**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, $\Delta$, 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 $\Delta$, instead developing a rough estimate of the reduction in vulnerable biomass. Substituting $\Delta$ 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.

**Inputs**

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 ($\Delta$). 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 $\Delta$ 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 $\text{Pauly}_{\text{nls-T}}$ estimator ( $M = 4.118k^{0.73}L_{\infty}^{-0.33}$; $k = 0.311$ and $L_{\infty} = 815.3$ from Robillard et al. 2009) 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.

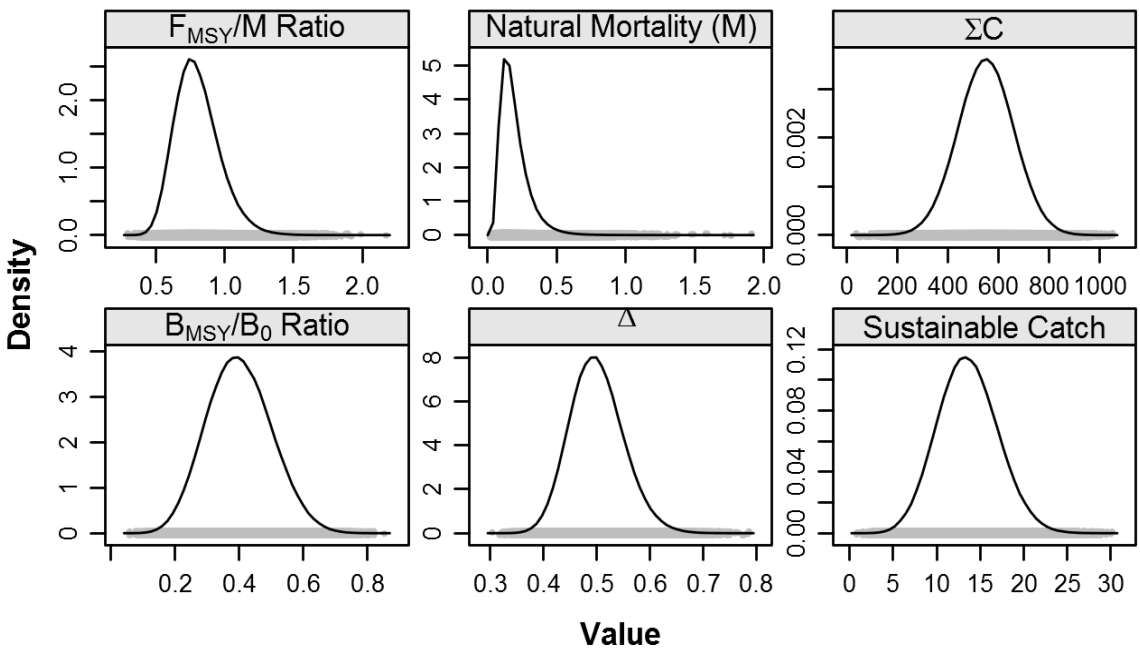
| Parameter | Value | Source | SD | Source | Distribution |
|---|---|---|---|---|---|
| CV of $\sum C$ | 0.2 | – | – | – | normal |
| M | 0.192 | Then et al. (2015) $\text{Pauly}_{\text{nls-T}}$ estimator | 0.5 | MacCall (2009) | lognormal |
| $F_{MSY}/M$ | 0.8 | MacCall (2009); Dick & MacCall (2011) | 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 |
| $\Delta$ | 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.

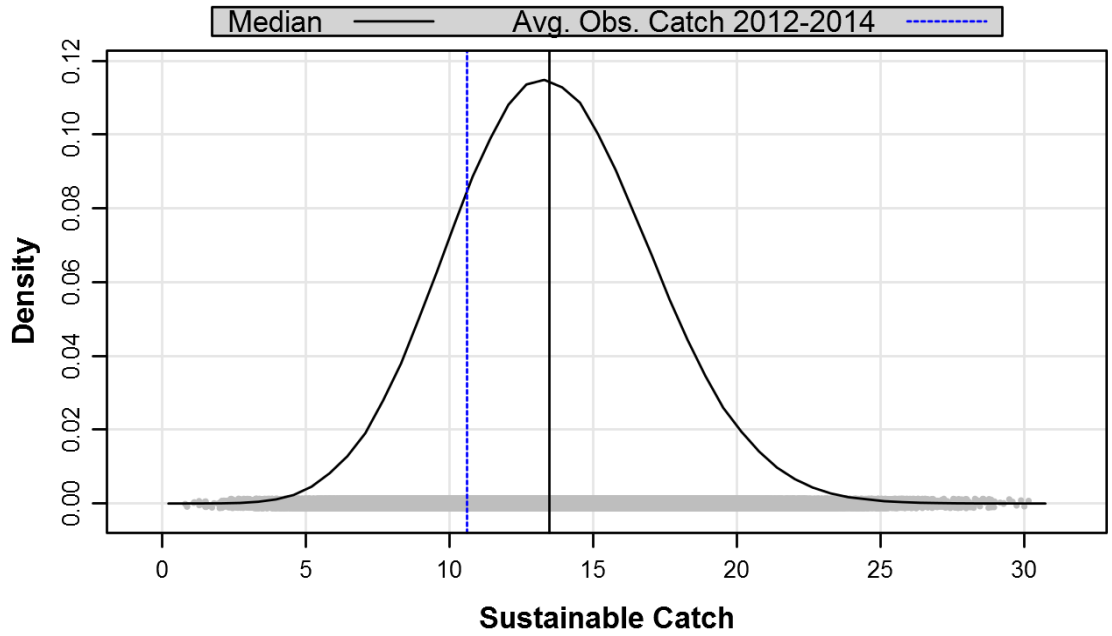
| | | 95% Confidence Interval | | 90% Confidence Interval | |
|---|---|---|---|---|---|
| **Average** | **Median** | **Lower** | **Upper** | **Lower** | **Upper** |
| 13,569.60 | 13,479.37 | 7,133.98 | 20,516.88 | 8,077.81 | 19,357.62 |




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).



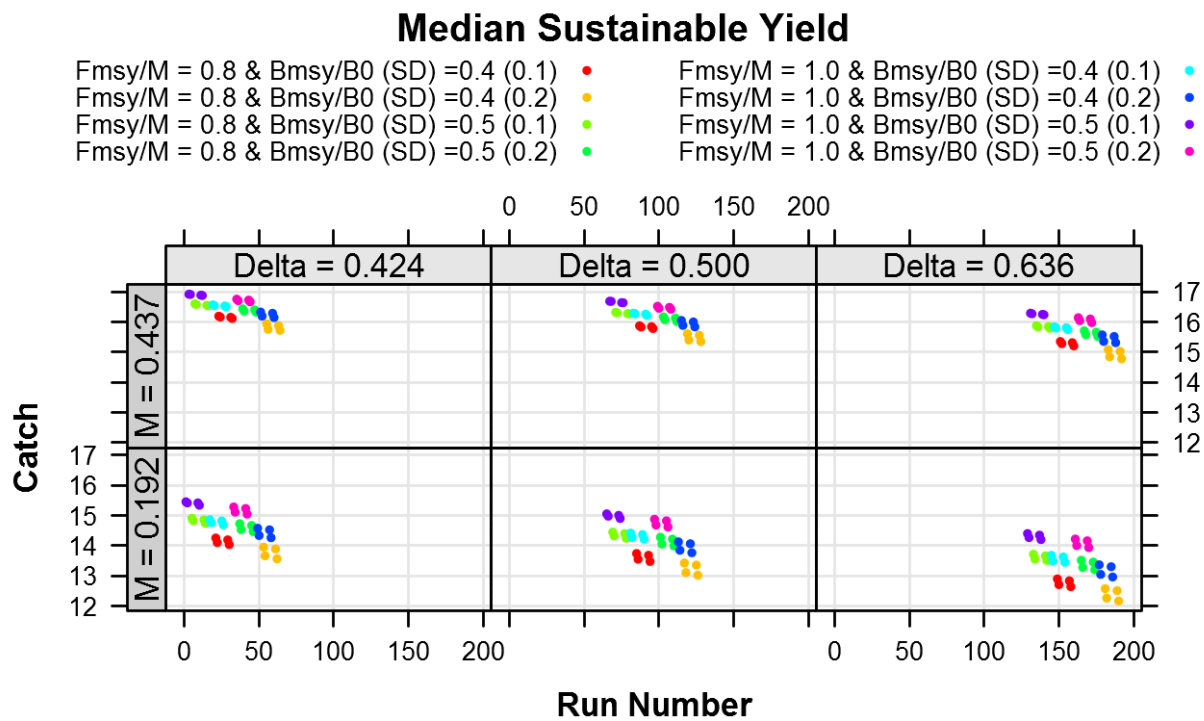

App. B4, Figure 2: Density plot of sustainable yield based on 1,000,000 Monte Carlo simulations of the DCAC base model. Vertical lines represent the median sustainable yield estimate (black) and observed average catch (blue) during the three terminal years (2012-2014) of the assessment.

**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) $\text{Hoenig}_{nls}$ | – | – |
| 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 5$^{th}$ and 95$^{th}$ percentiles of the estimate.

**Literature Cited**

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Fletcher, R. I. 1978. On the restructuring of the Pella-Tomlinson system. Fish. Bull, 76: 515-521.

Walters, C. J., S. J. Martell and J. Korman. 2006. A stochastic approach to stock reduction analysis. Canadian Journal of Fisheries and Aquatic Sciences 63(1): 212-223.

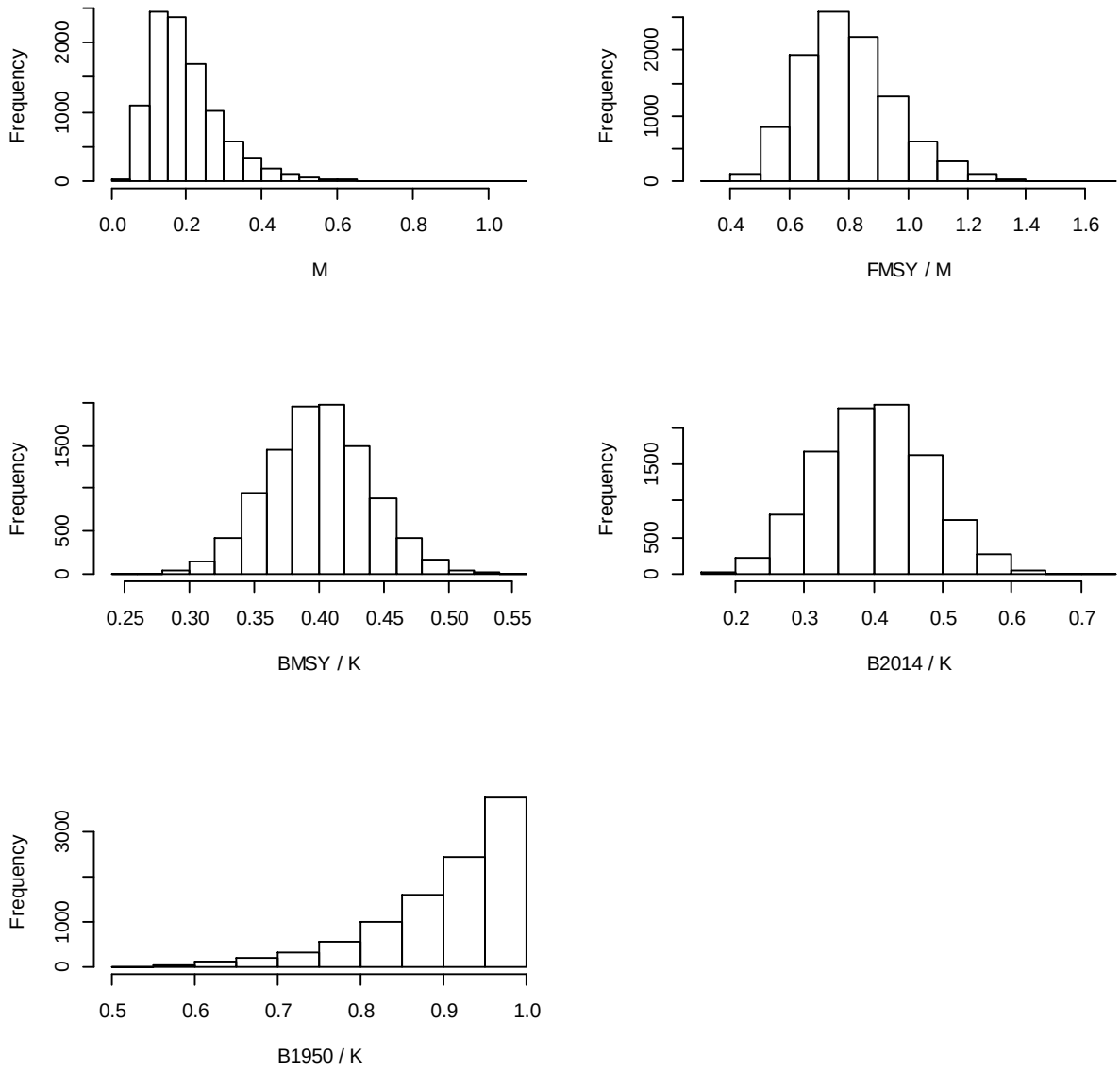
App. B5, Table.1. Input values for the base run of the DBSRA model for bluefish.

| 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 |

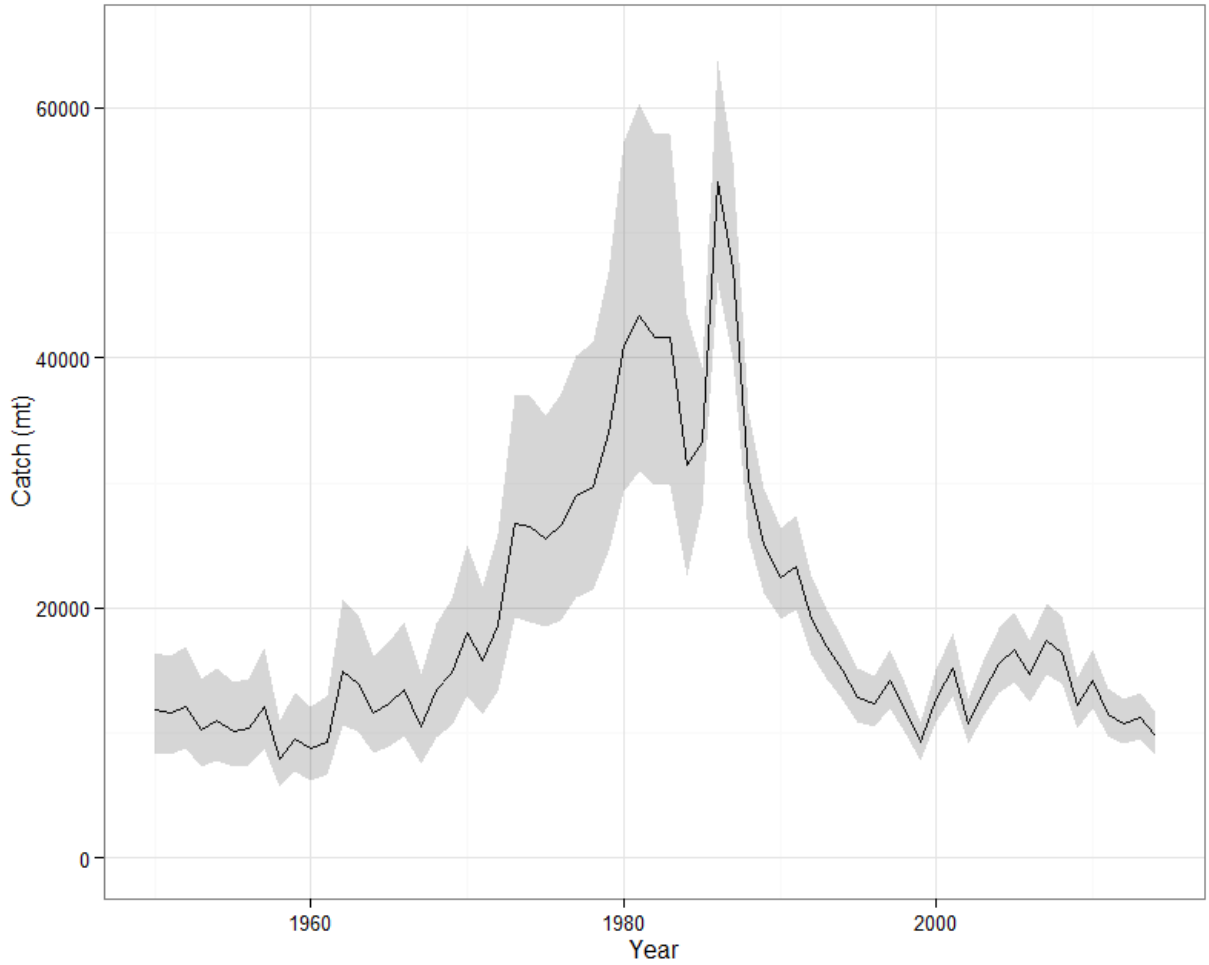
App. B5, Table 2: Median management benchmarks (and 5th and 95th quantiles) from DBSRA model.

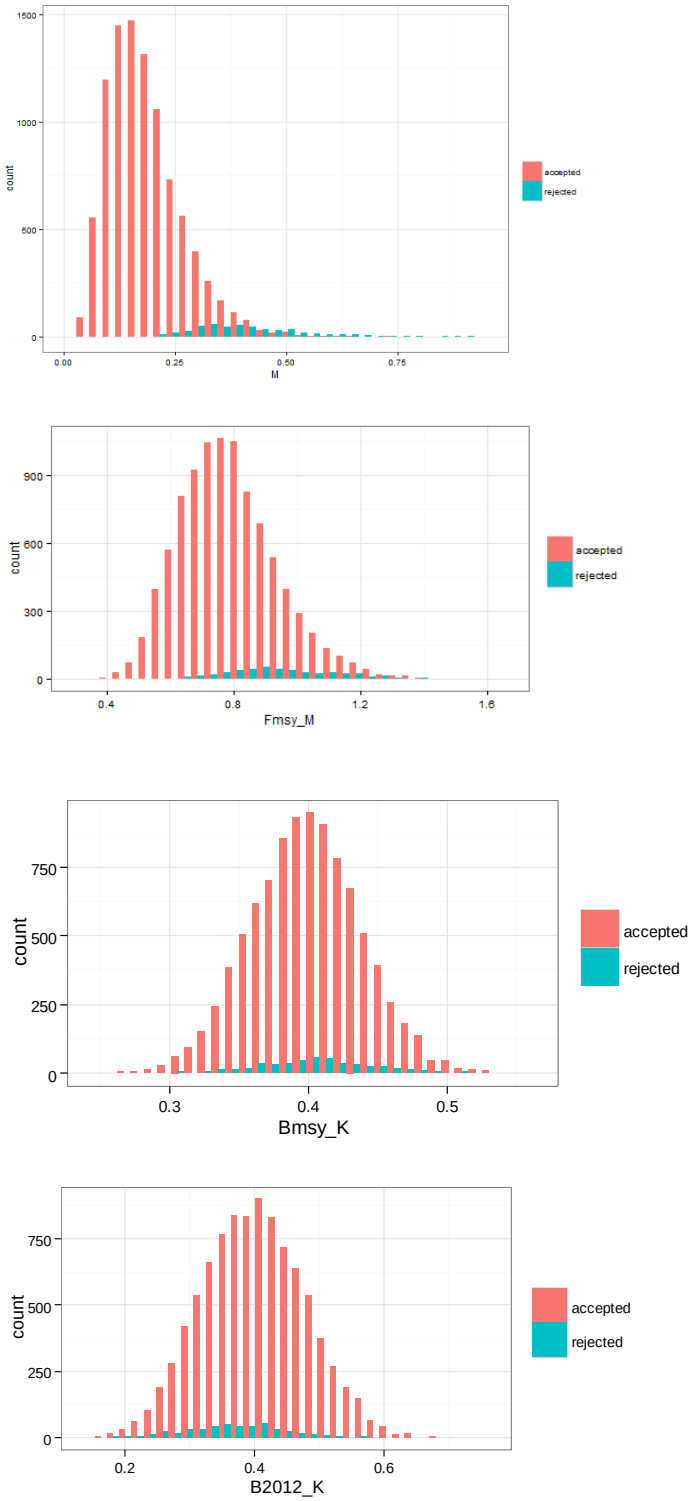
| | $U_{MSY}$ | K | MSY | $B_{MSY}$ |
|---|---|---|---|---|
| **Base run** | 0.12 (0.05 - 0.21) | 432,049 mt (277,232 – 831,884 mt) | 19,954 mt (14,905 – 24,943 mt) | 172,010 mt (110,510 – 324,853 mt) |
| $B_{1950}/K$= **1.0** | 0.11 (0.05 - 0.19) | 486,155 mt (335,848 – 818,767 mt) | 22,054 mt (17,196 – 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.

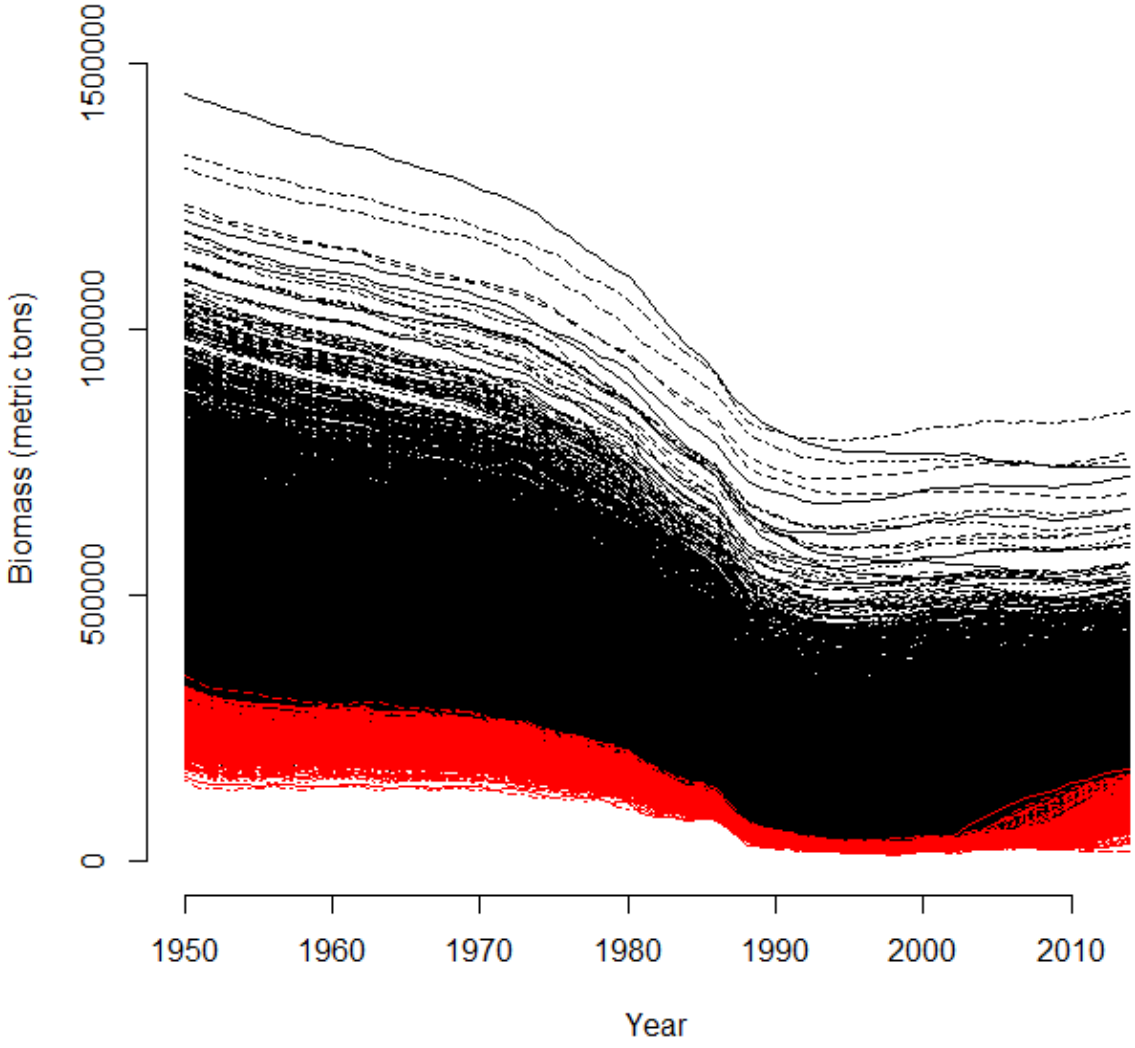


App. B5, Figure .2. Distribution of the drawn catch for the base model DBSRA runs for bluefish.

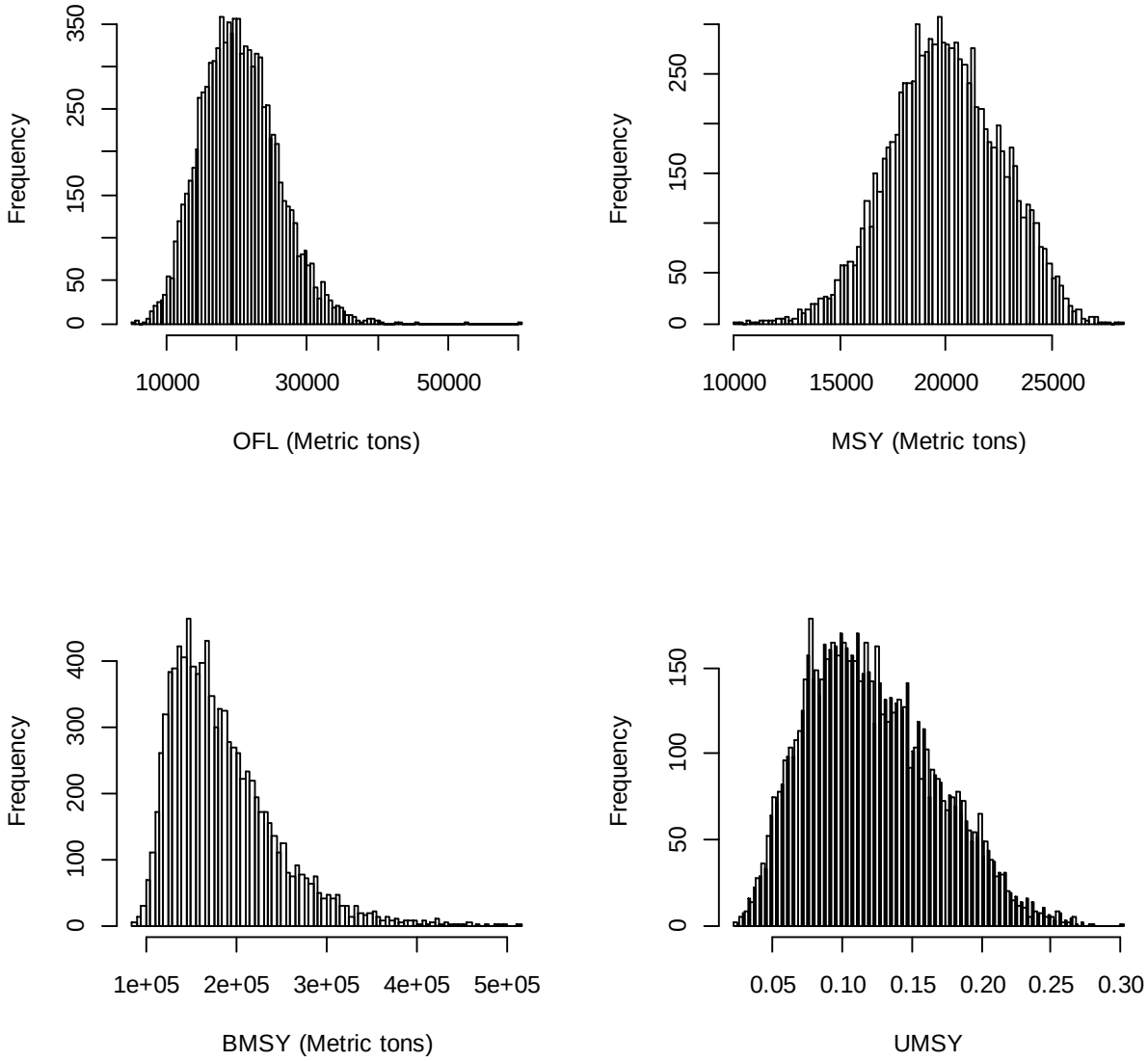





App. B5, Figure.3. Distributions of drawn parameters for runs that were accepted and rejected from the base model DBSRA configuration.




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 |
| $\mathbf{F_{THRESHOLD}}$ | $F_{MSY}$ | 0.19 | $F_{40\%SPR}$ | 0.181 |
| $\mathbf{B_{TARGET}}$ | $B_{MSY}$ | 147,052 mt | Equilibrium biomass under $F_{40\%SPR}$ | 126,504 mt |
| $\mathbf{B_{THRESHOLD}}$ | 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 (5$^{th}$ and 95$^{th}$ 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.

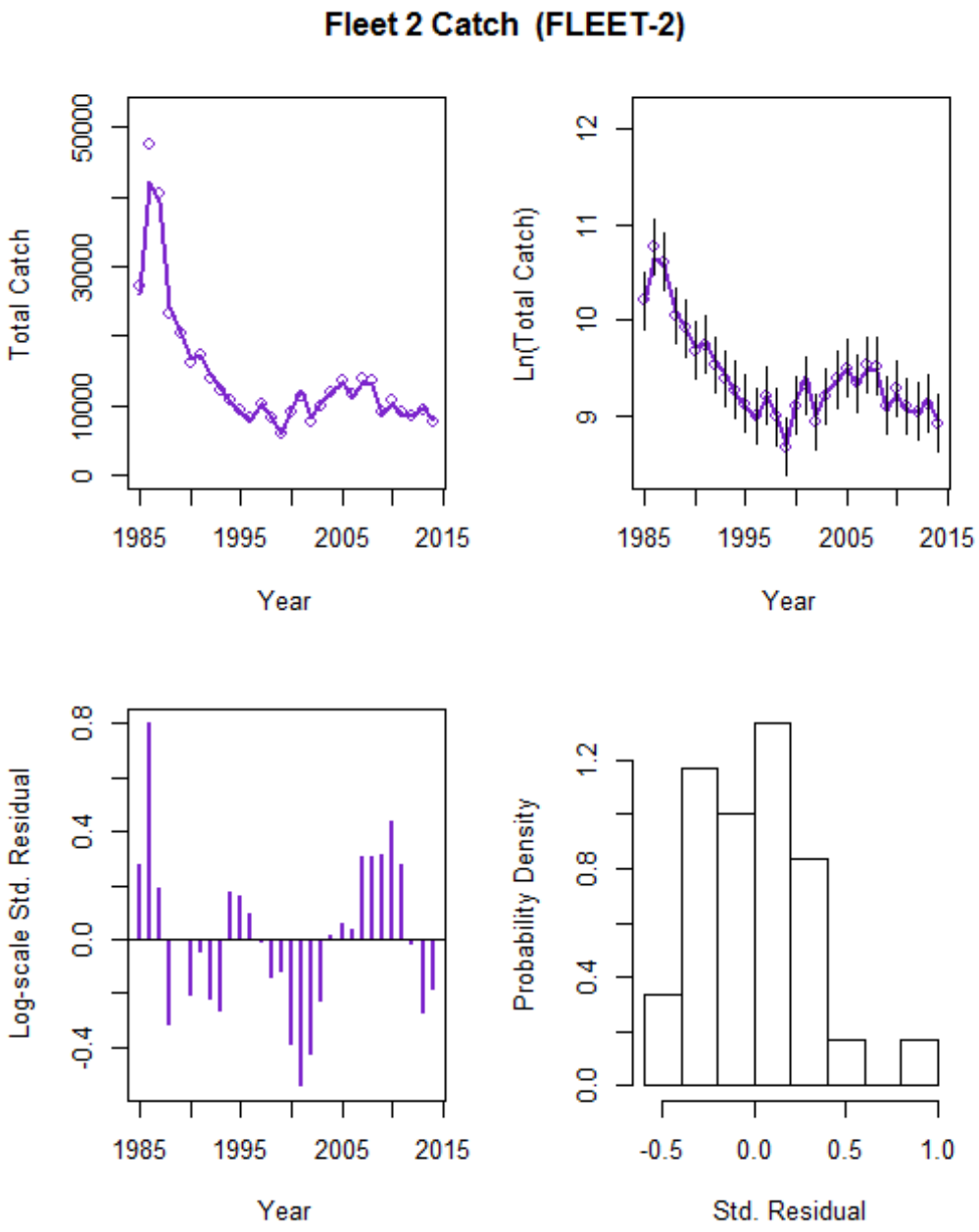
| F Scenario | Landings (mt) | | | Total Biomass (mt) | | | P (2018) > Bthreshold |
|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 | |
| FMSY = 0.181 | 12,752 | 12,332 | 12,420 | 114,731 | 112,758 | 111,347 | 1.00 |
| Ftarget = 0.163 | 11,552 | 11,306 | 11,512 | 114,731 | 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

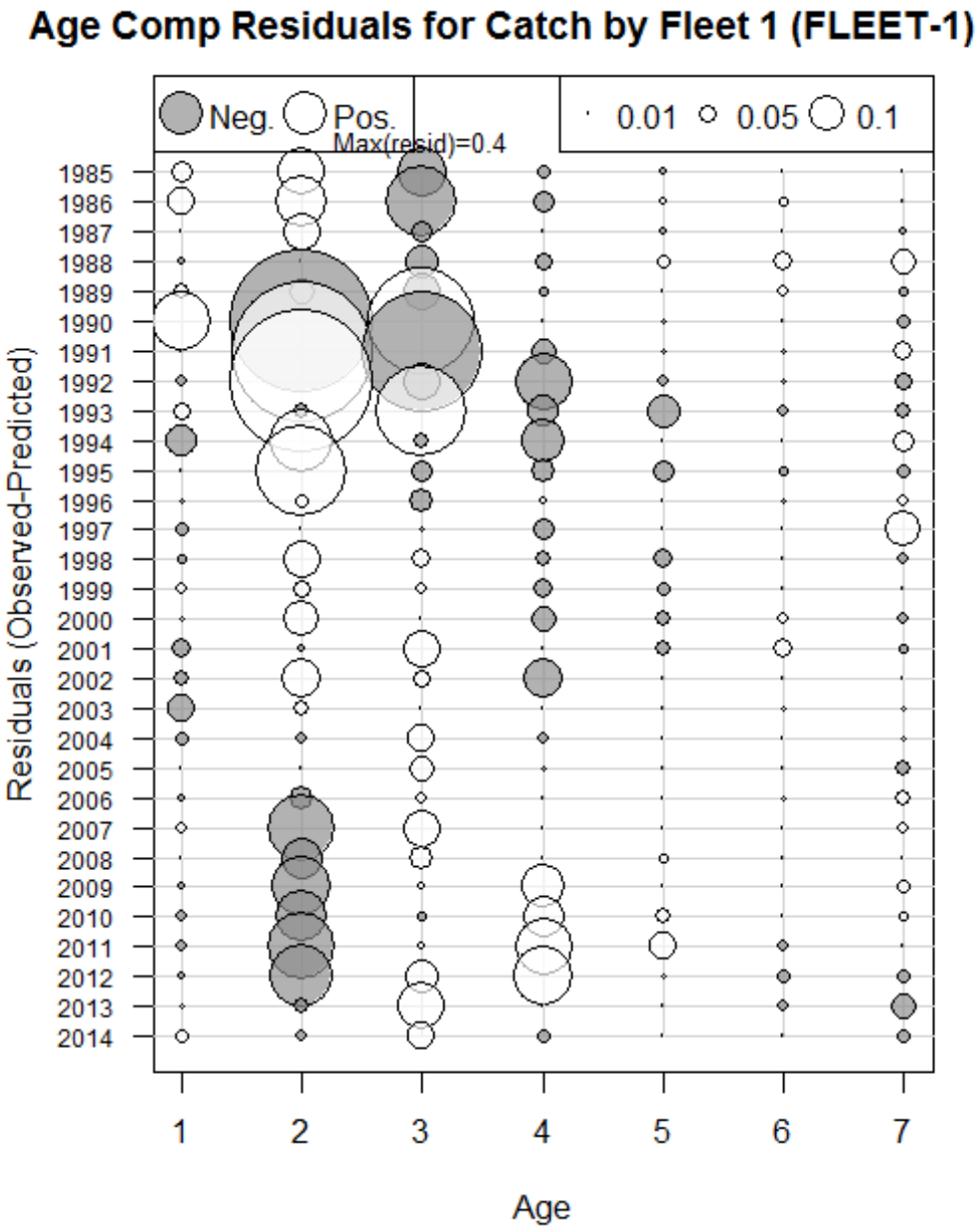
| | Landings (mt) | | | Total Biomass (mt) | | |
|---|---|---|---|---|---|---|
| F = Fmsy | 2016 | 2017 | 2018 | 2016 | 2017 | 2018 |
| Base model | 12,752 | 12,332 | 12,420 | 114,731 | 112,758 | 111,347 |
| Increased CVs | 12,984 | 12,599 | 12,615 | 114,699 | 112,497 | 110,765 |
| M=0.26 | 18,122 | 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.)***

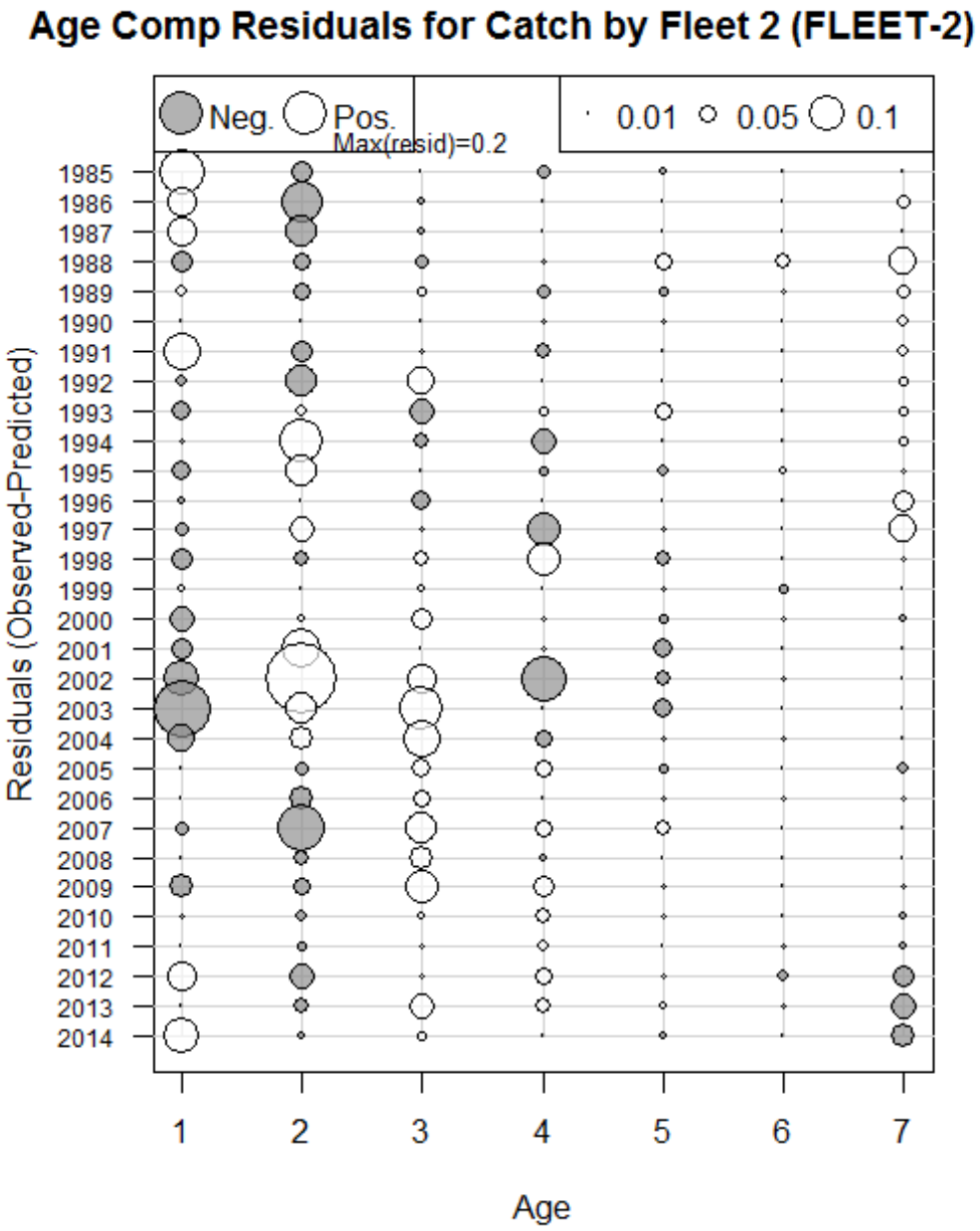



App. B7 App. B7 Figure B7.45. Final model fit to the recreational catch fleet with log-scale standardized residuals and residual probability density.

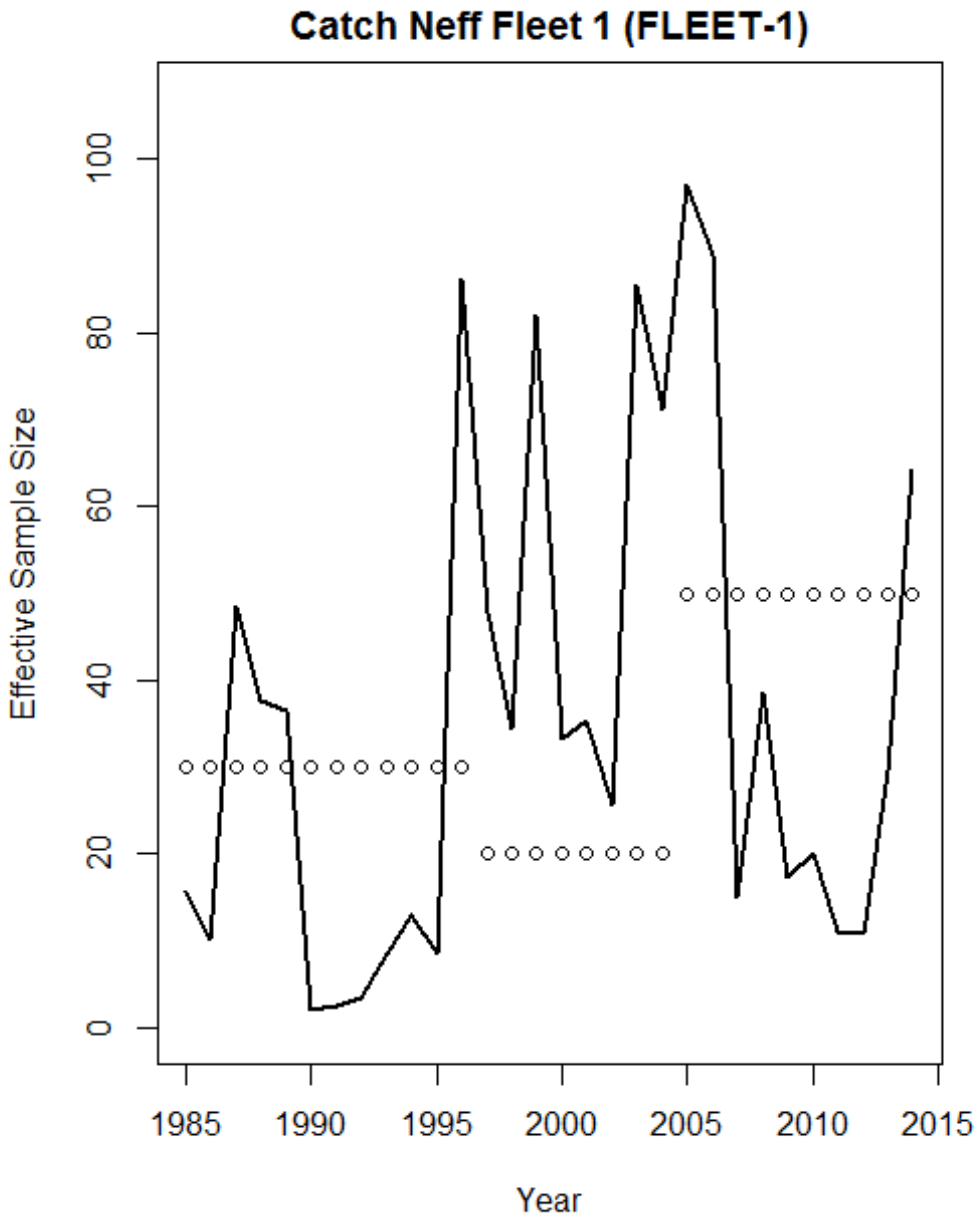
***( NOTE: The values presented in this Appendix B7 reflect the output from the early model presented in the draft WP document and at the peer review, before final revision. For the final SAW/SARC60 assessment results, readers should see the main body of the bluefish report.)***



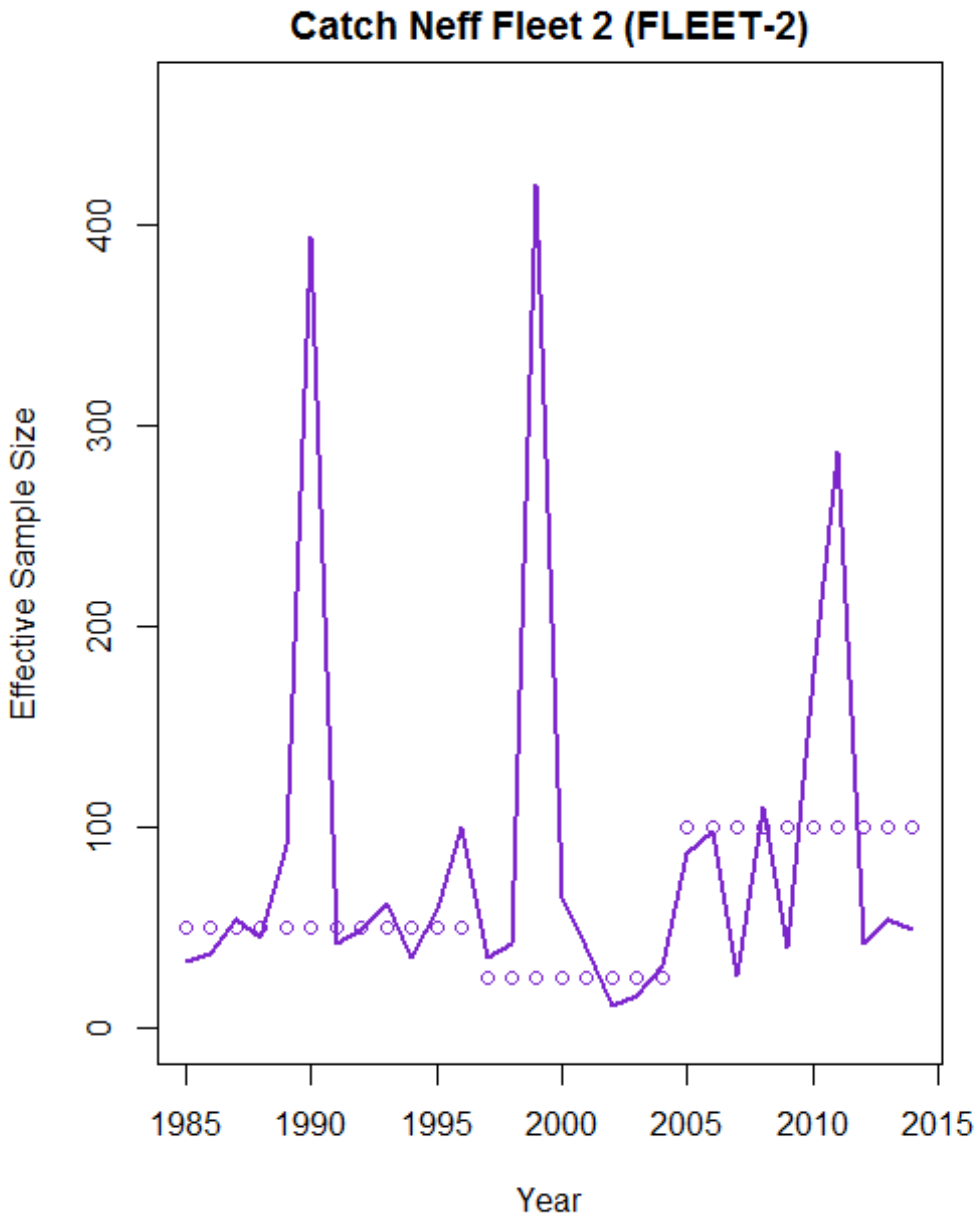

App. B7 Figure B7.46. Age-composition residuals for the commercial catch fleet.



