BLUEFISH BENCHMARK STOCK ASSESSMENT FOR 2015

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Acknowledgments
The Bluefish Working Group gratefully acknowledge the work done by the Bluefish Technical Committee, including Eric Durell (MD DNR), Beth Egbert (NC DMF), Jim Gartland (VIMS), Kurt Gottschall (CT DEP), John Maniscalco (NY DEC), Joseph Munyandero (FL FWC), Kevin Sullivan (NH DFW) and Rich Wong (DE DMF) during the data gathering, preparation, and analysis process, as well as their constructive comments during review of the final document.

In addition, the WG wishes to thank Gary Shepherd, Chris Legault, John Manderson, Jon Hare, Andre Schmidt, Laura Palamara, Josh Kohut, Rich Signell, Chris Bonsek, Sarah Gaichas, Kevin Spanik, Alicia Miller, Tim Miller, Mike Palmer, Mark Terceiro, and Jeff Brust for the analyses and insight they contributed.

B1. Executive Summary

TERM OF REFERENCE #1: Estimate catch from all sources including landings and discards. Evaluate and if necessary update the discard mortality estimate. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize the uncertainty in these sources of data.

Since 1982, fishery removals of bluefish have ranged from 9,617 mt (1999)to 54,091 (1986) mt. Fishery removals over the past five years have ranged from 14,320 mt (2010) to 9,817 mt (2014). Prior to 1981 there are no direct estimates of recreational removals and no attempt was made to hindcast recreational catch pre-1981. Over the assessment time series, recreational harvest has been the dominant source of fishery removals, constituting 37-80% of the total catch. Commercial landings have been a smaller component of fishery removals. Information on commercial discards was limited. There have been few regulatory changes (e.g. seasonal closures, trip limits, etc) that would induce high rates of discards. Based on the uncertainty in the discard estimates and the low level of commercial landings relative to total removals the SAW 60 WG chose not to include commercial discards in the SAW 60 assessment models.

Currently, both the commercial and recreational fisheries are primarily concentrated in the mid-Atlantic region. Historically, the recreational harvest was more broadly distributed between the Mid and South Atlantic.

The SAW 60 Working Group (WG) evaluated standardized catch per unit effort (CPUE) indices from the recreational fishery and considered its utility as an index of abundance. The MRIP index covers the entire range of the Atlantic coast stock of bluefish and includes information on older age classes that are poorly sampled by standard fishery independent surveys, so the SAW 60 WG chose to include it as an index of abundance.

TERM OF REFERENCE #2: Present and evaluate data and trends on life history information including, age, growth, natural mortality, food habits, and maturity.

Bluefish, Pomatomus saltatrix, is a coastal, pelagic species found in temperate and tropical marine waters throughout the world and inhabits both inshore and offshore waters along the east coast of the United States.

Bluefish spawn offshore in the western North Atlantic Ocean, from approximately Massachusetts to Florida. Bluefish are characterized as iteroparous spawners with indeterminate fecundity and spawn continuously during their spring migration. In addition to distinctive spring and summer cohorts, a fall-spawned cohort has been identified, demonstrating the potential of an extended bluefish spawning season.

The working group (WG) expended considerable time and effort tracking down all original sources of age data used at SAW41 as well as new sources of data. The WG recovered NC scale and otolith data from 1983-2000, VA/ODU age data from 1998-2005, and age data from a wide variety of east coast states from 2006 forward. With the expansion of a coast wide biological collection program, bluefish age data have become considerably more robust relative to pre-

SAW41. As in the previous SAW, age data were truncated to a 6+ category to reduce ageing error associated with scale ages.

Bluefish grow nearly one-third of their maximum length in their first year. von Bertalanfy growth curves were fit to data available from 1985-2014. Values for L∞ matched closely with both published estimates (87-128 cm FL) and to the largest individuals in the available catch data. The results from the sex based growth examination confirm the results of previous studies that growth rates do not differ between sexes. Although there was not enough data available from older fish in the south to do a comparison between northern and southern fish, there were data available to compare growth rates between ageing structures. Scale ages typically over-estimate younger ages and underestimate the age of older fish. Changes in the primary age structure for bluefish over the time series makes it difficult to determine if there has been a change in growth rates.

In past stock assessments, a value of 0.20 has been assumed as the instantaneous natural mortality (M) for bluefish over all ages and years. The WG used longevity and life-history based equations to estimate different possible values for age constant and age varying M. Based on the results of all the methods explored to estimate natural mortality for bluefish, the WG reasoned that the assumption of M = 0.2 was justifiable and was maintained for SAW60.

During oceanic larval development, bluefish diets are composed primarily of copepods and fish eggs in the smaller size classes (<30mm) expanding to amphipods, and crab larvae above this size. An onset to piscivory occurs for early juveniles, primarily inhibited by mouth-gape size, in estuarine waters leading to rapid increases in growth rates. Cannibalism has also been documented. Both seasonal and inter-annual differences in diet have been observed and are likely attributed to changes in prey availability, but also due to inter-annual variability in timing of estuarine arrival. The WG also evaluated diet data from three fishery independent surveys and found that overall, the diet of bluefish both in the Chesapeake Bay and the coastal ocean, from Cape Cod to Cape Canaveral, is dominated by fishes, regardless of the index by which the diet is quantified. These findings correspond with those of past studies that have sought to characterize bluefish diet in estuarine and ocean environments.

The WG evaluated maturity at length for all available fish, northern and southern fish, and males and females. The most accurate source of maturity at age for bluefish involved a histological examination of 1,437 female fish. However, because this maturity information did not apply to the entire bluefish stock (females only), the proportion mature at age for all fish was used as the input maturity for the catch-at-age model used in the benchmark assessment.

TERM OF REFERENCE #3: Present the survey data available for use in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.), evaluate the utility of the age-length key for use in stock assessment, and explore standardization of fishery- independent indices. Investigate the utility of recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data, including exploring environmentally driven changes in availability and related changes in size structure. Explore the spatial distribution of the stock over time, and whether there are consistent distributional shifts.

States and agencies provided indices from fisheries-dependent and fisheries-independent sources that were assumed to reflect trends in bluefish relative abundance. Bayesian hierarchical modeling was used to combine YOY indices into a single composite index, using the method developed by Conn (2010) that represents the coast wide recruitment dynamics of bluefish. Surveys included in the composite index were from NH Juvenile Finfish Seine Survey, RI Narragansett Bay Juvenile Finfish Beach Seine Survey, NY Western Long Island Seine Survey, NJ Delaware Bay Seine Survey, MD Juvenile Striped Bass Seine Survey, and VIMS Juvenile Striped Bass Seine Survey. In addition, the bluefish working group decided on 8 additional representative indices of bluefish abundance for the SAW60 assessment:

1. *NEFSC Fall inshore strata: 1985-2008 (age-0 – age-6+)*
2. *NEFSC Fall outer inshore strata (FSV Bigelow): 2009-2014 (age-0 – age-6+)*
3. *Marine Recreational Information Program CPUE: 1985-2014 (age-0 – age-6+)*
4. *NEAMAP Fall Inshore trawl survey: 2007-2014 (age-0 – age-6+)*
5. *Connecticut Long Island Sound Trawl Survey: 1985-2014 (age-0 – age-6+)*
6. *Pamlico Sound Independent Gillnet Survey; 2001-2014 (age-0 – 6+)*
7. *New Jersey Ocean Trawl Survey: 1990-2014 (age-0 – age-2)*
8. *SEAMAP Fall Inshore trawl survey: 1989-2014 (age-0)*

The WG thoroughly investigated age length data and evaluated the utility of age length keys for use in this assessment. NC scale and otolith data from early in the time series (1985-2000) required adjustments prior to their eventual use in this assessment. Some additional age data for the middle part of the time series (1997-2005) was available and was incorporated. NC, MA, and NJ resumed or began collecting age data after SAW41, and Addendum to Amendment 1 to the bluefish fishery management plan required additional states to collect age data and this has greatly improved the age length keys for use in this assessment.

Within the NEFSC survey, age 0 and age 1+ bluefish shifted distribution from 1973 through 2014 but not in a systematic direction. Analysis of the centers of biomass (COB) indicated that COB positions were correlated with variations in body size and abundance, but not temperature.

TERM OF REFERENCE #4: Estimate relative fishing mortality, annual fishing mortality, recruitment, total abundance, and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Explore inclusion of multiple fleets in the model. Include both internal and historical retrospective analyses to allow a comparison with previous assessment results and previous projections. Explore alternative modeling approaches if feasible.

The final model configuration included a number of notable changes since the previous peer reviewed model, including the addition of multiple fleets (one commercial, one recreational), updated maturity ogive, model estimated selectivities (two selectivity blocks), addition of new indices, changes to the way indices are fit in the model, and changes to model weighting factors and reduction in model penalties (lambdas and input CVs).

At the SARC review of bluefish the review panel discovered a model misspecification in the selectivity parameters for the MRIP index. A parameter in the function describing the curve for selectivity was fixed when it was intended to have been freely estimated by the model. This was causing patterning in the age composition residuals for this index. The final revised model corrects this misspecification. The values presented in this report reflect the output from the revised model as accepted at the review; for the original model results and diagnostics presented in the draft report, see Appendix B7.

The maximum F at age in 2014 was 0.157 on ages 1 and 2. Average F (age 2) has generally declined since its high in 1987 and in 2014 represents the lowest level in the time series. Recruitment in 2014 was 29.6 million fish, a value that is well above the median for time series. Recruitment has fluctuated over the time series without trend. Total bluefish abundance in 2014 was 82.0 million fish. Abundance was at its highest at the start of the time series at 124.3 million fish. Abundance declined to a low of 53.3 million fish in 1993 then abundance rose steadily through 2006. Abundance declined after 2006 until 2012, and has since risen to levels above the median for the time series. Total biomass in 2014 was 94,328 mt. Total biomass was at its highest at the start of the time series and declined to a low in 1997 and has steadily increased since. SSB in 2014 was estimated at 86,534 mt and trends mimic those of total biomass.

Retrospective patterns suggest that F is underestimated in the model, and that total and spawning stock biomass are overestimated. No clear retrospective pattern appears in model estimates of recruitment.

The working group was able to explore alternate modelling approaches that did not depend on age data (Depletion Corrected Average Catch and Depletion Based Stock Reduction Analysis) both of which suggested that recent harvest of bluefish in the terminal 3 years of the assessment was sustainable.

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

The current biological reference points for bluefish were determined in SARC 41 and are F_{MSY} (0.19) and B_{MSY} (147,052 mt). The basis for the reference points was the Sissenwine-Shepherd method using the Beverton-Holt stock recruitment parameters and SSB per recruit results generated by the SARC 41 ASAP model results. Overfishing of a stock occurs if F exceeds F_{MSY} and a stock is considered overfished if total biomass is less than half of B_{MSY} ($B_{THRESHOLD}$). The existing definition of overfishing is $F > 0.19$ and $B < 73,526$ mt.

The BTC and the SAW 60 WG concluded that new reference points were required because of the uncertainty present in the stock recruitment relationship estimated by the current model, as the time series of spawning stock biomass and recruitment does not contain any information about recruitment levels at low stock sizes. As a proxy for F_{MSY}, the BTC and the SAW 60 WG *recommend $F_{40\% SPR}$. To calculate the associated proxy for B_{MSY}, the population was projected forward for one hundred years under current conditions with fishing mortality set at the F_{MSY} proxy and recruitment drawn from the observed time series. The resulting equilibrium biomass is the recommended B_{MSY} proxy, with the overfishing threshold set at ½ B_{MSY}.*

The new reference points are $F_{MSY\ proxy}$ = F40% = 0.170 and $B_{threshold}$ = ½ $SSB_{MSY\ proxy}$ = 55,614 mt. The MSY_{proxy} = 13,967 mt.

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

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

The existing reference points are F_{MSY} = 0.19 and B_{MSY} = 147,052 mt (½ B_{MSY} = 73,526 mt). The 2014 F estimate (0.141) is well below F_{MSY} and the 2014 estimate of B is 92,755 mt, below B_{MSY} but well above ½ B_{MSY}. This indicates that overfishing is not occurring and that the stock is not overfished.

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

The new reference points are F_{MSY} proxy = F40% = 0.170 and SSB_{MSY} proxy = 111,228 mt (½ SSB_{MSY} = 55,614 mt). The 2014 F estimate (0.157) is below $F_{40\%}$ and the 2014 SSB estimate (86,534 mt) is greater than ½ SSB_{MSY}, indicating that overfishing is not occurring and that the stock is not overfished.

Reference Point	**SARC 41**		**Updated**	
	Definition[1]	Value	Definition[1]	Value
$F_{Threshold}$	F_{MSY}	0.19	$F_{MSY\ proxy} = F_{40\%SPR}$	0.170
B_{Target}	B_{MSY}	147,052 mt	Equilibrium SSB under $F_{40\%SPR}$	111,228 mt
$B_{Threshold}$	½ B_{MSY}	73,526 mt	½ $SSB_{MSY\ Proxy}$	55,614 mt

[1]: Note that the SARC 41 biomass reference points refer to total biomass, while the updated biomass reference points refer to spawning stock biomass.

TERM OF REFERENCE #7: Develop approaches and apply them to conduct stock projections and to compute the statistical distribution (e.g., probability density function) of the OFL (overfishing level; see Appendix to the SAW TORs).

a. **Provide annual projections (3 years). For given catches, each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).**

Short-term projections were conducted using AGEPRO v.4.2.2 (available from the NOAA Fisheries Toolbox, http://nft.nefsc.noaa.gov/AGEPRO.html).

Removals in 2015 were assumed to be equal to the 2015 quota (9,772 mt). For 2016-2018, a constant level of fishing mortality was applied. The population was projected forward under six different F levels (F_{low} = 0.100, F_{2014} = 0.157, $F_{0.1}$ = 0.187, F_{TARGET} = 90% $F_{MSY\ Proxy}$ = 0.153, $F_{MSY\ Proxy}$ = $F_{40\%SPR}$ = 0.170, $F_{35\%SPR}$ = 0.191).

Uncertainty was incorporated into the projections primarily via estimates of recruitment and initial abundance-at-age.

Estimates of recruitment were drawn from the 1985-2014 time-series of observed recruitment from the preferred ASAP model. Initial abundance-at-age estimates were drawn from distributions of terminal abundance-at-age developed from the MCMC runs of the preferred ASAP model. A small amount of uncertainty was incorporated into biological parameters such as weight-at-age, maturity-at-age, and natural mortality; estimates of these parameters were drawn from lognormal distributions with mean values used in the last three years of the assessment and a CV of 0.01.

A sensitivity analysis approach was used to determine the effects of major sources of model uncertainty that could not be encompassed through the MCMC runs of the base model. This included: limiting the empirical recruitment distribution to the CDF of observed recruitment for 2006-2014 (the years of the best available age data), higher M (M=0.26), increased uncertainty in biological parameters (CV of 0.1 instead of 0.01), using the upper and lower 95% confidence intervals for recreational catch, and using the continuity run instead of the new model configuration.

None of the fishing mortality scenarios resulted in total spawning stock biomass going below the biomass threshold (½ $SSB_{MSY\ Proxy}$) in any year of the projection; total spawning stock biomass remained above the SSB threshold with 100% probability in all years.

The overfishing limit (OFL) for 2016 was estimated to be 10,528 mt with a CV of 0.10. A qualitative inflation was applied for known sources of uncertainty that are not adequately captured in the projection process, including retrospective bias and uncertainty in the F_{MSY} proxy estimate, resulting in a recommended CV of 0.15.

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

The WG considers the base model configuration the most realistic projection scenario. While estimates of recruitment in the most recent 10 years of the time-series (derived in part from the best age information) are likely more reliable than the estimates from the beginning of the time-series, the median recruitment and projection time-series are virtually indistinguishable.

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

Bluefish are a fast-growing, fast-maturing species with a moderately long life span. Although they recruit to the fishery before they are fully mature, larger, older fish are considered unpalatable, reducing demand for those sizes in the commercial market and encouraging the release of those size classes in the recreational fishery. The resulting dome-shaped selectivity of the fleets offers protection to the spawning stock biomass. Although they are a popular gamefish, demand for this species is not extreme and the quota is rarely met or exceeded.

Bluefish are opportunistic predators that do not depend on a single prey species. Their range covers the whole of the Atlantic coast, and their spawning is protracted both temporally and geographically. As a result, they are not as vulnerable as many other species to major non-fishery drivers such as climate change that would result in the loss of critical forage or nursery habitat.

This assessment indicates bluefish are near their target biomass and well above their overfished threshold. Short-term projections indicate no risk of driving the biomass below the overfished threshold while fishing at or near the F_{MSY} *proxy. Overall, bluefish have a low degree of vulnerability to becoming overfished, and the ABC can be set on the basis of the* F_{MSY} *proxy without risk of causing the stock to become overfished.*

TERM OF REFERENCE #8: Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports, as well as MAFMC SSC model recommendations from 2005 and the research recommendations contained in its 23 September 2013 report to the MAFMC. Identify new research recommendations.

The SAW 60 WG reviewed the status of previous research recommendations and proposed new ones to address issues raised during WG meetings. The 2011 bluefish ageing workshop lead directly to the development of Addendum I to the Bluefish FMP (2012), with both items addressing research recommendations from SAW 41. Addendum I has resulted in increased sampling of commercial and recreational biological data (e.g., age, sex, weights) that was utilized by the SAW 60 WG in the assessment. Additionally the SAW 60 WG explored the application of two models designed to provide catch guidance in data poor situations: Depletion Corrected Average Catch Model (DCAC) and Depletion-Based Stock Reduction Analysis.

Lastly, the SAW 60 WG proposed eight new research recommendations to better understanding bluefish dynamics and assessing the population through the current or future models. These included some of the following: developing additional adult bluefish indices of abundance;

investigate species associations with recreational angler trips targeting bluefish; explore age- and time-varying natural mortality from predator-prey relationships; quantify effects of age- and time-varying natural mortality in the assessment model; and continue to evaluate the spatial, temporal, and sector-specific trends in bluefish growth and quantify their effects in the assessment model.

B2. Terms of Reference

1. Estimate catch from all sources including landings and discards. Evaluate and if necessary update the discard mortality estimate. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize the uncertainty in these sources of data.

2. Present and evaluate data and trends on life history information including, age, growth, natural mortality, food habits, and maturity.

3. Present the survey data available for use in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.), evaluate the utility of the age-length key for use in stock assessment, and explore standardization of fishery independent indices. Investigate the utility of recreational LPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data, including exploring environmentally driven changes in availability and related changes in size structure. Explore the spatial distribution of the stock over time, and whether there are consistent distributional shifts.

4. Estimate relative fishing mortality, annual fishing mortality, recruitment, total abundance, and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Explore inclusion of multiple fleets in the model. Include both internal and historical retrospective analyses to allow a comparison with previous assessment results and previous projections. Explore alternative modeling approaches if feasible.

5. 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.

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

    a. When working with the existing model, update it with new data and evaluate stock status (overfished and overfishing) with respect to the existing BRP estimates.
    b. Then use the newly proposed model and evaluate stock status with respect to "new" BRPs and their estimates (from TOR-5).

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

a. Provide annual projections (3 years). For given catches, each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment).
b. Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.
c. Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

8. Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports, as well as MAFMC SSC model recommendations from 2005 and the research recommendations contained in its 23 September 2013 report to the MAFMC. Identify new research recommendations.

B3. Introduction

The 60th Stock Assessment Workshop Working Group (SAW 60 WG) prepared the assessment report. The ASMFC Bluefish Technical Committee (TC) and the SAW 60 WG met February 18th - 20th, 2015 in Providence, RI to evaluate data sources in preparation for the SAW 60 WG assessment meeting held April 27-29th, 2015 at the Northeast Fisheries Science Center (NEFSC) in Woods Hole, MA. A complete list of technical committee and working group participants can be found in Appendix B.1 and B.2.

B3.1 Assessment History

Bluefish was assessed through SAW23 (1997) using the CAGEAN model, a catch-at-age model that used commercial and recreational catch tuned by recreational CPUE and survey catch-at-age data. The assessment found that bluefish were at historically low levels of spawning stock biomass and over-exploited. It recommended that fishing mortality should be reduced to halt the decline in SSB.

In 2004, the SAW WG put forward an ASPIC surplus production model at SARC-39. This assessment was not accepted as a basis for fishery management because the recreational CPUE did not correctly handle live-release data, creating a "severe" bias, the NEFSC data used as an index of fishable biomass represent only age-0 and age-1 fish, and the residuals in the commercial catch rate data showed strong autocorrelation, indicating model misspecification

The TC and WG continued work on the assessment, returning in 2005 with an age-structured assessment at SARC 41. The NFT ADAPT version of VPA was used as an initial model. The committee felt that the VPA model produced satisfactory results, but the assumption of no error in the catch-at-age matrix and the ADAPT method of modeling selectivity could produce misleading results. Therefore, a catch-at-age model, ASAP from the NFT models, was used as the primary assessment tool. Many of the results coming out of the ADAPT VPA model were used as input starting value for a statistical catch-at-age model (ASAP). The ASAP model was brought to review and was accepted by 2 out of 3 reviewers. The third reviewer was extremely critical of the way the model had been configured and the way some inputs and assumptions were handled.

The ASAP model from SAW/SARC 41 currently forms the basis of bluefish management advice.

B3.2. Fishery Management History

The Atlantic States Marine Fisheries Commission (ASMFC) and Mid-Atlantic Fishery Management Council (MAFMC) jointly developed the Fishery Management Plan (FMP) for the bluefish fishery and adopted the plan in 1989 (ASMFC 1989, MAFMC 1990). The Secretary of Commerce approved the FMP in March 1990. The FMP defines the management unit as bluefish (*Pomatomus saltatrix*) in U.S. waters of the western Atlantic Ocean.

The ASMFC and MAFMC approved Amendment 1 to the FMP in October 1998 and the National Marine Fisheries Service (NMFS) published the final rule to implement the Amendment 1 measures in July 2000 (MAFMC and ASMFC 1998). Amendment 1 implemented an annual coastwide quota to control bluefish landings. The ASMFC and MAFMC adjust the quota and harvest limit annually using the specification setting process detailed in Amendment 1. The recreational fishery is allocated 83% of the entire quota. Coastwide, the commercial fishery is limited to 17% of the total allowable landings each year. If the commercial quota is less than 10.5 million lbs, the quota can be increased up to 10.5 million lbs if it is anticipated that the recreational fishery will not land their entire allocation for the upcoming year. The coastwide commercial quota is divided into individual state-by-state quotas based on landings from 1981-1989 (Table B3.1). State by state management measures are included in table (Table B3.2)

In 2007, the MAFMC approved Amendment 2 which standardized bycatch reporting methodology (SBRM). The approval of Amendment 2 satisfies the requirement for all federal fisheries management plans that SBRM be included in those plans, as stipulated by the Magnuson-Stevens Act (MAFMC 2007).

In 2011, the MAFMC approved Amendment 3 (effective 1/1/2012) which incorporated the development of annual catch limits (ACLs) and accountability measures (AMs) into the specification process. This specified for Bluefish specifications that ACLs are annually set equal to the acceptable biological catch (ABC) (MAFMC 2011).

In 2012, ASMFC approved Addendum I (ASMFC 2012) that stipulated States that account for more than 5% of total coastwide bluefish harvest (recreational and commercial combined) for the 1998 – 2008 period are required to collect a minimum of 100 bluefish ages (50 from January through June, 50 from July through December). These states are: Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and North Carolina. Virginia was required to continue its sampling regime for bluefish and provide that same minimum 100 samples as the other states.

In 2014, the MAFMC approved Amendment 4 which modified recreational accountability measures to accommodate uncertainty in recreational management and catch estimation. NOAA Fisheries disapproved the use of a 3-yr moving average of the lower confidence limit of the recreational catch estimate to determine whether an ACL overage has occurred. By doing so, the status quo (as stipulated in Amendment 3) of a single-year point estimate from MRIP for the Atlantic bluefish fisheries remains as the mechanism to determine whether the recreational fishing ACL was exceeded in a given year (78 FR 76759).

B3.3. Current Assessment Approach

The current assessment model for bluefish has provided management advice since 2005 and was accepted at the Stock Assessment Workshop 41 review (NEFSC 2005). After reviewing several model types including a modified Delury model, a surplus production model, a VPA and catch-at-age models, the bluefish Technical Committee concluded that a statistical-catch-at-age (ASAP) model was the most appropriate for the bluefish assessment.

B3.4 Biology

B3.4.1 Life History

Bluefish, *Pomatomus saltatrix*, is a coastal, pelagic species found in temperate and tropical marine waters throughout the world (Goodbred and Graves 1996; Juanes et al. 1996). Inhabiting both inshore and offshore waters along the east coast of the United States, spawning takes place offshore (Kendall and Walford 1979; Kendall and Naplin 1981) and subsequent to larval development in continental shelf waters, juveniles eventually move to estuarine and nearshore shelf habitats (Marks and Conover 1993; Hare and Cowen 1995; Able and Fahay 1998; Able et al. 2003). Traveling in loose groups of fish aggregated by size, bluefish typically migrate north in the spring/summer and south in the fall/winter (Wilk 1977; Klein-MacPhee 2002). Their range during these periods of migration can extend as far north as Maine and as far south as Florida in the Unites States (Shepherd et al. 2006).

B3.4.2 Growth

Bluefish grow nearly one-third of their maximum length in their first year (Richards 1976, Wilk 1977). Variation in growth rates or sizes-at-age among young bluefish is evident from the appearance of intra-annual cohorts. Lassiter (1962) identified a spring-spawned cohort and a summer-spawned cohort from the bimodal appearance of size at Annulus I for fish aged from North Carolina and found the seasonal cohorts can differ in age by two to three months. Hare and Cowen (1993) however, suggest the bimodal length at age observed in bluefish is not the result of two distinct spawning events but rather a consequence of continuous spawning (March-September) with the summer spawned offspring having a lower probability of recruitment. Previous research suggests different growth rates at age with summer-spawned larvae and juveniles growing faster than spring-spawned larvae and juveniles (McBride and Conover 1991) with size differences at annual age diminishing greatly after three to four years (Lassiter 1962).

B3.4.3 Reproduction

Bluefish spawn offshore in the western North Atlantic Ocean, from approximately Massachusetts to Florida (Norcross et al. 1974; Kendall and Walford 1979; Kendall and Naplin 1981; Collins and Stender 1987). Bluefish are characterized as iteroparous spawners with indeterminate fecundity and spawn continuously during their spring migration (Robillard et al. 2008). In addition to distinctive spring and summer cohorts, Collins and Stender (1987) identified a fall-spawned cohort, demonstrating the potential of an extended bluefish spawning season. Bluefish mature quickly, with approximately half of the population mature at age 1 and close to one hundred percent mature (97%) by age 2.

B3.4.4 Stock Definition

Bluefish in the western North Atlantic are managed as a single stock (NEFSC 1997; Shepherd and Packer 2006). Genetic data support a unit stock hypothesis (Graves et al. 1992; Goodbred and Graves 1996; Davidson 2002). For management purposes, the ASMFC and MAFMC define the management unit as the portion of the stock occurring along the Atlantic Coast from Maine to the east coast of Florida.

B3.4.5 Habitat Description

Adult and juvenile bluefish are found primarily in waters less than 20 meters (m) deep along the Atlantic coast (Shepherd and Packer 2006). Adults use both inshore and offshore areas of the coast and favor warmer water temperatures although they are found in a variety of hydrographic environments (Ross 1991; Shepherd and Packer 2006). Bluefish can tolerate temperatures ranging from 11.8°-30.4°C, however they exhibit stress, such as an increase in swimming speed, at both extremes (Olla and Studholme 1971; Klein-MacPhee 2002). Temperature and photoperiod are the principal factors directing activity, migrations, and distribution of adult bluefish (Olla and Studholme 1971).

B3.5 Description of Fisheries

B3.5.1 Commercial Fishery

Over the last 33 years, commercial landings from the bluefish fishery ranged from a high of 7,162 mt (1983) (15.8 million pounds) to a low of 1,974 mt (2013) (4.4 million pounds). Gill nets are the dominant commercial gear used to target bluefish and account for over 40% of the bluefish commercial landings from 1982 to 2014, with primary use in the Mid-Atlantic and Florida. Other commercial gears including hook & line, pound nets, seines, and trawls, collectively account for approximately 50% of the commercial landings.

B3.5.2 Recreational Fishery

Recreational harvest estimates of bluefish has averaged over 14,000 mt (30.9 million pounds) annually since 1981. There has been an overall decline since 2007 to roughly 5,000-5,400 mt (11-11.9 million pounds) in 2011 and 2012. Harvest estimates for 2014 show a decrease to approximately 4,700 mt (10.4 million pounds). In 2014, recreational anglers along the Atlantic Coast caught 5.8 million bluefish, a 7.4% increase from 2013. The majority of recreational activity occurred from May to October, with the peak activity in July and August.

B4. TERM OF REFERENCE #1: Estimate catch from all sources including landings and discards. Evaluate and if necessary update the discard mortality estimate. Describe the spatial and temporal distribution of landings, discards, and fishing effort. Characterize the uncertainty in these sources of data.

B4.1. Commercial Data

Historical commercial landings (1950 to present) for all species on the Atlantic coast are maintained in the Atlantic Coastal Cooperative Statistics Program (ACCSP) Warehouse. The Data Warehouse is an online database of fisheries dependent data provided by the ACCSP state and federal partners. The Data Warehouse was queried on 11 March 2015 for all commercial bluefish landings (monthly summaries by state, gear and market category) from 1982-2014 for Florida (east coast), Georgia, South Carolina, North Carolina, Virginia, Maryland, Delaware, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, New Hampshire, and Maine (ACCSP, 2014). Data sources and collection methods are illustrated by state in Figure B4.1, and annual landings summaries were used when trip level data or monthly summaries were not available. The gear categories were decided upon by the working group based on knowledge of the fisheries and reporting tendencies. The specific ACCSP gears included in each category can be found in Table B4.1.

After review of the commercial landings data by ACCSP state partners, differences in the annual landings from 1996-2014 were identified between the Virginia Fishery Mandatory Reporting Program Trip (FSMRPT) historical landings database and the ACCSP data warehouse. Issues such as duplicate state and federal reporting of landings, and failure to sync data across programs when records are updated in local databases, may be responsible for the discordance across the federally reported and state reported commercial bluefish landings, and the Potomac River Fisheries Commission (PRFC) data, between the Virginia historical landings database and the ACCSP data warehouse. The difference in total commercial bluefish landings between the ACCSP data warehouse and Virginia historical landings database was approximately 1.5% from 1982-2014. It was decided that ACCSP would provide two datasets as options to be used in the assessment model for the Virginia commercial landings data for bluefish. Option 1 consists of commercial bluefish landings where each year of data from 1982-2014 was chosen from either the ACCSP data warehouse or the VA historical landings database, depending on which of these two had the greater annual landings total. The data sources for Option 1 can be seen in Table B4.2. Option 2 consists of commercial bluefish landings where the annual federal dealer landings, the annual state dealer landings, and the PRFC data were compared separately for each year from 1982-2014, and the greater selected from either the ACCSP data warehouse or the VA historical landings database. The data sources for Option 2 can be seen in Table B4.3. Both options are intended to err towards the creation of larger datasets in order to avoid underrepresenting the Virginia commercial bluefish landings data in the assessment. At the 27-29 April 2015 Working Group (WG) Modelling Workshop, the WG elected to use Option 1 since model output using the two Options were nearly identical, and Option 1 is less complex and hence less prone to error.

Prior to the SARC 60, the commercial landings data had been provided by the Northeast Fisheries Science Center (NEFSC) Commercial Fisheries Database (CFDBS), and supplemented with state data supplied directly from several local state collection programs. For past bluefish assessment updates, the NEFSC CFDBS was queried for the federal dealer reported landings and length data from Maine to Maryland, and occasionally for Virginia landings data for some years. However, the NEFSC CFDBS does not capture the commercial bluefish landings which are reported by state dealers who do not have federal reporting requirements. Therefore, it was necessary that additional state dealer reported landings and length data would be supplied by the Virginia Marine Resources Commission (VMRC), the North Carolina Department of Marine Fisheries (NCDMF) trip ticket program, and the Florida Fish and Wildlife Conservation Commission (FWC). To improve on the consistency and reproducibility of the data collection for future bluefish assessments, it was decided for SARC 60 that the commercial bluefish landings would be supplied by the ACCSP data warehouse, which maintains fisheries dependent data for all Atlantic coast species across all ACCSP state and federal partners. A comparison of the commercial bluefish landings across the NEFSC CFDBS, the ACCSP data warehouse, and the local state collection programs can be seen in Tables B4.4 and B4.5 for Virginia, North Carolina, and Florida.

Commercial fisheries landings data for states between North Carolina and Maine are collected via the NMFS dealer mandatory reporting system. Beginning in June 2004, an electronic dealer reporting was initiated in the northeast. The states of Florida, Georgia, and South Carolina use a trip ticket system.

B4.1.1 Commercial Landings

Over the last 33 years, commercial landings from the bluefish fishery (Table B4.6) ranged from a high of 7,162 mt (1983) (15.8 million pounds) to a low of 1,974 mt (2013) (4.4 million pounds). During this time landings have been consistently lower than the recreational catch (Figure B4.2). Gill nets are the dominant commercial gear used to target bluefish and account for over 40% of the bluefish commercial landings from 1982 to 2014, with primary use in the Mid-Atlantic and Florida. Other commercial gears including hook & line, pound nets, seines, and trawls, collectively account for approximately 50% of the commercial landings (Table B4.7).

Regional variations in commercial fishing activity are linked to the seasonal migration of bluefish. The majority of commercial fishing activity in the North and Mid-Atlantic occurs from late spring to early fall when bluefish are most abundant in these areas. As water temperatures decrease in late fall and winter, bluefish migrate south. Peak landings in the South Atlantic occur in late fall and winter. The majority of commercial landings over the time series (1950-present) have been taken in the Mid-Atlantic region (New York, New Jersey, and North Carolina), with the exception of Florida which accounted for a larger percent historically (early 1980s) and a diminishing proportion of landings over time (Table B4.6). Since 1982, approximately 64% of the coastwide total landings have been taken in this region.

Commercial landings decreased steadily from 4,819 mt (10.6 million pounds) in 1993 to 3,359 mt (7.4 million pounds) in 2003, and continued to declined less sharply to 1,974 mt (4.4 million pounds) in 2013 (Table B4.6). Commercial landings have been regulated by quota since implementation of Amendment 1 in 2000. Commercial landings for 2014 increased to 2,242 mt (4.94 million pounds).

The top commercial landings ports for bluefish in 2013 are shown in Table B4.8. Ten ports qualified as "top bluefish ports", i.e., those ports where 45.4 mt (100,000 pounds) or more of bluefish were landed. Wanchese, NC was the most important commercial bluefish port with over 272.2 mt (600,000 pounds) landed.

The Northeast Region is divided into 46 statistical areas for Federal fisheries management. According to VTR data, bluefish were commercially harvested in 36 statistical areas in 2013 (Figure B4.3). Six statistical areas, however, collectively accounted for more than 75 % of VTR-reported landings in 2013, with individual areas contributing 6% to 18% of the total. This trend is supported through time by VTR data over the last 20 years (Figure B4.4). These areas also represented 70% of the trips that landed bluefish suggesting that resource availability as expressed by catch per trip is fairly consistent through the range were harvest occurs.

B4.1.2 Revenue

In 2014, commercial vessels landed about 2,242 mt (4.94 million pounds) of bluefish valued at approximately \$3.0 million. Average coastwide ex-vessel price of bluefish was \$0.61/lb (\$1.33/kg) in 2014, a descrease from the previous years (2012 price = \$0.65/lb; \$1.43/kg; 2013 price =\$0.67/lb; \$1.48/kg). The relative value of bluefish is very low among commercially landed species, approximately 0.17 % of the total value, respectively of all finfish and shellfish landed along the U.S. Atlantic coast in 2013. A time series of bluefish revenue and price is provided in Figure B4.5.

B4.1.3 Commercial Biological Sampling

Maine to Virginia

Commercial fisheries from Maine to Virginia were sampled as part of the NEFSC data collection program. In addition, the Virginia Marine Resources Commission's (VMRC) Stock Assessment Program (SAP) has collected finfish biological data (length, weight, sex, and age) since 1988. At most sites, bluefish are sampled from 50-pound boxes of landed fish that have been graded, boxed, and iced. At sites associated with pound net or haul seine landings, bluefish are intercepted after they have been graded by market category and weighed. A 50-pound box (or partial box) of graded fish from all available species market categories (i.e. small, medium, large, and unclassified) are chosen for determination of length, weight, and sex information. In most cases, the entire 50-pound box of fish graded by species market category is sampled to account for within-box variation (see Chittenden and Barbieri 1990).

Each fish is measured for size (total length and usually weight). Weight is measured to the nearest 0.1 lbs; total length is measured to the nearest millimeter (mm), accurate to 2.5 mm, using electronic Limnoterra Fish Measuring Boards. Fork length is measured on a subsample basis. All fish, except those with damaged tails, are measured for total length from the tip of the snout to the end of the tail fin.

For ME-VA bluefish, the numbers of fish sampled has ranged from a low in 1995 of 189 fish to a maximum of 10912 fish in 2012 (Table B4.9). Sampling has averaged just over 6000 fish per year since the year 2000. ME-VA length sampling intensity per 100 lbs landed is presented in Tables B4.10-20. Expansion of length data was completed by market category and quarter of the year, with the results merged into half year periods. Market category/quarters with inadequate length samples were filled with length information from adjacent quarters within the same market category. Market category/quarters with landings and no associated lengths were combined with landings information from adjacent quarters.

North Carolina

Commercial bluefish landings are monitored through the North Carolina trip ticket program (1994-present). Under this program, licensed fishermen can only sell commercial catch to licensed North Carolina Division of Marine Fisheries (NCDMF) fish dealers. The dealer is required to complete a trip ticket every time licensed fishermen land fish. Trip tickets capture data on gears used, area fished, species harvested, and total weights of each individual species landed, by market grade. Trip tickets are submitted to NCDMF monthly.

Fishery-dependent sampling of NC commercial fisheries has been ongoing since 1982. Predominant gears sampled include: ocean sink nets, estuarine gill nets, winter trawls, long haul seines/swipe nets, beach haul seines, and pound nets. From the fishery-dependent data, NCDMF derives length and weight estimates by market grade for almost all of the commercial landings except catches by shrimp trawls, pots, long line, gigs, fyke nets, hand harvest, trolling, and rod & reel. Landings from these unsampled or ‘other’ commercial gears combined represent 0.2-1.1% of the 1997-2004 landings. Length frequency distributions from all sampled commercial gear were combined to represent landings by these other gears.

Bluefish length frequency samples, by gear, market category and year were obtained from dealers with a sample representing the landings from an individual trip. Sampling was done by market category as fish were culled at the dealers. Length distributions (and aggregate weights) from sampled trips by gear and market grade were expanded by respective landings, gear, and market grade. Length frequency distributions were combined to represent total landings, market grade, quarter, and year.

The number of bluefish sampled by NCDMF has ranged from a low in 1995 of 1820 fish to a maximum of 11112 fish in 2001 (Table B4.9). Sampling has averaged almost 8000 fish per year since the year 2000. NC length sampling intensity per 100 lbs landed is presented in Tables B4.13-20. Expansion of length data was completed by market category and quarter of the year, with the results merged into half year periods. Market category/quarters with inadequate length samples were filled with length information from adjacent quarters within the same market category. Market category/quarters with landings and no associated lengths were combined with landings information from adjacent quarters. NCDMF has completed aging bluefish otoliths from years 2006 through 2014. There were a total of 792 bluefish otoliths collected in 2014. Each fish was measured for fork and total length, total weight and sex were recorded, as well as sexual maturity and ovary weight for females.

Florida

Biological data collection for the bluefish fishery from Florida to North Carolina is sparse. FWC has collected an average of around 400 lengths per year from 1992 to 2014. However, there is a large range of values depending on year, from a minimum of 25 fish in 2003, to a maximum of 1618 fish in 1992. There is market category or quarter information associated with the FL lengths and lengths are provided by half year. FL length sampling and sampling intensity is presented in Tables B4.13-20. Expansion of FL length data was completed by half year. If half year information for length or landings were inadequate, expansion was carried out at an annual level.

B4.1.4 Commercial Length Frequency Distribution

The length frequency distribution from the commercial fisheries is characterized by a bi-modal distribution for much of the time-series (Figure B4.6). In the most recent years, a skewed distribution is present, lacking the multi-modal distribution seen in previous years; however, in 2014 the bi-modal distribution is present again. This bi-modal pattern has also been observed in recreational landings length frequencies (Figure B4.10A), and to a lesser degree the recreational discard length frequencies (Figure B4.10B). The bi-modal pattern is a result of an apparent low availability to the fisheries of age 3 to age 4 bluefish. Bluefish are known to school by size class and it is likely that unobserved movement dynamics at this age/size range affects availability of the population. It is possible a larger portion of the population at these sizes are staying south or offshore each year. Since the dominant fisheries for bluefish are coastal and north of Cape Hatteras, North Carolina this would account for a reduced available of this size/age class.

B4.1.5 Commercial Discards

Previous TCs and WGs have concluded that commercial discards for the Atlantic coast were minimal. The SAW60 TC and WG agreed, given: the comparatively small amount of discards relative to landings (1.5-10.7% of landings in any given year; Figure B4.2); the total commercial quota has not been landed for any of the years between 2000 and 2014. The bluefish FMP allows states with a surplus quota to transfer a portion or the entire quota to a state that has or will reach its quota; Amendment 1 to the FMP allows quota transfer from the recreational fishery to the commercial fishery; the need for a discard mortality rate where presently none are available; the need for commercial discard length frequency data where presently none are available; and high CVs around the discard estimates. For these reasons the TC and WG agreed that commercial discards are minimal relative to landings and their use would likely introduce more error than they would resolve.

B4.2 Recreational Data (MRFSS/MRIP)

The main source of information on catch, harvest, release numbers, harvest weights, and sizes for bluefish in the recreational fishery come from the National Marine Fisheries Service's Marine Recreational Information Program (MRIP), which was formerly the Marine Recreational Fisheries Statistical Survey (MRFSS). The MRFSS data collection program began in 1979, though estimates of recreationally caught Bluefish are not available until 1981. In 2005, the National Academy of Sciences' Natural Research Council was commissioned to review the MRFSS and provide recommendations for improving recreational fishing estimates. A major finding of the Council was that intercept methods resulted in a non-representative sample of recreational anglers and their catch-per-trip was not accounted for in the estimation methodology, resulting in potentially biased catch estimates and overestimated precision (MRIP website). Interviewers were instructed to maximize the number of intercepts made and site selection was at the interviewer's discretion. Interviewers were more likely to obtain intercepts from high pressure sites and disregard low pressure sites and the catch-per-trip at the low pressure sites was not adequately represented. The Council's review contributed to the implementation of the MRIP and a new estimation methodology. MRIP uses the same basic data as MRFSS but implements a new catch estimate methodology that better matches the sampling design used in the dockside intercept survey. The MRIP methodology is intended to account for the clustered sample design and the non-equal weighting used to select sample sites.

MRFSS/MRIP contain estimates for number of trips anglers are taking, the total amount of fish harvested (numbers or weight), total amount discarded, catch rates, and biological information. The survey is conducted coastwide and usually by state agency employees or contractors. In MRFSS/MRIP, anglers that fish from private boats and from shore are sampled using random dockside intercepts and telephone calls. During a dockside intercept, anglers are interviewed about their trip and the catch is counted, measured, and weighed. Angler access points are randomly selected in proportion to their expected fishing activity. To estimate effort, coastal households are randomly called and anglers are interviewed about the fishing trips taken during the previous 2 months. Similarly, a for-hire telephone survey is used to collect trip information directly from for-hire operators. Angler participation in MRIP surveys is voluntary. For details in addition to the description provided here, visit the NOAA recreational fisheries statistics website (www.st.nmfs.noaa.gov/recreational-fisheries).

Angler Catch Surveys (dockside intercepts) are interviews of anglers intercepted at public fishing access sites (e.g., marinas, piers) that collect information on the catch and fishing trip (see example questionnaire here http://www.st.nmfs.noaa.gov/Assets/recreational/pdf/append_a.pdf). Sampling is stratified by state, mode of fishing, and wave (bimonthly period) and is conducted continuously during the sampled wave. Recreational fishing estimates are provided for four major modes of fishing: private boats (including rentals), shoreline (e.g., pier, jetty, etc.), charter boats, and headboats (party boats). From 1981-1985 all for-hire boats (charter and party boats) were sampled as one category, producing a single mode that was undifferentiated. From 1986-2004 the party/charter mode was continued in the northeast states (Maine to Virginia), while in the southeast states (North Carolina to Florida) charter boats (only; as separate mode) were sampled by MRIP. Party boats are surveyed by the Southeast Head Boast Logbook Program which began in 1986. From 2005-to present the charter and party boats are sampled independently by the for-hire survey and stratified angler intercept survey; as such separate charter and party boat estimates are produced. Each shoreline angler is treated as being on an independent fishing trip whereas boat modes are treated as fishing parties under the assumption that all anglers on a boat are fishing the same. Sampling is conducted in six waves, each wave being two consecutive calendar months starting with wave 1 (January and February) and ending with wave 6 (November and December). Sampling is conducted during all six waves in Florida (except wave 1 in 1981) and during waves 2-6 in Georgia to Maine (with the exception of pilot studies during some years in GA and NC). Prior to 1993 sampling was divided evenly between the two months in a wave. Beginning in 1993, sampling was divided proportional to expected fishing pressure during each month. There are a minimum of 30 intercepts in each stratum for the shore and private boat modes and at least 45 intercepts in each stratum for the party and charter boat modes (to account for clustering effect). Sampling beyond the minimum is allocated

proportional to expected fishing pressure in each stratum based on the previous three year period. The number of Bluefish caught is recorded as harvested fish observed by the interviewer in whole form (type A), fish reported as harvested by the angler but not observed by the interviewer (bait, filleted, discarded dead) (type B1), and fish released alive (type B2).
Estimation of the variances associated with the average catch and weight of catch estimates obtained from the intercept survey is based on the assumptions that the primary sampling unit is a fishing trip by an individual angler and that there is no clustering effect due to the collection of groups of interviews at each visited site. These assumptions have been empirically verified in pilot surveys. Therefore, the variance is estimated using the standard variance equation for a stratified random sample.

The sampling variance of the estimated total catch is calculated in terms of the expected values and sampling variance the average catch and the total number of trips for each stratum. Total catch is not normally distributed and therefore direct examination of the precision of the estimates is difficult. However, simulation experiments indicate that a normal approximation is satisfactory for constructing 95 percent confidence intervals around the estimated total catch.

The proportional standard error (PSE) expresses that standard error as a percentage of the estimate. It provides an alternative measure of precision and is useful in comparing the relative precision of two estimates. A small PSE indicates a more precise estimate than does a large PSE.

Effort data are collected with the Coastal Household Telephone Survey (CHTS). The CHTS is a stratified random digit dialing telephone survey that includes only households in coastal counties (generally counties within 25-50 miles of coastline, depending on state). The CHTS is stratified by county and wave. Sampling is conducted over a two week period at the end of each wave (last week of the wave and first week of the next wave) and is allocated proportional to county population. Information is collected on the number of trips in the previous wave and details about those trips (see example CHTS questionnaire http://www.st.nmfs.noaa.gov/Assets/recreational/pdf/append_a.pdf). Outliers in effort (number of trips during the particular wave) recorded from telephone surveys are reduced to the 95th percentile of the distribution of effort for the last five years for the particular stratum being sampled.

Evaluation of the CHTS indicated that for-hire modes were being underrepresented due to the nature of these fisheries (out of state clients, etc.). Beginning in 2005, angler effort on charter boats and headboats has been sampled through the For-Hire Survey (FHS) and several overlapping sampling programs. The CHTS was replaced by the FHS for charter boats and headboats (the CHTS is still used for private boats and shoreline modes). The FHS is also a random dial telephone survey that uses a vessel directory as a sampling frame. Other overlapping programs include the Vessel Trip Report (VTR) Program for Maine through Virginia (census logbook), the Southeast Headboat Survey (since 1986) for North Carolina though Florida (census logbook), and state census logbook programs in South Carolina, Florida, and Maryland.

MRFSS vs. MRIP Estimates

Estimates of catch using the MRIP methodology are available from 2004 to the present.

However, prior to 2004, only catch estimates using the MRFSS methodology are available, since the site weight information needed to produce the MRIP estimates is not readily available for the older data. For some species, MRIP estimates were consistently higher or lower than MRFSS estimates, usually when catch rates at low pressure sites were significantly different from catch rates at high pressure sites.

However, for bluefish, there was not a consistent trend in the difference between MRFSS and MRIP estimates, and MRFSS estimates were within the 95% confidence intervals calculated from the MRIP PSEs (Figure B4.7). The TC and WG used the method developed by the MRIP calibration working group to calibrate pre-2004 MRFSS estimates. Difference between the two time-series were minimal.

B4.2.1 Recreational Catch and Harvest

Recreational harvest estimates of bluefish has averaged over 14,000 mt (30.9 million pounds) annually since 1981 (Table B4.23). From the early 1980s to the early 1990s, recreational harvest declined by about 70% [avg. 1981-1983 = 40,433 mt (89.1 million pounds); avg. 1991-1993 = 11,713 mt (25.8 million pounds)]. Recreational harvest estimates continued to decline at a somewhat slower rate until reaching their lowest level at 3,310 mt (7.3 million pounds) in 1999, but since have grown to a peak of 10,204 mt (22.5 million pounds) in 2007. There has been an overall decline since 2007 to roughly 5,000-5,400 mt (11-11.9 million pounds) in 2011 and 2012. Though harvest increased to approximately 7,000 mt (15.4 million pounds) in 2013, harvest estimates for 2014 show a decrease to approximately 4,700 mt (10.4 million pounds). In 2014, recreational anglers along the Atlantic Coast caught 5.8 million bluefish, a 7.4% increase from 2013 (Table B4.24). Recreational harvest has generally increased from a low of 3.6 million fish in 1999, the lowest harvest in the time series. Since then, recreational harvest averaged over 6.2 million fish annually. The majority of recreational activity occurred from May to October, with the peak activity in July and August. Most of the recreational activity occurs from July to October, when almost 70% of the bluefish harvest is taken.

Trends in recreational trips associated with targeting or harvesting bluefish from 1991 to 2013 are provided in Table B4.25. The lowest annual estimate of bluefish trips was 1.727 million trips in 1999, but last year (2013) was also very low with 1.733 million trips. The highest annual estimate of bluefish trips in this timeframe was 5.9 million trips in 1991. Relative to total angler effort in 2013, bluefish were the primary target of recreational trips only about 4.7% of the time.

Recreational Catches by Mode

Figure B4.8 reflects MRFSS/MRIP-based estimates of total removals by mode and indicates that the primary catch modes for bluefish are private boats and shore-based fishing. Less than 10 % of the catch came from for-hire boats over the same time period.

Recreational Catches by Area

MRIP classifies catch into three fishing areas: inland, nearshore ocean (< 3 mi), and offshore ocean (> 3 mi). About 54% of the catch of bluefish on a coastwide basis came from inland waters, followed by nearshore ocean (39%) (Figure B4.9). Offshore ocean is only about 7% of the total catch.

B4.2.2 Recreational Releases

MRFSS/MRIP Recreational release estimates have ranged from a low of 3.2 million fish (1985) to a high of 15 million fish (2007) from 1981-2014 (Table B4.26). Recreational release estimates have generally increased in proportion to harvested fish over the time series, increasing from approximately 4% of the total coastwide catch in 1981 to over approximately 60% in 2014. Recreational discards in 2014 were estimated at 2,808.4 mt and after adjusting for a 15% mortality rate the resulting discard loss was 421.4 mt.

B4.2.3 Recreational Discard Mortality

Since the 1997 assessment (23rd SAW), recreational discard mortality has been estimated at 15%. This was based on estimates calculated in a study by Malchoff (1995), and modified by the ASMFC Bluefish Technical Committee. Prior estimates used in 1994 (18th SAW), estimated a hooking mortality rate of 25% and was based on analogy with species such as striped bass (Diodati 1991), black sea bass (Bugley and Shepherd 1991), and Pacific halibut (IPHC 1988). The Technical Committee thoroughly reviewed the bluefish discard mortality literature (working paper B1) for SAW60. Four methods to calculate a point estimate of post release mortality were conducted, resulting in a range of estimates between 14% and 17%. The TC and WG approved a 15% (SD=0.143%) discard mortality estimate for use in SAW60 based on bluefish specific estimates from five known studies using Bartholomew and Bohnsack (2005) meta-analysis methodology. Supporting analysis using 70 studies and 21 different species from Bartholomew and Bohnsack (2005) (16% post release mortality) and an equal weighted estimate from bluefish specific papers (14% post release mortality) assisted the decision by the WG and TC. For more details see working paper B1.

B4.2.4 Recreational Biological Sampling

Recreational landings are sampled for length as part of the MRIP program. The MRIP length samples were used to expand recreational landings per half year. Recreational discards were characterized using lengths from bluefish tagged and released in the American Littoral Society tagging program (by definition B2 catches), as well as information provided by volunteer angler programs in RI, CT, and NJ.

Rhode Island Volunteer Angler Survey

The Rhode Island Department of Environmental Management Division of Fish and Wildlife (RIDFW) implemented a voluntary on-line angler logbook (eLOGBOOK) in 2010. The eLOGBOOK application, housed by the Atlantic Coastal Cooperative Statistics Program (ACCSP), enables recreational fishers to enter complete trip level catch and effort data online. Information collected includes trip date, fishing mode (party, charter, private, shore), area fished, number of fishers, number of lines, gear type, hours fished, species, disposition, length and quantity.

Connecticut Volunteer Angler Survey

The Connecticut DEEP Marine Fisheries Division has conducted a Volunteer Angler Survey (VAS) since 1979. This survey supplements the National Marine Fisheries Service, Marine Recreational Information Program (MRIP) by providing additional length measurement data particularly for fish that are released. The survey's initial objective was to collect marine recreational fishing information concerning finfish species with special emphasis on striped bass. In 1994, the collection of bluefish length measurements was added to the survey to enhance understanding of the bluefish fishery in Connecticut. In 1997, length measurement information for other marine finfish was added to the survey design.

The CT VAS is designed to collect trip and catch information from marine recreational (hook and line) anglers who volunteer to record their fishing activities by logbook. The logbook format consists of recording fishing effort, target species, fishing mode (boat and shore), area fished (subdivisions of Long Island Sound and adjacent waters), catch information concerning finfish kept (harvested) and released, and length measurements of striped bass (since 1979), bluefish (since 1994), and other common species (since 1997). Instructions for volunteers are provided on the inside cover of all postage paid logbooks. Each participating angler is assigned a personal numeric code for confidentiality purposes. After the logbook data are entered into a database, logbooks are returned to each volunteer for their own personal records.

New Jersey Programs

Recreational discard data were available from several New Jersey programs: the New Jersey volunteer angler survey (VAS) is an online, open access survey that began in 2006. The intent of the survey is to complement and supplement the MRIP survey. Two main objectives of the VAS are to allow anglers to submit data to increase buy-in to management measures as well as address sample size concerns of MRIP, and to collect additional length frequency data of discarded fish. The survey was designed based on the MRIP intercept survey, collecting effort, catch, and length information from marine recreational (hook and line) anglers in New Jersey waters. The survey is available online at http://www.njfishandwildlife.com/marinesurvey.htm.

The NJ Tournament and Party/Charter Boat biological sampling program is designed to collect marine recreational (hook and line) fishing information concerning finfish species. Tournament sampling consists of staff collecting biological data (length, weight, age, sex) of finfish kept (harvested) and released during fishing tournaments. In 2014, logbooks were created for tournament anglers who volunteered to record their fishing activities. The logbook format consists of recording fishing location, number of hours fished, fishing mode (surf or boat), number of anglers reporting on log, water temperature, catch information concerning finfish kept and released, and length measurements.

NJ Party/charter boat sampling consists of staff collecting biological data of finfish kept and released during fishing trips aboard party/charter boats. Party/charter boats can submit trip and catch information by logbook when staff are not present. The logbook format consists of recording fishing location, number of hours fished, number of fisherman, water temperature, weather conditions, catch information concerning finfish kept and released, and length measurements.

Length frequencies from the recreational catch and discards show a similar trend to the commercial length frequency. While previous years were characterized by a bimodal distribution, more recent years reveal a skewed distribution, with a main peak around 28 cm and a flat/slightly-decreasing distribution out to 90 cm (Figure B4.10A & B). Total length frequency distribution by season of the recreational landings and discards are presented in Figure B4.11. The average size of the recreationally released bluefish is larger than the average size of retained fish, an uncommon pattern most likely due to bluefish's unpalatability at larger sizes.

B5. TERM OF REFERENCE #2: Present and evaluate data and trends on life history information including, age, growth, natural mortality, food habits, and maturity.

B5.1 Life History

Bluefish, *Pomatomus saltatrix*, is a coastal, pelagic species found in temperate and tropical marine waters throughout the world (Goodbred and Graves 1996; Juanes et al. 1996). Inhabiting both inshore and offshore waters along the east coast of the United States, spawning takes place offshore (Kendall and Walford 1979; Kendall and Naplin 1981) and subsequent to larval development in continental shelf waters, juveniles eventually move to estuarine and nearshore shelf habitats (Marks and Conover 1993; Hare and Cowen 1995; Able and Fahay 1998; Able et al. 2003). Traveling in loose groups of fish aggregated by size, bluefish typically migrate north in the spring/summer and south in the fall/winter (Wilk 1977; Klein-MacPhee 2002). Their range during these periods of migration can extend as far north as Maine and as far south as Florida in the Unites States (Shepherd et al. 2006).

B5.2 Age Data

The working group (WG) expended considerable time and effort tracking down all original sources of age data used at SAW41, new sources of data, as well as constructing and reconstructing age length keys. The WG recovered NC scale data files from 1983-1996 and NC otolith data from 1996 to 2000 (scale and otolith samples were collected from the same fish in 1996; the WG elected to use 1996 otolith data only). Samples were primarily from commercial gears. Of note, the raw NC ages included many spring age 0 fish, which are uncommon in biological age samples (WP B5; ASMFC 2011). Exploration of spring NC data suggested, contrary to SAW41 (NEFSC 2005) language, that those data do not use a January 1 birthdate, making them incompatible with all other age data1. The WG initially considered using the raw data (with model adjustments), but at the modeling workshop quantitatively re-assigned NC spring scale ages based on the size and age of known samples from across the time series; for otolith ages, only spring age 0 samples (1996-2000) were adjusted to age 1. See WP B6 and TOR 3 for more details.

Additional data from this general time period (1984-19952) that were recovered included CT Long Island Sound Trawl Survey (LISTS) scale ages, NEFSC trawl scale ages, and NMFS commercial port sampling scale ages (Table B5.1, Figure B5.1). For SAW41, these data were used to age fishery independent or commercial landings only. The SAW60 WG reasoned that bringing all of these data into the ALKs was desirable as it lead to more complete ALKs. Given the limited age data from 1982-1984 the WG elected to start the model in 1985.

The WG recovered VA age length keys from 1998-2004 used at SAW 41. In 1997, VMRC established a cooperative fish ageing lab with Old Dominion University's Center for Quantitative Fisheries Ecology (CQFE) laboratory. The CQFE Lab ages fish harvested from Virginia's marine fisheries and provides the data to VMRC for management purposes. Collection of age samples was based on a quota by inch interval. The Virginia time series (1998-2004) contains

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1 Fall samples would not have suffered from a birthday concern, and so were used at SAW41, and also retained for SAW60 (WP B6).

2 NMFS port samples and NEFSC trawl samples were also available for 1996 but were inadvertently omitted from ALKs.

age information by gear, sex, market category, and location from approximately 2,700 samples, from sectioned otoliths only. The SAW60 WG augmented the VA spring ALKs with NC spring otoliths after adjusting the age 0s to age 1 (WP B6). This augmentation allowed for disaggregation of the previously combined 1998-2001 spring ALK into ALKs for 1998, 1999, and 2000-2001 (Table B5.2). With this exception, age keys from 1997-2004 were reconstructed according to the protocol specified at SAW41 (Table B5.2).

New sources of age data acquired since SAW41 include otolith ages from MA, RI, CT, NY, NJ, ChesMMAP, NC, NEAMAP, and SEAMAP (Figure B5.1). The Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) Trawl Survey samples the main stem of the Chesapeake Bay, from Poole's Island, MD to the Virginian Capes at the mouth of the bay since 2002. ChesMMAP conducts 5 cruises annually, during the months of March, May, July, September, and November. This survey is designed to sample the late juvenile and adult stages of the living marine resources in Chesapeake Bay, and as such the timing of sampling is meant to coincide with the seasonal residency of these life stages in the estuary. The NEAMAP and SEAMAP programs are described in TOR 3. With the addition of these new data sources, age keys since 2005 average a minimum of approximately 30 fish per age (Table B5.3, WP B5).

Several studies document the problems with bluefish ageing information, specifically problems with using scales to accurately age bluefish. False annuli, rejuvenated scales, identifying annuli on scales from larger fish, different annuli counts between scales from the same fish, and the timing of the first annulus formation can all cause inaccuracies (Lassiter 1962; Richards 1976; NCDMF 2000; Robillard et al. 2009). The divergence between scale ages and otolith ages occurs beyond age-6 (E. Robillard, CQFE, pers. comm. 2005). Therefore the catch-at-age matrices were truncated to a 6+ category to reduce ageing error associated with scale ages in the 1985-1995 time period.

The SAW-23 review expressed concern that use of a single age key collected in NC may not be representative of the coastal stock (NEFSC 1997). The SAW-41 review expressed concerns that ALKs have been combined across areas and years. Salerno et al. (2001) examined age data collected along the Atlantic coast in the NEFSC autumn trawl survey and compared the scale ages with the North Carolina commercial ages and concluded that the NC ages were representative of Atlantic coast bluefish. Other studies have used age at length information from commercial and recreational fisheries as well as fishery-independent surveys and have shown similar bluefish growth parameter estimates from Maine to North Carolina, providing further evidence that North Carolina age data are representative of the Atlantic Coast (VMRC 1999, 2000, 2001). Regional trends in age data are available in Figure B5.2A-B (and WP B5) and suggest similarities and differences.

The WG explicitly evaluated borrowing age data across years (WP B8), and the results suggested that this should generally be avoided. The SAW-60 WG accounted for historical borrowing and sparse ALKs (1997-2005) through model considerations (see TOR 4).

The SAW-41 review expressed concerns regarding gaps in sampling age 3, 4, and 5-year old fish (Jones 2005). In response to concerns about the adequacy of bluefish biological data, in February 2012 the Bluefish Management Board passed Addendum I to Amendment 1 to the bluefish fishery management plan that required states that accounted for >5% of total coast-wide bluefish harvest to collect a minimum of 100 bluefish ages (50 from January - June; 50 from July - December). A number of states implemented this program prior to 2012, including NC (2006+), MA (2009+), and NJ (2010+); and as noted above, VA has maintained an ageing program in conjunction with ODU since 1997. With the expansion of the biological collection program, bluefish age length keys have become considerably more robust relative to the time series described above (Figure B5.3 and B5.4). Working paper B5 describes the biological collection program in greater detail. See WP B5, B7, and B8 for more information on trends on age data.

B5.3 Growth and Reproduction

Bluefish spawn offshore in the western North Atlantic Ocean, from approximately Massachusetts to Florida (Norcross et al. 1974; Kendall and Walford 1979; Kendall and Naplin 1981; Collins and Stender 1987). Bluefish are characterized as iteroparous spawners with indeterminate fecundity and spawn continuously during their spring migration (Robillard et al. 2008). In addition to distinctive spring and summer cohorts, Collins and Stender (1987) identified a fall-spawned cohort, demonstrating the potential of an extended bluefish spawning season.

Bluefish grow nearly one-third of their maximum length in their first year (Richards 1976, Wilk 1977). Variation in growth rates or sizes-at-age among young bluefish is evident from the appearance of intra-annual cohorts. Lassiter (1962) identified a spring-spawned cohort and a summer-spawned cohort from the bimodal appearance of size at Annulus I for fish aged from North Carolina and found the seasonal cohorts can differ in age by two to three months. Hare and Cowen (1993) however, suggest the bimodal length at age observed in bluefish is not the result of two distinct spawning events but rather a consequence of continuous spawning (March-September) with the summer spawned offspring having a lower probability of recruitment. Previous research suggests different growth rates at age with summer-spawned larvae and juveniles growing faster than spring-spawned larvae and juveniles (McBride and Conover 1991) with size differences at annual age diminishing greatly after three to four years (Lassiter 1962).

To further explore differences in growth, von Bertalanfy growth curves were fit to data available from 1985-2014 (Table B5.4, Figures B5.5 and B5.6). Historically, scale ages have been used to estimate von Bertalanffy growth parameters (Lassiter 1962; Barger 1990; Terceiro and Ross 1993; Salerno et al. 2001) however more recent research validated otolith ages for bluefish and re-examined growth (Robillard et al. 2008). The values for L_∞ from all of these studies (87-128 cm FL) match closely to the largest individuals in the available catch data and are similar to the estimates presented here (Table B5.4).

The results from the sex based growth examination confirm the results of previous studies that growth rates do not differ between sexes (Hamer 1959; Salerno et al. 2001, Robillard et al. 2008) (Figure B5.6, Table B5.4). Although there was not enough data available from older fish in the south to do a comparison between northern and southern fish, there were data available to compare growth rates between ageing structures. Scale ages typically over-estimate younger ages and underestimate the age of older fish. The growth curve for scales from this study had more data to fit at older ages, and asymptotes at a much smaller L-infinity value (92.4cm) than the otolith ages (120 cm). The otolith ages seem to provide more realistic VBL growth parameter estimates (Table B5.4). Finally, the differences in growth curves by time block can be explained by the age structures. From 1985-1994 all of the age data is derived from scales, 1995-2004 age data comes from a mixture of scales and otoliths, and 2005-2014 data is otoliths only. Changes in the primary age structure for bluefish over the time series makes it difficult to determine if there has been a change in growth rates.

B5.4 Natural Mortality

In past stock assessments, a value of 0.2 has been assumed as the instantaneous natural mortality (M) for bluefish over all ages and years. To investigate the validity of this estimate, longevity and life-history based equations were used to estimate different possible values for M. Taking the maximum age for bluefish to be 14 years (observed age in the data used in these analyses), the 'Rule of thumb' method (3/tmax) gives a natural mortality estimate of 0.21. Additional longevity based estimates derived from equations in Hoenig (1983) and Hewitt and Hoenig (2005) give values of 0.32 and 0.3, respectively. Estimates based on equations that use growth parameters from Then et al. (2014) and Jensen (1996) give values of 0.20 and 0.195, respectively. The mean value for natural mortality using the estimates from these 5 approaches is 0.245.

Age-specific estimates were calculated based on the work of Lorenzen (1996, 2000) and Gislason et al. (2010). These values ranged from 1.70-0.17 over the age range of 0-14 (Table B5.5). The WG was concerned with the use of age-specific M estimates due to uncertainty in M particularly for younger ages of bluefish (Table B5.5; e.g., range of M for age 0 = 0.54-1.70). Based on the results of all the methods explored to estimate natural mortality for bluefish, the WG reasoned that the assumption of M = 0.2 was justifiable and was maintained for SAW60.

B5.6 Food habits

During oceanic larval development, bluefish diets are composed primarily of copepods and fish eggs in the smaller size classes (<30mm) expanding to amphipods, and crab larvae above this size (Marks and Conover 1993). An onset to piscivory occurs for early juveniles, primarily inhibited by mouth-gape size, in estuarine waters leading to rapid increases in growth rates with maximum rates reaching 2 mm/day (Juanes and Conover 1994). Cannibalism has also been documented, and therefore bluefish predation may influence recruitment of conspecifics (Bell et al. 1999). Increased predation on commercially important invertebrates such as blue crabs (*Callinectes sapidus*) may occur when fish prey are less available (Scharf et al. 2004). Both seasonal and inter-annual differences in diet have been observed and are likely attributed to changes in prey availability, but also due to inter-annual variability in timing of estuarine arrival (Nyman and Conover 1988). To confirm the findings of previous research and further investigate the diet of bluefish, data on diet composition collected from four surveys were evaluated.

Data from the NEFSC bottom trawl survey from the Mid-Atlantic and Southern New England regions was analyzed in 10 year blocks to look at bluefish diet composition. The proportion of empty stomachs ranged from 20-40% and in each ten year period, around 60-70 bluefish prey items were identified. Anchovies were a significant prey of bluefish across all time periods, as were butterfish and squids (Figure B5.7). Other prey have different levels of importance across time, including sandlances, herrings, bluefish, and scup (which has increased in the past two decades). Drums have also recently increased in bluefish diets. Prey composition percent by weight as shown in Figure B5.7 was calculated using the methods of Link and Almeida (2000).

Since 2007, the NEAMAP survey has sampled a total of 4,250 bluefish for diet from the Mid-Atlantic Bight and Southern New England. Of these, 56.0% (2,379 fish) have had prey in their stomach comprising 86 prey items. Percent by weight (%W) of each prey type was calculated following Bogstad et al. (1995) and Buckel et al. (1999). This data showed that fishes comprised greater than 96% of the bluefish diet by weight, with bay anchovy (53.9%), butterfish (7.4%), and striped anchovy (6.2%) accounting for the bulk of the prey consumed. For the invertebrates, the longfin inshore squid was the main identifiable prey type. Percent by number (%N) of each prey type was calculated following the same %W equation by replacing the biomass values with count data. These calculations presented a similar picture of bluefish diet, with fishes contributing 92.6% of the diet and the same three fishes dominating the diets of bluefish. Invertebrates were shown to be slightly more important in the bluefish diet using %N, likely due the large numbers of small-bodied invertebrates (e.g., crab megalope and mysid shrimps) that were encountered on several occasions.

The ChesMMAP survey has collected a total of 443 bluefish stomachs since 2002, and 54.0% of these have had prey items in their stomach. Of these 239 bluefish stomachs, 34 prey types were identified with fishes again dominating the diet of bluefish collected from Chesapeake Bay, as measured using the %W index. Fishes comprised approximately 87.7% of the bluefish diet by weight, with bay anchovy (39.9%), spot (18.8%), and Atlantic menhaden (9.1%) accounting for the bulk of the fishes consumed by bluefish. Silver perch and weakfish each accounted for 2.4% of the diet by weight. Of the invertebrates, the mysid shrimp was the main identifiable prey type. Fishes comprised nearly the same percentage of the bluefish diet when measured by the %N index. Fishes contributed 84.6% of the diet by number, while invertebrates accounted for 13.7%. The remainder was unidentifiable items.

The SEAMAP trawl survey sampling from Cape Hatteras, North Carolina to Cape Canaveral, Florida has collected 644 stomachs from 2011-2013. A total of 49 different types of prey were identified with the diet composition by weight consisting primarily of fishes (93.5%), most significantly anchovies (49.8%), Atlantic bumper (3.2%), and sciaenid fishes (1.2%). Penaeid shrimp, loliginid squids and cubozoan jellyfish contributed in highest proportions among the invertebrates. A similar composition is depicted in the %N calculations (WP B3).

Overall, the diet of bluefish both in the Chesapeake Bay and the coastal ocean, from Cape Cod to Cape Canaveral, is dominated by fishes, regardless of the index by which the diet is quantified. These findings correspond with those of past studies that have sought to characterize bluefish diet in estuarine and ocean environments. For more information see WP B3.

B5.7 Maturity

Bluefish maturity at age and length has been investigated in previous studies (Salerno et al. 2001, Robillard et al. 2008). To confirm these results and further investigate bluefish maturity, maturity at length is presented for all fish, northern and southern fish, and males and females (Figure B5.8 and B5.9).

This study presents maturity at length all fish, northern and southern fish, and males and females (Figure B5.8 and B5.9). The length estimate at 50% maturity for all fish (29.87 cm) was found to be smaller than the mean value of 33.65 cm estimated in Salerno et al. (2001)(Table B5.6). Given the larger sample size (N = 13,722 vs N = 3,334) and broader geographic region of the data presented here, these differences can be expected. Although it appears that southern fish mature at a smaller length than northern fish, this may also be an artifact of sampling (N = 12,909 fish in north, N = 813 fish in south). The length at maturity for males versus females was found to be slightly smaller for males (Table B5.6 A). Similarly, the data also indicate that female fish mature at an older age than male fish (Table B5.6, Figure B5.10). This is consistent with the maturity information from Robillard et al (2008). Finally, comparing maturity at age for otoliths to scales shifts the maturity ogive to slightly younger ages (Figure B5.10).

The most accurate source of maturity at age for bluefish involved a histological examination of 1,437 female fish (Robillard et al. 2008). However, because this maturity information does not apply to the entire bluefish stock, the proportion mature at age for all fish (estimated via logistic regression: A50 = 1.10, A95 = 1.85) was used as the input maturity for the catch-at-age model used in the benchmark assessment (Table B5.7, Figure B5.11). These estimates are nearly identical to the results from Salerno et al. (2001) (Table B5.7).

B5.8 Stock Definition

Bluefish in the western North Atlantic are managed as a single stock (NEFSC 1997; Shepherd and Packer 2006). Genetic data support a unit stock hypothesis (Graves et al. 1992; Goodbred and Graves 1996; Davidson 2002). For management purposes, the ASMFC and MAFMC define the management unit as the portion of the stock occurring along the Atlantic Coast from Maine to the east coast of Florida.

B5.9 Habitat Description

Bluefish eggs have been collected across the continental shelf from southern New England to Cape Hatteras from May through August, and their depth distribution during those months ranged from 30-70 m, with the majority at 30 m (Shepherd and Packer 2006). Larvae occur near the edge of the continental shelf in the south Atlantic Bight, in open oceanic waters in the mid-Atlantic Bight, and over mid-shelf depths farther north (Shepherd and Packer 2006). Spring spawned larvae are subject to advection to northern waters by the Gulf Stream (Shepherd and Packer 2006). Adult and juvenile bluefish are found primarily in waters less than 20 meters (m) deep along the Atlantic coast Shepherd and Packer 2006). Adults use both inshore and offshore areas of the coast and favor warmer water temperatures although they are found in a variety of hydrographic environments (Ross 1991; Shepherd and Packer 2006). Bluefish can tolerate temperatures ranging from 11.8°-30.4°C, however they exhibit stress, such as an increase in swimming speed, at both extremes (Olla and Studholme 1971; Klein-MacPhee 2002). Temperature and photoperiod are the principal factors directing activity, migrations, and distribution of adult bluefish (Olla and Studholme 1971).

B6. TERM OF REFERENCE #3: Present the survey data available for use in the assessment (e.g., indices of relative or absolute abundance, recruitment, state surveys, age-length data, etc.), evaluate the utility of the age-length key for use in stock assessment, and explore standardization of fishery- independent indices. Investigate the utility of recreational CPUE as a measure of relative abundance. Characterize the uncertainty and any bias in these sources of data, including exploring environmentally driven changes in availability and related changes in size structure. Explore the spatial distribution of the stock over time, and whether there are consistent distributional shifts.

B6.1 Fishery-Independent Surveys
Fishery-independent surveys from Florida to New Hampshire were reviewed for this assessment (Figure B6.1). Survey methods include estuarine and nearshore bottom trawl and beach seine surveys. The surveys caught predominantly age-0 and age-1 bluefish (<30 cm FL). Indices of relative abundance were calculated based on constraints of catch size, time, and location of sampling. Several surveys sample monthly or bi-monthly. The working group evaluated the timing of each survey and chose the period that had the highest availability of bluefish to the survey gear.

B6.1.1. NH Fish and Game Department, Marine Division Juvenile Finfish Seine Survey

The New Hampshire Fish and Game Department's Juvenile Finfish Seine Survey was initiated in 1997 and has sampled continuously since. The Survey is a fixed station survey. Fifteen fixed stations were chosen through sampling several sites within New Hampshire bays and estuaries in the years before 1997 and selected based on habitat type, depth of less than six feet (1.8 m), and with low enough tidal current to allow for the net to be pulled through the site. The stations, four of which are in the Hampton/Seabrook Estuary, three in Little Harbor, three in the Piscataqua River and five in Little Bay/Great Bay (Figure B6.2), are representative of juvenile finfish nursery habitat along New Hampshire's coastal waters. The beach seine used for this survey is a bag seine, 30.5 m long by 1.8 m high, with 6.4 mm mesh.

A single seine haul is performed at each station each month from June through November, resulting in 90 tows per year. Seine hauls are performed between two hours before and two hours after low tide, and always in daylight. Seine hauls are set by boat about 15-25 m from the beach and, ideally, in water depths less than 2 m, in order to prevent the foot rope of the seine from lifting off of the bottom.

All captured finfish are identified to the lowest possible taxon, measured in total length to the nearest millimeter (with a maximum of 25 individual lengths recorded per species per seine haul), and then enumerated. Water surface temperature (°C), salinity (ppt) and substrate type are recorded at each fixed station for each seine haul. Sampling occurs annually from June to November. All fifteen stations within all four areas (Great Bay, Hampton Harbor, Little Harbor, Piscataqua River) are sampled within each month. This sampling design results in a total of 15 seine hauls being collected monthly and 90 seine hauls being collected annually.

The annual geometric mean catch per tow from the New Hampshire Finfish Seine Survey is used as a measure of relative abundance (Table B6.1). In calculating the index, the full dataset between 1997 and 2014 was used and all survey months (June through November) were included. All fish encountered during time series of the survey ranged between 23 mm and 220 mm. A size cutoff of 250 mm is an assumed level at which bluefish would be classified as age 1 based on discussions of the technical committee, and therefore all bluefish used in the analysis are classified as young-of-the-year.

B6.1.2 Northeast Fisheries Science Center (NEFSC) Fall Inshore Trawl Survey

The NEFSC has conducted bottom trawl surveys over a large portion of the Atlantic shelf since 1963 (Avarovitz 1981). Sampling sites are randomly selected from within depth-defined strata; both inshore and offshore strata are sampled. The surveys run in the spring and fall and cover areas from 5 to 200 fathoms (9.1-365.8 m) deep, from Cape Hatteras, North Carolina to Canadian waters. Trawling locations are allocated according to a stratified-random sampling design. The research vessels F/RV Albatross IV and the F/RV Delaware II were used to conduct these surveys from 1963 to 2008. In 2009 the F/RV Albatross IV was decommissioned and the FSV Henry B. Bigelow took over as the permanent NEFSC survey vessel. This vessel change resulted in changes to the trawl gear and survey protocol (Table B6.2, adapted from Brooks et al. 2010 and NEFSC 2012).

Bluefish are predominantly caught in the fall, and in inshore waters. NEFSC fall inshore strata from Cape Hatteras to Cape Cod were used to build two indices for bluefish (Figures B6.3A-B). An F/RV Albatross index based on all inshore strata (1-46) was constructed from 1985 to 2008. F/RV Albatross tows were 30 minutes in duration and utilized a codend mesh liner of 1.27 cm to retain pre-recruits. An additional NEFSC index representing the current survey vessel, the FSV Henry B. Bigelow, was constructed from 2009 to 2014. The Bigelow is only able to sample the outer inshore band of strata and not able to sample as close to shore as previous vessels. FSV Bigelow tows are 20 minutes long and use a larger codend liner at 2.54 cm. Stratified mean numbers of bluefish per tow for both indices with associated CV estimates are presented in Table B6.1.

Mean number per tow at length were aged using age length keys from 1985 to 2014 developed for the assessment (see TOR 2 for details). The majority of bluefish caught in the fall are age-0 or age-1. The Albatross index shows large cohorts early in the time series in 1986, 1989, and to a lesser degree, later in the time series in 1999, 2003, and 2005 (Figure B6.3A). It is difficult to discern trends from the Bigelow index due to the short (6 year) time series. However, the SAW60 WG decided that while the Bigelow time series was short, it was important to separately include this index in the assessment. Previously, Albatross and Bigelow data were used in a combined index, with Bigelow numbers converted to Albatross units using a conversion factor of 1.16 (Miller et al. 2010). Bluefish have not had a benchmark assessment since 2005 and there will likely be an extended period of time before the next benchmark. The separate Bigelow index will continue to add value, without the need to apply conversion factors, as additional years are added.

B6.1.3 RI DEM Narragansett Bay Juvenile Finfish Beach Seine Survey

The Rhode Island Department of Environmental Management Division of Fish and Wildlife

(DEM) Narragansett Bay juvenile finfish survey began in 1988 to monitor the relative abundance and distribution of the juvenile life history stage of commercial and recreationally important species in Narragansett Bay. These are used to evaluate short and long term annual changes in juvenile population dynamics, to provide data for stock assessments, and to develop Fishery Management Plans. Additionally, the fish community data collected by this survey is used to continue to identify, characterize, and map essential juvenile finfish habitat in Narragansett Bay.

The survey encompasses 18 fixed stations throughout Rhode Island's Narragansett Bay (Figure B6.4. The survey began in 1986 with fifteen stations. The data represented begins in 1988 as the period of time when the survey began using consistent methodology with 15 stations, and then station 16 (Dyer Is.) was added in June 1990, station 17 (Warren R.) was added in July of 1993, and station 18 (Wickford) was added in July of 1995.

Finfish are collected using a 61 meter (200') x 3.05 meter (10'), 6.4 mm stretched (¼") mesh beach seine. The seine has a bag at its midpoint and a weighted footrope. The beach seine is set in a semi-circle, away from the shoreline and back again using an outboard powered 23' (7 m) boat. The net is then hauled toward the beach by hand and the bag is emptied into large water-filled totes. Area swept was calculated, to determine the area covered by an average set (5,837 sq ft; 542.3 sq m).

Physical parameters such as weather conditions, water temperature, dissolved oxygen, salinity, are taken at each station. Fish are sorted by species, measured and counted. If over 50 individuals of one species are collected a sub-sample is taken. Fish collected in the sub-sample are measured and counted. The fish are released immediately after measurements are taken. Relative abundances of invertebrates and aquatic vegetation are also noted. Finfish are sampled monthly, from June through October of each year (all months used in index). The index of abundance used a 25 cm YOY cutoff. Index of abundance is provided in Table B6.1.

The Rhode Island index was standardized using the delta lognormal model approach (Lo et al. 1992). Two generalized linear model (GLM) analyses are used to construct a single index. The first GLM procedure of proportion positive trips assumed a binomial error distribution while the procedure for catch rates on successful trips assumed a lognormal error distribution. The five factors included were year, month, station, temperature (^{o}C), and salinity (ppt).The standardization was accomplished using R statistical software package.

B6.1.4 CT DEEP Long Island Sound Trawl Survey

The Connecticut Department of Energy and Environmental Protection's (CTDEEP) Marine Fisheries Division has conducted the Long Island Sound Trawl Survey (LISTS) since 1984. The LISTS provides fishery independent monitoring of important recreational species, as well as annual total counts and biomass for all finfish taken in the Survey. The LISTS employs a stratified-random sampling and is conducted from longitude 72° 03' (New London, Connecticut) to longitude 73° 39' (Greenwich, Connecticut). The sampling area includes Connecticut and New York waters of Long Island Sound and is divided into 1.85 x 3.7 km (1 x 2 nautical miles) sites (Figure B6.5), with each site assigned to one of 12 strata defined by depth interval design using strata based on depth interval (0-9.0 m, 9.1-18.2 m, 18.3-27.3 m or, 27.4+ m) and bottom type (mud, sand, or transitional as defined by Reid et al. 1979. Sampling is divided into spring (April-June) and fall (Sept-Oct) periods, with 40 sites sampled monthly for a total of 200 sites annually. Species are sorted, weighed, and counted and all or a sub-sample of primary species are measured to nearest cm FL. Some species are sorted and subsampled by length group; so that all large individuals are measured and a subsample of small (often young-of-year) specimens is measured. The length frequency of each group is estimated by the proportion of individuals in each centimeter interval of the subsample expanded across the total number of individuals caught in the length group. The estimated length frequencies of each size group are then appended to complete the length frequency for that species (Gottschall & Pacileo, 2013).

Length sampling for bluefish began in 1984. LISTS bluefish length frequency since 1984 includes 167,132 fish. Connecticut initiated a biological sampling program for bluefish in 2012 as part of implementing Addendum I to Amendment I of the bluefish fishery management plan. Since 2012, the majority of the fish collected for this program have come from LISTS. All bluefish samples have been aged by otolith cross section methodologies approved during the May 2011 bluefish ageing workshop.

LISTS generates a spring and fall geometric mean catch per tow, however, few bluefish are taken in the spring. The current bluefish assessment uses LISTS fall index consisting of September and October samples to generate a geometric mean catch/tow (Table B6.1, Figure B6.5). LISTS employs a stratified-random sampling design. The bluefish index used is an age 0 through age 6+ design based index (non-standardized). The average fall geometric mean over the time series is 22.63 fish/tow, with an average of 91.8% positive tows.

B6.1.5 NY DEC Beach Seine Survey (NYSDEC WLIS)

The New York Department of Environmental Conservation's (NYSDEC) Western Long Island Beach Survey started in 1984, has employed a consistent methodology starting in 1987. The survey uses a 200 x 10 ft (61 m x 3 m) beach seine with ¼ inch (6.4 mm) square mesh to sample sites at fixed stations within western Long Island bays: Little Neck and Manhasset Bay on the north shore of Long Island, and Jamaica Bay on the south shore (1984-present). Oyster Bay has been sampled consistently since 2001, and Hempstead Harbor since 2006. Other bays have been sampled on a shorter time frame. Sites are sampled May through October. Pre-2000 sampling was conducted 2 times per month during May and June, once a month July through October. Now, Little Neck Bay, Manhasset Bay, and Jamaica Bay are sampled 2 times per month (bi-weekly) from May through October. Hempstead Harbor and Oyster Bay are sampled 1 time each month. Generally 5-10 seine sites are sampled in each Bay on each sampling trip.

All finfish species caught identified and counted. As many finfish as possible were measured at each station until 2000 when either all, if less than 30, or a subset of 30 individuals were measured for each species. Environmental information (air and water temperature, salinity, dissolved oxygen, tide stage, wind speed and direction, and wave height) has been recorded at each station. Bottom type, vegetation type, and percent cover have been recorded qualitatively since 1988. Young-of-the-year (YOY) vs. older bluefish have always been recorded, with more species being differentiated over time. 99% of bluefish caught by this survey are YOY, as defined by a 30 cm fork length size cutoff.

The index of abundance (Table B6.1, Figure B6.6) was standardized using a negative binomial GLM with bottom water temperature and bottom dissolved oxygen levels as significant covariates and included sampling during the months of June through October. Bay was not a significant factor.

B6.1.6 NJ DFW Ocean Trawl Survey

The New Jersey Division of Fish and Wildlife (NJDFW) Bureau of Marine Fisheries Ocean Trawl Survey is a multispecies trawl survey that started in August 1988 to monitor the abundance and distribution of marine recreational fishes in the state's nearshore coastal waters. The survey samples from the entrance of the New York Harbor south, to the entrance of the Delaware Bay five times per year in January, April, June, August, and October.

There are 15 strata (five strata assigned to three different depth regimes: inshore – 5.5 to 9 m, mid-shore – 9 to 18 m, and offshore – 18 to 28 m). Stations are randomly selected, and station allocation per stratum is proportional to stratum size. Samples are collected with a three-in-one trawl, so named because all the tapers are three to one. The net is a two-seam trawl with forward netting of 12 cm (4.7 inches) stretch mesh and rear netting of 8 cm (3.0 inches) and is lined with a 6.4 mm (0.25 inch) bar mesh liner. The headrope is 25 m (82 feet) long and the footrope is 30.5 m (100 feet) long.

A consistent protocol has been in place with 20 minute tows and 5 annual cruises since 1990. Exploratory analyses indicated the most consistently high catches (and often the plurality of catches) are from the October cruise. Consequently, the index of abundance is from the October cruise from 1990+. Catches are dominated by young of the year fish, but 7% of the catch over the time series consists of age 1+ fish. The index of abundance is a stratified geometric mean catch per tow of ages 0-2 (Table B6.1, Figure B6.7).For standard catches, the total weight of each species is measured (in kilograms) and the fork length of all individuals is measured to the nearest centimeter. For large catches, a subsample is also weighed and measured (nearest cm), and an expansion factor (total weight / subsample weight) is then applied to each frequency of the length-frequency distribution from the subsample. Each of 39 stations are sampling every October.

B6.1.7 NJ DFW Delaware River Seine Survey

Since 1980, the NJDFW Bureau has conducted a striped bass young-of-year (YOY) seine survey in the Delaware River. This survey collects a variety of other species of fish and invertebrates, with moderate numbers of bluefish collected, over 2,900, since its inception.

The Delaware River is divided into three regions based on habitat; region 1 includes brackish, tidal water extending from the springtime saltwater/freshwater interface to the Delaware Memorial Bridge; region 2 includes brackish to tidal fresh water extending from the Delaware memorial Bridge to the Schuylkill River at the Philadelphia Naval Yard; region 3 includes tidal freshwater from Philadelphia to the fall line at Trenton. In the history of the survey no bluefish have been collected in region 3 and so that region was excluded for purposes of a bluefish abundance index. The region 1 shoreline is dominated by saltmarsh vegetation while region 2 is primarily urban with a shoreline heavily developed for commerce and industry.

The sampling scheme has been modified over the years but the core survey area and station locations have remained consistent. In 2002, the second two weeks of June and first two weeks of July were added to the sampling protocol; exploratory analyses indicated that comparatively large numbers of bluefish are collected during that time, and so the index of abundance includes those months (and consequently starts in 2002).

Field sampling employed a bagged, 30.5 m (100-feet) long, by 2 m (6-feet) deep, with a 6 mm (1/4-inch) mesh beach seine. The seine is deployed as follows: one end of the seine is held fixed at the waterline while a vessel backs off the beach in a half-circle or elliptical pattern before returning to the beach with the other end of the seine. The two ends of the seine are drawn together and hauled on shore at which point all fish are identified to species level, quantified and a sub-sample of up to 30 lengths (FL cm) are recorded for each species from each seine haul; the total size range is also recorded. A size cutoff of less than or equal to 25 cm was used to distinguish young of the year bluefish. Basic water quality parameters, including water temperature, salinity and dissolved oxygen, were also recorded at each station. The geometric mean young-of-year index is reported as the number of young-of-year bluefish per seine haul (Table B6.1, Figure B6.8). The full survey takes place between the 2nd week in June and the last week in October, but exploratory analyses indicated a substantive drop in catch after September, and so the bluefish abundance index includes only the 2nd week of June through the end of September. During this timeframe, each of 24 stations are sampled twice per month (every two weeks).

B6.1.8 MD DNR Juvenile Striped Bass Seine Survey

The Maryland Department of Natural Resources' (MD DNR) Juvenile Striped Bass Seine Survey has documented annual year-class success and relative abundance of many fish species in Chesapeake Bay since 1954. Juvenile striped bass indices are developed from sampling at 22 fixed stations located in major spawning areas in Maryland's portion of the Chesapeake Bay. A subset of 13 sample sites was selected for the development of a juvenile bluefish index from 1981 to present. Other sites were excluded on the basis that bluefish were rarely, if ever, captured there. Each site is visited monthly, from July to September, and up to two samples are collected at each visit.

Fixed sample sites are located in three areas of Maryland's Chesapeake Bay: the Choptank and Potomac rivers and the Upper Chesapeake Bay region north of the Chesapeake Bay Bridge. Sites have occasionally been lost due to erosion, bulkheading, or proliferation of submerged grasses. When necessary, replacement sites are located as close as possible to the original site. Effort was slightly variable prior to 1998, with sample sizes ranging from 72 to 80 seine hauls per year. From 1998 to present effort was standardized and sample size has been constant at n=75.Samples are collected with a 30.5 m x 1.24 m bagless beach seine of untreated 6.4 mm bar mesh set by hand. One end of the net is held on shore, while a biologist pulls the other end of the net perpendicular from shore to the 1.2 m depth contour or the net's full extension, whichever comes first. The net is then pulled parallel to shore to sweep the largest area possible and returned to the beach. All fish captured are sorted and counted by species.

A random subsample of up to 30 individuals is measured for species of interest. Select species are separated into age 0 and age 1+ groups. Ages are assigned from length frequencies and verified by direct examination of scales. Additional data collected at each site include: time of first haul, maximum distance from shore, surface water temperature, surface salinity, primary and secondary substrates types, percent submerged aquatic vegetation, dissolved oxygen, pH, and turbidity.

Annual indices of relative abundance were calculated as the non-stratified Geometric Mean catch per haul of YOY bluefish using data from July-September (Table B6.1, Figure B6.9). Age was assigned by length frequency, with 250 mm FL used as a cutoff for age 0 fish. Attempts at index standardization did not improve indices, so the design-based survey index was recommended.

B6.1.9 NEAMAP Mid-Atlantic/Southern New England Nearshore Trawl Survey

The Northeast Area Monitoring and Assessment Program, Mid-Atlantic/Southern New England Nearshore Trawl Survey (hereafter, NEAMAP) has been sampling the coastal ocean from Martha's Vineyard, MA to Cape Hatteras, NC since the fall of 2007 (Figure B6.10). NEAMAP conducts two cruises per year, one in the spring and one in the fall, mirroring the efforts of the Northeast Fisheries Science Center (NEFSC) Bottom Trawl Surveys offshore. Spring cruises begin during the third week in April and conclude around the end of May, while the fall surveys span from the third week in September until the beginning of November. Sampling progresses from south to north in the spring and in the opposite direction in the fall, so as to follow the general migratory pattern of the living marine resources of these regions.

The survey area is stratified by both latitudinal/longitudinal region and depth. Depth strata between Montauk, NY and Cape Hatteras are 6.1m-12.2m and 12.2m-18.3m, while those in Block Island Sound and Rhode Island Sound are 18.3m-27.4m and 27.4m-36.6m. It is worth noting that, between Montauk and Hatteras, the outer boundary of the NEAMAP Survey any the inner boundary of the NEFSC Survey align. Both programs sample in Block Island Sound and Rhode Island Sound.

Sampling sites are selected for each cruise using a stratified random design; site allocation for a given stratum is proportional to the surface area of that stratum. A total of 150 sites are sampled per cruise, except 160 sites were sampled in the spring and fall of 2009 as part of an investigation into the adequacy of the program's stratification approach. A four-seam, three-bridle, 400x12cm bottom trawl is towed for 20 minutes at each sampling site with a target speed-over-ground of 3.0kts. The gear is of the same size as and nearly identical in design to that used by the NEFSC survey, only sweep configuration and trawl door type differ between the two programs. Tow times and tow speeds are consistent between the two programs. The net is outfitted with a 2.54cm knotless nylon liner to retain the early life stages of the various fishes and invertebrates sampled by the trawl. Trawl wingspread, doorspread, headline height, and bottom contact are measured during each tow, and those in which net performance falls outside of defined acceptable ranges are either re-towed or excluded from analyses in an effort to maintain sampling consistency. A number of hydrographic variables (profiles of water temperature, salinity, dissolved oxygen, and photosynthetically active radiation [PAR]), atmospheric data, and station identification information are recorded at each sampling site.

Following each tow, the catch is sorted by species and, if appropriate, by size group within a species. Size groups are not predetermined for each species, but rather are defined relative to the size composition of that species for that tow. As such, size designations and ranges of small, medium, and large for a species may vary somewhat among tows. Such an approach facilitates representative subsampling, and therefore proper catch characterization, for each tow.

A subsample of five bluefish is selected from each size group from each tow for full processing. Specifically, individual fork length (mm), whole and eviscerated weight (kg), sex, and maturity stage are recorded. Stomachs are removed for diet analysis and otoliths are removed for age determination. For specimens not taken for full processing, aggregate weight and individual fork length measurements (mm) are recorded by size group.

While bluefish are sampled during both spring and fall cruises, catches are more sporadic during the spring survey. Specifically, bluefish have been encountered on only 6.5% of tows on average during the spring cruises, with cruise-specific encounter rates ranging from 4.6% to 9.4%. Although a relatively broad size (106 mm FL to 770 mm FL) and age (age-1 to age-9) range of bluefish have been sampled over the course of the NEAMAP spring surveys, individual catches are typically very small, with 97.8% of tows comprised of two or fewer bluefish. In contrast, bluefish have been encountered on 70.5% of fall tows overall, and this rate has ranged from 62.7% to 79.3% among cruises. Spatially, the percentage of tows in which bluefish were collected by survey region has varied between approximately 53.7% and 91.1%. The size and age ranges sampled during fall cruises are similar to those seen on spring surveys (65 mm FL to 785 mm FL; age-0 to age-10, respectively), but the fall cruises typically yield a greater number of bluefish per tow than do the spring surveys. While only 2.2% of spring tows were comprised of greater than two bluefish, 53.8% of fall tows yielded more than 2 specimens, by comparison.

Bluefish abundance indices as measured by the NEAMAP survey included all ages, all strata, but were limited to fall surveys only. Specifically, a geometric mean catch per standard area swept (Table B6.1) was determined for each year (fall only) by:

$$\hat{N} = \exp\left(\sum_{s=1}^{n_s} \hat{A}_s \hat{\bar{N}}_s \right)$$

where n_s is the total number of strata in which the species was captured, $\hat{A}_s$ is an estimate of the proportion of the total survey area in stratum *s*, and $\hat{\bar{N}}_s$ is an estimate of the $\log_e$ transformed mean catch (number or biomass) of the species per standard area swept in stratum *s* during that cruise. The latter term is calculated using:

$$\hat{\bar{N}}_s = \frac{\sum_{t=1}^{n_{t,s}} \log_e \left(\frac{c_{t,s}}{\hat{a}_{t,s}/25000} \right)}{n_{t,s}}$$

where $\hat{a}_{t,s}$ is an estimate of the area swept by the trawl (generated from wing spread and tow track data) during tow *t* in stratum *s*, 25,000m^2 is the approximate area swept on a typical tow (making the quantity [$\hat{a}_{t,s}$ / 25000] approximately 1), $n_{t,s}$ is the number of tows *t* in stratum s that produced the species of interest, and $c_{t,s}$ is the catch of the species from tow *t* in stratum *s*.

B6.1.10 VIMS Juvenile Striped Bass Seine Survey

The Virginia Institute of Marine Science (VIMS) initiated a seine survey in 1967 designed to monitor the abundance of juvenile striped bass in the James, York, and Rappahannock Rivers, as well as in the main tributaries of these systems (Figure B6.11). While primarily designed to collect striped bass in the shore zones, this survey also has consistently sampled bluefish throughout its time series. Specifically, sampling of fixed sites has occurred twice per month during the months of July, August, and September from 1967-1973 and again from 1980 to the present.

At each site, a 30.5m long by 1.2m deep bagless seine (0.64cm bar mesh) is deployed perpendicular to the shore and then swept back to the land, resulting in the sampling of a quarter-circle quadrant. Two tows are made at each “index” sampling site, while a single sweep is made at auxiliary locations. The two index tows are separated by a minimum of a half hour. Length measurements (mm, fork length) are recorded for up to 25 bluefish per tow. If greater than 25 specimens are collected, the remainder are counted.

In developing an index of abundance (Table B6.1) for young-of-the-year (YOY) bluefish from this survey, areas in which this species have never been encountered (i.e., freshwater reaches of tributaries) were removed from the dataset. All months were included, and bluefish less than 260 mm FL were considered YOY. Overall, since 1981, bluefish have been encountered on 5.5% of the seine tows. This encounter rate varied between 0% and 17.5% across years, and 4.7% and

6.5% among the bi-monthly sampling rounds. Catches ranged from 0 to 19 bluefish. The YOY index of abundance was calculated as geometric mean catch-per-tow and, while variable throughout the time series, seem to show relatively few instances of large recruitment after 1997.

B6.1.11 NC Pamlico Sound Independent Gill Net Survey

The North Carolina Division of Marine Fisheries (DMF) Pamlico Sound Independent Gill Net Survey was initiated on March 1, 2001 and field sampling began in May 2001. The primary objective of the project is to provide independent relative abundance indices for key estuarine species in Pamlico Sound and adjacent rivers.

A stratified random sampling design is used, based on area and water depth. The SAS procedure PLAN was used to randomly select sampling grids within each area (SAS Institute 1985). Sampling gear consists of an array of nets consisting of 30-yard (27.4 m) segments of 3, 3½, 4, 4½, 5, 5½, 6, and 6½ inch (7.6, 8.9, 10.2, 11.4, 14.0, 15.2, 16.5 cm) stretched mesh webbing [240 yards (219.5 m) of gill net per sample]. Gear was typically deployed within an hour of sunset and fished the following morning to keep all soak times at a standard 12 hours.

For every random grid selected, both a deep (1.8 m contour) and shallow array of nets are set. Some deep grids outside the 1.8 m contour were dropped in 2005 due sea turtle interactions and low catch rates of target species. The PSIGNS study is divided into two regions that includes eastern Pamlico Sound and western Pamlico Sound.

Floating gill nets are used to sample shallow strata while sink nets are fished in deep strata. Catches from an array of gill nets comprised a single sample and two samples (one shall, one deep), totaling 480 yards (438.9 m) of gill nets fished, are completed in each field trip.

Sampling initially occurred during all 12 months of the year. This was changed in 2002 and sampling no longer occurs between December 15 - February 14 due to extremely low catches and unsafe working conditions (limited daylight hours and cold temperatures) for the technicians.

Each area within a region is sampled twice monthly during most of the year. This sampling design results in a total of approximately 32 gill net samples (16 deep and 16 shallow samples) being collected per month in each the PSIGNS areas. Beginning in 2011, Area 1 of Region 1 is not sampled during the months of June through August. This reduction in sampling results in loss of 12 samples per year.

Catch rates of bluefish are calculated annually and expressed as an overall CPUE along with corresponding length class distributions. The overall CPUE provides a relative index of abundance showing availability of each species to the study, while the length distribution and age CPUE estimates show the size structure of each species for a given year. The overall CPUE was defined as the number of a species of fish captured per sample and was further expressed as the number of a species of fish at length per sample, with a sample being one array of nets fished for 12 hours. Due to disproportionate sizes of each stratum and region, the final CPUE estimate was weighted. The total area of each region by stratum was quantified using the one-minute by one-minute grid system and then used to weight the observed catches for calculating the abundance indices. Based on these modifications, uniform weighting factors by region and strata were applied to all years and were as follows:

Eastern Pamlico 1: Shallow water - 134.5 square nautical miles (461.9 square km)
Eastern Pamlico1: Deep water - 70.5 square nautical miles (242.1 square km)
Western Pamlico 2: Shallow water - 82.5 square nautical miles (283.3 square km)
Western Pamlico 2: Deep water - 54.5 square nautical miles (187.2 square km)

The CPUE for each age is calculated as an arithmetic mean weighted by strata (Table B6.1, Figure B6.12). The length frequency was determined for both seasons (spring, February – June, and fall July – December), and all four strata. The seasonal Catch-at-age (CAA) was estimated for both seasons using the seasonal length frequencies with seasonal age-length-keys (ALKs). The annual CAA was calculated by number of fish at each age for spring and fall. The annual CAA, in each stratum was multiplied by the stratum weight, and added across stratum to produce the weighted estimate for each age. The weighted estimate for each age is then divided by the total number of samples summed across all strata, producing a weighted annual CPUE for each age. All ages and sizes available were used to calculate the CPUE.

B6.1.12 SEAMAP

The Southeast Area Monitoring and Assessment Program (SEAMAP) fishery-independent trawl survey has sampled the coastal zone of the South Atlantic Bight between Cape Hatteras, North Carolina and Cape Canaveral, Florida since 1989. Its primary intent is to sample the coastal zone of the South Atlantic Bight (SAB) between Cape Hatteras, NC, to Cape Canaveral, FL.

A stratified random sampling design is used, based on area and water depth. For this design, coastal waters of the SAB are divided into 24 coastal latitudinal strata bounded inshore and offshore by the 4 m and 10 m depth contours, respectively. During each sampling season, a random subset of stations within each strata are selected for sampling using paired 75-ft (22.9 m) mongoose-type Falcon trawl nets towed for 20 minutes at 4.6 km/hr (2.5 knots).

Since the inception of the program the SEAMAP-SA Coastal Trawl Survey has used the R/V Lady Lisa to conduct annual surveys of finfish and invertebrate species. During each season, at each randomly selected station the SEAMAP-SA Coastal Trawl Survey deploys paired 75-ft (22.9 m) mongoose-type Falcon trawl nets to conduct bottom trawl surveys. At each randomly selected station, a bottom trawl is conducted by deploying the paired nets for 20 minutes at a constant speed of 4.6 km/hr (2.5 knots). Data elements include numbers caught by species, individual fork lengths (FL; nearest cm), and a suite of environmental information including bottom and sea surface water temperature, depth, and salinity.

The survey is conducted seasonally, with a spring (mid-April to mid-May), summer (mid-July to mid-August), and fall (late-September to mid-November) cruise annually. During each cruise, 52-112 stations between North Carolina and Florida (Figure B6.13) are selected for sampling via optimal allocation among strata for a total of approximately 158-336 stations sampled annually. The proportion of positive tows for age-0 Bluefish averaged approximately 27% across the time series for the fall survey. Index values are provided in Table B6.1.

B6.2 General Survey Results

Correlations among survey indices at age are shown in Figure B6.15. Of 131 comparisons (pairwise n > 0), 89 were positive and 40 were negative. Positive correlations outnumbered negative correlations for all ages except age 0.

Biases

All surveys were designed to sample either species in addition to bluefish or species other than bluefish. However, the BCT set a minimum for % positive tows and minimum for consecutive years of sampling (to eliminate intermittent sampling), consistent with other species (e.g., black sea bass, Atlantic menhaden, tautog), to help ensure surveys were representative of bluefish abundance. In several instance indices were standardized (e.g., RI and SEAMAP), but biases could result if important factors that affect standardization were not included. In most cases, the standardized index and the design-based index resulted in nearly identical trends.

B6.3 Composite YOY Index

States from New Hampshire to Virginia conduct seine surveys for juvenile finfish that capture YOY bluefish (Figure B6.14). These surveys are noisy and cover small geographical areas, compared to the range of bluefish. Bayesian hierarchical modeling was used to combine these indices into a single composite index, using the method developed by Conn (2010), that represents the coast wide recruitment dynamics of bluefish. Surveys included in the composite index were from NH Juvenile Finfish Seine Survey, RI Narragansett Bay Juvenile Finfish Beach Seine Survey, NY Western Long Island Seine Survey, NJ Delaware Bay Seine Survey, MD Juvenile Striped Bass Seine Survey, and VIMS Juvenile Striped Bass Seine Survey (Figure B6.16).

Conn's (2010) method assumes that all indices are tracking the abundance of recruits, but are also influenced by sampling error and process error (e.g., sampling different components of the coastwide recruit population).

$$\log(U_t) = Normal(\log(\mu_t) + \log(q_{it}), (\sigma_{it}^{p})^2 + (\sigma_{it}^{p})^2)$$

A Bayesian analysis was performed to estimate the true trend in relative abundance of recruits as well as the process error and catchability associated with each survey. The input parameters and priors were chosen to be the same as Conn (2010) and the Atlantic Menhaden assessment (SEDAR 2015) used.

A Normal(log(100), 1) distribution was chosen for $\nu_t = \log(\mu_t)$ The mean of this distribution, log(100), was chosen so that the mean of the relative abundance time series would be approximately 100. This number is arbitrary, since we are interested in the trends in relative abundance, not the actual number.

For catchability, which is assumed constant and estimated in log-space, χ_i was set as χ_i = Normal(log(0.01), 0.5), which gives reasonable support to plausible parameter values.

Finally, for process error, Gelman (2006) suggests that a Uniform(0,m) distribution may outperform other choices when there is a small number of group effects. We specified a Uniform(0, 5) prior distribution for σ^p, which gives equal weight to all plausible precision values.

The observed CVs from the surveys was used as the input sampling error. Zero observations were treated as missing data.

All posterior simulation was performed using the software package WinBUGS (Lunn et al. 2000), with the package R2WinBUGS (Sturtz et al. 2005) used to pass data sets between WinBUGS and the R programming environment (R Development Core Team 2007). Standard Bayesian diagnostics were used to assess convergence and stability of results.

The final composite index (Table B6.3) tracked several consistently strong recruitment events that were registered by multiple surveys, and smoothed out the noise somewhat in years with weaker signals (Figure B6.16).

B6.4 MRIP CPUE

The MRIP intercept data was queried to develop a set of directed bluefish trips, defined as any trip that caught bluefish (regardless of disposition) or where the angler reported targeting bluefish. This resulted in a total of 208,947 trips with the complete suite of explanatory variables, of which 46.2% were positive bluefish trips (Figure B6.17 and B6.18).

Factors considered for standardization included:

- Year
- Wave
- Mode (Shore, For Hire, Private/Rental Boat)
- Area Fished (Inshore, Offshore)
- State (Maine – Florida)
- Avidity (number of days that the angler reported fishing in the past year)

An interaction term between State and Wave was also considered, but the model did not converge with that included. The log of effort (number of contributing anglers) was treated as an offset in the models. GLMs using a Poisson distribution and a negative binomial distribution were explored, as well as a zero-inflated model.

Initial model comparisons suggest a negative binomial distribution is more appropriate than a Poisson distribution. (Dispersion = 1.62 with the negative binomial distribution vs. 9.76 with the Poisson distribution; likelihood ratio test of overdispersion of count data was significant at $p < 0.0001$). The zero-inflated model did not converge. The negative binomial was chosen as the final standardization approach, although there is still some overdispersion in the data (Figure B6.19).

All factors were significant for the negative binomial model. However, Area Fished reduced the deviance by less than 5% (Table B6.4) and was dropped from the model. This also resulted in a lower AIC value compared to the full model. The final GLM-standardized estimates of catch-per-unit-effort from the MRIP survey are provided in Table B6.5.

The MRIP CPUE shows a decline in catch per trip during the 1980s and mid-1990s, before rebounding in the late 1990s to fairly stable levels since 2000 (Figure B6.20).

B6.5 Spatial distribution of stock over time

For SAW60 Manderson et al. (2015; WP B4) investigated bluefish distributions and the degree to which spatial distribution shifts were statistically related to changes in ocean temperature, abundance and body size. Manderson et al. (2015) also described the development and evaluation of time varying estimates of the proportion of thermal habitat suitability for bluefish sampled on the NEAMAP & NEFSC bottom trawl surveys that could be used to account for effects of ocean temperature on the availability of the population to surveys in the stock assessment. The details are available in WP B4.

Within the NEFSC survey, age 0 (≤ 28 cm) and age 1+ bluefish (> 28 cm) shifted distribution from 1973 through 2014 but not in a systematic direction. Analysis of the centers of biomass (COB) indicated that COB positions were correlated with variations in body size and abundance, but not temperature. A parametric thermal niche model for bluefish using data from the NEFSC and NEAMAP bottom trawl surveys from 2008-2014 was used to evaluate with data collected by NEFSC before 2008 and 6 inshore surveys performed on along the US east coast at locations ranging from Jacksonville, Florida to Massachusetts. The model estimated that ~44% of thermal habitat suitability available from Cape Hatteras to Nova Scotia was sampled by the NEFSC inshore and "offshore" inshore strata to be used in the 2015 assessment. In the NEAMAP survey ~20% of available thermal habitat suitability on the northeast US shelf was sampled. Yearly estimates of the proportion of thermal habitat suitability surveyed did not exhibit consistent trends (Figure B6.21).

B6.6 Age-length data and utility of age data for stock assessment

As noted elsewhere in this document (TOR 2), the WG expended considerable effort investigating age length data and evaluating the utility of age length keys for use in this assessment. The WG could not recover any age data from 1982 (the first year in the SAW41 model) and determined that age data were too sparse from 1983 and 1984 to be considered reliable. Consequently, the WG elected to start the model in 1985.

NC scale and otolith data from early in the time series (1985-2000) required adjustments prior to their eventual use in this assessment. The SAW41 assessment document suggested that the raw spring NC data used a January 1 birthday and that other sources of spring data were incompatible with the NC data, but the WG determined that the reverse situation existed. The WG graphically demonstrated that a birthday problem existed with the spring early NC scale and otolith data (Figure B6.22, Figure B6.23), subsequently demonstrated that a birthday problem did not exist in other sources of spring data, and ultimately used all sources of age data with a January 1 birthday to inform a reclassification of spring NC age data (see WP B6 for more details).

In response to concerns expressed at SAW41 about sharing data across time, the WG conducted an analysis (WP B8) and quantitatively determined that in general sharing age data across time should be avoided. This put the WG in the position to have to either reclassify spring NC age data on an annual basis where sample sizes were small, not use spring NC age data (which would have truncate the time series considerably), or pool spring January 1 birthday data to inform reclassifying spring NC data. The WG felt comfortable that the adjustment algorithm[3] provided reliable results (Figure B6.24) and was a superior outcome to the alternatives of further truncating the times series (especially in light of available data from 1997-2005) or using the raw data. It is important to note that all fall data used a January 1 birthday and therefore required no adjustments.

Age data from 1997-2004 garnered a lot of attention from reviewers at SAW41 (Jones 2005). An additional source of age data from this time period was evaluated by the SAW60 WG and used for the present assessment. As noted above, NC otolith data from 1996-2000 was considered incompatible with existing data for SAW41; but the SAW60 WG determined that with the exception of spring age 0 fish (Figure B6.23), which were changed to age 1 based on biological considerations, those data could be used for this assessment. This addition allowed for some disaggregation of multi-year spring keys (Table B5.2), however, since no additional sources of fall data were available for the same years, the SAW60 WG was not in a superior position with respect to the age data for this general time period. In terms of utility for stock assessment, the WG elected to set effective sample sizes to a low value for this time period (1997-2004[4]) in acknowledgement of the data uncertainty. See TOR4 for more details.

The situation for age data in the years following SAW41 is very good. Beginning in 2006 NC resumed a bluefish biological collection program. Substantial numbers of bluefish otoliths have been collected as part of this program (Table B6.6). In an effort to further improve coast wide age length keys, MA initiated its own biological collection program in 2009, and NJ followed in 2010. In 2012, Addendum to Amendment 1 to the bluefish fishery management plan required additional states (those that accounted for >5% of total coast-wide bluefish harvest) to collect a minimum of 100 bluefish ages (50 from January - June; 50 from July - December), further improving the quality of age length keys. These additions to the coast wide biological collection program have greatly improved the age length keys for use in this assessment (Figure B5.3 and B5.4 and WP B5).

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3 Briefly, based on biological considerations, all NC spring age 0 fish were changed to age 1. For all other ages, save 6+ which would not require any adjustments, from all data (by age) known to have a January 1 birthday, use the mean + $t_{0.05(2)}$ * SD (~ 2 * SD) of age i fish as the criterion to determine whether NC spring fish become age i+1. That is, for example, if the length of an age 1 NC fish was > the mean + $t_{0.05(2)}$ * SD of all other data sources of age 1 spring fish, the NC fish age would change to 2.
4 The WG also used a low ESS for 1995, which had a very sparse spring ALK (Table B5.3).

B7. TERM OF REFERENCE #4: Estimate relative fishing mortality, annual fishing mortality, recruitment, total abundance, and stock biomass (both total and spawning stock) for the time series, and estimate their uncertainty. Explore inclusion of multiple fleets in the model. Include both internal and historical retrospective analyses to allow a comparison with previous assessment results and previous projections. Explore alternative modeling approaches if feasible.

B7.1 Bluefish SAW 60 Assessment model

B7.1.1 History of the current (SAW41) bluefish assessment model

The current assessment model for bluefish has provided management advice since 2005 and was accepted at the Stock Assessment Workshop 41 review (NEFSC 2005). After reviewing several model types including a modified Delury model, a surplus production model, a VPA and catch-at-age models, the bluefish Technical Committee concluded that age-based models such as a VPA or catch-at-age were the most appropriate for the bluefish assessment. The bluefish data were truncated to an age-6+ category to reduce the influence of ageing error. In addition, the catch-at-age distribution in past assessments was bimodal, which was reduced with inclusion of more ages into a plus group.

The NFT ADAPT version of VPA was used as an initial model with a catch-at-age matrix from 1982 to 2004 through age-6+. The SAW-17 review of a bluefish assessment suggested that values of M should range from 0.2-0.25 instead of M=0.35 (NEFSC 1994a). Since the oldest aged bluefish is 14, an M of 0.2 was appropriate, using M=3/oldest age. The initial input PR was bimodal with a maximum value at age-1 of 1.0 and age-5 value of 0.74. The F ratio was set at 1.4 to create a higher F in the age-6+ group, forcing the model towards a bimodal F pattern. Full F was calculated as an average of F from age-2 to age-4.

Maturity at age was held constant over time as 0 at age-0, 0.25 at age-1, 0.75 at age-2 and 1.0 thereafter. Following initial runs including all available indices, the tuning indices were truncated based on proportional variance contributions to the overall model variance. The final tuning indices were limited to those with adults present:

1. NEFSC inshore (age-0 – age-6+)
2. CT trawl indices (age-0 – age-6+)
3. NJ trawl indices (age-0 – age-2)
4. DE adult trawl indices (age-0 – age-2)
5. Recreational CPUE (age-0 – age-6+)
6. SEAMAP series to include an age-0 recruitment series from the South Atlantic Bight.

Tuning was made to mid-year population size.

The Technical Committee concluded that although the VPA produced satisfactory results, the assumption of no error in the catch-at-age matrix and the way ADAPT handles selectivity may produce misleading results. Therefore, a catch-at-age model, ASAP from the NFT models, was chosen as the primary assessment tool. The ability of the ASAP model to allow error in the catch-at-age as well as the assumption of separability into year and age components makes it better suited to handle the selectivity patterns and catch data from the bluefish fishery.

The input values from ADAPT were used as initial values for the ASAP model. ASAP allows selectivity and catchability patterns to vary over time. The model was structured to allow greater deviations from the indices than from the catch-at-age data. A selectivity pattern was fitted to the data and held constant for the periods 1982-1990, 1991-1998 and 1999-2004. Recruitment was allowed to deviate from the fitted model after the 4th year. Full details of the SAW41 model characteristics and settings are provided in the 'SAW60 Model Building' section under 'Update the current model.'

The Bluefish Technical Committee concluded that the results of the ASAP model were the best representation of the Atlantic coast bluefish population. There was some tradeoff in the goodness of fit between the catch-at-age and survey indices in the model, but the overall model results were considered acceptable. The results also corresponded well to ADAPT model results. Although the agreement between models did not validate either model, it indicates that there was some signal in the data that could produce consistent output in two models with different assumptions. The model results lead to the conclusion that the Atlantic stock of bluefish was not experiencing overfishing nor was it overfished.

B7.2 SAW60 Model Building Introduction

The SAW60 model building procedure for bluefish was accomplished over multiple steps. The first step was to carry out a continuity run, which updated the current assessment model with data through 2014. A base model was then constructed by adding new data (CAA, WAA, and maturity) and indices to the continuity run, keeping the same model settings and weights. A model bridge was then built from the base model to a final model by changing model settings, weights, and data. In total, about 75 models were explored during this bridge building procedure. The model steps with the most important changes that provide a linear path from the base model to the final model are presented below. Table B7.1 provides a brief model description and a summary of the important parameters at each step.

The SAW60 working group maintained ASAP as the model for assessing bluefish. ASAP is an age-structured model that uses forward computations assuming 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 years. Weights (Lambda and input CVs) 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 age composition are modeled assuming a multinomial distribution, while most other model components are assumed to have lognormal error. Specifically, lognormal error is assumed for: total catch in weight by fleet, survey indices, stock recruit relationship, and annual deviations in fishing mortality. 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 recruit relationship). For more technical details, the reader is referred to the technical manual (Supporting documentation: ASAP manual, Legault 2012).

B7.3 Building a model bridge from the current model to the final model

B7.3.1 Update the current model through 2014: Model B001: Continuity Run

The current model for bluefish is heavily weighted towards the catch. Recreational landings, recreational discards, and commercial landings are input into the model as a single fleet. The input CV around catch is set at 0.01 and the effective sample size is constant at a value of 30. The model weighting parameter (lambda) for the catch is set at twice the value of the indices. Selectivities are fixed for both catch and the indices and multiple penalties constrain different estimates included in the objective function. These include penalties on recruitment deviations, FMult in the first year, index catchabilities, and numbers in the first year. A stock recruitment relationship is not fit in the model and steepness is fixed at a value of 1. The weighting factors and penalties in the continuity run result in a very constrained model.

Model B001, the continuity run, is the first model explored in the model building process for SAW 60. The continuity run was carried out as update of the SAW41 final model. Total catch, catch-at-age, weight-at-age, and indices-at-age were updated for 2014. The fishery was modeled as a single fleet with selectivity fixed as a bimodal pattern with full recruitment at age 1 (selectivity values = 0.338, 1.0, 0.942, 0.476, 0.343, 0.694, and 0.914, for ages 0-6+, respectively). In addition, 6 indices of abundance were updated for 2014:

1. NEFSC inshore (age-0 – age-6+)
2. CT trawl indices (age-0 – age-6+)
3. NJ trawl indices (age-0 – age-2)
4. DE adult trawl indices (age-0 – age-2)
5. Recreational CPUE (age-0 – age-6+)
6. SEAMAP series to include an age-0 recruitment series from the South Atlantic Bight.

Indices were input at age with full selectivity (1.0) fixed on the input age. Natural mortality was kept constant at 0.2 for all ages and all years. Maturity was fixed across years at a value of 0 for Age 0, 0.25 for Age 1, 0.75 for Age 2, and full maturity at Age 3+. Complete model specifications and weightings for model B001 are presented in Table B7.2.

The component contribution of the objective function for model B001 show how the model is weighted very heavily towards the single catch fleet (Figure B7.1). Estimates from the model show a decrease in total abundance since 2006, declining from 83.6 million to 57.7 million fish (Figure B7.2). Following a peak in recruitment in 2006 of 30.8 million fish, recruitment has remained below the time series average of 20.5 million, and stays below average in 2014 at an estimate of 14.7 million fish (Figure B7.3). Total biomass in 2014 (Jan 1) equaled 92,755 mt, a slight decrease from the 2013 estimate of 107,443. Corresponding spawning stock biomass (SSB) in 2014 was 84,800 mt, a slight decrease from the 2013 estimate of 98,070 mt (Figure B7.4).

The 2014 F_{MULT} value equals 0.141. Fishing mortality steadily declined from 0.35 in 1987 to 0.12 in 2012 and has increased over the past two years (Figure B7.5).

Retrospective bias for the continuity run was examined for F, SSB, and recruitment (Figure B7.6). The analysis shows consistent but minor bias in the estimates of F and SSB, with Mohn's rho values of -0.09 and 0.10, respectively. A more prominent retrospective bias is present in the recruitment estimates going back to the early 2000's (Figure B7.6). This bias has been increasing in recent years, and has flipped from a positive bias early on to negative bias more recently (Mohn's rho avlue = -0.19). The variation in the final continuity model estimates for F and SSB was determined using a Monte Carlo Markov Chain with 1000 iterations and a thinning factor of 100. The MCMC distribution for SSB ranged from 74,656 to 98,154 mt, with an 80% CI between 79,384 mt and 89,590 mt. (Figure B7.7). The MCMC results of variation around F ranged from 0.12 to 0.161, with the 80% CI between 0.132 and 0.150 (Figure B7.8).

Model B002: Cropping the continuity run to start in 1985

The working group re-built catch-at-age and weight-at-age information back to 1985 using all available age data and length samples. The working group was unable to find original age length keys and was unable to find raw age data from 1982-1984. Instead of using the current CAA and WAA information from those years (carried over from SAW41) the working group made the decision to start the new model in 1985. Model run B002 examines the effects of cropping off data from 1982-1984 on the continuity run. The main effect of starting the model in 1985 was to shift recruitment and total stock numbers upwards. F, SSB, and TSB increased minimally while TSN (000s) increased from 57,671 to 70,867, and recruitment (000s) increased from 14,696 to 21,528 (Table B7.1).

B7.3.2 Moving from the continuity run to a final model

Model B004: Base Model

The base model run uses continuity model specifications with newly calculated CAA, WAA, and total landings data from 1985-2014, and new survey indices of abundance. The new indices of abundance are input at age to maintain consistency with the continuity run. The bluefish working group decided on 9 representative indices of bluefish abundance for the SAW60 assessment:

1. NEFSC Fall inner inshore strata: 1985-2008 (age-0 – age-6+)
2. NEFSC Fall outer inshore strata: 1985-2014 (age-0 – age-6+)
3. Marine Recreational Information Program CPUE: 1985-2014 (age-0 – age-6+)
4. NEAMAP Fall Inshore trawl survey: 2007-2014 (age-0 – age-6+)
5. Connecticut Long Island Sound Trawl Survey: 1985-2014 (age-0 – age-6+)
6. Pamlico Sound Independent Gillnet Survey; 2001-2014 (age-0 – 6+)
7. New Jersey Ocean Trawl Survey: 1990-2014 (age-0 – age-2)
8. SEAMAP Fall Inshore trawl survey: 1989-2014 (age-0)

9. Composite YOY seine survey: 1985-2014 (age-0)

In past stock assessments, the instantaneous natural mortality (M) for bluefish has been assumed constant over all ages and years at a value of 0.2. This study used longevity and life-history based equations to estimate different possible values for M. Taking the maximum age for bluefish to be 14 years (observed age in the data used in these analyses), the 'Rule of thumb' method (3/tmax) give a natural mortality estimate of 0.21. Additional longevity based estimates from equations in Hoenig (1983) and Hewitt and Hoenig (2005) give values of 0.32 and 0.3, respectively. Estimates based on equations that use growth parameters from Then et al. (2014) and Jensen (1996) give values of 0.20 and 0.195, respectively. The mean value for natural mortality using the estimates from these 5 approaches is 0.245. Age-specific estimates were calculated using based on the work of Lorenzen (1996, 2000) and Gislason et al. (2010). These values ranged from 1.70-0.17 over the age range of 0-14 (Table B5.5). Based on the results of all the methods explored to estimate natural mortality for bluefish, the assumption of M = 0.2 is reasonable and is maintained for the benchmark assessment.

The results from the base model are very similar to the continuity run (B001), and differ in total number and recruitment estimates when compared to model B002. Using the newly calculated data and new indices in model B004 resulted in almost no change in the 2014 F between model B002 (F = 0.145) and model B004 (F = 0.146). However, estimates of F from model B004 were consistently higher from 2002 to 2013 (Figure B7.9). Total stock numbers (000s) decreased from 70,867 to 57,534, and recruitment estimates (000s) decreased from 21,528 to 15,731. These changes are driven by lower estimates of Age 0 through Age 2 numbers from the new data (Table B7.1 and Figure B7.10).

Model B006: Change indices from at-age to estimate age composition

The preferred approach for including survey indices of abundance in ASAP has shifted from at-age input to a catch-at-age matrix input. In this model run, the new input survey indices are shifted from at-age to a catch-at-age matrix, and are modeled with multinomial error to estimate proportions at age. The total numerical index for each survey is modeled with lognormal error to estimate overall population trend. Young of the year indices (SEAMAP and the composite YOY index) are still input at-age.

Estimating age composition for each of the survey indices in model B006 resulted in a noticeable increase in all 2014 model estimates except for F. The objective function increased considerably and while a direct comparison cannot be made to the objective function from model B004, the increased contribution of the index fit and index age composition is important to note. This model, while still heavily weighted towards the catch is now being driven more by the indices (Figure B7.11). The estimate of F decreased to 0.119, and estimates for total stock numbers, spawning stock biomass, total stock biomass, and recruitment all increased considerably. The scale of total biomass and spawning stock biomass was shifted downwards at the beginning of the time series resulting in flatter trends from 1985-2014 (Table B7.1, Figure B7.12). Figure B7.13 shows the estimates for index selectivity from model B006.

Model B007: From single catch fleet to two fleets: Commercial and Recreational

The fishery for bluefish is predominantly a recreational fishery (80+%) and the recreational data on landings, lengths, and discards are collected very when compared to the commercial fishery data. There is enough information for both fisheries to build separate catch-at-age, weight-at-age and total landings time series. Model B007 separates the single fleet fishery into a commercial and recreational fleet. Incorporating multiple fleets addresses a specific portion in term of reference 4 which tasks the working group to "Explore inclusion of multiple fleets in the model." In addition, it is more appropriate method for modeling the bluefish stock because of the differences between the fisheries.

Separating the fleet data into two fisheries scaled up the entire time-series of fishing mortality estimates and decreased estimates of total stock numbers and biomass (Table B7.1, Figure B7.14). The recruitment time-series from model B007 is similar to model B006 but seems to be smoothed at the end of the time series (Figure B7.15).

Model B008: Update maturity information

Maturity-at-age was updated from a preliminary analysis of data presented in the section and working paper for TOR2. Estimates of maturity-at-age for bluefish have persisted from the 2005 ADAPT VPA model (modeling work prior to the final SAW41 ASAP model) where values were (arbitrarily?) chosen to be: 0, 0.25, 0.75, and 1.00 for ages 0 to 3+, respectively. For this model run a maturity ogive was fit using logistic regression to a preliminary bluefish age/maturity dataset and the estimates of: 0, 0.41, 0.86, and 1.00 for ages 0 to 3+, respectively, were used. It should be noted that further along in the model building process final estimates for the maturity ogive were used (model B023). At this step, the new maturity information was not that different from the maturity-at-age previously used, and only resulted in a slight increase in spawning stock biomass (Table B7.1, Figure B7.14).

Model B011: Change from fixed fleet selectivities to estimated

Prior to model B011, fleet selectivity has been fixed assuming a bi-model selectivity at-age carried over from SAW41. The bi-modal selectivity pattern for the bluefish fishery has been present since the beginning of the assessment time-series. This pattern has been observed in both commercial and recreational length frequencies and as a result in the CAA matrix input to the model. There is a dynamic of the bluefish population that occurs at age 3 – age 4 that is unobserved and likely affects availability of the population at these ages. Bluefish carry out sized based migrations so a larger portion of the population at these ages may be staying south or offshore each year. Since the main fisheries for bluefish are coastal and operate north of Cape Hatteras, North Carolina this would result in reduced available of this size/age class.

Model B011 estimates fleet selectivites and assumes starting values equal to the previously fixed values. Full selectivity is fixed at age 1 in both the commercial and recreational fleet. Estimated selectivities for both fleets maintain a bi-modal pattern, with the recreational fleet having higher selectivity at all ages (Figure B7.16). Estimates of F slightly increased in model B011 to a value of 0.145. Total stock numbers, recruitment, and biomass estimates increased at a larger scale as a result of estimating fleet selectivities (Table B7.1).

Model B020: Estimate 2 selectivity blocks per fleet

A number of model iterations were conducted that investigated different selectivity blocks for each fleet between model B011 and B020. The working group decided to continue the model building process with two selectivity blocks per fleet: 1985-2005, 2006-2014. These blocks were chosen based on data quality assumptions associated with age data early on in the time series (scale age data) versus later in the time series (otolith age data). The working group put a great deal of effort into uncovering, addressing and resolving these issues. A full write up on the age data can be found in TOR 2 and 3 sections of this document.

Changing the model to include two estimated selectivity blocks per fleet resulted in significant shifts in all estimates (Table B7.1). Selectivity in block 1 for both fleets was estimated assuming bi-modal selectivity-at-age with full selectivity fixed at age-1. Selectivity in block 2 for both fleets was estimated assuming a bi-modal selectivity-at-age with full selectivity at age-2. The shift to full selectivity at age-2 was made after multiple iterations and fitting both at-age selectivity and assuming a double logistic fit. Commercial and recreational fleet selectivity in time block 2 are dome shaped with a single mode, unlike the bi-modal selectivities estimated in the early time block (Figure B7.17). The domed selectivity at older ages in block two is resulting in the large increase in biomass estimates from Model B011 to B020 (Figure B7.18).

Model B020A: ESS = 0 in middle time-block (1997-2005)

The age keys used from 1997-2005 have the least amount of year specific information. As described in TOR 2 and 3 of this document many of the seasonal keys borrow across years during this time period. Previous reviews (SAW41) highlighted the negatives of this approach and the how it is likely inappropriate to borrow across years or seasons to fill in the sparse age keys. A number of analyses were carried out and confirm that borrowing across years is not valid for bluefish (WP B8). Unfortunately, the keys are too sparse during this time period and borrowing is unavoidable. To mitigate the effects of borrowed keys model B020A sets the effective sample size for these years equal to 0, and does not fit to the age composition. This has a minimal effect on the model estimates when compared to model B020A (Table B7.1 and Figure B7.18).

Model B021: Change weighting factor input style. Set Lambdas = 0 or 1.

Model B021 was an important step in the model building process. Up until this point, model weighting factors (lambdas) were consistent with the inputs used in the continuity run (Table B7.1). The method of weighting used in the continuity run is not the preferred method, and in some cases was emphasizing portions of the objective function more than expected. The preferred method is to use the lambda values as a switch to turn on or off portions of the objective function (0 = off, 1 = 0). When these weighting factors are switched on, the input value and input CV act as a prior during the minimization of the associated portion of the objective function. In the continuity run, and all models in the bridge up to this point, many of the lambda values were > 1 and acting as both a switch, and a weight. This resulted in very constrictive priors around the associated portions of the objective function.

The switch in weighting style for this model gave equal weight to the two catch fleets, and the 9 survey indices. This equal weighting is reflected in the likelihood contribution for each of the components in the objective function (Figure B7.19). Estimates of F did not significantly change from Model B020A, however the entire scale of total population numbers and biomass time-series decreased dramatically. Surprisingly, recruitment estimates remained almost identical to model B020A (Table B7.1).

Model B021A: Turn likelihood constants off in the objective function

Recently, an issue with constants in likelihood function of ASAP has been uncovered. The specific issue has to do with a constant that depends on recruitment parameters. The lognormal distribution with notation specified for application to recruitment deviations is:

$$\frac{1}{R_{y,v}\sqrt{2\pi}\sigma} e^{-\frac{(\ln(R_{y,v})-\ln(R_{y,e}))^2}{2\sigma^2}}$$

where $R_{y,v}$ is the recruitment value estimated in year y, σ is the user supplied standard deviation of the recruitment deviations, and $R_{y,e}$ is the recruitment expected from the underlying stock-recruit curve. The negative log likelihood, $-\ln(L)$, which is what is used in the objective function for most applications, equals:

$$-\ln(L) = n_{rec}\frac{ln(2\pi)}{2} + \sum ln(R_{y,v}) + n_{rec}ln(\sigma) + \frac{1}{2}\sum\frac{\left(\ln(R_{y,v}) - \ln(R_{y,e})\right)^2}{\sigma^2}$$

where n_{rec} is the number of recruitment deviations. The first three terms on the right hand side of the equation are often referred to as constants (assuming σ is not an estimated parameter) that do not affect model estimation and so are often dropped from the likelihood. However, in this case, the term $\sum \ln(R_{y,v})$ is not a constant and depends on model parameters. Consequently, ignoring this term as a constant is technically incorrect, while retaining the term may have unintended consequences for model fit. Preliminary work demonstrates that including this term can, in some cases, lead to underestimates of recruitment because the objective function can be reduced by lowering the estimated recruitment values.

Model B021A turns off the likelihood constants in the objective function, the current preferred method for dealing with the above issues. All estimates from the model increased when these likelihood constants were turned off (Table B7.1). The recruitment estimates are no longer being lowered by the specific likelihood constant which is likely resulting in the increased estimates.

Model B022: No penalty on numbers in the first year deviations

Model B022 removes one of the two remaining penalties on numbers in the first year deviations. Lambda for these values was switched on in all previous model runs and the input CV was set at 0.9. This penalty served to scale the initial population biomass by assuming a prior distribution around the numbers in the first year. We do not have any prior information relating to initial stock numbers so it is preferable to allow the model complete flexibility around these estimates. Turning off this penalty reduced the estimates of F from model B021A, and caused numbers and biomass estimates to scale up again (Table B7.1 and Figure B7.20).

Model B023: Finalized maturity-at-age data

Maturity-at-age was updated from a final analysis of data presented in TOR 2 and WP B2. In previous models, the estimates of maturity-at-age were from an analysis of a preliminary bluefish age/maturity dataset: 0, 0.41, 0.86, and 1.00 for ages 0 to 3+, respectively, were used. After compiling a final dataset of all available bluefish maturity-at-age information a logistic regression was refit to estimate a maturity ogive. The final values used in model B023 were: 0, 0.40, 0.97, and 1.00 for ages 0 to 3+, respectively. Spawning stock biomass estimates were the only minor change resulting from this new maturity ogive (Table B7.1).

Model B 024: Increase the CV around recruitment deviations from 0.5 to 1.0

Model B024 increased the CV around the recruitment deviations from 0.5 to 1.0 to give the model more flexibility around these estimates. This causes very little change in estimates from the previous model (Table B7.1). It should be noted that sensitivity runs were carried out in an attempt to remove this penalty completely; however, the resulting models had issues with convergence and scale.

Model B025 and Model B027: Change some selectivities

Model B025 and B027 shifted selectivities on time block 2 of the fleets from selectivity-at-age to double logistic, and from double logistic to selectivity-at-age for the NEFSC survey indices. These changes were to better match the selectivity patterns coming out of the previous models. Making these changes resulted in very little differences in model estimates from previous model runs (Table B7.1).

Figure B7.21 shows the differences in model estimates from model B022 and B027 to gauge the impacts of the various minor changes between these model steps. The total effect was to minimally decrease the main estimates coming out the model.

Model B028: Revert back to 1 selectivity block per fleet

During the model meeting for the SAW60 bluefish assessment the working group discovered an issue with the early spring scale age data coming from North Carolina. The working group was always aware of a disparity between the scale age data in the early time series (1985-1996) and the otolith age data later (2006-2014). The reason for the disparity was pinpointed to spring North Carolina ages and the likelihood that some of these ages represent a biological birth date as opposed to assuming a Jan 1 birth date (the accepted ageing protocol practice for bluefish). A very detailed description of the analyses and the correction the working group made to these scale ages can be found in the TOR3 age section of this document and WP B6.

Model B028 was run in anticipation of including corrected data in the model. The working group's initial justification for splitting the fleets into selectivity blocks was the disparity in age data between time blocks. Having corrected these data, there was no longer justification to split the fleet selectivities into two blocks. It should be noted there have been no specific fishery changes or management changes for bluefish over the time series that would result in a fishery selectivity change.

Fleet selectivity was estimated at-age for both fleets assuming starting values equal to the fixed selectivity values from SAW41. Shifting back to one selectivity block per fleet had a small effect on the model estimates and shifted the scale of all estimates down (Table B7.1).

Model B029: Change the NEFSC surveys to split off the Bigelow survey

For model runs previous to this model, the NEFSC fall survey has been split into inner inshore strata and outer inshore strata. The inner inshore strata time-series was sampled by F/V Albatross IV from 1985-2008. The sampling of these strata has been taken over by the NEAMAP survey, which is included as an index of abundance from 2007-2014. The outer inshore strata were sampled by F/V Albatross IV from 1985-2008, and from the NEFSC new research vessel the R/V Bigelow from 2009-2014. The Bigelow is not able to sample the shallower inner inshore band which the NEAMAP survey now samples. For the outer inshore survey, a conversion factor has always been applied to Bigelow units to correct them to Albatross equivalents. The value used in past update assessments was 1.16 and comes from an extensive calibration study between the vessels (Miller et al. 2010).

At the model meeting for SAW60, the working group decided to shift the NEFSC indices and move forward with the Bigelow split off a separate time series. It has been a decade since the last benchmark assessment for bluefish and it is likely there will be an extended period before the next benchmark. While the Bigelow time series is currently only 6 years, the value of this time series to the model, without having to use a conversion factor, will increase over the next few years.

In model run B029, an NEFSC inshore survey using all inshore strata (all Albatross data) and a Bigelow survey representing the outer inshore band of strata were used as indices of abundance. Splitting off the Bigelow time-series and changing the input indices for the NEFSC fall survey had very minor impacts on the model estimates. The estimates of fishing mortality, total stock numbers, recruitment and biomass all decreased very slightly from the previous model run (Table B7.1).

Model B030: Switch MRIP selectivity to match fleet 2

Model B030 is a result of questions raised at the bluefish SAW60 model meeting. Previous to Model B030, the MRIP index assumed different starting values for selectivity than the recreational fleet. The question was raised as to why the two selectivities did not match even though the time series of landings and the CPUE index are derived from the same data. This fact is not entirely true, and the working group has addressed that in a later model run (B042).

The comparison to the selectivity of fleet 2 was not the only issue discovered with the input selectivity for the MRIP Index. The previous selectivity was not fixed at any age and the model was free to estimate all parameters. Previous model runs should have had a fully selected age for this index and without it the biomass estimates from these models were biased low. The MRIP index is the most important index in the bluefish assessment as it drives age composition estimates for the older ages. Most of the other surveys do not catch many older fish.

Model B030 changes the starting values for the MRIP index selectivity to match the starting values for the selectivity of fleet 2. Fish are fully selected at age one and the input matches the previously described bi-modal pattern. Figure B7.22 presents the model B029 selectivity estimates for the MRIP index, as well as model B030 selectivity estimates for both the MRIP index and Fleet 2. The MRIP index has higher selectivity at older ages than Fleet 2. See the write up for B042 for an explanation of why the selectivities are different, and why at-age selectivity for MRIP is probably not appropriate.

Switching the input selectivity patterns for the MRIP index significantly increased biomass estimates. As mentioned previously, MRIP is the most important index in the model, especially for tracking older ages. The doming of the selectivity estimates at older ages seemed to create a lot of cryptic biomass in model run B030. Estimates of fishing mortality declined slightly from previous models and estimates of total stock numbers, and recruitment increased (Table B7.1 and Figure B7.23).

Model B033: Early NC scale ages corrected and data were re-calculated

Model B033 has the same model specifications as Model B030 except revised data are used. In this model issues with NC scale age data from 1985 to 1996 have been corrected (see TOR 2 and 3 of this document and WP B6 for a detailed explanation). The implemented correction decided up on by the working group bumped groups of scales up 1 age. This had a predictable outcome of decreasing F, and increasing the estimates of numbers and biomass when compared to model B030 (Table B7.1, Figure B7.23).

Model B035: Switch PSIGN selectivity from double logistic to at-age

This model made minor change to the PSIGN selectivity which was being estimated as a double logistic selectivity curve. The selectivity for this index was switched to at-age and the resulting changes to the model estimates were minor increases in stock numbers and biomass (Table B7.1).

This model was final model formulation coming out of the SAW60 model meeting. Plans were to make minor changes to input CVs, and effective sample size changes to finalize the model. The working group was concerned about the inflated biomass estimates and the problem of cryptic biomass. However, no cause or resolution was determined prior to the end of the meeting. Part of the finalization of the model involved running a retrospective analysis. The results indicated somewhat severe retrospective bias in all of the estimates (Figure B7.24). In order to determine the cause of the retrospective patterns, retrospective analyses were carried out in a stepwise manner, for each previous model in the model building process. It was determined that the dome in MRIP selectivity was causing the retrospective patterns as well as the cryptic biomass.

Model B042: Change MRIP selectivity to single logistic and increase fleet 2 input CV

In model B042, a flat-top, single logistic curve was input for the MRIP selectivity. This fixed both the retrospective patterns seen in model B033 and removed the cryptic biomass being estimated by the model.

Re-visiting an earlier question: Why is the selectivity of the MRIP index different from Fleet 2 (the recreational catch) if they are developed from the same data? For the recreational catch the working group assumed a 15% mortality rate for the recreational discards. However, to calculate the MRIP index at-age, all of discard data were used. This is important because there is a very noticeable difference in the size distributions of landed fish versus discarded fish. Bluefish are a unique recreational species in that the size distribution of the discards is much larger than the landed fish (Figure B4.11). This can be attributed to the fact that bluefish are a very oily fish, more so at larger sizes, and for many people large bluefish are unpalatable. This leads to a domed selectivity for the recreational catch because most of the larger sized fish are released. However, it is safe to assume these ages are fully selected by the discards and should be fully selected for the MRIP index since 100% of the discards are used to calculate the age proportions. The working group used this reasoning to justify shifting the selectivity for MRIP from a selectivity-at-age to a flat-top, single logistic curve, that fully selects the older ages.

The estimates from model B042 are have shifted drastically from prior model runs. Fishing mortality increased, and total stock numbers, recruitment, and biomass estimates have decreased. As mentioned previously, the new selectivity estimates for MRIP eliminated the cryptic biomass being estimated by earlier models and greatly reduced the retrospective bias in the estimates. Total biomass and spawning stock biomass estimates from model B042 were around 50% of the estimates from the previous model (Table B7.1 and Figure B7.25).

Model B043: adjustments to input CVs and effective sample sizes

One of the final changes in the model building process was iterative adjustments to the input CV of each index to account for additional process error. The model was re-run and adjustments were made for each index until the root mean square error of the index was close to a value of 1.0. In addition to fine tuning the input CVs of the surveys, a low effective sample size was assigned to the middle period time block 1997-2005. The working group decided while the age information in this time block was poor (because of pooled age keys and borrowing across years) a small effective sample size should be input to generate some information about age composition in these years.

Model B043 had similar estimates to model B042 with slightly greater fishing mortality, total stock number, and recruitment estimates, and slightly decreased estimates of biomass (Table

B7.1).

<u>Please note, this model was the final SAW60 WG model that was taken to the SARC60 review. For full diagnostics and results from this model please see appendix B7.</u>

B7.3.3 A Final Model

Model B044 (BFINAL): Final model after SARC60 review

Model B044 is the new final bluefish model resulting from the SARC60 benchmark review. At the review, the review panel discovered a model misspecification in the selectivity parameters for the MRIP index. A parameter in the function describing the curve for selectivity was fixed when it was intended to have been freely estimated by the model. This was causing patterning in the age composition residuals for this index. The final revised model corrects this misspecification. The values presented in this report reflect the output from the revised model as accepted at the review.

Final model data summary: Catch proportions for the recreational fleet ranged from 66% to 84% of the total catch (Figure B7.26). Catch-at-age for both fleets is predominantly age 0 to age 3, with the recreational fleet catching more age 0, and both fleets catching lesser numbers at older ages (Figures B7.27 and B7.28). Overall survey index trends are generally flat, with noticeable peaks for some of the indices early in the time series, and around 2005 (Figure B7.29). Input age composition for the indices are presented in Figures B7.30 through B7.35. Final model inputs for weight-at-age of the fleets, natural mortality, and maturity-at-age are presented in Figures B7.36 through B7.41.

The main contributions to the objective function were from the likelihood components of the index and catch age compositions (Figure B7.42). Compared to the previous assessment model from SAW41, which was heavily weighted towards the single catch fleet, model BFINAL gives equal weight to all components.

B7.4 Final Model Diagnostics

BFINAL model diagnostic plots for the fit to the two catch fleets are presented in Figures B7.44 through B7.51. Diagnostic plots for the 9 survey indices are presented in Figures B7.52 through B7.81. For reference when viewing some of the plots:

Fleet 1 = Commercial
Fleet 2 = Recreational
Index 1 = NEFSC Inshore trawl
Index 2 = NEFSC Bigelow trawl
Index 3 = MRIP recreational CPUE
Index 4 = NEAMAP trawl
Index 5 = SEAMAP Age 0
Index 6 = PSIGN gillnet

Index 7 = CT LISTS trawl
Index 8 = NJ Ocean trawl
Index 9 = Composite YOY seine

The final model estimated higher fishing mortality and lower abundance and biomass than model B043 (Table B7.1). Selectivity at-age estimates for the two catch fleets were both domed, with a bi-modal pattern still evident in the commercial fleet (Figures B7.82 and B7.83). Fishing mortality for the recreational fleet has always been higher than the commercial fleet, in some year two to three times as much. Fishing mortality estimates in 2014 for the commercial and recreational fleets were 0.049 and 0.108, respectively (Figure B7.84). Final model estimates for the index selectivities show a rapid decrease in selectivity after age 0. A few of the indices have higher selectivity towards larger/older fish, the most important being MRIP and PSIGNS, and to a lesser extent the Bigelow survey (Figure B7.85). Observed and predicted catch-at-age for the two fleets and nine indices are presented in Figures B7.86 through B7.103. Estimates of age composition at older ages are poorly predicted for some of the components.

B7.5 Final Model Results
Average F for from 1985 to 2014 from the final model was 0.284 and average SSB was 79,449 mt (Table B7.4). Spawning stock biomass dipped from a high of 154,633 mt in 1985 to a low of 52,775 mt in 1997 and has steadily increased to a value of 86,534 mt in 2014 (Table B7.4, Figure B7.104). The majority of the spawning stock biomass (50-60%) is in the age 6+ group for the entire time-series (Figure B7.105). Estimates of F have remained below average since 1997 and the 2014 estimate of 0.157 is well below the time series average (Table B7.4, Figure B7.104). There has been a steady decline in fishing mortality since 2007.

Estimates from model BFINAL showed a decrease in total abundance since 2006, declining from 91.5 million to 65.2 million fish in 2012 (Table B7.5, Figure B7.106). Total abundance increased in 2013, and 2014, to 72.1 and 82.0 million, respectively. Age 0 and age 1 fish collectively average around 50% of abundance for the time-series. Below average (24.0 million) recruitment began in 2008 with an estimate of 23.1 million fish (Table B7.4, Figure B7.107). Low recruitment persisted through 2012 to the lowest estimate of the time-series at 16.7 million. Recruitment for 2013 and 2014 have increased above the average to 25.1 and 29.6 million fish, respectively. Throughout the time series the plus group contains the majority of the biomass (Table B7.6). Biomass estimates for 6-plus bluefish have remained above the time series average of 41,600 mt since 2010. Total mean biomass in 2014 equaled 94,328 mt, a slight decrease from the 2013 estimate of 96,922 mt (Table B7.6, Figure B7.108).

Retrospective bias for the final model was examined for F, spawning stock biomass, recruitment, total biomass, exploitable biomass, total abundance, and abundance-at-ages 1 through 6. The analysis shows small bias in the estimates of F (Mohn's rho = -0.12), SSB (Mohn's rho = 0.19), and recruitment (Mohn's rho = 0.05) (Figure B7. 109). Similarly, there is little retrospective bias in estimates of total biomass (Mohn's rho = 0.18), exploitable biomass (Mohn's rho = 0.10) and total abundance (Mohn's rho = 0.06) (Figure B7.110). There does appear to be minor retrospective bias in some of the estimates of abundance-at-age, particularly numbers at age 5 (Mohn's rho = 0.19) and numbers at age 6 (Mohn's rho = 0.23) (Figures B7.111 and B7.112).

The variation in the final model results for F and SSB was determined using a Monte Carlo Markov chain with 1000 iterations and a thinning factor of 1000 (1,000,000 iterations). Trace plots for both SSB and F show little to no patterning (Figures B7.113 and B7.114).There is no significant autocorrelation in the F chain (Figure B7.115). Autocorrelation plots show minor autocorrelation in the SSB (both 1985 and 2014) chain at a lag of 1, with no autocorrelation at a lag greater than 2 (Figure B7.116). The MCMC results of SSB for 2014 ranged from 50,804 mt to 112,588 mt, with a median estimate of 76,062 mt, and 80% confidence interval ranging from 65,078 mt to 86,752 mt. The 2014 SSB point estimate from the final model (86,534 mt) is greater than the median estimate from the MCMC distribution (Figure B7.117 and B7.118). Variation around F ranged from 0.110 to 0.282, with the 80% CI between 0.139 and 0.202. The point estimate from the final model (0.157) is less than the median estimate (0.166) from the MCMC distribution (Figure B7.119 and B7.120).

B7.6 Final model sensitivity runs

A number of sensitivity runs were carried out by changing data inputs to the final model.

Changes to the recreational data

The first group of sensitivities explored different changes made to the estimation of various components of the recreational catch. A total of 5 sensitivity runs were conducted for the recreational data: 1. Assume recreational landings (AB1) lengths apply to the recreational discards (B2), 2. Assume recreational catch at the upper 95% CI of estimates, 3. Assume recreational catch at the lower 95% CI of the estimates, 4. Use MRFSS numbers prior to 2004 (no conversion to MRIP equivalents), and 5. Assume 17% recreational discard mortality instead of 15%. Comparisons between final model and sensitivity run estimates of F, total stock numbers, recruitment, and SSB are presented in Figures B7.121 through B7.125.

Changes to data structure and inputs

Additional final model sensitivity runs were conducted that changed other components of the input data: 1, A regional sensitivity run was explored that used northern and southern regional age-length keys to age the fleets and surveys from 2006 to 2014, 2. Length-weight coefficients were varied over time by three time blocks, 1985-1994, 1995-2004, 2005-2014, 3. Virginia landings date were calculated using a different methodology (VA set 2). Comparisons between final model and sensitivity run estimates of F, total stock numbers, recruitment, and SSB for these sensitivity runs are presented in Figures B7.126 through B7.128.

Sensitivity runs were also carried out the final model assuming different input values for natural mortality. A profile of the objective function was calculated over a range of natural mortality estimates, and the objective function was minimized at a value of 0.263 (Table B7.7 and Figures B7.129 and B7.130). Age-based inputs for natural mortality were also explored (Table 1.50 and Figure B7.131). The estimates assuming age-based M derived from equations in Gislason et al. 2010 resulted in unrealistic model estimates (Table B7.8).

Changes to the survey indices

Sensitivity of the final model to individual survey indices was also tested by removing each index and re-running the model (Table B7.9). The model is fairly insensitive to the removal of all the indices except for the MRIP recreational CPUE index, which is driving the model along with the two catch fleets. The reason this index is so important is because it provides most of the information for model estimates at older ages. Removing the MRIP index and re-running the final model results in a significant decrease in fishing mortality estimates and an increase in abundance and biomass estimates (Table B7.9 and Figure B7.132). An additional model run using just the two catch fleets and the single MRIP index was also conducted. Without the other indices the model loses some information to inform estimates of younger ages and recruitment is scaled up. However, the overall trend and scale of biomass and fishing mortality estimates are not that different from the final model (Figure B7.132).

Investigating habitat suitability indices

Habitat suitability information was also investigated for the NEFSC surveys as well as the NEAMAP survey. Annual estimates of habitat suitability were input as a covariate on availability in the ASAP model (catchability = availability*efficiency, where efficiency was assumed = 1). The use of the habitat suitability indices did not improve the fit of the model to the respective indices. This is not surprising, since the annual estimates of available thermal habitat sampled by the NEFSC and NEAMAP surveys did not show significant trends which would cause a bias in trends of relative abundance (Figure B6.21). In addition, these indices used a hindcasted estimate of sea bottom temperature to derive estimates of bluefish habitat suitability. The ocean model used to hindcast these temperatures was not available for 2013 and 2014 and as a result no index of habitat suitability was available for these years (See WP B4 for full details). The working group decided to go forward without incorporating habitat suitability in the model. There was concern because recent information was not available, as well concern for the ocean model that was used to develop the indices. A habitat suitability index developed from an ocean model using real-time or forecasted sea-surface temperature would be more appropriate for bluefish. This is included as a research recommendation and could be developed for future bluefish assessments.

B7.7 Historical retrospective analysis

Historical retrospective comparisons between the final model and both the continuity run, and the SAW41 assessment show fairly consistent results among estimates (Figure B7.133). Over time, annual updates of the SAW41 model shifted model estimates of total stock numbers, recruitment and fishing mortality. The shift can be observed in comparisons of the continuity run and the SAW41 model. The SAW60 final model for bluefish brings these estimated time-series back in line with the SAW41 model estimates.

B7.8 Alternative Model Runs

B7.8.1 Depletion Corrected Average Catch Model

As an alternative to the base model run using the statistical catch-at-age (SCAA) framework detailed above, we estimated sustainable yield using MacCall's (2009) Depletion-Corrected Average Catch (DCAC). The sum of landings from 1985-2014 is approximately 550,000 mt with an annual average of 18,325 mt (Table B7.10). DCAC requires an estimate of fractional depletion ("delta," which is the change in relative biomass, in units of unfished relative biomass). Our delta estimate is based on preliminary model runs and results of the last update (47.1%; http://www.asmfc.org/uploads/file/552ea3fe2014BluefishStockAssessmentUpdate.pdf) that suggested approximately a 50% depletion in spawning stock biomass over the catch period. Our point estimate for natural mortality (M) was based on the work of Then et al. (2015) and their $\text{Pauly}_{\text{nls-T}}$ estimator ($M = 4.118k^{0.73}L_{\infty}^{-0.33}$; $k = 0.311$ and $L_{\infty} = 815.3$ from Robillard et al. 2009). This is very similar to the M estimate assumed in ASAP SCAA base model. Other DCAC parameters were set to be consistent with MacCall (2009) and Dick and MacCall (2011) (Table B7.10; Figure B7.134). DCAC was implemented with software available from the NMFS toolbox (DCAC V2.1.1; http://nft.nefsc.noaa.gov/DCAC.html). The median of the DCAC distribution was 13,479 mt (Figure B7.135). The average harvest of bluefish throughout the region during the period 2012-2014 was 10,618 mt, with no year exceeding 11,254 mt. This suggests that recent annual harvests were at sustainable levels.

We performed a number of DCAC sensitivity analyses to look at the impact assumed model parameters had on sustainable yield estimates (Table B7.11). All possible combinations of input parameters were investigated, resulting in a total of 192 individual model runs (including the base run presented above). Results of all runs suggested that recent average harvest of bluefish in the terminal 3 years of the assessment (10,618 mt) were sustainable as median sustainable yield levels from all DCAC runs exceeded this value (Figure B7.136).

B7.7.2 Depletion Based Stock Reduction Analysis (DBSRA)

Depletion-based stock reduction analysis (DBSRA) is a technique proposed by Dick and MacCall (2010, 2011) to generate sustainable yield reference points for data-poor groundfish stocks in the Pacific Northwest. It is a variation on stochastic stock reduction analysis (Walters *et al.,* 2006) that uses a production model rather than an age-structured model to describe the underlying population dynamics.

$$B_{t+1} = B_t + \gamma \cdot m \cdot \left(\frac{B_t}{K}\right) - \gamma \cdot m \cdot \left(\frac{B_t}{K}\right)^n - C_t$$

We can select reasonable values to describe the productivity of the population, and then ask the question: if the population sustains *y* years of observed catch, what did the virgin population size have to be in order to both (1) sustain those catches without being driven to extinction and (2) end up at some known fraction of *K* at the end of the time series?

Similar to DCAC, input parameters (Table B7.12, Figure B7.137) are drawn from distributions based on expert opinion about bluefish and meta-analysis of similar stocks. Uncertainty about these parameters is incorporated into the final estimates of *K* and the management parameters of interest (MSY, OFL). DBSRA requires as complete a time-series of catch as possible, so harvest from 1950-2014 was used. Estimates of commercial landings were available from 1950 onwards through ACCSP. Recreational harvest estimates are available from MRFSS/MRIP from 1982 onwards. To hindcast recreational landings, the average ratio of recreational to commercial harvest from 1982-2014 was used to scale the commercial landings up from 1950-1982. Dick and MacCall (2011) assume that catch is known without error, which is not the case with a recreationally important species like bluefish. To incorporate some of that uncertainty into this analysis, the catch history was also drawn from a series of lognormal distributions that used each year of the observed time-series of catch as the median. Natural mortality was assumed to be 0.2, consistent with the ASAP model runs. The ratio of F_{MSY} to M and B_{MSY} to K followed distributions recommended by MacCall (2009), as was done with the DCAC runs. The ratio of B_{2014} to K was based on the estimates of B_{2014} to B_{MSY} from the most recent update of the ASAP model where a stock-recruitment model was used to estimate MSY-based reference points.

DBSRA estimated a median MSY for bluefish of 19,954 mt, with an OFL for 2015 of 20,0245 mt (Table B7.13, Figure B7.138). This method cannot be used to assess stock status (i.e., overfished or experiencing overfishing), because status relative to K is one of the inputs to the model. However, the management parameters (MSY, OFL) derived from this model are robust to assumptions about stock status. Results of all runs suggested that recent average harvest of bluefish in the terminal 3 years of the assessment (10,618 mt) were sustainable, as they are below the estimated MSY from the DBSRA.

B7.7.3 Model Comparisons

The data poor models corroborate the scale of the ASAP model and agree with the determination that harvest in recent years has been sustainable.

All three models produced roughly similar estimates of sustainable harvest for bluefish, and indicate that recent harvest has been below the maximum sustainable yield. DBSRA estimated the highest MSY, but encompasses the estimates of the other two models in the 5th and 95th percentiles of the estimate.

B8. TERM OF REFERENCE #5: State the existing stock status definitions for "overfished" and "overfishing". Then update or redefine biological reference points (BRPs; point estimates or proxies for B_{MSY}, $B_{THRESHOLD}$, F_{MSY}, and MSY) and provide estimates of their uncertainty. If analytic model-based estimates are unavailable, consider recommending alternative measurable proxies for BRPs. Comment on the scientific adequacy of existing BRPs and the "new" (i.e., updated, redefined, or alternative) BRPs.

The current biological reference points for bluefish were determined in SARC 41 and are F_{MSY} (0.19) and B_{MSY} (147,052 mt). The basis for the reference points was the Sissenwine-Shepherd method using the Beverton-Holt stock recruitment parameters and SSB per recruit results generated by the SARC 41 ASAP model results. B_{MSY} was calculated using mean weights at age and is therefore comparable to mean biomass in year *t*. Overfishing of a stock occurs if F exceeds F_{MSY} and a stock is considered overfished if total biomass is less than half of B_{MSY} ($B_{THRESHOLD}$). The existing definition of overfishing is F > 0.19 and B < 73,526 mt.

The TC and WG concluded that new reference points were required because of the uncertainty present in the stock recruitment relationship estimated by the current model. The time series of spawning stock biomass and recruitment does not contain any data about recruitment levels at low stock sizes (Figure B8.1), and the BTC and the SAW 60 WG did not believe the fitted parameters adequately described the stock-recruitment relationship for bluefish.

Because MSY based reference points require a stock recruitment relationship, MSY proxies are required. As a proxy for F_{MSY}, the BTC and the SAW 60 WG recommend $F_{40\%\ SPR}$. The input maturity and composite selectivity curves are shown in Figure B8.2. The resulting YPR and SPR curves are shown in Figure B8.3.

To calculate the associated target and threshold for biomass, the population was projected forward for one hundred years under current conditions with fishing mortality set at the F_{MSY} proxy and recruitment drawn from the observed time series. The WG originally proposed that the biomass threshold be based on total biomass, to be consistent with the previous assessment and current management, but the SARC panel determined that spawning stock biomass was a more appropriate reference point. The resulting equilibrium spawning stock biomass is the recommended SSB_{MSY} proxy, with the overfishing threshold set at ½ SSB_{MSY}. Similarly, the equilibrium landings under projected under F_{MSY} proxy = $F_{40\%SPR}$ were set as the MSY proxy.

The revised reference points are F_{MSY} proxy = F40% = 0.170 and B_{MSY} proxy = 111,228 mt (½ SSB_{MSY} = 55,614 mt). The MSY proxy is 13,967 mt.

The usage of these proxies has been accepted in many other assessments and is considered adequate in cases where a stock recruitment relationship is not estimable. Recent SAW assessments where MSY proxies have been used include the Gulf of Maine haddock (2014), summer flounder (2013), and white hake (2013).

SPR-based reference points are not sensitive to uncertainty in the stock-recruitment relationship, but do not link future recruitment to spawning stock biomass. The projection approach used to establish the B_{MSY} proxy incorporates the observed variability in recruitment, but assumes that recruitment is independent of SSB. This assumption is not unreasonable over the observed high levels of bluefish abundance, and maintaining the stock close to the proposed target should minimize the risk of this assumption.

B9. TERM OF REFERENCE #6: Evaluate stock status with respect to the existing model (from previous peer review accepted assessment) and with respect to a new model developed for this peer review.

B9.1 Stock status from the continuity run

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

The existing reference points are F_{MSY} = 0.19 and B_{MSY} = 147,052 mt (½ B_{MSY} = 73,526 mt). The 2014 F estimate (0.141) is well below F_{MSY} and the 2014 estimate of B is 92,755 mt, below B_{MSY} but well above ½ B_{MSY}. This indicates that overfishing is not occurring and that the stock is not overfished (Figure B9.1).

B9.2 Stock status for the current assessment

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

The new reference points are F_{MSY} proxy = F40% = 0.170 and SSB_{MSY} proxy = 111,228 mt (½ SSB_{MSY} = 55,614 mt). The 2014 F estimate (0.157) is below $F_{40\%}$ and the 2014 SSB estimate (86,534 mt) is greater than ½ SSB_{MSY}, indicating that overfishing is not occurring and that the stock is not overfished (Figure B9.2 and B9.3).

Reference Point	**SARC 41** Definition[1]	Value	**Updated** Definition[1]	Value
$\mathbf{F_{Threshold}}$	F_{MSY}	0.19	$F_{MSY\ proxy} = F_{40\%SPR}$	0.170
$\mathbf{B_{Target}}$	B_{MSY}	147,052 mt	Equilibrium SSB under $F_{40\%SPR}$	111,228 mt
$\mathbf{B_{Threshold}}$	½ B_{MSY}	73,526 mt	½ $SSB_{MSY\ Proxy}$	55,614 mt

[1]: Note that the SARC 41 biomass reference points refer to total biomass, while the updated biomass reference points refer to spawning stock biomass.

B10. TERM OF REFERENCE #7: Develop approaches and apply them to conduct stock projections and to compute the statistical distribution (e.g., probability density function) of the OFL (overfishing level; see Appendix to the SAW TORs).

B10.1 Provide annual projections (3 years). **For given catches, each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment)**

Short-term projections were conducted using AGEPRO v.4.2.2 (available from the NOAA Fisheries Toolbox, http://nft.nefsc.noaa.gov/AGEPRO.html).

Removals in 2015 were assumed to be equal to the 2015 quota (9,722 mt). For 2016-2018, a constant level of fishing mortality was applied. The population was projected forward under five different F levels:

- $F_{low} = 0.100$
- $F_{status\ quo} = 0.136$
- $F_{0.1} = 0.203$
- $F_{TARGET} = 90\%F_{MSY\ Proxy} = 0.163$
- $F_{MSY\ Proxy} = F_{40\%SPR} = 0.181$

Uncertainty was incorporated into the projections primarily via estimates of recruitment and initial abundance-at-age.

Estimates of recruitment were drawn from the 1985-2014 time-series of observed recruitment from the preferred ASAP model. Initial abundance-at-age estimates were drawn from distributions of terminal abundance-at-age developed from the MCMC runs of the preferred ASAP model. A small amount of uncertainty was incorporated into biological parameters such as weight-at-age, maturity-at-age, and natural mortality; estimates of these parameters were drawn from lognormal distributions with mean values used in the terminal year of the assessment and a CV of 0.01.

The projections were conducted with a single fleet. Selectivity was calculated by summing the commercial and recreational F-at-age for each age from the preferred ASAP model over the last three years of the model and dividing by the maximum F-at-age to develop a composite selectivity curve. A CV of 0.01 was also applied to the selectivity-at-age estimates.

The model exhibited a minor retrospective pattern. Estimates of retrospective bias-adjusted SSB and F were within the credible intervals from the MCMC runs of the accepted model estimates Figure B10.1), so a retrospective adjustment was not deemed necessary.

None of the fishing mortality scenarios resulted in total biomass going below the biomass threshold (½ $SSB_{MSY\ Proxy}$) in any year of the projection; spawning stock biomass remained above the biomass threshold with 100% probability in all years (Table B10.1, Figure B10.2).

The overfishing limit (OFL) for 2016 was estimated to be 10,528 mt (23.2 million lbs) with a CV of 0.10 (Table B10.1, Figure B10.3). A qualitative inflation was applied for known sources of uncertainty that are not adequately captured in the projection process, including retrospective bias and uncertainty in the F_{MSY} proxy estimate, resulting in a recommended CV of 0.15.

A sensitivity analysis approach was used to determine the effects of major sources of model uncertainty that could not be encompassed through the MCMC runs of the base model. This included:

- Limiting the empirical recruitment distribution to the CDF of observed recruitment for 2006-2014 (the years of the best available age data)
- Higher M (M=0.26)
- Increased uncertainty in selectivity-at-age, weight-at-age, and maturity-at-age (CV of 0.1 instead of 0.01)

Please note: these sensitivity runs were carried out with the results of Model B043, not the revised BFINAL model.

Using the more limited recruitment time series did not significantly change the estimates of landings or biomass from the projections (Table B10.2, Figure B10.4). This is not surprising, since the median recruitment of the 2005-2014 period (26.4 million fish) is not significantly different from the median recruitment of the entire time series (24.5 million fish). Higher M values resulted in higher estimates of landings and biomass, but did not change the probability of going below the biomass threshold (0% in all years). Increasing the CV on the biological parameters did not significantly change the median of the distributions for biomass or landings in each year, but did increase the confidence intervals. The probability of being above the biomass threshold remained 100%.

B10.2 Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.

The WG considers the base model configuration the most realistic projection scenario. While estimates of recruitment in the most recent 10 years of the time-series (derived in part from the best age information) are likely more reliable than the estimates from the beginning of the time-series, the median recruitment and projection time-series are virtually indistinguishable.

B10.3 Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.
Bluefish are a fast-growing, fast-maturing species with a moderately long life span. Although they recruit to the fishery before they are fully mature, larger, older fish are considered unpalatable, reducing demand for those sizes in the commercial market and encouraging the release of those size classes in the recreational fishery. The resulting dome-shaped selectivity of the fleets offers protection to the spawning stock biomass. Although they are a popular gamefish, demand for this species is not extreme and the quota is rarely met or exceeded.

Bluefish are opportunistic predators that do not depend on a single prey species. Their range covers the whole of the Atlantic coast, and their spawning is protracted both temporally and geographically. As a result, they are not as vulnerable as many other species to major non-fishery drivers such as climate change that would result in the loss of critical forage or nursery habitat.

This assessment indicates bluefish are near their target biomass and well above their overfished threshold. Short-term projections indicate no risk of driving the biomass below the overfished threshold while fishing at or near the FMSY proxy. Overall, bluefish have a low degree of vulnerability to becoming overfished, and the ABC can be set on the basis of the FMSY proxy without risk of causing the stock to become overfished.

B11. TERM OF REFERENCE #8: Review, evaluate and report on the status of the SARC and Working Group research recommendations listed in most recent SARC reviewed assessment and review panel reports, as well as MAFMC SSC model recommendations from 2005 and the research recommendations contained in its 23 September 2013 report to the MAFMC. Identify new research recommendations.

B11.1 Progress Made in Addressing Previous Research Recommendations.

Commercial Data

- Increase sampling of size and age composition by gear type and statistical area
- Target landings for biological data collection and increase intensity of sampling for biological data.

Addendum I to the Bluefish FMP has resulted in additional commercial biological data (e.g., age, sex, weights) being available (e.g., from NC and NY). Prior to Addendum I, the NC biological collection program targeted commercial landings for biological data (e.g., 2006-2011, age, sex, weight).

Recreational Data

- Increase sampling of size and age composition by gear type and statistical area
- Target landings for biological data collection and increase intensity of sampling for biological data

Addendum I to the Bluefish FMP has resulted in additional recreational biological data (e.g., age, sex, weights) being available from all participating states; in addition, volunteer recreational angler surveys from several states (CT, RI, and NJ) are now providing recreational discard data for use in the bluefish stock assessment.

Ageing Data

- Complete a scale-otolith comparison study

Both independent research and an inter-agency bluefish ageing workshop confirmed that the use of sectioned otoliths is the preferred method by which to age this species (Robillard et al. 2009; ASMFC 2011). Further, each agency follows the standard otolith processing, reading, and age-assignment protocols developed by ODU. Some variations do exist with respect to processing, but these are relatively minor (e.g., baking before or after sectioning, mounting sections using various adhesives, etc.) and allowable as determined by the 2011 Bluefish Ageing Workshop. In response, all organizations that currently are involved with efforts to age bluefish for the purposes of informing the stock assessment for this species do so using sectioned otoliths and the 2011 protocol. The WG determined at the model meeting (WP B6) that historic age scale ages (excluding NC spring scales) were comparable to otolith ages and hence historic scale age data were retained for model runs.

- Conduct study or workshop to address discrepancies between estimated bluefish age from scales and otoliths and the chronological age. Examine issues of inter- and intra-reader variation in interpretation of ages

It was unclear to the WG exactly what this research recommendation was suggesting (especially in light of the previous research recommendation). To the extent that this research recommendation is related to a non-January 1 birthday for early NC spring age data, at the model meeting the WG made adjustments to the NC spring scale and otolith data (WP B6); those corrected spring ages were incorporated into the final assessment.

For the second part of the research recommendation, an ageing workshop was held in 2011 to produce guidelines for future aging work on bluefish. Intra-agency measures of ageing precision are available for nearly all of the organizations currently collecting age data (WP B5). The few organizations that were unable to provide estimates of precision due to staffing limitations (i.e., no second reader), will likely will be able to do so in the future as ageing programs develop further and assuming additional resources become available. Based on inter-agency measures and the 2011 Workshop, the WG felt comfortable using the expanded sources of age data.

- Examine the feasibility of each state collecting samples of hard parts for ageing, with one or two laboratories interpreting the annuli for consistency

The 2011 workshop resulted in Addendum I to the bluefish fishery management plan, which required all states that capture a substantial portion of bluefish landings to collect and age a minimum of 100 bluefish samples per year. Inter-agency comparability of age data is currently maintained through the adherence to standardized processing and ageing protocols for bluefish, while the digital reference collection developed by the states and maintained by the ASMFC also promotes this consistency by serving as a training tool and reference collection. Formal ageing exchanges meant to quantify inter-agency precision and bias have yet to occur for bluefish. It should be noted, however, that recent exchanges for other species, including black sea bass and summer flounder have shown that standard exchange practices are effort-intensive and often suffer from serious design flaws (ASMFC 2013). The latter issue results in measures of inter-agency precision and bias from the exchange that are not representative of the quality of age data provided by the participating organizations to the assessment process, and are therefore wholly uninformative. Further, discussions regarding the consolidation of all processing and ageing of bluefish under a single agency have determined that the current multi-agency approach is the superior design (WP B5). Gains in consistency that are realized using a single set of processors/readers are offset by increases in bias that arise due to lack of localized knowledge regarding life history and growth.

Fishery-Independent Data

- Continue research on species interactions and predator-prey relationships

No progress made on this item beyond development of working paper summarizing diet information (WP B3) for bluefish derived from NEFSC, NEAMAP, ChesMMAP, and SEAMAP which addressed portions of TOR #2.

- Examine alternative weighting schemes for the available fishery-independent surveys (area, inverse variance, N, etc.)

The Conn (2010) hierarchical approach which implicitly weights surveys by uncertainty was applied to combine multiple noisy state YOY indices that were criticized during the previous review as being unrepresentative of coastwide recruitment due to their individual limited spatial and temporal extent. The WG did not have time to explore model runs using weighting schemes alternative to this.

Finally, the WG adjusted fishery independent survey input CVs in the assessment model to get the RMSEs near 1, and ESS for fishery independent surveys to reflect confidence in age data over different time periods.

- Investigate the feasibility of alternative survey methods that target bluefish across all age classes to create a more representative fishery-independent index of abundance

No specific progress made on this item regarding survey gear types. However, the TC included additional fishery independent surveys (e.g., PSIGNS) that do target a wider age range (0-6+) in the current assessment.

- Initiate sampling of offshore populations in winter months

No progress made on this recommendation.

- Conduct research on influences on recruitment including pathways of larval bluefish

Research has been conducted on recruitment dynamics of bluefish (e.g., multiple cohorts; see paragraph below) however, time constraints prevented the WG from incorporating cohort-specific indices in the model.

Recent research has focused on the factors that influence bluefish survival from the young-of-year stage to age-1. Taylor et al. (2006) concluded that young of year bluefish almost exclusively utilize habitats on the inner continental shelf. Scharf et al. (2006) quantified the inter cohort dynamics of young of year bluefish. Taylor and Able (2006) provide additional information on cohort hatch date and differences in growth between spring and summer cohorts. Morely et al. (2007) explored how energy storage influenced juvenile young of year survival. Taylor et al. (2007) provide further information on fine scale habitat selection of young of year bluefish. Wuenschel et al. (2012) synthesized coastwide data to develop a conceptual model of the processes underlying bluefish recruitment. Morely et al. (2013) documented size selective overwinter mortality of young of year bluefish.

- Initiate coastal surf zone seine study to provide more complete indices of juvenile abundance

Research suggests that the coastal surf zone is important habitat (Able et al. 2013). No progress made on this item.

Models, Inputs, and Outputs

- Explore a tag based assessment and associated costs compared to age based assessments

No progress made on this recommendation. The WG determined that this item is no longer relevant given the potential costs and limited benefits.

- Determine if a tag based assessment could supplement or replace other assessment techniques

No progress made on this recommendation. The WG determined that this item is no longer relevant given the potential costs and limited benefits.

- Continue to examine alternative models including a forward projection catch-at-age model

The intent of this item was not entirely clear to the WG since the previous assessment model was a forward projecting catch at age model. This notwithstanding, the SAW 60 WG explored the application of two models designed to provide catch guidance in data poor situations: Depletion Corrected Average Catch Model (DCAC) and Depletion-Based Stock Reduction Analysis. (See Section B7.3 and Appendices for more details.) Both methods suggest that recent annual harvests were at sustainable levels.

B11.2 New Research Recommendations

High Priority

- Determine whether NC scale data from 1985-1995 are available for age determination; if available, re-age based on protocols outlined in ASMFC (2011); if re-aging results in changes to age assignments, quantify the effects of scale data on the assessment
    - Would allow for validation of the adjustments to the early NC spring age data made by WG at model meeting (WP B6)
- Develop additional adult bluefish indices of abundance (e.g., broad spatial scale longline survey or gillnet survey)
    - Given the limited information on older (e.g., age 2+) bluefish collected by existing fishery independent surveys this item addresses the need to adequately characterize dynamics of older fish that are currently not well sampled by fishery independent trawl surveys.
- Expand age structure of SEAMAP index

- Given patterns of bluefish migration and recruitment (Shepherd et al. 2006, Wuenschel et al. 2012), it is important to monitor bluefish abundance in SAB; currently, the SEAMAP index used in the assessment indexes age 0 abundance only, but recent age data from SEAMAP suggests collection of age 1 and 2 fish that would help inform the SAB age structure

Moderate priority

- Investigate species associations with recreational angler trips targeting bluefish (on a regional and seasonal basis) to potentially modify the MRIP index used in the assessment model
  - Given the importance of the MRIP index in the assessment model, this addresses a need to accurately estimate effort for of the MRIP index (reduce risk of hyperstability)
- Explore age- and time-varying natural mortality from, for example, predator prey relationships; quantify effects of age- and time-varying natural mortality in the assessment model
  - This addresses the issue of predation on bluefish by, for example, coastal sharks and/or limited prey resources (top down effects, bottom up effects, and/or environmental effects)
- Continue to evaluate the spatial, temporal, and sector-specific trends in bluefish growth and quantify their effects in the assessment model
  - Addresses appropriateness of WG pooling age data spatially (and temporally) for potential changes regarding the efficiency of the biological collection program
- Continue to examine alternative models that take advantage of length-based assessment frameworks. Evaluate the source of bimodal length frequency in the catch (e.g., migration, differential growth rates);
  - This item would address a source of uncertainty in the assessment with age data from different hard parts & provide means to examine the appearance of bimodal length frequency in the catch data
- Modify thermal niche model to incorporate water temperature data more appropriate for bluefish in a timelier manner [e.g., sea surface temperature data & temperature data that cover the full range of bluefish habitat (SAB and estuaries)].

- This addresses the current limitations of the habitat suitability model for bluefish (limited to hindcast bottom temps, in the MAB).

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Tables

Table B3.1 State shares of Commercial Quota as specified in Amendment 1.

State	% of Federal Quota
Maine	0.6685
New Hampshire	0.4145
Massachusetts	6.7167
Rhode Island	6.8081
Connecticut	1.2663
New York	10.3851
New Jersey	14.8162
Delaware	1.8782
Maryland	3.0018
Virginia	11.8795
North Carolina	32.0608
South Carolina	0.0352
Georgia	0.0095
Florida	10.0597
Coastwide Total	**100**

Table B3.2 State by state Recreational and Commercial Management Measures

State	Recreational Bag Limit	Recreational Season	Recreational Size Limit	Commercial Trip Limit	Commercial Open Season
ME	3 fish	All year	None		
NH	10 fish	All year	None		JUL 1 – SEP 30
MA	10 fish	All year	None	5,000 lbs/day	
RI	15 fish	All year	None		
CT	10 fish	All year	None	750 lbs/day between 1/1-4/30 until 30% of the state quota is landed; 500 lbs/day	JAN 1 – DEC 31
NY	15 fish	All year	No more than 10 under 12" TL	Varies based on available quota	
NJ	15 fish	All year	None		Gear-specific
DE	10 fish	All year	None		
MD	10 fish	All year	8" minimum		
PRFC	10 fish	All year	None	Daily limits when 80% of VA and MD quotas are met	
VA	10 fish	All year	None		
NC	15 fish	All year	Only 5 greater than 24" TL		
SC	15 fish	All year	None		
GA	15 fish	MAR 16 – NOV 30	12" minimum FL	15 fish	MAR 16 – NOV 30
FL	10 fish	All year	12" minimum FL	7,500 lbs/day	

Table B4.1 ACCSP Gears included in each of the SAW 60 Assessment Gear Categories

SARC 60	ACCSP Gear Types	
Gear Category	**Type Code**	**Gear Type**
Gill Nets	006	GILL NETS
Hook and Line	014	BY HAND
Hook and Line	013	HAND LINE
Hook and Line	007	HOOK AND LINE
Pound Nets	003	FIXED NETS
Seines	001	HAUL SEINES
Seines	002	PURSE SEINES
Trawls	004	TRAWLS
Other	010	DIP NETS AND CAST NETS
Other	009	DREDGE
Other	008	LONG LINES
Other	015	OTHER GEARS
Other	005	POTS AND TRAPS
Other	011	RAKES, HOES, AND TONGS
Other	012	SPEARS AND GIGS
Not Coded	000	NOT CODED

Table B4.2 Data sources for the Virginia bluefish commercial landings data used in Option 1. The greater annual landings were chosen from either the ACCSP data warehouse (ACCSP DW) and the Virginia historical landings database (VA FSMRPT).

YEAR	Database Source
1982	ACCSP DW
1983	ACCSP DW
1984	ACCSP DW
1985	ACCSP DW
1986	ACCSP DW
1987	ACCSP DW
1988	ACCSP DW
1989	ACCSP DW
1990	ACCSP DW
1991	ACCSP DW
1992	ACCSP DW
1993	ACCSP DW
1994	ACCSP DW
1995	ACCSP DW
1996	ACCSP DW
1997	ACCSP DW
1998	ACCSP DW
1999	VA FSMRPT
2000	VA FSMRPT
2001	VA FSMRPT
2002	VA FSMRPT
2003	VA FSMRPT
2004	ACCSP DW
2005	ACCSP DW
2006	VA FSMRPT
2007	ACCSP DW
2008	VA FSMRPT
2009	ACCSP DW
2010	ACCSP DW
2011	VA FSMRPT
2012	VA FSMRPT
2013	VA FSMRPT
2014	ACCSP DW

Table B4.3 Data sources for the Virginia bluefish commercial landings data used in Option 2. The greater annual landings for state dealer reported data, federal dealer reported data, and Potomac River Fisheries Commission (PRFC) were each chosen from either the ACCSP data warehouse (ACCSP) and the Virginia FSMRPT database (VA).

YEAR	STATE	FED	PRFC
1982	ACCSP	ACCSP	ACCSP
1983	ACCSP	ACCSP	ACCSP
1984	ACCSP	ACCSP	ACCSP
1985	ACCSP	ACCSP	ACCSP
1986	ACCSP	ACCSP	ACCSP
1987	ACCSP	ACCSP	ACCSP
1988	ACCSP	ACCSP	ACCSP
1989	ACCSP	ACCSP	ACCSP
1990	ACCSP	ACCSP	ACCSP
1991	ACCSP	ACCSP	ACCSP
1992	ACCSP	ACCSP	ACCSP
1993	ACCSP	ACCSP	ACCSP
1994	ACCSP	ACCSP	ACCSP
1995	ACCSP	ACCSP	ACCSP
1996	VA	ACCSP	ACCSP
1997	VA	ACCSP	ACCSP
1998	ACCSP	ACCSP	ACCSP
1999	VA	ACCSP	ACCSP
2000	VA	VA	ACCSP
2001	VA	ACCSP	ACCSP
2002	VA	ACCSP	ACCSP
2003	VA	ACCSP	ACCSP
2004	ACCSP	VA	ACCSP
2005	VA	ACCSP	ACCSP
2006	VA	ACCSP	VA
2007	ACCSP	ACCSP	VA
2008	VA	VA	VA
2009	ACCSP	ACCSP	ACCSP
2010	VA	VA	ACCSP
2011	VA	VA	ACCSP
2012	VA	VA	ACCSP
2013	VA	VA	ACCSP
2014	ACCSP	ACCSP	VA

Table B4.4 Comparison of commercial bluefish landings data (in pounds) from the NEFSC database, the ACCSP data warehouse, and the local state records. State data supplied by Florida Department of Environmental Protection, North Carolina Department of Marine Fisheries trip ticket program, and the Virginia Marine Resources Commission.

	2011			2012			2013		
	NEFSC	**State**	**ACCSP**	**NEFSC**	**State**	**ACCSP**	**NEFSC**	**State**	**ACCSP**
FL	203,000	244,447	245,868	?	178,197	181,491	110,489	142,199	151,958
NC	1,613,585	1,901,143	1,897,408	569,275	746,720	758,858	952,307	1,135,481	1,159,580
VA	255,250	256,889	252,854	516,062	183,861	514,220	315,954	300,310	282,482

Table B4.5 Percent difference in commercial bluefish landings data between the NEFSC database, or the ACCSP data warehouse, and the local state records. State data supplied by Florida Department of Environmental Protection, North Carolina Department of Marine Fisheries trip ticket program, and the Virginia Marine Resources Commission.

	2011		**2012**		**2013**	
	NEFSC	**ACCSP**	**NEFSC**	**ACCSP**	**NEFSC**	**ACCSP**
FL	-17%	1%	-100%	2%	-22%	7%
NC	-15%	0%	-26%	-1%	-16%	2%
VA	-1%	-2%	181%	180%	5%	-6%

Table B4.6 Bluefish Atlantic coast commercial landings (mt) by state. Asterisks indicate confidential data. Data Source ACCSP

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA	FL	Total
1982	74.8	30.3	406.1	270.4	136.2	781.4	898.5	231.8	131.0	1,176.2	1,946.3	4.2	1.0	910.8	6,999.2
1983	77.1	13.8	453.8	235.5	31.5	765.3	872.9	131.7	149.9	689.4	3,060.4	5.1	0.1	679.8	7,166.5
1984	22.0	8.0	318.3	462.3	45.4	742.1	767.5	71.3	83.9	525.2	1,614.8	0.9	0.1	719.1	5,381.0
1985	41.0	10.3	362.1	767.8	82.5	967.6	902.1	85.3	231.0	749.8	1,634.9	0.8	0.1	288.5	6,123.9
1986	46.9	27.7	708.8	518.4	86.2	733.6	1,362.2	181.5	207.1	686.4	1,565.0	3.8	1.0	528.5	6,657.2
1987	47.9	58.1	361.5	537.4	79.7	709.7	1,148.5	160.8	165.0	536.2	2,068.9	1.5	1.2	702.0	6,578.6
1988	3.9	10.4	365.7	464.3	46.3	510.4	1,126.5	94.9	467.7	1,186.5	2,285.7	1.6	1.3	596.8	7,162.1
1989	34.6	62.2	562.4	549.6	88.0	256.1	717.9	47.3	125.1	349.5	1,493.0	1.2	0.2	453.0	4,740.0
1990	24.4	89.4	546.1	537.4	81.3	731.3	984.7	65.2	129.5	495.1	2,076.6	0.5	0.2	488.3	6,250.3
1991	56.6	57.7	343.0	676.1	116.8	716.0	1,110.3	153.1	105.8	373.8	1,778.0	0.6	0.1	650.1	6,138.2
1992	39.3	103.4	376.3	703.1	121.9	677.1	997.1	42.0	93.6	269.1	1,287.8	0.9	0.4	495.6	5,207.7
1993	8.3	73.8	288.6	542.1	61.0	702.7	994.0	13.4	60.6	294.8	1,227.1	0.2	0.2	551.8	4,818.6
1994	24.5	124.9	543.0	409.1	68.9	667.6	858.3	15.7	74.8	284.7	808.5	3.0	0.3	423.1	4,306.2
1995	8.8	84.8	253.0	350.2	53.2	590.2	384.6	16.5	48.9	243.8	1,365.6	*	0.5	228.6	3,628.8
1996	5.5	72.5	409.2	291.2	45.9	719.8	731.0	62.5	37.3	279.4	1,496.2	1.0	0.2	60.9	4,212.8
1997	1.2	28.4	197.0	270.5	32.7	682.4	559.2	13.3	44.3	335.4	1,815.8	0.2	0.3	128.8	4,109.5
1998		7.6	164.8	258.9	25.6	716.0	627.5	12.6	84.1	360.5	1,327.2	1.1	0.3	154.7	3,740.8
1999	*	5.5	186.4	272.3	24.1	644.7	490.0	8.9	65.9	217.2	1,252.4	0.3	0.2	157.1	3,325.1
2000	0.1	10.9	128.1	157.6	15.2	843.9	608.4	13.2	38.2	252.1	1,528.2	0.1	0.4	64.0	3,660.3
2001		5.3	158.1	219.2	20.8	624.3	583.6	8.5	59.2	366.4	1,844.3	0.1	0.2	62.7	3,952.8
2002	0.4	2.4	184.5	254.6	24.6	669.1	600.9	20.8	51.5	216.0	1,054.1		0.2	36.9	3,115.9
2003	0.3	3.9	150.2	189.6	20.3	707.6	459.2	13.9	24.0	171.6	1,574.0	*	0.4	44.3	3,359.3
2004	0.3	11.3	209.3	267.9	19.1	652.7	485.7	12.2	21.1	217.9	1,707.7	0.1	0.9	54.8	3,661.1
2005	0.1	2.4	214.6	248.9	17.7	516.6	543.6	20.1	55.4	233.5	1,287.1	0.1	0.2	70.5	3,210.8
2006	0.1	13.1	231.5	268.7	18.8	535.4	475.4	18.8	31.8	347.0	1,266.0	0.1	0.0	45.1	3,251.8
2007	2.2	5.3	260.2	267.8	10.3	666.0	636.4	8.9	66.3	329.4	1,056.7	0.1	0.2	76.2	3,386.1
2008	0.4	4.0	231.6	180.6	17.0	572.1	463.5	10.3	40.6	267.0	875.6	0.2	*	67.3	2,730.3
2009	0.5	1.7	174.8	225.6	21.6	587.4	649.5	10.1	74.3	206.0	1,070.5	0.1	0.1	97.1	3,119.2
2010	0.1	1.4	265.8	159.3	19.0	379.8	627.0	8.7	55.8	184.5	1,458.8	0.2	0.1	143.4	3,303.7
2011		1.9	262.4	185.7	21.0	531.5	321.8	5.3	36.5	115.3	860.6	0.2	0.1	110.9	2,453.3
2012	0.6	14.0	311.3	285.1	38.8	500.3	312.7	7.3	83.3	233.7	344.2	*		80.8	2,212.1
2013	*	0.1	268.3	207.5	14.5	572.1	157.2	4.6	22.6	136.5	526.0	*	*	67.9	1,977.4
2014		1.4	213.8	229.0	14.1	427.4	230.9	1.5	36.1	92.3	915.8	*		74.1	2,236.5

Table B4.7 Bluefish Atlantic coast commercial landings (mt) by gear category. Data source: ACCSP.

Year	GILL NETS	HOOK-N-LINE	NOT CODED	OTHER GEARS	POUND NETS	SEINES	TRAWLS	Percentage of landings by gillnets
1982	2,513.7	512.3		912.5	947.7	494.3	1,618.5	35.9%
1983	2,307.7	532.6		682.4	728.9	427.2	2,487.5	32.2%
1984	1,988.6	440.0		719.5	573.4	379.9	1,279.2	37.0%
1985	2,184.5	454.1		391.0	822.0	588.1	1,684.2	35.7%
1986	2,801.6	436.0	528.5	13.7	782.4	575.5	1,519.4	42.1%
1987	3,306.2	512.9	702.0	14.7	678.4	282.9	1,081.5	50.3%
1988	3,129.7	481.5	596.8	5.1	1,395.2	331.9	1,221.8	43.7%
1989	2,509.9	295.0	453.0	1.9	232.3	169.7	1,078.1	53.0%
1990	3,408.5	440.6	488.3	5.9	514.9	309.6	1,082.4	54.5%
1991	3,129.0	384.3	586.5	5.6	382.9	443.1	1,206.7	51.0%
1992	2,637.3	350.1	87.7	30.3	375.9	275.7	1,450.6	50.6%
1993	2,902.4	372.5	13.7	16.7	438.0	189.9	885.4	60.2%
1994	2,575.7	168.5	301.3	24.1	285.8	129.6	821.1	59.8%
1995	2,215.8	144.8	83.5	21.4	307.9	98.7	756.6	61.1%
1996	2,611.4	388.6	27.7	11.5	243.5	90.3	839.9	62.0%
1997	2,789.1	150.7	26.6	12.7	241.4	114.9	777.9	67.8%
1998	2,427.2	168.8	42.1	32.0	291.4	80.1	699.1	64.9%
1999	2,084.4	167.0	11.5	16.1	224.0	145.0	687.0	62.5%
2000	2,572.5	129.8	12.0	7.6	219.8	58.8	659.8	70.3%
2001	2,821.5	148.5	28.4	12.5	363.3	54.8	526.6	71.3%
2002	2,022.9	158.0	17.7	18.0	325.0	43.8	533.3	64.9%
2003	2,413.4	170.1	0.2	31.6	311.2	42.7	392.0	71.8%
2004	2,273.5	157.1	651.1	164.3	99.2	33.7	294.6	61.9%
2005	1,683.8	140.7	653.7	151.1	196.3	56.7	333.0	52.4%
2006	1,942.5	172.1	686.8	36.8	150.2	49.5	247.7	59.1%
2007	1,816.0	165.7	812.6	39.3	347.5	69.5	139.4	53.6%
2008	1,463.6	136.4	624.3	37.7	181.4	56.5	230.3	53.6%
2009	1,782.1	145.9	760.1	45.4	128.1	64.5	193.0	57.1%
2010	2,116.8	235.0	522.5	57.3	147.3	35.0	189.8	64.1%
2011	1,343.8	175.7	630.5	29.4	43.8	26.9	203.2	54.8%
2012	910.6	190.2	725.1	35.6	63.3	23.9	263.4	41.2%
2013	906.6	174.4	634.4	35.5	63.8	11.8	150.8	45.9%
2014	1,204.3	219.2	539.7	12.5	140.1	16.5	116.0	53.6%

Table B4.8 Top ports of bluefish landings (in metric tons), based on NMFS 2013 dealer data. Since this table includes only the “top ports” (ports where landings of bluefish were > 45.4 mt), it does not include all of the landings for the year.

Port[a]	Metric Tons	# Vessels
WANCHESE, NC	277.7	15
POINT JUDITH, RI	181.7	90
MONTAUK, NY	160.8	84
HAMPTON BAYS, NY	156.8	30
HATTERAS, NC	79.0	13
AMAGANSETT, NY	69.0	4
POINT PLEASANT, NJ	56.6	67
CHATHAM, MA	56.5	24
BELFORD, NJ	52.3	13
SHINNECOCK, NY	48.9	-

Table B4.9 Commercial landings (mt) by state grouping used in length expansions.

Year	State Groupings Landings (mt)			Total	State Groupings Lengths			Total
	ME - VA	NC	SC-FL		ME - VA	NC	SC-FL	
1985	4,199.6	1,635.0	289.4	**6,124.0**	1,581	5,243		**6,824**
1986	4,558.8	1,565.0	533.3	**6,657.1**	1,838	3,748		**5,586**
1987	3,804.9	2,068.9	704.7	**6,578.5**	1,105	3,576		**4,681**
1988	4,276.6	2,285.7	599.7	**7,162.0**	1,961	3,831		**5,792**
1989	2,792.7	1,493.0	454.4	**4,740.1**	590	5,149		**5,739**
1990	3,684.4	2,076.6	489.0	**6,250.0**	201	7,447		**7,648**
1991	3,709.2	1,778.0	650.8	**6,138.0**	201	5,540		**5,741**
1992	3,422.9	1,287.8	496.9	**5,207.6**	400	6,004	1,618	**8,022**
1993	3,039.3	1,227.1	552.2	**4,818.6**	200	3,613	1,445	**5,258**
1994	3,071.5	808.5	426.4	**4,306.4**	763	1,983	463	**3,209**
1995	2,034.0	1,365.6	229.1	**3,628.7**	189	1,820	258	**2,267**
1996	2,654.4	1,496.2	62.1	**4,212.7**	1,321	2,253	966	**4,540**
1997	2,164.6	1,815.8	129.3	**4,109.7**	1,520	4,086	278	**5,884**
1998	2,257.7	1,327.2	156.1	**3,741.0**	4,107	4,222	341	**8,670**
1999	1,915.0	1,252.4	157.6	**3,325.0**	3,183	6,608	48	**9,839**
2000	2,067.8	1,528.2	64.5	**3,660.5**	1,779	8,163	76	**10,018**
2001	2,045.4	1,844.3	63.0	**3,952.7**	2,964	11,112	139	**14,215**
2002	2,024.9	1,054.1	37.1	**3,116.1**	4,579	7,979	95	**12,653**
2003	1,740.6	1,574.0	44.7	**3,359.3**	4,636	7,663	25	**12,324**
2004	1,897.5	1,707.7	55.8	**3,661.0**	6,134	9,495	48	**15,677**
2005	1,853.0	1,287.1	70.8	**3,210.9**	5,955	9,277	92	**15,324**
2006	1,940.6	1,266.1	45.2	**3,251.9**	8,520	9,995	437	**18,952**
2007	2,252.8	1,056.8	76.5	**3,386.1**	5,942	8,184	128	**14,254**
2008	1,787.1	875.6	67.5	**2,730.2**	7,244	7,463	81	**14,788**
2009	1,951.5	1,070.5	97.3	**3,119.3**	7,038	7,184	660	**14,882**
2010	1,701.5	1,458.8	143.7	**3,304.0**	6,556	6,671	706	**13,933**
2011	1,481.4	860.7	111.2	**2,453.3**	8,390	5,722	261	**14,373**
2012	1,787.1	344.2	80.8	**2,212.1**	10,912	7,007	603	**18,522**
2013	1,383.4	526.0	67.9	**1,977.3**	5,388	6,920	383	**12,691**
2014	1,246.5	915.8	74.1	**2,236.4**	4,371	6,333	207	**10,911**

Table B4.10 Landings (lbs), lengths sampled, and sampling intensity (lengths/100 lbs landed) for ME-VA and NC-FL by quarter and market category from 1985-1987.

