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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Northeast Fisheries Science Center Reference Documents

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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
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UK
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Dr. Robin Cook
Senior Research Fellow
MASTS Marine Population Modelling Group
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Glasgow, UK
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Dr. Yan Jiao
Professor
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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** **Gary Nelson, Mike Celestino**	**Alicia Miller**
10:30 – 10:45 AM	Break	
10:45 – 12:30 PM	Assessment Presentation (B. Striped bass) **Katie Drew** **Gary Nelson, Mike Celestino**	**Alicia Miller**
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**)**

<u>Thursday, Nov. 29</u>

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**

<u>Friday, Nov. 30</u>

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
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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
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Kiley Dancy	MAFMC	kdancy@mafmc.org
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Tony Wood	NEFSC	anthony.wood@noaa.gov
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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

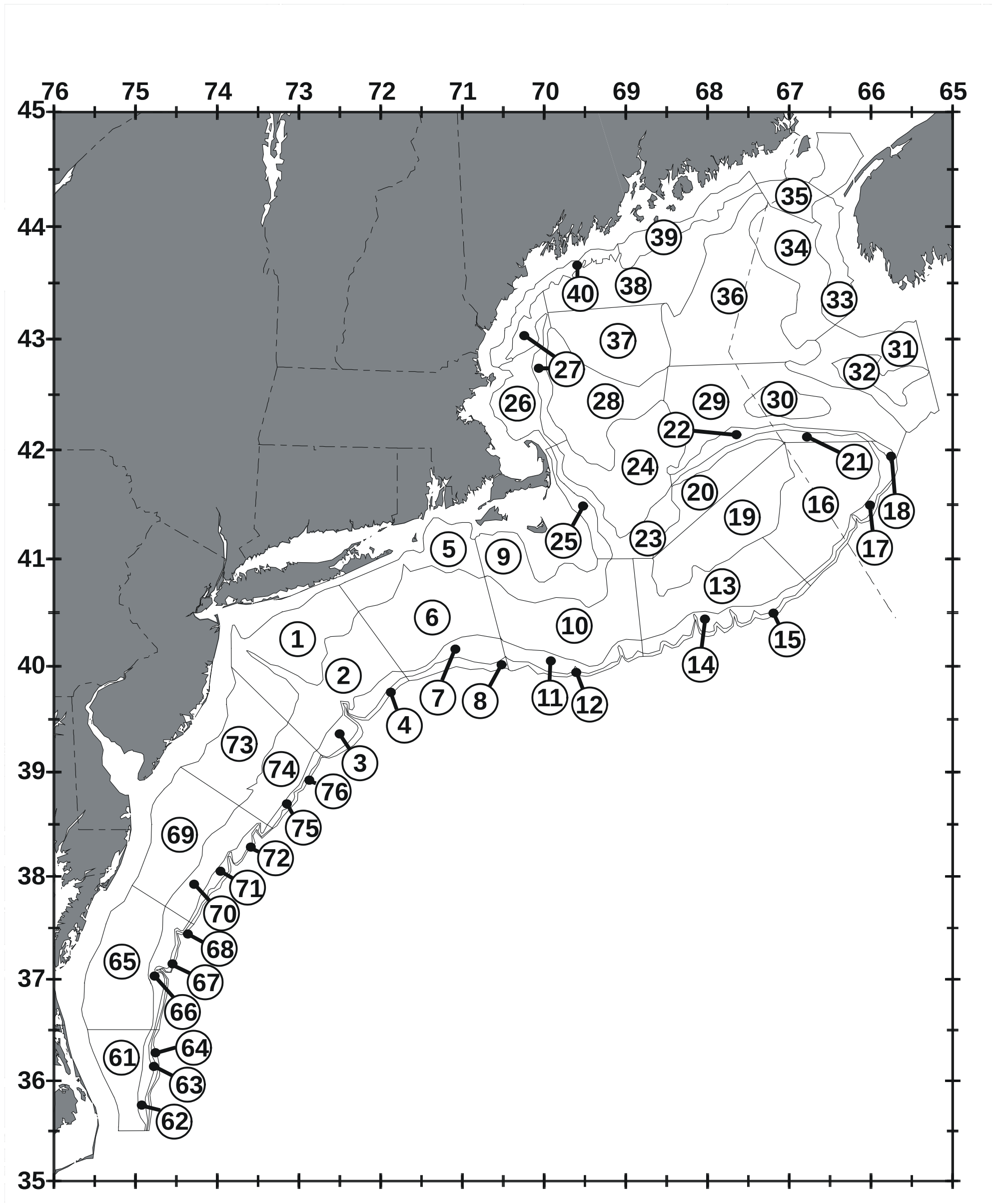

Figure 1. Offshore depth strata that have been sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.

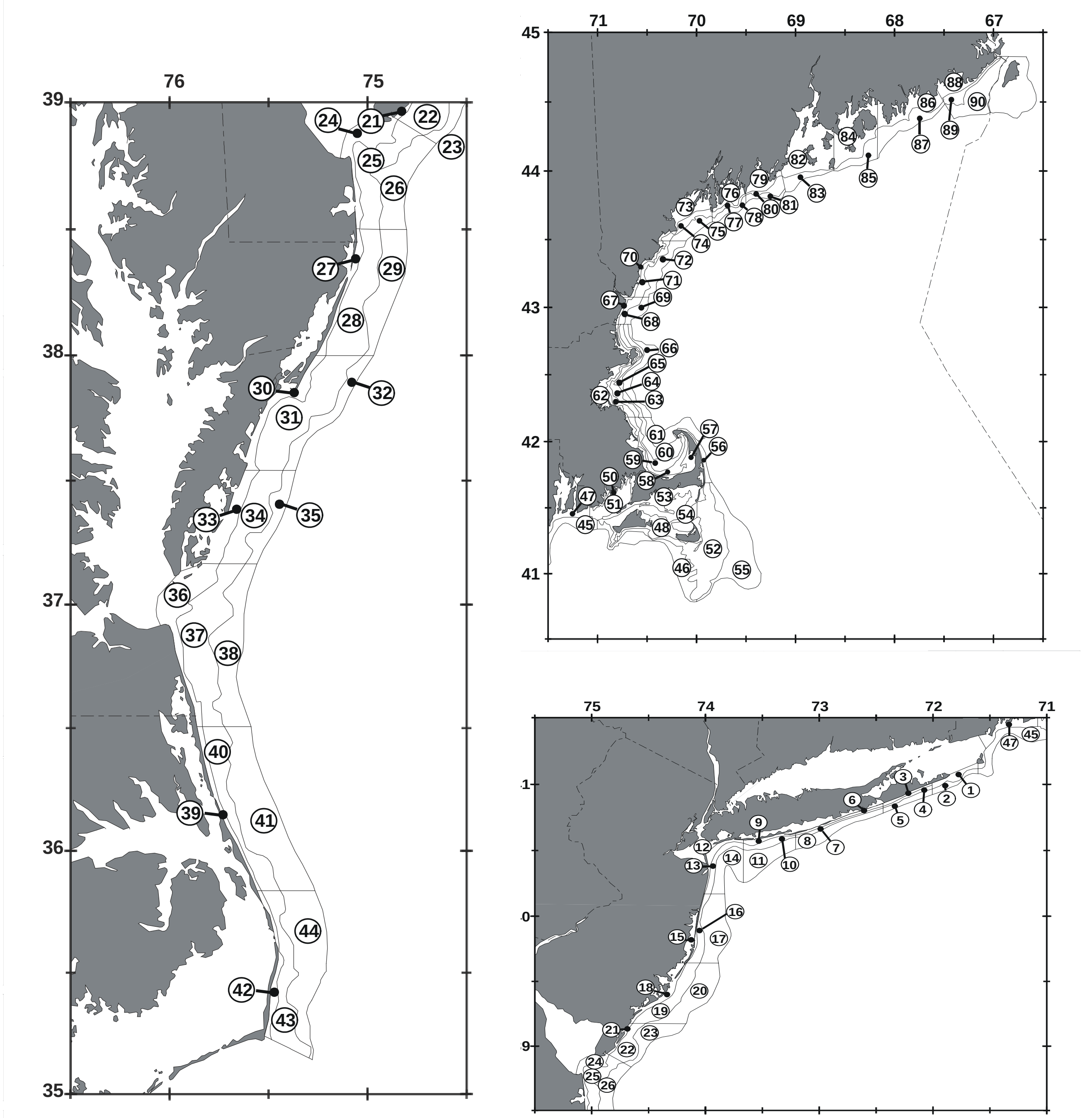

Figure 2. Inshore depth strata that have been sampled during Northeast Fisheries Science Center bottom trawl research surveys. Some of these may not be sampled presently.

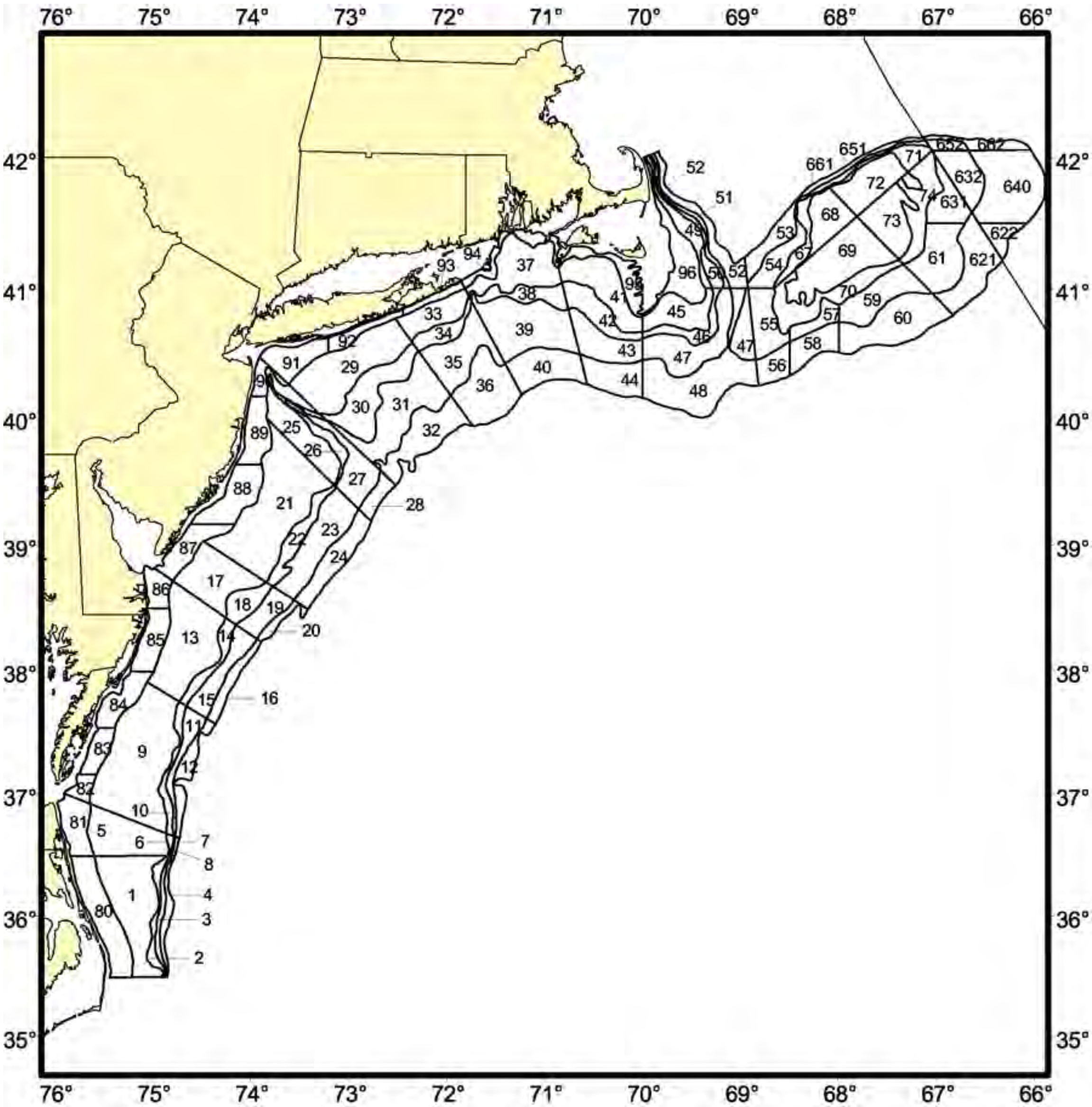

Figure 3. Depth strata sampled during Northeast Fisheries Science Center shellfish surveys.

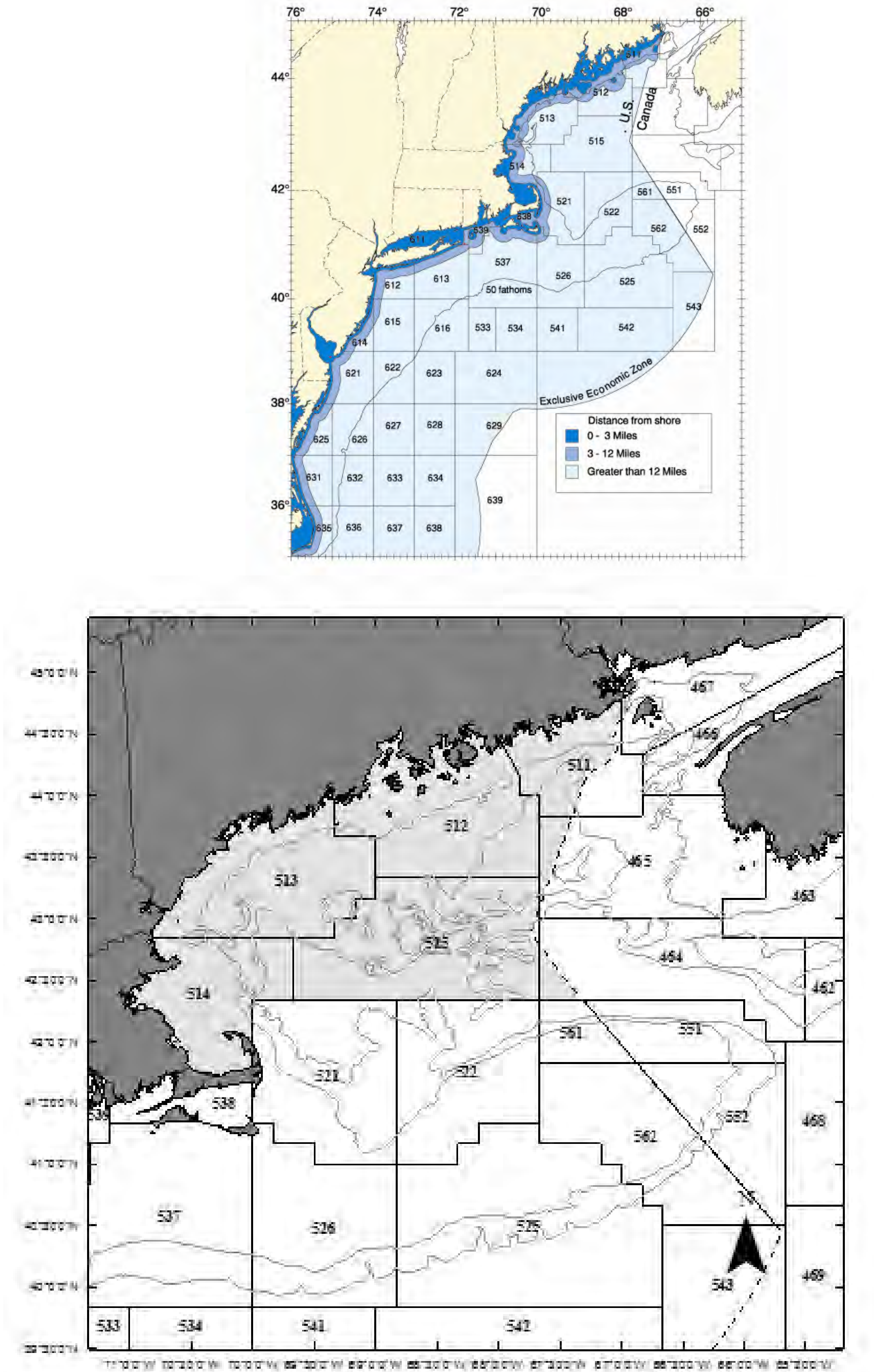

Figure 4. Statistical areas used for reporting commercial catches.

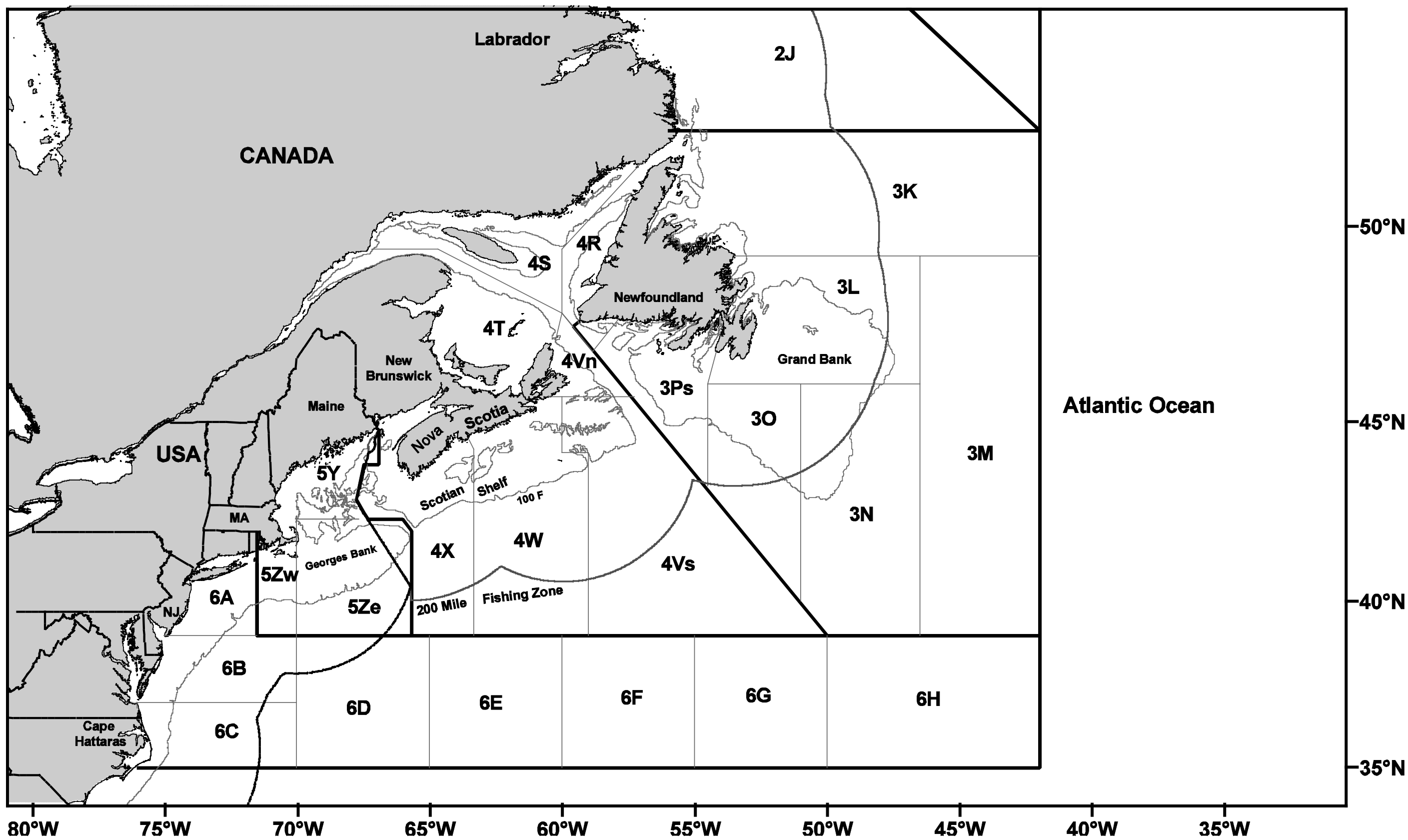

Figure 5. Catch reporting areas of the Northwest Atlantic Fisheries Organization (NAFO) for Subareas 3-6.

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.

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

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 (50th 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 (50th 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 (50th 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 (50th 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 (50th 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 (50th 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
1959	2.517	3.347	2.932
1960	1.579	1.583	1.581
1961	3.358	1.492	2.425
1962	1.917	1.063	1.490
1963	0.965	0.083	0.524
1964	1.171	0.246	0.708
1965	1.079	0.679	0.879
1966	1.833	0.567	1.200
1967	0.685	0.135	0.410
1968	0.321	0.042	0.181
1969	0.347	0.033	0.190
1970	0.243	0.071	0.157
1971	0.525	0.067	0.296
1972	0.269	0.000	0.135
1973	1.071	0.322	0.697
1974	3.503	0.581	2.042
1975	2.428	1.272	1.850
1976	8.917	2.674	5.795
1977	2.451	0.350	1.401
1978	1.196	0.528	0.862
1979	1.136	0.590	0.863
1980	0.967	0.100	0.533
1981	4.917	1.284	3.101
1982	2.160	0.835	1.497
1983	1.975	0.629	1.302
1984	0.736	0.451	0.594
1985	0.554	0.432	0.493
1986	1.197	0.889	1.043
1987	1.467	1.842	1.654
1988	1.133	0.713	0.923
1989	0.667	0.096	0.381
1990	0.224	0.078	0.151
1991	1.536	0.188	0.862
1992	0.519	0.228	0.374
1993	0.621	0.083	0.352
1994	0.329	0.163	0.246
1995	0.971	1.258	1.115
1996	1.971	1.713	1.842
1997	1.708	2.071	1.890
1998	2.308	2.258	2.283
1999	4.536	4.475	4.506

Year	Fox Is	Whale Rk	Average
2000	4.783	8.161	6.472
2001	4.413	5.367	4.890
2002	6.842	8.375	7.608
2003	5.751	7.786	6.769
2004	4.146	4.921	4.533
2005	2.775	3.958	3.367
2006	2.018	2.956	2.487
2007	5.007	4.422	4.715
2008	6.808	5.725	6.267
2009	6.644	10.771	8.708
2010	6.229	9.238	7.710
2011	8.211	17.889	10.793
2012	5.621	6.142	5.756
2013	3.150	4.208	3.679
2014	3.071	4.136	3.603
2015	4.255	4.882	4.569
2016	2.824	4.510	3.667
2017	10.019	5.712	7.865

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	2008_SAW47	2013_SAW57	2016 Update	2018 SAW-66	2018 SAW-66
Model	ASAP SCAA	ASAP SCAA	ASAP SCAA	ASAP SCAA	ASAP SCAA
				Recommended	Alternative
	M=0.25	M=0.25	M=0.25	M=0.25	M=0.25
	Full F = age 3+	Full F = age 4	Full F = age 4	Full F = age 4	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

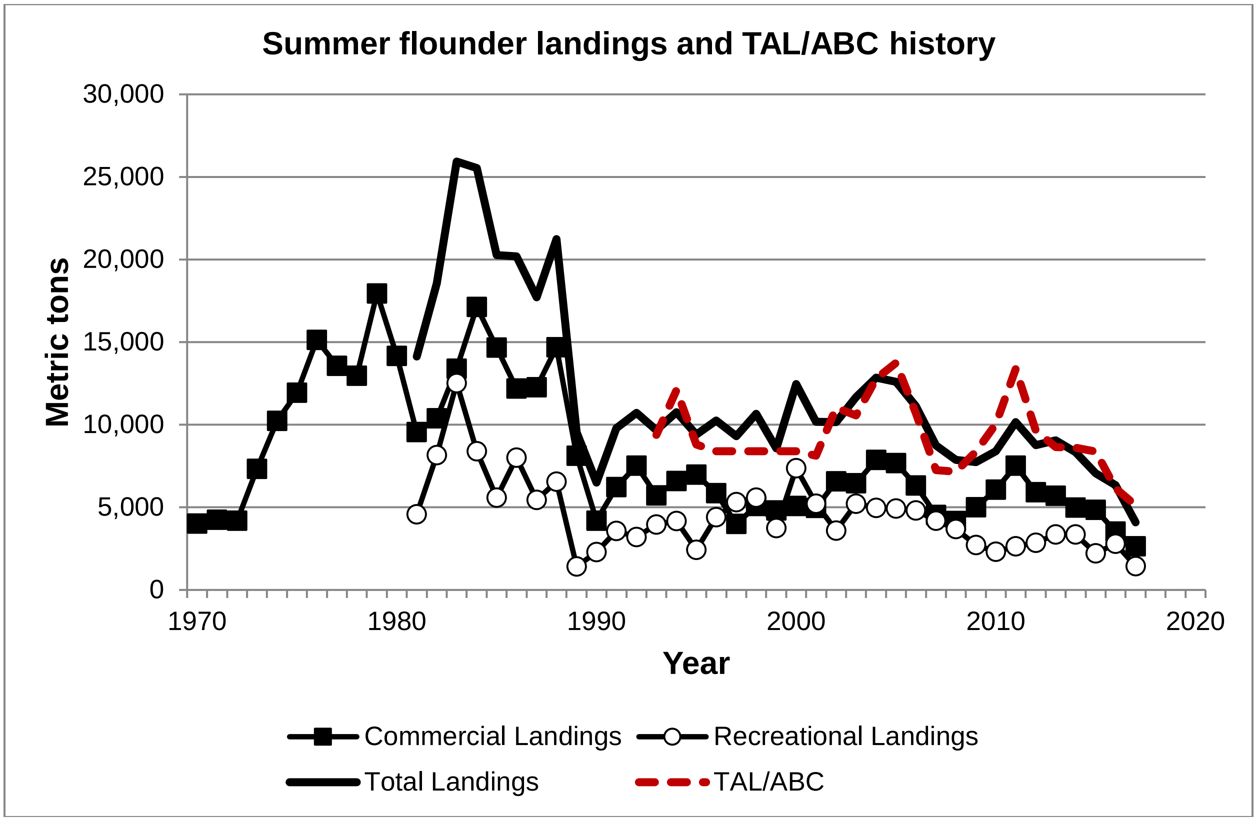


Figure A1. Summer flounder recent commercial (1970-2017), recreational (1981-2017), total fishery (1981-2017) landings history for summer flounder. TAL/ABC is the Total Allowable Landings / Acceptable Biological Catch under the management system established in 1993 that includes the commercial fishery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

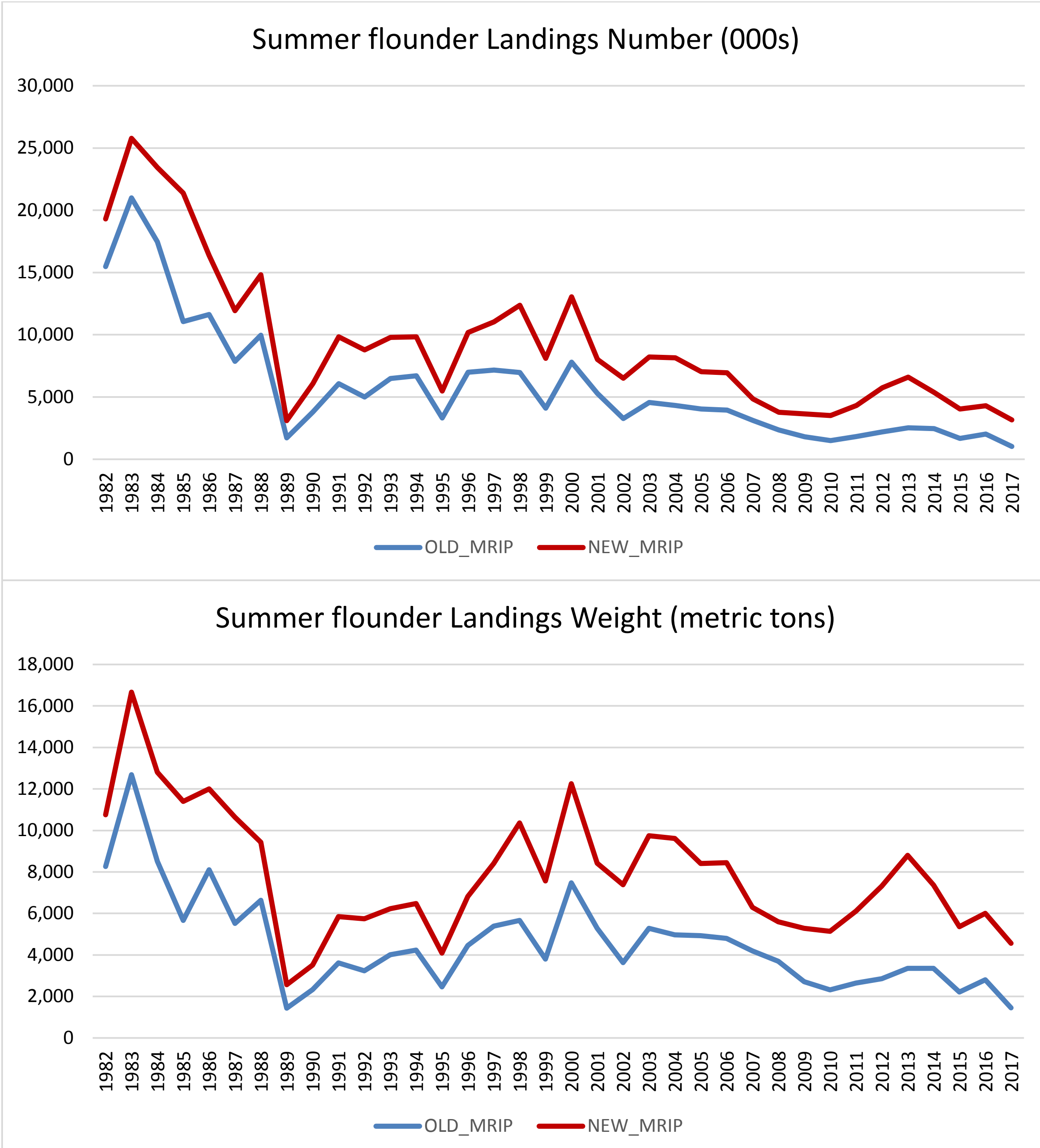


Figure A2. Comparison of summer flounder recreational fishery landings numbers (top; thousands of fish, 000s) and landings weight (metric tons) from the ‘Old’ and ‘New’ Marine Recreational Information Program (MRIP) estimates.

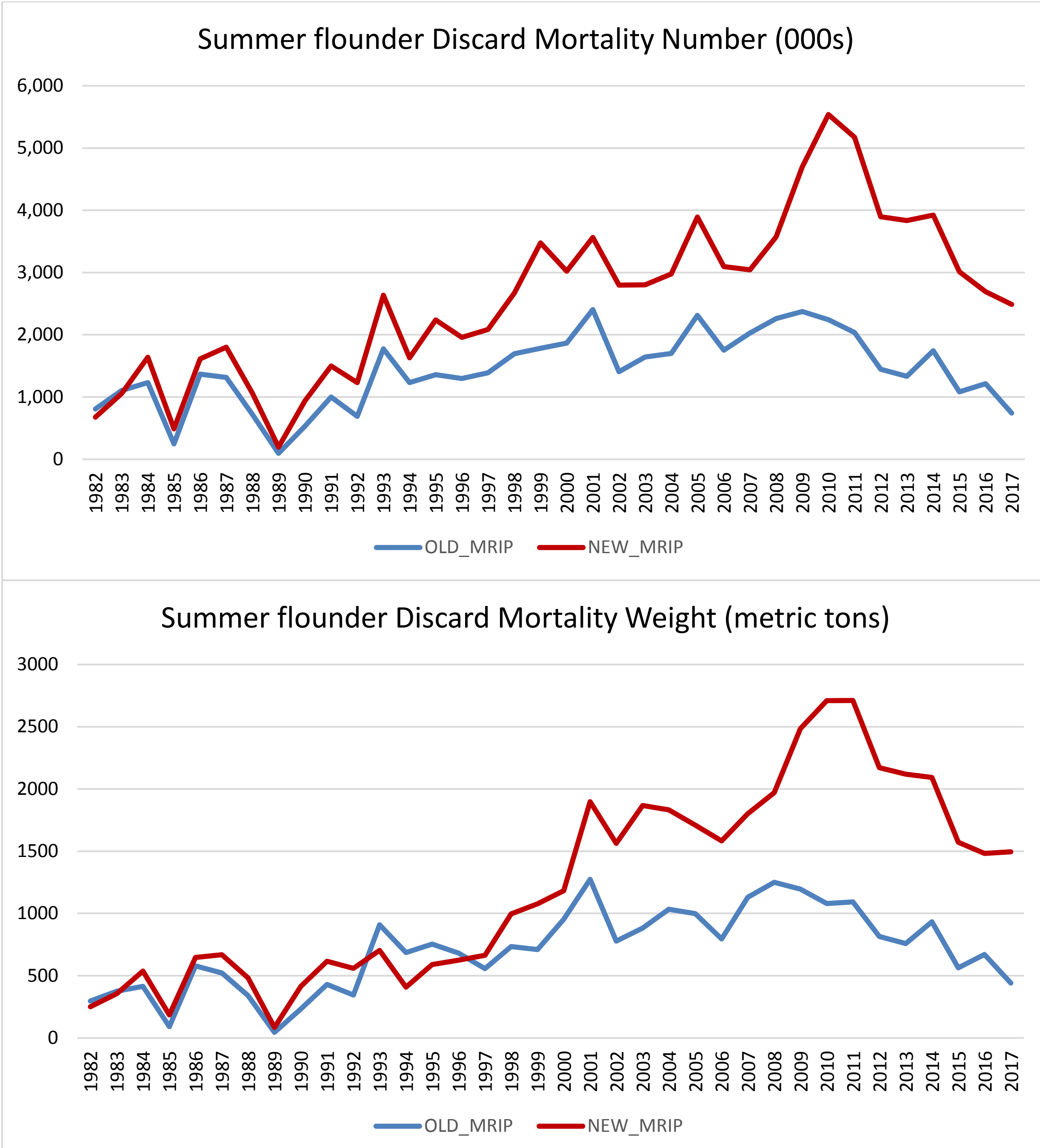


Figure A3. Comparison of summer flounder recreational fishery discards numbers (top; thousands of fish, 000s) and discards weight (metric tons) from the 'Old' and 'New' Marine Recreational Information Program (MRIP) estimates.

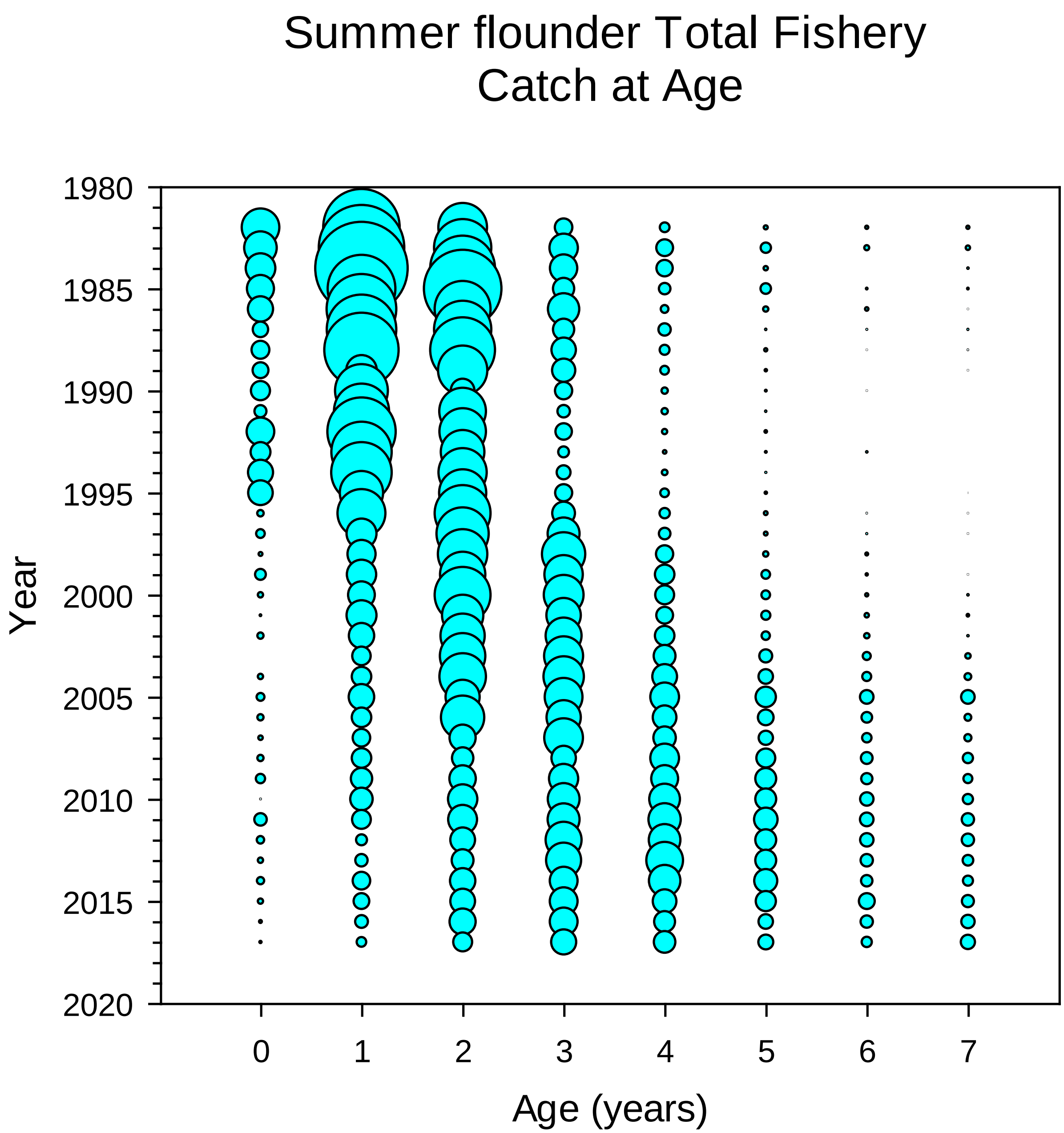


Figure A4. Total fishery catch at age for summer flounder – 'New' Marine Recreational Information Program (MRIP).

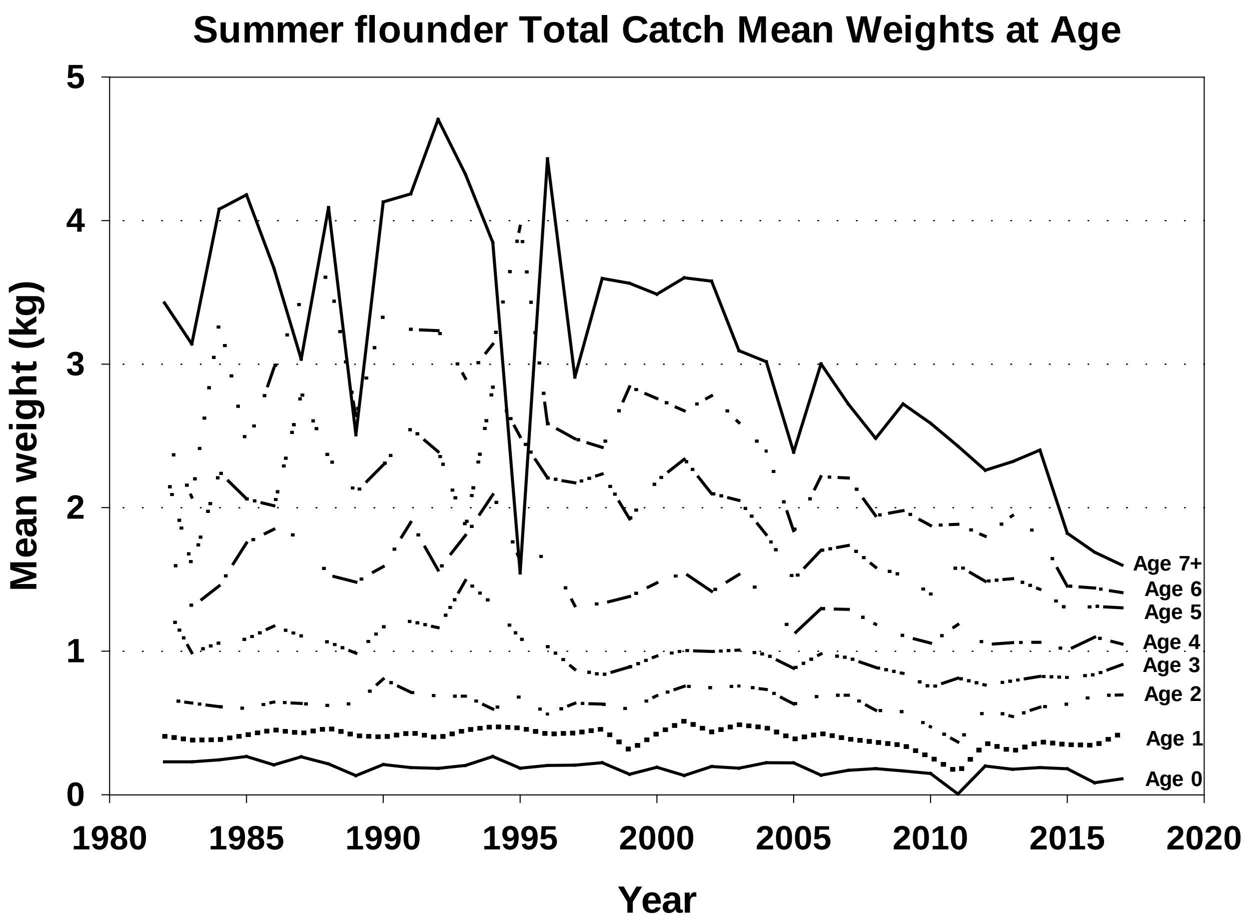


Figure A5. Mean weight at age in the total fishery catch of summer flounder –‘New’ Marine Recreational Information Program (MRIP).

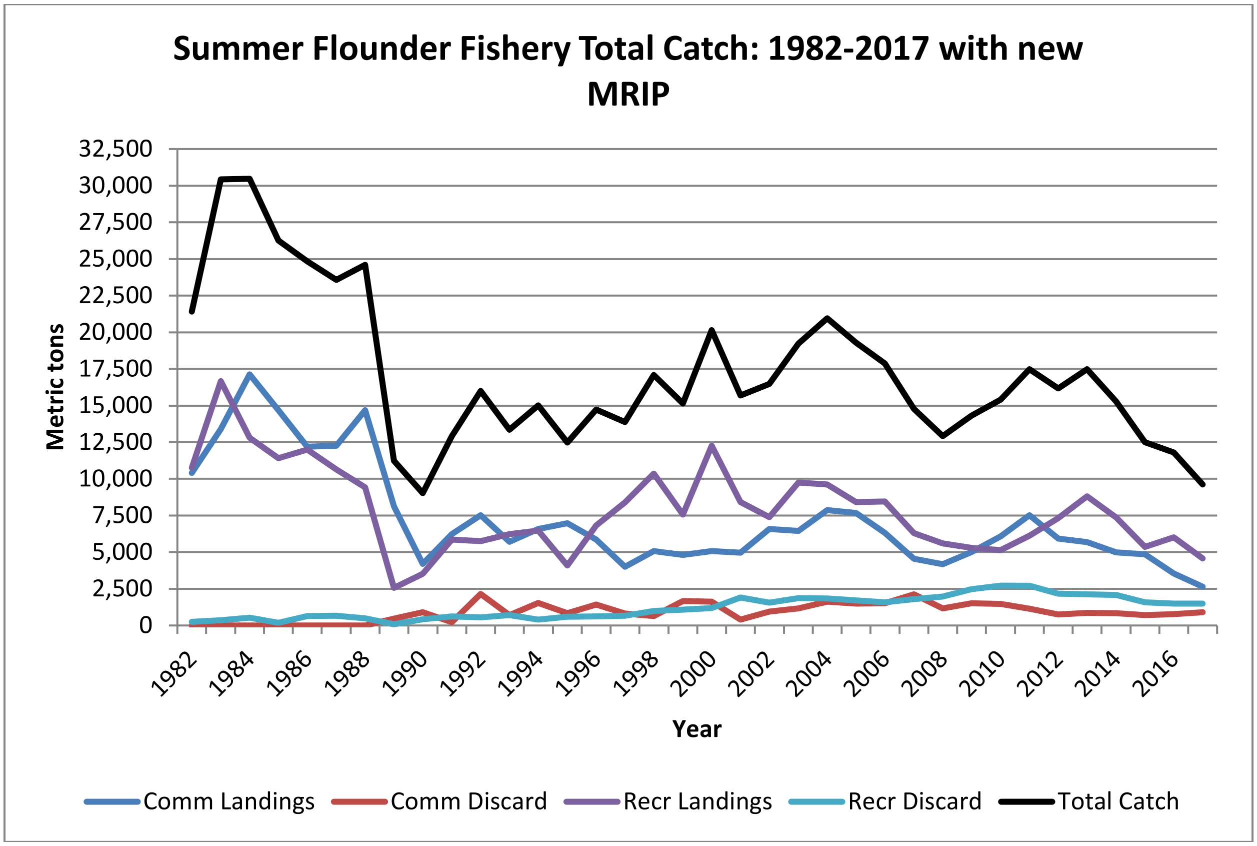


Figure A6. Summer flounder fishery total catch included in the assessment model. Components are commercial landings, commercial discards, recreational landings, and recreational discards from the 'New' Marine Recreational Information Program (MRIP) estimates.

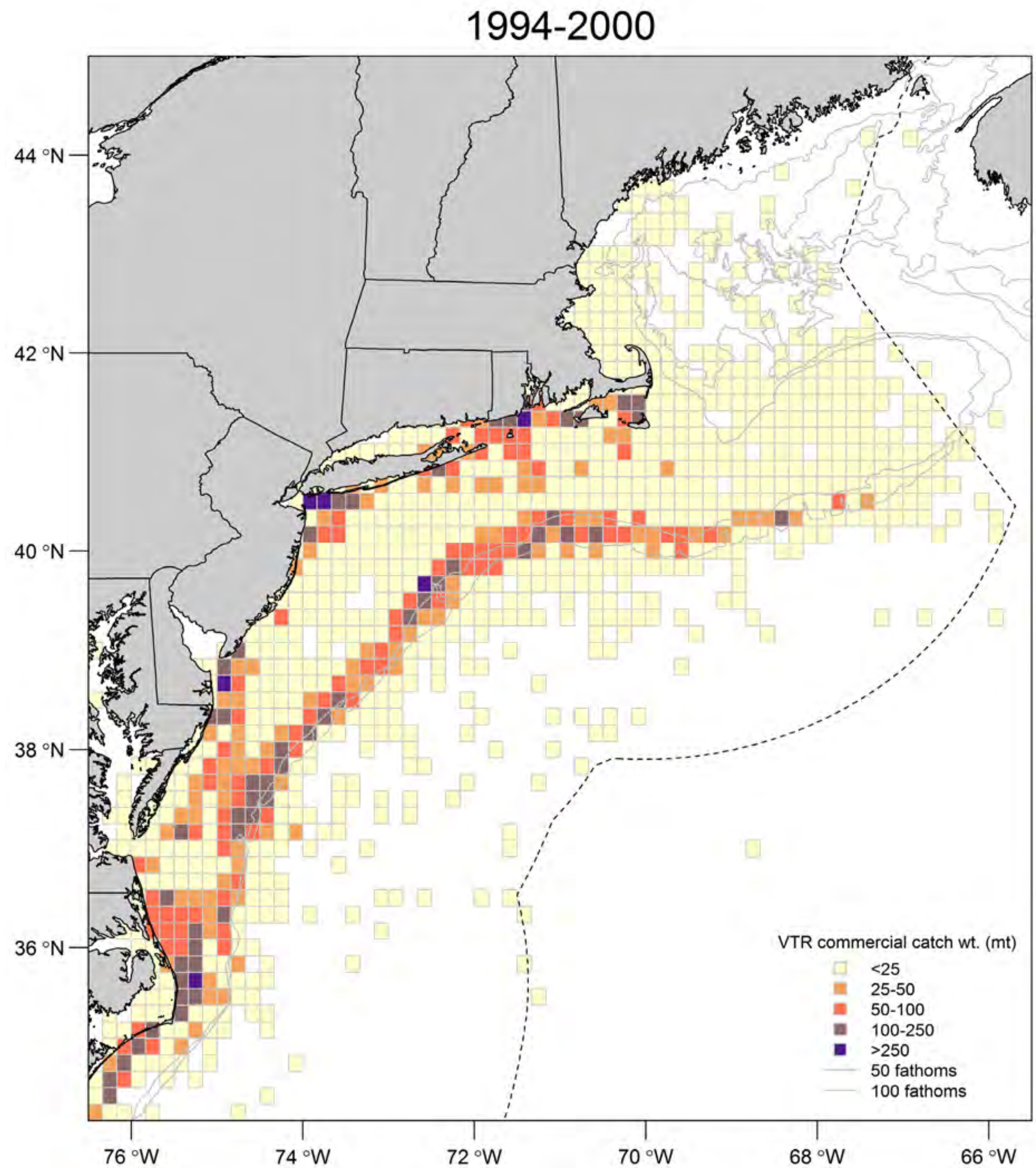


Figure A7. Spatial distribution of commercial Vessel Trip Report (VTR) reported catch weight (landings and discards) binned to ten minute squares from 1994-2000.

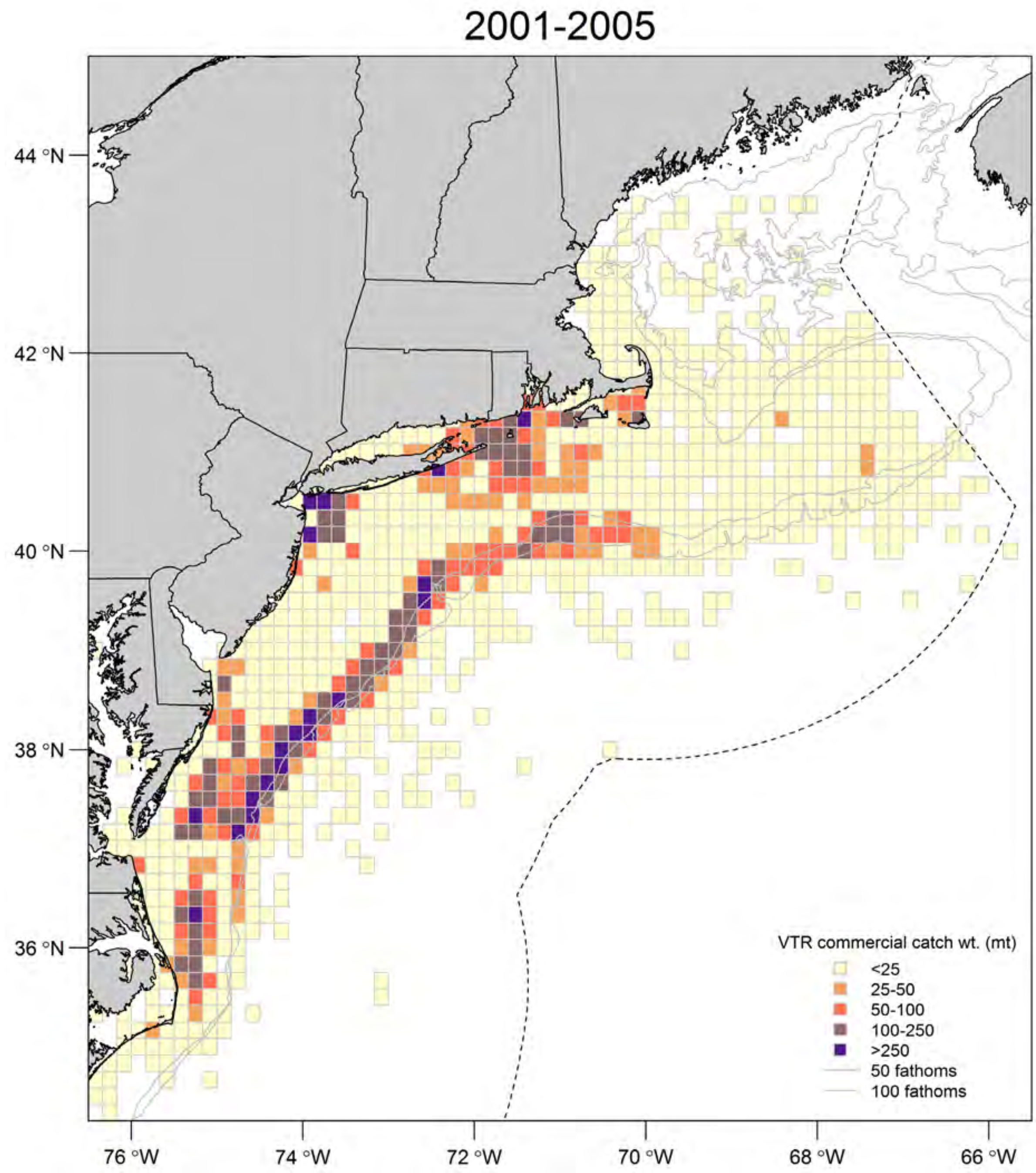


Figure A8. Spatial distribution of commercial Vessel Trip Report (VTR) reported catch weight (landings and discards) binned to ten minute squares from 2001-2005.

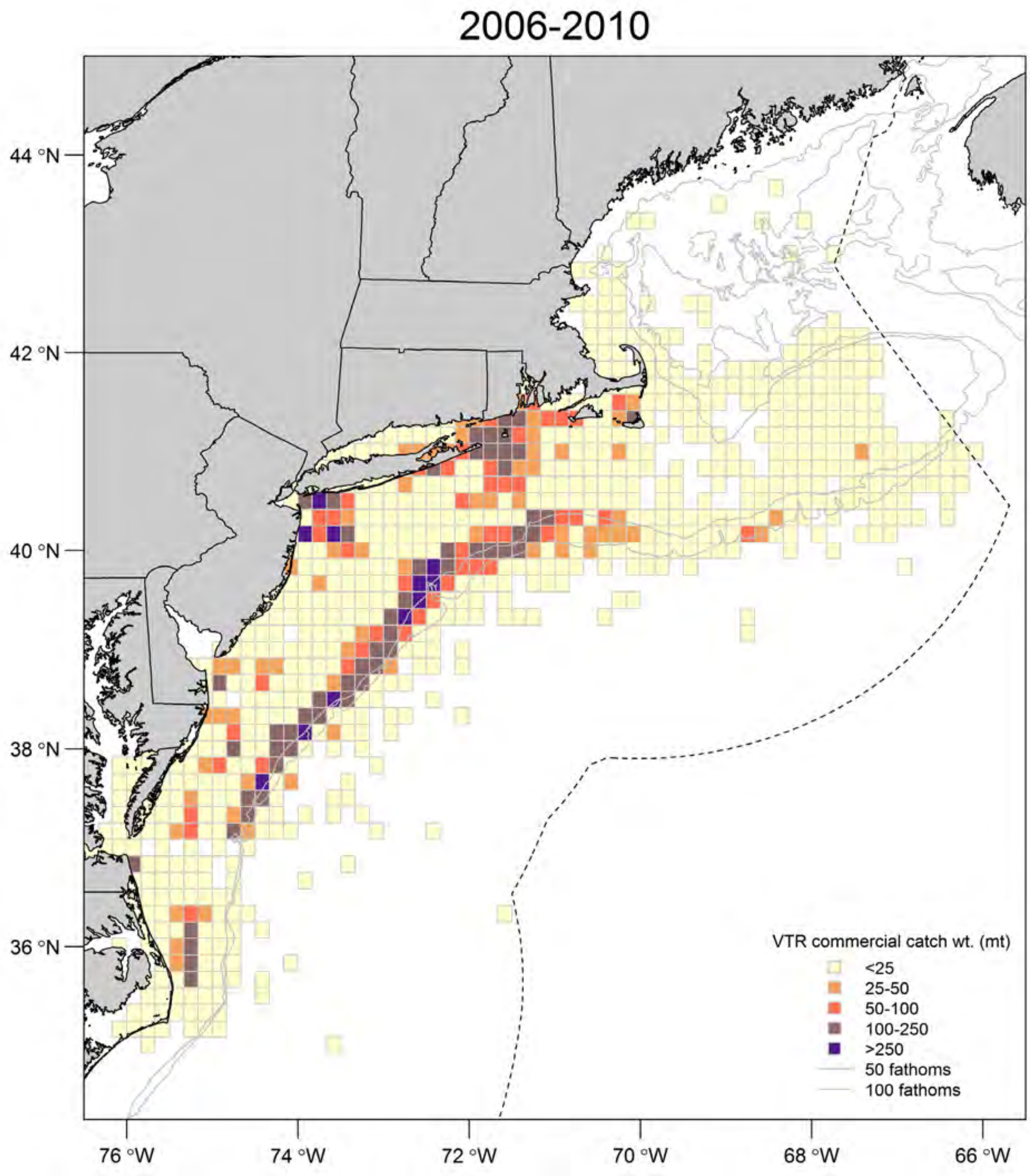


Figure A9. Spatial distribution of commercial Vessel Trip Report (VTR) reported catch weight (landings and discards) binned to ten minute squares from 2006-2010.

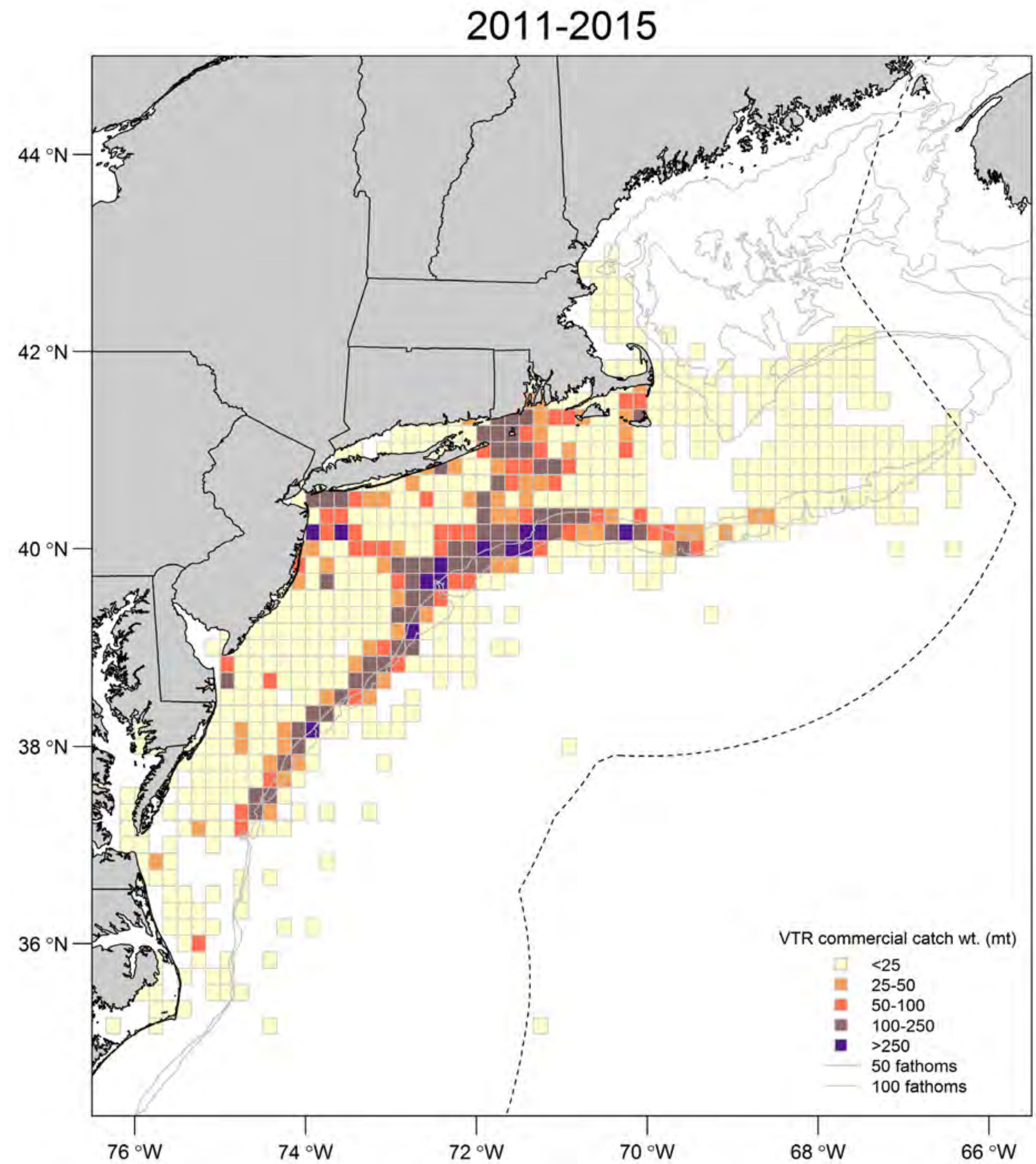


Figure A10. Spatial distribution of commercial Vessel Trip Report (VTR) reported catch weight (landings and discards) binned to ten minute squares from 2011-2015.

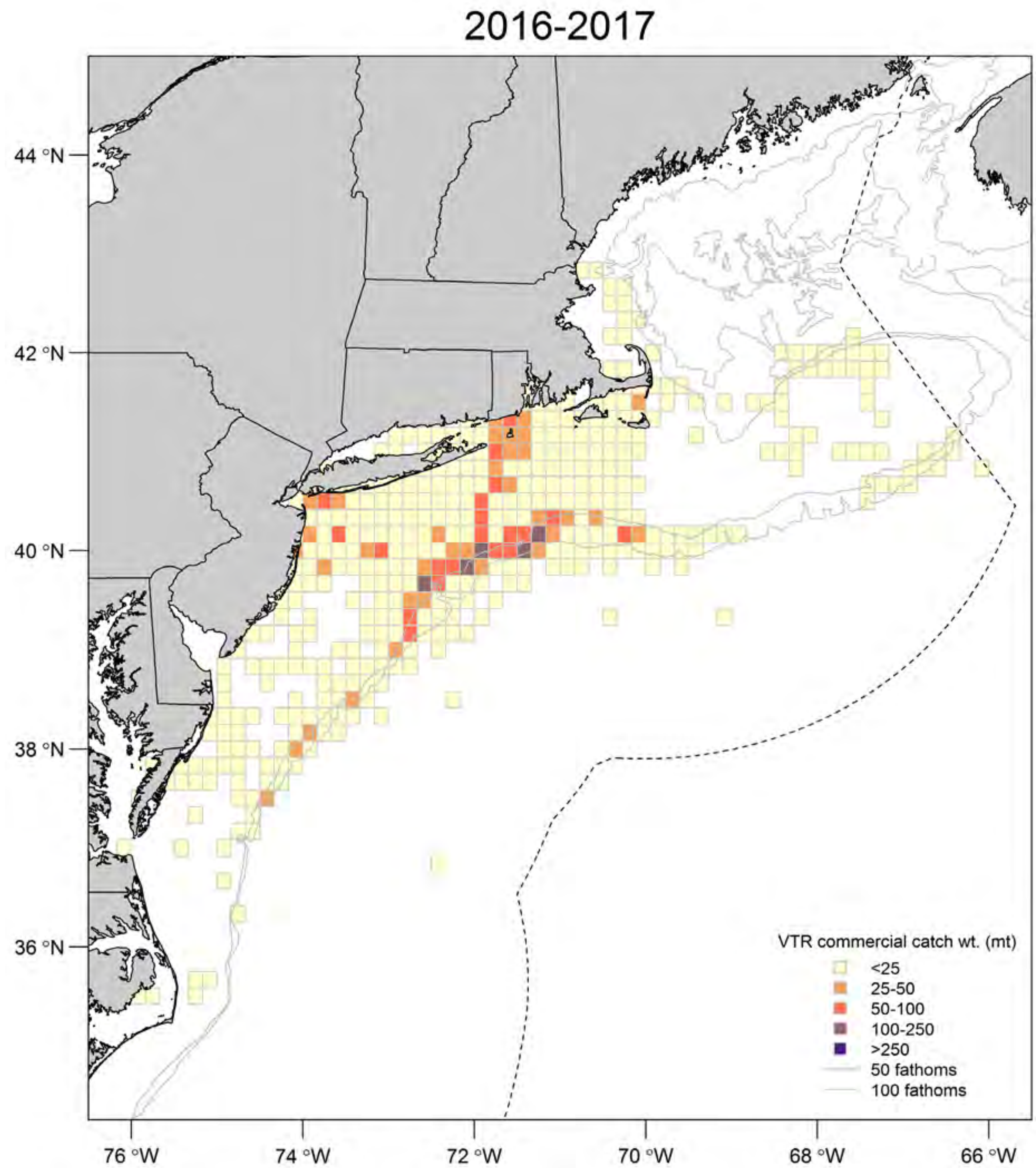


Figure A11. Spatial distribution of commercial Vessel Trip Report (VTR) reported catch weight (landings and discards) binned to ten minute squares from 2016-2017.

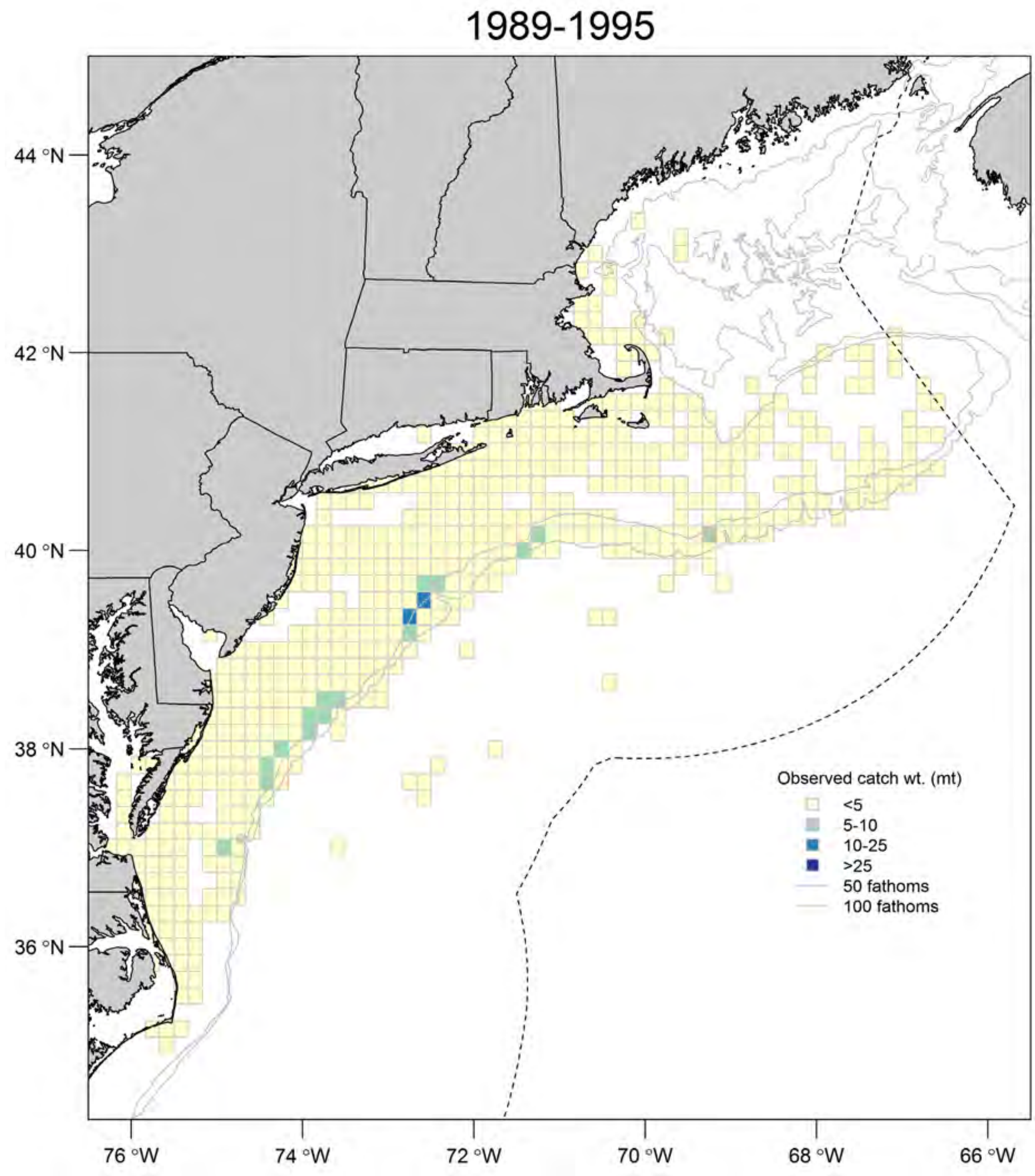


Figure A12. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 1989-1995.

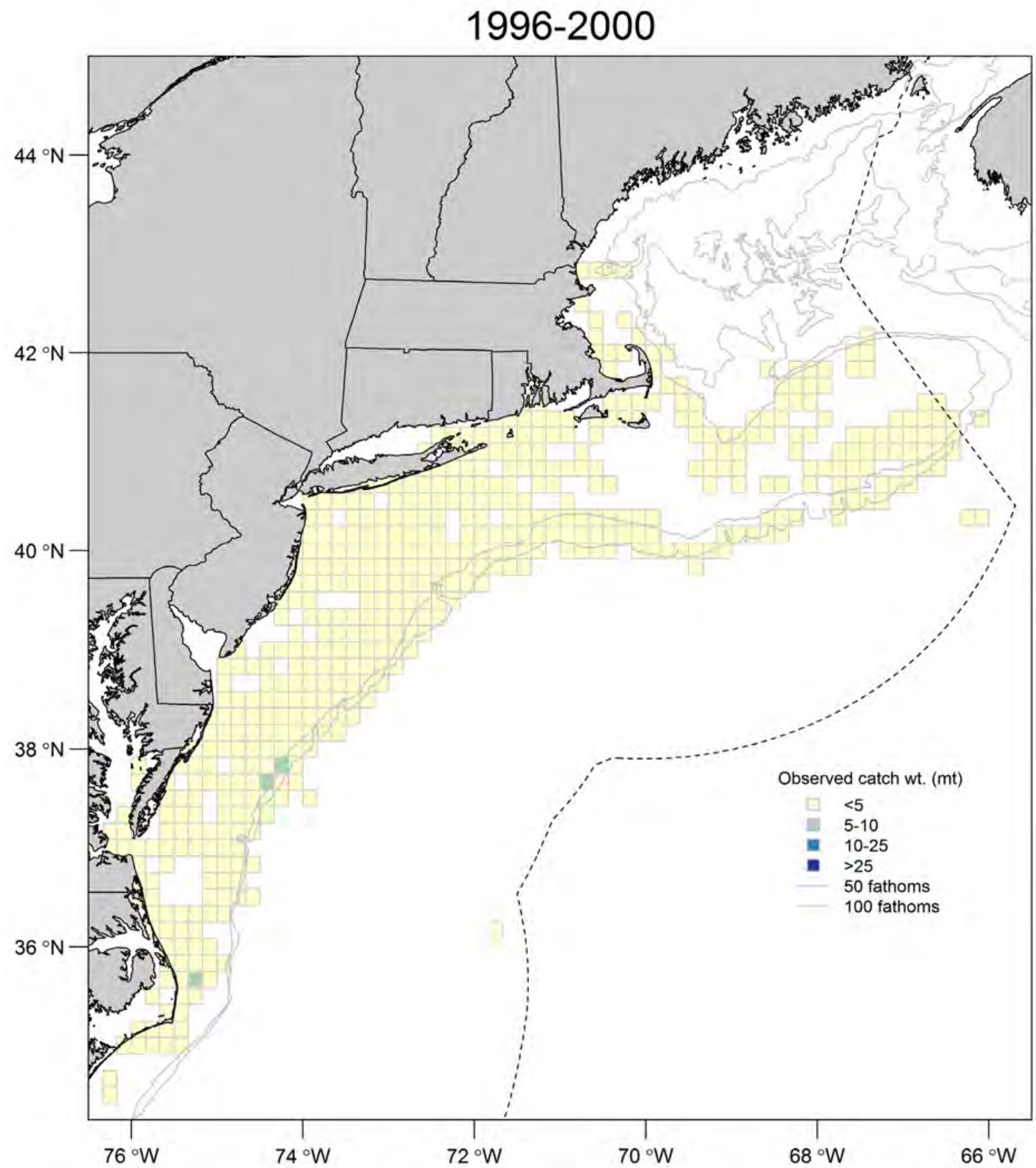


Figure A13. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 1996-2000.

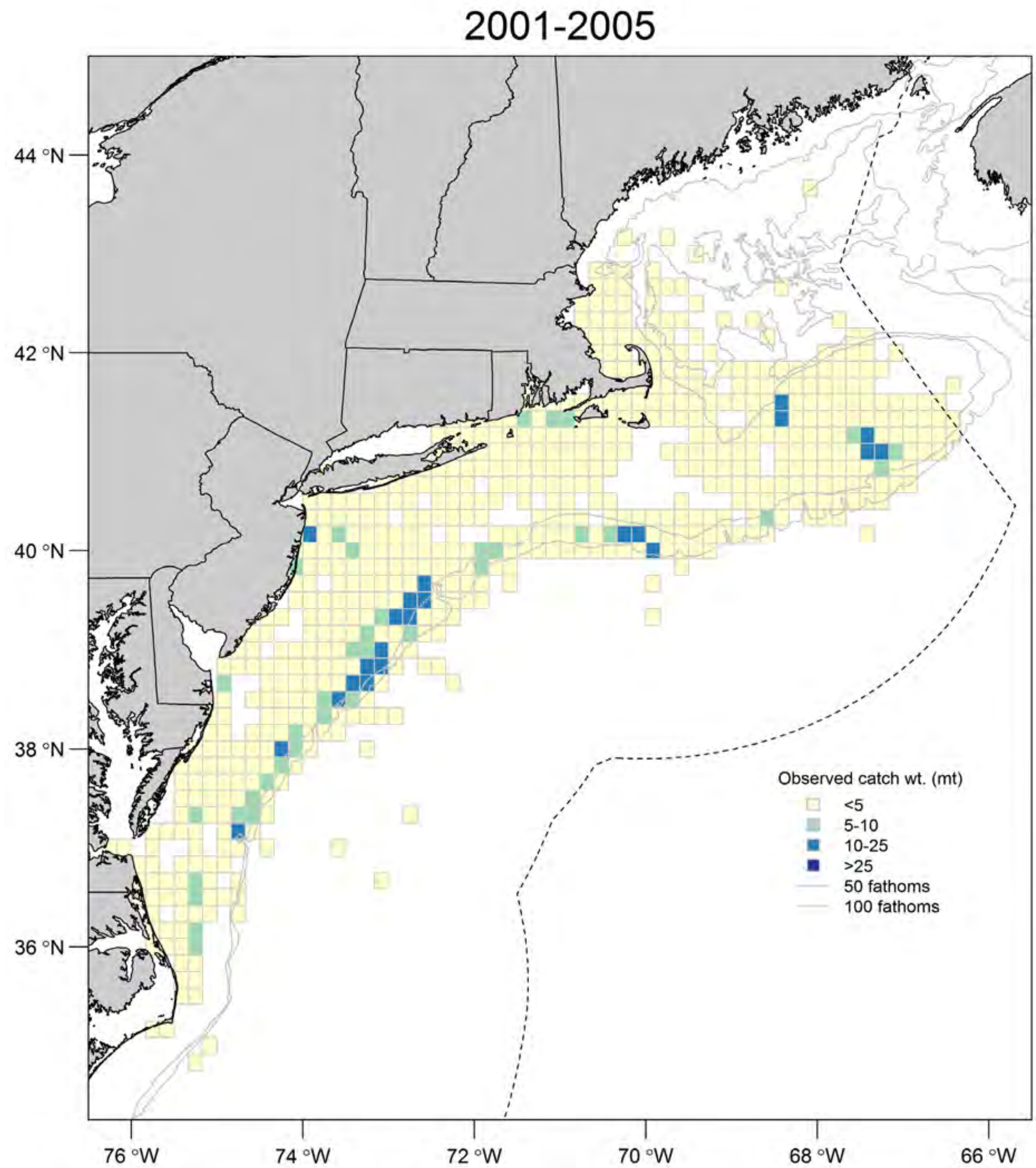


Figure A14. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 2001-2005.

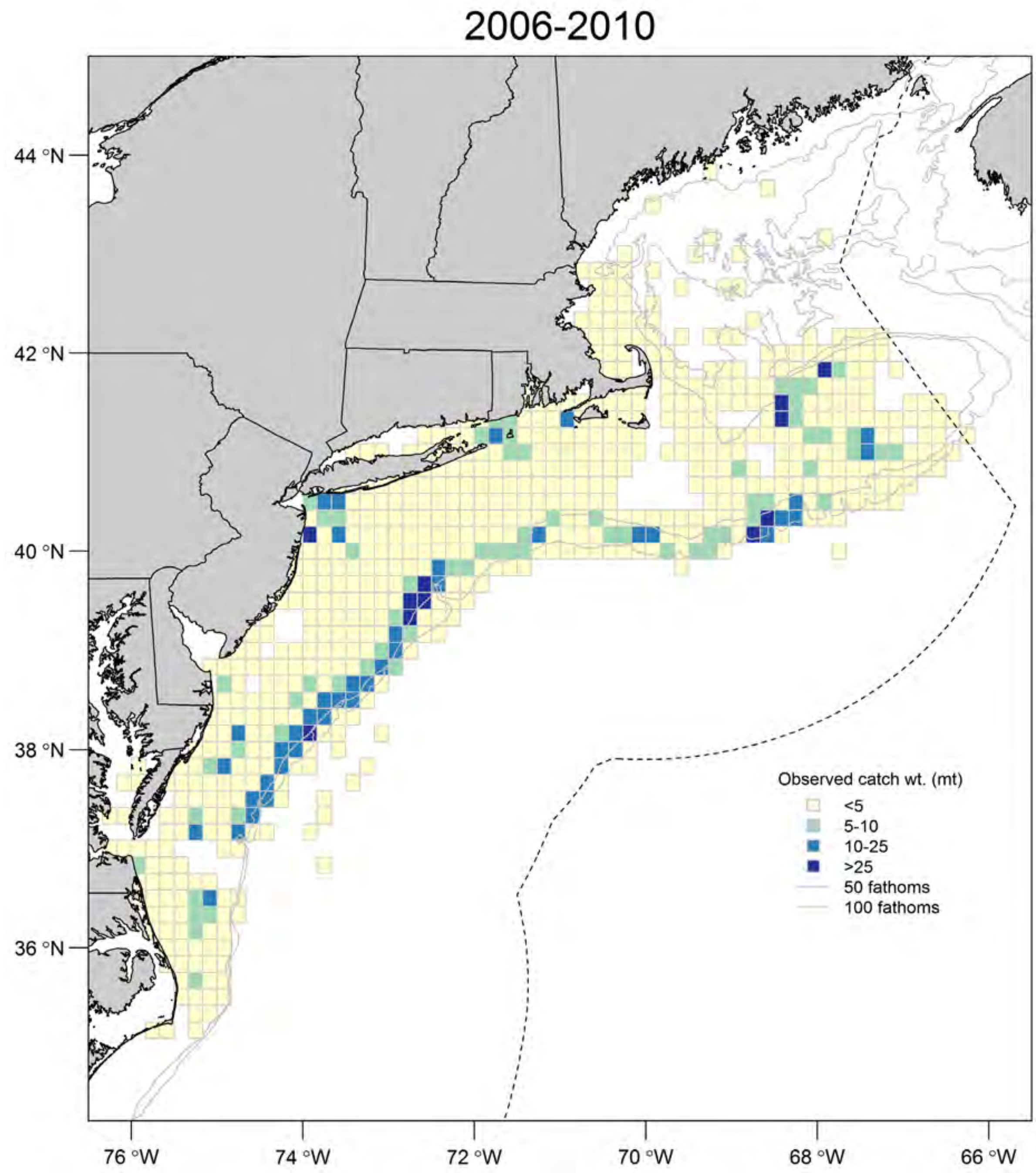


Figure A15. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 2006-2010.

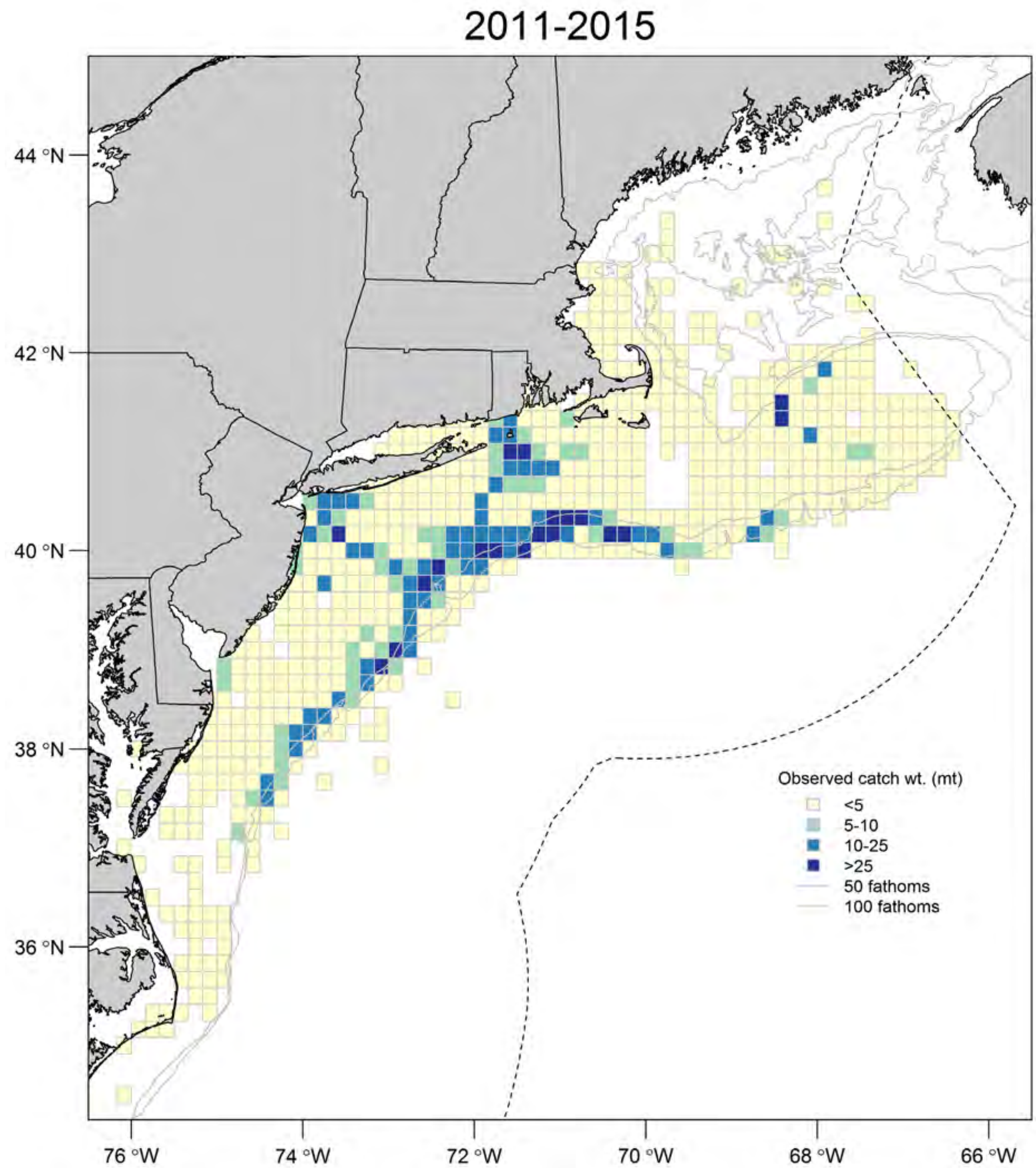


Figure A16. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 2011-2015.

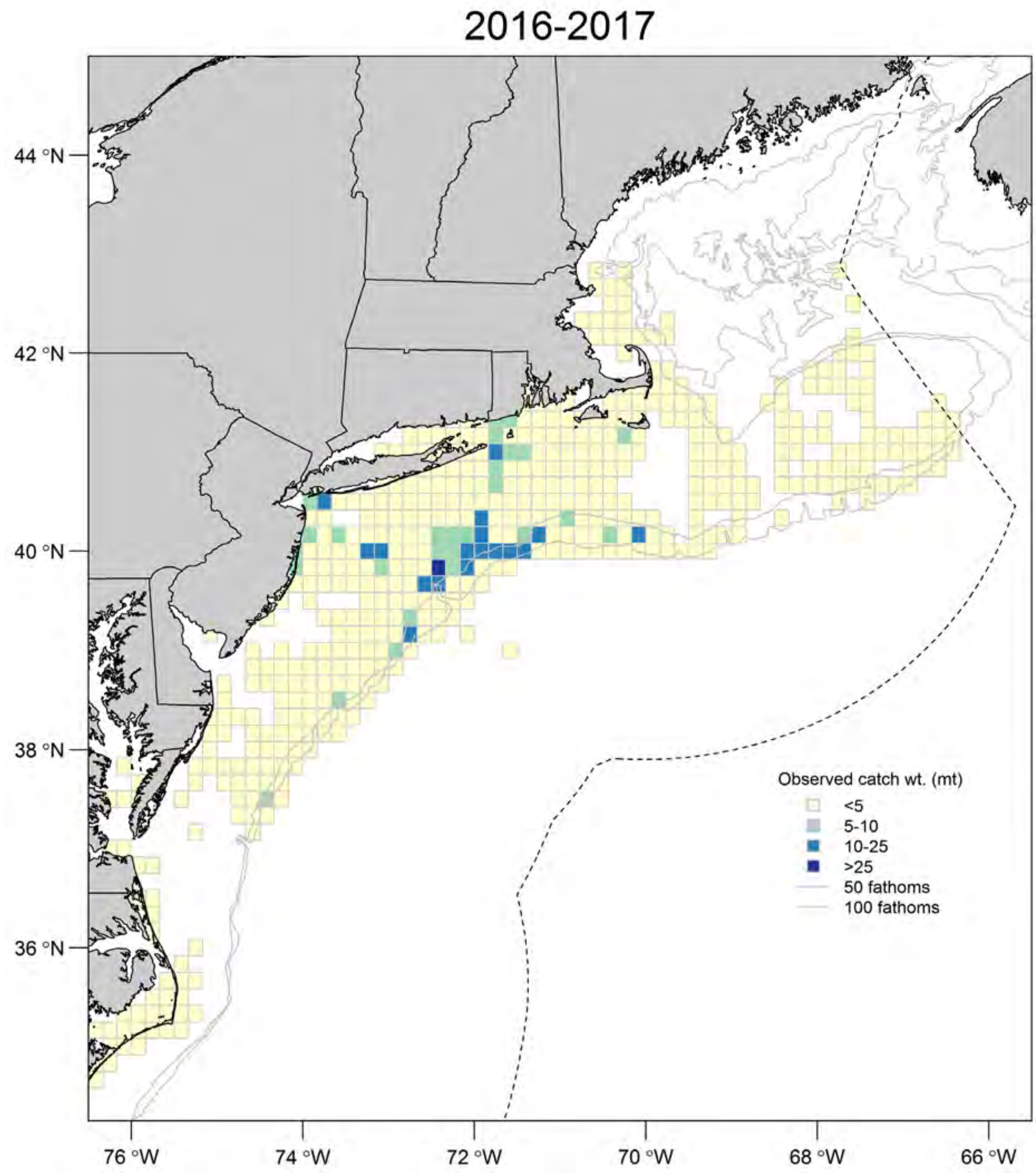


Figure A17. Spatial distribution of total observed catch weight (landings and discards) binned to ten minute squares from 2016-2017.

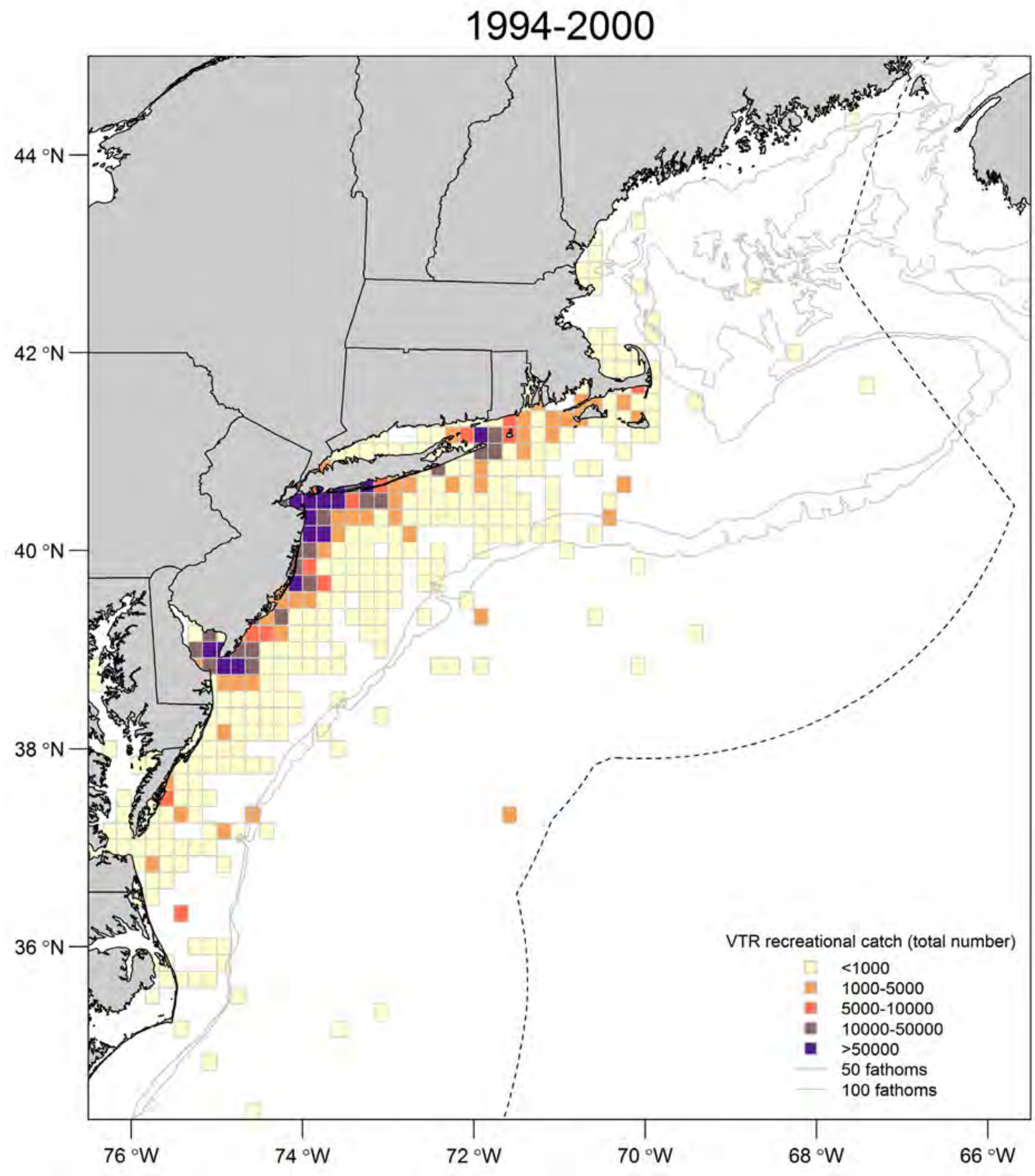


Figure A18. Spatial distribution of recreational (party and charter boat) Vessel Trip Report (VTR) reported catch (total number) binned to ten minute squares from 1994-2000.

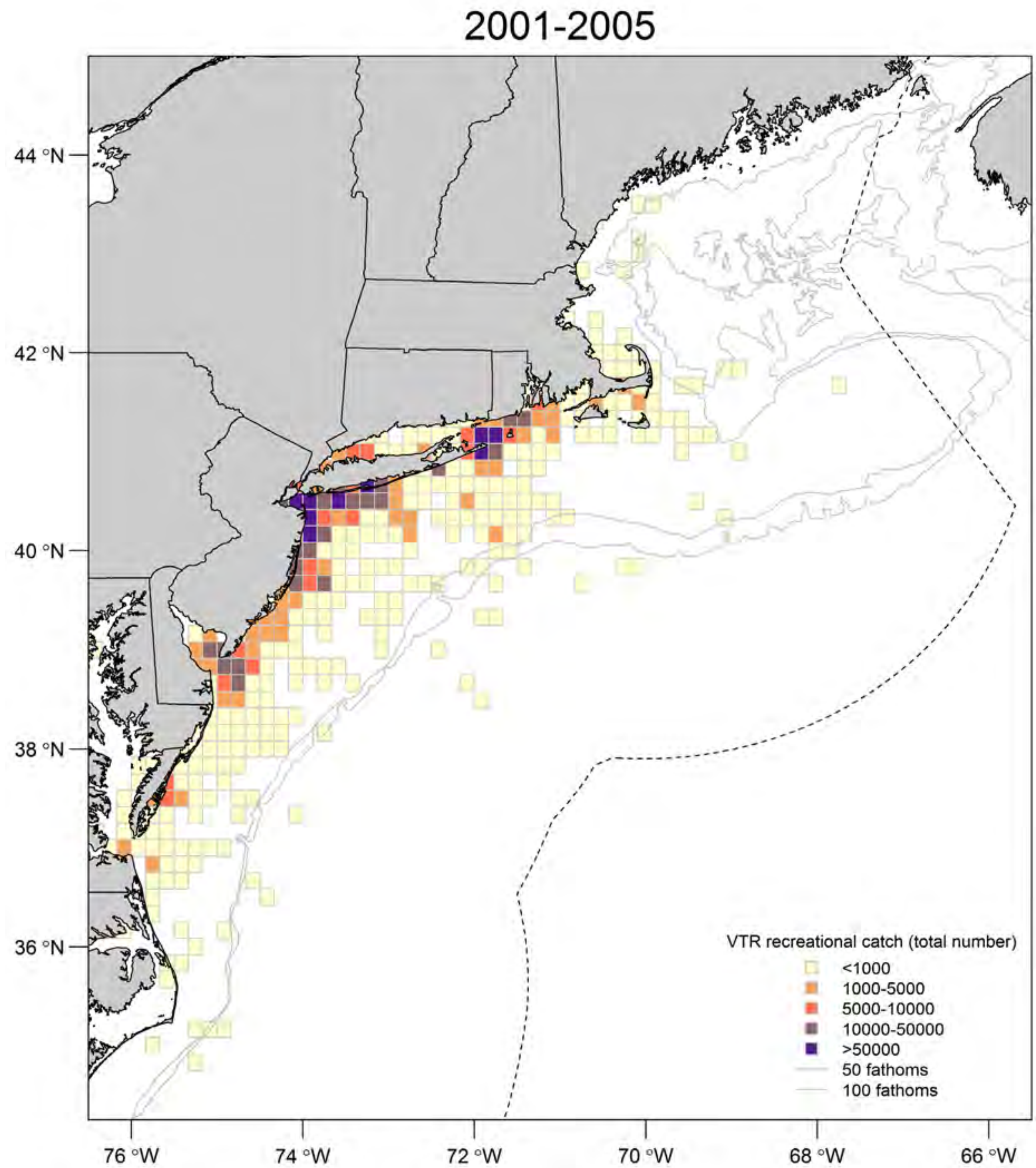


Figure A19. Spatial distribution of recreational (party and charter boat) Vessel Trip Report (VTR) reported catch (total number) binned to ten minute squares from 2001-2005.

