SEDAR

SouthEast Data, Assessment, and Review

4055 Faber Place Drive #201
North Charleston SC 29405

Phone (843) 571-4366
Fax (843) 769-4520
www.sedarweb.org

The SEDAR 41 South Atlantic Red Snapper Corrected Assessment Workshop Report (April 2017) is also available as Addenda 2 in the SEDAR 41 South Atlantic Red Snapper Stock Assessment Report - Revision 1 (April 2017).

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
75 Virginia Beach Drive
Miami, Florida 33149 U.S.A.
(305) 361-4200 Fax: (305) 361-4499

April 19, 2017

Memorandum To: Gregg Waugh, Executive Director, SAFMC

From: Bonnie J. Ponwith, Ph.D BRAINERD.THEOPHILUS.R.DR.1365819285 Digitally signed by BRAINERD.THEOPHILUS.R.DR.1365819285 Date: 2017.04.19 13:02:33 -04'00'
Science and Research Director

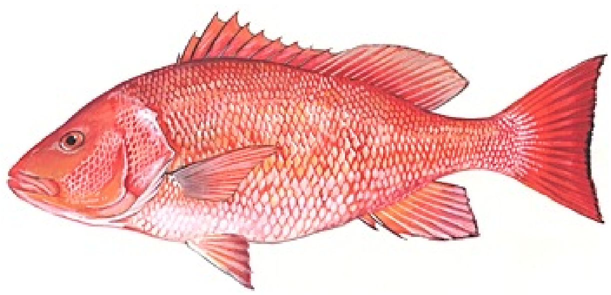
Subject: Red Snapper Assessment Errata

Southeast Fisheries Science Center Analysis discovered an error in the Red Snapper Assessment in the Headboat Discard Index input to the model. The input data were corrected and the model was rerun. The difference between the original run and corrected run is negligible. Monte Carlo Bootstrap uncertainty analysis shows almost no change. The attached report contains the corrected base run.

This information will be discussed at the upcoming SSC meeting.

Stock Assessment of Red Snapper off the Southeastern United States

SEDAR Benchmark Assessment



Southeast Fisheries Science Center
National Marine Fisheries Service

Last revision: April, 2017

Document History

February, 2016 Original release.

March, 2016 This release incorporates some of the corrections made during the Review Workshop, including corrected age composition data from the MARMAP program.

April, 2016 This release incorporates all of the corrections made during the Review Workshop, including corrected chevron trap age composition data. The corrections resulted in a new base run, for which iterative reweighting of the likelihood components and the starting value analysis were re-run. The new base run results, including updated uncertainty analyses and projections are included. The sensitivities and retrospectives, however, are unchanged. The Reviewers did not request that sensitivities or retrospectives be re-run because the base run changes were relatively small.

April, 2017 This release corrects the data used for the Headboat at-sea discard index. The correction resulted in a new base run, for which iterative reweighting of the likelihood components was conducted. The new base run results, including updated uncertainty analyses and projections are included. The sensitivities and retrospectives, however, are unchanged.

Contents

List of Tables

List of Figures

2 Data Review and Update

The input data for this assessment are described below, with focus on modifications from the SEDAR41 DW.

2.1 Data Review

In this benchmark assessment, the Beaufort assessment model (BAM) was fitted to data sources developed during the SEDAR 41 DW with some modifications and additions.

Model input compiled during the DW

- Life history: Life history meristics, population growth, female maturity, proportion female, number of batches at age, size-dependent batch fecundity, and discard mortality
- Landings and discards: Commercial handline landings and discards, Headboat landings and discards, Recreational landings and discards
- Indices of abundance: Commercial handline, Headboat, Headboat discards, SERFS chevron trap, SERFS video

Model input modified or developed after the DW

- Life history: Fishery-dependent growth estimates, Growth estimates during the 20 inch size regulation, Age–specific natural mortality
- Landings and discards: changes to the recreational discards
- Indices of abundance: Fishery–independent indices combined (Chevron trap and Video)
- Length compositions: Commercial handline, Headboat, Recreational
- Age compositions: Commercial handline, Headboat, Recreational, Chevron trap

2.2 Data Update

2.2.1 Life History

Estimates of the von Bertalanffy growth parameters were provided by the DW for the population as a whole: (911.36mm, 0.24yr^{-1}, and -0.33yr). Two alternative von Bertalanffy curves were generated: one for all fisheries when no size limit was in place, and another to represent the fish captured by all fisheries under a 20 inch size limit regulation. Age-specific mortality was updated due to an error in the original calculation which forced the t_0 value to 0. Life-history information is summarized in Tables 1 and 2.

2.2.2 Landings and Discards

The fleet structure to be modeled was decided after the DW. The general recreational fleet comprises the charterboat and private boat fleets, while the headboat fleet stands alone. The decision was made to separate headboat from all other recreational fishing modes because length compositions diverge later in the time series. The general recreational fleet discards contained some zeros (years 1982, 1986, and 1990) that the panel considered unlikely to be accurate due to the magnitude of the surrounding years' values. The decision was made by the panel to fill in the zeros with the lowest observed discards in the regulatory time block of the zero value. Total removals as used in the assessment are in Table 3.

2.2.3 Indices of Abundance

The DW provided a SERFS chevron trap and video index separately. However, because the data are collected from the same sampling platforms (i.e. cameras mounted on the chevron traps), the two indices are not independent measures of abundance. Therefore, the panel decided to combine the two using the Conn (2010) method for combining indices. All indices and their corresponding CVs are shown in Table 4, and Figure 1 shows the indices as recommended by the data workshop plotted with the new CVID index for comparison. Fishery dependent indices of abundance were assumed to have CVs of 0.2, which is consistent with Francis (2003).

2.2.4 Length Compositions

Length compositions for all data sources were developed in 3-cm bins over the range 21–99 cm (labeled at bin center). All lengths below and above the minimum and maximum bins were pooled. The commercial handline, general recreational and headboat lengths were weighted by the region and landings (SEDAR41-AW05 2015). For inclusion, length compositions in any given year had to meet the sample size criteria of $nfish > 30$ and $ntrips \geq 10$ (Table 5). Furthermore, the AW panel decided to eliminate length comps where age comps were available. There were conflicts between the length compositions and age compositions, and the panel thought, given the relative ease of ageing this species and the fact the model is age-structured, the age compositions would provide more informative signals of year-class strength and better represent the catch in each fleet or survey.

2.2.5 Age Compositions

For age composition data, the upper range was pooled at 13 years old because a very small proportion of the data exist past age 13. The age compositions were weighted by the length compositions in attempt to address bias in selection of fish to be aged. For inclusion, age compositions in any given year had to meet the sample size criteria of $nfish > 10$ and $ntrips \geq 10$ (Table 5). Age composition was preferred over length composition when both were available from a given fleet in a given year. Age compositions were further corrected at the Review Workshop (SEDAR41-RW07 2016).

2.2.6 Additional Data Considerations

Size limits were in place beginning in 1983 (12 inch minimum size limit TL), and changed in 1992 (20 inch minimum size limit TL). A moratorium was put in place for Red Snapper in 2010, and three subsequent mini-seasons were allowed (2011-2014) with no size limit. The panel examined size composition data and determined that three time blocks should be used to account for size limits, or the lack thereof: 1950-1991, 1992-2009, and 2010-2014. Data available for this assessment are summarized in Tables 1–5.

3 Stock Assessment Methods

3.1 Overview

The primary model discussed during the Assessment Workshop (AW) was a statistical catch-age model implemented using the Beaufort Assessment Model (BAM) software (Williams and Shertzer 2015). BAM applies a statistical catch-age formulation, coded using AD Model Builder (Fournier et al. 2012). BAM is referred to as an integrated analysis because it uses all population dynamics-relevant data (e.g. removals, length and age compositions, and indices of abundance) in a single modeling framework. In contrast, production models (e.g. ASPIC or ASPM) or catch curve analyses only use subsets of the available data and often require simplifying assumptions. In essence, the catch-age model simulates a population forward in time while including fishing processes (Quinn and Deriso 1999; Shertzer et al. 2008). Quantities to be estimated are systematically varied until characteristics of the simulated population matches available data on the real population. The model is similar in structure to Stock Synthesis (Methot 1989; 2009). Versions of BAM have been used in previous SEDAR assessments of reef fishes in the U.S. South Atlantic, such as Red Porgy, Black Sea Bass, Tilefish, Blueline Tilefish, Gag, Greater Amberjack, Red Grouper, Snowy Grouper, and Vermilion Snapper, as well as in the previous SEDAR assessments of Red Snapper (SEDAR24 2010). In addition, a surplus production model implemented using ASPIC and a catch curve analysis (SEDAR41-AW08 2015) were used to provide supplementary information.

3.2 Data Sources

The catch-age model included data from three fleets that caught Red Snapper in southeastern U.S. waters: general recreational (charter and private boat), commercial handlines (hook-and-line), and recreational headboats. The model was fitted to data on annual landings (in numbers for the recreational fleets, in whole weight for commercial fleet); annual discards (in numbers for all fleets), annual length compositions of removals; annual age compositions of landings and surveys; three fishery dependent indices of abundance (commercial handlines, headboat, and headboat discards); and one fishery independent index of abundance (combined SERFS chevron trap and SERFS video index). Removals included landings and dead discards, assuming the mortality rates provided by the Data Workshop. Data used in the model are tabulated in §2 of this report.

3.3 Model Configuration

The assessment time period was 1950–2014. A general description of the assessment model follows.

3.4 Stock dynamics

In the assessment model, new biomass was acquired through growth and recruitment, while abundance of existing cohorts experienced exponential decay from fishing and natural mortality. The population was assumed closed to immigration and emigration. The model included age classes $1 - 20^{+}$, where the oldest age class 20^{+} allowed for the accumulation of fish (i.e., plus group).

3.5 Initialization

Initial (1950) numbers at age assumed the stable age structure computed from expected recruitment and the initial, age-specific total mortality rate. That initial mortality was the sum of natural mortality and fishing mortality, where fishing mortality was the product of an initial fishing rate (F_{init}) and F-weighted average selectivity. The initial fishing rate was estimated using a prior centered around $F_{\text{init}} = 0.03$. The assumption matches what was used for SEDAR24 with the justification that the value should be small given the relatively low volume of landings prior to the assessment period. The initial recruitment in 1950 was assumed to be the expected value from the spawner-recruit curve. For the remainder of the initialization period (1950–1977), recruitment was assumed equal to expected values. Without sufficient age/length composition data prior to 1978, there is little information to estimate those historic recruitment deviations with accuracy.

3.6 Natural mortality rate

The natural mortality rate (M) was assumed constant over time, but decreasing with age. The form of M as a function of age was based on Charnov et al. (2013), a change from SEDAR24 which based natural mortality on the findings of Lorenzen (1996). The Charnov et al. (2013) approach inversely relates the natural mortality at age to somatic growth. As in previous SEDAR assessments, the age-dependent estimates of M_a were rescaled to provide the same fraction of fish surviving from age 4 through the oldest observed age (51 yr) as would occur with constant $M = 0.134$. This approach using cumulative mortality allows that fraction at the oldest age to be consistent with the findings of Then et al. (2014).

3.7 Growth

Mean size at age of the population, fishery removals under no size limit, and fishery removals under a 20 inch size limit (total length, TL) were modeled with the von Bertalanffy equation, and weight at age (whole weight, WW) was modeled as a function of total length (Figure 2, Table 2). Parameters of growth and conversions (TL-WW) were treated as input to the assessment model. For fitting length composition data, the distribution of size at age was assumed normal with a CV estimated by the assessment model for each growth curve.

3.8 Female maturity and sex ratio

Female maturity was modeled with a logistic function; parameters for this model and a vector of maturity at age were provided by the DW and treated as input to the assessment model (Table 2). The sex ratio was assumed to be 50:50, as recommended by the DW.

3.9 Spawning stock

Spawning biomass was modeled as population fecundity (number of eggs). For Red Snapper, peak spawning was considered to occur at the end of June. This included information on batch size as a function of age, as well as information on the number of annual batches as a function of age (SEDAR41-DW49 (2015) and Fitzhugh et al. (2012)).

3.10 Recruitment

Expected recruitment of age-1 fish was predicted from spawning biomass using the Beverton–Holt spawner-recruit model. Steepness, h, is a key parameter of this model, and unfortunately it is often difficult to estimate reliably (Conn et al. 2010). In this assessment, many initial attempts to estimate steepness resulted in a value near its upper bound of 1.0, indicating that the data were insufficient for estimation. Likelihood profiling showed that the value was likely above 0.92, and was unreliably estimated between 0.92 and 0.98. The AW Panel decided to assume an average annual recruitment while estimating lognormal deviations around that average. This was achieved by fixing steepness at $h = 0.99$.

3.11 Landings

Time series of landings from three fleets were modeled: commercial handline (1950–2014), general recreational (1955–2014), and headboat (1955–2014). Landings were modeled with the Baranov catch equation (Baranov 1918) and were fitted in either weight or numbers, depending on how the data were collected (1000 lb whole weight for commercial fleets, and 1000 fish for recreational). The DW provided observed landings back to the first assessment year (1950) for the commercial fleet and back to 1955 for the recreational fleets. However, sampling of headboats began in 1972 and other recreational sectors in 1981. Thus, historic landings of the recreational fleets were estimated indirectly by the DW using the FHWAR ratio method (SEDAR41-DW17). Historic landings were considered (and treated) in this assessment as a primary source of uncertainty.

3.12 Discards

As with landings, discard mortalities (in units of 1000 fish) were modeled with the Baranov catch equation (Baranov 1918), which required estimates of discard selectivities and release mortality probabilities. Discards were assumed to have fleet-specific, year-specific mortality probabilities, as suggested by the DW. Until 2007, the rate for commercial handlines was 0.48, and 0.38 thereafter. Until 2011, the general recreational and headboat rate was 0.37, with 0.285 thereafter. Annual discard mortalities, as fit by the model, were computed by multiplying total discards (tabulated in the DW report) by the fleet-specific and year-specific discard mortality rate. For general recreational and headboat fleets, discard time series were assumed to begin in 1981; for the commercial handlines fleet, discards were modeled starting in 1992 corresponding to the implementation of the 20-inch size limit.

3.13 Fishing

For each time series of removals (landings and discards), the assessment model estimated a separate full fishing mortality rate (F). Age-specific rates were then computed as the product of full F and selectivity at age. The across-fleet annual F was represented by apical F, computed as the maximum of F at age summed across fleets.

3.14 Selectivities

Selectivity curves applied to landings were estimated using a parametric approach. This approach applies plausible structure on the shape of the curves, and achieves greater parsimony than occurs with unique parameters for each age. Flat-topped selectivities were modeled as a two-parameter logistic function. Dome-shaped selectivities were modeled by combining two logistic functions: a two-parameter logistic function to describe the ascending limb of the curve, and a two-parameter logistic function to describe the descending limb. To model landings, the AW Panel recommended flat-topped selectivity for commercial handlines and dome-shaped selectivity for headboat and the general recreational fleets.

The assessment panel devoted substantial discussion and exploration to the pattern (flat-topped or dome-shaped) of selectivity at age. Several working papers and scientific literature (SEDAR24-AW05, SEDAR24-AW09, SEDAR24-AW12, SEDAR31-AW04, SEDAR31-AW12, SEDAR41-DW50, SEDAR41-DW08, Patterson et al. (2012), Wells et al. (2008), and Mitchell et al. (2014)) helped guide the panel's decisions by providing insight into selectivity based on length and age compositions, depth distributions of fishing effort, skill levels of fishermen, and how circumstances contrasted between the Atlantic and Gulf of Mexico. The choice of flat-topped selectivity for commercial handlines landings and dome-shaped for all others was based on several criteria. Two related considerations were the fleet-specific depths of fishing effort and the distribution of age at depth. In general, the commercial handlines fleet fish in deeper water than other fleets, and although there was only weak correlation between depth and age of older fish (5^+), younger fish (1–5) were more readily caught in shallower depths (SEDAR24-AW05, and Mitchell et al. (2014)). It was also suggested that commercial gear and fishermen can better handle larger fish (SEDAR24-AW12). Catch curve data were consistent with the hypothesis that older fish are more vulnerable to the commercial handlines fleet than to recreational fleets (SEDAR41-AW08 2015).

Selectivity of each fleet was fixed within each block of size-limit regulations, but was permitted to vary among blocks where possible or reasonable. Fisheries experienced four blocks of size-limit regulations (no limit prior to 1983, 12-inch limit during 1983–1991, 20-inch limit during 1992–2009, and no size limit during the moratorium/miniseasons 2010–2014). However, the panel combined blocks one and two after seeing that the 12-inch size limit had a negligible effect on the selectivity pattern. Age and length composition data are critical for estimating selectivity parameters, and ideally, a model would have sufficient composition data from each fleet over time to estimate distinct selectivities in each period of regulations. That was not the case here, and thus additional assumptions were applied to define selectivities, as follows. Because the general recreational fleet had little age or length composition data prior to 1998, this fleet mirrored the headboat fleet until the final time block. All domed-shaped selectivities meant to characterize landings were configured so as not to allow a selectivity of 0 at older ages, which was considered implausible. Size and age composition data show larger, older fish are caught by all fleets. However, the selectivity functions would reach zero before the plus group age of 20. Therefore, the panel examined the age composition data and used the information they contained to create a plus group for the selectivities. Headboat selectivities were fixed as constant after age 10 at the value estimated for age 10. For the general recreational fleet, the constant age at which we fixed selectivity was 13. These plus groups were consistent with how the age composition data were fitted.

Selectivities of discards were estimated in a similar fashion to the landings in that the general recreational fleet discards mirrored the headboat fleet discards. Both the commercial handline discards and the headboat discards had sufficient length composition to estimate selectivities.

Selectivities of fishery dependent indices were the same as those of the relevant fleet. The fishery independent CVID index selectivity was assumed logistic and informed by the SERFS chevron trap age compositions.

3.15 Indices of abundance

The model was fit to three fishery dependent indices of relative abundance (headboat 1976–2009; headboat discards 2005–2014; and commercial handlines 1993–2009), and one fishery independent index of abundance (SERFS combined video and trap, CVID). Predicted indices were conditional on selectivity of the corresponding fleet or survey, and were computed from abundance at the midpoint of the year or, in the case of commercial handlines, biomass. The headboat discard index tracks small fish (less than 20 inches) and was included as a measure of recruitment strength.

3.16 Catchability

In the BAM, catchability scales indices of relative abundance to the estimated population at large. For the base model, the AW Panel recommended a time-invariant catchability.

A sensitivity run adopted a time-varying catchability for the headboat index. In this formulation, catchability was estimated in two stanzas, pre- and post-1992. Choice of the year 1992 was based on the implementation of a fishery management plan that may have changed fishing behavior.

3.17 Biological reference points

Biological reference points (benchmarks) were calculated based on the fishing rate that would allow a stock to attain 30% of the maximum spawning potential which would have been obtained in the absence of fishing mortality. Computed benchmarks included the MSY proxy, fishing mortality rate at $F_{30\%}$, total biomass at $F_{30\%}$, and spawning stock at $F_{30\%}$ (Gabriel and Mace 1999). In this assessment, spawning stock measures total eggs of the mature stock. These benchmarks are conditional on the estimated selectivity functions and the relative contributions of each fleet's fishing mortality. The selectivity pattern used here was the effort-weighted selectivities at age, with effort from each fleet estimated as the full F averaged over the last three years of the assessment.

3.18 Fitting criterion

The fitting criterion was a penalized likelihood approach in which observed removals (landings and discards) were fit closely, and observed composition data and abundance indices were fit to the degree that they were compatible. Removals and index data were fit using lognormal likelihoods. Length and age composition data were fit using robust multinomial likelihoods (Francis 2011), and only from years that met minimum sample size criteria ($nfish > 30$ and $ntrips \geq 10$) for length compositions and ($nfish > 10$ and $ntrips \geq 10$) for age compositions. Commercial and headboat discard length composition minimum sample size threshold was set lower ($nfish > 10$) due to the fact that the discard composition data were the only information available to estimate selectivity.

The model includes the capability for each component of the likelihood to be weighted by user-supplied values. For data components, these weights were applied by either adjusting CVs (lognormal components) or adjusting effective sample sizes (multinomial components). In this application to Red Snapper, CVs of landings and discards (in arithmetic space) were assumed equal to 0.05, to achieve a close fit to these time series yet allowing some imprecision. In practice, the small CVs are a matter of computational convenience, as they help achieve the desired result of close fits to the landings, while avoiding having to solve the Baranov equation iteratively (which is complex when there are multiple fisheries). Weights on other data components (indices, age/length compositions) were adjusted iteratively, starting from initial weights as follows. The CVs of indices were set equal to the values estimated by the GLMs used for standardization or at the fixed value of 0.2 for the headboat and commercial handline indices. Effective sample sizes of the multinomial components were assumed equal to the number of trips sampled annually, rather than the number of fish measured, reflecting the belief that the basic sampling unit occurs at the level of trip. These initial weights were then adjusted until standard deviations of normalized residuals were near 1.0 (Francis 2011). In sensitivity runs, weights on the fishery dependent indices were adjusted upward to explore their effects (not because up-weighted runs were considered equally plausible).

For parameters defining selectivities, CV of size at age, and σ_R, normal priors were applied to maintain parameter estimates near reasonable values, and to prevent the optimization routine from drifting into parameter space with negligible gradient in the likelihood. For σ_R, the prior mean (0.6) and standard deviation (0.25) were based on Beddington and Cooke (1983) and Mertz and Myers (1996).

3.19 Configuration of a base run

The base run was configured as described above. This configuration does not necessarily represent reality better than all other possible configurations, and thus this assessment attempted to portray uncertainty in point estimates through sensitivity analyses and through a Monte-Carlo/bootstrap approach (described below).

3.20 Sensitivity analyses

Sensitivity runs were chosen to investigate issues that arose specifically with this benchmark assessment. They were intended to demonstrate directionality of results with changes in inputs or simply to explore model behavior, and not all were considered equally plausible. These model runs vary from the base run as follows:

- S1: Remove the 2008 and 2009 years from the handline and headboat indices
- S2: Upweight fishery independent index further than was explored in the Assessment Workshop (10X likelihood weight after the iterative reweighting)
- S3: Upweight handline and headboat indices (3X likelihood weight after iterative reweighting)
- S4: Fishery dependent indices only
- S5: High value of M
- S6: Low value of M
- S7: Low discard mortality probabilities (commercial handlines rate set to 0.38 or 0.28, all recreational set to 0.27 or 0.20)
- S8: High discard mortality probabilities (commercial handlines rate set to 0.58 or 0.48, all recreational set 0.45 or 0.36)
- S9: Longer combined chevron trap and video (CVID) index (2005-2014)
- S10: Reduced general recreational landings in 1984 and 1985 by taking the geometric mean of surrounding years
- S11: Steepness $h = 0.84$
- S12: Headboat discard index excluded after 2009
- S13: Ageing error matrix included
- S14: Low value for age-specific number of batches
- S15: High value for age-specific number of batches
- S16: Headboat discard index dropped
- S17: High landings
- S18: Low landings
- S19: High discards
- S20: Low discards
- S21: Dome-shaped selectivity for commercial handline fleet
- S22: Separate video and trap index rather than a single CVID index
- S23: Fishery independent index only
- S24: Continuity run: changes include SEDAR24 values such as M, steepness, maturity, and SSB
- S25: Two time blocks for Headboat logbook index catchability (pre- and post-1992)
- S26: Retrospective - 1 year of data
- S27: Retrospective - 2 years of data
- S28: Retrospective - 3 years of data
- S29: Retrospective - 4 years of data

- S30: Use 1978 as the starting year, applied a loose prior to the estimation of F_{init} that corresponds to the geometric mean of the fishing mortality for 1950-1977
- S31: Estimate selectivities without fixing a plus group (for the selectivity estimation)

Sensitivities 5, 6, 14, 15, and 17-20 used the 10th and 90th quantiles (as the low and the high respectively) from the bootstraps of the observed data described in the uncertainty analysis methods (Section 3.24).

3.21 Parameters Estimated

The model estimated annual fishing mortality rates of each fleet, selectivity parameters, catchability coefficients associated with indices, parameters of the spawner-recruit model (except steepness), annual recruitment deviations, and CV of size at age for each age and growth relationship.

3.22 Per Recruit and Equilibrium Analyses

Yield per recruit and spawning potential ratio were computed as functions of F, as were equilibrium landings and spawning biomass. Equilibrium landings and discards were also computed as functions of biomass B, which itself is a function of F. As in the computation of benchmarks (described in §3.23), per recruit and equilibrium analyses applied the most recent selectivity patterns averaged across fleets, weighted by each fleet's F from the last three years of the assessment (2012–2014).

3.23 Benchmark/Reference Point Methods

In this assessment of Red Snapper, the quantities $F_{30\%}$, $\mathrm{SSB}_{\mathrm{F30\%}}$, $B_{\mathrm{F30\%}}$, and $L_{\mathrm{F30\%}}$ were estimated as proxies for MSY-based reference points. Steepness was not reliably estimable, so the stock-recruit relationship was not used to identify a maximum yield. Instead, steepness was fixed at 0.99 in order to assume an average level of recruitment while estimating deviations around the mean. $F_{30\%}$ was used in the rebuilding plan for Red Snapper, therefore, it was used here to generate fishing benchmarks. However, because the stock-recruitment relationship was not estimated, assumptions about recruitment are required to generate biomass benchmarks. Here, equilibrium recruitment was assumed equal to expected recruitment (arithmetic average). On average, expected recruitment is higher than that estimated directly from the spawner-recruit curve, because of lognormal deviation in recruitment. Thus, in this assessment, the method of benchmark estimation accounted for lognormal deviation by including a bias correction in equilibrium recruitment. The bias correction (ς) was computed from the variance (σ_R^2) of recruitment deviation in log space: $\varsigma = \exp(\sigma_R^2/2)$. Then, equilibrium recruitment (R_{eq}) associated with any F is,

$$R_{eq} = \frac{R_0 \left[\varsigma 0.8 h \Phi_F - 0.2(1-h)\right]}{(h-0.2)\Phi_F} \tag{1}$$

where R_0 is virgin recruitment, h is steepness which is fixed in this assessment, and $\Phi_F = \phi_F/\phi_0$ is spawning potential ratio given growth, maturity, and total mortality at age (including natural and fishing mortality rates). Because steepness is fixed at 0.99, R_{eq} as a function of F is approximately a straight line. The R_{eq} and mortality schedule imply an equilibrium age structure and an average sustainable yield (ASY). The estimate of $F_{30\%}$ is the F giving 30% of the SPR, and the estimate of $L_{\mathrm{F30\%}}$ is that ASY. The estimate of $\mathrm{SSB}_{\mathrm{F30\%}}$ follows from the corresponding equilibrium age structure, as does the estimate of discard mortalities $D_{F30\%\}}$, here separated from ASY (and consequently, $L_{\mathrm{F30\%}}$).

Estimates of $L_{\mathrm{F30\%}}$ and related benchmarks are conditional on selectivity pattern. The selectivity pattern used here was an average of terminal-year selectivities from each fleet, where each fleet-specific selectivity was weighted in proportion to its corresponding estimate of F averaged over the last three years (2012–2014). If the selectivities or relative fishing mortalities among fleets were to change, so would the estimates of $L_{\mathrm{F30\%}}$ and related benchmarks.

The maximum fishing mortality threshold (MFMT) is defined by the SAFMC as $F_{30\%}$, and the minimum stock size threshold (MSST) as $75\%\mathrm{SSB}_{\mathrm{F30\%}}$. Overfishing is defined as $F >$ MFMT and overfished as SSB $<$ MSST. However, because this stock is currently under a rebuilding plan, increased emphasis is given to SSB relative to $\mathrm{SSB}_{\mathrm{F30\%}}$ (rather than MSST), as $\mathrm{SSB}_{\mathrm{F30\%}}$ is the rebuilding target. Current status of the stock is represented by SSB in the latest assessment year (2014), and current status of the fishery is represented by the geometric mean of F from the latest three years (2012–2014). Recent SEDAR assessments have considered the mean over the terminal three years to be a more robust metric.

3.24 Uncertainty and Measures of Precision

As in SEDAR24, this assessment used a mixed Monte Carlo and bootstrap (MCB) approach to characterize uncertainty in results of the base run. Monte Carlo and bootstrap methods (Efron and Tibshirani 1993; Manly 1997) are often used to characterize uncertainty in ecological studies, and the mixed approach has been applied successfully in stock assessment, including Restrepo et al. (1992), Legault et al. (2001), SEDAR4 (2004), and many South Atlantic SEDAR assessments since SEDAR19 (2009). The approach is among those recommended for use in SEDAR assessments (SEDAR Procedural Guidance 2010).

The approach translates uncertainty in model input into uncertainty in model output, by fitting the model many times with different values of "observed" data and key input parameters. A chief advantage of the approach is that the results describe a range of possible outcomes, so that uncertainty is characterized more thoroughly than it could be by any single fit or handful of sensitivity runs. A minor disadvantage of the approach is that computational demands are relatively high.

In this assessment, the BAM was successively re-fit in $n = 4000$ trials that differed from the original inputs by bootstrapping on data sources, and by Monte Carlo sampling of several key input parameters. The value of $n = 4000$ was chosen because a minimum of 3000 runs were desired, and it was anticipated that not all runs would converge or otherwise be valid. Of the 4000 trials, approximately 1.9% were discarded, because the model did not properly converge (in most cases, an estimated quantity was at its upper bound). This left $n = 3926$ MCB trials used to characterize uncertainty, which was sufficient for convergence of standard errors in management quantities.

The MCB analysis should be interpreted as providing an approximation to the uncertainty associated with each output. The results are approximate for two related reasons. First, not all combinations of Monte Carlo parameter inputs are equally likely, as biological parameters might be correlated. Second, all runs are given equal weight in the results, yet some might provide better fits to data than others.

3.24.1 Bootstrap of observed data

To include uncertainty in the indices of abundance, multiplicative lognormal errors were applied through a parametric bootstrap. To implement this approach in the MCB trials, random variables ($x_{s,y}$) were drawn for each year y of time series s from a normal distribution with mean 0 and variance $\sigma^2_{s,y}$ [that is, $x_{s,y} \sim N(0, \sigma^2_{s,y})$]. Annual observations were then perturbed from their original values ($\hat{O}_{s,y}$),

$$O_{s,y} = \hat{O}_{s,y}[\exp(x_{s,y} - \sigma^2_{s,y}/2)] \tag{2}$$

The term $\sigma^2_{s,y}/2$ is a bias correction that centers the multiplicative error on the value of 1.0. Standard deviations in log space were computed from CVs in arithmetic space, $\sigma_{s,y} = \sqrt{\log(1.0 + CV^2_{s,y})}$. As used for fitting the base run, CVs of indices of abundance were those provided by, or modified from, the data providers (tabulated in Table 4 of this assessment report).

Uncertainty was modeled for historical commercial landings similarly to the indices, and by the CVs provided by the commercial working group at the DW. No commercial discard CVs, headboat landings CVs, or headboat discard CVs by year were provided, therefore the panel had to make some assumptions. We assumed a value of $CV = 0.20$ for commercial discards and headboat discards. For headboat landings, we used information from the headboat program to assume a decreasing CV by time blocks (i.e. $CV = 0.15$ 1981-1995, $CV = 0.1$ for 1996-2007, and $CV = 0.05$ thereafter). General recreational landings and discards had complementary CVs, and those were used as provided except in a few instances. A CV greater than 1 was capped at 1, which was sufficiently large to represent high uncertainty but not so high that bootstrapped values caused implausible time series. The panel thought the resulting draws sufficiently represented uncertainty in spite of the dampening of a few years' CVs (Table 6).

Uncertainty in age and length compositions were included by drawing new distributions for each year of each data source, following a multinomial sampling process. Ages (or lengths) of individual fish were drawn at random with replacement using the cell probabilities of the original data. For each year of each data source, the number of fish sampled was the same as in the original data.

3.24.2 Monte Carlo sampling

In each successive fit of the model, several parameters were fixed (i.e., not estimated) at values drawn at random from distributions described below.

3.25 Natural mortality

A vector of age-specific natural mortality was provided by the Life History Working Group. They used the Charnov et al. (2013) estimator scaled to the Then et al. (2014) max age asymptotic M, and then used the uncertainty around the determination of maximum age to provide an upper and lower bound to the M vector. The Assessment Panel thought the upper ($M = 0.14$) and lower ($M = 0.12$) bound were too similar to the base vector to represent the true uncertainty around M. Instead, the AW Panel wanted to carry the uncertainty forward in both maximum age and the parameters of the Then et al. (2014) estimator of asymptotic M:

$$M = aT^b_{max} \tag{3}$$

To estimate uncertainty in a and b, we acquired the data of Then et al. (2014) and conducted a bootstrap of $n = 10,000$ iterations, drawing from the original data set with replacement. For each MCB iterations, one of the 10,000 fits was drawn at random, thus maintaining any correlation structure between a and b. We then drew T_{max} from a uniform distribution and calculated asymptotic M. For the age-dependent vector, we started with the Charnov age-dependent curve, and scaled it to the M estimate we calculated in the previous steps. A new M value was drawn and a new age-dependent vector was calculated for each MCB trial.

3.26 Discard mortality

The discard mortality working group provided an upper and lower bound for each time block (pre- and post-regulation) and fishery (commercial and recreational). Commercial rates before 2007 ranged from 38% to 58%, and 2007 to present ranged from 28% to 48%. Recreational rates before 2011 ranged from 27% to 45%, and 2011 on ranged from 20% to 36%. The rates decreased in response to the implementation of circle hooks, which are meant to cause fewer fatal bycatch events. We drew the rate for the earlier time period for each fleet from a truncated normal distribution with mean equal to the point estimate and a standard deviation devised to provide a 95% confidence interval similar to what the working group provided above. For the later time period for each fleet we also drew from a truncated normal distribution created similarly as in the previous step but with the upper bound fixed at the random draw from the earlier time period. The last step is meant to ensure that the second value is not larger than the first, so as to maintain the feature that discard mortality has decreased due to the circle hook regulation.

3.27 Batch Fecundity

Prior to the MCB analysis, a bootstrap procedure was run on the data set used to estimate batch fecundity at age for the base run. For each of 10000 bootstrap runs, the 69 paired observations of batch fecundity and fish length were sampled 69 times with replacement, the regression model refit, and the bootstrap parameters estimates saved to a data matrix. Once all bootstraps were run, the parameter matrix was trimmed by removing runs where either parameter value was outside of its 95% confidence interval. The parameters were found to be highly correlated, so during the MCB analysis, pairs of parameters were randomly drawn, with replacement, from the trimmed bootstrap parameter matrix. For each MCB run, predicted batch fecundity at age was calculated using a set of bootstrap parameters and a vector of length at age.

3.28 Batch number

Prior to the MCB analysis, a similar but separate bootstrap procedure was run on the data set used to estimate batch number at age for the base run. For each of 10000 bootstrap runs, the 1472 paired observations of spawning indicator presence, fish length, and day of the year were sampled 1472 times with replacement and the regression model refit. Predicted batch number at age was then calculated from the bootstrap parameter estimates and a vector of length at age, and the vectors saved to a data matrix. Once all bootstraps were run, the batch number at age matrix was trimmed by first summing batch number at age for each run, yielding lifetime batch number; runs where lifetime batch number was outside of the 95% confidence interval were trimmed. During the MCB analysis, a vector of batch number at age was randomly drawn, with replacement, from the trimmed bootstrap batch number at age matrix for each MCB run.

3.29 Projections

Projections were run to predict stock status in years after the assessment, 2015–2044. The year 2044 is the last year of the current rebuilding plan.

The structure of the projection model was the same as that of the assessment model, and parameter estimates were those from the assessment. Any time-varying quantities, such as recreational selectivity, were fixed to the most recent values of the assessment period. A single selectivity curve was applied to calculate removals, averaged across fleets using geometric mean Fs from the last three years of the assessment period, similar to computation of $L_{\mathrm{F30\%}}$ benchmarks (§3.23).

Expected values of SSB (time of peak spawning), F, recruits, and removals were represented by deterministic projections using parameter estimates from the base run. These projections were built on the spawner-recruit relationship with steepness fixed ($h = 0.99$) and with bias correction, and were thus consistent with estimated benchmarks in the sense that long-term fishing at $F_{30\%}$ would yield $L_{\mathrm{F30\%}}$ from a stock size at $\mathrm{SSB}_{\mathrm{F30\%}}$. Uncertainty in future time series was quantified through stochastic projections that extended the Monte Carlo/Bootstrap (MCB) fits of the stock assessment model.

3.29.1 Initialization of projections

Initial age structure at the start of 2015 was computed by the assessment model.

Fishing rates that define the projections were assumed to start in 2017. Because the assessment period ended in 2014, the projections required an initialization period (2015–2016). For 2015, a moratorium year, the landings selectivity was set to 0 and the discard selectivity was rescaled to peak at 1. Then, an optimization routine solved for the F that matched the current dead discards (mean of 2012-2014) in numbers. In 2016, a similar routine soved for the F that matched current landings (mean of 2012-2014), assuming a mini-season would occur.

3.29.2 Uncertainty of projections

To characterize uncertainty in future stock dynamics, stochasticity was included in replicate projections, each an extension of a single MCB assessment model fit. Thus, projections carried forward uncertainties in natural mortality, reproduction, landings, discards, and discard mortalities, as well as in estimated quantities such as selectivity curves, and in initial (start of 2015) abundance at age.

Initial and subsequent recruitment values were generated with stochasticity using a Monte Carlo procedure, in which the estimated Beverton–Holt model (i.e. R_0, σ_R estimated, and $h = 0.99$) of each MCB fit was used to compute mean annual recruitment values ($\bar{R}_y$). Variability was added to the mean values by choosing multiplicative deviations at random from a lognormal distribution,

$$R_y = \bar{R}_y \exp(\epsilon_y). \tag{4}$$

Here ϵ_y was drawn from a normal distribution with mean 0 and standard deviation σ_R, where σ_R is the standard deviation from the relevant MCB fit.

The procedure generated 20,000 replicate projections of MCB model fits drawn at random (with replacement) from the MCB runs. In cases where the same MCB run was drawn, projections would still differ as a result of stochasticity in projected recruitment streams. Central tendencies were represented by the deterministic projections of the base run, as well as by medians of the stochastic projections. Precision of projections was represented graphically by the 10^{th} and 90^{th} percentiles of the replicate projections.

3.30 Rebuilding time frame

Based on results from the previous SEDAR24 benchmark assessment, Red Snapper is currently under a rebuilding plan. In this plan, the terminal year is 2044, and rebuilding is defined by the criterion that projection replicates achieve stock recovery (i.e., $\mathrm{SSB}_{2044} \geq \mathrm{SSB}_{\mathrm{F30\%}}$) with probability of at least 50%. Here, the probability of stock recovery in each year of the rebuilding plan was computed as the proportion of stochastic projections where $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{F30\%}}$, with $\mathrm{SSB}_{\mathrm{F30\%}}$ taken to be iteration-specific (i.e., from that particular MCB run).

Projection scenarios Five projection scenarios were considered.

- Scenario 1: $F = 0$
- Scenario 2: $F = F_{\text{current}}$
- Scenario 3: $F = F_{30\%}$
- Scenario 4: $F_{target} = 98\% F_{30\%}$
- Scenario 5: $F = F_{\text{rebuild}}$, with rebuilding probability of 0.5 in 2044
- Scenario 6: Discards only

The F_{current} is represented by the geometric mean of fishing mortalities from 2012-2014. The F_{rebuild} is defined as the maximum F that achieves rebuilding in the allowable time frame. The discards only scenario treated the initialization year 2016 the same as 2015 (discards only), and then applied the mean F (from 2015-2016) forward starting in 2017.

3.31 Surplus Production Model

3.31.1 Overview

A logistic surplus production model, implemented in ASPIC (Version 7.03; Prager 2005), was used to estimate stock status of Red Snapper off the southeastern U.S. While primary assessment of the stock was performed using the age-structured BAM, the surplus production approach was intended as a complement, for additional comparison with the age-structured model's results. More specifically, this model focuses on the dynamics of the removals as they relate to the indices of abundance, while ignoring any age data or age-structure in the population.

3.31.2 Data Sources

Data sources supplied to a production model include a time series of removals (i.e. landings plus dead discards) and one or more indices of abundance (i.e. catch per unit of effort). These inputs should be in units of biomass (i.e. weight), therefore some of the data developed at the SEDAR41 DW required additional formatting. These changes are detailed below.

Removals

The available removals time series comprised commercial landings (1950-2014), recreational landings (1955-2014), commercial dead discards (1992-2014), and recreational dead discards (1981-2014), in pounds, summed by year.

Commercial Landings

The SEDAR41 DW reported commercial landings in pounds, thus these data did not need to be modified for the production model.

Recreational landings

During the SEDAR41 DW, recreational landings for the historical period (1955-1980) were estimated in numbers of individuals using the The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey (FHWAR) census method (see SEDAR41-DW17). For the contemporary period (1981-2014), the SEDAR-41 DW reported Southeast Region Headboat Survey (SRHS) and Marine Recreational Information Program (MRIP) recreational landings in numbers and weights. Recreational landings from this period did not need to be modified, but were used to convert historical landings to weight.

Following a similar approach used in SEDAR24, recreational landings in weight and numbers for all fleets were combined by year for the first three years of the contemporary period; dividing annual landings in weight by landings in numbers produced annual mean weight estimates. The average of these three mean weights (3.4 lb) was then multiplied by the historical landings in numbers to convert them to weight. The historical and combined contemporary recreational landings series were then joined to produce a single time series of recreational landings, in pounds.

Dead Discards

Discard estimates were generated in numbers at the SEDAR-41 DW. Since many discarded fish survive after release, discard mortality rates were applied to discards in numbers to calculate dead discards. For commercial discards, a discard mortality rate of 0.48 was applied prior to regulations in 2007, and a rate of 0.38 was applied from 2007 onward. For recreational discards, a discard mortality rate of 0.37 was applied prior to regulations in 2011, and a rate of 0.285 was applied from 2011 onward.

Mean weight of commercial discards was estimated by converting lengths of commercial discards to weights using data and a conversion equation supplied by the SEDAR-41 DW, and then calculating the average weight of these individuals. The data on lengths of commercial discards were divided into two time periods before (2007-2009) and after (2010-2013) the fishery was closed. The average estimated weights of commercial discards from each time period (before = 2.93 lb; after = 8.84 lb) were multiplied by discards in numbers, for years before and after the closure, respectively.

Mean weight of recreational discards was estimated by converting lengths of recreational headboat-at-sea observer discards to weights using data and a conversion equation supplied by the SEDAR-41 DW, and then calculating the average weight of these individuals. Year-specific mean weight estimates were multiplied by recreational discards in numbers for corresponding years when available (2005-2014). For years prior to 2005 where year-specific mean weights were not available, discards in numbers were multiplied by the average mean weight across the available years before the 2010 closure (1.96 lb).

Indices of Abundance

Five indices of abundance were produced by the SEDAR-41 DW for Red Snapper: commercial logbook handline index (hereafter commercial handline; units = lb kept per hook-hour), headboat (number of fish kept per angler), headboat-at-sea-observer (number of fish caught $<20''$ per angler), Southeast Reef Fish Survey (SERFS) chevron trap (number of fish caught per trap), and the SERFS video (number of fish observed per video). The commercial handline index was already in weight and did not need to be converted. The headboat index was converted to pounds by multiplying by year-specific mean weights, generated by dividing headboat landings in pounds by landings in numbers for each year. The headboat-at-sea-observer index was converted to pounds by multiplying by the same mean weights used to convert recreational discards to weight. The SERFS chevron trap and video indices were converted to weights by multiplying by year-specific mean weights calculated from combined recreational (headboat and MRIP) landings in weight divided by landings in numbers.

3.31.3 Model Configuration and Equations

Production modeling used the model formulation and ASPIC software (version 7.03) of Prager (1994; 2005). This is an observation-error estimator of the continuous-time form of the Schaefer (logistic) production model (Schaefer 1954; 1957). Estimation was conditioned on catch. The logistic model for population growth is the simplest form of a differential equation which satisfies a number of ecologically realistic constraints, such as a carrying capacity (a consequence of limited resources). When written in terms of stock biomass, this model specifies that

$$\frac{dB_t}{dt} = rB_t - \frac{r}{K}B_t^2 \tag{5}$$

where B_t is biomass in year t, r is the intrinsic rate of increase in absence of density dependence, and K is carrying capacity (Schaefer 1954; 1957). This equation may be rewritten to account for the effects of fishing by introducing an instantaneous fishing mortality term, F_t :

$$\frac{dB_t}{dt} = (r - F_t)B_t - \frac{r}{K}B_t^2 \tag{6}$$

By writing the term F_t as a function of catchability coefficients and effort expended by fishermen in different fisheries, Prager (1994) showed how to estimate model parameters from time series of yield and effort.

For Red Snapper, the model proved difficult to fit. It was configured using various combinations of removals, indices, starting dates, prior distributions and starting values, resulting in approximately 324 configurations. Many of these runs were completed during early model development but many others incorporated small changes to data inputs or model specifications suggested by AW panel members during the Assessment Workshop. As the BAM developed, most of these runs became obsolete and are not presented here. The run configured according to recommendations by the SEDAR41 AW panel is presented here. This model configuration (run 320) contained removals from 1950 to 2014 and the four indices used in the BAM (Comm, HB, HB-at-sea, CVID) from 1976 to 2014. Following the recommendations of the AW panel, the CVID index was upweighted by a factor of three (i.e. CVs divided by three), and the headboat-at-sea index was shifted forward by one year, since it indexes younger fish than the other indices.

Three other runs (318, 319, and 323) are also presented to relate the main run (320) to ASPIC results from the previous Red Snapper assessment (SEDAR 24). All three runs contain only the commercial and headboat indices, starting in 1993 and 1976 respectively, and removals starting in 1950. But in run 318 (the continuity run), the final year of removals and indices is 2009, as in SEDAR 24, while in run 319 (the updated continuity run) the final year of removals and indices is 2014, as in the BAM for the current assessment. Since both the commercial and headboat indices ended in 2009 the only difference between the continuity run and updated continuity run is the removals estimates from 2010-2014. Finally a run was completed (run 323; best configuration $\frac{B_1}{K}$ fixed) that is identical to the best configuration run, but with $\frac{B_1}{K}$ fixed at the estimate for the continuity run, for reasons described below.

To evaluate the uncertainty in the model fit and parameter estimates of the best configuration run, 1000 bootstrap runs were conducted. Percentile confidence intervals were also calculated for parameters.

4 Stock Assessment Results

4.1 Measures of Overall Model Fit

In general, the Beaufort assessment model (BAM) fit well to the available data. Predicted length compositions from the commercial handline and discards from the commercial and headboat fleets were reasonably close to observed data in most years, as were predicted age compositions (Figure 3). The model was configured to fit observed commercial and recreational removals closely (Figures 4–9). Fits to indices of abundance generally captured the observed trends but not all annual fluctuations (Figures 10–13).

4.2 Parameter Estimates

Estimates of all parameters from the catch-age model are shown in Appendix B. Estimates of management quantities and some key parameters are reported in sections below.

4.3 Stock Abundance and Recruitment

In general, estimated abundance at age showed truncation of the older ages through most of the assessment period, but with some signs of increase during the last decade (Figure 14; Table 7). Total estimated abundance was at its lowest value in the early 1990s, but near its highest levels at the end of the time series, comparable to those in the early 1970s, but with a more truncated age structure. The MCB results reflect the same patterns with their associated uncertainties for total abundance and abundance of age 2+ (Figure 18). Annual number of recruits is shown in Table 7 (age-1 column) and in Figure 15. The highest recruitment values were predicted to have occurred in the mid-1980s, 2006, and the terminal year of the model (2014).

4.4 Total and Spawning Biomass

Estimated biomass at age followed a similar pattern as abundance at age (Figure 16; Table 9). Total biomass and spawning biomass showed similar trends—general decline through to the early-1990s, and relatively stable or slowly increasing patterns since the mid-1990s (Figure 17; Table 10). Terminal year estimates are at levels not seen since the 1970s.

4.5 Selectivity

Selectivity of the SERFS index is shown in Figure 19, and selectivities of landings from commercial and recreational fleets are shown in Figures 20, 21, and 22. Selectivities of discards from commercial and recreational fleets are shown in Figures 23, 24, and 25. In the most recent years, full selection occurred near ages 2–4, depending on the fleet and time block.

Average selectivities of landings, dead discards, and the total weighted average of all selectivities were computed from F-weighted selectivities in the most recent three assessment years (Figure 26). This average selectivity was used in computation of point estimates of benchmarks, as well as in projections. All selectivities from each time block, including average selectivities, are tabulated in Tables 11, 12, and 13.

4.6 Fishing Mortality and Removals

Estimates of total F at age are shown in Table 15. In any given year, the maximum F at age (i.e., apical F) may be less than that year's sum of fully selected Fs across fleets. This inequality is due to the combination of two features of estimated selectivities: full selection occurs at different ages among gears and several sources of mortality have dome-shaped selectivity.

Estimated time series of landings and discards are shown in Tables 16, 17, 18, 19. Table 20 shows total landings at age in numbers, and Table 21 in weight. Table 22 shows total discards at age in numbers, and Table 23 in weight. Landings have been dominated by the general recreational and commercial handline fleet until recent years when the general recreational fleet became the dominant source of removals (Tables 16 and 17). Also since 2010, total landings remained below the level at $L_{\mathrm{F30\%}}$ (Figure 29).

Estimated discard mortalities occurred on a smaller scale than landings until the implementation of regulations and the use of mini-seasons, and have been above the $D_{F_{30\%}}$ level for most of the moratorium years (Tables 18 and 19, and Figure 30).

4.7 Spawner-Recruitment Parameters

The Beverton–Holt spawner-recruit curve is shown in Figure 31, along with the effect of density dependence on recruitment, depicted graphically by recruits per spawner as a function of spawning stock (1E8 Eggs). Values of recruitment-related parameters were as follows: steepness $h = 0.99$ (fixed), unfished age-1 recruitment $\widehat{R_0} = 320738$, and standard deviation of recruitment residuals in log space $\widehat{\sigma}_R = 0.81$ (which resulted in bias correction of $\varsigma = 1.40$). Uncertainty in these quantities was estimated through the MCB analysis (Figure 32).

4.8 Per Recruit and Equilibrium Analyses

Yield per recruit and spawning potential ratio were computed as functions of F. These computations applied the most recent selectivity patterns averaged across fleets, weighted by F from the last three years (2012–2014) (Figures 33 and 34).

As in per recruit analyses, equilibrium landings and spawning biomass were computed as functions of F (Figure 35). $F_{30\%}$ is used as a proxy for MSY, and the corresponding landings and spawning biomass are $L_{\mathrm{F30\%}}$ and $\mathrm{SSB}_{\mathrm{F30\%}}$.

4.9 Benchmarks / Reference Points

As described in §3.23, biological reference points (benchmarks) were derived analytically assuming equilibrium dynamics, corresponding to the spawner-recruit curve with fixed steepness $h = 0.99$ (Figure 31). Reference points estimated were $F_{30\%}$, $L_{\mathrm{F30\%}}$, $B_{\mathrm{F30\%}}$ and $\mathrm{SSB}_{\mathrm{F30\%}}$. Based on $F_{30\%}$, three possible values of F at optimum yield (OY) were considered—$F_{\mathrm{OY}} = 65\% F_{30\%}$, $F_{\mathrm{OY}} = 75\% F_{30\%}$, and $F_{\mathrm{OY}} = 85\% F_{30\%}$—and for each, the corresponding yield was computed. Standard errors of benchmarks were approximated as those from MCB analysis (§3.24).

Maximum likelihood estimates (base run) of benchmarks, as well as median values from MCB analysis, are summarized in Table 24. Point estimates of $L_{\mathrm{F30\%}}$-related quantities were $F_{30\%} = 0.15$ (y^{-1}), $L_{\mathrm{F30\%}} = 427.01$ (1000 lb), $B_{\mathrm{F30\%}} = 3637.2$ (mt), and $\mathrm{SSB}_{\mathrm{F30\%}} = 327705.9$ (1E8 Eggs). Median estimates were $F_{30\%} = 0.15$ (y^{-1}), $L_{\mathrm{F30\%}} = 415.17$ (1000 lb), $B_{\mathrm{F30\%}} = 3524.9$ (mt), and $\mathrm{SSB}_{\mathrm{F30\%}} = 293943.5$ (1E8 Eggs). Distributions of these benchmarks from the MCB analysis are shown in Figure 36.

4.10 Status of the Stock and Fishery

Estimated time series of stock status SSB/$SSB_{F30\%}$ showed general decline throughout the beginning of the assessment period, a leveling off, and then a modest increase since 2010 (Figure 37, Table 10). Base-run estimates of spawning biomass have remained below the threshold (MSST) since the early-1970s. Current stock status was estimated in the base run to be SSB/$SSB_{F30\%}$ = 0.15 (Table 24), indicating that the stock has not yet recovered to $SSB_{F30\%}$. Median values from the MCB analysis indicated similar results SSB/$SSB_{F30\%}$ =0.16. The uncertainty analysis suggested that the terminal estimate of stock status is robust (Figures 38, 39). Of the MCB runs, 100% indicated that the stock was below $SSB_{F30\%}$ in 2014. Age structure estimated by the base run showed fewer older fish in the last few decades than the (equilibrium) age structure expected at $L_{F30\%}$ (Figure 40). However, there is improvement in the terminal year(2014), particularly for ages younger than ten.

The estimated time series of $F/F_{30\%}$ suggests that overfishing has occurred throughout most of the assessment period (Table 10, Figure 37). Current fishery status in the terminal year, with current F represented by the geometric mean from 2012–2014, was estimated by the base run to be $F/F_{30\%}$ = 2.7 (Table 24). The fishery status was also robust (Figures 38, 39). Of the MCB runs, approximately 99.1% agreed with the base run that the stock is currently experiencing overfishing.

4.11 Sensitivity and Retrospective Analyses

Sensitivity runs, described in §3.3, were used for exploring data or model issues that arose during the assessment process, for evaluating implications of assumptions in the base assessment model, and for interpreting MCB results in terms of expected effects of input parameters. In some cases, sensitivity runs are simply a tool for better understanding model behavior, and therefore all runs are not considered equally plausible in the sense of alternative states of nature. Time series of $F/F_{30\%}$ and SSB/$SSB_{F30\%}$ are plotted to demonstrate sensitivity to the changing conditions in each run. The sensitivity of the base run to changes in natural mortality, steepness, dome-shaped selectivity for the commercial handline fleet, various index adjusts for both the fishery dependent indices and fishery independent index, the use of an ageing error matrix and high and low levels of landings and discards was explored (Figures 41–53). Sensitivity 24 is a version of a continuity run in that various assumptions made about parameters for SEDAR 24 were adopted for this sensitivity (e.g. higher discard mortalities, lower M, using gonad weight as a proxy for SSB, different female maturity and fecundity information, higher max age, lower steepness, different time of year for peak spawning, and fixed recruitment standard deviation). Time series of stock and fishery status estimated by this assessment are similar to those from the previous, SEDAR24 assessment (Figure 54). Trends in $F/F_{30\%}$ from the two assessments generally track each other, though the magnitude of the variations differ. Trends in SSB/$SSB_{F30\%}$ track each other, though there is divergence at the end of the time series where the current model estimates a more optimistic stock status.

None of the sensitivities show a recovered stock in 2014. A couple sensitivities suggest the stock is undergoing less overfishing than is estimated in the base. However, those runs eliminate the fishery independent index entirely, or upweight the fishery dependent indices to the point of swamping out any signal from the survey data. The vast majority of runs agree with the status indicated by the base run (Figure 55, Table 25). Results appeared to be most sensitive to natural mortality and steepness.

Retrospective analyses suggest a pattern of overestimating fishing mortality in the terminal year, however, the trend is less apparent for SSB (Figure 56).

4.12 Projections

Projections based on $F = 0$ allowed the spawning stock to grow such that the majority of replicate projections recovered to $\mathrm{SSB}_{\mathrm{F30\%}}$ by 2025 (Figure 57, Table 26), however the stock is already in a rebuilding plan so other projections were also requested in the TORs. This was not the case for projections based on $F = F_{\mathrm{current}}$ (Figure 58, Table 27), or if the fishing rate were reduced to $F_{30\%}$ (Figure 59, Table 28) or F_{target} (Figure 60, Table 29). By design, projections based on $F = F_{\mathrm{rebuild}}$ showed recovery with the desired probability in 2044 (Figure 61, Table 30). The projection with discard mortality only showed similar trajectories to the run assuming no other fishing mortality(Table 31 and Figure 62).

4.13 Surplus Production Model

4.13.1 Model Fit

For the best configuration run, model predictions underestimated observed values for the headboat index for the first ten years of the time series (1976-1985; Figure 63). They also underestimated the commercial index during the first five years of that series (1993-1997), while overestimating the headboat index for those same years. The model provided a very poor fit to the headboat-at-sea discard index (2006-2014) but produced a much better fit to the upweighted CVID index (2005-2014). The model did not fit high index values in 2008 and 2009 very closely, but predicted a slight decline from 2007-2009 followed by an increasing trend from 2010 to 2014.

4.13.2 Parameter Estimates and Uncertainty

The ASPIC model fits three main parameters ($\frac{B_1}{K}$, MSY, and F_{MSY}) as well as catchability coefficients (q_i) for each index i. Several other parameters can then be derived from these estimates: $r = 2F_{MSY}$, $K = \frac{2MSY}{F_{MSY}}$ and $B_{MSY} = \frac{K}{2}$. Recent status indicators $\frac{F}{F_{MSY}}$ and $\frac{B}{B_{MSY}}$ are calculated with the most recent estimates of F (2014) and B (2015). Estimates of the main parameters and recent status indicators for all four runs are presented in Table 32. Prior distributions and model estimates of the main parameters for the best configuration run are presented in Figure 64.

Across all runs, most of the main parameters varied very little (e.g. CV $MSY = 0.0027$; CV $F_{MSY} = 0.014$). By contrast $\frac{B_1}{K}$ varied widely (CV $\frac{B_1}{K} = 0.74$), due to variation in B_1 (CV $B_1 = 0.74$) rather than K (CV $K = 0.013$; Table 32). Among bootstrap runs based on the best configuration, distributions of $\frac{B_1}{K}$, MSY, and F_{MSY} were unimodal and relatively symmetrical (Figure 65).

4.13.3 Status of the Stock and Fishery

In the current best configuration run of the surplus production model, $\frac{B}{B_{MSY}}$ is greater than one, suggesting that the South Atlantic stock of Red Snapper is not overfished. The 95% bootstrap percentile confidence intervals for $\frac{B}{B_{MSY}}$ do not contain one (Figure 65). Since the surplus production model estimates that $\frac{F}{F_{MSY}}$ is less than one, the stock is considered to not be undergoing overfishing (Table 32; Figure 66). The 95% bootstrap percentile confidence intervals for $\frac{F}{F_{MSY}}$ do not contain one (Figure 65).

4.13.4 Interpretation

Status indicators in the continuity run (318), agree with the surplus production model from SEDAR 24 that South Atlantic Red Snapper were overfished and undergoing overfishing in 2009 (Table 32). However, in the updated continuity run (319), which is identical to the continuity run except for the 2010-2014 addition of landings data from 2010-2014, the surplus production model suggests that the stock is no longer overfished or undergoing overfishing. Despite several differences between the updated continuity run and the best configuration run (320), described above, most of the parameter estimates and status indicators are similar (Table 32). However the model estimate of $\frac{B_1}{K}$ is much lower in the best configuration run, driven by a lower estimate of B_1. After observing this difference, run 323 was configured by taking the best configuration run and fixing $\frac{B_1}{K}$ at the estimate from the continuity run to investigate potential influence. Fixing $\frac{B_1}{K}$ at this much lower value had little effect on status or most parameters, but caused the estimate of B_1 to go much lower.

As described above, the only data that go into a surplus production model are biomass of removals and abundance indices. Therefore such a model does not make use of many other sources of information such as sex, maturity, growth, fecundity, or population age and size structure. Because such data are available for Red Snapper, a model that uses them would be preferred for a detailed assessment on which to base management.

5 Discussion

5.1 Comments on the Assessment

Estimated benchmarks played a central role in this assessment. Values of $\mathrm{SSB}_{\mathrm{F30\%}}$ and $F_{30\%}$ were used to gauge the status of the stock and fishery to be consistent with established definitions of $MFMT$ and the existing rebuilding plan. The computation of the benchmarks was conditional on selectivity. If selectivity patterns change in the future, for example as a result of new size limits or different relative catch allocations among sectors, estimates of benchmarks would likely change as well.

The base run of the BAM indicated that the stock remains overfished $\mathrm{SSB}/\mathrm{SSB}_{\mathrm{F30\%}}$ =0.15, and that overfishing is occurring $F/F_{30\%}$ =2.7, though at a lower rate than in 2009 (F/F_{MSY} =4.12 for SEDAR 24). Median values from the MCB analyses were in qualitative agreement with those results. This assessment estimates that, since 2010, the stock has been increasing at a modest rate and is now at levels not seen since the 1970s.