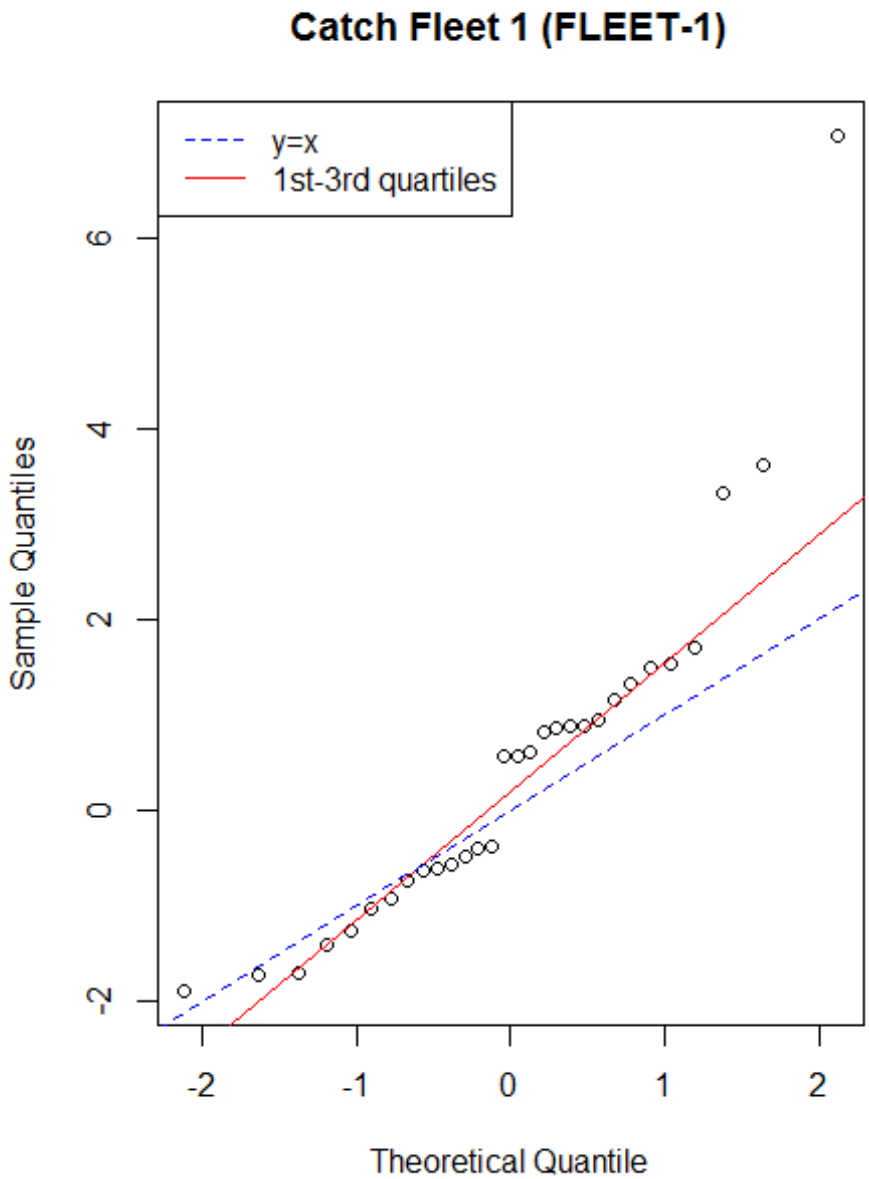

App. B7 Figure B7.47. Age composition residuals for the recreational catch fleet.



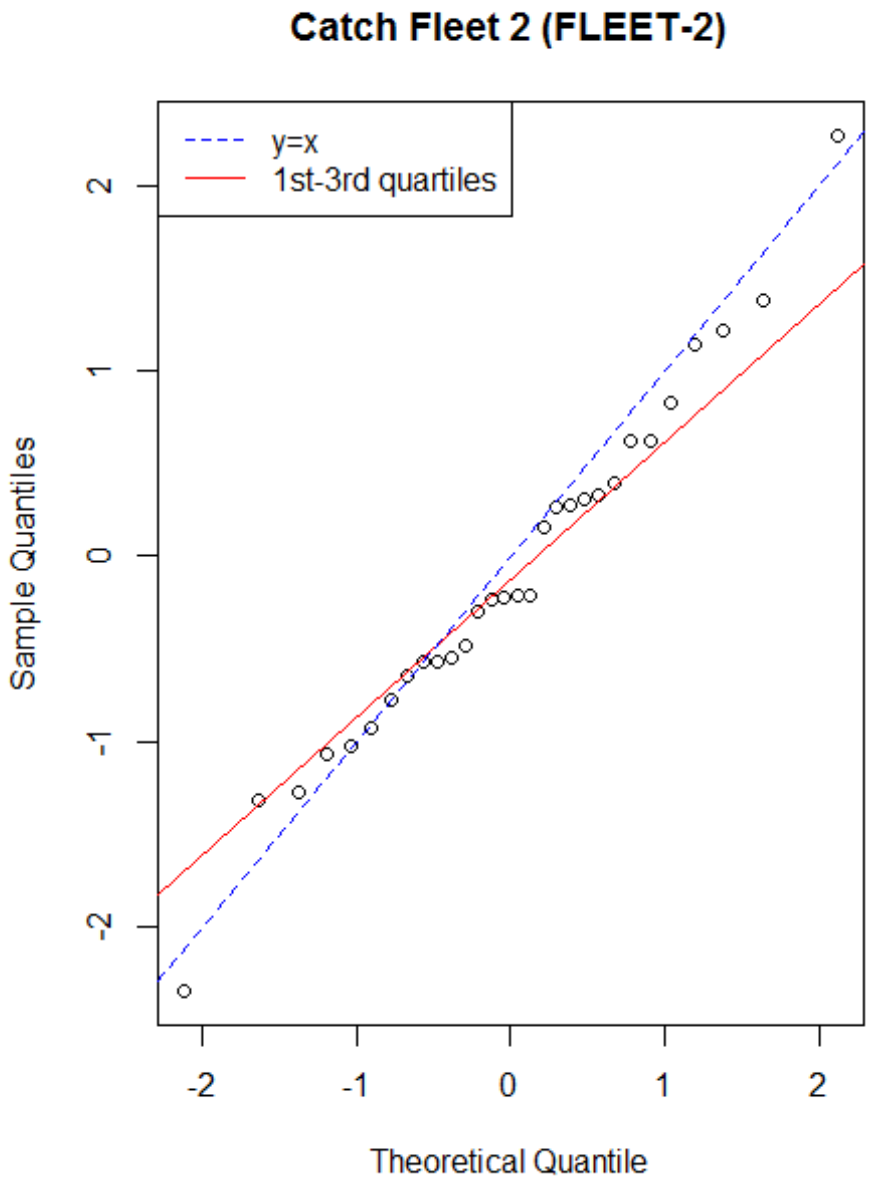

App. B7 Figure B7.48. Input and estimated effective sample size for the commercial catch fleet.



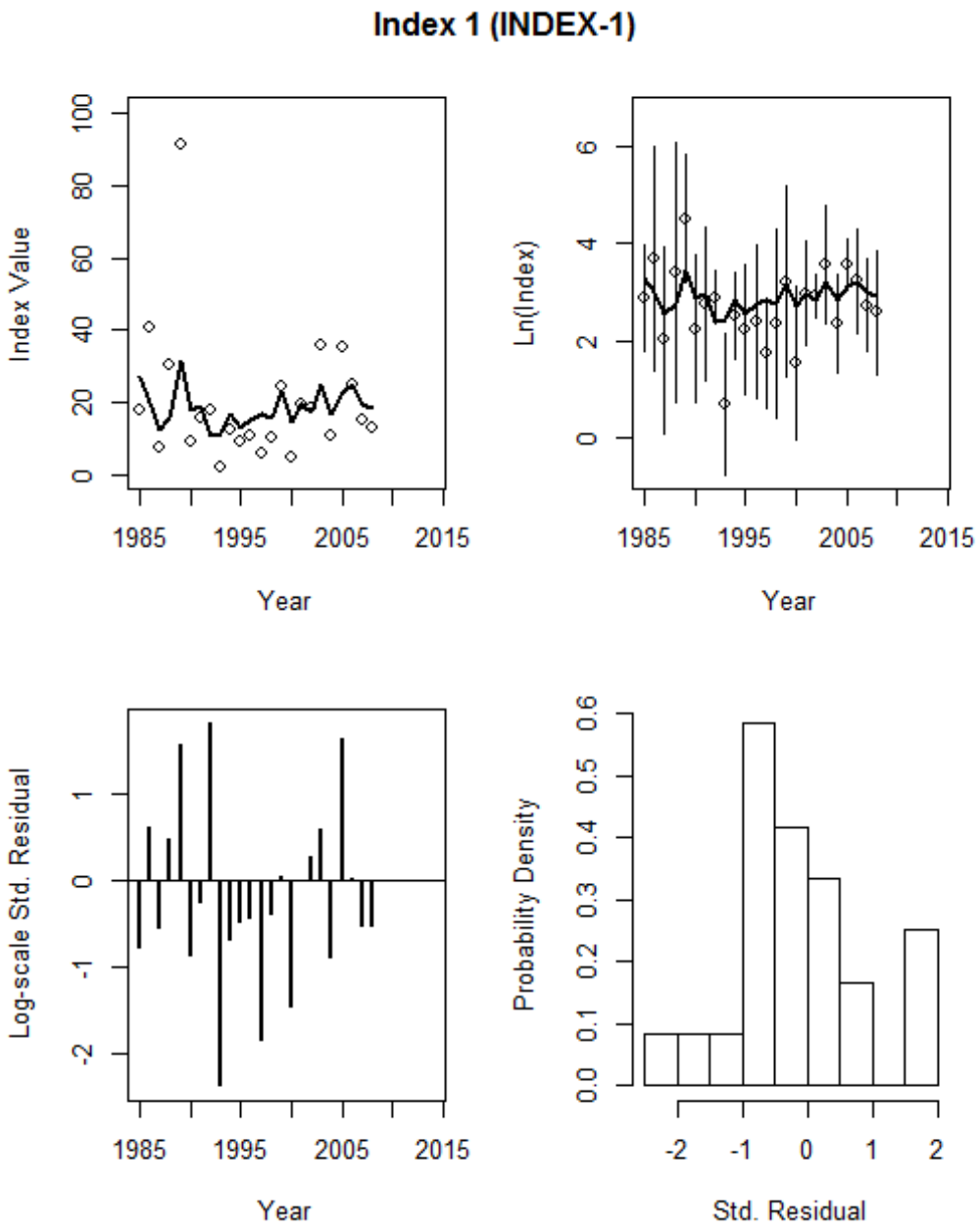

App. B7 Figure B7.49. Input and estimated effective sample size for the recreational catch fleet.



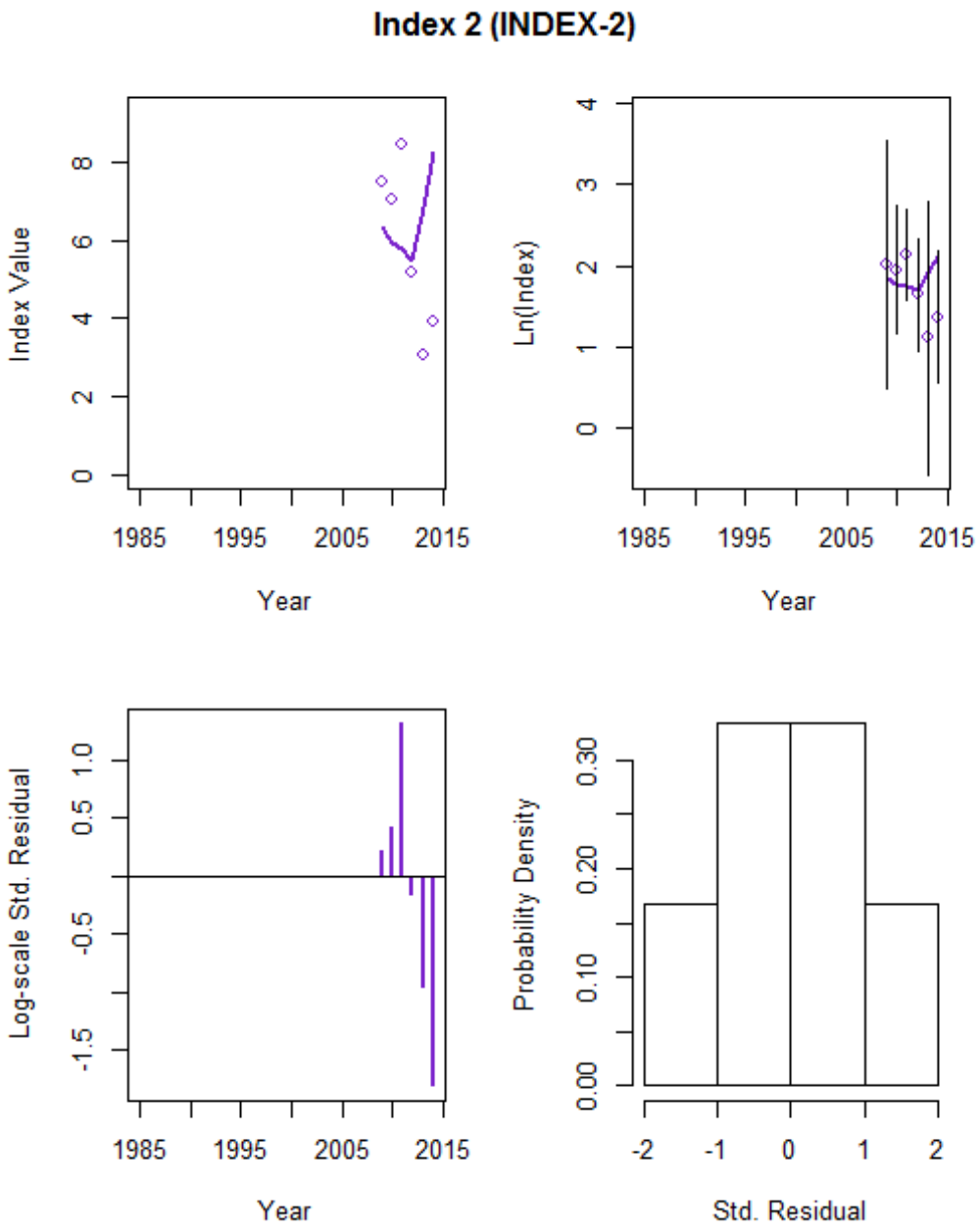

App. B7 Figure B7.50. QQ-plot for the observed versus predicted mean catch for the commercial catch fleet.



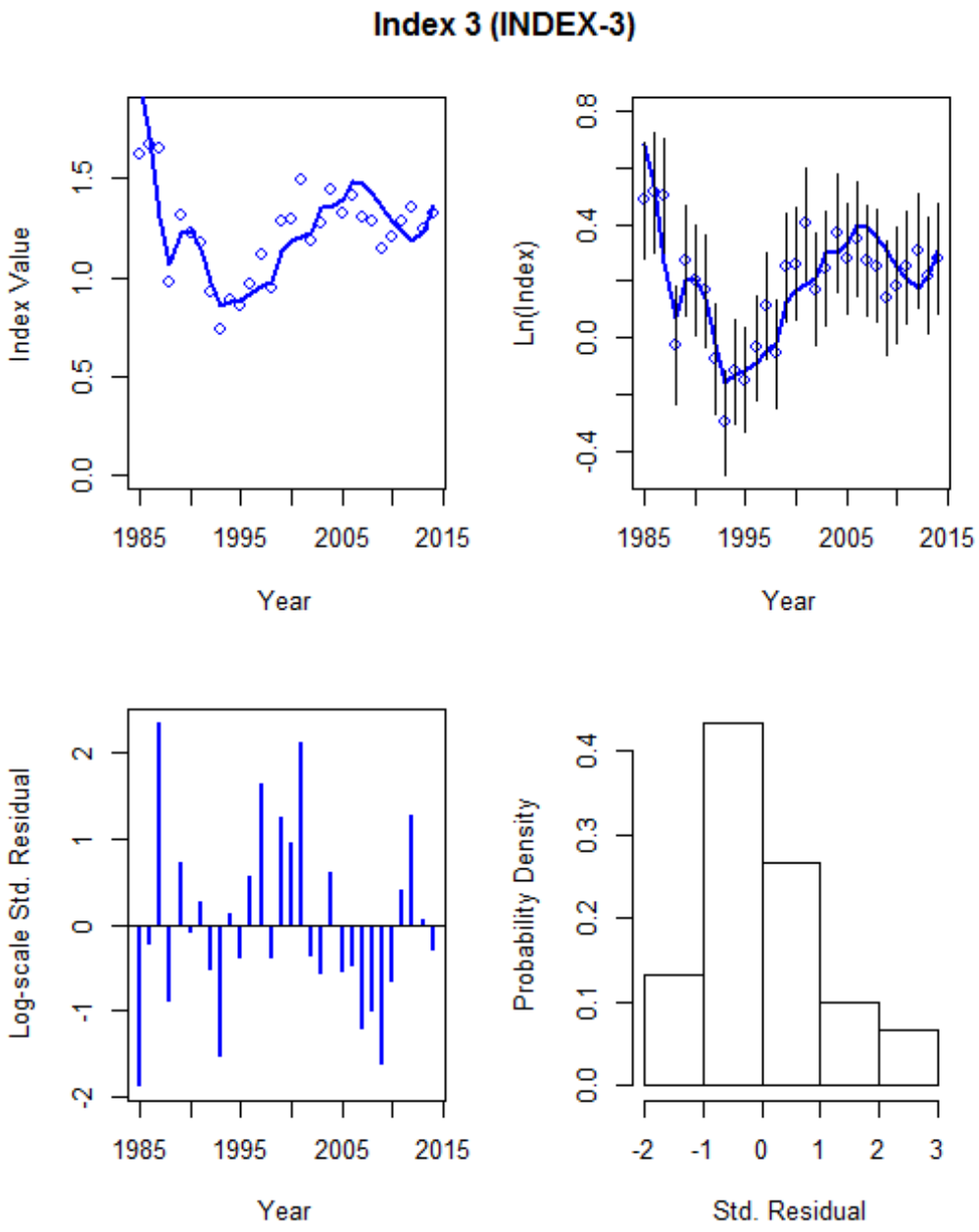

App. B7 Figure B7.51. QQ-plot for the observed versus predicted mean catch for the recreational catch fleet.



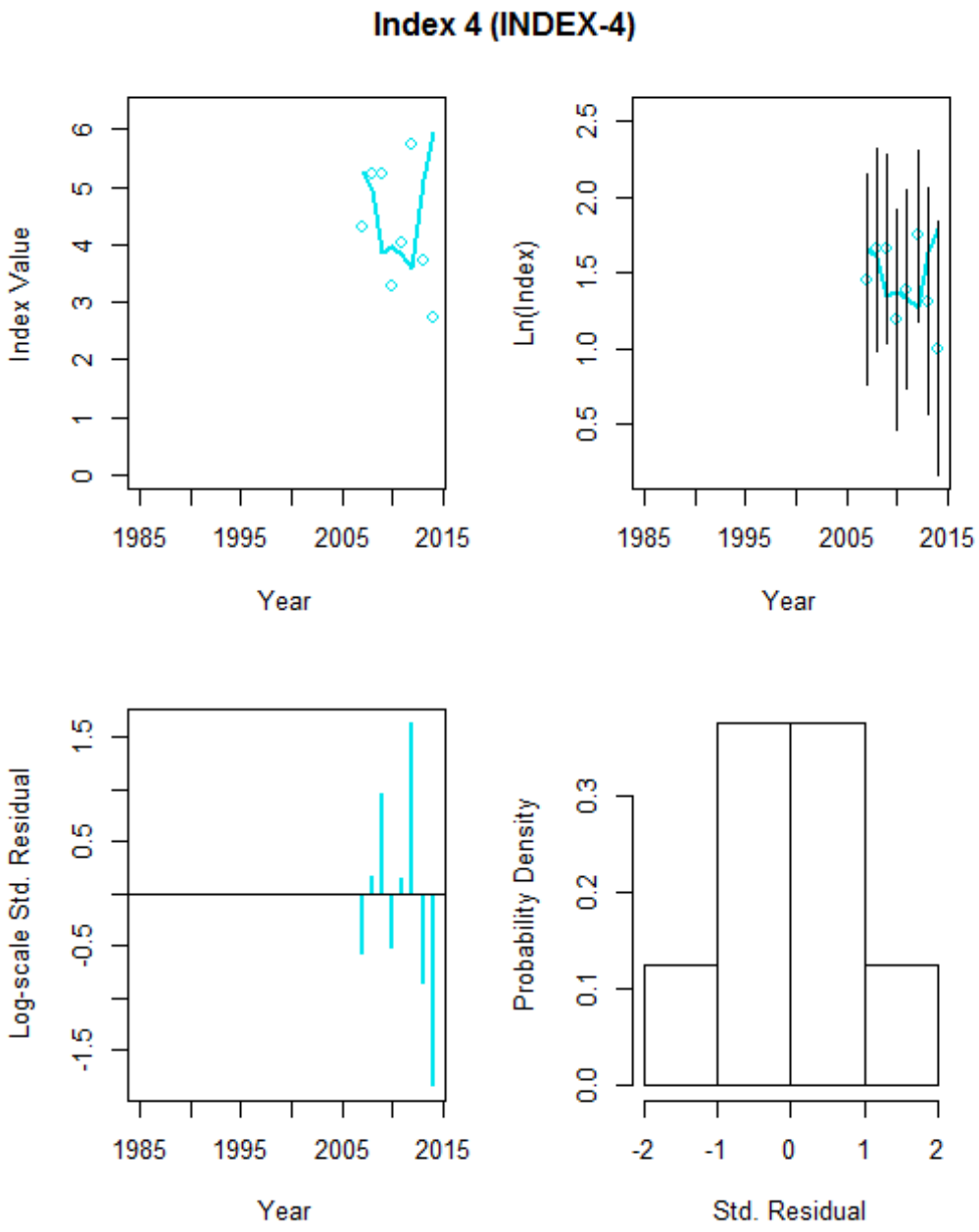

App. B7 Figure B7.52. Final model fit to the NEFSC Inshore survey with log-scale standardized residuals and residual probability density.



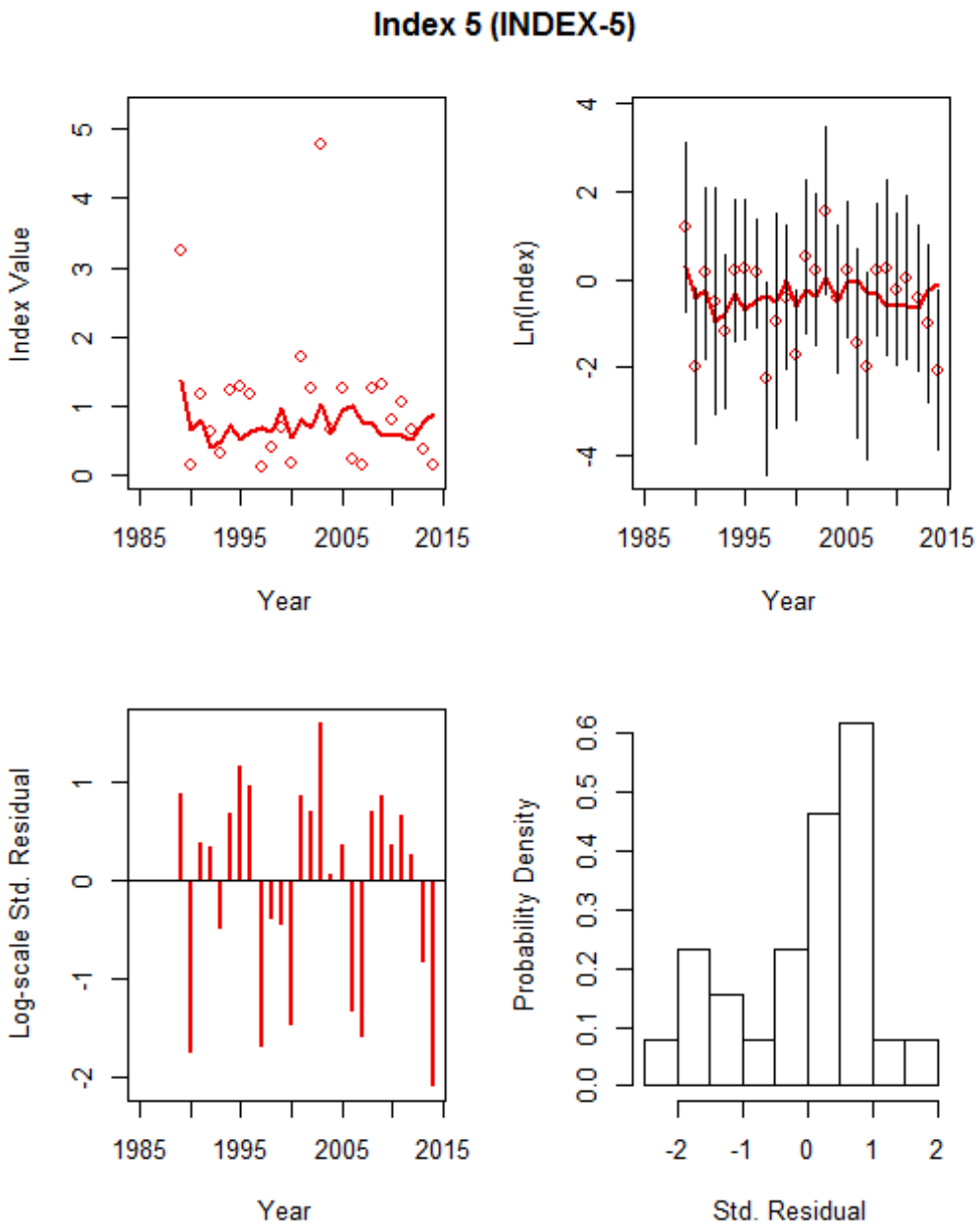

App. B7 Figure B7.53. Final model fit to the NEFSC Bigelow survey with log-scale standardized residuals and residual probability density.



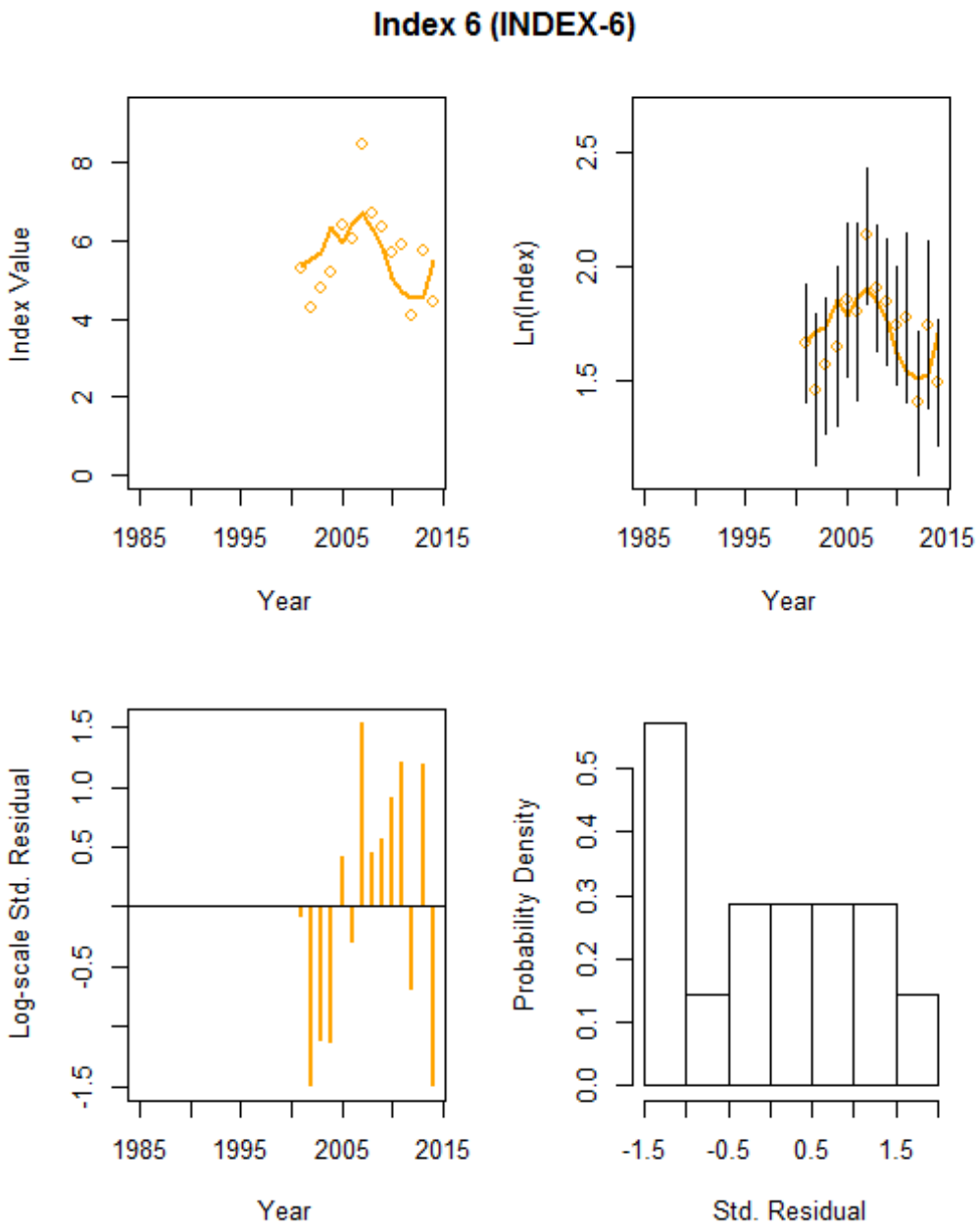

App. B7 Figure B7.54. Final model fit to the MRIP recreational CPUE index with log-scale standardized residuals and residual probability density.



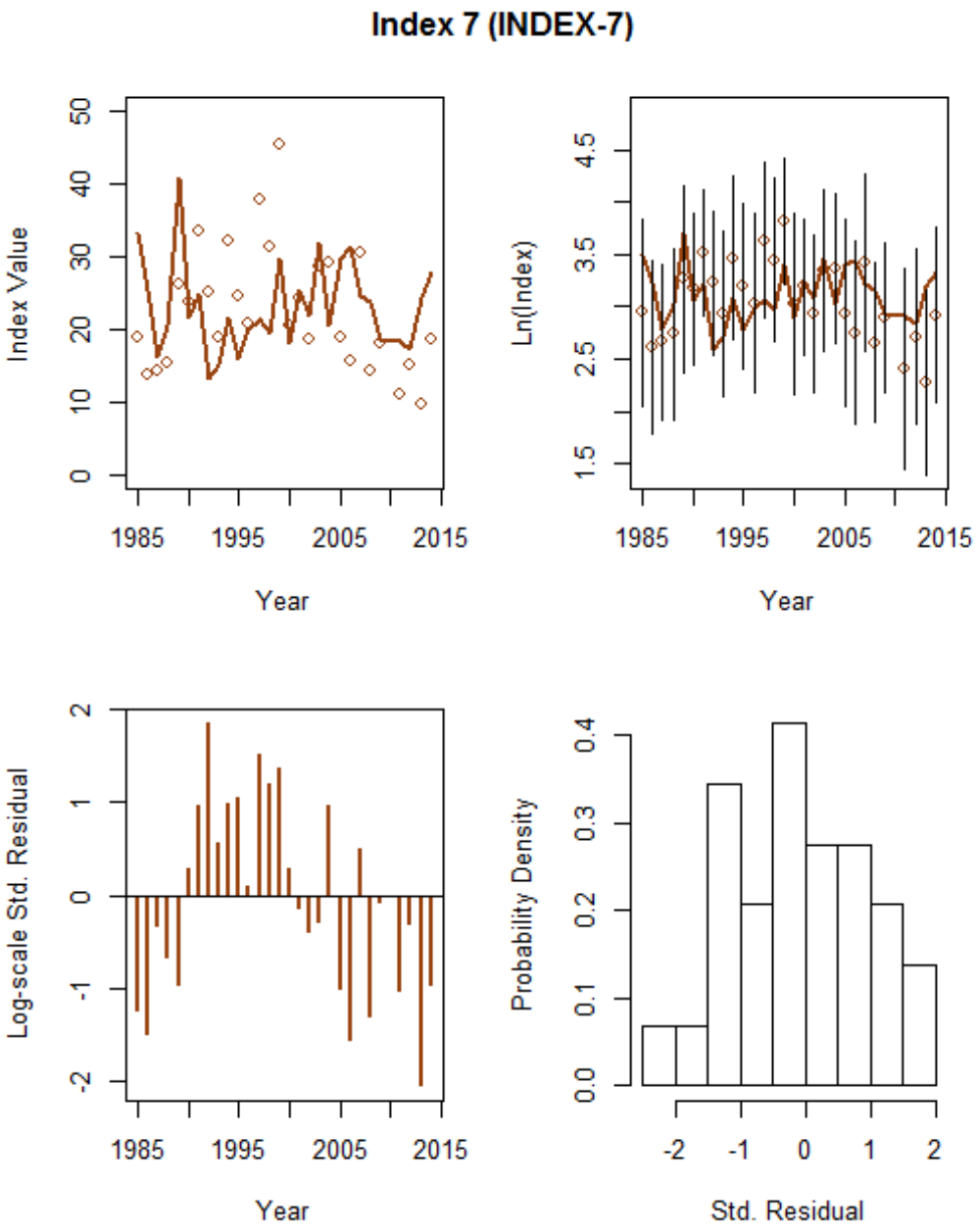

App. B7 Figure B7.55. Final model fit to the NEAMAP survey with log-scale standardized residuals and residual probability density.



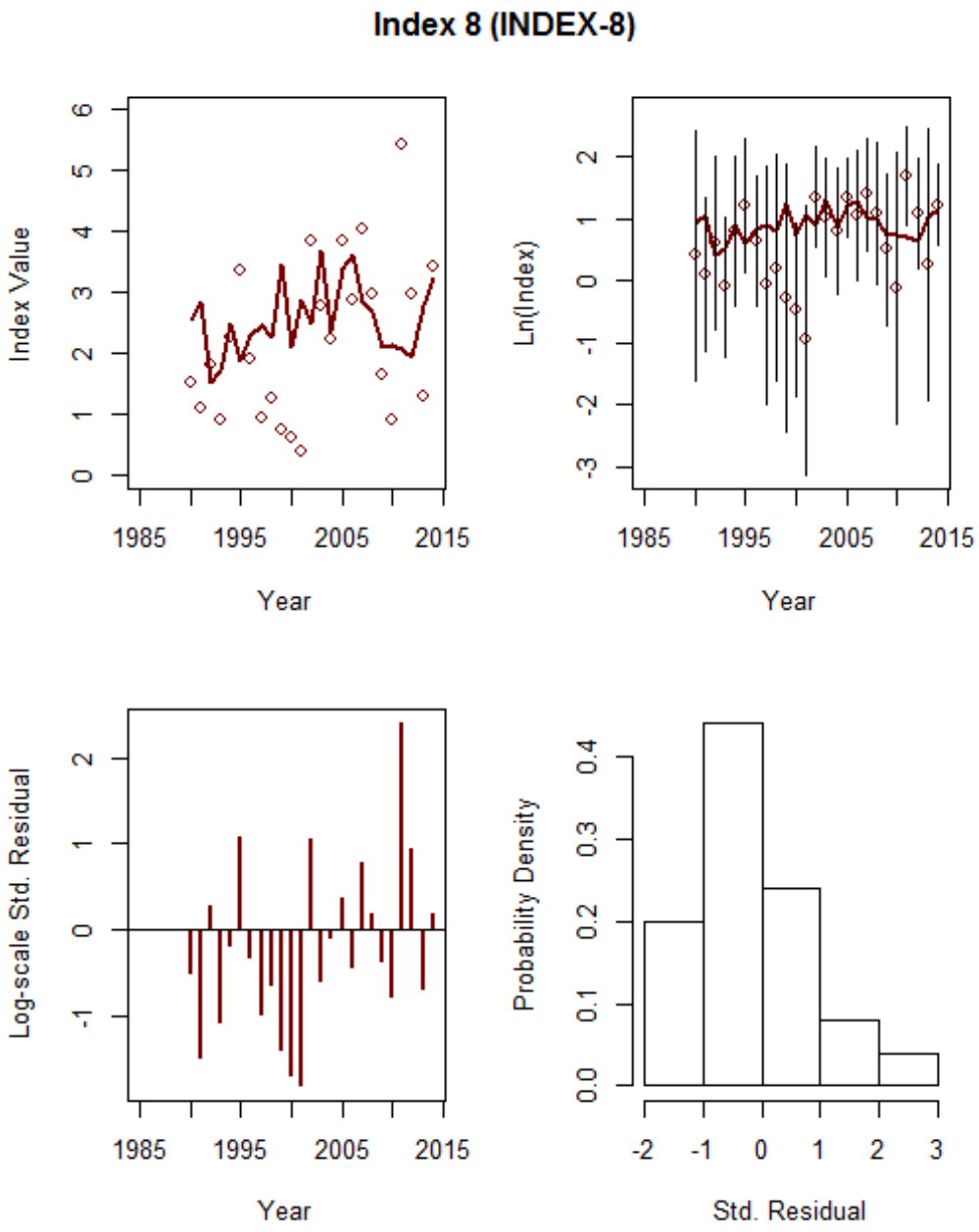

App. B7 Figure B7.56. Final model fit to the SEAMAP Age 0 index with log-scale standardized residuals and residual probability density.



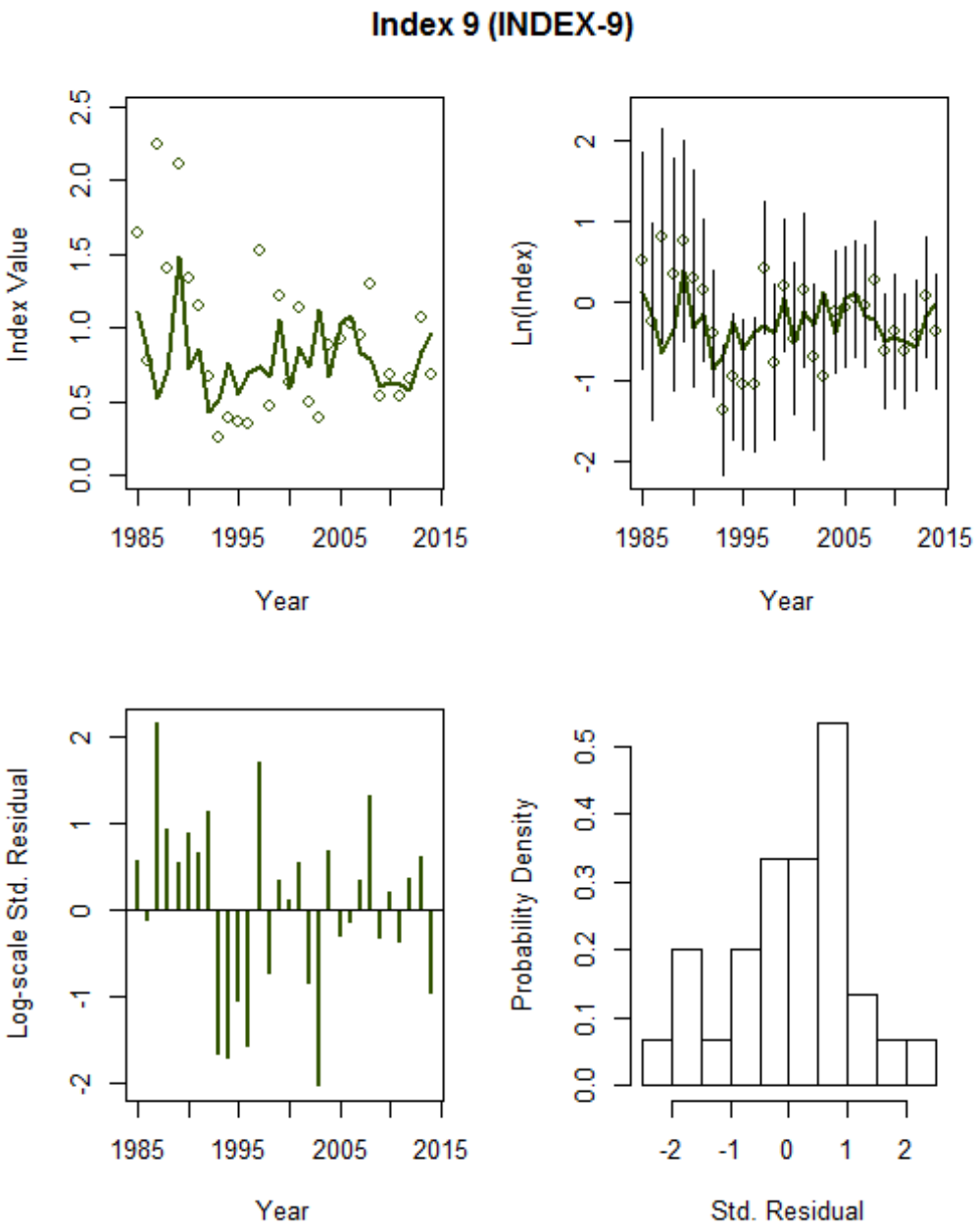

App. B7 Figure B7.57. Final model fit to the PSIGNS gillnet survey with log-scale standardized residuals and residual probability density.



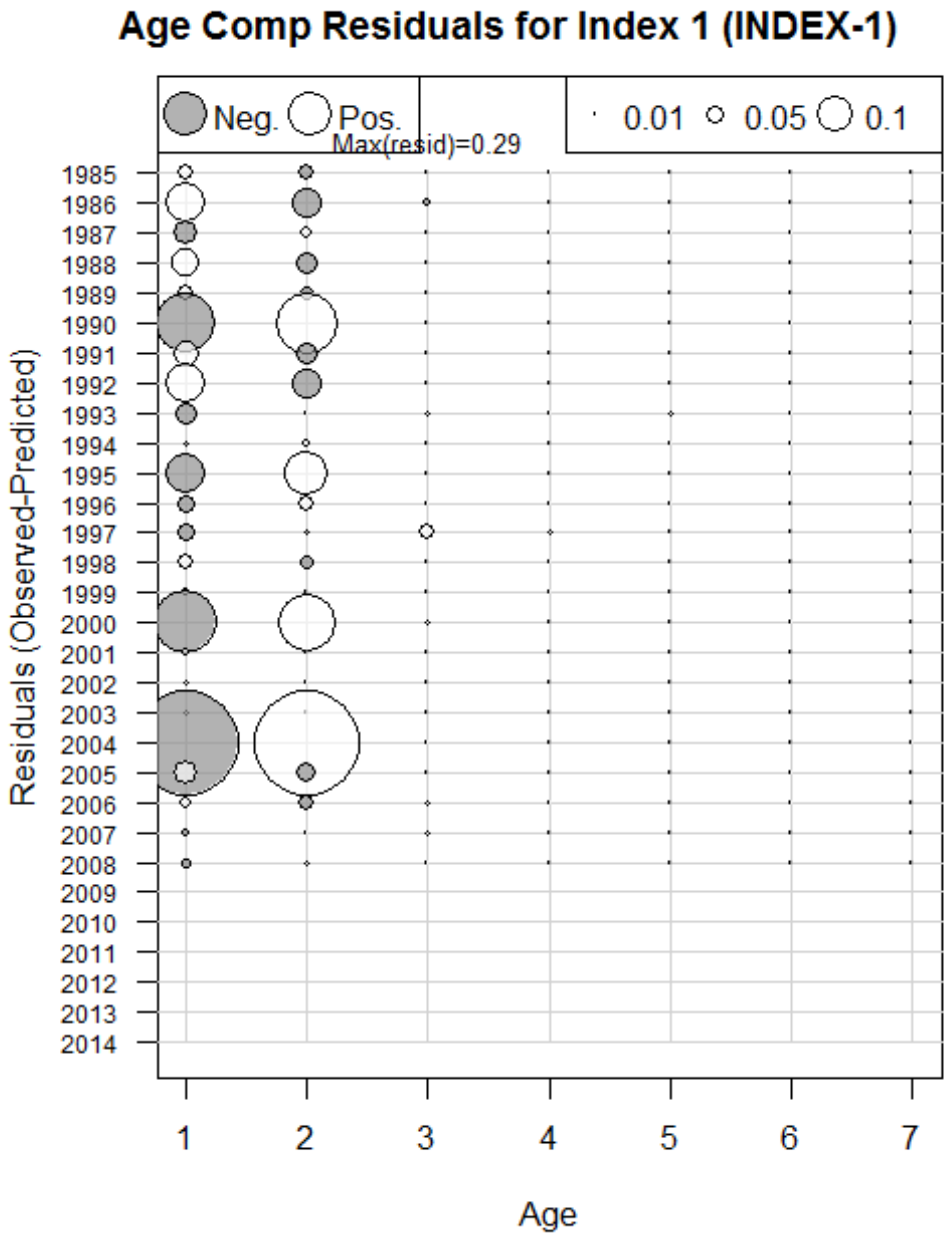

App. B7 Figure B7.58. Final model fit to the CT LISTS trawl survey with log-scale standardized residuals and residual probability density.



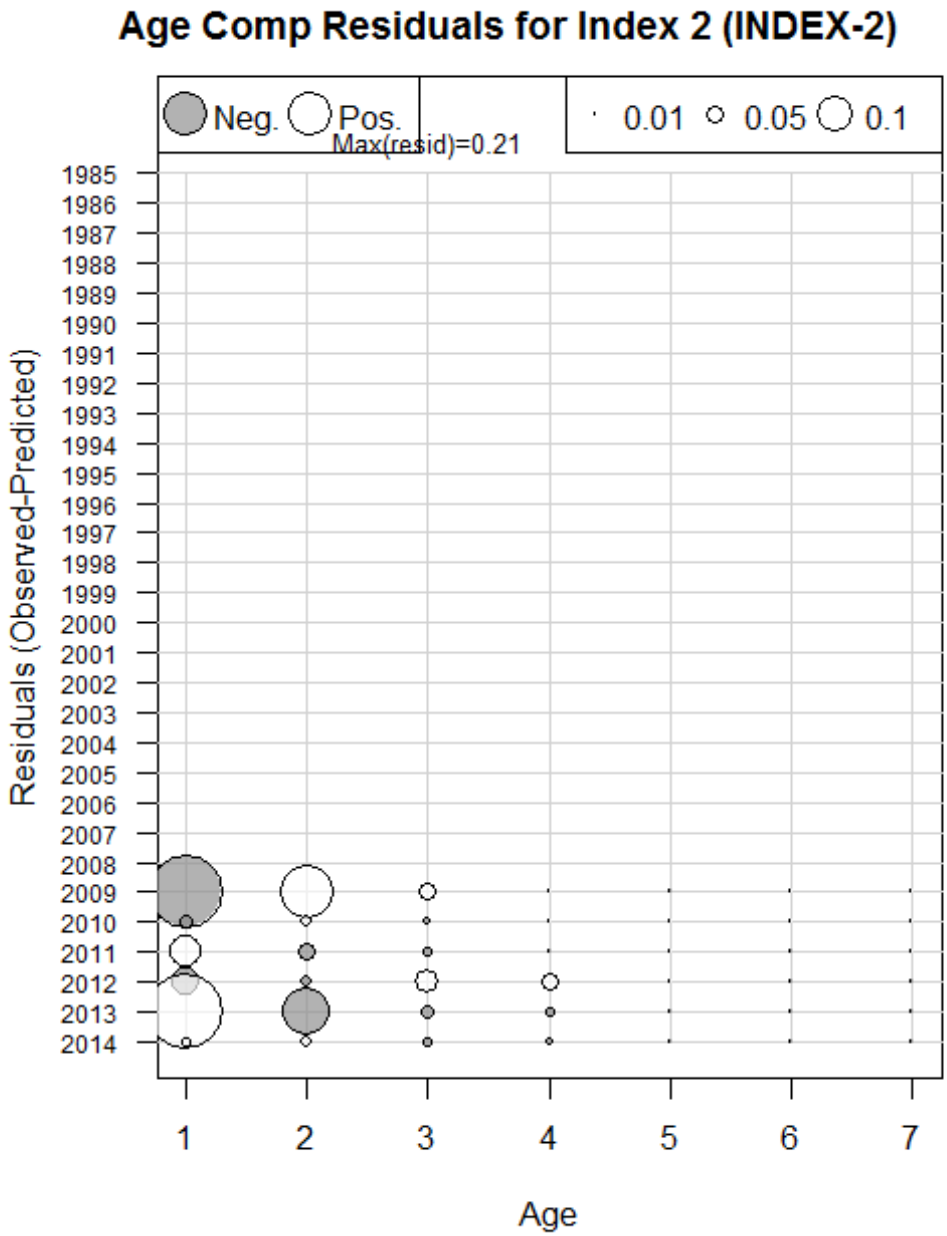

App. B7 Figure B7.59. Final model fit to the NJ ocean trawl survey with log-scale standardized residuals and residual probability density.



