0	0	0	0	0	0
568	2005														11	5	3	1	0	0	0	0	0	1	0	0	0
581	2006															12	5	1	3	0	0	0	0	0	0	0	0
389	2007																4	8	2	2	1	0	0	0	0	0	0
530	2008																	7	7	3	1	1	0	0	0	0	0
456	2009																		6	3	7	1	1	1	0	0	0
501	2010																			9	3	1	2	2	2	1	0
326	2011																				7	5	3	2	1	0	0
504	2012																					8	9	2	3	0	0
596	2013																						13	2	3	2	2
487	2014																							6	8	3	3
454	2015																								7	7	2
348	2016																									7	4
710	2017																										16

NYOHS/NYTRL* ≥ 18”

Tagged		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	2012	2013	2014	2015	2016	2017
1610	1988	7	6	16	22	10	16	8	10	6	4	4	4	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1608	1989		9	23	19	12	29	13	13	6	7	3	2	2	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
804	1990			9	16	9	5	4	2	4	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
985	1991				25	15	17	9	13	10	10	6	4	2	2	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
998	1992					16	16	10	21	10	9	12	5	1	1	2	0	3	0	1	0	0	0	0	0	0	0	0	0	0	0
1247	1993						19	11	16	10	12	4	7	3	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1643	1994							15	22	39	34	25	23	7	7	2	2	3	1	1	1	0	0	0	0	0	0	0	0	0	0
1505	1995								32	39	33	27	14	10	4	7	6	4	0	0	0	1	0	0	0	0	0	0	0	0	0
659	1996									9	11	17	14	1	0	2	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0
1080	1997										18	12	12	3	5	3	3	3	2	0	0	0	0	0	1	0	0	0	0	0	0
1101	1998											11	15	8	7	4	4	2	3	2	0	0	0	0	0	0	0	0	0	0	0
1040	1999												24	16	23	15	6	9	2	2	0	0	0	0	0	0	0	0	0	0	0
998	2000													12	14	7	18	6	4	2	1	3	0	2	0	0	0	0	0	0	0
1200	2001														22	24	24	12	7	8	4	2	3	1	1	0	0	0	0	0	0
968	2002															24	17	12	3	7	1	7	3	1	1	2	0	0	0	0	0
756	2003																18	7	15	9	1	1	3	0	2	0	1	1	0	0	0
661	2004																	11	5	3	6	2	3	3	2	1	0	0	0	0	0
1149	2005																		16	8	10	9	5	3	4	1	1	0	1	0	0
681	2006																			7	13	16	11	2	4	1	0	0	0	0	0
867	2007																				4	4	7	5	8	5	2	2	1	0	0
1340	2008																					18	25	23	13	12	5	2	0	0	0
268	2009																						5	5	4	2	4	0	1	0	0
119	2010																							4	2	2	1	0	0	2	0
364	2011																								11	9	7	2	0	4	0
120	2012																									6	2	1	3	0	0

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
1610	1988	107	61	42	20	16	12	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1608	1989		152	92	57	19	17	10	4	1	0	1	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
804	1990			57	21	9	7	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
985	1991				52	32	25	12	3	5	6	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
998	1992					66	27	16	10	3	2	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1247	1993						58	24	11	10	2	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1643	1994							101	32	22	18	2	5	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1505	1995								69	43	28	9	5	1	2	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
659	1996									38	11	11	2	2	0	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
1080	1997										66	17	8	5	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1101	1998											54	17	4	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1040	1999												40	13	15	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
998	2000													43	15	12	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0
1200	2001														53	20	10	5	1	2	0	0	0	0	0	0	0	0	0	0	0
968	2002															53	11	7	2	1	0	0	0	0	0	0	0	0	0	0	0
756	2003																31	13	7	2	0	0	1	1	0	0	0	0	0	0	0
661	2004																	29	12	8	1	0	0	0	0	0	0	0	0	0	0
1149	2005																		61	17	11	0	1	0	0	0	0	0	0	0	0
681	2006																			43	13	2	1	0	1	0	0	0	0	0	0
867	2007																				45	13	3	3	0	0	0	0	0	0	0
1340	2008																					52	29	8	0	0	1	0	0	0	0
268	2009																						17	2	0	0	0	0	0	1	0
119	2010																							7	1	0	1	0	0	1	0
364	2011																								14	3	2	0	0	0	0
120	2012																									2	1	1	0	0	0

*NYOHS (1988–2007), NYTRL (2008–2012)

NJDB ≥ 18”

Tagged		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	2012	2013	2014	2015	2016	2017
473	1989	3	7	11	1	7	4	4	1	0	3	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	1990		2	1	0	1	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
297	1991			2	2	0	3	2	5	1	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
765	1992				8	10	2	7	8	4	5	3	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1680	1993					11	8	33	32	23	15	10	7	4	1	1	2	1	1	1	0	0	0	0	0	0	0	1	0	0
2287	1994						21	45	69	52	44	24	20	6	8	6	1	4	2	1	0	1	0	0	1	0	0	0	0	0
1819	1995							38	63	59	40	30	13	10	8	7	4	3	3	3	2	0	1	1	1	0	1	0	0	0
1941	1996								64	55	60	33	24	22	10	7	11	2	1	1	1	0	2	1	0	1	0	1	0	0
405	1997									11	6	4	2	3	5	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0
811	1998										37	17	29	22	9	7	4	5	1	1	0	0	0	0	0	0	0	0	0	0
1796	1999											34	56	47	29	23	17	20	10	4	2	0	1	0	0	0	0	1	0	0
2397	2000												65	89	53	59	34	19	9	10	5	2	4	3	1	1	0	0	1	0
2305	2001													80	65	64	31	29	14	5	6	2	1	1	0	0	0	0	0	0
1828	2002														40	40	42	24	14	8	8	3	3	3	1	0	0	0	0	0
2190	2003															61	58	52	19	21	16	9	4	3	3	2	2	0	1	0
1856	2004																83	54	40	27	27	17	7	3	0	4	0	0	2	0
1162	2005																	38	25	25	13	11	10	1	2	0	0	0	1	0
1466	2006																		33	38	37	28	14	12	8	3	1	0	1	0
1090	2007																			46	41	24	26	15	8	2	1	0	0	0
1407	2008																				48	50	46	32	11	6	7	3	1	0
2239	2009																					57	63	52	25	15	11	3	3	1
1195	2010																						33	27	28	26	7	4	3	2
755	2011																							31	18	20	11	0	5	2
184	2012																								6	1	1	2	2	1
241	2013																									16	13	3	0	0
130	2014																										1	1	1	0
188	2015																											1	1	2
121	2016																												6	3
35	2017																													0

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
473	1989	47	34	19	9	6	4	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	1990		15	1	3	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
297	1991			20	8	7	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
765	1992				53	32	21	6	0	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1680	1993					111	60	30	30	9	5	4	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2287	1994						145	87	82	30	16	5	0	1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1819	1995							121	104	42	35	7	4	7	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0
1941	1996								139	76	42	9	7	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
405	1997									35	12	9	2	2	0	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0
811	1998										59	21	13	6	5	4	0	2	0	0	0	0	0	0	0	0	0	0	0	0
1796	1999											99	52	23	16	5	4	1	2	1	0	0	0	0	0	0	0	0	0	0
2397	2000												142	62	22	14	5	2	1	0	0	0	0	0	0	0	0	0	0	0
2305	2001													135	51	27	11	5	0	3	0	0	0	1	0	0	0	0	0	0
1828	2002														66	55	15	9	2	1	1	1	0	0	0	0	0	0	0	0
2190	2003															127	67	27	13	2	3	1	1	0	1	0	0	0	0	0
1856	2004																113	51	16	6	2	1	1	0	2	0	0	0	0	0
1162	2005																	78	23	10	5	0	2	2	0	0	0	0	0	0
1466	2006																		81	34	13	3	4	4	1	0	0	0	0	0
1090	2007																			57	15	11	3	5	1	0	1	0	0	0
1407	2008																				66	28	14	6	4	0	2	0	0	0
2239	2009																					136	57	19	10	3	1	1	0	0
1195	2010																						45	24	14	6	0	1	0	1
755	2011																							25	20	6	1	0	2	0
184	2012																								5	7	1	0	0	0
241	2013																									16	3	3	0	0
130	2014																										6	3	1	0
188	2015																											7	1	1
121	2016																												8	0
35	2017																													1

NCCOOP ≥ 18”

Tagged		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	2012	2013	2014	2015	2016	2017
1323	1988	17	3	17	25	31	16	9	10	4	4	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
1153	1989		11	11	10	12	6	2	2	2	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1946	1990			50	46	31	25	7	11	8	7	3	6	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1779	1991				56	46	40	32	29	14	19	7	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
1007	1992					56	36	19	20	11	10	8	7	3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
527	1993						22	9	10	8	7	5	2	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
4341	1994							136	106	73	52	45	24	8	6	2	5	2	3	1	3	0	0	0	0	0	1	1	0	0	0
639	1995								35	15	23	17	8	3	2	6	1	1	3	0	0	1	0	0	0	0	0	0	0	0	0
661	1996									29	17	13	3	4	3	4	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0
1347	1997										87	42	19	11	13	0	3	3	1	0	1	0	1	0	0	0	0	0	0	0	0
460	1998											26	12	6	9	2	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0
271	1999												24	8	5	3	0	2	2	2	1	0	2	0	0	0	0	0	0	0	0
4539	2000													147	61	35	17	12	6	4	1	1	1	0	0	0	0	0	0	0	0
2387	2001														111	58	46	17	16	9	3	1	2	0	1	2	0	0	0	1	0
3813	2002															187	109	54	26	16	8	4	3	2	1	0	0	0	0	0	0
1906	2003																85	57	30	15	13	8	7	4	4	1	0	0	0	0	0
2468	2004																	119	63	35	19	8	5	2	4	1	0	1	0	0	0
3960	2005																		91	40	22	7	8	2	2	1	1	1	0	1	1
4453	2006																			188	120	67	44	33	18	11	11	5	1	2	5
370	2007																				24	22	10	3	6	4	1	0	0	0	0
1033	2008																					78	42	29	15	7	2	4	3	2	0
146	2009																						3	3	1	1	0	0	0	0	0
566	2010																							16	9	8	4	2	0	0	1
107	2011																								9	3	3	1	0	1	0
6	2012																									1	0	0	0	0	0
2006	2013																										104	64	29	27	17
920	2014																											49	22	19	9
1375	2015																												67	39	28
1348	2016																													67	52
881	2017																														40

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
1323	1988	100	49	29	18	17	4	5	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1153	1989		42	29	19	8	3	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1946	1990			91	55	21	21	8	2	5	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1779	1991				91	45	43	24	5	6	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1007	1992					55	23	14	9	2	3	3	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
527	1993						25	14	9	3	3	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4341	1994							193	86	25	18	11	6	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
639	1995								27	6	2	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
661	1996									12	5	4	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1347	1997										38	22	9	6	3	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0
460	1998											21	14	2	2	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0
271	1999												7	5	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
4539	2000													147	33	12	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2387	2001														70	28	15	8	2	6	2	2	1	0	0	0	0	0	0	0	0
3813	2002															100	43	14	9	4	1	3	0	0	0	0	0	0	0	0	0
1906	2003																40	15	9	11	3	2	0	1	1	0	0	0	0	0	0
2468	2004																	64	27	18	7	2	1	1	0	0	0	0	0	0	0
3960	2005																		47	19	4	5	2	0	0	0	1	0	0	0	0
4453	2006																			126	54	21	9	9	2	2	0	0	0	0	0
370	2007																				10	2	2	0	0	0	0	0	0	0	0
1033	2008																					26	14	5	5	1	2	2	0	0	0
146	2009																						2	1	0	1	0	1	0	0	0
566	2010																							5	0	1	0	1	0	0	0
107	2011																								5	0	0	0	1	0	0
6	2012																									0	0	0	0	0	0
2006	2013																										45	13	13	5	5
920	2014																											16	10	1	2
1375	2015																												34	14	7
1348	2016																													27	14
881	2017																														14