In addition to including the more recent years of data, this benchmark assessment contained several modifications to the previous data of SEDAR24, such as the use of APAIS-adjusted MRIP estimates instead of MRFSS, a new method for the reconstruction of historic recreational catch, the inclusion of a new fishery-independent survey, and the corresponding age composition data. Furthermore, life-history information was updated, including female maturity, sex ratio, growth, natural mortality, fecundity, and meristics. The assessment model itself was also modernized to the current version of BAM. The sum of these improvements should result in a more robust assessment.

In general, fishery dependent indices of abundance may not track actual abundance well, because of factors such as hyperdepletion or hyperstability. Furthermore, this issue can be exacerbated by management measures. In this assessment, the commercial handline and headboat indices generated from logbook data, were not extended beyond 2009 because of the moratorium on Red Snapper. In general, management measures in the southeast U.S. have made the continued utility of fishery dependent indices will be questionable. This situation amplifies the importance of fishery independent sampling and sampling programs conducted by the states.

Many assessed stocks in the southeast U.S. have shown histories of heavy exploitation. High rates of fishing mortality can lead to adaptive responses in life-history characteristics, such as growth and maturity schedules. Such adaptations can affect expected yield and stock recovery, and thus resource managers might wish to consider possible evolutionary effects of fishing in their management plans (Dunlop et al. 2009; Enberg et al. 2009). Indeed, Red Snapper have a very young age at maturity relative to their maximum lifespan, and some have hypothesized that this may be an adaptive response to exploitation.

Because steepness could not be estimated reliably in this assessment, its value in the base run was fixed at 0.99. Fixing steepness at its upper bound was not meant to imply that the stock has perfect compensation at any exploitation or stock level. Rather, it was a computational convenience to use the stock recruitment curve with $h = 0.99$ in order to treat recruitment as an average through time while estimating deviations around that average. Thus MSY-based management quantities are not appropriate, and the AW Panel provided the proxy of $F_{30\%}$ as was used for management subsequent to the last assessment.

The assessment start year was 1950, so as to include the period of largest landings. To initialize the model in 1950, the initial age structure was assumed to be in equilibrium, based on natural mortality at age and F_{init}. Average recruitment was assumed until the recruitment deviations could be estimated at the onset of the composition data (1978). These assumptions are common in assessment models, and they were tested with sensitivity runs where the start was 1978 and with different values of F_{init}. The end results were qualitatively similar, which indicates that the base run is not sensitive to these assumptions.

A complementary analysis was conducted using a surplus production model (ASPIC). ASPIC treats the stock as a pooled biomass and ignores the age structure in the population and the landings. It is unable to take into account that different ages are differentially vulnerable to fishing and therefore was not able to incorporate the (time-varying) selectivities used in the BAM. ASPIC is also not able to take into account that the reproductive contribution of this species increases with age or that there is variability in recruitment through time. ASPIC is useful in examining the relationship between removals and the indices. However, for a long-lived species with age-based data available, the catch-age model (BAM) provides the best illustration of the stock and is a better indicator of stock status, because it can account for the age structure of the population and landings and for year-class strength.

5.2 Comments on the Projections

Projections should be interpreted in light of the model assumptions and key aspects of the data. Some major considerations are the following:

- In general, projections of fish stocks are highly uncertain, particularly in the long term (e.g., beyond 5–10 years).
- Although projections included many major sources of uncertainty, they did not include structural (model) uncertainty. That is, projection results are conditional on one set of functional forms used to describe population dynamics, selectivity, recruitment, etc.
- Fisheries were assumed to continue fishing at their estimated current proportions of total effort, using the estimated current selectivity patterns. New management regulations that alter those proportions or selectivities would likely affect projection results.
- The first five scenarios of projections assumed no change in the selectivity applied to discards. As stock increase generally begins with the smallest size classes, management action may be needed to meet that assumption.
- The projections assumed that the assumed spawner-recruit relationship applies in the future and that past deviations represent future uncertainty in recruitment. If future recruitment is characterized by runs of large or small year classes, possibly due to environmental or ecological conditions, stock projections may be affected.

- Projections apply the Baranov catch equation to relate F and landings using a one-year time step, as in the assessment. The catch equation implicitly assumes that mortality occurs throughout the year. This assumption is violated when seasonal closures or small intensive fishing seasons are in effect, introducing additional and unquantified uncertainty into the projection results.

5.3 Research Recommendations

- Increased fishery independent information, particularly maintaining reliable indices of abundance and composition data streams
- Red Snapper were modeled in this assessment as a unit stock off the southeastern U.S. For any stock, variation in exploitation and life-history characteristics might be expected at finer geographic scales. Modeling such sub-stock structure would require more data, such as information on the movements and migrations of adults and juveniles, as well as spatial patterns of larval dispersal and recruitment. In addition, it is unclear whether a spatial model would improve the assessment.
- More research to describe the juvenile life history of Red Snapper is needed, including more work to identify the location of juveniles before they recruit to the fishery.
- The effects of environmental variation on the changes in recruitment or survivorship.
- The Florida sampling program, during the miniseason in particular, provided invaluable data to this assessment. Programs such as these would be useful in all South Atlantic states, particularly if the management regulations continue to make established methods of index development or composition sampling from fleets less regular or possible.

6 References

Baranov, F. I. 1918. On the question of the biological basis of fisheries. Nauchnye Issledovaniya Ikhtiologicheskii Instituta Izvestiya **1**:81–128.

Beddington, J. R., and J. G. Cooke, 1983. The potential yield of fish stocks. FAO Fish. Tech. Pap. 242, 47 p.

Charnov, E. L., H. Gislason, and J. G. Pope. 2013. Evolutionary assembly rules for fish life histories. Fish and Fisheries **14(2)**:213–224.

Conn, P. B. 2010. Hierarchical analysis of multiple noisy abundance indices. Canadian Journal of Fisheries and Aquatic Sciences .

Conn, P. B., E. H. Williams, and K. W. Shertzer. 2010. When can we reliably estimate the productivity of fish stocks? Canadian Journal of Fisheries and Aquatic Sciences **67**:511–523.

Dunlop, E. S., K. Enberg, C. Jorgensen, and M. Heino. 2009. Toward Darwinian fisheries management. Evolutionary Applications **2**:245–259.

Efron, B., and R. Tibshirani. 1993. An Introduction to the Bootstrap. Chapman and Hall, London.

Enberg, K., C. Jorgensen, E. S. Dunlop, M. Heino, and U. Dieckmann. 2009. Implications of fisheries-induced evolution for stock rebuilding and recovery. Evolutionary Applications **2**:394–414.

Fitzhugh, G. R., K. W. Shertzer, G. T. Kellison, and D. M. Wyanski. 2012. Review of size- and age dependence in batch spawning: implications for stock assessment of fish species exhibiting indeterminate fecundity. Fishery Bulletin pages 413–425.

Fournier, D. A., H. J. Skaug, J. Ancheta, J. Ianelli, A. Magnusson, M. N. Maunder, A. Nielsen, and J. Sibert. 2012. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Optimization Methods and Software **27**:233–249.

Francis, R. 2003. Quantifying annual variation in catchability for commercial and research fishing. Fishery Bulletin **101**:293–304.

Francis, R. 2011. Data weighting in statistical fisheries stock assessment models. Canadian Journal of Fisheries and Aquatic Sciences **68**:1124–1138.

Gabriel, W. L., and P. M. Mace, 1999. A review of biological reference points in the context of the precautionary approach. NOAA Technical Memorandum-F/SPO-40.

Legault, C. M., J. E. Powers, and V. R. Restrepo. 2001. Mixed Monte Carlo/bootstrap approach to assessing king and Spanish mackerel in the Atlantic and Gulf of Mexico: Its evolution and impact. Amercian Fisheries Society Symposium **24**:1–8.

Lorenzen, K. 1996. The relationship between body weight and natural mortality in juvenile and adult fish: a comparison of natural ecosystems and aquaculture. Journal of Fish Biology **49**:627–642.

Manly, B. F. J. 1997. Randomization, Bootstrap and Monte Carlo Methods in Biolog, 2nd edition. Chapman and Hall, London.

Mertz, G., and R. Myers. 1996. Influence of fecundity on recruitment variability of marine fish. Canadian Journal of Fisheries and Aquatic Sciences **53**:1618–1625.

Methot, R. D. 1989. Synthetic estimates of historical abundance and mortality for northern anchovy. American Fisheries Society Symposium **6**:66–82.

Methot, R. D., 2009. User Manual for Stock Synthesis, Model Version 3.04. NOAA Fisheries, Seattle, WA.

Mitchell, W. A., G. T. Kellison, N. M. Bacheler, J. C. Potts, C. M. Schobernd, and L. Hale. 2014. Depth-related distribution of postjuvenile Red Snapper in southeastern U.S. Atlantic Ocean waters: ontogenic patters and implications for management. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science **6**:142–155.

Patterson, W. F., C. E. Porch, J. H. Tarnecki, and A. J. Strelcheck. 2012. Effect of circle hook size on reef fish catch rates, species composition, and selectivity in the northern Gulf of Mexico recreational fishery. Bulletin of Marine Science **88**:647–665.

Prager, M. H. 1994. A suite of extensions to a nonequilibrium surplus-production model. Fishery Bulletin **92**:374–389.

Prager, M. H., 2005. User's Manual for ASPIC: A Stock-Production Model Incorporating Covariates (ver. 5) And Auxiliary Programs. National Marine Fishery Service, Beaufort Laboratory Document BL-2004-01, Beaufort, NC.

Quinn, T. J., and R. B. Deriso. 1999. Quantitative Fish Dynamics. Oxford University Press, New York, New York.

Restrepo, V. R., J. M. Hoenig, J. E. Powers, J. W. Baird, and S. C. Turner. 1992. A simple simulation approach to risk and cost analysis, with applications to swordfish and cod fisheries. Fishery Bulletin **90**:736–748.

Schaefer, M. B. 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Bulletin of the Inter-American Tropical Tuna Commission **1**:27–56.

Schaefer, M. B. 1957. A study of the dynamics of the fishery for yellowfin tuna in the eastern tropical Pacific Ocean. Bulletin of the Inter-American Tropical Tuna Commission **2**:247–268.

SEDAR Procedural Guidance, 2010. SEDAR Procedural Workshop IV: Characterizing and Presenting Assessment Uncertainty.

SEDAR19, 2009. SEDAR 19: South Atlantic Red Grouper. SEDAR, North Charleston, SC.

SEDAR24, 2010. SEDAR 24: South Atlantic Red Snapper. SEDAR, North Charleston, SC.

SEDAR4, 2004. SEDAR 4: Stock assessment of the deepwater snapper-grouper complex in the South Atlantic. SEDAR, North Charleston, SC.

SEDAR41-AW05, 2015. Commercial age and length composition weightings for Atlantic red snapper (Lutjanus campechanus).

SEDAR41-AW08, 2015. South Atlantic U.S. Atlantic red snapper (Lutjanus campechanus) catch curve analysis.

SEDAR41-DW49, 2015. Estimating annual fecundity of Red Snapper by size using nonlinear models. SEDAR41-DW49. SEDAR, North Charleston, SC.

SEDAR41-RW07, 2016. Modifications to the Southeast Reef Fish Survey Chevron Trap Age Compositions for Red Snapper and Gray Triggerfish.

Shertzer, K. W., M. H. Prager, D. S. Vaughan, and E. H. Williams, 2008. Fishery models. Pages 1582–1593 *in* S. E. Jorgensen and F. Fath, editors. Population Dynamics. Vol. [2] of Encyclopedia of Ecology, 5 vols. Elsevier, Oxford.

Then, A. Y., J. M. Hoenig, N. G. Hall, and D. A. Hewitt. 2014. Evaluating the predictive performance of empirical estimators of natural mortality rate using information on over 200 fish species. ICES Journal of Marine Science **72**:82–92.

Wells, R. D., K. M. Boswell, J. H. Cowan Jr., and W. F. Patterson. 2008. Size selectivity of sampling gears targeting red snapper in the northern Gulf of Mexico. Fisheries Research **89**:294–299.

Williams, E. H., and K. W. Shertzer, 2015. Technical documentation of the Beaufort Assessment Model (BAM). NOAA Technical Memorandum-NMFS-SEFSC-671.

7 Tables

Table 1. Life-history characteristics at age, including average body total length (TL) and weight (mid-year), proportion female, annual proportion females mature, and natural mortality at age. The CV of length was estimated by the assessment model; other values were treated as input.

Age	Avg. TL (mm)	Avg. TL (in)	CV length	Avg. Whole weight (kg)	Avg. Whole weight (lb)	Fem. maturity	Proportion Female	Nat. mortality
1	323.9	12.8	0.1	0.53	1.17	0.43	0.5	0.595
2	449.3	17.7	0.1	1.41	3.10	0.73	0.5	0.364
3	547.9	21.6	0.1	2.55	5.62	0.91	0.5	0.271
4	625.4	24.6	0.1	3.78	8.34	0.97	0.5	0.222
5	686.4	27.0	0.1	5.00	11.02	0.99	0.5	0.193
6	734.4	28.9	0.1	6.12	13.49	1.00	0.5	0.174
7	772.2	30.4	0.1	7.11	15.67	1.00	0.5	0.162
8	801.9	31.6	0.1	7.96	17.54	1.00	0.5	0.153
9	825.2	32.5	0.1	8.67	19.12	1.00	0.5	0.146
10	843.6	33.2	0.1	9.26	20.42	1.00	0.5	0.142
11	858.1	33.8	0.1	9.74	21.48	1.00	0.5	0.138
12	869.4	34.2	0.1	10.13	22.34	1.00	0.5	0.135
13	878.4	34.6	0.1	10.45	23.04	1.00	0.5	0.133
14	885.4	34.9	0.1	10.70	23.59	1.00	0.5	0.132
15	891.0	35.1	0.1	10.90	24.04	1.00	0.5	0.130
16	895.3	35.2	0.1	11.06	24.39	1.00	0.5	0.129
17	898.7	35.4	0.1	11.19	24.67	1.00	0.5	0.129
18	901.4	35.5	0.1	11.29	24.89	1.00	0.5	0.128
19	903.5	35.6	0.1	11.37	25.07	1.00	0.5	0.128
20	905.2	35.6	0.1	11.43	25.21	1.00	0.5	0.127

Table 2. Size (TL) in inches and weight in pounds (lb) at age as applied to the population (Pop), fishery–dependent portion of the population (FD), and fishery–dependent portion of the population during the 20 mm size limit (FD20). The CV of length was estimated by the assessment model; other values were treated as input through the von Bertalanffy growth parameters.

Age	Pop.TL	CV.Pop.TL	Pop.lb	FD.TL	CV.FD.TL	FD.lb	FD20.TL	CV.FD20.TL	FD20.lb
1	12.8	0.1	1.2	11.2	0.14	0.8	16.2	0.1	2.4
2	17.7	0.1	3.1	16.2	0.14	2.4	19.5	0.1	4.1
3	21.6	0.1	5.6	20.2	0.14	4.6	22.2	0.1	6.1
4	24.6	0.1	8.3	23.4	0.14	7.2	24.5	0.1	8.2
5	27.0	0.1	11.0	26.0	0.14	9.8	26.5	0.1	10.3
6	28.9	0.1	13.5	28.1	0.14	12.3	28.1	0.1	12.4
7	30.4	0.1	15.7	29.7	0.14	14.7	29.5	0.1	14.3
8	31.6	0.1	17.5	31.1	0.14	16.7	30.6	0.1	16.0
9	32.5	0.1	19.1	32.1	0.14	18.5	31.6	0.1	17.6
10	33.2	0.1	20.4	33.0	0.14	20.0	32.5	0.1	19.0
11	33.8	0.1	21.5	33.7	0.14	21.3	33.2	0.1	20.3
12	34.2	0.1	22.3	34.2	0.14	22.4	33.7	0.1	21.4
13	34.6	0.1	23.0	34.7	0.14	23.3	34.2	0.1	22.4
14	34.9	0.1	23.6	35.0	0.14	24.0	34.7	0.1	23.2
15	35.1	0.1	24.0	35.3	0.14	24.6	35.0	0.1	23.9
16	35.2	0.1	24.4	35.6	0.14	25.0	35.3	0.1	24.5
17	35.4	0.1	24.7	35.7	0.14	25.4	35.6	0.1	25.1
18	35.5	0.1	24.9	35.9	0.14	25.8	35.8	0.1	25.5
19	35.6	0.1	25.1	36.0	0.14	26.0	36.0	0.1	25.9
20	35.6	0.1	25.2	36.1	0.14	26.2	36.1	0.1	26.2

Table 3. Observed time series of landings(L) and discards(D) for commercial lines (cH), headboat (HB), and general recreational (GR). Commercial landings are in units of 1000 lb whole weight. Recreational landings and discards and commercial discards are in units of 1000 fish. Confidential data have been redacted.

Year	cH.L	HB.L	GR.L	cH.D	HB.D	GR.D
1950	368.657	.	.	.	.	.
1951	499.765	.	.	.	.	.
1952	385.930	.	.	.	.	.
1953	398.279	.	.	.	.	.
1954	593.207	.	.	.	.	.
1955	493.315	12.501	24.035	.	.	.
1956	483.907	13.652	26.248	.	.	.
1957	867.291	14.803	28.460	.	.	.
1958	612.508	15.953	30.673	.	.	.
1959	657.736	17.104	32.885	.	.	.
1960	671.075	18.255	35.098	.	.	.
1961	796.374	19.908	38.276	.	.	.
1962	645.983	21.561	41.454	.	.	.
1963	488.789	23.214	44.633	.	.	.
1964	537.589	24.867	47.811	.	.	.
1965	558.108	26.520	50.989	.	.	.
1966	554.506	26.676	51.288	.	.	.
1967	725.503	26.831	51.587	.	.	.
1968	865.520	26.986	51.885	.	.	.
1969	538.190	27.142	52.184	.	.	.
1970	513.023	27.297	52.483	.	.	.
1971	457.393	29.995	57.670	.	.	.
1972	406.641	32.693	62.857	.	.	.
1973	296.560	35.391	68.044	.	.	.
1974	478.352	38.088	73.231	.	.	.
1975	600.790	40.786	78.418	.	.	.
1976	571.504	41.246	79.303	.	.	.
1977	596.339	41.707	80.187	.	.	.
1978	594.356	42.167	81.072	.	.	.
1979	420.936	42.627	81.957	.	.	.
1980	385.485	43.087	82.842	.	.	.
1981	378.759	36.031	93.458	.	.	4.435
1982	308.445	19.553	36.294	.	.	4.435
1983	316.818	30.698	68.469	.	.	4.435
1984	253.431	31.146	212.547	.	0.069	61.825
1985	250.824	50.336	288.971	.	0.111	64.088
1986	219.440	16.625	100.736	.	0.037	64.088
1987	191.701	24.996	47.373	.	0.055	64.088
1988	173.689	36.527	80.821	.	0.08	50.274
1989	266.942	23.453	97.147	.	0.052	19.383
1990	226.542	20.919	12.092	.	0.046	19.383
1991	143.546	13.857	34.717	.	0.03	19.383
1992	104.374	5.301	51.908	19.603	2.51	27.994
1993	220.153	7.347	11.326	16.725	3.478	68.149
1994	195.319	8.225	18.313	21.134	3.894	66.54
1995	177.312	8.826	13.482	21.068	4.178	50.89
1996	138.671	5.543	9.342	20.727	2.624	20.445
1997	110.595	5.770	34.238	22.392	2.732	16.574
1998	89.602	4.741	13.015	16.171	2.244	26.789
1999	93.595	6.836	39.579	13.641	3.236	162.71
2000	104.165	8.437	45.347	14.552	3.994	248.597
2001	196.697	12.028	31.587	15.141	5.694	202.665
2002	187.967	12.931	35.062	29.848	6.122	123.362
2003	138.342	5.706	25.977	8.372	2.701	159.329
2004	172.083	10.842	28.914	2.425	18.79	199.638
2005	129.700	8.907	29.443	10.177	9.876	72.855
2006	86.382	5.945	26.769	4.817	17.233	119.735
2007	114.973	6.889	17.646	13.778	71.886	288.276
2008	252.146	18.943	81.638	12.553	73.609	511.984
2009	362.386	21.507	54.666	14.466	57.327	240.516
2010	6.448	0.477	0.062	17.438	38.443	138.478
2011	− − −	− − −	0.062	40.107	41.391	33.484
2012	8.142	2.127	15.628	19.214	46.782	142.961
2013	31.600	1.520	7.588	19.302	46.74	83.992
2014	65.443	5.904	28.186	27.008	46.612	285.962

Table 4. Observed indices of abundance and CVs from commercial line (cH), headboat (HB), combined chevon trap and video (CVID), and headboat discard (HB.D).

Year	cH	cH CV	HB	HB CV	CVID	CVID CV	HB.D	HB.D CV
1976	.	.	2.37	0.2	.	.	.	.
1977	.	.	2.16	0.2	.	.	.	.
1978	.	.	2.13	0.2	.	.	.	.
1979	.	.	2.23	0.2	.	.	.	.
1980	.	.	1.45	0.2	.	.	.	.
1981	.	.	2.95	0.2	.	.	.	.
1982	.	.	1.20	0.2	.	.	.	.
1983	.	.	1.64	0.2	.	.	.	.
1984	.	.	1.42	0.2	.	.	.	.
1985	.	.	2.07	0.2	.	.	.	.
1986	.	.	0.48	0.2	.	.	.	.
1987	.	.	0.58	0.2	.	.	.	.
1988	.	.	0.56	0.2	.	.	.	.
1989	.	.	0.90	0.2	.	.	.	.
1990	.	.	0.87	0.2	.	.	.	.
1991	.	.	0.69	0.2	.	.	.	.
1992	.	.	0.08	0.2	.	.	.	.
1993	1.09	0.2	0.16	0.2	.	.	.	.
1994	0.89	0.2	0.26	0.2	.	.	.	.
1995	0.89	0.2	0.28	0.2	.	.	.	.
1996	0.61	0.2	0.25	0.2	.	.	.	.
1997	0.59	0.2	0.27	0.2	.	.	.	.
1998	0.66	0.2	0.24	0.2	.	.	.	.
1999	0.80	0.2	0.29	0.2	.	.	.	.
2000	0.74	0.2	0.41	0.2	.	.	.	.
2001	1.27	0.2	0.76	0.2	.	.	.	.
2002	1.38	0.2	0.88	0.2	.	.	.	.
2003	1.04	0.2	0.52	0.2	.	.	.	.
2004	1.42	0.2	0.76	0.2	.	.	.	.
2005	1.19	0.2	0.76	0.2	.	.	0.33	0.34
2006	0.60	0.2	0.43	0.2	.	.	0.4	0.4
2007	0.67	0.2	0.44	0.2	.	.	2.49	0.19
2008	1.22	0.2	1.71	0.2	.	.	1.99	0.29
2009	1.94	0.2	1.81	0.2	.	.	0.95	0.26
2010	.	.	.	.	0.90	0.26	0.44	0.29
2011	.	.	.	.	0.66	0.23	0.46	0.34
2012	.	.	.	.	1.10	0.18	1.16	0.25
2013	.	.	.	.	0.87	0.20	0.96	0.27
2014	.	.	.	.	1.47	0.17	0.82	0.28

Table 5. Sample sizes (number of trips) of length compositions (len) or age compositions (age) by survey or fleet. Data sources are commercial lines (cH), headboat (HB), headboat discard (HB.D), general recreational (GR),and MARMAP chevron trap (CVT).

Year	len.cH	len.cH.D	len.HB.D	age.cH	age.HB	age.GR	age.CVT
1978	.	.	.	.	80	.	.
1979	.	.	.	.	31	.	.
1980	.	.	.	.	30	.	.
1981	.	.	.	.	141	.	.
1982	.	.	.	.	55	.	.
1983	.	.	.	.	167	.	.
1984	125	.	.	.	166	.	.
1985	139	.	.	.	160	.	.
1986	94	.	.	.	97	.	.
1987	89	.	.	.	60	.	.
1988	84	.	.	.	.	.	.
1989	88	.	.	.	.	.	.
1990	63	.	.	11	23	.	.
1991	106	.	.	.	13	.	.
1992	82	.	.	11	.	.	.
1993	.	.	.	.	.	.	.
1994	.	.	.	14	.	.	.
1995	.	.	.	.	.	.	.
1996	.	.	.	48	.	.	.
1997	.	.	.	45	.	.	.
1998	.	.	.	14	.	.	.
1999	.	.	.	15	.	.	.
2000	.	.	.	28	.	.	.
2001	.	.	.	23	.	15	.
2002	.	.	.	.	.	84	.
2003	.	.	.	10	.	91	.
2004	.	.	.	25	.	83	.
2005	.	.	37	53	22	78	.
2006	.	.	29	84	49	26	.
2007	.	.	64	132	34	.	.
2008	.	.	61	158	47	.	.
2009	.	13	56	263	241	58	.
2010	.	.	50	.	.	.	73
2011	.	.	48	.	.	.	70
2012	.	.	56	39	40	121	148
2013	.	13	60	109	35	139	139
2014	.	.	56	64	49	315	150

Table 6. Coefficients of variation used for the MCB bootstraps of landings and discards. Commercial handline landings (cv.L.cH), headboat landings (cv.L.HB), general recreational landings (cv.L.GR), commercial handline discards (cv.D.cH), headboat discards (cv.D.HB), and general recreational discards (cv.D.GR).

Year	CV.L.cH	CV.L.HB	CV.L.GR	CV.D.cH	CV.D.HB	CV.D.GR
1950	0.25	–	–	–	–	–
1951	0.25	–	–	–	–	–
1952	0.25	–	–	–	–	–
1953	0.25	–	–	–	–	–
1954	0.25	–	–	–	–	–
1955	0.25	0.59	0.59	–	–	–
1956	0.25	0.59	0.59	–	–	–
1957	0.25	0.59	0.59	–	–	–
1958	0.25	0.59	0.59	–	–	–
1959	0.25	0.59	0.59	–	–	–
1960	0.25	0.59	0.59	–	–	–
1961	0.25	0.59	0.59	–	–	–
1962	0.20	0.59	0.59	–	–	–
1963	0.20	0.59	0.59	–	–	–
1964	0.20	0.59	0.59	–	–	–
1965	0.20	0.59	0.59	–	–	–
1966	0.20	0.59	0.59	–	–	–
1967	0.20	0.59	0.59	–	–	–
1968	0.20	0.59	0.59	–	–	–
1969	0.20	0.59	0.59	–	–	–
1970	0.20	0.59	0.59	–	–	–
1971	0.20	0.59	0.59	–	–	–
1972	0.20	0.59	0.59	–	–	–
1973	0.20	0.59	0.59	–	–	–
1974	0.20	0.59	0.59	–	–	–
1975	0.20	0.59	0.59	–	–	–
1976	0.20	0.59	0.59	–	–	–
1977	0.20	0.59	0.59	–	–	–
1978	0.10	0.59	0.59	–	–	–
1979	0.10	0.59	0.59	–	–	–
1980	0.10	0.59	0.59	–	–	–
1981	0.10	0.15	0.27	–	–	1.00
1982	0.10	0.15	0.34	–	–	1.00
1983	0.10	0.15	0.18	–	–	1.00
1984	0.10	0.15	0.22	–	0.20	0.56
1985	0.10	0.15	0.20	–	0.20	1.34
1986	0.05	0.15	0.29	–	0.20	1.00
1987	0.05	0.15	0.20	–	0.20	1.00
1988	0.05	0.15	0.28	–	0.20	1.33
1989	0.05	0.15	0.21	–	0.20	1.18
1990	0.05	0.15	0.29	–	0.20	1.00
1991	0.05	0.15	0.31	–	0.20	1.00
1992	0.05	0.15	0.19	0.20	0.20	0.79
1993	0.05	0.15	0.22	0.20	0.20	0.68
1994	0.05	0.15	0.27	0.20	0.20	0.81
1995	0.05	0.15	0.29	0.20	0.20	0.53
1996	0.05	0.10	0.42	0.20	0.20	1.00
1997	0.05	0.10	0.52	0.20	0.20	0.54
1998	0.05	0.10	0.24	0.20	0.20	0.96
1999	0.05	0.10	0.23	0.20	0.20	0.47
2000	0.05	0.10	0.23	0.20	0.20	0.45
2001	0.05	0.10	0.18	0.20	0.20	0.42
2002	0.05	0.10	0.17	0.20	0.20	0.56
2003	0.05	0.10	0.20	0.20	0.20	0.47
2004	0.05	0.10	0.21	0.20	0.20	0.29
2005	0.05	0.10	0.24	0.20	0.20	0.23
2006	0.05	0.10	0.26	0.20	0.20	0.31
2007	0.05	0.10	0.24	0.20	0.20	0.26
2008	0.05	0.05	0.27	0.20	0.20	0.36
2009	0.05	0.05	0.25	0.20	0.20	0.38
2010	0.05	0.05	1.00	0.20	0.20	0.39
2011	0.05	0.05	1.00	0.20	0.20	0.34
2012	0.05	0.05	0.17	0.20	0.20	0.39
2013	0.05	0.05	0.18	0.20	0.20	0.31
2014	0.05	0.05	0.11	0.20	0.20	0.21

Table 7. Estimated total abundance at age (1000 fish) at start of year.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1950	448.20	247.12	169.84	125.87	97.87	78.34	63.91	52.77	43.96	36.88	31.07	26.27	22.29	18.94	16.12	13.74	11.72	10.00	8.55	50.37	1573.85
1951	448.20	247.12	169.75	125.71	97.75	78.24	63.83	52.70	43.91	36.84	31.03	26.24	22.26	18.92	16.10	13.72	11.71	9.99	8.54	50.30	1572.86
1952	448.19	247.09	169.04	124.30	96.54	77.27	63.04	52.05	43.36	36.38	30.64	25.91	21.98	18.68	15.90	13.55	11.56	9.87	8.43	49.68	1563.45
1953	448.19	247.11	169.61	124.90	96.34	77.03	62.84	51.88	43.22	36.26	30.55	25.83	21.91	18.62	15.85	13.51	11.53	9.84	8.40	49.52	1562.94
1954	448.18	247.10	169.55	125.18	96.70	76.79	62.57	51.66	43.04	36.11	30.41	25.72	21.82	18.54	15.78	13.45	11.48	9.79	8.37	49.31	1561.56
1955	448.17	247.05	168.47	123.08	95.28	75.76	61.32	50.57	42.13	35.34	29.77	25.18	21.36	18.15	15.44	13.17	11.23	9.59	8.19	48.26	1547.50
1956	448.13	246.27	161.68	115.37	88.99	71.61	58.66	48.54	40.74	34.41	29.12	24.63	20.89	17.75	15.10	12.88	10.99	9.38	8.01	47.21	1510.35
1957	448.09	246.14	160.15	109.64	82.67	66.38	55.10	46.21	38.97	33.19	28.29	24.04	20.39	17.33	14.74	12.57	10.73	9.15	7.82	46.08	1477.69
1958	448.01	245.87	156.61	103.41	74.79	58.79	48.77	41.52	35.54	30.44	26.19	22.41	19.10	16.23	13.81	11.77	10.05	8.57	7.32	43.16	1422.36
1959	447.91	245.76	156.56	102.08	71.33	53.86	43.82	37.35	32.49	28.27	24.48	21.14	18.15	15.50	13.18	11.24	9.59	8.19	6.99	41.21	1389.12
1960	447.81	245.57	154.94	100.16	69.17	50.53	39.56	33.11	28.88	25.57	22.50	19.56	16.95	14.58	12.46	10.62	9.06	7.73	6.61	38.94	1354.30
1961	447.69	245.37	153.37	97.47	66.79	48.29	36.64	29.56	25.35	22.52	20.19	17.84	15.55	13.50	11.62	9.96	8.50	7.25	6.19	36.50	1320.15
1962	447.52	245.05	150.43	92.97	62.68	45.07	33.93	26.59	22.02	19.27	17.35	15.61	13.84	12.09	10.50	9.06	7.77	6.63	5.66	33.38	1277.43
1963	447.34	244.81	149.35	90.83	59.67	42.32	31.76	24.75	19.96	16.89	15.00	13.56	12.23	10.87	9.50	8.27	7.14	6.12	5.23	30.83	1246.44
1964	447.18	244.59	148.74	90.39	58.55	40.55	30.08	23.43	18.82	15.53	13.35	11.90	10.79	9.76	8.67	7.60	6.62	5.72	4.91	28.93	1226.11
1965	446.99	244.28	146.42	87.60	56.77	38.85	28.22	21.77	17.51	14.42	12.10	10.44	9.33	8.48	7.68	6.84	6.00	5.23	4.52	26.75	1200.20
1966	446.77	243.94	144.01	83.93	53.62	36.81	26.49	20.07	16.03	13.24	11.10	9.35	8.09	7.25	6.59	5.98	5.33	4.68	4.08	24.42	1171.76
1967	446.51	243.71	142.75	81.39	50.68	34.33	24.82	18.65	14.64	12.02	10.11	8.51	7.19	6.23	5.59	5.09	4.62	4.12	3.62	22.08	1146.66
1968	446.14	243.33	139.35	76.51	46.59	30.80	22.00	16.63	12.97	10.47	8.76	7.40	6.24	5.28	4.59	4.12	3.76	3.41	3.05	19.01	1110.41
1969	445.55	242.80	135.12	69.95	41.00	26.56	18.56	13.89	10.91	8.77	7.22	6.06	5.14	4.34	3.68	3.20	2.88	2.63	2.39	15.44	1066.07
1970	444.99	242.56	137.16	71.34	39.54	24.69	16.93	12.41	9.67	7.83	6.42	5.31	4.47	3.79	3.21	2.73	2.37	2.14	1.95	13.24	1052.74
1971	444.50	242.22	136.61	71.99	40.09	23.68	15.66	11.27	8.60	6.91	5.71	4.70	3.90	3.29	2.80	2.37	2.01	1.75	1.58	11.25	1040.89
1972	444.02	241.66	134.40	70.33	39.80	23.72	14.90	10.38	7.81	6.16	5.06	4.20	3.47	2.88	2.43	2.07	1.76	1.50	1.30	9.54	1027.37
1973	443.53	241.07	131.86	67.68	38.16	23.21	14.78	9.83	7.18	5.60	4.53	3.74	3.11	2.57	2.14	1.81	1.54	1.31	1.11	8.09	1012.86
1974	443.13	240.54	130.42	66.37	36.85	22.43	14.64	9.92	6.95	5.28	4.23	3.43	2.84	2.37	1.96	1.63	1.39	1.18	1.00	7.05	1003.62
1975	442.41	239.62	123.15	58.64	32.34	19.50	12.83	8.97	6.43	4.70	3.68	2.96	2.41	2.00	1.67	1.38	1.16	0.98	0.84	5.71	971.39
1976	440.88	238.23	113.91	47.92	24.83	15.02	9.89	7.04	5.26	3.96	3.00	2.36	1.90	1.55	1.29	1.08	0.89	0.75	0.63	4.23	924.61
1977	438.36	236.64	107.35	40.16	18.46	10.57	7.05	5.07	3.88	3.06	2.40	1.82	1.44	1.16	0.95	0.79	0.66	0.55	0.46	2.99	883.81
1978	490.78	234.27	98.35	32.15	13.18	6.76	4.31	3.17	2.47	2.01	1.66	1.30	0.99	0.78	0.63	0.52	0.43	0.36	0.30	1.89	896.34
1979	363.96	260.76	87.23	23.53	8.46	3.92	2.27	1.62	1.30	1.09	0.93	0.77	0.61	0.46	0.37	0.30	0.24	0.20	0.17	1.03	759.23
1980	539.19	193.18	96.76	21.20	6.32	2.58	1.36	0.88	0.69	0.60	0.53	0.45	0.38	0.30	0.23	0.18	0.15	0.12	0.10	0.59	865.79
1981	186.41	284.13	63.96	19.23	4.71	1.63	0.77	0.46	0.34	0.29	0.27	0.23	0.20	0.17	0.13	0.10	0.08	0.07	0.05	0.31	563.53
1982	307.89	97.40	88.82	11.21	3.77	1.07	0.43	0.23	0.16	0.13	0.11	0.11	0.09	0.08	0.07	0.05	0.04	0.03	0.03	0.15	511.87
1983	878.93	163.24	36.96	20.86	2.86	1.07	0.34	0.15	0.09	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.01	0.07	1104.92
1984	999.37	458.86	45.27	4.82	3.02	0.48	0.21	0.08	0.04	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	1512.31
1985	458.06	507.73	129.72	7.48	0.92	0.69	0.13	0.07	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.01	1104.93
1986	228.35	225.81	125.77	18.96	1.31	0.20	0.19	0.05	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	600.73
1987	784.38	112.09	87.32	37.54	6.38	0.50	0.09	0.09	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1028.46
1988	576.82	406.58	50.66	32.13	15.16	2.84	0.24	0.05	0.05	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	1084.58
1989	215.42	301.94	194.02	20.83	14.48	7.51	1.54	0.14	0.03	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	755.97
1990	69.98	113.91	147.92	82.21	9.63	7.31	4.12	0.91	0.09	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	436.13
1991	63.82	36.48	66.17	84.38	50.19	6.19	4.90	2.86	0.65	0.07	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	315.75
1992	338.34	31.78	18.77	33.07	46.35	29.83	3.94	3.32	2.03	0.48	0.05	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	507.98
1993	118.87	172.64	19.71	8.50	10.74	16.91	13.01	2.04	1.98	1.34	0.34	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	366.14
1994	210.63	54.54	100.84	8.76	2.76	3.87	6.95	5.98	1.02	1.05	0.74	0.19	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	397.38
1995	97.19	97.24	31.92	46.52	2.99	1.03	1.63	3.26	3.05	0.55	0.59	0.43	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00	286.55
1996	253.91	42.82	54.98	14.64	16.41	1.17	0.45	0.80	1.72	1.71	0.32	0.35	0.26	0.07	0.01	0.00	0.00	0.00	0.00	0.00	389.61
1997	172.65	129.31	27.19	29.34	6.28	7.54	0.58	0.25	0.46	1.03	1.05	0.20	0.22	0.16	0.04	0.00	0.00	0.00	0.00	0.00	376.30
1998	322.66	87.46	77.95	9.48	5.88	1.46	2.22	0.22	0.11	0.23	0.58	0.62	0.12	0.14	0.10	0.03	0.00	0.00	0.00	0.00	509.24
1999	436.64	167.71	56.50	42.70	4.21	2.80	0.76	1.26	0.13	0.07	0.15	0.38	0.42	0.08	0.09	0.07	0.02	0.00	0.00	0.00	714.00
2000	442.42	203.70	98.01	24.16	12.76	1.42	1.13	0.36	0.69	0.08	0.04	0.10	0.26	0.29	0.06	0.06	0.05	0.01	0.00	0.00	785.62
2001	323.07	192.88	113.53	41.23	7.21	4.30	0.57	0.53	0.20	0.41	0.05	0.03	0.07	0.18	0.20	0.04	0.05	0.03	0.01	0.00	684.60
2002	268.67	139.89	108.50	52.48	14.48	2.78	1.88	0.28	0.29	0.11	0.25	0.03	0.02	0.04	0.11	0.13	0.03	0.03	0.02	0.01	590.04
2003	346.83	119.88	79.98	51.09	19.20	5.86	1.28	0.97	0.16	0.17	0.07	0.16	0.02	0.01	0.03	0.08	0.08	0.02	0.02	0.02	625.93
2004	128.50	157.16	70.55	43.92	24.16	9.77	3.26	0.77	0.63	0.11	0.12	0.05	0.12	0.01	0.01	0.02	0.06	0.06	0.01	0.03	439.31
2005	52.34	44.17	75.58	32.50	17.10	10.48	4.79	1.78	0.46	0.40	0.07	0.08	0.03	0.08	0.01	0.01	0.01	0.04	0.04	0.03	240.01
2006	942.72	17.68	20.67	33.07	11.87	7.06	4.99	2.59	1.06	0.30	0.27	0.05	0.06	0.02	0.06	0.01	0.00	0.01	0.03	0.05	1042.56
2007	653.29	480.63	11.07	9.31	10.57	4.26	3.01	2.49	1.48	0.67	0.20	0.19	0.03	0.04	0.02	0.04	0.01	0.00	0.01	0.06	1177.37
2008	736.26	296.64	279.22	4.79	2.89	3.68	1.72	1.39	1.28	0.82	0.39	0.12	0.11	0.02	0.03	0.01	0.02	0.00	0.00	0.04	1329.44
2009	113.51	293.11	154.42	105.26	1.19	0.81	1.25	0.70	0.65	0.67	0.46	0.23	0.07	0.07	0.01	0.02	0.01	0.02	0.00	0.02	672.46
2010	144.25	39.53	140.62	62.97	32.07	0.41	0.32	0.56	0.35	0.35	0.37	0.26	0.13	0.04	0.04	0.01	0.01	0.00	0.01	0.02	422.31
2011	212.06	67.20	22.10	82.13	38.03	20.31	0.27	0.23	0.42	0.27	0.28	0.30	0.21	0.10	0.03	0.03	0.01	0.01	0.00	0.02	443.99
2012	227.48	110.51	42.57	14.38	54.64	26.14	14.42	0.20	0.17	0.32	0.21	0.21	0.23	0.16	0.08	0.03	0.02	0.00	0.01	0.02	491.78
2013	506.39	109.61	63.60	24.45	7.85	29.93	14.96	8.65	0.12	0.11	0.21	0.14	0.14	0.15	0.11	0.05	0.02	0.02	0.00	0.02	766.53
2014	859.61	262.50	69.29	41.06	15.43	5.01	19.69	10.12	6.00	0.09	0.08	0.15	0.10	0.10	0.11	0.08	0.04	0.01	0.01	0.01	1289.51
2015	431.84	430.16	156.09	38.69	19.63	7.06	2.36	9.65	5.14	3.13	0.05	0.04	0.08	0.05	0.06	0.06	0.04	0.02	0.01	0.01	1104.18

Table 8. Estimated biomass at age (mt) at start of year

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1950	237.3	347.9	432.7	476.4	489.3	479.4	454.3	419.9	381.2	341.6	302.7	266.3	232.9	202.7	175.7	152.0	131.2	113.0	97.2	575.9	6309.5
1951	237.3	347.9	432.5	475.8	488.7	478.8	453.7	419.4	380.7	341.1	302.3	265.9	232.6	202.5	175.5	151.8	131.0	112.8	97.1	575.1	6302.5
1952	237.3	347.8	430.7	470.5	482.6	472.8	448.1	414.2	376.0	336.9	298.6	262.6	229.7	199.9	173.3	149.9	129.4	111.4	95.8	568.0	6235.5
1953	237.3	347.9	432.1	472.7	481.7	471.3	446.7	412.8	374.8	335.8	297.6	261.8	229.0	199.3	172.8	149.4	129.0	111.1	95.5	566.2	6224.8
1954	237.3	347.8	432.0	473.8	483.5	469.9	444.8	411.1	373.2	334.4	296.3	260.7	228.0	198.5	172.0	148.8	128.4	110.6	95.1	563.8	6209.9
1955	237.3	347.8	429.2	465.9	476.3	463.6	435.9	402.4	365.3	327.3	290.1	255.2	223.2	194.3	168.4	145.7	125.7	108.2	93.1	551.8	6106.4
1956	237.2	346.7	411.9	436.7	444.9	438.2	417.0	386.2	353.3	318.7	283.7	249.6	218.3	190.0	164.7	142.5	123.0	105.9	91.1	539.7	5899.1
1957	237.2	346.5	408.0	415.0	413.3	406.2	391.7	367.7	337.9	307.4	275.7	243.6	213.1	185.5	160.8	139.1	120.0	103.4	88.9	526.9	5687.7
1958	237.2	346.1	399.0	391.4	373.9	359.7	346.7	330.4	308.1	281.9	255.1	227.1	199.6	173.7	150.6	130.2	112.4	96.8	83.3	493.4	5296.7
1959	237.1	346.0	398.9	386.4	356.6	329.6	311.5	297.2	281.7	261.8	238.5	214.3	189.6	165.9	143.8	124.4	107.3	92.4	79.5	471.1	5033.6
1960	237.1	345.7	394.7	379.1	345.8	309.2	281.2	263.5	250.4	236.8	219.3	198.3	177.1	156.0	135.8	117.5	101.4	87.3	75.1	445.2	4756.4
1961	237.0	345.4	390.7	368.9	333.9	295.5	260.5	235.2	219.8	208.6	196.7	180.8	162.5	144.5	126.7	110.1	95.1	81.9	70.4	417.3	4481.6
1962	236.9	345.0	383.2	351.9	313.4	275.8	241.2	211.6	190.9	178.5	169.1	158.2	144.6	129.4	114.5	100.3	86.9	74.9	64.4	381.6	4152.2
1963	236.8	344.6	380.5	343.8	298.3	258.9	225.8	197.0	173.0	156.4	146.1	137.4	127.8	116.3	103.6	91.5	79.9	69.2	59.5	352.5	3899.1
1964	236.7	344.3	378.9	342.1	292.7	248.1	213.8	186.4	163.2	143.8	130.1	120.6	112.7	104.4	94.6	84.1	74.1	64.6	55.8	330.8	3722.0
1965	236.6	343.9	373.0	331.6	283.8	237.7	200.6	173.3	151.9	133.6	117.9	105.8	97.5	90.7	83.7	75.7	67.1	59.0	51.4	305.9	3520.6
1966	236.5	343.4	366.9	317.7	268.1	225.2	188.3	159.7	139.0	122.6	108.1	94.7	84.5	77.6	71.9	66.1	59.7	52.8	46.4	279.2	3308.4
1967	236.4	343.1	363.7	308.1	253.4	210.1	176.4	148.4	126.9	111.3	98.5	86.2	75.1	66.7	60.9	56.3	51.7	46.5	41.2	252.5	3113.3
1968	236.2	342.5	355.0	289.6	232.9	188.5	156.4	132.3	112.4	96.9	85.3	74.9	65.2	56.5	50.0	45.6	42.1	38.5	34.6	217.3	2853.1
1969	235.9	341.8	344.2	264.7	205.0	162.5	131.9	110.6	94.6	81.2	70.3	61.4	53.7	46.5	40.1	35.4	32.2	29.6	27.1	176.5	2545.4
1970	235.6	341.5	349.4	270.0	197.7	151.1	120.3	98.8	83.8	72.5	62.5	53.8	46.7	40.6	35.0	30.2	26.6	24.1	22.2	151.4	2413.7
1971	235.3	341.0	348.0	272.5	200.4	144.9	111.3	89.7	74.6	64.0	55.6	47.6	40.7	35.2	30.5	26.2	22.5	19.8	18.0	128.6	2306.5
1972	235.1	340.2	342.4	266.2	199.0	145.1	105.9	82.6	67.7	57.0	49.3	42.6	36.2	30.8	26.5	22.9	19.7	16.9	14.8	109.0	2209.9
1973	234.8	339.4	335.9	256.2	190.8	142.0	105.0	78.2	62.3	51.9	44.1	37.9	32.5	27.5	23.3	20.0	17.3	14.8	12.7	92.5	2119.0
1974	234.6	338.6	332.3	251.2	184.2	137.2	104.1	78.9	60.2	48.9	41.2	34.8	29.7	25.4	21.4	18.1	15.5	13.3	11.4	80.7	2061.7
1975	234.2	337.3	313.7	222.0	161.7	119.3	91.2	71.4	55.8	43.6	35.9	30.0	25.2	21.4	18.2	15.3	12.9	11.1	9.5	65.2	1894.9
1976	233.4	335.4	290.2	181.4	124.1	91.9	70.3	56.0	45.6	36.7	29.2	23.9	19.9	16.6	14.0	11.9	10.0	8.4	7.2	48.4	1654.6
1977	232.1	333.1	273.5	152.0	92.3	64.7	50.1	40.3	33.6	28.3	23.4	18.5	15.0	12.4	10.3	8.7	7.4	6.2	5.2	34.2	1441.3
1978	259.8	329.8	250.6	121.7	65.9	41.4	30.7	25.2	21.4	18.6	16.1	13.2	10.4	8.4	6.9	5.7	4.8	4.1	3.4	21.6	1259.9
1979	192.7	367.1	222.2	89.1	42.3	24.0	16.1	12.9	11.3	10.1	9.1	7.8	6.3	5.0	4.0	3.3	2.7	2.3	1.9	11.8	1041.9
1980	285.4	271.9	246.5	80.2	31.6	15.8	9.6	7.0	6.0	5.6	5.1	4.6	3.9	3.2	2.5	2.0	1.6	1.4	1.1	6.8	992.0
1981	98.7	400.0	163.0	72.8	23.5	9.9	5.5	3.7	2.9	2.7	2.6	2.4	2.1	1.8	1.4	1.1	0.9	0.7	0.6	3.5	799.8
1982	163.0	137.1	226.3	42.4	18.8	6.6	3.1	1.9	1.4	1.2	1.1	1.1	1.0	0.9	0.7	0.6	0.5	0.4	0.3	1.7	609.8
1983	465.3	229.8	94.2	79.0	14.3	6.5	2.4	1.2	0.8	0.6	0.5	0.5	0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.8	897.9
1984	529.1	645.9	115.3	18.3	15.1	3.0	1.5	0.6	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.3	1330.7
1985	242.5	714.7	330.5	28.3	4.6	4.3	1.0	0.6	0.3	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.2	1327.6
1986	120.9	317.9	320.4	71.8	6.6	1.2	1.4	0.4	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	841.4
1987	415.2	157.8	222.5	142.1	31.9	3.1	0.6	0.7	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	974.6
1988	305.4	572.3	129.1	121.6	75.8	17.4	1.7	0.4	0.5	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1224.6
1989	114.0	425.0	494.3	78.8	72.4	45.9	10.9	1.1	0.3	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1243.5
1990	37.0	160.3	376.8	311.2	48.1	44.7	29.3	7.2	0.8	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1016.2
1991	33.8	51.4	168.6	319.4	250.9	37.9	34.8	22.7	5.6	0.6	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	926.2
1992	179.1	44.7	47.8	125.2	231.7	182.6	28.0	26.4	17.6	4.4	0.5	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	888.4
1993	62.9	243.0	50.2	32.2	53.7	103.5	92.4	16.2	17.1	12.4	3.3	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	687.7
1994	111.5	76.8	256.9	33.2	13.8	23.7	49.4	47.6	8.9	9.7	7.2	1.9	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	641.0
1995	51.5	136.9	81.3	176.1	14.9	6.3	11.6	25.9	26.5	5.1	5.8	4.3	1.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	547.6
1996	134.4	60.3	140.1	55.4	82.0	7.1	3.2	6.3	14.9	15.8	3.1	3.6	2.7	0.7	0.1	0.0	0.0	0.0	0.0	0.0	529.9
1997	91.4	182.0	69.3	111.1	31.4	46.1	4.2	2.0	4.0	9.5	10.2	2.0	2.3	1.7	0.5	0.1	0.0	0.0	0.0	0.0	567.7
1998	170.8	123.1	198.6	35.9	29.4	8.9	15.8	1.7	0.9	2.2	5.6	6.3	1.3	1.5	1.1	0.3	0.0	0.0	0.0	0.0	603.3
1999	231.2	236.1	143.9	161.6	21.1	17.1	5.4	10.0	1.1	0.6	1.5	3.9	4.4	0.9	1.0	0.8	0.2	0.0	0.0	0.0	840.8
2000	234.2	286.7	249.7	91.4	63.8	8.7	8.0	2.9	6.0	0.7	0.4	1.0	2.8	3.1	0.6	0.7	0.5	0.1	0.0	0.0	961.6
2001	171.0	271.5	289.2	156.1	36.1	26.3	4.1	4.3	1.7	3.8	0.5	0.3	0.7	2.0	2.2	0.4	0.5	0.4	0.1	0.0	971.2
2002	142.2	196.9	276.4	198.6	72.4	17.0	13.4	2.2	2.5	1.0	2.4	0.3	0.2	0.5	1.3	1.4	0.3	0.3	0.2	0.1	929.7
2003	183.6	168.8	203.8	193.4	96.0	35.8	9.1	7.7	1.4	1.6	0.7	1.6	0.2	0.1	0.3	0.8	0.9	0.2	0.2	0.2	906.6
2004	68.0	221.2	179.7	166.2	120.8	59.8	23.2	6.2	5.4	1.0	1.2	0.5	1.2	0.2	0.1	0.2	0.6	0.7	0.1	0.3	856.7
2005	27.7	62.2	192.6	123.0	85.5	64.1	34.1	14.2	4.0	3.7	0.7	0.8	0.4	0.8	0.1	0.1	0.2	0.4	0.5	0.3	615.3
2006	499.1	24.9	52.7	125.2	59.4	43.2	35.5	20.6	9.2	2.7	2.6	0.5	0.6	0.3	0.6	0.1	0.0	0.1	0.3	0.6	878.1
2007	345.8	676.6	28.2	35.3	52.8	26.1	21.4	19.9	12.8	6.2	1.9	1.9	0.4	0.4	0.2	0.4	0.1	0.0	0.1	0.6	1231.1
2008	389.8	417.6	711.4	18.1	14.5	22.5	12.3	11.1	11.1	7.6	3.8	1.2	1.2	0.2	0.3	0.1	0.3	0.0	0.0	0.4	1623.4
2009	60.1	412.6	393.4	398.4	5.9	5.0	8.9	5.6	5.7	6.2	4.4	2.3	0.7	0.7	0.1	0.2	0.1	0.2	0.0	0.3	1310.8
2010	76.4	55.6	358.3	238.3	160.3	2.5	2.3	4.5	3.0	3.2	3.6	2.6	1.4	0.4	0.4	0.1	0.1	0.0	0.1	0.2	913.4
2011	112.3	94.6	56.3	310.9	190.1	124.3	1.9	1.8	3.6	2.5	2.7	3.0	2.2	1.1	0.4	0.4	0.1	0.1	0.0	0.2	908.3
2012	120.4	155.6	108.4	54.4	273.2	160.0	102.5	1.6	1.5	2.9	2.0	2.2	2.4	1.7	0.9	0.3	0.3	0.1	0.1	0.2	990.5
2013	268.1	154.3	162.0	92.5	39.2	183.2	106.4	68.9	1.1	1.0	2.0	1.4	1.5	1.6	1.2	0.6	0.2	0.2	0.0	0.2	1085.6
2014	455.1	369.5	176.5	155.4	77.2	30.7	139.9	80.6	52.0	0.8	0.8	1.5	1.0	1.1	1.2	0.9	0.4	0.1	0.1	0.2	1545.1
2015	228.6	605.5	397.7	146.4	98.1	43.2	16.8	76.8	44.6	29.0	0.5	0.4	0.8	0.6	0.6	0.7	0.5	0.2	0.1	0.2	1691.2

Table 9. Estimated biomass at age (1000 lb) at start of year

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total
1950	523.2	767.0	953.9	1050.3	1078.7	1056.9	1001.6	925.7	840.4	753.1	667.3	587.1	513.5	446.9	387.4	335.1	289.2	249.1	214.3	1269.6	13910.0
1951	523.2	767.0	953.5	1049.0	1077.4	1055.6	1000.2	924.6	839.3	752.0	666.5	586.2	512.8	446.4	386.9	334.7	288.8	248.7	214.1	1267.9	13894.6
1952	523.2	766.8	949.5	1037.3	1063.9	1042.3	987.9	913.2	828.9	742.7	658.3	578.9	506.4	440.7	382.1	330.5	285.3	245.6	211.2	1252.2	13746.9
1953	523.2	767.0	952.6	1042.1	1062.0	1039.0	984.8	910.1	826.3	740.3	656.1	577.2	504.9	439.4	381.0	329.4	284.4	244.9	210.5	1248.3	13723.3
1954	523.2	766.8	952.4	1044.5	1065.9	1036.0	980.6	906.3	822.8	737.2	653.2	574.7	502.7	437.6	379.2	328.0	283.1	243.8	209.7	1243.0	13690.5
1955	523.2	766.8	946.2	1027.1	1050.1	1022.1	961.0	887.1	805.3	721.6	639.6	562.6	492.1	428.4	371.3	321.2	277.1	238.5	205.3	1216.5	13462.3
1956	522.9	764.3	908.1	962.8	980.8	966.1	919.3	851.4	778.9	702.6	625.5	550.3	481.3	418.9	363.1	314.2	271.2	233.5	200.8	1189.8	13005.3
1957	522.9	763.9	899.5	914.9	911.2	895.5	863.5	810.6	744.9	677.7	607.8	537.0	469.8	409.0	354.5	306.7	264.6	228.0	196.0	1161.6	12539.2
1958	522.9	763.0	879.6	862.9	824.3	793.0	764.3	728.4	679.2	621.5	562.4	500.7	440.0	382.9	332.0	287.0	247.8	213.4	183.6	1087.8	11677.2
1959	522.7	762.8	879.4	851.9	786.2	726.6	686.7	655.2	621.0	577.2	525.8	472.5	418.0	365.7	317.0	274.3	236.6	203.7	175.3	1038.6	11097.2
1960	522.7	762.1	870.2	835.8	762.4	681.7	619.9	580.9	552.0	522.1	483.5	437.2	390.4	343.9	299.4	259.0	223.5	192.5	165.6	981.5	10486.1
1961	522.5	761.5	861.3	813.3	736.1	651.5	574.3	518.5	484.6	459.9	433.6	398.6	358.3	318.6	279.3	242.7	209.7	180.6	155.2	920.0	9880.2
1962	522.3	760.6	844.8	775.8	690.9	608.0	531.8	466.5	420.9	393.5	372.8	348.8	318.8	285.3	252.4	221.1	191.6	165.1	142.0	841.3	9154.0
1963	522.1	759.7	838.9	757.9	657.6	570.8	497.8	434.3	381.4	344.8	322.1	302.9	281.8	256.4	228.4	201.7	176.1	152.6	131.2	777.1	8596.0
1964	521.8	759.1	835.3	754.2	645.3	547.0	471.3	410.9	359.8	317.0	286.8	265.9	248.5	230.2	208.6	185.4	163.4	142.4	123.0	729.3	8205.6
1965	521.6	758.2	822.3	731.1	625.7	524.0	442.2	382.1	334.9	294.5	259.9	233.2	215.0	200.0	184.5	166.9	147.9	130.1	113.3	674.4	7761.6
1966	521.4	757.1	808.9	700.4	591.1	496.5	415.1	352.1	306.4	270.3	238.3	208.8	186.3	171.1	158.5	145.7	131.6	116.4	102.3	615.5	7293.8
1967	521.2	756.4	801.8	679.2	558.7	463.2	388.9	327.2	279.8	245.4	217.2	190.0	165.6	147.0	134.3	124.1	114.0	102.5	90.8	556.7	6863.6
1968	520.7	755.1	782.6	638.5	513.5	415.6	344.8	291.7	247.8	213.6	188.1	165.1	143.7	124.6	110.2	100.5	92.8	84.9	76.3	479.1	6290.0
1969	520.1	753.5	758.8	583.6	451.9	358.3	290.8	243.8	208.6	179.0	155.0	135.4	118.4	102.5	88.4	78.0	71.0	65.3	59.7	389.1	5611.6
1970	519.4	752.9	770.3	595.2	435.9	333.1	265.2	217.8	184.7	159.8	137.8	118.6	103.0	89.5	77.2	66.6	58.6	53.1	48.9	333.8	5321.3
1971	518.7	751.8	767.2	600.8	441.8	319.4	245.4	197.8	164.5	141.1	122.6	104.9	89.7	77.6	67.2	57.8	49.6	43.7	39.7	283.5	5085.0
1972	518.3	750.0	754.9	586.9	438.7	319.9	233.5	182.1	149.3	125.7	108.7	93.9	79.8	67.9	58.4	50.5	43.4	37.3	32.6	240.3	4872.0
1973	517.6	748.2	740.5	564.8	420.6	313.1	231.5	172.4	137.3	114.4	97.2	83.6	71.7	60.6	51.4	44.1	38.1	32.6	28.0	203.9	4671.6
1974	517.2	746.5	732.6	553.8	406.1	302.5	229.5	173.9	132.7	107.8	90.8	76.7	65.5	56.0	47.2	39.9	34.2	29.3	25.1	177.9	4545.3
1975	516.3	743.6	691.6	489.4	356.5	263.0	201.1	157.4	123.0	96.1	79.1	66.1	55.6	47.2	40.1	33.7	28.4	24.5	20.9	143.7	4177.5
1976	514.6	739.4	639.8	399.9	273.6	202.6	155.0	123.5	100.5	80.9	64.4	52.7	43.9	36.6	30.9	26.2	22.0	18.5	15.9	106.7	3647.8
1977	511.7	734.4	603.0	335.1	203.5	142.6	110.5	88.8	74.1	62.4	51.6	40.8	33.1	27.3	22.7	19.2	16.3	13.7	11.5	75.4	3177.5
1978	572.8	727.1	552.5	268.3	145.3	91.3	67.7	55.6	47.2	41.0	35.5	29.1	22.9	18.5	15.2	12.6	10.6	9.0	7.5	47.6	2777.6
1979	424.8	809.3	489.9	196.4	93.3	52.9	35.5	28.4	24.9	22.3	20.1	17.2	13.9	11.0	8.8	7.3	6.0	5.1	4.2	26.0	2297.0
1980	629.2	599.4	543.4	176.8	69.7	34.8	21.2	15.4	13.2	12.3	11.2	10.1	8.6	7.1	5.5	4.4	3.5	3.1	2.4	15.0	2187.0
1981	217.6	881.8	359.4	160.5	51.8	21.8	12.1	8.2	6.4	6.0	5.7	5.3	4.6	4.0	3.1	2.4	2.0	1.5	1.3	7.7	1763.3
1982	359.4	302.3	498.9	93.5	41.4	14.6	6.8	4.2	3.1	2.6	2.4	2.4	2.2	2.0	1.5	1.3	1.1	0.9	0.7	3.7	1344.4
1983	1025.8	506.6	207.7	174.2	31.5	14.3	5.3	2.6	1.8	1.3	1.1	1.1	1.1	0.9	0.9	0.7	0.4	0.4	0.4	1.8	1979.5
1984	1166.5	1424.0	254.2	40.3	33.3	6.6	3.3	1.3	0.7	0.4	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.7	2933.7
1985	534.6	1575.6	728.6	62.4	10.1	9.5	2.2	1.3	0.7	0.4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.4	2926.9
1986	266.5	700.8	706.4	158.3	14.6	2.6	3.1	0.9	0.4	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1855.0
1987	915.4	347.9	490.5	313.3	70.3	6.8	1.3	1.5	0.4	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2148.6
1988	673.3	1261.7	284.6	268.1	167.1	38.4	3.7	0.9	1.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2699.8
1989	251.3	937.0	1089.7	173.7	159.6	101.2	24.0	2.4	0.7	0.7	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2741.4
1990	81.6	353.4	830.7	686.1	106.0	98.5	64.6	15.9	1.8	0.4	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2240.3
1991	74.5	113.3	371.7	704.2	553.1	83.6	76.7	50.0	12.3	1.3	0.2	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2041.9
1992	394.8	98.5	105.4	276.0	510.8	402.6	61.7	58.2	38.8	9.7	1.1	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1958.6
1993	138.7	535.7	110.7	71.0	118.4	228.2	203.7	35.7	37.7	27.3	7.3	0.9	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1516.1
1994	245.8	169.3	566.4	73.2	30.4	52.2	108.9	104.9	19.6	21.4	15.9	4.2	0.4	0.0	0.2	0.0	0.0	0.0	0.0	0.0	1413.2
1995	113.5	301.8	179.2	388.2	32.8	13.9	25.6	57.1	58.4	11.2	12.8	9.5	2.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1207.2
1996	296.3	132.9	308.9	122.1	180.8	15.7	7.1	13.9	32.8	34.8	6.8	7.9	6.0	1.5	0.2	0.0	0.0	0.0	0.0	0.0	1168.2
1997	201.5	401.2	152.8	244.9	69.2	101.6	9.3	4.4	8.8	20.9	22.5	4.4	5.1	3.7	1.1	0.2	0.0	0.0	0.0	0.0	1251.6
1998	376.5	271.4	437.8	79.1	64.8	19.6	34.8	3.7	2.0	4.9	12.3	13.9	2.9	3.3	2.4	0.7	0.0	0.0	0.0	0.0	1330.0
1999	509.7	520.5	317.2	356.3	46.5	37.7	11.9	22.0	2.4	1.3	3.3	8.6	9.7	2.0	2.2	1.8	0.4	0.0	0.0	0.0	1853.6
2000	516.3	632.1	550.5	201.5	140.7	19.2	17.6	6.4	13.2	1.5	0.9	2.2	6.2	6.8	1.3	1.5	1.1	0.2	0.0	0.0	2120.0
2001	377.0	598.6	637.6	344.1	79.6	58.0	9.0	9.5	3.7	8.4	1.1	0.7	1.5	4.4	4.9	0.9	1.1	0.9	0.2	0.0	2141.1
2002	313.5	434.1	609.4	437.8	159.6	37.5	29.5	4.9	5.5	2.2	5.3	0.7	0.4	1.1	2.9	3.1	0.7	0.7	0.4	0.2	2049.6
2003	404.8	372.1	449.3	426.4	211.6	78.9	20.1	17.0	3.1	3.5	1.5	3.5	0.4	0.2	0.7	1.8	2.0	0.4	0.4	0.4	1998.7
2004	149.9	487.7	396.2	366.4	266.3	131.8	51.1	13.7	11.9	2.2	2.6	1.1	2.6	0.4	0.2	0.4	1.3	1.5	0.2	0.7	1888.7
2005	61.1	137.1	424.6	271.2	188.5	141.3	75.2	31.3	8.8	8.2	1.5	1.8	0.9	1.8	0.2	0.2	0.4	0.9	1.1	0.7	1356.5
2006	1100.3	54.9	116.2	276.0	131.0	95.2	78.3	45.4	20.3	6.0	5.7	1.1	1.3	0.7	1.3	0.2	0.0	0.2	0.7	1.3	1935.9
2007	762.4	1491.6	62.2	77.8	116.4	57.5	47.2	43.9	28.2	13.7	4.2	4.2	0.9	0.9	0.4	0.9	0.2	0.0	0.2	1.3	2714.1
2008	859.4	920.6	1568.4	39.9	32.0	49.6	27.1	24.5	24.5	16.8	8.4	2.6	2.6	0.4	0.7	0.2	0.7	0.0	0.0	0.9	3579.0
2009	132.5	909.6	867.3	878.3	13.0	11.0	19.6	12.3	12.6	13.7	9.7	5.1	1.5	1.5	0.2	0.4	0.2	0.4	0.0	0.7	2889.8
2010	168.4	122.6	789.9	525.4	353.4	5.5	5.1	9.9	6.6	7.1	7.9	5.7	3.1	0.9	0.9	0.2	0.2	0.0	0.2	0.4	2013.7
2011	247.6	208.6	124.1	685.4	419.1	274.0	4.2	4.0	7.9	5.5	6.0	6.6	4.9	2.4	0.9	0.9	0.2	0.2	0.0	0.4	2002.5
2012	265.4	343.0	239.0	119.9	602.3	352.7	226.0	3.5	3.3	6.4	4.4	4.9	5.3	3.7	2.0	0.7	0.7	0.2	0.2	0.4	2183.7
2013	591.1	340.2	357.1	203.9	86.4	403.9	234.6	151.9	2.4	2.2	4.4	3.1	3.3	3.5	2.6	1.3	0.4	0.4	0.0	0.4	2393.3
2014	1003.3	814.6	389.1	342.6	170.2	67.7	308.4	177.7	114.6	1.8	1.8	3.3	2.2	2.4	2.6	2.0	0.9	0.2	0.2	0.4	3406.4
2015	504.0	1334.9	876.8	322.8	216.3	95.2	37.0	169.3	98.3	63.9	1.1	0.9	1.8	1.3	1.3	1.5	1.1	0.4	0.2	0.4	3728.5

Table 10. Estimated time series of status indicators, fishing mortality, and biomass. Fishing mortality rate is apical F. Total biomass (B, mt) is at the start of the year, and spawning biomass (SSB, 1E8 eggs) at the time of peak spawning (mid-year). The $MSST_{\mathrm{F30}}$ is defined by $\mathrm{MSST} = (1 - M)SSB_{\mathrm{F30}}$, *with constant* $M = 0.134$.