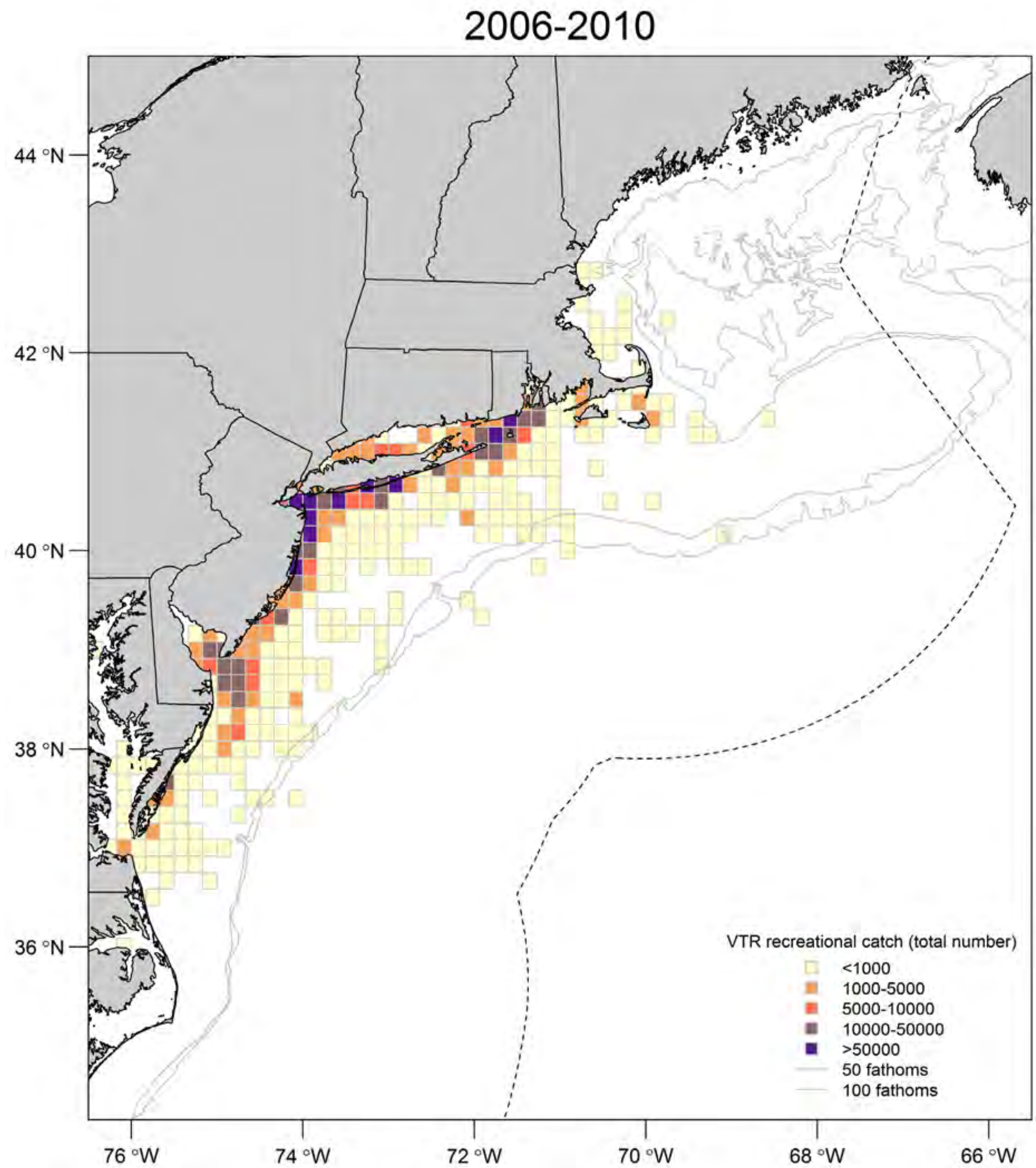


Figure A20. Spatial distribution of recreational (party and charter boat) Vessel Trip Report (VTR) reported catch (total number) binned to ten minute squares from 2006-2010.

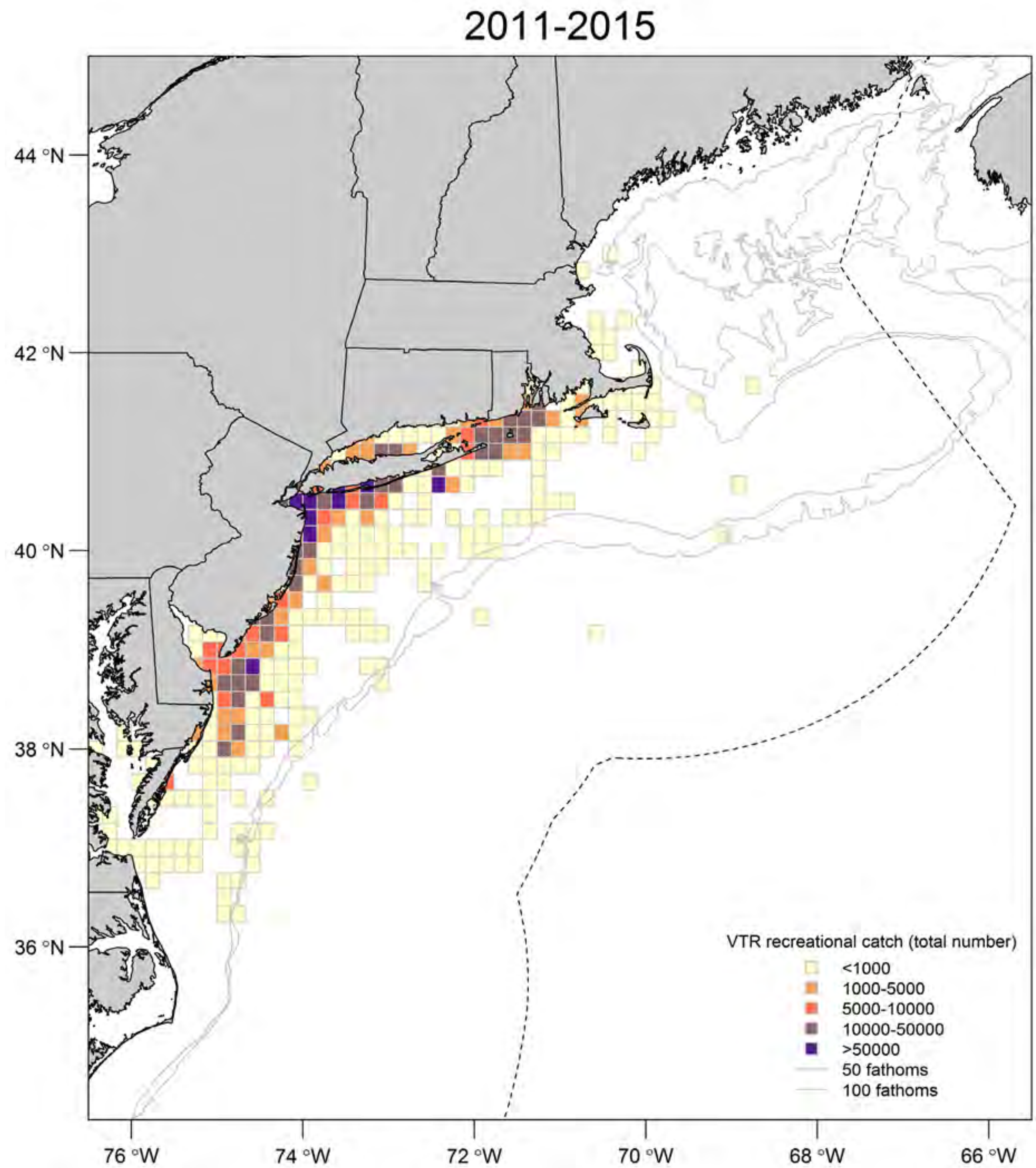


Figure A21. Spatial distribution of recreational (party and charter boat) Vessel Trip Report (VTR) reported catch (total number) binned to ten minute squares from 2011-2015.

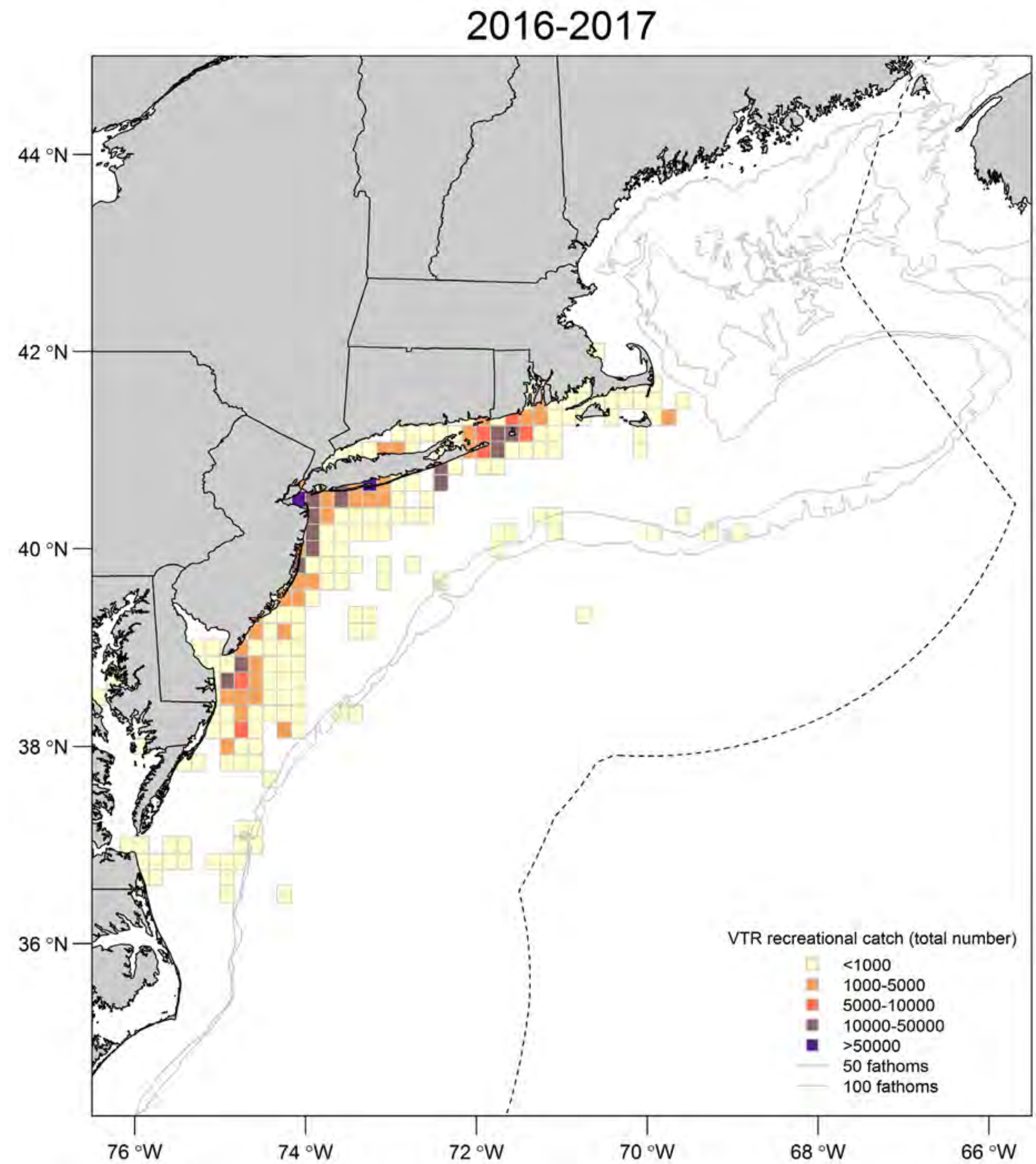


Figure A22. Spatial distribution of recreational (party and charter boat) Vessel Trip Report (VTR) reported catch (total number) binned to ten minute squares from 2016-2017.

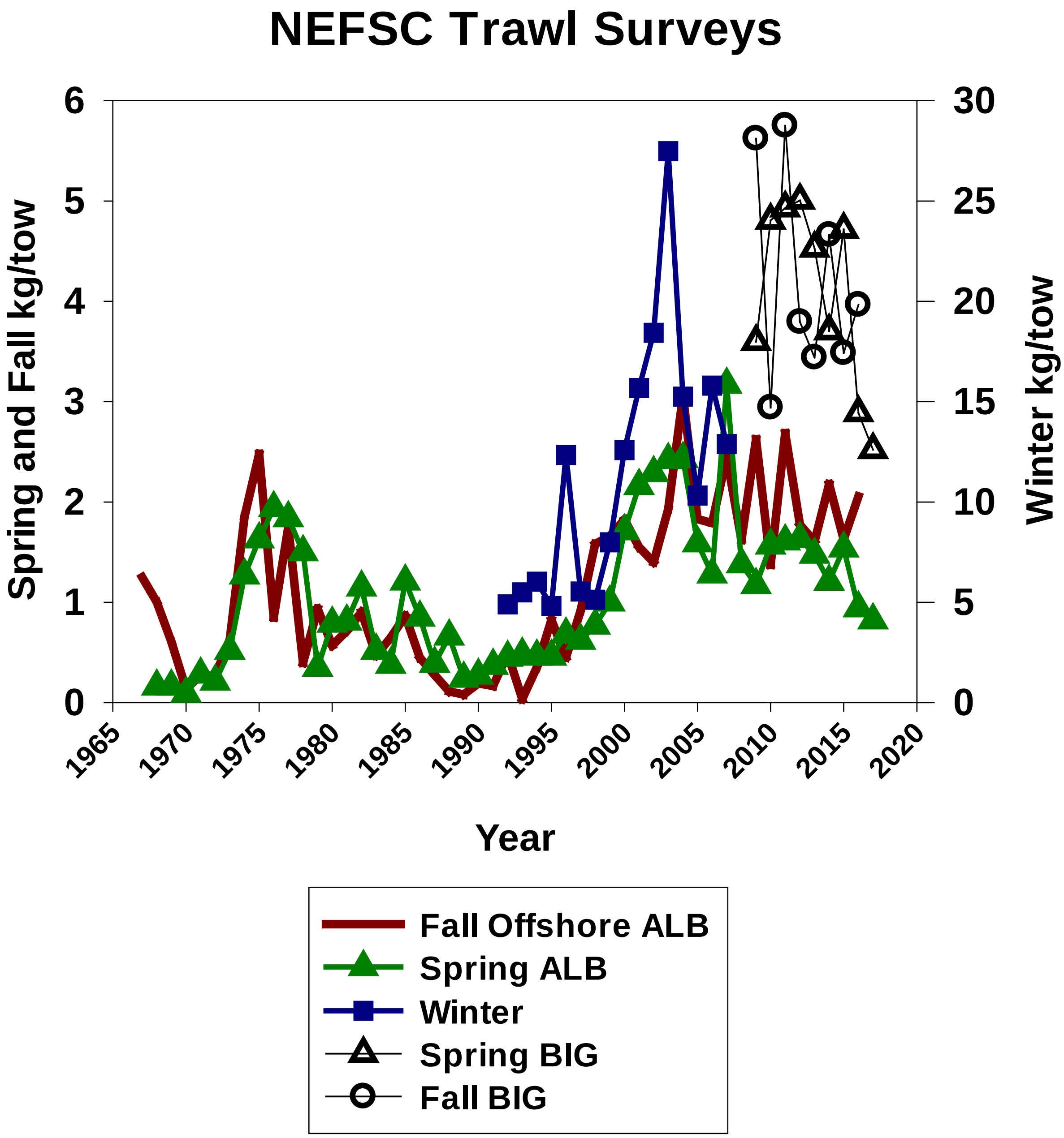


Figure A23. Trends in Northeast Fisheries Science Center (NEFSC) trawl survey biomass indices for summer flounder. Surveys conducted aboard the FSV *Albatross IV* (ALB) and the FSV *Henry B. Bigelow* (BIG).

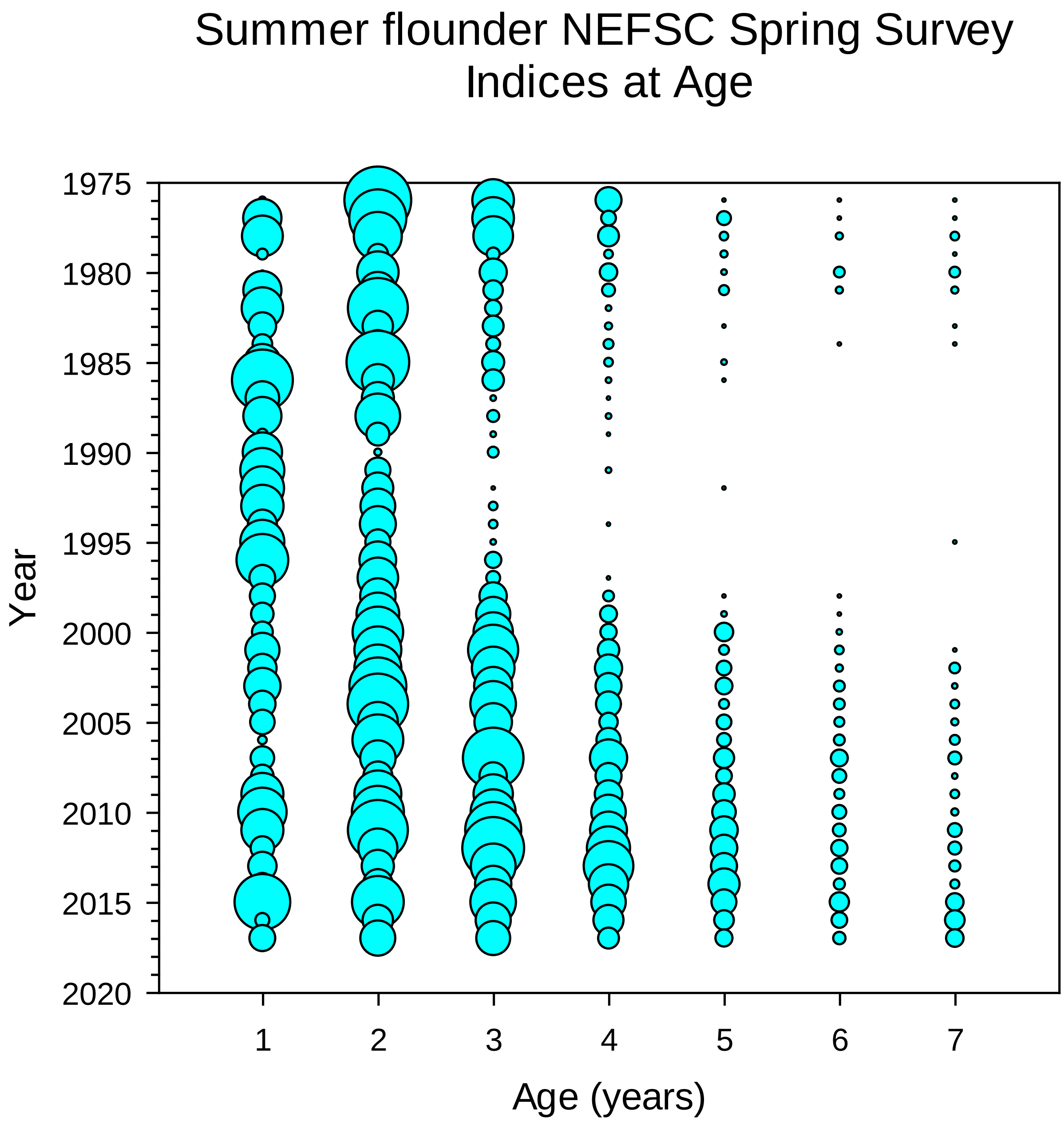


Figure A24. Relative age composition of summer flounder caught in the Northeast Fisheries Science Center (NEFSC) spring trawl survey.

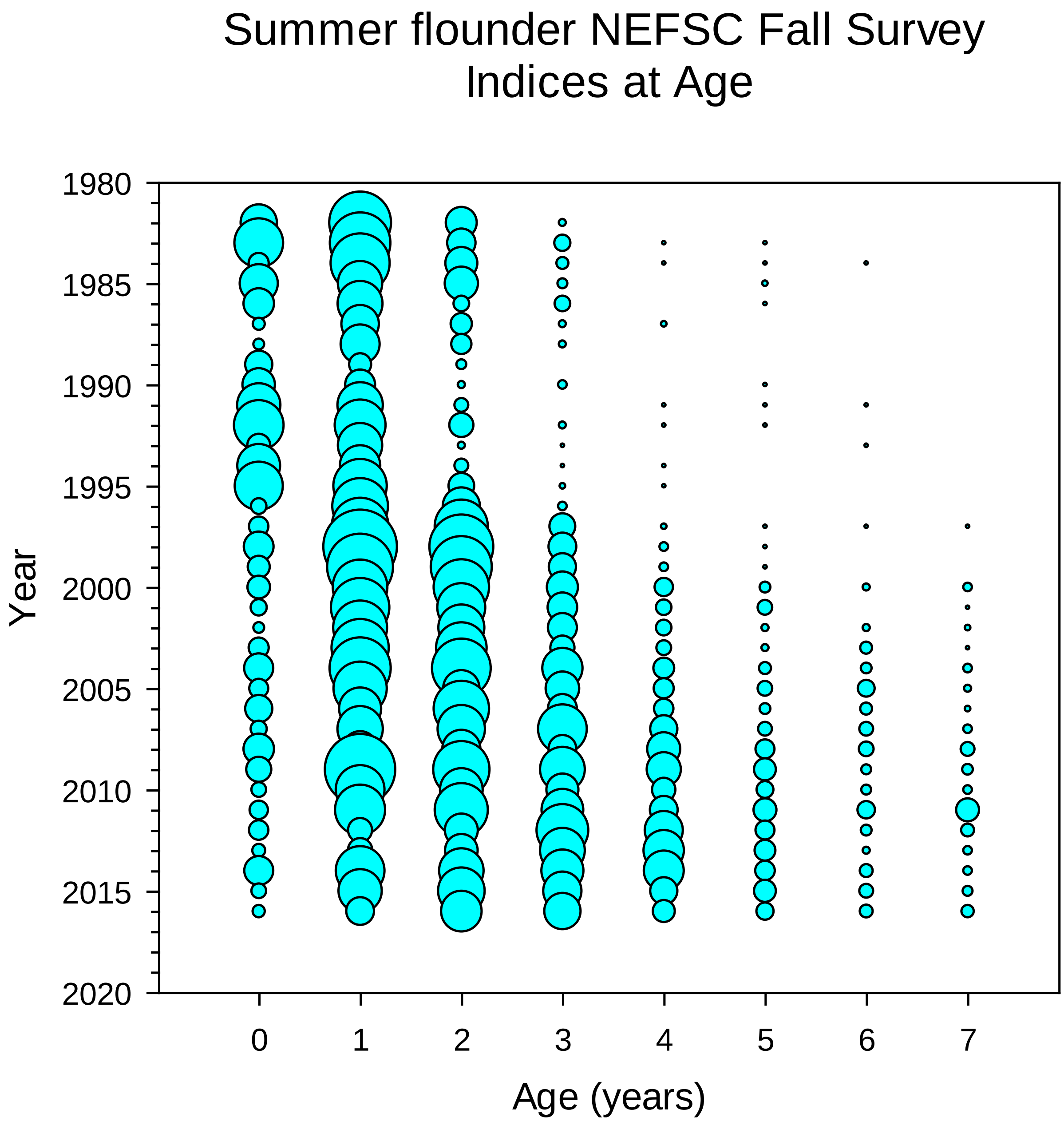


Figure A25. Relative age composition of summer flounder caught in the Northeast Fisheries Science Center (NEFSC) fall trawl survey.

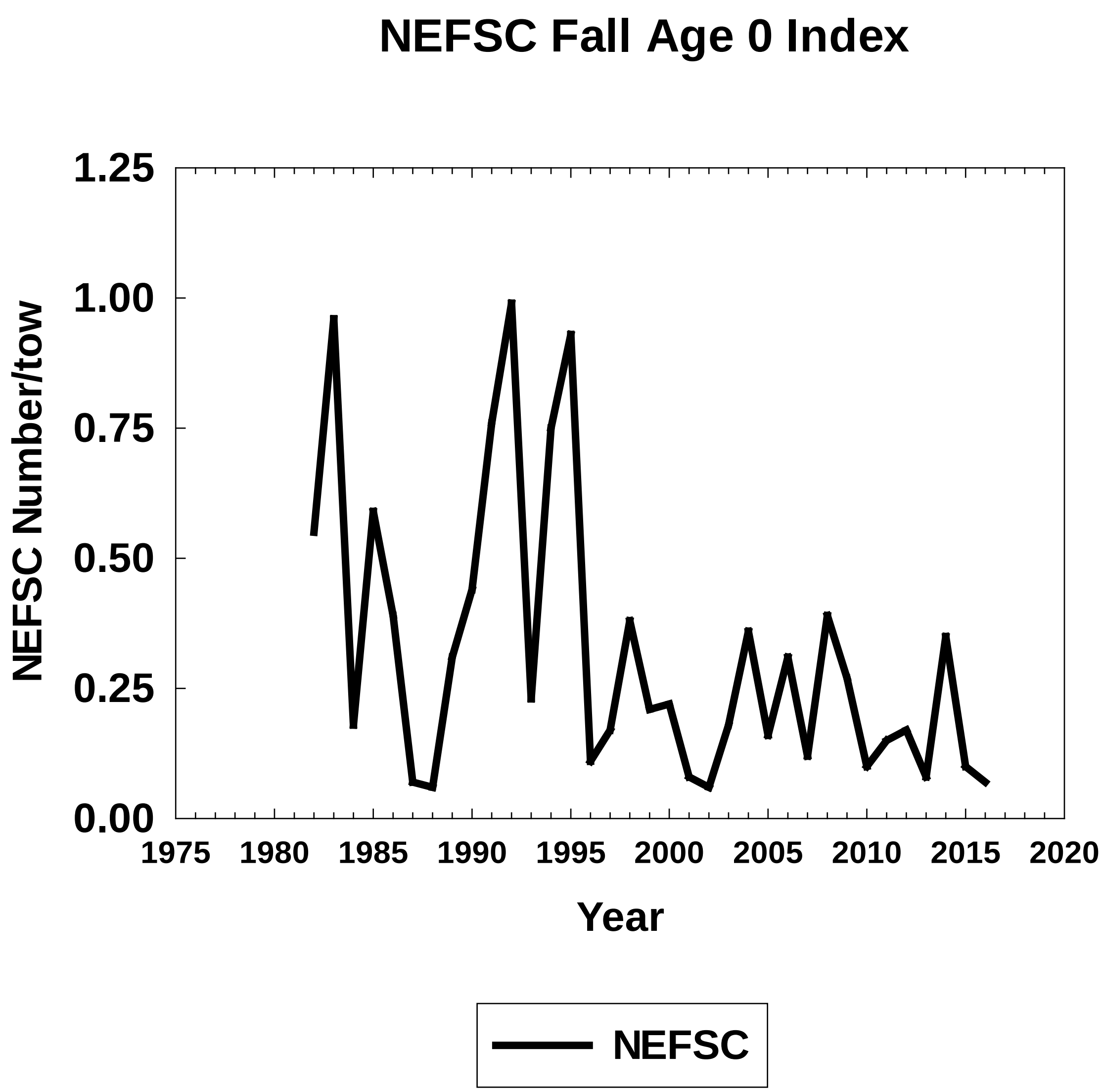


Figure A26. Trend in the Northeast Fisheries Science Center (NEFSC) trawl survey recruitment index for summer flounder young of the year (YOY).

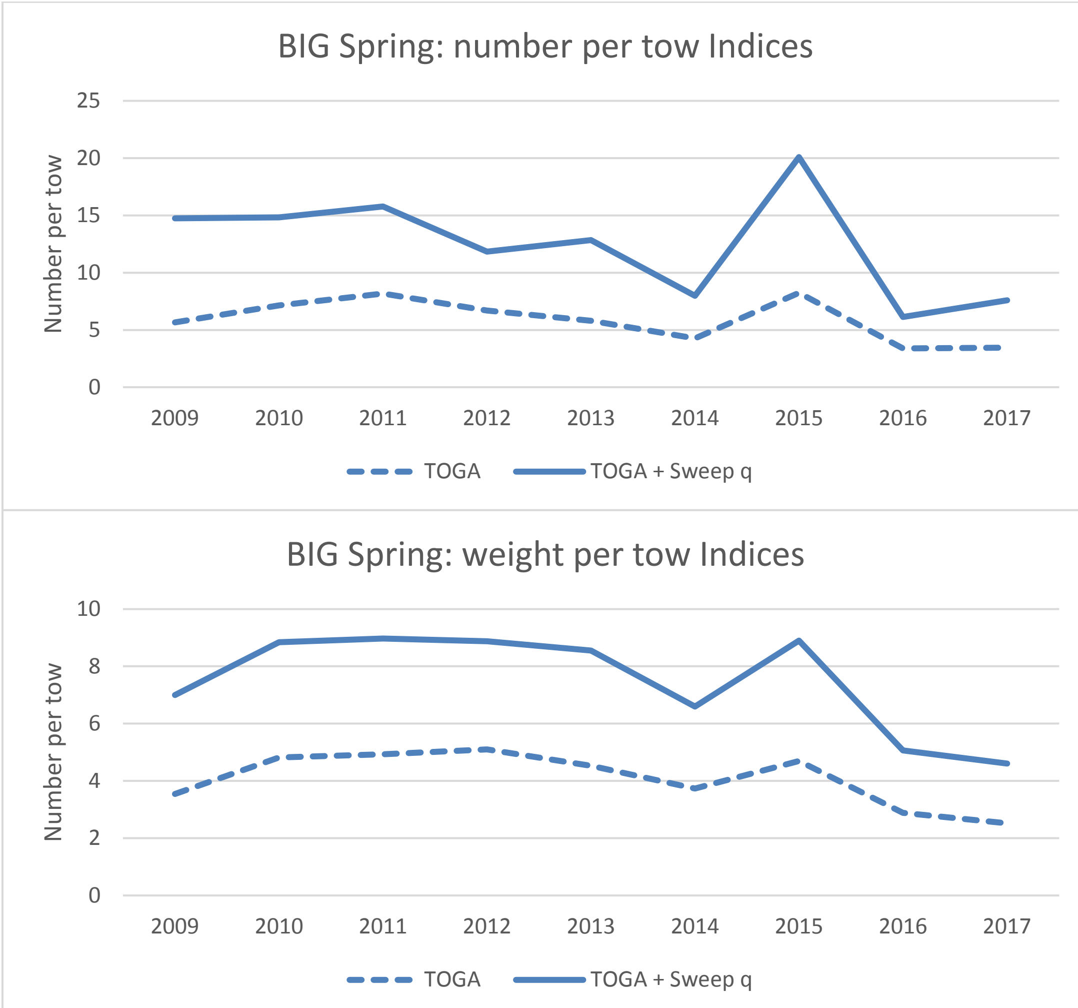


Figure A27. Northeast Fisheries Science Center (NEFSC) spring trawl survey FSV *Henry B. Bigelow* (BIG) indices in number and weight per tow. TOGA are 'standard' indices compiled with TOGA acceptance criteria. TOGA + Sweep q are 'absolute' indices incorporating the 'twin trawl sweep study' mean efficiencies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

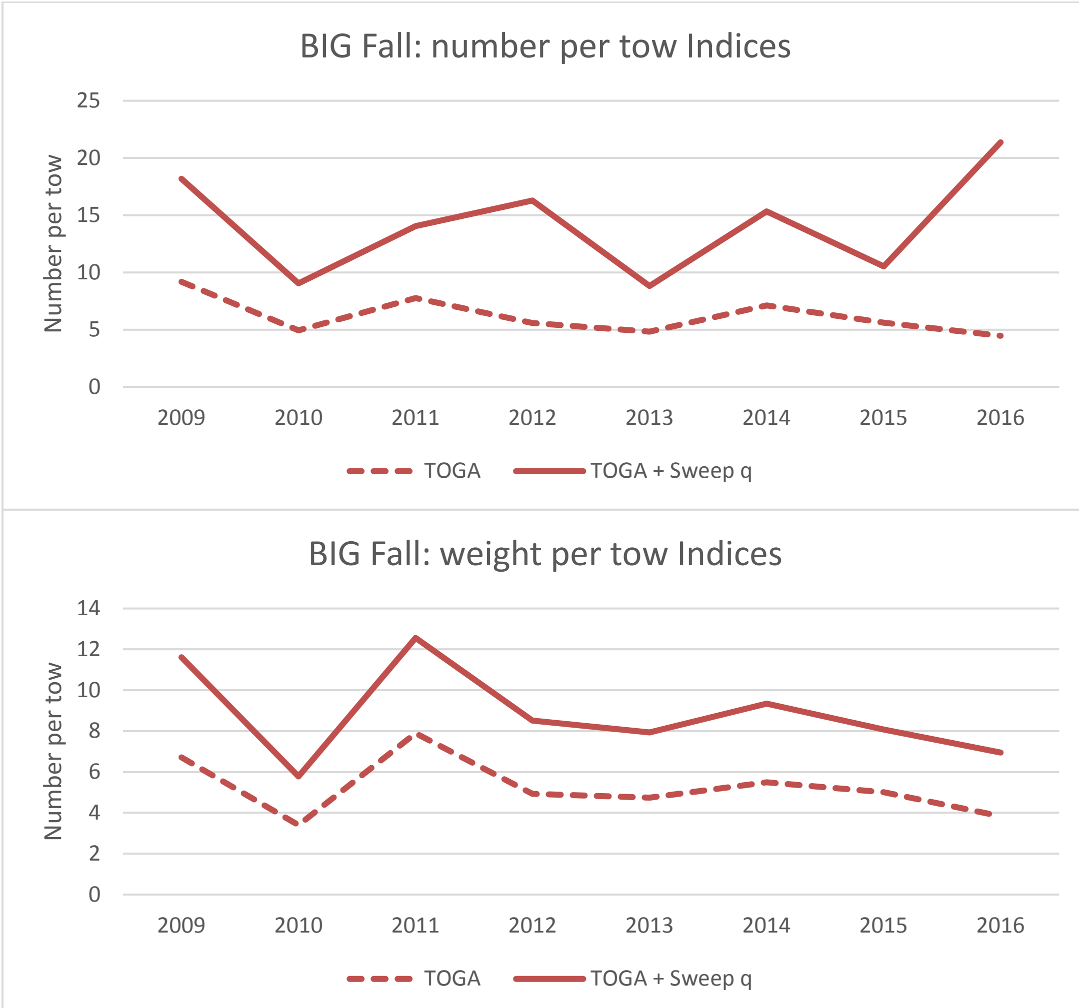


Figure A28. Northeast Fisheries Science Center (NEFSC) fall trawl survey FSV *Henry B Bigelow* (BIG) indices in number and weight per tow. TOGA are 'standard' indices compiled with TOGA acceptance criteria. TOGA + Sweep q are 'absolute' indices incorporating the 'twin trawl sweep study' mean efficiencies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

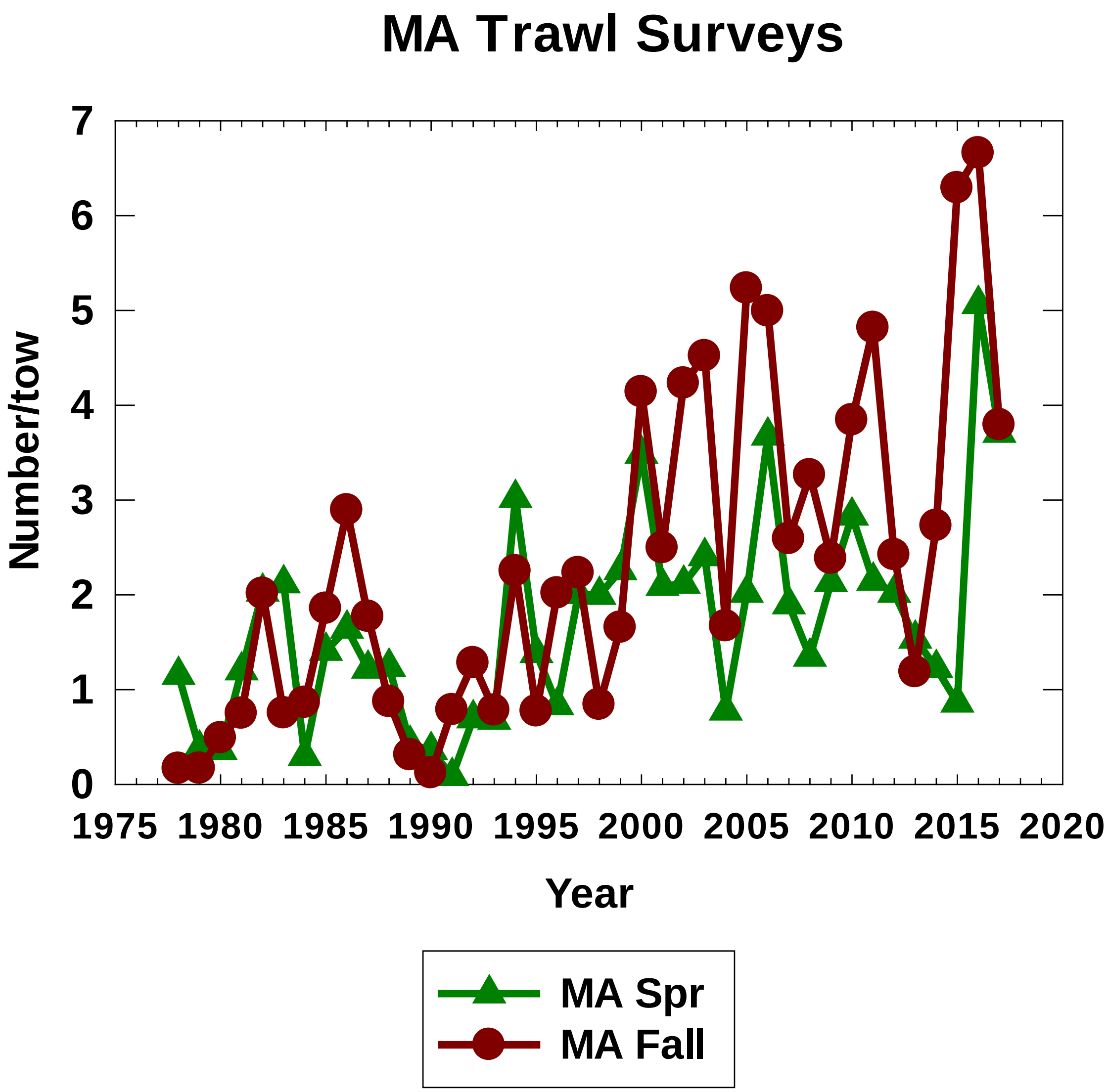


Figure A29. Trends in Massachusetts (MA) trawl survey abundance indices for summer flounder.

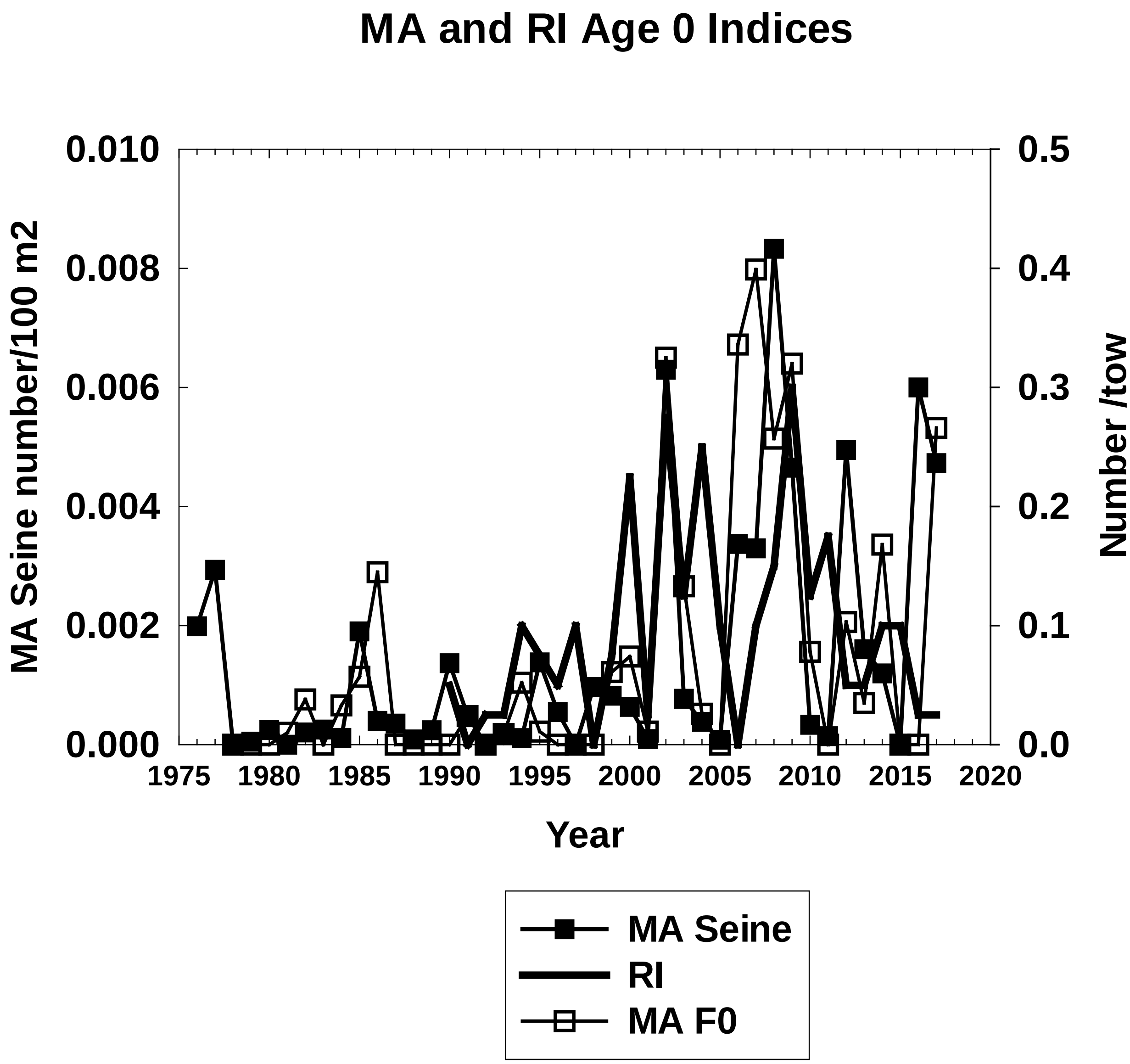


Figure A30. Trends in Massachusetts (MA) and Rhode Island (RI) trawl survey recruitment indices for summer flounder young of the year (YOY).

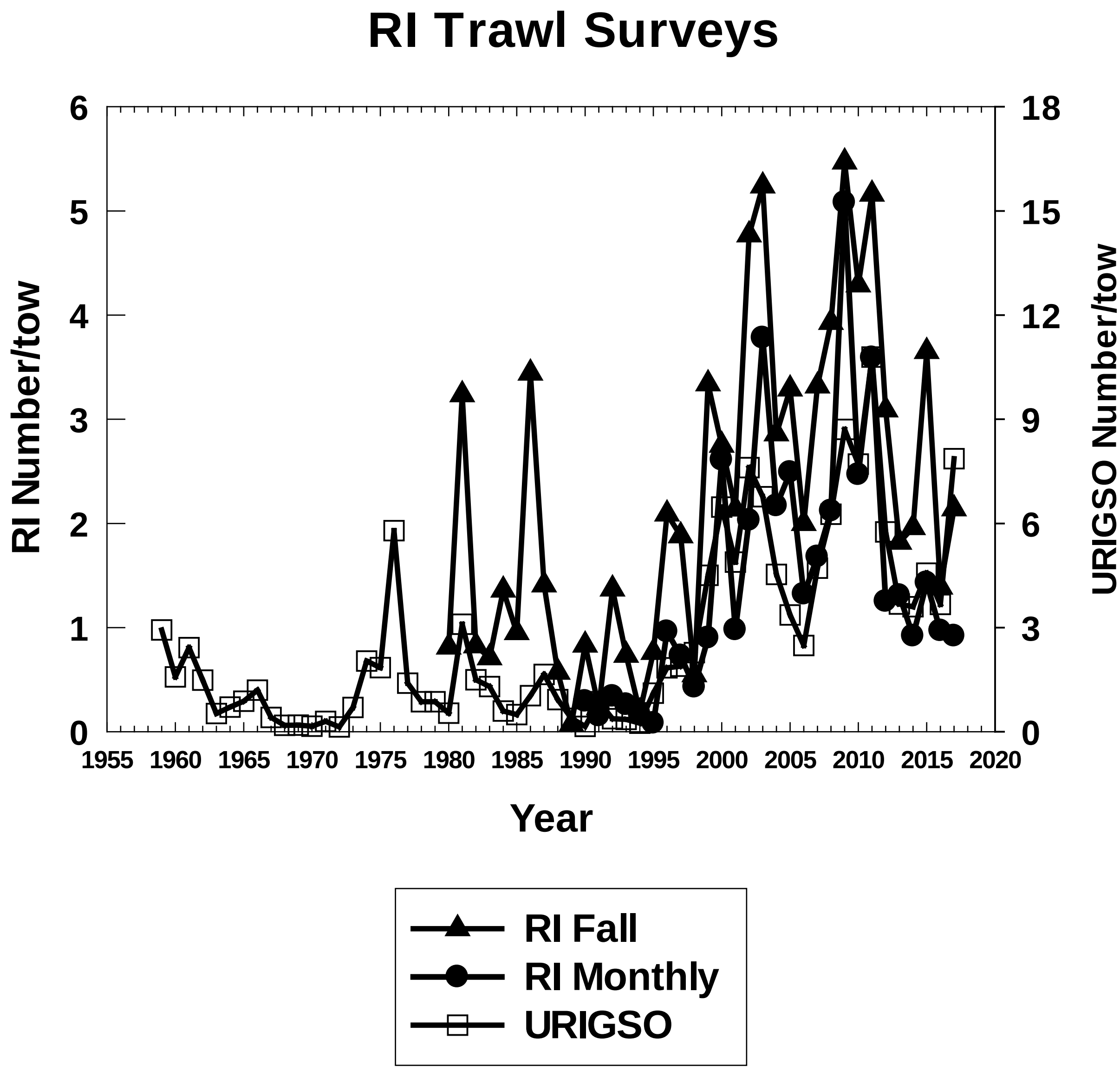


Figure A31. Trends in Rhode Island (RI) fall, monthly, and University of Rhode Island Graduate School of Oceanography (URIGSO) trawl survey abundance indices for summer flounder.

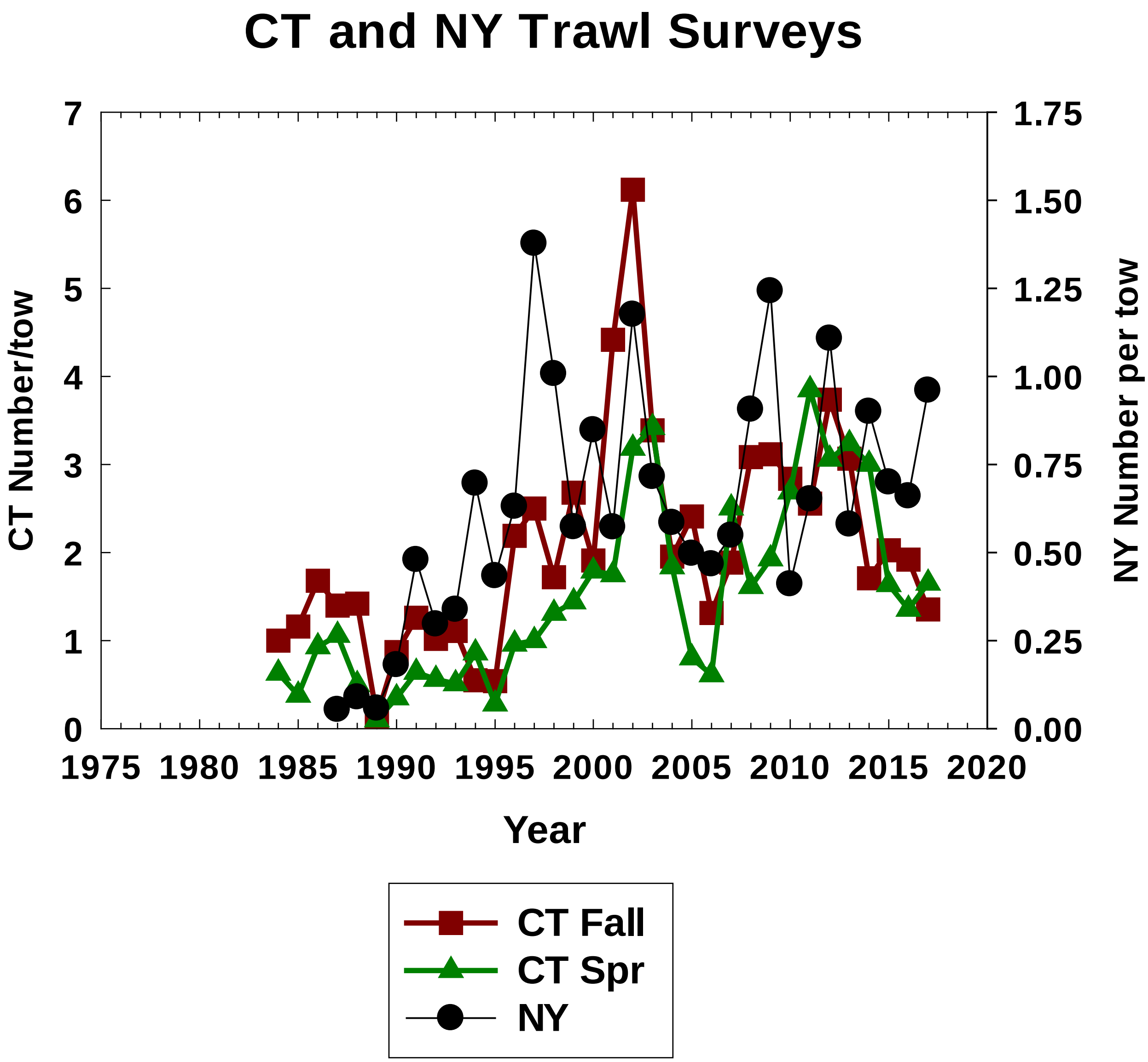


Figure A32. Trends in Connecticut (CT) and New York (NY) trawl survey abundance indices for summer flounder.

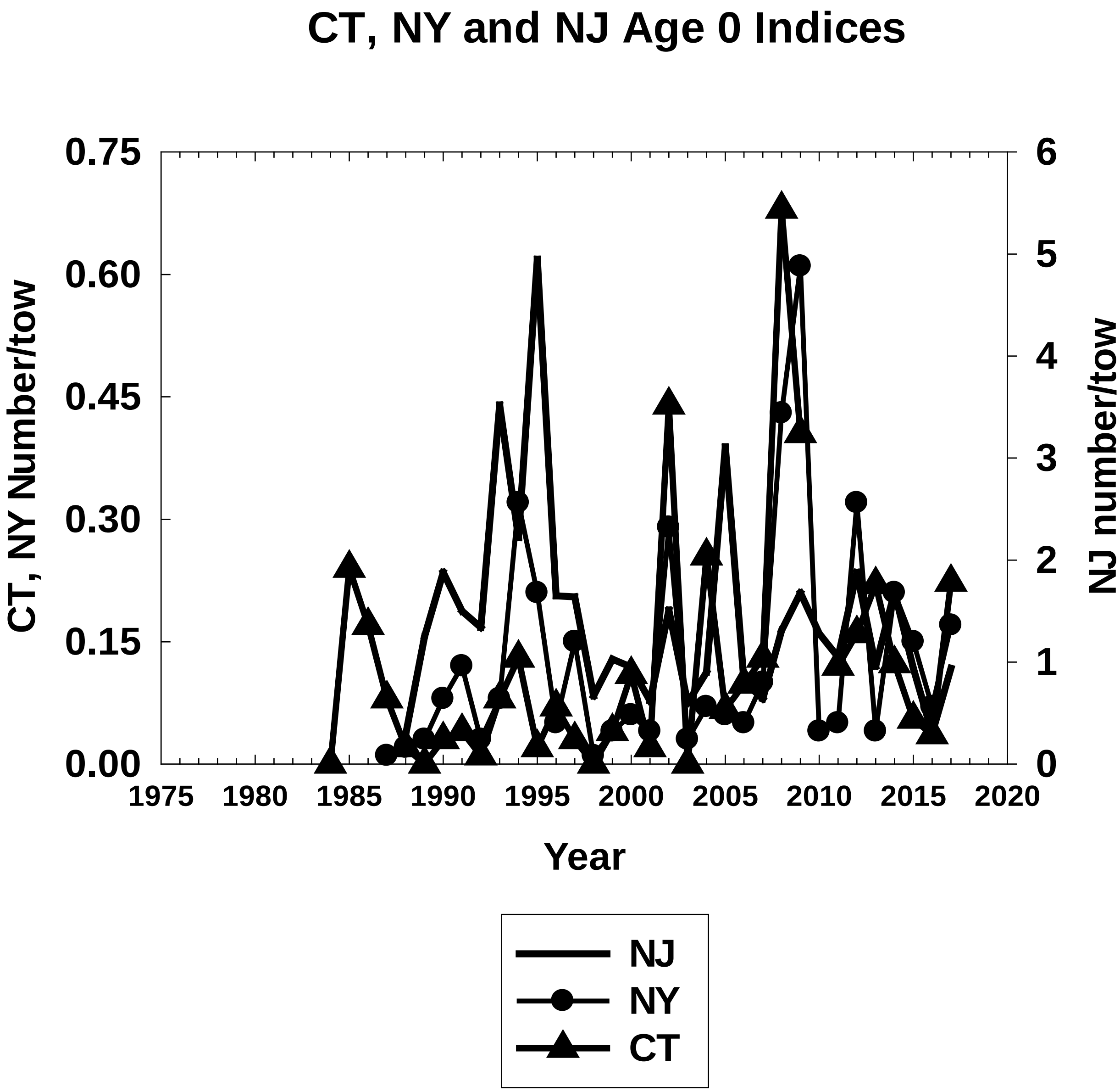


Figure A33. Trends in Connecticut (CT), New York (NY), and New Jersey (NJ) trawl survey recruitment indices for summer flounder young of the year (YOY).

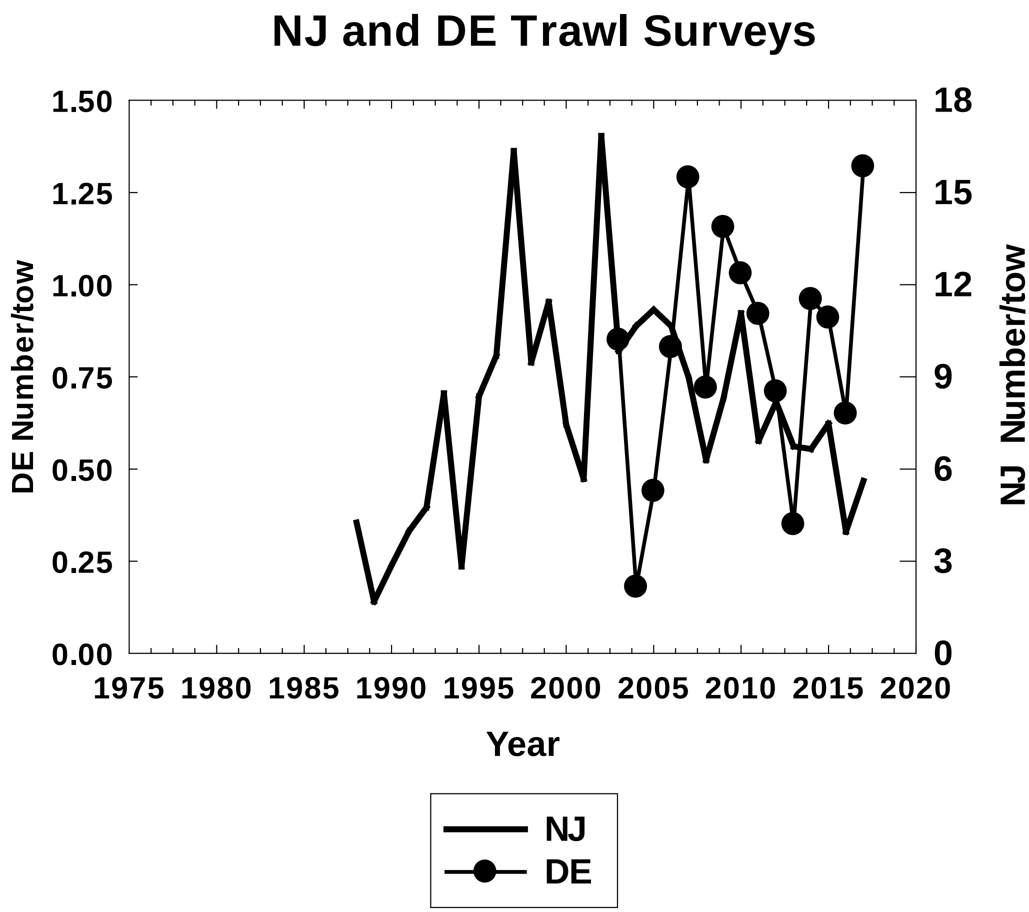


Figure A34. Trends in New Jersey (NJ) and Delaware (DE) trawl survey abundance indices for summer flounder.

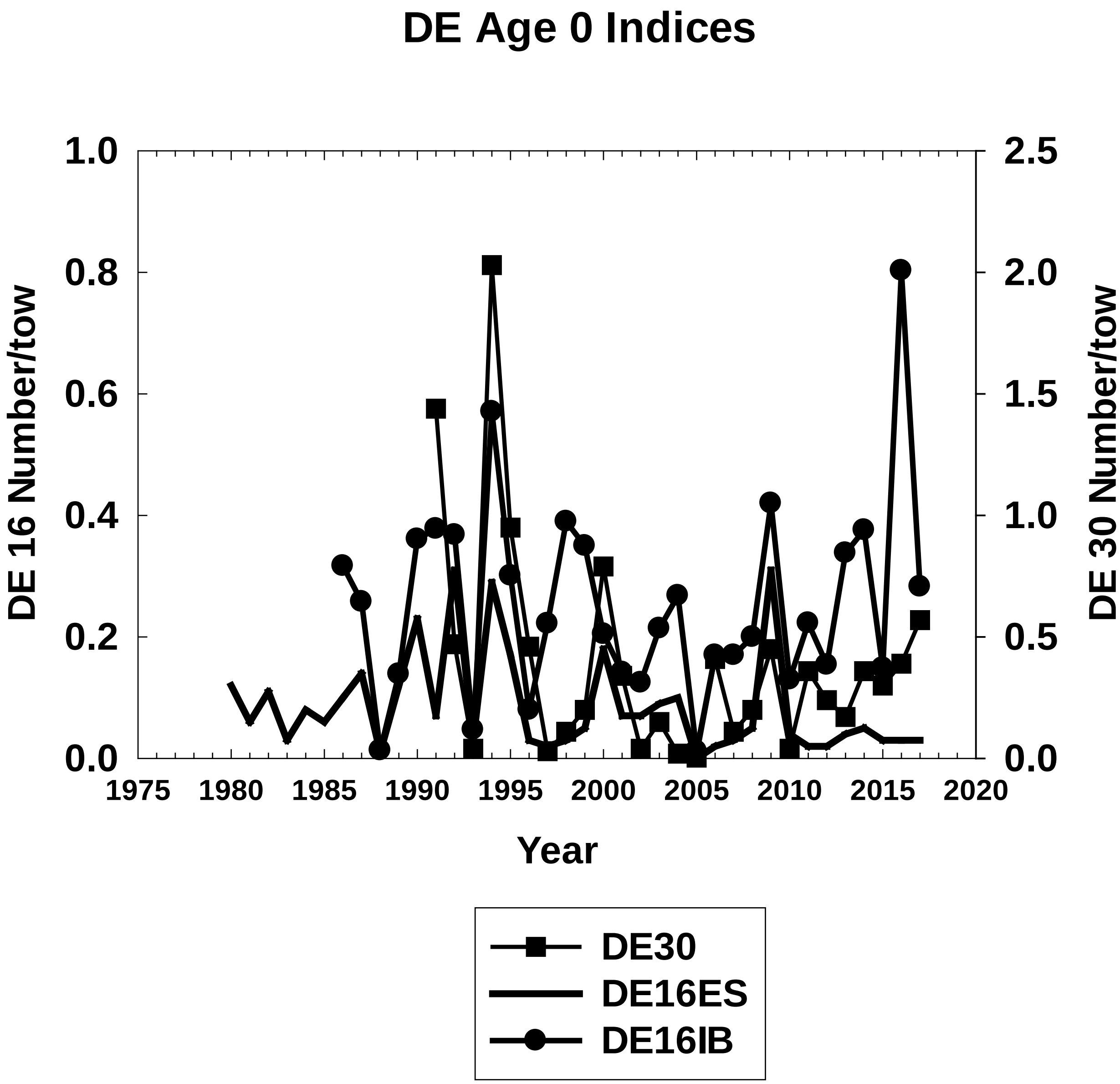


Figure A35. Trends in Delaware (DE) trawl survey recruitment indices for summer flounder young of the year (YOY).

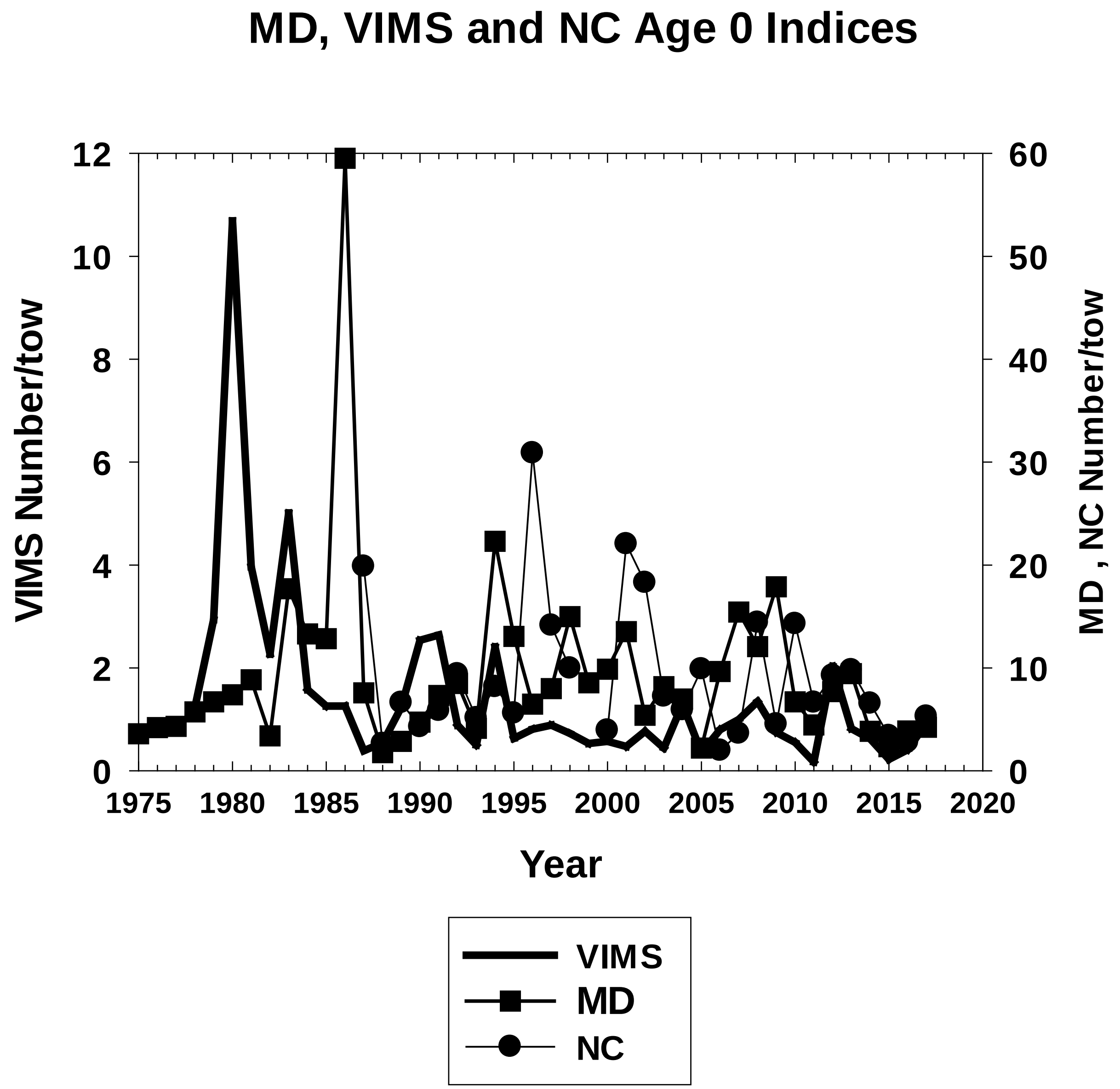


Figure A36. Trends in Maryland (MD), Virginia Institute of Marine Science (VIMS) and North Carolina (NC) trawl survey recruitment indices for summer flounder young of the year (YOY).

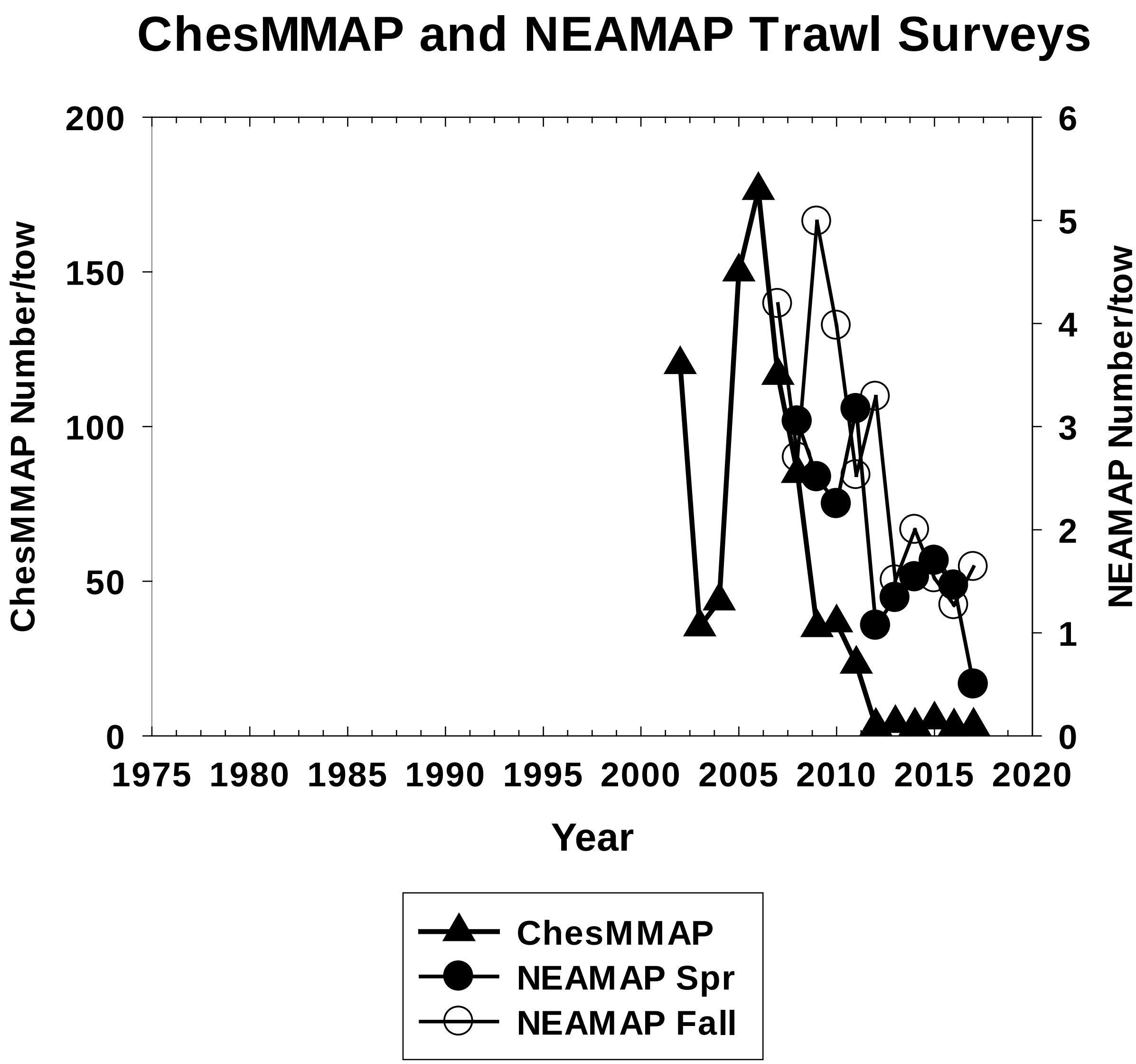


Figure A37. Trends in Northeast Area Monitoring and Assessment Program (NEAMAP) and Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) trawl survey abundance indices for summer flounder.

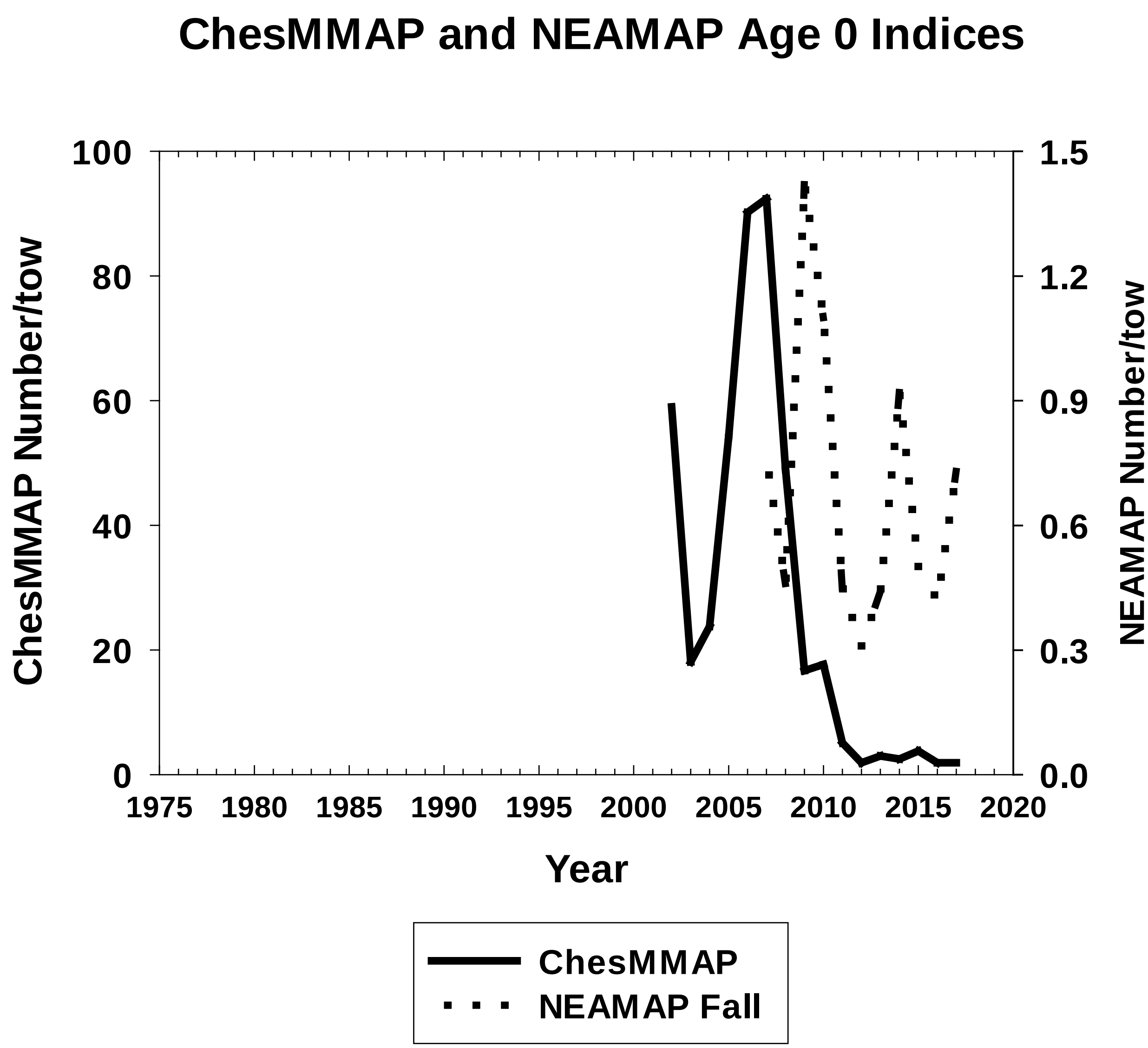


Figure A38. Trends in Northeast Area Monitoring and Assessment Program (NEAMAP) and Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) trawl survey abundance indices and trawl survey recruitment indices for summer flounder young of the year (YOY).

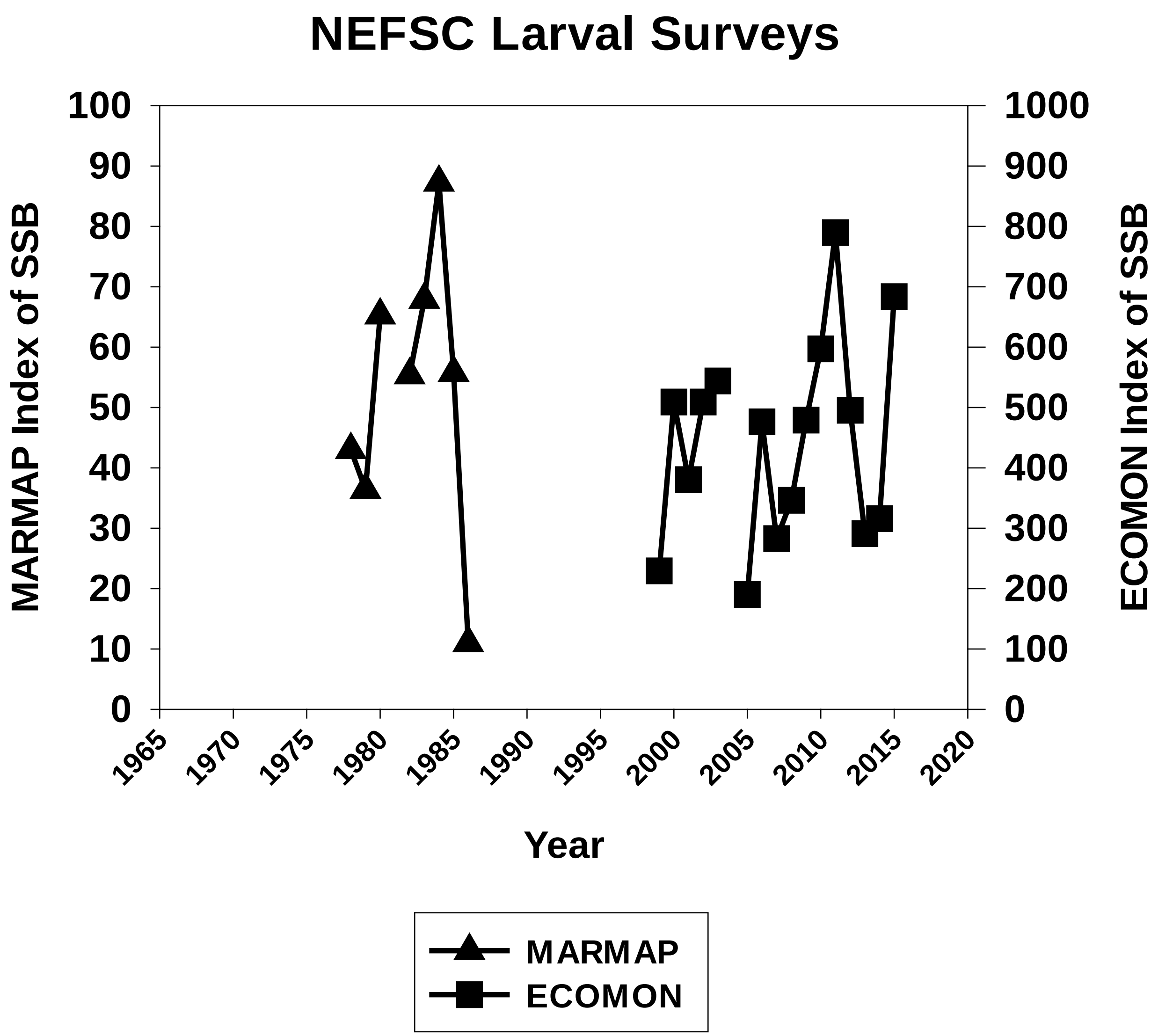
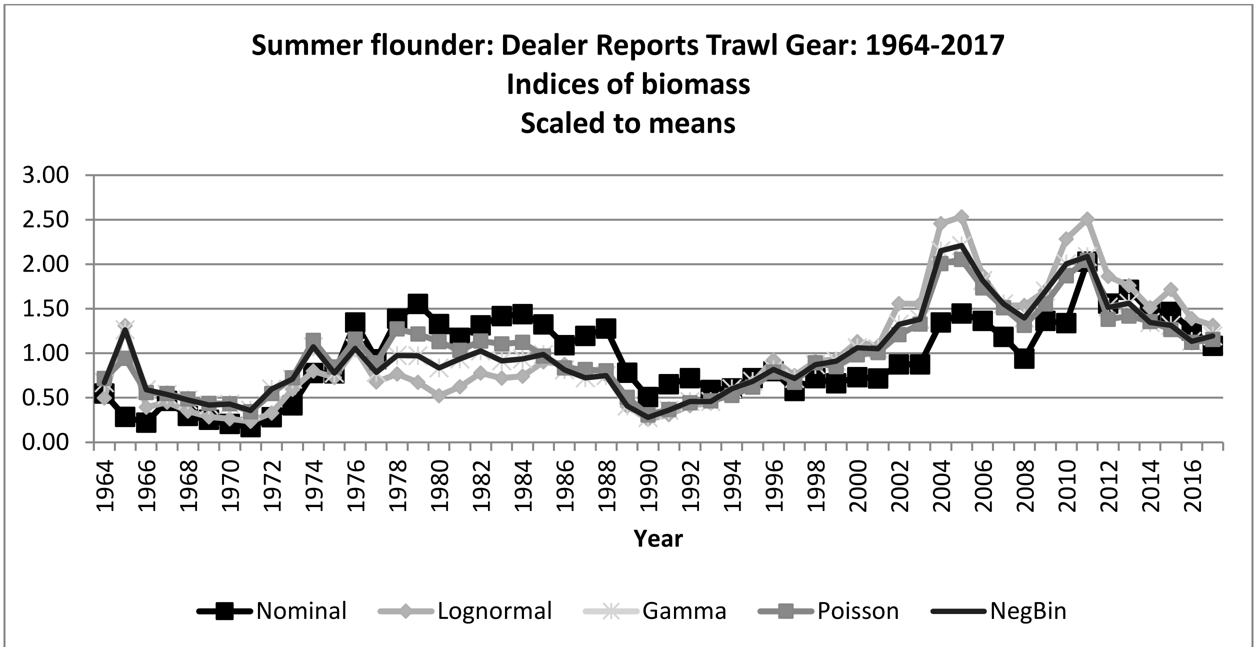


Figure A39. Trends in Northeast Fisheries Science Center (NEFSC) MARMAP and ECOMON larval survey Spawning Stock Biomass (SSB) indices for summer flounder.



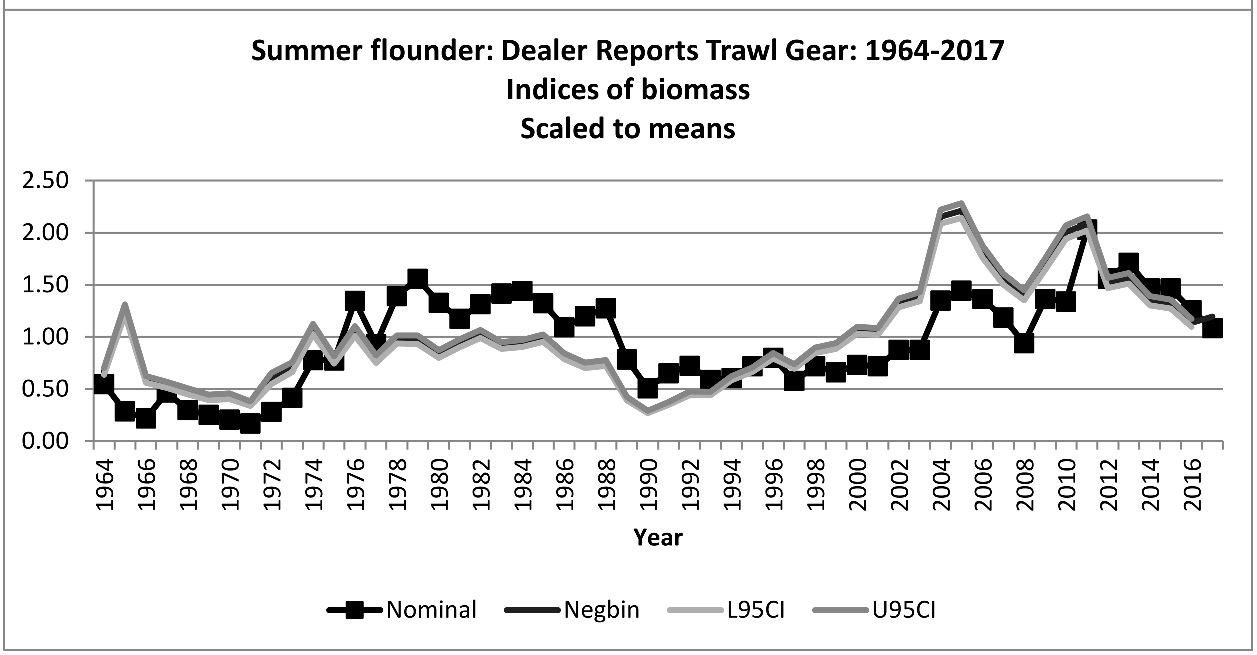
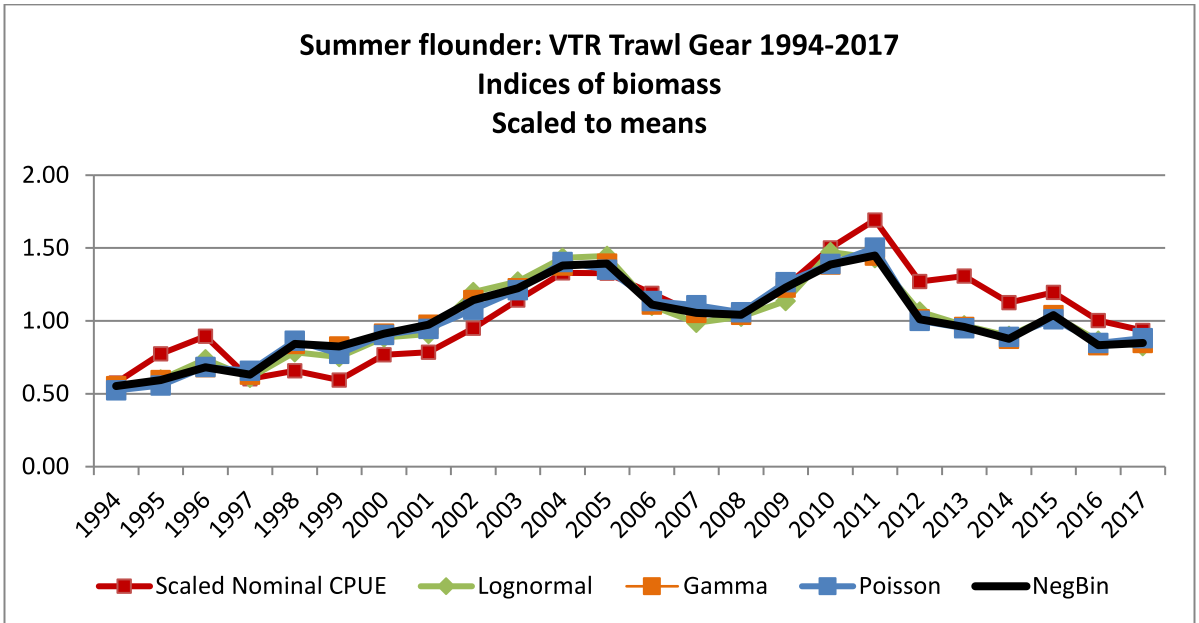


Table A40. Top - comparison of the Dealer report trawl gear landings and effort nominal index and model-based standardized indices. Bottom - comparison of the Dealer report trawl gear landings and effort nominal index and negbin model-based standardized index and 95% confidence intervals.



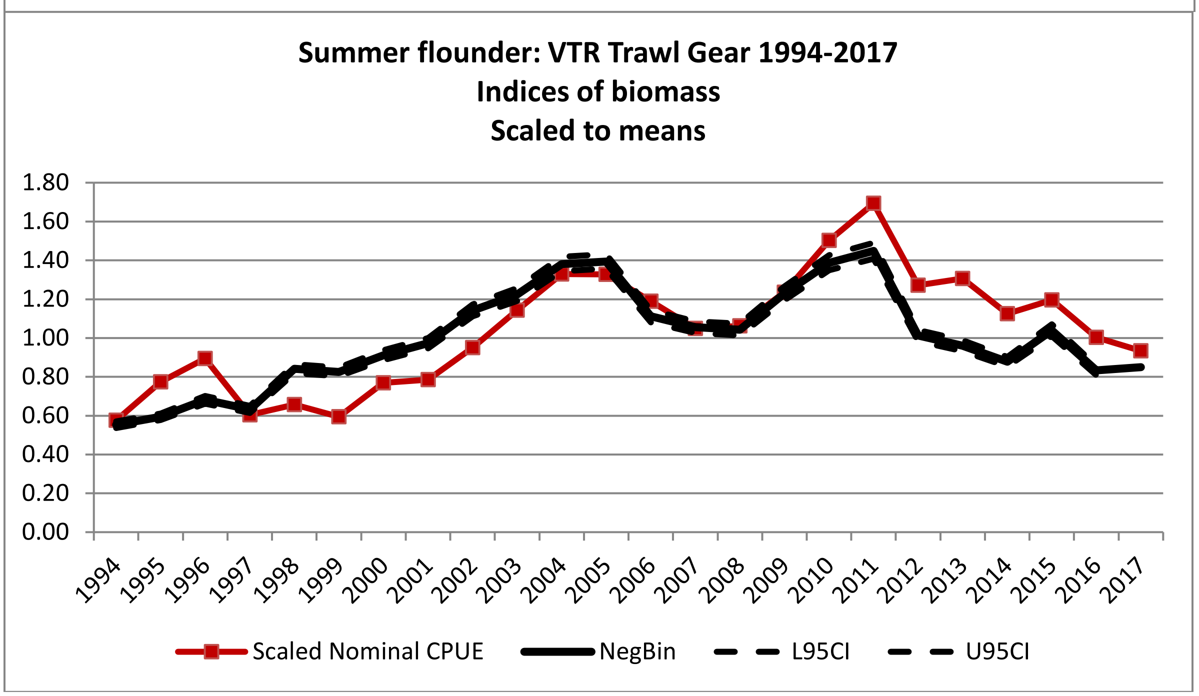


Table A41. Top - comparison of the Vessel Trip Report (VTR) trawl gear landings and effort nominal index and model-based standardized indices. Bottom - comparison of the Vessel Trip Report (VTR) report trawl gear landings and effort nominal index and negbin model-based standardized index and 95% confidence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

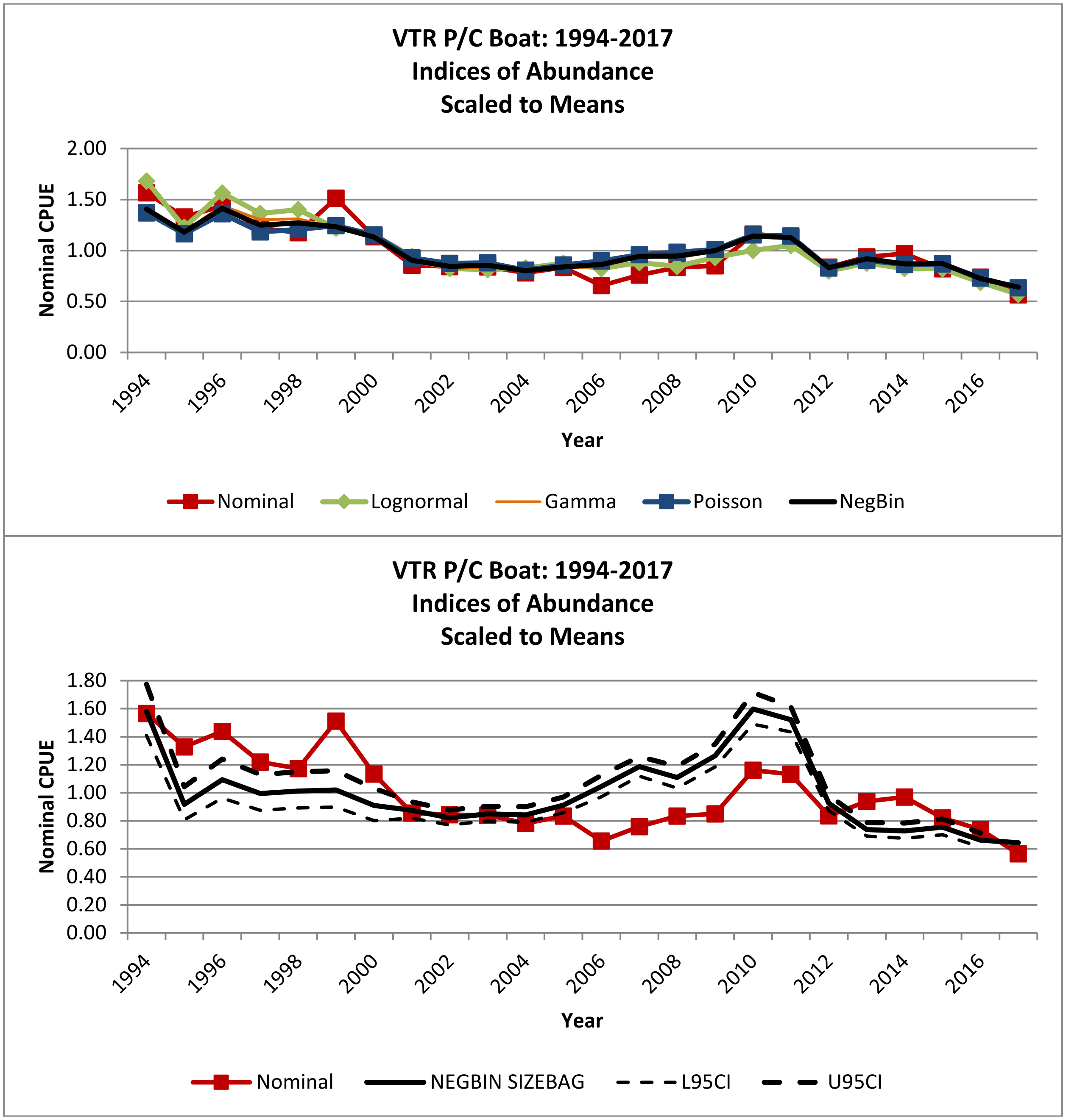


Figure A42. Top - comparison of the Vessel Trip Report (VTR) Party/Charter boat nominal index and model-based standardized indices. Bottom - comparison of the negbin six-factor ST-SZE-BAG model-based indices and the nominal index.

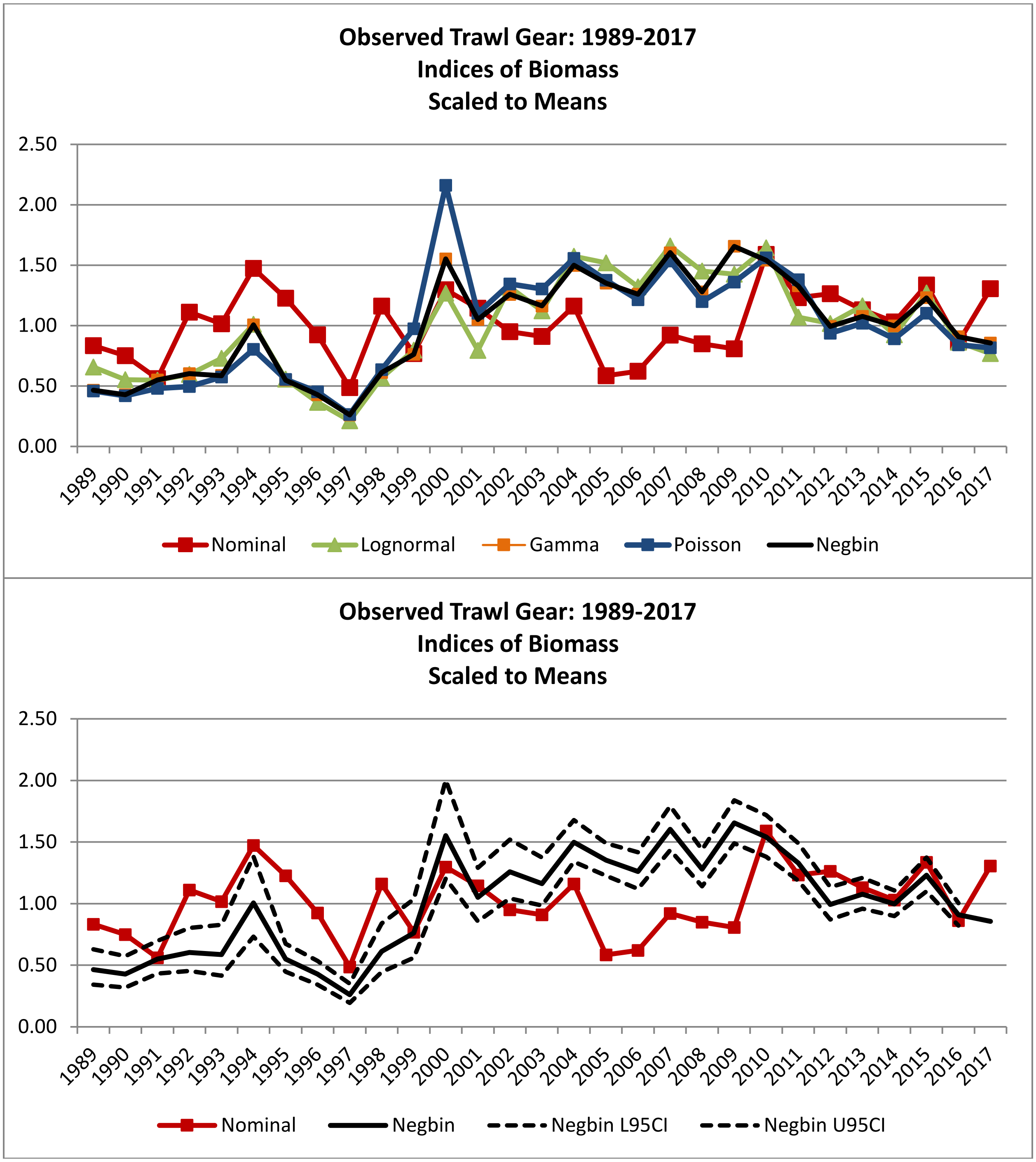


Figure A43. Top - comparison of the Observed trawl gear nominal index and model-based standardized indices. Bottom - comparison of the Observed trawl gear negbin model-based index and the nominal index.

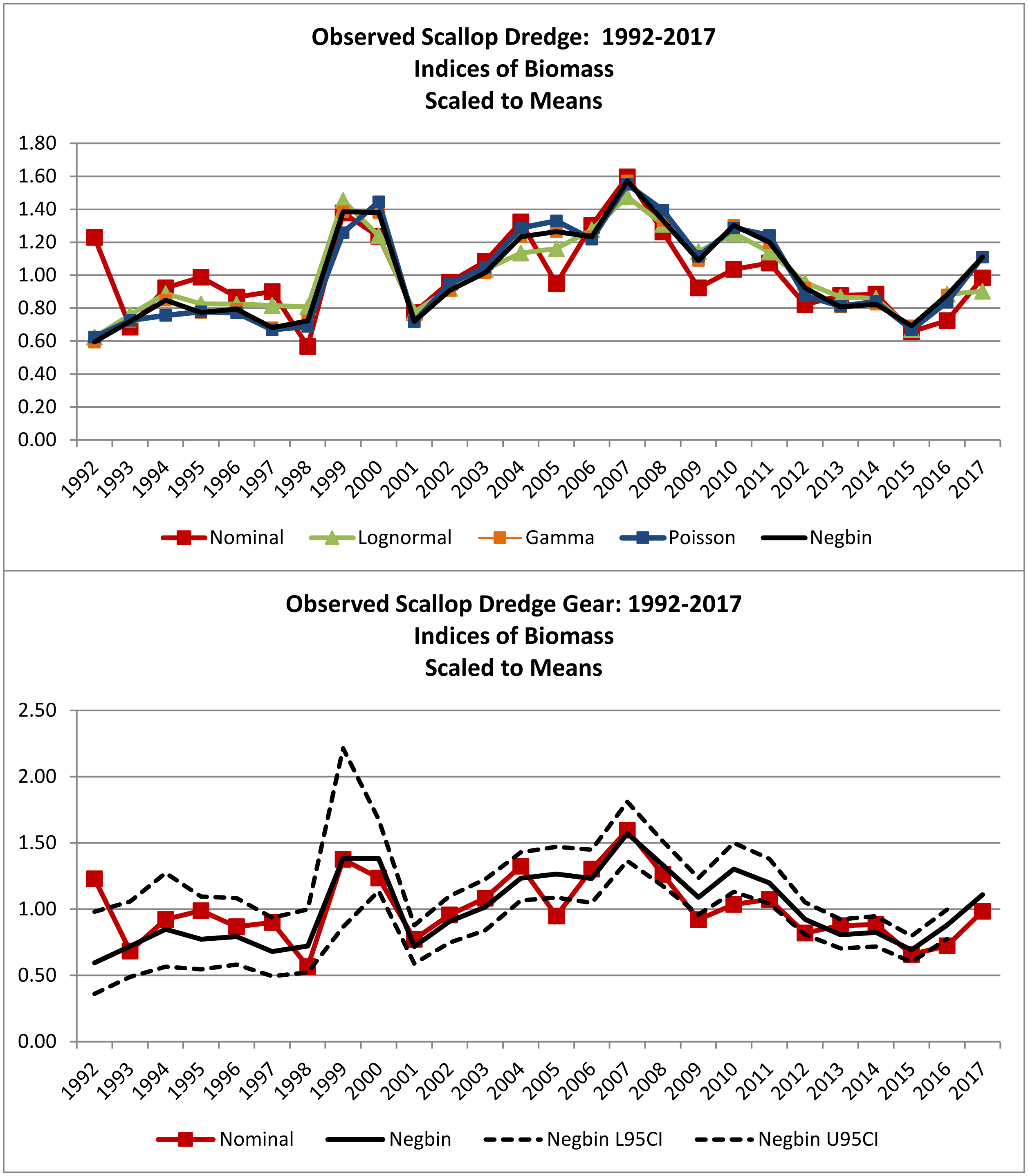


Figure A44. Top - comparison of the Observed scallop dredge gear nominal index and model-based standardized indices. Bottom - comparison of the Observed scallop dredge gear negbin model-based index and the nominal index.