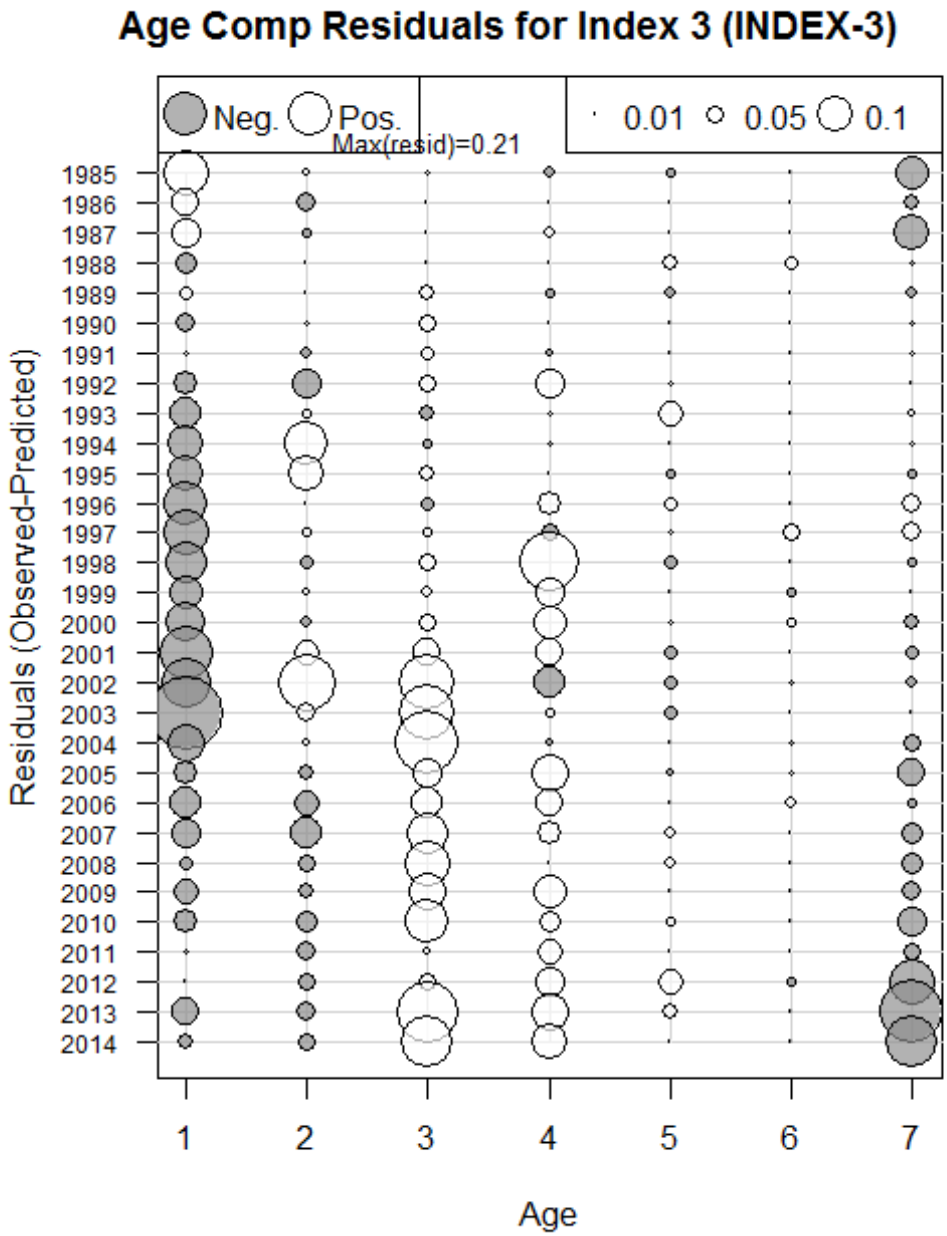

App. B7 Figure B7.60. Final model fit to the composite YOY seine survey with log-scale standardized residuals and residual probability density.



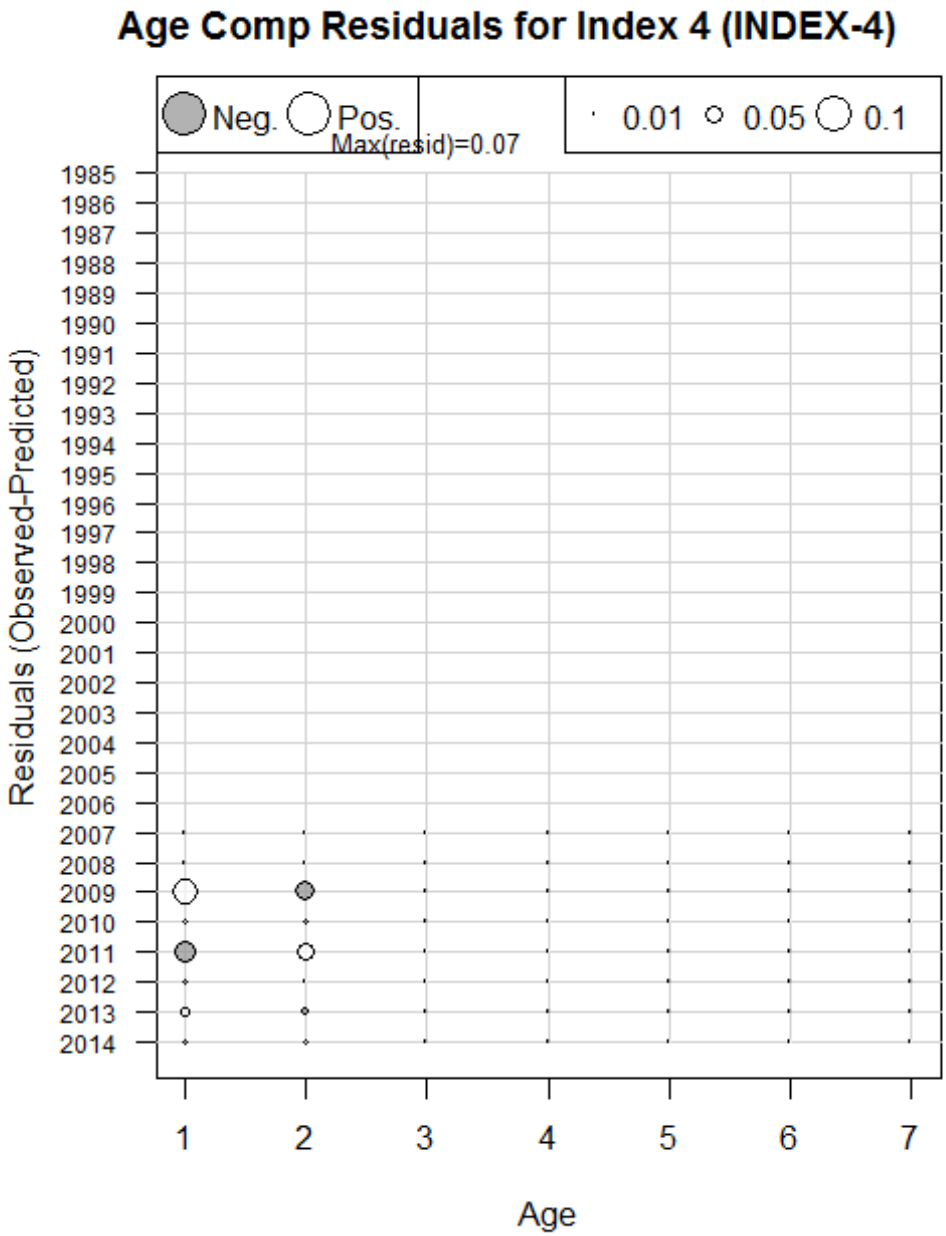

App. B7 Figure B7.61. Age composition residuals for the NEFSC Inshore survey.



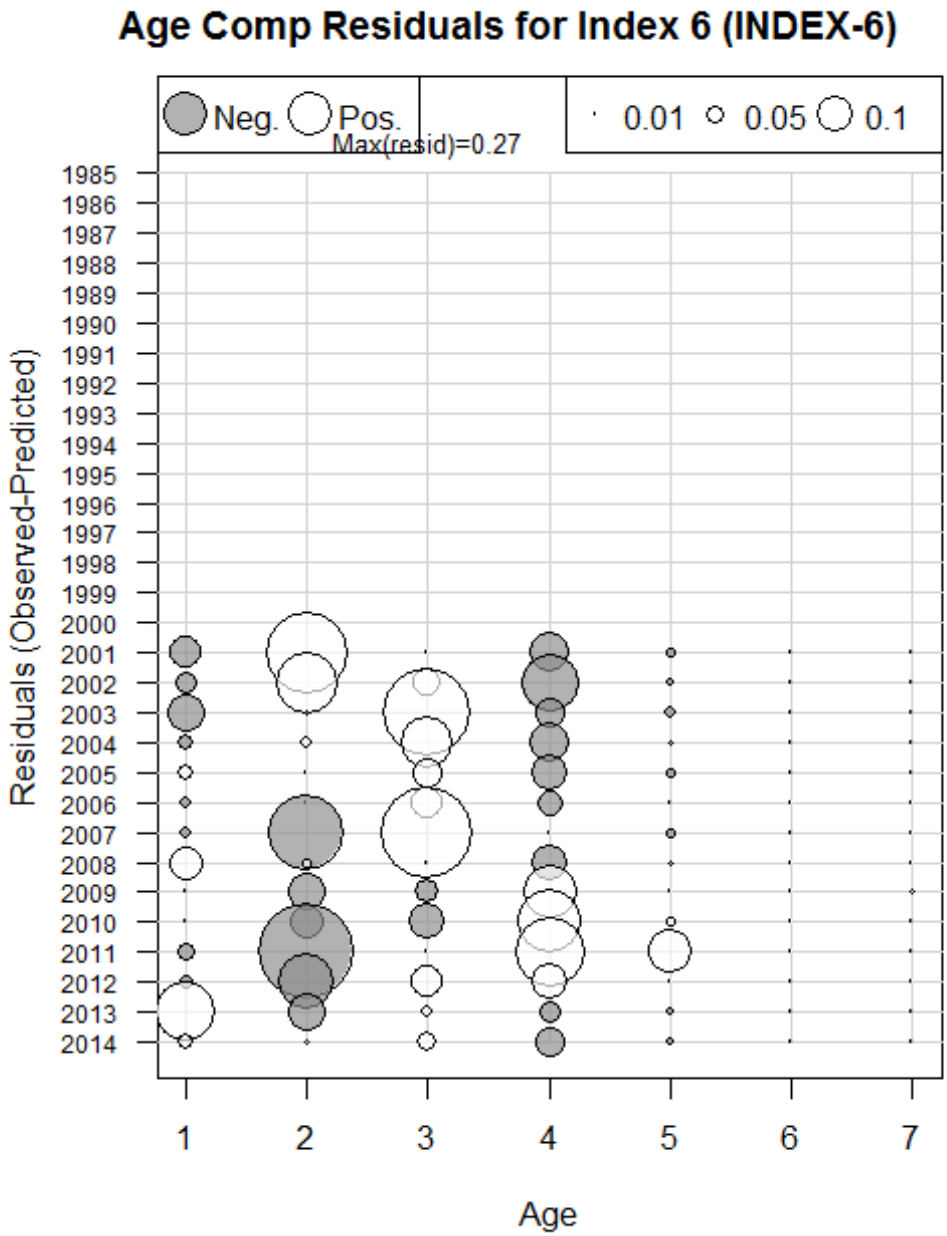

App. B7 Figure B7.62. Age composition residuals for the NEFSC Bigelow survey.



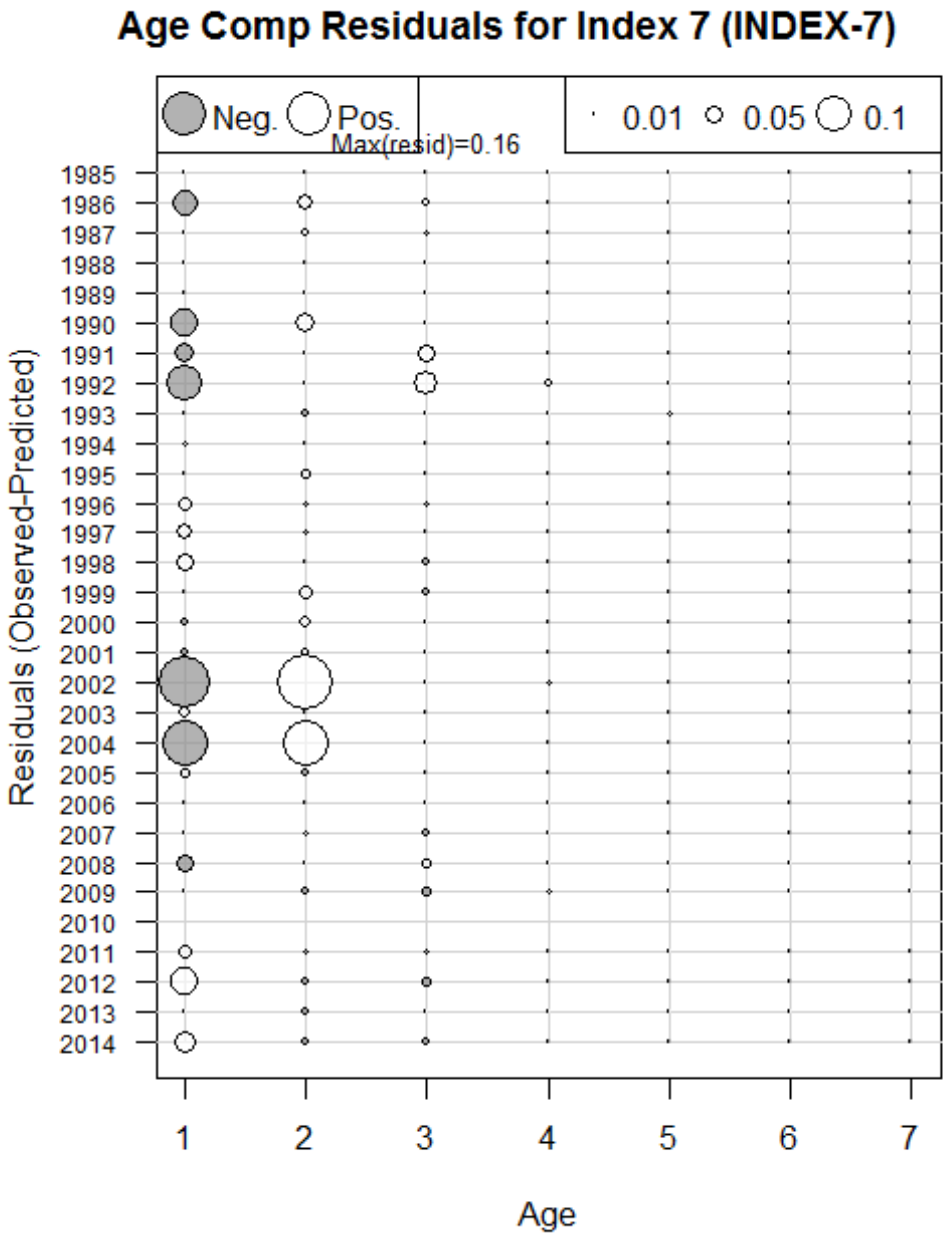

App. B7 Figure B7.63. Age composition residuals for the MRIP recreational CPUE index.



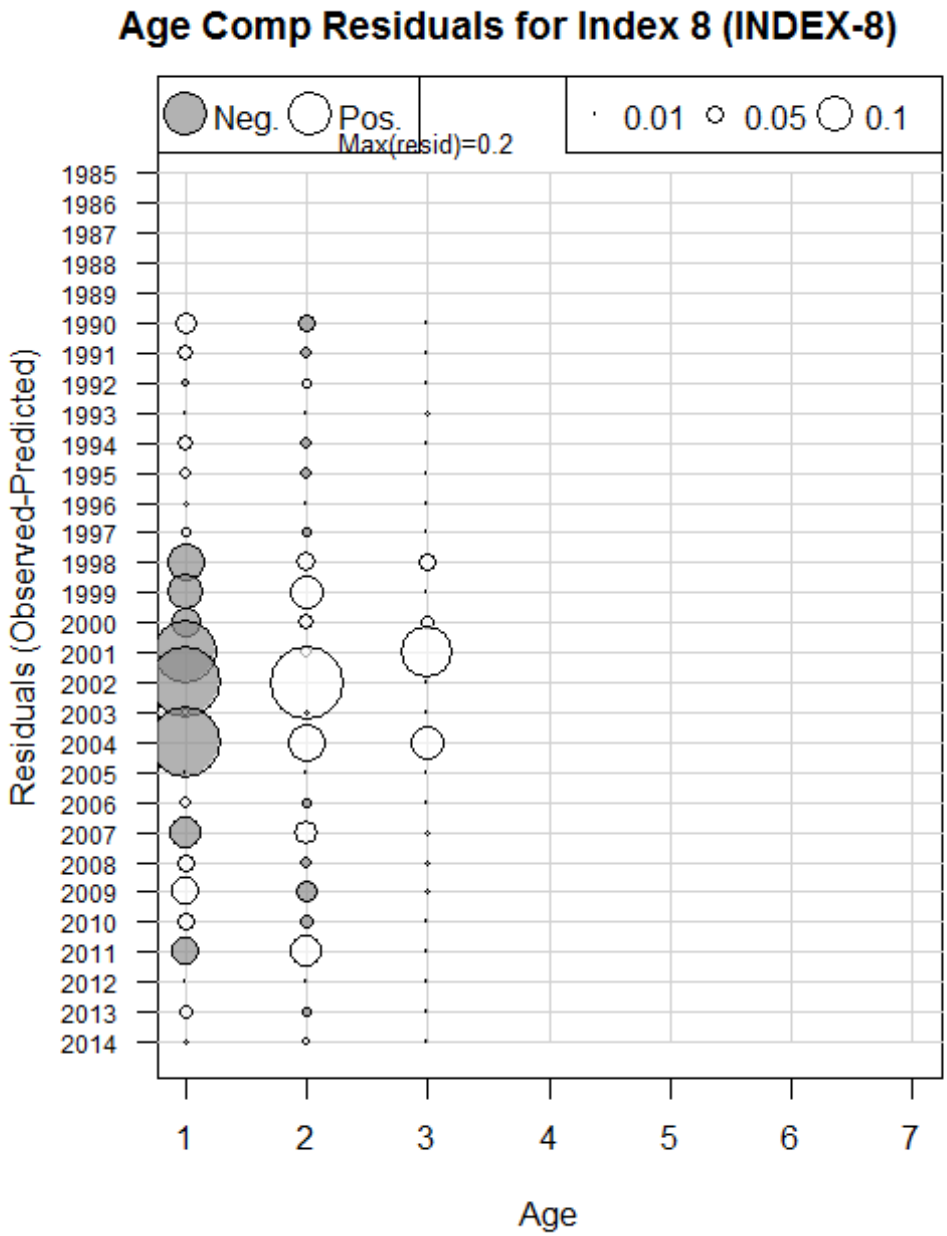

App. B7 Figure B7.64. Age composition residuals for the NEAMAP survey.



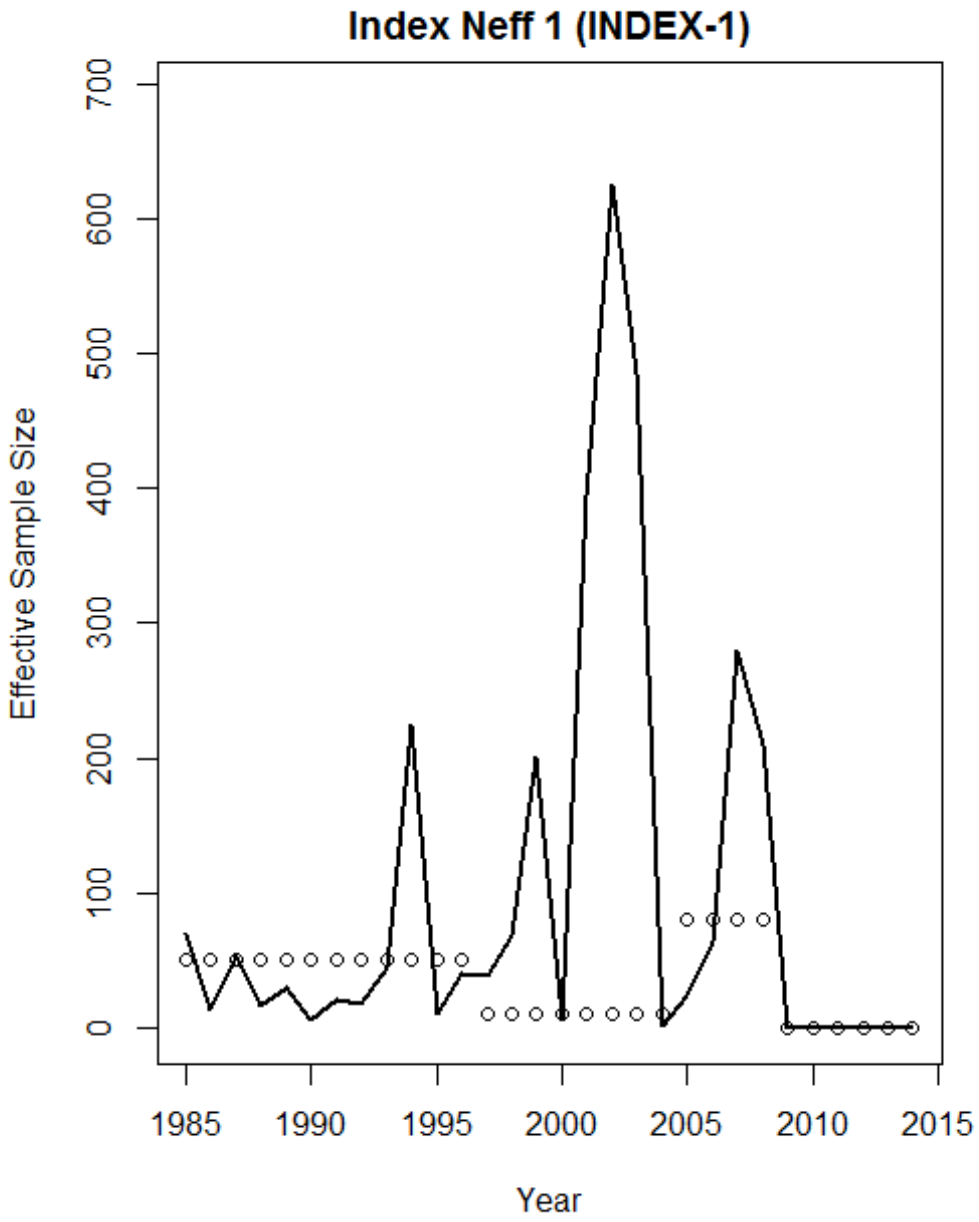

App. B7 Figure B7.65. Age composition residuals for the PSIGNS gillnet survey.



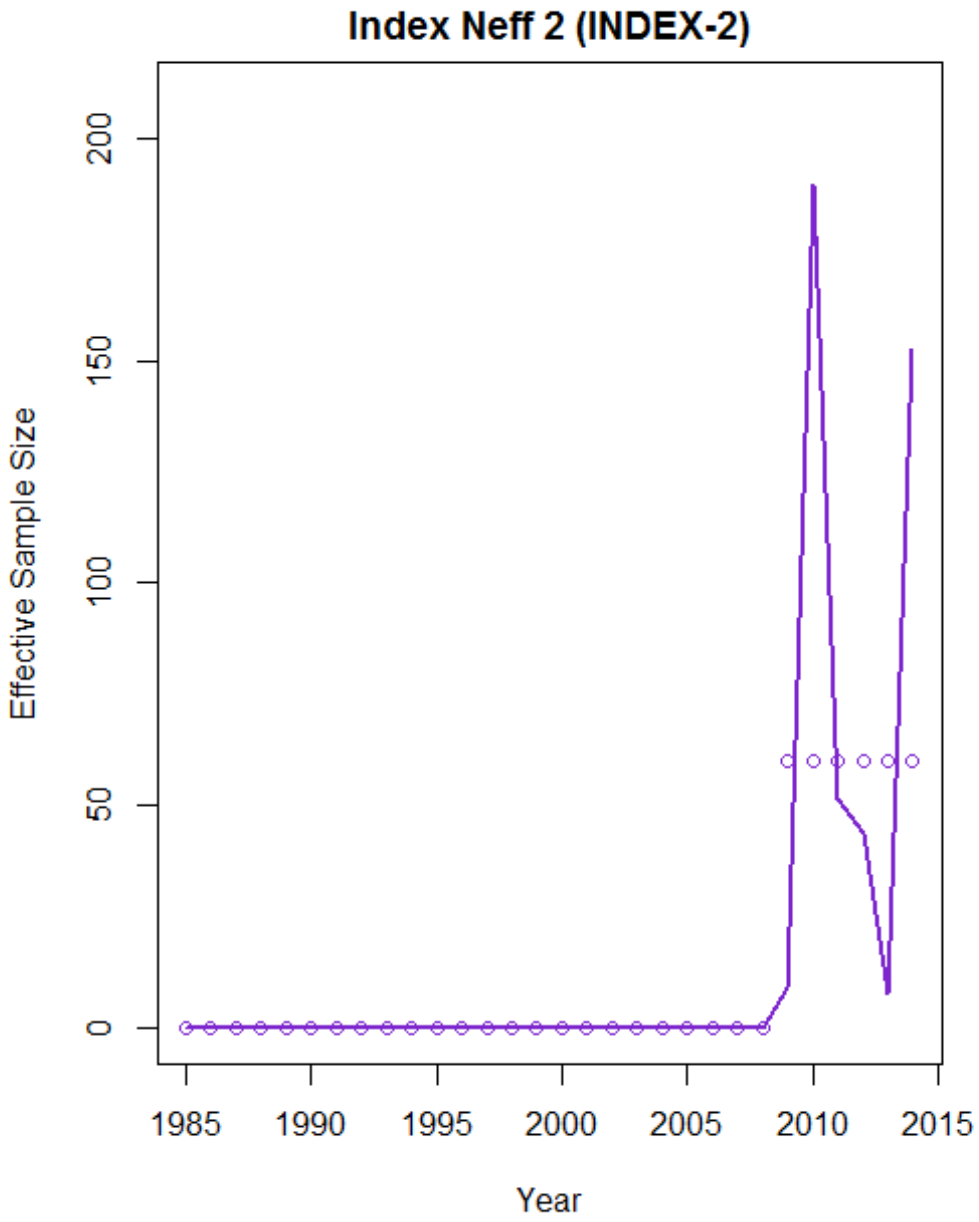

App. B7 Figure B7.66. Age composition residuals for the CT LISTS trawl survey.



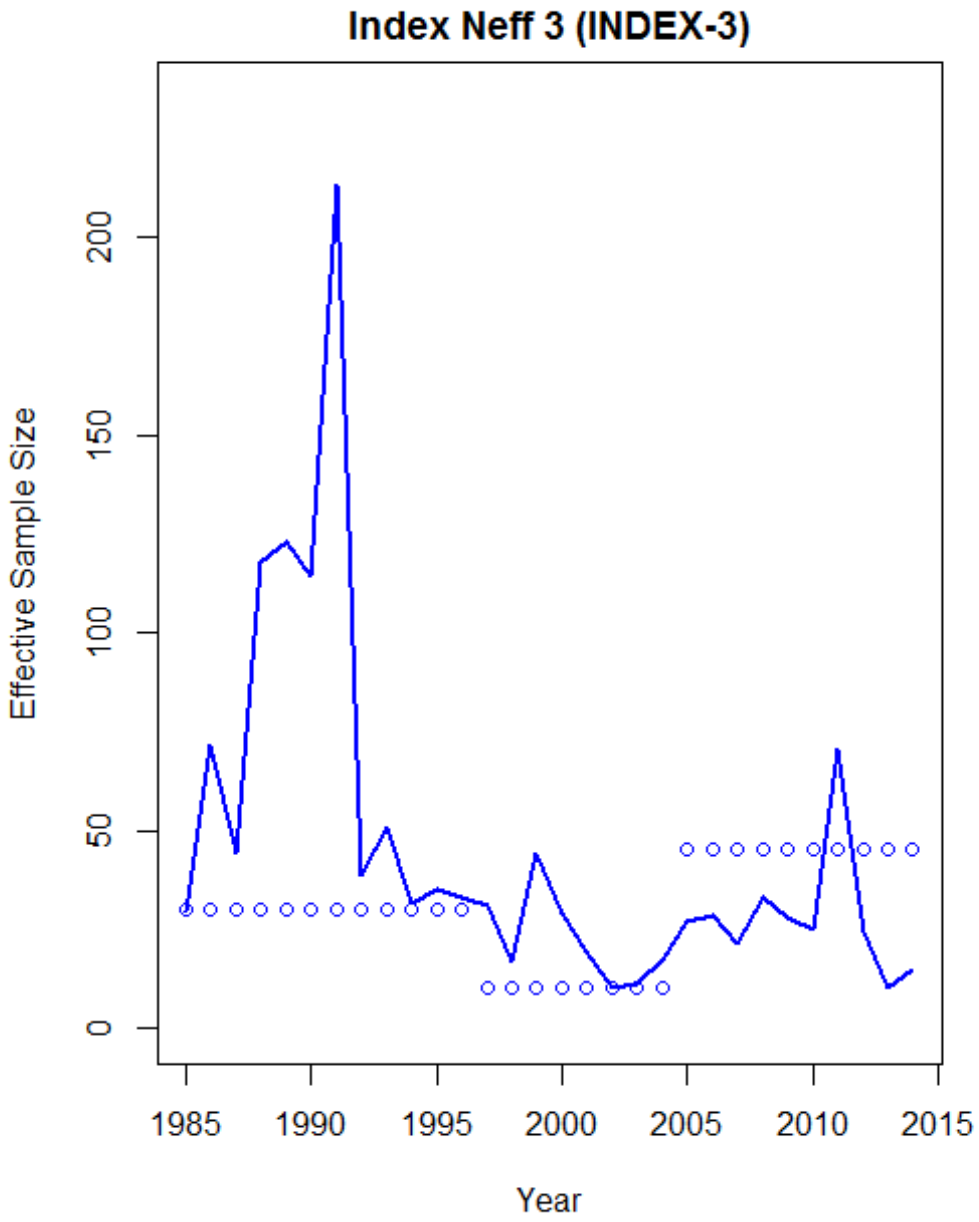

App. B7 Figure B7.67. Age composition residuals for the NJ ocean trawl survey.



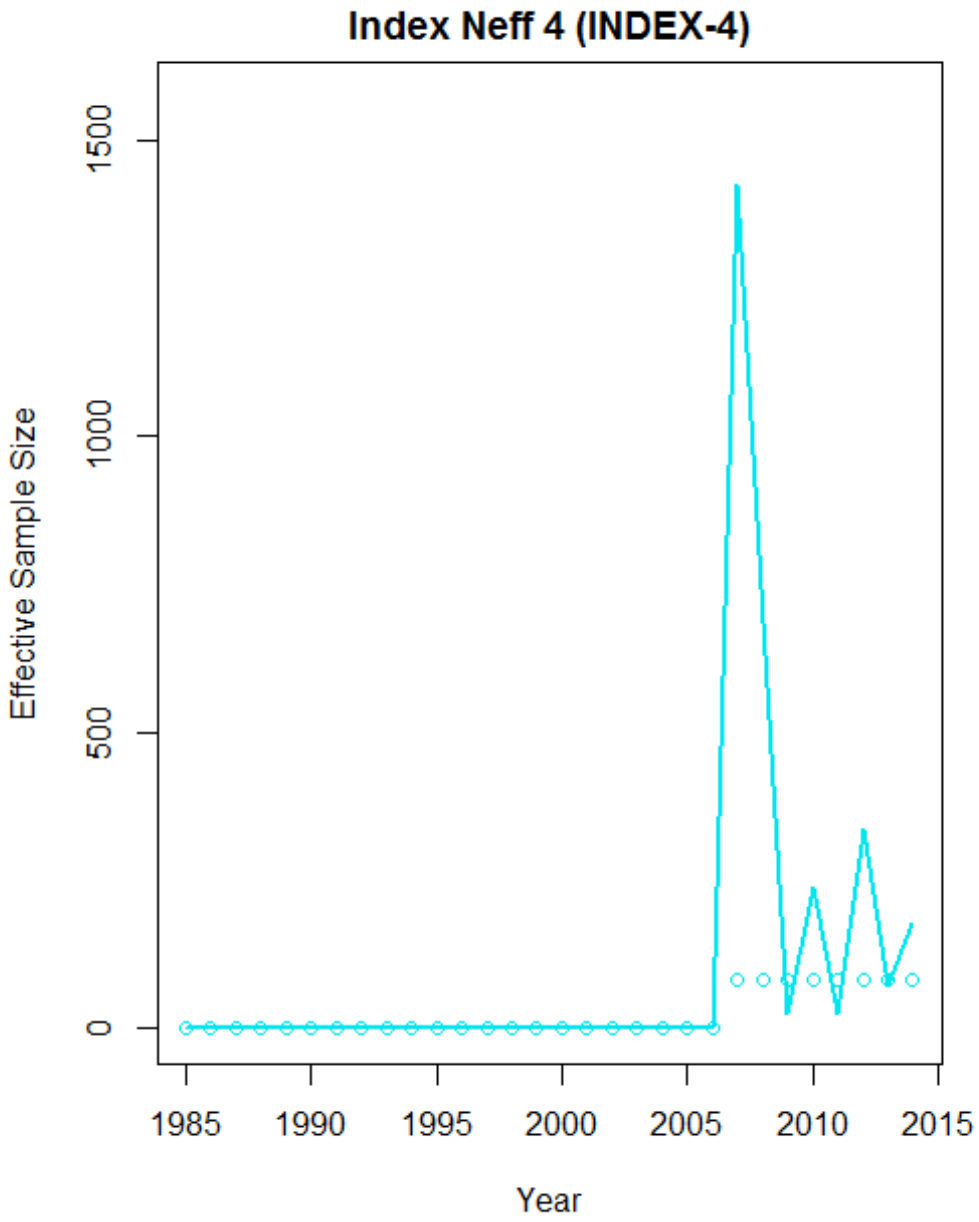

App. B7 Figure B7.68. Input and estimated effective sample size for the NEFSC Inshore survey.



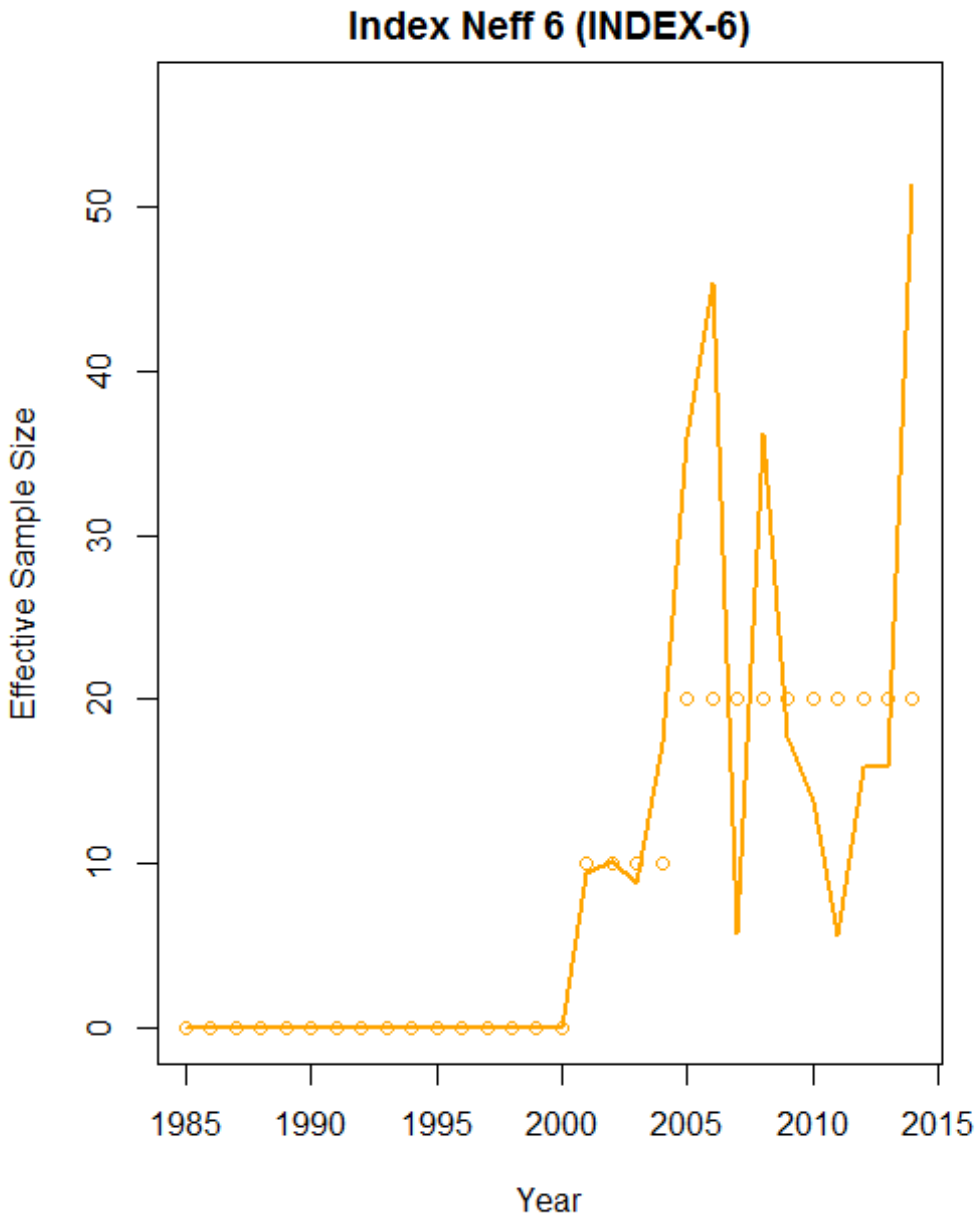

App. B7 Figure B7.69. Input and estimated effective sample size for the NEFSC Bigelow survey.



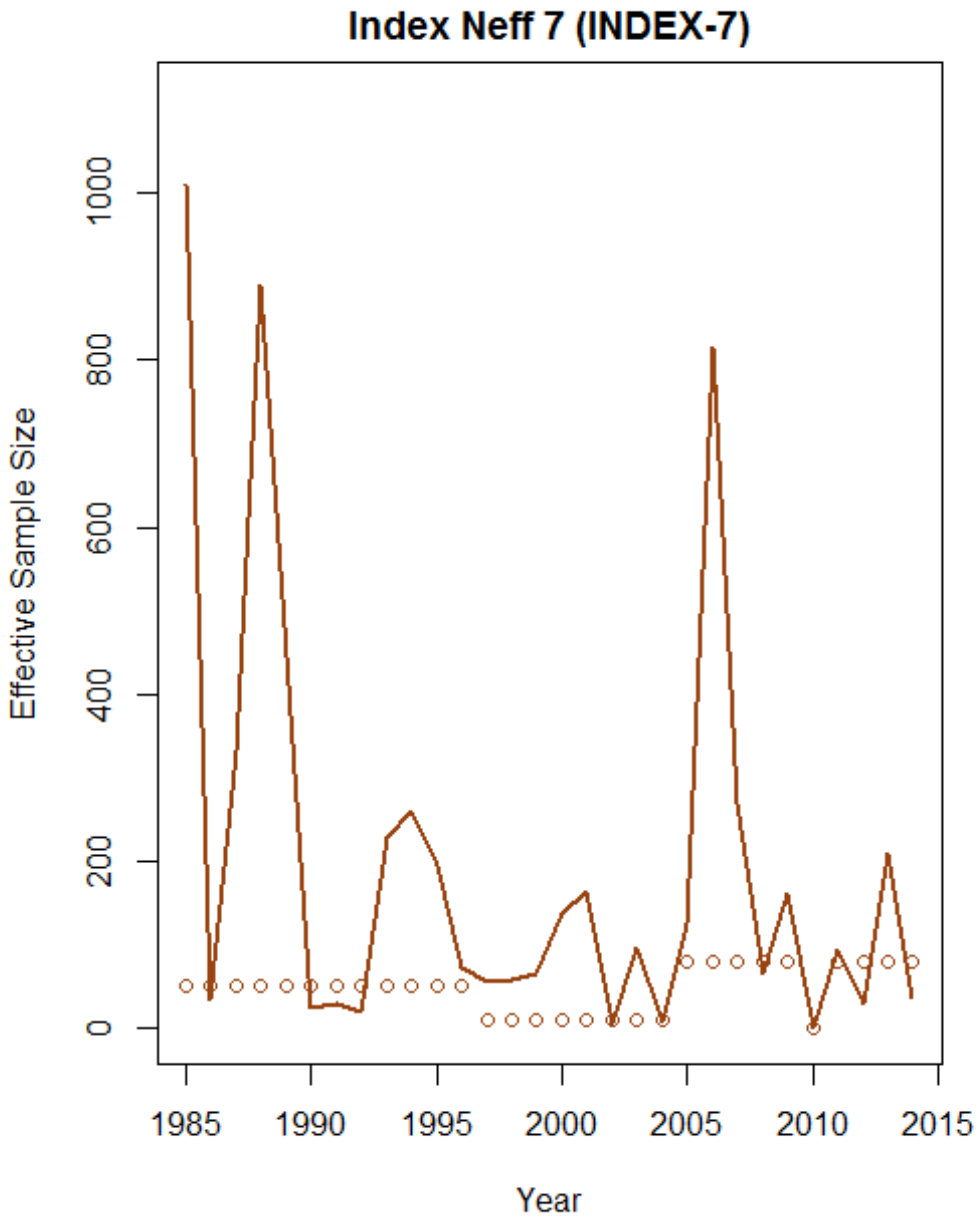

App. B7 Figure B7.70. Input and estimated effective sample size for the MRIP recreational CPUE index.



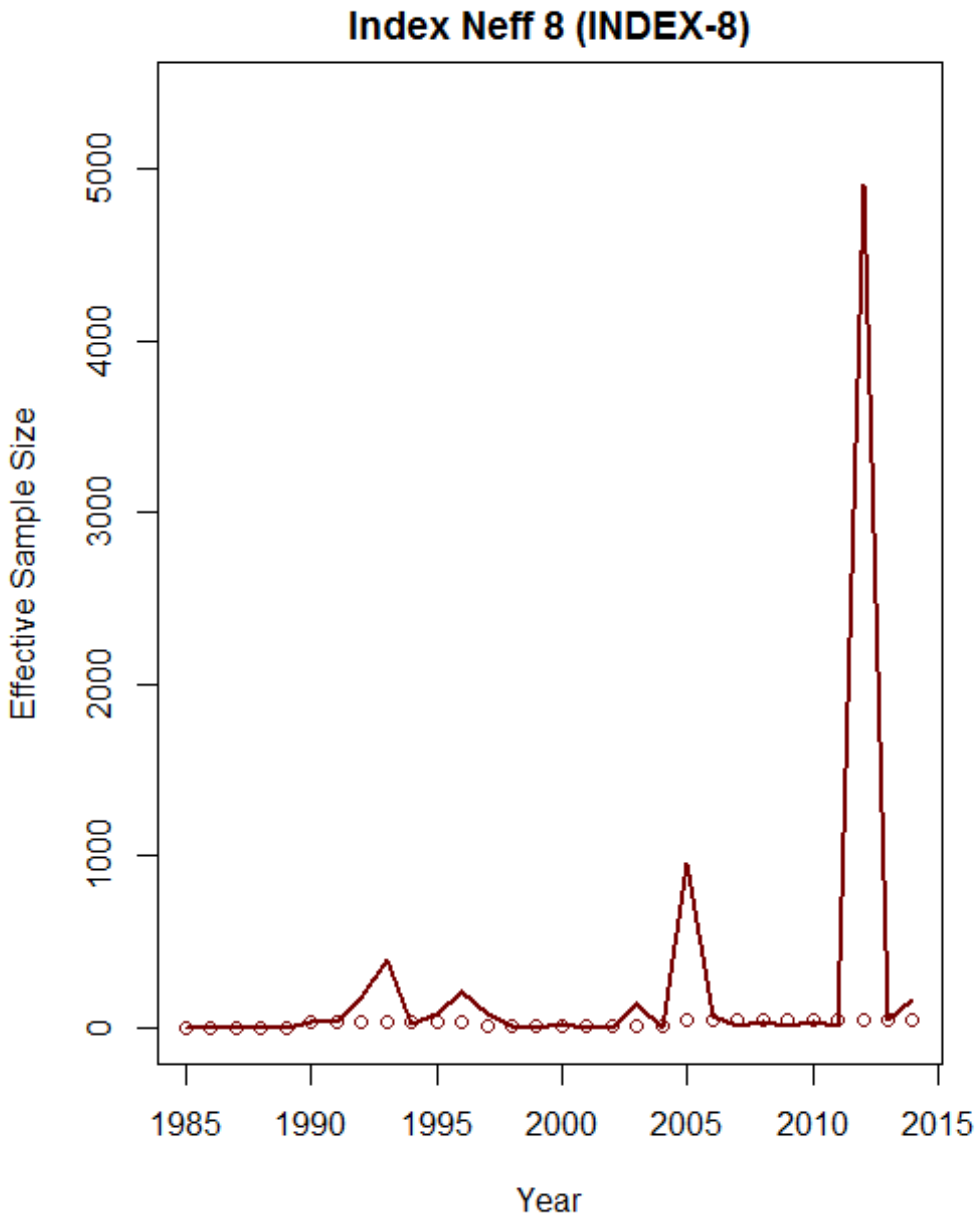

App. B7 Figure B7.71. Input and estimated effective sample size for the NEAMAP survey.