HUDSON ≥ 18”

Tagged		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	2012	2013	2014	2015	2016	2017
826	1988	14	14	12	15	7	6	3	6	5	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
669	1989		10	16	10	5	7	9	4	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
783	1990			19	17	12	11	4	6	2	4	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
546	1991				15	15	9	8	9	6	3	1	0	1	0	1	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0
1135	1992					40	31	16	13	18	14	11	6	3	2	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
940	1993						34	22	16	24	13	8	5	3	1	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0
643	1994							20	25	27	13	9	5	4	4	3	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0
628	1995								30	25	23	19	11	2	1	1	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1069	1996									67	47	40	18	3	9	5	3	5	2	1	1	0	0	0	0	0	0	0	0	0	0
241	1997										22	7	8	6	3	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
698	1998											49	35	14	8	14	5	1	1	4	1	1	0	0	0	0	0	0	0	0	0
798	1999												47	18	25	10	15	6	4	3	1	3	1	1	1	0	0	0	0	0	0
846	2000													32	20	23	13	12	9	5	4	0	0	1	0	0	0	0	0	0	0
1069	2001														40	30	15	13	9	9	1	4	0	0	1	0	0	0	0	0	0
597	2002															19	11	11	6	6	5	4	4	1	1	0	0	0	0	0	0
1379	2003																54	57	35	16	15	6	3	3	4	0	0	0	0	0	0
1273	2004																	65	38	32	18	5	4	5	3	1	0	1	0	1	0
1325	2005																		46	34	23	9	8	10	0	4	2	0	1	0	0
1130	2006																			46	33	34	14	11	9	4	3	2	0	0	0
755	2007																				29	31	15	7	6	6	1	2	2	3	0
1236	2008																					42	37	32	10	10	3	2	1	1	2
507	2009																						31	26	13	6	4	2	1	0	0
840	2010																							40	24	11	6	5	1	0	1
338	2011																								25	12	9	4	2	1	1
705	2012																									30	25	15	8	3	4
887	2013																										48	23	10	13	8
551	2014																											20	12	9	8
1130	2015																												28	24	18
1303	2016																													33	33
852	2017																														43

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
826	1988	41	49	32	11	11	8	4	0	0	4	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
669	1989		49	30	12	8	3	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
783	1990			71	30	22	11	6	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
546	1991				42	29	7	6	2	1	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1135	1992					76	38	27	14	5	6	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
940	1993						66	38	20	8	9	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
643	1994							39	16	7	5	1	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
628	1995								30	16	12	4	1	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1069	1996									53	36	16	10	3	2	2	2	1	3	0	1	0	0	0	0	0	0	0	0	0	0
241	1997										10	6	5	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
698	1998											25	20	4	2	8	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
798	1999												29	17	7	4	2	4	2	1	0	0	0	0	0	0	0	0	0	0	0
846	2000													42	13	12	16	8	2	2	0	0	1	0	0	0	0	0	0	0	0
1069	2001														44	31	10	3	3	2	1	0	1	0	0	0	0	0	0	0	0
597	2002															26	9	8	2	4	2	1	1	1	0	0	0	0	0	0	0
1379	2003																66	28	19	12	3	0	1	1	0	0	0	0	1	0	0
1273	2004																	53	25	15	9	2	1	1	2	1	0	0	0	0	0
1325	2005																		57	30	14	9	0	1	1	0	0	1	0	0	0
1130	2006																			36	28	12	7	1	1	2	1	1	0	0	0
755	2007																				22	19	9	2	2	1	0	0	0	0	0
1236	2008																					48	21	13	4	3	1	1	1	0	0
507	2009																						20	14	5	3	5	1	0	1	0
840	2010																							25	15	7	6	1	1	1	1
338	2011																								10	9	4	1	2	0	1
705	2012																									13	16	8	3	7	3
887	2013																										26	25	13	5	1
551	2014																											13	22	15	5
1130	2015																												17	22	12
1303	2016																													32	20
852	2017																														21

DE/PA ≥ 18”

Tagged		Harvested recaptures																								
Number	Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
265	1993	10	9	3	9	4	3	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
313	1994		14	10	7	6	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
477	1995			22	96	4	10	2	5	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
313	1996				17	5	5	3	6	2	2	1	2	0	1	0	0	1	0	0	0	0	0	0	0	0
513	1997					24	12	8	4	4	1	2	1	1	0	0	0	1	0	0	0	0	0	0	0	0
715	1998						39	13	11	9	5	8	2	1	1	1	2	0	0	0	0	0	0	0	0	0
407	1999							15	13	5	4	4	2	0	1	0	1	0	0	0	0	0	0	0	0	0
651	2000								38	22	9	5	3	4	0	1	0	0	0	0	0	0	0	0	0	0
902	2001									54	21	25	8	7	4	1	2	4	1	2	0	0	0	0	0	0
616	2002										35	21	4	7	3	2	1	1	1	0	0	0	0	0	0	0
657	2003											38	20	11	7	3	0	4	2	2	0	0	0	0	0	0
384	2004												23	9	6	3	0	2	3	0	0	0	0	0	0	0
326	2005													12	6	2	2	4	0	1	1	0	0	0	0	0
583	2006														27	10	7	4	4	3	1	0	0	0	0	0
393	2007															9	7	1	3	0	0	1	0	1	0	0
484	2008																13	7	6	2	1	3	0	0	0	0
375	2009																	17	7	6	1	3	0	0	0	0
447	2010																		17	6	1	2	0	1	2	1
746	2011																			17	11	3	2	5	1	0
707	2012																				31	9	8	4	1	0
788	2013																					35	16	11	4	2
150	2014																						12	2	3	0
367	2015																							4	1	0
426	2016																								10	6
331	2017																									14

Tagged		Released recaptures (event 1 only)																								
Number	Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
265	1993	13	10	2	2	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
313	1994		16	12	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
477	1995			29	20	9	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
313	1996				18	10	6	1	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
513	1997					23	26	12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
715	1998						35	11	5	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
407	1999							17	8	5	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
651	2000								28	25	8	8	3	2	1	0	0	0	0	0	0	0	0	0	0	0
902	2001									36	19	11	4	4	1	0	0	0	0	1	0	0	0	0	0	0
616	2002										15	20	4	5	0	0	0	0	0	0	0	0	0	0	0	0
657	2003											31	15	5	1	1	0	1	1	0	0	0	0	0	0	0
384	2004												11	4	4	2	0	1	0	0	0	0	0	0	0	0
326	2005													27	10	5	0	0	0	0	0	0	0	0	0	0
583	2006														32	8	4	3	2	0	0	0	0	0	0	0
393	2007															15	3	3	0	1	0	0	0	0	0	0
484	2008																25	13	4	3	1	0	0	0	0	0
375	2009																	21	6	2	1	0	1	1	0	0
447	2010																		22	11	1	2	1	1	0	1
746	2011																			39	10	4	4	2	0	0
707	2012																				27	7	1	0	1	0
788	2013																					31	24	2	2	0
150	2014																						5	4	1	1
367	2015																							10	4	0
426	2016																								15	9
331	2017																									10

MDCB ≥ 18”

Tagged		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	2012	2013	2014	2015	2016	2017
1409	1987	1	9	0	21	21	24	20	8	8	6	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2240	1988		7	3	30	41	48	25	14	19	7	10	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2343	1989			4	53	65	64	34	22	18	11	4	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1365	1990				35	37	34	16	11	7	4	10	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1452	1991					57	56	44	14	22	10	10	5	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1615	1992						85	57	40	26	12	11	8	10	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2154	1993							98	83	63	39	33	19	15	3	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1824	1994								90	94	45	39	28	17	7	2	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	0
1353	1995									106	61	40	20	11	8	3	2	5	0	1	2	0	1	0	0	0	0	0	0	0	0	0
1680	1996										117	70	66	23	10	8	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
841	1997											72	43	23	6	2	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
919	1998												84	28	10	7	5	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0
592	1999													42	23	10	3	1	2	1	0	1	1	0	0	0	0	0	0	0	0	0
931	2000														64	23	11	7	7	2	1	2	1	0	2	0	0	0	0	0	0	0
1104	2001															55	21	20	8	2	3	0	1	0	1	0	0	0	0	0	0	0
1134	2002																55	48	16	7	1	4	0	2	0	0	0	0	0	1	0	0
791	2003																	43	24	11	9	2	4	0	0	1	0	0	0	1	0	0
682	2004																		28	15	10	2	3	1	2	2	1	0	0	0	0	0
876	2005																			40	26	10	5	3	1	1	1	0	2	0	1	0
605	2006																				30	9	5	6	3	0	2	0	0	0	0	0
457	2007																					14	8	4	2	2	1	1	0	0	0	0
429	2008																						17	8	4	4	1	0	0	0	0	0
718	2009																							52	11	6	3	0	2	1	0	0
668	2010																								37	11	6	2	2	1	0	0
1098	2011																									66	15	8	5	1	0	2
538	2012																										28	10	9	4	2	1
811	2013																											58	20	5	6	4
714	2014																												61	13	6	4
981	2015																													50	23	12
950	2016																														40	21
1154	2017																															43

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
1409	1987	52	34	25	21	21	23	9	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2240	1988		84	59	56	35	23	18	8	4	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2343	1989			74	73	47	33	15	11	5	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1365	1990				48	31	28	9	4	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1452	1991					57	50	20	17	9	1	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1615	1992						80	39	24	17	8	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2154	1993							71	61	31	17	7	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1824	1994								87	45	22	8	9	4	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1353	1995									62	31	11	7	5	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1680	1996										84	38	13	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
841	1997											36	17	2	2	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
919	1998												45	11	9	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
592	1999													18	13	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
931	2000														42	8	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1104	2001															37	11	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0
1134	2002																29	12	5	1	2	1	0	0	0	0	0	0	0	0	0	0
791	2003																	20	6	4	3	2	0	0	0	0	0	0	0	0	0	0
682	2004																		17	5	3	1	2	0	1	1	0	0	0	0	0	0
876	2005																			16	6	2	0	2	0	0	0	0	0	0	0	0
605	2006																				16	5	2	0	0	1	0	0	0	0	0	0
457	2007																					8	4	0	1	0	0	0	0	0	0	0
429	2008																						6	1	2	0	1	0	0	0	0	0
718	2009																							9	5	2	0	0	0	0	0	0
668	2010																								14	4	1	1	0	0	0	0
1098	2011																									16	3	0	1	0	1	0
538	2012																										4	4	0	0	1	0
811	2013																											15	5	1	0	0
714	2014																												6	5	1	0
981	2015																													15	2	2
950	2016																														18	6
1154	2017																															29

VARAP ≥ 18”