	1985				1986				1987			
	ME-VA Landings (lbs)				**ME-VA Landings (lbs)**				**ME-VA Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	0	0	9896307	0	0	0	11226201	0	0	0	9942058
Large	0	0	0	0	0	0	0	0	0	0	0	0
Medium	0	0	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0	0	0
	NC-FL Landings (lbs)				**NC-FL Landings (lbs)**				**NC-FL Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	1216531	685832	0	1702082	1591089	398486	641679	818976	1548739	966302	535134	1510926
Large	0	0	0	0	0	0	0	0	0	0	0	0
Medium	0	0	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0	0	0
	ME-VA LENGTHS				**ME-VA LENGTHS**				**ME-VA LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	0	0	1581	0	0	0	1838	0	0	0	1105
Large	0	0	0	0	0	0	0	0	0	0	0	0
Medium	0	0	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0	0	0
	NC LENGTHS				**NC LENGTHS**				**NC LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	1622	1506	0	2115	2477	180	58	1033	2270	394	5	907
Large	0	0	0	0	0	0	0	0	0	0	0	0
Medium	0	0	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0	0	0
	LENGTHS/100 LBS ME-VA				**LENGTHS/100 LBS ME-VA**				**LENGTHS/100 LBS ME-VA**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.016	0.000	0.000	0.000	0.011
Large	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Medium	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Small	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	LENGTHS/100 LBS NC-FL				**LENGTHS/100 LBS NC-FL**				**LENGTHS/100 LBS NC-FL**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.133	0.220	0.000	0.124	0.156	0.045	0.009	0.126	0.147	0.041	0.001	0.060
Large	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Medium	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Small	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table B4.11 Landings (lbs), lengths sampled, and sampling intensity (lengths/100 lbs landed) for ME-VA and NC-FL by quarter and market category from 1988-1990.

	1988				1989				1990			
	ME-VA Landings (lbs)				**ME-VA Landings (lbs)**				**ME-VA Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	0	0	10750523	0	0	0	7158323	0	2215473	0	6985824
Large	0	0	0	0	0	0	0	0	0	0	0	0
Medium	0	0	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0	0	0
	NC-FL Landings (lbs)				**NC-FL Landings (lbs)**				**NC-FL Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	2577962	1115345	412704	933028	1192144	383105	405966	1310253	1668557	652815	566638	1690162
Large	0	0	0	0	0	0	0	0	0	0	0	0
Medium	0	0	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0	0	0
	ME-VA LENGTHS				**ME-VA LENGTHS**				**ME-VA LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	0	0	1961	0	0	0	590	0	104	0	97
Large	0	0	0	0	0	0	0	0	0	0	0	0
Medium	0	0	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0	0	0
	NC LENGTHS				**NC LENGTHS**				**NC LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	2719	151	643	318	2144	784	19	2202	1151	843	357	5096
Large	0	0	0	0	0	0	0	0	0	0	0	0
Medium	0	0	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0	0	0
	LENGTHS/100 LBS ME-VA				**LENGTHS/100 LBS ME-VA**				**LENGTHS/100 LBS ME-VA**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.000	0.000	0.000	0.018	0.000	0.000	0.000	0.008	0.000	0.005	0.000	0.001
Large	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Medium	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Small	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	LENGTHS/100 LBS NC-FL				**LENGTHS/100 LBS NC-FL**				**LENGTHS/100 LBS NC-FL**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.105	0.014	0.156	0.034	0.180	0.205	0.005	0.168	0.069	0.129	0.063	0.302
Large	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Medium	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Small	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table B4.12 Landings (lbs), lengths sampled, and sampling intensity (lengths/100 lbs landed) for ME-VA and NC-FL by quarter and market category for 1991

1991				
ME-VA Landings (lbs)				
Market	1	2	3	4
Uncl	0	0	0	9612438
Large	0	0	0	0
Medium	0	0	0	0
Small	0	0	0	0
NC-FL Landings (lbs)				
Market	1	2	3	4
Uncl	1565142	1066933	437117	850594
Large	0	0	0	0
Medium	0	0	0	0
Small	0	0	0	0
ME-VA LENGTHS				
Market	1	2	3	4
Uncl	0	0	0	201
Large	0	0	0	0
Medium	0	0	0	0
Small	0	0	0	0
NC LENGTHS				
Market	1	2	3	4
Uncl	1681	2877	554	428
Large	0	0	0	0
Medium	0	0	0	0
Small	0	0	0	0
LENGTHS/100 LBS ME-VA				
Market	1	2	3	4
Uncl	0.000	0.000	0.000	0.002
Large	0.000	0.000	0.000	0.000
Medium	0.000	0.000	0.000	0.000
Small	0.000	0.000	0.000	0.000
LENGTHS/100 LBS NC-FL				
Market	1	2	3	4
Uncl	0.107	0.270	0.127	0.050
Large	0.000	0.000	0.000	0.000
Medium	0.000	0.000	0.000	0.000
Small	0.000	0.000	0.000	0.000

Table B4.13 Landings (lbs), lengths sampled, and sampling intensity (lengths/100 lbs landed) for ME-VA and NC and FL by quarter and market from 1992-1994

	1992				1993				1994			
	ME-VA Landings (lbs)				**ME-VA Landings (lbs)**				**ME-VA Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	0	0	7546329	0	0	0	6700454	0	0	0	6771230
Large	0	0	0	0	0	0	0	0	0	0	0	0
Medium	0	0	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0	0	0
	NC-FL Landings (lbs)				**NC-FL Landings (lbs)**				**NC-FL Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	1119651	760851	367899	590656	1053609	708245	207112	736312	0	22791	4169	4652
Large	0	0	0	0	0	0	0	0	953853	223986	0	118162
Medium	0	0	0	0	0	0	0	0	12174	96908	0	197038
Small	0	0	0	0	0	0	0	0	6265	75054	39326	27971
	FL Landings (lbs)				**FL Landings (lbs)**				**FL Landings (lbs)**			
Market	1	2			1	2			1	2		
ALL	886286	209119			911803	305561			751367	188513		
	ME-VA LENGTHS				**ME-VA LENGTHS**				**ME-VA LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	0	0	400	0	0	0	200	0	0	0	763
Large	0	0	0	0	0	0	0	0	0	0	0	0
Medium	0	0	0	0	0	0	0	0	0	0	0	0
Small	0	0	0	0	0	0	0	0	0	0	0	0
	NC LENGTHS				**NC LENGTHS**				**NC LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
	1580	3687	74	664	1706	1667	9	232	0	223	152	22
	0	0	0	0	0	0	0	0	117	69	0	4
	0	0	0	0	0	0	0	0	2	53	0	366
	0	0	0	0	0	0	0	0	14	868	1	91
	FL LENGTHS				**FL LENGTHS**				**FL LENGTHS**			
Market	1	2			1	2			1	2		
ALL	1534	84			1064	381			339	124		

Table B4.13 continued

LENGTHS/100 LBS ME-VA					LENGTHS/100 LBS ME-VA				LENGTHS/100 LBS ME-VA			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.011
Large	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Medium	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Small	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LENGTHS/100 LBS NC-FL					**LENGTHS/100 LBS NC-FL**				**LENGTHS/100 LBS NC-FL**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
	0.141	0.485	0.020	0.112	0.162	0.235	0.004	0.032	0.000	0.979	3.650	0.480
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.031	0.000	0.003
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.055	0.000	0.186
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.221	1.157	0.003	0.326
LENGTHS/100 LBS FL					**LENGTHS/100 LBS FL**				**LENGTHS/100 LBS FL**			
Market	1	2			1	2			1	2		
ALL	0.173	0.040			0.117	0.125			0.045	0.066		

Table B4.14 Landings (lbs), lengths sampled, and sampling intensity (lengths/100 lbs landed) for ME-VA and NC and FL by quarter and market from 1995-1997

	1995				1996				1997			
	ME-VA Landings (lbs)				**ME-VA Landings (lbs)**				**ME-VA Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	0	0	4484236	0	0	0	4022405	0	549995	1663339	929822
Large	0	0	0	0	0	436711	0	397946	0	230725	134306	198149
Medium	0	0	0	0	0	311974	220725	162051	22291	155799	312025	279245
Small	0	0	0	0	0	0	0	300320	0	0	0	295935
	NC-FL Landings (lbs)				**NC-FL Landings (lbs)**				**NC-FL Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	16025	5887	4193	36676	6226	1258	20537	683	2236	3251	16886
Large	1362944	309057	0	377058	0	1807659	4150	808059	1617501	133168	15645	1150077
Medium	352888	201006	141958	98275	32294	270928	107081	58020	180629	286555	161528	277247
Small	7498	55519	24521	53822	16695	81983	17949	29064	0	77853	29417	50486
	FL Landings (lbs)				**FL Landings (lbs)**				**FL Landings (lbs)**			
Market	1	2			1	2			1	2		
ALL	481975	23158			47042	89692			143374	141728		
	ME-VA LENGTHS				**ME-VA LENGTHS**				**ME-VA LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	0	0	189	0	0	0	198	0	161	97	185
Large	0	0	0	0	0	94	0	100	0	200	104	59
Medium	0	0	0	0	0	100	100	229	100	83	69	156
Small	0	0	0	0	0	0	0	500	0	0	0	306
	NC LENGTHS				**NC LENGTHS**				**NC LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
	0	109	1295	2	1	300	76	15	22	475	78	27
	32	43	0	19	0	556	5	16	154	4	1	231
	8	2	20	89	42	138	63	109	212	686	155	602
	10	18	17	155	10	100	28	794	0	896	102	442
	FL LENGTHS				**FL LENGTHS**				**FL LENGTHS**			
Market	1	2			1	2			1	2		
ALL	253	5			247	719			196	82		

Table B4.14 continued.

LENGTHS/100 LBS ME-VA					LENGTHS/100 LBS ME-VA				LENGTHS/100 LBS ME-VA			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.005	0.000	0.029	0.006	0.020
Large	0.000	0.000	0.000	0.000	0.000	0.022	0.000	0.025	0.000	0.087	0.077	0.030
Medium	0.000	0.000	0.000	0.000	0.000	0.032	0.045	0.141	0.449	0.053	0.022	0.056
Small	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.166	0.000	0.000	0.000	0.103

LENGTHS/100 LBS NC-FL					LENGTHS/100 LBS NC-FL				LENGTHS/100 LBS NC-FL			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.000	0.679	22.005	0.053	0.002	4.814	6.071	0.073	3.251	21.234	2.388	0.160
Large	0.002	0.014	0.000	0.005	0.000	0.031	0.116	0.002	0.010	0.003	0.006	0.020
Medium	0.002	0.001	0.014	0.091	0.130	0.051	0.059	0.188	0.117	0.239	0.096	0.217
Small	0.132	0.033	0.067	0.289	0.061	0.122	0.156	2.730	0.000	1.151	0.346	0.876

LENGTHS/100 LBS FL			LENGTHS/100 LBS FL		LENGTHS/100 LBS FL	
Market	1	2	1	2	1	2
ALL	0.052	0.022	0.525	0.802	0.137	0.058

Table B4.14 continued.

Table B4.15 Landings (lbs), lengths sampled, and sampling intensity (lengths/100 lbs landed) for ME-VA, NC and FL by qtr and mkt from 1998-2000

	1998				1999				2000			
	ME-VA Landings (lbs)				**ME-VA Landings (lbs)**				**ME-VA Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	633916	1E+06	993435	30497	662807	1E+06	813393	0	735574	1283634	748623
Large	0	197731	199747	277190	0	220623	113921	338687	0	0	0	1052196
Medium	0	296007	212184	325364	0	146088	115502	167659	0	109380	112652	196955
Small	0	62723	288506	147584	0	47842	133366	87347	0	22488	181189	115596
	NC-FL Landings (lbs)				**NC-FL Landings (lbs)**				**NC-FL Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	32222	18298	3031	3178	1781	40725	1106	618	785	7776	2850	12439
Large	1253323	156499	7399	251938	1383951	267491	2982	63114	1877721	604071	0	109261
Medium	265311	530196	80354	208319	540410	323717	55285	25387	33943	164704	146149	333541
Small	16167	55664	9115	34920	6551	30192	6658	11123	6678	32515	19485	17256
	FL Landings (lbs)				**FL Landings (lbs)**				**FL Landings (lbs)**			
Market	1	2			1	2			1	2		
ALL	261535	82568			216411	131167			82395.89	59538.65		
	ME-VA LENGTHS				**ME-VA LENGTHS**				**ME-VA LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	361	556	242	5	807	292	139	0	131	231	100
Large	0	117	295	65	0	454	58	94	0	0	0	19
Medium	0	582	241	570	0	27	378	66	0	316	389	94
Small	0	201	857	20	0	168	543	152	0	120	252	127
	NC LENGTHS				**NC LENGTHS**				**NC LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
	31	53	118	24	26	164	22	22	338	131	92	100
	386	160	0	252	1175	191	30	200	1528	739	0	410
	297	1484	226	146	3260	546	205	33	64	1537	752	2120
	3	236	84	723	2	45	5	682	57	99	10	186
FL LENGTHS					**FL LENGTHS**				**FL LENGTHS**			
Market	1	2			1	2			1	2		
ALL	176	165			31	17			27	49		

Table B4.15 continued

LENGTHS/100 LBS ME-VA					LENGTHS/100 LBS ME-VA				LENGTHS/100 LBS ME-VA			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.000	0.057	0.041	0.024	0.016	0.122	0.022	0.017	0.000	0.018	0.018	0.013
Large	0.000	0.059	0.148	0.023	0.000	0.206	0.051	0.028	0.000	0.000	0.000	0.002
Medium	0.000	0.197	0.114	0.175	0.000	0.018	0.327	0.039	0.000	0.289	0.345	0.048
Small	0.000	0.320	0.297	0.014	0.000	0.351	0.407	0.174	0.000	0.534	0.139	0.110
LENGTHS/100 LBS NC-FL					**LENGTHS/100 LBS NC-FL**				**LENGTHS/100 LBS NC-FL**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.096	0.288	3.900	0.740	1.472	0.403	1.954	3.619	43.110	1.684	3.237	0.803
Large	0.031	0.102	0.000	0.100	0.085	0.071	1.007	0.316	0.081	0.122	0.000	0.375
Medium	0.112	0.280	0.281	0.070	0.603	0.169	0.371	0.129	0.189	0.933	0.515	0.635
Small	0.020	0.425	0.917	2.071	0.031	0.150	0.078	6.128	0.860	0.303	0.053	1.076
LENGTHS/100 LBS FL					**LENGTHS/100 LBS FL**				**LENGTHS/100 LBS FL**			
Market	1	2			1	2			1	2		
ALL	0.067	0.200			0.014	0.013			0.033	0.082		

Table B4.16 Landings (lbs), lengths sampled, and sampling intensity (lengths/100 lbs landed) for ME-VA and NC and FL by quarter and market from 2001-2003

	2001				2002				2003			
	ME-VA Landings (lbs)				ME-VA Landings (lbs)				ME-VA Landings (lbs)			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	805131	1E+06	778394	0	678907	1E+06	625413	0	662155	1013769	701414
Large	0	463262	199838	232986	0	478070	116171	163468	0	232833	241607	220684
Medium	0	276613	159410	139296	0	459751	133368	130594	0	207303	185263	267065
Small	0	9611	93506	104163	6747	24477	217447	177921	0	16998	48405	39659
	NC-FL Landings (lbs)				NC-FL Landings (lbs)				NC-FL Landings (lbs)			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	10405	43284	7894	2359	1691	16439	6636	4495	5127	45489	11192	13896
Large	1830585	461745	0	431941	1106634	142963	24559	426592	1273604	426179	0	606910
Medium	694884	340755	100816	49511	249271	97726	78640	108361	449807	388971	106195	78996
Small	16829	35303	18921	20770	9658	20105	10821	19381	25251	30074	4256	4155
	FL Landings (lbs)				FL Landings (lbs)				FL Landings (lbs)			
Market	1	2			1	2			1	2		
ALL	65955.5	72971			41290.42	40426.75			51507.94	47117.09		
	ME-VA LENGTHS				ME-VA LENGTHS				ME-VA LENGTHS			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	546	506	126	0	397	591	115	0	967	527	78
Large	0	5	102	276	0	311	6	22	0	342	353	112
Medium	0	438	242	104	0	376	1414	305	0	914	318	538
Small	0	92	513	14	29	174	427	412	0	94	277	116
	NC LENGTHS				NC LENGTHS				NC LENGTHS			
Market	1	2	3	4	1	2	3	4	1	2	3	4
	4	311	50	22	578	37	107	64	11	284	110	22
	1307	741	0	208	884	628	532	482	1460	1429	0	851
	5429	918	281	39	1709	962	523	216	1255	724	369	184
	252	974	174	403	19	372	37	829	96	589	19	259
	FL LENGTHS				FL LENGTHS				FL LENGTHS			
Market	1	2			1	2			1	2		
ALL	97	42			67	28			16	9		

Table B4.16 continued.

LENGTHS/100 LBS ME-VA					LENGTHS/100 LBS ME-VA				LENGTHS/100 LBS ME-VA			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.000	0.068	0.041	0.016	0.000	0.058	0.047	0.018	0.000	0.146	0.052	0.011
Large	0.000	0.001	0.051	0.118	0.000	0.065	0.005	0.013	0.000	0.147	0.146	0.051
Medium	0.000	0.158	0.152	0.075	0.000	0.082	1.060	0.234	0.000	0.441	0.172	0.201
Small	0.000	0.957	0.549	0.013	0.430	0.711	0.196	0.232	0.000	0.553	0.572	0.292
LENGTHS/100 LBS NC-FL					**LENGTHS/100 LBS NC-FL**				**LENGTHS/100 LBS NC-FL**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.035	0.717	0.633	0.914	34.186	0.223	1.613	1.418	0.222	0.625	0.980	0.161
Large	0.071	0.160	0.000	0.048	0.080	0.439	2.165	0.113	0.115	0.335	0.000	0.140
Medium	0.781	0.269	0.279	0.078	0.686	0.984	0.665	0.199	0.279	0.186	0.347	0.233
Small	1.495	2.759	0.918	1.942	0.197	1.852	0.342	4.277	0.381	1.959	0.450	6.222
LENGTHS/100 LBS FL					**LENGTHS/100 LBS FL**				**LENGTHS/100 LBS FL**			
Market	1	2			1	2			1	2		
ALL	0.147	0.058			0.162	0.069			0.031	0.019		

Table B4.17 Landings (lbs), lengths sampled, and sampling intensity (lengths/100 lbs landed) for ME-VA and NC and FL by quarter and market from 2004-2006

	2004				2005				2006			
	ME-VA Landings (lbs)				**ME-VA Landings (lbs)**				**ME-VA Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	298155	835685	704000	0	294102	771819	683274	0	319591	889968	1047738
Large	0	405767	434333	340119	0	269187	402303	313423	0	459678	355681	245392
Medium	0	316733	355258	319993	0	476997	338647	425710	0	316411	300782	214663
Small	0	25732	92369	55319	0	54610	34022	20870	0	23816	67187	37137
	NC-FL Landings (lbs)				**NC-FL Landings (lbs)**				**NC-FL Landings (lbs)**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	31115	9208	4320	19356	6088	14823	5028	13595	467	8132	4074	13161
Large	1492357	420338	11737	721649	973177	391382	3858	588585	1518621	181056	8768	107665
Medium	392065	308445	103907	203167	268925	300991	150863	73184	360414	248423	131789	170221
Small	4466	20910	10923	10830	1570	29532	8216	7801	0	22834	7255	8283
	FL Landings (lbs)				**FL Landings (lbs)**				**FL Landings (lbs)**			
Market	1	2			1	2			1	2		
ALL	60418.6	62611			71433.66	84448.1			42083.76	57529.35		
	ME-VA LENGTHS				**ME-VA LENGTHS**				**ME-VA LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	823	1595	1099	0	456	1450	630	0	887	1392	423
Large	0	422	365	240	0	232	570	159	0	220	370	399
Medium	0	206	193	273	0	385	338	809	0	558	1173	1196
Small	0	112	687	119	0	178	519	229	0	268	1043	591
	NC LENGTHS				**NC LENGTHS**				**NC LENGTHS**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
	23	131	106	27	18	159	43	390	7	103	90	150
	1773	792	25	921	2539	971	18	925	3139	505	3	26
	2378	578	138	1859	649	1822	269	431	1703	969	644	1387
	22	380	7	335	16	439	2	587	0	661	53	556
	FL LENGTHS				**FL LENGTHS**				**FL LENGTHS**			
Market	1	2			1	2			1	2		
ALL	6	42			39	53			17	420		

Table B4.17 continued.

LENGTHS/100 LBS ME-VA					LENGTHS/100 LBS ME-VA				LENGTHS/100 LBS ME-VA			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.000	0.276	0.191	0.156	0.000	0.155	0.188	0.092	0.000	0.278	0.156	0.040
Large	0.000	0.104	0.084	0.071	0.000	0.086	0.142	0.051	0.000	0.048	0.104	0.163
Medium	0.000	0.065	0.054	0.085	0.000	0.081	0.100	0.190	0.000	0.176	0.390	0.557
Small	0.000	0.435	0.744	0.215	0.000	0.326	1.525	1.097	0.000	1.125	1.552	1.591
LENGTHS/100 LBS NC-FL					**LENGTHS/100 LBS NC-FL**				**LENGTHS/100 LBS NC-FL**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.075	1.420	2.456	0.140	0.301	1.069	0.845	2.871	1.415	1.263	2.209	1.140
Large	0.119	0.188	0.216	0.128	0.261	0.248	0.456	0.157	0.207	0.279	0.032	0.024
Medium	0.607	0.187	0.132	0.915	0.241	0.605	0.178	0.589	0.472	0.390	0.488	0.815
Small	0.499	1.818	0.061	3.091	0.997	1.485	0.021	7.525	0.000	2.895	0.728	6.715
LENGTHS/100 LBS FL					**LENGTHS/100 LBS FL**				**LENGTHS/100 LBS FL**			
Market	1	2			1	2			1	2		
ALL	0.010	0.067			0.055	0.063			0.040	0.730		

Table B4.18 Landings (lbs), lengths sampled, and sampling intensity (lengths/100 lbs landed) for ME-VA and NC and FL by quarter and market from 2007-2009

	2007				2008				2009			
	ME-VA Landings (lbs)				ME-VA Landings (lbs)				ME-VA Landings (lbs)			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	465365	1E+06	548862	22008	327421	751174	543981	0	269608	598791	394198
Large	65689	904730	392156	366176	7541	728030	582739	226150	0	567637	824265	584772
Medium	0	418065	249503	313920	2996	187301	299217	192331	53251	328039	336058	196535
Small	0	15494	58743	0	0	3971	56070	8983	6712	11821	26950	103524
	NC-FL Landings (lbs)				NC-FL Landings (lbs)				NC-FL Landings (lbs)			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	367	10210	9639	9577	3667	13037	4717	8610	4769	13723	13148	5735
Large	804366	260947	29271	345664	531879	275869	10541	74647	931732	460649	9076	20080
Medium	216473	311792	128549	114460	455107	239747	106767	113300	232061	202218	235373	101714
Small	12479	24438	13427	38066	34227	27240	15438	15604	0	46454	66454	16897
	FL Landings (lbs)				FL Landings (lbs)				FL Landings (lbs)			
Market	1	2			1	2			1	2		
ALL	67723	100976			87619.44	61223			111982.79	102311.58		
	ME-VA LENGTHS				ME-VA LENGTHS				ME-VA LENGTHS			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	691	1324	372	32	765	1517	620	0	314	1342	776
Large	35	691	89	301	201	326	158	325	0	628	270	553
Medium	0	481	792	393	6	627	985	583	467	368	804	819
Small	0	285	488	0	0	146	400	553	33	95	102	467
	NC LENGTHS				NC LENGTHS				NC LENGTHS			
Market	1	2	3	4	1	2	3	4	1	2	3	4
	190	636	438	260	19	90	45	250	11	133	1222	152
	1408	684	125	34	2222	383	13	3	1733	281	1	3
	407	2149	470	333	1472	702	993	390	1343	671	634	124
	21	481	27	522	184	242	25	430	0	252	4	621
	FL LENGTHS				FL LENGTHS				FL LENGTHS			
Market	1	2			1	2			1	2		
ALL	68	60			21	60			3	657		

Table B4.18 continued

LENGTHS/100 LBS ME-VA					LENGTHS/100 LBS ME-VA				LENGTHS/100 LBS ME-VA			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.000	0.148	0.113	0.068	0.145	0.234	0.202	0.114	0.000	0.116	0.224	0.197
Large	0.053	0.076	0.023	0.082	2.665	0.045	0.027	0.144	0.000	0.111	0.033	0.095
Medium	0.000	0.115	0.317	0.125	0.200	0.335	0.329	0.303	0.877	0.112	0.239	0.417
Small	0.000	1.839	0.831	0.000	0.000	3.677	0.713	6.156	0.492	0.804	0.378	0.451
LENGTHS/100 LBS NC-FL					**LENGTHS/100 LBS NC-FL**				**LENGTHS/100 LBS NC-FL**			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	51.653	6.233	4.543	2.717	0.514	0.689	0.958	2.902	0.230	0.970	9.294	2.644
Large	0.175	0.262	0.425	0.010	0.418	0.139	0.123	0.004	0.186	0.061	0.013	0.012
Medium	0.188	0.689	0.365	0.291	0.324	0.293	0.930	0.344	0.579	0.332	0.269	0.122
Small	0.171	1.967	0.200	1.372	0.537	0.890	0.164	2.755	0.000	0.543	0.005	3.677
LENGTHS/100 LBS FL					**LENGTHS/100 LBS FL**				**LENGTHS/100 LBS FL**			
Market	1	2			1	2			1	2		
ALL	0.100	0.059			0.024	0.098			0.003	0.642		

Table B4.19 Landings (lbs), lengths sampled, and sampling intensity (lengths/100 lbs landed) for ME-VA and NC and FL by quarter and market from 2010-2012

	2010				2011				2012			
	ME-VA Landings (lbs)				ME-VA Landings (lbs)				ME-VA Landings (lbs)			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	237692	618572	308954	42503	349938	466963	382370	146624	451638	568411	443292
Large	26636	717445	767847	398163	6473	335076	527652	388626	40891	448697	396498	509195
Medium	17057	183256	212521	154476	41928	231137	216890	194785	65092	260851	248729	191214
Small	3015	27140	55531	22491	5909	10628	43734	21346	23469	26539	63109	55486
	NC-FL Landings (lbs)											
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	41	5436	1290	2581	129	3145	937	1213	175	4609	14176	12842
Large	1198520	462031	8851	513023	684156	145537	3326	2075	0	72822	5217	1958
Medium	146810	306739	255907	229495	204295	426733	315047	47882	32403	197746	259299	115494
Small	0	42099	15530	27671	1595	43235	12727	5384	4236	15509	15375	7001
	FL Landings (lbs)				FL Landings (lbs)				FL Landings (lbs)			
Market	1	2			1	2			1	2		
ALL	191790	124812			133662.4	111432			82186.47	96103.7		
	ME-VA LENGTHS				ME-VA LENGTHS				ME-VA LENGTHS			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0	390	1261	836	208	489	1735	1006	362	1059	1522	903
Large	43	460	763	577	13	645	758	800	204	702	651	807
Medium	1	533	241	389	88	358	163	854	293	494	1138	919
Small	26	52	367	617	134	12	264	863	99	697	675	387
	NC LENGTHS				NC LENGTHS				NC LENGTHS			
Market	1	2	3	4	1	2	3	4	1	2	3	4
	5	240	61	102	51	195	11	70	174	537	147	323
	1634	74	1	587	471	169	2	2	0	29	1	2
	773	1134	700	695	986	2644	829	87	574	2773	1883	151
	0	537	33	95	1	101	33	68	36	99	5	271
	FL LENGTHS				FL LENGTHS				FL LENGTHS			
Market	1	2			1	2			1	2		
ALL	637	69			92	169			373	230		

Table B4.19 continued

LENGTHS/100 LBS ME-VA					LENGTHS/100 LBS ME-VA				LENGTHS/100 LBS ME-VA			
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	0.000	0.164	0.204	0.271	0.489	0.140	0.372	0.263	0.247	0.234	0.268	0.204
Large	0.161	0.064	0.099	0.145	0.201	0.192	0.144	0.206	0.499	0.156	0.164	0.158
Medium	0.006	0.291	0.113	0.252	0.210	0.155	0.075	0.438	0.450	0.189	0.458	0.481
Small	0.862	0.192	0.661	2.743	2.268	0.113	0.604	4.043	0.422	2.626	1.070	0.697

LENGTHS/100 LBS NC-FL												
Market	1	2	3	4	1	2	3	4	1	2	3	4
Uncl	11.725	4.409	4.727	3.940	39.818	6.213	1.191	5.779	99.447	11.662	1.036	2.519
Large	0.136	0.016	0.011	0.114	0.069	0.116	0.066	0.117	0.000	0.040	0.027	0.100
Medium	0.526	0.370	0.274	0.303	0.483	0.620	0.263	0.181	1.773	1.403	0.726	0.131
Small	0.000	1.277	0.215	0.345	0.053	0.233	0.261	1.272	0.854	0.637	0.032	3.875

LENGTHS/100 LBS FL			LENGTHS/100 LBS FL		LENGTHS/100 LBS FL	
Market	1	2	1	2	1	2
ALL	0.332	0.055	0.069	0.152	0.454	0.239

Table B4.20 Landings (lbs), lengths sampled, and sampling intensity (lengths/100 lbs landed) for ME-VA and NC and FL by quarter and market from 2013-2014

	2013				2014			
	ME-VA Landings (lbs)				**ME-VA Landings (lbs)**			
Market	1	2	3	4	1	2	3	4
Uncl	74489	429754	735891	242154	12776	302644	541012	183442
Large	3783	113071	409792	283111	5415	273359	347966	460803
Medium	32736	266550	265895	108906	0	199598	238909	114482
Small	23059	34376	18162	8156	0	14929	23986	28753
	NC-FL Landings (lbs)				**NC-FL Landings (lbs)**			
Market	1	2	3	4	1	2	3	4
Uncl	47	22781	6905	3180	100	7751	2033	2817
Large	208502	50108	7711	12568	774680	296359	0	16488
Medium	41515	366361	183875	200098	242259	172269	280088	179284
Small	0	33537	12390	10008	0	21422	8543	14960
	FL Landings (lbs)				**FL Landings (lbs)**			
Market	1	2			1	2		
ALL	62430.1	80232			163413.5	0		
	ME-VA LENGTHS				**ME-VA LENGTHS**			
Market	1	2	3	4	1	2	3	4
Uncl	285	283	959	486	1	493	1140	1004
Large	51	145	371	350	3	267	121	279
Medium	344	550	576	342	0	132	270	284
Small	17	304	303	22	0	104	69	204
	NC LENGTHS				**NC LENGTHS**			
Market	1	2	3	4	1	2	3	4
	1	83	7	25	1	44	6	6
	98	65	2	102	1066	110	0	287
	85	3199	951	2176	1285	1110	1220	1072
	0	4	32	90	0	63	13	50
	FL LENGTHS				**FL LENGTHS**			
Market	1	2			1	2		
ALL	216	167			207	0		

Table B4.20 continued

. LENGTHS/100 LBS ME-VA					LENGTHS/100 LBS ME-VA			
Market	1	2	3	4	1	2	3	4
Uncl	0.383	0.066	0.130	0.201	0.008	0.163	0.211	0.547
Large	1.348	0.128	0.091	0.124	0.055	0.098	0.035	0.061
Medium	1.051	0.206	0.217	0.314	0.000	0.066	0.113	0.248
Small	0.074	0.884	1.668	0.270	0.000	0.697	0.288	0.709

LENGTHS/100 LBS NC-FL					LENGTHS/100 LBS NC-FL			
Market	1	2	3	4	1	2	3	4
Uncl	2.128	0.363	0.096	0.781	1.000	0.570	0.289	0.226
Large	0.047	0.129	0.028	0.815	0.138	0.037	0.000	1.742
Medium	0.206	0.873	0.517	1.087	0.531	0.644	0.436	0.598
Small	0.000	0.013	0.259	0.899	0.000	0.292	0.155	0.337

LENGTHS/100 LBS FL			LENGTHS/100 LBS FL	
Market	1	2	1	2
ALL	0.346	0.208	0.127	0.000

Table B4.21 Commercial catch-at-age for bluefish from 1985 to 2014

	Age						
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
1985	607.2	3297.1	432.6	168.2	82.3	151.6	359.0
1986	599.0	2297.6	729.8	197.3	295.0	285.6	278.0
1987	209.2	1837.1	793.3	696.3	157.7	179.1	240.6
1988	173.8	905.6	476.5	221.2	433.2	345.4	497.9
1989	655.4	1505.7	163.6	182.6	193.9	326.1	162.0
1990	1354.6	1267.6	2827.6	215.4	80.9	155.8	114.2
1991	468.9	5026.4	425.3	16.1	48.9	62.9	798.6
1992	89.1	8150.2	1014.7	95.6	24.8	24.4	71.0
1993	572.0	1238.2	3001.7	74.2	31.6	22.1	86.9
1994	34.1	1388.3	359.1	51.4	157.6	229.4	300.0
1995	296.3	3761.3	704.0	7.0	6.5	49.3	132.2
1996	178.7	1126.9	726.0	317.6	137.9	88.4	266.0
1997	112.7	1096.9	509.7	183.2	134.2	75.2	402.9
1998	192.4	2383.4	1360.2	178.4	31.3	120.6	82.9
1999	495.0	1549.9	1106.4	183.4	15.4	124.3	129.6
2000	284.4	2736.9	1013.6	143.5	20.7	283.5	46.5
2001	68.7	851.7	1445.5	300.9	40.8	303.3	67.4
2002	52.6	1575.2	708.4	136.7	137.7	123.0	149.8
2003	37.8	966.4	704.2	222.7	168.2	142.5	176.6
2004	30.9	1216.6	790.2	225.5	119.0	183.1	191.1
2005	225.5	787.9	1112.0	224.7	167.1	90.4	55.5
2006	143.2	924.6	563.3	352.2	133.2	159.6	251.9
2007	242.7	648.4	1006.8	233.5	187.0	108.0	250.8
2008	137.7	470.7	744.1	279.5	137.2	116.5	124.0
2009	50.2	417.6	585.7	558.4	152.5	89.8	232.2
2010	46.5	338.0	513.2	514.7	275.1	151.1	220.5
2011	40.0	294.3	461.3	557.6	288.0	75.9	166.4
2012	59.8	301.3	625.3	498.6	163.5	47.1	119.1
2013	190.3	536.9	729.6	241.4	96.4	57.5	64.2
2014	259.9	848.2	608.6	134.9	130.7	79.2	116.0

Table B4.22 Commercial weight-at-age (kg) for bluefish from 1985 to 2014

	Age						
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
1985	0.29	0.55	1.49	2.23	3.34	4.67	5.99
1986	0.29	0.57	1.16	2.60	3.83	4.26	5.24
1987	0.29	0.65	1.35	2.29	3.56	4.43	5.44
1988	0.25	0.70	1.03	2.42	3.28	4.15	5.22
1989	0.23	0.65	1.29	3.11	3.60	4.12	4.86
1990	0.15	0.47	1.23	2.12	3.55	4.11	5.13
1991	0.15	0.14	0.72	2.67	3.36	4.31	5.70
1992	0.13	0.45	0.76	1.92	3.39	4.23	5.27
1993	0.15	0.41	1.14	1.95	2.80	4.23	5.37
1994	0.26	0.45	0.80	2.64	3.48	4.19	5.82
1995	0.18	0.54	0.85	1.84	3.82	4.35	5.22
1996	0.16	0.62	1.09	1.88	3.09	4.18	4.88
1997	0.19	0.47	0.93	1.78	2.77	3.72	5.26
1998	0.20	0.49	0.80	2.00	3.25	4.14	5.83
1999	0.19	0.44	0.77	1.88	3.48	3.98	6.12
2000	0.19	0.42	0.69	2.86	2.96	3.62	5.72
2001	0.18	0.42	0.82	2.28	3.39	3.92	5.70
2002	0.18	0.49	0.94	1.67	2.52	3.37	4.53
2003	0.16	0.53	1.01	1.96	2.56	3.43	4.41
2004	0.20	0.51	1.06	1.87	2.77	3.47	4.26
2005	0.30	0.57	0.88	2.19	3.48	4.18	4.86
2006	0.24	0.46	0.78	1.54	2.54	3.23	3.80
2007	0.18	0.39	0.84	1.54	2.42	3.66	4.15
2008	0.19	0.50	0.96	1.68	2.80	3.36	4.11
2009	0.19	0.47	1.03	1.10	2.49	3.40	4.35
2010	0.20	0.39	1.01	0.90	2.19	3.58	4.72
2011	0.20	0.42	0.82	0.79	1.24	3.89	5.11
2012	0.19	0.45	0.72	0.90	2.12	3.98	5.31
2013	0.21	0.49	0.75	1.31	2.48	3.84	5.42
2014	0.24	0.41	0.72	1.61	2.81	3.55	4.48

Table B4.23 Recreational Harvest (A+B1) Total Weight (mt) 1982-2014. Data source: MRFSS/MRIP

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA	FL	Total
1982	10.0	7.2	1,662.8	8,864.6	8,155.0	5,399.5	4,959.1	179.6	3,114.3	2,213.5	1,649.9	141.8	15.4	1,278.2	37,650.9
1983	140.7	23.5	3,718.4	10,268.4	1,265.6	4,317.8	7,531.7	580.8	3,552.9	1,448.9	6,485.4	61.0	23.6	1,006.1	40,425.0
1984	0.3	13.5	2,155.3	1,241.8	5,200.5	5,380.1	8,816.9	395.0	2,203.3	471.0	3,566.6	80.3	34.9	1,036.7	30,596.2
1985	146.3	0.0	1,309.8	2,661.9	3,686.3	3,919.6	2,978.6	118.1	4,405.7	1,432.3	2,424.8	154.0	6.2	576.6	26,289.7
1986	439.0	303.2	6,039.4	5,306.3	5,474.2	7,880.6	9,303.8	156.3	3,034.4	1,719.3	1,853.8	183.7	8.0	430.7	45,576.8
1987	1,074.5	319.5	3,225.5	1,141.7	3,732.5	9,056.0	8,765.4	140.5	3,210.7	784.4	2,393.3	102.1	113.8	709.3	38,613.1
1988	302.3	132.7	2,212.9	931.0	1,739.8	2,815.2	4,495.3	245.7	3,543.4	1,599.1	3,054.8	51.1	17.4	732.7	21,508.4
1989	145.1	100.6	1,522.5	1,299.8	2,072.1	3,368.3	4,948.0	294.1	1,374.9	530.6	1,405.5	150.2	1.9	594.4	18,953.1
1990	230.9	120.1	1,278.9	626.0	2,501.0	3,251.9	2,961.0	114.4	660.7	585.9	1,189.2	35.9	18.3	286.1	14,002.2
1991	225.7	123.0	1,998.7	766.1	2,419.9	3,421.1	2,394.3	188.5	1,283.8	727.9	751.0	30.9	14.7	621.6	14,509.2
1992	421.1	77.9	888.1	560.1	1,869.5	2,663.7	2,739.0	143.3	332.0	184.3	496.8	57.2	14.7	563.4	11,738.1
1993	110.8	167.2	1,534.0	432.8	1,932.4	2,597.4	861.9	192.5	247.9	62.5	461.4	28.9	4.1	570.5	9,811.5
1994	290.7	80.9	1,727.1	200.5	1,327.9	1,501.8	888.0	66.2	307.6	86.7	266.5	46.1	1.1	258.1	7,972.6
1995	33.5	49.6	1,197.5	230.8	1,278.1	1,134.0	1,493.8	89.1	285.8	140.3	206.8	72.8	4.8	272.5	7,322.7
1996	7.7	7.9	806.4	229.5	1,074.1	723.3	1,504.6	132.7	235.2	126.3	335.6	13.6	1.2	129.9	5,689.8
1997	35.1	109.3	1,053.4	370.9	645.4	566.7	1,670.4	70.0	415.9	648.7	602.3	41.0	2.0	256.1	6,918.9
1998	6.7	14.0	705.2	422.3	510.4	638.5	1,898.6	91.5	381.9	173.8	417.2	50.8	10.4	273.4	6,048.1
1999	12.8	15.0	317.9	380.0	413.2	516.0	1,433.2	41.8	162.4	96.4	191.0	9.2	3.9	150.7	3,310.6
2000	0.0	4.1	646.8	779.1	327.1	821.4	1,225.0	99.0	204.5	74.5	324.0	28.4	6.4	270.3	4,940.6
2001	55.0	24.0	842.9	490.9	563.7	863.1	1,680.5	86.1	287.1	211.1	531.2	40.9	3.5	320.9	6,743.4
2002	57.5	62.5	587.0	406.5	570.5	1,077.7	1,182.1	81.1	237.3	63.9	338.5	32.9	1.0	459.4	5,199.0
2003	21.9	23.2	590.1	420.5	917.5	1,177.6	1,580.5	74.4	154.7	147.5	370.2	24.7	0.7	454.9	7,116.3
2004	44.4	35.2	819.5	522.4	1,049.9	2,458.1	1,513.0	46.2	177.9	158.1	568.3	52.4	0.2	408.8	8,513.9
2005	82.6	53.1	1,114.4	379.9	586.5	1,690.0	3,510.6	106.6	205.8	327.6	578.6	75.7	1.7	296.5	9,654.4
2006	13.2	20.9	1,546.5	461.2	1,020.4	1,424.5	1,498.7	110.1	284.5	377.5	477.7	32.4	1.7	284.5	7,890.9
2007	102.5	87.5	1,223.5	394.1	1,326.7	3,205.0	1,936.2	70.5	461.8	142.0	576.9	52.8	3.0	288.0	10,204.7
2008	76.2	16.5	1,358.6	437.1	1,681.4	2,410.3	1,565.9	37.8	246.7	144.5	673.4	42.4	2.4	284.9	9,865.5
2009	4.6	0.9	896.7	159.3	670.4	2,073.9	1,392.3	51.3	334.2	49.2	434.6	56.5	0.6	440.1	6,736.4
2010	23.6	6.2	1,223.2	54.8	1,195.0	1,825.2	1,551.2	17.4	174.3	196.2	432.3	161.4	4.4	546.0	7,971.5
2011	1.5	8.3	532.9	236.2	795.0	1,411.9	1,192.2	26.0	141.9	24.3	453.2	72.5	0.8	318.3	5,720.4
2012	7.6	14.5	588.8	106.8	1,118.8	1,491.2	1,217.4	18.5	55.5	54.9	458.4	66.2	1.2	171.7	5,863.5
2013	28.4	0.0	971.2	626.9	1,901.7	1,671.4	831.5	11.9	29.7	124.6	448.5	49.5	1.7	234.2	7,062.9
2014	0.3	2.4	751.2	157.9	549.6	851.2	1,411.2	56.0	109.6	38.9	436.0	47.8	5.5	326.8	4,772.1

Table B4.24 Recreational harvest (A+B1) by state (numbers of fish) 1982-2014. Data Source: MRFSS/MRIP

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA	FL	Total
1982	9,028	1,323	666,541	2,869,064	5,451,071	3,128,211	2,935,851	235,461	2,165,924	1,078,140	2,926,732	475,530	36,962	1,743,831	23,723,669
1983	39,041	5,118	1,450,528	3,741,228	1,207,856	5,426,404	3,952,550	340,839	2,124,159	577,478	4,310,991	148,062	100,217	1,459,072	24,883,543
1984	136	5,771	795,041	745,651	3,271,917	5,821,703	2,941,418	203,356	1,737,086	454,614	2,196,749	278,736	179,994	2,165,749	20,797,921
1985	45,986	0	430,804	1,478,197	3,134,579	3,760,052	2,682,711	120,191	3,642,442	649,555	1,754,375	430,927	20,153	1,095,752	19,245,724
1986	148,542	66,261	2,243,859	1,873,890	2,514,539	6,914,320	4,808,361	161,429	2,064,470	849,833	1,679,049	156,624	19,436	940,237	24,440,850
1987	289,408	74,178	1,420,481	825,341	2,534,984	5,386,239	4,726,822	99,808	2,241,352	564,701	1,737,660	164,392	43,928	966,996	21,076,290
1988	62,840	31,625	692,553	440,261	663,699	1,453,538	1,754,447	255,122	1,228,546	437,135	1,821,847	87,164	8,012	968,222	9,905,011
1989	37,520	22,647	411,504	486,802	1,467,939	3,984,450	2,888,757	323,562	711,110	707,077	1,605,431	226,047	16,235	710,857	13,599,938
1990	47,294	26,782	416,331	446,687	1,034,237	2,737,554	2,176,865	242,129	707,293	743,031	2,228,907	76,037	42,898	439,313	11,365,358
1991	114,909	41,060	840,326	441,074	1,729,165	3,471,086	2,011,959	147,079	953,321	666,051	820,536	39,078	24,441	642,522	11,942,607
1992	94,690	23,518	345,096	249,797	1,184,831	1,195,920	1,907,876	188,684	366,588	163,359	681,805	33,253	7,535	714,803	7,157,755
1993	29,083	27,622	510,703	188,254	825,333	1,440,297	656,435	137,934	217,055	65,856	722,668	81,249	5,179	817,688	5,725,356
1994	65,584	18,343	434,172	296,726	512,044	1,605,331	941,152	120,327	472,915	231,183	451,718	118,314	3,595	496,547	5,767,951
1995	8,937	11,745	404,748	126,146	608,269	1,041,725	1,242,904	183,141	285,231	212,501	386,623	154,037	14,732	487,240	5,167,979
1996	9,638	3,449	285,239	361,211	624,072	545,273	957,039	136,241	345,912	323,679	298,588	54,815	4,197	255,751	4,205,104
1997	13,151	25,329	316,398	412,091	518,809	816,331	942,127	158,807	432,616	446,772	742,424	89,242	5,129	493,811	5,413,037
1998	1,735	2,856	237,168	193,900	386,501	767,789	817,361	149,749	284,445	223,304	527,061	170,529	21,797	417,916	4,202,111
1999	8,020	3,830	196,605	329,615	440,444	710,399	809,040	84,247	166,535	133,679	517,744	34,462	12,036	235,184	3,681,840
2000	0	1,372	221,400	280,394	389,715	718,078	1,235,628	131,815	344,249	149,737	877,586	87,807	20,252	438,974	4,897,007
2001	15,449	8,029	357,242	364,597	716,477	1,005,457	1,430,605	101,503	428,589	260,817	1,265,790	118,264	9,672	580,746	6,663,237
2002	24,163	19,147	228,530	324,557	569,340	750,577	1,321,223	116,616	198,527	130,898	777,396	78,625	1,980	758,610	5,300,189
2003	13,980	7,730	374,327	334,257	457,759	1,146,759	1,570,656	89,387	214,414	171,573	952,694	66,269	1,222	644,036	6,045,063
2004	15,665	14,148	355,500	257,455	588,833	1,894,833	1,530,834	126,224	366,454	221,352	1,231,782	133,013	321	513,991	7,250,405
2005	37,383	20,583	550,213	345,310	247,360	1,683,647	2,367,766	127,120	167,545	323,856	1,382,613	246,643	4,410	444,731	7,949,180
2006	7,477	8,940	652,516	470,758	506,812	1,832,376	1,183,300	96,982	419,856	368,269	917,634	133,707	3,246	433,306	7,035,179
2007	49,329	34,412	682,528	295,213	450,500	2,150,532	1,654,412	153,056	675,638	313,792	1,257,420	175,372	10,543	471,152	8,373,899
2008	30,189	6,019	519,490	281,773	623,183	1,483,713	1,027,640	68,592	551,105	384,359	1,176,983	127,399	7,198	376,509	6,664,152
2009	2,716	426	343,453	64,956	261,998	1,293,144	813,980	97,912	591,214	137,088	827,788	134,899	1,596	623,072	5,194,242
2010	13,660	1,662	473,946	103,020	590,844	1,026,392	910,018	32,365	272,764	318,197	1,104,077	444,340	12,563	786,982	6,090,830
2011	481	2,118	224,501	124,143	306,858	927,493	1,149,558	45,786	259,286	85,092	1,152,105	225,058	2,742	556,172	5,061,393
2012	4,341	9,446	336,552	672,541	480,079	1,149,529	1,190,391	35,596	113,698	151,233	888,888	206,361	6,312	278,318	5,523,285
2013	19,542	0	371,734	312,040	875,068	983,041	740,335	24,391	55,544	188,367	1,183,627	298,451	3,408	409,076	5,464,624
2014	112	950	385,754	136,089	315,788	1,419,801	1,350,919	129,813	170,228	161,233	1,080,853	172,561	20,277	525,631	5,870,009

Table B4.25 Number of bluefish recreational fishing trips, recreational harvest limit, and recreational landings from 1991 to 2013.

Year	Number of Bluefish Trips[a]	Recreational Landings (N)	Recreational Landings per "Bluefish" Trip
1991	5,948,808	11,942,608	2.0
1992	4,549,536	7,157,754	1.6
1993	4,269,162	5,725,355	1.3
1994	3,587,131	5,767,953	1.6
1995	3,608,325	5,167,979	1.4
1996	2,820,059	4,205,103	1.5
1997	2,384,133	5,413,036	2.3
1998	2,180,471	4,202,111	1.9
1999	1,727,175	3,681,841	2.1
2000	2,041,450	4,897,008	2.4
2001	2,661,032	6,663,237	2.5
2002	2,324,253	5,300,189	2.3
2003	2,647,840	6,045,062	2.3
2004	2,898,679	7,250,407	2.5
2005	3,233,133	7,949,179	2.5
2006	2,781,357	7,035,179	2.5
2007	3,620,374	8,373,899	2.3
2008	3,024,787	6,664,150	2.2
2009	2,088,857	5,194,242	2.5
2010	2,468,273	6,090,830	2.5
2011	2,128,166	5,061,391	2.4
2012	2,394,988	5,523,282	2.3
2013	1,733,408	5,464,623	3.2

[a]Estimated number of recreational fishing trips where the primary target was bluefish or bluefish were harvested regardless of target, Maine – Florida's East Coast. Source: MRFSS (1991-2003)/MRIP (2004 fwd).

Table B4.26 Recreational Releases by state (numbers of fish) 1982-2014. Data Source: MRFSS/MRIP

Year	MA	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA	FL	Total
1982	2,526	0	58,662	151,692	885,850	197,039	346,279	46,666	690,368	452,410	301,407	106,967	52,725	204,229	3,496,820
1983	1,869	1,357	636,226	42,406	63,887	1,743,414	783,690	36,255	710,716	170,376	765,433	16,833	67,142	214,243	5,253,847
1984	0	0	354,473	55,112	257,048	2,570,029	709,282	88,522	512,129	137,656	241,685	76,673	37,048	670,670	5,710,327
1985	8,009	1,436	159,512	123,111	326,913	954,786	536,572	34,052	257,457	118,007	333,415	181,773	37,918	155,181	3,228,142
1986	24,524	22,791	1,317,955	70,619	154,507	1,852,425	1,161,718	44,113	287,291	315,260	449,139	48,390	28,596	192,331	5,969,659
1987	190,933	7,710	639,358	267,972	290,633	1,879,441	1,697,153	63,898	477,607	181,407	544,698	46,986	32,881	206,404	6,527,081
1988	22,683	2,032	298,163	70,265	26,995	735,486	437,364	34,551	266,401	715,455	550,135	64,029	6,982	229,433	3,459,974
1989	4,994	16,815	265,861	86,237	130,858	1,474,146	1,084,233	190,685	445,682	293,665	750,152	144,811	21,930	127,248	5,037,317
1990	35,875	5,651	307,904	316,809	228,175	1,261,626	1,061,846	103,942	388,238	279,760	728,228	65,675	132,154	164,937	5,080,820
1991	327,363	23,818	579,410	195,279	552,421	1,367,011	1,545,379	58,518	369,022	450,673	551,446	17,359	65,760	245,757	6,349,216
1992	66,824	12,812	451,273	234,709	415,060	783,716	535,540	121,771	98,748	277,874	796,444	15,999	43,968	387,567	4,242,305
1993	18,464	21,650	389,842	153,377	260,932	974,737	561,092	105,346	194,429	163,020	784,495	55,550	22,434	494,532	4,199,900
1994	52,002	8,181	350,282	200,649	281,574	1,171,234	894,344	46,181	246,091	461,658	1,480,854	140,081	20,395	798,748	6,152,274
1995	4,962	6,868	585,071	69,858	170,633	719,237	637,486	126,899	273,367	417,066	1,200,514	220,576	84,948	808,418	5,325,903
1996	57,386	2,604	467,296	439,224	366,885	661,066	959,185	82,525	464,609	420,224	735,622	85,814	25,869	547,497	5,315,806
1997	82,858	2,857	644,331	320,201	293,238	898,423	849,370	193,056	891,449	661,907	1,149,328	197,452	19,566	956,476	7,160,512
1998	0	515	510,309	203,146	404,953	588,706	701,638	274,589	492,406	404,793	534,295	200,317	71,385	615,103	5,002,155
1999	19,584	5,094	397,468	784,301	744,419	1,156,348	1,823,535	322,548	604,763	228,200	986,417	58,598	13,728	660,842	7,805,845
2000	3,520	955	595,606	496,896	863,248	2,629,264	1,906,915	303,491	1,150,171	321,013	1,630,426	181,600	79,385	1,200,887	11,363,377
2001	39,774	13,877	947,782	892,975	1,429,180	2,543,456	2,055,555	220,644	1,074,250	625,089	2,328,952	152,378	48,454	1,376,402	13,748,768
2002	41,753	13,965	628,185	801,379	662,319	1,017,366	2,168,272	435,157	576,603	381,997	1,609,804	162,644	25,597	1,391,963	9,917,004
2003	22,747	16,964	1,018,898	931,770	541,938	1,304,618	1,913,100	119,732	517,975	340,331	1,416,064	215,426	22,800	621,877	9,004,240
2004	42,112	8,710	1,294,329	801,789	979,185	2,529,207	2,225,662	408,033	593,724	548,400	1,761,560	386,264	16,120	498,806	12,093,901
2005	48,536	48,327	1,813,373	526,790	575,611	3,381,001	2,292,400	190,721	236,084	540,719	2,043,699	316,726	21,147	368,768	12,403,902
2006	49,690	22,911	1,843,798	554,255	1,167,223	2,378,930	1,803,840	288,995	777,916	449,250	1,836,657	622,242	22,335	718,402	12,536,444
2007	73,780	17,877	1,240,404	685,758	887,907	2,650,325	2,735,060	538,156	1,171,858	915,930	2,376,886	677,031	103,088	932,359	15,006,419
2008	55,667	2,568	1,301,663	491,213	1,143,879	3,224,070	1,476,829	167,326	1,631,409	711,317	2,136,350	333,028	116,329	498,919	13,290,567
2009	25,900	1,978	952,521	159,523	295,061	1,792,884	1,476,248	167,083	670,494	349,936	1,553,376	252,310	72,398	680,521	8,450,233
2010	9,680	562	1,028,388	94,021	714,853	1,471,387	1,885,821	57,496	161,424	359,451	2,221,130	318,430	107,709	1,620,958	10,051,310
2011	7,603	1,360	597,774	327,849	996,737	1,598,098	1,910,805	127,519	408,323	197,276	1,923,767	551,024	69,915	912,206	9,630,256
2012	126,096	4,970	713,753	427,449	678,733	1,809,011	1,995,812	117,951	138,495	207,798	1,036,297	168,650	51,646	1,110,650	8,587,311
2013	22,184	85	457,740	622,771	724,547	1,007,911	876,798	70,335	260,957	220,068	1,871,916	309,021	7,375	1,492,011	7,943,719
2014	0	1,556	2,185,959	114,222	436,605	1,506,963	1,864,489	325,357	144,742	187,617	1,537,352	297,608	118,547	1,456,688	10,177,705

Table B4.27 Recreational catch-at-age for bluefish from 1985 to 2014

	Age						
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
1985	5731.8	6903.4	3542.6	915.2	631.9	461.2	1665.5
1986	5466.7	3977.4	6494.3	2917.3	1517.4	1176.6	3084.5
1987	4225.1	3783.6	3732.0	4642.1	1906.8	1012.2	1923.2
1988	1319.6	1482.5	1260.3	1077.1	1589.0	913.6	1662.9
1989	4945.8	2582.7	1582.1	571.3	370.8	902.3	1500.0
1990	1665.4	5356.3	1462.8	430.2	259.5	469.5	1160.7
1991	4111.3	2583.2	3827.4	545.5	233.5	288.8	1376.4
1992	714.7	2178.3	1941.2	1641.0	433.9	219.2	788.3
1993	757.7	1603.9	1178.6	935.7	1123.7	134.9	616.8
1994	1569.6	2567.8	559.3	554.0	384.2	420.0	632.9
1995	702.7	2869.9	923.4	326.9	289.3	341.2	553.3
1996	933.4	1353.1	907.3	540.1	262.1	196.6	647.9
1997	1146.8	2477.1	902.1	352.4	221.4	229.1	943.0
1998	644.5	1458.6	1180.9	951.5	154.1	132.0	380.3
1999	1333.1	1290.4	1041.7	560.3	150.4	88.0	261.4
2000	418.8	2817.1	1583.9	975.0	226.2	295.7	244.2
2001	1161.9	2780.0	2271.5	1117.9	163.7	318.1	380.8
2002	445.7	3448.6	1505.1	327.2	138.7	202.3	433.1
2003	580.0	2564.5	2447.6	689.9	311.1	304.9	504.6
2004	554.0	4020.8	2485.3	783.0	329.7	407.6	484.1
2005	1986.7	1844.5	3043.6	1623.1	521.9	391.8	398.2
2006	1922.3	2258.7	1704.0	1307.1	388.5	571.6	743.5
2007	1283.8	2187.9	3189.1	1501.6	1397.2	413.8	651.5
2008	1290.9	1997.7	2616.8	1076.4	541.8	428.4	705.7
2009	390.1	1509.2	1906.0	1520.6	479.7	188.9	467.3
2010	961.8	1480.8	1758.8	1471.2	935.2	442.4	548.5
2011	1028.3	1503.0	1199.5	1219.4	607.0	388.9	559.7
2012	1537.6	1283.6	1407.7	1195.5	759.9	212.7	414.4
2013	1342.6	1269.9	1674.9	1144.3	619.6	305.4	299.6
2014	2290.1	2134.0	1275.6	736.1	343.2	240.0	306.4

Table B4. 28 Recreational weight-at-age (kg) for bluefish from 1985 to 2014

	Age						
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
1985	0.10	0.58	1.30	2.31	3.58	4.57	6.83
1986	0.07	0.59	1.34	2.24	3.28	4.42	6.24
1987	0.08	0.59	1.30	2.17	3.50	4.46	6.19
1988	0.15	0.52	1.16	2.29	3.04	3.89	5.90
1989	0.10	0.62	1.60	2.92	3.55	4.31	5.85
1990	0.15	0.51	1.12	2.50	4.10	4.48	6.31
1991	0.10	0.51	1.15	2.06	3.36	4.13	5.80
1992	0.06	0.50	1.18	2.12	3.18	4.28	5.89
1993	0.15	0.50	1.08	2.37	2.92	3.99	6.21
1994	0.10	0.50	1.25	2.04	3.31	4.13	7.03
1995	0.16	0.51	1.14	2.21	3.44	4.52	6.10
1996	0.12	0.62	0.94	1.74	2.84	4.43	5.84
1997	0.09	0.50	1.07	2.06	2.75	3.68	5.93
1998	0.11	0.53	0.98	2.72	3.79	3.94	6.28
1999	0.11	0.51	1.07	2.56	3.70	4.05	6.38
2000	0.14	0.41	0.96	2.87	3.66	4.09	6.30
2001	0.12	0.41	1.08	2.82	4.15	4.48	5.96
2002	0.12	0.51	1.16	2.00	2.95	3.80	5.25
2003	0.09	0.52	1.15	1.81	2.70	3.77	5.10
2004	0.11	0.48	1.35	2.23	2.90	3.71	4.95
2005	0.15	0.52	0.96	2.23	3.38	4.35	5.48
2006	0.11	0.50	0.98	1.88	2.83	3.10	4.17
2007	0.15	0.42	1.00	1.54	2.13	3.72	4.33
2008	0.16	0.47	1.37	1.98	3.23	3.61	5.01
2009	0.15	0.40	1.17	1.39	2.64	3.37	4.70
2010	0.12	0.37	1.02	0.95	2.59	3.73	5.36
2011	0.13	0.34	0.95	1.09	2.08	4.16	5.45
2012	0.11	0.35	0.90	1.23	2.68	4.24	5.51
2013	0.14	0.42	1.10	1.89	2.66	3.77	5.89
2014	0.13	0.41	1.08	1.92	2.92	3.98	5.39

Table B4.29 Total weight-at-age (kg) for bluefish from 1985 to 2014

	Age						
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
1985	0.12	0.57	1.32	2.30	3.55	4.59	6.68
1986	0.09	0.59	1.32	2.27	3.37	4.39	6.16
1987	0.09	0.61	1.31	2.18	3.51	4.45	6.10
1988	0.16	0.59	1.13	2.31	3.09	3.96	5.74
1989	0.12	0.63	1.57	2.97	3.57	4.26	5.75
1990	0.15	0.50	1.19	2.37	3.97	4.39	6.21
1991	0.10	0.27	1.11	2.08	3.36	4.16	5.76
1992	0.07	0.46	1.04	2.11	3.19	4.28	5.84
1993	0.15	0.46	1.13	2.34	2.92	4.02	6.11
1994	0.10	0.48	1.07	2.10	3.36	4.15	6.64
1995	0.17	0.53	1.02	2.20	3.45	4.50	5.93
1996	0.13	0.62	1.01	1.79	2.93	4.36	5.56
1997	0.10	0.49	1.02	1.97	2.76	3.69	5.73
1998	0.13	0.51	0.88	2.61	3.70	4.04	6.20
1999	0.14	0.47	0.92	2.40	3.68	4.01	6.29
2000	0.16	0.41	0.86	2.87	3.60	3.86	6.21
2001	0.13	0.41	0.98	2.70	3.64	4.20	5.92
2002	0.13	0.50	1.09	1.90	2.74	4.01	5.07
2003	0.09	0.52	1.12	1.84	2.65	3.67	4.92
2004	0.11	0.48	1.28	2.15	2.87	3.63	4.75
2005	0.17	0.54	0.94	2.23	3.13	4.08	5.40
2006	0.12	0.49	0.93	1.81	2.76	3.40	4.32
2007	0.15	0.42	0.96	1.54	2.17	3.71	4.28
2008	0.16	0.48	1.28	1.92	3.14	3.56	4.87
2009	0.15	0.41	0.94	1.31	2.60	3.38	4.58
2010	0.12	0.37	1.00	1.14	2.50	3.69	5.18
2011	0.13	0.36	0.92	1.14	1.81	4.11	5.37
2012	0.11	0.37	0.84	1.13	2.58	4.19	5.46
2013	0.15	0.44	1.00	1.79	2.64	3.78	5.80
2014	0.14	0.41	0.96	1.87	2.89	3.87	5.14

Table B4.30 Jan-1 weight-at-age (kg) for bluefish from 1985 to 2014

	Age						
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**
1985	0.05	0.37	1.01	1.90	3.19	4.04	6.68
1986	0.03	0.27	0.87	1.73	2.78	3.95	6.16
1987	0.04	0.23	0.88	1.70	2.82	3.87	6.10
1988	0.08	0.23	0.83	1.74	2.60	3.73	5.74
1989	0.06	0.32	0.96	1.83	2.87	3.63	5.75
1990	0.11	0.24	0.87	1.93	3.43	3.96	6.21
1991	0.05	0.20	0.75	1.57	2.82	4.06	5.76
1992	0.03	0.21	0.53	1.53	2.58	3.79	5.84
1993	0.08	0.18	0.72	1.56	2.48	3.58	6.11
1994	0.04	0.27	0.70	1.54	2.80	3.48	6.64
1995	0.09	0.23	0.70	1.53	2.69	3.89	5.93
1996	0.07	0.32	0.73	1.35	2.54	3.88	5.56
1997	0.04	0.25	0.80	1.41	2.22	3.29	5.73
1998	0.07	0.23	0.66	1.63	2.70	3.34	6.20
1999	0.08	0.25	0.69	1.45	3.10	3.85	6.29
2000	0.10	0.24	0.64	1.62	2.94	3.77	6.21
2001	0.07	0.26	0.63	1.52	3.23	3.89	5.92
2002	0.07	0.26	0.67	1.36	2.72	3.82	5.07
2003	0.04	0.26	0.75	1.42	2.24	3.17	4.92
2004	0.05	0.21	0.82	1.55	2.30	3.10	4.75
2005	0.10	0.24	0.67	1.69	2.59	3.42	5.40
2006	0.06	0.29	0.71	1.30	2.48	3.26	4.32
2007	0.08	0.22	0.69	1.20	1.98	3.20	4.28
2008	0.10	0.27	0.73	1.36	2.20	2.78	4.87
2009	0.10	0.26	0.67	1.29	2.23	3.26	4.58
2010	0.07	0.24	0.64	1.04	1.81	3.10	5.18
2011	0.08	0.21	0.58	1.07	1.44	3.21	5.37
2012	0.06	0.22	0.55	1.02	1.72	2.75	5.46
2013	0.09	0.22	0.61	1.23	1.73	3.12	5.80
2014	0.08	0.25	0.65	1.37	2.27	3.20	5.14

Table B5.1 Table of age sample sizes by geographic origin (all seasons combined). Note that NEAMAP and SEAMAP samples have been assigned to states from which they were collected (as were nmfsPort samples for 2013). NNCNcomb = combined nmfsPort, nefscTrawl, CT, and NC scale data from spring samples (see working paper B6 for more details). nmfsPort = commercial NMFS samples; nefscTrawl = NEFSC trawl scale ages. Note too that data are shared among some years between 1997-2004. CB = Chesapeake Bay (ChesMMAP); CB samples prior to 2005 were inadvertently omitted from ALKs, as were nmfsPort and nefscTrawl samples from 1996.

Year	nmfsPort	nefscTrawl	MA	RI	CT	NY	NJ	DE	MD	CB	VA	NNCNcomb	NC	SC	GA	FL
1985	159	404	0	0	799	0	0	0	0	0	0	399	193	0	0	0
1986	225	271	0	0	572	0	0	0	0	0	0	360	244	0	0	0
1987	132	281	0	0	448	0	0	0	0	0	0	264	128	0	0	0
1988	186	174	0	0	270	0	0	0	0	0	0	311	158	0	0	0
1989	49	316	0	0	0	0	0	0	0	0	0	198	145	0	0	0
1990	12	271	0	0	0	0	0	0	0	0	0	171	220	0	0	0
1991	66	164	0	0	0	0	0	0	0	0	0	213	104	0	0	0
1992	15	260	0	0	0	0	0	0	0	0	0	426	288	0	0	0
1993	9	145	0	0	0	0	0	0	0	0	0	378	352	0	0	0
1994	41	389	0	0	0	0	0	0	0	0	0	316	247	0	0	0
1995	11	358	0	0	0	0	0	0	0	0	0	311	341	0	0	0
1996	214	273	0	0	0	0	0	0	0	0	0	0	230	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	446	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	399	0	658	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	442	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	412	0	291	0	0	0
2002	0	0	0	0	0	0	0	0	0	34	1442	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	74	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	26	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	70	332	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	22	327	0	89	0	0	0
2007	0	0	0	12	50	86	183	43	69	50	487	0	469	0	0	0
2008	0	0	0	32	45	95	48	40	40	27	519	0	713	0	0	0
2009	0	0	13	29	37	153	120	37	50	11	513	0	553	0	0	0
2010	0	0	70	50	45	88	290	23	29	29	529	0	564	0	0	0
2011	0	0	69	18	35	72	326	41	43	7	533	0	744	47	37	83
2012	0	0	113	114	169	260	253	75	40	8	648	0	999	58	39	13
2013	0	0	133	296	282	339	406	28	24	32	495	0	859	68	70	35
2014	0	0	113	116	224	572	236	40	18	39	418	0	929	55	74	45

Table B5.2 Age sample sizes used to develop age length keys. All 1997 from NC otoliths. Spring 1998-2004 VA and NC otoliths; fall 1999-2000 includes VA and NC otoliths; fall 2001+ from VA otoliths only. Note that at SAW41 all spring 2001 samples were applied to springs of 1998-2001. Shading is added to help illustrate where data were shared. Dotted lines surrounding 1998-2001 added to illustrate previously shared years of data. Empty cells = 0.

Spring	A0	A1	A2	A3	A4	A5	A6+	Total
1997		202	153	38	18	14	32	457
1998		155	126	28	9	15	28	0
1999		140	90	7	13	13	26	0
2000		145	4			1	1	0
2001		12	32	2	2	3	11	62
2002		103	85	6	8	42	38	282
2003			147	4	13	17	45	226
2004		82	131	23		3	2	241

Fall	A0	A1	A2	A3	A4	A5	A6+	Total
1997	65	128	14	1			9	217
1998								0
1999	85	134	59	7	1	2	49	337
2000	21	108	10				1	140
2001		116	109		2	5	40	272
2002	7	319	56	5	1	2	5	395
2003	34	51	12		6	41	70	214
2004		66	14	3				83

Table B5.3Age length key sample size by year, age, and season from post-SAW41. See Figure B5.1 for the source (state or sampling program of origin) of age data by year.

Spring							
Year	**A0**	**A1**	**A2**	**A3**	**A4**	**A5**	**A6+**
2005	0	20	87	8	3	2	1
2006	0	39	73	26	2	5	41
2007	0	82	217	29	10	15	82
2008	0	197	267	51	11	20	45
2009	0	99	106	63	18	20	66
2010	0	105	142	165	85	38	68
2011	0	209	166	181	91	22	72
2012	2	344	277	205	124	43	133
2013	4	301	467	335	177	44	63
2014	1	291	205	115	130	68	125
Avg	1	169	201	118	65	28	70
Median	0	151	186	89	52	21	67

Fall							
Year	**A0**	**A1**	**A2**	**A3**	**A4**	**A5**	**A6+**
2005	89	93	54	9	9	10	17
2006	40	94	65	11	10	3	29
2007	494	253	162	63	13	8	21
2008	518	244	132	31	8	6	29
2009	580	205	142	150	39	10	18
2010	471	250	116	138	58	32	49
2011	589	300	123	126	51	49	76
2012	673	288	273	201	119	29	78
2013	847	281	244	148	66	49	41
2014	674	462	259	190	132	103	124
Avg	498	247	157	107	51	30	48
Median	549	252	137	132	45	20	35

Table B5.4 Von Bertalanfy growth parameters for multiple groupings of bluefish data

	ALL	NORTH	SOUTH	MALES	FEMALES	OTOLITHS	SCALES	1985-1994	1995-2004	2005-2014
Linf	112.998	93.618	742.365	114.614	129.600	120.303	92.377	91.272	105.811	130.907
K	0.126	0.196	0.011	0.118	0.094	0.109	0.214	0.222	0.143	0.0944
t0	-1.604	-1.149	-3.055	-1.630	-1.881	-1.661	-1.245	-1.204	-1.614	-1.708

Table B5.5 Estimates of natural mortality for bluefish based on methodologies using longevity and life history characteristics.

Age	3/tmax Rule of Thumb	Hoenig (1983)	Hewitt and Hoenig (2005)	Then et al. (2014): Pauly	Jensen 1996	Gislason et al. (2010)	Lorenzen (1996, 2000)	Lorenzen Scaled to Rule of Thumb	Lorenzen Scaled to Hoenig	Lorenzen Scaled to H&H
0	0.21	0.30	0.32	0.20	0.195	1.70	0.94	0.54	0.78	0.83
1	0.21	0.30	0.32	0.20	0.195	0.87	0.64	0.37	0.53	0.56
2	0.21	0.30	0.32	0.20	0.195	0.53	0.48	0.28	0.40	0.42
3	0.21	0.30	0.32	0.20	0.195	0.40	0.40	0.23	0.33	0.36
4	0.21	0.30	0.32	0.20	0.195	0.30	0.34	0.20	0.28	0.30
5	0.21	0.30	0.32	0.20	0.195	0.24	0.30	0.17	0.25	0.26
6	0.21	0.30	0.32	0.20	0.195	0.21	0.28	0.16	0.23	0.25
7	0.21	0.30	0.32	0.20	0.195	0.20	0.27	0.16	0.23	0.24
8	0.21	0.30	0.32	0.20	0.195	0.20	0.27	0.16	0.22	0.24
9	0.21	0.30	0.32	0.20	0.195	0.19	0.26	0.15	0.22	0.23
10	0.21	0.30	0.32	0.20	0.195	0.18	0.26	0.15	0.21	0.23
11	0.21	0.30	0.32	0.20	0.195	0.17	0.25	0.14	0.21	0.22
12	0.21	0.30	0.32	0.20	0.195	0.17	0.25	0.14	0.21	0.22
13	0.21	0.30	0.32	0.20	0.195	0.17	0.24	0.14	0.20	0.22
14	0.21	0.30	0.32	0.20	0.195	0.17	0.24	0.14	0.20	0.22
Mean	**0.21**	**0.30**	**0.32**	**0.20**	**0.195**	**0.38**	**0.36**	**0.21**	**0.3**	**0.32**

Table B5.6 Bluefish length (A) and age (B) at 50% and 95% maturity for different groupings

A.

	ALL	NORTH	SOUTH	MALES	FEMALES
L50	29.87	30.42	24.04	29.49	30.11
L95	44.33	44.69	33.08	43.96	44.34

B.

	ALL	OTOLITH	SCALES	MALES	FEMALES
A50	1.1	1.07	1.13	1.05	1.14
A95	1.85	1.79	1.92	1.72	2.01

Table B5. 7 Bluefish maturity at age for two previous studies and this study using all fish. The values from this study were used as final input values for the benchmark assessment.

Age	Robillard et al. 2009**	Salerno et al. 2001	ALL Fish this study
0	0.00	0.00	0.00
1	0.21	0.41	0.40
2	0.86	0.98	0.97
3	0.92	1.00	1.00
4	1.00	1.00	1.00
5	1.00	1.00	1.00
6+	1.00	1.00	1.00

** Maturity based on histology not gross maturity and females only

Table B6.1 Survey indices used in final model configuration. Note:YOY indices from NH, RI, NY-NJ, MD , and VA were combined.

NH YOY	
Year	YOY
1985	
1986	
1987	
1988	
1989	
1990	
1991	
1992	
1993	
1994	
1995	
1996	
1997	0.00
1998	0.00
1999	0.20
2000	0.04
2001	0.12
2002	0.01
2003	0.01
2004	0.00
2005	0.02
2006	0.09
2007	0.06
2008	0.17
2009	0.32
2010	0.10
2011	0.08
2012	0.35
2013	0.41
2014	0.05

RI YOY		
Year	YOY	CV
1985		
1986		
1987		
1988	7.93	0.42
1989	9.29	0.36
1990	7.06	0.36
1991	17.81	0.33
1992	1.48	0.48
1993	1.05	0.36
1994	7.30	0.45
1995	2.93	0.32
1996	6.29	0.38
1997	11.07	0.29
1998	7.61	0.40
1999	46.86	0.28
2000	3.30	0.40
2001	7.99	0.37
2002	3.87	0.36
2003	2.64	0.52
2004	7.51	0.41
2005	14.06	0.31
2006	6.76	0.40
2007	7.45	0.52
2008	11.02	0.37
2009	1.19	0.34
2010	3.67	0.38
2011	1.95	0.45
2012	4.24	0.46
2013	3.91	0.35
2014	1.38	0.52

CT, geoMean								
Year	0	1	2	3	4	5	6+	Total
1985	16.98	0.95	0.63	0.25	0.15	0.02	0.04	19.01
1986	10.82	1.18	1.17	0.19	0.13	0.09	0.08	13.66
1987	12.17	1.01	0.51	0.38	0.13	0.06	0.07	14.32
1988	14.27	0.21	0.49	0.14	0.17	0.13	0.09	15.49
1989	25.00	0.58	0.46	0.04	0.02	0.07	0.09	26.25
1990	19.37	2.97	0.93	0.16	0.13	0.12	0.20	23.88
1991	28.49	1.28	3.27	0.12	0.06	0.05	0.16	33.43
1992	18.87	1.76	2.79	1.32	0.18	0.06	0.23	25.22
1993	16.78	0.11	1.03	0.32	0.57	0.03	0.08	18.92
1994	30.52	0.76	0.24	0.16	0.14	0.17	0.07	32.06
1995	21.70	1.96	0.60	0.06	0.05	0.04	0.07	24.46
1996	19.81	0.22	0.41	0.25	0.01	0.03	0.08	20.80
1997	36.59	0.60	0.48	0.07	0.07	0.03	0.06	37.90
1998	29.87	0.97	0.38	0.16	0.01	0.00	0.01	31.41
1999	41.88	2.89	0.22	0.20	0.05	0.01	0.06	45.31
2000	17.28	2.03	1.07	0.15	0.00	0.03	0.02	20.57
2001	21.47	1.13	1.40	0.18	0.02	0.01	0.02	24.24
2002	14.01	3.79	0.64	0.09	0.02	0.08	0.12	18.75
2003	27.34	0.43	0.60	0.07	0.02	0.03	0.04	28.53
2004	21.45	5.52	1.46	0.33	0.07	0.16	0.15	29.13
2005	17.77	0.09	0.66	0.21	0.09	0.05	0.04	18.89
2006	14.24	0.49	0.55	0.29	0.06	0.01	0.02	15.66
2007	27.26	1.98	0.72	0.43	0.11	0.07	0.09	30.66
2008	11.83	0.56	1.09	0.37	0.12	0.15	0.16	14.28
2009	15.69	0.52	0.43	0.81	0.30	0.07	0.30	18.11
2010								
2011	10.21	0.23	0.21	0.17	0.16	0.05	0.06	11.10
2012	14.34	0.27	0.19	0.13	0.08	0.02	0.03	15.06
2013	8.89	0.03	0.41	0.19	0.09	0.04	0.06	9.71
2014	18.14	0.21	0.07	0.06	0.07	0.04	0.02	18.61

Table B6.1 continued

NY YOY		
Year	YOY	CV
1985		
1986		
1987	36.9525	0.23554
1988	23.9299	0.32567
1989	40.7855	0.27558
1990	15.1449	0.28677
1991	8.45391	0.27238
1992	11.6167	0.26606
1993	1.62819	0.27099
1994	1.38648	0.3095
1995	1.85487	0.30232
1996	0.93605	0.54367
1997		
1998	1.65264	0.33874
1999	4.03057	0.30377
2000	6.39818	0.23123
2001	17.4834	0.26251
2002	4.98182	0.24177
2003	2.7814	0.22905
2004	10.2012	0.23079
2005	8.88195	0.23202
2006	15.0959	0.24829
2007	9.72859	0.23067
2008	18.393	0.227
2009	5.89022	0.23852
2010	9.06616	0.26044
2011	7.75543	0.23713
2012	5.38529	0.24329
2013	21.1646	0.23184
2014	12.2976	0.24793

NJ Ocean trawl			
Year	0	1	2
1985			
1986			
1987			
1988			
1989			
1990	1.437	0.084	0.001
1991	1.087	0.010	0.014
1992	1.561	0.237	0.025
1993	0.844	0.037	0.032
1994	2.238	0.008	0.002
1995	3.163	0.153	0.058
1996	1.835	0.077	0.007
1997	0.901	0.025	0.010
1998	1.013	0.153	0.077
1999	0.637	0.103	0.013
2000	0.493	0.092	0.035
2001	0.293	0.028	0.063
2002	2.762	1.068	0.027
2003	2.676	0.070	0.019
2004	1.546	0.448	0.249
2005	3.606	0.130	0.098
2006	2.760	0.078	0.025
2007	3.307	0.585	0.148
2008	2.888	0.082	0.011
2009	1.624	0.029	0.005
2010	0.868	0.018	0.008
2011	4.562	0.835	0.020
2012	2.732	0.195	0.044
2013	1.269	0.020	0.000
2014	3.155	0.268	0.010

NJ YOY	
Year	YOY
1985	
1986	
1987	
1988	
1989	
1990	
1991	
1992	
1993	
1994	
1995	
1996	
1997	
1998	
1999	
2000	
2001	
2002	0.454
2003	0.279
2004	0.264
2005	0.869
2006	0.495
2007	0.707
2008	0.604
2009	0.385
2010	0.749
2011	0.265
2012	0.274
2013	0.428
2014	0.587

Table B6.1 continued.

MD YOY		
Year	Index	CV
1985	0.37429	2.114
1986	0.05744	2.793
1987	0.1246	2.808
1988	0.10251	2.068
1989	0.30574	2.163
1990	0.47125	4.342
1991	0.05733	2.209
1992	0.08233	3.719
1993	0.01143	4.541
1994	0.03101	3.507
1995	0.03446	2.293
1996	0.0188	2.643
1997	0.25664	2.087
1998	0.04181	2.407
1999	0.08692	2.032
2000	0.12554	3.485
2001	0.07519	3.290
2002	0.02739	2.830
2003	0.09015	2.542
2004	0.07413	2.424
2005	0.02608	2.834
2006	0.16223	2.504
2007	0.16629	2.665
2008	0.15423	2.110
2009	0.42171	3.783
2010	0.01932	3.181
2011	0.06433	2.251
2012	0.09245	5.185
2013	0.10367	2.818
2014	0.0558	2.840

NEAMAP									
Year	0	1	2	3	4	5	6+	Total	CV
1985									
1986									
1987									
1988									
1989									
1990									
1991									
1992									
1993									
1994									
1995									
1996									
1997									
1998									
1999									
2000									
2001									
2002									
2003									
2004									
2005									
2006									
2007	3.878	0.318	0.063	0.015	0.009	0.004	0.002	4.290	0.076
2008	4.779	0.362	0.055	0.020	0.007	0.003	0.003	5.230	0.073
2009	5.095	0.090	0.024	0.013	0.004	0.002	0.002	5.230	0.068
2010	3.081	0.112	0.028	0.027	0.019	0.007	0.006	3.280	0.080
2011	3.471	0.439	0.052	0.047	0.005	0.003	0.004	4.020	0.072
2012	5.174	0.413	0.087	0.043	0.009	0.001	0.003	5.730	0.062
2013	3.617	0.054	0.023	0.012	0.002	0.000	0.002	3.710	0.082
2014	2.505	0.189	0.009	0.007	0.004	0.005	0.002	2.720	0.093

Table B6.1 continued.

VIMS	
Year	YOY
1985	0.160
1986	0.033
1987	0.169
1988	0.059
1989	0.091
1990	0.114
1991	0.093
1992	0.014
1993	0.126
1994	0.006
1995	0.045
1996	0.009
1997	0.167
1998	0.042
1999	0.042
2000	0.053
2001	0.011
2002	0.030
2003	0.032
2004	0.040
2005	0.034
2006	0.018
2007	0.070
2008	0.048
2009	0.035
2010	0.035
2011	0.006
2012	0.053
2013	0.021
2014	

PSIGNS								
Year	0	1	2	3	4	5	6+	Total
1985								
1986								
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995								
1996								
1997								
1998								
1999								
2000								
2001	0.13	2.99	2.16	0.00	0.00	0.00	0.00	5.28
2002	0.13	2.86	1.29	0.01	0.00	0.00	0.00	4.29
2003	0.16	1.84	2.74	0.03	0.00	0.01	0.00	4.78
2004	0.16	2.99	1.99	0.05	0.00	0.00	0.00	5.19
2005	1.08	2.24	3.02	0.04	0.01	0.00	0.01	6.40
2006	0.53	2.97	1.85	0.44	0.10	0.05	0.11	6.05
2007	0.44	2.33	4.78	0.81	0.04	0.01	0.05	8.46
2008	1.21	2.89	2.31	0.23	0.01	0.03	0.04	6.72
2009	0.38	2.04	1.48	1.96	0.29	0.06	0.13	6.34
2010	0.47	1.57	1.36	1.84	0.39	0.04	0.00	5.67
2011	0.24	0.95	1.65	2.04	0.92	0.04	0.04	5.88
2012	0.21	1.11	1.62	0.91	0.16	0.01	0.04	4.06
2013	1.69	1.65	1.90	0.39	0.05	0.01	0.01	5.70
2014	0.74	2.28	1.29	0.10	0.00	0.00	0.02	4.44

SEAMAP	
Year	YOY
1985	
1986	
1987	
1988	
1989	3.238
1990	0.140
1991	1.151
1992	0.614
1993	0.306
1994	1.225
1995	1.270
1996	1.151
1997	0.106
1998	0.387
1999	0.670
2000	0.181
2001	1.711
2002	1.246
2003	4.772
2004	0.654
2005	1.26
2006	0.24
2007	0.14
2008	1.25
2009	1.31
2010	0.80
2011	1.04
2012	0.65
2013	0.37
2014	0.13

Table B6.1 continued.

NEFSC Inshore bands 1985-2008									
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6+**	**Total**	**CV**
1985	15.34	1.95	0.24	0.13	0.04	0.01	0.04	17.74	0.15
1986	38.84	1.51	0.17	0.09	0.05	0.04	0.06	40.75	0.43
1987	5.64	1.25	0.13	0.19	0.10	0.05	0.10	7.45	0.31
1988	30.04	0.19	0.03	0.03	0.07	0.04	0.07	30.47	0.57
1989	90.17	0.95	0.05	0.02	0.02	0.03	0.04	91.27	0.19
1990	5.91	3.29	0.01	0.02	0.01	0.02	0.06	9.32	0.22
1991	15.29	0.33	0.11	0.05	0.01	0.00	0.00	15.80	0.23
1992	16.06	1.66	0.06	0.05	0.01	0.01	0.02	17.87	0.07
1993	1.63	0.19	0.08	0.02	0.05	0.01	0.01	1.98	0.21
1994	11.10	1.13	0.03	0.03	0.05	0.04	0.01	12.38	0.12
1995	6.80	2.45	0.06	0.01	0.01	0.03	0.02	9.39	0.19
1996	9.12	1.42	0.17	0.09	0.02	0.02	0.02	10.86	0.23
1997	4.76	0.45	0.32	0.14	0.01	0.01	0.02	5.70	0.16
1998	9.51	0.78	0.11	0.12	0.00	0.00	0.00	10.52	0.32
1999	22.93	1.45	0.08	0.10	0.00	0.00	0.01	24.57	0.32
2000	2.84	1.56	0.15	0.03	0.00	0.01	0.00	4.59	0.23
2001	17.82	1.27	0.29	0.05	0.00	0.01	0.00	19.43	0.15
2002	16.01	2.35	0.06	0.05	0.01	0.02	0.00	18.51	0.06
2003	32.93	2.58	0.16	0.00	0.01	0.02	0.02	35.72	0.17
2004	5.42	4.85	0.23	0.05	0.01	0.01	0.03	10.59	0.14
2005	34.50	0.68	0.13	0.15	0.04	0.06	0.02	35.59	0.07
2006	22.98	1.41	0.64	0.16	0.04	0.05	0.01	25.27	0.14
2007	12.43	2.21	0.53	0.03	0.01	0.00	0.01	15.23	0.13
2008	10.94	1.72	0.40	0.09	0.03	0.01	0.03	13.20	0.18
2009									
2010									
2011									
2012									
2013									
2014									

Table B6.1 continued.

NEFSC Bigelow 2009-2014									
Year	**0**	**1**	**2**	**3**	**4**	**5**	**6+**	**Total**	**CV**
1985									
1986									
1987									
1988									
1989									
1990									
1991									
1992									
1993									
1994									
1995									
1996									
1997									
1998									
1999									
2000									
2001									
2002									
2003									
2004									
2005									
2006									
2007									
2008									
2009	2.39	3.60	0.95	0.43	0.10	0.03	0.03	7.52	0.49
2010	3.87	2.08	0.38	0.38	0.18	0.06	0.09	7.03	0.23
2011	5.64	1.99	0.29	0.30	0.15	0.03	0.04	8.44	0.16
2012	2.57	1.37	0.69	0.44	0.08	0.01	0.01	5.17	0.20
2013	2.70	0.26	0.04	0.02	0.02	0.00	0.00	3.05	0.58
2014	2.63	1.20	0.05	0.02	0.01	0.00	0.00	3.91	0.24

Table B6.2 NEFSC vessel gear and tow characteristics.

Measure	*FSV* Henry B. Bigelow	*FSV* Albatross IV
Tow Speed	3.0 knots SOG	3.8 knots SOG
Tow Duration	20 minutes	30 minutes
Headrope Height	3.5 to 4m	1 to 2m
Ground Gear	Rockhopper Sweep Total Length: 25.5m Center: 8.9m with 16 inch rockhoppers Wings: 8.2m each 14 inch rockhoppers	Roller Sweep Total Length: 24.5m Center: 5m with 16 inch rollers Wings: 9.75m each with 4 inch cookies
Mesh	Poly webbing Forward portion of trawl: 12cm, 4mm Square aft to codend: 6cm, 2.5mm Codend: 12cm, 4mm dbl. Codend liner: 2.54cm, knotless	Nylon webbing Body of Trawl: 12.7cm Codend: 11.5cm Codend and top-belly liner: 1.27cm, knotless
Net Design	4 Seam, 3 Bridle	Yankee 36 (recent years)
Door type	550 kg PolyIce oval	450 kg Polyvalent
Other	Wing End to Door length: 36.5m	Wing End to Door length: 9m

Table B6.3 Composite Young of Year (YOY) Index 1981-2014.

Year	Base Model	95% LCI	95% UCI	CV
1981	0.94	0.15	3.18	0.90
1982	1.66	0.32	5.12	0.80
1983	2.18	0.37	7.27	0.89
1984	1.46	0.22	5.12	0.99
1985	1.64	0.31	5.19	0.83
1986	0.77	0.13	2.60	0.90
1987	2.24	0.63	5.29	0.55
1988	1.41	0.49	3.09	0.48
1989	2.12	0.72	4.67	0.50
1990	1.33	0.49	2.96	0.48
1991	1.15	0.42	2.60	0.50
1992	0.67	0.21	1.53	0.52
1993	0.26	0.10	0.59	0.51
1994	0.39	0.12	1.00	0.61
1995	0.35	0.13	0.82	0.51
1996	0.35	0.10	0.89	0.59
1997	1.52	0.44	3.87	0.60
1998	0.47	0.15	1.15	0.57
1999	1.22	0.35	3.28	0.65
2000	0.63	0.24	1.36	0.47
2001	1.14	0.41	2.45	0.46
2002	0.50	0.20	1.03	0.44
2003	0.39	0.15	0.85	0.47
2004	0.88	0.34	1.84	0.45
2005	0.92	0.37	1.93	0.44
2006	1.03	0.40	2.14	0.44
2007	0.94	0.38	1.96	0.43
2008	1.29	0.52	2.61	0.42
2009	0.53	0.20	1.15	0.46
2010	0.68	0.27	1.43	0.44
2011	0.53	0.20	1.12	0.46
2012	0.65	0.26	1.40	0.46
2013	1.06	0.39	2.26	0.46
2014	0.68	0.23	1.50	0.49

Table B6.4 Deviance table for standardization of MRIP CPUE.

	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)	Percent Deviance Explained
NULL	NA	NA	208946	199775	NA	NA
YEAR	33	3827.811	208913	195947.2	0.00E+00	23.75
MODE	2	3791.219	208911	192156	0.00E+00	23.52
AVIDITY	1	2091.646	208910	190064.3	0.00E+00	12.98
STATE	13	5198.157	208897	184866.2	0.00E+00	32.25
WAVE	5	988.7111	208892	183877.5	1.67E-211	6.13
AREA	1	218.4265	208891	183659	1.99E-49	1.36

Table B6.5 GLM-standardized estimates of catch-per-unit-effort from the MRIP survey.

Year	Continuity Run	Standard Error	Benchmark	Standard Error
1981	1.12	0.02	1.73	0.09
1982	1.00	0.02	1.76	0.10
1983	0.77	0.02	1.34	0.07
1984	0.97	0.02	1.57	0.09
1985	1.09	0.02	1.62	0.08
1986	0.98	0.02	1.67	0.09
1987	0.98	0.02	1.65	0.09
1988	0.50	0.02	0.97	0.05
1989	0.76	0.01	1.31	0.06
1990	0.67	0.01	1.22	0.06
1991	0.63	0.01	1.18	0.06
1992	0.48	0.01	0.93	0.05
1993	0.30	0.02	0.74	0.04
1994	0.43	0.02	0.89	0.04
1995	0.39	0.02	0.86	0.04
1996	0.44	0.02	0.96	0.05
1997	0.67	0.02	1.12	0.06
1998	0.53	0.02	0.95	0.05
1999	0.76	0.02	1.28	0.07
2000	0.75	0.02	1.30	0.07
2001	0.87	0.02	1.49	0.08
2002	0.79	0.02	1.18	0.06
2003	0.73	0.02	1.27	0.07
2004	0.85	0.02	1.44	0.07
2005	0.77	0.02	1.32	0.07
2006	0.80	0.02	1.42	0.08
2007	0.81	0.02	1.31	0.07
2008	0.74	0.02	1.29	0.07
2009	0.62	0.02	1.15	0.06
2010	0.70	0.02	1.20	0.06
2011	0.77	0.02	1.28	0.07
2012	0.74	0.02	1.36	0.07
2013	0.74	0.02	1.25	0.07
2014	0.72	0.02	1.32	0.07

Table B6.6 Age data sample sizes by state or agency from post-SAW41.

Year	MA	RI	CT	NY	NJ	CB	VA	NEAMAP	NC	SEAMAP
2005	0	0	0	0	0	70	332	0	0	0
2006	0	0	0	0	0	22	327	0	89	0
2007	0	0	0	0	0	50	383	584	432	0
2008	0	0	0	0	0	27	326	550	656	0
2009	13	0	0	0	0	11	354	650	488	0
2010	70	0	0	0	201	29	401	489	527	0
2011	69	0	0	0	196	7	441	483	552	307
2012	113	86	124	131	167	8	514	609	811	226
2013	133	252	227	290	340	32	378	404	737	274
2014	113	92	190	518	169	39	343	361	792	262

Table B7.1 Bluefish model building starting with continuity run and ending at final model. The models shown highlight the important changes in the progression from one model to the next. 2014 estimates of F, F40%, total stock numbers, spawning stock biomass, total stock biomass and recruitment are presented for each model step.

MODEL	DESCRIPTION	Obj Func	#pars	2014 Estimates					
				F	F40%	TSN (000s)	SSB (mt)	TSB (mt)	Rec (000s)
B001	Continuity run. Update SAW2005 model through 2014.	3094.79	101	0.141	0.171	57,671	84,800	92,755	14,696
B002	Continuity run cropped to start in 1985: No age data for 1982-1984 found.	2637.25	95	0.145	0.200	70,867	84,551	91,808	21,528
B004	Base model run. SAW2005 model with new CAA, WAA, and Indices.	2282.17	114	0.146	0.172	57,534	81,241	90,381	15,731
B006	Changed indices from index-at-age to estimating age composition.	7692.99	108	0.119	0.175	76,803	105,632	103,359	23,573
B007	Changed from one catch fleet to two: Recreational and commercial.	8546.78	138	0.143	0.172	64,470	83,839	91,462	16,174
B008	New maturity ogive based on preliminary analyses of maturity data.	8546.78	138	0.143	0.175	64,470	85,738	91,462	16,174
B011	Change from fixed fleet selectivities-at-age estimated selectivities.	8480.29	148	0.145	0.202	78,047	117,234	125,019	18,723
B020	Change to two selectivity blocks per fleet: 1985-2005, 2006-2014	7748.80	155	0.105	0.146	109,651	182,995	193,733	23,828
B020A	No estimated age composition for fleets in middle time period 1997-2005: ESS = 0	7559.01	155	0.103	0.148	112,281	189,369	200,420	24,194
B021	Set Lambdas to 0 or 1 to act as a switch for CV and inclusion in Obj Func. Needed to adjust fleet ESS and CV to get model to converge.	2719.28	164	0.111	0.128	82,875	102,157	110,871	24,289
B021A	Turn Likelihood constant off in objective function.	8134.61	164	0.155	0.224	102,891	142,077	152,889	28,581
B022	Turn number in the first year deviation penalty off	7937.38	164	0.136	0.230	117,420	174,184	186,480	31,335

Table B7.1 continued. *SAW60 WG final model (B043) results and diagnostics can be found in appendix B7.

MODEL	DESCRIPTION	Obj Func	#pars	2014 Estimates					
				F	F40%	TSN (000s)	SSB (mt)	TSB (mt)	Rec (000s)
B023	New maturity ogive based on final analyses of maturity data.	7937.38	164	0.136	0.230	117,420	174,888	186,480	31,334
B024	Increase CV on recruitment from 0.5 to 1.0.	7950.68	164	0.137	0.230	117,082	174,284	185,906	31,286
B025	Switch from selectivity-at-age to double logistic in time block 2.	7951.81	159	0.134	0.223	115,067	169,754	181,167	30,933
B027	Switch from double logistic selectivity to selectivity-at-age for NEFSC surveys.	7942.52	164	0.135	0.221	113,697	167,409	178,658	30,509
B028	Switch back to one selectivity block per fleet before including corrected data.	8014.38	155	0.126	0.191	101,276	153,752	164,139	27,028
B029	Switch NEFSC surveys to split off Bigelow: Inshore bands 1985-2008, Bigelow (Outer Inshore band) 2009-2014.	7641.45	155	0.128	0.189	99,476	149,216	159,673	26,856
B030	Switch MRIP selectivity to match starting values at-age of Rec fleet.	7649.17	154	0.113	0.194	114,851	184,961	197,207	29,543
B033	New data that corrects North Carolina scale ages from 1985-1996.	7425.96	154	0.094	0.204	142,050	243,972	258,068	34,263
B035	Switched PSIGN from double logistic selectivity to selectivity-at-age.	7427.21	156	0.091	0.205	147,082	256,007	270,667	35,152
B042	Switch MRIP selectivity from at-age to single logistic. Increased CV around recreational fleet from 0.1 to 0.15.	7464.98	151	0.124	0.178	90,014	126,802	135,011	24,583
B043*	Final adjustments to index input CV and ESS. Low ESS in middle block: 1997-2005.	8593.52	151	0.136	0.181	94,202	117,827	127,061	31,054
B044 (BFINAL)	Final model from SARC60 review: Fixed a misspecification in the A50 selectivity parameter for the MRIP index	8581.45	152	0.157	0.170	82,031	86,534	94,328	29,607

Table B7.2. Model specifications for Model B001, the continuity run.

	Age						
Time Frame: All Years	0	1	2	3	4	5	6+
Natural Mortality	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Maturity	0.00	0.25	0.75	1.00	1.00	1.00	1.00
Fleet Selectivity: Fixed	0.338	1	0.942	0.476	0.343	0.694	0.914

Fleet 1		
CV	0.01	All Years
ESS	30	All Years

Recruitment Deviations		
CV	0.5	All Years
Lambda	1	--

Lambda for Catch weight	10
Lambda for Fmult Year 1	0.5
CV Fmult Year 1	0.9
Lambda Fmult Deviations	0
CV Fmult Deviations	0.9

	Lambda	CV
N in First Year Deviations	1	0.9
Deviation from initial Steepness	0	0.6
Deviation from initial SR Scaler	0	0.6

Indices		
	1	2 to 28
Lambda	10	5
Lambda for Catchability	0.01	0.01
CV for Catchability	0.9	0.9
Lambda for Catchability Deviations	100	100
CV for Catchability Deviations	0.9	0.9
Index Selectivities	Input at-age: Fixed	

Phases	
Fmult in year 1	2
Fmult deviations	3
Recruitment Devs	3
N in year 1	4
Catchability in year 1	1
Catchability Devs	-5
SR Scaler	2
Steepness	-4

Table B7.3. Model specifications for Model B044, the final model.

	Age						
Time Frame: All Years	0	1	2	3	4	5	6+
Natural Mortality	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Maturity	0.00	0.40	0.97	1.00	1.00	1.00	1.00
Fleet 1 Selectivity: Input	0.338	-1	0.942	0.476	0.343	0.694	0.914
Fleet 2 Selectivity: Input	0.338	-1	0.942	0.476	0.343	0.694	0.914

Fleets			
	1	2	Time Block
CV	0.1	0.15	All Years
ESS	30	50	1985-1996
ESS	20	25	1997-2005
ESS	50	100	2006-2014

Recruitment Deviations		
CV	1.0	All Years
Lambda	1	--

	Fleet 1	Fleet 2
Lambda for Catch weight	1	1
Lambda for Fmult Year 1	0	0
CV Fmult Year 1	0.9	0.9
Lambda Fmult Deviations	0	0
CV Fmult Deviations	0.9	0.9

	Lambda	CV
N year 1	0	0.9
Steepness	0	0.6
SR Scaler	0	0.6

Indices	
	ALL
Lambda	1
Lambda for Catchability	0
CV for Catchability	0.9
Lambda for Catchability Deviations	0
CV for Catchability Deviations	0.9

Phases	
Fmult in year 1	2
Fmult deviations	3
Recruitment Devs	1
N in year 1	1
Catchability in year 1	1
Catchability Devs	-5
SR Scaler	1
Steepness	-5

Table B7.3 continued

Input Index Selectivities (-1 = fixed full selectivity)							
Index	Age						
	0	1	2	3	4	5	6+
NEFSC Inshore	-1	0.25	0.1	0.1	0.1	0.05	0.05
NEFSC Bigelow	-1	0.25	0.1	0.1	0.1	0.05	0.05
MRIP	Single Logistic: A50 = 1, Slope = 0.5						
NEAMAP	-1	0.25	0.1	0.1	0.1	0.05	0.05
SEAMAP	-1						
PSIGN	0.338	-1	0.942	0.476	0.343	0.694	0.914
CT LISTS	-1	0.25	0.1	0.1	0.1	0.05	0.05
NJ OCEAN	-1	0.5	0.1				
COMPOSITE YOY	-1						

Table B7.4 Annual SSB (mt), recruitment (000s), total abundance (000s), and F from the ASAP model updated through 2013.

Year	SSB	Recruitment	F
1985	191,476	36,743	0.246
1986	172,059	28,771	0.400
1987	147,048	18,084	0.450
1988	114,649	24,369	0.421
1989	106,535	50,212	0.344
1990	99,809	24,293	0.345
1991	87,241	29,153	0.403
1992	82,983	14,284	0.342
1993	80,624	17,023	0.325
1994	80,088	25,342	0.274
1995	77,967	17,817	0.243
1996	72,796	22,581	0.248
1997	72,173	24,542	0.290
1998	81,296	21,778	0.219
1999	85,940	33,833	0.162
2000	96,940	19,205	0.196
2001	102,797	28,505	0.220
2002	93,860	23,700	0.169
2003	96,980	36,430	0.197
2004	104,483	21,891	0.200
2005	115,988	33,629	0.200
2006	99,731	35,477	0.205
2007	97,077	27,160	0.238
2008	118,635	25,661	0.182
2009	105,828	19,474	0.162
2010	114,135	20,560	0.187
2011	114,025	19,666	0.161
2012	119,665	18,354	0.151
2013	126,473	27,184	0.150
2014	117,827	31,054	0.136
Average	**105,904**	**25,892**	**0.249**

Table B7.5 Abundance at age (000s) for bluefish from the final SAW60 model, B044.

Year	Age							**Total**
	0	1	2	3	4	5	6+	
1985	34,564	40,376	16,902	8,067	5,733	3,382	15,262	**124,286**
1986	26,963	25,856	25,430	10,645	5,180	3,810	13,121	**111,005**
1987	17,036	18,924	13,843	13,616	5,834	2,998	10,747	**82,998**
1988	23,544	11,748	9,612	7,032	7,111	3,240	8,471	**70,758**
1989	48,104	16,609	6,102	4,992	3,807	4,089	7,341	**91,043**
1990	23,162	34,626	9,321	3,425	2,885	2,311	7,416	**83,146**
1991	27,509	16,827	19,315	5,200	1,991	1,766	6,406	**79,012**
1992	13,464	19,569	8,750	10,044	2,841	1,156	5,187	**61,011**
1993	16,164	9,762	10,827	4,841	5,799	1,729	4,181	**53,304**
1994	23,972	11,784	5,484	6,083	2,836	3,573	3,892	**57,624**
1995	16,905	17,792	7,012	3,264	3,751	1,825	5,010	**55,560**
1996	21,365	12,694	10,998	4,334	2,081	2,485	4,765	**58,722**
1997	22,575	16,072	7,812	6,768	2,762	1,379	5,025	**62,395**
1998	20,113	16,674	9,402	4,570	4,112	1,756	4,346	**60,973**
1999	30,628	15,271	10,578	5,964	2,992	2,787	4,320	**72,540**
2000	17,326	23,791	10,365	7,179	4,155	2,139	5,214	**70,170**
2001	25,488	13,218	15,511	6,758	4,798	2,864	5,276	**73,912**
2002	21,503	19,236	8,371	9,823	4,393	3,228	5,713	**72,267**
2003	32,848	16,569	12,930	5,627	6,749	3,100	6,510	**84,333**
2004	19,679	24,963	10,781	8,413	3,741	4,627	6,859	**79,064**
2005	30,560	14,929	16,183	6,989	5,572	2,556	8,140	**84,930**
2006	32,190	23,094	9,677	10,489	4,610	3,790	7,630	**91,480**
2007	24,533	24,327	14,832	6,215	6,883	3,124	8,076	**87,991**
2008	23,123	18,228	14,992	9,141	3,914	4,499	7,737	**81,634**
2009	17,626	17,544	11,976	9,850	6,101	2,689	8,735	**74,521**
2010	18,595	13,572	11,840	8,082	6,779	4,309	8,375	**71,550**
2011	17,815	14,160	8,882	7,748	5,403	4,669	9,077	**67,753**
2012	16,738	13,693	9,568	6,001	5,326	3,810	10,020	**65,155**
2013	25,149	12,904	9,372	6,548	4,169	3,788	10,180	**72,109**
2014	29,607	19,363	8,847	6,425	4,547	2,962	10,280	**82,031**

Table B7.6. Jan-1 Biomass at age (mt) for bluefish as estimated from the final SAW60 model, B044.

Year	Age							**Total**
	0	1	2	3	4	5	6+	
1985	1,870	15,125	17,013	15,328	18,301	13,653	101,950	**183,239**
1986	933	6,880	22,058	18,427	14,422	15,040	80,825	**158,584**
1987	600	4,434	12,170	23,096	16,467	11,612	65,559	**133,937**
1988	1,898	2,707	7,980	12,232	18,455	12,081	48,623	**103,976**
1989	2,828	5,273	5,872	9,146	10,932	14,836	42,209	**91,097**
1990	2,589	8,480	8,071	6,606	9,906	9,150	46,053	**90,855**
1991	1,282	3,386	14,389	8,180	5,617	7,175	36,899	**76,929**
1992	368	4,197	4,637	15,371	7,318	4,384	30,293	**66,568**
1993	1,356	1,751	7,806	7,553	14,394	6,192	25,548	**64,600**
1994	1,040	3,162	3,848	9,371	7,952	12,439	25,844	**63,655**
1995	1,505	4,096	4,906	5,008	10,097	7,098	29,710	**62,419**
1996	1,431	4,122	8,046	5,857	5,285	9,636	26,493	**60,870**
1997	1,000	4,057	6,212	9,547	6,140	4,535	28,796	**60,287**
1998	1,376	3,765	6,174	7,457	11,101	5,864	26,943	**62,680**
1999	2,505	3,775	7,246	8,668	9,273	10,735	27,175	**69,377**
2000	1,733	5,700	6,590	11,666	12,214	8,061	32,382	**78,346**
2001	1,690	3,385	9,832	10,297	15,510	11,135	31,232	**83,081**
2002	1,398	4,905	5,596	13,404	11,948	12,333	28,967	**78,551**
2003	1,281	4,308	9,675	7,968	15,145	9,830	32,027	**80,234**
2004	976	5,187	8,795	13,056	8,598	14,351	32,579	**83,542**
2005	3,059	3,638	10,870	11,808	14,455	8,746	43,957	**96,535**
2006	2,063	6,665	6,858	13,682	11,438	12,364	32,962	**86,032**
2007	2,058	5,461	10,173	7,437	13,641	9,997	34,567	**83,335**
2008	2,312	4,890	10,992	12,409	8,607	12,505	37,679	**89,396**
2009	1,683	4,493	8,044	12,755	13,633	8,759	40,008	**89,375**
2010	1,289	3,197	7,581	8,367	12,267	13,346	43,380	**89,427**
2011	1,374	2,942	5,182	8,273	7,761	14,965	48,741	**89,238**
2012	921	3,003	5,261	6,119	9,134	10,492	54,708	**89,638**
2013	2,281	2,839	5,701	8,029	7,200	11,830	59,042	**96,922**
2014	2,339	4,802	5,750	8,786	10,341	9,469	52,841	**94,328**

Table B7.7 Final model objective function profiled over different estimates of natural mortality.

M	Objective Function	F40%
0.10	8594.98	0.114
0.15	8588.11	0.145
0.20	8581.45	0.17
0.25	8576.89	0.189
0.26	8576.37	0.192
0.27	8576.00	0.195
0.28	8575.78	0.198
0.29	8575.70	0.201
0.30	8575.76	0.204
0.35	8578.03	0.217
0.40	8582.85	0.229

Table B7.8 Final model (B044) sensitivity runs at different age-based estimates of natural mortality.

MODEL	DESCRIPTION	Obj Func	#pars	2014 Estimates					
				F	F40%	TSN (000s)	SSB (mt)	TSB (mt)	Rec (000s)
B044	Final bluefish model estimates	8581.45	152	0.157	0.170	82,031	86,534	94,328	29,607
B044_M_LROT	M at age: Lorenzen scaled to Rule of Thumb (0.21)	8605.99	152	0.152	0.144	100,052	80,906	90,010	42,259
B044_M_L29	M at age: Lorenzen scaled to minimum objective function M (0.29)	8659.71	152	0.061	0.200	297,237	289,278	321,098	140,027
B044_M_LGIS	M at age: Gislason et al 2010	8686.76	152	0.075	0.17	518,498	155,860	204,324	397,560

Table B7.9 Sensitivity of the final model to removal of individual indices.

MODEL	DESCRIPTION	Obj Func	#pars	2014 Estimates					
				F	F40%	TSN (000s)	SSB (mt)	TSB (mt)	Rec (000s)
B044	Final bluefish model estimates	8581.45	152	0.157	0.170	82,031	86,534	94,328	29,607
B044-1	Remove NEFSC inshore survey	8097.87	145	0.158	0.170	81,550	85,539	93,283	29,496
B044-2	Remove NEFSC Bigelow survey	8209.91	145	0.155	0.170	81,820	86,894	94,268	30,011
B044-3	Remove MRIP rec CPUE	6965.31	150	0.087	0.215	179,828	305,764	326,698	50,254
B044-4	Remove NEAMAP survey	8372.90	145	0.157	0.170	84,229	86,274	94,302	31,896
B044-5	Remove SEAMAP age 0 index	8569.90	151	0.157	0.170	83,155	86,548	94,430	30,527
B044-6	Remove PSIGN survey	8269.00	145	0.158	0.169	81,788	82,014	89,381	30,031
B044-7	Remove CT LISTS survey	7918.29	145	0.151	0.170	83,944	89,998	97,853	29,403
B044-8	Remove NJ Ocean Trawl survey	8352.91	149	0.159	0.170	80,812	85,269	93,104	29,381
B044-9	Remove composite YOY index	8588.93	151	0.157	0.170	82,936	86,309	94,158	30,691
B044MRIP	All removed except MRIP rec CPUE	6323.18	112	0.151	0.168	93,742	83,384	91,128	41,835

Table B7.10 DCAC based model run assumed parameter estimates and error distributions.

Parameter	Value	Source	SD	Source	Distribution
CV of $\sum C$	0.2	–	–	–	normal
M	0.192	Then et al. (2015) $\text{Pauly}_{\text{nls-T}}$ estimator	0.5	MacCall (2009)	lognormal
F_{MSY}/M	0.8	MacCall (2009); Dick & MacCall (2011)	0.2	MacCall (2009)	lognormal
B_{MSY}/B_0	0.4	MacCall (2009); Dick & MacCall (2011)	0.1	MacCall (2009); Dick & MacCall (2011)	bounded beta
Δ	0.5	Preliminary SCAA model runs	0.1	–	lognormal

Table B7.11 DCAC alternative assumed parameter estimates.

		Alternative 1		Alternative 2	
Variable	**Value**	**Value**	**Source**	**Value**	**Source**
CV of $\sum C$	0.2	0.1	–	–	–
M	0.192	0.437	Then et al. (2015) Hoenig_{nls}	–	–
SD of M	0.5	–	–	–	–
F_{MSY}/M	0.8	1.0	MacCall (2009)	–	–
SD of F_{MSY}/M	0.2	0.1	Lower variance estimate	–	–
B_{MSY}/B_0	0.4	0.5	MacCall (2009)	–	–
SD of B_{MSY}/B_0	0.1	0.2	–	–	–
Δ	0.5	0.424	B_0: 1.5xSSB in 1982*	0.636	B_0: SSB in 1982*

* – based on the 2014 update stock assessment based on the 41st SAW/SARC benchmark stock assessment of bluefish.

Table B7.12 Drawn parameters and their distributions for the DBSRA model

Parameter	Value	Source	SD	Source	Distribution
Annual harvest	–	ACCSP, MRIP	0.1	MRIP PSEs	lognormal
M	0.2	2015 Assessment	0.5	MacCall (2009)	lognormal
F_{MSY}/M	0.8	MacCall (2009); Dick & MacCall (2011)	0.2	MacCall (2009)	lognormal
B_{MSY}/K	0.4	MacCall (2009); Dick & MacCall (2011)	0.1	MacCall (2009); Dick & MacCall (2011)	bounded beta
B_{2014}/K	0.4	2014 Assessment Update	0.2	–	bounded beta

Table B7.13 Median management benchmarks (and 5th and 95th quantiles) from DBSRA model.

	U_{MSY}	K	MSY	B_{MSY}
Base run	0.12 (0.05 - 0.21)	432,049 mt (277,232 – 831,884 mt)	19,954 mt (14,905 – 24,943 mt)	172,010 mt (110,510 – 324,853 mt)

Table B10.1. Short-term projections of catch and biomass for bluefish under various F scenarios, with the associated probability that biomass in 2018 will be above the biomass threshold.

	Catch (mt)			Spawning Stock Biomass (mt)			$P(SSB_{2018}) >$
F Scenario	2016	2017	2018	2016	2017	2018	$SSB_{threshold}$
$F_{MSY\ proxy} = 0.170$	**10,528***	10,578	11,023	83,936	82,200	85,400	1.00
90% $F_{MSY\ proxy} = 0.153$	9,533	9,698	10,218	84,448	83,736	88,045	1.00
$F_{2014} = 0.157$	9,768	9,908	10,413	84,327	83,371	87,416	1.00
$F_{low} = 0.100$	6,351	6,716	7,326	86,064	88,715	96,865	1.00
$F_{0.1} = 0.187$	11,510	11,423	11,772	83,426	80,701	82,839	1.00
$F_{35\%SPR} = 0.191$	11,740	11,617	11,941	83,307	80,352	82,247	1.00

*****: The OFL for 2016, derived from catch projections under the F_{MSY} proxy.

Table B10.2 Sensitivity analysis for short-term projections for bluefish

	Landings (mt)			Total Biomass (mt)		
F = Fmsy	2016	2017	2018	2016	2017	2018
Base model	12,752	12,332	12,420	114,731	112,758	111,347
Increased CVs	12,984	12,599	12,615	114,699	112,497	110,765
M=0.26	18,122	16,513	15,891	147,636	137,192	128,747
2006-2014 recruitment	12,743	12,279	12,313	114,670	112,483	110,758
High rec landings	13,285	12,902	13,038	120,611	118,971	117,867
Low rec landings	11,500	11,104	11,271	108,055	106,100	104,870
Continuity model	12,641	12,055	11,641	90,271	86,258	84,003
F = F 2014	2016	2017	2018	2016	2017	2018
Base model	9,725	9,691	10,031	114,731	115,922	117,645
Increased CVs	9,904	9,905	10,198	114,699	115,712	117,161
M=0.26	9,187	8,969	9,166	147,636	146,276	146,042
2006-2014 recruitment	9,717	9,651	9,944	114,670	115,645	117,029
High rec landings	10,668	10,624	10,980	120,611	121,710	123,335
Low rec landings	7,899	7,927	8,333	108,055	109,868	112,427
Continuity model	10,006	9,846	9,747	90,271	88,955	89,055

Note: these sensitivity runs were conducted with Model B043, not the revised final model.

Figures

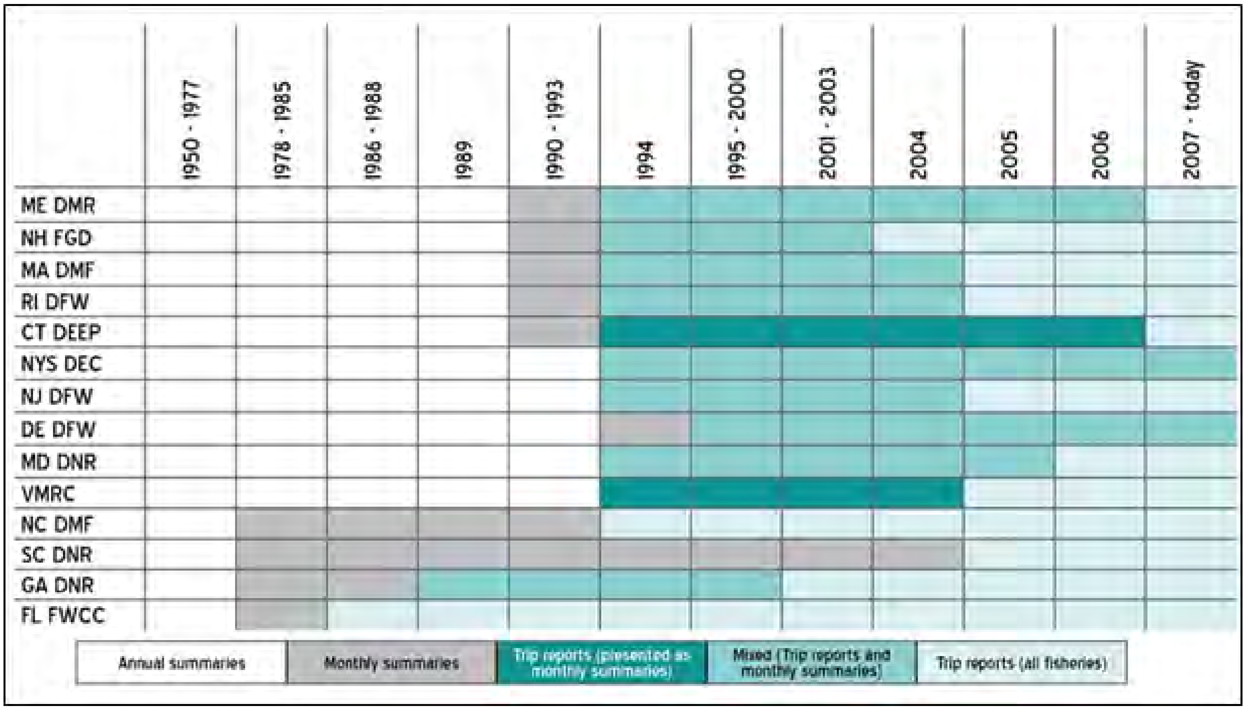


Figure B4.1. ACCSP data sources and collection methods.

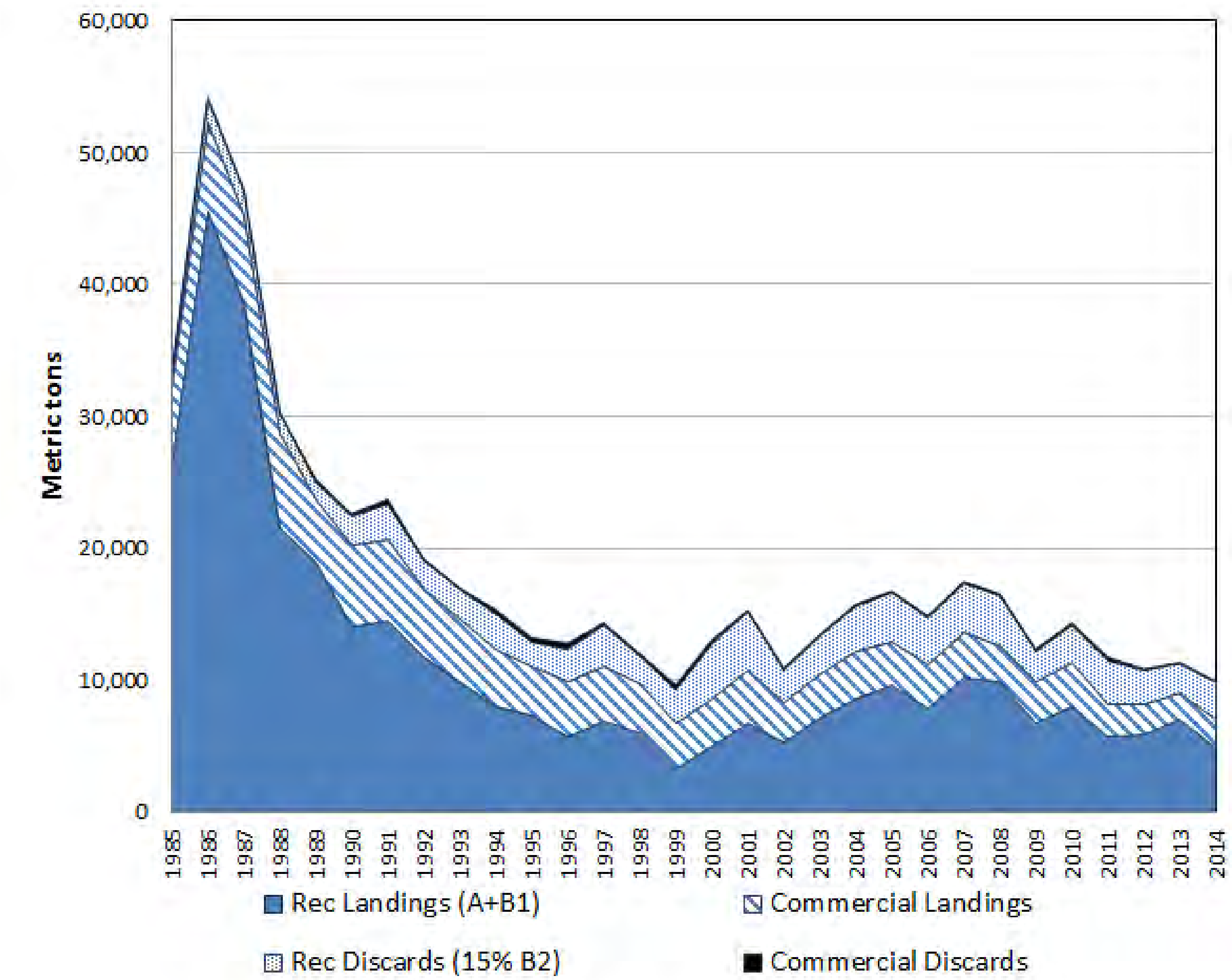


Figure B4.2. Bluefish landings by fleet and disposition.

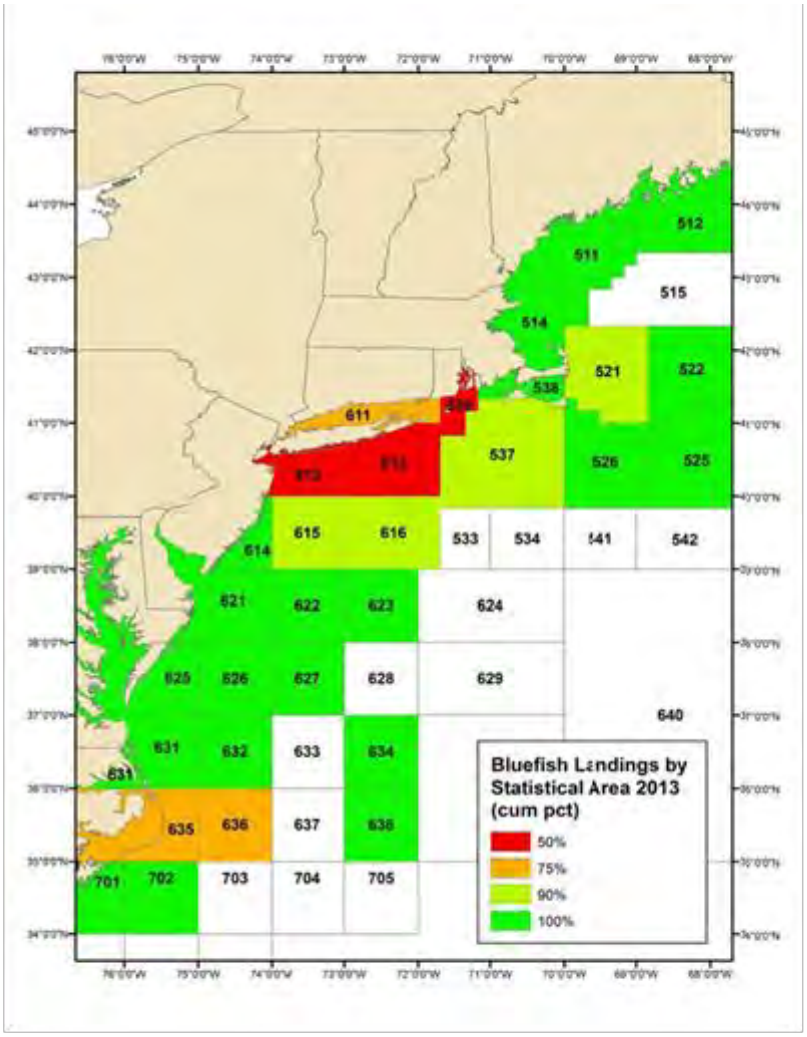


Figure B4.3. Bluefish landings by NMFS statistical areas. Shading reflects the cumulative percentage of landings with red and orange being the primary areas where the commercial landings are taken.

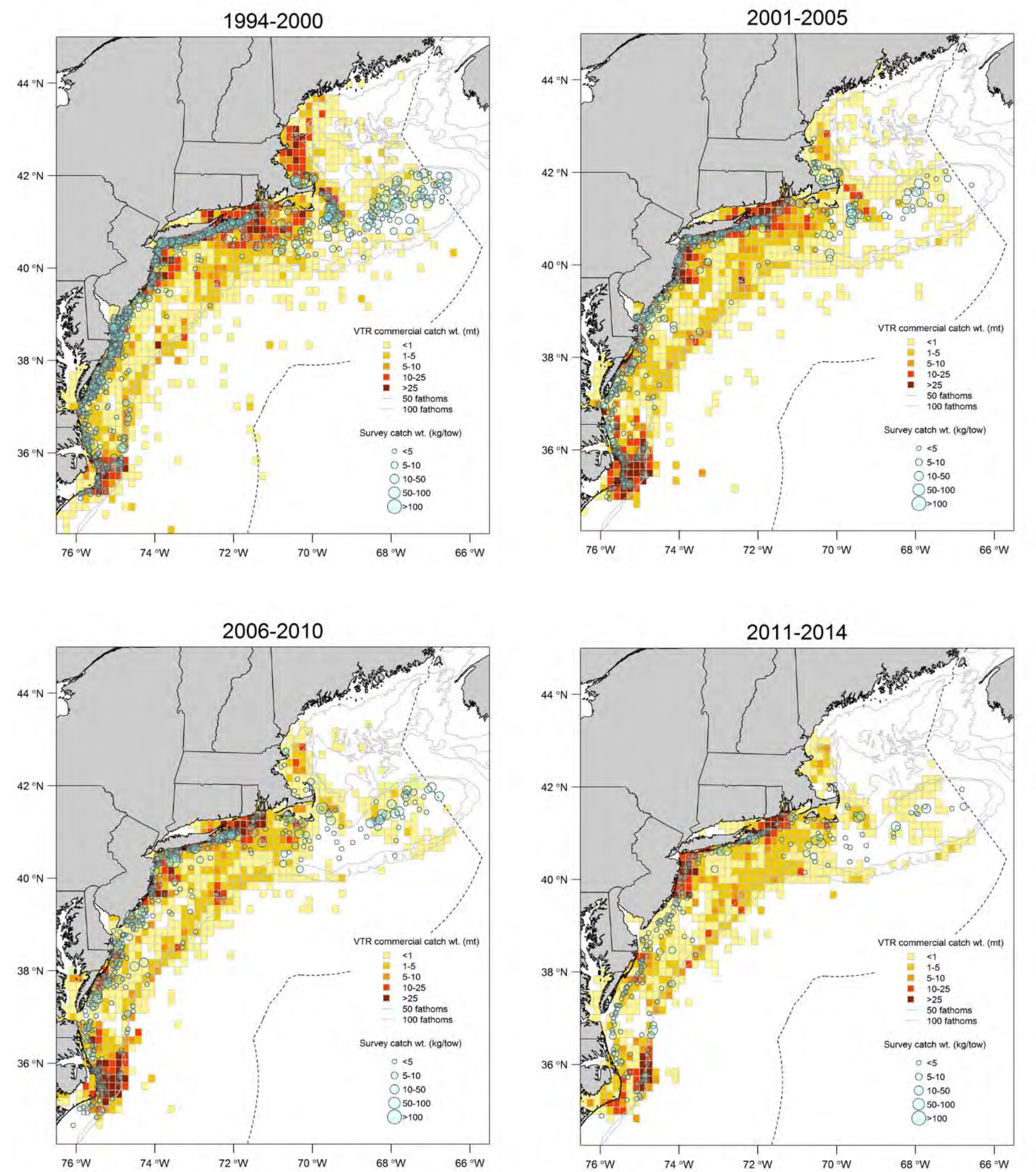


Figure B4.4. Spatial distribution of bluefish commercial catch by time period as reported through Vessel Trip Reports (VTR). Source: NEFSC.

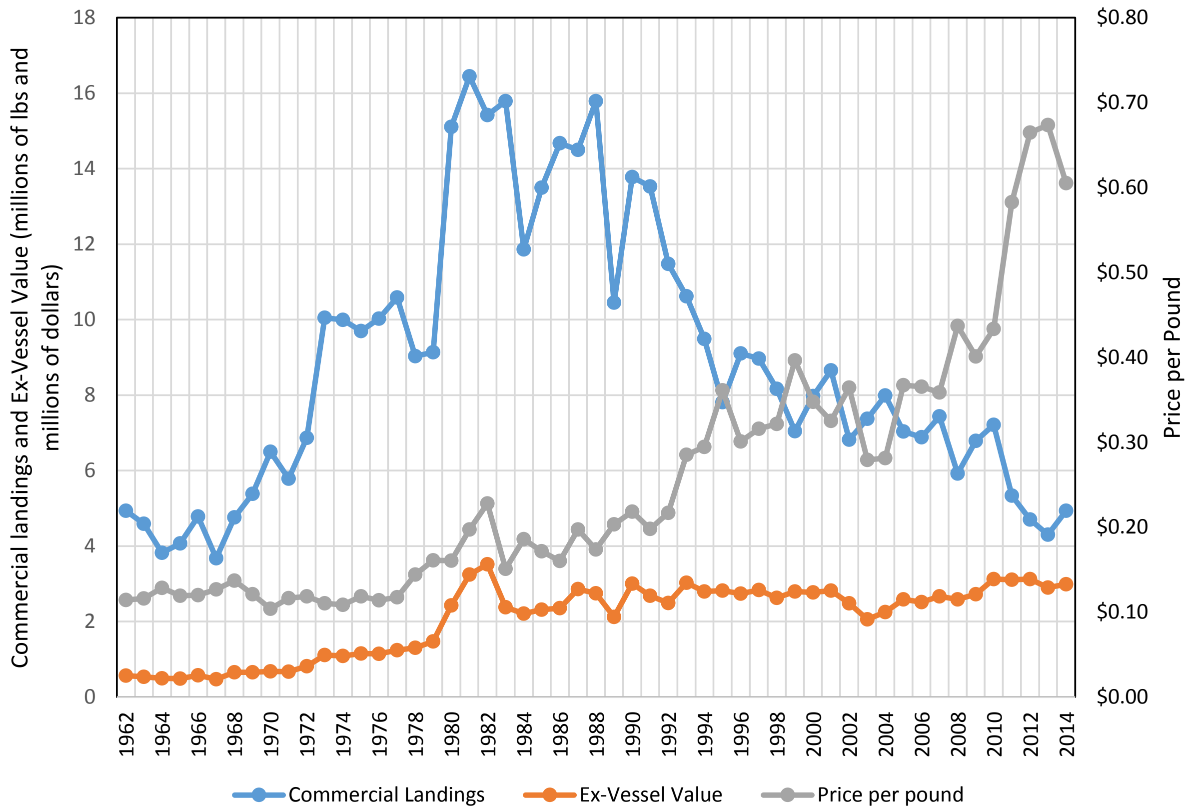


Figure B4.5. Landings, ex-vessel value, and price for bluefish, 1960 - 2014. Source: ACCSP Data Warehouse. Prices are not adjusted for inflation.

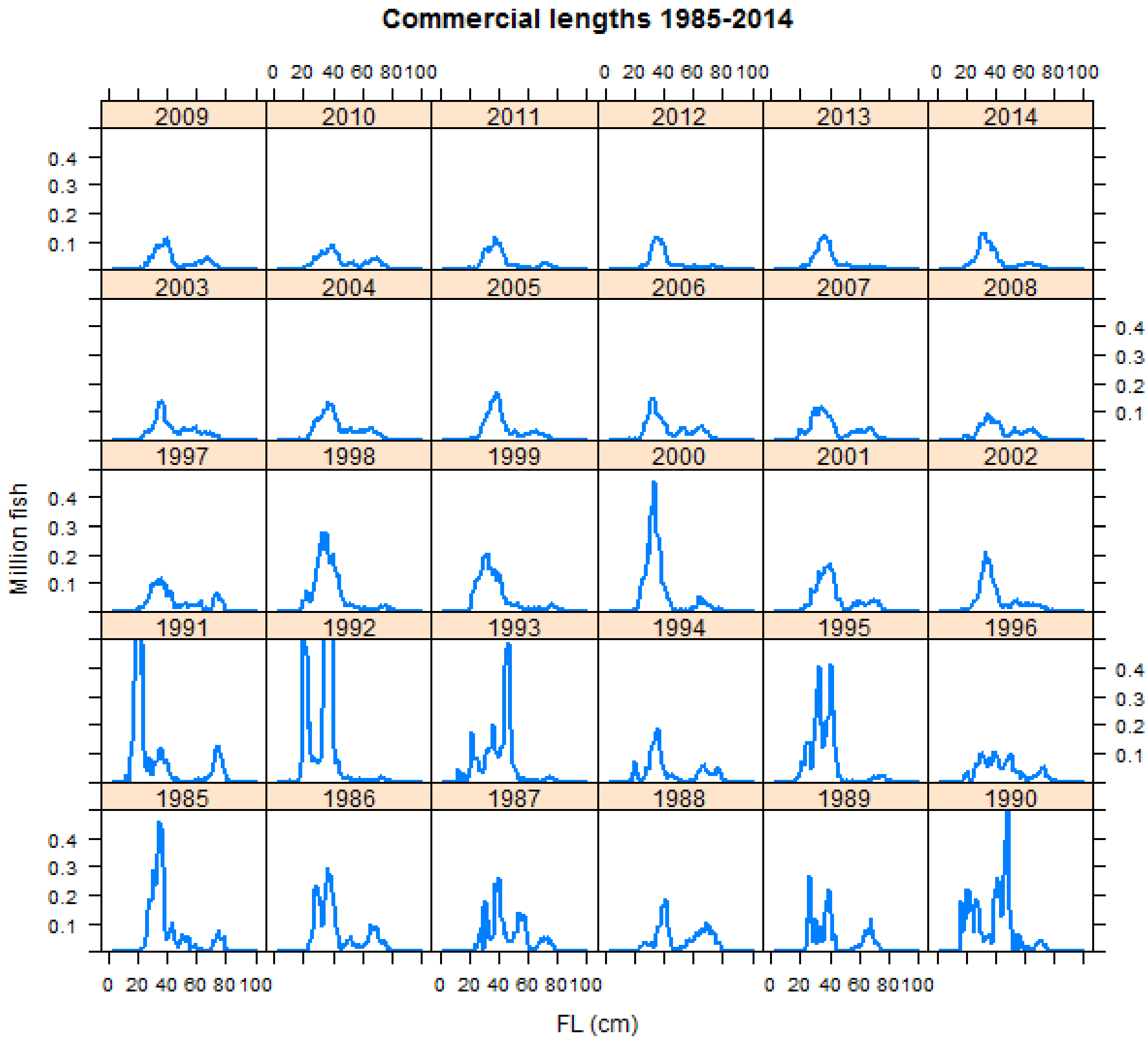


Figure B4.6. Length frequency distributions of commercial bluefish landings from Maine to Florida.

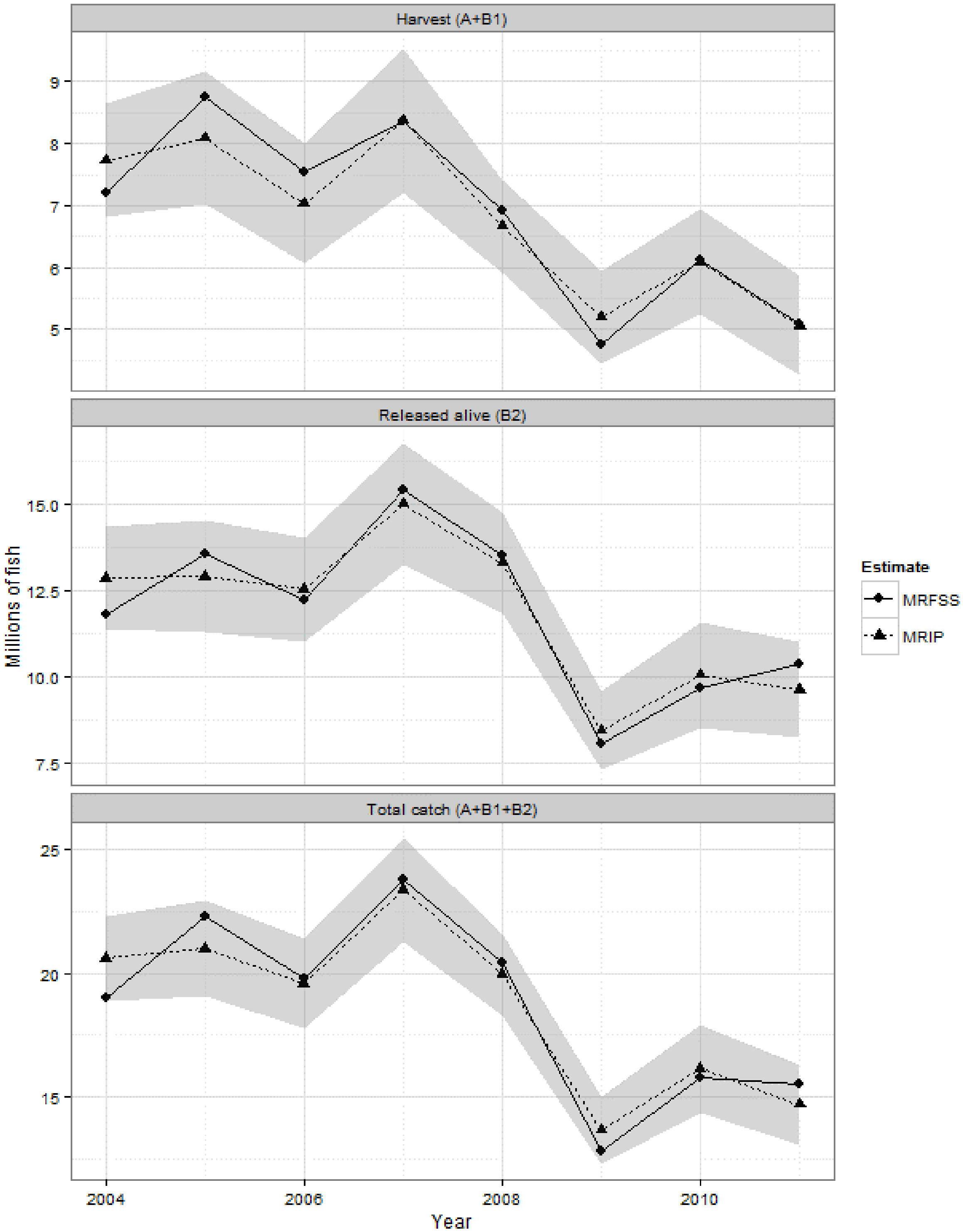


Figure B4.7. Comparison of MRFSS and MRIP estimates of bluefish catch for 2004 - 2011. Shaded bands indicate 95% confidence intervals calculated from MRIP PSEs.

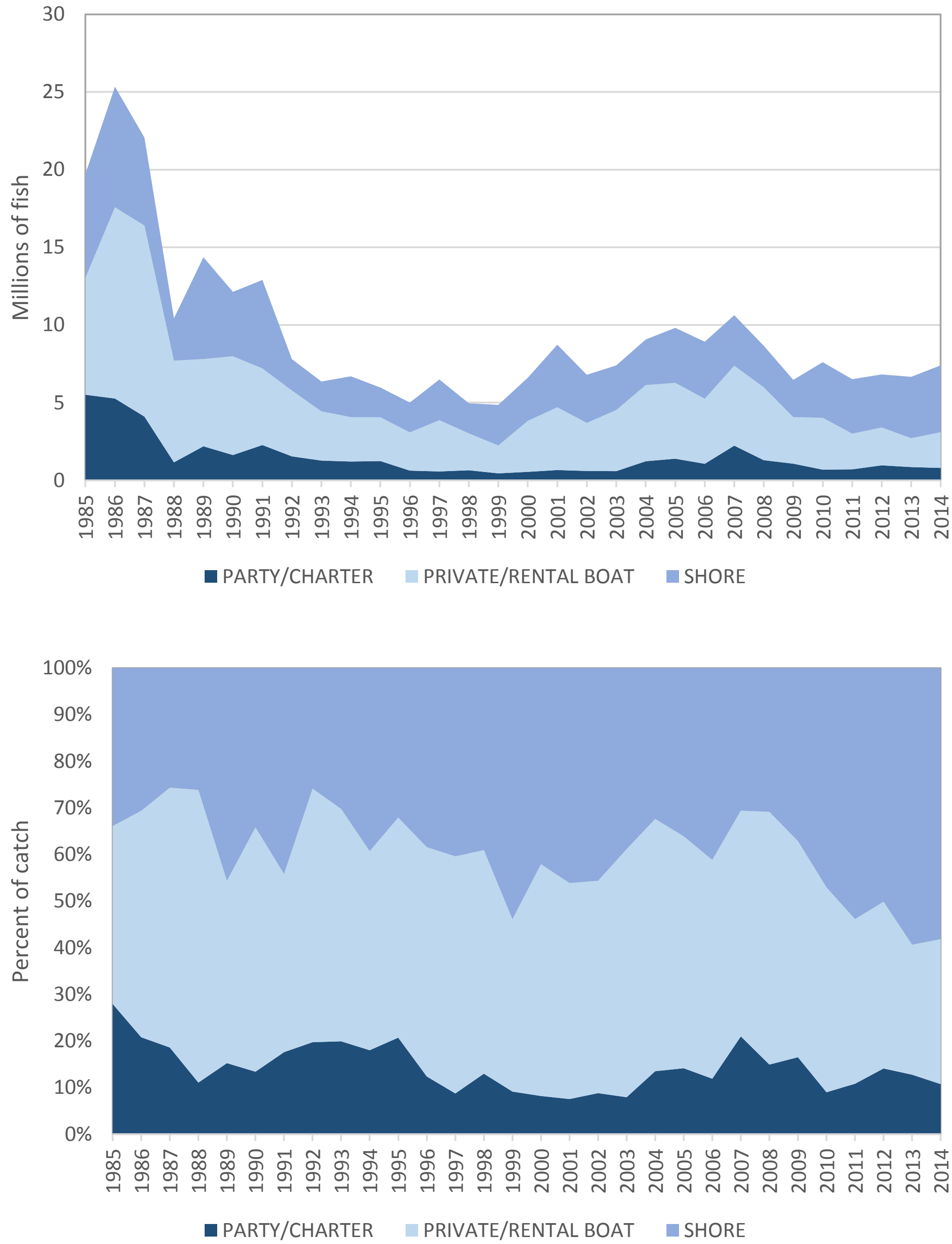


Figure B4.8. Bluefish recreational removals by mode for the Atlantic coast, shown in numbers of fish (top) and percent of catch (bottom.).

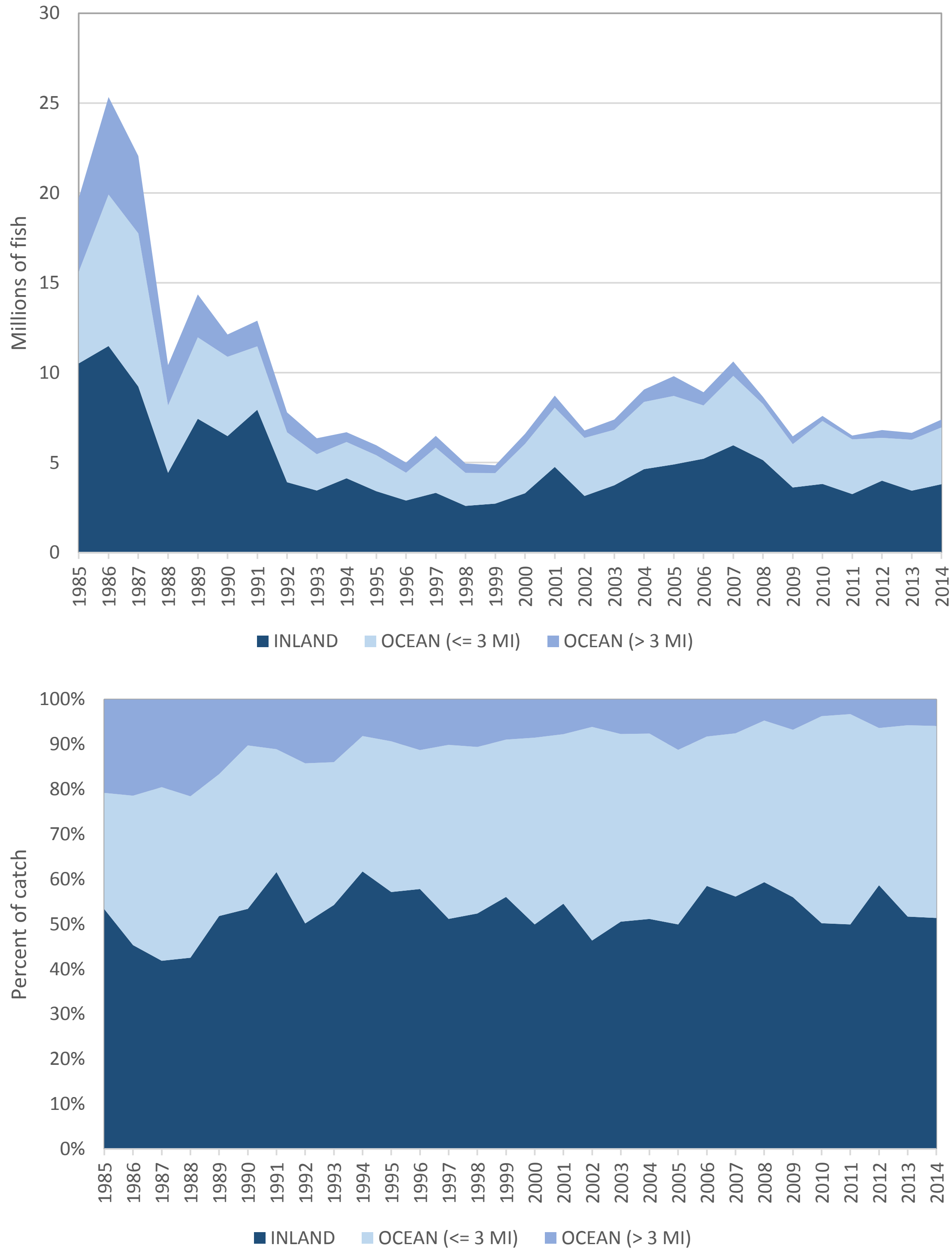


Figure B4.9. Bluefish recreational removals by area fished for the Atlantic coast, shown in numbers of fish (top) and percent of catch (bottom).

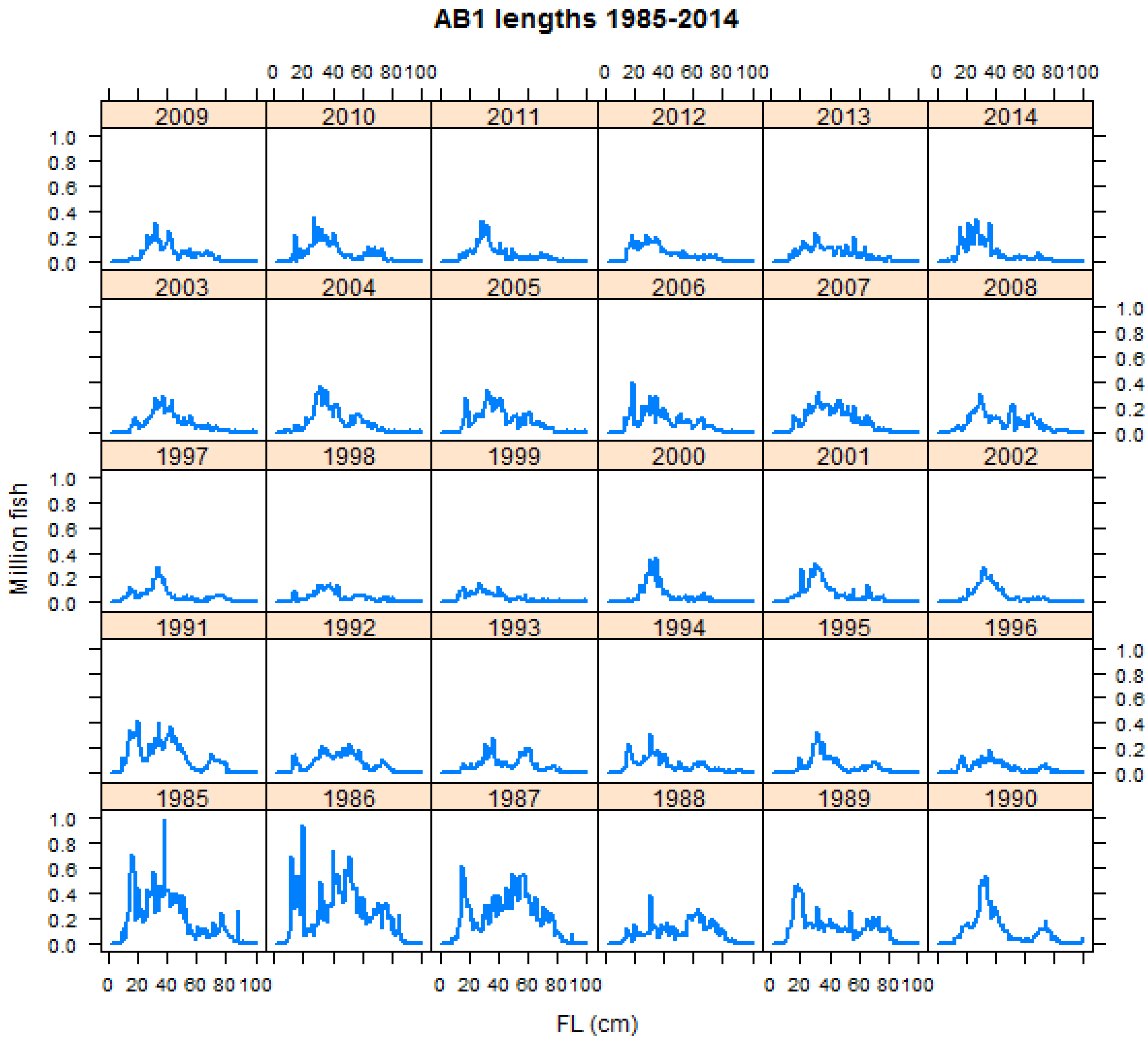


Figure B4.10A. Length frequency distributions of recreational landings for the Atlantic coast.

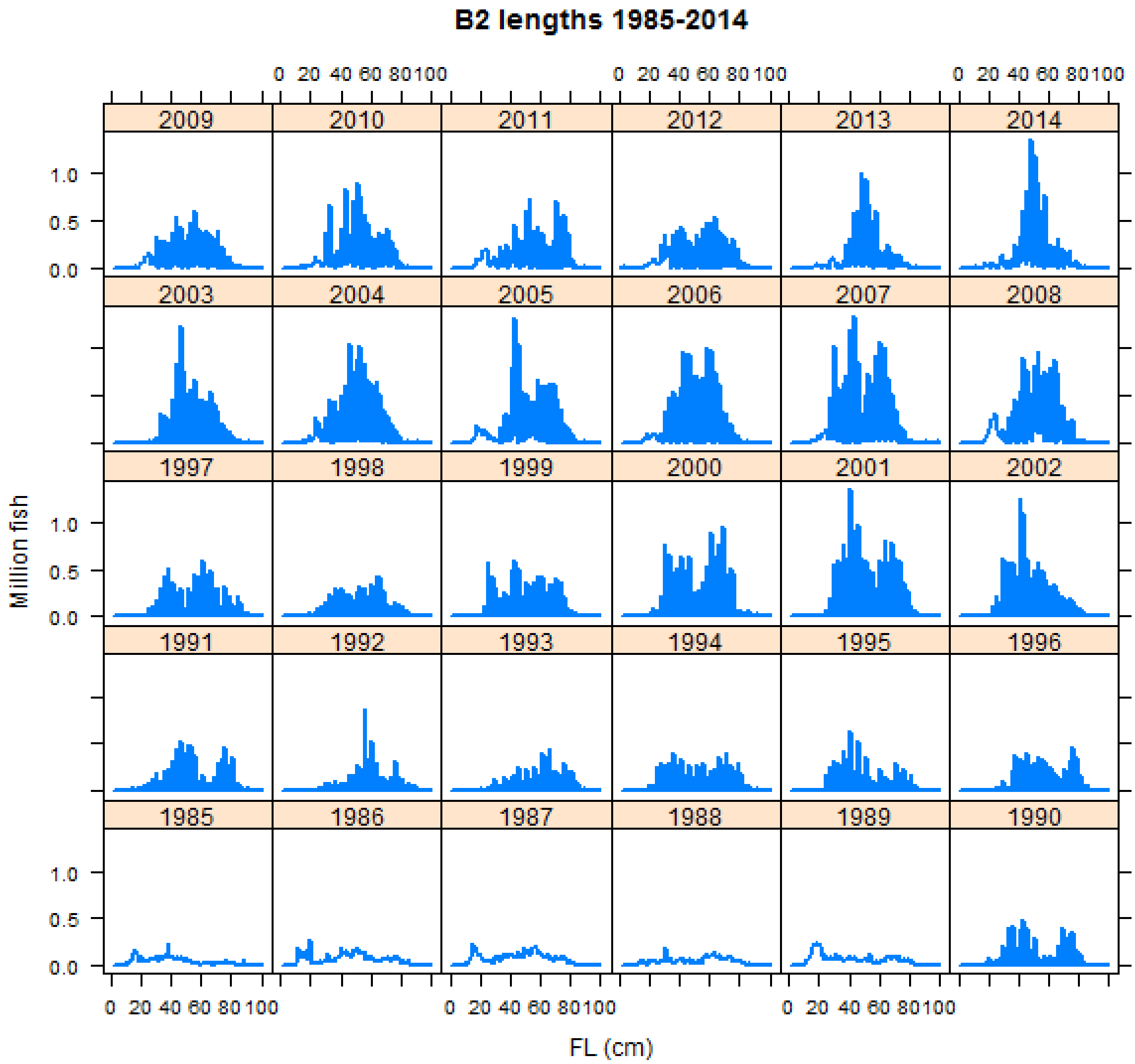


Figure B4.10B. Length frequency distributions of recreational discards for the Atlantic coast.

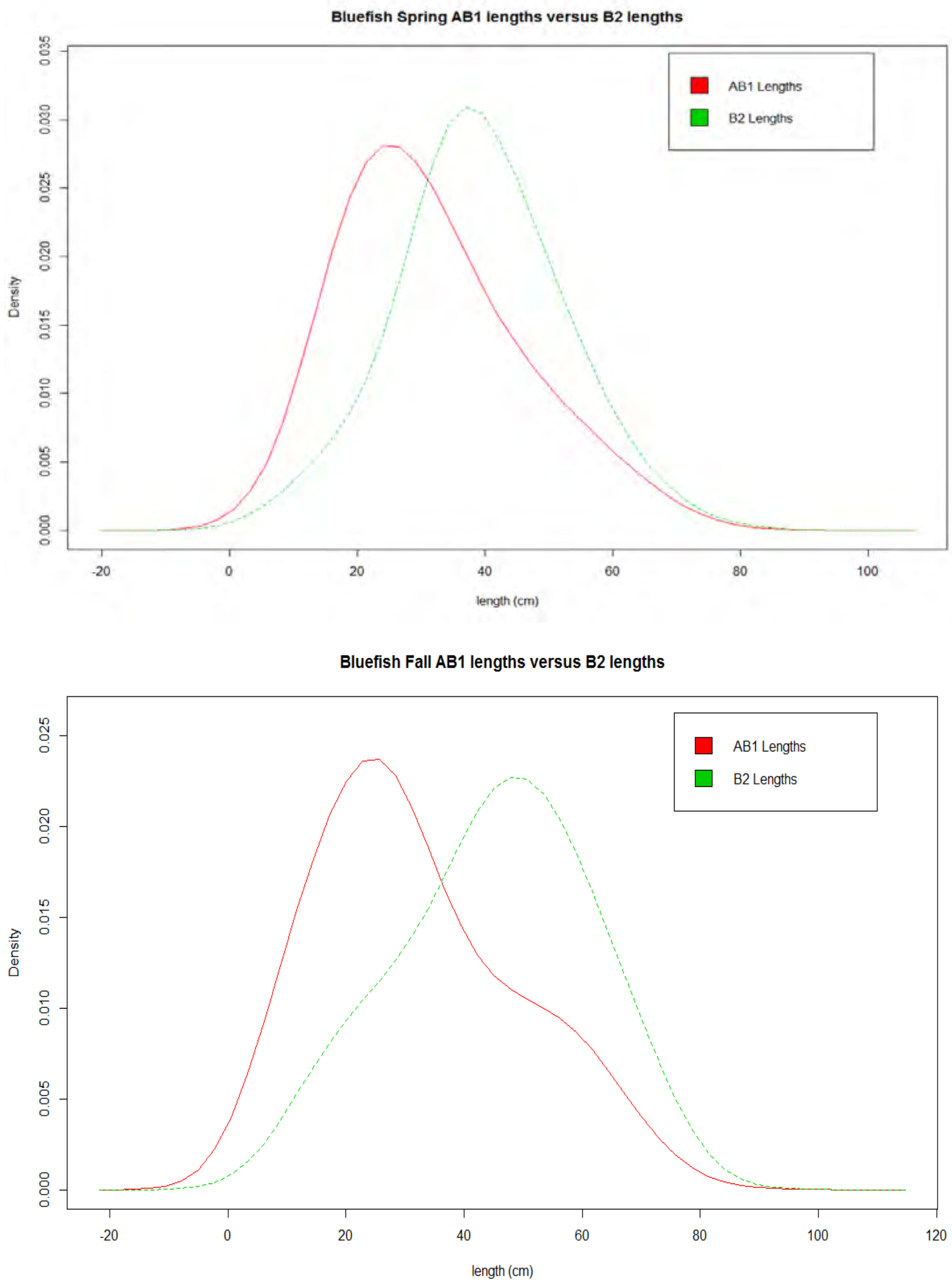


Figure B4.11. Density plots of the length frequency distributions of recreational landings (A+B1) versus discards (B2) for bluefish in the spring (top) and fall (bottom).

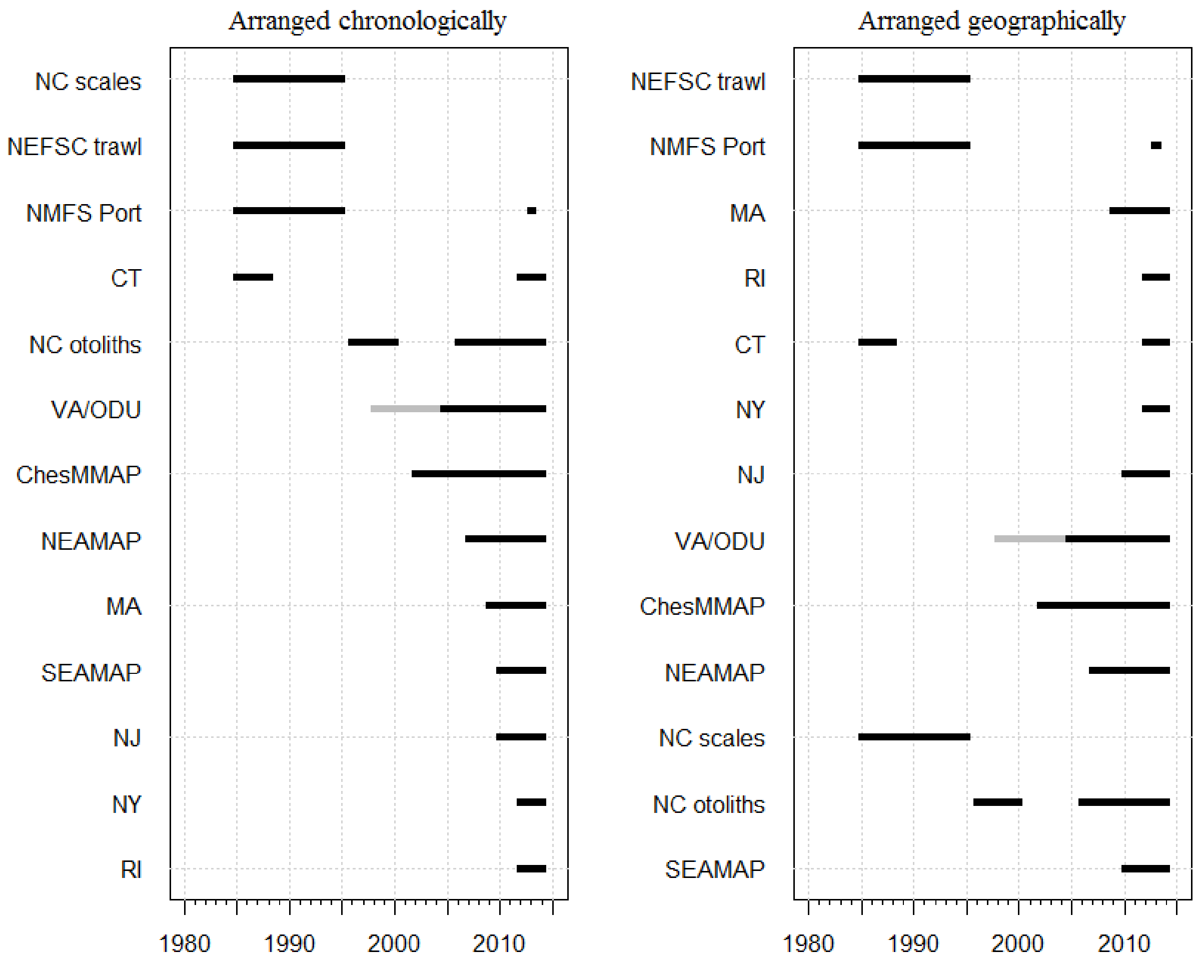


Figure B5.1. Depiction of available bluefish age data arranged chronologically (left) and geographically (right). Samples from 1985-1995 are scales, all others are otoliths. NMFS Port samples in 2013 came from RI, NY, and NJ (state of origin not retrievable prior to 2013); NEAMAP samples came from states between MA/RI and NC, inclusive; SEAMAP samples came from states between NC and FL, inclusive. Grey bar at VA/ODU represents years where age data were shared across some years.

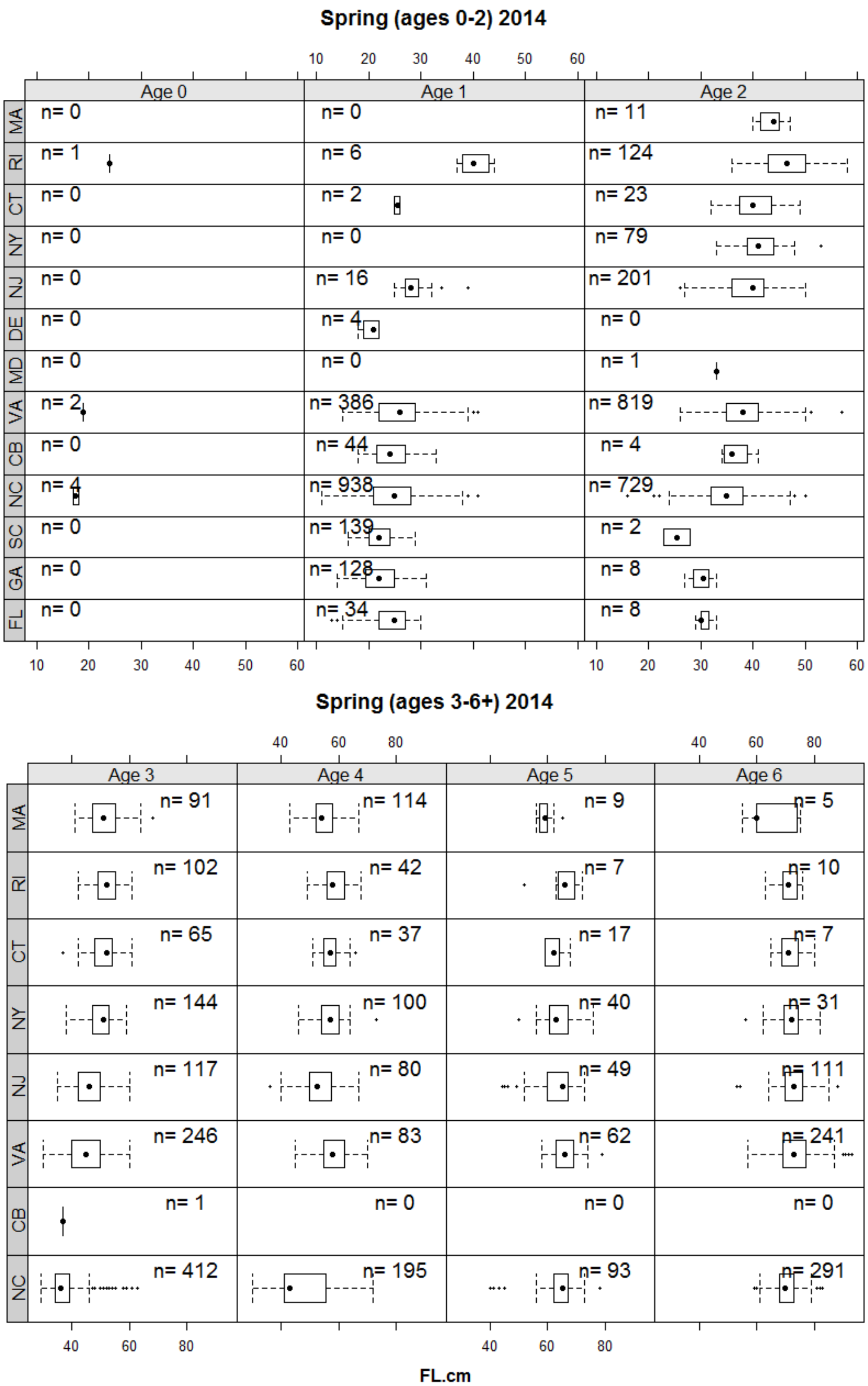


Figure B5.2A. Boxplots of size at age by state in spring 2014.

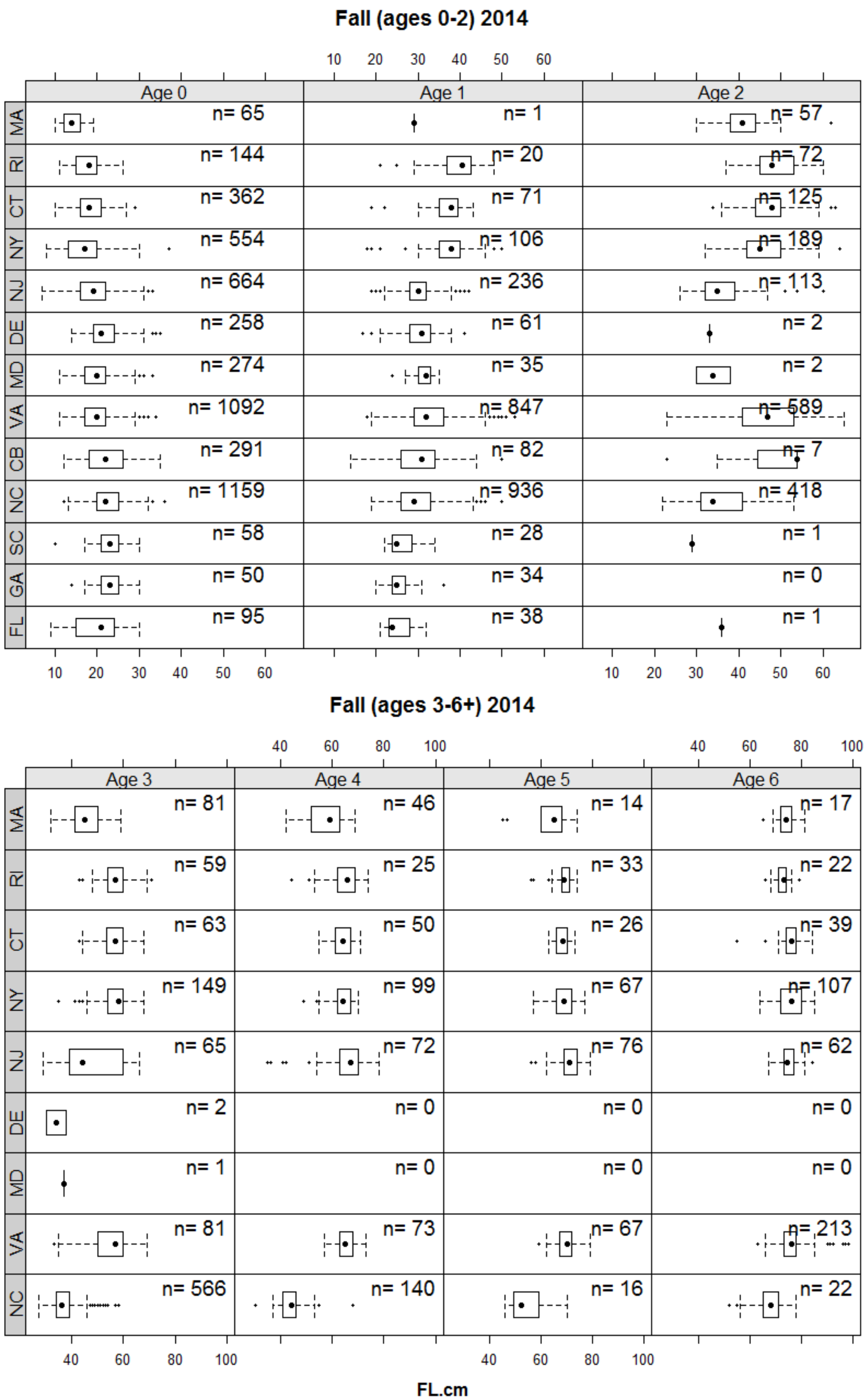


Figure B5.2B. Boxplots of size at age by state in fall 2014.

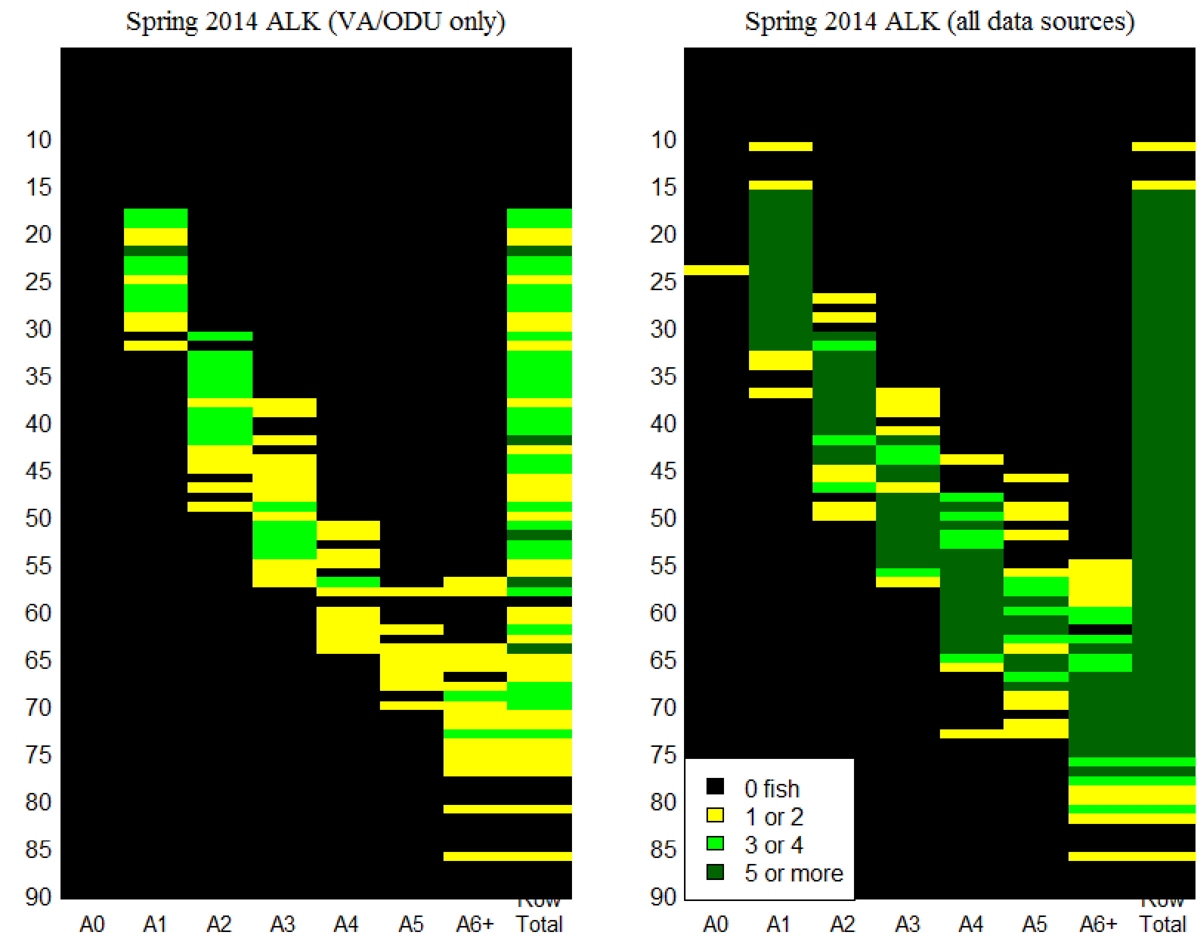


Figure B5.3. Comparison of age-length keys derived from VA/ODU versus all data sources ALK for spring 2014. Column on far right of each plot depicts the row total. Y-axis is FL (cm).

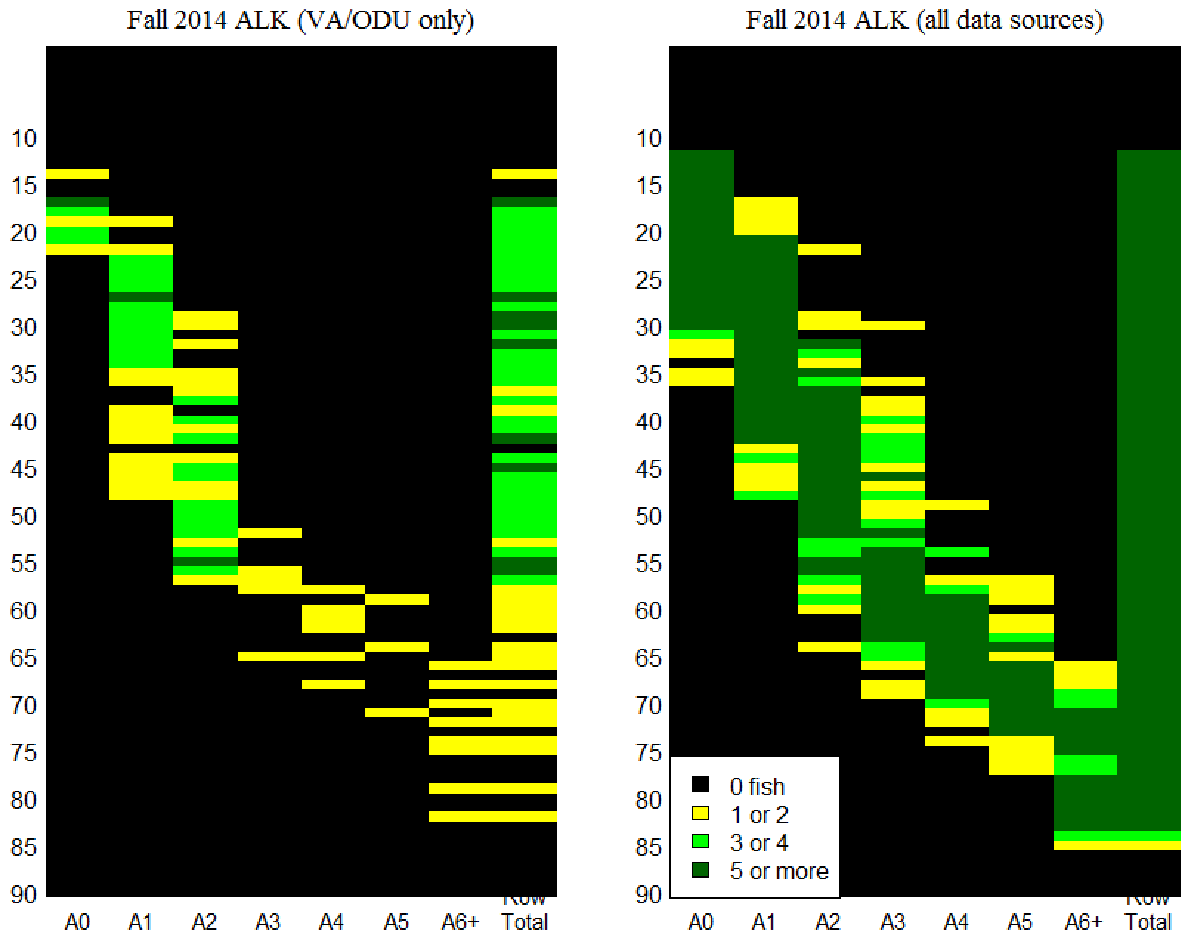


Figure B5.4. Comparison of age-length keys derived from VA/ODU versus all data sources ALK for fall 2014. Column on far right of each plot depicts the row total. Y-axis is FL (cm).

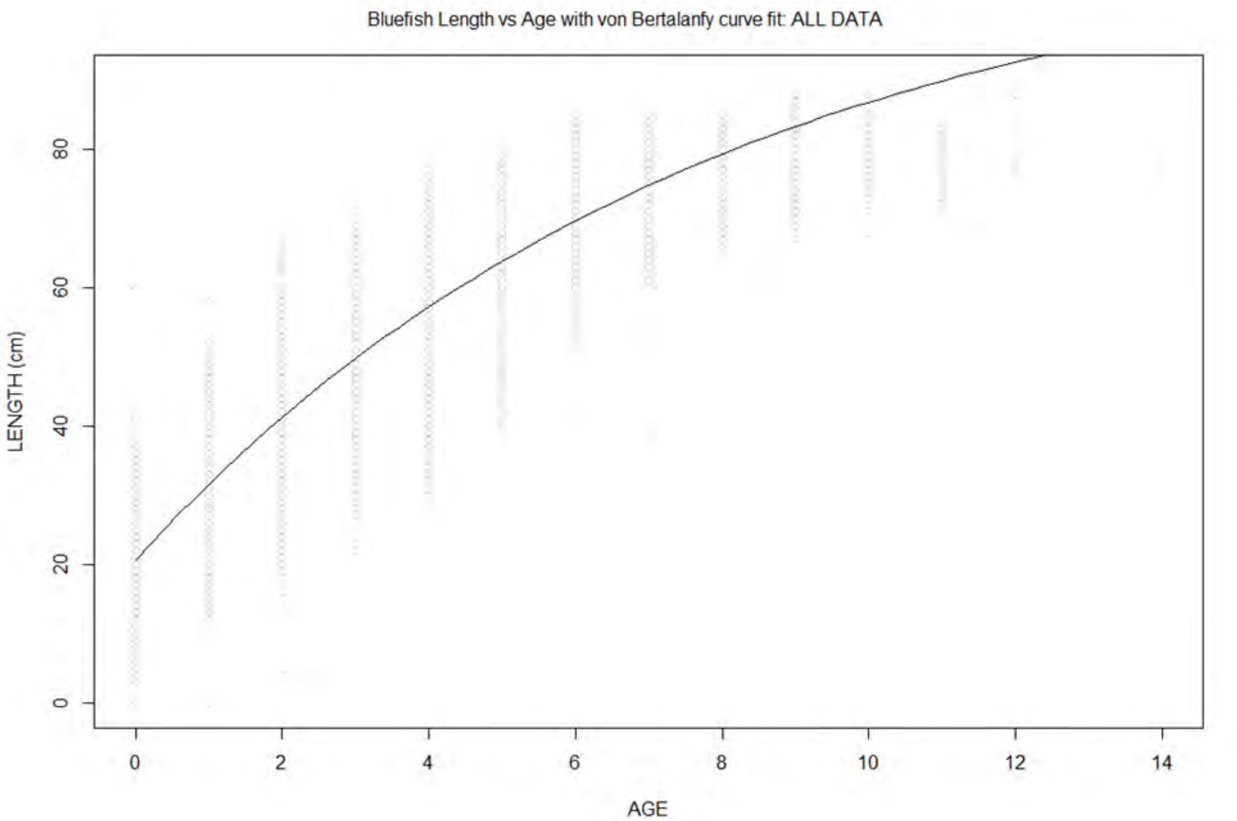


Figure B5.5. Von Bertalanffy growth curve fit to all bluefish data.

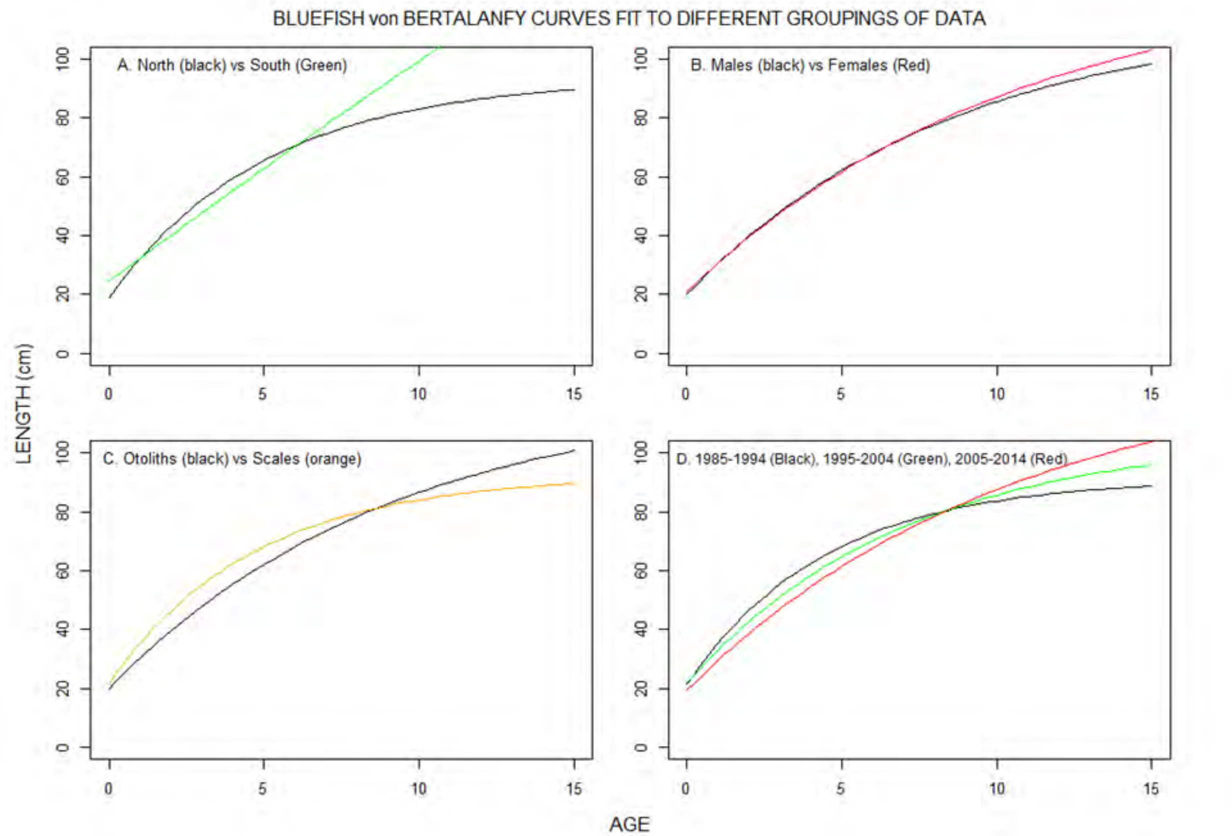


Figure B5.6. Von Bertalanfy growth curves fit to different groupings of data. (A) Northern and Southern fish, (B) Male and Females, (C) Otolith Ages and Scale Ages, and (D) Three time blocks.

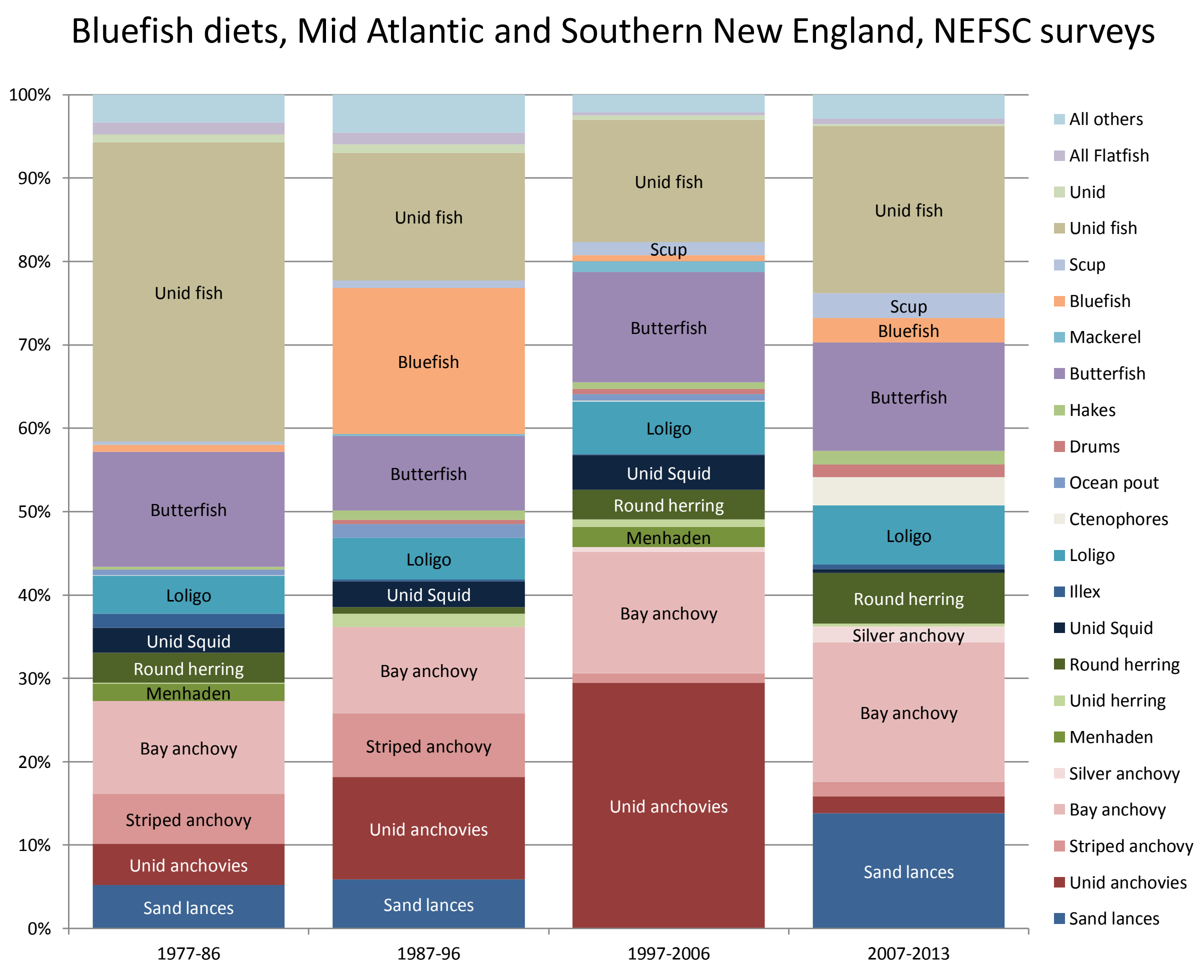


Figure B5.7. Bluefish historic diet composition: prey proportion by weight in 10-year intervals.

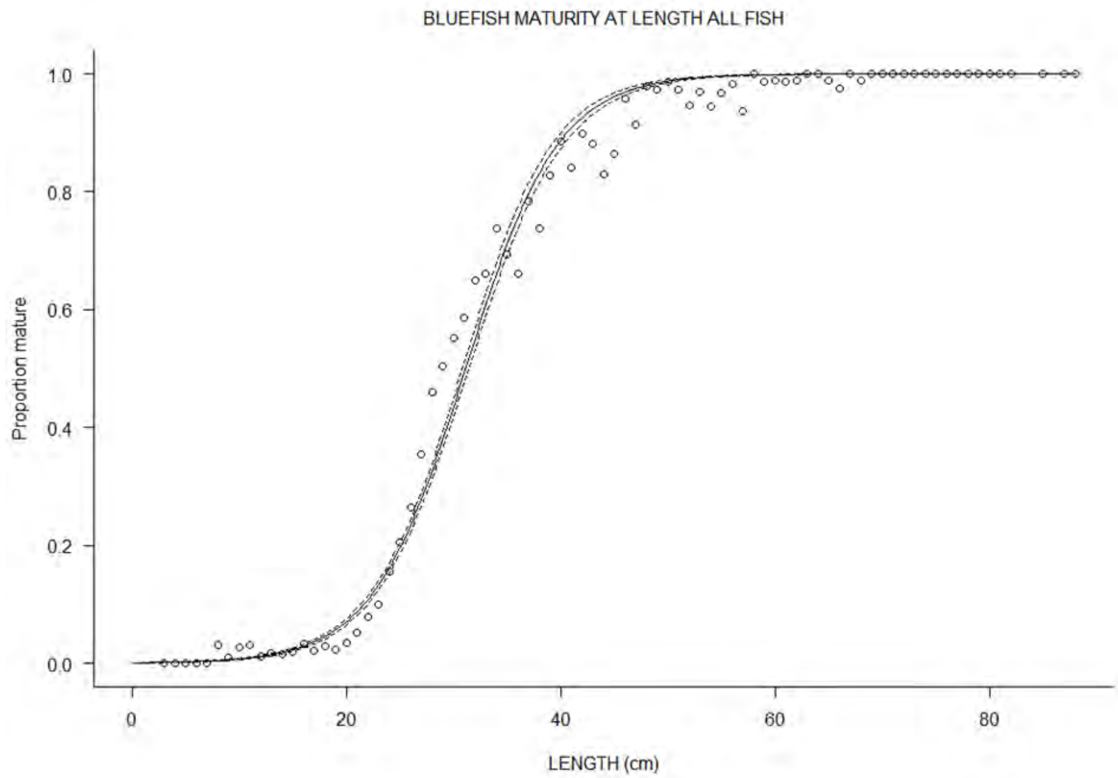


Figure B5.8. Bluefish maturity at length for all fish in the study. (L50 = 29.9 cm, L95 = 44.3 cm).

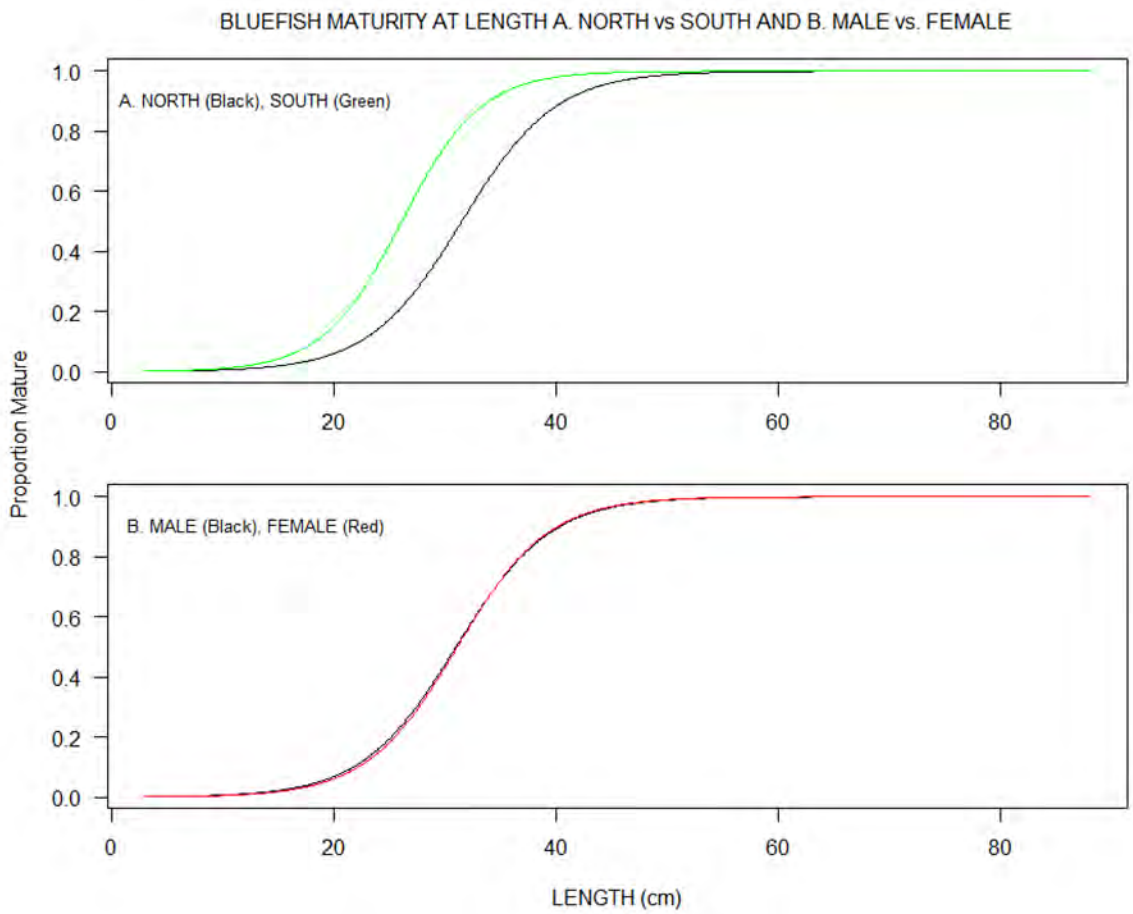


Figure B5.9. Bluefish maturity at length by region (A) and sex (B).