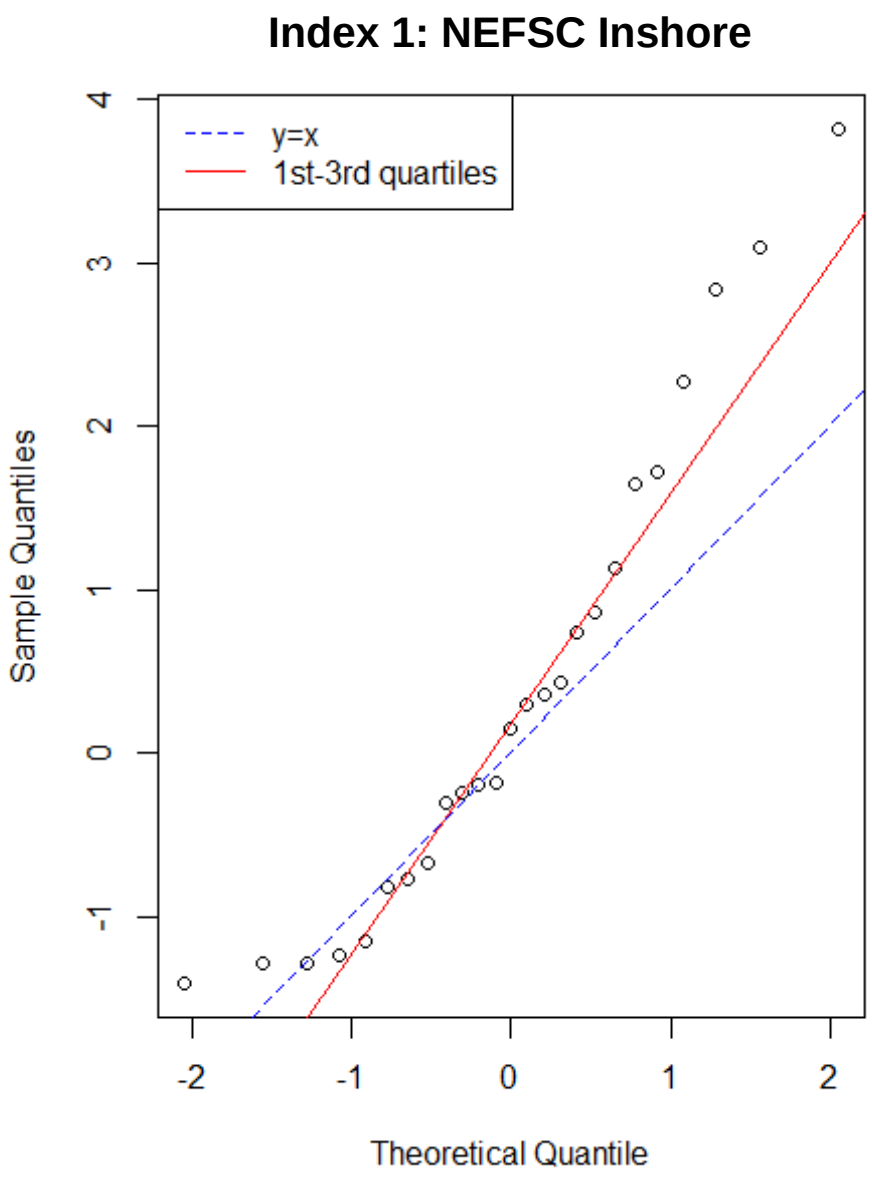

App. B7 Figure B7.72. Input and estimated effective sample size for the PSIGNS gillnet survey.




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

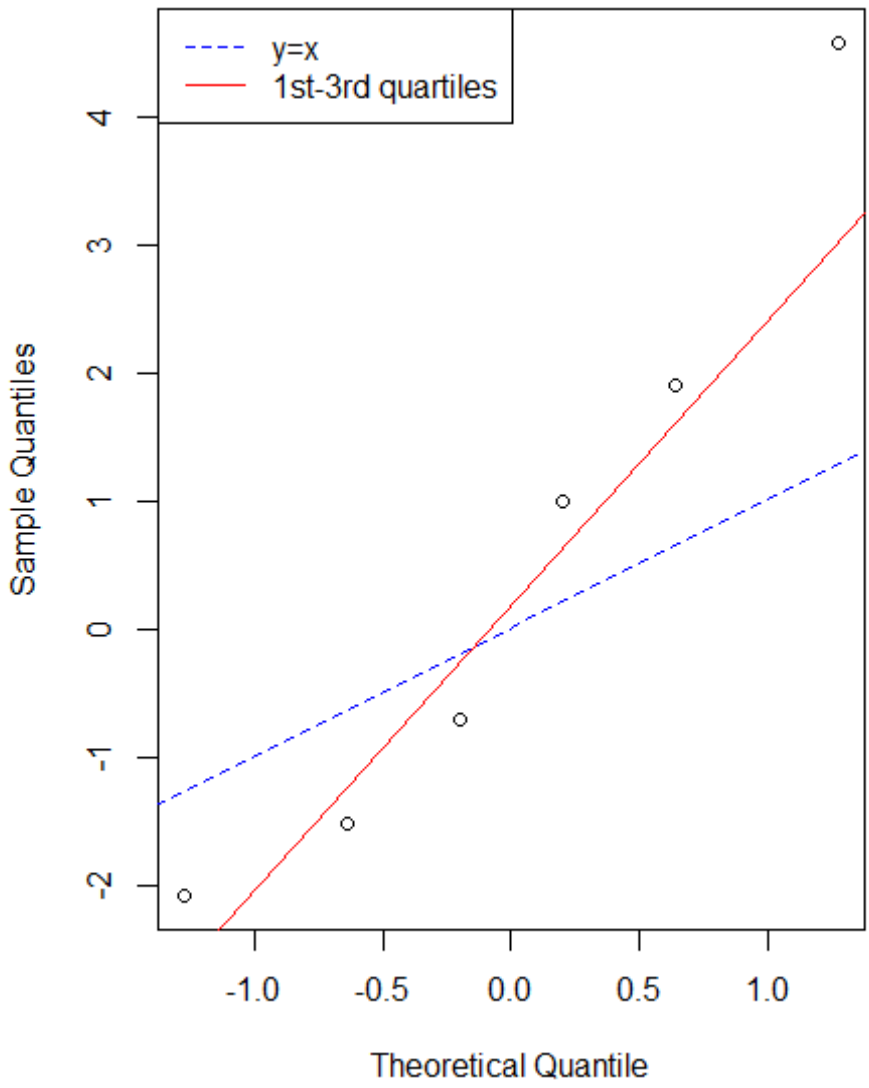



App. B7 Figure B7.74. Input and estimated effective sample size for the NJ ocean trawl survey.



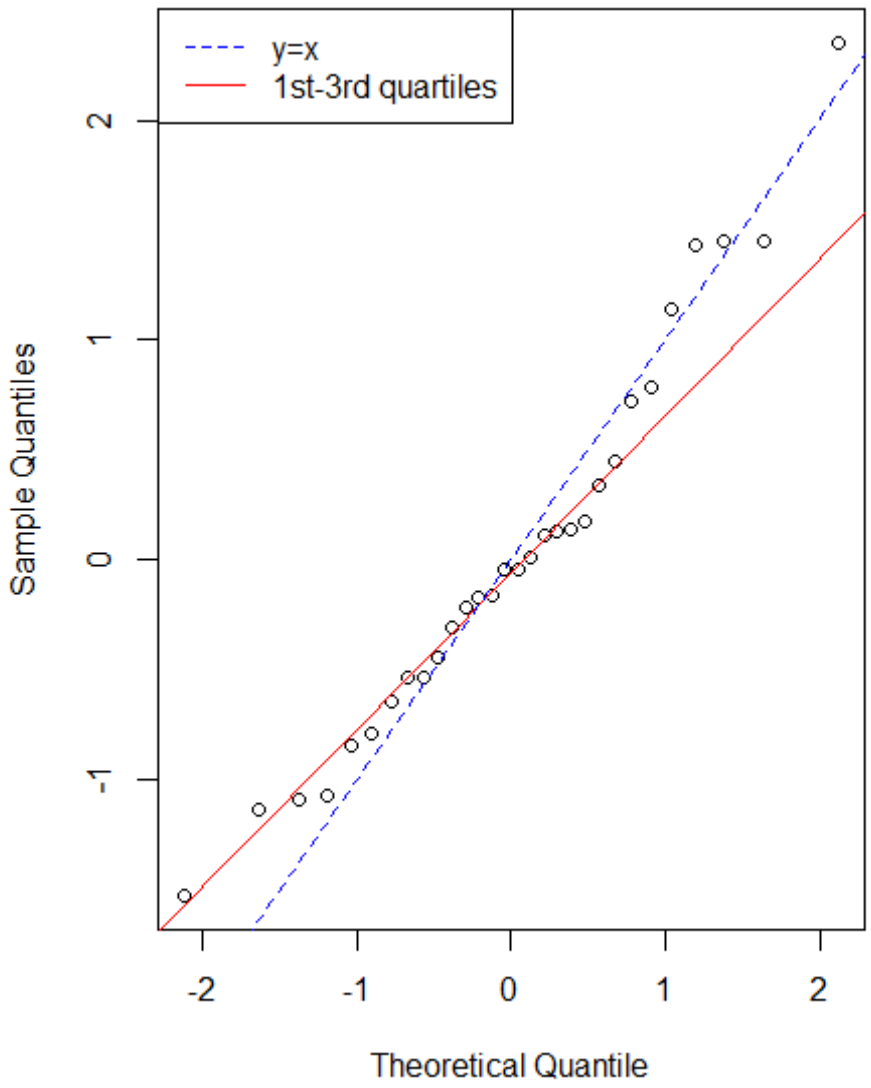

App. B7 Figure B7.75. QQ-plot for the observed versus predicted mean catch for the NEFSC Inshore survey.

## Index 2: NEFSC Bigelow

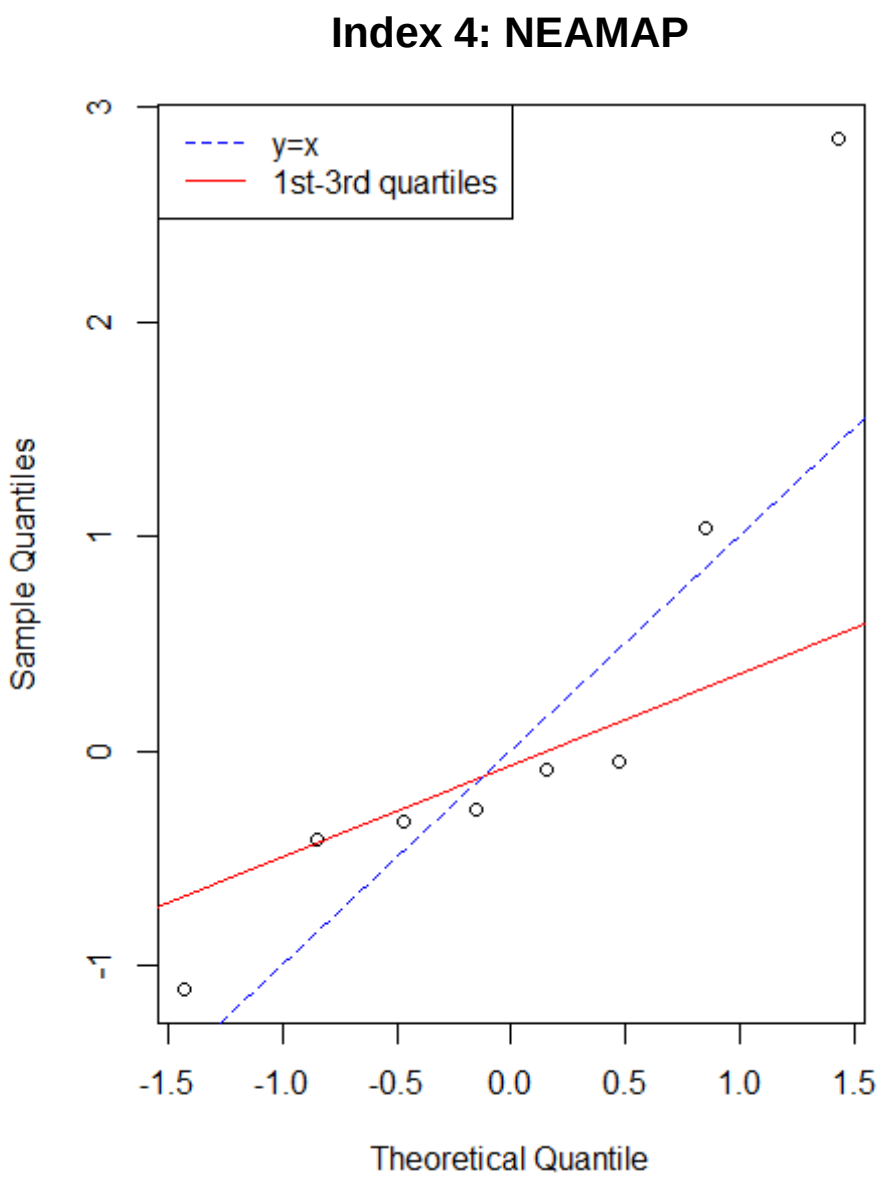



App. B7 Figure B7.76. QQ-plot for the observed versus predicted mean catch for the NEFSC Bigelow survey.

## Index 3: MRIP

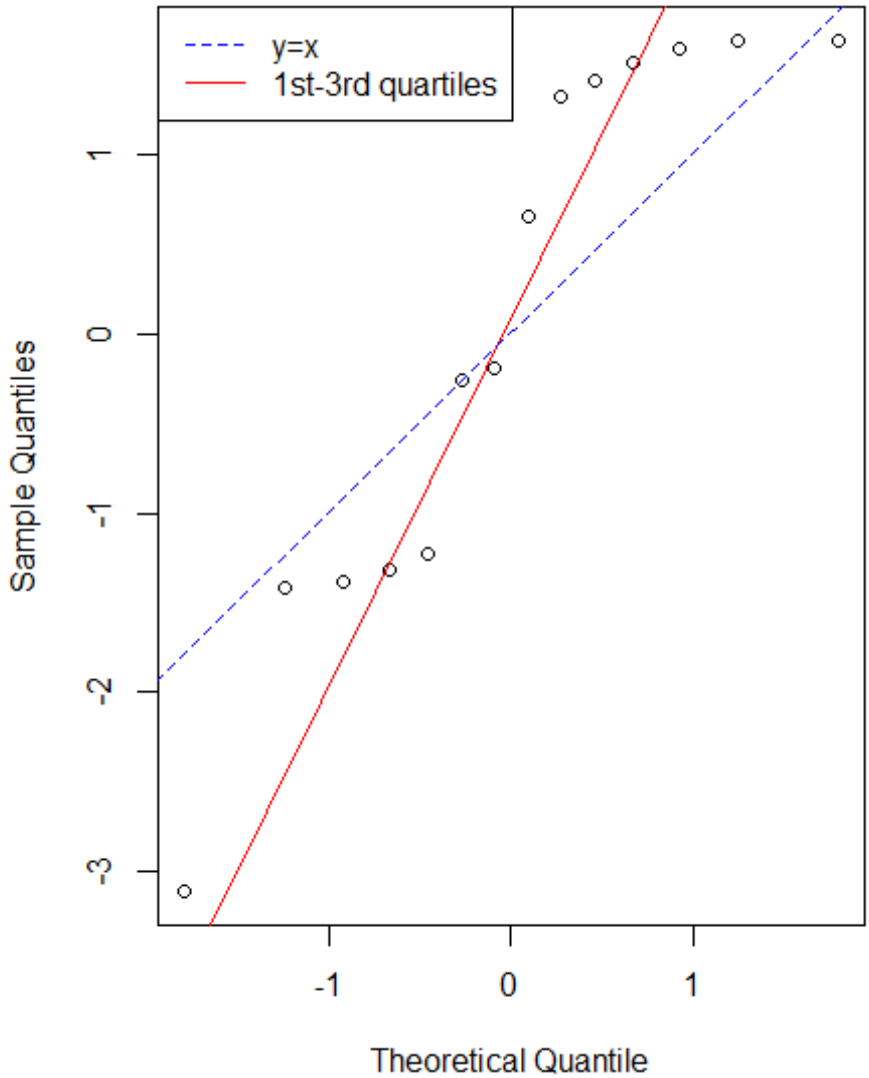



App. B7 Figure B7.77. QQ-plot for the observed versus predicted mean catch for the MRIP recreational CPUE index.

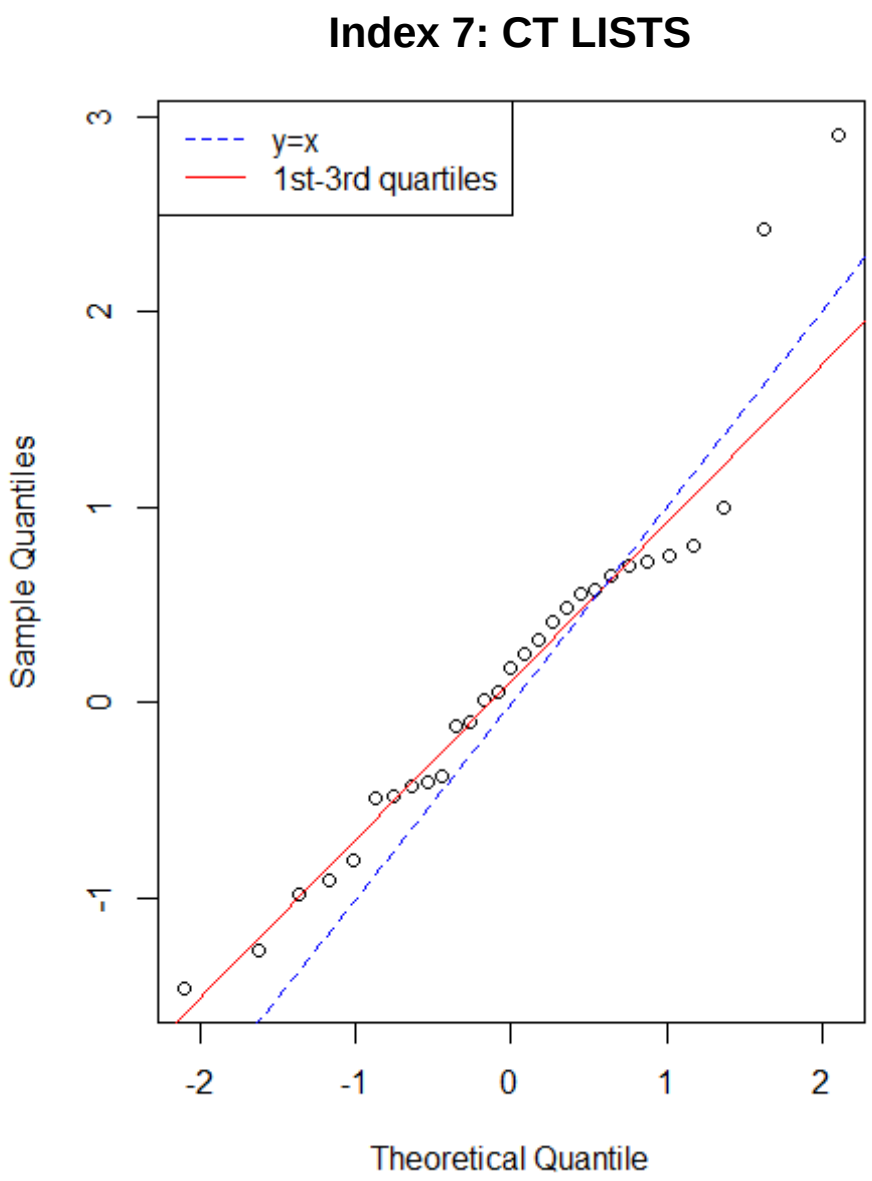



App. B7 Figure B7.78. QQ-plot for the observed versus predicted mean catch for the NEAMAP survey.

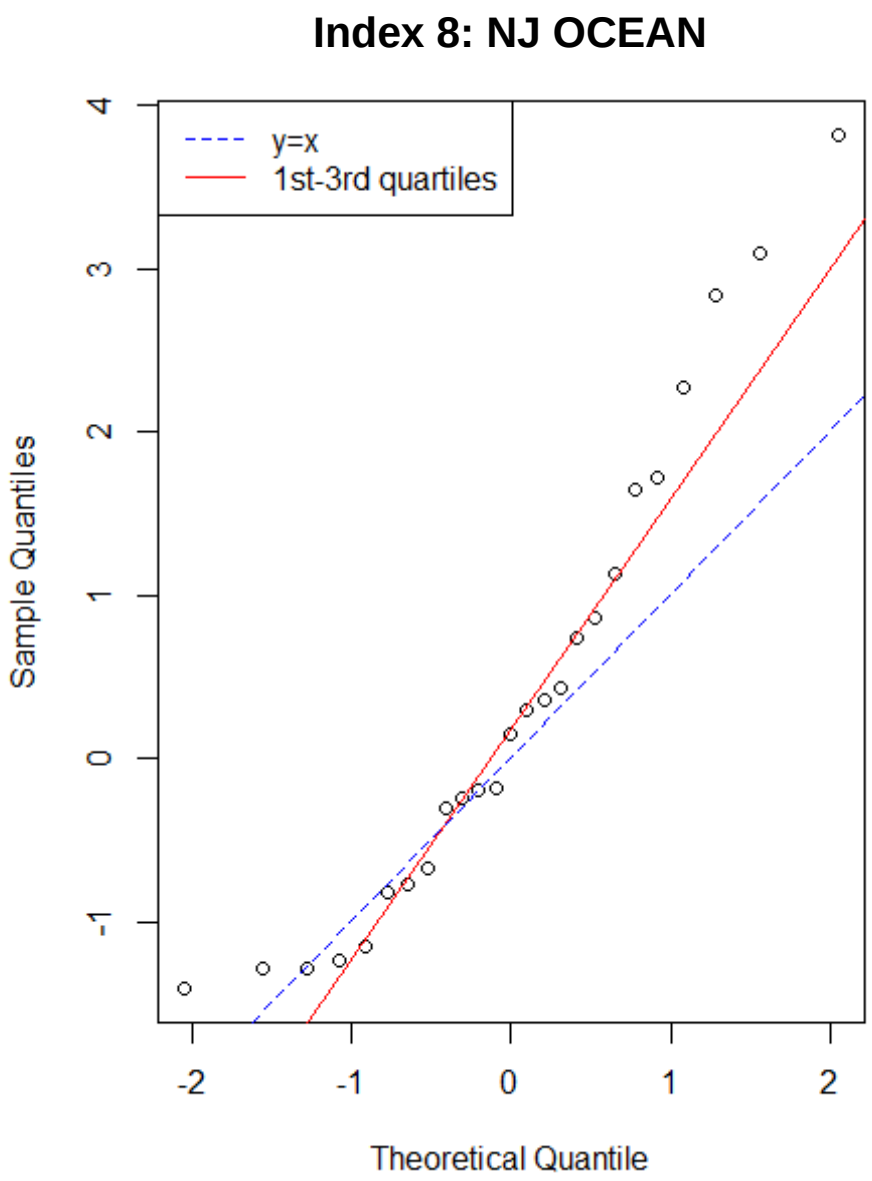
# Index 6: PSIGN



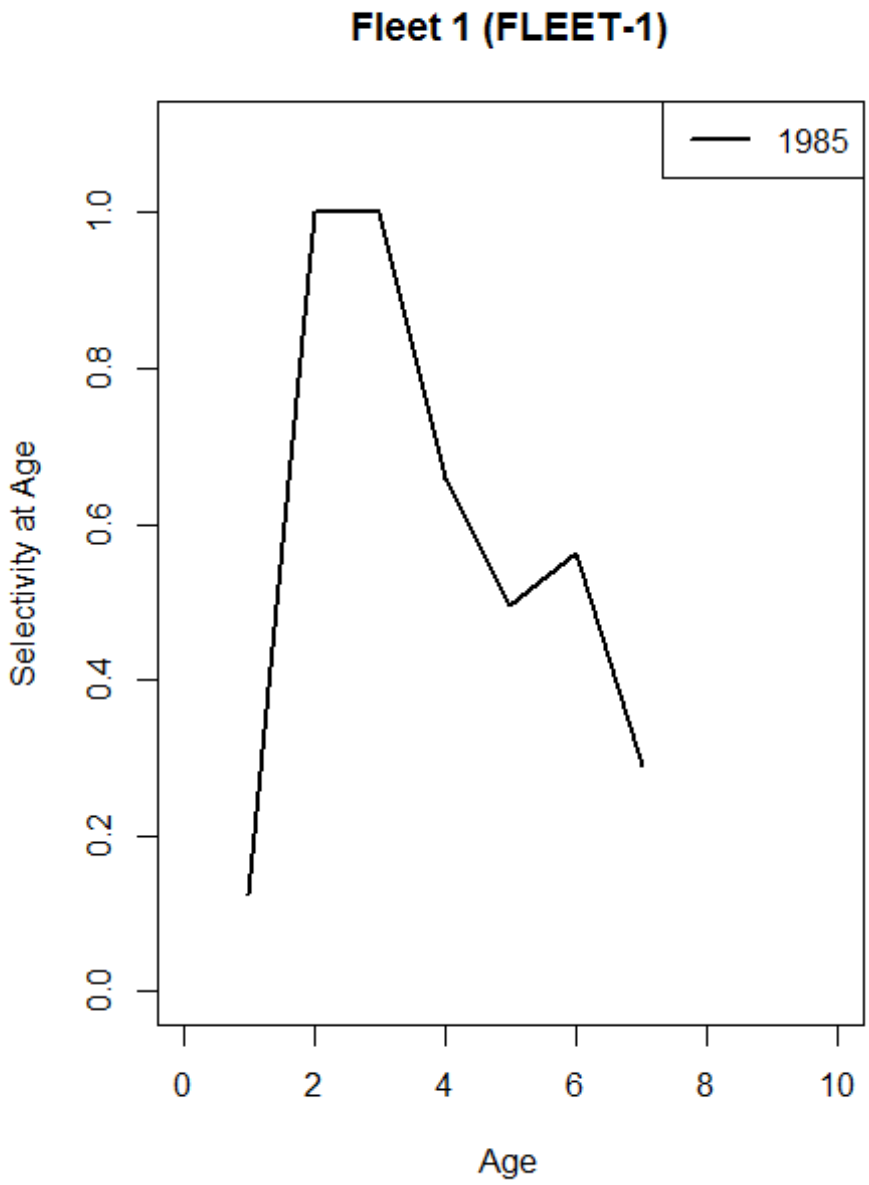

App. B7 Figure B7.79. QQ-plot for the observed versus predicted mean catch for the PSIGNS gillnet survey.



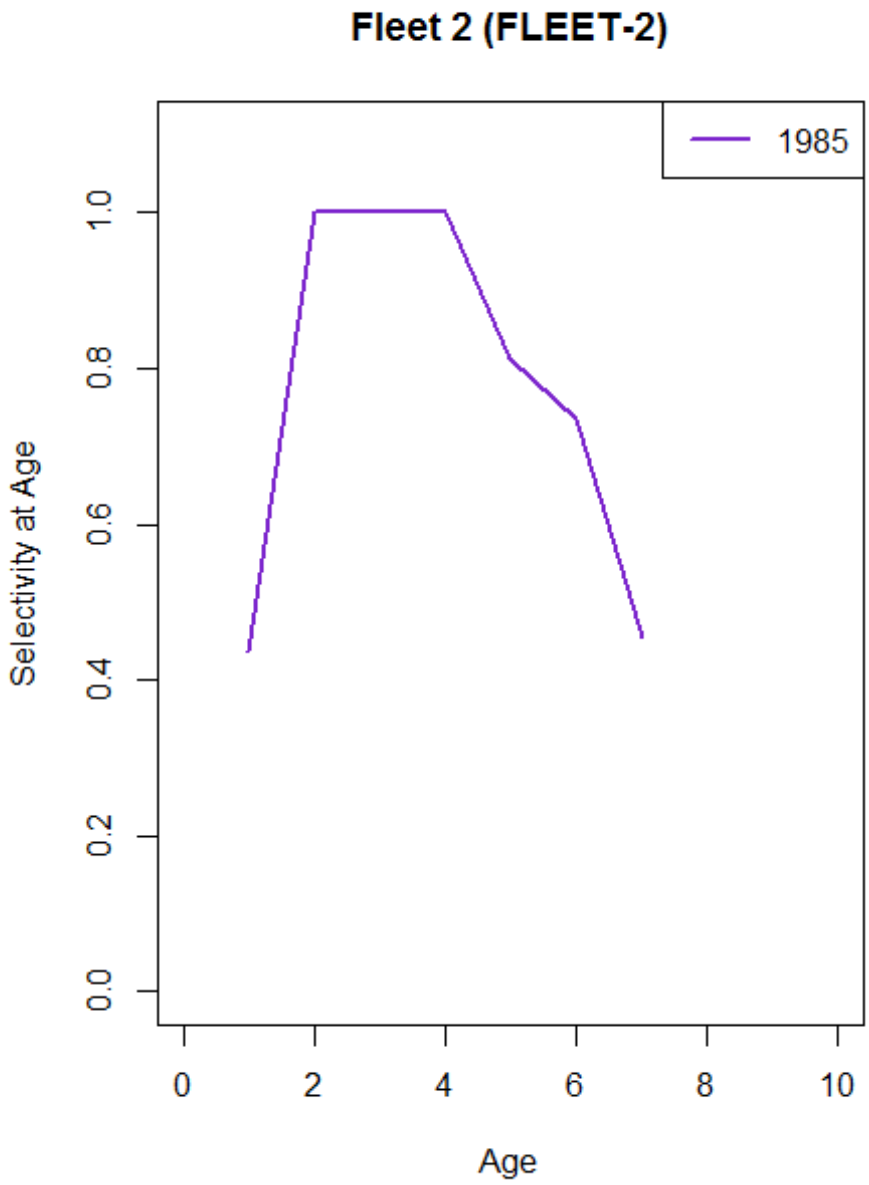

App. B7 Figure B7.80. QQ-plot for the observed versus predicted mean catch for the CT LISTS trawl survey.




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

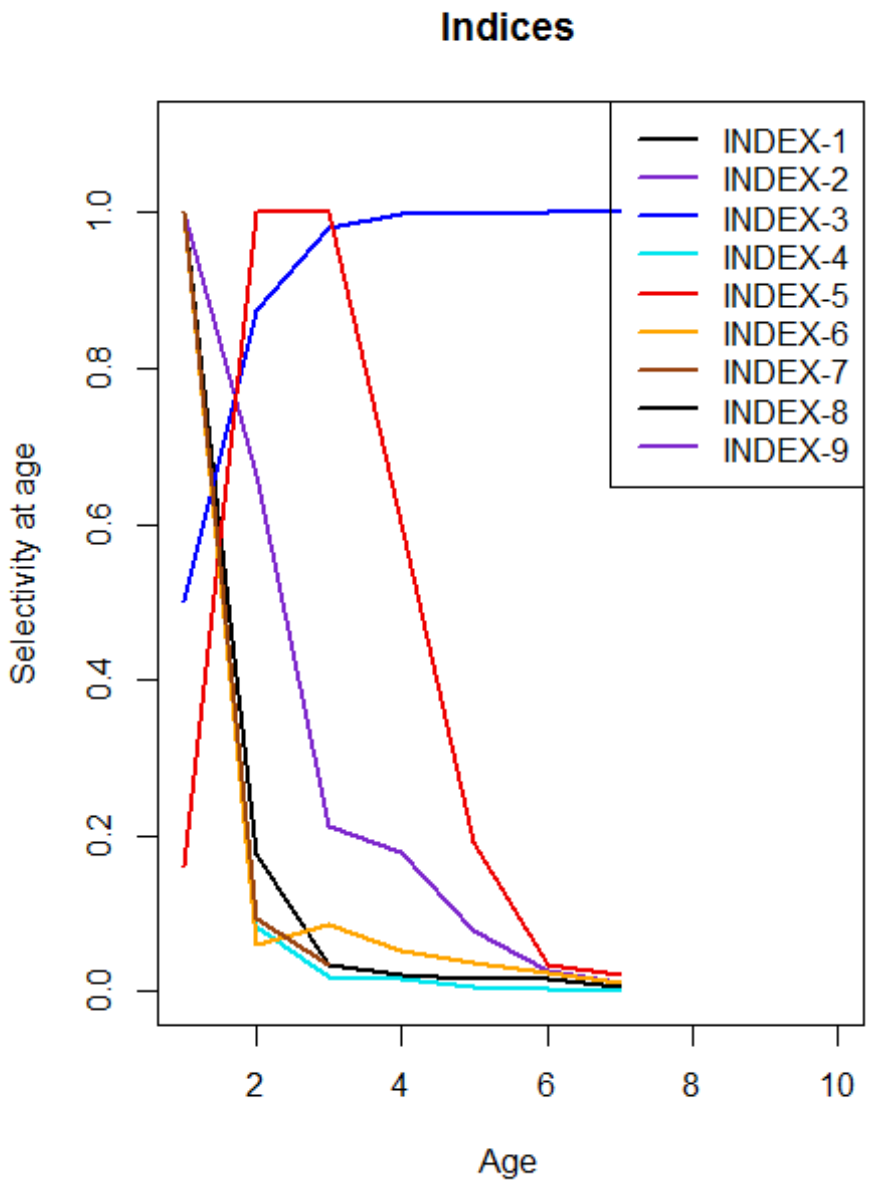



App. B7 Figure B7.82. Estimated selectivity for the commercial fleet from the final model

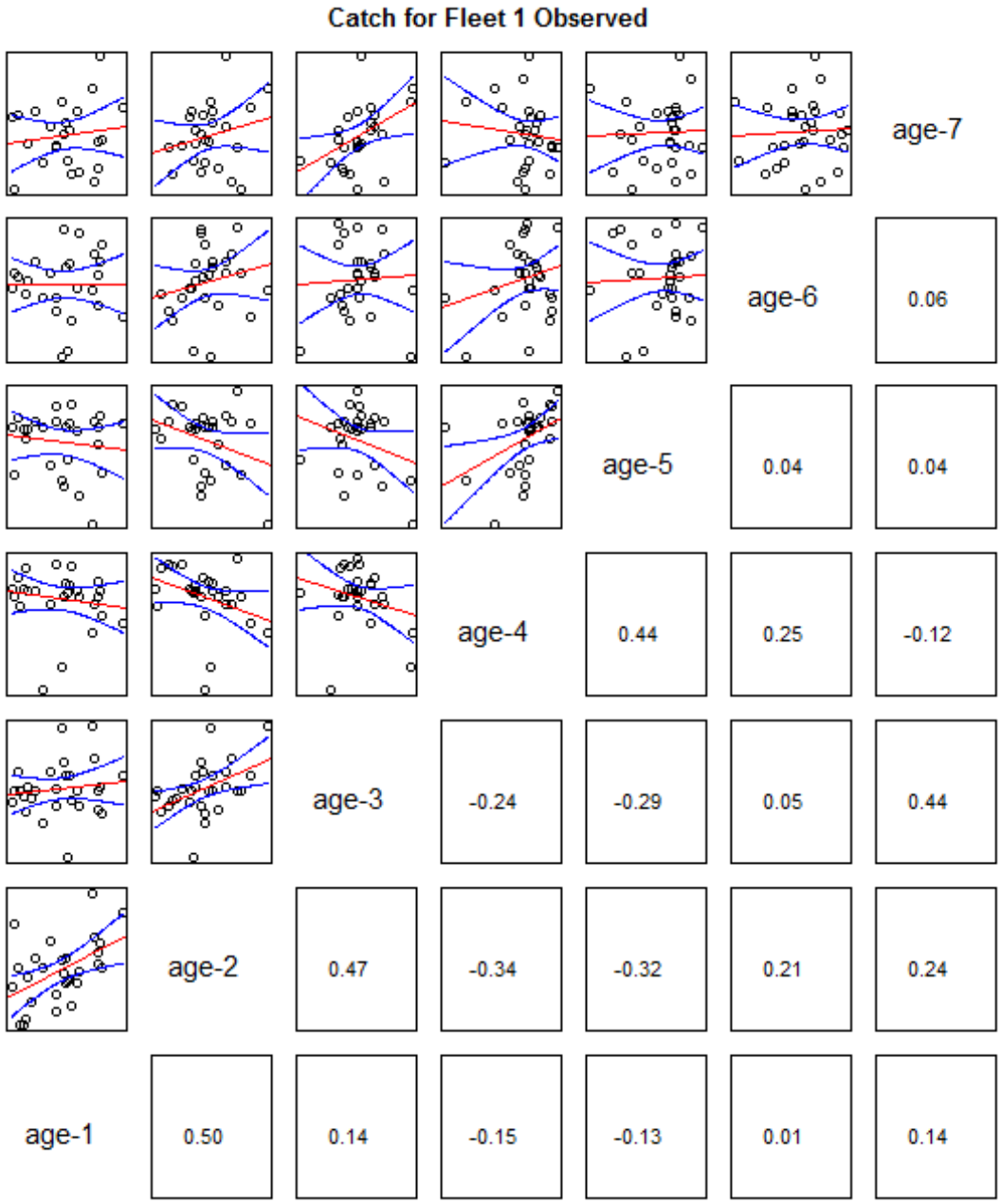



App. B7 Figure B7.83. Estimated selectivity for the recreational fleet from the final model.

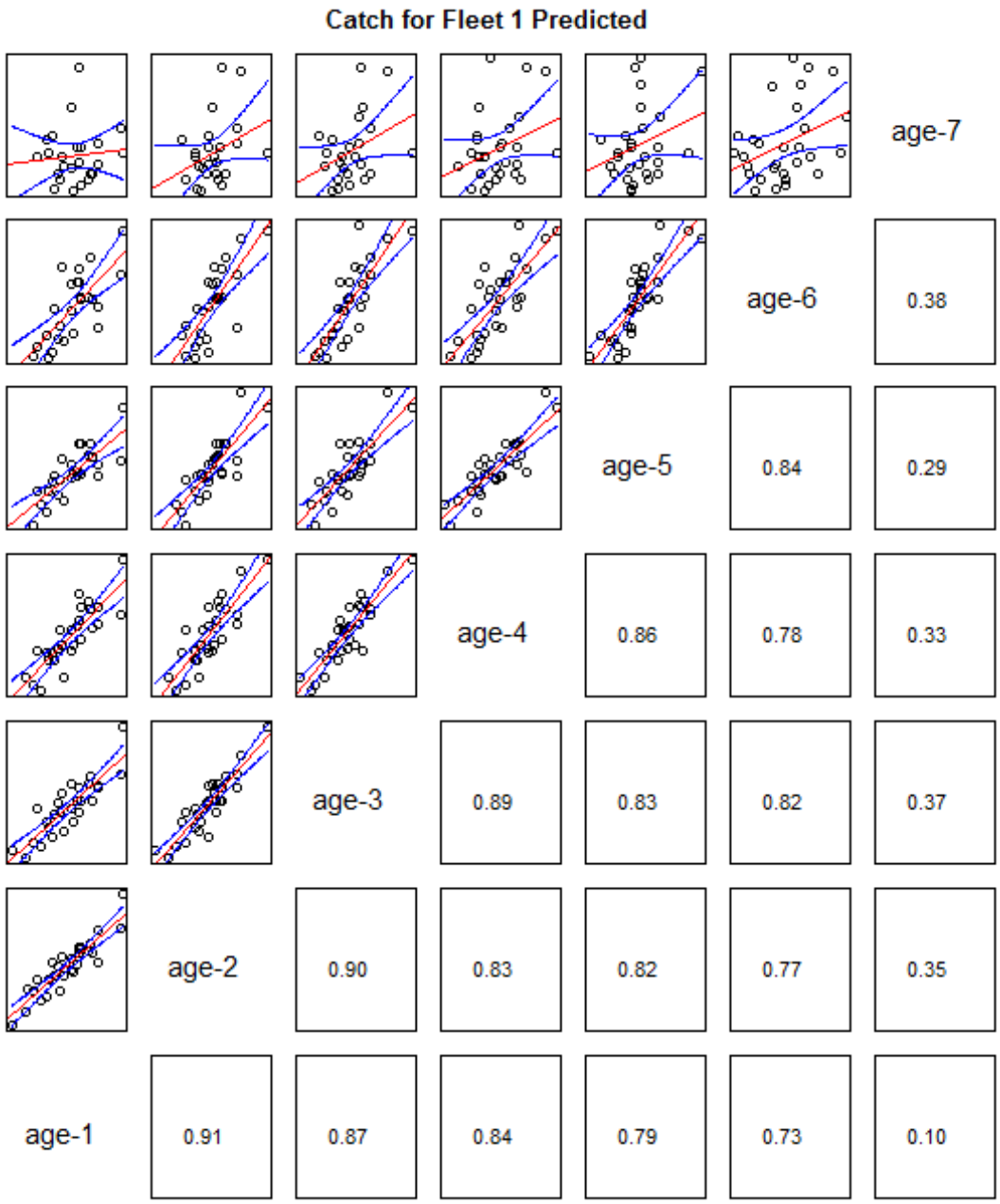
App. B7 Figure B7.84. Fmult estimates for the commercial (fleet 1) and recreational (fleet 2) fleets.



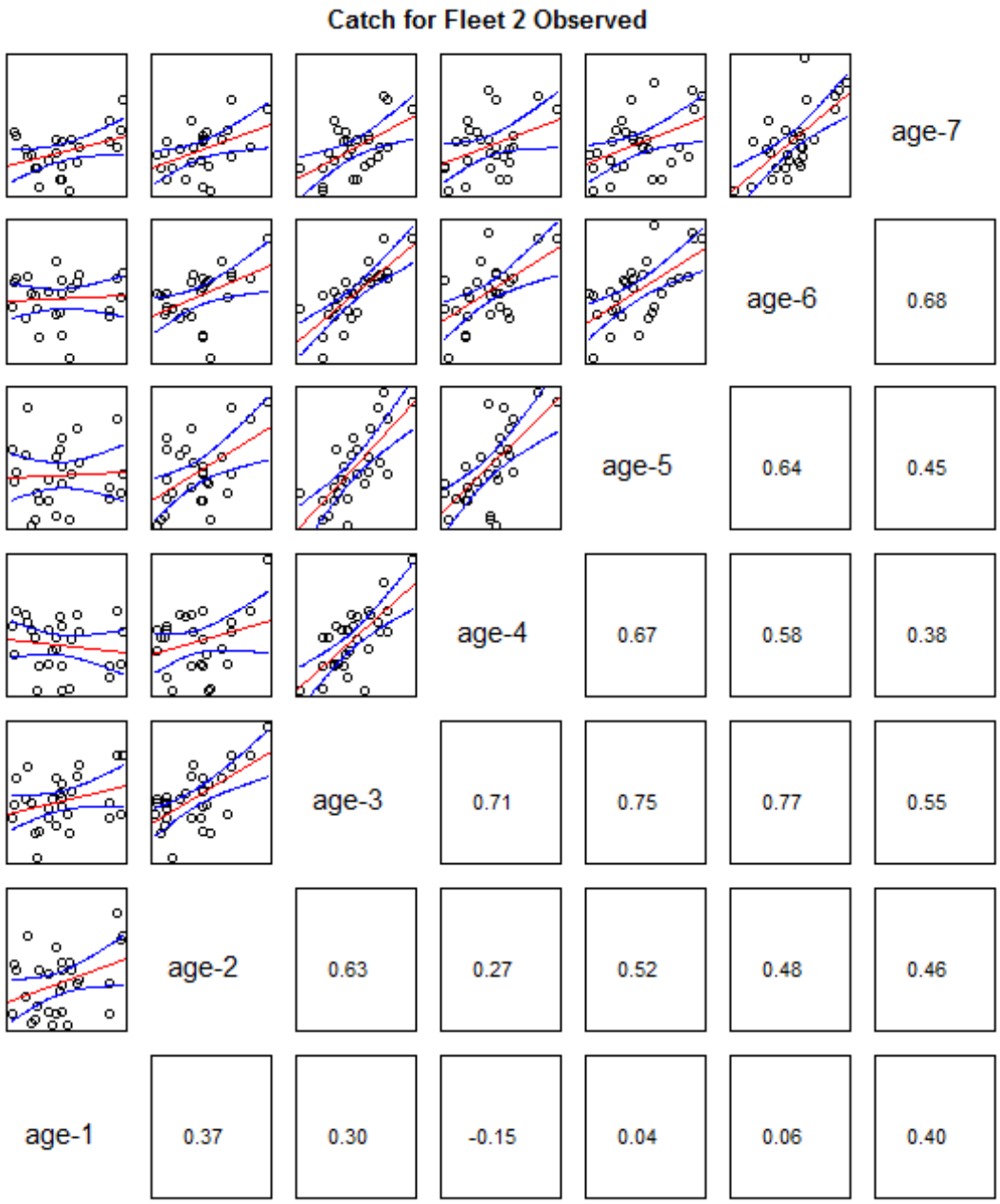

App. B7 Figure B7.85. Estimated selectivities for the indices from the final model. Note the two age 0 indices are not plotted so only 7 selectivities are shown. In this plot: Index 1 = NEFSC Inshore, Index 2 = NEFSC Bigelow, Index 3 = MRIP, Index 4 = NEAMAP, Index 5 = PSIGN, Index 6 = CT LISTS, and Index 7 = NJ ocean.



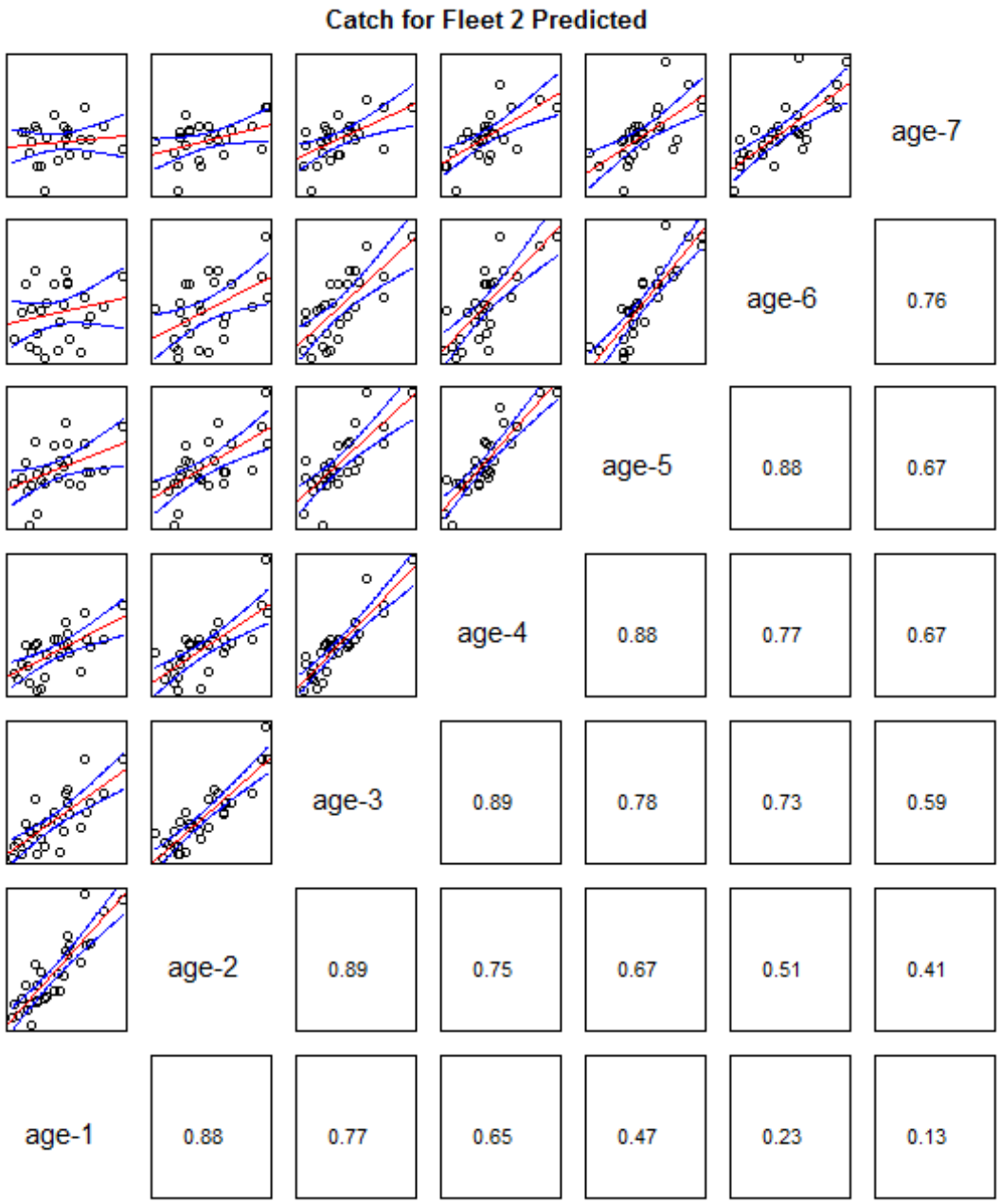

App. B7 Figure B7.86. Observed catch for the commercial fleet.