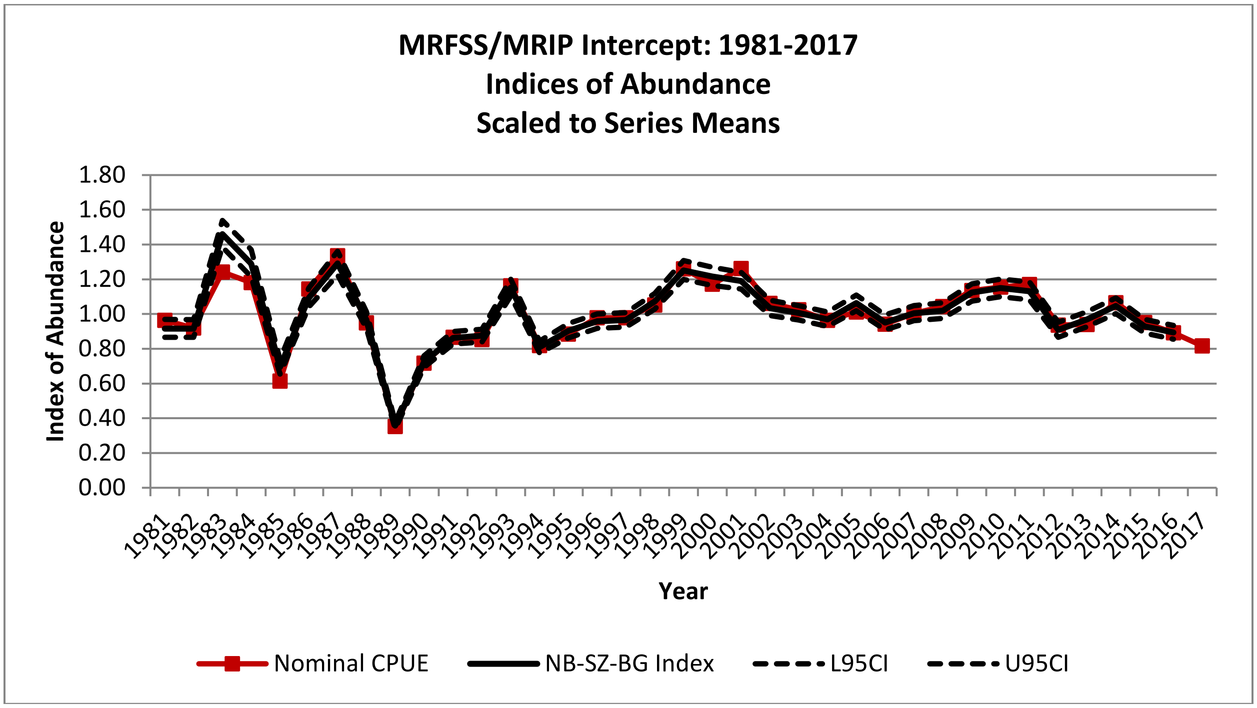


Figure A45. Comparison of the Marine Recreational Fishery Statistics Survey (MRFSS) / Marine Recreational Information Program (MRIP) intercept negbin six-factor ST-SZ-BG model-based indices and the nominal index.

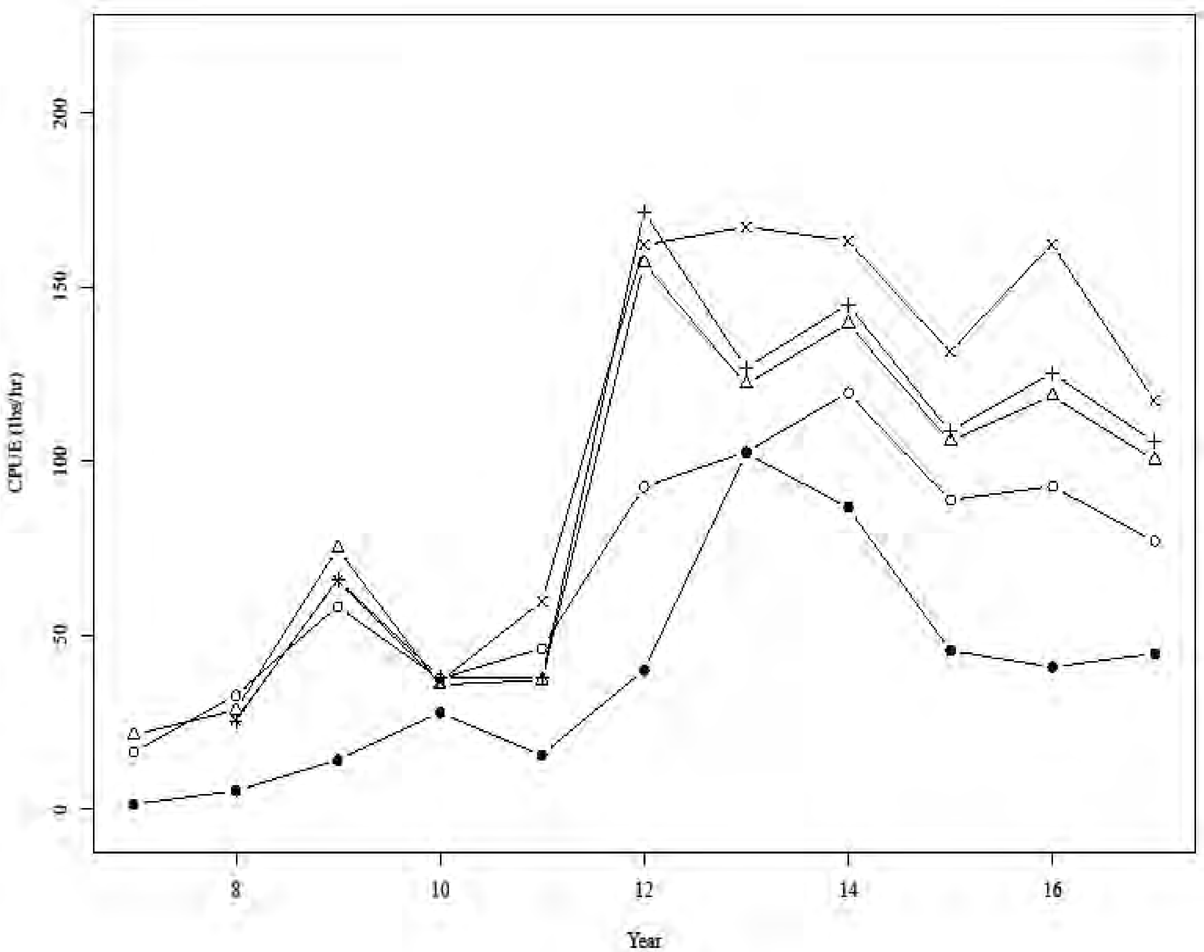
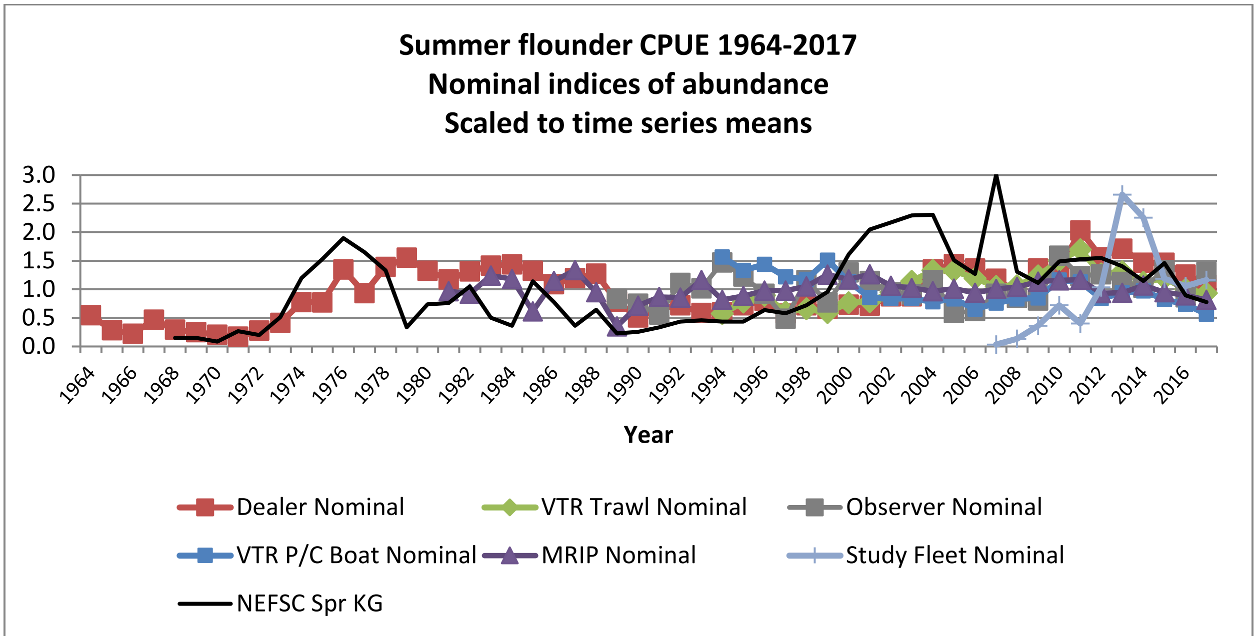


Figure A46. The annul catch-per-unit effort (CPUE) index for summer flounder derived from the NEFSC Cooperative Research Study Fleet Program self-reported data at various quantification levels of 'directed' trips. Values are in pounds per hour (lbs/hr). Filled circles represent All trips, open circles 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.



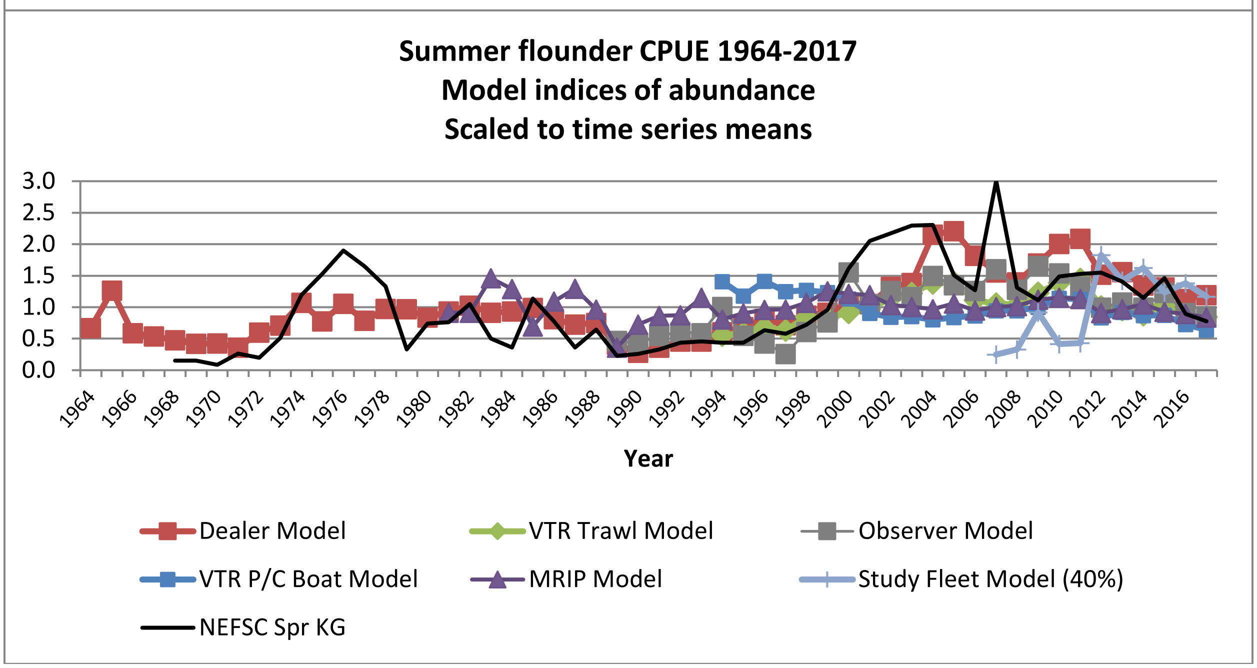


Figure A47. Top - trends in fishery dependent nominal indices of summer flounder stock size. Bottom - trends in fishery dependent model indices of summer flounder stock size Indices are compared with the Northeast Fisheries Science Center (NEFSC) spring survey biomass (KG) index, and all are scaled to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

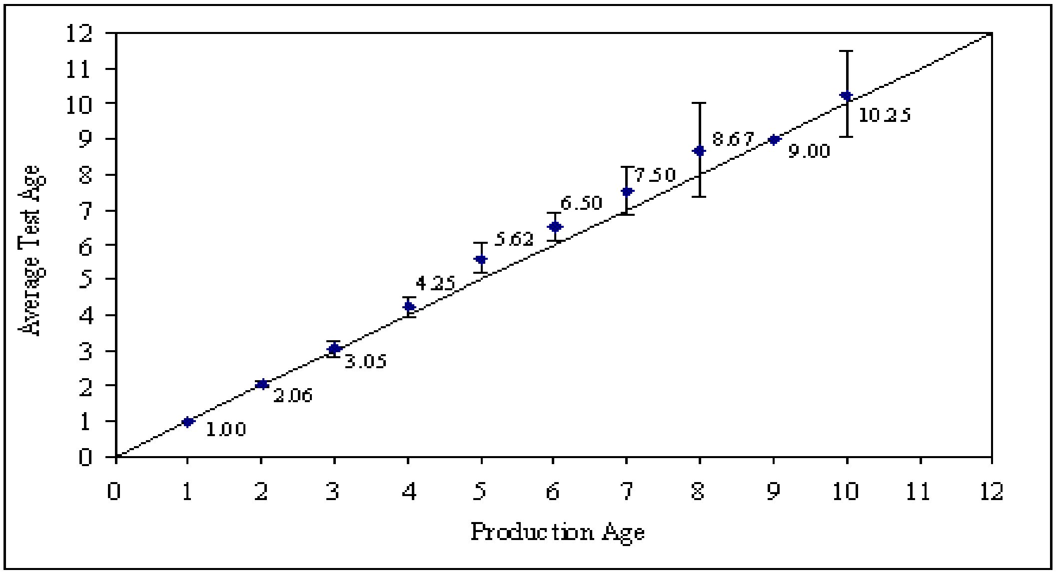


Figure A48. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2011 spring survey ages, 75% agreement.

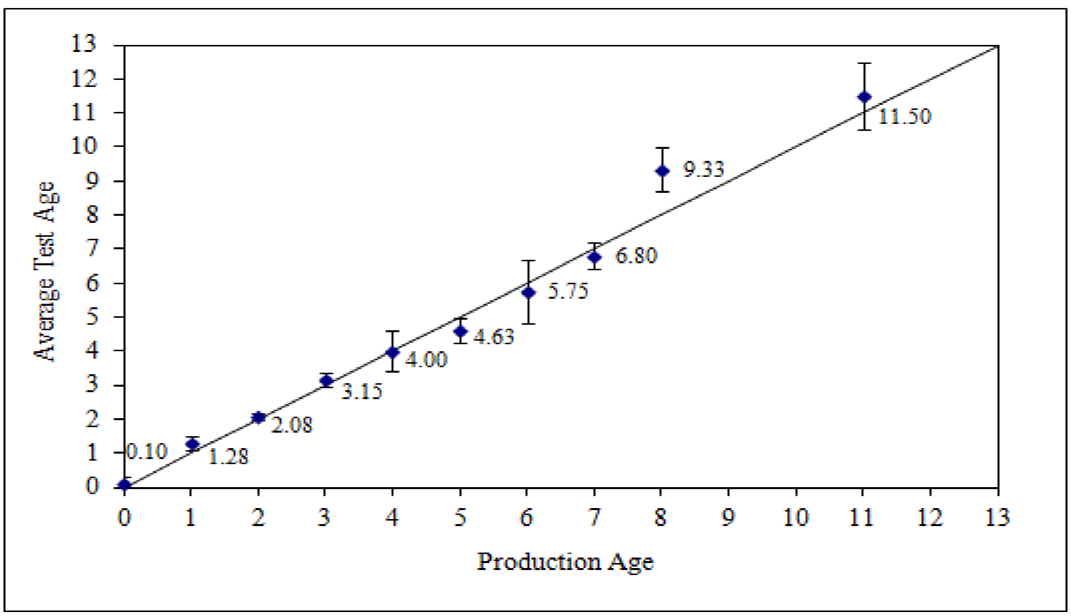


Figure A49. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2011 fall survey ages, 73% agreement.

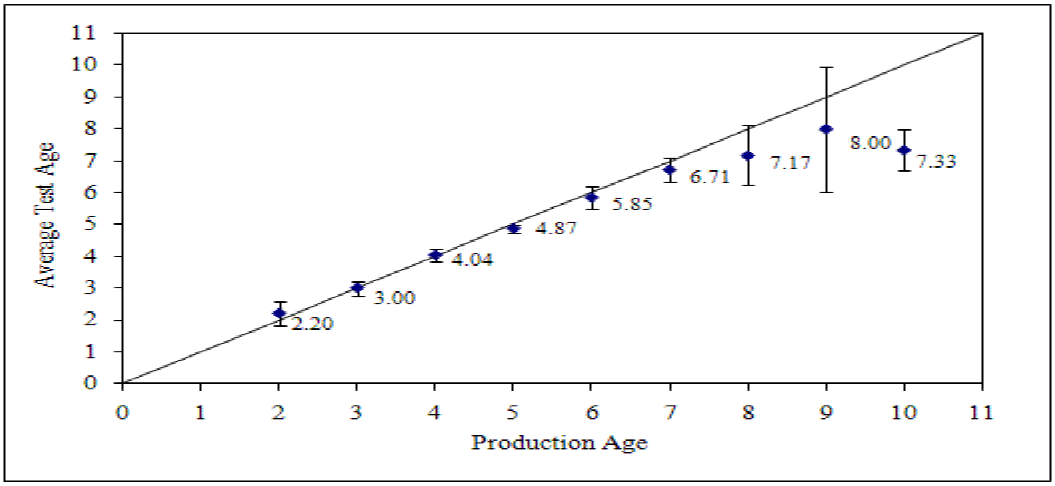


Figure A50. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2011 quarter 1 commercial ages, 69% agreement.

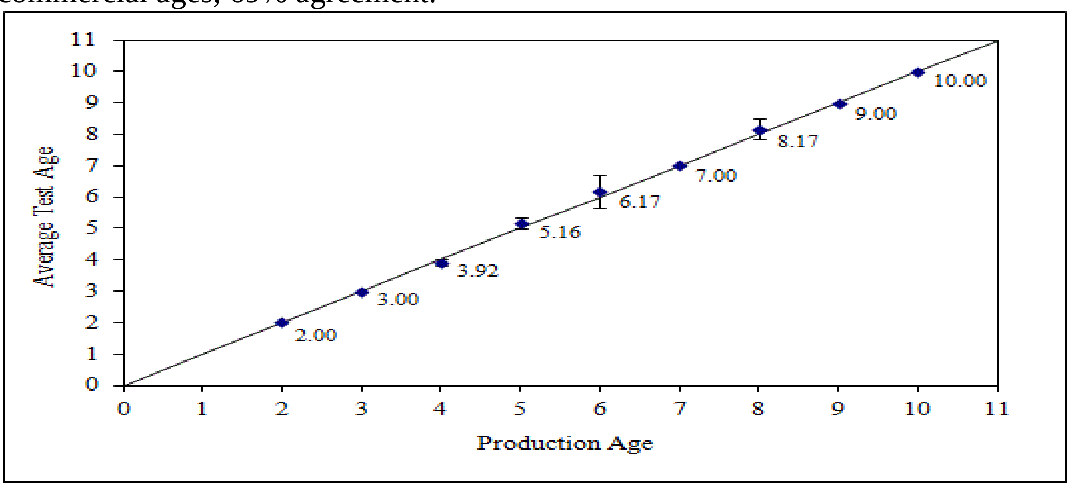


Figure A51. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2011 quarter 2 commercial ages, 92% agreement.

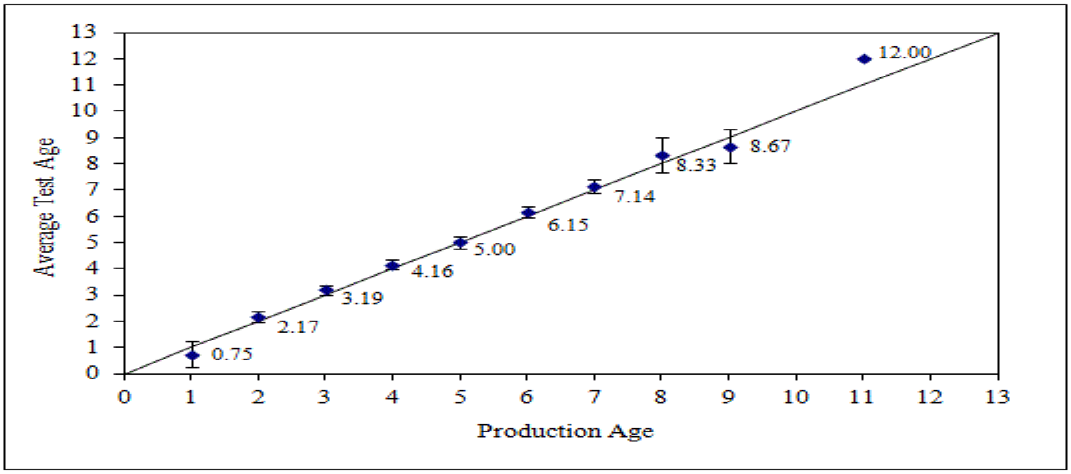


Figure A52. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2011 quarter 3-4 commercial ages, 80% agreement.

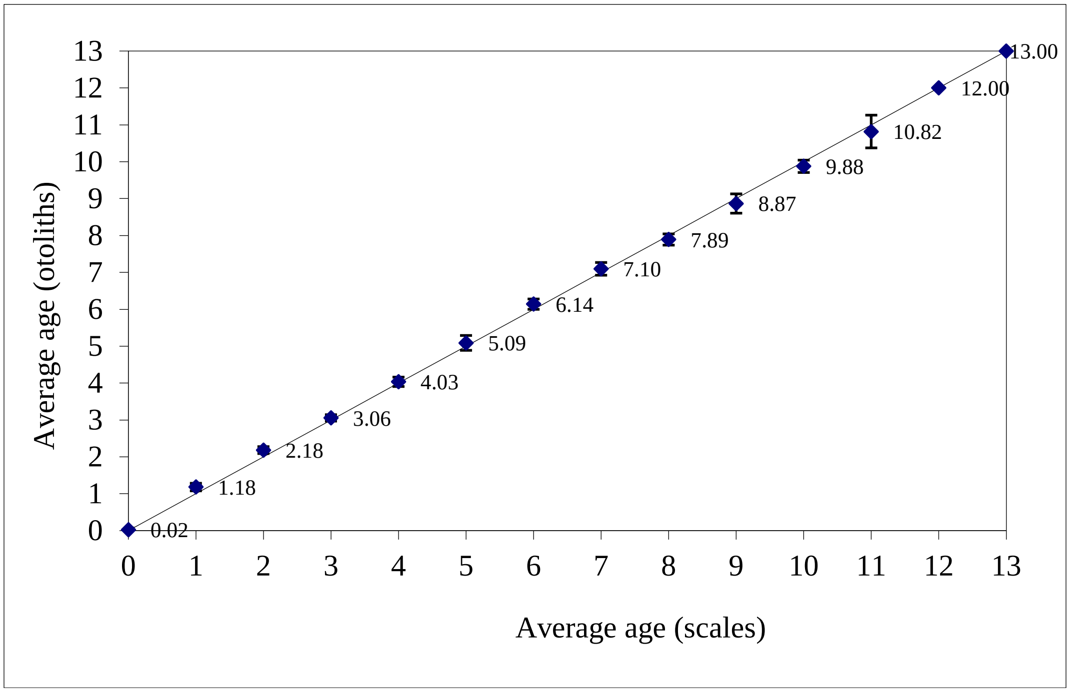


Figure A53. Age bias plot from the Atlantic States Marine Fisheries Commission (ASMFC) 2014 ageing workshop comparing scale and otolith ages for 619 summer flounder collected during 2009-2013. There was 79% agreement with 4.6% coefficient of variation.

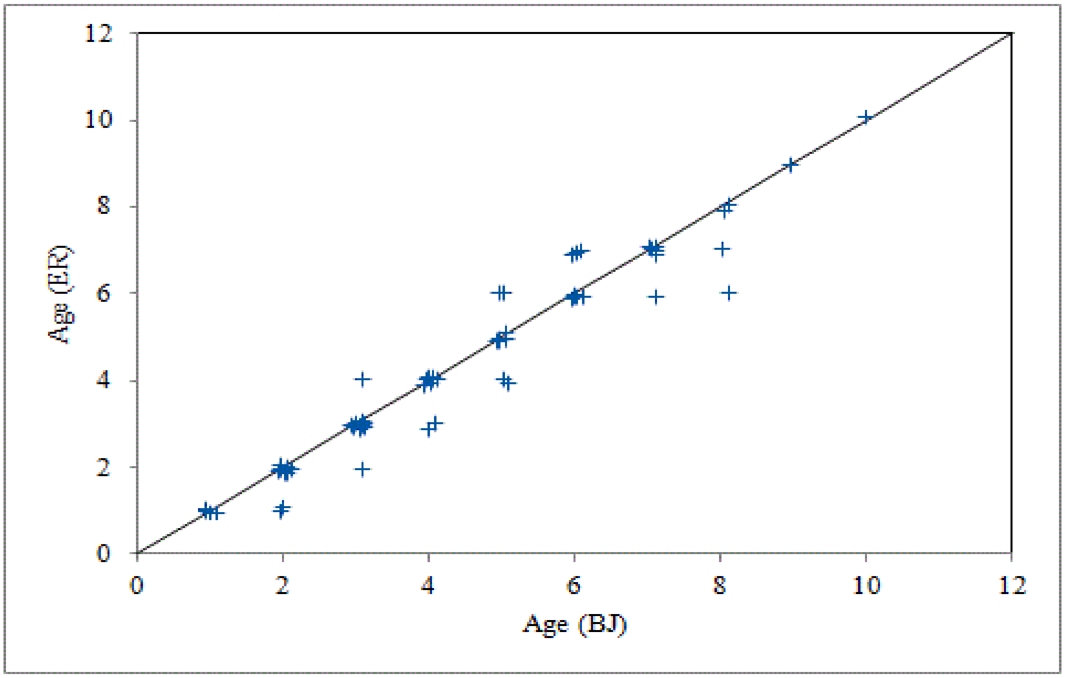


Figure A54. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2016 spring survey ages, 77% agreement.

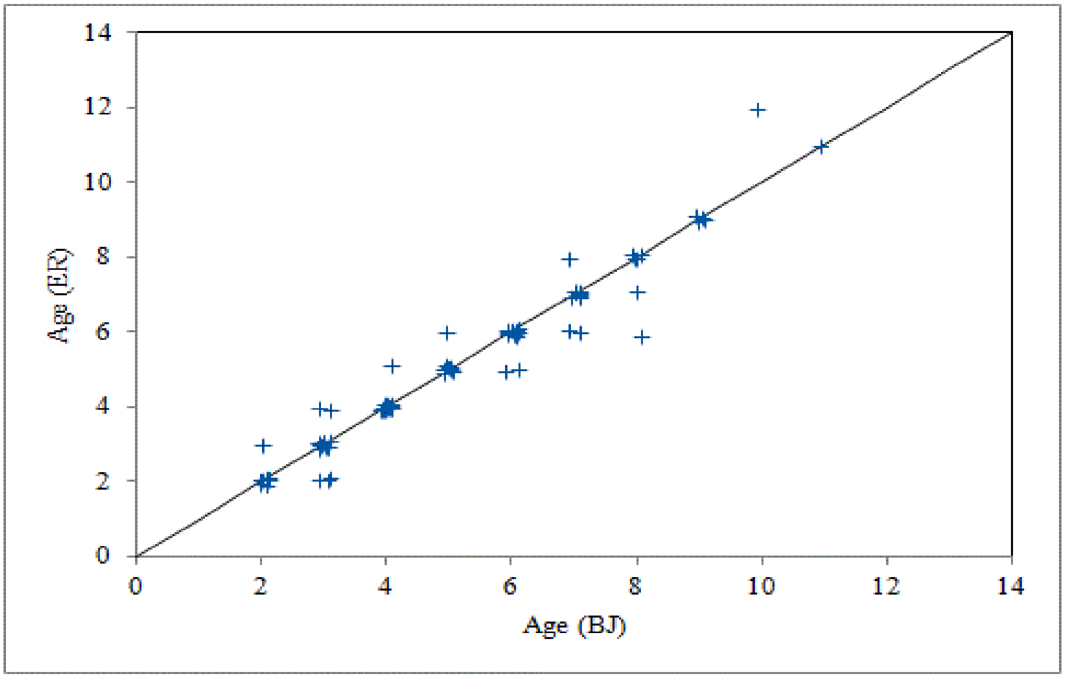


Figure A55. Age bias plot for Northeast Fisheries Science Center (NEFSC) 2016 quarter 1 commercial ages, 83% agreement.

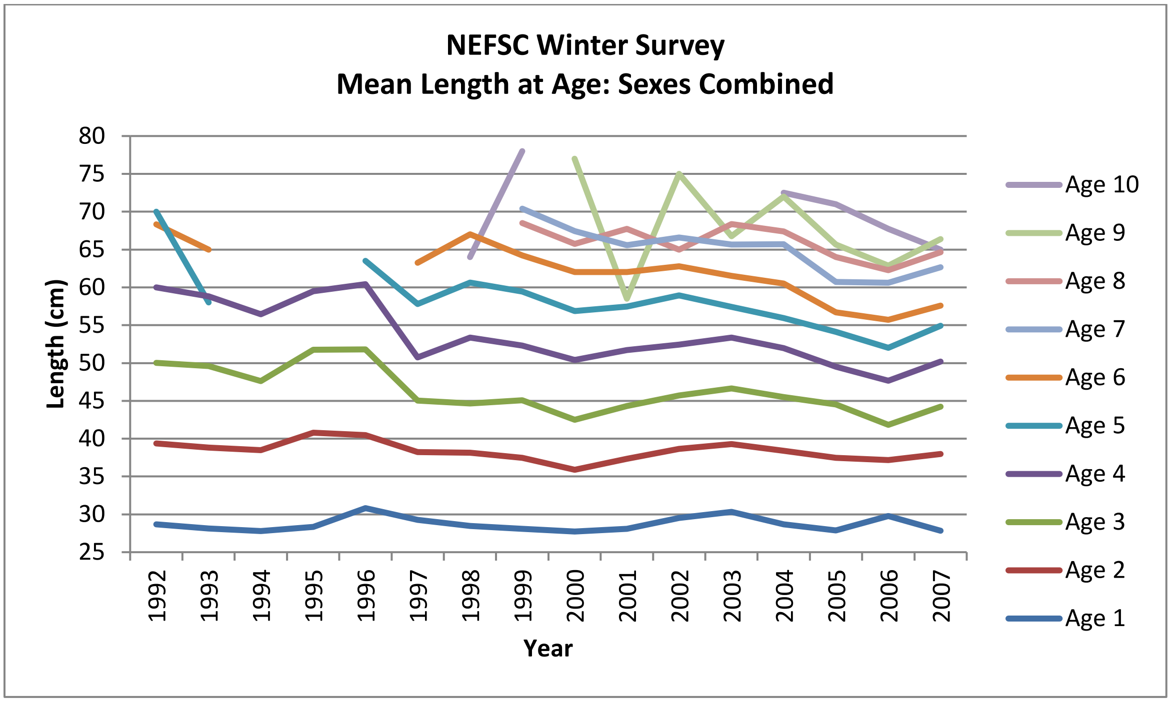


Figure A56. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) winter trawl survey: sexes combined.

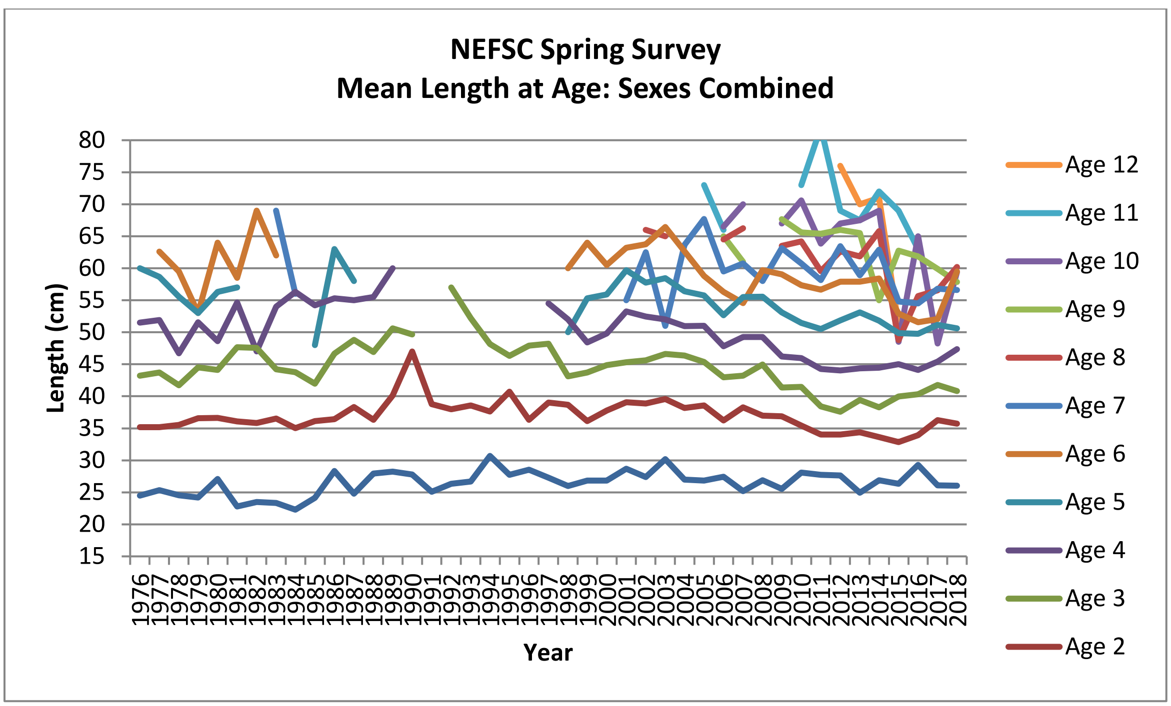


Figure A57. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) spring trawl survey: sexes combined.

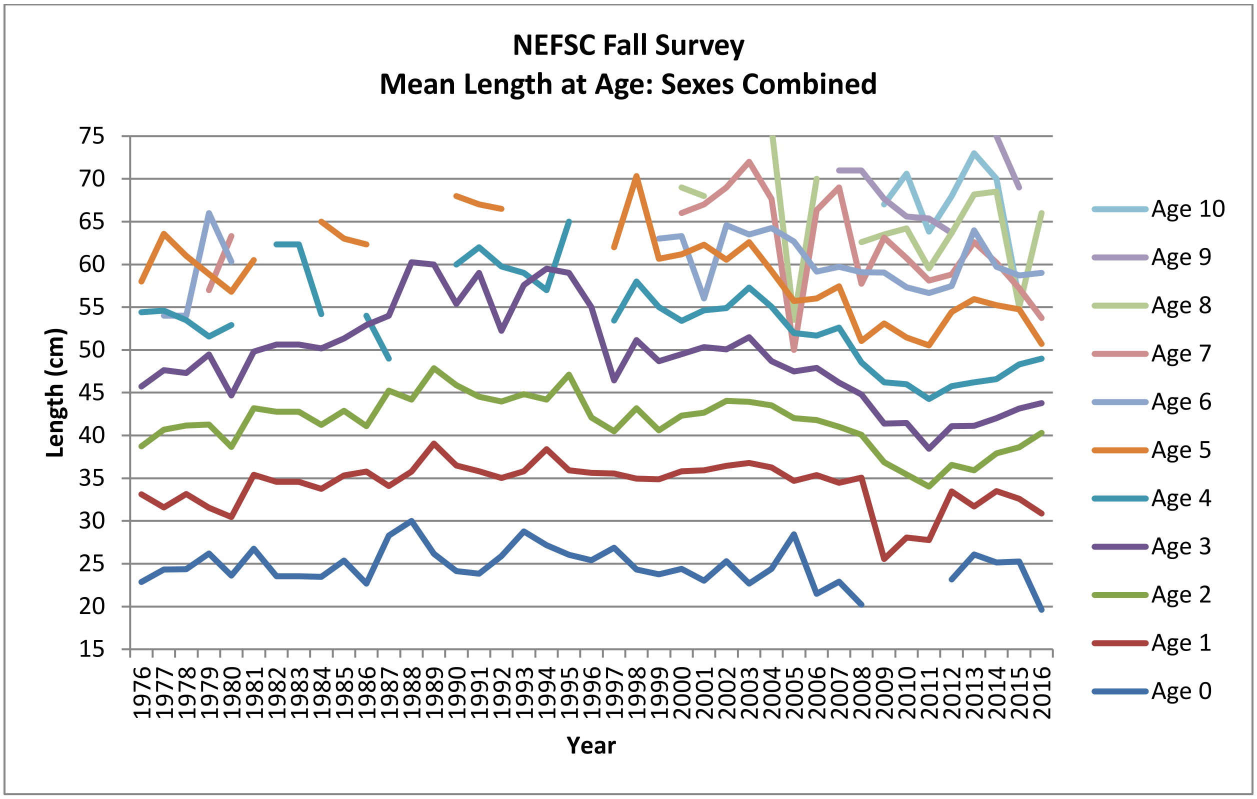


Figure A58. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) fall trawl survey: sexes combined.

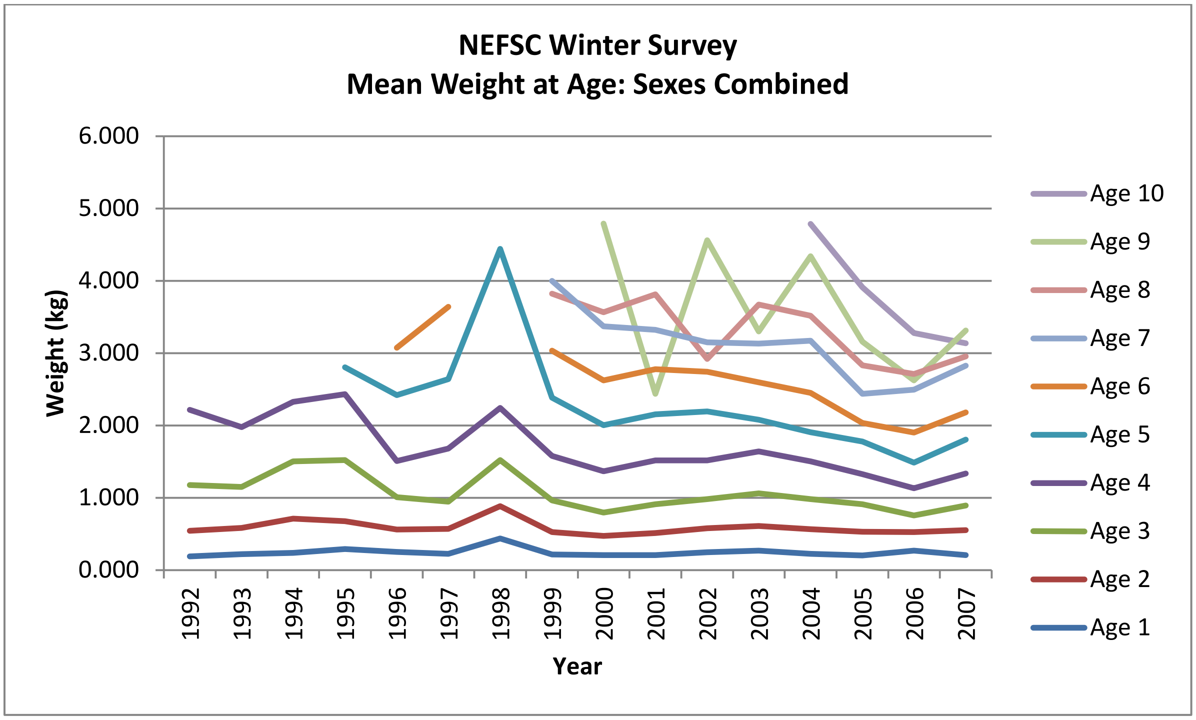


Figure A59. Trend in mean weight at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) winter trawl survey: sexes combined.

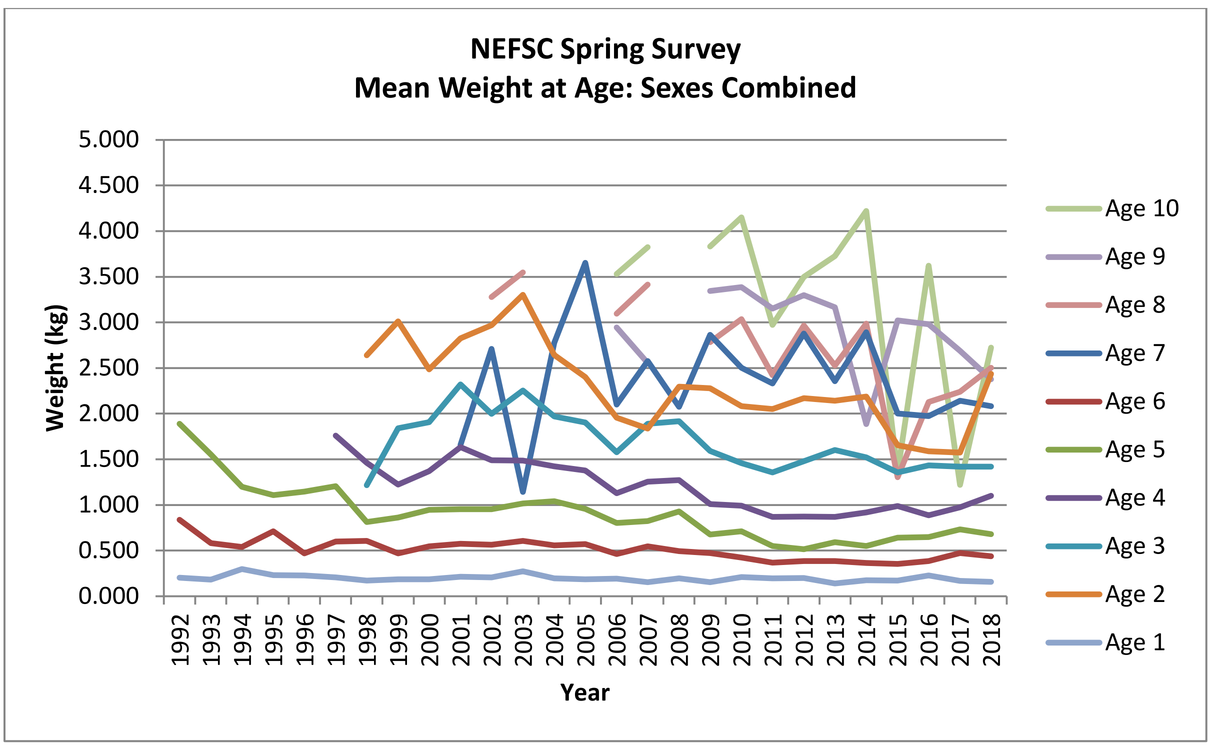


Figure A60. Trend in mean weight at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) spring trawl survey: sexes combined.

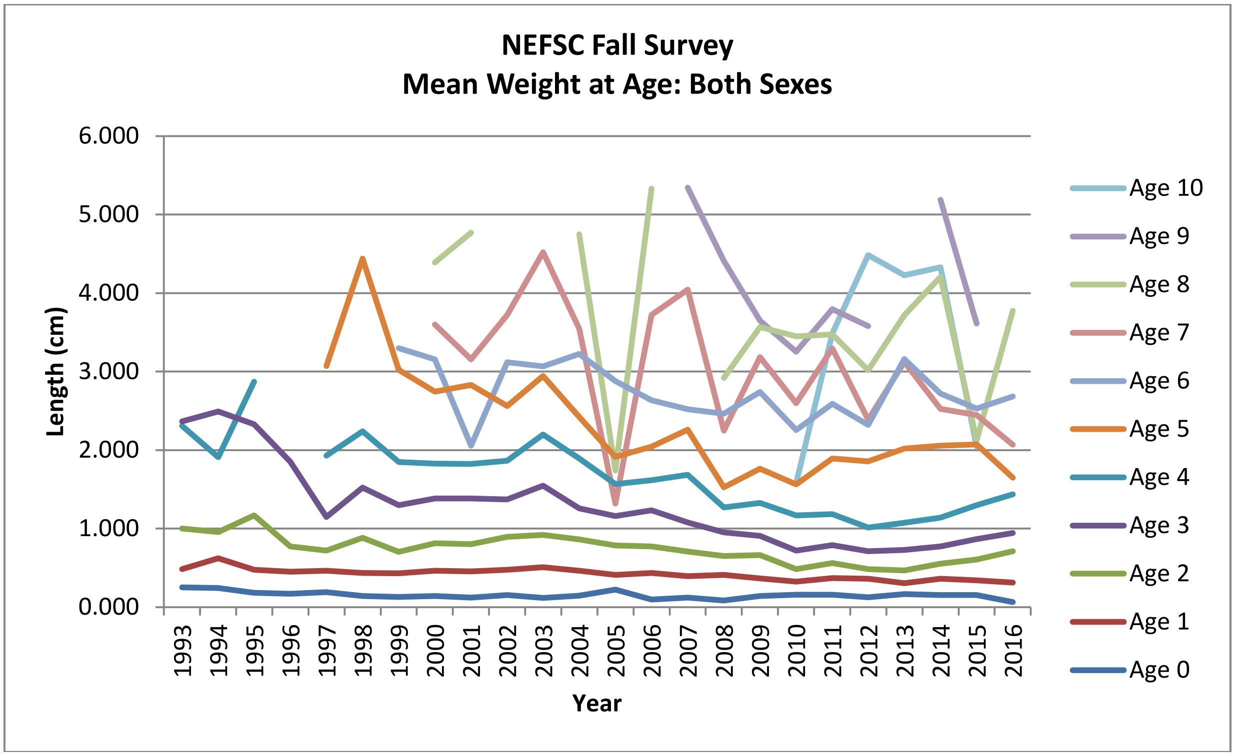


Figure A61. Trend in mean weight at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) fall trawl survey: sexes combined.

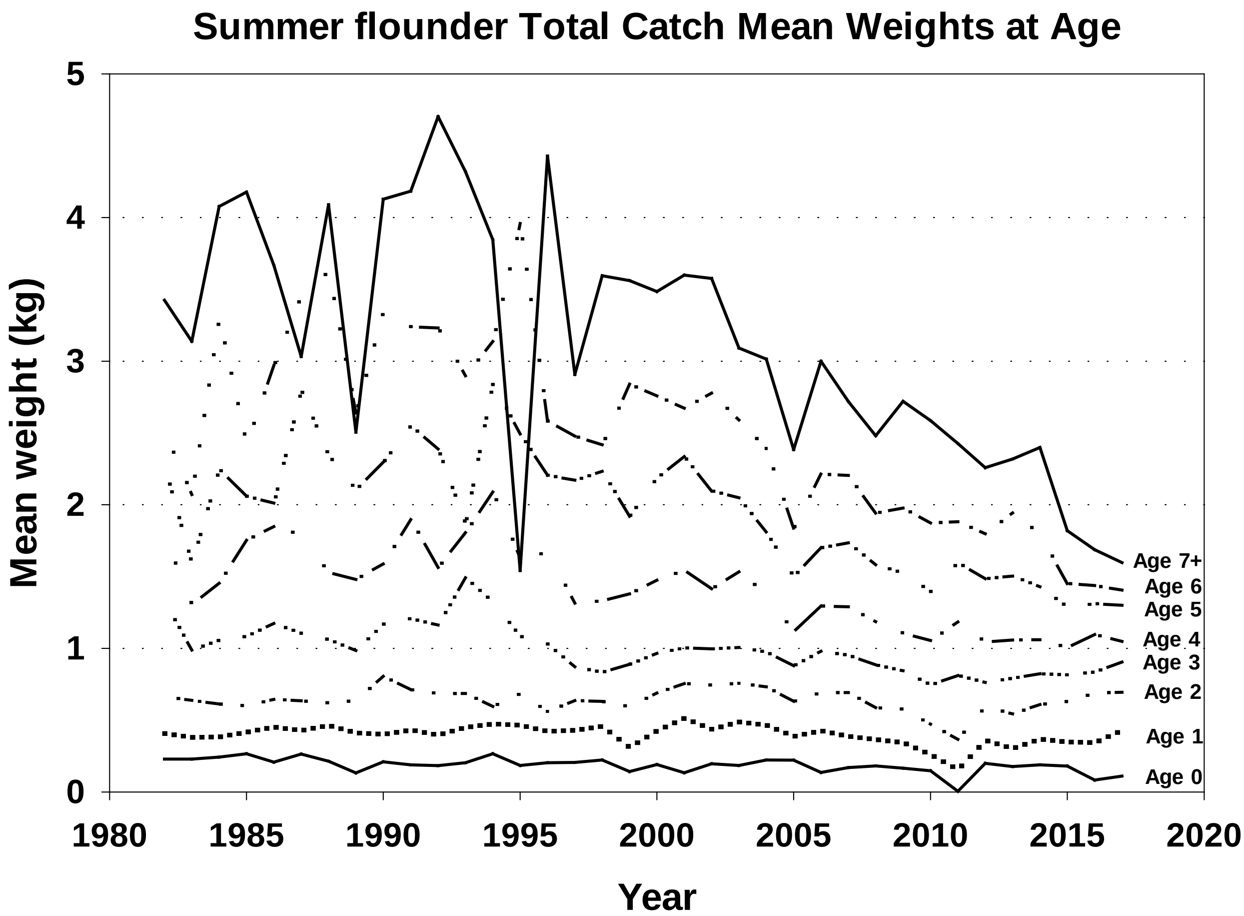
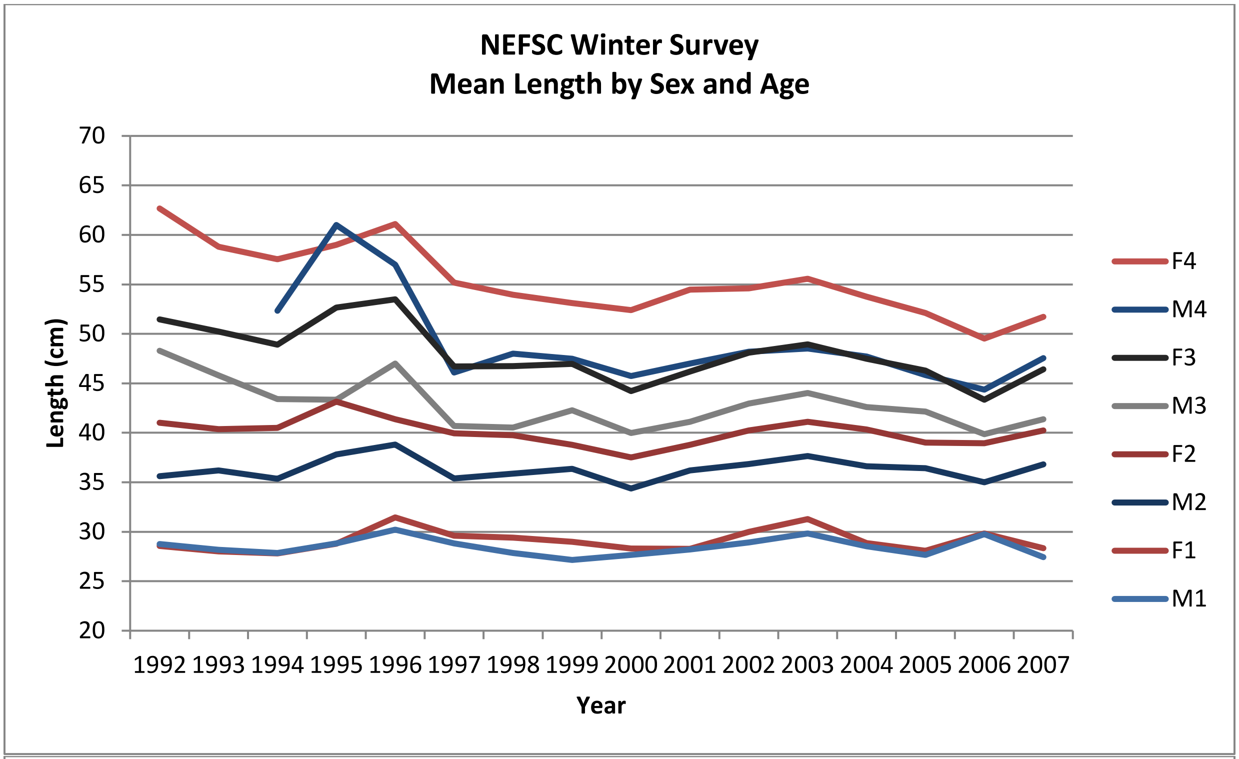


Figure A62. Trend in mean weight at age for the fishery total catch (sampled lengths converted to weights): sexes combined.



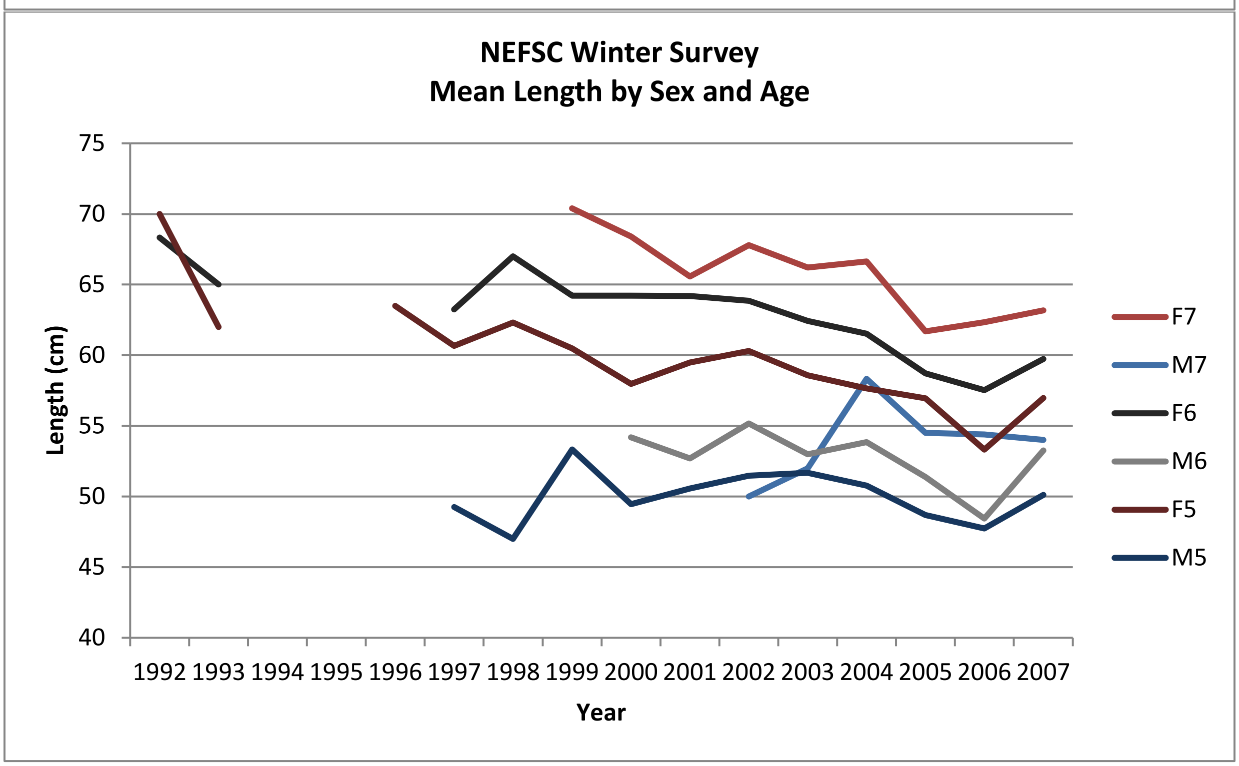


Figure A63. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) winter trawl survey: by sex and age; e.g., M1 = age 1 males, F7 = age 7 females.

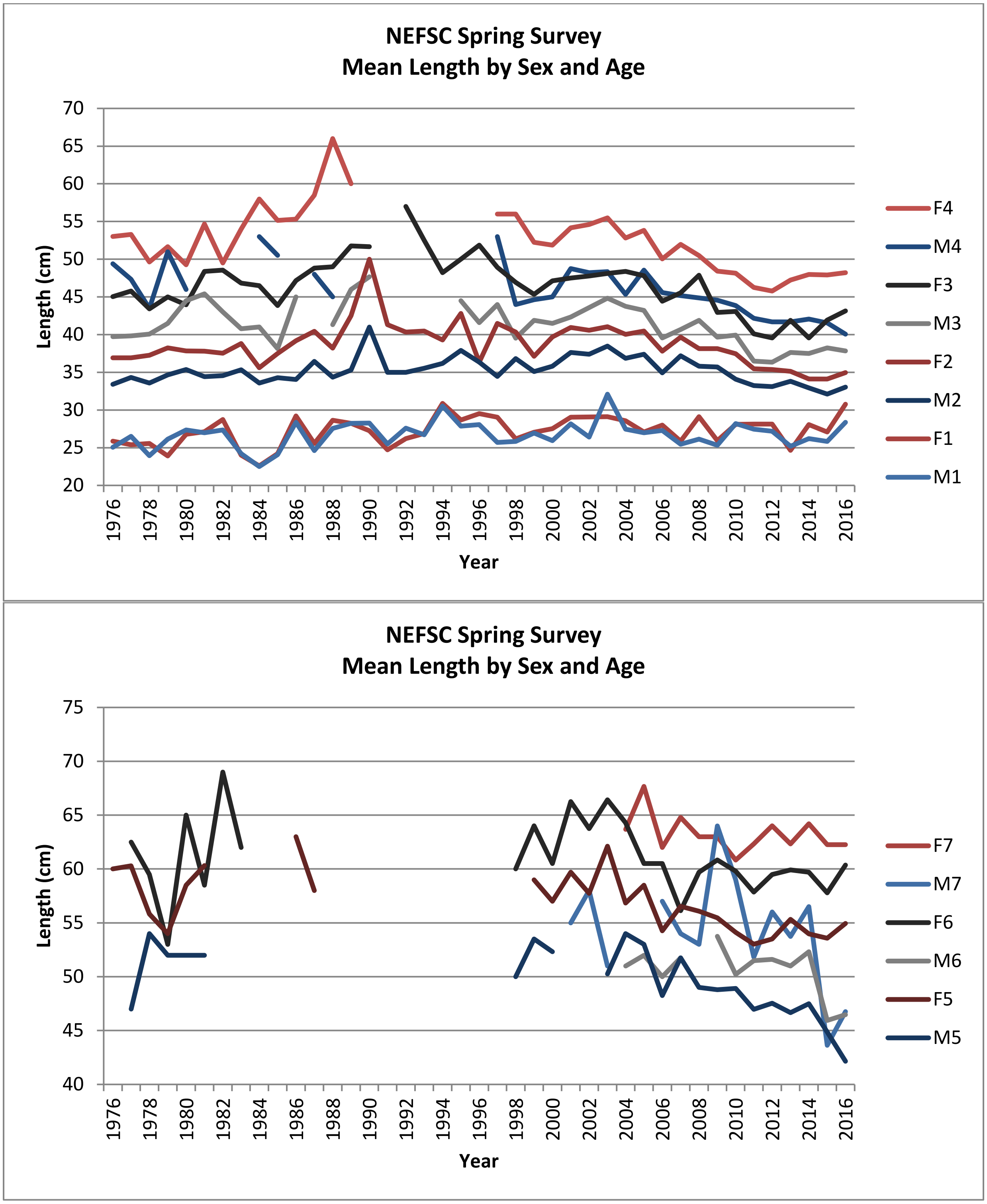
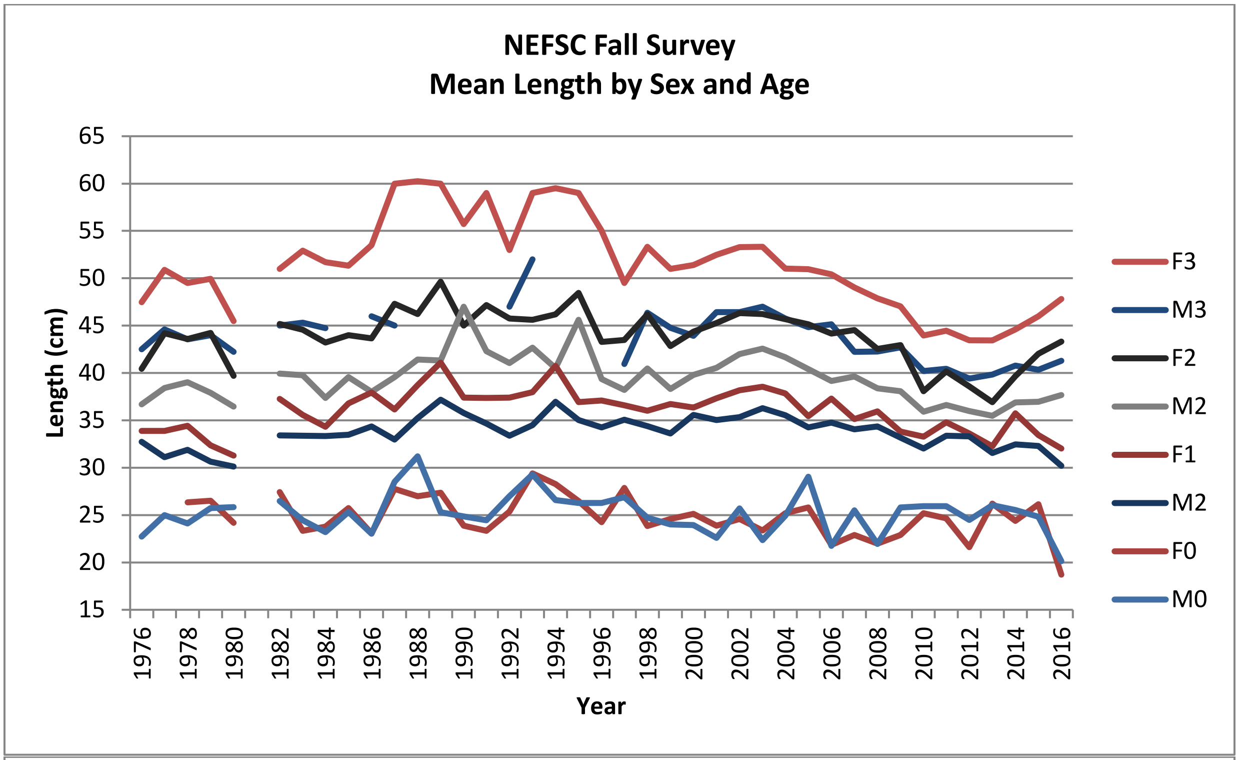


Figure A64. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) spring trawl survey: by sex and age; e.g., M1 = age 1 males, F7 = age 7 females.



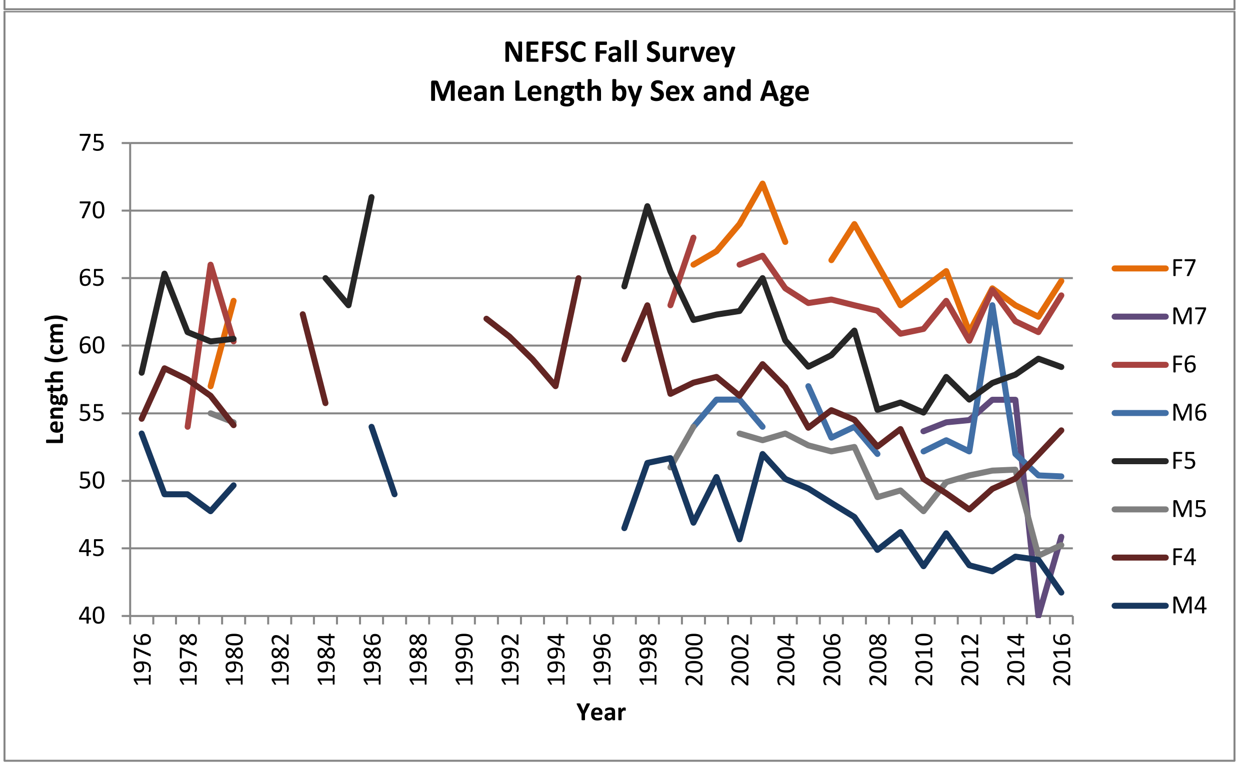


Figure A65. Trend in mean length at age for fish sampled in the Northeast Fisheries Science Center (NEFSC) fall trawl survey: by sex and age; e.g., M0 = age 0 males, F7 = age 7 females.

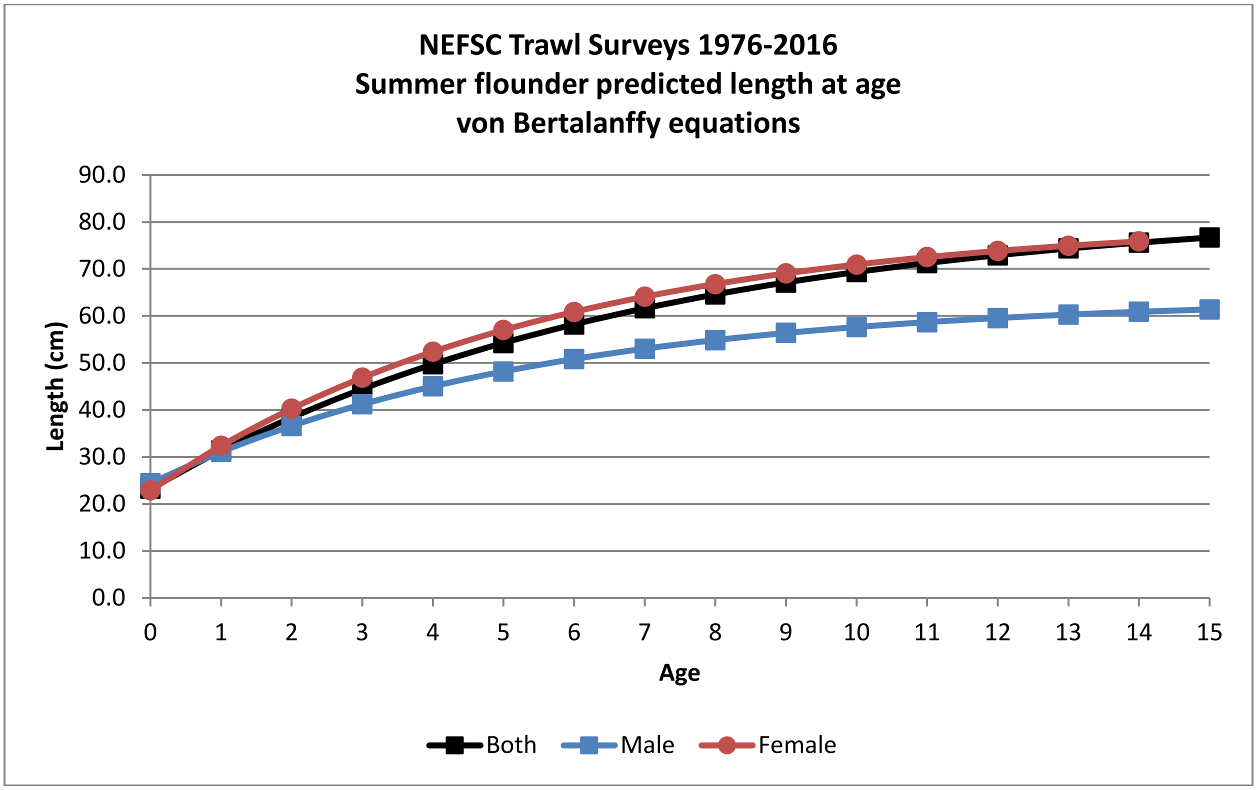
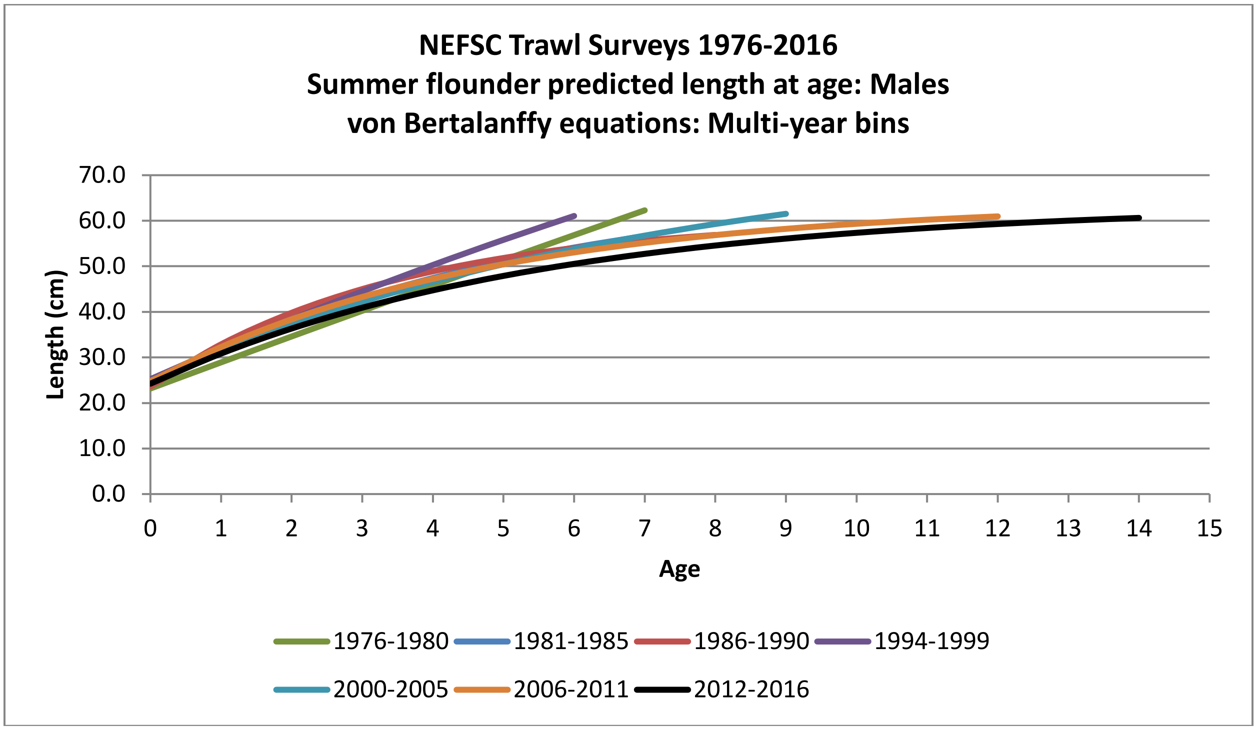


Figure A66. Predicted length at age from von Bertalanffy equations parameters estimated from Northeast Fisheries Science Center (NEFSC) trawl survey data. Maximum observed age for males is age 15; for females is age 14.



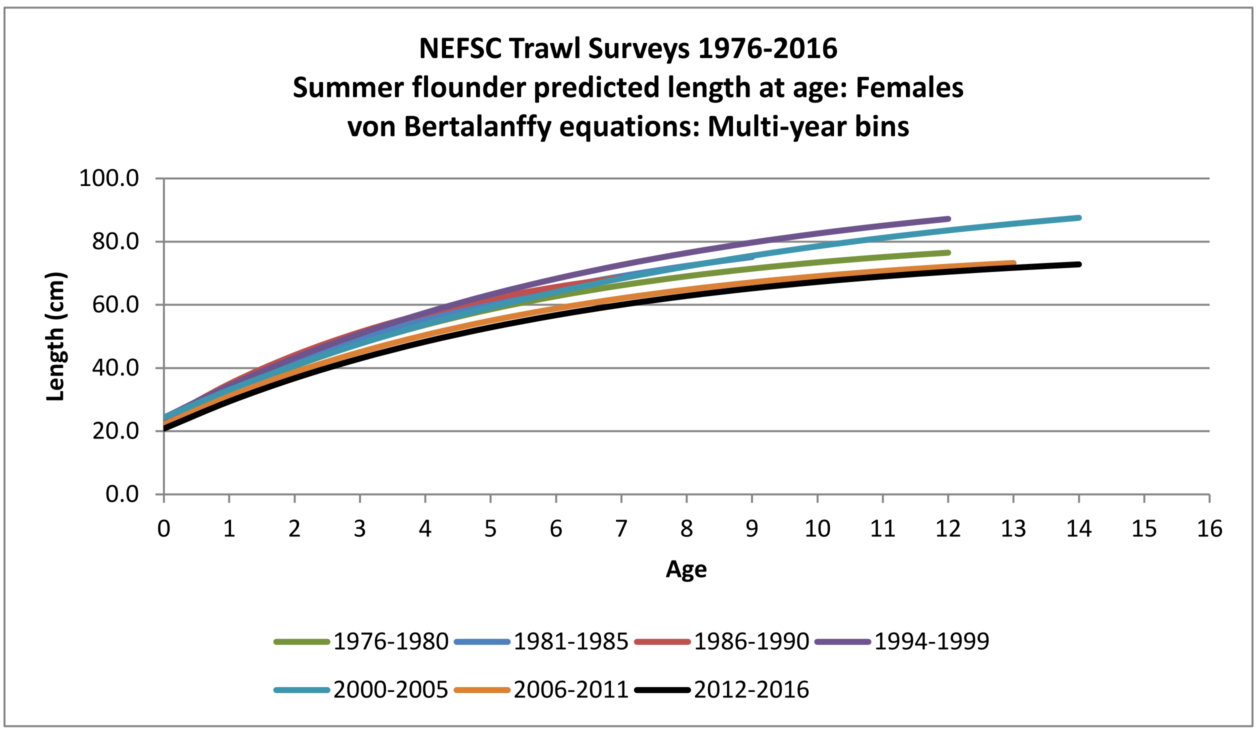


Figure A67. Predicted length at age from von Bertalanffy equations parameters estimated from Northeast Fisheries Science Center (NEFSC) trawl survey data for multi-year bins by sex. Curves plotted through the maximum observed ages for each bin and sex.

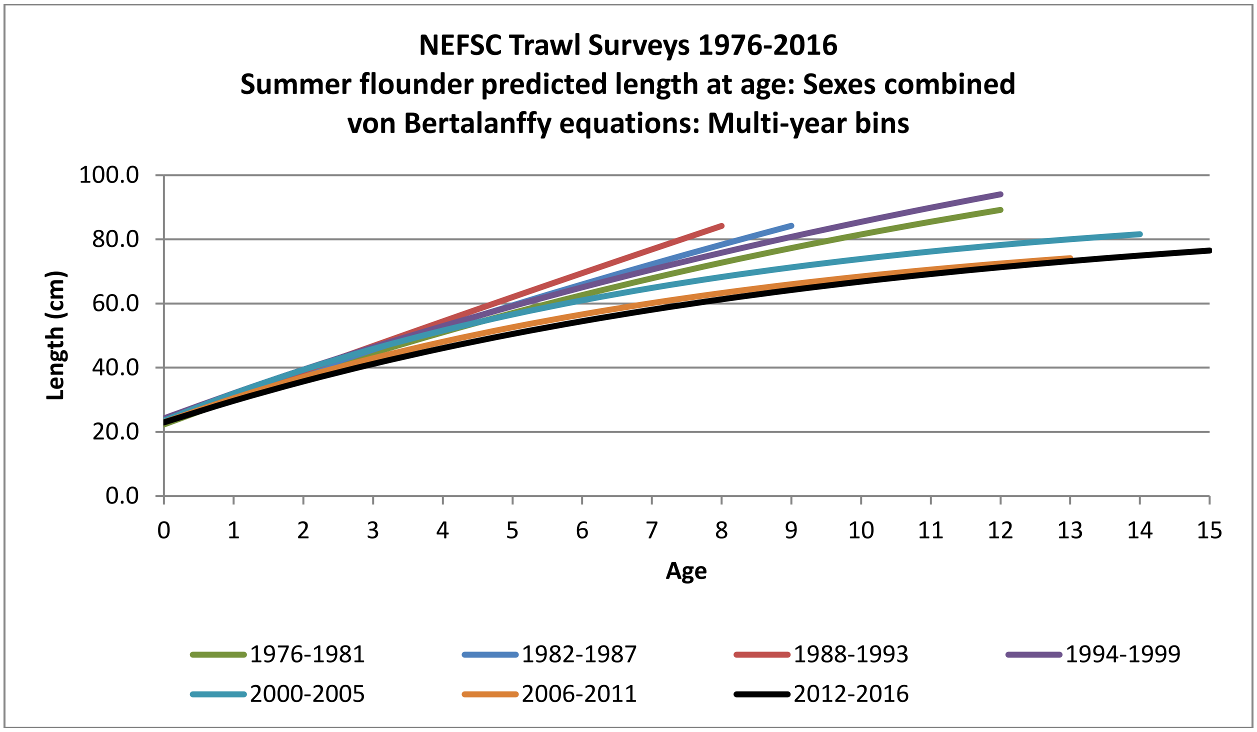


Figure A68. Predicted length at age from von Bertalanffy equations parameters estimated from Northeast Fisheries Science Center (NEFSC) trawl survey data for multi-year bins by sexes combined. Curves plotted through the maximum observed ages for each bin.

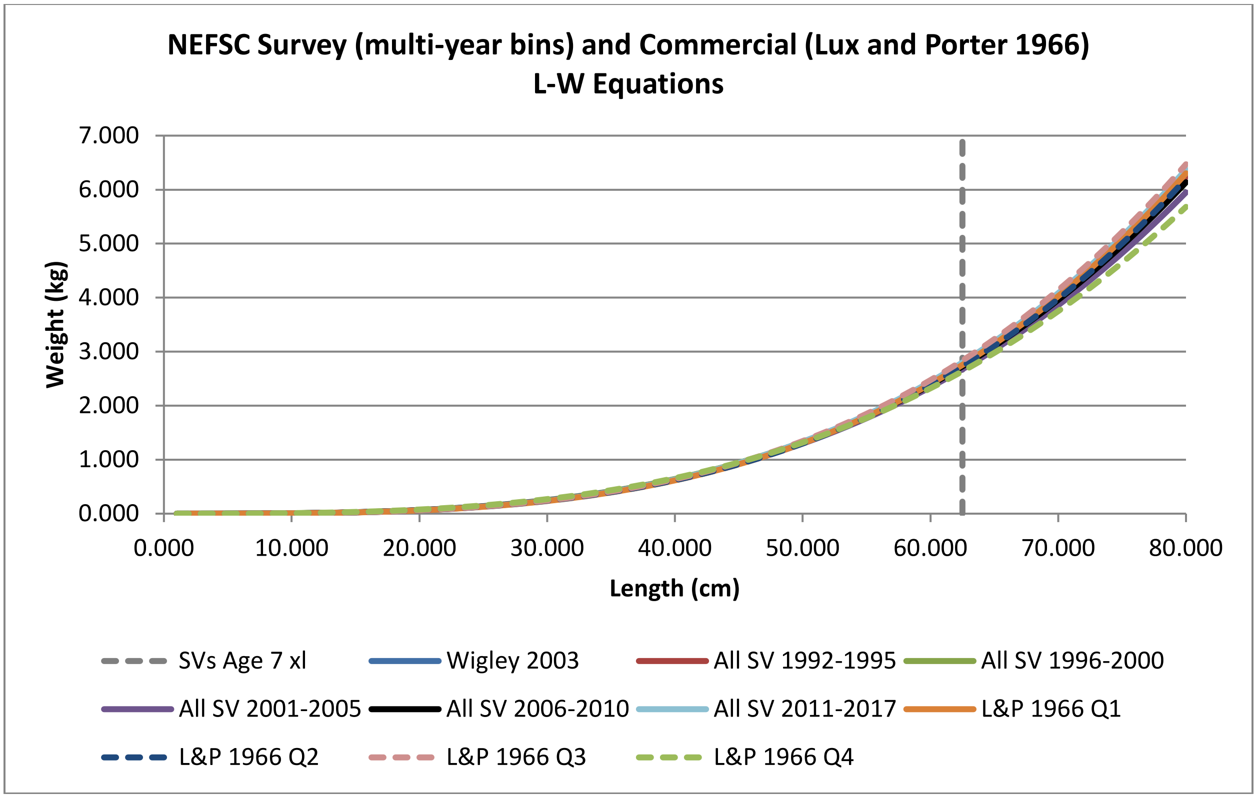


Figure A69. Length-weight relationships from the works of Lux and Porter (1966; L&P), Wigley et al. (2003; Wigley), and the current work (all surveys combined multi-year bins) Vertical gray line is the mean length of age 7 in Northeast Fisheries Science Center (NEFSC) surveys.

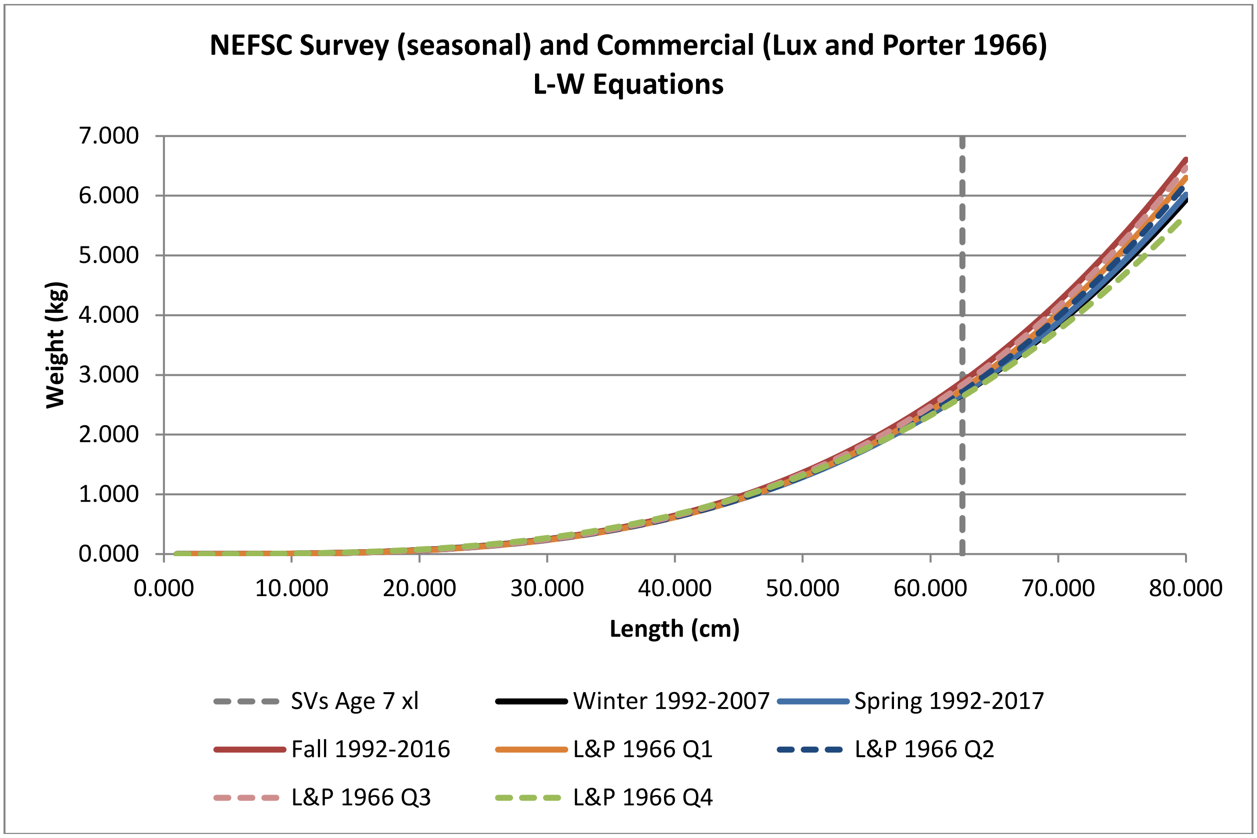


Figure A70. Length-weight relationships from the works of Lux and Porter (1966; L&P) and the current work (seasonal surveys: winter 1992-2007, spring 1992-2017, fall 1992-2016). Vertical gray line is the mean length of age 7 in Northeast Fisheries Science Center (NEFSC) surveys.

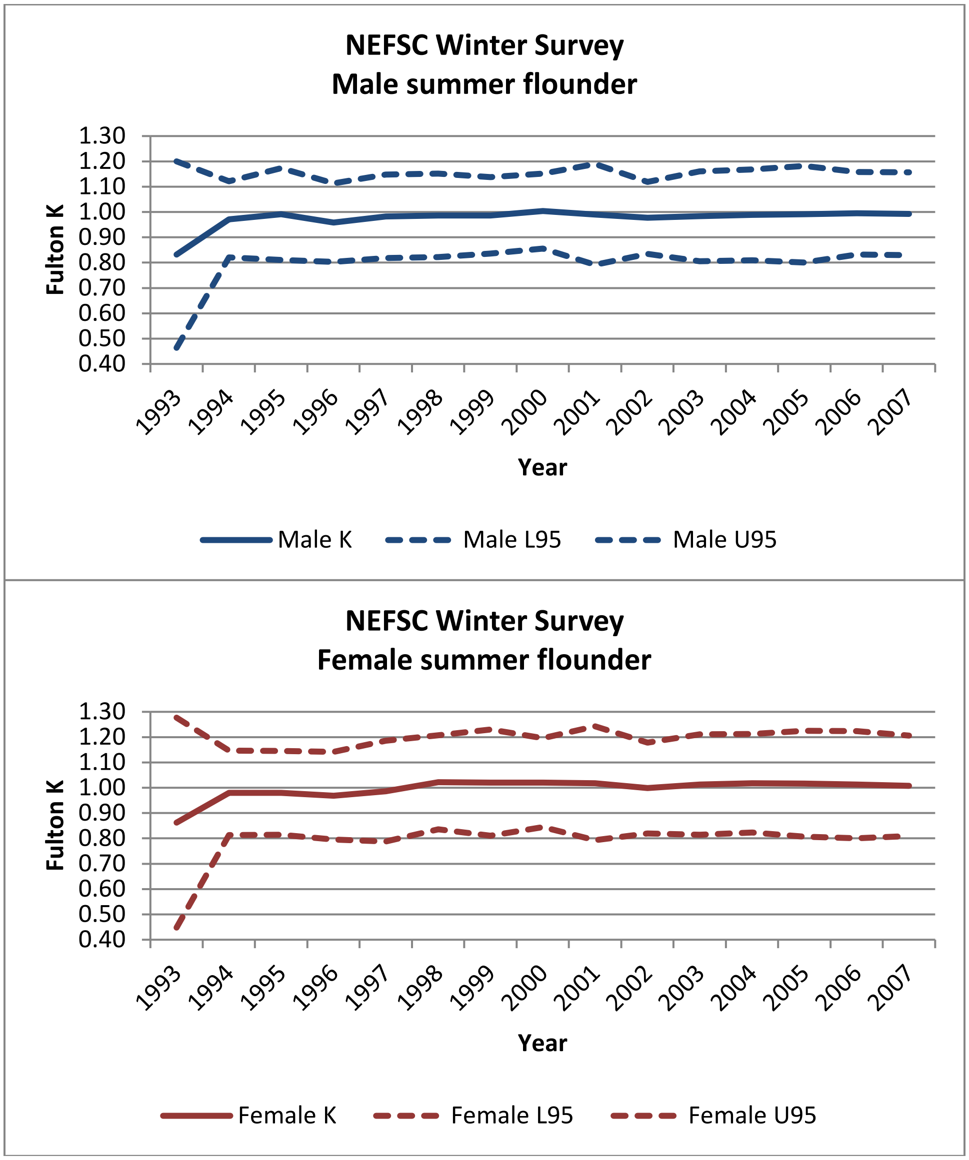


Figure A71. Seasonal condition factor of summer flounder: Northeast Fisheries Science Center (NEFSC) winter survey by sex.

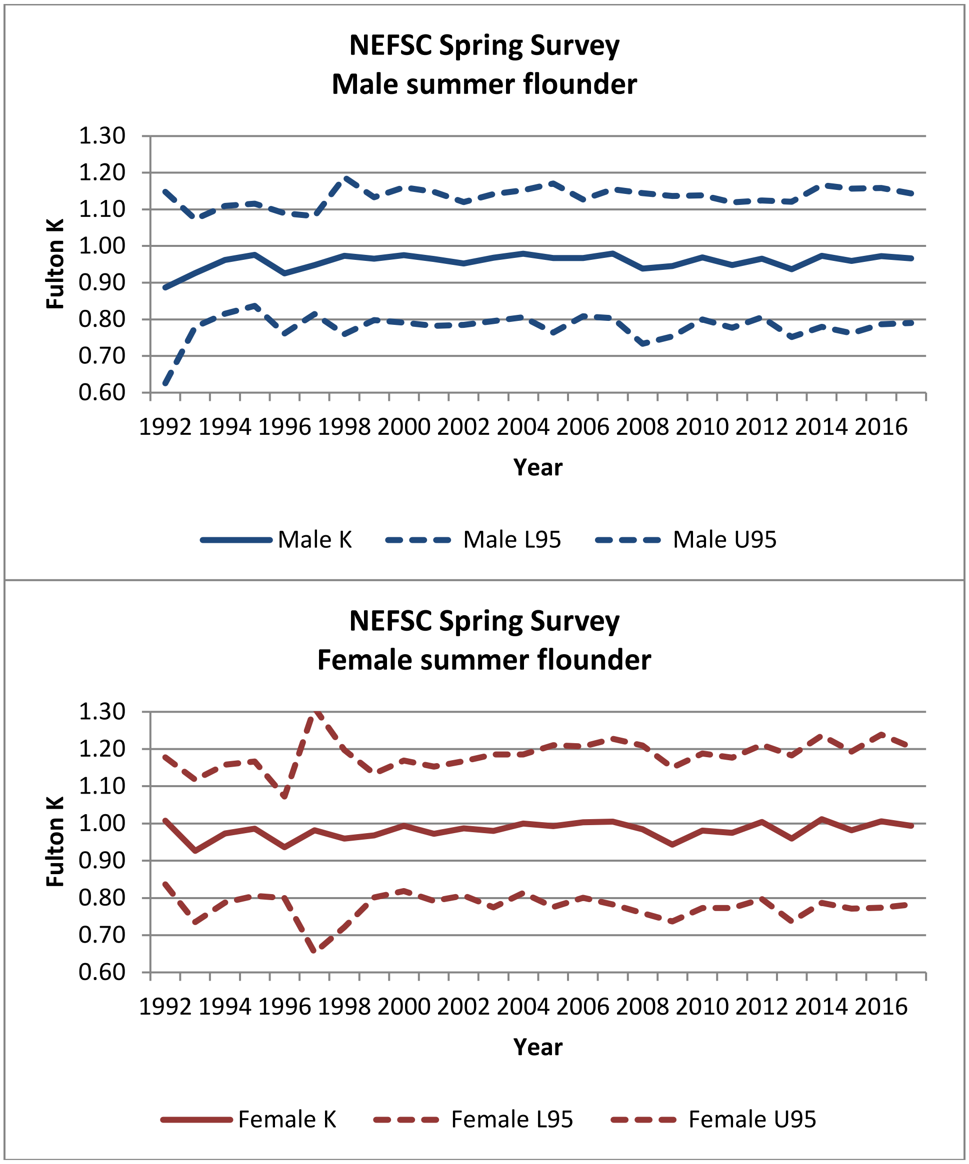


Figure A72. Seasonal condition factor of summer flounder: Northeast Fisheries Science Center (NEFSC) spring survey by sex.