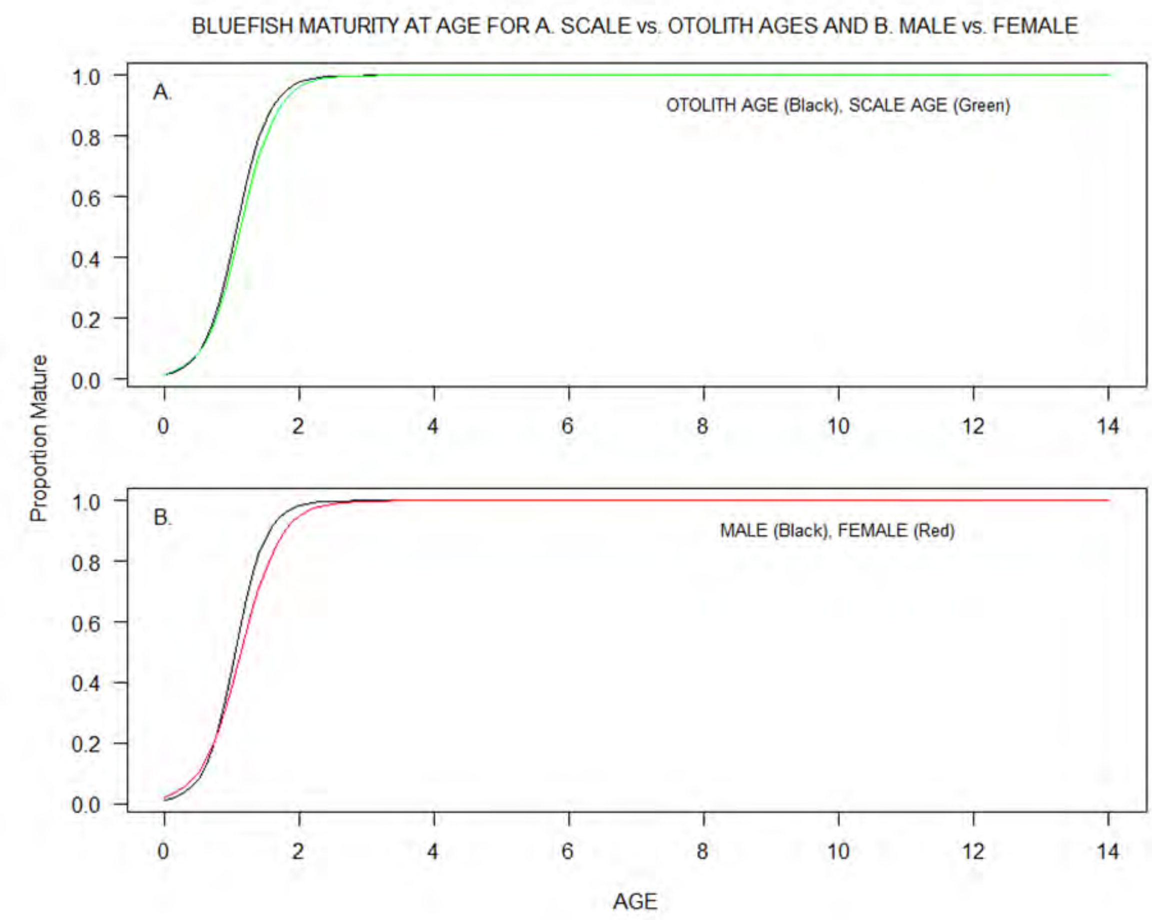


Figure B5.10. Bluefish maturity at age by ageing structure (A) and sex (B).

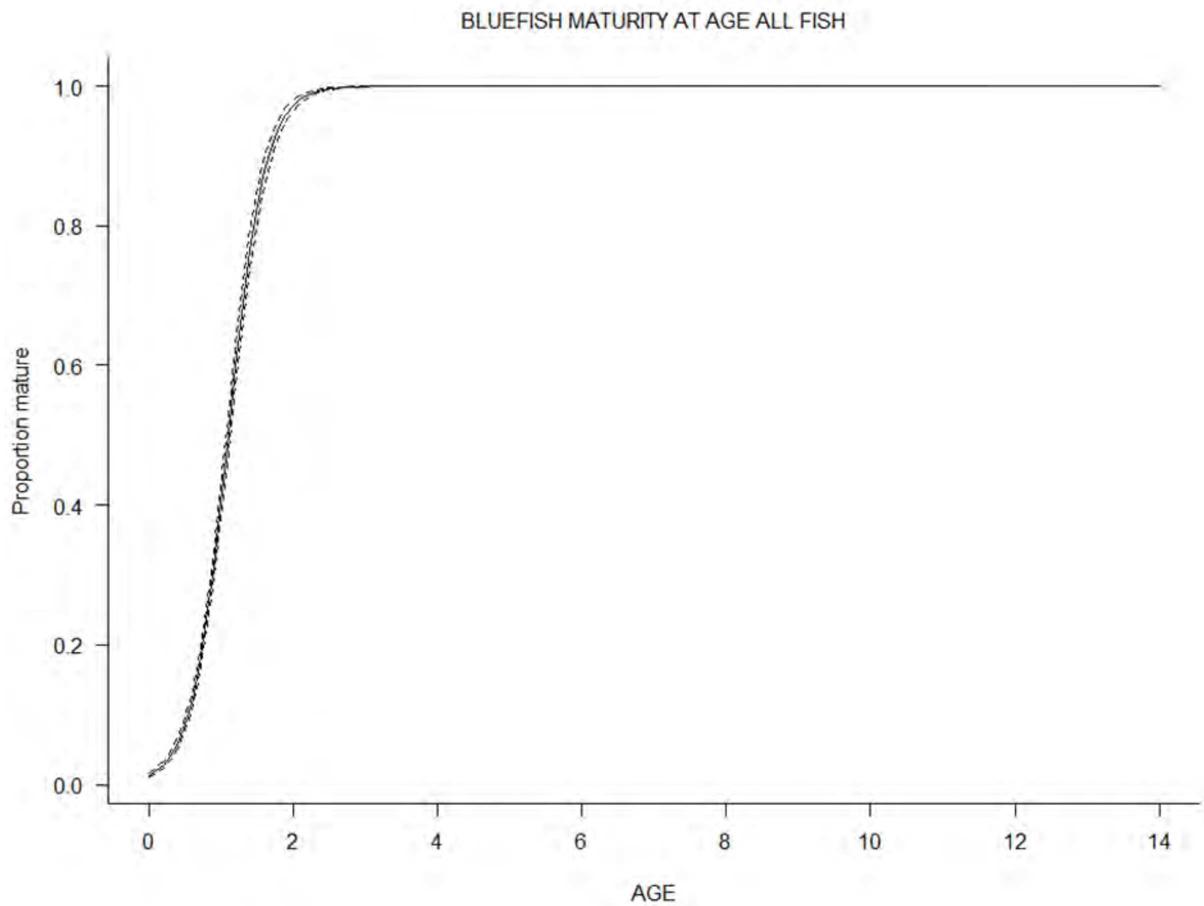


Figure B5.11. Bluefish maturity at age for all fish in the study. (A50 = 1.1 years, A95 = 1.84 years)

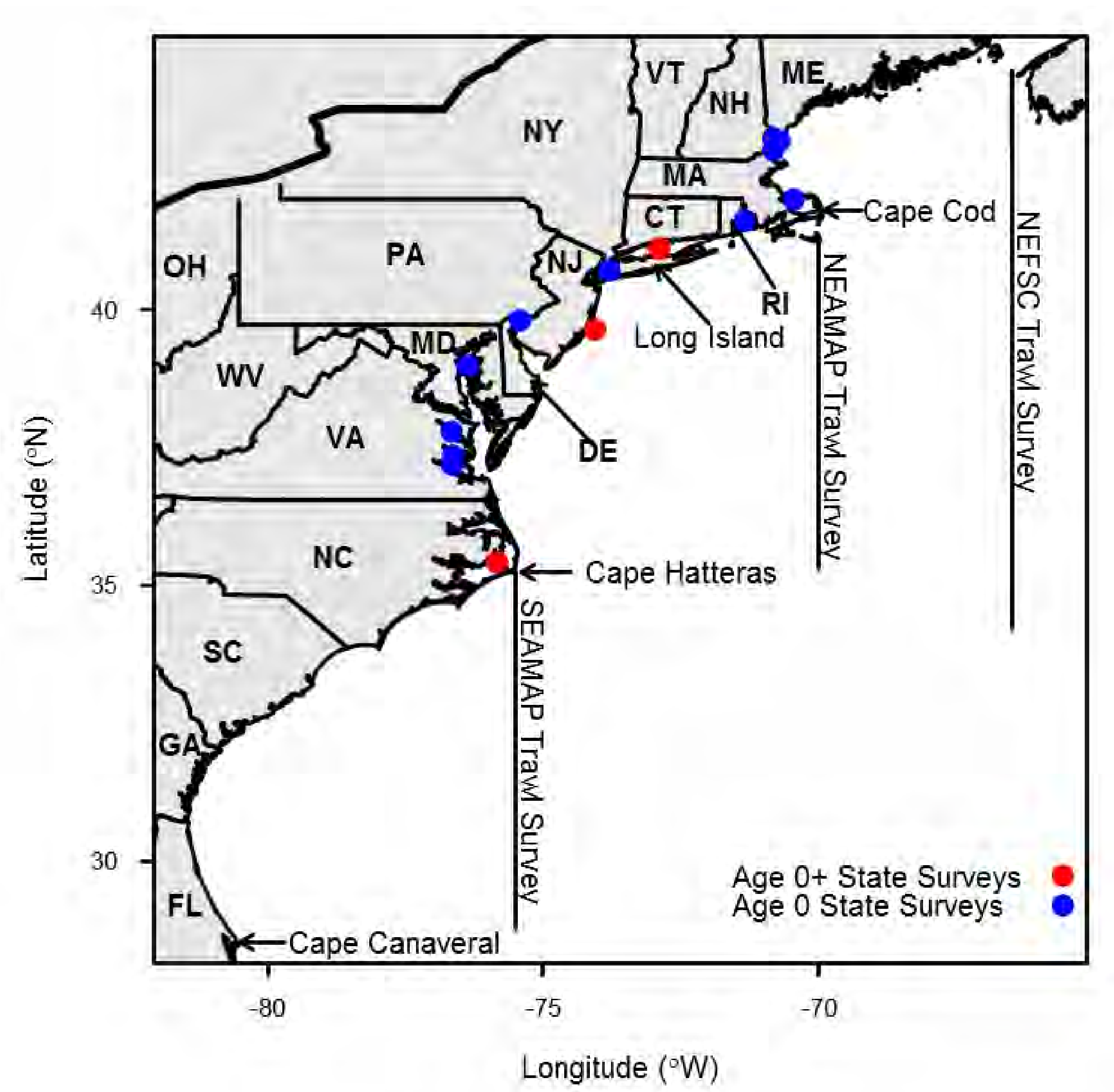


Figure B6.1. Map of available regional and state specific surveys. Regional surveys include SEAMAP Fall Trawl Survey Age-0 Index, NEAMAP Trawl Survey, and NEFSC Fall Trawl Surveys (R/V Albatross and R/V Bigelow). Vertical lines associated with regional surveys represent their latitudinal extent. State surveys include New Hampshire Juvenile Finfish Survey, Massachusetts Inshore Bottom Trawl Survey (not included in final base run), Rhode Island Seine Survey, Connecticut Long Island Sound Trawl Survey, New York Western Long Island Sound Seine Survey, New Jersey Delaware River Seine Survey, New Jersey Ocean Trawl Survey, Maryland Juvenile Striped Bass Survey, VIMS Juvenile Striped Bass Survey, and North Carolina PSIGNS.

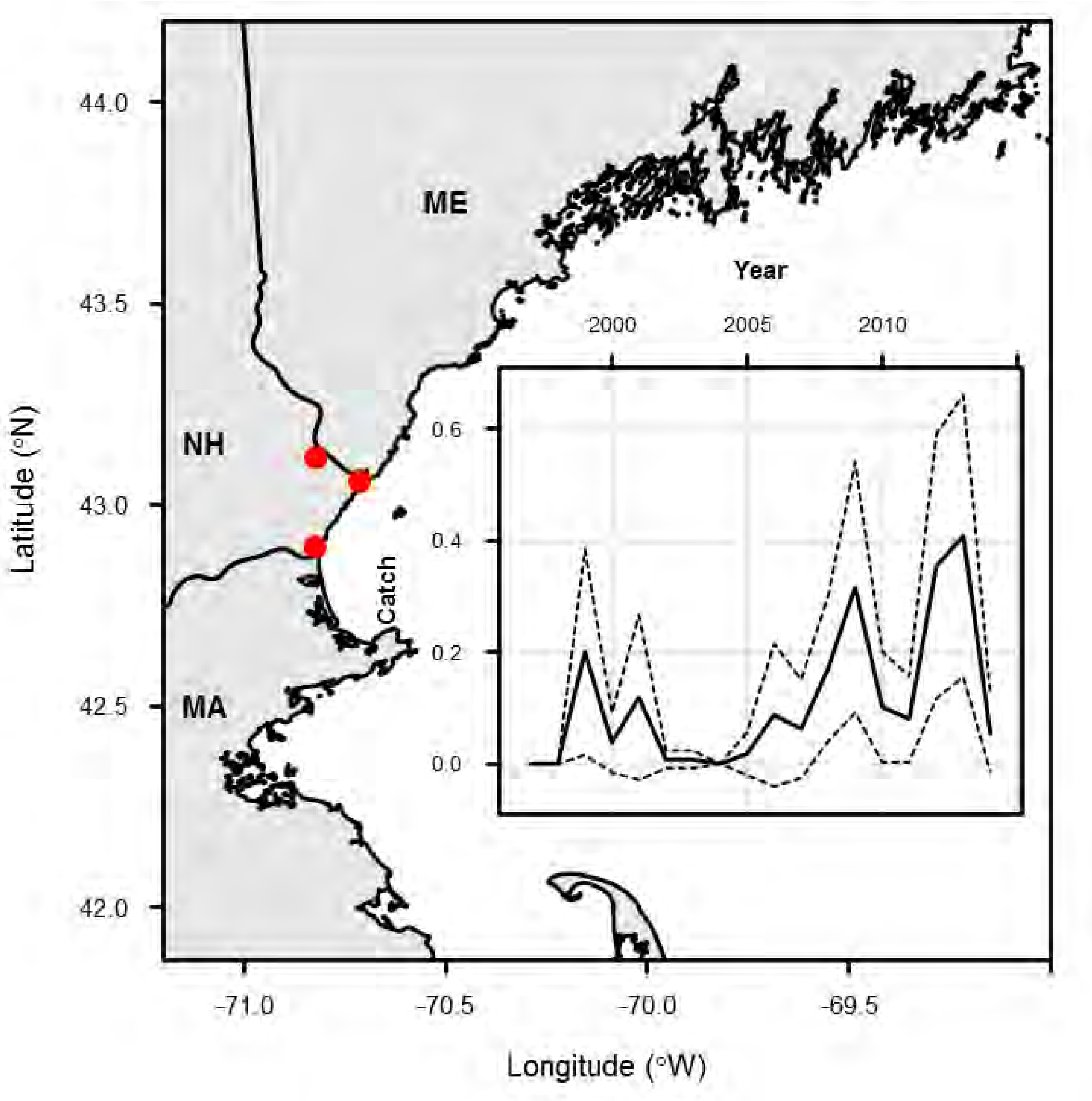


Figure B6.2. Map of the New Hampshire Juvenile Finfish Seine Survey area and resulting index of abundance (inset). Red dot indicates the center point in each of the three river systems surveyed.

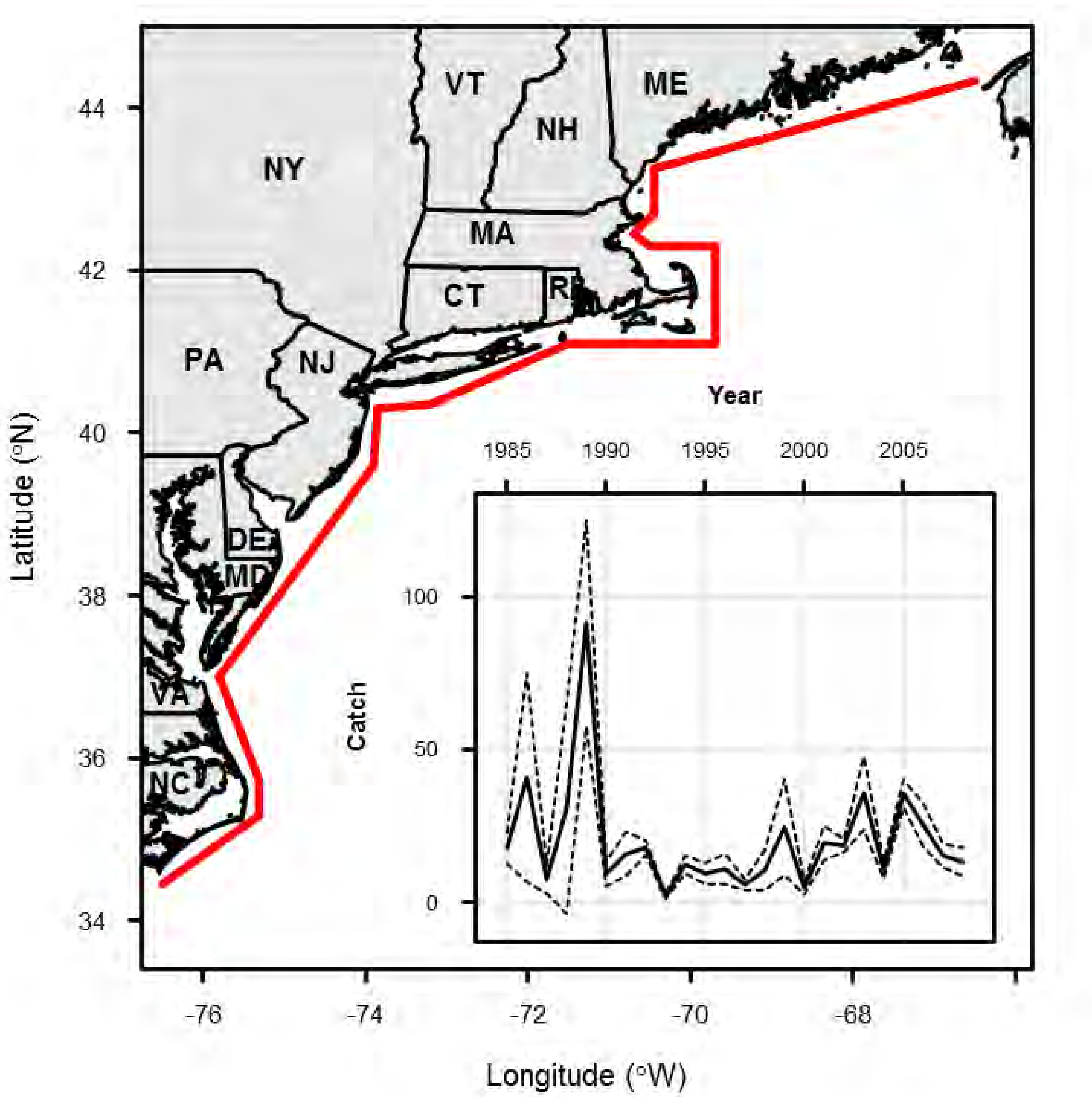


Figure B6.3A. Map of the NEFSC Fall Bottom Trawl Survey area and resultant index from the R/V Albatross years (inset). Red line represents extent of the survey area.

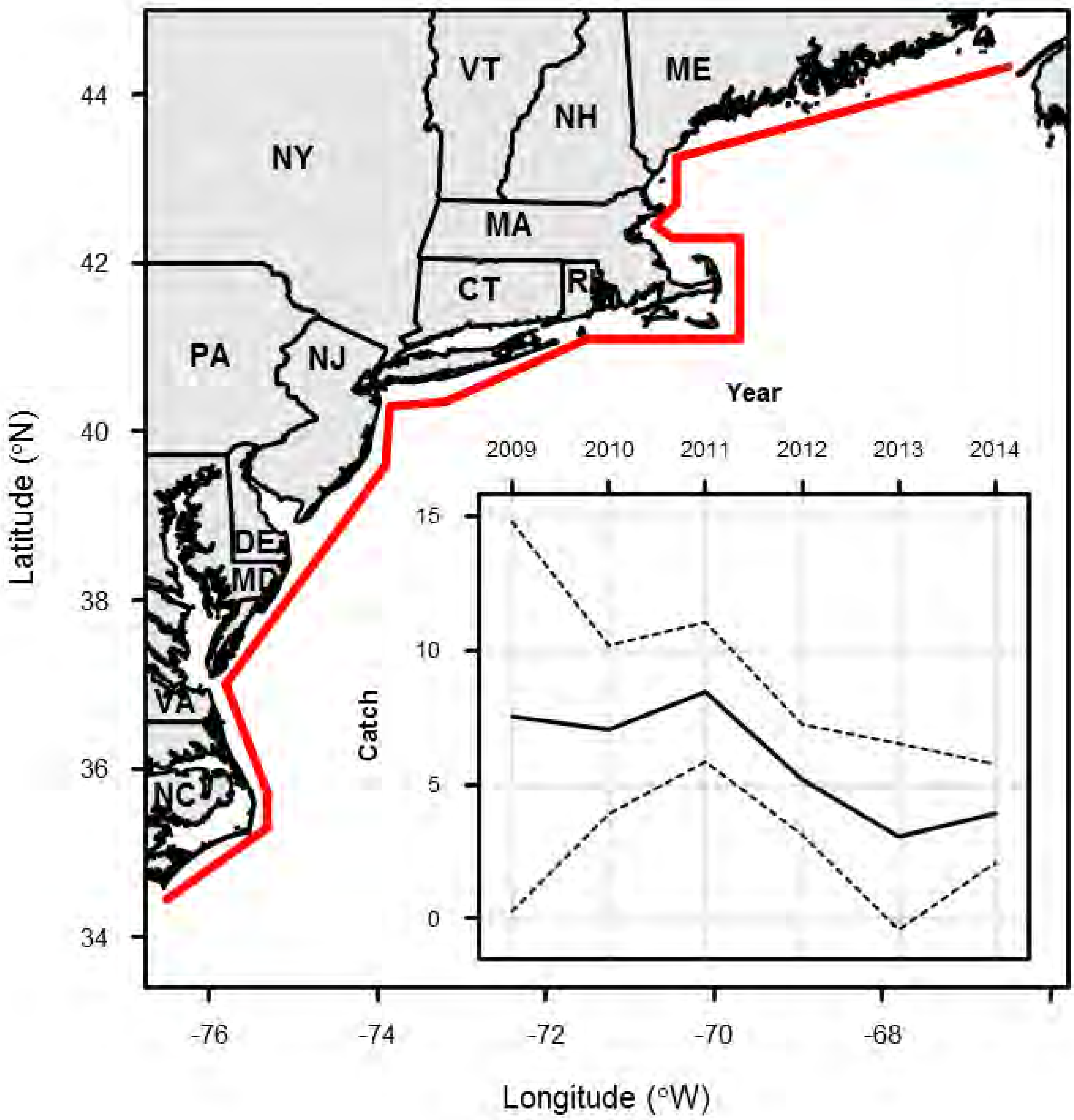


Figure B6.3B. Map of the NEFSC Fall Bottom Trawl Survey area and resultant index from the R/V Bigelow years (inset). Red line represents extent of the survey area.

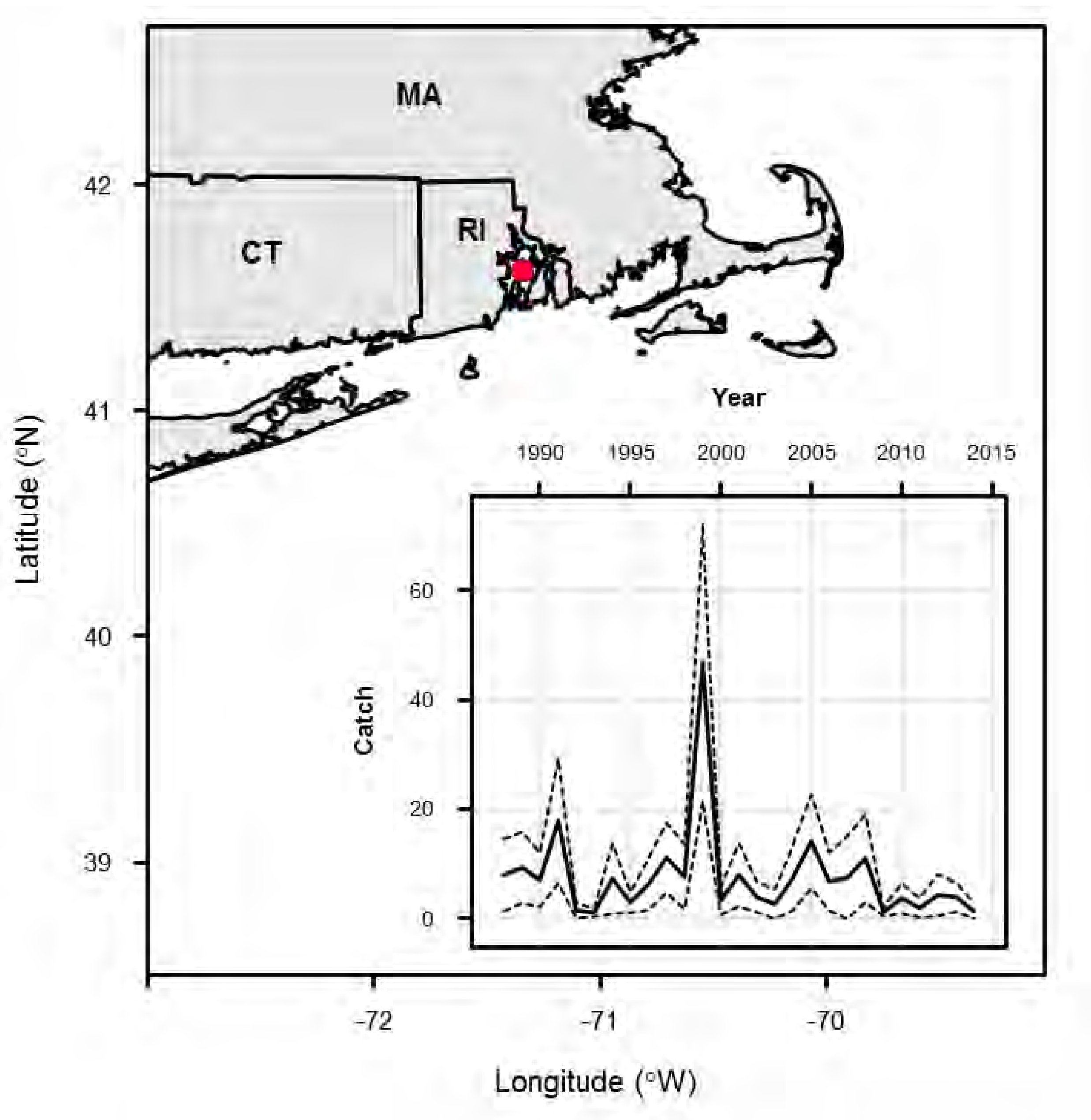


Figure B6.4. Map of the Rhode Island Narragansett Bay Juvenile Finfish Beach Seine Survey and resultant index of abundance (inset). Red dot indicates center point of survey area.

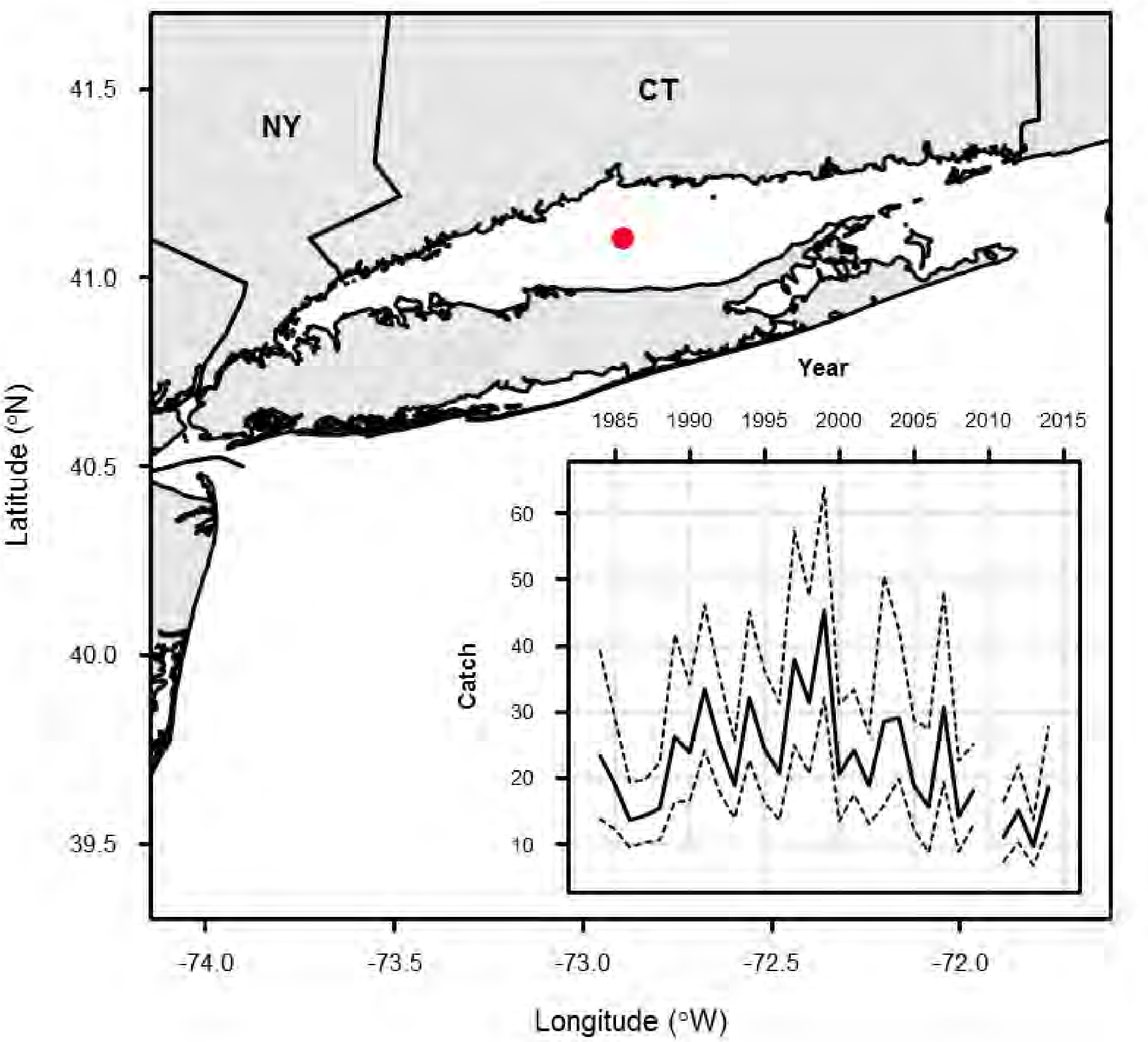


Figure B6.5. Map of the Connecticut Long Island Sound Bottom Trawl Survey and resultant index of abundance (inset). Red dot indicates center point of survey area.

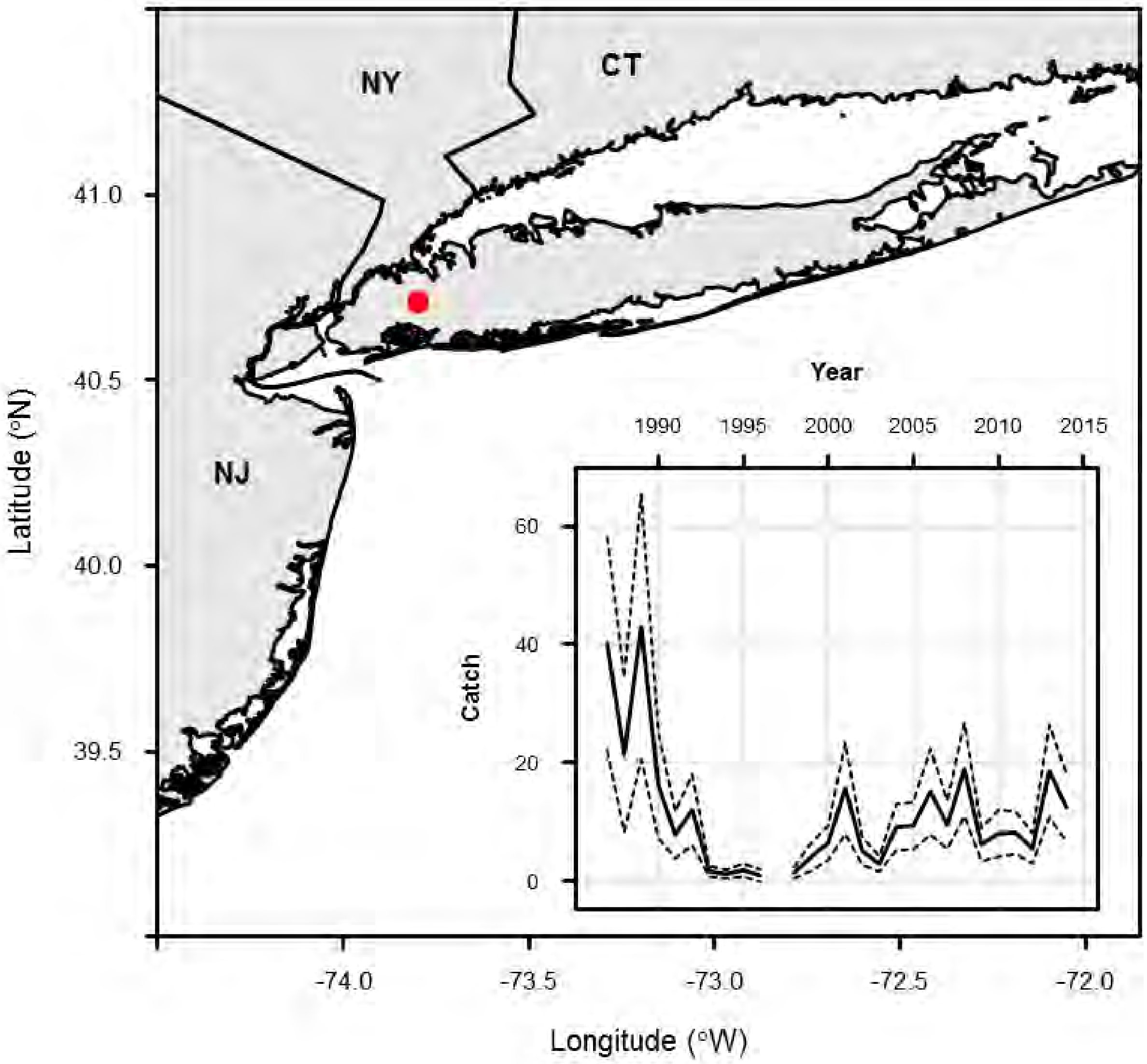


Figure B6.6. Map of the New York Western Long Island Sound Beach Seine Survey and resultant index of abundance (inset). Red dot indicates center point of survey area.

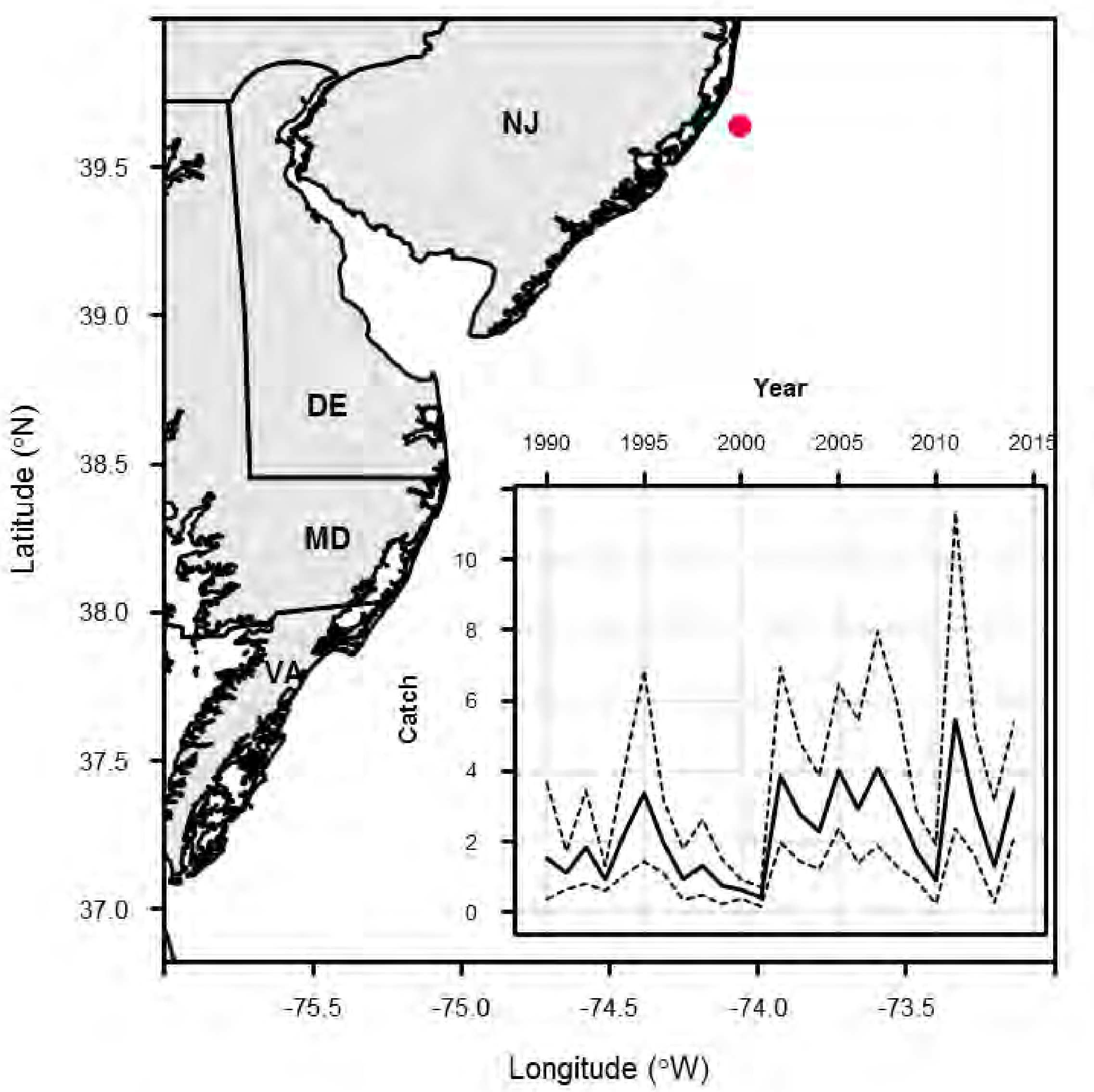


Figure B6.7. Map of the New Jersey Ocean Bottom Trawl Survey and resultant index of abundance (inset). Red dot indicates center point of survey area.

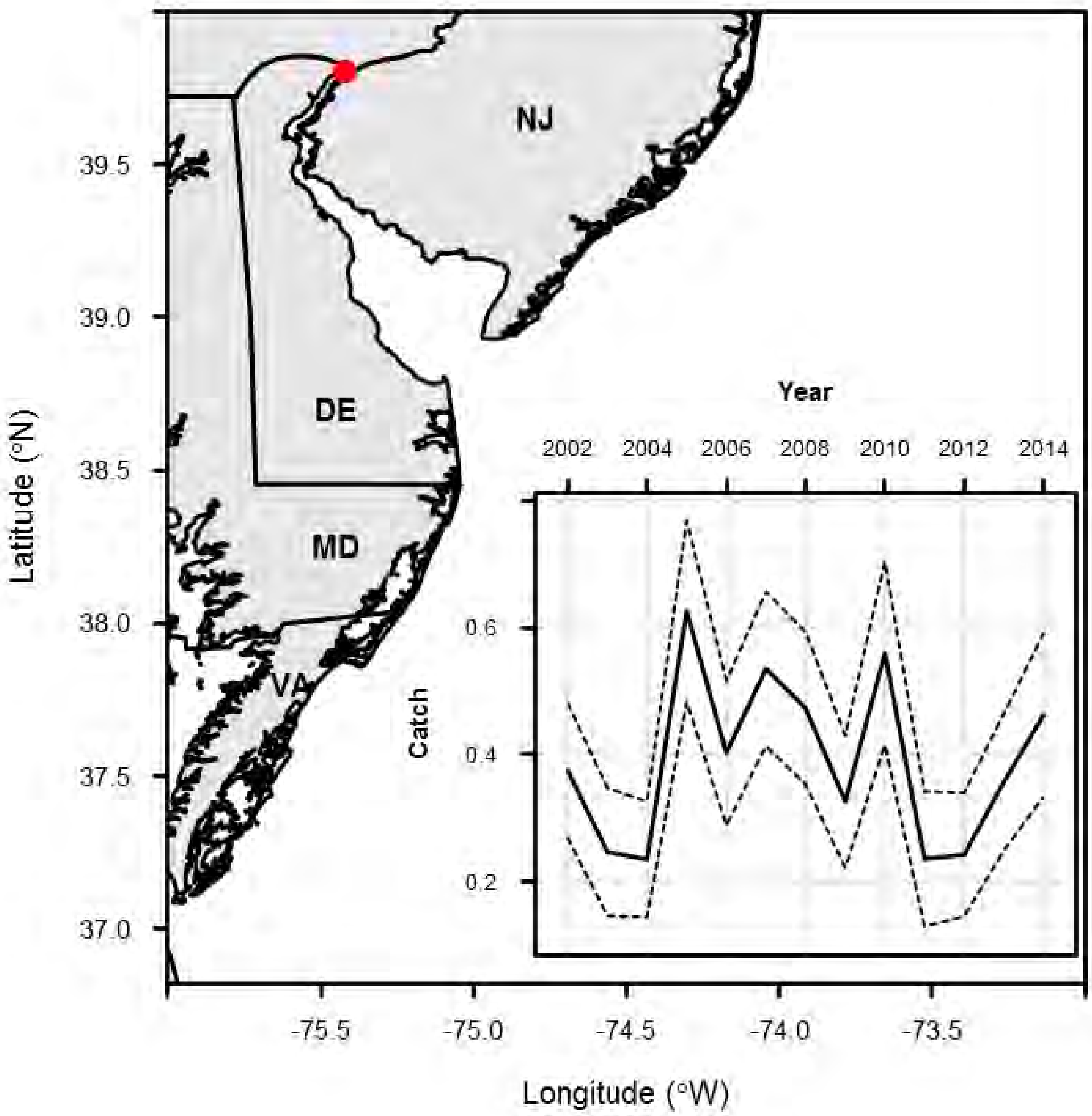


Figure B6.8. Map of the New Jersey Delaware River Seine Survey and resultant index of abundance (inset). Red dot indicates center point of survey area.

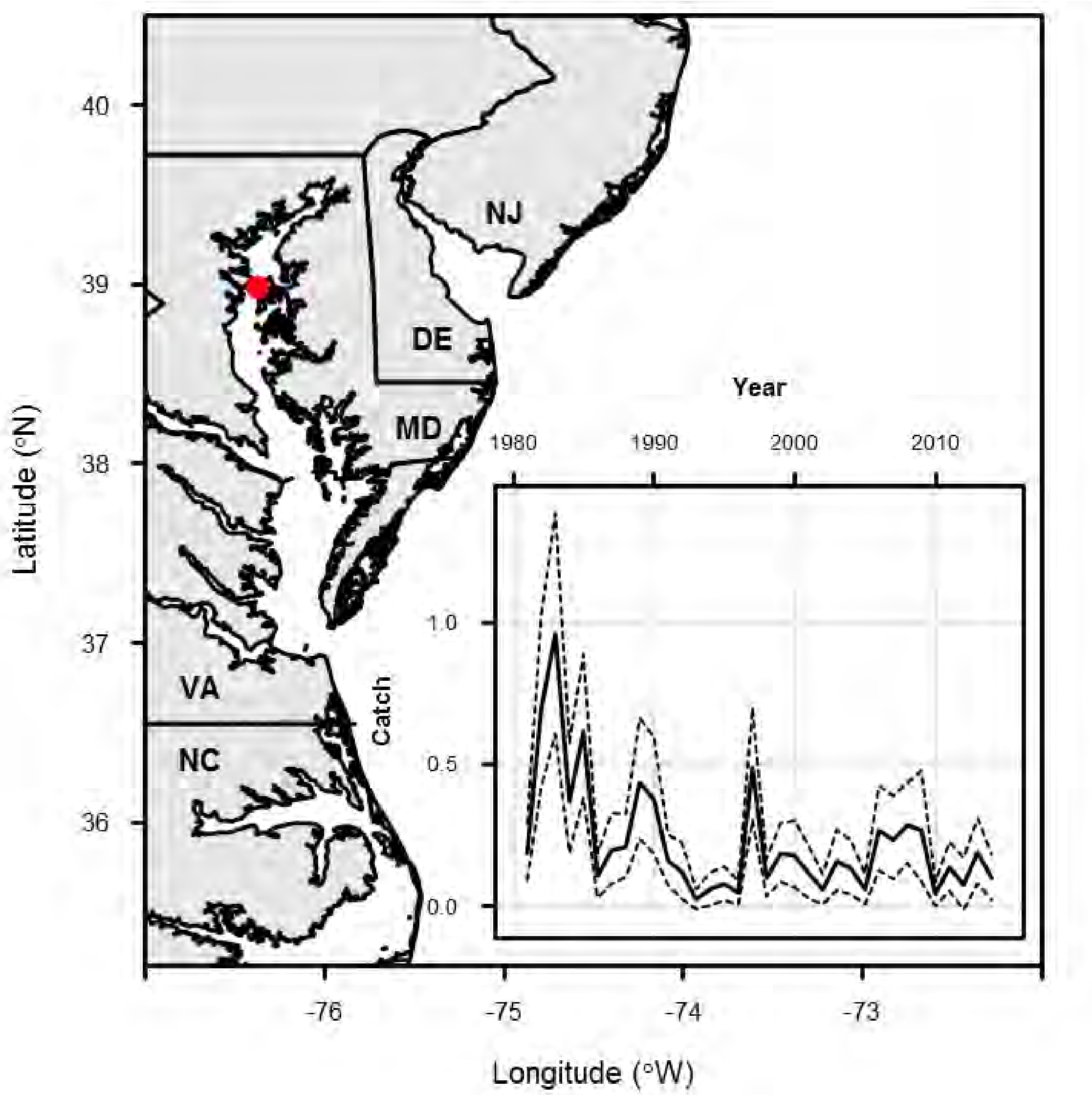


Figure B6.9. Map of the Maryland Juvenile Striped Bass Seine Survey and resultant index of abundance (inset). Red dot indicates center point of survey area.

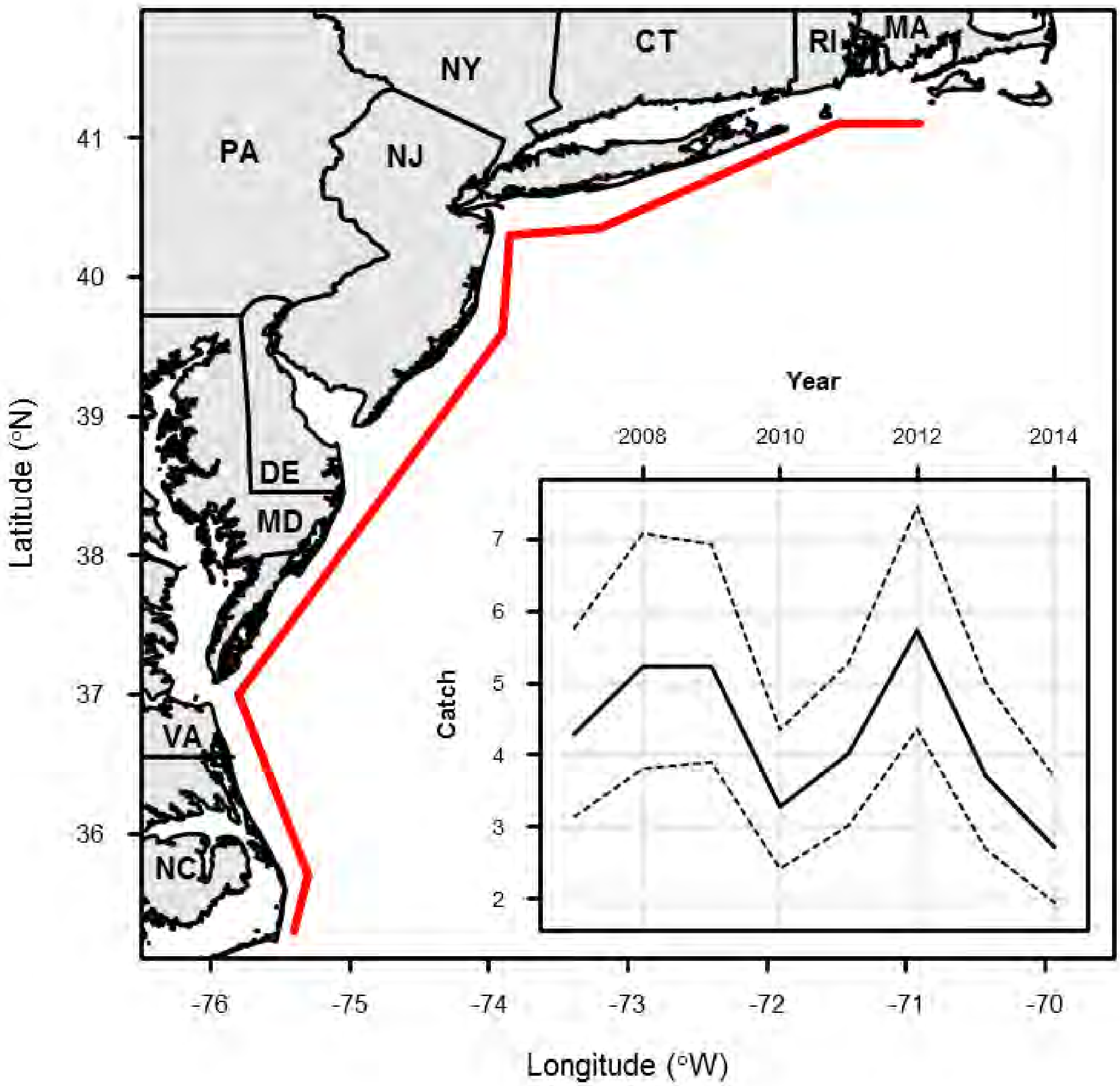


Figure B6.10. Map of the NEAMAP Fall Bottom Trawl survey area and resultant index (inset). Red line represents extent of the survey area.

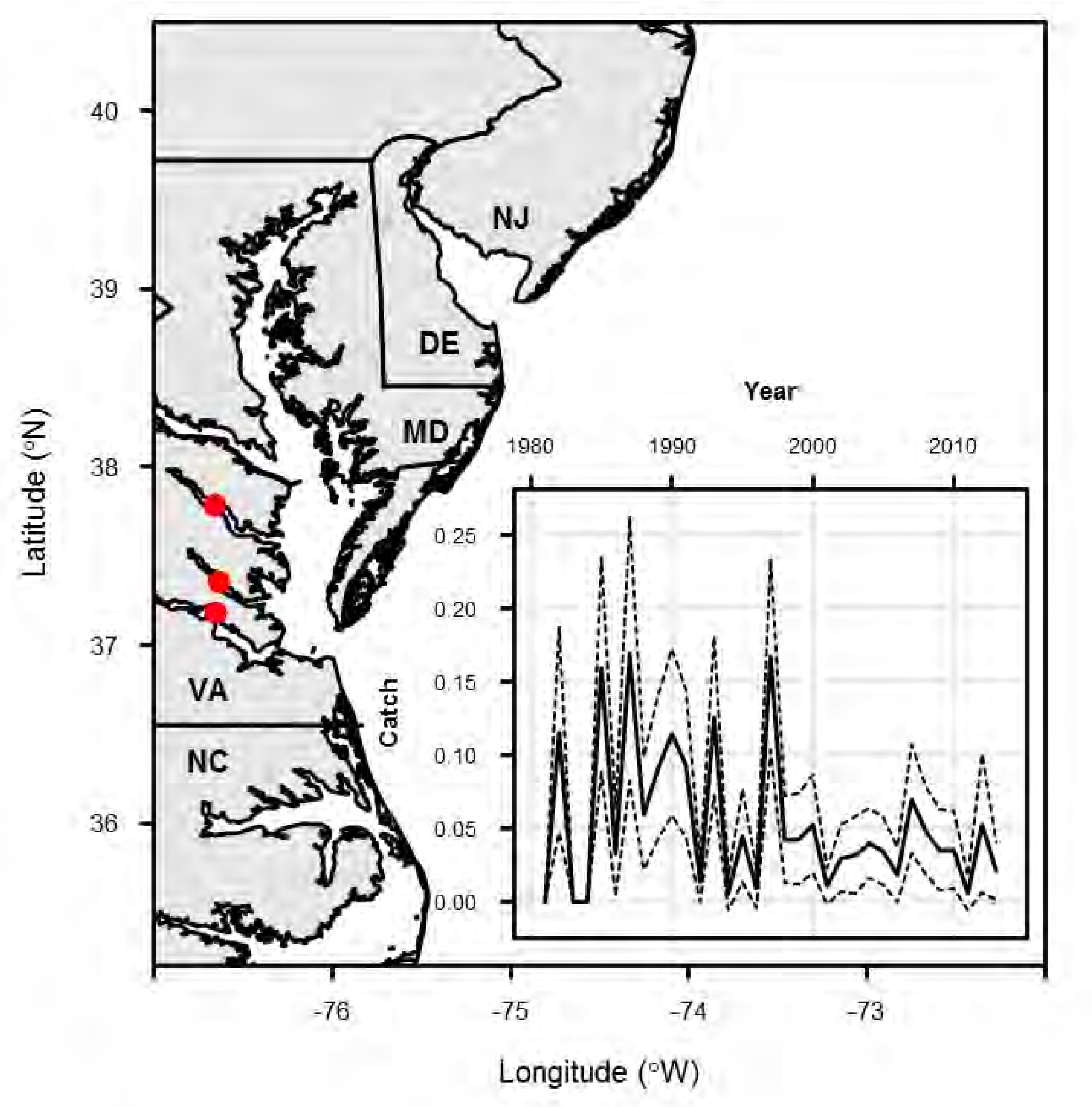


Figure B6.11. Map of the VIMS Juvenile Striped Bass Seine Survey area and resulting index of abundance (inset). Red dot indicates the center point in each of the three river systems surveyed.

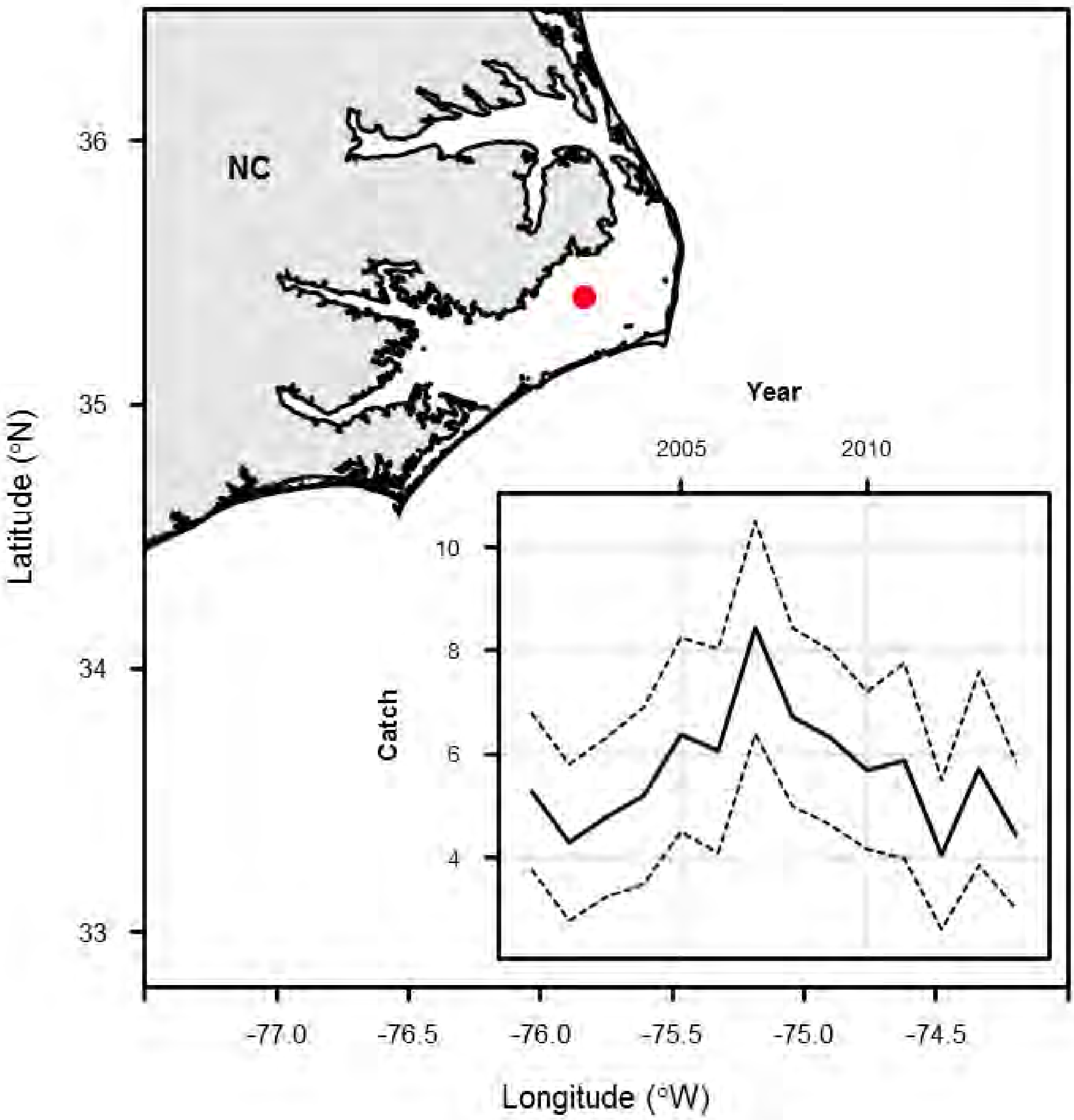


Figure B6.12. Map of the North Carolina Pamlico Sound Independent Gillnet Survey and resultant index of abundance (inset). Red dot indicates center point of survey area.

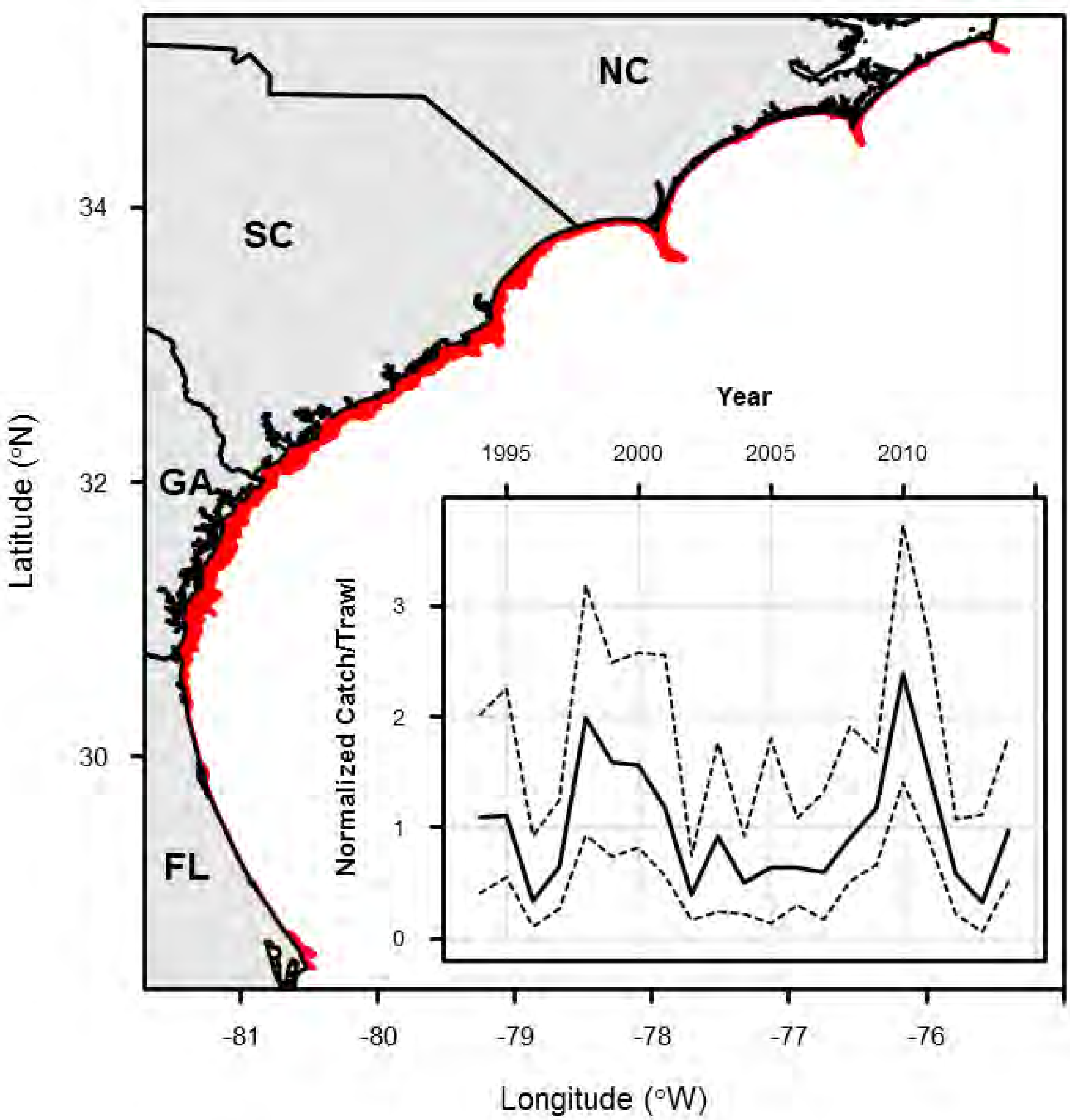


Figure B6.13. Map of the SEAMAP-SA Fall Bottom Trawl survey area and resultant index (inset). Red area represents total survey area.

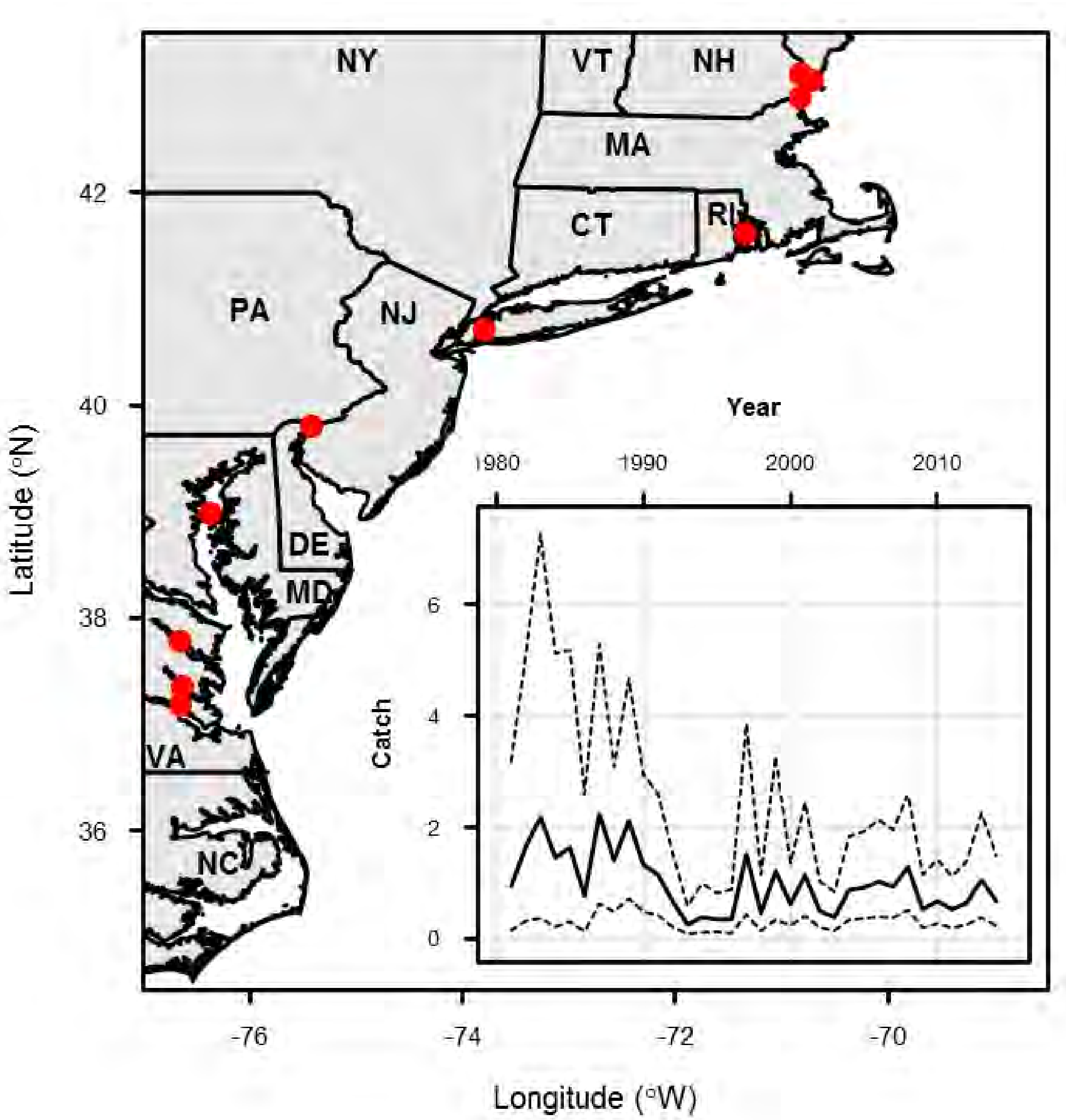


Figure B6.14. Map of all state seine surveys included in the composite young-of-year index with resultant index (inset).

Age 0

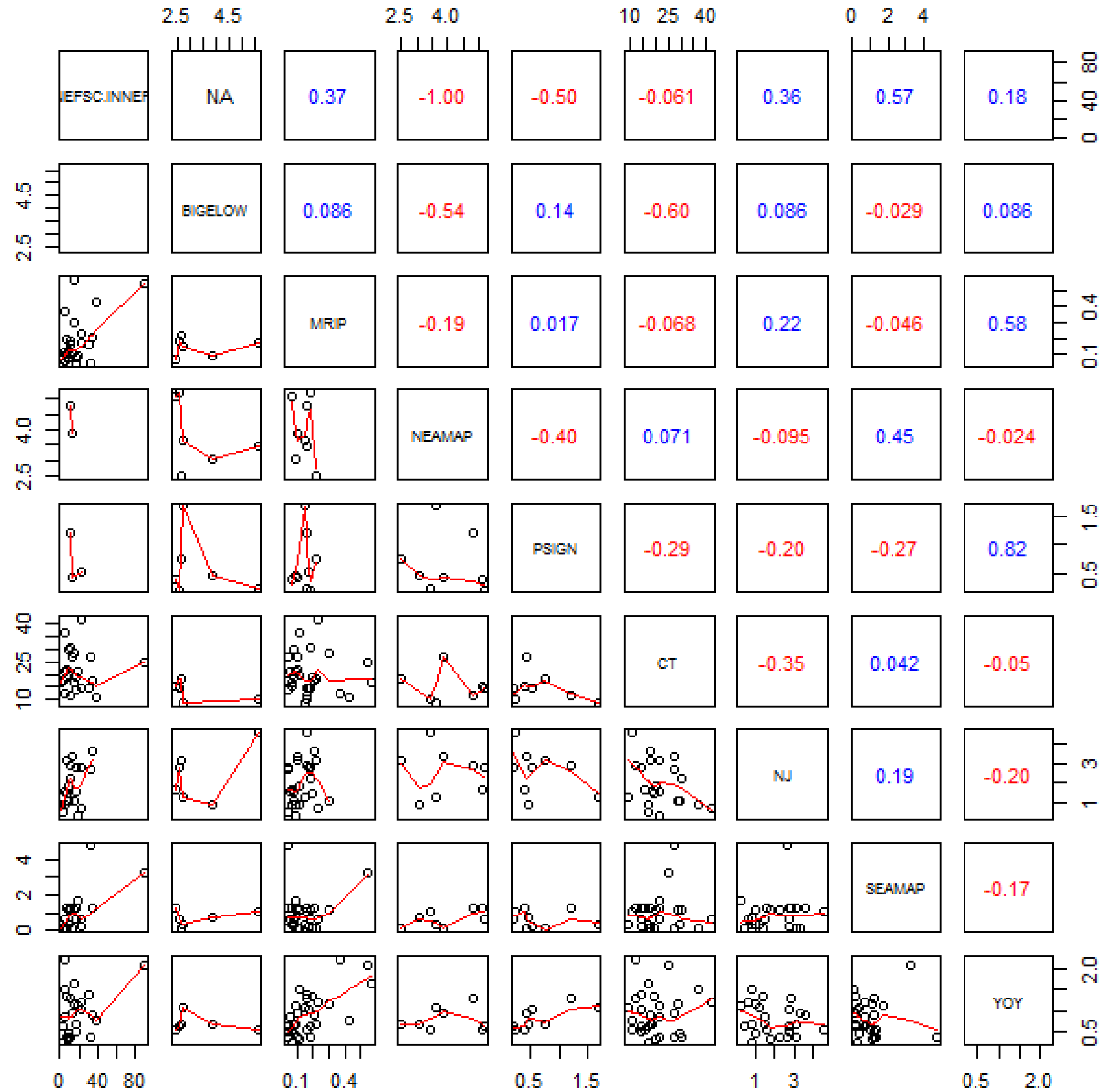


Figure B6.15. Correlation matrices of age specific indices. A locally-weighted polynomial regression smoother (lowess) trend line (red) is added to each pairwise comparison. Spearman correlation coefficients are indicated in the upper half of the matrix (red for negative correlations, blue for positive)

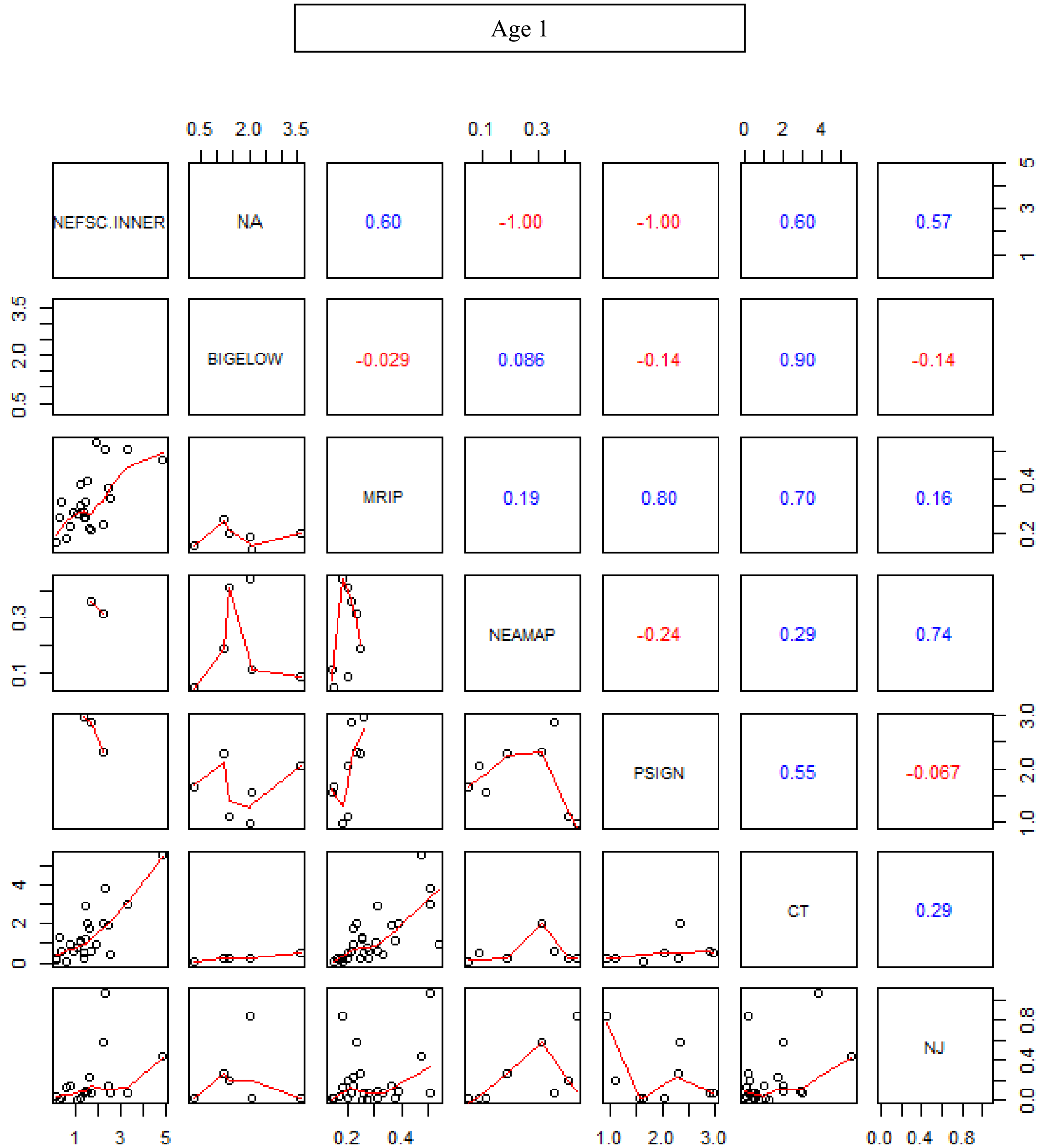


Figure B6.15 (cont.)

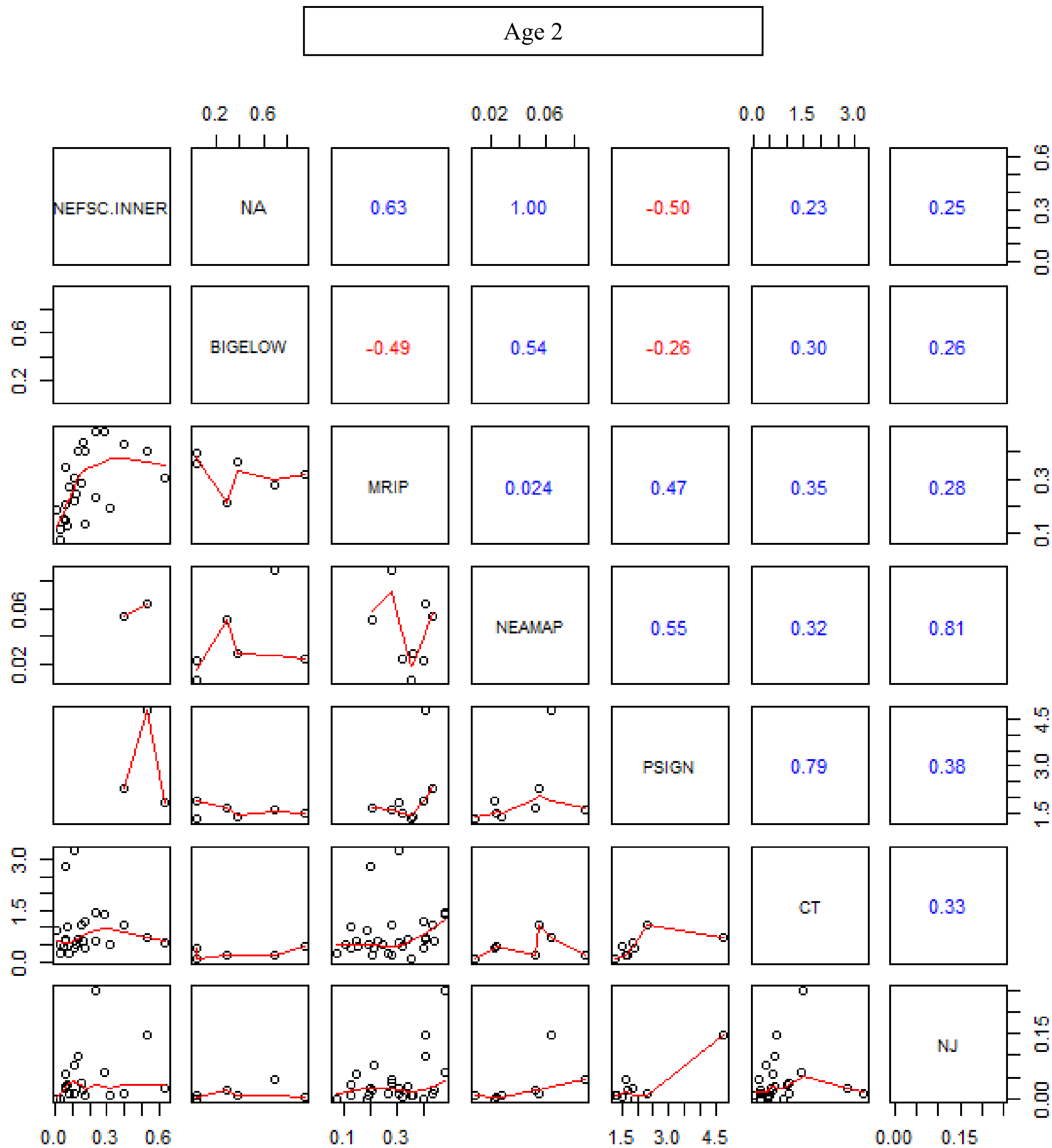


Figure B6.15 (cont.)

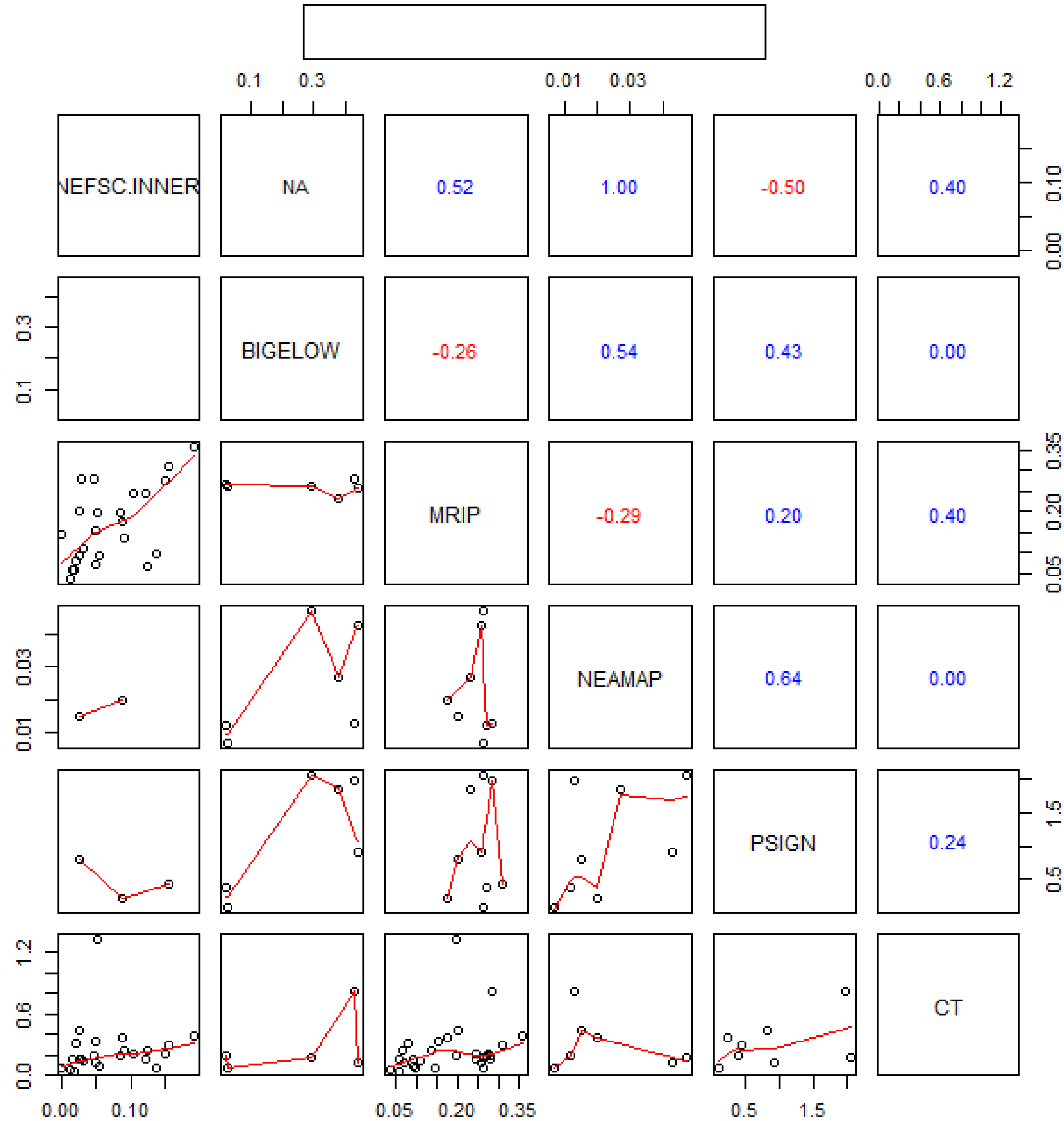


Figure B6.15 (cont.)

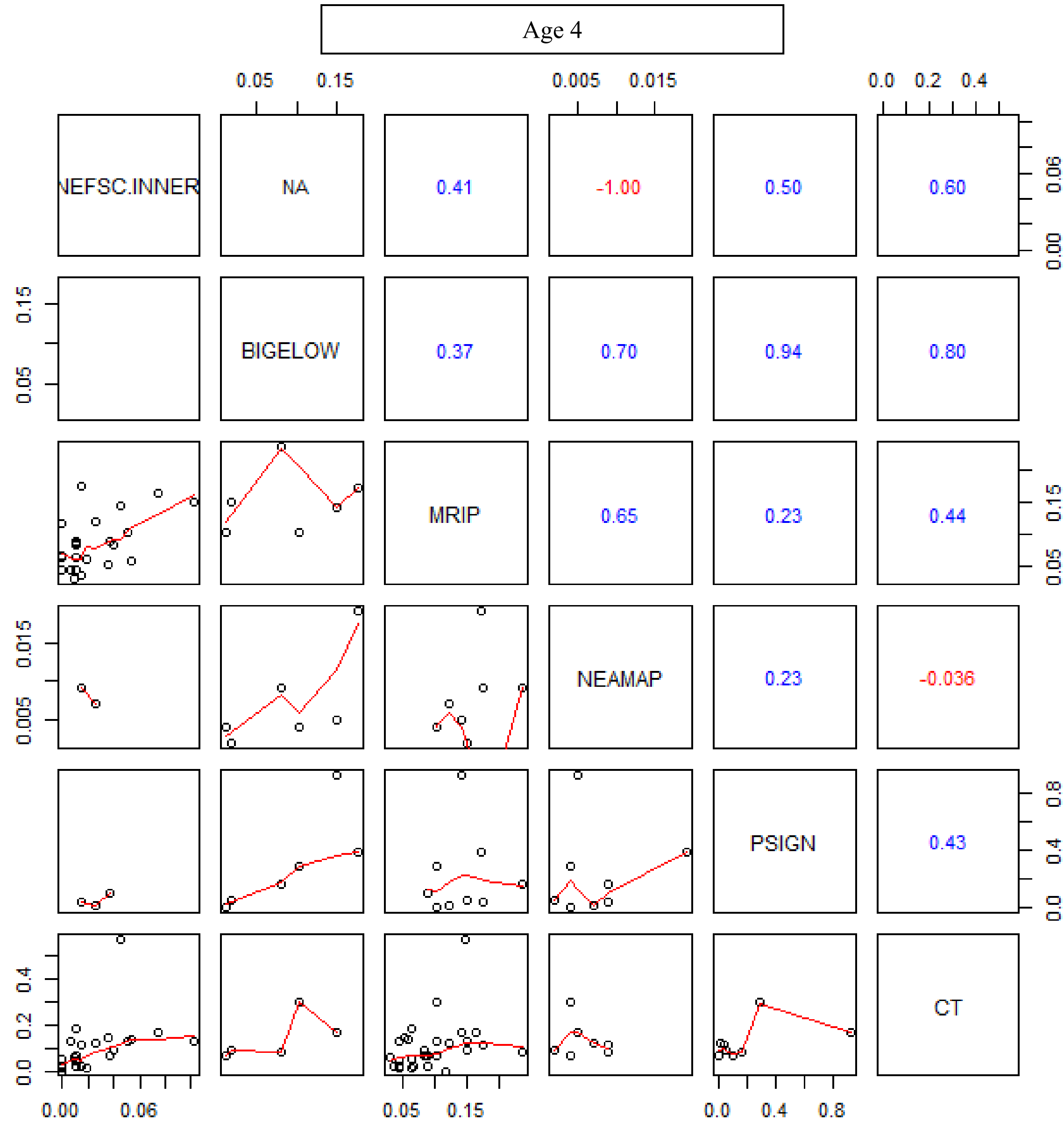


Figure B6.15 (cont.)

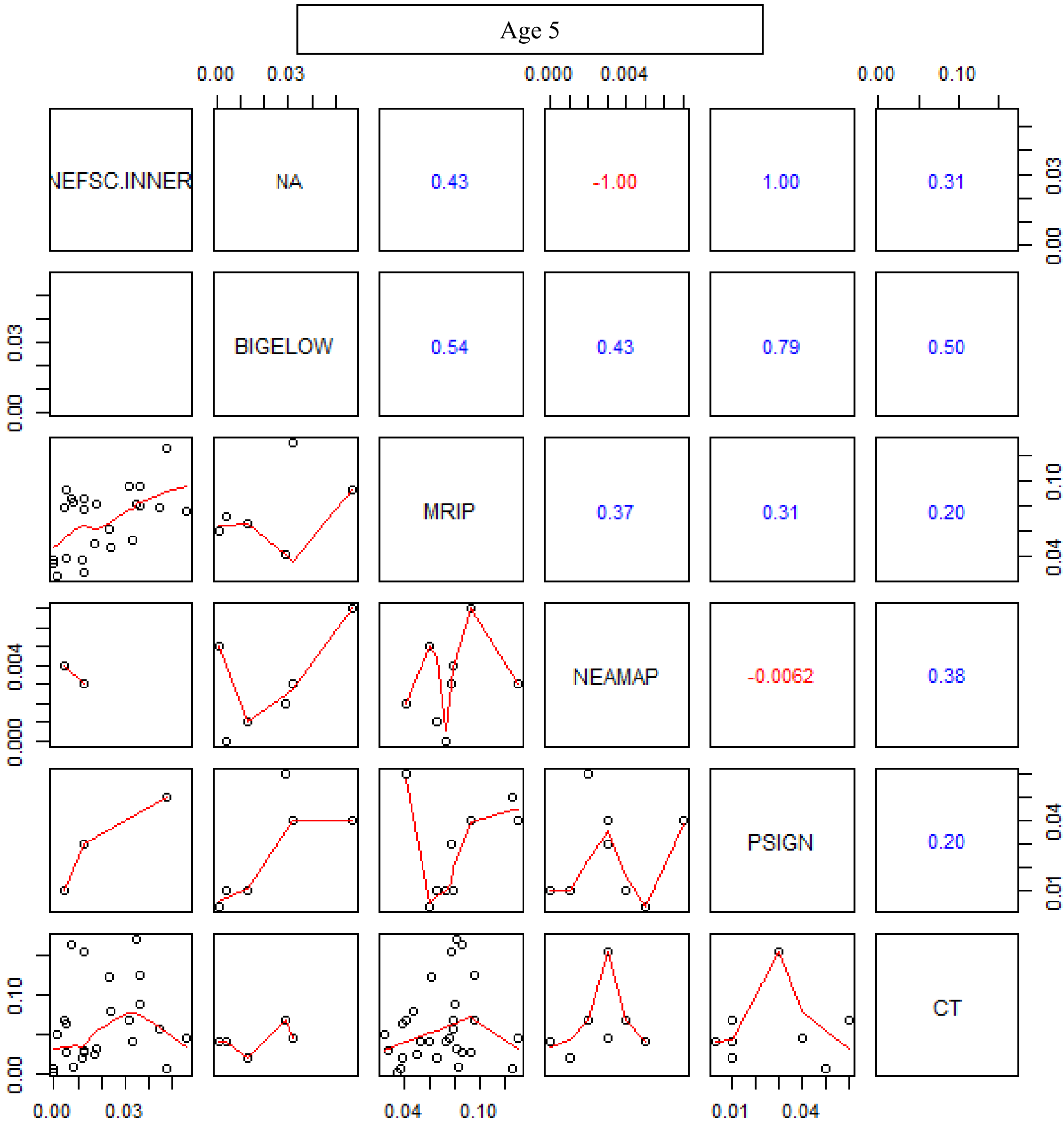


Figure B6.15 (cont.)

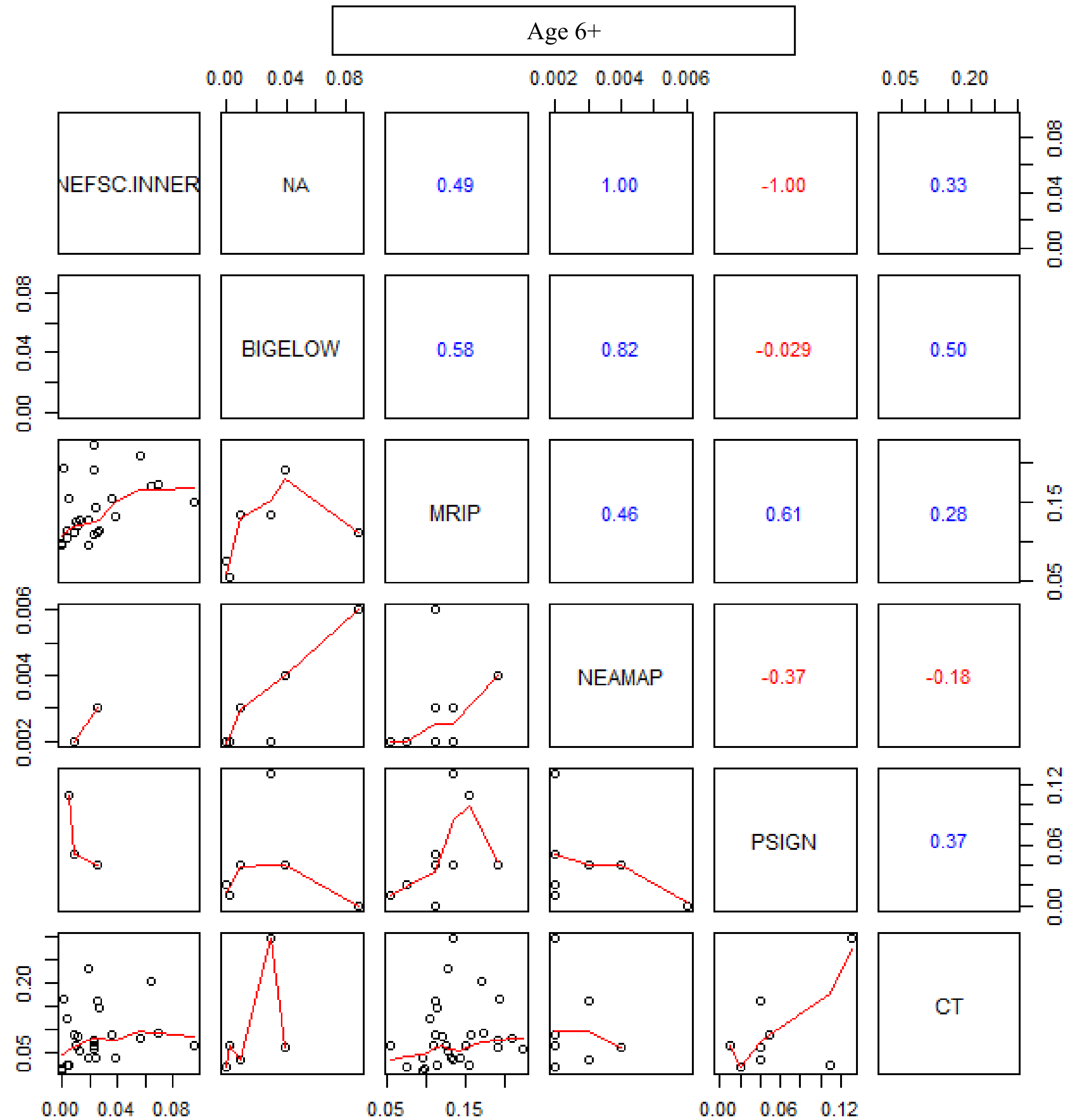


Figure B6.15 (cont.)

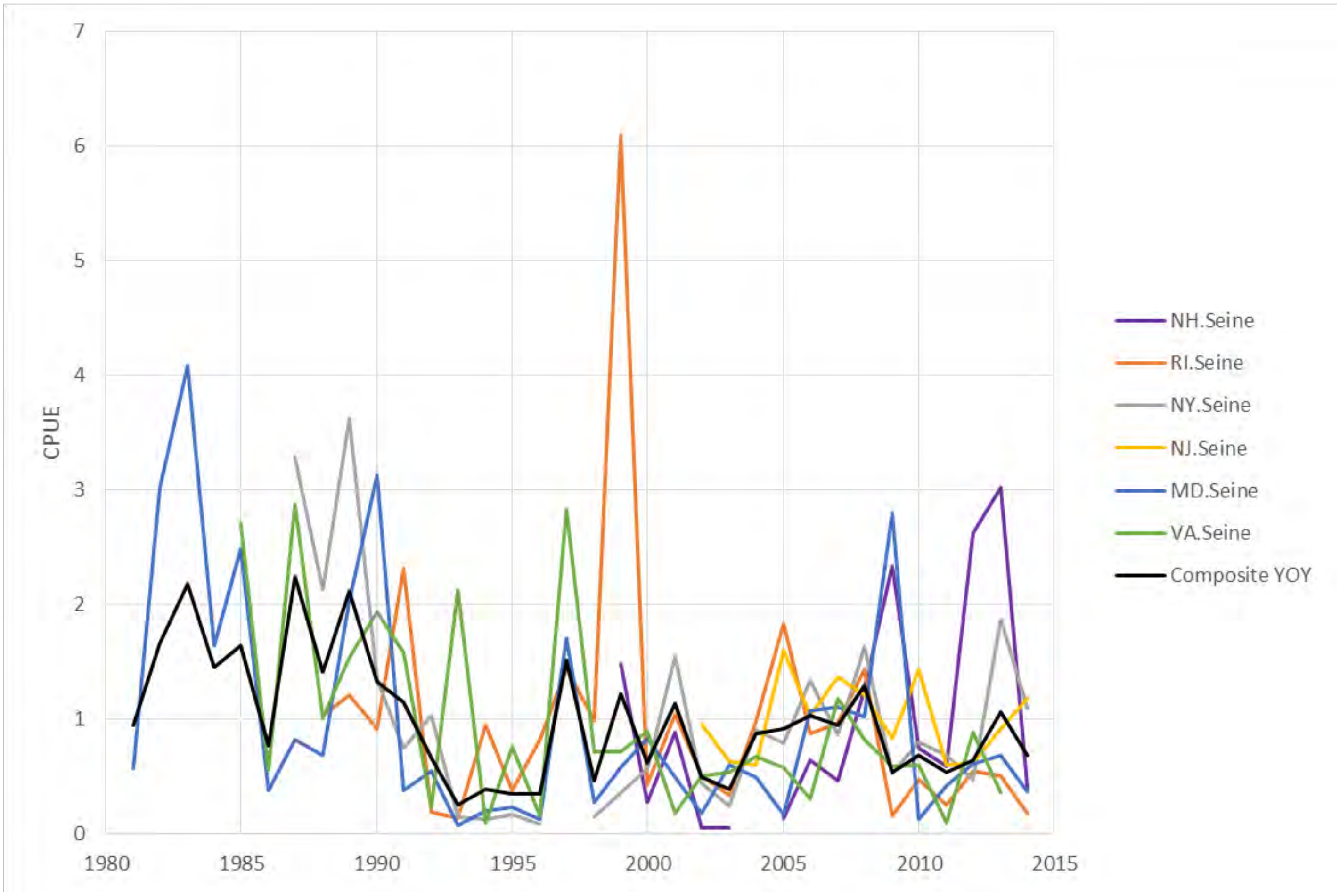


Figure B6.16. Composite young-of-year index plotted with component state indices. All indices are scaled to their mean.

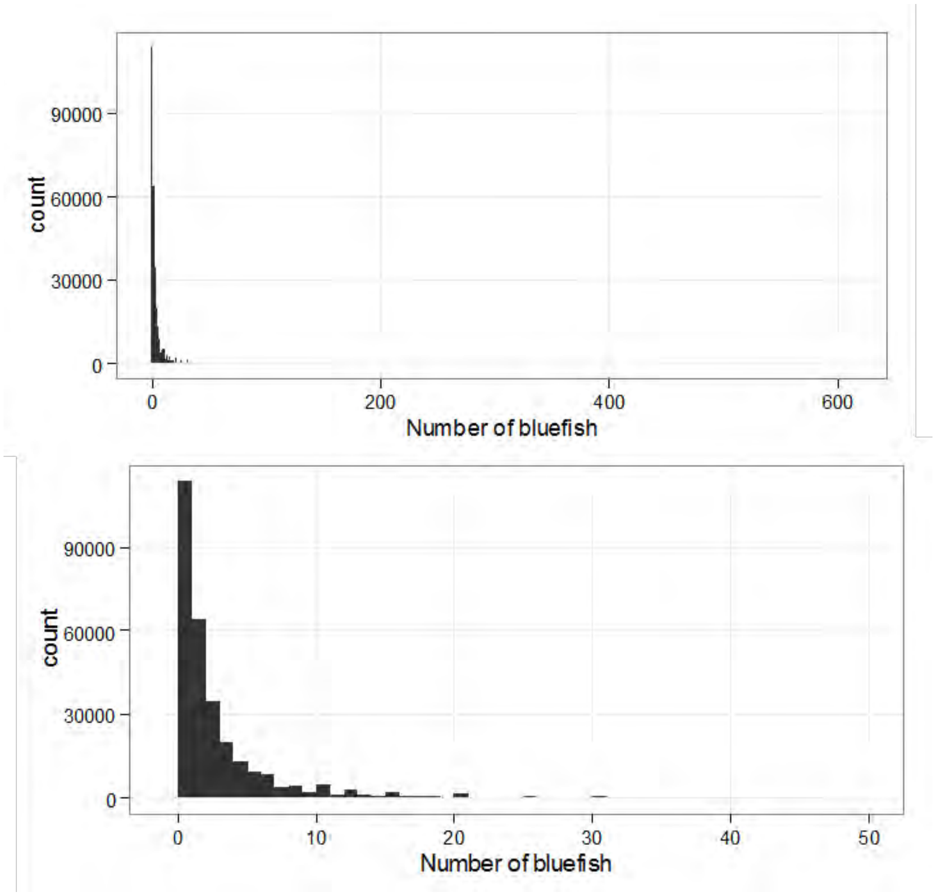


Figure B6.17. Distribution of observed catch-per-trip of bluefish. Lower figure has been truncated to trips with less than 50 bluefish per trip to improve readability.

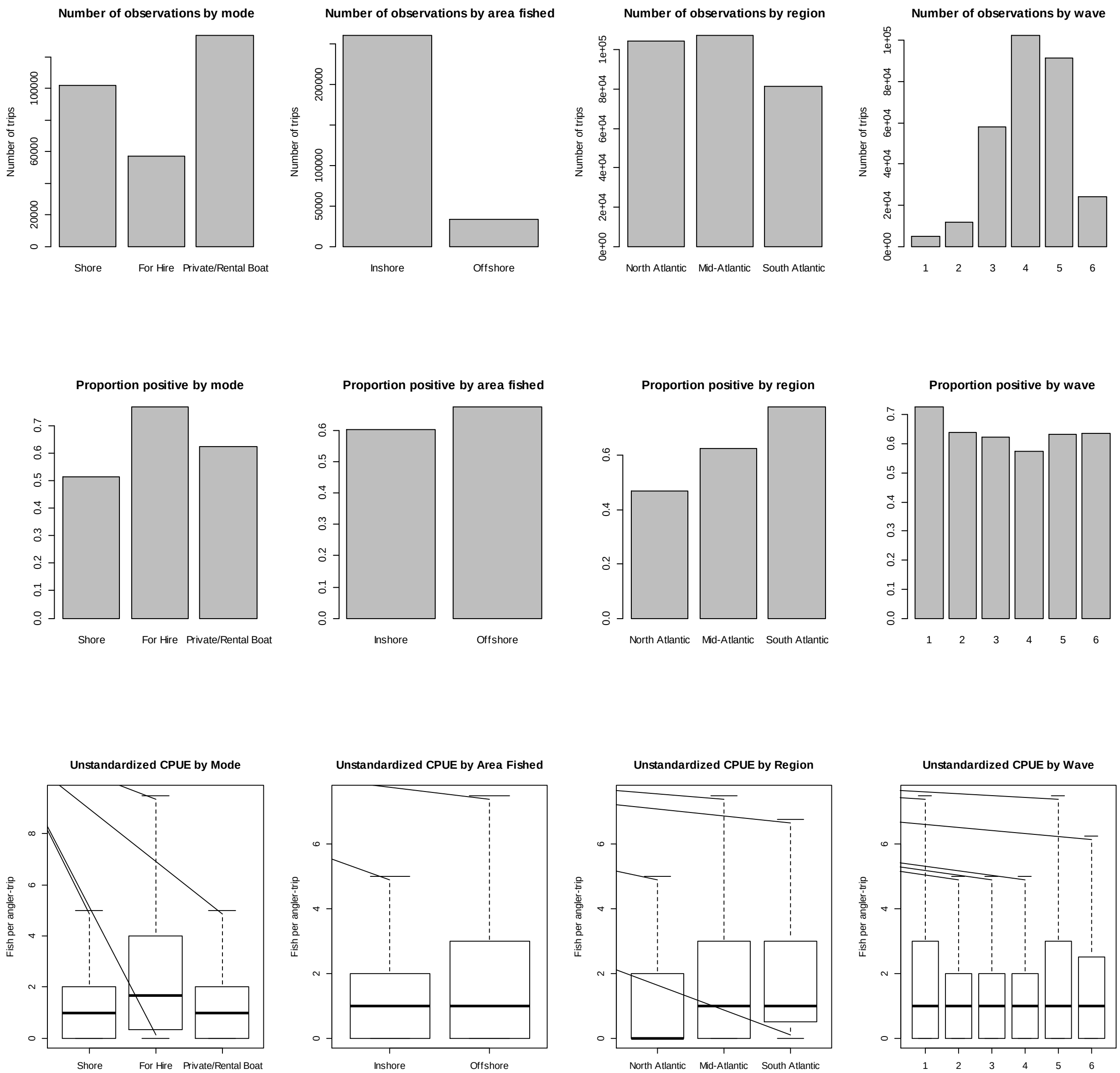


Figure B6.18. Number of observations (top), proportion positive trips (middle), and unstandardized CPUE (bottom) by factor for MRIP intercept data.

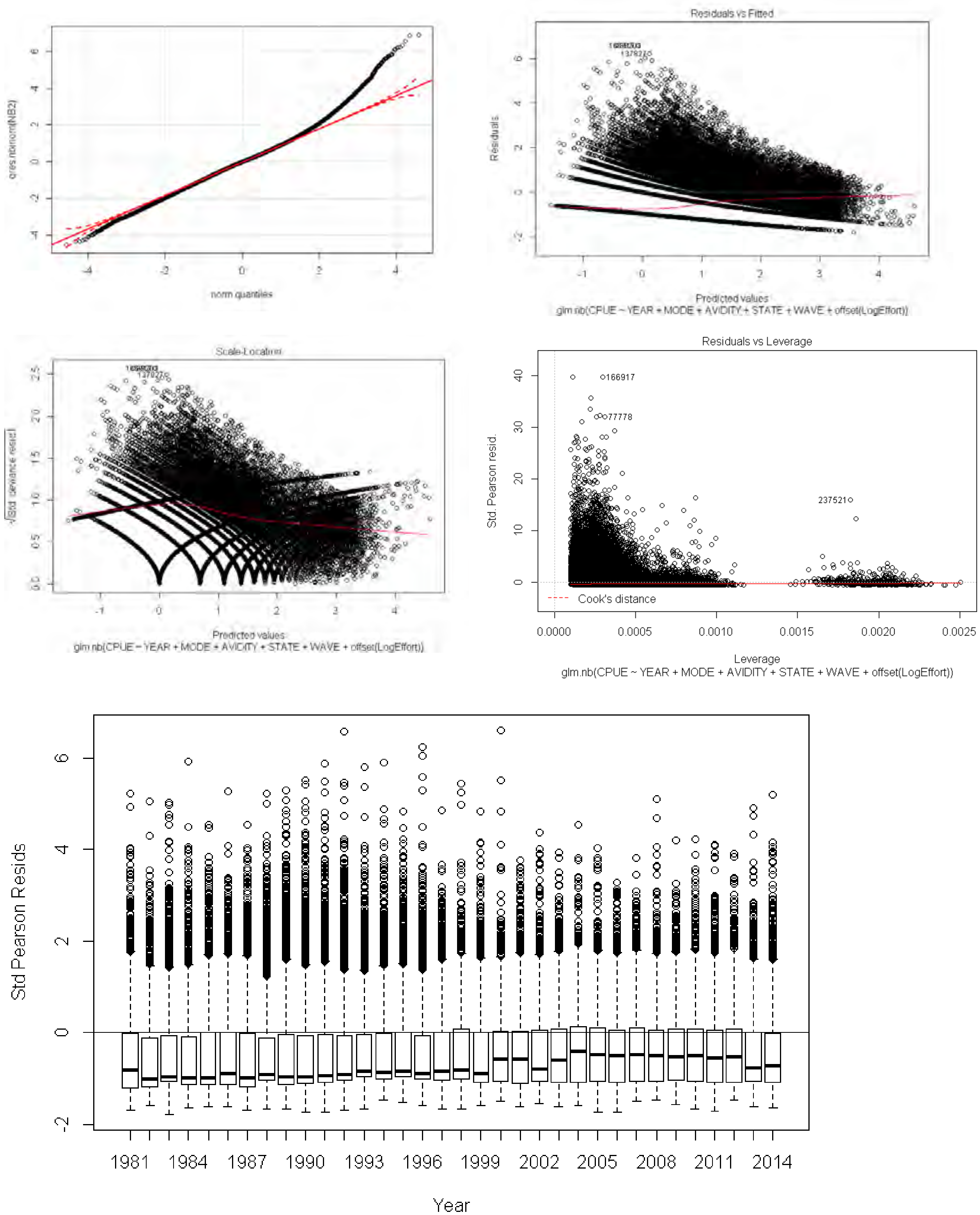


Figure B6.19.Diagnostic plots for GLM standardization of MRIP CPUE.

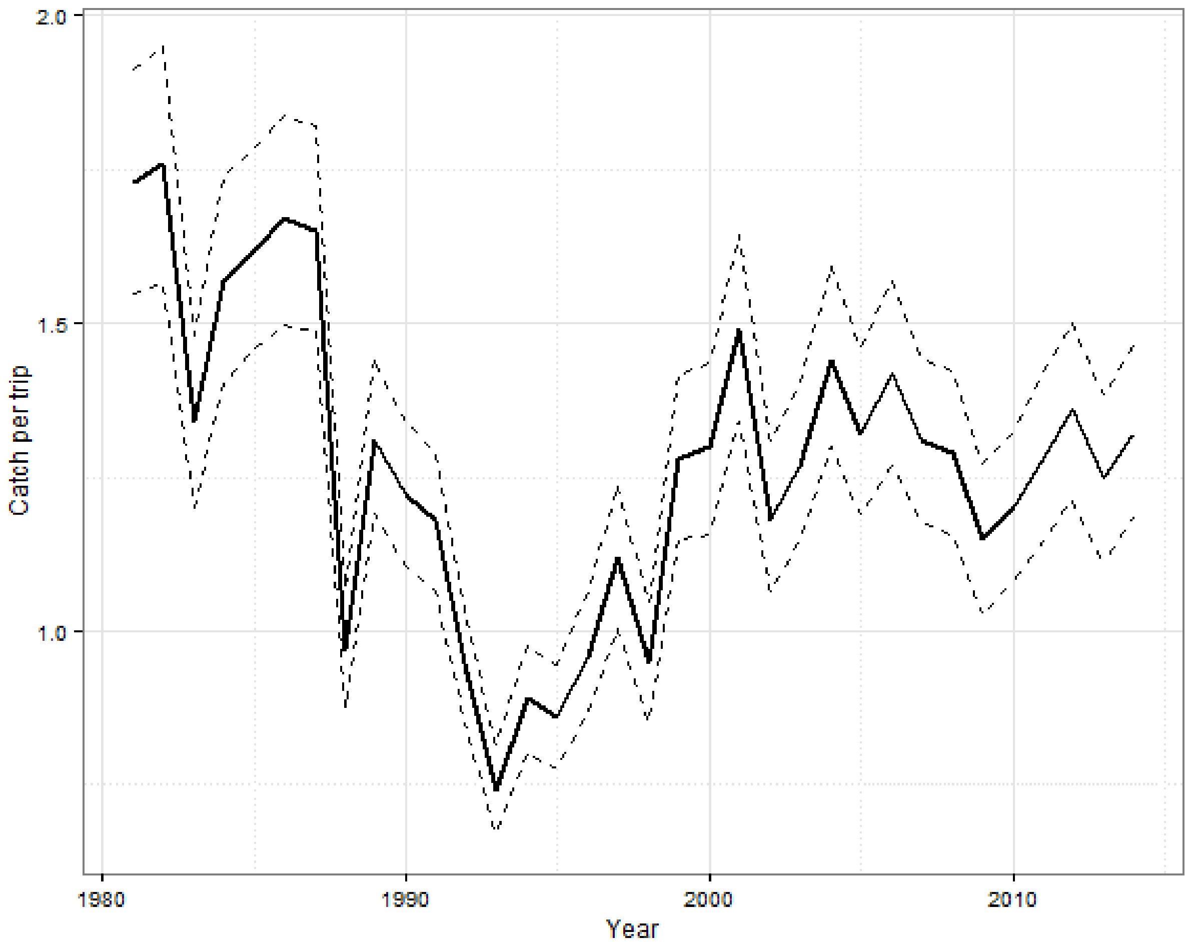


Figure B6.20.Standardized MRIP CPUE with 95% confidence intervals.

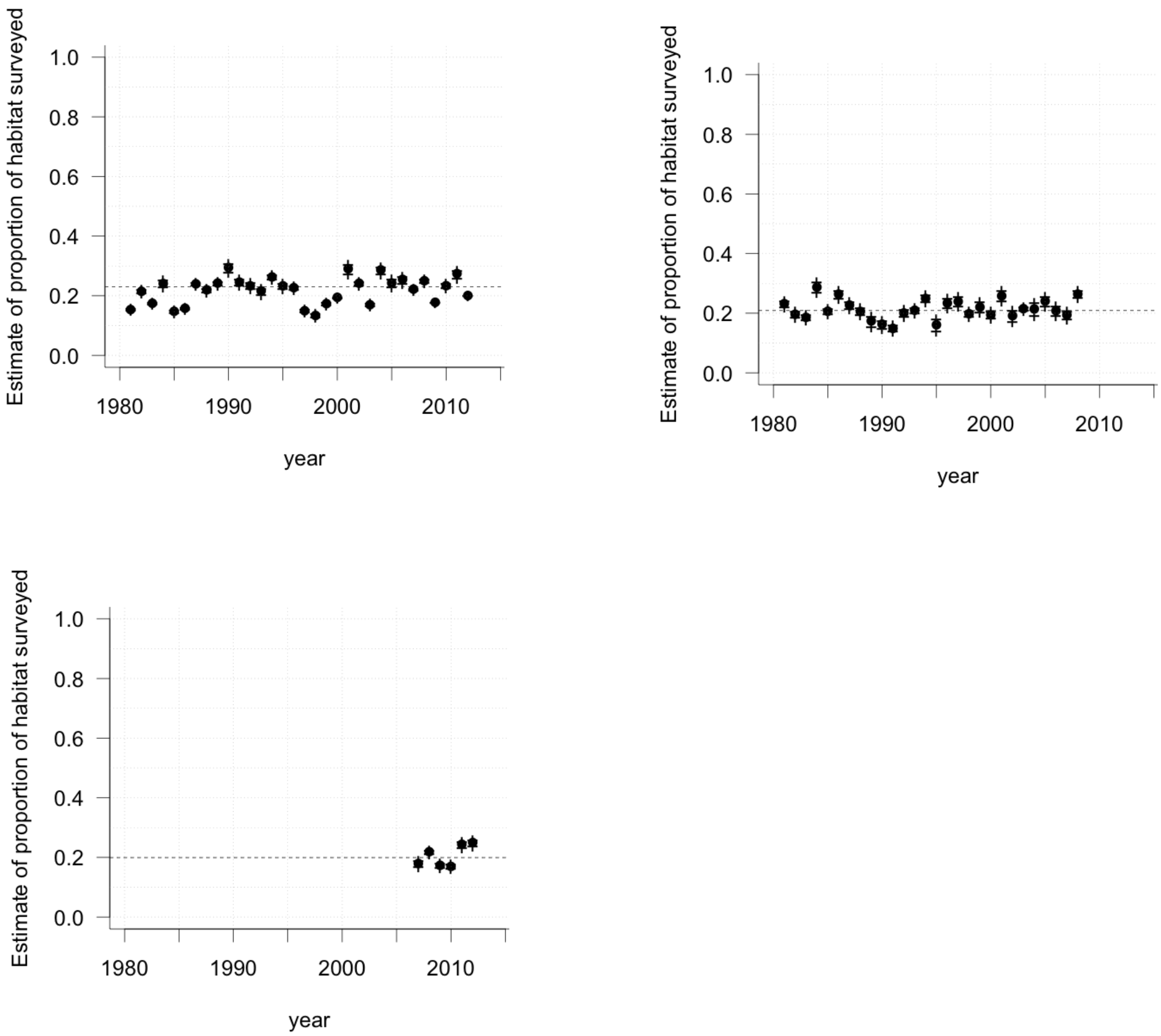


Figure B6.21 Estimates of the proportion of thermal habitat suitability surveyed for bluefish estimated using the niche model coupled to the debiased bottom temperature hindcast for NEFSC “offshore” inshore strata (top left), NEFSC “inshore” inshore strata and NEAMAP survey strata during the fall.

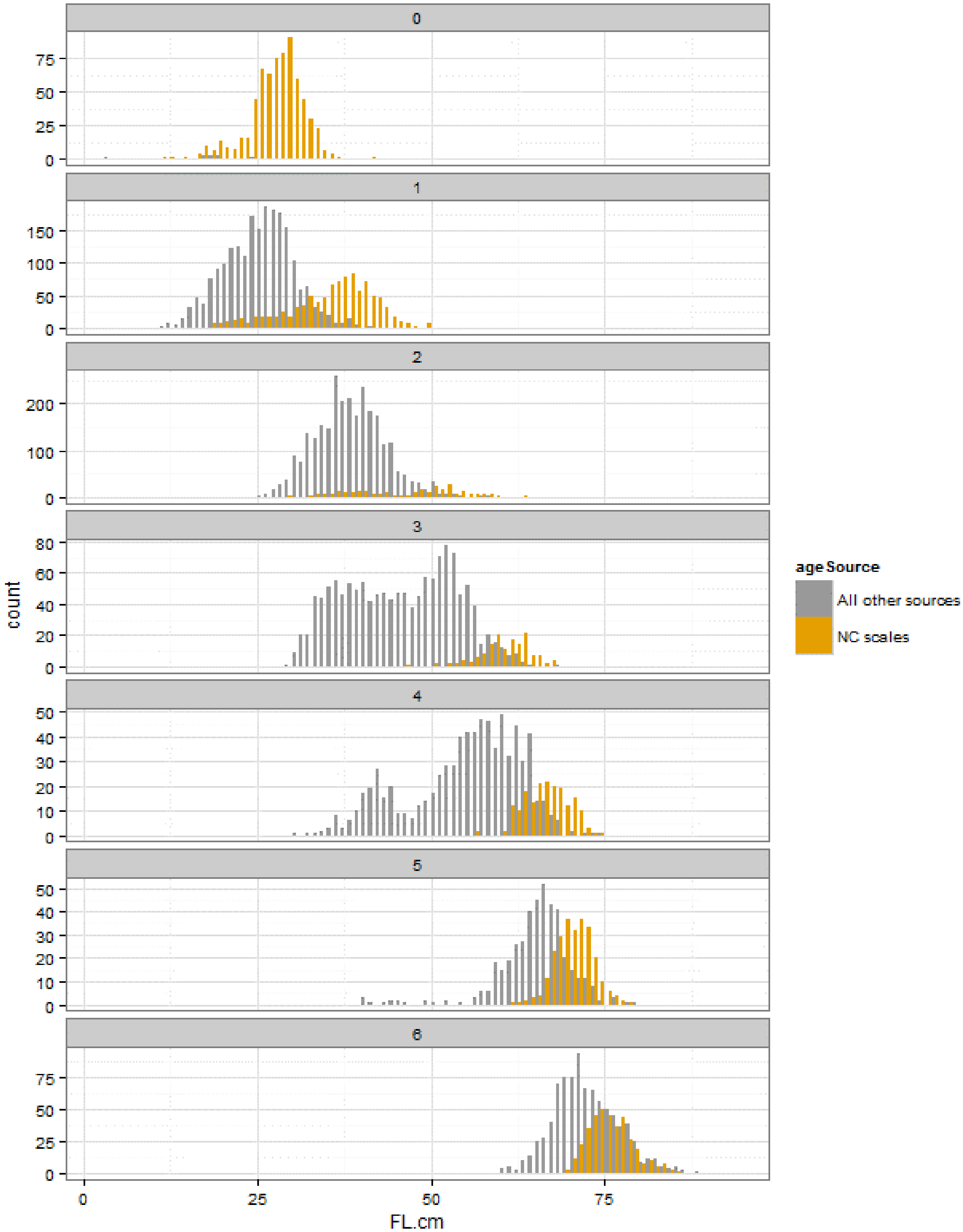


Figure B6.22. Length frequency of spring age data by age and source.

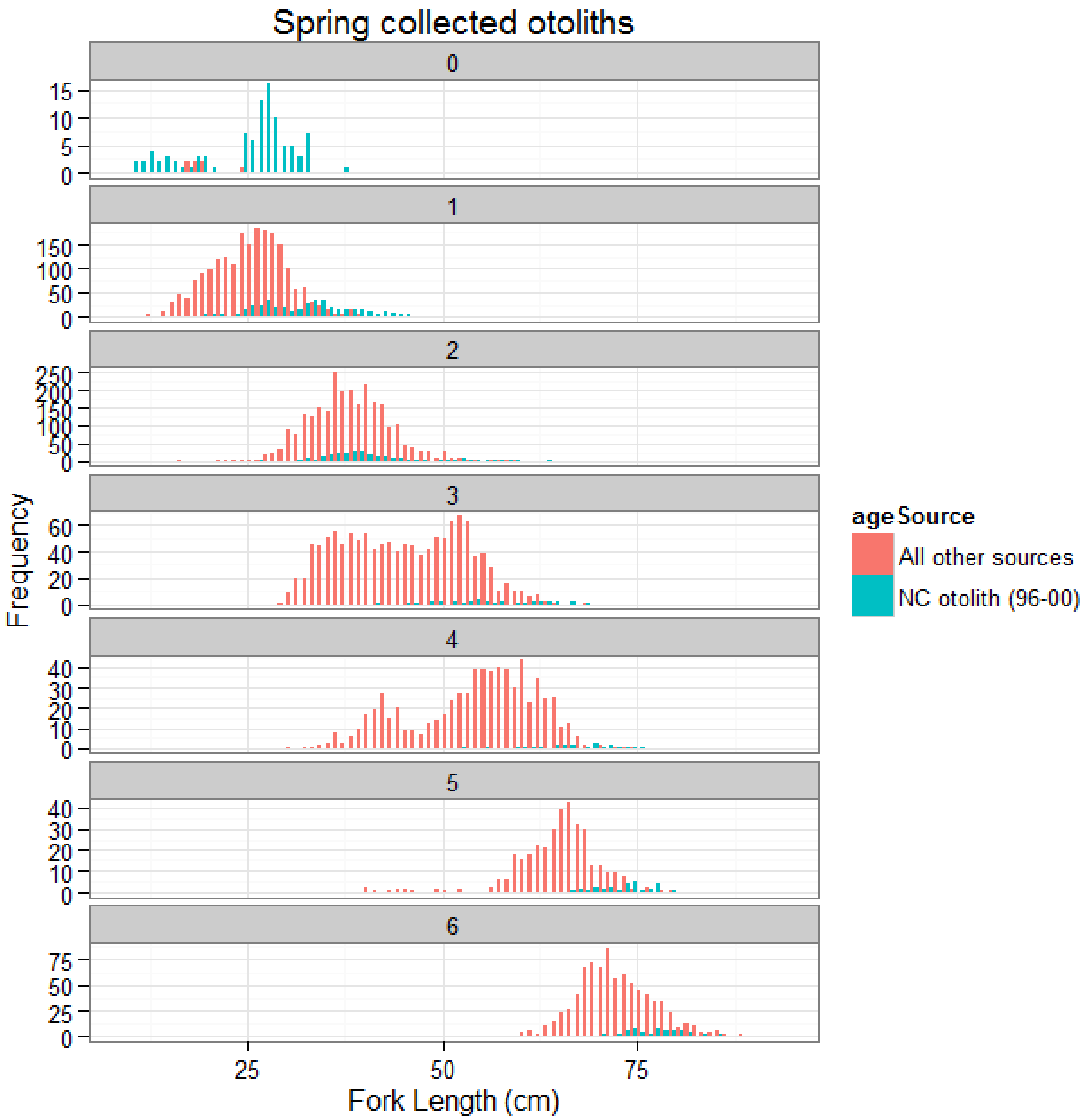


Figure B6.23. Length frequency of spring collected otolith data by age and source.

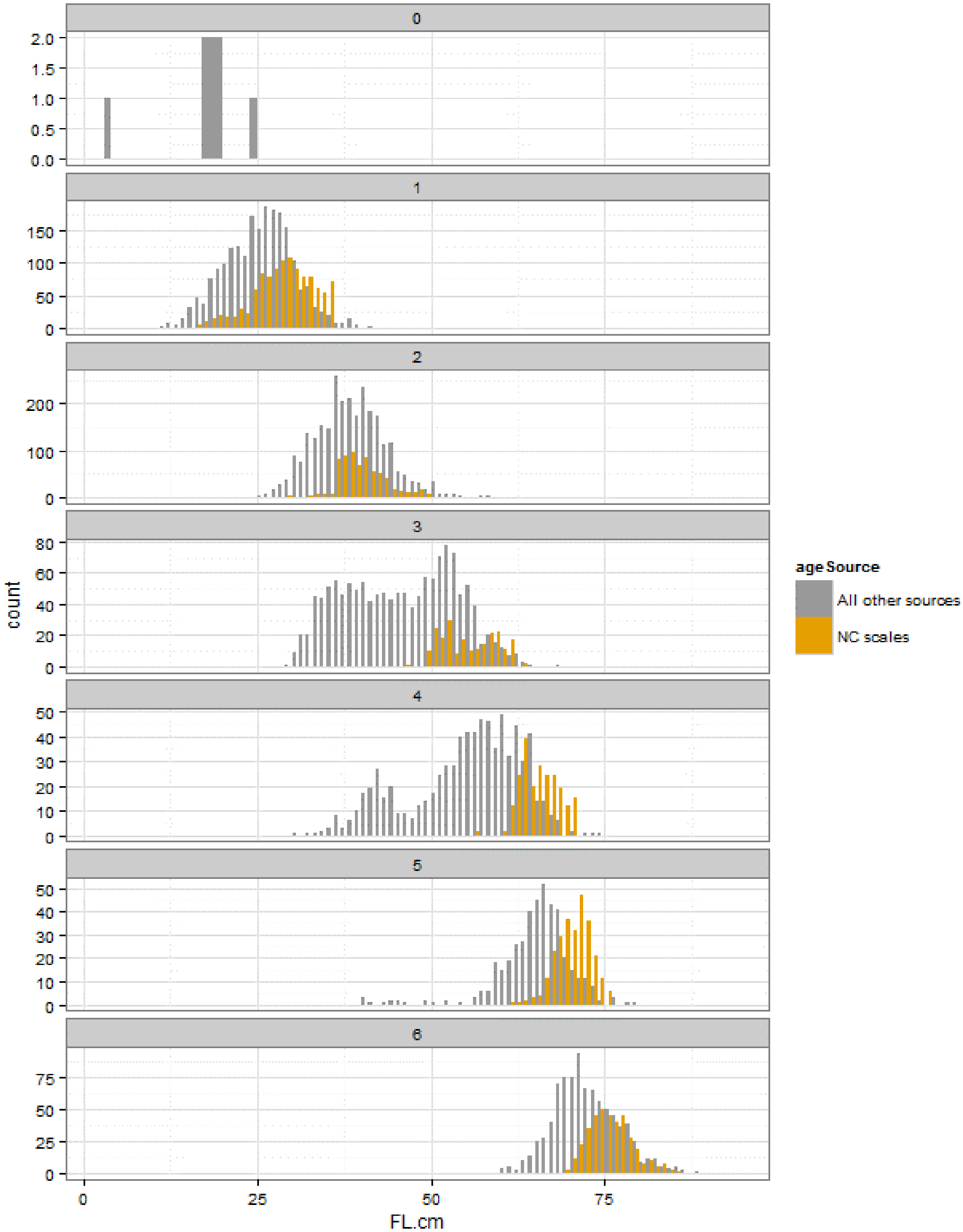


Figure B6.24. Length frequency of spring collected fish by age and source, with NC scales corrected for the birthday issue.

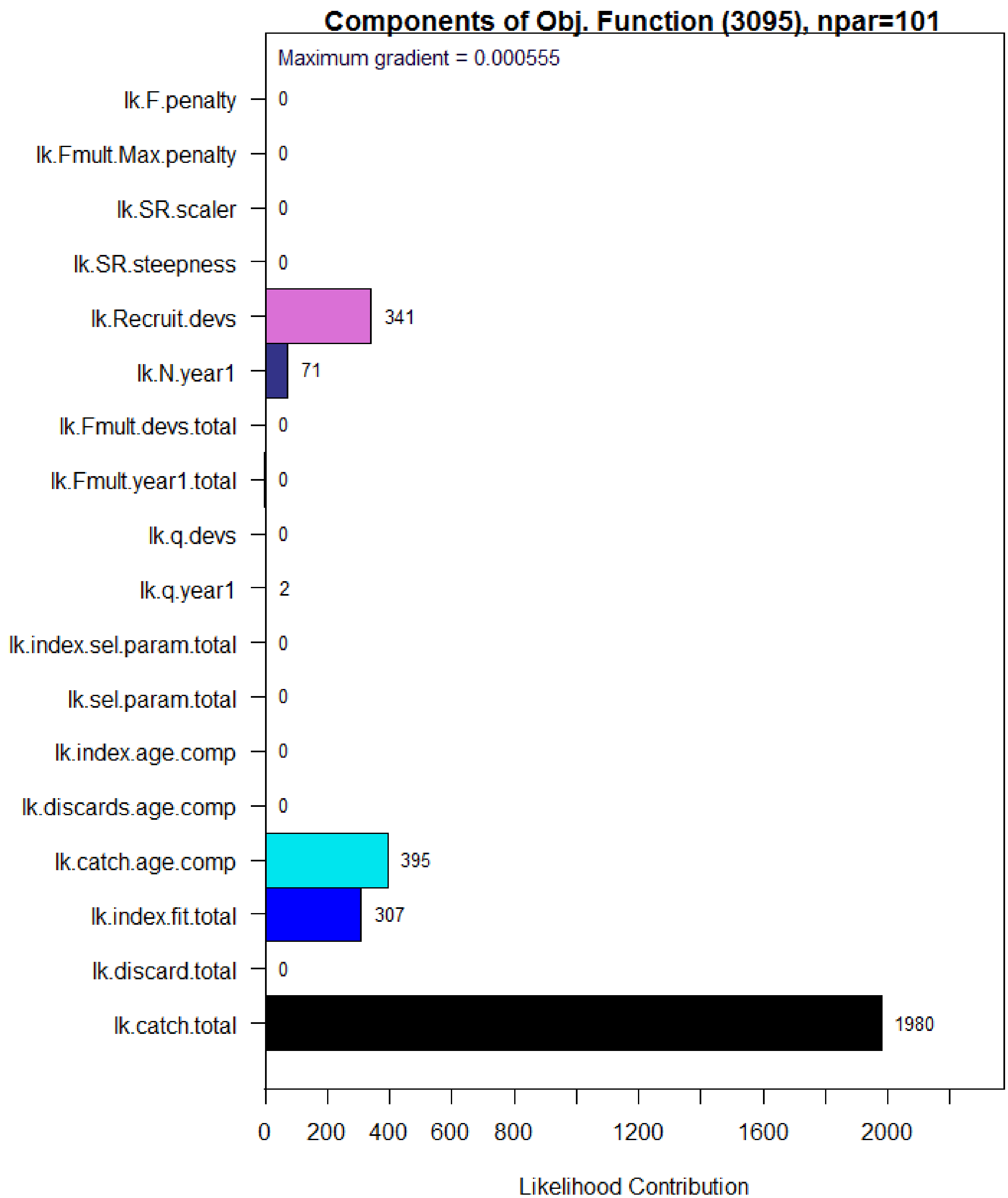


Figure B7.1. Likelihood components from the bluefish continuity model run (B001) showing the relative contribution of each component to the objective function.

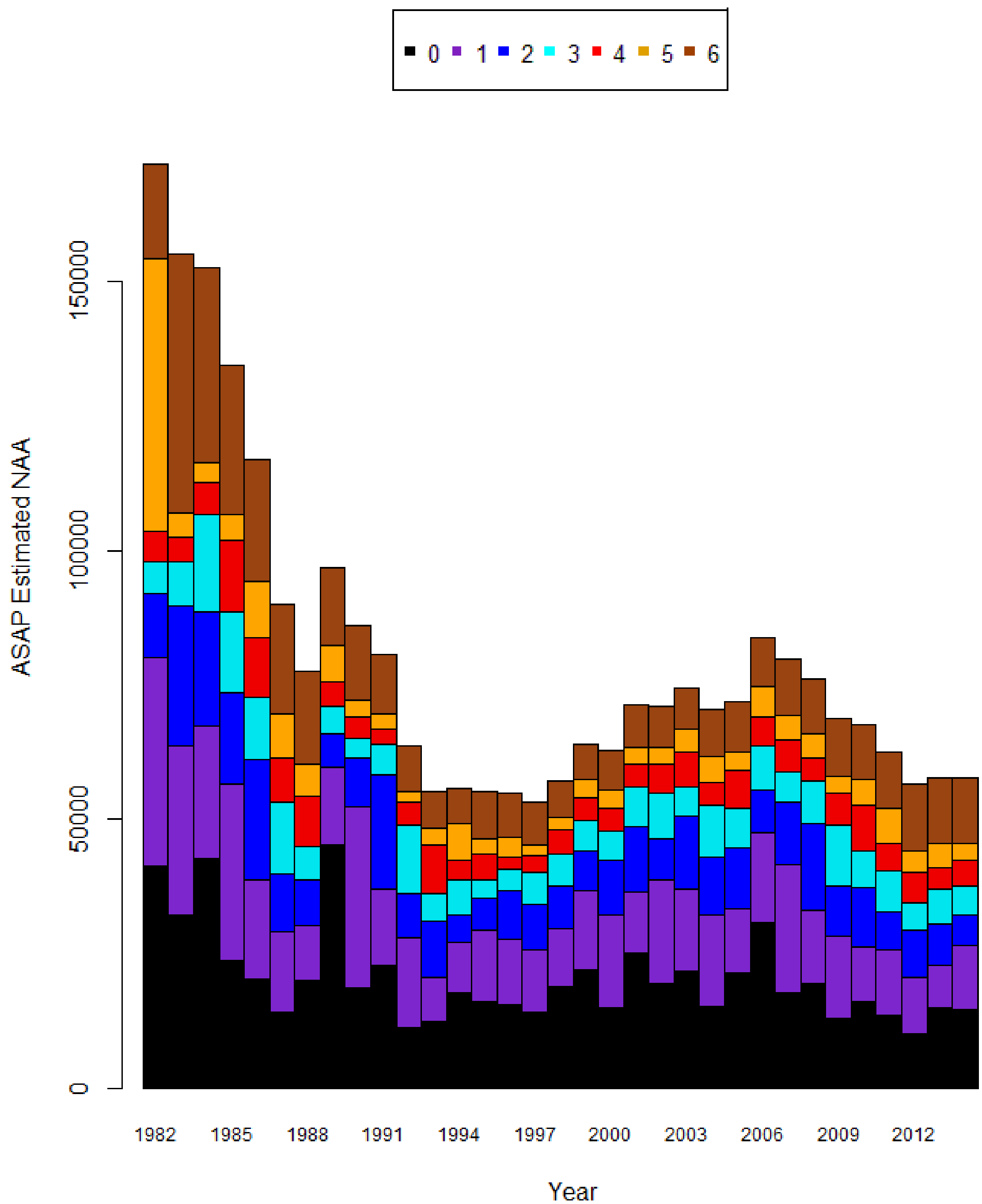


Figure B7.2. Bluefish numbers at age from 1982-2014 estimated from the continuity model run (B001).

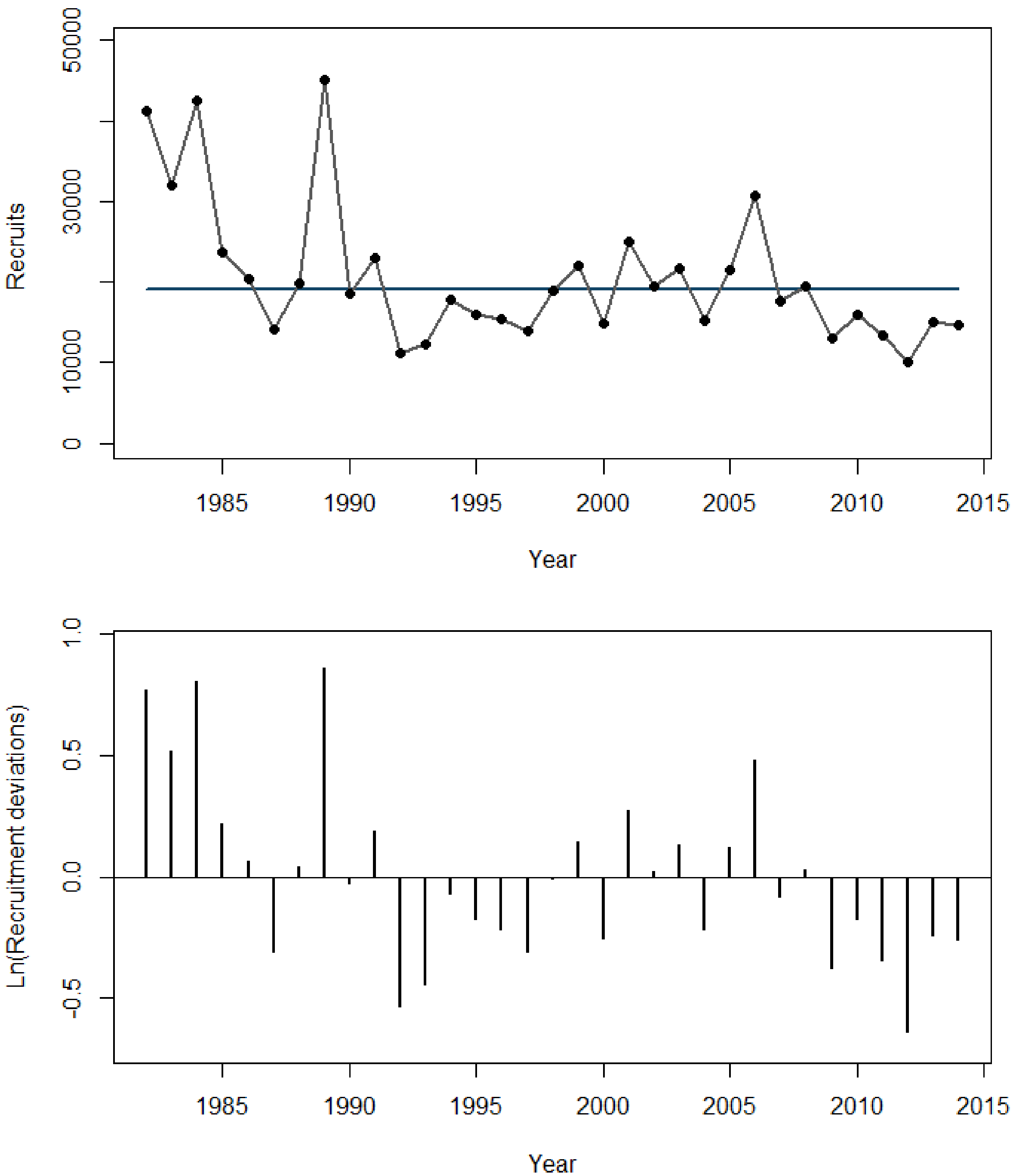


Figure B7.3. Bluefish recruitment, average recruitment over the time series (horizontal line), and recruitment deviations from the continuity model run (B001).

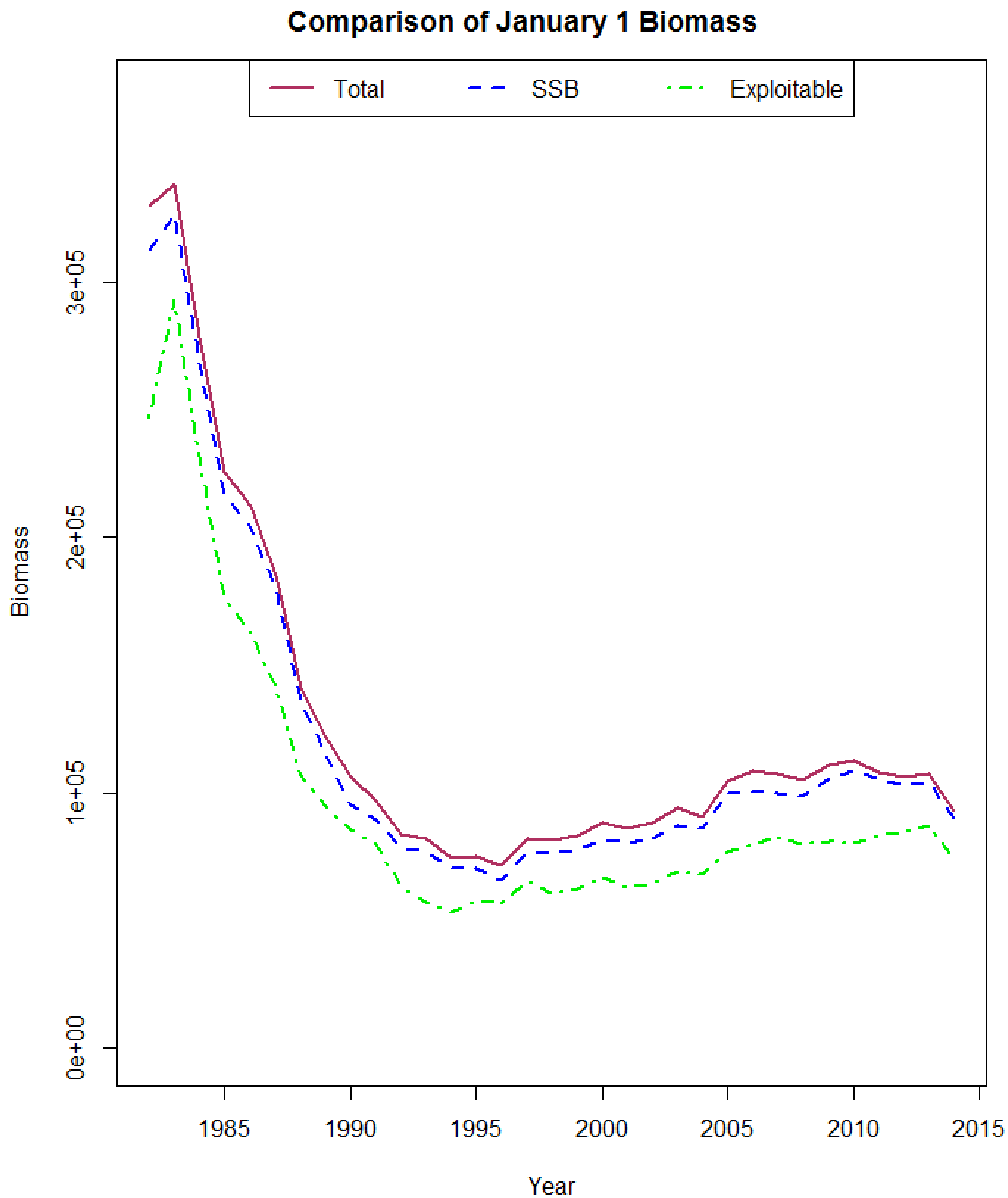


Figure B7.4. A comparison of bluefish total biomass (Jan-1), spawning stock biomass, and exploitable biomass estimated from the continuity model run (B001).

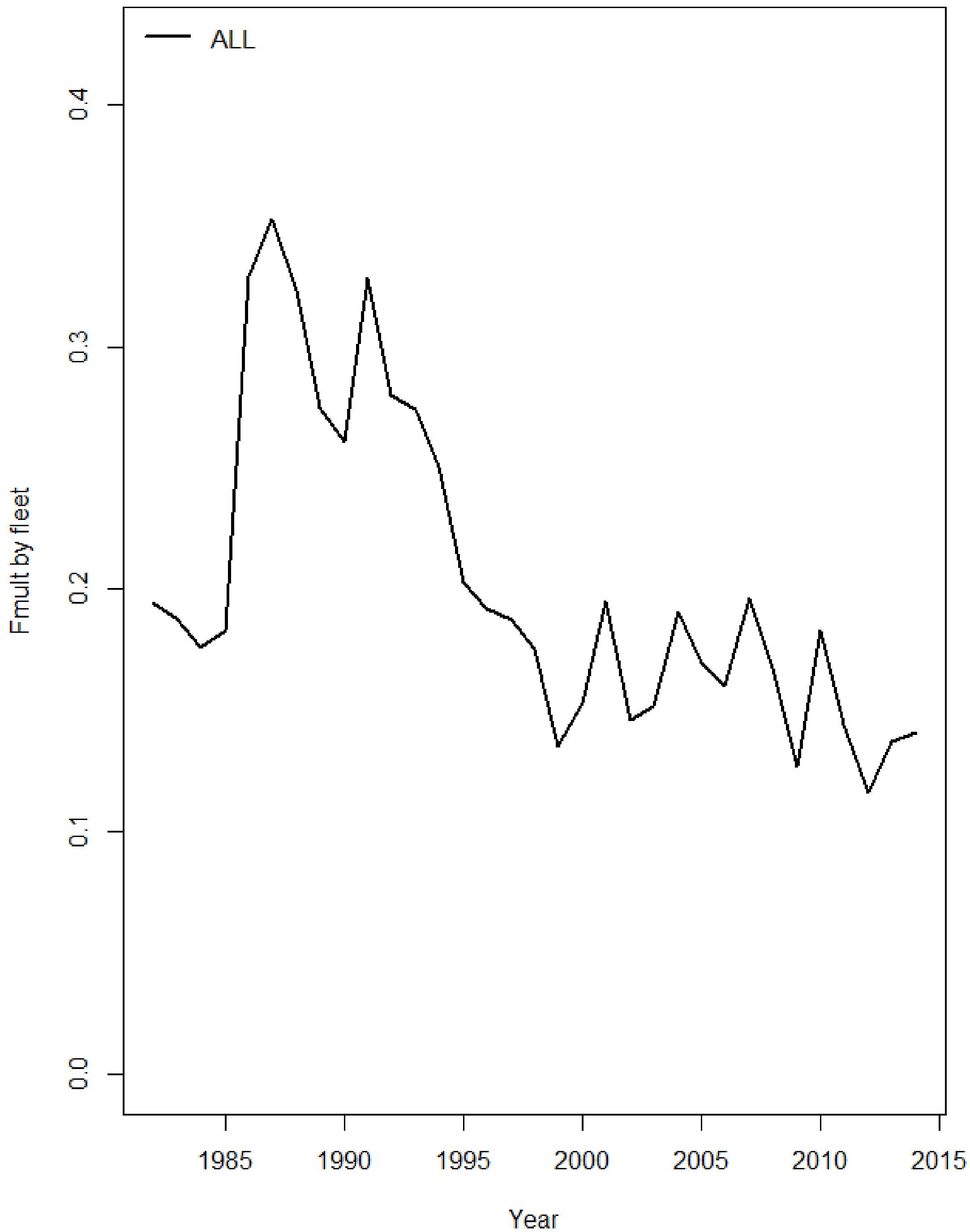


Figure B7.5. Estimates of fishing mortality for bluefish from 1982 to 2014 from model B001, the continuity run.

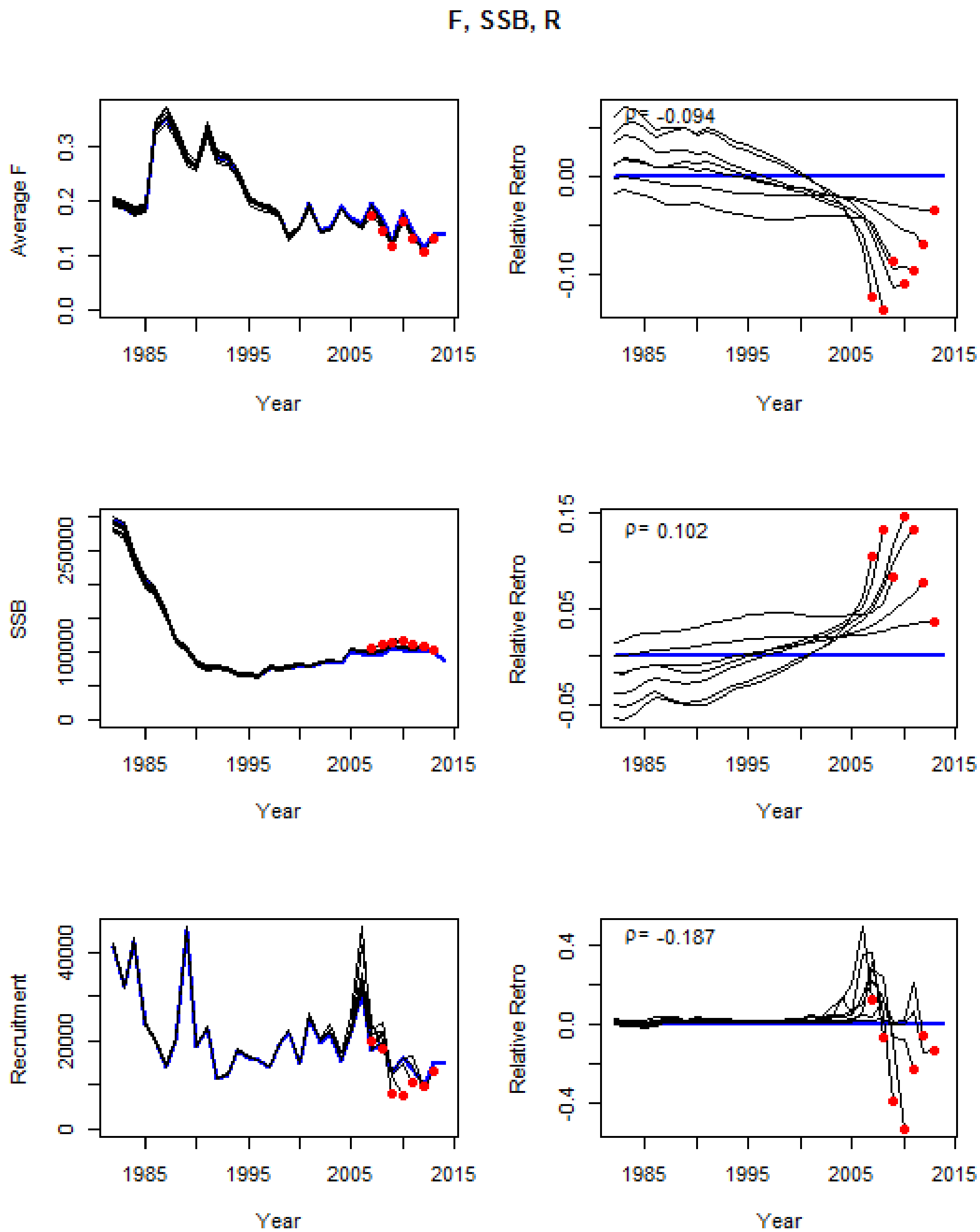


Figure B7.6. Retrospective bias for F, SSB, and Recruitment estimated from the bluefish model continuity run (B001).

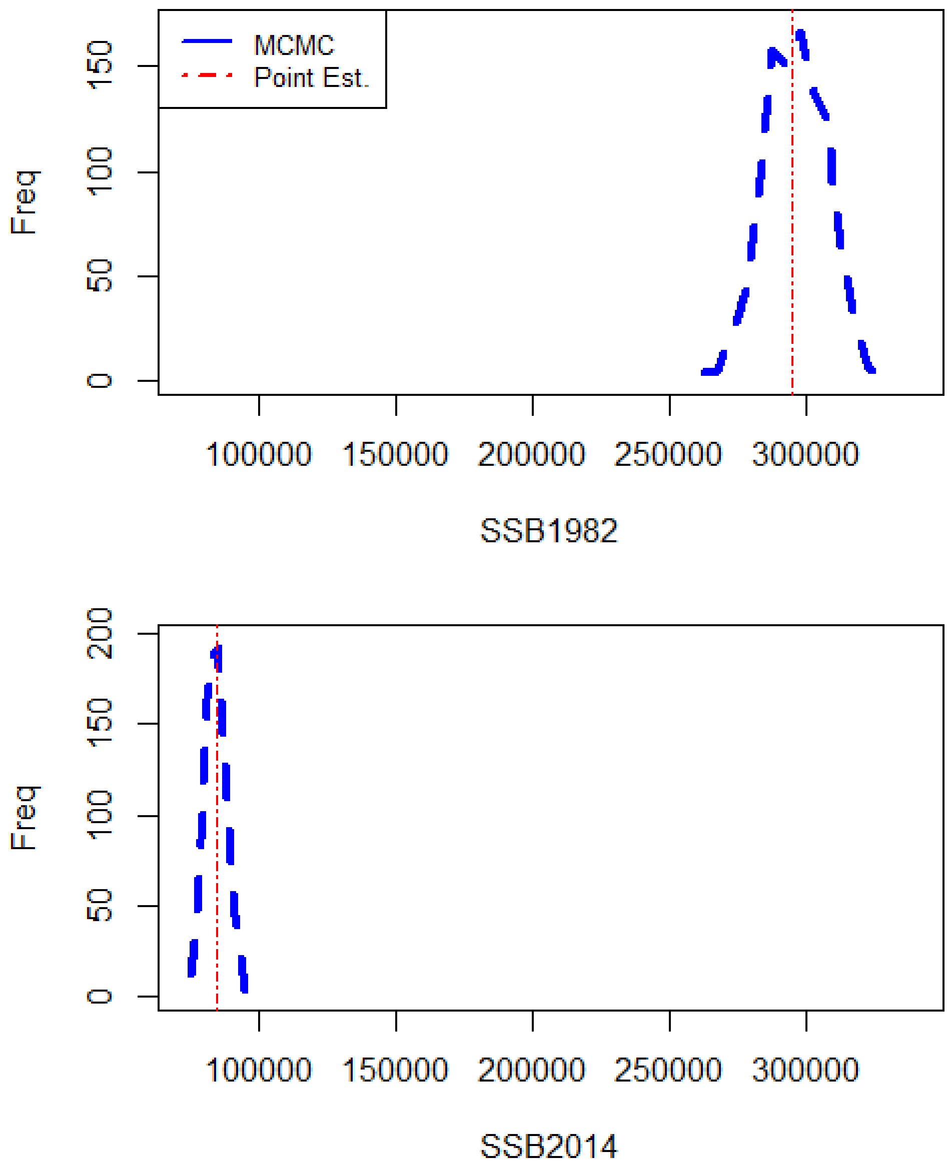


Figure B7.7. MCMC distribution of bluefish spawning stock biomass in 1982 and 2014 from 1000 iterations (thinning factor of 1000) of the continuity model (B001).

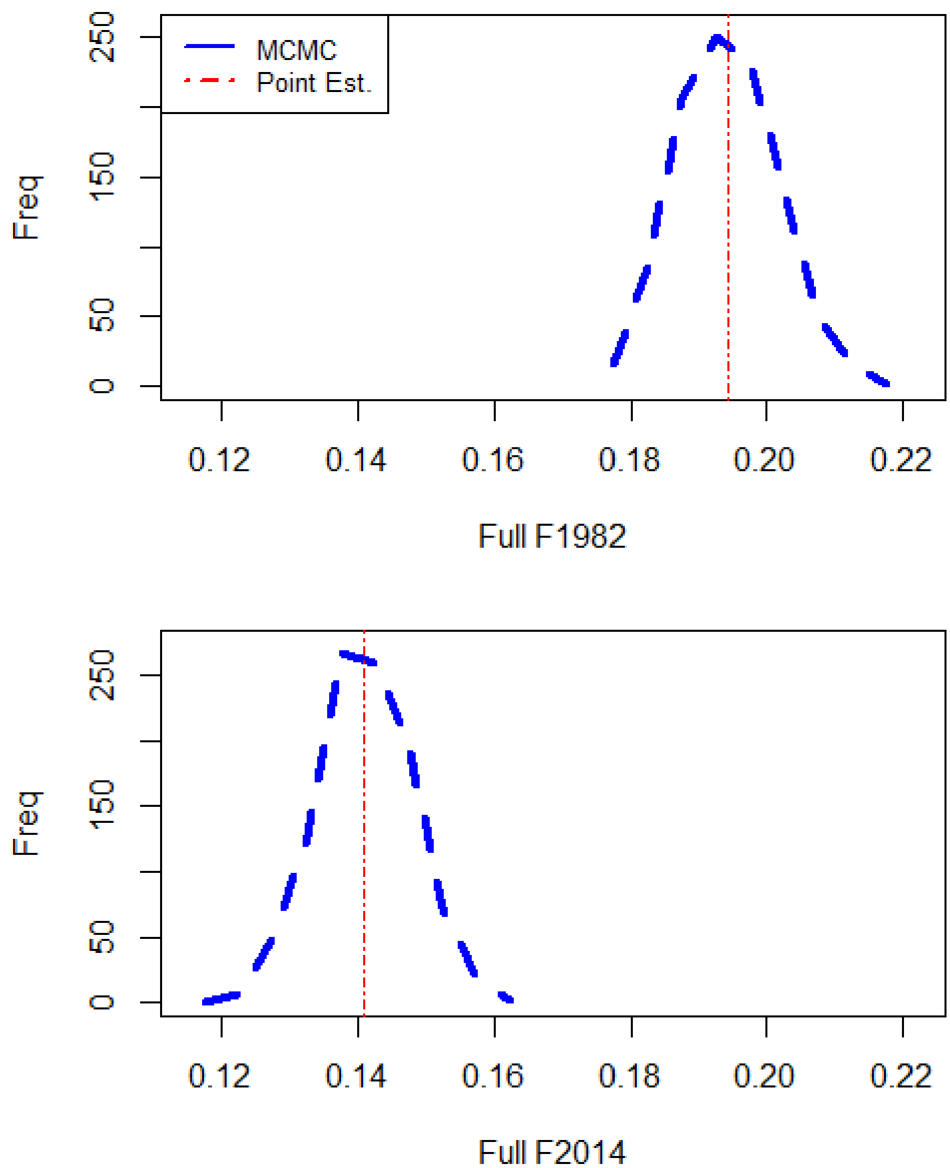


Figure B7.8. MCMC distribution of bluefish fishing mortality in 1982 and 2014 from 1000 iterations (thinning factor of 1000) of the continuity model (B001).

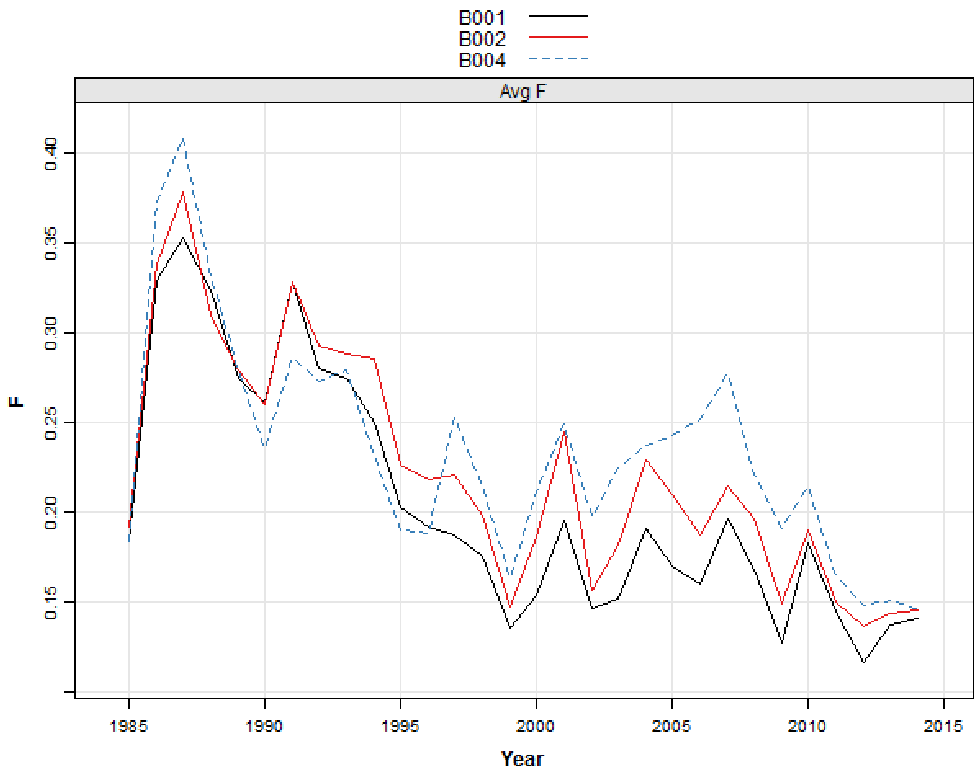


Figure B7.9. A comparison of bluefish fishing mortality estimates between the continuity run (B001: 1982-2014), the cropped continuity run (B002: 1985-2014), and the base model run (B004: 1985-2014).

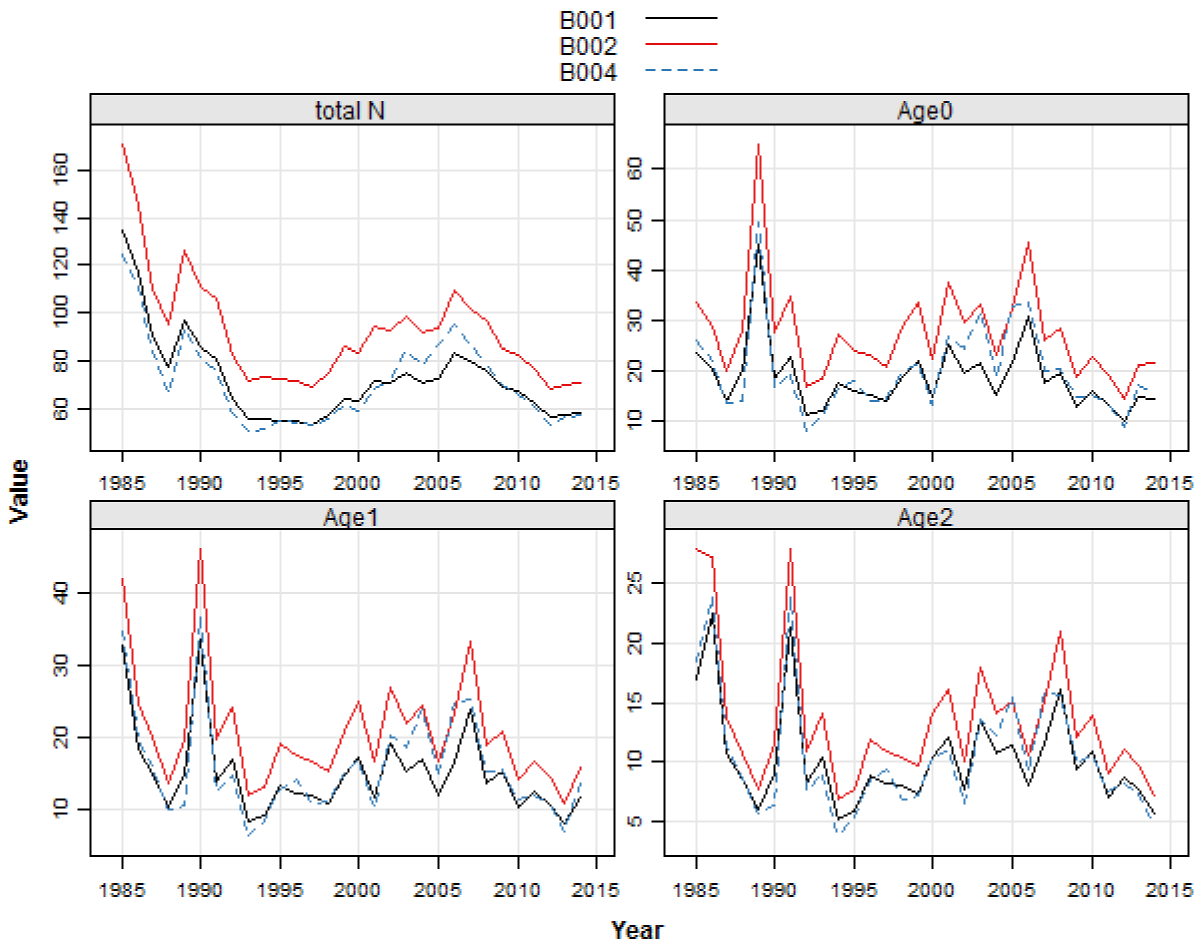


Figure B7.10. A comparison of bluefish total stock numbers and numbers at age for age 0 – age 2. Consistently lower estimates for numbers at age 0 to age 2 for model B004 are driving the differences in total stock numbers and recruitment from model B002.

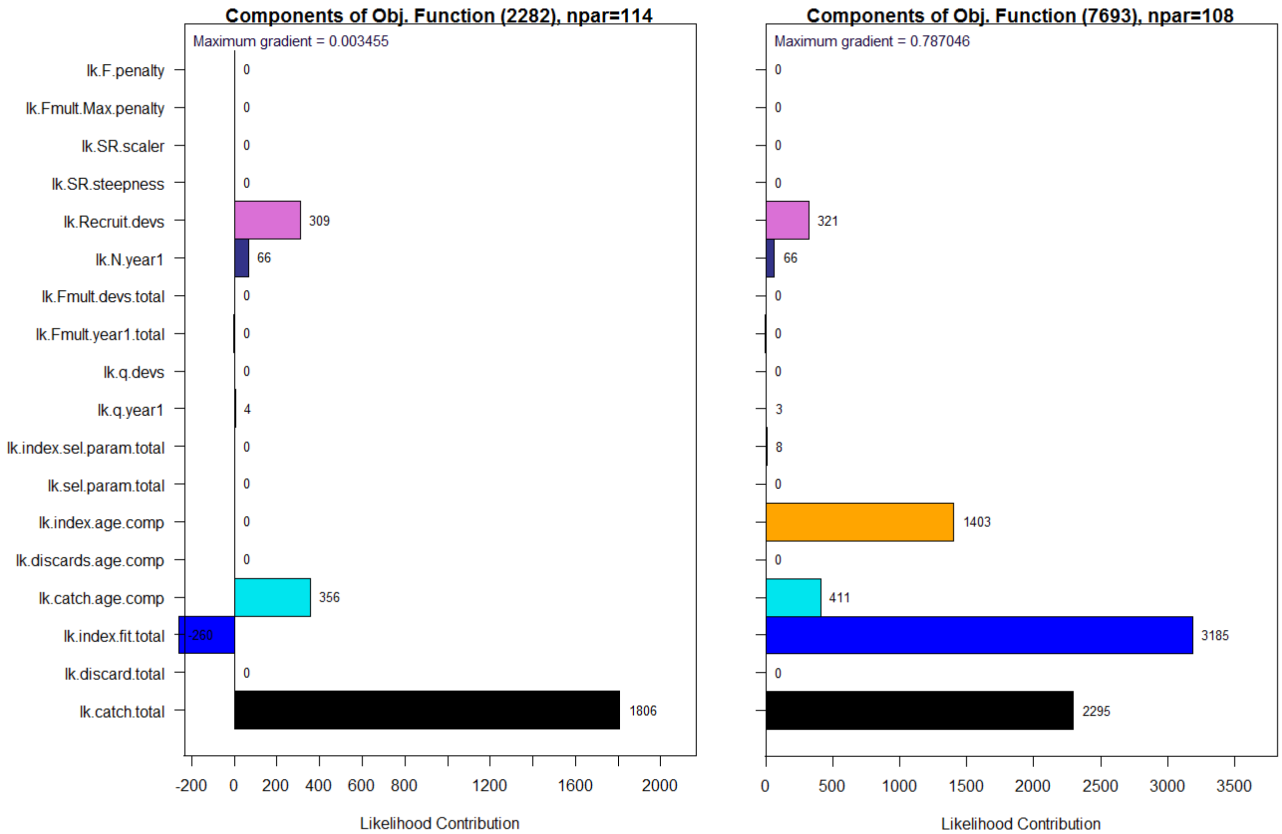


Figure B7.11. Overall contributions to the likelihood for components of model B004 (left) and B006 (right). Indices for model B006 are now input in catch-at-age format and age composition is estimated. The model is still heavily weighted to the catch, but the indices are now the majority of the objective function.

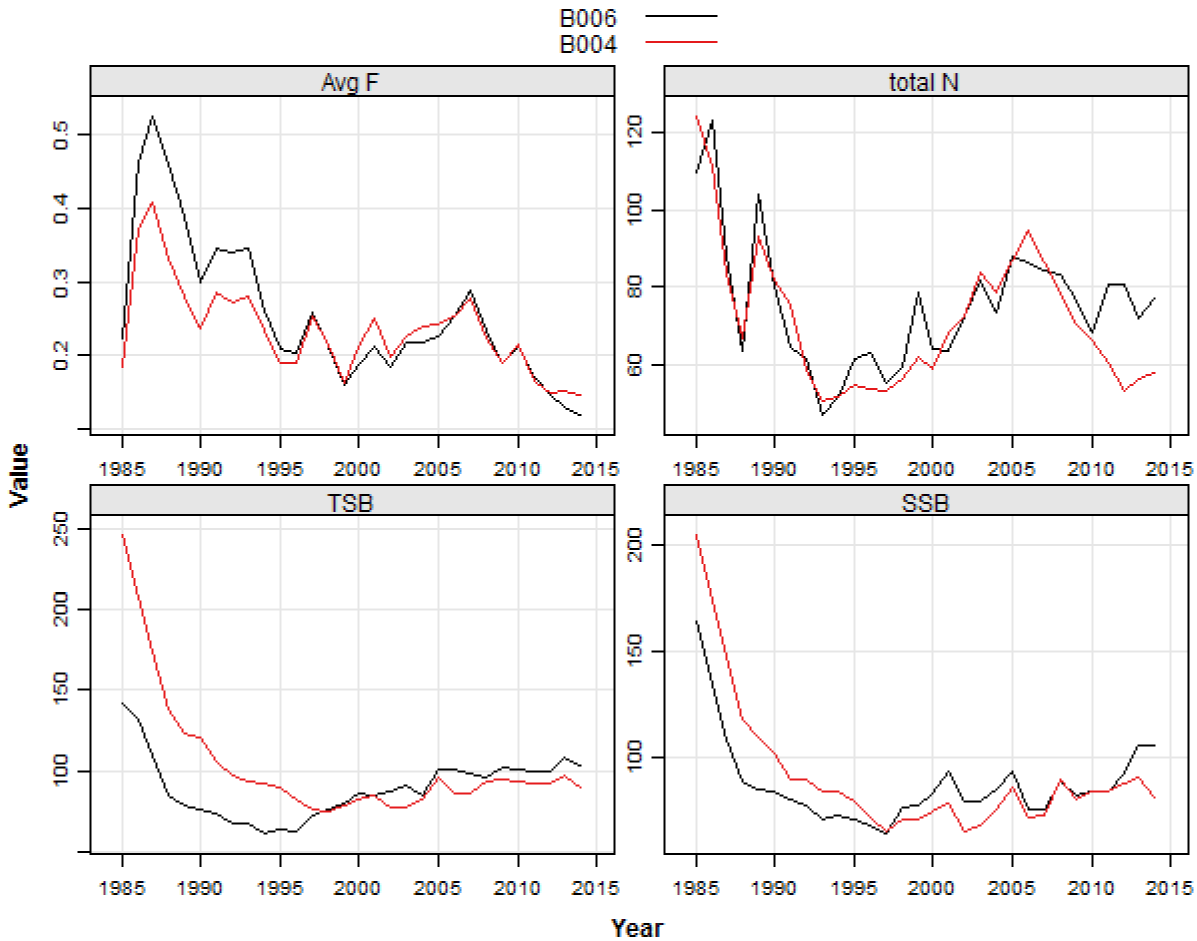


Figure B7.12. A comparison of bluefish fishing mortality, total stock numbers, total biomass, and spawning stock biomass between models B004 and B006. Estimating age composition for the survey indices results in a lower F, and higher 2014 estimates of TSN, TSB, and SSB. In addition, fitting to the age composition of the surveys decreases the scale of biomass at the beginning of the time series.

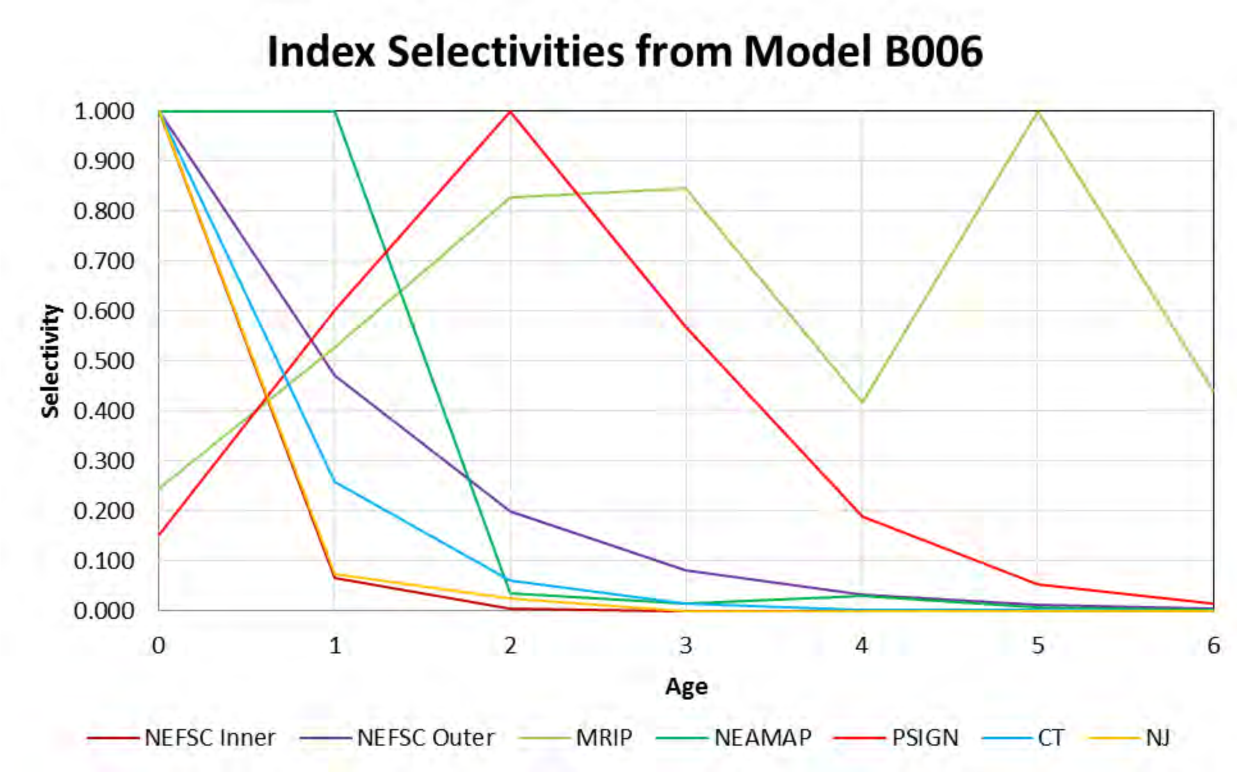


Figure B7.13. Index selectivity estimates from model B006, where the indices were input in a catch-at-age format to estimate age composition.

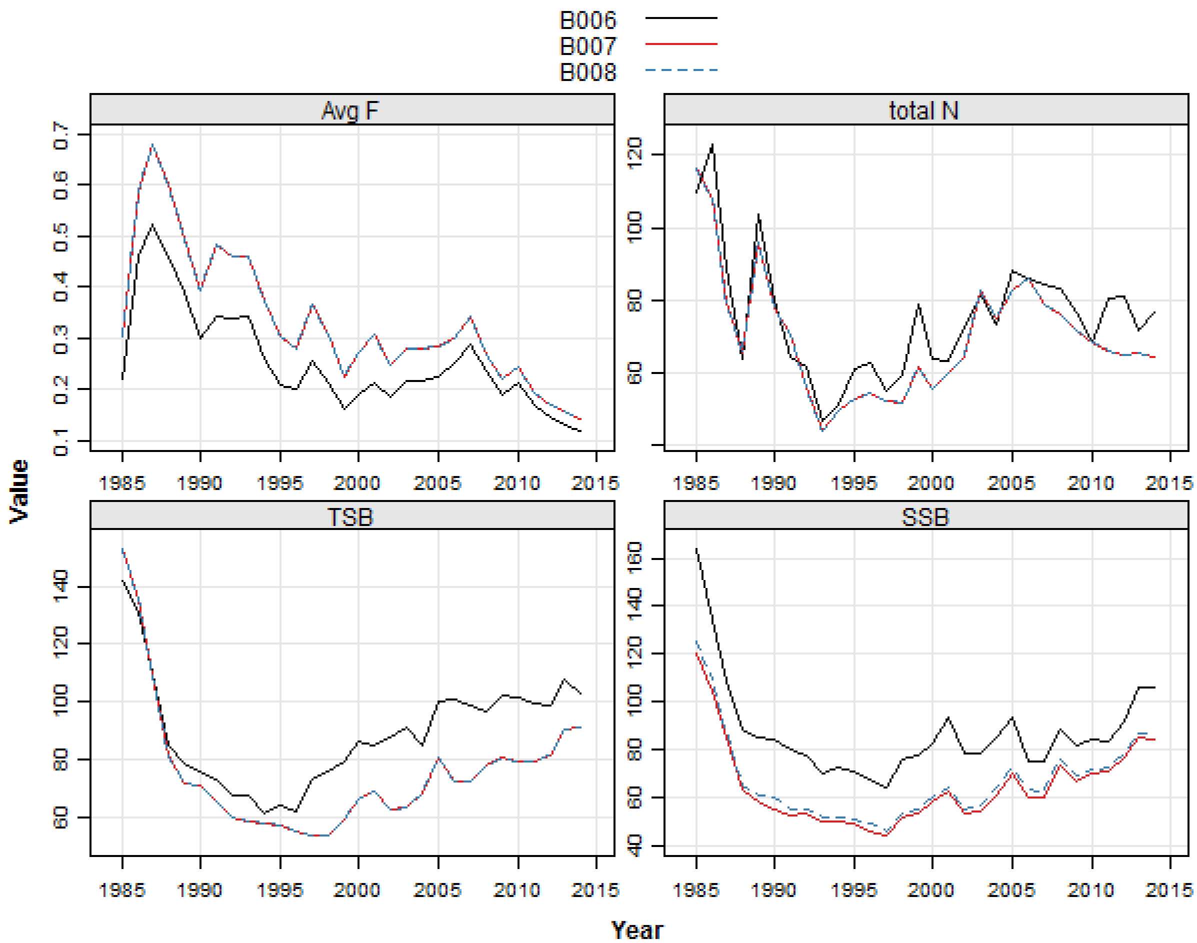


Figure B7.14. A comparison of bluefish fishing mortality, total stock numbers, total biomass, and spawning stock biomass between models B006, B007 (2 fleets) and B008 (new maturity-at-age). Separating the input data into separate commercial and recreational fleets increased the scale of fishing mortality and scaled down the time-series of total numbers and biomass. New maturity information in model B008 resulted in only a slight increase in SSB.

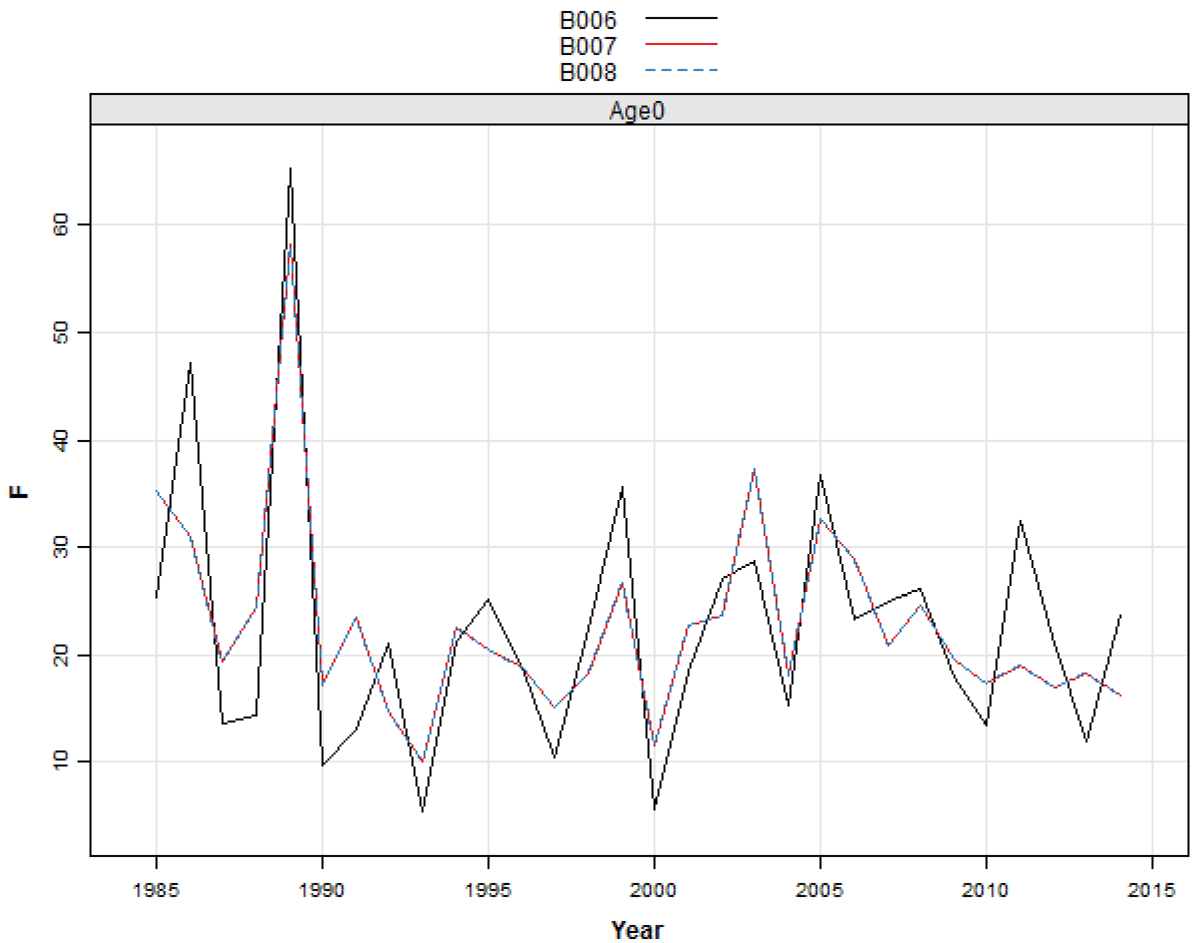


Figure B7.15. The separation of data into a commercial and recreational fleet did not change the recruitment time-series significantly but resulted in a smoother trend at the end of the B007 time-series.

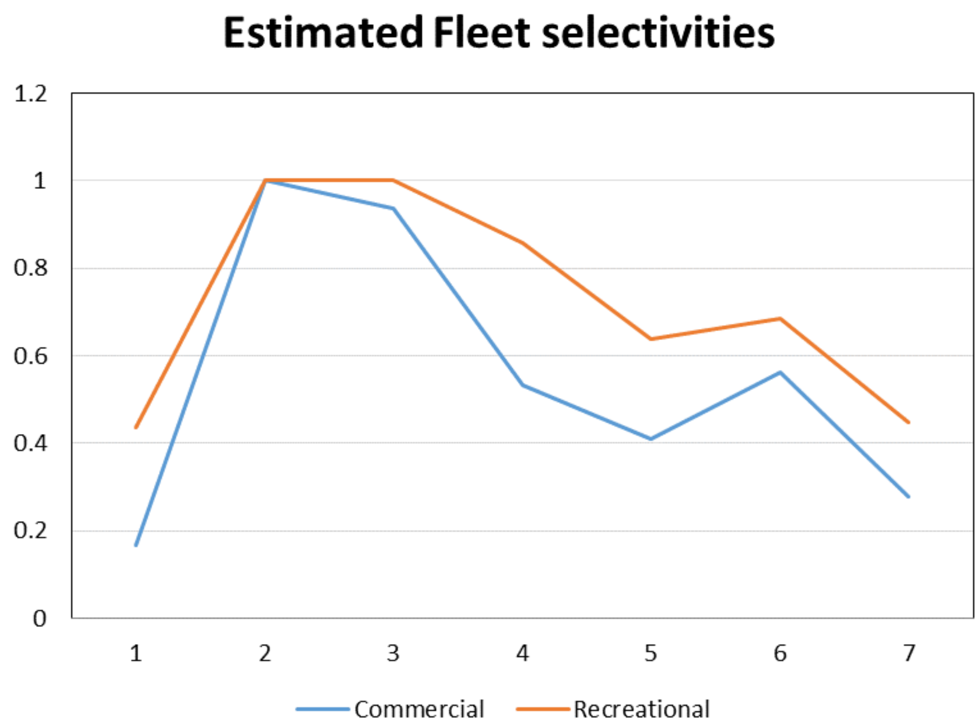


Figure B7.16. Estimated commercial and recreational fleet selectivities from model B011. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

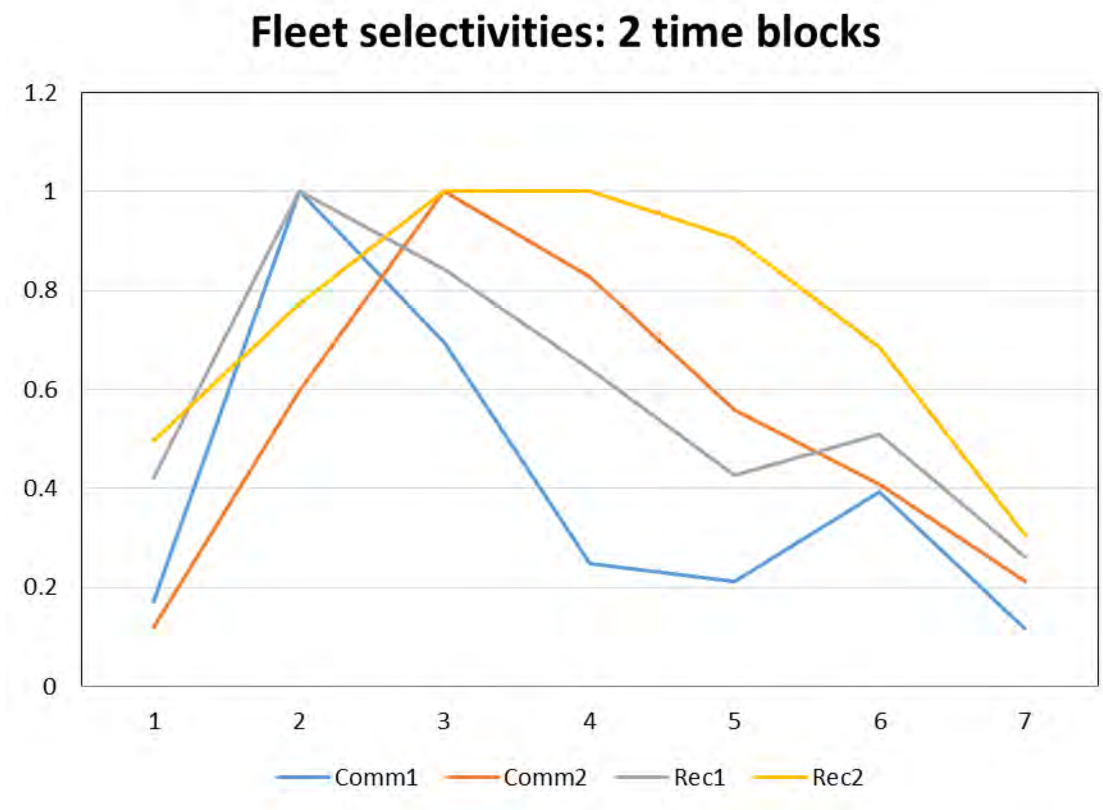


Figure B7.17. Estimated commercial and recreational fleet selectivities in two time blocks (1985-2005 and 2006-2014) from model B020. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

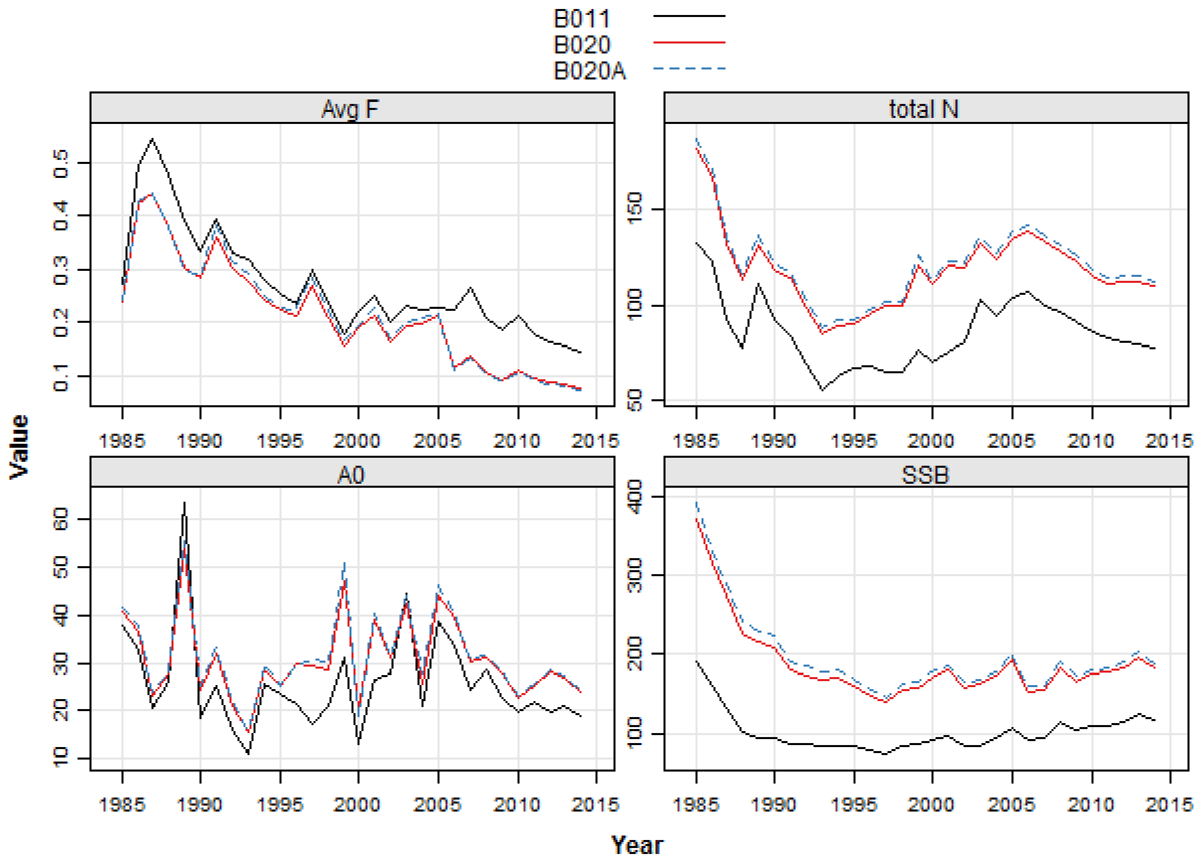


Figure B7.18. A comparison of bluefish fishing mortality, total stock numbers, recruitment, and spawning stock biomass between models B011, B020 (2 fleet selectivity blocks) and B020A (ESS = 0 for 1997-2005). Adding 2 selectivity blocks to the fleets decreases fishing mortality estimates and increases stock numbers, recruitment, and biomass estimates.

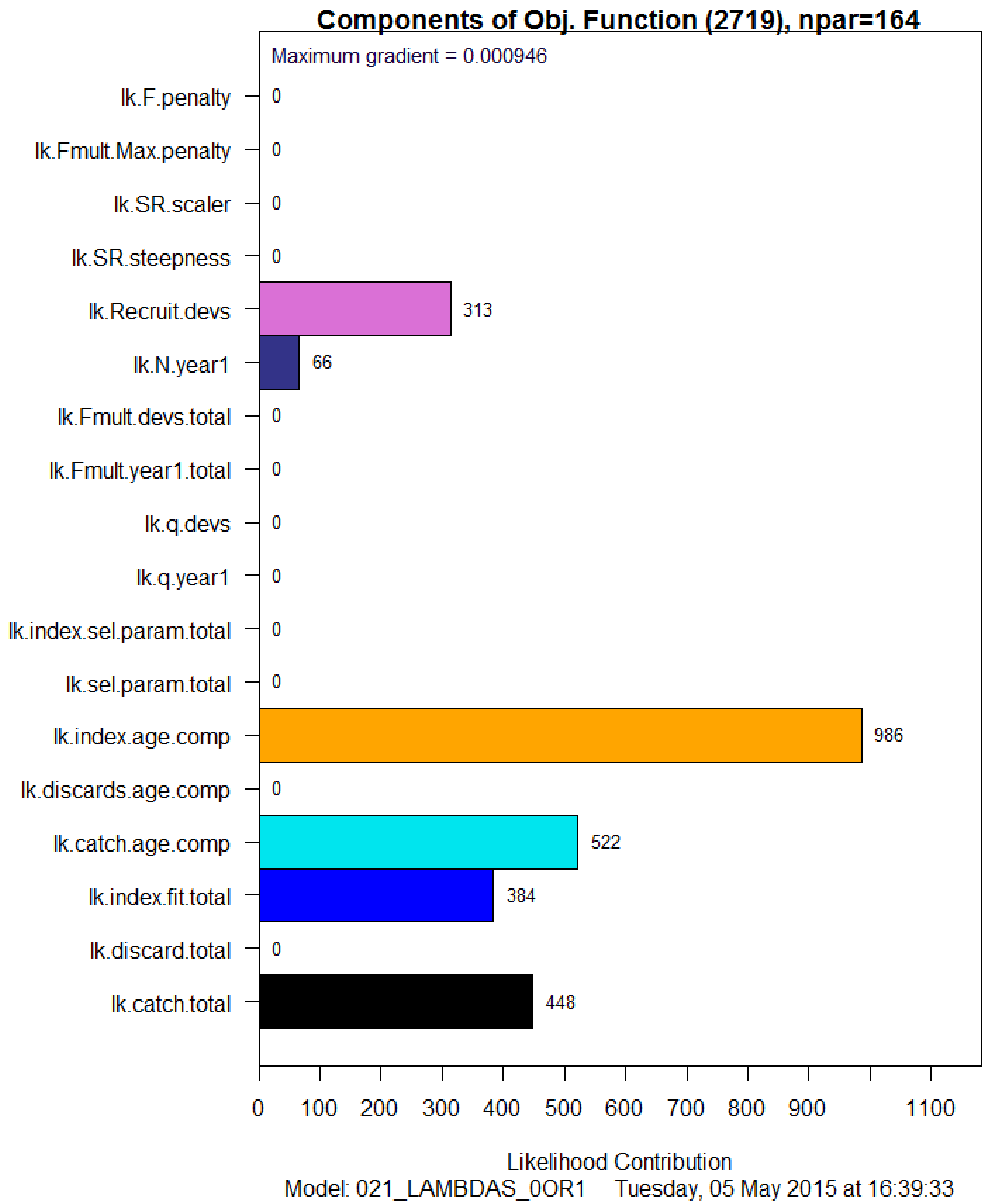


Figure B7.19. Overall contributions to the likelihood for components of model B021. This model shifted the lambdas to 1's or 0's, acting as switches to turn on or off the components of the objective function. If lambda is turned on for a component it is then included in the objective function and associated input CV is used as a weight (acting like a prior).

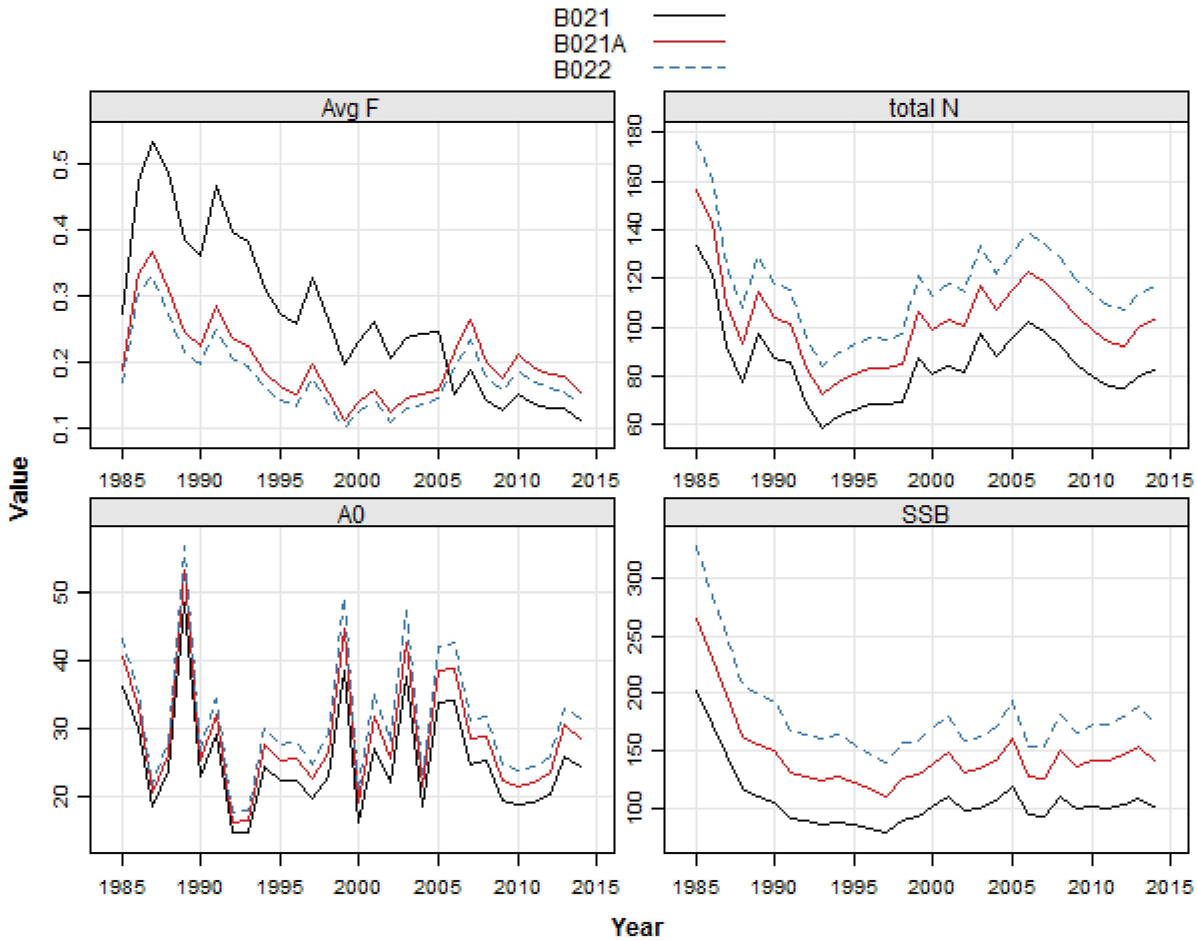


Figure B7.20. A comparison of bluefish fishing mortality, total stock numbers, recruitment, and spawning stock biomass between models B021 (new model weighting: Lambdas = 0 or 1), B021A (Likelihood constants off) and B022 (penalty on Nyear1 off).