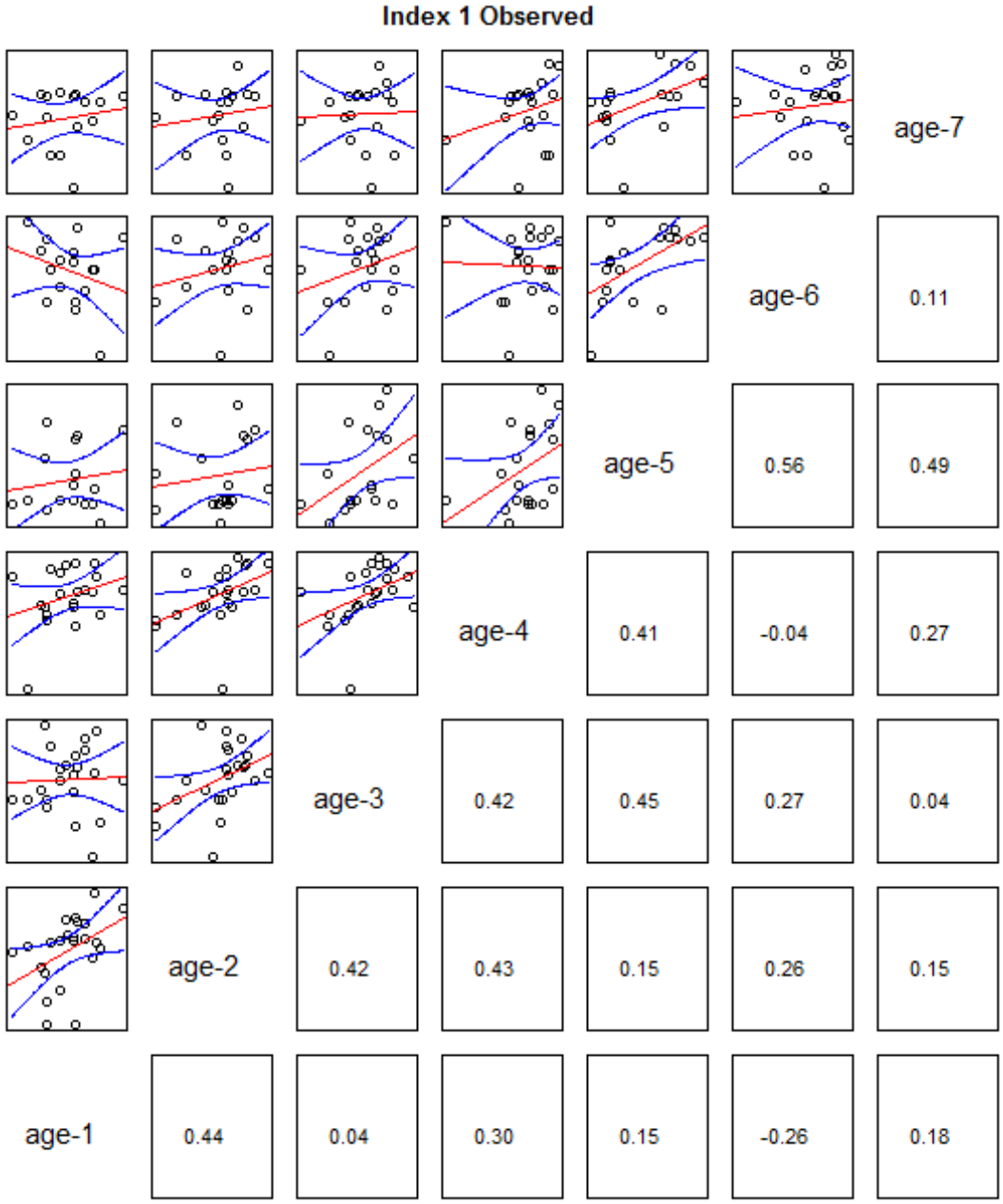

App. B7 Figure B7.87. Predicted catch for the commercial fleet.



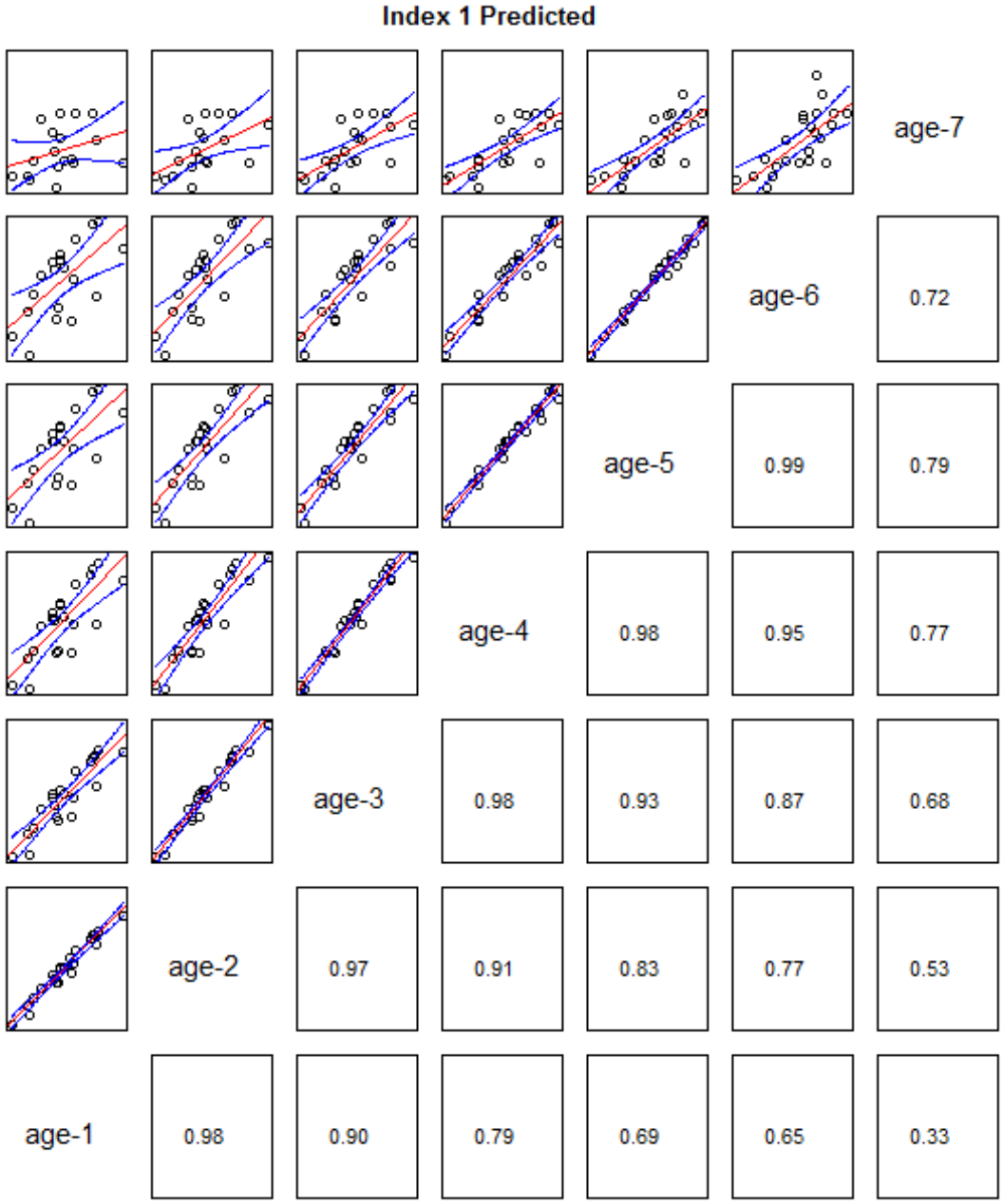

App. B7 Figure B7.88. Observed catch for the recreational fleet.



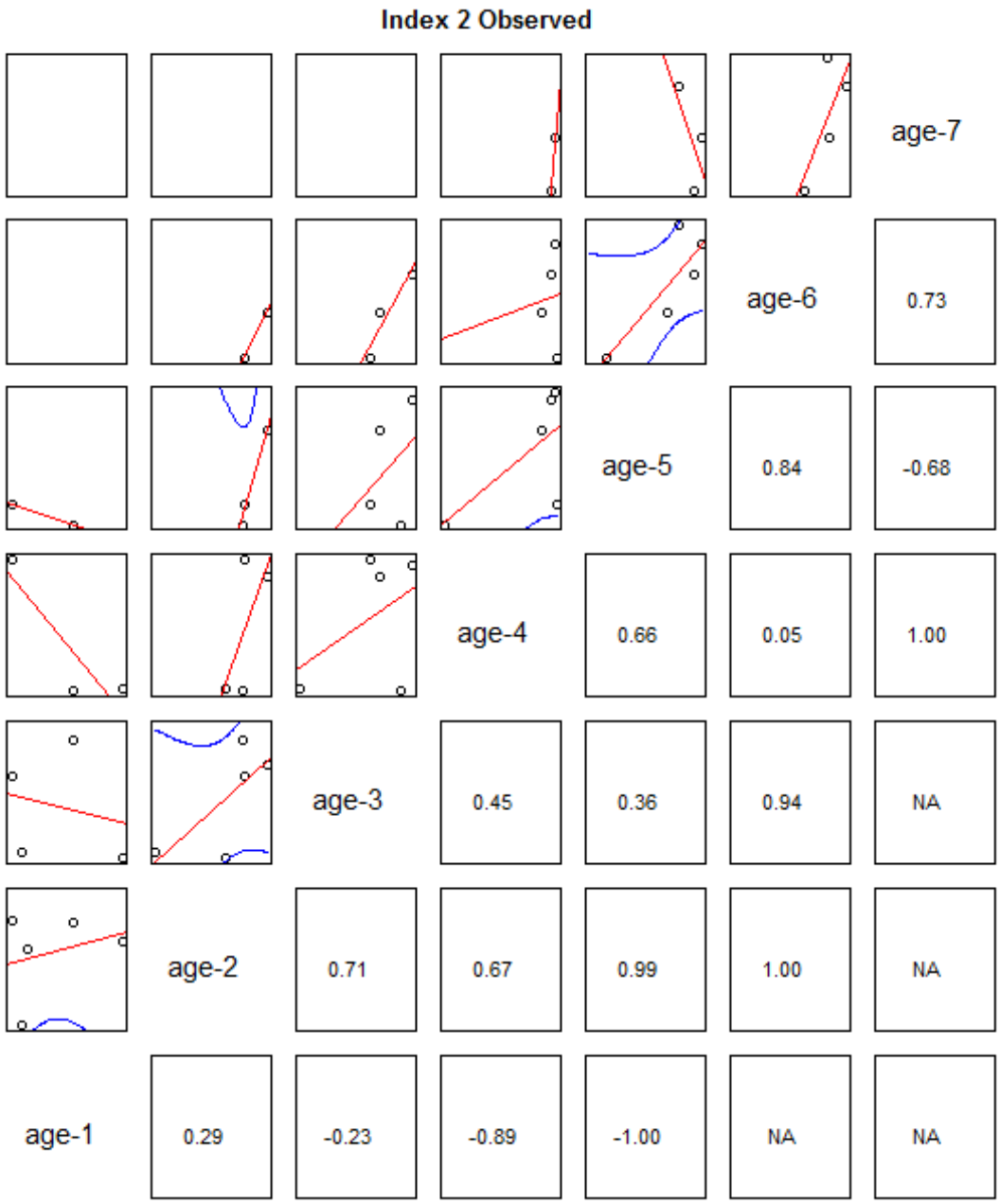

App. B7 Figure B7.89. Predicted catch for the recreational fleet.



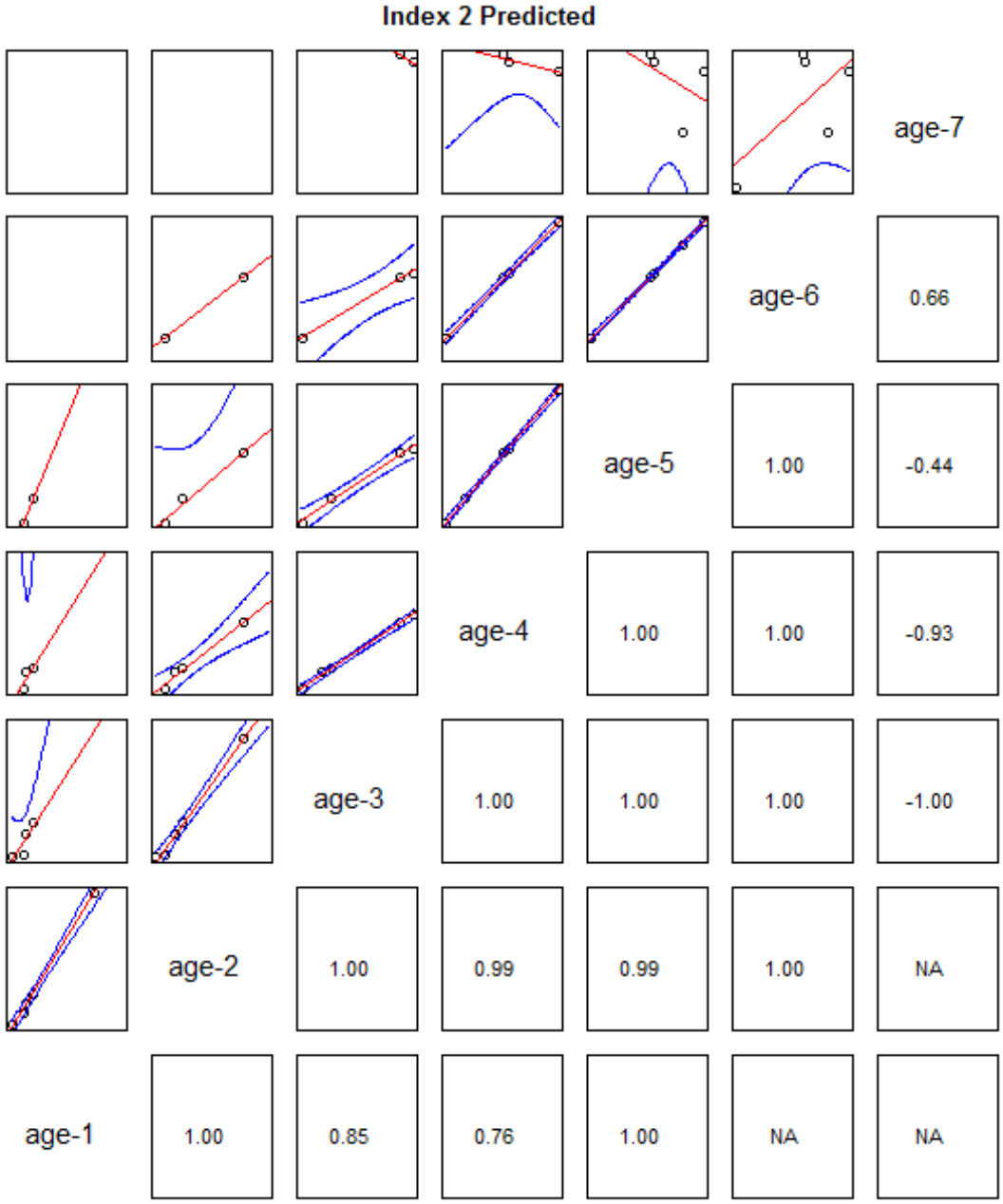

App. B7 Figure B7.90. Observed catch for the NEFSC Inshore survey.



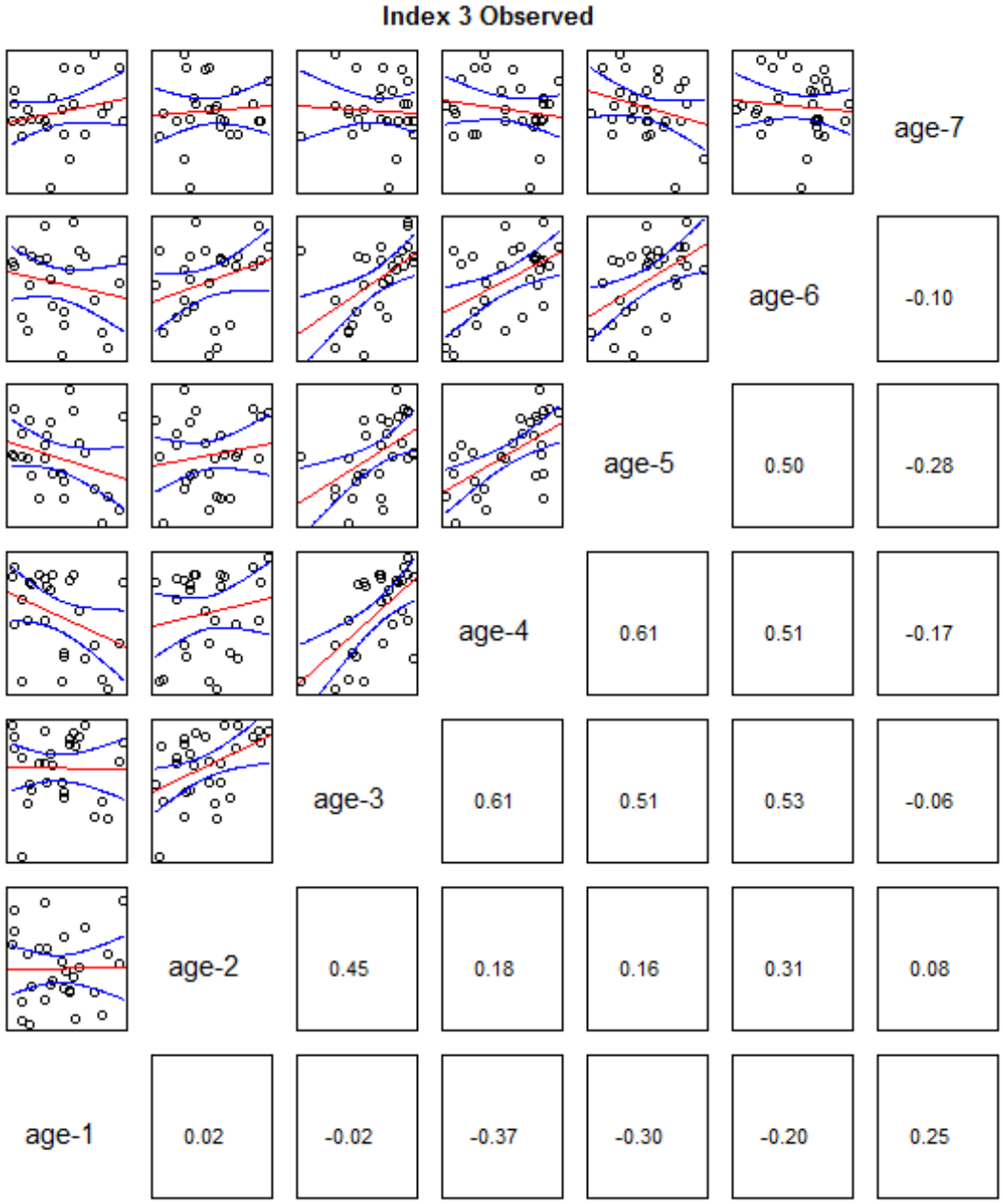

App. B7 Figure B7.91. Predicted catch for the NEFSC Inshore survey.



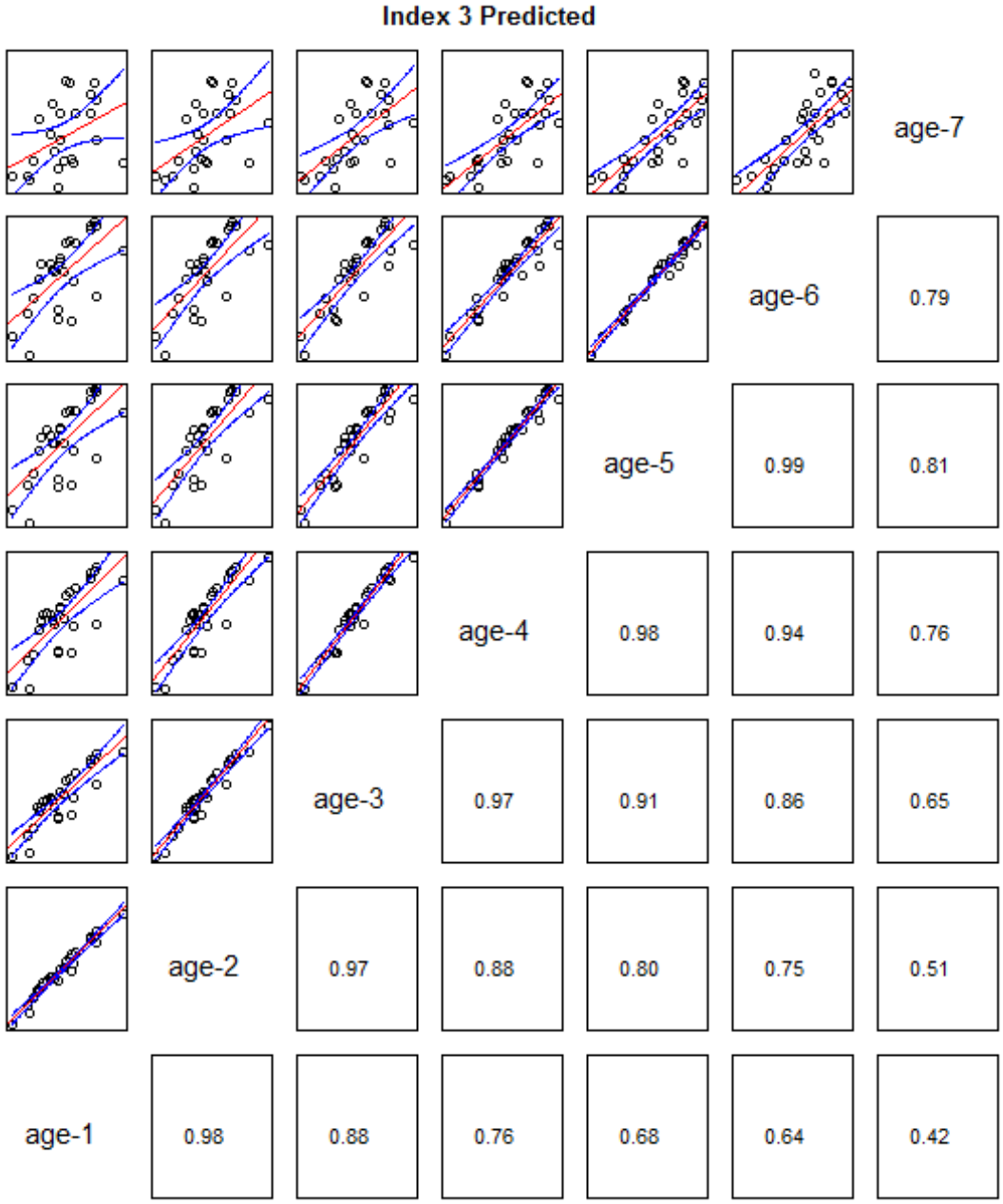

App. B7 Figure B7.92. Observed catch for the NEFSC Bigelow survey.



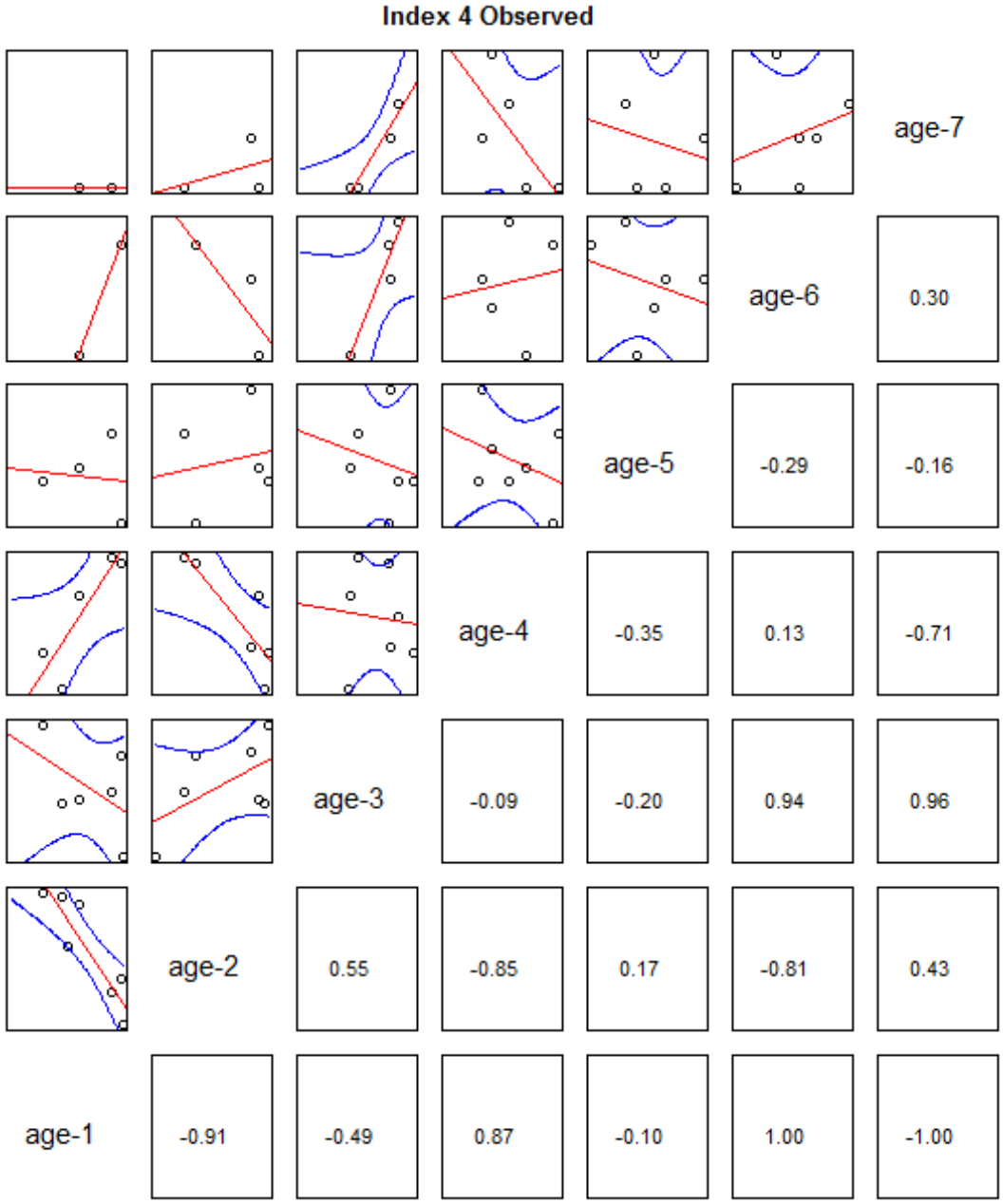

App. B7 Figure B7.93. Predicted catch for the NEFSC Bigelow survey.



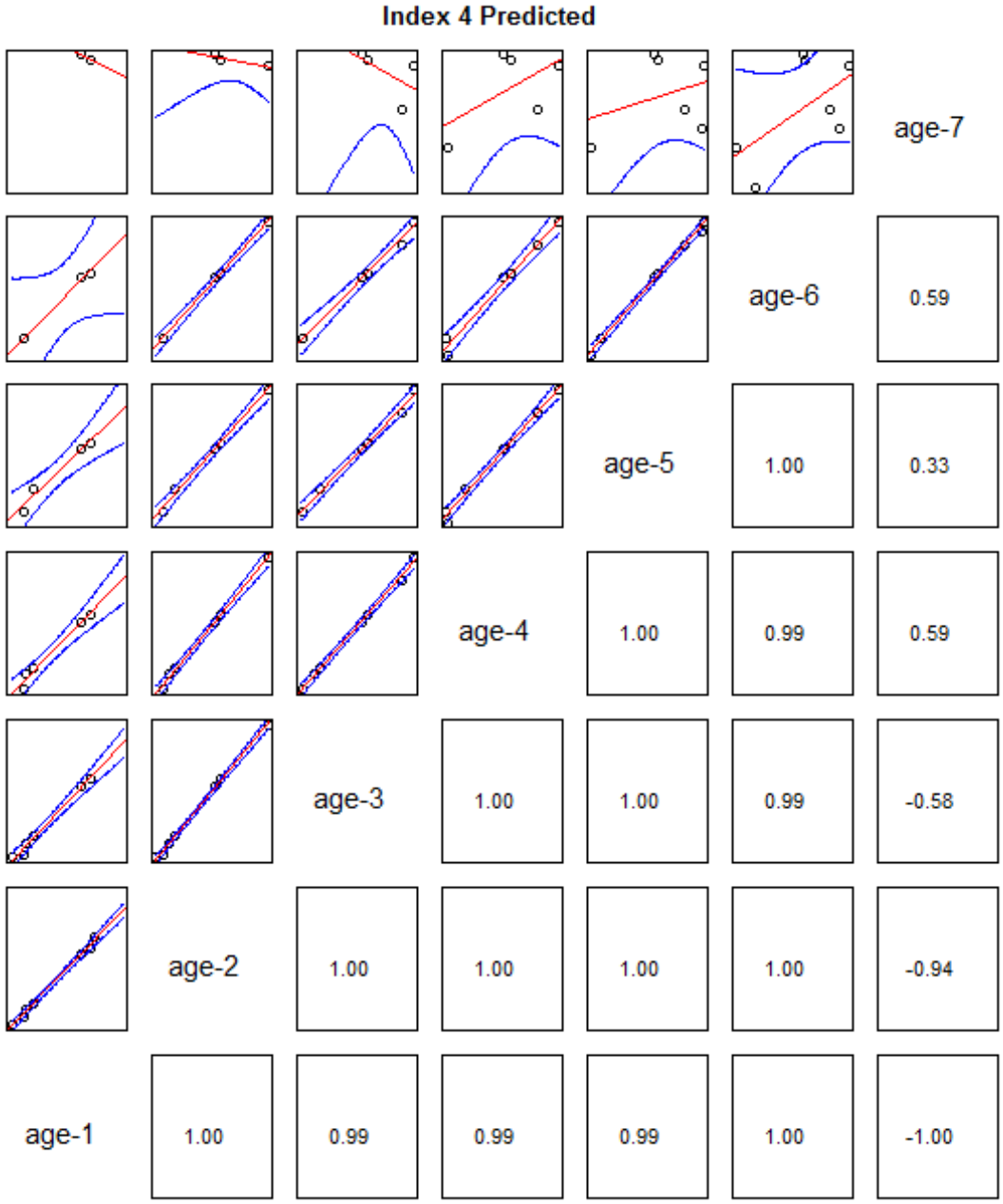

App. B7 Figure B7.94. Observed catch for the MRIP recreational CPUE index.



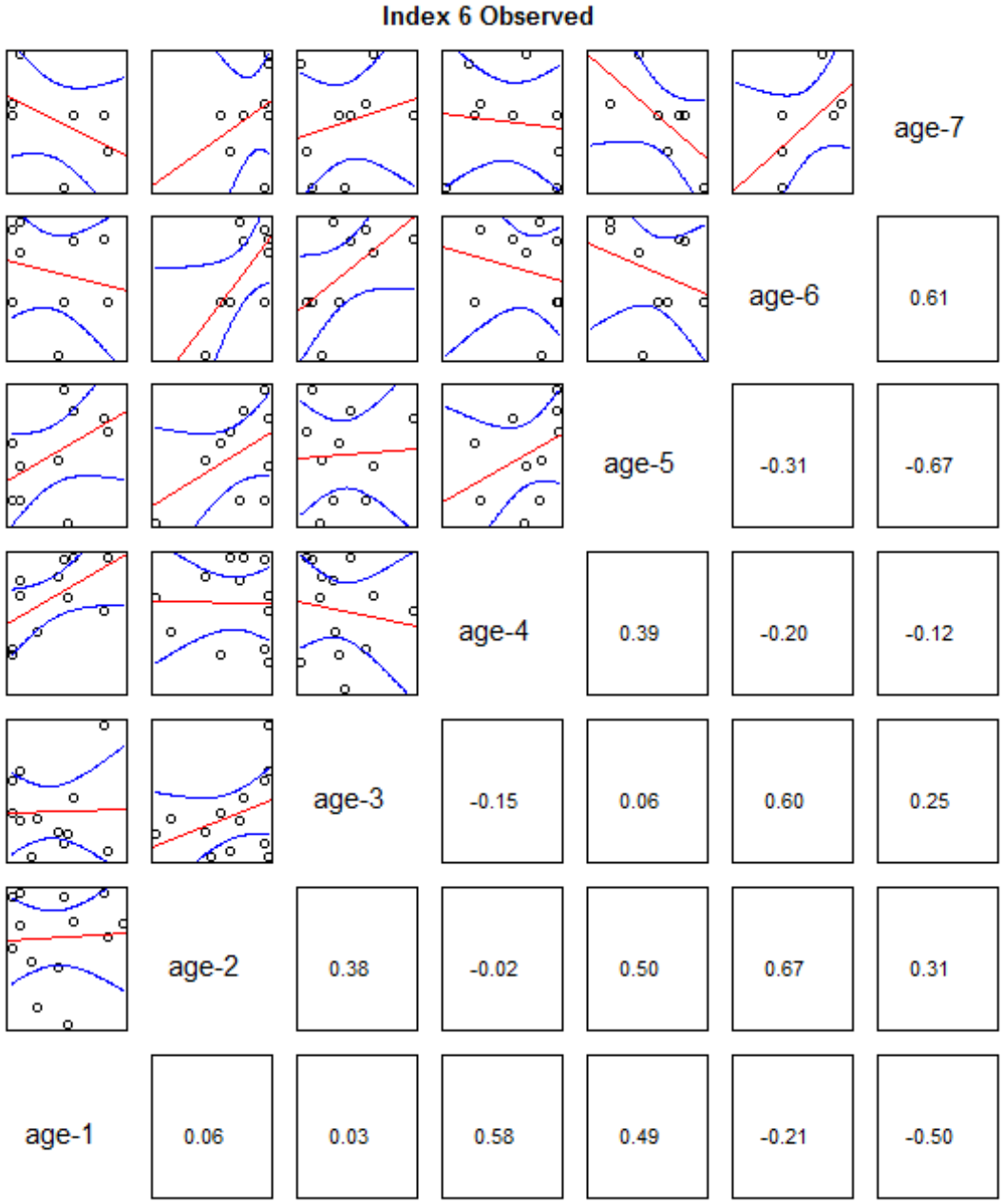

App. B7 Figure B7.95. Predicted catch for the MRIP recreational CPUE index.




App. B7 Figure B7.96. Observed catch for the NEAMAP survey.

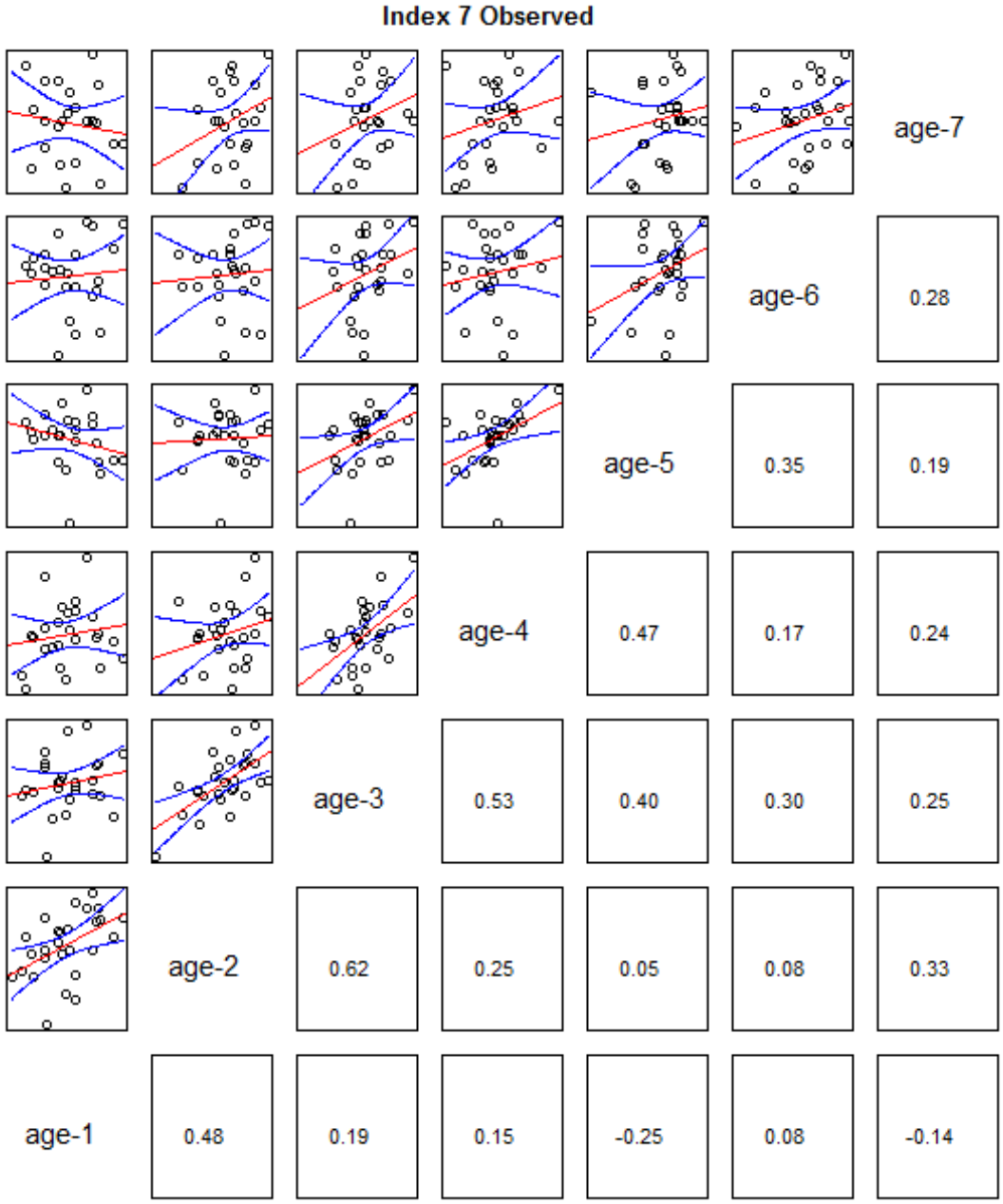



App. B7 Figure B7.97. Predicted catch for the NEAMAP survey.

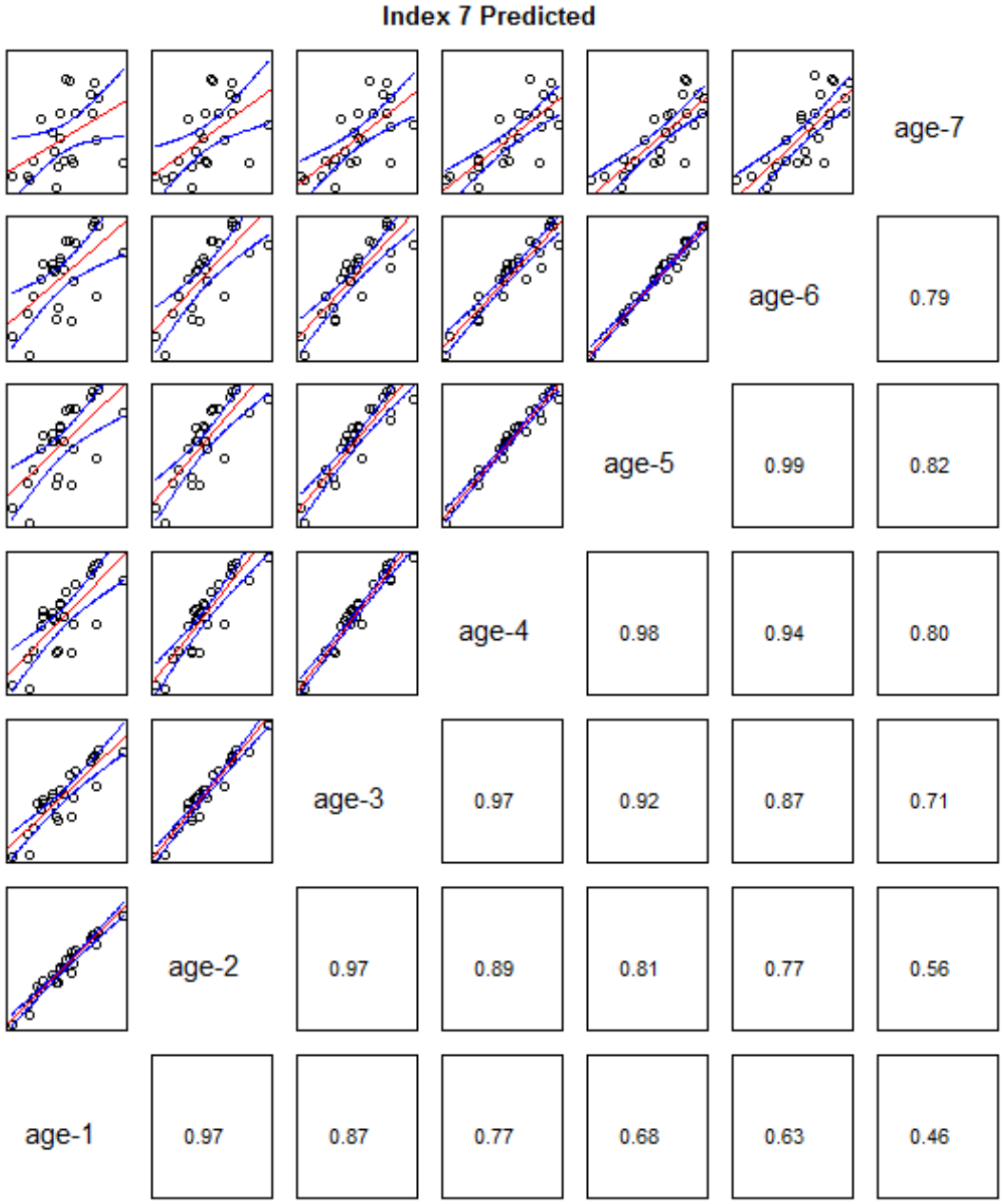



App. B7 Figure B7.98. Observed catch for the PSIGNS gillnet survey.

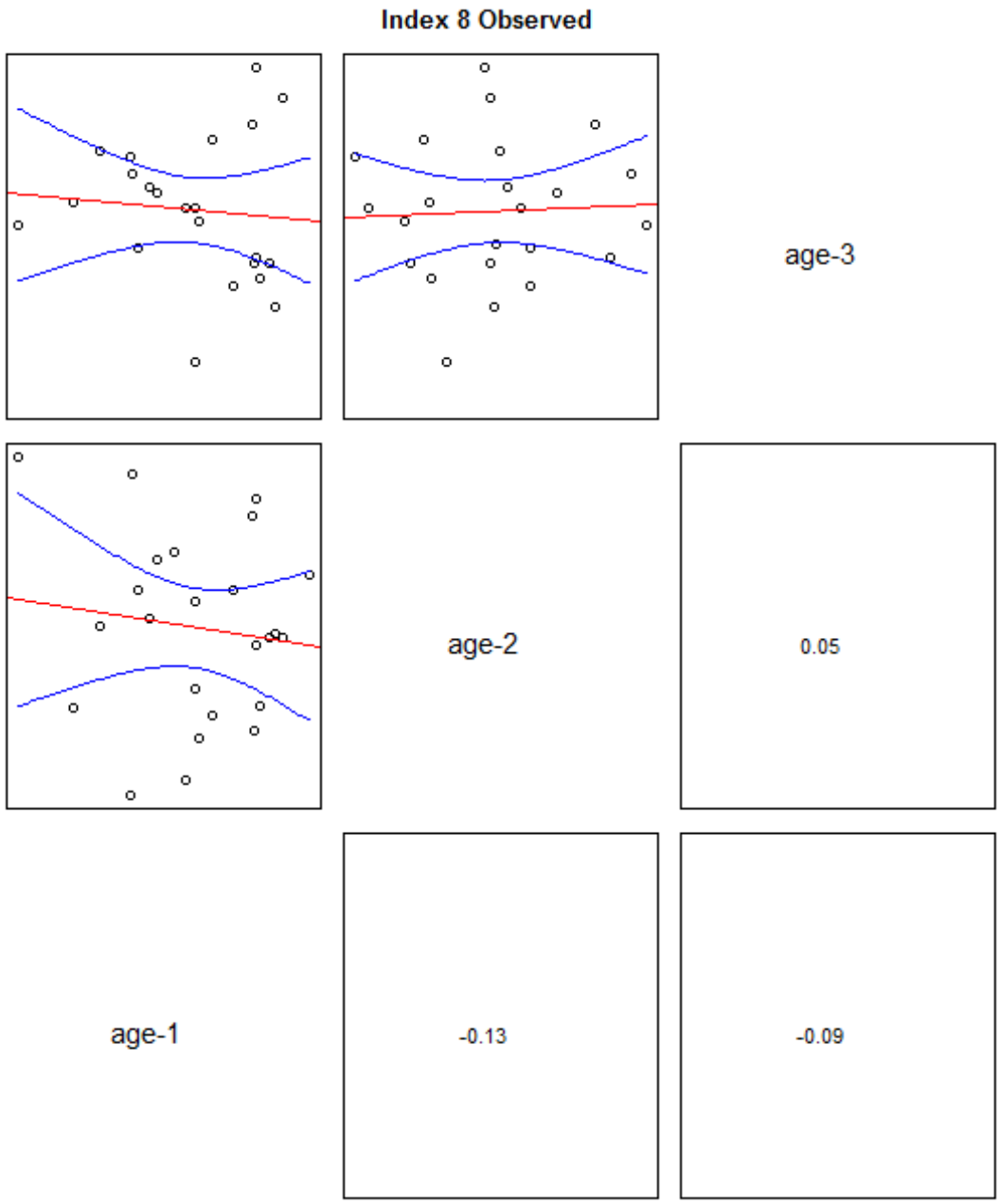
App. B7 Figure B7.99. Predicted catch for the PSIGNS gillnet survey.