Year	F	F/F_{30}	B	B/B_{unfished}	SSB	$SSB/SSBB_{\mathrm{F30}}$	$SSB/MSST_{\mathrm{F30}}$
1950	0.031	0.211	6309	0.789	778399	2.375	3.167
1951	0.042	0.288	6303	0.788	771030	2.353	3.137
1952	0.033	0.224	6235	0.780	766363	2.339	3.118
1953	0.034	0.232	6225	0.779	763741	2.331	3.107
1954	0.051	0.349	6210	0.777	752534	2.296	3.062
1955	0.108	0.736	6106	0.764	732688	2.236	2.981
1956	0.117	0.803	5899	0.738	707974	2.160	2.881
1957	0.166	1.139	5688	0.711	663309	2.024	2.699
1958	0.157	1.074	5297	0.663	619670	1.891	2.521
1959	0.176	1.201	5034	0.630	578307	1.765	2.353
1960	0.192	1.317	4756	0.595	535242	1.633	2.178
1961	0.230	1.570	4482	0.561	486562	1.485	1.980
1962	0.233	1.597	4152	0.519	442383	1.350	1.800
1963	0.231	1.581	3899	0.488	408720	1.247	1.663
1964	0.258	1.768	3722	0.466	376971	1.150	1.534
1965	0.286	1.953	3521	0.440	344137	1.050	1.400
1966	0.300	2.049	3308	0.414	312478	0.954	1.271
1967	0.353	2.412	3113	0.389	275954	0.842	1.123
1968	0.418	2.861	2853	0.357	232992	0.711	0.948
1969	0.368	2.515	2545	0.318	202988	0.619	0.826
1970	0.374	2.556	2414	0.302	182221	0.556	0.741
1971	0.393	2.688	2307	0.289	165389	0.505	0.673
1972	0.415	2.839	2210	0.276	151460	0.462	0.616
1973	0.416	2.843	2119	0.265	141616	0.432	0.576
1974	0.528	3.614	2062	0.258	126555	0.386	0.515
1975	0.673	4.602	1895	0.237	103334	0.315	0.420
1976	0.772	5.277	1655	0.207	79258	0.242	0.322
1977	0.935	6.393	1441	0.180	56261	0.172	0.229
1978	1.159	7.929	1260	0.158	35804	0.109	0.146
1979	1.144	7.821	1042	0.130	24108	0.074	0.098
1980	1.345	9.200	992	0.124	16265	0.050	0.066
1981	1.470	10.056	800	0.100	11267	0.034	0.046
1982	1.178	8.055	610	0.076	8746	0.027	0.036
1983	1.765	12.074	898	0.112	6173	0.019	0.025
1984	1.530	10.462	1331	0.166	8305	0.025	0.034
1985	1.652	11.299	1328	0.166	9969	0.030	0.041
1986	0.938	6.416	841	0.105	11769	0.036	0.048
1987	0.729	4.986	975	0.122	14235	0.043	0.058
1988	0.618	4.227	1225	0.153	19963	0.061	0.081
1989	0.588	4.020	1244	0.156	28089	0.086	0.114
1990	0.290	1.985	1016	0.127	38849	0.119	0.158
1991	0.423	2.891	926	0.116	46176	0.141	0.188
1992	0.903	6.173	888	0.111	37334	0.114	0.152
1993	0.902	6.172	688	0.086	27160	0.083	0.111
1994	0.854	5.844	641	0.080	22693	0.069	0.092
1995	0.820	5.611	548	0.068	19406	0.059	0.079
1996	0.625	4.278	530	0.066	18083	0.055	0.074
1997	1.386	9.482	568	0.071	14062	0.043	0.057
1998	0.589	4.027	603	0.075	15399	0.047	0.063
1999	0.986	6.741	841	0.105	16923	0.052	0.069
2000	0.987	6.751	962	0.120	18635	0.057	0.076
2001	0.825	5.641	971	0.121	21573	0.066	0.088
2002	0.783	5.358	930	0.116	23781	0.073	0.097
2003	0.527	3.605	907	0.113	27137	0.083	0.110
2004	0.721	4.934	857	0.107	27692	0.085	0.113
2005	0.785	5.369	615	0.077	24579	0.075	0.100
2006	0.919	6.284	878	0.110	19523	0.060	0.079
2007	0.948	6.483	1231	0.154	20795	0.063	0.085
2008	1.171	8.010	1623	0.203	27476	0.084	0.112
2009	0.967	6.612	1311	0.164	29515	0.090	0.120
2010	0.282	1.932	913	0.114	36650	0.112	0.149
2011	0.186	1.269	908	0.114	46989	0.143	0.191
2012	0.409	2.796	990	0.124	49264	0.150	0.200
2013	0.256	1.750	1086	0.136	51560	0.157	0.210
2014	0.589	4.028	1545	0.193	48993	0.150	0.199
2015	.	.	1691	0.212	.	.	.

Table 11. Selectivity at age for combined chevon trap and video (CVID), commercial handlines (cH), headboat (HB), and general recreational (GR) landings (L) and discards (D). For time-varying selectivities, values shown are from selectivity block 1 (1950–1991).

Age	CVID	cH.L	HB.L	GR.L	cH.D	HB.D	GR.D
1	0.065	0.012	0.049	0.049	1.000	1.000	1.000
2	0.637	0.374	0.667	0.667	0.956	0.709	0.709
3	0.978	0.967	1.000	1.000	0.663	0.275	0.275
4	0.999	0.999	0.897	0.897	0.331	0.073	0.073
5	1.000	1.000	0.749	0.749	0.133	0.017	0.017
6	1.000	1.000	0.586	0.586	0.048	0.004	0.004
7	1.000	1.000	0.429	0.429	0.017	0.001	0.001
8	1.000	1.000	0.297	0.297	0.006	0.000	0.000
9	1.000	1.000	0.196	0.196	0.002	0.000	0.000
10	1.000	1.000	0.125	0.125	0.001	0.000	0.000
11	1.000	1.000	0.125	0.125	0.000	0.000	0.000
12	1.000	1.000	0.125	0.125	0.000	0.000	0.000
13	1.000	1.000	0.125	0.125	0.000	0.000	0.000
14	1.000	1.000	0.125	0.125	0.000	0.000	0.000
15	1.000	1.000	0.125	0.125	0.000	0.000	0.000
16	1.000	1.000	0.125	0.125	0.000	0.000	0.000
17	1.000	1.000	0.125	0.125	0.000	0.000	0.000
18	1.000	1.000	0.125	0.125	0.000	0.000	0.000
19	1.000	1.000	0.125	0.125	0.000	0.000	0.000
20	1.000	1.000	0.125	0.125	0.000	0.000	0.000

Table 12. Selectivity at age for combined chevon trap and video (CVID), commercial handlines (cH), headboat (HB), and general recreational (GR) landings (L) and discards (D). For time-varying selectivities, values shown are from selectivity block 2 (1992–2009).

Age	CVID	cH.L	HB.L	GR.L	cH.D	HB.D	GR.D
1	0.065	0.001	0.001	0.005	1.000	1.000	1.000
2	0.637	0.026	0.030	0.068	0.956	0.709	0.709
3	0.978	0.425	0.697	0.547	0.663	0.275	0.275
4	0.999	0.954	1.000	1.000	0.331	0.073	0.073
5	1.000	0.998	0.763	0.909	0.133	0.017	0.017
6	1.000	1.000	0.518	0.716	0.048	0.004	0.004
7	1.000	1.000	0.320	0.515	0.017	0.001	0.001
8	1.000	1.000	0.185	0.342	0.006	0.000	0.000
9	1.000	1.000	0.102	0.213	0.002	0.000	0.000
10	1.000	1.000	0.055	0.127	0.001	0.000	0.000
11	1.000	1.000	0.055	0.074	0.000	0.000	0.000
12	1.000	1.000	0.055	0.042	0.000	0.000	0.000
13	1.000	1.000	0.055	0.024	0.000	0.000	0.000
14	1.000	1.000	0.055	0.024	0.000	0.000	0.000
15	1.000	1.000	0.055	0.024	0.000	0.000	0.000
16	1.000	1.000	0.055	0.024	0.000	0.000	0.000
17	1.000	1.000	0.055	0.024	0.000	0.000	0.000
18	1.000	1.000	0.055	0.024	0.000	0.000	0.000
19	1.000	1.000	0.055	0.024	0.000	0.000	0.000
20	1.000	1.000	0.055	0.024	0.000	0.000	0.000

Table 13. Selectivity at age for combined chevon trap and video (CVID), commercial handlines (cH), headboat (HB), and general recreational (GR) landings (L) and discards (D). For time-varying selectivities, values shown are from selectivity block 3 (2010–2014).

Age	CVID	cH.L	HB.L	GR.L	cH.D	HB.D	GR.D
1	0.065	0.006	0.017	0.005	0.032	0.714	0.714
2	0.637	0.067	0.336	0.036	0.219	0.883	0.883
3	0.978	0.446	1.000	0.232	0.704	0.990	0.990
4	0.999	0.901	0.916	0.710	0.953	1.000	1.000
5	1.000	0.990	0.738	0.952	0.994	0.911	0.911
6	1.000	0.999	0.566	0.994	0.999	0.753	0.753
7	1.000	1.000	0.416	0.999	1.000	0.570	0.570
8	1.000	1.000	0.295	1.000	1.000	0.401	0.401
9	1.000	1.000	0.203	1.000	1.000	0.267	0.267
10	1.000	1.000	0.137	1.000	1.000	0.171	0.171
11	1.000	1.000	0.137	1.000	1.000	0.171	0.171
12	1.000	1.000	0.137	1.000	1.000	0.171	0.171
13	1.000	1.000	0.137	1.000	1.000	0.171	0.171
14	1.000	1.000	0.137	1.000	1.000	0.171	0.171
15	1.000	1.000	0.137	1.000	1.000	0.171	0.171
16	1.000	1.000	0.137	1.000	1.000	0.171	0.171
17	1.000	1.000	0.137	1.000	1.000	0.171	0.171
18	1.000	1.000	0.137	1.000	1.000	0.171	0.171
19	1.000	1.000	0.137	1.000	1.000	0.171	0.171
20	1.000	1.000	0.137	1.000	1.000	0.171	0.171

Table 14. Estimated time series of fully selected fishing mortality rates for commercial handlines (F.cH.L), headboat (F.HB.L), recreational (F.GR.L) landings (L) and discards (D). Also shown is Full F, the maximum F at age summed across fleets, which may not equal the sum of fully selected F's because of dome-shaped selectivities.

Year	F.cH.L	F.HB.L	F.GR.L	F.cH.D	F.HB.D	F.GR.D	Full F
1950	0.031	0.000	0.000	0.000	0.000	0.000	0.031
1951	0.042	0.000	0.000	0.000	0.000	0.000	0.042
1952	0.033	0.000	0.000	0.000	0.000	0.000	0.033
1953	0.034	0.000	0.000	0.000	0.000	0.000	0.034
1954	0.051	0.000	0.000	0.000	0.000	0.000	0.051
1955	0.044	0.022	0.043	0.000	0.000	0.000	0.108
1956	0.044	0.025	0.049	0.000	0.000	0.000	0.117
1957	0.085	0.029	0.056	0.000	0.000	0.000	0.166
1958	0.064	0.033	0.063	0.000	0.000	0.000	0.157
1959	0.073	0.036	0.069	0.000	0.000	0.000	0.176
1960	0.080	0.039	0.076	0.000	0.000	0.000	0.192
1961	0.103	0.045	0.086	0.000	0.000	0.000	0.230
1962	0.091	0.050	0.096	0.000	0.000	0.000	0.233
1963	0.073	0.055	0.105	0.000	0.000	0.000	0.231
1964	0.086	0.060	0.115	0.000	0.000	0.000	0.258
1965	0.096	0.066	0.127	0.000	0.000	0.000	0.286
1966	0.103	0.068	0.131	0.000	0.000	0.000	0.300
1967	0.148	0.072	0.138	0.000	0.000	0.000	0.353
1968	0.202	0.076	0.147	0.000	0.000	0.000	0.418
1969	0.141	0.079	0.152	0.000	0.000	0.000	0.368
1970	0.144	0.080	0.154	0.000	0.000	0.000	0.374
1971	0.137	0.089	0.171	0.000	0.000	0.000	0.393
1972	0.129	0.099	0.191	0.000	0.000	0.000	0.415
1973	0.099	0.109	0.210	0.000	0.000	0.000	0.416
1974	0.173	0.124	0.238	0.000	0.000	0.000	0.528
1975	0.255	0.146	0.280	0.000	0.000	0.000	0.673
1976	0.301	0.165	0.316	0.000	0.000	0.000	0.772
1977	0.404	0.187	0.358	0.000	0.000	0.000	0.935
1978	0.551	0.214	0.412	0.000	0.000	0.000	1.159
1979	0.500	0.226	0.435	0.000	0.000	0.000	1.144
1980	0.575	0.270	0.519	0.000	0.000	0.000	1.345
1981	0.683	0.225	0.584	0.000	0.000	0.006	1.470
1982	0.678	0.182	0.339	0.000	0.000	0.006	1.178
1983	0.960	0.259	0.578	0.000	0.000	0.002	1.765
1984	0.494	0.133	0.912	0.000	0.000	0.025	1.530
1985	0.345	0.194	1.113	0.000	0.000	0.044	1.652
1986	0.306	0.088	0.532	0.000	0.000	0.082	0.938
1987	0.278	0.156	0.295	0.000	0.000	0.037	0.729
1988	0.191	0.133	0.293	0.000	0.000	0.029	0.618
1989	0.196	0.076	0.316	0.000	0.000	0.021	0.588
1990	0.147	0.086	0.050	0.000	0.000	0.048	0.290
1991	0.098	0.087	0.217	0.000	0.000	0.086	0.423
1992	0.110	0.083	0.701	0.032	0.003	0.038	0.903
1993	0.403	0.223	0.272	0.036	0.007	0.139	0.902
1994	0.380	0.135	0.333	0.043	0.007	0.125	0.854
1995	0.360	0.178	0.266	0.063	0.012	0.148	0.820
1996	0.314	0.113	0.197	0.040	0.004	0.034	0.625
1997	0.317	0.167	0.899	0.045	0.005	0.030	1.386
1998	0.242	0.088	0.260	0.022	0.003	0.033	0.589
1999	0.205	0.116	0.658	0.014	0.003	0.147	0.986
2000	0.212	0.118	0.646	0.014	0.003	0.214	0.987
2001	0.320	0.133	0.365	0.017	0.006	0.216	0.825
2002	0.263	0.132	0.375	0.041	0.008	0.161	0.783
2003	0.178	0.061	0.279	0.011	0.003	0.181	0.527
2004	0.225	0.130	0.341	0.005	0.040	0.426	0.721
2005	0.194	0.125	0.427	0.047	0.052	0.389	0.785
2006	0.176	0.148	0.596	0.003	0.009	0.063	0.919
2007	0.340	0.231	0.376	0.006	0.037	0.149	0.948
2008	0.350	0.139	0.674	0.006	0.040	0.277	1.171
2009	0.381	0.154	0.412	0.015	0.085	0.357	0.967
2010	0.006	0.003	0.001	0.041	0.051	0.184	0.282
2011	0.000	0.010	0.001	0.106	0.041	0.033	0.186
2012	0.007	0.018	0.172	0.056	0.046	0.140	0.409
2013	0.030	0.012	0.093	0.053	0.030	0.054	0.256
2014	0.064	0.033	0.339	0.060	0.018	0.112	0.589

Table 15. Estimated instantaneous fishing mortality rate (per yr) at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1950	0.000	0.012	0.030	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
1951	0.001	0.016	0.041	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
1952	0.000	0.012	0.032	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
1953	0.000	0.013	0.033	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.034
1954	0.001	0.019	0.049	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
1955	0.004	0.060	0.108	0.102	0.093	0.082	0.072	0.063	0.056	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
1956	0.004	0.066	0.117	0.111	0.100	0.088	0.076	0.067	0.059	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
1957	0.005	0.088	0.166	0.161	0.148	0.134	0.121	0.110	0.101	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095	0.095
1958	0.005	0.087	0.157	0.149	0.135	0.120	0.105	0.092	0.083	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076
1959	0.006	0.097	0.176	0.167	0.152	0.135	0.118	0.104	0.094	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086
1960	0.007	0.107	0.192	0.183	0.166	0.147	0.129	0.114	0.102	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094	0.094
1961	0.008	0.125	0.230	0.220	0.200	0.179	0.159	0.141	0.128	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119
1962	0.008	0.131	0.233	0.221	0.200	0.176	0.153	0.134	0.119	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109	0.109
1963	0.009	0.134	0.231	0.217	0.193	0.167	0.142	0.121	0.105	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093	0.093
1964	0.010	0.149	0.258	0.243	0.217	0.189	0.161	0.138	0.120	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
1965	0.011	0.164	0.286	0.269	0.240	0.209	0.179	0.153	0.134	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
1966	0.011	0.172	0.300	0.282	0.253	0.220	0.189	0.162	0.142	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.128
1967	0.012	0.195	0.353	0.336	0.305	0.271	0.238	0.210	0.189	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174	0.174
1968	0.013	0.224	0.418	0.402	0.369	0.333	0.298	0.268	0.246	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230
1969	0.013	0.207	0.368	0.349	0.314	0.277	0.240	0.210	0.186	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
1970	0.013	0.210	0.374	0.354	0.320	0.281	0.245	0.214	0.190	0.173	0.173	0.173	0.173	0.173	0.173	0.173	0.173	0.173	0.173	0.173
1971	0.014	0.225	0.393	0.371	0.332	0.290	0.249	0.214	0.188	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169	0.169
1972	0.016	0.242	0.415	0.389	0.346	0.299	0.254	0.215	0.186	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165	0.165
1973	0.017	0.250	0.416	0.386	0.338	0.286	0.236	0.194	0.162	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.139
1974	0.020	0.306	0.528	0.497	0.443	0.384	0.328	0.280	0.244	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218
1975	0.024	0.380	0.673	0.637	0.574	0.505	0.438	0.382	0.338	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308	0.308
1976	0.027	0.433	0.772	0.732	0.661	0.582	0.507	0.443	0.395	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361
1977	0.032	0.514	0.935	0.892	0.811	0.723	0.637	0.565	0.510	0.472	0.472	0.472	0.472	0.472	0.472	0.472	0.472	0.472	0.472	0.472
1978	0.037	0.624	1.159	1.113	1.020	0.918	0.820	0.737	0.674	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629	0.629
1979	0.038	0.627	1.144	1.092	0.994	0.886	0.783	0.696	0.629	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582	0.582
1980	0.046	0.741	1.345	1.283	1.166	1.037	0.914	0.809	0.730	0.674	0.674	0.674	0.674	0.674	0.674	0.674	0.674	0.674	0.674	0.674
1981	0.054	0.799	1.470	1.408	1.288	1.157	1.030	0.923	0.841	0.784	0.784	0.784	0.784	0.784	0.784	0.784	0.784	0.784	0.784	0.784
1982	0.040	0.605	1.178	1.145	1.068	0.983	0.901	0.832	0.780	0.743	0.743	0.743	0.743	0.743	0.743	0.743	0.743	0.743	0.743	0.743
1983	0.055	0.919	1.765	1.710	1.586	1.450	1.319	1.208	1.124	1.064	1.064	1.064	1.064	1.064	1.064	1.064	1.064	1.064	1.064	1.064
1984	0.082	0.899	1.530	1.433	1.277	1.106	0.943	0.805	0.699	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625	0.625
1985	0.112	1.032	1.652	1.520	1.324	1.110	0.906	0.733	0.601	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508
1986	0.117	0.586	0.938	0.868	0.771	0.669	0.572	0.490	0.427	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383	0.383
1987	0.062	0.430	0.729	0.684	0.616	0.542	0.471	0.412	0.366	0.334	0.334	0.334	0.334	0.334	0.334	0.334	0.334	0.334	0.334	0.334
1988	0.052	0.376	0.618	0.575	0.510	0.440	0.374	0.317	0.274	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244	0.244
1989	0.042	0.350	0.588	0.550	0.490	0.426	0.365	0.313	0.273	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245
1990	0.056	0.179	0.290	0.271	0.249	0.226	0.205	0.187	0.173	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.163
1991	0.102	0.301	0.423	0.377	0.327	0.276	0.229	0.188	0.157	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136	0.136
1992	0.078	0.113	0.521	0.903	0.815	0.656	0.498	0.365	0.268	0.204	0.166	0.144	0.131	0.131	0.131	0.131	0.131	0.131	0.131	0.131
1993	0.184	0.174	0.540	0.902	0.827	0.716	0.615	0.538	0.484	0.450	0.436	0.427	0.422	0.422	0.422	0.422	0.422	0.422	0.422	0.422
1994	0.178	0.172	0.503	0.854	0.793	0.691	0.596	0.519	0.465	0.430	0.412	0.401	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395
1995	0.225	0.206	0.508	0.820	0.748	0.646	0.555	0.484	0.435	0.404	0.389	0.381	0.376	0.376	0.376	0.376	0.376	0.376	0.376	0.376
1996	0.080	0.090	0.357	0.625	0.585	0.515	0.452	0.402	0.367	0.345	0.334	0.328	0.324	0.324	0.324	0.324	0.324	0.324	0.324	0.324
1997	0.085	0.142	0.782	1.386	1.268	1.049	0.834	0.656	0.526	0.440	0.392	0.364	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347
1998	0.059	0.073	0.331	0.589	0.549	0.475	0.405	0.347	0.307	0.280	0.266	0.258	0.253	0.253	0.253	0.253	0.253	0.253	0.253	0.253
1999	0.167	0.173	0.579	0.986	0.896	0.737	0.581	0.452	0.357	0.295	0.260	0.239	0.227	0.227	0.227	0.227	0.227	0.227	0.227	0.227
2000	0.235	0.221	0.595	0.987	0.895	0.737	0.583	0.455	0.362	0.301	0.266	0.246	0.234	0.234	0.234	0.234	0.234	0.234	0.234	0.234
2001	0.242	0.211	0.501	0.825	0.758	0.651	0.551	0.470	0.411	0.374	0.354	0.343	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336
2002	0.212	0.195	0.482	0.783	0.712	0.602	0.499	0.416	0.356	0.318	0.298	0.286	0.279	0.279	0.279	0.279	0.279	0.279	0.279	0.279
2003	0.197	0.166	0.328	0.527	0.483	0.411	0.342	0.285	0.244	0.217	0.202	0.193	0.188	0.188	0.188	0.188	0.188	0.188	0.188	0.188
2004	0.473	0.368	0.504	0.721	0.642	0.538	0.443	0.366	0.311	0.275	0.257	0.246	0.240	0.240	0.240	0.240	0.240	0.240	0.240	0.240
2005	0.490	0.395	0.555	0.785	0.691	0.568	0.455	0.363	0.298	0.255	0.232	0.219	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
2006	0.079	0.104	0.526	0.919	0.833	0.680	0.531	0.408	0.319	0.260	0.228	0.209	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198
2007	0.195	0.179	0.567	0.948	0.862	0.730	0.608	0.512	0.444	0.401	0.381	0.369	0.362	0.362	0.362	0.362	0.362	0.362	0.362	0.362
2008	0.326	0.289	0.705	1.171	1.073	0.905	0.741	0.606	0.507	0.443	0.407	0.385	0.373	0.373	0.373	0.373	0.373	0.373	0.373	0.373
2009	0.460	0.370	0.626	0.967	0.882	0.758	0.643	0.551	0.485	0.442	0.420	0.407	0.399	0.399	0.399	0.399	0.399	0.399	0.399	0.399
2010	0.169	0.218	0.267	0.282	0.264	0.226	0.183	0.143	0.111	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089	0.089
2011	0.057	0.092	0.159	0.186	0.182	0.169	0.154	0.140	0.129	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121
2012	0.135	0.188	0.284	0.384	0.409	0.384	0.348	0.315	0.289	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270
2013	0.062	0.095	0.167	0.238	0.256	0.245	0.229	0.213	0.201	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192	0.192
2014	0.097	0.156	0.312	0.516	0.589	0.578	0.551	0.525	0.505	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490

Table 16. Estimated time series of landings in number (1000 fish) for commercial handlines (L.cH), headboat (L.HB), and recreational (L.GR).

Year	L.cH	L.HB	L.GR	Total
1950	26.72	0.00	0.00	26.72
1951	36.24	0.00	0.00	36.24
1952	28.03	0.00	0.00	28.03
1953	28.96	0.00	0.00	28.96
1954	43.21	0.00	0.00	43.21
1955	35.86	12.50	24.03	72.40
1956	35.07	13.65	26.24	74.96
1957	63.01	14.80	28.46	106.27
1958	44.96	15.95	30.67	91.58
1959	48.92	17.10	32.88	98.90
1960	50.72	18.25	35.09	104.06
1961	61.33	19.91	38.27	119.50
1962	50.87	21.56	41.44	113.87
1963	39.36	23.21	44.62	107.18
1964	44.17	24.86	47.79	116.83
1965	46.83	26.51	50.96	124.30
1966	47.63	26.67	51.26	125.56
1967	64.06	26.82	51.56	142.44
1968	79.27	26.98	51.85	158.10
1969	51.58	27.13	52.15	130.87
1970	51.08	27.29	52.44	130.81
1971	46.95	29.98	57.62	134.55
1972	42.73	32.68	62.79	138.19
1973	31.74	35.37	67.96	135.07
1974	52.01	38.06	73.12	163.19
1975	67.36	40.74	78.26	186.37
1976	67.80	41.21	79.16	188.17
1977	76.47	41.63	79.89	197.98
1978	84.98	42.15	81.02	208.15
1979	69.21	42.66	82.06	193.94
1980	66.23	43.10	82.90	192.24
1981	74.29	36.05	93.58	203.92
1982	55.18	19.58	36.38	111.13
1983	66.37	30.70	68.48	165.55
1984	64.77	31.16	213.19	309.12
1985	57.44	50.35	289.40	397.20
1986	42.79	16.62	100.67	160.09
1987	33.05	24.98	47.32	105.35
1988	34.45	36.50	80.66	151.61
1989	47.25	23.44	96.85	167.54
1990	33.10	20.91	12.09	66.10
1991	16.78	13.85	34.68	65.31
1992	9.05	5.30	51.69	66.04
1993	18.28	7.35	11.33	36.96
1994	19.78	8.23	18.34	46.35
1995	17.56	8.83	13.49	39.89
1996	13.95	5.54	9.34	28.83
1997	10.90	5.77	34.06	50.73
1998	10.12	4.74	13.02	27.87
1999	10.34	6.84	39.64	56.81
2000	12.00	8.44	45.33	65.77
2001	22.84	12.03	31.58	66.44
2002	21.23	12.95	35.21	69.39
2003	14.86	5.71	26.00	46.57
2004	17.62	10.84	28.85	57.30
2005	12.98	8.91	29.45	51.34
2006	7.97	5.94	26.71	40.62
2007	11.46	6.89	17.64	35.99
2008	32.29	18.97	81.94	133.19
2009	42.58	21.56	55.04	119.18
2010	0.80	0.48	0.06	1.34
2011	0.06	1.36	0.06	1.48
2012	0.76	2.13	15.63	18.52
2013	3.01	1.52	7.58	12.11
2014	6.86	5.90	28.19	40.96

Table 17. Estimated time series of landings in whole weight (1000 lb) for commercial handlines (L.cH), headboat (L.HB), and recreational (L.GR).

Year	L.cH	L.HB	L.GR	Total
1950	368.62	0.00	0.00	368.62
1951	499.70	0.00	0.00	499.70
1952	385.89	0.00	0.00	385.89
1953	398.23	0.00	0.00	398.23
1954	593.08	0.00	0.00	593.08
1955	493.22	105.75	203.31	802.28
1956	483.80	114.78	220.66	819.24
1957	866.92	122.74	235.97	1225.63
1958	612.30	129.58	249.12	991.00
1959	657.47	136.40	262.22	1056.09
1960	670.77	143.03	274.96	1088.76
1961	795.90	153.17	294.44	1243.51
1962	645.64	162.58	312.54	1120.76
1963	488.57	172.14	330.92	991.63
1964	537.30	181.95	349.75	1068.99
1965	557.76	191.13	367.39	1116.28
1966	554.13	188.87	363.02	1106.02
1967	724.79	186.03	357.57	1268.39
1968	864.41	181.64	349.13	1395.18
1969	537.72	177.02	340.23	1054.96
1970	512.55	175.05	336.44	1024.04
1971	456.98	190.36	365.84	1013.18
1972	406.28	205.65	395.20	1007.13
1973	296.34	220.73	424.13	941.21
1974	477.72	234.66	450.83	1163.20
1975	599.63	242.92	466.60	1309.14
1976	570.47	232.73	447.08	1250.28
1977	594.82	220.92	423.98	1239.72
1978	593.46	206.52	396.94	1196.93
1979	421.56	195.11	375.36	992.03
1980	385.97	194.12	373.36	953.44
1981	379.07	152.91	396.94	928.92
1982	309.64	92.64	172.14	574.42
1983	317.08	113.40	252.95	683.43
1984	253.59	107.39	734.77	1095.75
1985	250.90	197.92	1137.61	1586.42
1986	219.44	76.40	462.69	758.53
1987	191.49	119.79	226.91	538.19
1988	173.48	154.01	340.42	667.91
1989	266.36	116.12	479.86	862.34
1990	226.27	128.96	74.56	429.79
1991	143.44	107.22	268.45	519.11
1992	104.28	55.54	552.83	712.65
1993	219.96	72.37	111.99	404.32
1994	195.68	65.04	151.15	411.87
1995	177.58	76.82	117.98	372.38
1996	138.61	46.80	80.59	265.99
1997	110.34	50.02	290.38	450.75
1998	89.59	36.77	100.84	227.20
1999	93.62	56.24	318.87	468.74
2000	104.14	66.54	352.23	522.91
2001	196.53	95.73	249.85	542.11
2002	188.45	106.61	291.45	586.52
2003	138.42	48.99	225.26	412.67
2004	171.75	95.44	258.03	525.22
2005	129.65	78.12	269.04	476.81
2006	86.18	56.31	251.10	393.59
2007	114.51	55.91	129.07	299.49
2008	251.87	137.40	583.25	972.53
2009	363.67	173.98	441.18	978.83
2010	6.45	3.30	0.54	10.28
2011	0.57	11.10	0.62	12.29
2012	8.14	16.71	177.71	202.56
2013	31.60	10.73	87.37	129.70
2014	65.44	34.94	300.40	400.78

Table 18. Estimated time series of discard mortalities in numbers (1000 fish) for commercial handlines (D.cH), headboat (D.HB), and recreational (D.GR).

Year	D.cH	D.HB	D.GR	Total
1981	.	.	1.64	.
1982	.	.	1.64	.
1983	.	.	1.64	.
1984	.	0.03	22.88	.
1985	.	0.04	23.71	.
1986	.	0.01	23.71	.
1987	.	0.02	23.71	.
1988	.	0.03	18.60	.
1989	.	0.02	7.17	.
1990	.	0.02	7.17	.
1991	.	0.01	7.18	.
1992	9.41	0.93	10.36	20.70
1993	8.03	1.29	25.24	34.56
1994	10.15	1.44	24.64	36.23
1995	10.12	1.55	18.85	30.52
1996	9.95	0.97	7.57	18.49
1997	10.75	1.01	6.13	17.90
1998	7.76	0.83	9.91	18.51
1999	6.55	1.20	60.22	67.96
2000	6.98	1.48	91.96	100.42
2001	7.27	2.11	75.03	84.41
2002	14.33	2.27	45.68	62.27
2003	4.02	1.00	58.97	63.98
2004	1.16	6.95	74.05	82.16
2005	4.89	3.66	27.12	35.66
2006	2.31	6.38	44.31	53.00
2007	5.24	26.60	106.67	138.51
2008	4.77	27.24	189.47	221.48
2009	5.50	21.22	89.22	115.94
2010	6.63	14.24	51.45	72.32
2011	15.29	11.80	9.55	36.64
2012	7.30	13.34	40.83	61.48
2013	7.34	13.33	23.98	44.65
2014	10.26	13.29	81.59	105.14

Table 19. Estimated time series of discard mortalities in whole weight (1000 lb) for commercial handlines (D.cH), headboat (D.HB), and recreational (D.GR).

Year	D.cH	D.HB	D.GR	Total
1981	.	.	3.60	.
1982	.	.	2.76	.
1983	.	.	2.26	.
1984	.	0.04	36.31	.
1985	.	0.08	47.41	.
1986	.	0.03	52.04	.
1987	.	0.03	34.54	.
1988	.	0.06	34.77	.
1989	.	0.05	17.92	.
1990	.	0.05	22.49	.
1991	.	0.03	20.02	.
1992	16.93	1.31	14.66	32.90
1993	20.82	2.95	57.87	81.64
1994	24.91	2.76	47.22	74.88
1995	29.00	3.56	43.42	75.98
1996	20.52	1.59	12.40	34.51
1997	25.11	2.02	12.24	39.37
1998	16.37	1.44	17.22	35.03
1999	13.52	2.09	105.29	120.90
2000	15.50	2.76	171.76	190.03
2001	18.39	4.36	155.23	177.98
2002	37.87	4.71	95.05	137.64
2003	9.49	1.85	109.24	120.58
2004	3.61	17.36	184.84	205.81
2005	18.73	10.48	77.71	106.92
2006	3.11	7.88	54.79	65.79
2007	10.82	50.42	202.22	263.47
2008	11.11	52.43	364.70	428.24
2009	19.25	62.33	262.02	343.60
2010	48.30	74.13	267.83	390.25
2011	134.28	59.46	48.10	241.84
2012	67.40	62.09	190.03	319.52
2013	62.72	44.02	79.16	185.90
2014	73.25	35.67	219.04	327.97

Table 20. Estimated landings at age in numbers (1000 fish)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1950	0.13	2.38	4.37	3.43	2.71	2.19	1.79	1.49	1.24	1.05	0.88	0.75	0.63	0.54	0.46	0.39	0.33	0.29	0.24	1.44
1951	0.17	3.24	5.94	4.65	3.67	2.96	2.43	2.02	1.69	1.42	1.20	1.01	0.86	0.73	0.62	0.53	0.45	0.39	0.33	1.95
1952	0.13	2.52	4.62	3.59	2.83	2.29	1.88	1.56	1.30	1.09	0.92	0.78	0.66	0.56	0.48	0.41	0.35	0.30	0.25	1.50
1953	0.14	2.61	4.79	3.73	2.92	2.36	1.93	1.60	1.34	1.13	0.95	0.81	0.68	0.58	0.50	0.42	0.36	0.31	0.26	1.55
1954	0.21	3.91	7.15	5.58	4.38	3.51	2.87	2.38	1.99	1.67	1.41	1.20	1.02	0.86	0.74	0.63	0.54	0.46	0.39	2.30
1955	1.26	12.07	15.09	10.75	7.67	5.48	3.92	2.87	2.15	1.66	1.40	1.19	1.01	0.86	0.73	0.62	0.53	0.45	0.39	2.29
1956	1.41	13.27	15.74	10.92	7.73	5.55	3.99	2.90	2.17	1.68	1.42	1.21	1.02	0.87	0.74	0.63	0.54	0.46	0.39	2.32
1957	1.75	17.45	21.59	14.62	10.37	7.66	5.80	4.46	3.49	2.81	2.40	2.04	1.73	1.47	1.26	1.07	0.91	0.78	0.67	3.93
1958	1.83	17.29	20.01	12.90	8.62	6.10	4.49	3.40	2.63	2.08	1.79	1.53	1.31	1.11	0.95	0.81	0.69	0.59	0.50	2.96
1959	2.03	19.16	22.18	14.14	9.15	6.24	4.52	3.44	2.71	2.18	1.89	1.64	1.41	1.20	1.02	0.87	0.74	0.64	0.54	3.20
1960	2.23	20.91	23.87	15.09	9.66	6.37	4.44	3.32	2.62	2.15	1.89	1.65	1.43	1.23	1.05	0.90	0.77	0.65	0.56	3.29
1961	2.57	24.31	27.70	17.30	11.06	7.28	4.97	3.62	2.84	2.36	2.12	1.87	1.64	1.42	1.22	1.05	0.90	0.76	0.65	3.85
1962	2.77	25.35	27.58	16.63	10.36	6.70	4.46	3.10	2.31	1.85	1.67	1.51	1.34	1.17	1.02	0.88	0.75	0.64	0.55	3.24
1963	2.94	25.89	27.14	15.96	9.57	5.99	3.89	2.62	1.85	1.40	1.25	1.13	1.02	0.91	0.79	0.69	0.60	0.51	0.44	2.58
1964	3.23	28.52	29.84	17.58	10.43	6.42	4.14	2.81	1.99	1.48	1.28	1.14	1.03	0.94	0.83	0.73	0.64	0.55	0.47	2.78
1965	3.56	31.20	32.06	18.61	11.07	6.74	4.27	2.87	2.04	1.52	1.28	1.11	0.99	0.90	0.82	0.73	0.64	0.56	0.48	2.85
1966	3.70	32.45	32.87	18.61	10.93	6.70	4.22	2.80	1.98	1.49	1.25	1.05	0.91	0.82	0.74	0.67	0.60	0.53	0.46	2.76
1967	4.03	36.40	37.45	20.96	12.17	7.51	4.87	3.29	2.35	1.80	1.51	1.28	1.08	0.94	0.84	0.77	0.70	0.62	0.54	3.33
1968	4.47	41.25	42.12	22.88	13.15	8.04	5.25	3.64	2.64	2.01	1.68	1.42	1.20	1.02	0.89	0.80	0.73	0.66	0.59	3.67
1969	4.36	38.30	36.72	18.58	10.10	5.91	3.67	2.44	1.73	1.28	1.05	0.89	0.75	0.64	0.54	0.47	0.42	0.39	0.35	2.27
1970	4.41	38.78	37.78	19.21	9.89	5.58	3.40	2.22	1.56	1.16	0.96	0.79	0.67	0.57	0.48	0.41	0.36	0.32	0.29	1.98
1971	4.80	41.19	39.23	20.13	10.36	5.49	3.19	2.02	1.37	1.01	0.83	0.69	0.57	0.48	0.41	0.35	0.30	0.26	0.23	1.65
1972	5.24	43.82	40.36	20.49	10.66	5.65	3.09	1.87	1.24	0.88	0.72	0.60	0.50	0.41	0.35	0.30	0.25	0.21	0.19	1.37
1973	5.60	45.09	39.65	19.57	10.02	5.33	2.88	1.61	1.00	0.68	0.55	0.45	0.38	0.31	0.26	0.22	0.19	0.16	0.14	0.99
1974	6.55	53.57	47.44	23.52	12.09	6.61	3.80	2.26	1.40	0.97	0.78	0.63	0.52	0.44	0.36	0.30	0.26	0.22	0.18	1.30
1975	7.91	64.19	53.63	25.08	12.97	7.15	4.23	2.65	1.73	1.17	0.92	0.74	0.60	0.50	0.42	0.35	0.29	0.24	0.21	1.43
1976	8.93	71.11	54.58	22.60	11.03	6.13	3.66	2.35	1.60	1.12	0.85	0.67	0.54	0.44	0.37	0.31	0.26	0.21	0.18	1.21
1977	10.29	80.96	58.30	21.60	9.45	5.05	3.09	2.04	1.45	1.08	0.85	0.64	0.51	0.41	0.34	0.28	0.23	0.19	0.16	1.06
1978	13.60	92.86	60.64	19.75	7.79	3.78	2.25	1.55	1.14	0.88	0.73	0.57	0.44	0.35	0.28	0.23	0.19	0.16	0.13	0.84
1979	10.36	103.78	53.38	14.30	4.92	2.14	1.15	0.76	0.57	0.45	0.39	0.32	0.25	0.19	0.15	0.12	0.10	0.08	0.07	0.43
1980	18.18	86.66	64.53	14.06	4.03	1.55	0.76	0.46	0.34	0.28	0.24	0.21	0.17	0.14	0.11	0.08	0.07	0.06	0.05	0.27
1981	6.57	133.43	44.49	13.35	3.16	1.04	0.46	0.26	0.18	0.15	0.14	0.12	0.10	0.09	0.07	0.05	0.04	0.03	0.03	0.16
1982	7.70	37.48	55.17	7.00	2.29	0.62	0.24	0.12	0.08	0.06	0.06	0.05	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.07
1983	34.04	84.34	27.85	15.79	2.12	0.77	0.23	0.10	0.06	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.04
1984	41.53	229.69	31.96	3.38	2.02	0.30	0.12	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01
1985	22.39	273.77	94.45	5.37	0.63	0.43	0.07	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
1986	5.57	76.91	66.80	9.95	0.65	0.09	0.08	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	14.62	31.26	39.68	16.83	2.69	0.19	0.03	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	9.84	102.03	20.47	12.68	5.55	0.93	0.07	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	3.44	72.31	75.79	7.96	5.14	2.41	0.44	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	0.43	12.75	31.36	17.39	1.93	1.36	0.71	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	0.74	6.38	19.04	23.54	12.74	1.38	0.93	0.46	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	0.89	1.33	6.32	17.65	23.66	13.27	1.44	0.94	0.45	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	0.15	4.74	6.42	4.49	5.52	7.99	5.56	0.79	0.71	0.46	0.11	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	0.30	1.54	30.73	4.46	1.38	1.78	2.90	2.26	0.36	0.34	0.24	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.12	2.42	9.37	22.76	1.43	0.45	0.64	1.17	1.01	0.17	0.18	0.13	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.25	0.85	13.06	6.02	6.60	0.43	0.15	0.25	0.49	0.47	0.09	0.09	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.61	7.52	12.49	19.97	4.16	4.55	0.31	0.11	0.17	0.34	0.32	0.06	0.06	0.04	0.01	0.00	0.00	0.00	0.00	0.00
1998	0.37	1.88	17.94	3.76	2.26	0.51	0.68	0.06	0.03	0.05	0.13	0.13	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.00
1999	1.07	6.92	20.10	24.05	2.29	1.35	0.31	0.43	0.04	0.02	0.03	0.08	0.08	0.02	0.02	0.01	0.00	0.00	0.00	0.00
2000	1.04	8.14	34.48	13.54	6.92	0.68	0.46	0.12	0.20	0.02	0.01	0.02	0.05	0.06	0.01	0.01	0.01	0.00	0.00	0.00
2001	0.48	5.41	33.86	20.52	3.50	1.90	0.22	0.19	0.06	0.12	0.01	0.01	0.02	0.05	0.05	0.01	0.01	0.01	0.00	0.00
2002	0.40	3.87	31.14	25.07	6.70	1.16	0.69	0.09	0.08	0.03	0.06	0.01	0.00	0.01	0.03	0.03	0.01	0.01	0.00	0.00
2003	0.38	2.36	16.29	18.34	6.68	1.82	0.34	0.22	0.03	0.03	0.01	0.03	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00
2004	0.16	3.65	18.30	19.49	10.38	3.75	1.08	0.22	0.16	0.02	0.03	0.01	0.02	0.00	0.00	0.00	0.01	0.01	0.00	0.01
2005	0.08	1.17	20.74	15.10	7.69	4.17	1.62	0.51	0.11	0.08	0.01	0.02	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00
2006	2.19	0.70	7.18	18.00	6.17	3.23	1.91	0.81	0.27	0.06	0.05	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01
2007	1.04	15.27	3.84	5.12	5.60	2.04	1.27	0.93	0.50	0.21	0.06	0.05	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.02
2008	1.80	12.81	109.43	2.96	1.75	2.03	0.84	0.59	0.48	0.27	0.12	0.04	0.03	0.01	0.01	0.00	0.01	0.00	0.00	0.01
2009	0.17	8.78	50.40	57.22	0.64	0.40	0.55	0.28	0.23	0.22	0.15	0.07	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.01
2010	0.01	0.04	0.61	0.43	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	0.03	0.19	0.19	0.68	0.27	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.18	1.07	1.99	1.57	7.57	3.78	2.11	0.03	0.03	0.05	0.03	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00
2013	0.30	0.81	2.40	2.03	0.80	3.15	1.58	0.92	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00
2014	1.57	5.66	7.38	9.54	4.39	1.48	5.86	3.03	1.81	0.03	0.02	0.05	0.03	0.03	0.03	0.02	0.01	0.00	0.00	0.00

Table 21. Estimated landings at age in whole weight (1000 lb)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1950	0.19	8.14	25.65	29.12	30.02	29.57	28.20	26.25	23.99	21.63	19.29	17.06	14.99	13.10	11.40	9.89	8.56	7.39	6.37	37.82
1951	0.26	11.09	34.80	39.47	40.69	40.08	38.22	35.57	32.52	29.31	26.14	23.12	20.31	17.75	15.45	13.41	11.60	10.01	8.63	51.25
1952	0.20	8.64	27.07	30.49	31.39	30.93	29.49	27.45	25.09	22.62	20.17	17.84	15.67	13.70	11.92	10.35	8.95	7.73	6.66	39.54
1953	0.21	8.94	28.08	31.68	32.39	31.88	30.40	28.29	25.86	23.31	20.79	18.38	16.16	14.12	12.29	10.66	9.23	7.96	6.86	40.76
1954	0.31	13.41	41.93	47.41	48.55	47.44	45.19	42.05	38.44	34.65	30.90	27.33	24.02	20.99	18.27	15.85	13.71	11.84	10.20	60.59
1955	1.86	41.38	88.47	91.31	85.13	74.09	61.63	50.56	41.50	34.40	30.67	27.13	23.84	20.83	18.13	15.73	13.61	11.75	10.13	60.14
1956	2.09	45.48	92.26	92.69	85.74	75.06	62.71	51.17	41.95	34.74	31.12	27.52	24.19	21.14	18.40	15.96	13.81	11.92	10.28	61.02
1957	2.58	59.81	126.59	124.17	114.99	103.69	91.24	78.66	67.37	58.15	52.46	46.62	40.97	35.80	31.16	27.04	23.39	20.20	17.40	103.35
1958	2.71	59.26	117.29	109.54	95.64	82.52	70.59	59.94	50.66	42.95	39.11	35.00	30.90	27.01	23.50	20.40	17.65	15.23	13.13	77.96
1959	3.00	65.68	130.04	120.10	101.55	84.41	71.04	60.61	52.24	45.12	41.35	37.35	33.21	29.16	25.38	22.02	19.05	16.45	14.18	84.17
1960	3.29	71.65	139.93	128.15	107.12	86.19	69.81	58.51	50.55	44.42	41.39	37.63	33.77	29.86	26.11	22.66	19.60	16.92	14.58	86.60
1961	3.79	83.32	162.40	146.90	122.67	98.56	78.20	63.89	54.86	48.81	46.30	42.80	38.65	34.50	30.38	26.49	22.92	19.78	17.05	101.25
1962	4.10	86.89	161.71	141.21	114.90	90.59	70.13	54.63	44.49	38.38	36.58	34.42	31.61	28.39	25.24	22.16	19.26	16.63	14.33	85.10
1963	4.34	88.74	159.12	135.51	106.14	81.11	61.21	46.20	35.67	29.07	27.32	25.83	24.15	22.05	19.73	17.48	15.31	13.28	11.44	67.94
1964	4.78	97.76	174.97	149.28	115.73	86.80	65.16	49.50	38.35	30.66	27.89	26.00	24.42	22.71	20.65	18.42	16.28	14.22	12.31	73.11
1965	5.26	106.95	187.99	158.06	122.80	91.22	67.21	50.71	39.43	31.52	27.98	25.26	23.39	21.85	20.23	18.35	16.32	14.38	12.54	74.84
1966	5.47	111.24	192.74	158.06	121.30	90.61	66.37	49.34	38.23	30.75	27.28	24.03	21.54	19.84	18.46	17.04	15.41	13.67	12.03	72.60
1967	5.97	124.77	219.57	177.96	135.05	101.57	76.59	58.07	45.43	37.18	33.11	29.14	25.50	22.74	20.85	19.34	17.81	16.06	14.23	87.47
1968	6.62	141.40	246.94	194.29	145.87	108.74	82.57	64.22	50.85	41.56	36.80	32.50	28.42	24.73	21.96	20.09	18.58	17.06	15.37	96.61
1969	6.44	131.28	215.27	157.76	112.09	80.00	57.74	43.11	33.38	26.46	23.06	20.26	17.78	15.46	13.40	11.86	10.82	9.98	9.15	59.65
1970	6.52	132.92	221.47	163.13	109.66	75.50	53.53	39.19	30.12	24.10	20.91	18.08	15.77	13.77	11.92	10.30	9.10	8.28	7.62	52.18
1971	7.10	141.16	230.00	170.96	114.88	74.24	50.23	35.66	26.52	20.81	18.21	15.67	13.47	11.69	10.16	8.77	7.56	6.66	6.05	43.38
1972	7.75	150.18	236.63	173.98	118.21	76.47	48.64	33.01	23.85	18.16	15.79	13.70	11.72	10.01	8.65	7.50	6.46	5.55	4.88	35.99
1973	8.28	154.53	232.44	166.22	111.14	72.07	45.30	28.43	19.29	14.04	12.02	10.37	8.94	7.60	6.47	5.58	4.82	4.14	3.55	25.97
1974	9.69	183.62	278.16	199.71	134.07	89.38	59.71	39.80	27.05	20.00	16.95	14.40	12.34	10.58	8.96	7.60	6.53	5.63	4.83	34.20
1975	11.70	219.99	314.42	212.94	143.83	96.68	66.45	46.79	33.30	24.16	20.02	16.83	14.20	12.10	10.34	8.73	7.38	6.33	5.45	37.50
1976	13.21	243.73	319.98	191.94	122.39	83.00	57.52	41.49	30.93	23.24	18.62	15.31	12.79	10.73	9.11	7.76	6.53	5.51	4.72	31.77
1977	15.21	277.49	341.79	183.42	104.82	68.26	48.64	36.05	27.99	22.32	18.50	14.70	12.01	9.98	8.34	7.06	5.99	5.03	4.24	27.88
1978	20.12	318.26	355.52	167.71	86.42	51.10	35.42	27.29	21.92	18.25	15.91	13.09	10.33	8.39	6.94	5.79	4.88	4.14	3.47	21.98
1979	15.33	355.70	312.97	121.44	54.63	28.98	18.08	13.37	10.99	9.33	8.44	7.30	5.96	4.68	3.79	3.12	2.60	2.19	1.85	11.29
1980	26.88	297.02	378.36	119.39	44.73	21.01	11.95	8.09	6.49	5.71	5.32	4.78	4.10	3.34	2.61	2.10	1.73	1.43	1.21	7.20
1981	9.71	457.32	260.84	113.36	35.10	14.06	7.28	4.62	3.48	3.05	2.97	2.74	2.45	2.09	1.69	1.32	1.06	0.87	0.72	4.19
1982	11.38	128.45	323.47	59.41	25.35	8.44	3.75	2.18	1.55	1.28	1.23	1.19	1.09	0.97	0.83	0.67	0.52	0.42	0.34	1.91
1983	50.34	289.06	163.29	134.07	23.49	10.35	3.64	1.73	1.07	0.80	0.70	0.67	0.64	0.59	0.52	0.44	0.35	0.27	0.22	1.18
1984	61.41	787.25	187.39	28.66	22.42	4.07	1.89	0.70	0.35	0.22	0.18	0.16	0.15	0.14	0.13	0.11	0.10	0.08	0.06	0.30
1985	33.11	938.32	553.74	45.61	6.96	5.88	1.17	0.60	0.24	0.13	0.09	0.07	0.06	0.06	0.06	0.05	0.05	0.04	0.03	0.15
1986	8.23	263.59	391.65	84.52	7.18	1.24	1.23	0.29	0.18	0.09	0.06	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.07
1987	21.62	107.14	232.65	142.89	29.83	2.61	0.48	0.51	0.13	0.09	0.05	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.05
1988	14.55	349.71	120.03	107.67	61.55	12.64	1.11	0.21	0.23	0.06	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03
1989	5.09	247.82	444.36	67.56	57.04	32.55	6.85	0.63	0.12	0.15	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.02
1990	0.64	43.71	183.88	147.65	21.40	18.42	11.10	2.54	0.26	0.06	0.07	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.01
1991	1.09	21.88	111.62	199.91	141.39	18.61	14.58	8.03	1.69	0.16	0.04	0.05	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01
1992	2.88	6.82	45.36	163.90	268.90	177.03	21.81	15.93	8.17	1.62	0.15	0.03	0.03	0.01	0.01	0.00	0.00	0.00	0.00	0.01
1993	0.49	24.22	46.06	41.71	62.74	106.60	84.36	13.33	13.02	8.97	2.34	0.26	0.06	0.08	0.02	0.02	0.01	0.01	0.00	0.02
1994	0.98	7.85	220.37	41.39	15.67	23.80	43.97	38.06	6.52	6.78	4.91	1.29	0.15	0.03	0.04	0.01	0.01	0.00	0.00	0.01
1995	0.38	12.37	67.22	211.42	16.22	6.03	9.79	19.64	18.48	3.40	3.75	2.79	0.75	0.09	0.02	0.03	0.01	0.01	0.00	0.01
1996	0.79	4.36	93.65	55.89	74.99	5.77	2.32	4.14	9.08	9.18	1.79	2.01	1.52	0.41	0.05	0.01	0.01	0.00	0.00	0.01
1997	1.96	38.42	89.55	185.51	47.30	60.77	4.68	1.86	3.21	6.78	6.67	1.26	1.39	1.05	0.28	0.03	0.01	0.01	0.00	0.01
1998	1.19	9.59	128.65	34.91	25.71	6.77	10.39	0.99	0.49	1.05	2.63	2.88	0.58	0.68	0.51	0.14	0.02	0.00	0.00	0.00
1999	3.46	35.38	144.18	223.34	26.02	18.04	4.73	7.19	0.67	0.33	0.68	1.68	1.81	0.37	0.43	0.32	0.09	0.01	0.00	0.01
2000	3.36	41.59	247.26	125.80	78.63	9.13	7.02	2.08	3.58	0.38	0.21	0.46	1.18	1.34	0.27	0.32	0.24	0.06	0.01	0.01
2001	1.54	27.67	242.83	190.58	39.78	25.39	3.41	3.15	1.14	2.38	0.30	0.18	0.43	1.16	1.31	0.27	0.31	0.23	0.06	0.01
2002	1.29	19.78	223.36	232.87	76.19	15.49	10.43	1.49	1.47	0.57	1.24	0.16	0.10	0.24	0.64	0.72	0.15	0.17	0.13	0.04
2003	1.22	12.04	116.81	170.33	75.87	24.23	5.22	3.79	0.59	0.62	0.25	0.58	0.07	0.05	0.11	0.30	0.34	0.07	0.08	0.08
2004	0.50	18.67	131.22	181.04	117.96	50.01	16.43	3.72	2.88	0.48	0.54	0.23	0.53	0.07	0.04	0.11	0.28	0.32	0.06	0.14
2005	0.24	5.96	148.72	140.23	87.38	55.70	24.64	8.52	2.03	1.65	0.29	0.33	0.14	0.33	0.04	0.03	0.07	0.18	0.20	0.13
2006	7.08	3.56	51.50	167.17	70.13	43.08	29.00	13.60	4.97	1.25	1.07	0.19	0.22	0.10	0.23	0.03	0.02	0.05	0.12	0.22
2007	3.37	78.06	27.51	47.53	63.69	27.26	19.35	15.72	9.09	4.07	1.23	1.18	0.22	0.28	0.12	0.29	0.04	0.02	0.06	0.42
2008	5.81	65.47	784.82	27.51	19.89	27.14	12.77	9.96	8.78	5.40	2.54	0.77	0.75	0.15	0.18	0.08	0.18	0.02	0.01	0.30
2009	0.56	44.90	361.43	531.43	7.23	5.34	8.38	4.65	4.30	4.40	3.06	1.55	0.49	0.49	0.10	0.12	0.05	0.12	0.02	0.20
2010	0.01	0.14	3.58	3.63	2.55	0.04	0.04	0.07	0.05	0.05	0.05	0.04	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2011	0.04	0.64	1.10	5.81	3.00	1.58	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2012	0.27	3.68	11.68	13.29	83.95	51.12	33.18	0.52	0.49	0.98	0.67	0.73	0.81	0.59	0.30	0.10	0.10	0.02	0.02	0.07
2013	0.45	2.79	14.07	17.24	8.89	42.63	24.86	16.15	0.25	0.24	0.49	0.33	0.36	0.40	0.29	0.15	0.05	0.05	0.01	0.04
2014	2.32	19.42	43.26	80.99	48.74	19.98	92.12	53.50	34.84	0.55	0.52	1.04	0.71	0.75	0.84	0.60	0.31	0.10	0.10	0.11

Table 22. Estimated discards at age in numbers (1000 fish)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1951	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1955	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1956	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1957	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1958	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1959	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1960	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1961	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1962	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1965	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1966	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1967	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1968	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1969	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1971	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1972	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1973	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1974	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1975	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1981	0.85	0.74	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1982	1.31	0.25	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1983	1.48	0.15	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1984	18.14	4.62	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1985	14.48	8.56	0.70	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1986	13.47	8.53	1.65	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	21.09	2.01	0.56	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	12.37	5.94	0.27	0.05	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	3.28	3.15	0.74	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	2.47	2.99	1.49	0.23	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	3.97	1.63	1.13	0.40	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	18.28	1.53	0.43	0.27	0.15	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	15.05	18.45	0.87	0.12	0.05	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	25.79	5.71	4.57	0.13	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	14.79	12.87	1.90	0.94	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	14.49	2.25	1.51	0.16	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	10.04	6.90	0.66	0.26	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	13.69	3.30	1.44	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	50.09	15.54	1.92	0.39	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	69.66	25.89	4.53	0.29	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	52.49	25.58	5.75	0.56	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	38.69	17.03	5.61	0.86	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	46.72	13.11	3.47	0.61	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	37.18	37.36	6.45	1.02	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	15.59	11.07	7.83	0.98	0.16	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	51.78	0.77	0.31	0.13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	86.83	51.15	0.41	0.09	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	155.08	50.12	16.20	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	32.07	68.13	13.42	2.31	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	17.03	6.48	28.41	13.54	6.56	0.07	0.05	0.07	0.03	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2011	8.82	4.80	2.66	11.83	5.49	2.79	0.03	0.03	0.05	0.03	0.03	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
2012	21.63	14.93	7.28	2.57	9.21	3.91	1.82	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2013	22.73	7.50	6.19	2.63	0.82	2.84	1.25	0.63	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
2014	58.80	26.23	8.99	5.45	1.91	0.56	1.89	0.83	0.42	0.01	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00

Table 23. Estimated discards at age in whole weight (1000 lb)

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1950	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1951	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1952	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1953	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1954	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1955	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1956	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1957	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1958	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1959	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1960	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1961	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1962	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1963	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1964	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1965	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1966	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1967	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1968	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1969	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1970	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1971	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1972	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1973	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1974	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1975	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1977	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1981	0.99	2.29	0.29	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1982	1.53	0.79	0.42	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1983	1.73	0.46	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1984	21.17	14.33	0.81	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1985	16.90	26.57	3.92	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1986	15.73	26.46	9.29	0.58	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	24.62	6.25	3.13	0.55	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	14.44	18.42	1.51	0.39	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	3.83	9.78	4.14	0.18	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	2.88	9.29	8.39	1.90	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	4.63	5.06	6.36	3.35	0.63	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992	21.34	4.76	2.40	2.28	1.62	0.47	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	17.56	57.26	4.86	0.96	0.54	0.35	0.10	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1994	30.10	17.74	25.64	1.07	0.15	0.09	0.06	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	17.26	39.93	10.66	7.82	0.24	0.03	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	16.91	7.00	8.50	1.32	0.75	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	11.72	21.41	3.73	2.13	0.24	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	15.97	10.23	8.09	0.54	0.16	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	58.46	48.24	10.81	3.24	0.13	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	81.30	80.35	25.46	2.41	0.48	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	61.26	79.38	32.27	4.70	0.31	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	45.15	52.86	31.50	7.16	0.87	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2003	54.53	40.69	19.48	5.10	0.70	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2004	43.40	115.94	36.22	8.49	1.55	0.19	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2005	18.19	34.36	44.01	8.17	1.72	0.39	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2006	60.43	2.38	1.76	1.05	0.14	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2007	101.34	158.74	2.33	0.72	0.29	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2008	180.99	155.54	91.00	0.54	0.11	0.04	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2009	37.43	211.44	75.38	19.25	0.08	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010	19.87	20.12	159.56	112.98	72.27	0.98	0.74	1.15	0.60	0.51	0.58	0.42	0.22	0.07	0.07	0.01	0.02	0.01	0.02	0.03
2011	10.29	14.91	14.96	98.75	60.56	37.58	0.54	0.47	0.87	0.57	0.62	0.69	0.50	0.26	0.08	0.08	0.02	0.02	0.01	0.05
2012	25.24	46.33	40.86	21.46	101.54	52.81	28.58	0.36	0.28	0.46	0.32	0.34	0.38	0.28	0.14	0.05	0.04	0.01	0.01	0.03
2013	26.52	23.29	34.75	21.96	9.00	38.33	19.60	11.05	0.15	0.13	0.26	0.18	0.19	0.21	0.15	0.08	0.02	0.02	0.00	0.02
2014	68.63	81.41	50.52	45.46	21.08	7.52	29.69	14.52	8.02	0.11	0.10	0.21	0.14	0.15	0.16	0.12	0.06	0.02	0.02	0.02

Table 24. Estimated status indicators, benchmarks, and related quantities from the base run of the Beaufort catch-age model, conditional on estimated current selectivities averaged across fleets. Also presented are median values and measures of precision (standard errors, SE) from the Monte Carlo/Bootstrap analysis. Rate estimates (F) are in units of y^{-1}*; status indicators are dimensionless; and biomass estimates are in units of metric tons or pounds, as indicated. Spawning stock biomass (SSB) is measured as population fecundity (number of eggs)*

Quantity	Units	Estimate	Median	SE
$F_{30\%}$	y^{-1}	0.15	0.15	0.01
$85\%F_{30\%}$	y^{-1}	0.12	0.13	0.01
$75\%F_{30\%}$	y^{-1}	0.11	0.11	0.01
$65\%F_{30\%}$	y^{-1}	0.10	0.10	0.01
$F_{30\%}$	y^{-1}	0.15	0.15	0.01
$F_{40\%}$	y^{-1}	0.11	0.11	0.01
$B_{\mathrm{F30\%}}$	metric tons	3637	3525	6052
$\mathrm{SSB}_{\mathrm{F30\%}}$	Eggs (1E8)	327706	293944	91136
MSST	Eggs (1E8)	245779	220458	68352
$L_{\mathrm{F30\%}}$	1000 lb whole	427	415	77
$R_{\mathrm{F30\%}}$	number fish	446642	455926	110006
$L_{85\%\mathrm{F30\%}}$	1000 lb whole	411	399	74
$L_{75\%\mathrm{F30\%}}$	1000 lb whole	395	384	71
$L_{65\%\mathrm{F30\%}}$	1000 lb whole	375	365	67
$F_{2012-2014}/F_{30\%}$	—	2.70	2.66	0.90
$\mathrm{SSB}_{2014}/\mathrm{MSST}$	—	0.20	0.21	0.12
$\mathrm{SSB}_{2014}/\mathrm{SSB}_{\mathrm{F30\%}}$	—	0.15	0.16	0.09

Table 25. Results from sensitivity runs of the Beaufort catch-age model. Current F represented by geometric mean of last three assessment years. Runs should not all be considered equally plausible.