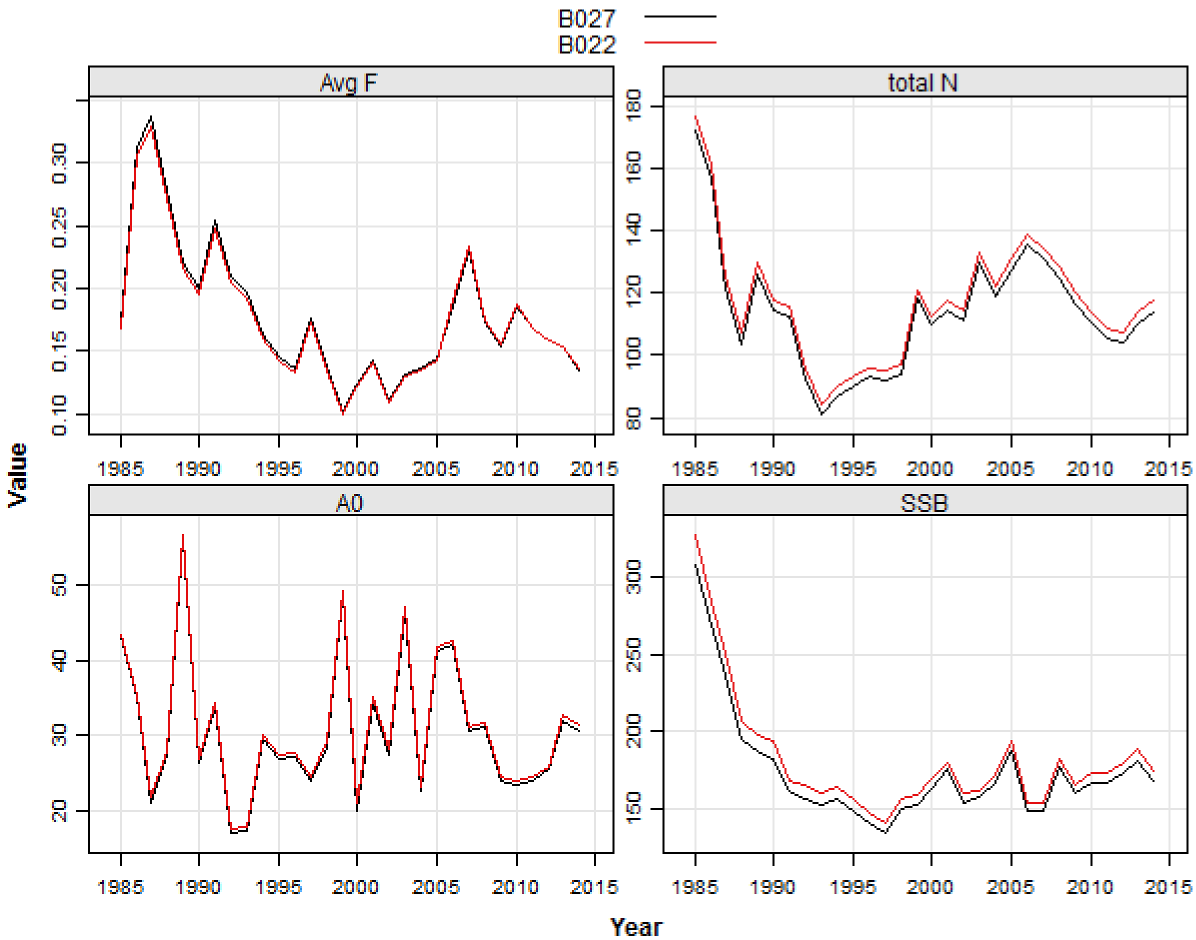


Figure B7.21. Minor changes were made to input CVs and selectivity estimates between model B022 and B027. The result of these changes was very little difference in the estimates of fishing mortality, total stock numbers, recruitment, and spawning stock biomass.

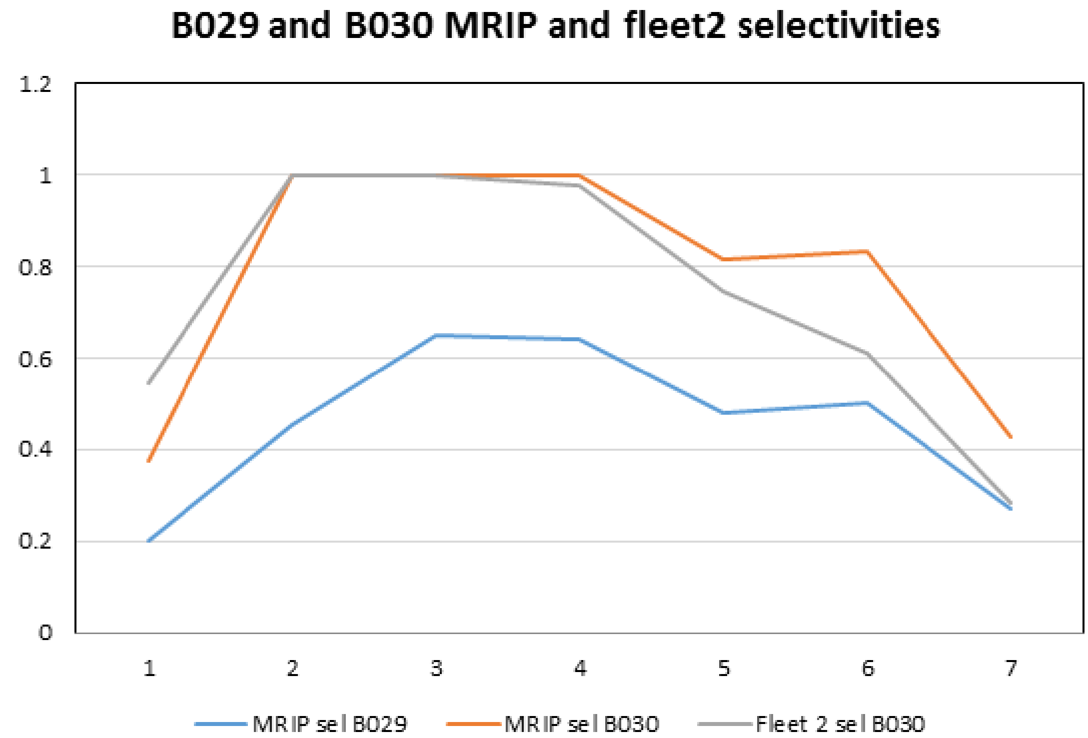


Figure B7.22. MRIP index selectivities and fleet 2 selectivity coming out of model B029 and B030. Note that age class labels are 1 greater than the modeled age class, so that “age-1” corresponds to age 0, “age-2” corresponds to age 1, etc.

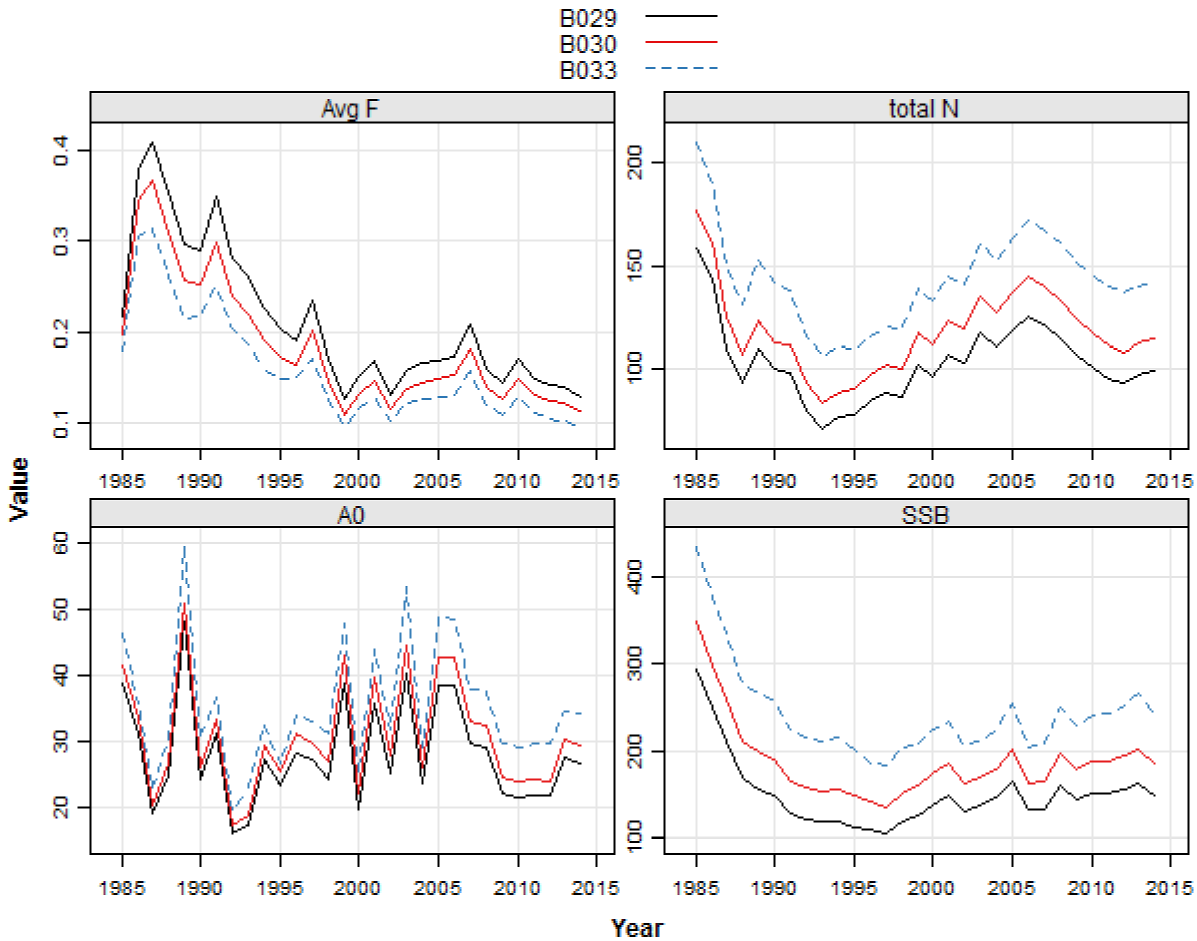


Figure B7.23. A comparison of bluefish fishing mortality, total stock numbers, recruitment, and spawning stock biomass between models B029 (Split off Bigelow survey), B030 (MRIP index selectivity to match fleet 2) and B033 (Corrected NC scale data).

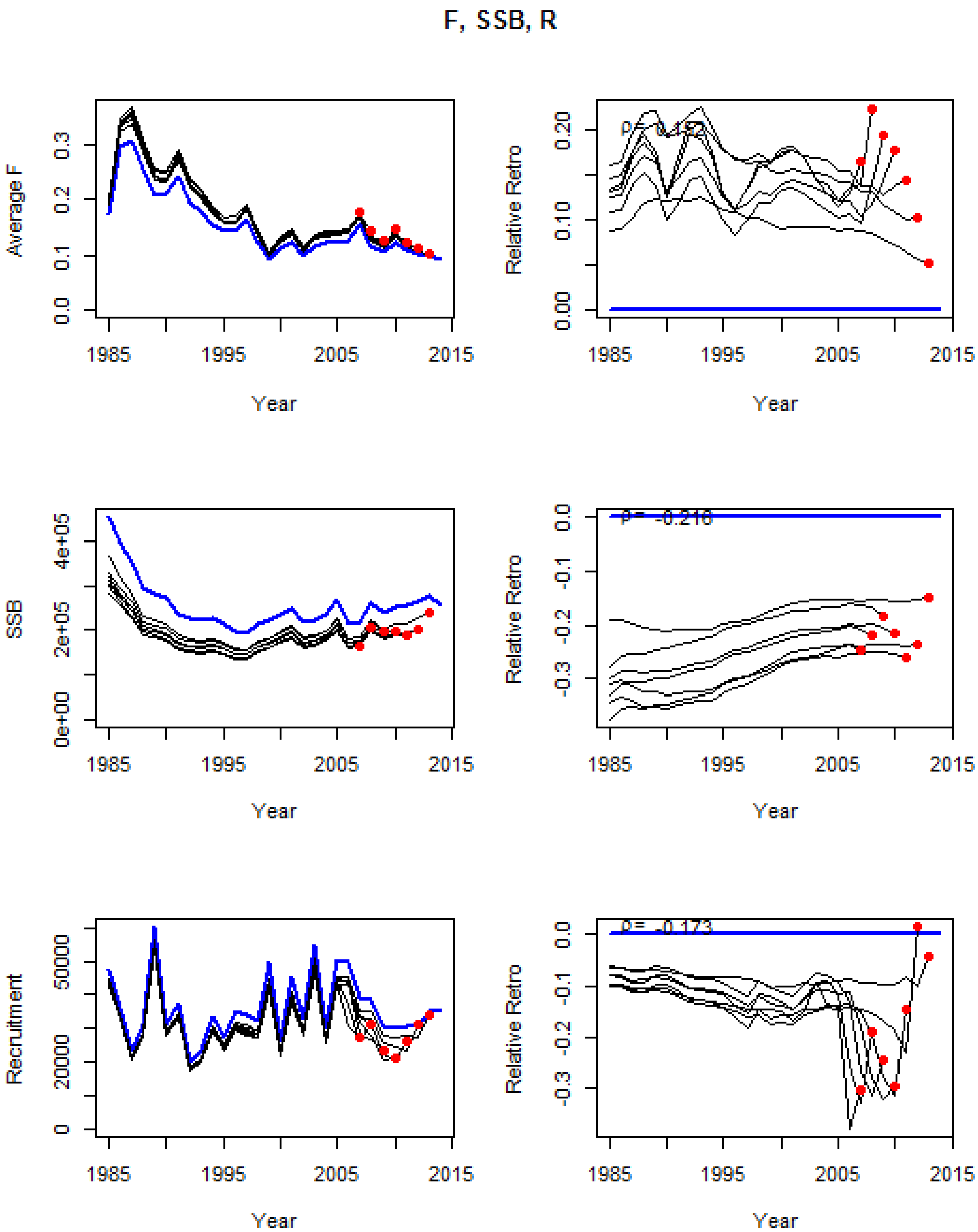


Figure B7.24. Significant retrospective bias in estimates of fishing mortality, spawning stock biomass and recruitment from model B035.

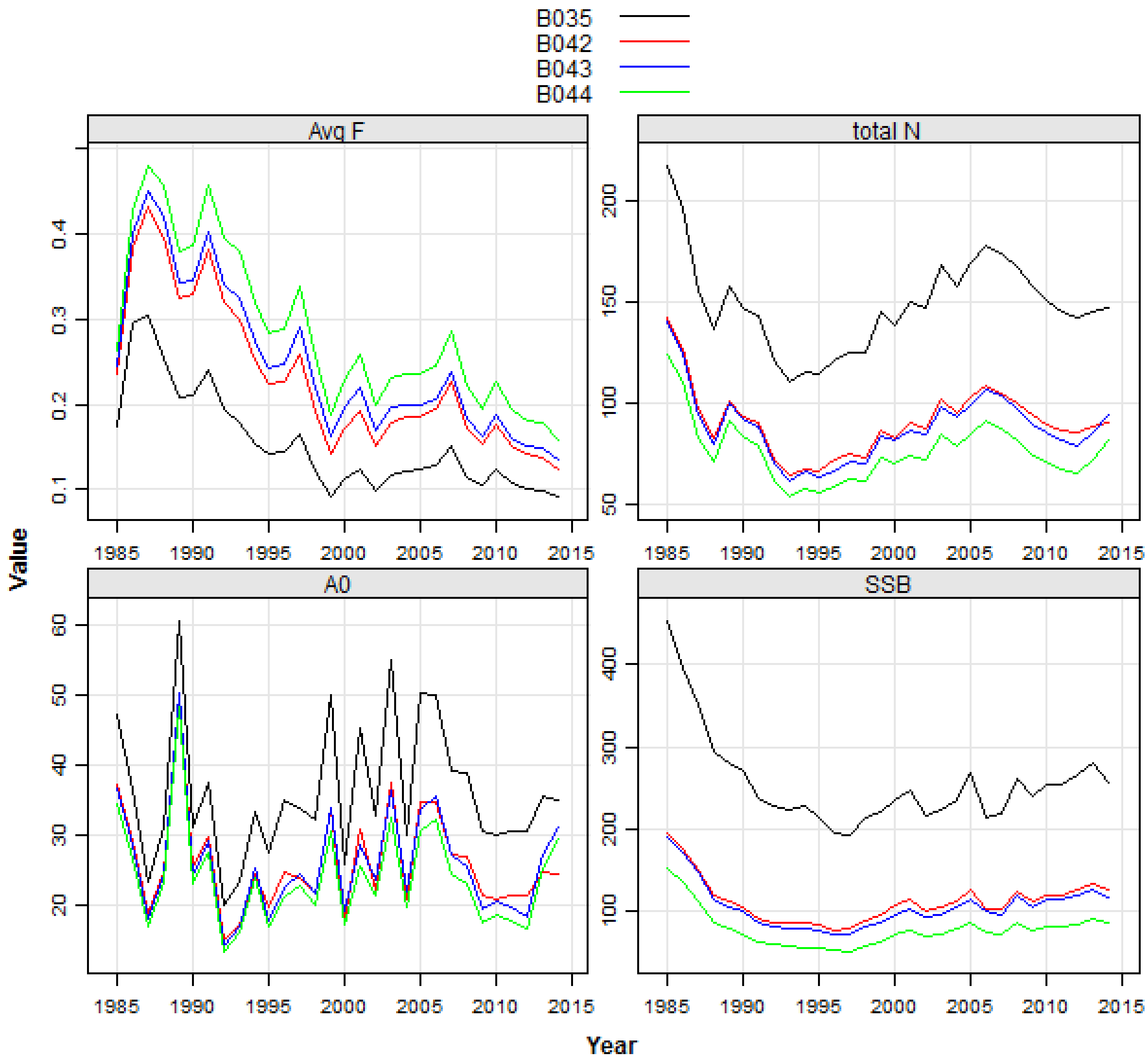
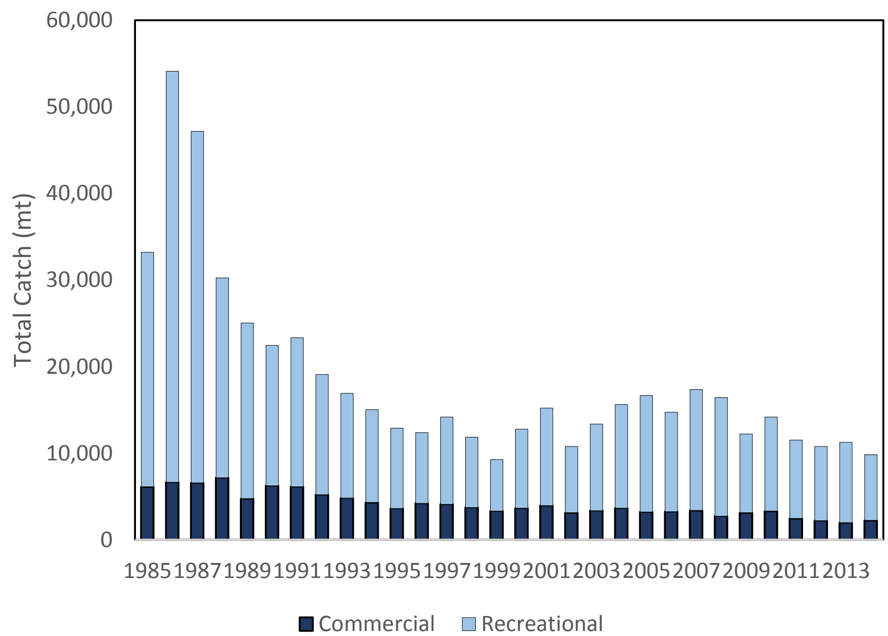


Figure B7.25. A comparison of bluefish fishing mortality, total stock numbers, recruitment, and spawning stock biomass between models B035 (PSIGN to sel-at-age), B042 (MRIP index selectivity to single logistic), B043 (adjustments to CVs and ESS), and B044 (final model accepted by SARC panel).



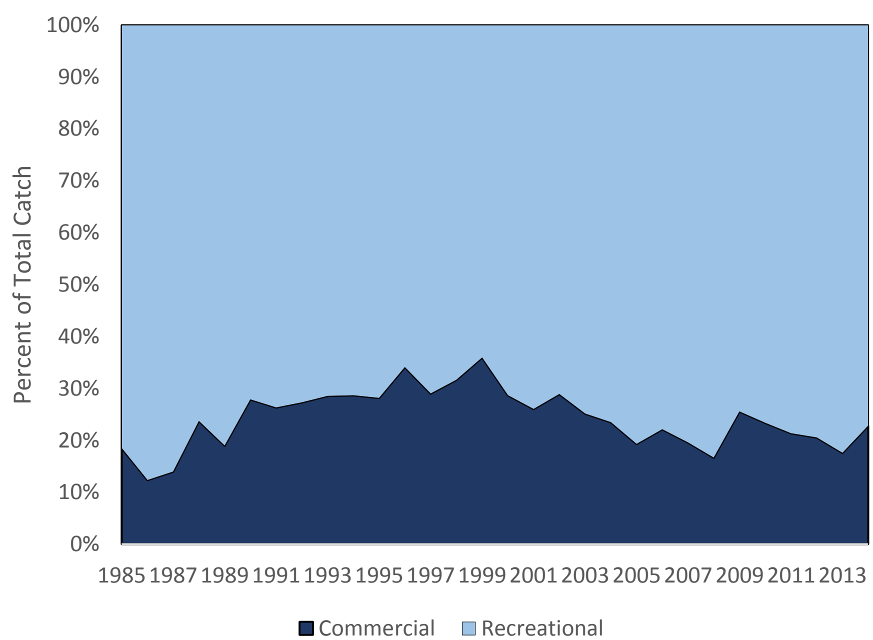


Figure B7.26. Bluefish catch by fleet in metric tons (top) and percent of total catch (bottom) from 1985 to 2014.

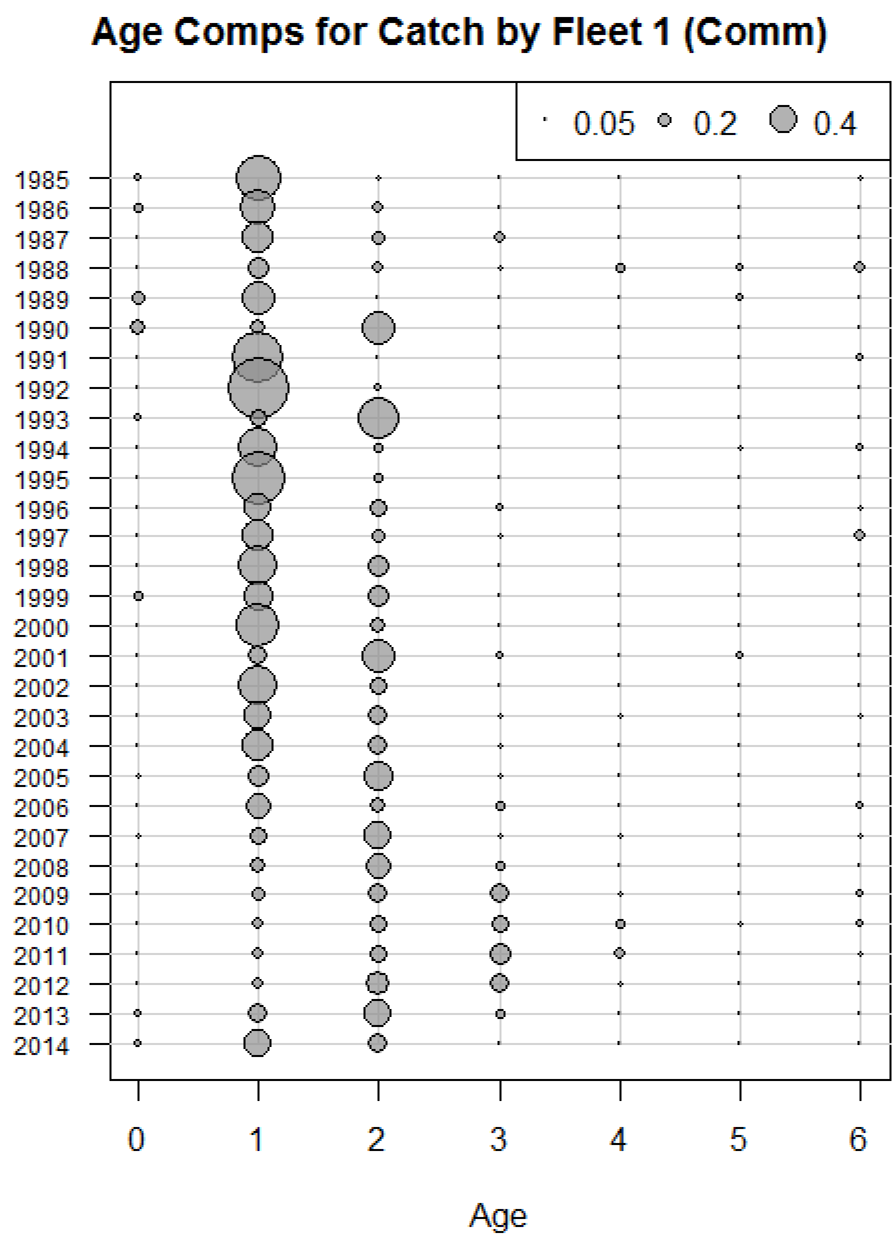


Figure B7.27. Bluefish age composition (catch-at-age) for the commercial fleet input into the final model run.

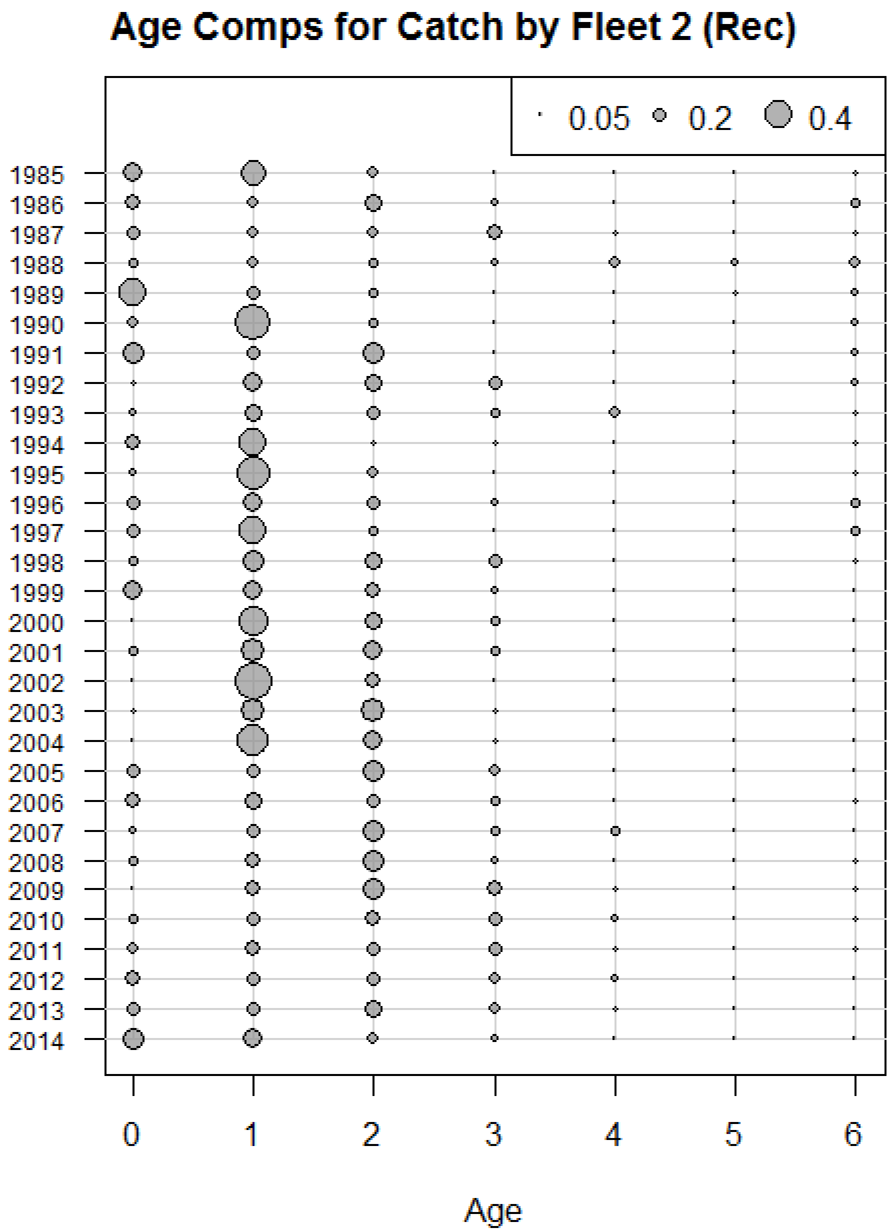


Figure B7.28. Bluefish age composition (catch-at-age) for the recreational fleet input into the final model run.

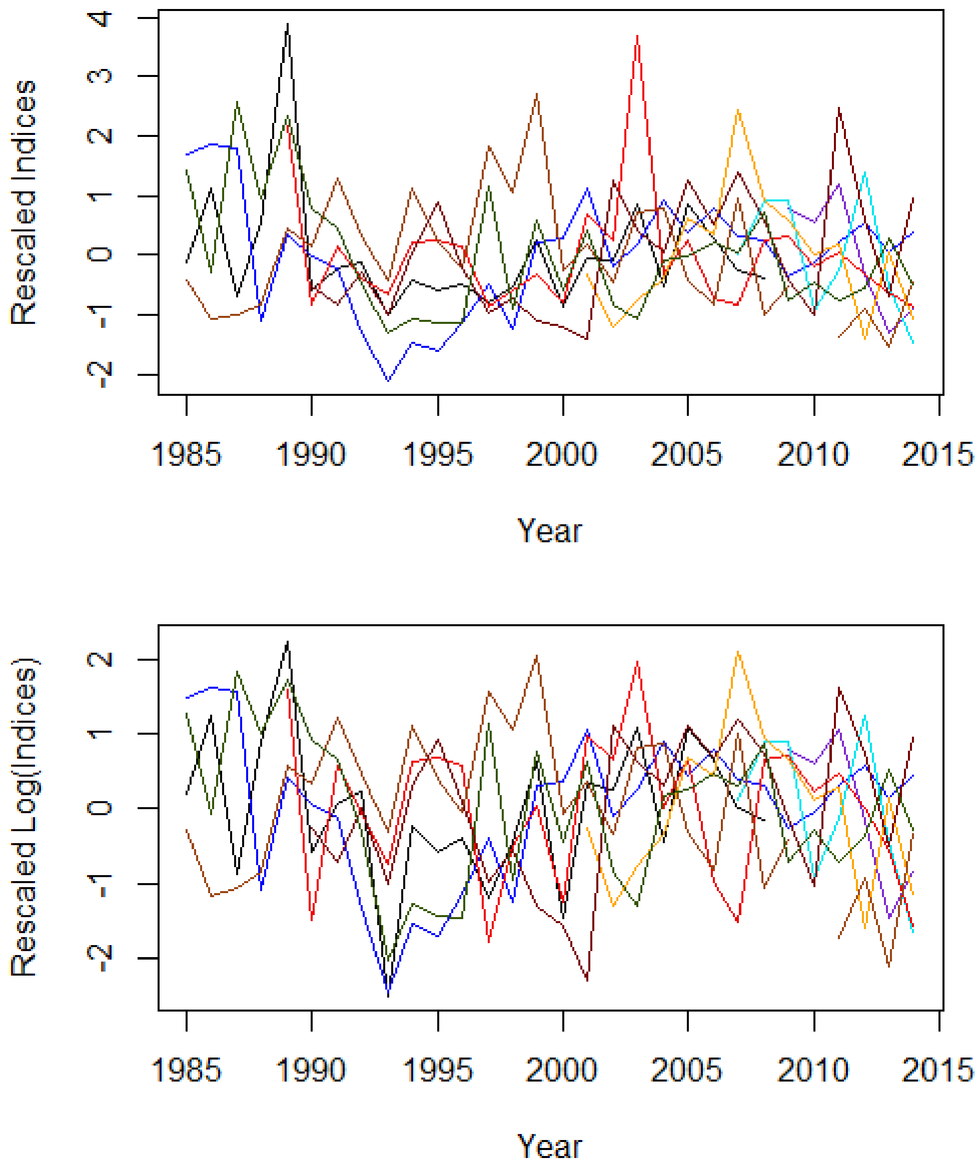


Figure B7.29. Bluefish survey indices re-scaled to their mean values and log-survey indices rescaled to their mean values.

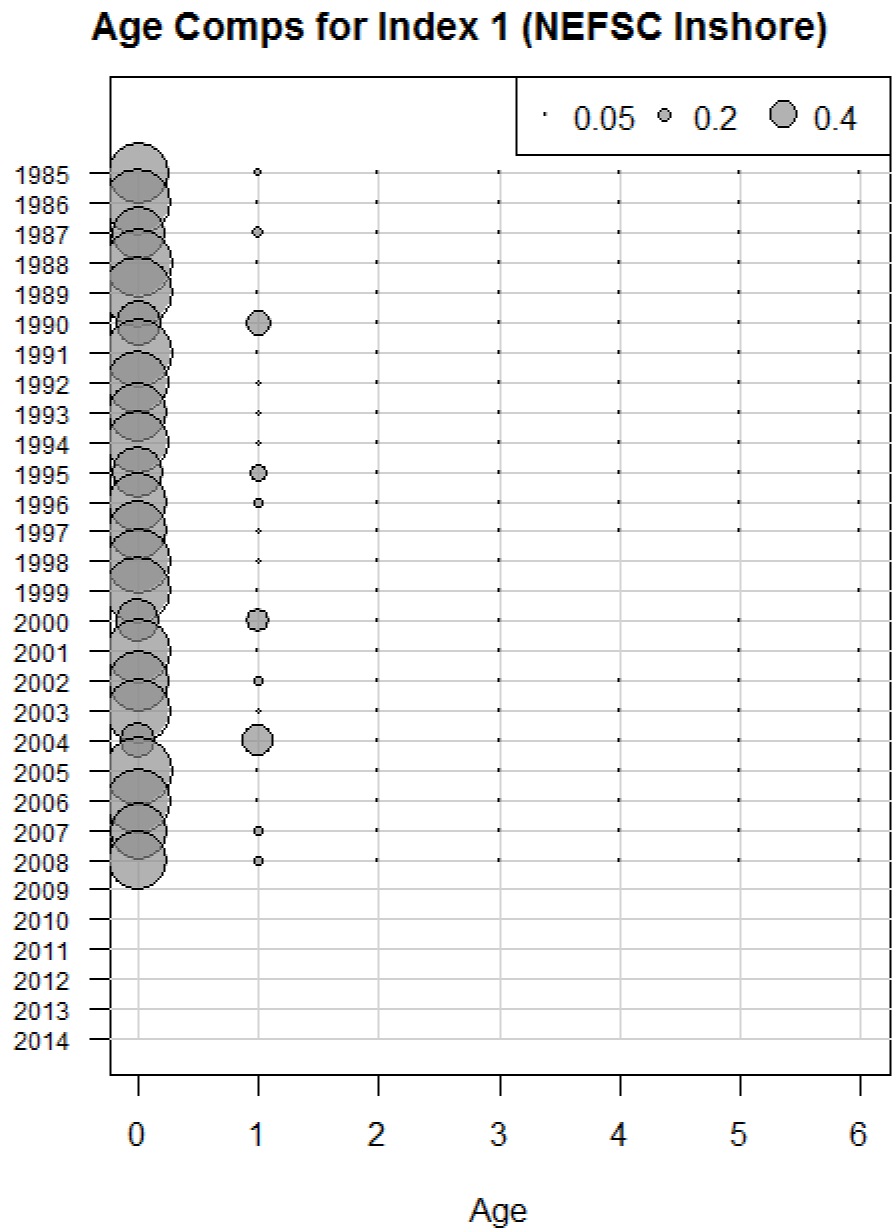


Figure B7.30. Input age composition for the NEFSC Inshore survey (Albatross survey from 1985 to 2008).

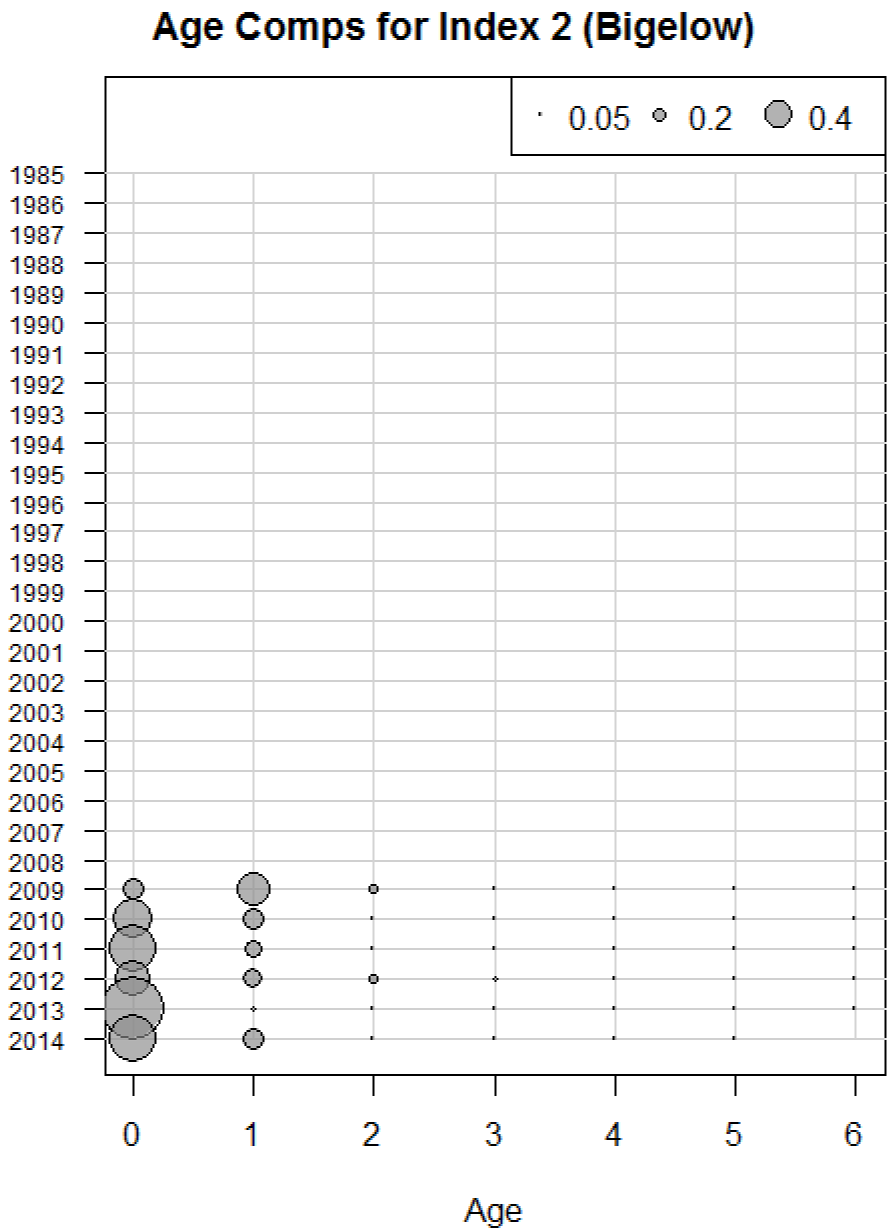


Figure B7.31. Input age composition for the NEFSC Bigelow survey (2009 to 2014).

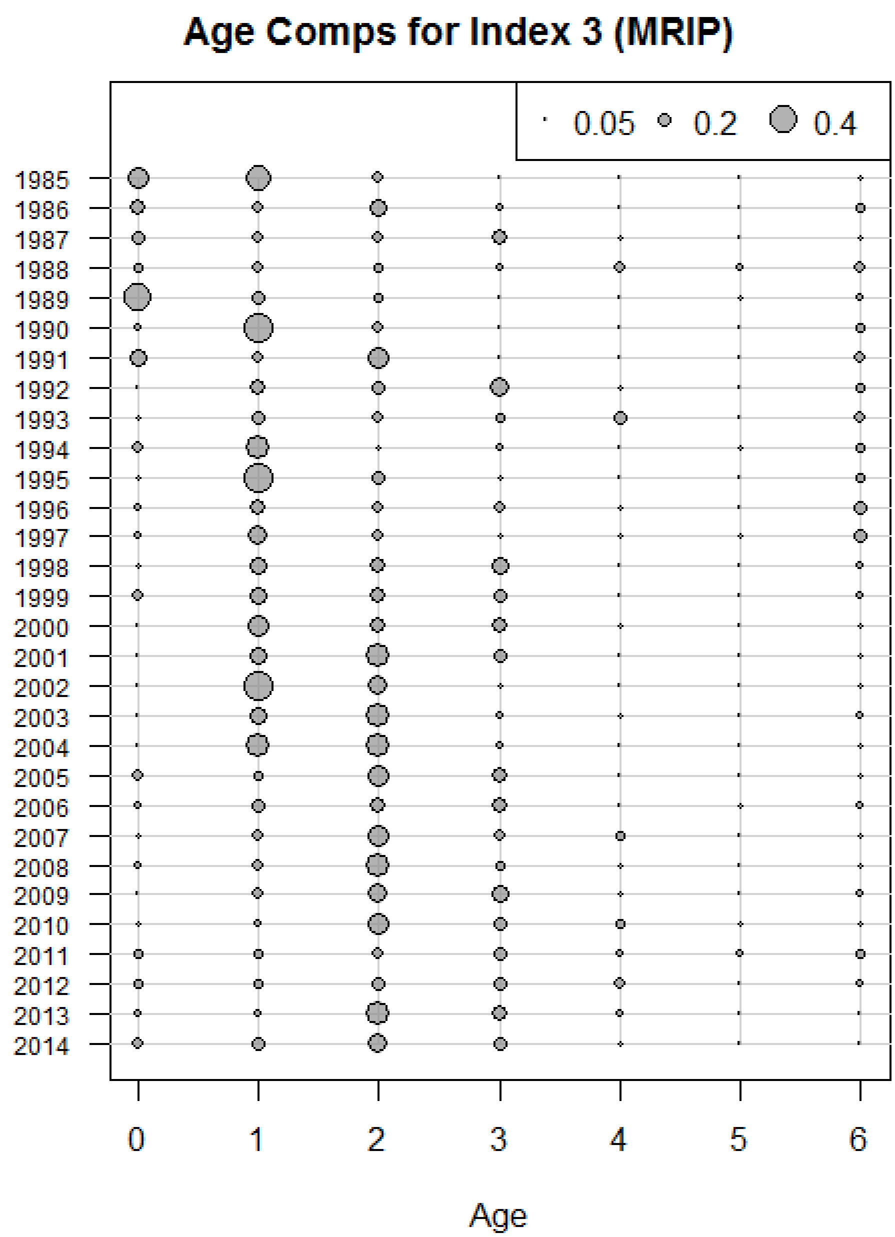


Figure B7.32. Input age composition for the MRIP recreation CPUE index from 1985 to 2014.

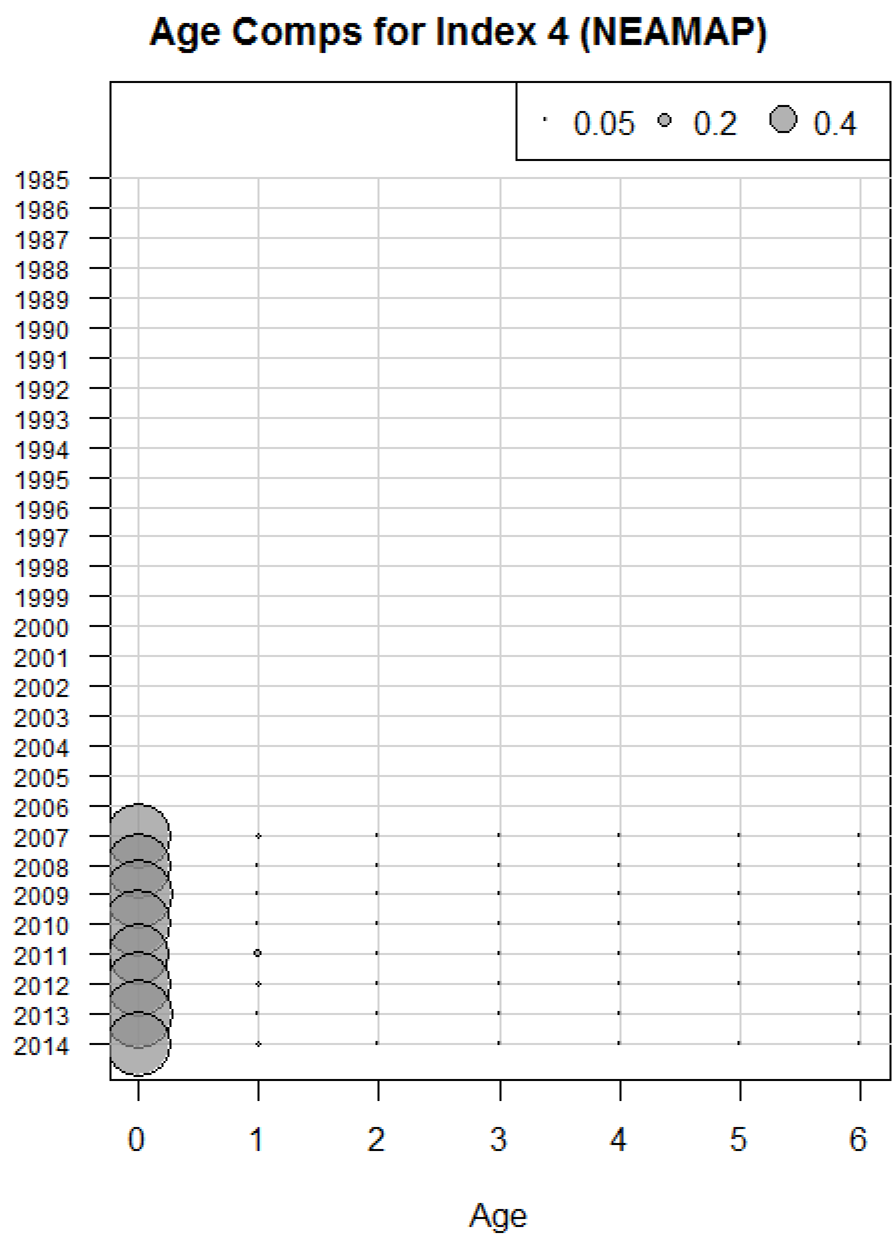


Figure B7.33. Input age composition for the NEAMAP trawl survey index from 2007 to 2014.

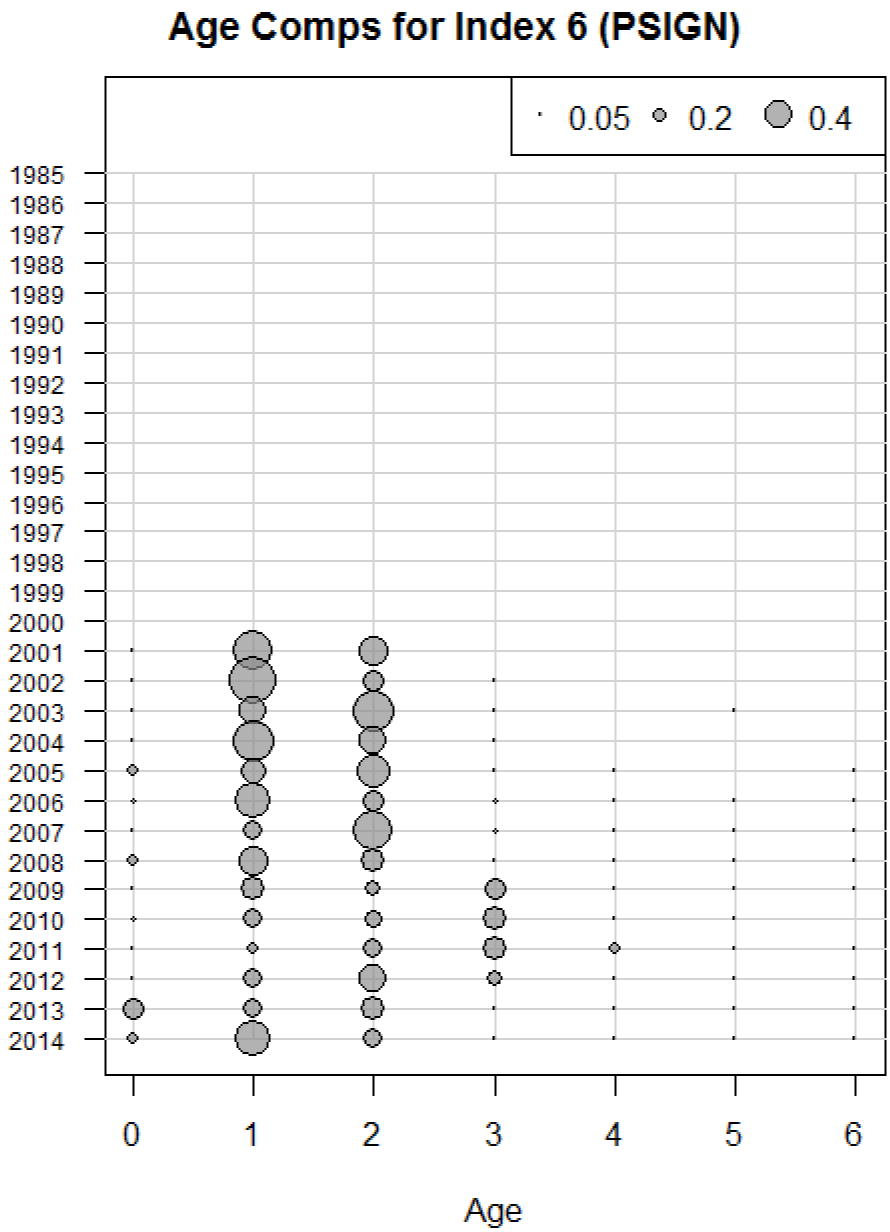


Figure B7.34. Input age composition for the PSIGN gillnet survey index from 2001 to 2014.

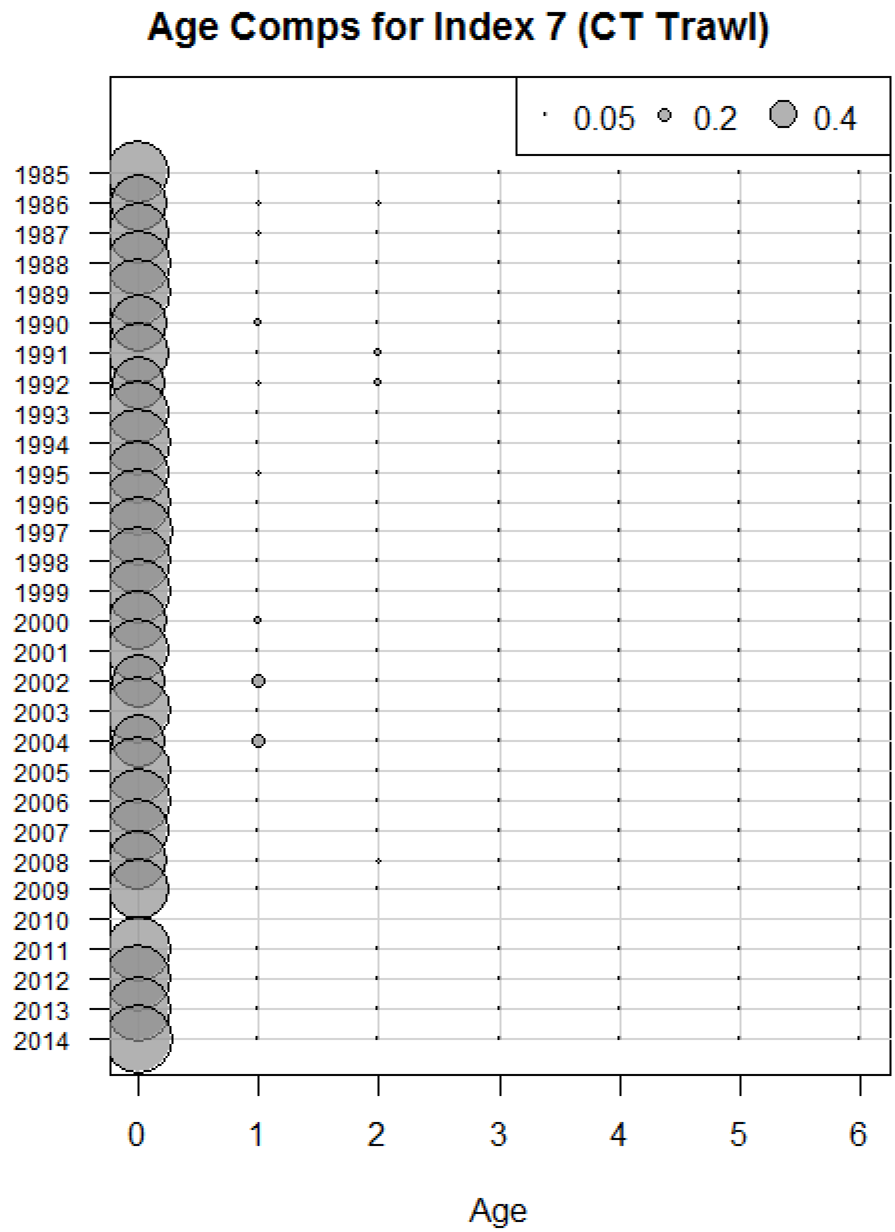


Figure B7.35. Input age composition for the CT LISTS trawl survey index from 1985 to 2014.

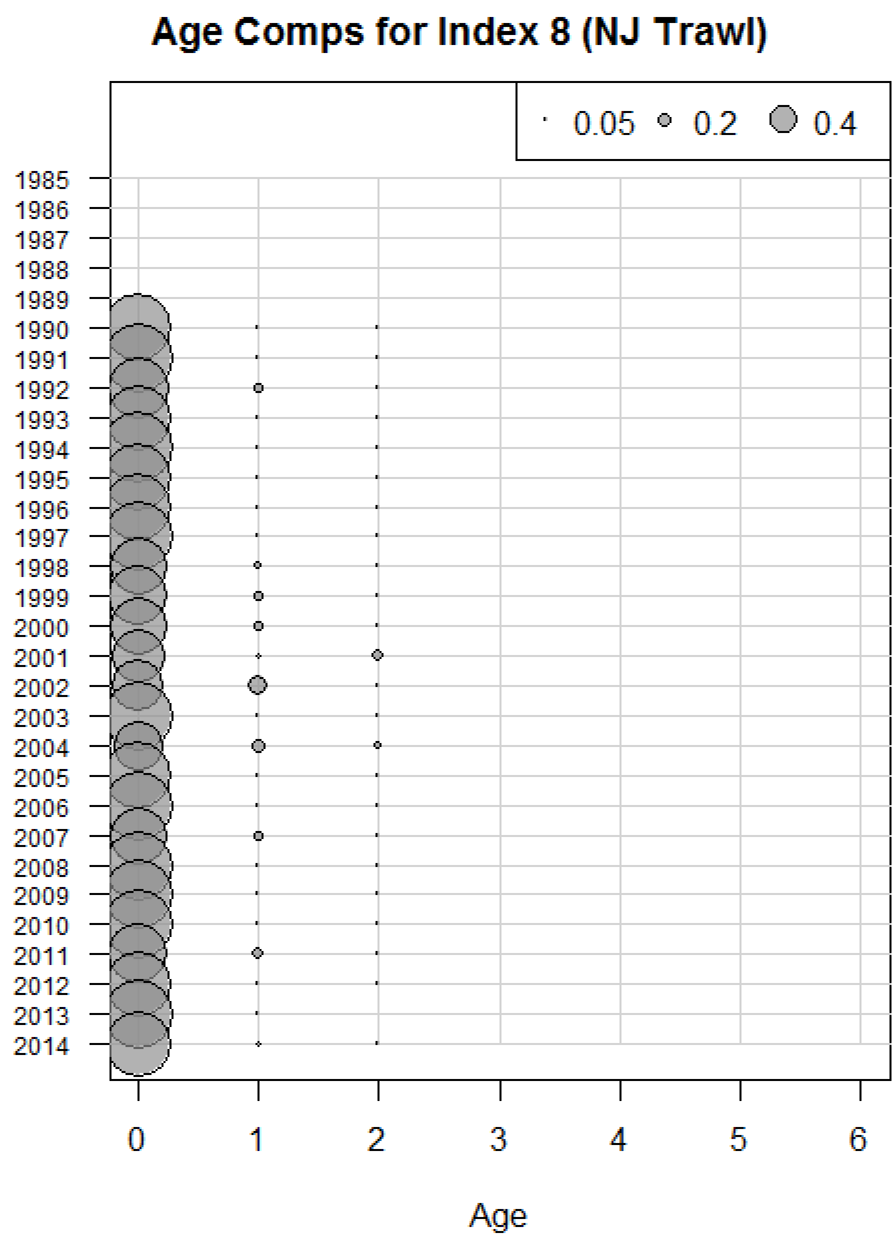


Figure B7.35A. Input age composition for the NJ Ocean trawl survey index from 1990 to 2014.

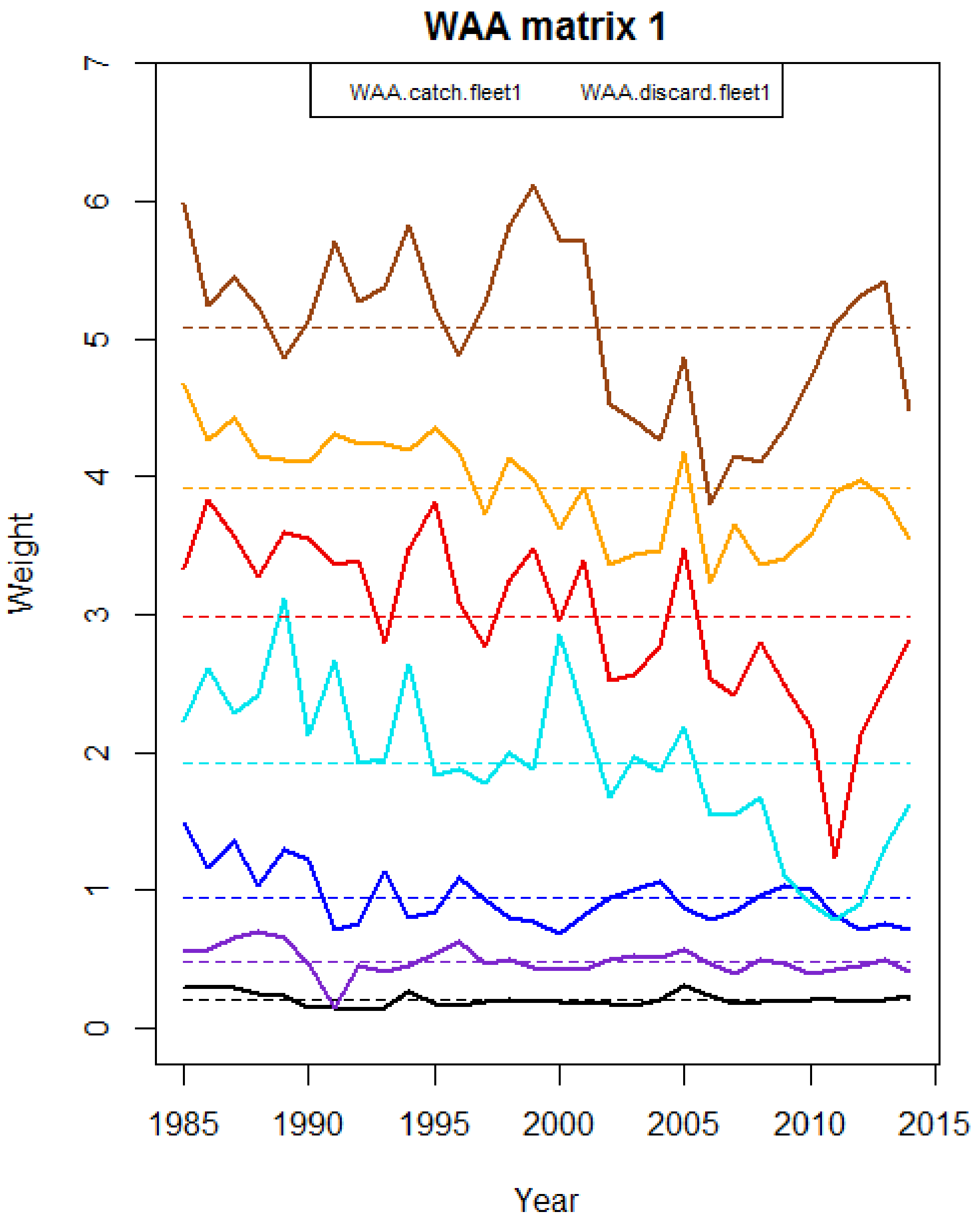


Figure B7.36. Bluefish weight-at-age (Ages 0-6+) for the commercial fleet from 1985 to 2014.

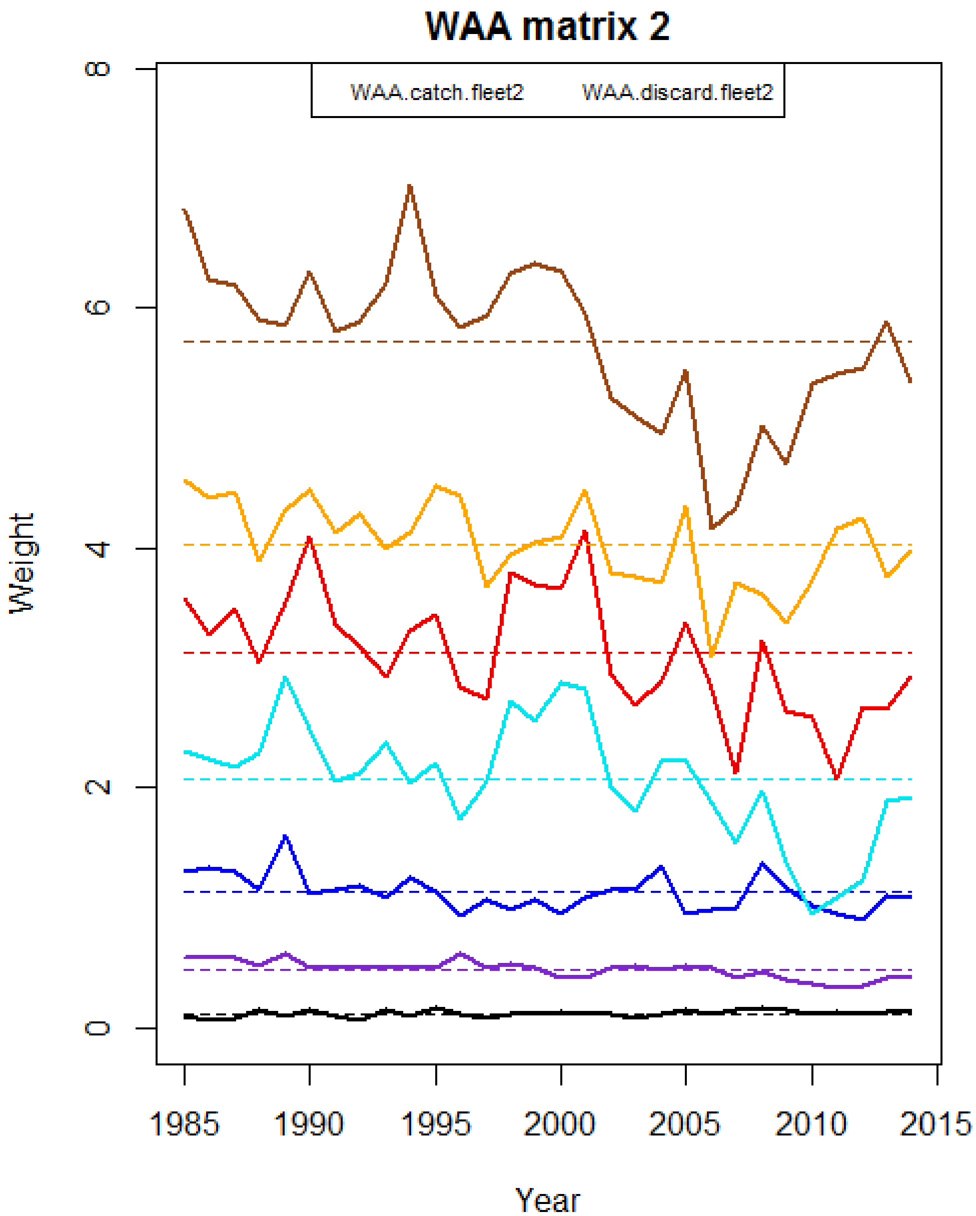


Figure B7.37. Bluefish weight-at-age (Ages 0-6+) for the recreational fleet from 1985 to 2014.

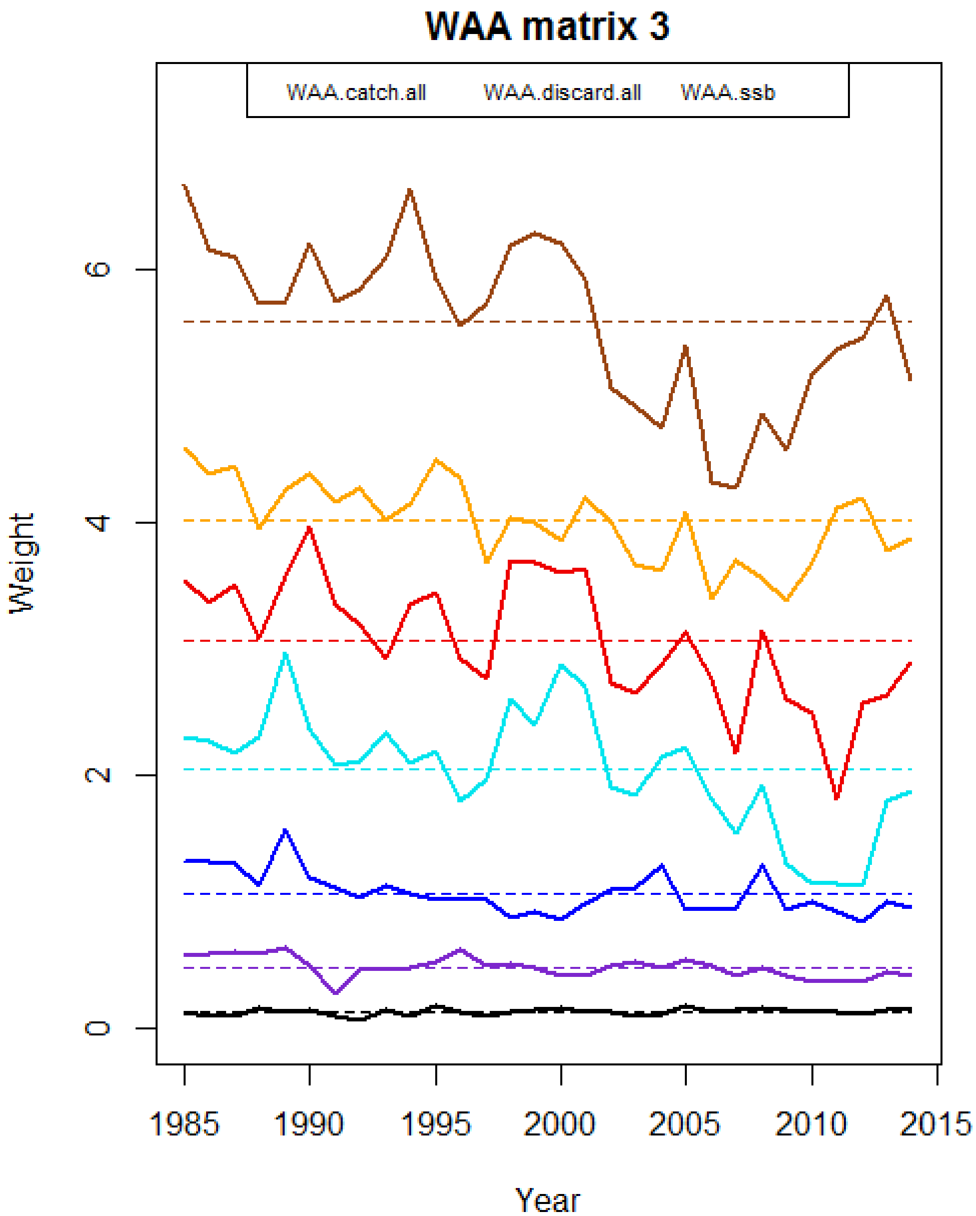


Figure B7.38. Bluefish weight-at-age (Ages 0-6+) for the catch (all fleets) from 1985 to 2014.

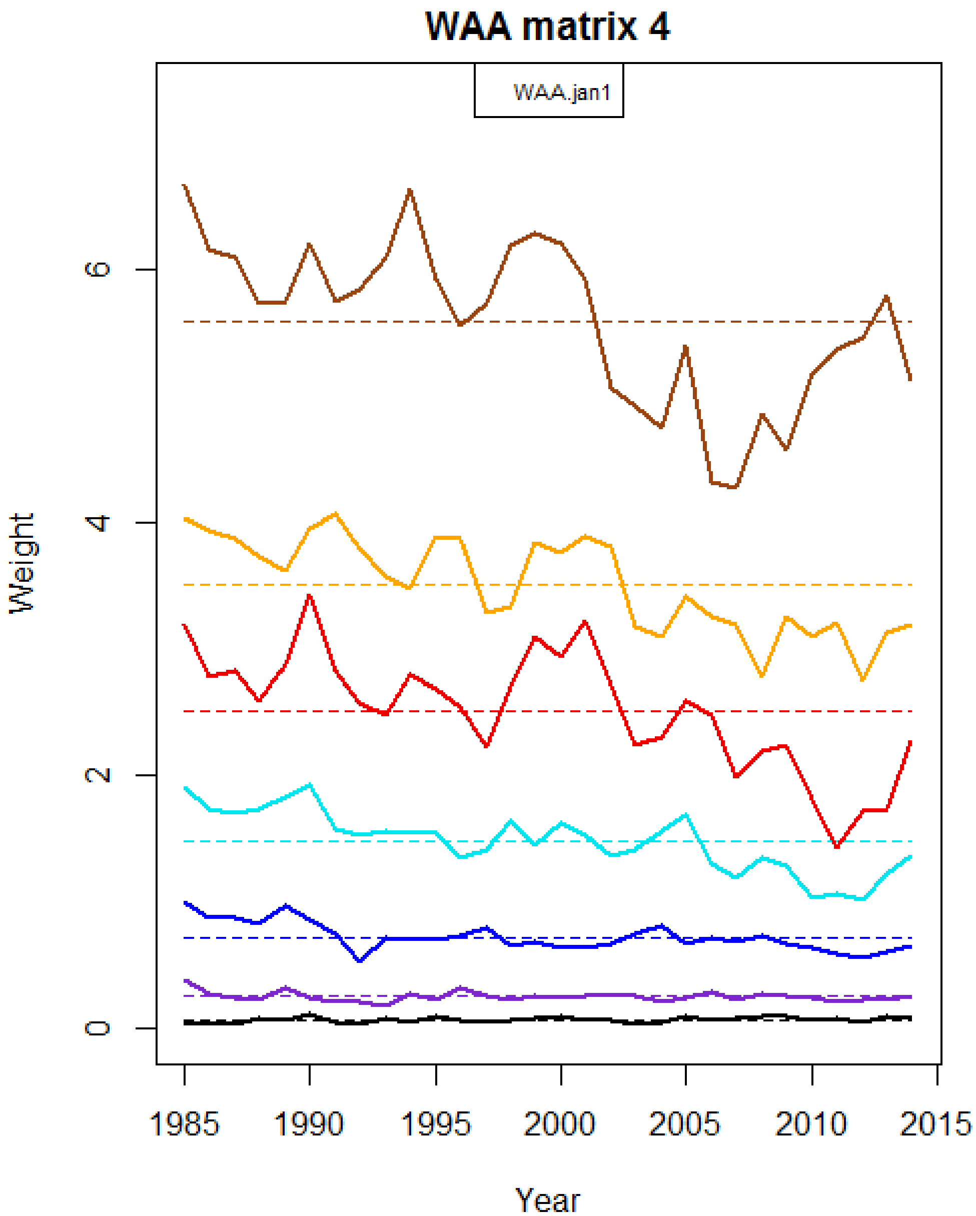


Figure B7.39. Bluefish Jan-1 weight-at-age (Ages 0-6+) for all fleets from 1985 to 2014.

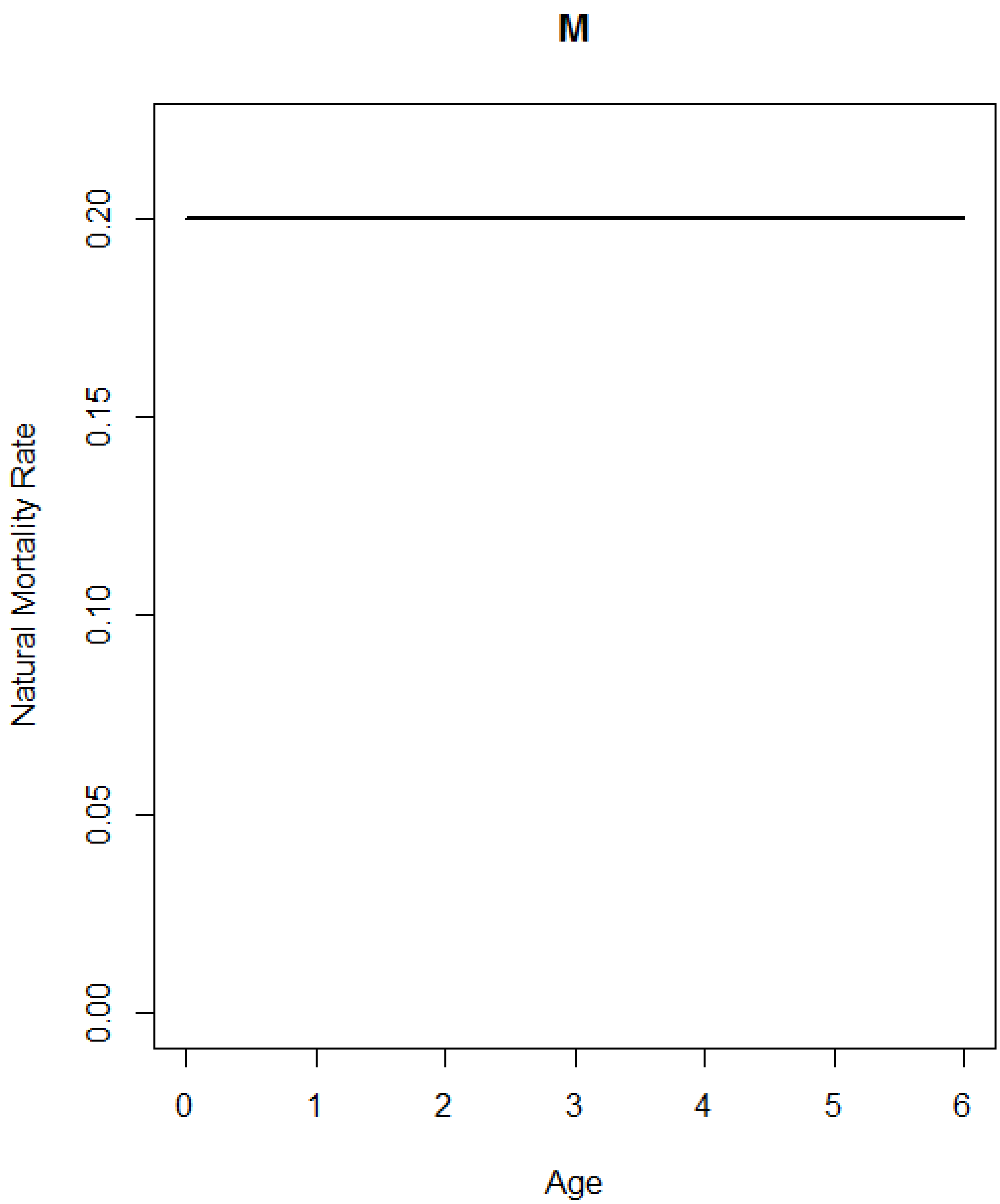


Figure B7.40. Bluefish natural mortality for the final model, kept constant at 0.2 for all ages across all years.

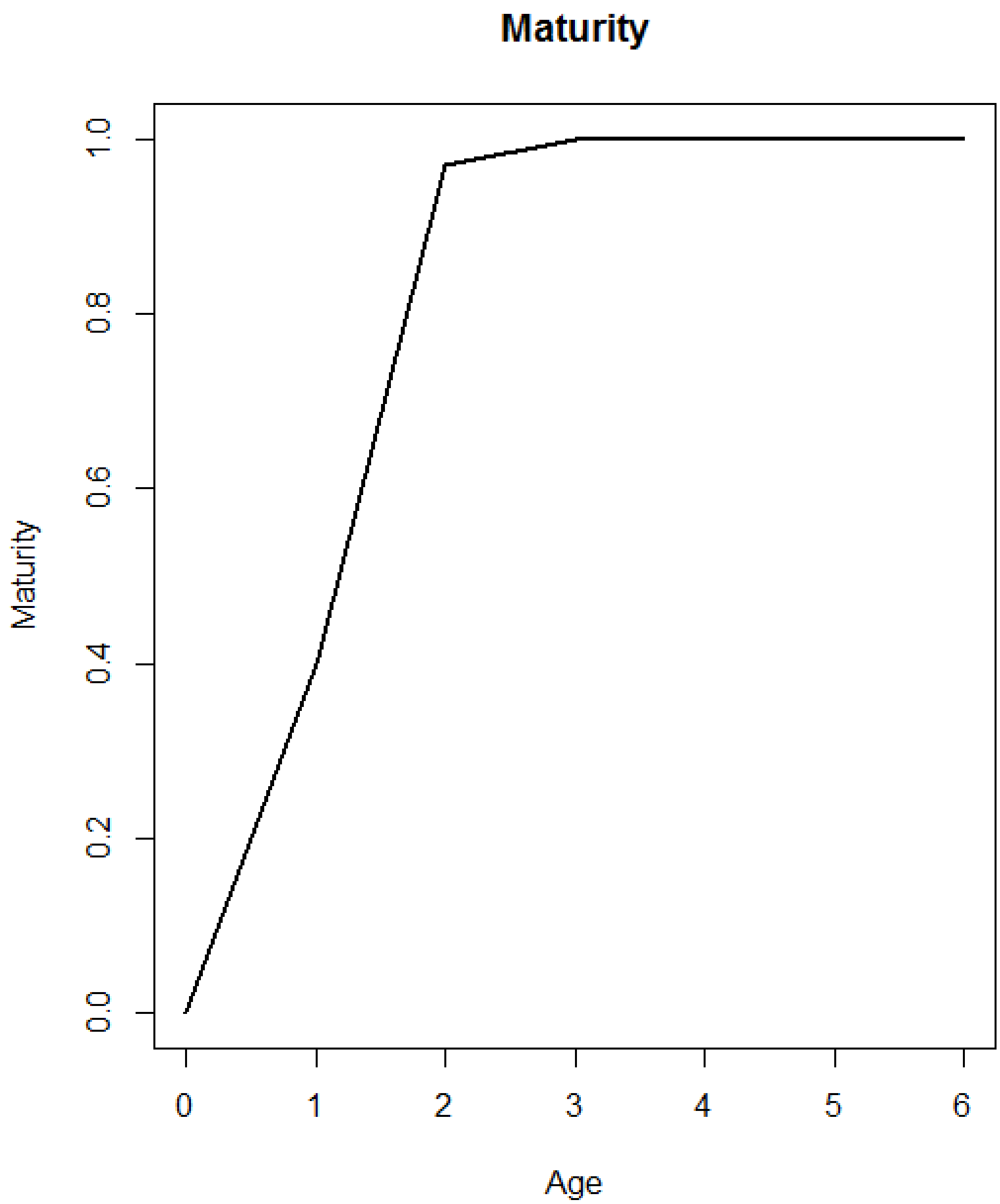


Figure B7.41. Bluefish maturity-at-age for the final model, kept constant across all years.

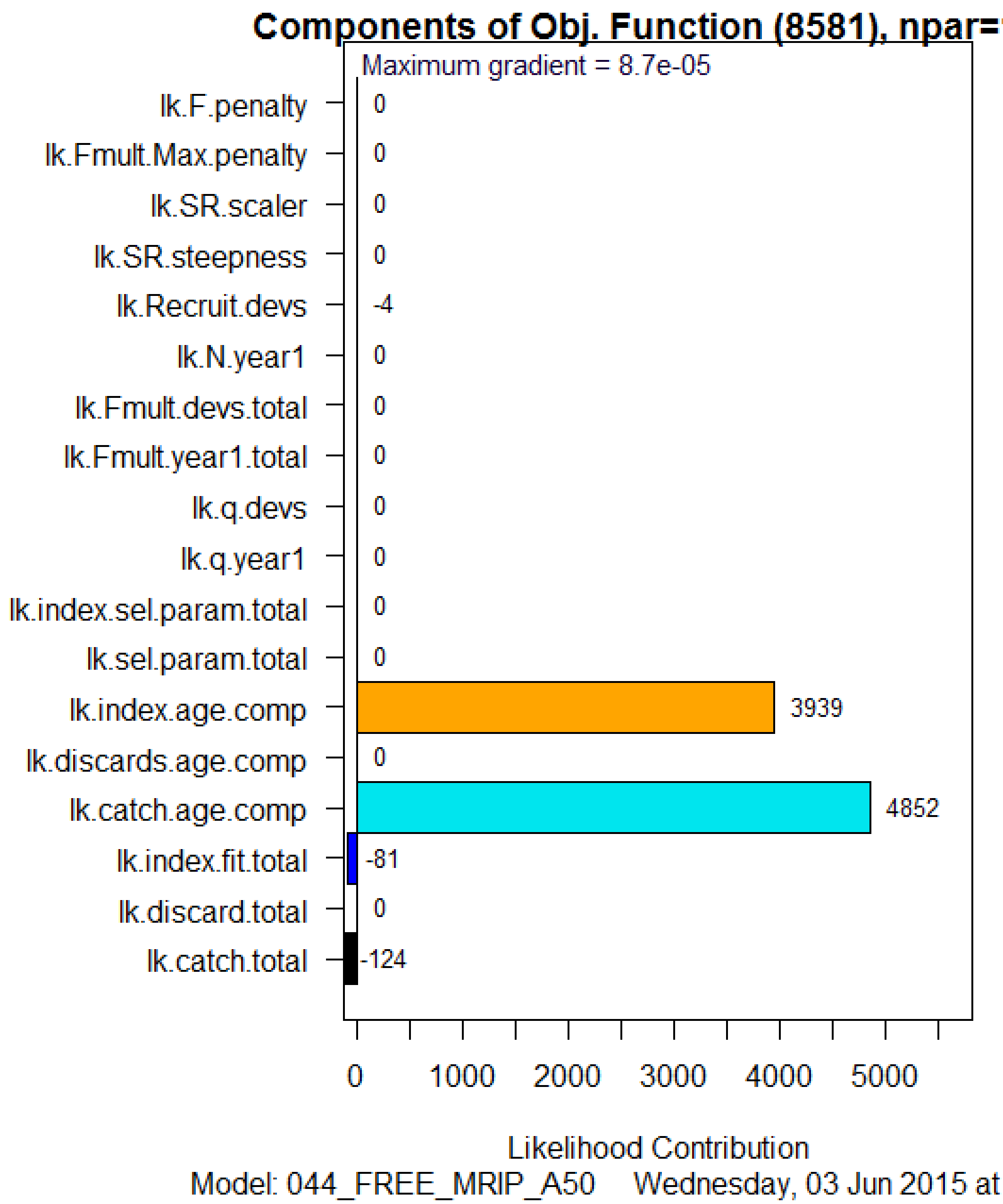


Figure B7.42. Objective function components of model BFINAL.

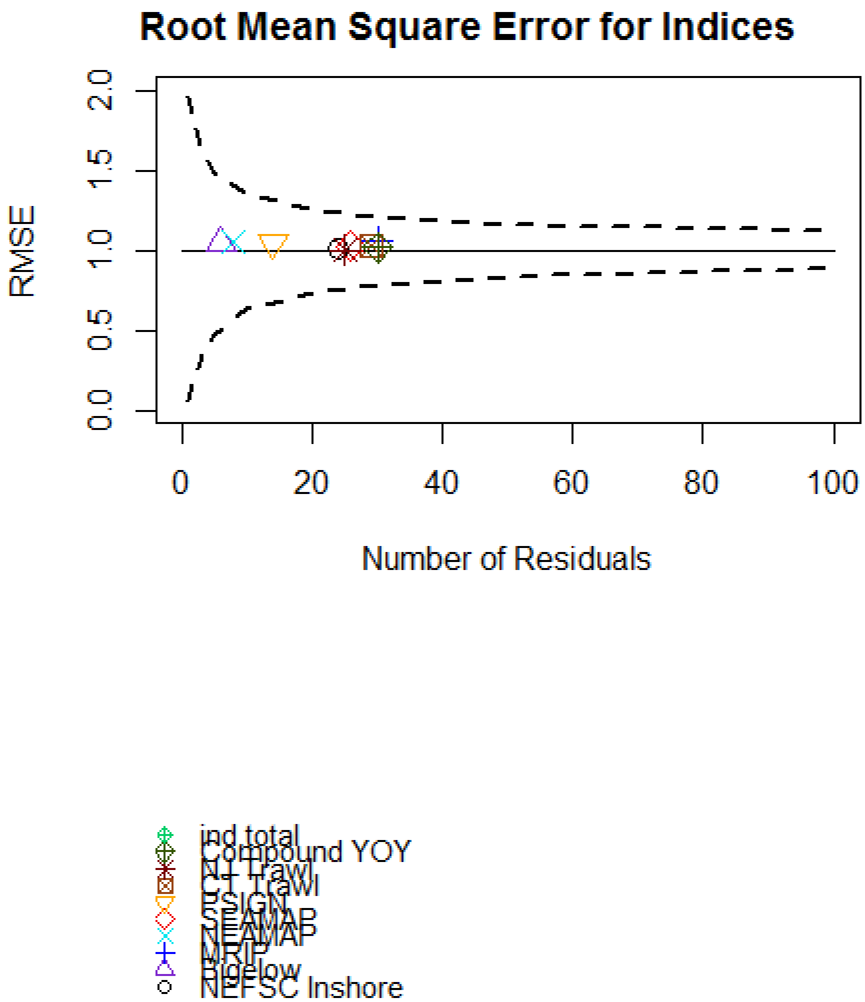


Figure B7.43. RMSE of the final indices after iterative adjustment of the input CVs.

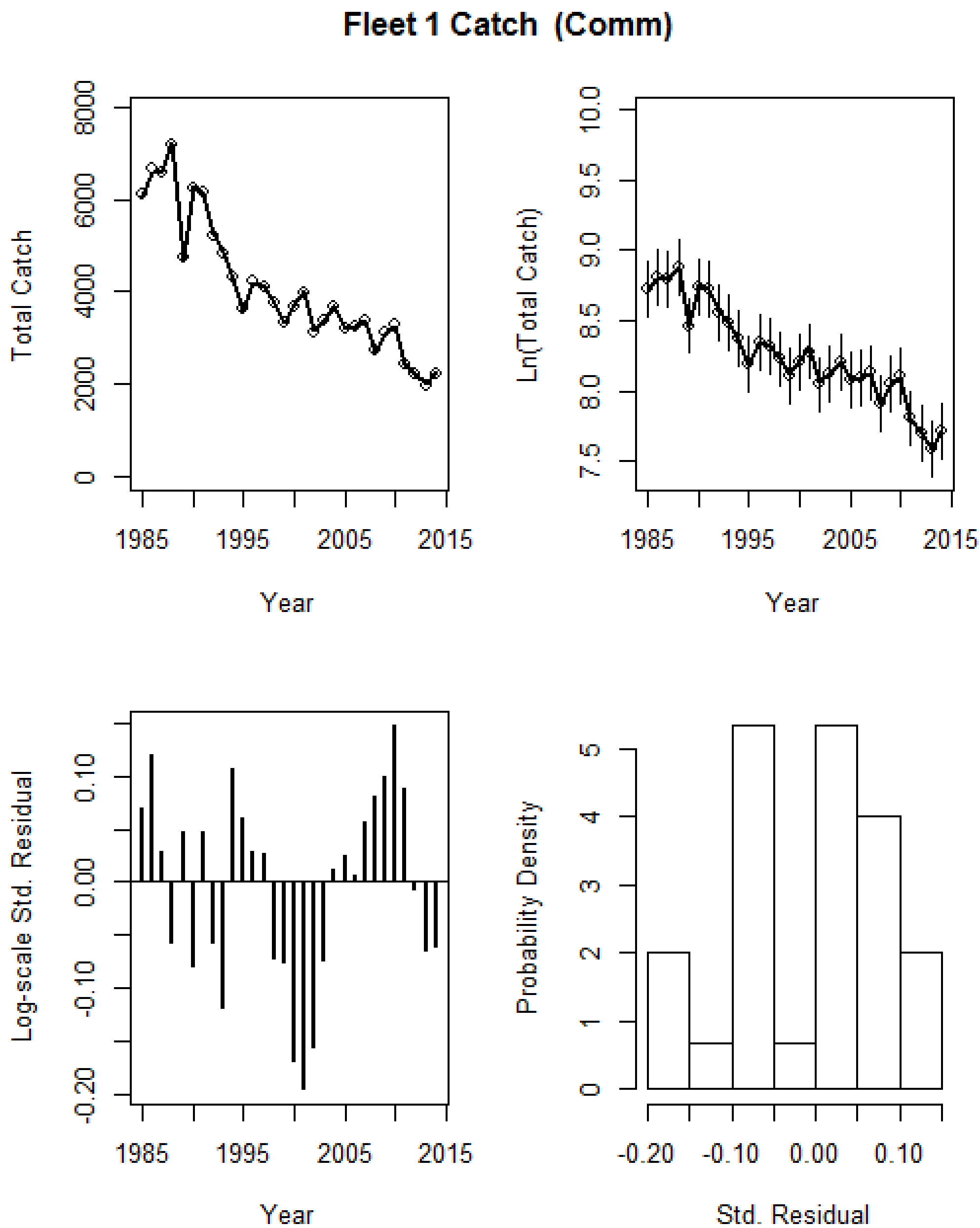


Figure B7.44. Final model fit to the commercial catch fleet with log-scale standardized residuals and residual probability density.

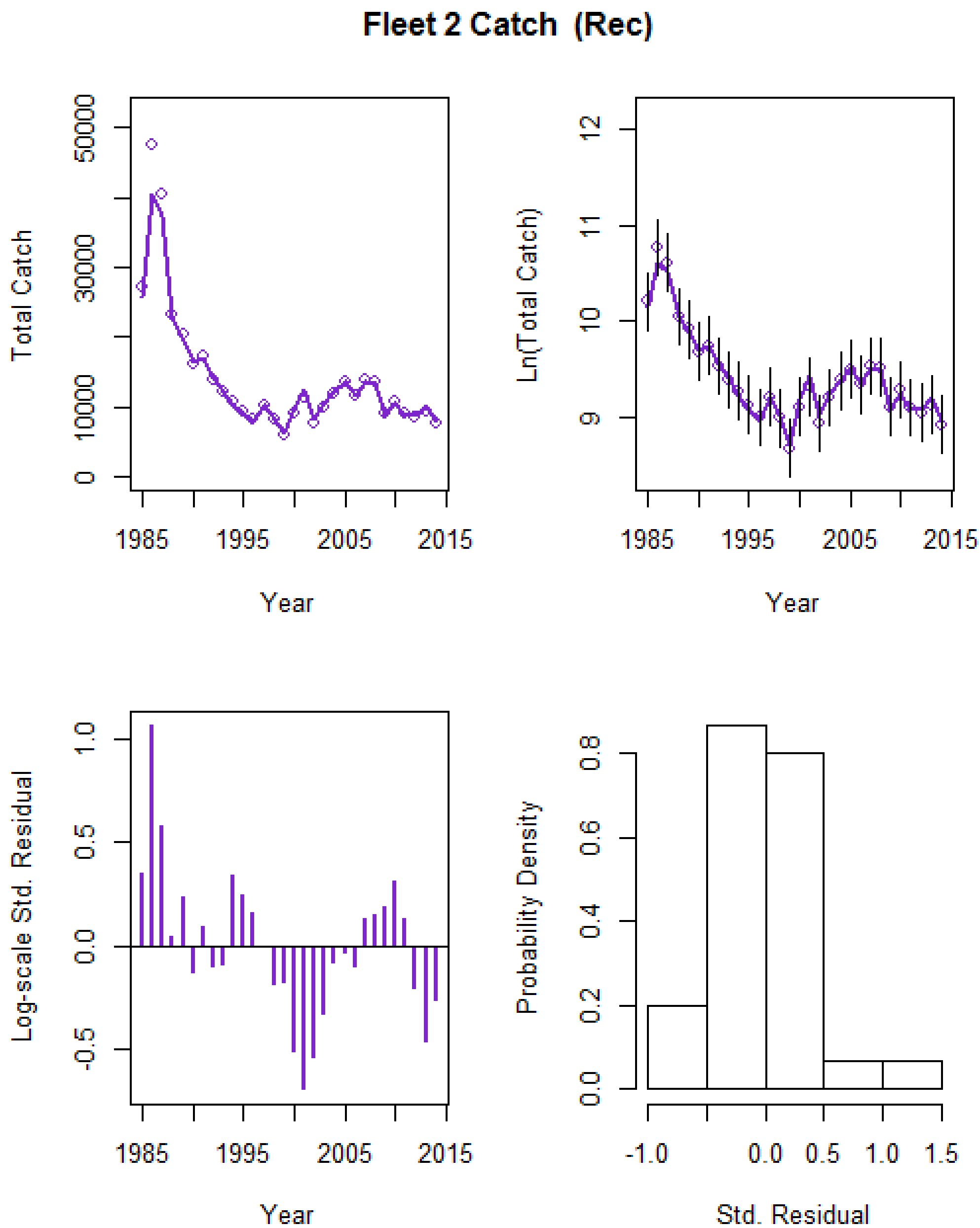


Figure B7.45. Final model fit to the recreational catch fleet with log-scale standardized residuals and residual probability density.

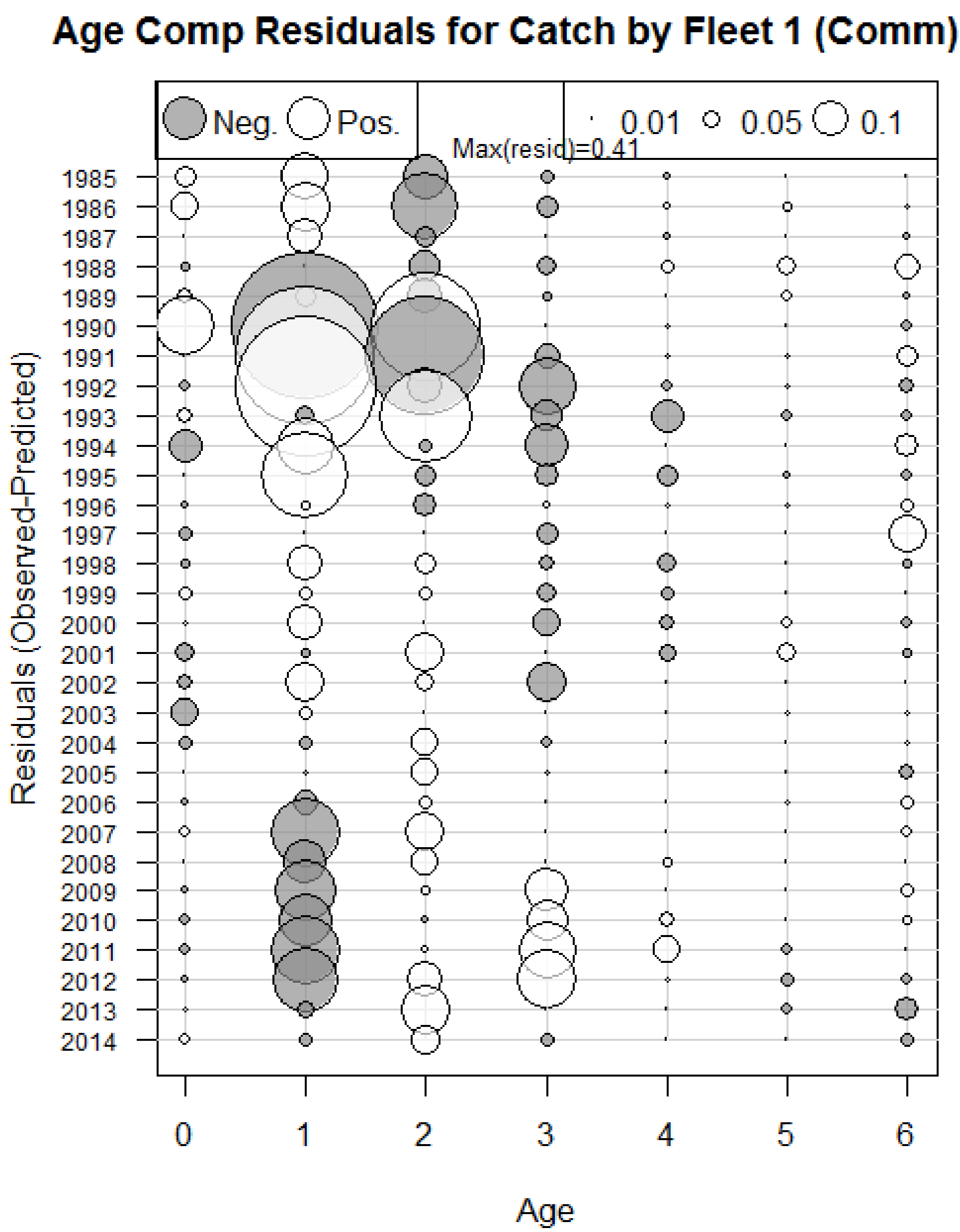


Figure B7.46. Age-composition residuals for the commercial catch fleet.

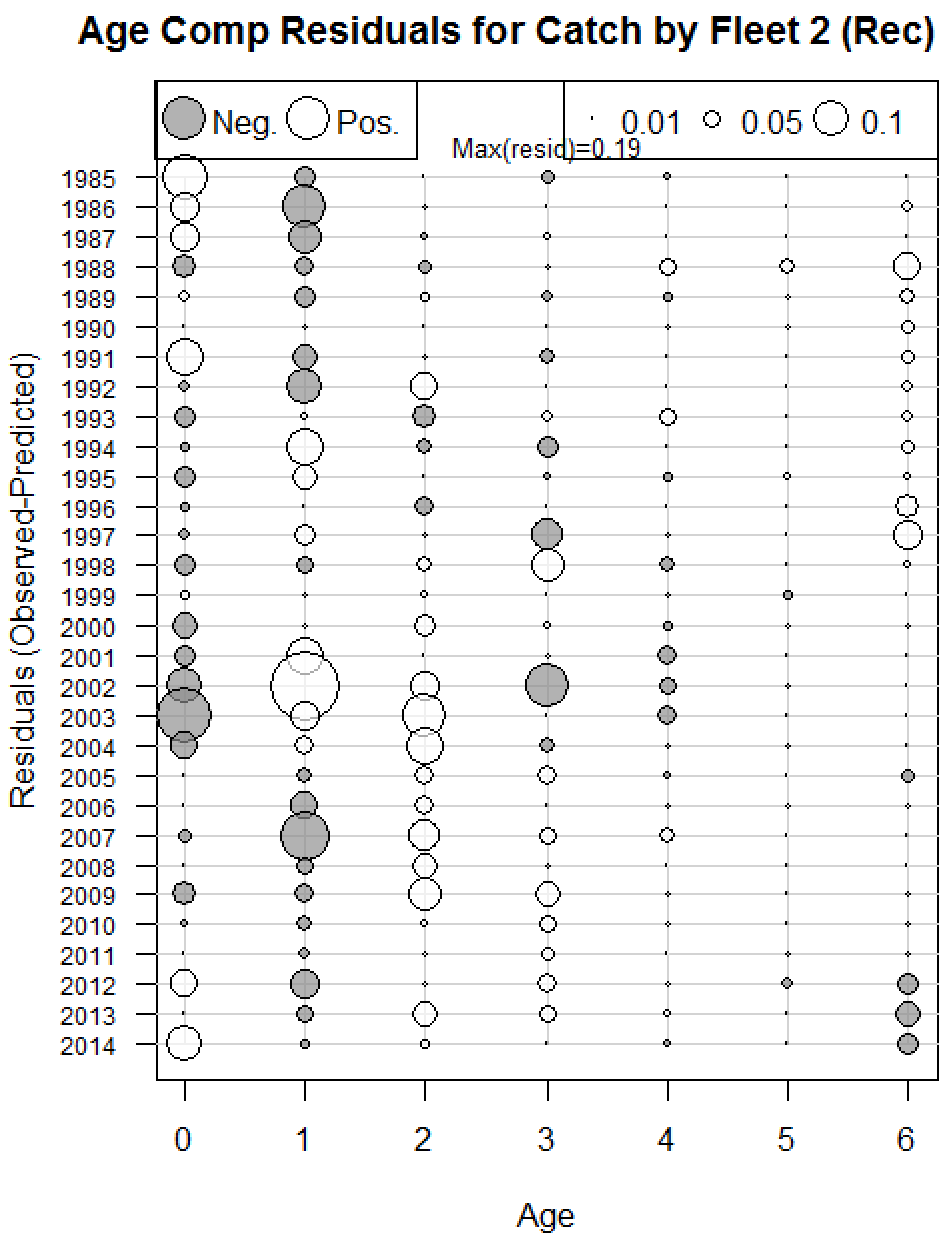


Figure B7.47. Age composition residuals for the recreational catch fleet.

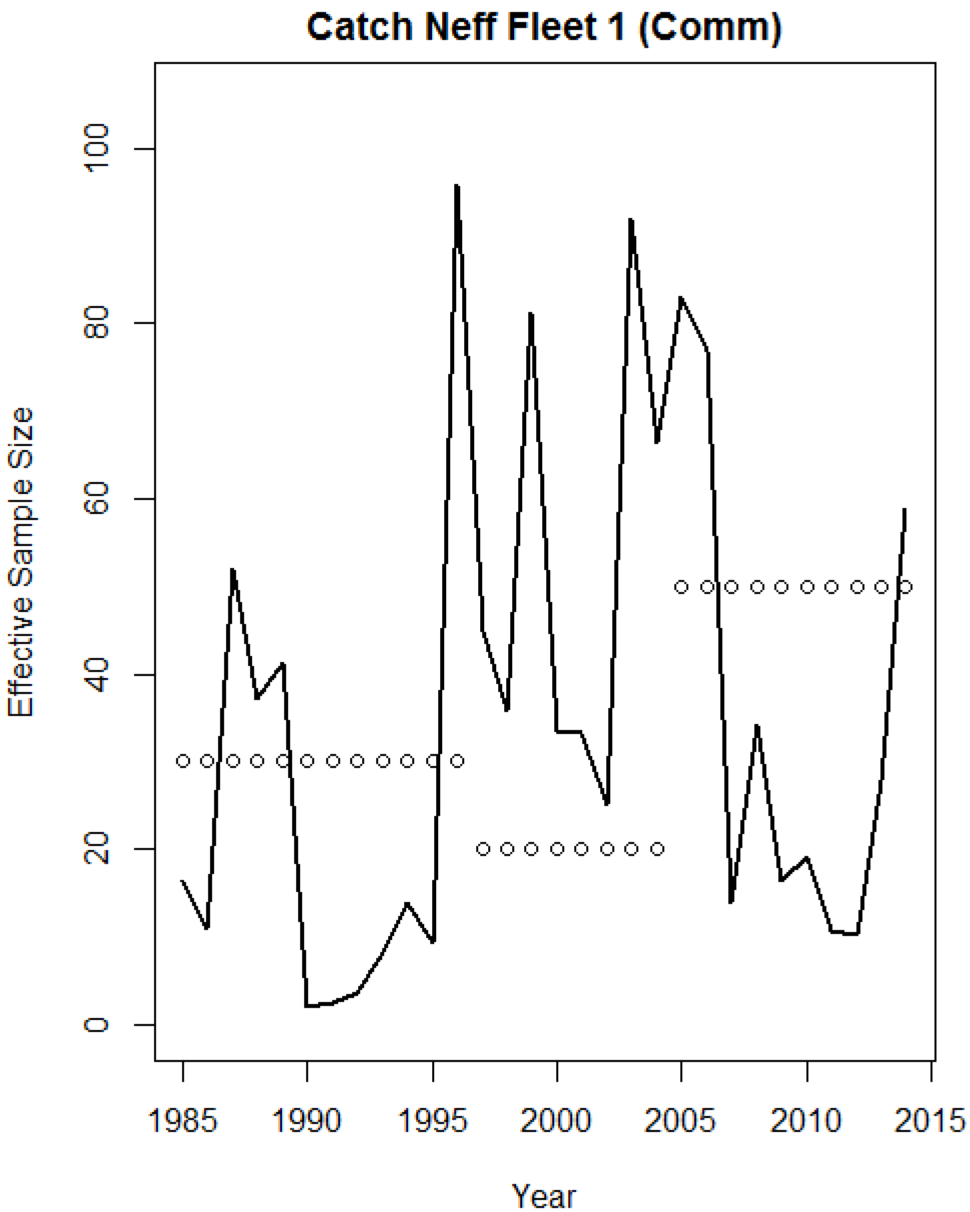


Figure B7.48. Input and estimated effective sample size for the commercial catch fleet.

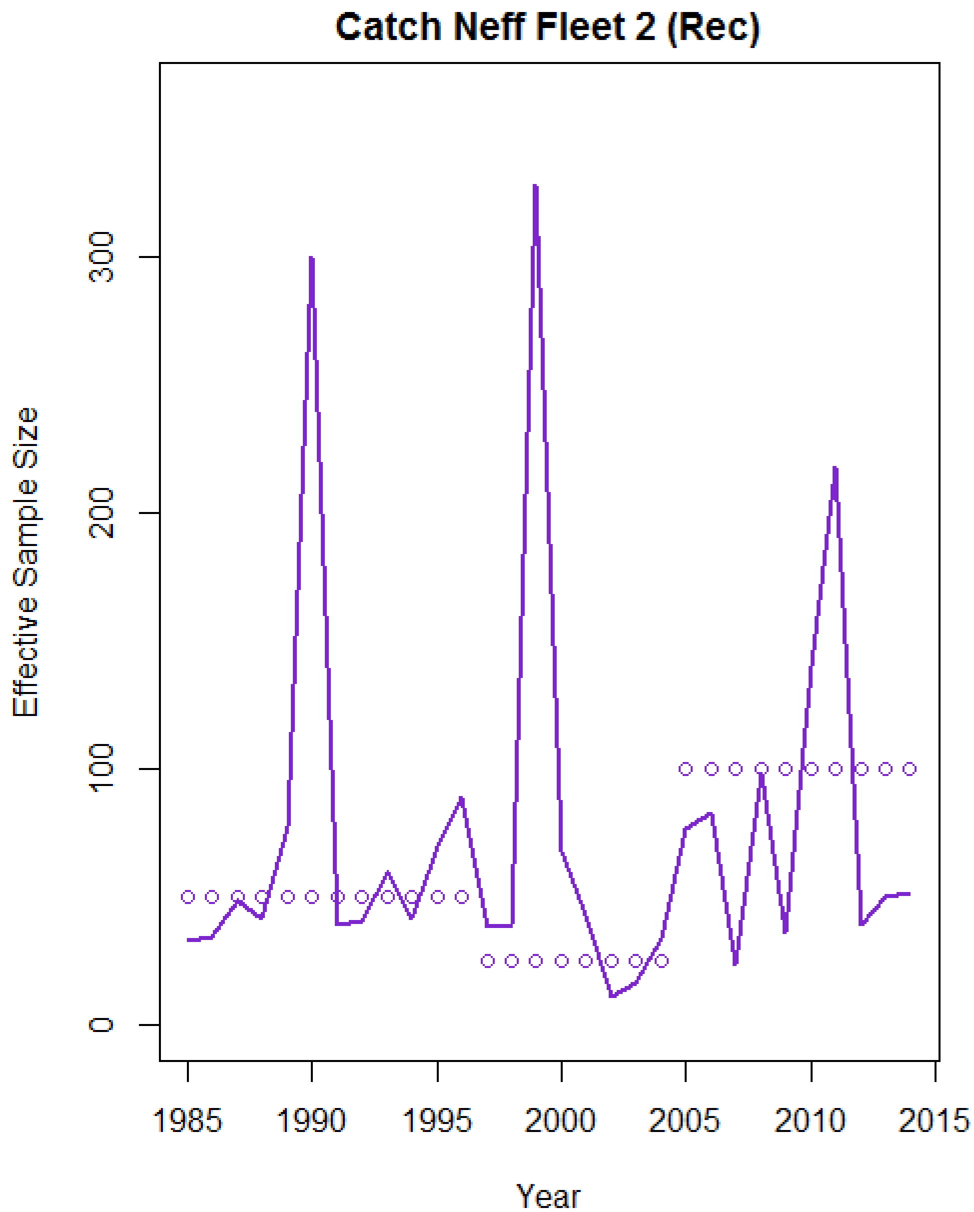


Figure B7.49. Input and estimated effective sample size for the recreational catch fleet.

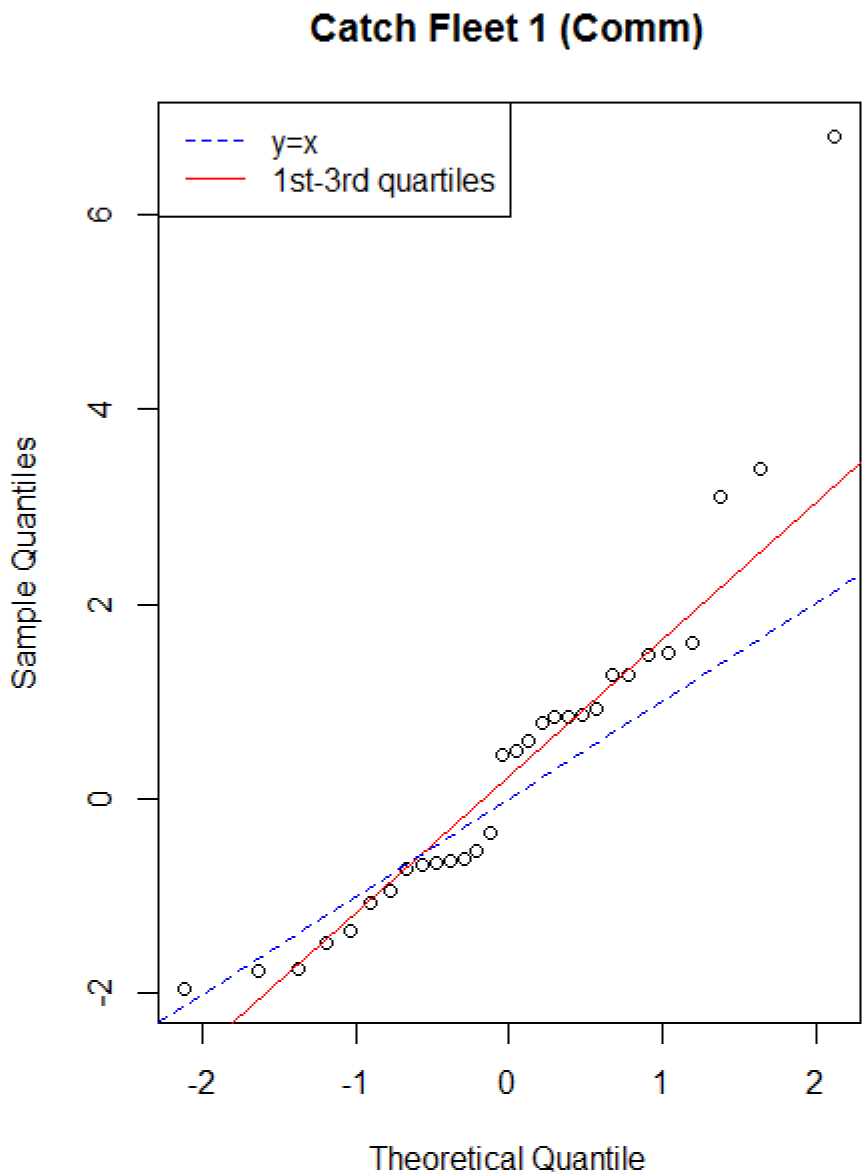


Figure B7.50. QQ-plot for the observed versus predicted mean catch for the commercial catch fleet.

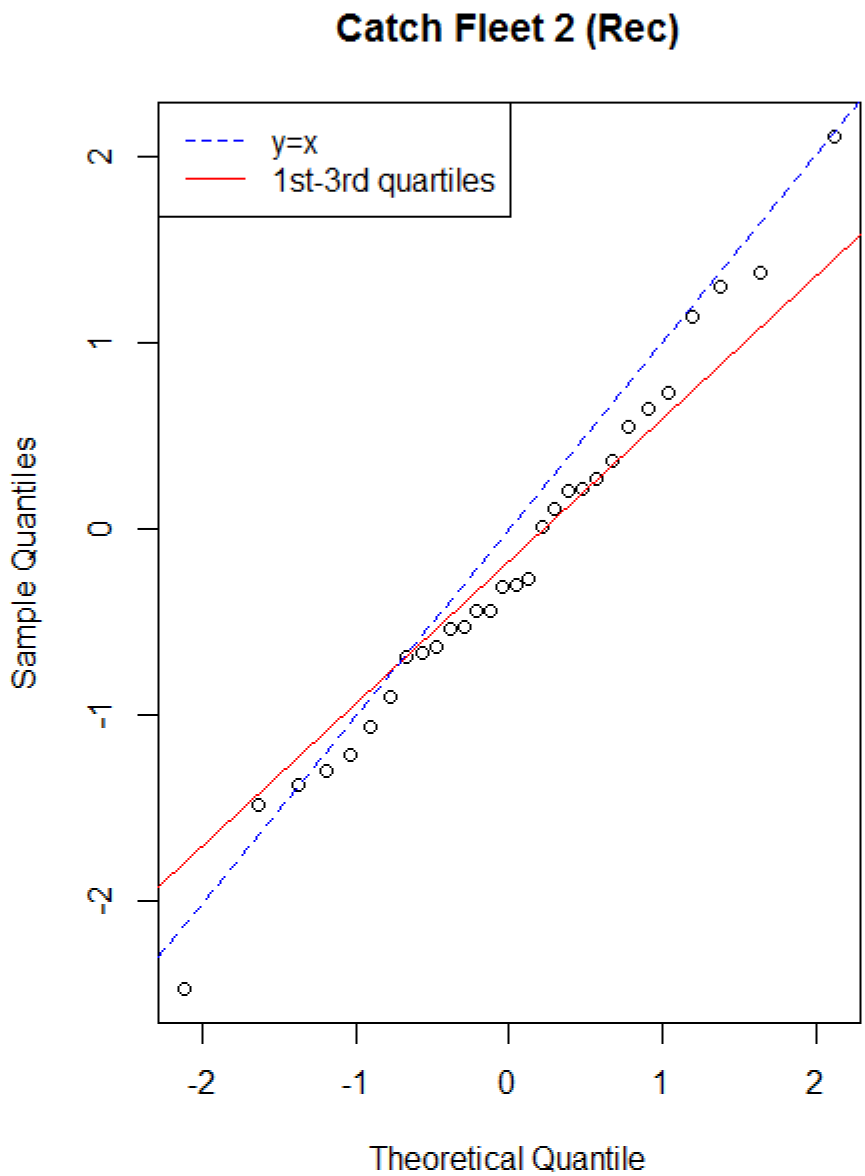


Figure B7.51. QQ-plot for the observed versus predicted mean catch for the recreational catch fleet.

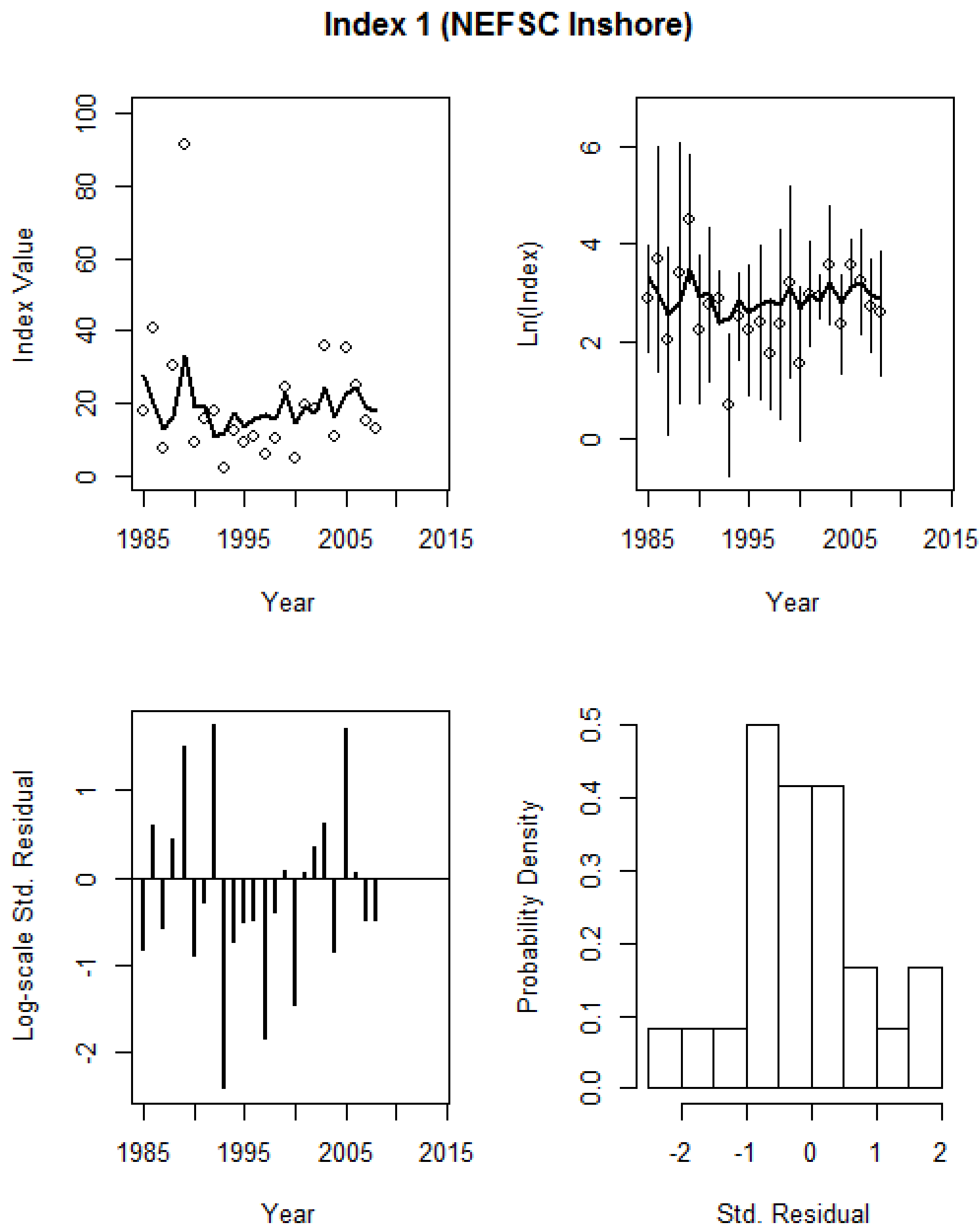


Figure B7.52. Final model fit to the NEFSC Inshore survey with log-scale standardized residuals and residual probability density.

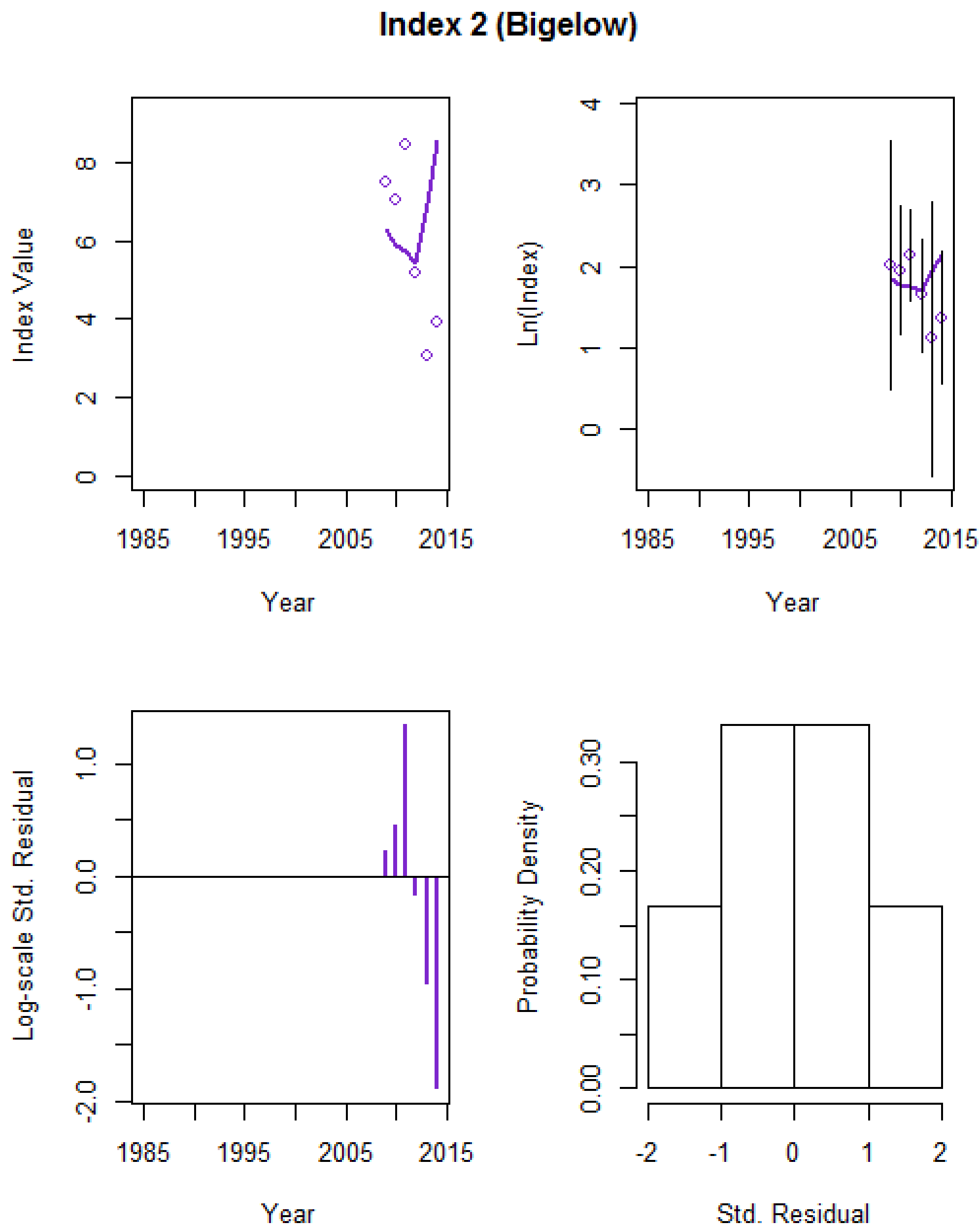


Figure B7.53. Final model fit to the NEFSC Bigelow survey with log-scale standardized residuals and residual probability density.

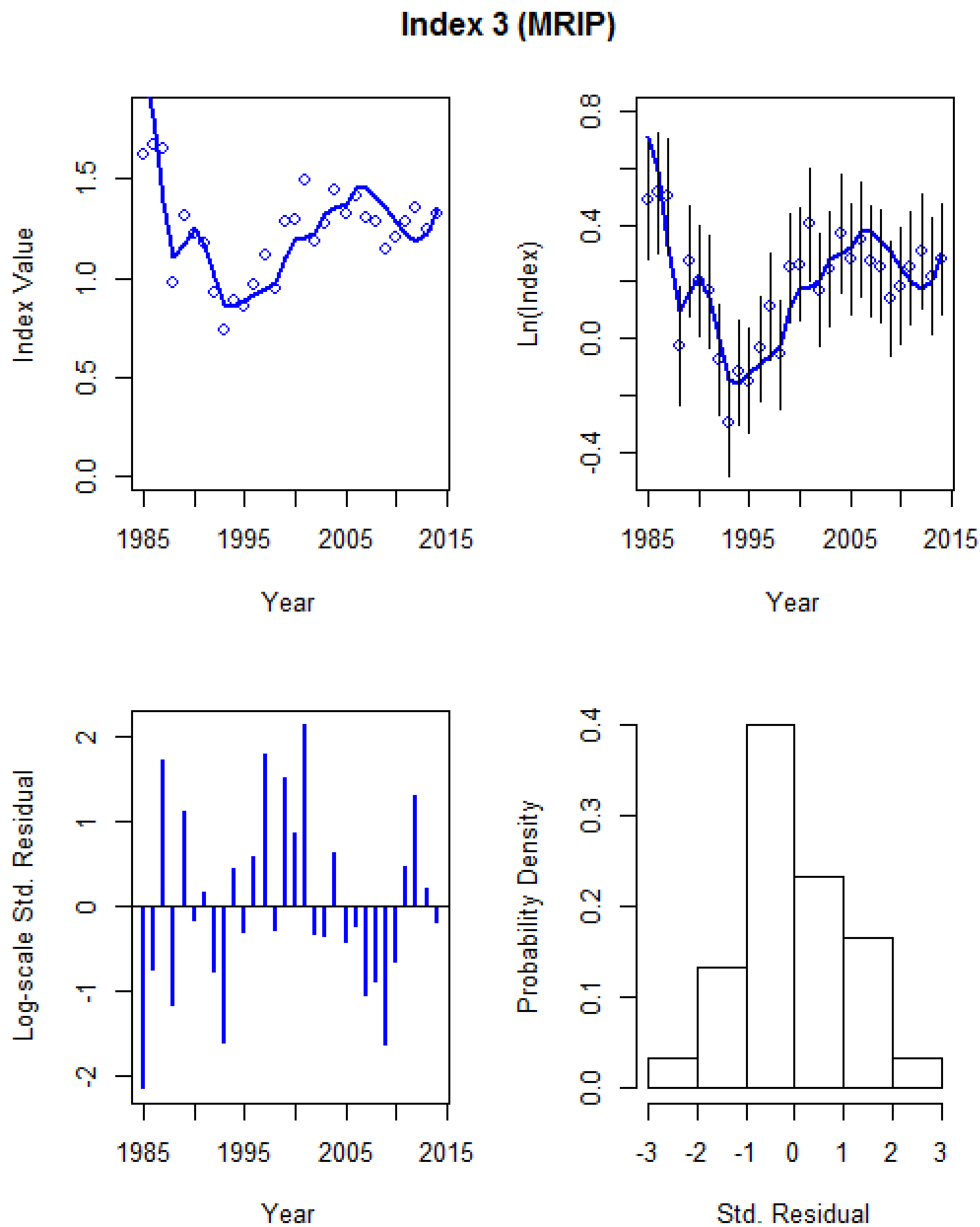


Figure B7.54. Final model fit to the MRIP recreational CPUE index with log-scale standardized residuals and residual probability density.

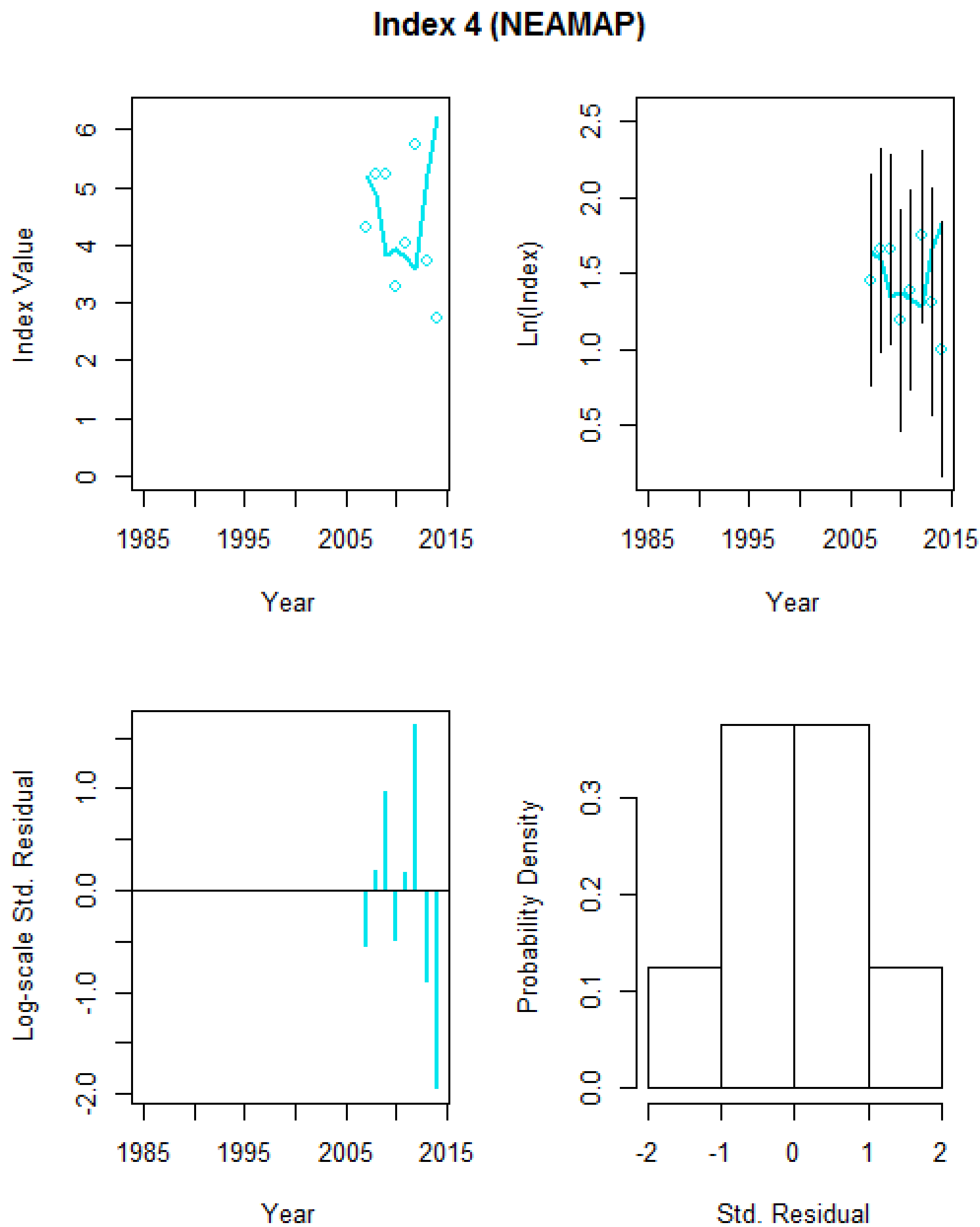


Figure B7.55. Final model fit to the NEAMAP survey with log-scale standardized residuals and residual probability density.

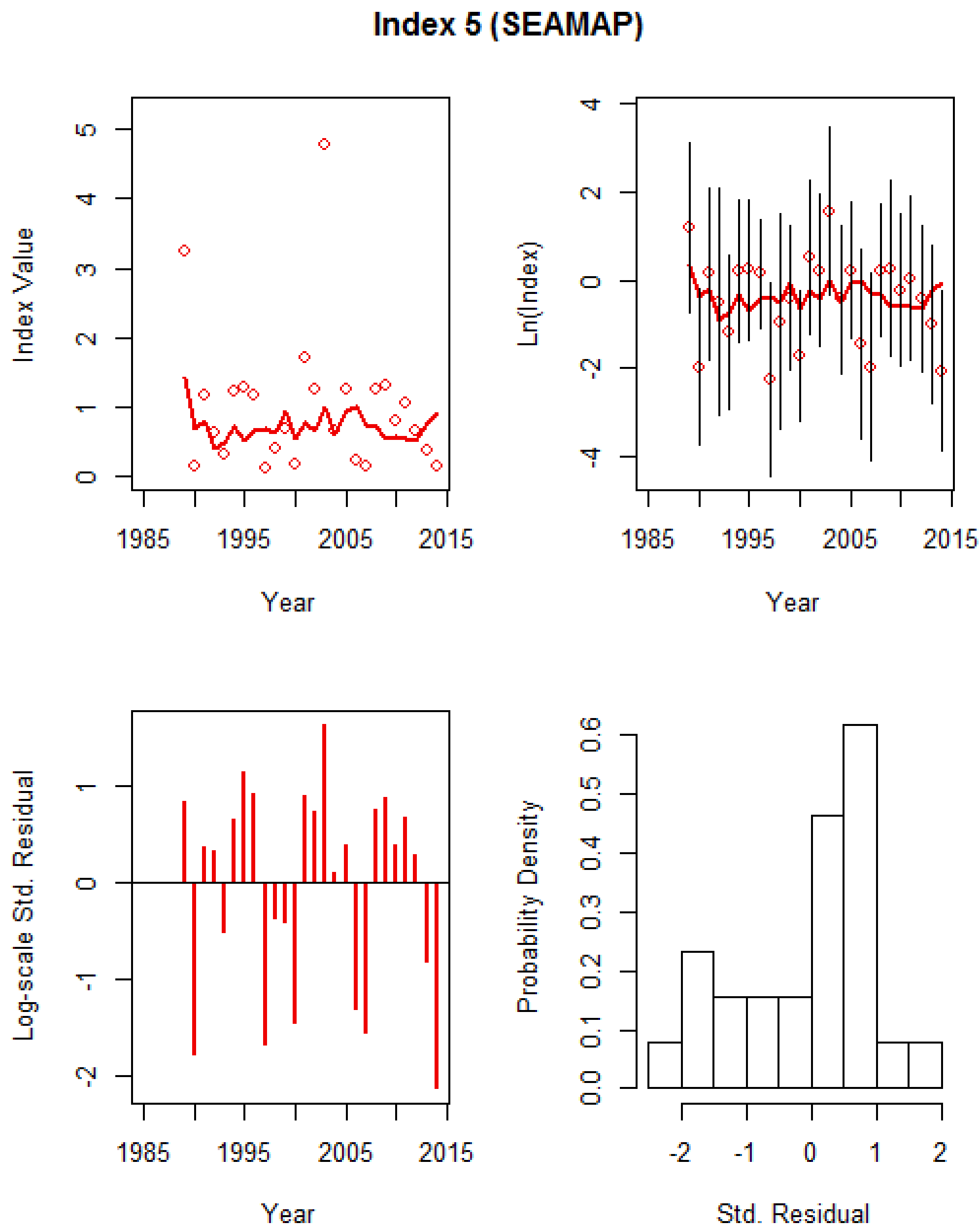


Figure B7.56. Final model fit to the SEAMAP Age 0 index with log-scale standardized residuals and residual probability density.

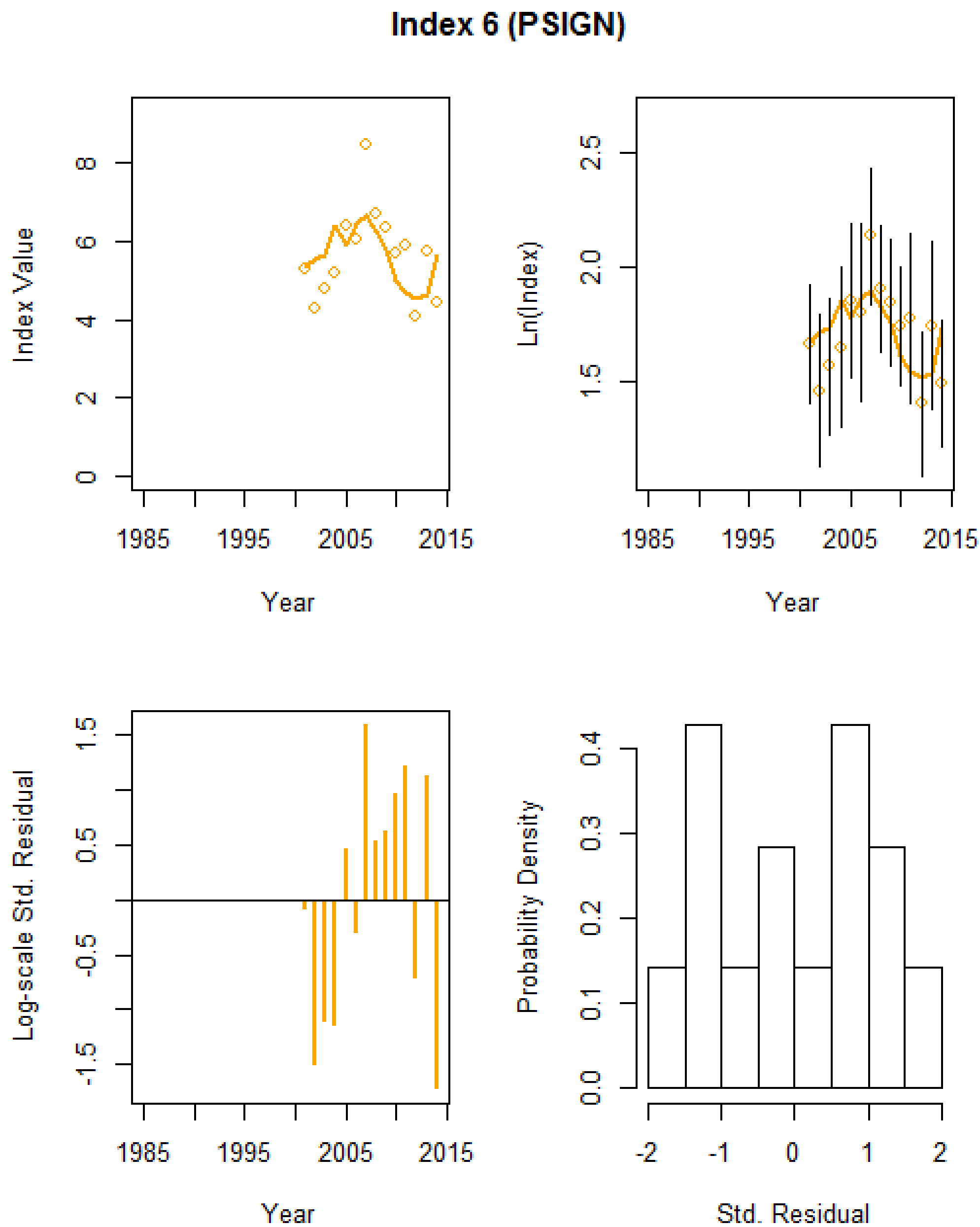


Figure B7.57. Final model fit to the PSIGNS gillnet survey with log-scale standardized residuals and residual probability density.

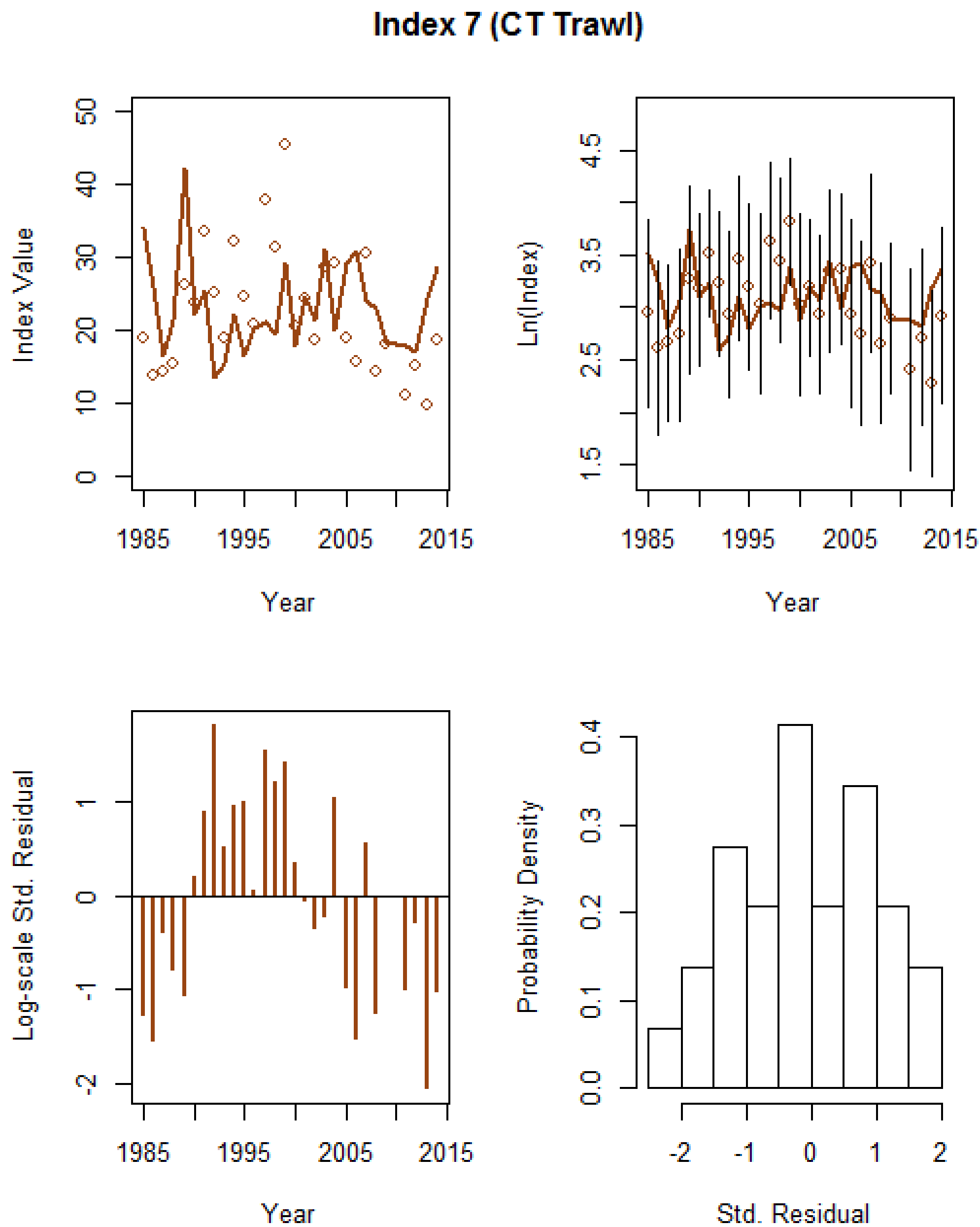


Figure B7.58. Final model fit to the CT LISTS trawl survey with log-scale standardized residuals and residual probability density.

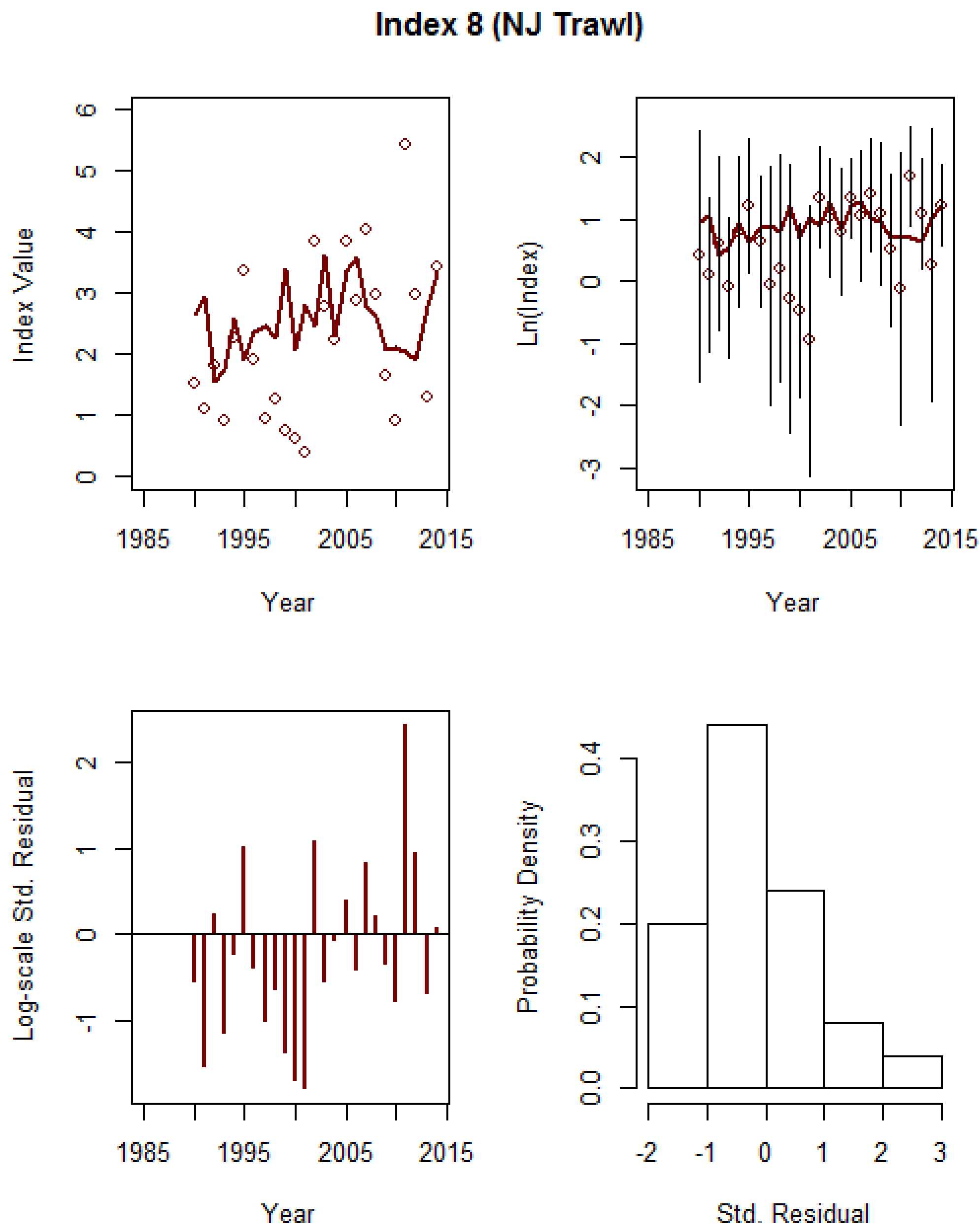


Figure B7.59. Final model fit to the NJ ocean trawl survey with log-scale standardized residuals and residual probability density.

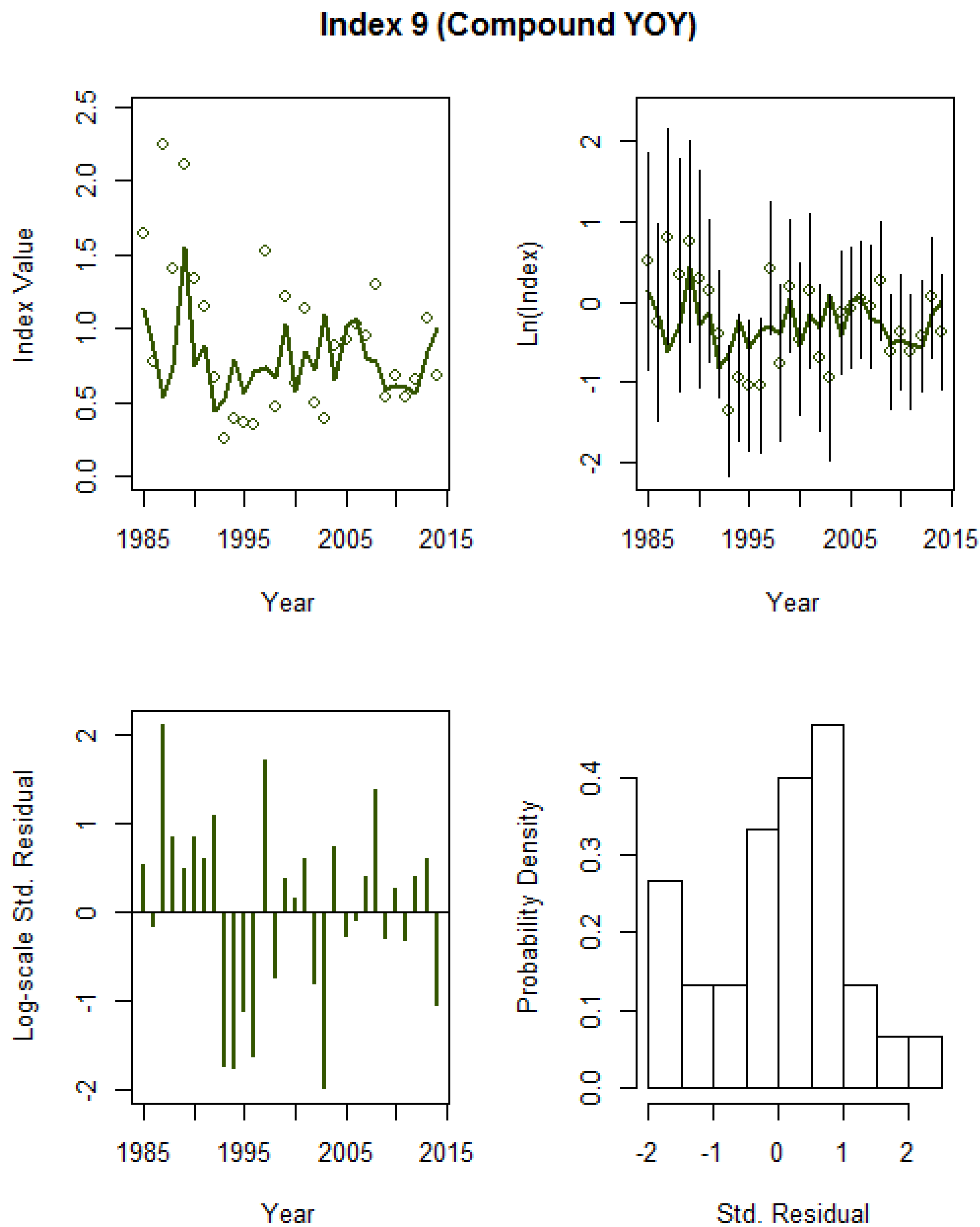


Figure B7.60. Final model fit to the composite YOY seine survey with log-scale standardized residuals and residual probability density.

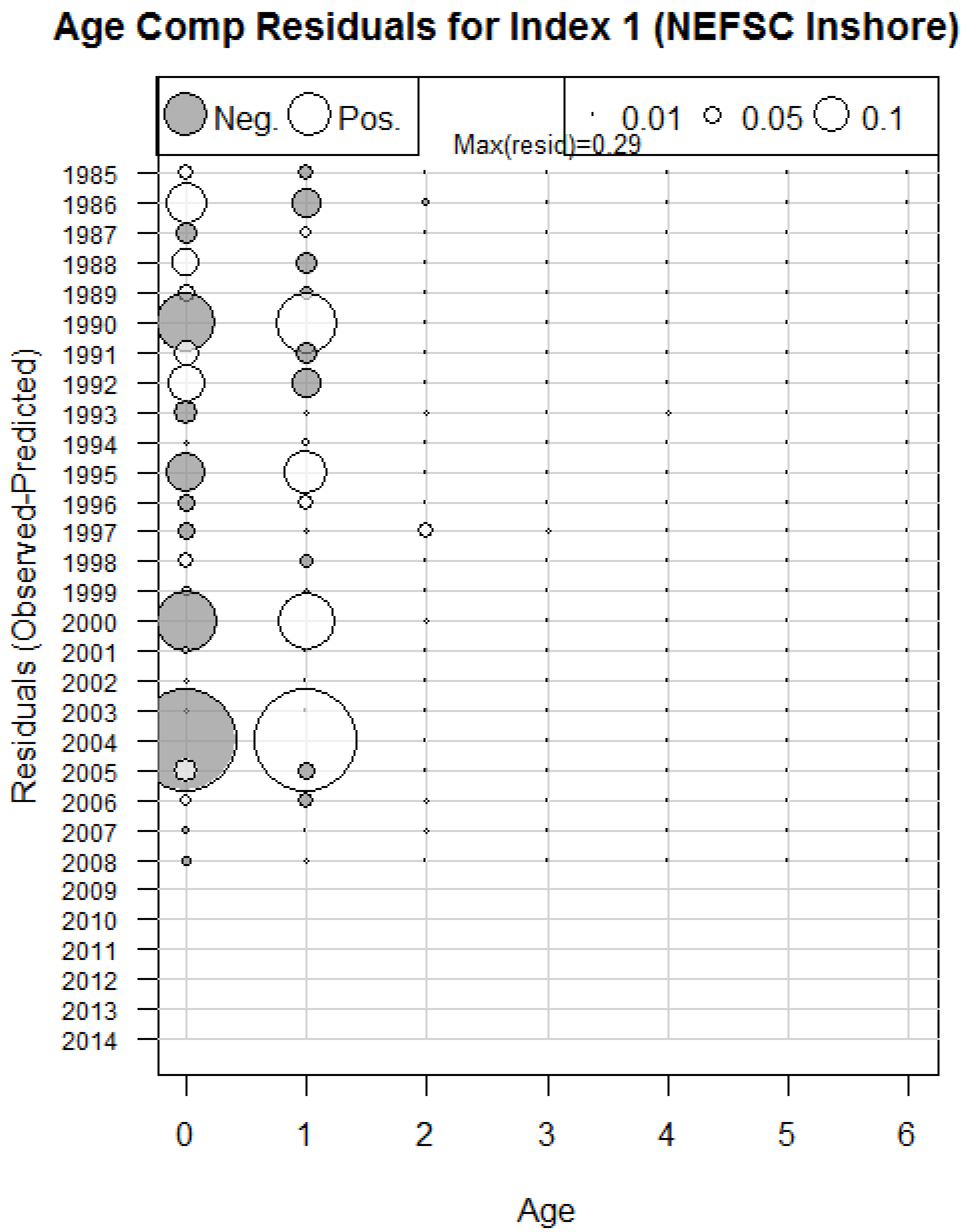


Figure B7.61. Age composition residuals for the NEFSC Inshore survey.

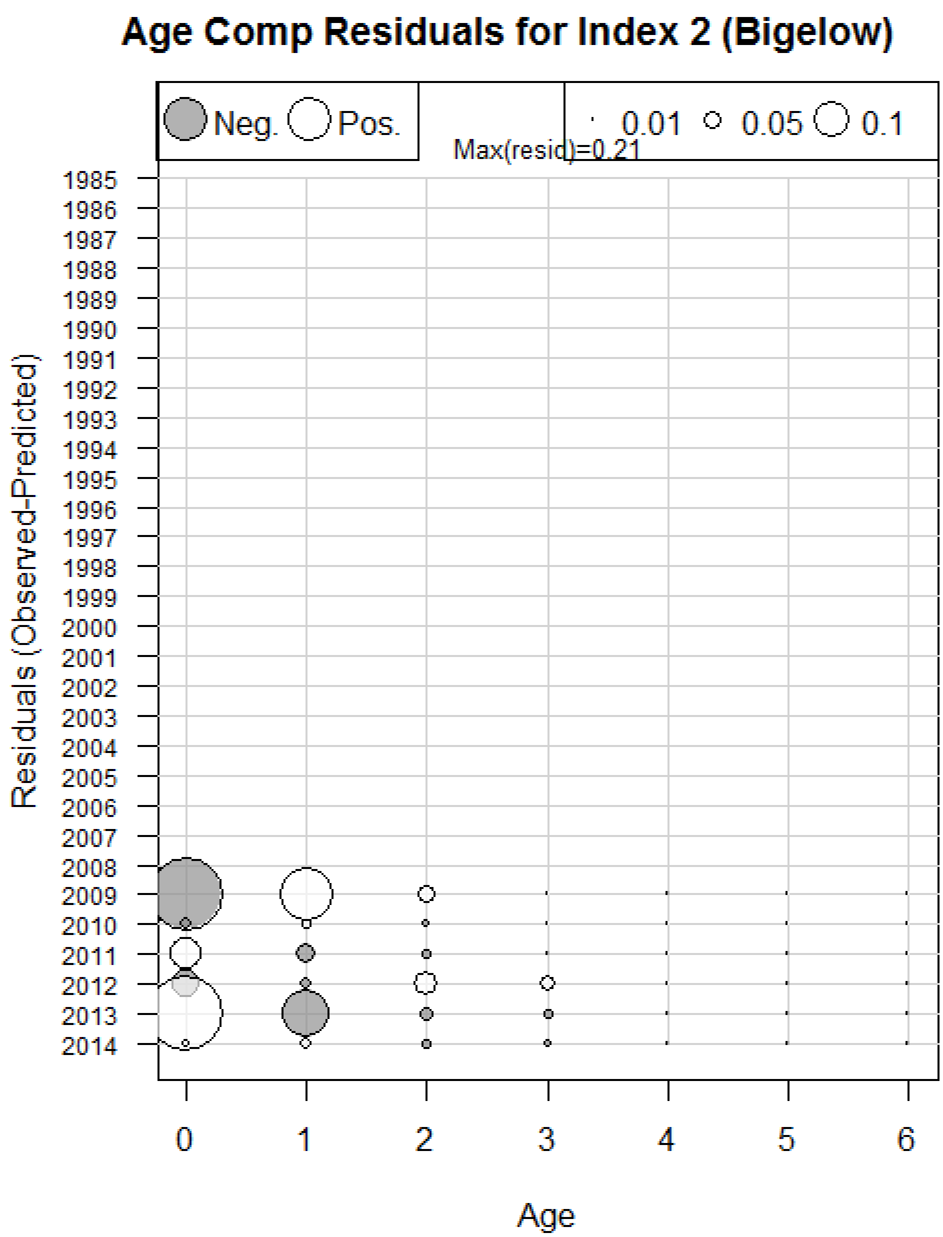


Figure B7.62. Age composition residuals for the NEFSC Bigelow survey.

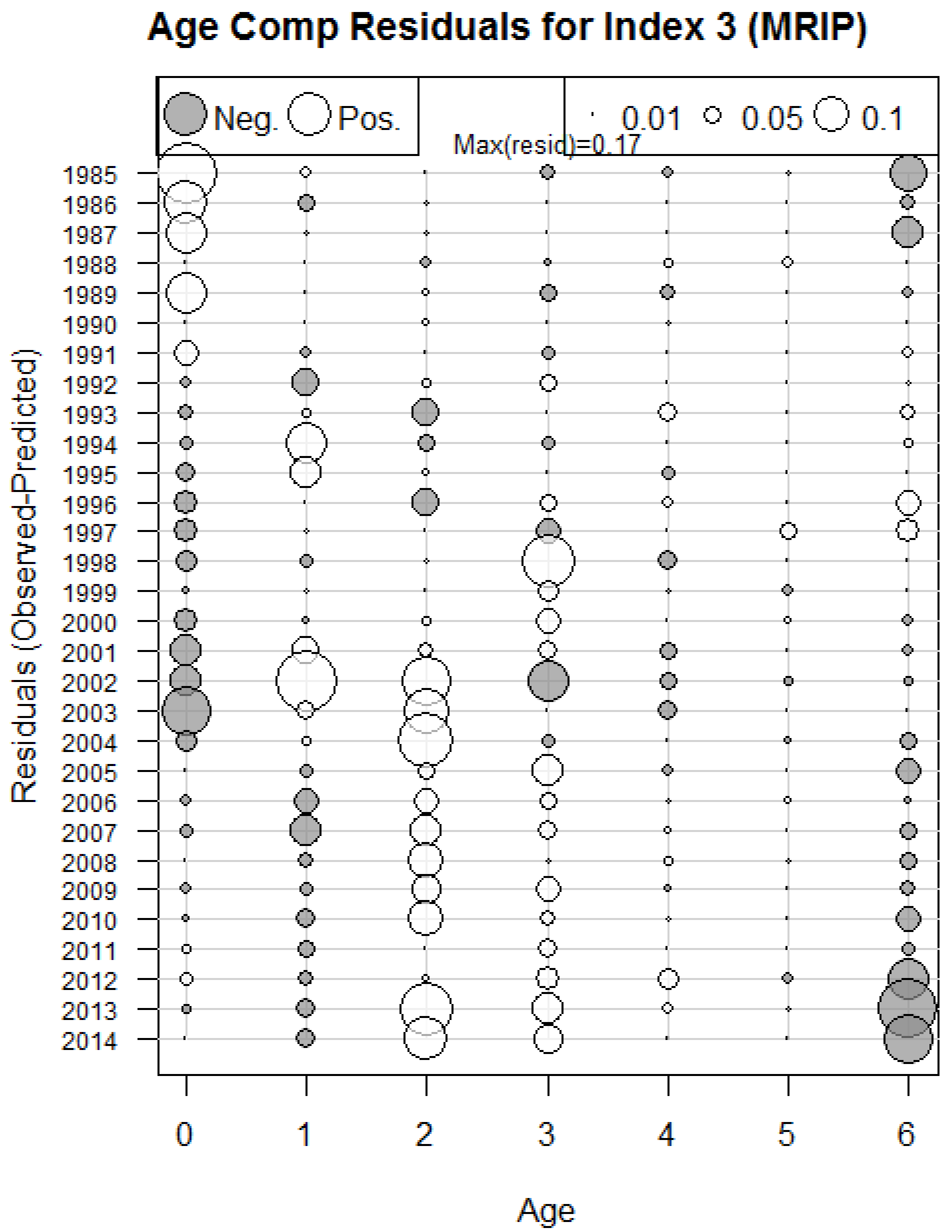


Figure B7.63. Age composition residuals for the MRIP recreational CPUE index.

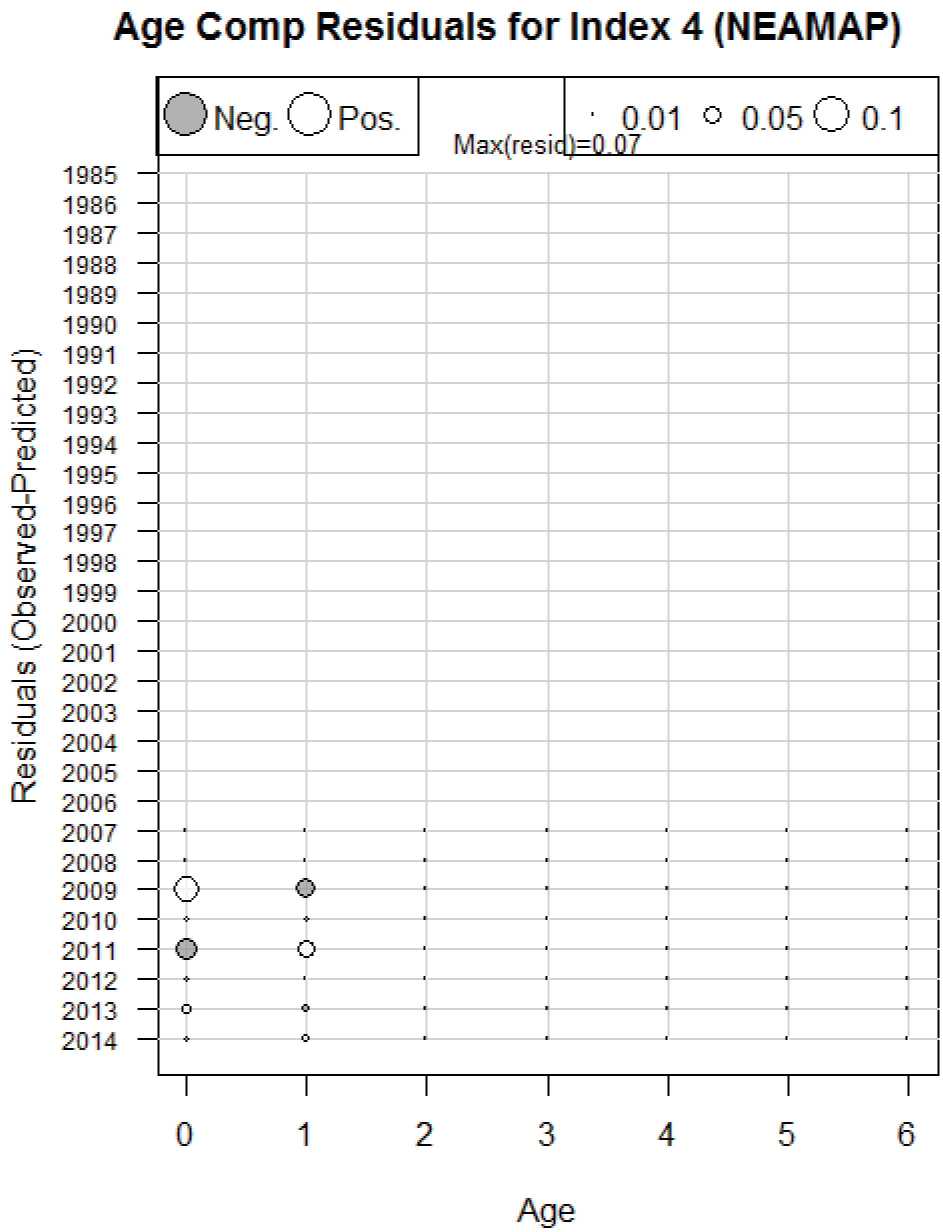


Figure B7.64. Age composition residuals for the NEAMAP survey.

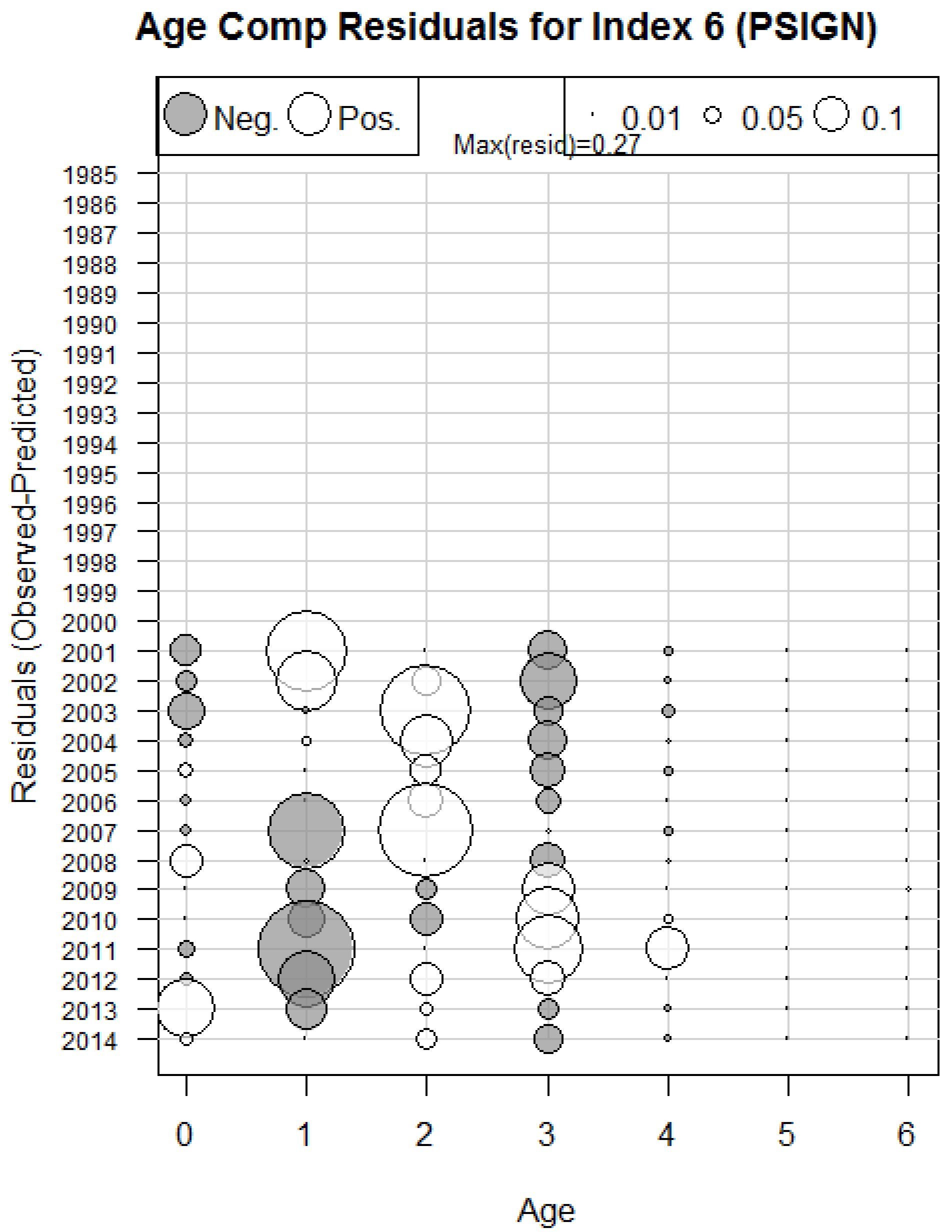


Figure B7.65. Age composition residuals for the PSIGNS gillnet survey.

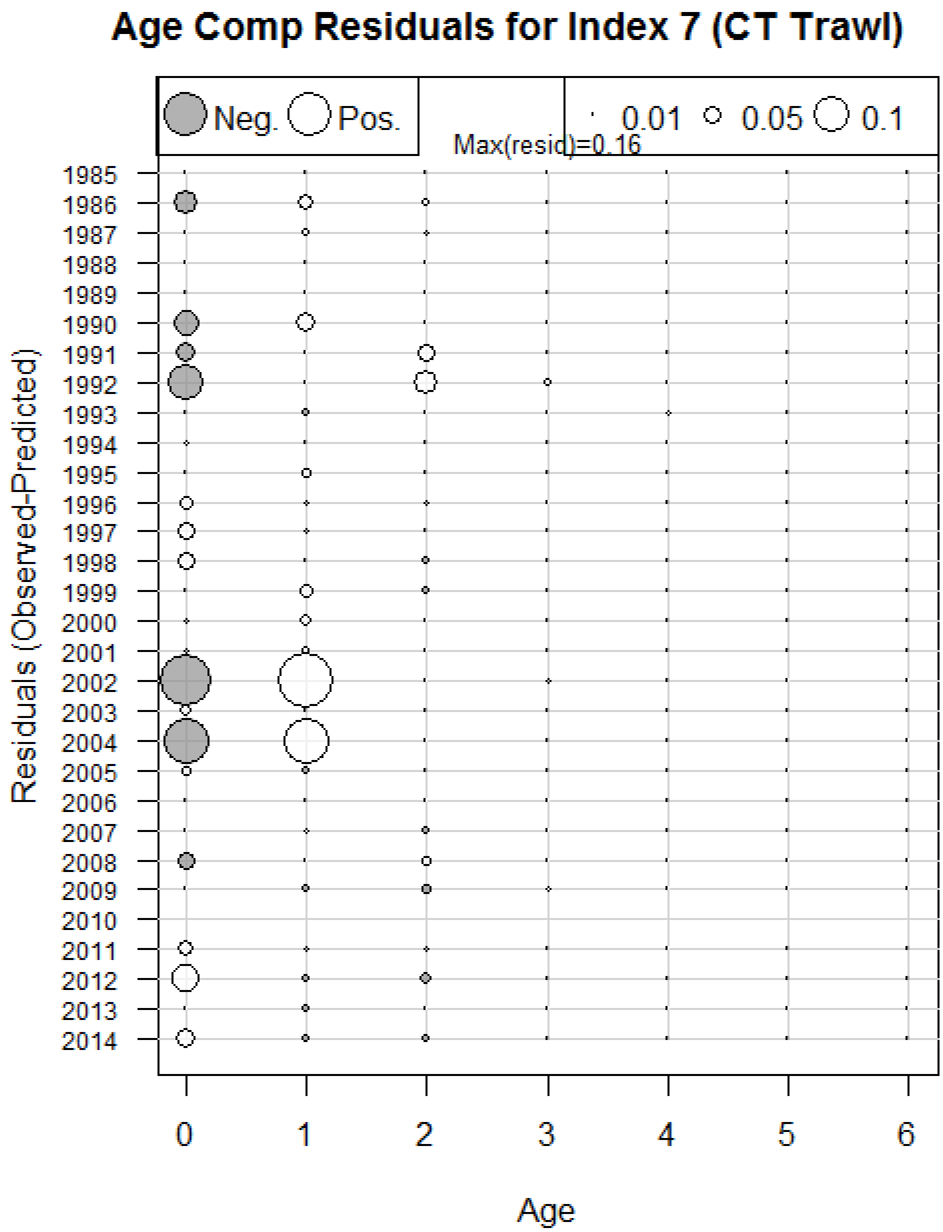


Figure B7.66. Age composition residuals for the CT LISTS trawl survey.

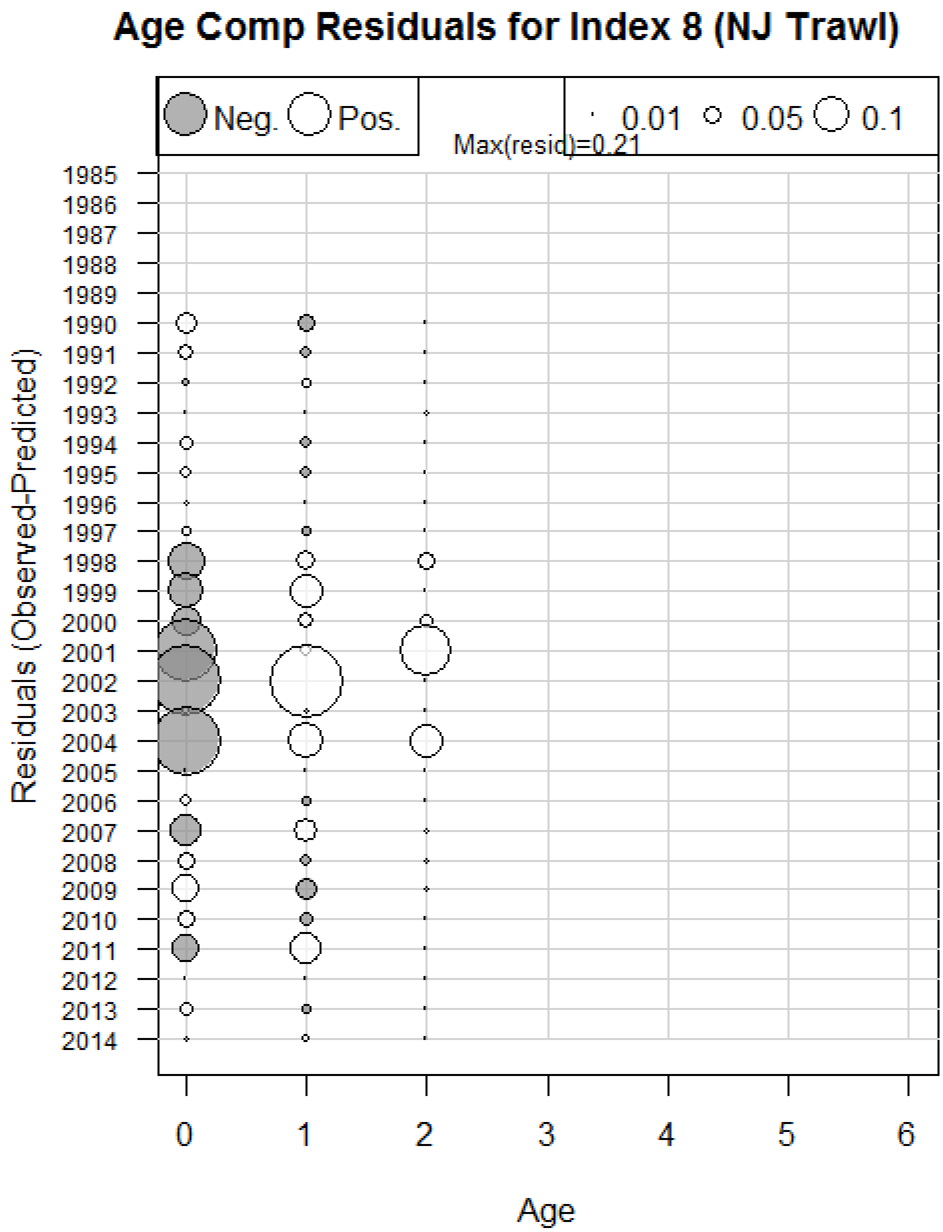


Figure B7.67. Age composition residuals for the NJ ocean trawl survey.

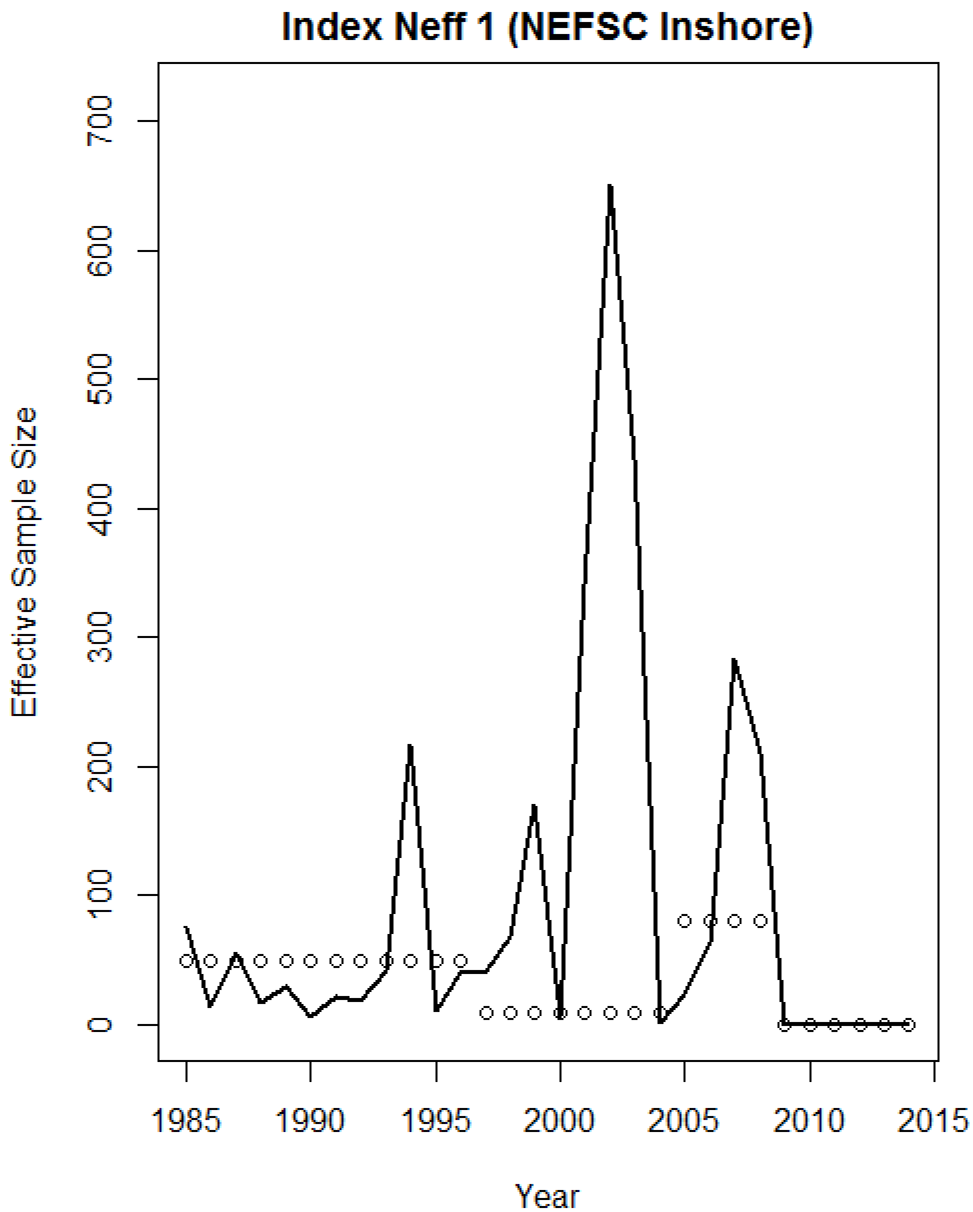


Figure B7.68. Input and estimated effective sample size for the NEFSC Inshore survey.

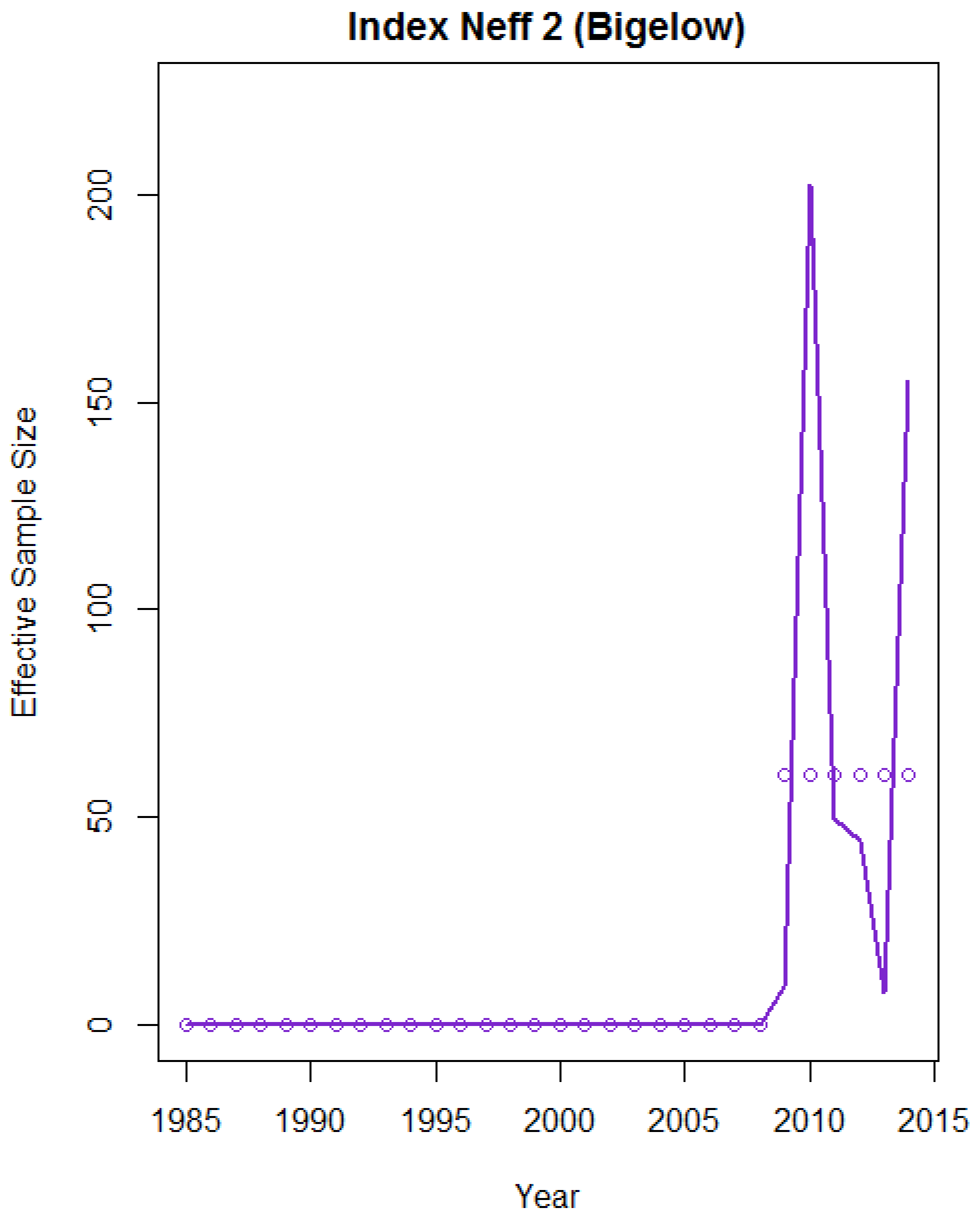


Figure B7.69. Input and estimated effective sample size for the NEFSC Bigelow survey.

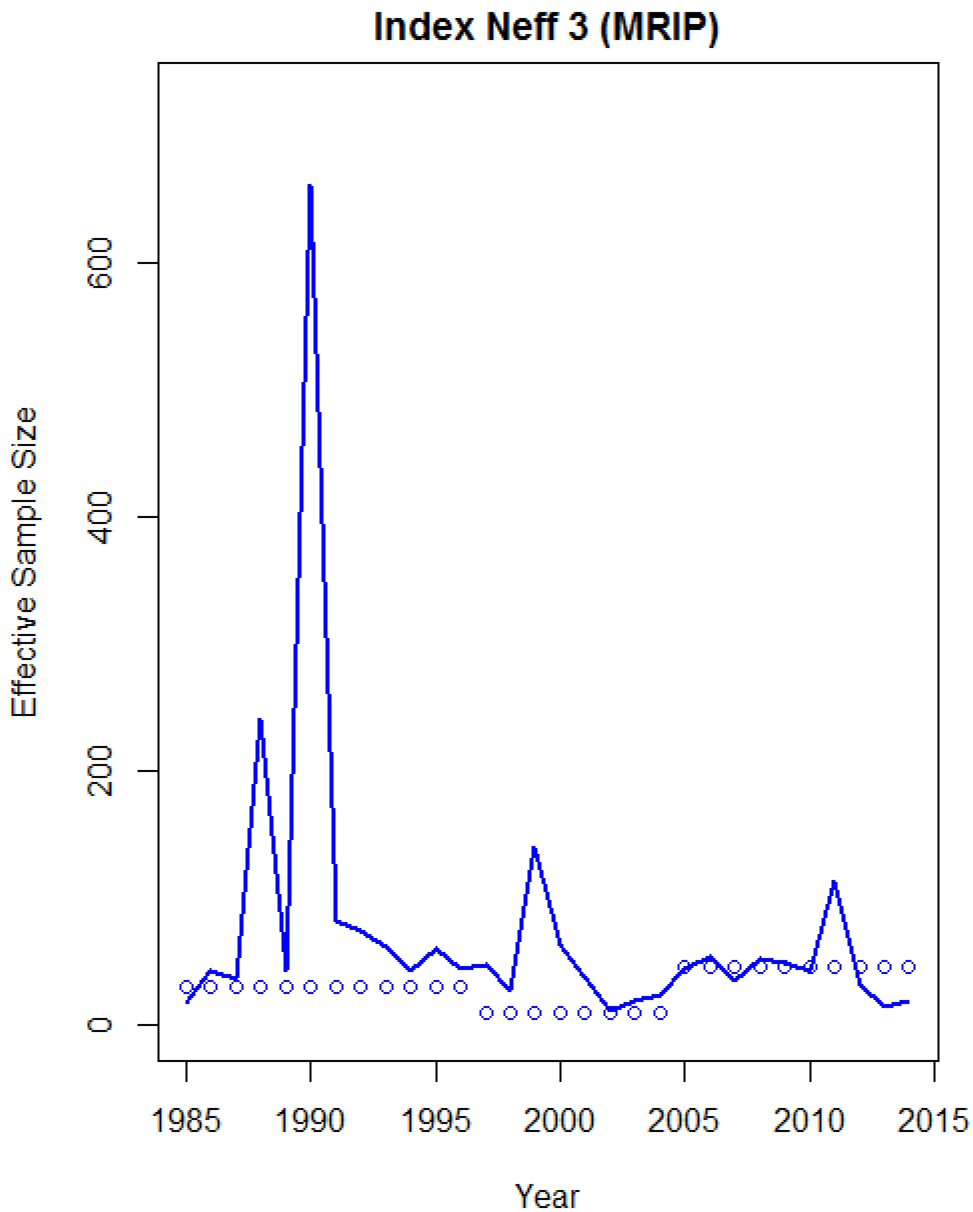


Figure B7.70. Input and estimated effective sample size for the MRIP recreational CPUE index.

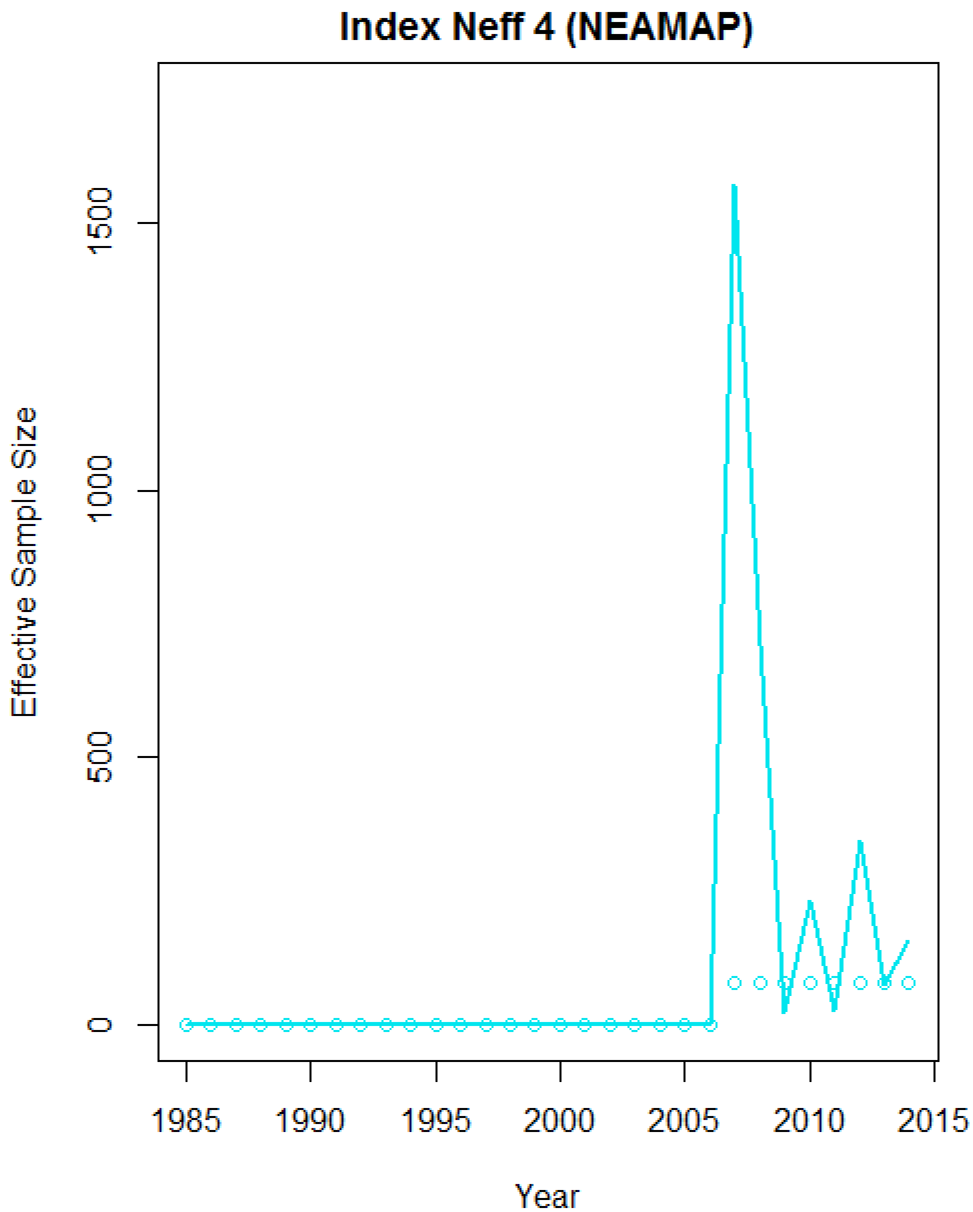


Figure B7.71. Input and estimated effective sample size for the NEAMAP survey.

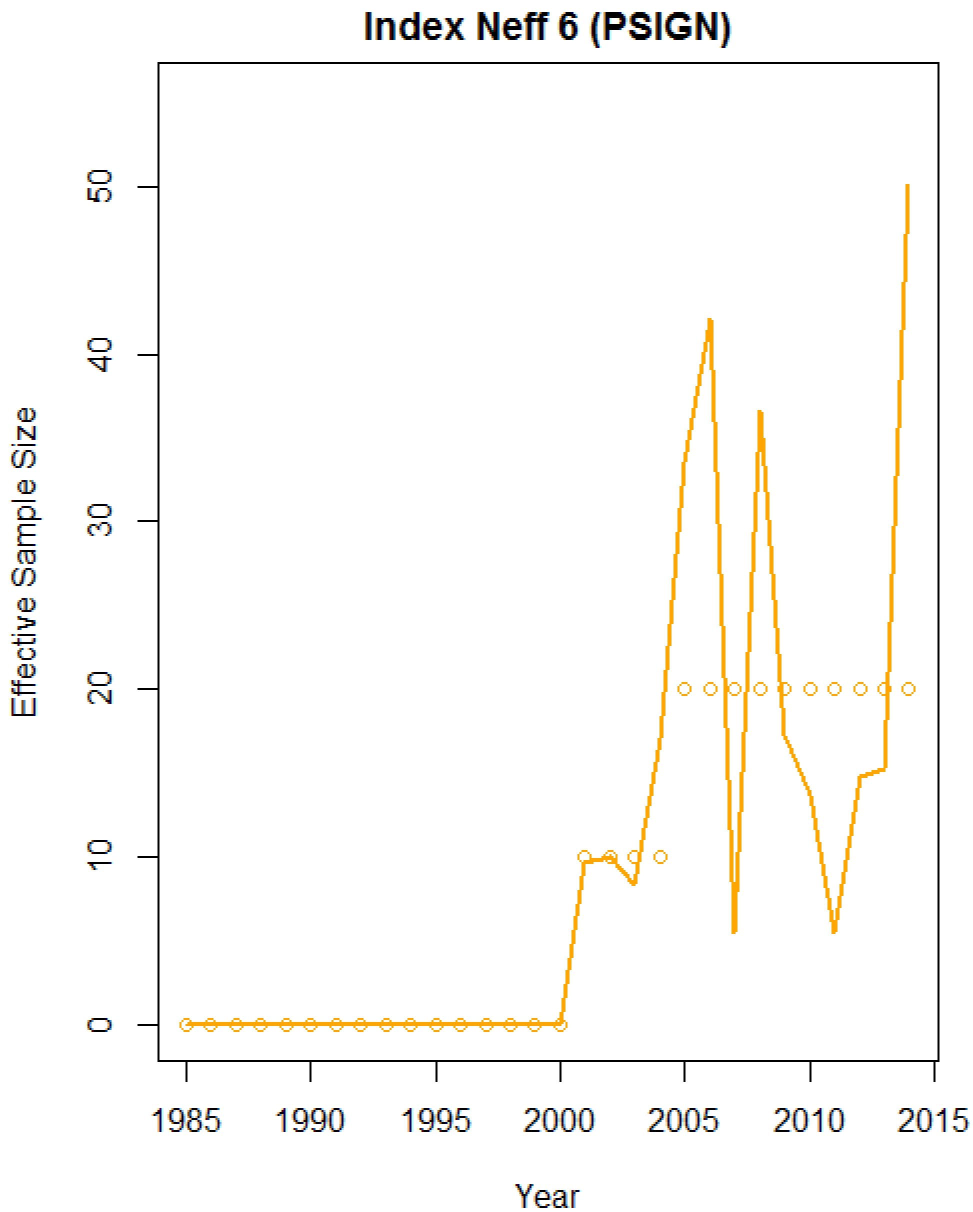


Figure B7.72. Input and estimated effective sample size for the PSIGNS gillnet survey.