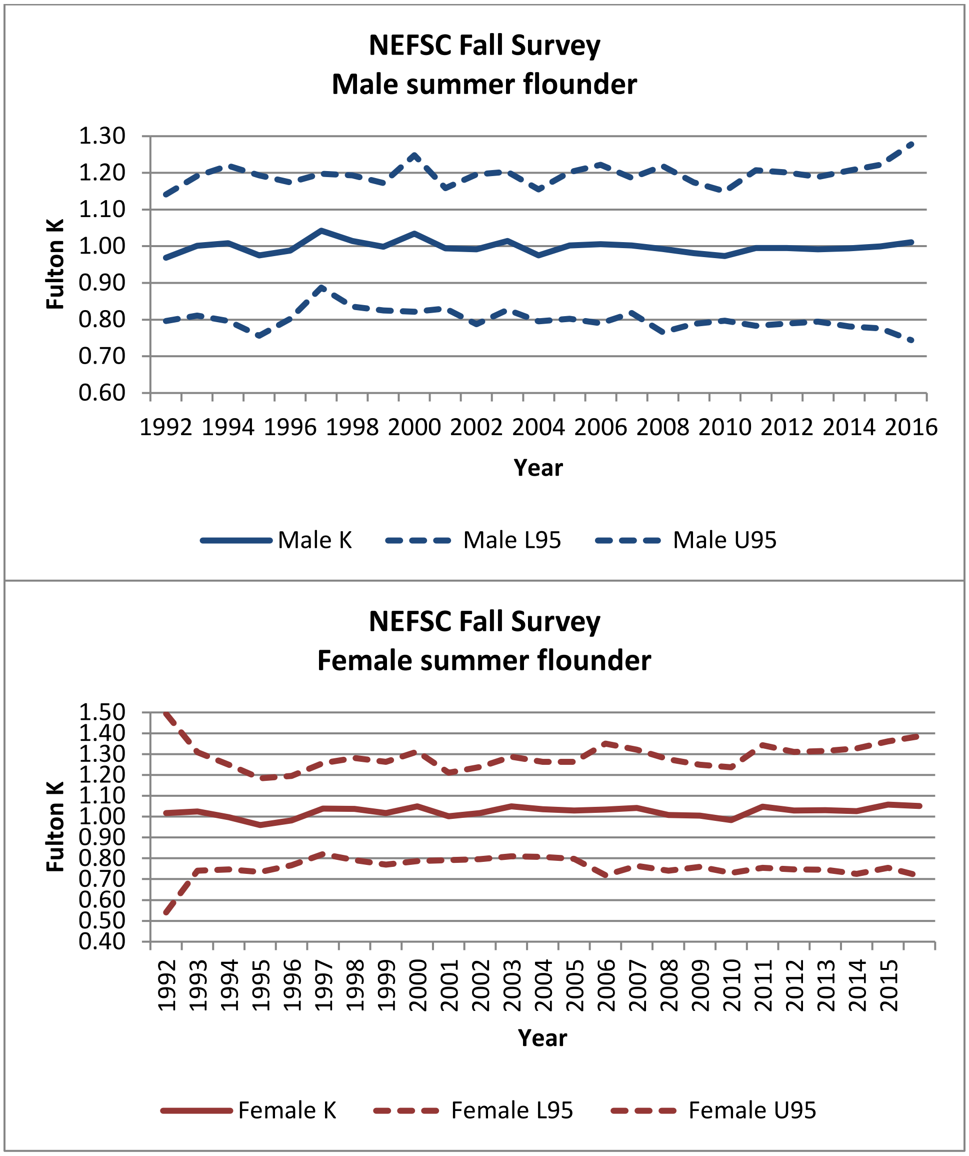


Figure A73. Seasonal condition factor of summer flounder: Northeast Fisheries Science Center (NEFSC) fall survey by sex.

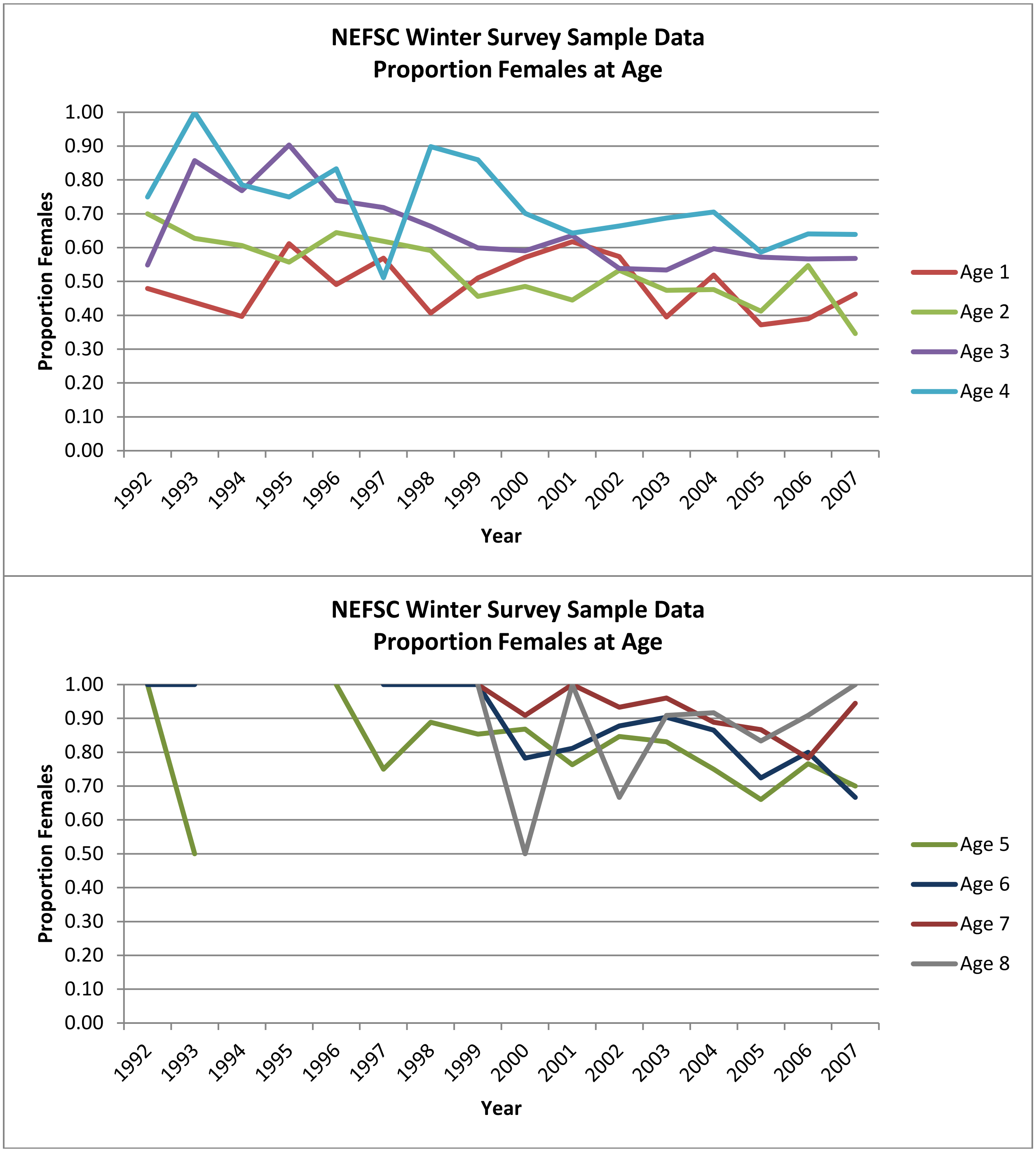


Figure A74. Northeast Fisheries Science Center (NEFSC) winter survey sample data: proportion female at age.

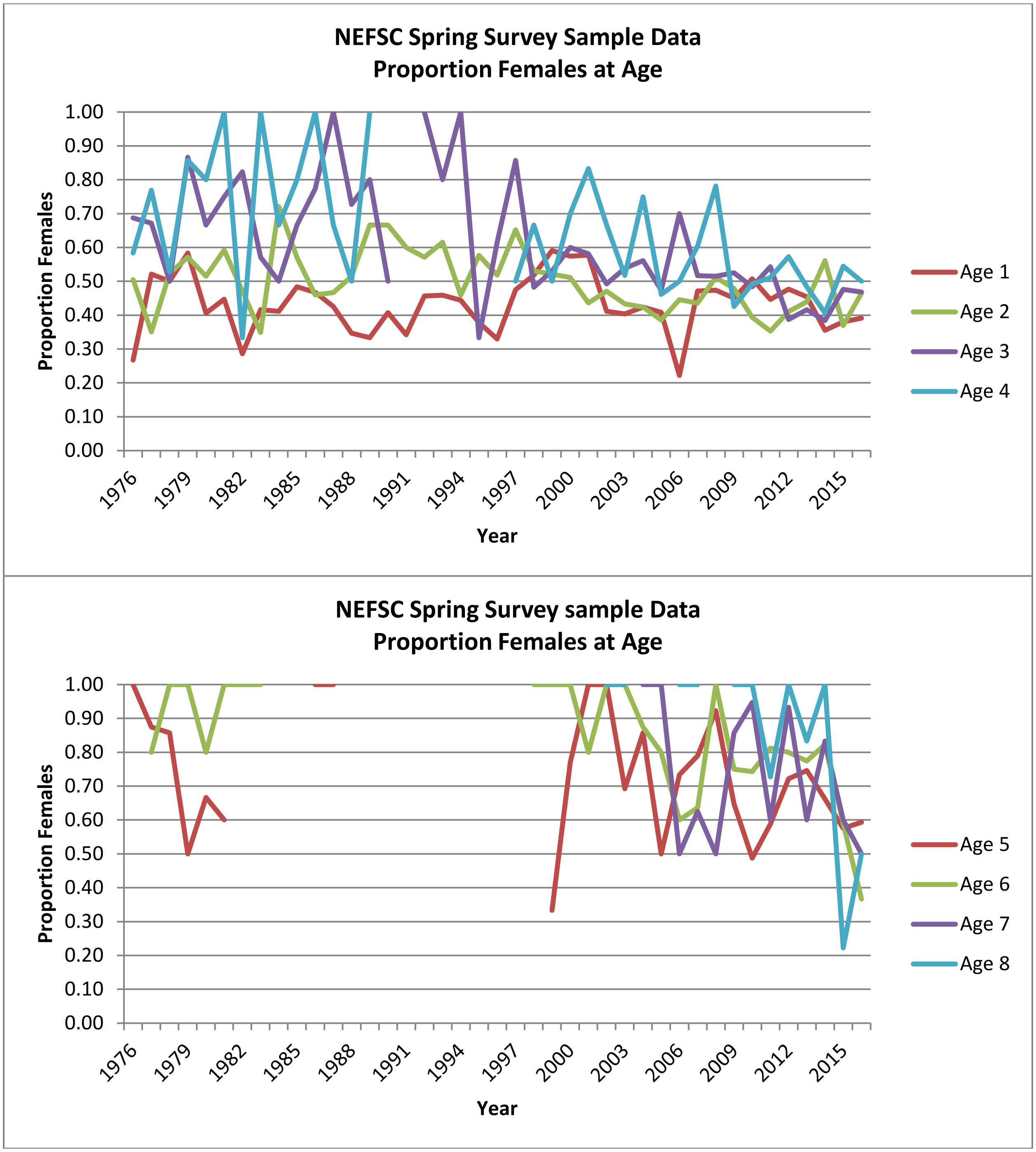


Figure A75: Northeast Fisheries Science Center (NEFSC) spring survey sample data: proportion female at age.

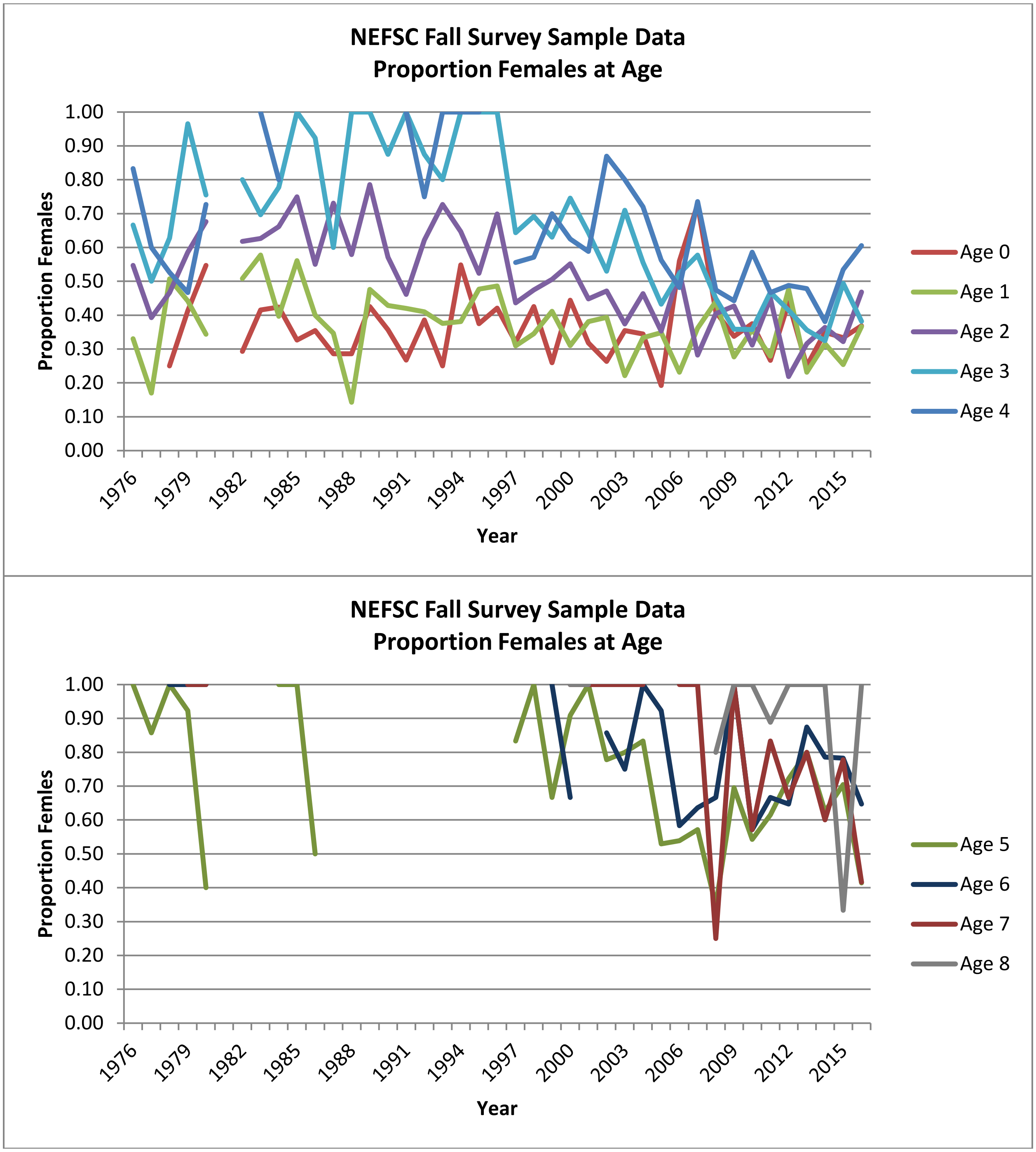


Figure A76: Northeast Fisheries Science Center (NEFSC) fall survey: proportion female at age.

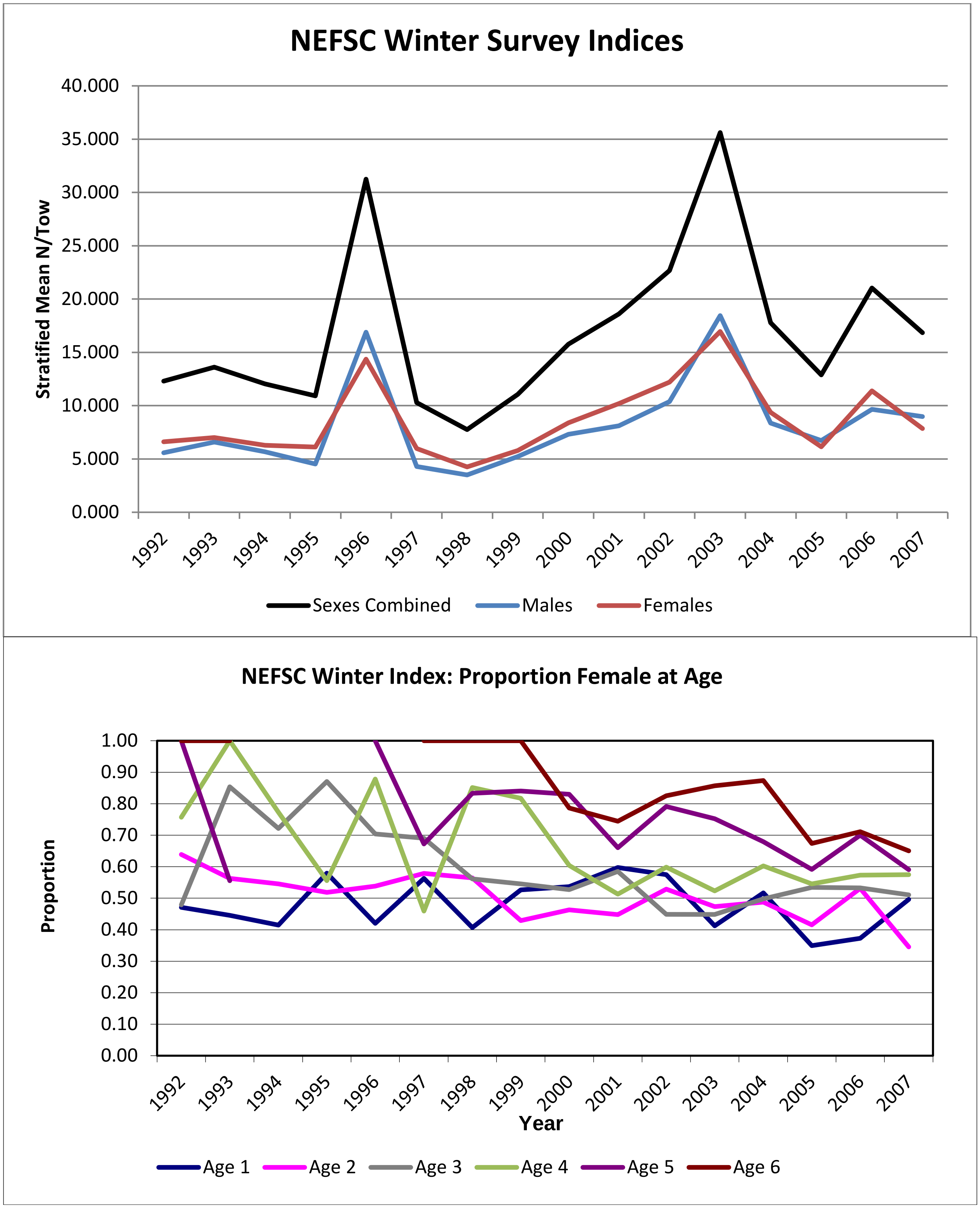


Figure A77. Northeast Fisheries Science Center (NEFSC) winter survey indices of abundance (number per tow) for males, females, and sexes combined (top) and proportion female by age (bottom).

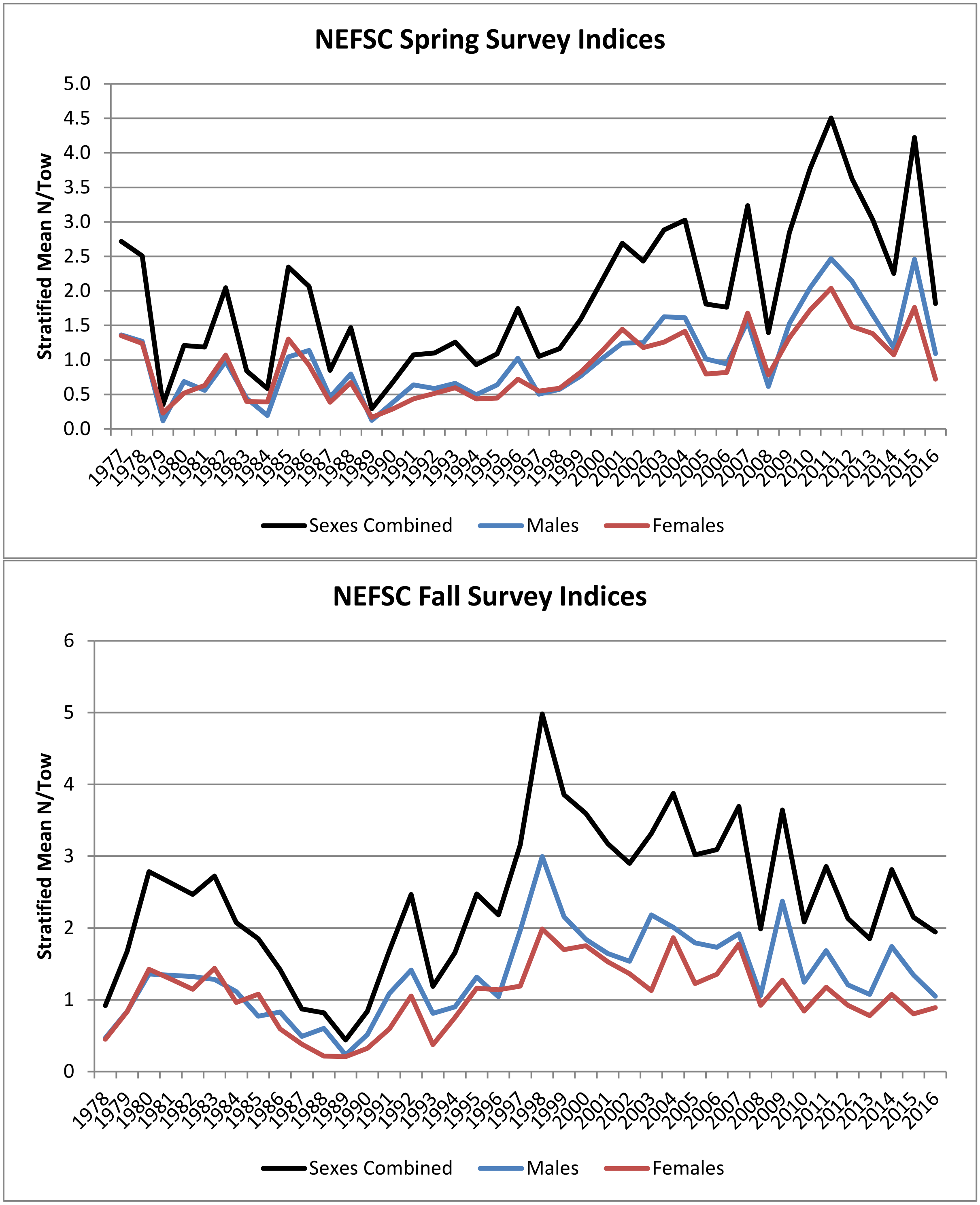


Figure A78. Northeast Fisheries Science Center (NEFSC) spring and fall survey indices of abundance (number per tow) for males, females, and sexes combined.

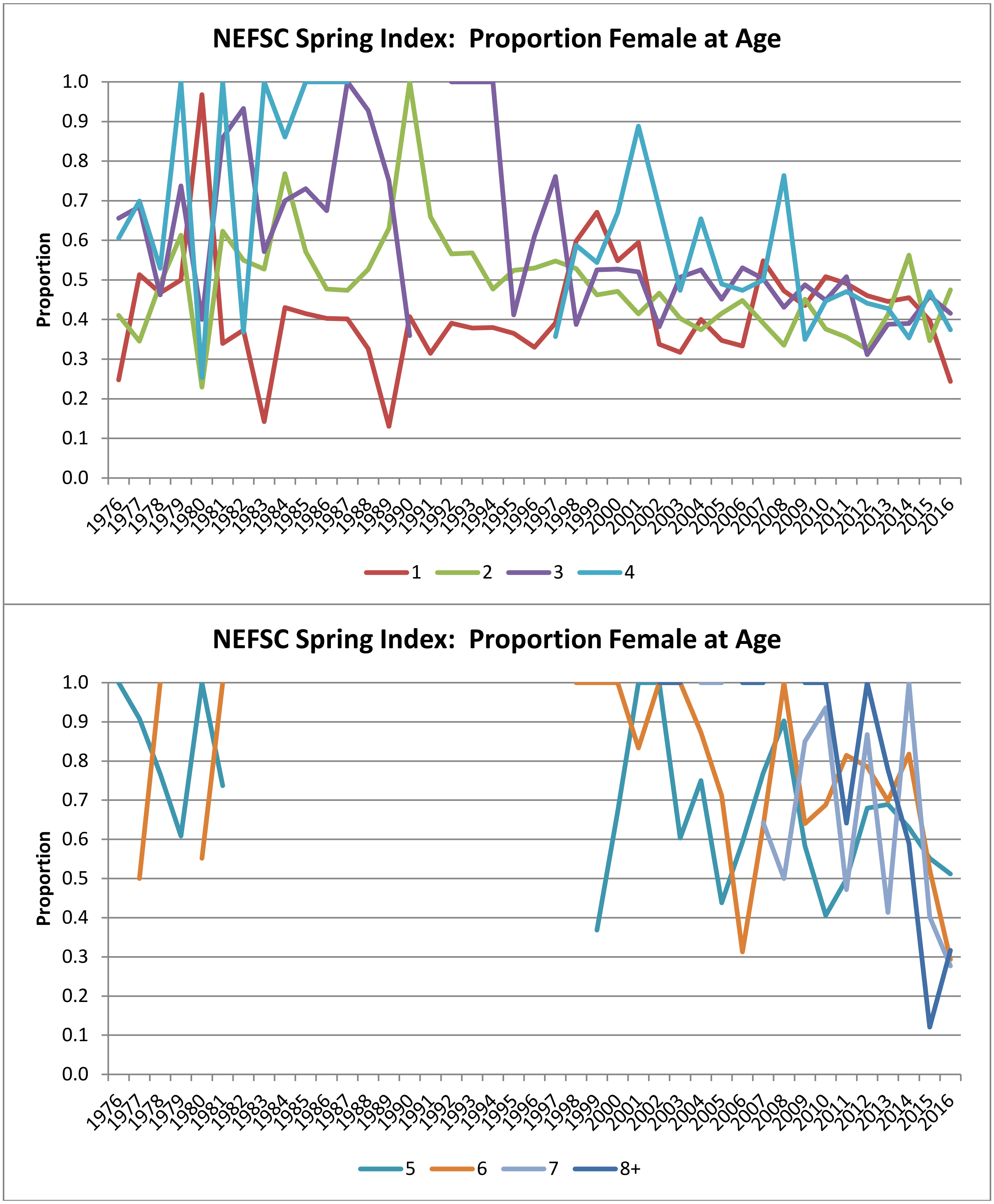


Figure A79. Northeast Fisheries Science Center (NEFSC) spring survey index proportion female by age.

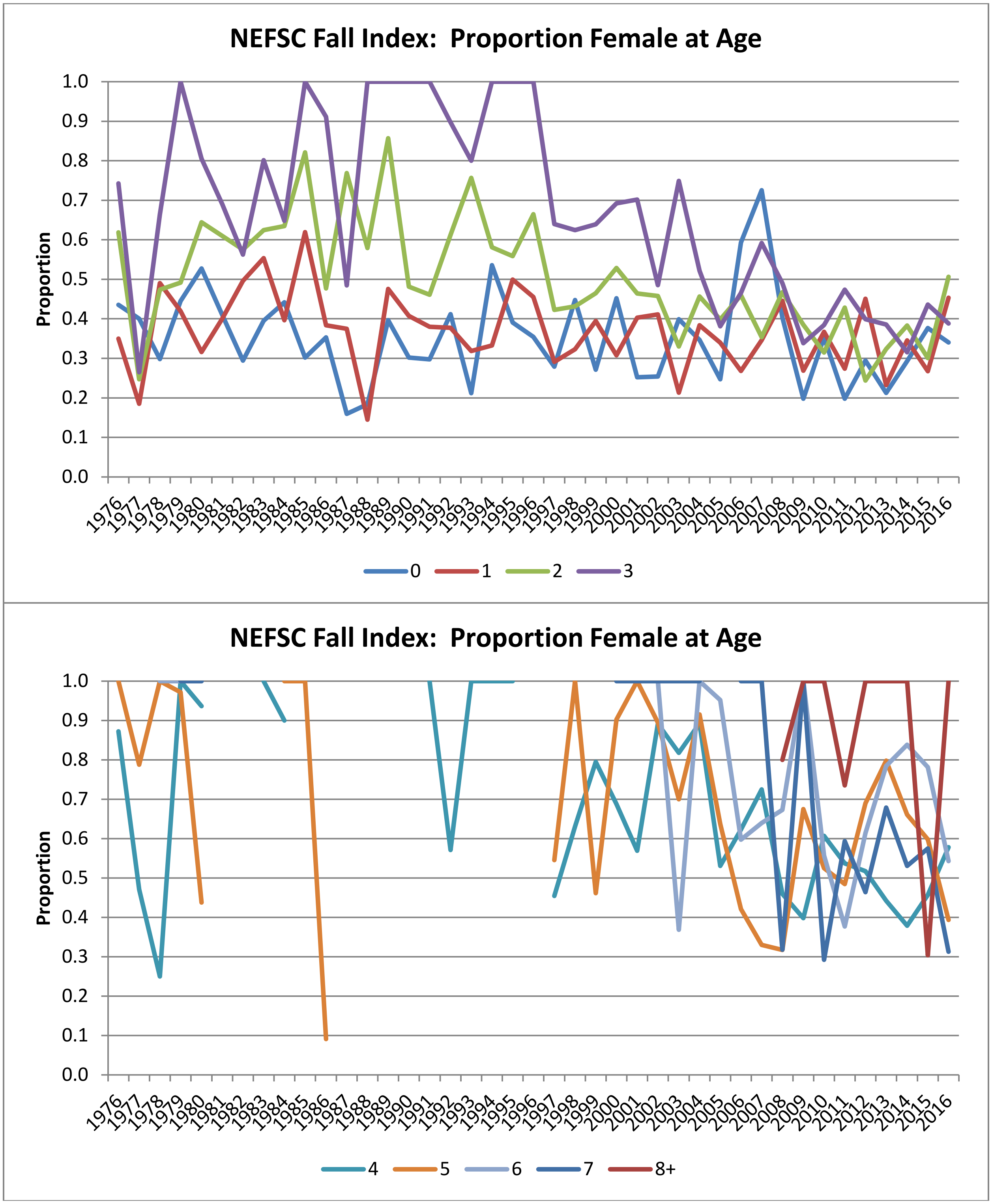


Figure A80. Northeast Fisheries Science Center (NEFSC) fall survey index proportion female by age.

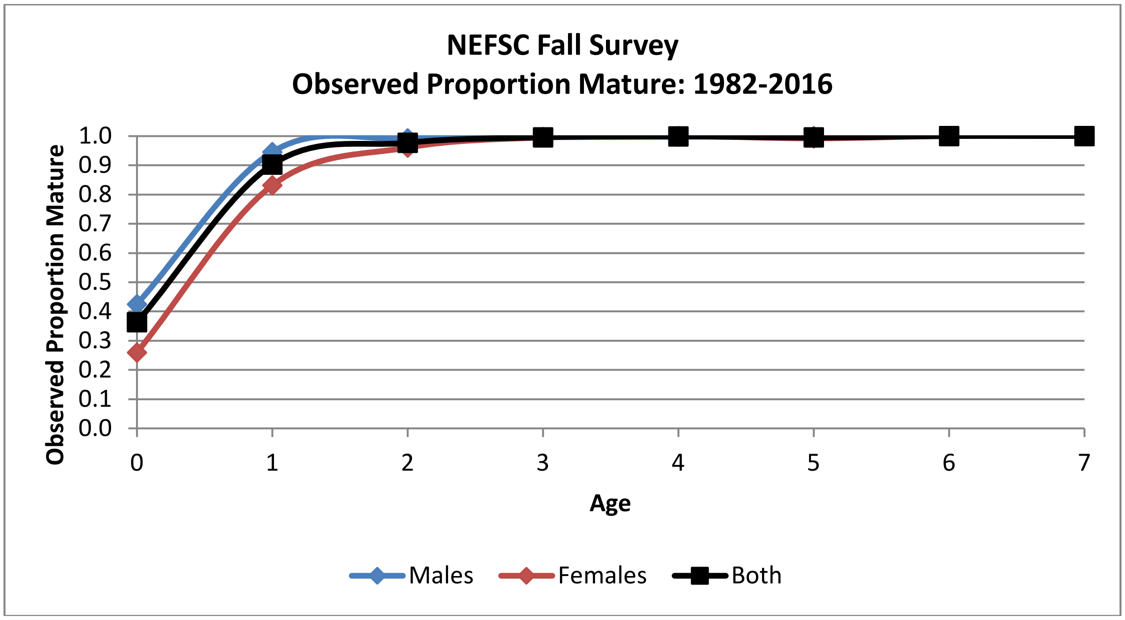


Figure A81. Observed proportion mature at age and sex from the Northeast Fisheries Science Center (NEFSC) Fall survey time series.

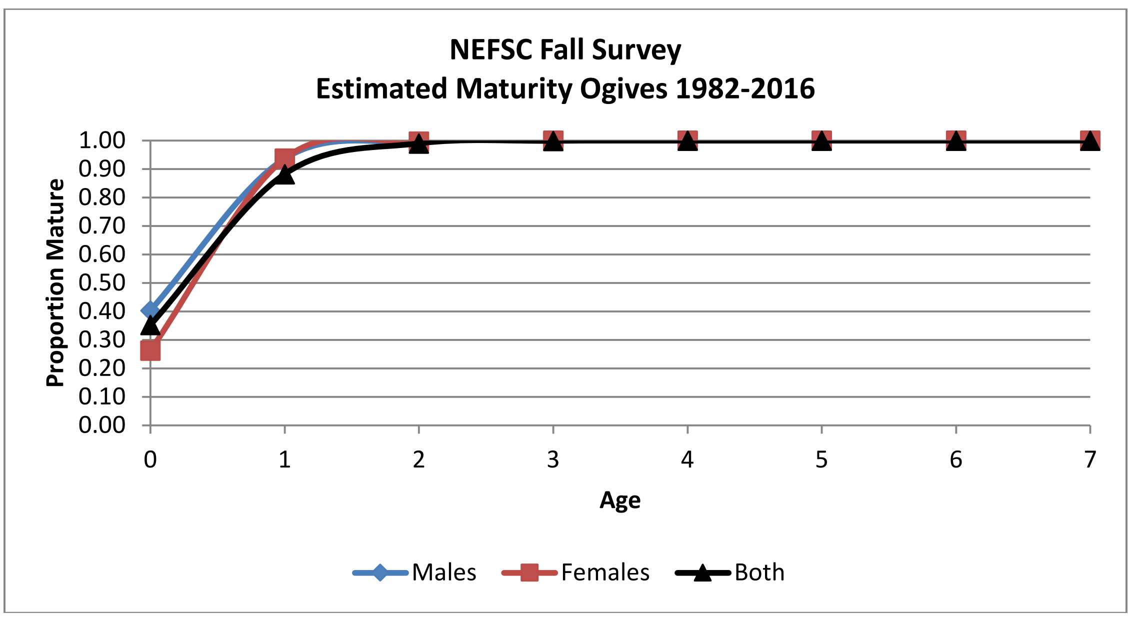


Figure A82. Estimated proportion mature at age and sex from the Northeast Fisheries Science Center (NEFSC) Fall survey time series.

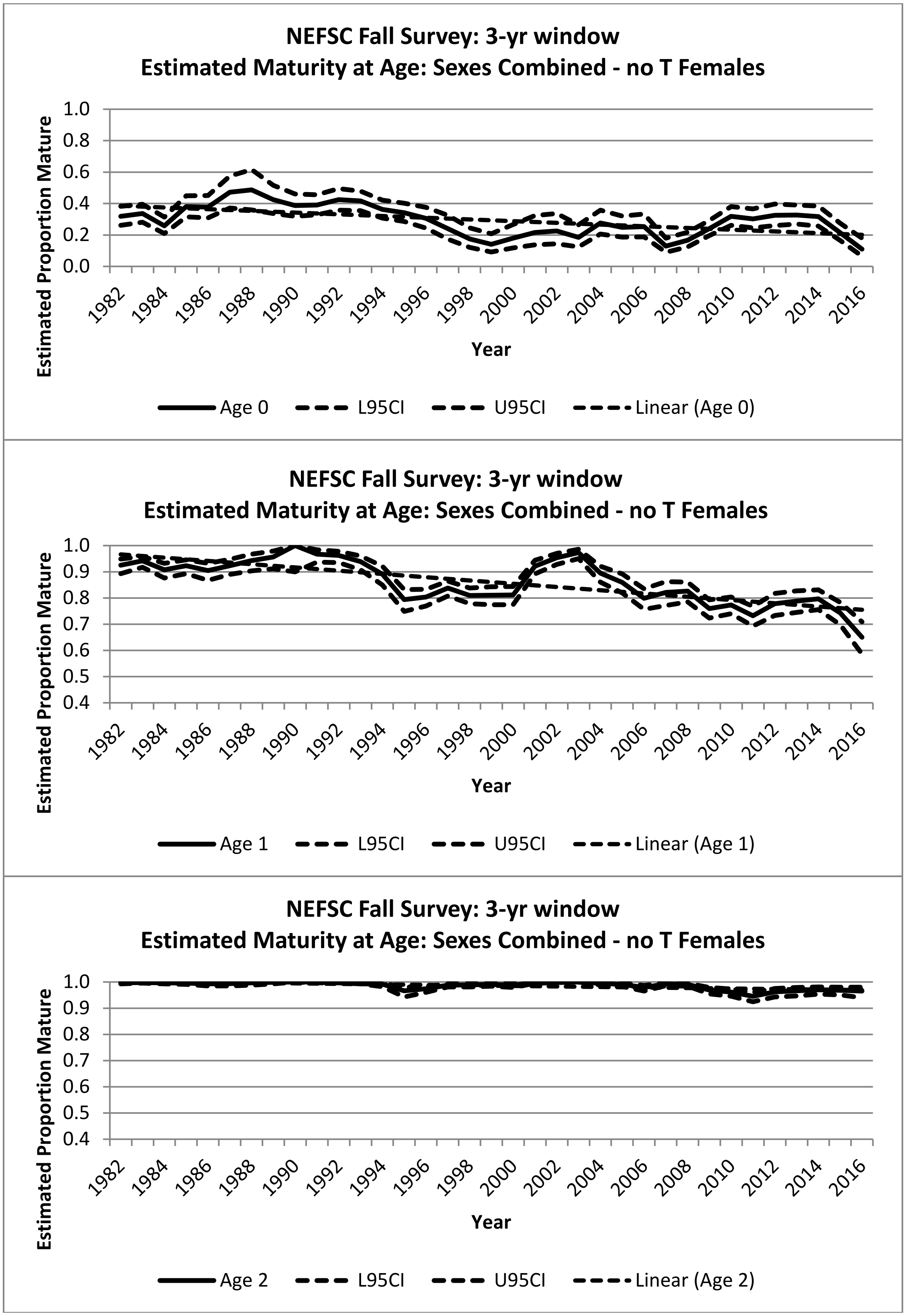


Figure A83. Estimated maturity at ages, 0, 1, and 2, for sexes combined by 3-year moving window, resting (T) females removed. Straight dashed lines are fit linear trends.

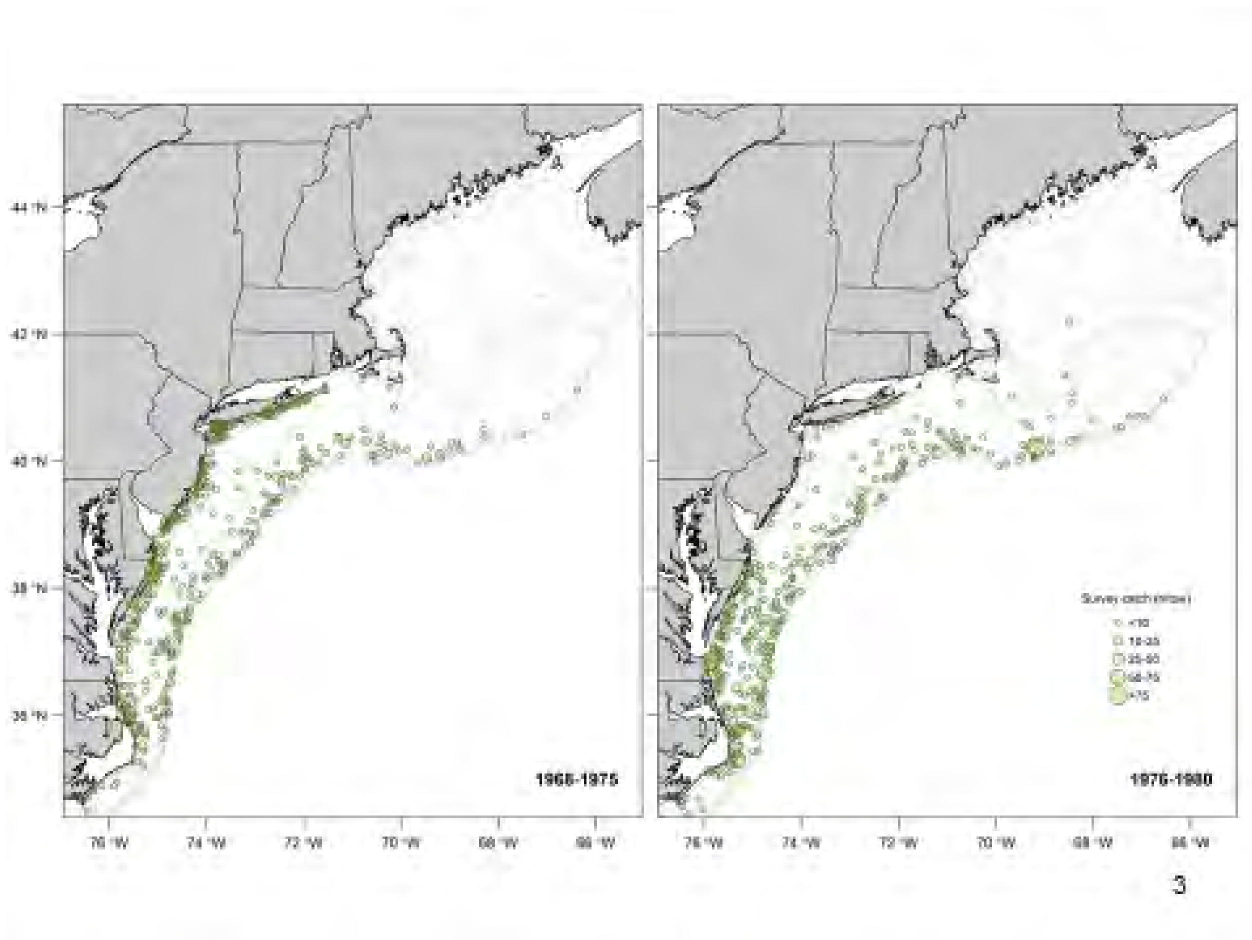


Figure A84. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: spring 1968-1975 and 1976-1980.

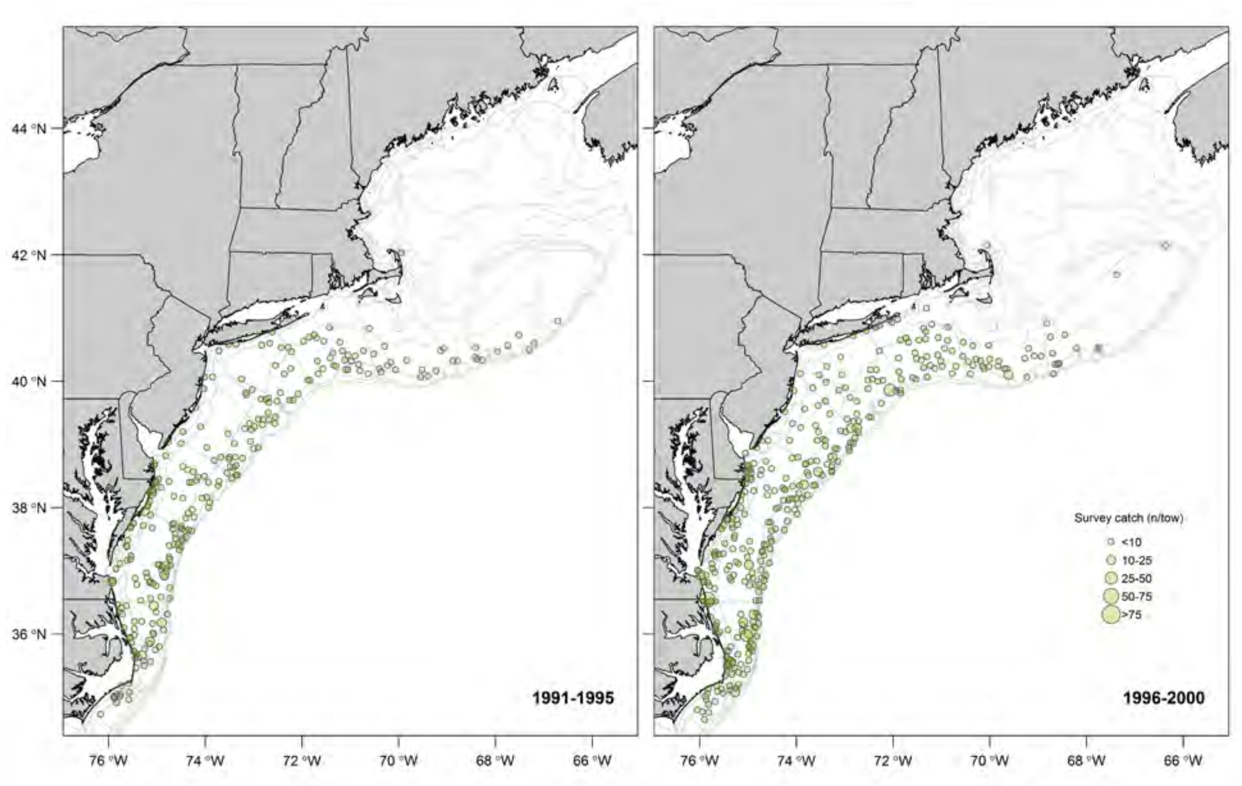


Figure A85. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: spring 1991-1995 and 1996-2000.

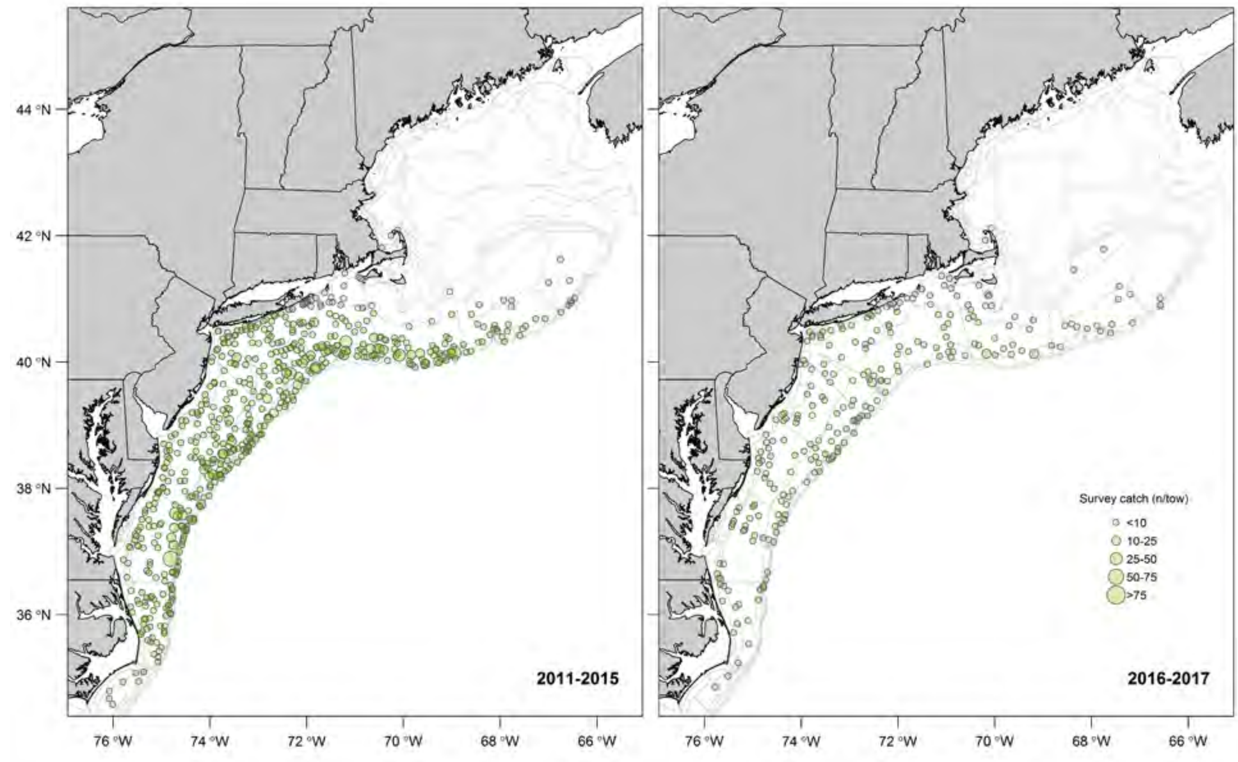


Figure A86. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: spring 2011-2015 and 2016-2017.

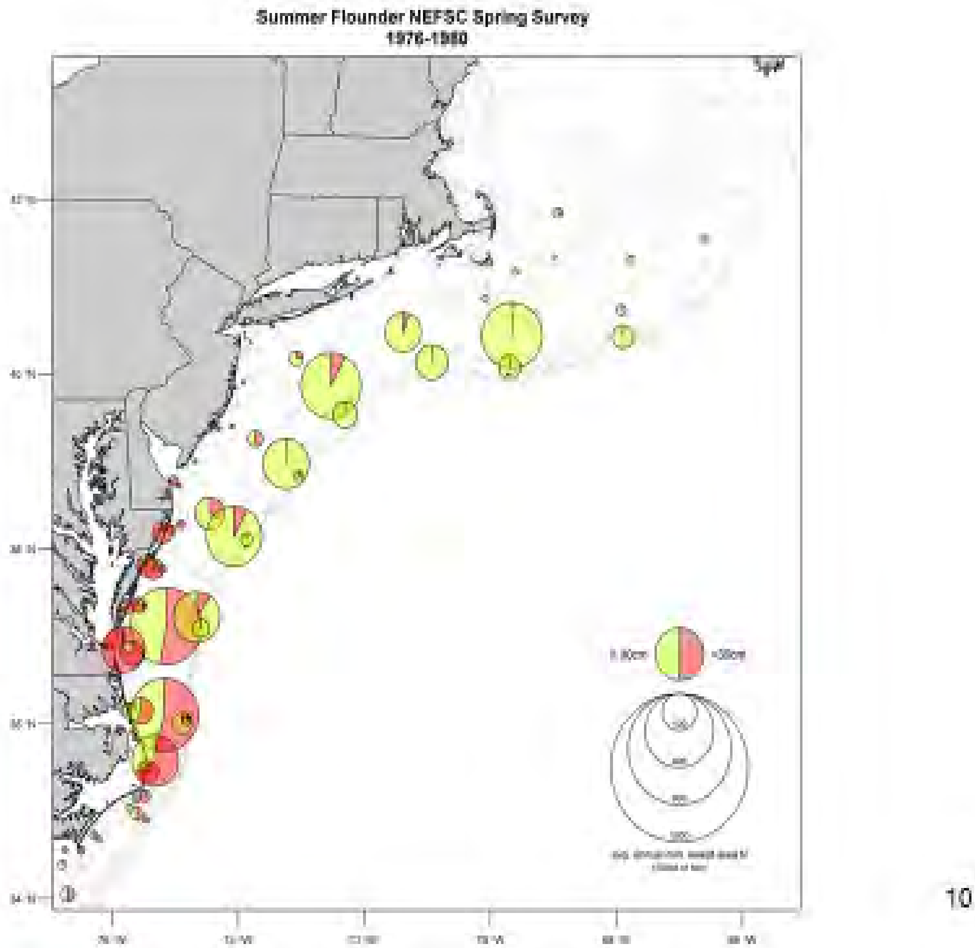


Figure A87. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for spring 1976-1980.

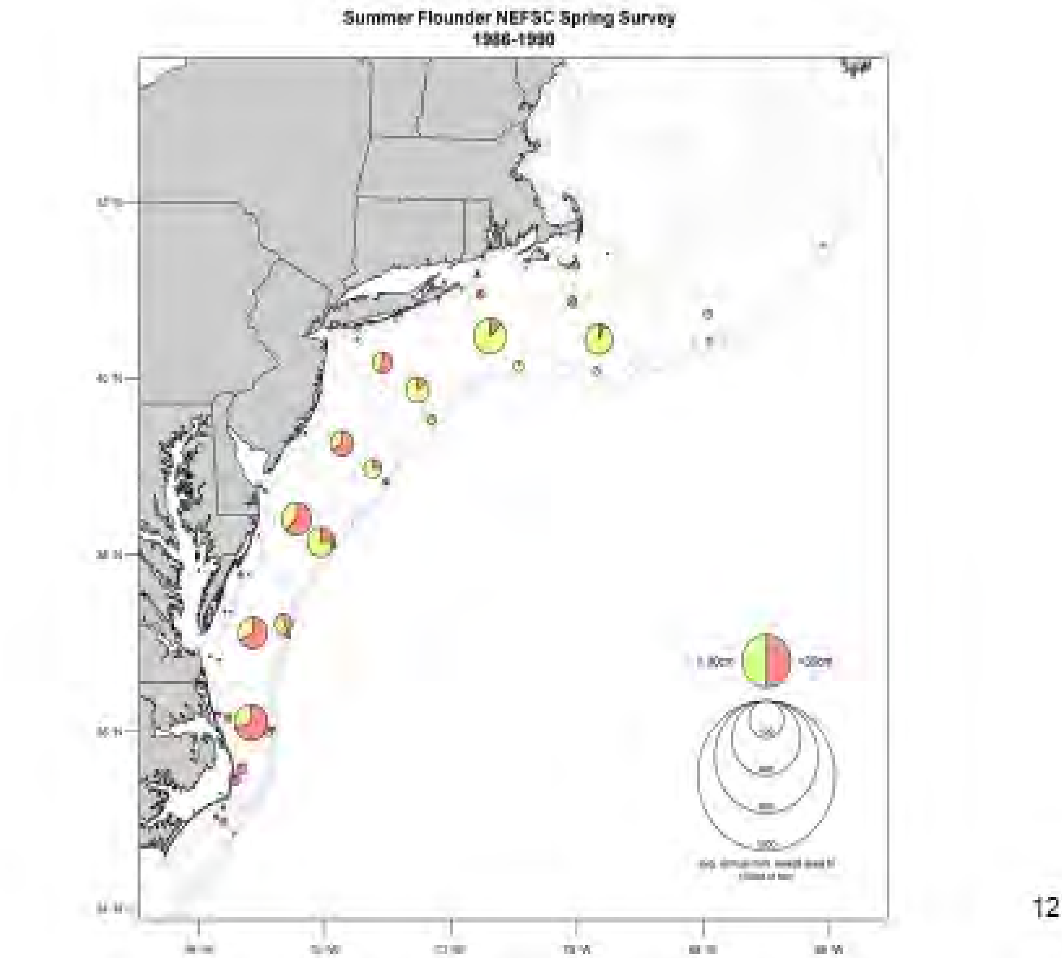


Figure A88. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for spring 1986-1990.

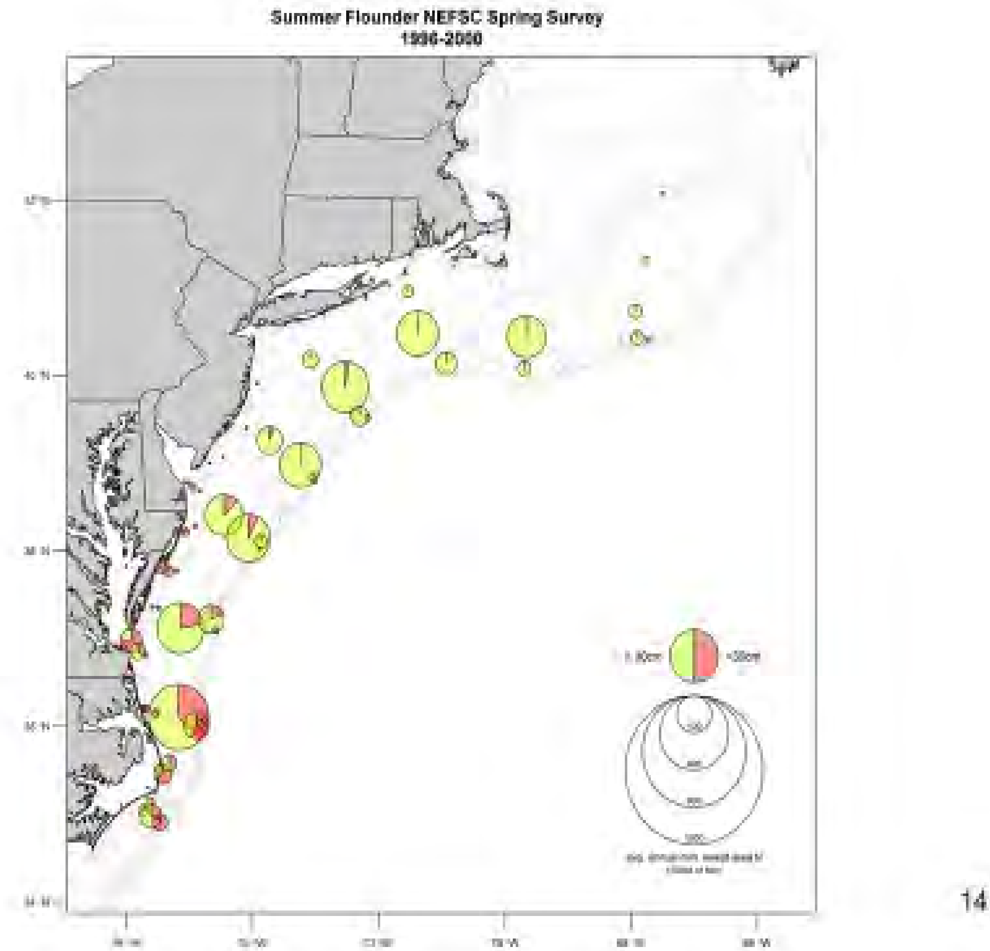


Figure A89. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for spring 1996-2000.

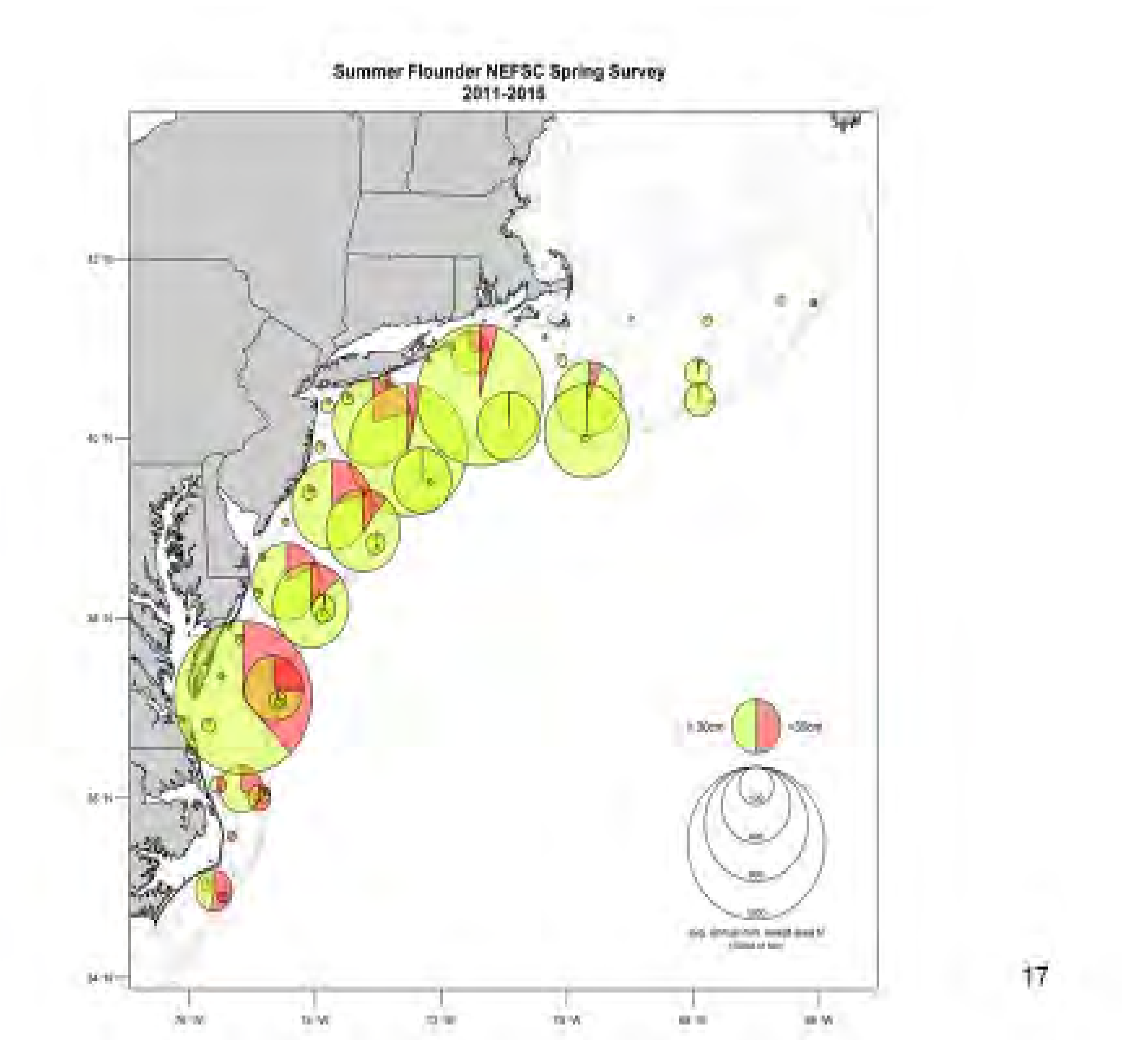


Figure A90. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for spring 2011-2015.

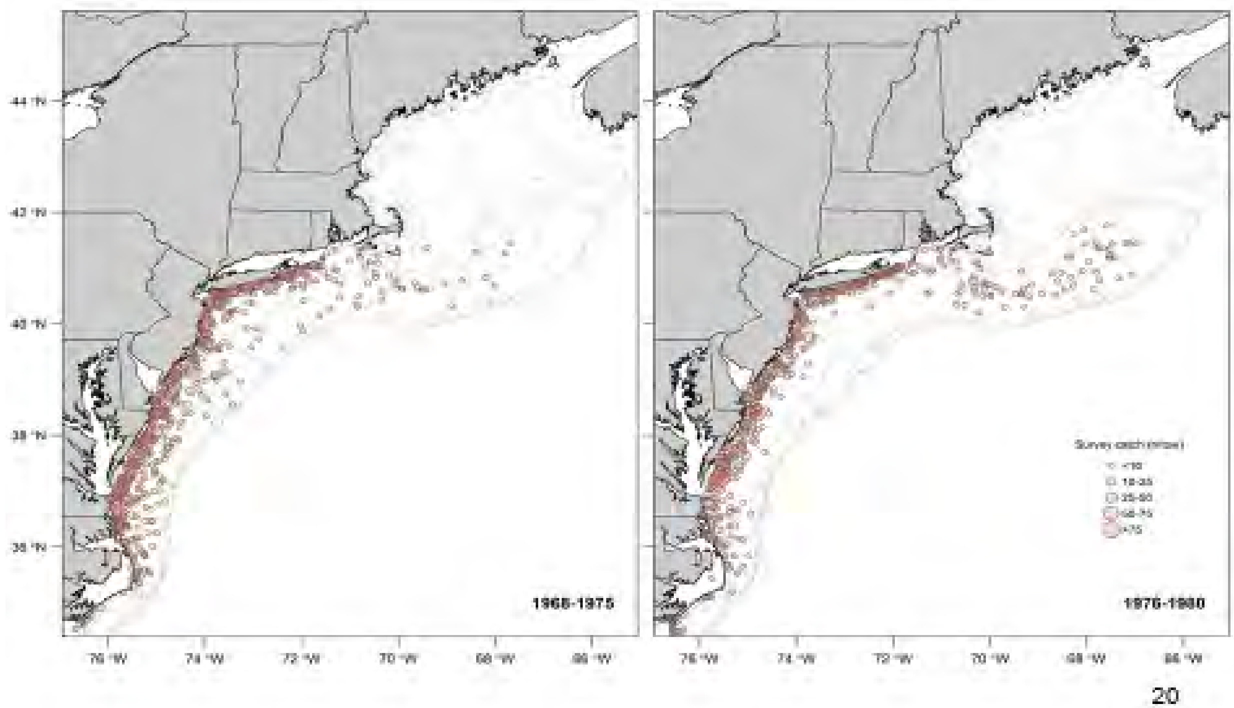


Figure A91. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: fall 1968-1975 and 1976-1980.

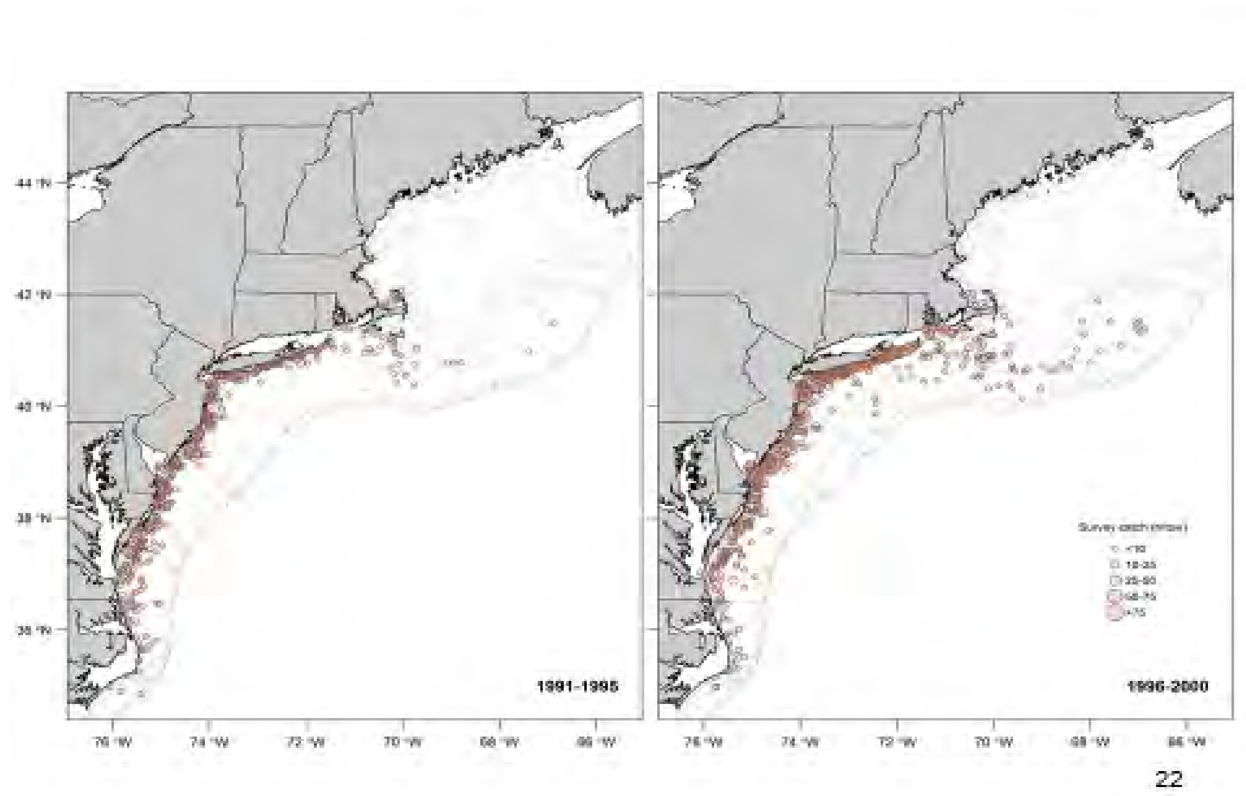


Figure A92. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: fall 1991-1995 and 1996-2000.

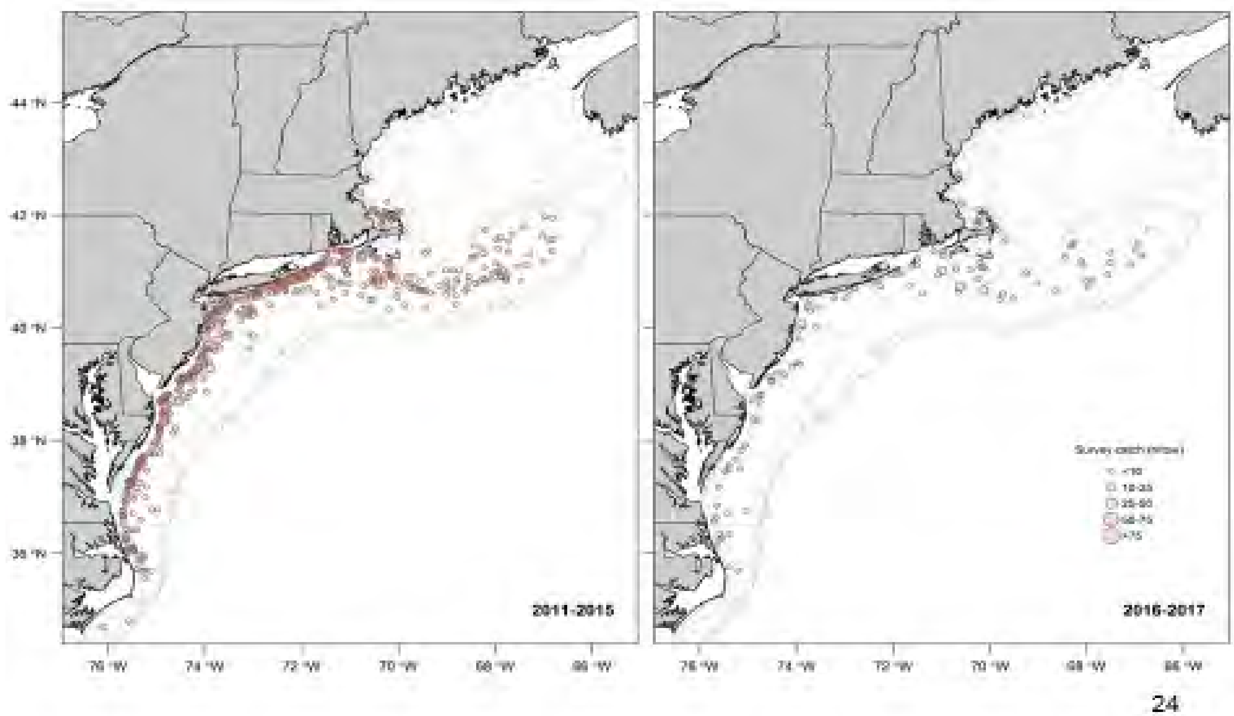


Figure A93. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: fall 2011-2015 and 2016-2017.

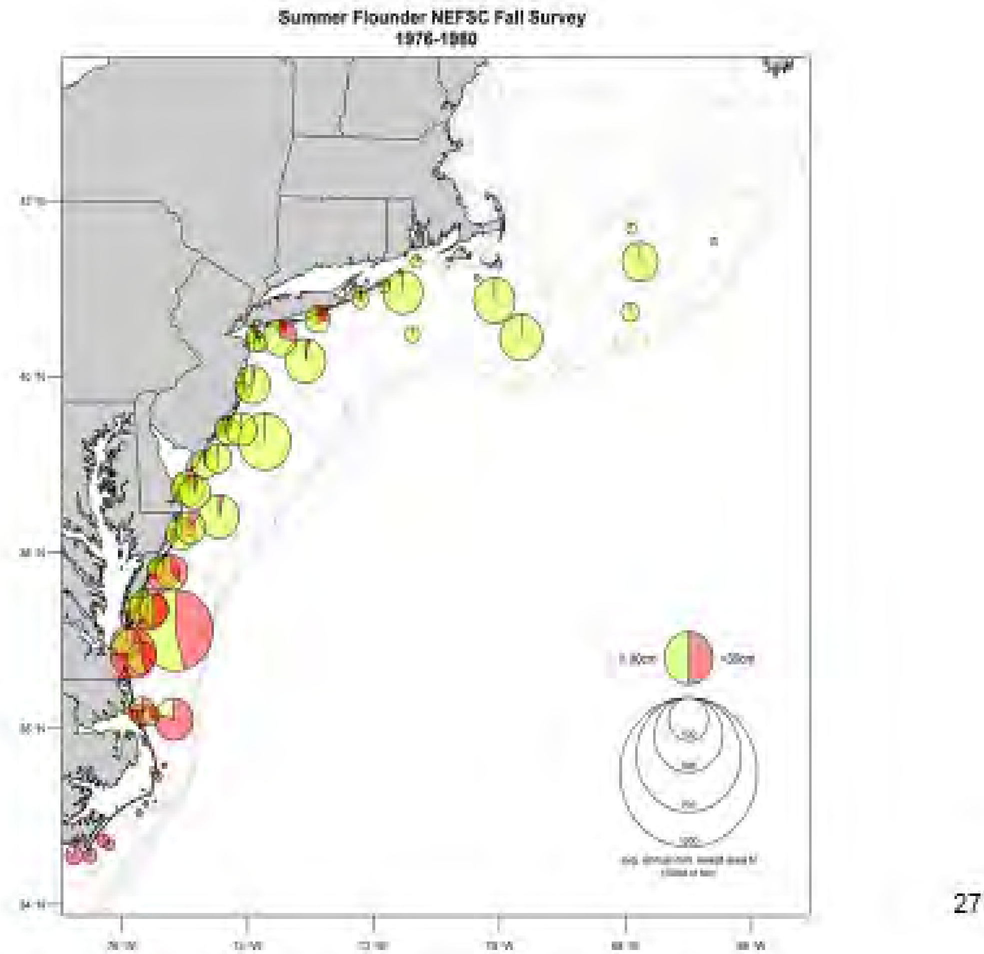


Figure A94. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for fall 1976-1980.

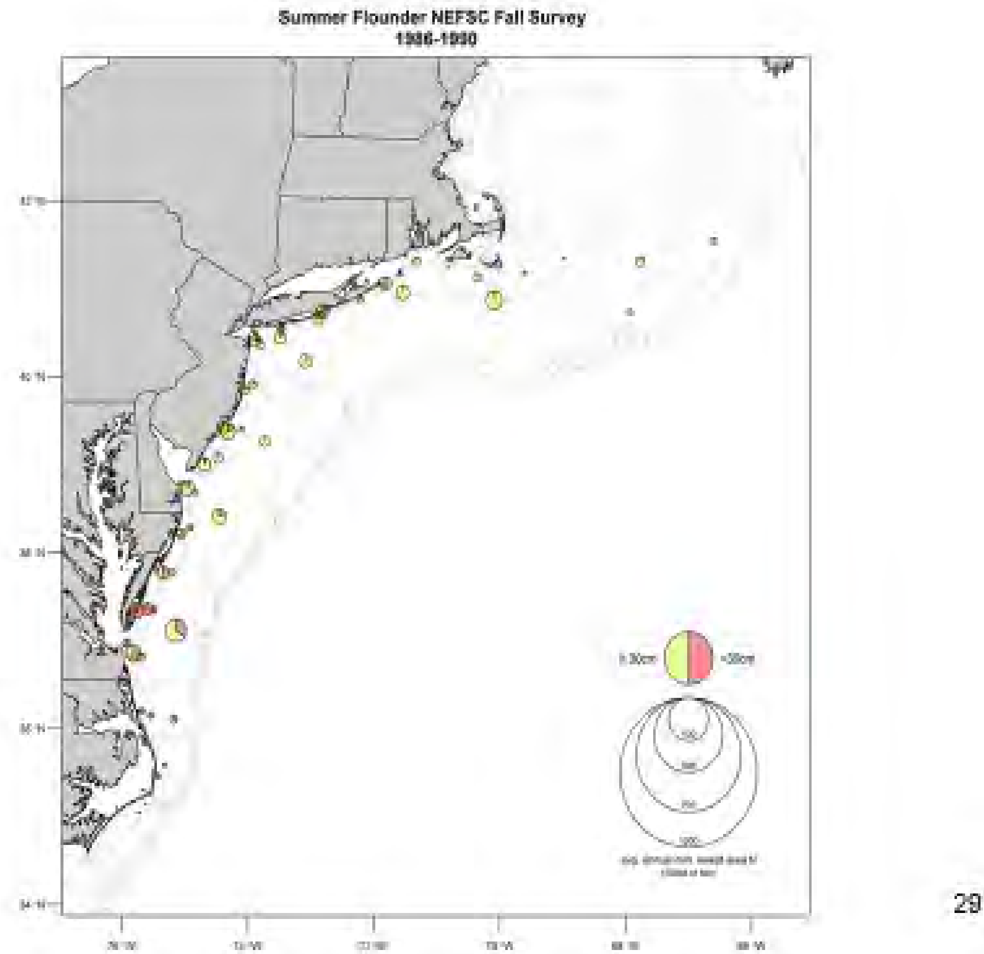


Figure A95. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for fall 1986-1990.

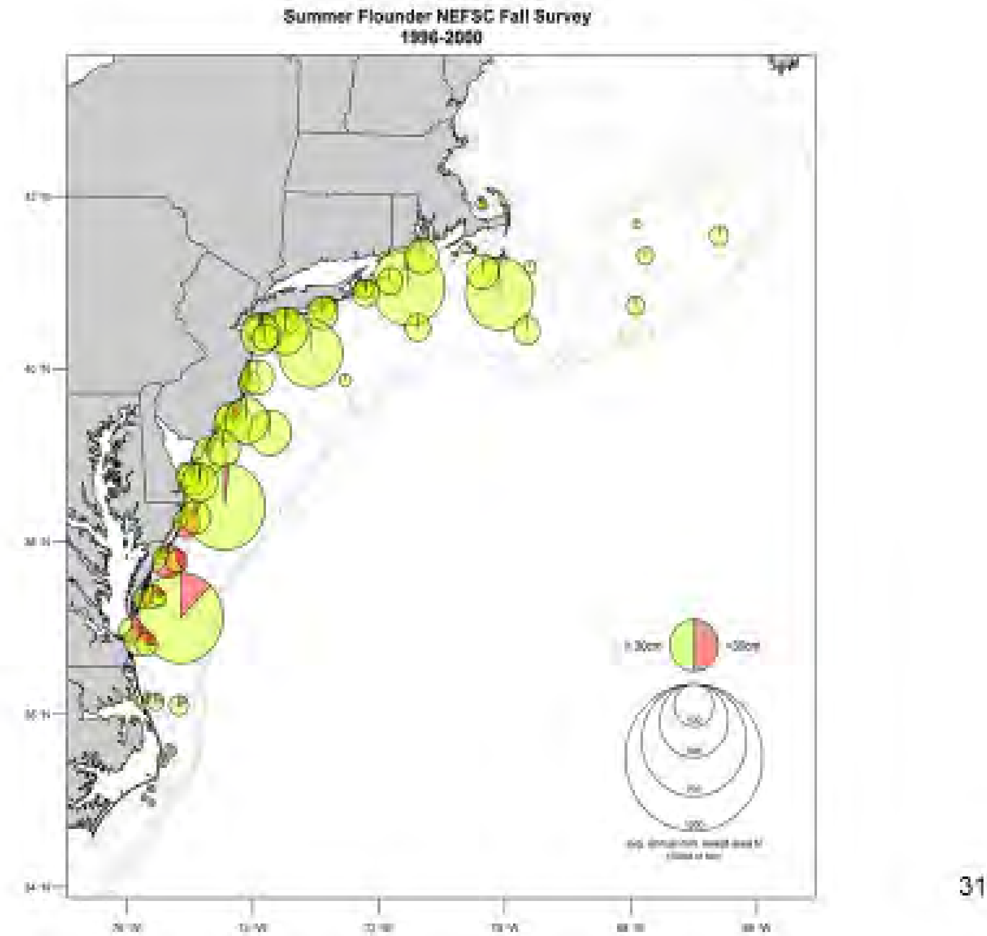


Figure A96. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for fall 1996-2000.

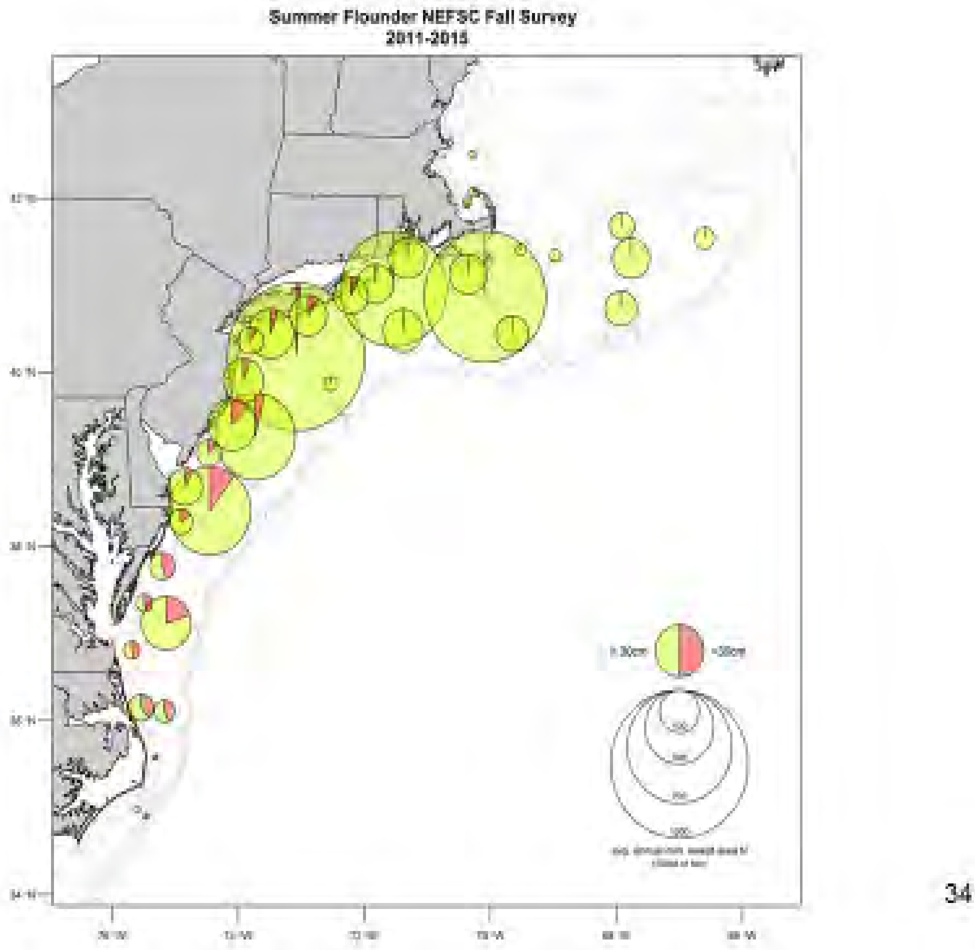


Figure A97. Northeast Fisheries Science Center (NEFSC) trawl survey catches of summer flounder: juveniles (<30 cm) and adults (>=30 cm) for fall 2011-2015.

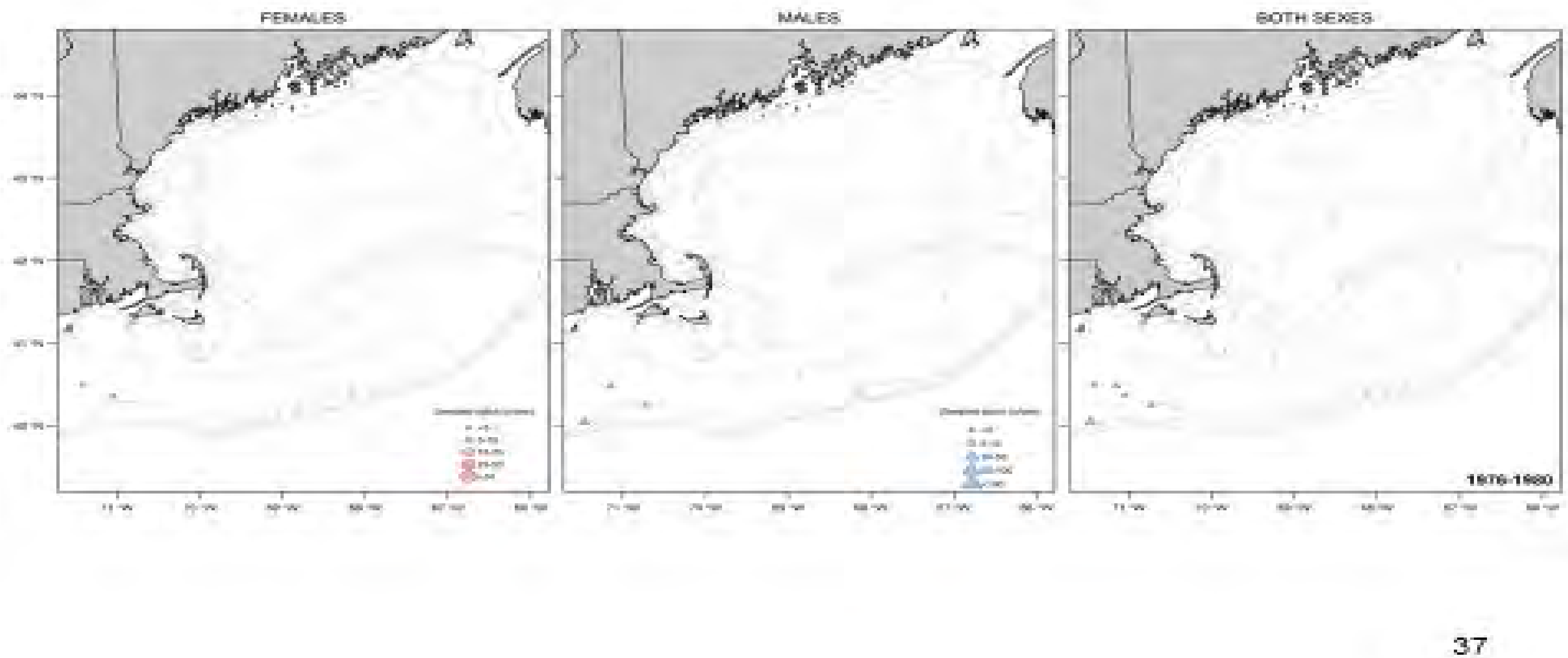


Figure A98. Northeast Fisheries Science Center (NEFSC) / Massachusetts Division of Marine Fisheries (MADMF) spring survey distribution of summer flounder by sex: Gulf of Maine-Georges Bank 1975-1980.

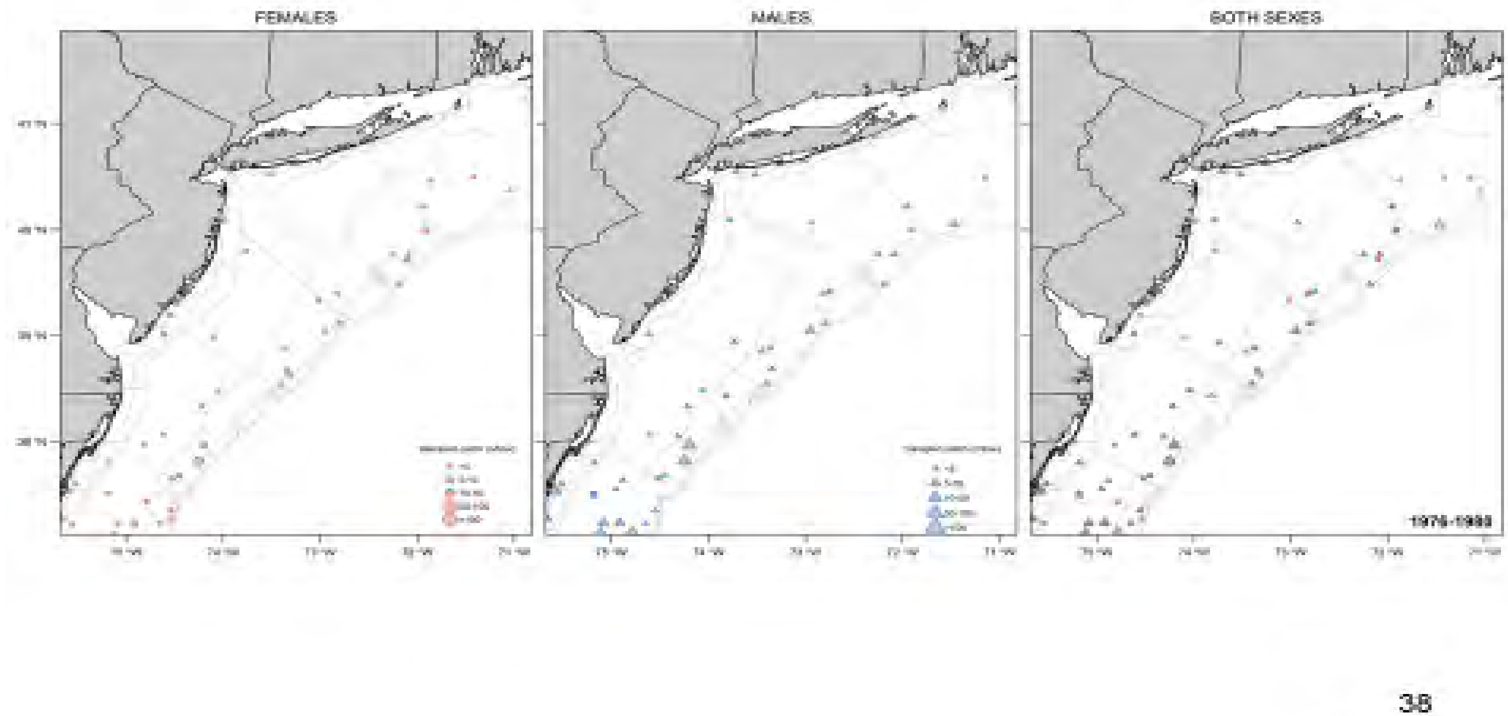


Figure A99. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Southern New England 1975-1980.

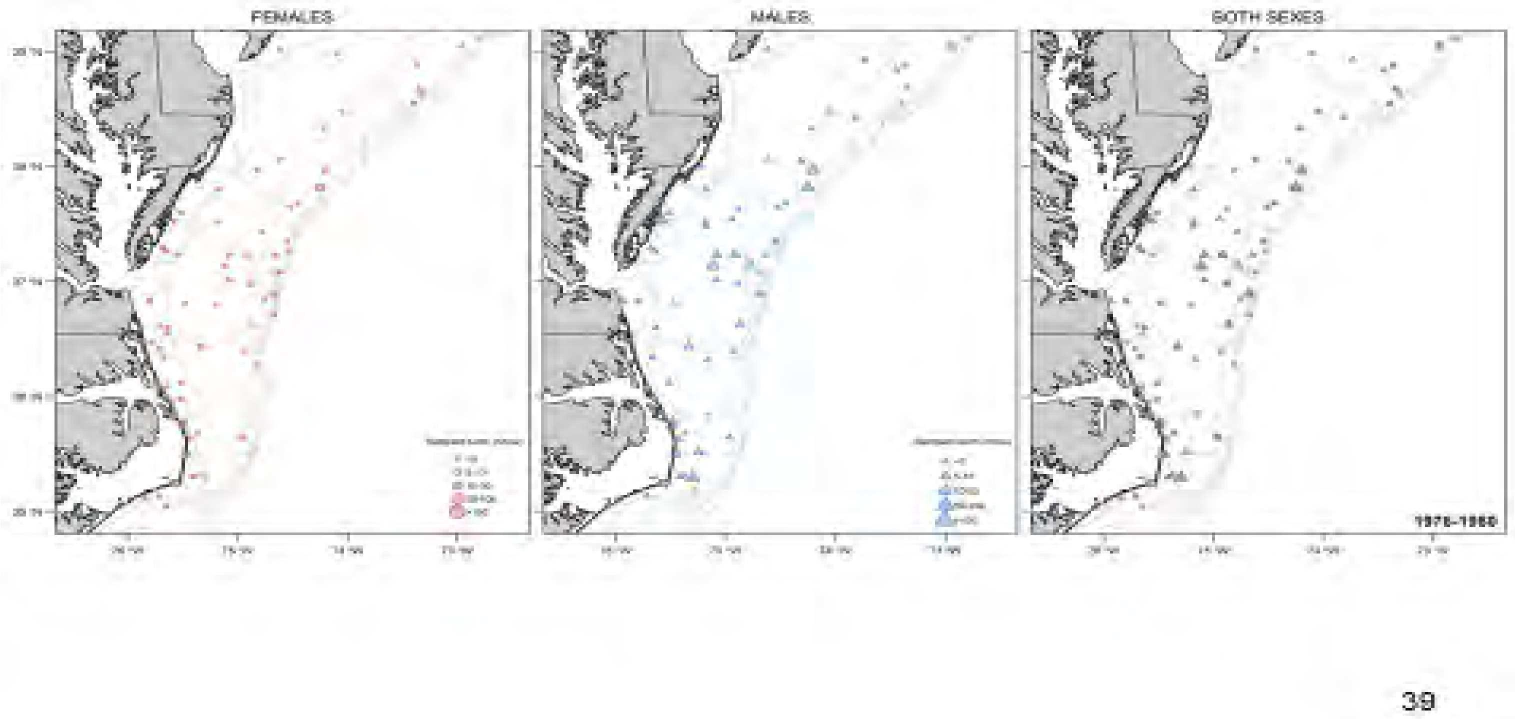


Figure A100. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Mid-Atlantic Bight 1975-1980.

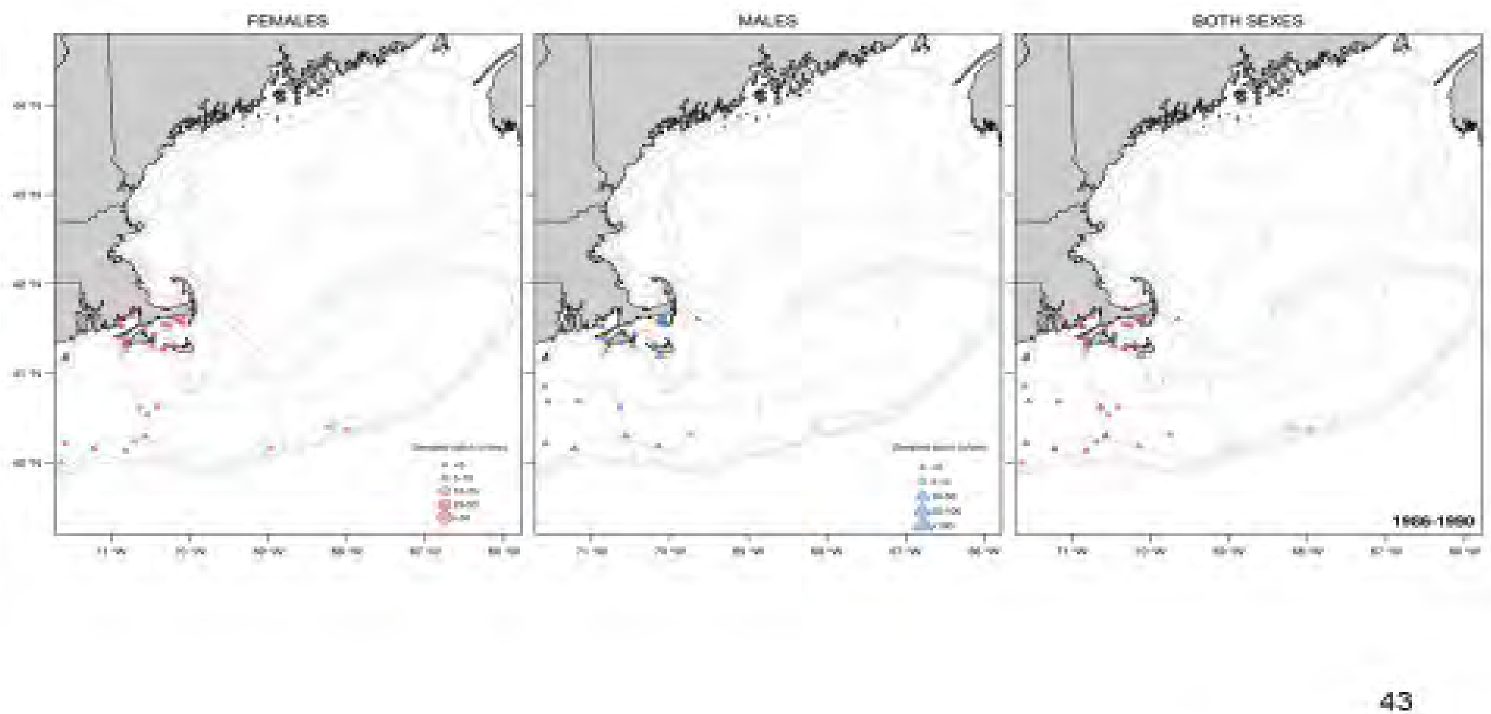


Figure A101. Northeast Fisheries Science Center (NEFSC) / Massachusetts Division of Marine Fisheries (MADMF) spring survey distribution of summer flounder by sex: Gulf of Maine-Georges Bank 1986-1990.