Run	Description	$F_{30\%}$	$\mathrm{SSB}_{\mathrm{F30\%}}$ (1E8 Eggs)	$L_{\mathrm{F30\%}}$ (1000 lb)	$\mathrm{F}_{\mathrm{current}}/F_{30\%}$	$\mathrm{SSB}_{end}/\mathrm{SSB}_{\mathrm{F30\%}}$	R0(1000)	sigmaR	Finit
Base	—	0.147	329948	459	2.84	0.18	331	0.79	0.03
S1	remove 2008/9 from FD	0.147	329929	468	2.86	0.18	330	0.79	0.03
S2	upweight FI 10X	0.146	332402	438	2.07	0.28	325	0.82	0.03
S3	upweight FD 3X	0.146	344879	448	1.71	0.36	338	0.82	0.03
S4	FD only	0.145	332259	325	1.19	0.64	347	0.74	0.03
S5	M upper	0.169	246562	424	1.65	0.4	430	0.82	0.03
S6	M lower	0.133	406658	470	3.73	0.12	285	0.75	0.03
S7	Disc. M lower	0.147	328444	520	2.12	0.24	317	0.83	0.03
S8	Disc. M upper	0.146	335957	424	2.82	0.2	354	0.72	0.03
S9	Longer CVID index	0.147	334145	470	1.99	0.3	344	0.76	0.03
S10	Smooth 1984/5 MRIP peak	0.147	328483	462	2.53	0.22	327	0.8	0.03
S11	h=0.84	0.146	396289	525	3.56	0.11	497	0.6	0.03
S12	Truncated HB disc. index	0.147	331524	470	2.6	0.21	334	0.78	0.03
S13	Ageing error matrix	0.144	334881	409	1.63	0.39	319	0.85	0.03
S14	Batch number lower	0.154	220597	468	2.47	0.24	330	0.79	0.03
S15	Batch number upper	0.146	362022	465	2.63	0.21	333	0.78	0.03
S16	Drop HB disc. index	0.147	331560	470	2.59	0.21	334	0.78	0.03
S17	Higher landings	0.147	441258	654	1.94	0.25	406	0.89	0.03
S18	Lower landings	0.146	232011	298	3.36	0.18	258	0.64	0.03
S19	Higher discards	0.146	338021	500	2.6	0.19	362	0.7	0.03
S20	Lower discards	0.147	327352	561	1.89	0.26	306	0.87	0.03
S21	Dome-shaped selectivity for cH	0.15	355593	490	2.28	0.23	333	0.87	0.03
S22	Separate video and trap indices	0.143	331956	391	1.58	0.41	341	0.76	0.03
S23	FI index only	0.146	330170	436	2.75	0.18	342	0.75	0.03
S24	Continuity	0.102	817833	501	5.97	0.06	114	1.18	0.04
S25	Split q for HB CPUE	0.147	331168	466	2.61	0.2	333	0.79	0.03
S26	1978 start year	0.147	299224	418	2.93	0.19	320	0.7	0.2
S27	Estimate selex for all ages	0.148	328522	465	2.61	0.2	332	0.78	0.03

Table 26. Projection results with fishing mortality rate fixed at $F = 0$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1E8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), pr.reb = proportion of stochastic projection replicates with $\mathrm{SSB} \geq \mathrm{SSB}_{F30\%}$. The extension b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b(1E8)	S.med(1E8)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2015	432	310	0.12	0.13	63370	58040	0	0	0	0	70	69	279	281	0.001
2016	436	308	0.24	0.26	87803	78457	28	28	244	243	71	66	343	329	0.004
2017	439	314	0.00	0.00	126462	111544	0	0	0	0	0	0	0	0	0.015
2018	442	314	0.00	0.00	180342	157052	0	0	0	0	0	0	0	0	0.067
2019	444	318	0.00	0.00	241177	207405	0	0	0	0	0	0	0	0	0.192
2020	446	316	0.00	0.00	305554	261097	0	0	0	0	0	0	0	0	0.390
2021	446	325	0.00	0.00	371340	315588	0	0	0	0	0	0	0	0	0.605
2022	447	319	0.00	0.00	436842	369565	0	0	0	0	0	0	0	0	0.776
2023	447	320	0.00	0.00	499775	422387	0	0	0	0	0	0	0	0	0.892
2024	448	318	0.00	0.00	559749	473142	0	0	0	0	0	0	0	0	0.953
2025	448	325	0.00	0.00	615542	521524	0	0	0	0	0	0	0	0	0.983
2026	448	322	0.00	0.00	666967	565810	0	0	0	0	0	0	0	0	0.993
2027	448	327	0.00	0.00	714392	606683	0	0	0	0	0	0	0	0	0.997
2028	448	321	0.00	0.00	757163	644437	0	0	0	0	0	0	0	0	0.999
2029	448	324	0.00	0.00	795659	680658	0	0	0	0	0	0	0	0	1.000
2030	448	321	0.00	0.00	830549	711124	0	0	0	0	0	0	0	0	1.000
2031	448	322	0.00	0.00	861736	739593	0	0	0	0	0	0	0	0	1.000
2032	448	320	0.00	0.00	889361	764257	0	0	0	0	0	0	0	0	1.000
2033	448	320	0.00	0.00	913872	786749	0	0	0	0	0	0	0	0	1.000
2034	448	319	0.00	0.00	935454	806215	0	0	0	0	0	0	0	0	1.000
2035	448	321	0.00	0.00	954544	824197	0	0	0	0	0	0	0	0	1.000
2036	448	323	0.00	0.00	971405	839359	0	0	0	0	0	0	0	0	1.000
2037	448	322	0.00	0.00	986280	853107	0	0	0	0	0	0	0	0	1.000
2038	448	319	0.00	0.00	999400	865349	0	0	0	0	0	0	0	0	1.000
2039	448	319	0.00	0.00	1010969	876882	0	0	0	0	0	0	0	0	1.000
2040	448	322	0.00	0.00	1021170	885872	0	0	0	0	0	0	0	0	1.000
2041	448	320	0.00	0.00	1030164	891838	0	0	0	0	0	0	0	0	1.000
2042	448	322	0.00	0.00	1038093	899554	0	0	0	0	0	0	0	0	1.000
2043	448	320	0.00	0.00	1045082	903786	0	0	0	0	0	0	0	0	1.000
2044	448	321	0.00	0.00	1051243	910470	0	0	0	0	0	0	0	0	1.000

Table 27. Projection results with fishing mortality rate fixed at $F = F_{\mathrm{current}}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1E8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), pr.reb = proportion of stochastic projection replicates with $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{F30\%}}$. The extension b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b(1E8)	S.med(1E8)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2015	432	310	0.12	0.13	63370	58040	0	0	0	0	70	69	279	281	0.001
2016	436	308	0.24	0.26	87803	78457	28	28	244	243	71	66	343	329	0.004
2017	439	314	0.39	0.40	101048	88970	54	47	506	447	111	94	596	507	0.009
2018	441	313	0.39	0.40	104221	90788	50	43	504	438	103	87	559	475	0.014
2019	441	314	0.39	0.40	103601	89616	45	39	475	411	98	84	522	447	0.018
2020	441	311	0.39	0.40	101372	87427	43	37	451	390	96	82	496	426	0.021
2021	441	319	0.39	0.40	98928	85355	41	35	433	376	95	82	481	414	0.023
2022	441	313	0.39	0.40	96768	83444	40	35	422	367	94	81	472	410	0.024
2023	440	313	0.39	0.40	94914	82528	40	35	415	362	94	81	468	405	0.024
2024	440	311	0.39	0.40	93436	81291	40	34	409	358	94	81	466	404	0.025
2025	440	318	0.39	0.40	92263	80530	39	34	406	355	94	81	464	405	0.023
2026	440	314	0.39	0.40	91381	79593	39	34	403	354	94	81	463	404	0.023
2027	440	319	0.39	0.40	90750	79116	39	34	401	352	94	81	462	404	0.023
2028	440	313	0.39	0.40	90288	78840	39	34	400	352	93	81	462	402	0.022
2029	440	316	0.39	0.40	89959	78457	39	34	399	351	93	81	461	400	0.022
2030	440	313	0.39	0.40	89733	78412	39	34	398	349	93	81	461	402	0.022
2031	440	314	0.39	0.40	89574	78504	39	34	398	348	93	81	461	403	0.021
2032	440	312	0.39	0.40	89461	78546	39	34	398	349	93	81	461	402	0.021
2033	440	312	0.39	0.40	89383	78488	39	34	398	349	93	80	461	400	0.019
2034	440	311	0.39	0.40	89328	78699	39	34	397	348	93	80	460	400	0.019
2035	440	312	0.39	0.40	89290	78393	39	34	397	347	93	80	460	400	0.018
2036	440	315	0.39	0.40	89263	78314	39	34	397	348	93	80	460	398	0.018
2037	440	314	0.39	0.40	89245	77966	39	34	397	348	93	80	460	398	0.017
2038	440	311	0.39	0.40	89232	77935	39	34	397	348	93	80	460	399	0.017
2039	440	310	0.39	0.40	89224	78213	39	34	397	348	93	80	460	399	0.018
2040	440	314	0.39	0.40	89217	78131	39	34	397	348	93	80	460	399	0.019
2041	440	312	0.39	0.40	89213	78267	39	34	397	348	93	81	460	399	0.020
2042	440	313	0.39	0.40	89210	78063	39	34	397	348	93	81	460	400	0.020
2043	440	312	0.39	0.40	89208	78081	39	34	397	346	93	81	460	401	0.019
2044	440	313	0.39	0.40	89207	78117	39	34	397	348	93	80	460	401	0.020

Table 28. Projection results with fishing mortality rate fixed at $F = F_{30\%}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1E8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), pr.reb = proportion of stochastic projection replicates with $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{F30\%}}$. The extension b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b(1E8)	S.med(1E8)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2015	432	310	0.12	0.13	63370	58040	0	0	0	0	70	69	279	281	0.001
2016	436	308	0.24	0.26	87803	78457	28	28	244	243	71	66	343	329	0.004
2017	439	314	0.15	0.15	116361	102522	22	20	207	195	44	39	241	218	0.009
2018	442	314	0.15	0.15	146966	127331	24	22	253	233	45	40	266	239	0.021
2019	443	317	0.15	0.15	175465	149920	26	23	285	258	46	41	281	252	0.040
2020	444	315	0.15	0.15	200733	169768	27	24	310	279	46	41	291	261	0.064
2021	445	323	0.15	0.15	222841	187374	28	25	332	298	47	42	299	267	0.096
2022	445	318	0.15	0.15	241979	202838	29	26	350	313	47	42	304	273	0.133
2023	446	319	0.15	0.15	257965	216120	29	27	365	327	47	42	310	279	0.167
2024	446	317	0.15	0.15	271354	227528	30	27	377	339	47	43	315	284	0.203
2025	446	324	0.15	0.15	282261	237107	30	27	387	349	48	43	319	288	0.234
2026	446	320	0.15	0.15	291141	244945	31	28	395	357	48	43	322	292	0.265
2027	446	325	0.15	0.15	298461	252233	31	28	401	364	48	43	324	295	0.293
2028	446	320	0.15	0.15	304304	258346	31	28	407	370	48	43	326	297	0.319
2029	446	323	0.15	0.15	308994	262872	31	29	411	375	48	44	328	298	0.340
2030	446	320	0.15	0.15	312828	266655	31	29	414	378	48	44	329	300	0.357
2031	447	320	0.15	0.15	315895	269863	31	29	417	380	48	44	330	301	0.373
2032	447	318	0.15	0.15	318319	271942	32	29	419	382	48	44	331	303	0.387
2033	447	319	0.15	0.15	320248	273385	32	29	421	384	48	44	332	302	0.398
2034	447	317	0.15	0.15	321769	275170	32	29	422	385	48	44	332	302	0.406
2035	447	319	0.15	0.15	322982	276801	32	29	423	386	48	44	332	303	0.413
2036	447	322	0.15	0.15	323949	277909	32	29	424	387	48	43	333	302	0.420
2037	447	321	0.15	0.15	324719	278086	32	29	424	387	48	44	333	303	0.422
2038	447	318	0.15	0.15	325331	278898	32	29	425	387	48	44	333	303	0.426
2039	447	317	0.15	0.15	325818	279526	32	29	425	389	48	44	333	304	0.429
2040	447	321	0.15	0.15	326206	279292	32	29	426	388	48	43	334	303	0.431
2041	447	318	0.15	0.15	326513	279646	32	29	426	388	48	44	334	304	0.433
2042	447	320	0.15	0.15	326758	280069	32	29	426	389	48	44	334	303	0.434
2043	447	319	0.15	0.15	326953	280511	32	29	426	389	48	44	334	304	0.436
2044	447	320	0.15	0.15	327107	281317	32	29	426	389	48	44	334	305	0.438

Table 29. Projection results with fishing mortality rate fixed at $F = 98\%F_{30\%}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1E8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb*), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $\mathrm{SSB} \geq \mathrm{SSB}_{\mathrm{F30\%}}$. *The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b(1E8)	S.med(1E8)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2015	432	310	0.12	0.13	63370	58040	0	0	0	0	70	69	279	281	0.001
2016	436	308	0.24	0.26	87803	78457	28	28	244	243	71	66	343	329	0.004
2017	439	314	0.14	0.15	116554	102701	22	20	204	191	43	39	236	214	0.009
2018	442	314	0.14	0.15	147566	127869	24	22	249	229	44	40	261	235	0.021
2019	443	317	0.14	0.15	176574	150930	25	23	280	255	45	40	277	248	0.041
2020	444	315	0.14	0.15	202402	171207	27	24	306	276	45	40	287	257	0.068
2021	445	323	0.14	0.15	225080	189241	28	25	328	294	46	41	295	263	0.101
2022	445	318	0.14	0.15	244772	205267	28	26	346	310	46	41	301	270	0.140
2023	446	319	0.14	0.15	261274	218931	29	26	362	324	46	42	306	276	0.177
2024	446	317	0.14	0.15	275135	230819	30	27	374	336	47	42	311	281	0.216
2025	446	324	0.14	0.15	286462	240644	30	27	384	346	47	42	315	285	0.250
2026	446	320	0.14	0.15	295709	248731	30	28	392	354	47	43	318	289	0.283
2027	446	325	0.14	0.15	303348	256468	31	28	399	362	47	43	321	292	0.314
2028	446	320	0.14	0.15	309463	262888	31	28	404	367	47	43	323	294	0.340
2029	446	323	0.14	0.15	314383	267501	31	28	408	373	47	43	324	295	0.366
2030	447	320	0.14	0.15	318413	271419	31	28	412	376	47	43	326	297	0.384
2031	447	320	0.14	0.15	321643	274734	31	28	415	378	47	43	327	298	0.401
2032	447	318	0.14	0.15	324202	277080	31	29	417	380	47	43	328	300	0.419
2033	447	319	0.14	0.15	326244	278482	31	29	418	382	47	43	328	299	0.429
2034	447	317	0.14	0.15	327857	280438	31	29	420	383	47	43	329	299	0.437
2035	447	319	0.14	0.15	329147	282062	31	29	421	385	47	43	329	300	0.445
2036	447	322	0.14	0.15	330176	283369	31	29	422	386	47	43	330	300	0.451
2037	447	321	0.14	0.15	330997	283572	32	29	423	385	47	43	330	300	0.454
2038	447	318	0.14	0.15	331652	284239	32	29	423	386	47	43	330	300	0.457
2039	447	318	0.14	0.15	332173	284986	32	29	424	387	47	43	330	301	0.461
2040	447	321	0.14	0.15	332589	284754	32	29	424	387	47	43	330	300	0.463
2041	447	318	0.14	0.15	332920	285289	32	29	424	387	47	43	330	301	0.466
2042	447	320	0.14	0.15	333184	285527	32	29	424	387	47	43	331	300	0.468
2043	447	319	0.14	0.15	333393	286147	32	29	425	387	47	43	331	301	0.469
2044	447	320	0.14	0.15	333561	286879	32	29	425	388	47	43	331	302	0.473

Table 30. Projection results with fishing mortality rate fixed at $F = F_{\text{rebuild}}$ starting in 2017. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1E8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb), pr.reb = proportion of stochastic projection replicates with $\text{SSB} \geq \text{SSB}_{F30\%}$. The extension b indicates expected values (deterministic) from the base run; the extension med indicates median values from the stochastic projections.

Year	R.b	R.med	F.b	F.med	S.b(1E8)	S.med(1E8)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2015	432	310	0.12	0.13	63370	58040	0	0	0	0	70	69	279	281	0.001
2016	436	308	0.24	0.26	87803	78457	28	28	244	243	71	66	343	329	0.004
2017	439	314	0.14	0.14	116573	102855	21	20	203	186	43	38	236	209	0.010
2018	442	314	0.14	0.14	147623	128689	24	21	249	224	44	39	261	230	0.025
2019	443	317	0.14	0.14	176680	152227	25	22	280	250	45	39	277	244	0.049
2020	444	315	0.14	0.14	202560	173676	26	23	306	272	45	40	287	253	0.083
2021	445	323	0.14	0.14	225292	192272	28	24	328	291	46	40	294	259	0.124
2022	445	318	0.14	0.14	245038	208432	28	25	346	306	46	41	300	266	0.168
2023	446	319	0.14	0.14	261589	222291	29	26	361	321	46	41	306	273	0.210
2024	446	317	0.14	0.14	275495	235178	30	27	374	334	47	41	311	278	0.251
2025	446	324	0.14	0.14	286862	245047	30	27	384	344	47	42	315	282	0.288
2026	446	320	0.14	0.14	296144	253406	30	27	392	352	47	42	318	285	0.323
2027	446	325	0.14	0.14	303815	260726	31	28	399	360	47	42	320	288	0.355
2028	446	320	0.14	0.14	309955	266702	31	28	404	366	47	42	322	290	0.380
2029	446	323	0.14	0.14	314897	271842	31	28	408	371	47	42	324	292	0.403
2030	447	320	0.14	0.14	318946	276078	31	28	412	374	47	42	325	293	0.421
2031	447	320	0.14	0.14	322193	278737	31	28	414	376	47	42	326	295	0.436
2032	447	318	0.14	0.14	324765	281639	31	28	417	378	47	42	327	296	0.452
2033	447	319	0.14	0.14	326817	283858	31	28	418	380	47	43	328	296	0.462
2034	447	317	0.14	0.14	328439	285560	31	28	420	382	47	42	328	296	0.471
2035	447	319	0.14	0.14	329736	286369	31	29	421	382	47	42	329	297	0.477
2036	447	322	0.14	0.14	330772	287263	31	29	422	383	47	42	329	296	0.482
2037	447	321	0.14	0.14	331598	288575	32	29	422	383	47	42	329	296	0.485
2038	447	318	0.14	0.14	332257	289369	32	29	423	383	47	42	330	297	0.490
2039	447	317	0.14	0.14	332782	290043	32	29	423	384	47	42	330	298	0.495
2040	447	321	0.14	0.14	333200	290214	32	29	424	384	47	42	330	297	0.497
2041	447	319	0.14	0.14	333533	290371	32	29	424	385	47	42	330	297	0.496
2042	447	320	0.14	0.14	333799	290884	32	29	424	385	47	43	330	297	0.496
2043	447	319	0.14	0.14	334010	291259	32	29	424	386	47	43	330	298	0.495
2044	447	320	0.14	0.14	334179	291227	32	29	425	385	47	43	330	298	0.496

Table 31. Projection results with fishing mortality rate applied only to discards. R = number of age-1 recruits (in 1000s), F = fishing mortality rate (per year), S = spawning stock (1E8 eggs), L = landings expressed in numbers (n, in 1000s) or whole weight (w, in 1000 lb*), and D = dead discards expressed in numbers (n, in 1000s) or whole weight (w, in 1000* lb*), pr.reb = proportion of stochastic projection replicates with* $SSB \geq SSB_{F30\%}$*. The extension* b *indicates expected values (deterministic) from the base run; the extension* med *indicates median values from the stochastic projections.*

Year	R.b	R.med	F.b	F.med	S.b(1E8)	S.med(1E8)	L.b(n)	L.med(n)	L.b(w)	L.med(w)	D.b(n)	D.med(n)	D.b(w)	D.med(w)	pr.reb
2015	432	306	0.12	0.13	63370	58033	0	0	0	0	70	69	279	282	0.001
2016	436	311	0.11	0.12	93943	84171	0	0	0	0	70	69	346	345	0.004
2017	440	312	0.12	0.13	129264	113133	0	0	0	0	76	71	430	414	0.016
2018	443	316	0.12	0.13	165018	141286	0	0	0	0	77	71	472	443	0.052
2019	444	314	0.12	0.13	199126	167365	0	0	0	0	77	72	496	459	0.110
2020	445	322	0.12	0.13	230244	191136	0	0	0	0	77	73	511	470	0.181
2021	446	317	0.12	0.13	258437	212321	0	0	0	0	78	73	522	480	0.251
2022	446	318	0.12	0.13	283795	231043	0	0	0	0	78	74	531	489	0.313
2023	446	319	0.12	0.13	305879	246463	0	0	0	0	79	74	541	498	0.366
2024	446	324	0.12	0.13	325137	260140	0	0	0	0	79	75	552	509	0.414
2025	447	320	0.12	0.13	341463	272140	0	0	0	0	79	76	561	517	0.452
2026	447	325	0.12	0.13	355334	282256	0	0	0	0	80	76	569	527	0.484
2027	447	319	0.12	0.13	367293	291101	0	0	0	0	80	76	575	533	0.512
2028	447	323	0.12	0.13	377276	298167	0	0	0	0	80	77	581	539	0.535
2029	447	320	0.12	0.13	385681	304830	0	0	0	0	80	77	585	543	0.554
2030	447	320	0.12	0.13	392908	310205	0	0	0	0	81	77	589	547	0.567
2031	447	320	0.12	0.13	398981	315115	0	0	0	0	81	77	592	549	0.581
2032	447	320	0.12	0.13	404020	319257	0	0	0	0	81	77	595	552	0.592
2033	447	319	0.12	0.13	408235	322070	0	0	0	0	81	77	597	552	0.601
2034	447	319	0.12	0.13	411727	324568	0	0	0	0	81	77	599	554	0.609
2035	447	323	0.12	0.13	414665	326003	0	0	0	0	81	77	601	554	0.614
2036	447	321	0.12	0.13	417136	327593	0	0	0	0	81	77	602	556	0.620
2037	447	318	0.12	0.13	419213	328401	0	0	0	0	81	77	603	557	0.625
2038	447	318	0.12	0.13	420958	330168	0	0	0	0	81	78	604	558	0.628
2039	447	323	0.12	0.13	422424	331400	0	0	0	0	81	77	605	559	0.631
2040	447	318	0.12	0.13	423655	332671	0	0	0	0	81	78	606	559	0.632
2041	447	320	0.12	0.13	424689	332754	0	0	0	0	81	78	606	560	0.634
2042	447	321	0.12	0.13	425557	333040	0	0	0	0	81	78	607	563	0.638
2043	447	321	0.12	0.13	426286	333165	0	0	0	0	81	78	607	562	0.639
2044	447	320	0.12	0.13	426898	334378	0	0	0	0	81	78	607	562	0.640

Table 32. Parameter estimates from selected ASPIC surplus production model runs 318 (continuity), 319 (updated continuity), 320 (best configuration), and 323 (best configuration with B_1/K fixed) All parameter values are rounded to 3 significant digits. MSY, B_1, and K are in units of 1000 pounds. Catchability parameters correspond to the commercial (q_1), headboat (q_2), headboat-at-sea (q_3), and CVID (q_4) indices.

Run	F/F_{MSY}	B/B_{MSY}	B_1/K	MSY	F_{MSY}	q_1	q_2	q_3	q_4	B_1	K
318	2.15	0.53	0.467	805	0.313	9.35e-07	7.14e-07			2400	5140
319	0.614	1.3	1.94	802	0.314	9.42e-07	7.14e-07			9930	5110
320	0.531	1.48	0.91	805	0.322	8.69e-07	6.98e-07	2.98e-07	4.04e-07	4560	5010
323	0.53	1.47	0.467	807	0.321	8.74e-07	7e-07	2.99e-07	4.02e-07	2350	5030

8 Figures

Figure 1. Indices of abundance used in fitting the assessment model. HB indicates the headboat logbook index; Handline indicated the the commercial handline logbook index; HB Disc indicated the headboat discard observer index, CVT indicates the SERFS chevron trap index; VID indicates the SERFS video index, and CVID indicates the combined chevron trap and video index. The CVT and VID indices were only used during sensitivity runs.

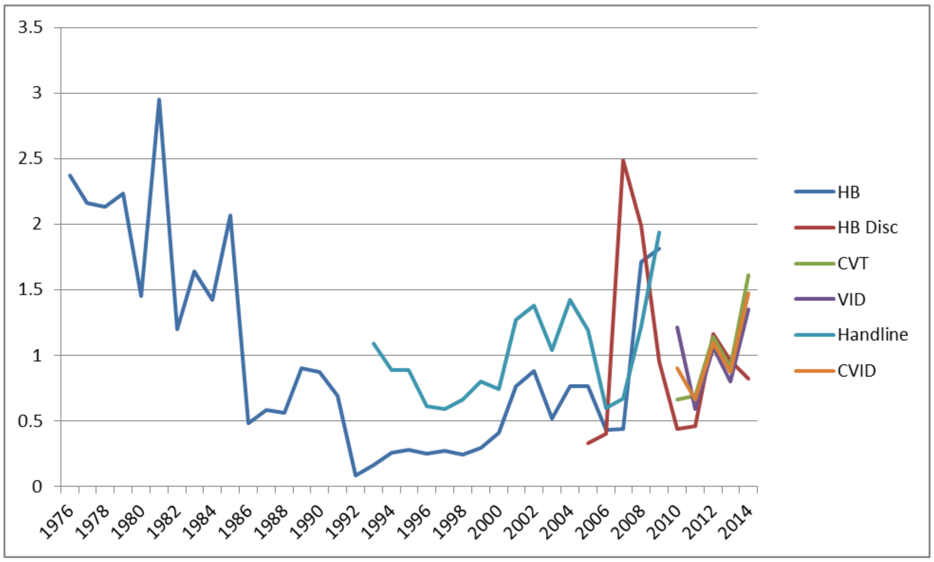


Figure 2. Mean total length at age (mm) and estimated upper and lower 95% confidence intervals of the population.

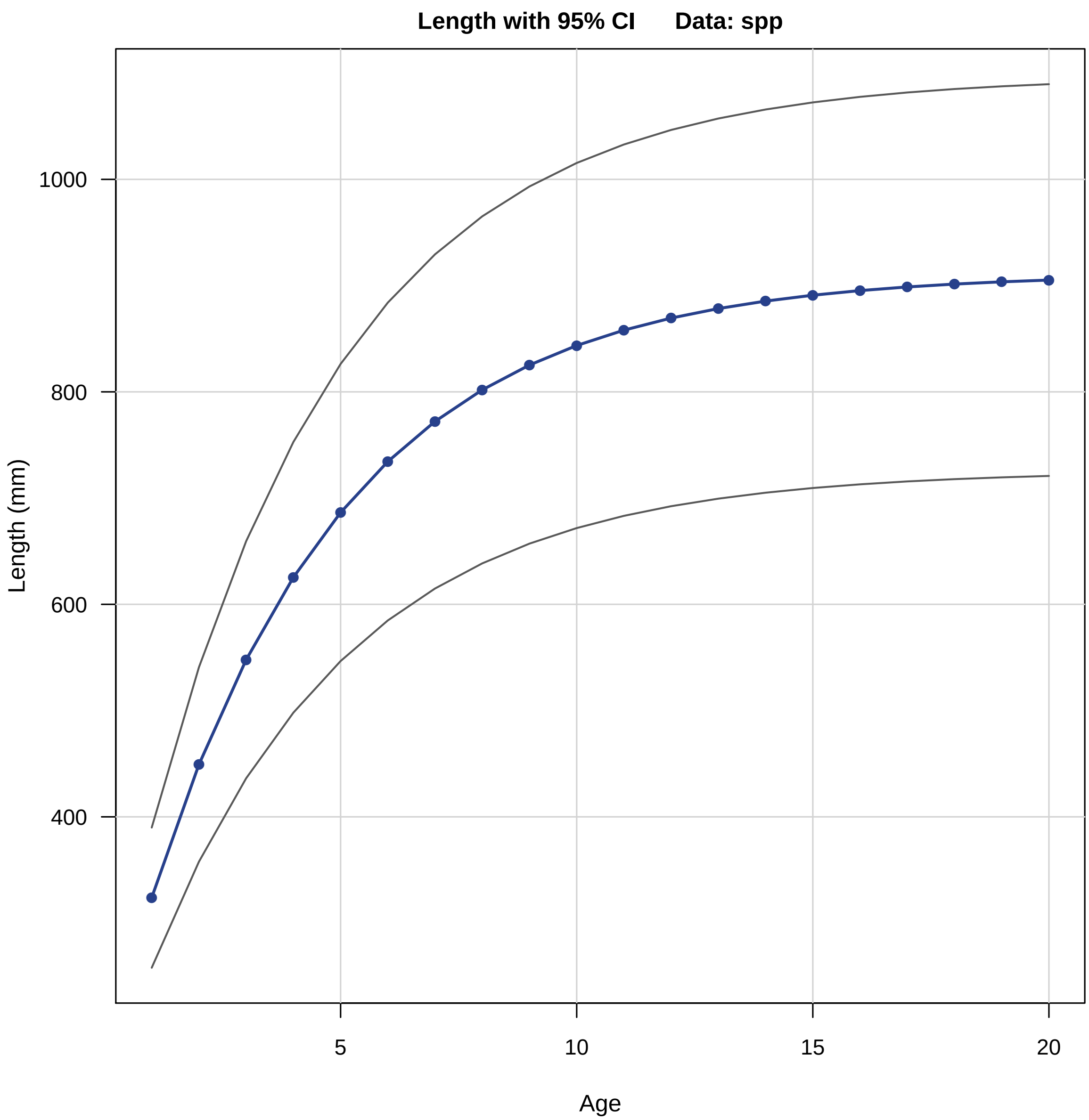


Figure 3. Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey. In panels indicating the data set, lcomp refers to length compositions, acomp to age compositions, CVT to MARMAP chevron trap, cH to commercial handline, HB to headboat and GR to general recreational.

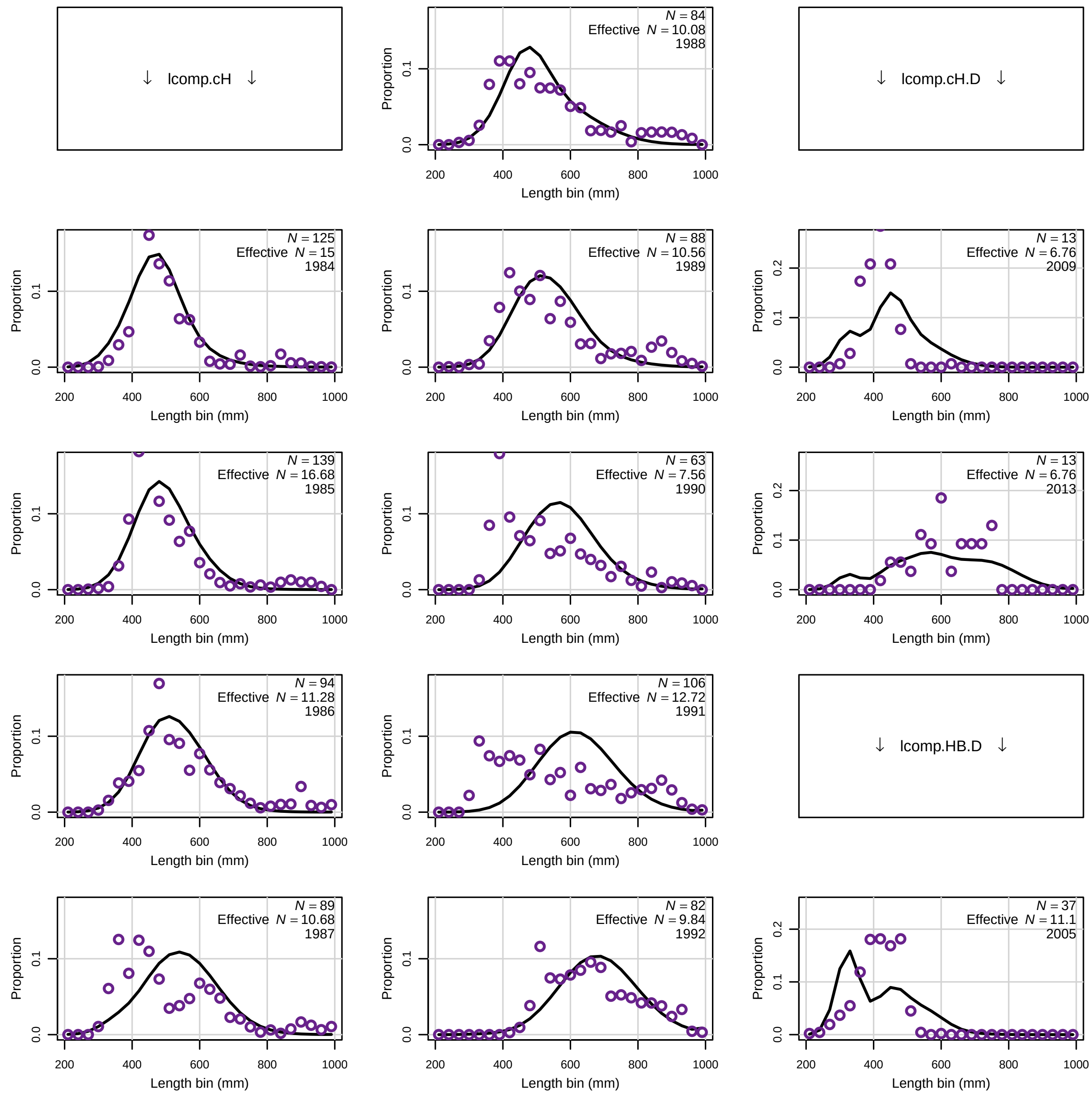


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

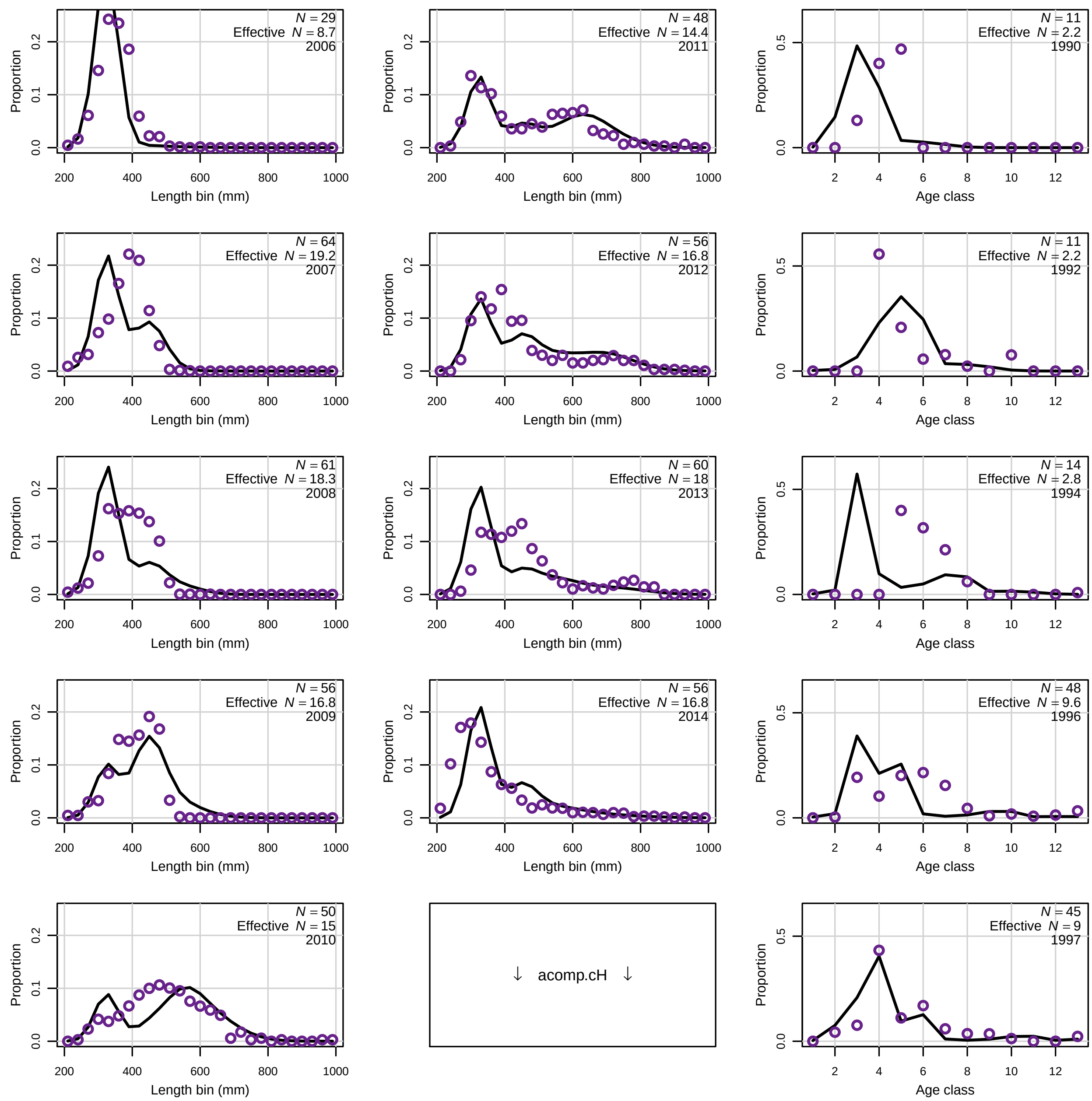


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

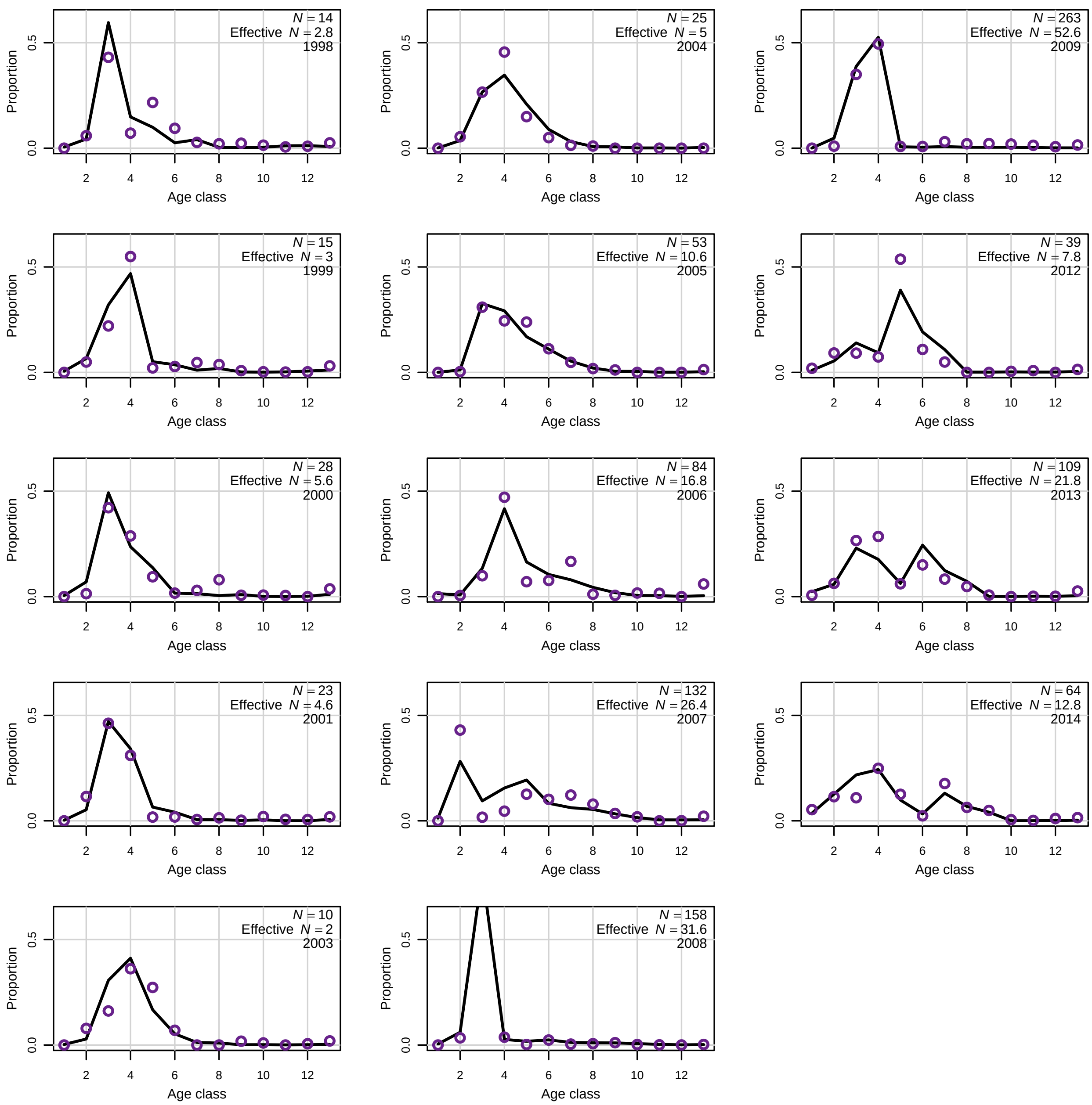


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

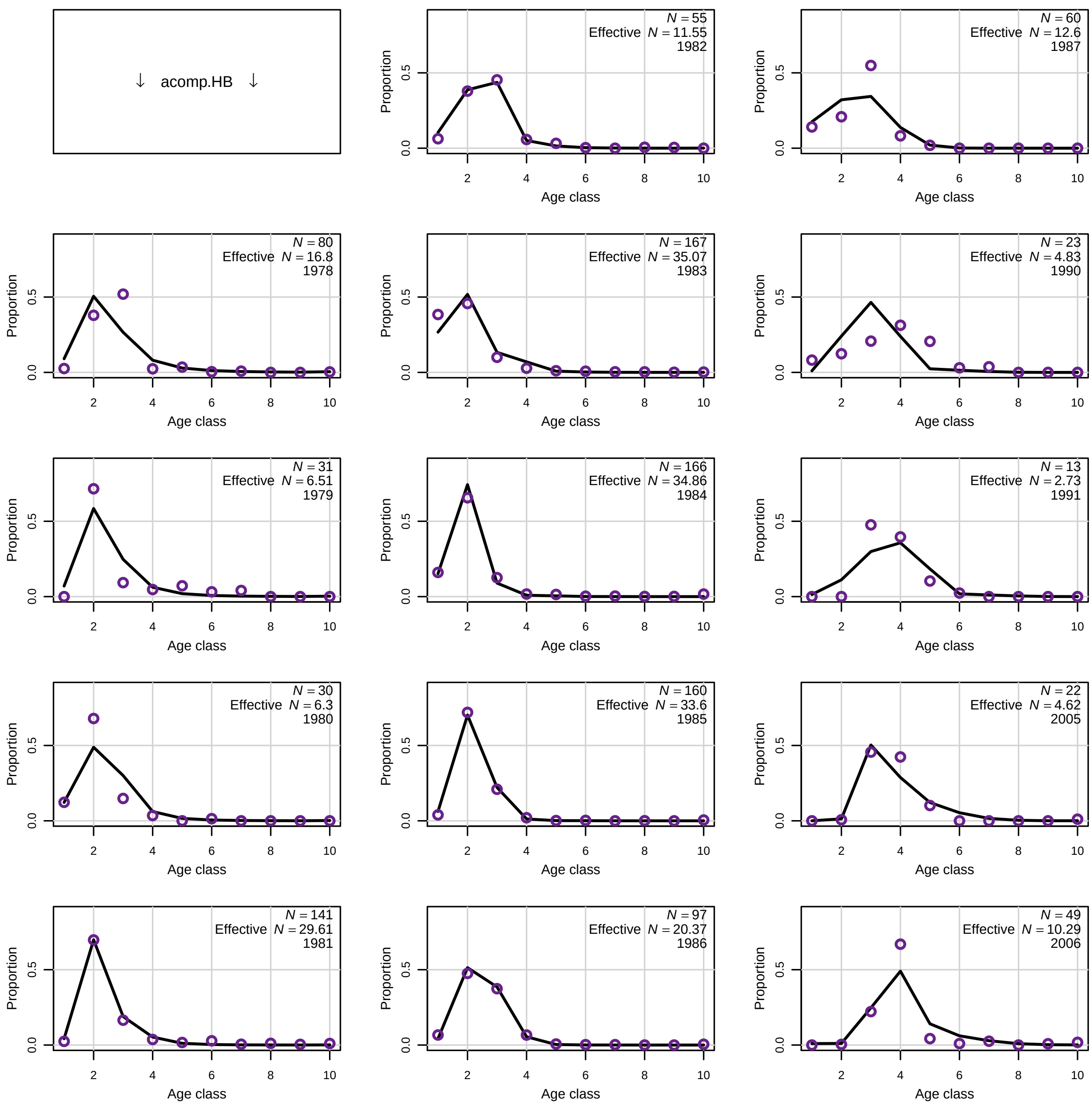


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

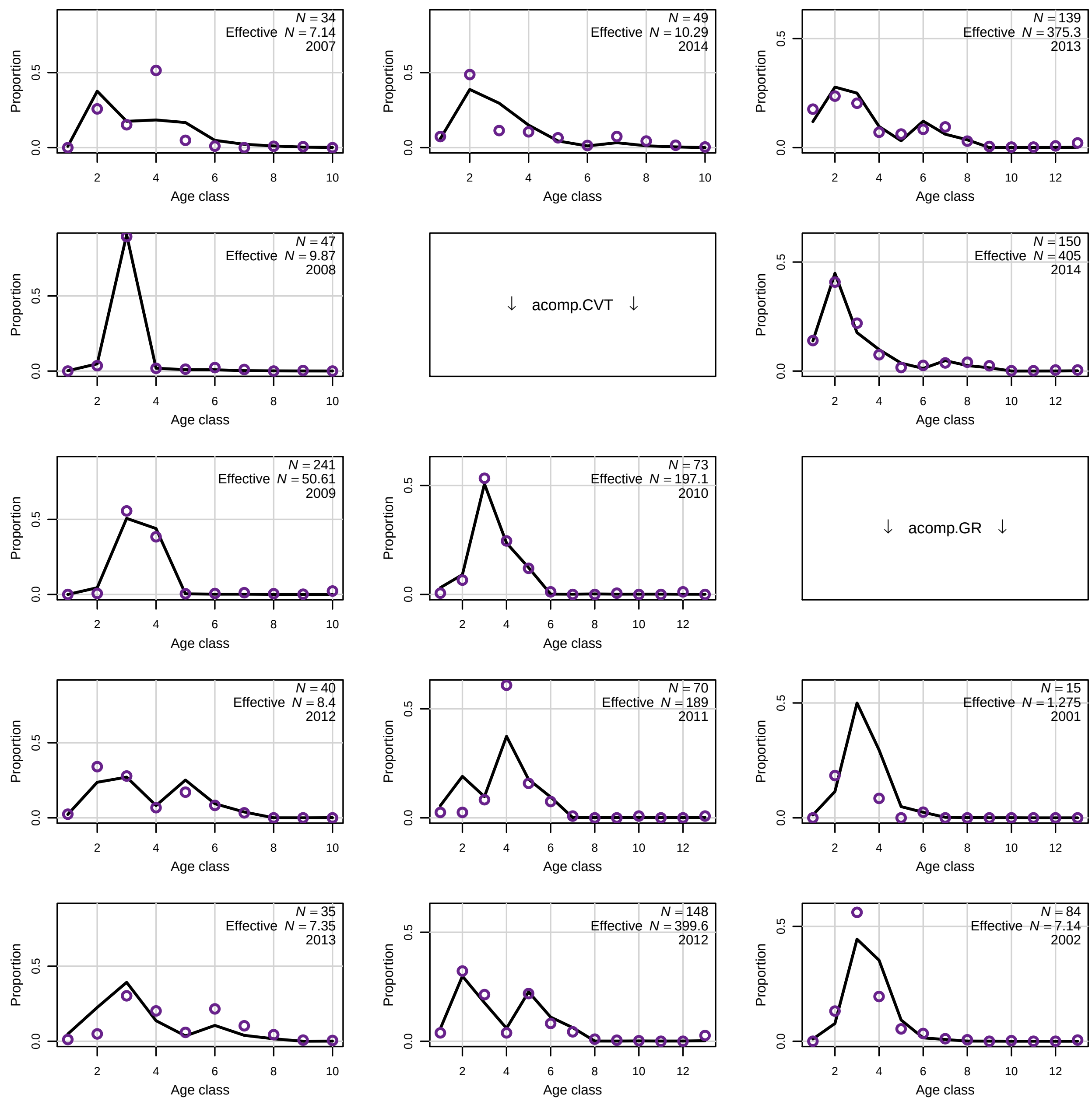


Figure 3. (cont.) Observed (open circles) and estimated (solid line) annual length and age compositions by fleet or survey.

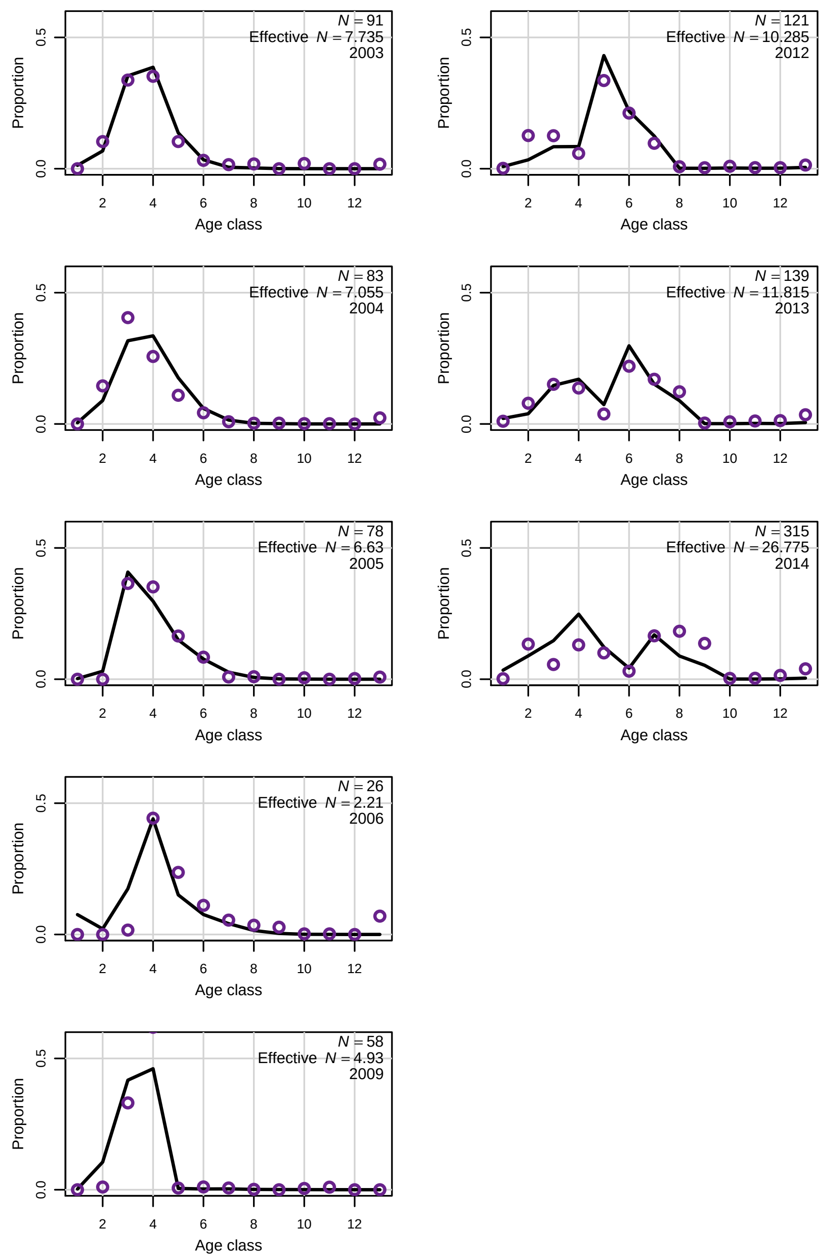


Figure 4. Observed (open circles) and estimated (solid line, circles) commercial handline landings in 1000 lb whole weight.