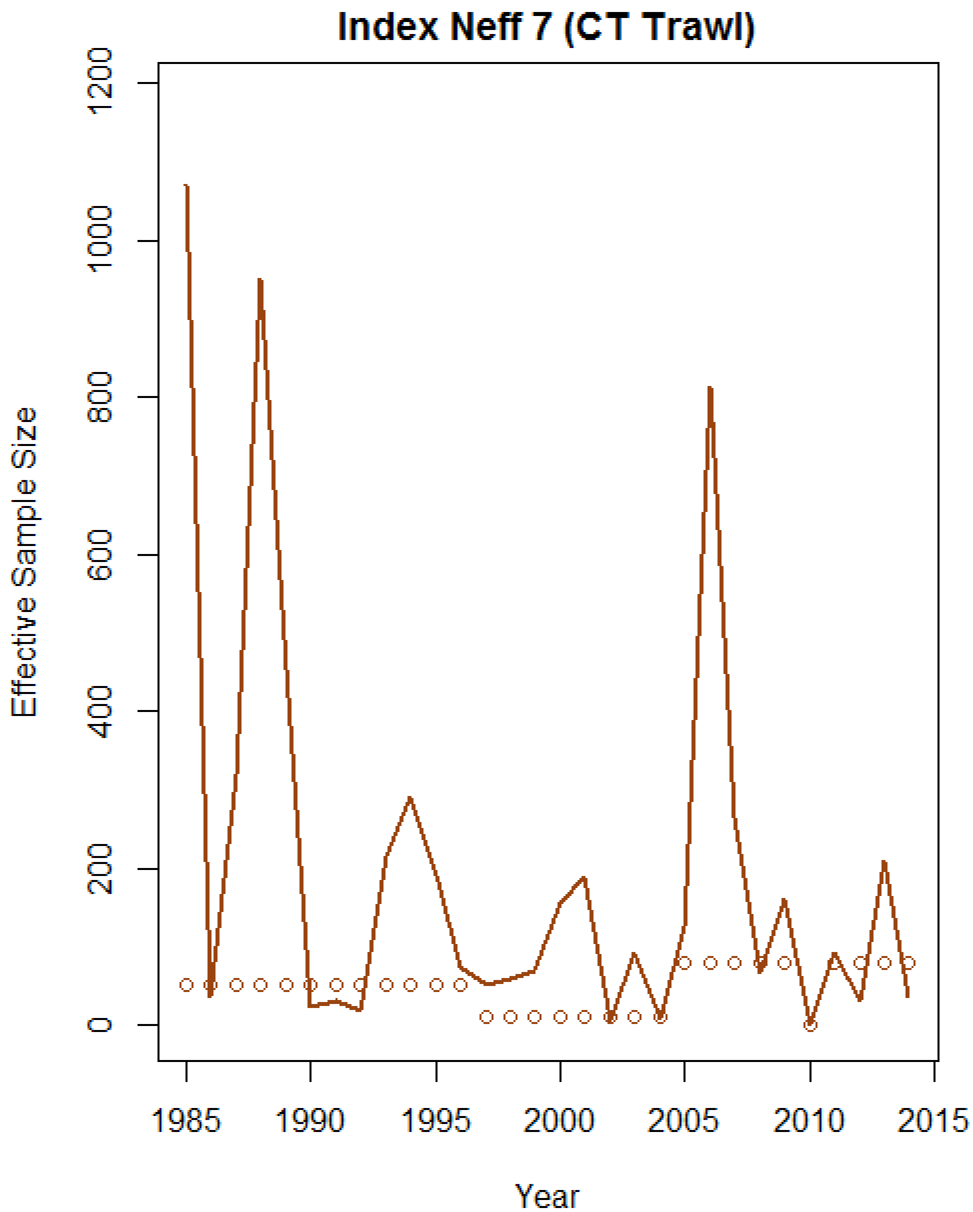


Figure B7.73. Input and estimated effective sample size for the CT LISTS trawl survey.

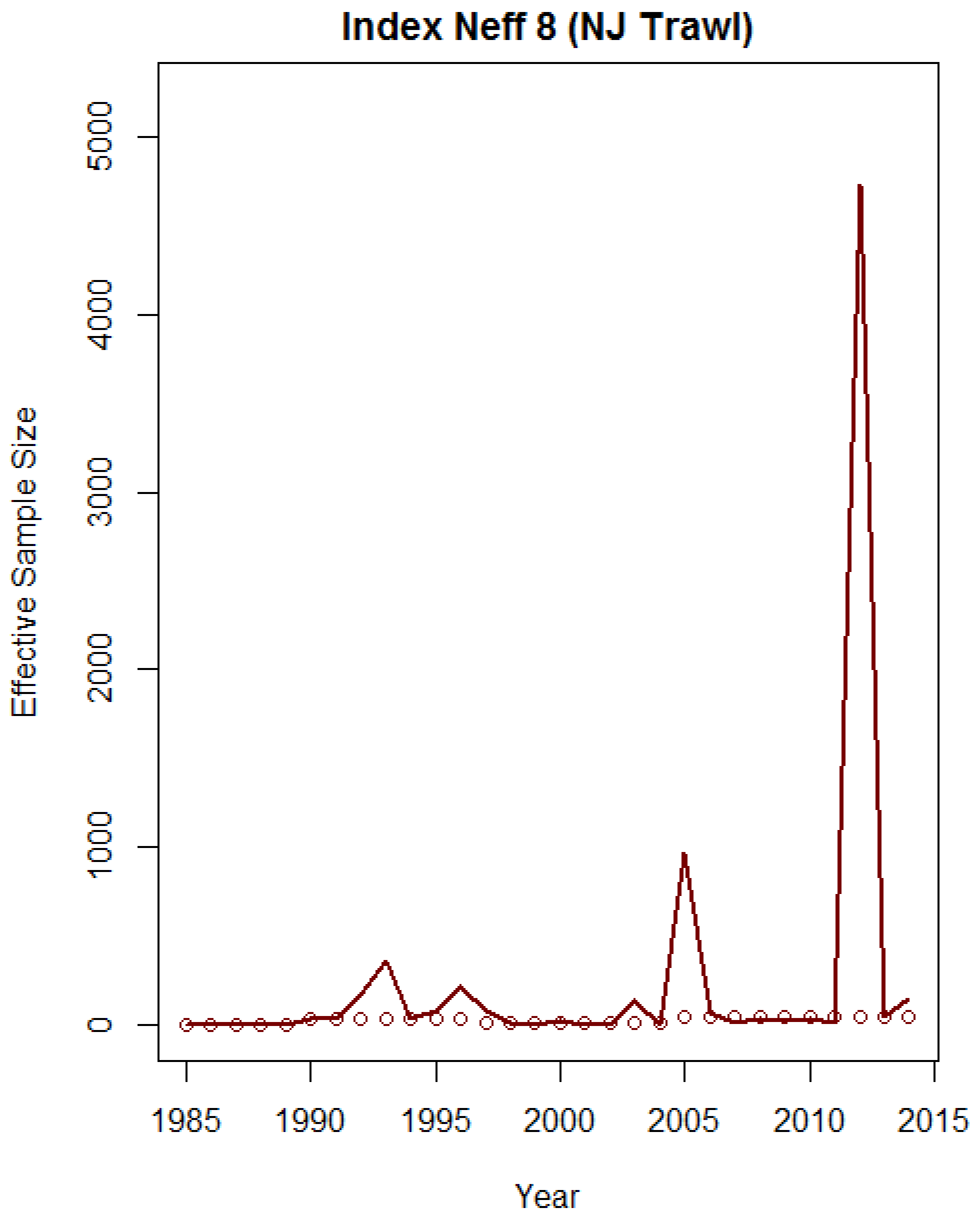


Figure B7.74. Input and estimated effective sample size for the NJ ocean trawl survey.

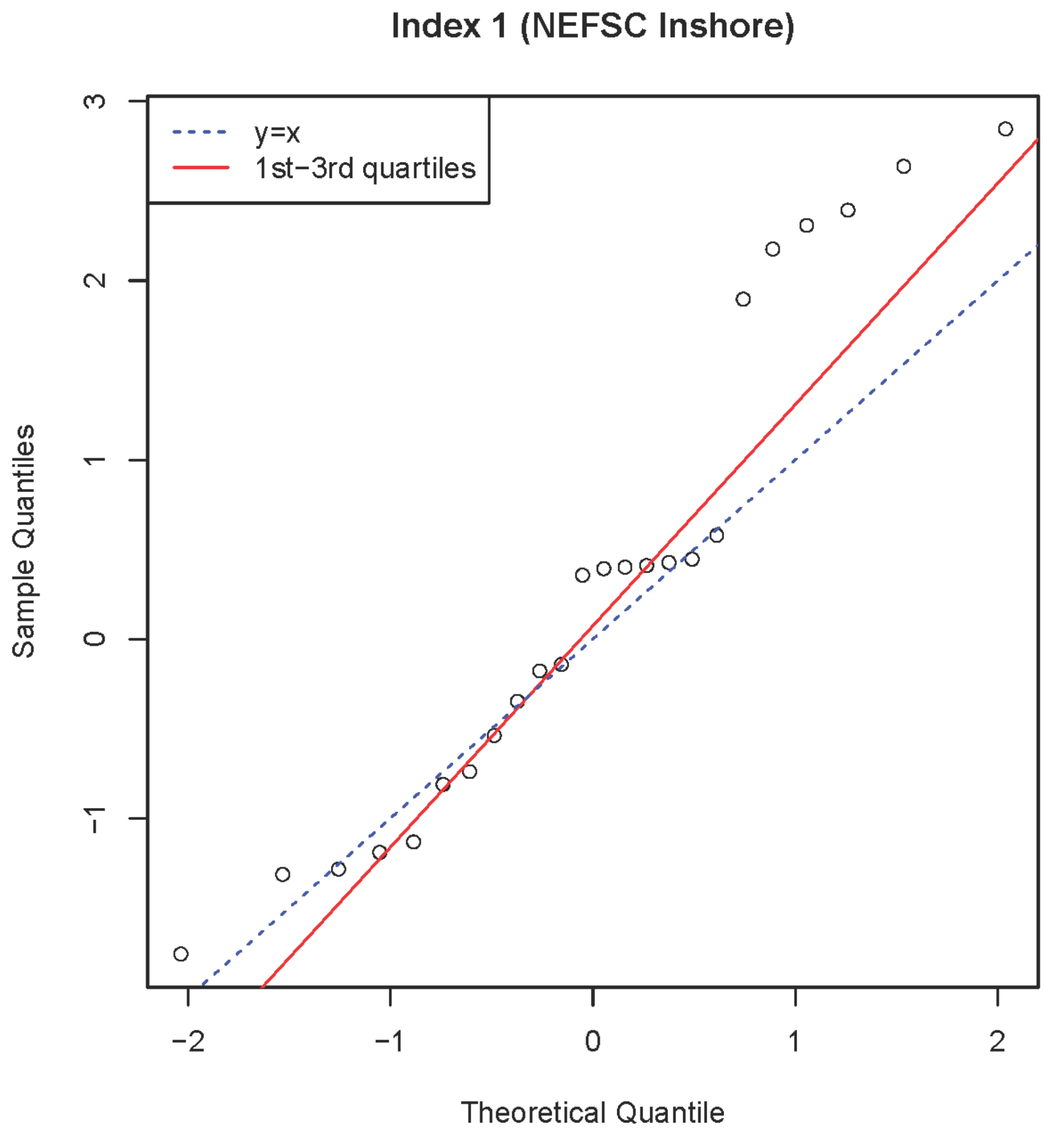


Figure B7.75. QQ-plot for the observed versus predicted mean catch for the NEFSC Inshore survey.

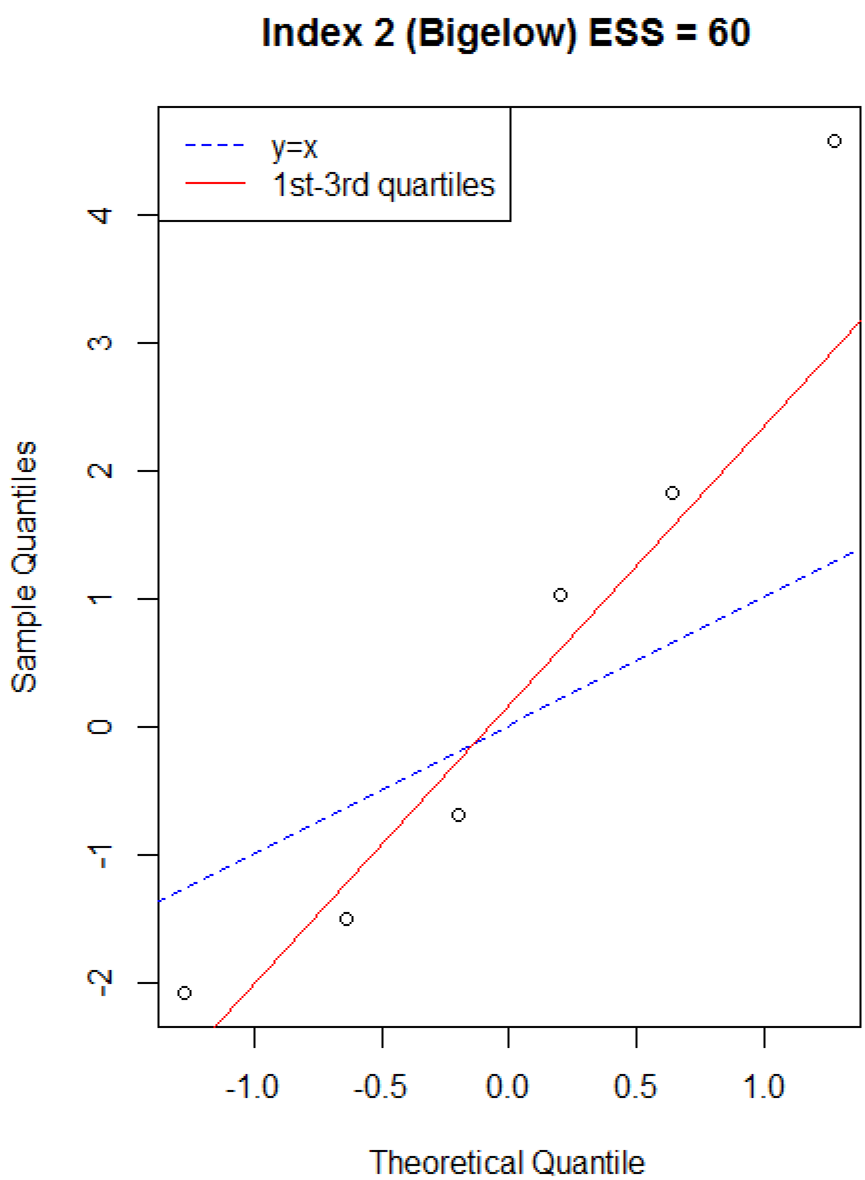


Figure B7.76. QQ-plot for the observed versus predicted mean catch for the NEFSC Bigelow survey.

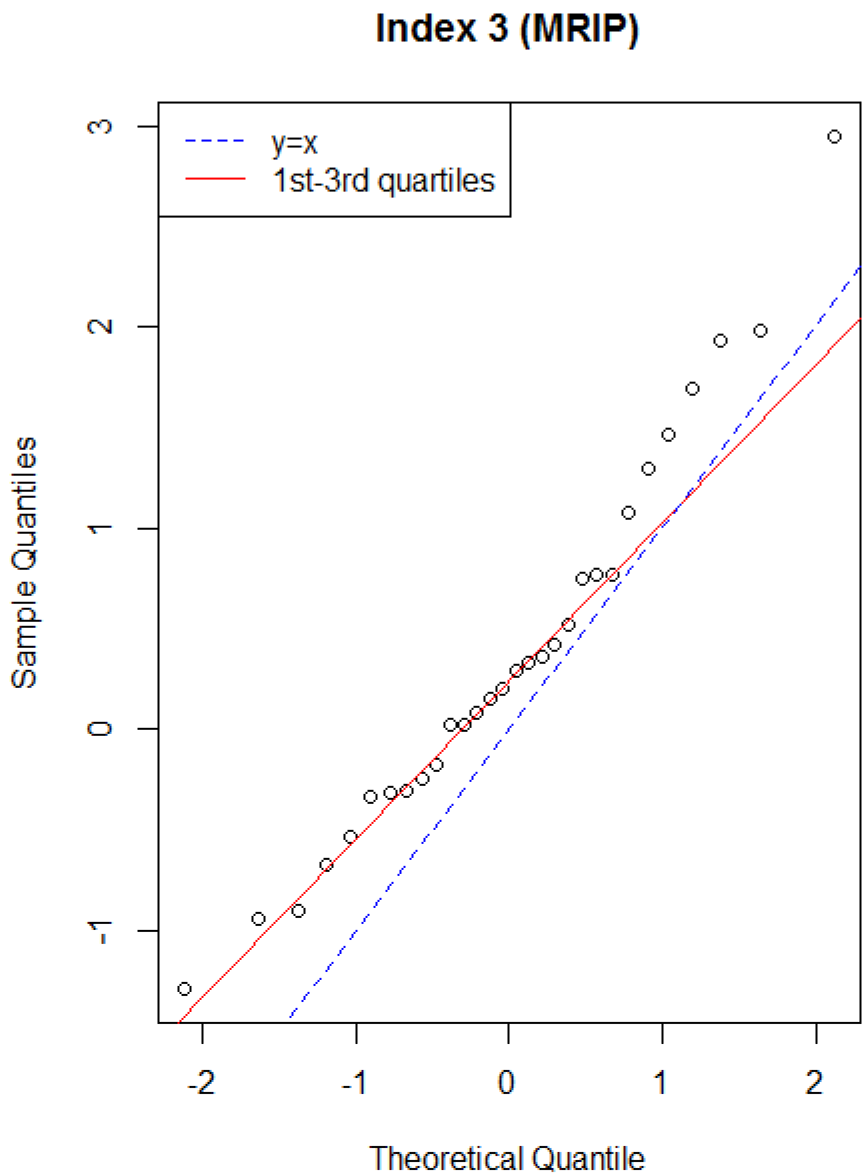


Figure B7.77. QQ-plot for the observed versus predicted mean catch for the MRIP recreational CPUE index.

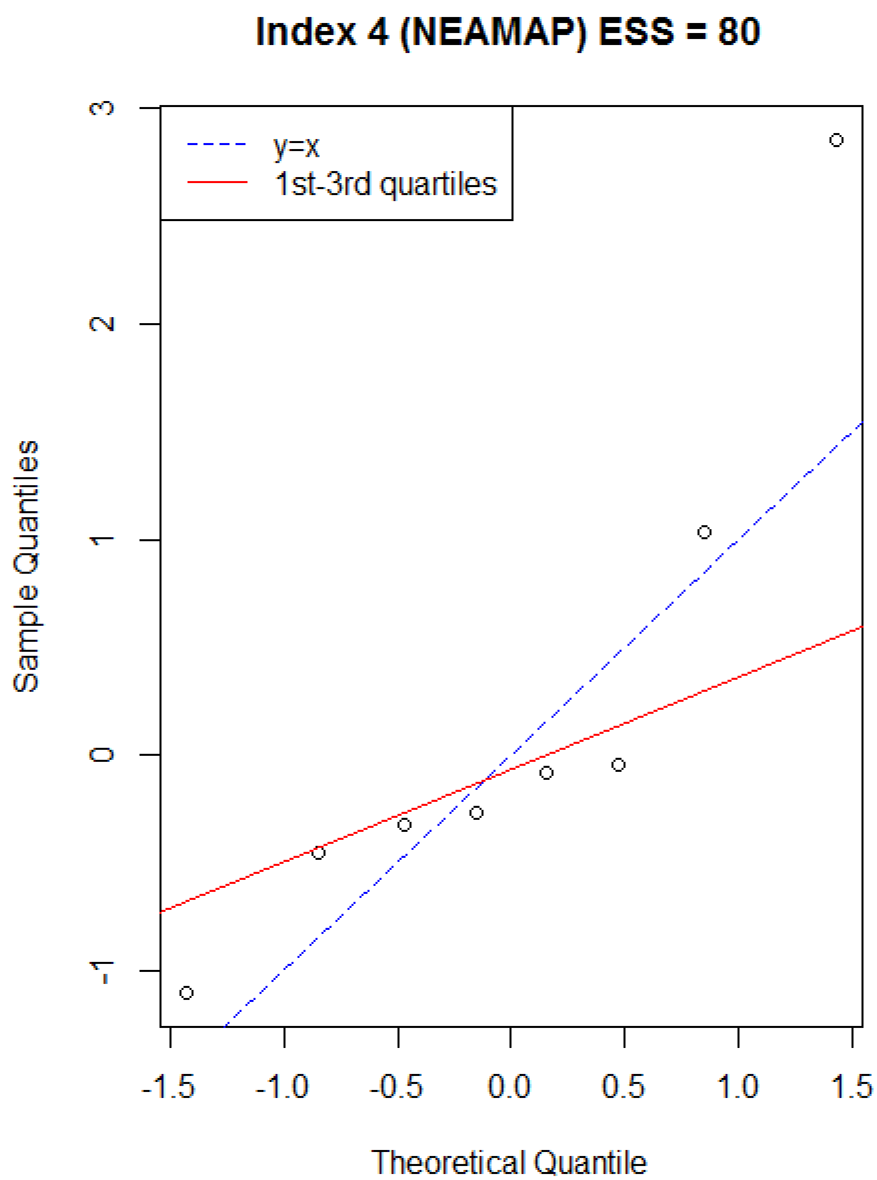


Figure B7.78. QQ-plot for the observed versus predicted mean catch for the NEAMAP survey.

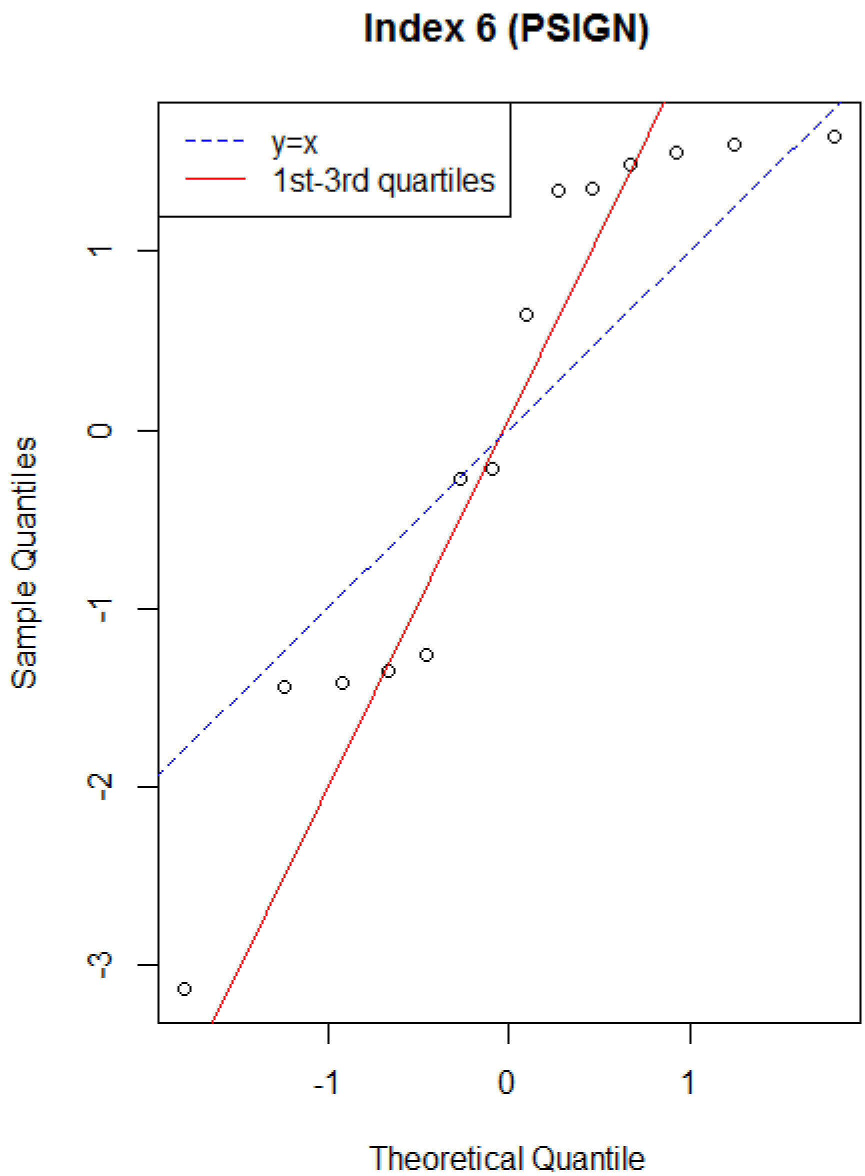


Figure B7.79. QQ-plot for the observed versus predicted mean catch for the PSIGNS gillnet survey.

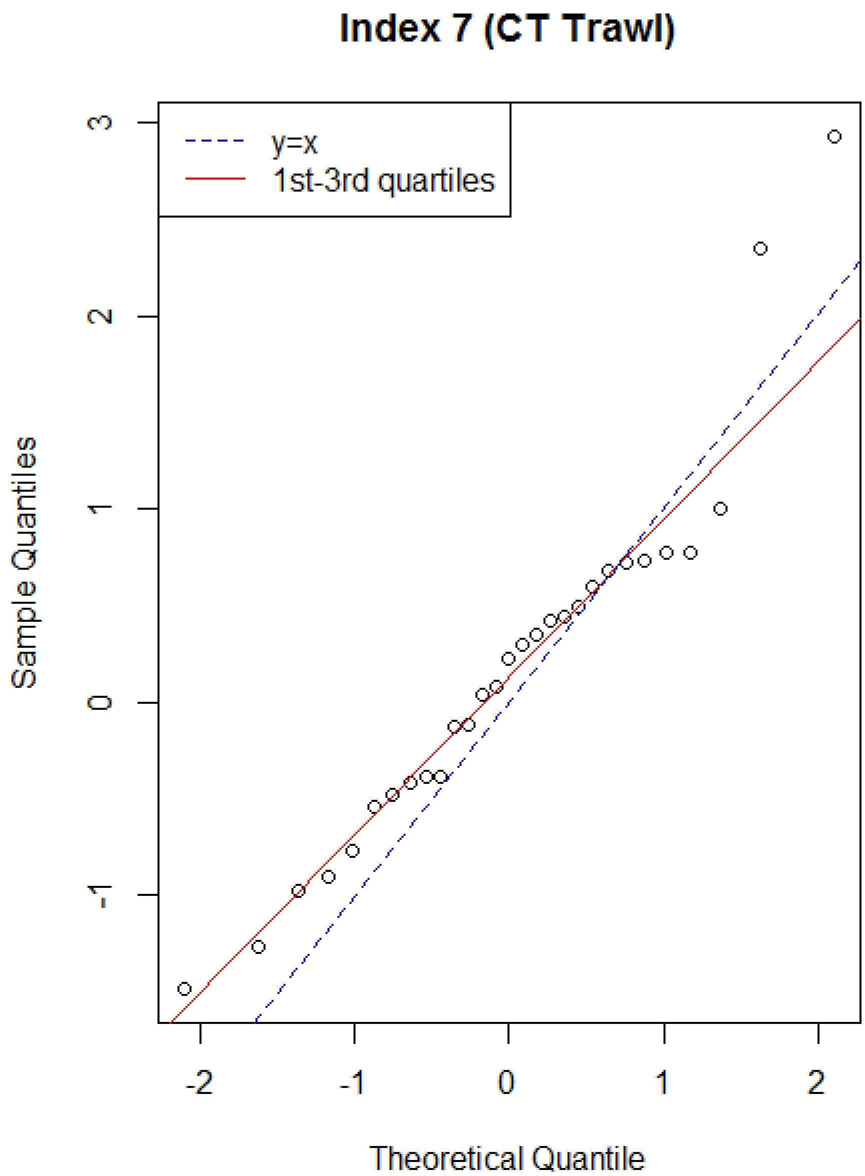


Figure B7.80. QQ-plot for the observed versus predicted mean catch for the CT LISTS trawl survey.

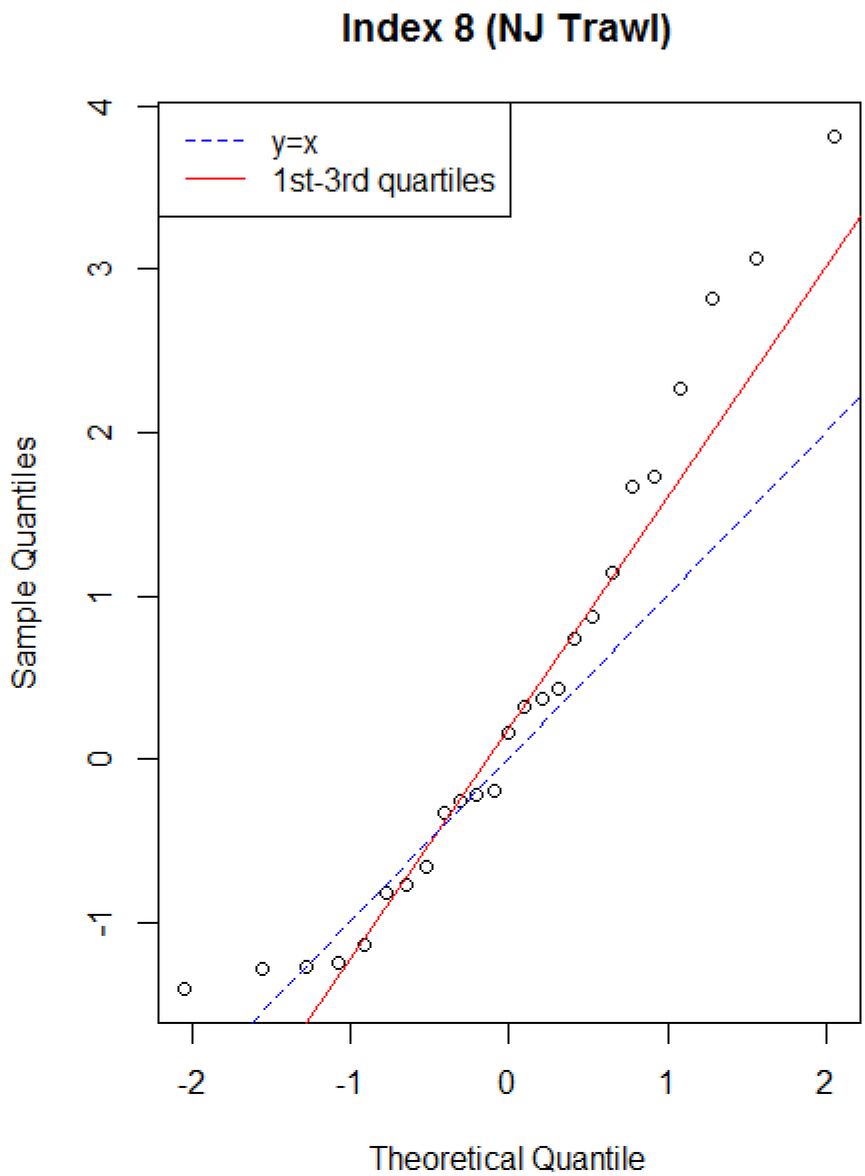


Figure B7.81. QQ-plot for the observed versus predicted mean catch for the NJ ocean trawl survey.

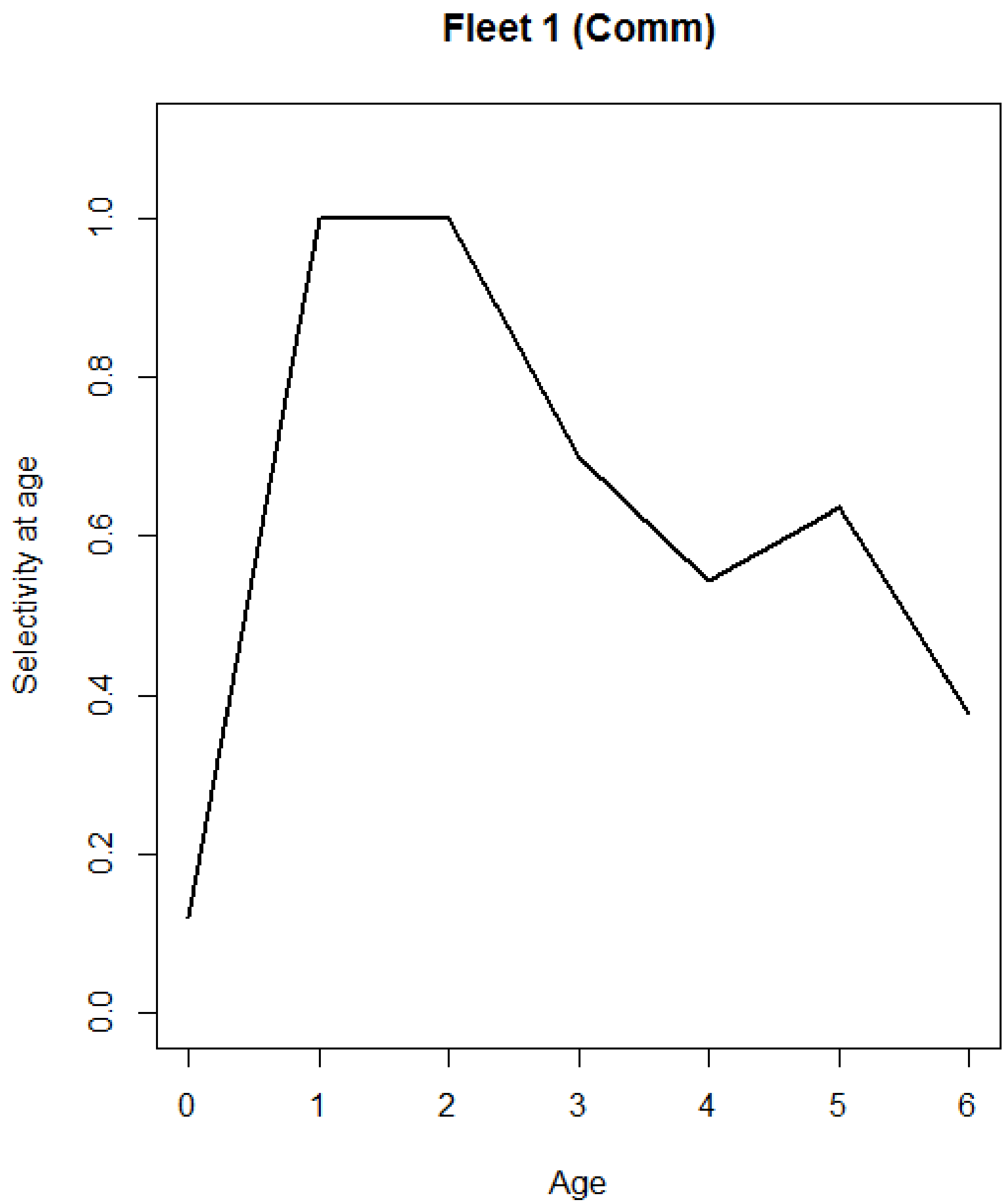


Figure B7.82. Estimated selectivity for the commercial fleet from the final model

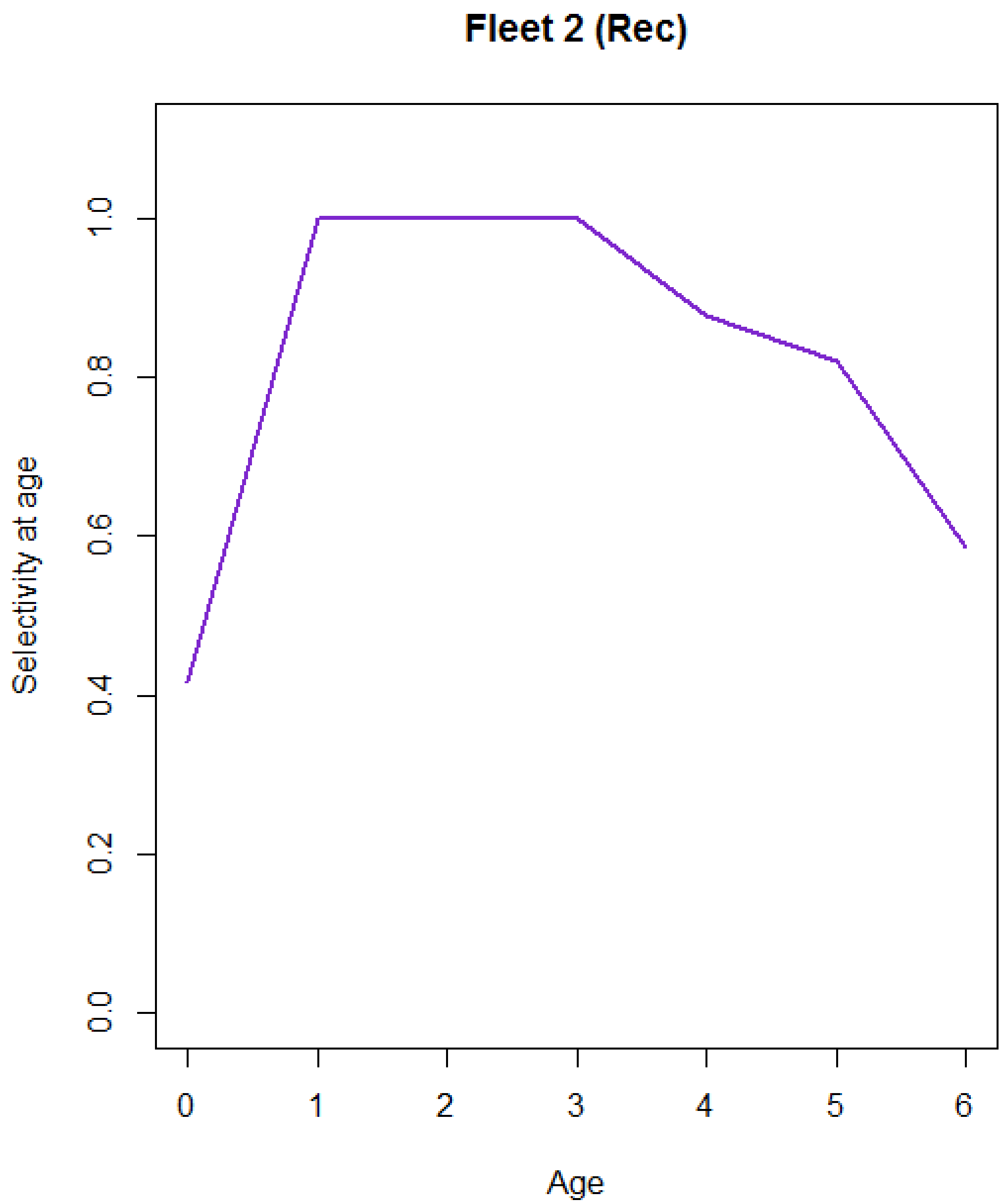


Figure B7.83. Estimated selectivity for the recreational fleet from the final model.

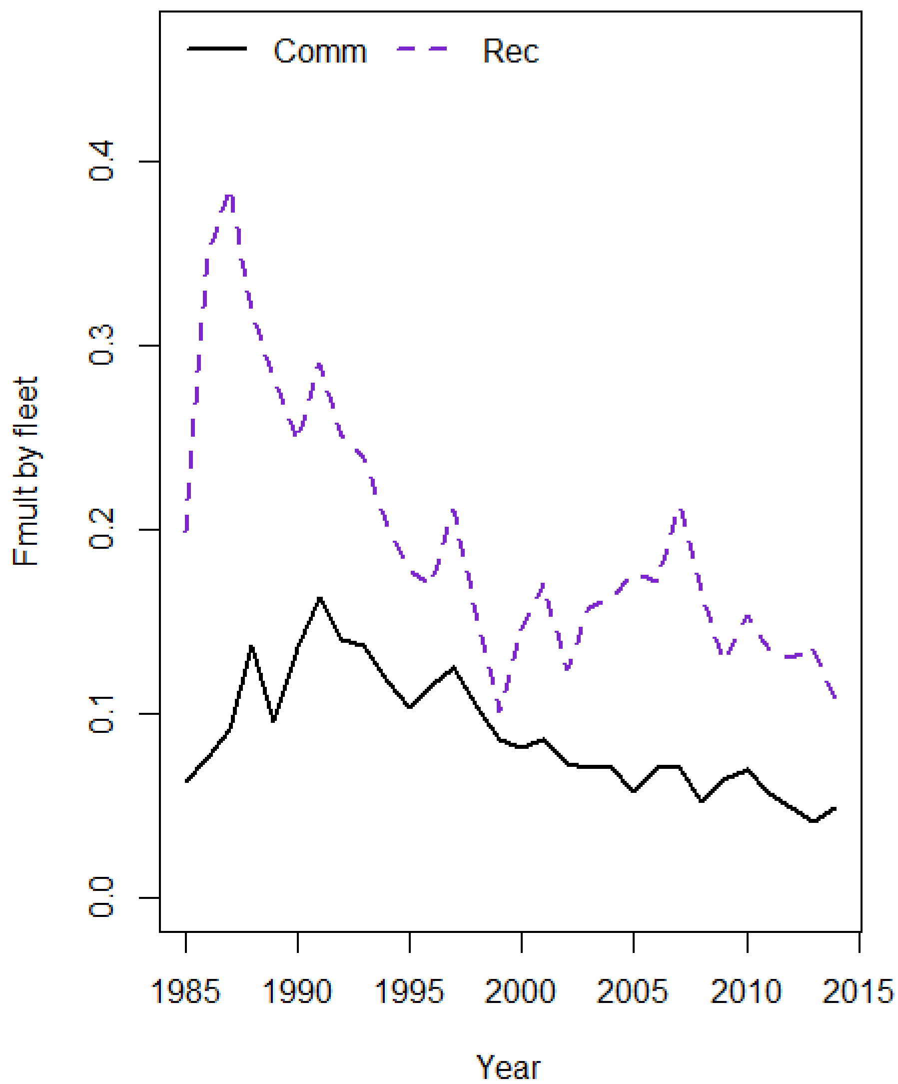


Figure B7.84. Full F (F_{mult}) estimates for the commercial (fleet 1) and recreational (fleet 2) fleets.

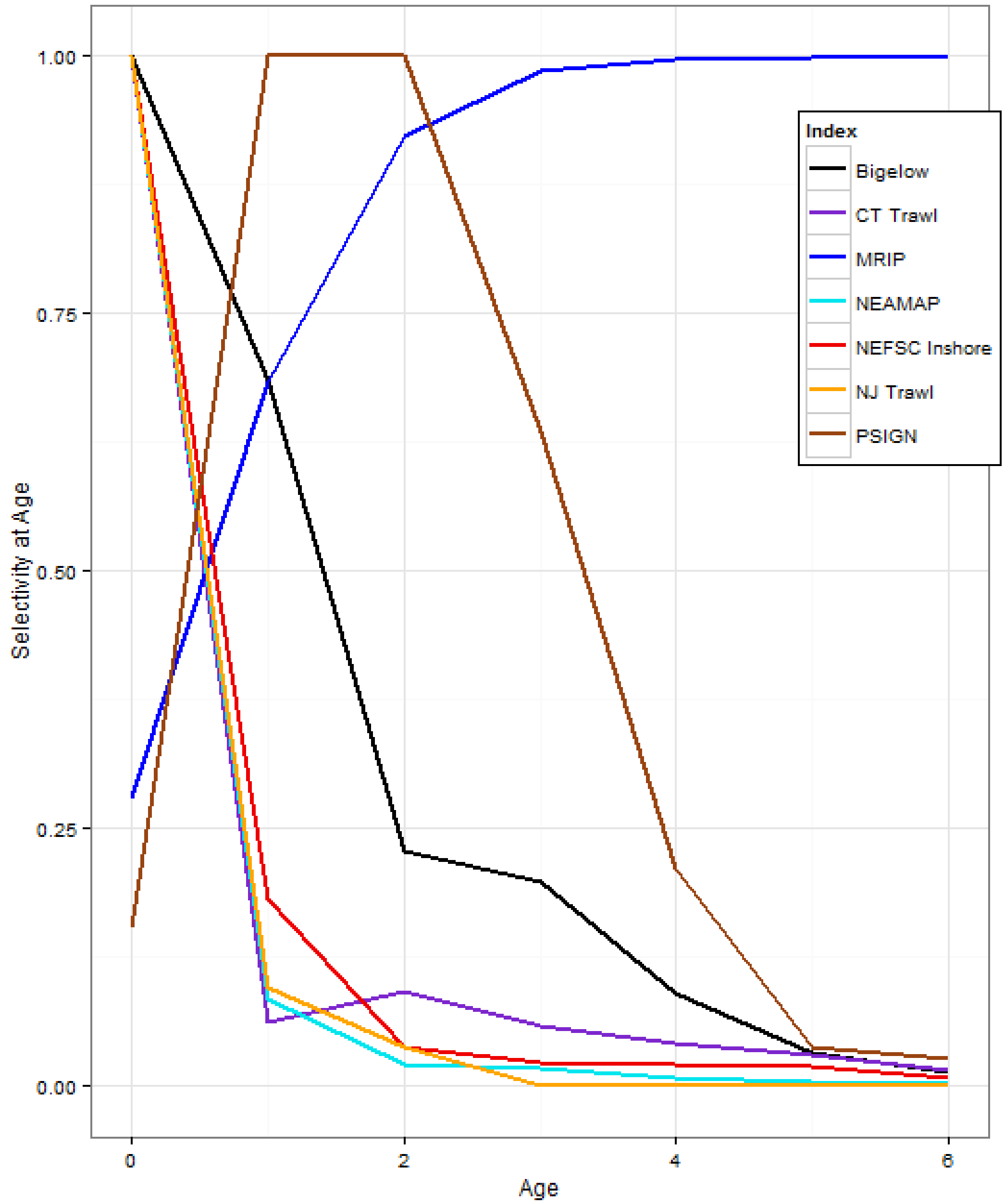


Figure B7.85. Estimated selectivities for the indices from the final model. Note the two age 0 indices are not plotted so only 7 selectivities are shown.

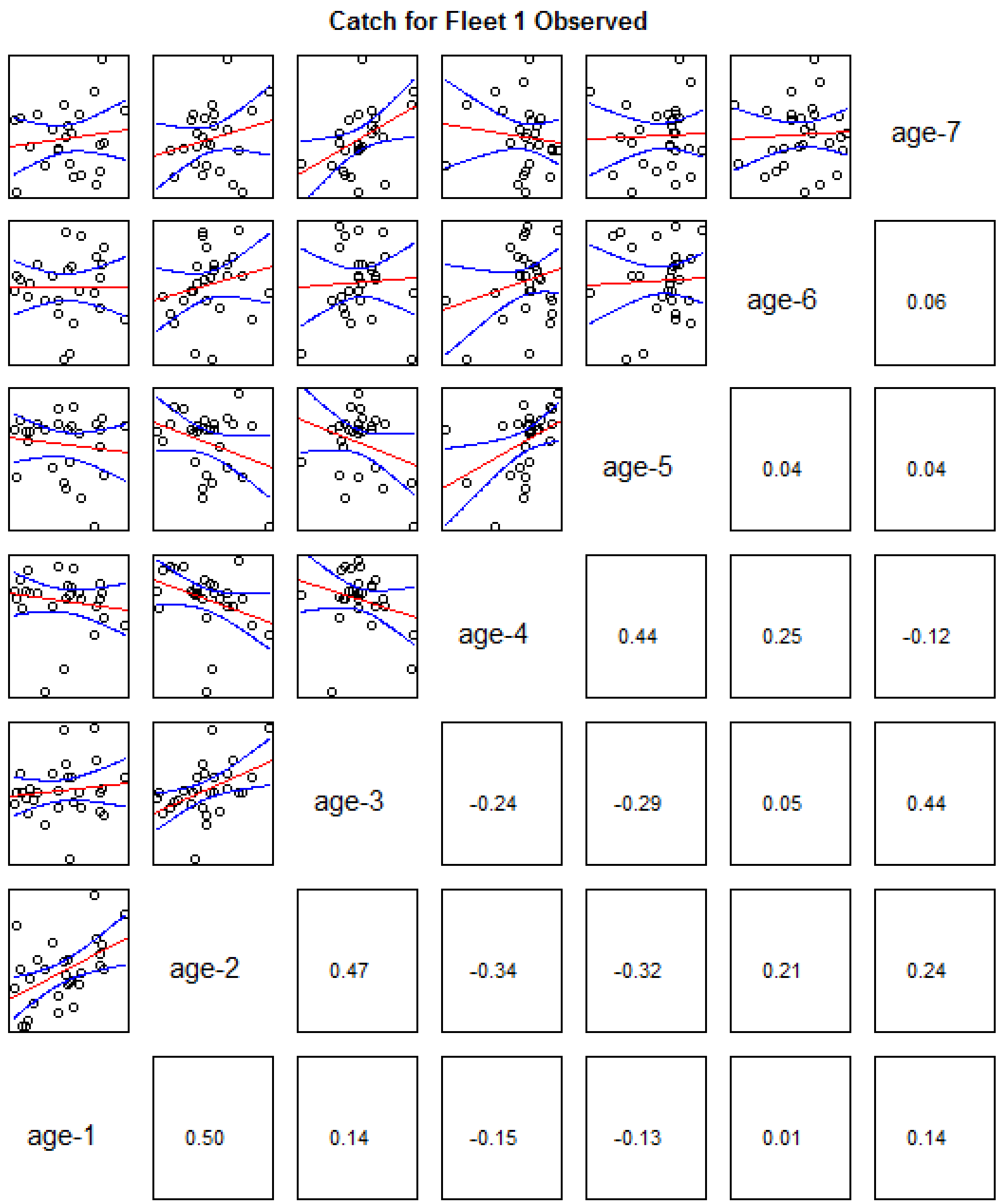


Figure B7.86. Observed catch for the commercial fleet. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

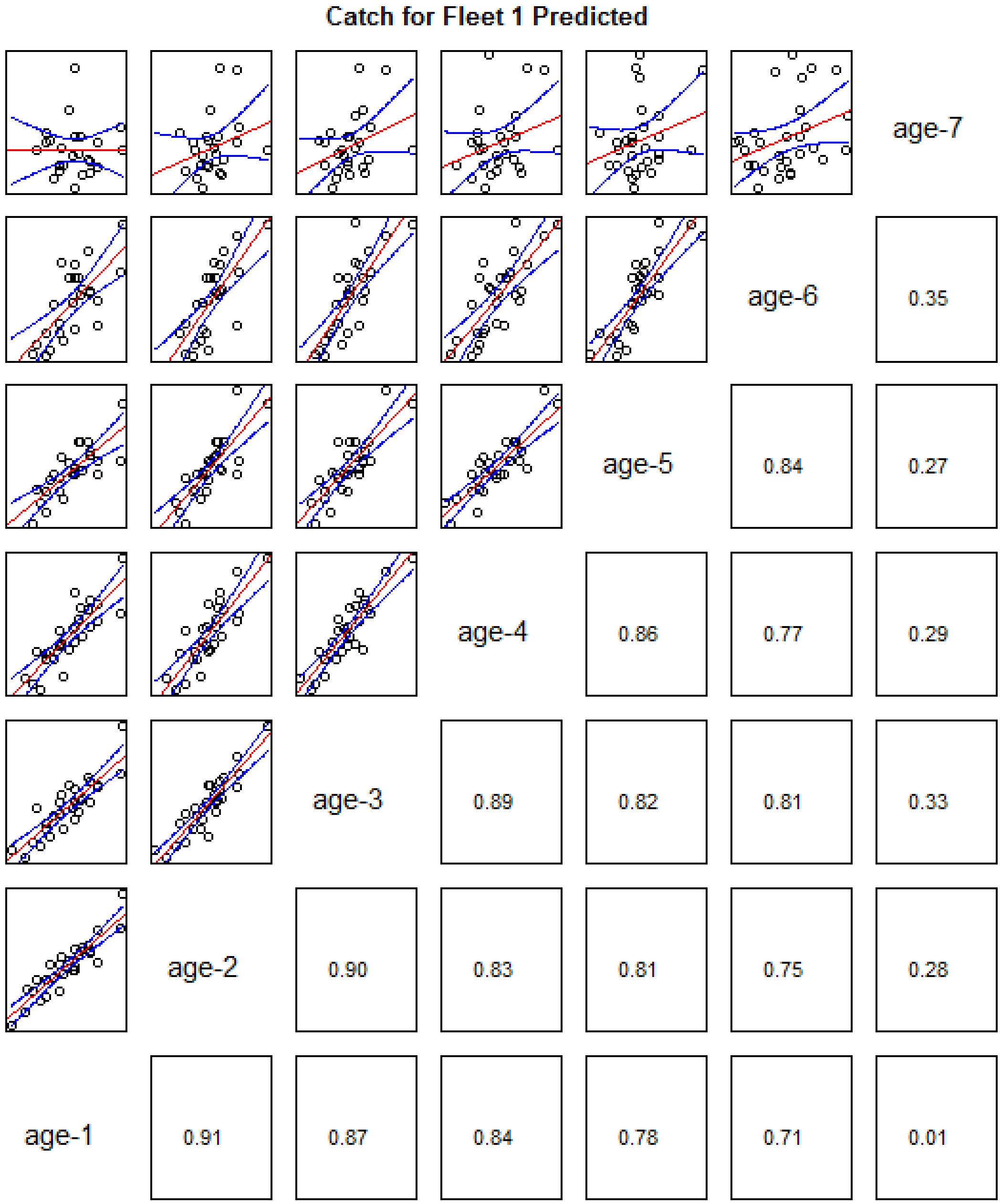


Figure B7.87. Predicted catch for the commercial fleet.
Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

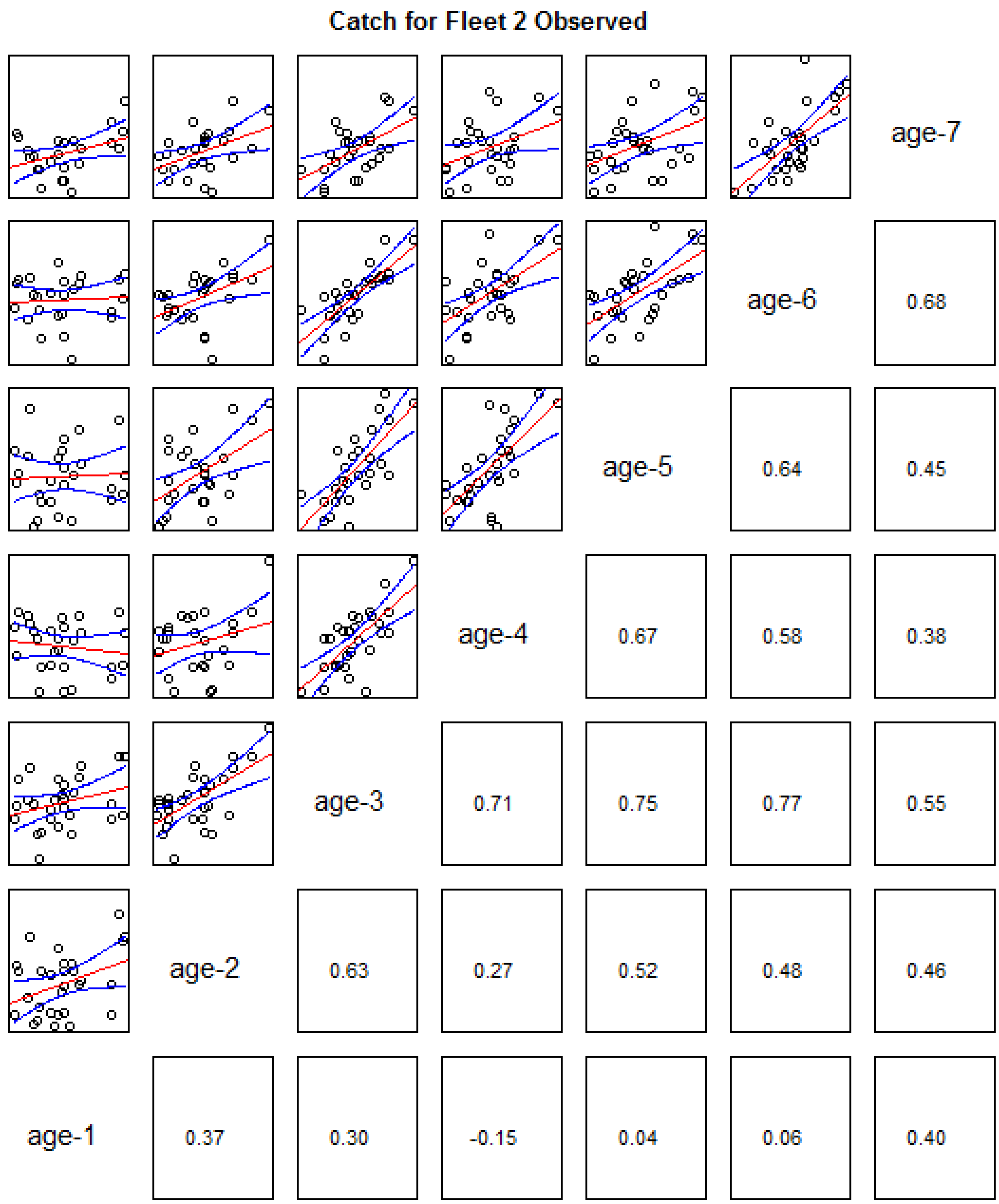


Figure B7.88. Observed catch for the recreational fleet. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

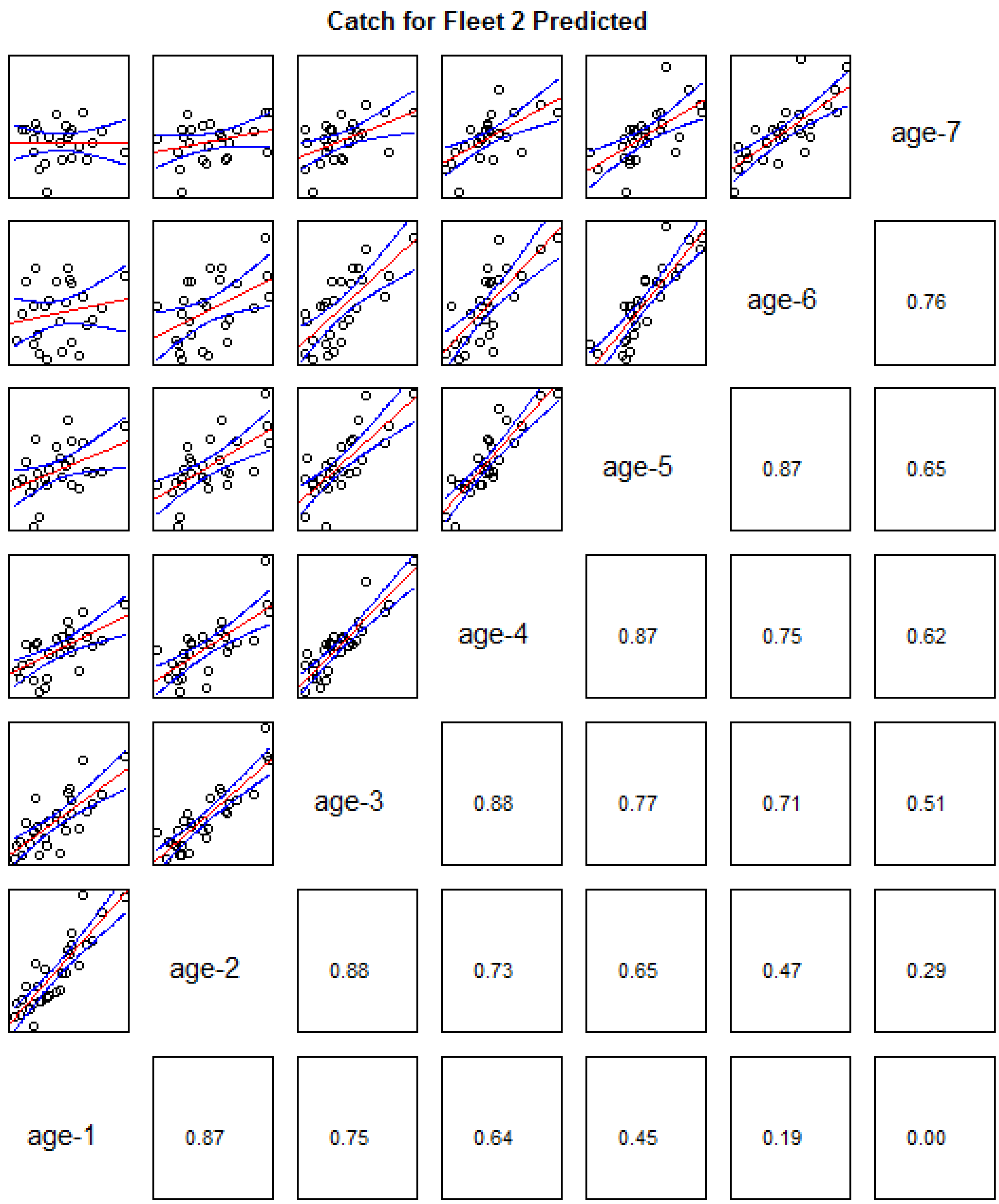


Figure B7.89. Predicted catch for the recreational fleet. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

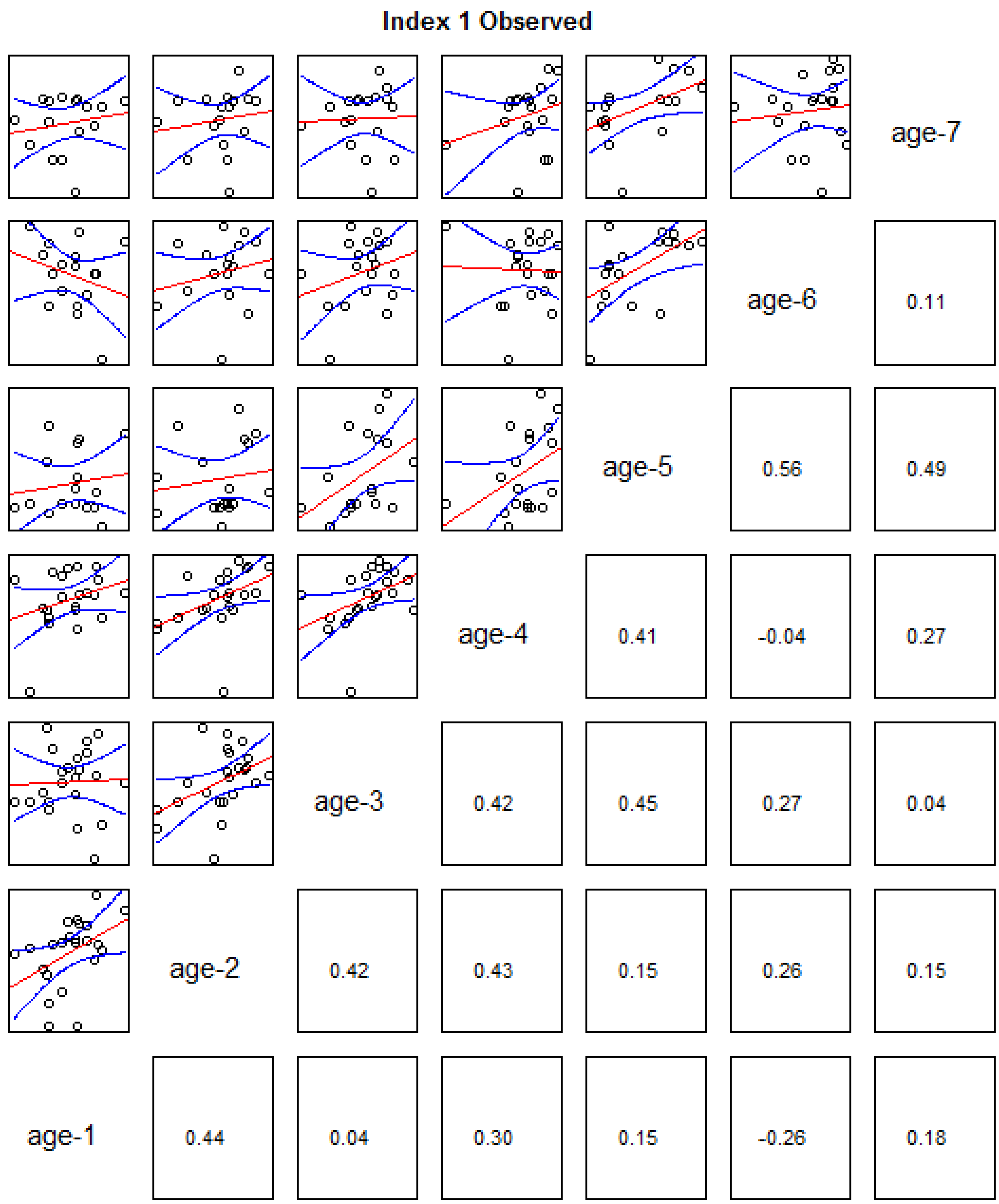


Figure B7.90. Observed catch for the NEFSC Inshore survey. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

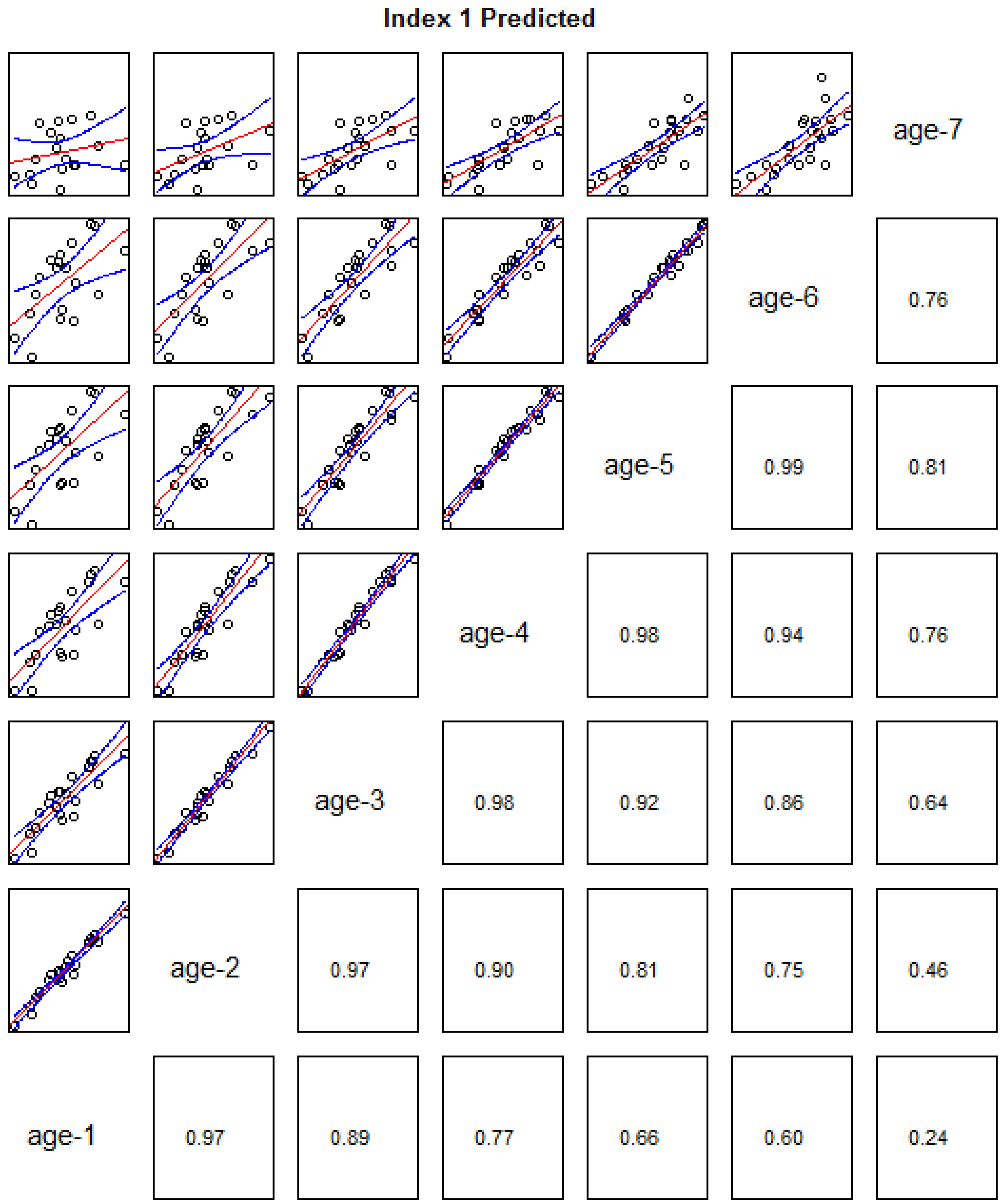


Figure B7.91. Predicted catch for the NEFSC Inshore survey. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

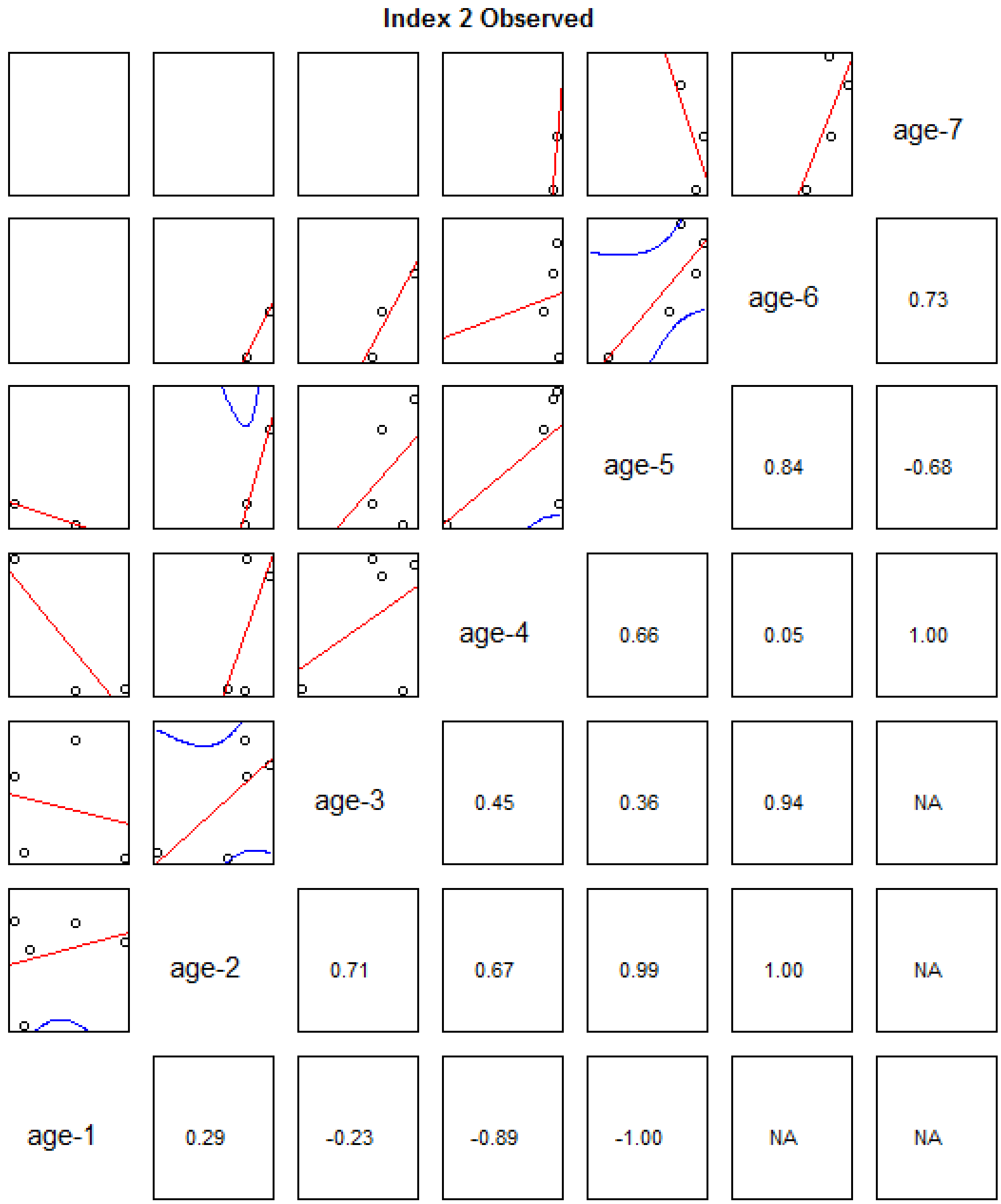


Figure B7.92. Observed catch for the NEFSC Bigelow survey. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

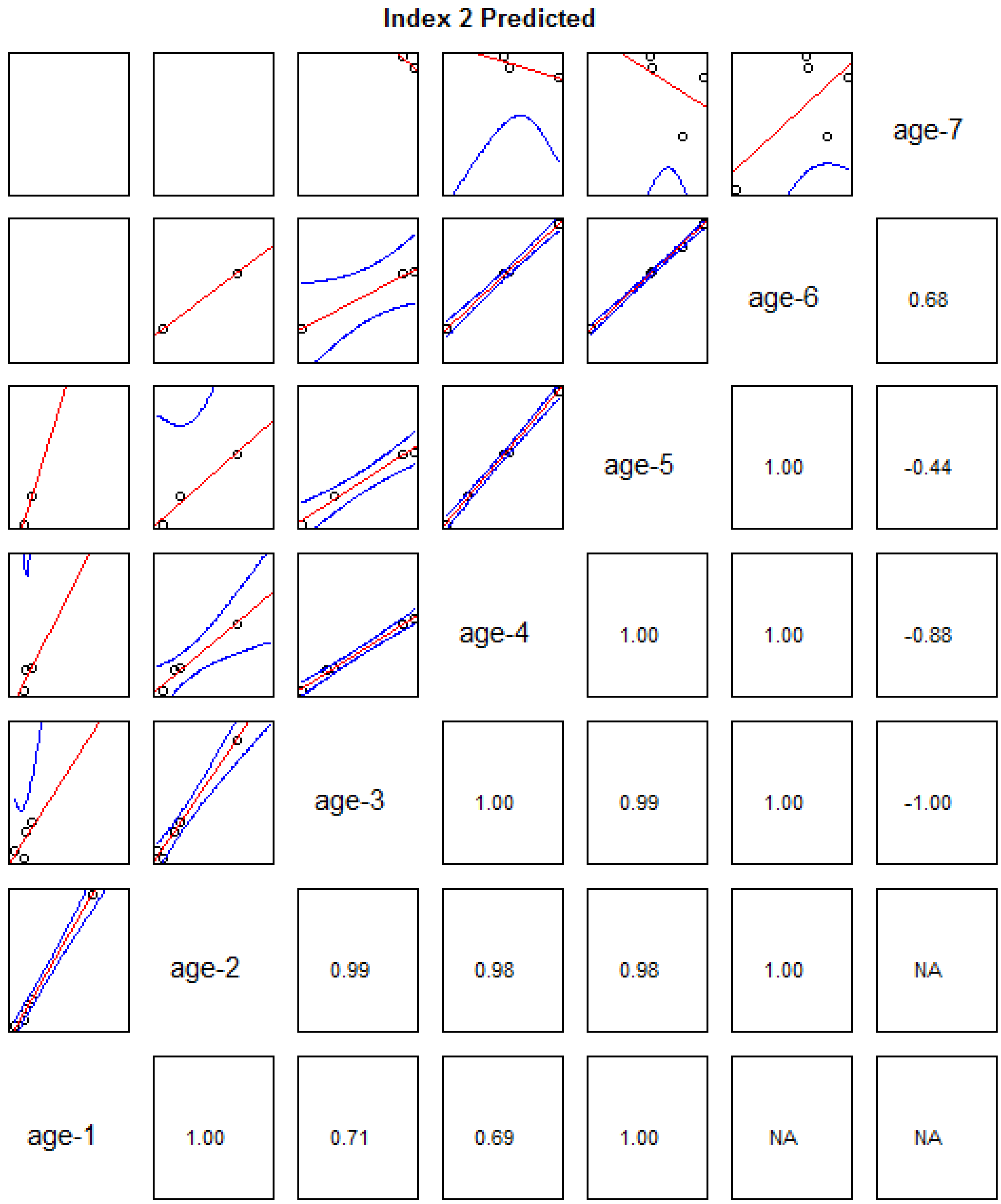


Figure B7.93. Predicted catch for the NEFSC Bigelow survey. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

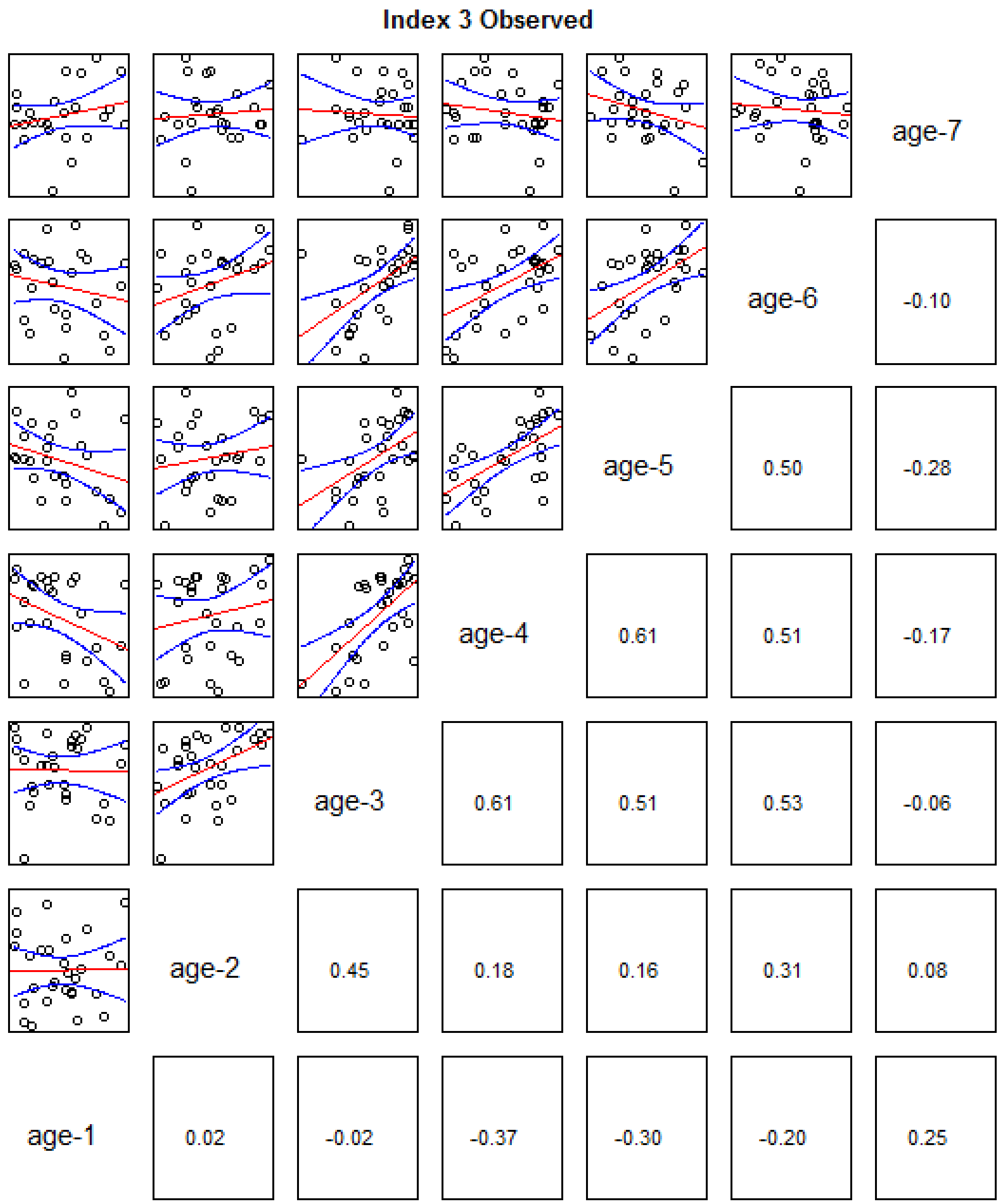


Figure B7.94. Observed catch for the MRIP recreational CPUE index. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

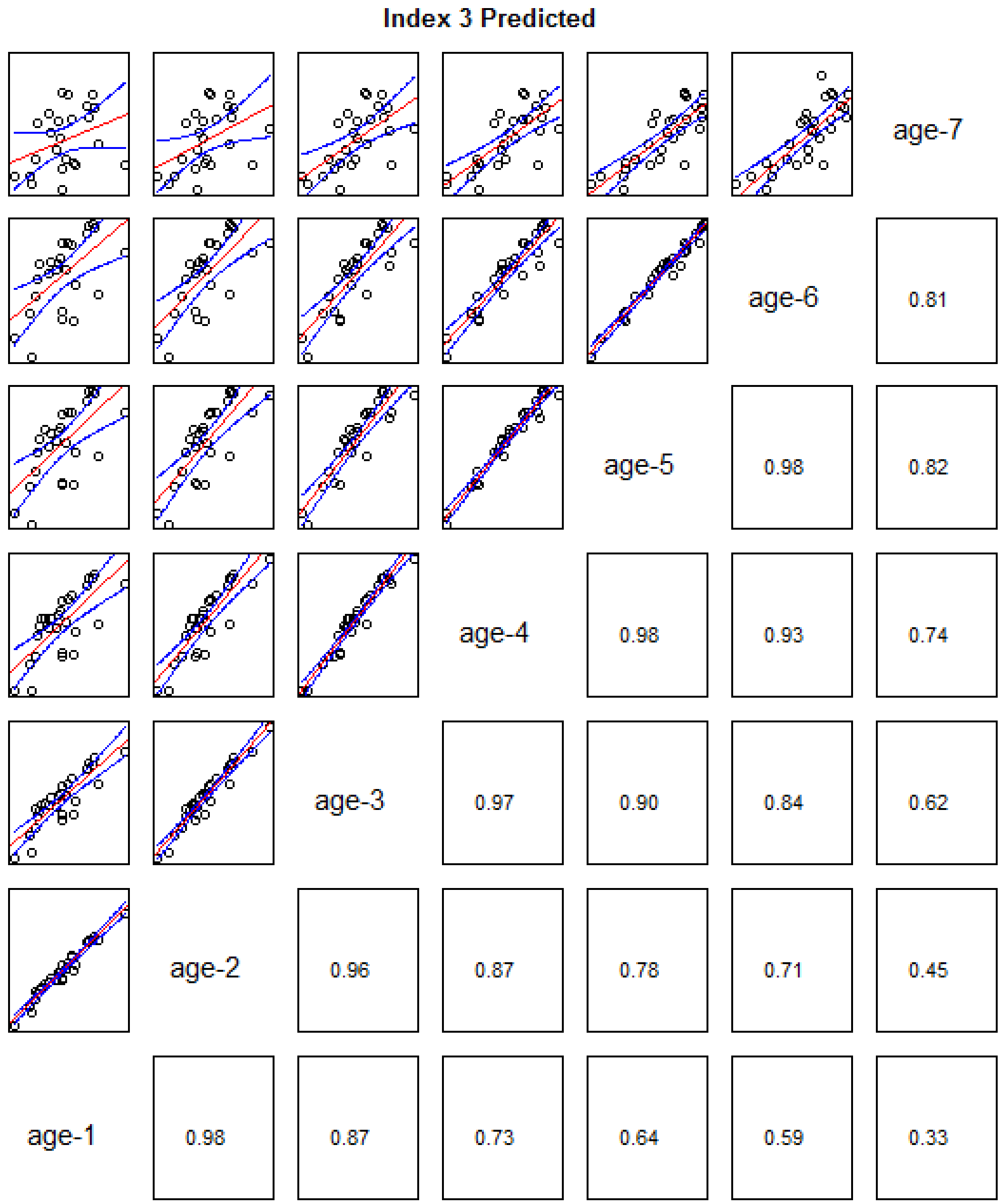


Figure B7.95. Predicted catch for the MRIP recreational CPUE index. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

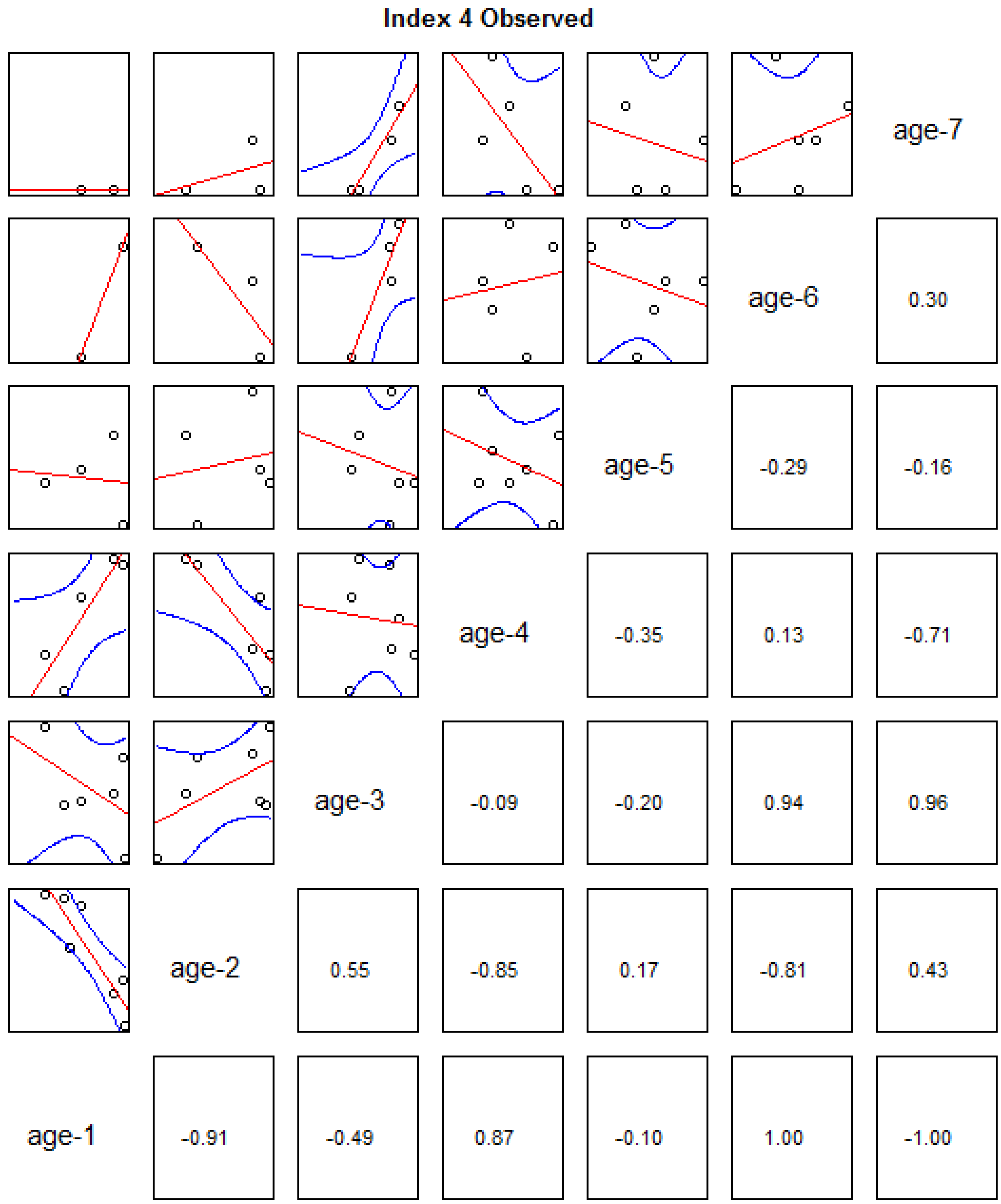


Figure B7.96. Observed catch for the NEAMAP survey. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

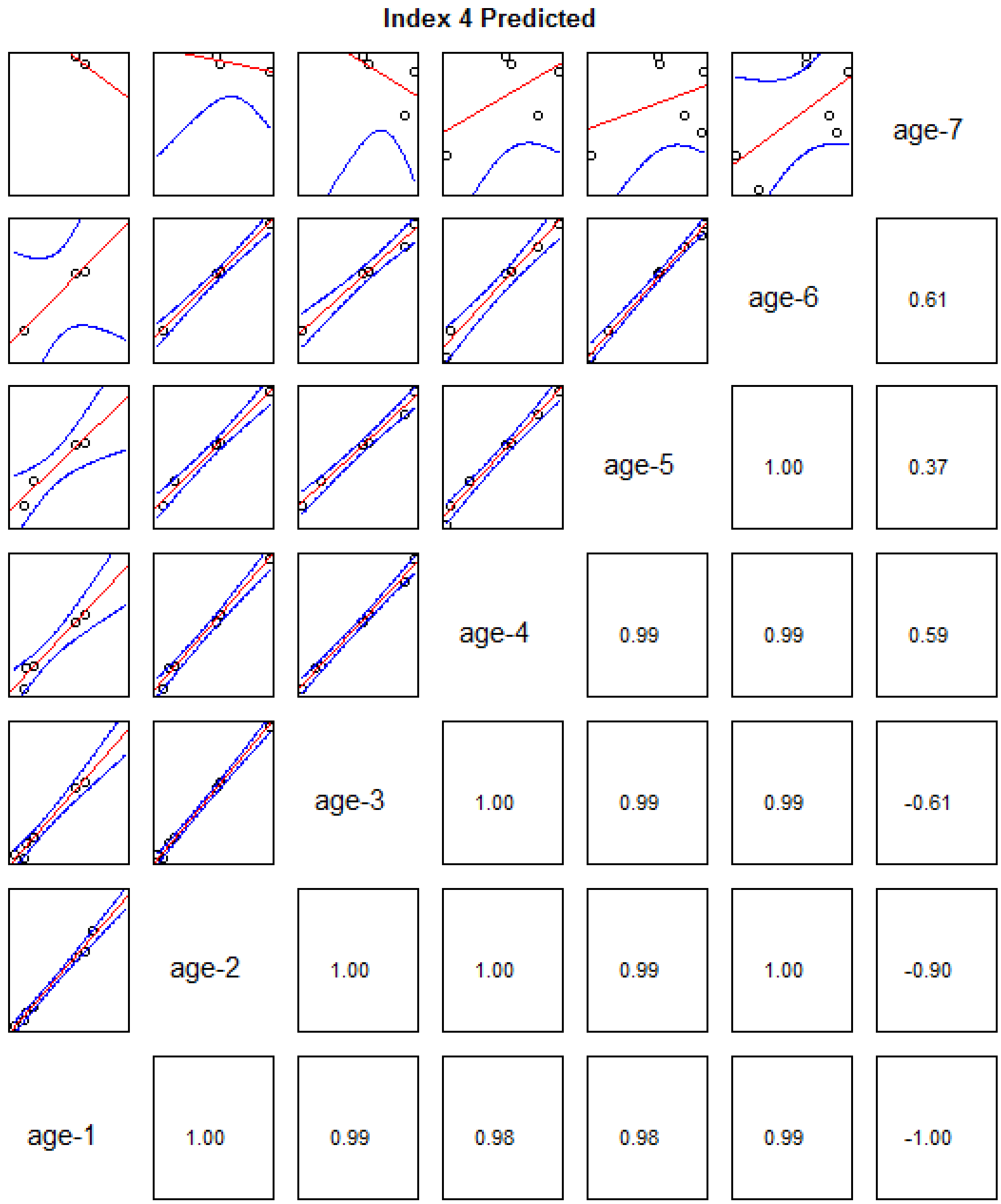


Figure B7.97. Predicted catch for the NEAMAP survey. Note that age class labels are 1 greater than the modeled age class, so that “age-1” corresponds to age 0, “age-2” corresponds to age 1, etc.

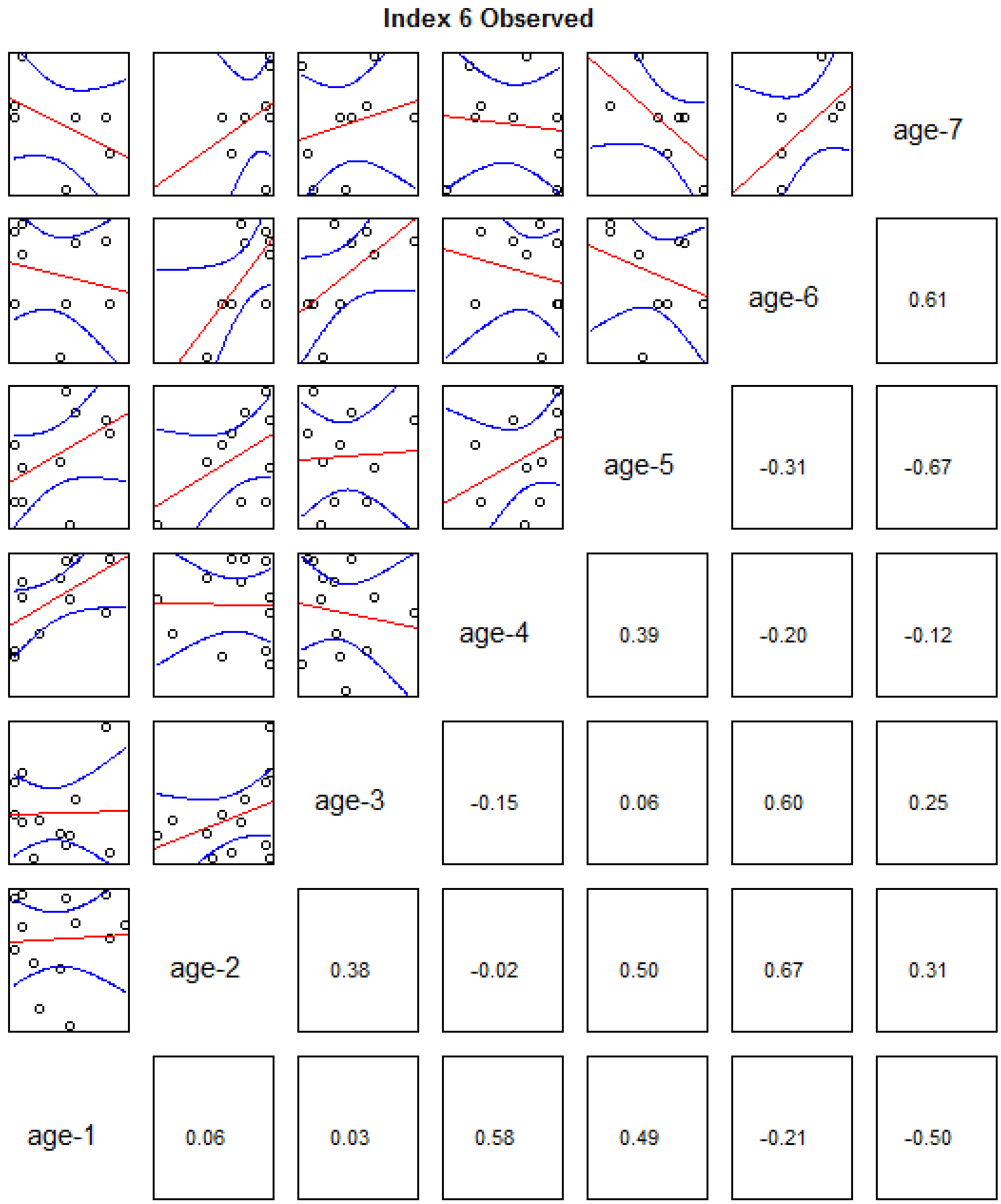


Figure B7.98. Observed catch for the PSIGNS gillnet survey. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

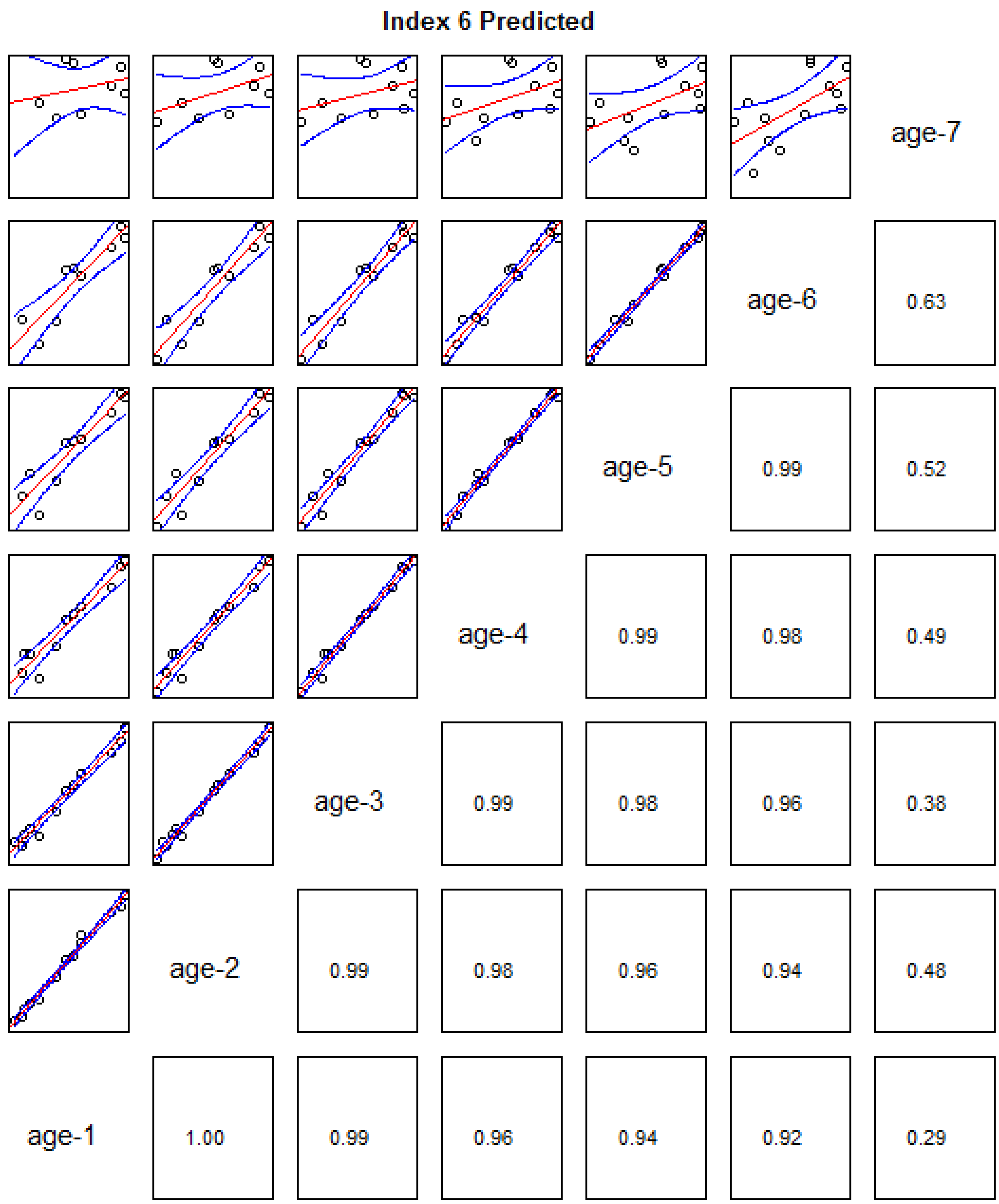


Figure B7.99. Predicted catch for the PSIGNS gillnet survey. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

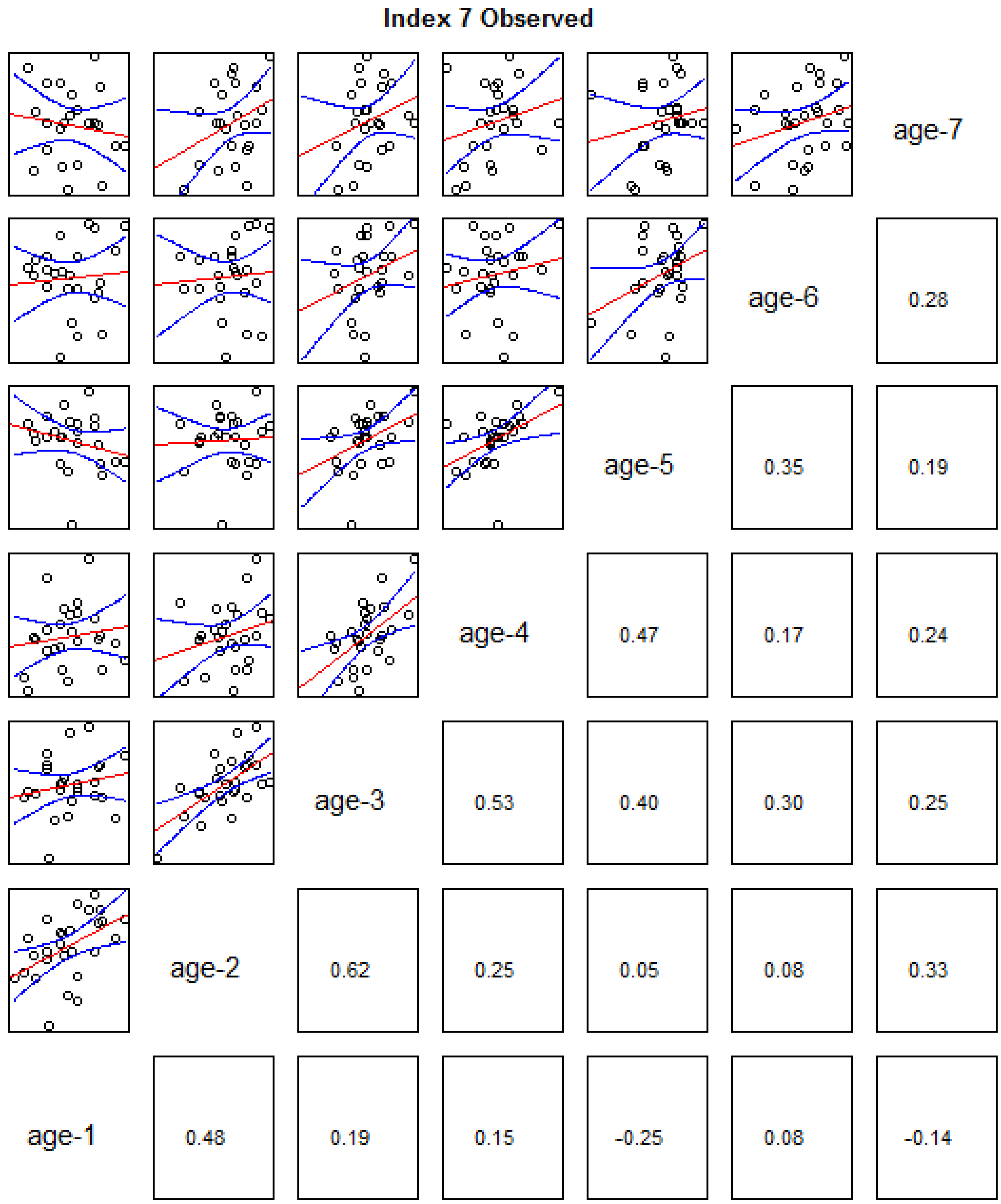


Figure B7.100. Observed catch for the CT LISTS trawl survey. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

Index 7 Predicted

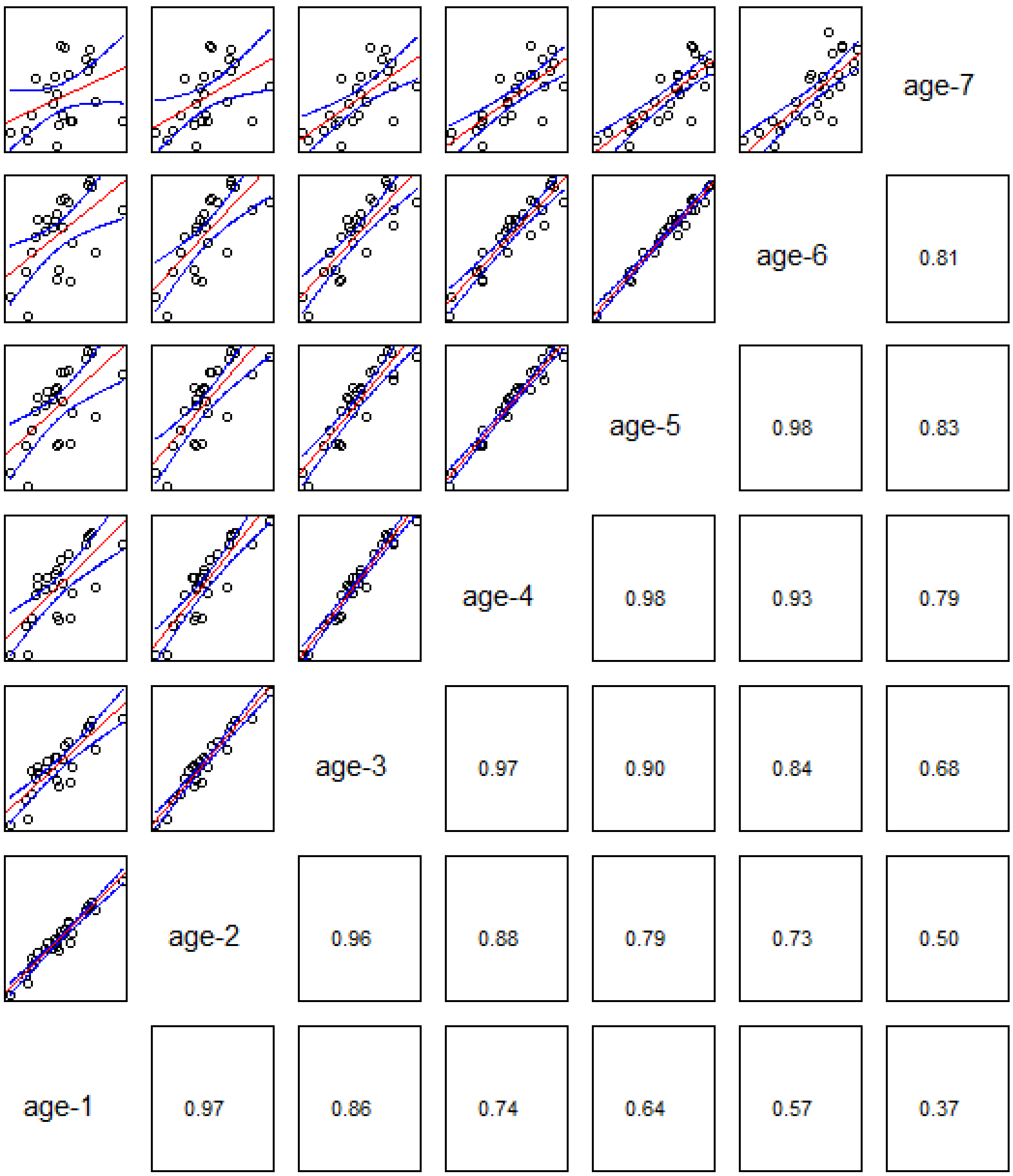


Figure B7.101. Predicted catch for the CT LISTS trawl survey. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

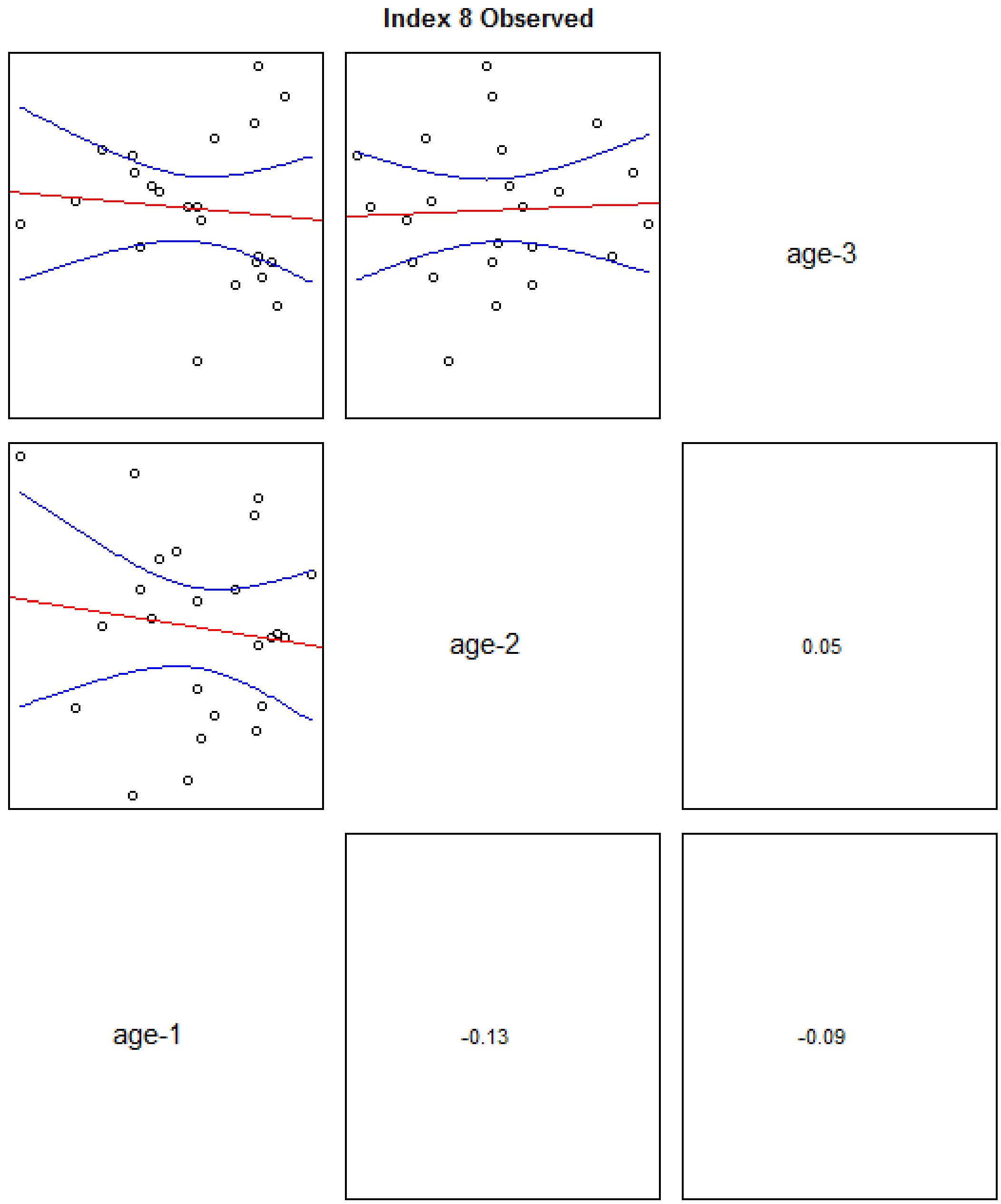


Figure B7.102. Observed catch for the NJ ocean trawl survey. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.

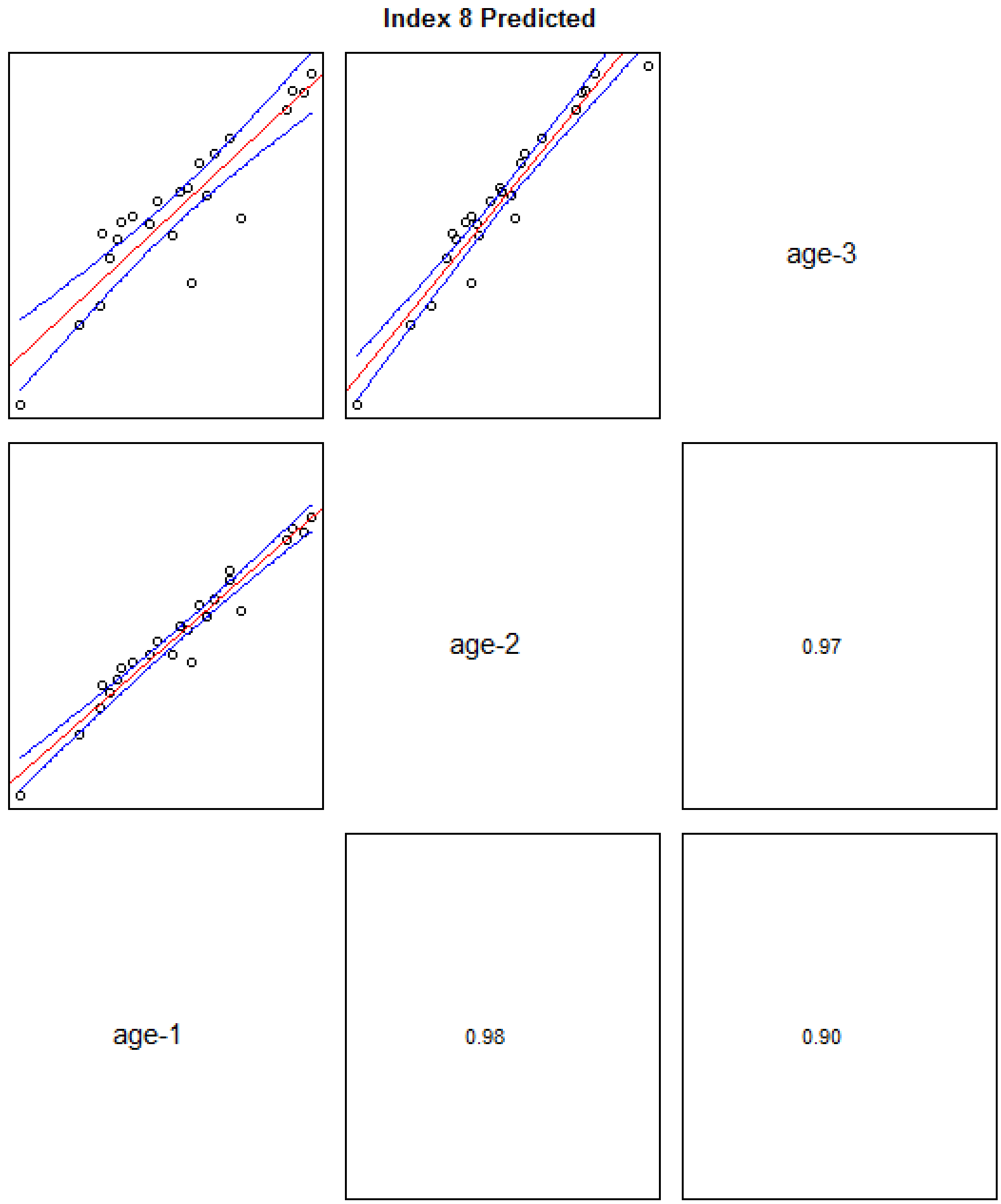
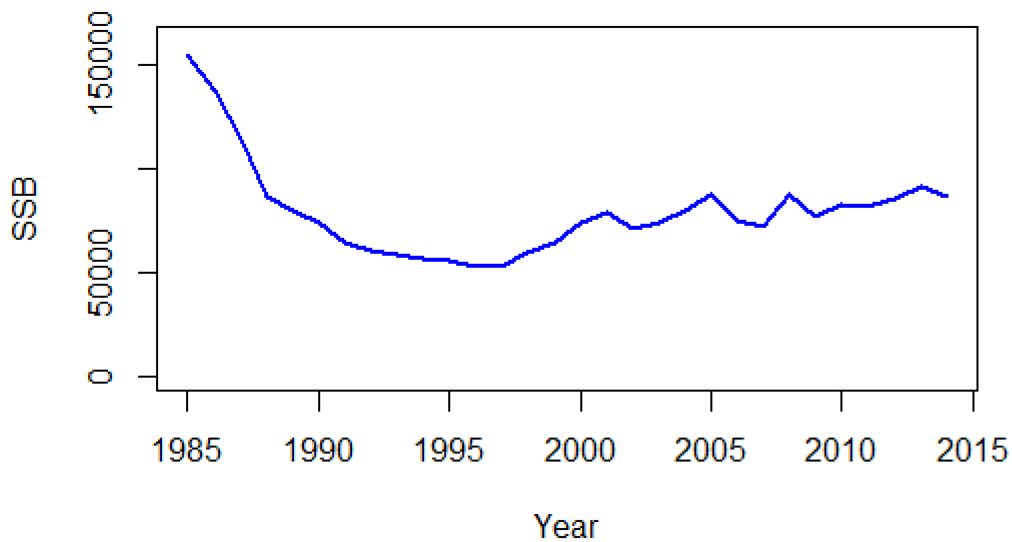


Figure B7.103. Predicted catch for the NJ ocean trawl survey. Note that age class labels are 1 greater than the modeled age class, so that "age-1" corresponds to age 0, "age-2" corresponds to age 1, etc.



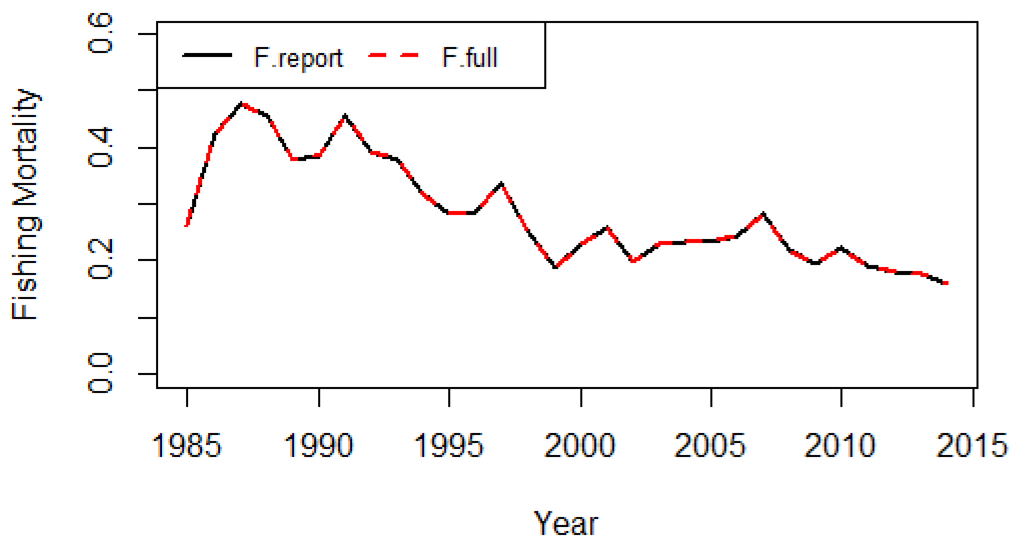


Figure B7.104. Estimated spawning stock biomass (top) and full fishing mortality (bottom) from 1985 to 2014 from the revised final model.

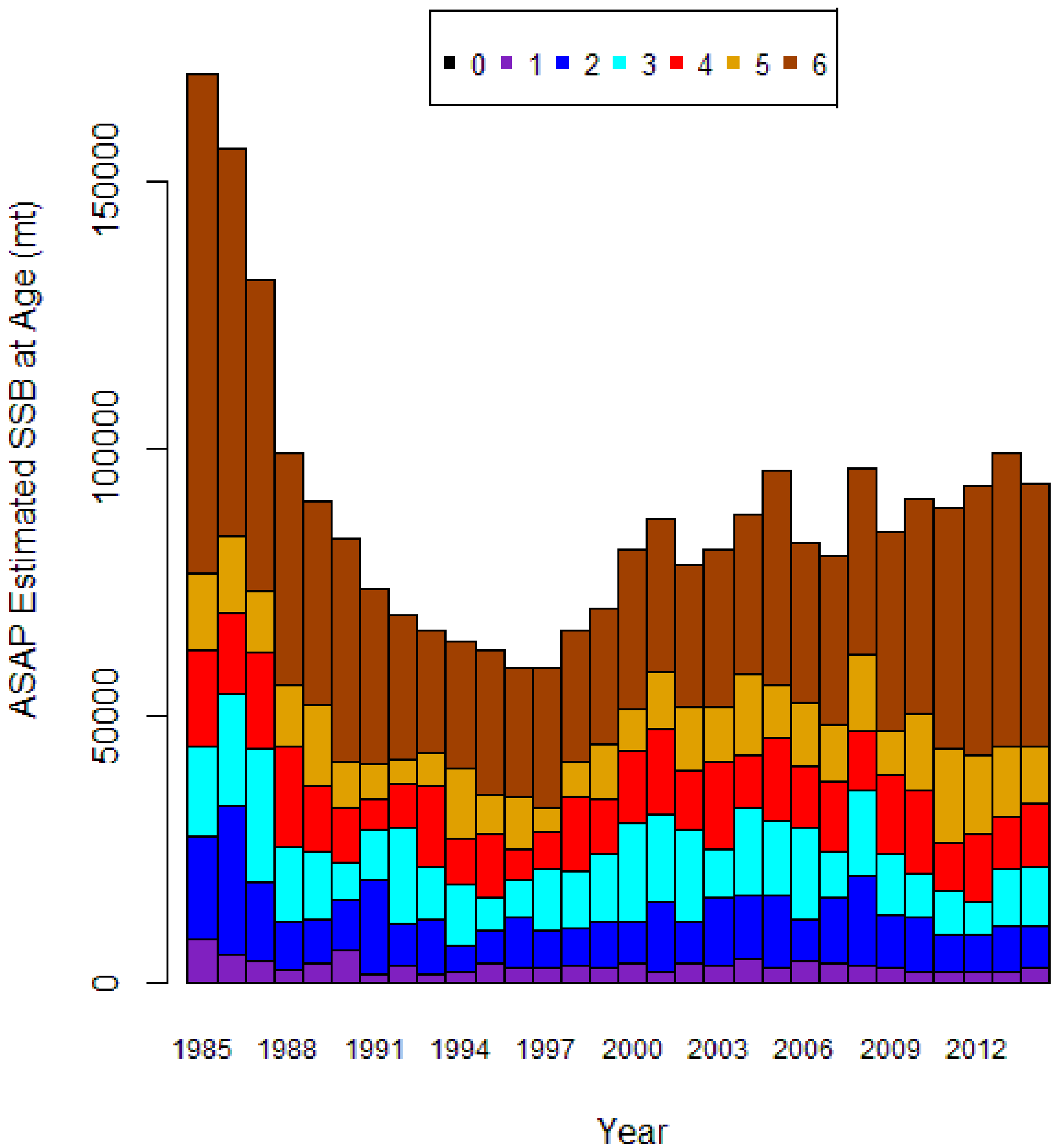


Figure B7.105. Age composition of the spawning stock biomass from 1985 to 2014.

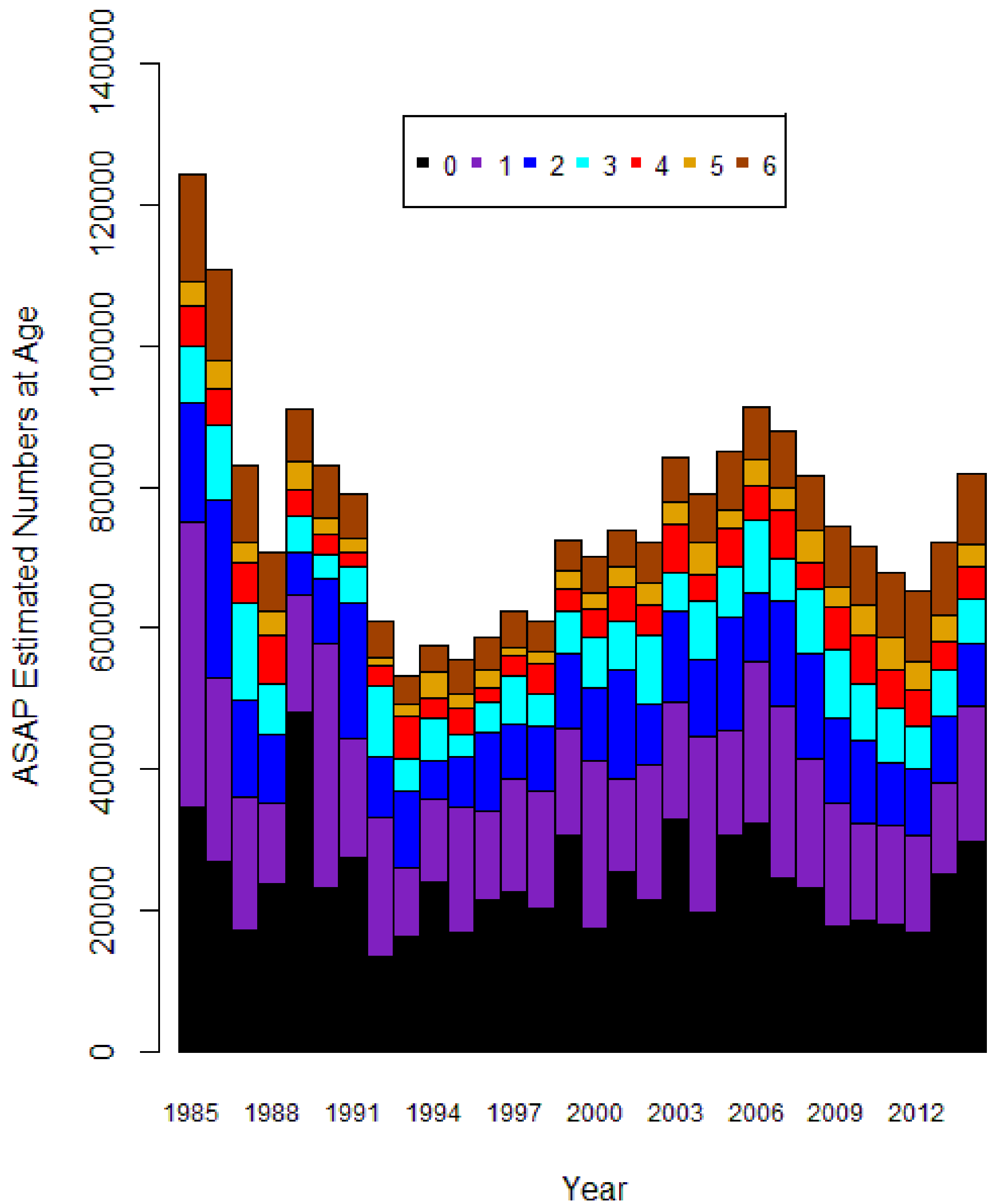
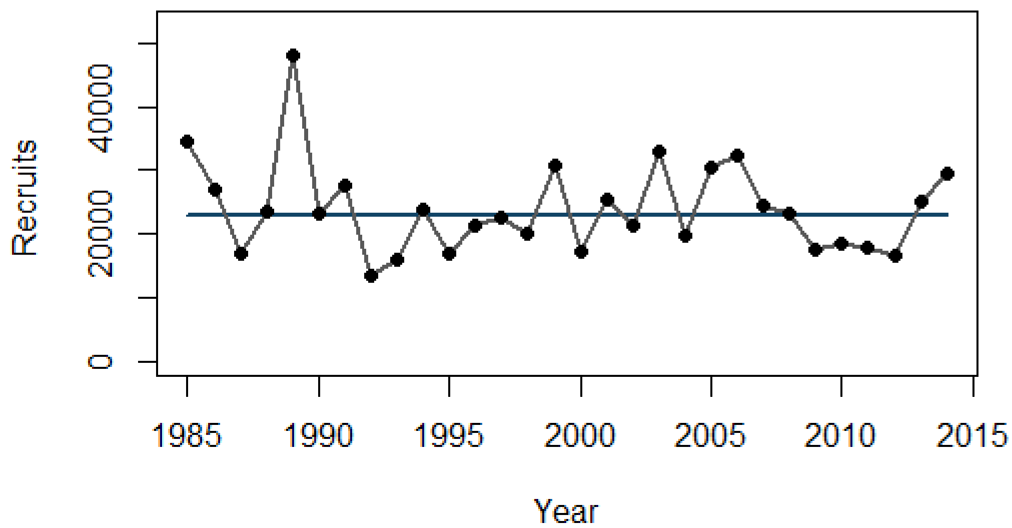


Figure B7.106. Estimated total numbers at age from 1985 to 2014.



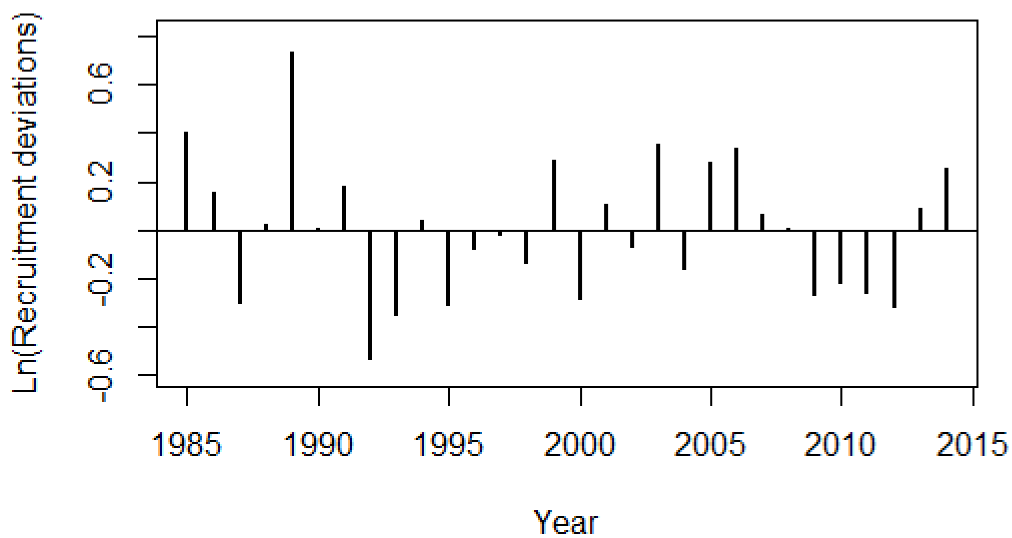


Figure B7.107. Recruitment estimates, mean recruitment, and recruitment deviations (log) from 1985 to 2014 from the final model.

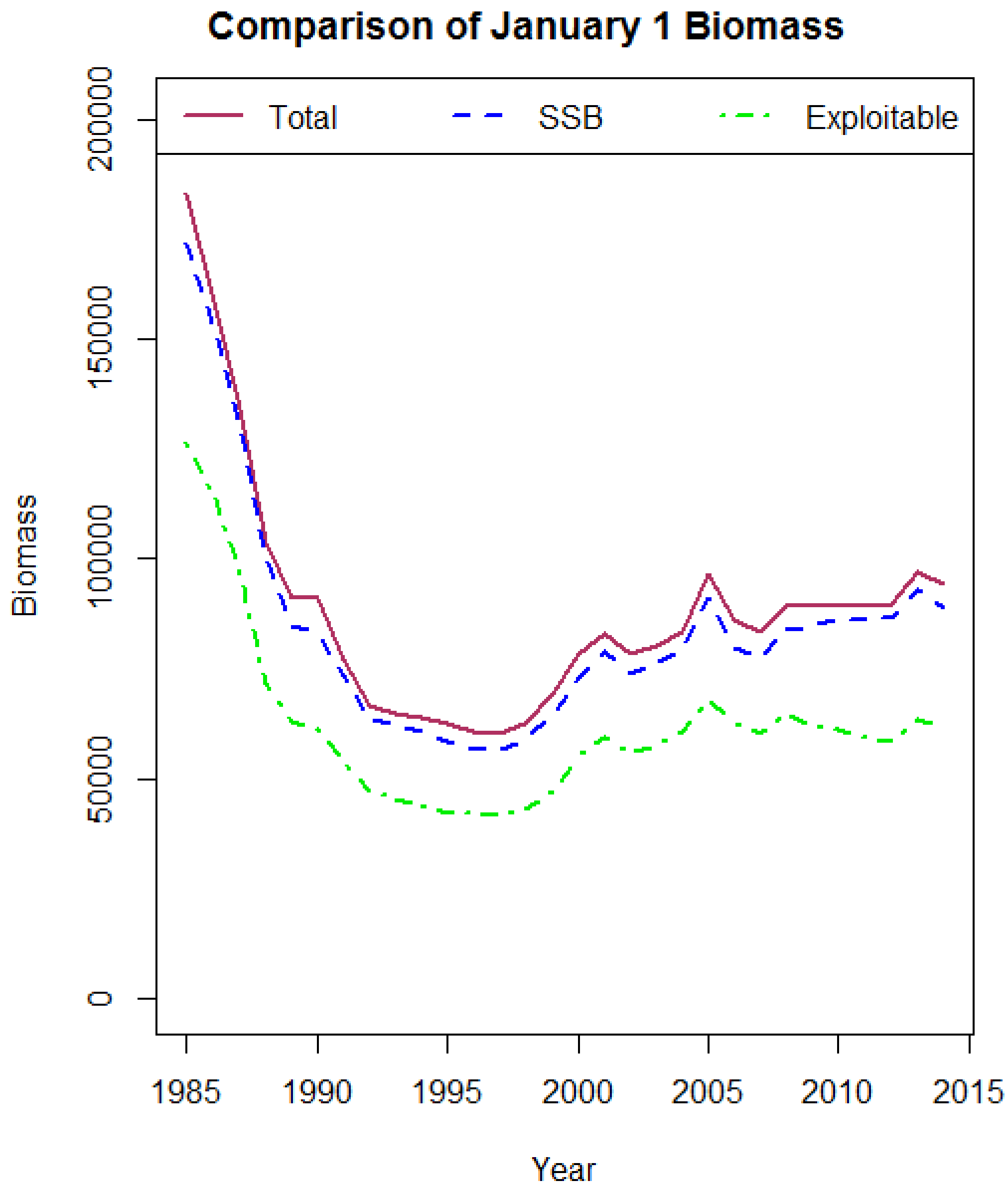


Figure B7.108. A comparison of total, spawning stock, and exploitable biomass from 1985 to 2014 from the final model.

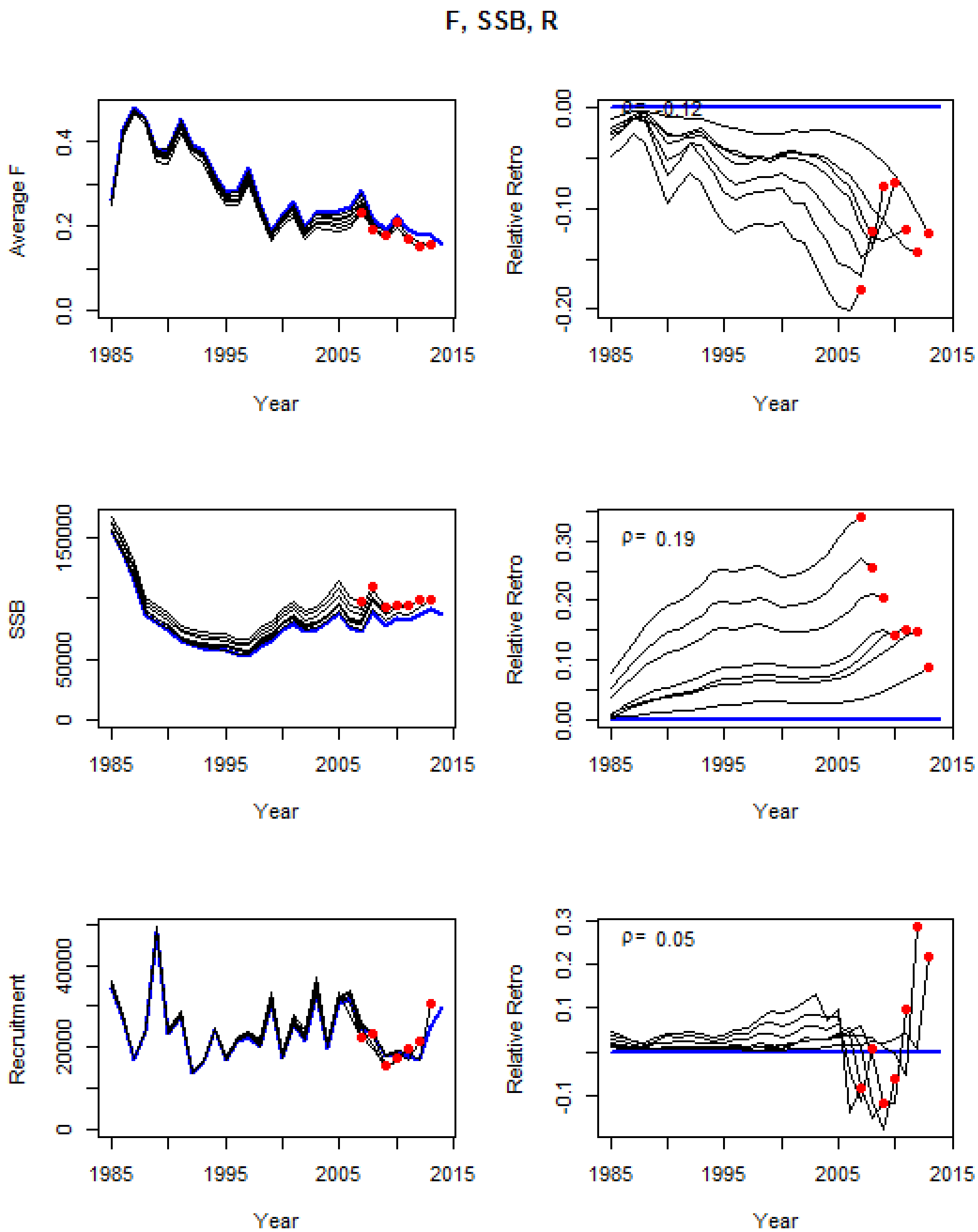


Figure B7.109. Retrospective plots for average fishing mortality, spawning stock biomass and recruitment from a 7 year peel carried out on the revised final model.

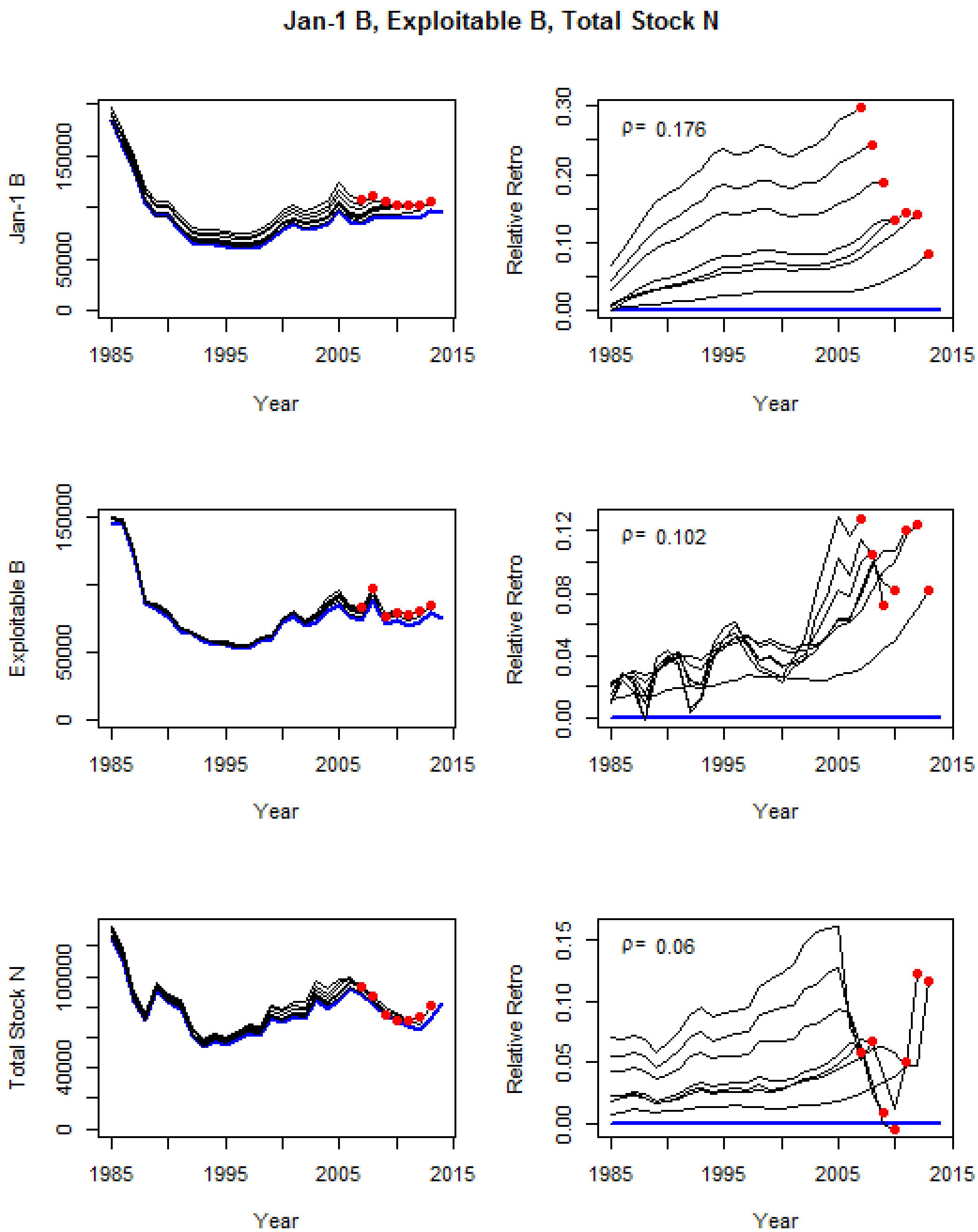


Figure B7.110. Retrospective plots for January-1 biomass, total biomass, and total stock numbers, from a 7 year peel carried out on the revised final model.

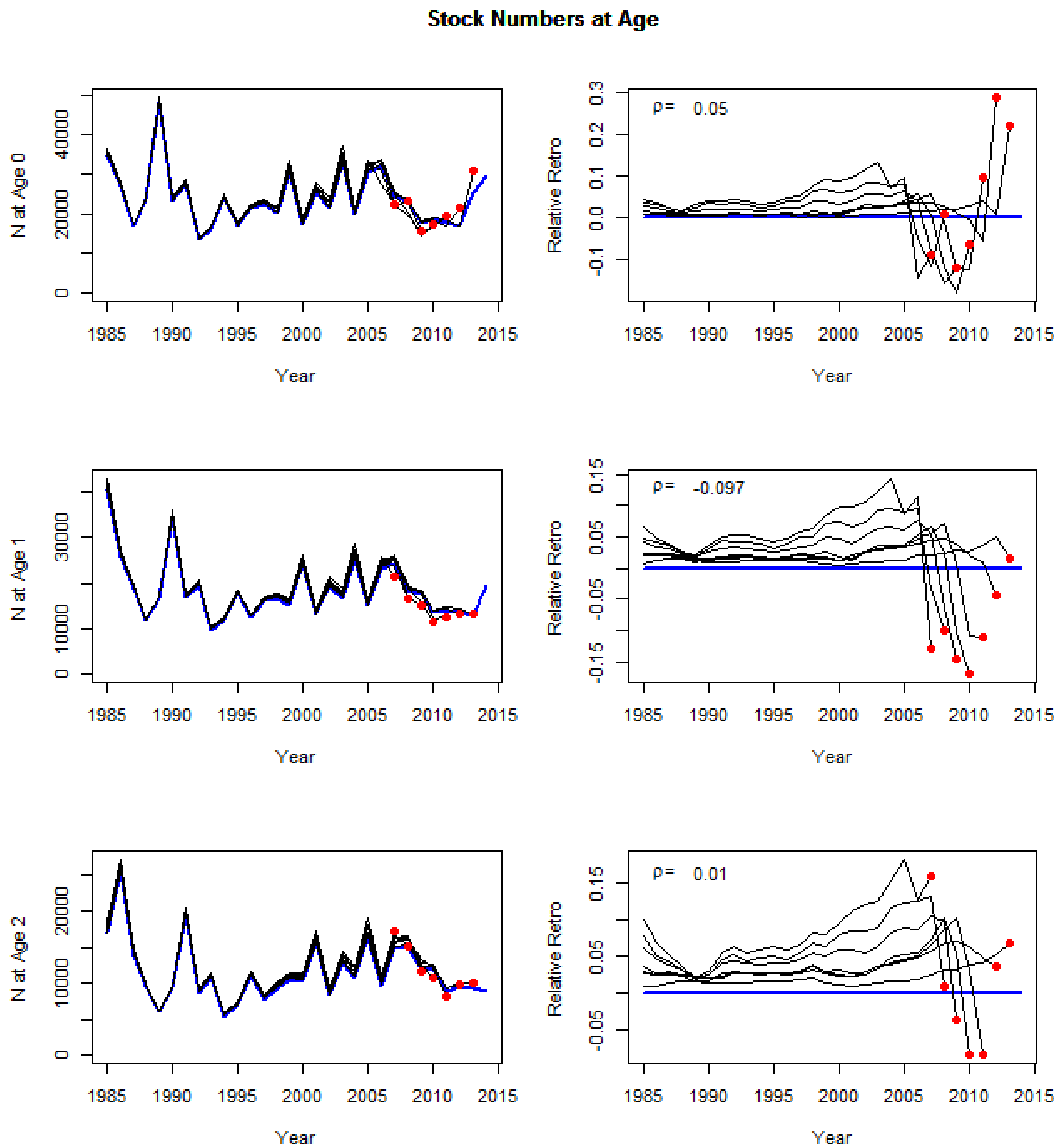


Figure B7.111. Retrospective plots for ages 0-2 from a 7 year peel carried out on the final model.

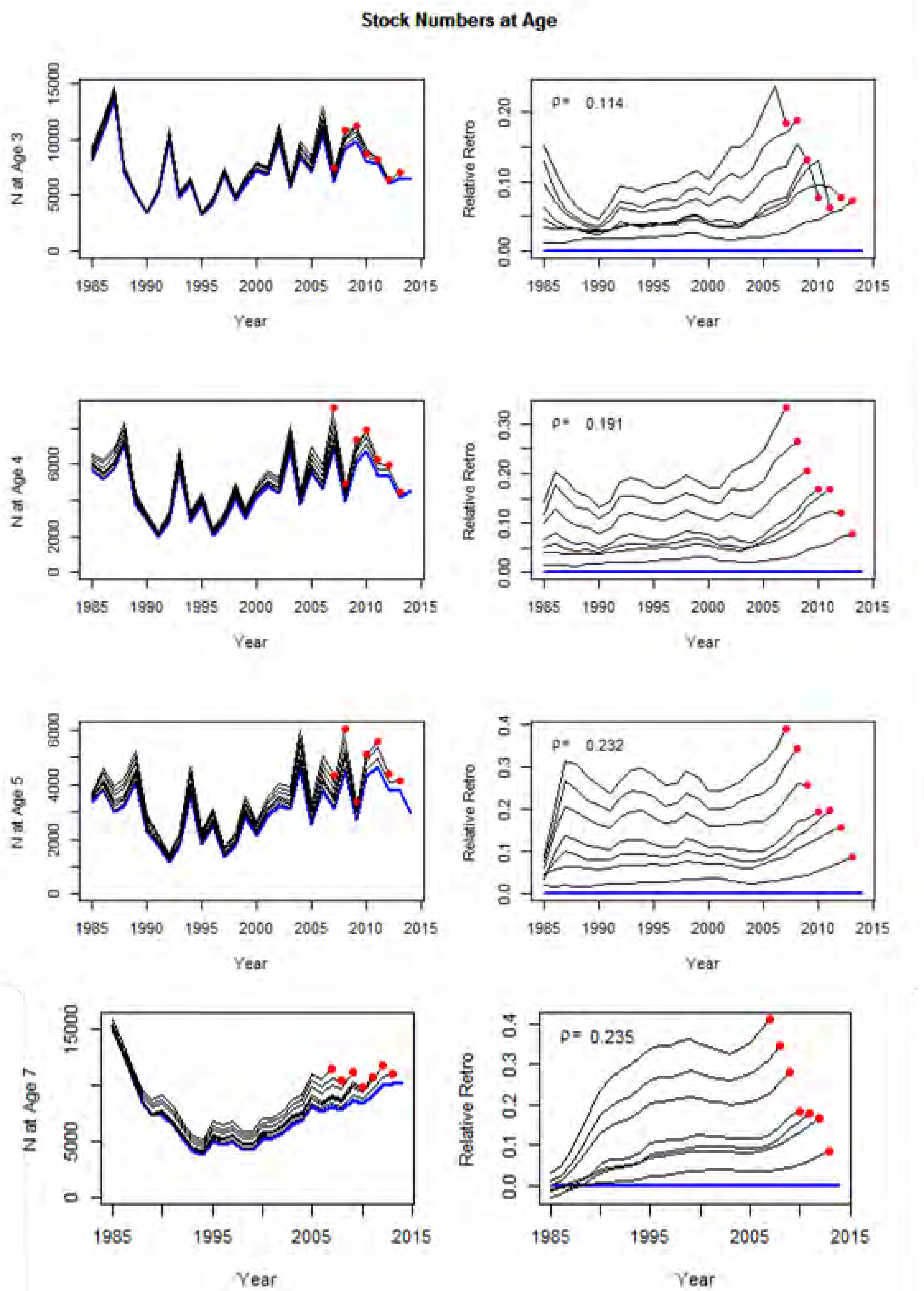


Figure B7.112. Retrospective plots for ages 3-6+ from a 7 year peel carried out on the final model.

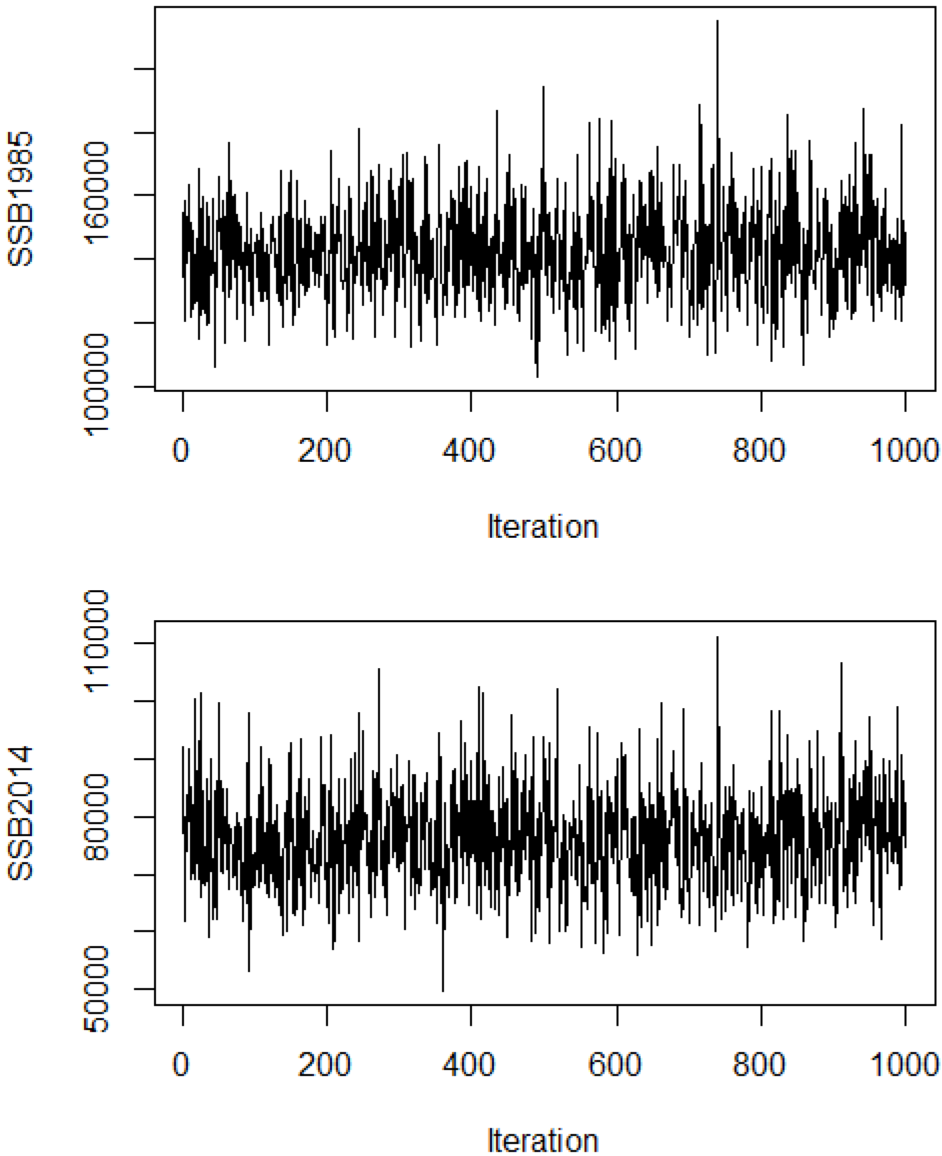


Figure B7.113. Trace plots for fishing mortality in 1985 and 2014 from 1000 MCMC and a thinning rate of 1000 (1,000,000 iterations).

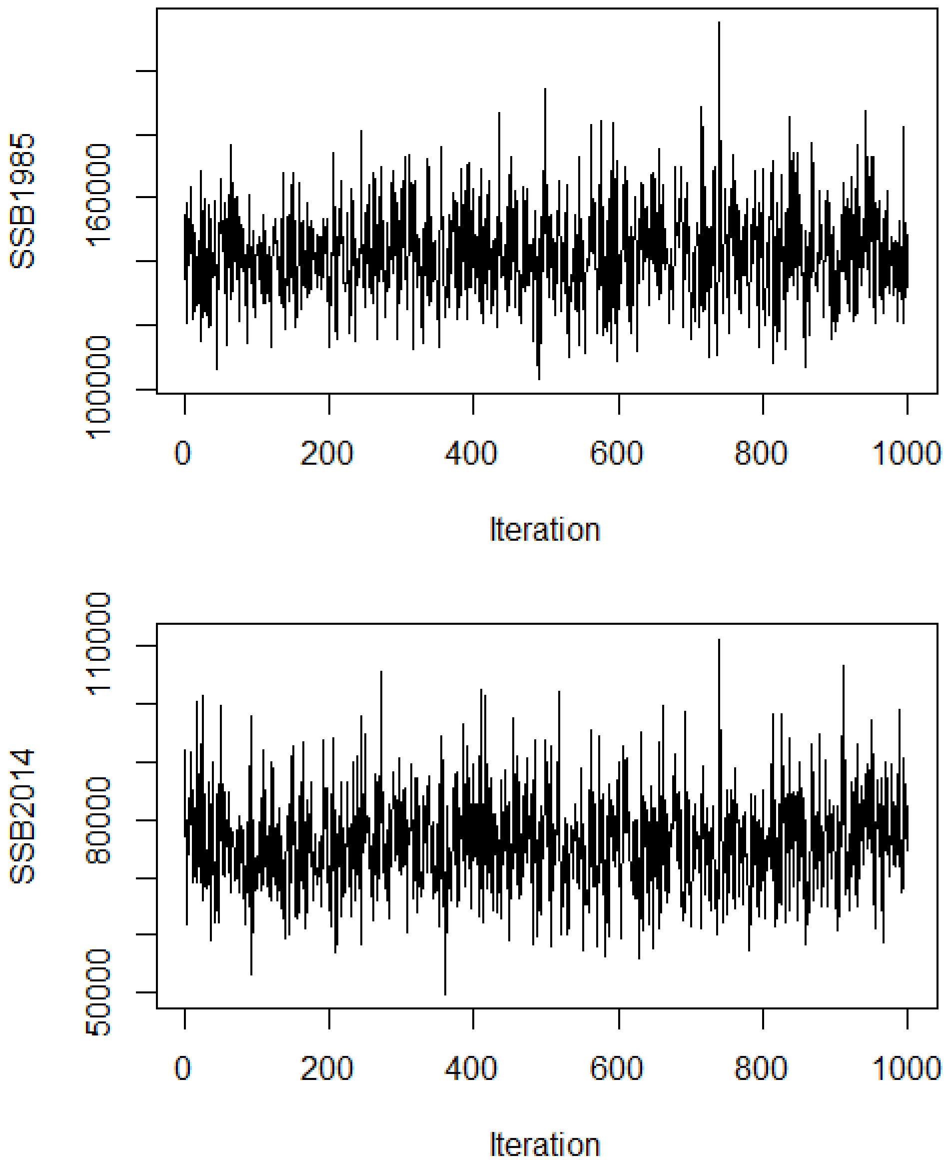


Figure B7.114. Trace plots for spawning stock biomass in 1985 and 2014 from 1000 MCMC and a thinning rate of 1000 (1,000,000 iterations).

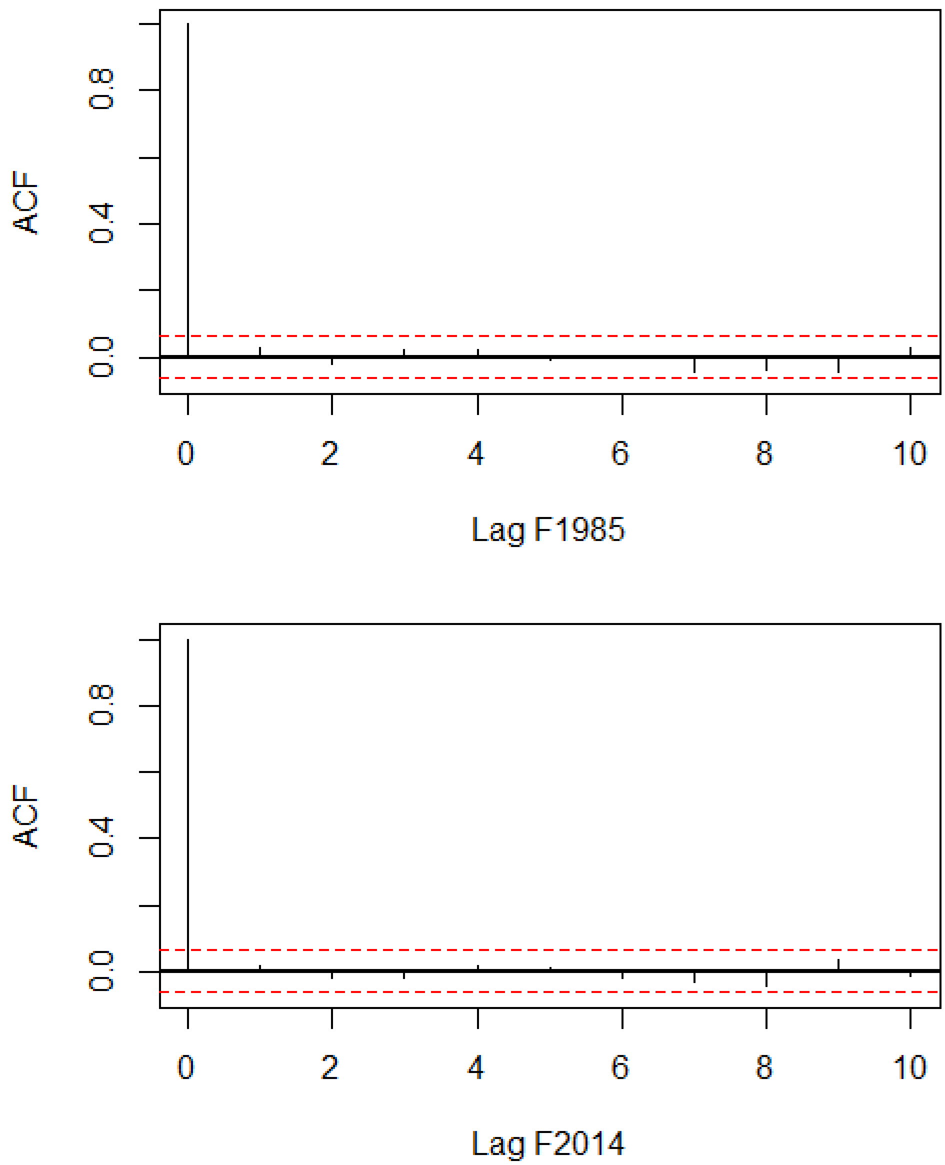
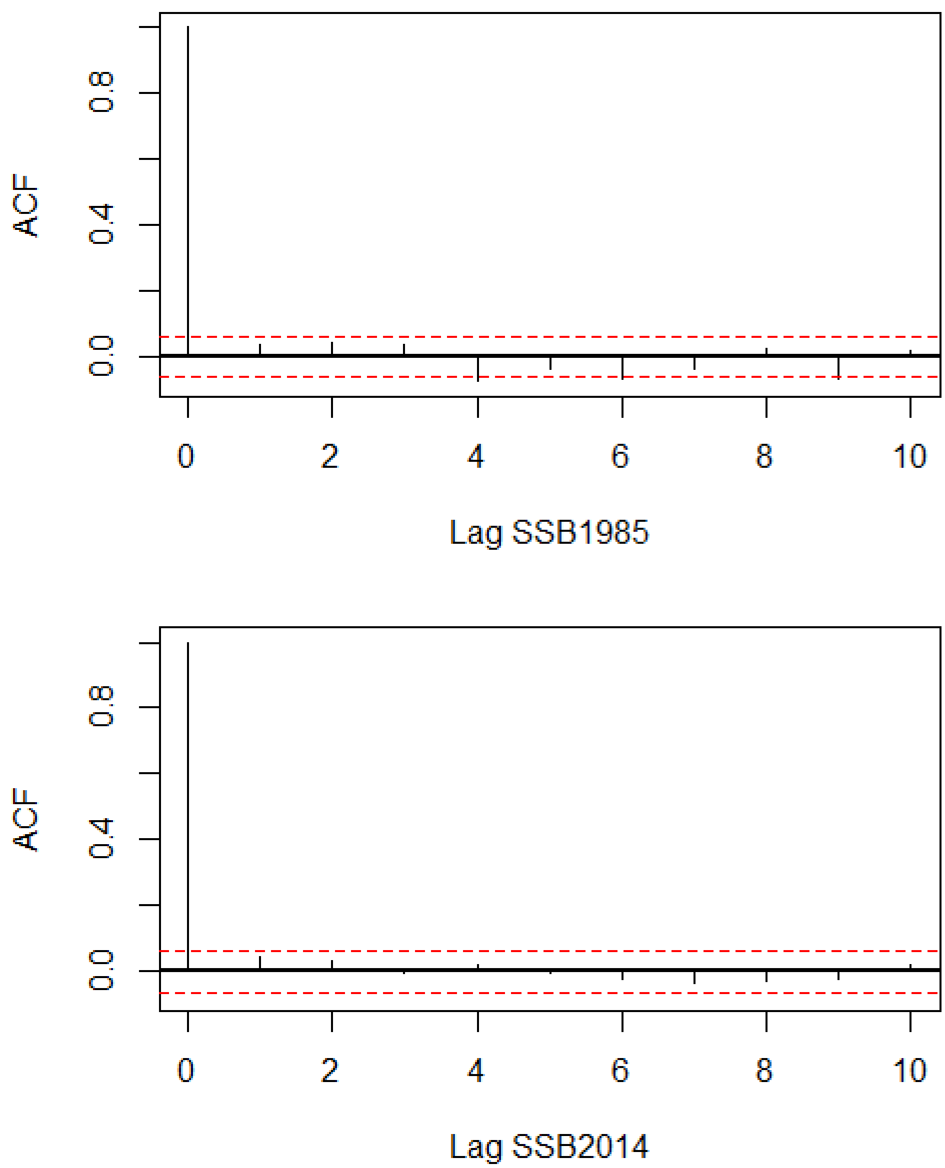


Figure B7.115. Autocorrelation for fishing mortality in the MCMC runs.

Figure B7.116. Autocorrelation for SSB in the MCMC runs.



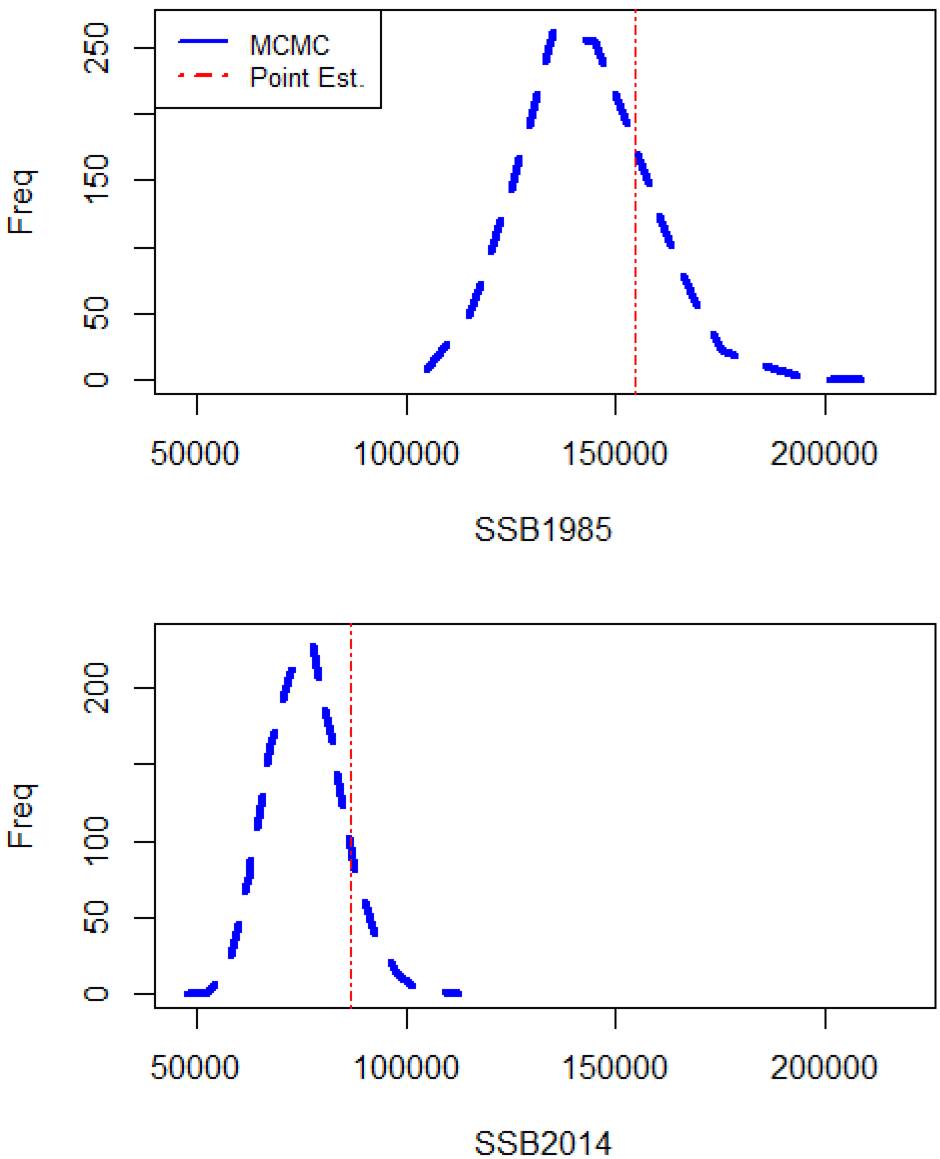


Figure B7.117. MCMC distribution plots for spawning stock biomass in 1985 and 2014 with point estimates from the revised final model.

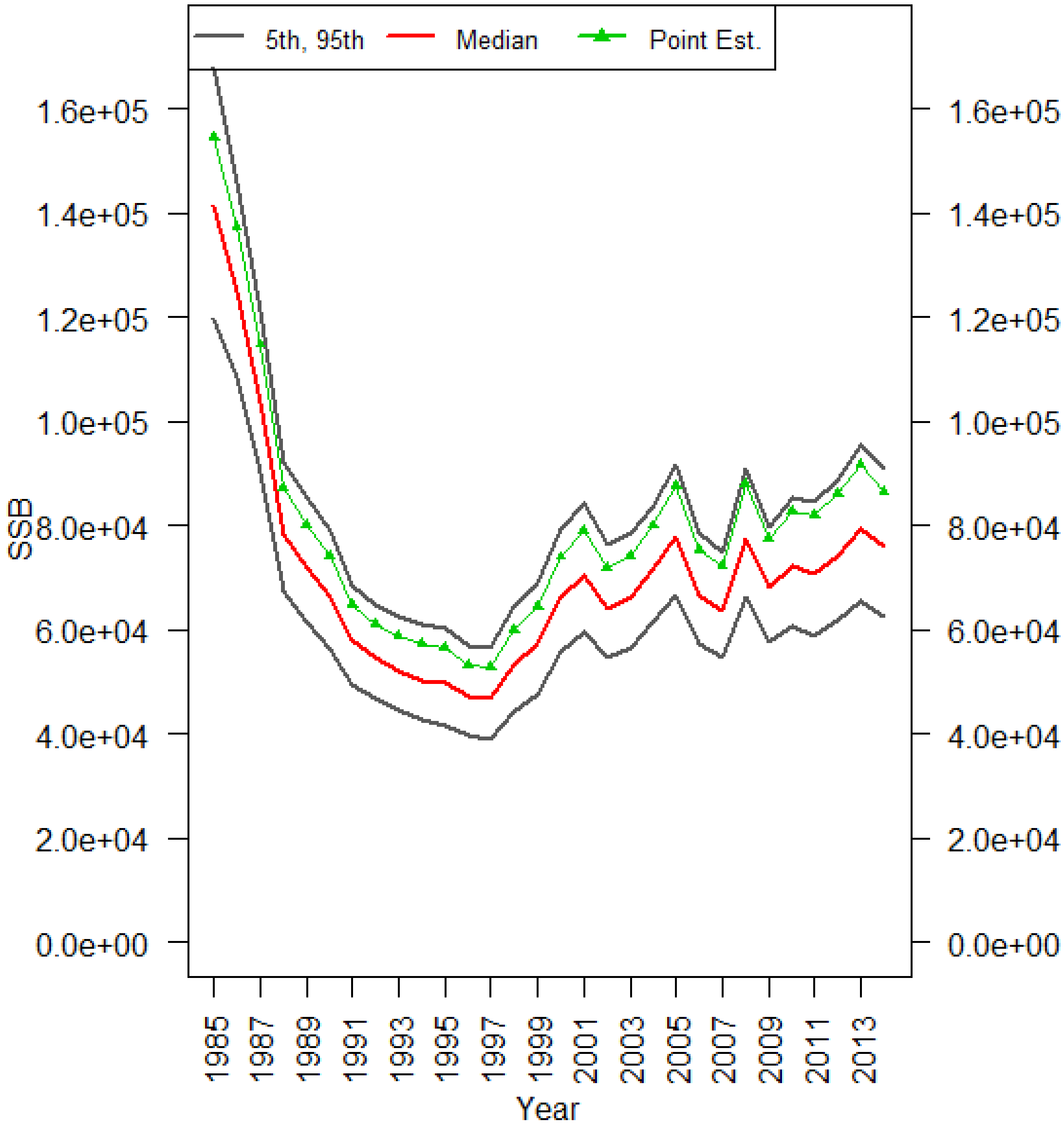


Figure B7.118. Median spawning stock biomass and 95 confidence intervals from the MCMC runs with point estimates from the revised final model.

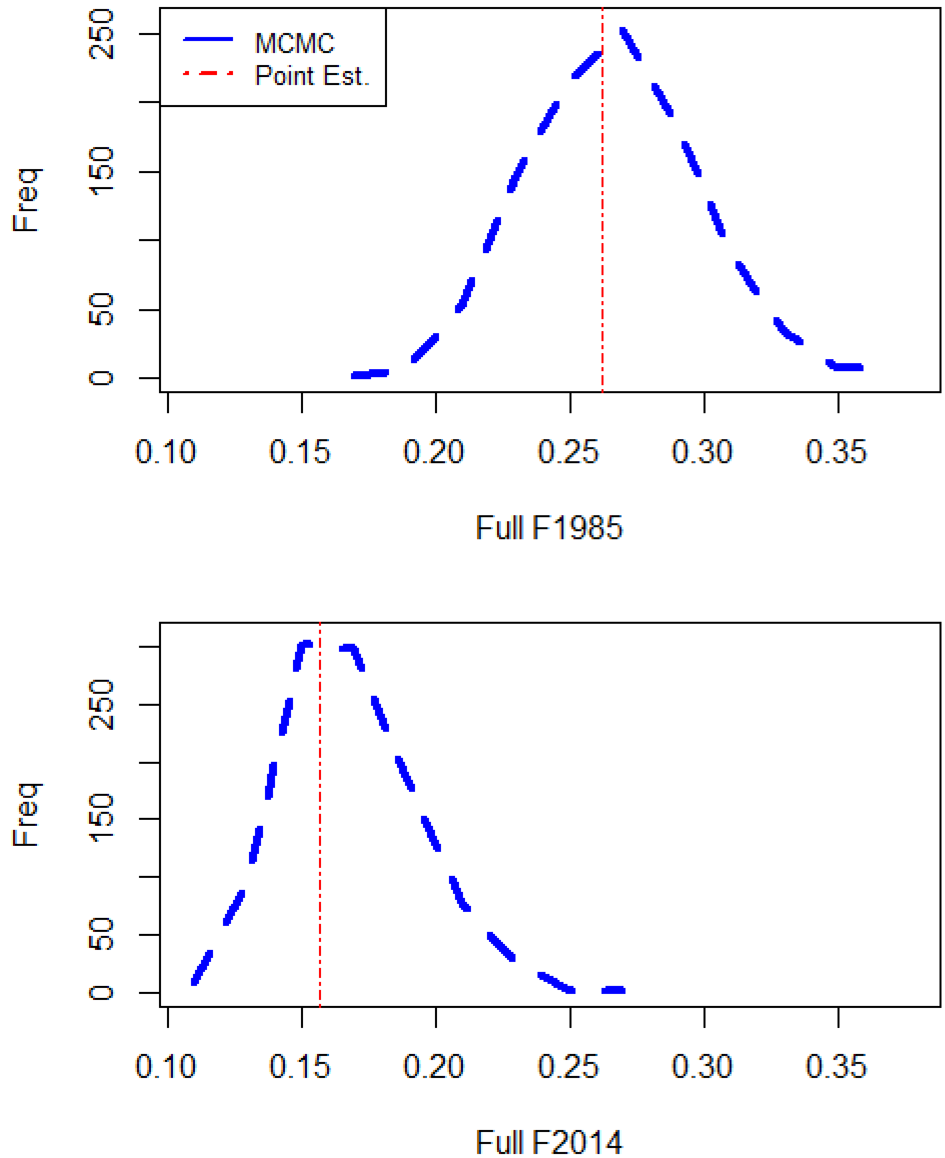


Figure B7.119. MCMC distribution plots for fishing mortality in 2985 and 2014 with point estimates from the revised final model.

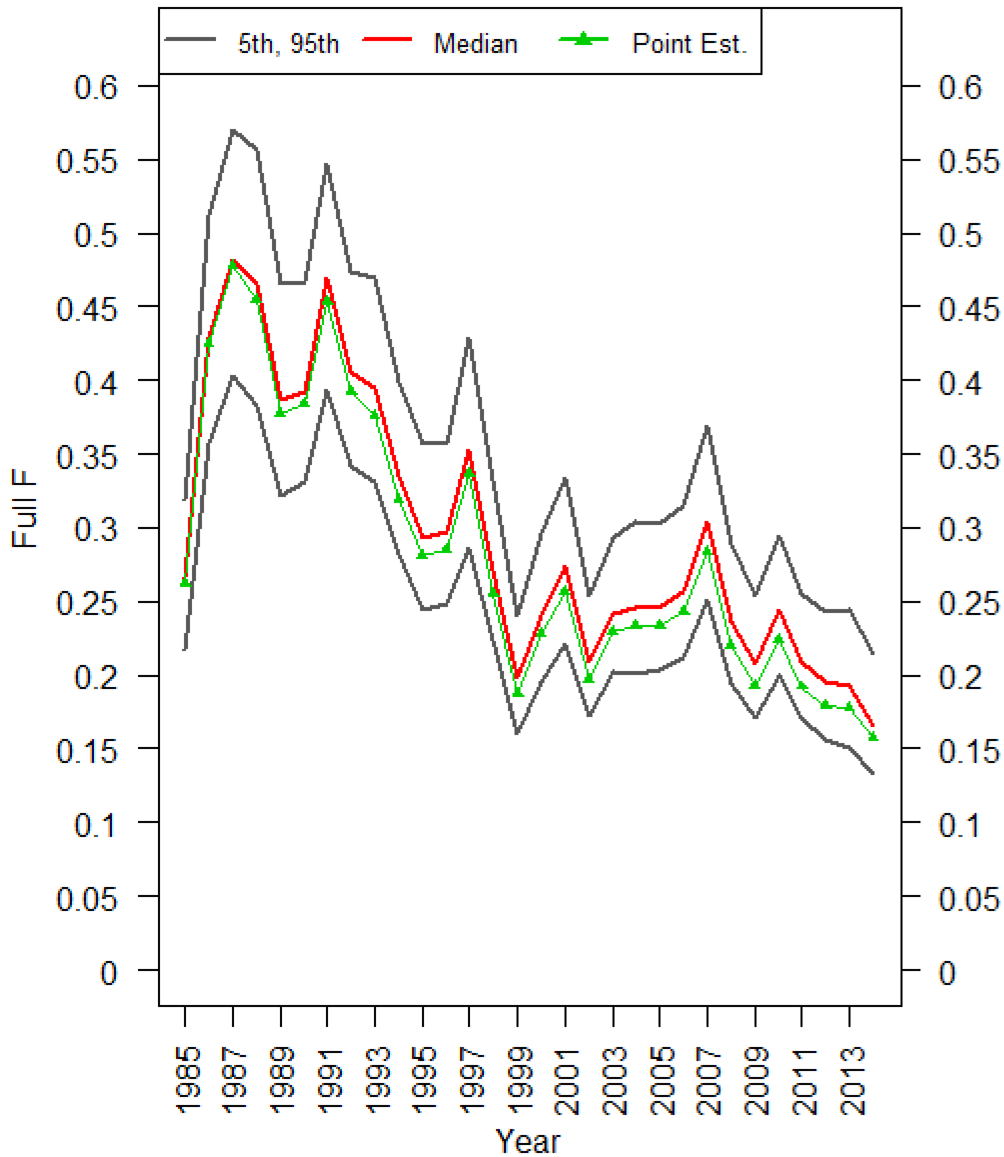


Figure B7.120. Median fishing mortality and 95% confidence intervals from the MCMC runs with point estimates from the revised final model.

Figure B7.121. Final model sensitivity run assume AB1 lengths for the recreational discards. Trends for the revised final model (B044) estimates are represented by the red line, with sensitivity run estimates (B044S5) represented by the black line.

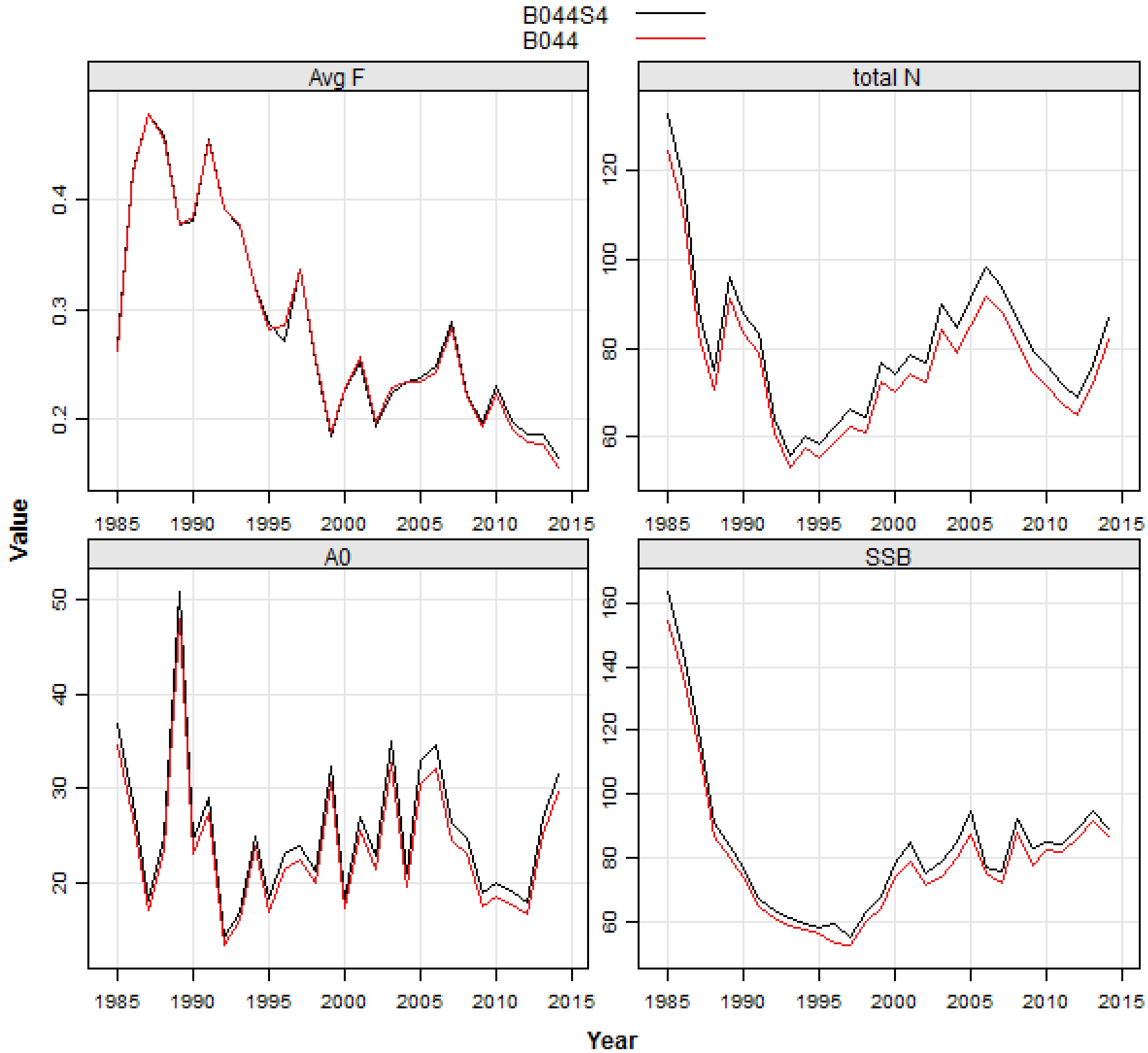


Figure B7.122. Final model sensitivity run assuming upper 95% CI for recreational catch.
Trends for the revised final model (B044) estimates are represented by the red line, with sensitivity run estimates (B044S4) represented by the black line.

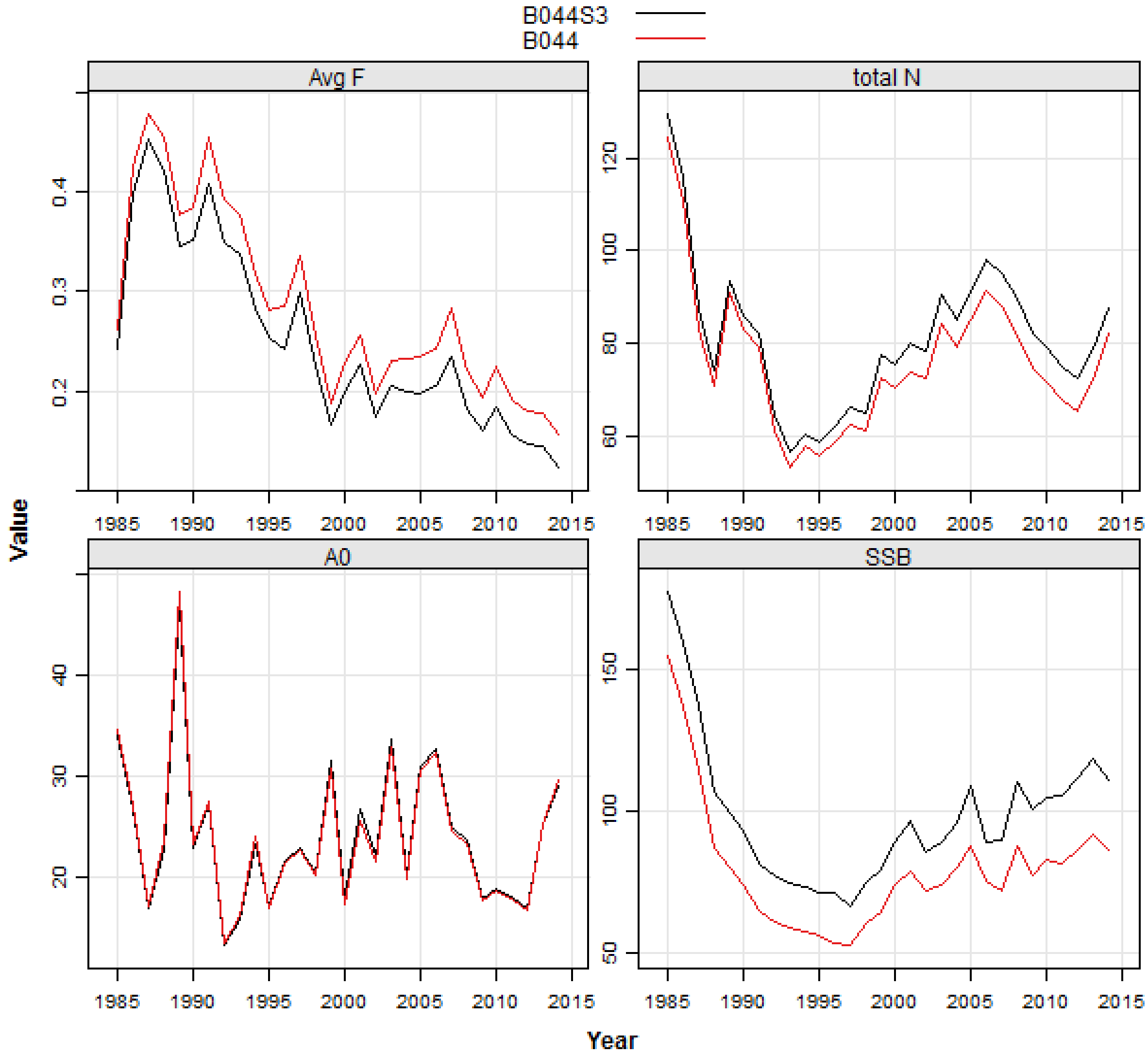


Figure B7.123. Final model sensitivity run assuming lower 95% CI for recreational catch.
Trends for the final model (B044) estimates are represented by the red line, with sensitivity run estimates (B044S3) represented by the black line.

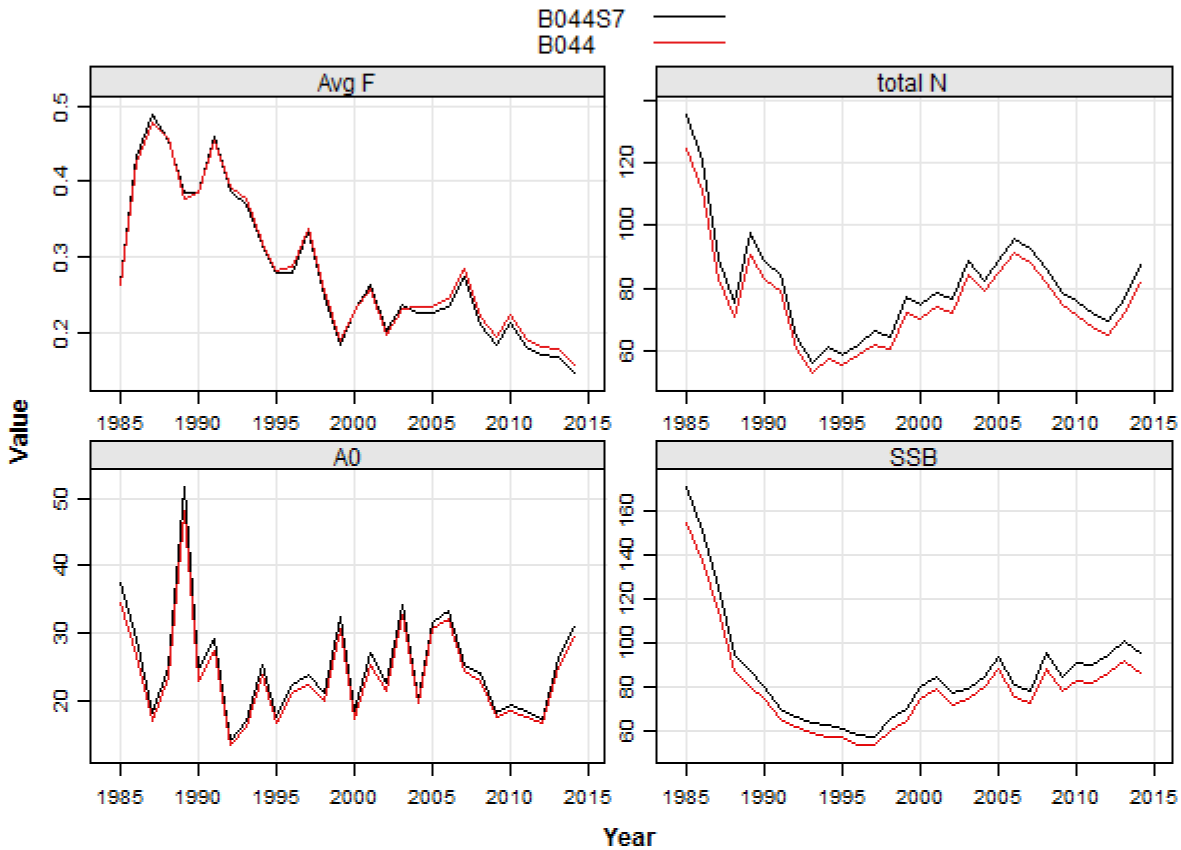


Figure B7.124. Final model sensitivity run assuming MRFSS number prior to 2004 for the recreational catch. Trends for the revised final model (B044) estimates are represented by the red line, with sensitivity run estimates (B044S7) represented by the black line.

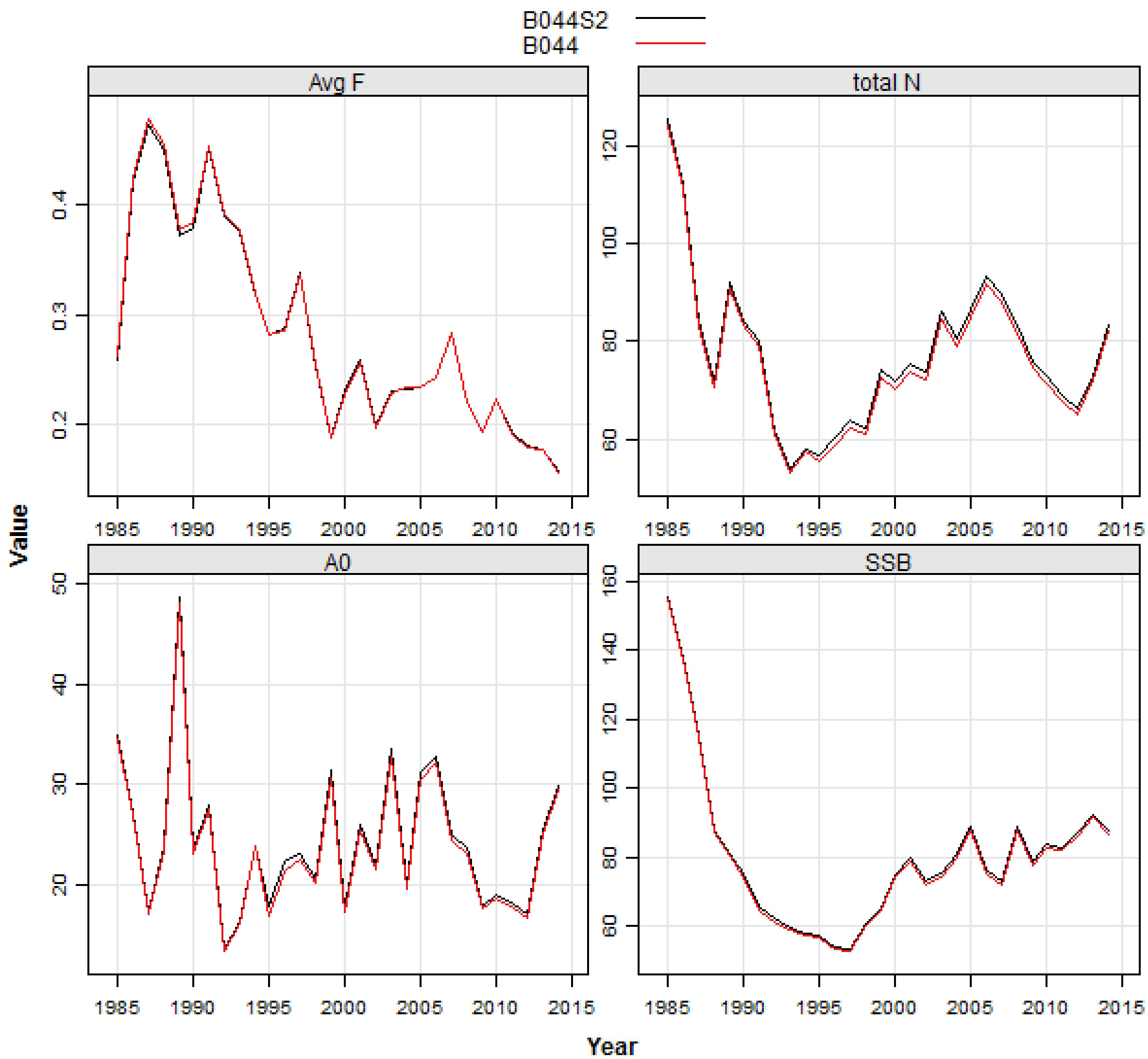


Figure B7.125. Final model sensitivity run assuming 17% mortality (instead of 15%) for the recreational discards. Trends for the final model (B044) estimates are represented by the red line, with sensitivity run estimates (B044S2) represented by the black line.

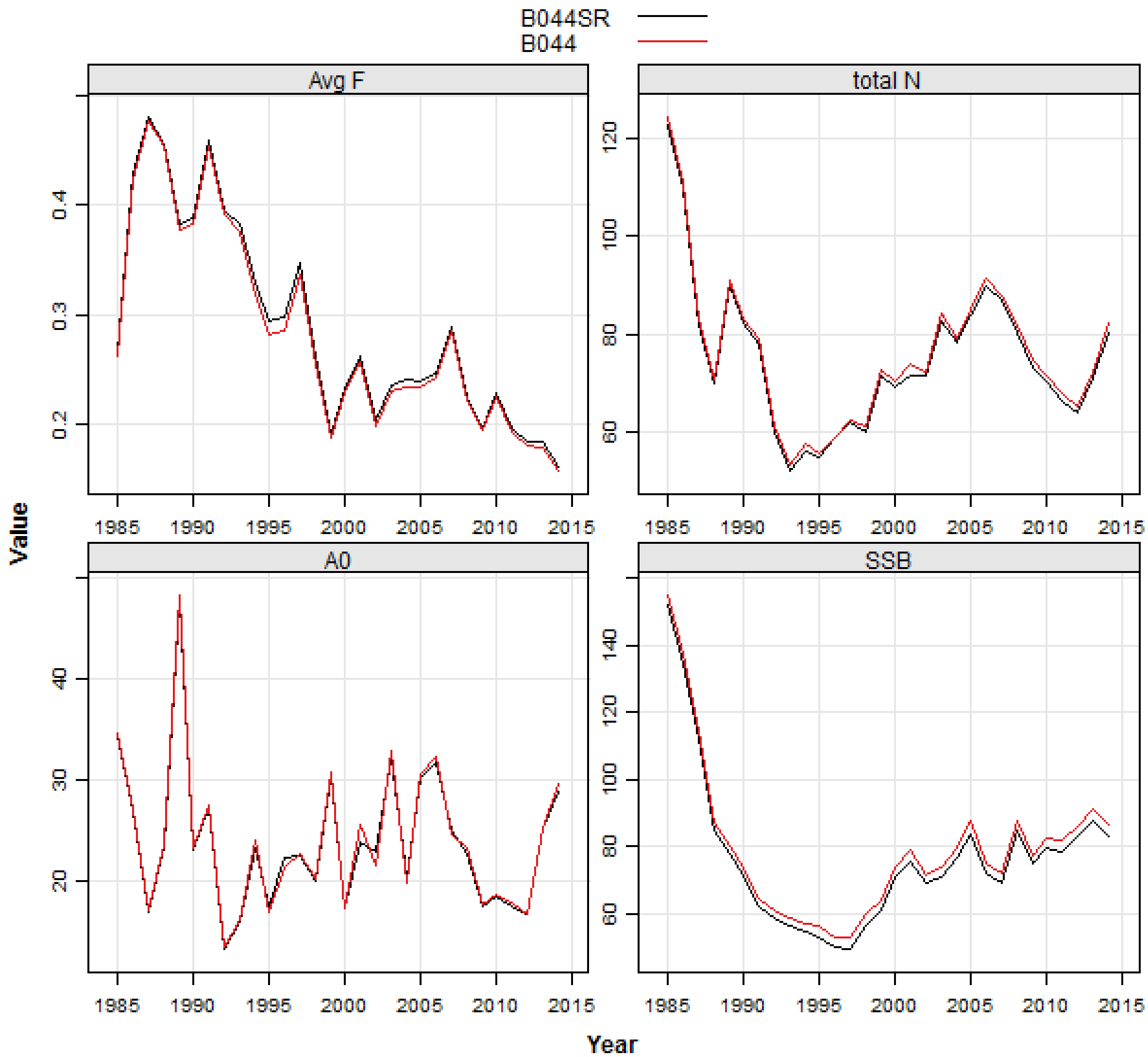


Figure B7.126. Final model sensitivity run assuming regional age-length keys from 2006 to 2014. Trends for the revised final model (B044) estimates are represented by the red line, with sensitivity run estimates (B044SR) represented by the black line.