Tagged		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	2012	2013	2014	2015	2016	2017
1466	1990	21	19	25	10	8	9	2	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2481	1991		47	38	22	14	3	1	2	1	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	1992			7	4	1	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
621	1993				18	17	12	3	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195	1994					6	7	4	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
698	1995						24	12	9	4	1	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
377	1996							3	10	3	2	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
712	1997								26	17	10	2	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
784	1998									28	16	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
853	1999										30	7	4	2	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1767	2000											42	25	11	7	3	7	1	1	0	0	0	0	0	0	0	0	0	0
797	2001												31	13	6	7	1	0	0	0	0	0	0	0	0	0	0	0	0
315	2002													10	3	6	2	1	1	1	0	0	0	0	0	0	0	0	0
852	2003														31	20	4	5	3	2	1	2	0	0	0	0	1	0	0
1477	2004															45	14	6	6	3	1	1	0	0	0	0	0	0	0
921	2005																25	18	7	1	4	0	1	0	0	0	0	0	0
668	2006																	26	4	6	5	3	4	0	0	0	0	0	0
1961	2007																		62	35	16	4	5	0	1	1	1	0	0
523	2008																			15	6	0	0	0	0	1	0	0	0
867	2009																				26	7	2	2	0	1	0	0	0
2050	2010																					28	7	9	2	0	1	0	1
416	2011																						12	4	0	0	1	0	0
1222	2012																							33	12	5	2	0	0
760	2013																								23	8	7	1	0
454	2014																									8	3	4	0
313	2015																										8	4	2
798	2016																											11	5
307	2017																												5

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
1466	1990	61	46	17	12	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2481	1991		82	42	28	13	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
130	1992			5	4	3	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
621	1993				22	20	3	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
195	1994					6	1	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
698	1995						21	8	8	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
377	1996							10	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
712	1997								12	8	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
784	1998									21	7	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
853	1999										19	15	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1767	2000											50	23	8	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
797	2001												16	10	7	0	1	0	1	0	0	0	0	0	0	0	0	0	0
315	2002													6	3	3	0	0	1	0	0	0	0	0	0	0	0	0	0
852	2003														12	6	8	1	0	1	0	0	0	0	0	0	0	1	0
1477	2004															23	6	6	1	0	1	0	0	0	0	0	0	0	0
921	2005																13	9	2	0	1	1	0	0	0	0	0	0	0
668	2006																	18	7	0	1	1	0	0	0	0	0	0	0
1961	2007																		33	11	1	1	0	1	0	1	0	0	0
523	2008																			6	3	2	0	0	0	0	0	0	0
867	2009																				14	4	0	0	0	0	0	0	0
2050	2010																					14	1	1	0	1	0	0	0
416	2011																						5	0	0	0	0	1	0
1222	2012																							16	4	0	0	0	0
760	2013																								6	2	1	0	0
454	2014																									6	2	0	3
313	2015																										5	0	0
798	2016																											11	0
307	2017																												2

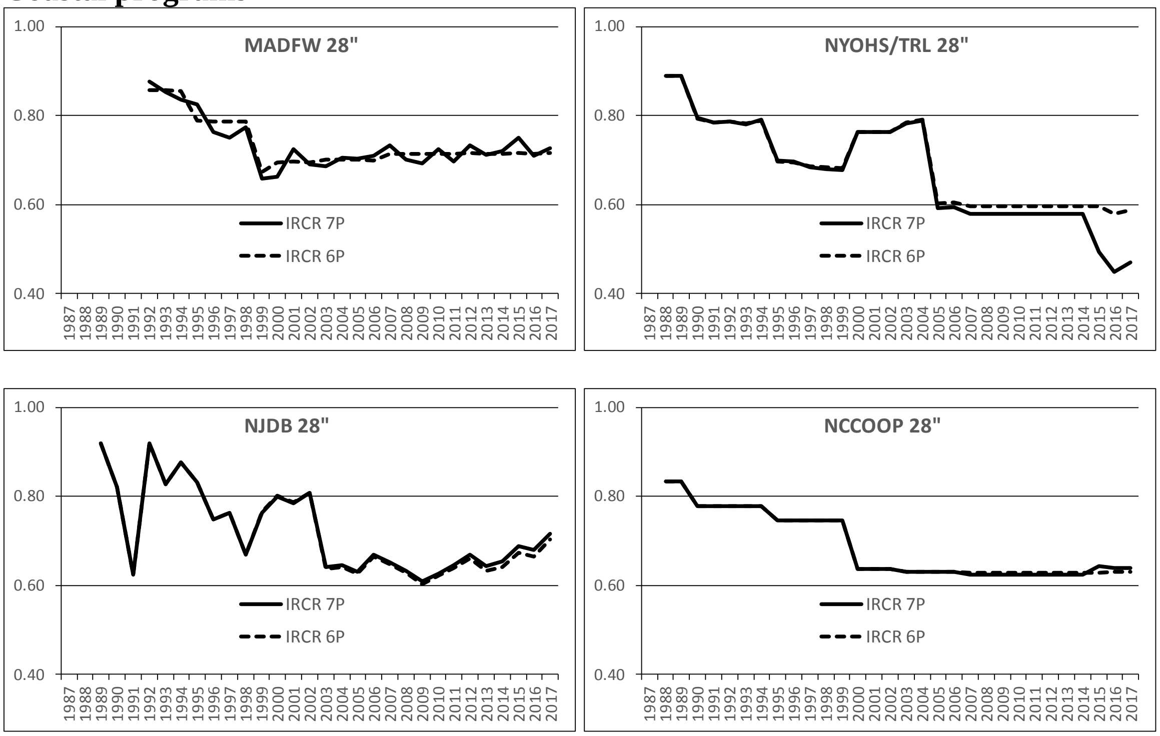
Chesapeake Bay 18–28” males (data combined from MDCB and VARAP)

Tagged		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	2012	2013	2014	2015	2016	2017
1308	1987	1	6	0	18	19	21	17	6	7	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1852	1988		4	2	23	26	37	23	10	12	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1916	1989			1	39	51	57	30	19	9	6	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1172	1990				22	28	26	11	10	4	3	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1080	1991					34	43	29	9	10	4	5	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1149	1992						62	41	26	9	5	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1627	1993							66	54	34	18	15	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1255	1994								58	63	19	16	15	8	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1125	1995									61	31	16	7	5	2	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
982	1996										48	31	24	6	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
955	1997											48	26	10	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1274	1998												69	22	6	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
1075	1999													39	20	7	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2034	2000														75	21	16	5	3	2	0	0	0	0	0	0	0	0	0	0	0	0
1120	2001															53	17	10	3	0	0	0	0	0	0	0	0	0	0	0	0	0
996	2002																42	26	12	1	1	1	0	0	0	0	0	0	0	0	0	0
899	2003																	35	20	5	5	1	1	0	0	0	0	0	0	0	0	0
1068	2004																		36	12	0	1	0	0	0	0	0	0	0	0	0	0
1136	2005																			38	25	4	1	2	0	0	1	0	0	0	0	0
792	2006																				30	5	1	5	1	0	0	0	0	0	0	0
1344	2007																					37	14	6	1	0	0	0	0	0	0	0
702	2008																						22	7	1	1	0	0	0	0	0	0
1018	2009																							53	7	7	2	0	0	0	0	0
1935	2010																								45	13	6	1	1	1	0	0
996	2011																									53	7	4	2	1	0	0
1099	2012																										44	13	9	4	0	0
928	2013																											56	12	3	3	1
611	2014																												42	11	5	0
901	2015																													47	22	8
1329	2016																														32	18
1071	2017																															39

Tagged		Released recaptures (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	2012	2013	2014	2015	2016	2017
1308	1987	49	31	18	18	16	21	8	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1852	1988		64	42	37	25	18	11	5	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1916	1989			53	50	26	24	8	8	5	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1172	1990				41	22	17	6	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1080	1991					38	31	15	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1149	1992						56	17	12	13	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1627	1993							38	42	18	11	5	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1255	1994								54	27	14	4	3	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1125	1995									51	19	9	4	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
982	1996										46	19	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
955	1997											37	13	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1274	1998												47	11	7	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1075	1999													29	18	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2034	2000														70	17	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1120	2001															36	3	6	1	1	0	0	0	0	0	0	0	0	0	0	0	0
996	2002																26	8	4	0	0	0	0	0	0	0	0	0	0	0	0	0
899	2003																	14	5	3	1	0	0	0	0	0	0	0	0	0	1	0
1068	2004																		20	4	1	0	1	0	0	0	0	0	0	0	0	0
1136	2005																			20	5	2	0	1	0	0	0	0	0	0	0	0
792	2006																				25	7	0	0	0	0	0	0	0	0	0	0
1344	2007																					26	6	0	1	0	0	0	1	0	0	0
702	2008																						12	2	3	0	0	0	0	0	0	0
1018	2009																							18	2	1	0	0	0	0	0	0
1935	2010																								20	2	1	0	0	0	0	0
996	2011																									13	2	0	0	0	1	0
1099	2012																										17	2	0	0	1	0
928	2013																											14	3	1	0	0
611	2014																												6	1	0	0
901	2015																													15	1	2
1329	2016																														28	5
1071	2017																															24