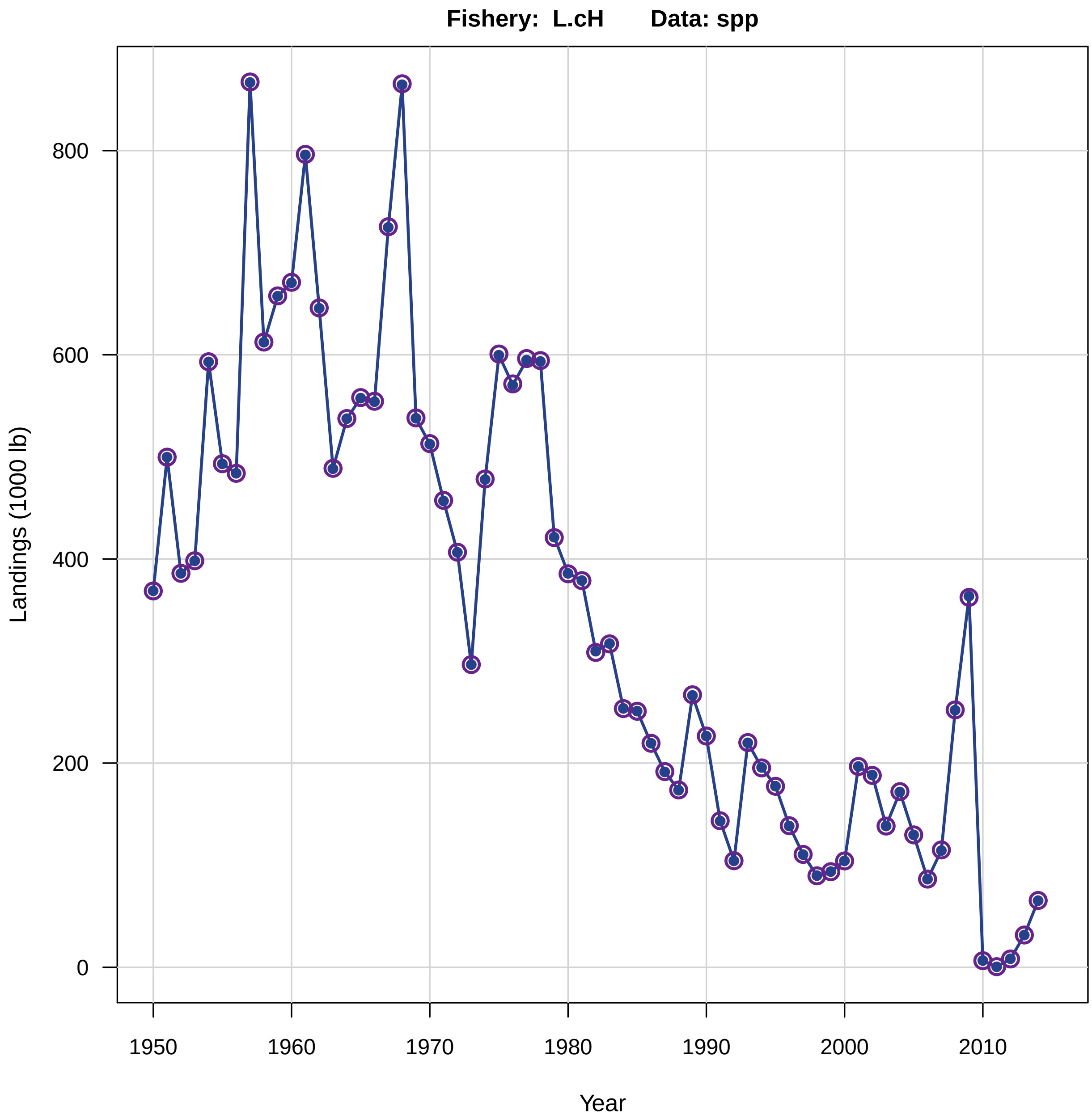


Figure 5. Observed (open circles) and estimated (solid line, circles) headboat landings in 1000s of fish.

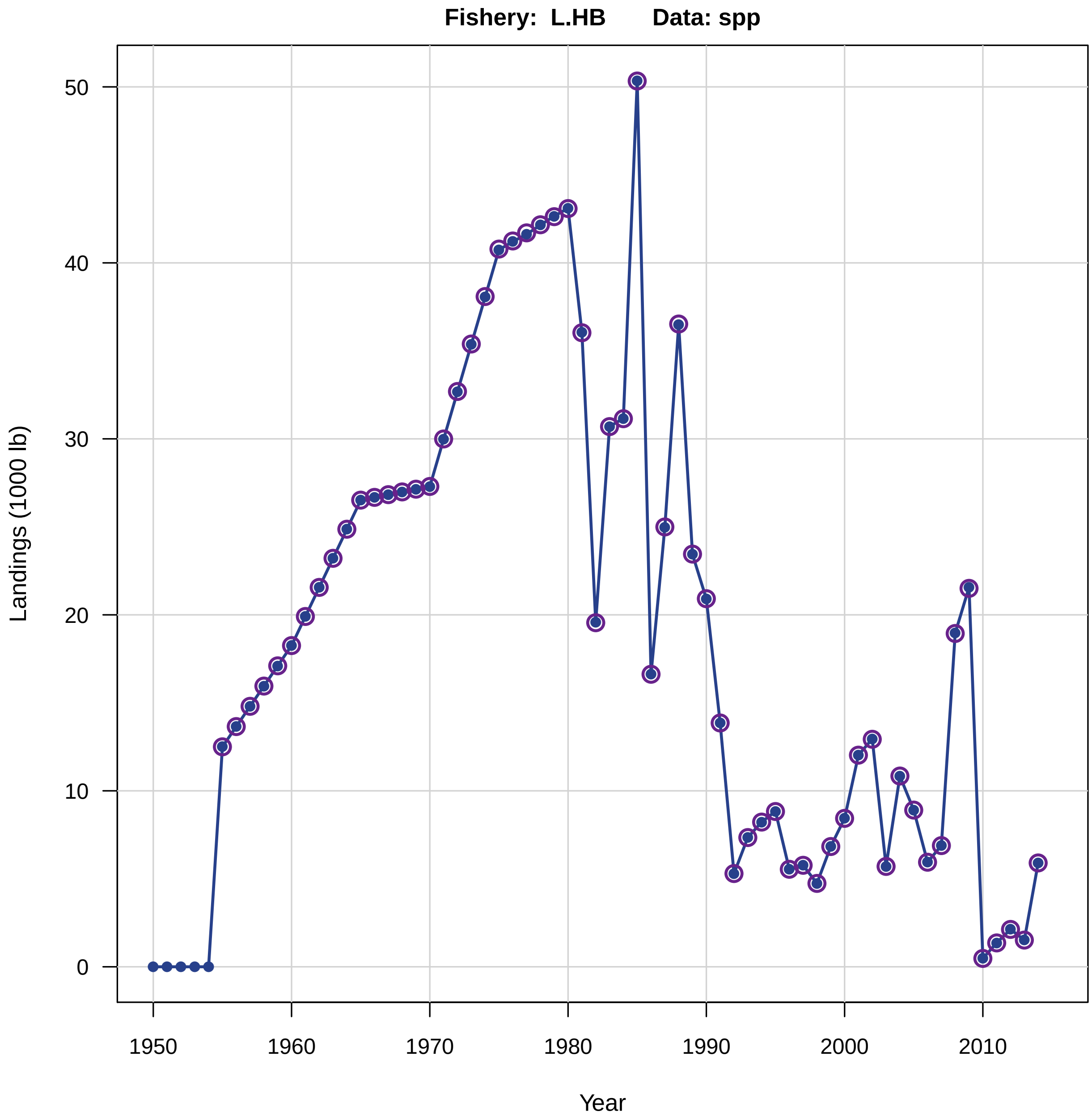


Figure 6. Observed (open circles) and estimated (solid line, circles) general recreational landings in 1000s of fish.

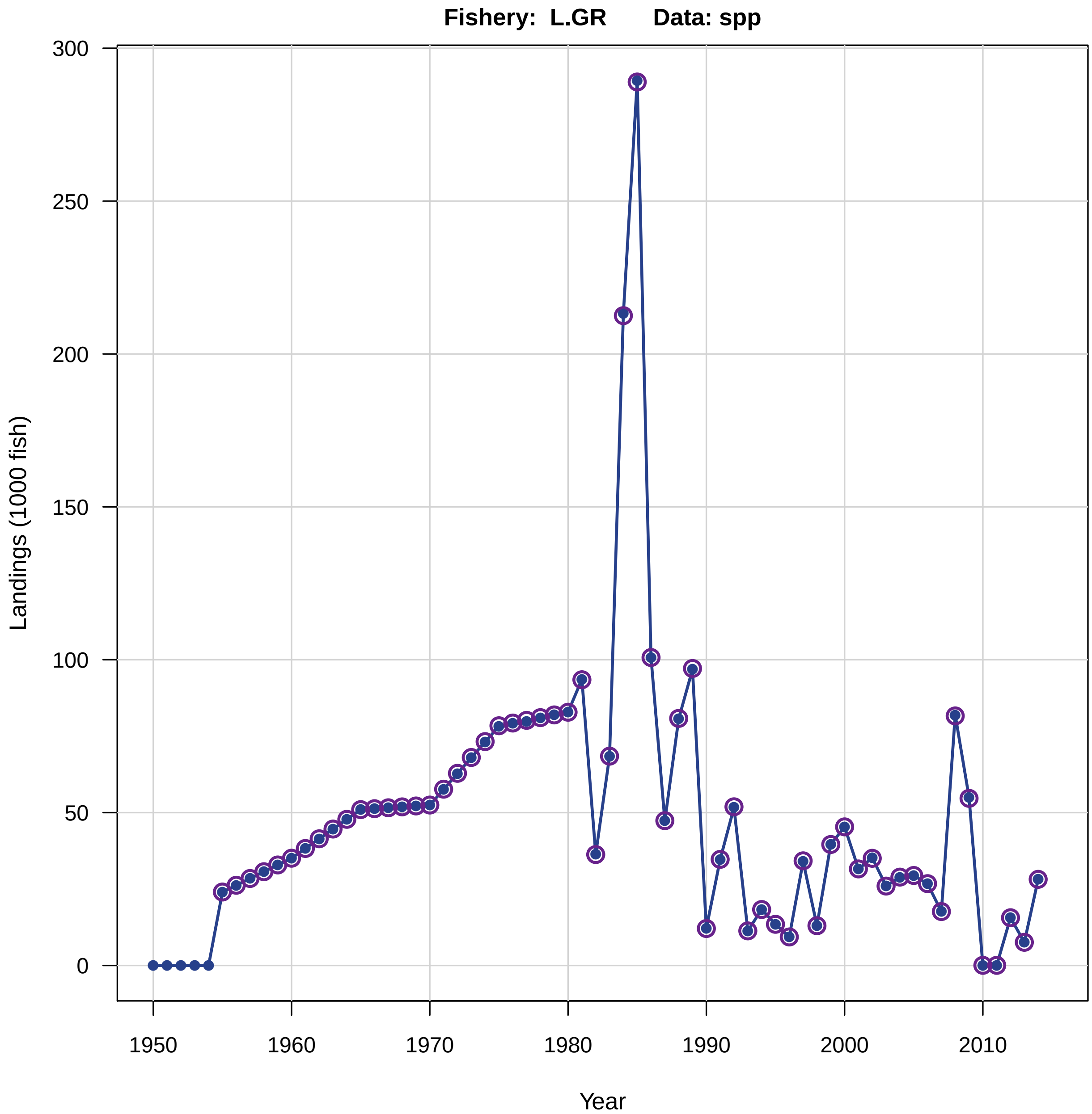


Figure 7. Observed (open circles) and estimated (solid line, circles) commercial handline discard mortalities.

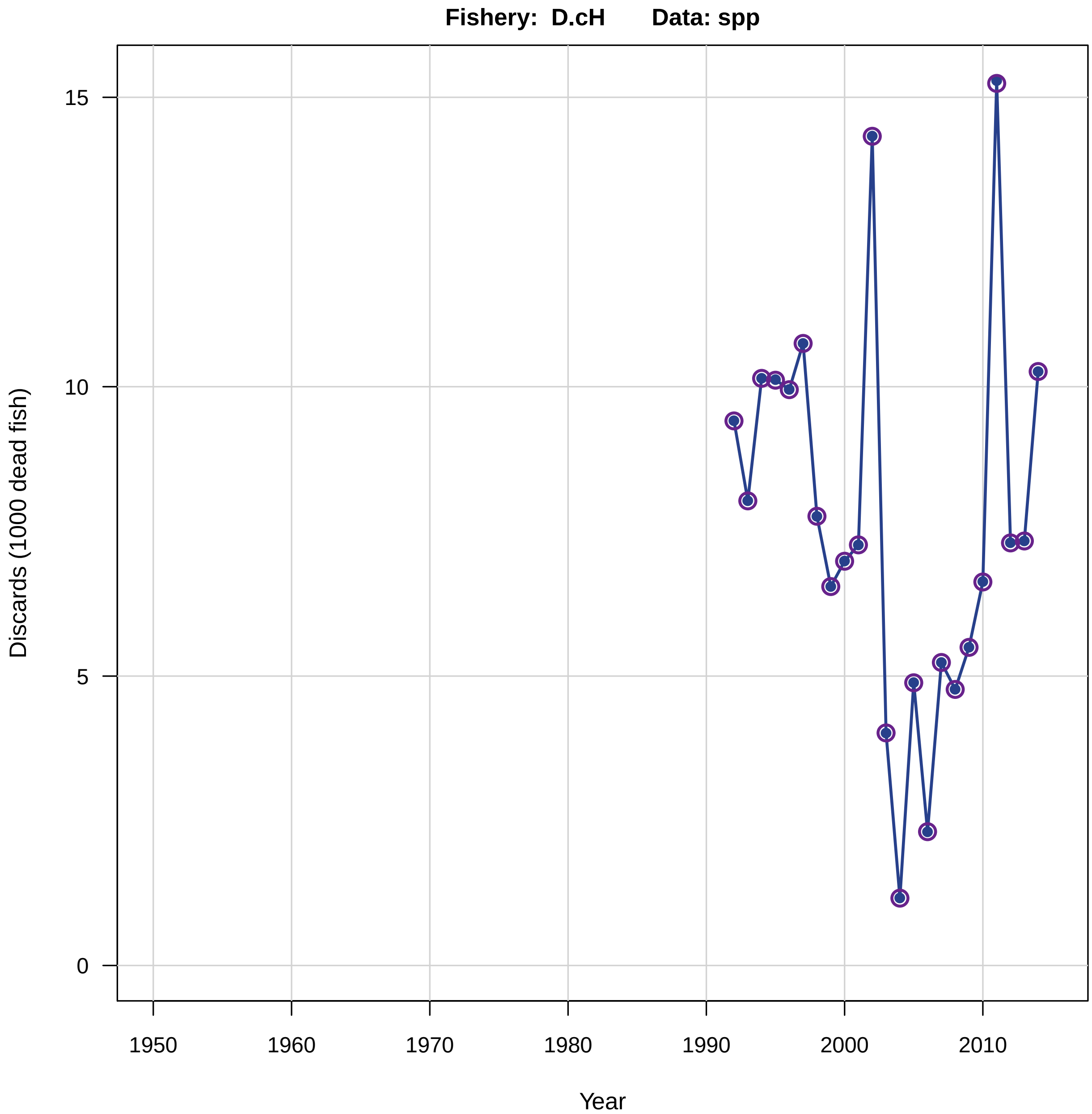


Figure 8. Observed (open circles) and estimated (solid line, circles) headboat discard mortalities.

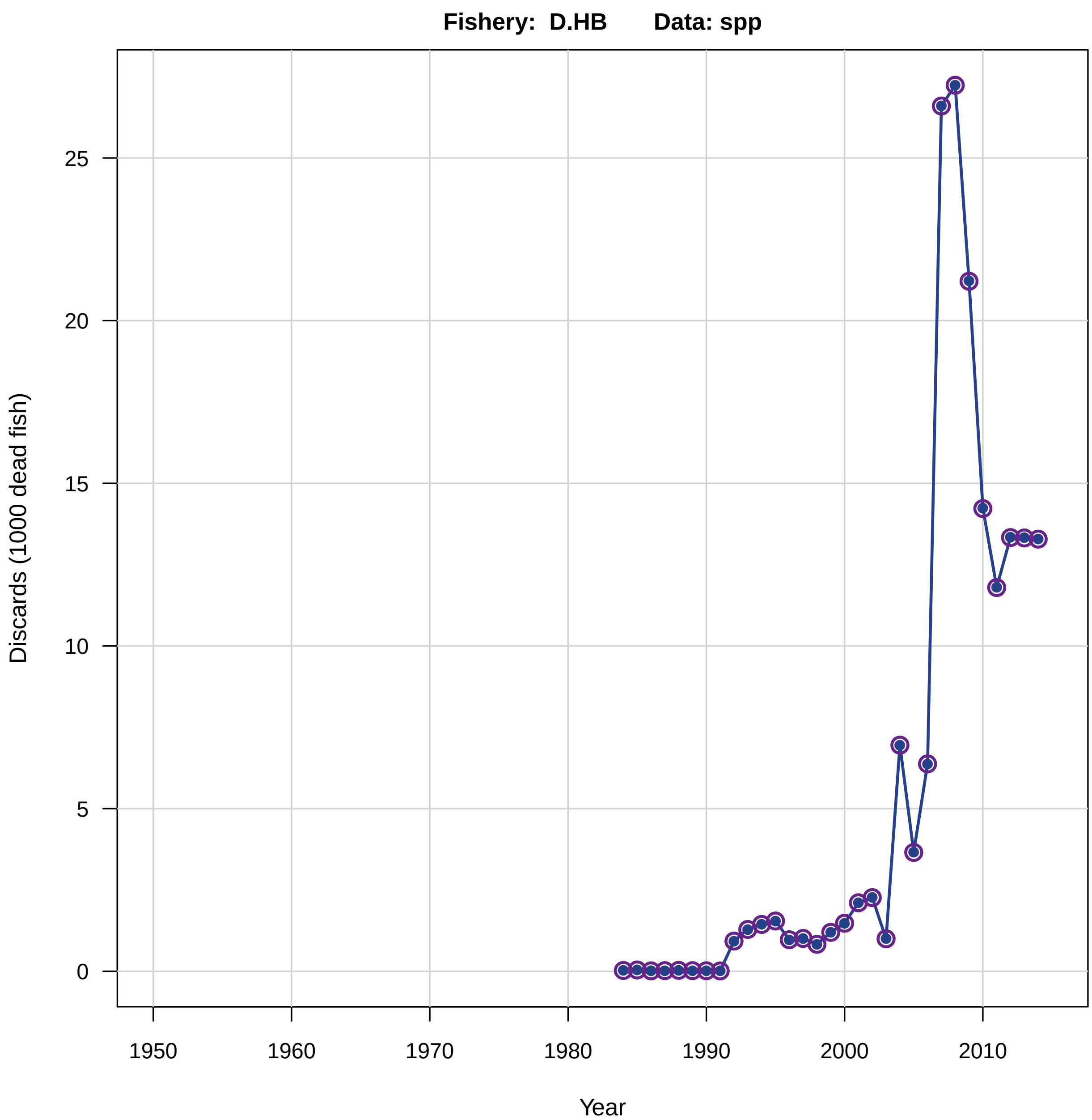


Figure 9. Observed (open circles) and estimated (solid line, circles) general recreational discard mortalities.

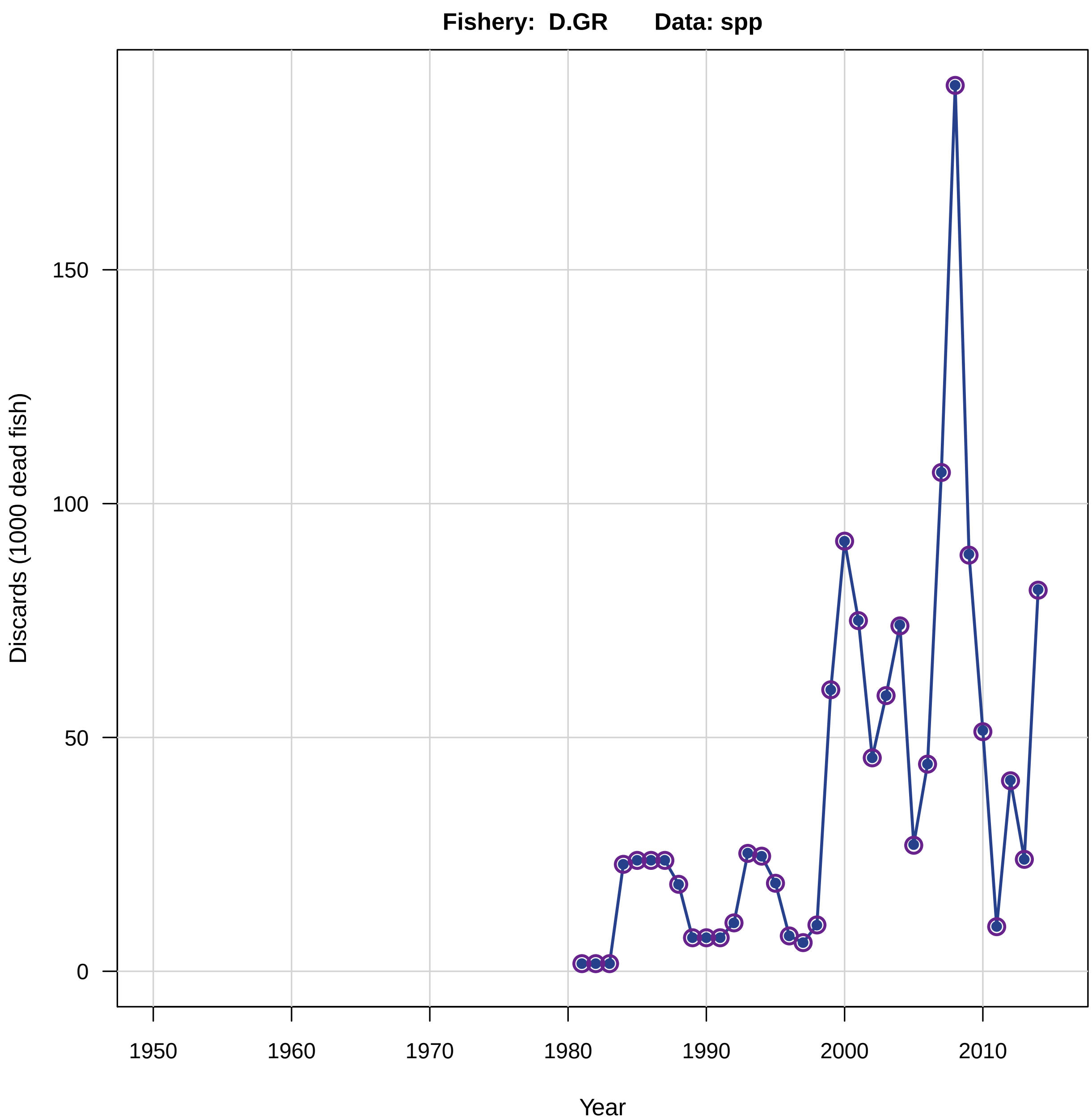


Figure 10. Observed (open circles) and estimated (solid line, circles) index of abundance from the SERFS combined trap and video index. The error bars represent the annual CV provided by the GLM standardization divided by the likelihood weight on the index.

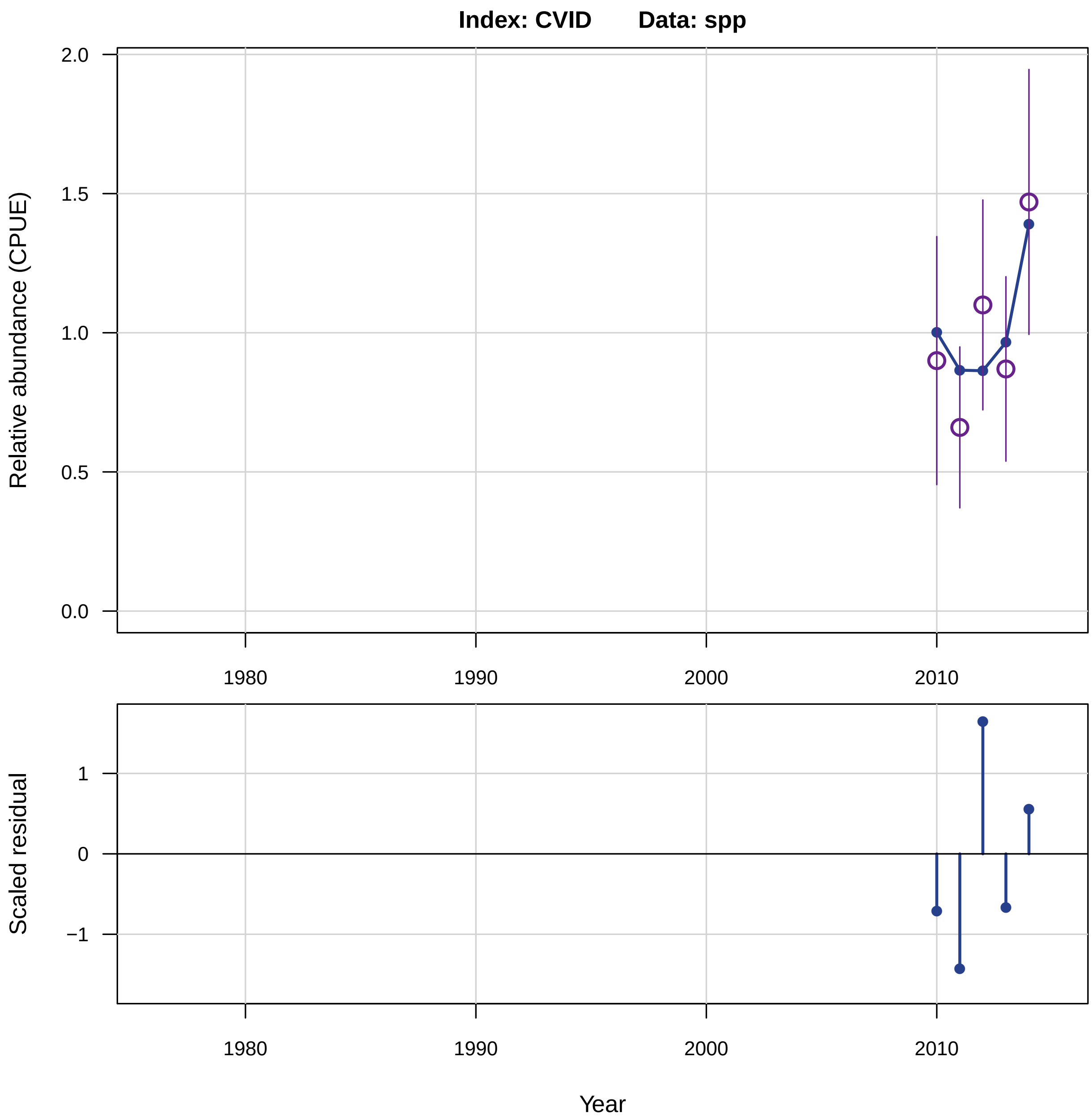


Figure 11. Observed (open circles) and estimated (solid line, circles) index of abundance from the commercial handline fleet. The error bars represent the annual CV of the index (0.2) divided by the likelihood weight on the index.

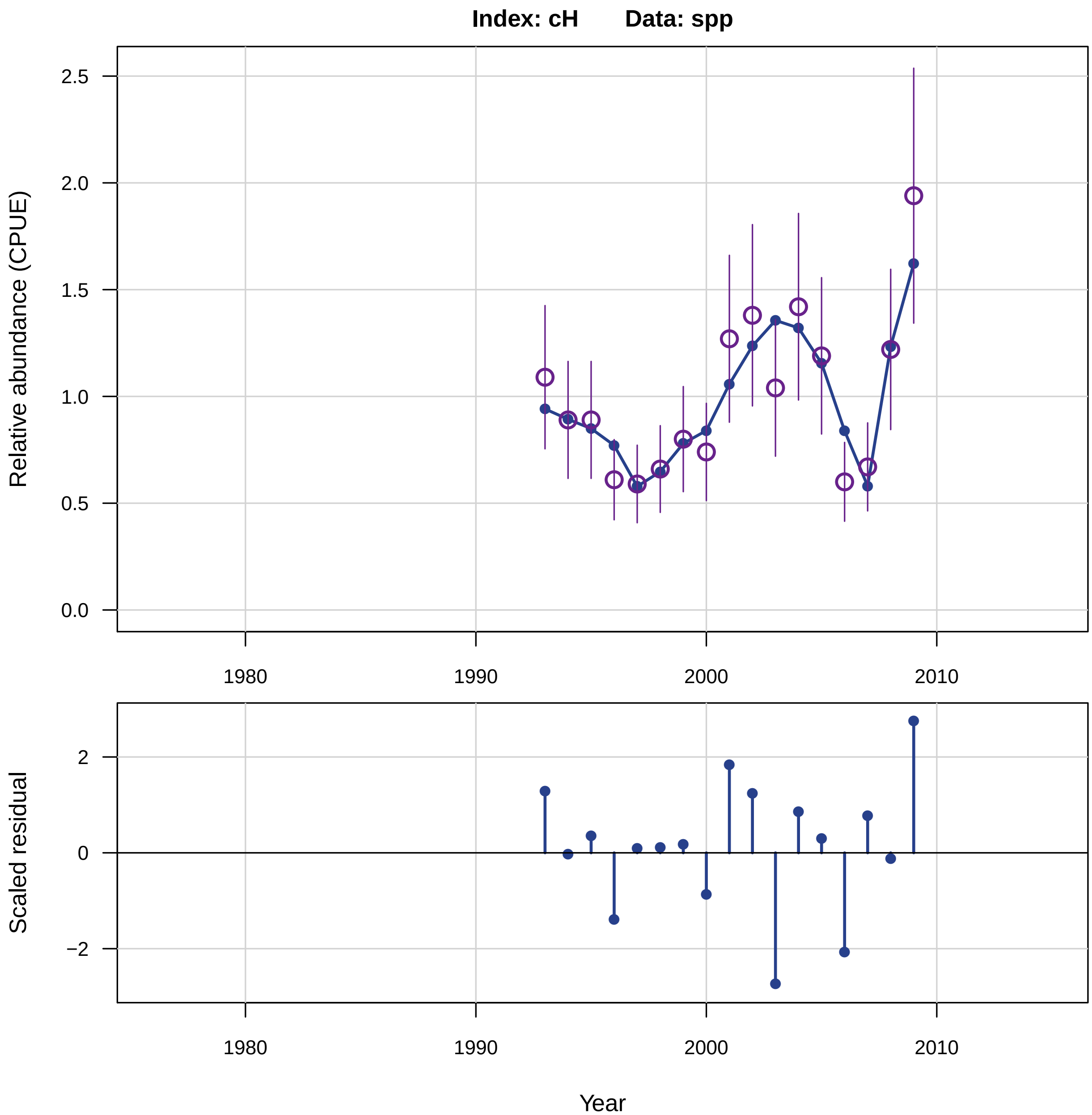


Figure 12. Observed (open circles) and estimated (solid line, circles) abundance from the headboat fleet. The error bars represent the annual CV of the index (0.2) divided by the likelihood weight on the index.

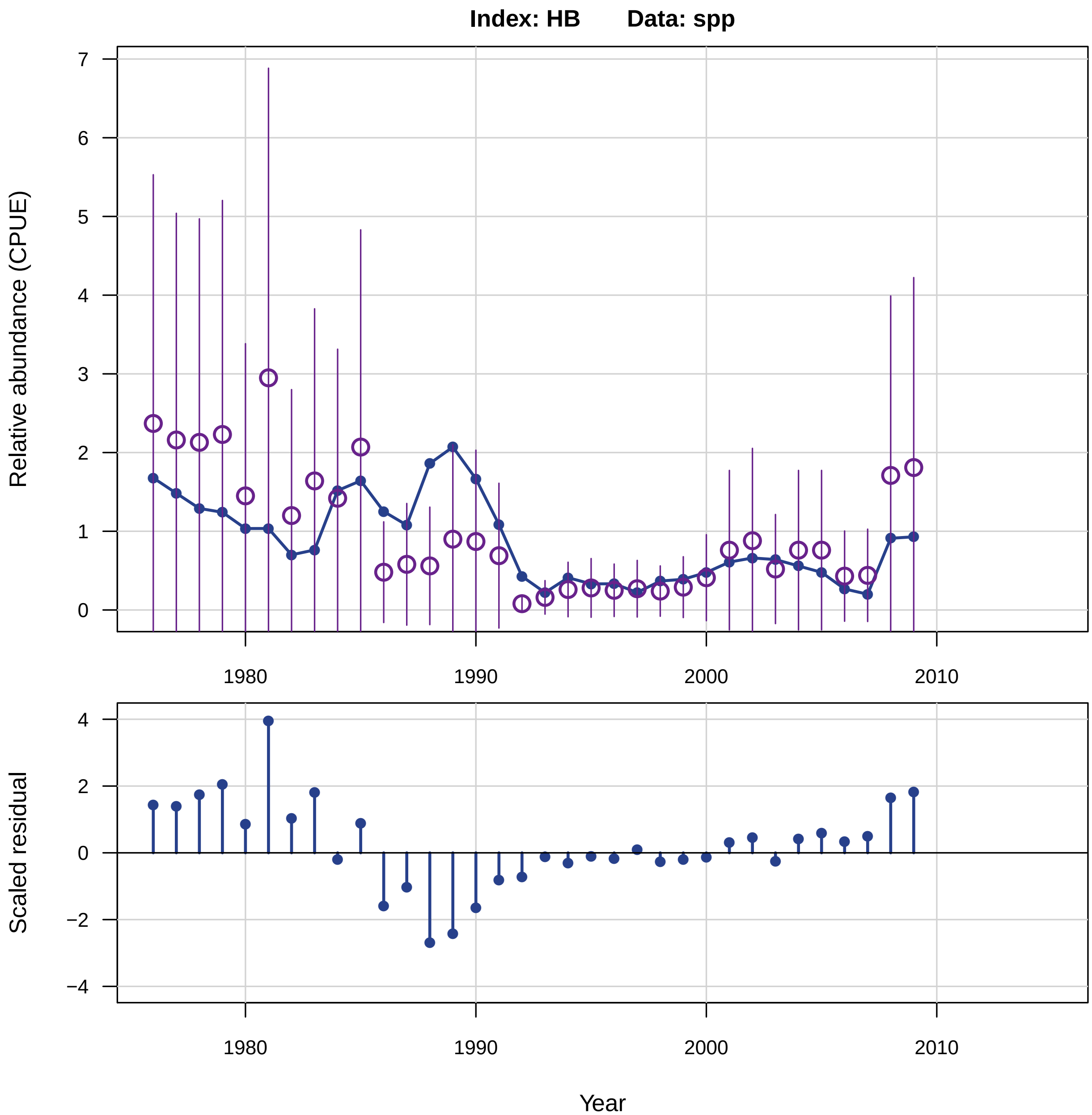


Figure 13. Observed (open circles) and estimated (solid line, circles) abundance from the headboat fleet (discards). The error bars represent the annual CV provided by the GLM standardization divided by the likelihood weight on the index.

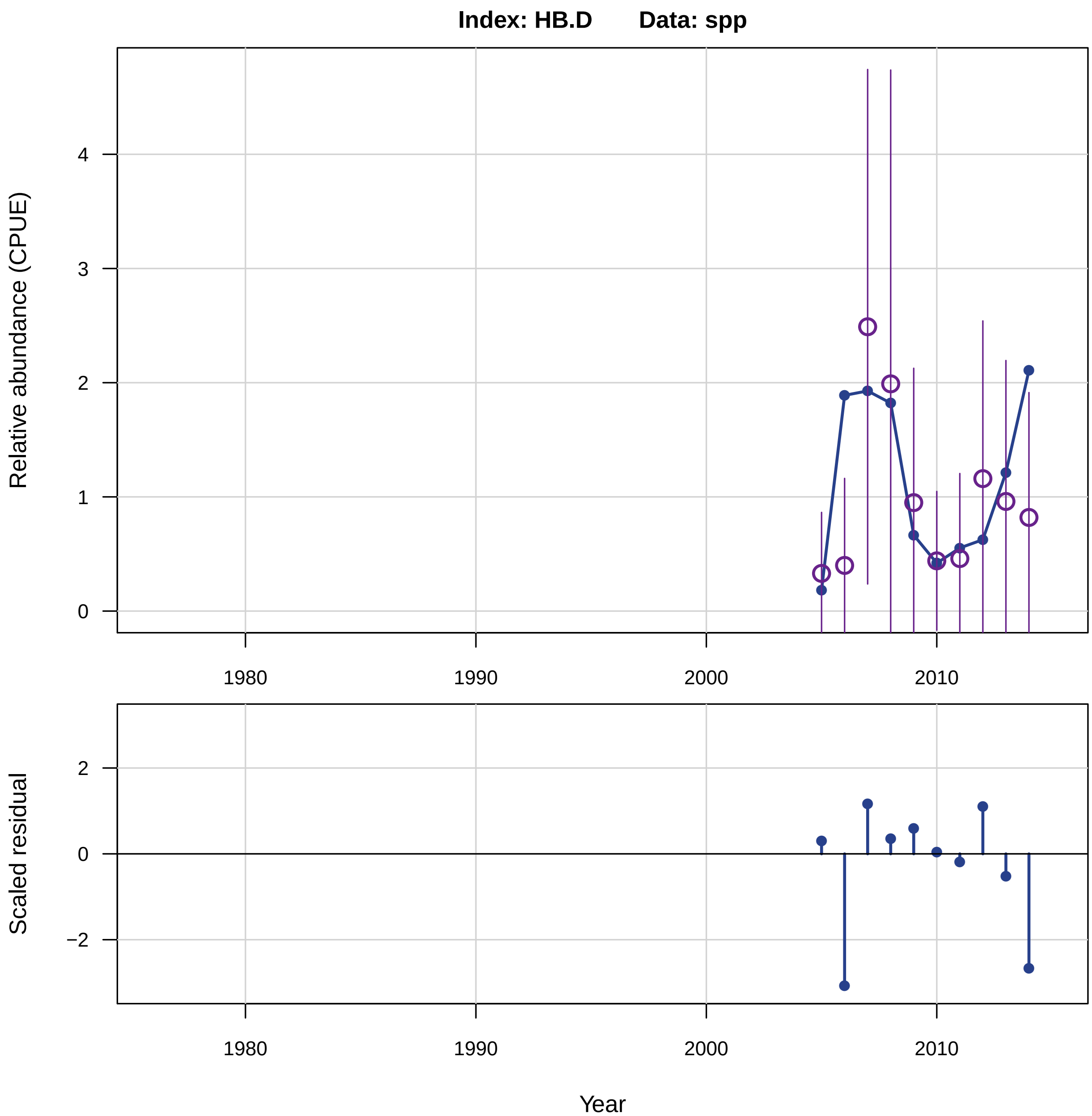


Figure 14. Estimated abundance at age at start of year.

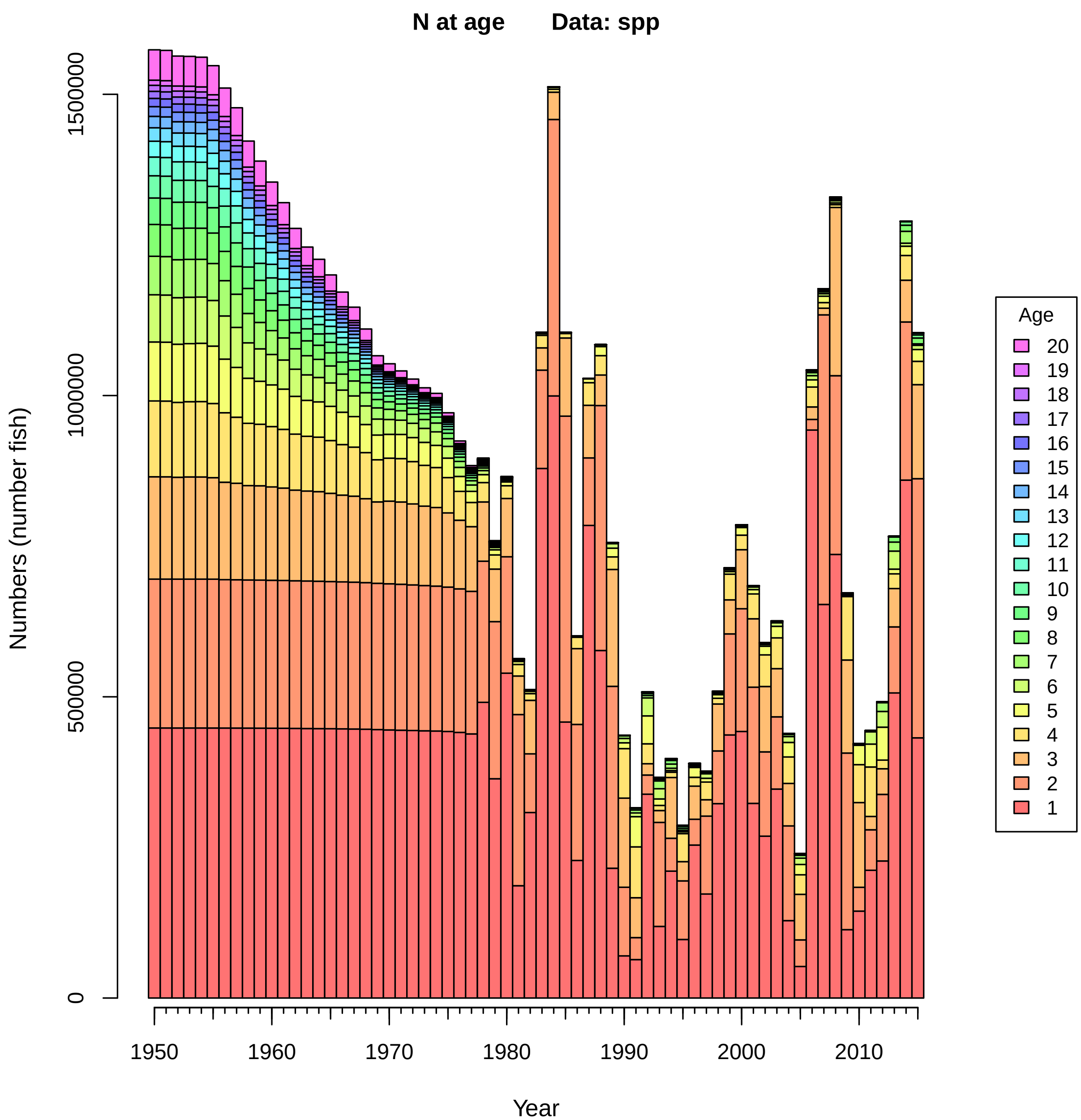
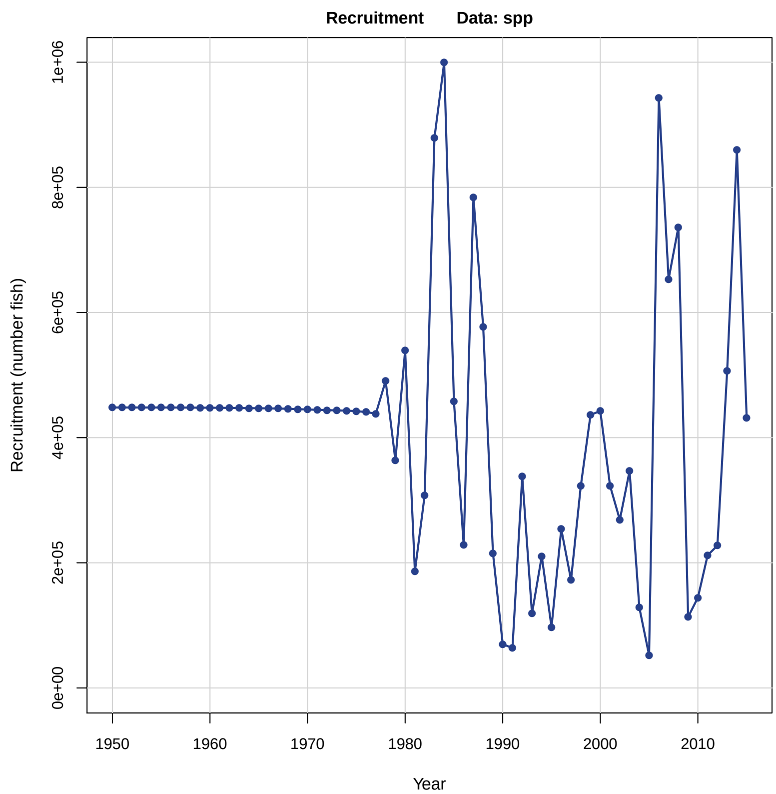


Figure 15. Top panel: Estimated recruitment of age-1 fish. Horizontal dashed line indicates $R_{F30\%}$. Bottom panel: log recruitment residuals.



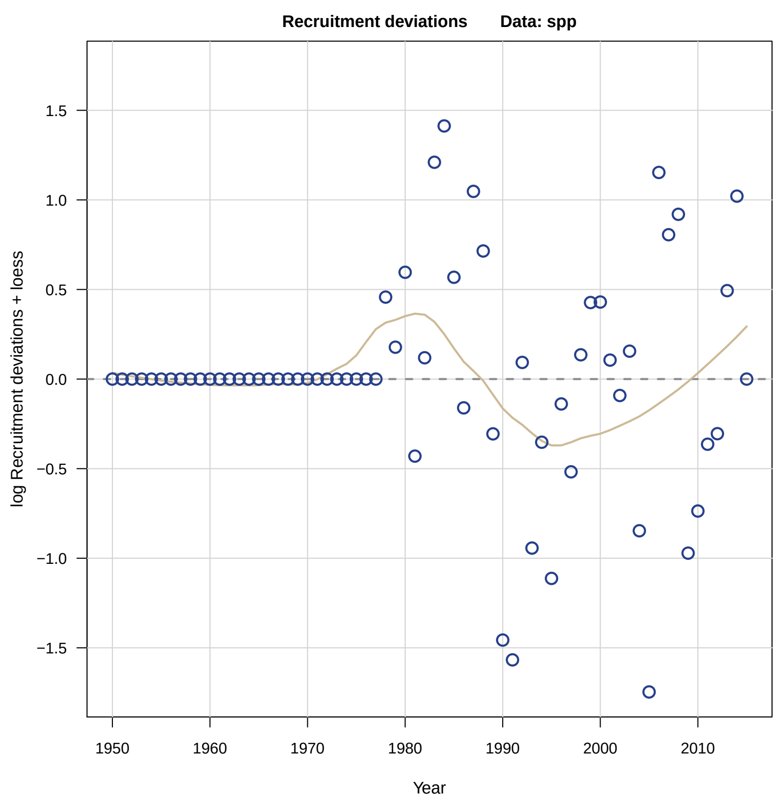


Figure 16. Estimated biomass at age at start of year.

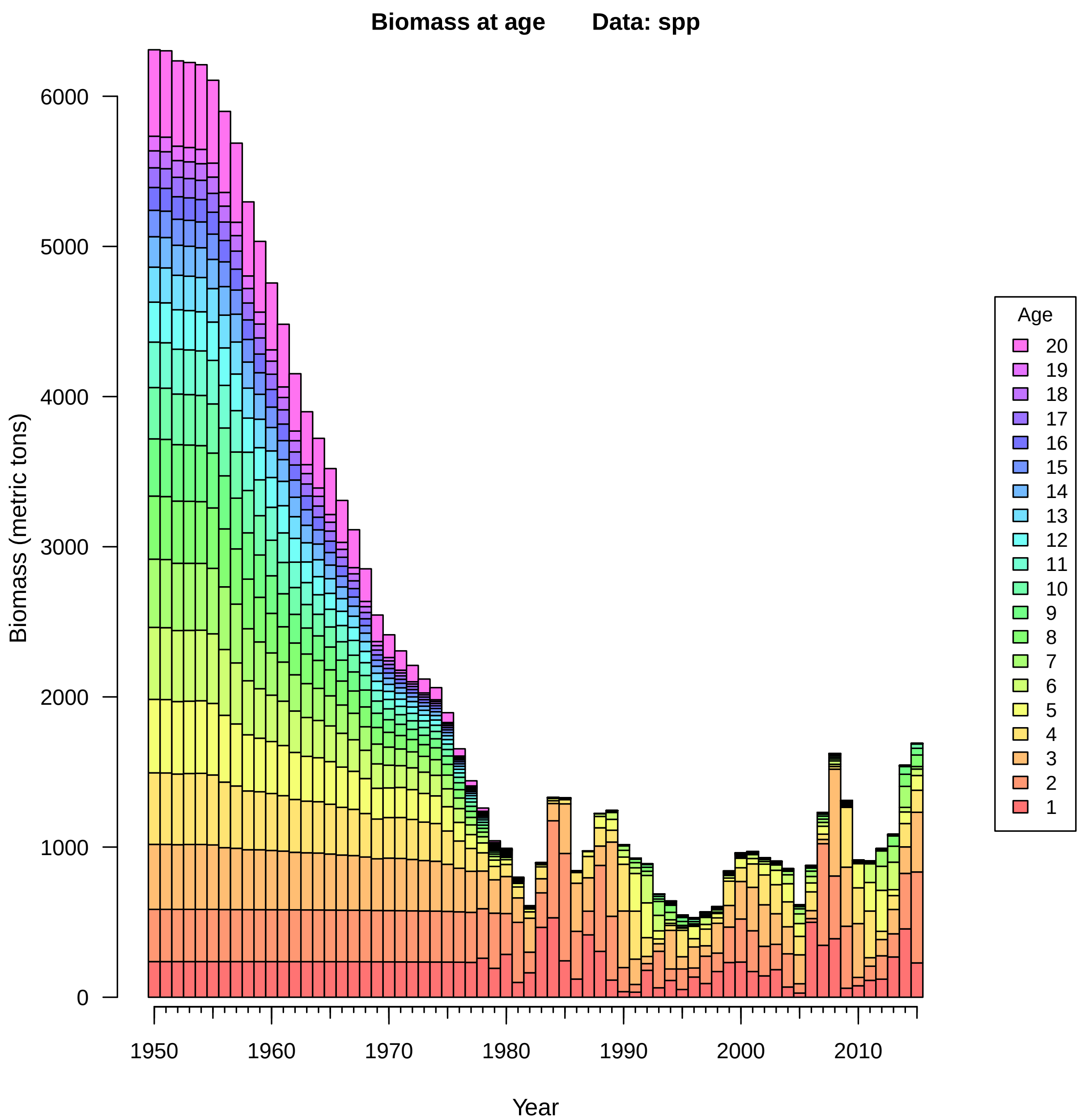
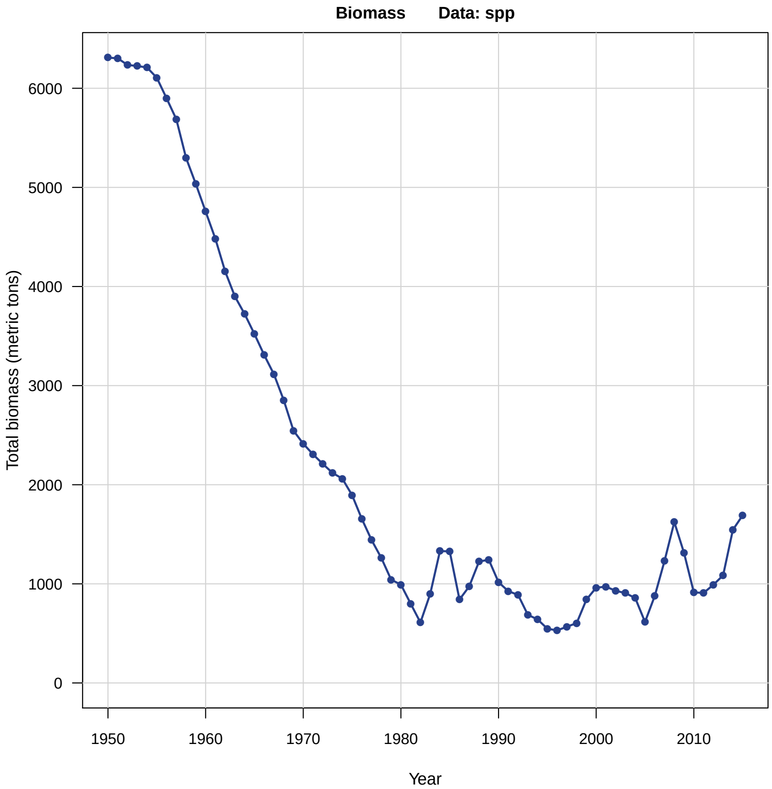


Figure 17. Top panel: Estimated total biomass (metric tons) at start of year. Horizontal dashed line indicates $B_{F30\%}$. Bottom panel: Estimated spawning stock (population fecundity) at time of peak spawning.



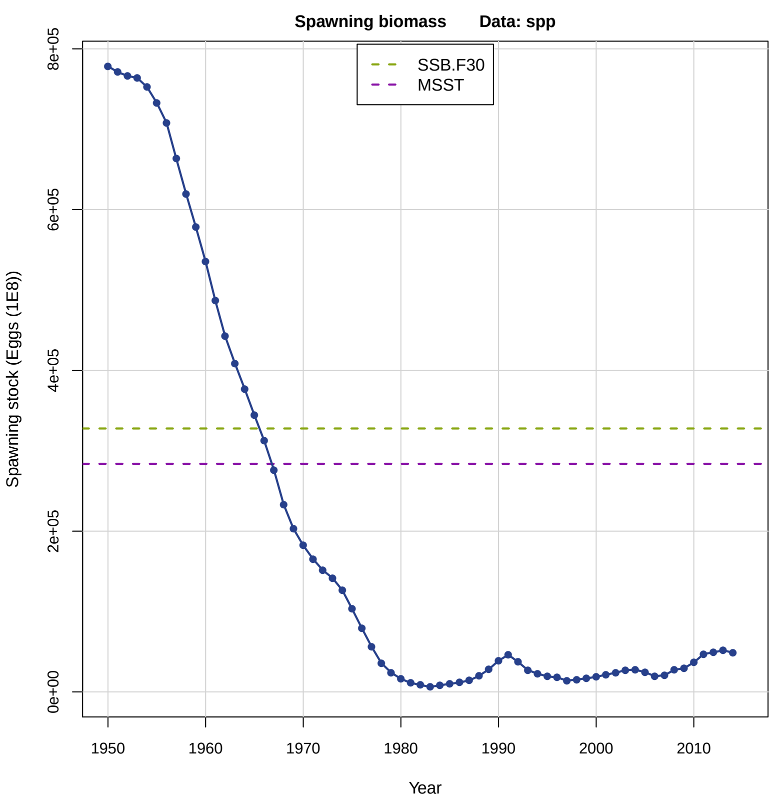


Figure 18. Monte Carlo Bootstrap estimates of population abundance. Top panel is all ages, and the bottom panel represents age 2+.

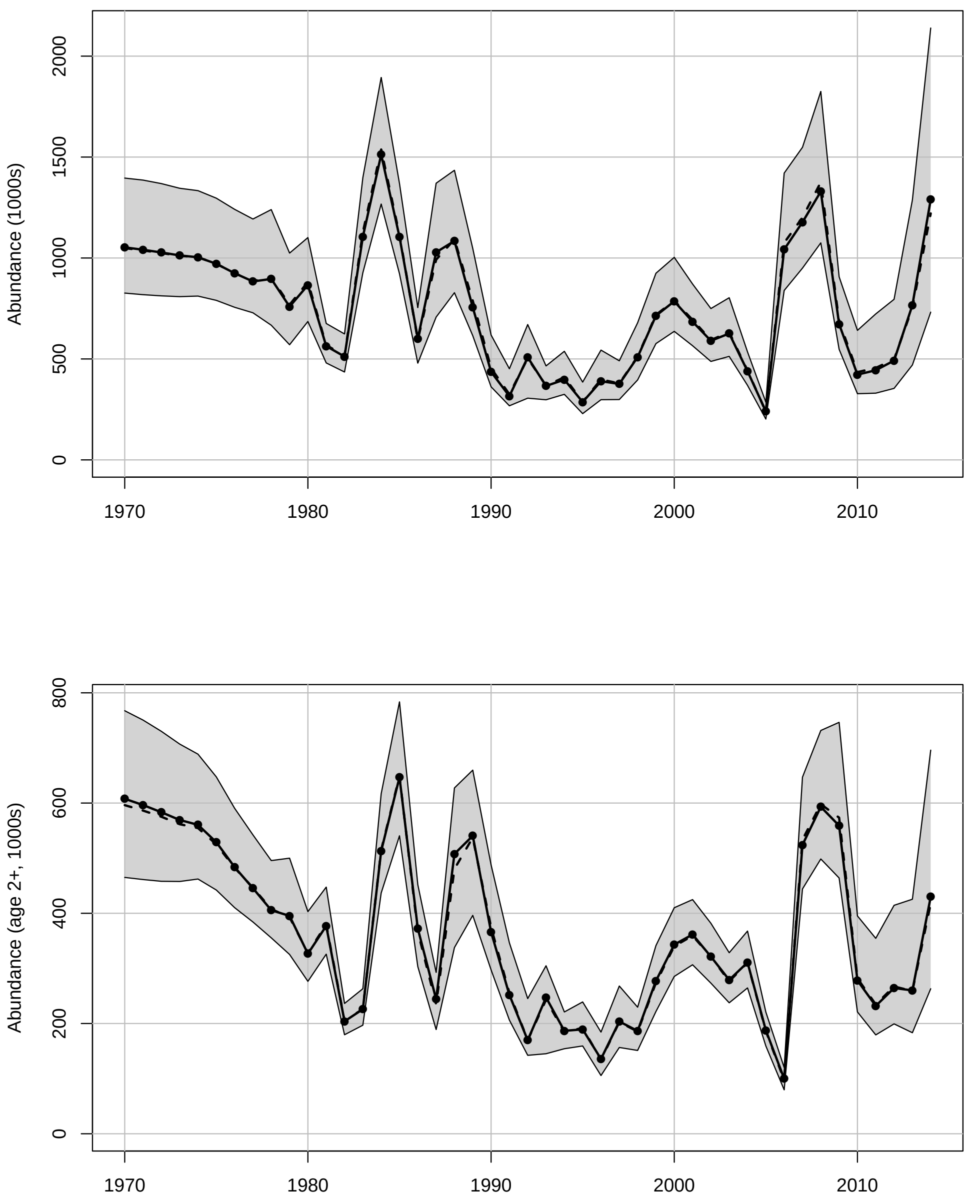


Figure 19. Selectivity of SERFS index.

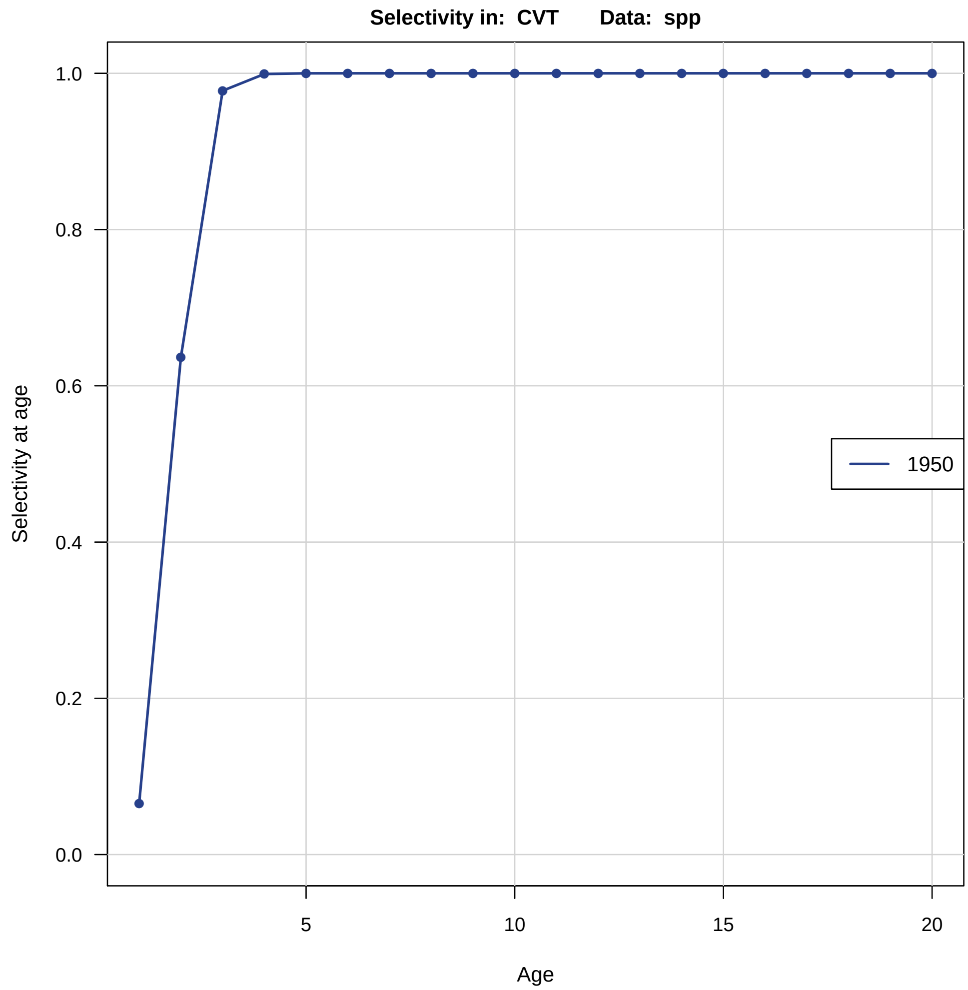


Figure 20. Selectivities of commercial handline landings. The legend indicates the first year each selectivity curve applies to the fleet.