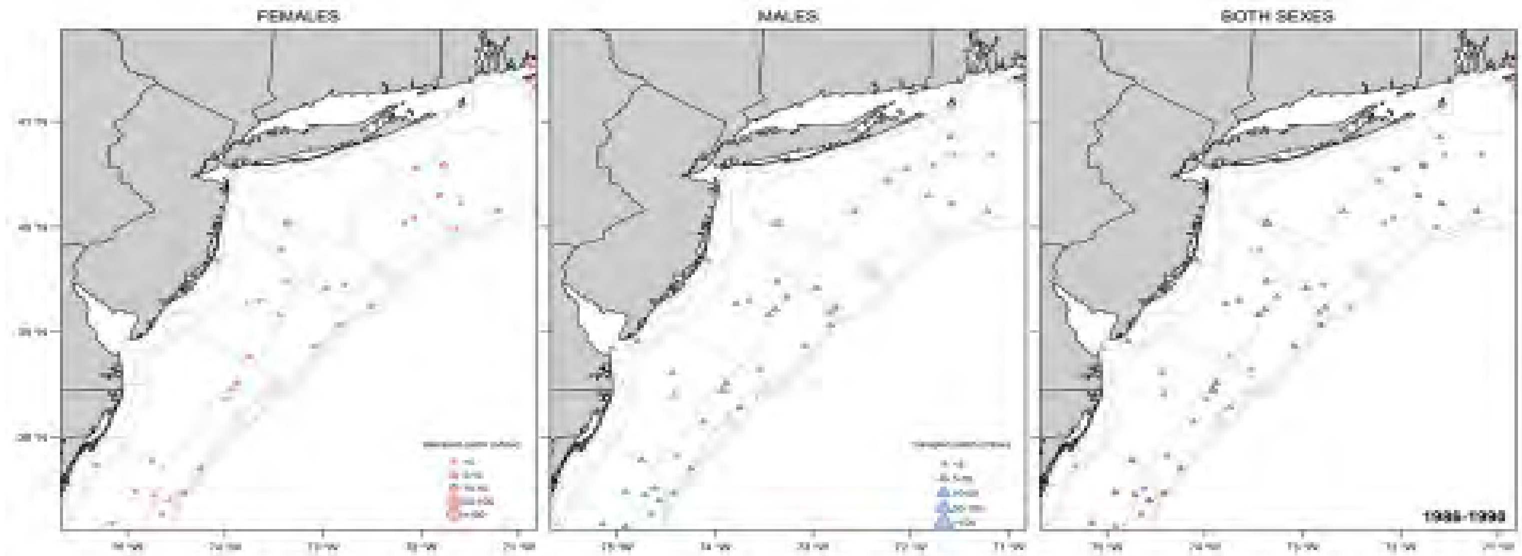


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Figure A102. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Southern New England 1986-1990.

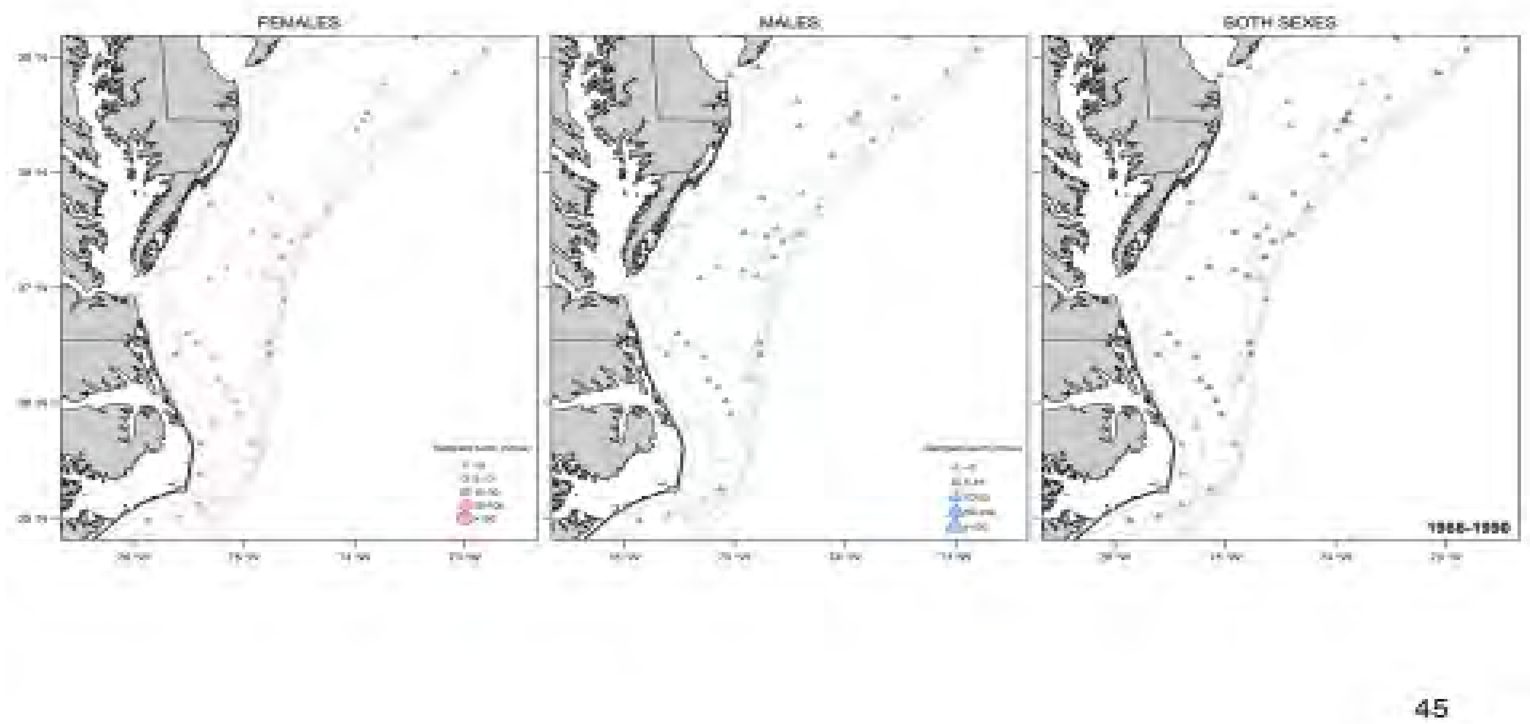

Figure A103. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Mid-Atlantic Bight 1986-1990.

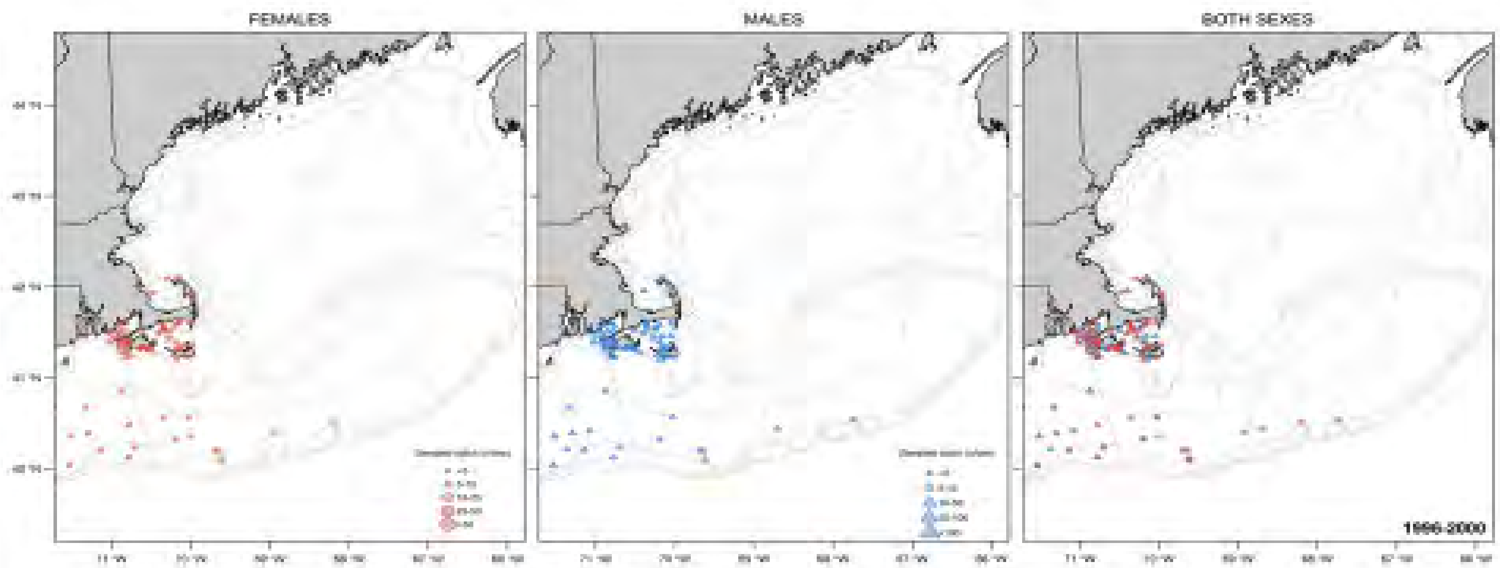

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Figure A104. Northeast Fisheries Science Center (NEFSC) / Massachusetts Division of Marine Fisheries (MADMF) spring survey distribution of summer flounder by sex: Gulf of Maine-Georges Bank 1996-2000.

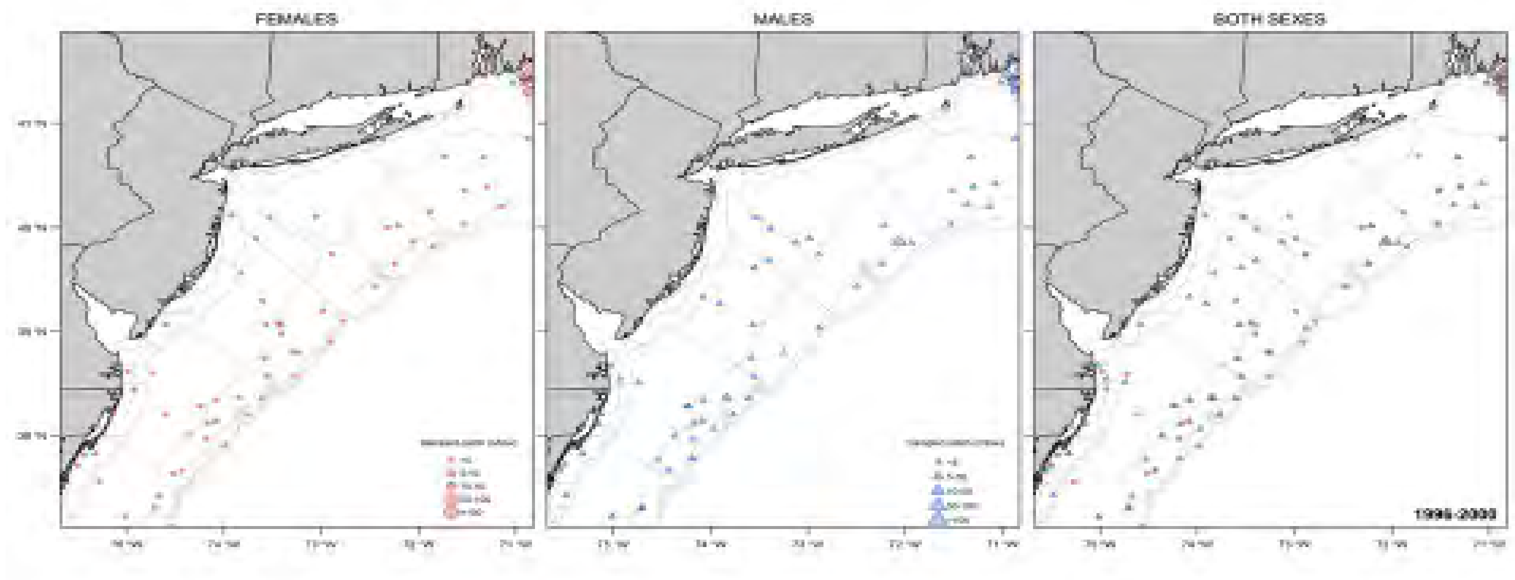

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Figure A105. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Southern New England 1996-2000.

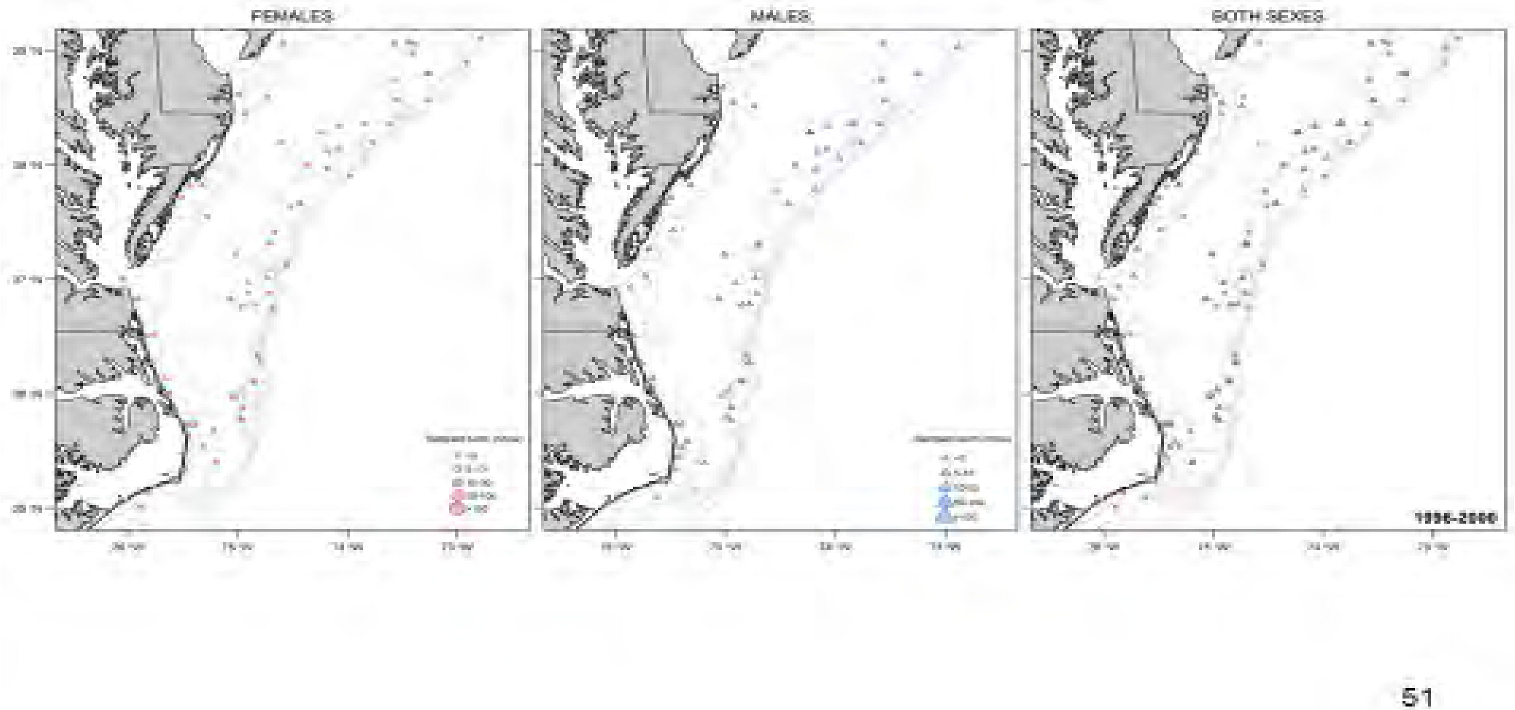


Figure A106. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Mid-Atlantic Bight 1996-2000.

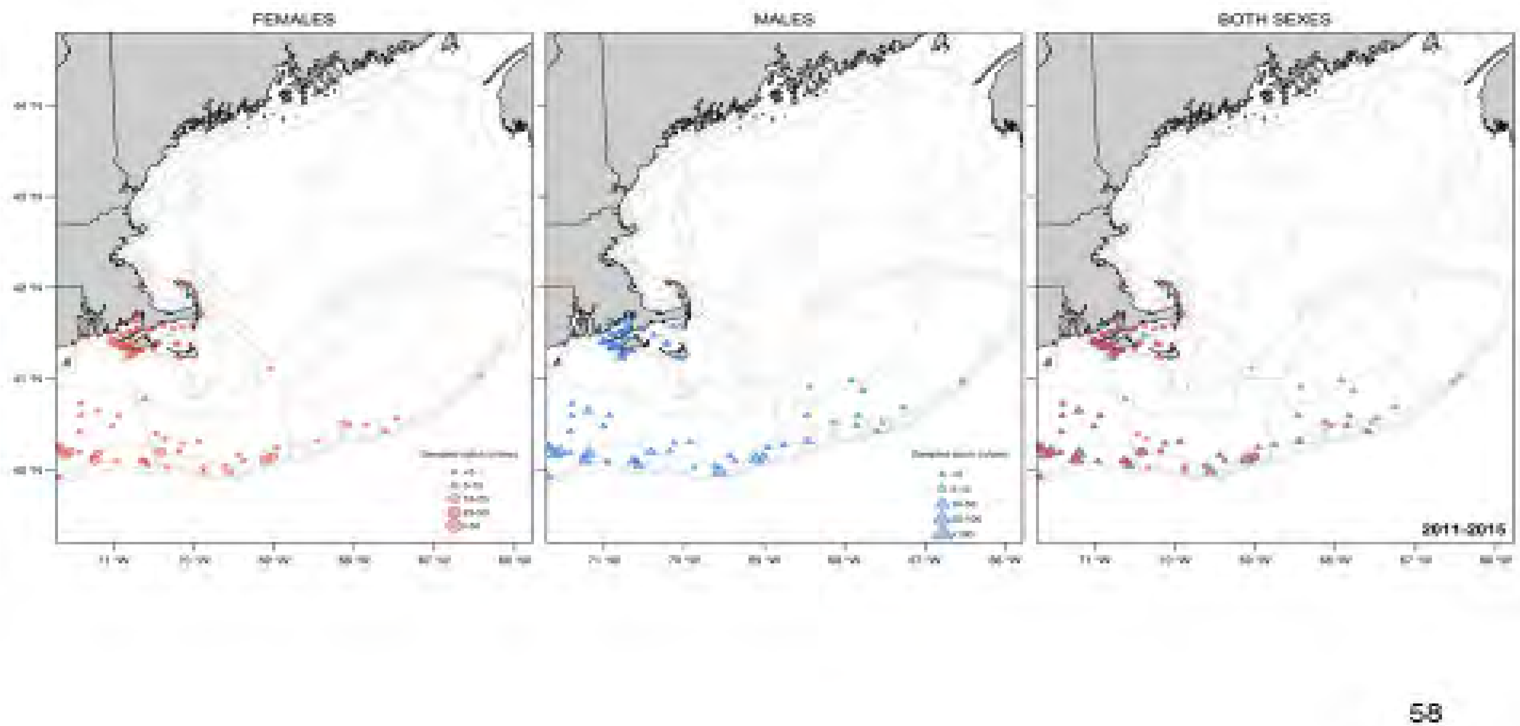


Figure A107. Northeast Fisheries Science Center (NEFSC) / Massachusetts Division of Marine Fisheries (MADMF) spring survey distribution of summer flounder by sex: Gulf of Maine-Georges Bank 2011-2015.

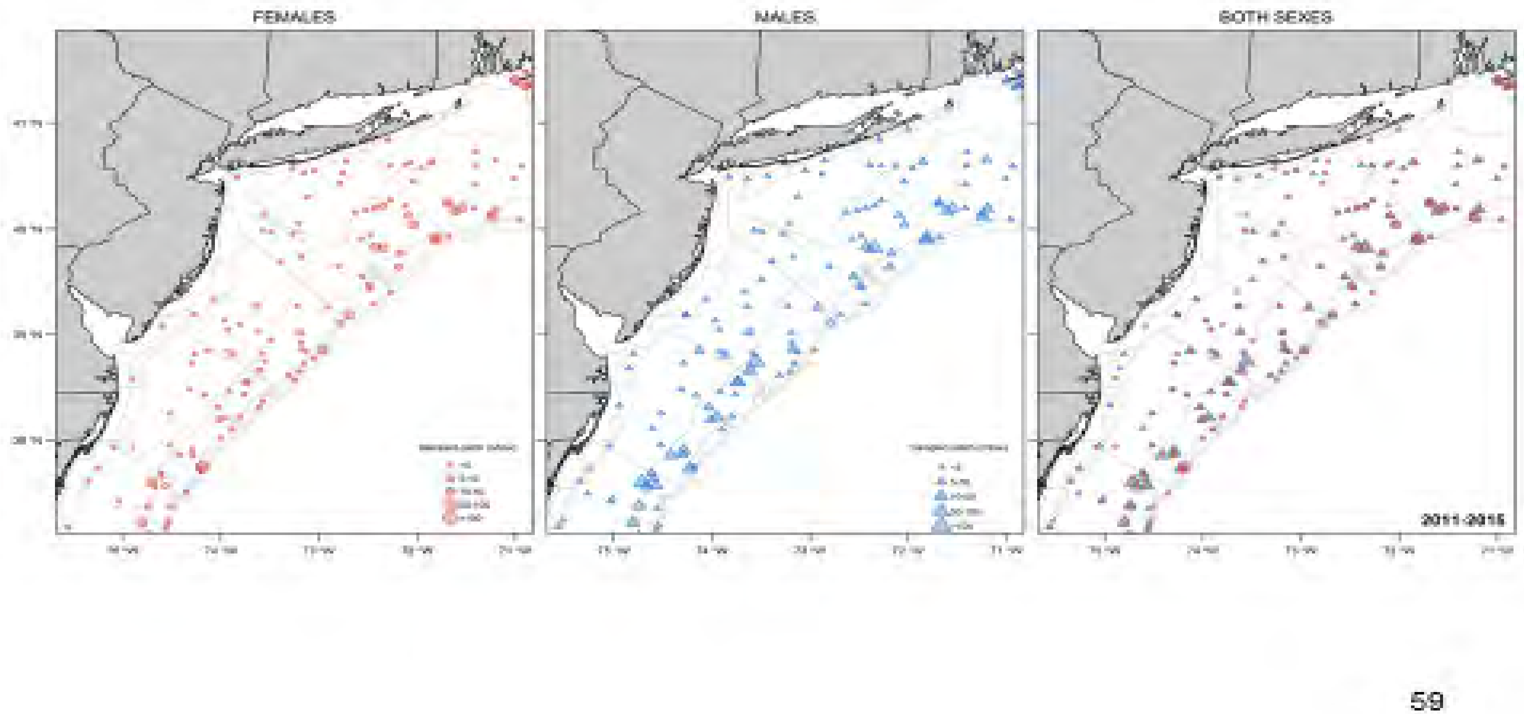


Figure A108. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Southern New England 2011-2015.

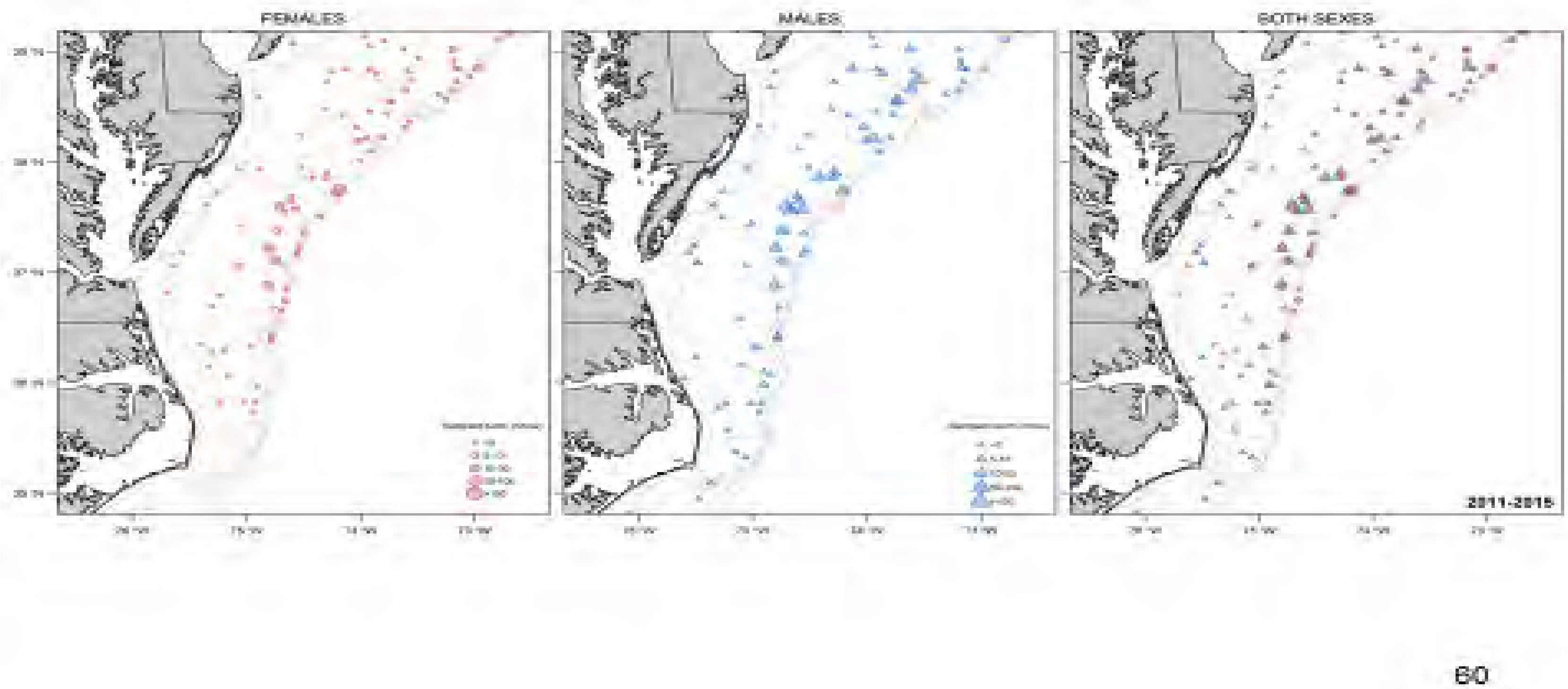


Figure A109. Northeast Fisheries Science Center (NEFSC) spring survey distribution of summer flounder by sex: Mid-Atlantic Bight 2011-2015.

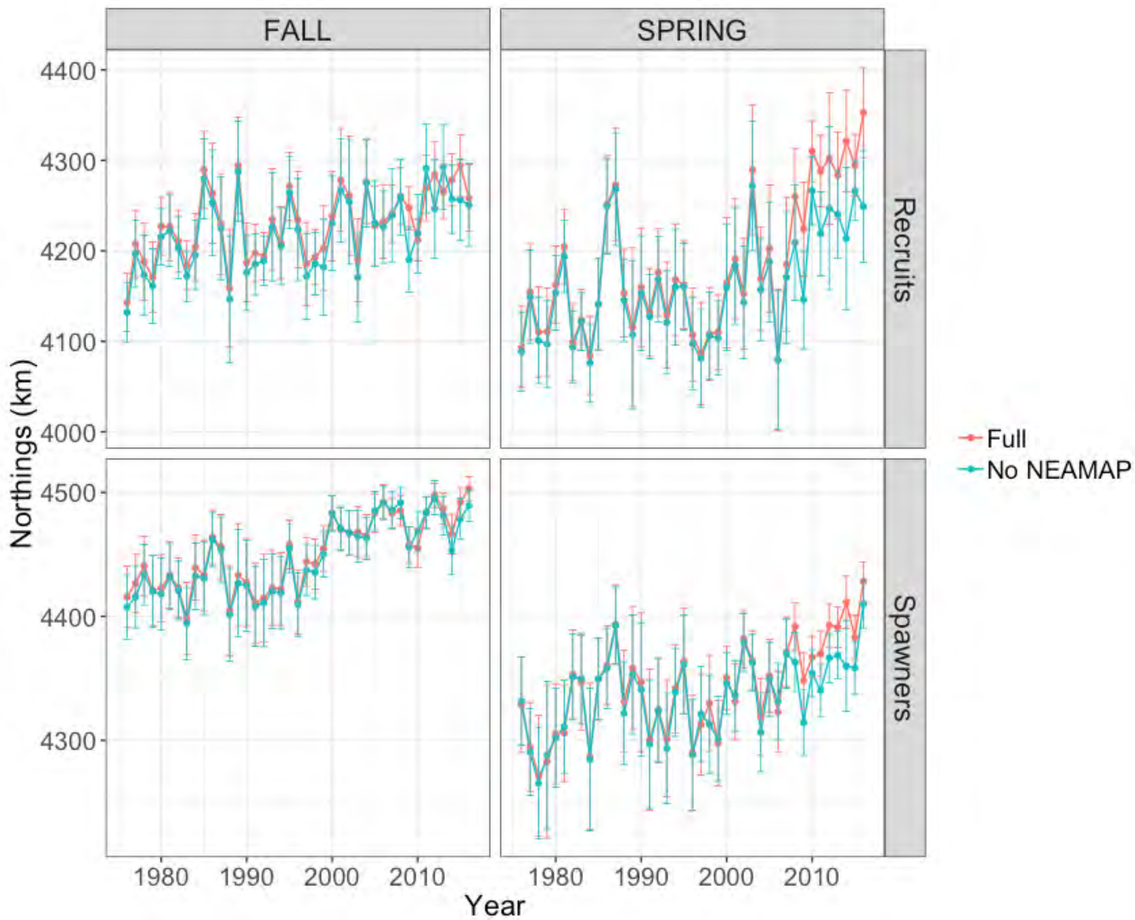


Figure A110. Center-of-gravity of northings for model with and without Northeast Area Monitoring and Assessment Program (NEAMAP) survey data.

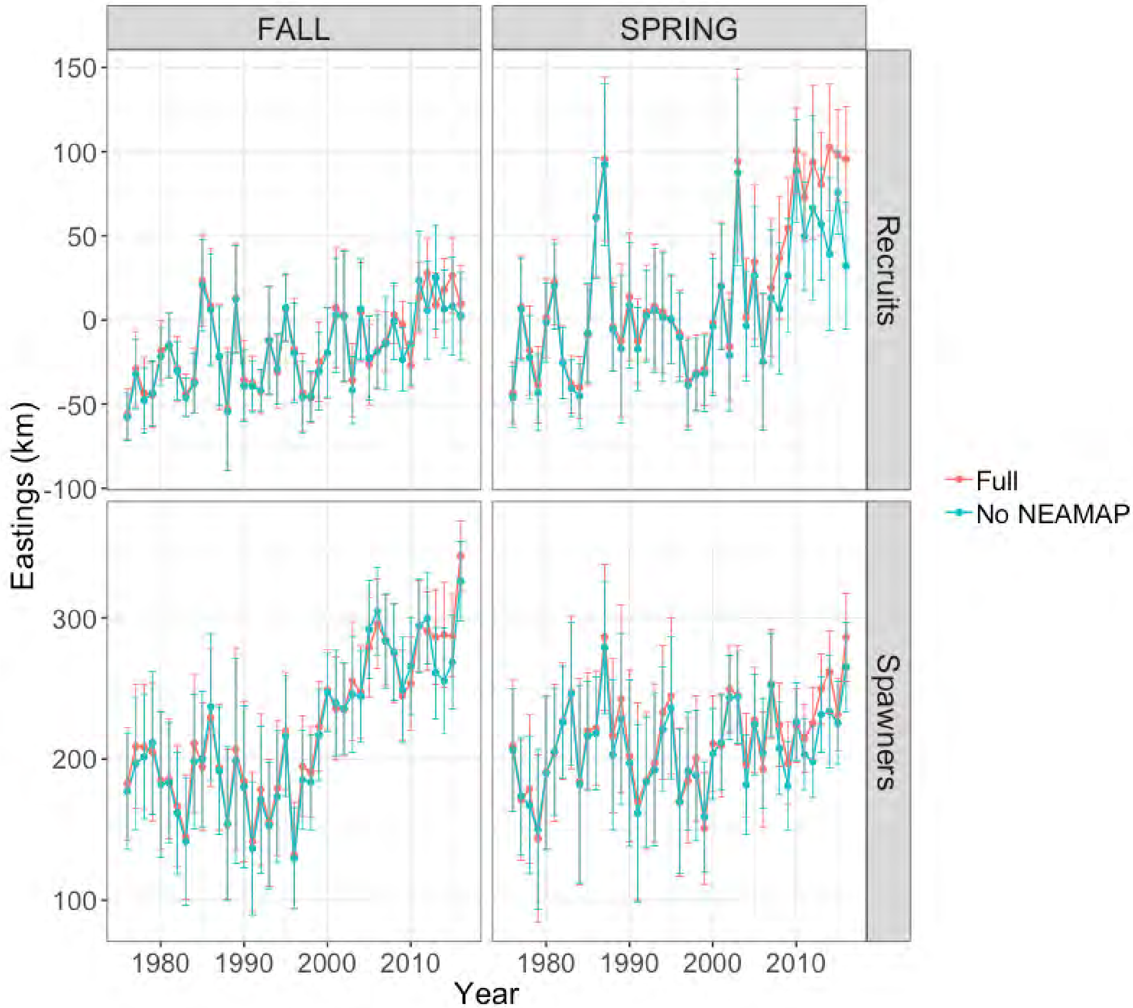


Figure A111. Center-of-gravity of eastings for model with and without Northeast Area Monitoring and Assessment Program (NEAMAP) survey data.

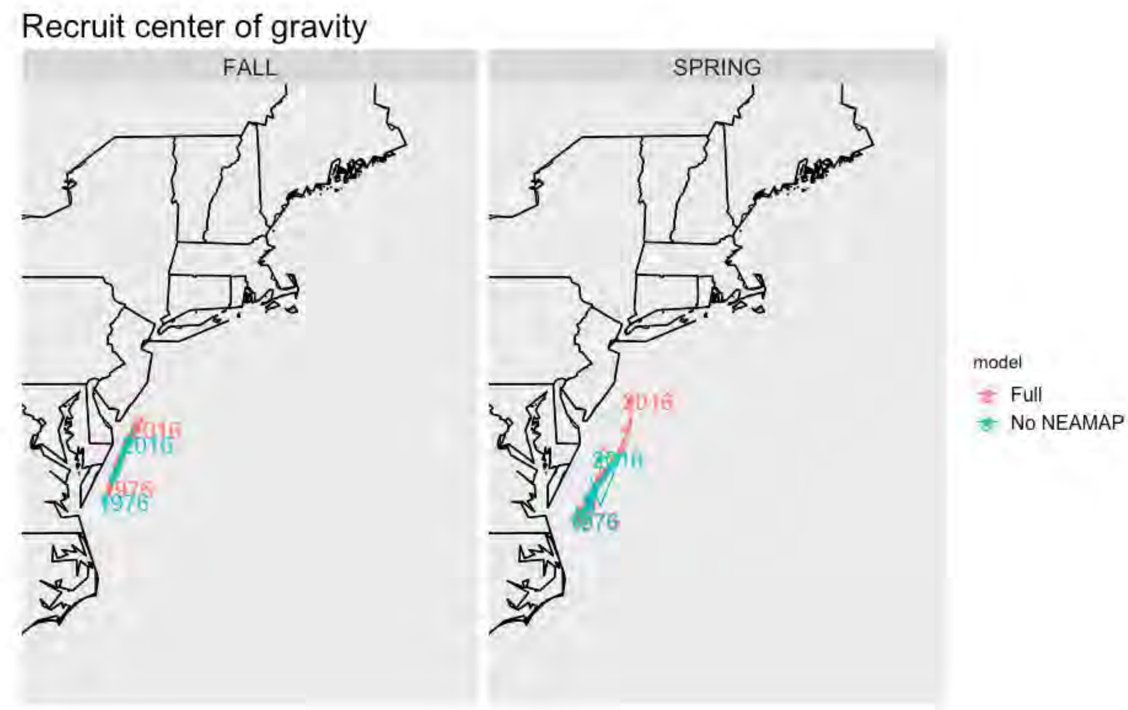


Figure A112. Recruits center of gravity, comparison between Vector Auto-regressive Spatio-Temporal (VAST) model with and without Northeast Area Monitoring and Assessment Program (NEAMAP) survey data.

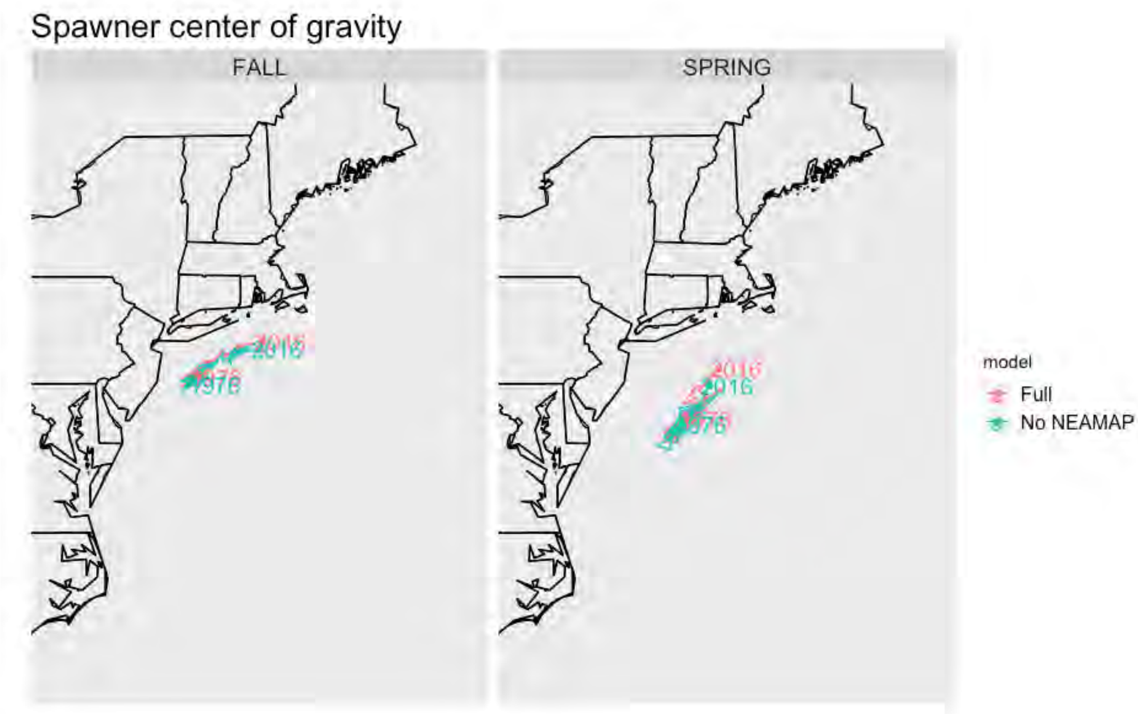


Figure A113. Spawner center of gravity, comparison between Vector Auto-regressive Spatio-Temporal (VAST) model with and without Northeast Area Monitoring and Assessment Program (NEAMAP) survey data.

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.

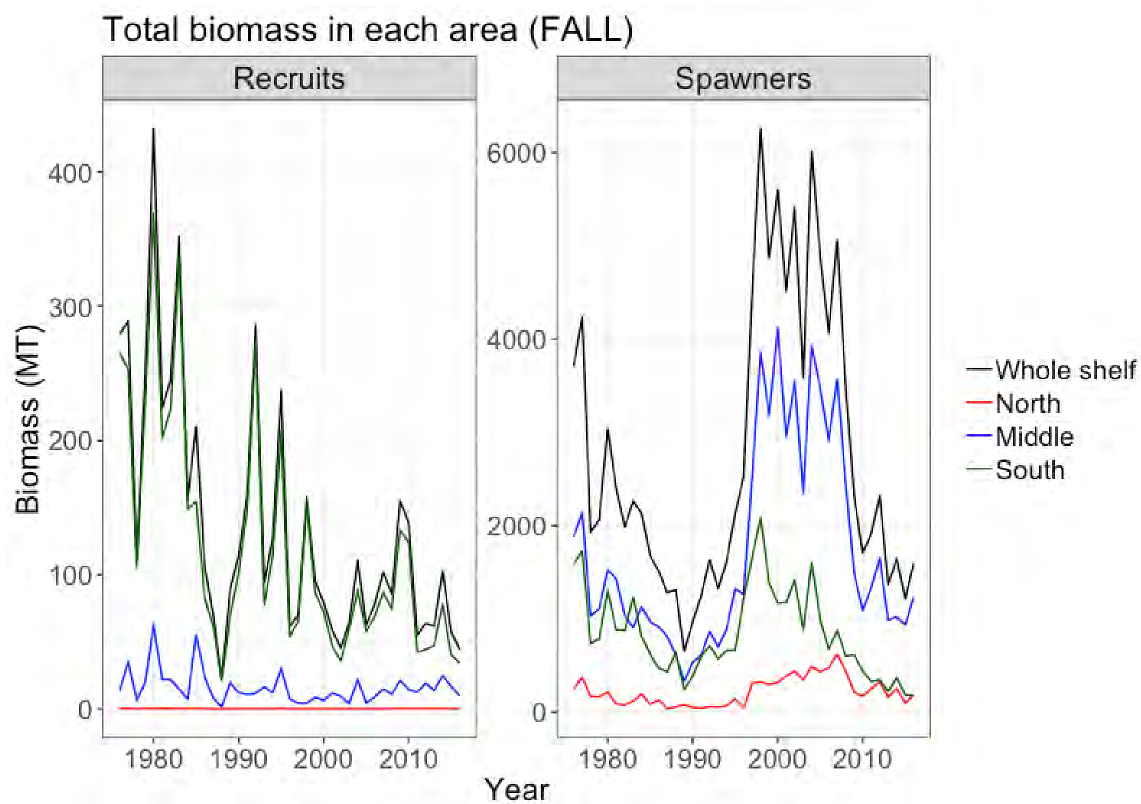


Figure A115. Total biomass in each subarea in the fall.

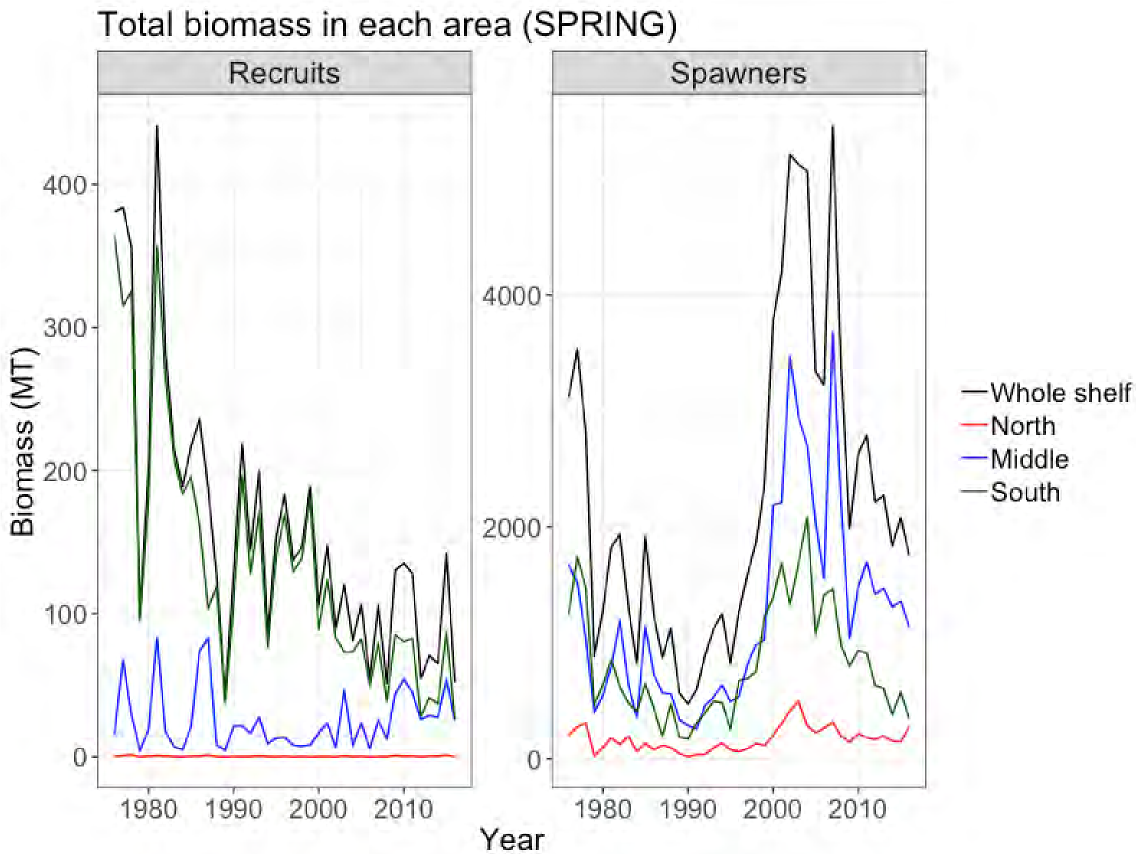


Figure A116. Total biomass in each subarea in the spring.

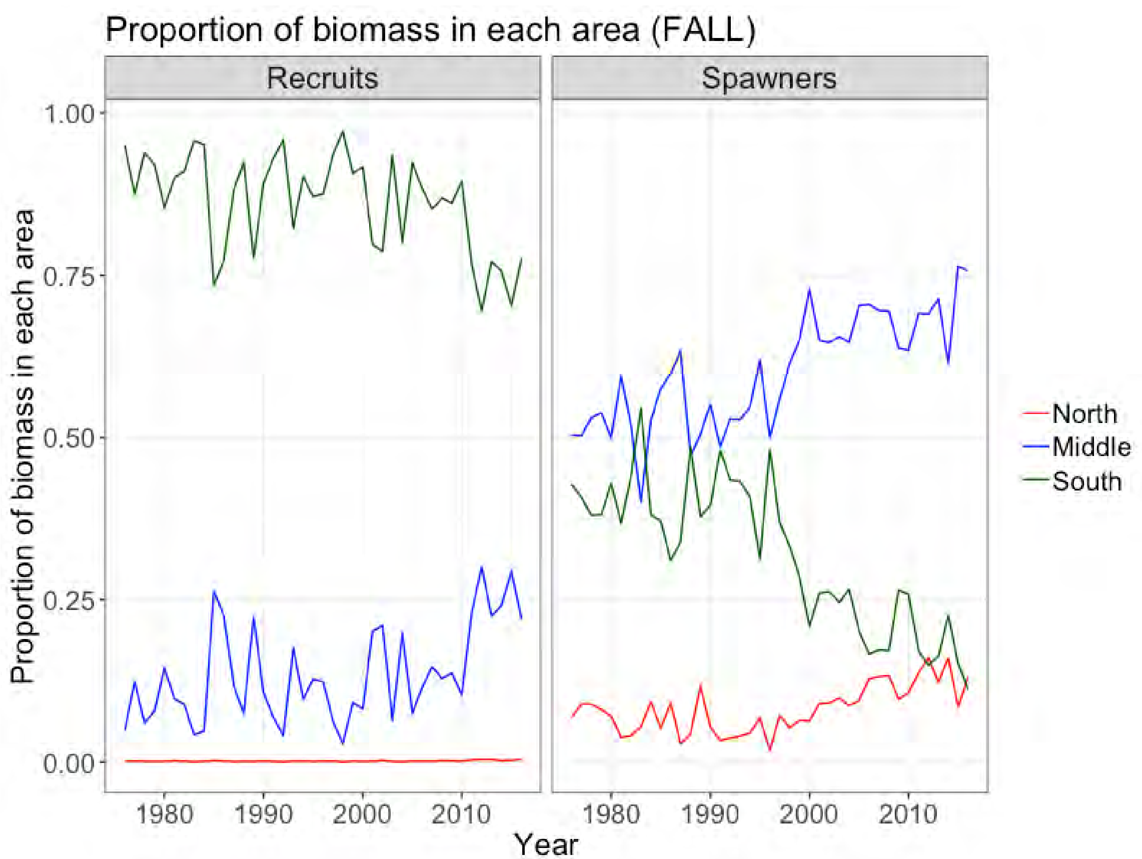


Figure A117. Proportion of biomass in each subarea in the fall.

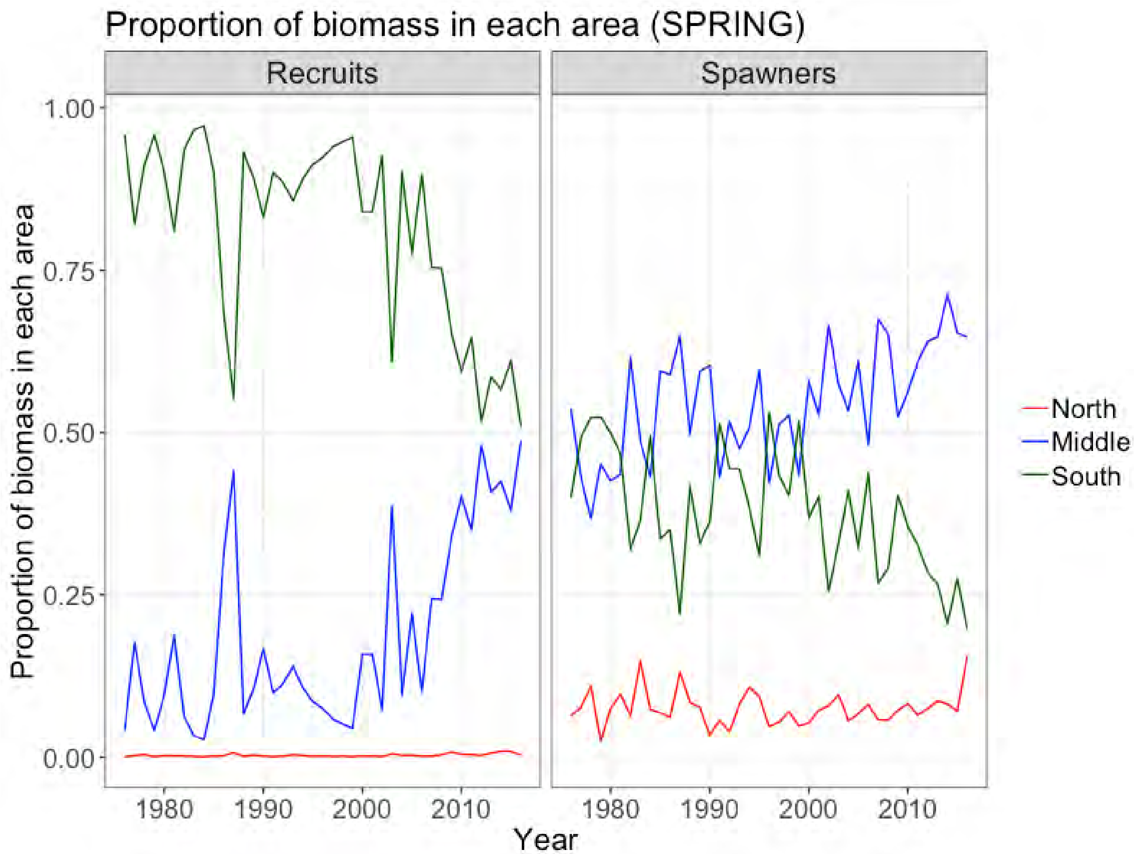


Figure A118. Proportion of biomass in each subarea in the spring.

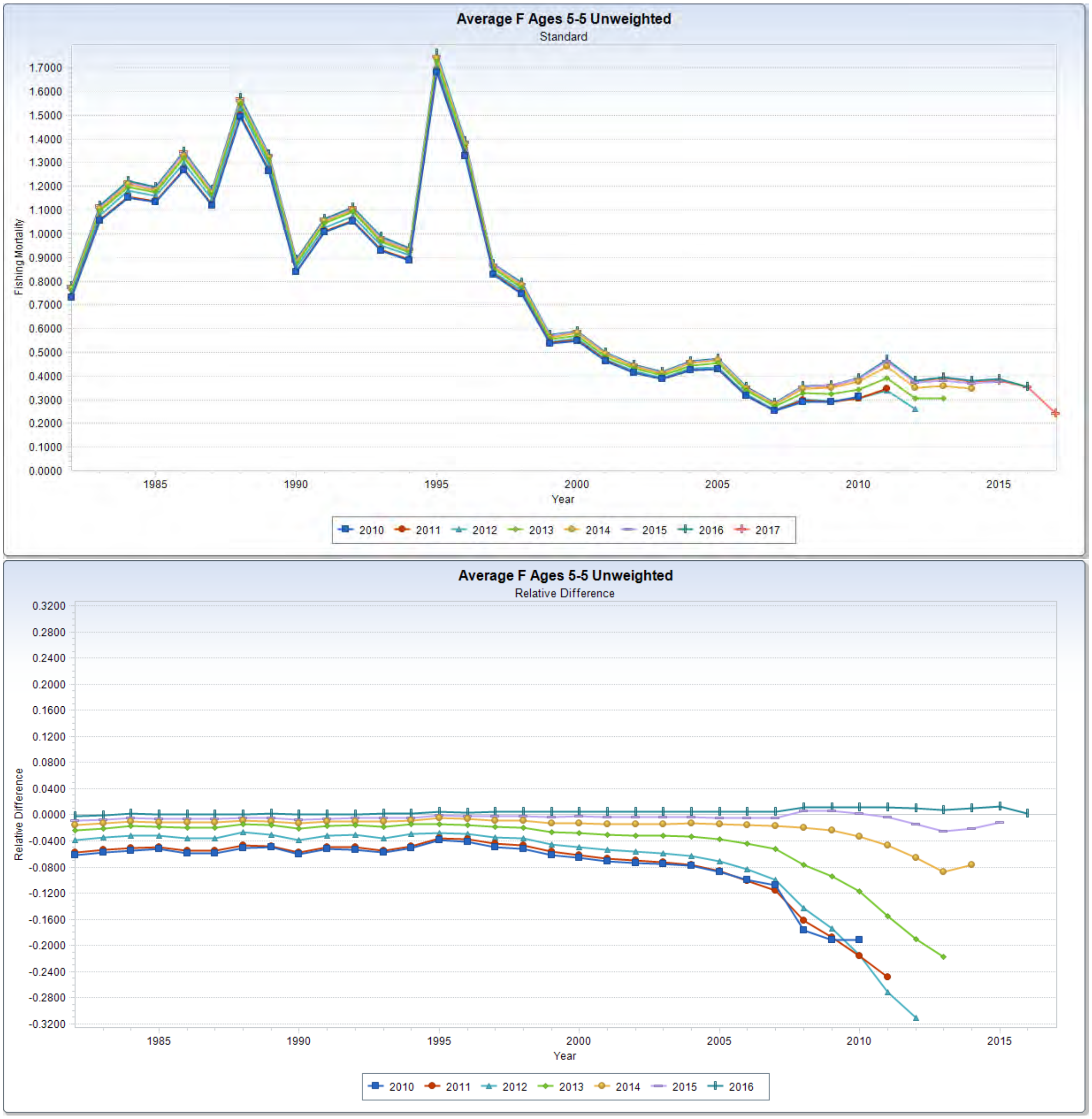


Figure A119. Results of internal model retrospective analysis for the existing (current) ASAP assessment model F2018: fully recruited F (true age 4, model age 5); average retrospective error = -15%.

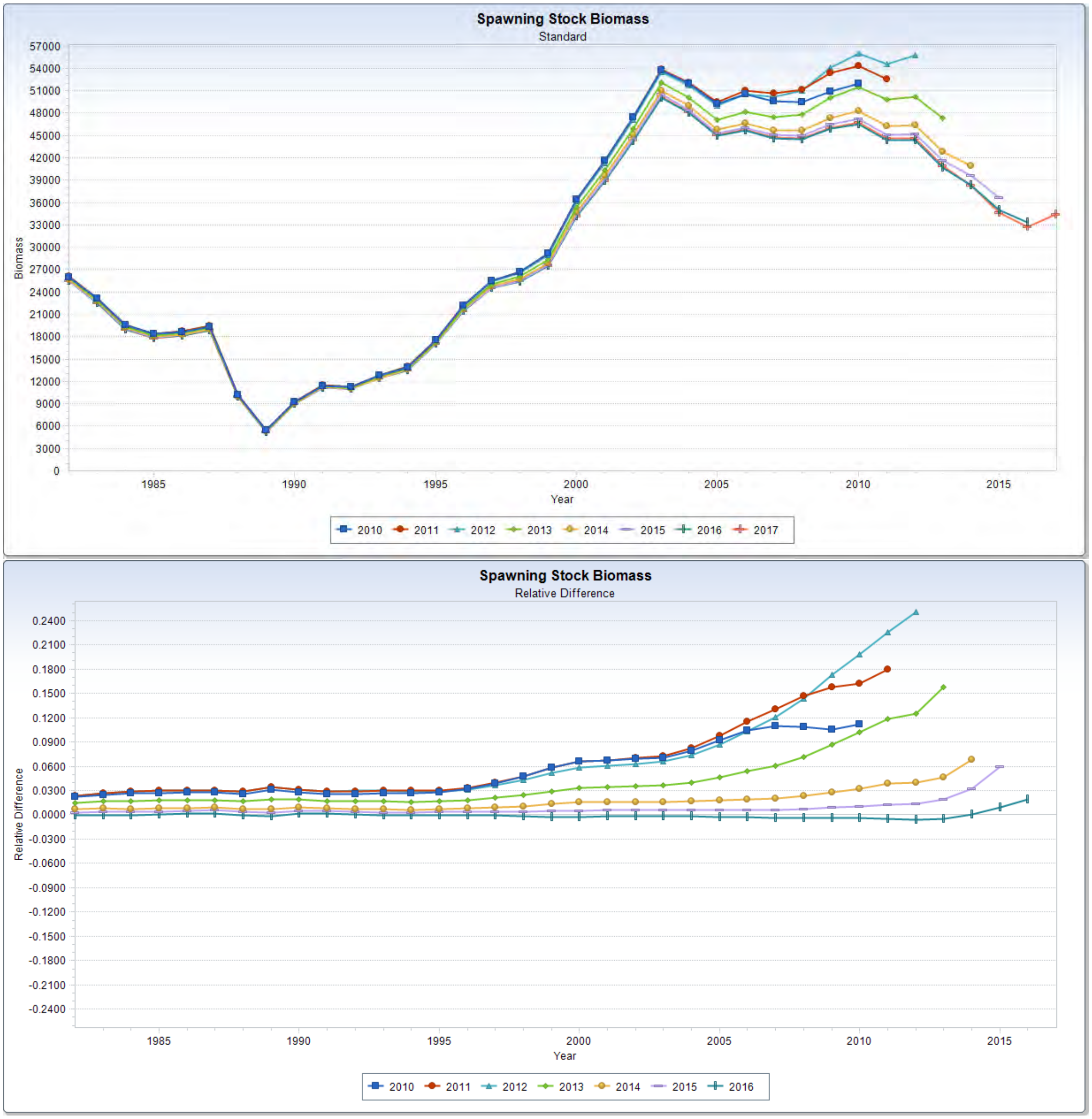


Figure A120. Results of internal model retrospective analysis for the existing (current) ASAP assessment model F2018: Spawning Stock Biomass; average retrospective error = +12%.

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.

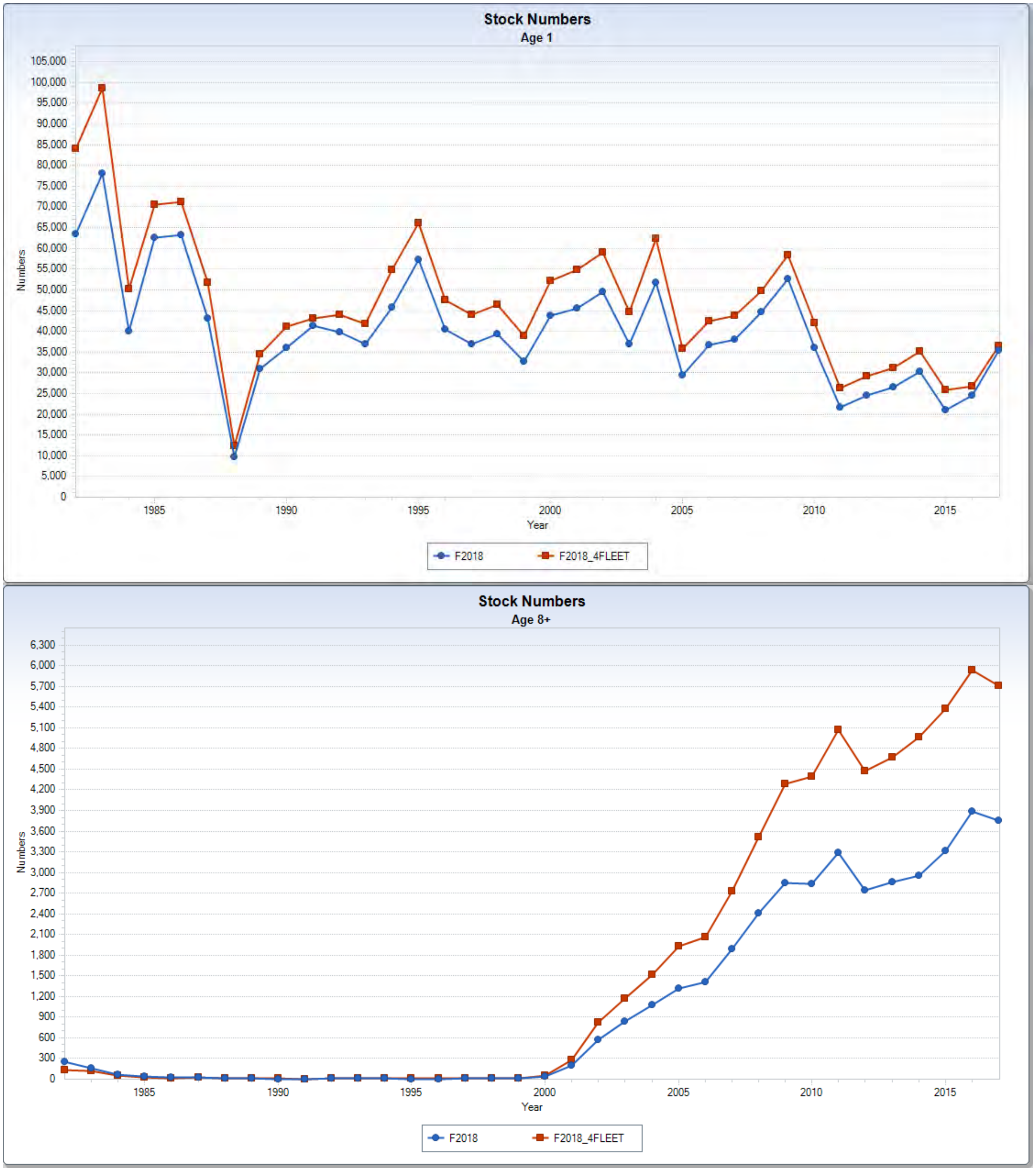


Figure A123. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018 model (2 fleets) with the F2018_4FLEET configuration of the ASAP model for summer flounder.

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.

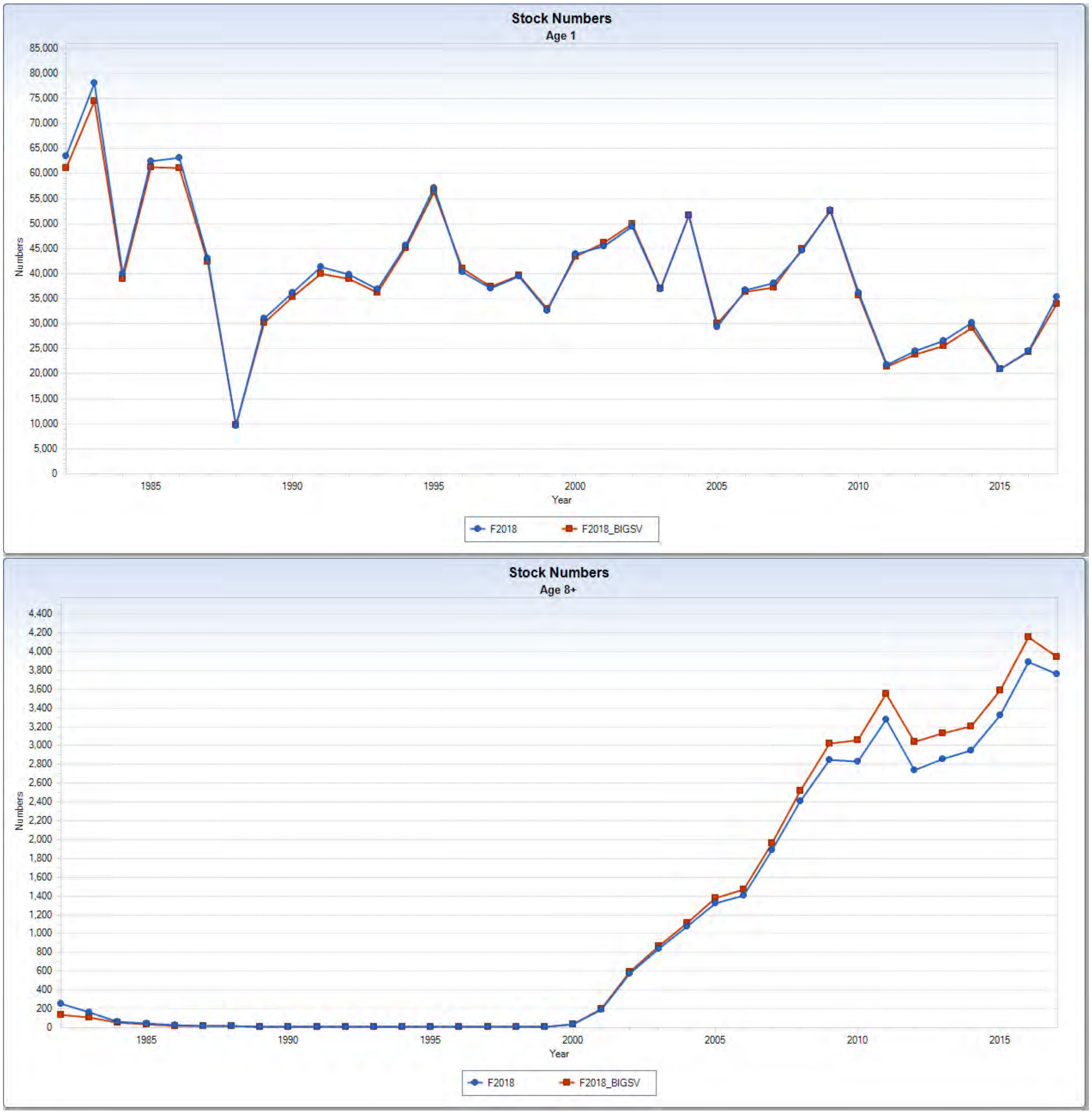


Figure A125. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018 model (2 fleets) with the F2018_BIGSV configuration of the ASAP model for summer flounder.

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.

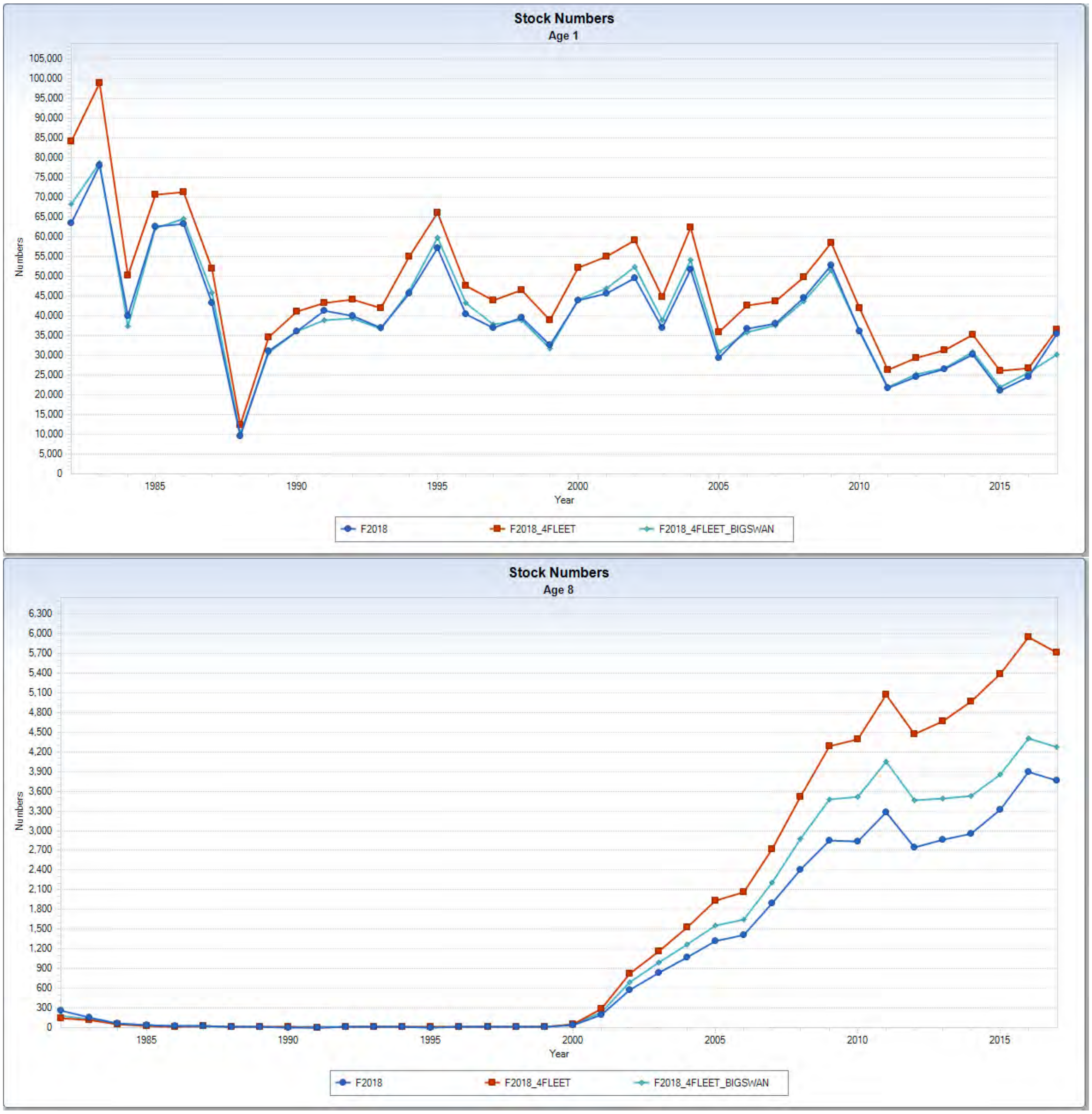


Figure A127. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018 model (2 fleets), F2018_4FLEET, and F2018_4FLEET_BIGSWAN configurations of the ASAP model for summer flounder.

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.

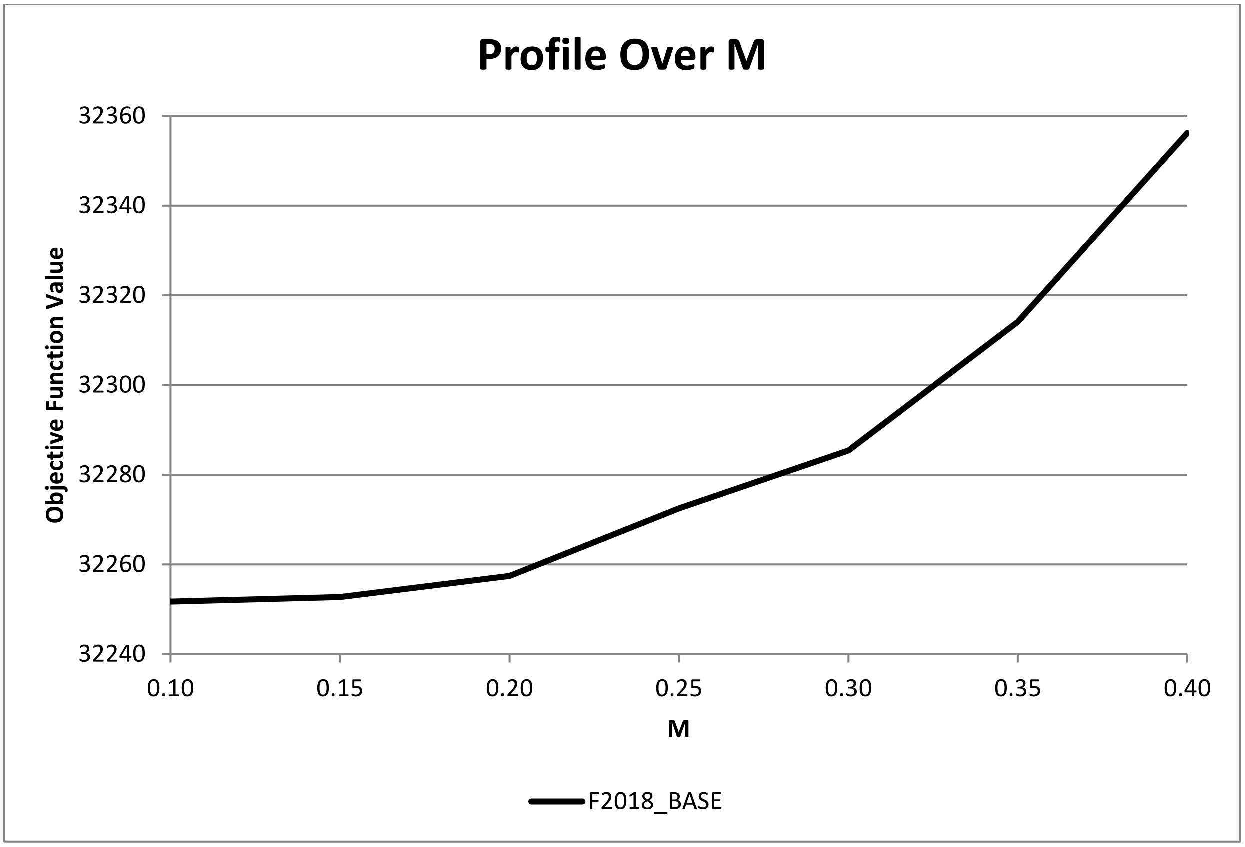


Figure A130. Likelihood profile for the F2018_BASE run over M values from 0.10 to 0.40.

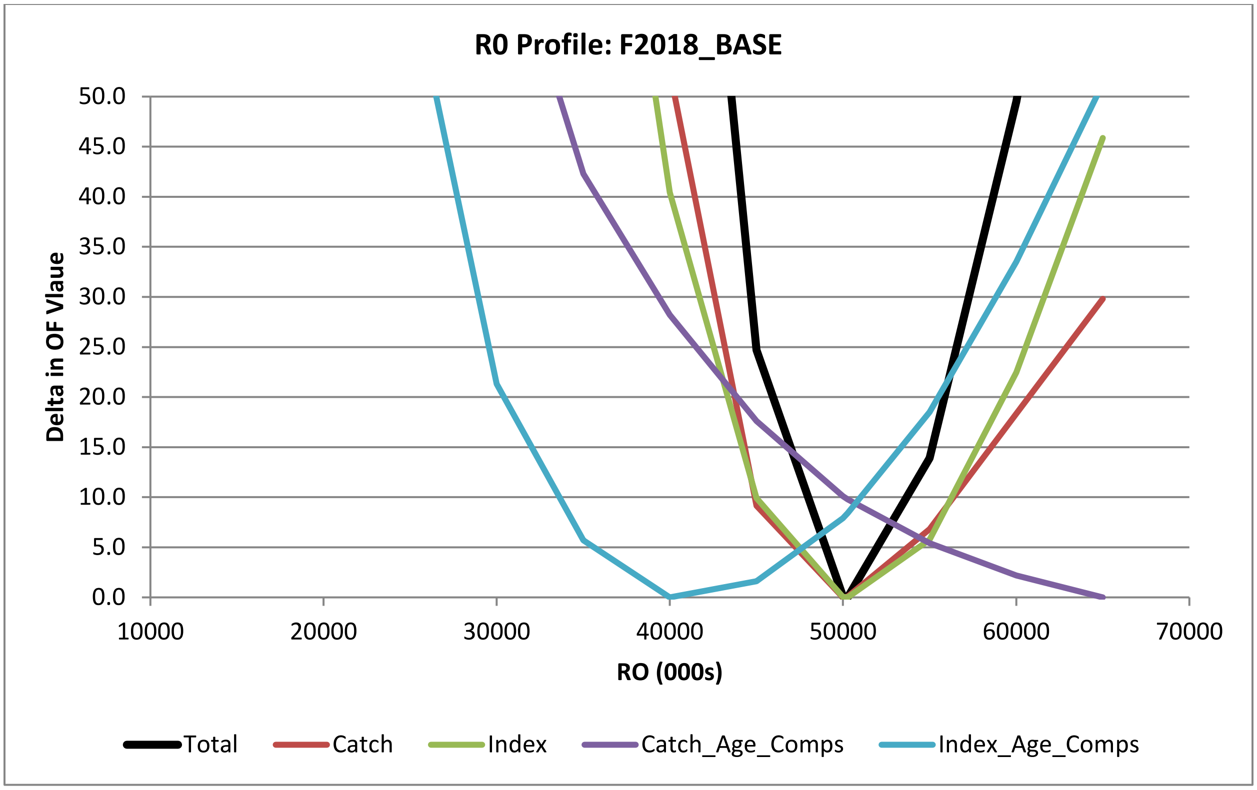
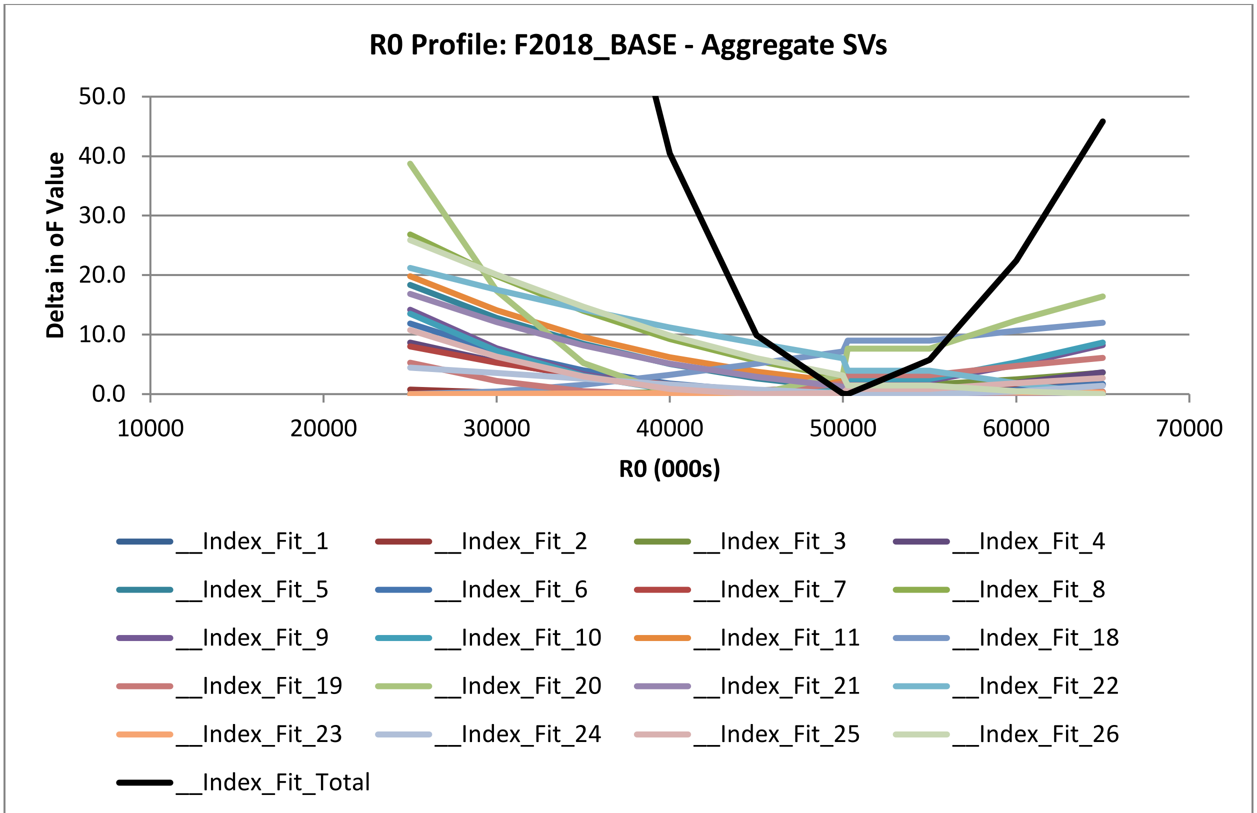


Figure A131. Likelihood profile for the F2018_BASE run over R0 values.



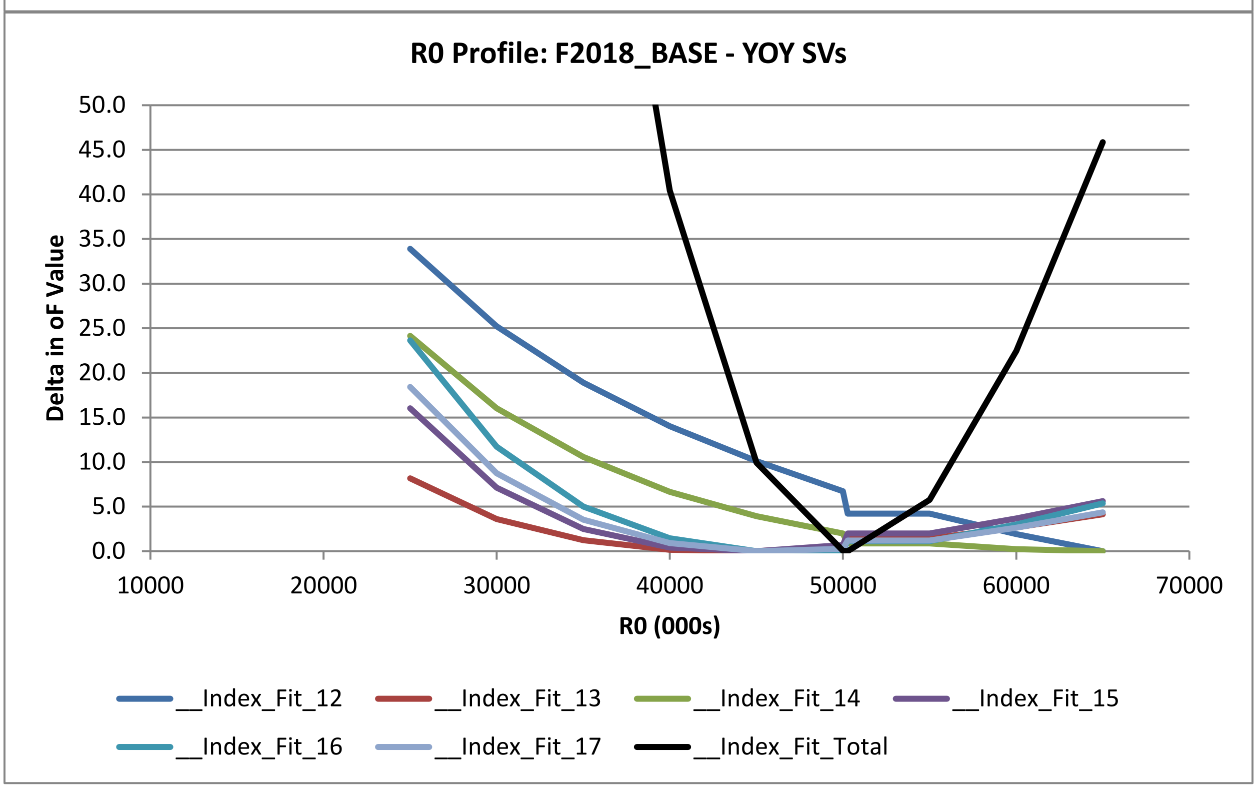


Figure A132 continued. Likelihood profile for the F2018_BASE run over R0 values.

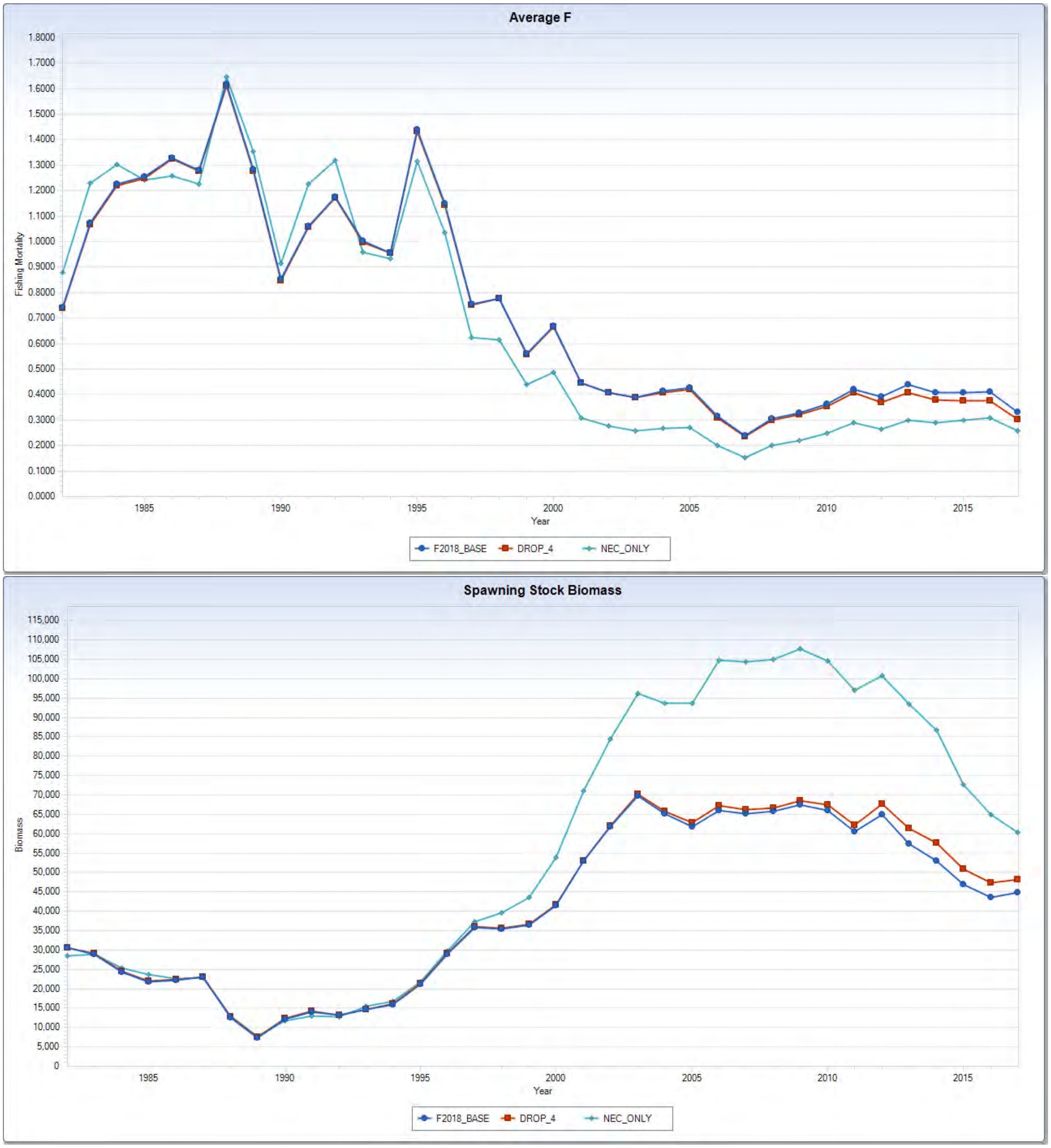


Figure A133. Comparison of the fishing mortality (top panel) and Spawning Stock Biomass (bottom panel) results for the F2018_BASE model with the DROP_4 and NEC_ONLY configurations.

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).

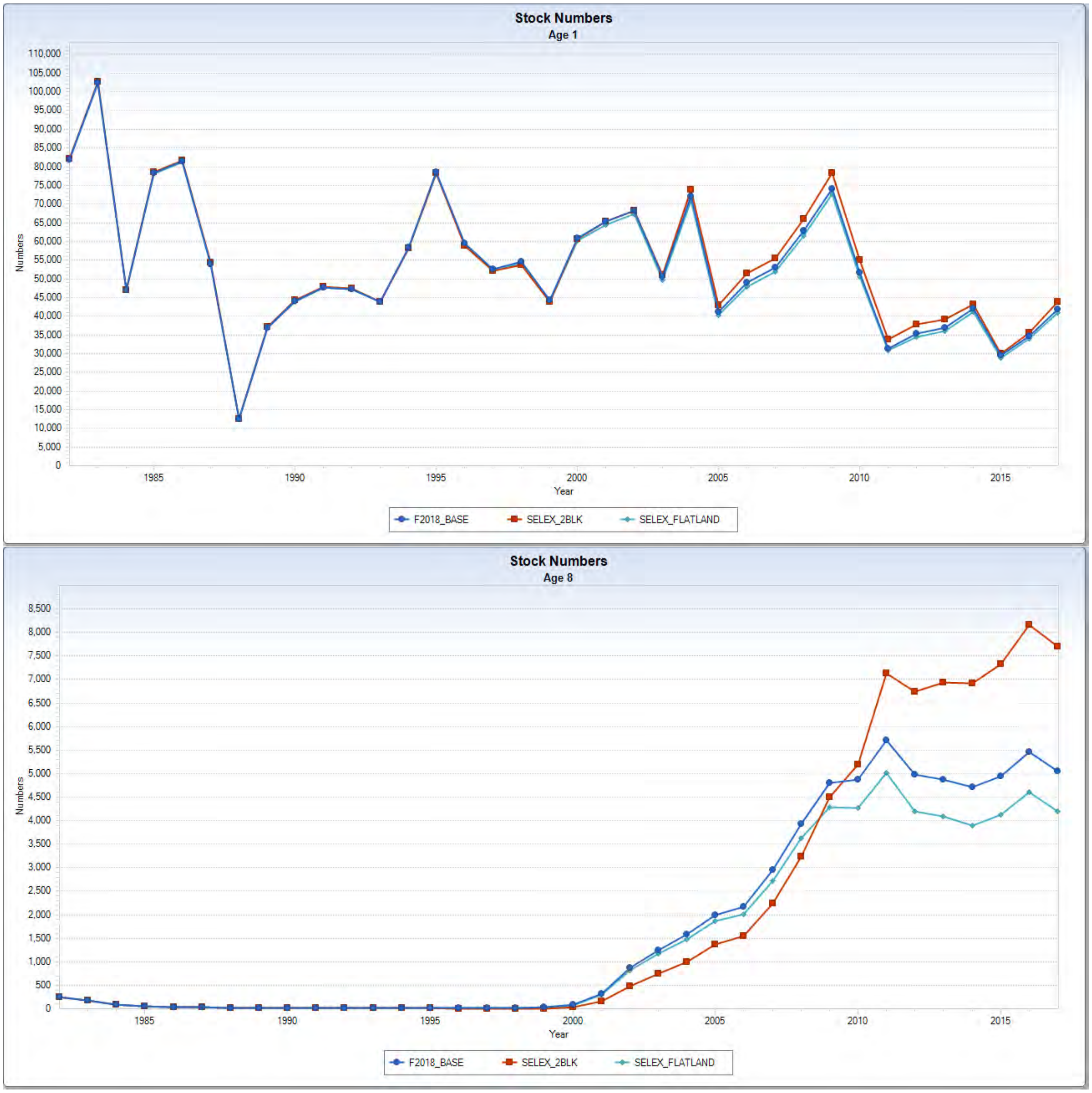


Figure A136. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018_BASE model (three selectivity time blocks) with a two selection block version (1982-1994, 1995-2017; SELEX_2BLK), and a version with fixed flat-topped landings selectivity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

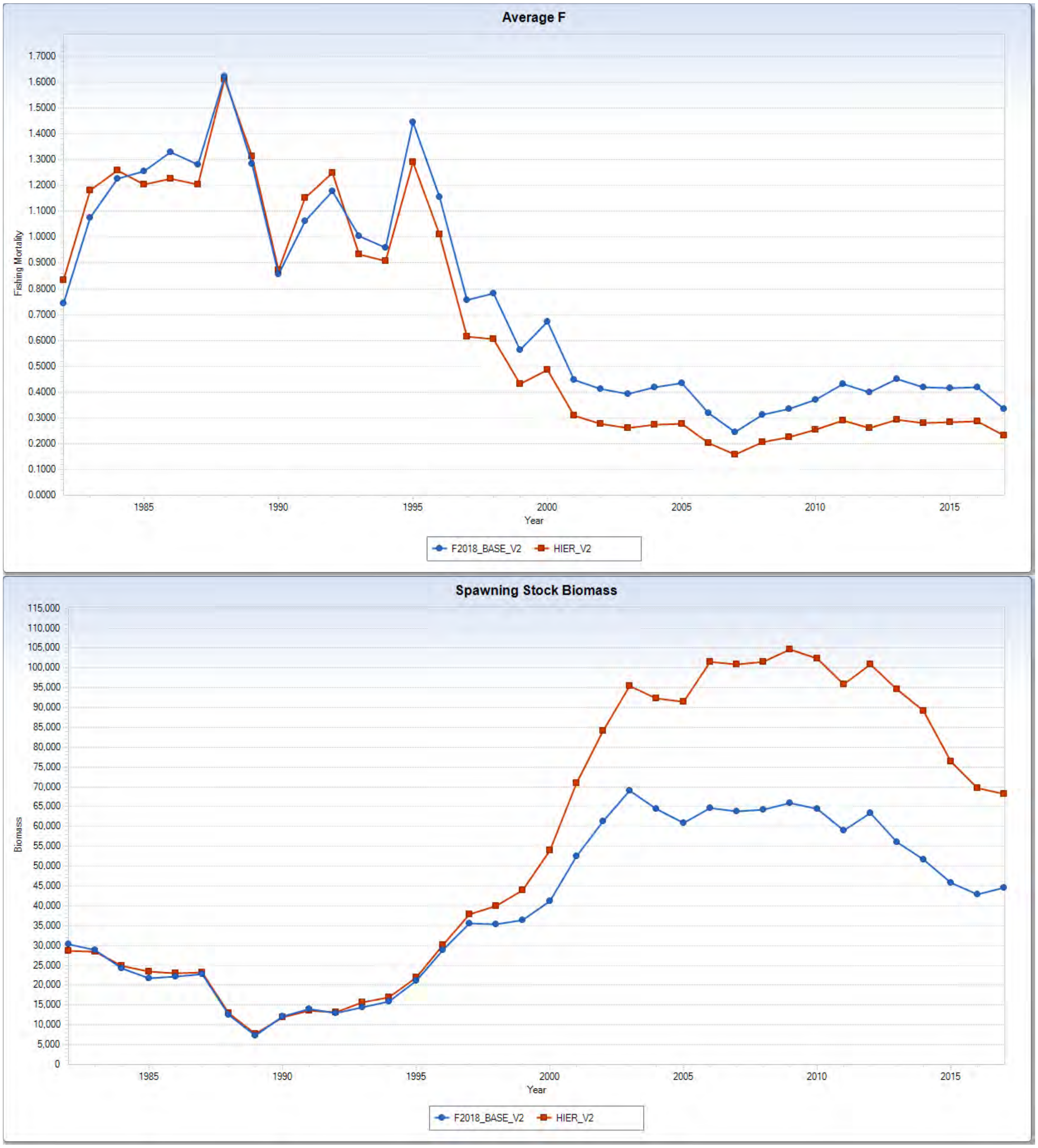


Figure A137. Comparison of the fishing mortality (top panel) and Spawning Stock Biomass (bottom panel) results for the F2018_BASE_V2 model with those for the hierarchical 'aggregate index' model HIER_V2.