Plots of Survival Estimates With and Without an Additional Regulatory Period

Coastal programs



Producer area programs

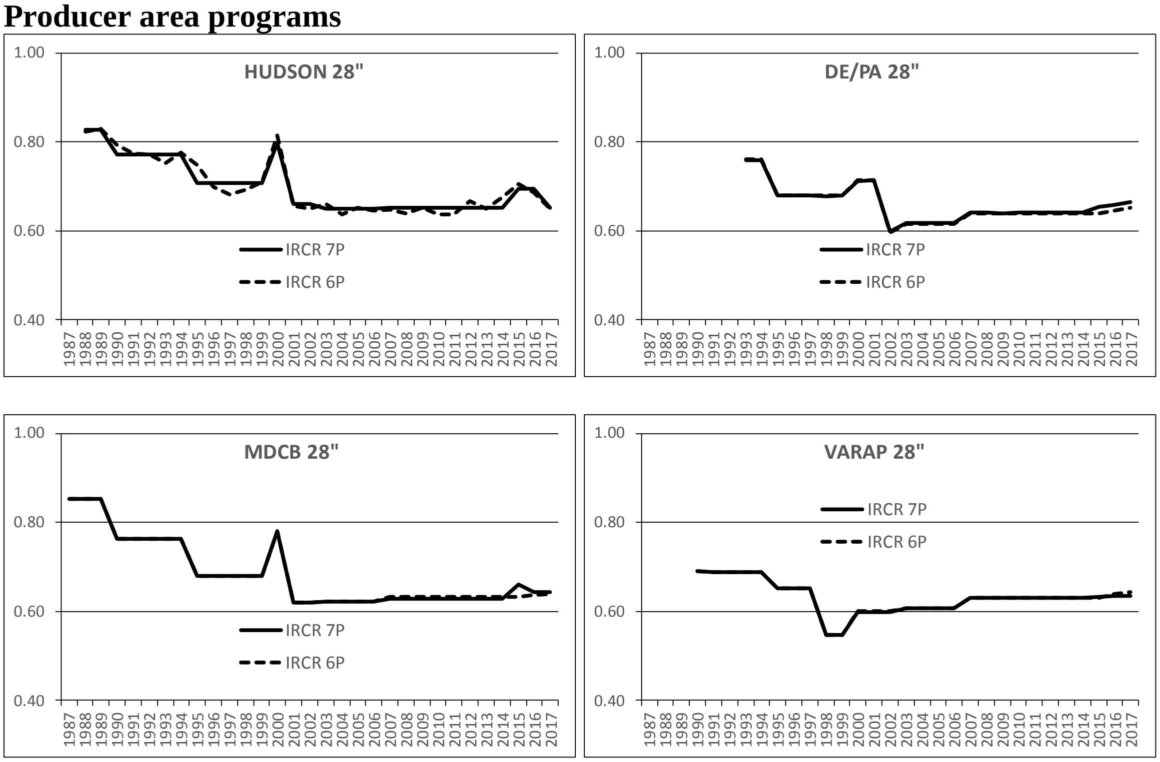
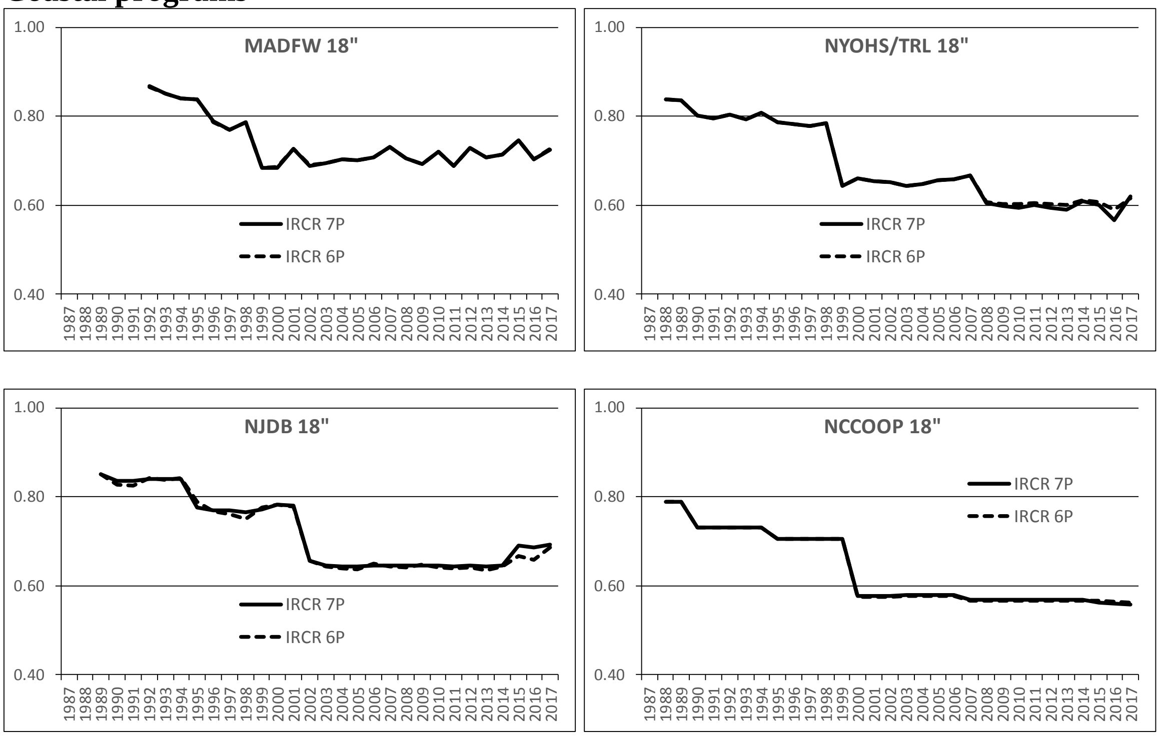


Figure 1. Survival estimates from IRCR analyses of fish tagged at ≥ 28 inches. Model averaged estimates are from separate analyses of (1) candidate models structured with seven regulatory periods (IRCR 7P) and (2) candidate models structured with six regulatory periods (IRCR 6P).

Coastal programs



Producer area programs

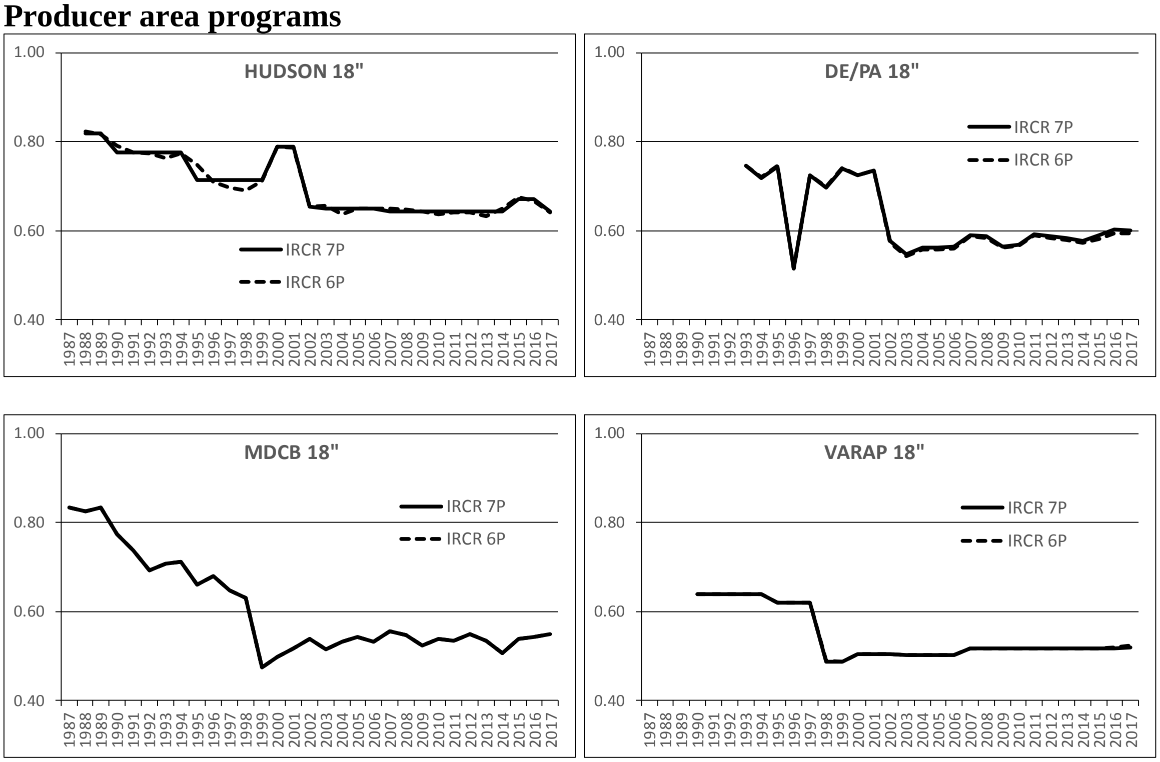
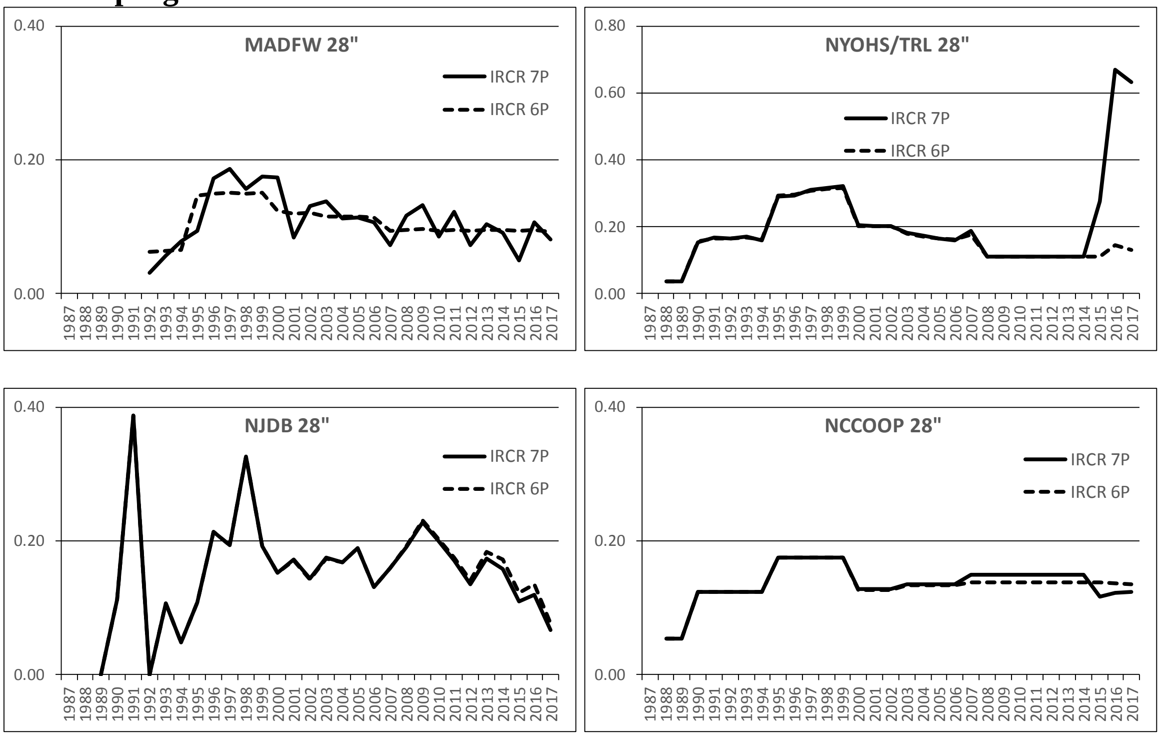


Figure 2. Survival estimates from IRCR analyses of fish tagged at ≥ 18 inches. Model averaged estimates are from separate analyses of (1) candidate models structured with seven regulatory periods (IRCR 7P) and (2) candidate models structured with six regulatory periods (IRCR 6P).