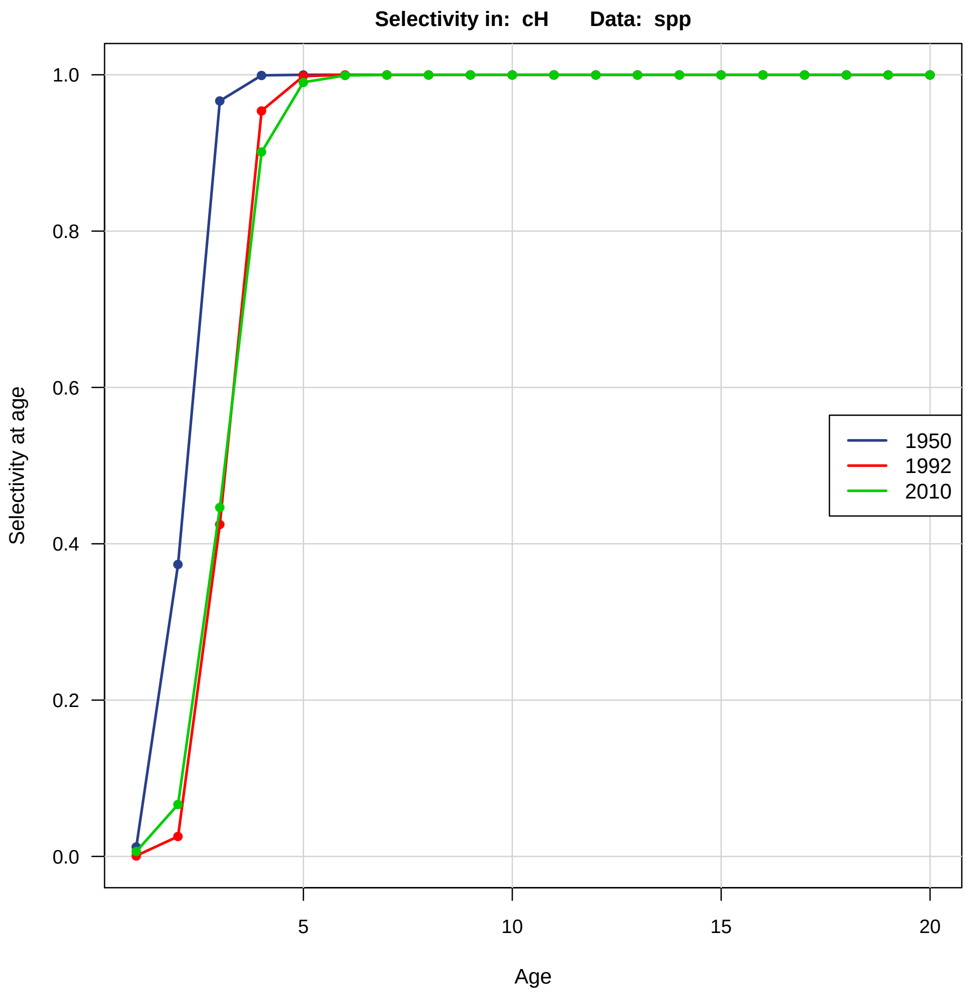


Figure 21. Selectivities of headboat landings. The legend indicates the first year each selectivity curve applies to the fleet.

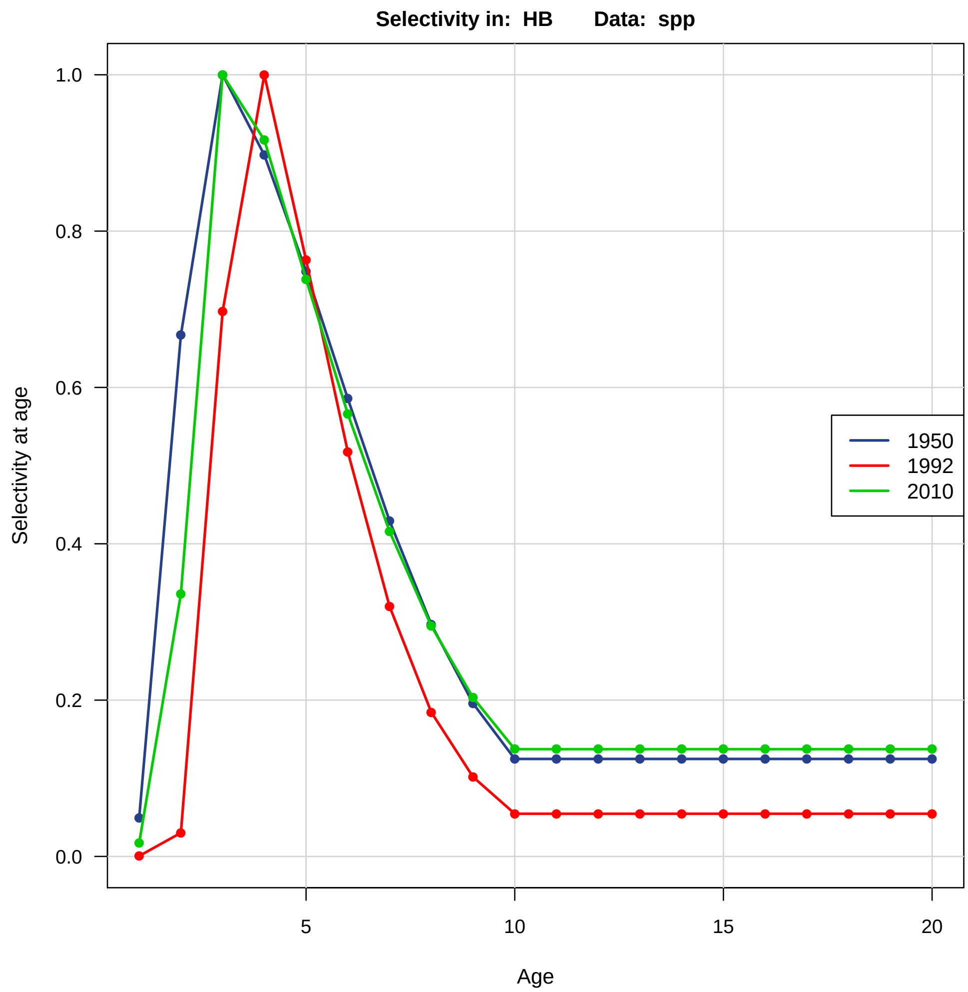


Figure 22. Selectivities of general recreational landings. The legend indicates the first year each selectivity curve applies to the fleet.

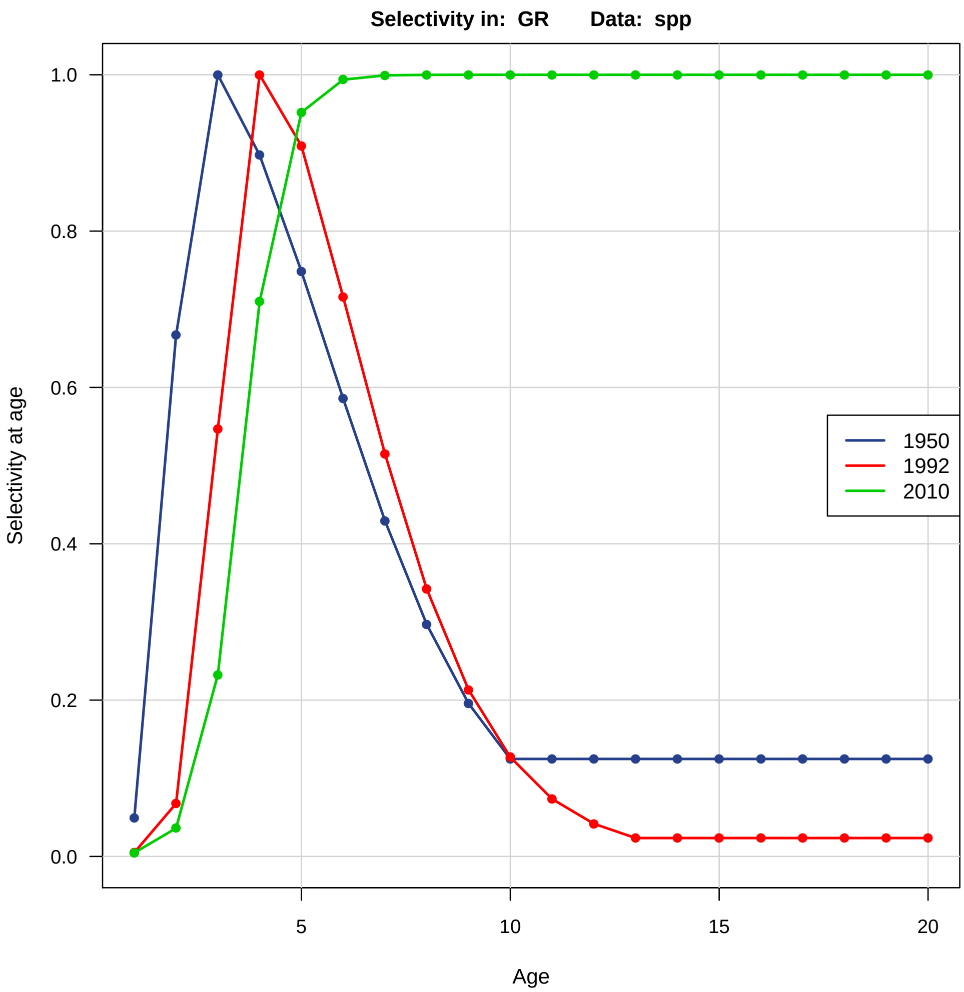


Figure 23. Selectivities of commercial handline discards. The legend indicates the first year each selectivity curve applies to the fleet.

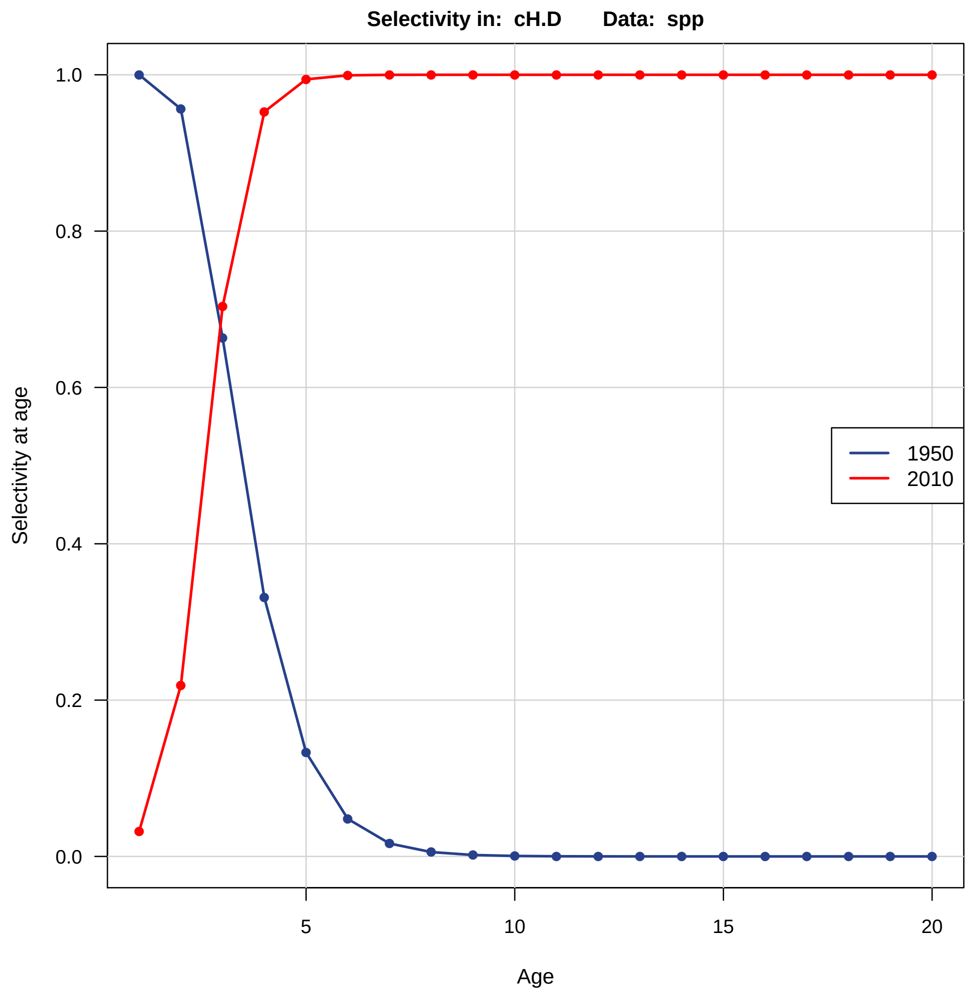


Figure 24. Selectivities of headboat discards. The legend indicates the first year each selectivity curve applies to the fleet.

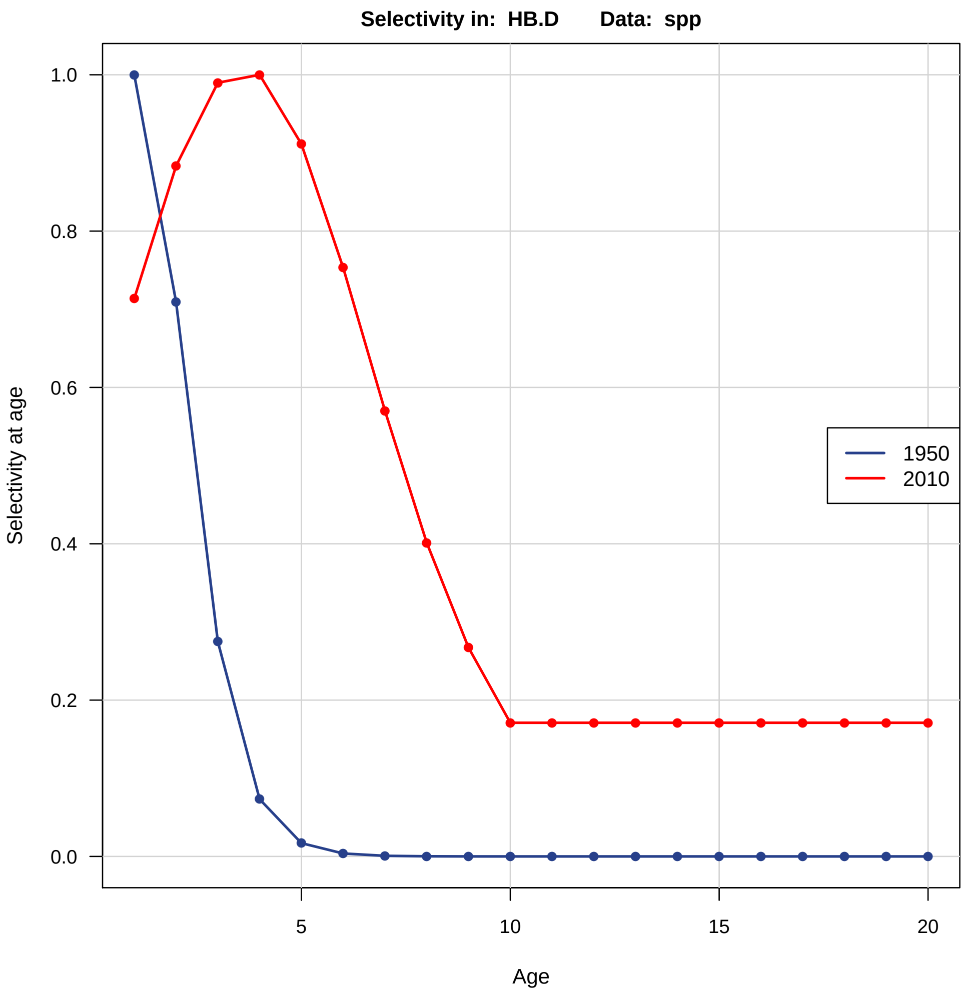


Figure 25. Selectivities of general recreational discards. The legend indicates the first year each selectivity curve applies to the fleet.

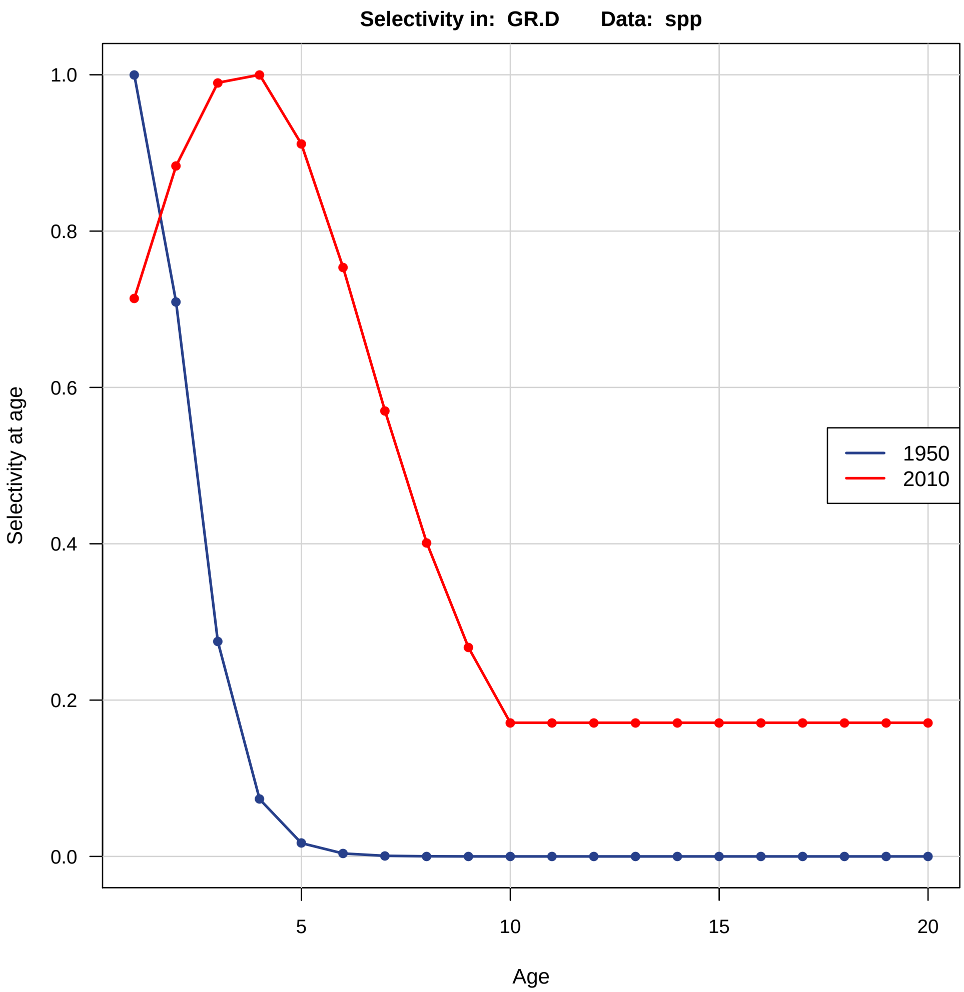


Figure 26. Average selectivity of discards(top left), landings (top right), and total weighted average (bottom) from the terminal assessment years, weighted by geometric mean F's from the last three assessment years, and used in computation of benchmarks and projections.

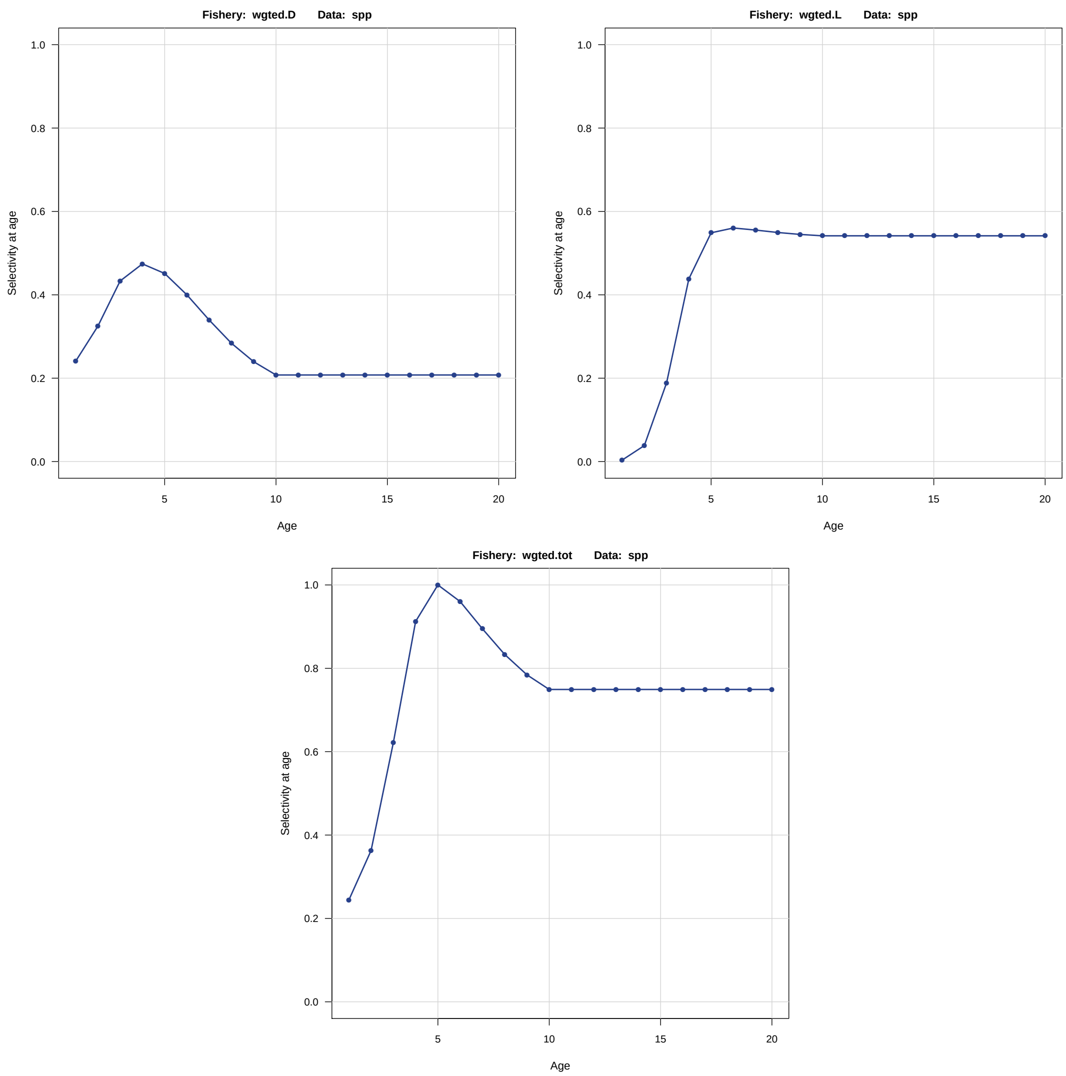


Figure 27. Estimated fully selected fishing mortality rate (per year) by fleet. cH refers to commercial handlines, HB to headboat, GR to general recreational, and D refers to discard mortality.

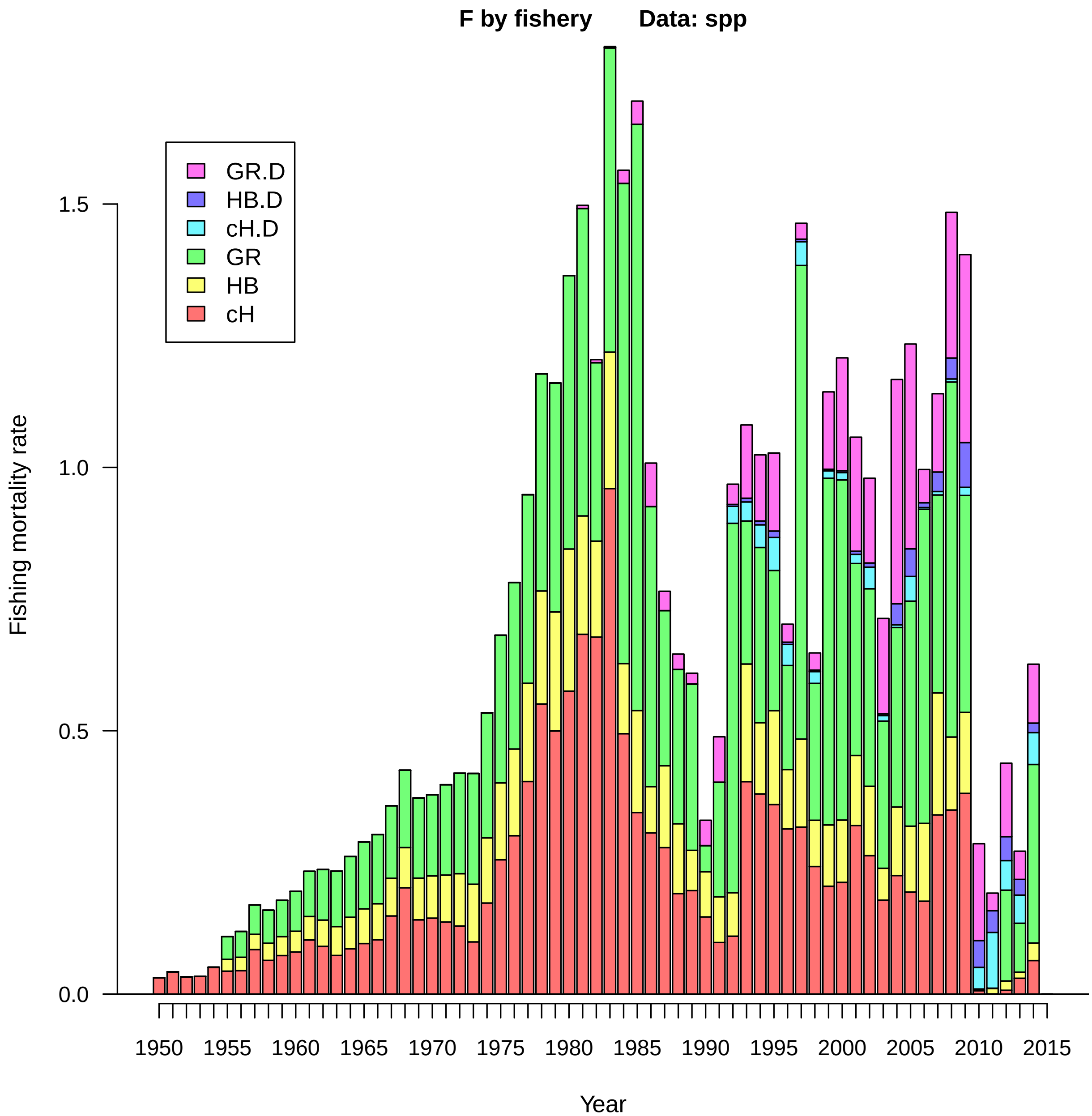
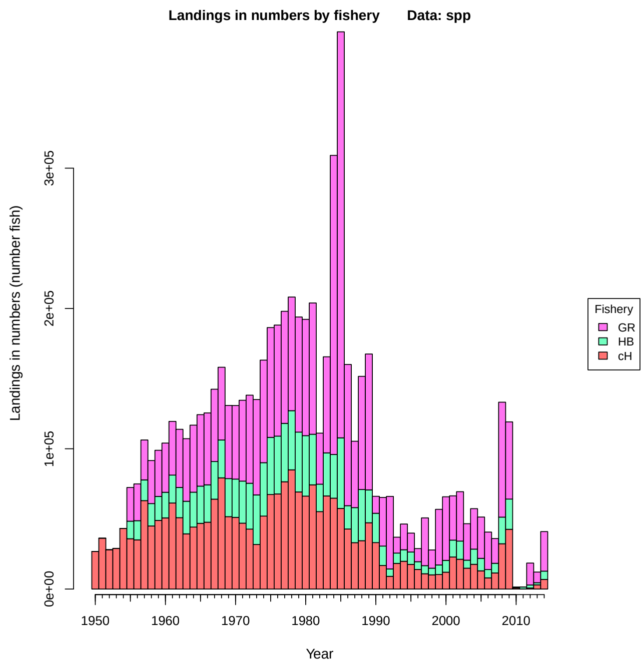


Figure 28. Estimated landings in numbers by fleet from the catch-age model. cH refers to commercial handlines, HB to headboat, and GR to general recreational. Horizontal dashed line in the top panel corresponds to the point estimate of $L_{F30\%}$ in numbers.



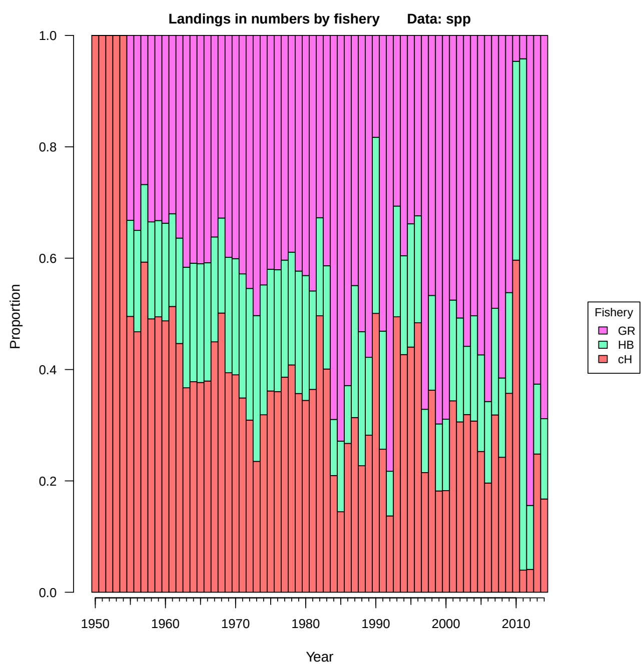
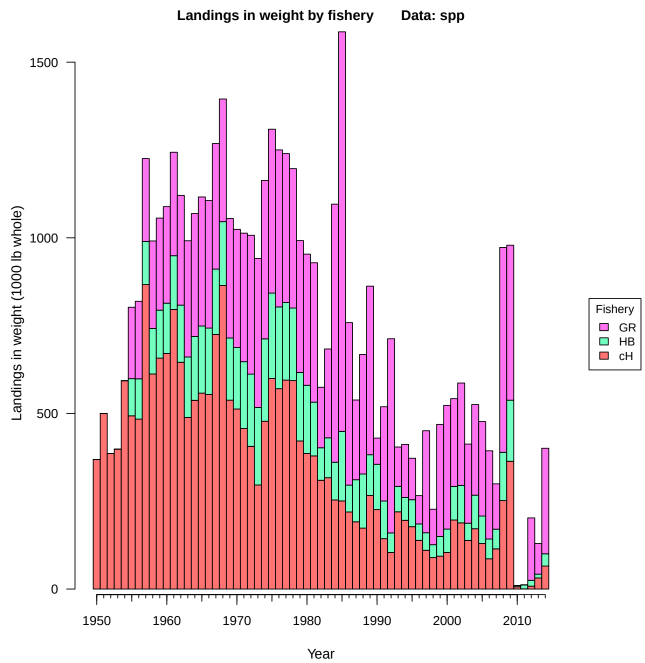


Figure 29. Estimated landings in whole weight by fleet from the catch-age model. cH refers to commercial handlines, HB to headboat, and GR to general recreational. Horizontal dashed line in the top panel corresponds to the point estimate of $L_{F30\%}$ in weight.



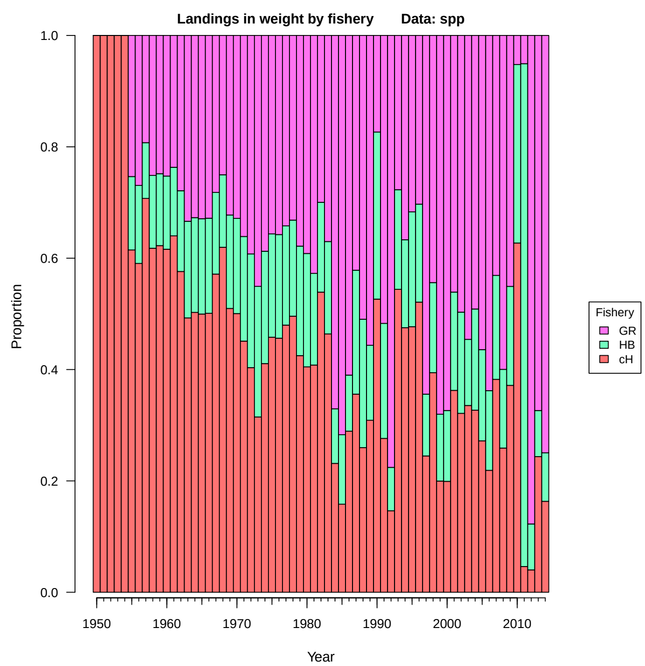


Figure 30. Estimated discard mortalities by fleet from the catch-age model. cH refers to commercial lines, hb to headboat, rec to general recreational. Horizontal dashed line in the top panel corresponds to the point estimate of $D_{F_{30\%}}$ in numbers.

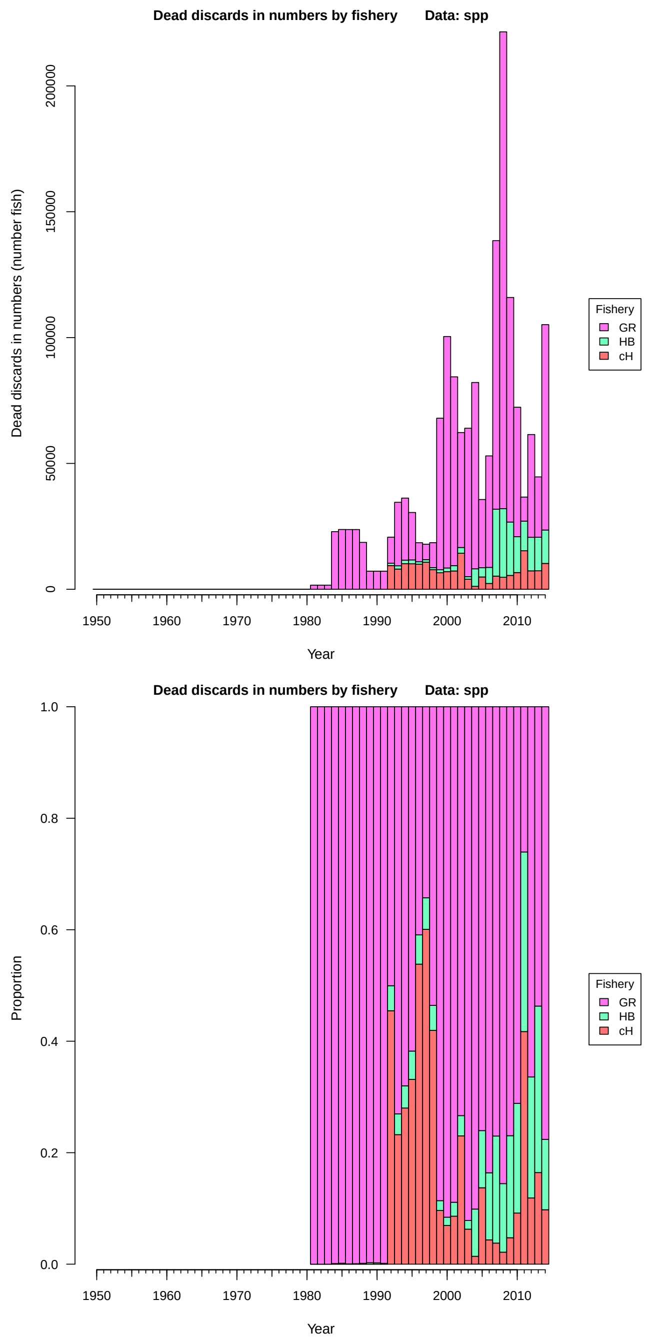


Figure 31. Top panel: Beverton–Holt spawner-recruit curves, with and without lognormal bias correction. The expected (upper) curve was used for computing management benchmarks. Bottom panel: log of recruits (number age-1 fish) per spawner as a function of spawners.

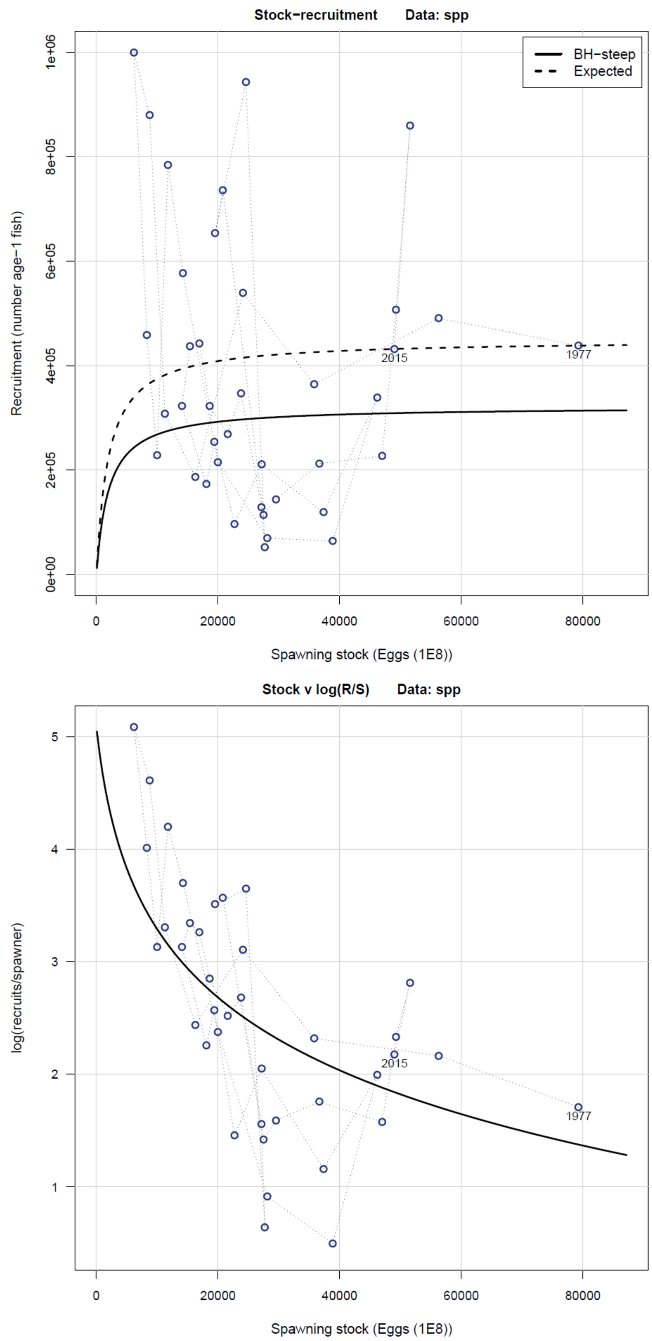


Figure 32. Probability densities of spawner-recruit quantities R0 (unfished recruitment of age-1 fish), steepness (fixed at 0.99), unfished spawners per recruit, and standard deviation of recruitment residuals in log space. Solid vertical lines represent point estimates or values from the base run of the Beaufort Assessment Model; dashed vertical lines represent medians from the MCB runs.

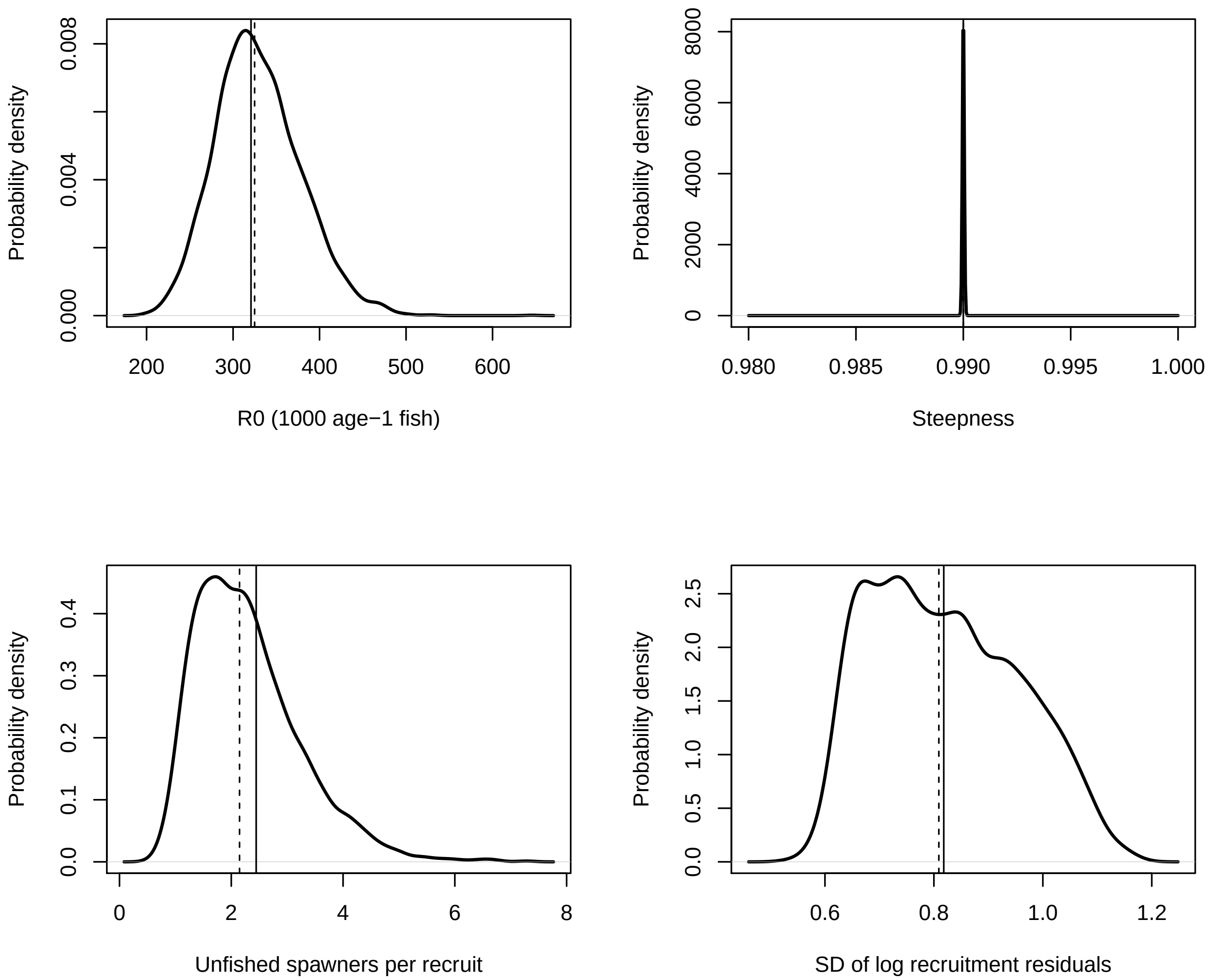


Figure 33. Yield per recruit based on average selectivity from the end of the assessment period.

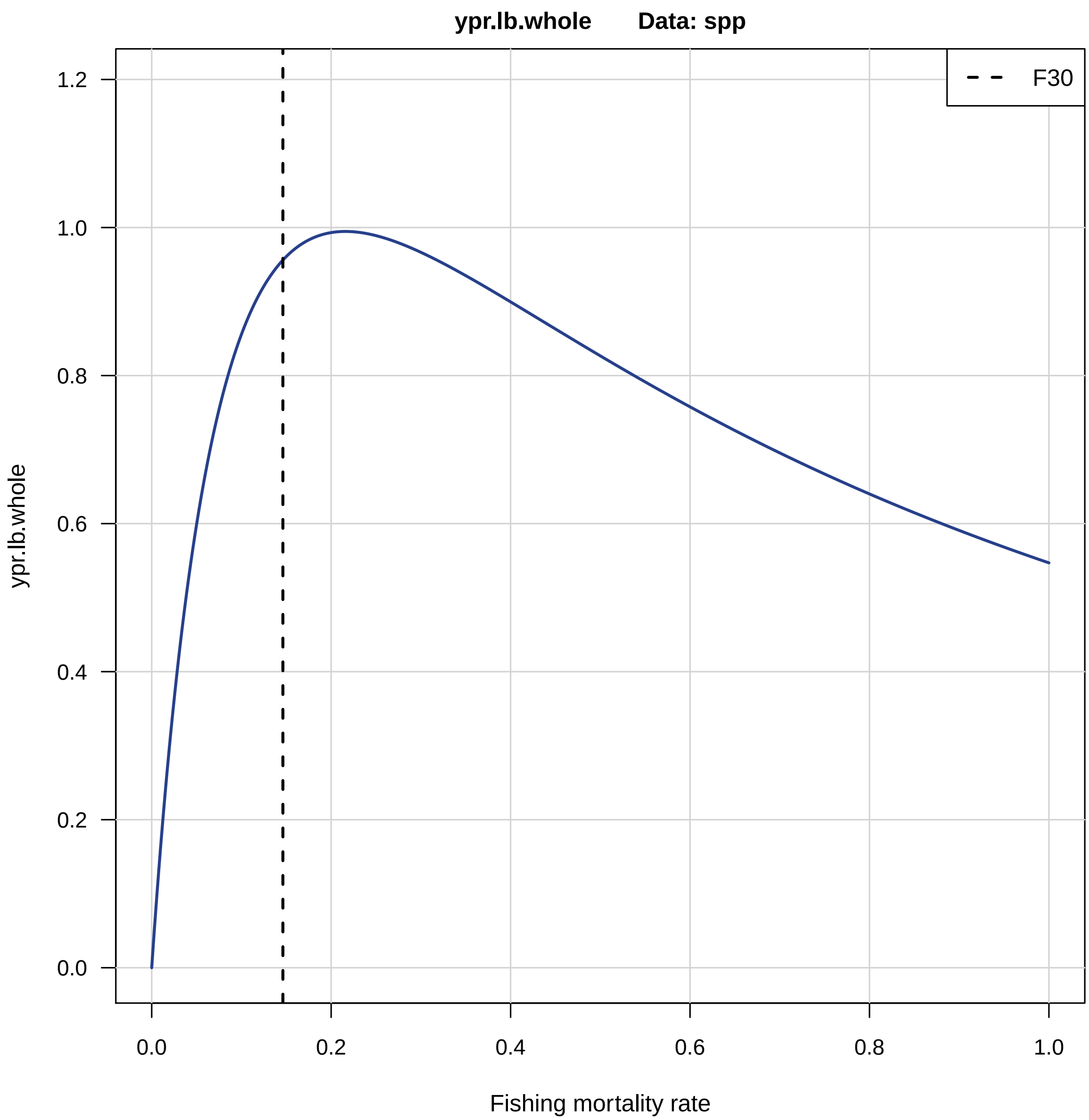


Figure 34. Spawning potential ratio (spawning biomass per recruit relative to that at the unfished level), from which the X% level of SPR provides $F_{X\%}$. SPR is based on average selectivity from the end of the assessment period.

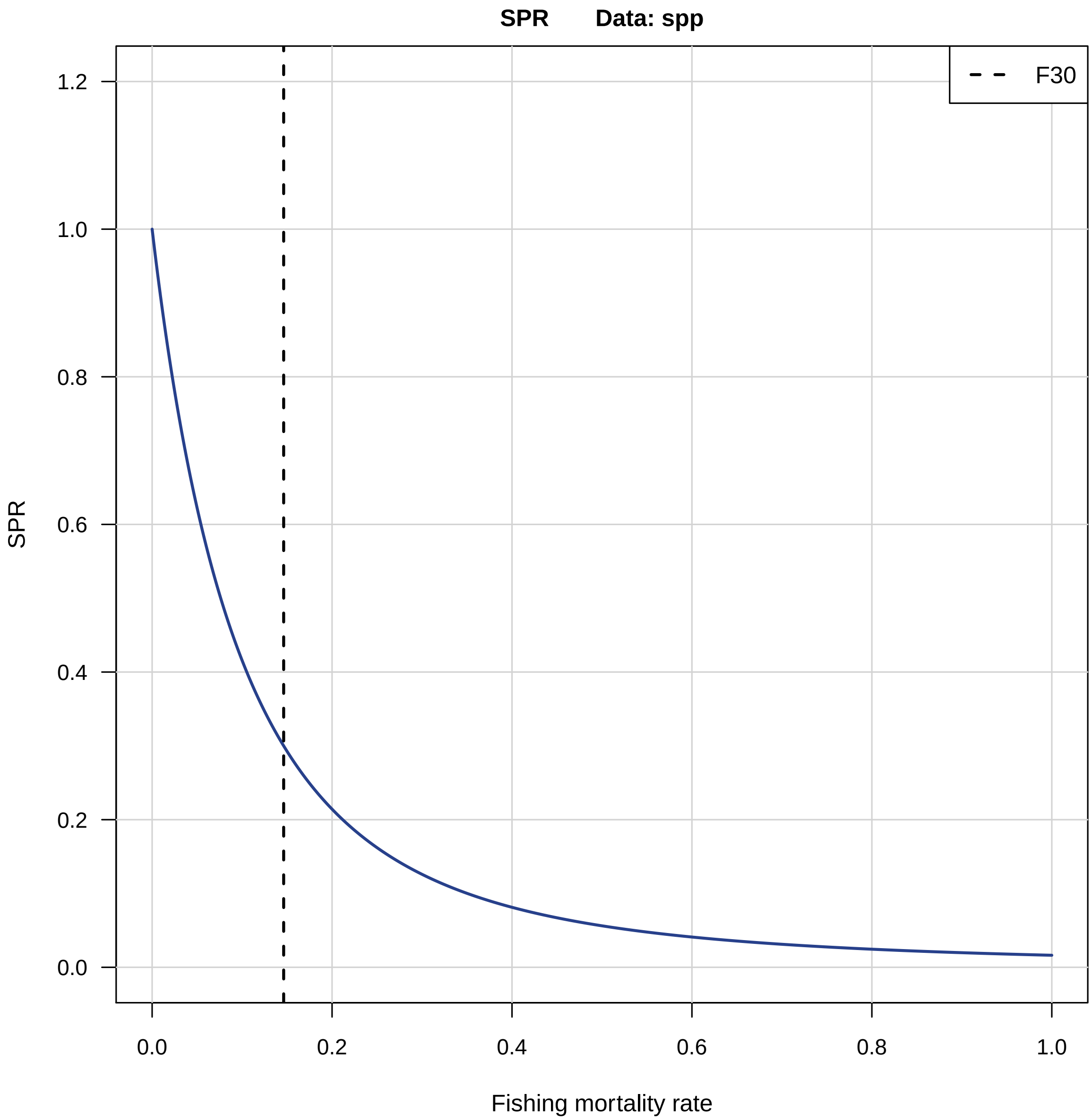


Figure 35. Equilibrium spawning biomass based on average selectivity from the end of the assessment period.

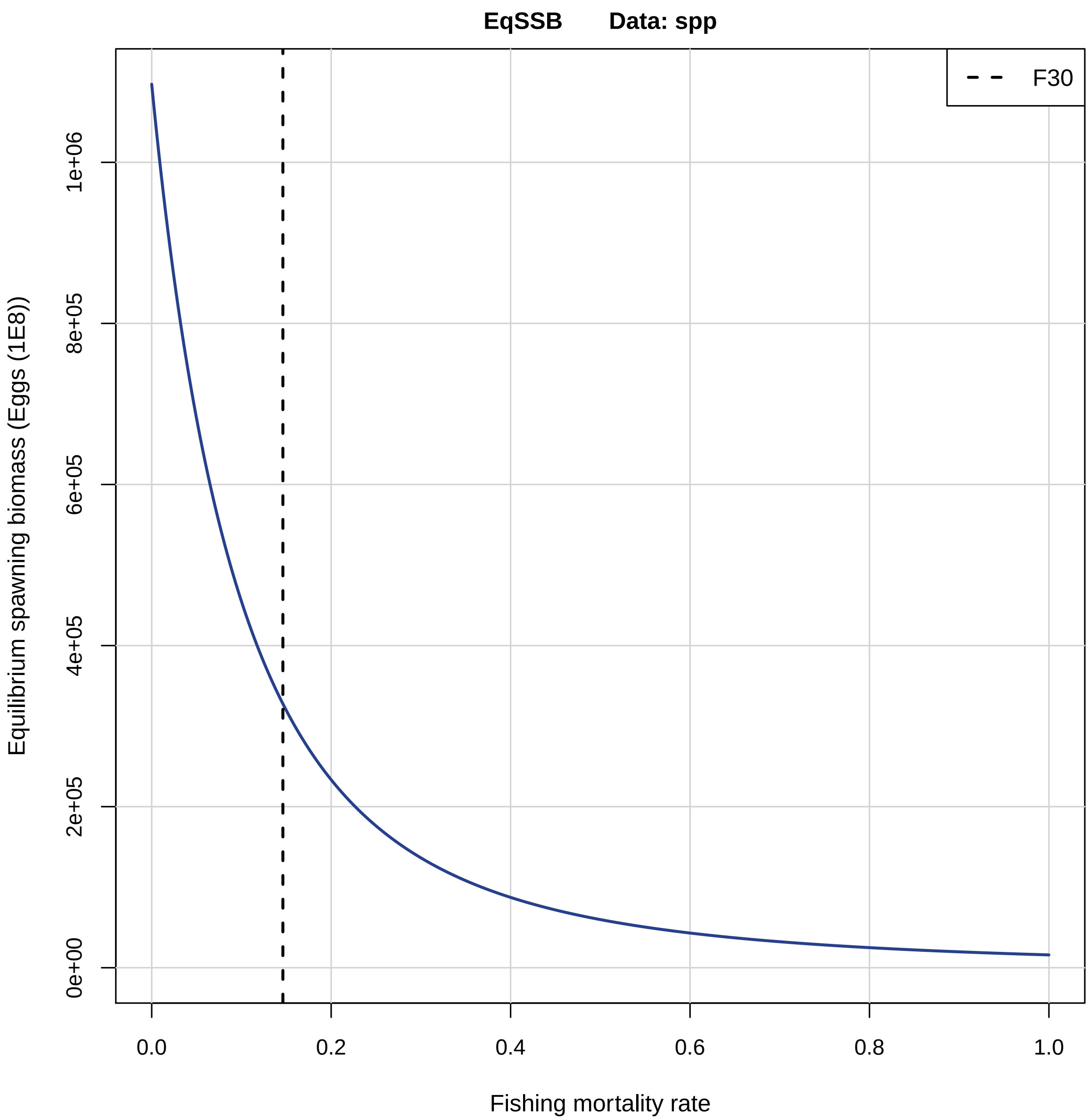


Figure 36. Probability densities of $F_{30\%}$-related benchmarks from MCB analysis of the Beaufort Assessment Model. Solid vertical lines represent point estimates from the base run; dashed vertical lines represent median values.

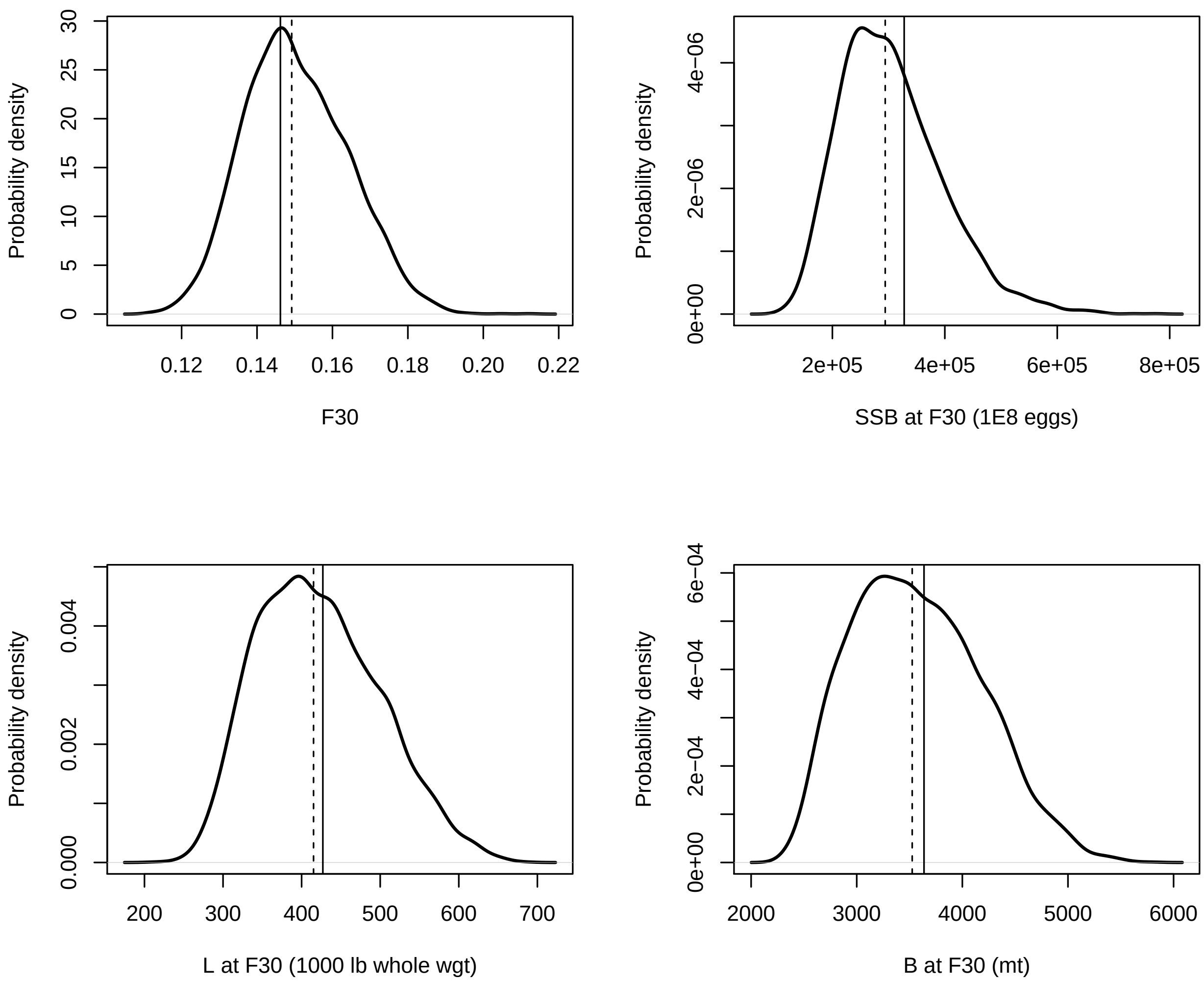


Figure 37. Estimated time series relative to benchmarks. Solid line indicates estimates from base run of the Beaufort Assessment Model; dashed lines represent median values; gray error bands indicate 5^{th} and 95^{th} percentiles of the MCB trials. Top panel: spawning biomass relative to $\mathrm{SSB}_{\mathrm{F30\%}}$*. Bottom panel: F relative to* $F_{30\%}$*.*

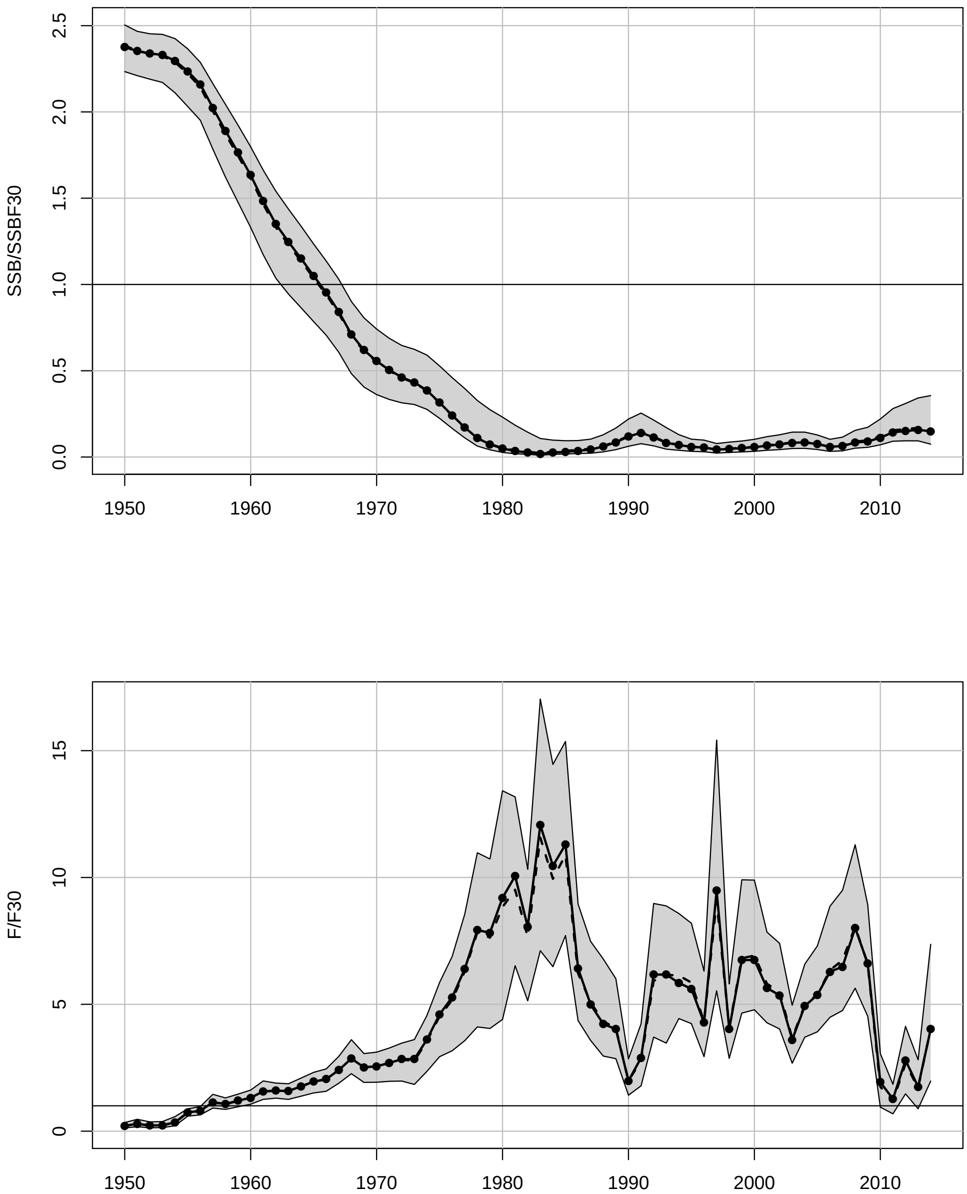
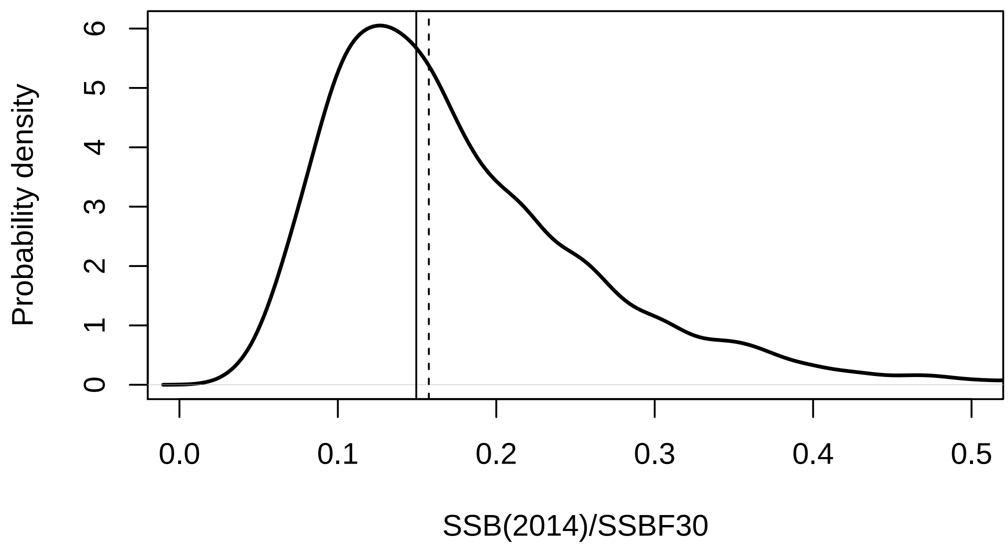


Figure 38. Probability densities of terminal status estimates from MCB analysis of the Beaufort Assessment Model. Solid vertical lines represent point estimates from the base run; dashed vertical lines represent median values.