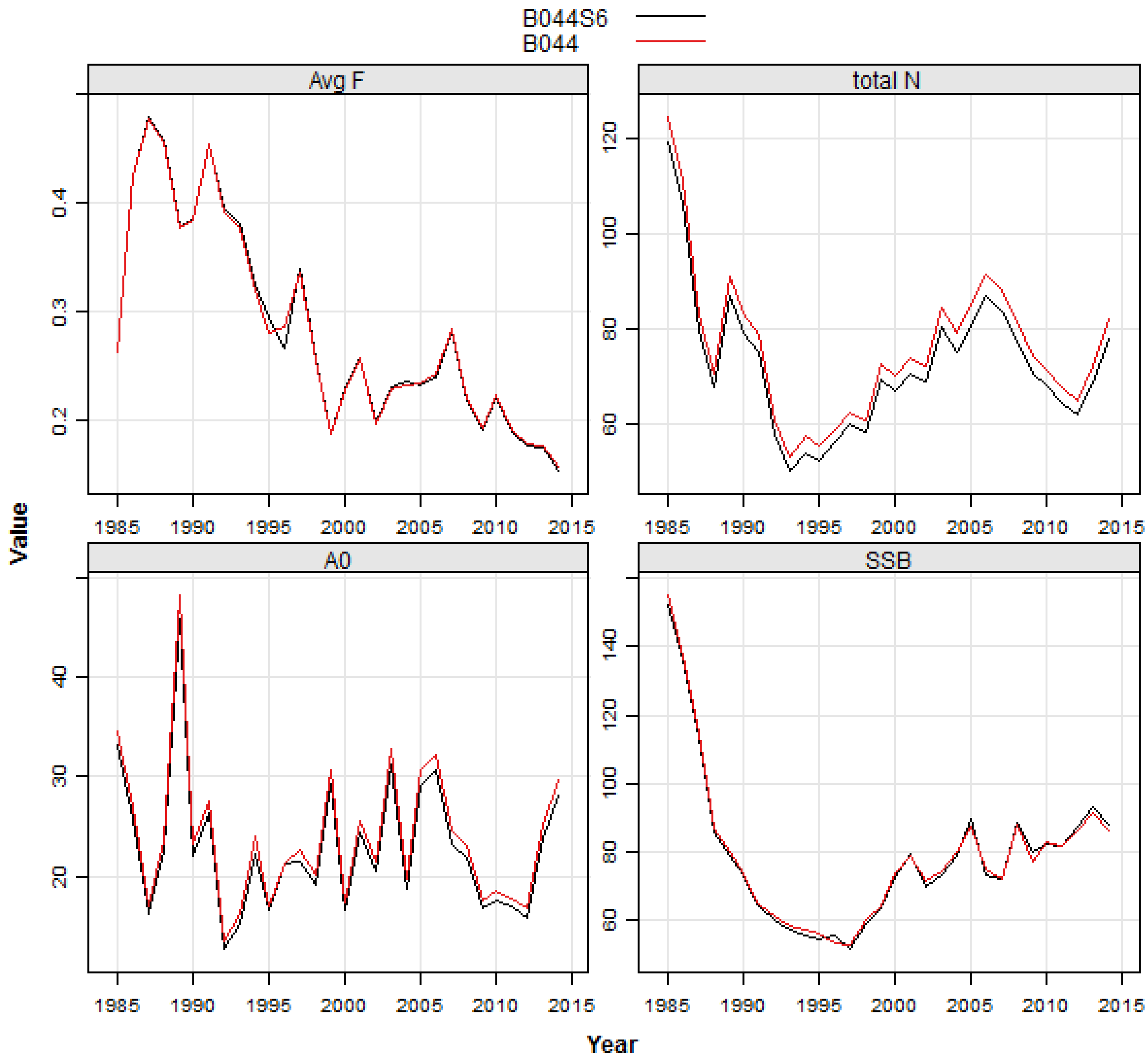


Figure B7.127. Final model sensitivity run assuming 3 time blocks for length-weight coefficients (1985-1994, 1995-2004, 2005-2014). Trends for the revised final model (B044) estimates are represented by the red line, with sensitivity run estimates (B044S6) represented by the black line.

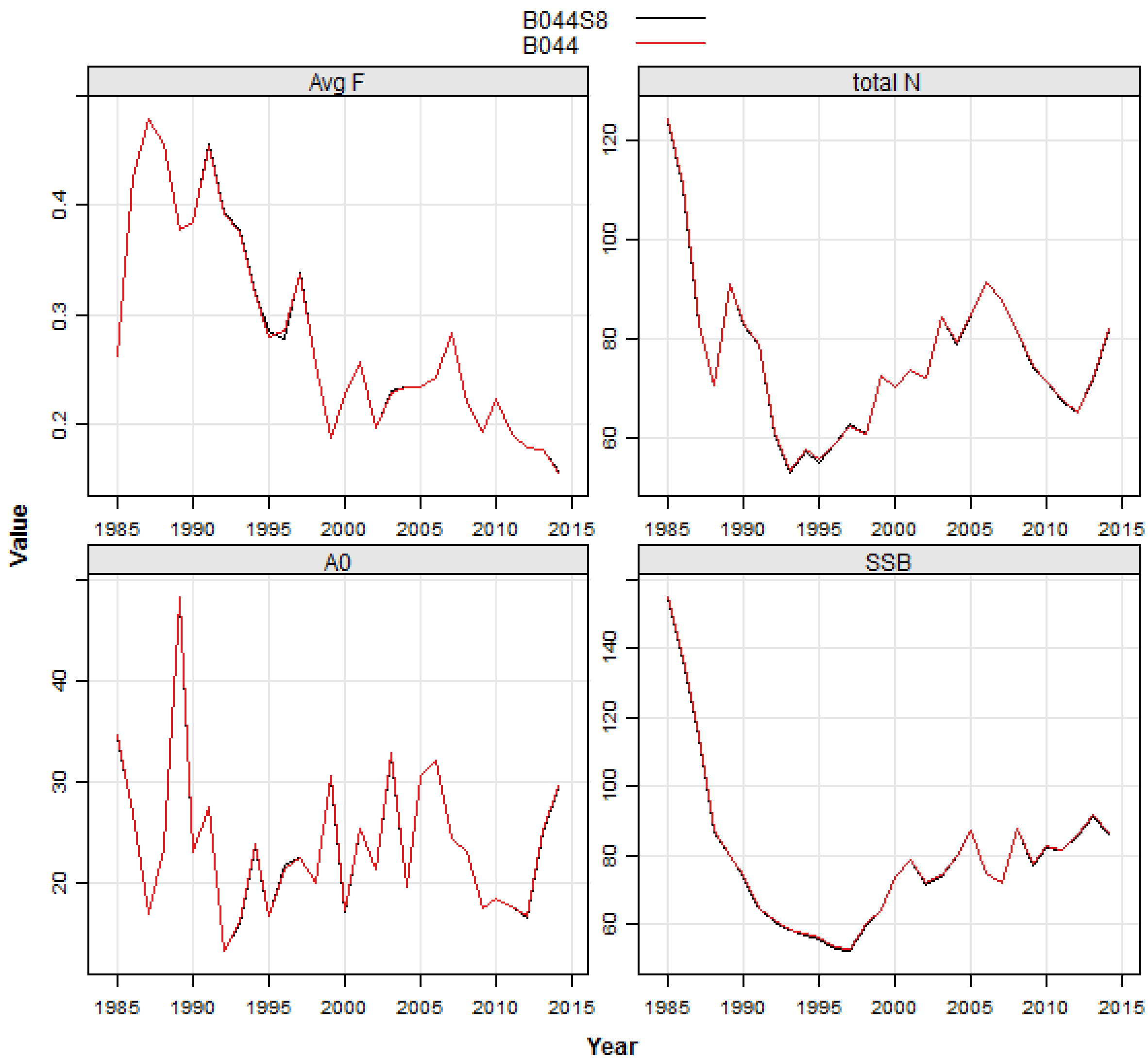


Figure B7.128. Final model sensitivity run assuming VA set 2 landings.
Trends for the revised final model (B044) estimates are represented by the red line, with sensitivity run estimates (B044S8) represented by the black line.

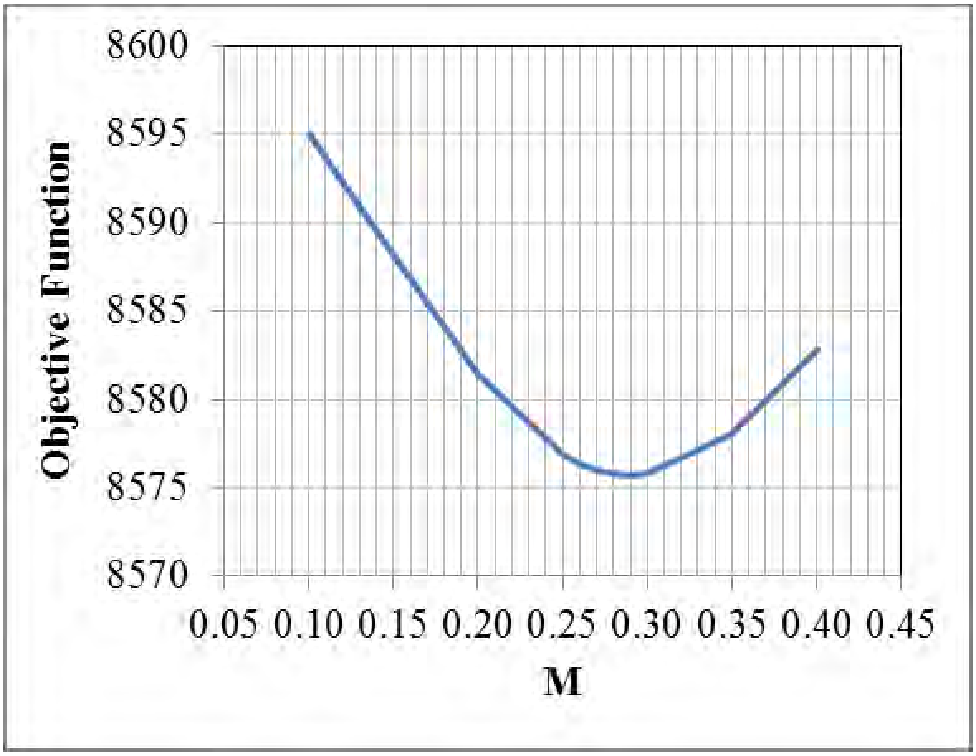


Figure B7.129. Final model objective function profile over different values of natural mortality.

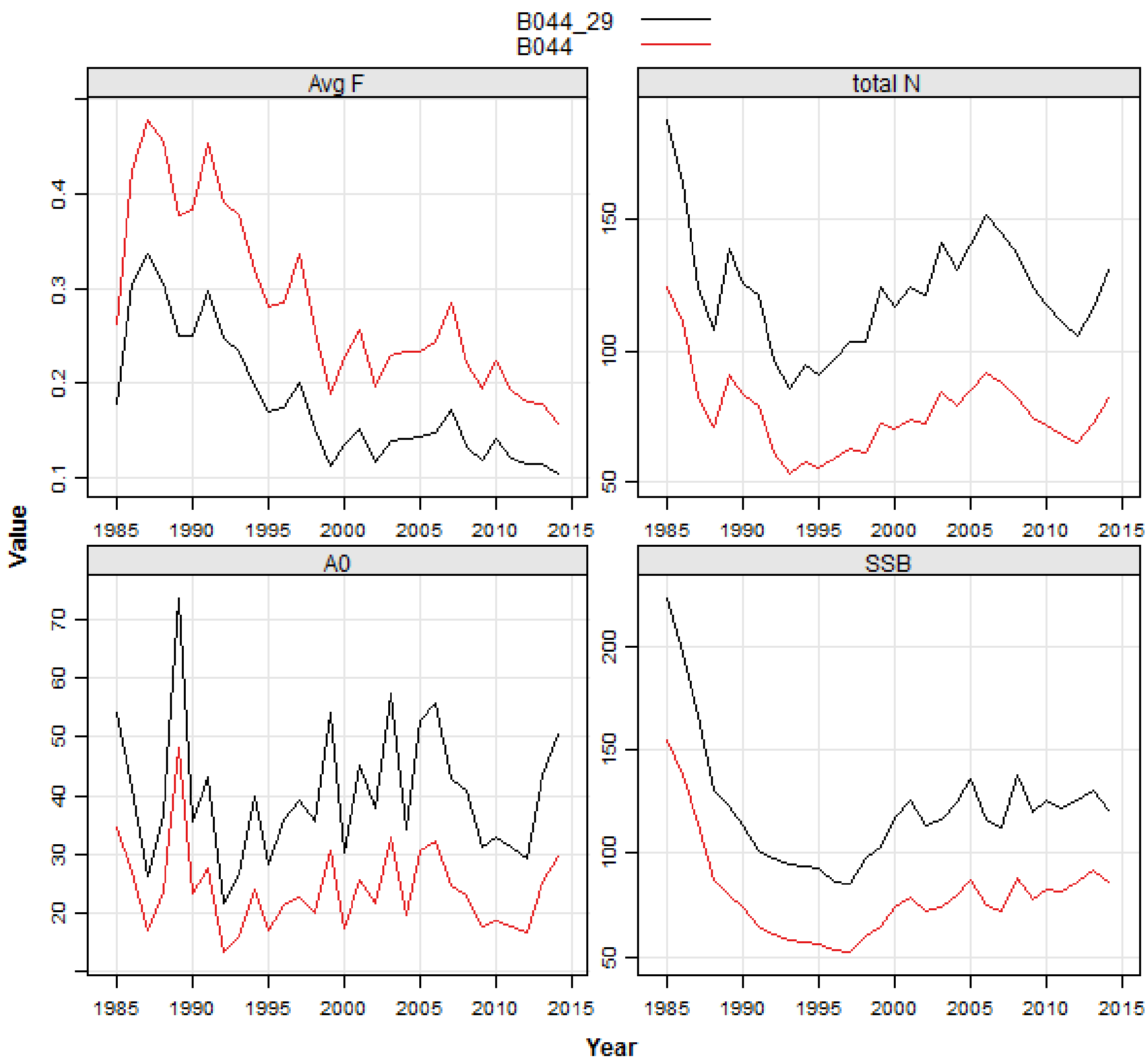


Figure B7.130. Final model sensitivity run assuming natural mortality equal to 0.29 (the value that minimizes the objective function). Trends for the final model (B044) estimates are represented by the blue line, with sensitivity run estimates (B044_29) represented by the black line.

Figure B7.131. Final model sensitivity run assuming age-based natural mortality estimates: Lorenzen scaled to Rule of Thumb (0.21) and Lorenzen scaled to (0.263: the value that minimizes the objective function. Trends for the revised final model (B044) estimates are represented by the blue line, with sensitivity run estimates from B043_LROT (Lorenzen scaled to rule of thumb: 0.21) represented by the red line and B043_L263 (Lorenzen scaled to 0.263) represented by the black line.

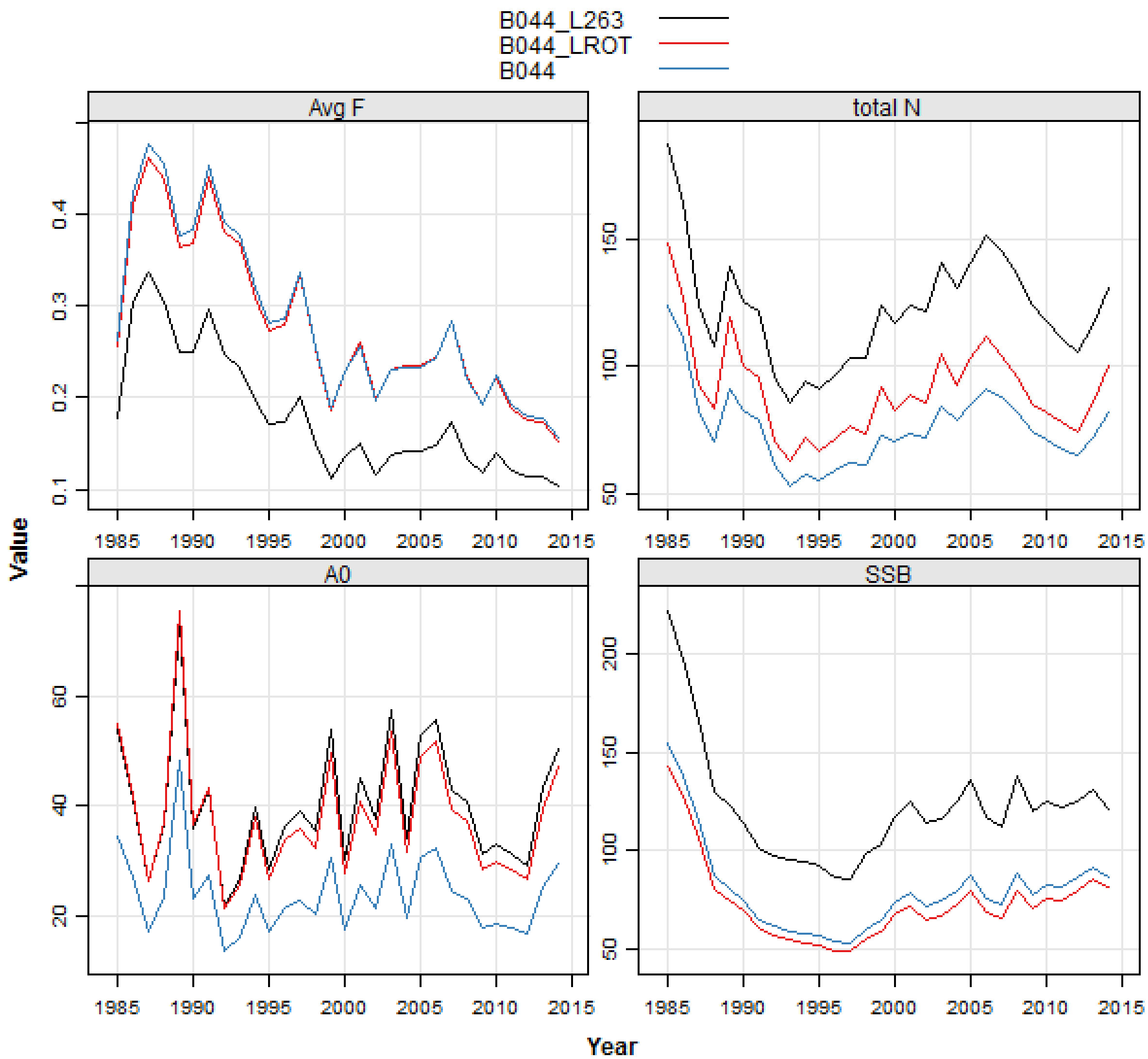
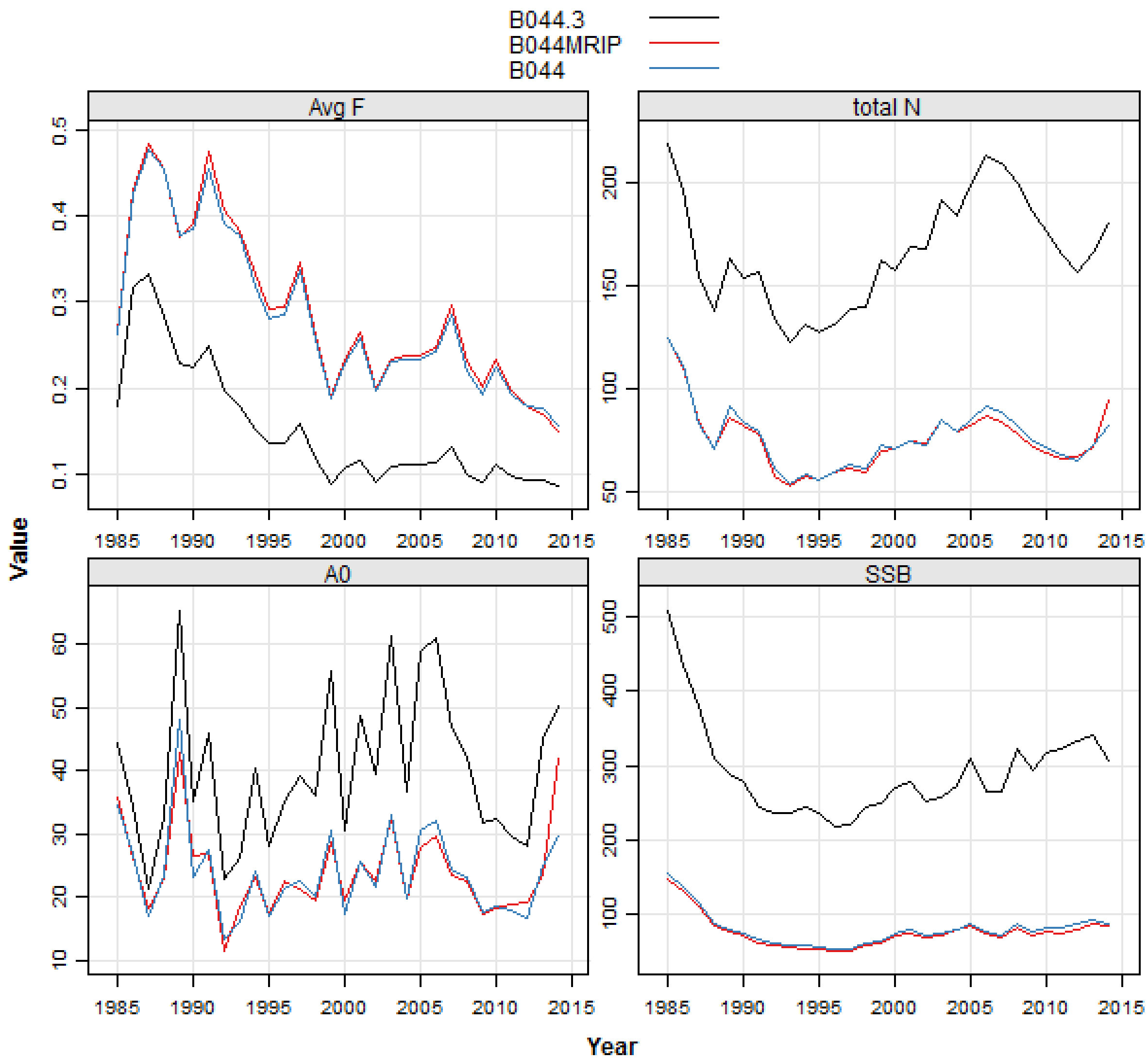


Figure B7.132. Final model sensitivity run exploring the effects of removing the MRIP index, and running the final model with only the fleets and MRIP index. Trends for the final model (B044) estimates are represented by the blue line, with sensitivity run estimates from B043MRIP (2 fleets+MRIP index) represented by the red line and B044.3 (no MRIP) represented by the black line.



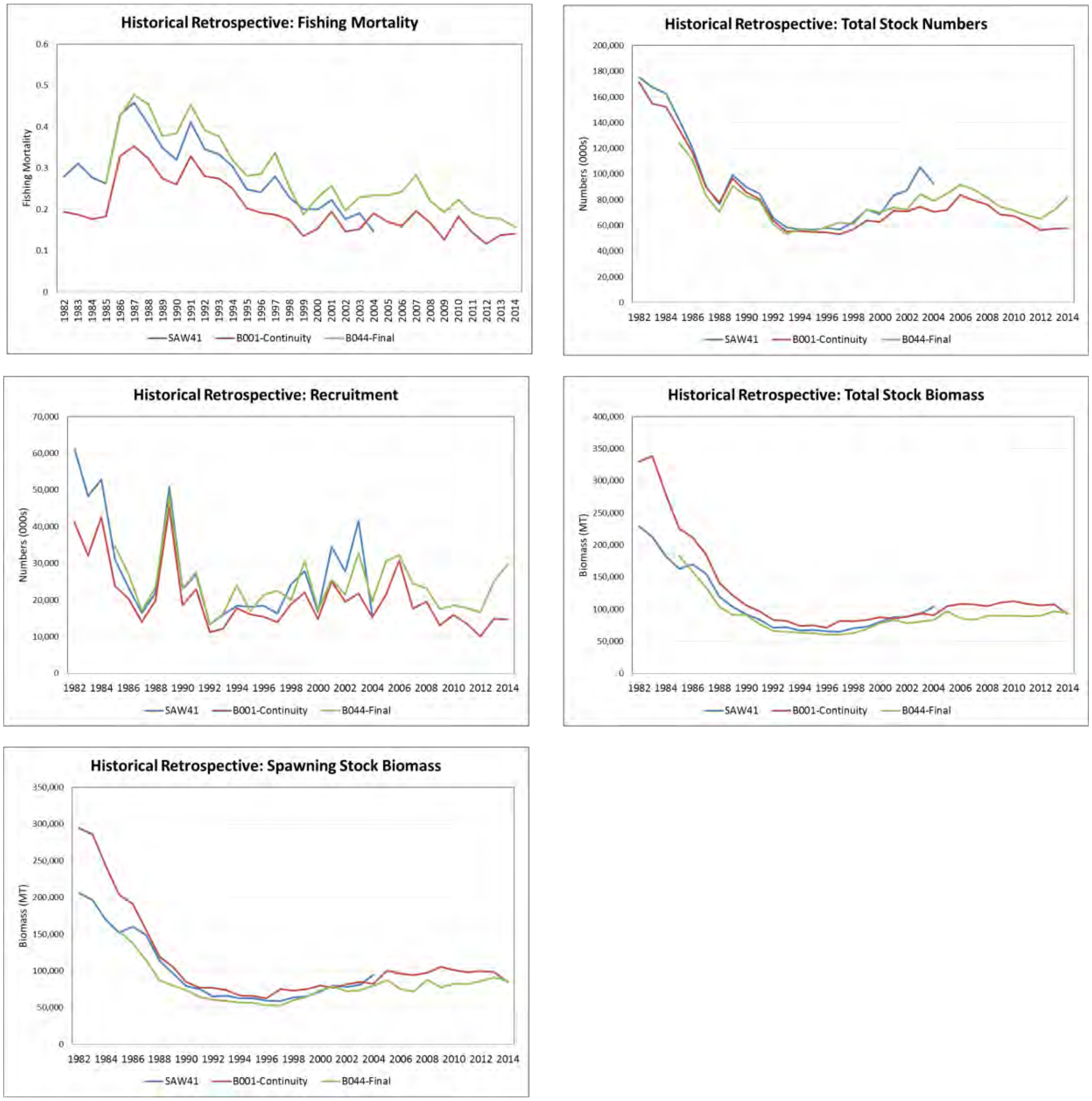


Figure B7.133. Historical retrospective plots comparing estimates of F, abundance, recruitment, total biomass and spawning stock biomass across the previous benchmark assessment model (SAW 41), the continuity run with updated data (B001) and the final preferred model from this assessment (BFinal).

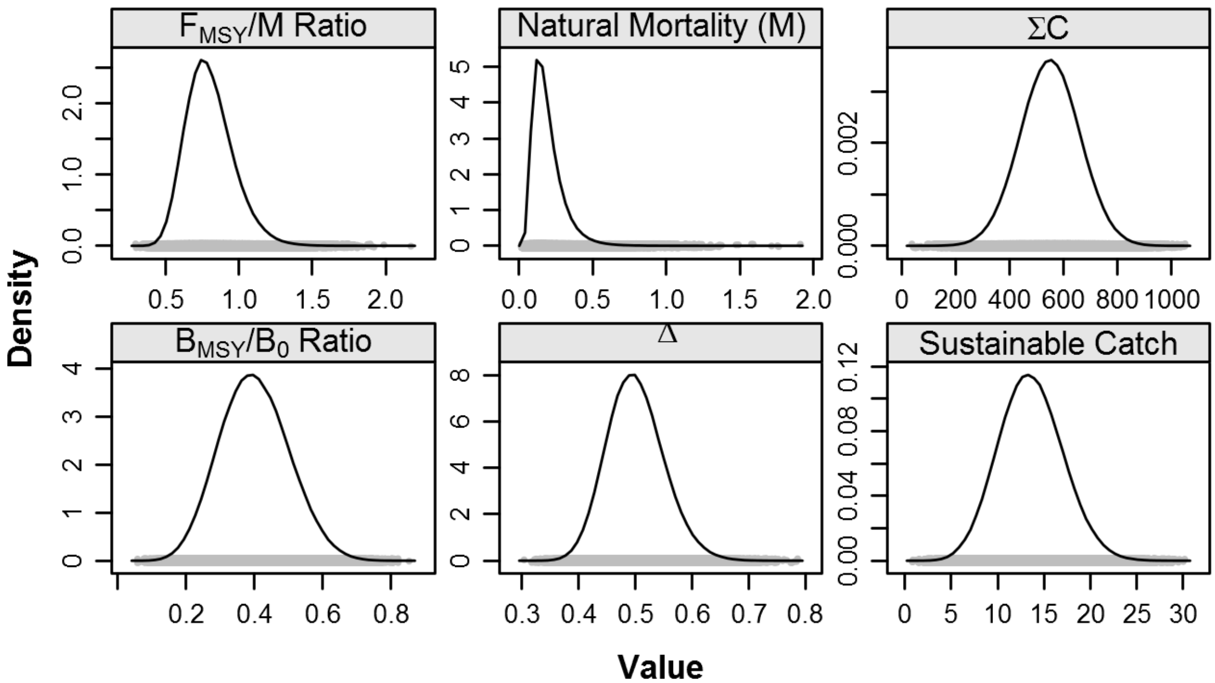


Figure B7.134: Density plot of individual parameter draws (top row panels; bottom row left & middle panels) and sustainable yield estimates (bottom right panel) based on 1,000,000 Monte Carlo simulations of the DCAC base model.

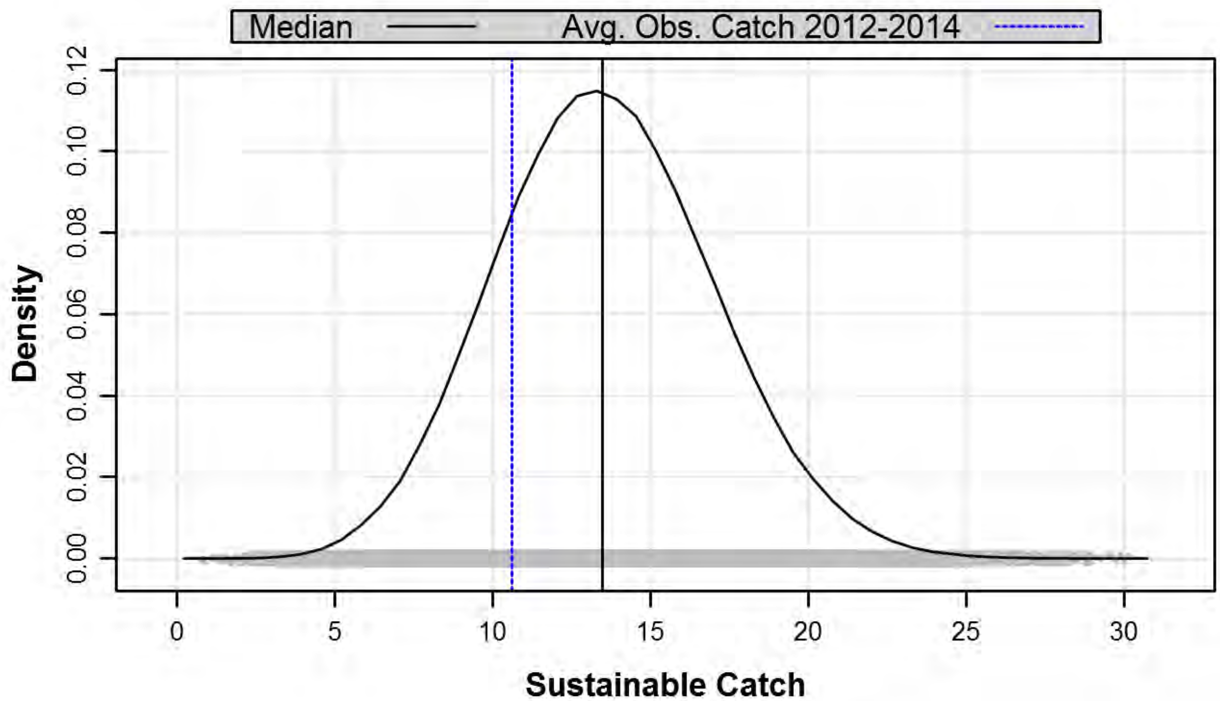


Figure B7.135: Density plot of sustainable yield based on 1,000,000 Monte Carlo simulations of the DCAC base model. Vertical lines represent the median sustainable yield estimate (black) and observed average catch (blue) during the three terminal years (2012-2014) of the assessment

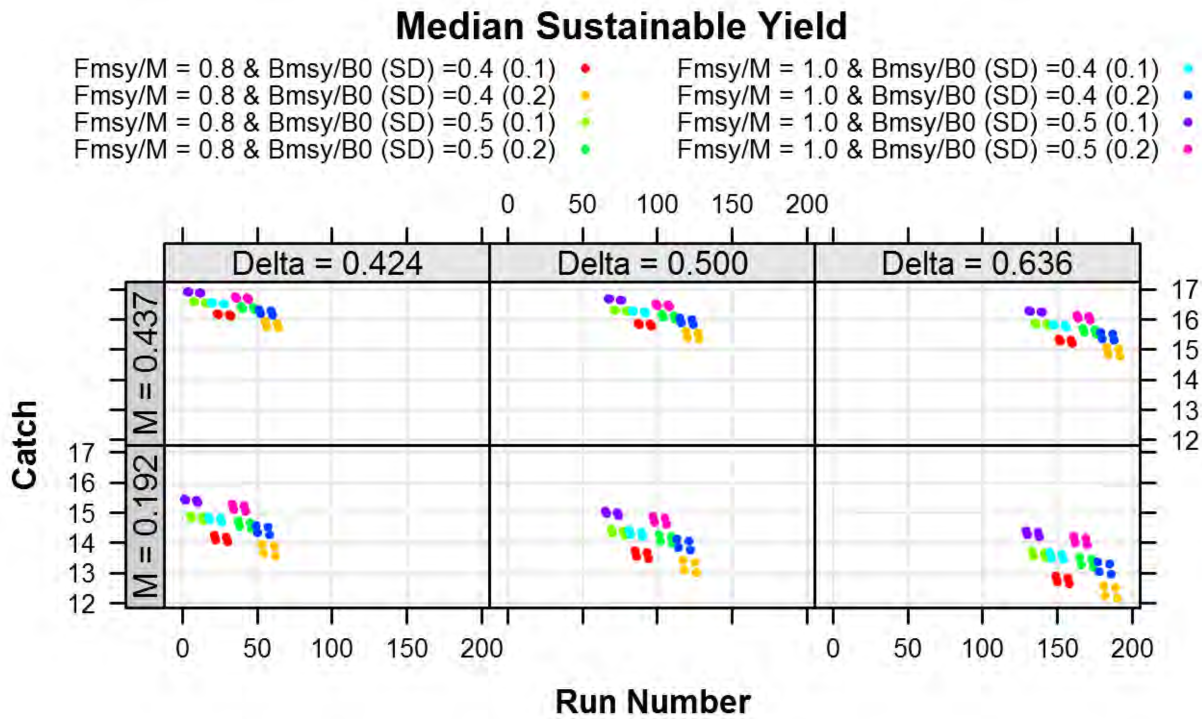


Figure B7.136: Y_{sust} **median estimates (in mt) derived from each of the 192 different model configurations (including the base DCAC model).**

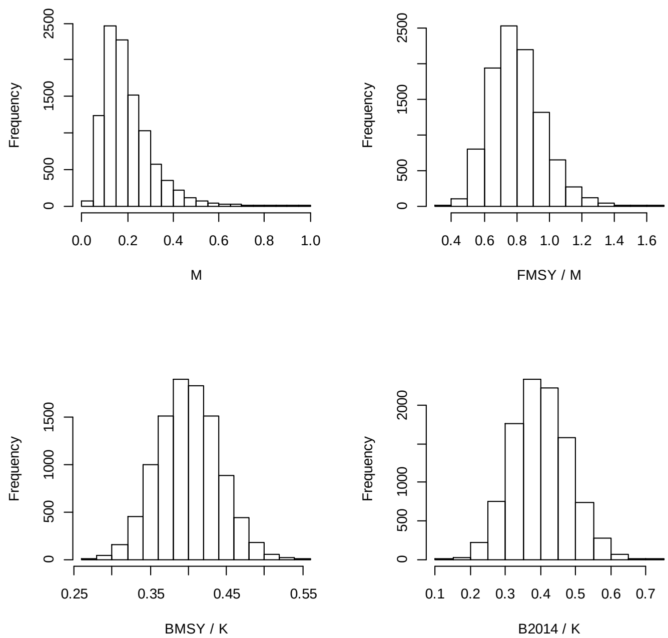


Figure B7.137. Distributions of drawn parameters for DBSRA model.

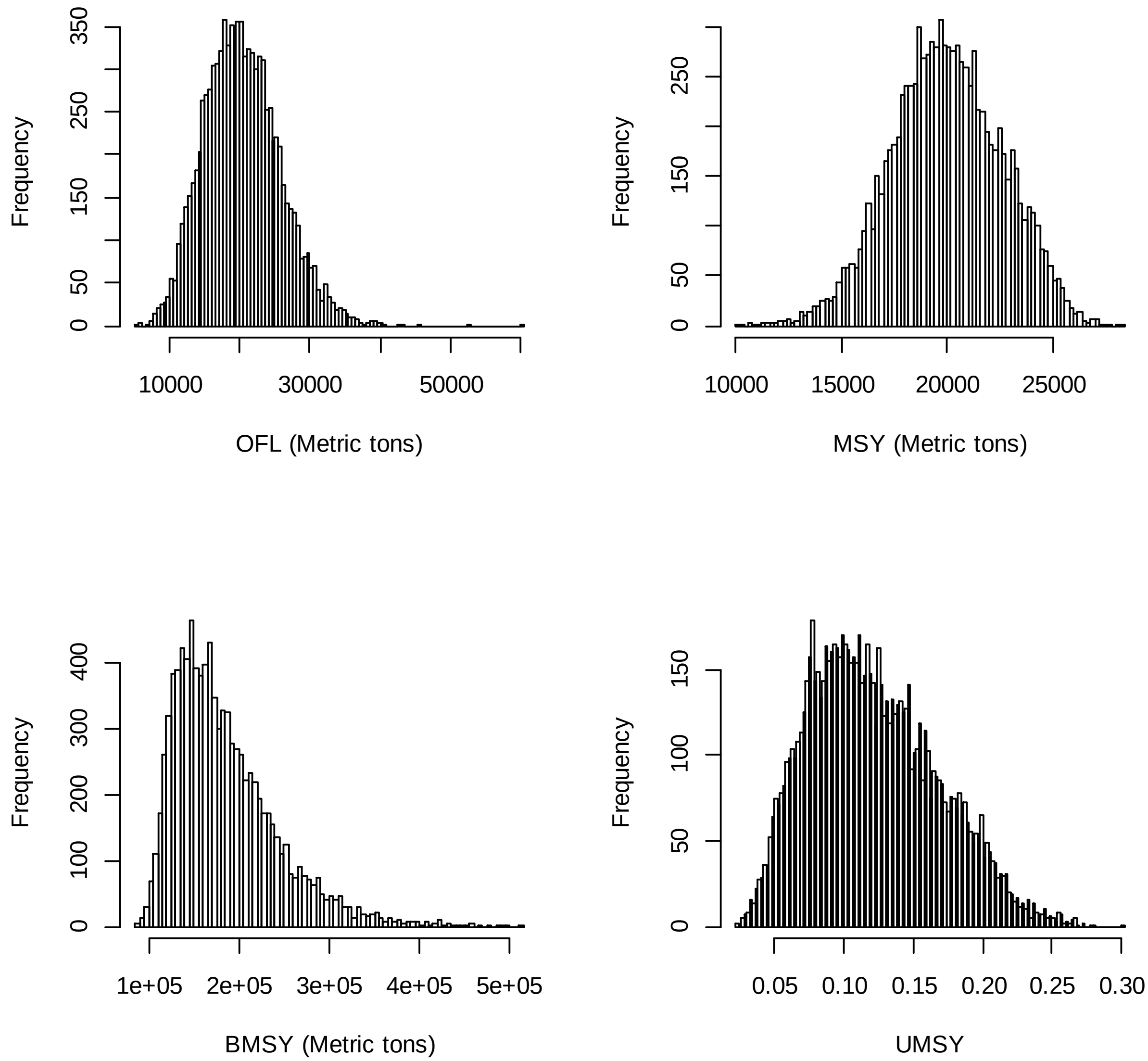


Figure B7.138. Distribution of management parameters from successful DBSRA model runs.

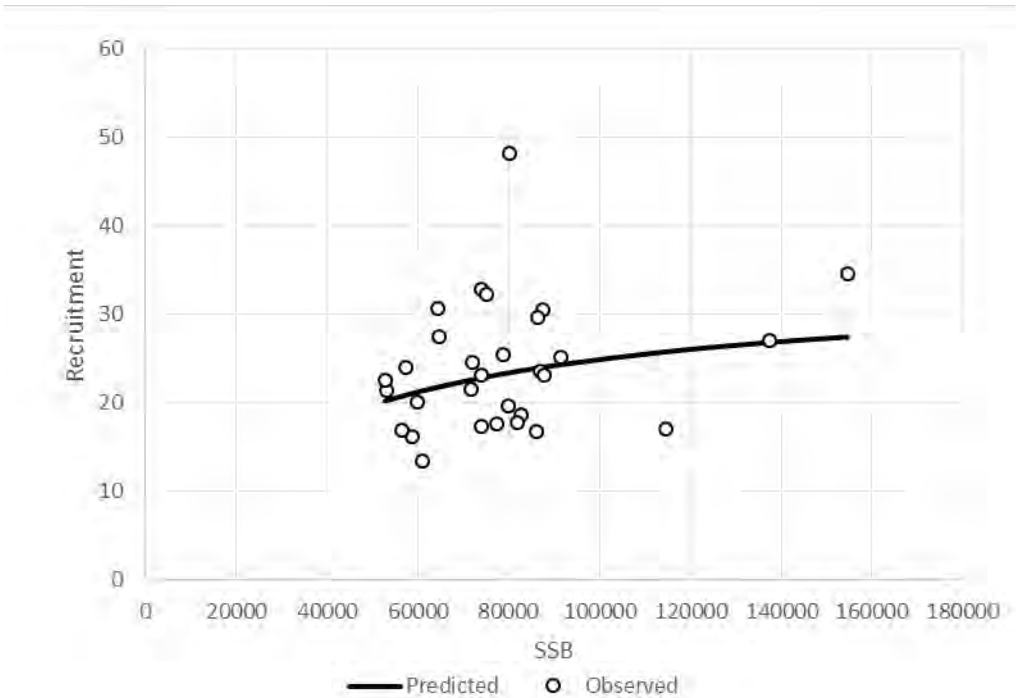


Figure B8.1. Observed stock-recruitment relationship plotted with a fitted curve.

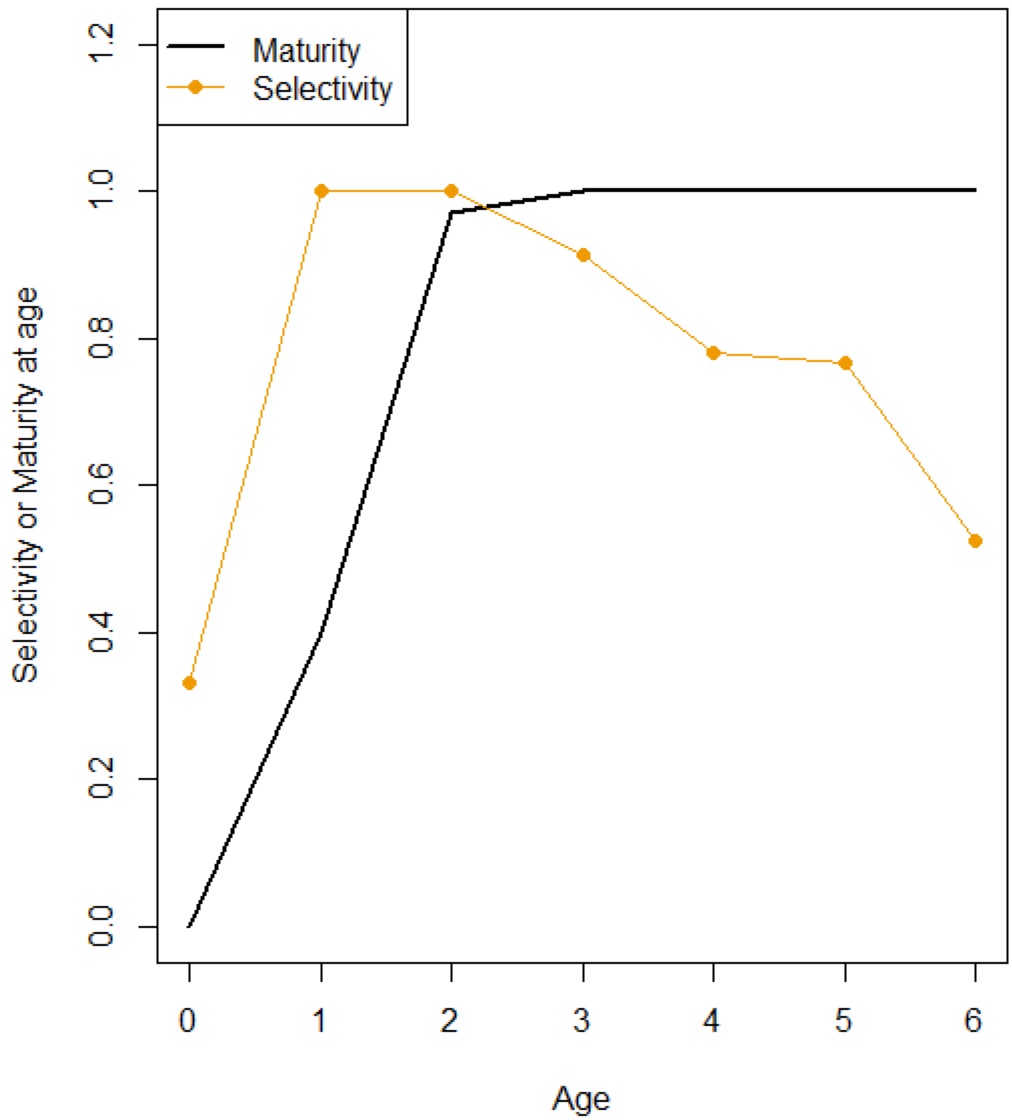


Figure B8.2. Maturity ogive and composite selectivity pattern used to estimate bluefish reference points.

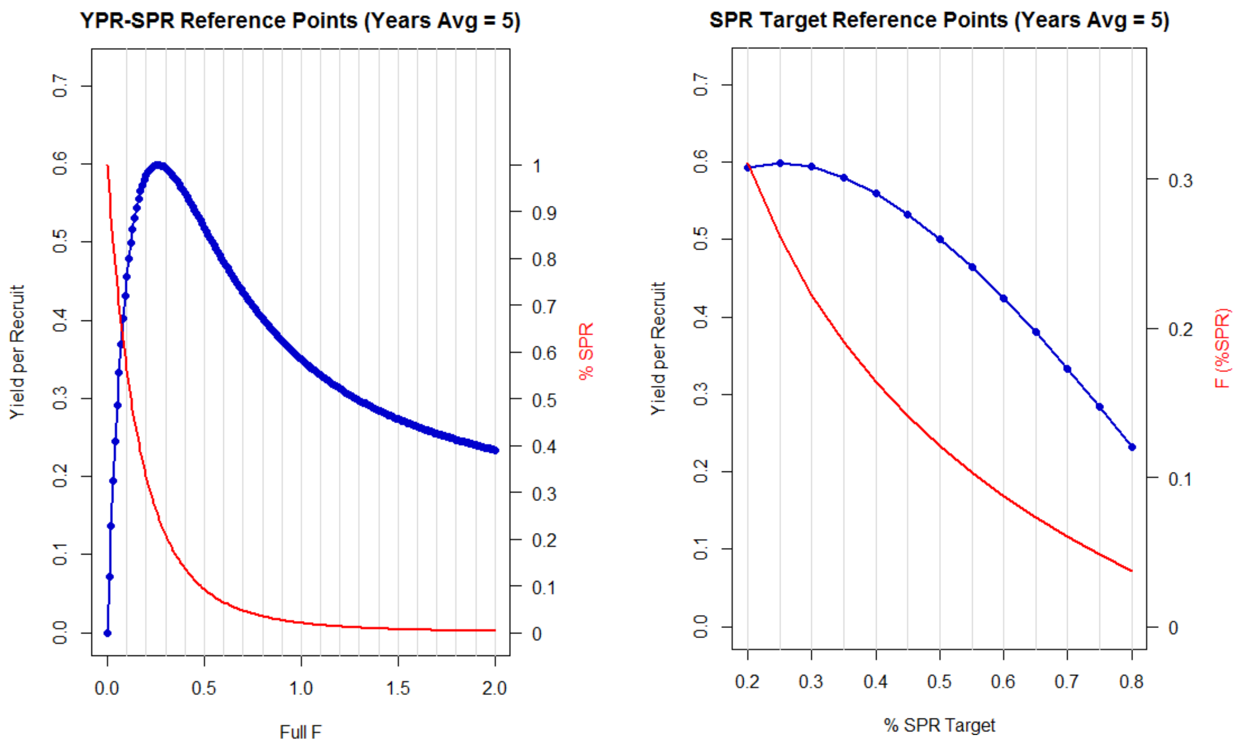


Figure B8.3. YPR and SPR curves for bluefish.

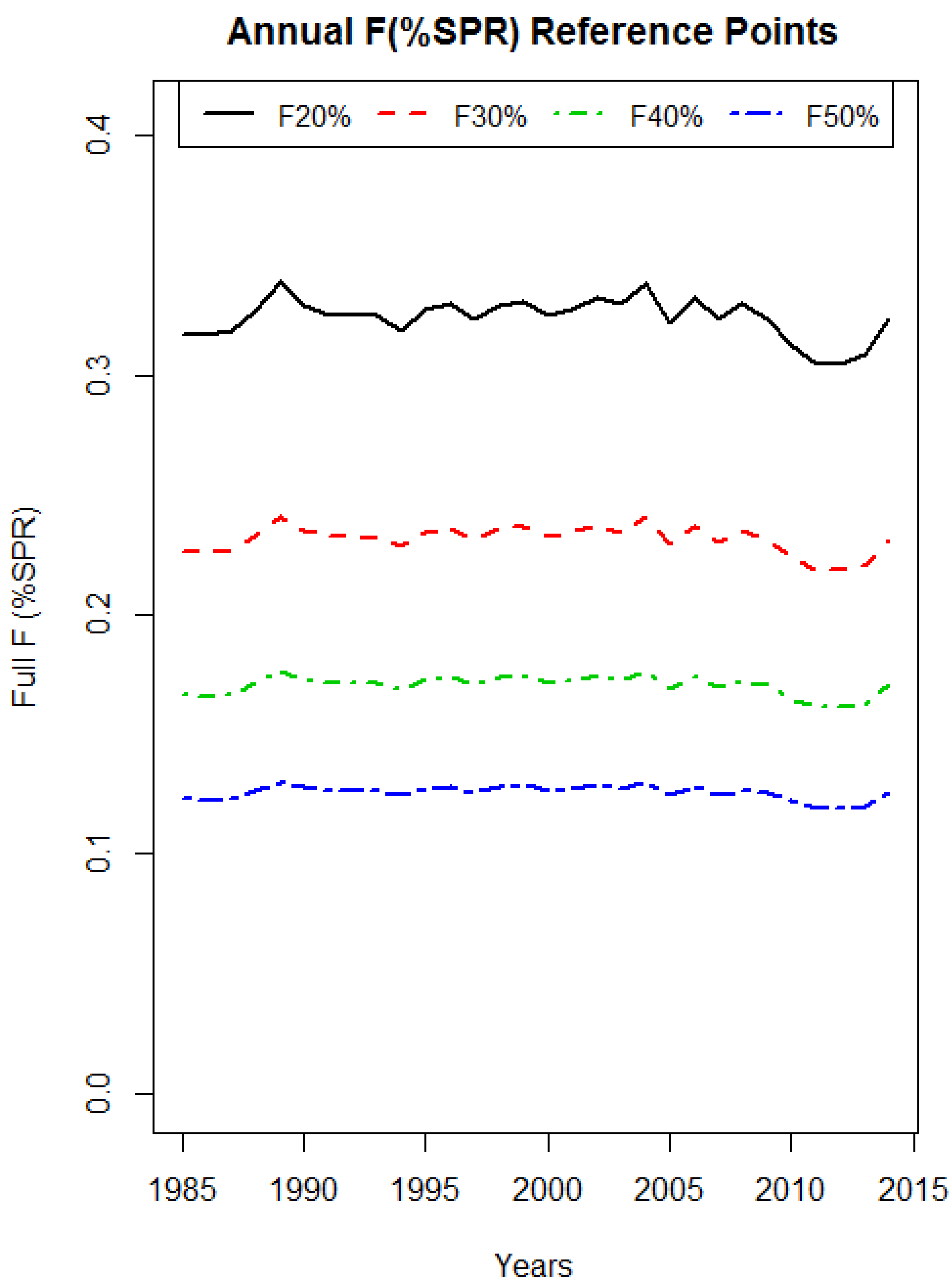


Figure B8.4. Annual estimates of F %SPR reference points.

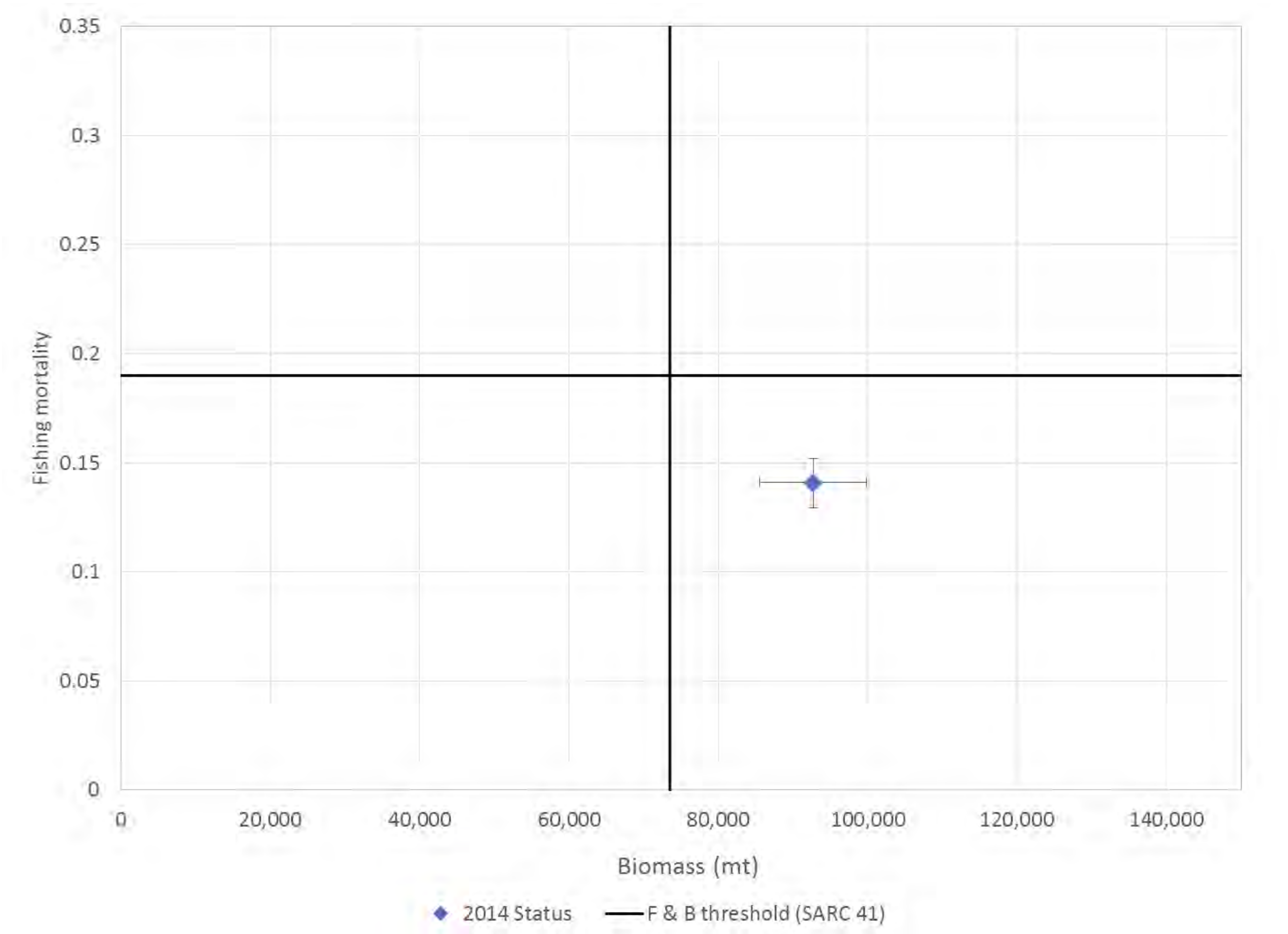


Figure B9.1. Stock status in 2014 (diamond) from the continuity run plotted with the F and biomass thresholds from the previous benchmark assessment (solid lines).
Error bars on the status estimated indicate 95% confidence intervals.

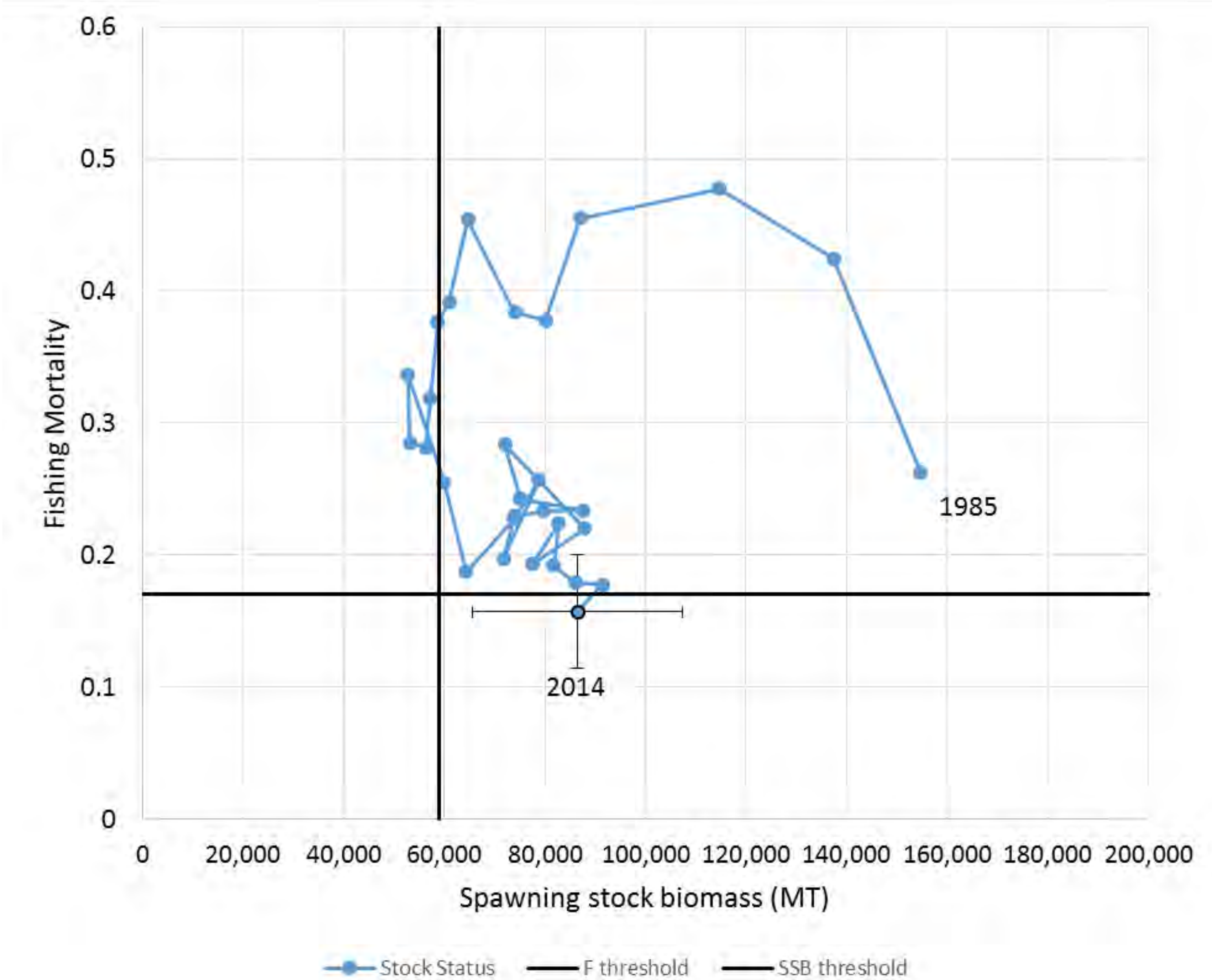
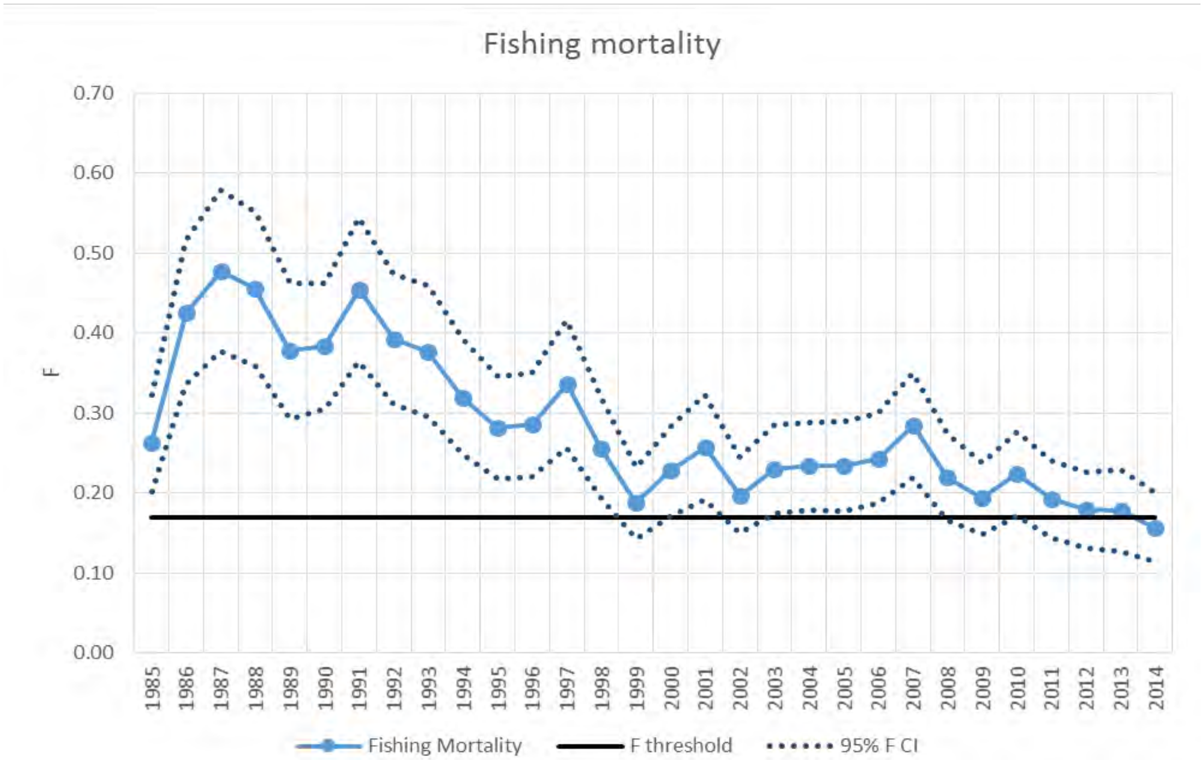


Figure B9.2. Annual stock status estimates from the final revised model run plotted with the F and biomass thresholds for this assessment (solid lines). Error bars on the status estimated indicate 95% confidence intervals.



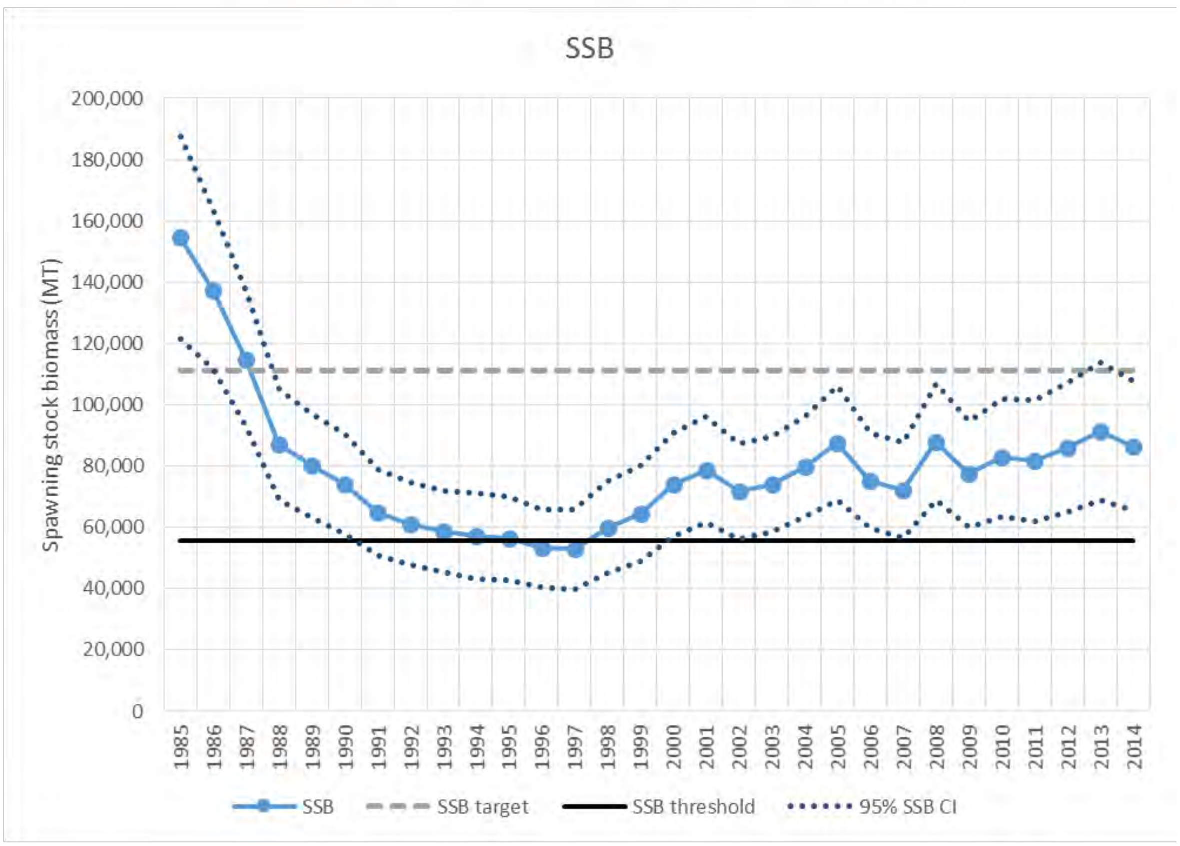


Figure B9.3. Fully selected F (top) and spawning stock biomass (bottom) from the final revised model run plotted with their respective overfishing and overfished thresholds and 95% confidence intervals.

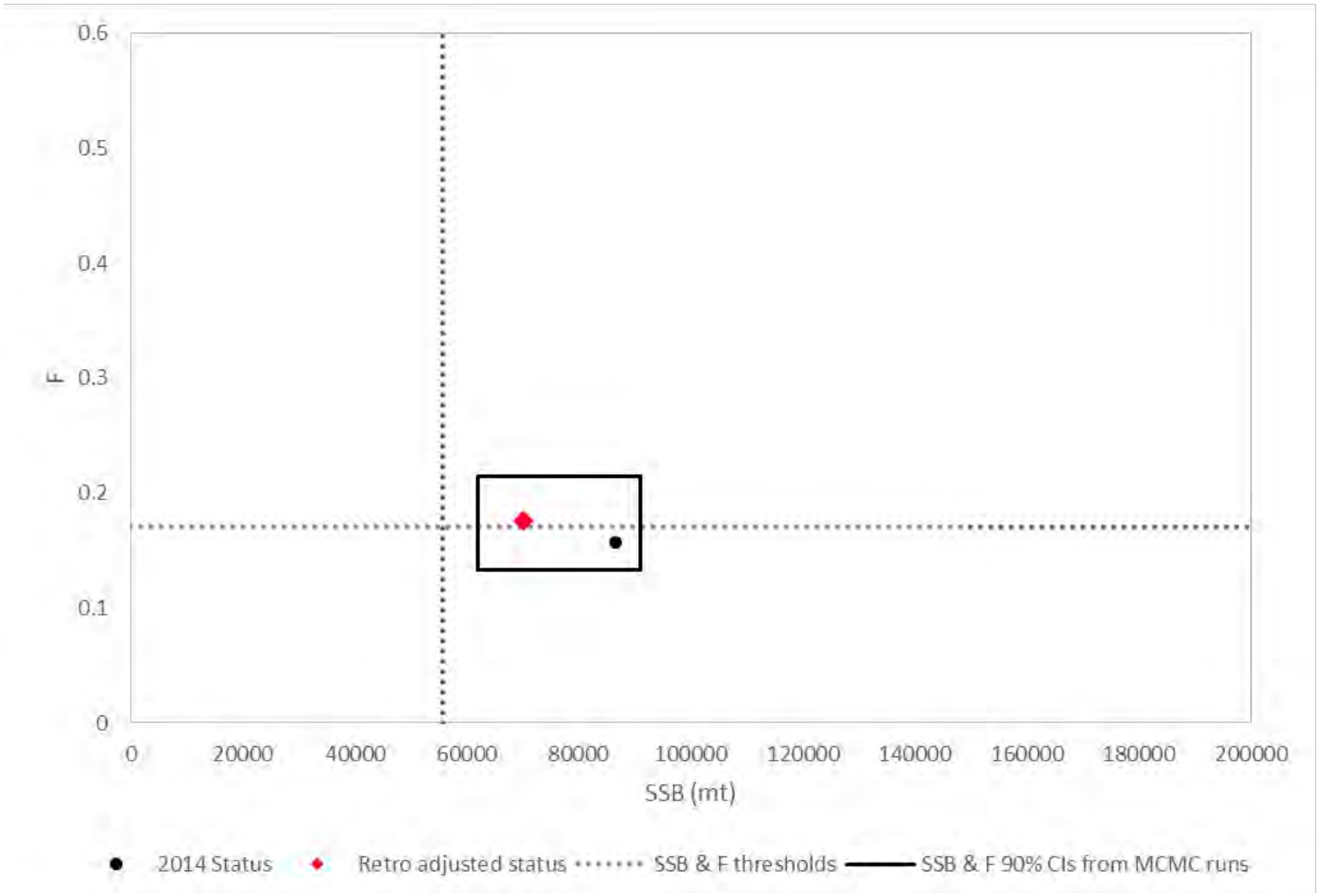
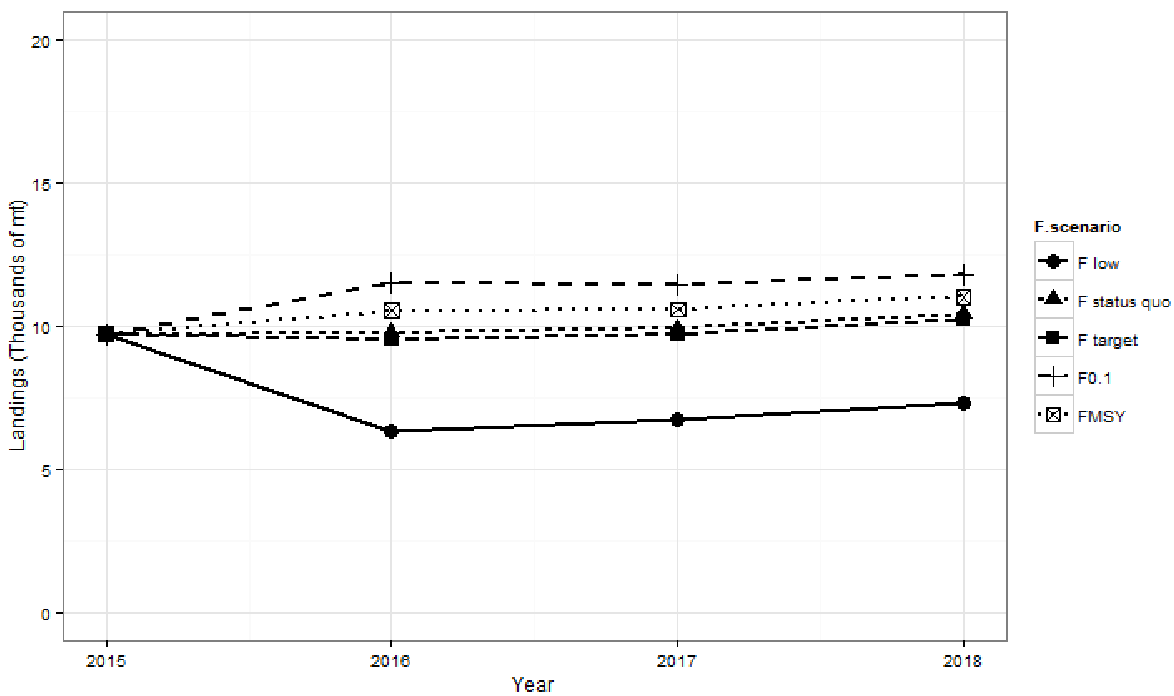
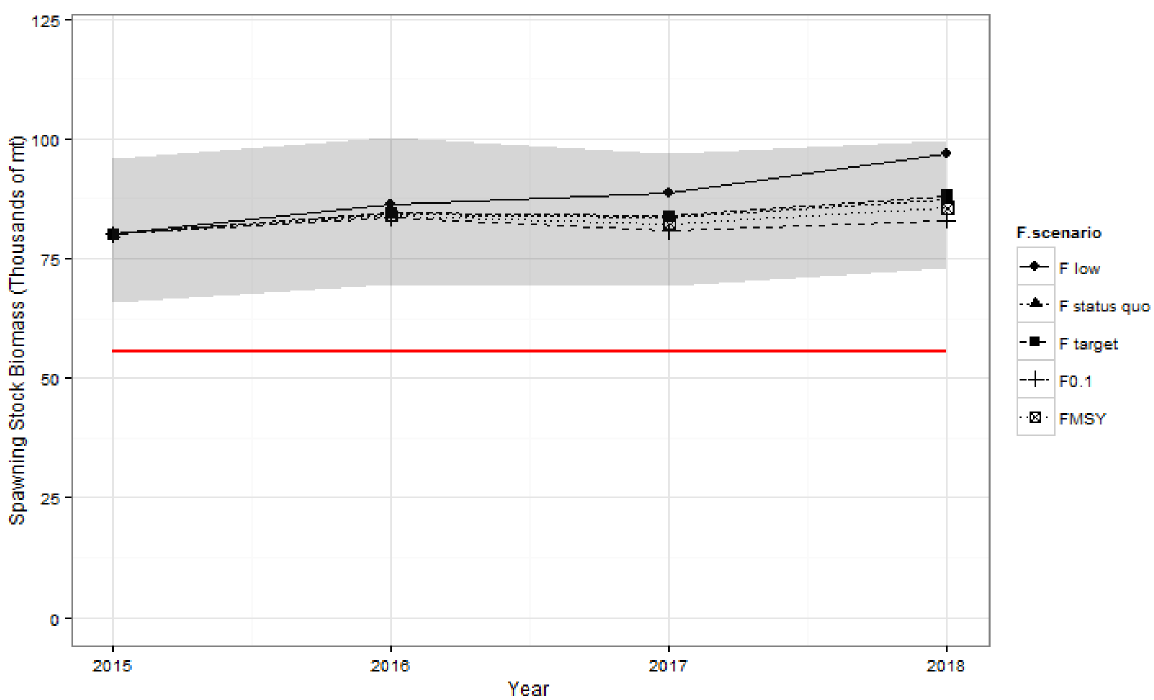


Figure B10.1. 2014 Stock status of bluefish with and without adjustment for retrospective bias, compared to the 90% confidence bounds of the MCMC model runs.

Figure B10.2. **Projected landings (top) and spawning stock biomass (bottom) under various F scenarios. Shaded bands indicated the 5th and 95th percentiles of the F_{MSY} bootstrap runs. The solid red line indicates the overfished biomass threshold.**





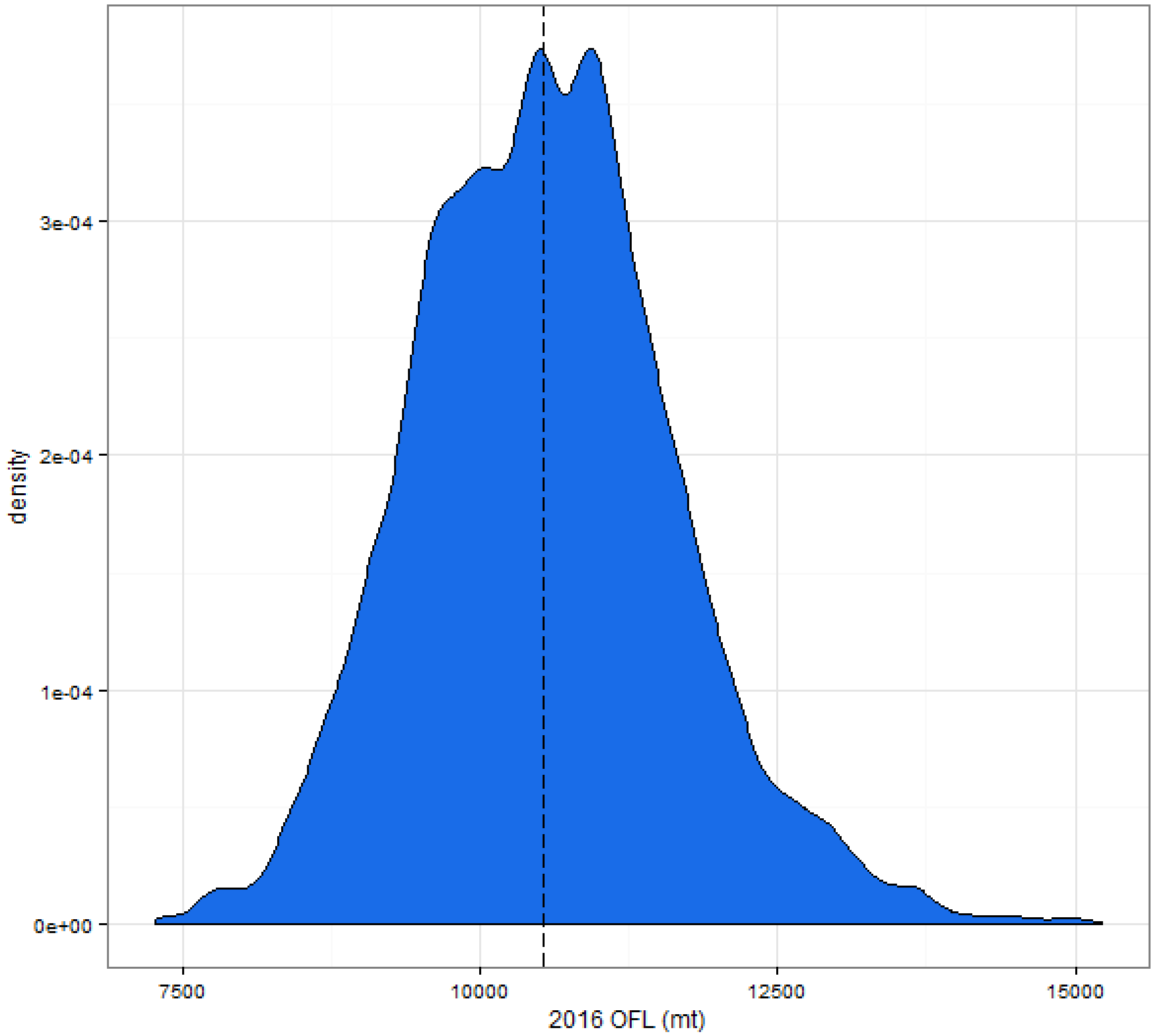
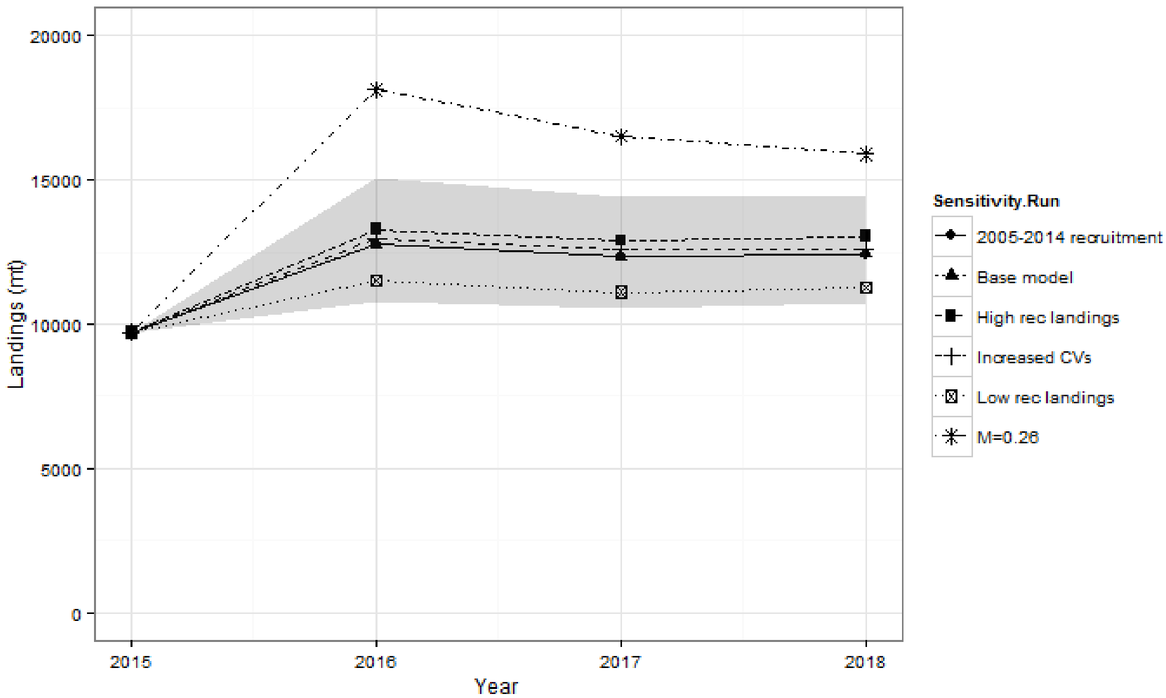


Figure B10.3. Distribution of 2016 OFL estimate from revised final model projections. The dashed vertical line indicates the median estimate.



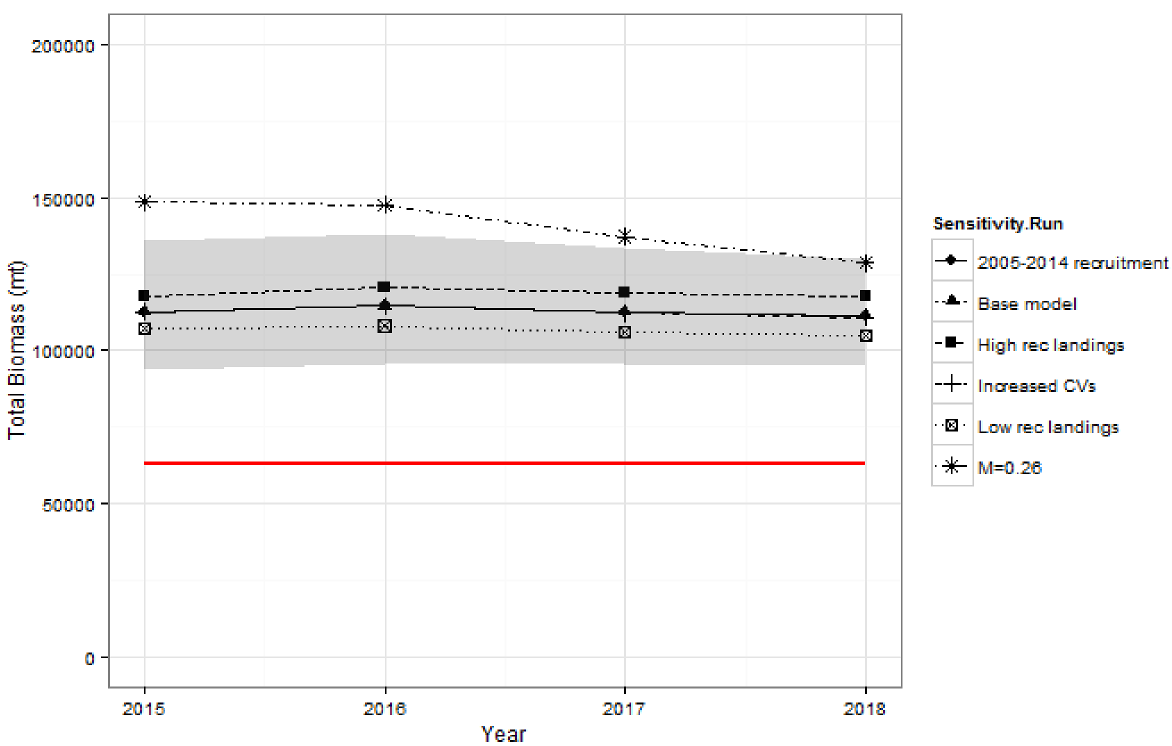
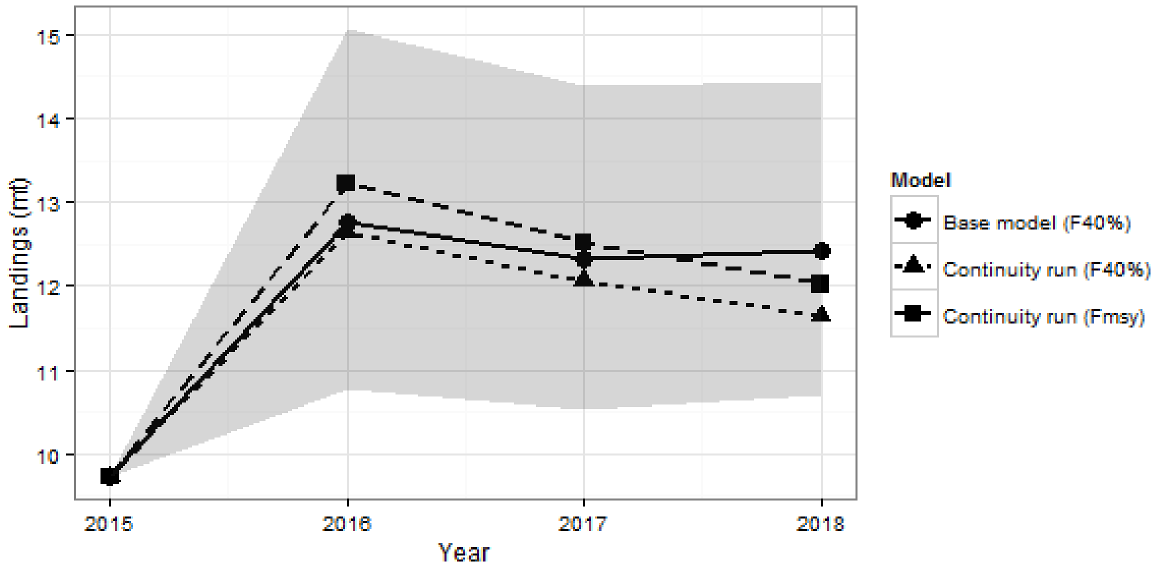


Figure B10.4. Sensitivity runs of projected landings (top) and biomass (bottom) under F_{MSY}. Shaded bands indicated the 5th and 95th percentiles of the preferred base model bootstrap runs. The solid red line indicates the overfished biomass threshold.



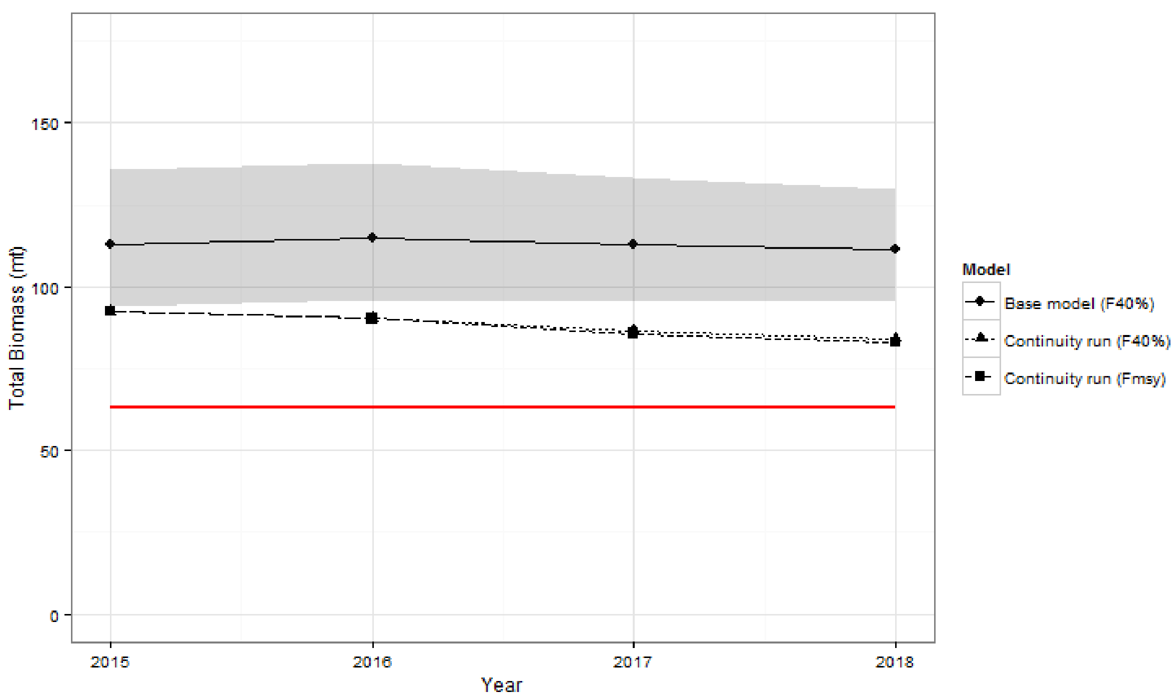


Figure B10.5. Projected landings (top) and biomass (bottom) for the continuity run model and the final revised model from this assessment. Shaded bands indicated the 5th and 95th percentiles of the preferred base model bootstrap runs. The solid red line indicates the overfished biomass threshold from the final revised model.

Appendix B1 – Data Workshop Attendance

The Atlantic States Marine Fisheries Commission (ASMFC) Bluefish Technical Committee met in Providence, RI on February 17-20, 2015 with the following participants:

Joey Ballenger – SC Dept. of Natural Resources
Mike Bednarski – MA Div. Marine Fisheries
Mike Celestino – NJ Dept Env. Protection
Katie Drew – ASMFC
Eric Durell- MD Dept Natural Resources
Beth Egbert – NC Div. Marine Fisheries (via phone)
Jim Gartland – VA Institute of Marine Science
Kurt Gottschall – CT Dept. Environmental Protection
Nicole Lengyel – RI DEM Div. Fish and Wildlife
John Maniscalco – NY DEC (via phone)
José Montañez – Mid-Atlantic Fisheries Management Council
Joseph Munyandero – FL Fish & Wildlife Conservation Commission
Kirby Rootes-Murdy – ASMFC
Kevin Sullivan – NH Dept. Fish and Wildlife
Rich Wong – DE Division Marine Fisheries
Tony Wood – Northeast Fisheries Science Center

Appendix B2 – Modeling Workshop & Working Group

The SAW60 Bluefish Working Group met in Woods Hole, MA on April 27-29, 2015 with the following participants:

Joey Ballenger – SC Dept. of Natural Resources
Mike Bednarski – MA Div. Marine Fisheries
Mike Celestino – NJ Dept Env. Protection
Katie Drew – ASMFC
Nicole Lengyel – RI DEM Div. Fish and Wildlife
José Montañez – Mid-Atlantic Fisheries Management Council
Kirby Rootes-Murdy – ASMFC
Tony Wood – Northeast Fisheries Science Center

Appendix B3 – Other Surveys considered

Rhode Island

RIDEM Marine Fisheries Trawl Survey

The Rhode Island Department of Environmental Management Division of Fish and Wildlife (DEM) initiated a seasonal trawl survey in 1979 to monitor recreationally important finfish stocks in Narragansett Bay, Rhode Island Sound, and Block Island Sound. The survey aims to monitor trends in abundance and distribution, to determine population size/age composition, and to evaluate the biology and ecology of estuarine and marine finfish and invertebrate species occurring in RI waters. Over the years this survey has become an important component of fisheries resource assessment and management at the state and regional levels.

The survey employs a stratified random and fixed design defined by 12 fixed stations in Narragansett Bay, 14 random stations in Narragansett Bay, 6 fixed stations in Rhode Island Sound, and 12 fixed stations in Block Island Sound (Figure 13.17). In 2005, the Division replaced the research vessel and survey gear that has been utilized by the survey since its inception. The R/V Thomas J. Wright was replaced with a 50' research vessel, the R/V John H. Chafee. During the spring and summer of 2005, a series of paired tow trials were conducted using modern acoustic equipment and new nets designed to match the trawl net used by the National Marine Fisheries Service. The results of this experiment were used to calibrate the old and new vessels in order to maintain the continuity of the survey time series. Unfortunately, the new net design was too large for the new research vessel and could not be successfully towed in many of the areas required by the trawl survey. Because of this a new net was designed in the same dimensions as the net previously used for the survey and is used for the trawl survey. By using a similar net design to the previous survey net, the continuity of the survey is able to be maintained, though analysis to confirm this is still pending. In 2012 new doors were installed on the R/V John H. Chafee. A rigorous calibration experiment was done to calibrate the new trawl configuration with the new doors to the old trawl configuration with the old doors. The analysis has been conducted, but is unpublished at this point. The findings of the analysis were that there were not significant differences in the catch of lobster between the old and new door datasets. The net is a ¾ size North American type two seam otter trawl (40 in headrope/ 55 in. footrope) rigged with a 5/16 chain sweep and a 2 in. codend liner (¼ in. stretched mesh).

At each station a standard 20 minute tow is conducted at 2.5 knots. Catch is sorted by species. Length (cm/mm) is recorded for all finfish, skates, squid, scallops, Whelk lobster, blue crabs and horseshoe crabs. Similarly, weights (gm/kg) and number are recorded as well. Data on wind direction and speed, sea condition, air temperature and cloud cover as well as surface and bottom water temperatures, are recorded at each station. Sampling at each random and fixed station during the fall component of the survey typically occurs in September and October of each year however sampling has in the past also occurred in November.

New York

NYDEC Small Mesh Trawl Survey

The New York Department of Environmental Conservation's (NYSDEC) Peconic Bay Small Mesh Trawl Survey started in 1987. The survey area is divided into 77 sampling blocks each of which measured 1' latitude by 1' longitude located in the Peconic estuary in eastern Long Island (Figure 13.19). Each year from May to October, 16 stations are randomly chosen each week and sampled by an otter trawl (16 foot shrimp trawl with small mesh liner) and towed for 10 minutes

at 2.5 knots during daylight hours only.
Fish collected in each tow are sorted, identified, counted and measured to the nearest mm (fork or total length). Large catches were subsampled, with length measurement taken on a minimum of 30 randomly selected individual fish of each species. Some samples were stratified by length group such that all large individuals were measured and only a subsample of small (YOY or yearlings) specimens were measured. Subsampled counts could then be expanded by length group for each tow.

Catches of bluefish, which peak in August and September, consist almost entirely of YOY (99%).

Delaware

Delaware DFW Juvenile Trawl Survey

Delaware's Department of Natural Resources and Environmental Control (DNREC) Division of Fish and Wildlife's juvenile trawl survey targets juvenile fish and shellfish. This program was initiated in 1980 to monitor distribution, relative abundance, and year-class strength. The survey conducts monthly sampling from April to October at fixed stations in the Delaware Bay and River. Tows conducted during September were used to estimate an index of abundance as the geometric mean number per tow.

Delaware DFW Adult Trawl Survey

The DNREC Division of Fish and Wildlife began an adult trawl survey in 1966. The survey was discontinued in 1971, started again in 1979, discontinued after 1984, and finally resumed again in 1990. The aim is intended to track temporal trends in abundance and distribution and to characterize the size composition of select species. Trawl tows are carried out monthly from March to December at fixed stations in the Delaware Bay. Large numbers of bluefish are not common, but bluefish do occur in the catches, peaking in the fall. Tows from August to October were used to calculate the geometric mean number per tow as an index of bluefish abundance.

Virginia

Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP)

The Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) Trawl Survey has been sampling the mainstem of the Chesapeake Bay, from Poole's Island, MD to the Virginian Capes at the mouth of the bay since 2002. ChesMMAP conducts 5 cruises annually, during the months of March, May, July, September, and November. This survey is designed to sample the late juvenile and adult stages of the living marine resources in Chesapeake Bay, and as such the timing of sampling is meant to coincide with the seasonal residency of these life stages in the estuary.

The ChesMMAP survey area is stratified into five latitudinal regions, and each region is comprised of three depth strata. Depth strata bounds are consistent across regions, and correspond to shallow (3.0m to 9.1m), middle (9.1m to 15.2m), and deep (>15.2m) waters in the bay. Sampling sites are selected for each cruise using a stratified random design; site allocation for a given stratum is proportional to the surface area of that stratum. A total of 80 sites are sampled per cruise, and a four-seam, two-bridle, semi-balloon bottom trawl is towed for 20 minutes at each sampling site with a target speed-over-ground of 3.5kts.

Encounter rates of bluefish on the ChesMMAP Survey are relatively low. Bluefish have yet to be collected during a March cruise, which is reasonable given the usual timing of the seasonal migrations of this species. Overall, bluefish have been collected on 6.3% of tows conducted between May and November since the inception of the survey. The percentage of tows with bluefish ranged from 2.5% to 14.7% per year, and between 3.2% and 10.4% by month over the time series. Bluefish were encountered most frequently during September and November cruises. Bluefish collected by ChesMMAP ranged between 119 mm FL to 537 mm FL and from age-0 to age-3. Catches ranged from 0 to 85 bluefish per tow, and 83.1% of tows where bluefish were caught comprised of two or fewer specimens.

VIMS Juvenile Fish and Blue Crab Trawl Survey

The VIMS Juvenile Fish and Blue Crab Trawl Survey has been sampling the Virginia portion of the mainstem of Chesapeake Bay, along with the James, York, and Rappahannock River systems, since 1955. This survey samples the three rivers each month of the year, and the mainstem bay in all but January and March. This survey is designed to sample the juvenile stages of the living marine resources in Chesapeake Bay. Survey design and sampling protocols have been consistent since 1988.

This trawl survey area is stratified by depth and latitudinal regions in the bay, and by depth and longitudinal region in each of the rivers. Depth strata bounds are consistent across regions, and correspond to shallow (1.2m to 3.7m), shallow-middle (3.7m to 9.1m), middle-deep (9.1m to 12.8m) and deep (>12.8m) areas. Sampling sites are selected using a stratified random design in the bay and rivers, while additional fixed sites are sampled in the river systems to maintain continuity with historical collections. Between 66 and 111 sites are sampled per cruise, and a four-seam, two-bridle, semi-balloon bottom trawl is towed for 5 minutes at each station. The trawl has a headline length of 9.1m, and is made of 15.2cm stretch mesh webbing in the body of the net and 7.6cm stretch mesh in the codend. The codend is outfitted with a 6.35mm stretch mesh liner, which is designed to retain juvenile fishes and invertebrates found in the survey area.

Encounter rates of bluefish on this survey are relatively low. Bluefish have yet to be collected between December and April, which is consistent with the seasonal residency of this species in this estuary. When considering the remaining months, bluefish have been collected on 2.8% of tows since 1988. The percentage of tows with bluefish ranged from 0.8% to 6.5% per year, and between 1.2% and 5.1% by month over the time series. Bluefish were encountered most frequently during October and November cruises. Catches ranged from 0 to 58 bluefish per tow, and 88.1% of tows where bluefish were caught comprised of two or fewer bluefish.

North Carolina

NCDMF Juvenile Trawl Survey

NCDMF has conducted a juvenile fish trawl survey during May and June since 1979. The survey samples fixed stations from the Cape Fear River to the mouth of Albemarle and Currituck Sounds at depths <2 meters. One-minute tows are carried out using a trawl with a 3.2 m headrope and 3.2 mm (0.13 in) mesh cod end. Indices of abundance developed from this survey using data for shrimp, croaker, and spot have shown good correlation with landings for those species, but catches of bluefish were typically low.

North Carolina Pamlico Sound Trawl Survey

NCDMF Pamlico Sound Trawl Survey began in 1987 and was initially designed to provide a long-term fishery-independent database for the waters of the Pamlico Sound, eastern Albemarle Sound and the lower Neuse and Pamlico rivers. However, in 1990 the Albemarle Sound sampling in March and December was eliminated, and sampling now occurs only in the Pamlico Sound and associated rivers and bays in June and September. From 1987-1989, a mongoose or falcon trawl was used for comparison with SEAMAP data of inshore and offshore catches. From 1990 to the present, fifty-two randomly selected stations (grids) are sampled over a two-week period, usually the second and third week of the month in both June and September. The stations sampled are randomly selected from strata based upon depth and geographic location. There are seven designated strata: Neuse River, Pamlico River, Pungo River, shallow (6-12 ft) and deep (>12 ft) Pamlico Sound east of Bluff Shoal, and shallow and deep Pamlico Sound west of Bluff Shoal. A minimum of three stations are maintained in each strata and a minimum of 104 stations are trawled every year. Tow duration is 20 minutes at 2.5 knots using the R/V Carolina Coast pulling double rigged demersal mongoose trawls (9.1 m headrope, 1.0 m x 0.6 m doors, 2.2 cm bar mesh body, 1.9 cm bar mesh cod end and a 100 mesh tailbag extension. All species are sorted and a total number and weight is recorded for each species. For target species, 30-60 individuals are measured and total weights are measured. The two catches from each tow are combined to form a single sample in an effort to reduce variability.

Appendix B4 – Depletion Corrected Average Catch Model (DCAC)

Introduction

In the late 2000s a host of work was done to develop modeling techniques that would allow the setting of an annual catch limit (ACL) for data-poor fisheries (e.g. fisheries lacking effort data, life history data, etc. that would be needed for more data intensive stock assessment procedures). This stemmed from the requirement, set forth in the reauthorized Magnuson-Stevens Fisheries Conservation and Management Act of 2007, to set ACLs for all federally managed species by 2011. Each of these approaches aimed to determine yield estimates that are likely to be sustainable for various stocks while allowing for moderately high yield from the stock. One such approach, originally proposed by MacCall (2009), is called Depletion-Corrected Average Catch (DCAC).

In such a data poor situation, the question becomes how does one come up with a sustainable yield estimate for data poor fisheries. The DCAC approach stems from the idea that, in the absence of other data, the most direct evidence for a sustainable yield is a prolonged period during which the average yield has been taken without any indication of a change in underlying resource abundance (i.e. average catch over period when population appears stable; MacCall 2009). While simple in theory, this is difficult to implement in practice because rarely does exploitation occur without changing underlying annual abundance, especially when the resource is initially exploited and hence theoretically causing a decline in population abundance from environmental carrying capacity. This initial decline in population abundance due to exploitation is the foundation of all surplus production models. In this situation, a portion of the harvest derives from that one-time decline and does not represent potential future yield supported by surplus production. The DCAC approach is designed to account for that initial “windfall” harvest that is not sustainable, and hence should not be included in any average harvest estimates of sustainable yield (MacCall 2009). DCAC accounts for the initial “windfall” harvest by representing this harvest in terms of “years” of potential harvest, and ultimately increasing the denominator used to calculate average catch over a period for which catch records are available. To this end, the DCAC is based on the potential-yield formula of Alverson and Pereyra (1969) and Gulland (1970):

$$Y_{pot} = \frac{B_{MSY}}{B_0} * \frac{F_{MSY}}{M} * M * B_0. \qquad (1)$$

Here, Y_{pot} is potential yield, B_{MSY} is the population biomass at maximum sustainable yield, B_0 is the population carrying capacity, F_{MSY} is the fishing mortality rate associated with maximum sustainable yield, and M is the natural morality rate. Based on this, the “windfall” harvest is the total harvest associated with reducing abundance from B_0 to the assumed B_{MSY} level (MacCall 2009). After that initial reduction in biomass, Y_{pot} can be considered a sustainable annual yield. To represent this in terms of “years” of potential harvest, the “windfall ratio”,

$$\frac{W}{Y_{pot}} = \frac{\frac{B_{MSY}}{B_0} * B_0}{\frac{B_{MSY}}{B_0} * \frac{F_{MSY}}{M} * M * B_0} = \frac{1}{\frac{F_{MSY}}{M} * M}, \qquad (2)$$

is calculated, where W is the “windfall” harvest (MacCall 2009). This ratio expresses the magnitude of the windfall harvest relative to a single year of potential yield.

In this form, the windfall harvest is not very flexible because it does not take into account current stock status of the population. Hence, MacCall (2009) proposed an even more flexible accounting of the windfall harvest based on the relative reduction in vulnerable stock abundance from the first year to the last year of the catch time-series, i.e. where $W = B_{\text{first year}} - B_{\text{last year}}$. In most situations where this approach is applied, there is not enough information to directly estimate the change in biomass from the first year to the last year of the catch series. Instead, we estimate a relative decline in abundance, Δ, where

$$\Delta = \frac{B_{\text{first year}} - B_{\text{last year}}}{B_0} \text{ (MacCall 2009).} \quad (3)$$

Generally, we do not have enough information to directly estimate Δ, instead developing a rough estimate of the reduction in vulnerable biomass. Substituting Δ for $\frac{B_{MSY}}{B_0}$ in the numerator of equation 2, the general windfall ratio becomes

$$\frac{W}{Y_{pot}} = \frac{\Delta * B_0}{\frac{B_{MSY}}{B_0} * \frac{F_{MSY}}{M} * M * B_0} = \frac{\Delta}{\frac{B_{MSY}}{B_0} * \frac{F_{MSY}}{M} * M}. \quad (4)$$

MacCall (2009) allows the windfall ratio expressed in equation 4 to form the basis for a depletion correction of average catch in the DCAC method. MacCall (2009) argues, assuming that each year, on average, produces one unit of annual sustainable yield, the resulting catch stream is the sum of two components, one derived from sustainable annual production, and the other from a one-time windfall harvest. For a catch (C) series of length n, the total cumulative catch ($\sum C$) constitutes n years of sustainable production, plus a windfall equivalent to W / Y_{pot} years of potential yield, where the sustainable harvest (Y_{sust}) is estimated as

$$Y_{sust} = \frac{\sum C}{n + \frac{W}{Y_{pot}}} \text{ (MacCall 2009).} \quad (5)$$

To provide uncertainty estimates about the Y_{sust}, MacCall (2009) proposes the use of Monte Carlo exploration of DCAC estimates.

<u>Inputs</u>

To perform DCAC analysis, several data inputs or assumed data values are needed, including total catch ($\sum C$) during a given time period of length n, an estimate of stock productivity as represented by the ratio of B_{MSY} / B_0, an estimate of the ratio of F_{MSY} to M (F_{MSY} / M), and an estimate of the relative decline of abundance over the time series (Δ). Associated with each of these measures is an assumed level of uncertainty to be incorporated into Monte Carlo simulations. Based on the work of MacCall (2009) and Dick and MacCall (2011) we have some general recommendations for assumed values of many of these parameters.

Using the same landings data available for the ASAP statistical catch-at-age model (App. B4 Table 1), the sum of landings from 1985-2014 is approximately 550,000 mt with an annual average of 18,325 mt.

For the base model DCAC run, our Δ estimate is based on preliminary SCAA model runs and results of the last update (47.1%; http://www.asmfc.org/uploads/file/552ea3fe2014BluefishStockAssessmentUpdate.pdf) that suggested approximately a 50% depletion in spawning stock biomass over the catch period. For natural mortality (M), we used the Pauly$_{\text{nls-T}}$ estimator ($M = 4.118k^{0.73}L_{\infty}^{-0.33}$; $k = 0.311$ and $L_{\infty} = 815.3$ from Robillard et al. 2009) as presented in Then et al. (2015). This is very similar to the M estimate assumed in the ASAP SCAA base model. Other DCAC parameters were set to be consistent with MacCall (2009) and Dick and MacCall (2011) (App. B4 Table 2). DCAC was implemented with software available from the NMFS toolbox (DCAC V2.1.1; http://nft.nefsc.noaa.gov/DCAC.html). To estimate uncertainty, we performed 1,000,000 Monte Carlo simulations of the base DCAC model with the assumed parameters.

App. B4 Table 1. Total annual bluefish catch (in mt) from 1985-2014. Total catch over this 30 year time period is 549,747.11 mt.

Year	Catch	Year	Catch	Year	Catch
1985	33191.81	1995	12899.28	2005	16665.69
1986	54091.97	1996	12367.80	2006	14719.17
1987	47176.64	1997	14179.93	2007	17345.17
1988	30254.80	1998	11831.31	2008	16426.11
1989	25035.84	1999	9260.16	2009	12223.08
1990	22446.76	2000	12775.56	2010	14161.38
1991	23342.82	2001	15203.13	2011	11504.13
1992	19089.97	2002	10788.29	2012	10784.64
1993	16896.05	2003	13374.64	2013	11253.74
1994	15035.67	2004	15604.59	2014	9816.98

App. B4 Table 2: DCAC based model run assumed parameter estimates and error distributions.

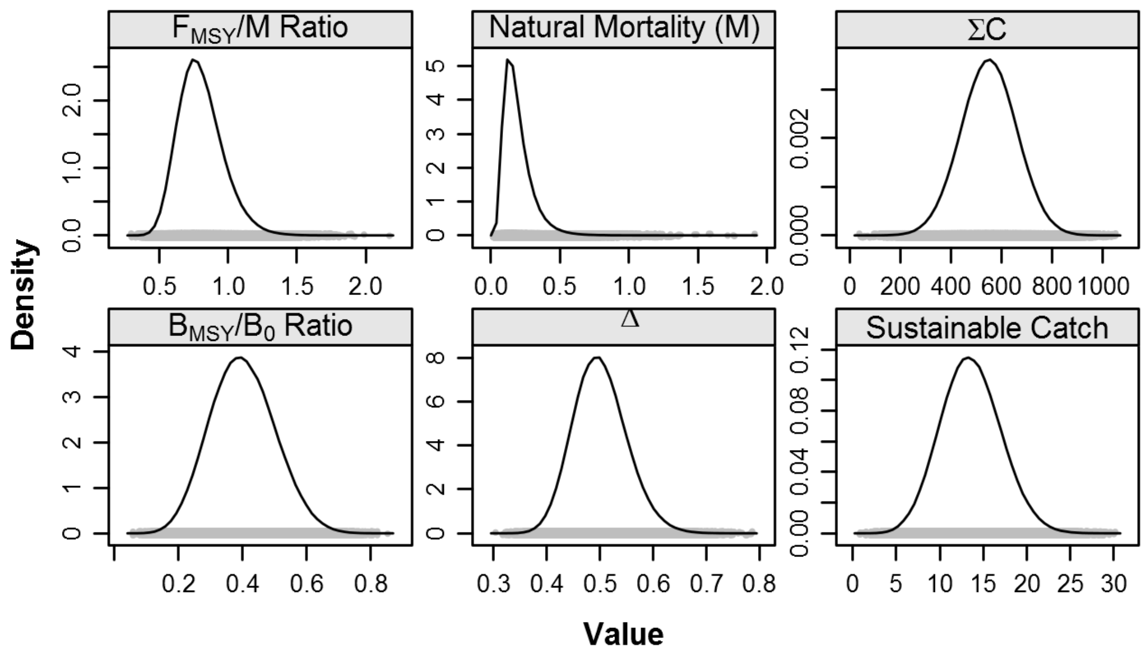
Parameter	Value	Source	SD	Source	Distribution
CV of $\sum C$	0.2	–	–	–	normal
M	0.192	Then et al. (2015) $\text{Pauly}_{\text{nls-T}}$ estimator	0.5	MacCall (2009)	lognormal
F_{MSY}/M	0.8	MacCall (2009); Dick & MacCall (2011)	0.2	MacCall (2009)	lognormal
B_{MSY}/B_0	0.4	MacCall (2009); Dick & MacCall (2011)	0.1	MacCall (2009); Dick & MacCall (2011)	bounded beta
Δ	0.5	Preliminary SCAA model runs	0.1	–	lognormal

Base Run Results

Based on the Monte Carlo simulations, the median estimate of Y_{sust} is approximately 13,480 mt, with a 95% confidence interval of approximately 7,130 mt to 20,520 mt (App. B4 Table 3, Figure X).

App. B4 Table 3. Y_{sust} estimates derived from 1,000,000 Monte Carlo simulations using the base DCAC model assumptions.

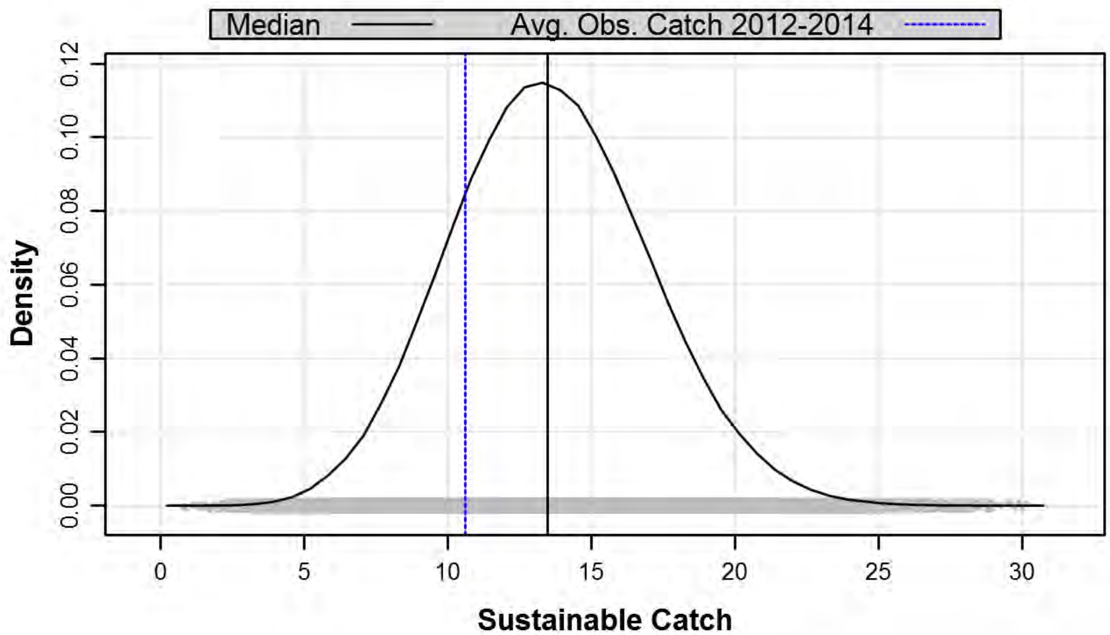
		95% Confidence Interval		90% Confidence Interval	
Average	**Median**	**Lower**	**Upper**	**Lower**	**Upper**
13,569.60	13,479.37	7,133.98	20,516.88	8,077.81	19,357.62



App. B4, Figure.1: Density plot of individual parameter draws (top row panels; bottom row left & middle panels) and sustainable yield estimates (bottom right panel) based on 1,000,000 Monte Carlo simulations of the DCAC base model.

Recent Catch vs DCAC Sustainable Catch

The average harvest of bluefish throughout the region during the period 2012-2014 was 10,618 mt, with no year exceeding 11,254 mt. This suggests that recent annual harvests were at sustainable levels as compared to the median Y_{sust} estimate from the base DCAC model run (App. B4, Figure 2).



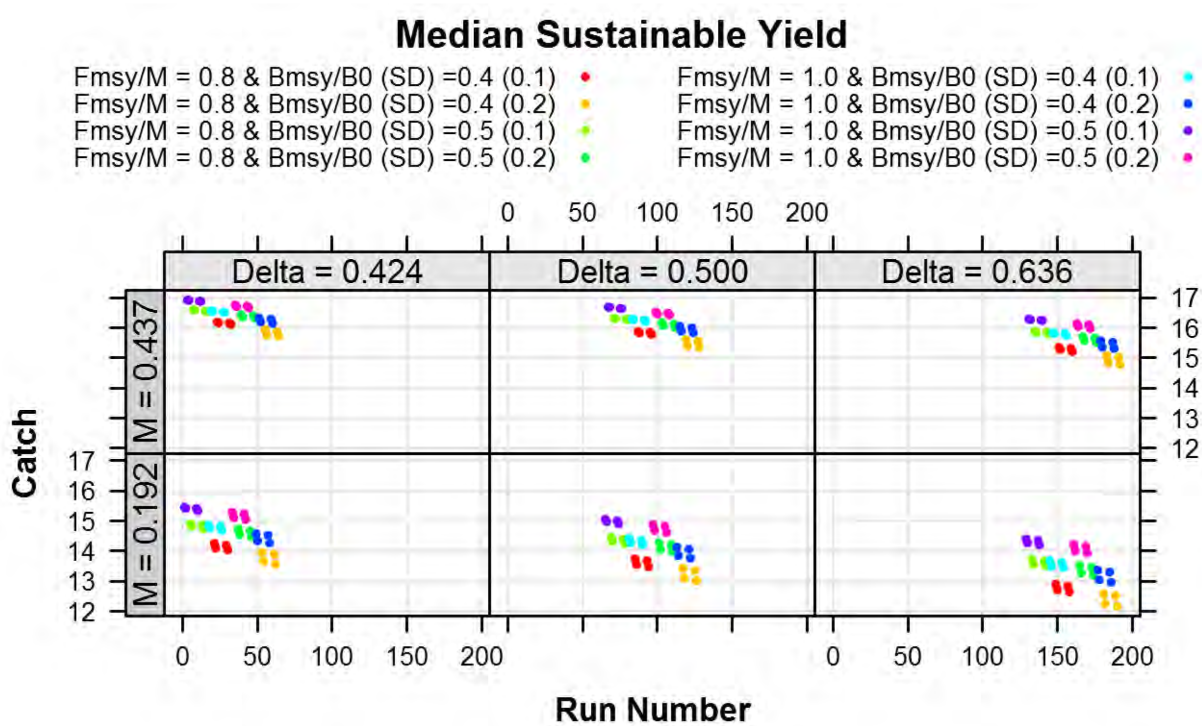
App. B4, Figure 2: Density plot of sustainable yield based on 1,000,000 Monte Carlo simulations of the DCAC base model. Vertical lines represent the median sustainable yield estimate (black) and observed average catch (blue) during the three terminal years (2012-2014) of the assessment.

Sensitivity Analyses

We performed a number of DCAC sensitivity analyses to look at the impact assumed model parameters had on sustainable yield estimates (App. B4, Table 4). All possible combinations of input parameters were investigated, resulting in a total of 192 individual model runs (including the base run presented above). Results of all runs suggested that recent average harvest of bluefish in the terminal 3 years of the assessment (10,618 mt) were sustainable as median sustainable yield levels from all DCAC runs exceeded this value (App. B4, Figure 3).

App. B4, Table 4. DCAC alternative assumed parameter estimates for sensitivity analyses.

		Alternative 1		Alternative 2	
Variable	**Value**	**Value**	**Source**	**Value**	**Source**
CV of $\sum C$	0.2	0.1	–	–	–
M	0.192	0.437	Then et al. (2015) Hoenig_{nls}	–	–
SD of M	0.5	–	–	–	–
F_{MSY}/M	0.8	1.0	MacCall (2009)	–	–
SD of F_{MSY}/M	0.2	0.1	Lower variance estimate	–	–
B_{MSY}/B_0	0.4	0.5	MacCall (2009)	–	–
SD of B_{MSY}/B_0	0.1	0.2	–	–	–
Δ	0.5	0.424	B_0: 1.5xSSB in 1982*	0.636	B_0: SSB in 1982*



App. B4, Figure 3: Y_{sust} median estimates (in mt) derived from each of the 192 different model configurations (including the base DCAC model).

Appendix B5 – Depletion-Based Stock Reduction Analysis (DBSRA)

Introduction

Depletion-based stock reduction analysis (DBSRA) is a technique developed by Dick and MacCall (2010, 2011) to generate sustainable yield reference points for data-poor groundfish stocks in the Pacific Northwest. It has been used to provide management advice or as complementary analysis on the Atlantic coast with species like black drum and tautog (e.g., ASMFC 2015). It is a variation on stochastic stock reduction analysis (Walters et al., 2006) that uses a production model rather than an age-structured model to describe the underlying population dynamics.

Natural mortality (M), the ratio of fishing mortality corresponding to MSY and natural mortality (F_{MSY}/M), biomass corresponding to MSY relative to carrying capacity (B_{MSY}/K), and biomass in the terminal year relative to carrying capacity (B_{2014}/K) are leading parameters used to derive MSY reference points and are based on data, meta-analysis, or expert opinion. F_{MSY} is derived from the product of F_{MSY}/M and M.

The only additional parameter necessary to derive reference points is K. The first year of the removal time series is assumed to be the first year of exploitation and, therefore, the stock is assumed to be at unfished conditions (i.e., K) in the beginning of the first year. An initial K parameter is specified and stock biomass is projected forward in each subsequent year with a production model and the time series of removals. K is then solved for iteratively conditional on the assumed B_{2014}/K and specified bounds around K. If the absolute difference between the estimated B_{2014}/K and assumed B_{2014}/K is not within a specified range (tolerance), or if any biomass estimates are non-positive, the model is considered implausible and is rejected. If the model is accepted, the parameters are used to derive MSY reference points.

Model Structure

The Pella-Tomlinson production function used in DB-SRA was reparameterized by Fletcher (1978).

$$P = g * MSY * \left(\frac{B_{t-a}}{K}\right) - g * MSY * \left(\frac{B_{t-a}}{K}\right)^n$$

The production function was hybridized with a Schaefer production function to address excessive production estimates at low biomasses of highly skewed Pella-Tomlinson production curves, as noted by Fletcher (1978). The hybridized production function estimates production with a Pella- Tomlinson-Fletcher production function at biomasses above a specified biomass (B_{join}) and a Schaefer production function at biomasses below B_{join}. The optimal B_{join} is dependent on the shape of the production curve (i.e., BMSY/K) and recommendations by Dick and McCall (2011) were used for specifying B_{join}. The recommendations result in a hybridized production function that estimates production for low biomass levels similar to a Beverton-Holt stock-recruitment relationship.

$$if\,\frac{B_{MSY}}{K} < 0.3, \frac{B_{join}}{K} = \frac{0.5B_{MSY}}{K};$$

$$if\; 0.3 < \frac{B_{MSY}}{K} > 0.5, \frac{B_{join}}{K} = 0.75\left(\frac{B_{MSY}}{K}\right) - 0.075$$

$$if\,\frac{B_{MSY}}{K} > 0.5, use\ PTF\ for\ all\ biomass\ estimates$$

Biomass was estimated using a delay-difference model in the original method developed by Dick and McCall (2011) that requires an additional age-at-maturity parameter. Bluefish recruit to exploitable biomass before age-at-maturity. Therefore, biomass was estimated in this analysis using a traditional production model with no lag between production and recruitment by setting the age-at-maturity equal to one.

Uncertainty of leading parameters is addressed by drawing the parameters from a prior distribution and running a specified number of model iterations. MSY reference points from each plausible iteration are output in probability distributions. The model was coded in the R software language, version 3.0.2 for Windows (R Development Core Team 2013).

Model Inputs

Input parameters (App. B5, Table 1; App. B5, Figure 1) are drawn from distributions based on expert opinion about bluefish and meta-analysis of similar stocks. Uncertainty about these parameters is incorporated into the final estimates of *K* and the management parameters of interest (MSY, OFL). DBSRA requires as complete a time-series of catch as possible, so harvest from 1950-2014 was used. Estimates of commercial landings were available from 1950 onwards through ACCSP. Recreational harvest estimates are available from MRFSS/MRIP from 1982 onwards. To hindcast recreational landings, the average ratio of recreational to commercial harvest from 1982-2014 was used to scale the commercial landings up from 1950-1982. Dick and MacCall (2011) assume that catch is known without error, which is not the case with a recreationally important species like bluefish. To incorporate some of that uncertainty into this analysis, the catch history was also drawn from a series of lognormal distributions that used each year of the observed time-series of catch as the median (App. B5, Figure 2). The standard deviation was assumed higher in the early years of the time series (s.d.=0.2 for 1950-1981, s.d.=0.1 for 1982-2014) to account for the higher degree of uncertainty in the hindcast recreational catch estimates. Natural mortality was assumed to be 0.2, consistent with the ASAP model runs. The ratio of F_{MSY} to M and B_{MSY} to K followed distributions recommended by MacCall (2009), as was done with the DCAC runs. The ratio of B_{2014} to K was based on the estimates of B_{2014} to B_{MSY} from the most recent update of the ASAP model where a stock-recruitment model was used to estimate MSY-based reference points.

Dick and MacCall (2011) assume the population starts out at K; however, it is easy to extend this model to allow the population to start out at some level relative to K and treat this ratio of B_1/K as another leading parameter. For this analysis, the population was assumed to be near K (B_1/K =

0.90), due to the low levels of exploitation occurring at the beginning of the time series.

A series of sensitivity runs were also conducted to look at the sensitivity of management parameters to the assumptions about leading parameters. These included:

- Higher natural mortality (M=0.30)
- Higher ratio of F_{MSY} to M (F_{MSY}/M = 0.95)
- Lower ratio of B in the terminal year to K (B_{2014}/K = 0.15)
- Fixing the ratio of B in the initial year to K at 1 (B_{1950}/K = 1)

Results

The base model had a relatively high acceptance rate for parameter combinations, with approximately 75% of all runs being accepted. This is most likely due to the fact that the bluefish population does not become heavily depleted over the time-series, and thus the model does not have to thread the needle of maintaining observed catch without driving the population extinct or ending at too high a biomass. There was not a noticeable pattern in the distributions of accepted vs. rejected parameters, with the exception of natural mortality, where the rejected runs used higher values of M (App. B5, Figure .3).

DBSRA estimated a median MSY for bluefish of 18,822 mt, with an OFL for 2015 of 18,835 mt (App. B5, Table.2; App. B5., Figure.5). This method cannot be used to assess stock status (i.e., overfished or experiencing overfishing), because status relative to *K* is one of the inputs to the model. However, the management parameters (MSY, OFL) derived from this model are robust to assumptions about stock status. Results of all runs suggested that recent average harvest of bluefish in the terminal 3 years of the assessment (10,618 mt) were sustainable, as they are below the estimated MSY from the DBSRA.

Discussion

The data poor models corroborate the scale of the ASAP model and agree with the determination that harvest in recent years has been sustainable.

All three models produced roughly similar estimates of sustainable harvest for bluefish, and indicate that recent harvest has been below the maximum sustainable yield. DBSRA estimated the highest MSY, but encompasses the estimates of the other two models in the 5th and 95th percentiles of the estimate.

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Fletcher, R. I. 1978. On the restructuring of the Pella-Tomlinson system. Fish. Bull, 76: 515-521.

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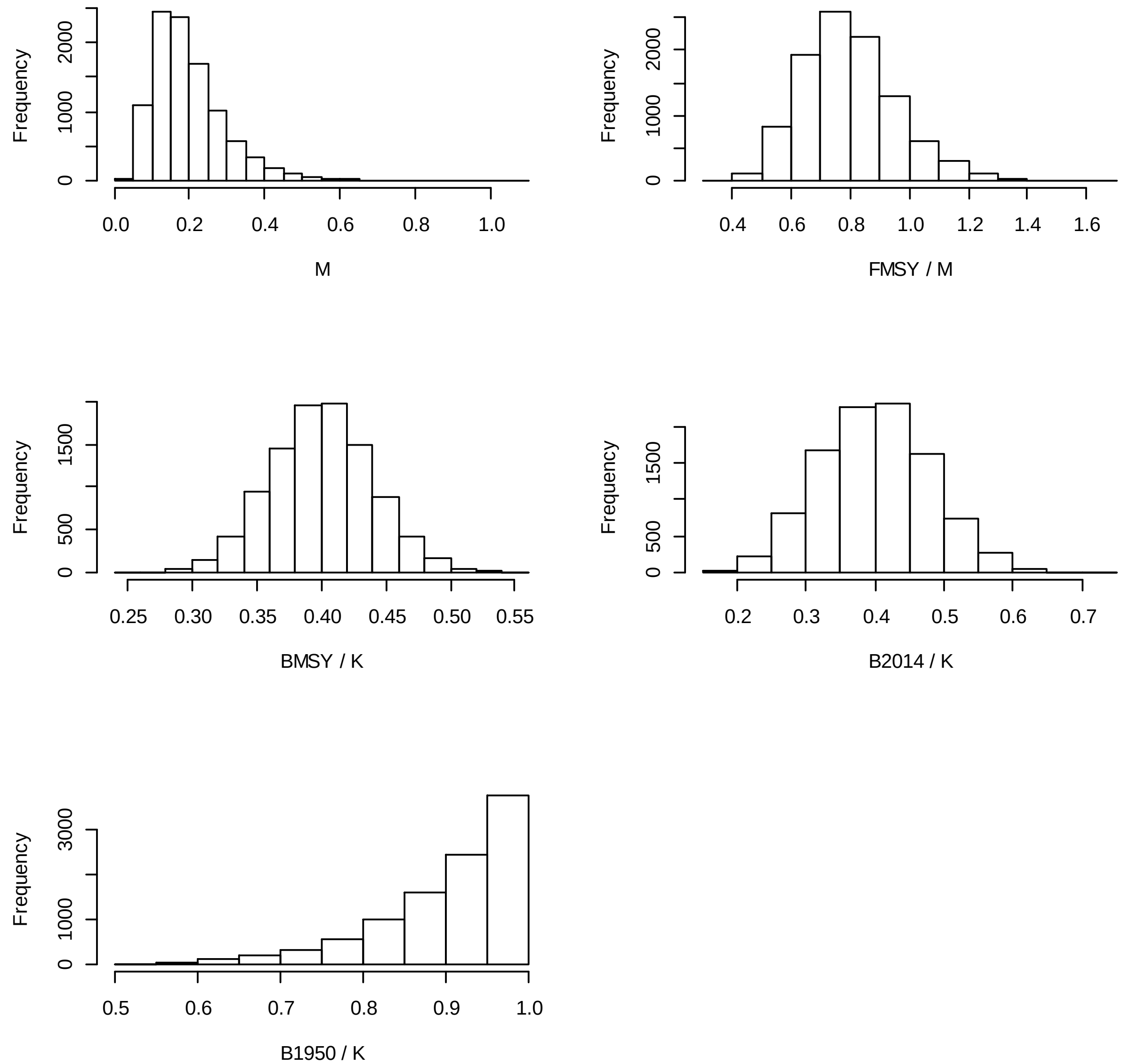
App. B5, Table.1. Input values for the base run of the DBSRA model for bluefish.

Parameter	Value	Source	SD	Source	Distribution
Annual harvest	–	ACCSP, MRIP	0.2,0.1	MRIP PSEs	lognormal
M	0.2	2015 Assessment	0.5	MacCall (2009)	lognormal
F_{MSY}/M	0.8	MacCall (2009); Dick & MacCall (2011)	0.2	MacCall (2009)	lognormal
B_{MSY}/K	0.4	MacCall (2009); Dick & MacCall (2011)	0.1	MacCall (2009); Dick & MacCall (2011)	bounded beta
B_{2014}/K	0.4	2014 Assessment Update	0.2	–	bounded beta
B_{1950}/K	0.90	Expert opinion	0.1	--	bounded beta

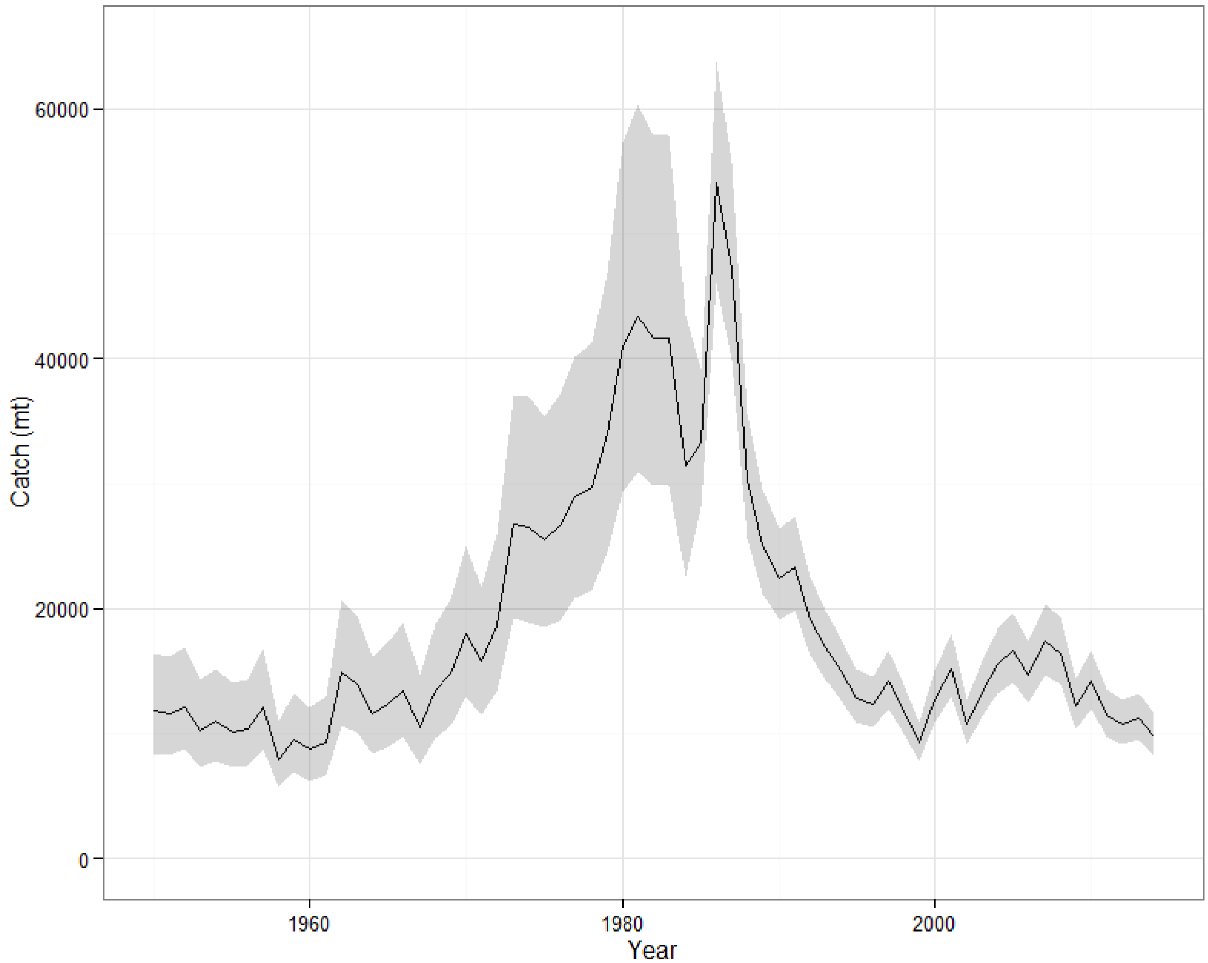
App. B5, Table 2: Median management benchmarks (and 5th and 95th quantiles) from DBSRA model.

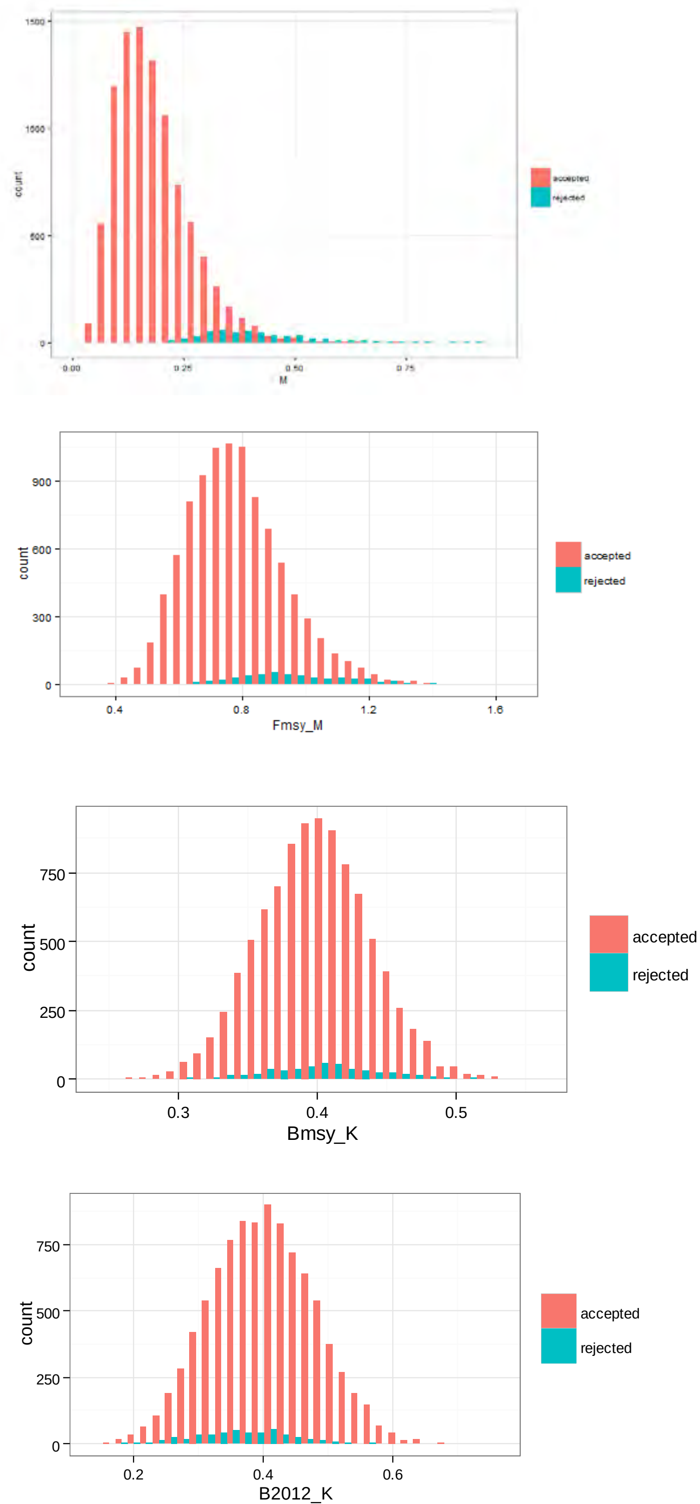
	U_{MSY}	K	MSY	B_{MSY}
Base run	0.12 (0.05 - 0.21)	432,049 mt (277,232 – 831,884 mt)	19,954 mt (14,905 – 24,943 mt)	172,010 mt (110,510 – 324,853 mt)
B_{1950}/K**= 1.0**	0.11 (0.05 - 0.19)	486,155 mt (335,848 – 818,767 mt)	22,054 mt (17,196 – 26,991 mt)	193,296 mt (134,003 – 323,877 mt)
M=0.3	0.15 (0.07 – 0.25)	362,326 mt (253,605 – 643,905 mt)	21,602 mt (16,559 – 25,919 mt)	144,444 mt (100,799 – 253,396 mt)
B_{2014}/K **= 0.15**	0.11 (0.05 – 0.20)	431,900 mt (293,528 – 695,749 mt)	19,097 mt (12,610 – 24,226 mt)	171,582 mt (118,868 – 279,060 mt)
F_{MSY}/M **= 0.95**	0.13 (0.06 – 0.23)	394,231 mt (264,141 – 730,846 mt)	20,735 mt (15,575 – 25,517 mt)	156,604 mt (105,296 – 287,679 mt)

App. B5, Figure.1. Distributions of leading parameters for the base model DBSRA runs for bluefish.

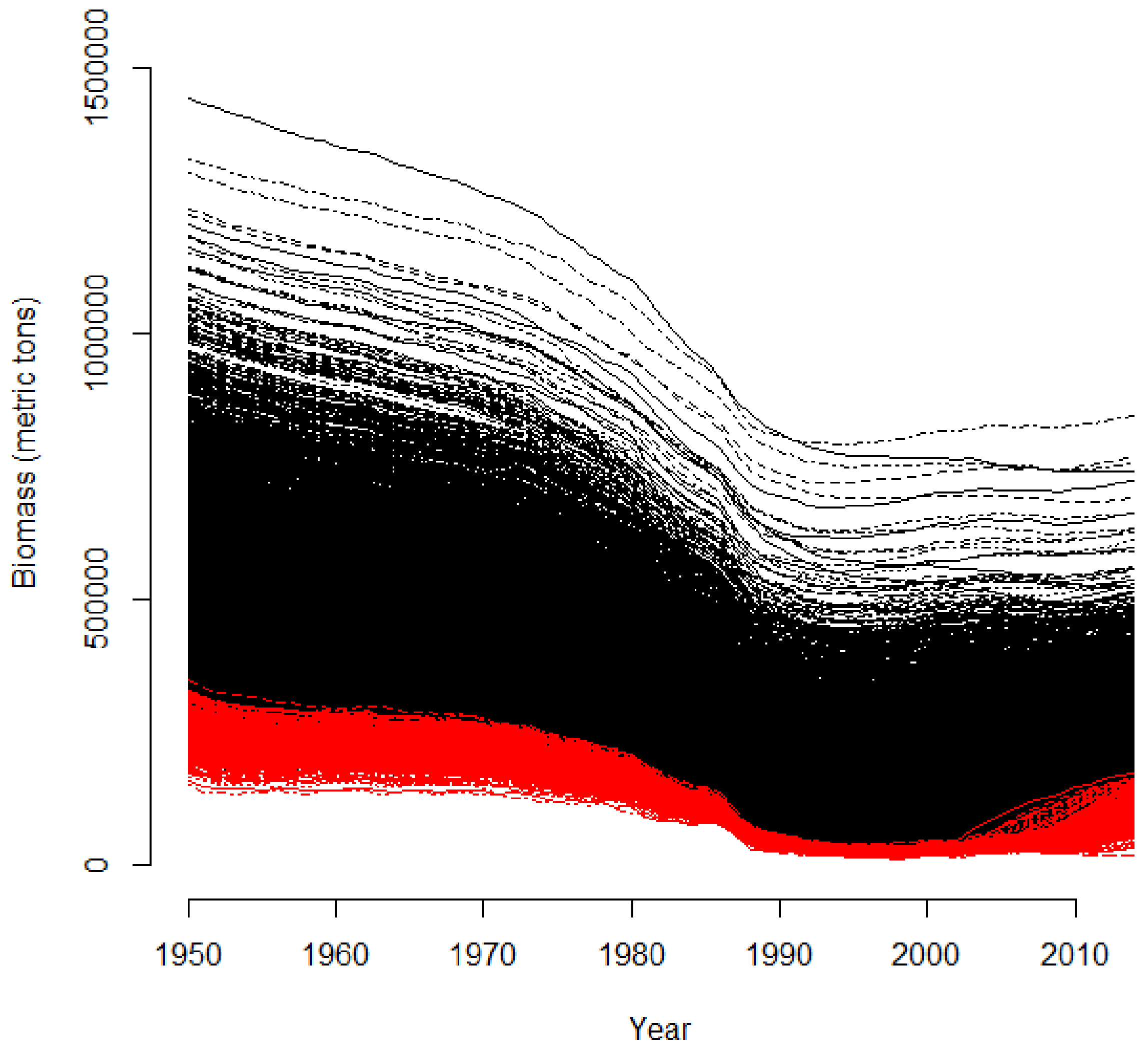


App. B5, Figure .2. Distribution of the drawn catch for the base model DBSRA runs for bluefish.

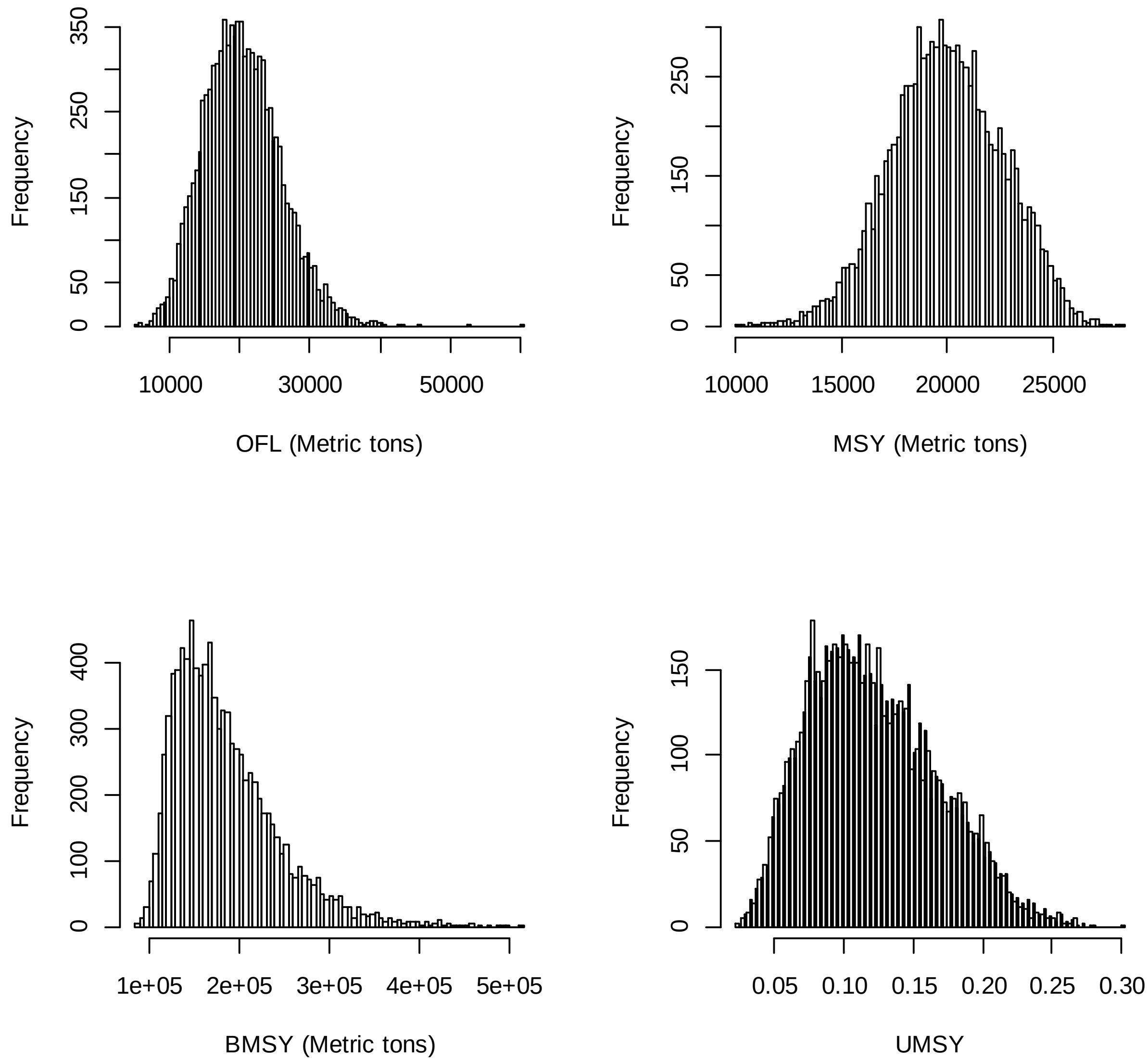




App. B5, Figure.3. Distributions of drawn parameters for runs that were accepted and rejected from the base model DBSRA configuration.



App. B5, Figure.4. Biomass trajectories of accepted DBSRA runs (black) and rejected DBSRA runs (red) for the base model configuration.



App. B5, Figure 5. Distribution of management parameters from successful runs of the base DBSRA model for bluefish.

Appendix B6 – Response to SARC 41 comments on 2005 bluefish benchmark assessment

Prepared by: SAW 60 Working Group

Introduction

The SARC 41 reviewed the 2005 bluefish benchmark stock assessment. The SARC 41 provided a constructive criticism, which provided guidance on how to improve future bluefish assessments. This document details how the specific recommendations of the SARC 41 were addressed by the SAW 60 working group for the 2015 bluefish benchmark stock assessment.

First recommendation - **Continue to develop statistically appropriate models for this stock, including evaluation of uncertainty and sensitivity. This modeling should also test sensitivity to data quality. The Bluefish Technical Committee (BTC) should avoid double use of the data as model input.**

The SARC 41 praised the 2005 bluefish assessment for using a catch-at-age model to assess stock status. Accordingly, the SAW 60 working group continued to utilize this approach while concurrently working to improve the statistical validity of the model. The model was adjusted to increase the CV present on several indices and for several results, allowing the data to better guide the model. The SAW 60 WG explored 13 sensitivity runs to examine the effects of factors such as different levels of constant mortality, age varying natural mortality, different selectivity blocks etc. These sensitivity runs served to guide the research recommendations put forth by the SAW 60 WG and the BTC.

Second recommendation - **Evaluate the fishery-independent surveys used to tune the model with special emphasis on determining if the state surveys can be combined to yield better temporal and spatial representation of stock abundance. The BTC should encourage the states to coordinate their survey efforts for bluefish to improve the quality of data that can be obtained. We suggest a workshop to address this and other data issues.**

The ASMFC convened a data workshop with the BTC in February 2015 to discuss which surveys were available to include in the benchmark assessment. The group reached a consensus on which surveys were appropriate or inappropriate for further consideration.

Because changes in design to existing state surveys were not a feasible option, the BTC standardized indices using a GLM based approach to better combine and compare indices among states.

Further, the SAW 60 WG created a composite young of year index for bluefish using the Conn et al. method. This index used a hierarchical approach to combine seine surveys among many states, resulting in a more realistic representation of young of year abundance - providing better information for which the model to estimate recruitment from.

Third recommendation - **Evaluate the use of otolith and scale ageing of bluefish. We suggest this be a separate workshop to evaluate the best ageing structure and its reliability for stock assessment input. After the evaluation, intensify collection of age data from commercial and recreational fisheries, and evaluate the validity of combining age classes**

across years in an ALK.

The ASMFC convened a bluefish aging workshop in 2011. At this workshop, aging experts concluded that otoliths are the preferred structure with which to age bluefish, set a standardized processing and reading method, recommended that a digital archive of reference structures be created, and recommended that a coastwide sampling program for obtaining bluefish otoliths be begun in 2012.

Based on the recommendations of the aging workshop, the ASMFC added addendum 1 to the bluefish FMP, requiring all states that account for >5% of total coastwide harvest to provide at least 100 otolith based bluefish ages. Most of this data was available for the 2015 benchmark assessment and was utilized by the SAW 60 WG.

To evaluate the validity of combining age classes across years in an ALK, the SAW 60 WG explored several methods. First, the SAW 60 WG performed sensitivity runs of the ASAP model based on pooled versus non pooled keys to see how model results were influenced by the pooling age data. Second, the SAW 60 WG constructed several sets of ALKs using multinomial logistic regression. Within the regression model set, models that included parameters for effects such as year or state were compared to models that did not include such factors using AICc.

Fourth Recommendation - **Improve sampling coast wide by gear and fishery sector to obtain information with special emphasis on mid-size fish. This may require alternative fisheries independent assessment methodologies (such as lidar, archival tagging, sonar).**

Progress has been made towards better capturing information on mid-sized bluefish. At the request of the SAW 60 WG and the BTC, Manderson and Hare constructed a parametric thermal niche model that quantified the influence of temperature on bluefish distribution, providing a measure of bluefish availability for index interpretation. Availability will be able to be incorporated as a covariate in the next version of ASAP, and future assessments are likely to be able to incorporate variables, such as temperature, that may influence survey catches.

Fifth Recommendation - **Increase fishery-independent sampling to better represent the population's offshore and southern habitat.**

In response to a 2011 bluefish aging workshop, the ASMFC added Addendum I to the bluefish fishery management plan. This Addendum required the states of MA, RI, CT, NY, NJ, NC and VA to collect a minimum of 100 bluefish otoliths. The information garnered from these collections was included in the 2015 benchmark assessment.

Sixth Recommendation - **Determine if discard mortality of 15% for the recreational fishery is accurate.**

The SAW 60 WG performed a meta-analysis on available data to better determine if a discard rate of 15% was appropriate for the 2015 bluefish benchmark assessment. Four methods were used to calculate point estimates of post-release mortality. These methods resulted in a range of estimates from 14-17%. The SAW 60 WG and the BTC approved a 15% (S.D. = 0.143) discard mortality rate for the 2015 bluefish benchmark assessment.

Appendix B7 – Model Results and Diagnostics From Original Final Model B043 as Presented to the SARC Panel

At the SARC review of bluefish the review panel discovered a model misspecification in the selectivity parameters for the MRIP index. A parameter in the function describing the curve for selectivity was fixed when it was intended to have been freely estimated by the model. This was causing patterning in the age composition residuals for this index. The final revised model corrects this misspecification. ***The values presented in this appendix reflect the output from the early model presented in the draft WP document and at the peer review, before final revision. For the final SAW/SARC60 assessment results, readers should see the main body of the bluefish report.***

B7 TERM OF REFERENCE #4: ESTIMATE RELATIVE FISHING MORTALITY, ANNUAL FISHING MORTALITY, RECRUITMENT, TOTAL ABUNDANCE, AND STOCK BIOMASS (BOTH TOTAL AND SPAWNING STOCK) FOR THE TIME SERIES, AND ESTIMATE THEIR UNCERTAINTY. EXPLORE INCLUSION OF MULTIPLE FLEETS IN THE MODEL. INCLUDE BOTH INTERNAL AND HISTORICAL RETROSPECTIVE ANALYSES TO ALLOW A COMPARISON WITH PREVIOUS ASSESSMENT RESULTS AND PREVIOUS PROJECTIONS. EXPLORE ALTERNATIVE MODELING APPROACHES IF FEASIBLE.

B7.3.3 A Final Model

Model BFINAL final adjustments to input CVs and effective sample sizes

Final model data summary: Catch proportions for the recreational fleet ranged from 66% to 84% of the total catch (App. B7 Figure B7.26). Catch-at-age for both fleets is predominantly age 0 to age 3, with the recreational fleet catching more age 0, and both fleets catching lesser numbers at older ages (App. B7 Figures B7.27 and B7.28). Overall survey index trends are generally flat, with noticeable peaks for some of the indices early in the time series, and around 2005 (App. B7 Figure B7.29). Input age composition for the indices are presented in App. B7 Figures B7.30 through B7.35. Final model inputs for weight-at-age of the fleets, natural mortality, and maturity-at-age are presented in App. B7 Figures B7.36 through B7.41.

The main contributions to the objective function were from the likelihood components of the index and catch age compositions (App. B7 Figure B7.42). Compared to the previous assessment model from SAW41, which was heavily weighted towards the single catch fleet, model BFINAL gives equal weight to all components. One of the final changes to model BFINAL was iterative adjustments made to the input CV of each index to account for additional process error. The model was re-run and adjustments were made for each index until the root mean square error of the index was close to a value of 1.0 (App. B7 Figure B7.43). In addition to fine tuning the input CVs of the surveys, a low effective sample size was assigned to the middle period time block 1997-2005. The working group decided while the age information in this time block was poor (because of pooled age keys and borrowing across years) a small effective sample size should be input to generate some information about age composition in these years.

B7.4 Final Model Diagnostics

BFINAL model diagnostic plots for the fit to the two catch fleets are presented in App. B7 Figures B7.44 through B7.51. Diagnostic plots for the 9 survey indices are presented in App. B7 Figures B7.52 through B7.81. For reference when viewing some of the plots:

Fleet 1 = commercial
Fleet 2 = recreational
Index 1 = NEFSC Inshore trawl
Index 2 = NEFSC Bigelow trawl
Index 3 = MRIP recreational CPUE
Index 4 = NEAMAP trawl
Index 5 = SEAMAP Age 0
Index 6 = PSIGN gillnet
Index 7 = CT LISTS trawl
Index 8 = NJ Ocean trawl
Index 9 = Composite YOY seine

The final model run had similar estimates to model B042 with slightly greater fishing mortality, total stock number, and recruitment estimates, and slightly decreased estimates of biomass (Table B7.1). Selectivity at-age estimates for the two catch fleets were both domed, with a bi-modal pattern still evident in the commercial fleet (App. B7 Figures B7.82 and B7.83). Fishing mortality for the recreational fleet has always been higher than the commercial fleet, in some year two to three times as much. Fishing mortality estimates in 2014 for the commercial and recreational fleets were 0.043 and 0.092, respectively (App. B7 Figure B7.84). Final model estimates for the index selectivities show a rapid decrease in selectivity after age 0. A few of the indices have higher selectivity towards larger/older fish, the most important being MRIP and PSIGNS, and to a lesser extent the Bigelow survey (App. B7 Figure B7.85). Observed and predicted catch-at-age for the two fleets and nine indices are presented in App. B7 Figures B7.86 through B7.103. Estimates of age composition at older ages are poorly predicted for some of the components.

B7.5 Final Model Results
Average F for from 1985 to 2014 from the final model was 0.249 and average SSB was 105,904 mt (Table B7.4). Spawning stock biomass dipped from a high of 191,476 mt in 1985 to a low of 72,173 mt in 1997 and has steadily increased to a value of 117,827 mt in 2014 (Table B7.4, App. B7 Figure B7.104). The majority of the spawning stock biomass (50-60%) is in the age 6+ group for the entire time-series (App. B7 Figure B7.105). Estimates of F have remained below average since 1997 and the 2014 estimate of 0.136 is well below the time series average (Table B7.4, App. B7 Figure B7.104). There has been a steady decline in fishing mortality since 2007.

Estimates from model BFINAL showed a decrease in total abundance since 2006, declining from 106.5 million to 78.1 million fish in 2012 (Table B7.5, App. B7 Figure B7.106). Total abundance increased in 2013, and 2014, to 84.9 and 94.2 million, respectively. Age 0 and age 1 fish collectively average around 50% of abundance for the time-series. Below average (25.9 million) recruitment began in 2008 with an estimate of 25.7 million fish (Table B7.4, App. B7 Figure B7.107). Low recruitment persisted through 2012 to the lowest estimate of the time-series at 18.4 million. Recruitment for 2013 and 2014 have increased above the average to 27.2 and 31.1 million fish, respectively. Throughout the time series the plus group contains the majority of the biomass (Table B7.6). Biomass estimates for 6-plus bluefish have remained above the time series average of 60,492 mt since 2010. Total mean biomass in 2014 equaled 127,061 mt, a slight decrease from the 2013 estimate of 132,930 mt (Table B7.6, App. B7 Figure B7.108).

Retrospective bias for the final model was examined for F, spawning stock biomass, recruitment, total biomass, exploitable biomass, total abundance, and abundance-at-ages 1 through 6. The analysis shows little evidence of bias in the estimates of F (Mohn's rho = -0.057), SSB (Mohn's rho = 0.076), and recruitment (Mohn's rho = -0.012) (App. B7 Figure B7. 109). Similarly, there is little retrospective bias in estimates of total biomass (Mohn's rho = 0.071), exploitable biomass (Mohn's rho = 0.046) and total abundance (Mohn's rho = -0.005) (App. B7 Figure B7.110). There does appear to be minor retrospective bias in some of the estimates of abundance-at-age, particularly numbers at age 1 (Mohn's rho = -0.139) and numbers at age 5 (Mohn's rho = 0.13) (App. B7 Figures B7.111 and B7.112).

The variation in the final model results for F and SSB was determined using a Monte Carlo Markov chain with 1000 iterations and a thinning factor of 1000 (1,000,000 iterations). Trace plots for both SSB and F show little to no patterning (App. B7 Figures B7.113 and B7.114).There is no significant autocorrelation in the F chain (App. B7 Figure B7.115). Autocorrelation plots show minor autocorrelation in the SSB (both 1985 and 2014) chain at a lag of 1, with no autocorrelation at a lag greater than 2 (App. B7 Figure B7.116). The MCMC results of SSB for 2014 ranged from 82,000 to 137,000 mt, with a median estimate of 105,000 mt, and 80% confidence interval ranging from 92,119 mt to 121,467 mt. The 2014 SSB point estimate from the final model (117,827 mt) is greater than the median estimate from the MCMC distribution (App. B7 Figure B7.117 and B7.118). Variation around F ranged from 0.103 to 0.193, with the 80% CI between 0.121 and 0.166. The point estimate from the final model (0.136) is slightly less than the median estimate (0.142) from the MCMC distribution (App. B7 Figure B7.119 and B7.120).

B7.6 Final model sensitivity runs

A number of sensitivity runs were carried out by changing data inputs to the final model.

Changes to the recreational data

The first group of sensitivities explored different changes made to the estimation of various components of the recreational catch. A total of 5 sensitivity runs were conducted for the recreational data: 1. Assume recreational landings (AB1) lengths apply to the recreational discards (B2), 2. Assume recreational catch at the upper 95% CI of estimates, 3. Assume recreational catch at the lower 95% CI of the estimates, 4. Use MRFSS numbers prior to 2004 (no conversion to MRIP equivalents), and 5. Assume 17% recreational discard mortality instead of 15%. Comparisons between final model and sensitivity run estimates of F, total stock numbers, recruitment, and SSB are presented in App. B7 Figures B7.121 through B7.125.

Changes to data structure and inputs

Additional final model sensitivity runs were conducted that changed other components of the input data: 1, A regional sensitivity run was explored that used northern and southern regional age-length keys to age the fleets and surveys from 2006 to 2014, 2. Length-weight coefficients were varied over time by three time blocks, 1985-1994, 1995-2004, 2005-2014, 3. Virginia landings date were calculated using a different methodology (VA set 2). Comparisons between final model and sensitivity run estimates of F, total stock numbers, recruitment, and SSB for these sensitivity runs are presented in App. B7 Figures B7.126 through B7.128.

Sensitivity runs were also carried out the final model assuming different input values for natural mortality. A profile of the objective function was calculated over a range of natural mortality estimates, and the objective function was minimized at a value of 0.263 (Table B7.7 and App. B7 Figures B7.129 and B7.130). Age-based inputs for natural mortality were also explored (Table 1.50 and App. B7 Figure B7.131). The estimates assuming age-based M derived from equations in Gislason et al. 2010 resulted in unrealistic model estimates (Table B7.8).

Changes to the survey indices

Sensitivity of the final model to individual survey indices was also tested by removing each index and re-running the model (Table B7.9). The model is fairly insensitive to the removal of all the indices except for the MRIP recreational CPUE index, which is driving the model along with the two catch fleets. The reason this index is so important is because it provides most of the information for model estimates at older ages. Removing the MRIP index and re-running the final model results in a significant decrease in fishing mortality estimates and an increase in abundance and biomass estimates (Table B7.9 and App. B7 Figure B7.132). An additional model run using just the two catch fleets and the single MRIP index was also conducted. Without the other indices the model loses some information to inform estimates of younger ages and recruitment is scaled up. However, the overall trend and scale of biomass and fishing mortality estimates are not that different from the final model (App. B7 Figure B7.132).

Investigating habitat suitability indices

Habitat suitability information was also investigated for the NEFSC surveys as well as the NEAMAP survey. Annual estimates of habitat suitability were input as a covariate on availability in the ASAP model (catchability = availability*efficiency, where efficiency was assumed = 1). The use of the habitat suitability indices did not improve the fit of the model to the respective indices. This is not surprising, since the annual estimates of available thermal habitat sampled by the NEFSC and NEAMAP surveys did not show significant trends which would cause a bias in trends of relative abundance (App. B7 Figure B6.21). In addition, these indices used a hindcasted estimate of sea bottom temperature to derive estimates of bluefish habitat suitability. The ocean model used to hindcast these temperatures was not available for 2013 and 2014 and as a result no index of habitat suitability was available for these years (See

WP B4 for full details). The working group decided to go forward without incorporating habitat suitability in the model. There was concern because recent information was not available, as well concern for the ocean model that was used to develop the indices. A habitat suitability index developed from an ocean model using real-time or forecasted sea-surface temperature would be more appropriate for bluefish. This is included as a research recommendation and could be developed for future bluefish assessments.

B8 TERM OF REFERENCE #5: STATE THE EXISTING STOCK STATUS DEFINITIONS FOR "OVERFISHED" AND "OVERFISHING". THEN UPDATE OR REDEFINE BIOLOGICAL REFERENCE POINTS (BRPS; POINT ESTIMATES OR PROXIES FOR B_{MSY}, $B_{THRESHOLD}$, F_{MSY}, AND MSY) AND PROVIDE ESTIMATES OF THEIR UNCERTAINTY. IF ANALYTIC MODEL-BASED ESTIMATES ARE UNAVAILABLE, CONSIDER RECOMMENDING ALTERNATIVE MEASURABLE PROXIES FOR BRPS. COMMENT ON THE SCIENTIFIC ADEQUACY OF EXISTING BRPS AND THE "NEW" (I.E., UPDATED, REDEFINED, OR ALTERNATIVE) BRPS.

The current biological reference points for bluefish were determined in SARC 41 and are F_{MSY} (0.19) and B_{MSY} (147,052 mt). The basis for the reference points was the Sissenwine-Shepherd method using the Beverton-Holt stock recruitment parameters and SSB per recruit results generated by the SARC 41 ASAP model results. B_{MSY} was calculated using mean weights at age and is therefore comparable to mean biomass in year *t*. Overfishing of a stock occurs if F exceeds F_{MSY} and a stock is considered overfished if total biomass is less than half of B_{MSY} ($B_{THRESHOLD}$). The existing definition of overfishing is F > 0.19 and B < 73,526 mt.

The TC and WG concluded that new reference points were required because of the uncertainty present in the stock recruitment relationship estimated by the current model. The time series of spawning stock biomass and recruitment does not contain any data about recruitment levels at low stock sizes (App. B7 Figure B8.1), and the BTC and the SAW 60 WG did not believe the fitted parameters adequately described the stock-recruitment relationship for bluefish.

Because MSY based reference points require a stock recruitment relationship, MSY proxies are required. As a proxy for F_{MSY}, the BTC and the SAW 60 WG recommend $F_{40\%\ SPR}$. The input maturity and composite selectivity curves are shown in App. B7 Figure B8.2. The resulting YPR and SPR curves are shown in App. B7 Figure B8.3.

To calculate the associated proxy for B_{MSY}, the population was projected forward for one hundred years under current conditions with fishing mortality set at the F_{MSY} proxy and recruitment drawn from the observed time series. The resulting equilibrium biomass is the recommended B_{MSY} proxy, with the overfishing threshold set at ½ B_{MSY}. Similarly, the equilibrium landings under $F_{40\%SPR}$ were set as the MSY proxy.

The revised reference points are F_{MSY} proxy = F40% = 0.181 and B_{MSY} proxy = 126,504 mt (½ B_{MSY} = 63,252 mt). The MSY proxy is 14,188 mt.

The usage of these proxies has been accepted in many other assessments and is considered adequate in cases where a stock recruitment relationship is not estimable. Recent SAW assessments where MSY proxies have been used include the Gulf of Maine haddock (2014), summer flounder (2013), and white hake (2013).

SPR-based reference points are not sensitive to uncertainty in the stock-recruitment relationship, but do not link future recruitment to spawning stock biomass. The projection approach used to establish the B_{MSY} proxy incorporates the observed variability in recruitment, but assumes that recruitment is independent of SSB. This assumption is not unreasonable over the observed high levels of bluefish abundance, and maintaining the stock close to the proposed target should minimize the risk of this assumption.

B9 TERM OF REFERENCE #6: EVALUATE STOCK STATUS WITH RESPECT TO THE EXISTING MODEL (FROM PREVIOUS PEER REVIEW ACCEPTED ASSESSMENT) AND WITH RESPECT TO A NEW MODEL DEVELOPED FOR THIS PEER REVIEW.

B9.1 Stock status from the continuity run

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

The existing reference points are F_{MSY} = 0.19 and B_{MSY} = 147,052 mt (½ B_{MSY} = 73,526 mt). The 2014 F estimate (0.141) is well below F_{MSY} and the 2014 estimate of B is 92,755 mt, below B_{MSY} but well above ½ B_{MSY}. This indicates that overfishing is not occurring and that the stock is not overfished (App. B7 Figure B9.1).

B9.2 Stock status for the current assessment

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

The new reference points are F_{MSY} proxy = F40% = 0.181 and B_{MSY} proxy = 126,504 mt (½ B_{MSY} = 63,252 mt). The 2014 F estimate (0.136) is below $F_{40\%}$ and the 2014 B estimate (127,061 mt) is greater than ½ B_{MSY}, indicating that overfishing is not occurring and that the stock is not overfished (App. B7 Figure B9.2 and B9.3).

In addition, since biomass is greater than the B target, the stock can be considered rebuilt.

	SARC 41		**Updated**	
Reference Point	Definition	Value	Definition	Value
$F_{THRESHOLD}$	F_{MSY}	0.19	$F_{40\%SPR}$	0.181
B_{TARGET}	B_{MSY}	147,052 mt	Equilibrium biomass under $F_{40\%SPR}$	126,504 mt
$B_{THRESHOLD}$	½ B_{MSY}	73,526 mt	½ $B_{MSY\ Proxy}$	63,252 mt

B10. TERM OF REFERENCE #7: DEVELOP APPROACHES AND APPLY THEM TO CONDUCT STOCK PROJECTIONS AND TO COMPUTE THE STATISTICAL DISTRIBUTION (E.G., PROBABILITY DENSITY FUNCTION) OF THE OFL (OVERFISHING LEVEL; SEE APPENDIX TO THE SAW TORS).

B10.1 Provide annual projections (3 years). For given catches, each projection should estimate and report annual probabilities of exceeding threshold BRPs for F, and probabilities of falling below threshold BRPs for biomass. Use a sensitivity analysis approach in which a range of assumptions about the most important uncertainties in the assessment are considered (e.g., terminal year abundance, variability in recruitment)

Short-term projections were conducted using AGEPRO v.4.2.2 (available from the NOAA Fisheries Toolbox, http://nft.nefsc.noaa.gov/AGEPRO.html).

Removals in 2015 were assumed to be equal to the 2015 quota (9,722 mt). For 2016-2018, a constant level of fishing mortality was applied. The population was projected forward under five different F levels:

- $F_{low} = 0.1$
- $F_{status\ quo} = 0.136$
- $F_{0.1} = 0.203$
- $F_{TARGET} = 90\% F_{MSY\ Proxy} = 0.163$
- $F_{MSY\ Proxy} = F_{40\%SPR} = 0.181$

Uncertainty was incorporated into the projections primarily via estimates of recruitment and initial abundance-at-age. Estimates of recruitment were drawn from the 1985-2014 time-series of observed recruitment from the preferred ASAP model. Initial abundance-at-age estimates were drawn from distributions of terminal abundance-at-age developed from the MCMC runs of the preferred ASAP model. A small amount of uncertainty was incorporated into biological parameters such as weight-at-age, maturity-at-age, and natural mortality; estimates of these parameters were drawn from lognormal distributions with mean values used in the terminal year of the assessment and a CV of 0.01.

The projections were conducted with a single fleet. Selectivity was calculated by summing the commercial and recreational F-at-age for each age from the preferred ASAP model over the last three years of the model and dividing by the maximum F-at-age to develop a composite selectivity curve. A CV of 0.01 was also applied to the selectivity-at-age estimates.

None of the fishing mortality scenarios resulted in total biomass going below the biomass threshold (½ $B_{MSY\ Proxy}$) in any year of the projection; total biomass remained above the biomass threshold with 100% probability in all years (Table B10.1, App. B7 Figure B10.1).

The median OFL for 2016, calculated as landings at $F_{MSY\ Proxy}$ was estimated as 12,752 mt (5th and 95th percentiles = 10,722 – 15,074 mt).
A sensitivity analysis approach was used to determine the effects of major sources of model uncertainty that could not be encompassed through the MCMC runs of the base model. This

included:

- Limiting the empirical recruitment distribution to the CDF of observed recruitment for 2006-2014 (the years of the best available age data)
- Higher M (M=0.26)
- Increased uncertainty in selectivity-at-age, weight-at-age, and maturity-at-age (CV of 0.1 instead of 0.01)

Using the more limited recruitment time series did not significantly change the estimates of landings or biomass from the projections (Table B10.2, App. B7 Figure B10.2). This is not surprising, since the median recruitment of the 2005-2014 period (26.4 million fish) is not significantly different from the median recruitment of the entire time series (24.5 million fish). Higher M values resulted in higher estimates of landings and biomass, but did not change the probability of going below the biomass threshold (0% in all years). Increasing the CV on the biological parameters did not significantly change the median of the distributions for biomass or landings in each year, but did increase the confidence intervals. The probability of being above the biomass threshold remained 100%.

B10.2 Comment on which projections seem most realistic. Consider the major uncertainties in the assessment as well as sensitivity of the projections to various assumptions.

The WG considers the base model configuration the most realistic projection scenario. While estimates of recruitment in the most recent 10 years of the time-series (derived in part from the best age information) are likely more reliable than the estimates from the beginning of the time-series, the median recruitment and projection time-series are virtually indistinguishable.

B10.3 Describe this stock's vulnerability (see "Appendix to the SAW TORs") to becoming overfished, and how this could affect the choice of ABC.

Bluefish are a fast-growing, fast-maturing species with a moderately long life span. Although they recruit to the fishery before they are fully mature, larger, older fish are considered unpalatable, reducing demand for those sizes in the commercial market and encouraging the release of those size classes in the recreational fishery. The resulting dome-shaped selectivity of the fleets offers protection to the spawning stock biomass. Although they are a popular gamefish, demand for this species is not extreme and the quota is rarely met or exceeded.

Bluefish are opportunistic predators that do not depend on a single prey species. Their range covers the whole of the Atlantic coast, and their spawning is protracted both temporally and geographically. As a result, they are not as vulnerable as many other species to major non-fishery drivers such as climate change that would result in the loss of critical forage or nursery habitat.

This assessment indicates bluefish are near their target biomass and well above their overfished threshold. Short-term projections indicate no risk of driving the biomass below the overfished threshold while fishing at or near the FMSY proxy. Overall, bluefish have a low degree of vulnerability to becoming overfished, and the ABC can be set on the basis of the FMSY proxy without risk of causing the stock to become overfished.

App. B7 Table B7.1. Bluefish model building starting with continuity run and ending at final model. The models shown highlight the important changes in the progression from one model to the next. 2014 estimates of F, F40%, total stock numbers, spawning stock biomass, total stock biomass and recruitment are presented for each model step.

MODEL	DESCRIPTION	Obj Func	#pars	2014 Estimates					
				F	F40%	TSN (000s)	SSB (mt)	TSB (mt)	Rec (000s)
B001	Continuity run. Update SAW2005 model through 2014.	3094.79	101	0.141	0.171	57,671	84,800	92,755	14,696
B002	Continuity run cropped to start in 1985: No age data for 1982-1984 found.	2637.25	95	0.145	0.200	70,867	84,551	91,808	21,528
B004	Base model run. SAW2005 model with new CAA, WAA, and Indices.	2282.17	114	0.146	0.172	57,534	81,241	90,381	15,731
B006	Changed indices from index-at-age to estimating age composition.	7692.99	108	0.119	0.175	76,803	105,632	103,359	23,573
B007	Changed from one catch fleet to two: Recreational and commercial.	8546.78	138	0.143	0.172	64,470	83,839	91,462	16,174
B008	New maturity ogive based on preliminary analyses of maturity data.	8546.78	138	0.143	0.175	64,470	85,738	91,462	16,174
B011	Change from fixed fleet selectivities-at-age estimated selectivities.	8480.29	148	0.145	0.202	78,047	117,234	125,019	18,723
B020	Change to two selectivity blocks per fleet: 1985-2005, 2006-2014	7748.80	155	0.105	0.146	109,651	182,995	193,733	23,828
B020A	No estimated age composition for fleets in middle time period 1997-2005: ESS = 0	7559.01	155	0.103	0.148	112,281	189,369	200,420	24,194
B021	Set Lambdas to 0 or 1 to act as a switch for CV and inclusion in Obj Func. Needed to adjust fleet ESS and CV to get model to converge.	2719.28	164	0.111	0.128	82,875	102,157	110,871	24,289
B021A	Turn Likelihood constant off in objective function.	8134.61	164	0.155	0.224	102,891	142,077	152,889	28,581

B022	Turn number in the first year deviation penalty off	7937.38	164	0.136	0.230	117,420	174,184	186,480	31,335
B023	New maturity ogive based on final analyses of maturity data.	7937.38	164	0.136	0.230	117,420	174,888	186,480	31,334
B024	Increase CV on recruitment from 0.5 to 1.0.	7950.68	164	0.137	0.230	117,082	174,284	185,906	31,286
B025	Switch from selectivity-at-age to double logistic in time block 2.	7951.81	159	0.134	0.223	115,067	169,754	181,167	30,933
B027	Switch from double logistic selectivity to selectivity-at-age for NEFSC surveys.	7942.52	164	0.135	0.221	113,697	167,409	178,658	30,509
B028	Switch back to one selectivity block per fleet before including corrected data.	8014.38	155	0.126	0.191	101,276	153,752	164,139	27,028
B029	Switch NEFSC surveys to split off Bigelow: Inshore bands 1985-2008, Bigelow (Outer Inshore band) 2009-2014.	7641.45	155	0.128	0.189	99,476	149,216	159,673	26,856
B030	Switch MRIP selectivity to match starting values at-age of Rec fleet.	7649.17	154	0.113	0.194	114,851	184,961	197,207	29,543
B033	New data that corrects North Carolina scale ages from 1985-1996.	7425.96	154	0.094	0.204	142,050	243,972	258,068	34,263
B035	Switched PSIGN from double logistic selectivity to selectivity-at-age.	7427.21	156	0.091	0.205	147,082	256,007	270,667	35,152
B042	Switch MRIP selectivity from at-age to single logistic. Increased CV around recreational fleet from 0.1 to 0.15.	7464.98	151	0.124	0.178	90,014	126,802	135,011	24,583
BFINAL	Final adjustments to index input CV and ESS. Low ESS in middle block: 1997-2005.	8593.52	151	0.136	0.181	94,202	117,827	127,061	31,054

App. B7 Table B7.2. Model specifications for Model B001, the continuity run.

	Age						
Time Frame: All Years	**0**	**1**	**2**	**3**	**4**	**5**	**6+**
Natural Mortality	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Maturity	0.00	0.25	0.75	1.00	1.00	1.00	1.00
Fleet Selectivity: Fixed	0.338	1	0.942	0.476	0.343	0.694	0.914

Fleet 1		
CV	0.01	All Years
ESS	30	All Years

Recruitment Deviations		
CV	0.5	All Years
Lambda	1	--

Lambda for Catch weight	10
Lambda for Fmult Year 1	0.5
CV Fmult Year 1	0.9
Lambda Fmult Deviations	0
CV Fmult Deviations	0.9

	Lambda	**CV**
N in First Year Deviations	1	0.9
Deviation from initial Steepness	0	0.6
Deviation from initial SR Scaler	0	0.6

Indices		
	1	2 to 28
Lambda	10	5
Lambda for Catchability	0.01	0.01
CV for Catchability	0.9	0.9
Lambda for Catchability Deviations	100	100
CV for Catchability Deviations	0.9	0.9
Index Selectivities	Input at-age: Fixed	

Phases	
Fmult in year 1	2
Fmult deviations	3
Recruitment Devs	3
N in year 1	4
Catchability in year 1	1
Catchability Devs	-5
SR Scaler	2
Steepness	-4

App. B7 Table B7.3. Model specifications for Model B043, the final model.

	Age						
Time Frame: All Years	**0**	**1**	**2**	**3**	**4**	**5**	**6+**
Natural Mortality	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Maturity	0.00	0.40	0.97	1.00	1.00	1.00	1.00
Fleet 1 Selectivity: Input	0.338	-1	0.942	0.476	0.343	0.694	0.914
Fleet 2 Selectivity: Input	0.338	-1	0.942	0.476	0.343	0.694	0.914

Fleets			
	1	2	Time Block
CV	0.1	0.15	All Years
ESS	30	50	1985-1996
ESS	20	25	1997-2005
ESS	50	100	2006-2014

Recruitment Deviations		
CV	1.0	All Years
Lambda	1	--

	Lambda	CV
N year 1	0	0.9
Steepness	0	0.6
SR Scaler	0	0.6

	Fleet 1	**Fleet 2**
Lambda for Catch weight	1	1
Lambda for Fmult Year 1	0	0
CV Fmult Year 1	0.9	0.9
Lambda Fmult Deviations	0	0
CV Fmult Deviations	0.9	0.9

Phases	
Fmult in year 1	2
Fmult deviations	3
Recruitment Devs	1
N in year 1	1
Catchability in year 1	1
Catchability Devs	-5
SR Scaler	1
Steepness	-5

Indices	
	ALL
Lambda	1
Lambda for Catchability	0
CV for Catchability	0.9
Lambda for Catchability Deviations	0
CV for Catchability Deviations	0.9

App. B7 Table B7.3 continued

Input Index Selectivities (-1 = fixed full selectivity)							
Index	**Age**						
	0	**1**	**2**	**3**	**4**	**5**	**6+**
NEFSC Inshore	-1	0.25	0.1	0.1	0.1	0.05	0.05
NEFSC Bigelow	-1	0.25	0.1	0.1	0.1	0.05	0.05
MRIP	Single Logistic: A50 = 1, Slope = 0.5						
NEAMAP	-1	0.25	0.1	0.1	0.1	0.05	0.05
SEAMAP	-1						
PSIGN	0.338	-1	0.942	0.476	0.343	0.694	0.914
CT LISTS	-1	0.25	0.1	0.1	0.1	0.05	0.05
NJ OCEAN	-1	0.5	0.1				
COMPOSITE YOY	-1						

App. B7 Table B7.4. Annual SSB (mt), recruitment (000s), total abundance (000s), and F from the ASAP model updated through 2013.

Year	SSB	Recruitment	F
1985	191,476	36,743	0.246
1986	172,059	28,771	0.400
1987	147,048	18,084	0.450
1988	114,649	24,369	0.421
1989	106,535	50,212	0.344
1990	99,809	24,293	0.345
1991	87,241	29,153	0.403
1992	82,983	14,284	0.342
1993	80,624	17,023	0.325
1994	80,088	25,342	0.274
1995	77,967	17,817	0.243
1996	72,796	22,581	0.248
1997	72,173	24,542	0.290
1998	81,296	21,778	0.219
1999	85,940	33,833	0.162
2000	96,940	19,205	0.196
2001	102,797	28,505	0.220
2002	93,860	23,700	0.169
2003	96,980	36,430	0.197
2004	104,483	21,891	0.200
2005	115,988	33,629	0.200
2006	99,731	35,477	0.205
2007	97,077	27,160	0.238
2008	118,635	25,661	0.182
2009	105,828	19,474	0.162
2010	114,135	20,560	0.187
2011	114,025	19,666	0.161
2012	119,665	18,354	0.151
2013	126,473	27,184	0.150
2014	117,827	31,054	0.136
Average	**105,904**	**25,892**	**0.249**

App. B7 Table B7.5 Abundance at age (000s) for bluefish from the final SAW60 model, BFINAL.

Year	**Age**							**Total**
	0	**1**	**2**	**3**	**4**	**5**	**6+**	
1985	36,743	44,412	19,267	9,316	6,757	3,989	19,373	**139,857**
1986	28,771	27,522	28,434	12,335	6,087	4,616	17,077	**124,842**
1987	18,084	20,214	15,100	15,600	6,933	3,681	14,641	**94,254**
1988	24,369	12,483	10,552	7,882	8,380	4,044	12,101	**79,810**
1989	50,212	17,252	6,707	5,669	4,419	5,068	10,831	**100,158**
1990	24,293	36,344	10,016	3,894	3,390	2,812	10,965	**91,714**
1991	29,153	17,776	21,082	5,810	2,355	2,181	9,658	**88,014**
1992	14,284	20,937	9,727	11,536	3,340	1,455	8,104	**69,382**
1993	17,023	10,466	12,178	5,657	6,998	2,154	6,743	**61,218**
1994	25,342	12,545	6,189	7,201	3,484	4,567	6,272	**65,600**
1995	17,817	18,997	7,811	3,854	4,641	2,358	7,721	**63,199**
1996	22,581	13,488	12,194	5,014	2,551	3,208	7,383	**66,420**
1997	24,542	17,121	8,619	7,792	3,317	1,763	7,719	**70,873**
1998	21,778	18,312	10,485	5,278	4,953	2,220	6,827	**69,854**
1999	33,833	16,668	12,048	6,899	3,582	3,494	6,709	**83,232**
2000	19,205	26,421	11,608	8,391	4,929	2,633	7,740	**80,927**
2001	28,505	14,759	17,776	7,810	5,786	3,520	7,754	**85,911**
2002	23,700	21,705	9,700	11,682	5,267	4,058	8,301	**84,414**
2003	36,430	18,382	15,007	6,706	8,254	3,835	9,326	**97,940**
2004	21,891	27,898	12,354	10,085	4,604	5,871	9,797	**92,501**
2005	33,629	16,744	18,707	8,284	6,907	3,268	11,595	**99,134**
2006	35,477	25,630	11,226	12,542	5,650	4,885	11,071	**106,481**
2007	27,160	27,066	17,087	7,484	8,539	3,992	11,815	**103,142**
2008	25,661	20,428	17,469	11,028	4,933	5,876	11,543	**96,938**
2009	19,474	19,671	13,937	11,919	7,640	3,532	13,003	**89,175**
2010	20,560	15,112	13,699	9,706	8,458	5,581	12,573	**85,688**
2011	19,666	15,802	10,259	9,300	6,725	6,061	13,569	**81,382**
2012	18,354	15,237	11,016	7,152	6,592	4,907	14,856	**78,113**
2013	27,184	14,256	10,731	7,758	5,110	4,840	15,060	**84,939**
2014	31,054	21,086	10,050	7,565	5,538	3,748	15,161	**94,202**

App. B7 Table B7.6 Jan-1 Biomass at age (mt) for bluefish as estimated from the final SAW60 model: BFINAL

Year	Age							Total
	0	1	2	3	4	5	6+	
1985	1,988	16,637	19,394	17,701	21,571	16,102	129,412	**222,805**
1986	995	7,323	24,664	21,352	16,946	18,224	105,194	**194,699**
1987	637	4,736	13,274	26,463	19,571	14,256	89,313	**168,249**
1988	1,964	2,876	8,760	13,711	21,749	15,076	69,457	**133,595**
1989	2,952	5,478	6,455	10,386	12,689	18,388	62,279	**118,627**
1990	2,716	8,901	8,672	7,511	11,642	11,133	68,090	**118,665**
1991	1,359	3,576	15,706	9,140	6,646	8,864	55,627	**100,919**
1992	390	4,491	5,154	17,654	8,604	5,518	47,325	**89,136**
1993	1,428	1,878	8,780	8,825	17,371	7,713	41,197	**87,192**
1994	1,100	3,366	4,342	11,093	9,769	15,898	41,647	**87,216**
1995	1,586	4,373	5,466	5,913	12,493	9,168	45,786	**84,783**
1996	1,513	4,380	8,921	6,775	6,476	12,443	41,051	**81,559**
1997	1,087	4,321	6,854	10,991	7,372	5,797	44,230	**80,653**
1998	1,490	4,135	6,886	8,612	13,373	7,414	42,329	**84,238**
1999	2,768	4,120	8,253	10,026	11,101	13,459	42,198	**91,924**
2000	1,921	6,330	7,381	13,634	14,489	9,924	48,063	**101,742**
2001	1,890	3,780	11,268	11,901	18,702	13,688	45,906	**107,135**
2002	1,541	5,535	6,484	15,941	14,325	15,505	42,087	**101,418**
2003	1,421	4,779	11,229	9,497	18,521	12,161	45,885	**103,494**
2004	1,086	5,797	10,078	15,650	10,581	18,209	46,537	**107,938**
2005	3,366	4,081	12,566	13,995	17,917	11,184	62,611	**125,721**
2006	2,274	7,397	7,956	16,360	14,018	15,936	47,828	**111,768**
2007	2,279	6,076	11,720	8,956	16,923	12,774	50,569	**109,297**
2008	2,566	5,481	12,808	14,972	10,848	16,332	56,216	**119,223**
2009	1,860	5,038	9,362	15,433	17,070	11,507	59,551	**119,821**
2010	1,425	3,560	8,771	10,048	15,306	17,286	65,126	**121,522**
2011	1,516	3,284	5,985	9,929	9,661	19,428	72,867	**122,671**
2012	1,009	3,342	6,058	7,292	11,305	13,513	81,111	**123,630**
2013	2,466	3,136	6,528	9,513	8,827	15,114	87,347	**132,930**
2014	2,453	5,229	6,532	10,345	12,595	11,981	77,925	**127,061**

App. B7 Table B7.7 Final model objective function profiled over different estimates of natural mortality.

M	Objective Function	F40%
0.10	8610.89	0.125
0.15	8601.51	0.157
0.20	8593.52	0.181
0.21	8592.36	0.185
0.22	8591.38	0.189
0.23	8590.61	0.192
0.24	8590.04	0.196
0.25	8589.68	0.199
0.26	8589.54	0.202
0.263	8589.53	0.203
0.27	8589.60	0.205
0.28	8589.86	0.208
0.29	8590.30	0.211
0.30	8590.92	0.214
0.35	8596.06	0.228

App. B7 Table B7.8 Final model sensitivity runs at different age-based estimates of natural mortality.

MODEL	DESCRIPTION	Obj Func	#pars	2014 Estimates					
				F	F40%	TSN (000s)	SSB (mt)	TSB (mt)	Rec (000s)
B043	Final bluefish model estimates	8593.52	151	0.136	0.181	94,202	117,827	127,061	31,054
B043_M_LROT	M at age: Lorenzen scaled to Rule of Thumb (0.21)	8643.51	151	0.119	0.166	124,516	142,528	154,100	51,450
B043_M_L263	M at age: Lorenzen scaled to minimum objective function M (0.263)	8652.55	151	0.081	0.189	206,655	213,470	234,845	93,210
B043_M_LGIS	M at age: Gislason et al 2010	8840.99	151	0	0.211	5.23E+09	2.96E+07	3.46E+07	3.67E+09

(NOTE: The values presented in this Appendix B7 reflect the output from the early model presented in the draft WP document and at the peer review, before final revision. For the final SAW/SARC60 assessment results, readers should see the main body of the bluefish report.)

App. B7 Table B7.9 Sensitivity of the final model to removal of individual indices.

MODEL	DESCRIPTION	Obj Func	#pars	2014 Estimates					
				F	F40%	TSN (000s)	SSB (mt)	TSB (mt)	Rec (000s)
B043	Final bluefish model estimates	8593.52	151	0.136	0.181	94,202	117,827	127,061	31,054
B043-1	Remove NEFSC inshore survey	8109.97	144	0.136	0.181	93,737	116,829	126,008	30,948
B043-2	Remove NEFSC Bigelow survey	7740.18	144	0.135	0.181	93,234	116,929	125,605	31,175
B043-3	Remove MRIP rec CPUE	6484.00	149	0.088	0.215	177,579	300,527	321,140	49,791
B043-4	Remove NEAMAP survey	7903.23	144	0.137	0.181	95,704	116,638	126,068	33,058
B043-5	Remove SEAMAP age 0 index	8099.78	150	0.136	0.181	94,787	116,800	126,071	31,826
B043-6	Remove PSIGN survey	7800.24	144	0.138	0.180	92,534	111,302	119,983	30,988
B043-7	Remove CT LISTS survey	7448.40	144	0.131	0.181	95,626	120,743	129,982	30,559
B043-8	Remove NJ Ocean Trawl survey	7882.93	148	0.139	0.181	92,035	115,006	124,216	30,517
B043-9	Remove composite YOY index	8119.36	150	0.136	0.181	94,748	117,175	126,426	31,964
B043MRIP	All removed except MRIP rec CPUE	6323.18	111	0.132	0.18	101,459	114,326	123,152	39,596

App. B7 Table B10.1 Short-term projections for bluefish under different F scenarios.

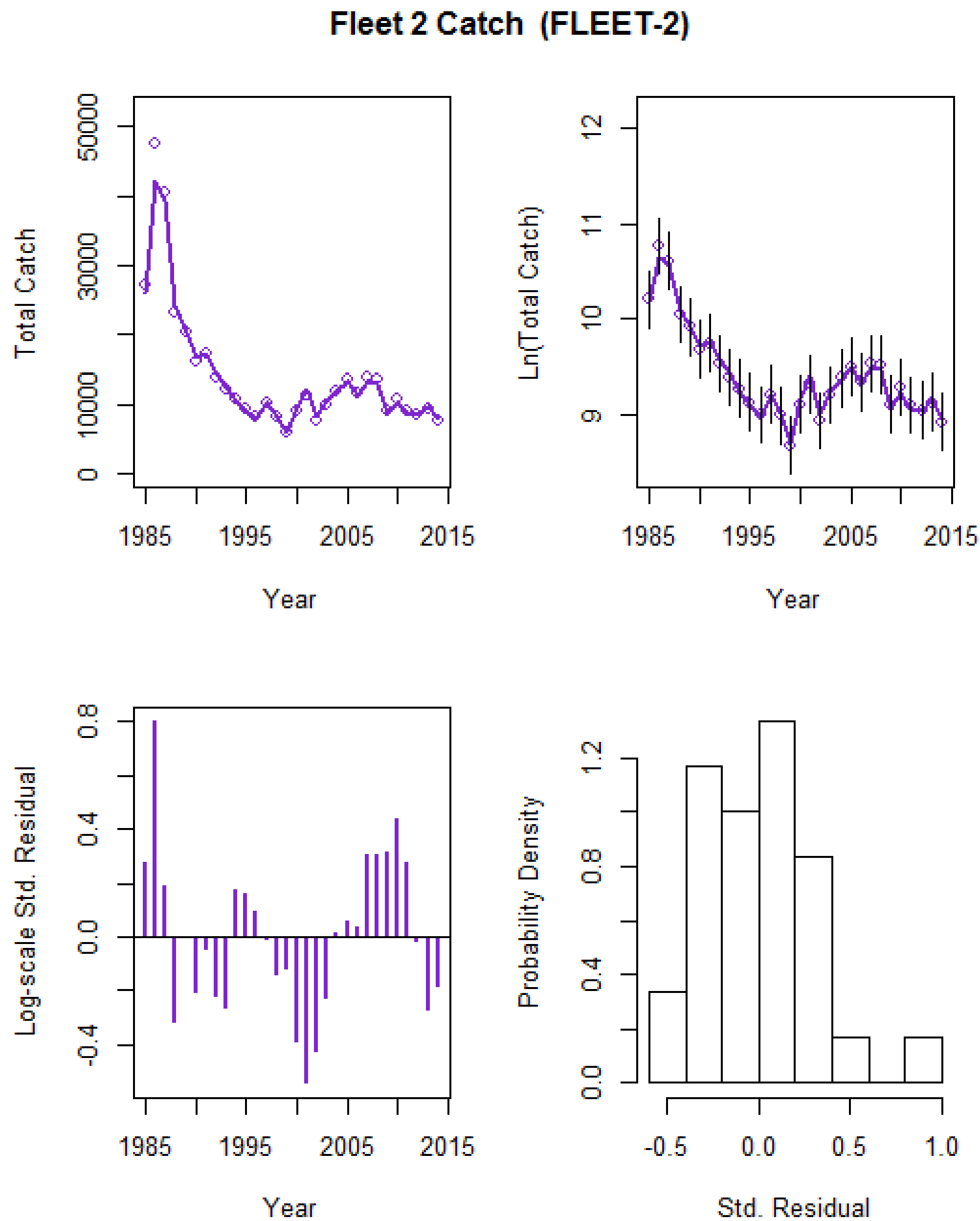
F Scenario	Landings (mt)			Total Biomass (mt)			P (2018) > Bthreshold
	2016	2017	2018	2016	2017	2018	
FMSY = 0.181	12,752	12,332	12,420	114,731	112,758	111,347	1.00
Ftarget = 0.163	11,552	11,306	11,512	114,731	114,010	113,818	1.00
F2014 = 0.136	9,725	9,691	10,031	114,731	115,922	117,645	1.00
Flow = 0.100	7,236	7,388	7,817	114,731	118,530	122,966	1.00
F0.1 = 0.203	14,200	13,531	13,452	114,731	111,240	108,405	1.00

(NOTE: The values presented in this Appendix B7 reflect the output from the early model presented in the draft WP document and at the peer review, before final revision. For the final SAW/SARC60 assessment results, readers should see the main body of the bluefish report.)