Coastal programs



Producer area programs

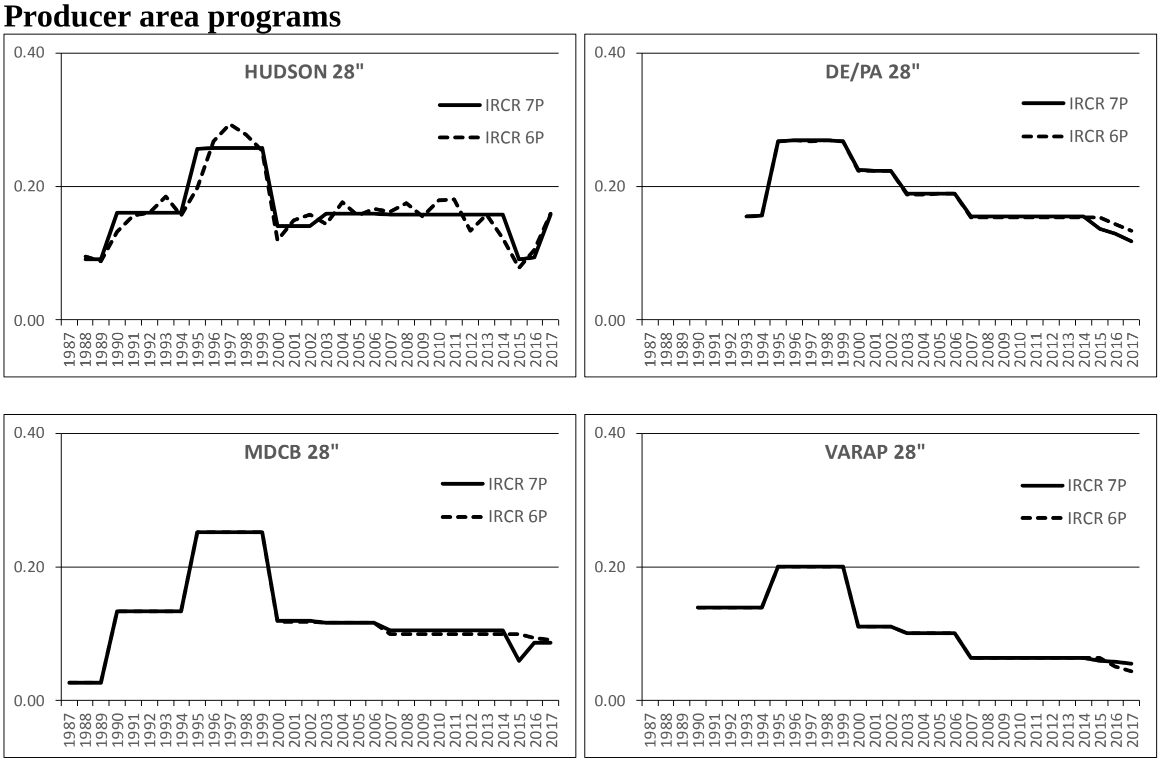
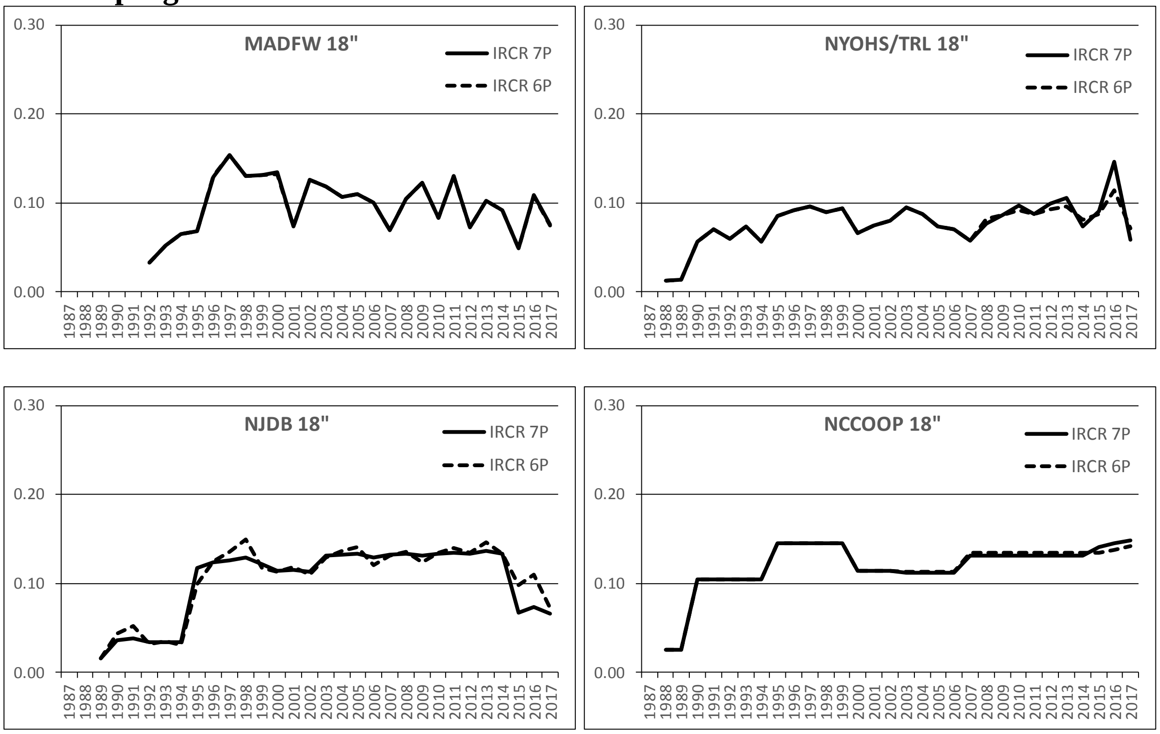


Figure 3. Instantaneous fishing mortality rate estimates from IRCR analyses of fish tagged at ≥ 28 inches. Model averaged estimates are from separate analyses of (1) candidate models structured with seven regulatory periods (IRCR 7P) and (2) candidate models structured with six regulatory periods (IRCR 6P).

Coastal programs



Producer area programs

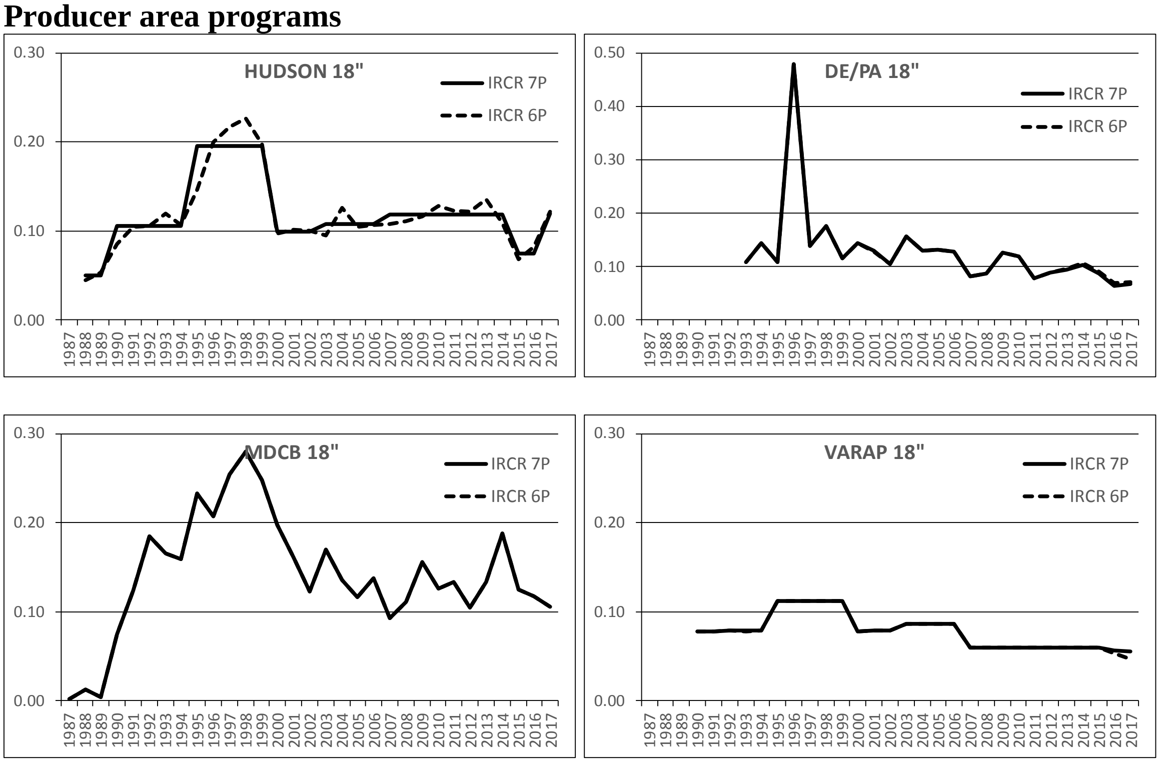
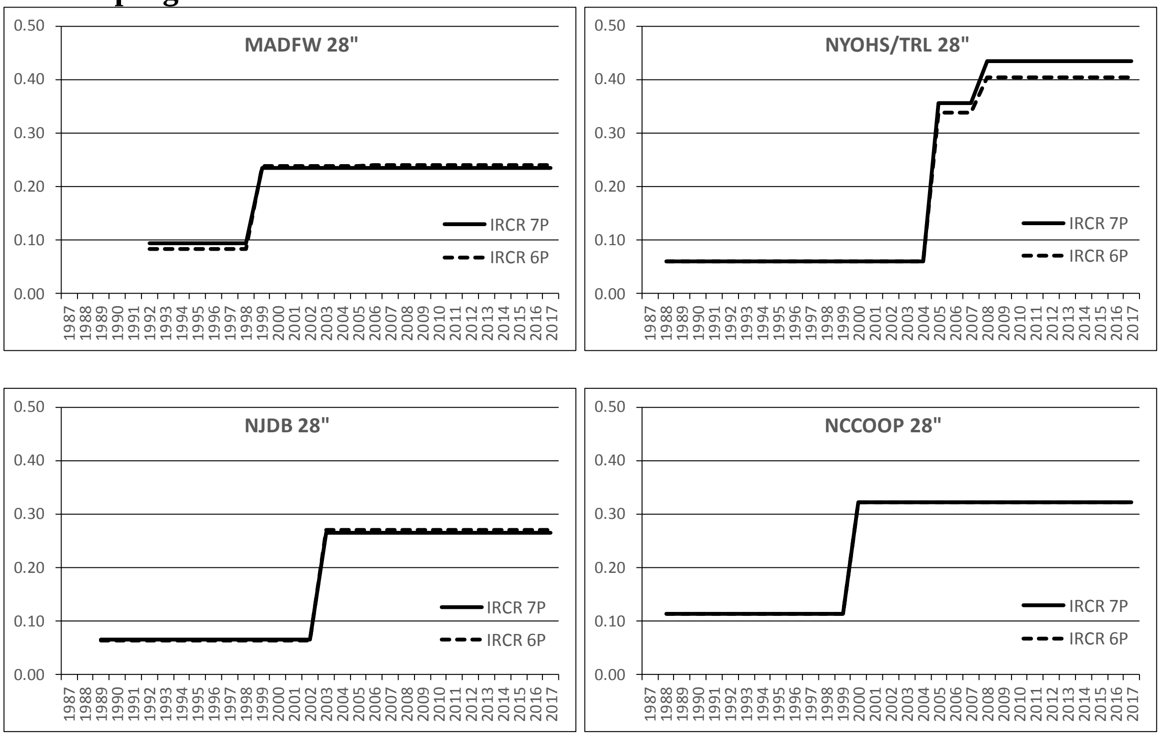


Figure 4. Instantaneous fishing mortality rate estimates from IRCR analyses of fish tagged at ≥ 18 inches. Model averaged estimates are from separate analyses of (1) candidate models structured with seven regulatory periods (IRCR 7P) and (2) candidate models structured with six regulatory periods (IRCR 6P).