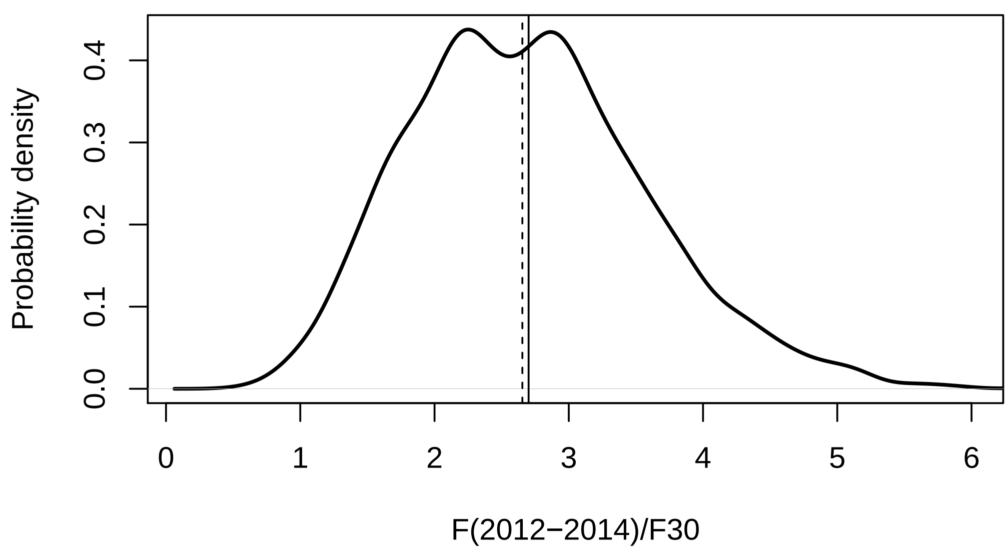


Figure 39. Phase plots of terminal status estimates from MCB analysis of the Beaufort Assessment Model. The intersection of crosshairs indicates estimates from the base run; lengths of crosshairs defined by 5^{th} and 95^{th} percentiles. Proportion of runs falling in each quadrant indicated.

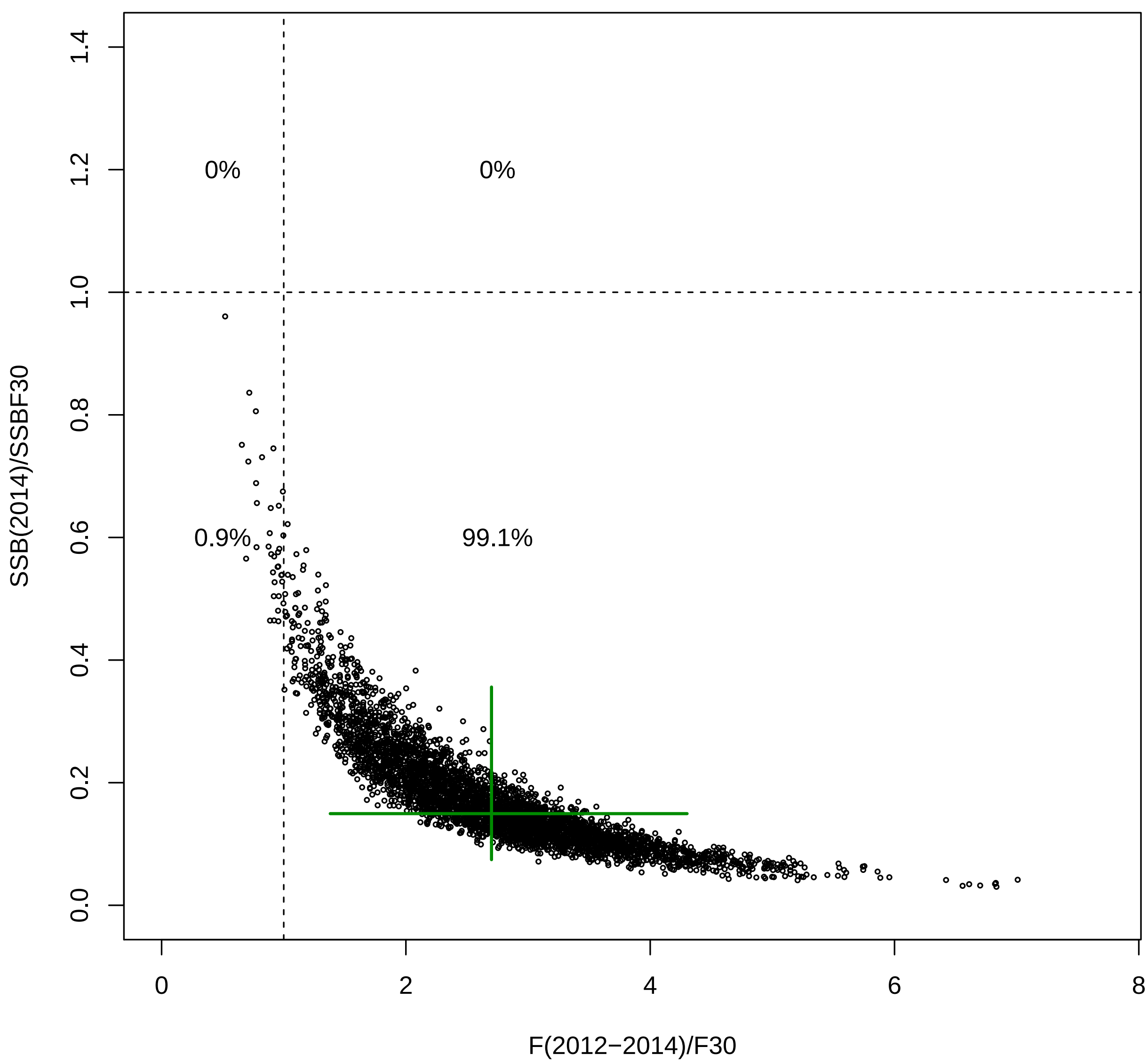


Figure 40. Age structure relative to the equilibrium expected at $F_{30\%}$.

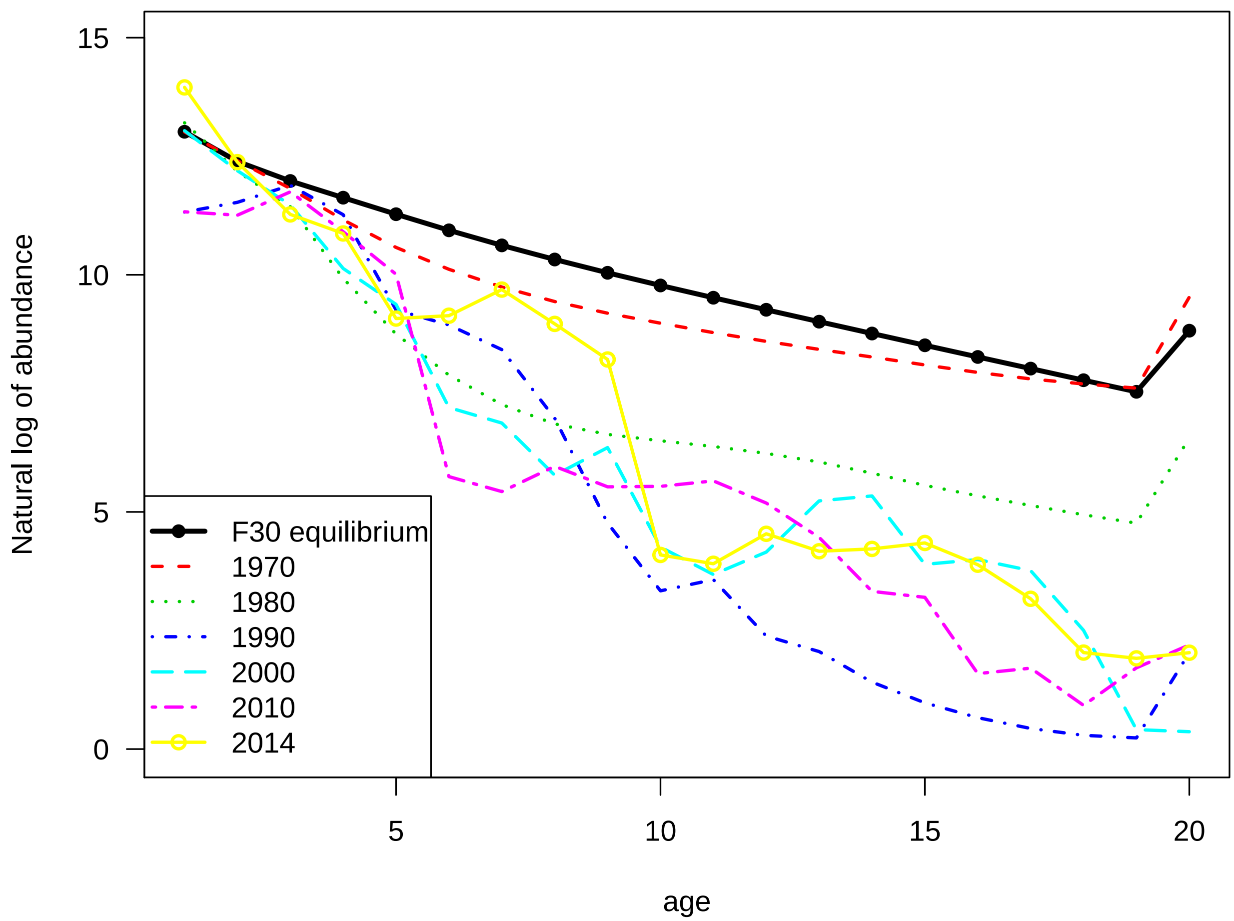


Figure 41. Sensitivity to changes in natural mortality (sensitivity runs S5 and S6). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

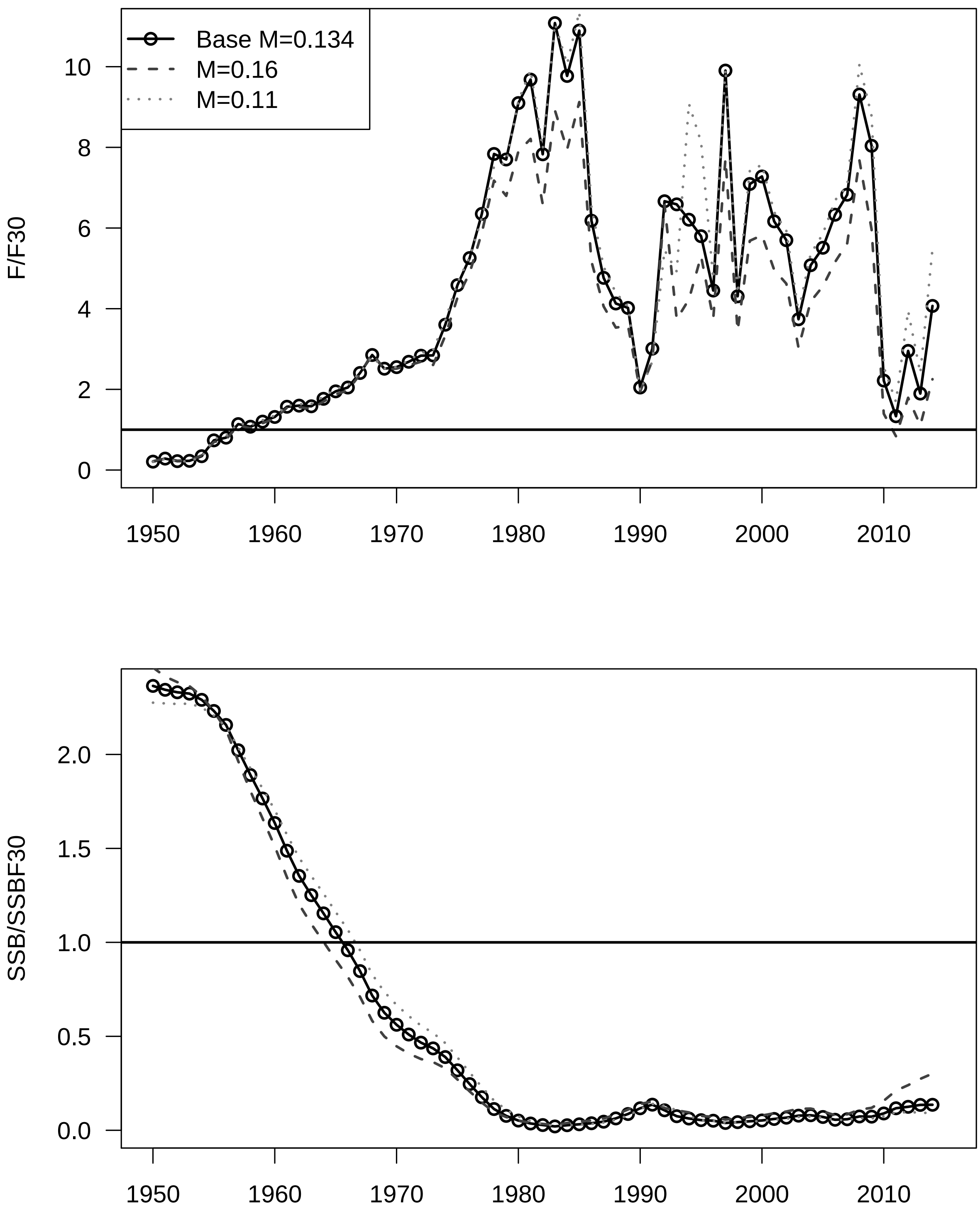


Figure 42. Sensitivity to steepness (sensitivity run S11). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

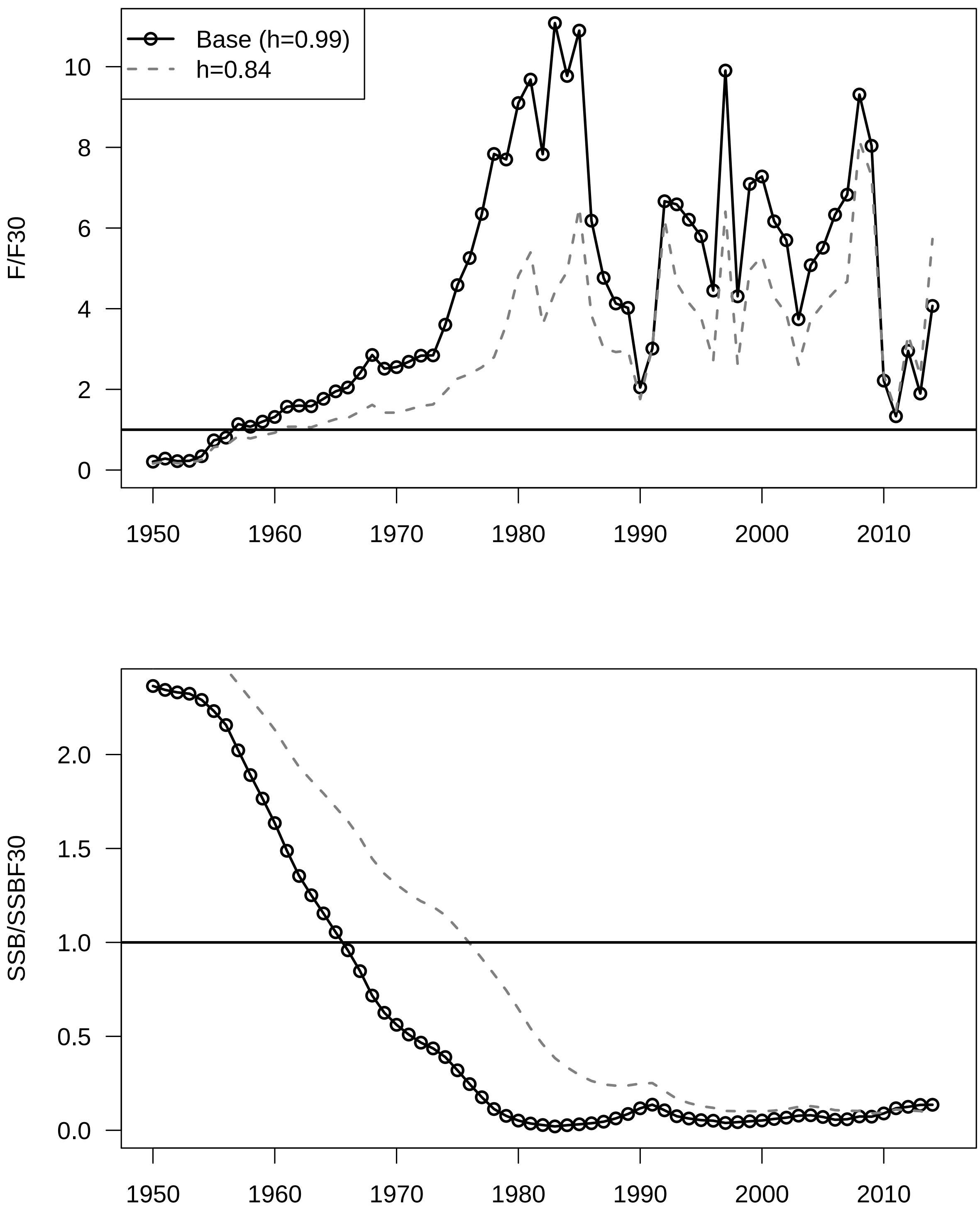


Figure 43. Sensitivity to start year (1978 compared to 1950) (sensitivity run S26). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

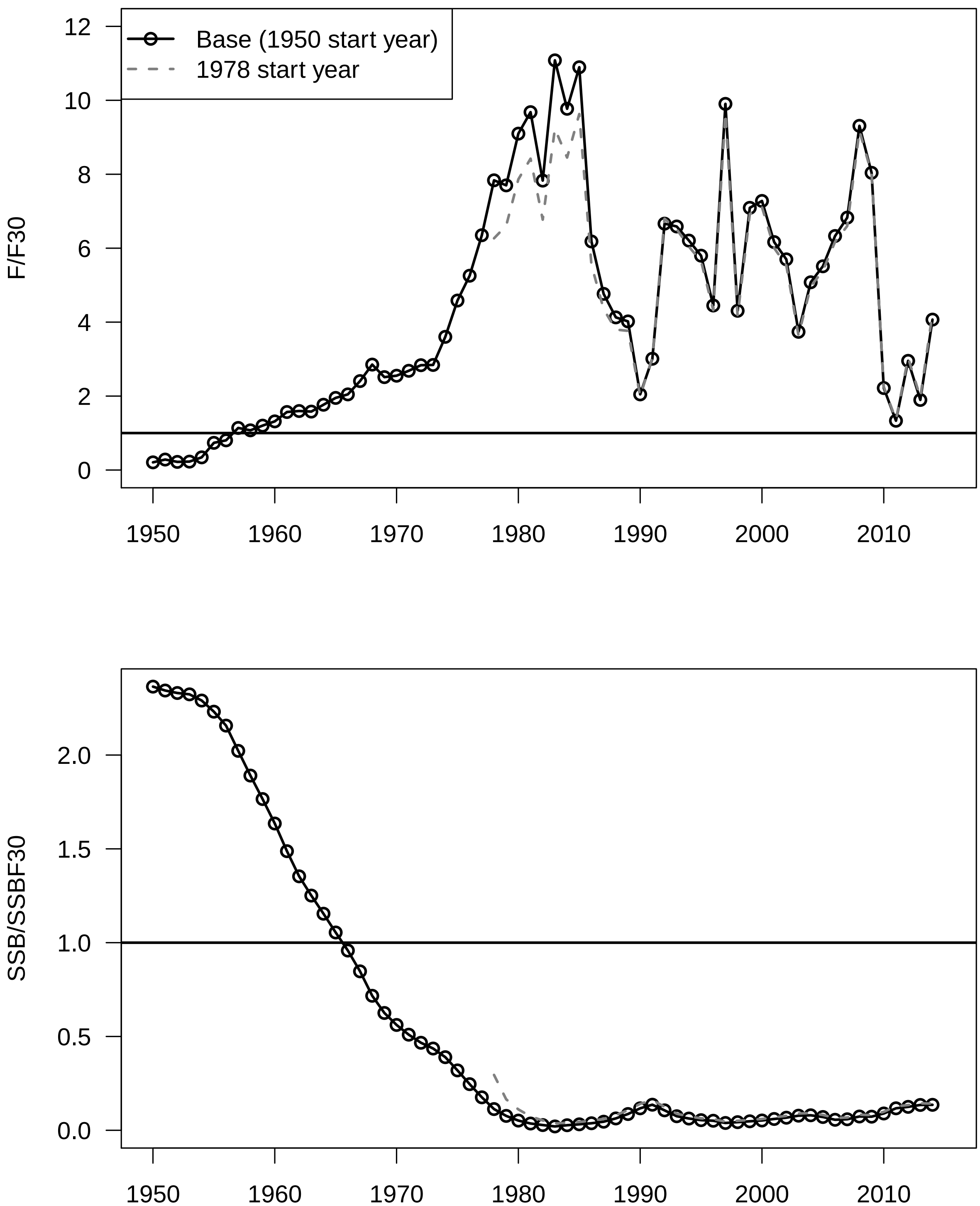


Figure 44. Sensitivity to aging error matrix (sensitivity run S13). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

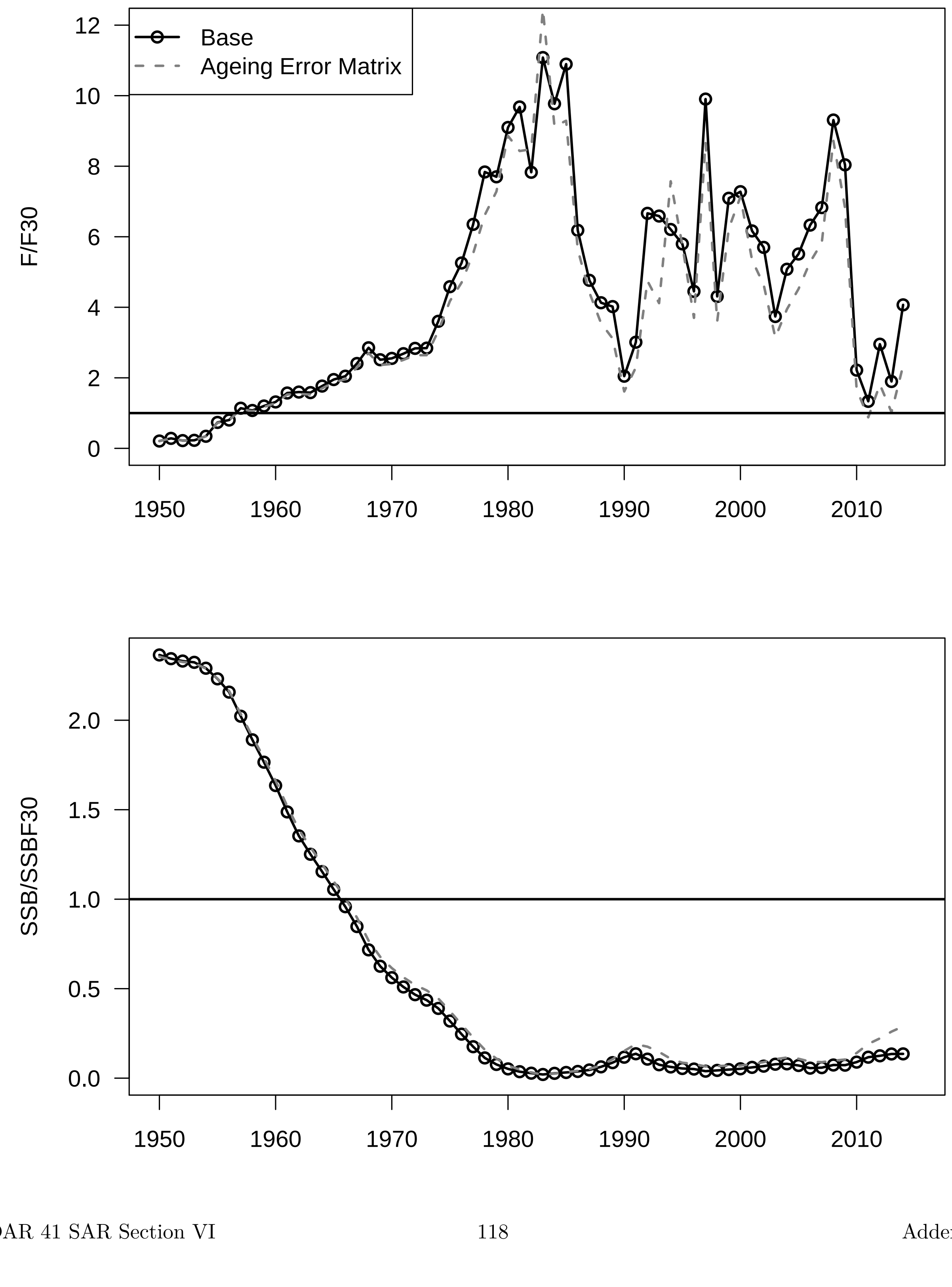


Figure 45. Sensitivity to batch number (sensitivity runs S14 and S15). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

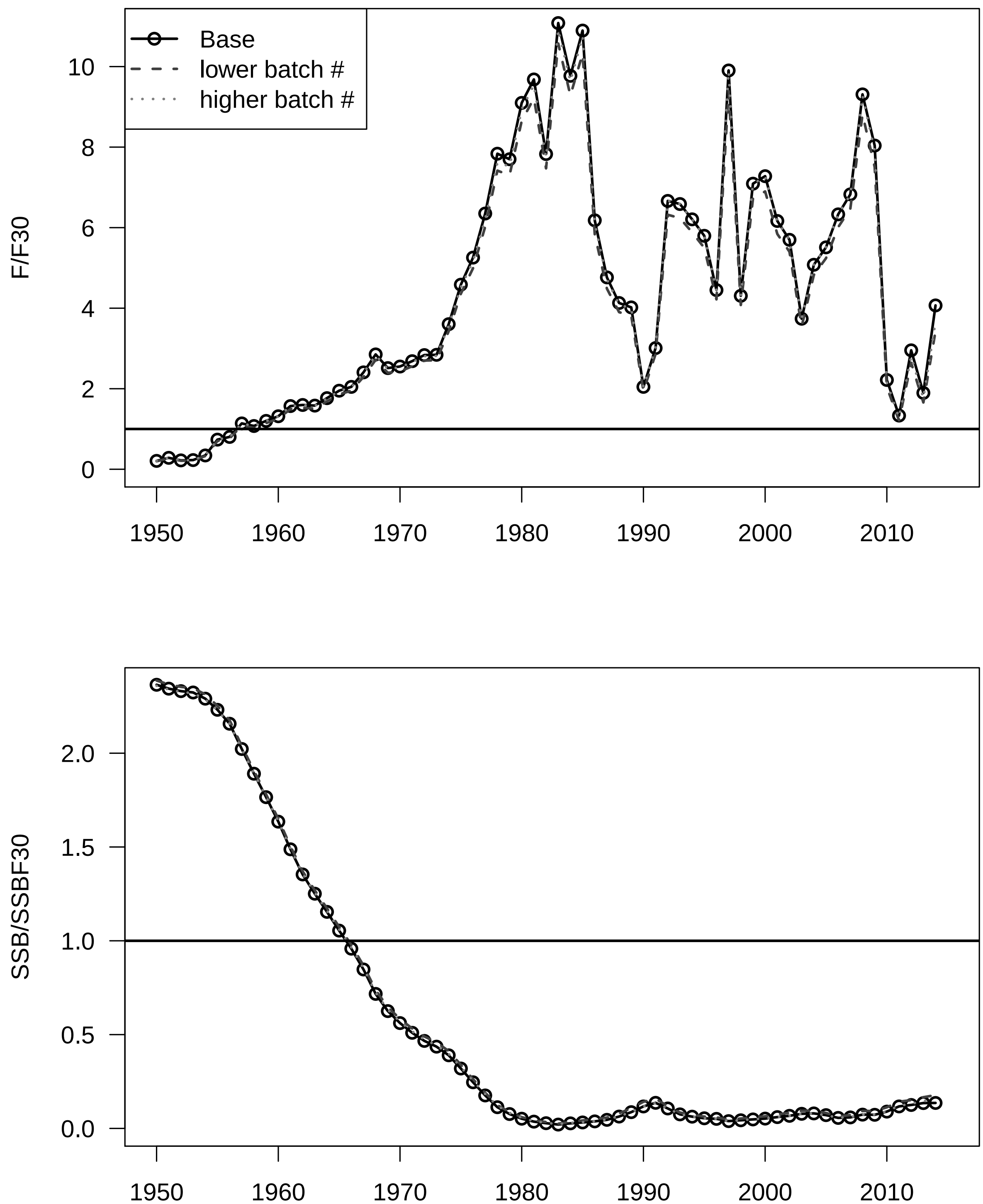


Figure 46. Sensitivity to various changes to SERFS video and trap indices (sensitivity runs S2, S9, S22 and S23). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

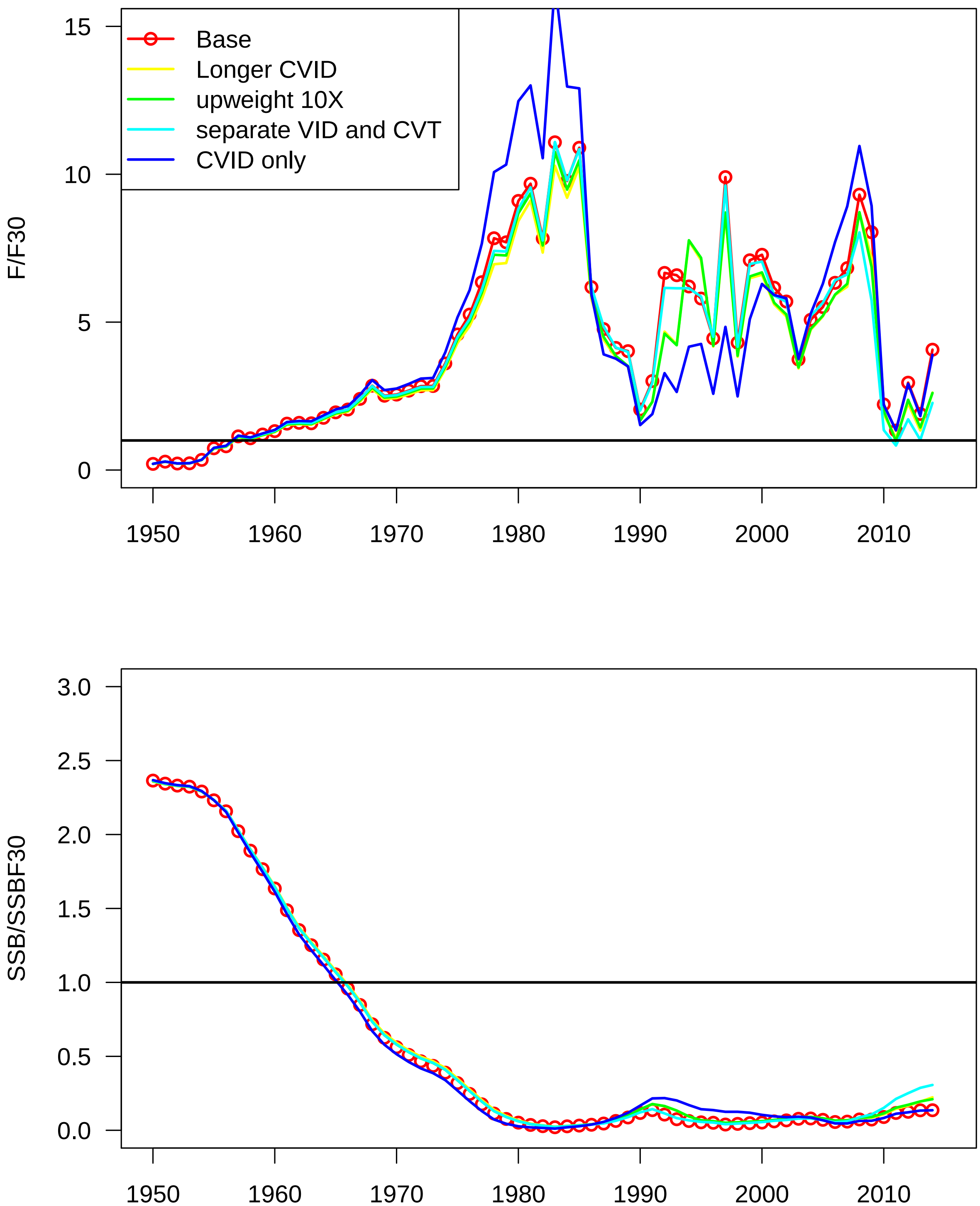


Figure 47. Sensitivity to discard mortality (sensitivity run S7 and S8). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

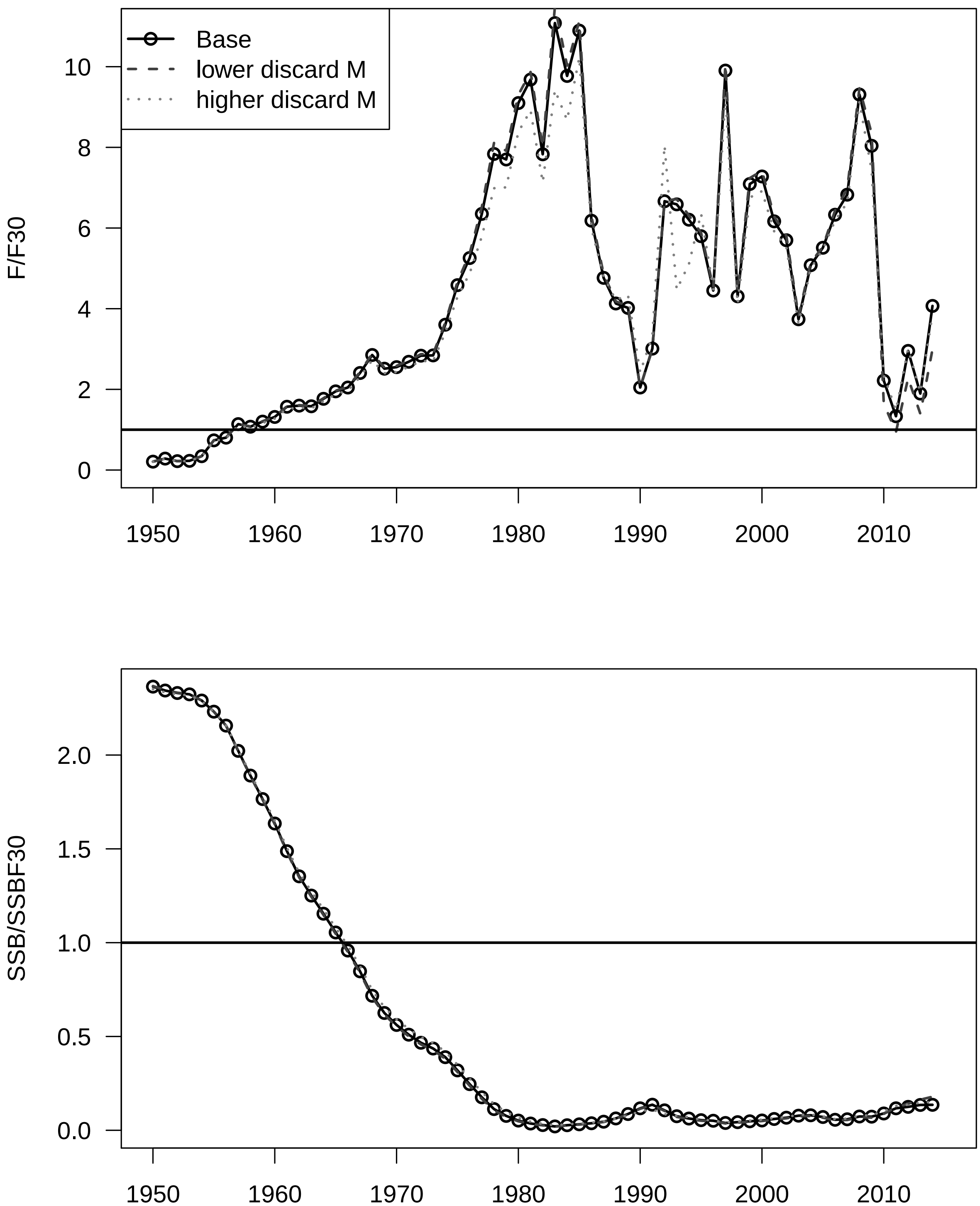


Figure 48. Sensitivity to dome-shaped selectivity for commercial handline (sensitivity run S21). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

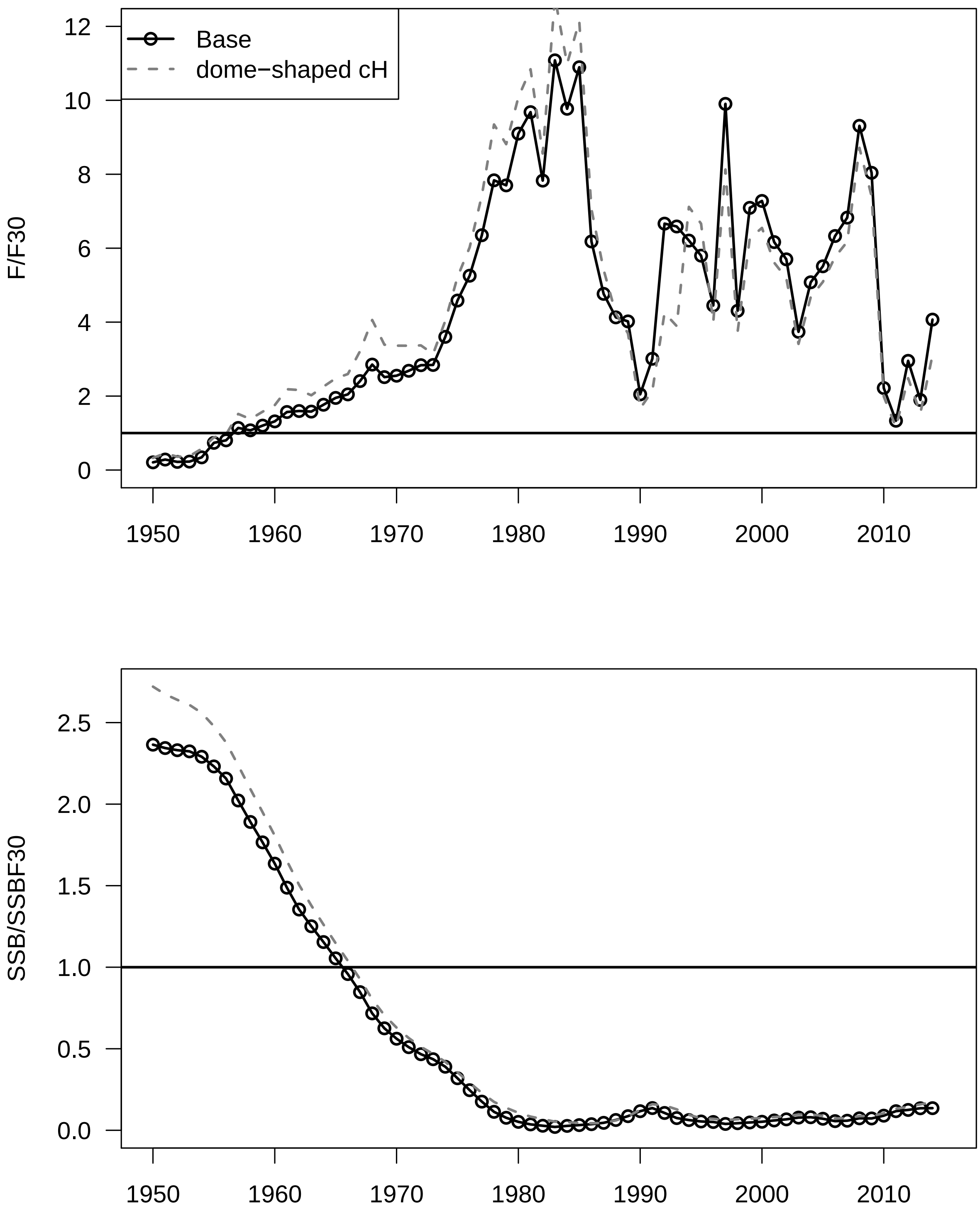


Figure 49. Sensitivity to various changes to fishery dependent indices (sensitivity runs S1, S3, S4, and S25). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

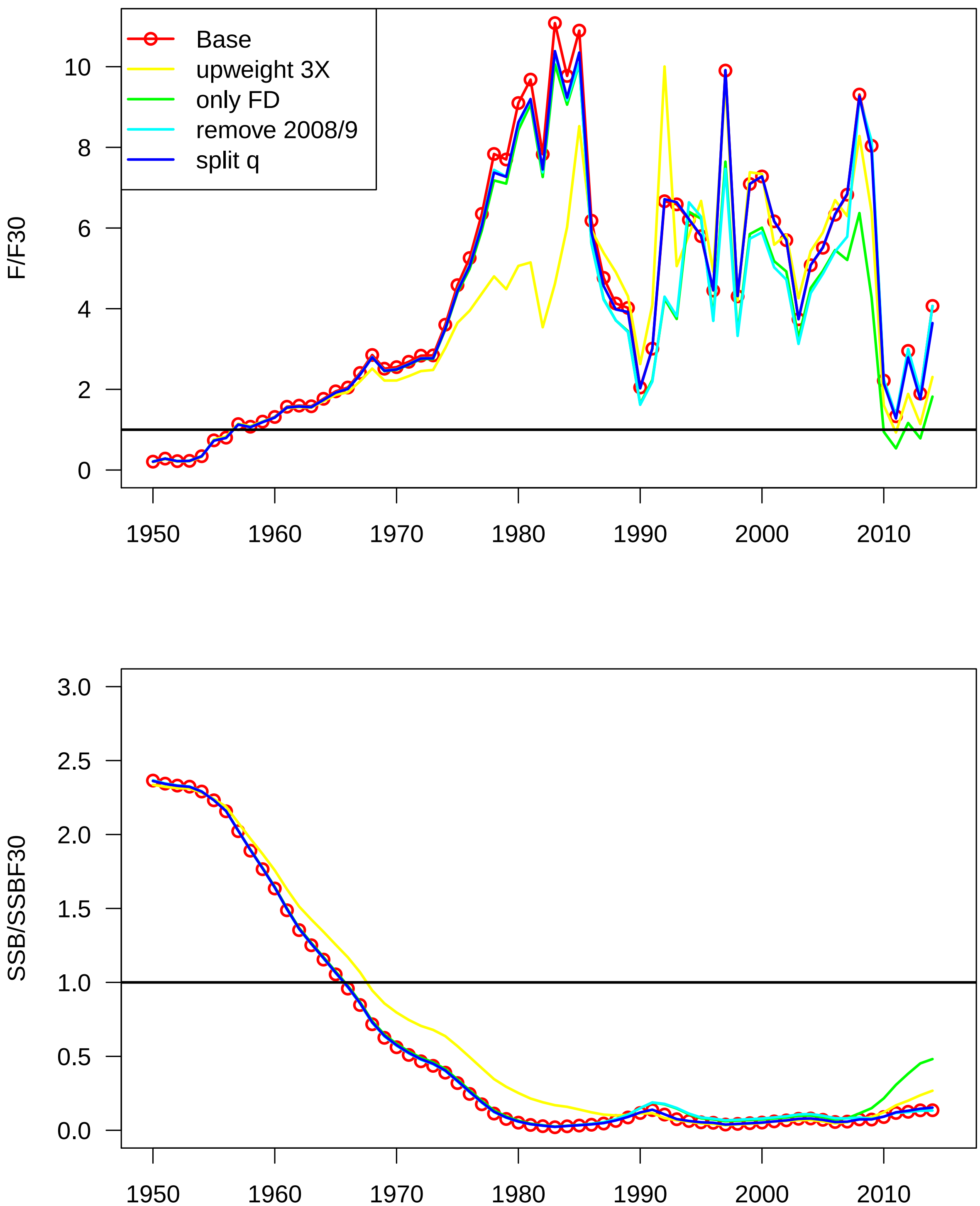


Figure 50. Sensitivity to not fixing selectivities (sensitivity run S27). Top panel: Ratio of F to $F_{30\%}$*. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

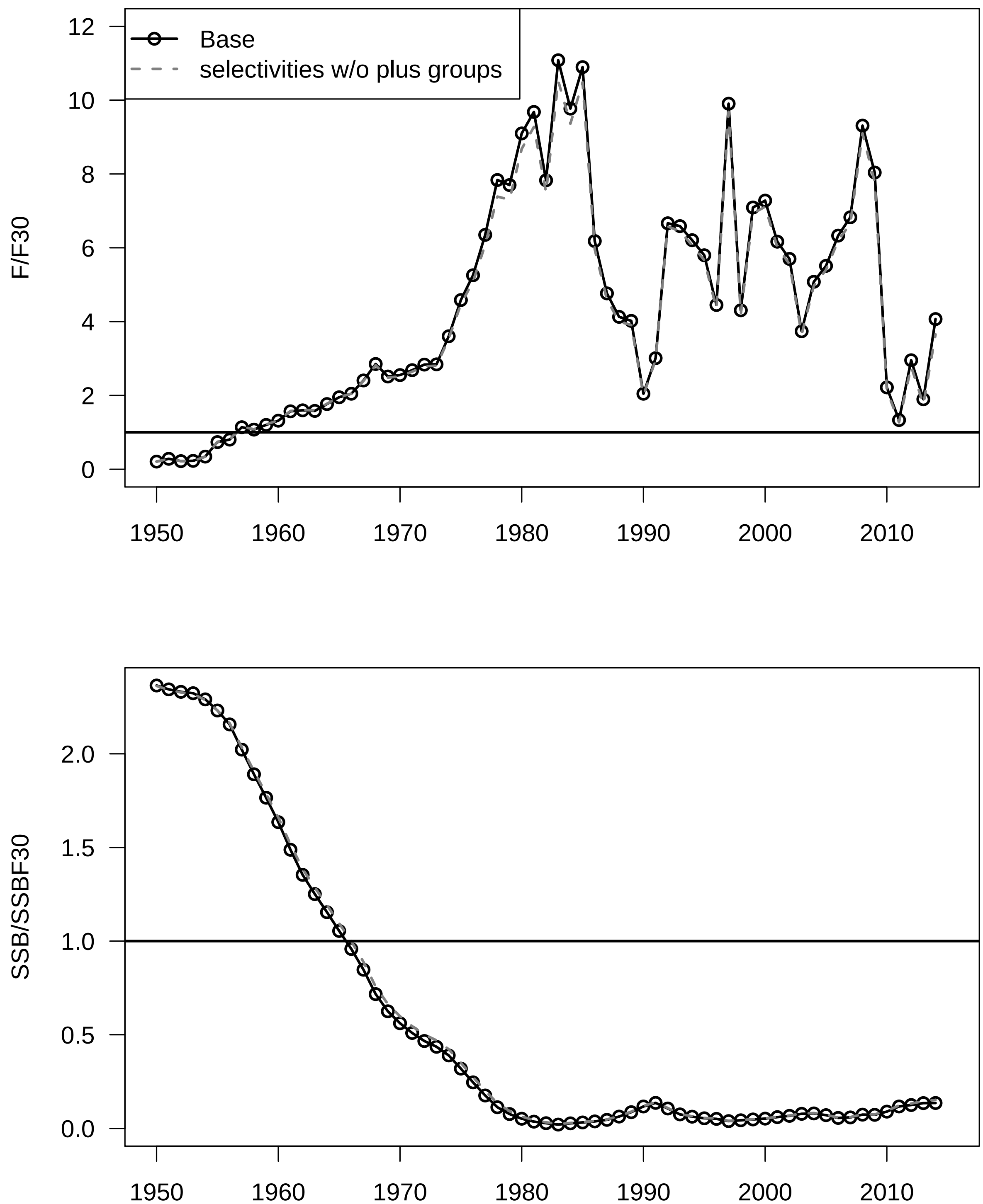


Figure 51. Sensitivity to dropping or truncating headboat discard index (sensitivity runs S12 and S16). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

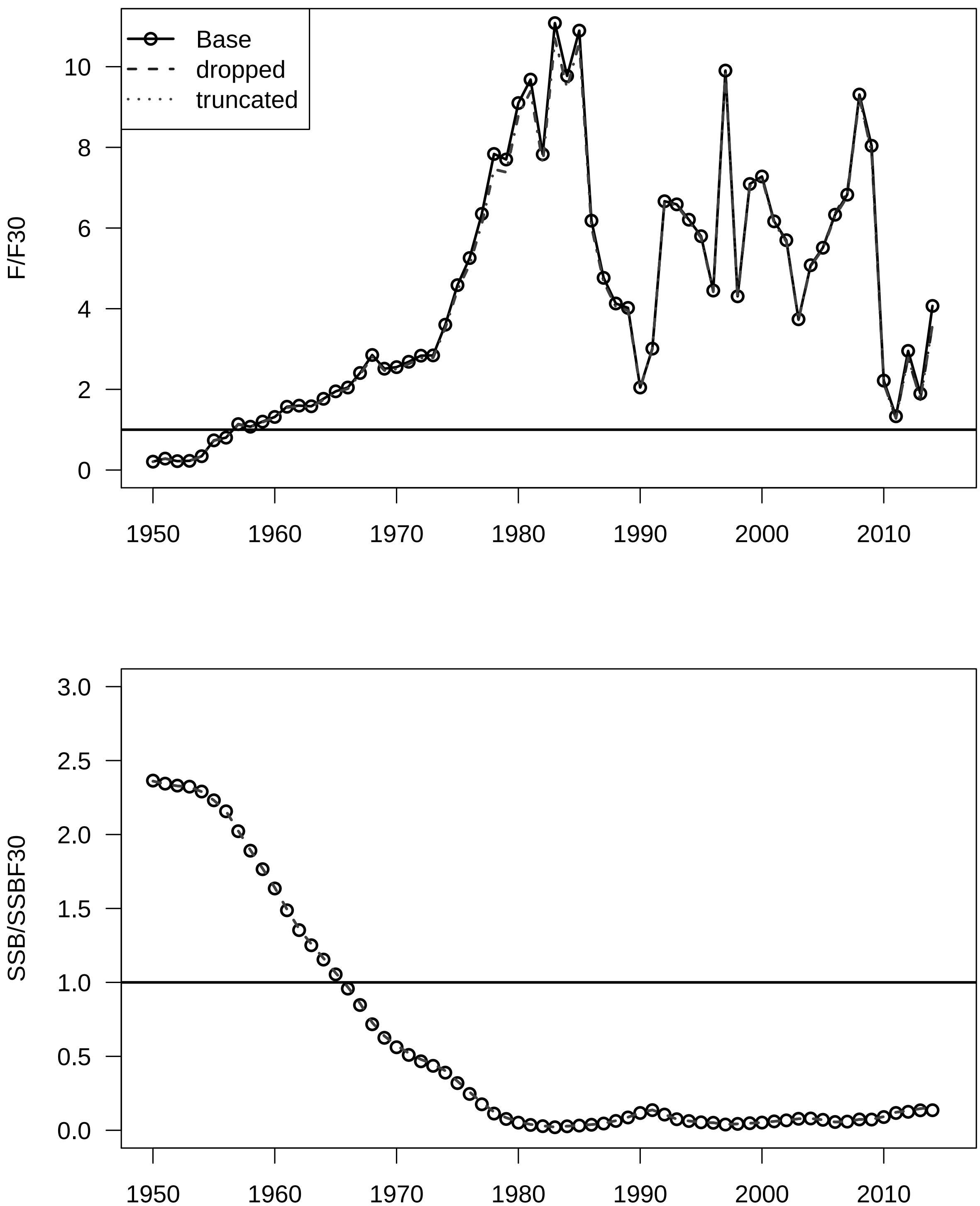


Figure 52. Sensitivity to higher or lower estimates of landings and discards (sensitivity runs S17–S20). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

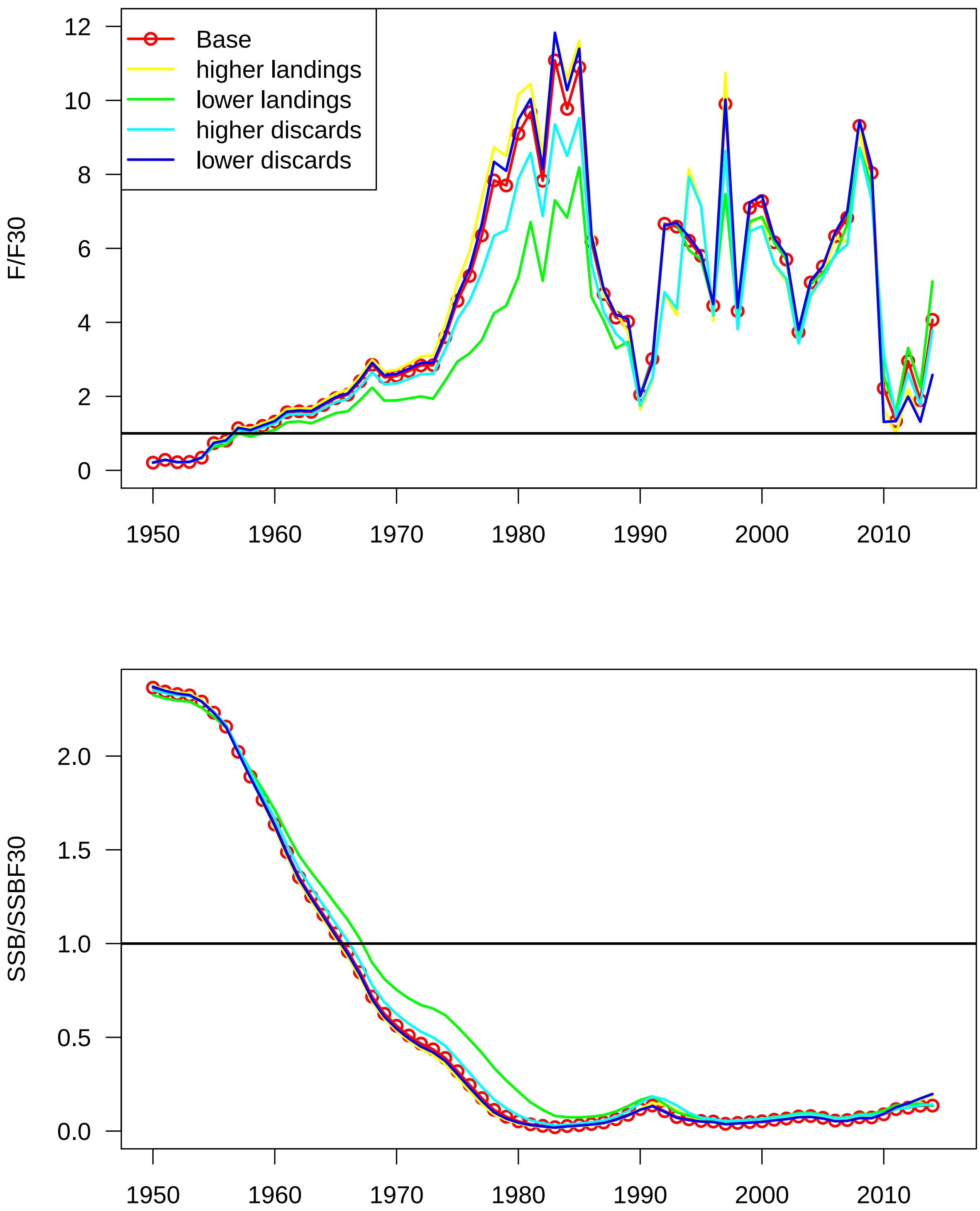


Figure 53. Sensitivity to smoothed 1984 and 1985 MRIP landings (sensitivity run S10). Top panel: Ratio of F to $F_{30\%}$. Bottom panel: Ratio of SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$.