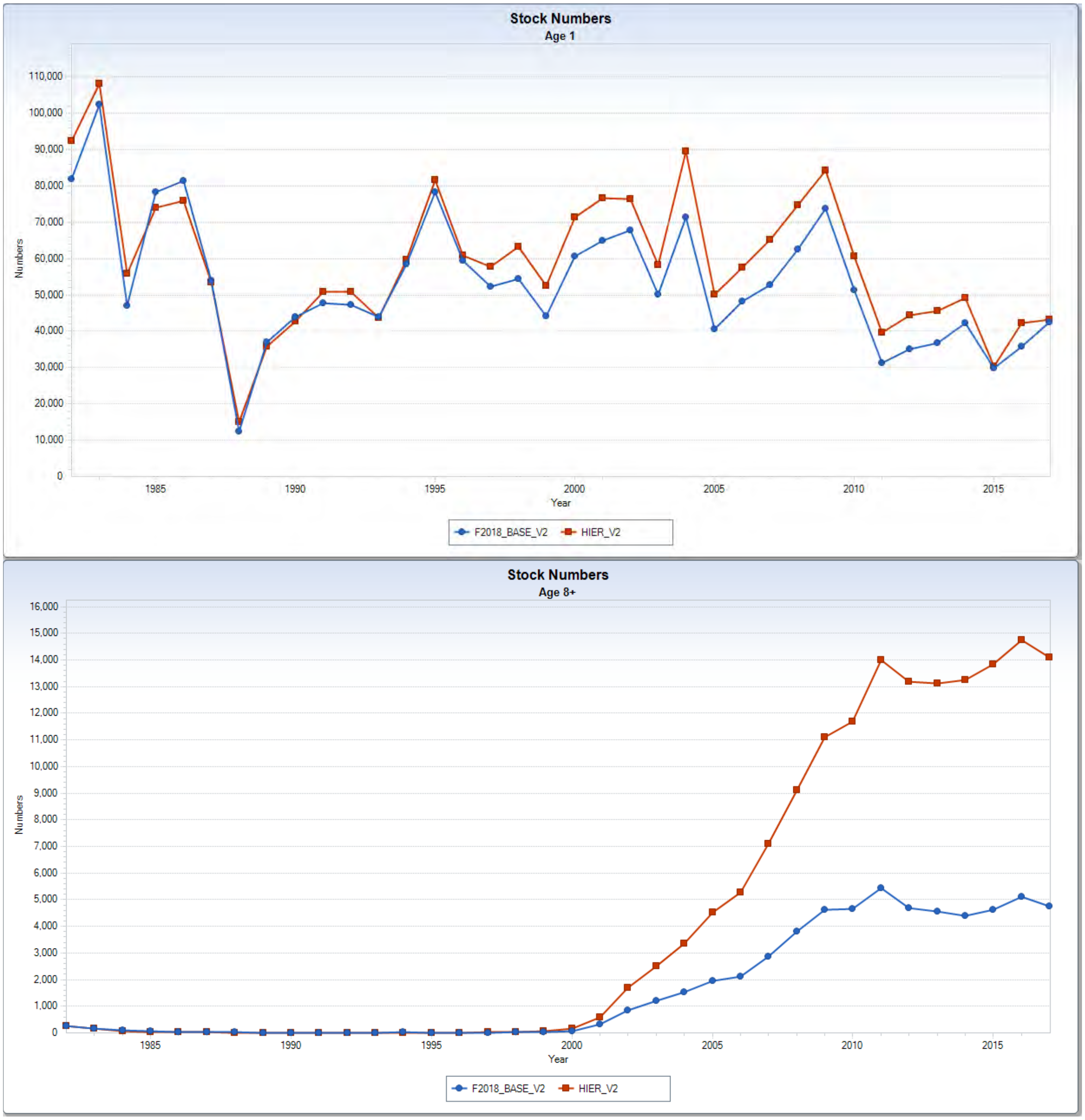


Figure A138. Comparison of the estimated stock numbers for age 0 (model age 1) and for the age 7+ group (model age 8+) for the F2018_BASE_V2 model with those for the hierarchical 'aggregate index' model HIER_V2.

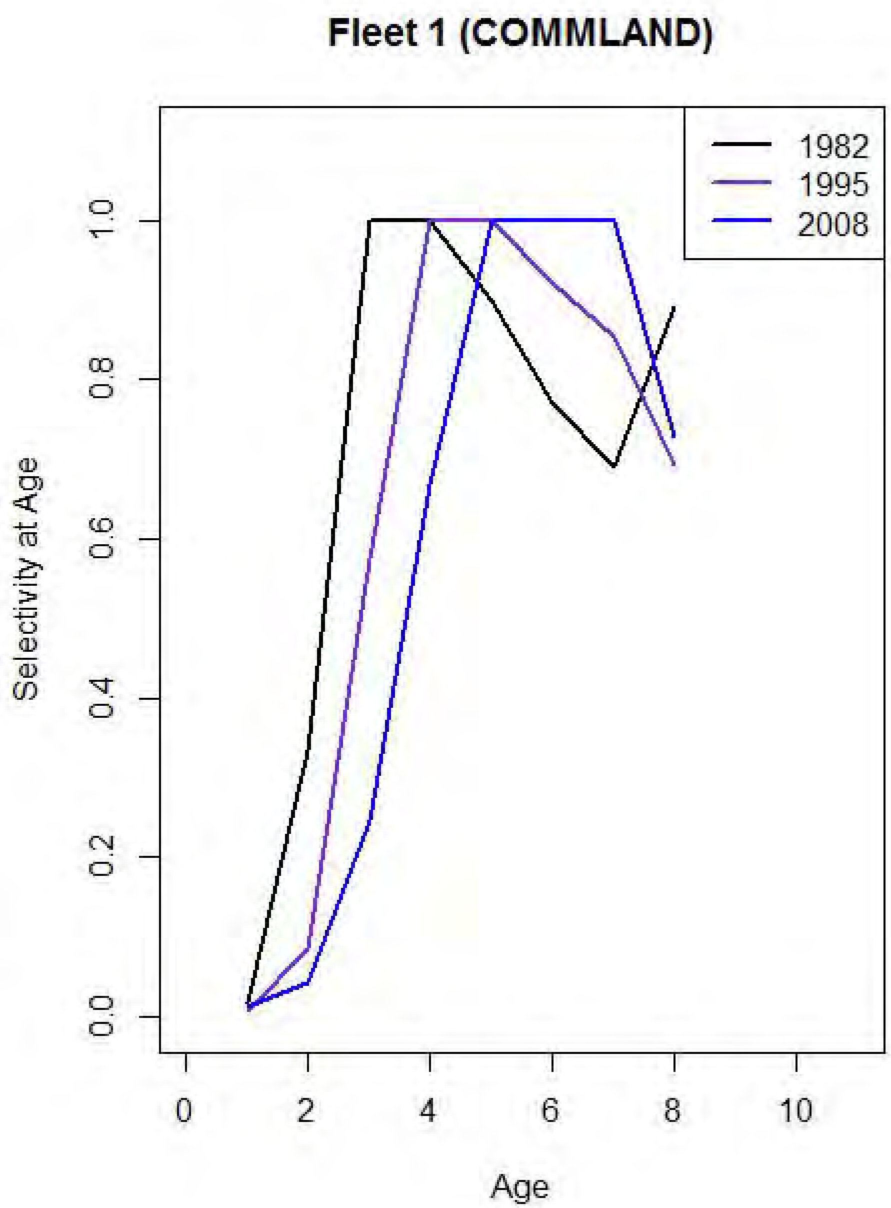


Figure A139. Commercial landings fleet selectivity patterns for the F2018_BASE_V2 model run.

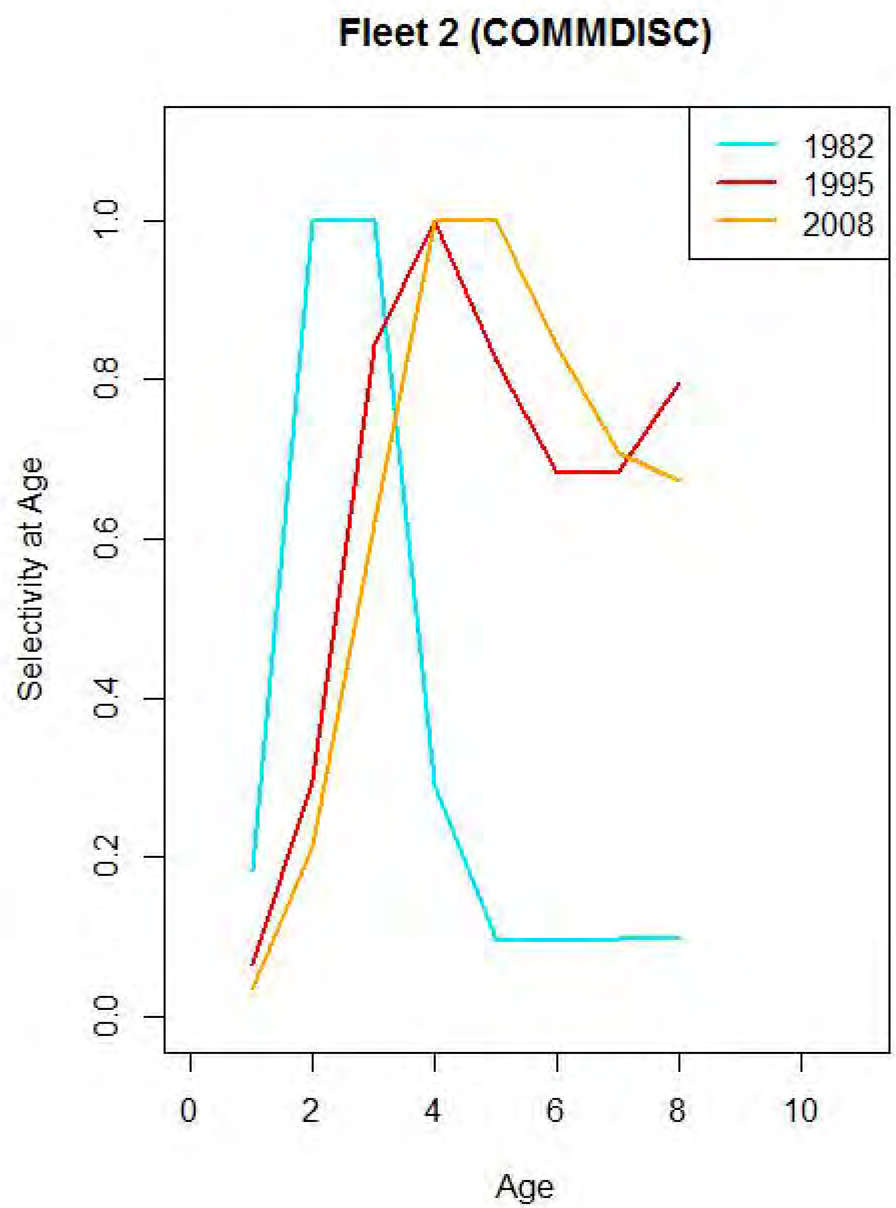


Figure A140. Commercial discards fleet selectivity patterns for the F2018_BASE_V2 model run.

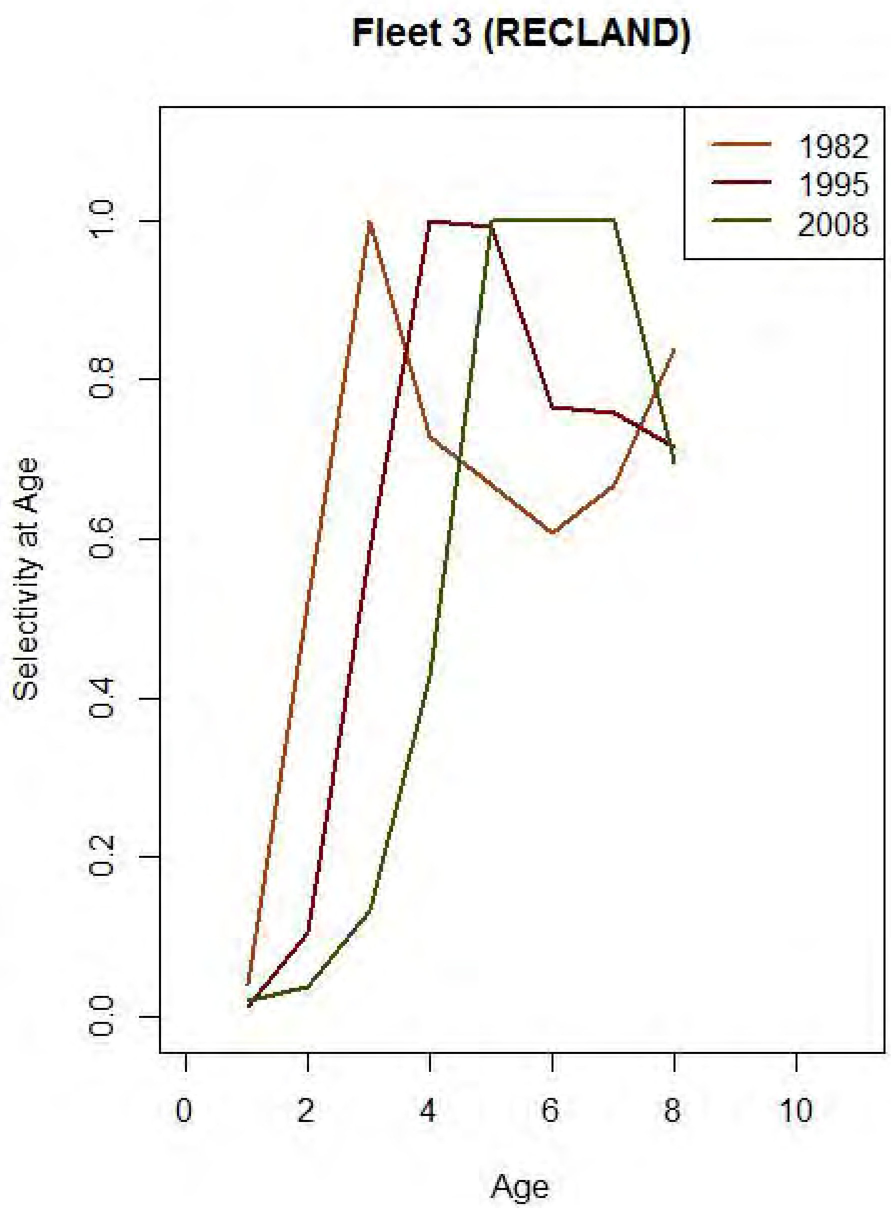


Figure A141. Recreational landings fleet selectivity patterns for the F2018_BASE_V2 model run.

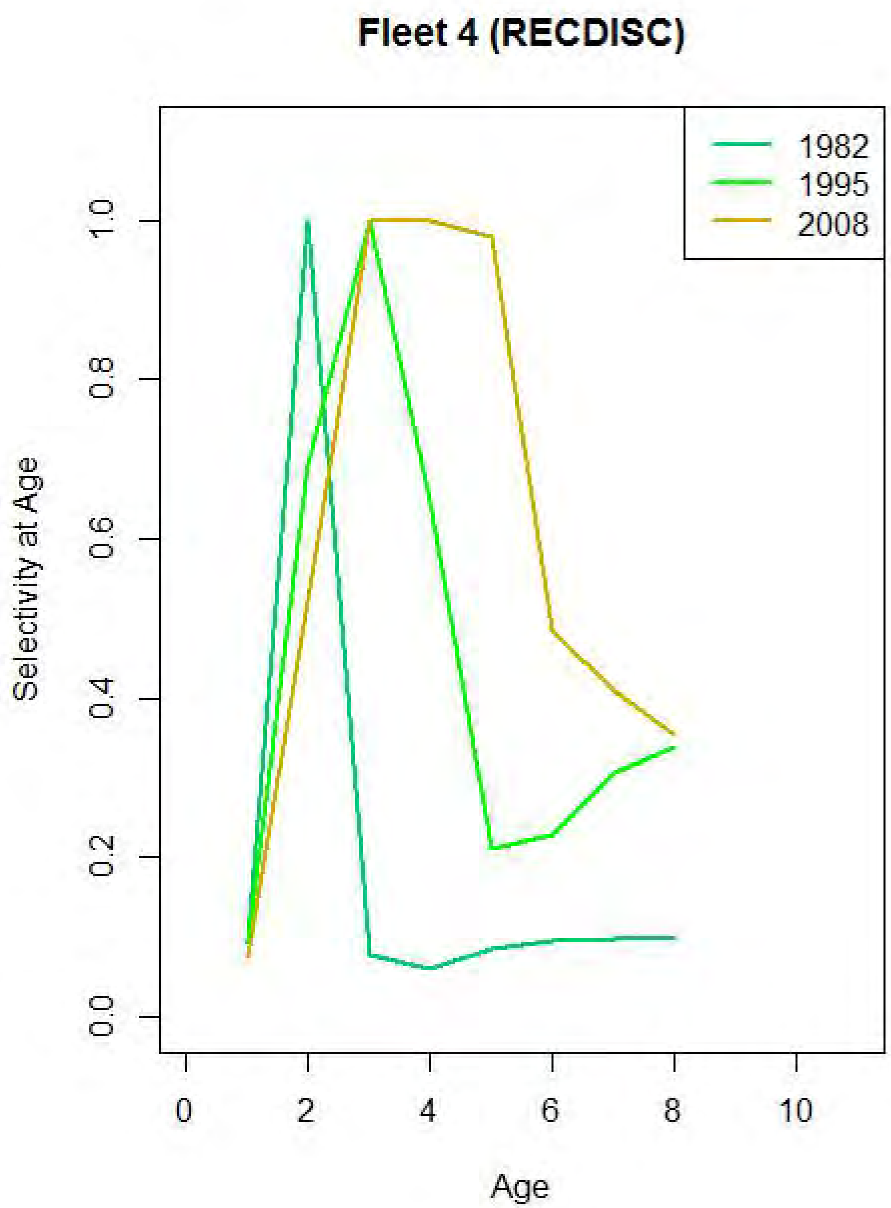


Figure A142. Recreational discards fleet selectivity patterns for the F2018_BASE_V2 model run.

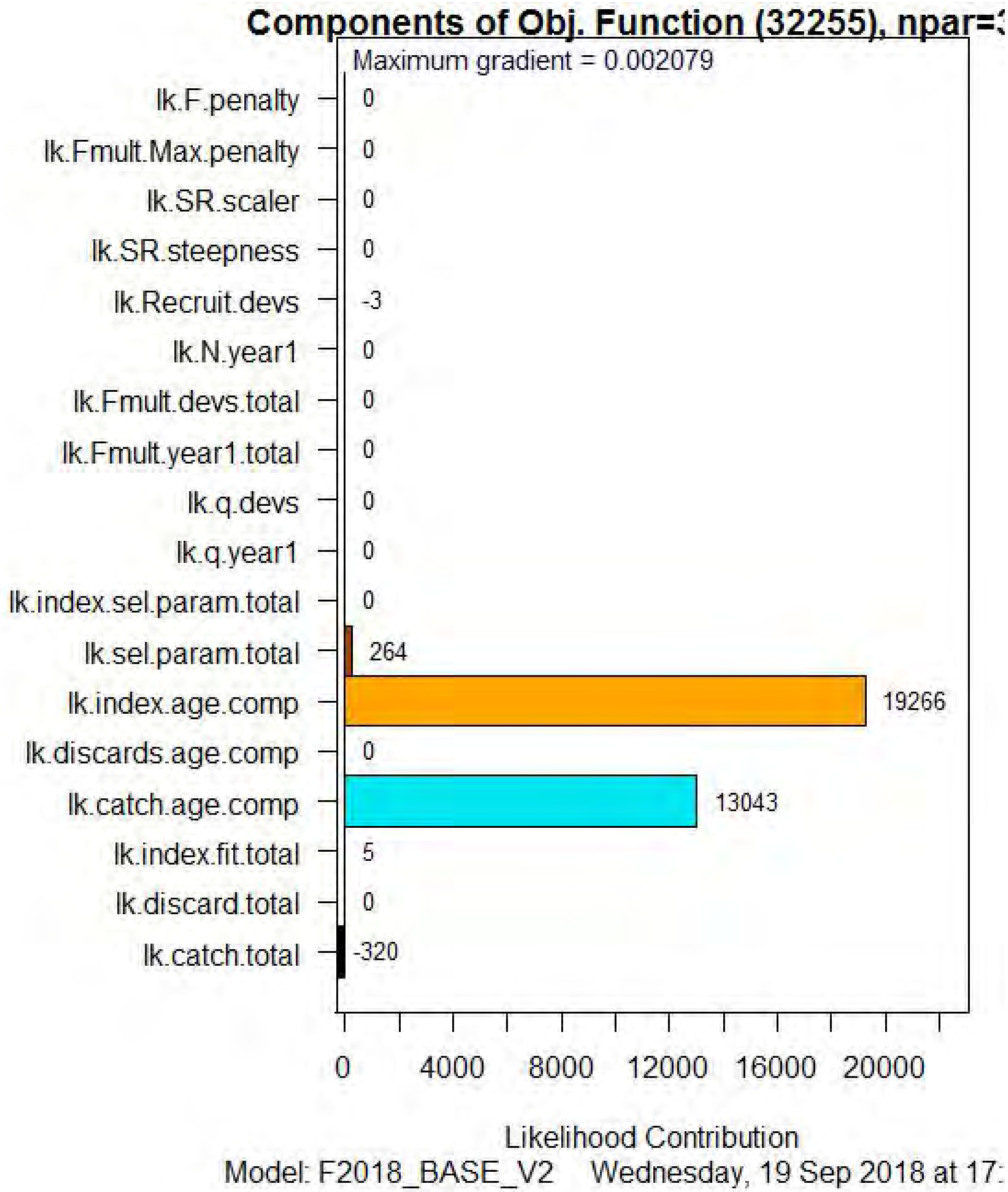


Figure A143. Distribution of the objective function components contribution to total likelihood for the F2018_BASE_V2 model run.

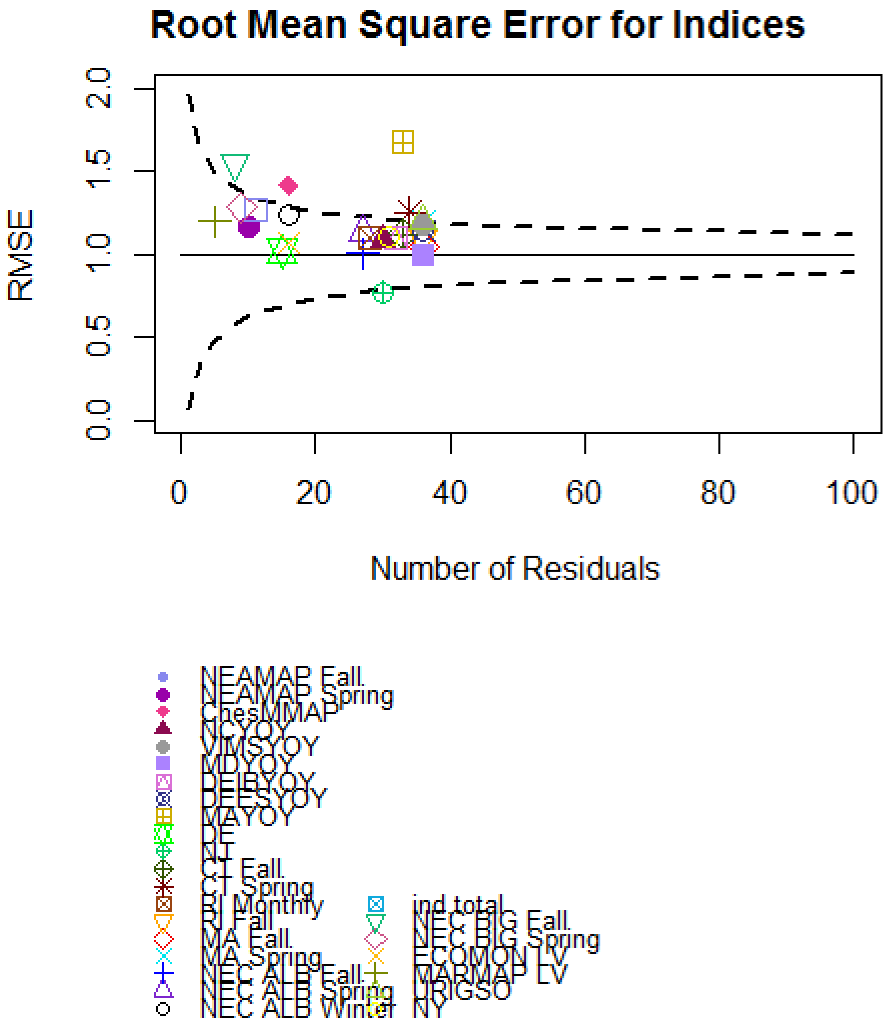


Figure A144. Root Mean Square Error (RMSE) for aggregate survey indices from the F2018_BASE_V2 model run.

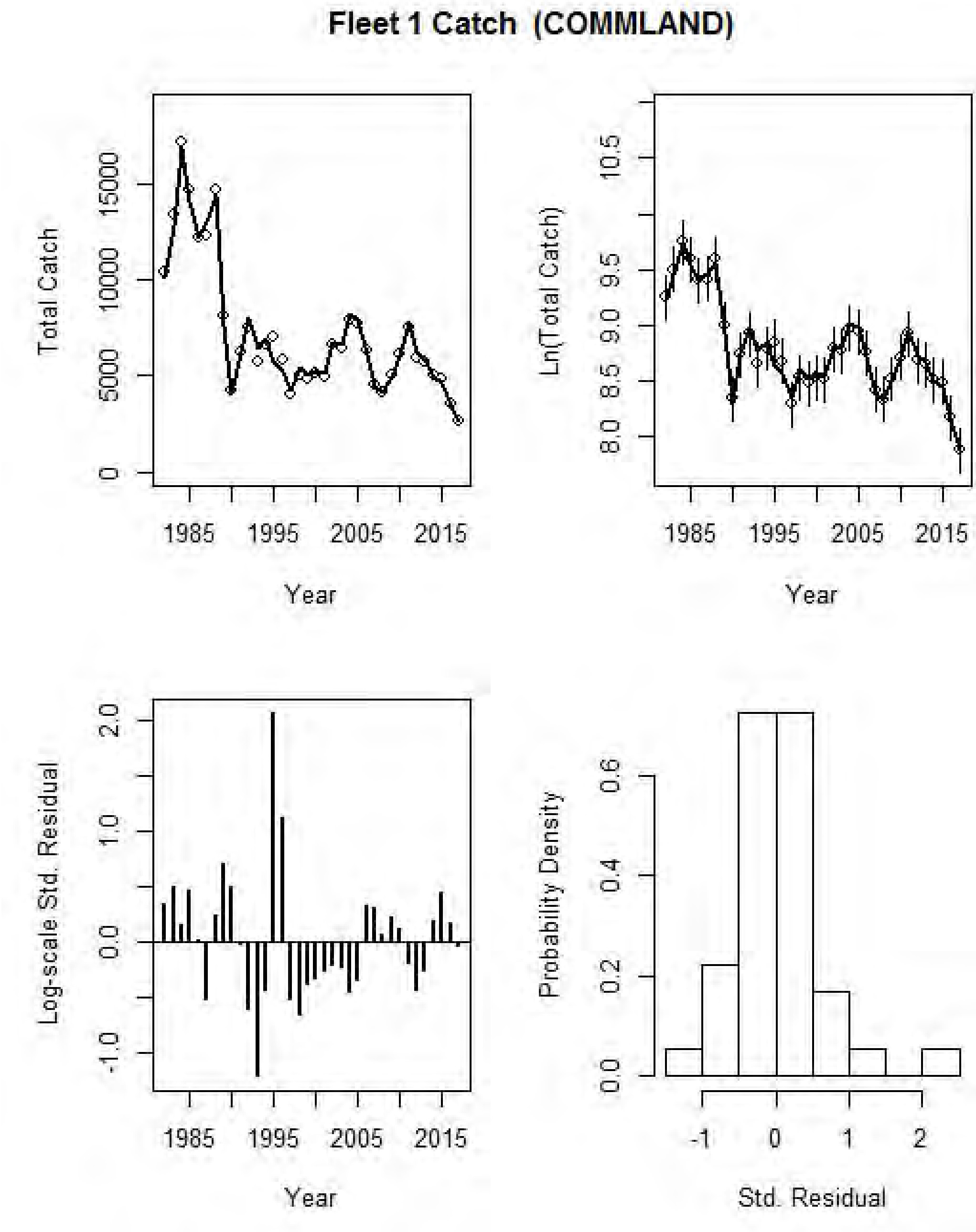


Figure A145. Fit diagnostics for the commercial fishery landings from the F2018_BASE_V2 model run.

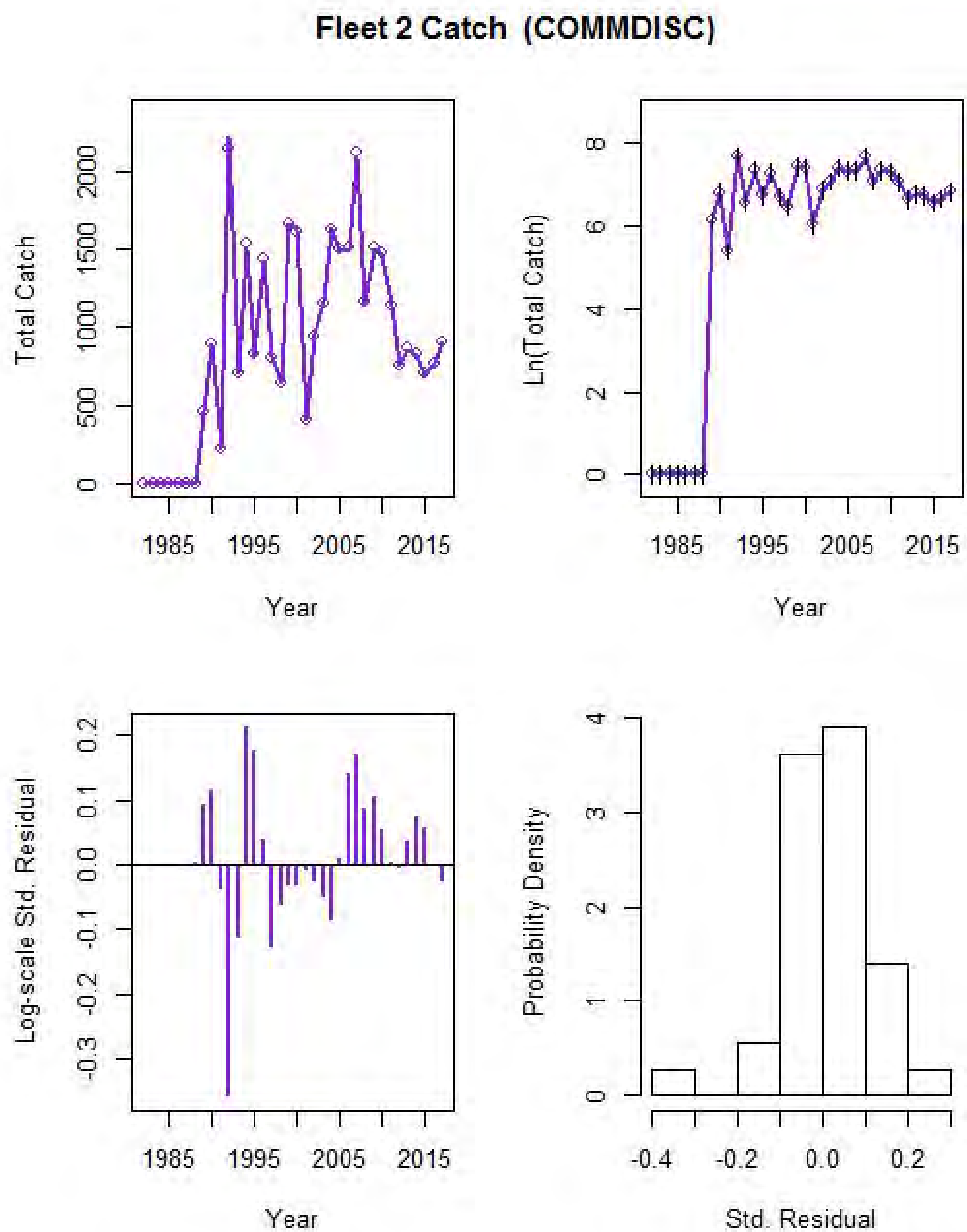


Figure A146. Fit diagnostics for the commercial fishery discards from the F2018_BASE_V2 model run.

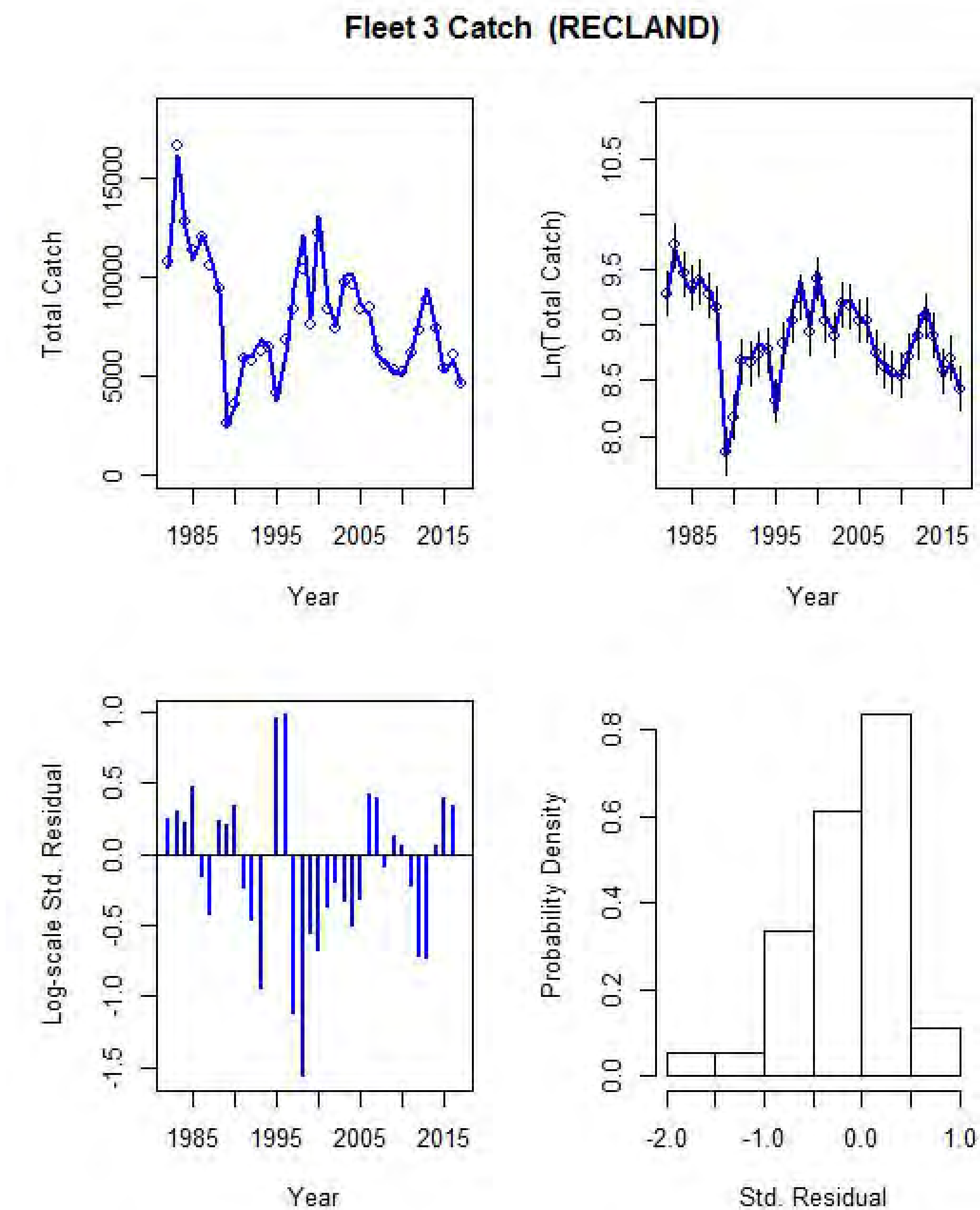


Figure A147. Fit diagnostics for the recreational fishery landings from the F2018_BASE_V2 model run.

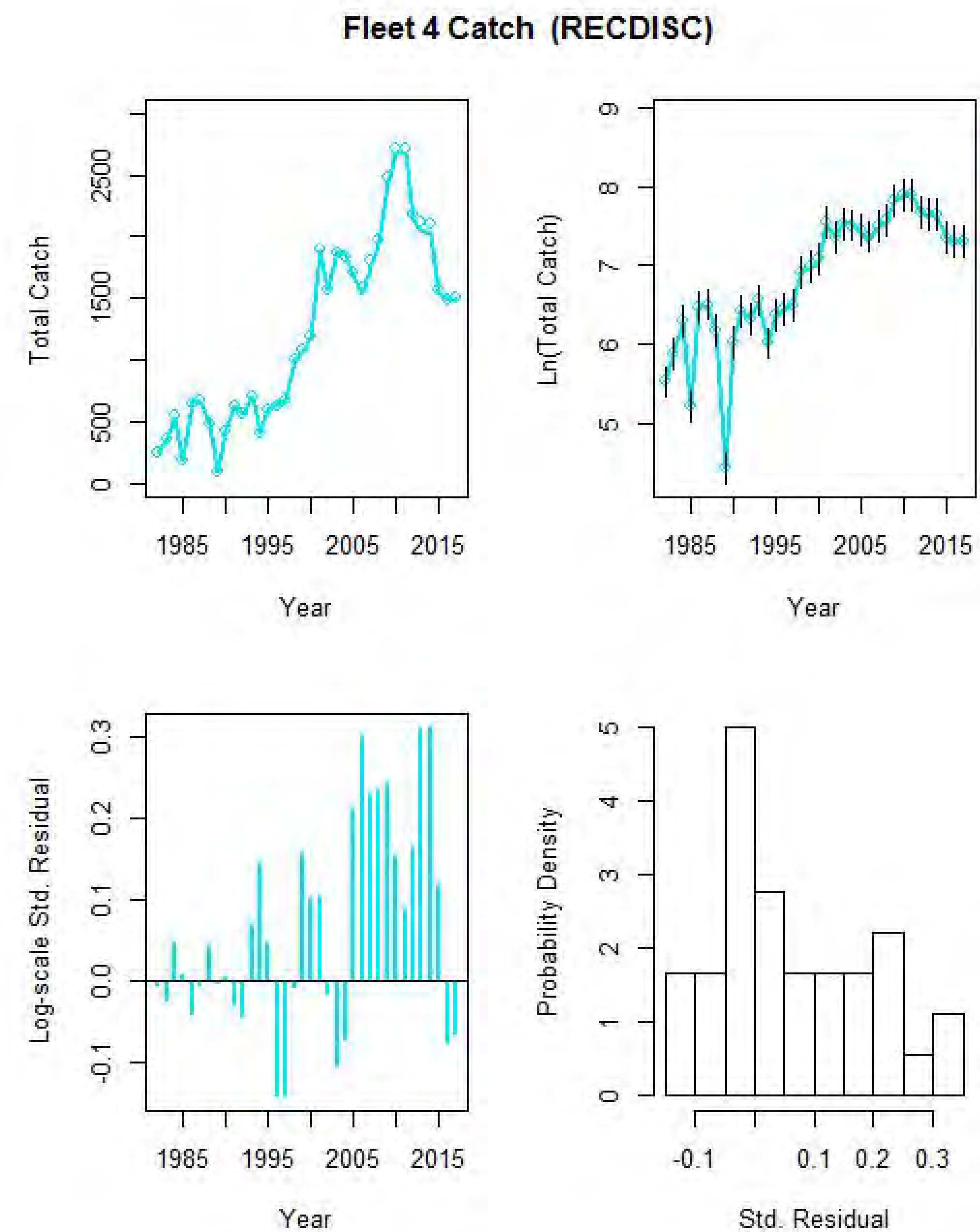


Figure A148. Fit diagnostics for the recreational fishery discards from the F2018_BASE_V2 model run.

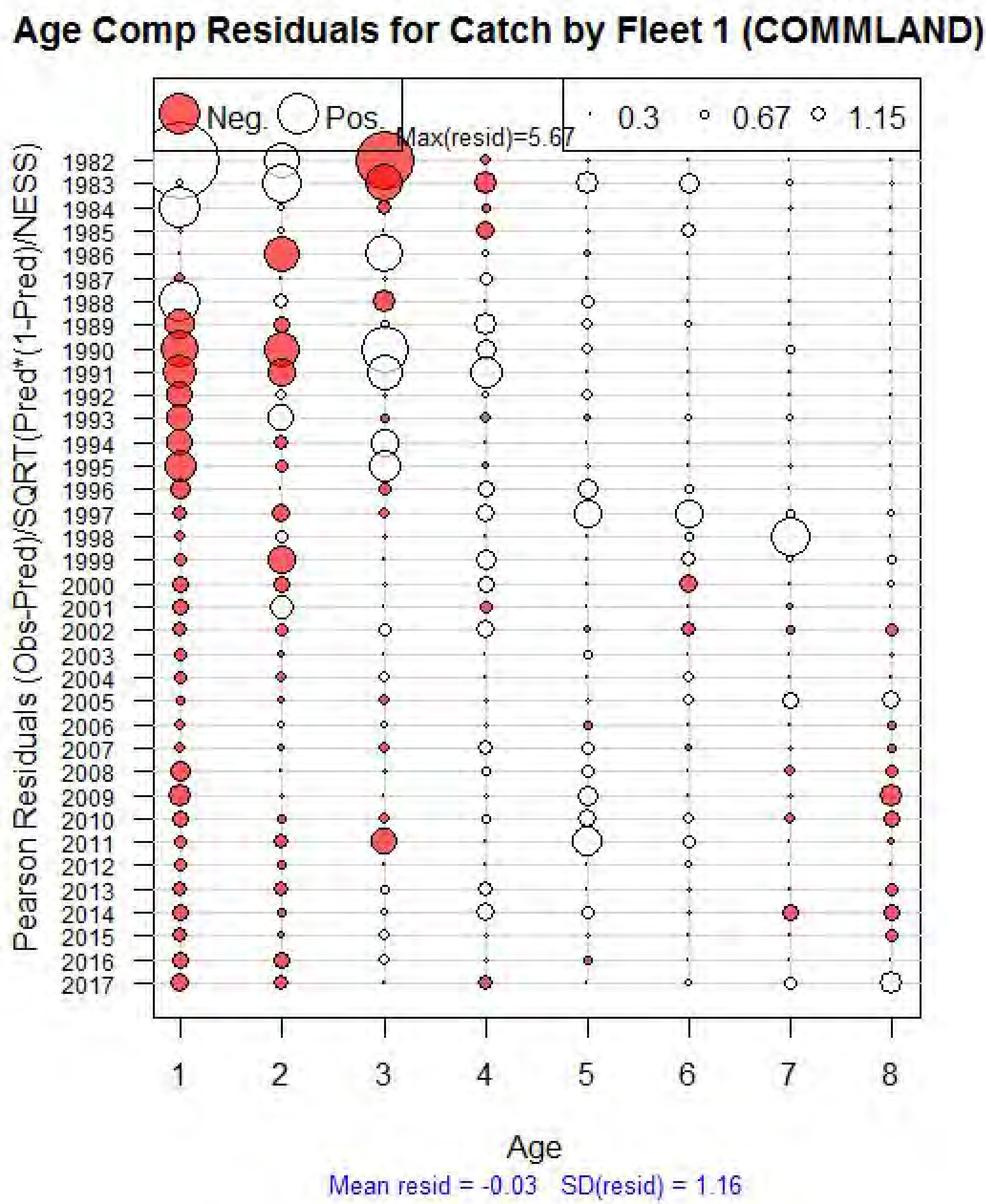


Figure A149. Commercial fishery landings age composition residuals from the F2018_BASE_V2 model run.

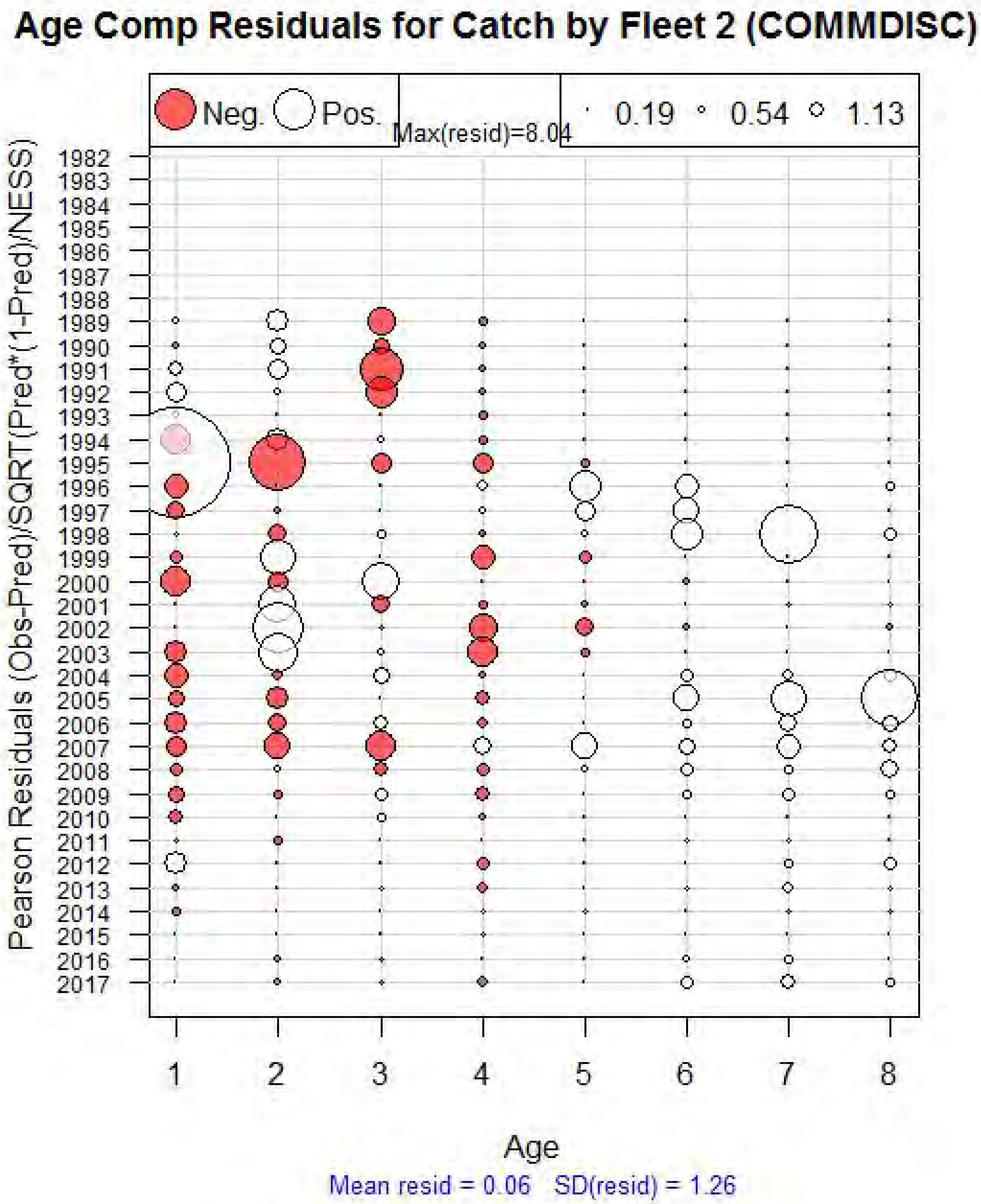


Figure A150. Commercial fishery discards age composition residuals from the F2018_BASE_V2 model run.

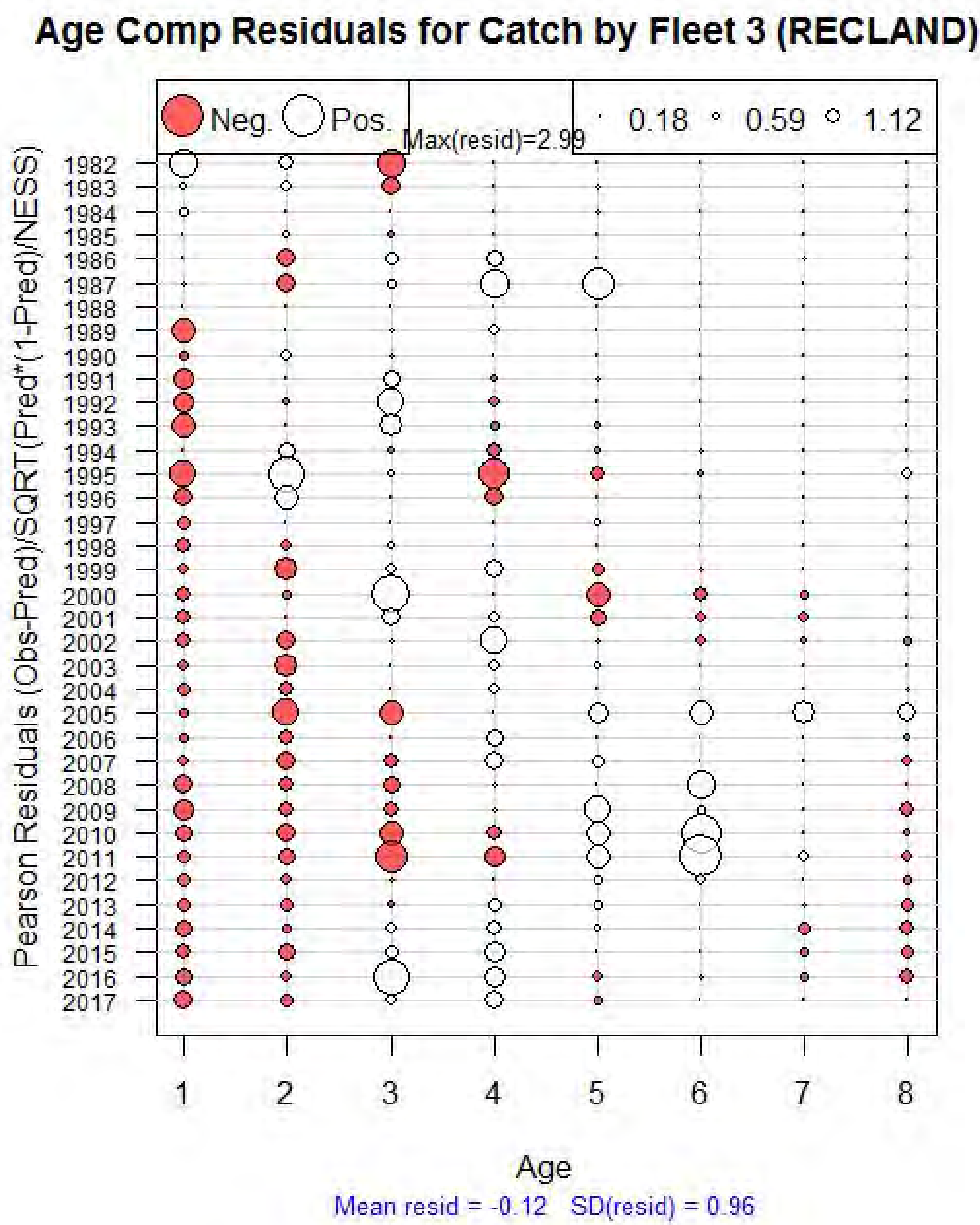


Figure A151. Recreational fishery landings age composition residuals from the F2018_BASE_V2 model run.

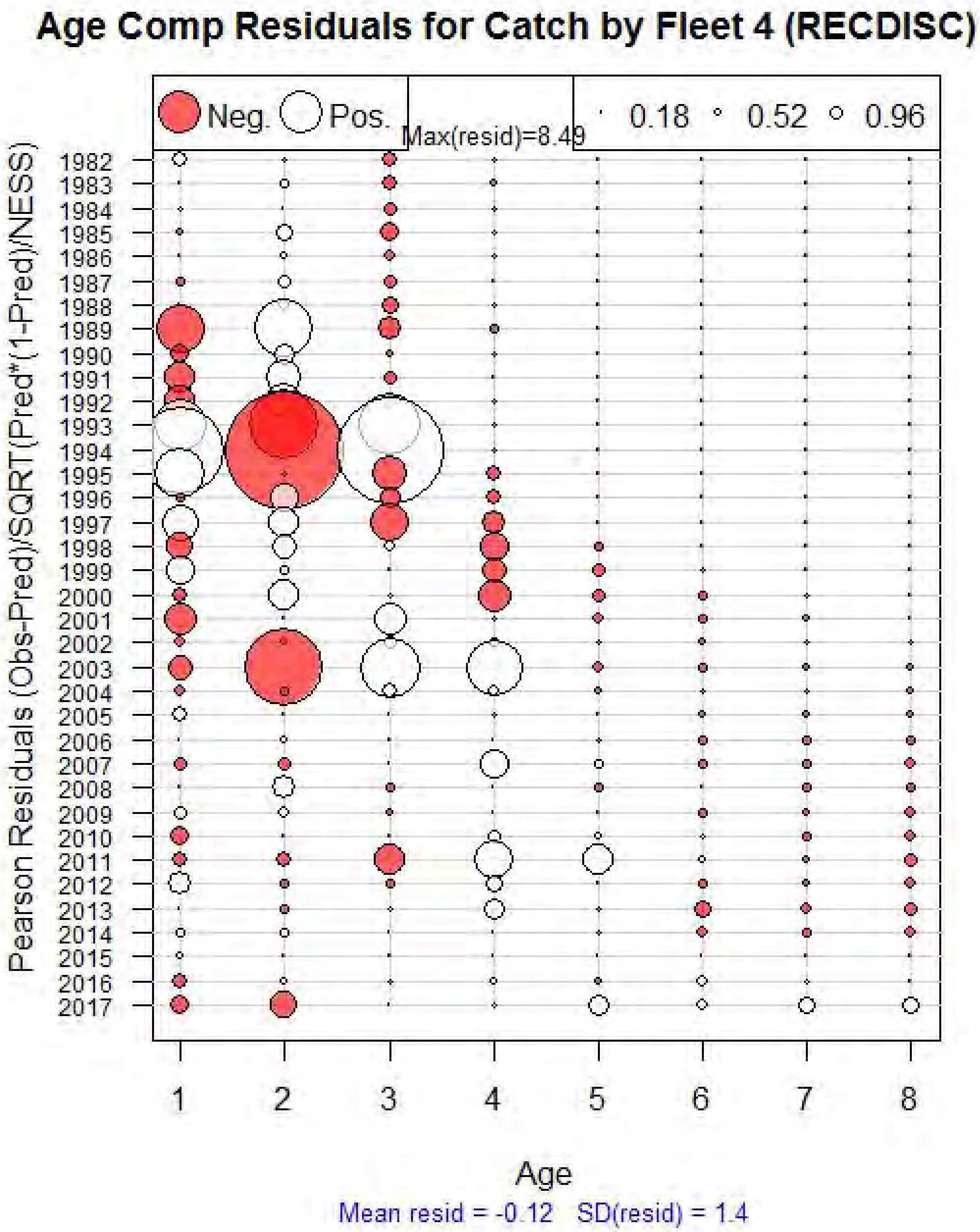


Figure A152. Recreational fishery discards age composition residuals from the F2018_BASE_V2 model run.

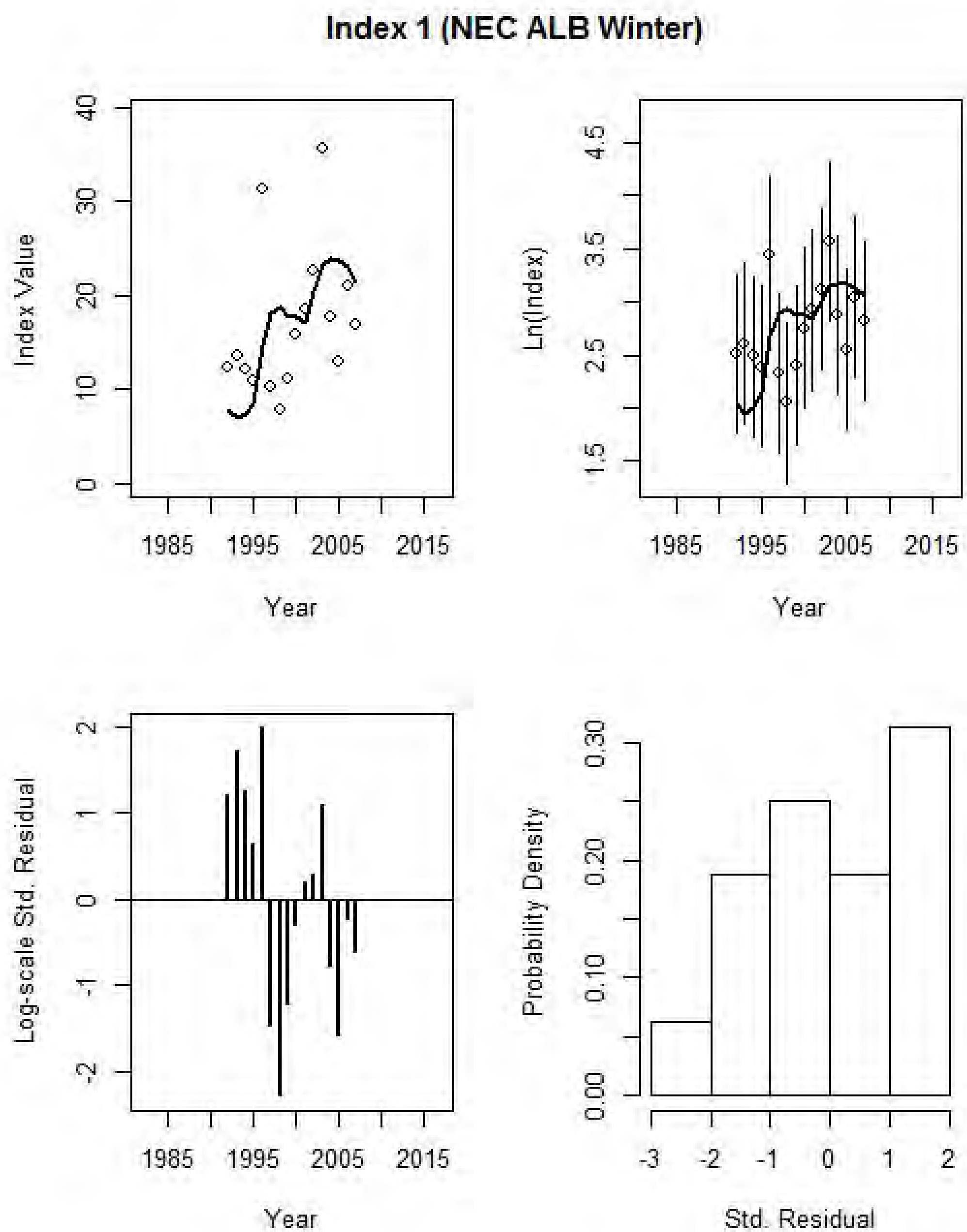


Figure A153. Fit diagnostics for the Northeast Fisheries Science Center (NEC) Albatross (ALB) winter trawl survey from the F2018_BASE_V2 model run.

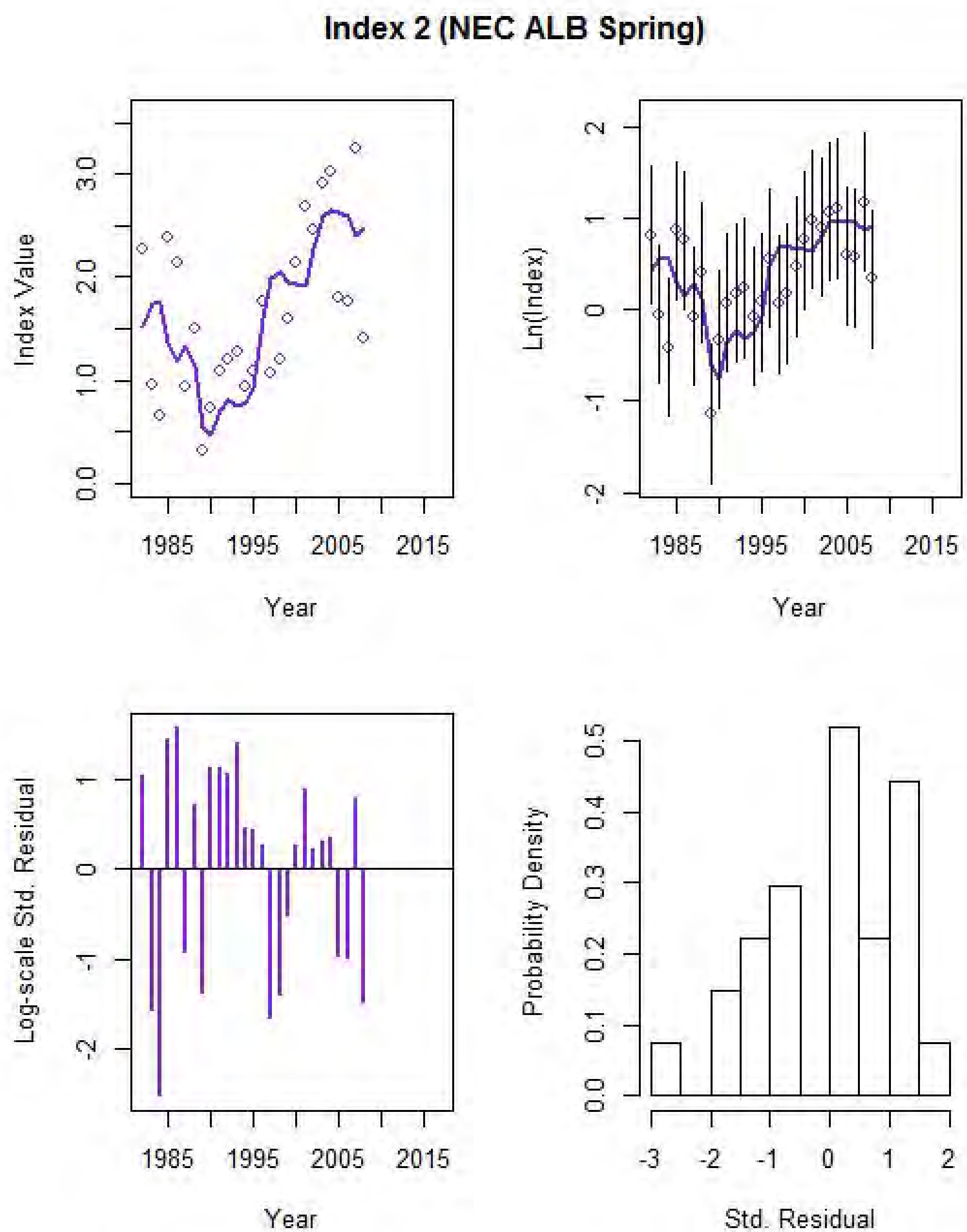


Figure A154. Fit diagnostics for the Northeast Fisheries Science Center (NEC) spring Albatross (ALB) trawl survey from the F2018_BASE_V2 model run.

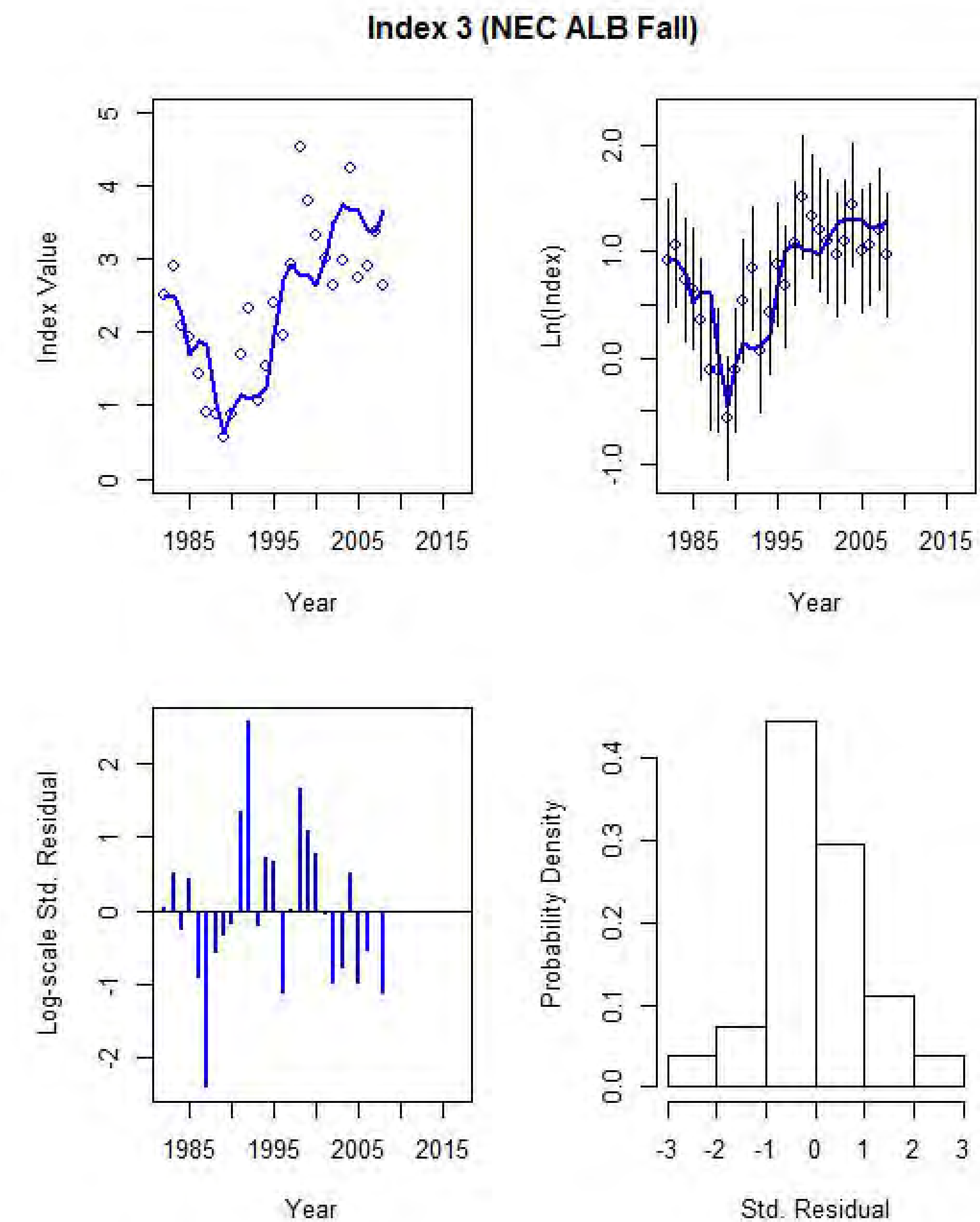


Figure A155. Fit diagnostics for the Northeast Fisheries Science Center (NEC) fall Albatross (ALB) trawl survey from the F2018_BASE_V2 model run.

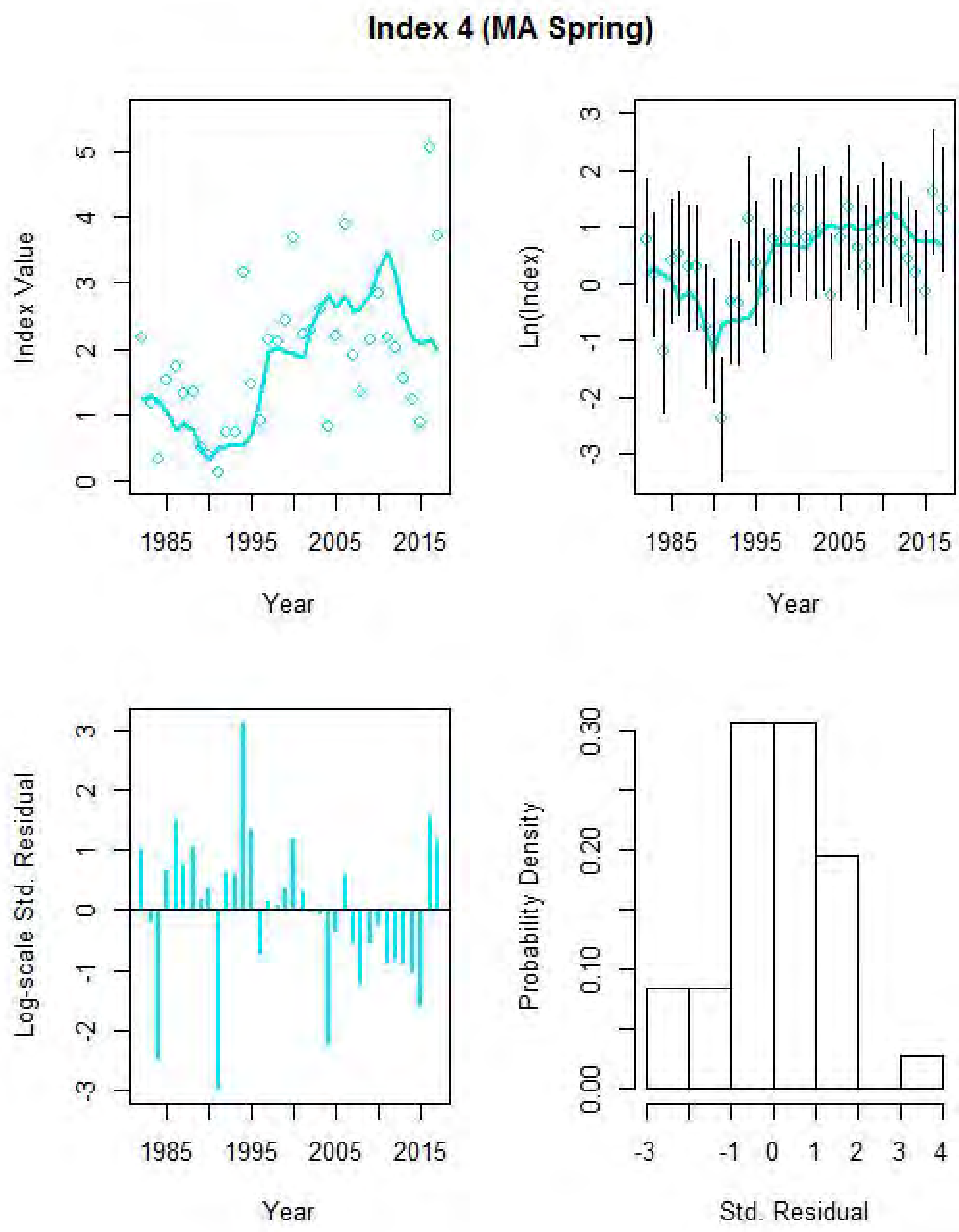


Figure A156. Fit diagnostics for the Massachusetts Division of Marine Fisheries (MA) spring trawl survey from the F2018_BASE_V2 model run.

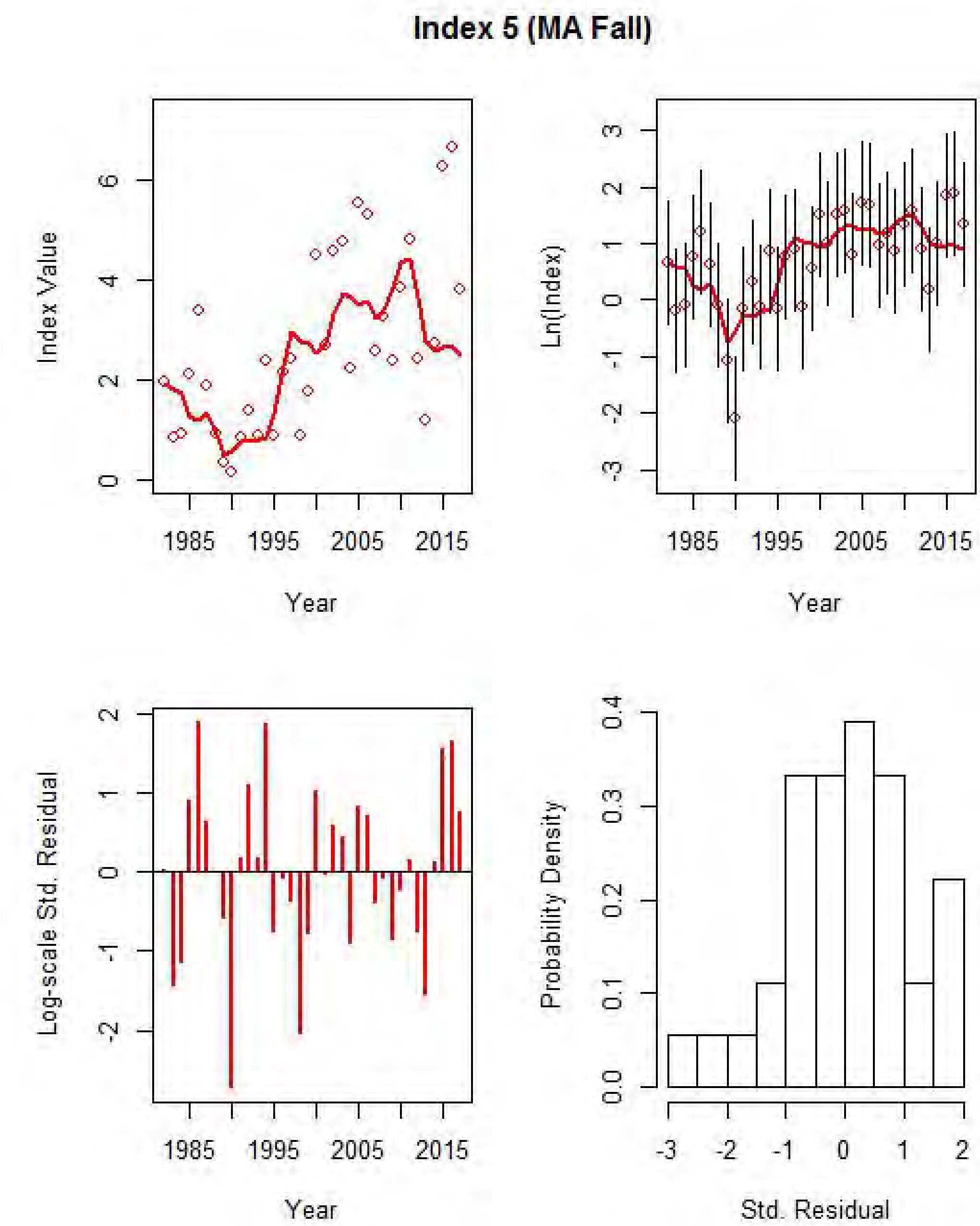


Figure A157. Fit diagnostics for the Massachusetts Division of Marine Fisheries (MA) fall trawl survey from the F2018_BASE_V2 model run.

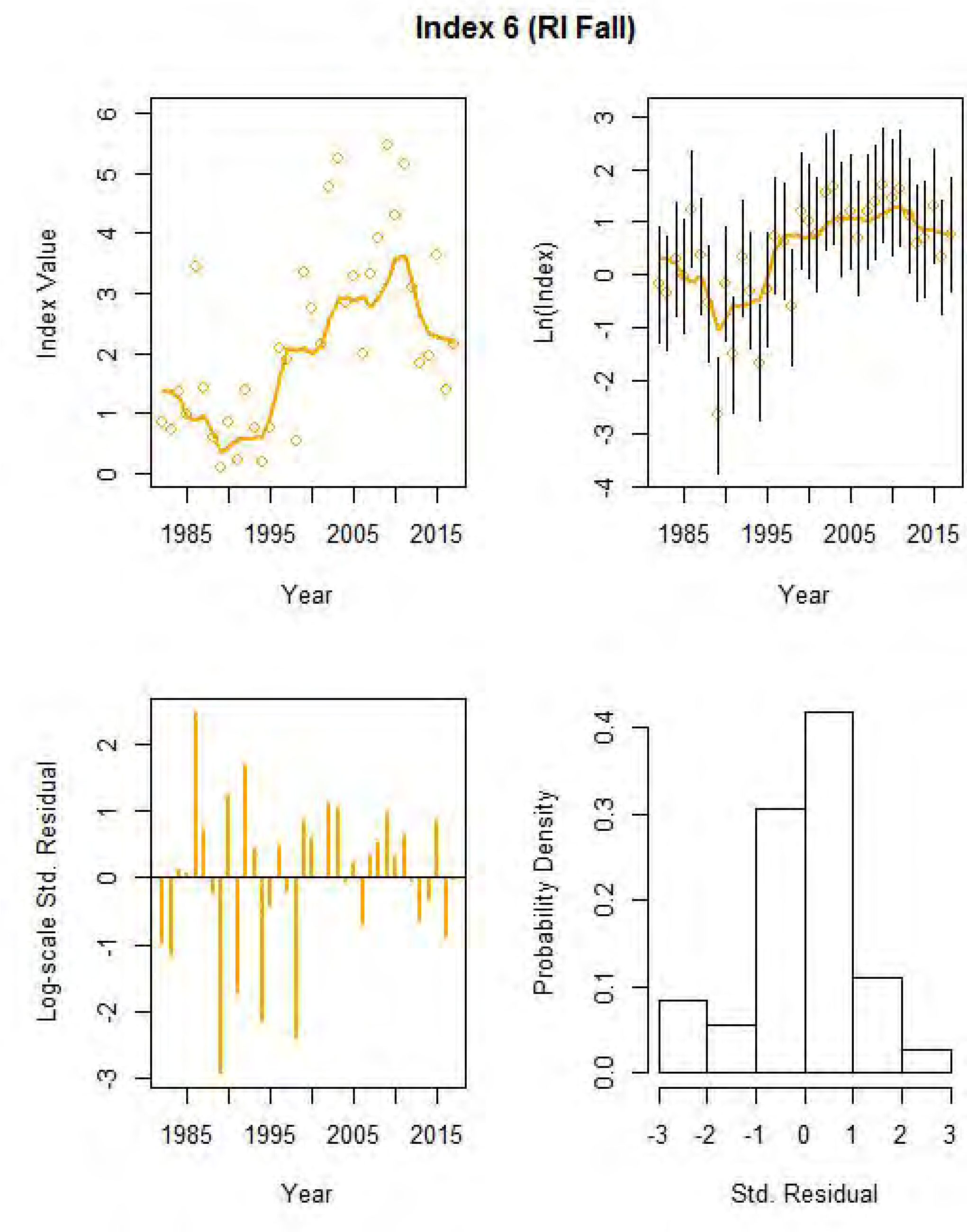


Figure A158. Fit diagnostics for the Rhode Island Department of Fish and Wildlife (RI) fall trawl survey from the F2018_BASE_V2 model run.

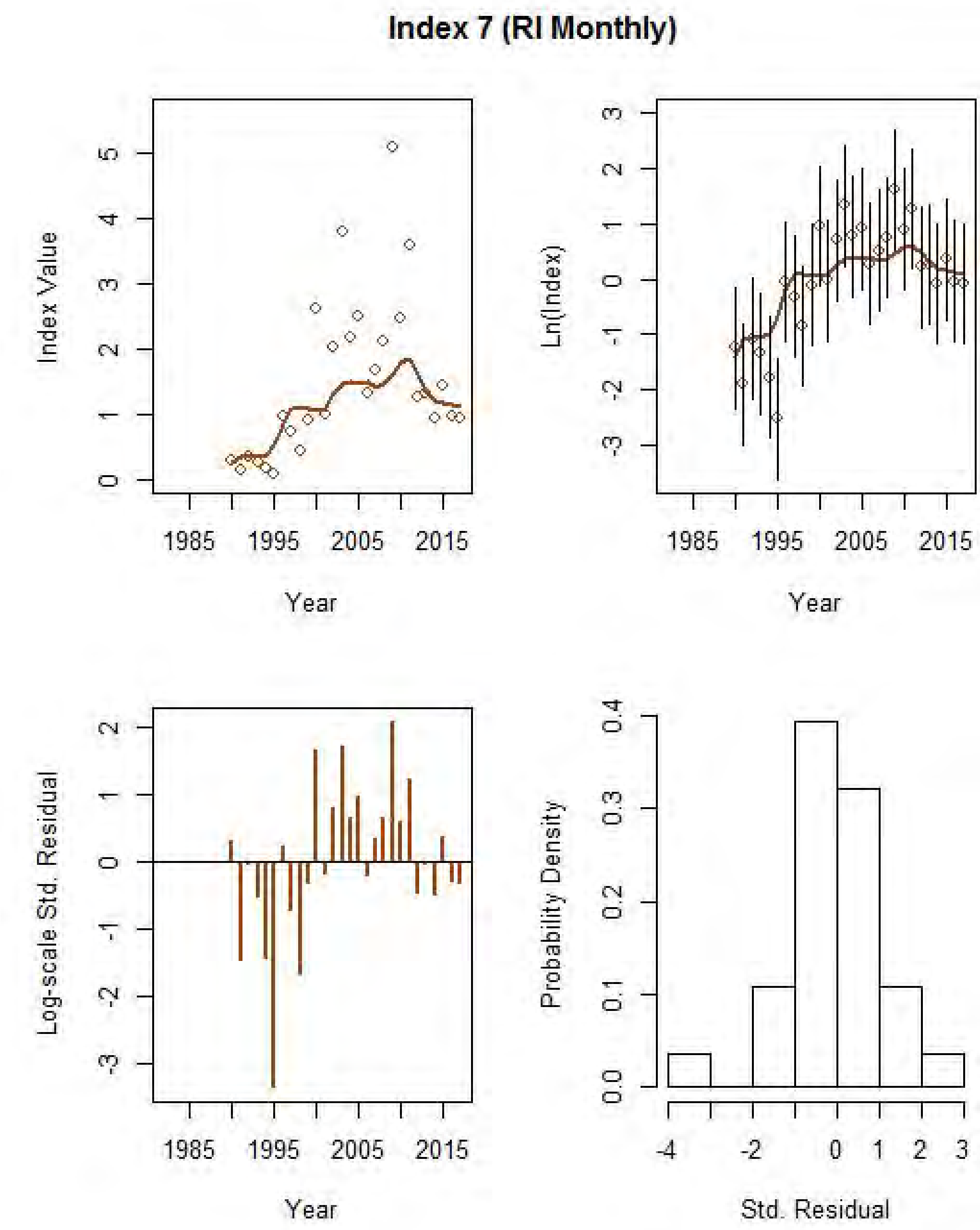


Figure A159. Fit diagnostics for the Rhode Island Department of Fish and Wildlife (RI) monthly trawl survey from the F2018_BASE_V2 model run.

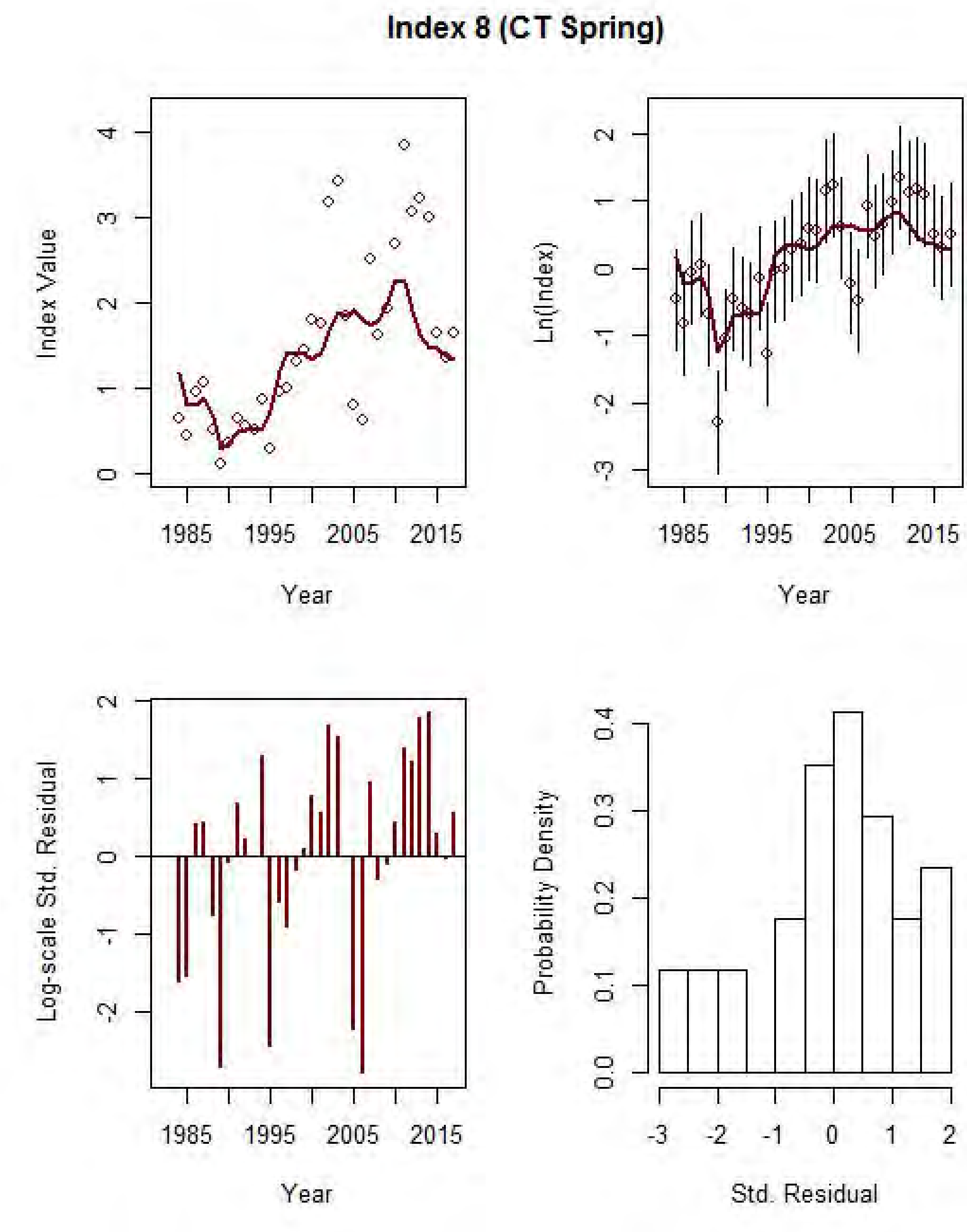


Figure A160. Fit diagnostics for the Connecticut Department of Energy and Environmental Protection (CT) spring trawl survey from the F2018_BASE_V2 model run.

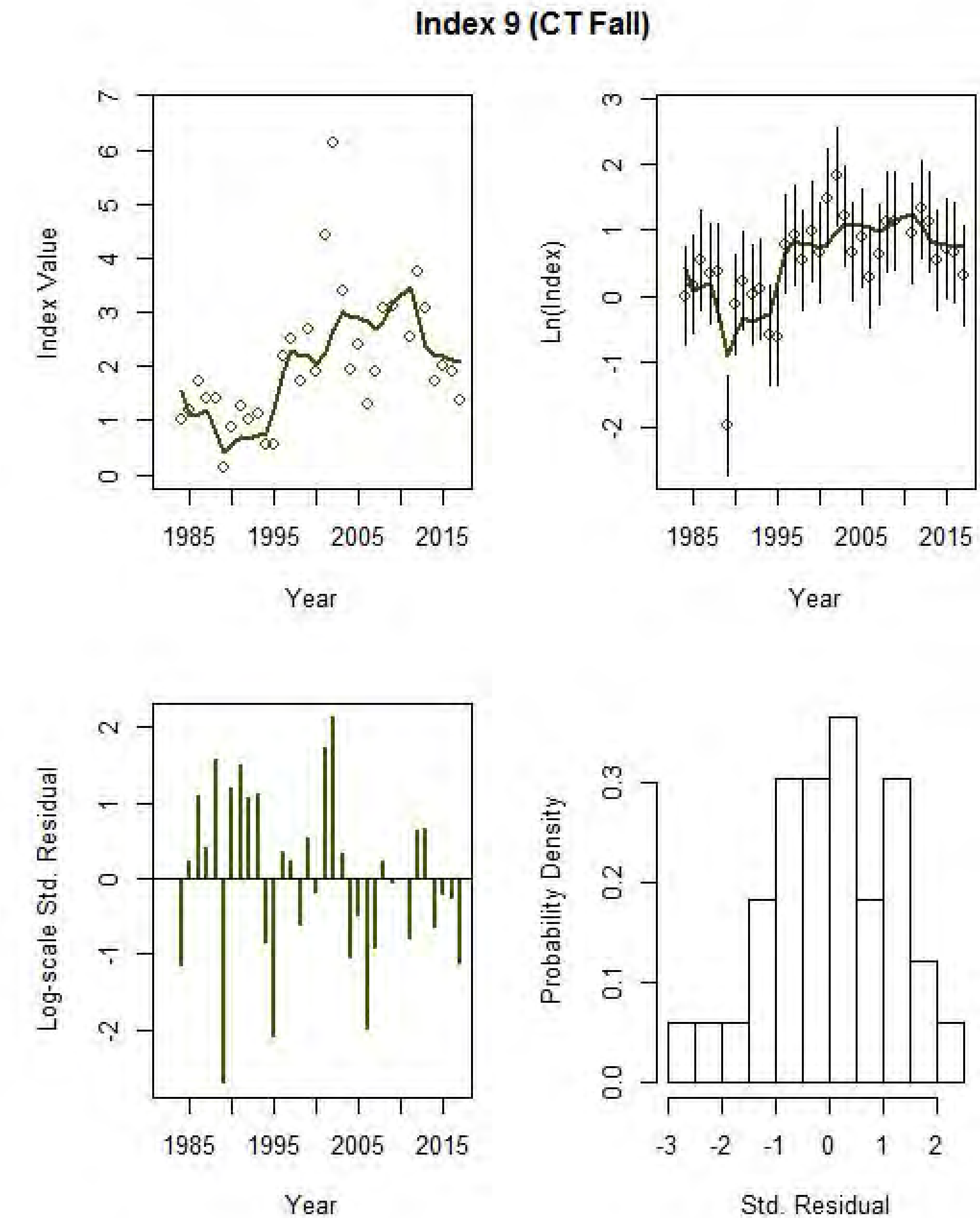


Figure A161. Fit diagnostics for the Connecticut Department of Energy and Environmental Protection (CT) fall trawl survey from the F2018_BASE_V2 model run.

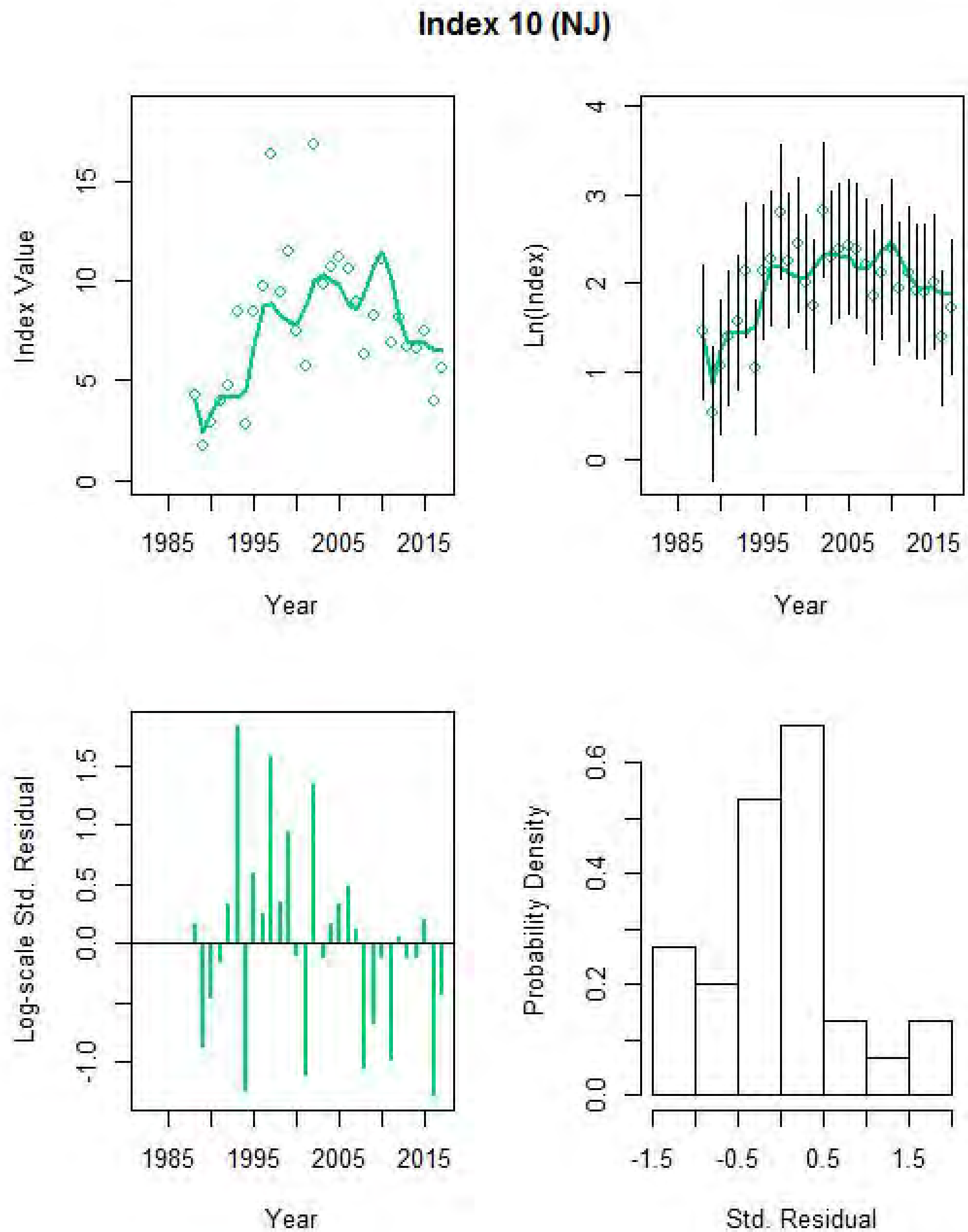


Figure A162. Fit diagnostics for the New Jersey Division of Fish and Wildlife (NJ) trawl survey from the F2018_BASE_V2 model run.

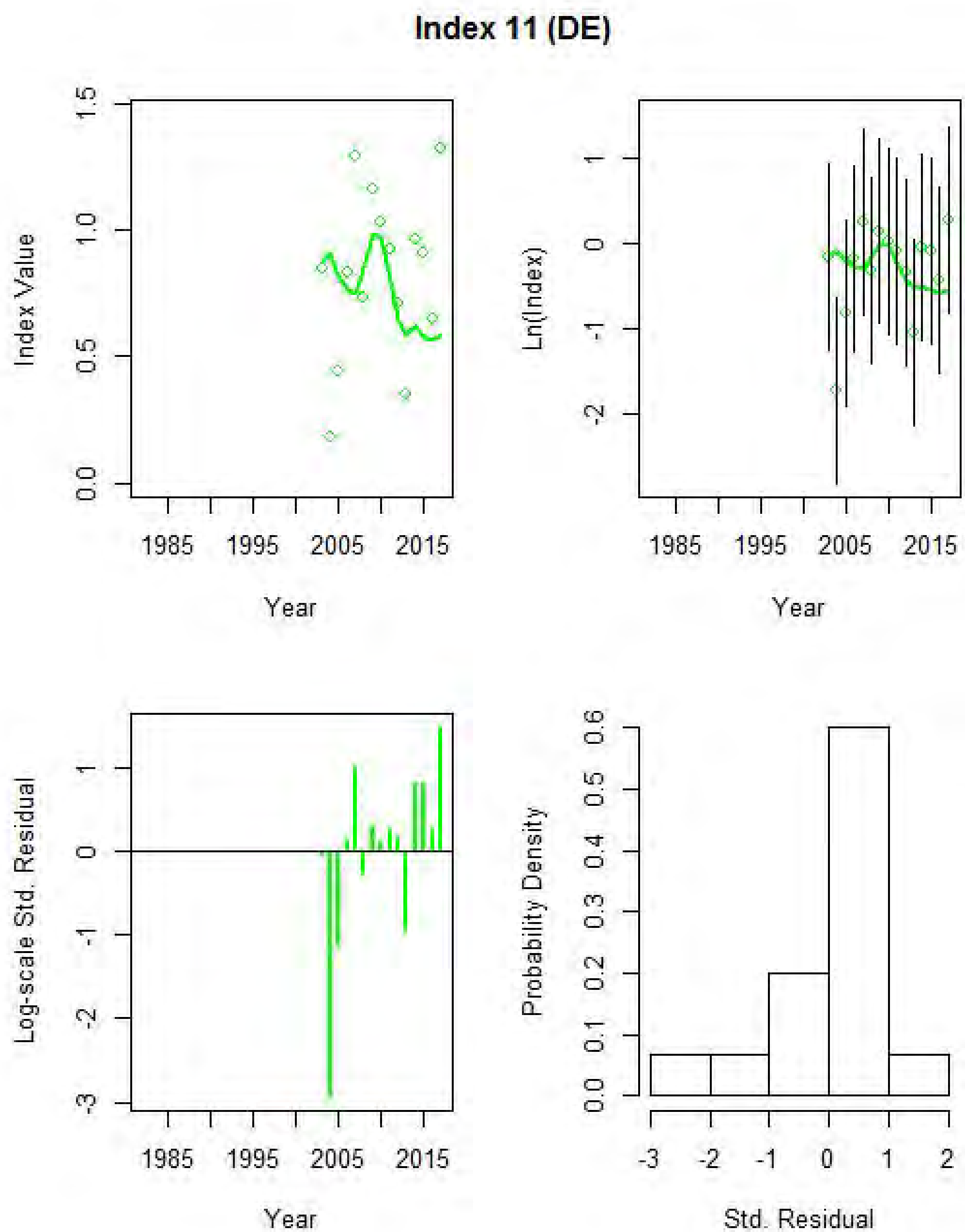


Figure A163. Fit diagnostics for the Delaware Division of Fish and Wildlife (DE) trawl survey from the F2018_BASE_V2 model run.