Coastal programs



Producer area programs

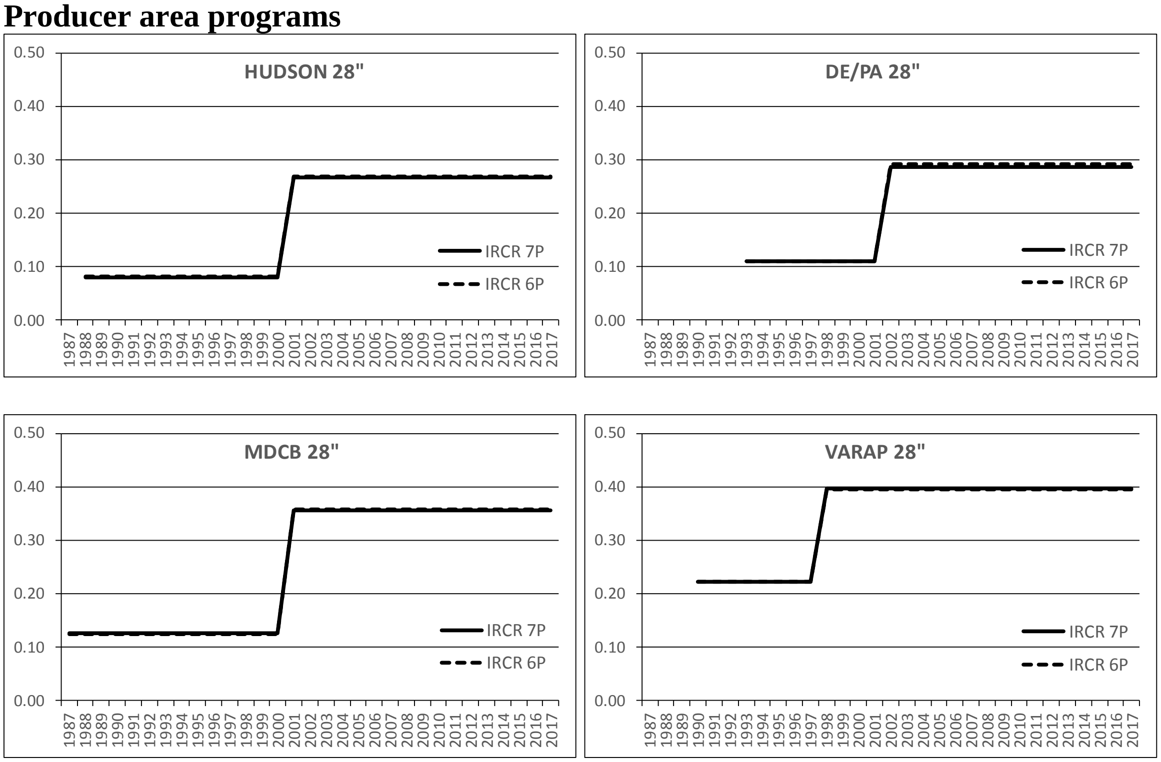
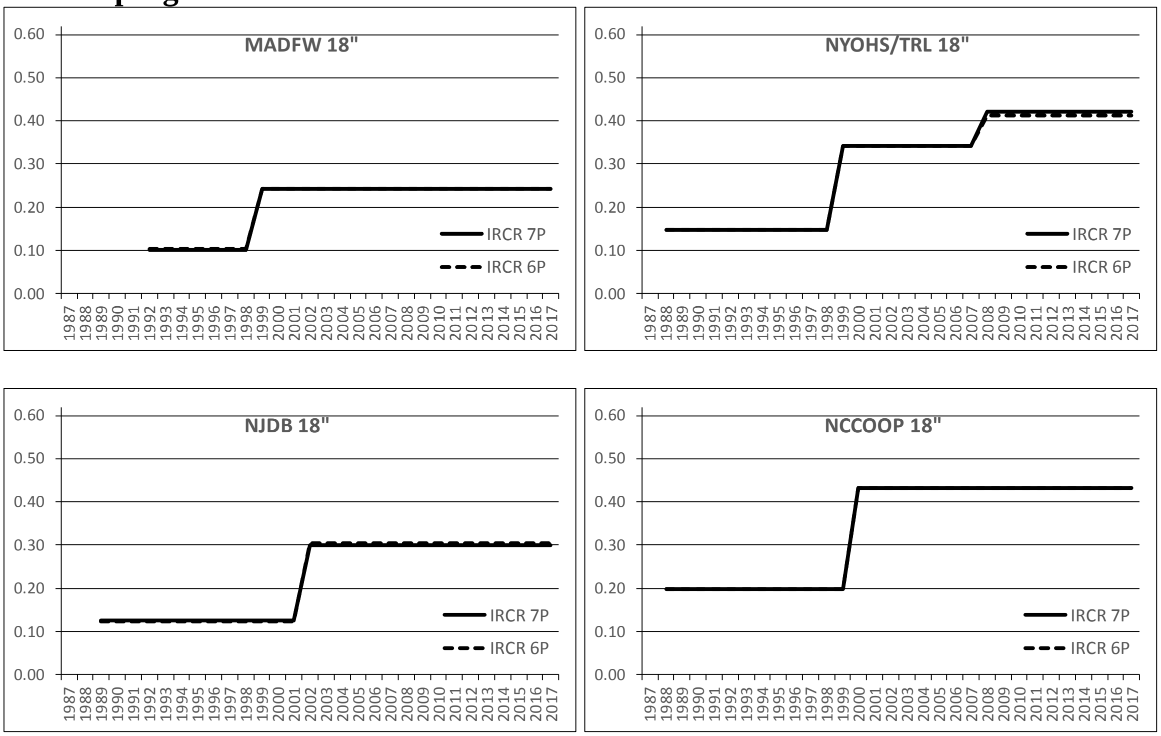


Figure 5. Instantaneous natural mortality rate estimates from IRCR analyses of fish tagged at ≥ 28 inches. Model averaged estimates are from separate analyses of (1) candidate models structured with seven regulatory periods (IRCR 7P) and (2) candidate models structured with six regulatory periods (IRCR 6P).

Coastal programs



Producer area programs

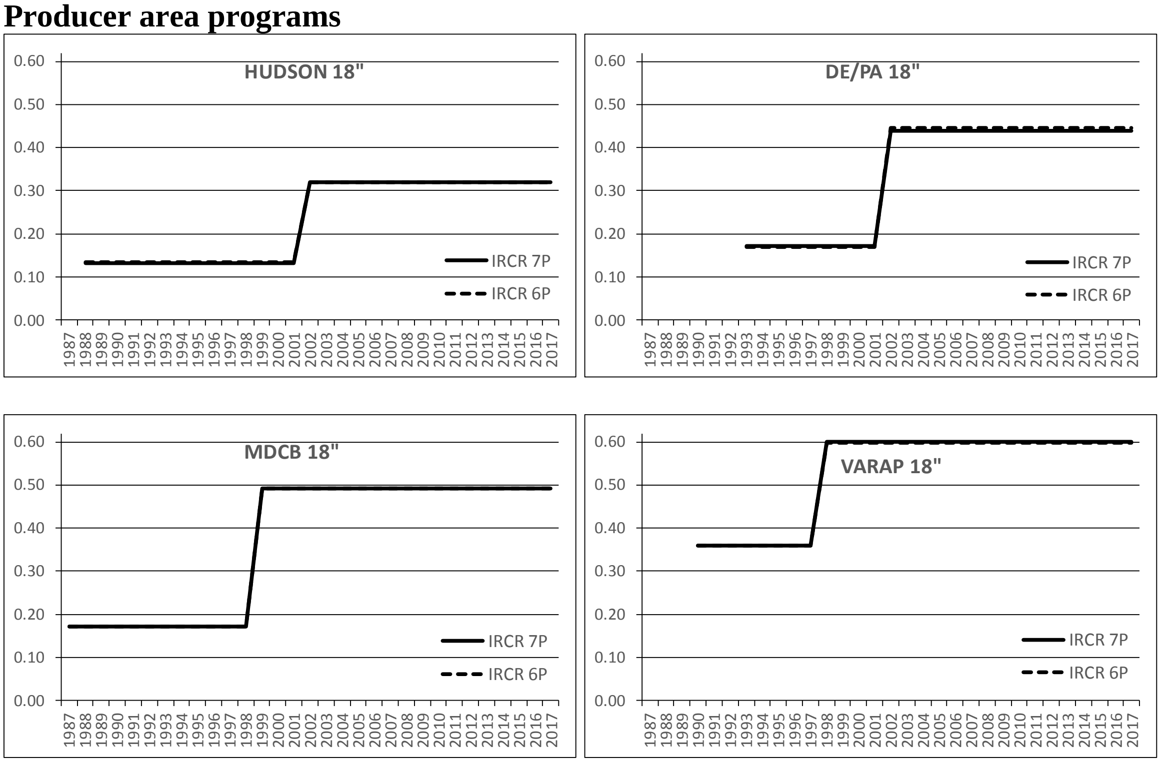


Figure 6. Instantaneous natural mortality rate estimates from IRCR analyses of fish tagged at ≥ 18 inches. Model averaged estimates are from separate analyses of (1) candidate models structured with seven regulatory periods (IRCR 7P) and (2) candidate models structured with six regulatory periods (IRCR 6P).

Appendix B12: TOR #6 (projections) for the non-migration SCA model.

The SARC66 peer review panel concluded that the two-stock statistical catch-at-age (2SCA) model presented to them was not acceptable to serve as a basis for fishery management advice. Instead, SARC66 recommends the use of the single-stock non-migration model for management use. Although the projections from the non-migration SCA were available to be reviewed at the SAW/SARC workshop, they were not part of the draft report, and are provided here as an appendix.

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. (TOR #6)

B10.1 Female Spawning Stock Biomass (SSB) and Fishing Mortality (F)

Several scenarios were run to investigate changes in female SSB over six-year projections. In the first scenario, the changes in SSB and F relative to their threshold reference points were examined by projecting the population forward assuming the catch taken in 2017 (7,058,838 fish) was also taken during 2018-2023. In the second scenario, the population was projected assuming the F observed in 2017 (0.307) was the same in 2018-2023. In the third and fourth scenarios, the population was projected assuming fishing mortality in 2018-2023 was equal to F associated with the 1993 and 1995 SSB thresholds assuming a Beverton-Holt stock recruitment relationship and empirical recruitment.

For each scenario, the model begins in year 2017 with known January-1 abundance-at-age data with associated standard errors from the SCA assessment model, the fully-recruited F estimate in 2017 (F=0.307), selectivity-at-age in 2017, Rivard weights in 2017, natural mortality, female sex proportions-at-age, and female maturity-at-age are used to calculate female SSB as modeled in the SCA model. For 2018, the January-1 abundance-at-age is calculated from the known values of 2017 abundance-at-age, selectivity and fully-recruited F. For the remaining years, the January-1 abundance-at-age is projected and is calculated by using the previous year's abundance-at-age, selectivity, F, and natural mortality following the standard exponential decay model. In the constant catch scenario, the fully-recruited F in 2018-2023 is estimated by using an iterative approach in which catch-at-age is calculated by using the catch equation given a January-1 abundance-at-age, F, and selectivity-at-age. The sum of age-specific catches are then compared to the assumed constant catch for 2018-2023. This procedure is repeated by changing fully-recruited F until the square of the log difference between predicted catch and total catch is minimized. Given the value of fully-recruited F, SSB for the current year is then calculated. For the constant F scenarios, total catch is calculated each year from the January-1 abundances and the current year F.

For each iteration of the simulation, the abundance-at-age in 2017 is randomly drawn from a normal distribution parameterized with the 2017 estimates of January-1 abundance–at-age and associated standard errors from the SCA assessment model. For the remaining years, abundance of age-1 recruits is either randomly selected from the 1990-2017 recruitment estimates (empirical recruitment approach) or predicted from the hockey-stick Beverton-Holt stock recruitment relationship (BHSR approach) described under TOR #5. An age-15 plus-group is assumed. For years 2018-2023, selectivity-at-age is assumed equal to the geometric mean selectivity for years 2013-2017. Female spawning stock biomass was calculated by using geometric mean Rivard weight estimates from 2013-2017, sex proportions-at-age, and female maturity-at-age.