App. B7 Table B10.2. Sensitivity analysis for short-term projections for bluefish

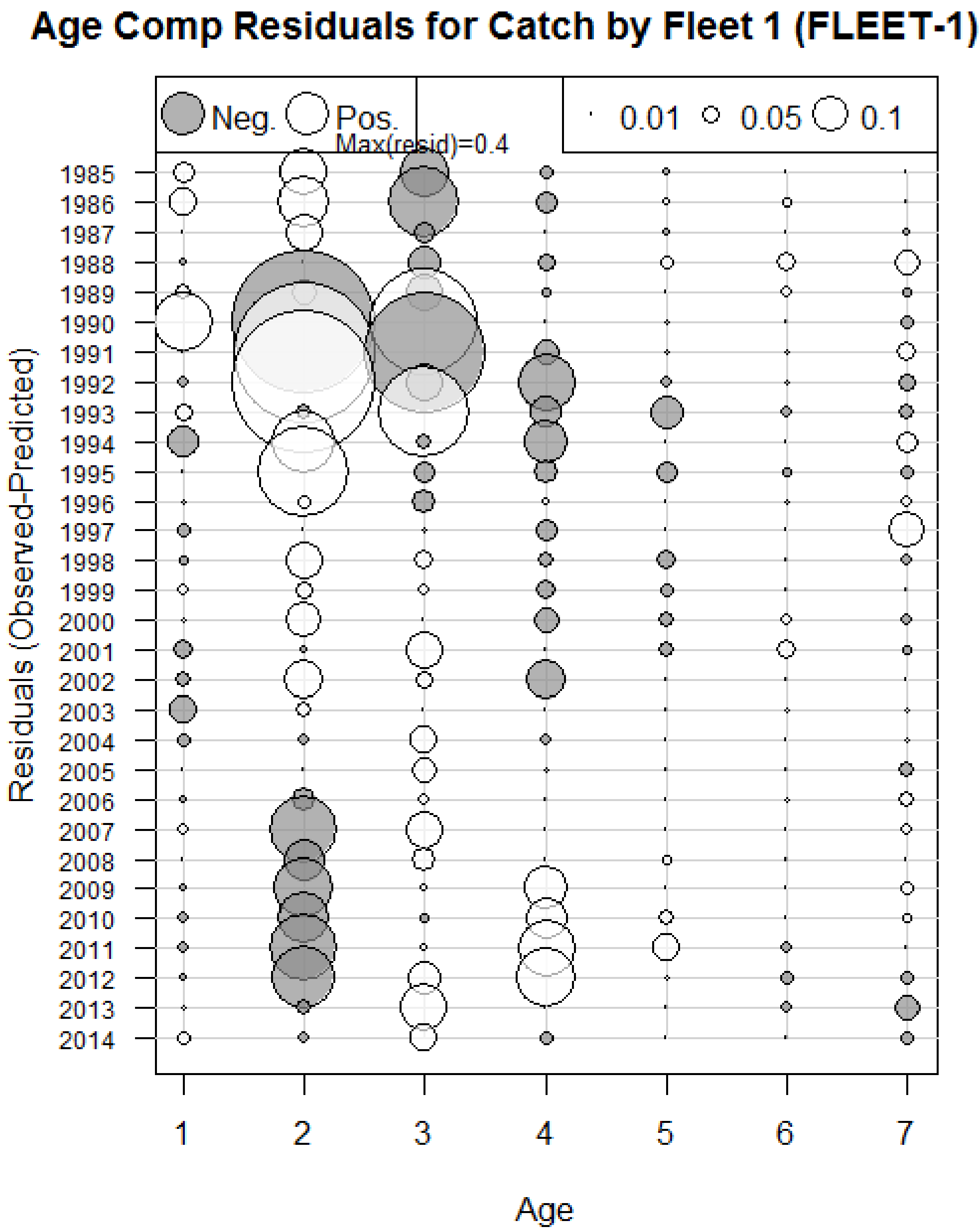
	Landings (mt)			Total Biomass (mt)		
F = Fmsy	2016	2017	2018	2016	2017	2018
Base model	12,752	12,332	12,420	114,731	112,758	111,347
Increased CVs	12,984	12,599	12,615	114,699	112,497	110,765
M=0.26	18,122	16,513	15,891	147,636	137,192	128,747
2006-2014 recruitment	12,743	12,279	12,313	114,670	112,483	110,758
High rec landings	13,285	12,902	13,038	120,611	118,971	117,867
Low rec landings	11,500	11,104	11,271	108,055	106,100	104,870
Continuity model	12,641	12,055	11,641	90,271	86,258	84,003
F = F 2014	2016	2017	2018	2016	2017	2018
Base model	9,725	9,691	10,031	114,731	115,922	117,645
Increased CVs	9,904	9,905	10,198	114,699	115,712	117,161
M=0.26	9,187	8,969	9,166	147,636	146,276	146,042
2006-2014 recruitment	9,717	9,651	9,944	114,670	115,645	117,029
High rec landings	10,668	10,624	10,980	120,611	121,710	123,335
Low rec landings	7,899	7,927	8,333	108,055	109,868	112,427
Continuity model	10,006	9,846	9,747	90,271	88,955	89,055

(NOTE: The values presented in this Appendix B7 reflect the output from the early model presented in the draft WP document and at the peer review, before final revision. For the final SAW/SARC60 assessment results, readers should see the main body of the bluefish report.)

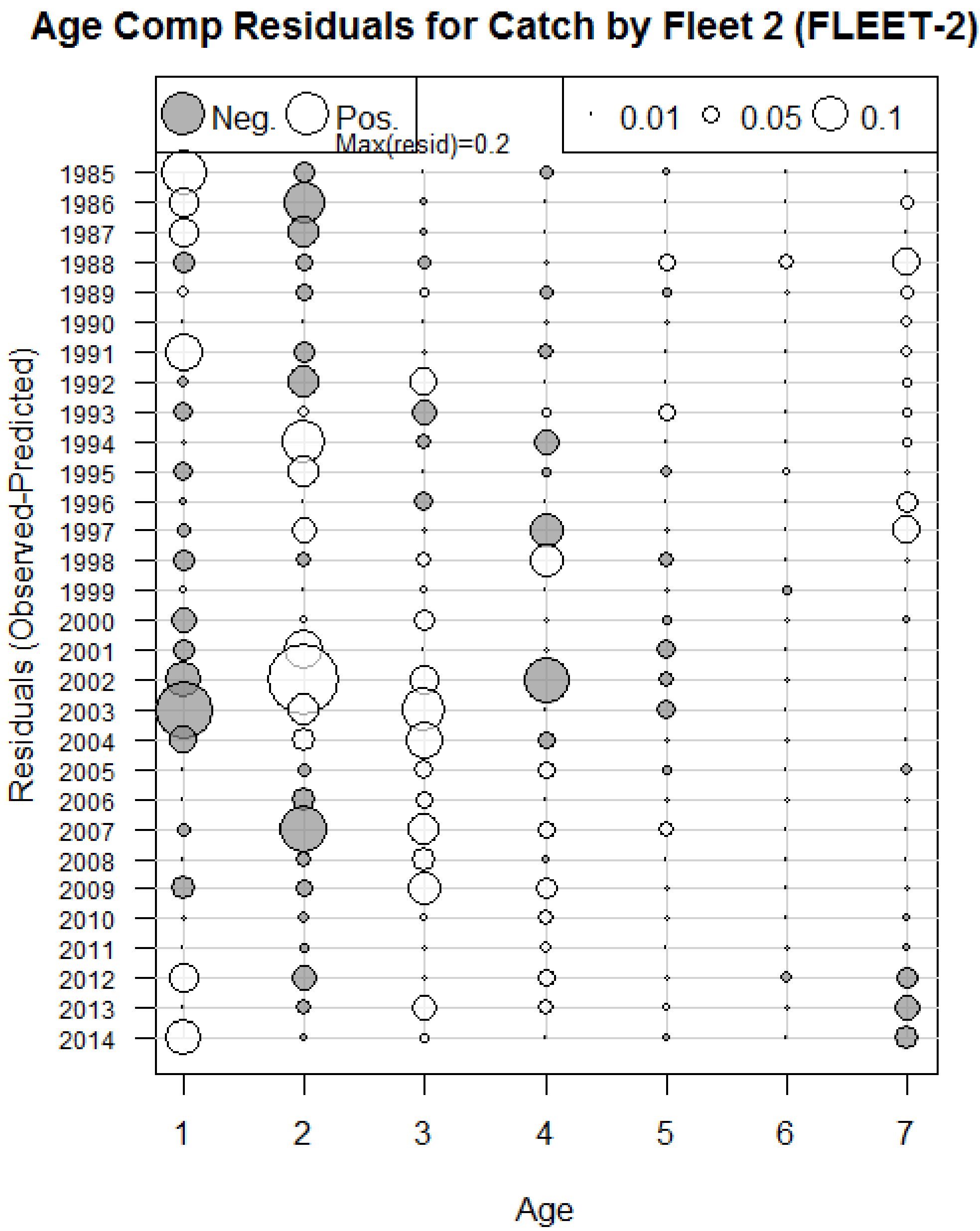


App. B7 App. B7 Figure B7.45. Final model fit to the recreational catch fleet with log-scale standardized residuals and residual probability density.

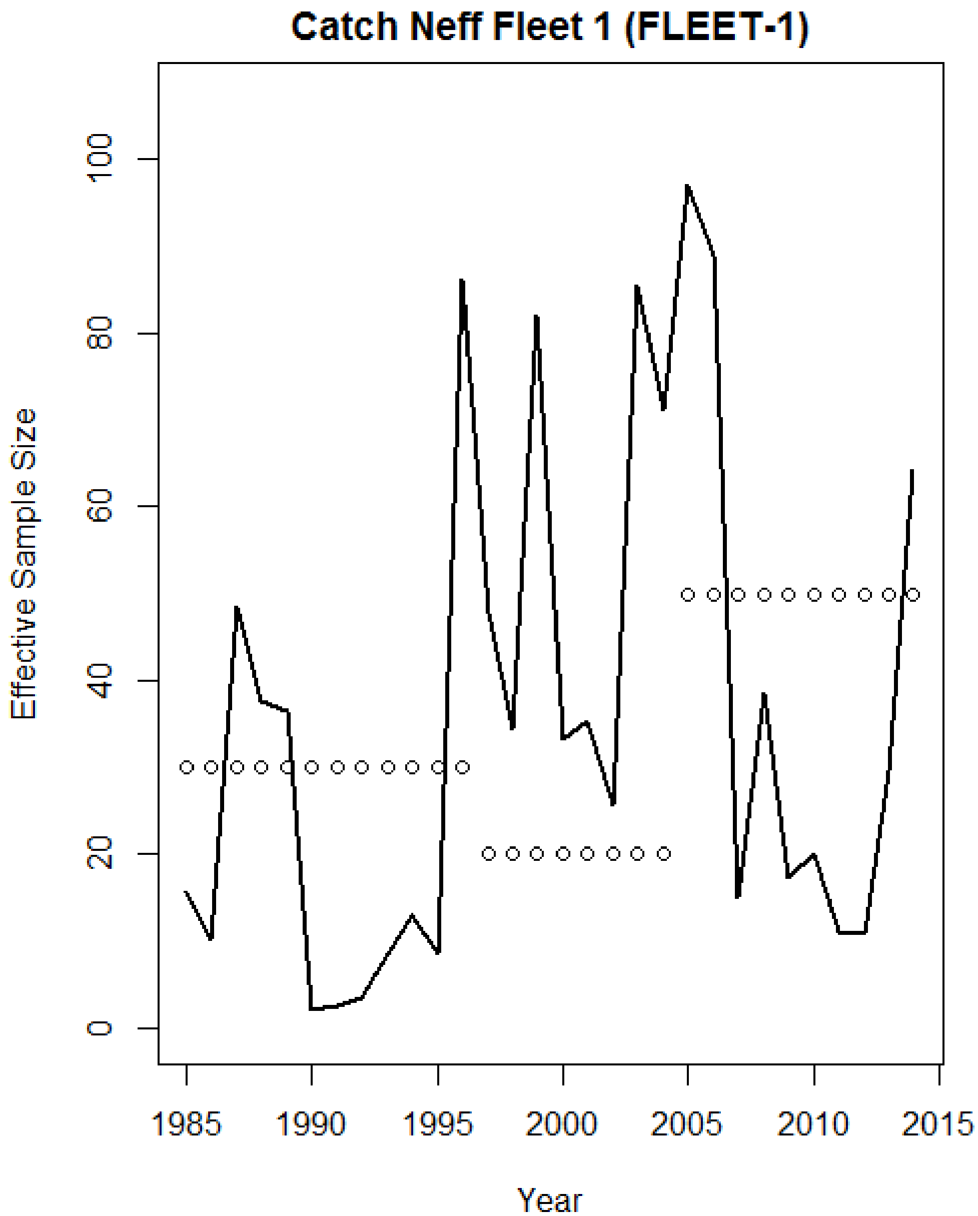
(NOTE: The values presented in this Appendix B7 reflect the output from the early model presented in the draft WP document and at the peer review, before final revision. For the final SAW/SARC60 assessment results, readers should see the main body of the bluefish report.)



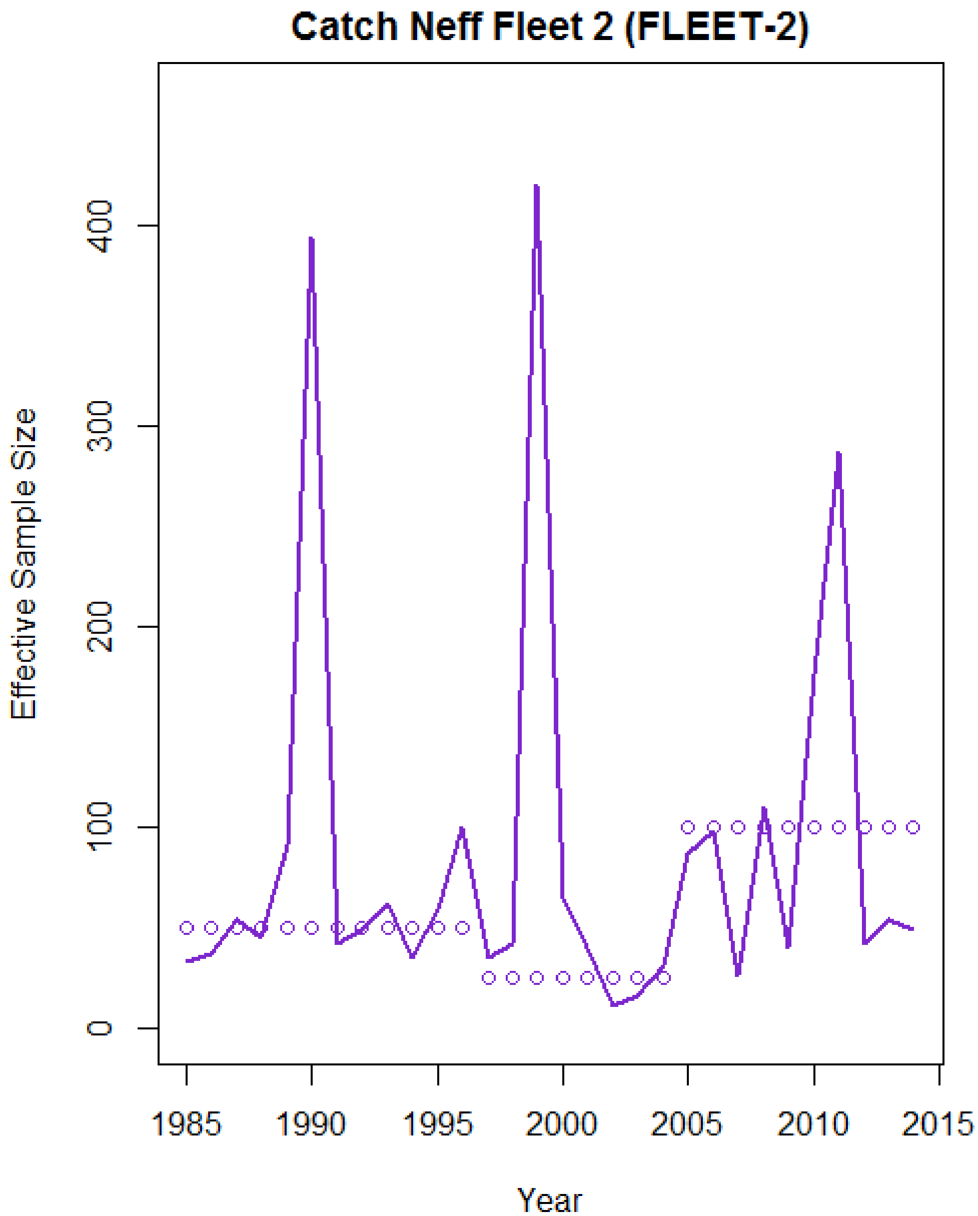
App. B7 Figure B7.46. Age-composition residuals for the commercial catch fleet.



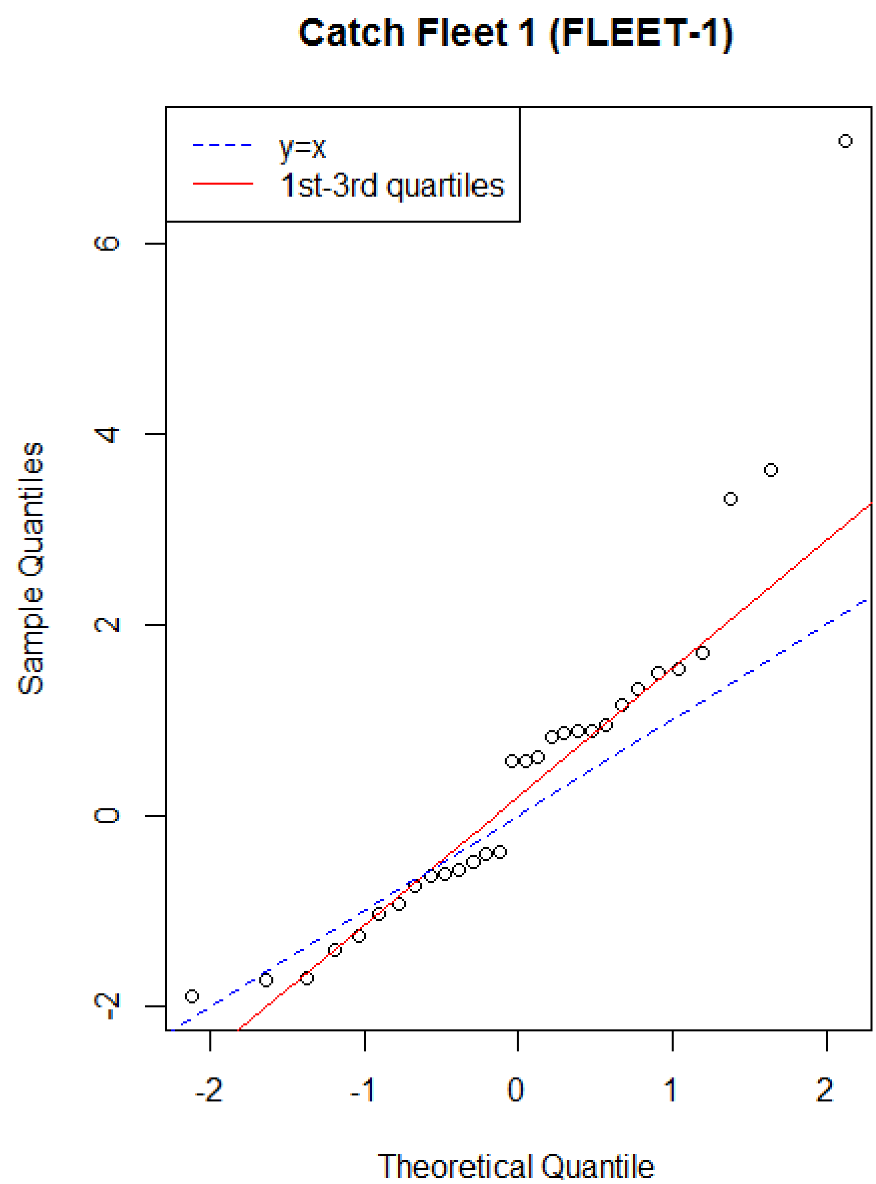
App. B7 Figure B7.47. Age composition residuals for the recreational catch fleet.



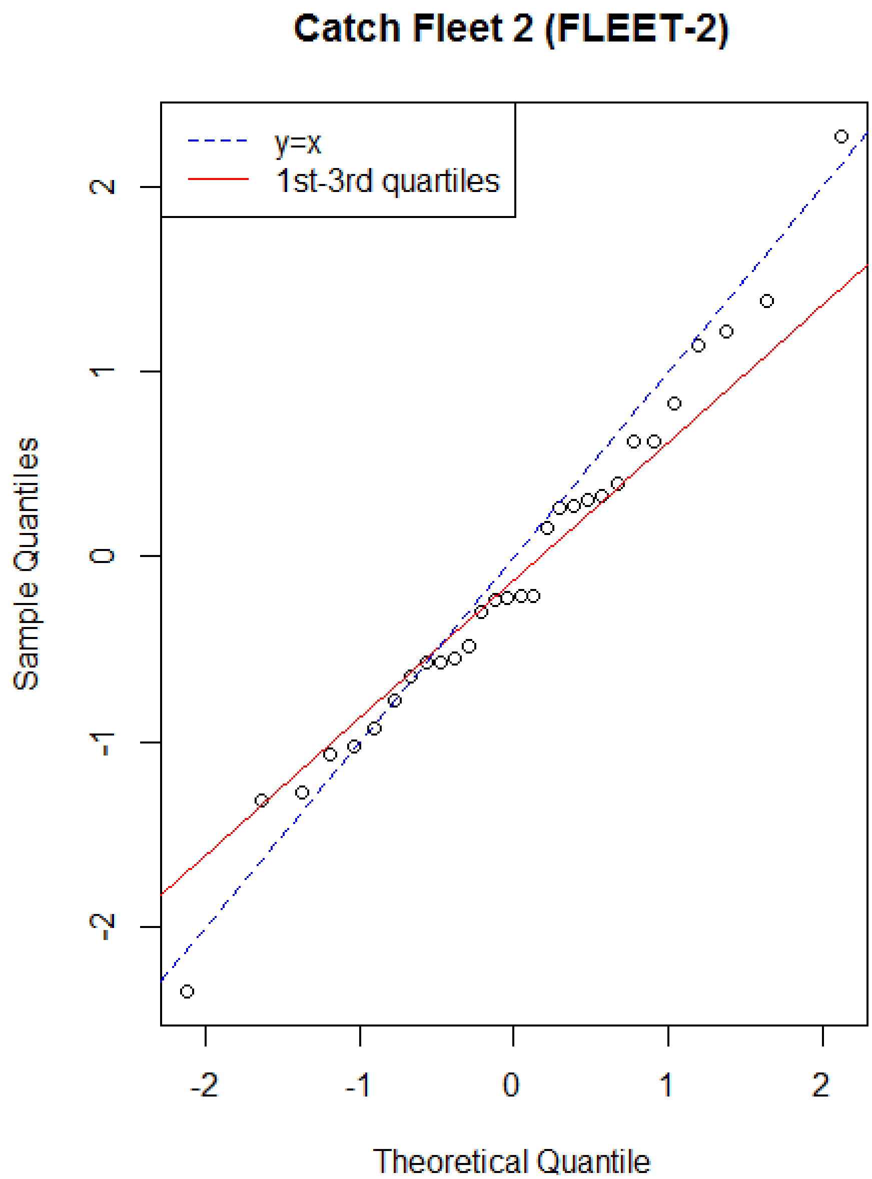
App. B7 Figure B7.48. Input and estimated effective sample size for the commercial catch fleet.



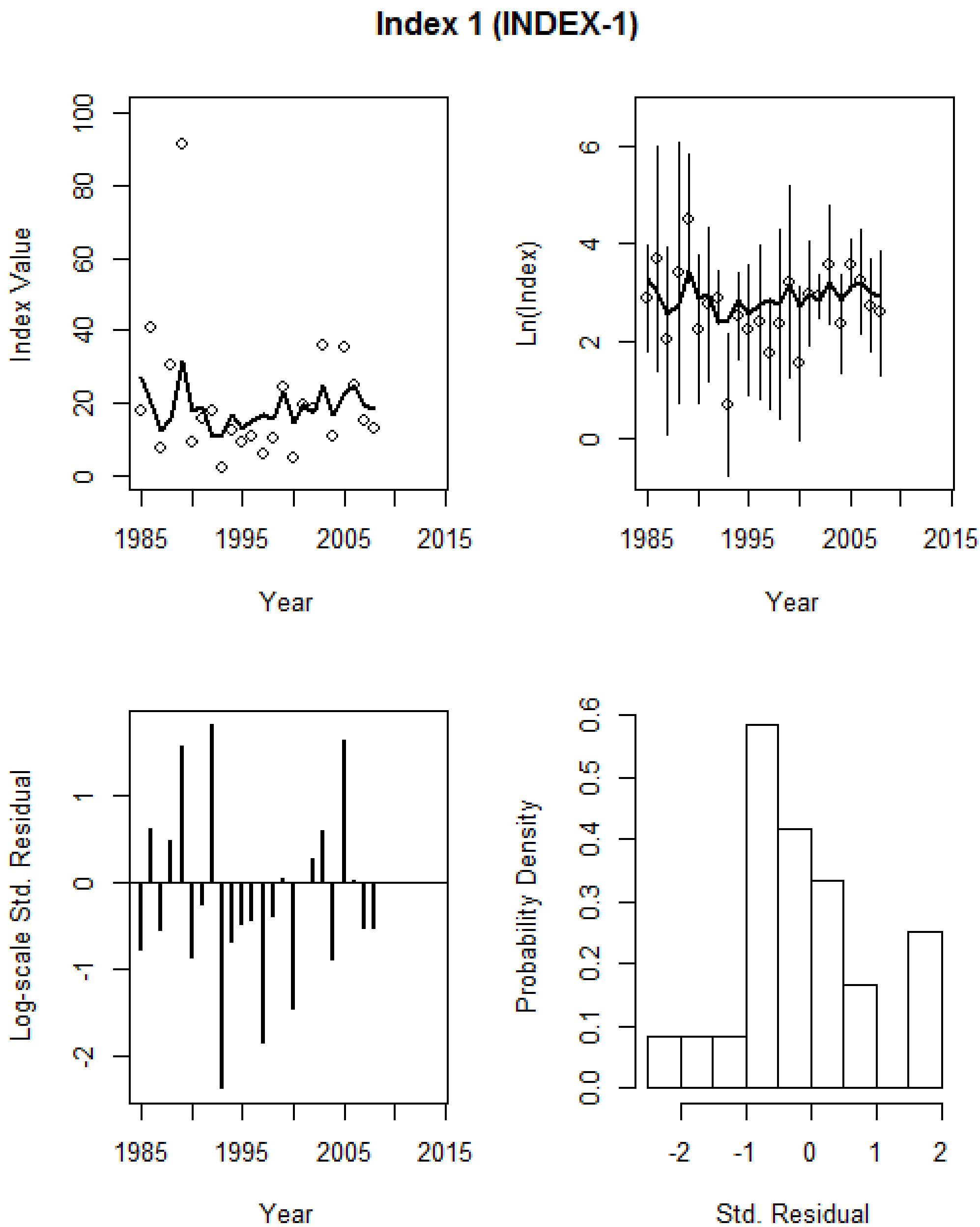
App. B7 Figure B7.49. Input and estimated effective sample size for the recreational catch fleet.



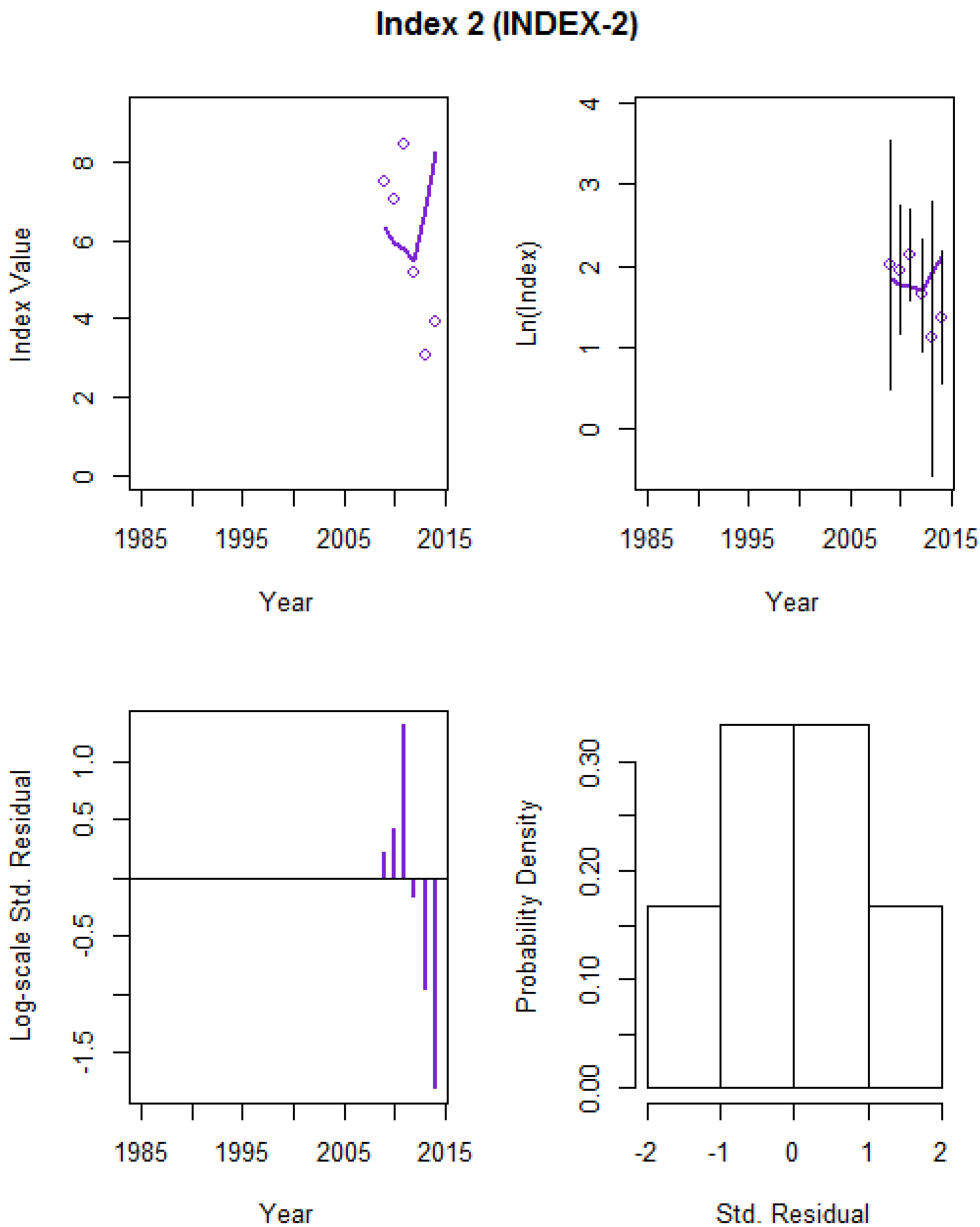
App. B7 Figure B7.50. QQ-plot for the observed versus predicted mean catch for the commercial catch fleet.



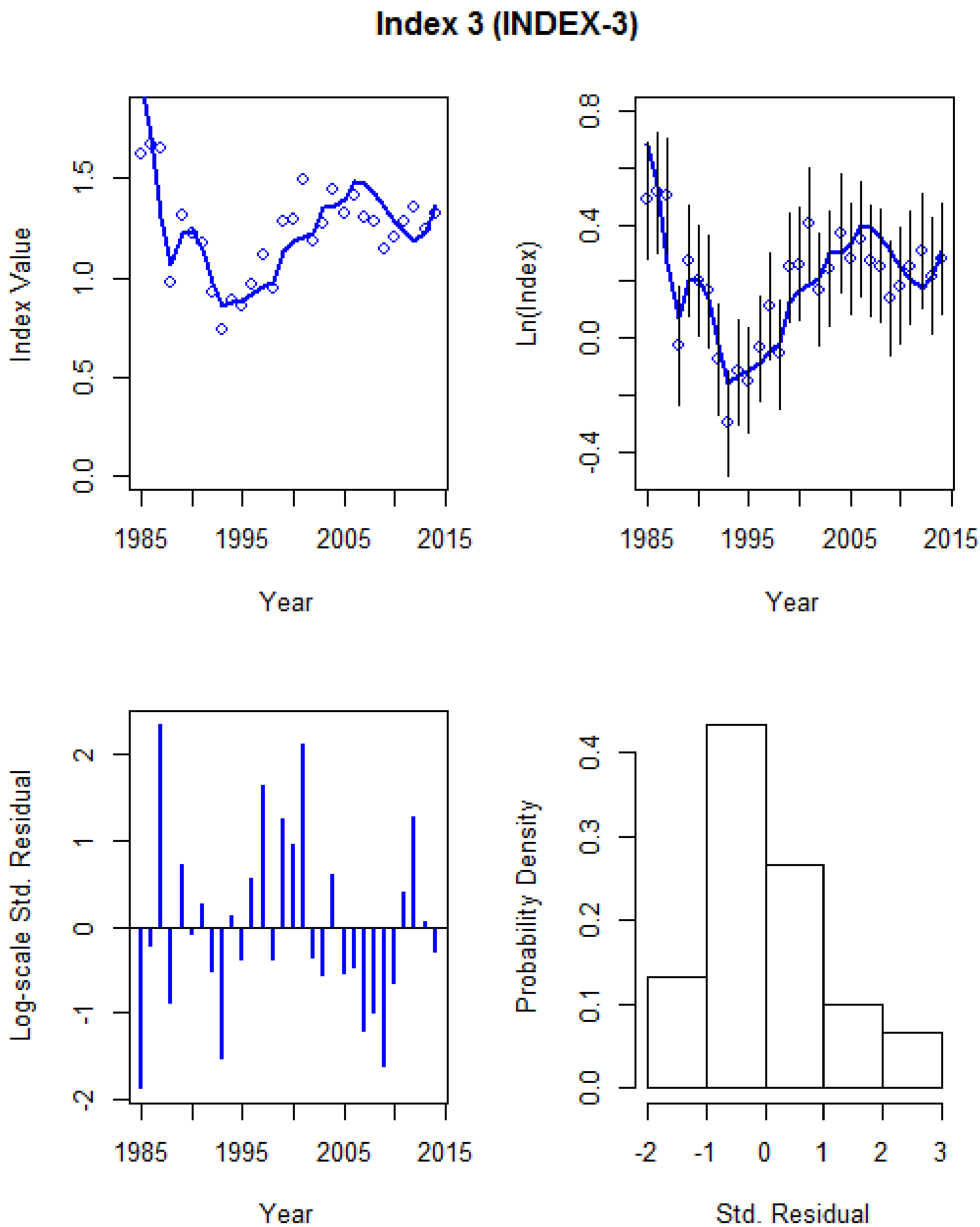
App. B7 Figure B7.51. QQ-plot for the observed versus predicted mean catch for the recreational catch fleet.



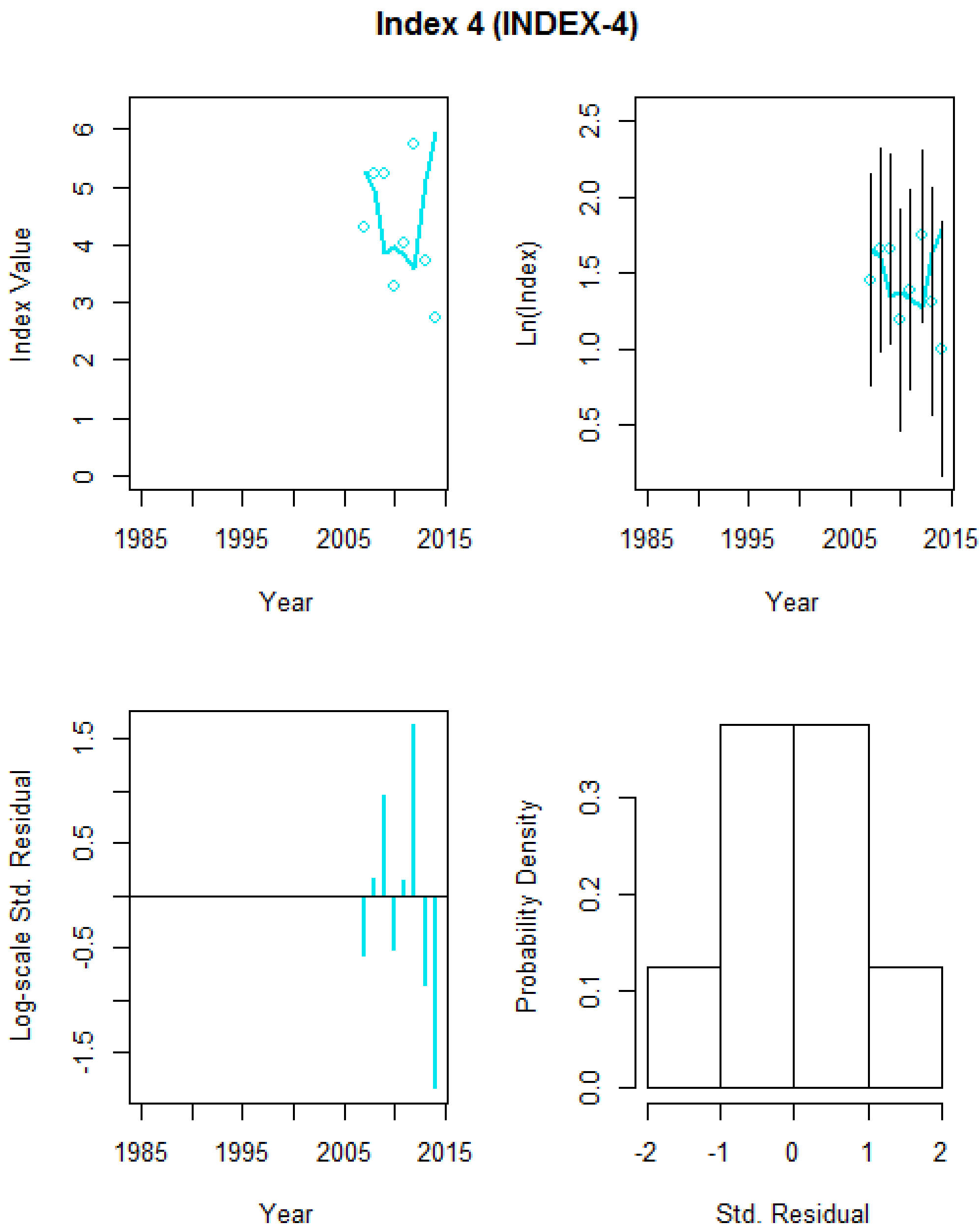
App. B7 Figure B7.52. Final model fit to the NEFSC Inshore survey with log-scale standardized residuals and residual probability density.



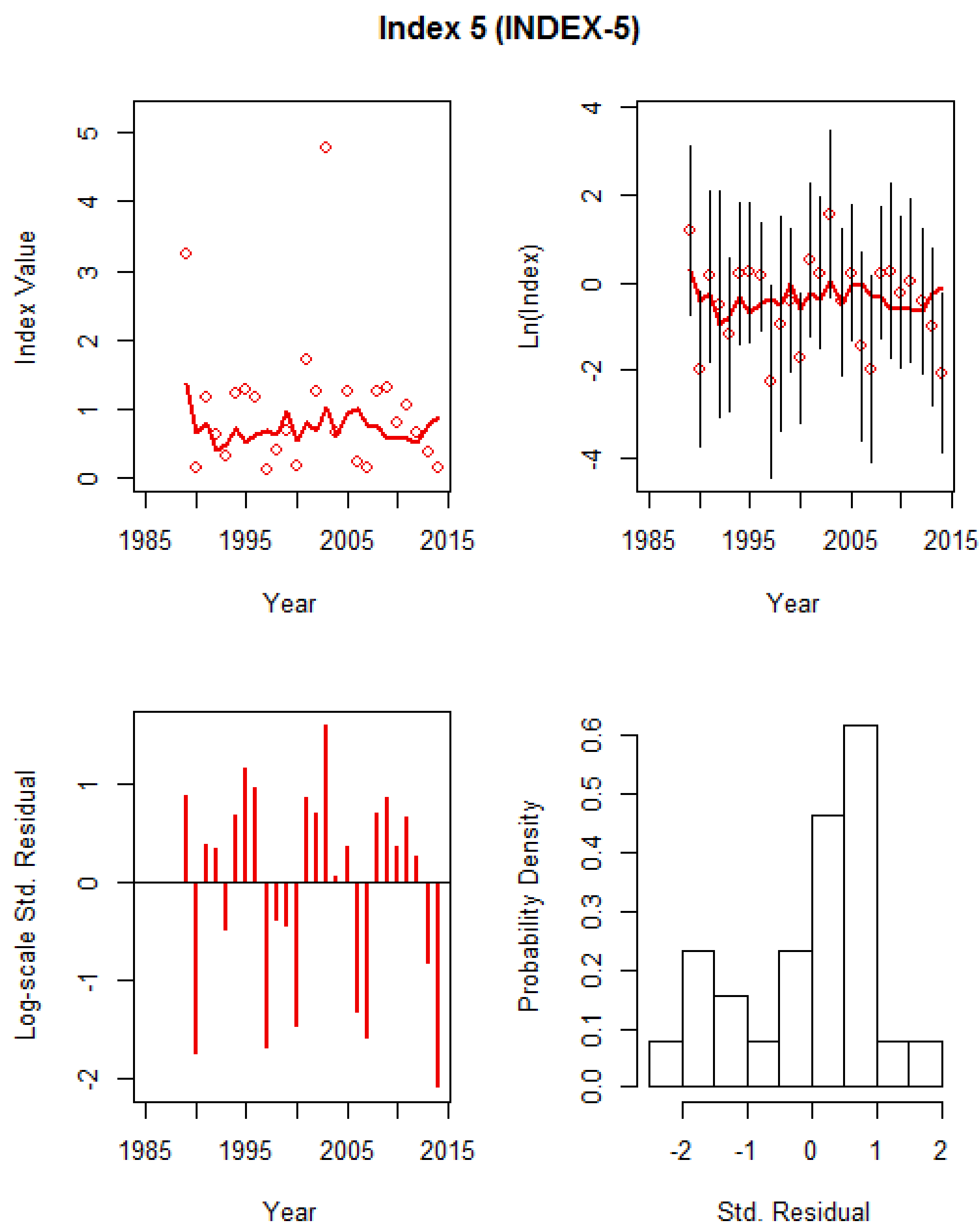
App. B7 Figure B7.53. Final model fit to the NEFSC Bigelow survey with log-scale standardized residuals and residual probability density.



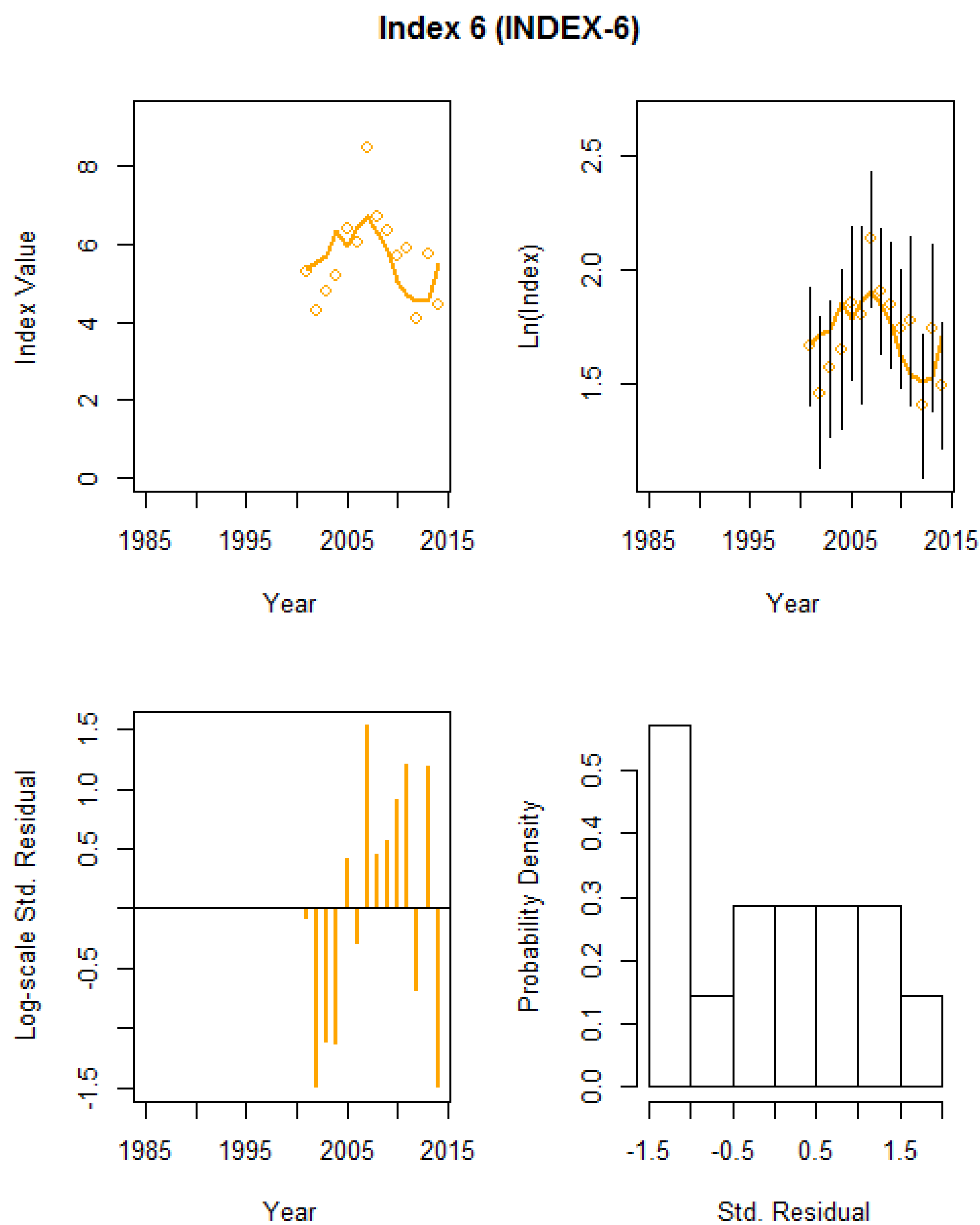
App. B7 Figure B7.54. Final model fit to the MRIP recreational CPUE index with log-scale standardized residuals and residual probability density.



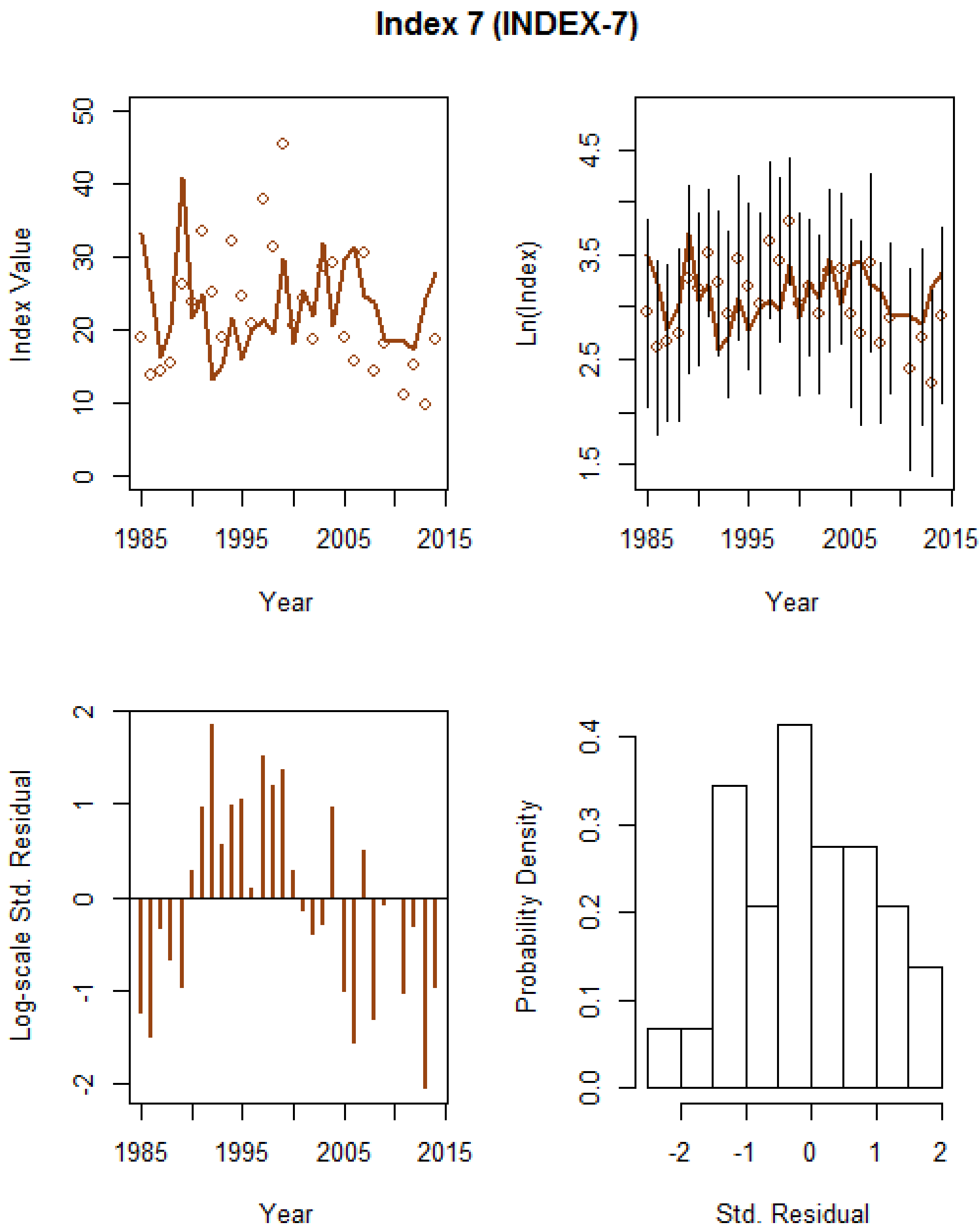
App. B7 Figure B7.55. Final model fit to the NEAMAP survey with log-scale standardized residuals and residual probability density.



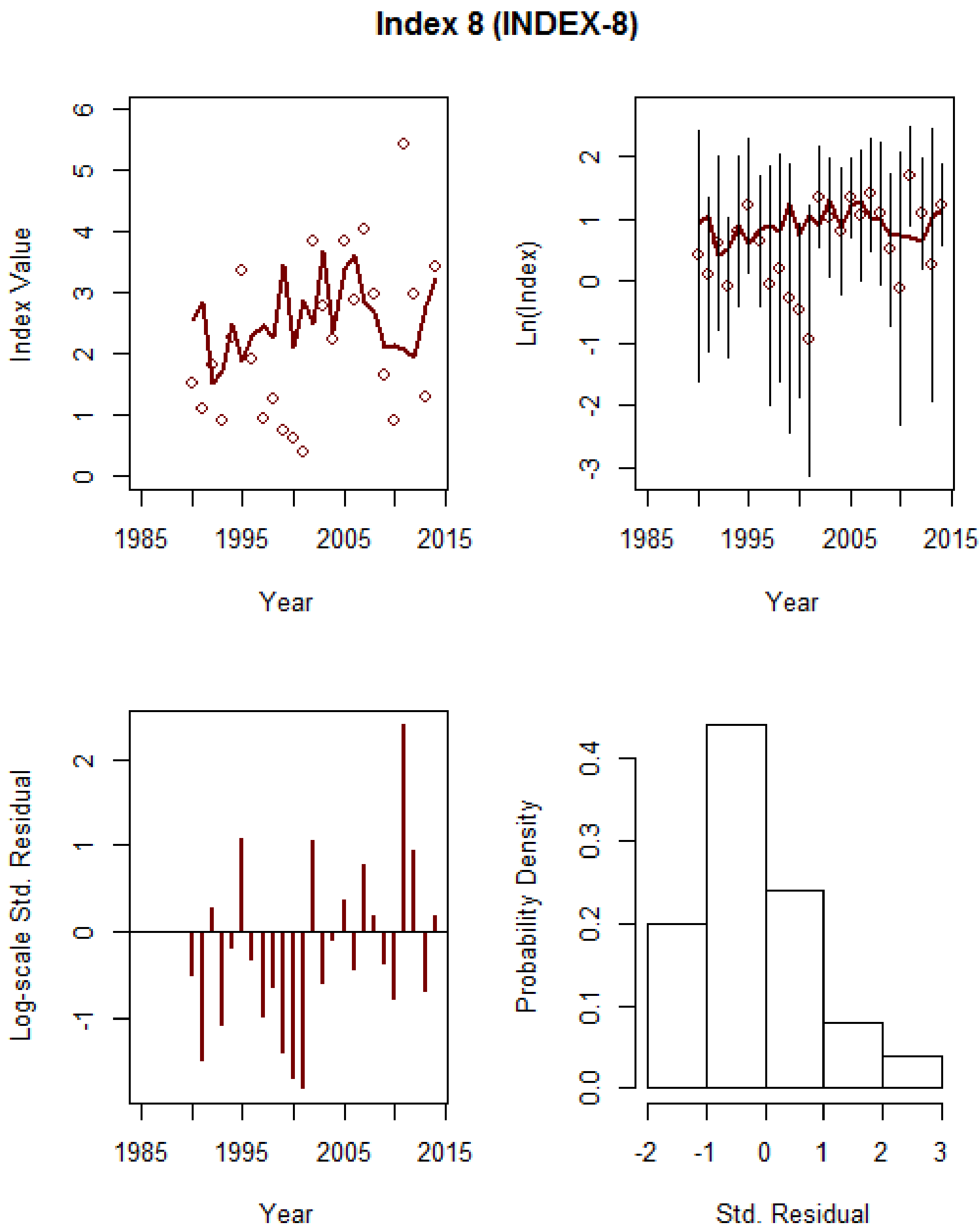
App. B7 Figure B7.56. Final model fit to the SEAMAP Age 0 index with log-scale standardized residuals and residual probability density.



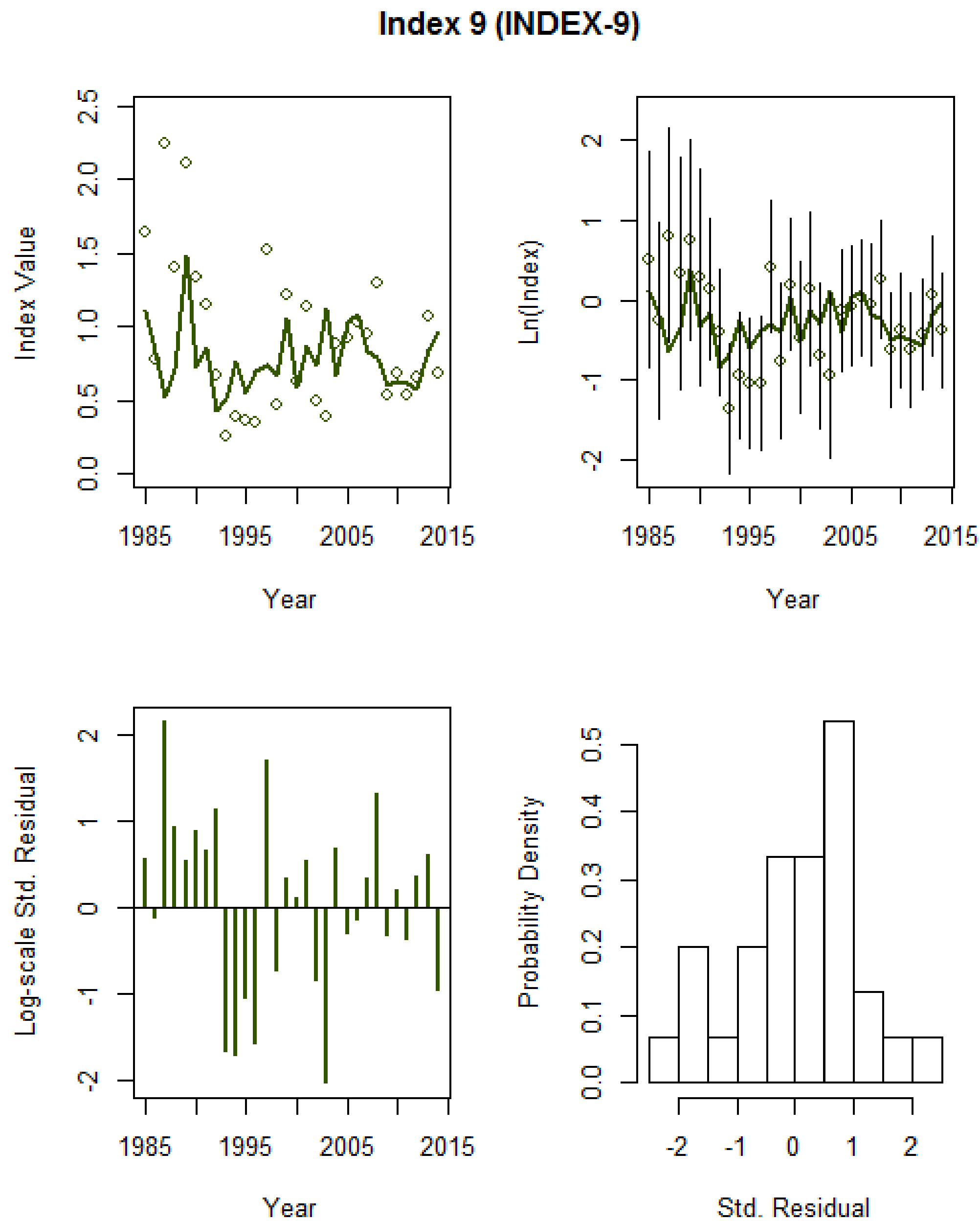
App. B7 Figure B7.57. Final model fit to the PSIGNS gillnet survey with log-scale standardized residuals and residual probability density.



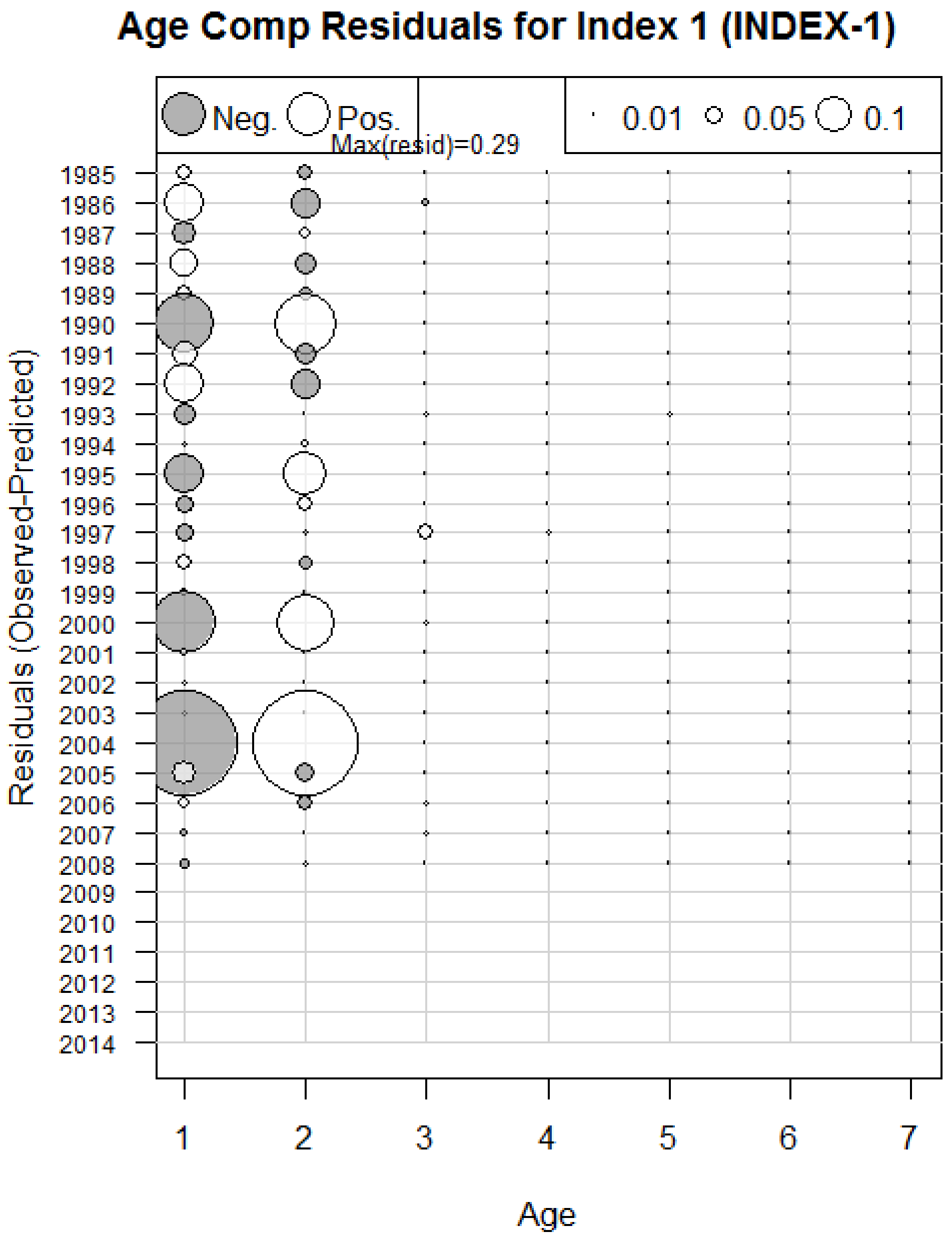
App. B7 Figure B7.58. Final model fit to the CT LISTS trawl survey with log-scale standardized residuals and residual probability density.



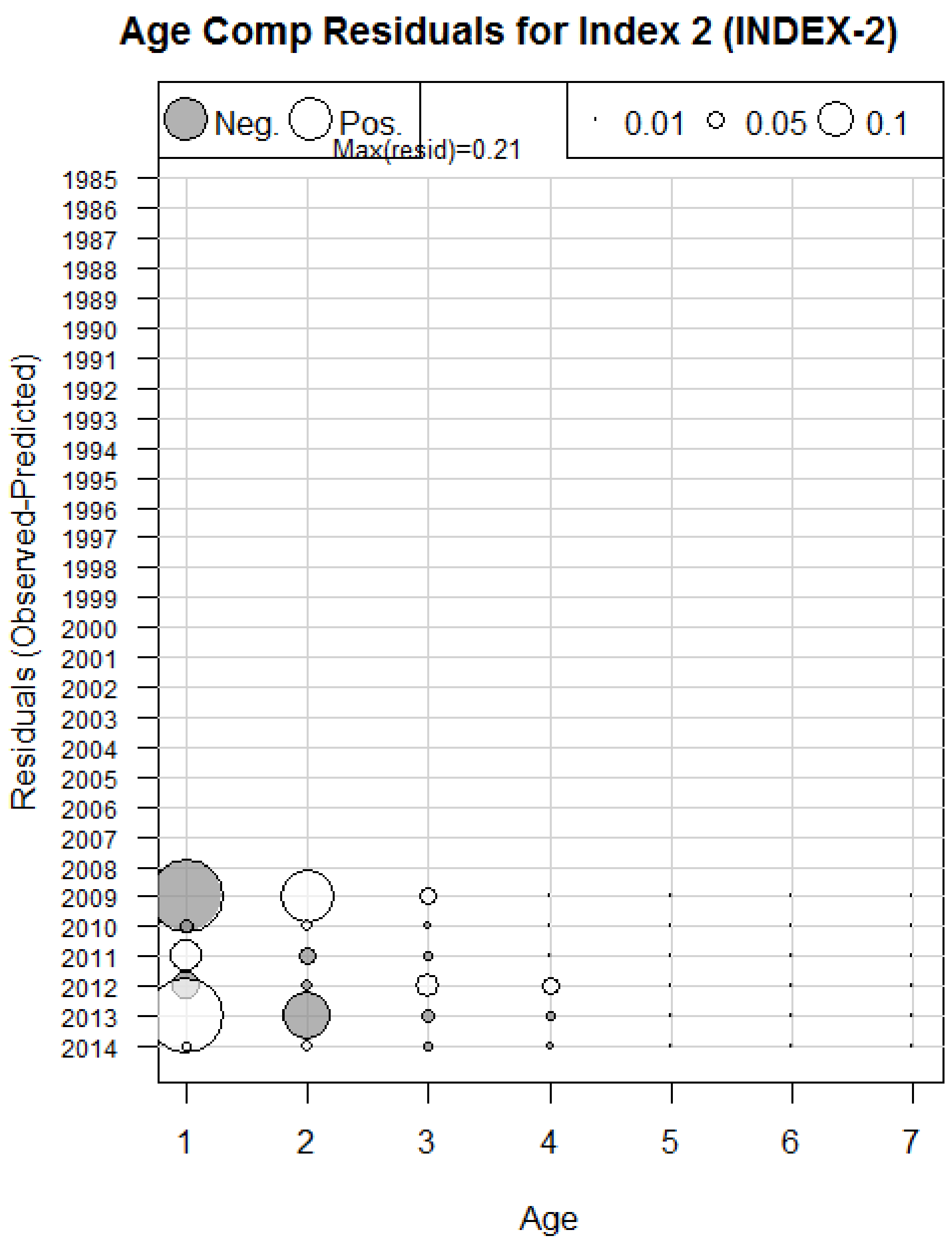
App. B7 Figure B7.59. Final model fit to the NJ ocean trawl survey with log-scale standardized residuals and residual probability density.



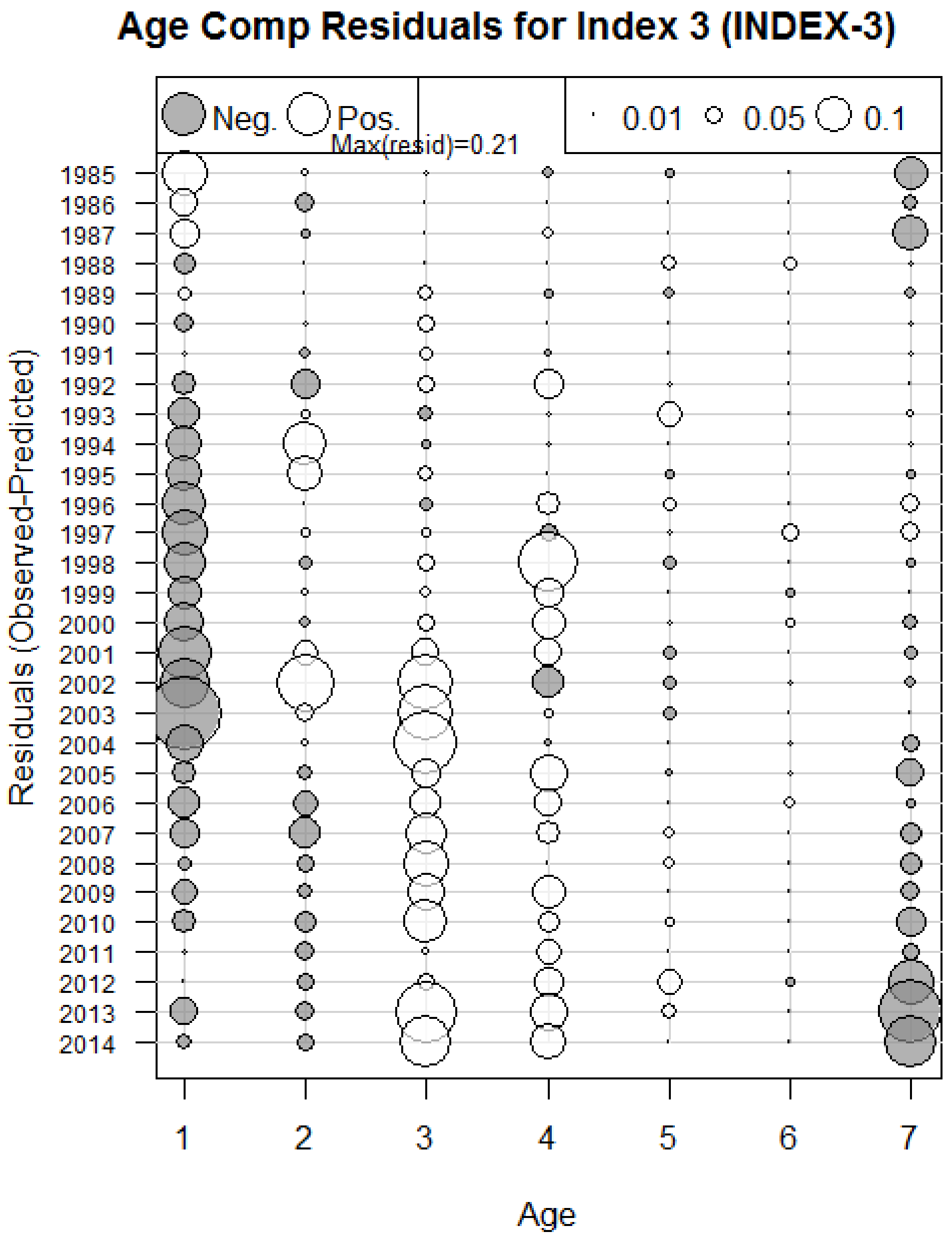
App. B7 Figure B7.60. Final model fit to the composite YOY seine survey with log-scale standardized residuals and residual probability density.



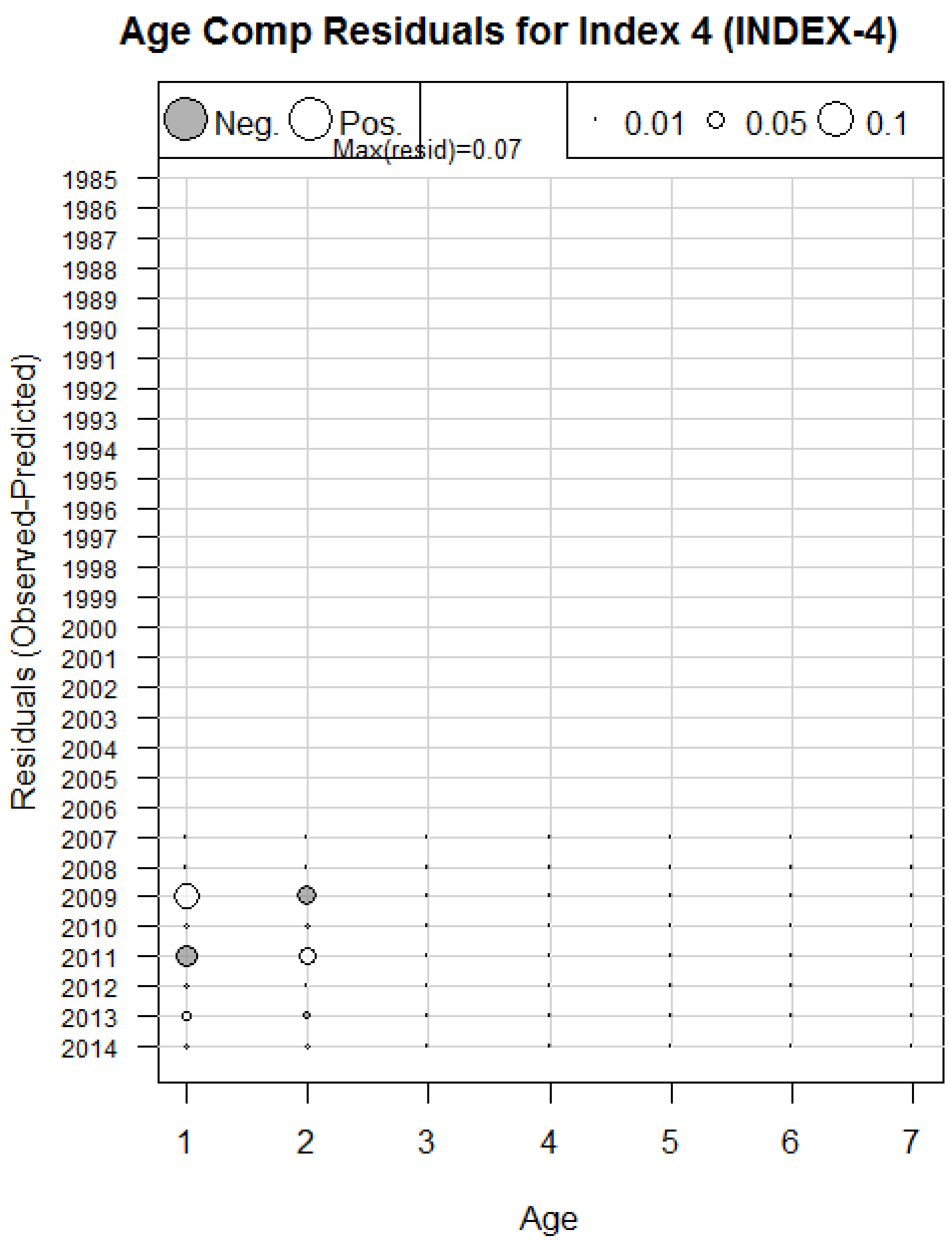
App. B7 Figure B7.61. Age composition residuals for the NEFSC Inshore survey.



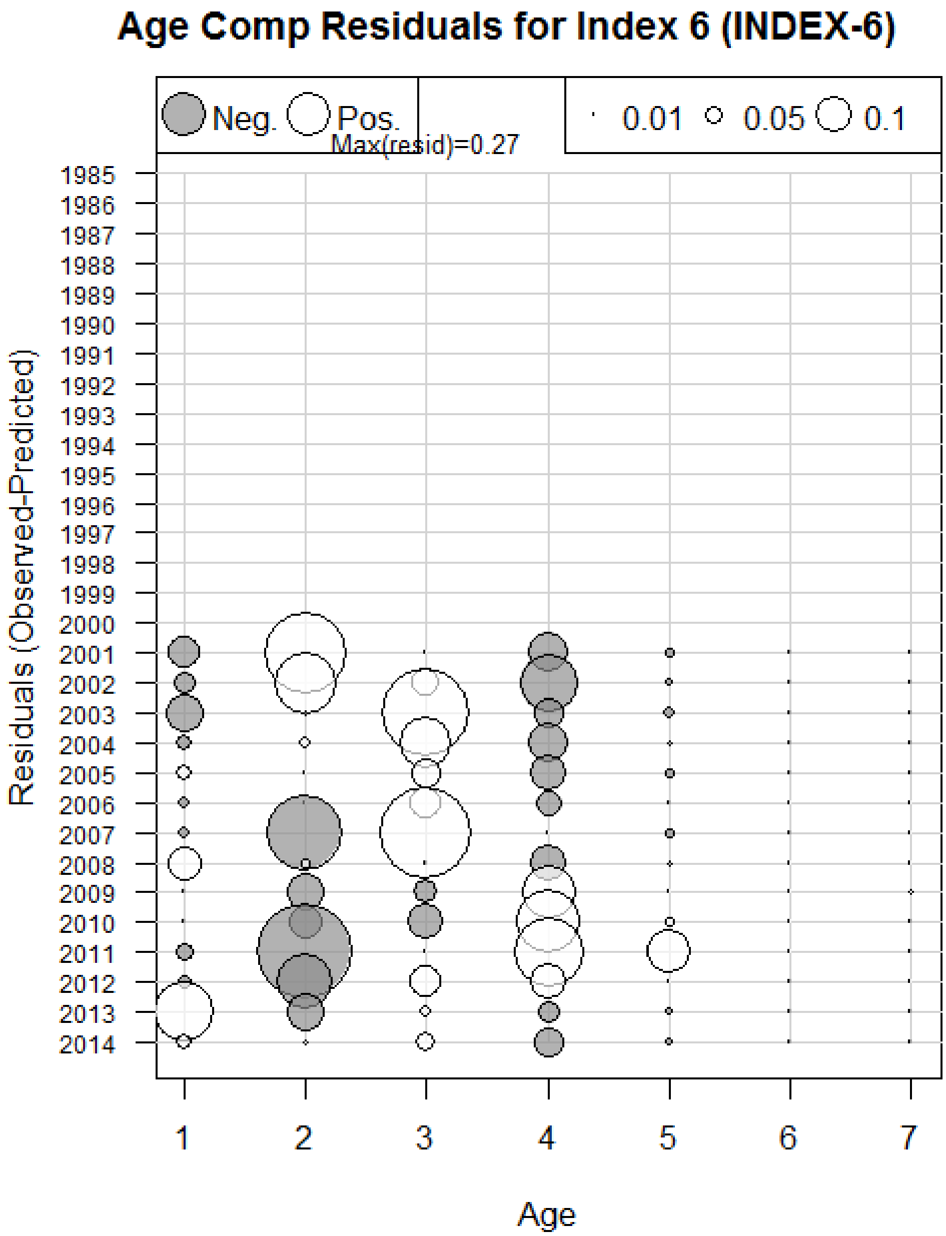
App. B7 Figure B7.62. Age composition residuals for the NEFSC Bigelow survey.



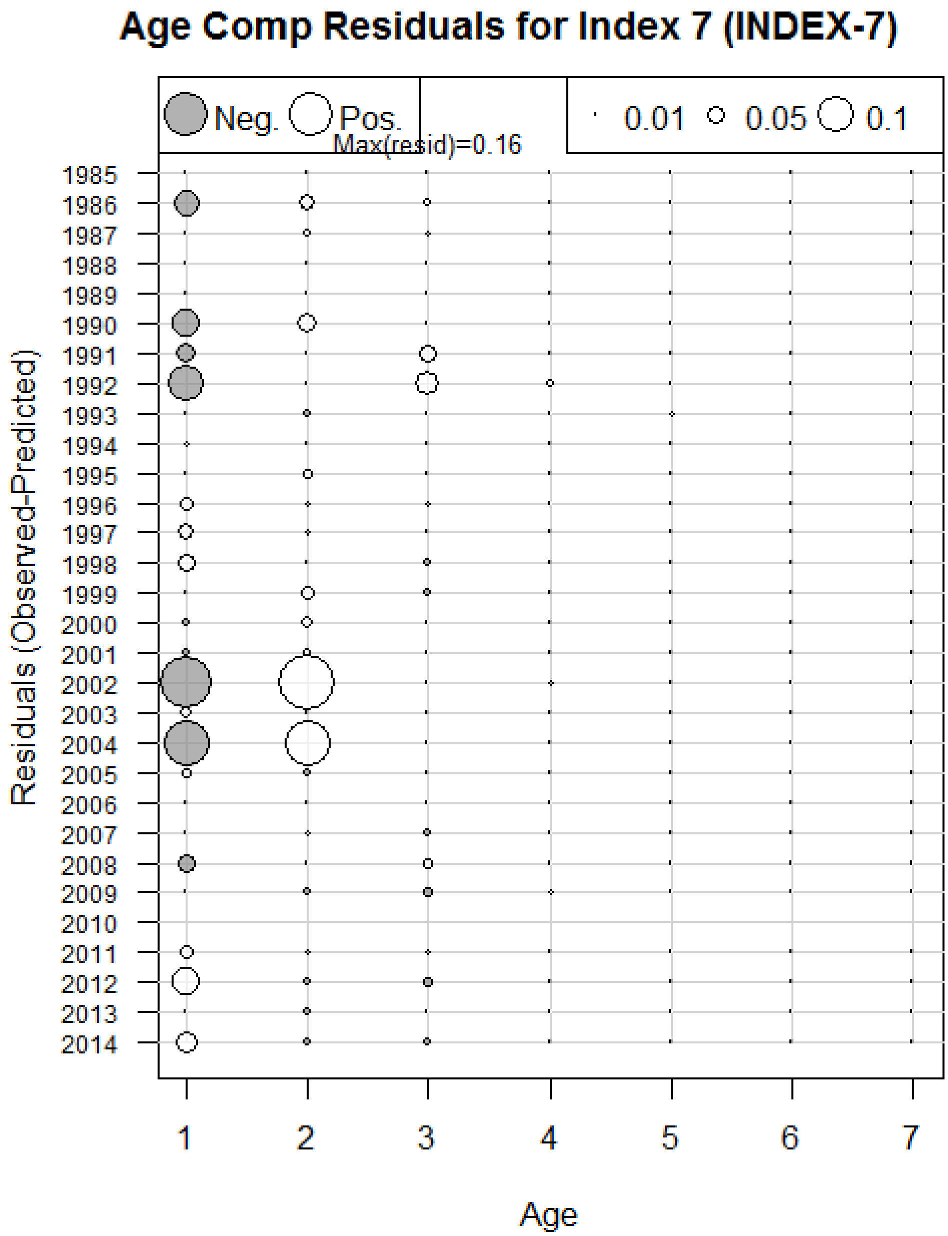
App. B7 Figure B7.63. Age composition residuals for the MRIP recreational CPUE index.



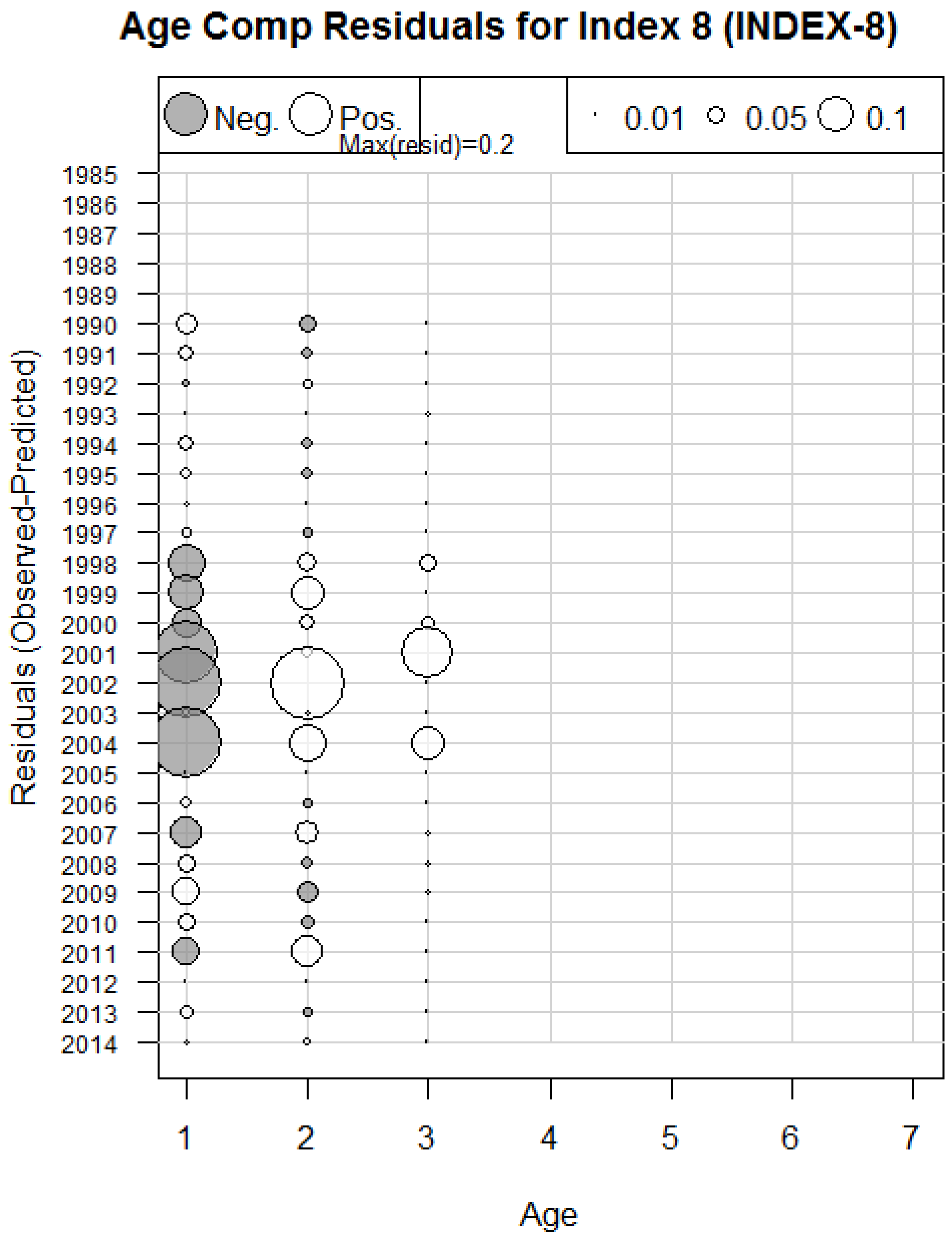
App. B7 Figure B7.64. Age composition residuals for the NEAMAP survey.



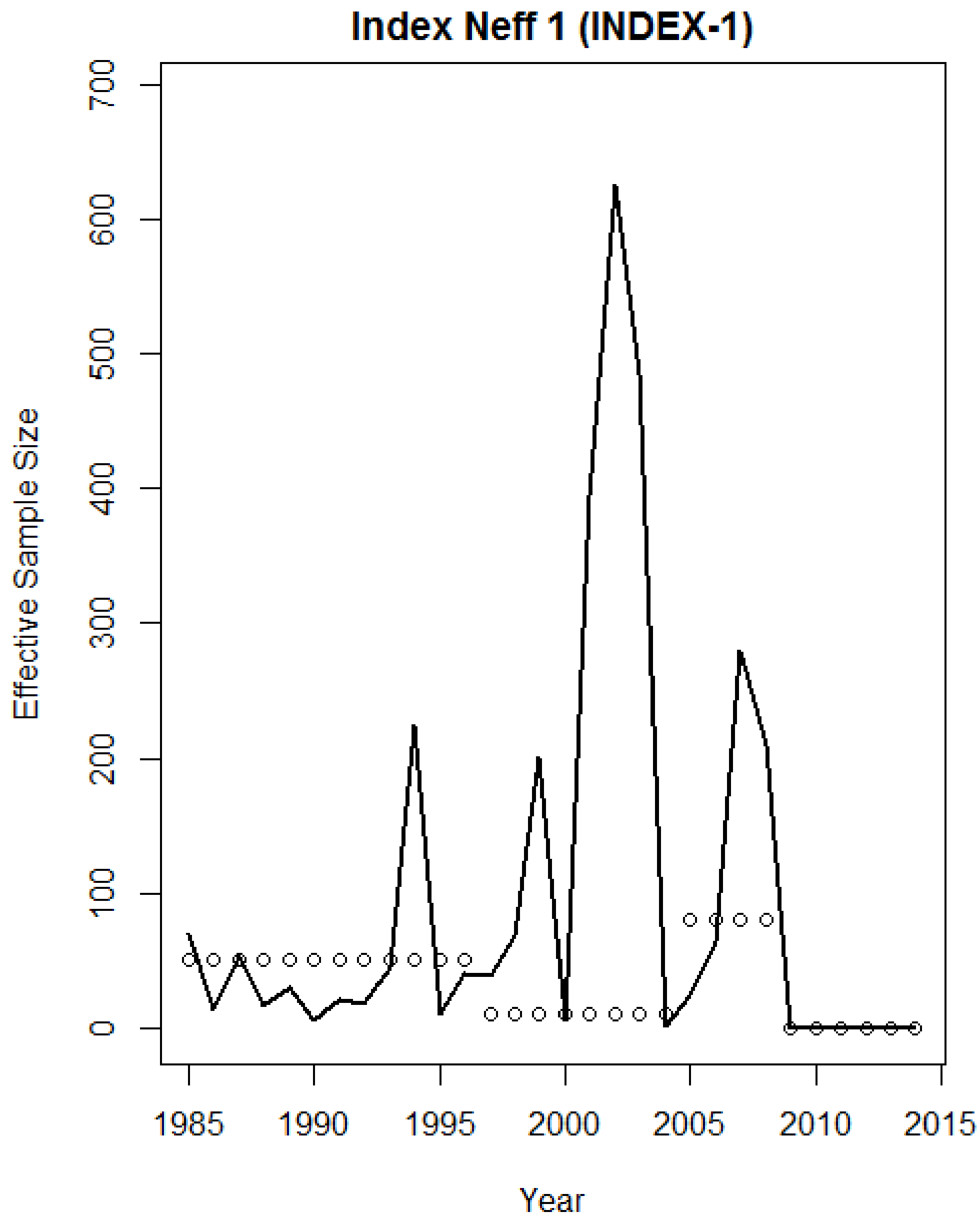
App. B7 Figure B7.65. Age composition residuals for the PSIGNS gillnet survey.



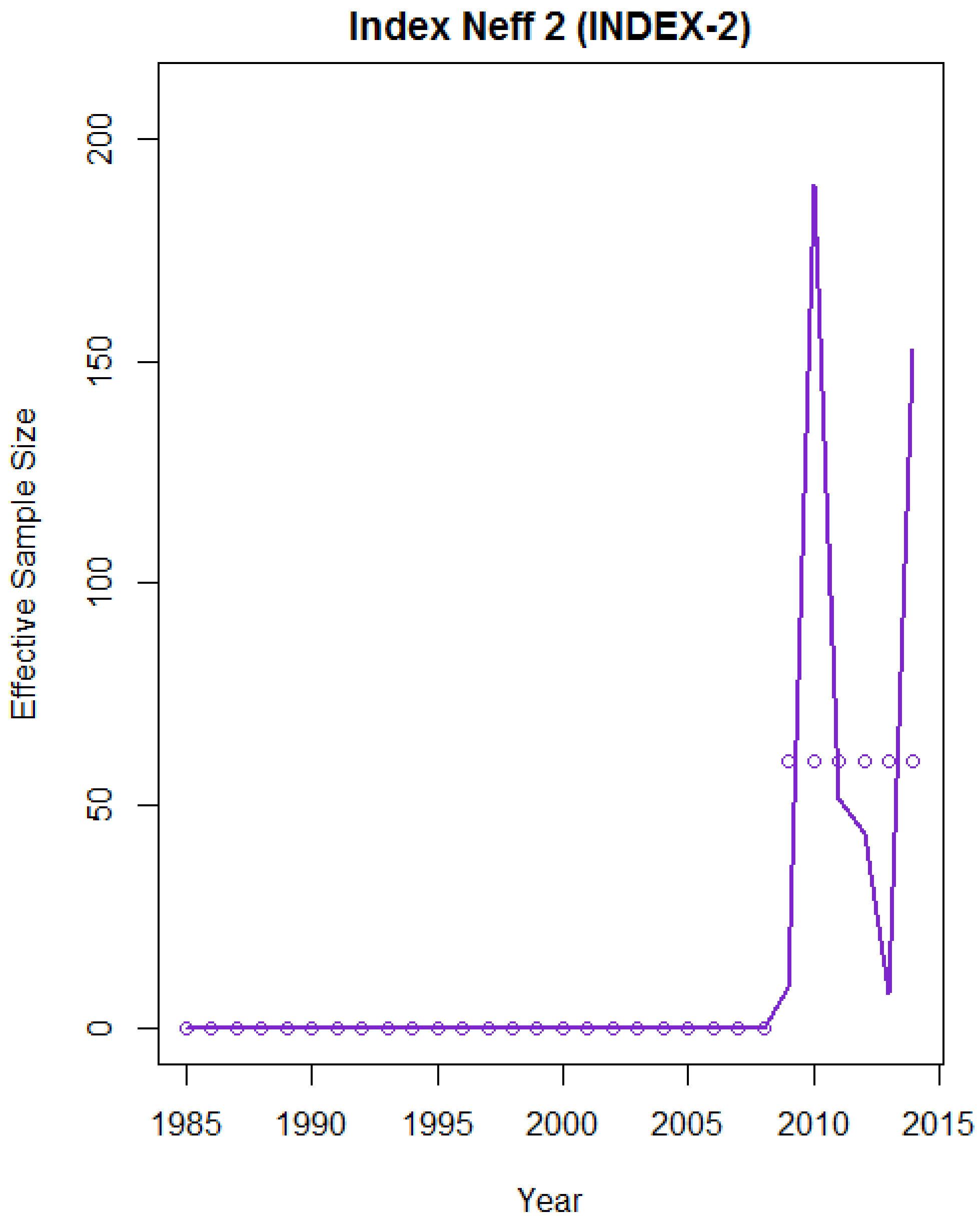
App. B7 Figure B7.66. Age composition residuals for the CT LISTS trawl survey.



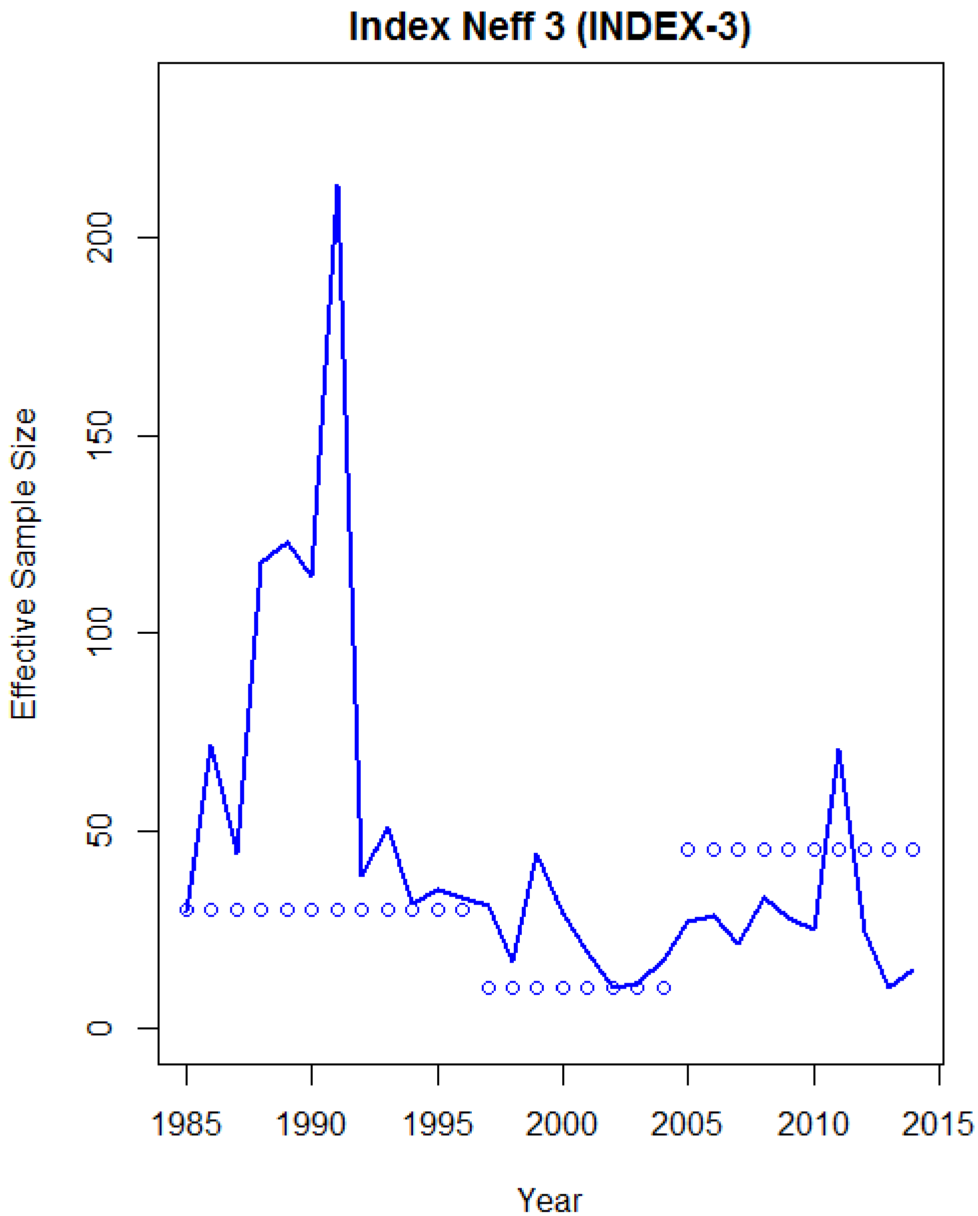
App. B7 Figure B7.67. Age composition residuals for the NJ ocean trawl survey.



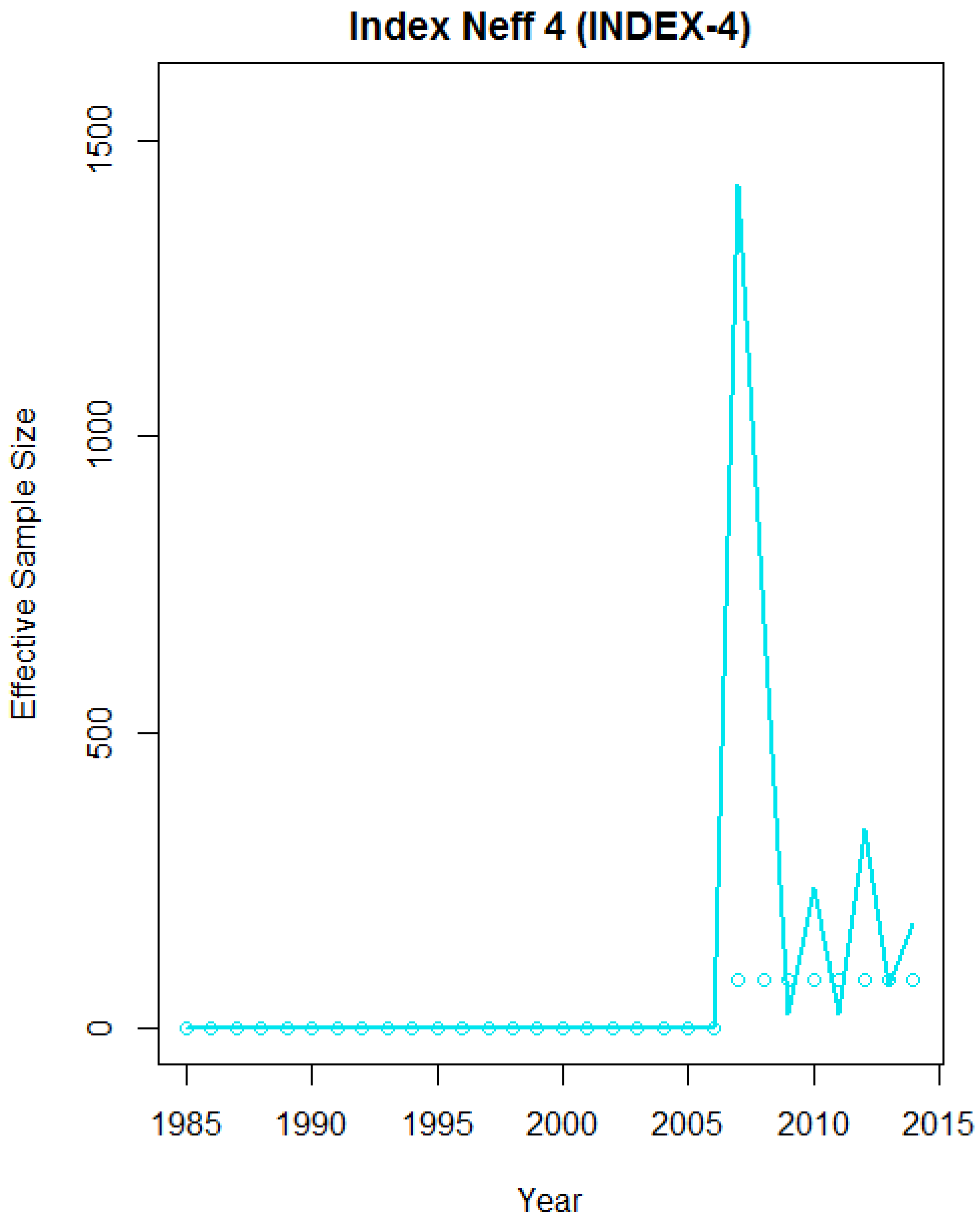
App. B7 Figure B7.68. Input and estimated effective sample size for the NEFSC Inshore survey.



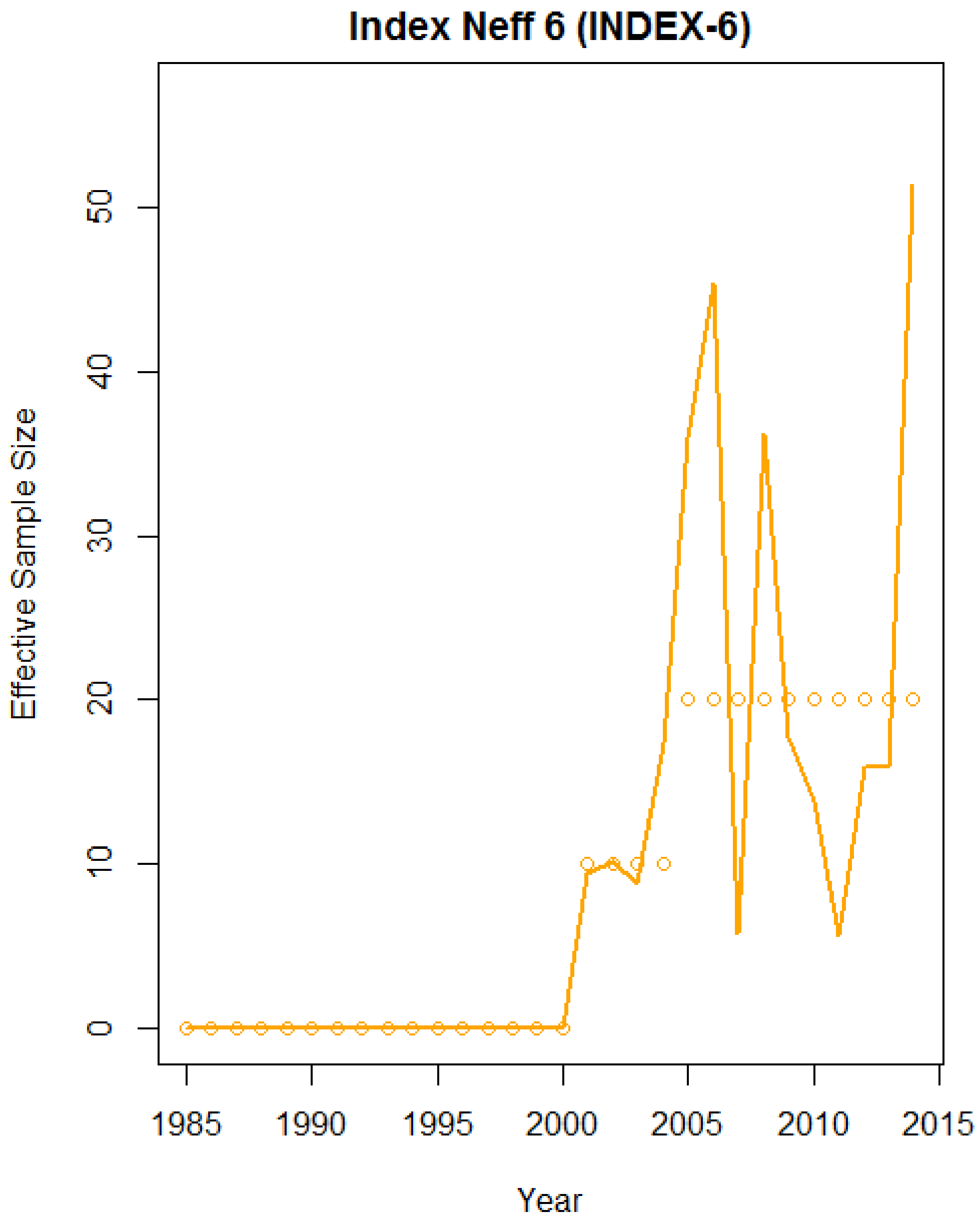
App. B7 Figure B7.69. Input and estimated effective sample size for the NEFSC Bigelow survey.



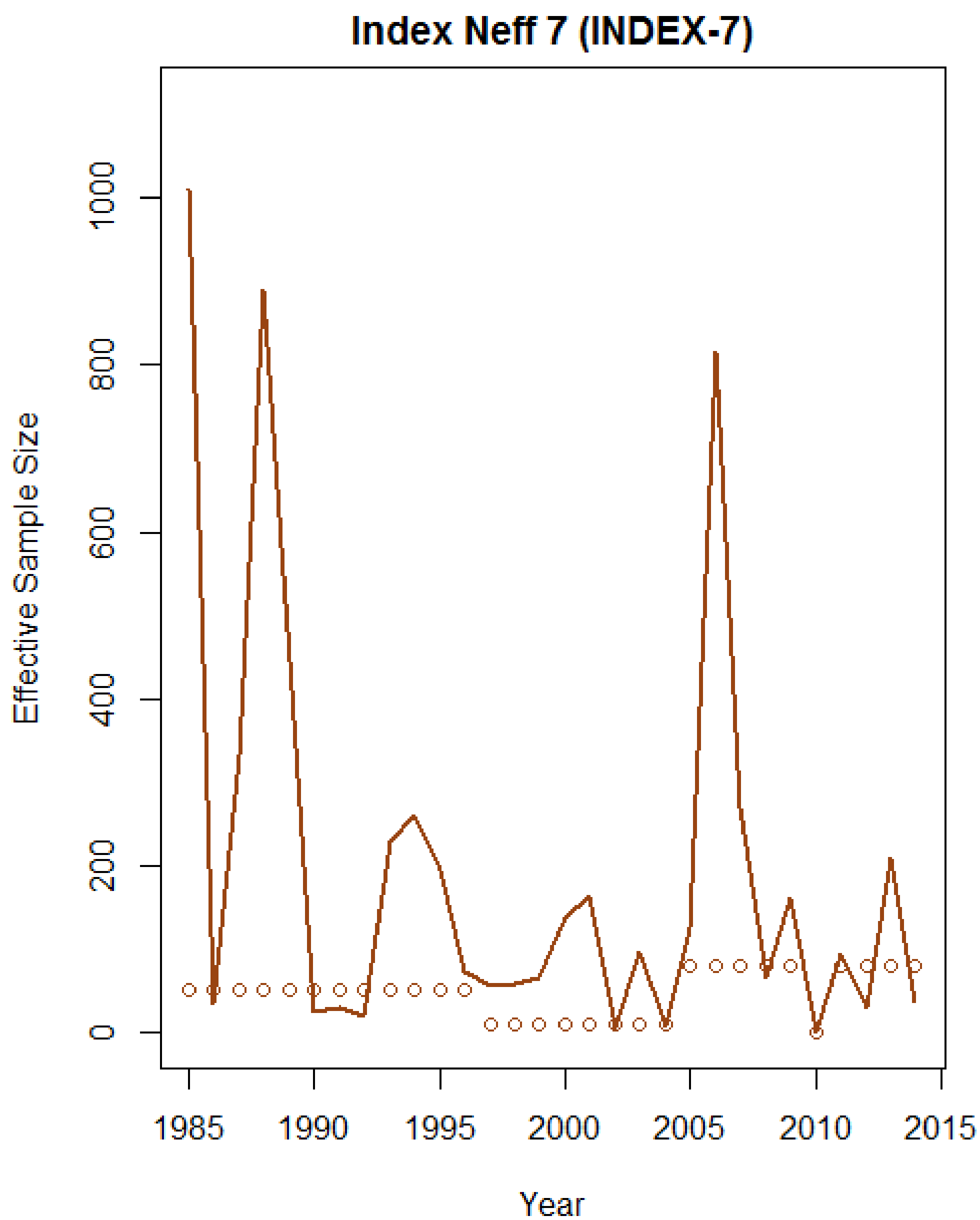
App. B7 Figure B7.70. Input and estimated effective sample size for the MRIP recreational CPUE index.



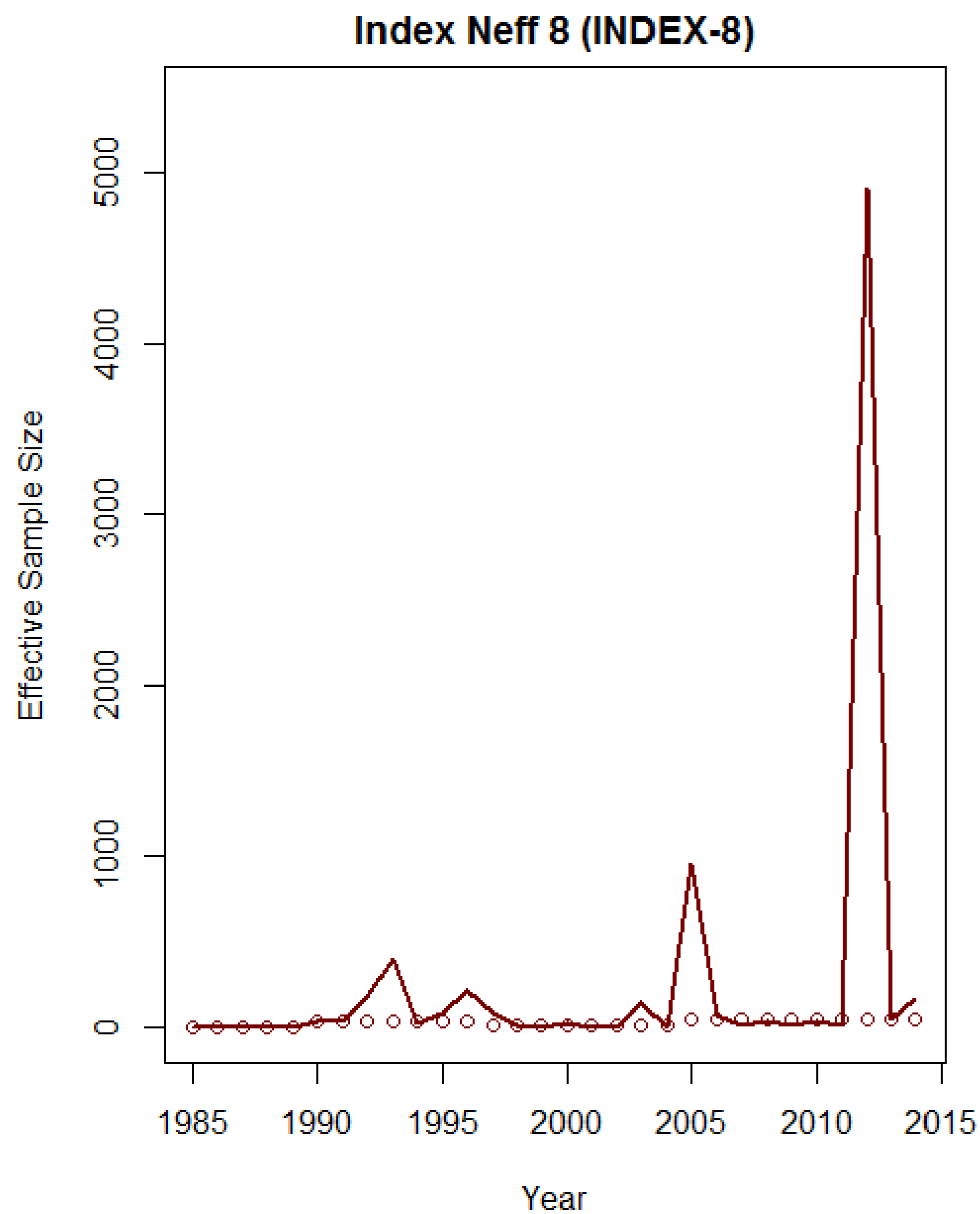
App. B7 Figure B7.71. Input and estimated effective sample size for the NEAMAP survey.



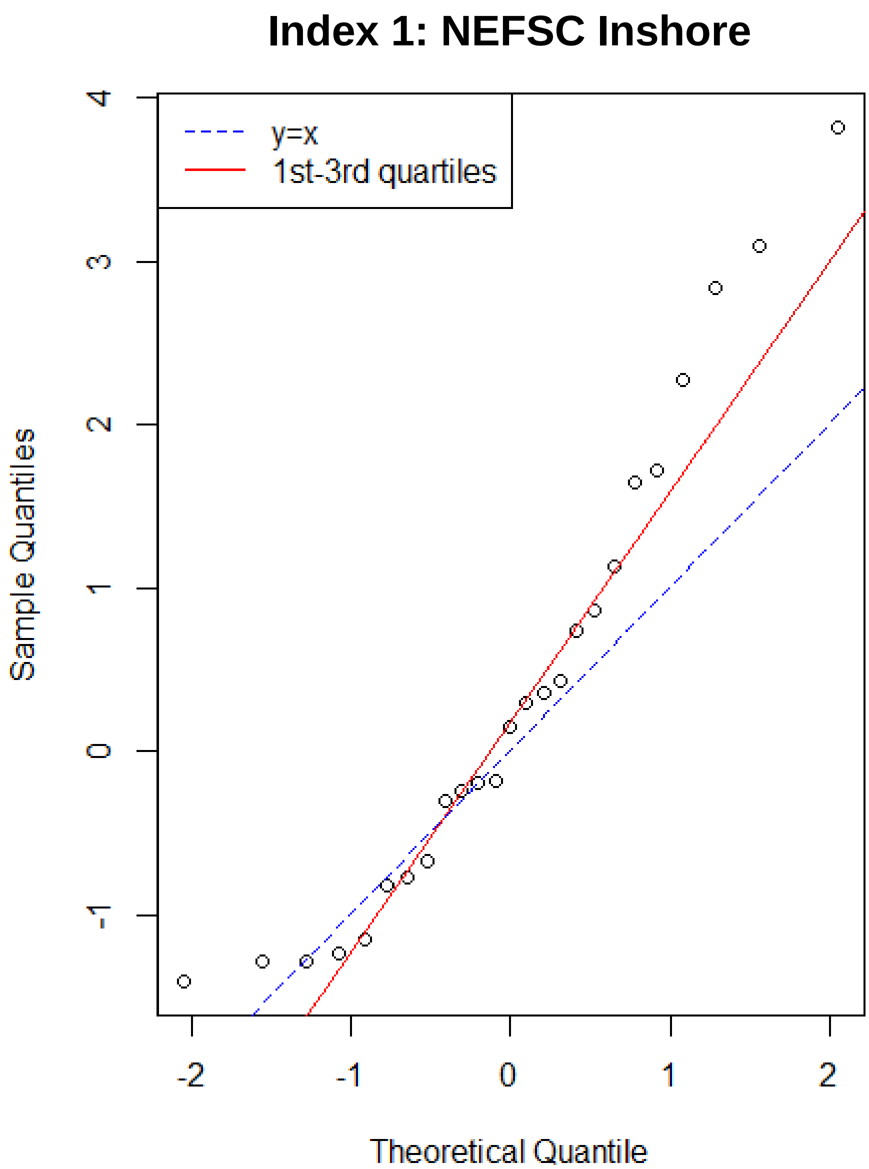
App. B7 Figure B7.72. Input and estimated effective sample size for the PSIGNS gillnet survey.



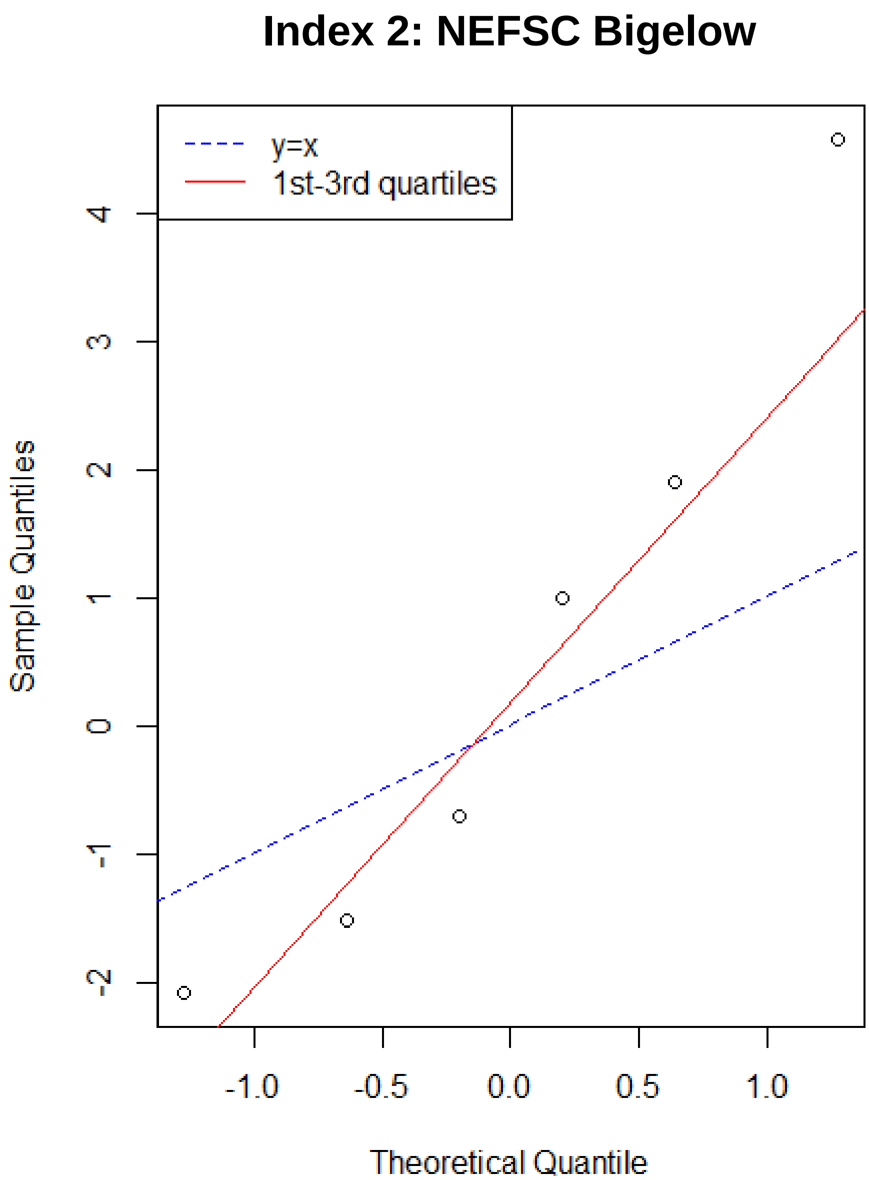
App. B7 Figure B7.73. Input and estimated effective sample size for the CT LISTS trawl survey.



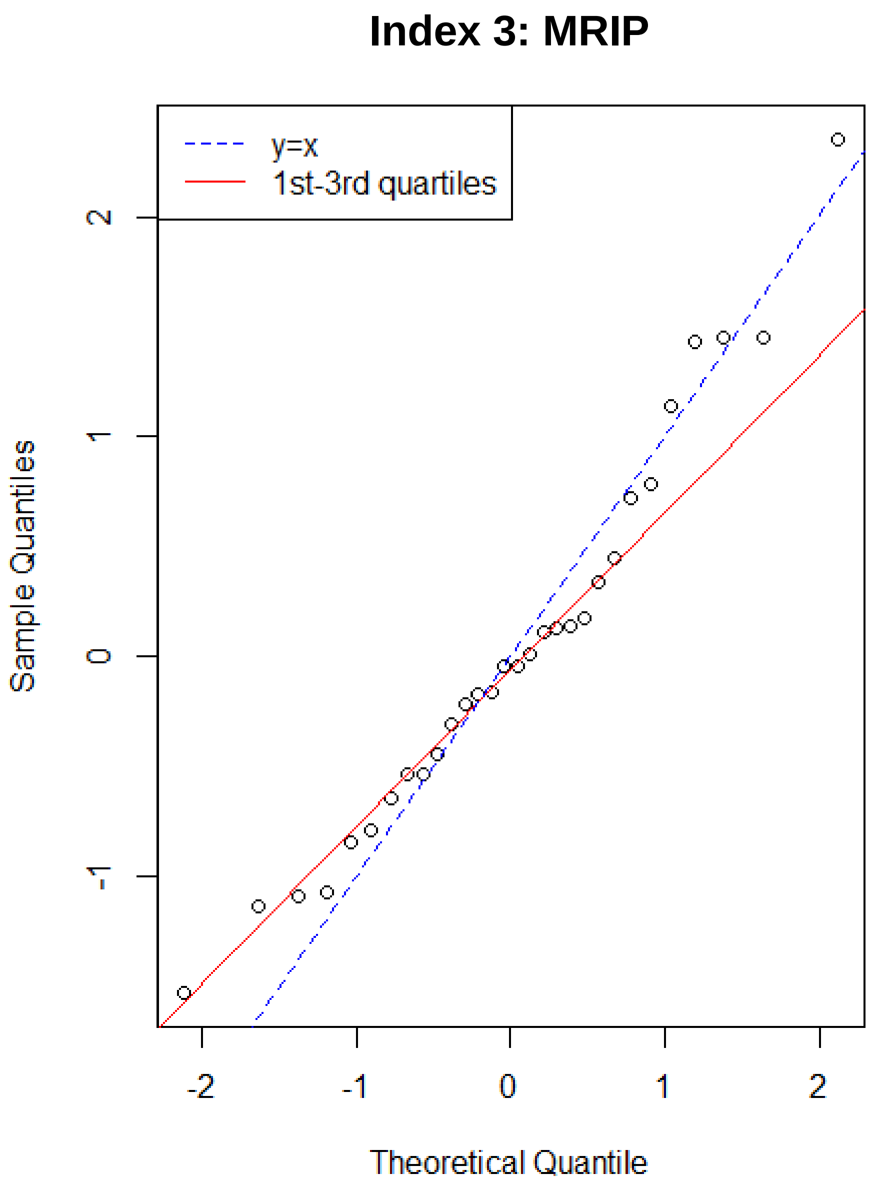
App. B7 Figure B7.74. Input and estimated effective sample size for the NJ ocean trawl survey.



App. B7 Figure B7.75. QQ-plot for the observed versus predicted mean catch for the NEFSC Inshore survey.

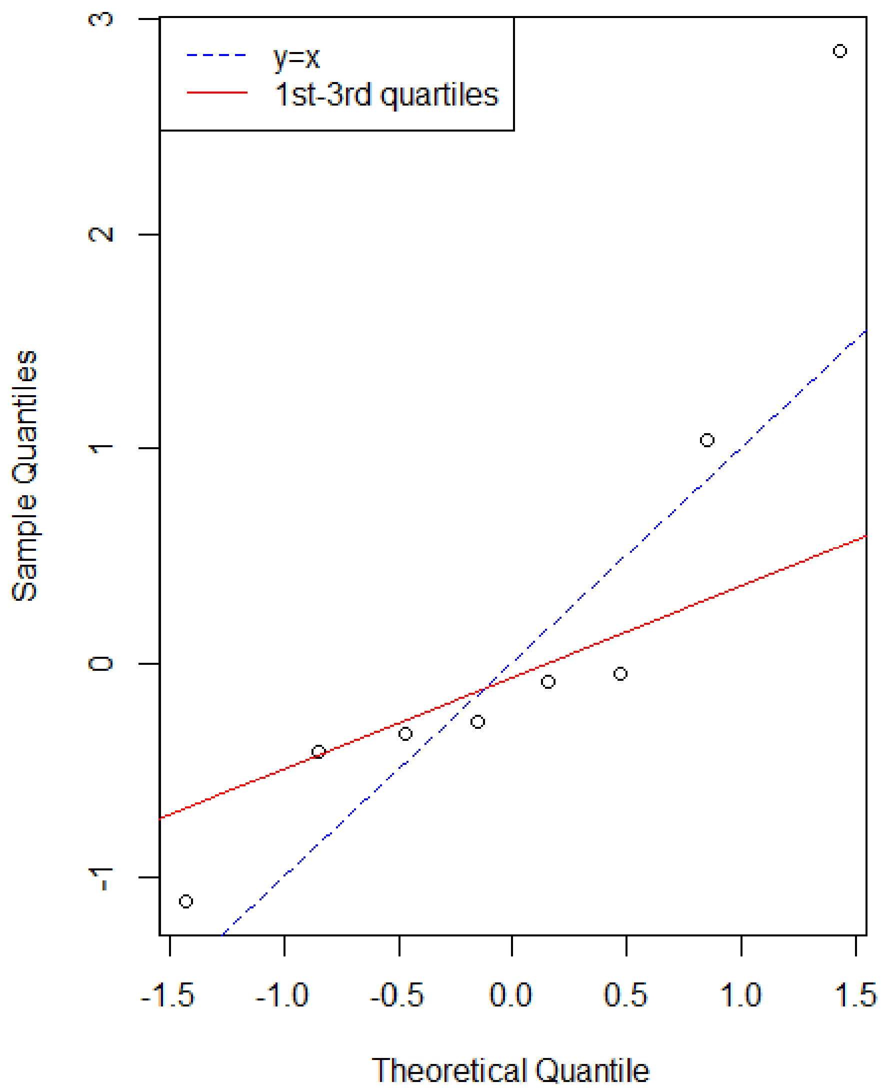


App. B7 Figure B7.76. QQ-plot for the observed versus predicted mean catch for the NEFSC Bigelow survey.

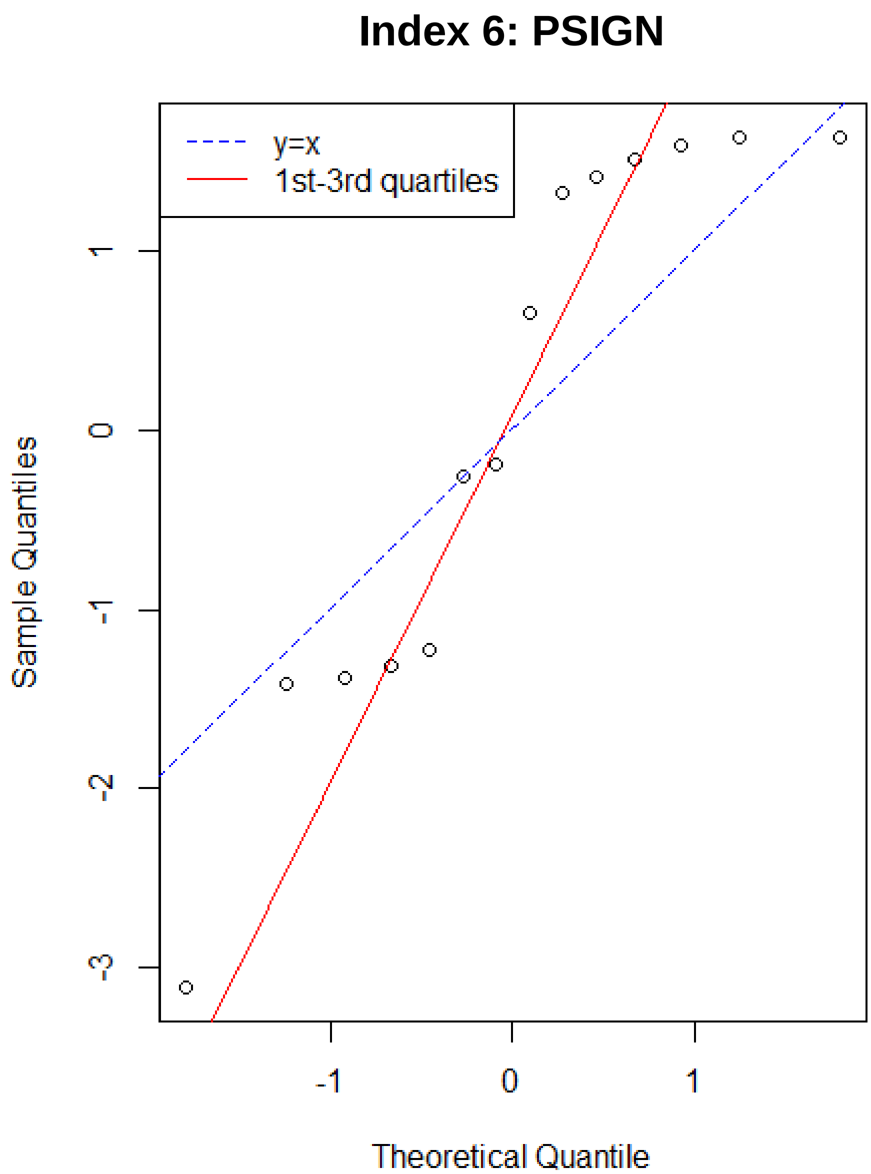


App. B7 Figure B7.77. QQ-plot for the observed versus predicted mean catch for the MRIP recreational CPUE index.

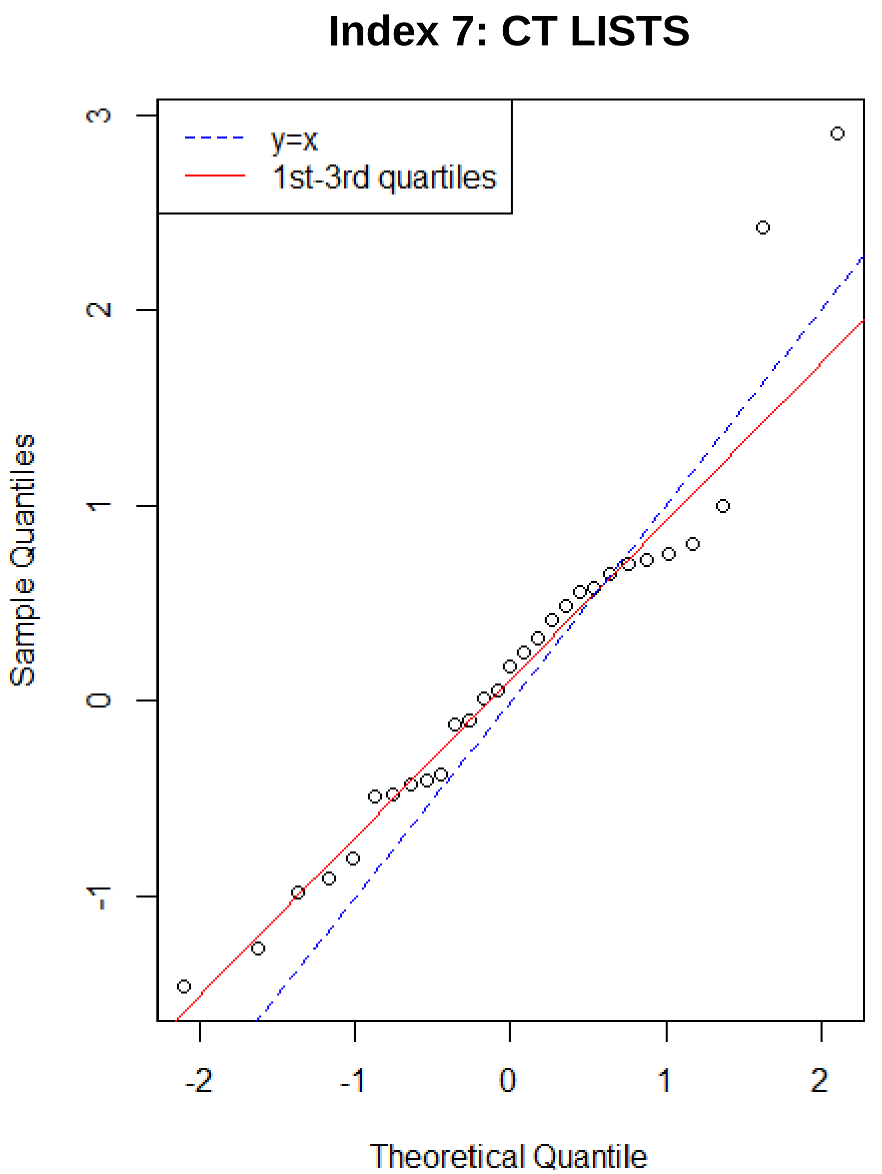
Index 4: NEAMAP



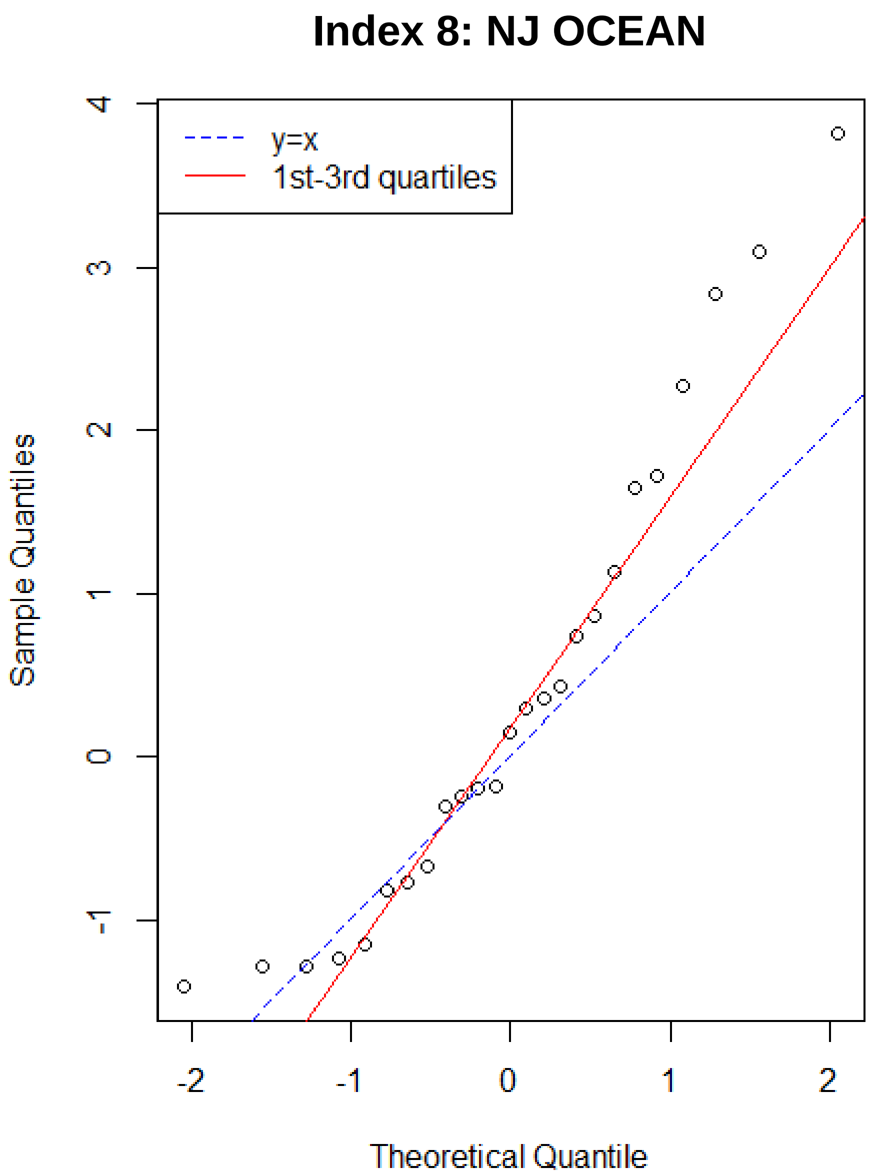
App. B7 Figure B7.78. QQ-plot for the observed versus predicted mean catch for the NEAMAP survey.



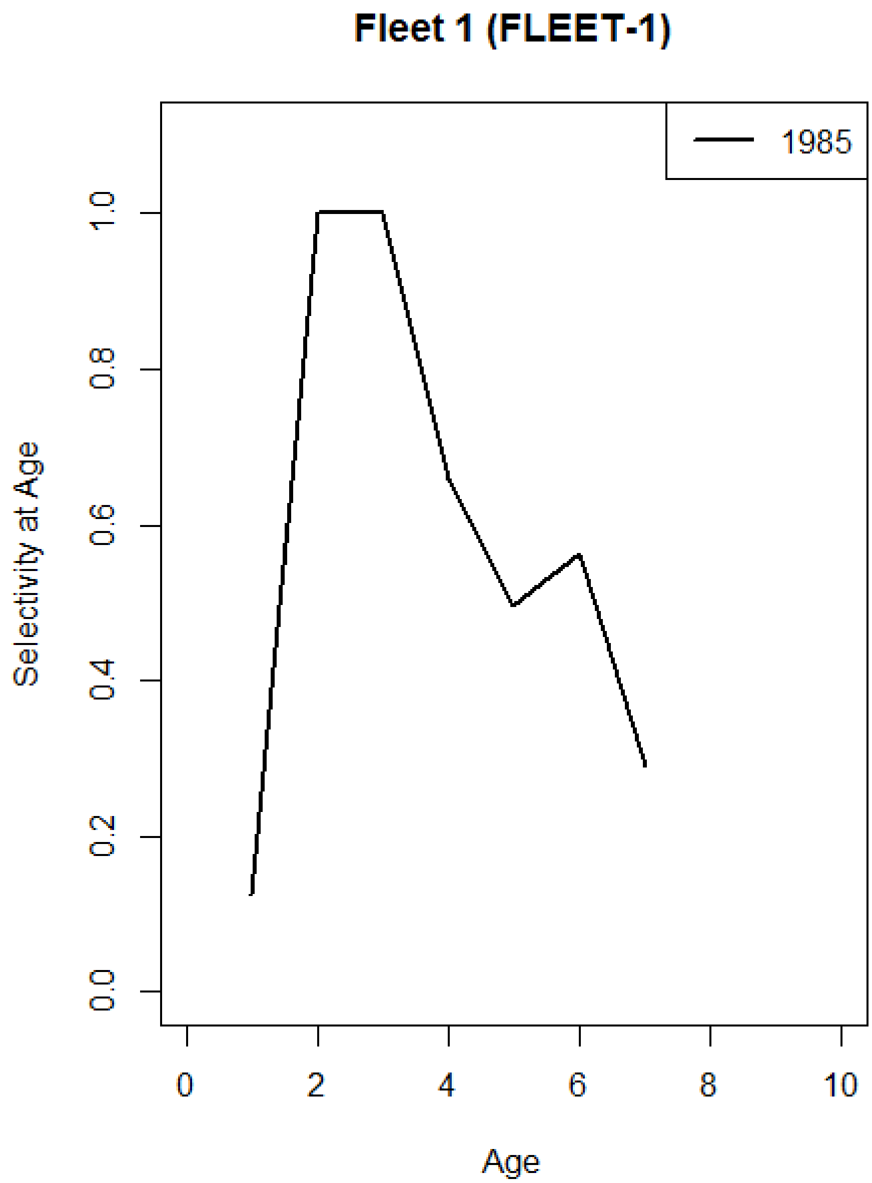
App. B7 Figure B7.79. QQ-plot for the observed versus predicted mean catch for the PSIGNS gillnet survey.



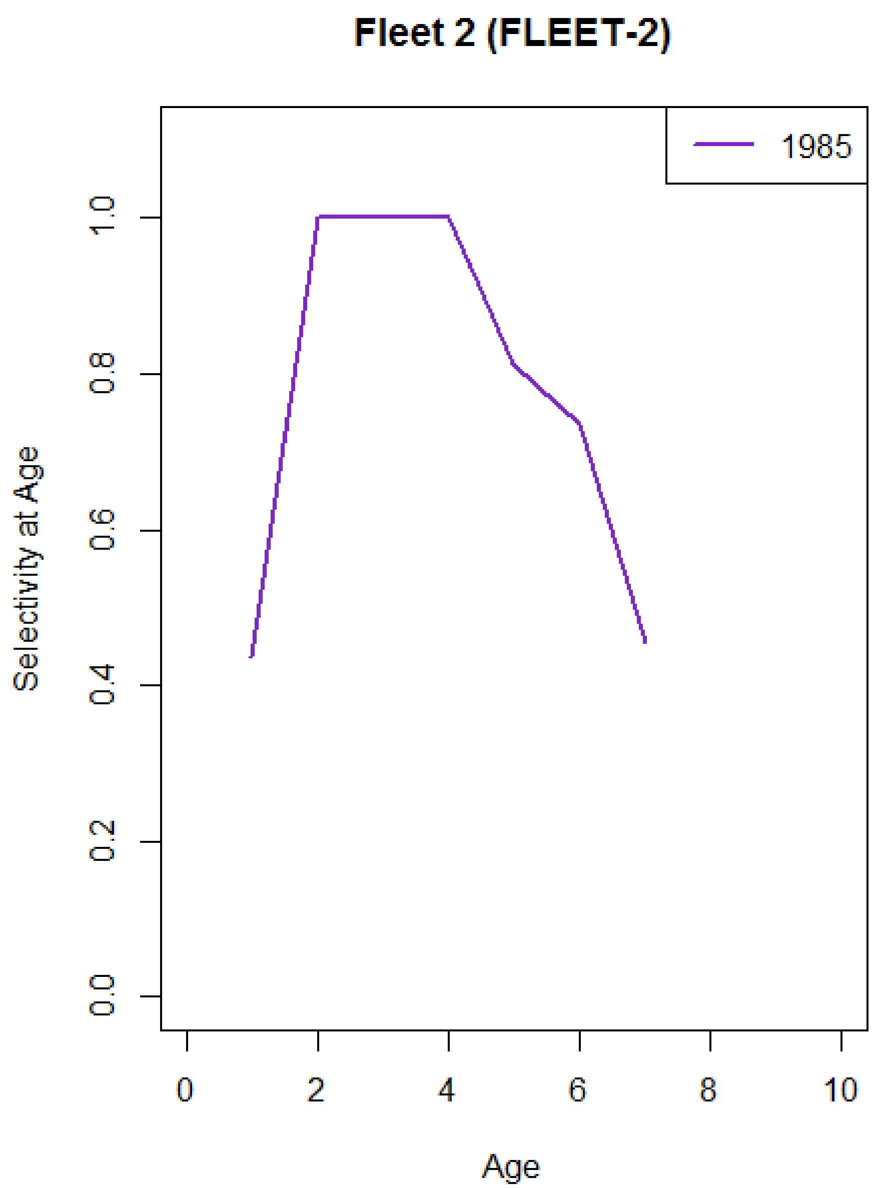
App. B7 Figure B7.80. QQ-plot for the observed versus predicted mean catch for the CT LISTS trawl survey.



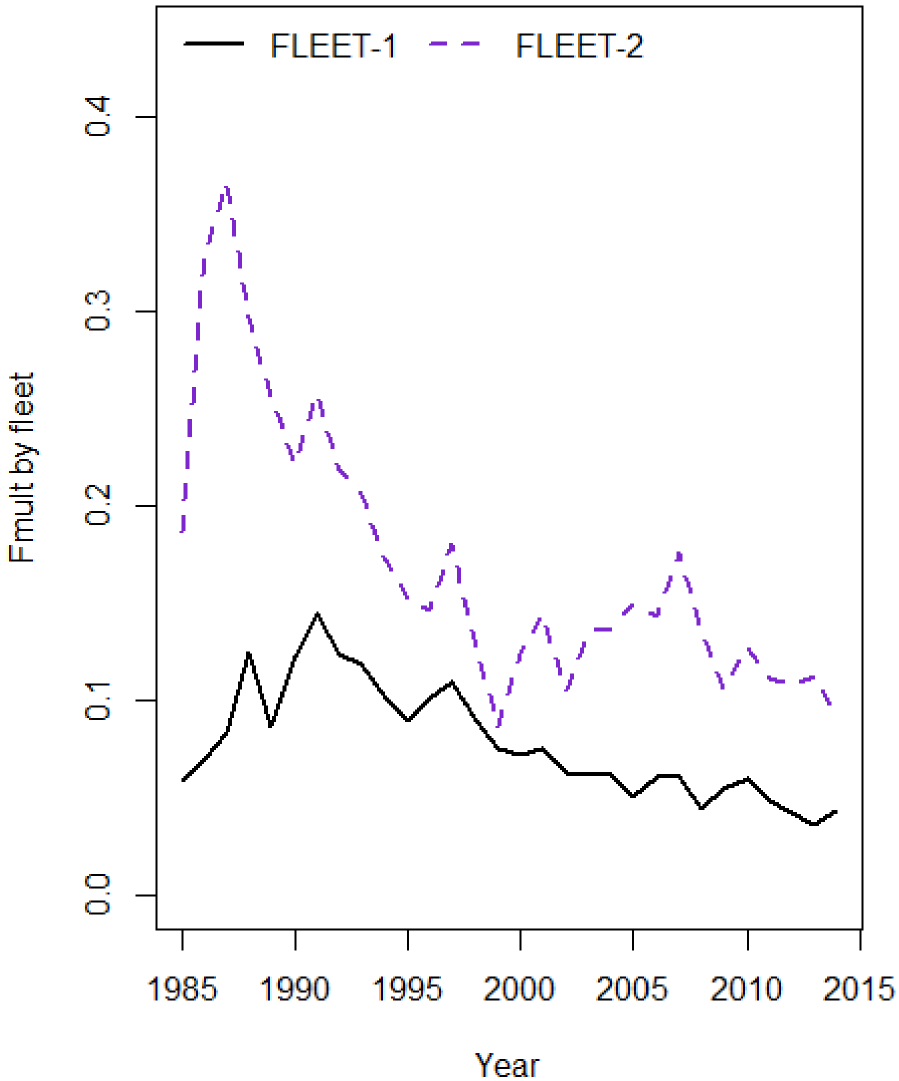
App. B7 Figure B7.81. QQ-plot for the observed versus predicted mean catch for the NJ ocean trawl survey.



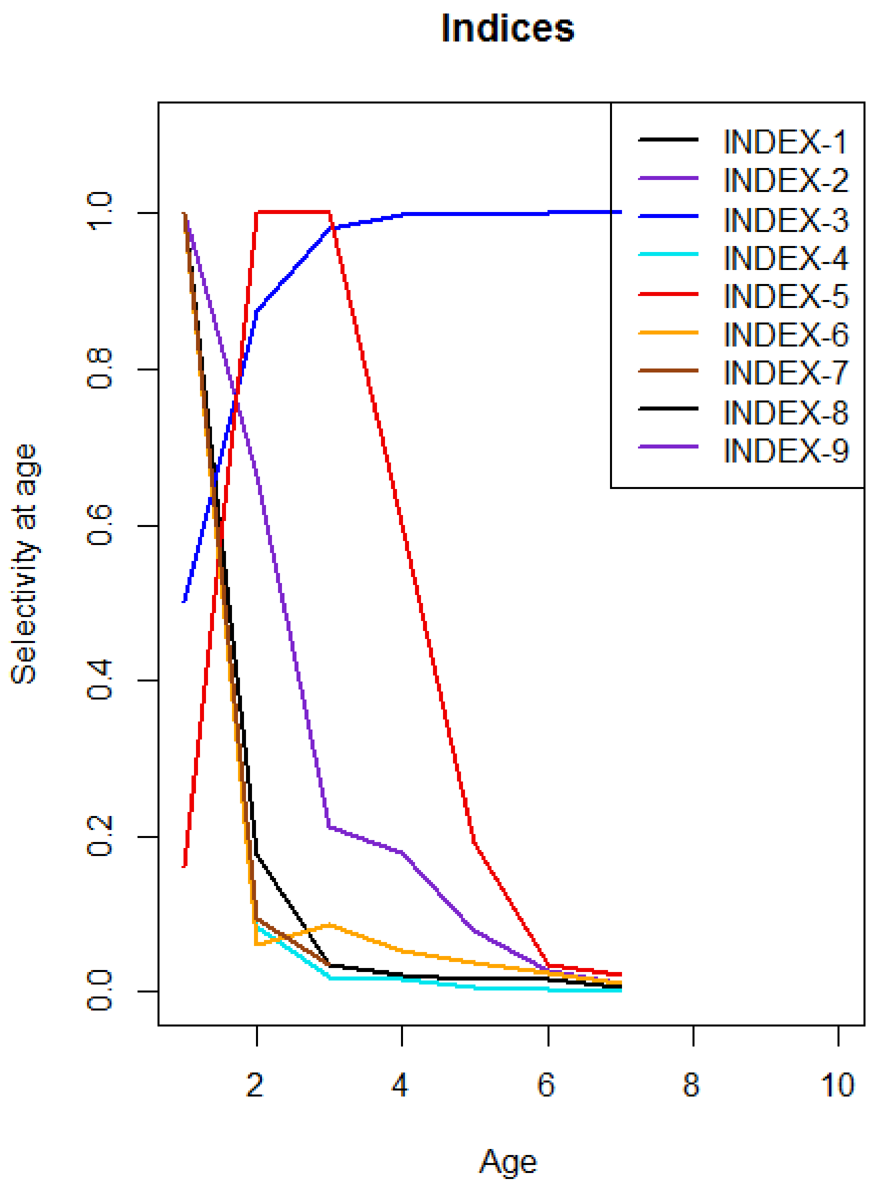
App. B7 Figure B7.82. Estimated selectivity for the commercial fleet from the final model



App. B7 Figure B7.83. Estimated selectivity for the recreational fleet from the final model.

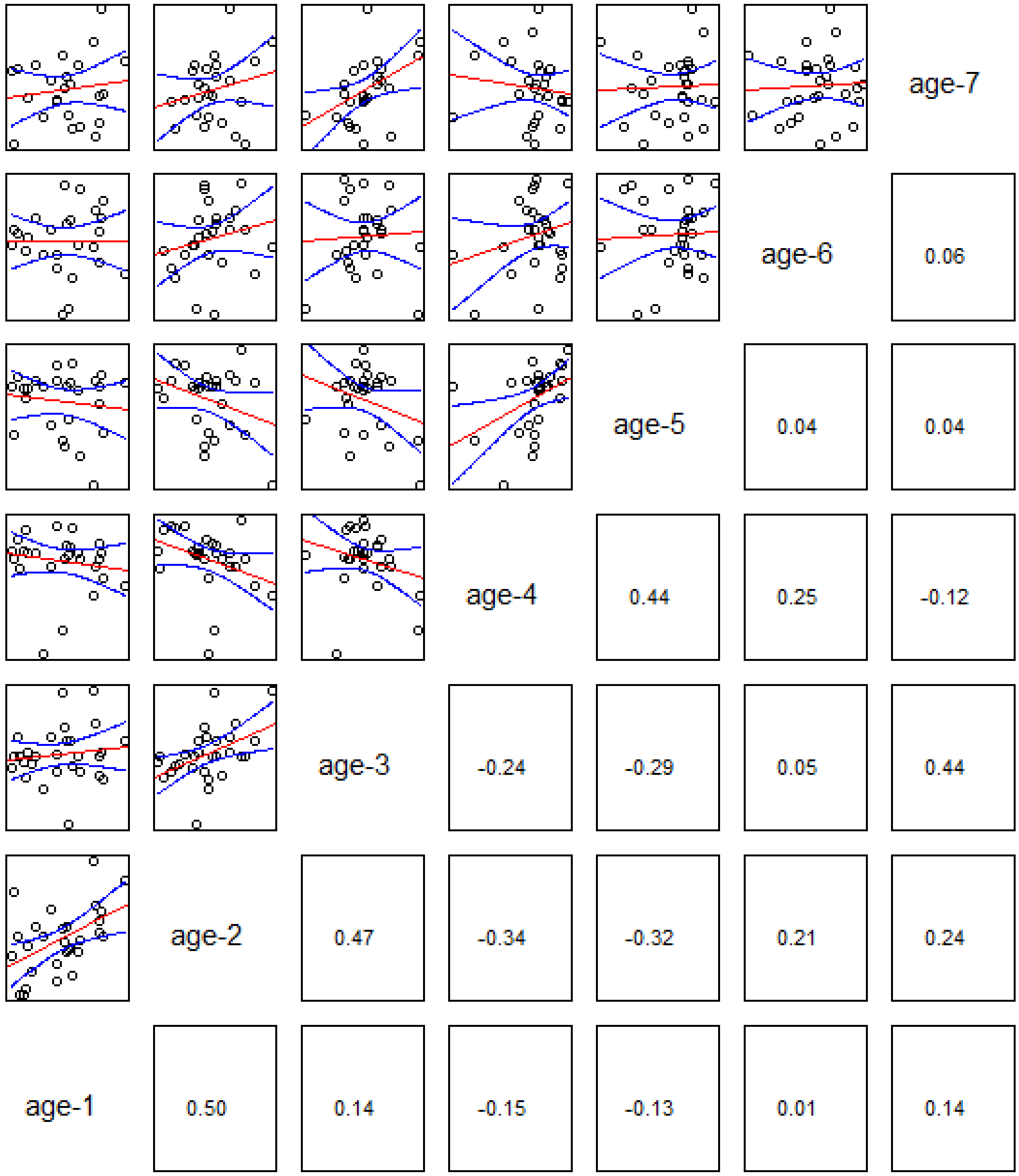


App. B7 Figure B7.84. Fmult estimates for the commercial (fleet 1) and recreational (fleet 2) fleets.

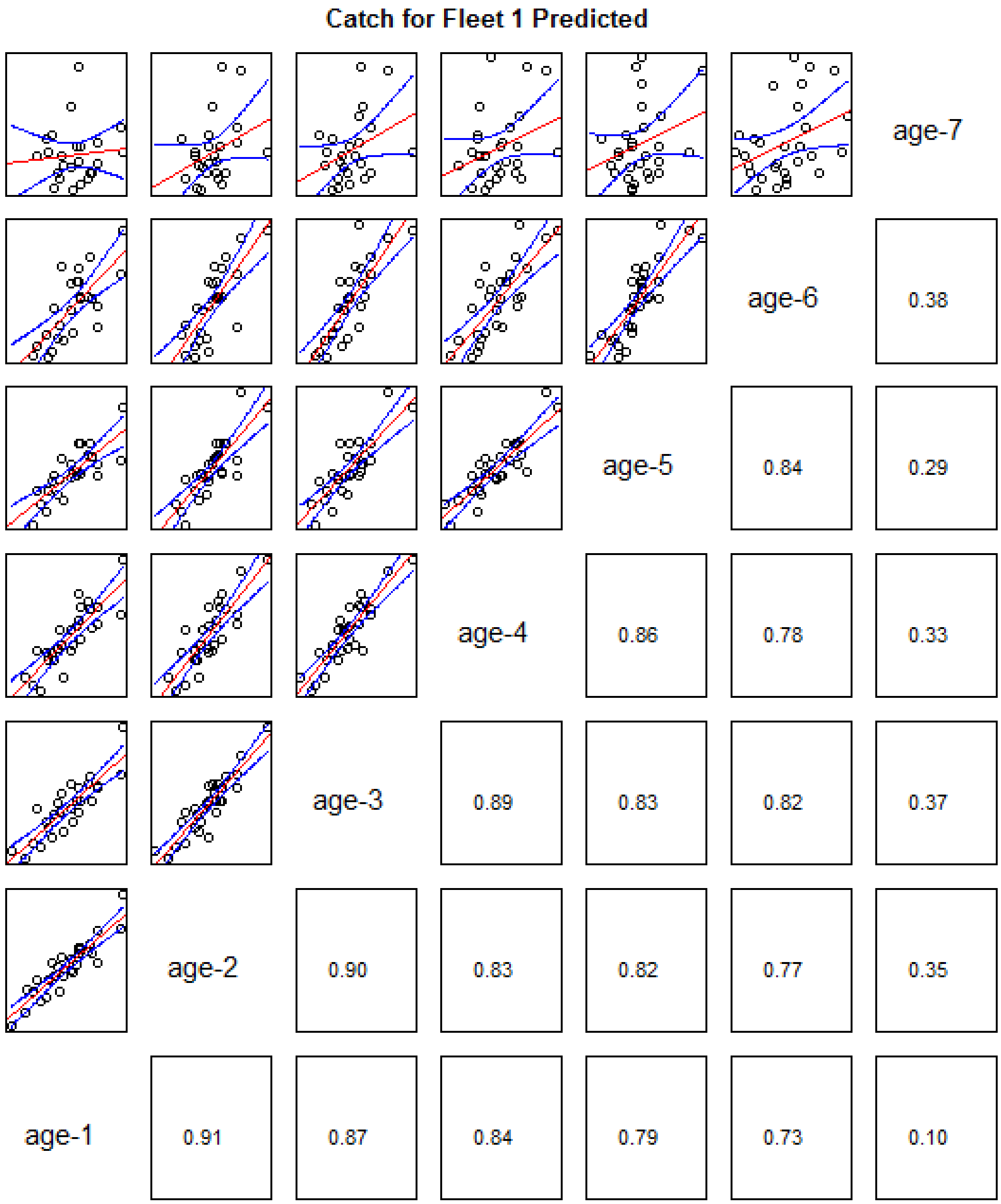


App. B7 Figure B7.85. Estimated selectivities for the indices from the final model. Note the two age 0 indices are not plotted so only 7 selectivities are shown. In this plot: Index 1 = NEFSC Inshore, Index 2 = NEFSC Bigelow, Index 3 = MRIP, Index 4 = NEAMAP, Index 5 = PSIGN, Index 6 = CT LISTS, and Index 7 = NJ ocean.

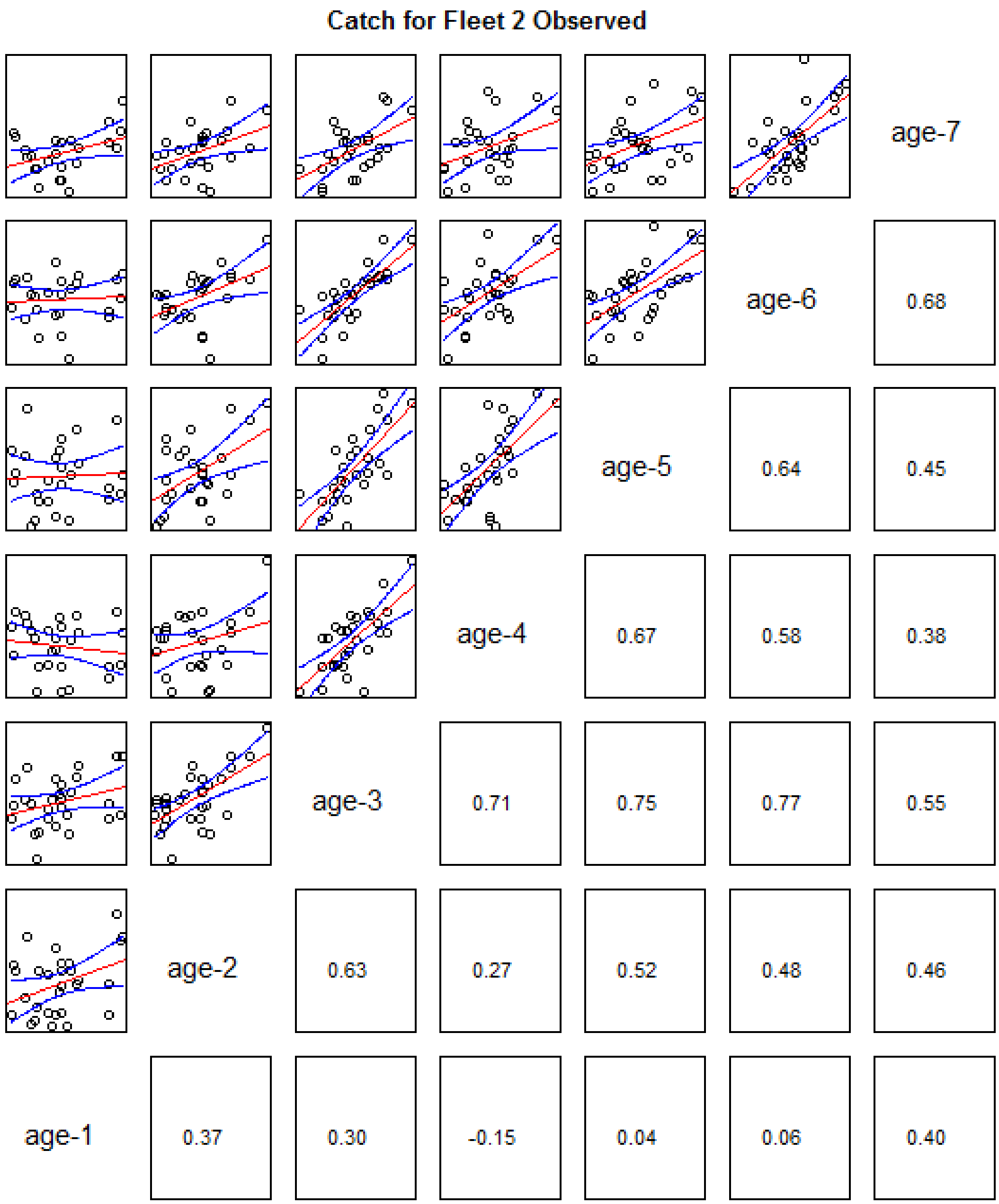
Catch for Fleet 1 Observed



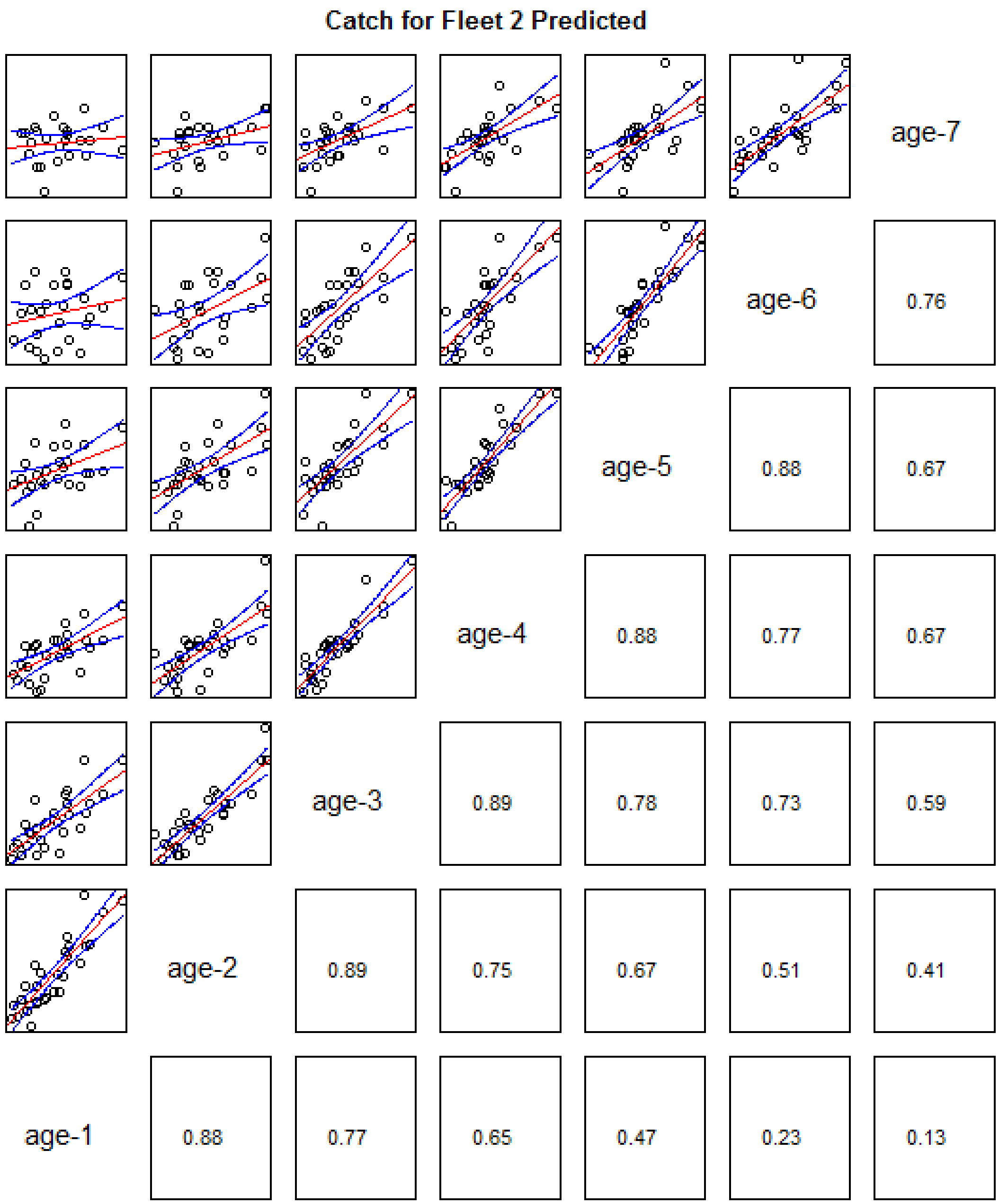
App. B7 Figure B7.86. Observed catch for the commercial fleet.



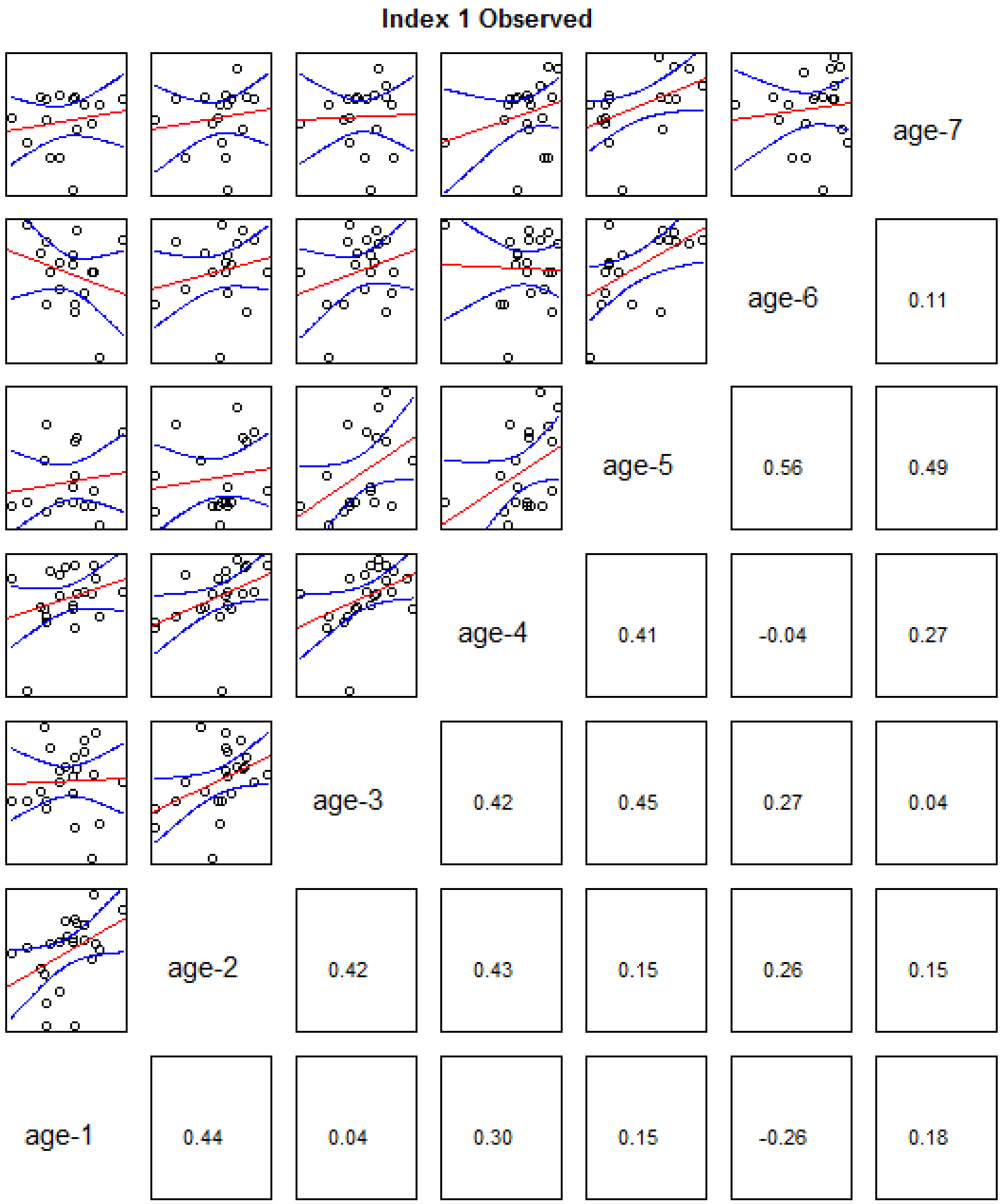
App. B7 Figure B7.87. Predicted catch for the commercial fleet.



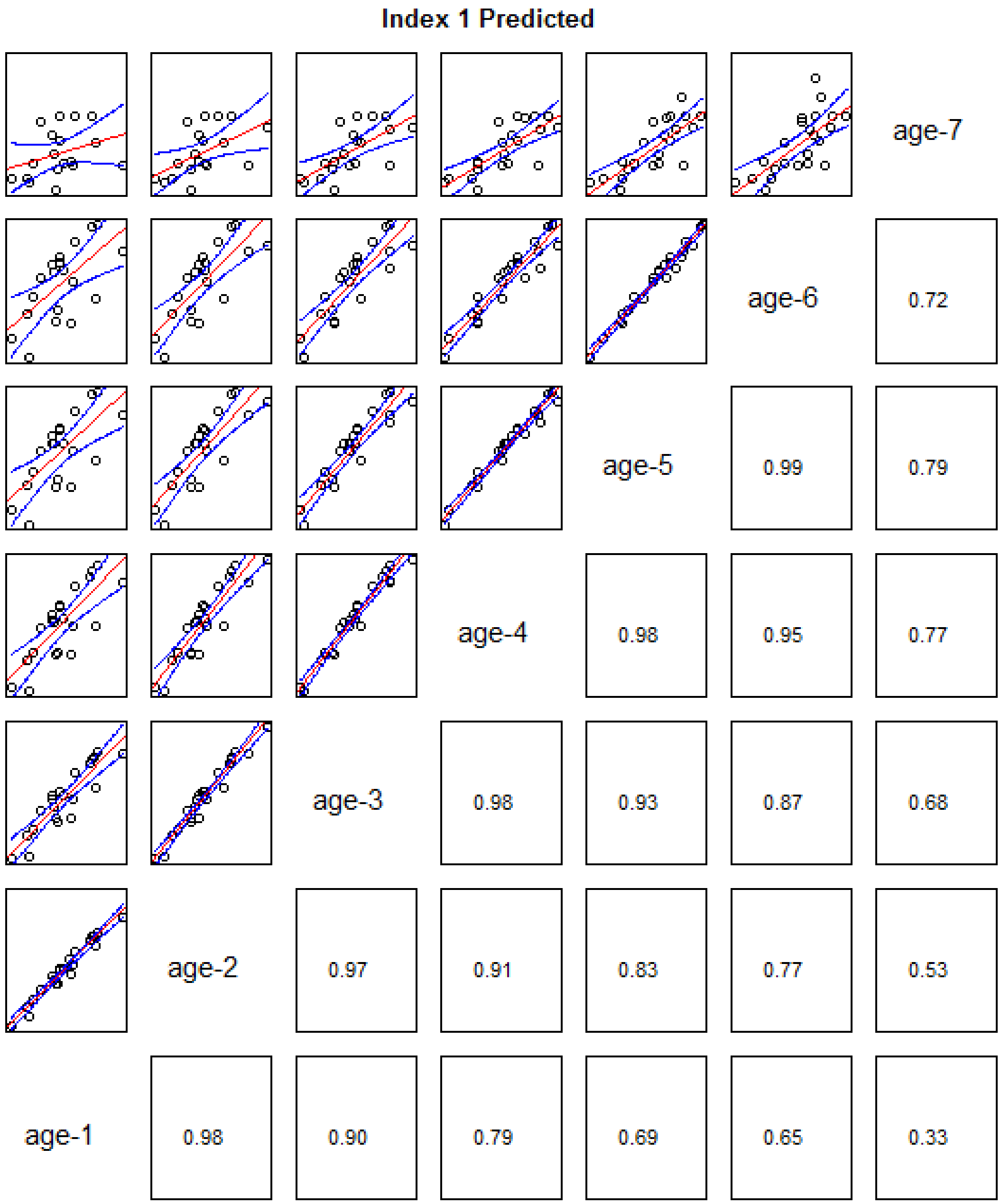
App. B7 Figure B7.88. Observed catch for the recreational fleet.



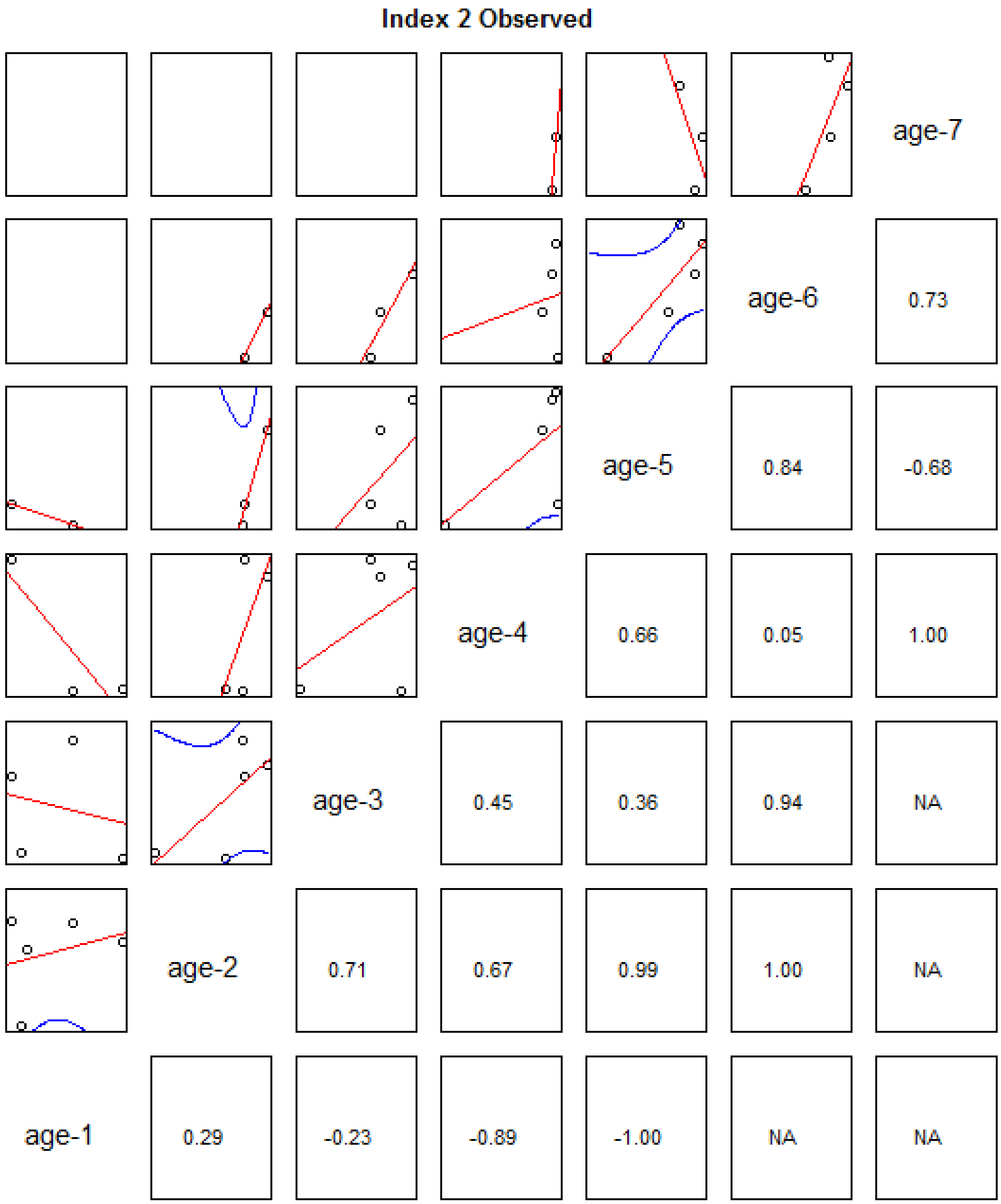
App. B7 Figure B7.89. Predicted catch for the recreational fleet.



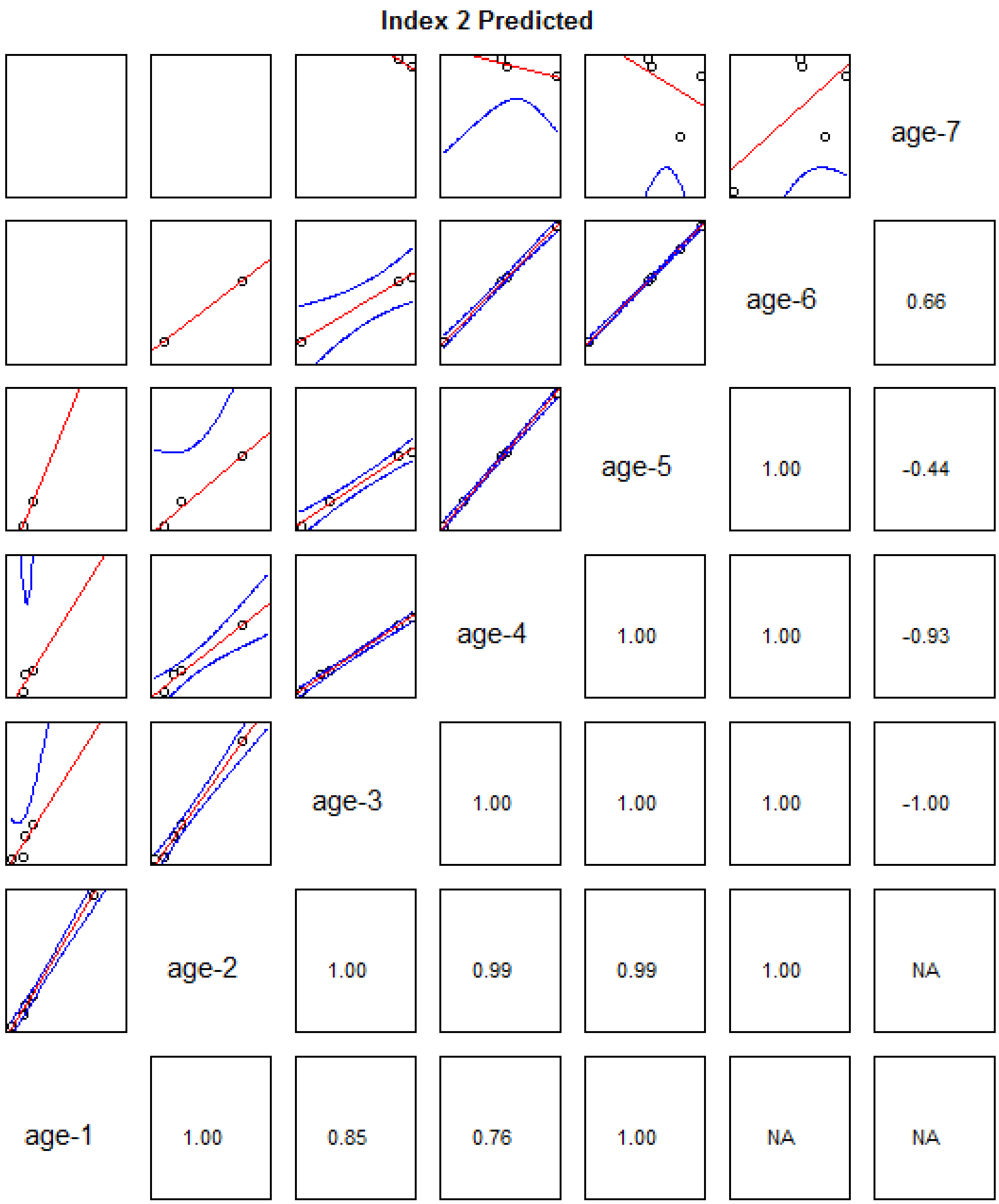
App. B7 Figure B7.90. Observed catch for the NEFSC Inshore survey.



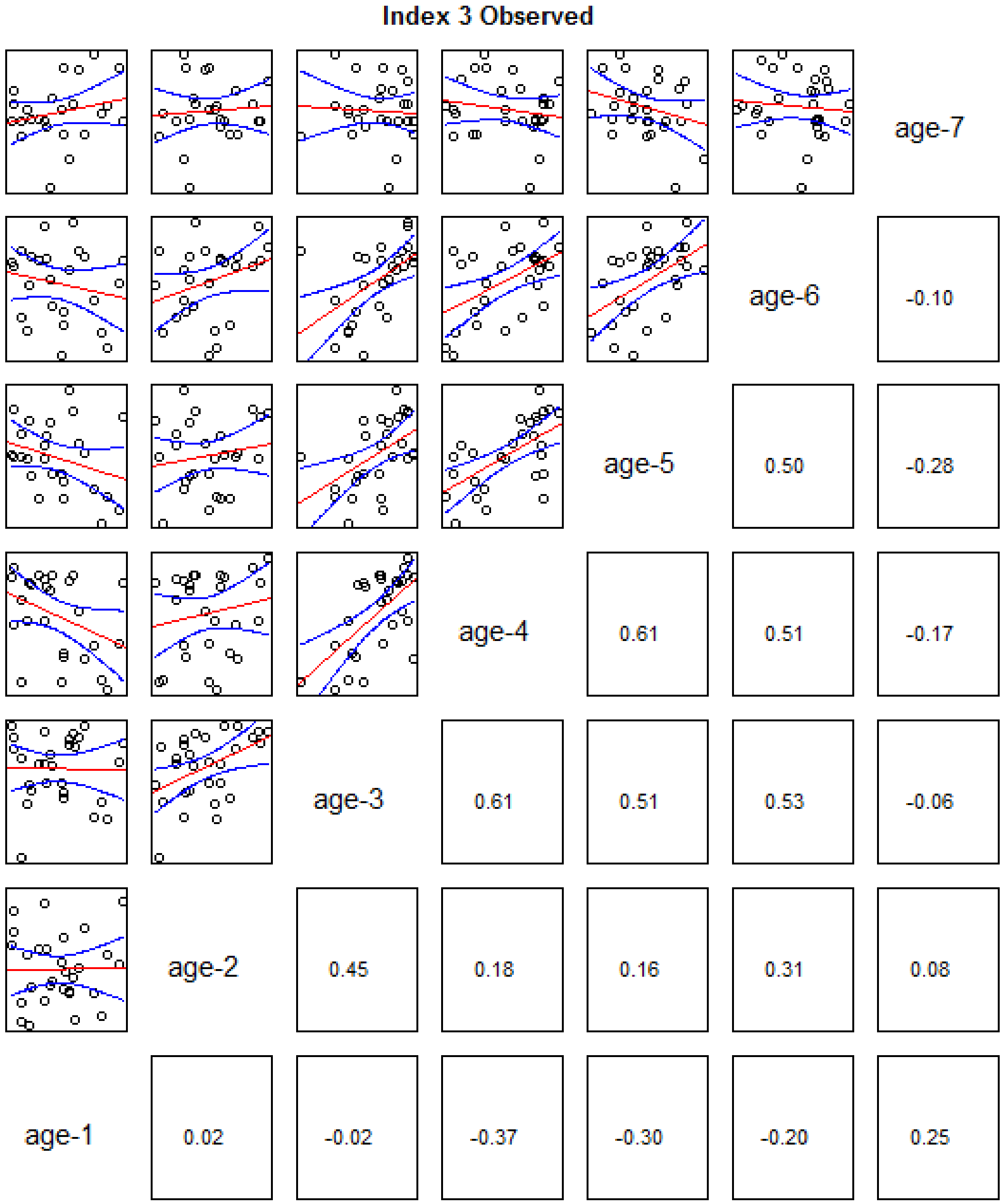
App. B7 Figure B7.91. Predicted catch for the NEFSC Inshore survey.



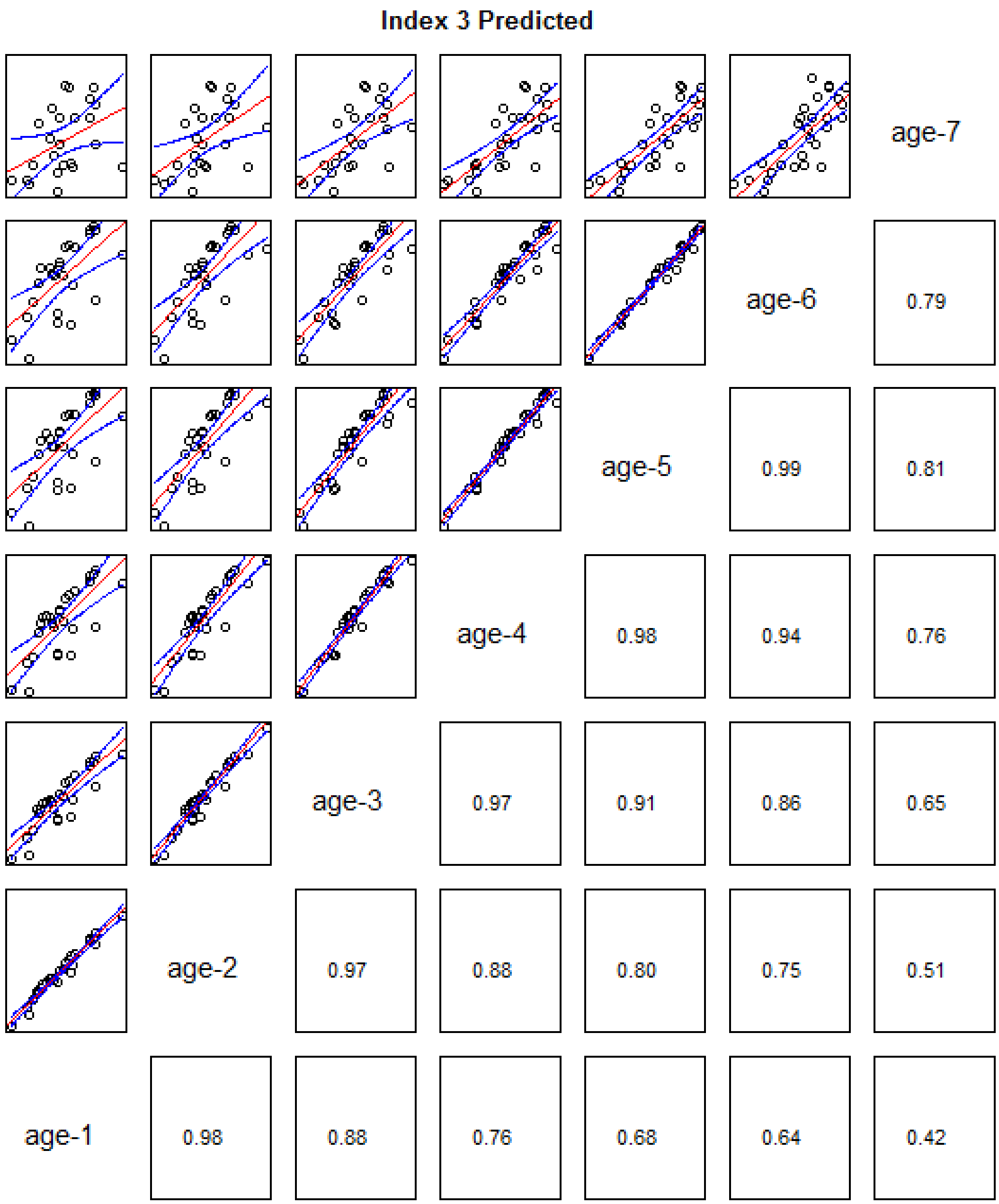
App. B7 Figure B7.92. Observed catch for the NEFSC Bigelow survey.



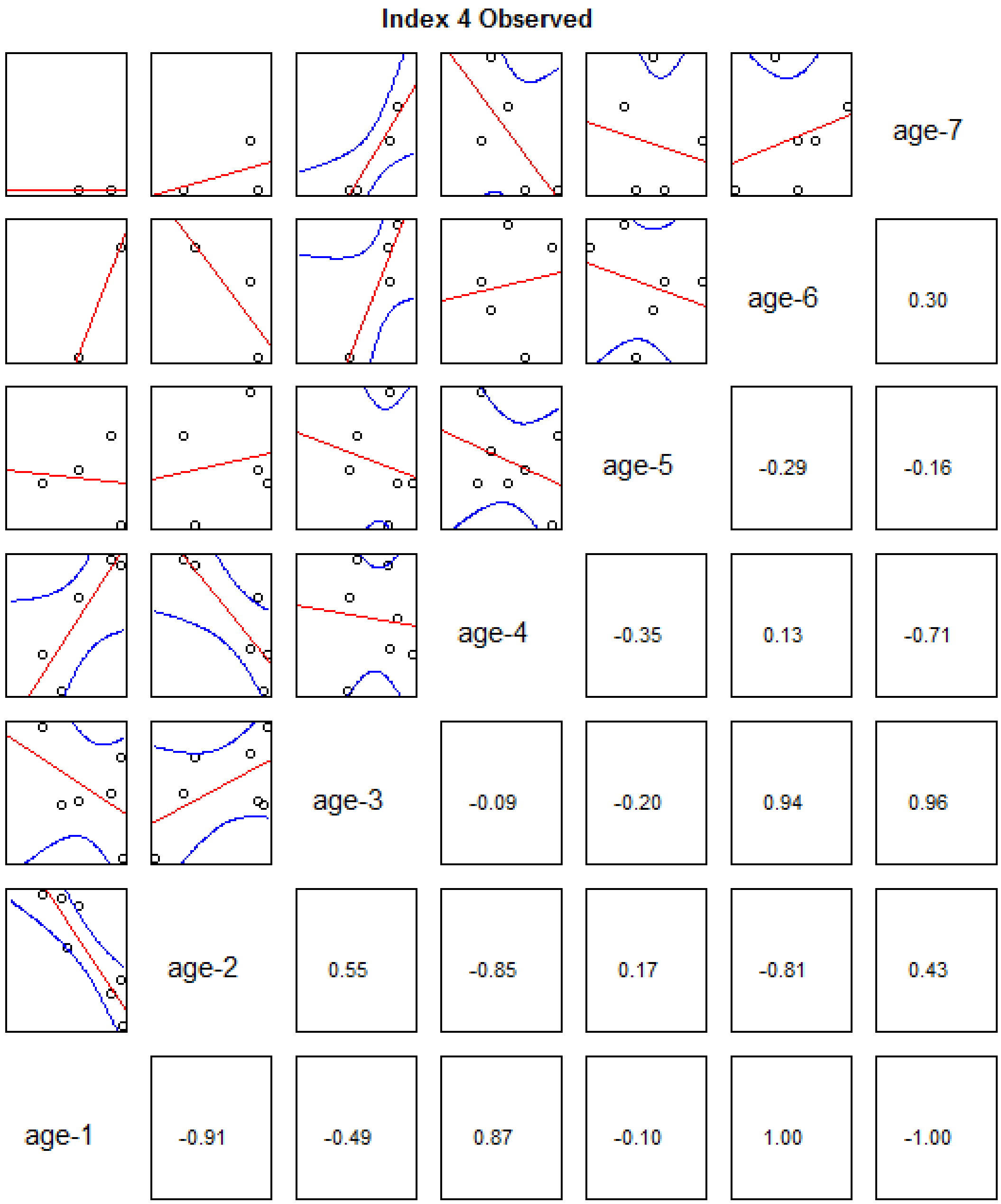
App. B7 Figure B7.93. Predicted catch for the NEFSC Bigelow survey.



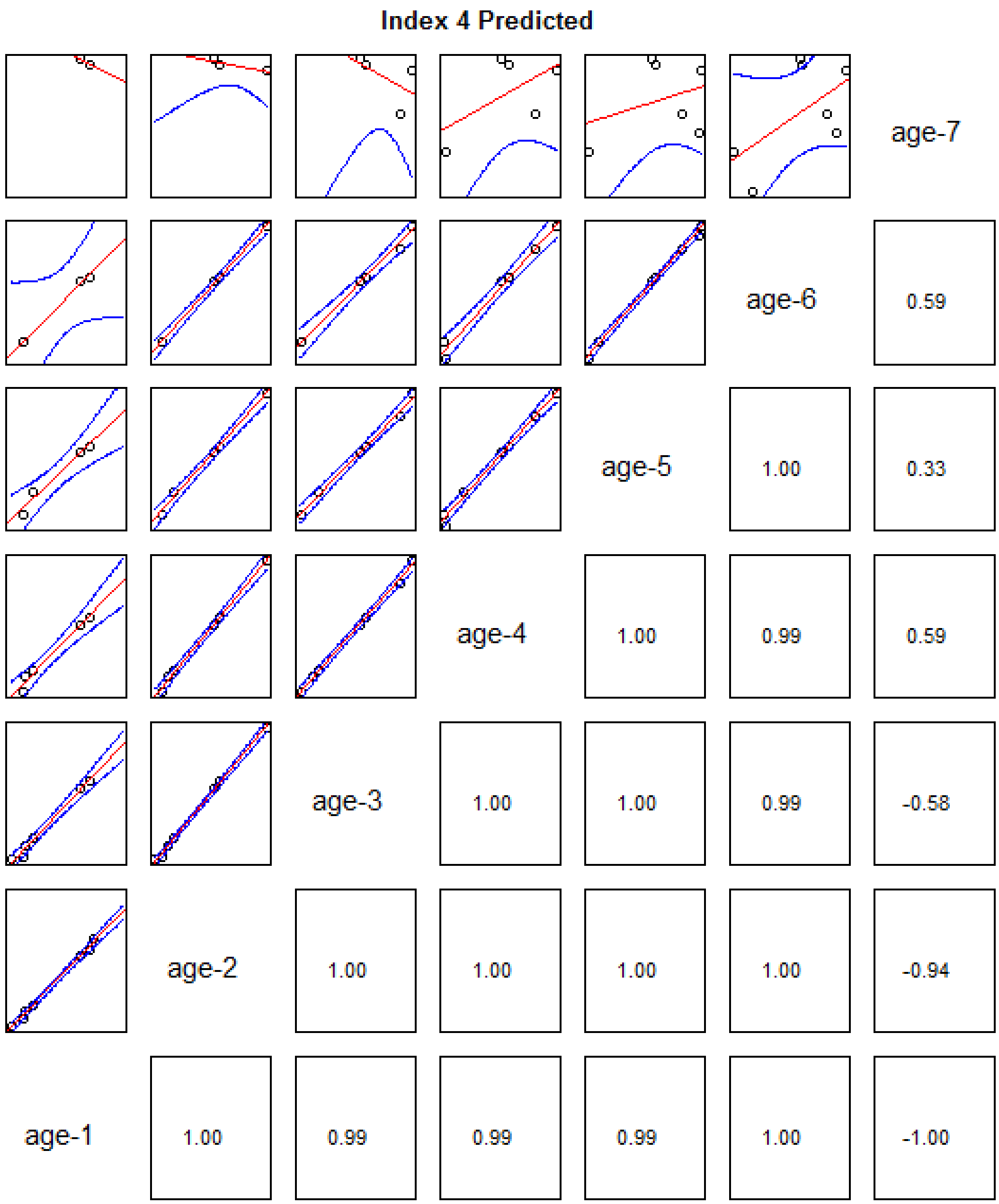
App. B7 Figure B7.94. Observed catch for the MRIP recreational CPUE index.



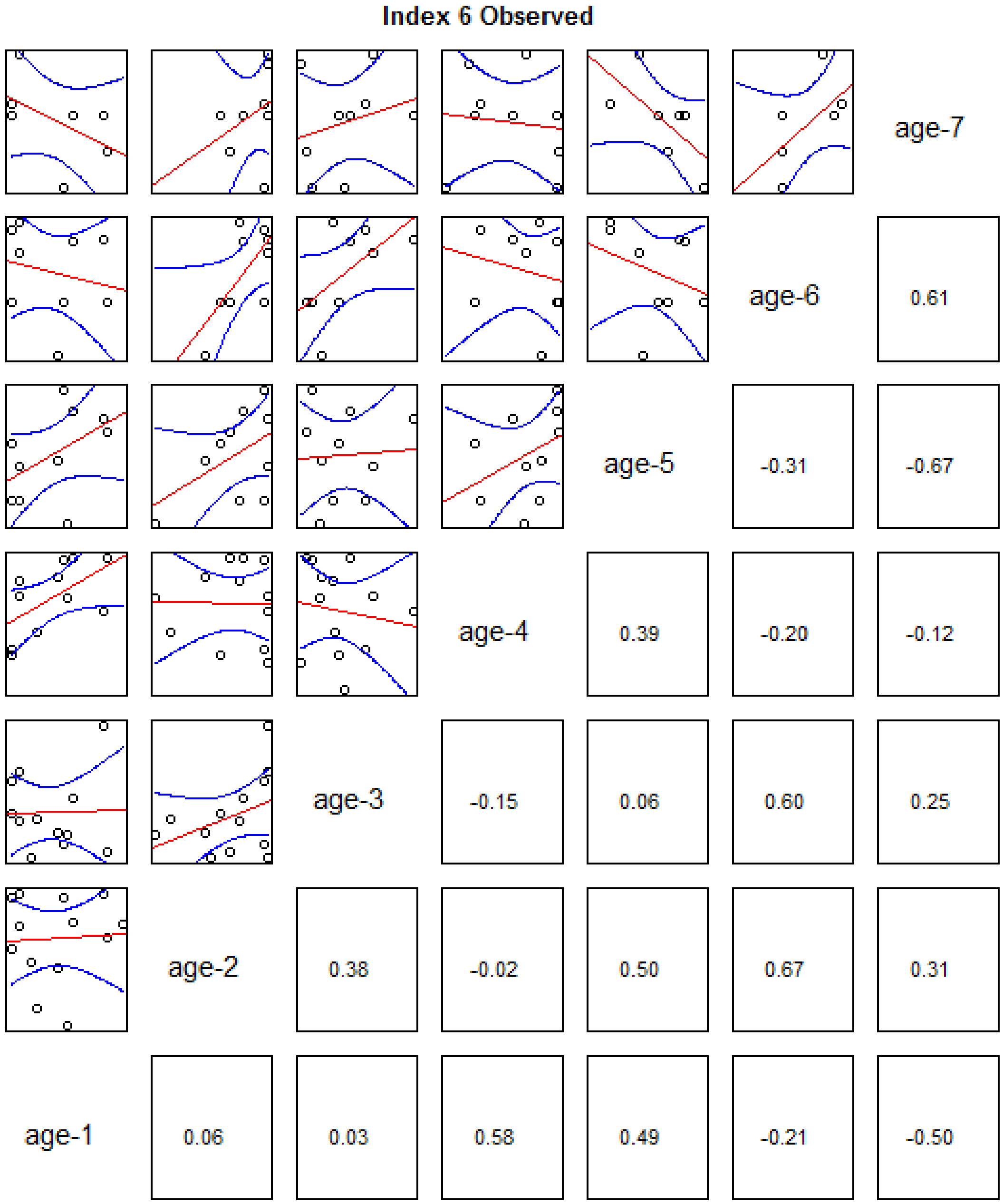
App. B7 Figure B7.95. Predicted catch for the MRIP recreational CPUE index.