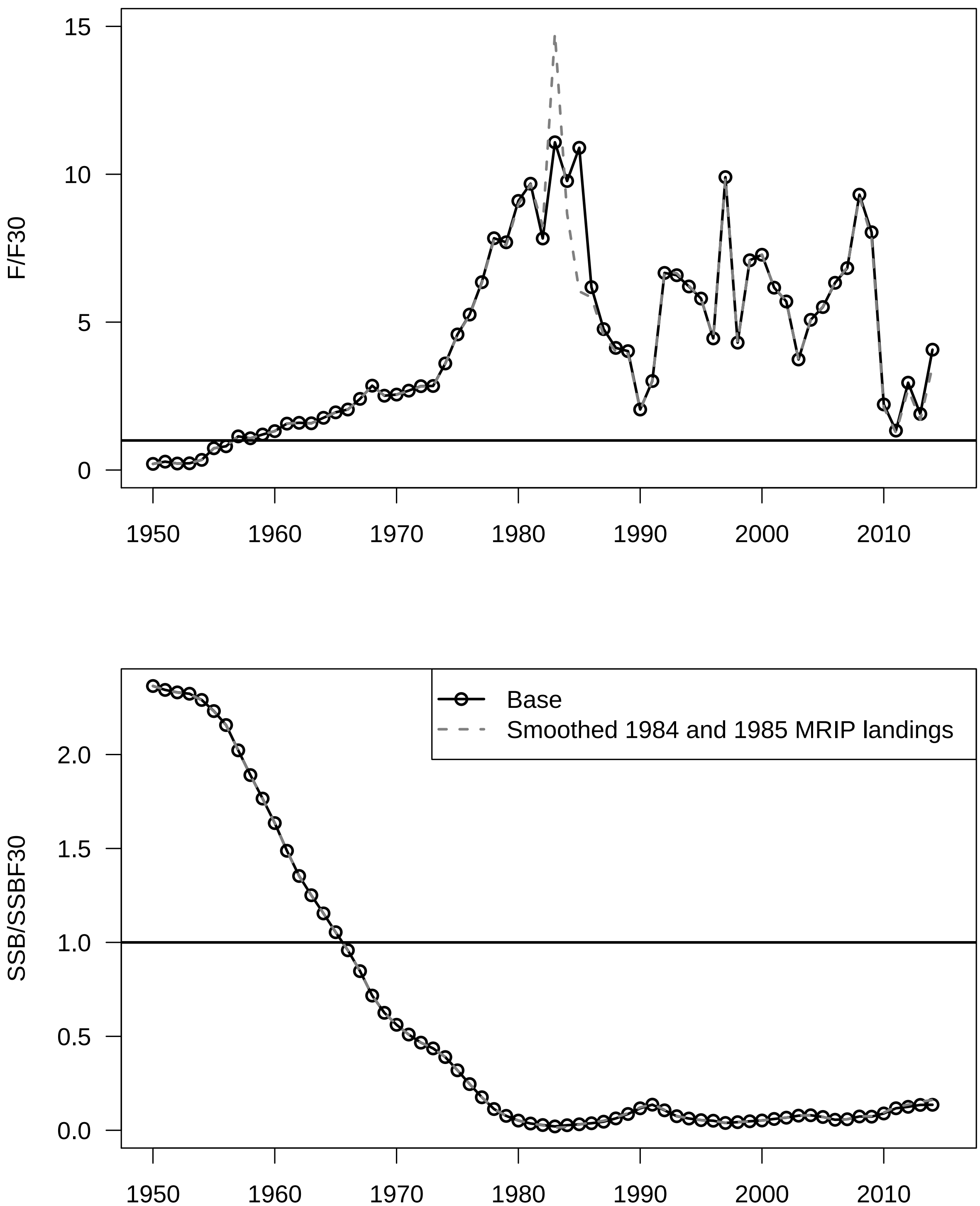


Figure 54. Sensitivity to continuity assumptions from SEDAR 24 (sensitivity run S24). Top panel: Ratio of F to $F_{30\%}$*. Bottom panel: Ratio of* SSB *to* $\mathrm{SSB}_{\mathrm{F30\%}}$*.*

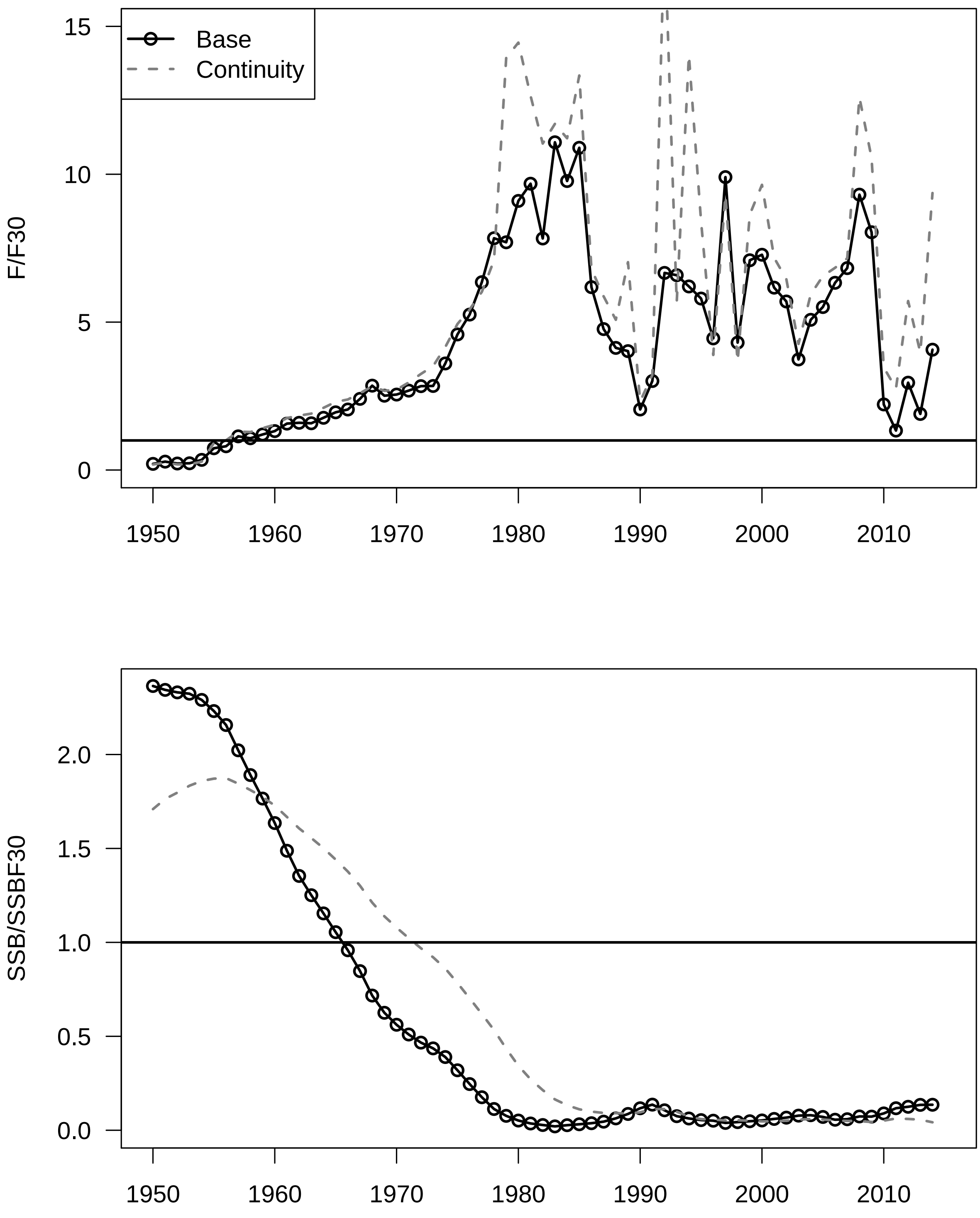


Figure 55. Phase plot of terminal status indicators from sensitivity runs of the Beaufort Assessment Model.

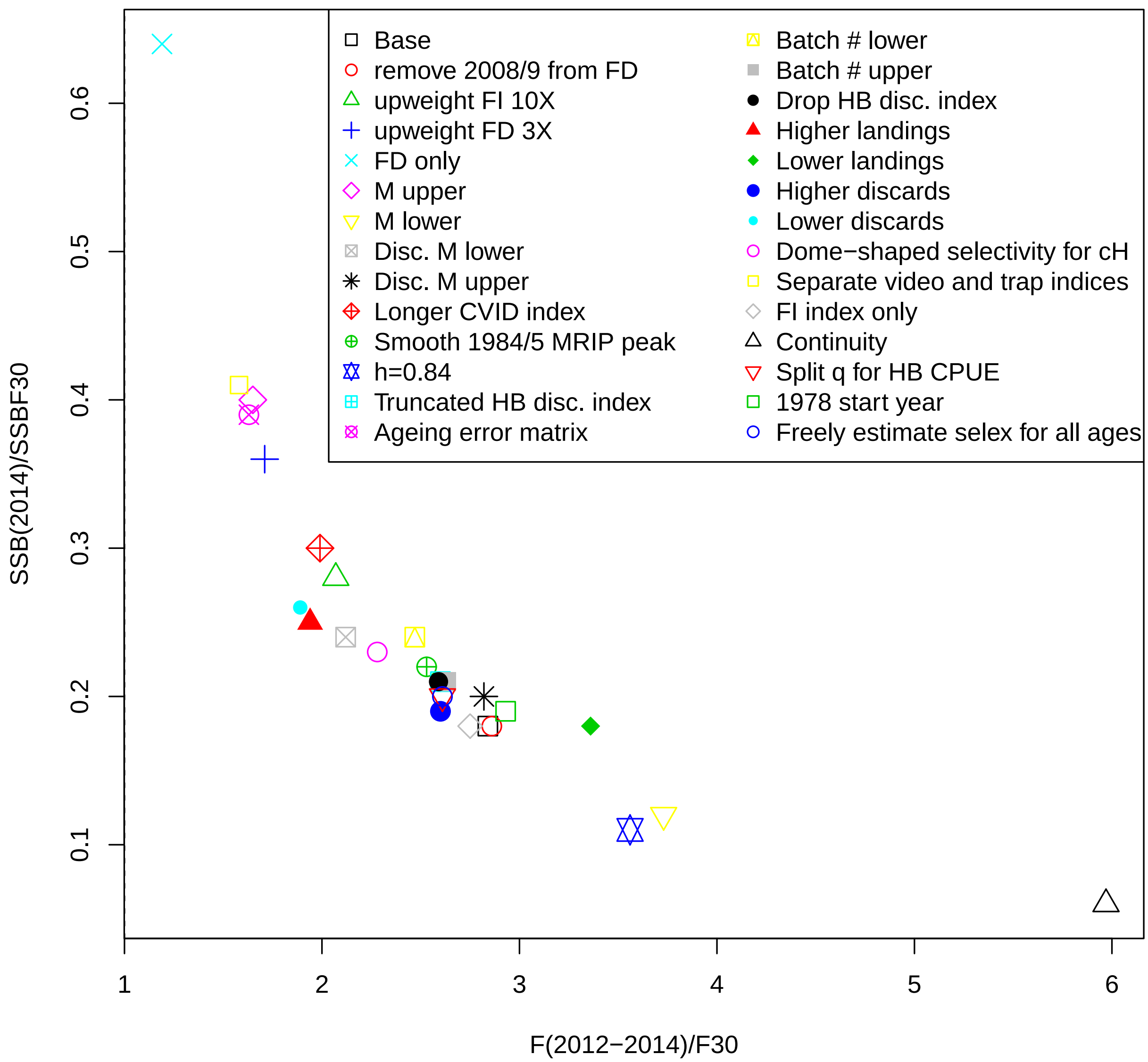


Figure 56. Retrospective analyses. Sensitivity to terminal year of data. Top panel: Fishing mortality rates. Middle panel: Recruits. Bottom panel: Spawning biomass. Closed circles show terminal-year estimates. Imperceptible lines overlap results of the base run.

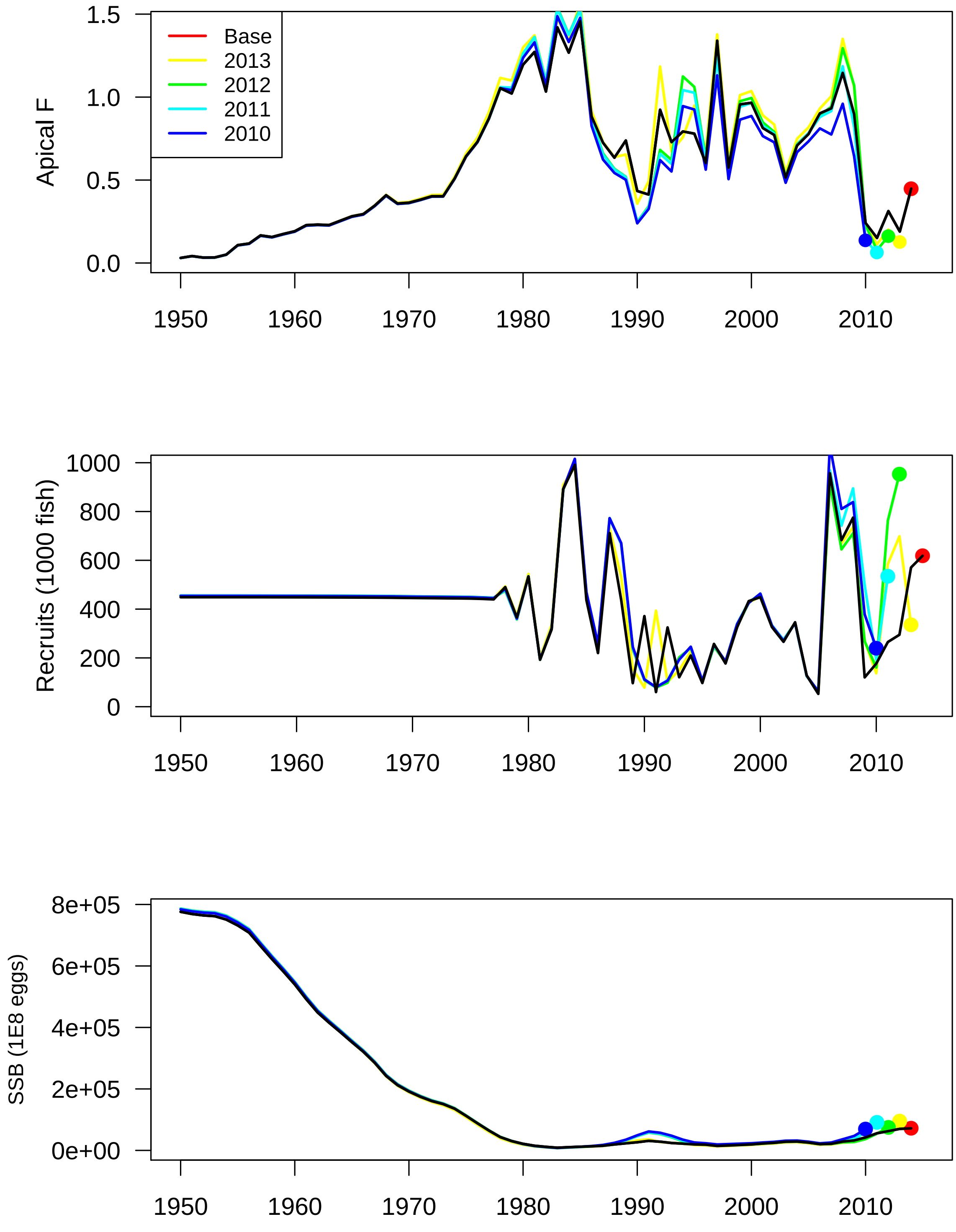


Figure 57. Projection results under scenario 1—fishing mortality rate at $F = 0$. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities; dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB_{F30\%}}$.

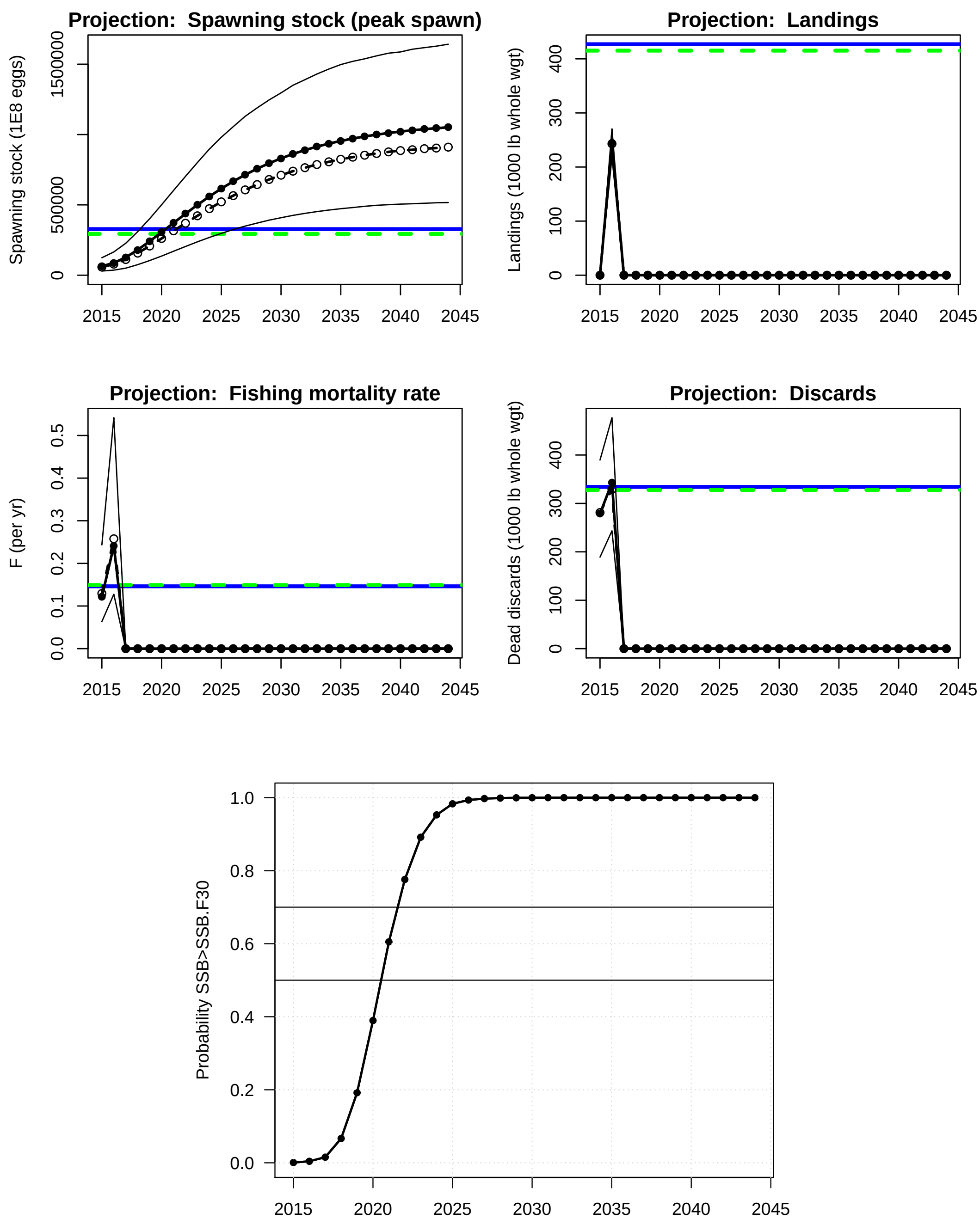


Figure 58. Projection results under scenario 2—fishing mortality rate at $F = F_{\mathrm{current}}$. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities; dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F30\%}}$.

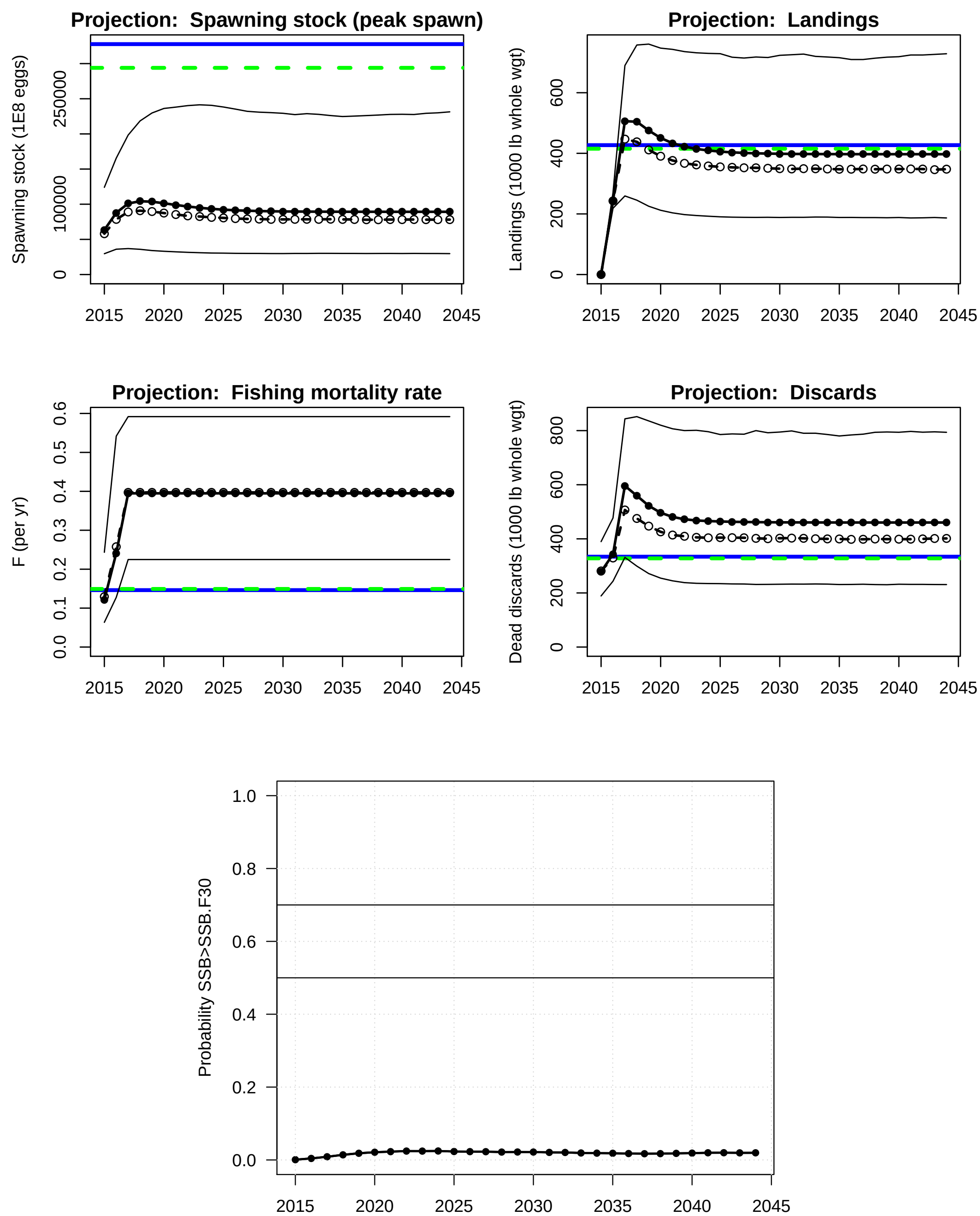


Figure 59. Projection results under scenario 3—fishing mortality rate at $F = F_{30\%}$. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities; dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F30\%}}$.

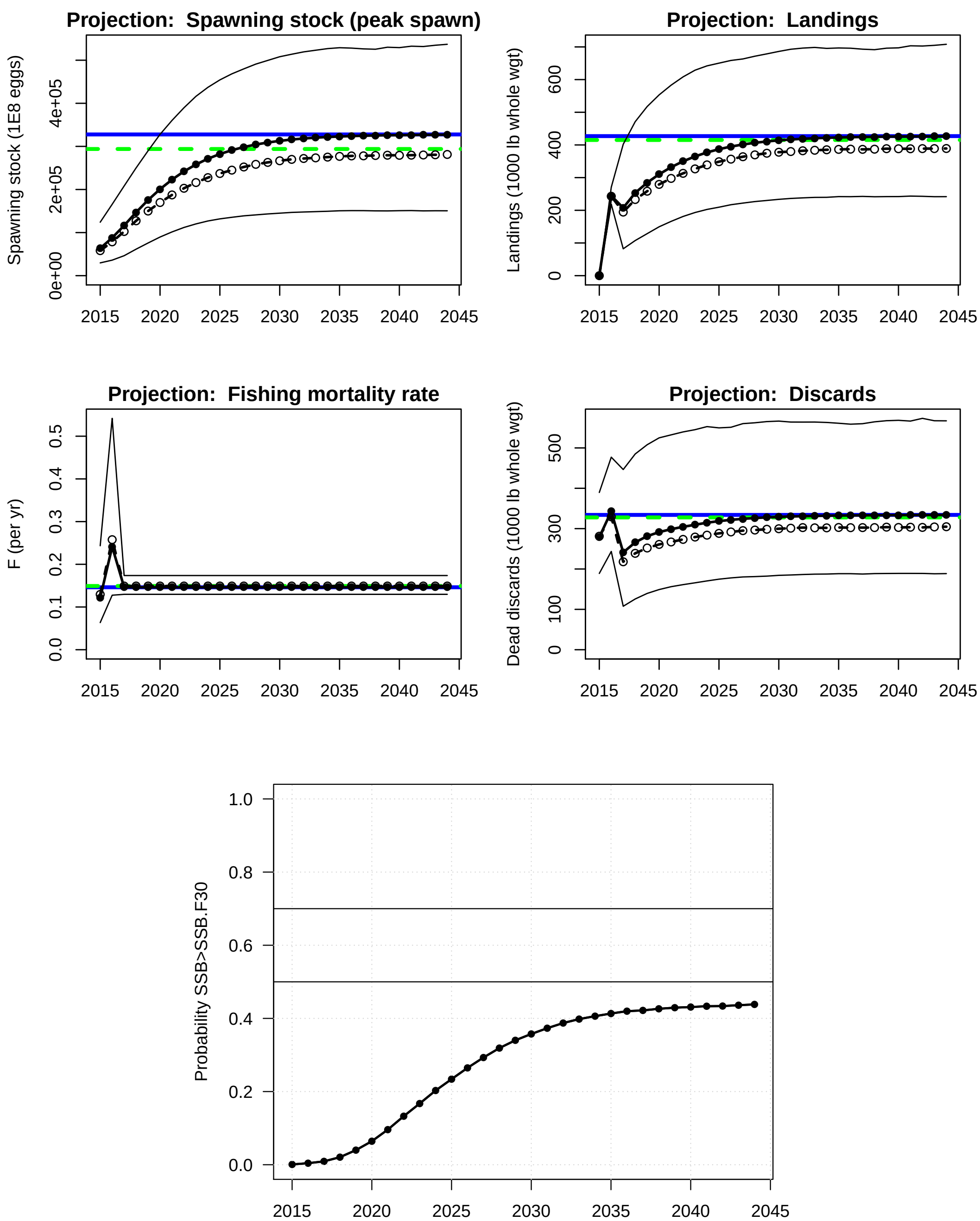


Figure 60. Projection results under scenario 4—fishing mortality rate at $F = 98\% F_{30\%}$. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities; dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F30\%}}$.

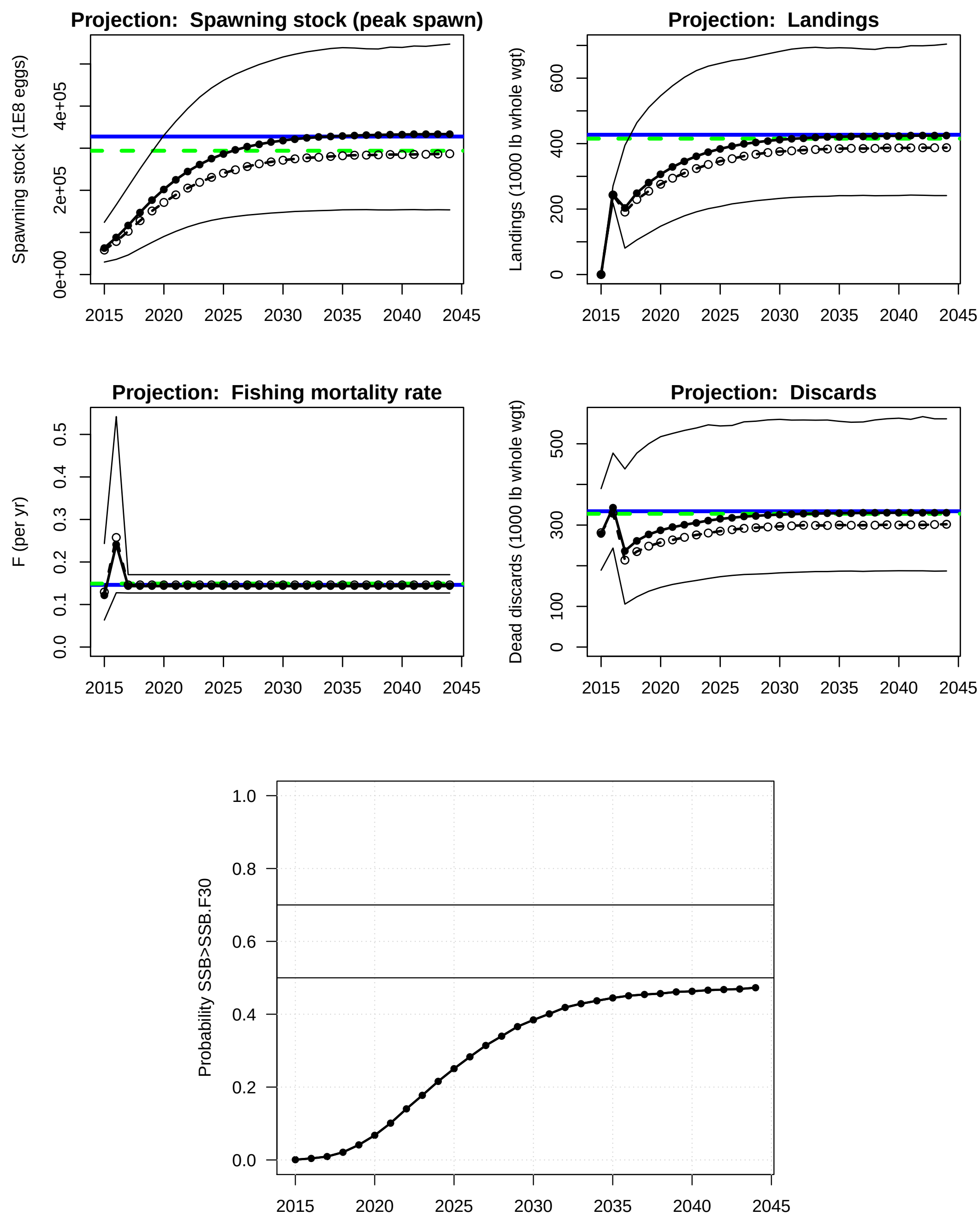


Figure 61. Projection results under scenario 5—fishing mortality rate at $F = F_{\mathrm{rebuild}}$, with rebuilding probability of 0.5 in 2044. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities; dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F30\%}}$.

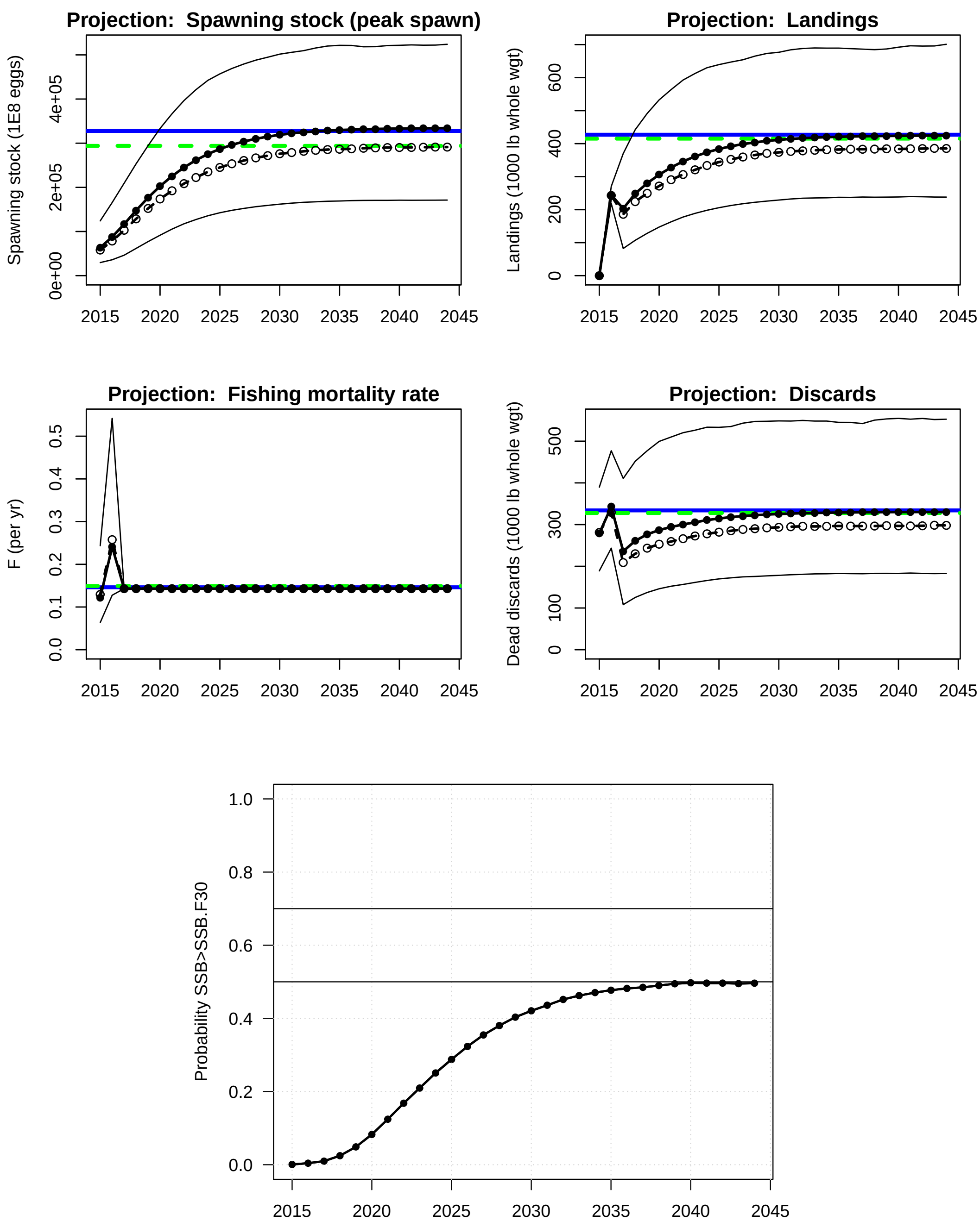
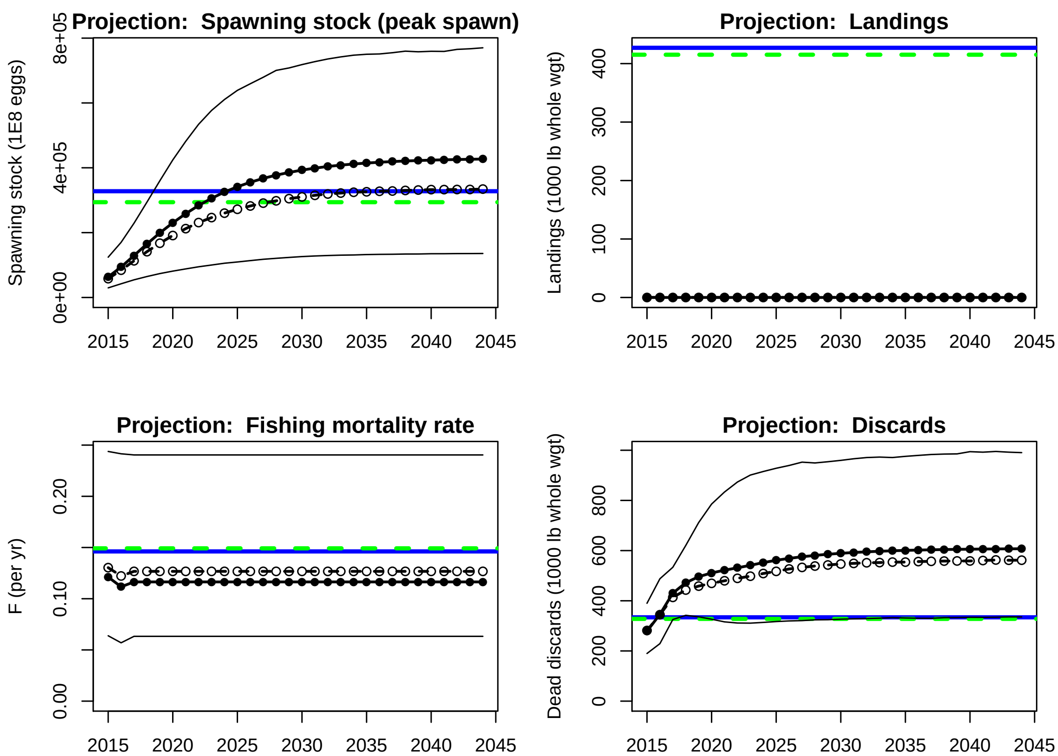


Figure 62. Projection results under scenario 6—fishing mortality rate set to average discard mortality rate only. In top four panels, expected values (base run) represented by solid lines with solid circles, medians represented by dashed lines with open circles, and uncertainty represented by thin lines corresponding to 5^{th} and 95^{th} percentiles of replicate projections. Solid horizontal lines mark $F_{30\%}$-related quantities; dashed horizontal lines represent corresponding medians. Spawning stock (SSB) is at time of peak spawning. In bottom panel, the curve represents the proportion of projection replicates for which SSB has reached the replicate-specific $\mathrm{SSB}_{\mathrm{F30\%}}$.



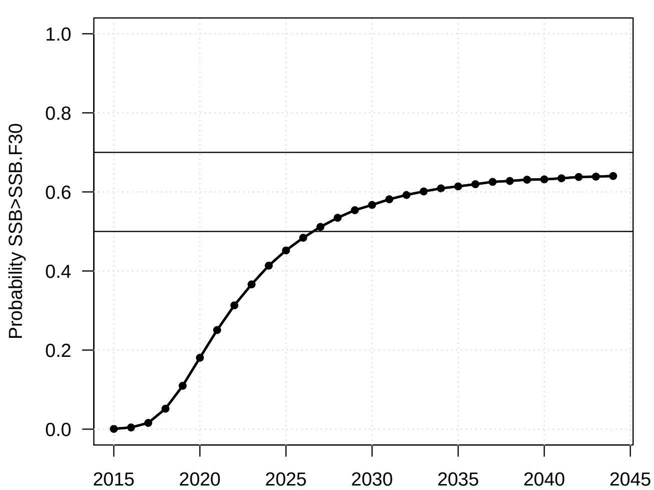


Figure 63. Abundance indices observed (obs.) and predicted (pred.) by the ASPIC surplus production model, and observed total removals (100,000 lbs) for South Atlantic red snapper. Comm = commercial, HB = headboat, HB.at.sea = headboat at sea discards, CVID = combined chevron trap-video index.

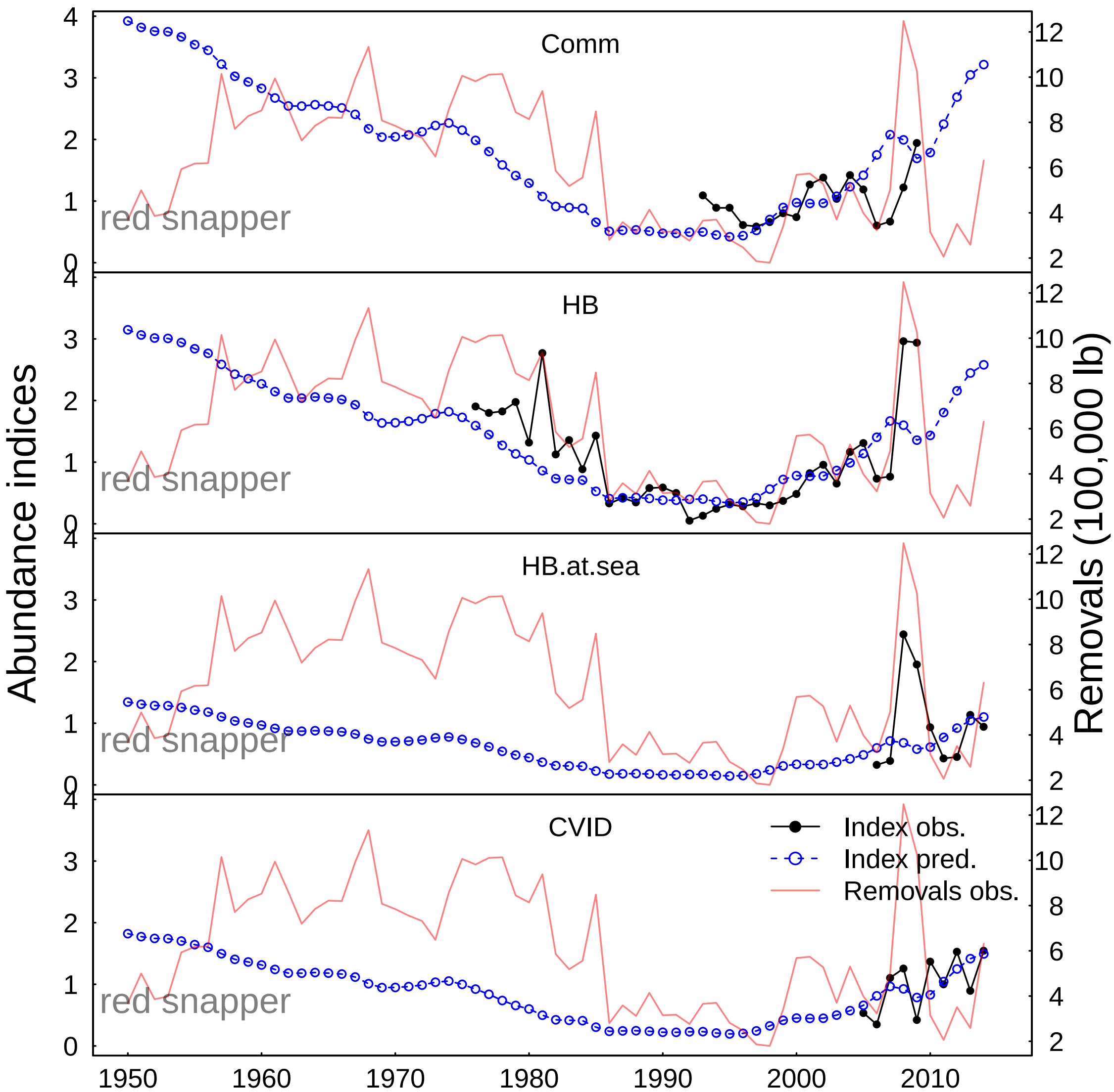


Figure 64. Prior distributions (blue shapes) and estimated parameter values (vertical black lines) for the South Atlantic red snapper ASPIC surplus production model.

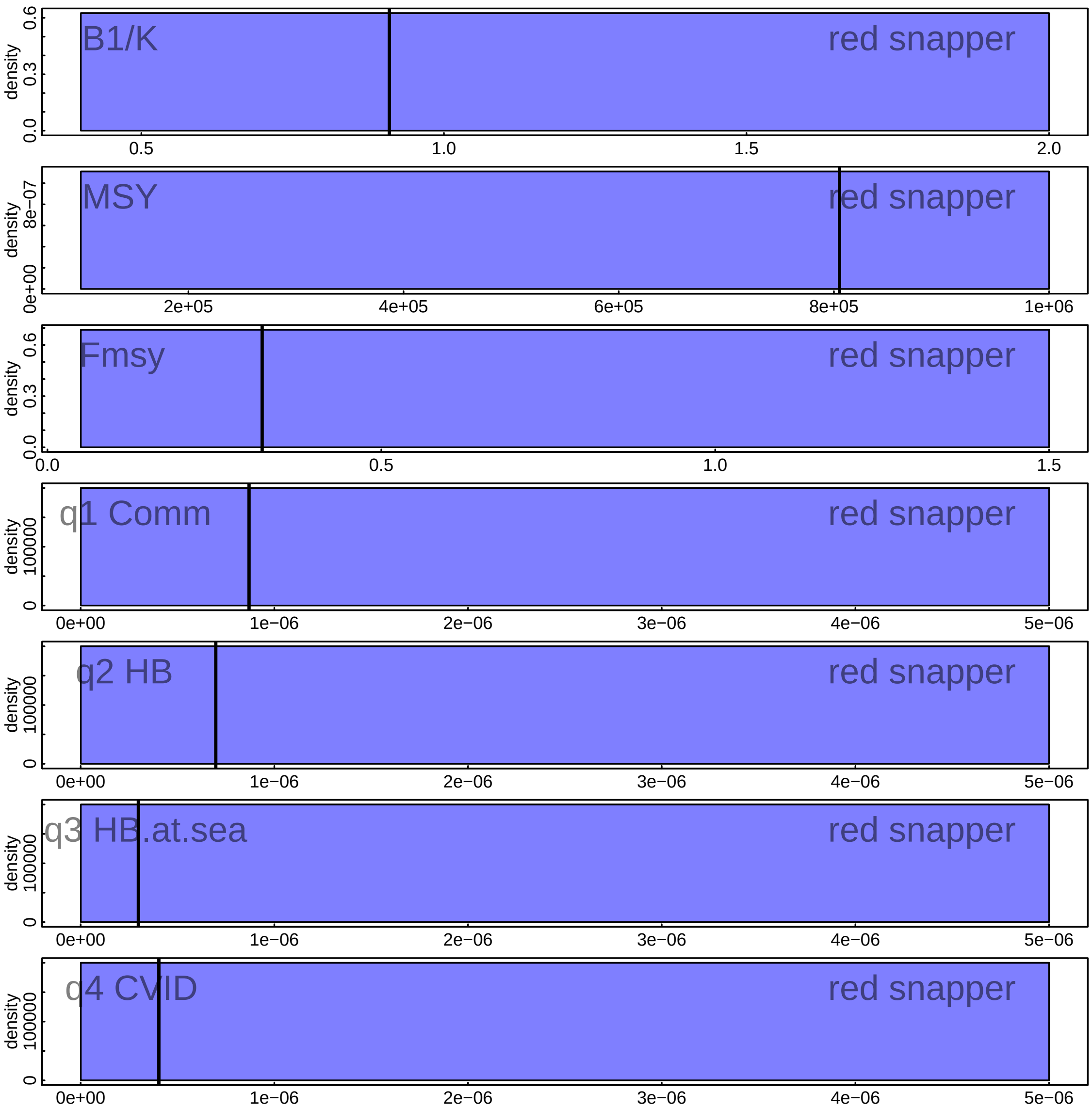


Figure 65. Bootstrap parameter values from ASPIC surplus production model run 320. Thick vertical lines represent ASPIC parameter estimates (solid) and 95% bootstrap percentile confidence intervals (dashed). Thin solid vertical lines are drawn at one in plots of F/F_{MSY} and B/B_{MSY} for reference.

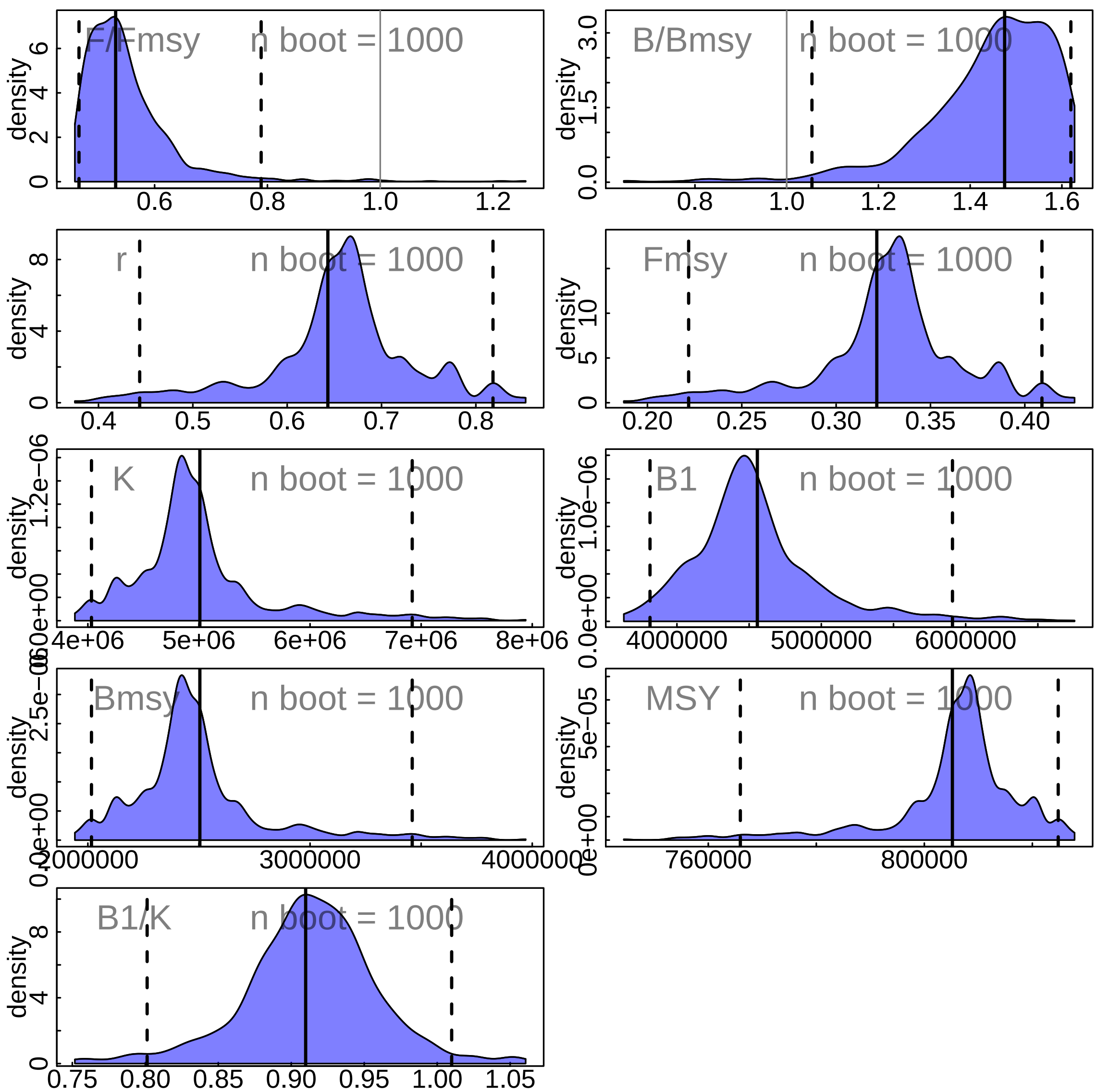
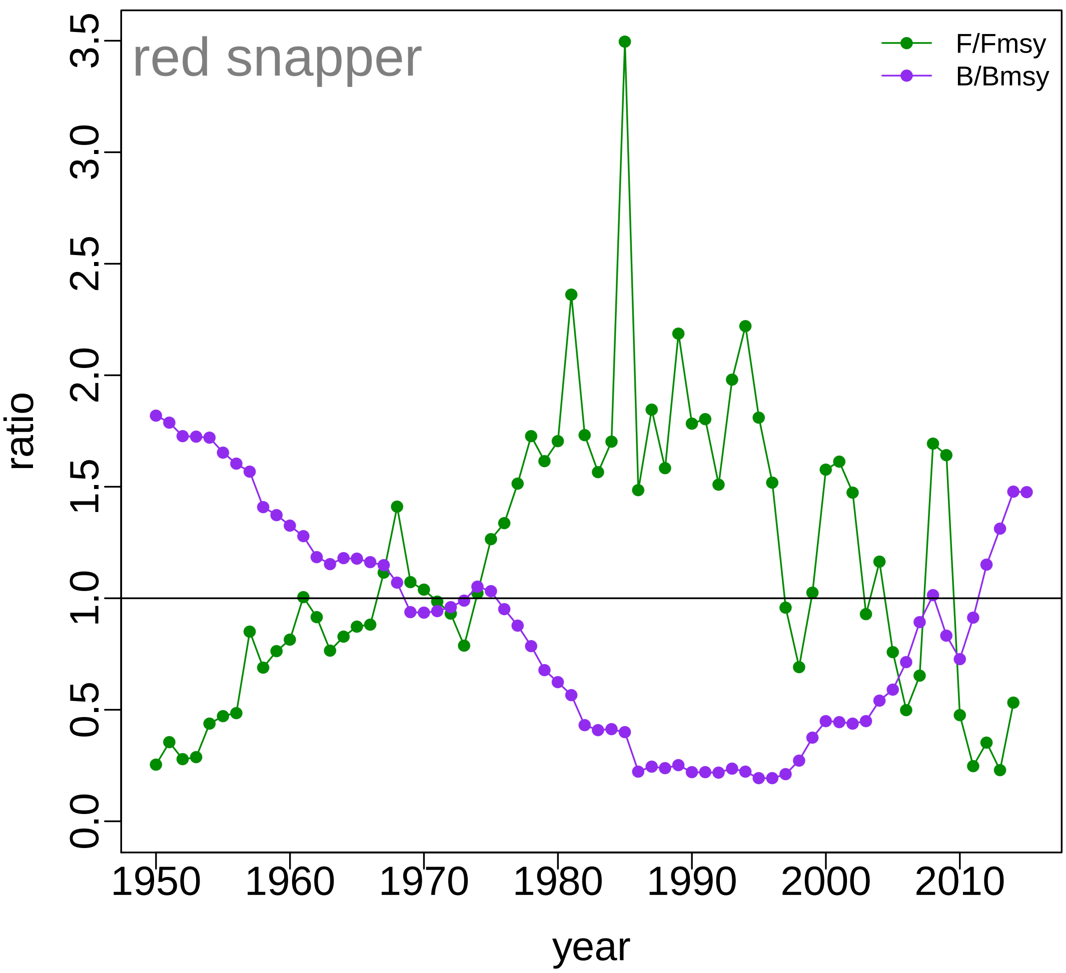


Figure 66. ASPIC surplus production model estimates of relative fishing rate (F/F_{MSY}) and biomass (B/B_{MSY}).



Appendix A Abbreviations and symbols

Table 33. Acronyms and abbreviations used in this report

Symbol	Meaning
ABC	Acceptable Biological Catch
AW	Assessment Workshop (here, for red snapper)
ASY	Average Sustainable Yield
B	Total biomass of stock, conventionally on January 1
BAM	Beaufort Assessment Model (a statistical catch-age formulation)
CPUE	Catch per unit effort; used after adjustment as an index of abundance
CV	Coefficient of variation
CVID	SERFS combined chevron trap and video survey
DW	Data Workshop (here, for red snapper)
F	Instantaneous rate of fishing mortality
$F_{30\%}$	Fishing mortality rate at which $F_{30\%}$ can be attained
F_{MSY}	Fishing mortality rate at which MSY can be attained
FL	State of Florida
FHWAR	The National Survey of Fishing, Hunting, and Wildlife-Associated Recreation Survey
GA	State of Georgia
GLM	Generalized linear model
K	Average size of stock when not exploited by man; carrying capacity
kg	Kilogram(s); 1 kg is about 2.2 lb.
klb	Thousand pounds; thousands of pounds
lb	Pound(s); 1 lb is about 0.454 kg
m	Meter(s); 1 m is about 3.28 feet.
M	Instantaneous rate of natural (non-fishing) mortality
MARMAP	Marine Resources Monitoring, Assessment, and Prediction Program, a fishery-independent data collection program of SCDNR
MCB	Monte Carlo/Bootstrap, an approach to quantifying uncertainty in model results
MFMT	Maximum fishing-mortality threshold; a limit reference point used in U.S. fishery management; often based on F_{MSY}
mm	Millimeter(s); 1 inch = 25.4 mm
MRFSS	Marine Recreational Fisheries Statistics Survey, a data-collection program of NMFS, predecessor of MRIP
MRIP	Marine Recreational Information Program, a data-collection program of NMFS, descended from MRFSS
MSST	Minimum stock-size threshold; a limit reference point used in U.S. fishery management. The SAFMC has defined MSST for red snapper as $(1 - M)\mathrm{SSB}_{\mathrm{MSY}} = 0.7\mathrm{SSB}_{\mathrm{MSY}}$.
MSY	Maximum sustainable yield (per year)
mt	Metric ton(s). One mt is 1000 kg, or about 2205 lb.
N	Number of fish in a stock, conventionally on January 1
NC	State of North Carolina
NMFS	National Marine Fisheries Service, same as "NOAA Fisheries Service"
NOAA	National Oceanic and Atmospheric Administration; parent agency of NMFS
OY	Optimum yield; SFA specifies that OY $\leq$ MSY.
PSE	Proportional standard error
R	Recruitment
SAFMC	South Atlantic Fishery Management Council (also, Council)
SC	State of South Carolina
SCDNR	Department of Natural Resources of SC
SDNR	Standard deviation of normalized residuals
SEDAR	SouthEast Data Assessment and Review process
SERFS	Southeast Regional Fishery-independent Sampling
SFA	Sustainable Fisheries Act; the Magnuson–Stevens Act, as amended
SL	Standard length (of a fish)
SRHS	Southeast Region Headboat Survey, conducted by NMFS-Beaufort laboratory
SPR	Spawning potential ratio
SSB	Spawning stock biomass; mature biomass of males and females
$\mathrm{SSB}_{\mathrm{MSY}}$	Level of SSB at which MSY can be attained
$\mathrm{SSB}_{\mathrm{F30\%}}$	Level of SSB at which $F_{30\%}$ can be attained
TIP	Trip Interview Program, a fishery-dependent biodata collection program of NMFS
TL	Total length (of a fish), as opposed to FL (fork length) or SL (standard length)
VPA	Virtual population analysis, an age-structured assessment
WW	Whole weight, as opposed to GW (gutted weight)
yr	Year(s)

Appendix B Parameter estimates from the Beaufort Assessment Model

```
# Number of parameters = 366  Objective function value = -1951.20  Maximum gradient component = 3.74112e-005
# Linf:
911.360000000
# K:
0.240000000000
# t0:
-0.330000000000
# len_cv_val:
0.103911613704
# Linf_L:
927.000000000
# K_L:
0.220000000000
# t0_L:
-0.660000000000
# len_cv_val_L:
0.139090983676
# Linf_20:
938.000000000
# K_20:
0.170000000000
# t0_20:
-2.41000000000
# len_cv_val_20:
0.100000029668
# log_Nage_dev:
 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000 0.00000000000
# log_R0:
12.6783793044
# steep:
0.990000000000
# rec_sigma:
0.818102531385
# R_autocorr:
0.00000000000
# log_rec_dev:
 0.457537558478 0.177887516656 0.596081349239 -0.430026388392 0.118926982008 1.21016744625 1.41291313014 0.568249030814 -0.160622680087 1.04766572397 0.714977120708 -0.305747974534 -1.45660939739 -1.56722307051
# selpar_A50_cH1:
2.13297154796
# selpar_slope_cH1:
3.88062143991
# selpar_A50_cH2:
3.09105863848
# selpar_slope_cH2:
3.33473916537
# selpar_A50_cH3:
3.08891050864
# selpar_slope_cH3:
2.42510949883
# selpar_A50_HB1:
1.88378267082
# selpar_slope_HB1:
3.54246021238
# selpar_A502_HB1:
3.79838916550
# selpar_slope2_HB1:
0.514619758261
# selpar_A50_HB2:
2.92961195540
# selpar_slope_HB2:
4.07669904945
# selpar_A502_HB2:
1.98351604776
# selpar_slope2_HB2:
0.653233646931
# selpar_A50_HB3:
2.29407884707
# selpar_slope_HB3:
3.37817174161
# selpar_A502_HB3:
2.19260024802
# selpar_slope2_HB3:
0.436836800807
# selpar_A50_GR2:
3.06592361767
# selpar_slope_GR2:
2.70676736368
# selpar_A502_GR2:
3.02073139942
# selpar_slope2_GR2:
0.588080290001
# selpar_A50_GR3:
3.57180467300
# selpar_slope_GR3:
2.08907291585
# selpar_A50_HB2_D:
0.766113358942
# selpar_slope_HB2_D:
0.484983160191
```

```
# selpar_A502_HB2_D:
1.15344665739
# selpar_slope2_HB2_D:
1.55677128989
# selpar_A50_HB3_D:
1.55070623873
# selpar_slope_HB3_D:
0.529401014875
# selpar_A502_HB3_D:
4.08062361079
# selpar_slope2_HB3_D:
0.516121290879
# selpar_A50_cH2_D:
0.912667864468
# selpar_slope_cH2_D:
0.488972548711
# selpar_A502_cH2_D:
1.70477627954
# selpar_slope2_cH2_D:
1.11106174907
# selpar_A50_cH3_D:
2.59513853167
# selpar_slope_cH3_D:
2.13645024460
# selpar_A50_CVT:
1.82586340241
# selpar_slope_CVT:
3.21899177029
# log_q_cH:
-6.33120989517
# log_q_HB:
-11.8810905835
# log_q_HB_D:
-12.8060356742
# log_q_CVT:
-12.2394582969
# M_constant:
0.134000000000
# log_avg_F_cH:
-1.98147518192
# log_F_dev_cH:
 -1.49687584191 -1.18611810279 -1.43746548361 -1.40355079721 -0.994476899346 -1.15200499920 -1.13248446861 -0.489280249664 -0.767142009048 -0.633713965540 -0.545597710092 -0.294220576158 -0.419521117751 -0.63101
# log_avg_F_HB:
-2.47173956726
# log_F_dev_HB:
 -1.32661816356 -1.19747207806 -1.06867014027 -0.953120143952 -0.855016377799 -0.761175117217 -0.638778346766 -0.525604485812 -0.431669732036 -0.341505724094 -0.246872928729 -0.210585614455 -0.164994735575 -0.10
# log_avg_F_GR:
-1.61803667431
# log_F_dev_GR:
 -1.52666935698 -1.39753187965 -1.26877505002 -1.15317139303 -1.05511310010 -0.961286518369 -0.838914340222 -0.725767285047 -0.631839134719 -0.541707815486 -0.447109690682 -0.410859004909 -0.365267028399 -0.3009
# log_avg_F_cH_D:
-3.72256331837
# log_F_dev_cH_D:
 0.292811823207 0.400833551825 0.576381470652 0.950509229335 0.500771663677 0.621339569425 -0.0750482116686 -0.537094562241 -0.542953545333 -0.336159205679 0.527801866279 -0.833215659609 -1.56395787905 0.6616494
# log_avg_F_HB_D:
-5.75855003085
# log_F_dev_HB_D:
 -4.73020931752 -3.72289661565 -4.19441528381 -4.60824727639 -4.22209722560 -4.04857749218 -3.32397085361 -3.16474888643 0.0869964083602 0.809321470525 0.843678532847 1.34886481821 0.329935038360 0.456159709437
# log_avg_F_GR_D:
-2.67216775093
# log_F_dev_GR_D:
 -2.41347222131 -2.48708991382 -3.40703651572 -1.01858950327 -0.450826242458 0.176279486394 -0.634044616253 -0.865374339250 -1.21402434434 -0.366618049618 0.220573093966 -0.587460476786 0.699171684388 0.59639720
# F_init:
0.0295838913167
```