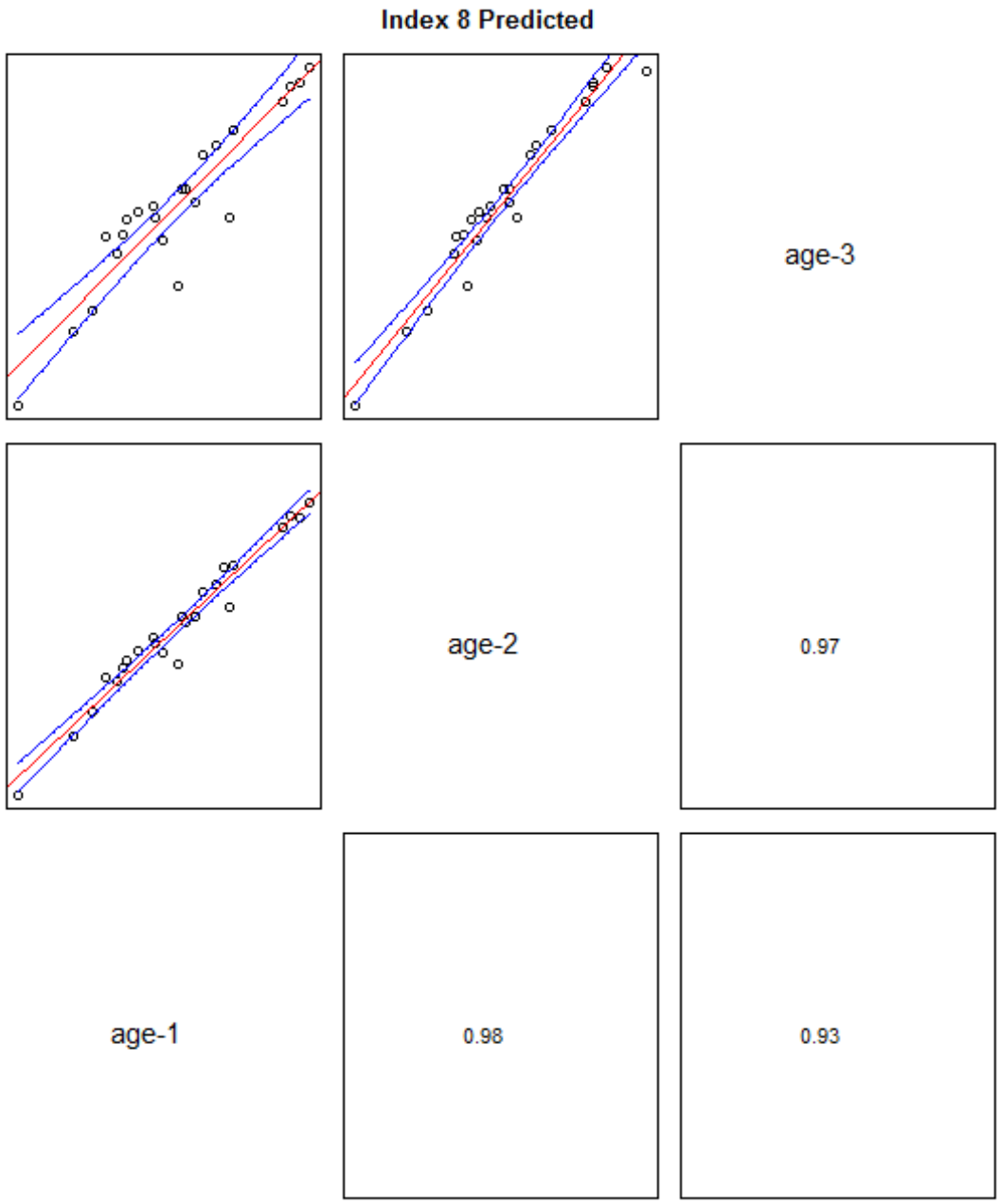

App. B7 Figure B7.100. Observed catch for the CT LISTS trawl survey.



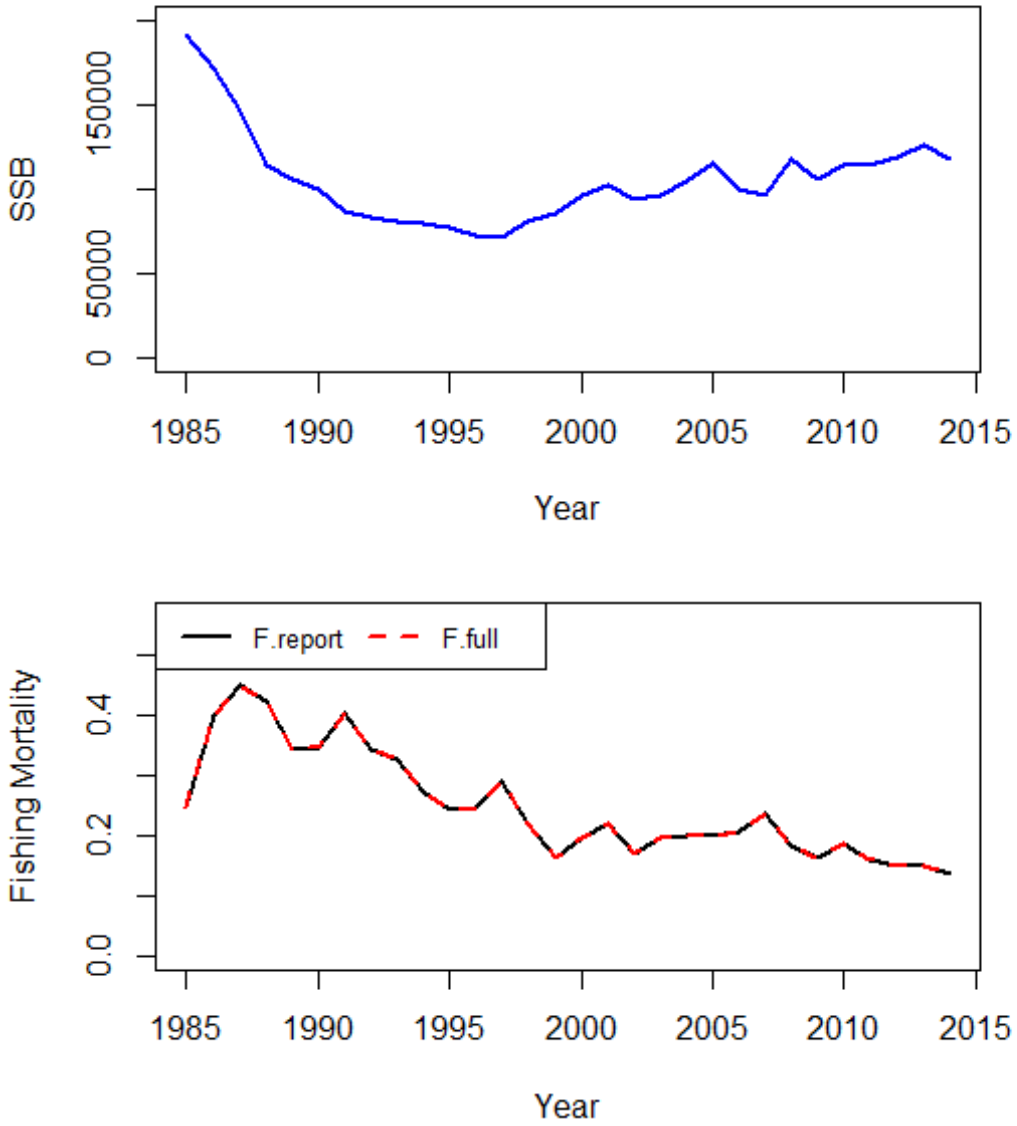

App. B7 Figure B7.101. Predicted catch for the CT LISTS trawl survey.



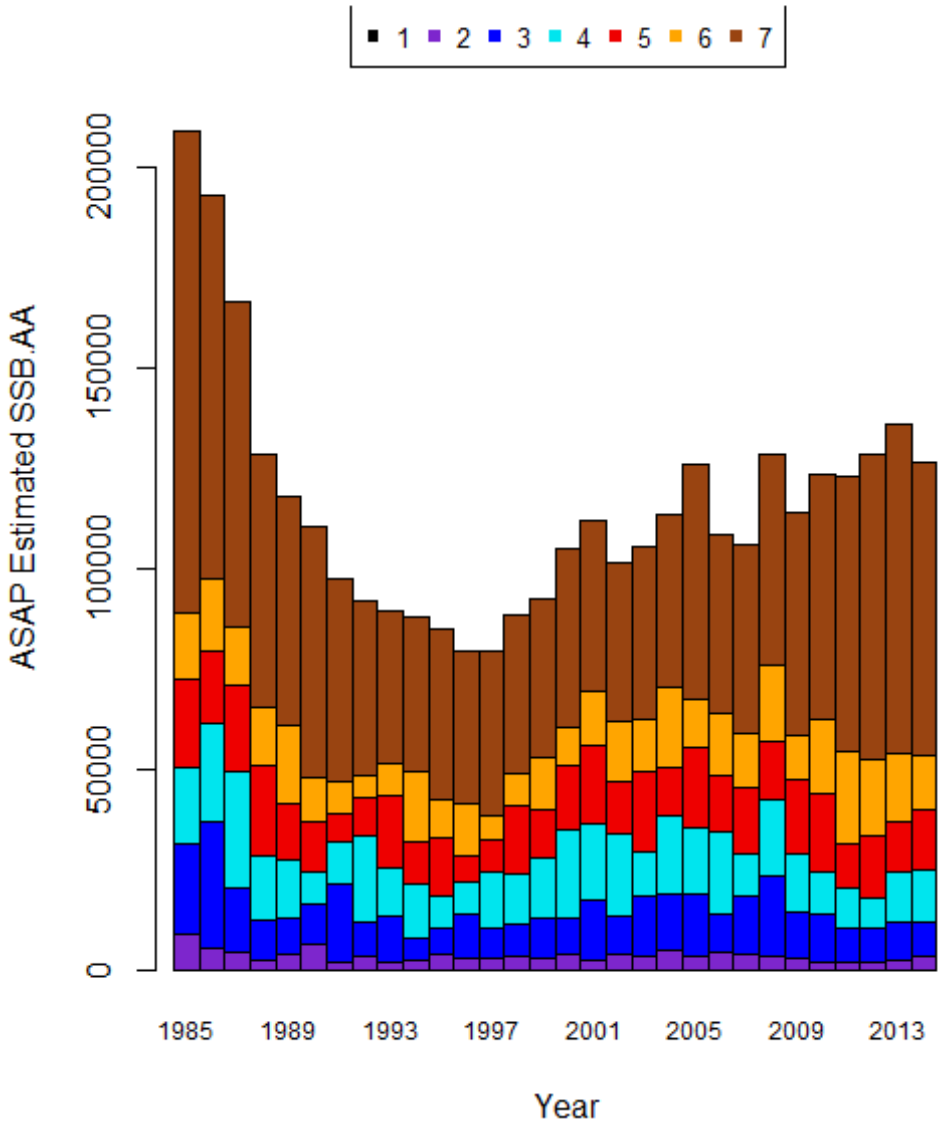

App. B7 Figure B7.102. Observed catch for the NJ ocean trawl survey.



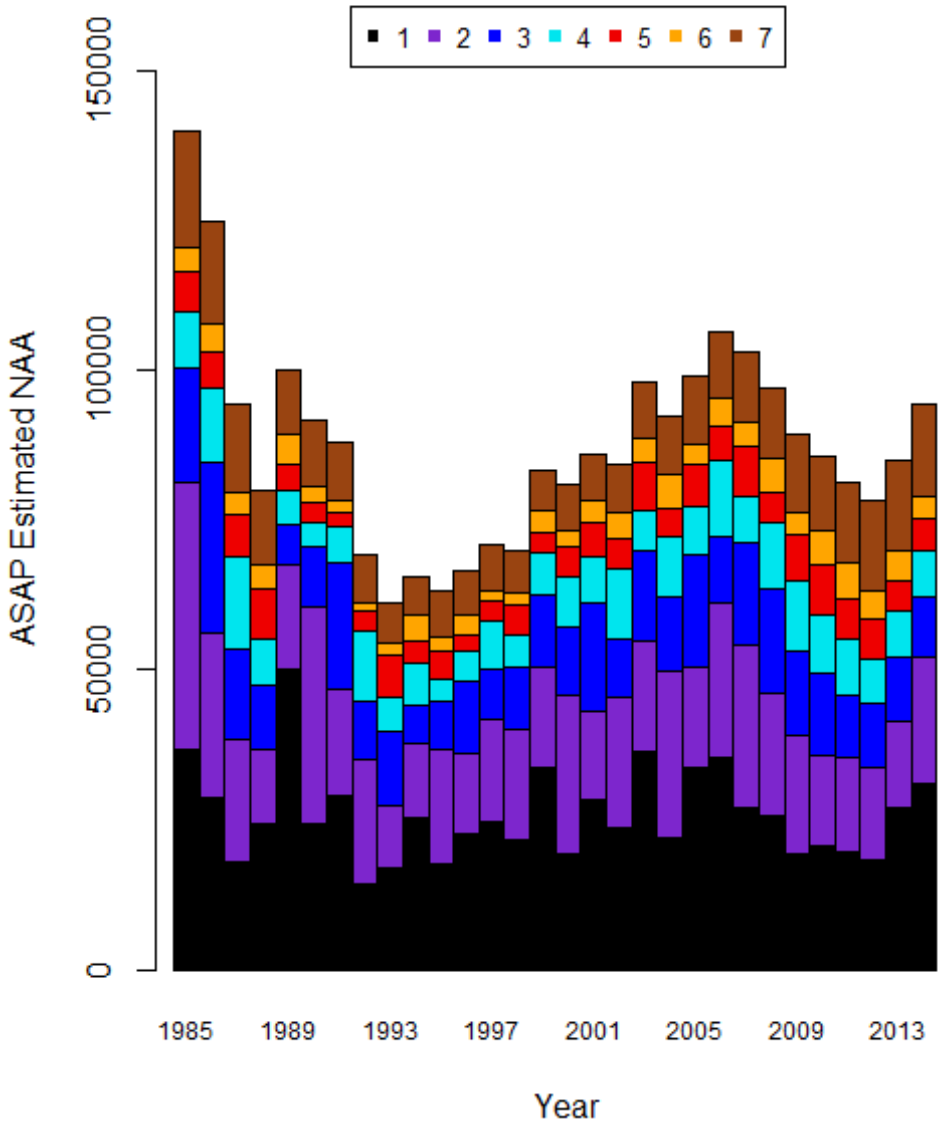

App. B7 Figure B7.103. Predicted catch for the NJ ocean trawl survey.



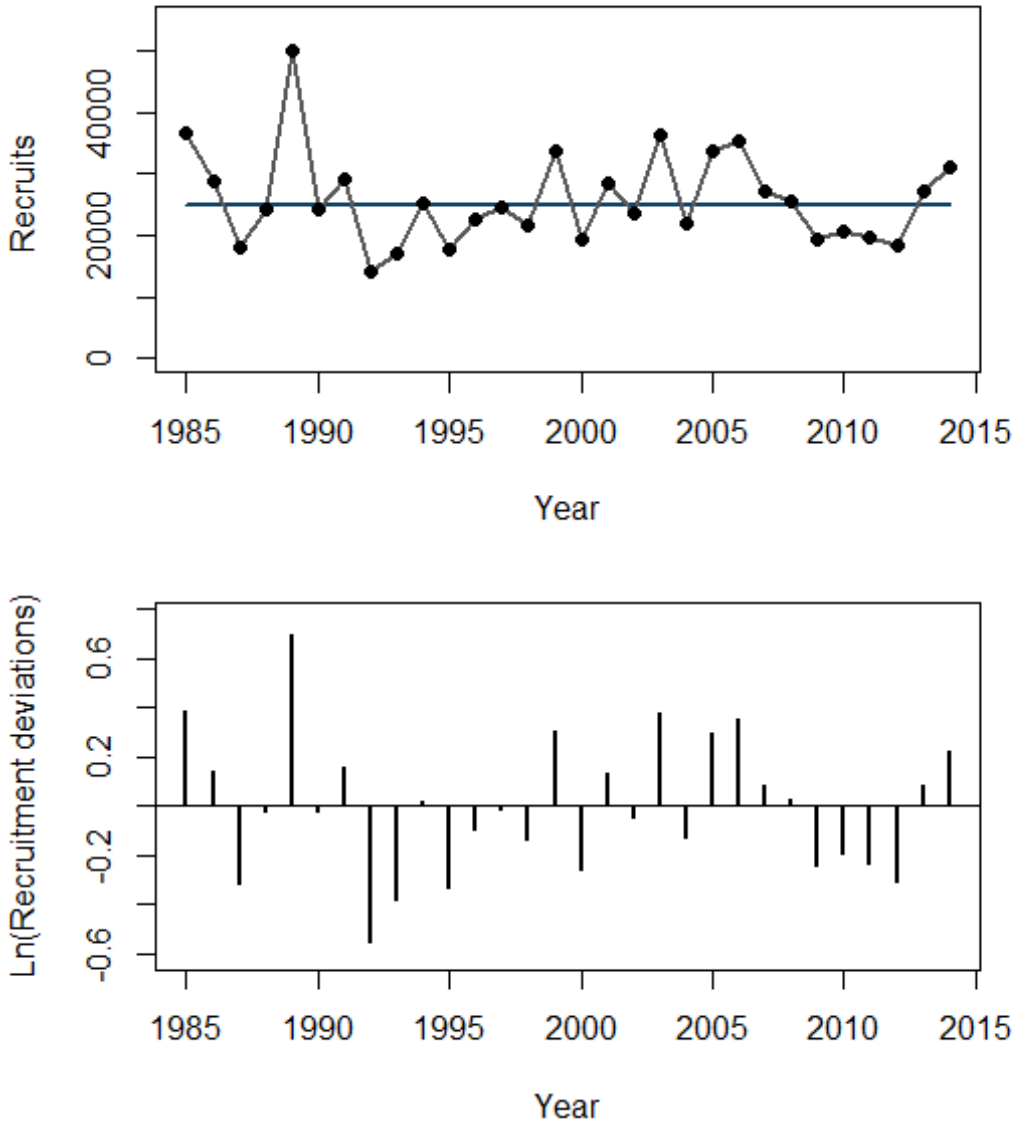

App. B7 Figure B7.104. Estimated spawning stock biomass and full fishing mortality from 1985 to 2014 from the final model.



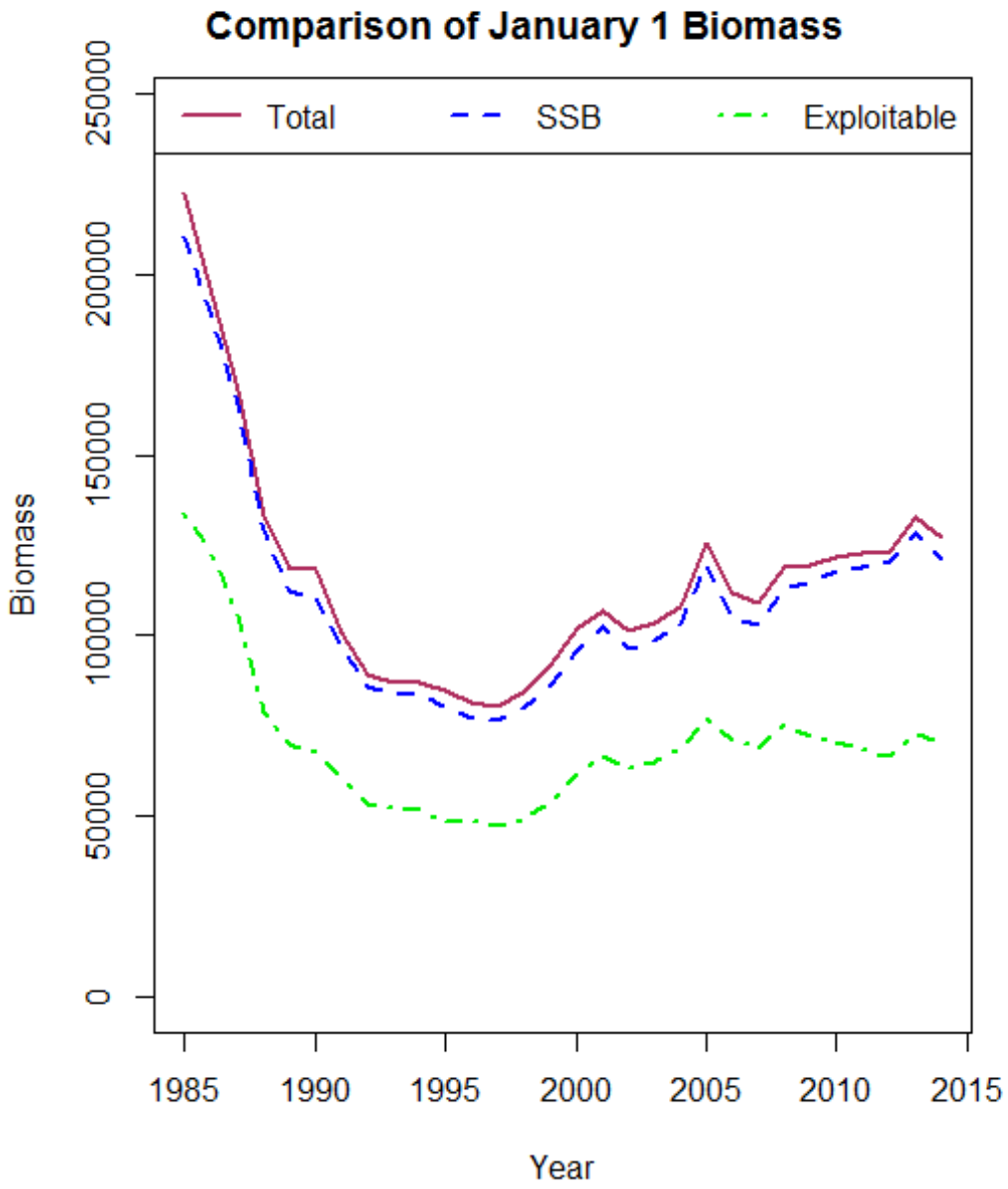

App. B7 Figure B7.105. Age composition of the spawning stock biomass from 1985 to 2014.



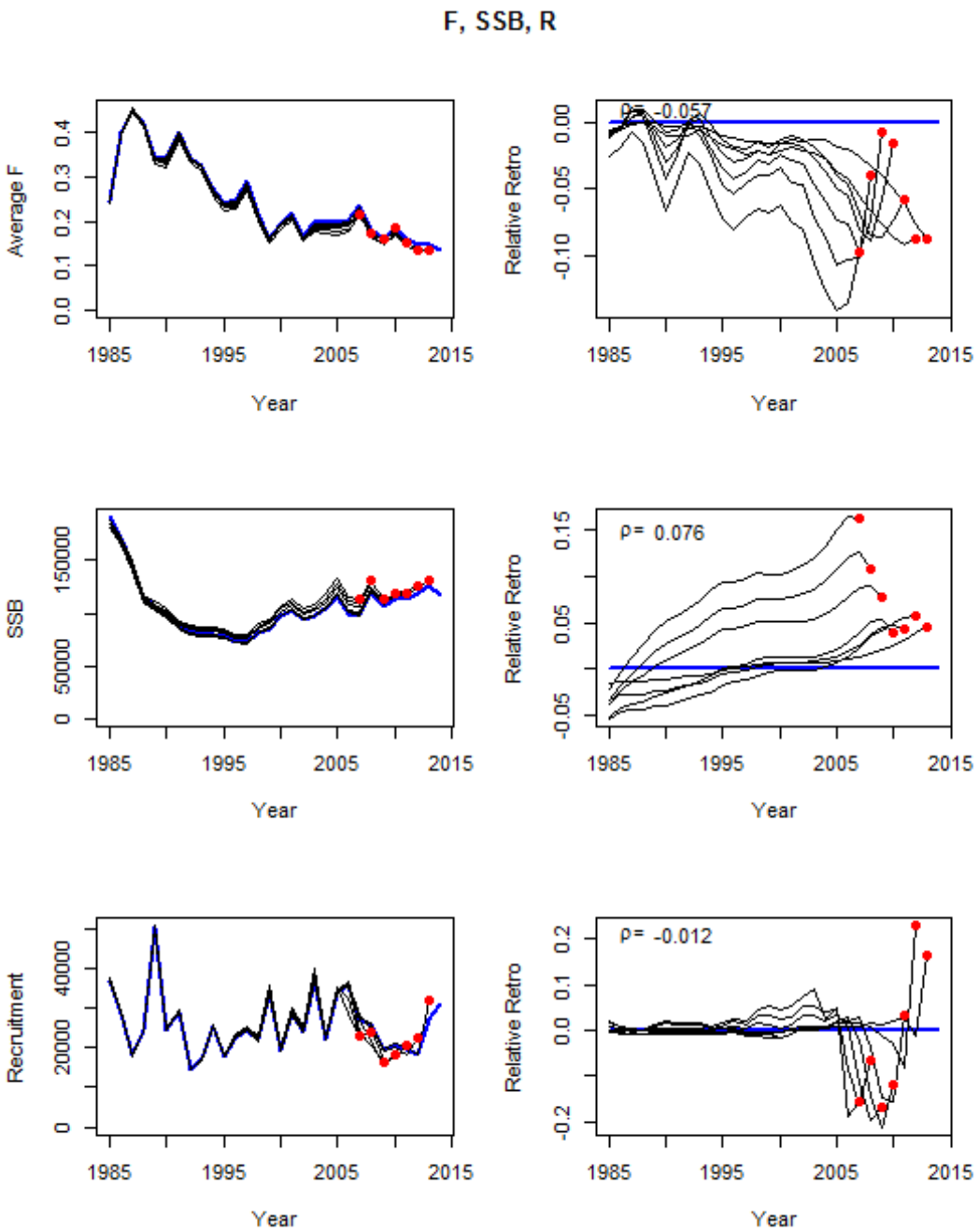

App. B7 Figure B7.106. Estimated numbers at age from the final model from 1985 to 2014.



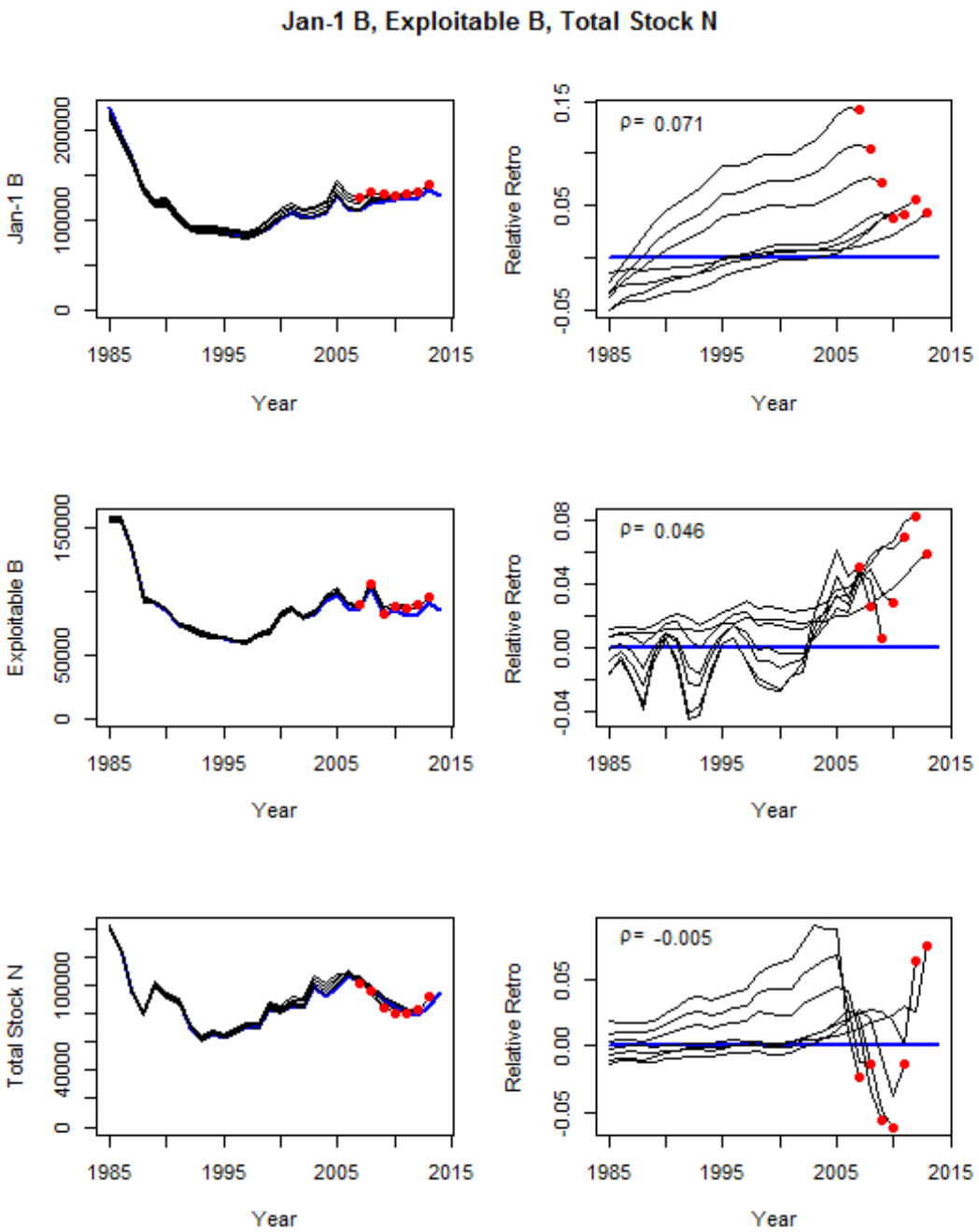

App. B7 Figure B7.107. Recruitment estimates, mean recruitment, and recruitment deviations (log) from 1985 to 2014 from the final model.



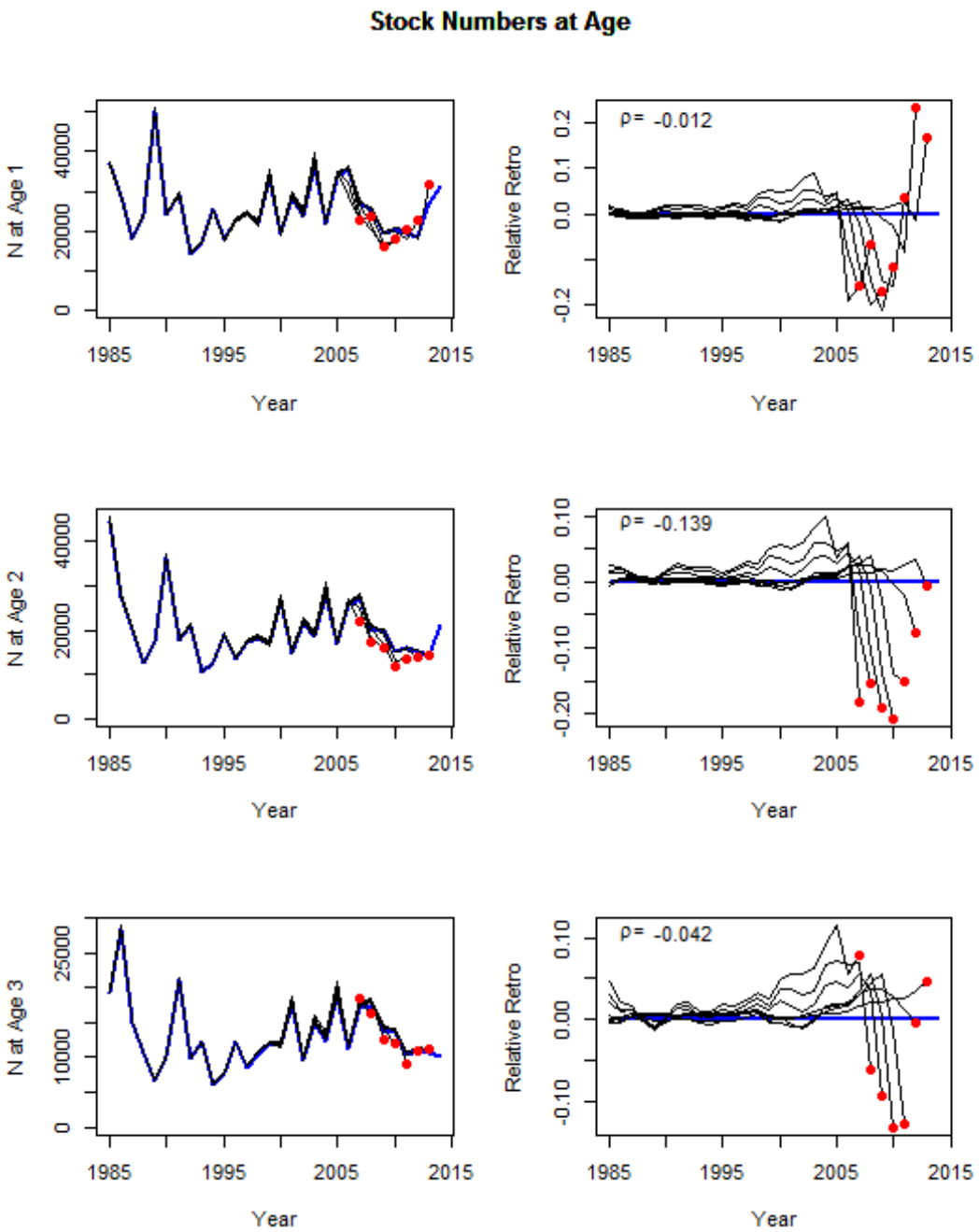

App. B7 Figure B7.108. A comparison of total, spawning stock, and exploitable biomass from 1985 to 2014 from the final model.



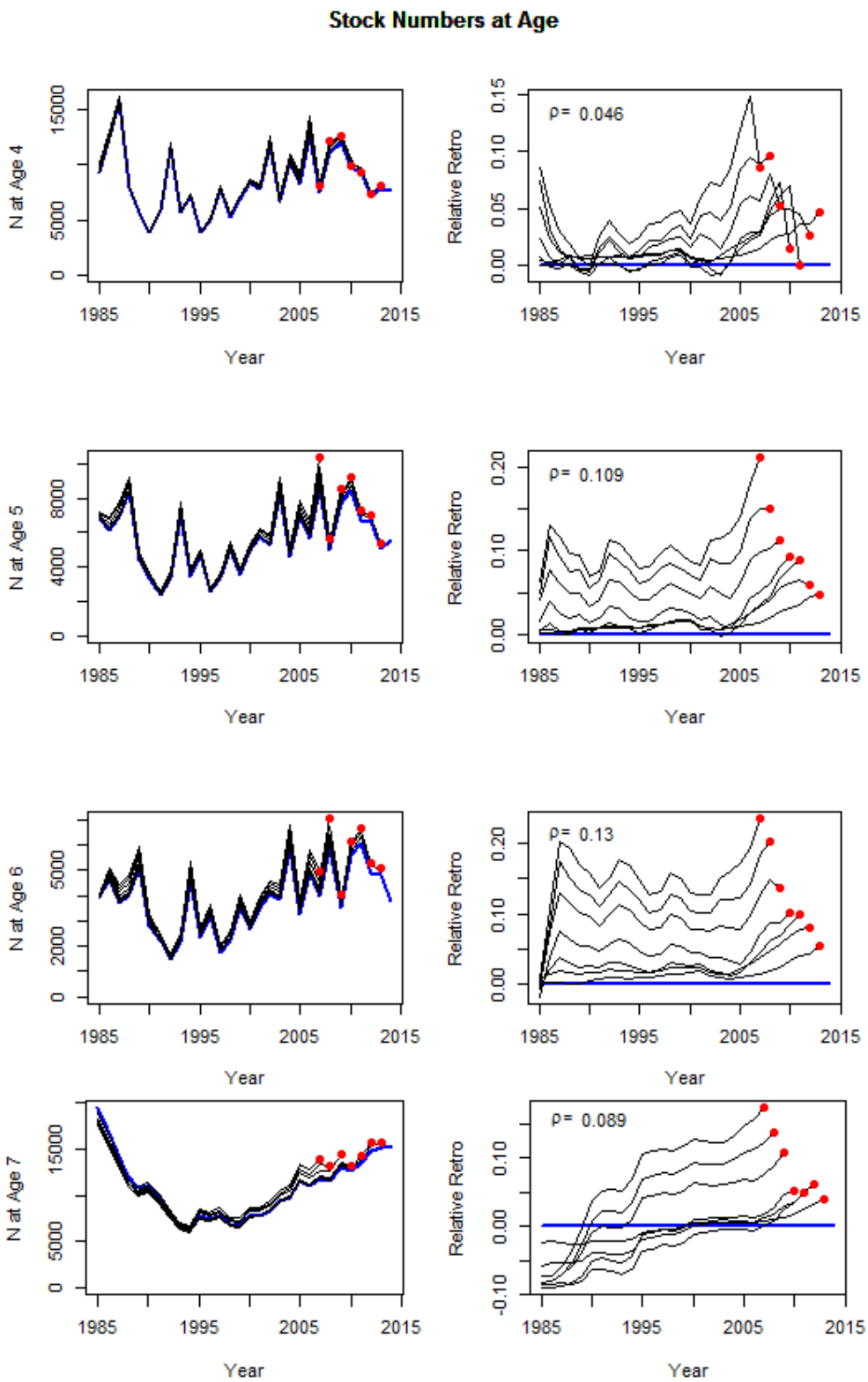

App. B7 Figure B7.109. Retrospective plots for average fishing mortality, spawning stock biomass and recruitment from a 7 year peel carried out on the final model.



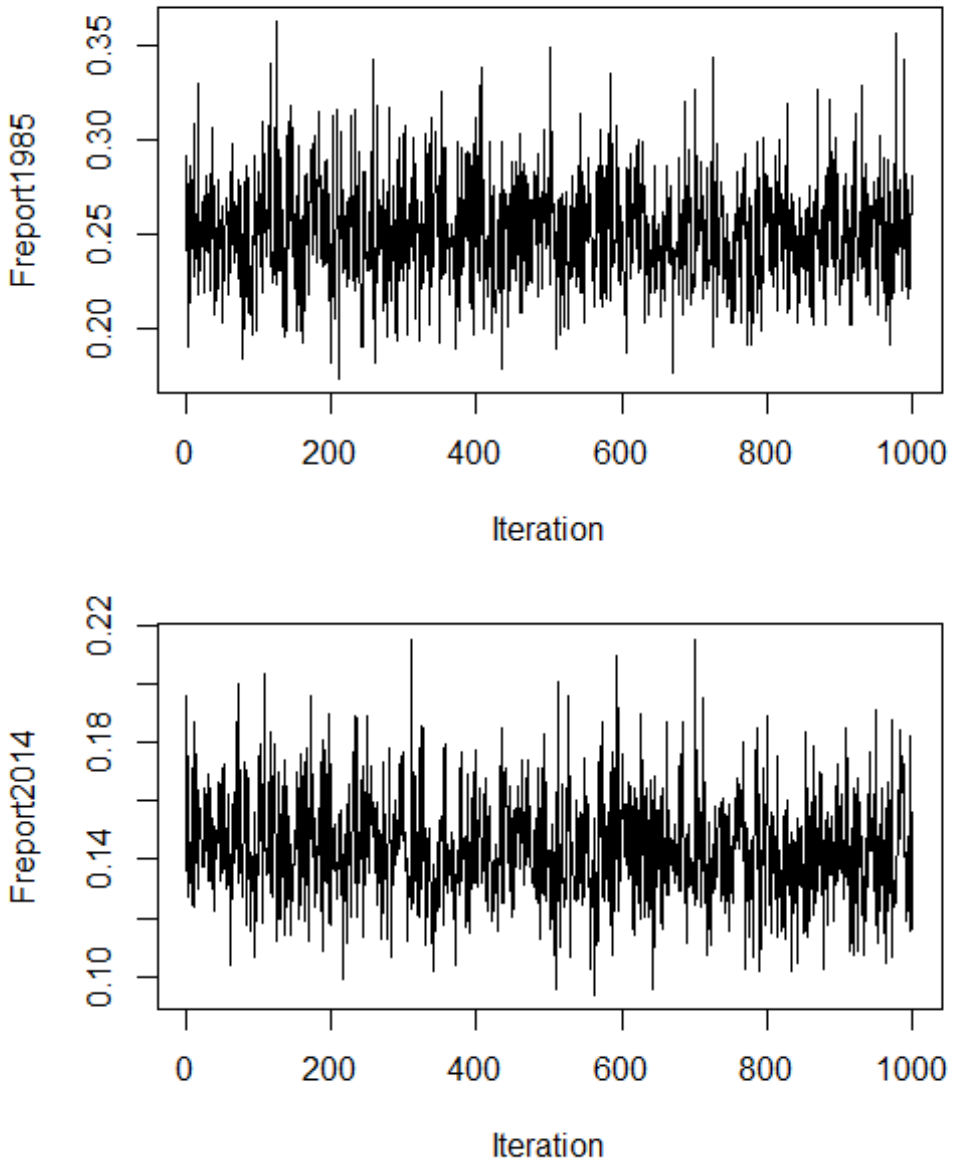

App. B7 Figure B7.110. Retrospective plots for January-1 biomass, total biomass, and total stock numbers, from a 7 year peel carried out on the final model.



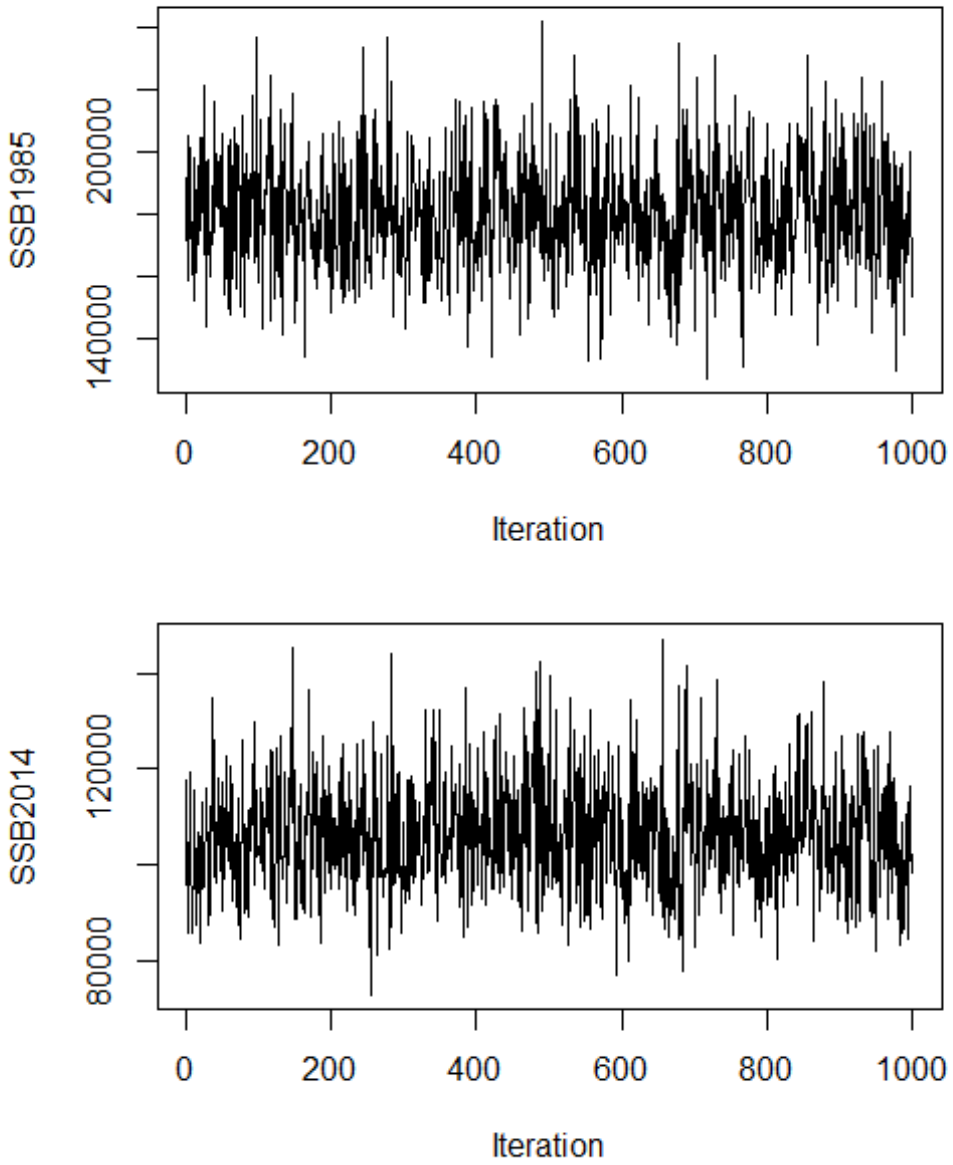

App. B7 Figure B7.111. Retrospective plots for ages 0-2 from a 7 year peel carried out on the final model.



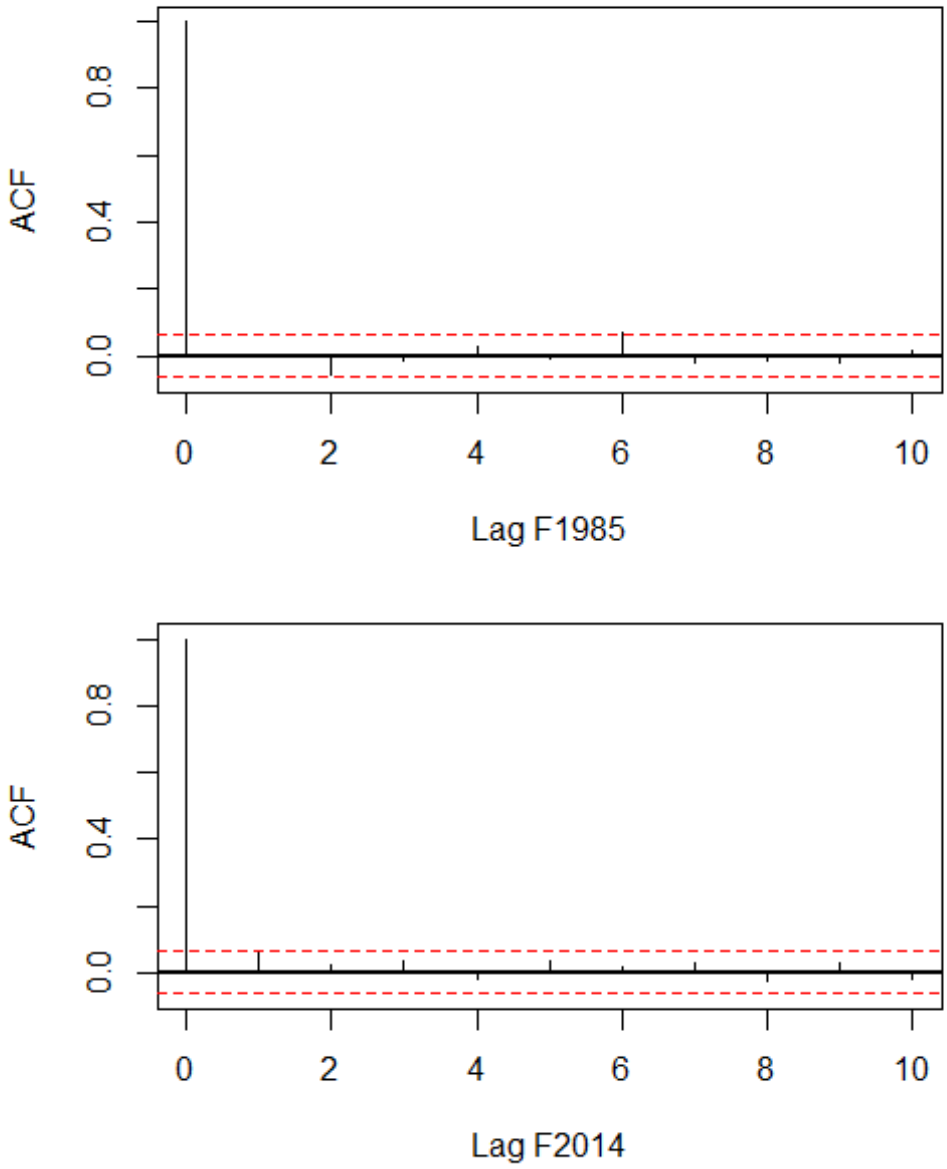

App. B7 Figure B7.112. Retrospective plots for ages 3-6+ from a 7 year peel carried out on the final model.