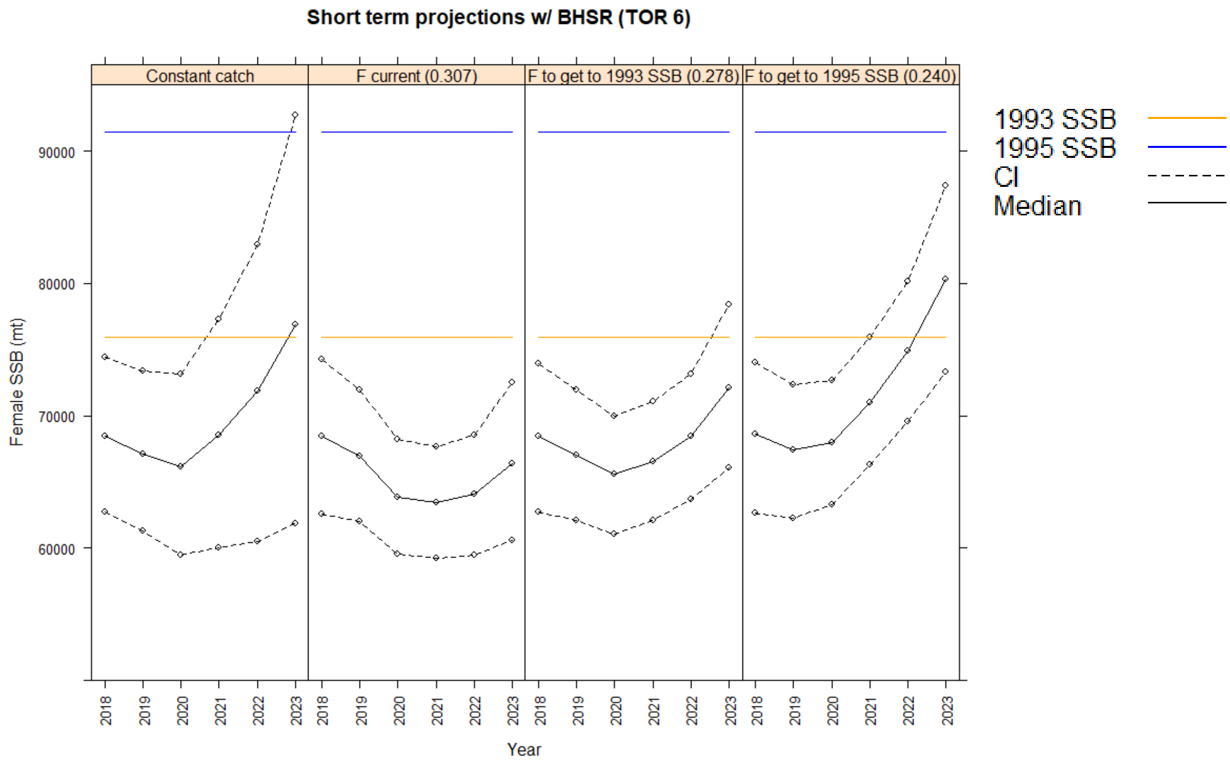
For each year of the projection, the probability of SSB being below the SSB reference point was calculated from 10,000 simulations using function *pgen* in R package *fishmethods*. The SSB reference point was the 1993 or 1995 SSB estimate and the error of the estimates of current SSB and SSB reference point were incorporated in the calculation of probability. Similarly, the probability of current F being above the F reference point was calculated from 10,000 simulations as well.

B10.2 Results

If the total fully-recruited F was assumed equal to the 2017 value (0.307) during 2018-2023, the probability of female SSB being below the 1995 SSB reference point, assuming BHSR, is 100% (Figure 1). The probability of female SSB being below the 1993 SSB reference point, again assuming BHSR, is always above 90%. If F is lowered during 2018-2023 to 0.240 or 0.278 (Fs associated with 1995 and 1993 SSB, respectively), the probability that female SSB is below the 1995 reference point remains above 95% (Figure 1). The probability that female SSB is below the 1993 reference point remains above 75% when F = 0.278, but drops to 23% in 2023 when F = 0.240. Under the constant catch scenario, the probabilities of female SSB being below the 1995 or 1993 SSB reference points, assuming BHSR, are similar to those from fishing at the F threshold (F = 0.240) (Figure 1).

If the constant catch of 7,058,838 fish was maintained during 2018-2023, the probability of being above the 1995 F reference point is greater than 50%; the probability of F being below the 1993 F reference point is below 50% from 2019-2023 (Figure 2).

Results from projections that assumed the empirical recruitment model (Figures 3 and 4) were similar to the hockey-stick recruitment results.



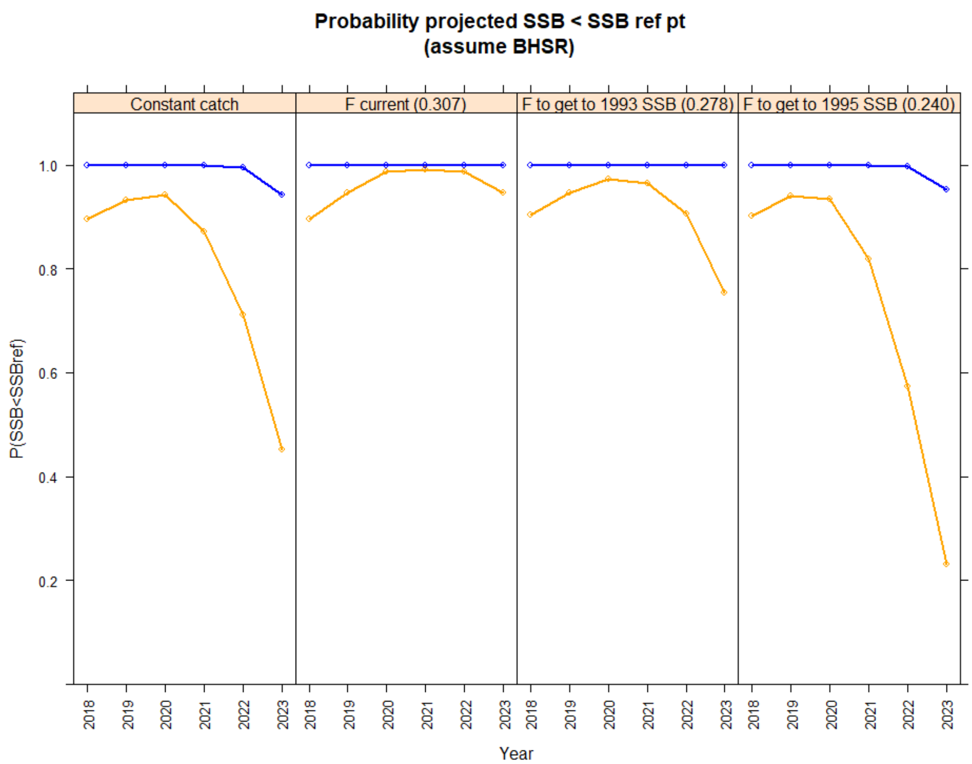
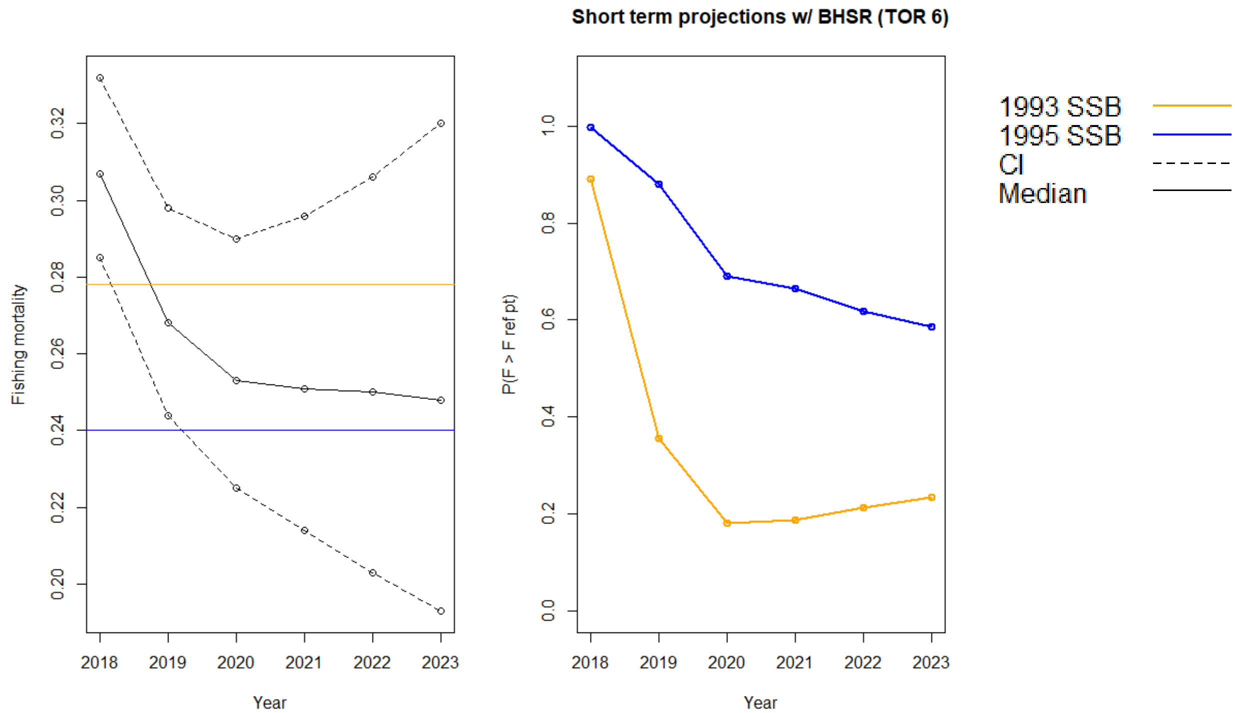


Figure 1. Short term projections of female spawning stock biomass with 95% confidence intervals (top) and probability of female SSB being below SSB reference points (bottom) under different fishing scenarios using Beverton Holt stock recruitment (BHSR).