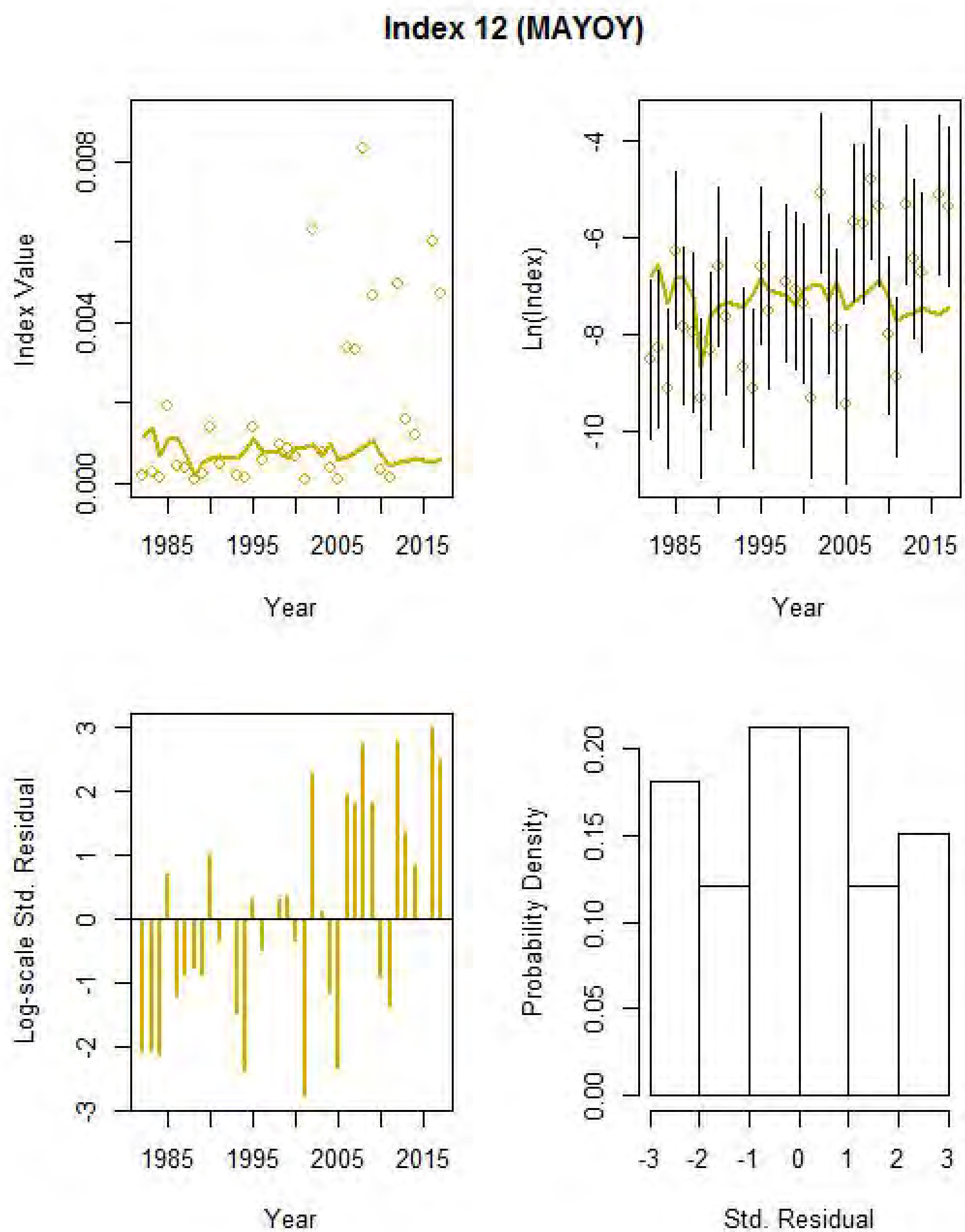


Figure A164. Fit diagnostics for the Massachusetts Division of Marine Fisheries young-of-the-year (MAYOY) seine survey from the F2018_BASE_V2 model run.

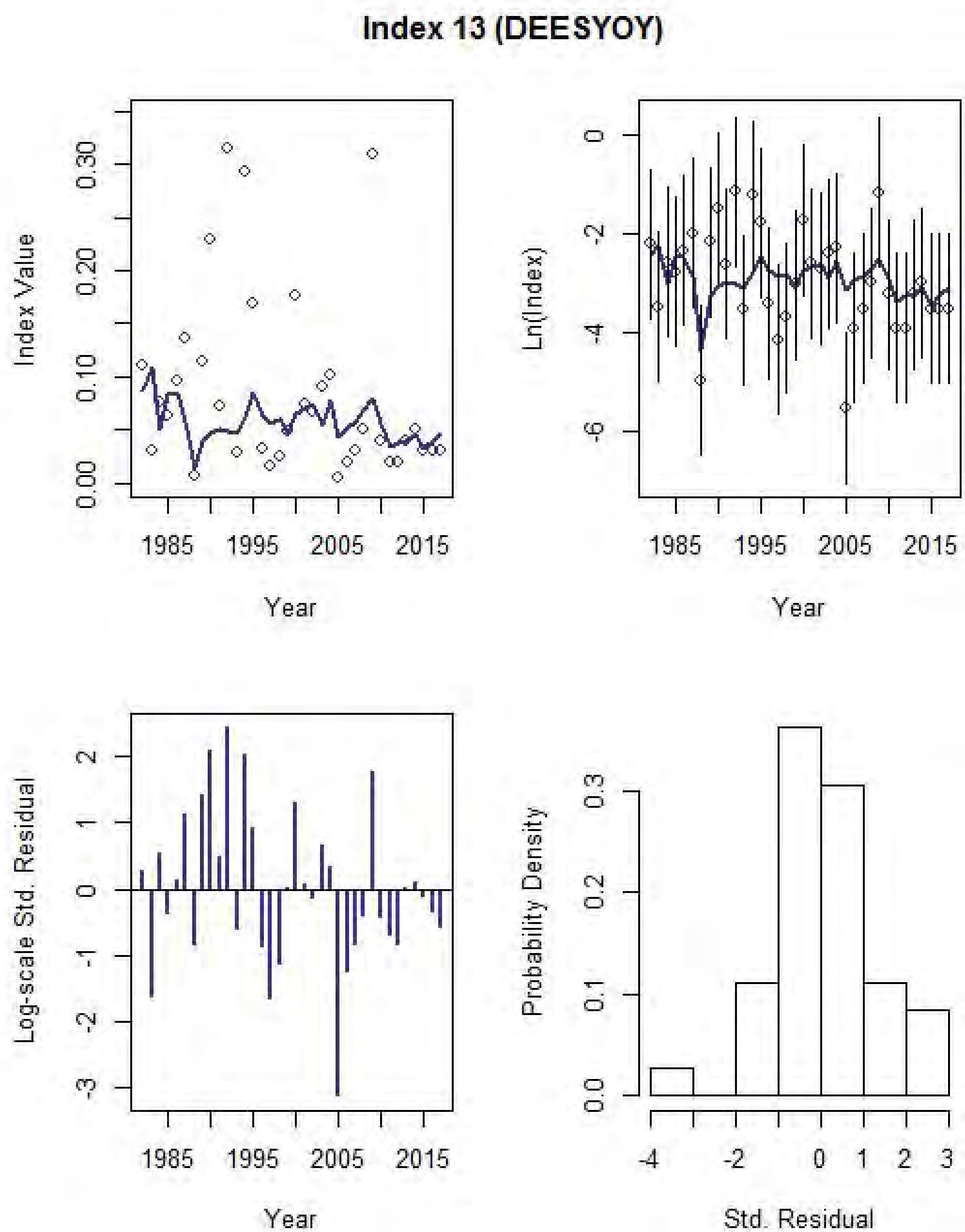


Figure A165. Fit diagnostics for the Delaware Division of Fish and Wildlife Estuaries young-of-the-year (DEESYOY) survey from the F2018_BASE_V2 model run.

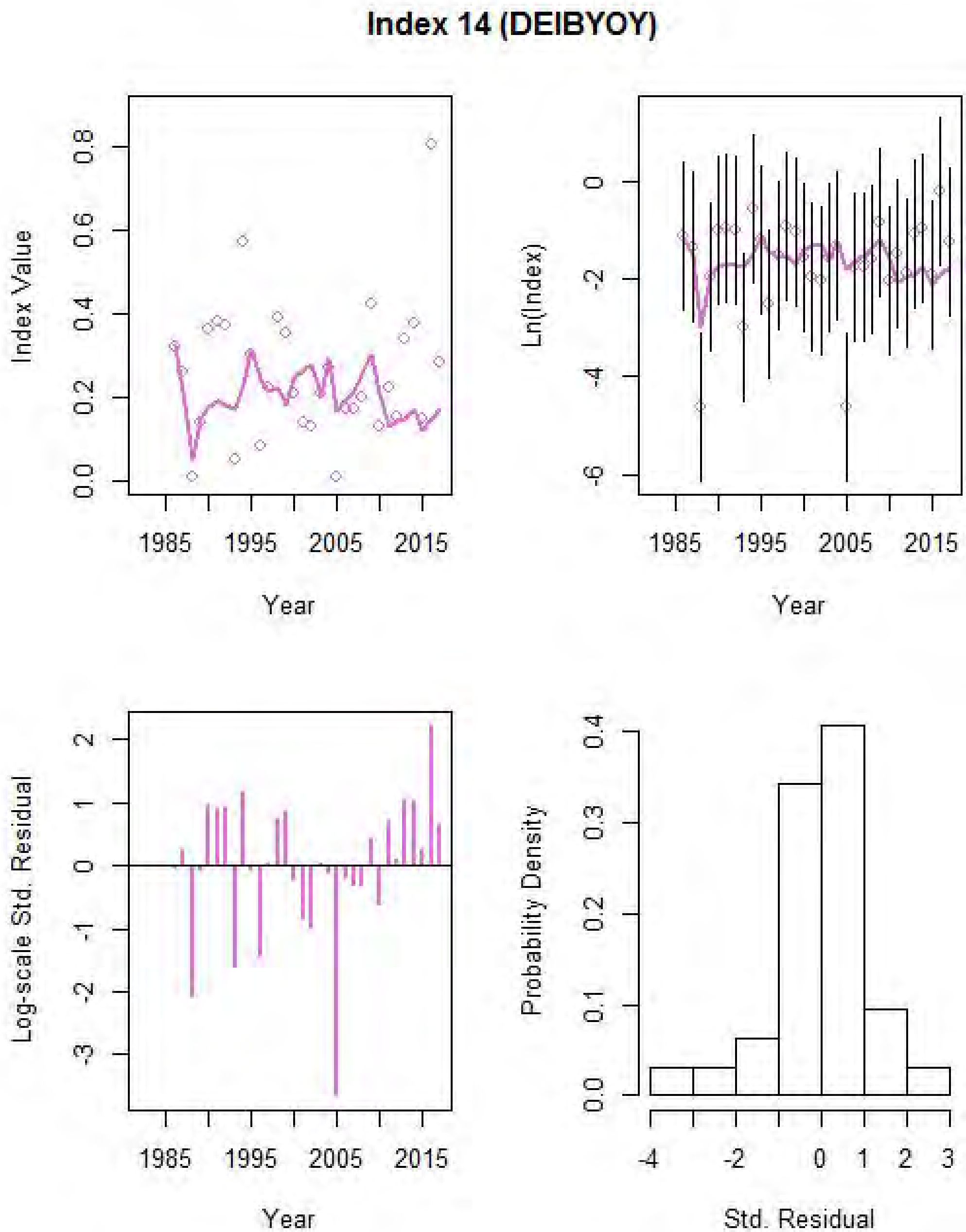


Figure A166. Fit diagnostics for the Delaware Division of Fish and Wildlife Inland Bays young-of-the-year (DEIBYOY) survey from the F2018_BASE_V2 model run.

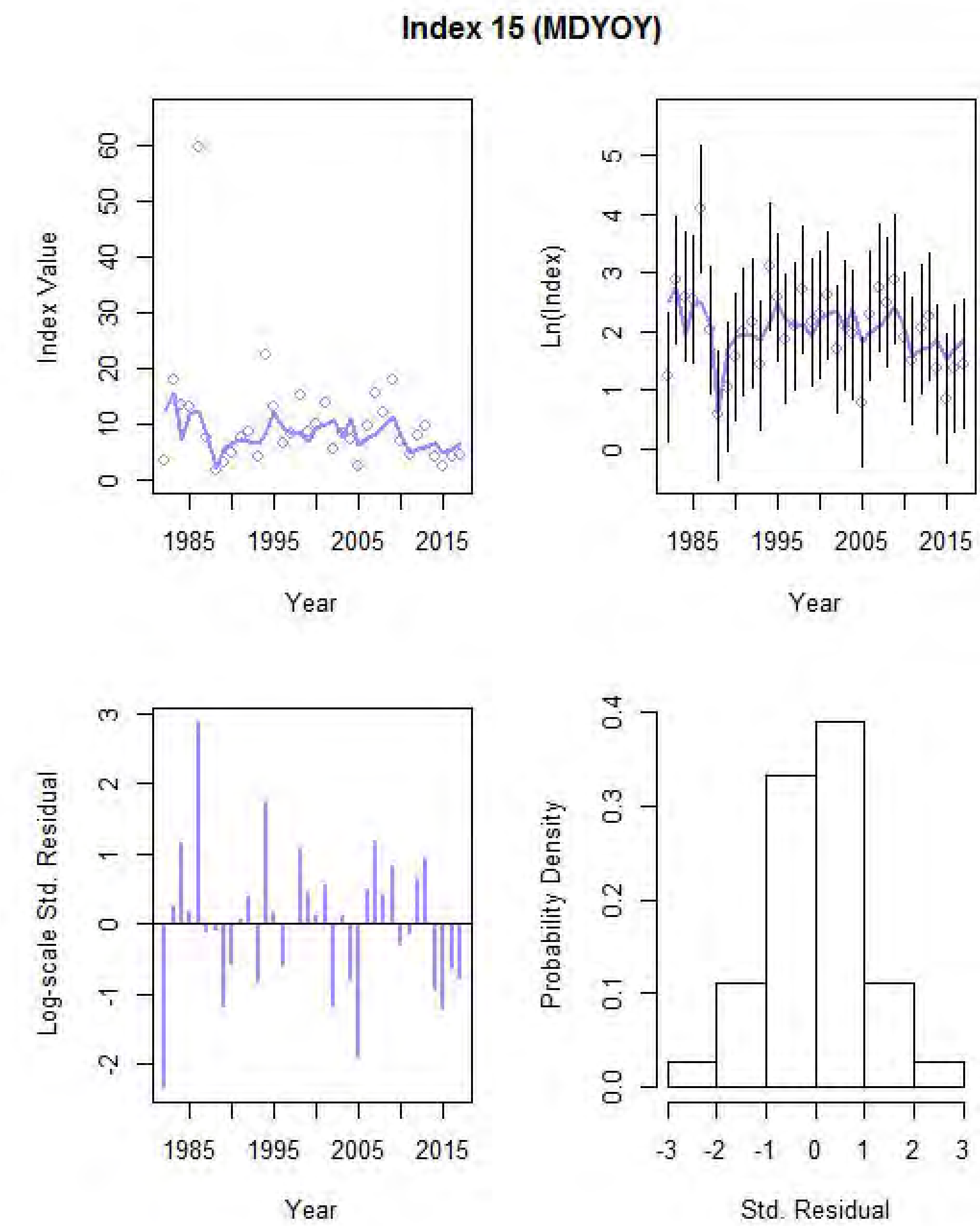


Figure A167. Fit diagnostics for the Maryland Department of Natural Resources young-of-the-year (MDYOY) survey from the F2018_BASE_V2 model run.

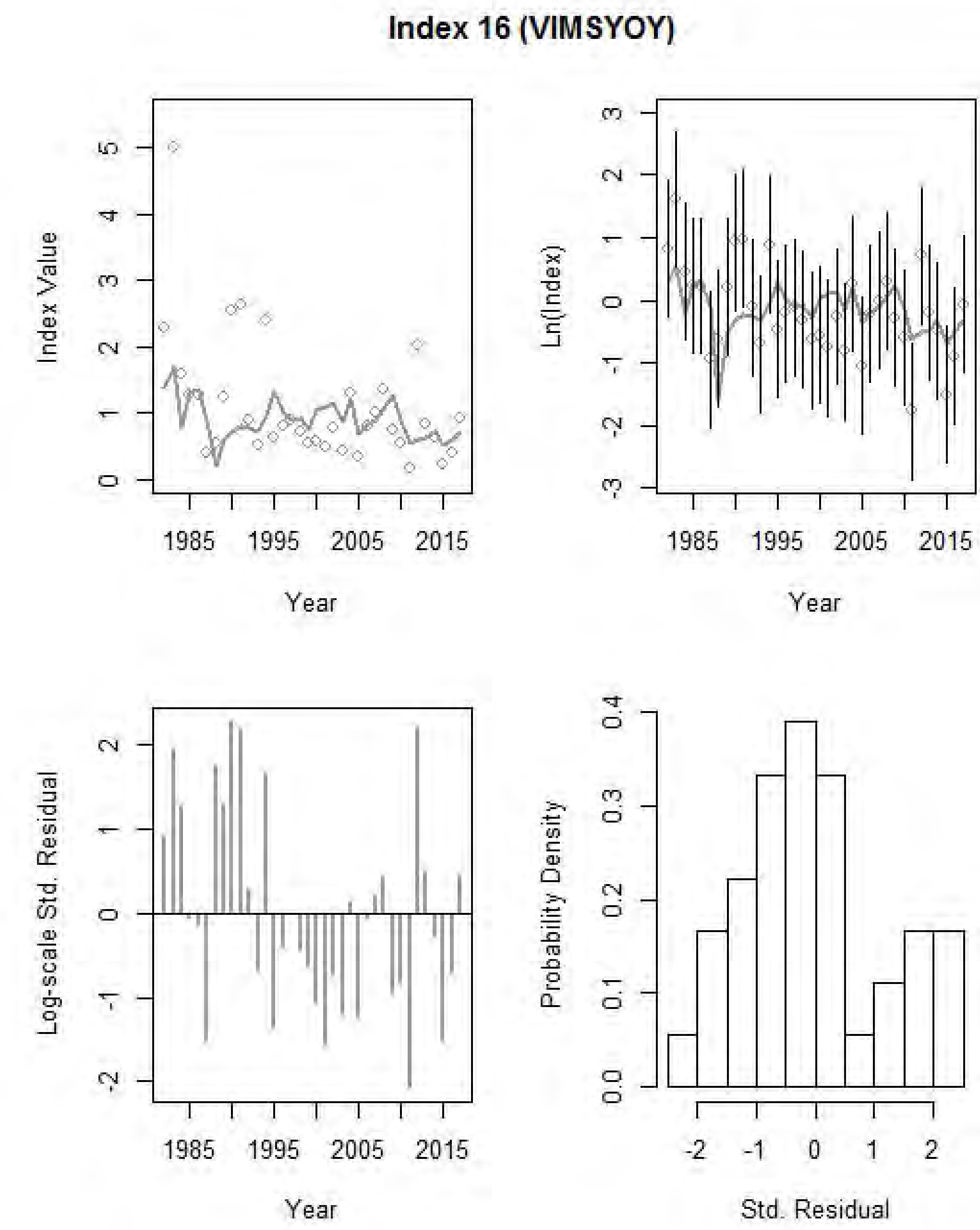


Figure A168. Fit diagnostics for the Virginia Institute of Marine Science young-of-the-year (VIMSYOY) survey from the F2018_BASE_V2 model run.

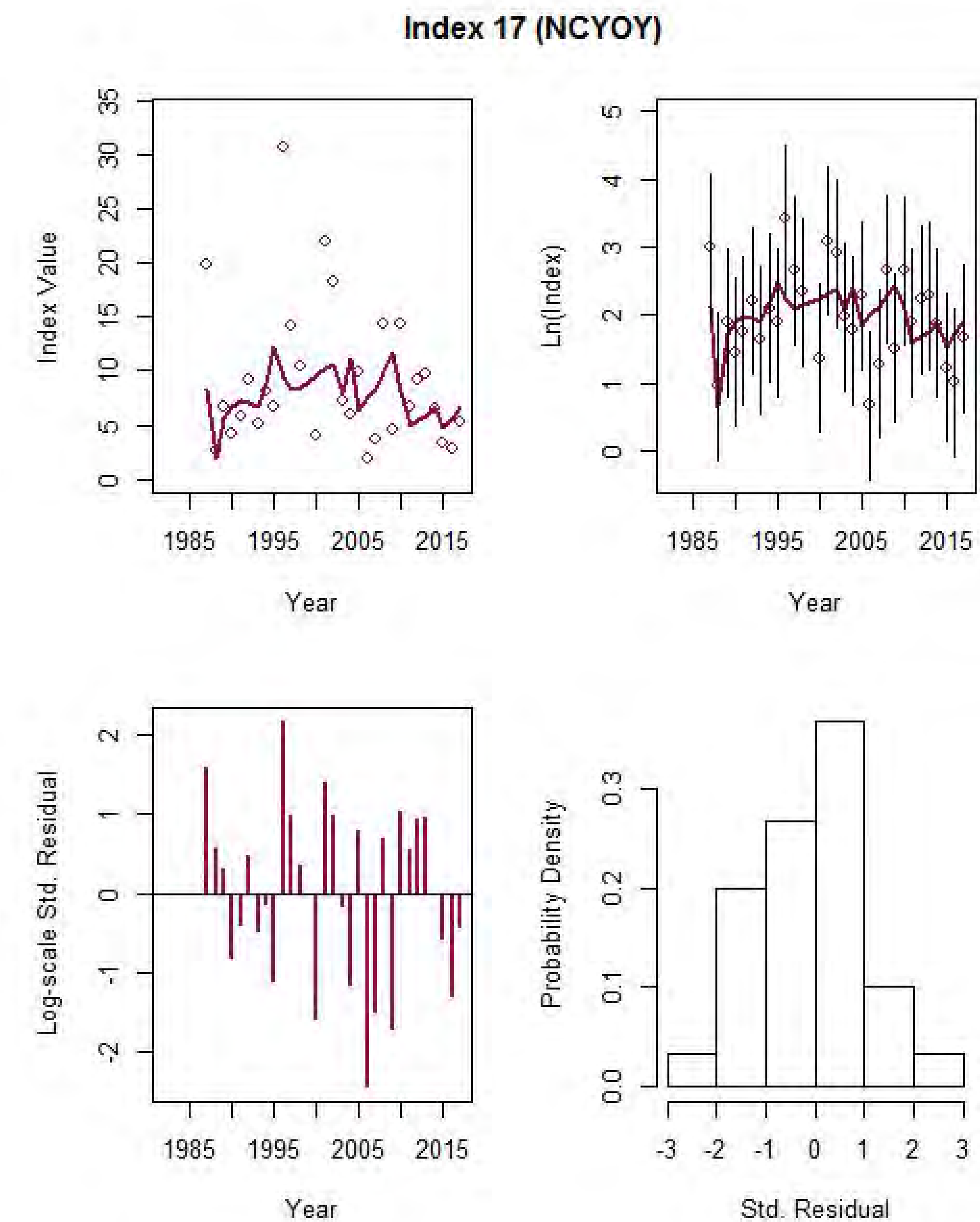


Figure A169. Fit diagnostics for the North Carolina Division of Marine Fisheries young-of-the-year (NCYOY) survey from the F2018_BASE_V2 model run.

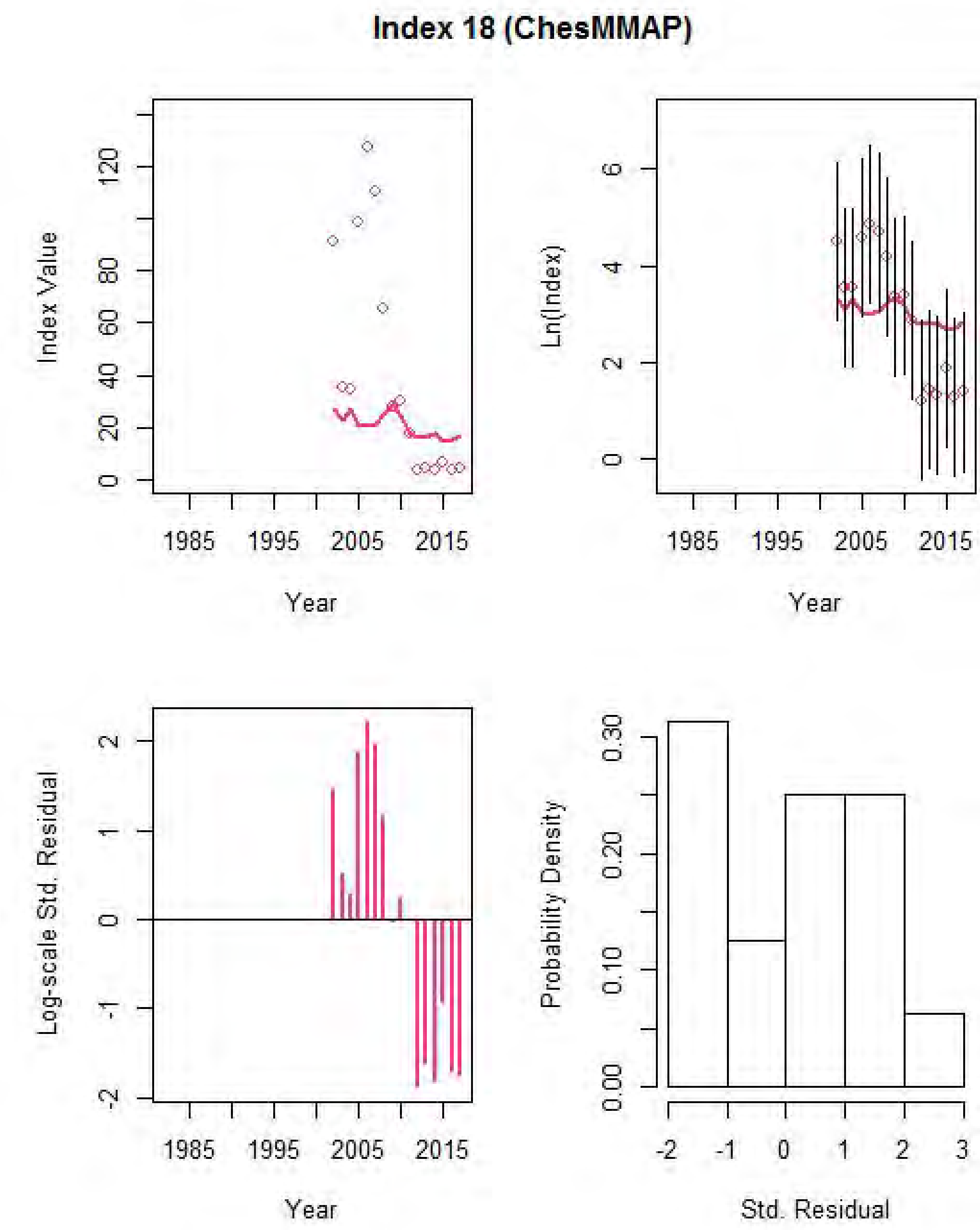


Figure A170. Fit diagnostics for the Virginia Institute of Marine Science Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) trawl survey from the F2018_BASE_V2 model run.

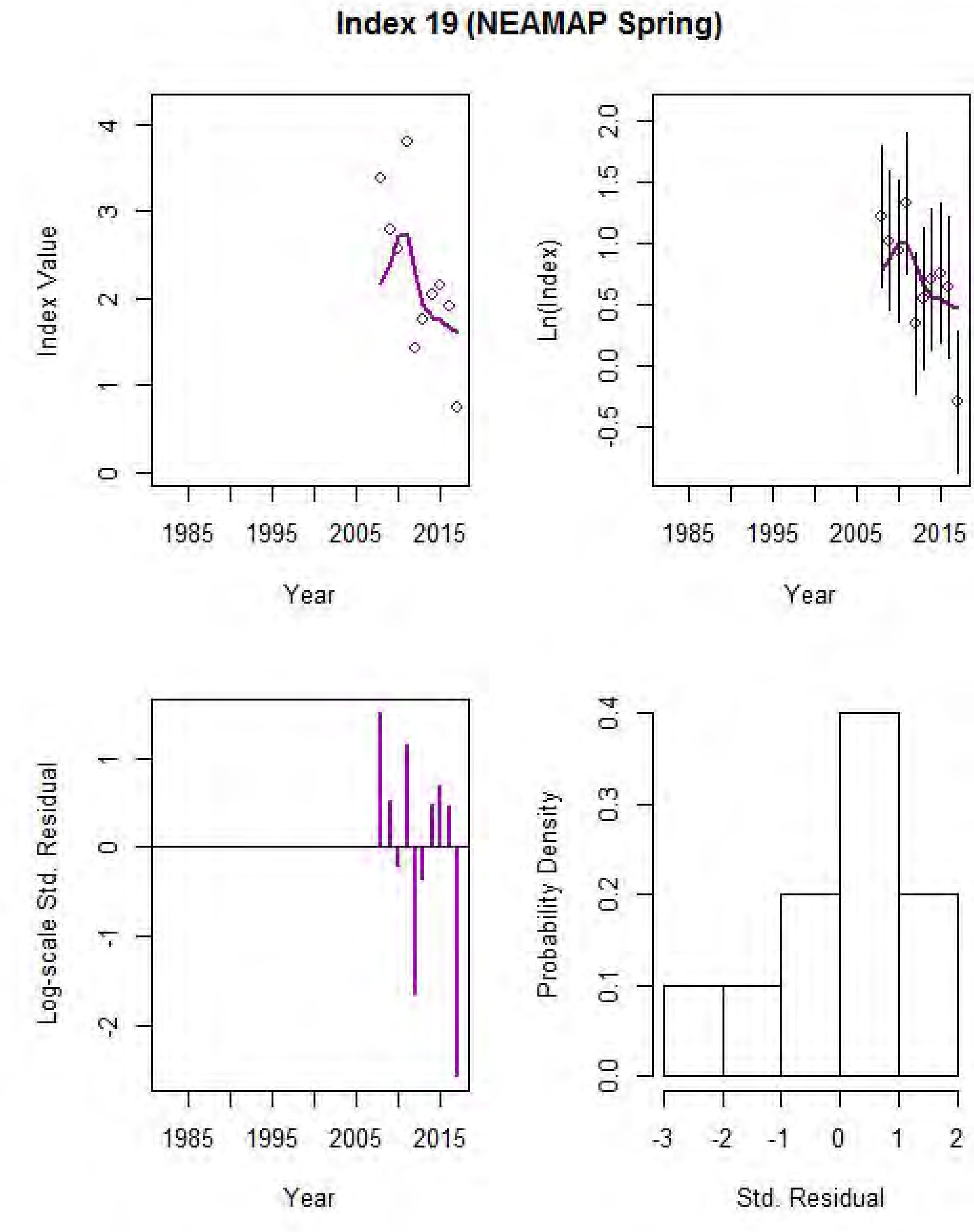


Figure A171. Fit diagnostics for the Virginia Institute of Marine Science Northeast Area Monitoring and Assessment Program (NEAMAP) spring trawl survey from the F2018_BASE_V2 model run.

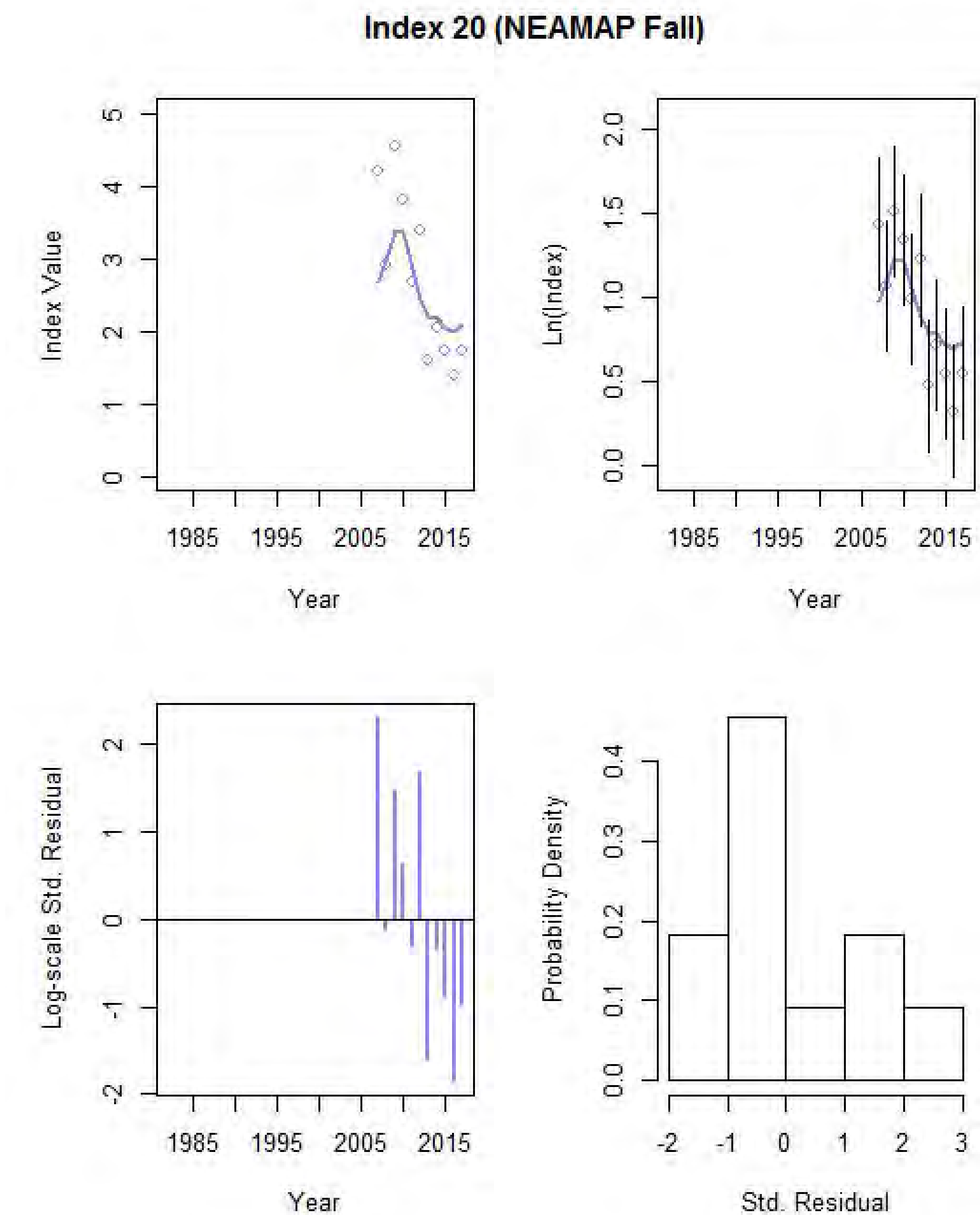


Figure A172. Fit diagnostics for the Virginia Institute of Marine Science Northeast Area Monitoring and Assessment Program (NEAMAP) fall trawl survey from the F2018_BASE_V2 model run.

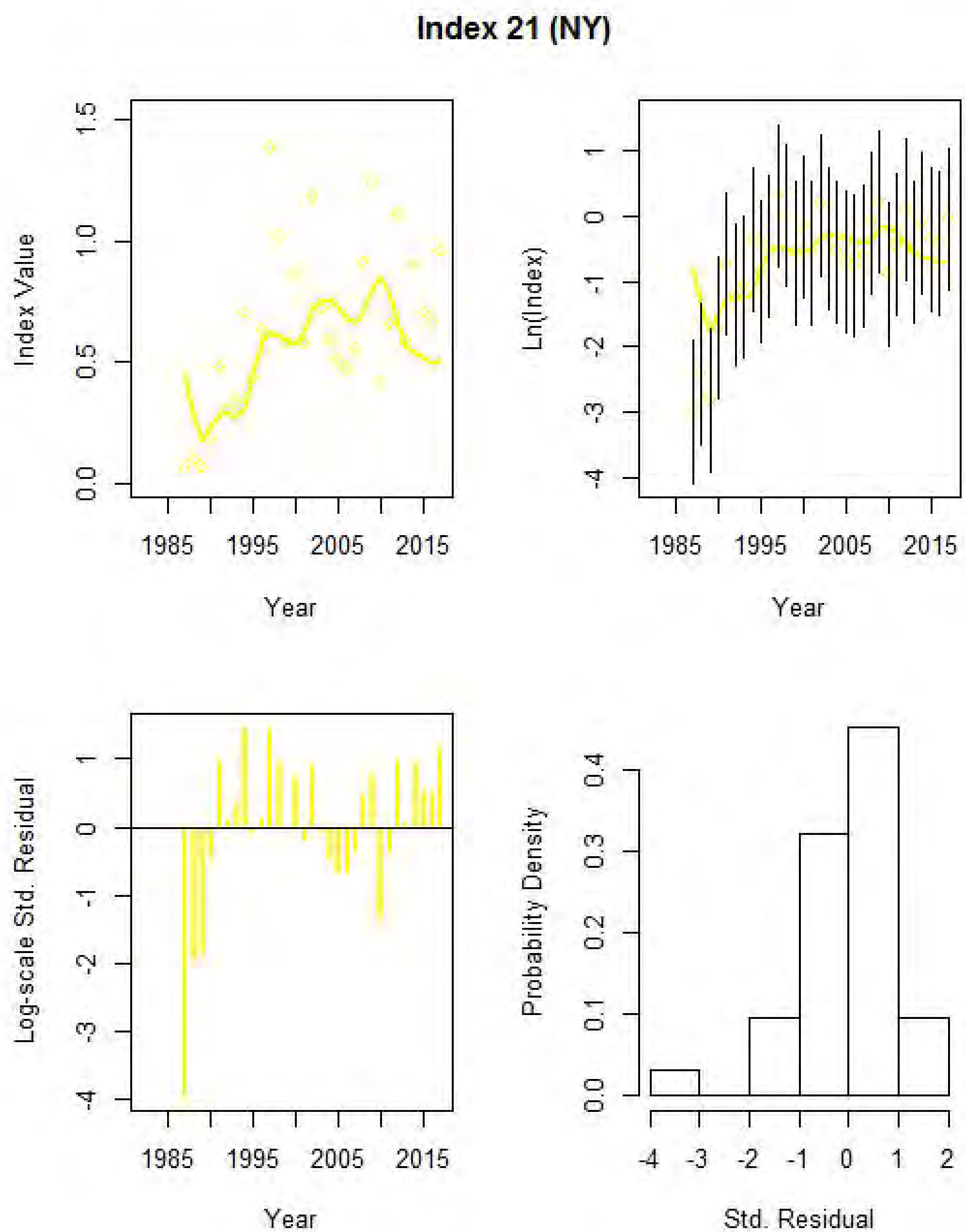


Figure A173. Fit diagnostics for the New York Department of Environmental Conservation (NY) trawl survey from the F2018_BASE_V2 model run.

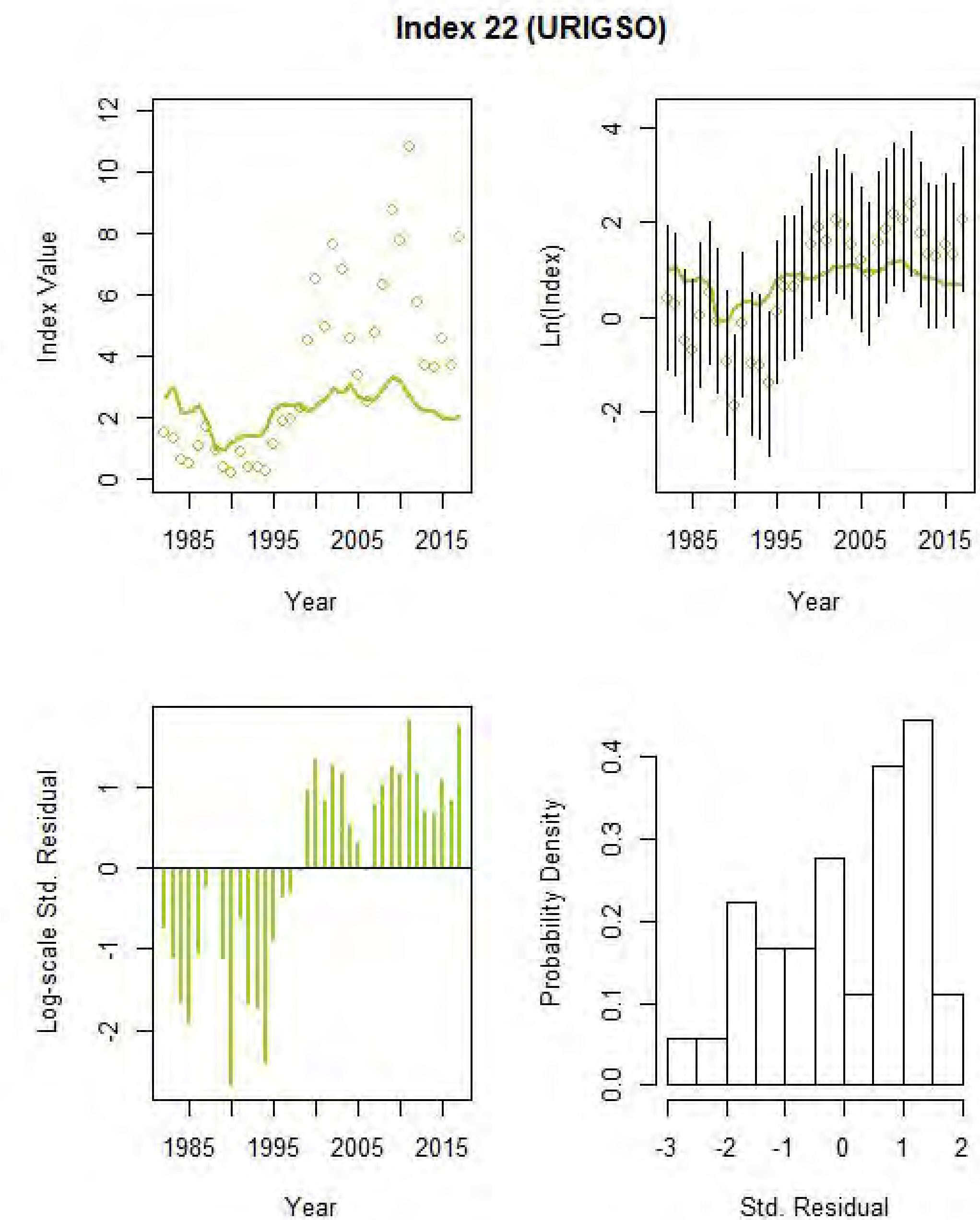


Figure A174. Fit diagnostics for the University of Rhode Island Graduate School of Oceanography (URIGSO) trawl survey from the F2018_BASE_V2 model run.

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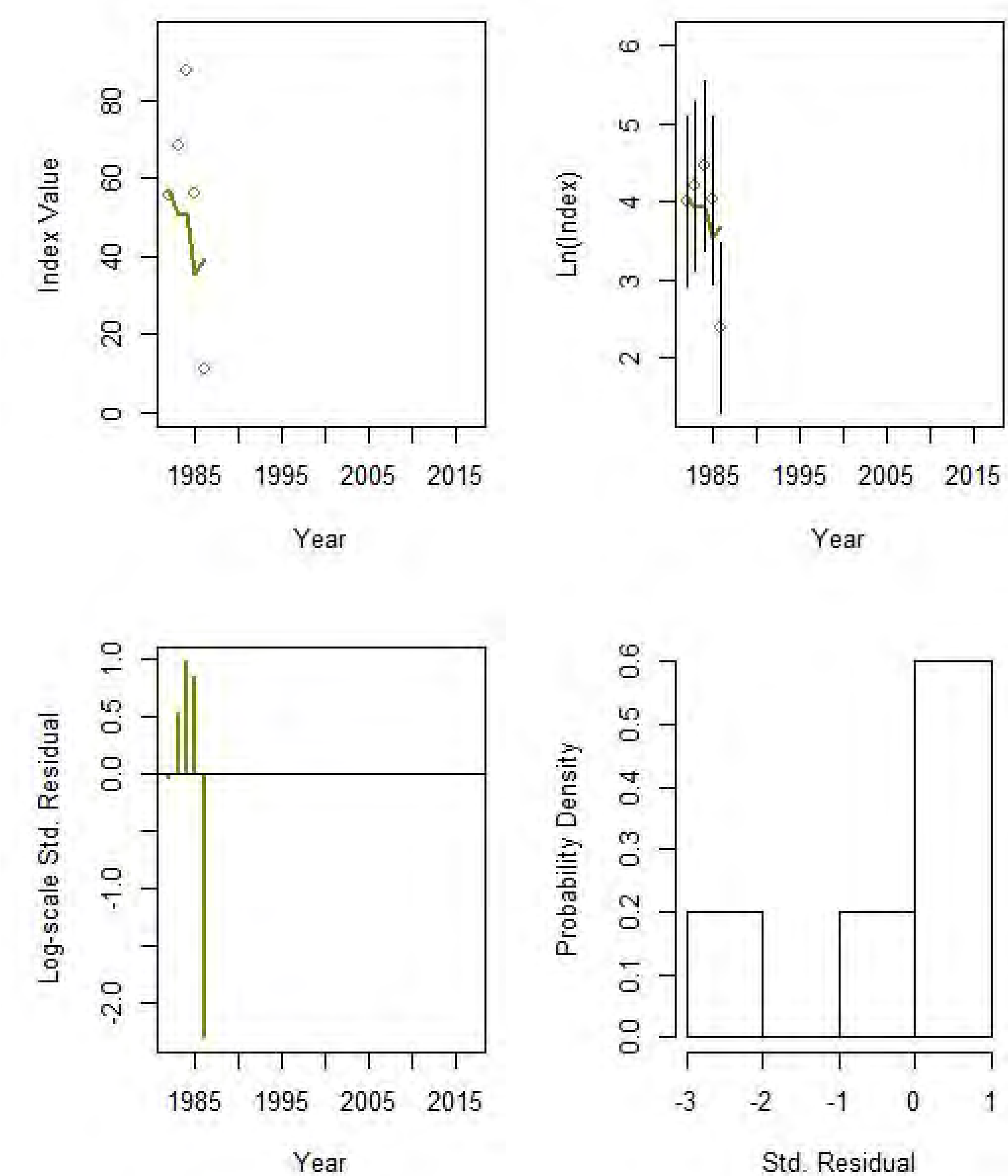


Figure A175. Fit diagnostics for the Northeast Fisheries Science Center MARMAP larval survey from the F2018_BASE_V2 model run.

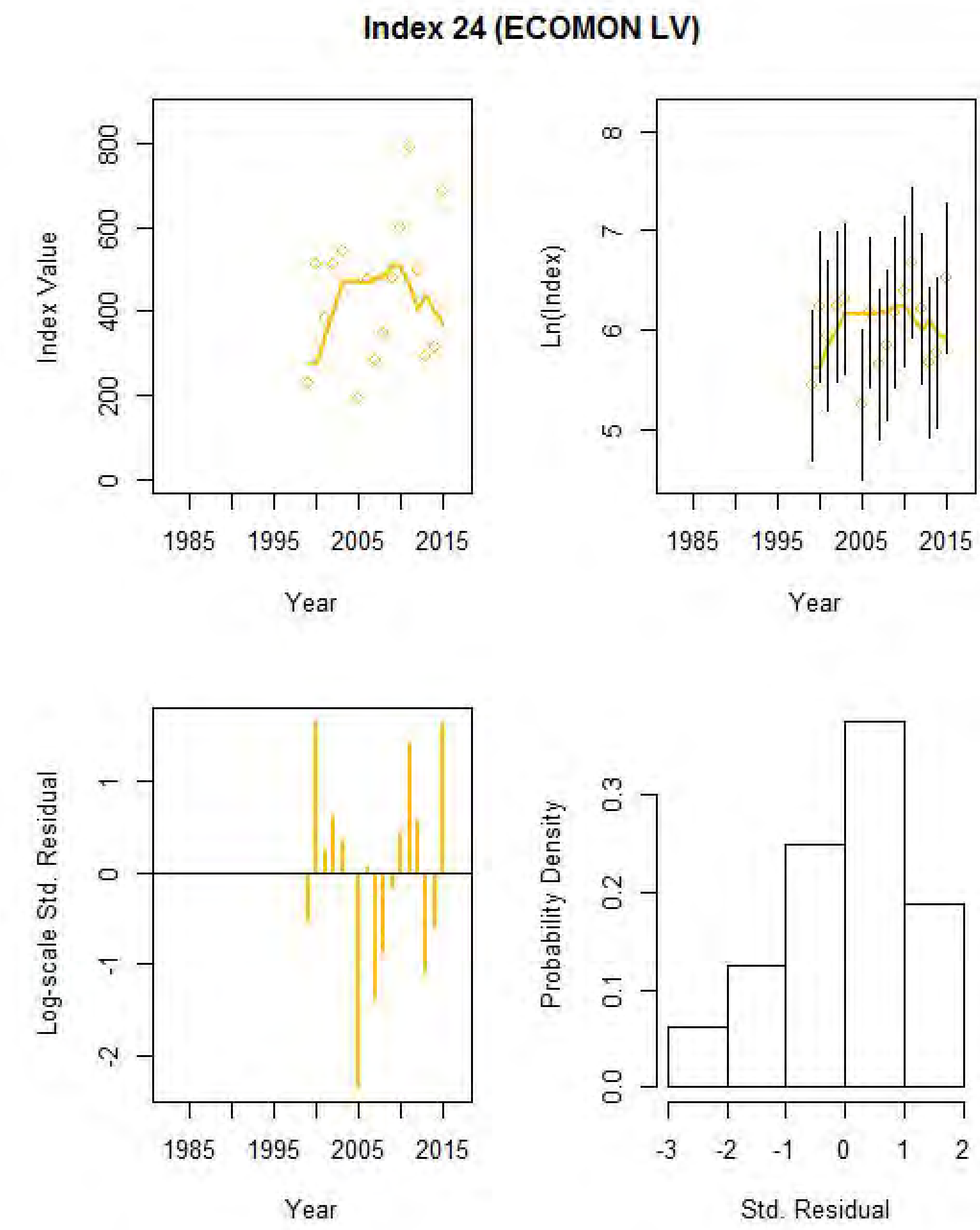


Figure A176. Fit diagnostics for the Northeast Fisheries Science Center ECOMON larval survey from the F2018_BASE_V2 model run.

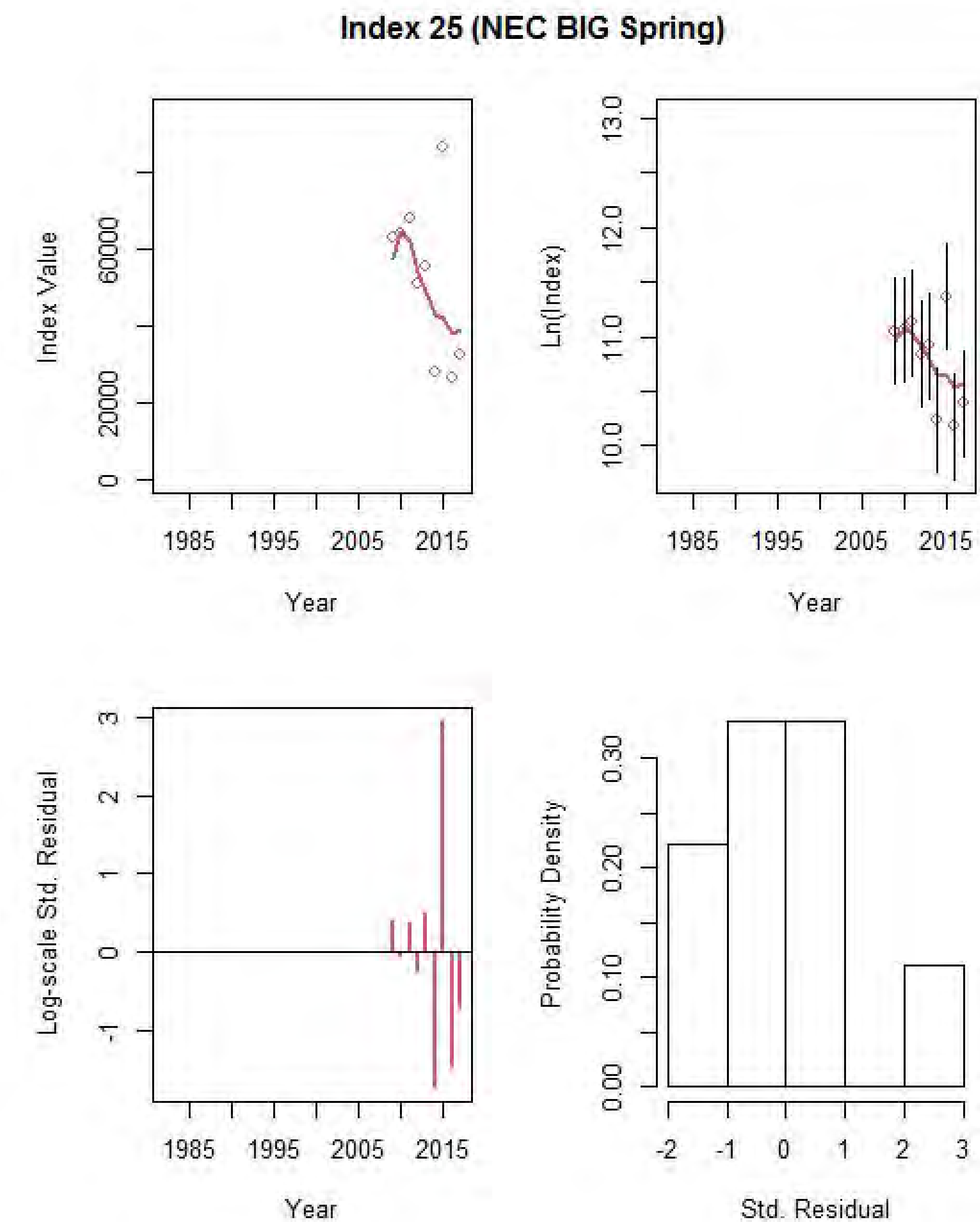


Figure A177. Fit diagnostics for the Northeast Fisheries Science Center (NEC) Bigelow (BIG) spring trawl survey from the F2018_BASE_V2 model run.

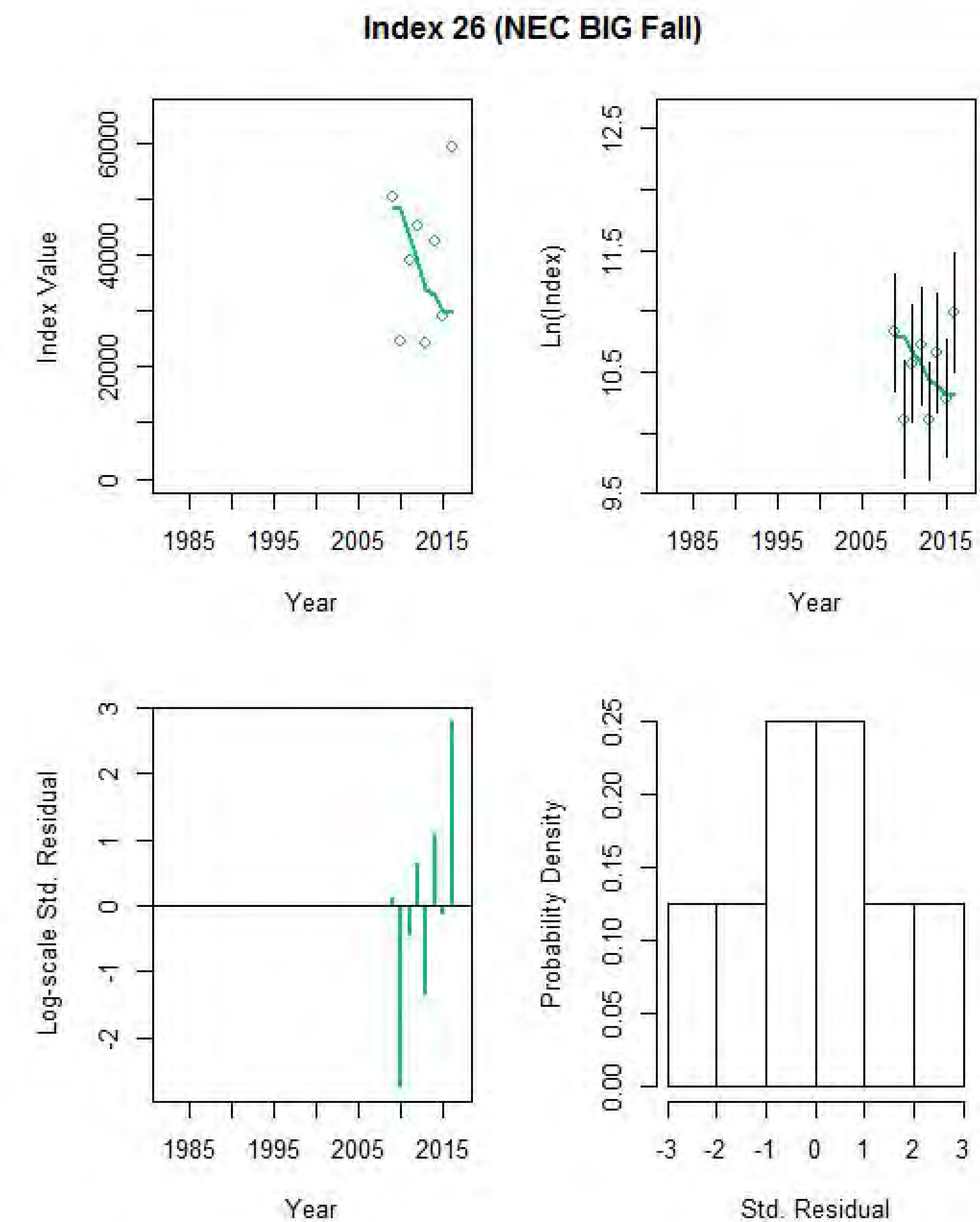


Figure A178. Fit diagnostics for the Northeast Fisheries Science Center (NEC) Bigelow (BIG) fall trawl survey from the F2018_BASE_V2 model run.

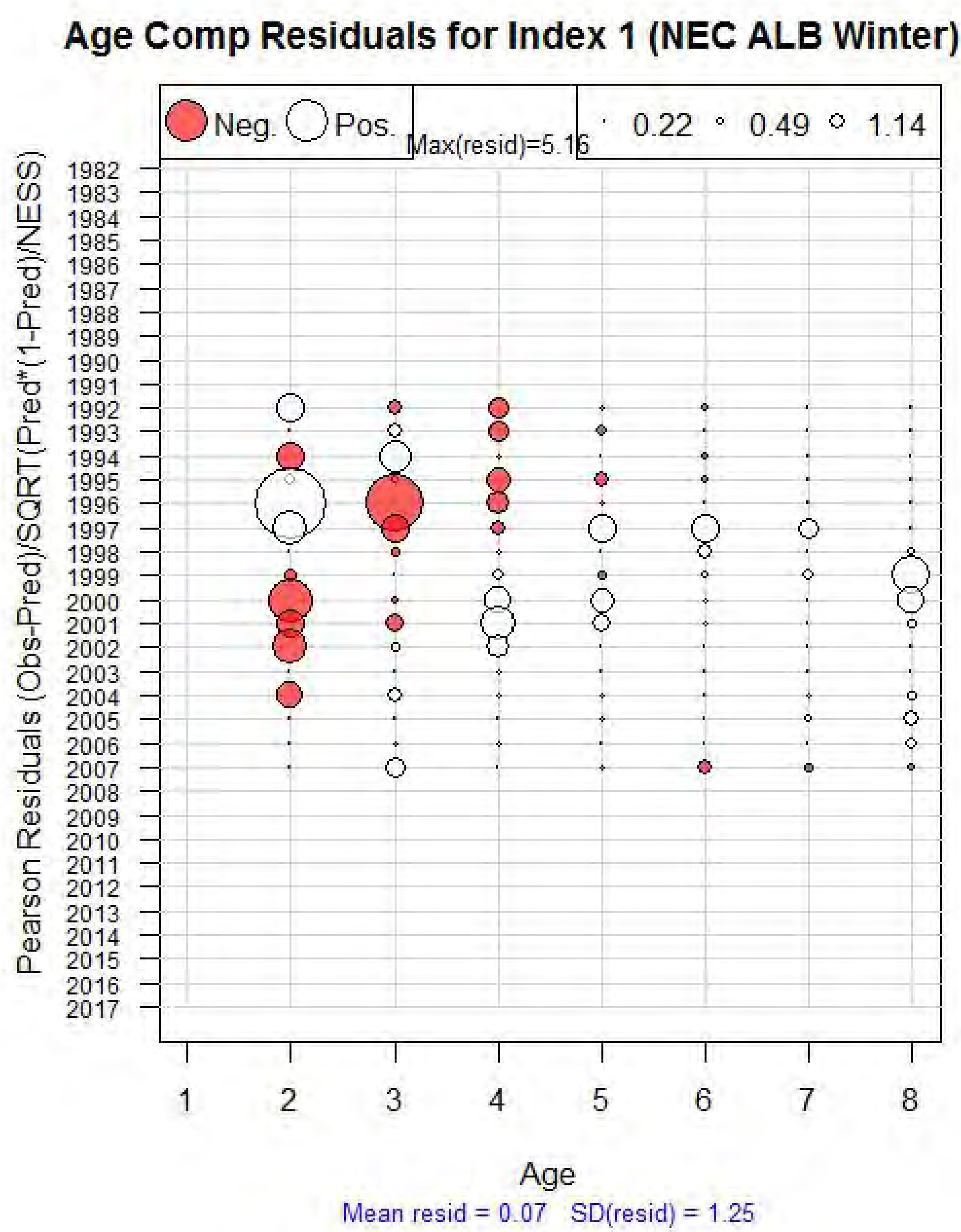


Figure A179. Age composition residuals for the Northeast Fisheries Science Center (NEC) Albatross (ALB) winter trawl survey from the F2018_BASE_V2 model run.

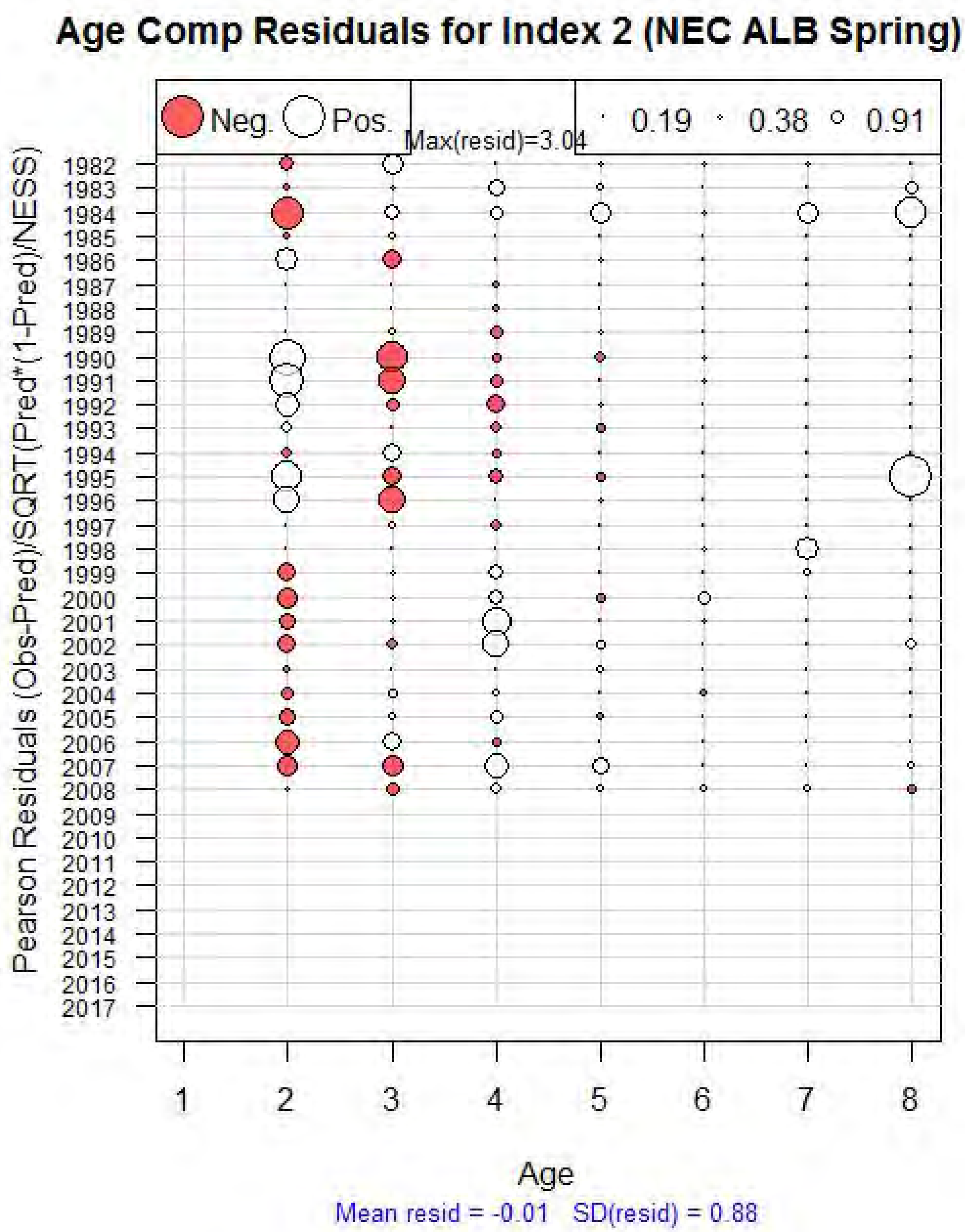


Figure A180. Age composition residuals for the Northeast Fisheries Science Center (NEC) Albatross (ALB) spring trawl survey from the F2018_BASE_V2 model run.

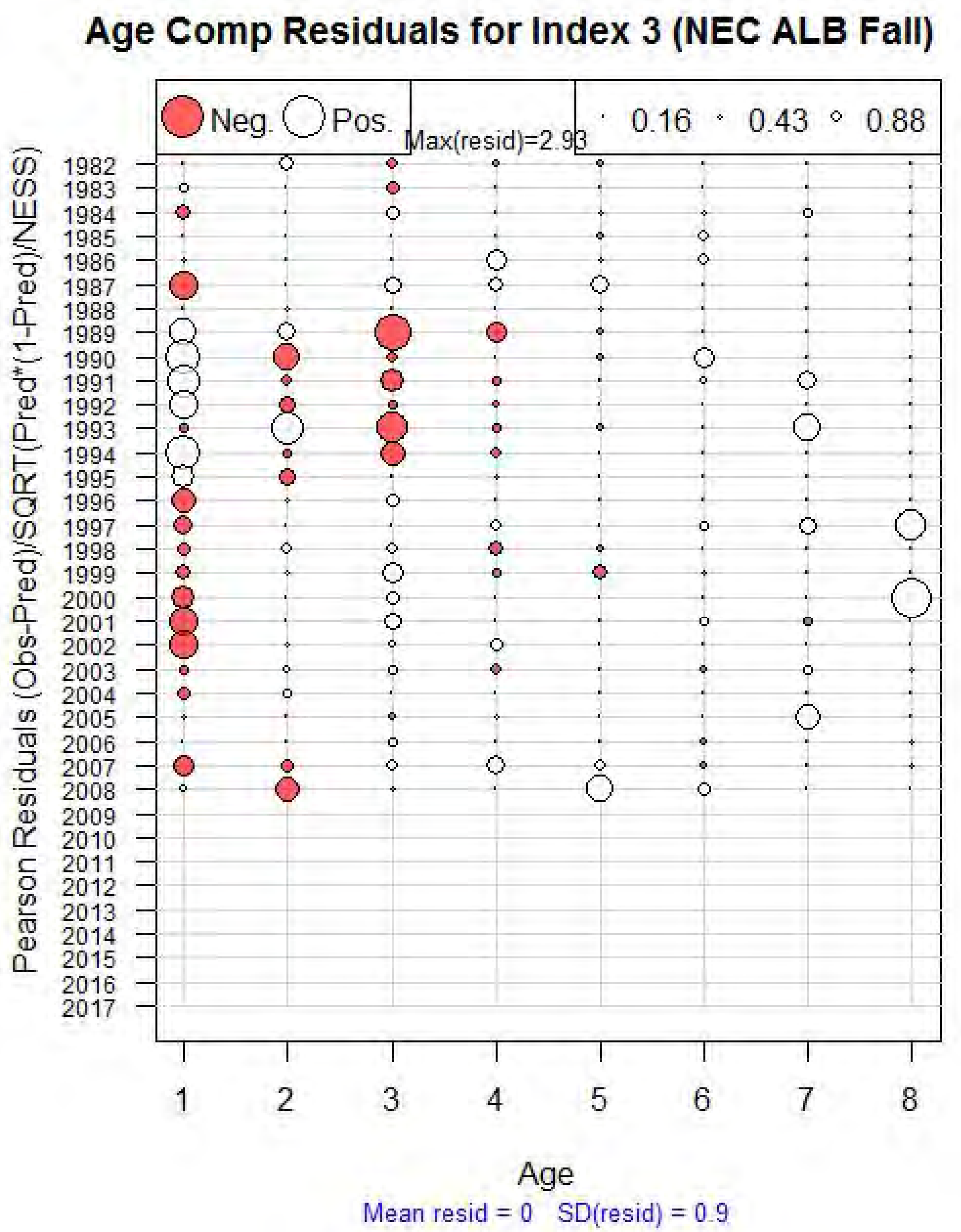


Figure A181. Age composition residuals for the Northeast Fisheries Science Center (NEC) Albatross (ALB) fall trawl survey from the F2018_BASE_V2 model run.

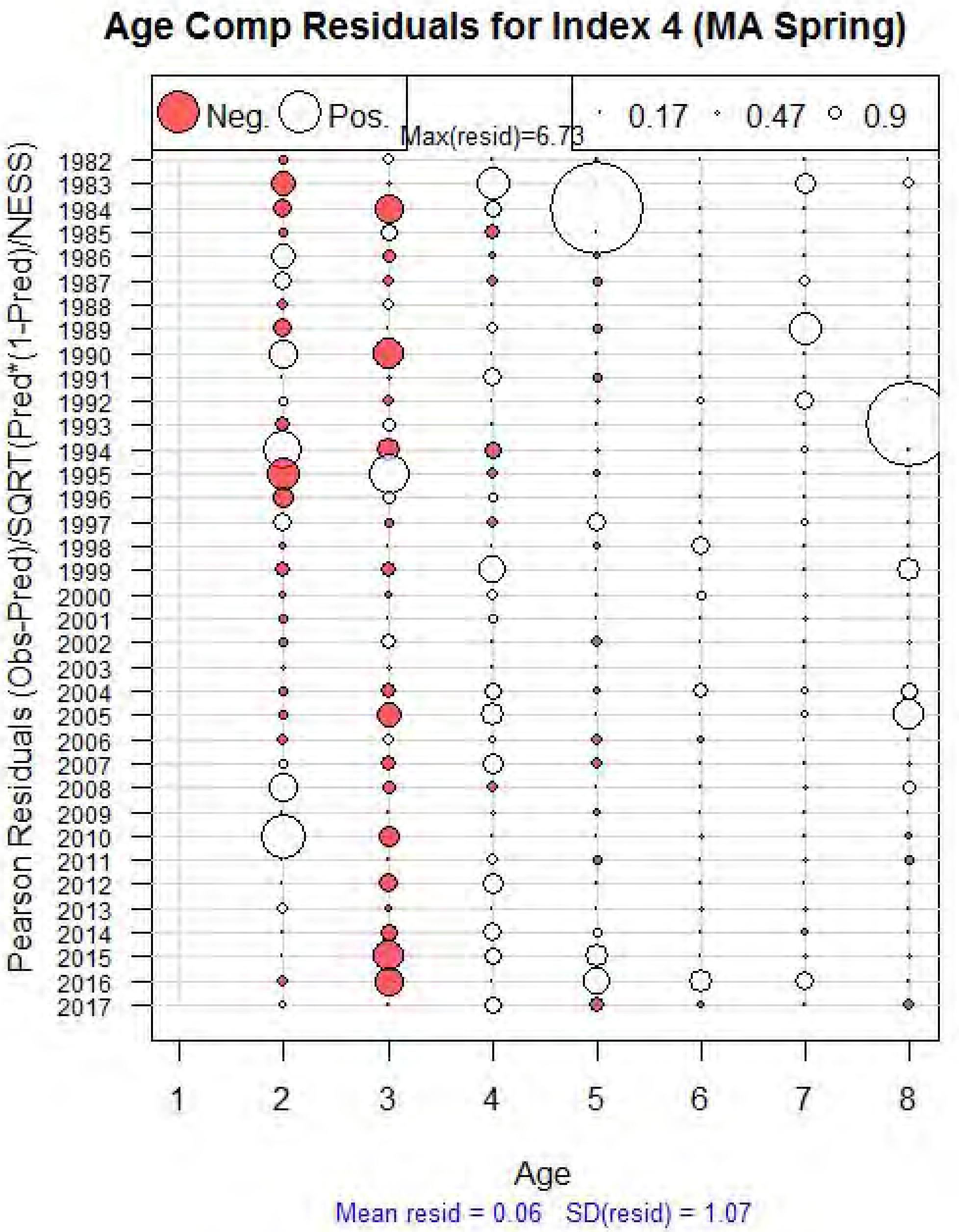


Figure A182. Age composition residuals for the Massachusetts Division of Marine Fisheries (MA) spring trawl survey from the F2018_BASE_V2 model run.

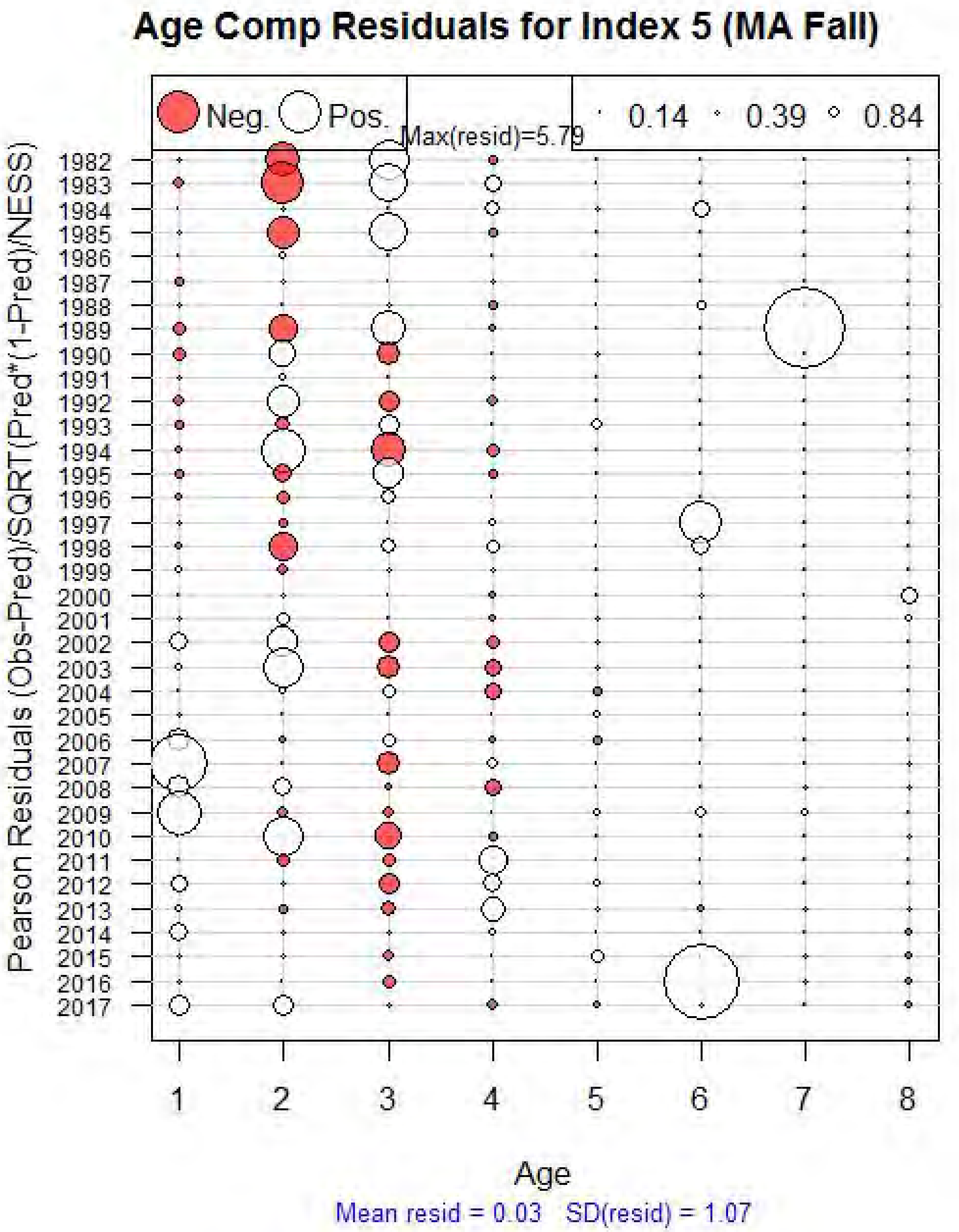


Figure A183. Age composition residuals for the Massachusetts Division of Marine Fisheries (MA) fall trawl survey from the F2018_BASE_V2 model run.

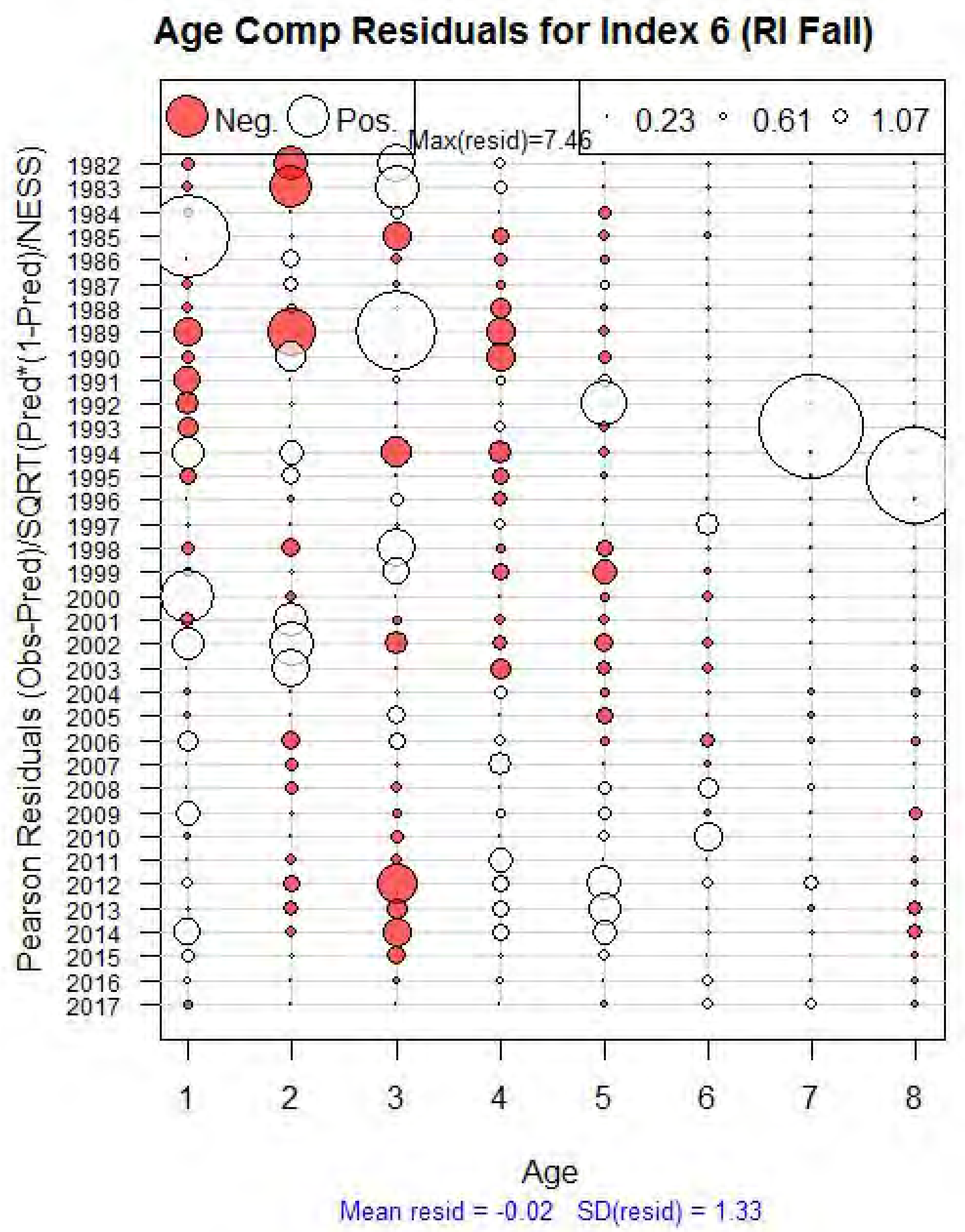


Figure A184. Age composition residuals for the Rhode Island Department of Fish and Wildlife (RI) fall trawl survey from the F2018_BASE_V2 model run.

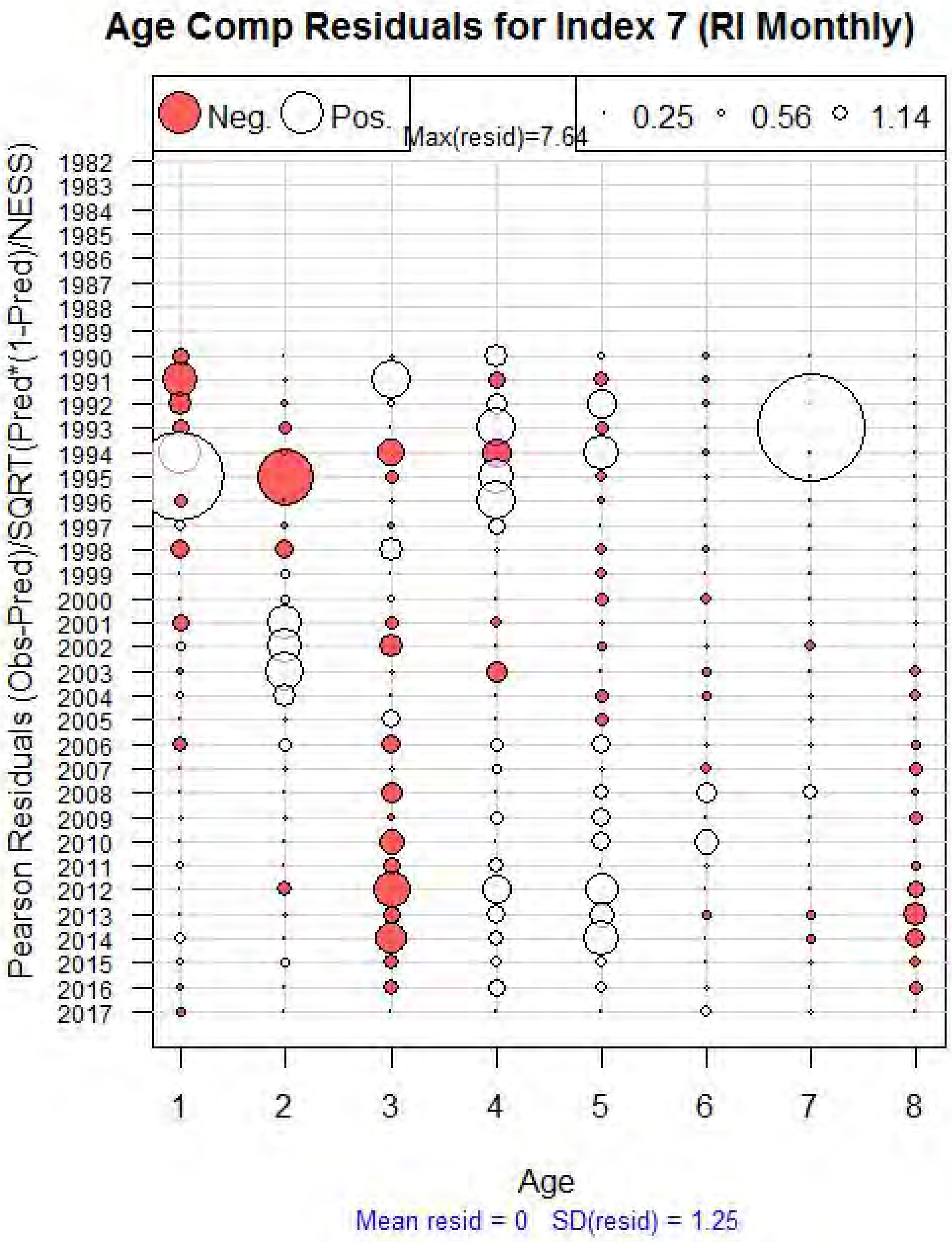


Figure A185. Age composition residuals for the Rhode Island Department of Fish and Wildlife (RI) monthly trawl survey from the F2018_BASE_V2 model run.

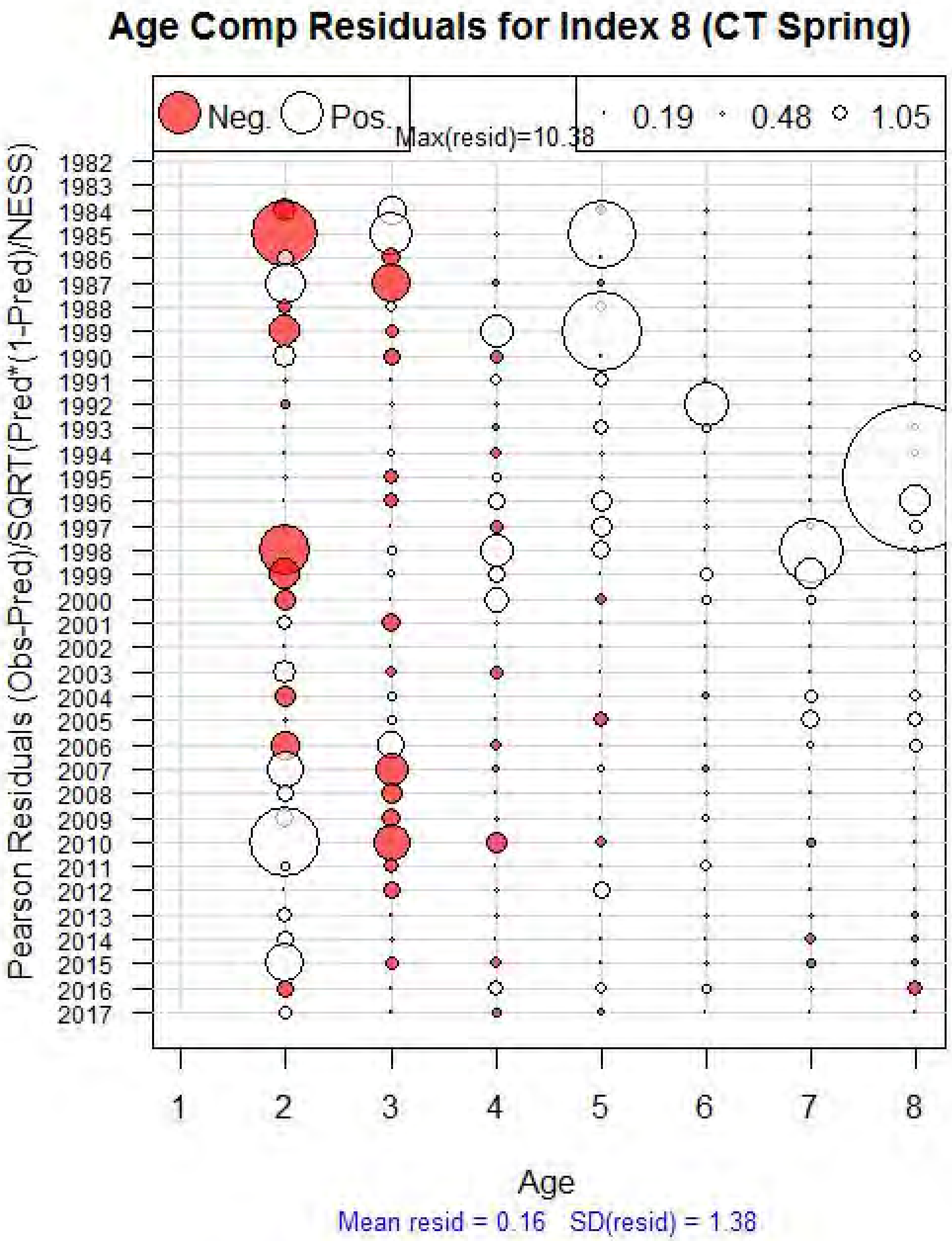


Figure A186. Age composition residuals for the Connecticut Department of Energy and Environmental Protection (CT) spring trawl survey from the F2018_BASE_V2 model run.

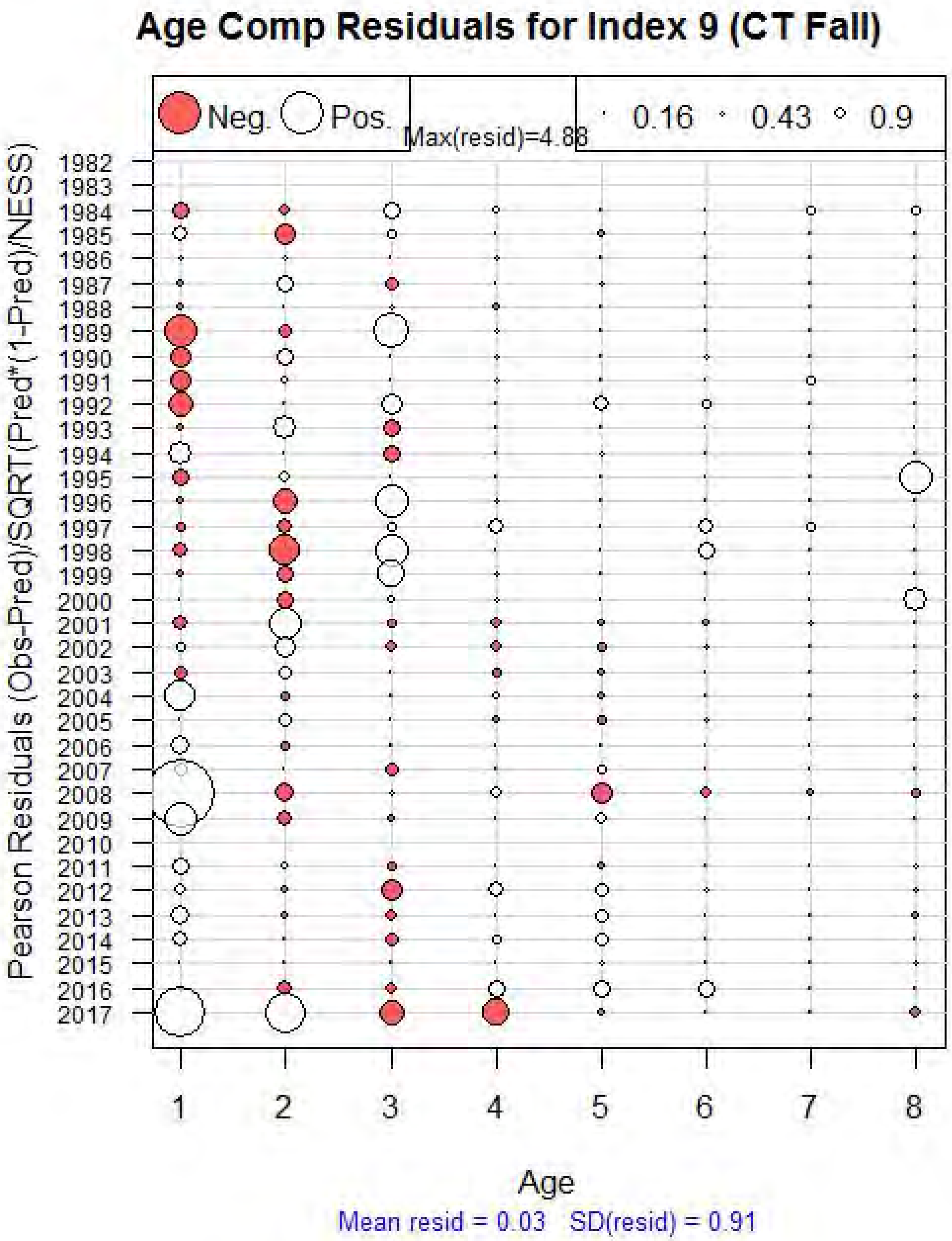


Figure A187. Age composition residuals for the Connecticut Department of Energy and Environmental Protection (CT) fall trawl survey from the F2018_BASE_V2 model run.

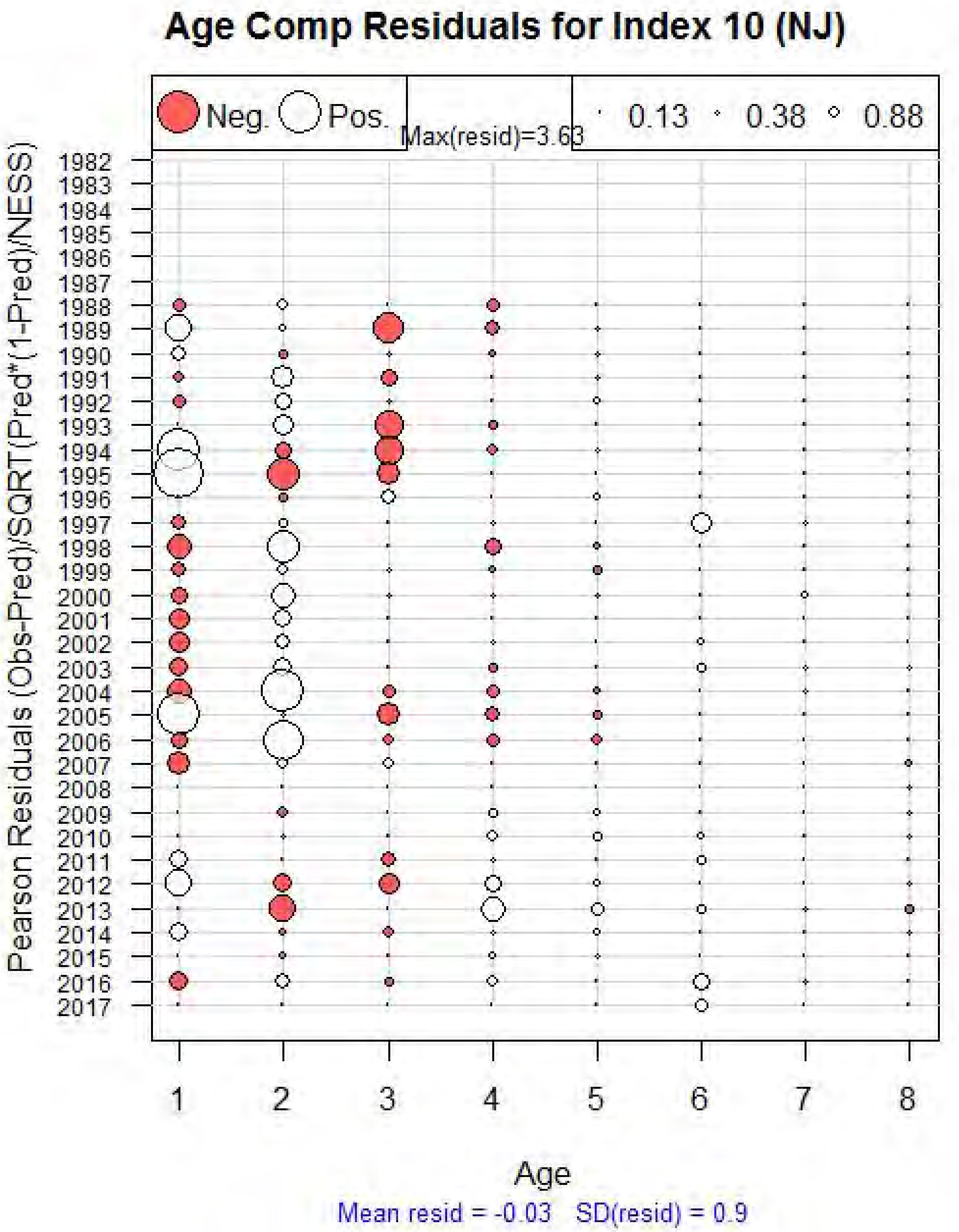


Figure A188. Age composition residuals for the New Jersey Division of Fish and Wildlife (NJ) trawl survey from the F2018_BASE_V2 model run.