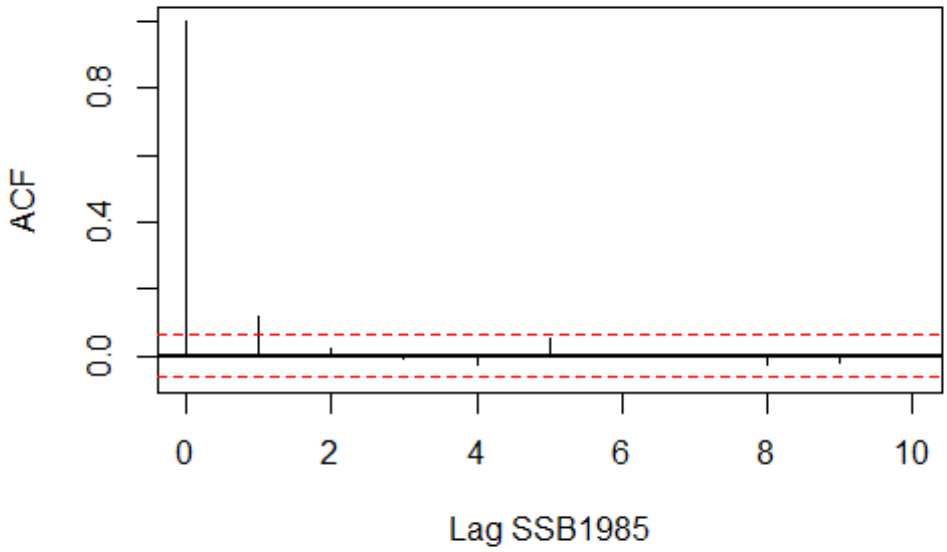

App. B7 Figure B7.113. Trace plots for fishing mortality in 1985 and 2014 from 1000 MCMC and a thinning rate of 1000 (1,000,000 iterations).

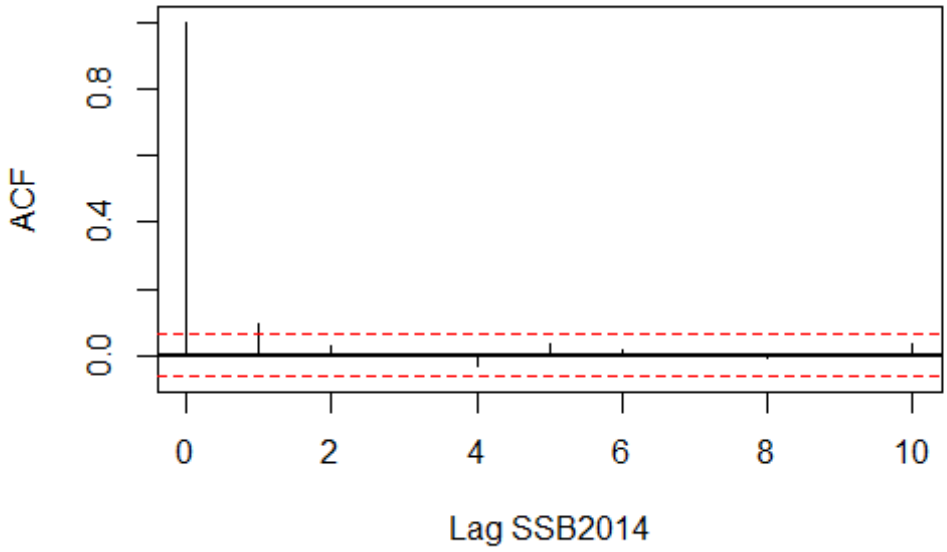



App. B7 Figure B7.114. Trace plots for spawning stock biomass in 1985 and 2014 from 1000 MCMC and a thinning rate of 1000 (1,000,000 iterations).

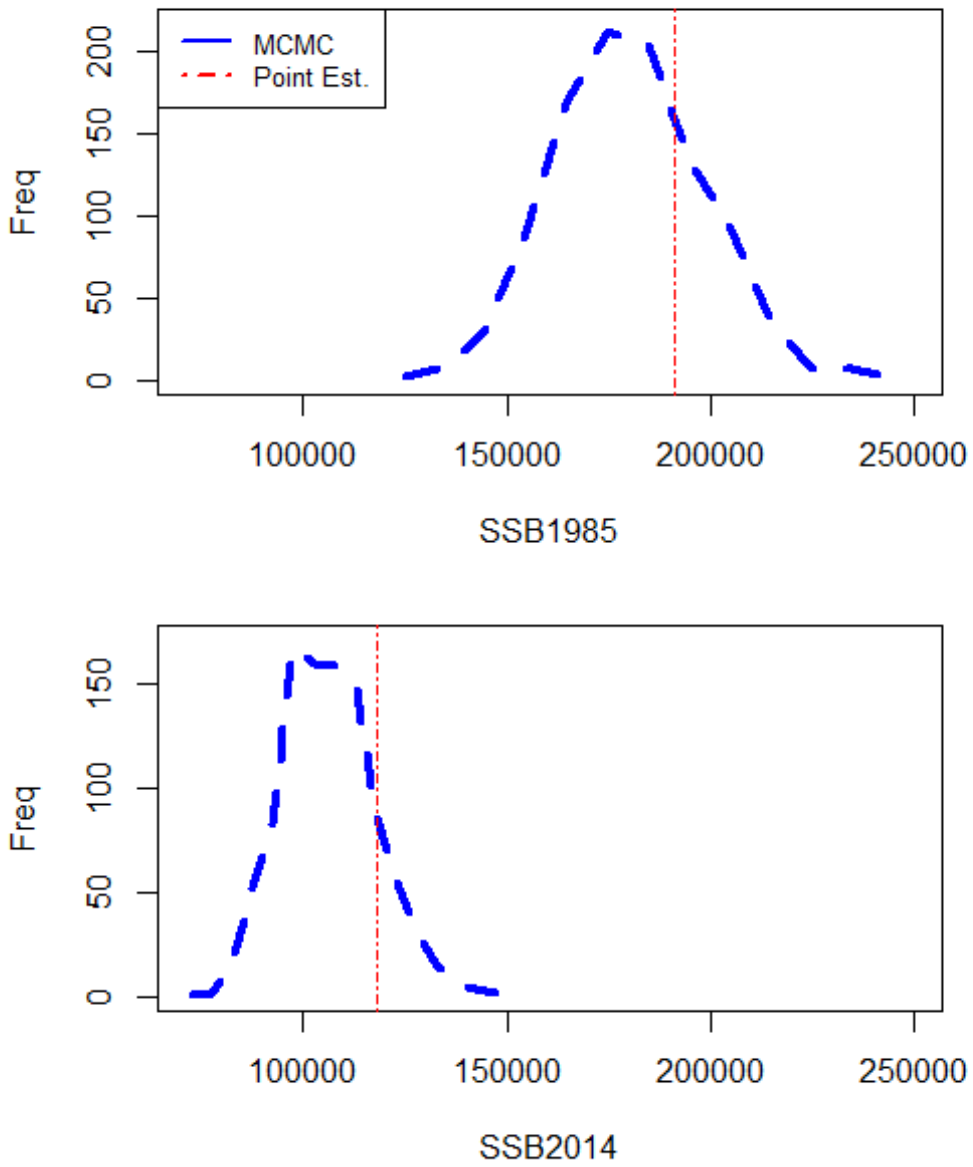



App. B7 Figure B7.115. Autocorrelation for fishing mortality in the MCMC runs.

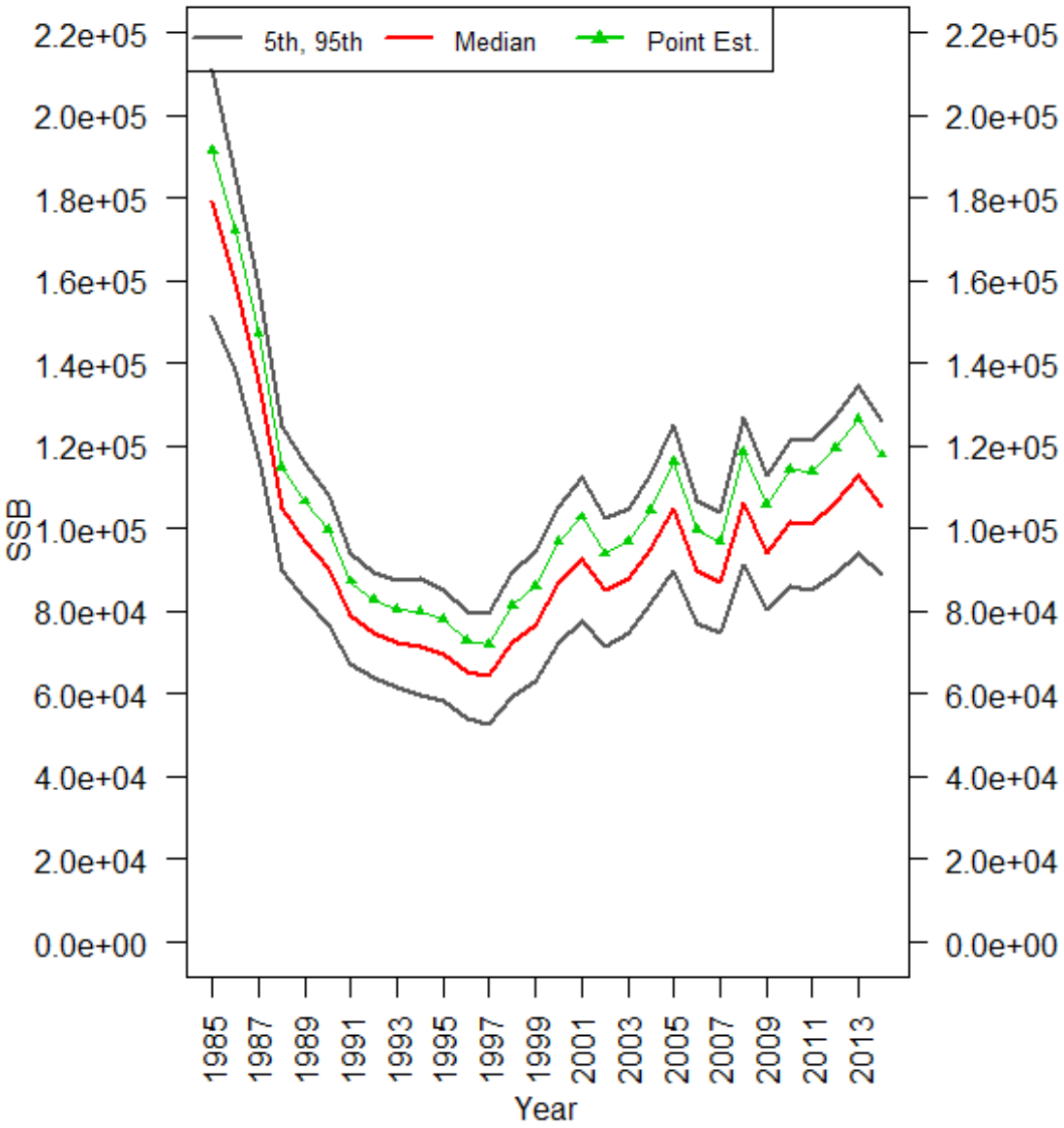


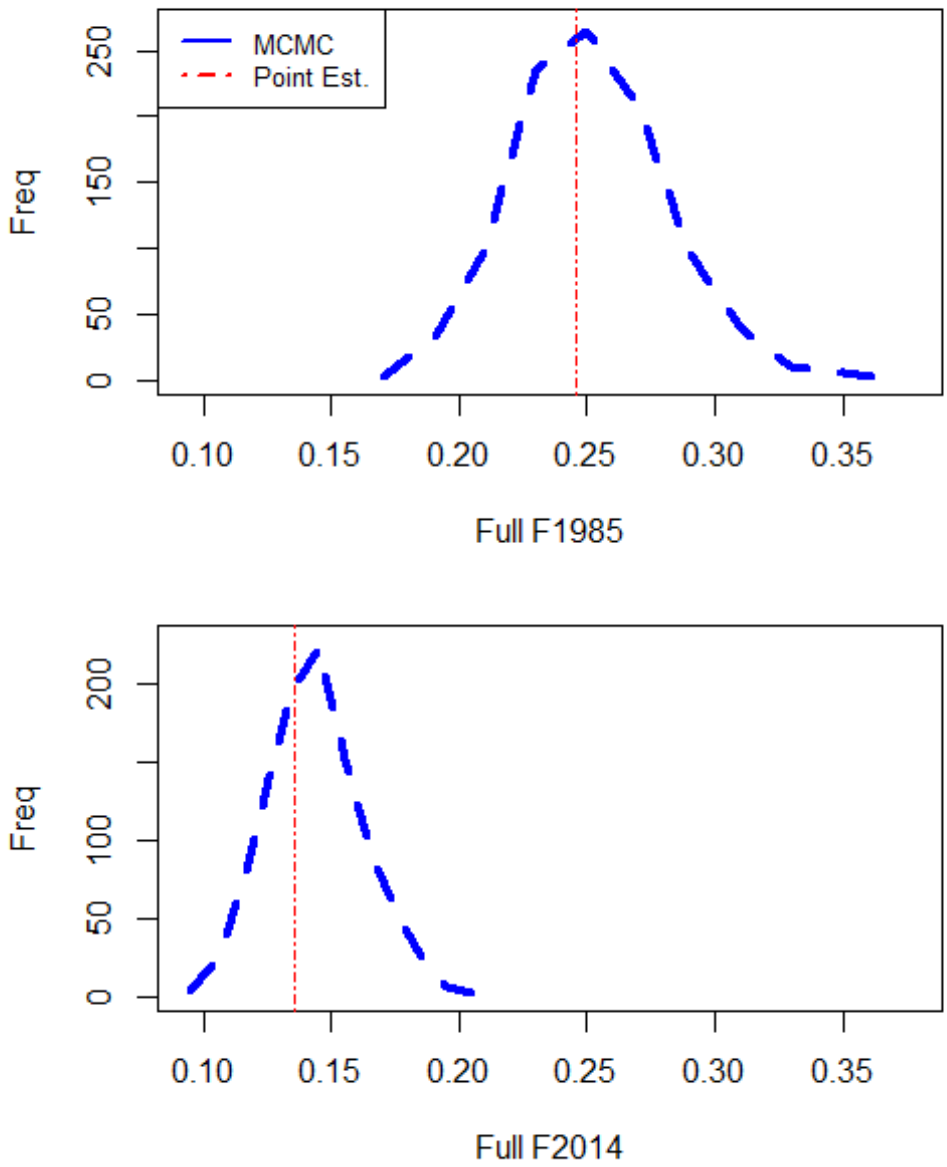

App. B7 Figure B7.116. Autocorrelation for SSB in the MCMC runs.



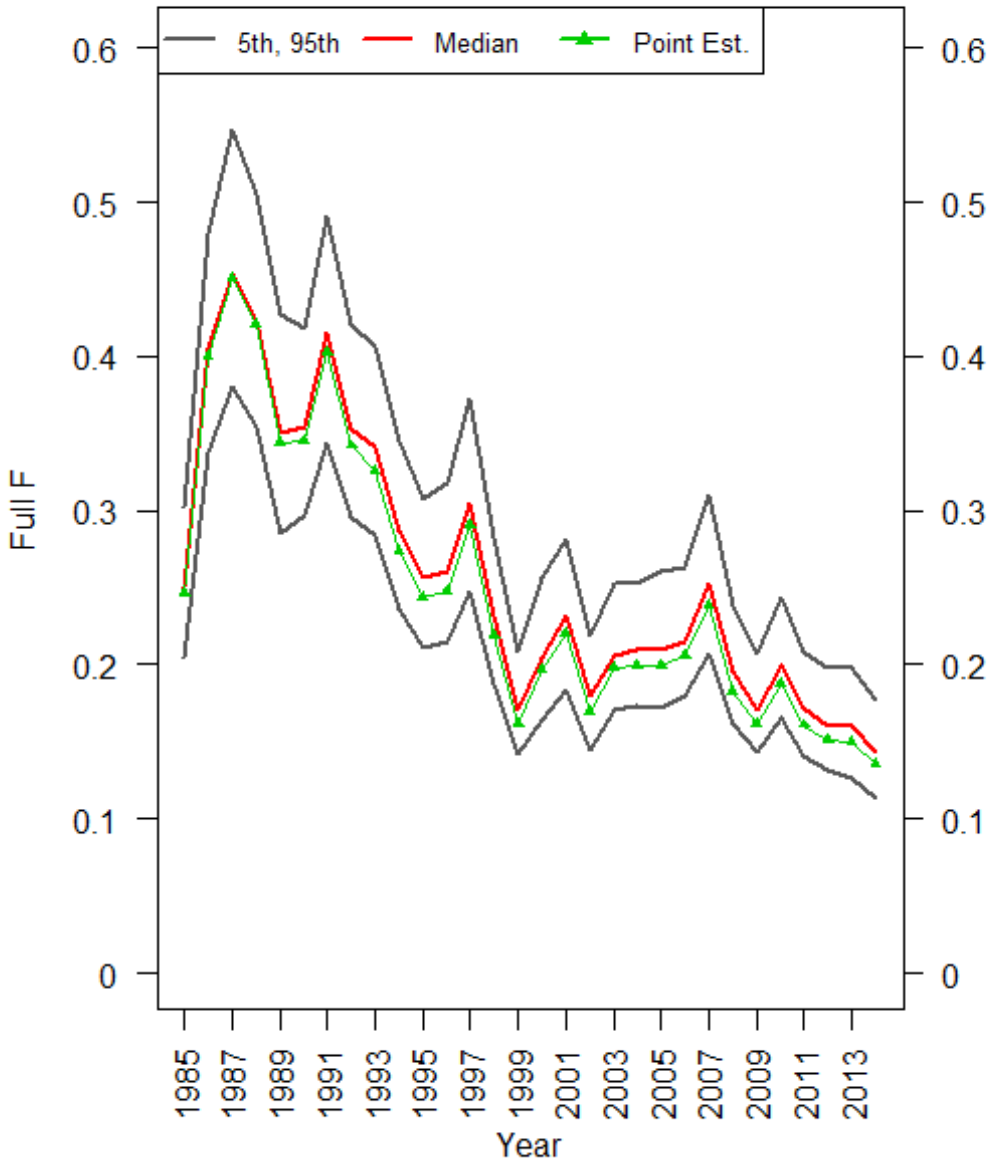

App. B7 Figure B7.117. MCMC distribution plots for spawning stock biomass in 1985 and 2014 with point estimates from the final model.



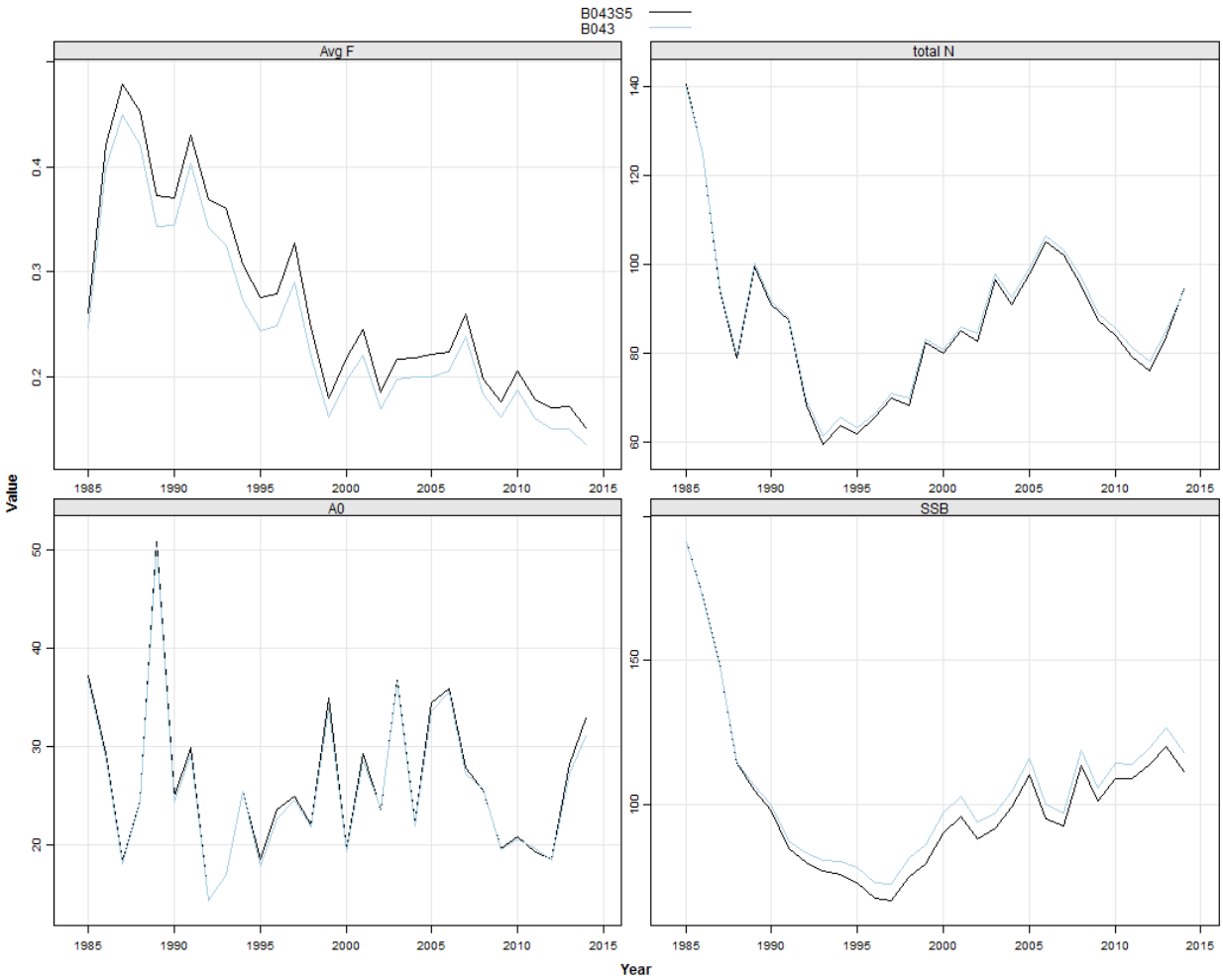

App. B7 Figure B7.118. Median spawning stock biomass and 95 confidence intervals from the MCMC runs with point estimates from the final model.



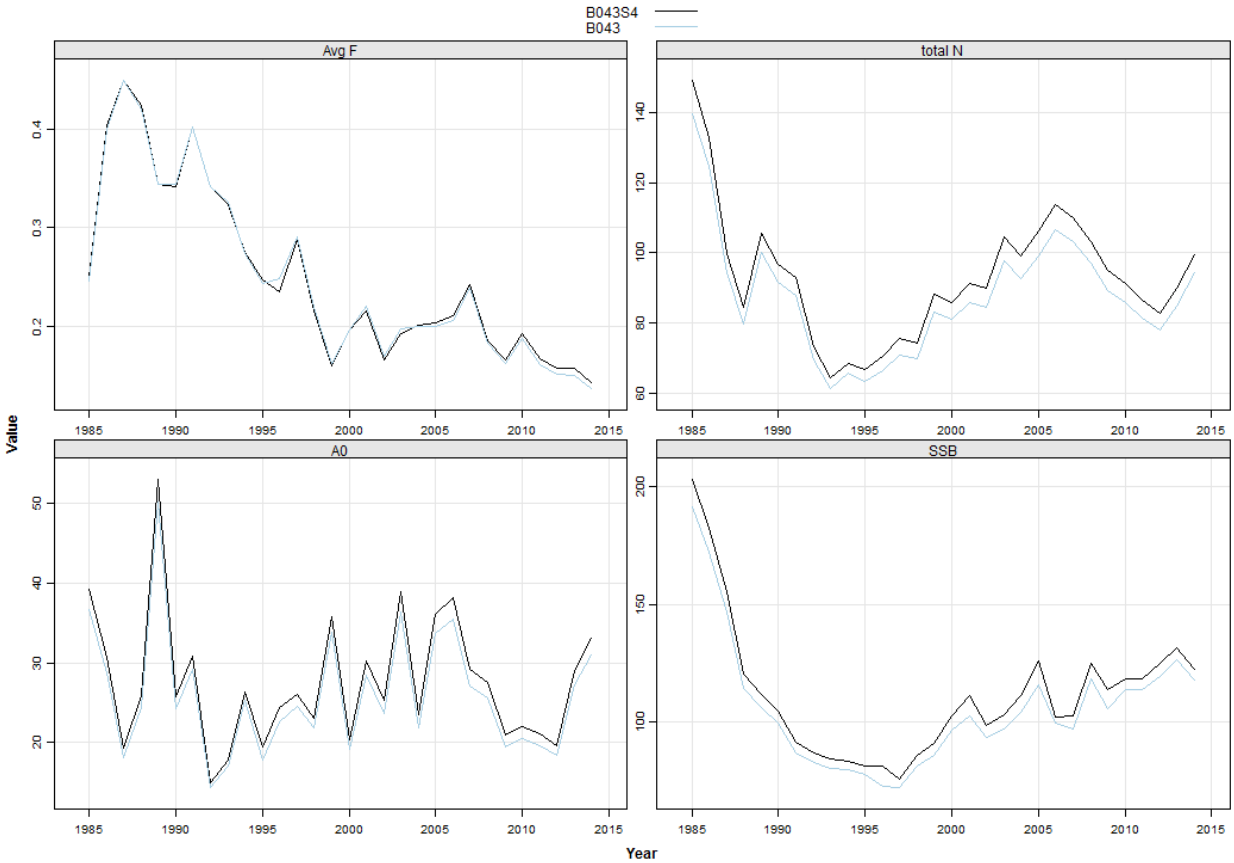

App. B7 Figure B7.119. MCMC distribution plots for fishing mortality in 1985 and 2014 with point estimates from the final model.



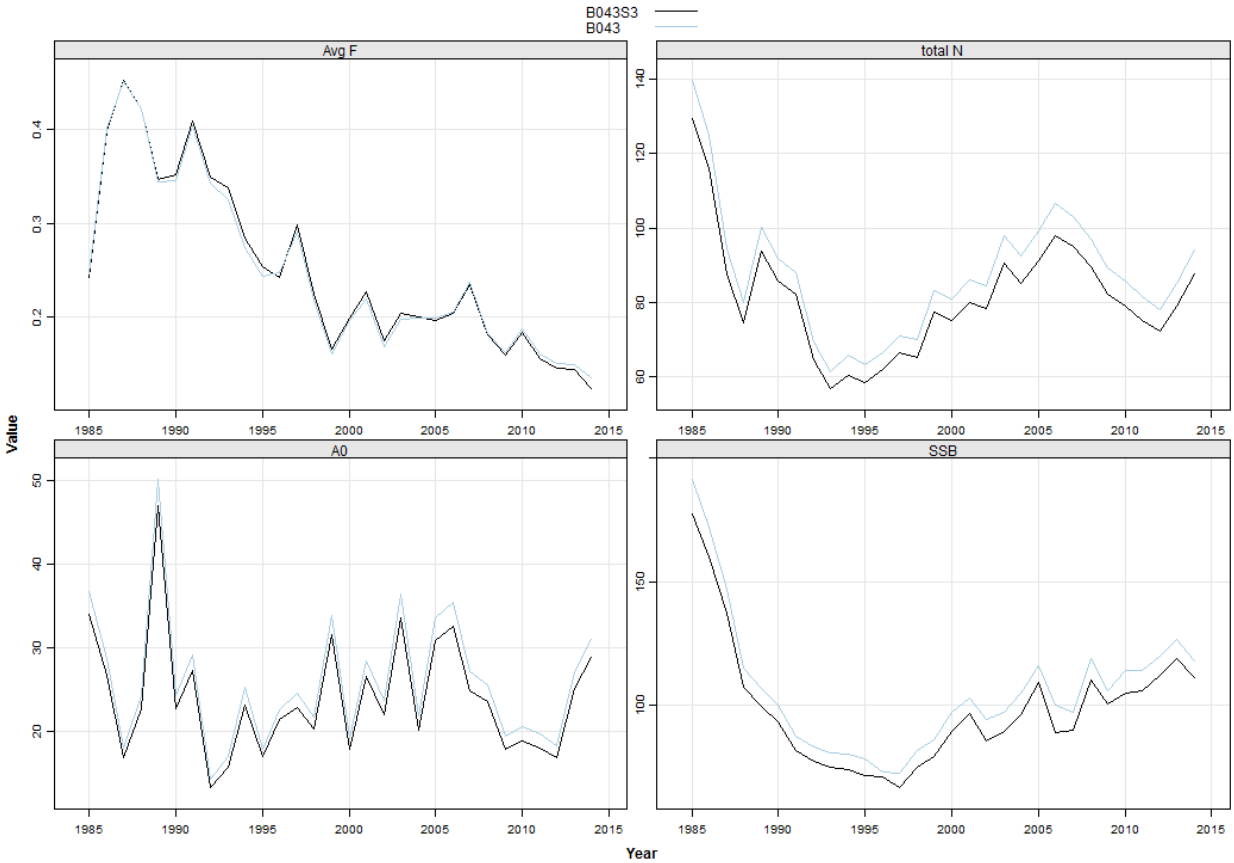

App. B7 Figure B7.120. Median fishing mortality and 95 confidence intervals from the MCMC runs with point estimates from the final model.



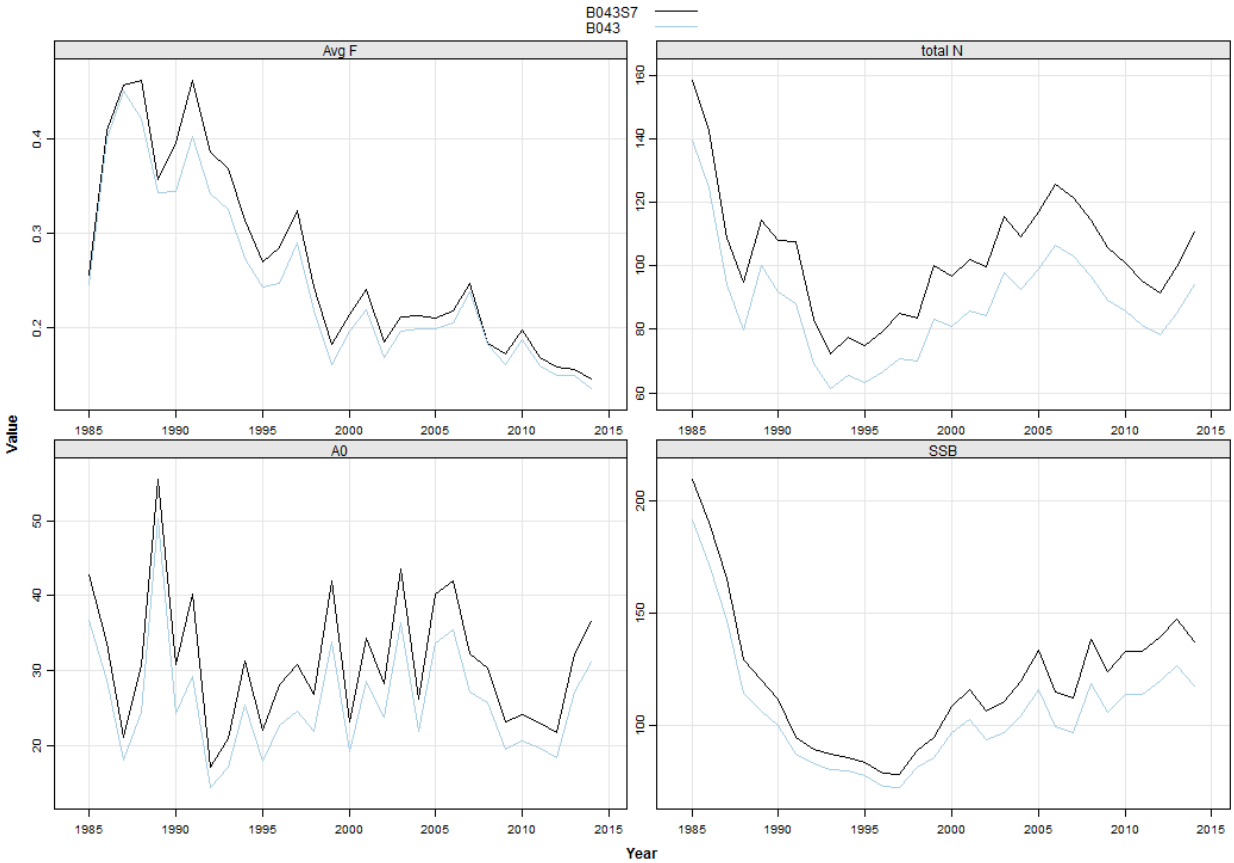

App. B7 Figure B7.121. Final model sensitivity run assume AB1 lengths for the recreational discards. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S5) represented by the black line.



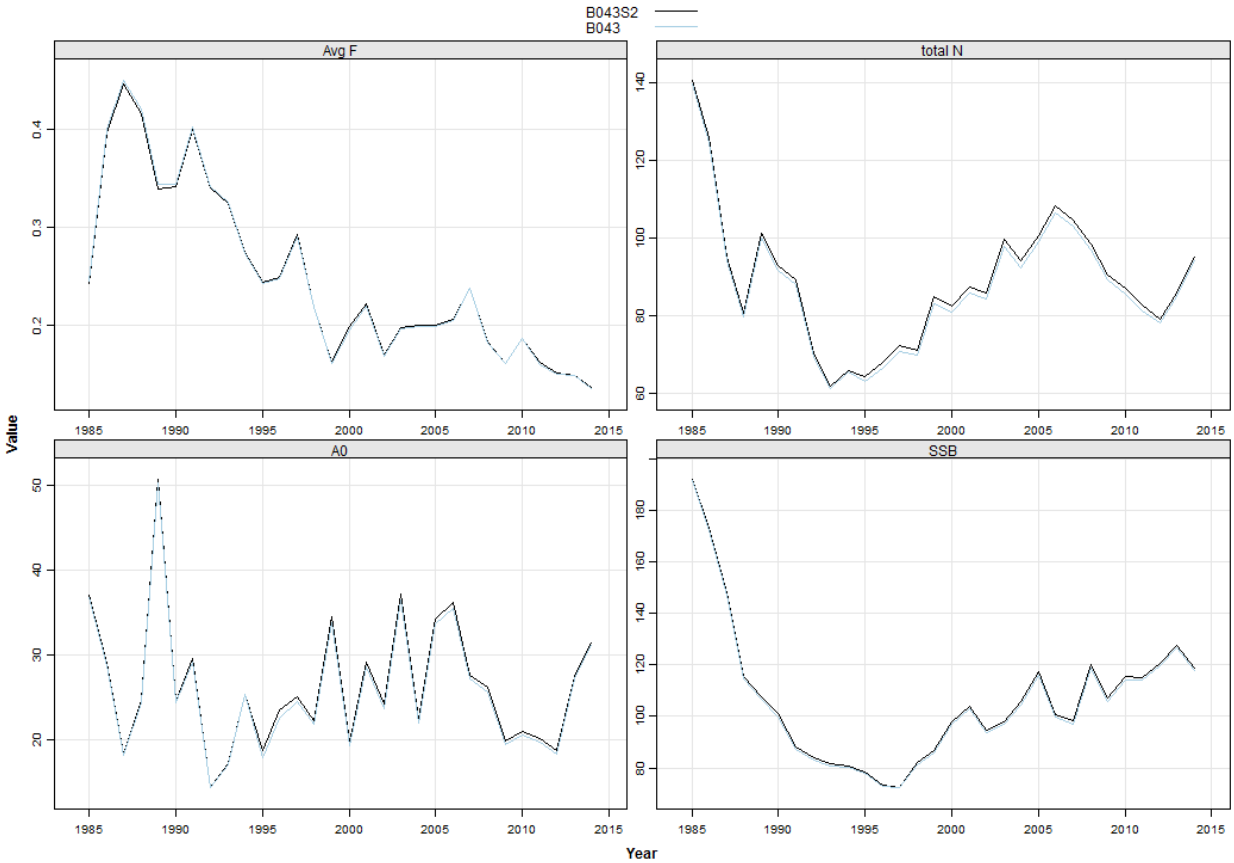

App. B7 Figure B7.122. Final model sensitivity run assuming upper 95% CI for recreational catch. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S4) represented by the black line.



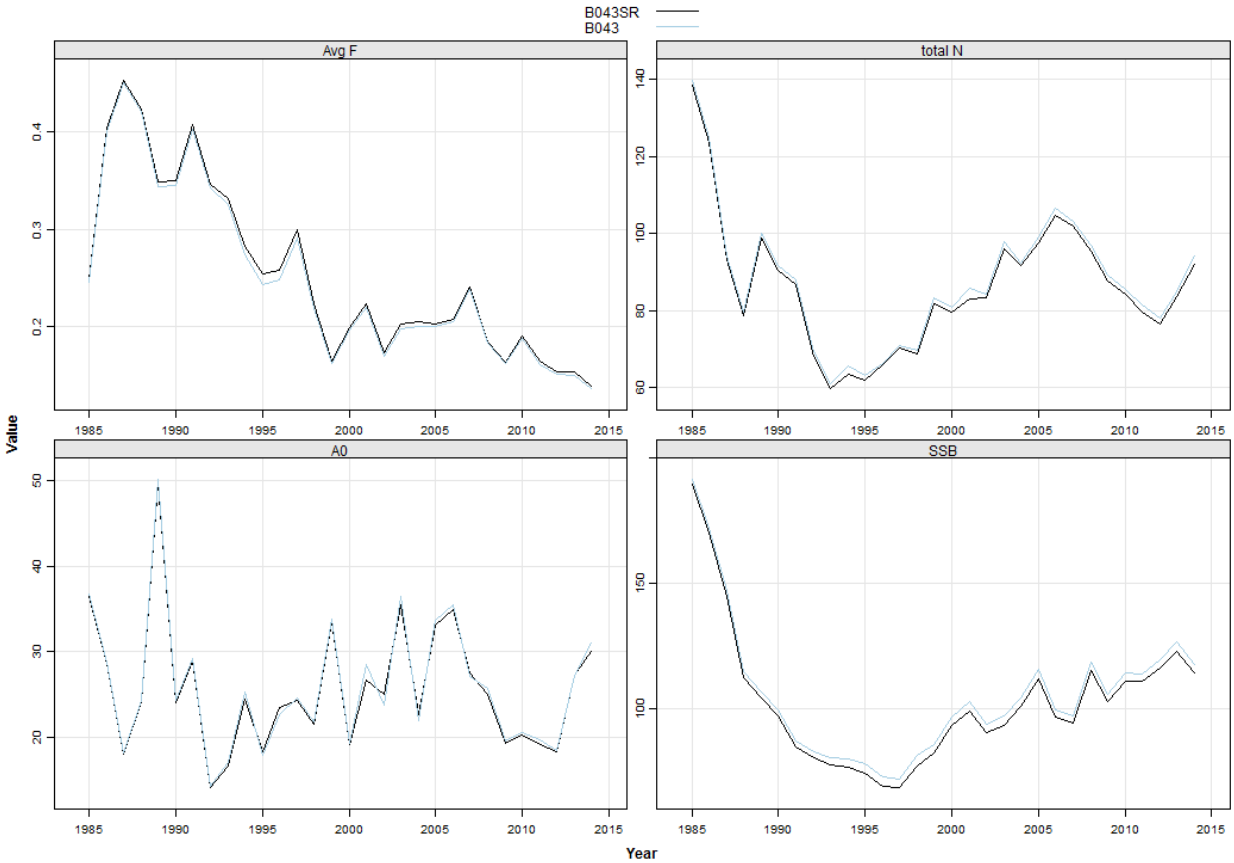

App. B7 Figure B7.123. Final model sensitivity run assuming lower 95% CI for recreational catch. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S3) represented by the black line.



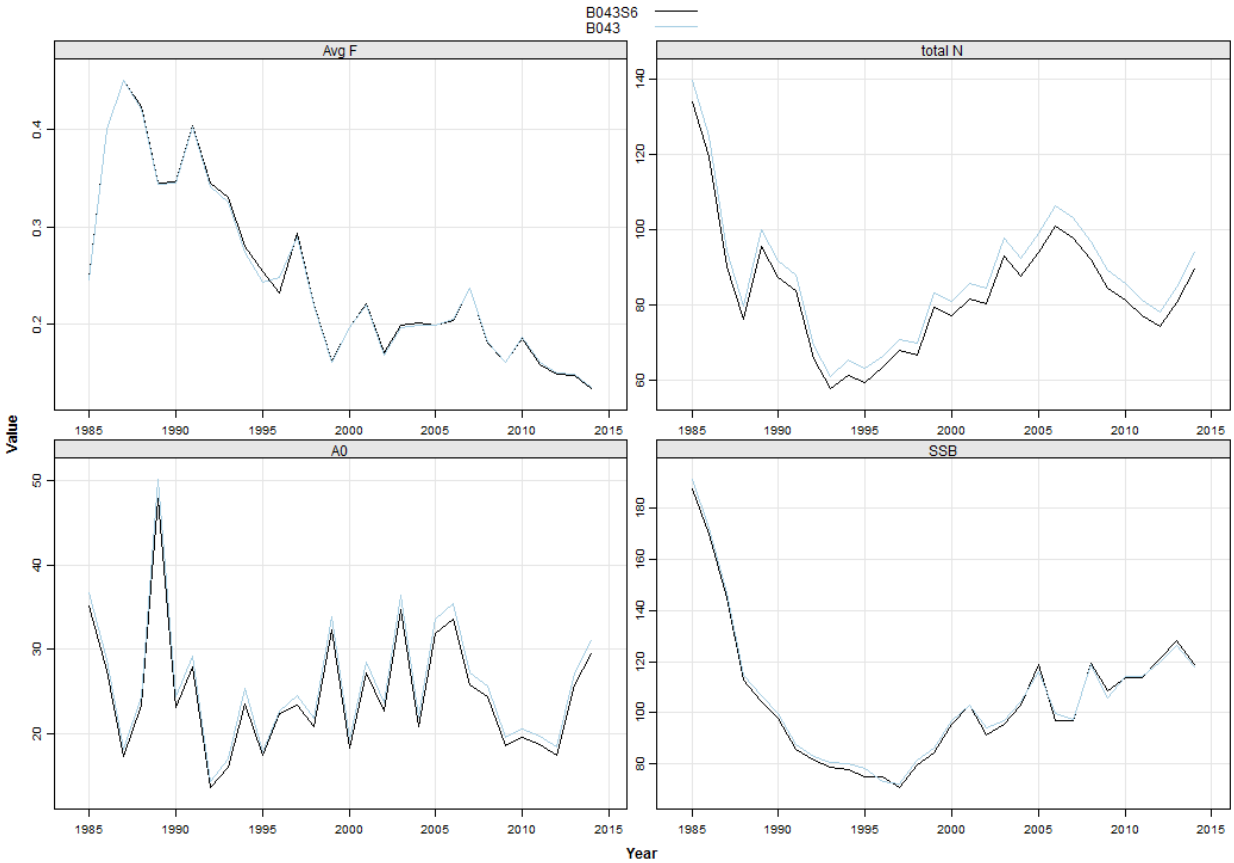

App. B7 Figure B7.124. Final model sensitivity run assuming MRFSS number prior to 2004 for the recreational catch. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S7) represented by the black line.



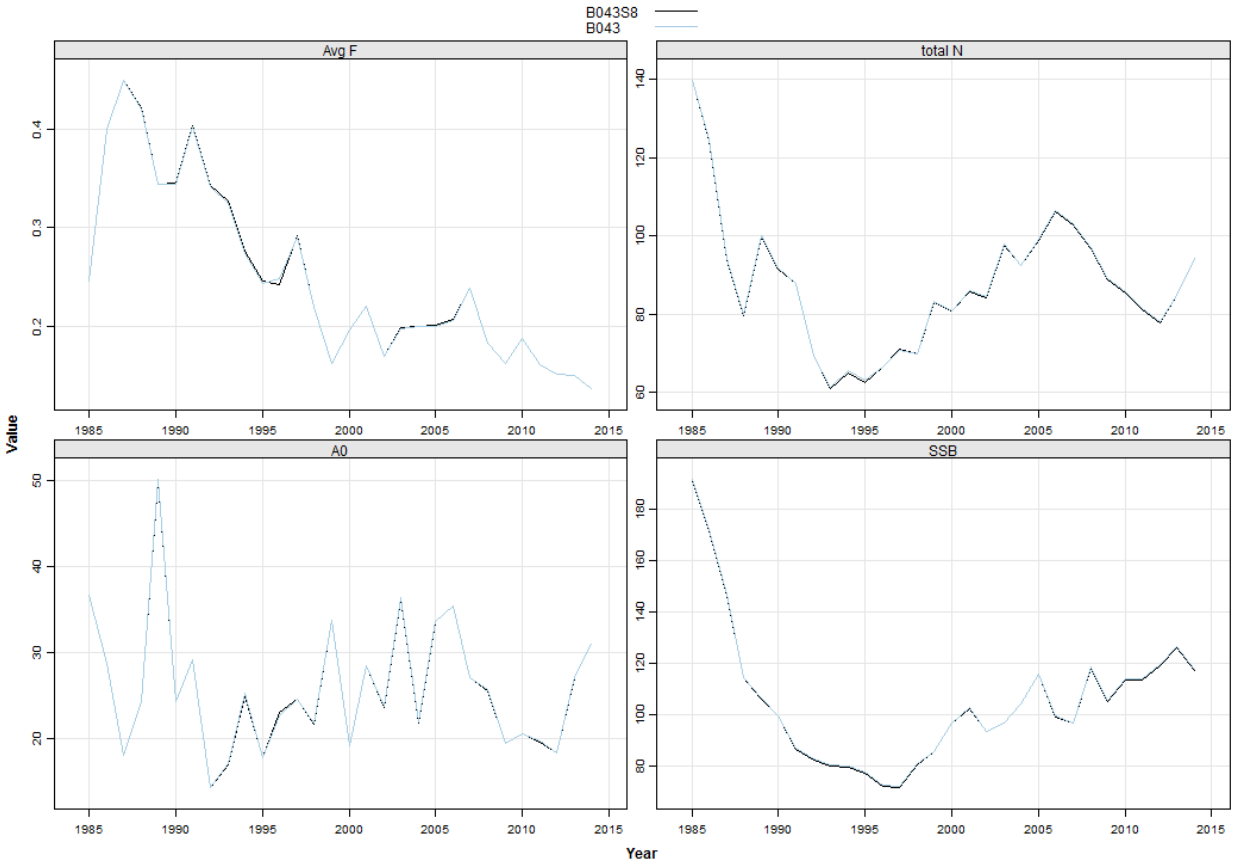

App. B7 Figure B7.125. Final model sensitivity run assuming 17% mortality (instead of 15%) for the recreational discards. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S7) represented by the black line.



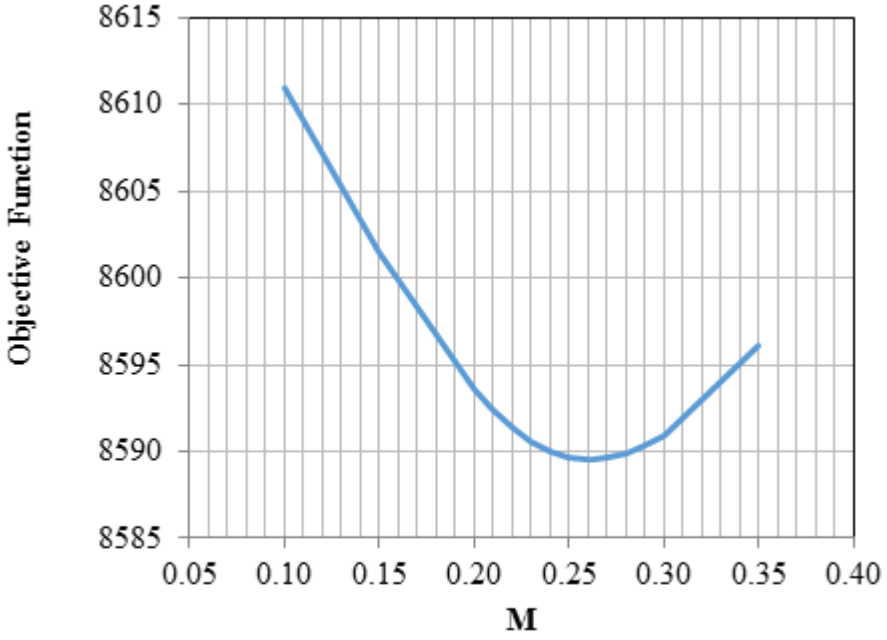

App. B7 Figure B7.126. Final model sensitivity run assuming regional age-length keys from 2006 to 2014. Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043SR) represented by the black line.