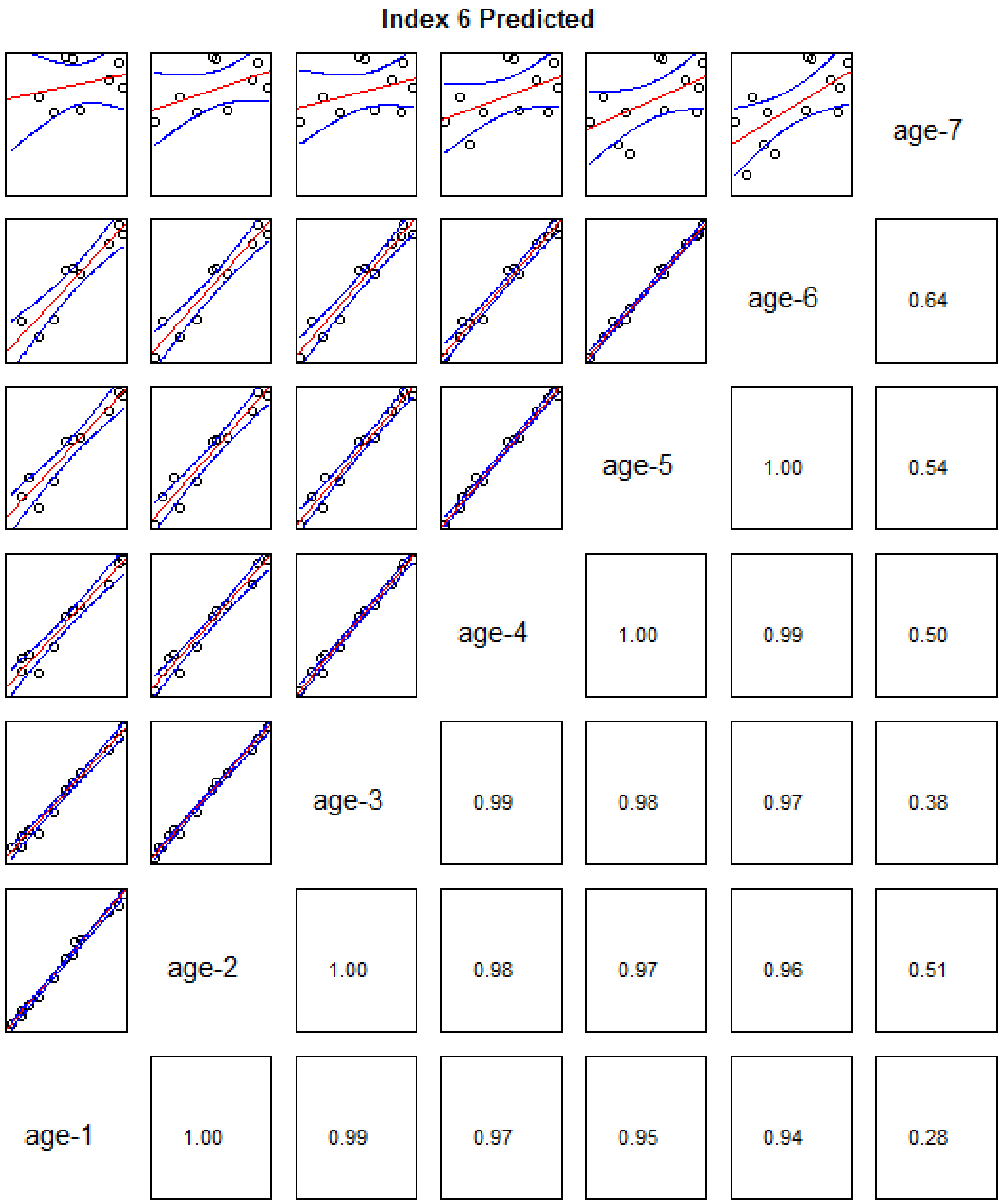
App. B7 Figure B7.96. Observed catch for the NEAMAP survey.



App. B7 Figure B7.97. Predicted catch for the NEAMAP survey.

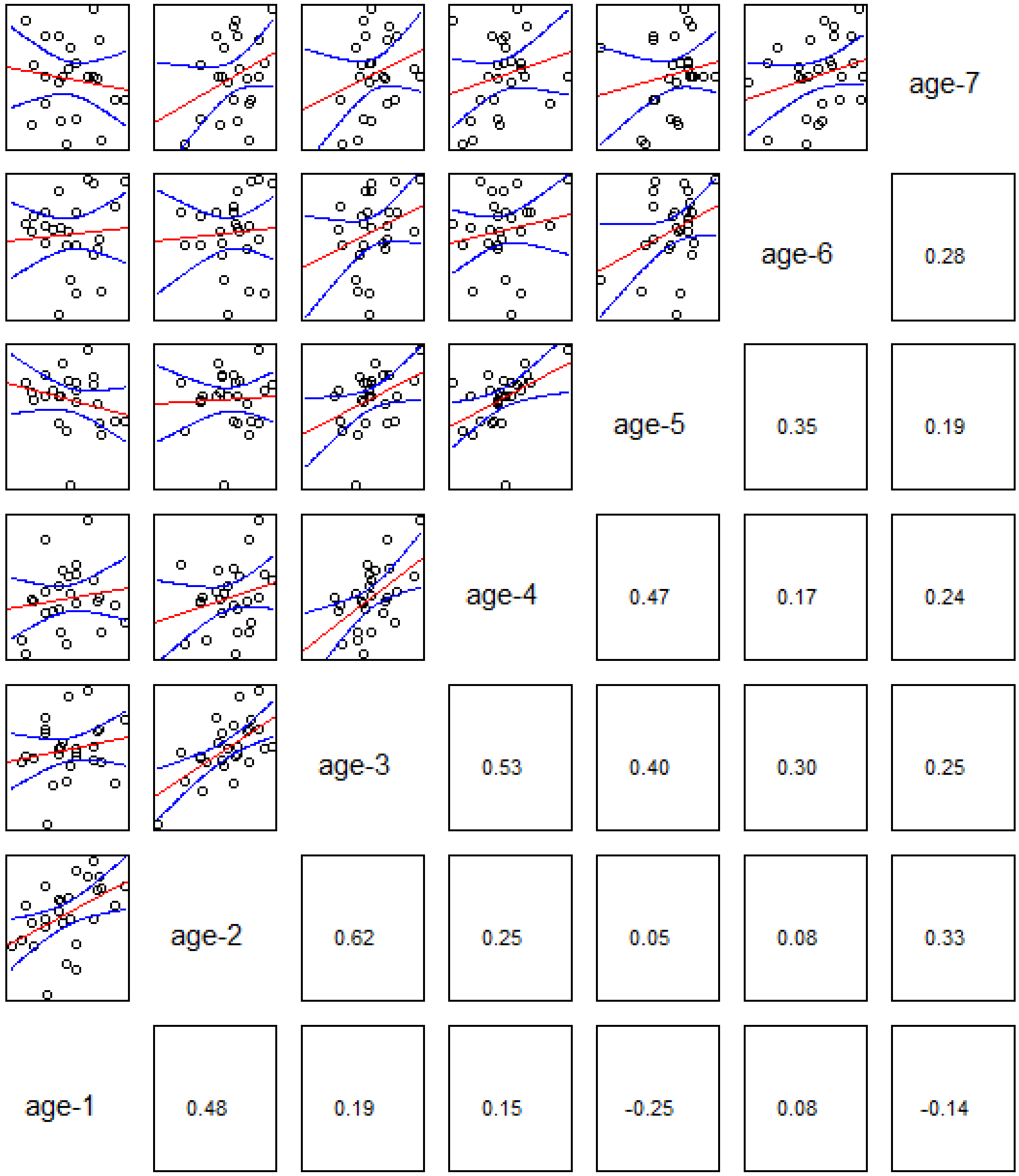


App. B7 Figure B7.98. Observed catch for the PSIGNS gillnet survey.

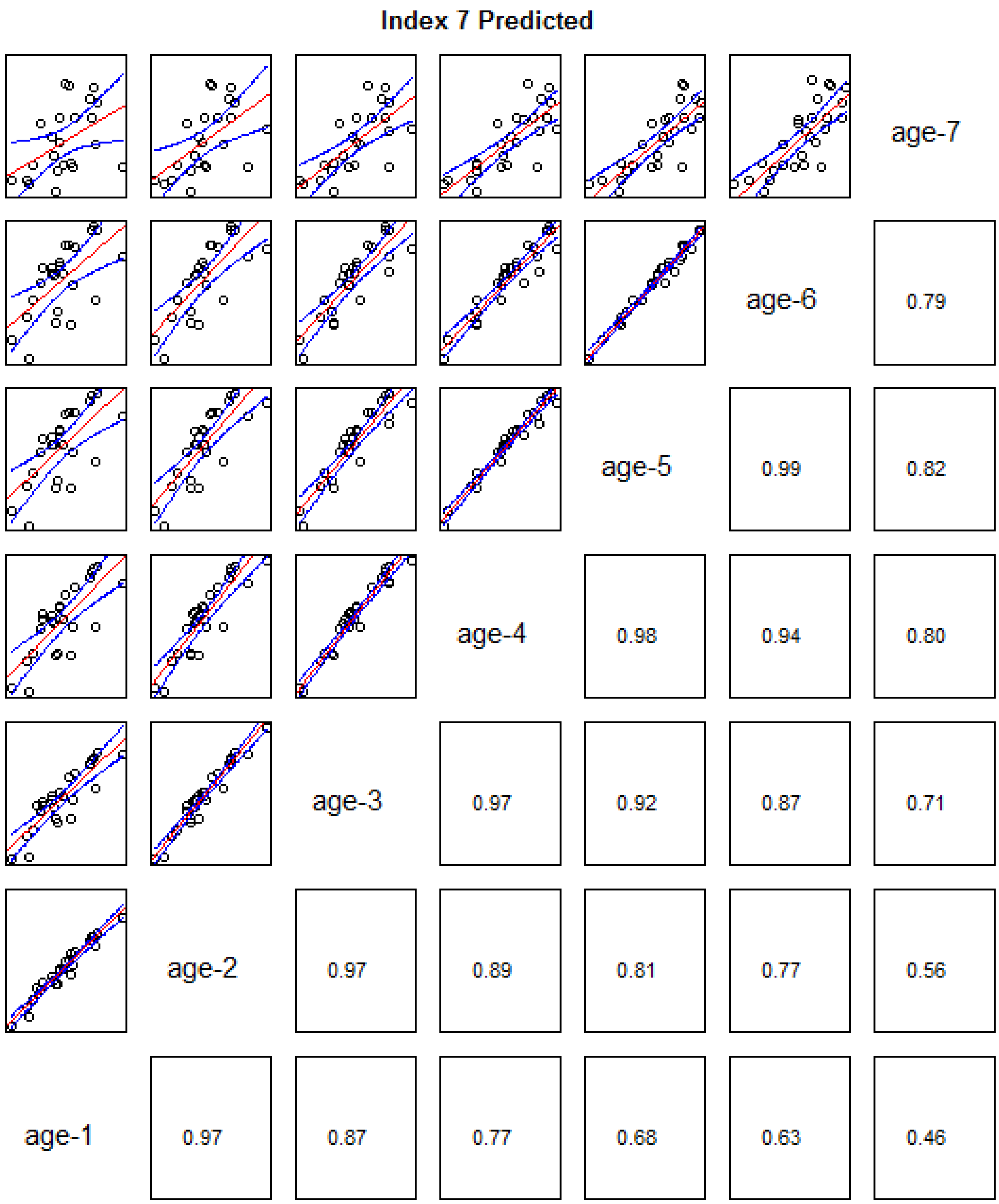


App. B7 Figure B7.99. Predicted catch for the PSIGNS gillnet survey.

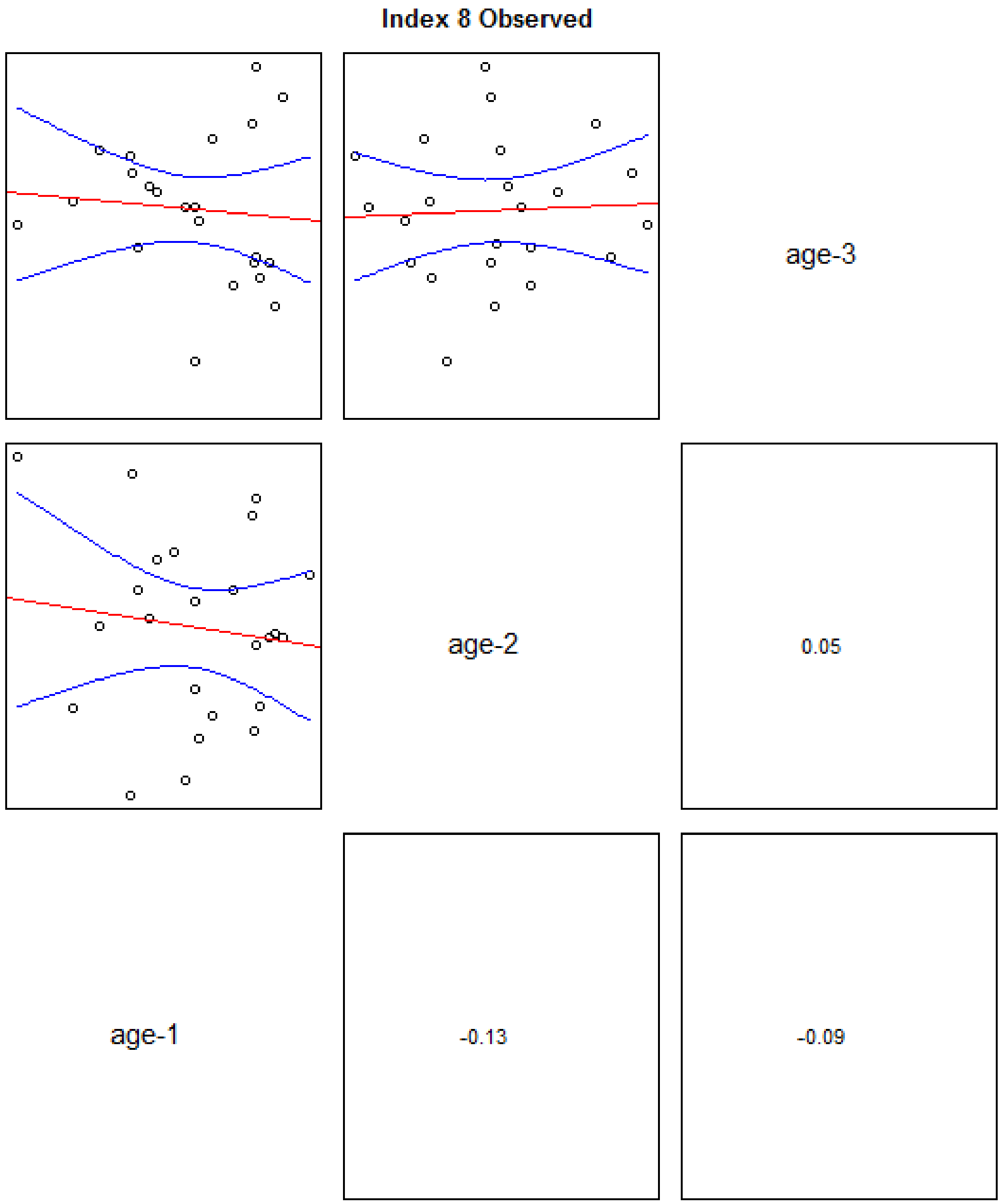
Index 7 Observed



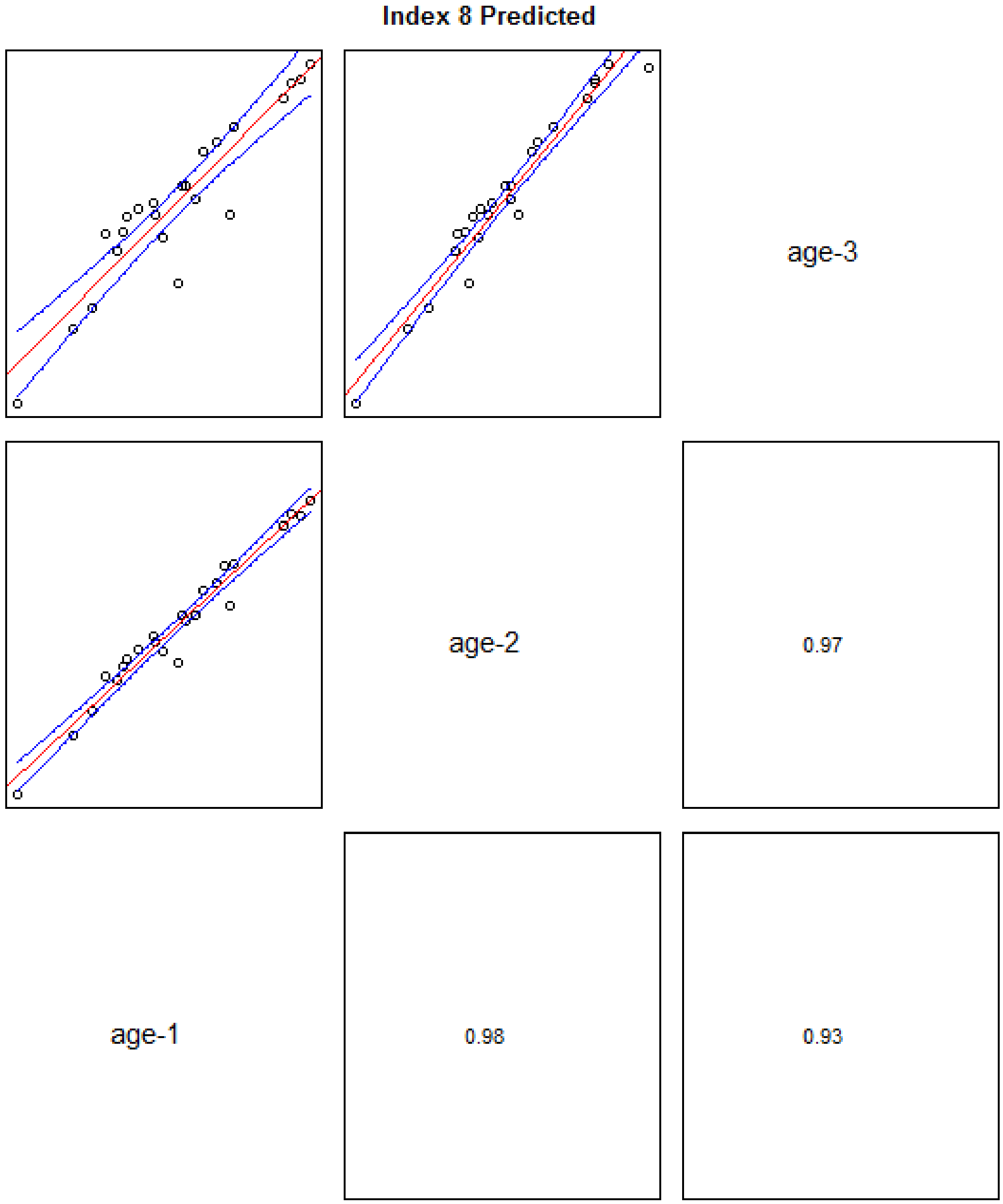
App. B7 Figure B7.100. Observed catch for the CT LISTS trawl survey.



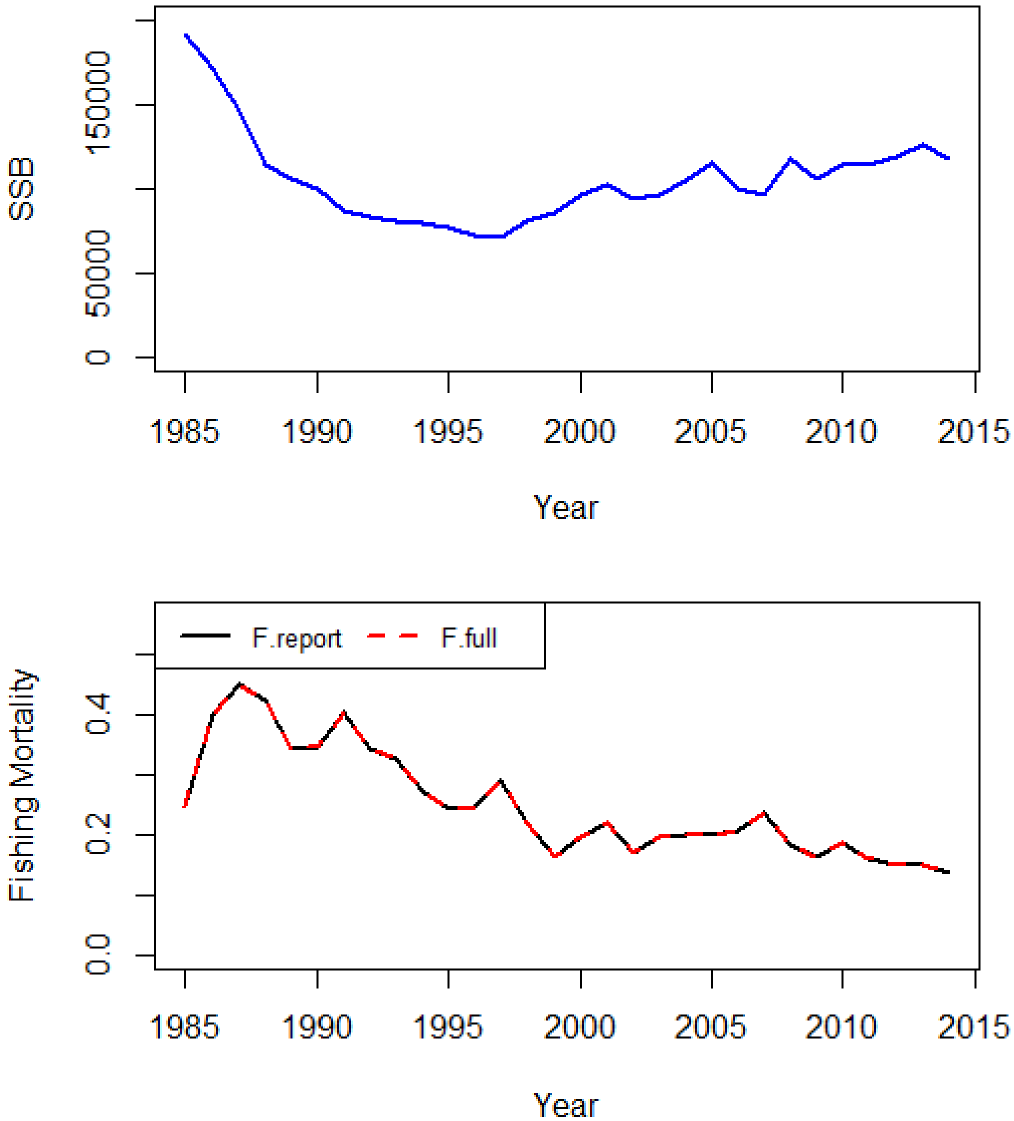
App. B7 Figure B7.101. Predicted catch for the CT LISTS trawl survey.



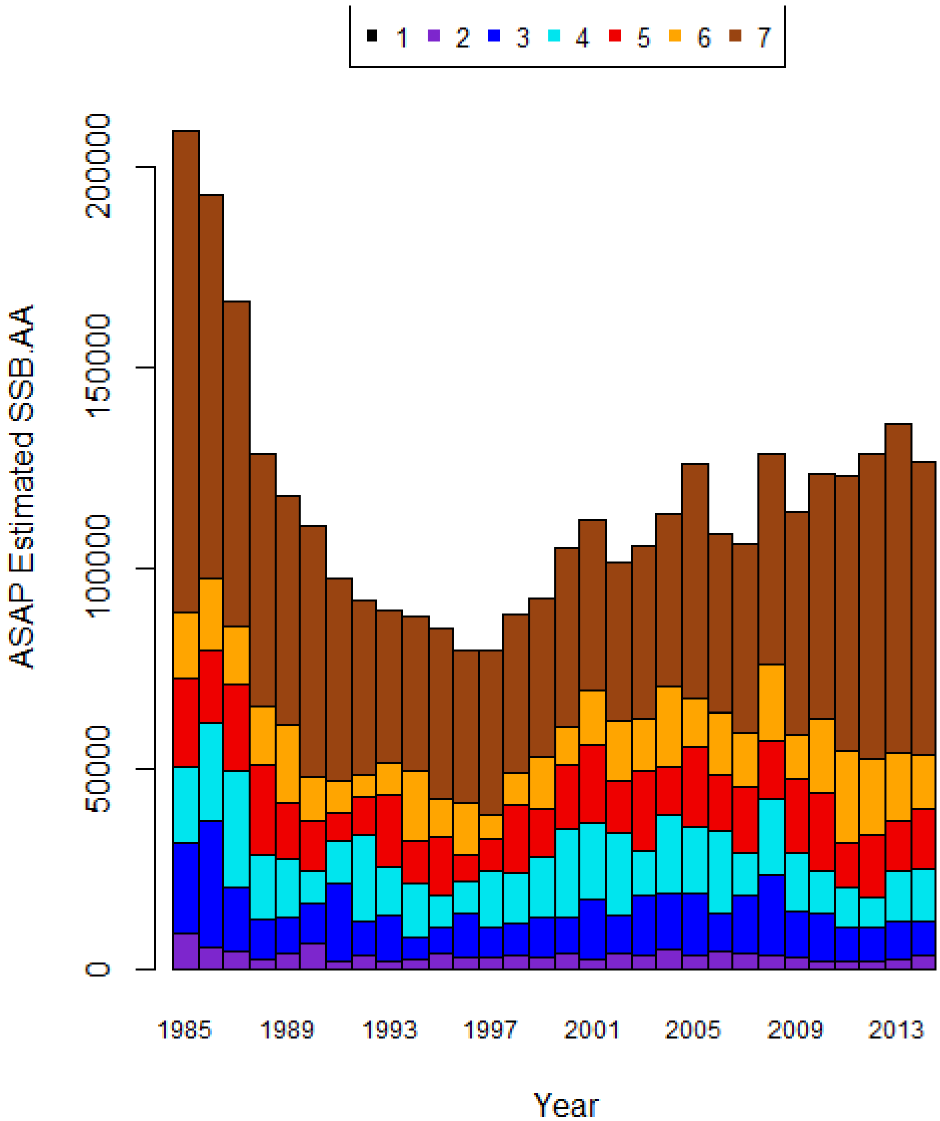
App. B7 Figure B7.102. Observed catch for the NJ ocean trawl survey.



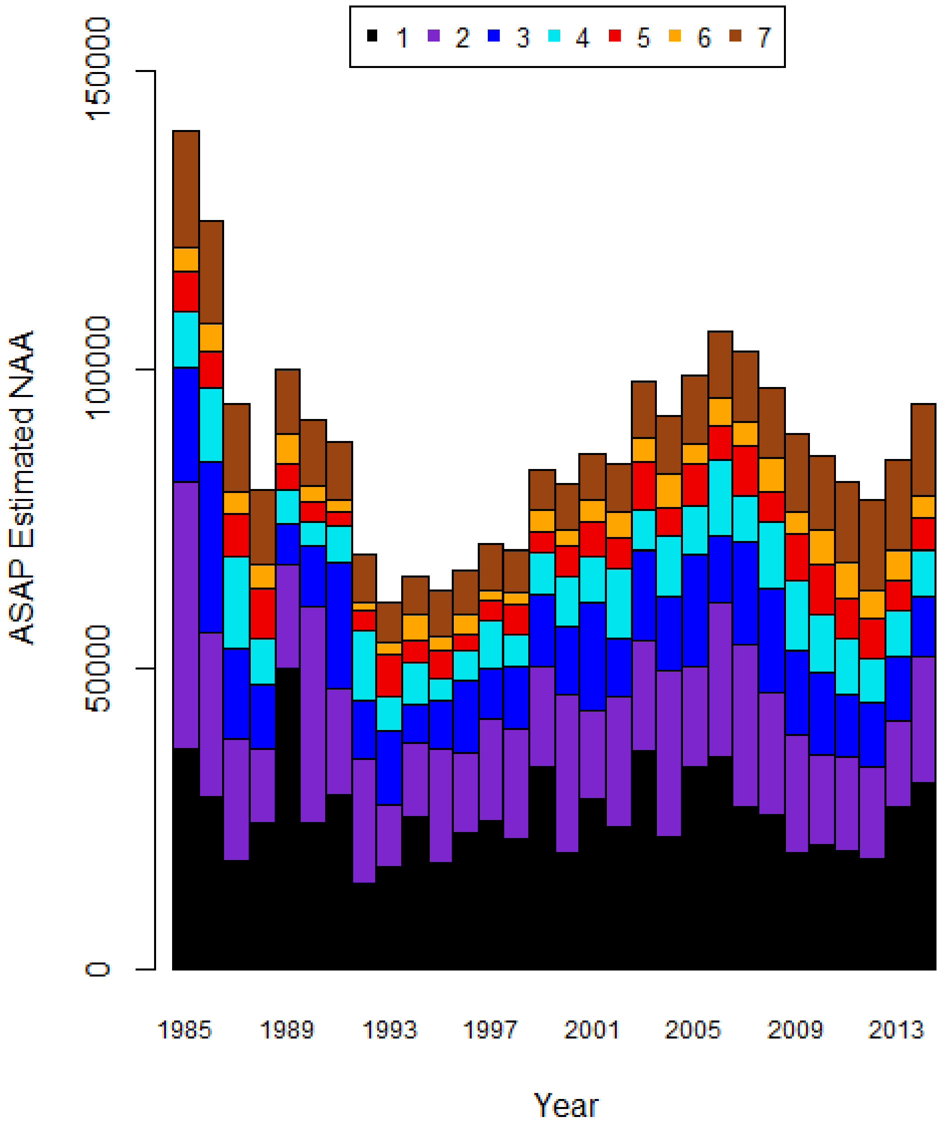
App. B7 Figure B7.103. Predicted catch for the NJ ocean trawl survey.



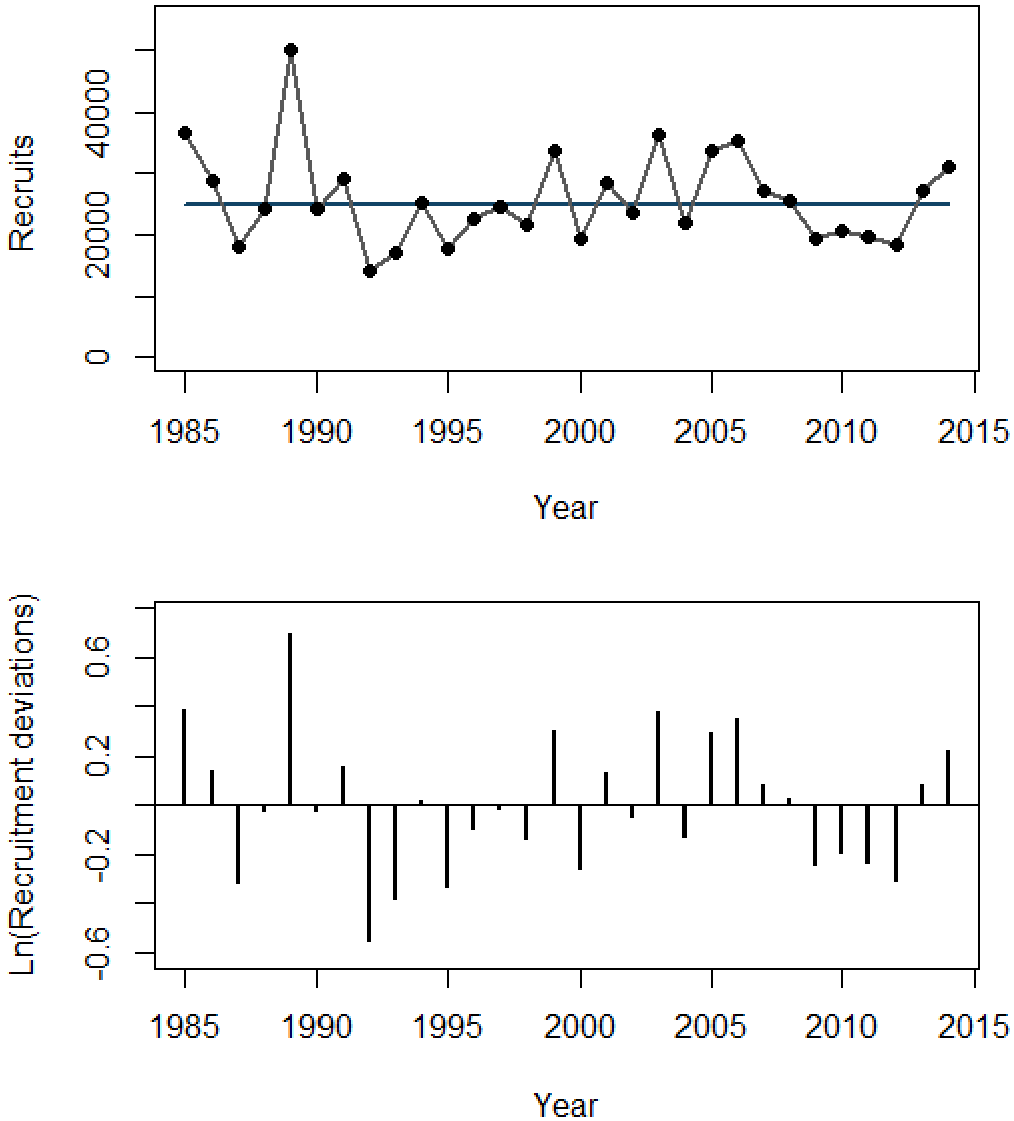
App. B7 Figure B7.104. Estimated spawning stock biomass and full fishing mortality from 1985 to 2014 from the final model.



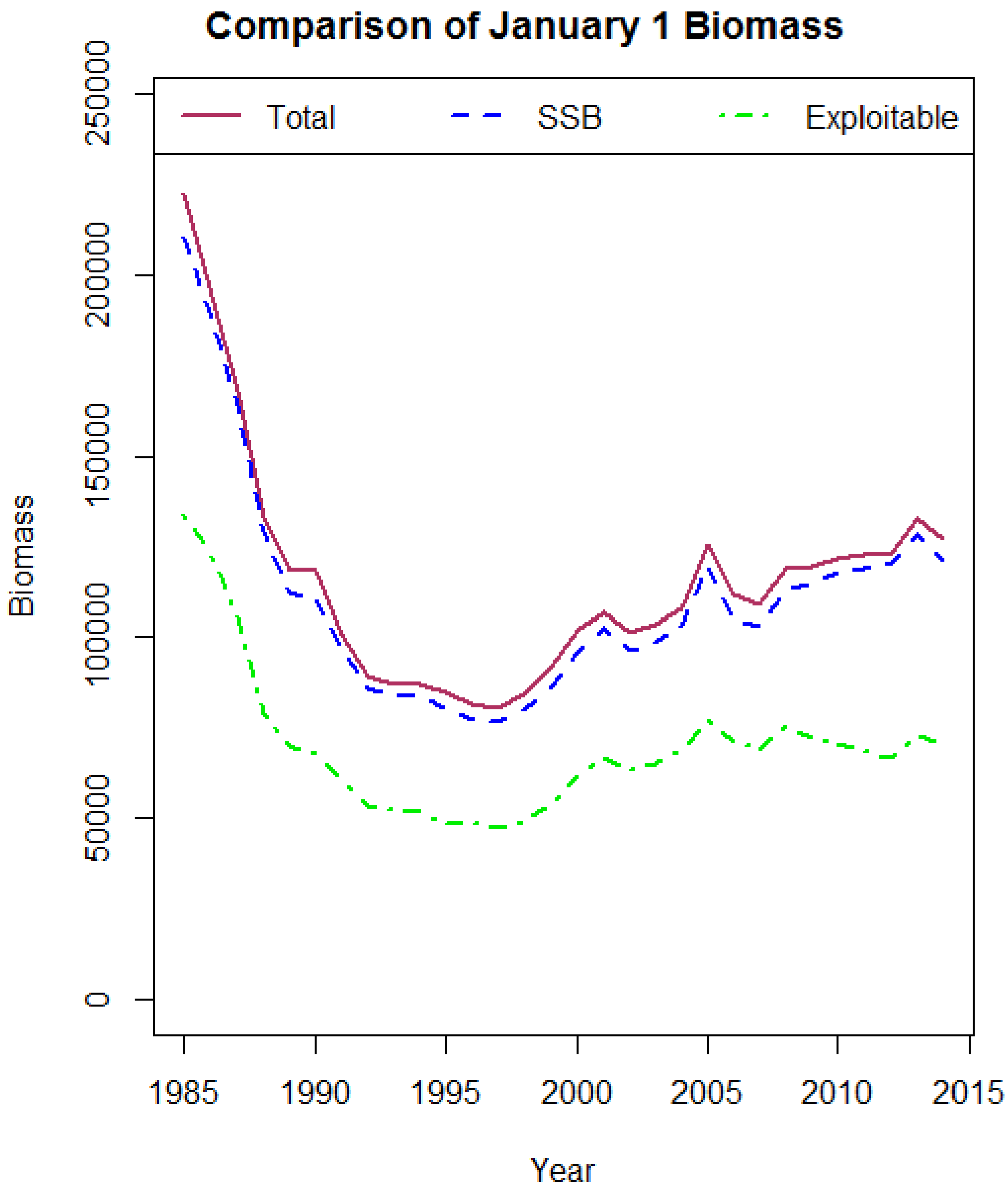
App. B7 Figure B7.105. Age composition of the spawning stock biomass from 1985 to 2014.



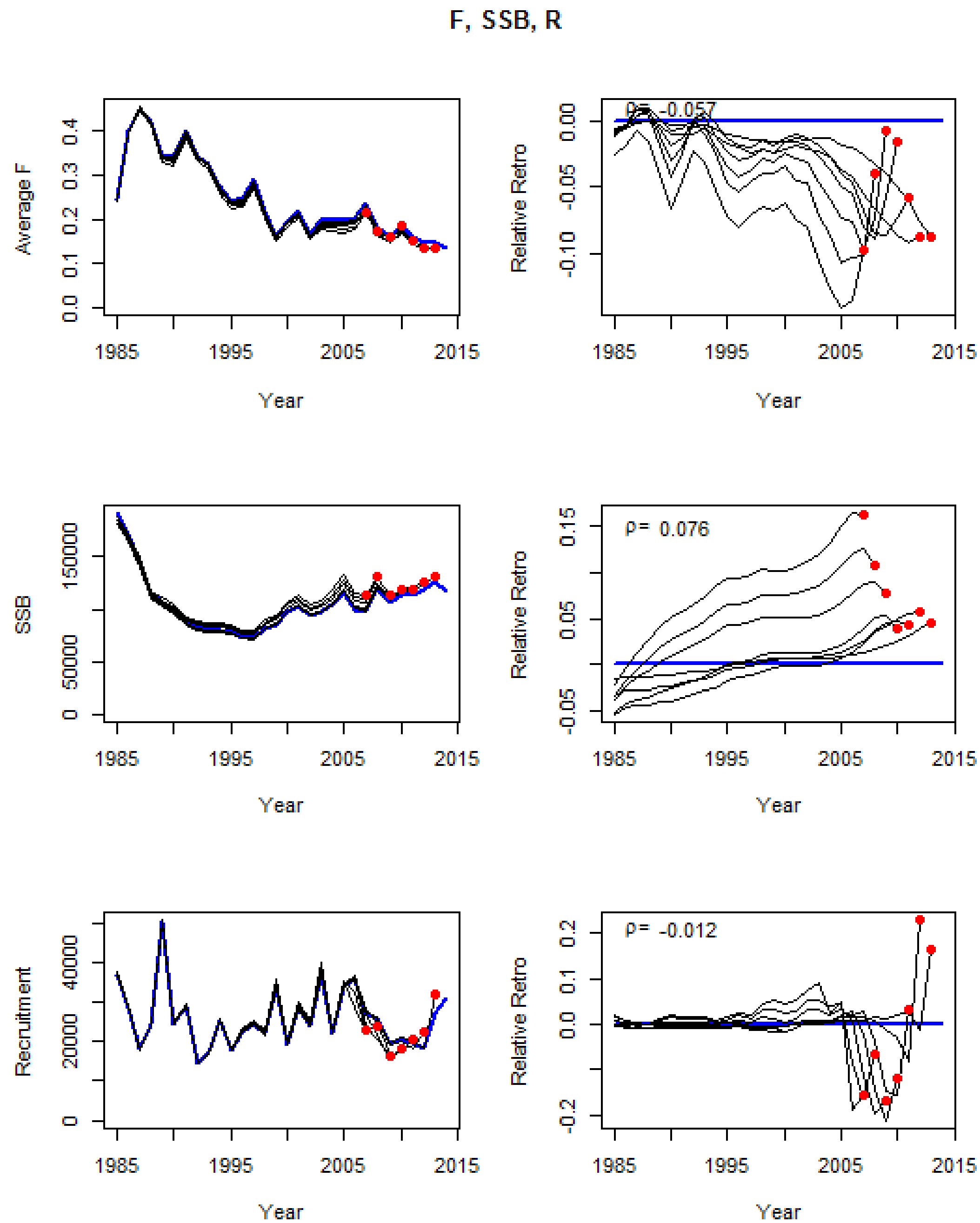
App. B7 Figure B7.106. Estimated numbers at age from the final model from 1985 to 2014.



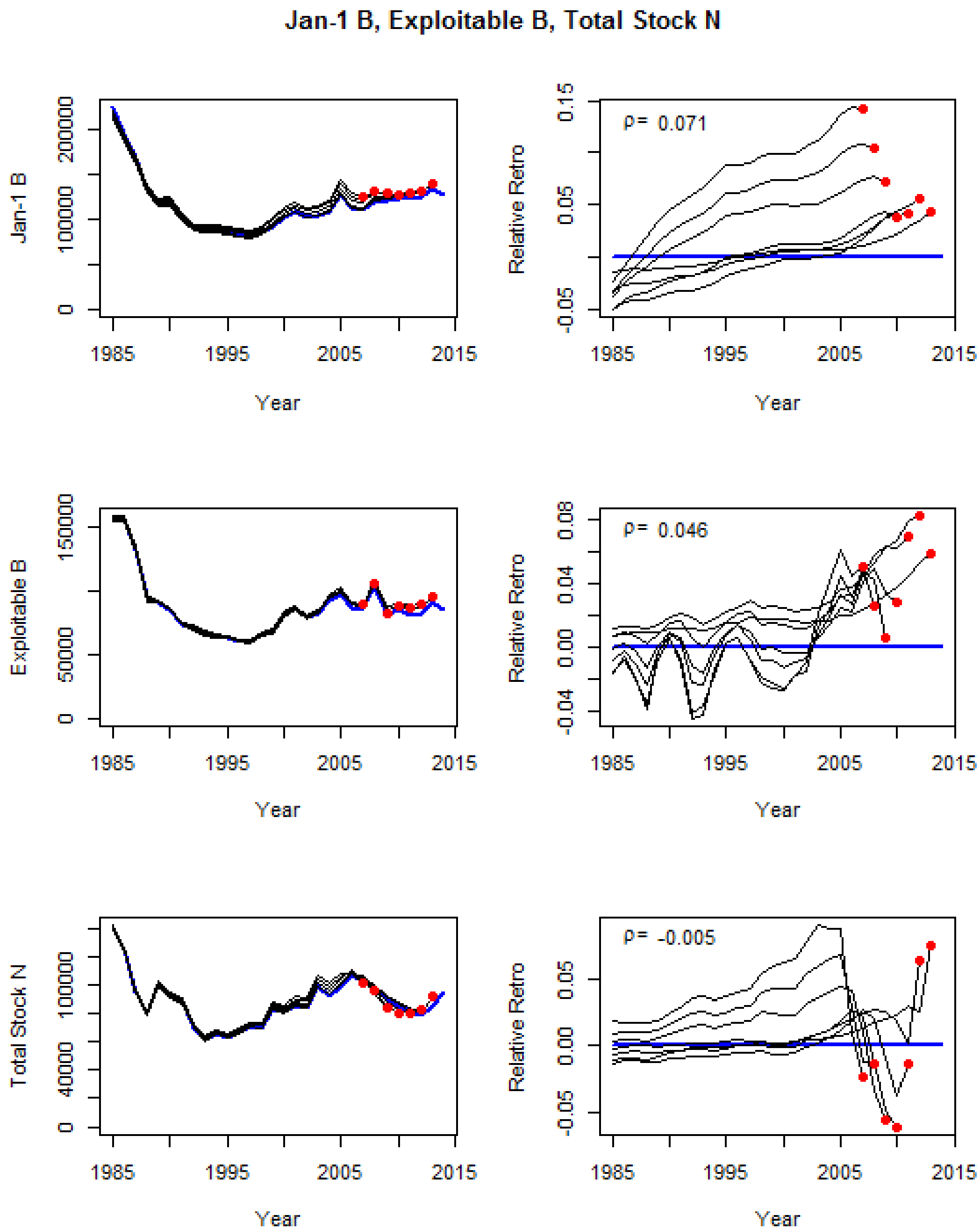
App. B7 Figure B7.107. Recruitment estimates, mean recruitment, and recruitment deviations (log) from 1985 to 2014 from the final model.



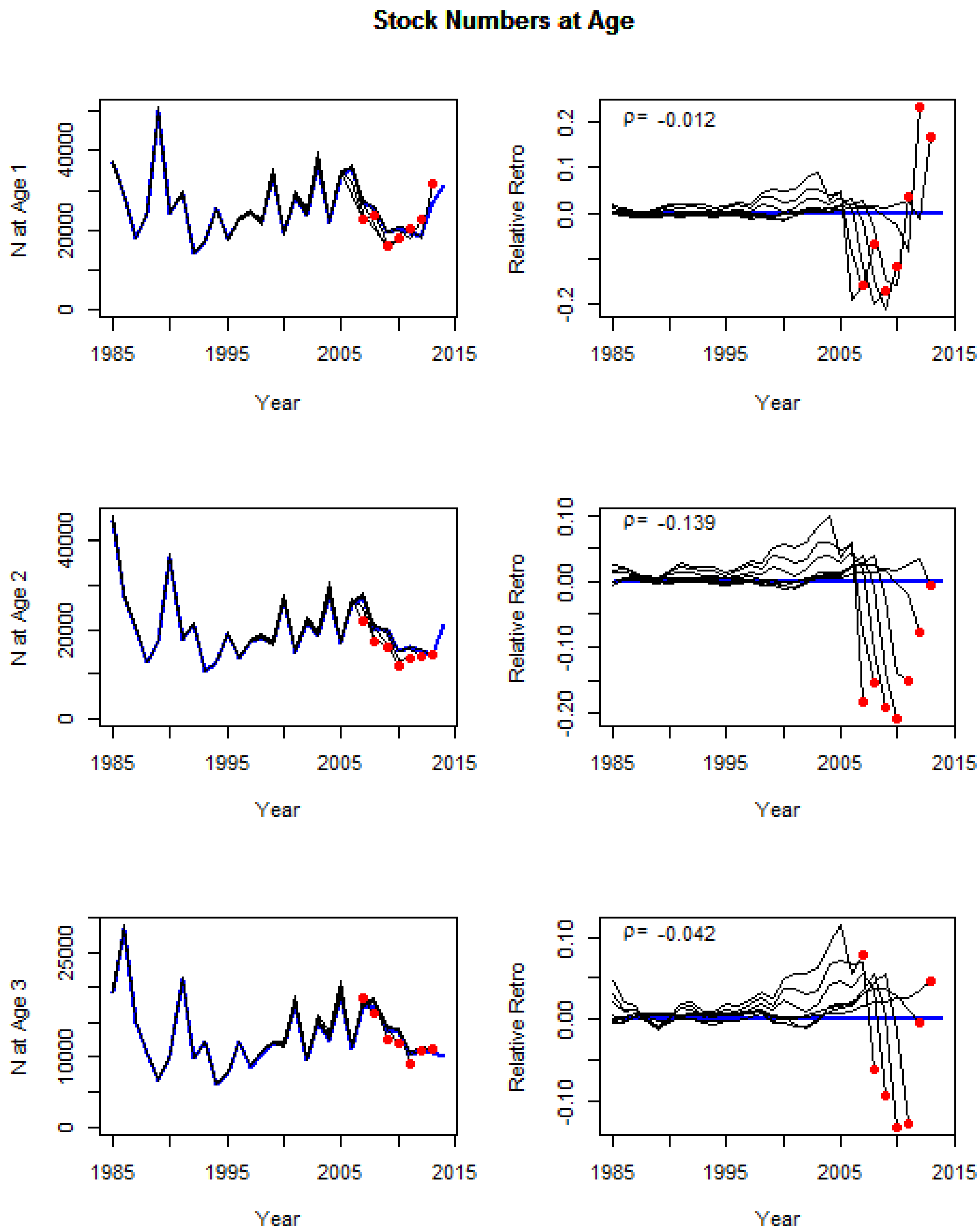
App. B7 Figure B7.108. A comparison of total, spawning stock, and exploitable biomass from 1985 to 2014 from the final model.



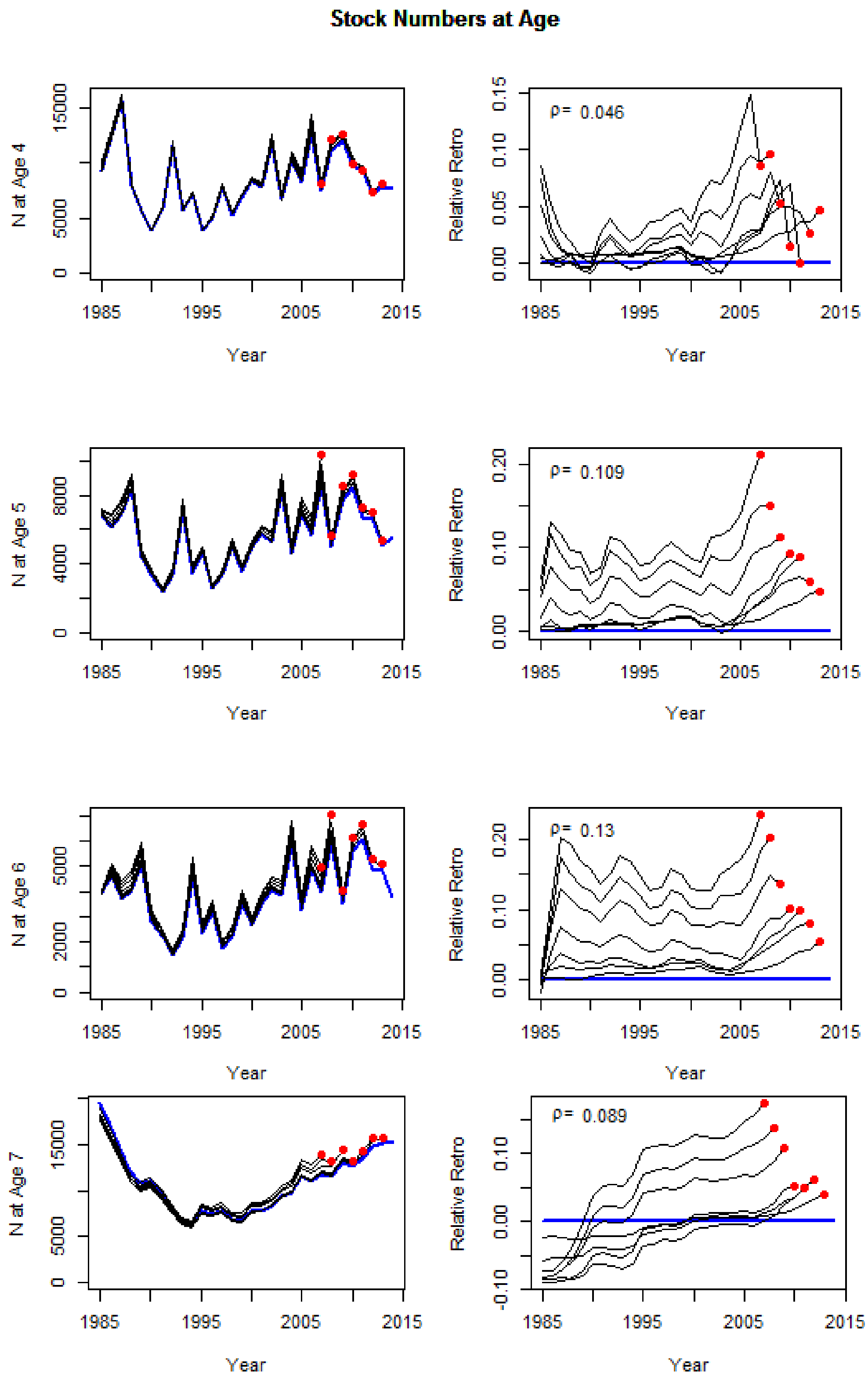
App. B7 Figure B7.109. Retrospective plots for average fishing mortality, spawning stock biomass and recruitment from a 7 year peel carried out on the final model.



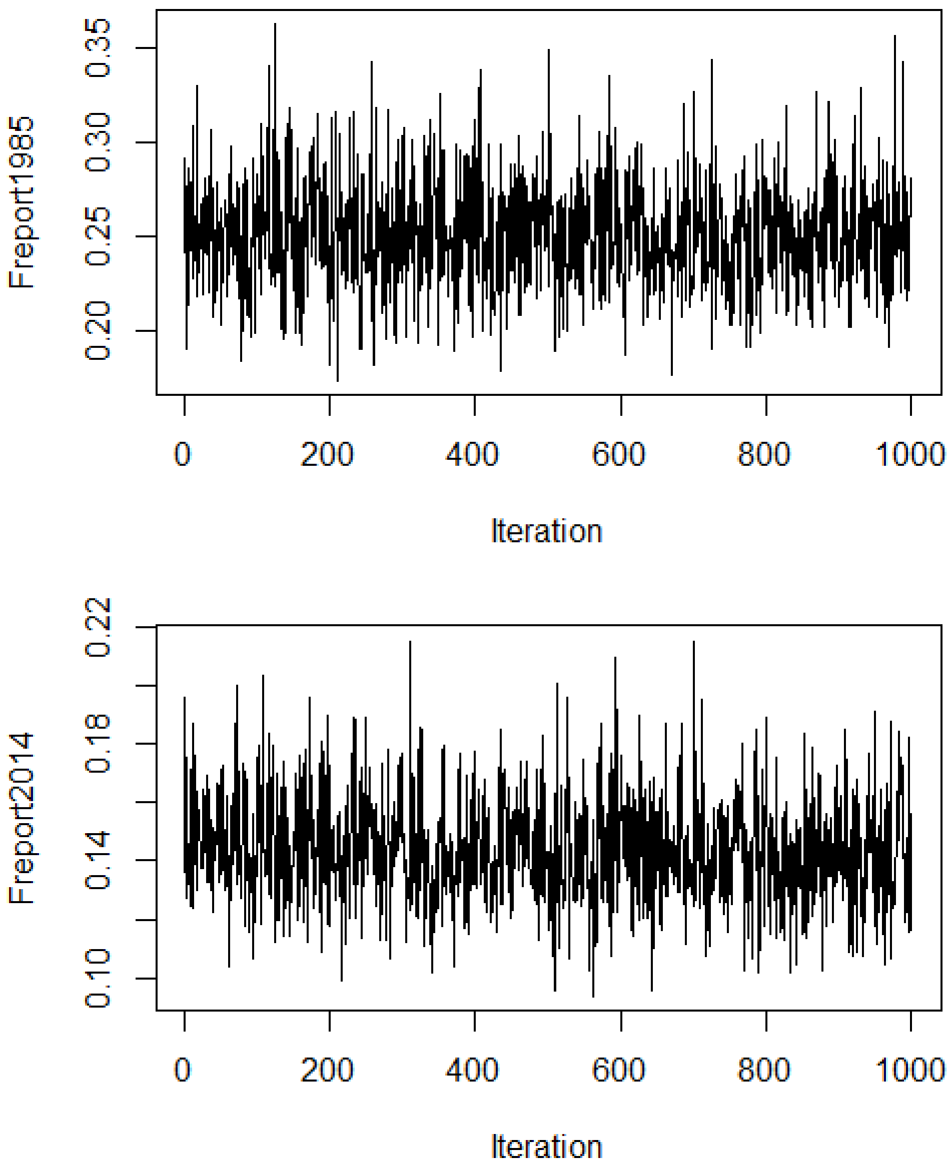
App. B7 Figure B7.110. Retrospective plots for January-1 biomass, total biomass, and total stock numbers, from a 7 year peel carried out on the final model.



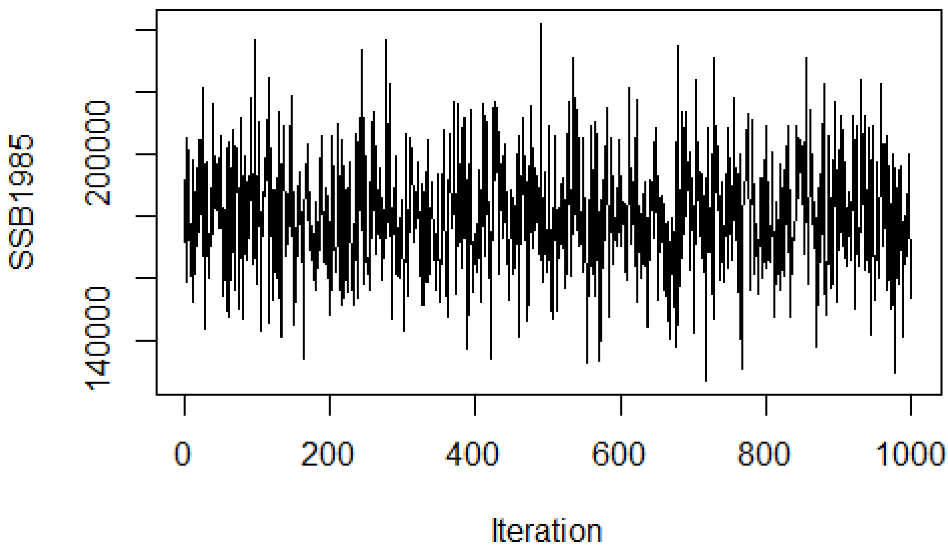
App. B7 Figure B7.111. Retrospective plots for ages 0-2 from a 7 year peel carried out on the final model.

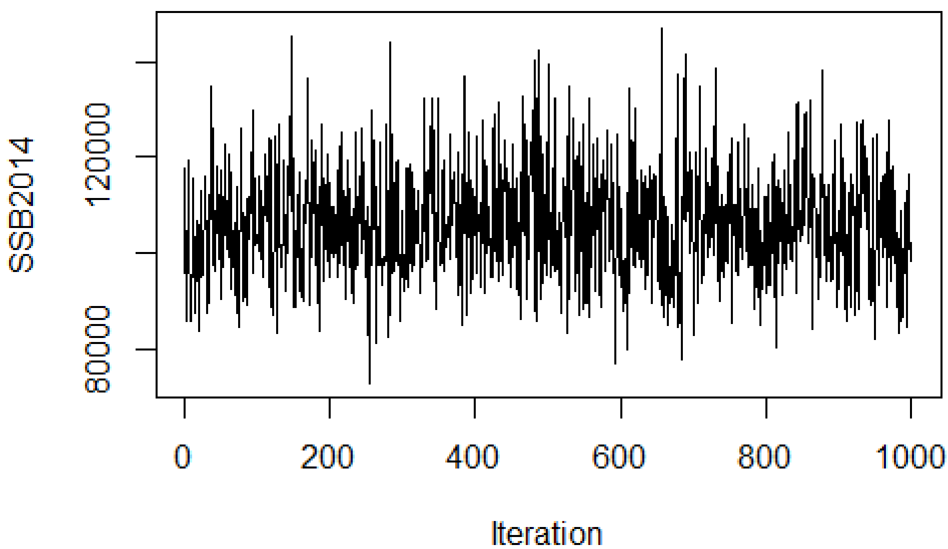


App. B7 Figure B7.112. Retrospective plots for ages 3-6+ from a 7 year peel carried out on the final model.

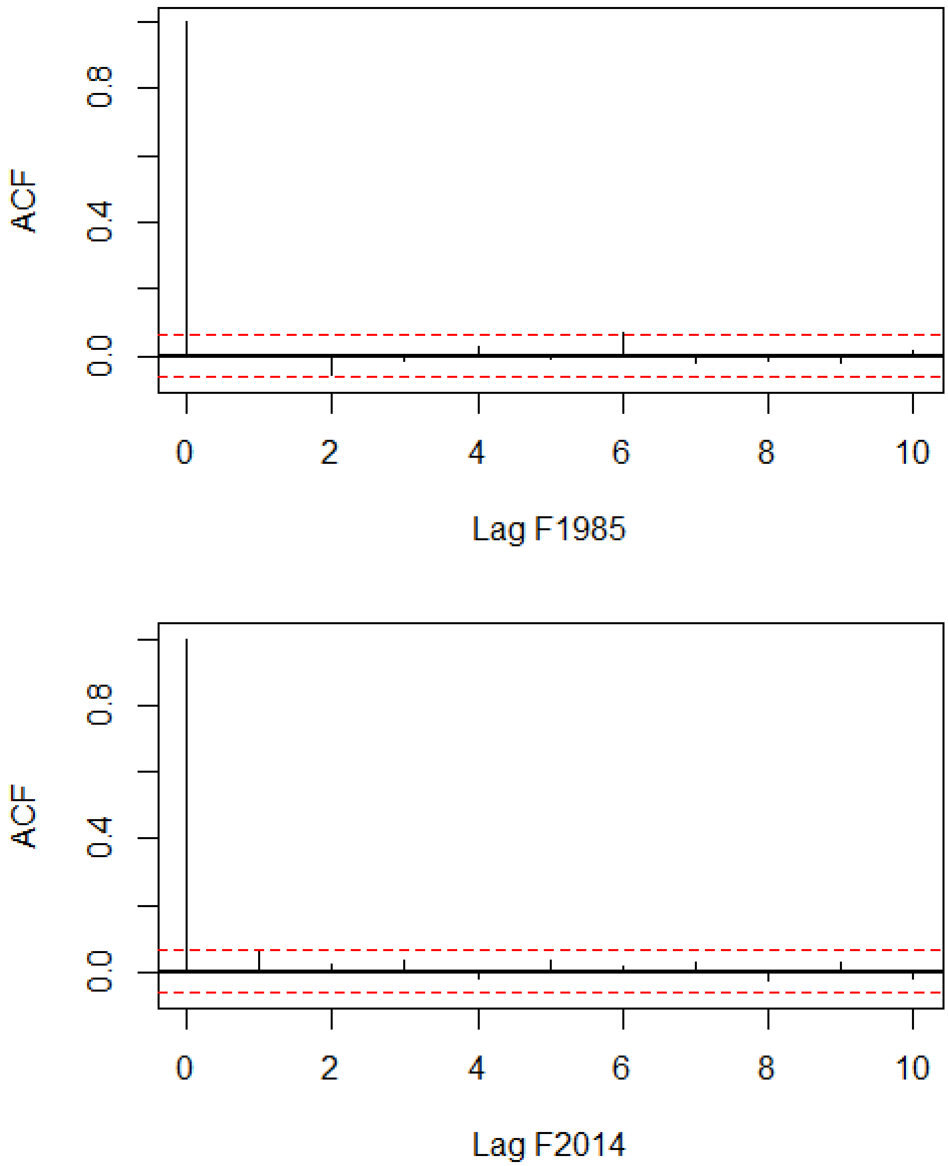


App. B7 Figure B7.113. Trace plots for fishing mortality in 1985 and 2014 from 1000 MCMC and a thinning rate of 1000 (1,000,000 iterations).

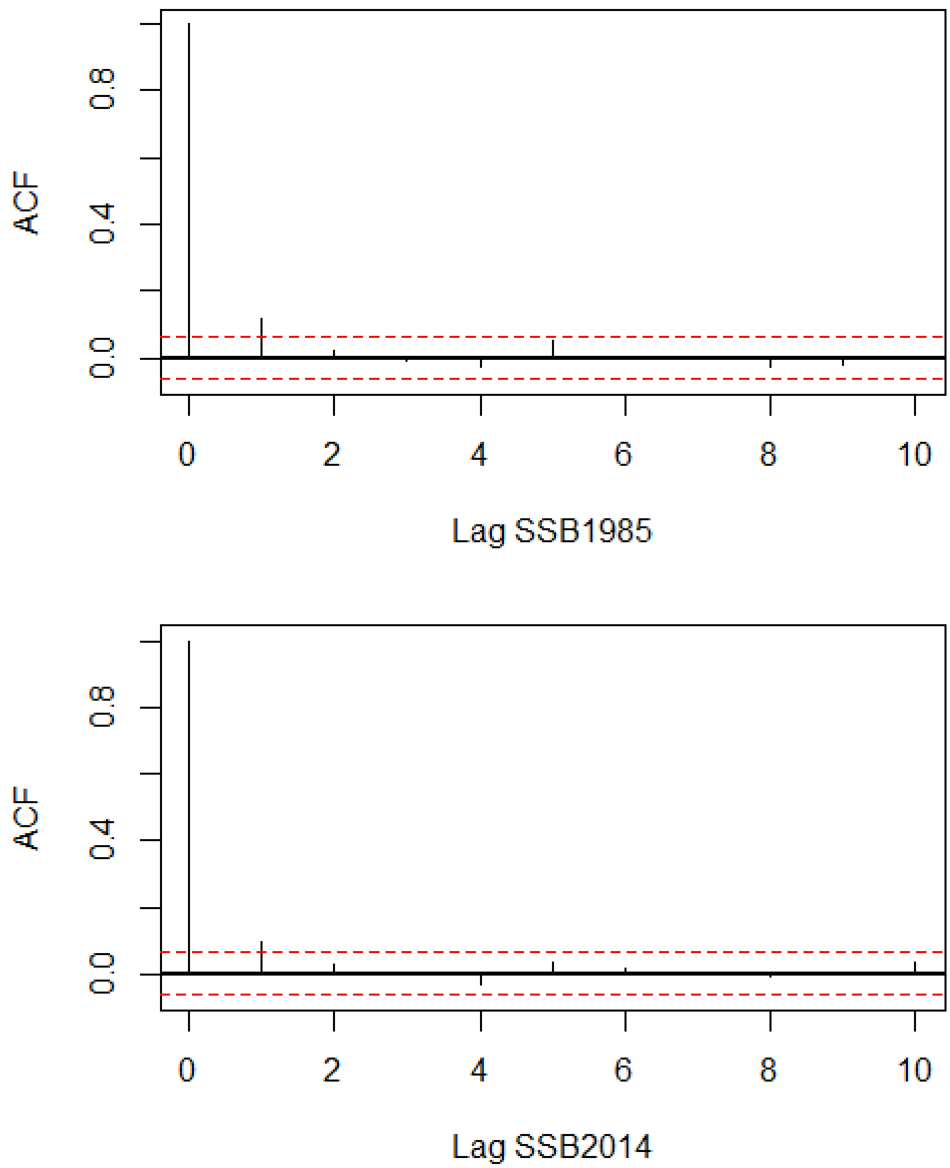




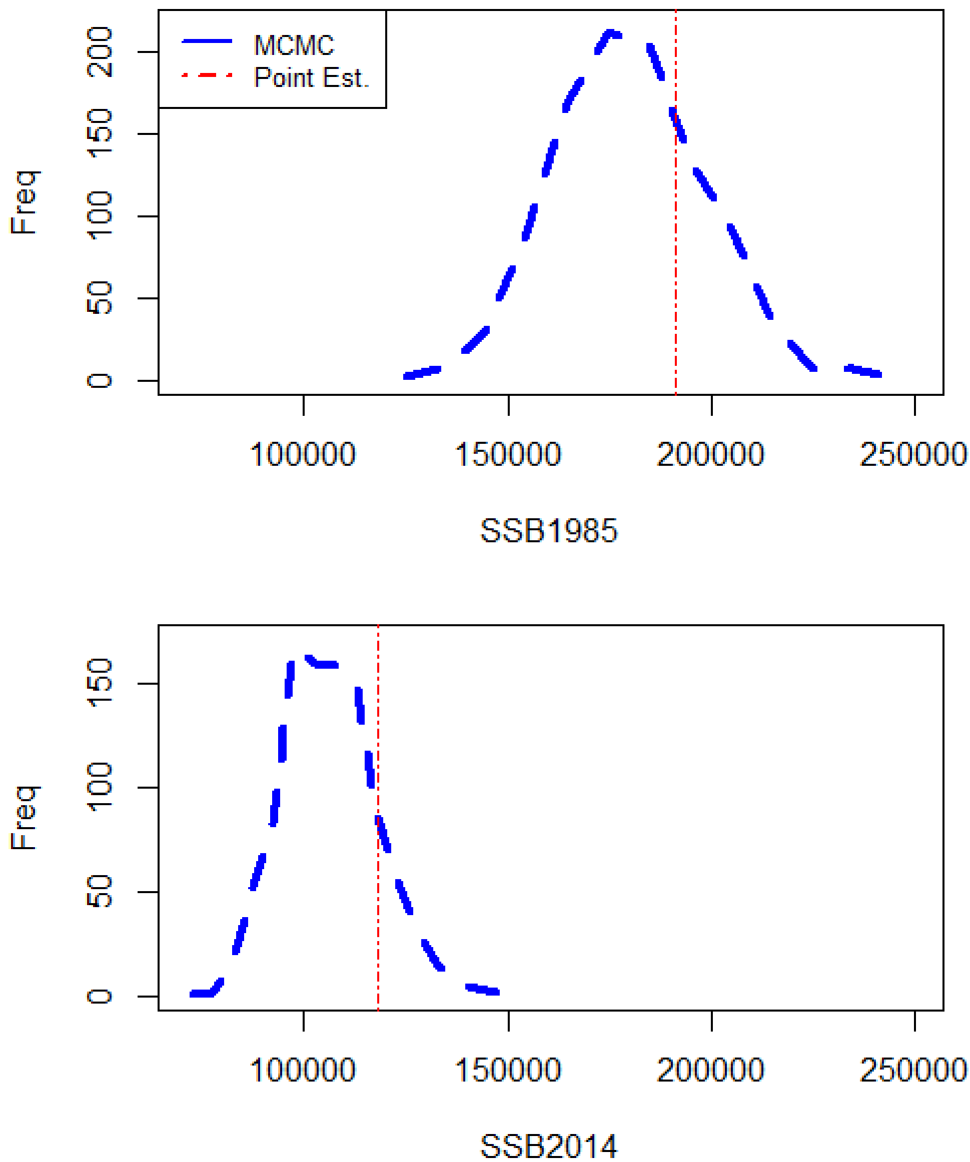
App. B7 Figure B7.114. Trace plots for spawning stock biomass in 1985 and 2014 from 1000 MCMC and a thinning rate of 1000 (1,000,000 iterations).



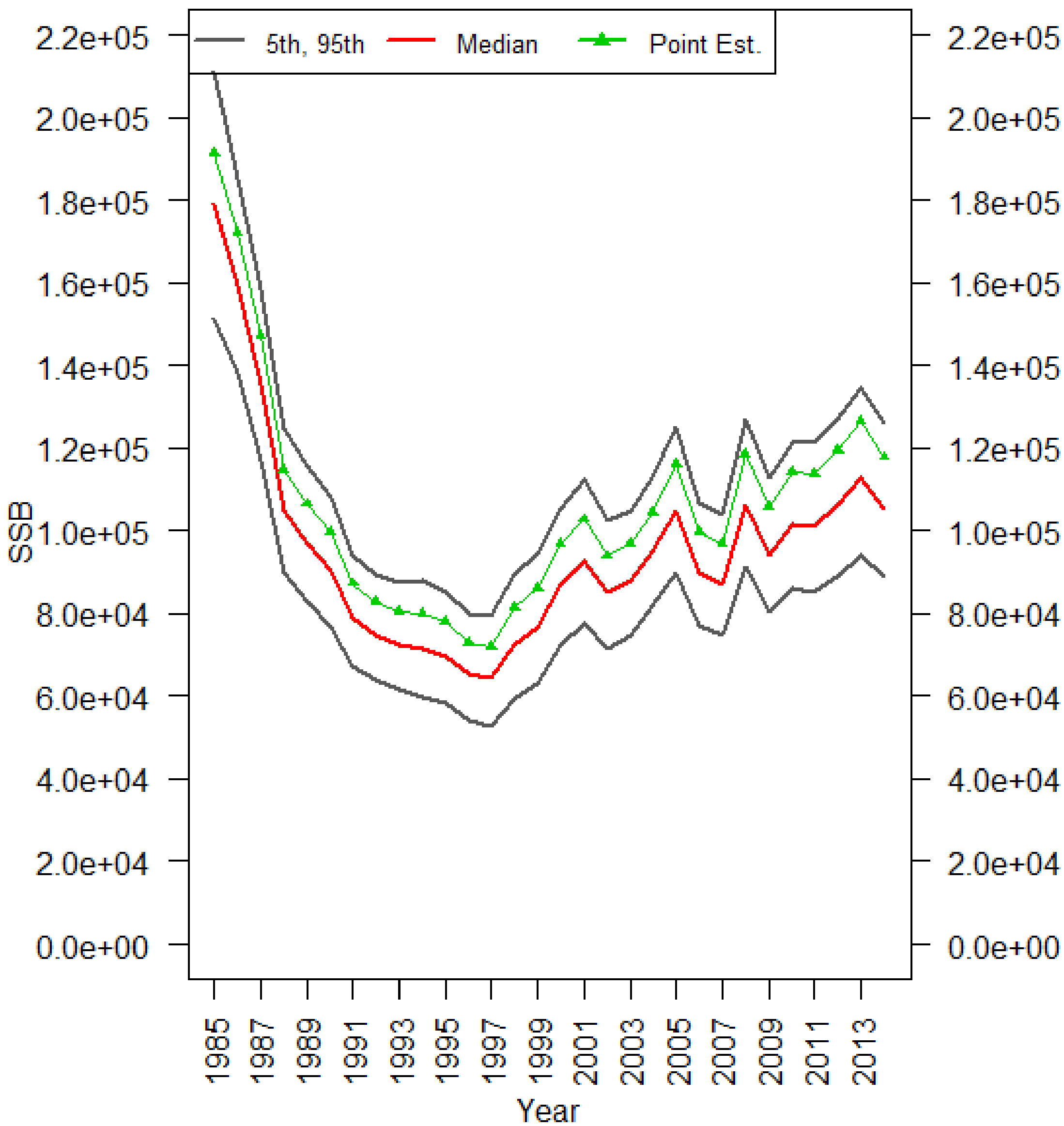
App. B7 Figure B7.115. Autocorrelation for fishing mortality in the MCMC runs.



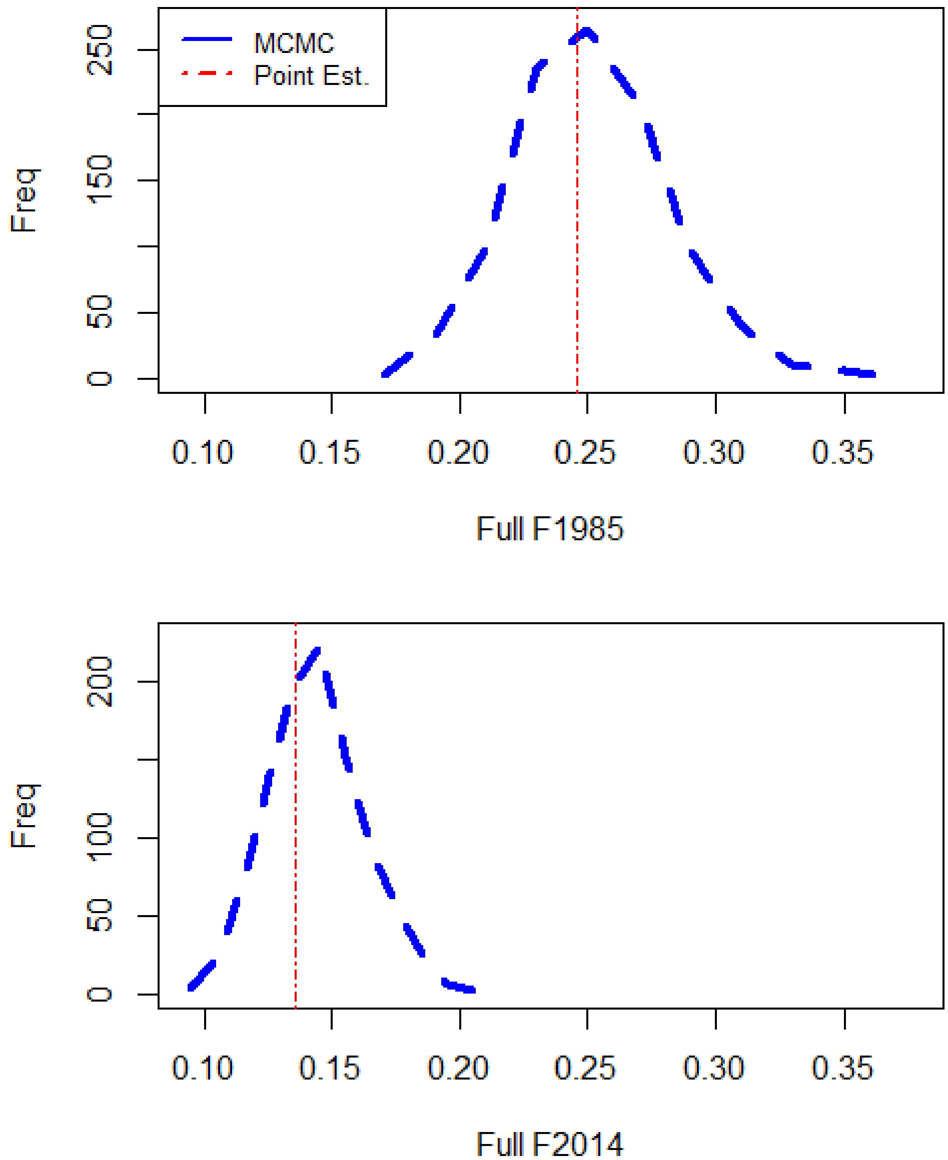
App. B7 Figure B7.116. Autocorrelation for SSB in the MCMC runs.



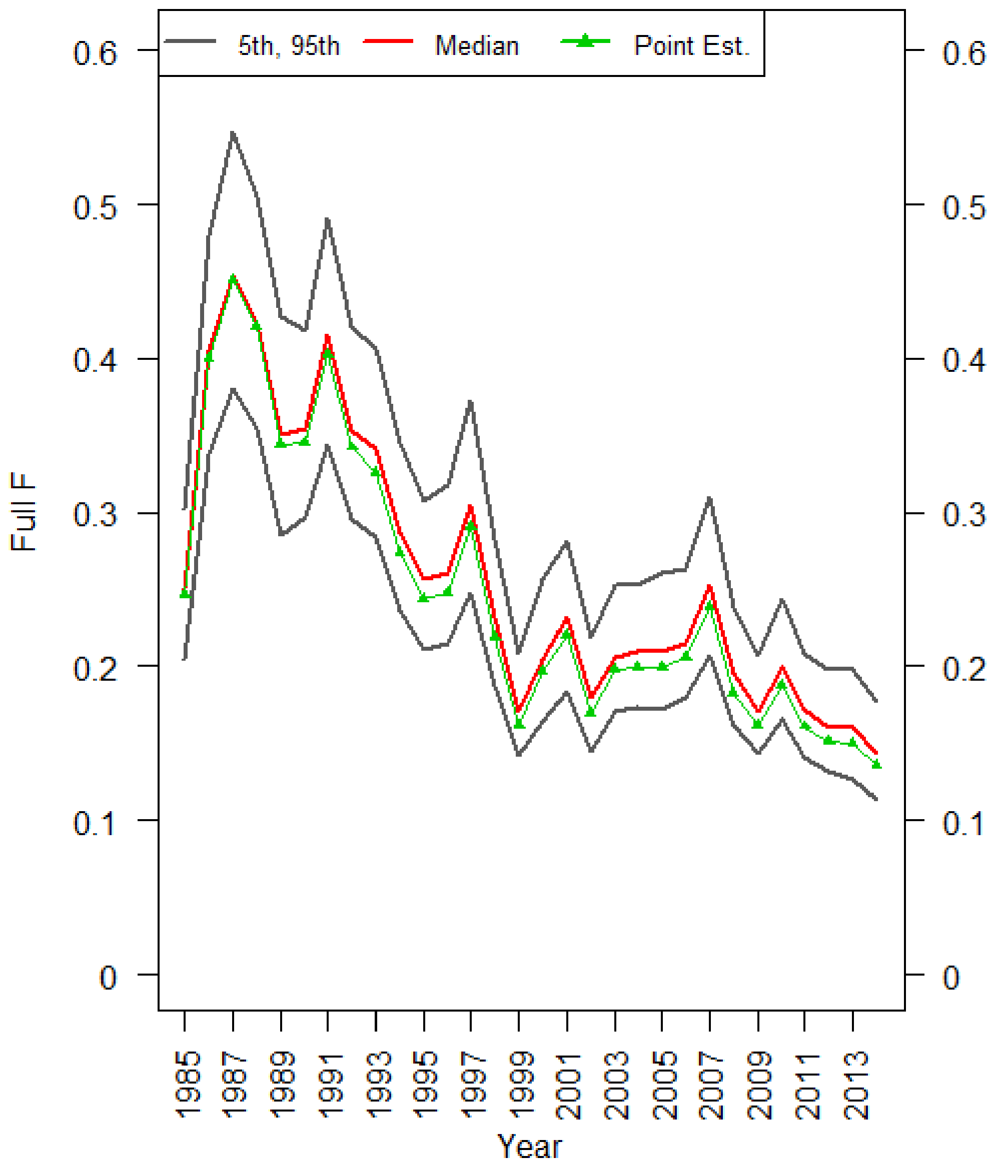
App. B7 Figure B7.117. MCMC distribution plots for spawning stock biomass in 1985 and 2014 with point estimates from the final model.



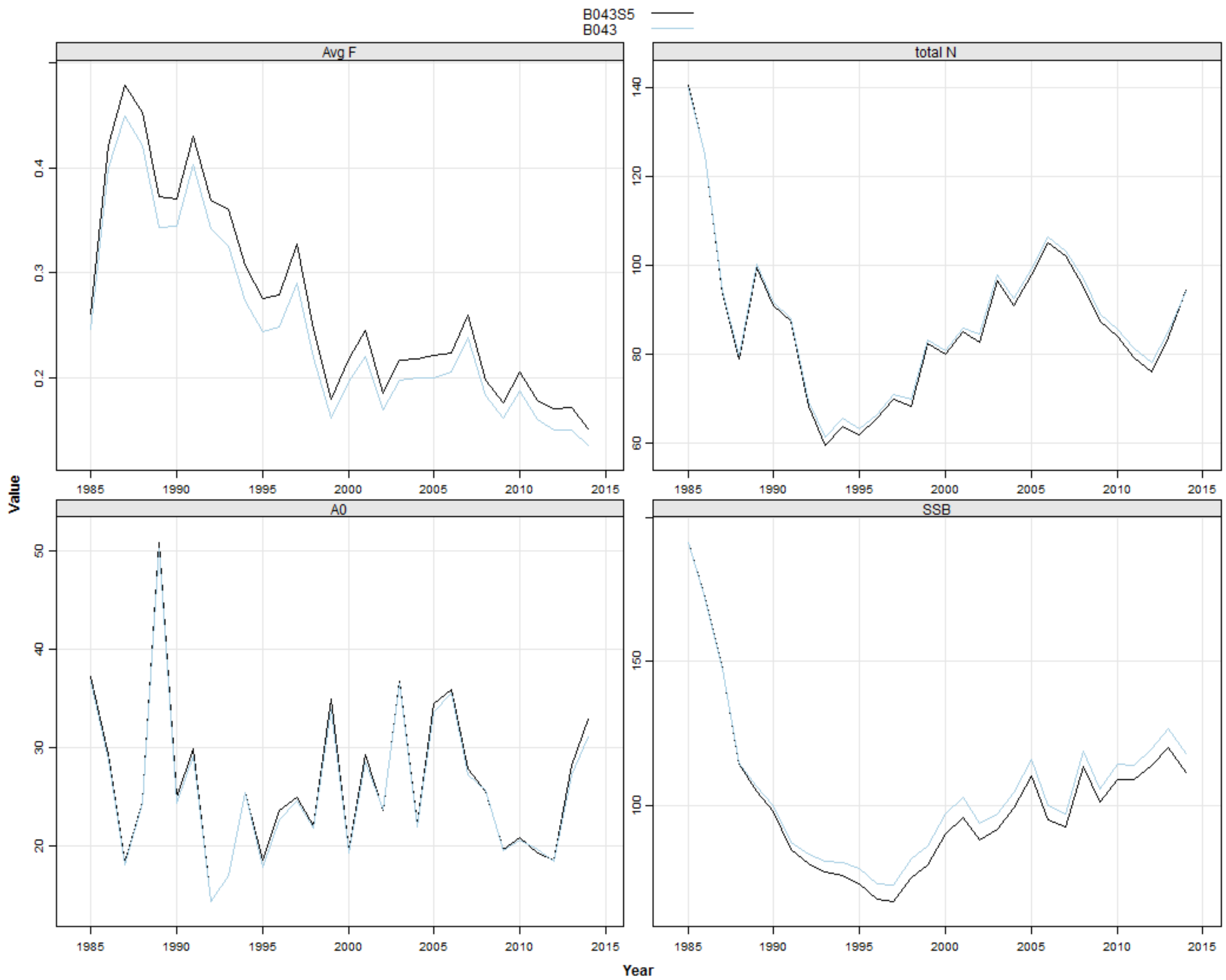
App. B7 Figure B7.118. Median spawning stock biomass and 95 confidence intervals from the MCMC runs with point estimates from the final model.



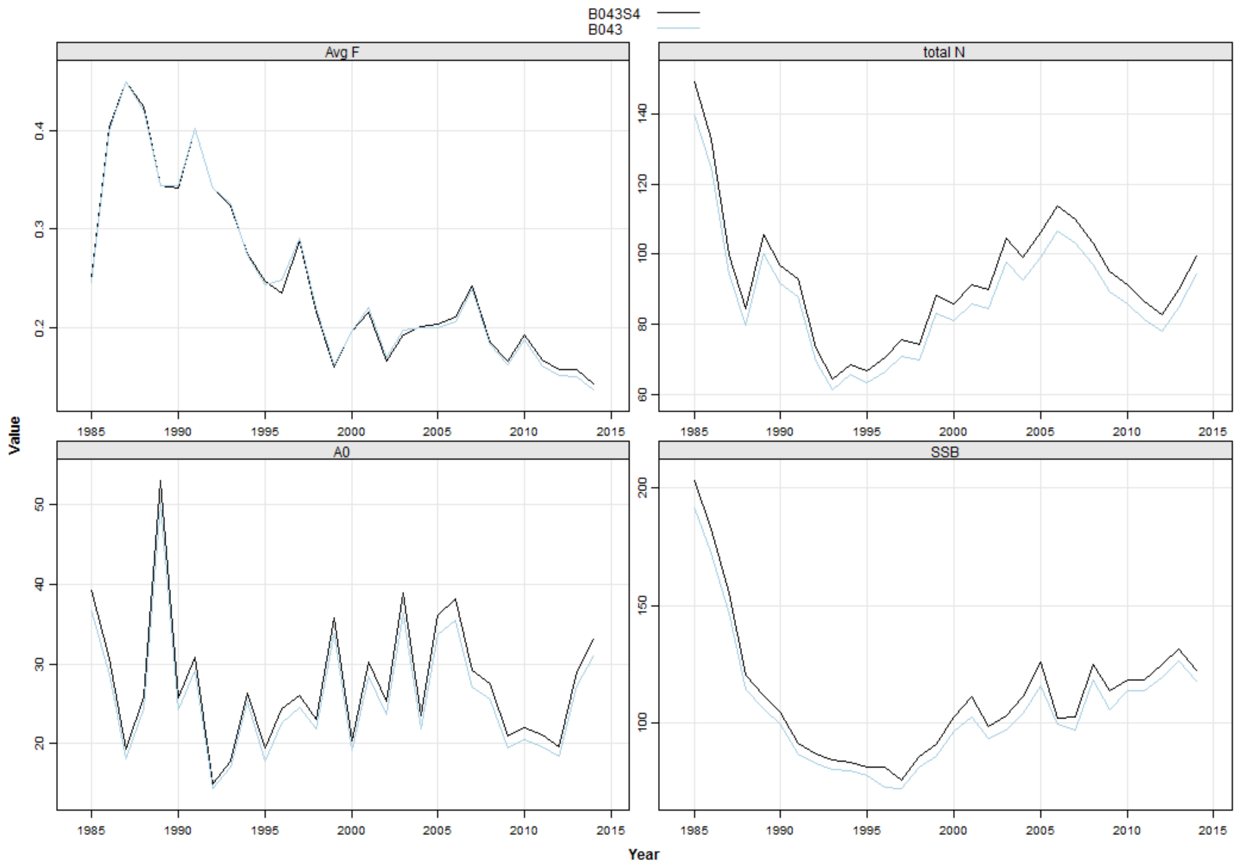
App. B7 Figure B7.119. MCMC distribution plots for fishing mortality in 1985 and 2014 with point estimates from the final model.



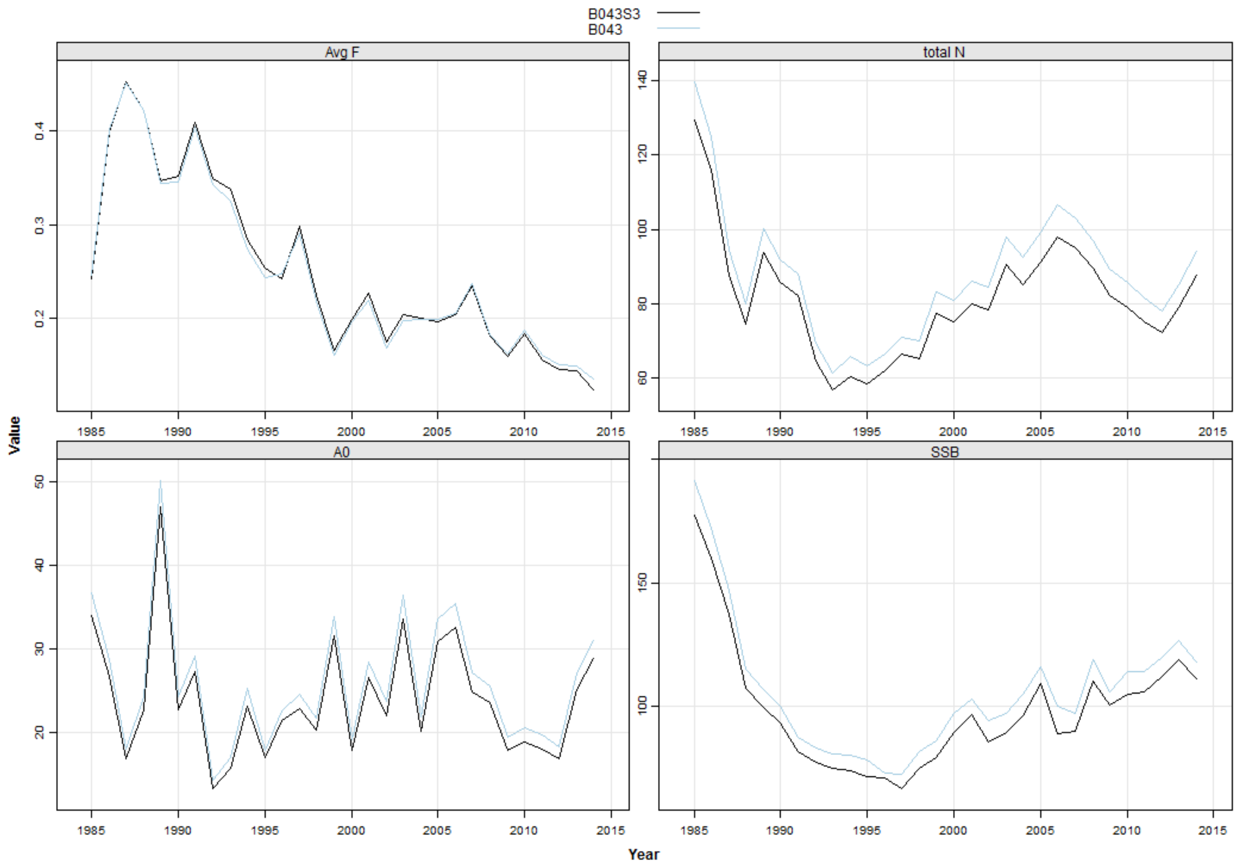
App. B7 Figure B7.120. Median fishing mortality and 95 confidence intervals from the MCMC runs with point estimates from the final model.



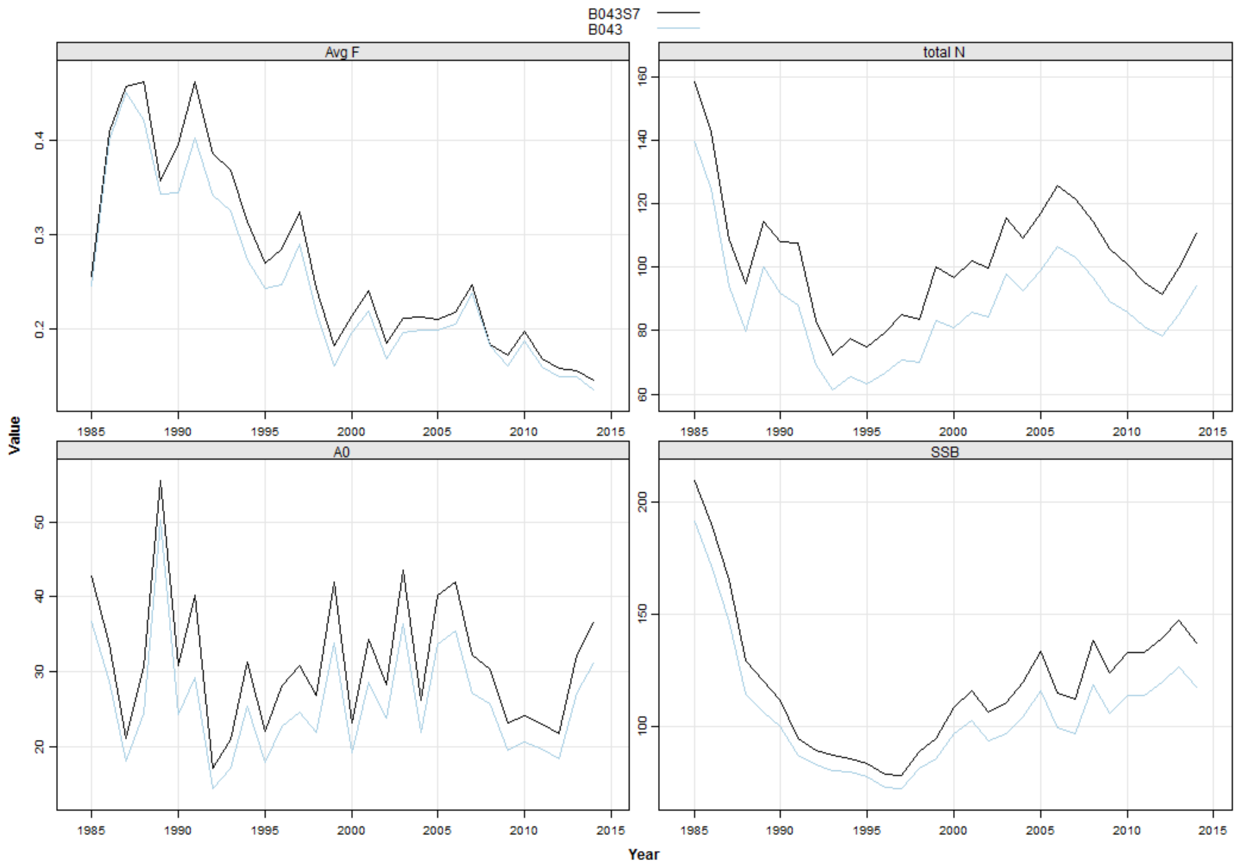
App. B7 Figure B7.121. Final model sensitivity run assume AB1 lengths for the recreational discards. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S5) represented by the black line.



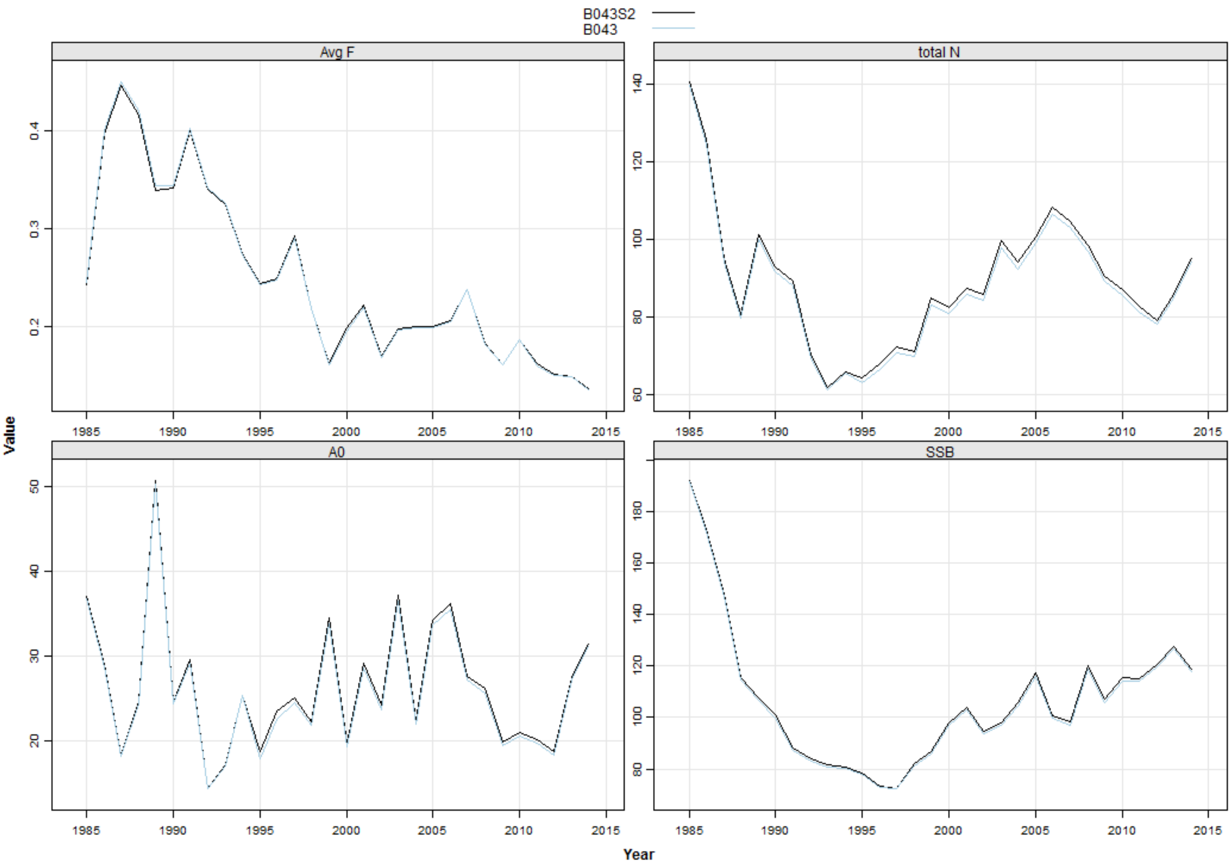
App. B7 Figure B7.122. Final model sensitivity run assuming upper 95% CI for recreational catch. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S4) represented by the black line.



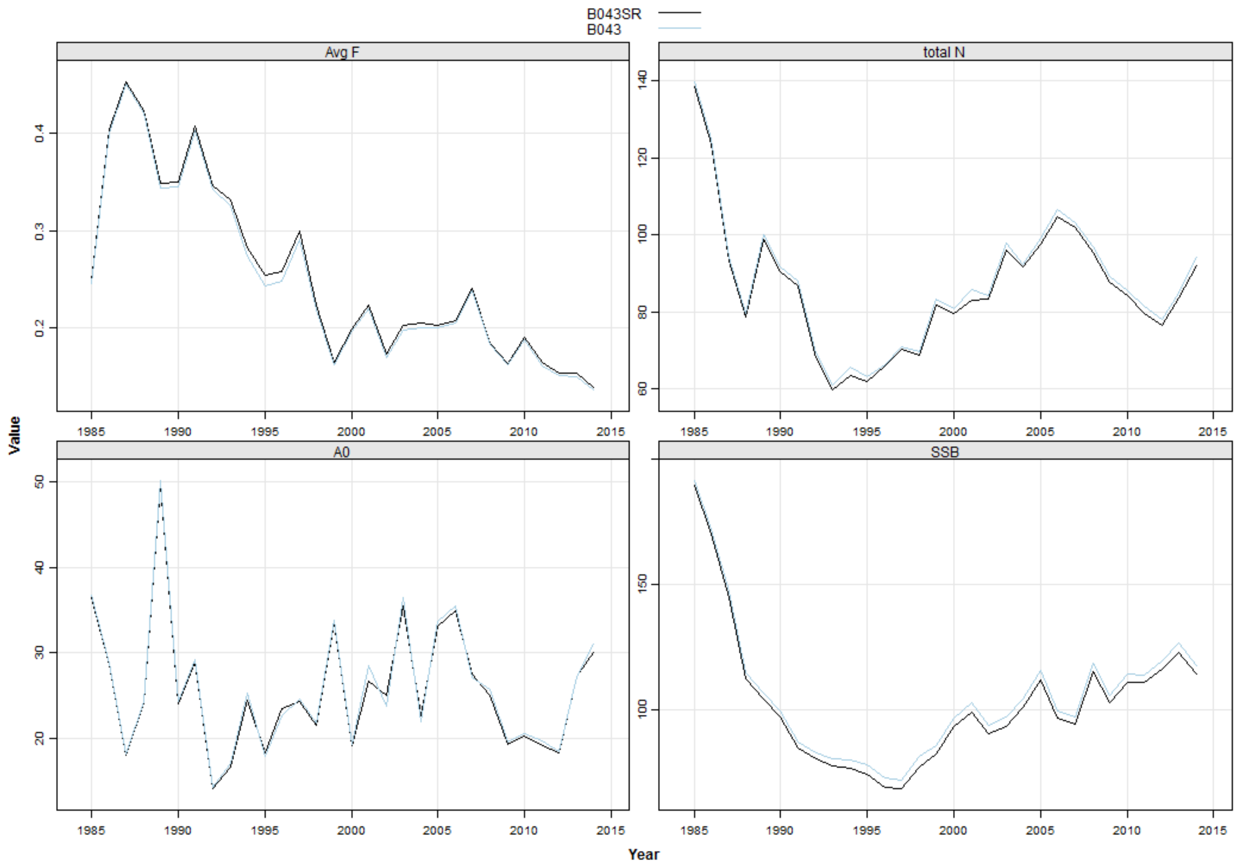
App. B7 Figure B7.123. Final model sensitivity run assuming lower 95% CI for recreational catch. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S3) represented by the black line.



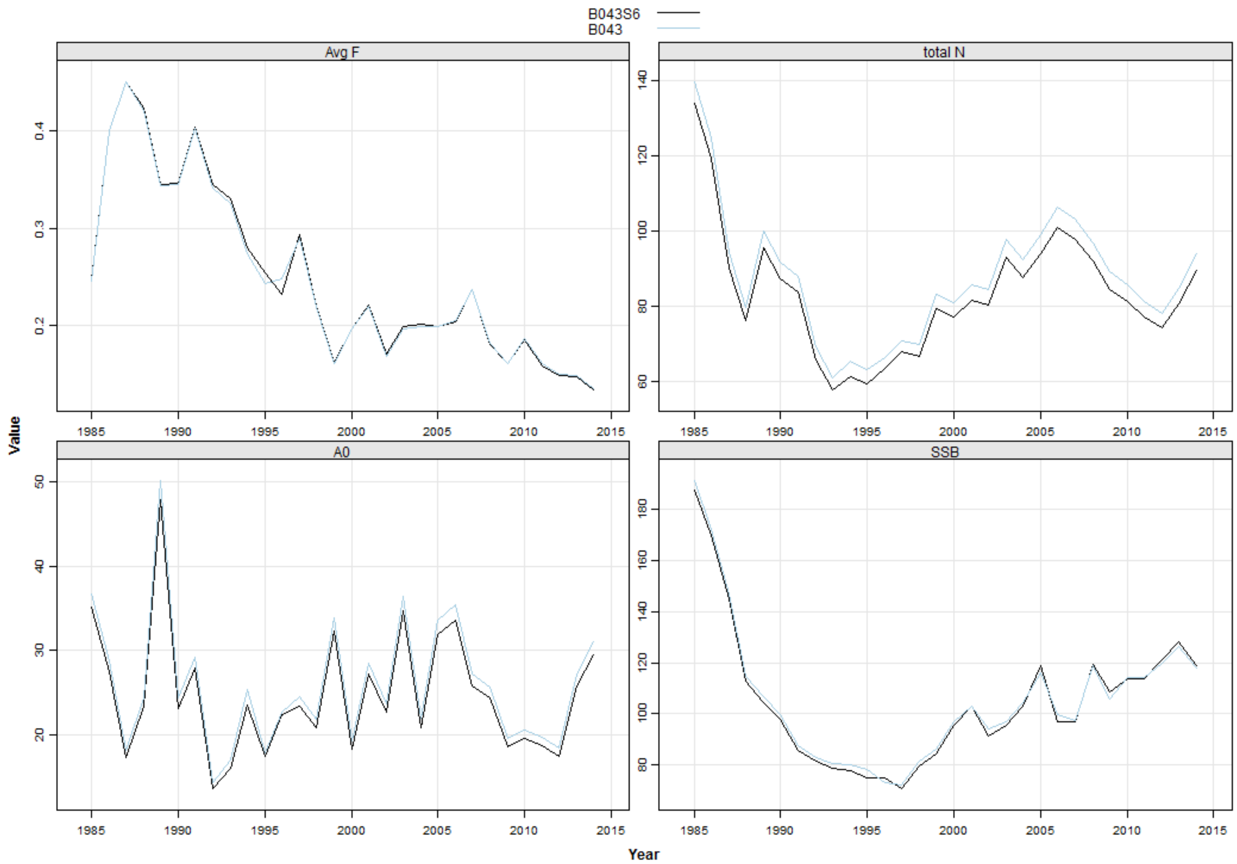
App. B7 Figure B7.124. Final model sensitivity run assuming MRFSS number prior to 2004 for the recreational catch. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S7) represented by the black line.



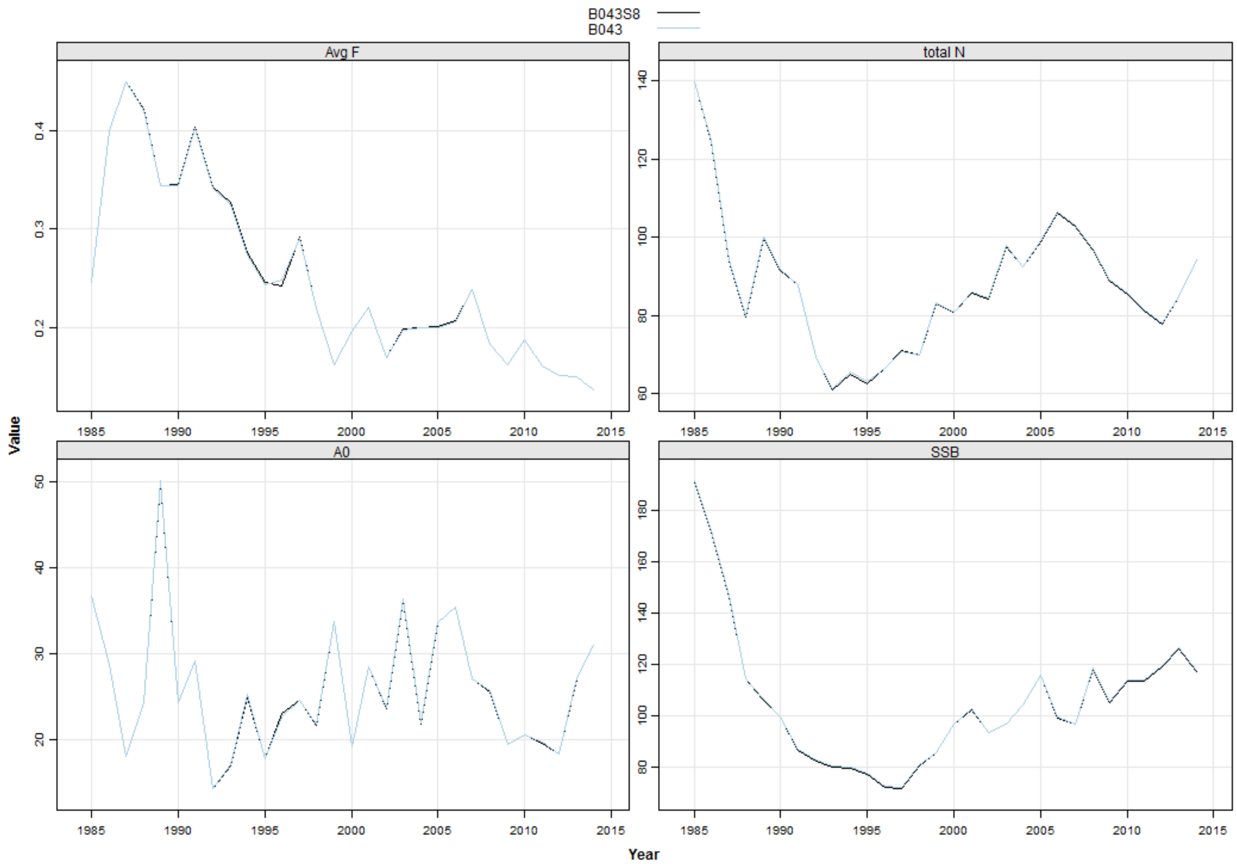
App. B7 Figure B7.125. Final model sensitivity run assuming 17% mortality (instead of 15%) for the recreational discards.   Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S7) represented by the black line.



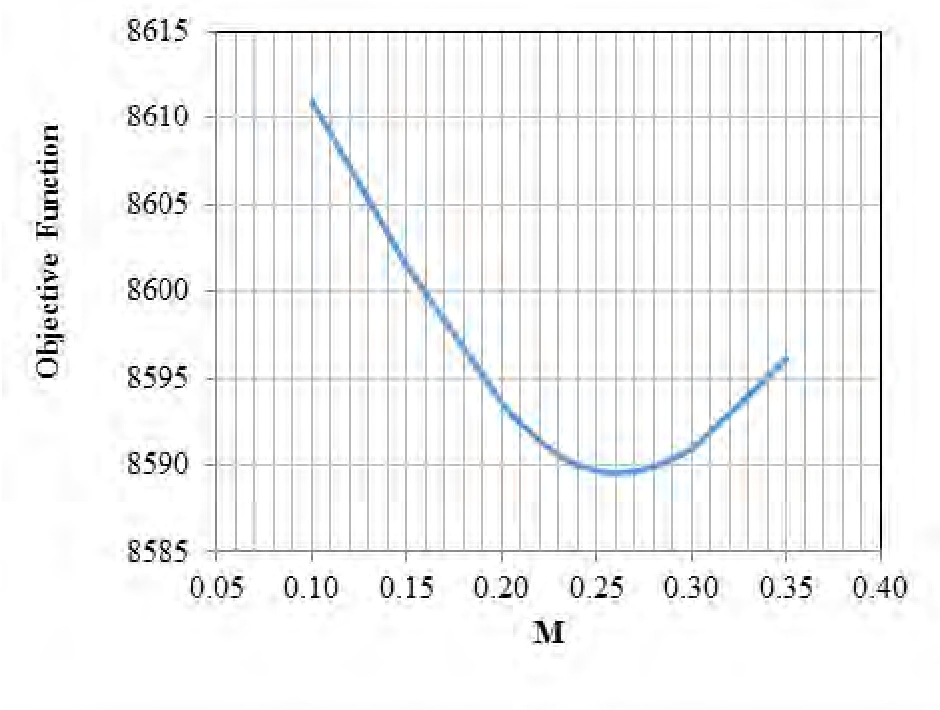
App. B7 Figure B7.126. Final model sensitivity run assuming regional age-length keys from 2006 to 2014. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043SR) represented by the black line.



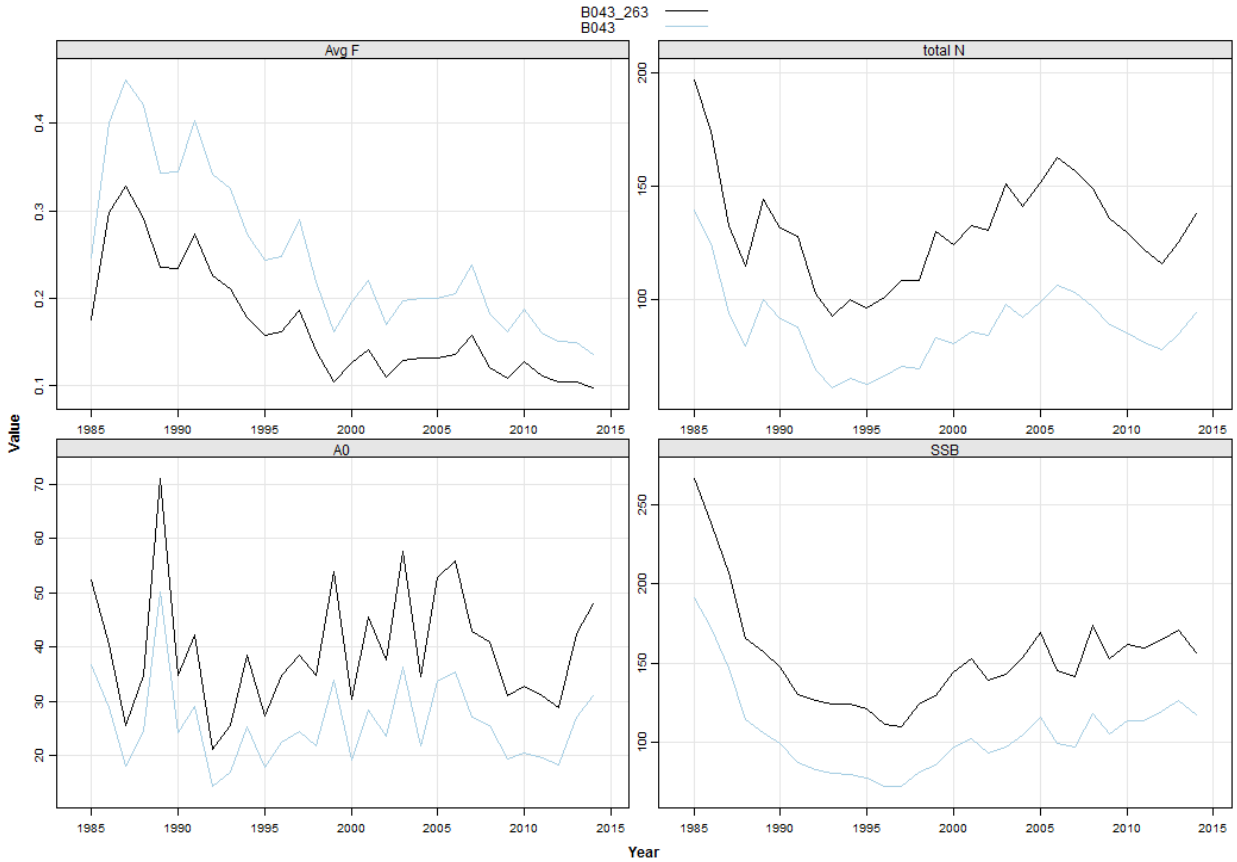
App. B7 Figure B7.127. Final model sensitivity run assuming 3 time blocks for length-weight coefficients (1985-1994, 1995-2004, 2005-2014). Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S6) represented by the black line.



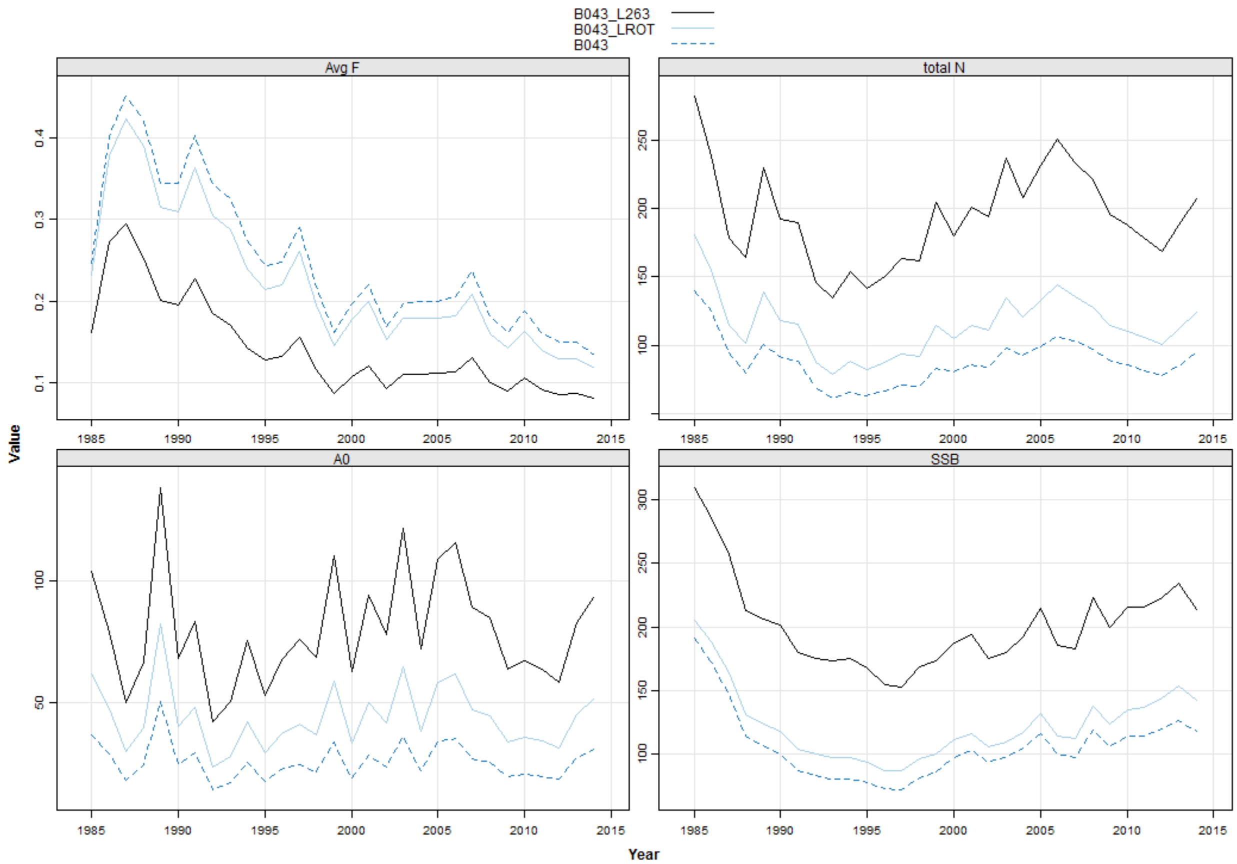
App. B7 Figure B7.128. Final model sensitivity run assuming VA set 2 landings. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S8) represented by the black line.



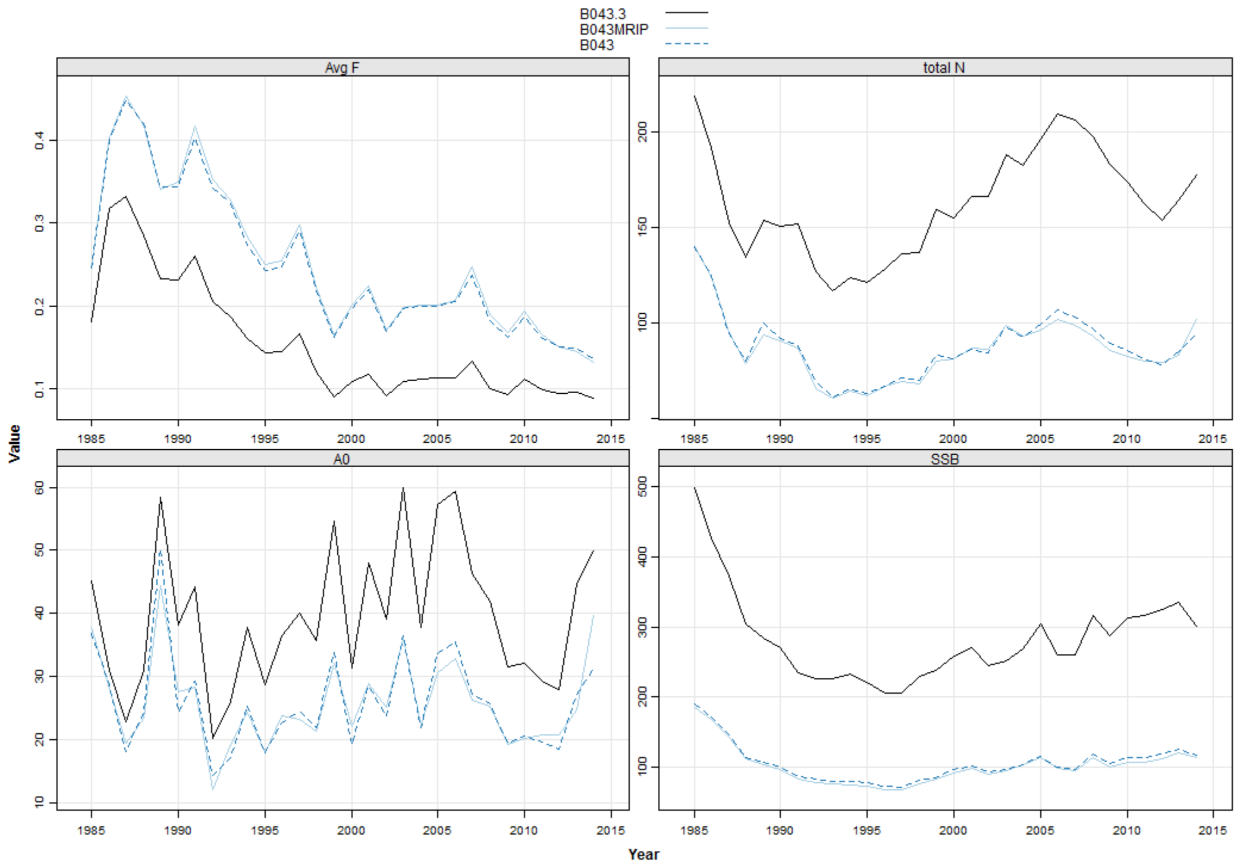
App. B7 Figure B7.129. Final model objective function profile over different values of natural mortality.



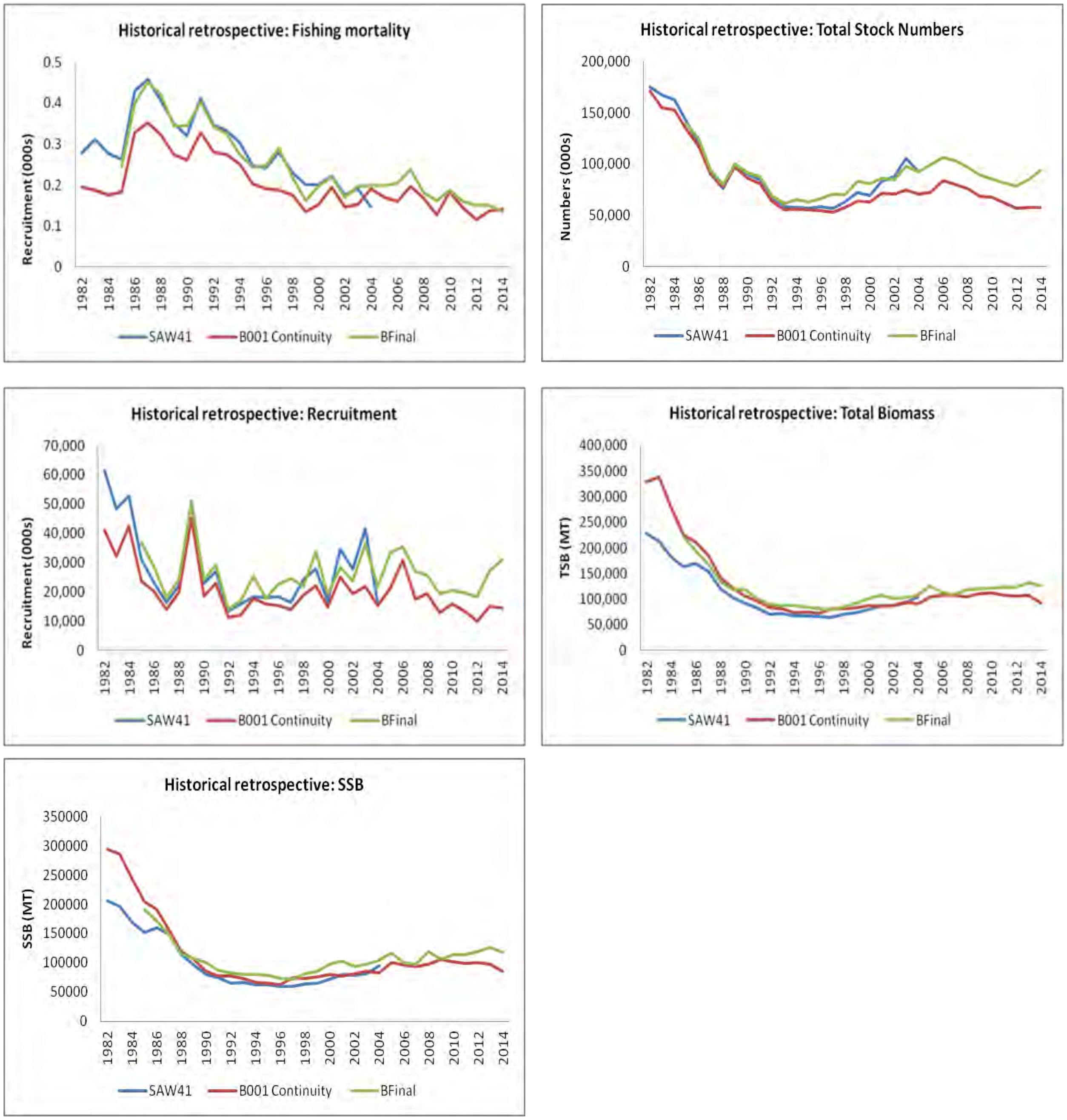
App. B7 Figure B7.130. Final model sensitivity run assuming natural mortality equal to 0.263 (the value that minimizes the objective function). Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043_263) represented by the black line.



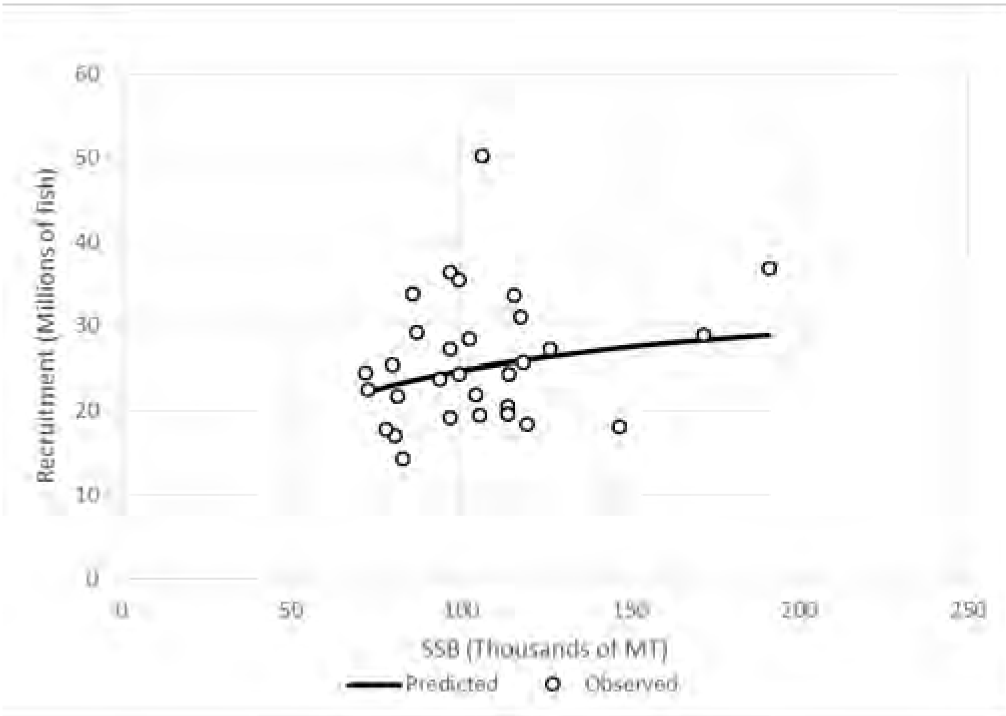
App. B7 Figure B7.131. Final model sensitivity run assuming age-based natural mortality estimates: Lorenzen scaled to Rule of Thumb (0.21) and Lorenzen scaled to (0.263: the value that minimizes the objective function. Trends for the final model (B043) estimates are represented by the dotted blue line, with sensitivity run estimates from B043_LROT (Lorenzen scaled to rule of thumb: 0.21) represented by the solid blue line and B043_L263 (Lorenzen scaled to 0.263) represented by the black line.



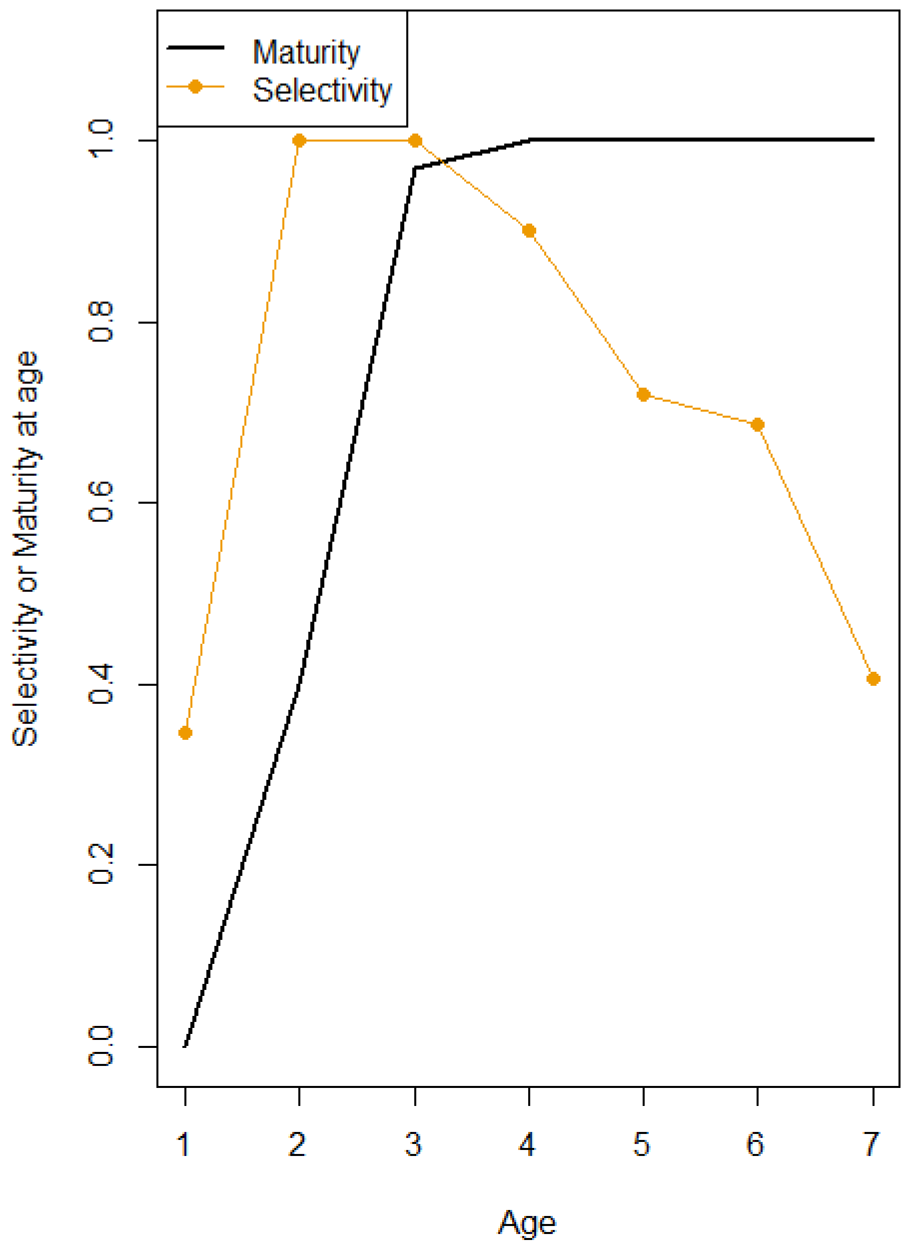
App. B7 Figure B7.132. Final model sensitivity run exploring the effects of removing the MRIP index, and running the final model with only the fleets and MRIP index. Trends for the final model (B043) estimates are represented by the dotted blue line, with sensitivity run estimates from B043MRIP (2 fleets+MRIP index) represented by the solid blue line and B043.3 (no MRIP) represented by the black line.



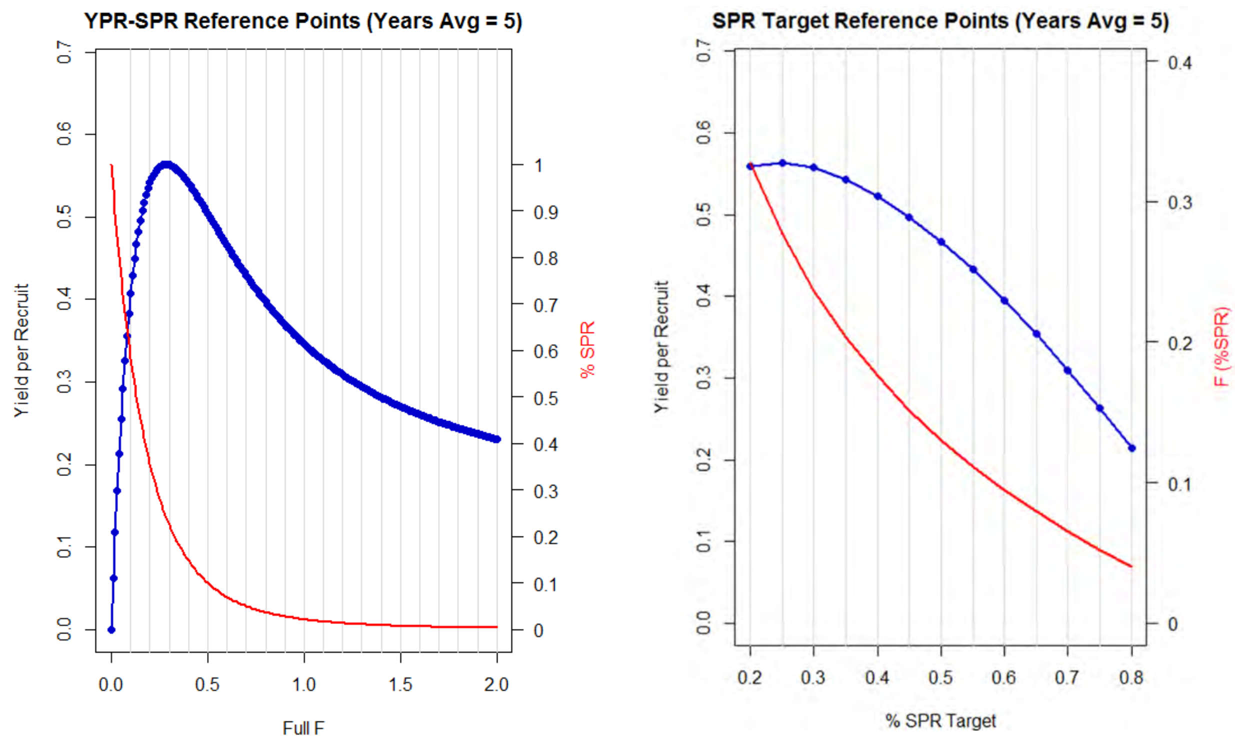
App. B7 Figure B7.133. Historical retrospective plots comparing estimates of F, abundance, recruitment, total biomass and spawning stock biomass across the previous benchmark assessment model (SAW 41), the continuity run with updated data (B001) and the final preferred model from this assessment (BFinal).



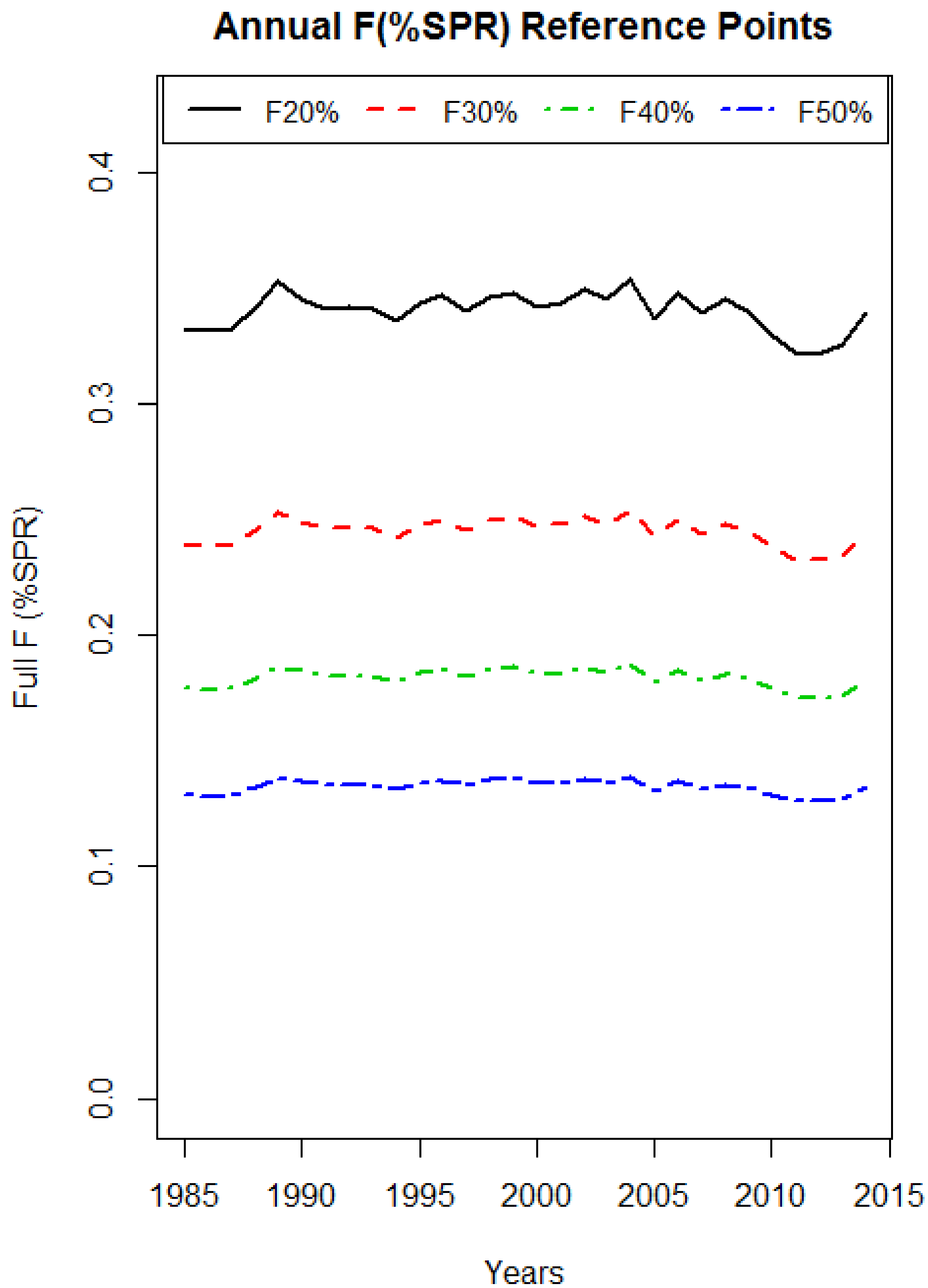
App. B7 Figure B8.1. Observed stock-recruitment relationship plotted with a fitted curve.



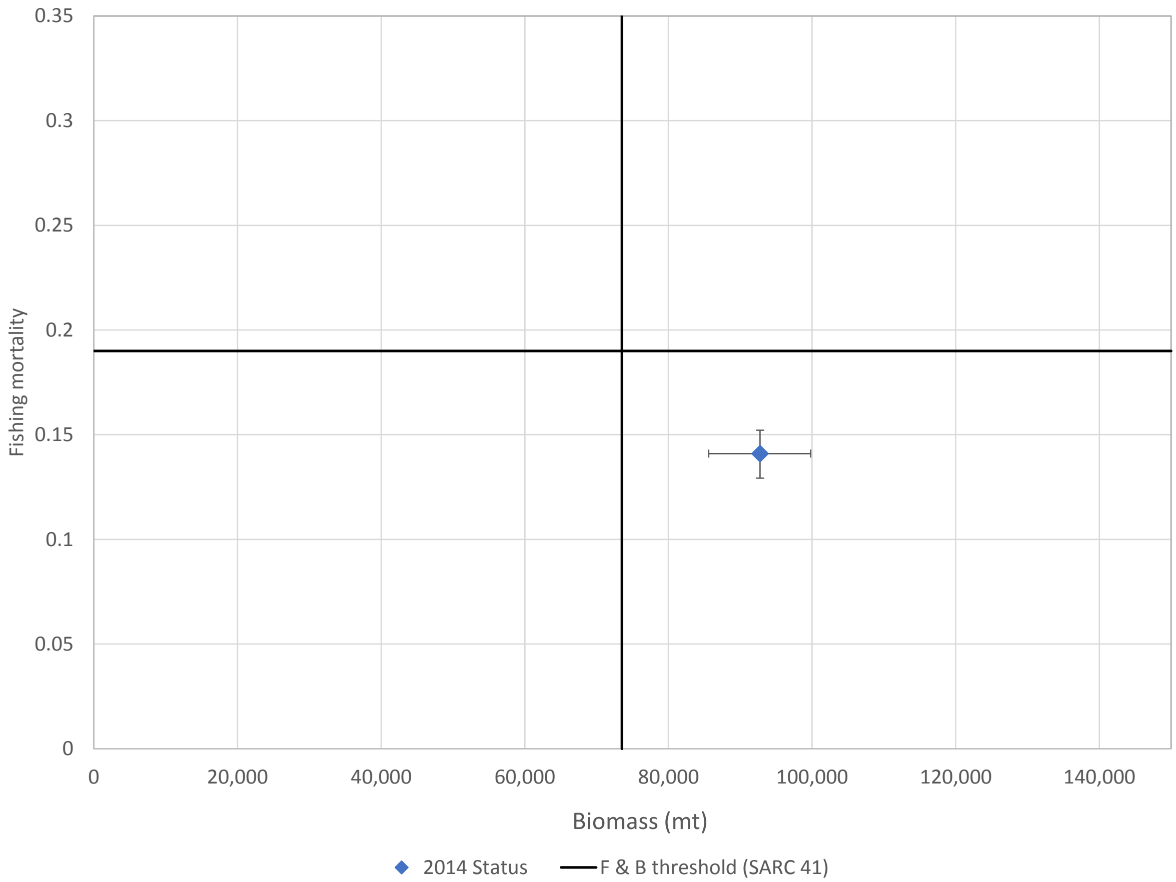
App. B7 Figure B8.2. Maturity ogive and composite selectivity pattern used to estimate bluefish reference points.



App. B7 Figure B8.3. YPR and SPR curves for bluefish.

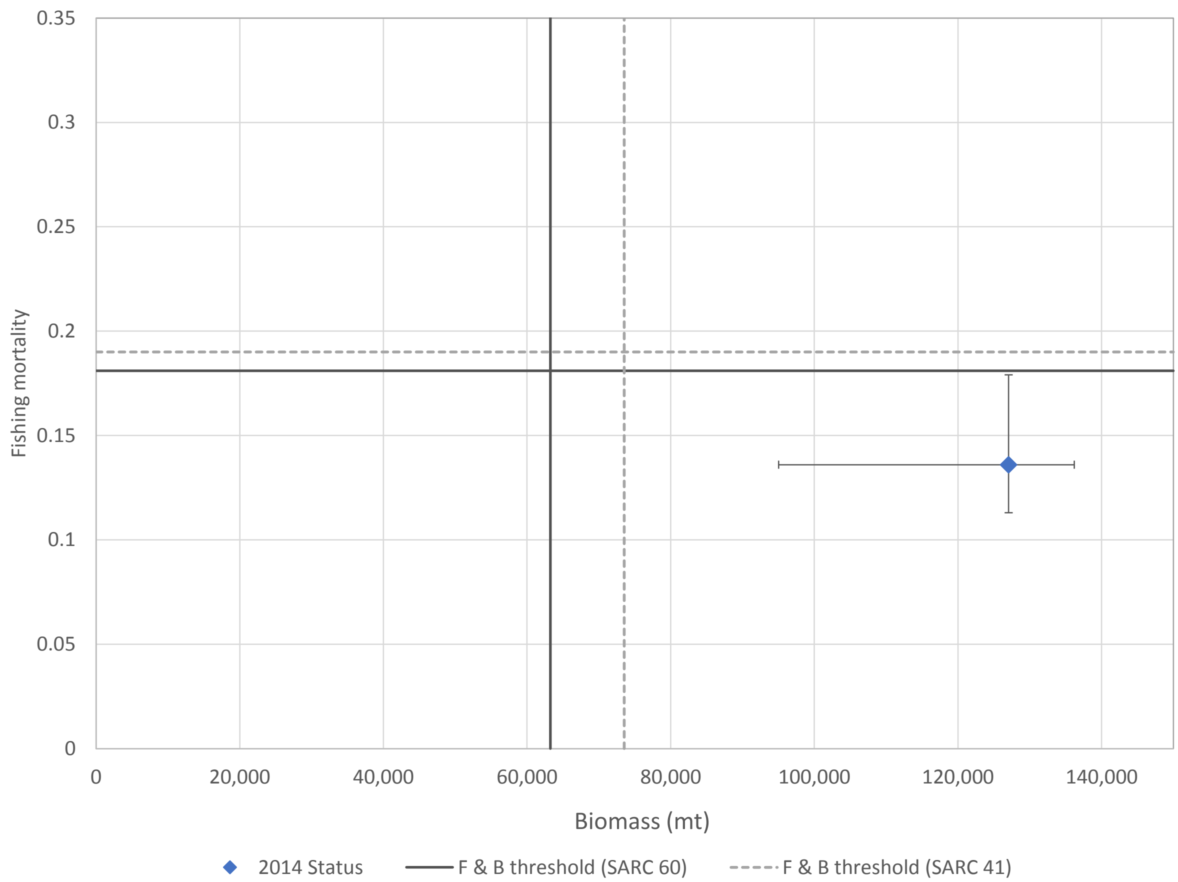


App. B7 Figure B8.4. Annual estimates of F %SPR reference points.



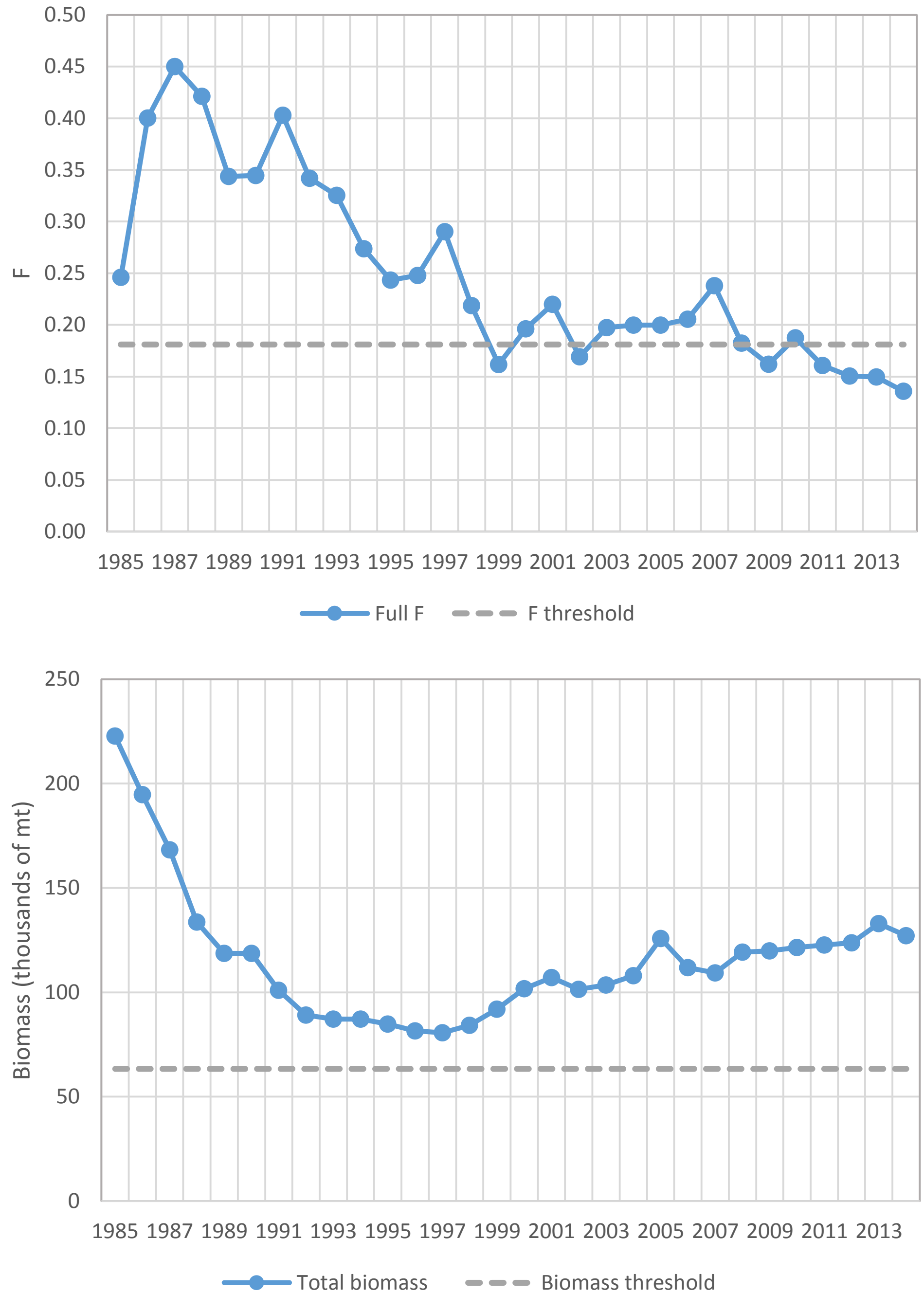
App. B7 Figure B9.1. Stock status in 2014 (diamond) from the continuity run plotted with the F and biomass thresholds from the previous benchmark assessment (solid lines).Error bars on the status estimated indicate 5th and 95th posterior probabilities.

(NOTE: The values presented in this Appendix B7 reflect the output from the early model presented in the draft WP document and at the peer review, before final revision. For the final SAW/SARC60 assessment results, readers should see the main body of the bluefish report.)



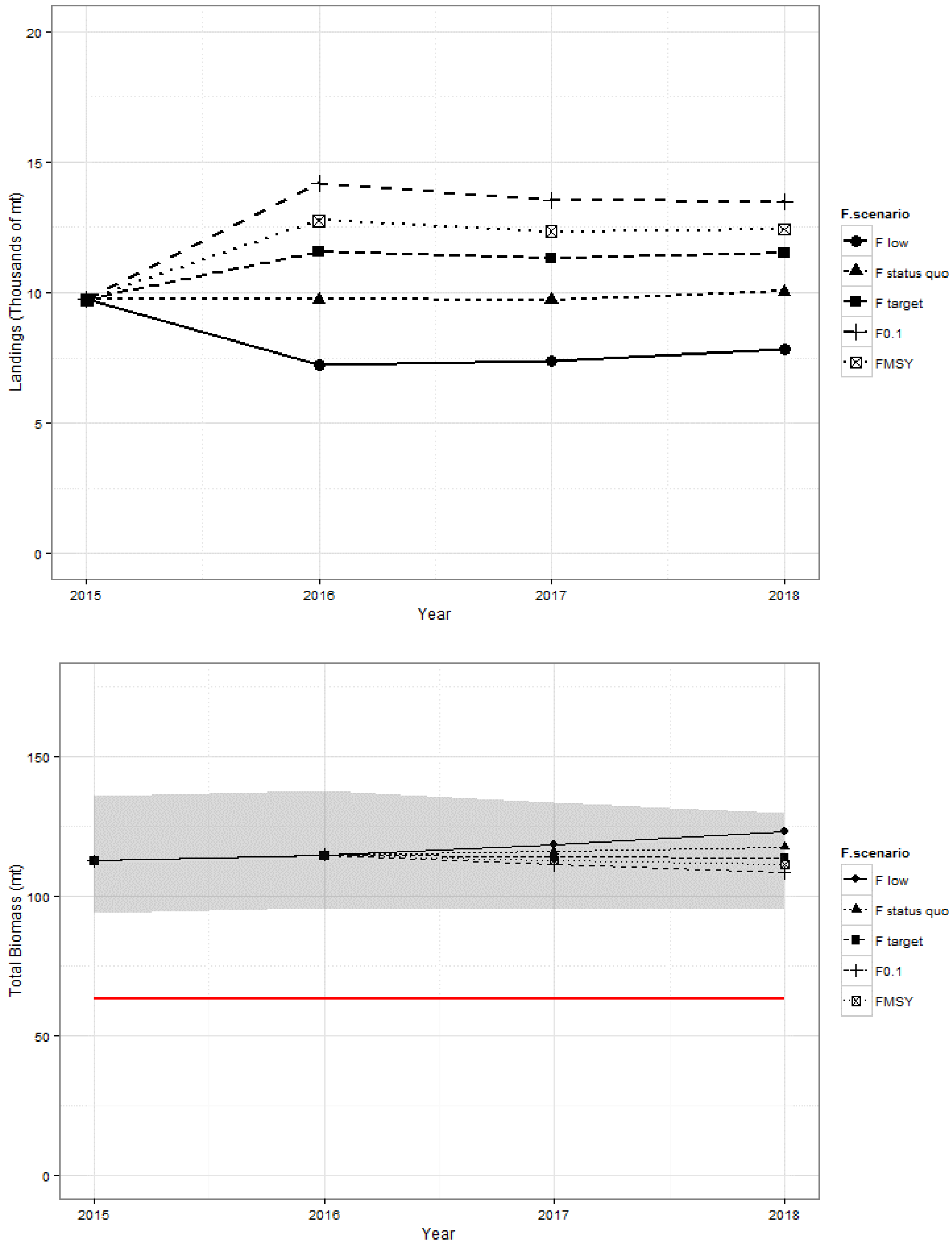
App. B7 Figure B9.2. Stock status in 2014 (diamond) from the final model run plotted with the F and biomass thresholds for this assessment (solid line) and the previous benchmark assessment (dashed line). Error bars on the status estimated indicate 5th and 95th posterior probabilities.

(NOTE: The values presented in this Appendix B7 reflect the output from the early model presented in the draft WP document and at the peer review, before final revision. For the final SAW/SARC60 assessment results, readers should see the main body of the bluefish report.)

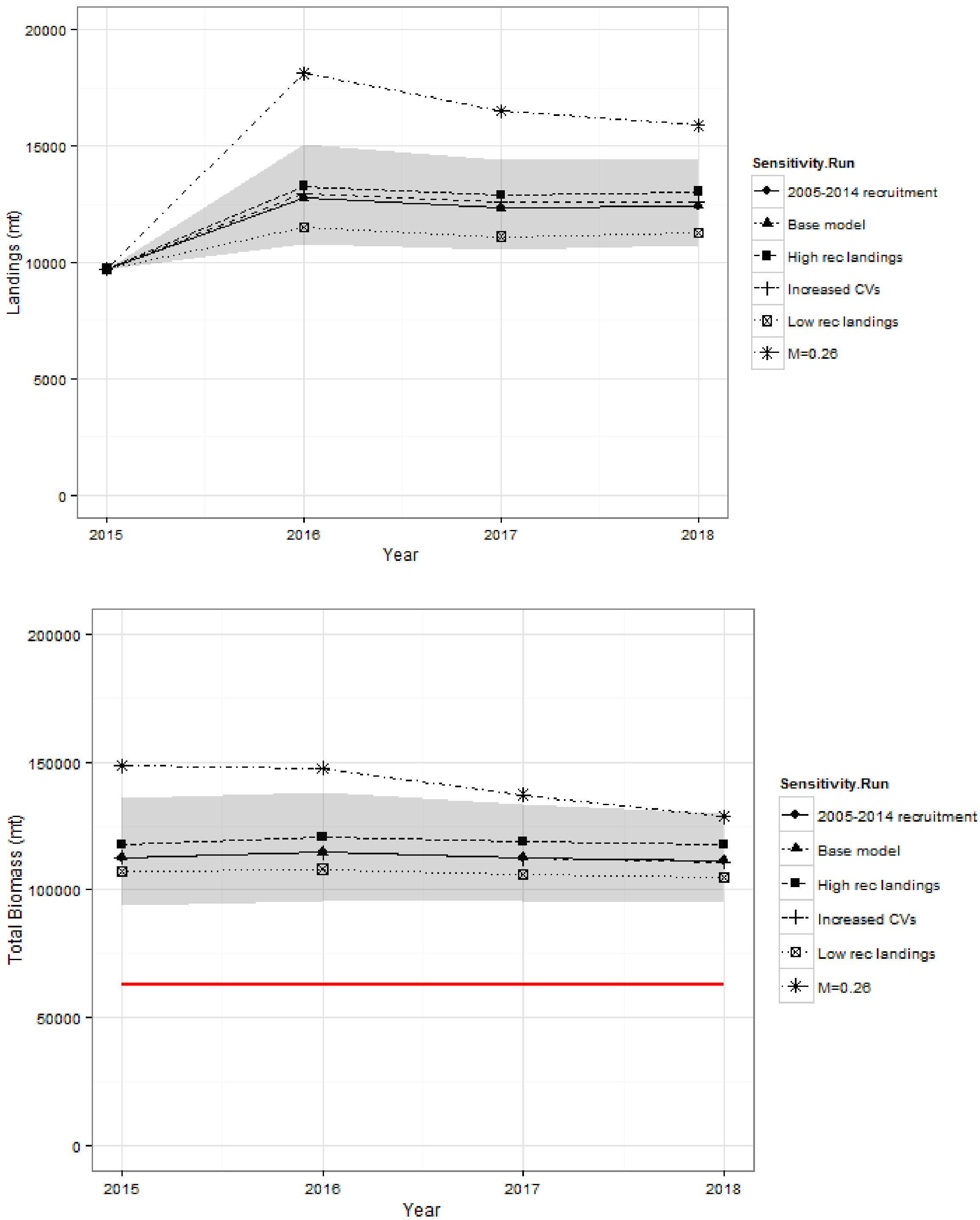


App. B7 Figure B9.3. Fully selected F (top) and total biomass (bottom) plotted with their respective overfishing and overfished thresholds.

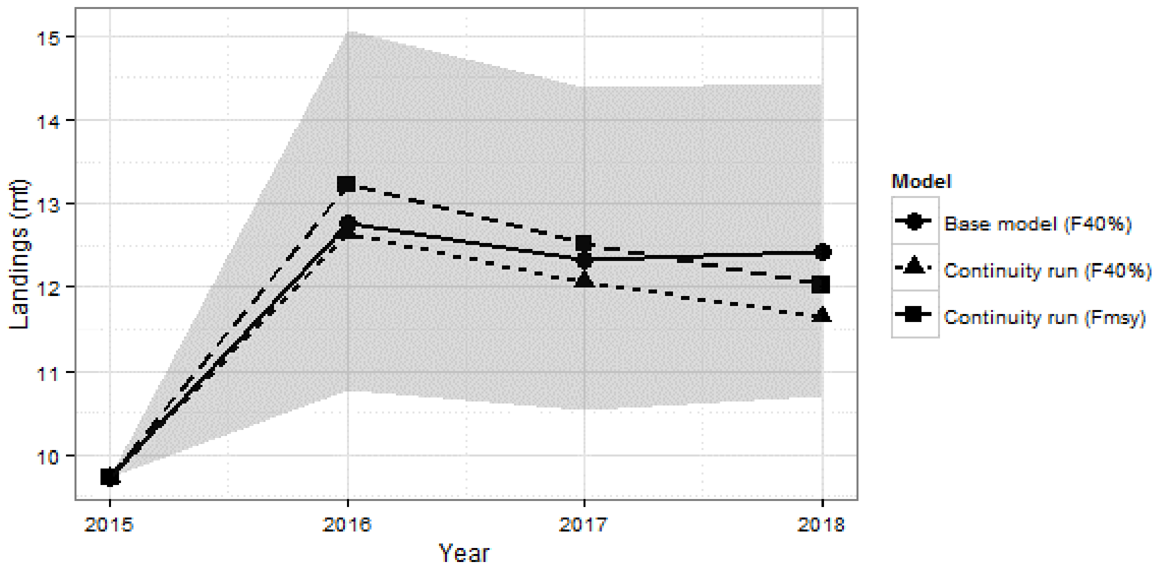
(NOTE: The values presented in this Appendix B7 reflect the output from the early model presented in the draft WP document and at the peer review, before final revision. For the final SAW/SARC60 assessment results, readers should see the main body of the bluefish report.)

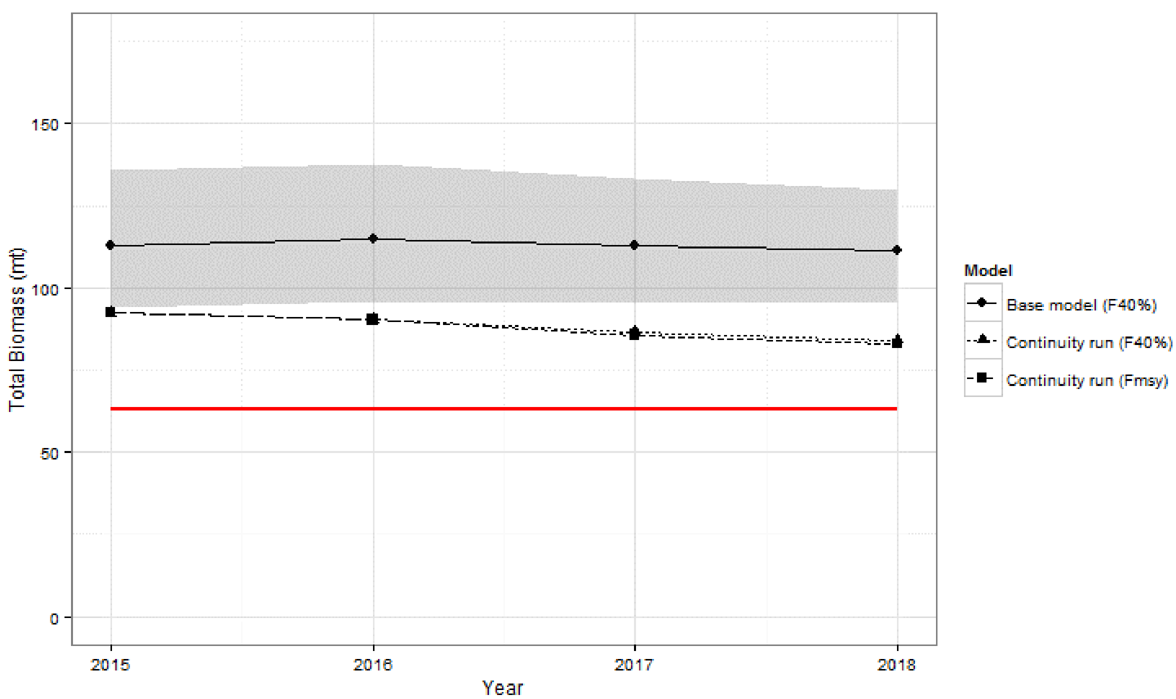


App. B7 Figure B10.1. Projected landings (top) and biomass (bottom) under various F scenarios. Shaded bands indicated the 5th and 95th percentiles of the F_{MSY} bootstrap runs. The solid red line indicates the overfished biomass threshold.



App. B7 Figure B10.2. Sensitivity runs of projected landings (top) and biomass (bottom) under F_{MSY}. Shaded bands indicated the 5th and 95th percentiles of the preferred base model bootstrap runs. The solid red line indicates the overfished biomass threshold.





App. B7 Figure B10.3. Projected landings (top) and biomass (bottom) for the continuity run model and the preferred model from this assessment. Shaded bands indicated the 5th and 95th percentiles of the preferred base model bootstrap runs. The solid red line indicates the overfished biomass threshold.

(NOTE: The values presented in this Appendix B7 reflect the output from the early model presented in the draft WP document and at the peer review, before final revision. For the final SAW/SARC60 assessment results, readers should see the main body of the bluefish report.)

Appendix B8 – Report of the July 2015 Meeting of the MAFMC SSC

[SAW Editor's Note:]

[The Mid-Atlantic Fishery Management Council's Scientific and Statistical Committee (MAFMC SSC) met in July 2015, shortly after the June 2015 SAW/SARC60 peer review. Based on the 2015 bluefish stock assessment, the SSC made a bluefish ABC recommendation to the MAFMC. During the SSC meeting, the SSC chose to revise the bluefish Biological Reference Points (BRPs) that were recommended by SAW/SARC60. The July 2015 MAFMC SSC report is included in Appendix B8 in its entirety.]

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Richard B. Robins, Jr., Chairman | Lee G. Anderson, Vice Chairman
Christopher M. Moore, Ph.D., Executive Director

MEMORANDUM

DATE: 27 July 2015

TO: Richard M. Robins, Jr., MAFMC Chairman

FROM: John Boreman, Ph.D., Chair, MAFMC Scientific and Statistical Committee

SUBJECT: Report of the July 2015 Meeting of the MAFMC SSC

The SSC met in Baltimore, MD, on 21-23 July 2015 for the main purpose of developing new ABC recommendations for Bluefish, Scup, Summer Flounder, and Black Sea Bass. The SSC also reviewed an early draft of the Terms for Reference for the upcoming benchmark assessment of Black Sea Bass, and were updated on a several ongoing activities of the MAFMC. The final meeting agenda is attached (Attachment 1).

A total of 10 SSC members were in attendance on July 21st, 13 in attendance on July 22nd, and 12 in attendance on July 23rd, all of which constituted quorums (Attachment 2). Also in attendance were staff from the NMFS Northeast Fisheries Science Center (in person and by phone), Council members and staff, ASMFC staff, and representatives from the fishing industry and general public. Discussion of ABC recommendations for each species began with a review of supporting information by the MAFMC staff lead and/or NEFSC assessment lead, then the SSC species leads (Attachment 3) and any members of the public attending the meeting were given an opportunity to comment, followed by SSC deliberations.

Most documents cited in this report can be accessed via the MAFMC SSC website (http://www.mafmc.org/ssc-meetings/2015/july-21-23).

Terms of reference (TORs) provided by the Council for the four species are in *italics*.

Bluefish

For Bluefish, the SSC will provide a written report that identifies the following for fishing years 2016-2018:

1) The level of uncertainty that the SSC deems most appropriate for the information content of the most recent stock assessment, based on criteria listed in the Omnibus Amendment.

The SARC 60 benchmark assessment was a significant improvement over previous assessments. Many uncertainties were addressed regarding input data and there was a characterization of uncertainty in the

OFL, which was adjusted upward by 50% from the model output by the assessment team to account for un-modeled uncertainty.

Despite these improvements, the SSC deems the assessment uncertainty level that requires an SSC-derived coefficient of variation (CV) for the OFL as the most appropriate for the new benchmark assessment, for the following reasons:

- The estimated OFL uncertainty provided by the assessment committee (15%) was low relative to meta-analysis results;
- There are uncertainties in the OFL that the assessment could not capture with respect to the highly influential MRIP index and selectivity;
- The OFL uncertainty provided by the assessment team is low relative to the between assessment model runs for SSB that examined assumptions for the natural mortality rate (M), selectivities, and including various indices.

2) If possible, the level of catch (in weight) and the probability of overfishing associated with the overfishing limit (OFL) based on the maximum fishing mortality rate threshold or, if appropriate, an OFL proxy.

The SSC noted that the F_{msy} proxy of $F_{40\%}$ might be inappropriate for Bluefish, a highly productive species (Thorson et al. 2012; Rothschild et al. 2012). A proxy of $F_{35\%}$ is indicated by various published meta-analyses for the order Perciformes.

Using $F_{35\%}$, the SSC recommends an OFL of:

2016 **11,686 mt**
2017 **11,995 mt**
2018 **12,688 mt**

3) The level of catch (in weight) and the probability of overfishing associated with the acceptable biological catch (ABC) for the stock, the number of fishing years for which the ABC specification applies and, if possible, interim metrics that can be examined to determine if multi-year specifications need reconsideration prior to their expiration.

A CV of 60% was applied to the OFL, instead of the previously used CV of 100%, to reflect the much-improved treatment of uncertainty in the current Bluefish assessment, and is consistent with the rationale used by the SSC to determine CV for the Summer Flounder assessment OFL. Three-year specifications are required. The OFL level for 2016 was determined by using $F_{35\%}$ = 0.19. The equilibrium catch (a proxy for MSY) under this scenario is 14,443 mt. The SSB_{msy} is therefore 101,343 mt and SSB_{2014} = 86,534 mt, so the SSB/SSB_{msy} = 0.85, with an SSB threshold of 50,672 mt. The SSC applied the Council policy of P* = 0.307 in 2016. This results in an ABC of:

2016 **8,825 mt** (P* = 0.307)
2017 **9,363 mt** (P* = 0.328)
2018 **9,895 mt** (P* = 0.327)

An updated assessment is preferred for the SSC review of the Bluefish ABCs next year.
Otherwise, the SSC would like to review an updated trawl survey index and updated MRIP index.

4) The most significant sources of scientific uncertainty associated with determination of OFL and ABC.

In order of importance:

- Uncertainty in the stock recruitment relationship adds to uncertainty in appropriate reference points.
- The uncertainty in MRIP sampling overall, which is the most influential data in the assessment. Questions have been raised about the uncertainty in the historical MRFSS/MRIP estimates in general, and are particularly relevant here given the highly episodic nature of Bluefish catches in the recreational fisheries coast wide.
- Approximately 60% of the population biomass is in the aggregated 6+ age group for which there is relatively little information.
- The extent to which the MRIP index and MRIP catch are partially redundant in the assessment needs to be determined.
- Commercial discards are assumed to be insignificant, which may not be the case.

5) Ecosystem considerations accounted for in the stock assessment, and any additional ecosystem considerations that the SSC took into account in selecting the ABC, including the basis for those additional considerations.

The ABCs were not modified by the SSC based on ecosystem considerations.

The stock assessment included ecosystem considerations:

- An index of habitat suitability was calculated based on a thermal niche model. It was fit as a covariate to survey catchability, but did not improve model fits.
- Diet compositions from multiple surveys were included as auxiliary information

6) Prioritized research or monitoring recommendations that would reduce the scientific uncertainty in the ABC recommendation and/or improve the assessment level.

- Develop a fishery independent index that better captures older, larger fish, which would reduce reliance on MRIP sampling.
- Develop Bluefish-specific MSY reference points or proxies.
- Evaluate species associations with recreational angler trips targeting Bluefish to potentially modify the MRIP index used in the assessment.
- Low frequency environmental variability may have caused changes in the timing of the movement of juvenile Bluefish through the region that, in turn, may have affected availability. Changes in the selectivity of age-0 Bluefish in the survey relative to water column or surface temperature and date should be examined.
- Evaluate methods for integrating disparate indices produced at multiple spatial and temporal resolutions into a stock-wide assessment model, especially for a migratory species like Bluefish.
- Initiate fishery-dependent and fishery-independent sampling of offshore populations of Bluefish.

7) The materials considered in reaching its recommendations.

- Montañez, J. 2015. Staff memorandum to Chris Moore, dated 7 July 2015, entitled: "Atlantic Bluefish Management Measures for 2016-2018." 30 pp.
- MAFMC Staff. 2015. Atlantic Bluefish Advisory Panel Information Document. Mid-Atlantic Fishery Management Council. 17 pp.

- MAFMC Staff. 2015. 2015 MAFMC Bluefish Fishery Performance Report. Mid-Atlantic Fishery Management Council. 6 pp.
- Northeast Fisheries Science Center. 2015. A Report of the 60th Northeast Regional Stock Assessment Workshop: Assessment summary report – pre-publication draft (dated 6-30-2015). 25 pp.
- Jones, C. M., N. Hall, S. Kupschus, and K. Stokes. 2015. Summary Report of the 60th Northeast Regional Stock Assessment Review Committee (SARC 60). Center for Independent Experts. 62 pp.
- Hall, N. G. 2015. Report on the SARC Review of SAW 60 Stock Assessments for Scup and Bluefish, June 2015. Center for Independent Experts. 57 pp.
- Kupschus, S. 2015. Review report for the benchmark stock assessment for Scup and Bluefish, SAW/SARC60. Center for Independent Experts. 45 pp.
- Stokes, K. 2015. Independent Peer Review Report on the 60th Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC): Benchmark stock assessments for Scup and Bluefish. Center for Independent Experts. 51 pp.
- Northeast Fisheries Science Center. 2015. A Report of the 60th Northeast Regional Stock Assessment Workshop: Assessment report. 864 pp.
- Thorson, J. T., J. M. Cope, T. A. Branch, and O. P. Jensen. 2012. Spawning biomass reference points for exploited marine fishes, incorporating taxonomic and body size information. Canadian Journal of Fisheries and Aquatic Sciences 69: 1–13 (2012).
- Rothschild, B. J., Y. Jiao, and S.-Y. Hyun. 2012. Simulation Study of Biological Reference Points for Summer Flounder. Transactions of the American Fisheries Society 141: 126-136.

8) A certification that the recommendations provided by the SSC represent the best scientific information available.

To the best of the SSC's knowledge, these recommendations are based on the best available scientific information.

General Comment

The SSC received the full description of the Bluefish stock assessment less than one day before our meeting to set Acceptable Biological Catches (ABCs) for this stock. This was a particular problem because the base model was changed during the peer review and the description, results, and diagnostics of the final configuration were not in the version of the assessment report for peer review that was previously provided to the SSC. Without the details in the full, updated assessment report, the SSC would have been unable to determine whether the assessment results constituted best available science and, thus, would not have been able to determine ABCs. Furthermore, the delay in providing the report to the SSC underserves the strong work that was done on the assessment by the stock assessment working group.

Scup

For Scup, the SSC will provide a written report that identifies the following for fishing years 2016-2018:

1) The level of uncertainty that the SSC deems most appropriate for the information content of the most recent stock assessment, based on criteria listed in the Omnibus Amendment.

The SSC determined the level of uncertainty of OFL in the assessment requires an SSC-specified CV.

The SSC accepted the MSY proxy used in the assessment as a reasonable foundation for OFL and ABC determination.

The SSC had typically used a CV = 100% for OFL as a default when the stock assessment lacked reliable guidance on the uncertainty. The Scup assessment is a clear improvement over this level. The SAW/SARC recommended a CV = 30%; however, in a meta-analysis of stock assessments, a CV = 30% is typical of the very best quality assessments that fully quantify all sources of uncertainty in the OFL (Ralston et al. 2011). Accordingly, the SSC recommends a CV = 60% based on: (1) the SSC's understanding that the assessment considers uncertainty primarily in biomass and does not include fully the uncertainty in the fishing mortality proxy or the association between the biomass and exploitation proxies; and (2) precedence with other assessments it has considered.

The SSC is committed to re-evaluating the CV for the uncertainty in the OFL for Scup in future specifications of ABC.

2) If possible, the level of catch (in weight) and the probability of overfishing associated with the overfishing limit (OFL) based on the maximum fishing mortality rate threshold or, if appropriate, an OFL proxy.

Based on projection estimates provided in the SAW/SARC document, the level of catch associated with the OFL for 2016-2018, assuming that 75% of the ABC in 2015 is caught, are:

2016	**16,238 mt**
2017	**14,556 mt**
2018	**13,464 mt**

3) The level of catch (in weight) and the probability of overfishing associated with the acceptable biological catch (ABC) for the stock, the number of fishing years for which the ABC specification applies and, if possible, interim metrics that can be examined to determine if multi-year specifications need reconsideration prior to their expiration.

The SSC accepted the CV of 60% in the OFL as the foundation for the ABC. Using the Council's published risk policy for a stock for which B/BMSY > 1, the recommended ABCs are as follows:

2016	**14,110 mt**
2017	**12,881 mt**
2018	**12,270 mt**

These values are equivalent to ~87% of the OFL.

Next year, in the absence of an assessment update, which the SSC prefers, the SSC will consider the following interim metrics to determine whether the ABCs recommended here are appropriate:

1. Survey CPUE (kg/tow) in the fall NEFSC survey;
2. Mean size and size-structure in the fall NEFSC survey; and
3. Exploitation ratio (catch / survey biomass).

4) The most significant sources of scientific uncertainty associated with determination of OFL and ABC.

- While older age Scup (age 3+) are represented in the catch used in the assessment model, most indices used in the model do not include ages 3+. As a result, the dynamics of the older ages of Scup are driven principally by catches and inferences regarding year class strength.
- Uncertainty exists with respect to the estimate of natural mortality (M) used in the assessment.
- Uncertainty exists as to whether the MSY proxies ($SSB_{40\%}$, $F_{40\%}$) selected and their precisions are appropriate for this stock.
- The SSC assumed that OFL has a lognormal distribution with a CV = 60%, based on a meta-analysis of survey and statistical catch at age (SCAA) model accuracies.
- Survey indices are particularly sensitive to Scup availability, which results in high inter-annual variability – efforts were made to address this question in the SAW/SARC that should be continued; and
- The projection on which the ABC was determined is based on an assumption that the quotas would be landed in 2016, 2017, and 2018.

5) Ecosystem considerations accounted for in the stock assessment, and any additional ecosystem considerations that the SSC took into account in selecting the ABC, including the basis for those additional considerations.

The ABCs were not modified based on ecosystem considerations. The stock assessment included ecosystems considerations, specifically efforts to estimate habitat suitability based on a thermal niche model that was fit to survey catchability, but this did not improve model fits.

6) Prioritized research or monitoring recommendations that would reduce the scientific uncertainty in the ABC recommendation and/or improve the assessment level.

In order of priority:

1. Improve estimates of discards and discard mortality for commercial and recreational fisheries.
2. Evaluate the degree of bias in the catch, particularly the commercial catch.
3. Explore the utility of incorporating ecological relationships, predation, and oceanic events that influence Scup population size on the continental shelf and its availability to resource surveys used in the stock assessment model.
4. An MSE could evaluate the effectiveness of Scup management procedures.
5. Conduct experiments to estimate catchability of Scup in NEFSC surveys.
6. Explore additional source of age-length data from historical surveys to inform the early part of the time series to provide additional context for model results.

7) The materials considered in reaching its recommendations.

- Northeast Fisheries Science Center. 2015. A Report of the 60th Northeast Regional Stock Assessment Workshop: Assessment summary report – pre-publication draft (dated 6-30-2015). 25 pp.
- Jones, C. M., N. Hall, S. Kupschus, and K. Stokes. 2015. Summary Report of the 60th Northeast Regional Stock Assessment Review Committee (SARC 60). Center for Independent Experts. 62 pp.
- Hall, N. G. 2015. Report on the SARC Review of SAW 60 Stock Assessments for Scup and Bluefish, June 2015. Center for Independent Experts. 57 pp.
- Kupschus, S. 2015. Review report for the benchmark stock assessment for Scup and Bluefish, SAW/SARC60. Center for Independent Experts. 45 pp.

- Stokes, K. 2015. Independent Peer Review Report on the 60th Stock Assessment Workshop/Stock Assessment Review Committee (SAW/SARC): Benchmark stock assessments for Scup and Bluefish. Center for Independent Experts. 51 pp.
- Northeast Fisheries Science Center. 2015. A Report of the 60th Northeast Regional Stock Assessment Workshop: Assessment report. 864 pp.
- Beaty, J., and K. Dancy. 2015. Staff memo to Chris Moore, dated 9 July 2015, entitled "Scup Management Measures for 2016 - 2018." 12 pp.
- Cadrin, S., J.-J. Maguire, and R. Leaf. 2015. Scup Stock Assessment Team Report. Science Center for Marine Fisheries (SCeMFiS). 39 pp.
- MAFMC. 2015. Summer Flounder, Scup, and Black Sea Bass Fishery Performance Reports June 2015. 9 pp.
- MAFMC. 2015. Summer Flounder, Scup, and Black Sea Bass Advisory Panel: Additional Comments, June 2015. 4 pp.
- MAFMC SSC. 2015. Draft working paper on "Description and Foundation of the Mid-Atlantic Council's ABC Control Rule," dated March 11, 2015. 11 pp.
- MAFMC. 2015. Scup fishery information document, June 2015. 11 pp.
- Ralston, S., A. E. Punt, O. S. Hamel, J. D. DeVore, and R. J. Conser. 2011. A meta-analytic approach to quantifying scientific uncertainty in stock assessments. Fishery Bulletin 109: 217-231.

8) A certification that the recommendations provided by the SSC represent the best scientific information available.

To the best of the SSC's knowledge, these recommendations are based on the best available scientific information.

Summer Flounder

For Summer Flounder, the SSC will provide a written report that identifies the following for fishing years 2016-2018:

1) The level of uncertainty that the SSC deems most appropriate for the information content of the most recent stock assessment, based on criteria listed in the Omnibus Amendment;

The SSC was provided with an assessment update based on the model formulation approved at SAW/SARC 57. The reference points accepted at the SAW/SARC were $F_{35\%}$ as F_{MSY} proxy = 0.309 and SSB_{MSY} proxy = 62,394 mt.

Because the assessment model was unchanged from SAW/SARC 57, the SSC did not alter its categorization of the assessment as an assessment requiring an SSC-derived CV for the OFL. The SSC also concluded that no new information was presented that would cause the SSC to deviate from using an OFL CV of 60%.

2) If possible, the level of catch (in weight) and the probability of overfishing associated with the overfishing limit (OFL) based on the maximum fishing mortality rate threshold or, if appropriate, an OFL proxy.

The level of catch associated with the OFL in 2016 is **8,194 mt**.

3) The level of catch (in weight) and the probability of overfishing associated with the acceptable biological catch (ABC) for the stock based on an approach which phases-in any required reductions in the ABC specifications over a three-year period without exceeding the OFL or P = 50%. If possible, identify interim metrics that can be examined to determine if multi-year specifications need reconsideration prior to their expiration.*

Using a three-year phase in of the required reduction in ABC assuming a CV in the OFL of 60% and that the ABC is caught in each year for the period under consideration are:

Year	ABC	P*	OFL	SSB
2016	**7,375 mt**	0.425	**8,194 mt**	45,885
2017	**7,193 mt**	0.344	**8,991 mt**	50,052
2018	**7,111 mt**	0.260	**10,159 mt**	54,966

The SSC recognizes that the phased in approach does not meet the Council's risk policy for the probability of overfishing in the first two years of the phased period. The Council asked the SSC to deviate from the Council's risk policy because of socio-economic concerns over the magnitude of the reduction in the fishery catch in 2016 that would be potentially destabilizing. The SSC notes that the projected biomass for the stock in 2018 is approximately equal to that expected to be present if the Council's risk policy had been followed for all three years.

An assessment update must be conducted in 2016 to guide the Council and SSC in determining future ABCs.

4) The most significant sources of scientific uncertainty associated with determination of OFL and ABC.

- Retrospective patterns evident in the assessment update have substantial implications for the reliability of model projections and inferences regarding the status of the stock. The causes of the retrospective pattern are unknown.
- Projections are made assuming the ABC will be harvested fully, but not exceeded. However, there are trends in harvest indicating an increasingly likelihood of catches exceeding ABCs.
- In 2016 and 2017, the probability of overfishing is higher than the Council's risk policy.
- The potential exists for sex-specific differences in life history parameters.
- The existence of spatially distinct size distributions.
- NEFSC surveys and PMAFS fishery sampling confirm sexually-dimorphic and time-varying spatial differences in growth that are not fully accounted for in the stock assessment because not all fishery and survey catches were fully and independently sampled by sex.
- Landings from commercial fishery assume no under-reporting of Summer Flounder landings and thus should be considered minimal estimates.
- The current assumption for M remains an ongoing source of uncertainty. M is highly influential on assessment results and impacts nearly all aspects of the assessment and evaluation of status.
- The stock-recruitment relationship could not be defined internally in the model and thus an F_{MSY} proxy was used to calculate the OFL.

5) Ecosystem considerations accounted for in the stock assessment, and any additional ecosystem considerations that the SSC took into account in selecting the ABC, including the basis for those additional considerations.

There were no additional ecosystem recommendations considered by the SSC.

6) Prioritized research or monitoring recommendations that would reduce the scientific uncertainty in the ABC recommendation and/or improve the assessment level.

The SSC recommends an expedited benchmark assessment to seek to improve model performance and reduce the retrospective bias present in the current assessment update.

The SSC recognizes the research recommendations provided in the assessment report. In addition, the SSC recommends research be conducted to:

- Evaluate uncertainties in biomass to determine potential modifications to OFL CV employed;
- Evaluate fully the sex- and size distribution of landed and discarded fish, by sex, in the Summer Flounder fisheries;
- Evaluate past and possible future changes to size regulations on retention and selectivity in stock assessments and projections; and
- Incorporate sex-specific differences in size at age into the stock assessment.

7) The materials considered in reaching its recommendations.

- Dancy, K., and J. Beaty. 2015. Staff memo to Chris Moore, dated 9 July 2015, entitled "Summer Flounder Management Measure for 2016 - 2018." 11 pp.
- Dancy, K., and J. Coakley. 2015. Staff memo to Chris Moore, dated 17 July 2015, entitled "Summer Flounder ABC Recommendations for 2016 – 2018." 2 pp.
- NEFSC. 2015. Stock assessment update of Summer Flounder for 2015. 17 pp.
- MAFMC. 2015. Summer Flounder, Scup, and Black Sea Bass Fishery Performance Reports, June 2015. 9 pp.
- MAFMC. 2015. Summer Flounder, Scup, and Black Sea Bass Advisory Panel: Additional Comments, June 2015. 4 pp.
- MAFMC. 2015. Summer Flounder fishery information document, June 2015. 14 pp.
- Amory, M. 2015. Letter to SSC, dated 16 July 2015. 2 pp.
- Virginia Seafood Council. 2015. Letter to SSC, dated 16 July 2015. 2 pp.
- Donofrio, J. 2015. Recreational Fishing Alliance letter to John Boreman, dated 21 July 2015. 2 pp.
- Schill, J. 2015. NC Fisheries Association letter to John Boreman, dated 21 July 2015. 1 pp.
- Pallone, F., Jr., R. Mendez, and C. A. Booker. 2015. Congressional letter to Richard B. Robins, Jr., and John Boreman, dated 21 July 2015. 2 pp.

8) A certification that the recommendations provided by the SSC represent the best scientific information available.

To the best of the SSC's knowledge, these recommendations are based on the best available scientific information.

Black Sea Bass

For Black Sea Bass, the SSC will provide a written report that identifies the following for fishing years 2016-2017:

1) The level of uncertainty that the SSC deems most appropriate for the information content of the most recent stock assessment, based on criteria listed in the Omnibus Amendment;

The SSC determined that the OFL could not be specified given the current state of knowledge.

2) If possible, the level of catch (in weight) and the probability of overfishing associated with the overfishing limit (OFL) based on the maximum fishing mortality rate threshold or, if appropriate, an OFL proxy.

Because no OFL was specified for this species, the level of catch cannot be derived.

3) The level of catch (in weight) and the probability of overfishing associated with the acceptable biological catch (ABC) for the stock, the number of fishing years for which the ABC specification applies and, if possible, interim metrics that can be examined to determine if multi-year specifications need reconsideration prior to their expiration.

The SSC recommends the 2016-2017 ABC should be based on a constant catch policy of **2,494 mt (= 5.5 M lbs)**. This revised constant catch level remains less than the 6 M lbs that was taken during rebuilding, is approximately the 50th percentile of the observed cumulative catch distribution, and likely represents approximately 75% of F_{MSY}.

The SSC notes in its advice to the Council that this is a short term, empirical measure. The SSC commits to evaluate a new approach to setting ABC developed by McNamee et al. (2015 working paper) in September 2015. This new approach has been proposed until a revised assessment is completed (expected December 2016) that will be reviewed by the SAW/SARC by Spring 2017 in time for ABC determination for 2018.

4) The most significant sources of scientific uncertainty associated with determination of OFL and ABC.

- Atypical life history strategy (protogynous hermaphrodite) means that determination of appropriate reference points is difficult;
- Assessment assumes a completely mixed stock, while tagging analyses suggest otherwise;
- Evidence of changes in the spatial distribution of the species, specifically an expansion of the species into more northern areas (Bell et al. 2014);
- Uncertainty exists with respect to M — because of the unusual life history strategy the current assumption of a constant M in the model for both sexes may not adequately capture the dynamics in M; and
- Concern about the application of trawl calibration coefficients (ALBATROSS IV vs BIGELOW) and their influence on the selectivity pattern and results of the assessment. There was concern that the pattern of the calibration coefficients across lengths was difficult to justify biologically.

5) Ecosystem considerations accounted for in the stock assessment, and any additional ecosystem *considerations that the SSC took into account in selecting the ABC, including the basis for those additional considerations.*

No additional ecosystem considerations were included in the determination of ABC.

6) Prioritized research or monitoring recommendations that would reduce the scientific uncertainty in the ABC recommendation and/or improve the assessment level.

1. Develop a first principles foundation for establishing reference points and assessment methods to account for Black Sea Bass' life history.
2. Explore the utility of a spatially structured assessment model for Black Sea Bass to address the incomplete mixing in the stock.
3. Consider a directed study of the genetic structure in the population north of Cape Hatteras.
4. Develop a reliable fishery independent index for Black Sea Bass beyond the existing surveys. This may require development and implementation of a new survey.
5. Additional monitoring and compliance investments to control ABCs at recommended levels are necessary if predicted scientific outcomes for future stock biomasses are to be realized.
6. Evaluate the implications of range expansion to stock and fishery dynamics.

7) The materials considered in reaching its recommendations.

- Dancy, K. 2015. Staff memo to Chris Moore, dated 10 July 2015, entitled "Black Sea Bass Management Measures for 2016 – 2017." 10 pp.
- NEFSC. 2015. Black Sea Bass 2014 Catch and Survey Information for Northern Stock. 19 pp.
- MAFMC. 2015. Summer Flounder, Scup, and Black Sea Bass Fishery Performance Reports, June 2015. 9 pp.
- MAFMC. 2015. Summer Flounder, Scup, and Black Sea Bass Advisory Panel: Additional Comments, June 2015. 4 pp.
- MAFMC. 2015. Black Sea Bass fishery information document. 14 pp.
- McNamee, J., G. Fay, and S. Cadrin. 2015. Data limited techniques for Tier 4 stocks: an alternative approach to setting harvest control rules using closed loop simulations for management strategy evaluation. RI Division of Fish and Wildlife and University of Massachusetts Dartmouth. 57pp.
- Miller, T. 2013. SSC memo to Richard B. Robins, Jr., dated 30 January 2013, entitled "Report of January 23, 2013 Meeting of the MAFMC Scientific and Statistical Committee on Black Sea Bass ABC determination." 9 pp.
- J. McNamee, G. Fay, and S. Cadrin. 2015. Memo to SSC, dated 18 July 2015, entitled "Recommendation for an ABC for Black Sea Bass based on the Data Limited analysis." 4 pp.
- Dawson, J. 2015. Email to Kiley Dancy, dated 19 July 2015, entitled "Black Sea Bass Stock Assessment."
- Bell, R. J., D. E. Richardson, J. A. Hare, P. D. Lynch, and P. S. Frantantoni. 2014. Disentangling the effects of climate, abundance, and size on the distribution of marine fish: an example based on four stocks from the Northeast US shelf. ICES Journal of Marine Science 72(5): 1311-1322.

8) A certification that the recommendations provided by the SSC represent the best scientific information available.

To the best of the SSC's knowledge, these recommendations are based on the best available scientific information.

Summary of Species Information Requests

The following is a summary of the information requests made at the meeting by the SSC for next year's round of ABC deliberations. Questions about specifics can be directed to the SSC species leads (Attachment 3).

The SSC would prefer to have updated assessments in 2016 for Bluefish and Scup. If updated assessments are not possible for either or both of these species, then the SSC would like to have the following information in hand prior to its July 2016 meeting:

- Bluefish: updated trawl survey index and updated MRIP index
- Scup:
  - Survey CPUE (kg/tow) in the fall NEFSC survey;
  - Mean size and size-structure in the fall NEFSC survey; and
  - Exploitation ratio (catch / survey biomass).

For Summer Flounder, an assessment update **must** be conducted in 2016 to guide the Council and SSC in determining future ABCs. Also, the SSC recommends an expedited benchmark assessment to seek to improve model performance and reduce the retrospective bias present in the current assessment update.

For Black Sea Bass, the SSC commits to evaluate a new approach to setting ABC developed by McNamee et al. (2015 working paper) in September 2015. This new approach has been proposed until a revised assessment is completed (expected December 2016) that will be reviewed by the SAW/SARC by Spring 2017 in time for ABC determination for 2018.

Other Business

The SSC Chair briefed the SSC on the status of several ongoing SSC projects, including development of non-OFL approaches for setting ABCs for Blueline Tilefish, the rumble strip approach for setting multi-year ABCs, and the report of the National SSC Workshop held in February 2015. Rich Seagraves briefed the SSC on progress being made to develop a universal list of research priorities for the MAFMC, and Julia Beaty briefed the SSC on progress being made by MAFMC staff to define and develop management options for forage species in the mid-Atlantic region. Finally, Olaf Jensen led the SSC through a review of an early draft of proposed terms of reference for the upcoming benchmark stock assessment for Black Sea Bass; suggested changes made by the SSC were transmitted to the NEFSC.

cc: SSC Members, Lee Anderson, Chris Moore, Rich Seagraves, Kiley Dancy, José Montañez, Julia Beaty, Mark Terceiro, Tony Wood, Gary Shepherd, Jason McNamee, Kirby Rootes-Murdy

Attachment 1

Mid-Atlantic Fishery Management Council
Scientific and Statistical Committee Meeting
July 21-23, 2015
Final Agenda

Tuesday, July 21 2015

1300 Bluefish 2016-2018 ABC Specifications (Montañez/Wood/Jones)
1730 Adjourn

Wednesday, July 22 2015

0800 Scup 2016-2018 ABC Specifications (Dancy/Beaty/Terceiro/Gabriel)
1245 Lunch
1345 Summer Flounder 2016-2018 ABC Specifications (Dancy/Terceiro/Wilberg)
1730 Adjourn

Thursday, July 23 2015

0800 Black Sea Bass 2016-2018 ABC Specifications (Dancy/Shepherd/McNamee/Jensen)
1130 Other Business
- Research Priorities (Seagraves)
- Update on Unmanaged Forage Initiative (Beaty)
- Blueline Tilefish Issues (Boreman)
- Fifth National SSC Report (Boreman)
- Rumble Strip Update (Wilberg)
- Review of Preliminary TORs for Black Sea Bass Benchmark Assessment (Jensen)

1300 Adjourn

Attachment 2

MAFMC Scientific and Statistical Committee
21-23 July Meeting
Baltimore, MD

Name	Affiliation
SSC Members in Attendance:	
John Boreman (SSC Chairman)	North Carolina State University
Tom Miller (SSC Vice-Chair, 7/22 and 7/23 only)	University of Maryland - CBL
Mike Wilberg	University of Maryland - CBL
Doug Lipton	NMFS
David Secor	University of Maryland – CBL
David Tomberlin (7/21 only)	NMFS Office of Science and Technology
Mark Holliday	NMFS (Retired)
Cynthia Jones (7/21 and 7/22 only)	Old Dominion University
Sarah Gaichas	NMFS Northeast Fisheries Science Center
Sunny Jardine (7/22 and 7/23 only)	University of Delaware
Mike Frisk	Stony Brook University
Olaf Jensen	Rutgers University
Wendy Gabriel	NMFS Northeast Fisheries Science Center
Ed Houde (7/22 and 7/23 only)	University of Maryland – CBL
Others in attendance:	
Rich Seagraves	MAFMC staff
José Moñtanez (7/21 only)	MAFMC staff
Julia Beaty``	MAFMC staff
Kiley Dancy	MAFMC staff
Chris Moore (7/22 only)	MAFMC staff
Tony Wood (7/21 only)	NMFS Northeast Fisheries Science Center
Gary Shepherd (by phone, 7/22 and 7/23 only)	NMFS Northeast Fisheries Science Center
Mark Terceiro (7/22 and 7/23 only)	NMFS Northeast Fisheries Science Center
Rick Robins (7/21 and 7/22 only)	MAFMC Chair
Greg DiDomenico (7/22 only)	GSSA
Kirby Rootes-Murdy	ASMFC staff
John Maniscalco (7/22 and 7/23 only)	NYDEC
Moira Kelly (7/22 and 7/23 only)	NMFS GARFO
Mike Luisi (7/22 only)	MD DNR, MAFMC Council Member
Jason McNamee (7/22 and 7/23 only)	RI F&W
Alexei Sharov (7/22 and 7/23 only)	MD DNR
Tom Fote (7/22 and 7/23 only)	ASMFC Commissioner, NJ
Joe Grist (7/22 and 7/23 only)	VMRC
Bob Rush (7/22 only)	United Boatmen of NJ
John DePersonaire (7/22 only)	Recreational Fishing Alliance (NJ)
Spencer Talmage (7/22 only)	ASMFC staff

Species and Topic Leads for MAFMC SSC Members

Species/Topic	Biology/Assessment Lead	Socio-economics Lead
Atlantic Mackerel	Dave Secor	Mark Holliday
Atlantic Surfclam	Wendy Gabriel	Bonnie McCay
Ocean Quahog	Ed Houde	Bonnie McCay
Spiny Dogfish	Yan Jiao	David Tomberlin
Bluefish	Cynthia Jones	Doug Lipton
Butterfish	Rob Latour	Mark Holliday
Black Sea Bass	Tom Miller/Olaf Jensen	Marty Smith
Golden Tilefish	Doug Vaughan	Marty Smith
Scup	Wendy Gabriel	Mark Holliday
Summer Flounder	Mike Wilberg	Doug Lipton
Long-finned Squid	Mike Frisk	Sunny Jardine
Short-finned Squid	Tom Miller	Sunny Jardine
Ecosystems	Ed Houde	Doug Lipton
Deep Sea Corals	John Boreman	Bonnie McCay
Blueline Tilefish	Sarah Gaichas	David Tomberlin