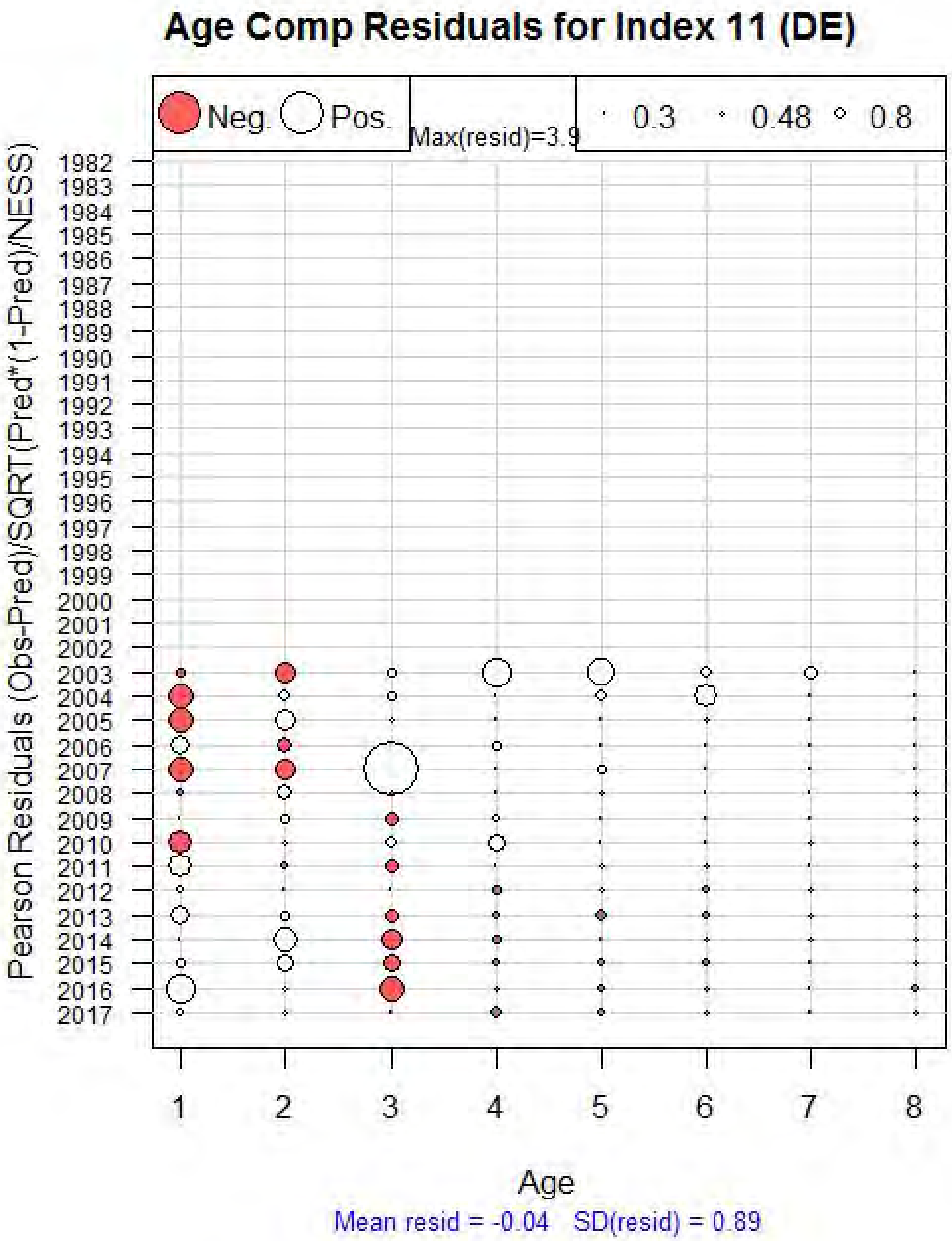


Figure A189. Age composition residuals for the Delaware Division of Fish and Wildlife (DE) trawl survey from the F2018_BASE_V2 model run.

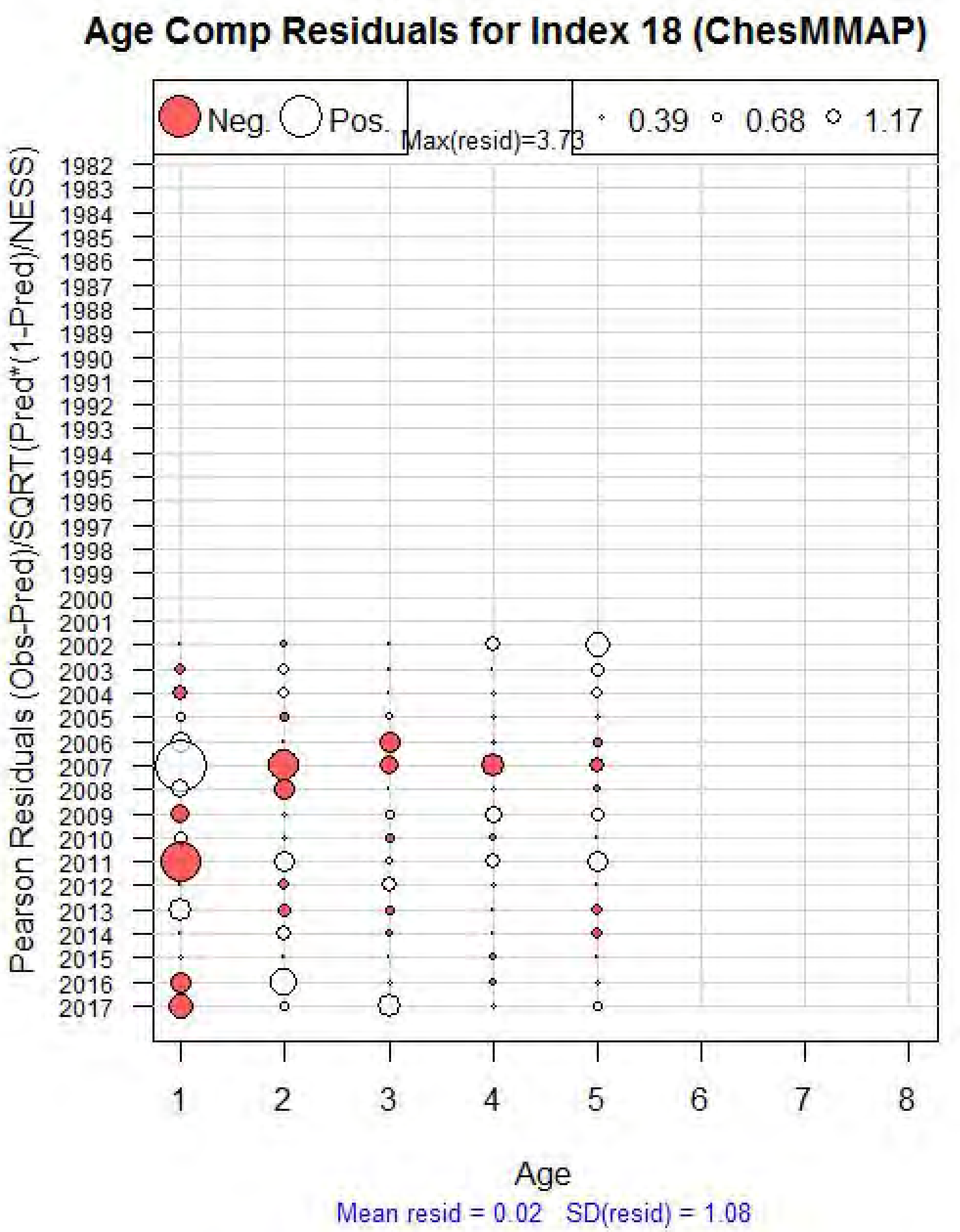


Figure A190. Age composition residuals for the Virginia Institute of Marine Science Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) trawl survey from the F2018_BASE_V2 model run.

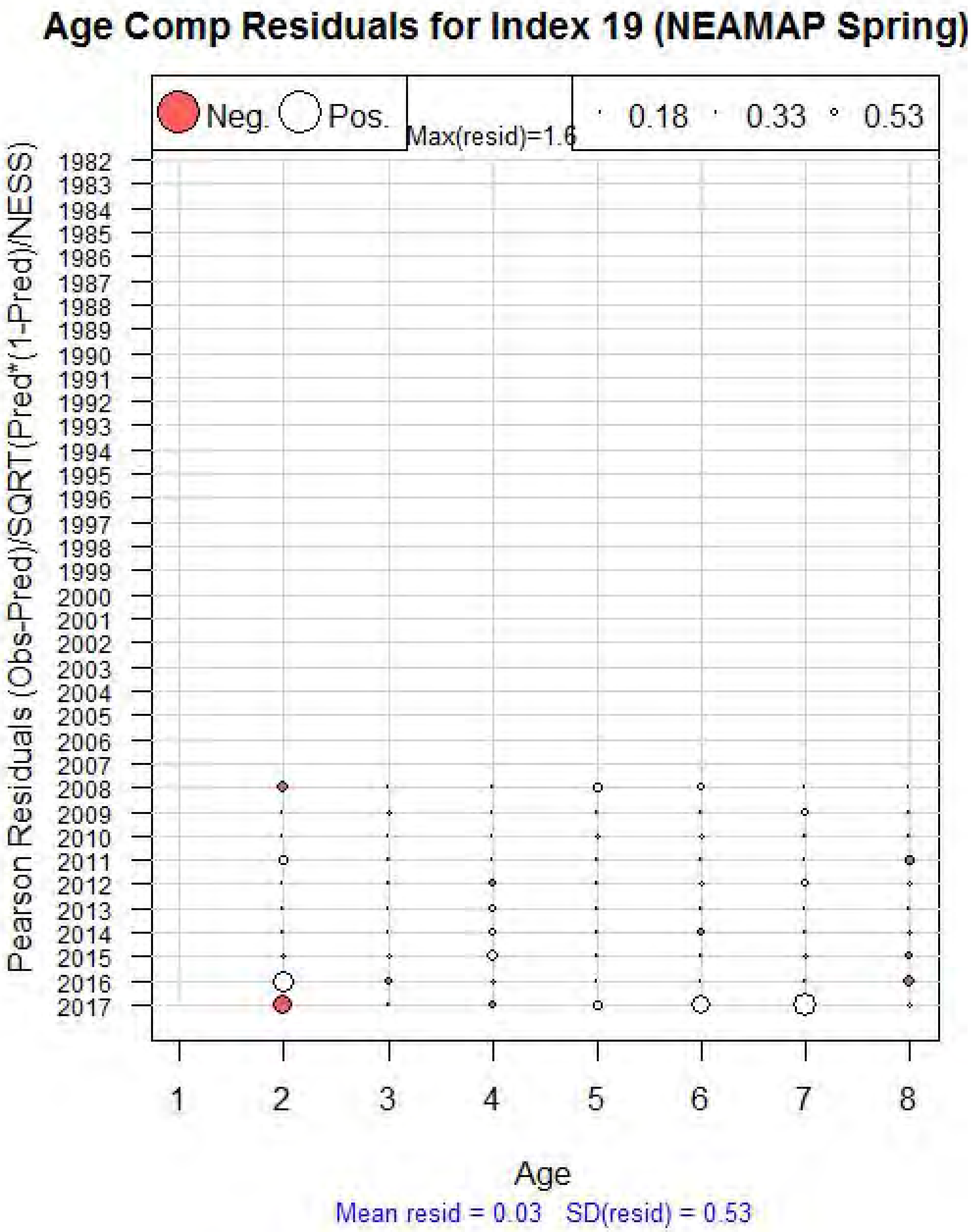


Figure A191. Age composition residuals for the Virginia Institute of Marine Science Northeast Area Monitoring and Assessment Program (NEAMAP) spring trawl survey from the F2018_BASE_V2 model run.

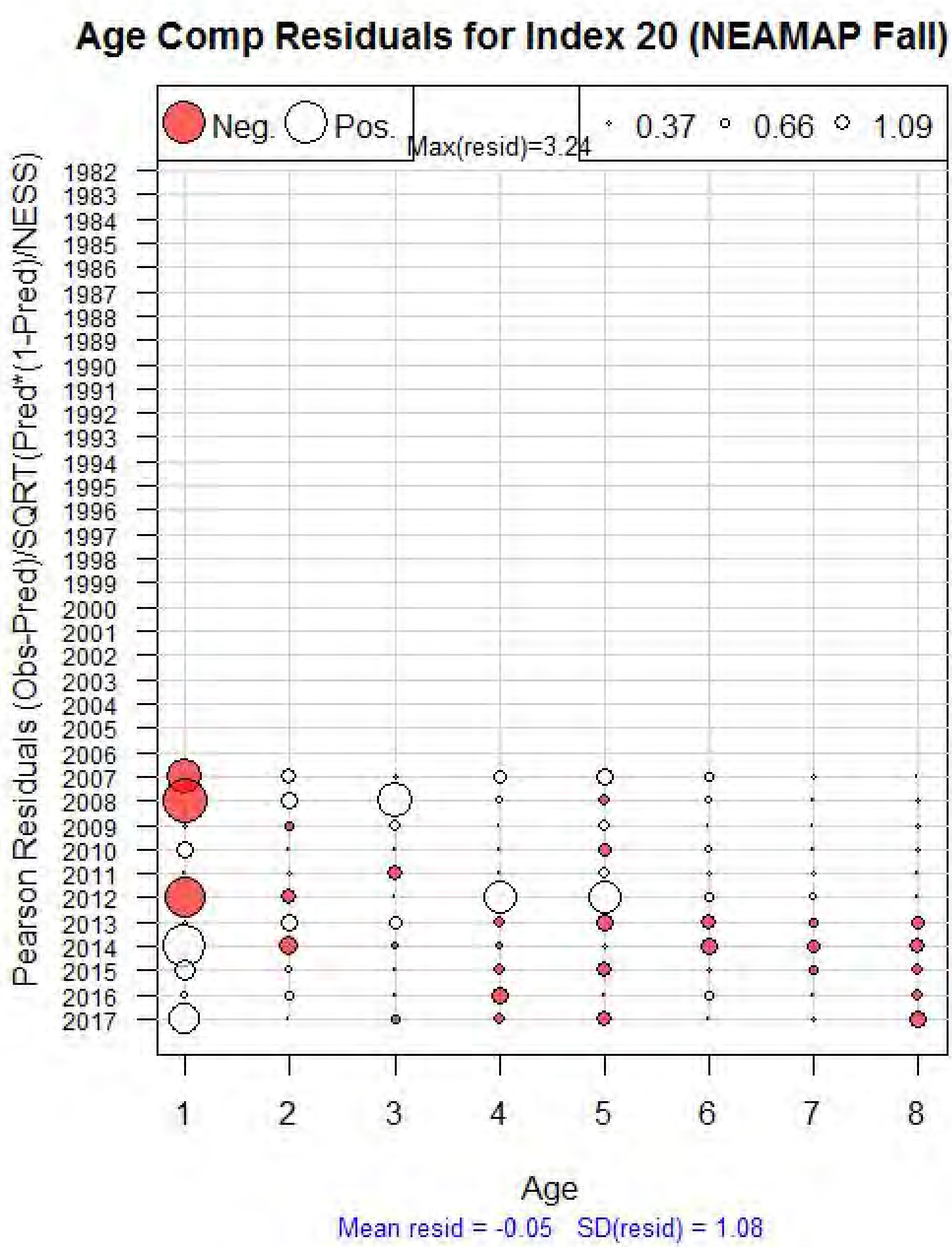


Figure A192. Age composition residuals for the Virginia Institute of Marine Science Northeast Area Monitoring and Assessment Program (NEAMAP) fall trawl survey from the F2018_BASE_V2 model run.

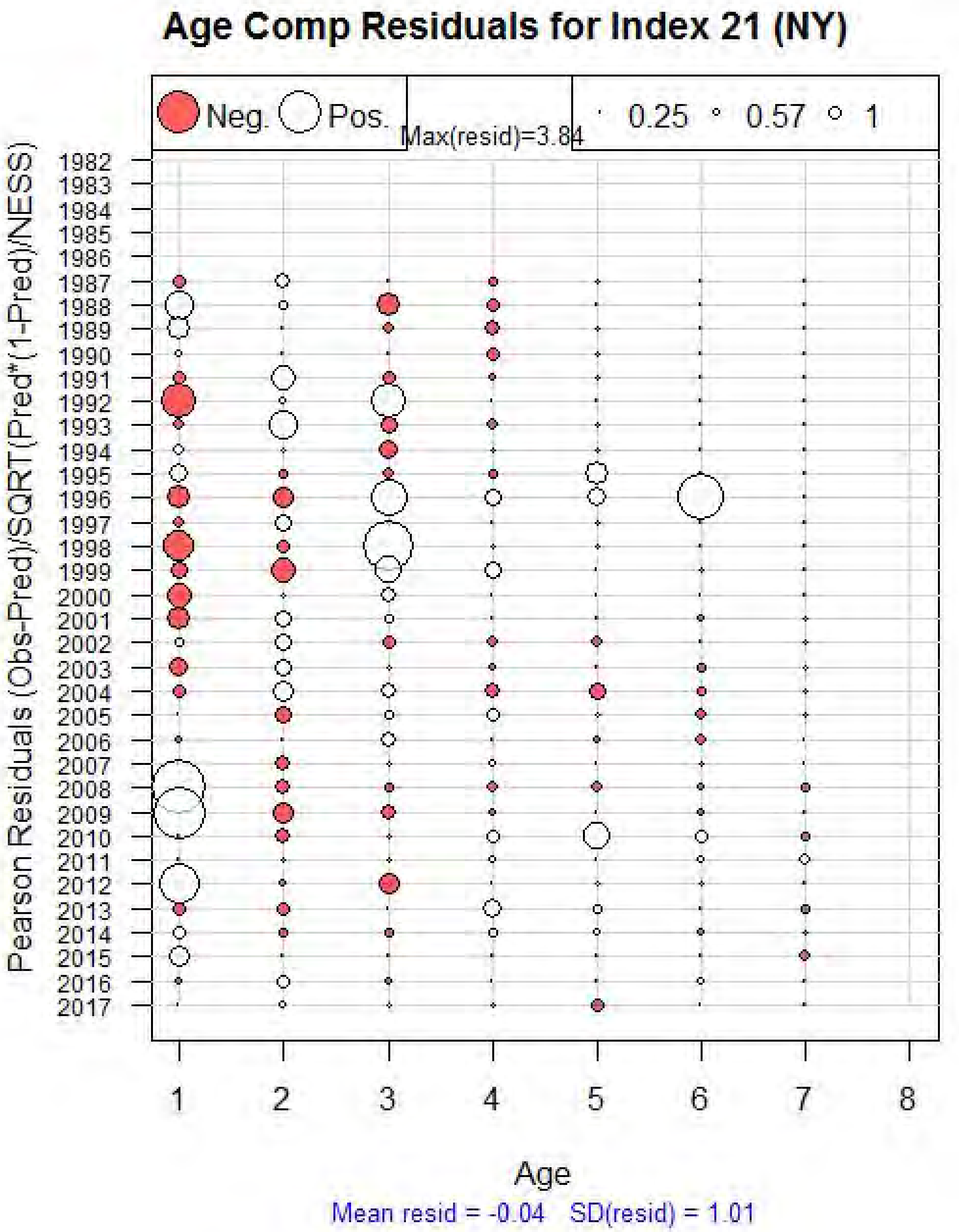


Figure A193. Age composition residuals for the New York Department of Environmental Conservation (NY) trawl survey from the F2018_BASE_V2 model run.

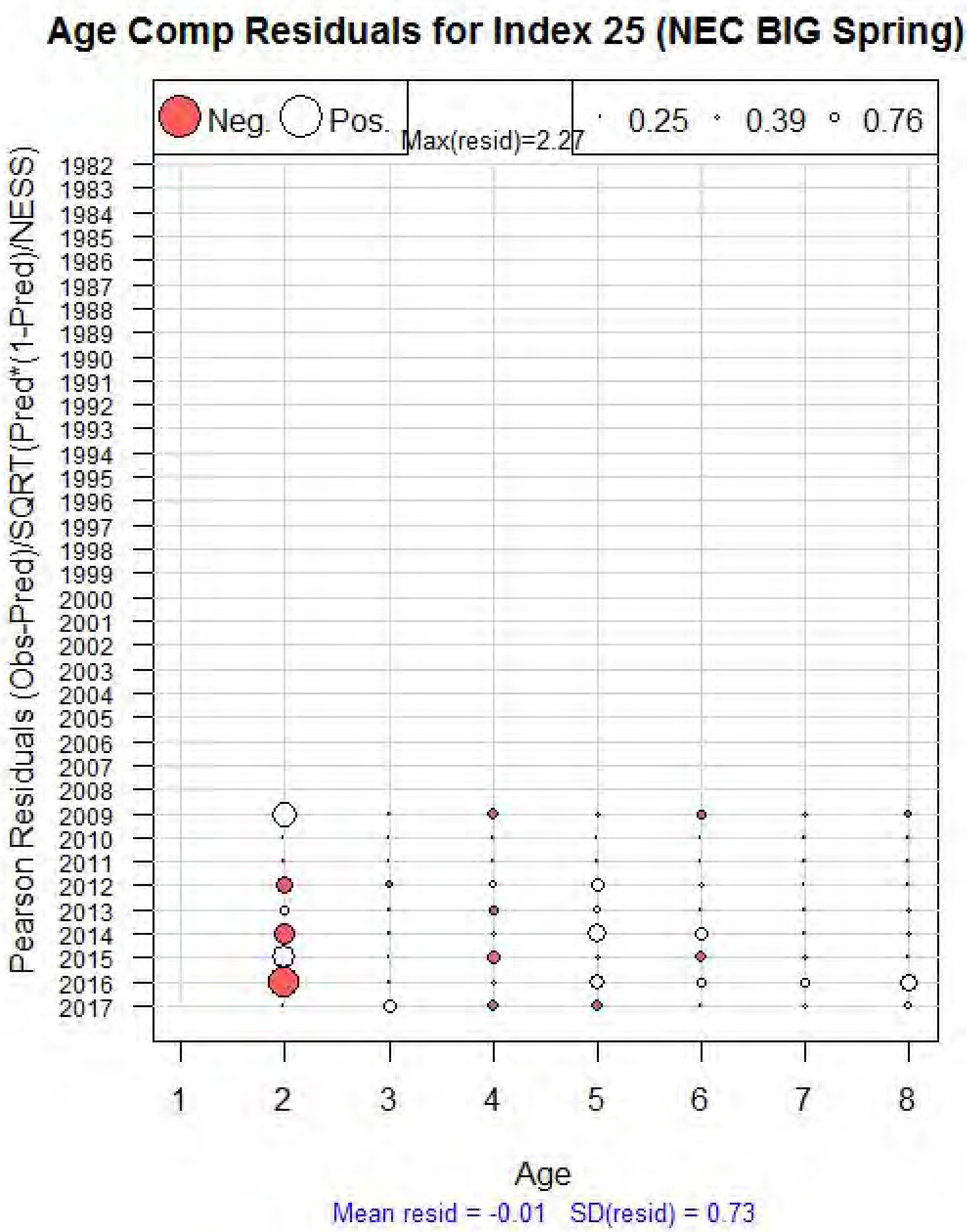


Figure A194. Age composition residuals for the Northeast Fisheries Science Center (NEC) Bigelow (BIG) spring trawl survey from the F2018_BASE_V2 model run.

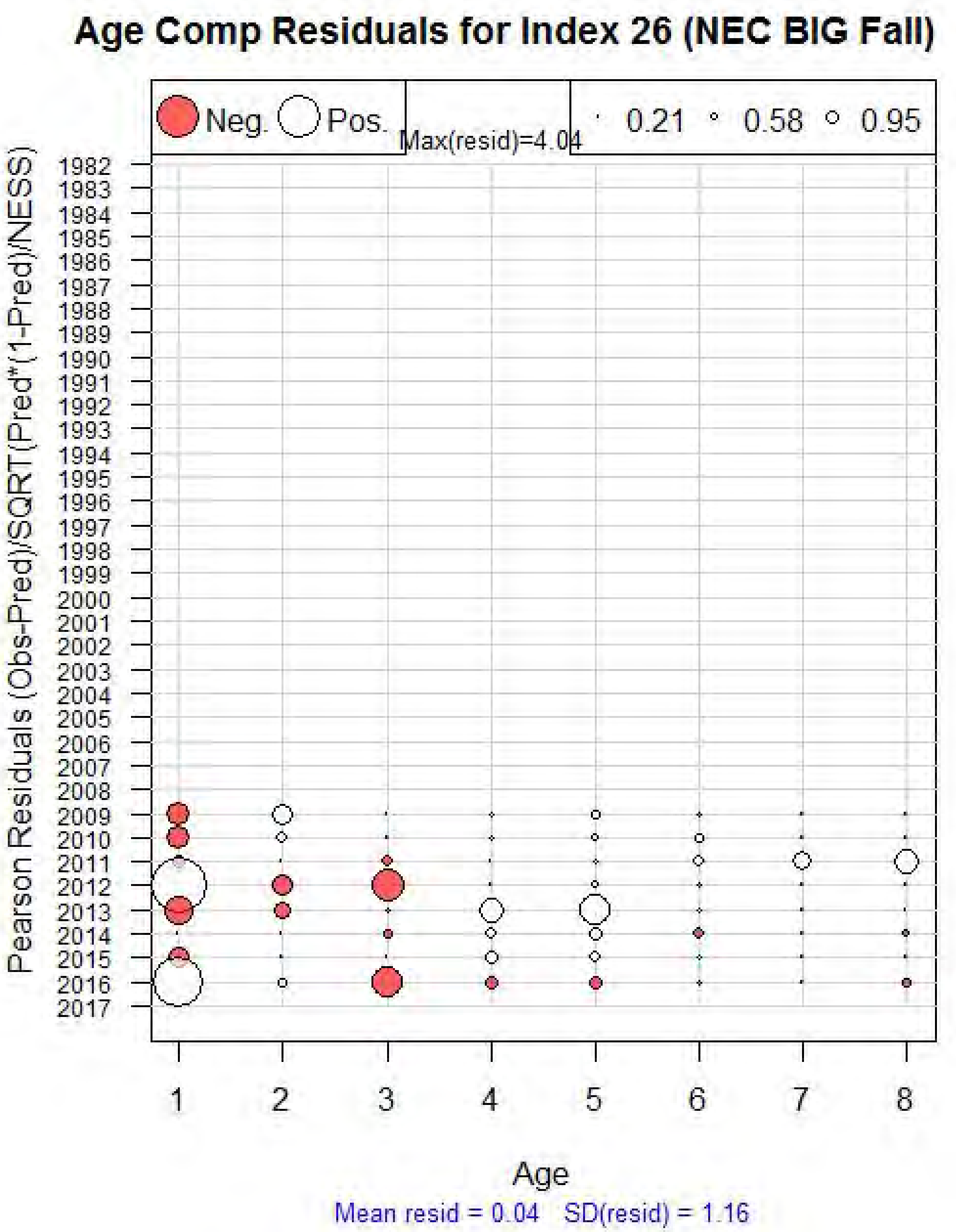


Figure A195. Age composition residuals for the Northeast Fisheries Science Center (NEC) Bigelow (BIG) fall trawl survey from the F2018_BASE_V2 model run.

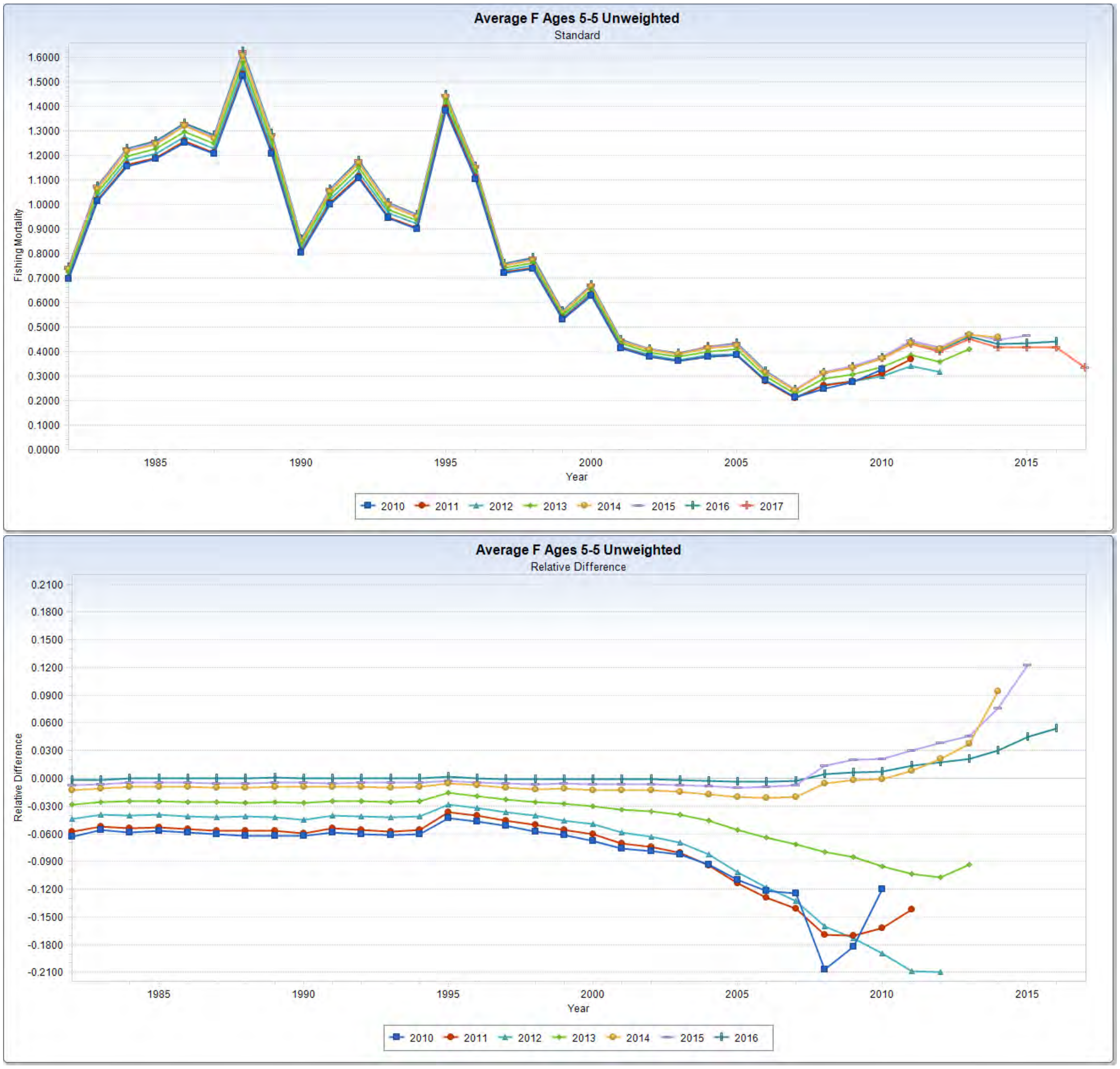


Figure A196. Results of internal model retrospective analysis for the F2018_BASE_V2 model: fully recruited F (true age 4, model age 5); average retrospective error = -4%.

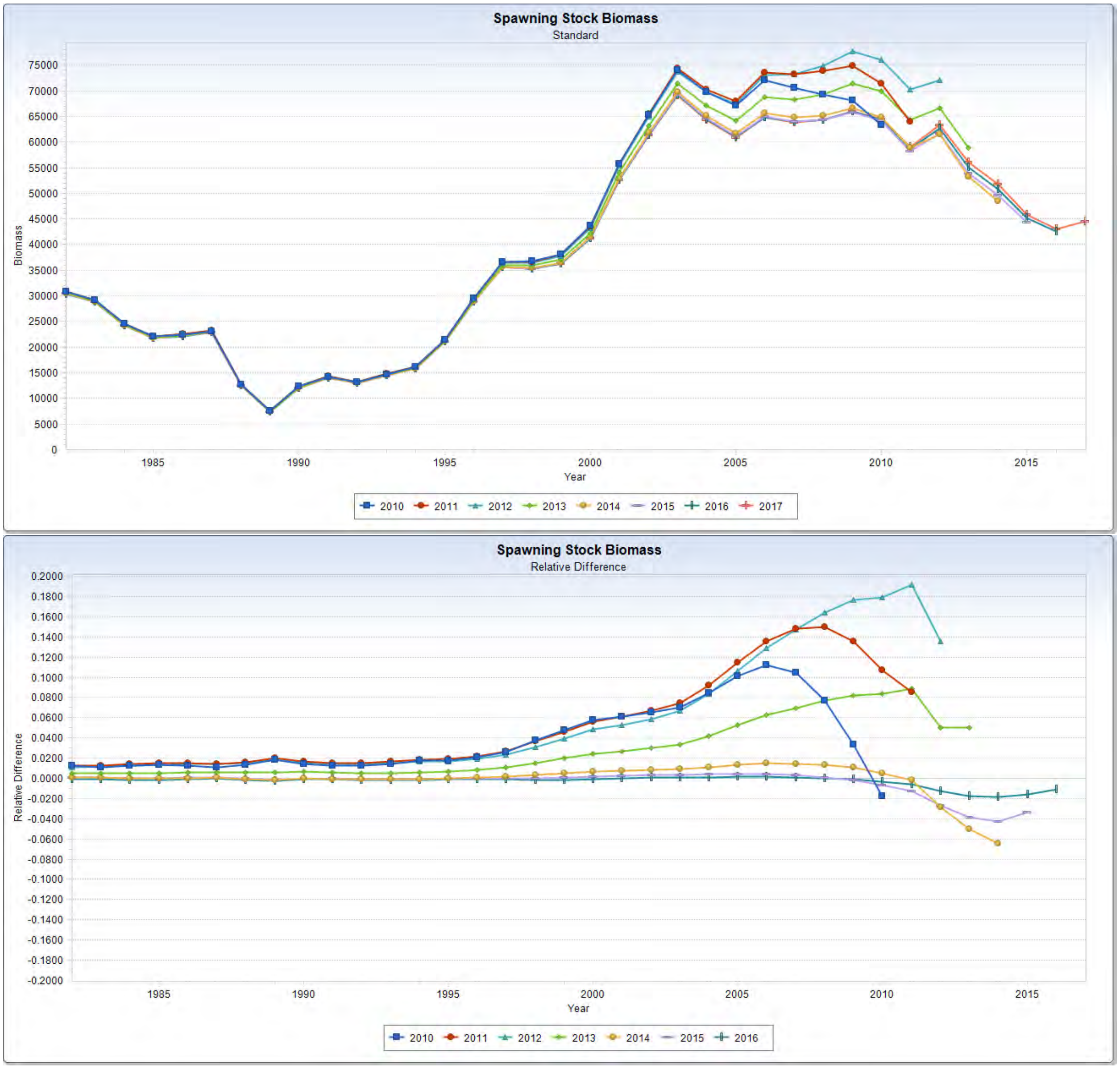


Figure A197. Results of internal model retrospective analysis for the F2018_BASE_V2 model: Spawning Stock Biomass; average retrospective error = +2%.

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%.

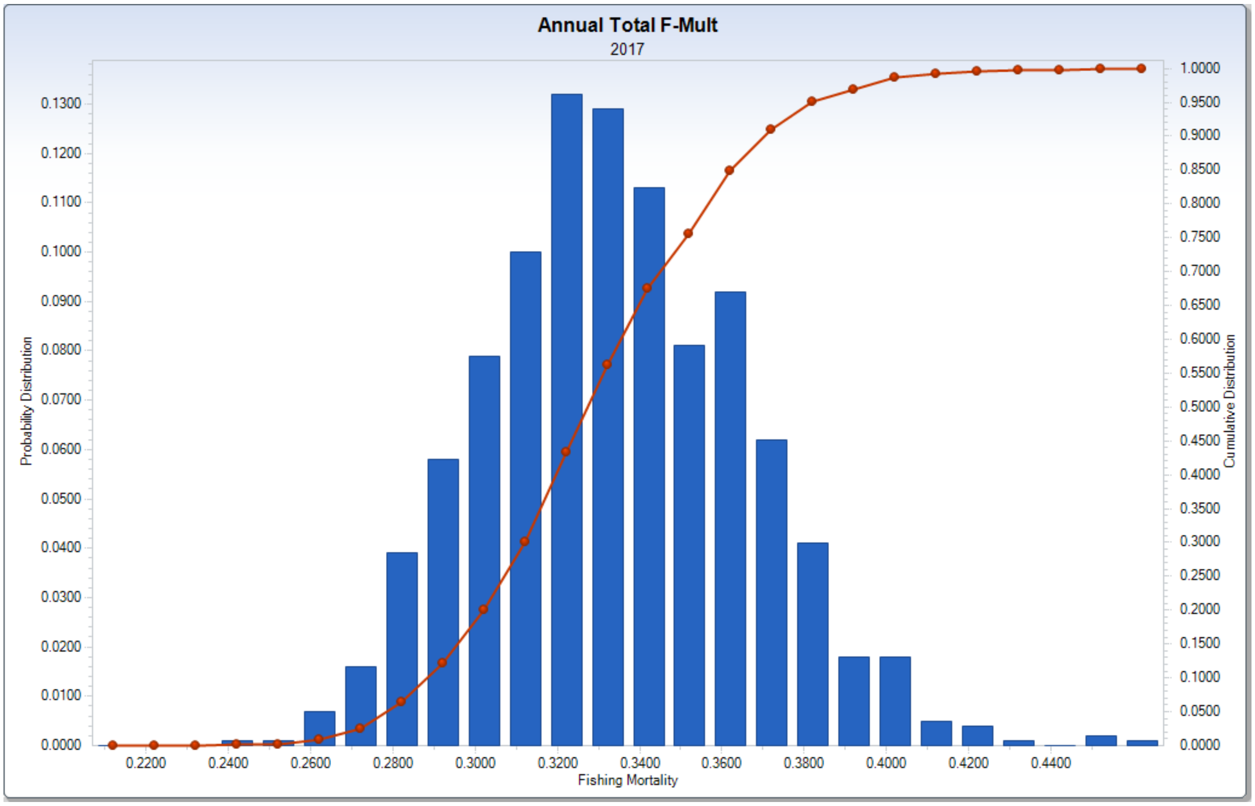


Figure A199. Markov Chain Monte Carlo probability distribution of fishing mortality rate in 2017 (fully recruited F = Fmult for model age 5 = true age 4) from model run F2018_BASE_V2.

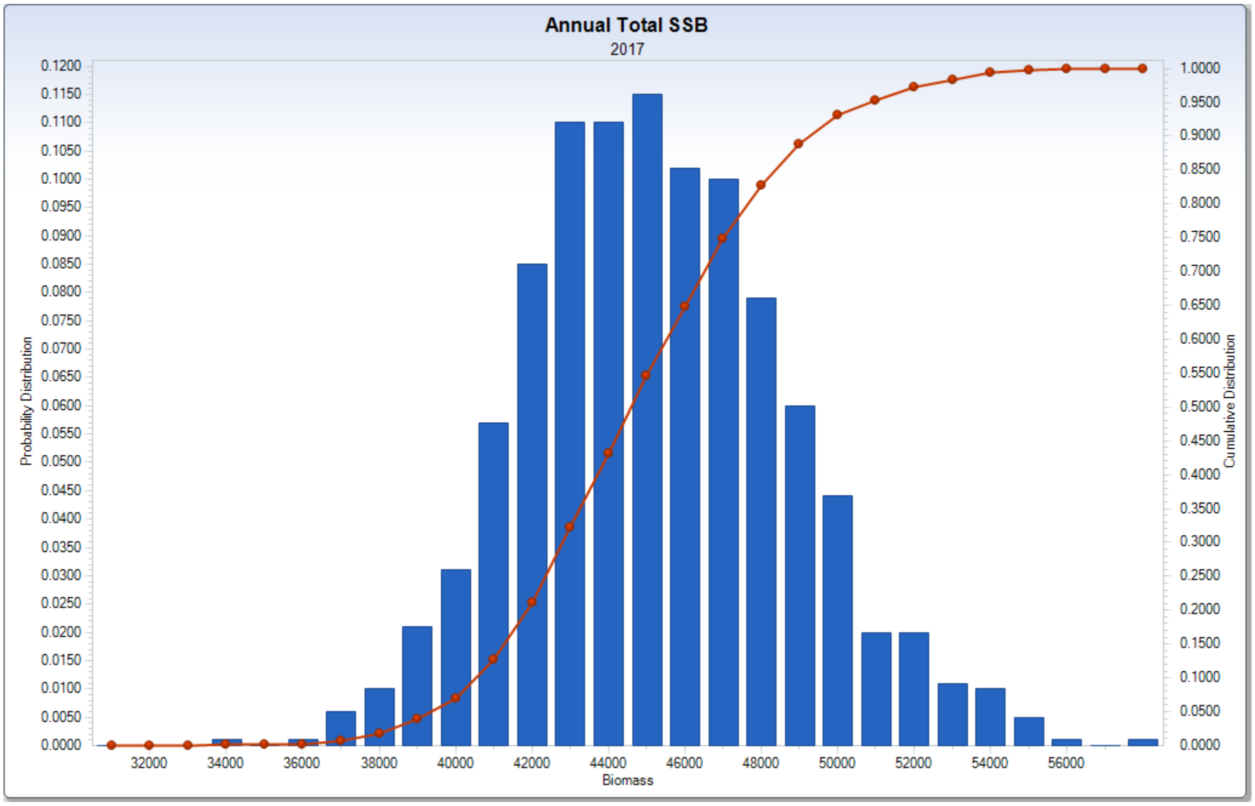
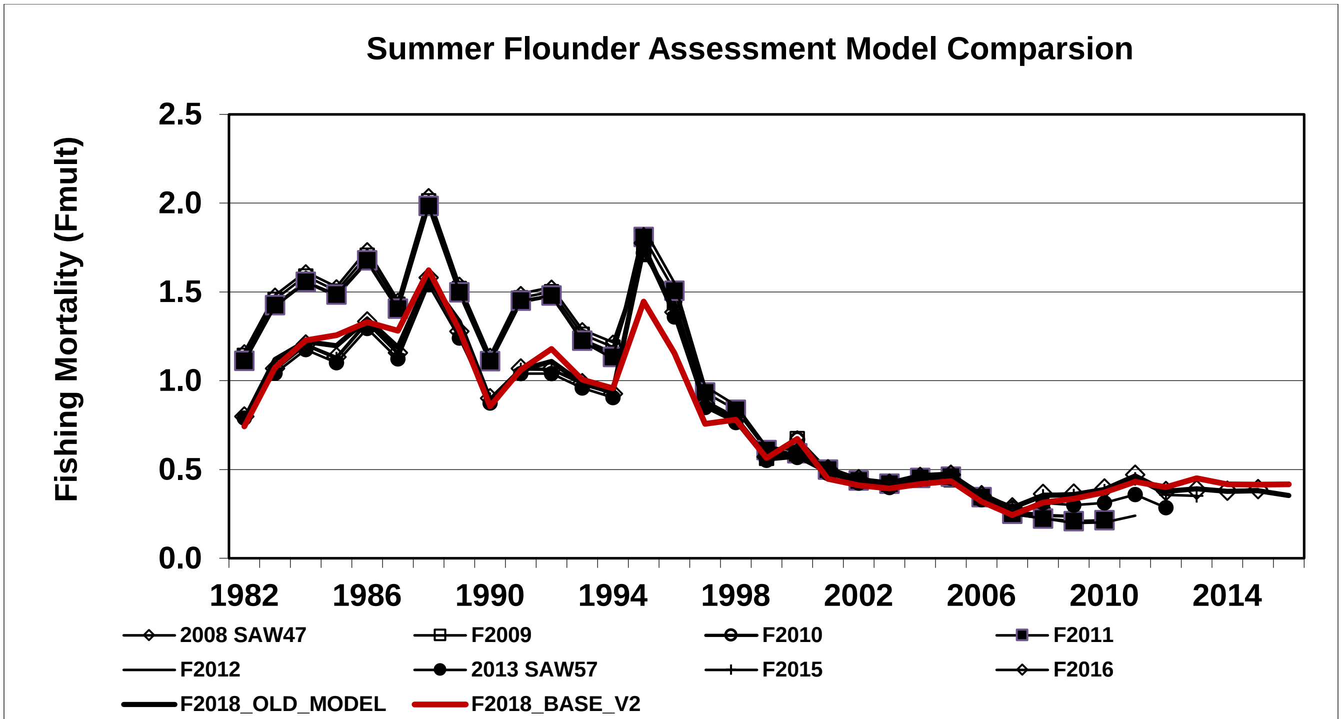


Figure A200. Markov Chain Monte Carlo probability distribution of Spawning Stock Biomass (SSB) in 2017 from model run F2018_BASE_V2.



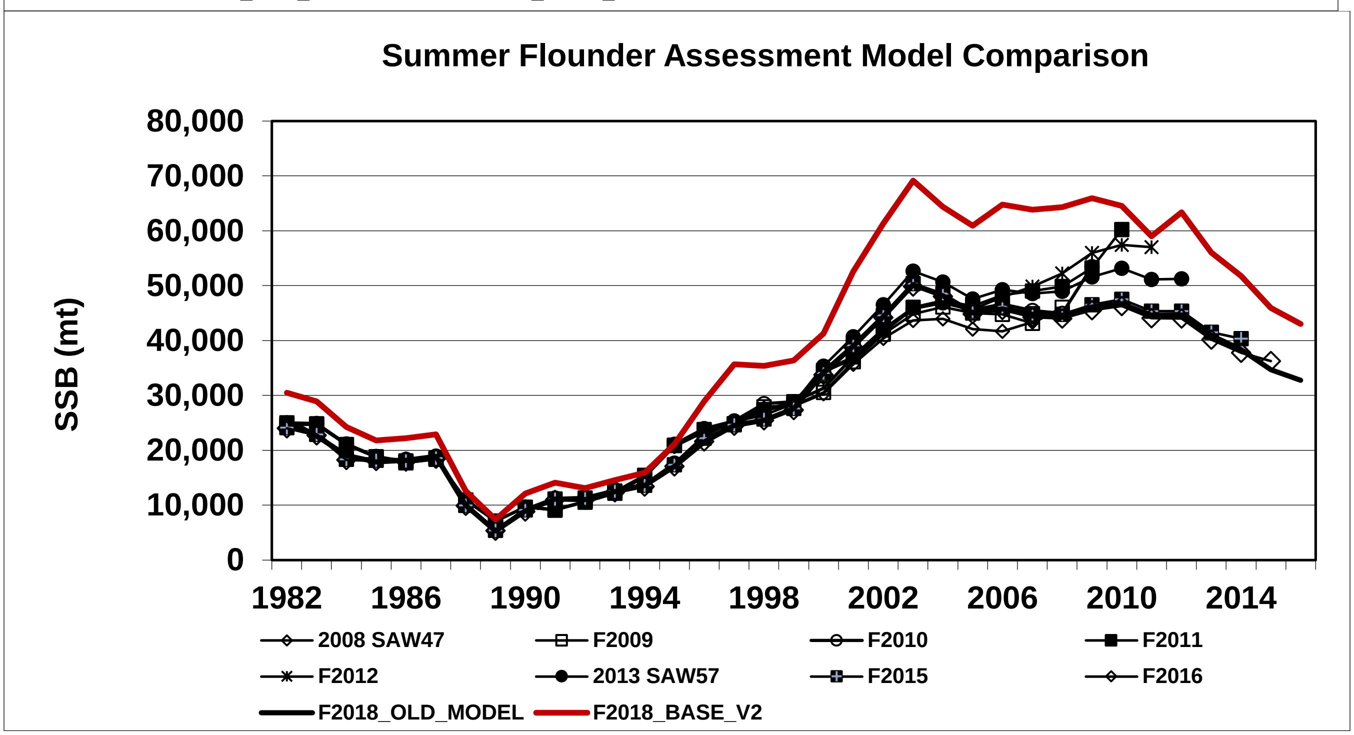


Figure A201. Comparison of the fishing mortality (top panel) and Spawning Stock Biomass (bottom panel) results from the 2008 SAW 47 benchmark assessment, the 2009-2012 assessment updates, 2013 SAW 57 benchmark assessment, the 2015-2016 assessment updates, the existing ('Old') model updated through 2017 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.

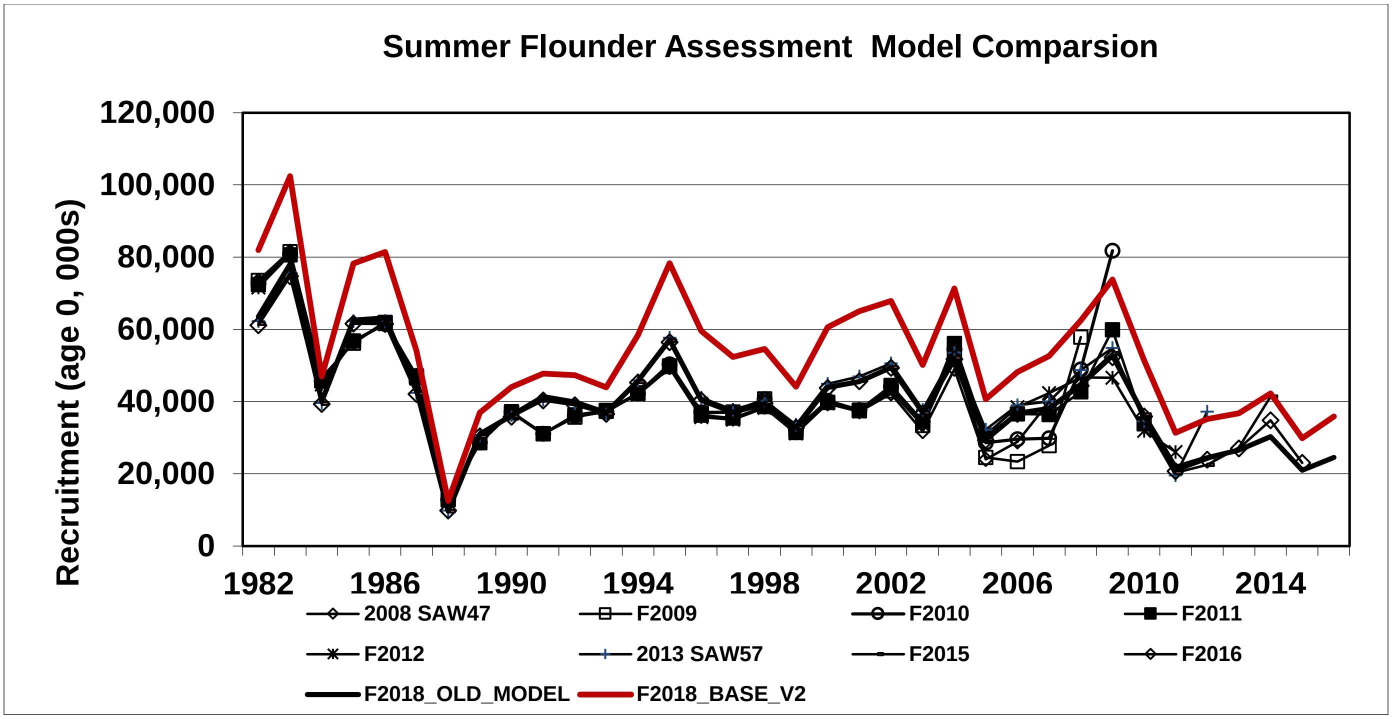


Figure A202. Comparison of the estimated stock numbers for age 0 (model age 1) from the 2008 SAW-47 benchmark assessment, the 2009-2012 assessment updates, 2013 SAW-57 benchmark assessment, the 2015-2016 assessment updates, the existing (‘Old’) model updated through 2017 with ‘Old’ MRIP (F2018_OLD_MODEL), and the final F2018_BASE_V2 model with ‘New’ MRIP (F2018_BASE_NEW) for the 2018 SAW-66 assessment.

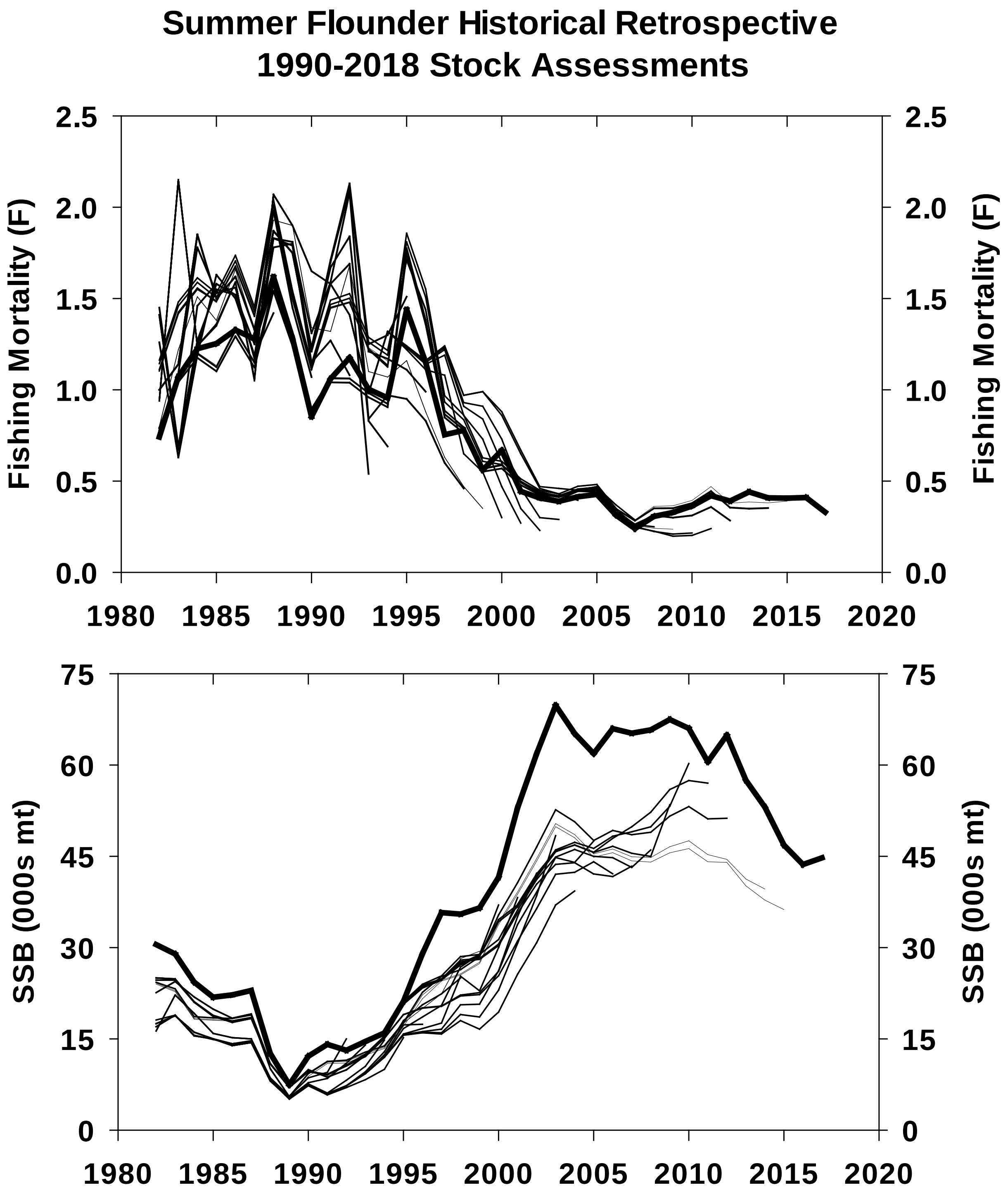


Figure A203. Historical retrospective of the 1990-2018 stock assessments of summer flounder. Note that F for the 1990-2007 assessments is reported for ages 2-7+, F for the 2008-2012 assessments is reported for ages 3-7+, while F for the 2013-2018 assessments is reported for age

4.

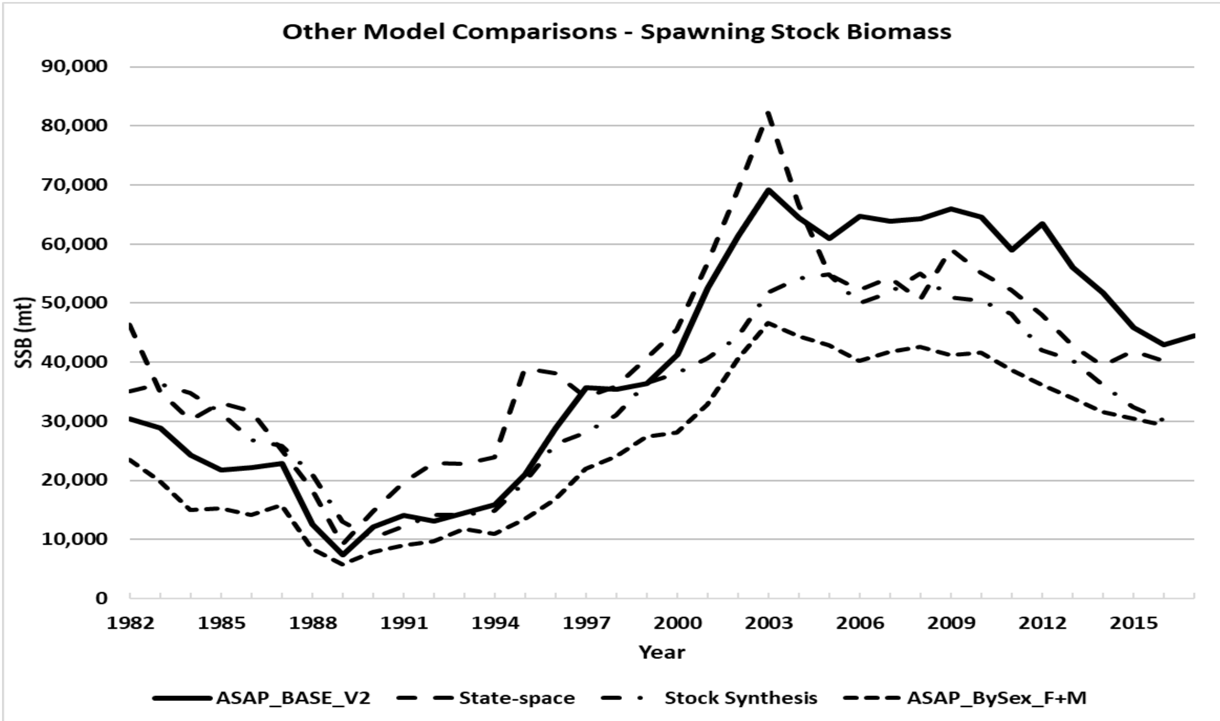


Figure A204. Comparison of spawning stock biomass from other non-preferred models to the ASAP_BASE_V2 final model configuration.

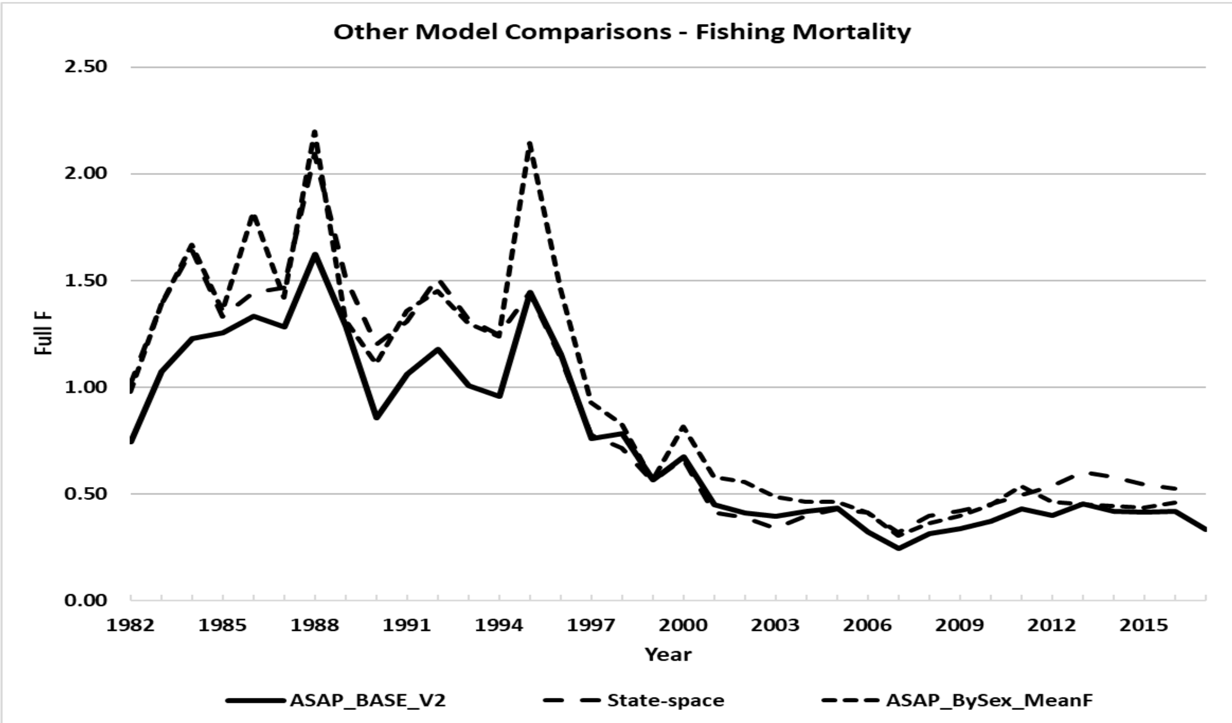


Figure A205. Comparison of fishing mortality from other non-preferred models to the ASAP_BASE_V2 final model configuration. Note: Because of Stock Synthesis use of dome-shaped, time-varying selectivity, it is not shown here.

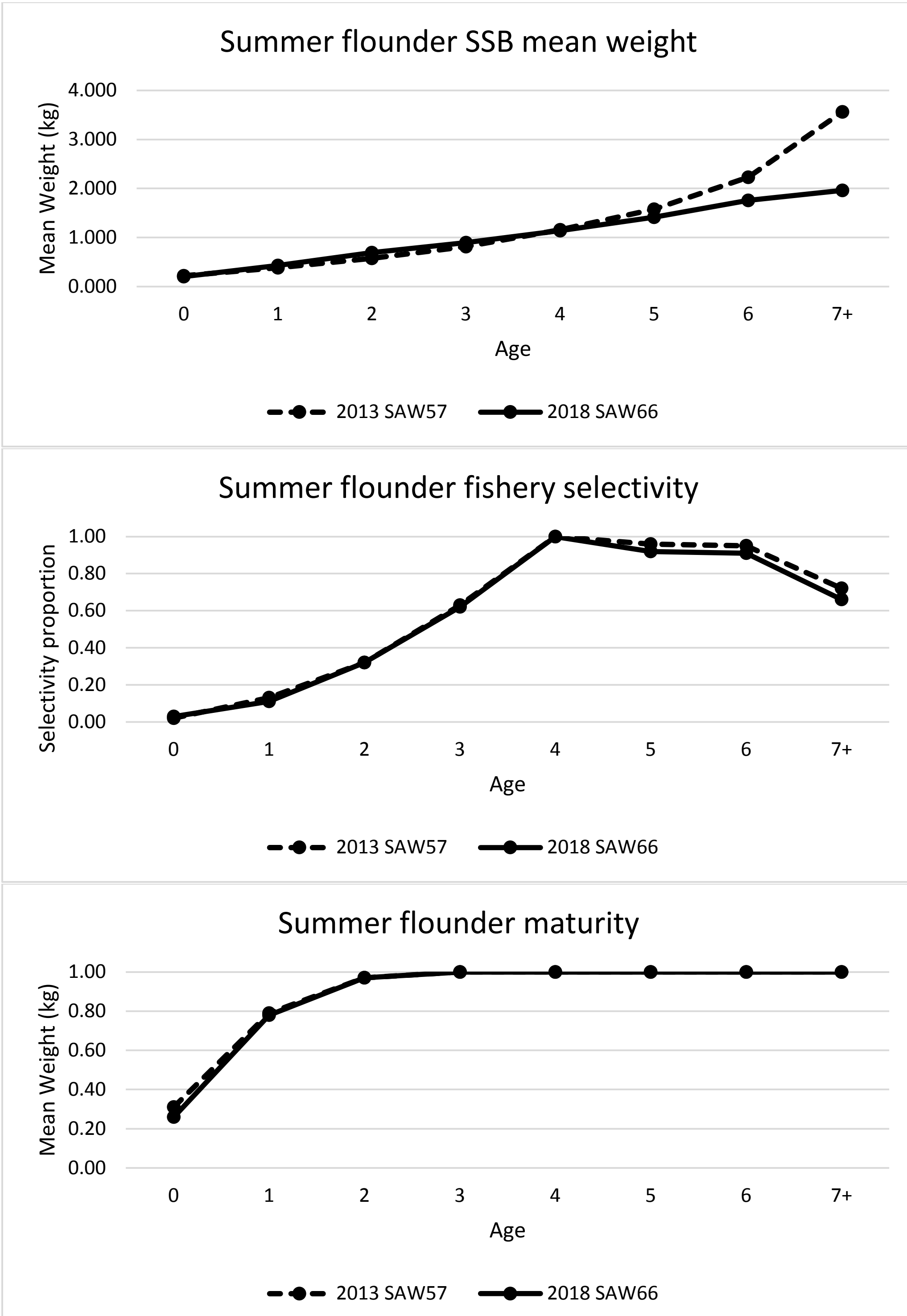


Figure A206. Patterns in Spawning Stock Biomass (SSB) mean weights at age (top), fishery selectivity at age (middle), and maturity at age (bottom) in the 2013 SAW-57 and 2018 SAW-66 summer flounder stock assessments.

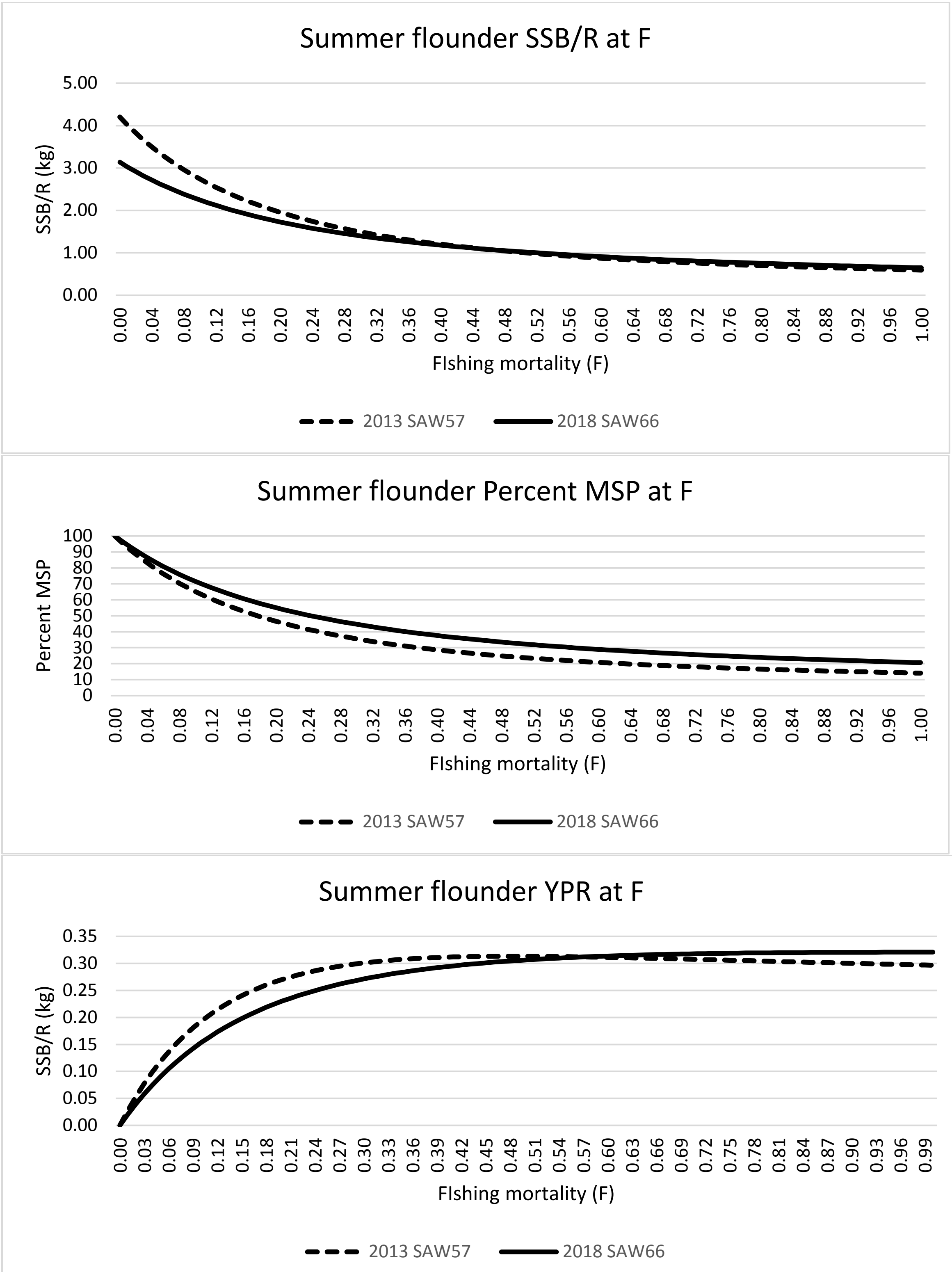


Figure A207. Patterns in Spawning Stock Biomass per Recruit (SSB/R; top), percent Maximum Spawning Potential (Percent MSP; middle), and Yield per Recruit (YPR; bottom) in the 2013 SAW-57 and 2018 SAW-66 summer flounder stock assessments.

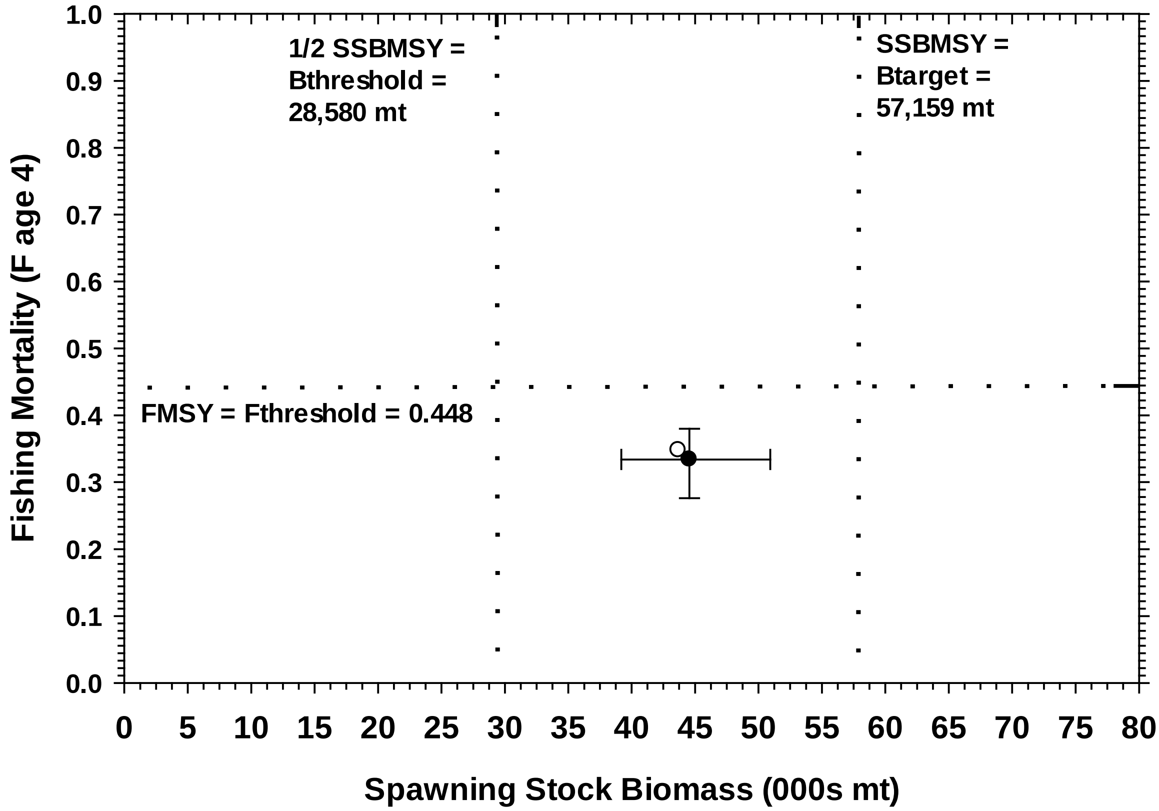


Figure A208. Estimates of summer flounder spawning stock biomass (SSB) and fully-recruited fishing mortality (F, peak at age 4) relative to the 2018 SAW-66 recommended biological reference points. Filled circle with 90% confidence intervals shows the assessment point estimates. The open circle shows the retrospectively adjusted estimates.

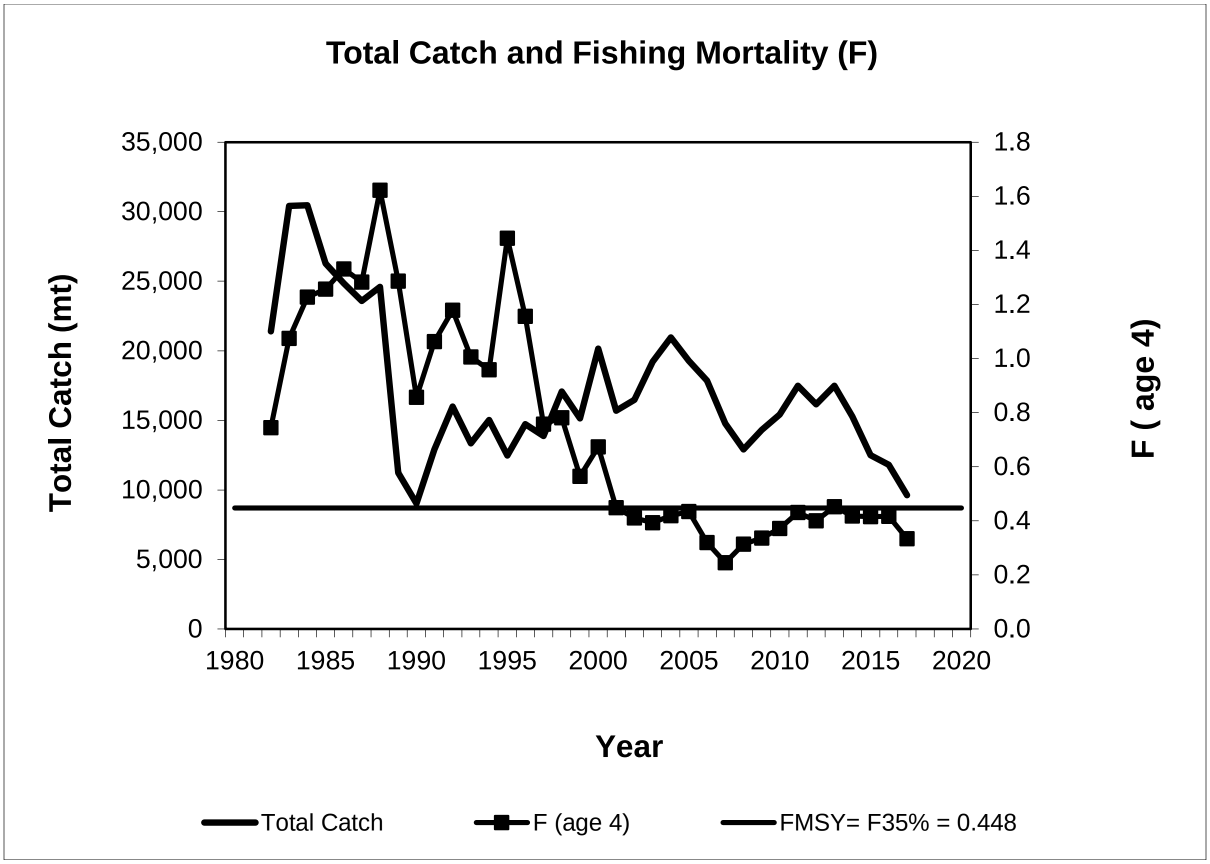


Figure A209. Total fishery catch (metric tons; mt; solid line) and fully-recruited fishing mortality (F, peak at age 4; squares) of summer flounder. The horizontal solid line is the 2018 SAW-66 recommended fishing mortality reference point proxy FMSY = F35% = 0.448.

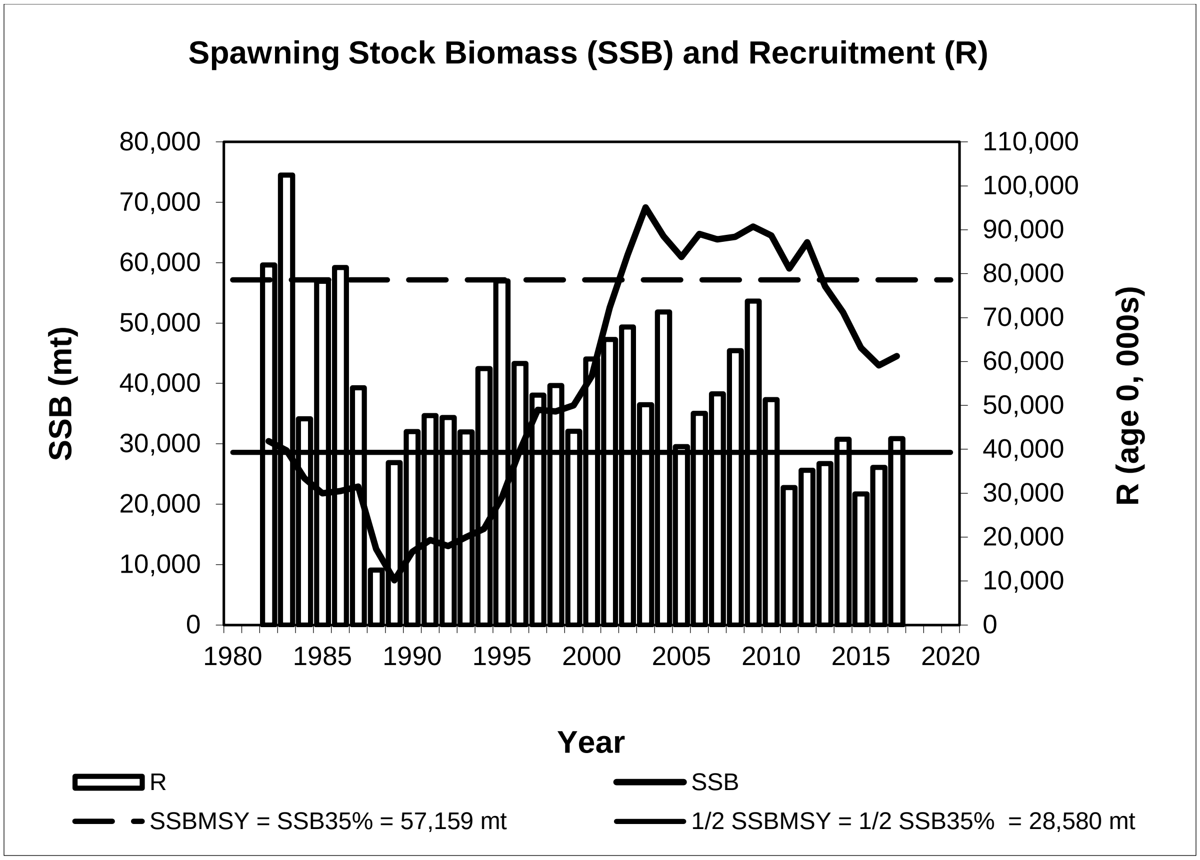


Figure A210. Summer flounder spawning stock biomass (SSB; solid line) and recruitment at age 0 (R; vertical bars) by calendar year. The horizontal dashed line is the 2018 SAW-66 recommended target biomass reference point proxy, SSBMSY = SSBF35% = 57,159 mt. The horizontal solid line is the 2018 SAW-66 recommended threshold biomass reference point proxy ½ SSBMSY = ½ SSBF35% = 28,580 mt.

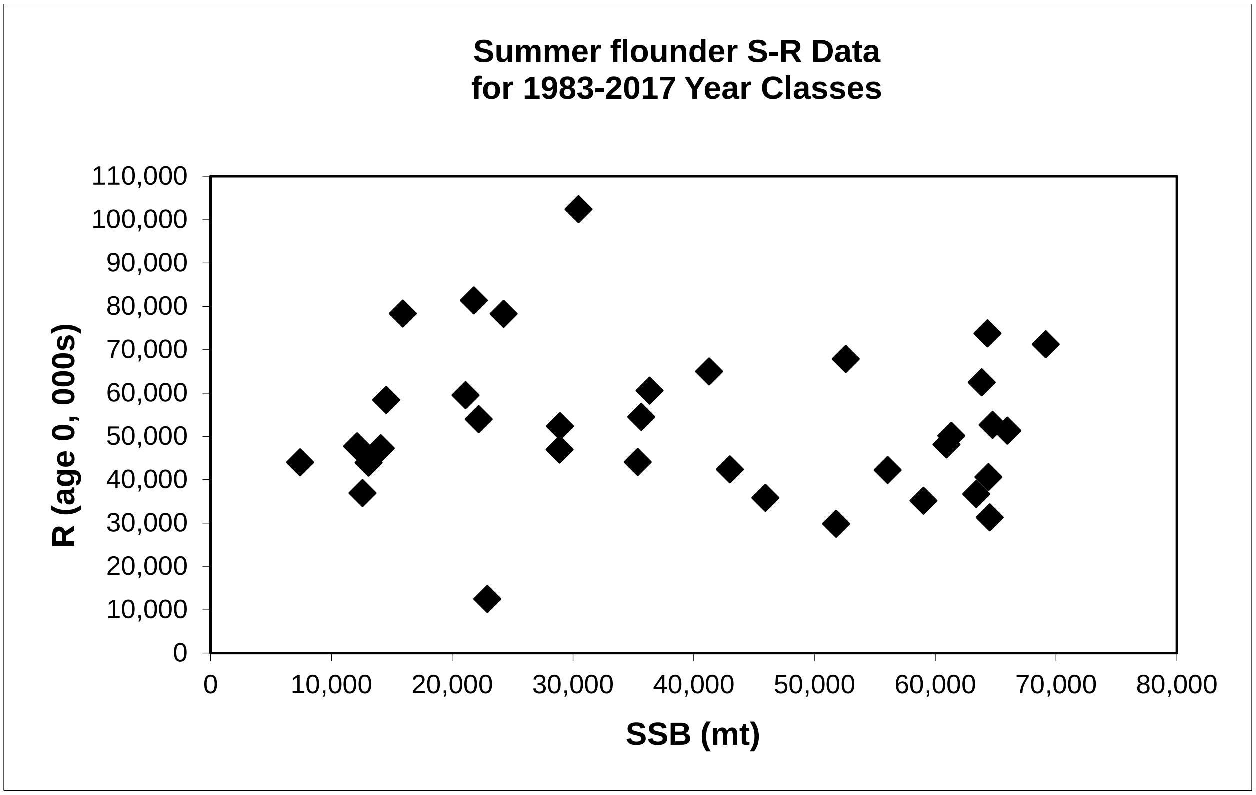


Figure A211. Stock-recruitment (SSB-R) scatter plot for the summer flounder 1983-2017 year classes. The largest recruitment (R) point is the 1983 year class (R = 102 million, SSB = 30,451 mt). The lowest recruitment point is for the 1988 year class (R = 12 million, SSB = 22,913 mt). The 2017 year class is at R = 42 million, SSB = 43,000 mt.

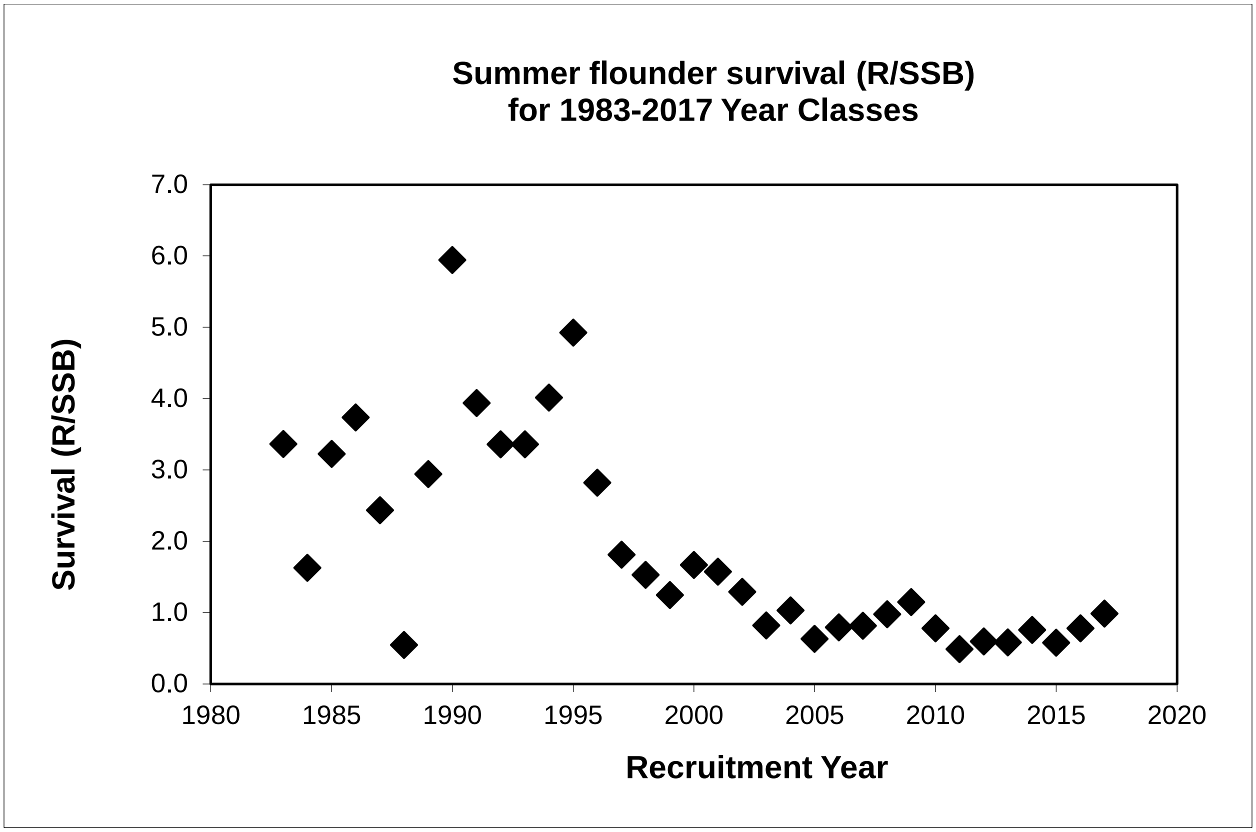
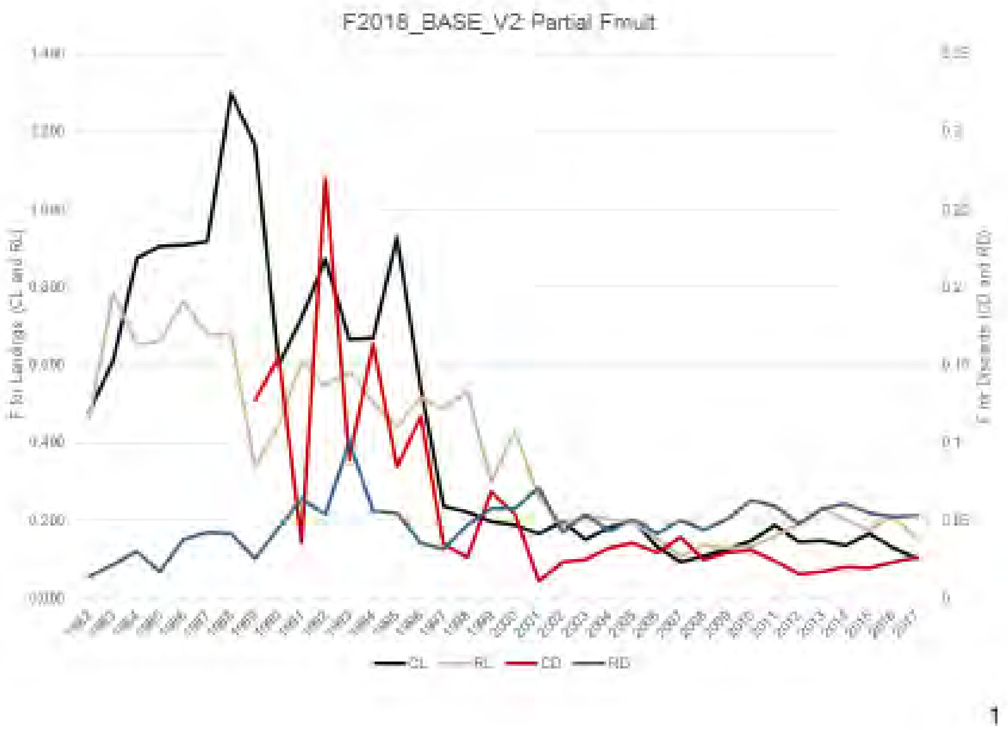
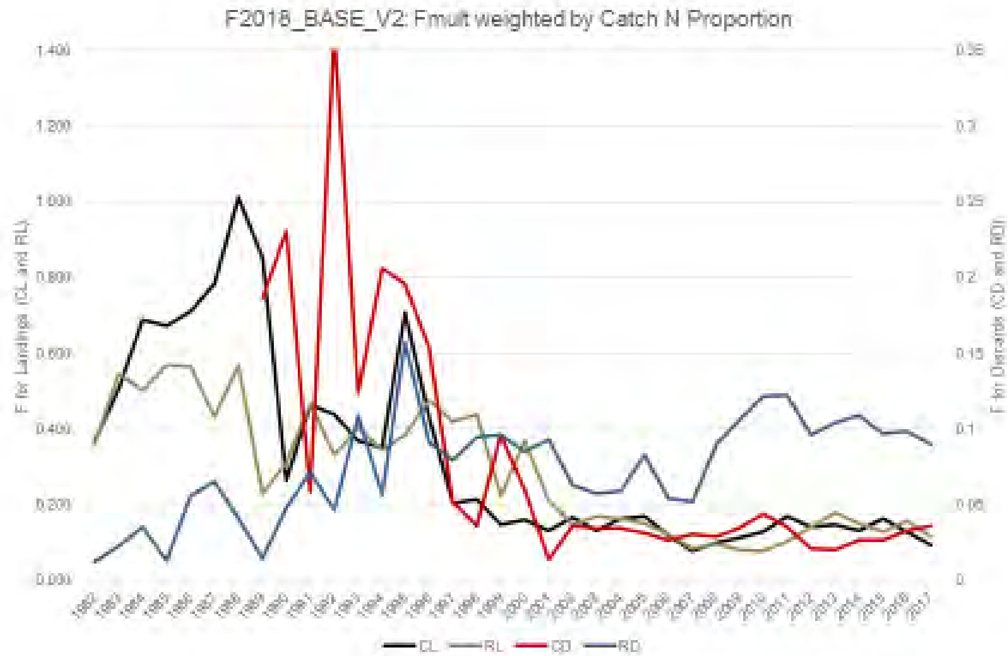


Figure A212. Recruits per Spawning Stock Biomass ratio (R/SSB) plot indicative of the relative survival of the summer flounder 1983-2017 year classes.

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.





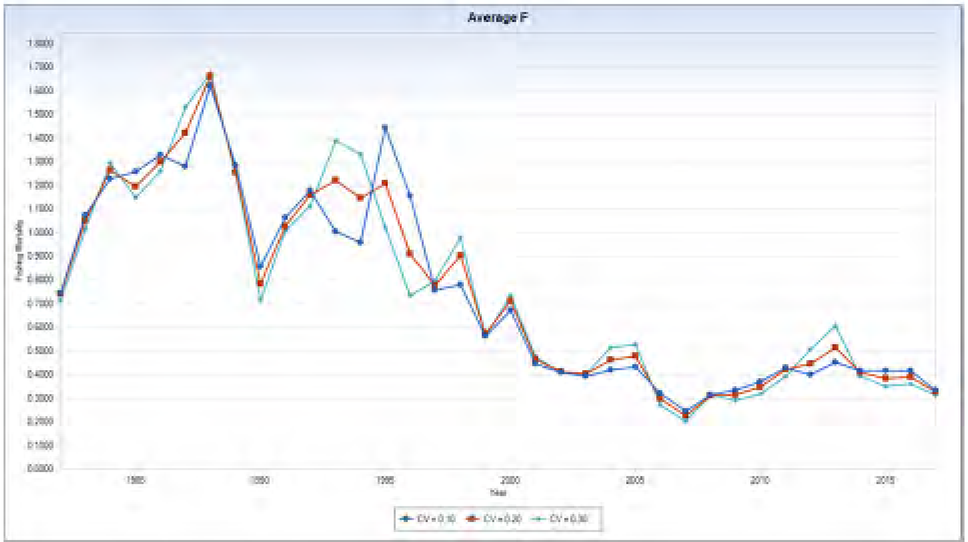
F2018_BASE_V2: Fmult weighted by Catch N Proportion
F for Landings (CL and RL)
F for Discards (CD and RD)
CL
RL
CD
RD

2

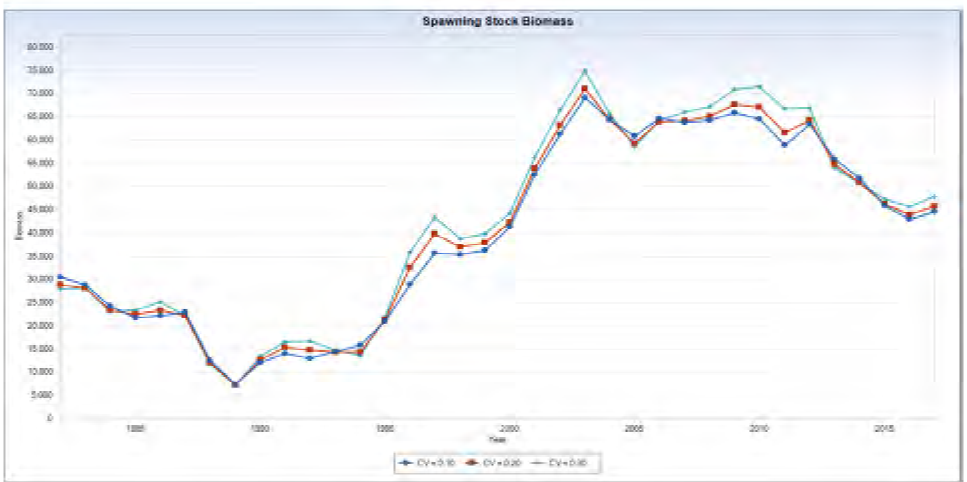
2) The SARC requested some models runs for which the catch CV (0.10 on all 4 fleets) was increased to explore the robustness of the model results when the model fit to the catch is relaxed. Alternatives models with CV = 0.20 and 0.30 were run and the comparative results presented to the SARC (figures 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
1.8000
1.7000
1.6000
1.5000
1.4000
1.3000
1.2000
1.1000
1.0000
0.9000
0.8000
0.7000
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
Fishing Mortality
1985
1990
1995
2000
2005
2010
2015
Year
CV = 0.10
CV = 0.20
CV = 0.30

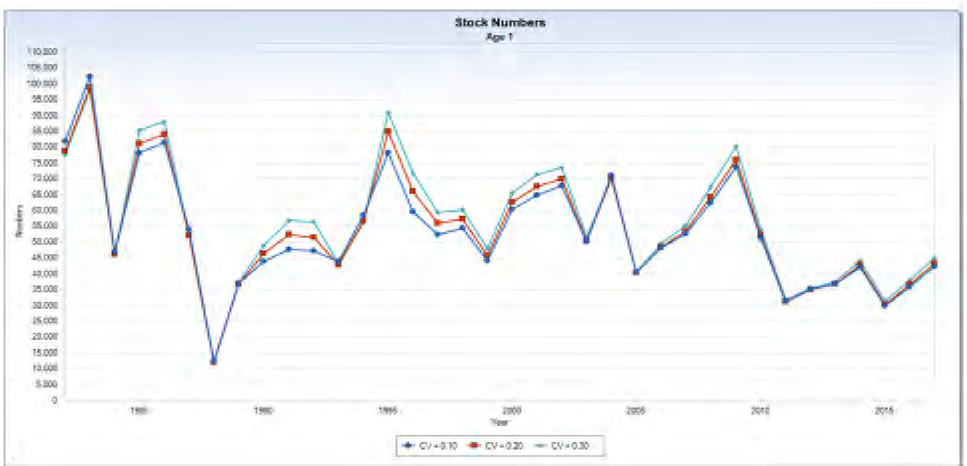
4


Spawning Stock Biomass
Biomass
1985
1990
1995
2000
2005
2010
2015
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