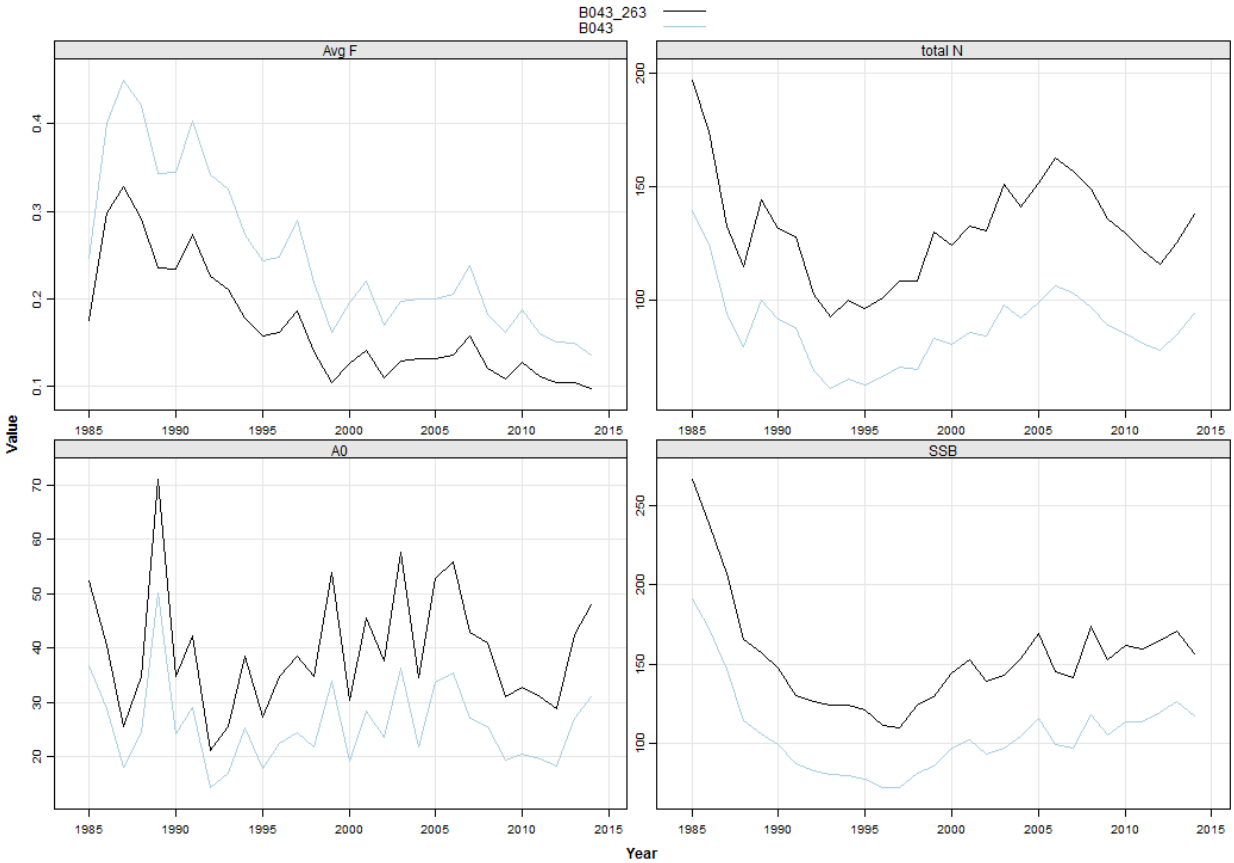

App. B7 Figure B7.127. Final model sensitivity run assuming 3 time blocks for length-weight coefficients (1985-1994, 1995-2004, 2005-2014). Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043S6) represented by the black line.




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.

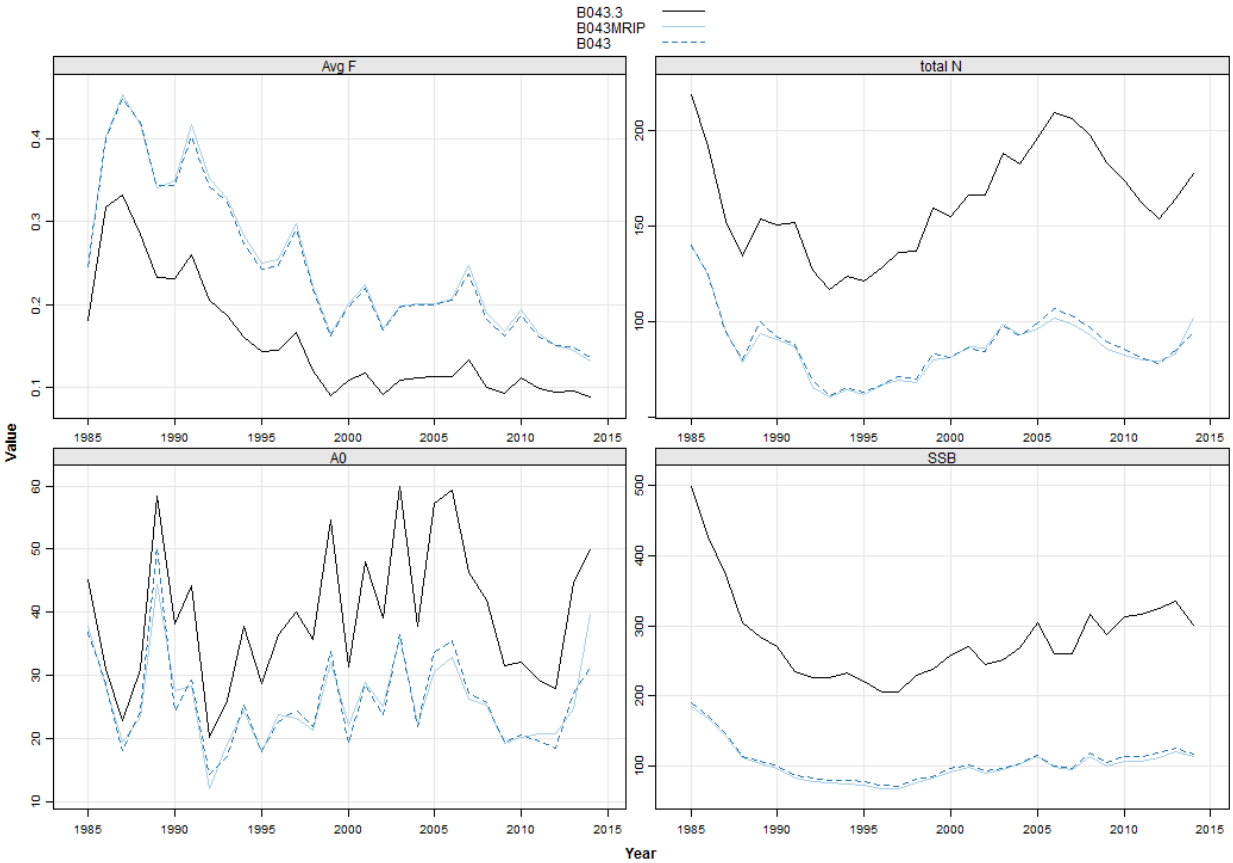



App. B7 Figure B7.129. Final model objective function profile over different values of natural mortality.

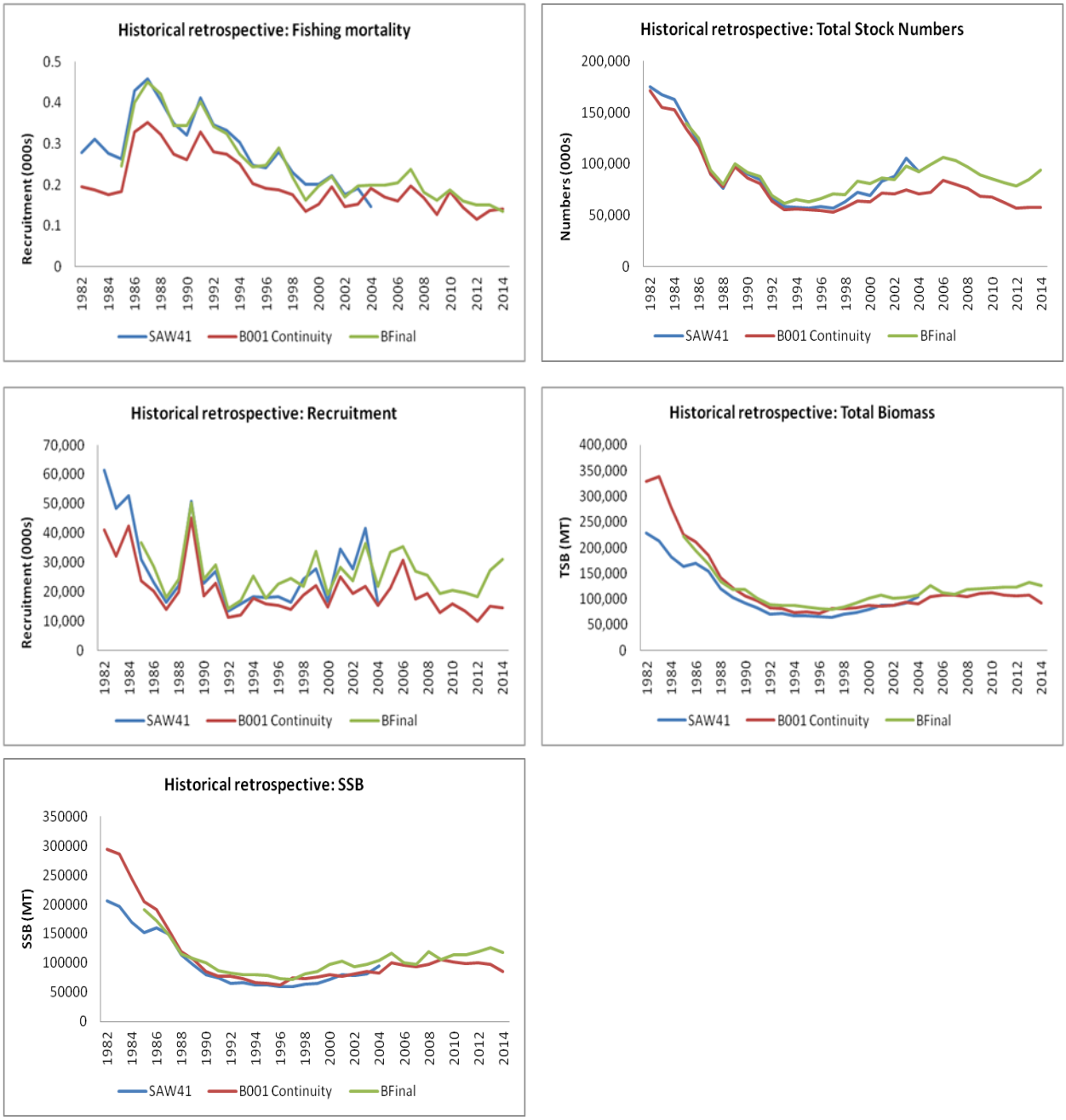



App. B7 Figure B7.130. Final model sensitivity run assuming natural mortality equal to 0.263 (the value that minimizes the objective function). Trends for the final model (B043) estimates are represented by the blue line, with sensitivity run estimates (B043_263) represented by the black line.

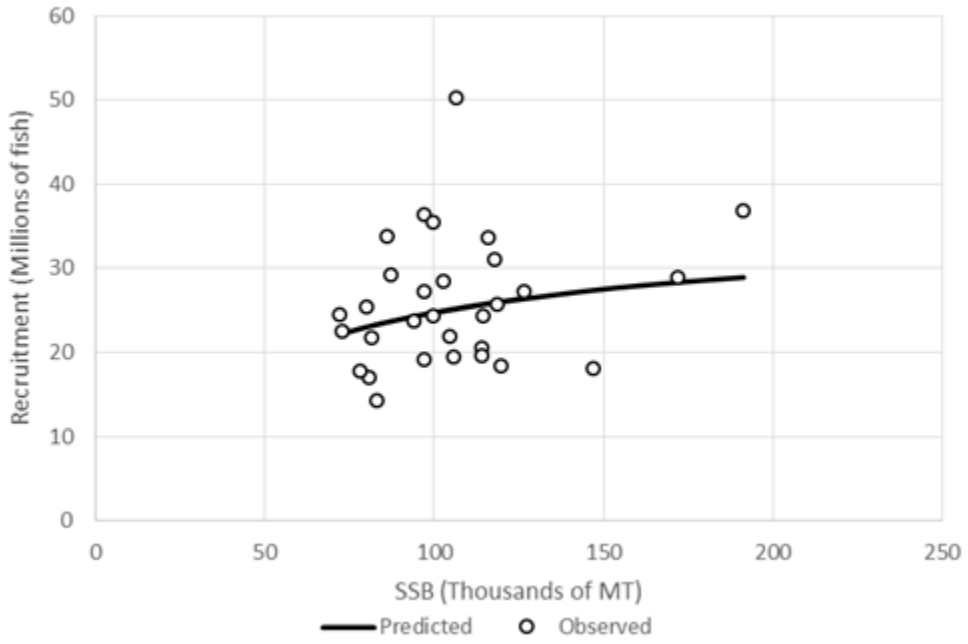
App. B7 Figure B7.131. Final model sensitivity run assuming age-based natural mortality estimates: Lorenzen scaled to Rule of Thumb (0.21) and Lorenzen scaled to (0.263: the value that minimizes the objective function. Trends for the final model (B043) estimates are represented by the dotted blue line, 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.



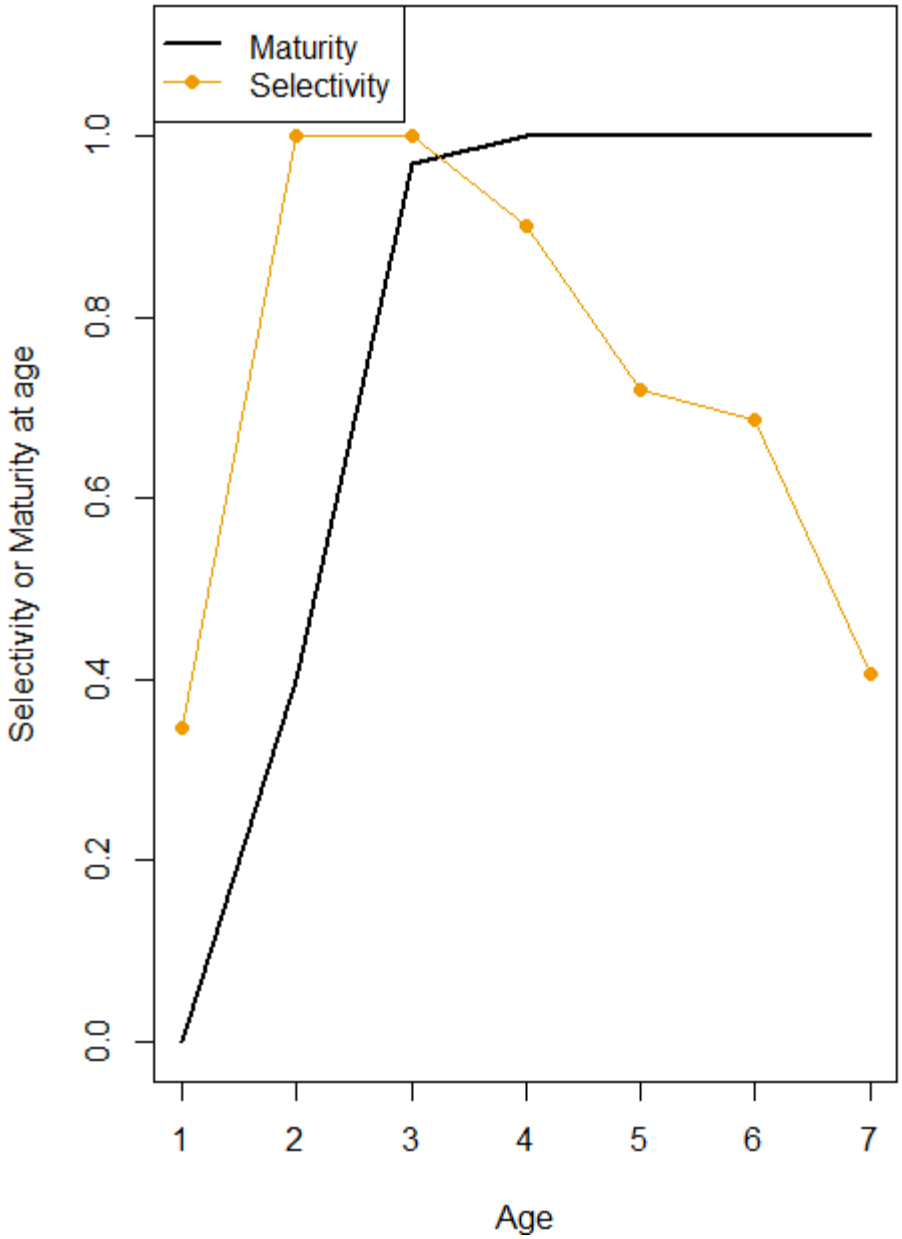

App. B7 Figure B7.132. Final model sensitivity run exploring the effects of removing the MRIP index, and running the final model with only the fleets and MRIP index. Trends for the final model (B043) estimates are represented by the dotted blue line, with sensitivity run estimates from B043MRIP (2 fleets+MRIP index) represented by the solid blue line and B043.3 (no MRIP) represented by the black line.



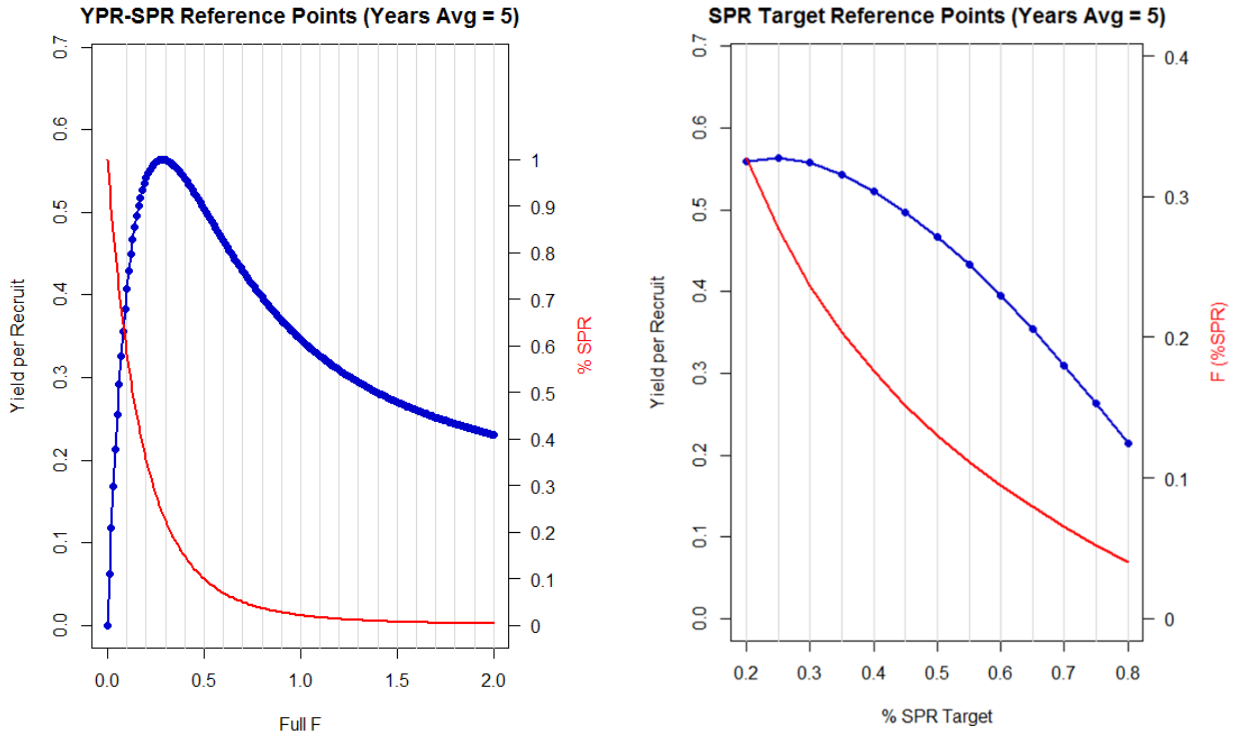

App. B7 Figure B7.133. Historical retrospective plots comparing estimates of F, abundance, recruitment, total biomass and spawning stock biomass across the previous benchmark assessment model (SAW 41), the continuity run with updated data (B001) and the final preferred model from this assessment (BFinal).



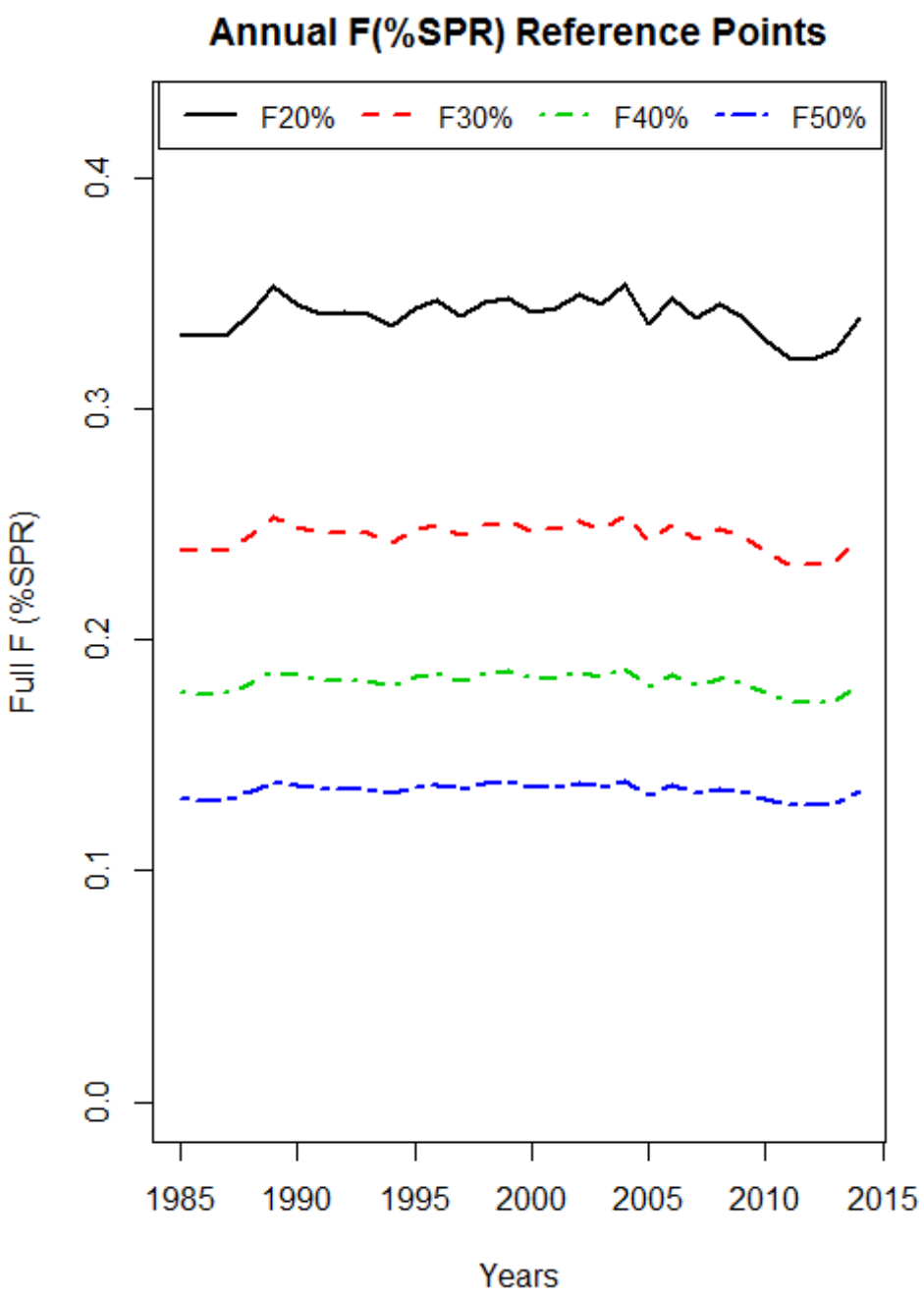

App. B7 Figure B8.1. Observed stock-recruitment relationship plotted with a fitted curve.



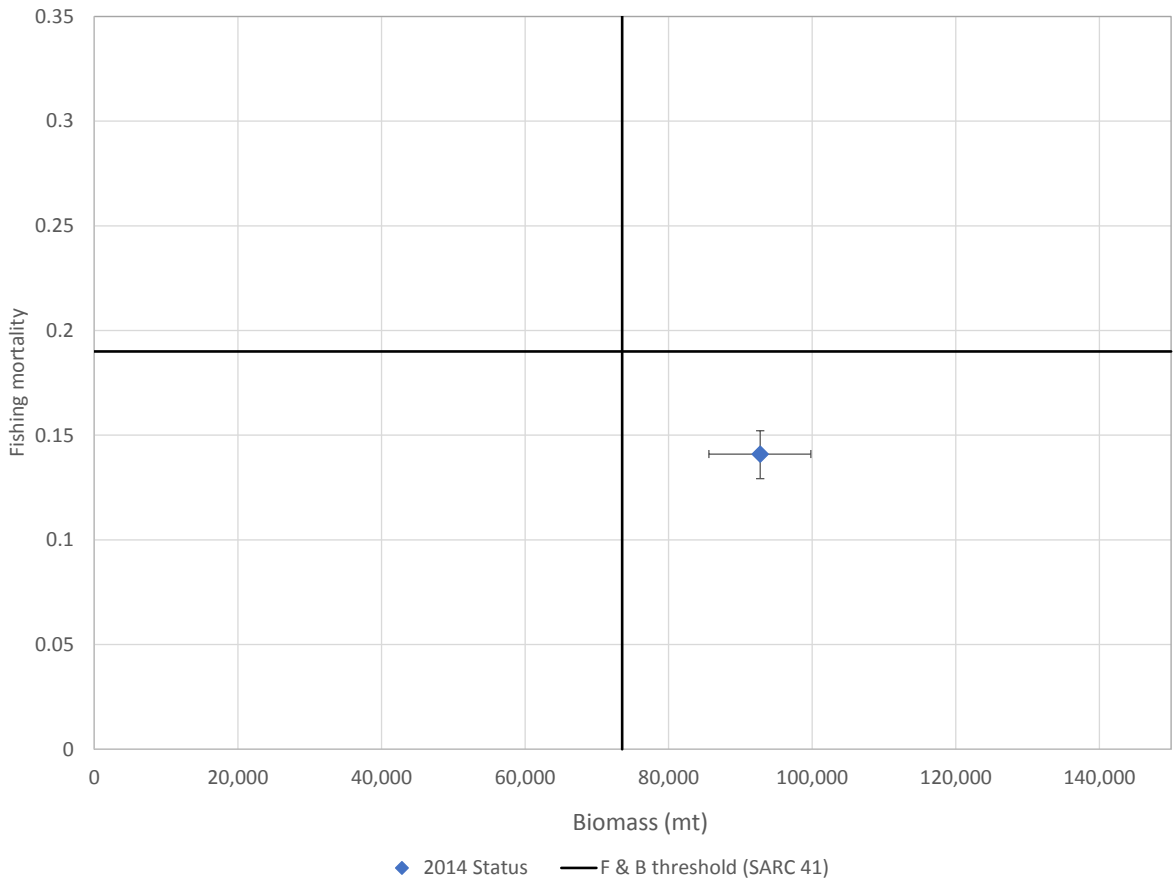

App. B7 Figure B8.2. Maturity ogive and composite selectivity pattern used to estimate bluefish reference points.




App. B7 Figure B8.3. YPR and SPR curves for bluefish.

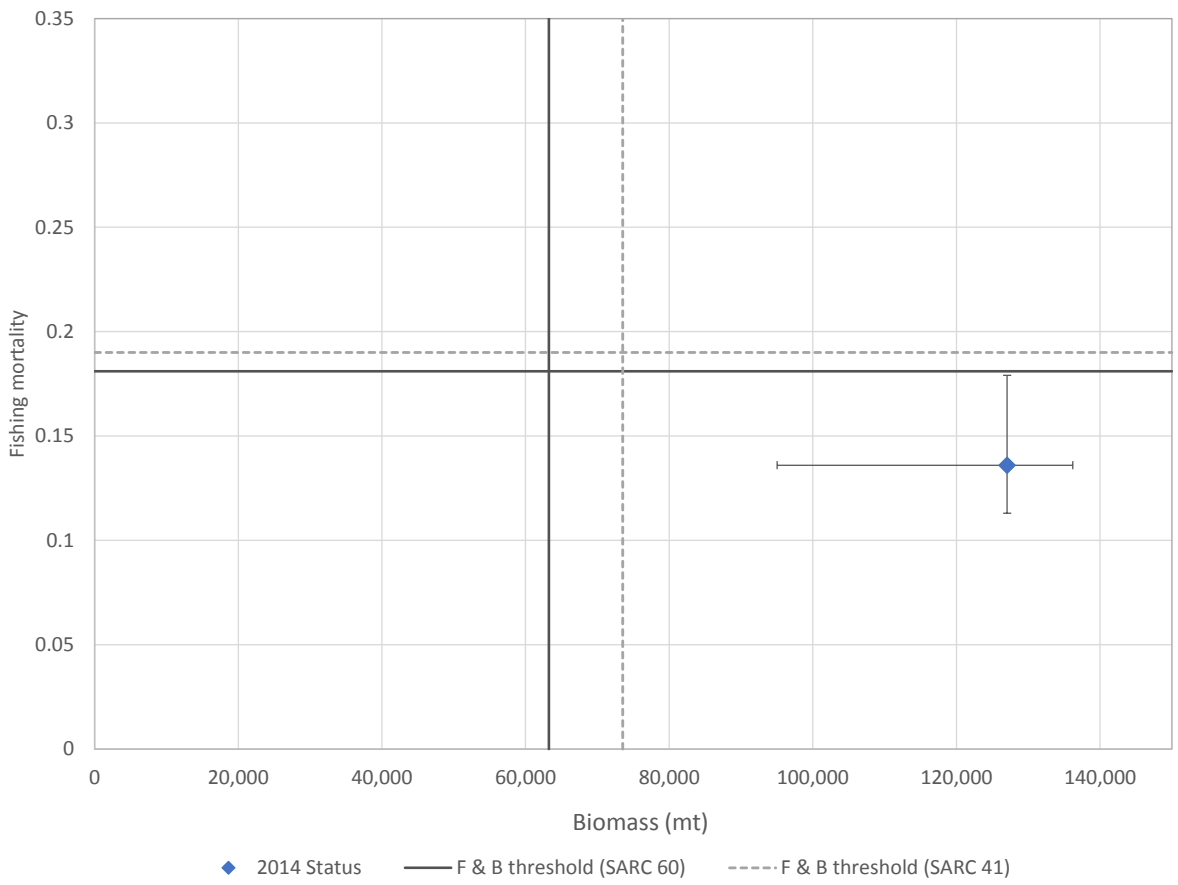



App. B7 Figure B8.4. Annual estimates of F %SPR reference points.



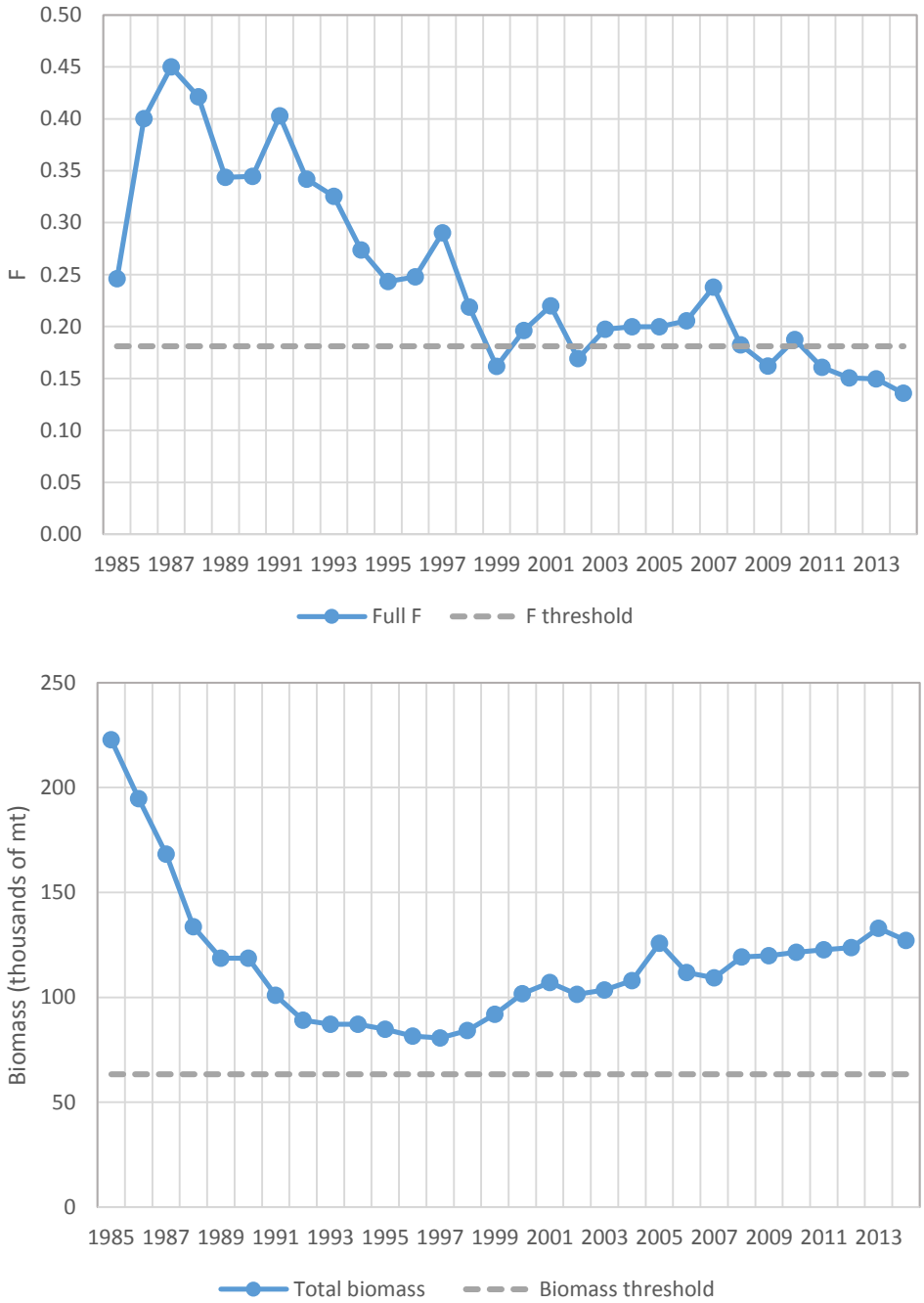

App. B7 Figure B9.1. Stock status in 2014 (diamond) from the continuity run plotted with the F and biomass thresholds from the previous benchmark assessment (solid lines).Error bars on the status estimated indicate 5th and 95th posterior probabilities.

***( 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.)***



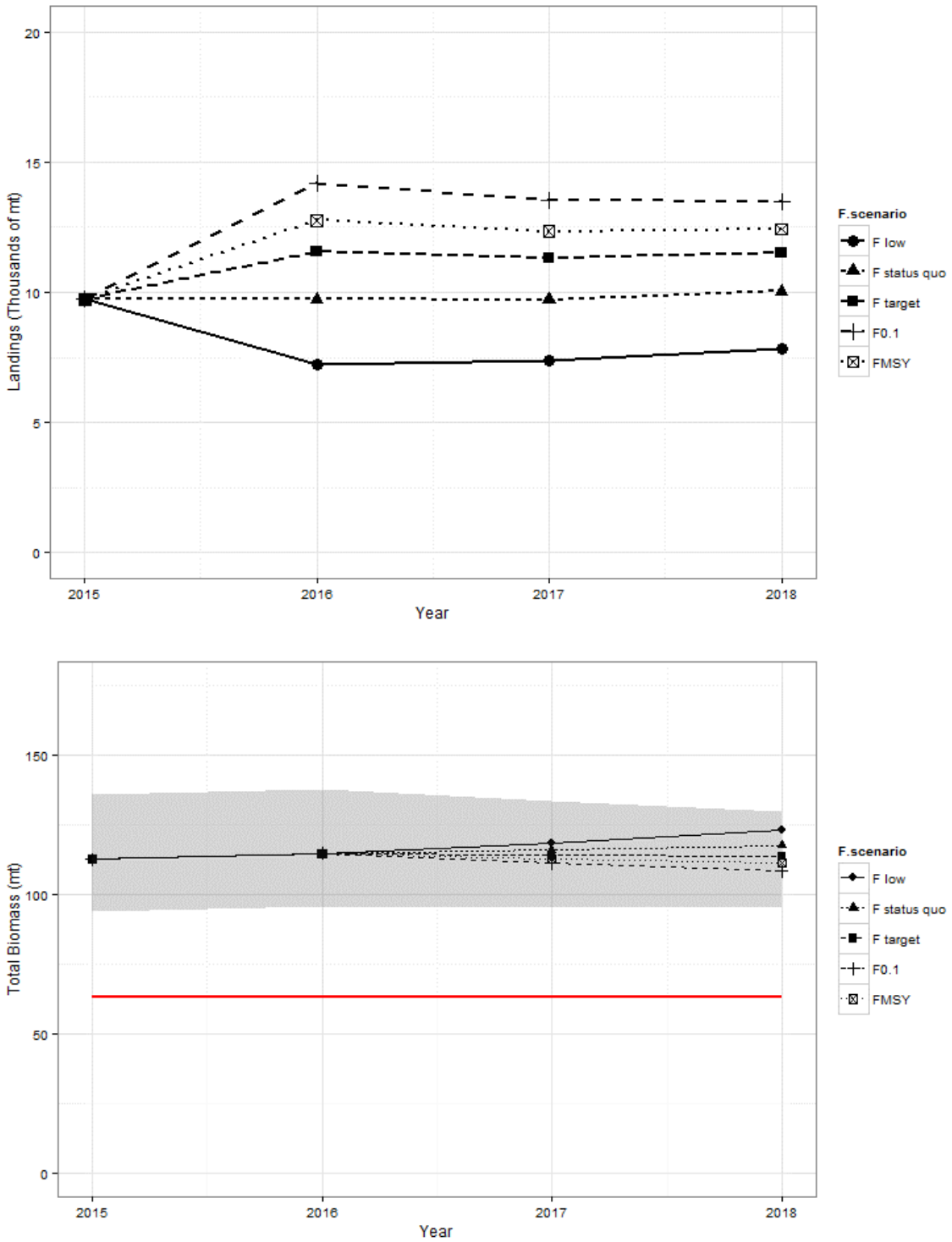

App. B7 Figure B9.2. Stock status in 2014 (diamond) from the final model run plotted with the F and biomass thresholds for this assessment (solid line) and the previous benchmark assessment (dashed line). Error bars on the status estimated indicate 5th and 95th posterior probabilities.

***( 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.)***

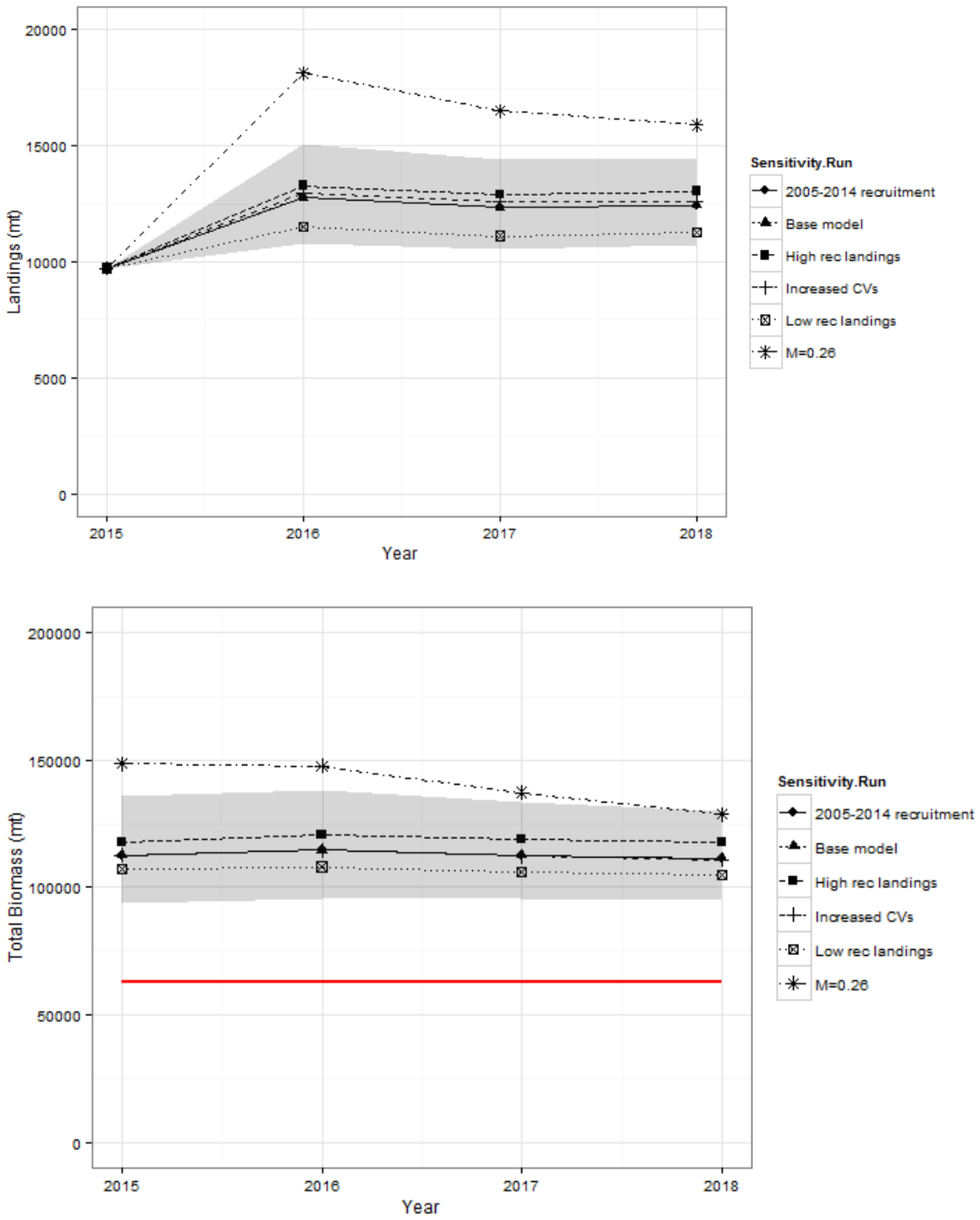



App. B7 Figure B9.3. Fully selected F (top) and total biomass (bottom) plotted with their respective overfishing and overfished thresholds.

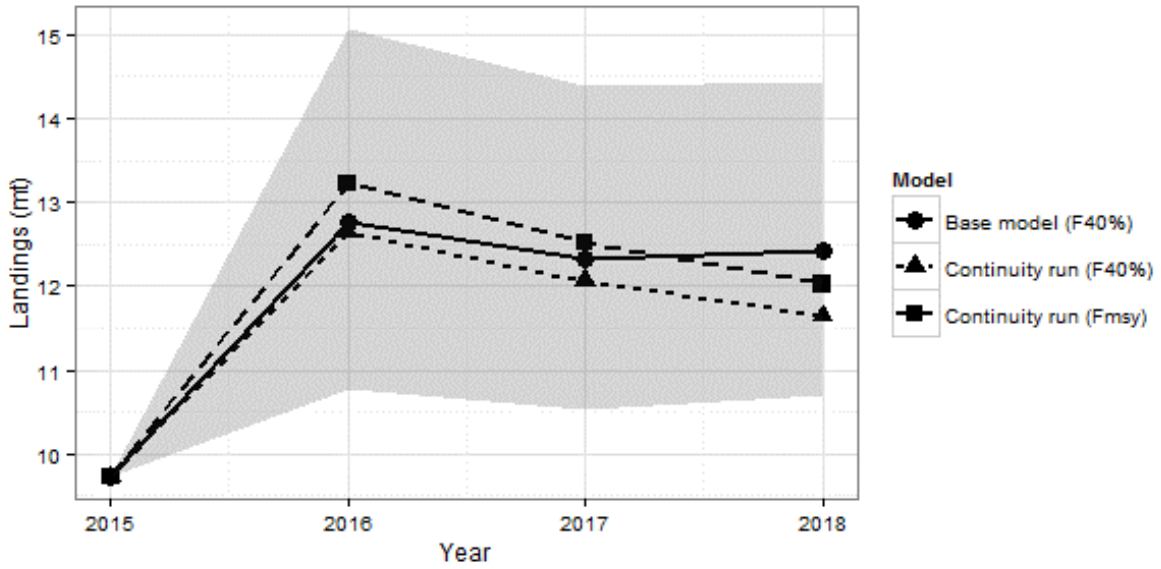
***( NOTE: The values presented in this Appendix B7 reflect the output from the early model presented in the draft WP document and at the peer review, before final revision. For the final SAW/SARC60 assessment results, readers should see the main body of the bluefish report.)***

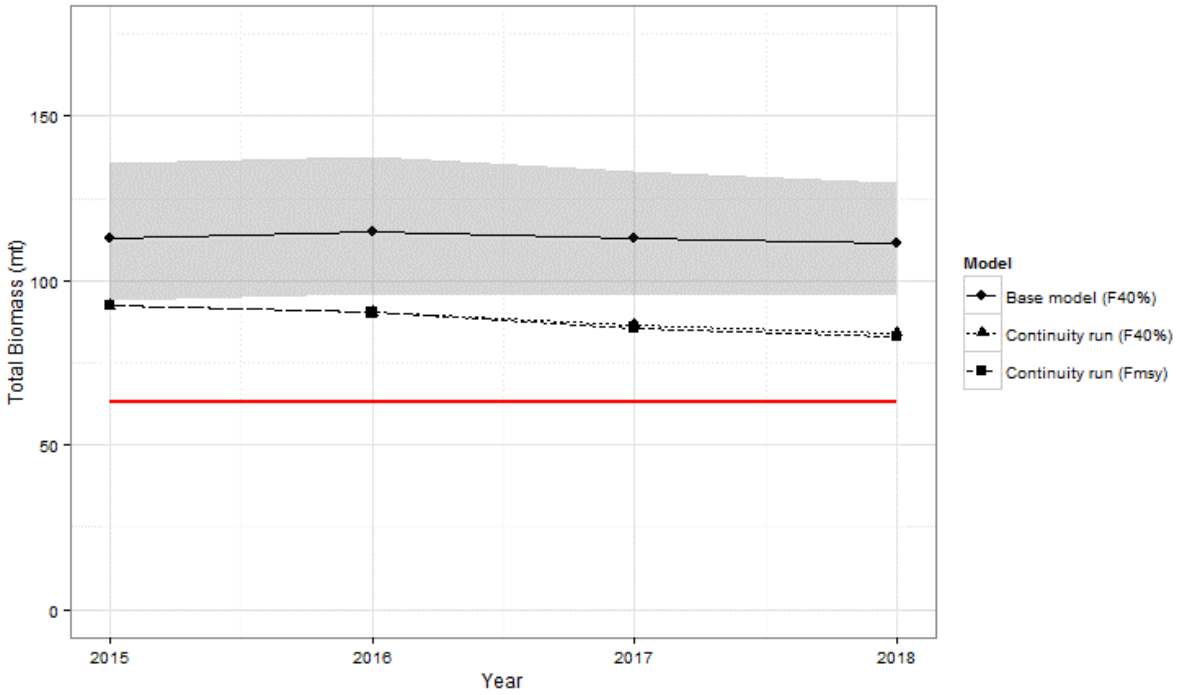



App. B7 Figure B10.1. Projected landings (top) and biomass (bottom) under various F scenarios. Shaded bands indicated the 5th and 95th percentiles of the $F_{MSY}$ bootstrap runs. The solid red line indicates the overfished biomass threshold.




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 50$^{th}$ 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 |