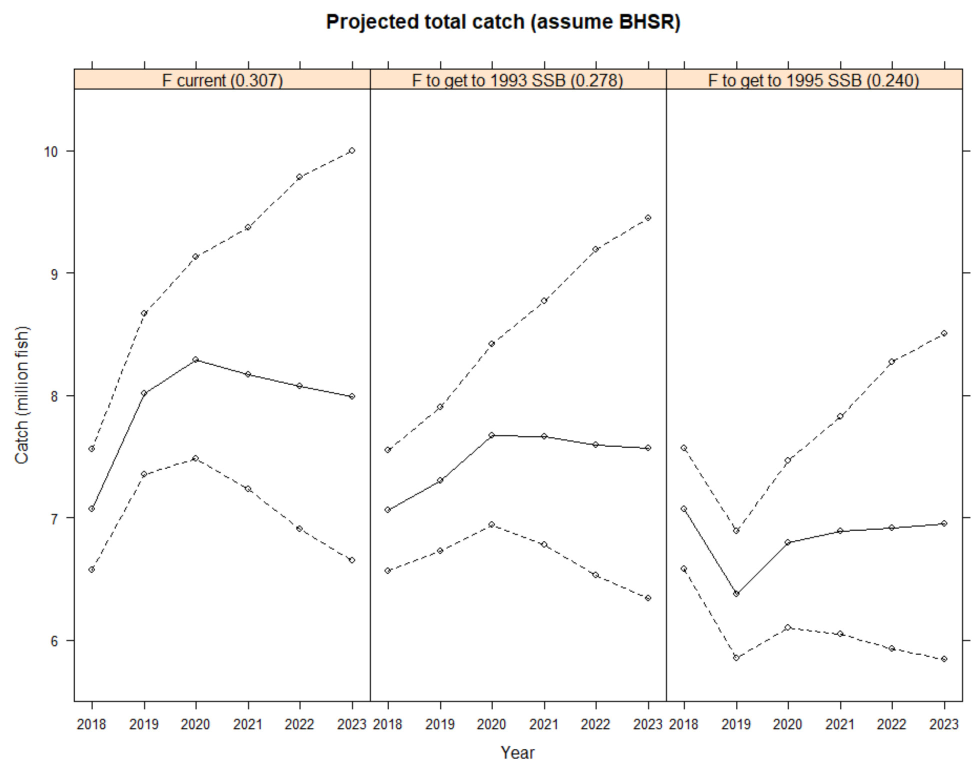


Figure 2. Probability of F being above the F reference points for the constant catch scenario (top) and projected total catch under different F scenarios (bottom) using Beverton Holt stock recruitment (BHSR).

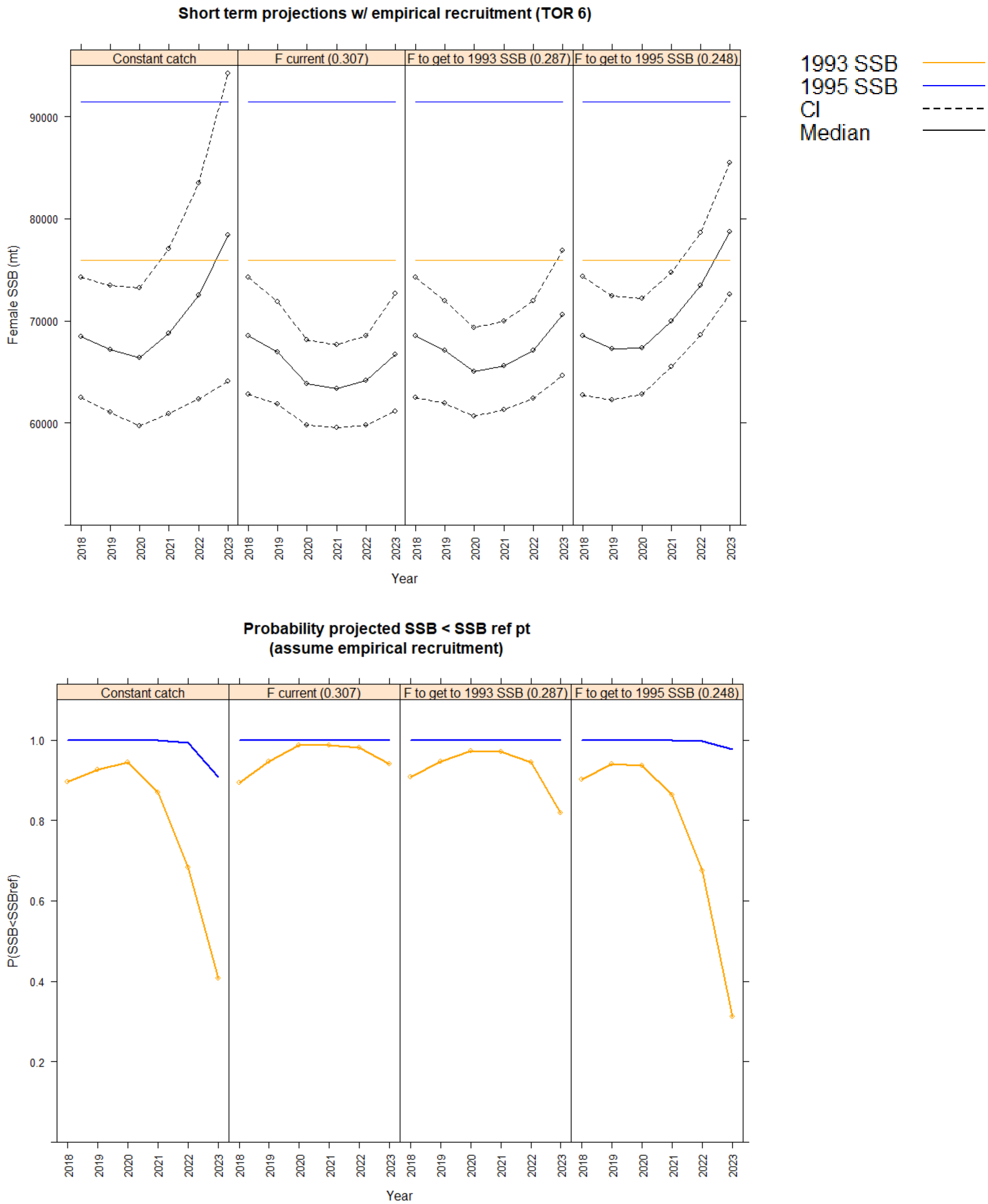


Figure 3. Short term projections of female spawning stock biomass with 95% confidence intervals (top) and probability of female SSB being below SSB reference points (bottom) under different fishing scenarios using empirical recruitment.

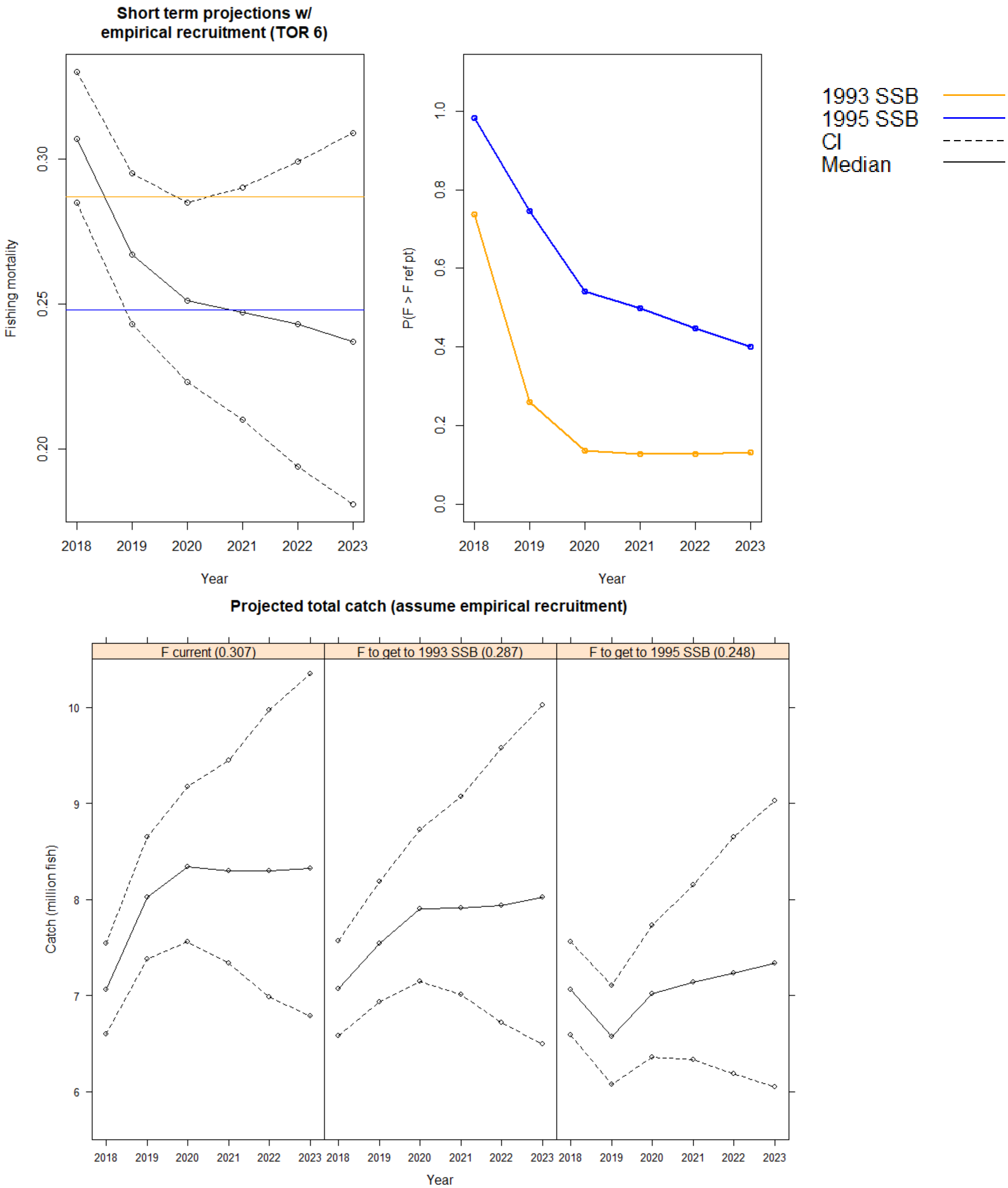


Figure 4. Probability of F being above the F reference points for the constant catch scenario (top) and projected total catch under different F scenarios (bottom) using empirical recruitment.

Appendix B13. Additional analysis for striped bass requested at SARC 66

The SARC 66 Review Panel expressed concerns about the way overfishing status was determined for the striped bass two-stock statistical catch-at-age (2SCA) model. The 2SCA model estimated F for a Chesapeake Bay fleet and an ocean fleet. The Striped Bass Stock Assessment Subcommittee (SAS) calculated an F threshold for each fleet and determined overfishing status for each fleet relative to its F threshold (see Section B9.2.1 and B9.3 in the main assessment report for more details).

The Panel recommended developing a single overfishing determination for the Chesapeake Bay stock by projecting the population forward under status quo F (i.e., maintaining F_{2017} for each fleet) and determining where the population stabilized relative to the SSB threshold and unfished SSB. If the population stabilized below the SSB threshold, then overfishing would be occurring; if the population stabilized at or above the SSB threshold, then overfishing would not be occurring. This approach would avoid having two overfishing status determinations for one stock, and provide a simpler metric than trying to calculate a single F value for the combined fleets, each of which operated on different components of the Chesapeake Bay stock of striped bass.

The results showed that both the Chesapeake Bay stock and the Delaware Bay/Hudson River stock were experiencing overfishing relative to the current threshold definitions (Table 1).

Table 1. Results of the projection-based approach to determine overfishing status for the striped bass 2SCA model.

Chesapeake Bay (Stock1)			
Reference point definition	Reference Point Value (Std. dev)	$SSB_{Status\ quo\ F}$ (Std. dev)	$p(SSB_{Status\ quo\ F} < SSB_{Ref})$
SSB 1995	52,893 (3,856)	38,882 (5,849)	0.97
SSB 1993	34,375 (2,747)	38,882 (5,849)	0.21

DE Bay/Hudson River (Stock 2)			
Reference point definition	Reference Point Value (Std. dev)	$SSB_{Status\ quo\ F}$ (Std. dev)	$p(SSB_{Status\ quo\ F} < SSB_{Ref})$
SSB 1995	24,683 (2,193)	14,779 (2182)	0.99
SSB 1993	19,637 (2,086)	14,779 (2182)	0.94

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